NUREG/IA-0519

International Agreement Report

Survey of Member Countries' Nuclear Power Plant Fire Protection Regulations by the OECD Nuclear Energy Agency (NEA) Fire Incidents Records Exchange (FIRE) Database Project – Topical Report No. 2

Organisation for Economic Co-operation and Development (OECD)
Nuclear Energy Agency (NEA)
Committee on the Safety of Nuclear Installations (CSNI)
Paris, France

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Division of Risk Analysis
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Washington, DC 20555-0001

Manuscript Completed: March 2020
Date Published: August 2020

Published by
U.S. Nuclear Regulatory Commission

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ABSTRACT

Nations establish and authorize agencies with the responsibility to protect the health and safety of the public and the environment by licensing and regulating nuclear power plants (NPP). Unwanted accidental fires have been shown to be a major risk to NPP safety. Fire protection regulations built on defense-in-depth principles have been established in each country to minimize this risk. The purpose of this report is to collect and share the fire protection regulations and strategies used in different countries to ensure reactor safety. The report is built by each member country assembling their major fire protection regulations with all the regulations translated in the common language of English. In addition, an international trend exists for regulations to evolve from prescriptive requirements to risk-informed performance-based requirements. This report includes that information where applicable. The completed report now provides a single reference where countries can review and contrast their NPP fire protection regulations with other member countries. Through international cooperation in projects such as this research effort, each member country may discover new insights and ideas for their NPP fire protection regulations.

FOREWORD

This work was completed as a part of the Organisation for Economic Co-operation and Development/Nuclear Energy Agency Fire Incidents Records Exchange Database Project. Each member country was responsible for assembling (and translating to English where necessary) their section on that country's nuclear power plant fire protection regulations. The U.S. Nuclear Regulatory Commission (NRC) volunteered to complete the final preparation of this report for publication as a NUREG/International Agreement Report.

The contents of this report should not be viewed as an official NRC endorsement or any other member country's endorsement of the results or observations in this report. In addition, this report should not be viewed as binding the NRC or any member country in its rulemaking, licensing, or adjudicatory process.

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EXECUTIVE SUMMARY

Operating experience from nuclear installations worldwide has shown that fires can occur throughout the NPP's lifetime, and they can pose a significant impact on plant operation. Fires that have occurred in nuclear installations worldwide demonstrate that fires in certain locations of a NPP may impair the required functions of items important to safety, and in particular, redundant safety systems.

Fires in NPPs have the potential to induce initiating events (e.g., plant transients) that cause failures of equipment necessary to mitigate them, and to adversely affect, directly or indirectly, the barriers for prevention of the release of radioactive materials. Fires can also simultaneously challenge more than one level of defense-in-depth.

Many countries employ various defense-in-depth approaches for ensuring nuclear safety and that the plant can be safely shut down in the event of a fire including:

- Minimizing the occurrence of fires and explosions.
- Minimizing combustible loading.
- Maximizing the plant ability to detect, control, and extinguish the fires that do occur.
- Ensuring that plant operations have redundancy and diversity to enable a safe shutdown of the reactor despite having a fire.
- Minimizing the risk of releases to the environment.

Two primary types of methodologies for assessing fire safety at nuclear power plants include:

- Deterministic (or prescriptive) requirements, which dictate the level of protection to ensure reactor shutdown systems will survive an assumed serious fire, and
- Risk-informed and performance-based requirements, which considers risk insights as well as other factors to better focus attention and resources on design and operational issues to match the levels of protection according to their importance to safety.

Many member countries ensure that the requirements of the country specific regulation are met, and the fire protection codes and standards are followed by implementing a fire protection program for all operational stages of the NPPs. The fire protection program demonstrates that fire protection measures are implemented in a controlled, coordinated and effective manner, in order to minimize both the probability of occurrence and the consequences of fire.

This Topical Report presents the overall structure related to fire safety regulations for the fourteen FIRE member countries and depicts the structure of that country's regulatory process. It provides the baseline information and references to detailed, country specific documentation materials.

In addition to the regulatory information, each member country has also answered a survey related to the implementation of risk-informed, performance-based fire protection in the national regulations and associated challenges. The survey also documents on a country-to-country basis if, and how, probabilistic versus deterministic requirements are implemented.

One general conclusion from the survey questionnaire is that several countries are using a combination of prescriptive and risk-informed approaches to fulfil their fire safety regulatory framework. The general trend among member countries is moving towards using Fire PSA[1] as a tool for gaining risk insights regardless of regulatory framework guidelines. This trend supports the conclusions from several investigations on the level of maturity for Fire PSA, which more recently (cf. [NEA-19]) is one of the areas of interest of the Organisation for Economic Co-operation and Development/Nuclear Energy Agency Committee on the Safety of Nuclear Installations Working Group on Risk Assessment.

1 In this report the abbreviations PRA (Probabilistic Risk Assessment) and PSA (Probabilistic Safety Assessment) are used synonymously.

ACKNOWLEDGMENTS

This activity was performed as a part of the Fire Incidents Records Exchange Database Project. This report would not be possible without the individual contributions from the member countries. The Organisation for Economic Co-operation and Development/Nuclear Energy Agency (OECD/NEA) Secretariat wishes to thank the experts listed below, who provided valuable time and considerable knowledge towards the development of this NUREG/International Agreement Report:

Charles Fourneau (Belgium)	Abderrazzaq Bounagui (Canada)	Frantisek Stvan (Czech Republic)
Matti Lehto (Finland)	Jean-Pierre Cayla (France)	Heinz-Peter Berg (Germany)
Alexandra Iancu (Germany)	Marina Röwekamp (Germany)	Hajime Kabashima (Japan)
Sang Kyu Lee (Korea)	Jong-Seuk Park (Korea)	Laima Kuriene (The Netherlands)
Eunate Armañanzas Albaizar (Spain)	Miguel Angel Jimenez Garcia (Spain)	Anna Häggström (Sweden)
Christian Karlsson (Sweden)	Ralph Nyman (Sweden)	Dominik Hermann (Switzerland)
Annette Ramezanian (Switzerland)	Simon Thompson (United Kingdom)	J. S. Hyslop (United States)
Nicholas Melly (United States)		

The authors would like to thank David Stroup from the NRC Office of Nuclear Regulatory Research (RES), Naeem Iqbal, Charles Moulton and Jennifer Whitman from NRC's Office of Nuclear Regulatory Regulation (NRR) for their suggestions, comments, and review on an early draft of this report.

The authors would like to thank the OECD/NEA administrators, Markus Beilmann, Neil Blundell, and Olli Nevander for their exceptional support and oversight on this project.

ABBREVIATIONS AND ACRONYMS

AEC	Atomic Energy Commission (United States)
AGR	Advanced Gas Cooled Reactor
AHJ	authority having jurisdiction
ALARA(P)	as low as reasonably achievable (practicable)
ANS	American Nuclear Society
ANVS	Autoriteit Nucleaire Veiligheid en Stralingsbescherming (The Netherlands)
ASME	American Society of Mechanical Engineers
ASN	Autorité de Sûreté Nucléaire (France)
Bel V	Belgian TSO, part of the FANC
BEST	Belgian Stress Test
BfE	Bundesamt für kerntechnische Entsorgungssicherheit (Germany); Federal Office for Nuclear Waste Mangement
BfS	Bundesamt für Strahlenschutz (Germany); Federal Office for Radiation Protection
BMU	Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit (Germany); Federal Ministry for the Environment, Nature Protection and Nuclear Safety
CCR	code compliance review
CDF	core damage frequency
CNRA	Committee on Nuclear Regulatory Activities (NEA)
CNSC	Canadian Nuclear Safety Commission
CP	construction permit
CRIEPI	Central Research Institute of the Electric Power Industry (Japan)
CSA	Canadian Standard Association
CSN	Consejo de Seguridad Nuclear (Spain)
CSNI	Committee on the Safety of Nuclear Installations (NEA)
DBA	design basis accident
DEC	design extension conditions
DSR	Dutch Safety Requirements
EA	environmental assessment
ENSI	Eidgenössisches Nuklearsicherheitsinspektorat (Switzerland)
EOP	emergency operating procedures

FANC	Federal Agency for Nuclear Control
FDF	fuel damage frequency
FHA	fire hazard analysis
FIRE	Fire Incidents Records Exchange (NEA)
FPP	fire protection programme
FSSA	fire safe shutdown analysis
GDA	generic design assessment
GRS	Gesellschaft für Anlagen- und Reaktorsicherheit (Germany)
HEAF	high energy arcing fault
HSK	Hauptabteilung für die Sicherheit der Kernanlagen (Switzerland)
HSWA	Health and Safety at Work Act
HTGR	High-Temperature Gas-cooled Reactor
I&C	instrument and control
IAEA	International Atomic Energy Agency
IRR	Ionizing Radiation Regulations
IRSN	Institut de Radioprotection et de Sûreté Nucléaire (France)
KAERI	Korea Atomic Energy Research Institute
KFD	Kernfysische Dienst (The Netherlands)
KINS	Korea Institute of Nuclear Safety
KTA	Kerntechnischer Ausschuss (Germany)
LAR	license amendment request
LC	License Condition
LERF	large early release frequency
LOCA	loss of coolant accident
LOOP	loss of offsite power
MCR	main control room
MSO	multiple spurious operation
NBCC	National Building Code of Canada
NSCA	Nuclear Safety and Control Act
NEA	Nuclear Energy Agency
NFCC	National Fire Code of Canada
NFPA	National Fire Protection Association

NIA	Nuclear Installations Act
NPP	nuclear power plant
NRA	Nuclear Regulatory Authority (Japan)
NRC	Nuclear Regulatory Commission (USA)
NRR	Office of Nuclear Reactor Regulation (NRC USA)
NRRC	Nuclear Risk Research Center (Japan)
NSSC	Nuclear Safety and Security Commission (Korea)
NSCA	Nuclear Safety and Control Act
OECD	Organisation for Economic Co-operation and Development
OL	operating license
ONR	Office for Nuclear Regulation (United Kingdom)
PIE	postulated initiating event
PORV	power-operated relief valve
PRA	Probabilistic Risk Assessment
PRG	project review group
PROC	power reactor operating license (Canada)
PSA	Probabilistic Safety Assessment
PSR	periodic safety review
PWR	Pressurized Water Reactor
RB	regulatory body
RD	royal decree
REPPIR	Radiation (Emergency Preparedness and Public Information) Regulations 2001
RES	Office of Nuclear Regulatory Research (NRC USA)
RGP	relevant good practice
RHWG	Reactor Harmonization Working Group
SAP	Safety Assessment Principle
SFAIRP	so far as is reasonably practicable
SONS	State Office for Nuclear Safety (SÚJB in Czech)
SSC	structures, systems and components
SSM	Strålsäkerhetsmyndigheten (Swedish Radiation Safety Authority)
STUK	Radiation and Nuclear Safety Authority (Finland)
TAG	Technical Assessment Guide

TEA	The Energy Act
TSO	Technical Safety Organisation
TUKES	Finnish Safety and Chemicals Agency (Finland)
TÜV	TÜVRheinland (Germany)
UJV	Ústav Jaderného Výzkumu (Czech Republic)
VNDS	Vienna Declaration on Nuclear Safety
WANO	World Association of Nuclear Operators
WENRA	Western European Nuclear Regulators Association
WGRISK	Working Group on Risk Assessment (NEA)
WGWD	Working Group on Waste and Decontamination (NEA)

1 INTRODUCTION

The purpose of the Organisation for Economic Co-operation and Development/Nuclear Energy Agency (OECD/NEA) Fire Incidents Records Exchange (FIRE) Database Project is to provide a platform for multiple countries to collaborate and exchange fire data and thereby to enhance the understanding of how fire phenomena affects the safe operation of nuclear power plants (NPP) and, in turn, to improve the quality of quantitative fire risk assessment requiring fire-related data. In that context, the Project aims to:

- Collect fire event experience (by international exchange) in an appropriate format in a quality-assured and consistent database (the “OECD FIRE Database”).
- Collect and analyze fire events over the long-term so as to better understand such events and their causes and to encourage their prevention.
- Generate qualitative insights into the root causes of fire events to derive approaches or mechanisms for their prevention and to mitigate their consequences.
- Establish a mechanism for efficient operation feedback on fire event experience including the development of policies of prevention such as indicators for risk-informed and performance-based inspections.
- Record characteristics of fire events to facilitate fire risk analysis including quantification of fire occurrence frequencies.

The Topical Reports are developed by members of the OECD/NEA participating in the FIRE Database Project (14 countries). The selections of the topic and of the participant members who are going to undertake the task are agreed upon during the FIRE Database Project Review Group (PRG) meetings.

The following is a list of topics where work has either commenced, or which are identified for future analysis:

- Fire event apparent causes and root cause analyses: This ongoing activity has a specific interest in the ability to derive approaches or mechanisms for future fire prevention and mitigation of potential consequences.
- Risk significant contributions in probabilistic safety assessment (PSA) for fires: This work involves an analysis of the available Fire PSAs to identify the significant elements in the PSA, either compartment wise or component wise. These would be analysed and investigated for consistency within the database;
- Multiple unit/fire area impacts: This effort is related to an earlier Topical Report on “Event Combinations of Fire and Other Events” [NEA-16] with a specific focus on potential effects for fire affecting multiple units or fire areas and the unique attributes for plant safety.
- Fire brigade effectiveness and implementation strategies: This topic includes an investigation of country-specific approaches to fire brigade and fire suppression techniques.

This Topical Report supports the database project by compiling the regulations of the member countries related to fire safety in NPPs. This compilation does not attempt to evaluate the approaches and merits of regulatory strategies in one country versus the other members but rather to provide a platform for understanding fire regulations across the member countries. This Topical Report evaluates regulatory trends as well as attempts to discuss the processes and methods each country undertakes at a high level to meet specific regulatory goals and requirements related to fire safety.

1.1 Previous Topical Reports

Two Topical Reports have already been published: The first one issued in 2013 [NEA-13] has provided results of the analysis of fires resulting from high energy arcing faults (HEAF). This Topical Report has resulted in an additional experimental research program by OECD/NEA, which included full-scale HEAF testing and analysis. The first test program results were published in 2017 [NEA-17]; a second phase, the international HEAF Project (HEAF, Phase 2), which covers further test series, has been started recently. Another Topical Report of the FIRE Database Project has presented results of analyses with respect to event combinations of fires and other anticipated events [NEA-16]. This report provided valuable insights on the operating experience feedback concerning the potential impact and consequences of fire event combinations. The insights have supported recent activities of the WGRISK regarding risk aggregation for hazards (including fires) for Site-Level PSA.

2 SCOPE AND OBJECTIVES

This report addresses the regulatory framework and structures of the member countries involved in the Fire Incidents Records Exchange (FIRE) Database Project. One of the primary aspects addressed in this report is the methods in which member countries address the risks associated with fire protection. Generally, member countries historically choose between two different approaches for assessing fire safety in nuclear power plants (NPPs): deterministic fire safety measures versus probabilistic fire risk assessment with the latter applied more for regulatory decision making. Although a deterministic assessment is performed to ensure that specific requirements for prescribed elements of defense-in-depth are met, the elements of the defense-in-depth concept can also provide a framework for the analysis within a Fire probabilistic safety assessment (PSA). Some countries have regulations containing a mix of these two approaches.

One benefit of the international FIRE Database Project is to provide the member countries a venue to discuss NPP fire-related experience in their countries. This Topical Report is an attempt to assemble and consolidate the fire protection and post-fire safe shutdown regulations of each FIRE Database Project member country. This will enable experts from member countries to better understand how their fire-specific regulations compare with those from other member countries.

The regulatory information reflected in this report is currently up to January 1, 2018, unless otherwise noted in the member countries regulatory section. The scope of this document covers commercial NPPs unless otherwise noted in the member countries regulatory section.

Due to differences between countries, the information was collected in a manner to facilitate a general understanding and to draw parallels between regulatory processes. The information is presented in the following format.

2.1 Description of the Work

2.1.1 Format/Structure

a. **Existing Reactors** – General overview of the fire-safety-specific regulations currently in place for existing reactors either in commercial operation or in post-commercial safe shutdown or under decommissioning.

b. **New Reactors** – Some member countries are currently in the process of building new nuclear facilities. An attempt was made to collect information as to the regulatory process for new build reactors to reveal if the regulations differed or have been updated to account for new information or designs.

c. **Supplementary Information** – Member countries were encouraged to provide supplementary information concerning the regulatory framework and structure within their regulatory bodies.

2.1.2 Member Country Survey Questionnaire

The purpose of the following survey was to generalize member countries fire-safety-related regulatory structures to provide feedback for a general comparison.

Q.1 Are the NPP fire protection regulations in your country based on prescriptive (deterministic) principles or performance-based risk-informed methods?

Q.2 Are Fire Probabilistic Risk Assessments (PRAs) used to support license applications?

Q.3 How does the regulator inspect and ensure the quality of the Fire PRA supporting the license amendment?

Q.4 If Fire PRAs are being developed and applied, what methodological guidance is being used and what issues/limitations have been identified, if any, with these methods?

3 FIRE PROTECTION AND POST-FIRE SAFE SHUTDOWN REGULATIONS IN MEMBER COUNTRIES

The following section presents the regulatory framework with respect to fire protection and post-fire safe shutdown in each of the fourteen Organisation for Economic Co-operation and Development/Nuclear Energy Agency (OECD/NEA) Fire Incidents Records Exchange (FIRE) member countries and the corresponding nuclear and applicable non-nuclear fire protection regulations. This covers existing operational reactors as well as reactors under construction. In principle, all countries consider the general requirements and high-level guidance documents related to fire protection by the International Atomic Energy Agency (IAEA), specifically NS-G2.1 [IAEA-00b] and NS-G-1.7 [IAEA-04]. Soon a revised guide [IAEA-19] will replace NS-G-1.7 merging it with NS-G-1.11 [IAEA-04a]. However, a lot of more detailed guidance is currently available on a national basis for most of the FIRE member countries.

3.1 Belgium

The information contained herein was accurate as of December 2018 and applies to major nuclear installations (defined as "Class I" in the Belgian regulation) in Belgium, including commercial nuclear power generating reactors.

3.1.1 Existing Reactors

3.1.1.1 Overview of the Regulatory Framework

The current form of the Belgian nuclear regulatory framework has been established by the Royal Decree of 20 July 2001 that enforces many articles of the Law of 15 April 1994 and made the Federal Agency for Nuclear Control (FANC), created by that Law, operational. This agency, which is endowed with wide competences, constitutes the Safety Authority.

In 2007, the FANC created Bel V as a subsidiary with the statute of a so-called 'foundation' as defined in Belgian law. Bel V is given a mandate to perform regulatory missions that can be delegated by the FANC, in line with the provision of the above law, including on-site routine inspections and technical support. The association of the FANC and Bel V is referred to as the Regulatory Body.

The main Belgian regulations regarding the nuclear safety are:

- The Law of 15 April 1994 on the protection of the population and the environment against the hazards of ionizing radiation and on the Federal Agency for Nuclear Control, amended for the last time in 2017 [BEL-01];
- Royal Decree of 20 July 2001, enforcing the above Law and laying down the General Regulation for the protection of the public, workers and the environment against the hazards of ionizing radiation (RGPRI/ARBIS), amended for the last time in 2018 [BEL-02];
- Royal Decree of 01 March 2018 establishing the nuclear and radiological emergency plan for the Belgian territory [BEL-03];
- Royal Decree of 30 November 2011 on the safety requirements for nuclear installations, transposing the WENRA (Western European Nuclear Regulators Association) Reference Levels of 2008 [WENRA-08] in the Belgian legislation, amended for the last time in 2015 [BEL-04].

3.1.1.2 Fire Protection Regulation

For historical reasons, the Belgian nuclear power sector followed the American rules for the design and construction of its nuclear power plants, i.e. the requirements of the Code of Federal Regulations (10 CFR 50) [NRC-04, NRC-01, NRC-02] and the documents issued by the U.S. NRC such as the Regulatory Guides, the Standard Review Plans, the NUREGs, as well as the application of the ASME code, or the ANS/IEEE standards, etc. As a consequence, National Fire Protection Association (NFPA) standards were largely adopted for the original design of the fire protection systems in the nuclear power plants currently in operation.

Nevertheless, the Belgian rules and regulations, including the transposition in the Belgian law of the relevant European directives have now to be followed. Bel V inspects and assesses the application of national regulations, and consequently national or European standards, wherever applicable.

Belgian nuclear facilities have to adhere to both conventional and nuclear specific fire protection regulations.

The main conventional fire protection regulations are:

- Royal Decree of 7 July 1994 [BEL-01] and subsequent amendments, defining the “Base Standards” for fire protection in buildings, other than individual housings. More specifically the Appendix 6 addresses the topic of fire protection in industrial buildings. Minimal requirements for compartmentalization and fire rating of structures, as well as automatic detection and suppression are covered in this document.
- Article 52 of the Belgian regulation for the protection of the workers (RGPT/ARAB) also known as the code for the welfare at work. This article covered multiple organizational aspects of the fire protection, among which the prevention measures, the evacuation planning, the fire-fighting measures, the periodical tests and control or the training of the workers. It was recognized for decades as the reference for planning and organization of fire protection in Belgium but was largely superseded by the Royal Decree of 28 March 2014 [BEL-07]. Some parts remain applicable.
- Articles 104 to 110 of the Belgian regulation for electrical installations (RGIE/AREI). These cover the fire resistance rating of electrical equipment and most notably electrical cables, along with the anti-deflagration properties in relation with the European ATEX directives.
- Royal Decree of 28 March 2014 f, now integrated in the Code of well-being at work (*Code du bien-être au travail*) [BEL-07], or fire protection at workplaces is the most recent development in the field of fire protection in Belgium. It updates and complements the requirements of the article 52 of the Belgian regulation for the protection of the workers. It also introduces the necessity to perform a risk analysis to demonstrate that fire prevention and protection measures are sufficient to ensure the safety of the workers.

For nuclear facilities, additional requirements are enforced through the Royal Decree of 30 November 2011 [BEL-04]. As presented above, this Royal Decree transposes the WENRA Safety Reference Levels of 2008 in the Belgian legislation.

Article 17 of this so-called “WENRA Royal Decree” covers the protection against internal fires for all Class I nuclear facilities and is a slightly amended transposition of the “Issue S” of the WENRA 2008 RLs. This includes the production of a Fire Hazard Analysis, using a deterministic approach.

17.1 Strategy for protection against internal fires;

17.2 Basic design principles;

17.3 Fire hazard analysis;

17.4 Fire protection systems;

17.5 Administrative controls and maintenance;

17.6 Firefighting organization.

The deterministic fire risk analysis should address the defense-in-depth principles applied to fire protection by systematically evaluating fire scenarios, using conservative assumptions, in all rooms containing, or related to rooms containing, equipment identified as important to safety. All plant operating modes must be covered and/or enveloped by the scenarios taken into consideration and the combinations of fire events with postulated independent initiating events such as long-term management of a large break loss of coolant accident (LOCA), loss of offsite power (LOOP) or safe shutdown state after an earthquake are studied.

The objectives of this analysis are met if the following safety functions (as well as all support systems to these functions) can be guaranteed at all time under the above conditions:

1. Removal of residual heat
2. Safe shutdown capabilities
3. Confinement
4. Long-term internal accident mitigation

Because Article 17 was established to be applicable to all Class I nuclear facilities, specific provisions for the protection against internal fires in nuclear power reactors were added in Article 32, including the production of a Fire Probabilistic Safety Analysis, or Fire PSA:

32.1 Basic design principles
The ability to perform the reactor shutdown, decay heat removal, radioactive products confinement and plant state monitoring must be maintained during and after the fire event;

32.2 Fire Risk Analysis
The fire hazard analysis shall be complemented by probabilistic fire analysis. In PSA level 1, the fires shall be assessed in order to evaluate the fire protection arrangements and to identify risks caused by fires;

32.3 Fire Protection Systems
The distribution loop for fire hydrants outside building and the internal standpipes shall provide adequate coverage of areas of the plant relevant to safety. The coverage shall be justified by the fire hazard analysis.

A new regulatory project was started by the FANC in order to translate the updated WENRA Safety Reference Levels of September 2014 [WENRA-14a] into the Belgian regulations. The regulatory project will amend the existing royal decree on the safety of nuclear installations (30 November 2011 [BEL-04) and is in final revision stage for publication in 2019. This regulatory evolution will especially result in stronger requirements for the analysis of events combinations.

In addition to the regulatory evolution, the BEST (Belgian Stress Test) project has led to all licensees re-evaluating the emergency preparedness and response plans as aftermath to the Fukushima disaster. Among the outcomes of these tests, additional intervention and emergency back-up means, including specific fire-fighting equipment for the on-site and off-site fire brigades, have been provisioned.

3.1.2 New Reactors

In 2015 the FANC published a new guidance on the Safety demonstration of new class I nuclear installations -Approach to Defense-in-Depth, radiological safety objectives and application of a graded approach to external hazards, updated in April 2017 [BEL-05]. This guideline is written in relation to the council directive 2014/87/Euratom of 8 July 2014 [EUR-14] amending directive 2009/71/Euratom [EUR-09]. In addition, to support the requirements already formulated in the Belgian regulation, this guideline is mainly inspired from recent WENRA publications on the safe design of new NPPs, from safety reference levels, as well as from recent IAEA publications.

The chapter specific to nuclear power reactors of the Belgian regulation [BEL-04] specifies that the selected design basis events will be grouped into a limited number of categories according to their probability of occurrence and requires the definition of acceptance criteria for each category such that there are no or minor radiological consequences for frequent events and that events with potential severe consequences must have a very low probability of occurrence. These general terms can be generalized to new class I nuclear installations. Design basis categories are addressed in this guideline, in relation to Defense-in-Depth and radiological safety objectives to be associated to these categories are discussed.

In addition to the above regulation, all new Class I nuclear installation (including nuclear reactors) will have to adhere to these guidelines for the safety demonstration, and in particular for internal hazard fire.

3.1.3 Supplementary Information

[BEL-01] Law of 15 April 1994 on the protection of the population and the environment against the hazards of ionizing radiation and on the Federal Agency for Nuclear Control, amended for the last time in 2017, http://www.jurion.fanc.fgov.be/jurdb-consult/consultatieLink?wettekstId=2182&appLang=fr&wettekstLang=fr.

[BEL-02] Royal Decree of 20 July 2001, enforcing the above Law and laying down the General Regulation for the protection of the public, workers and the environment against the hazards of ionizing radiation (RGPRI/ARBIS), amended for the last time in 2018, http://www.jurion.fanc.fgov.be/jurdb-consult/consultatieLink?wettekstId=7460&appLang=fr&wettekstLang=fr.

[BEL-03] Royal Decree of 01 March 2018 establishing the nuclear and radiological emergency plan for the Belgian territory, http://www.jurion.fanc.fgov.be/jurdb-consult/consultatieLink?wettekstId=26393&appLang=fr&wettekstLang=fr.

[BEL-04] Royal Decree of 30 November 2011 on the safety requirements for nuclear installations, transposing the WENRA (Western European Nuclear Regulators Association) Reference Levels of 2008 in the Belgian legislation, amended for the last time in 2015, http://www.jurion.fanc.fgov.be/jurdb-consult/consultatieLink?wettekstId=15152&appLang=fr&wettekstLang=fr.

[BEL-05] Guideline on the Safety demonstration of new class I nuclear installations - Approach to Defence-in-Depth, radiological safety objectives and application of a graded approach to external hazards, https://afcn.fgov.be/fr/system/files/guideline-safety-demonstration-new-classi-installations-rev1-final.pdf.

[BEL-06] Guidelines for new Class I nuclear installation (including external hazards aircraft crash, earthquake and flooding), https://afcn.fgov.be/fr/dossiers-dinformation/autres-etablissements-nucleaires/directives-pour-une-nouvelle-installation.

[BEL-07] Code du Bien-Être au Travail, Book III, Title 3, Fire prevention in the workplace, http://www.emploi.belgique.be/moduleDefault.aspx?id=1958.

[EUR-09] Council Directive 2009/71/Euratom of 25 June 2009 establishing a Community framework for the nuclear safety of nuclear installations, https://eur-lex.europa.eu/eli/dir/2009/71/oj.

[EUR-14] Council Directive 2014/87/Euratom of 8 July 2014 amending Directive 2009/71/Euratom establishing a Community framework for the nuclear safety of nuclear installations, http://data.europa.eu/eli/dir/2014/87/oj.

3.2 Canada

The Canadian Nuclear Safety Commission (CNSC) is the federal organization responsible for regulating the use of nuclear energy and materials in Canada. It regulates to protect health, safety, security and the environment, and to implement Canada's international commitments on the peaceful use of nuclear energy. The CNSC also disseminates objective scientific, technical, and regulatory information to the public.

The CNSC regulates the conduct of activities related to the use, production and distribution of nuclear energy and substances as defined by section 26 of the Nuclear Safety and Control Act (NSCA) [CAN-01]. This includes activities related to:

- Uranium mines and mills;
- Uranium fuel fabrication and processing;
- Nuclear power plants;
- Nuclear substance processing;
- Industrial and medical applications:
- Nuclear research and educational activities;
- Transportation of nuclear substances;
- Nuclear security and safeguards;
- Import and export activities;
- Waste management facilities;

The CNSC's regulatory framework (see Figure 1) consists of the NSCA and laws passed by Parliament that govern the regulation of Canada's nuclear industry, as well as regulations, licenses and documents that the CNSC uses to regulate the industry.

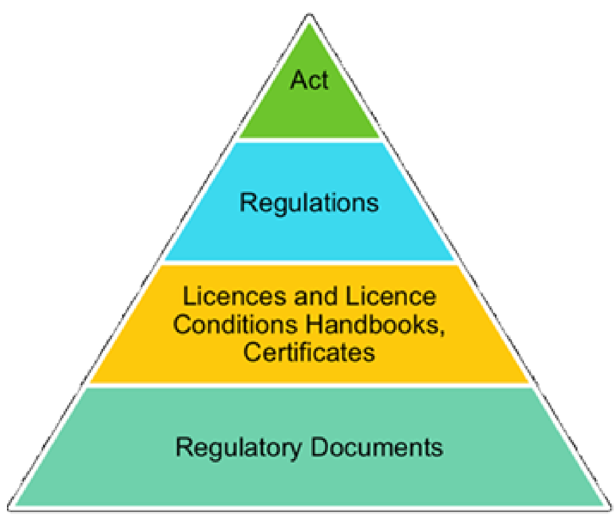

Figure 1 Key Elements of the CNSC's Regulatory Framework

The regulatory framework also includes guidance, which is used to inform the applicant or licensees on how to meet requirements, elaborate further on requirements, or provide best practices. While the CNSC sets requirements and provides guidance on how to meet requirements, an applicant or licensee may put forward a case to demonstrate that the intent of a requirement is addressed by other means. Such a case must be demonstrated with supportable evidence. CNSC staff consider guidance when evaluating the adequacy of any case submitted. This does not mean that the requirement is waived; rather, it is an indication that the regulatory framework provides flexibility for licensees to propose alternative means of achieving the intent of the requirement. The Commission is always the final authority as to whether the requirement has been met.

CNSC requirements and guidance take into account international regulatory best practices and modern codes and standards and align with the International Atomic Energy Agency's Safety Fundamentals and Safety Requirements. The CNSC cooperates with other organizations and jurisdictions to foster the development and application of a consistent, effective regulatory framework in Canada and for international nuclear regulators. The CNSC welcomes stakeholder feedback on its regulatory framework at any time.

Further information on the CNSC's regulatory framework can be found on the CNSC's regulatory framework overview Web page.

The regulatory requirements for fire risk mitigation are determined based upon:

1. Class of the facility pursuant to the regulations;
2. Risk to persons and the environment (graded requirements e.g. license conditions); and
3. Achieving the regulatory fire protection goals.

To meet the requirements of the NSCA and associated regulations, the regulatory fire projection goals are:

1. Health and safety of persons;
2. Protection of the environment;
3. Nuclear substances safety;
4. Nuclear criticality safety;
5. Reactor safety.

The CNSC's regulatory model in fire protection is based upon the implementation of the defense-in-depth concept (REGDOC-2.5.2, Design of Reactor Facilities: Nuclear Power Plants [CNSC-14]) to ensure the protection of the health and safety of persons and the environment.

From a fire protection perspective, defense in depth is achieved through a combination of design (e.g., physical barriers, spatial separation, fire protection detection and suppression systems), management of fire protection (e.g., operational procedures), quality assurance and emergency arrangements. The defense-in-depth applies to fire protection at all levels of the facility and its associated activities, from establishing high-level facility objectives to defining the detailed procedures and equipment required to meet those objectives.

To achieve a high level of confidence that the fire protection goals will be met, an appropriate level of defense-in-depth should be maintained throughout the lifetime of the facility, through the fulfilment of the five elements of the defense-in-depth principles (Figure 2).

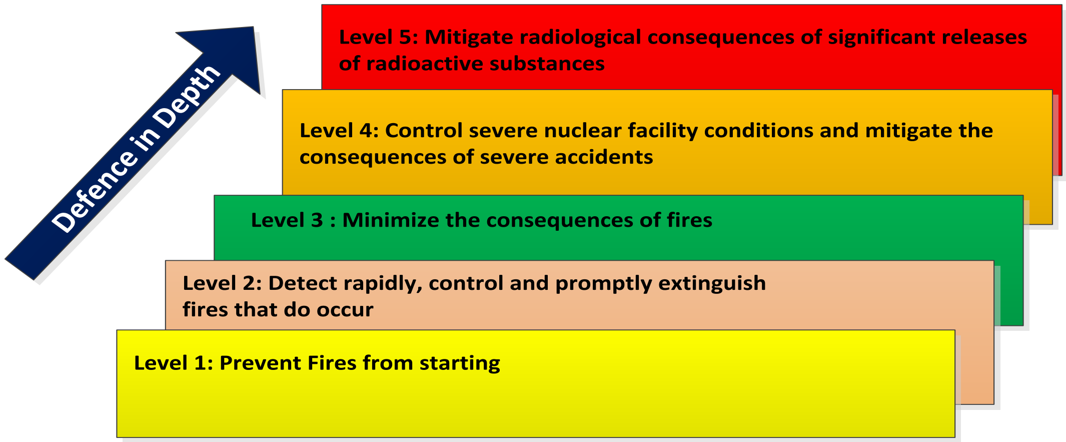

Figure 2 The Five Levels of Defense in Depth with Respect to Fire Protection

This is achieved by the implementation of the following fire protection standards:

- CSA N293, Fire protection for CANDU nuclear power plants [CSA-12] required for nuclear power plants;
- CSA N393, Fire protection for facilities that process, handle or store nuclear substances [CSA-13] required for others nuclear facilities.

These standards require the implementation of the National Building Code of Canada (NBCC) [NRCC-15], and the National Fire Code of Canada (NFCC) [NRCC-15a] (similar to NFPA 5000 [NFPA 18], 101 [NFPA 18a] & 1 [NFPA 18b]). The CSA standards are prescriptive in nature but allow for the use of alternative solutions to meet prescriptive requirements. The NBCC and the NFCC are objective based Codes and contain prescriptive requirements but state the objectives and functional statements for each prescriptive requirement and allow alternative solutions to meet these requirements.

The CSA N293 and CSA N393 standards require that:

- Licensees implement and maintain a comprehensive fire protection program (FPP) in order to reduce the occurrence of fires and limit their consequences and severity (the required elements of the program are prescribed in the CSA standards). The FPP is defined as a set of planned, coordinated and controlled activities which is documented and integrated into the operation of the facility; and

- Complete fire safety assessments include Fire hazard assessment (FHA), Fire safe shutdown analysis (FSSA), and Code Compliance review. The FHA and FSSA are deterministic analyses.

A Level 2 (Fire) PSA is a requirement of NPP licenses (through the license requirement for the preparation of a PSA in accordance with REGDOC 2.4.2, Probabilistic Safety Assessment (PSA) for Nuclear Power Plants" [CNSC-14a] (but is not currently required to be incorporated into to the Fire Protection Program. REGDOC 2.4.2 requires licensee to see CNSC acceptance of the methodology and computer codes to be used for the PSA before using them. The methodology typically used for the completion of Fire PSAs is NUREG/CR-6850 [NRC-08].

3.2.1 Existing Reactors

Existing NPP's are required to comply with CSA N293 [CSA-12]. As CSA N293 was written after the construction of all the Canadian NPP's, the design and construction requirements of this standard are not retroactively applied to existing structures, systems and components. However, these requirements apply for modification to the plant. The operational requirements of the standards do apply.

3.2.1.1 Refurbishment and Life Extension

As part of its licensing process, the CNSC requires Periodic Safety Reviews (PSRs), a technical assessment to be completed before authorizing a NPP refurbishment or life extension project through REGDOC-2.3.3 [CNSC-15]. A PSR involves an assessment of the current state of the plant and its performance to determine the extent to which it conforms to applicable modern codes, standards and practices, and to identify any factors that would limit safe long-term operation.

The PSR includes a systematic review of the all safety systems of the reactor to identify possible safety improvements to enhance safety and minimize environmental impacts. The PSR identifies all practicable safety improvements that could be made during the refurbishment.

The PSR provides for a rigorous review of the reactor's systems, structures and components against modern codes and standards, experience, best practices and research findings. The PSR considers a wide range of safety related topics (including plant design, environmental qualification, and probabilistic safety analysis).

For existing facilities preparing for refurbishment, a code compliance review (CCR) is completed against modern codes and standards. That is, the facility and operations are reviewed against the current edition of CSA N293, the NBCC and NFCC and the codes and standards referenced therein. The gaps identified in the CCR are either rectified during the refurbishment process, after the refurbishment (based on an approved corrective action plan) or are dispositioned (i.e. justified as requiring no action) using a documented performance-based approach.

3.2.2 New Reactors

The CNSC REGDOC 2.5.2 [CNSC-14] requires that suitable incorporation of operational procedures, redundant SSCs, physical barriers, spatial separation, fire protection systems, and design for fail-safe operation achieves the following general objectives:

- prevent the initiation of fires;
- limit the propagation and effects of fires that do occur by quickly detecting and suppressing fires to limit damage and confining the spread of fires and fire by-products that have not been extinguished;
- prevent loss of redundancy in safety and safety support systems;
- provide assurance of safe shutdown;
- ensure that monitoring of safety-critical parameters remains available, and
- prevent exposure, uncontrolled release, or unacceptable dispersion of hazardous substances, nuclear material, or radioactive material, due to fires;
- prevent the detrimental effects of event mitigation efforts, both inside and outside of containment; and
- ensure structural sufficiency and stability in the event of fire

To achieve the noted objectives, the REGDOC 2.5.2 requires new NPPs to comply with CSA N293, NBCC and NFCC. In addition, the REGDOC recommends the following as guidance documents: U.S. NRC, NUREG-1852 "Demonstrating the Feasibility and Reliability of Operator Manual Actions in Response to Fire", 2007 [NRC-35], and Nuclear Energy Institute, NEI 00-01, Guidance for Post-Fire Safe Shutdown Circuit Analysis, Washington, D.C., 2005 [NEI-05].

3.2.3 Supplementary Information

[CAN-01] Nuclear Safety and Control Act (NSCA), paragraph 3(a), subparagraph 9(a)(i), paragraph 24(4)(b). https://laws-lois.justice.gc.ca/PDF/N-28.3.pdf.

[CSA-12] Canadian Standard Association (CSA): Fire protection for nuclear power plants, CSA N293-12 (R 2017), Toronto, ONT, Canada, 2012.

[CSA-13] Canadian Standard Association (CSA): Fire protection for facilities that process, handle or store nuclear substances, CSA N393-13 (R 2018), Toronto, ONT, Canada, 2013.

[CNSC-14] Canadian Nuclear Safety Commission (CNSC): REGDOC-2.5.2, Design of Reactor Facilities: Nuclear Power Plants, Ottawa, ONT, Canada, May 2014, http://www.nuclearsafety.gc.ca/pubs_catalogue/uploads/REGDOC-2-5-2-Design-of-Reactor-Facilities-Nuclear-Power-Plants-eng.pdf.

[CNSC-14a] Canadian Nuclear Safety Commission (CNSC): Probabilistic Safety Assessment (PSA) for Nuclear Power Plants, REGDOC-2.4.2, Ottawa, ONT, Canada, May 2014, http://www.nuclearsafety.gc.ca/pubs_catalogue/uploads/REGDOC-2-4-2-Probabilistic-Safety-Assessment-NPP-eng.pdf.

[CNSC-15] Canadian Nuclear Safety Commission (CNSC): Operating Performance Periodic Safety Review, REGDOC-2.3.3, Ottawa, ONT, Canada, April 2015, http://www.nuclearsafety.gc.ca/pubs_catalogue/uploads/REGDOC-2-3-3-Periodic-Safety-Reviews-eng.pdf.

[NRCC-15] National Research Council Canada: National Building Code of Canada (NBCC) 2015, Toronto, ONT, Canada, 2015, https://nrc.canada.ca/en/certifications-evaluations-standards/codes-canada/codes-canada-publications.

[NRCC-15a] National Research Council Canada: National Fire Code of Canada (NFCC) 2015, Toronto, ONT, Canada, 2015, https://nrc.canada.ca/en/certifications-evaluations-standards/codes-canada/codes-canada-publications.

3.3 Czech Republic

3.3.1 Existing Reactors

Fire Specific Regulations in Czech NPPs is described in document ”Protection against internal fires - Safety instructions JB-3.1” [SONS-10], which was issued by the State Office for Nuclear Safety (Czech Regulatory Authority) in 2010.

Safety instructions JB-3.1 is part of a series of safety guidelines that elaborate requirements defined by the WENRA Reactor Safety Reference Levels, Issue S [WENRA-08], the Waste and Spent Fuel Safety Reference Levels Report [WENRA-14] and also apply the recommendations of the International Atomic Energy Agency (from [IAEA-94], [IAEA-95], [IAEA-96], [IAEA-97], [IAEA-98], [IAEA-98a], [IAEA-00], [IAEA-00a], [IAEA-00b], [IAEA-02], [IAEA-03], [IAEA-04], [IAEA-04a], [IAEA-04b], [IAEA-06].

Instruction JB-3.1 focuses primarily on nuclear facilities which include nuclear reactors with power above 50 MW_{th}, thus covering civilian nuclear power under the Convention on Nuclear Safety [IAEA-94]. Its principles and practices can be applied also to other kind of nuclear facilities defined by the Convention on the Safety Spent Fuel Management and the Safety of Radioactive Waste Management [IAEA-97] or research reactors.

It also addresses the influence of firefighting on nuclear safety. Personnel safety and property protection shall be ensured in accordance with valid legislation for fire protection.

The instruction JB-3.1 consists of eight main chapters covering the following topics:

- **Chapter 3** – Background, objectives and relevance
  - (3.2) Requirements for fire protection of nuclear facilities are defined by the implementing regulations of the Atomic Law - Decree no. 195/1999 [CZE-01]. The decree states in paragraph 9 the default requirements for fire protection of nuclear facilities and clarifies the requirements of legislation in the field of fire protection of nuclear facilities.
  - (3.3) The basic law in the field of fire protection is Act No. 133/1985 [CZE-02] about Fire Protection as amended, and the implementing regulations issued on its basis (Especially Decree No. 246/2001 [CZE-03] about Fire prevention and Decree No. 23/2008 [CZE-04] about Technical conditions of buildings fire protection). Fire protection requirements are further refined by technical standards, which contain requirements for fire protection and fire safety.
  - (3.4) Instruction JB-3.1 is designed especially for the licensee to operate nuclear facilities and offers possible processes for activities in the field of fire protection in accordance with the requirements of the Act No. 18/1997 [CZE-05] (so called Atomic law, from year 2016 replaced by new Act No. 263/2016 [CZE-06]), its implementing regulations and with relevant WENRA reference levels [WENRA-08], [WENRA-14a].
  - (3.8) Instruction JB-3.1 addresses the issue of internal risks associated with the possibility of fire and explosion caused by a fire during the operation of nuclear installation and also establishes requirements for fire detection and firefighting systems.
- **Chapter 4 –** Overall concepts; Combination of events External fires Explosion protection
- **Chapter 5 –** Building design; Fire Hazard Analysis

- **Chapter 6 –** Fire prevention
- **Chapter 7 –** Detection and firefighting; smoke and heat exhaust
- **Chapter 8 –** Limitation of secondary impact of fires
- **Annex 2 to instructions JB-3.1 –** Fire Hazard Analysis – General requirements for FHA

  (10.2) FHA reflects the depth of information that corresponds to the preparation stage of construction, respectively the operation of nuclear installations. The scope of input data changes and the timeliness of the methodology used for assessment will be assessed regularly (once a year). The update of the document or its part (new revision) shall be carried out flexibly with regard to the rate of input data changes, or changes of the assessment methodology. A new revision will be issued immediately after the completion of the electronic version. The printed document will be updated with regard to the scope of the changes. The edition of the printed document may be required by SONS (Czech regulatory authority).

  (10.4) The documentation of FHA, its creation, revision and updating, has to be checked and approved in accordance with the QA principles of the licensee [CZE-07] (QA principles are currently based on Decree No. 408/2016 [CZE-08] and Decree No. 358/2016 [CZE-09]). The current conditions shall be described for each fire zone throughout the nuclear facility. FHA shall be maintained as a "living document" throughout the operation of nuclear installations.

  (10.5) In processing of FHA is recommended to respect the concept and the breakdown corresponding to IAEA documentation.

  (10.6) Deterministic part of FHA should be following up on Level 1 PSA.

3.3.2 New Reactors

The acts and standards related to the nuclear regulation and the new fire protection guidelines and guides mentioned above are applicable for the existing reactors as well as for new reactors.

The paragraphs with relationship to new installations are primarily: 5.9, 5.21, 5.22, 6.1, 6.11, 6.30, 10.2, 10.4, 10.5 (see above) and naturally many others.

3.3.3 Supplementary Information

Annex 1 to instructions JB-3.1 – The comparison with WENRA Reactor Safety Reference Levels, Area S

WENRA Reactor Safety Reference Levels, Issue S	Referenced in chapter(s) of Guide JB-3.1
1. Fire safety objectives	4-8
1.1 The licensee shall implement the defence-in-depth principle to fire protection, providing measures to prevent fires from starting, to detect and extinguish quickly any fires that do start and to prevent the spread of fires and their effects in or to any area that may affect safety.	

2. Basic design principles	5.8 - 5.20
2.1 SSCs important to safety shall be designed and located so as to minimize the frequency and the effects of fire and to maintain capability for shutdown, residual heat removal, confinement of radioactive material and monitoring of plant state during and after a fire event.	
2.2 Buildings that contain equipment that is important to safety shall be designed as fire resistant, subdivided into compartments that segregate such items from fire loads and segregate redundant safety systems from each other. When a fire compartment approach is not practicable, fire cells shall be used, providing a balance between passive and active means, as justified by fire hazard analysis.	
2.3 Buildings that contain radioactive materials that could cause radioactive releases in case of fire shall be designed to minimize such releases.	8.13 - 8.15
2.4 Access and escape routes for fire-fighting and operating personnel shall be available.	8.4
3. Fire hazard analysis	5.21 – 5.28, 10, Annex No. 2
3.1 A fire hazard analysis shall be carried out and kept updated to demonstrate that the fire safety objectives are met, that the fire design principles are satisfied, that the fire protection measures are appropriately designed and that any necessary administrative provisions are properly identified.	
3.2 The fire hazard analysis shall be developed on a deterministic basis, covering at least: – For all normal operating and shutdown states, a single fire and consequential spread, anywhere that there is fixed or transient combustible material; – Consideration of credible combination of fire and other postulated initiating events (PIEs) likely to occur independently of a fire.	
3.3 The fire hazard analysis shall demonstrate how the possible consequential effects of fire and extinguishing systems operation have been taken into account.	
3.4 The fire hazard analysis shall be complemented by probabilistic fire analysis. In PSA level 1, the fires shall be assessed in order to evaluate the fire protection arrangements and to identify risks caused by fires.	

4. Fire protection systems	7.1 – 7.41
4.1 Each fire compartment or fire cell shall be equipped with fire detection and alarm features, with detailed annunciation for the control room staff of the location of a fire. These features shall be provided with non-interruptible emergency power supplies and appropriate fire resistant supply cables.	7.1 – 7.17
4.2 Fixed or mobile, automated or manual extinguishing systems shall be installed. They shall be designed and located so that their rupture, spurious or inadvertent operation does not significantly impair the capability of SSCs important to safety to carry out their safety functions.	7.18 – 7.28
4.3 The distribution loop for fire hydrants outside building and the internal standpipes shall provide adequate coverage of areas of the plant relevant to safety. The coverage shall be justified by the fire hazard analysis.	7.32 – 7.51
4.4 Ventilation systems shall be arranged such that each fire compartment fully fulfils its segregation purpose in case of fire.	7.53 – 7.56, 8.1 – 8.12
4.5 Parts of ventilation systems (such as connecting ducts, fan rooms and filters) that are located outside fire compartments shall have the same fire resistance as the compartment or be capable of isolation from it by appropriately rated fire dampers.	
5. Administrative controls and maintenance	4.10 – 4.14
5.1 In order to prevent fires, procedures shall be established to control and minimize the amount of combustible materials and minimize the potential ignition sources that may affect items important to safety. In order to ensure the operability of the fire protection measures, procedures shall be established and implemented. They shall include inspection, maintenance and testing of fire barriers, fire detection and extinguishing systems.	
6. Firefighting organization	3.1 – 4.9
6.1 The licensee shall implement adequate arrangements for controlling and ensuring fire safety, as identified by the fire hazard analysis	
6.2 Written emergency procedures that clearly define the responsibility and actions of staff in responding to any fire in the plant shall be established and kept up to date. A fire-fighting strategy shall be developed, kept up-to date, and trained for, to cover each area	
6.3 When reliance for manual fire-fighting capability is placed on an offsite resource, there shall be proper coordination between the plant personnel and the off-site response group, in order to ensure that the latter is familiar with the hazards of the plant.	
6.4 If plant personnel are required to be involved in fire-fighting, their organization, minimum staffing level, equipment, fitness requirements, and training shall be documented, and their adequacy shall be confirmed by a competent person.	

[CZE-01] Decree No. 195/1999, Requirements for nuclear installations to assure nuclear safety, radiation protection and emergency preparedness, SÚJB, 1999, https://www.sujb.cz/fileadmin/sujb/docs/legislativa/vyhlasky/R195_99.pdf.

[CZE-02] Act No. 133/1985, Fire protection, 1985, http://www.zakony.cz/zakon-SB1985133.

[CZE-03] Decree of the Ministry of Interior No. 246/2001, "The determination of fire safety conditions and state fire supervision (Decree on fire prevention), 2001, http://www.zakony.cz/zakon-SB2001246.

[CZE-04] Decree of the Ministry of Interior No. 23/2008, Technical conditions of fire protection of buildings, 2008, http://www.zakony.cz/zakon-SB2008023.

[CZE-05] Law No. 18/1997, Peaceful utilization of nuclear energy and ionizing radiation, SÚJB, 1997, http://www.zakony.cz/zakon-SB1997018.

[CZE-06] Law No. 263/2016, Atomic Law, SÚJB, 2016, http://www.zakony.cz/zakon-SB2016263.

[CZE-07] Decree no. 132/2008, Quality Assurance System for conducting activities related to the use of nuclear energy and radiation and quality assurance of classified equipment with respect to their safety classification, SÚJB 2008, http://www.zakony.cz/zakon-SB2008132.

[CZE-08] Decree No. 408/2016, The management system requirements, SÚJB, 2016, http://www.zakony.cz/zakon-SB2016408.

[CZE-09] Decree No. 358/2016 Requirements for quality assurance and technical security and compliance auditing and assessment of classified equipment, SÚJB 2016, http://www.zakony.cz/zakon-SB2016358.

[SONS-10] State Office for Nuclear Safety (SONS): Protection against Internal Fires - Safety Instructions JB-3.1, Prague, Czech Republic, 2010, https://www.sujb.cz/fileadmin/sujb/docs/dokumenty/publikace/Ochrana_proti_vnitrnim_pozarum_BN_JB_3.1.pdf.

3.4 Finland

The regulatory information provided by Finland is up to August 1, 2019.

The task of the Radiation and Nuclear Safety Authority (STUK) as the national authority responsible for oversight of the safety of the use of nuclear energy is based on the Nuclear Energy Act (990/1987) [FIN-01] and the Nuclear Energy Decree (161/1988) [FIN-02]. According to Section 7 r of the Nuclear Energy Act, STUK shall specify detailed safety requirements for the implementation of the safety level in accordance with the Nuclear Energy Act. STUK's general oversight procedures in regulating nuclear facilities are given in Guide YVL A.1. STUK's oversight includes the oversight of the fire protection arrangements of nuclear facilities in so far as they affect the nuclear and radiation safety of the facilities. STUK's fire protection requirements of nuclear facilities are given in Guide YVL B.8 [FIN-19].

The Regulation STUK Y/1/2018 [FIN-03] presents requirements for the safety design of nuclear power plants:

- Section 9 requires implementation of the defense-in-depth principles to prevent accidents and to mitigate their consequences;
- Section 15 requires that the internal hazards to be considered include at least fire, flood, explosion, electromagnetic radiation, pipe breaks, container ruptures, drop of heavy objects, missiles due to explosions or component failures, and other possible internal hazards;
- Section 16 presents requirements for the nuclear power plant's control room arrangements;
- Sections 18-23 present requirements for the nuclear power plant's construction, commissioning, operation, processing of operational experiences, safety research and the Operational Limits and Conditions; and
- Section 25 presents requirements for the organisation and personnel of a nuclear power plant.

The Regulation STUK Y/4/2018 [FIN-04] presents requirements for the safety design of the final disposal of nuclear waste: To prevent operational occurrences and accidents, Section 18 requires, among other things, that in a nuclear waste facility, the placement and protection of systems alongside operative methods shall ensure that fire, explosion or other internal hazards do not pose a threat to safety; Sections 22-24 present requirements for the construction, commissioning and operation of a nuclear facility.

The Ministry of the Environment issues technical regulations and guidelines on construction and structural fire protection [FIN-07]. The building inspection authority in each municipality sees to it that the regulations and guidelines issued by the Ministry are complied with in all construction activities.

Leadership and control of fire and rescue services, as well as the availability and quality of its services, rests with the Ministry of the Interior; the Ministry is also responsible for the preparation and arrangement of fire and rescue services at national level; and for co-ordination of the performance of different ministries involved in the fire and rescue services under the Rescue Act (379/2011) [FIN-08] and the Government Decree (407/2011) on fire and rescue services [FIN-09]. Regional State Administrative Agencies are responsible for the duties of rescue services in their sphere of activity. Municipalities are responsible in co-operation for fire and rescue services in a region determined by the Government (regional fire and rescue services). As regards the requirements, design, installation, maintenance, inspection and demonstration of conformity of the equipment of the rescue services, the Rescue Equipment Act (10/2007) [FIN-10] shall be observed.

The Government Decree (917/1996) [FIN-11] and the Ministry of Trade and Industry Decision (918/1996) [FIN-12] present the requirements for equipment and protective systems intended for potentially explosive atmospheres. The Government Decree (576/2003) [FIN-13] presents the requirements for prevention of personnel hazards caused by potentially explosive atmospheres. The Finnish Safety and Chemicals Agency (TUKES) and the Ministry of Social Affairs and Health provide guidelines on the application of the ATEX legislation in Finland [FIN-14].

STUK's activities do not affect any oversight activities required in the Land Use and Building Act (132/1999) [FIN-05], the Land Use and Building Decree (895/1999) [FIN-06], the Rescue Act (379/2011) [FIN-08] and the Government Decree (407/2011) on Rescue Services [FIN-09], unless otherwise agreed between the authorities. The regulatory framework in Finland is shown in Figure 3.

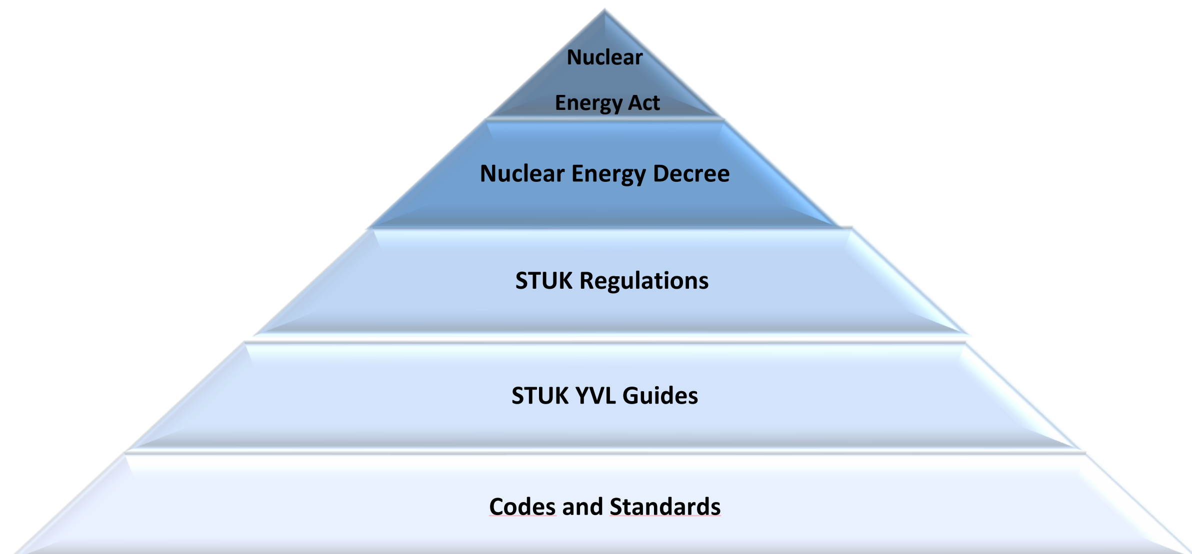

Figure 3 Overview of the Regulatory Framework in Finland

3.4.1 Existing Reactors

STUK Guide YVL B.8, Fire Protection at a Nuclear Facility [FIN-19] was published in November 2013. The publication of a new or revised YVL Guide shall not, as such, alter any previous decisions made by STUK. After having heard the parties concerned STUK will issue a separate decision as to how a new or revised YVL Guide is to be applied to operating nuclear facilities or those under construction, and to licensees' operational activities.

When considering how the new safety requirements presented in the YVL Guides shall be applied to the operating nuclear facilities, or to those under construction, STUK will take due account of the principles laid down in Section 7a of the Nuclear Energy Act (990/1987): *The safety of nuclear energy use shall be maintained at as high a level as practically possible. For the further development of safety, measures shall be implemented that can be considered* *justified considering operating experience, safety research and advances in science and technology.*

Under Section 7 r(3) of the Nuclear Energy Act, *the safety requirements of the Radiation and Nuclear Safety Authority (STUK) are binding on the licensee, while preserving the licensee's right to propose an alternative procedure or solution to that provided for in the regulations. If the licensee can convincingly demonstrate that the proposed procedure or solution will implement safety standards in accordance with this Act, the Radiation and Nuclear Safety Authority (STUK) may approve a procedure or solution by which the safety level set forth is achieved.*

3.4.2 New Reactors

STUK Guide YVL B.8, Fire Protection at a Nuclear Facility [FIN-19] was published in November 2013. The Guide shall apply as it stands to new nuclear facilities. The content of STUK Guide YVL B.8 is handled below.

3.4.2.1 Scope of Application

When this Guide sets requirements for nuclear facilities, reference is made, under the Nuclear Energy Act (990/1987), to facilities necessary for producing nuclear energy (nuclear power plants), including research reactors, facilities performing extensive final disposal of nuclear wastes, and facilities used for extensive fabrication, production, use, handling, storage of nuclear materials or nuclear wastes. Requirements for nuclear facilities always apply to nuclear power plants unless a requirement separately says they only apply to other nuclear facilities.

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

As regards fire protection at a nuclear facility construction site, this guide shall apply whenever fire protection is significant for the safety of nearby nuclear facilities and to ensure fulfilment of the design criteria of the nuclear facility under construction.

In addition to the fire protection requirements of this Guide, the following Guides also contain fire protection related requirements to be followed:

- Guide YVL A.1, Regulatory oversight of safety in the use of nuclear energy, sets forth requirements for nuclear facility design and oversight.
- Guide YVL A.3, Management system for a nuclear facility, sets forth detailed requirements related to the management system and quality management.
- Guide YVL A.5, Construction and commissioning of a nuclear facility, sets forth requirements for the management and oversight of the construction project at different stages of a nuclear facility's construction.
- Guide YVL A.6, Conduct of operations at a nuclear power plant, sets forth requirements for the operation of a nuclear power plant, such as for outages.
- Guide YVL A.7, Probabilistic risk assessment and risk management of a nuclear power plant [FIN-20], sets forth requirements for probabilistic fire risk assessments.
- Guide YVL A.11, Security of a nuclear facility, sets forth requirements for physical protection at a nuclear facility and its planning.
- Guide YVL B.1, Safety design of a nuclear power plant [FIN-17], sets forth requirements for the nuclear power plant’s safety design and the design of systems

important to safety.

- Guide YVL B.7, Provisions for internal and external hazards at a nuclear facility [FIN-18], sets forth requirements for nuclear facility layout design and the design to protect against internal and external threats.
- Guide YVL E.6, Buildings and structures of a nuclear facility, sets forth requirements for the design of civil structures.
- Guide YVL E.7, Electrical and I&C equipment of a nuclear facility, sets forth electrical equipment-specific requirements for protection against fire load-induced explosions.

3.4.2.2 General Design Requirements

Under Section 15 of the Regulation STUK Y/1/2018, structures, systems and components important to safety of a nuclear power plant shall be designed and located as well as protected in a way to make the likelihood of internal events (such as fires) small and their effect on facility safety insignificant.

A basis for the quality management of the nuclear power plant's construction and operation is provided in Section 25 of the Regulation STUK Y/1/2018 on the safety of nuclear power plants. It stipulates that organizations participating in the design, construction, operation and decommissioning of a nuclear power plant shall employ a management system for ensuring the management of nuclear safety, radiation safety and quality.

The fire protection for the nuclear facility shall be so planned that during and after a potential fire situation the nuclear facility can be brought to a safe state and the release of radioactive substances into the environment can be prevented.

The licensee can propose that also foreign regulations and guides be applied in designing the nuclear facility's fire protection arrangements. It shall then be demonstrated, however, that they form a feasible entity. The application of foreign regulations and guides is subject to STUK's approval.

An organization carrying out the fire protection design of buildings shall have an SFS-EN ISO 9001 compliant management system that has been documented and implemented for this purpose.

For the inclusion of all aspects of fire protection, an expert responsible for fire protection design shall be nominated for the duration of the nuclear facility's design and construction. The expert shall have sufficient qualifications and experience in nuclear, radiation and fire safety. Management of the entirety of the nuclear facility's fire protection arrangements places specific requirements on the combination of several design areas, such as facility layout, structural, heating/ventilation/air-conditioning, as well as electrical and I&C design.

In addition to the design requirements of this Guide, to complied with in the design of nuclear facilities are:

- the fire and building legislation in force in Finland.
- for applicable parts, the practices of risk-informed fire protection planning for nuclear power plants described in the IAEA Guides [IAEA-00b], [IAEA-14], [IAEA-15], [IAEA-16], [IAEA-16a], [IAEA-16b], [IAEA-17], as well as in a Technical Report [IAEA-98a].
- the practices of the WENRA reference requirement area S, "protection against internal fires" [WENRA-08].

3.4.2.3 Detailed Design Requirements

Detailed requirements are given on the following items:

- Defense-in-depth Approach to Fire Protection;
- Fire Hazard Analysis;
- Structural Fire Protection;
- Active Fire Protection;
- Emergency Lighting;
- Provision for Outages / Annual Maintenance;
- Fire Safety During Facility Operation.

3.4.3 Supplementary Information

[FIN-01] Nuclear Energy Act (990/1987), Finland, 1987, http://www.finlex.fi/en/laki/kaannokset/1987/en19870990.pdf.

[FIN-02] Nuclear Energy Decree (161/1988), Finland, 1988, http://www.finlex.fi/en/laki/kaannokset/1988/en19880161.pdf.

[FIN-03] Radiation and Nuclear Safety Authority STUK: Regulation on the Safety of a Nuclear Power Plant, STUK-Y/1/2018, Helsinki, Finland, 2018 http://www.finlex.fi/data/normit/42574-STUK-Y-1-2018.en.pdf.

[FIN-04] Radiation and Nuclear Safety Authority STUK: Regulation on the Safety of Disposal of Nuclear Waste, STUK-Y/1/2018, Helsinki, Finland, 2018, http://www.finlex.fi/data/normit/42578-STUK-Y-4-2018.en.pdf.

[FIN-05] Land Use and Building Act (132/1999), Finland, 1999, http://www.finlex.fi/en/laki/kaannokset/1999/en19990132.pdf.

[FIN-06] Land Use and Building Decree (895/1999), Finland, 1999 , http://www.finlex.fi/en/laki/kaannokset/1999/en19990895.pdf.

[FIN-07] Ministry of the Environment, Decree on the fire safety of buildings (848/2017), Finland, 2017, http://www.ym.fi/download/noname/%7B1A60A60B-75F6-4834-A746-767838898A8C%7D/139918.

[FIN-08] Rescue Act (379/2011), Finland, 2011, http://www.finlex.fi/en/laki/kaannokset/2011/en20110379.pdf.

[FIN-09] Government Decree on Rescue Services (407/2011), Finland, 2011, in Finnish only.

[FIN-10] Rescue Equipment Act (10/2007), Finland, 2007, in Finnish only.

[FIN-11] Government Decree on Equipment and Protection Systems Intended for Use in Potentially Explosive Atmospheres (917/1996), Finland, 1996, in Finnish only.

[FIN-12] Decision of the Ministry of Trade and Industry on Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres (918/1996), Finland, 1996, in Finnish only.

[FIN-13] Government Decree on the Prevention of Danger for Workers Caused by Explosive Atmospheres (576/2003), Finland, 2003, in Finnish only.

[FIN-14] Ministry of Social Affairs and Health, Department for Occupational Safety and Health, Finnish Safety and Chemicals Agency (Tukes): ATEX - Safety of Explosive Spaces, 2003, in Finnish only.

[FIN-15] Ministry of the Interior, Directive for Rescue Diving (48/2007), SM050:00/2006, in Finnish only.

[FIN-16] Ministry of the Interior: Decree on Automatic Fire Extinguishing Equipment (SM-1999-967/Tu-33), Finland, 1999, in Finnish only.

[FIN-17] Radiation and Nuclear Safety Authority STUK: Safety design of a nuclear power plant, STUK Guide YVL B.1, Helsinki, Finland, June 2019, http://www.finlex.fi/data/normit/41774-YVL_B.1e.pdf.

[FIN-18] Radiation and Nuclear Safety Authority STUK: Provisions for Internal and External Hazards at a Nuclear Facility, STUK Guide YVL B.7, Helsinki, Finland, November 2013, http://www.finlex.fi/data/normit/41791-YVL_B.7e.pdf.

[FIN-19] Radiation and Nuclear Safety Authority STUK: Fire Protection at a Nuclear Facility, STUK Guide YVL B.8, Helsinki, Finland, November 2013, http://www.finlex.fi/data/normit/41792-YVL_B.8e.pdf.

[FIN-20] Radiation and Nuclear Safety Authority STUK: Probabilistic Risk Assessment and Risk Management of a Nuclear Power Plant, STUK Guide YVL A.7, Helsinki, Finland, February 2019, http://www.finlex.fi/data/normit/41813-YVL_A.7e.pdf.

3.5 France

3.5.1 Existing Reactors

The new French regulation was initiated by the law of 13 June 2006 on transparency and security in the nuclear field, called "law TSN" [FRA-01]. It renovates in depth the legislative framework for nuclear activities and their control. It creates a Nuclear Safety Authority (ASN), an independent administrative authority responsible for supervising Nuclear Safety and Radiation Protection and public information in these areas.

The order laying down general rules for Basic Nuclear Installations of 7 February 2012, said order INB, was published in the Official Journal on 8 February 2012 [FRA-02]. It is a major element of this approach. This includes in particular the French law rules corresponding to international best practices. The provisions of the order INB are mainly dealing in the organization and responsibilities of the Basic Nuclear Installation operators, demonstration nuclear safety, nuisance control and their impact on health and the environment, waste management and the preparation and management of emergency situations. The scheme in Figure 4 below shows the new regulatory architecture.

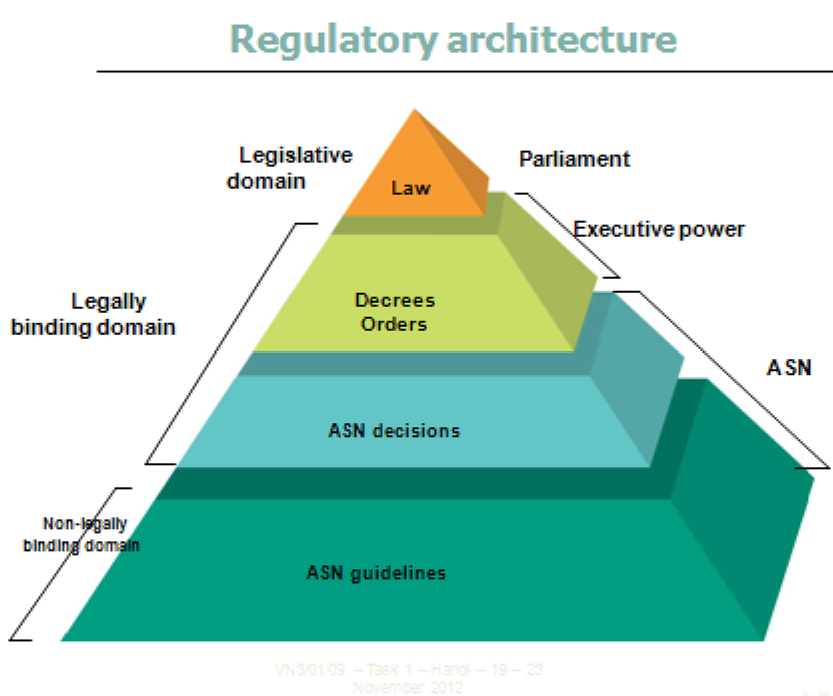

Figure 4 French Regulatory Architecture

The ASN resolution No 2014-DC-0417 of 28th January 2014 concerning the rules applicable to BNI with regard to management of fire risks [FRA-03] is applicable since 1st July 2014, except six articles dealing with new technical requirements which are applicable since 1st January 2017.

This resolution is divided into four titles. The first concerns the general provisions. It defines some terms and describes the objectives of the risk management process related to the fire that the operator must implement. It states that it is the operator who identifies, on the basis of the safety demonstration, the important elements for protection to be protected from the effects of fire and arrangements to ensure this protection. The three other titles detail the arrangements to be taken according to the different levels defined by the concept of defense-in-depth. Title II is devoted to the prevention of fire starts. Title III focuses on the detection and intervention against fire, and title IV deals with provisions to prevent the spread of fire and limit its consequences.

One of the principles of this resolution is the obligation of results and not of means. It sets targets without specifying the means to achieve it.

French ASN resolution 2014-DC-0417

ASN resolution 2014-DC-0417 of 28th January 2014 concerning the rules applicable to basic nuclear installations (BNI) with regard to the management of fire risks

ASN (Autorité de Sûreté Nucléaire – French Nuclear Safety Authority),

Having regard to the Environment Code, particularly title IX of book V; Having regard to the Labour Code;

Having regard to decree 2007-1557 of 2nd November 2007, amended, relative to BNIs and to the regulation of the transport of radioactive substances in terms of nuclear safety, and its articles 3, 20, 37 and 43 in particular;

Having regard to the order of 21st July 1994, amended, constituting the classification and certification of the conformity of the fire performance of electrical conductors and cables and approval of the test laboratories;

Having regard to the order of 7th February 2012, amended, setting out the general rules relative to basic nuclear installations, more specifically its articles 3.5 and 3.6;

Having regard to the results of the public consultations carried out on the ASN website from 27th December 2012 to 28th February 2013 and from 9th to 30th September 2013;

Having regard to the opinion of the French High Council for technological risk prevention, dated 17th January 2013;

Whereas a fire in a BNI can have significant safety consequences;

Whereas the order of 31st December 1999, amended, setting the general technical regulations intended to prevent and mitigate off-site detrimental effects and risks resulting from the operation of BNIs, more specifically its title VI-B, comprised detailed regulatory provisions concerning fire risks;

Whereas the above-mentioned order of 7th February 2012, which replaced the previous regulatory orders concerning BNIs, more specifically the above-mentioned order of 31st December 1999, requires that fire risks be taken into account, while leaving it up to ASN regulatory resolutions to clarify the corresponding procedures;

Whereas the specific technical aspects of the disposal of radioactive waste in deep geological formations could be the subject of special provisions with regard to the management of fire risks;

Whereas the WENRA association of the heads of European safety regulators adopted reference levels in January 2008 for protection against fire risks, which should be integrated into the French regulations;

Whereas, in a regulatory resolution, ASN shall specify the contents of the BNI safety analysis reports and that this resolution will create the framework for demonstrating management of the fire risks,

Article 1

The appendix to this resolution specifies the rules applicable to BNIs with regard to the management of fire risks. In this respect, it supplements the implementation procedures in Title III of the above- mentioned order of 7th February 2012.

Article 2

This resolution shall apply as of the issue of their creation authorizations to BNIs which, on the date of approval of this present resolution, do not yet have such an authorization and are not operating with benefit of acquired rights.

For the other BNIs, this resolution shall apply as of the first day of the first civil six-month period following approval of this resolution, except for Articles 1.3.2, 4.1.2, 4.1.3, 4.1.5, 4.3.2 and 4.4.1 of its appendix, which shall apply as of 1st January 2017. However, if the installation is the subject of a commissioning authorization application under examination on the date of approval of this resolution, or which is submitted no later than one year after this date, this resolution shall apply to it six months after issue of the commissioning authorization.

Article 3

As an interim measure, the elements concerning fire risk management contained in the safety analysis report that exists on the date of approval of this resolution shall constitute the fire risks management case as defined in Article 1.1.1 of the appendix to this resolution. These elements are updated in the conditions specified for implementation of the provisions concerning the nuclear safety case in Article 9.4 of the above-mentioned order of 7th February 2012. These conditions could be supplemented by an ASN resolution on the safety analysis report.

Article 4

In the event of particular difficulties with implementing this resolution, the licensee may send ASN a duly justified waiver request. It shall enclose with its request proposed compensatory measures accompanied with an implementation time frame. The licensee shall justify that given current knowledge and the best available techniques, the practices and the vulnerability of the installation, these measures enable a level of protection against fire risks to be achieved that is as high as possible, in economically acceptable conditions.

ASN may grant a waiver to which compensatory prescriptions are attached, by means of a resolution issued in accordance with the procedures defined in Article 18 of the above-mentioned decree of 2nd November 2007.

Article 5

The ASN Director General is tasked with implementation of this resolution, which shall be published in the ASN Official Bulletin after its approval by the Minister in charge of nuclear safety.

Provisions concerning the management of fire risks

TITLE 1 GENERAL PROVISIONS

Chapter 1.1 Definitions

Article 1.1.1 For the purposes of this resolution, the expressions: accident, activity important for protection (AIP), internal failure, nuclear safety case, element important for protection (EIP), establishment, defined requirement, licensee, normal operation, incident, emergency situation, dangerous substance, nuclear safety are as defined in the above-mentioned order of 7th February 2012.

For implementation of this resolution, the following definitions are adopted:

- general fire alarm: audible signal with the purpose of warning the occupants of the need to evacuate the premises;
- limited fire alarm: audible and visual signal other than the general alarm signal, with the purpose of warning either the establishment's fire safety unit, or the management or security guard, or the specially designated personnel, of the existence and location of an incident;
- protected route: a route needed by the personnel and the emergency services for access in the event of a fire to the locations necessary for attaining and maintaining a safe state in the BNI.
- fire risks management case: part of the nuclear safety case concerning the prevention of fire risks and protection against their effects;
- provisions concerning the management of fire risks: all technical and organizational steps taken to demonstrate the management of fire risks to prevent the fire risks and mitigate the effects;
- containment sector: a volume the characteristics of which, in a fire situation, ensure that dispersion outside this volume of radioactive or dangerous substances liable to compromise the interests mentioned in Article L. 593-1 of the Environment Code, is limited;
- fire sector: a volume bounded by walls such that a fire occurring inside it cannot extend outside or so that a fire occurring outside cannot propagate inside it for a time long enough to enable it to be extinguished;
- fire zone: a volume bounded by barriers (geographical separation or wall) such that a fire occurring inside it cannot extend outside or so that a fire occurring outside cannot propagate inside it for a time long enough to enable it to be extinguished;

Chapter 1.2 Objectives

Article 1.2.1 Pursuant to Article 3.1 of the above-mentioned order of 7th February 2012, the licensee applies the principle of defence in depth to the management of fire risks.

The licensee thus implements successive and sufficiently independent levels of defence designed to protect or perform the functions defined in Article 3.4 of the above-mentioned order of 7th February 2012.

These levels in particular apply to:

- preventing the outbreak of fire;

- detecting and rapidly extinguishing any outbreaks, on the one hand to prevent them leading to a fire and, on the other, to restore a normal operating situation or, failing which, attain then maintain a safe BNI state;
- mitigating the aggravation and propagation of a fire which has not been stopped, in order to minimize its impact on nuclear safety and enable a safe BNI state to be attained or maintained;
- the management of accident situations resulting from a fire which could not be stopped, in order to mitigate the consequences for individuals and the environment.

Article 1.2.2 With regard to the management of fire risks and for implementation of the provisions concerning the nuclear safety case defined in Title III of the above-mentioned order of 7th February 2012, a fire risks management case is presented by the licensee in its safety analysis report. This case justifies that the design, construction and operating provisions regarding fire risks are appropriate and defined in accordance with the principles set out in Article 1.2.1. It includes the assessments of the consequences specified in Article 3.7 of the above-mentioned order of 7th February 2012. It is established using an approach that is proportionate to the issues and implications, pursuant to the provisions of Article 1.1 of the above-mentioned order of 7th February 2012.

Article 1.2.3 Within the framework of Articles 1.2.1 and 1.2.2, the licensee implements fire risk management provisions taking account of all technical aspects and pertinent organizational and human factors.

In particular, in the event of a fire, these provisions help ensure the protection of the persons necessary for the operations involved in attaining and maintaining a safe BNI state and in providing the firefighting response.

Article 1.2.4 Prior to taking up their posts, all the licensee's personnel receive general training in what to do in the event of a fire and the fire risks specific to their workstation or their activity. For outside contractor personnel, the licensee ensures that they have received appropriate training in particular BNI risks, according to the duties assigned to them.

Chapter 1.3 Identification of provisions and EIP concerning the management of fire risks

Article 1.3.1 Among the EIP identified pursuant to Article 2.5.1 of the above-mentioned order of 7th February 2012, the licensee determines those which need to be protected from the effects of a fire, as well as the related defined requirements.

Article 1.3.2 On the basis of the fire risks management case, the licensee:

• identifies the EIP to be protected from the effects of a fire and the related defined requirements;

• determines the provisions for the prevention of fire risks and protection against their effects. Among these and in accordance with Articles 2.5.1 and 2.5.2 of the above- mentioned order of 7th February 2012, the licensee identifies the EIP and any AIP as well as the related defined requirements. These EIP are designed and installed in the BNI such as to reduce the probability of a fire occurring, ensuring detection and mitigating the consequences.

Chapter 1.4 Periodic checks and tests

Article 1.4.1 The fire risk management provisions are the subject of periodic checks, maintenance and tests, in accordance with the applicable regulations and standards and with the requirements arising from the fire risks management case.

The licensee defines and justifies the appropriate provisions to ensure management of the fire risks, as well as the nature and frequency of the planned checks.

TITLE 2 PROVISIONS TO PREVENT THE OUTBREAK OF FIRE

Chapter 2.1 Construction materials and layout

Article 2.1.1 The licensee chooses and utilizes construction materials, interior layouts and equipment such as to minimize the outbreak of fire, the development and the propagation of a fire and its effects.

Chapter 2.2 Management of combustible materials

Article 2.2.1 The licensee defines the procedures for managing, monitoring and tracking combustible materials and the organization put into place to minimize their quantities, in each volume, room or group of rooms, considered in the fire risk management demonstration. The nature, maximum quantity and location of the combustible materials considered in the fire risks management case are defined in documents belonging to the licensee's integrated management system.

The areas in which the combustible materials considered in the fire risks management case are either prohibited or authorized, are shown by continuous, visible and permanent marking in the rooms or groups of rooms, or outside the buildings.

Article 2.2.2 The licensee limits the quantities of combustible materials in the places they are used to only what is strictly necessary for the normal operation of the BNI and, in any case, to values not to exceed those considered in the fire risks management case.

Given the rapid spread of a fire involving flammable liquids or gases, fire risk management provisions are adopted to prevent such liquids or gases, which are present in the BNIs, from being able to cause a fire or fuel its spread. When not in use, they are placed in areas, rooms or equipment appropriate to their nature and quantity.

Article 2.2.3 The licensee takes the necessary steps to ensure that the flammability ranges for the gases or vapors present or generated in its BNI cannot be reached, except in specific situations justified in the fire risks management study.

Chapter 2.3 Prevention plan and fire permit

Article 2.3.1 “Hot spot” work can only be performed after issue of a fire permit for which a specific nuclear safety risk assessment was carried out and which has been duly signed by the licensee, after checking the possible interactions between simultaneous worksites.

Article 2.3.2 The licensee ensures the compatibility between the fire risks management case and the steps included in the prevention plan specified in Articles R. 4512-6 to R. 4512-12 of the Labour Code, or the fire permit for the works envisaged.

Article 2.3.3 The fire permit specifies the special measures to be taken to prepare for and carry out the work with regard to the fire risk. This document officially lays out all prevention and consequences mitigation measures to be taken to manage the fire risk presented by this work. It identifies any scheduled unavailability of the fire risk management provisions and defines the compensatory measures.

The fire risk management provisions disabled for the duration of this work, shall be returned to service as soon as their unavailability is no longer required.

Chapter 2.4 Prevention of risks of electrical or electrostatic origin

Article 2.4.1 The licensee takes steps to prevent any risk of an outbreak of a fire of electrical origin. It in particular ensures that the electrical equipment and its components and the ventilation systems removing the heat generated by the electrical equipment are suitably maintained and that the electrical protections are appropriately adjusted.

Article 2.4.2 The electrical conductors and cables present in the buildings housing radioactive or dangerous substances liable, in the event of a fire, to compromise the interests mentioned in Article L. 593-1 of the Environment Code, or the EIP to be protected from the effects of a fire, are in conformity with class C1, defined by the above-mentioned order of 21st July 1994 with respect to their reaction to fire.

However, if it is technically impossible to employ electrical conductors and cables conforming to this class, the licensee shall justify the use of another class in the fire risks management case.

Article 2.4.3 To protect the installations from the effects of stray currents, the licensee takes precautions to limit the build-up of electrostatic charges which could create a fire risk situation, in particular in the premises containing flammable substances, and ensures their evacuation in conditions that do not affect the safety of the BNI.

Article 2.4.4 The following construction and operation measures are in particular applied:

- electrical continuity and earthing of permanent or temporary conductors;
- limitation of the use of insulating materials liable to accumulate an electrostatic charge;
- limitation of flow rates of low-conductivity flammable fluids and flammable dusts.

Failing which, in the fire risks management case, the licensee justifies that the steps taken are compliant with the requirements of Article 2.4.3.

TITLE 3 FIRE DETECTION AND INTERVENTION PROVISIONS

Chapter 3.1 Fire detection and associated safety systems

Article 3.1.1 The BNI comprises one or more fire detection systems, designed to:

- monitor the premises and outdoor areas identified in the fire risks management case;
- ensure the operation of the associated safety systems, whether or not automatically actuated.

These systems and devices meet the requirements assigned to them in the fire risks management case.

The design and operation of these systems enable a fire outbreak to be rapidly, easily and accurately located, the general fire alarm concerned to be tripped plus, as necessary, the automatically actuated safety devices. These systems and devices are designed and built so as to be effective and function permanently; they are maintained so as to keep any period of unavailability to a minimum. They have a back-up electrical power supply of sufficient autonomy to ensure that a safe BNI state is maintained in the event of failure of the main power supply source.

Article 3.1.2 The limited fire alarm is transmitted to a location when monitoring personnel are permanently present. It allows easy interpretation of the information by the response teams. It is clearly distinct from any other alarm which could appear in the BNI.

Article 3.1.3 Failure of the fire detection systems or devices and automatically actuated safety devices is indicated by an alarm transmitted to a location where monitoring personnel are permanently present.

Chapter 3.2 Firefighting resources

Section 3.2.1 Infrastructures

Article 3.2.1-1 The BNIs are permanently equipped with fire response and firefighting resources specified in the fire risks management case. These resources are defined in particular to take account of the foreseeable types of fire, the risks specific to the BNI and any difficulties with access to the premises. The risk of criticality is in particular examined.

Article 3.2.1-2 The material response and firefighting resources put into place, as well as the system for recovery of the extinguishing agents used, are such that their implementation cannot lead to the loss of one of the functions mentioned in Article 3.4 of the above-mentioned order of 7th February 2012 or a loss of containment of dangerous substances liable to compromise the interests mentioned in Article L. 593-1 of the Environment Code in the event of a fire.

Article 3.2.1-3 The BNI's internal material response and firefighting resources are positioned at clearly marked locations that are rapidly accessible in all circumstances and kept in good working order.

Article 3.2.1-4 A network protected from frost, preferably a meshed network, supplies water to the firefighting systems such as the fire plugs and fire hydrants located outside the buildings and, as applicable, the dry or wet risers and the fire hose reels (RIA) inside the buildings. It is designed and installed consistently with the fire risks management case.

Section 3.2.2 Operational organization

Article 3.2.2-1 The fire response and firefighting resources available to the licensee internally are designed pursuant to III of Article 2.1.1 of the above-mentioned order of 7th February 2012. They are implemented according to an organization predetermined by the licensee. This organization enables action to be taken, the rapidity and effectiveness of which are compatible with the interventions included in the fire risks management case, more specifically for management of plausible trigger event combination situations, both in the BNI considered and in all the BNIs on a site. This leads to the definition of the equipment and personnel necessary for fire response and firefighting, consistently with the fire risks management case. All firefighting actions, in response to either a call-out or an alarm, shall be carried out at least in pairs, to ensure that it is done effectively.

Article 3.2.2-2 If the licensee does not itself have all the response and firefighting resources described in the fire risks management case, it proves that at all times it has sufficient material and human resources to carry out the steps necessary, pending the arrival of emergency resources from outside the BNI, taking account of any access difficulties.

The licensee justifies resorting to these outside services by considering the material, human and organizational provisions and their foreseeable deployment times in order to perform the actions identified in the fire risks management case. The steps taken to facilitate their intervention are specified. The licensee more specifically takes account of the risks associated with radioactive or dangerous substances and plausible combinations of the trigger events considered in the nuclear safety case, in accordance with the provisions of Article 3.2 of the above-mentioned order of 7th February 2012.

Article 3.2.2-3 In order to ensure the effectiveness of the organization of the response teams and their operational capability, the licensee uses regular exercises to test:

- the response methods, instructions, plans and organization notices designed to restore normal operation of the BNI or, failing which, to attain and maintain a safe BNI state, in the event of a fire;

- the use of response and personnel evacuation resources

- calling in and admitting outside emergency resources.

The response procedures take account of the risk of the dissemination of radioactive or dangerous substances liable to compromise the interests mentioned in Article L. 593-1 of the Environment Code, in the event of a fire.

Article 3.2.2-4 A sufficient number of available persons are designated as members of the response and firefighting teams. They are regularly trained and drilled, according to an annual programme appropriate to their duties.

Chapter 3.3 Access and circulation routes

Article 3.3.1 The access and circulation routes necessary for the fire risks management case, are clearly marked out and kept clear of anything liable to obstruct circulation. The circulation and maneuvering areas necessary for access by the fire and emergency services and for deployment of response and firefighting resources are designed and laid out so that the vehicles of these services can move around without difficulty, including with regard to extending ladders. They are thus designed and distributed so that they can be used in complete safety, taking account of the dimensions and layout of the buildings and their access bays.

Steps are taken to ensure that parked vehicles never obstruct the vehicles of the fire and emergency services.

Article 3.3.2 Inside the buildings, circulation ways and protected routes are laid out, marked and kept clear at all times, to facilitate the circulation and intervention of the emergency teams in the event of a fire.

TITLE 4 PROVISIONS DESIGNED TO PREVENT THE PROPAGATION OF A FIRE AND MITIGATE ITS CONSEQUENCES

Chapter 4.1 Sectorization

Article 4.1.1 The fire risks management case ensures that the BNI’s fire sectors and zones can be identified and justified.

The use of fire sectors shall be considered a priority.

Special steps are taken in particular to minimize the propagation of smoke and the propagation of a fire by hot gases or by flaming flows or projections, in particular in the case of fire zones. The possible temporary presence of combustible materials is taken into account when defining the steps taken.

Article 4.1.2 Steps are taken to ensure that a fire cannot simultaneously affect EIP that are to be protected from the effects of a fire and that provide functional redundancy. In this respect, they are not placed in the same fire sector or zone or, failing which, have sufficient protection to prevent failure caused by the same fire.

Article 4.1.3 The fire risks management case ensures that the protected routes can be identified and justified.

Article 4.1.4 The fire risks management case ensures that the containment sectors can be identified and justified.

The effectiveness of these sectors is maintained even in the case of deployment of the fire response and firefighting resources specified in the fire risks management case.

Article 4.1.5 In order to make the personnel more accountable for the implementation of preventive measures and to facilitate the response and firefighting, all accesses to the various sectors and zones and the entire length of all protected routes are clearly signposted inside the BNI.

Chapter 4.2 Fire resistance of structures

Article 4.2.1 The fire resistance of the structures of the buildings identified in the fire risks management case is sufficient to enable a safe BNI state to be attained and maintained in the event of a fire. The fire stability of the supporting elements of the structure of the buildings identified in the fire risks management case is at least two hours. This stability is calculated for a fire occurring inside or outside the buildings, considering the possible interactions with a fire developing in a nearby structure. The fire stability of the support elements of the structure of the buildings must not compromise the fire resistance of the fire sectors or zones inside them.

Article 4.2.2 In the case of existing buildings for which such a fire stability requirement could not be met in acceptable technical-economic conditions, the licensee identifies and justifies the specific measures for ensuring that a safe BNI state is attained and maintained in the event of a fire.

Chapter 4.3 Ventilation – smoke extraction

Article 4.3.1 The ventilation systems are designed and operated so that, in the event of a fire, they do not contribute to its propagation, while limiting:

- the dissemination of radioactive substances inside the BNI

- release into the environment of radioactive or dangerous substances liable to compromise the interests mentioned in Article L. 593-1 of the Environment Code.

Moreover, these systems facilitate intervention and the mitigation of the consequences in the areas involved in the fire, by managing the risks linked to pyrolysis gases and other unburned products.

If the objectives prove to be incompatible, the fire risks management case justifies the solution adopted.

Pursuant to the fire risks management case, operation of the ventilation in the event of a fire is the subject of a specific analysis and of particular procedures in the BNI. The organization put into place by the licensee enables these procedures to be implemented.

Article 4.3.2 The elements of the ventilation systems necessary for attaining and maintaining a safe BNI state are capable of performing their function despite the effects of a fire which could affect them for a given period, consistently with the fire risks management case or, as applicable, are protected from the effects of a fire. More specifically, when they participate in the boundaries between the fire sectors or zones they serve or through which they pass, these elements have a fire resistance equivalent to that of the fire sectors they serve, or are isolated from them by appropriate fire dampers.

In the case of premises presenting a risk of the release of radioactive or dangerous substances liable to compromise the interests mentioned in Article L. 593-1 of the Environment Code, in the event of a fire, the licensee justifies the situations for which static containment is preferable to dynamic containment or smoke extraction.

Article 4.3.3 The smoke-extraction systems in the buildings, identified by the fire risks management case, are also designed and utilized in order to:

- limit the propagation of the fire;
- facilitate the intervention by the response teams;

while limiting the dispersion into the environment of radioactive or dangerous substances liable to compromise the interests mentioned in Article L. 593-1 of the Environment Code, in the event of a fire.

Chapter 4.4 Operating devices

Article 4.4.1 The operating devices necessary for management of the fire risk, such as the fire damper controls, are designed and installed so that they can be operated and are operational in the event of a fire. More specifically, they are accessible from protected routes whenever necessary. The licensee has at its disposal the necessary trained personnel for utilization of these devices, along with the appropriate documentation.

3.5.2 New Reactors

There is no specific regulation for new reactors. New reactors are regulated using the same guidelines as existing reactors described in paragraph 3.5.1.

3.5.3 Supplementary Information

[FRA-01] Act No. 2006-686 of 13 June, 2006 on Transparency and Security in the Nuclear Field, http://www.french-nuclear-safety.fr/References/Regulations/Act-No.-2006-686-of-13-June-2006.

[FRA-02] Order of 7 February, 2012 setting the general rules relative to basic nuclear installations, http://www.french-nuclear-safety.fr/References/Regulations/Order-of-7-February-2012.

[FRA-03] ASN resolution 2014-DC-0417 of 28 January 2014 concerning the rules applicable to basic nuclear installations (BNI) with regard to the management of fire risks.

3.6 Germany

3.6.1 Existing Reactors

In principle, the regulatory framework for nuclear power plants (NPP) in Germany is based on deterministic requirements supplemented by probabilistic ones for safety assessment. The regulation comprises high level comprehensive claims such as the most recent “Safety Requirements for Nuclear Power Plants” [BMU-15] as well as lower level detailed technical nuclear safety standards and rules incorporated in a corresponding pyramid type legal structure as shown in Figure 5.

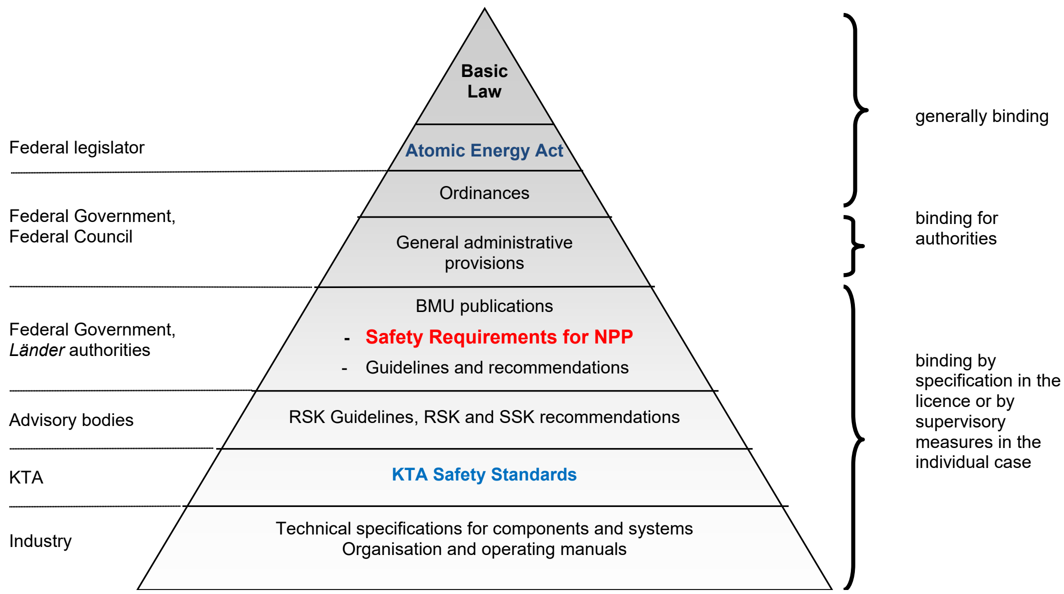

Figure 5 Nuclear Regulatory Framework in Germany

For nuclear facilities in Germany - covering commercially operated reactors as well as non-commercially operated ones (e.g., research reactors) and other installations such as nuclear waste storage facilities, fire safety is addressed in non-nuclear as well as nuclear specific regulations. These are valid for already existing facilities as well as for new built installations.

High level nuclear specific requirements on fire safety at nuclear power plants are most recently provided in the “*Safety Requirements for Nuclear Power Plants*” and its specific Annex 3 on “*Internal and External Hazards*” as promulgated in the Federal Gazette in January 2013 and updated in March 2015 [BMU-15]. These require in principle that all items required for safe shutdown of the nuclear reactor, for maintaining it in a shutdown state, for residual heat removal or for prevention of the release of radioactive materials shall be designed such and constantly kept in such a condition that they can fulfil their safety related tasks even in case of any internal hazard or site specifically identified external hazard, e.g., internal or external fire. The safety system as well as the emergency systems shall be designed such that they remain effective in the event of fire.

The general safety concept is based on a multi-level confinement of the radioactive inventory (Barrier Concept).

It is principally required that all equipment needed for the safe shutdown of the nuclear reactor, for maintaining it in a shutdown state, for residual heat removal or the prevention of a release of radioactive materials shall be designed as and constantly kept in a condition that they can fulfil their safety related functions even in the event of fire. Fires that might inadmissibly impair the required functions of equipment of the safety system shall either be reliably prevented or limited in their consequences. In this context, passive protection means shall be preferred. If inadmissible consequences cannot be reliably prevented by passive means, reliable active means shall be in place. Redundant parts of items important to safety shall be either installed in physically separated plant areas or protected such that in the event of any plant internal fire, a failure of more than one redundant train is reliably prevented.

Moreover, the technical safety concept requests that the design of systems, structures and components (SSC) against hazards including fires is based on:

- those natural hazards with the most severe consequences or other external hazards to be postulated at the site under consideration;
- the special characteristics of external hazards of long duration;
- combinations of several external hazards or combinations of these hazards with plant internal event; these combinations shall be postulated, if the combined events or hazards either show a causal relationship or if their simultaneous occurrence has to be postulated according to its probability and the expected extent of damage.

These general requirements shall be met by an in-depth protection concept starting with fire prevention. Precautionary measures shall ensure that fires impairing the required function of items important to safety shall be either prevented or sufficiently limited in their effects. The requirements concerning effectiveness and reliability of preventive measures depend on the occurrence frequency of those hazards, against which the protection is provided, and on their potential effects.

Protection means for the protection against plant internal fires and their consequences shall be in place both inside and outside of buildings. Inadmissible impacts of fires and their consequences shall be prevented by active and passive fire protection means.

Fire protection means shall be planned and implemented such that defense-in-depth is realized:

- Suitable protection means shall be in place to prevent the occurrence of incipient fires.
- Fires which have nevertheless occurred shall be quickly detected and extinguished.
- The propagation of any fire neither extinguished nor self-extinguished shall be limited.

A fire protection concept shall be developed and documented. The documentation shall be kept up to date. In case of any plant modification, its effects on the existing fire protection concept shall be assessed and as far as necessary enhanced.

A fire hazard analysis shall be performed and documented. The documentation shall be kept up to date.

The entire fire protection means shall ensure that even in the event of a random failure of a single fire protection means the required safety functions are not inadmissibly impaired.

An ignition of combustibles should be postulated. Deviations from this requirement are admitted, if the combustible is encapsulated and it has been demonstrated that the encapsulation maintains its operability during specified normal operation and in the event of any accident.

Fire loads and potential ignition sources shall be limited to the extent necessary for safe operation.

For prevention of an ignition by potential ignition sources, fire loads needed for plant operation shall be sufficiently physically separated from these ignition sources at any location, where permitted by design and requirements for the operation of items important to safety. Plant areas containing considerable fire loads should be separated by sufficiently rated fire barriers.

Redundant trains of the safety system should be separated by sufficiently rated fire barriers to prevent a loss of more than one redundant train in case of fire. If the protection required in the event of fire cannot be ensured by structural protection means due to systems engineering or operational reasons, an equivalent level of protection shall be ensured by other (compensatory) fire protection means or by a combination of different fire protection means.

For transient combustibles in connection with maintenance work special protection means shall ensure that the plant safety is not inadmissibly impaired.

Passive structural fire protections means shall ensure the fire safety of buildings and structures.

Only non-combustible constructions and structural elements should be used. The use of combustible materials is only permissible, if the use of such materials cannot be avoided, e.g. insulation materials for cooling pipes, de-contaminable coatings. Only non-combustible operating supplies should be used. Exceptions are control and lubricating fluids as well as other combustible materials that cannot be avoided for operational reasons.

Instrument and Control (I&C) wires and cables should be routed separately from heated pipes or pipes carrying combustible media. Power cables shall be sufficiently separated from signal and control cables. In the exceptional case of unavoidable crossings of I&C wires and cables with high-temperature pipes or pipes carrying combustible media or with power cables, particular protection means shall be in place. Adequate protection means shall ensure that even in the event of fire cables for power supply or I&C cables are not inadmissibly impaired.

The restrictions for the controlled area shall be considered in the selection and installation of active and passive fire protection means.

In the event of fire, particularly in plant areas with equipment of the safety system and in controlled areas, adequate protection means shall ensure a reliable and fast fire detection and alarm.

Adequate protection means for fire detection, alarm and suppression shall ensure that fires in the containment can be quickly and reliably detected and extinguished efficiently, even without smoke removal.

Adequate protection means for a timely detection and alarm of any hazard and appropriate precautions for rapid escape and rescue activities via escape and rescue routes shall ensure that in case of danger persons can reach the outside quickly and can be rescued from the outside.

Access and escape routes shall be provided within the buildings. These shall be protected against fire effects for an appropriate time period to allow for self-rescue, rescue of persons, fire extinguishing as well as for personnel actions required for safety reasons.

Stationary fire extinguishing systems should be actuated automatically. Remote controlled or local manually actuated extinguishing systems are permissible, if the fire effects are controlled until these extinguishing systems come into effect.

Automatically actuated stationary extinguishing systems shall be designed and secured in such a way that neither disturbances occurring at them or at parts of them nor faulty actions /

maloperations do neither impair the required function of equipment of the safety system nor of structural elements for separation of fire compartments.

The entire fire protection means shall regularly be subject to in-service inspections with respect to their required function. Test intervals shall be specified according to the safety significance of the equipment to be protected.

For fire suppression, an efficient professional on-site fire brigade shall be established, equipped and maintained according to the existing non-nuclear regulations. In addition, the local off-site fire brigade shall be familiarized with the plant and the different plant areas as well as with the specific boundary conditions at a nuclear power plant. The corresponding instructions shall be repeated at regular intervals. Fire drills shall be conducted at appropriate time intervals.

It shall be ensured that all means required for ensuring safe operation and control of events on levels of defense 3 and 4a can also be taken in the event of fire extinguishing.

3.6.2 New Reactors

Since Germany is in the process of nuclear phase out, regulations for new power reactors do not exist.

3.6.3 Supplementary Information

Detailed technical requirements are provided by the German nuclear standards of KTA (German abbreviation for Kerntechnischer Ausschuss, Nuclear Safety Standards Commission) available also in English, in particular:

[KTA-15] Nuclear Safety Standards Commission (KTA, German for Kerntechnischer Ausschuss): Fire Protection in Nuclear Power Plants, Part 1: Basic Requirements, KTA 2101.1, Safety Standards of the Nuclear Safety Standards Commission (KTA), 2015-11, December 2015, http://www.kta-gs.de/e/standards/2100/2101_1_engl_2015_11.pdf.

[KTA-15a] Nuclear Safety Standards Commission (KTA, German for Kerntechnischer Ausschuss): Fire Protection in Nuclear Power Plants, Part 2: Fire Protection of Civil Structures, KTA 2101.2, Safety Standards of the Nuclear Safety Standards Commission (KTA), 2015-11, December 2015, http://www.kta-gs.de/e/standards/2100/2101_2_engl_2015_11.pdf.

[KTA-15b] Nuclear Safety Standards Commission (KTA, German for Kerntechnischer Ausschuss): Fire Protection in Nuclear Power Plants, Part 3: Fire Protection of Mechanical and Electrical Plant Components, KTA 2101.3, Safety Standards of the Nuclear Safety Standards Commission (KTA), 2015-11, December 2015, http://www.kta-gs.de/e/standards/2100/2101_3_engl_2015_11.pdf.

The KTA fire safety standards provide nuclear specific technical requirements with specific focus on all deviations from non-nuclear ordinances, standards and norms, resulting from the nuclear requirements as given by the Atomic Energy Act and the next level of requirements represented by the above mentioned "*Safety Requirements for Nuclear Power Plants*".

The German and/or European non-nuclear requirements with regard to fire safety of industrial buildings and in industrial facilities cover:

Atomic Energy Act Energy Act	(01/2016)	Act on the Peaceful Utilisation of Atomic Energy and the Protection against its Hazards (Atomic Energy Act) of 23 December 1959, as amended and promulgated on 15 July 1985, last Amendment of 20 November 2015,

		http://www.bfs.de/SharedDocs/Downloads/BfS/EN/hns/a1-english/A1-01-16-AtG.html
ArbStättV	(12/2008)	Ordinance on work places (Work Place Ordinance – ArbStättV) of August 12, 2004 (BGBl. I, p. 2179) most recently changed by Article 9 of the ordinance of December 18, 2008 (BGBl. I, p. 2768)
AtSMV	(10/2010)	Ordinance on the Nuclear Safety Officer and the Reporting of Incidents and other Events (Nuclear Safety Officer and Reporting Ordinance) of 14 October 1992, last Amendment of 8 June 2010, http://www.bfs.de/SharedDocs/Downloads/BfS/EN/hns/a1-english/A1-10-10.pdf?__blob=publicationFile&v=3
BGV C 16, VBG 30	(01/1987)	Accident prevention regulation – nuclear power plants
BetrSichV	(02/2015)	Verordnung zur Neuregelung der Anforderungen an den Arbeitsschutz bei der Verwendung von Arbeitsmitteln und Gefahrstoffen (Artikel 1 Verordnung über Sicherheit und Gesundheitsschutz bei der Verwendung von Arbeitsmitteln (Betriebssicherheitsverordnung – BetrSichV; English: Operational Safety Ordinance)
SiAnf	(03/2015)	Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, *Safety Requirements for Nuclear Power Plants,* as amended and published on November 22, 2012 and revised version of March 3, 2015, [BMU-15]
MBO	(12/2009)	Reference building code (Special Commission on Construction Surveillance of the ARGEBAU)
Construction Supervision Guideline ”Ventilation Systems“	(01/1984)	Construction supervision guideline on fire protection requirements regarding ventilation systems

German non-nuclear norms DIN

DIN 3221	(01/1986)	Fire hydrants, under ground
DIN 3222	(01/1986)	Fire hydrants, above ground
DIN 4102-1	(05/1998)	
DIN 4102-2	(09/1977)	Fire behaviour of building materials and building components, Part 2: Building components; definitions, requirements and tests
DIN 14 090	(06/1977)	Areas for the fire brigade on premises
DIN 14 095	(08/1998)	Ground plans of buildings for fire brigade use
DIN 14 210	(11/1982)	Water pool for fire fighting

DIN 14 220	(04/1991)	Fire wells
DIN 14 230	(04/1991)	Underground water-tanks for fire fighting
DIN 14 461-1	(02/1998)	Delivery valve installation - Part 1: Hose reel with semi-rigid hose
DIN 14 461-6	(06/1998)	Delivery valve installation - Part 6: Dimensions of cabinets and installation of hose reels with lay-flat hoses according to DIN EN 671-2
DIN 18230-1	(2010-09)	Structural fire protection in industrial buildings - Part 1: Analytically required fire resistance time
DIN EN 54-1	(10/1996)	Fire detection and fire alarm systems - Part 1: Introduction; German version EN 54-1:1996
DIN EN 671-1	(02/1996)	Fixed firefighting systems - Hose systems - Part 1: Hose reels with semi-rigid hose; German version EN 671-1:2001
DIN EN 671-2	(02/1996)	Fixed firefighting systems - Hose systems - Part 2: Hose systems with lay-flat hose; German version EN 671-2:2001
DIN VDE 0833-1	(2014-10)	Alarm systems for fire, intrusion and hold-up - Part 1: General requirements
ASR 13/1, 2	(06/1997)	Fire suppression equipment (BArbBl. 1997, Nr. 7/8, p. 70-73)
ZH 1/201	(1996)	Standards on equipping work places with fire extinguishers

In addition, the following nuclear regulatory documents, such as ordinances and standards have to be considered:

BMI Guideline “Necessary Knowledge“	(10/1980)	Guideline relating to the assurance of the necessary knowledge of the persons otherwise engaged in the operation of nuclear power plants of October 30, 1980 (GMBl. 1980, p. 652)
RSK Guidelines for PWR	(10/1981)	RSK Guidelines for Pressurized Water Reactors, 3rd edition of October 14, 1981 (BAnz. No. 69 of April 14, 1982, Supplement No. 19/82)
Incident Guidelines	(10/1983)	Guidelines on the evaluation of the design of nuclear power plants with pressurized water reactors against incidents in terms of Sec. 28 para. 3 Radiological Protection Ordinance (Incident Guidelines) of October 18, 1983 (BAnz. No. 245 of December 31, 1983)
Radiation Protection Ordinance	(02/2012)	Ordinance on the protection from damage by ionizing radiation (Radiological Protection Ordinance - StrlSchV) of July 20, 2001, (BGBl. I S. 1714; 2002 I S. 1459), most recently changed by article 5, par. 7 of the law of February 24, 2012 (BGBl. I, p. 212

Recommendation Accident Management Measures	(10/1977)	Recommendations on the planning of accident management measures by the operator of nuclear power plants of December 27, 1976 (GMBl. 1977, p. 48), most recently changed by ordinance of October 18, 1977 (GMBl. 1977, S. 664)
PSA Guide	(11/2005)	Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU): Sicherheitsüberprüfung für Kernkraftwerke gemäß §19a des Atomgesetzes - Leitfaden Probabilistische Sicherheitsanalyse, 31. Januar 2005, Bekanntmachung vom 30. August 2005, Bundesanzeiger, Jahrgang 57, Nummer 207a, ISSN 0720-6100, 3. November 2005 [BMU 05]
Supplement on PSA Methods to PSA Guide	(10/2005)	Facharbeitskreis (FAK) Probabilistische Sicherheitsanalyse für Kernkraftwerke: Methoden zur probabilistischen Sicherheitsanalyse für Kernkraftwerke (Probabilistic Safety Analysis for Nuclear Power Plants: Methods for Probabilistic Safety Analysis), Stand: August 2005, BfS-SCHR-37/05, Salzgitter, Germany, October 2005 (in German only) [FAK 05]
Supplement on PSA Data to PSA Guide	(10/2005)	Facharbeitskreis (FAK) Probabilistische Sicherheitsanalyse für Kernkraftwerke: Daten zur Quantifizierung von Ereignisablaufdiagrammen und Fehlerbäumen (Probabilistic Safety Analysis for Nuclear Power Plants: Data for Quantification of Event Sequence Diagrams and Fault Trees), Stand: August 2005, BfS-SCHR-38/05, Salzgitter, Germany, October 2005 (in German only) [FAK 05a]
Additional Supplement on PSA Methods and Data	(09/2016)	Facharbeitskreis (FAK) Probabilistische Sicherheitsanalyse für Kernkraftwerke: Methoden und Daten zur probabilistischen Sicherheitsanalyse für Kernkraftwerke, Stand: Mai 2015, BfS-SCHR-61-16, Salzgitter, Germany, September 2016 (in German only) [FAK 16]

Further German Nuclear KTA standards:

KTA-1201	(2015-11)	Requirements for the operating manual, http://www.kta-gs.de/e/standards/1200/1201_engl_2015_11.pdf
KTA-1202	(2017-11)	Requirements for the testing manual, http://www.kta-gs.de/e/standards/1200/1202_engl_2017_11.pdf
KTA-1301.1	(2017-11)	Radiation Protection Considerations for Plant Personnel in the Design and Operation of Nuclear Power Plants; Part 1: Design, http://www.kta-gs.de/e/standards/1300/1301_1_engl_2017_11.pdf
KTA-1301.2	(2014-01)	Radiation Protection Considerations for Plant Personnel in the Design and Operation of Nuclear Power Plants; Part 2: Operation, http://www.kta-gs.de/e/standards/1300/1301_2_engl_2014_11.pdf
KTA-1401	(2017-11)	General Requirements Regarding Quality Assurance, http://www.kta-gs.de/e/standards/1400/1401_engl_2017_11.pdf

KTA-1402	(2017-11)	Integrated Management Systems for the Safe Operation of Nuclear Power Plants, http://www.kta-gs.de/e/standards/1400/1401_engl_2017_11.pdf
KTA-1403	(2017-11)	Ageing Management in Nuclear Power Plants, http://www.kta-gs.de/e/standards/1400/1403_engl_2017_11.pdf
KTA-1404	(2013-11)	Documentation During the Construction and Operation of Nuclear Power Plants, http://www.kta-gs.de/e/standards/1400/1404_engl_2013_11.pdf
KTA-2103	(2015-11)	Explosion Protection in Nuclear Power Plants with Light Water Reactors (General and Case-Specific Requirements), http://www.kta-gs.de/e/standards/2100/2103_engl_2015_11.pdf
KTA-2201.1	(2011-11)	Design of Nuclear Power Plants Against Seismic Events, Part 1: Principles, http://www.kta-gs.de/e/standards/2200/2201_1_engl_2011_11.pdf
KTA-2201.2	(2012-11)	Design of Nuclear Power Plants Against Seismic Events, Part 2: Subsoil, http://www.kta-gs.de/e/standards/2200/2201_2_engl_2012_11.pdf
KTA-2201.3	(2013-11)	Design of Nuclear Power Plants Against Seismic Events, Part 3: Structural Components, http://www.kta-gs.de/e/standards/2200/2201_3_engl_2013_11.pdf
KTA-2201.4	(2012-11)	Design of Nuclear Power Plants Against Seismic Events, Part 4: Components, http://www.kta-gs.de/e/standards/2200/2201_4_engl_2012_11.pdf
KTA-2201.5	(2015-11)	Design of Nuclear Power Plants Against Seismic Events, Part 5: Seismic Instrumentation Components, http://www.kta-gs.de/e/standards/2200/2201_5_engl_2015_11.pdf
KTA-2201.6	(2015-11)	Design of Nuclear Power Plants Against Seismic Events, Part 6: Post-Seismic Measures, http://www.kta-gs.de/e/standards/2200/2201_6_engl_2015_11.pdf
KTA-2206	(2009-11)	Design of Nuclear Power Plants Against Damaging Effects from Lightning, http://www.kta-gs.de/e/standards/2200/2206_engl_2009_11.pdf
KTA-2207	(2004-11)	Flood Protection for Nuclear Power Plants, http://www.kta-gs.de/e/standards/2200/2207_engl_2004_11.pdf
KTA-2501	(2010-11)	Structural Waterproofing of Nuclear Power Plants, http://www.kta-gs.de/e/standards/2500/2501_engl_2015_11.pdf
KTA-3301	(2015-11)	Residual Heat Removal Systems of Light Water Reactors, http://www.kta-gs.de/e/standards/3300/3301_engl_2015_11.pdf
KTA-3402	(2014-11)	Airlocks on the Reactor Containment of Nuclear Power Plants - Personnel Airlocks, http://www.kta-gs.de/e/standards/3400/3402_engl_2014_11.pdf

KTA-3403	(2010-11)	Cable Penetrations through the Reactor Containment Vessel, http://www.kta-gs.de/e/standards/3400/3403_engl_2015_11.pdf
KTA-3501	(2015-11)	Reactor Protection System and Monitoring Equipment of the Safety System, http://www.kta-gs.de/e/standards/3500/3501_engl_2015_11.pdf
KTA-3601	(2017-11)	Ventilation Systems in Nuclear Power Plants, http://www.kta-gs.de/e/standards/3600/3601_engl_2017_11.pdf
KTA-3602	(2003-11)	Storage and Handling of Fuel Assemblies and Associated Items in Nuclear Power Plants with Light Water Reactors, http://www.kta-gs.de/e/standards/3600/3602_engl_2003_11.pdf
KTA-3604	(2005-11)	Lagerung, Handhabung und innerbetrieblicher Transport radioaktiver Stoffe (mit Ausnahme von Brennelementen) in Kernkraftwerken, http://www.kta-gs.de/e/standards/3600/3604_engl_2005_11.pdf
KTA-3605	(2017-11)	Treatment of Radioactively Contaminated Gases in Nuclear Power Plants with Light Water Reactors, http://www.kta-gs.de/e/standards/3600/3605_engl_2017_11.pdf
KTA-3701	(2014-11)	General requirements for the electrical power supply in nuclear power plants, http://www.kta-gs.de/e/standards/3700/3701_engl_2014_11.pdf
KTA-3702	(2014-11)	Emergency Power Generating Facilities with Diesel-Generator Units in Nuclear Power Plants, http://www.kta-gs.de/e/standards/3700/3702_engl_2014_11.pdf
KTA-3705	(2013-11)	Switchgear Facilities, Transformers and Distribution Networks for the Electrical Power Supply of the Safety System in Nuclear Power Plants, http://www.kta-gs.de/e/standards/3700/3705_engl_2013_11.pdf
KTA-3901	(2017-11)	Communication Means for Nuclear Power Plants, http://www.kta-gs.de/e/standards/3900/3901_engl_2017_11.pdf
KTA-3904	(2017-11)	Control Room, Remote Shutdown Station and Local Control Stations in Nuclear Power Plants, http://www.kta-gs.de/e/standards/3900/3904_engl_2017_11.pdf

3.7 Japan

3.7.1 Existing Reactors

The legal framework on fire protection in Japan consists of three acts:

a. Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors [JPN-01],

b. Fire Service Act [JPN-02],

c. Building Standard Act [JPN-03].

Under the act (a), new fire protection requirements are defined in the following ordinances (i), (ii), regulatory guides (iii), (iv), and review standard (v), which came into force on July 8th, 2013:

i. The NRA Ordinance on Standards for the Location, Structures and Equipment of Commercial Power Reactors (Article 6 and 8) [JPN-04],

ii. The NRA Ordinance on Technical Standards for Commercial Power Reactors Facilities (Article 7 and 11) [JPN-05],

iii. The Regulatory Guide of the NRA Ordinance on Standards for the Location, Structure, and Equipment of Commercial Power Reactors [JPN-06],

iv. The Regulatory Guide of the NRA Ordinance on Technical Standards for Commercial Power Reactors Facilities [JPN-07],

v. The Fire Protection Review Standard for Commercial Power Reactor Facilities [JPN-08].

3.7.1.1 General Technical Requirements for Nuclear Reactor Facilities

In the ordinance (i) [JPN-04], there are two requirements on the basic design of the fire protection:

- Article 6: Prevention of damage due to external hazards

  Structures, systems and components (SSCs) with safety functions shall be designed so that the safety of the nuclear reactor facilities will not be impaired by other postulated external hazards than earthquake, tsunami and concomitant events. SSCs with safety functions of especially high importance shall be of the design that reflects appropriate safety considerations against the severest conditions of postulated external hazards or appropriate combinations of natural forces and design basis accidents induced loads.

  "*Postulated external hazards*" refer to on-site natural phenomena possible to occur including flood, wind (typhoon), tornado, freezing, rainfall, snowing, lightning, landslide, volcanic effects, biological effects, external fires (forest fires, nearby industrial facilities fires and aircraft crash fires), etc.

- Article 8: Prevention of damage due to fire

  The nuclear reactor facilities shall be designed such that their safety will not be impaired by fire considering individual protective measures for preventing, detecting and extinguishing fire, and mitigating its effects. These protective measures shall also be designed such as not to impair the required functions of SSCs with safety functions as a result of their failure or malfunction.

The Regulatory Guide of the NRA Ordinance that specifies the standard of the location, structure and equipment of the power reactor facilities (iii) [JPN-06] provides supplemental explanations on the standard (i) [JPN-04].

3.7.1.2 Detailed Technical Requirements for Nuclear Reactor Facilities

In the ordinance that specifies the technical standard of the power reactor facilities (ii) [JPN-05], two articles (Article 7 and Article 11) are required on the detailed design of the fire protection similar to the two articles in (i) [JPN-04].

The Regulatory Guide of the NRA Ordinance that specifies the technical standard of the power reactor facilities (iv) [JPN-07] provides supplemental explanations on the technical standard (ii) [JPN-05].

3.7.2 New Reactors

In Japan, there are currently no regulatory requirements that stipulate application to new reactors.

3.7.3 Supplementary Information

Fire Protection Review Standard for Power Reactor Facilities

The Fire Protection Review Standard [JPN-08] specifies the matters to be considered regarding details of fire protection measures for light water nuclear power reactor facilities (hereinafter referred to as “nuclear reactor facilities”) based on the fire protection design policy defined in Article 8 of the standard (i).

1.1 General Requirements

(1) Appropriate fire protection measures shall be taken to protect the SSCs equipped with safety functions that are installed in the fire areas and fire zones of the nuclear reactor facilities through fire prevention, fire detection and suppression, and mitigation of the effects of fires, based on whether the fire areas and fire zones that have the SSCs to be protected fall into fire area/zone category [1] or [2] defined below:

[1] Fire areas and fire zones in which SSCs equipped with safety functions for hot and/or cold shutdowns of the nuclear reactor and for maintaining the reactor shut down are installed,

[2] Fire areas in which SSCs equipped with functions to store or contain radioactive materials are installed.

(2) A Fire Protection Plan shall be formulated that includes detailed description of the fire protection measures to be taken and of the procedures, equipment and staffing required to implement the fire protection measures.

1.2 Fire prevention

(1) Protection of leakage, ventilation and explosion resistance for combustible or inflammable substances

(2) Protection for hydrogen produced by radiolysis

(3) Use of incombustible or fire-retardant substances

(4) Use of fire-retardant electric cables (should be tested by IEEE383/IEEE1202, UL1581, etc.)

1.3 Fire detection and suppression

(1) Design to be able to conduct early fire detection and suppression

- Fire area for installation of fire detectors
- Combination of different types of detectors or devices with equivalent capability
- Ensuring electricity in case of loss of electrical source
- Design to be able to monitor fires in the main control room
- Installation of fixed automatic or manual suppression systems in a fire areas/zones with SSCs to ensure the safety function
- Redundancy or diversity of water supply and suppression pumps
- Design of fire suppression systems with independency for the separation of redundant trains
- Design of water-based fire suppression system to ensure the largest expected flow rate for a period of 2 hours

(2) Design to maintain the fire detection and suppression function, even if natural phenomena such as earthquake, freezing, flood, high wind (typhoon), etc. have occurred

(3) Design not to lose the safety function by the malfunction or mishandling

(4) Influence to the safety function by flooding should be evaluated by the guide of evaluation for internal flooding

1.4 Fire mitigation

(1) Design for implementing the fire mitigating measures according to the safety significance for SSCs

- Separation of fire area having SSCs with function for hot and cold shutdown by fire barriers of 3 hours resistance rating
- Design for preventing the intra- and inter-fire propagation of the fire zones for the separation of redundant SSCs and related non-safety cables

(2) Design to be able to maintain hot and cold shutdown without losing simultaneously the function of each multiple redundant train, in case that the safety protection system and the reactor shutdown system are required to act in case of fire

(3) It should be evaluated by the fire hazard analysis that hot and old shutdown can be maintained.

1.5 Confirmation of separation of redundant trains

(1) Separation of redundant SSCs and cables for fire protection by a fire barrier with a 3-hours rating should be achieved.

(2) Separation of redundant SSCs and cables for fire protection by a horizontal distance of more than 6.1 m (20 ft) with no fire hazard should be achieved. In addition, fire detectors and an automatic fire suppression system should be installed in the fire area.

(3) Enclosure of redundant SSCs and cables for fire protection by means of fire barriers with a 1-hour rating should be achieved. In addition, fire detectors and an automatic fire suppression system should be installed in the fire area.

Guide for Evaluating the Effects of Internal Fires at Nuclear Power Stations

For fire protection of safety related SSCs installed in fire areas and fire zones in power generation nuclear reactor facilities, the fire protection requirements of Article 8 of the standard (i) [JPN-04] and Article 11 of the standard (ii) [JPN-05] should be properly implemented in the design.

The Evaluation Guide [JPN-09] presents examples of procedures for evaluations of the effects of internal fires conducted to confirm that the fire protection measures taken based on these requirements to ensure that the safety functions relating to hot shutdowns and cold shutdowns of nuclear reactors (hereinafter collectively referred to as "*safe shutdowns*") will function correctly in the event of a fire in a nuclear reactor facility. In addition, this Evaluation Guide will be used by examiners as a source of reference when they judge the adequacy of evaluations of the effects of internal fires. With regard to methods for evaluating the effects of fires, it is considered necessary, in view of their present technical standard, to continuously review them in the future taking into consideration the experience of their application.

Guide for Evaluating the Effects of External Fires at Nuclear Power Stations

The fire protection requirements of Article 6 of the standard (i) [JPN-04] and Article 7 of the standard (ii) [JPN-05] should be properly implemented in the design. For equipment of nuclear power stations ("power stations") that is important for safety, measures have been taken to prevent it from being damaged, such as adopting sufficient margin in the design, adopting configurations with redundancy and diversity and performing appropriate maintenance.

The Evaluation Guide [JPN-09] is a guide for evaluations to verify that, even if a forest fire approaches a nuclear power station, the nuclear reactor facilities will be unaffected, as part of efforts to increase the safety against fires that occur off the premises of power stations.

[JPN-01] Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors, http://www.japaneselawtranslation.go.jp/law/detail/?printID=&ft=2&re=02&dn=1&yo=Act+on+the+Regulation+of+Nuclear+Source+Material%2C+Nuclear+Fuel+Material+and+Reactors&x=8&y=20&ky=&page=1&vm=02.

[JPN-02] Fire Service Act, http://www.japaneselawtranslation.go.jp/law/detail/?printID=&ft=2&re=02&dn=1&yo=fire+service+act&x=36&y=21&ky=&page=1&vm=02.

[JPN-03] Building Standards Act, in Japanese only, http://elaws.e-gov.go.jp/search/elawsSearch/elaws_search/lsg0500/detail?lawId=325AC0000000201_20180925_430AC0000000067&openerCode=1.

[JPN-04] NRA Ordinance on Standards for the Location, Structures and Equipment of Commercial Power Reactors, http://nsr-portal/kyoyu0101/SARIS_Attachment/L03The%20NRA%20Ordinance%20on%20Standards%20for%20the_.pdf.

[JPN-05] NRA Ordinance on Technical Standards for Commercial Power Reactors Facilities, http://nsr-portal/kyoyu0101/SARIS_Attachment/L02The%20NRA%20Ordinance%20on%20Technical%20Standards.pdf.

[JPN-06] Regulatory Guide of the NRA Ordinance on Standards for the Location, Structure, and Equipment of Commercial Power Reactors, http://nsr-portal/kyoyu0101/SARIS_Attachment/L04The%20Regulatory%20Guide%20of%20the%20NRA%20Ordinance_.pdf.

[JPN-07] Regulatory Guide of the NRA Ordinance on Technical Standards for Commercial Power Reactors Facilities, http://nsr-portal/kyoyu0101/SARIS_Attachment/L05(For%20SARIS%20module%20Module9-5%20QID63)Article%2035%20of%20the_.pdf.

[JPN-08] Fire Protection Review Standard for Power Reactor Facilities, in Japanese only, http://warp.da.ndl.go.jp/info:ndljp/pid/8729504/www.nsr.go.jp/nra/kettei/data/20130628_jitsuyounaiki03.pdf.

[JPN-09] Guide for Evaluating the Effects of Internal Fires at Nuclear Power Stations, in Japanese only, http://warp.da.ndl.go.jp/info:ndljp/pid/8729504/www.nsr.go.jp/nra/kettei/data/20130628_jitsuyounaikasai.pdf.

3.8 Korea

Korea's regulatory framework (Figure 6) that the nuclear regulatory body (RB[2]) has established for fire protection in nuclear power plant consists of two enforcements, two supporting notices, and regulatory guidelines: Article 20, "Details of Periodic Safety Review" to *Enforcement,* "Enforcement Regulation of the Nuclear Safety Act" [KOR-01]; Article 14, "protection against fire protection, etc." [KOR-02]and Article 59, "Fire Protection Program" to *Enforcement*, "Regulations on Technical Standards for Nuclear Reactor Facilities, Etc." [KOR-03]; *Notice* 2015-11, "Technical Standards for Fire Hazard Analysis" [KOR-04]; *Notice* 2015-12, "Establishment and Implementation of Fire Protection Program" [KOR-05]. Except regulatory guidelines, these NPP fire protection regulations promulgated by the RB are categorized as regulations. The use of the RB's regulatory guides for nuclear reactors and industrial codes/standards, which are referred to in those regulatory guides, is acceptable in complying those regulations and achieving license. The compliance with those regulations is required to not only existing reactors but also new reactors on the basis of the plant's applicability of specific regulations.

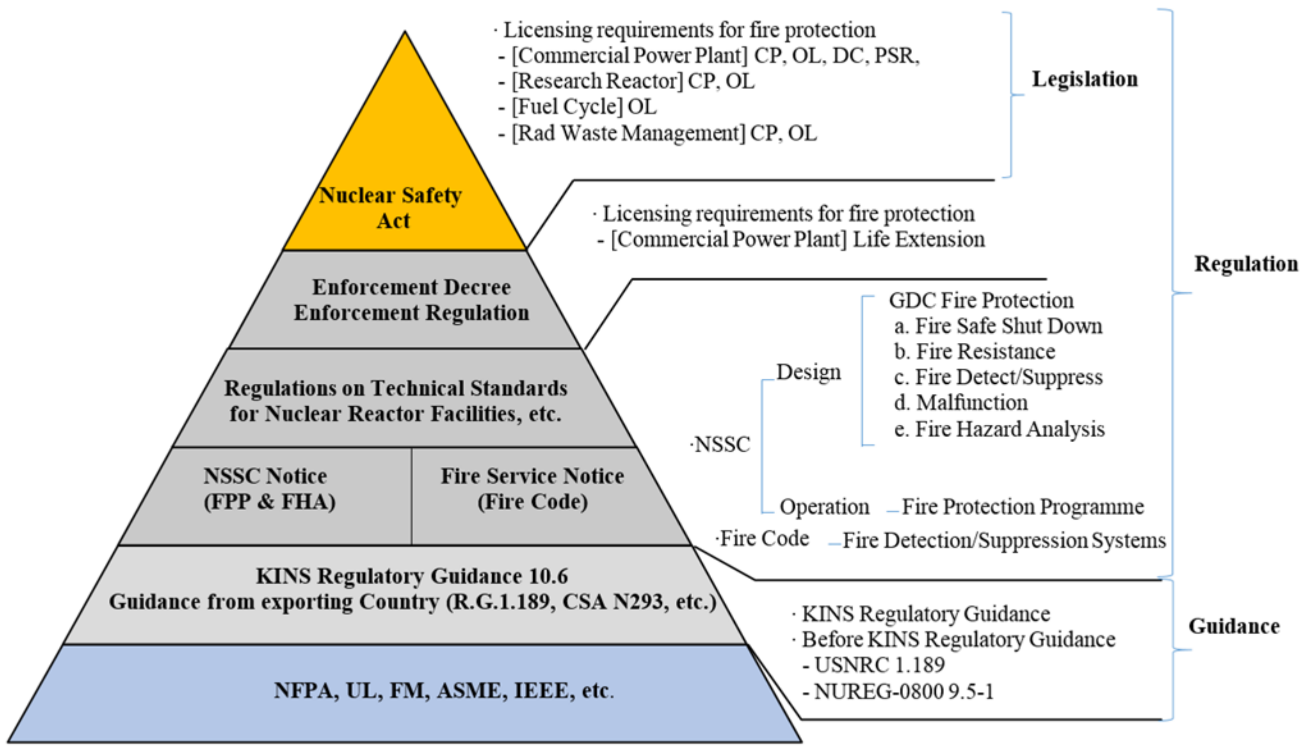

Figure 6 Overview of the Regulatory Framework for Fire Protection in Korea

3.8.1 Existing Reactors

All existing nuclear power plants were adopting plant-specific licensing base for fire protection which was provided from exporting countries such as U.S. NRC SRP CMEB 9.5-1 [NRC-34] and CAN/CSA N293 [CSA-12] in accordance with Article 14,"protection against fire protection, etc." to *Enforcement*, "Regulations on Technical Standards for Nuclear Reactor Facilities, Etc." [KOR-02] the RB considers acceptable for use in implementing those plant-specific licensing

[2] Korea's Regulatory Body: Korea's RB for nuclear safety consists of two organization, Nuclear Safety and Security Commission (NSSC) which is governmental agency, Korea Institute of Nuclear Safety (KINS) which is the governmental regulatory organization.

bases for fire protection as compliance with Article 14,“protection against fire protection, etc.” to *Enforcement*, “Regulations on Technical Standards for Nuclear Reactor Facilities, Etc.”[KOR-02].

The RB requires that licensee should provide results of fire hazard analysis every ten years after their submittal of fire hazard analysis for permit of operating license including post-fire safe shutdown analysis in accordance with *Notice* which is effective at the date of evaluation. Most licensees are requested to re-establish their fire protection plan in accordance with recently issued *Notices* like *Notice* 2015-12 [KOR-05] regardless of plant-specific licensing base.

Periodic Safety Reviews should be required every ten years for licensee to perform reanalysis of the aging effect of fire protection system, to reanalyze fire and explosion hazard in NPP, and to reflect the operational experience and recommendations from recent research related to fire protection in accordance with Article 20, “Details of Periodic Safety Review” to *Enforcement,* “Enforcement Regulation of the Nuclear Safety Act” [KOR-01]. In the process of analyzing fire and explosion hazard, licensee should re-evaluate fire hazard analysis based on latest *Notice* such as *Notice* 2015-11. Regardless of plant-specific licensing base for fire protection, licensee should be required to comply with the paragraph for safe shutdown analysis specified in currently effective and latest *Notice* such as *Notice 2015-11* [KOR-04]. Fire Probabilistic Safety Assessment (PSA) is also required in accordance with Article 20, “Details of Periodic Safety Review” to *Enforcement,* “Enforcement Regulation of the Nuclear Safety Act” [KOR-01]. The methodology of Fire PSA should be adopted NUREG/CR-6850 (ERPI TR-105928) [NRC-08] based on the effective date of evaluation.

KINS Regulatory Guide 10.6 [KOR-06] or the applicable U.S. NRC Regulatory Guide [NRC-09] and CSA standard [CSA-12] apply to all facilities where these guidance documents are referenced as a license condition by the regulatory body.

For facilities obtained the construction permit (CP) prior to the current edition of guidance, the deviations from previous edition of guidance are enhanced through Licensee’s Periodic Safety Review (PSR) which is submitted every 10 years after obtaining the operating license (OL). The RB does not require retrofits to facilities constructed prior to the effective edition of guidance but enhancements are recommended by the regulatory body based on operational experiences and recommendations from research related with fire protection. However, regardless of referenced edition of guidance, all deviations apart from fire safety shutdown criteria shall be retroactively enhanced based on currently effective edition of guidance. In case that compliance with the deterministic requirements is not possible due to existing condition, the regulatory body can accept the implementation of the equivalent level of spatial or physical separation, fire detection and suppression as a fire safety shutdown criterion.

3.8.1.1 Overview

1. **Article 20,“Details of Periodic Safety Review”***, Enforcement, “Enforcement Regulation of the Nuclear Safety Act”* [KOR-01]

   Fire PSA, internal/external fire risk assessment, degradation due to aging, and operational experience/research findings should be re-evaluated through every 10 years Periodic Safety Review process, which is required for all licensees to conduct and submit for regulatory body’s approval. For licensees being not required to submit Fire PSA in the construction permit/operating license phase, Fire PSA should be conducted on the basis of KINS/GE-07, “Safety Review Guides for PSR” [KOR-07] and submitted on the upcoming PSR after November 2014.

2. **Article 14 “Protection against Fire Protection, etc.”***, Enforcement, “Regulations on Technical Standards for Nuclear Reactor Facilities, Etc.”* [KOR-02]

This regulation is based on the concept of defense-in-depth, (1) prevent fires from starting, (2) detect rapidly, suppress and extinguish fire promptly, and (3) protection SSCs important to safety, so that a fire which is not extinguished will not prevent the safe shutdown abilities. Three categories of fire protection apply to all existing NPP as regulation. This regulation also require that licensee should provide fire hazard analysis and conduct reanalysis in accordance with recently issued FHA *Notice* such as *Notice* 2015-11 [KOR-04].

3. **Article 59 "Fire Protection Program",** *Enforcement, "Regulations on Technical Standards for Nuclear Reactor Facilities, Etc."* [KOR-03]

   Nuclear Safety Enforcement "Regulation on Technical Standards for Nuclear Reactor Facilities, Etc." Article 59(Fire Protection Program) requires that all licensee implement and maintain comprehensive fire protection program (FPP) which consists of fire prevention activities, firefighting and response strategy including initial fire brigade, and maintenance of fire protection features and fire safety shutdown condition.

4. **NSSC Notice 2015-11 "Technical Standards for Fire Hazard Analysis"** [KOR-04]

   Fire Hazard Analysis (FHA) is also required to access fire hazard, fire protection features, and safety shutdown ability based on Nuclear Safety and Security Commission (NSSC) *Notice* 2015-11 "Technical Standards for Fire Hazard Analysis" KOR-04]. Every ten years, every in-situ and transient fire hazard should be identified including updates of plant changes for each fire area (like fire compartment) and fire protection features should be assessed based on applicable current codes and standards. Fire safety shutdown ability shall be obtained and maintained based on current safety shutdown criteria which is mentioned in NSSC *Notice* 2015-11 KOR-04]. Any deviations from current applicable codes and standards related to fire protection features could be enhanced by the RB's recommendation but not mandatory. The RB does not strictly allow any deviations from fire safety shutdown criteria but can accept the implementation of the equivalent level of spatial or physical separation, fire detection and suppression as fire safety shutdown criteria. MSO (multiple spurious operation) should be included and submitted on the upcoming PSR after December 2015.

5. **NSSC Notice 2015-12 "Establishment and Implementation of Fire Protection Program"** [KOR-05]

   NSSC Notice 2015-12 requires that licensees of all facilities establish organization and entitlement, fire prevention activities, fire response strategy, fire safety shutdown procedure, and fire brigade drill and education program.

6. **KINS Regulatory Guide 10.6 "Fire Protection for Nuclear Power Plants"** [KOR-06]

   KINS Regulatory Guide 10.6 [KOR-06] presents the detailed guidelines for nuclear power plants related to fire protection program, fire prevention, fire detection and suppression, building design and passive features, safe shutdown capability, fire protection for areas important to safety, protection of special fire hazards exposing areas important to safety, etc.

3.8.2 New Reactors

The acts and standards related to the nuclear regulation and the fire protection guides mentioned above are applicable for the existing reactors as well as for new reactors. The chapter 8 "fire protection for new reactor" in the KINS regulatory guide 10.6 [KOR-06] presents enhanced standard and guide such as NFPA 804 [NFPA-15].

3.8.3 Supplementary Information

Regulatory Requirements

Regulation Level

[KOR-01] Nuclear Laws of the Republic of Korea: Enforcement Regulation of the Nuclear Safety Act, Article 20: Details of Periodic Safety Review, Korea Institute of Nuclear Safety (KINS), Enacted by Regulation of the Prime Minister No. 2, Nov. 11, 2011 (Entered into force, Nov. 11, 2011), Amended by Presidential Decree No. 24689, August 16, 2013, http://www.nssc.go.kr/nssc/en/nci/elif/Enforcement_Regulation_of_the_Nuclear_Safety_Act.pdf.

[KOR-02] Nuclear Laws of the Republic of Korea: Regulation on Technical Standards for Nuclear Reactor Facilities, Etc., Article 14: Protection against Fire Protection, Etc., Korea Institute of Nuclear Safety (KINS), Enacted by Ordinance of the Ministry of Education, Science and Technology No. 16, Apr. 18, 2000, Amended by Ordinance of the Ministry of Education, Science and Technology No. 31, Jul. 28, 2001, Ordinance of the Ministry of Education, Science and Technology No. 92, Jul. 19, 2006, Ordinance of the Ministry of Education, Science and Technology No. 1, Mar. 4, 2008Regulation of the Nuclear Safety and Security Commission No. 3, Nov. 11, 2011, http://www.nssc.go.kr/nssc/en/nci/elif/Regulations_on_Technical_Standards_for_Nuclear_Reactor_Facilities,ETC.pdf.

[KOR-03] Nuclear Laws of the Republic of Korea: Regulation on Technical Standards for Nuclear Reactor Facilities, Etc., Article 59: Fire Protection Program, Korea Institute of Nuclear Safety (KINS), 2008, Regulation of the Nuclear Safety and Security Commission No. 3, Nov. 11, 2011. http://www.nssc.go.kr/nssc/en/nci/elif/Regulations_on_Technical_Standards_for_Nuclear_Reactor_Facilities,ETC.pdf.

[KOR-04] Nuclear Safety and Security Commission (NSSC): Notice 2015-11: Technical Standards for Fire Hazard Analysis, in Korean only, http://www.law.go.kr/admRulLsInfoP.do?chrClsCd=010202&admRulSeq=2100000033523.

[KOR-05] Nuclear Safety and Security Commission (NSSC) Notice 2015-12: Regulation on Establishment and Implementation of Fire Protection Program, 2015, in Korean only, http://www.law.go.kr/admRulLsInfoP.do?chrClsCd=010202&admRulSeq=2100000033524.

Guidance Level

[KOR-06] Korea Institute of Nuclear Safety (KINS): Fire Protection for Nuclear Power Plants, Regulatory Guide 10.6, in Korean only, http://www.kins.re.kr/nsic.do?menu_item=technologyStatus.

[KOR-07] Korea Institute of Nuclear Safety (KINS): KINS/GE-07: Safety Review Guides for PSR.

[NRC-09] United States Nuclear Regulatory Commission (NRC), Office of Nuclear Regulatory Research: Fire Protection for Nuclear power Plants, Regulatory Guide

1.189, Rev. 2, Washington, DC, USA, October 2009, https://www.nrc.gov/docs/ML0925/ML092580550.pdf.

[NRC-34] United States Nuclear Regulatory Commission (NRC): Fire Protection for NPPs, NUREG-0800 BTP CMEB 9.5-1 Standard Review Plan, Rev. 3, Washington, DC, USA, July 1981, https://www.nrc.gov/docs/ML0706/ML070660454.pdf.

3.9 The Netherlands

3.9.1 Existing Reactors

All nuclear facilities in the Netherlands, including the Borssele NPP, operate under license, authorized after a safety assessment has been carried out. The license is granted by the regulatory body under the Nuclear Energy Act [NED-01], called Kew.

An important step in 2015 was an update of the Kew with legally establishing the new Authority for Nuclear Safety and Radiation Protection, ANVS, as an independent administrative authority (see https://english.autoriteitnvs.nl/).

The Kew is a framework law, which sets out the basic rules on the application of nuclear technology and materials, makes provision for radiation protection, designates the competent authorities and outlines their responsibilities. More detailed legislation is provided by associated Decrees and Ordinances. In the Netherlands the (modified) International Atomic Energy Agency (IAEA) requirements and guides are the basis of the regulation of the existing NPP, including the Western European Nuclear Regulators Association (WENRA) Reference Levels.

International Atomic Energy Agency (IAEA):

- Fire Safety in the Operation of Nuclear Power Plants Safety Guide, IAEA Safety Standards Series NS-G-2.1, 2000 [IAEA-00b]:
  In the Netherlands this IAEA SG has been adopted to: NVR NS-G-2.1 'Brandveiligheid in de bedrijfsvoering van kernenergiecentrales'[NED-02];
- Protection against Internal Fires and Explosions in the Design of Nuclear Power Plants Safety Guide, IAEA Safety Standards Series, NS-G-1.7, 2004 [IAEA-04]:
  In the Netherlands this IAEA SG is adopted to: NVR NS-G-1.7 'Bescherming tegen interne branden en explosies in het ontwerp van kernenergiecentrales' [NED-03];
- IAEA Safety Guide Safety Standard Series No. NS-G-1.11, Protection Against Internal Hazards other than Fires and Explosions in the Design of NPPs [IAEA-04a]:
  In the Netherlands this IAEA SG is adopted to: NPPs NVR NS-G-1.11 'Bescherming tegen interne gevaren anders dan branden en explosies in het ontwerp van kernenergiecentrales' [NED-04];
- Performance of a Fire Hazard Analysis, IAEA Safety Standards Series No. 50-P-9, Vienna, 1995 [IAEA-95];
- Preparation of a Fire Hazard Analysis, IAEA Safety Reports Series No. 8, Vienna, 1998 [IAEA-98];
- Use of operational experience in fire safety assessment of nuclear power plants, IAEA–TECDOC–1134, Vienna, January 2010 [IAEA. [IAEA-00c].

Under Article 41 of the Kew, the local authorities also have the responsibility for making regional/local contingency plans for emergencies. Firefighting service, police and health services will be involved. These include: NVR-NS-R1 [NED-05] and NVR-SSG-2 [NED-06] stating that a full range of events must be postulated in order to ensure that all credible events with potential for serious consequences and significant probability have been anticipated and can be accommodated by the design base of the plant. For the safety analysis of the Borssele NPP, the postulated initiating events have been defined in the following categories according to their entrance probability.

The Safety Regions Act (Wet Veiligheidsregio's, WVR) [NED-07] is a Dutch law that came into force on October 1, 2010. This act replaces the Fire Service Act (Brandweerwet, 1985) and provides the legal frame for firefighting.

The Decree Safety Regions (Besluit veiligheidsregio's) [NED-08], of June 24, 2010 lays down rules on the organization and functions of the Safety Regions (Veiligheidsregio's) and municipal fire departments.

The Building Decree (Bouwbesluit, 2012) [NED-09] came into force on April 1, 2012. This is the legal frame for fire and smoke resistance of walls, floors and ceilings, protected escape routes and fire compartments of the buildings.

3.9.2 New Reactors

In 2015 the new Dutch Safety Guidelines have been completed for (new) water cooled reactors, with Dutch acronym 'VOBK'. The VOBK consists of an (extensive) introductory part and a technical part, the 'Dutch Safety Requirements', the DSR [NED-10]. The DSR is based on the IAEA Safety Fundamentals, several Safety Requirements guides and some Safety Guides, safety objectives for new NPPs published by WENRA. An annex to the DSR is dedicated to Research Reactors and describes application of the DSR with a graded approach. The DSR takes into account the latest (post-Fukushima) insights and is in line with the European Directive on Nuclear Safety 22 and the objectives of the Vienna Declaration on Nuclear Safety (VNDS) [NED-11].

3.9.3 Supplementary Information

Further guidance can be revealed from harmonized European non-nuclear fire protection standards (e.g., NEN-EN for technical requirements regarding fire detection and extinguishing equipment). Consideration can also be given to existing state-of-the-art international nuclear fire safety standards for operating NPPs taking also into account the difficulties of older plants meeting formally more recent requirements, such as the German nuclear fire protection standard KTA 2101, Part 1-3 [KTA-00], [KTA-00a], [KTA-00b], representing rules written for recently designed plants as well as for plants designed to former standards.

[NED-01] Nuclear Energy Act ('Kernenergiewet' or Kew), 1963, https://wetten.overheid.nl/BWBR0002402/2018-10-16.

[NED-02] NVR NS-G-2.1: Brandveiligheid in de bedrijfsvoering van kernenergiecentrales.

[NED-03] NVR NS-G-1.7: Bescherming tegen interne branden en explosies in het ontwerp van kernenergiecentrales.

[NED-04] NVR NS-G-1.11: Bescherming tegen interne gevaren anders dan branden en explosies in het ontwerp van kernenergiecentrales.

[NED-05] NVR-NS-R1 (Safety Requirements for Nuclear Power Plant Design), https://www.iaea.org/publications/6002/safety-of-nuclear-power-plants-design.

[NED-06] NVR-SSG-2 (Deterministic Safety Analysis), https://www-pub.iaea.org/MTCD/publications/PDF/Pub1428_web.pdf.

[NED-07] The Safety Regions Act (Wet Veiligheidsregio's, WVR), October 1, 2010, http://wetten.overheid.nl/BWBR0027466/geldigheidsdatum_11-10-2014.

[NED-08] The Decree Safety Regions (Besluit veiligheidsregio's, une 24, 2010, http://wetten.overheid.nl/BWBR0027844/geldigheidsdatum_11-10-2014.

[NED-09] The Building Decree (Bouwbesluit, 2012), April 1, 2012, http://wetten.overheid.nl/BWBR0030461/geldigheidsdatum_11-10-2014.

[NED-10] Dutch Safety Requirements for Nuclear Reactors: Fundamental Safety Requirements, 19.03.2015, https://www.oecd-nea.org/nsd/docs/2015/csni-r2015-15.pdf.

[NED-11] Vienna Declaration on Nuclear Safety (VNDS), https://english.autoriteitnvs.nl/topics/guidelines-on-the-safe-design-and-operation-of-nuclear-reactors.

3.10 Spain

3.10.1 Existing Reactors

The Nuclear Safety Council's Instruction IS-30 [CSN-13] on the requirements of the fire protection program at nuclear power plants is the national regulation that requires nuclear power station license holders to setup and maintain a fire protection program at their facilities. This fire protection program includes all the features regarding fire protection (prevention, detection, extinction, firefighting) and analysis performed to ensure that the safe shutdown is achieved and maintained in case of any postulated fire event at any fire area of the facility, including the main control room. This capacity includes the adequate confinement of radioactive materials so that the likelihood of offsite releases of radioactive materials is minimized.

For some time, the Nuclear Safety Council (CSN) has required the nuclear power plant licensees to implement a fire protection program in keeping with the requirements demanded of U.S. plants and with the licensing conditions for fire protection applied to each plant in particular. Pursuant to the provisions of article 8.3 of the Regulation on Nuclear and Radioactive Facilities, (Royal Decree 1836/1999, of December 3rd [SPN-03], modified by Royal Decree 35/2008, of January 18th [SPN-04]), and further to the need to incorporate these requirements into the Spanish legal framework, Nuclear Safety Council Instruction IS-30 dealing with the requirements of the fire protection program at nuclear power plants (Official State Gazette "BOE" No. 40 of February 16th, 2011) was approved on January 19th, 2011.

In drawing up this Council Instruction, consideration was given to the work performed by the Western European Nuclear Regulators' Association (WENRA) in order to harmonize the regulations of the different countries. As a result of this effort, a set of common requirements known as «reference levels» was established, these to be reflected in the national standards.

Specifically, in its chapter S (Protection against internal fires) [WENRA-08] the WENRA reference levels document sets out the basic applicable requirements which, in the terminology traditionally used within the Spanish documentary and legal framework, are known as "Fire Protection at nuclear power plants".

In order to give consistency to the standards development process undertaken by the CSN as a result of this harmonization effort, it was considered necessary to draw up a Council Instruction contemplating the aforementioned requirements, this giving rise to approval of the said Instruction IS-30, of January 19th, 2011 Subsequently, in view of the experience gleaned from application, the need to regulate the different specific characteristics of both the design and the original licensing basis of the system for fire protection of each of the different Spanish nuclear power plants and the evolution of the fire protection regulations, revision 1 of Instruction IS-30 of February 21st, 2013 was approved. Finally, the current version of the IS-30 was issued in order to clarify and facilitate the practical application of the term «exemption», splitting the term coined in revision 1 into two new terms, exemption and equivalent measures, which fit perfectly into the regulatory framework governing nuclear safety and radiological protection. Revision 2 of the Instruction, approved by the Council on November 16th, 2016, came into force the day after its publication in the "Official State Gazette" (Wednesday November 30th, 2016) [SPN-05].

3.10.1.1 Purpose and scope of application

The purpose of this Council Instruction is requiring nuclear power station license holders to implement a fire protection program and defining the criteria that must be fulfilled by such program. This Instruction shall apply to the licensees of all Spanish nuclear power plants with an operating license.

3.10.1.2 The Nuclear Safety Council's criteria for fire protection at nuclear power plants.

The fire protection objectives must be fulfilled by any license holder under the scope of the Instruction under the principle of defense-in-depth in fire protection, namely implementing measures to prevent a fire before it starts, to detect, control and extinguish it as soon as possible in case it occurs, and to prevent the spread thereof to other areas that might affect safety.

On the other hand, by means of confinement in fire areas, it must be ensured that a fire that cannot be extinguished will not damage at least one of the redundant safe shutdown trains such that the power plant may achieve and maintain such safe shutdown and the likelihood of offsite radioactive releases is minimized.

3.10.1.3 Safe shutdown capacity

A fire risk analysis that proves that fire safety objectives are fulfilled, design bases are complied with, active and passive fire protection systems have been properly designed and administrative controls have been properly implemented must be conducted and kept up to date. This analysis must prove that the possible consequences and effects of both the intentional and spurious actuation of fire extinction systems has been taken into consideration.

On the other hand, a safe shutdown analysis must demonstrate, from the identification of the redundant safe shutdown trains considered in the facility that, under a postulated fire in any fire area of the plant, damages to systems are limited so that one train of the systems needed to achieve and maintain safe shutdown conditions from the control room or from the panel for remote shutdown in case of a fire is undamaged by the fire; and the systems needed to achieve and maintain cold shutdown from the control room or from the panel for remote shutdown in case of a fire can be repaired within the 72 hours following the start of the fire.

For fire areas where all redundant trains of any system necessary to achieve safe shutdown in case of fire maybe affected by a fire an alternative or dedicated shutdown capacity independent from the cables, systems and components located in this area, or even control room abandonment is required, if the deterministic post-fire shutdown analysis concludes so for the specific configuration of these areas. The use of operator manual actions in case of fire is an acceptable means of compliance requiring a case-by-case assessment by the CSN.

There must be an alternative or dedicated shutdown capability, independent from the cables, systems and components located in the main control room. The analysis of deterministic safe shutdown capacity in case of fire in this area shall be carried out in accordance with the methodology provided in NEI 00-01 [NEI-05].

A valid alternative to meet these requirements is to follow a "risk-informed, performance-based" methodology previously accepted by the CSN.

3.10.1.4 Additional requirements

The Instruction also establishes additional requirements to fire protection systems in areas important to safety at the facility as well as to the quality assurance program applicable to their design, acquisition, assembly, testing and the administrative controls.

Procedures must also be established to control and minimize the amount of combustible material and ignition sources that might affect equipment important to safety.

Effective firefighting capability is also under the scope of the Instruction IS-30, which establishes specific requirements onto fire brigade organization and co-ordination, composition, duties, physical conditions, training and available resources.

3.10.1.5 Regulatory supervision of the fire protection program at nuclear power plants in Spain

The former set of analysis, procedures and documents constitute the Fire Protection Program of the facility and any change in them that could impair the capacity in fulfilling the objectives of fire protection must be approved by CSN. With this aim, a Complementary Technical Instruction was issued by the CSN last June 2018 to all holders of an operation license in Spain to set the conditions for the regulatory control of this Fire Protection Program and its changes caused by either physical or document modifications.

3.10.2 New Reactors

The Instruction IS-30 of CSN [SPN-05] states, in its Sole Additional Provision, that:

In the case of new nuclear power plants, it shall be considered from the very early stages of design that among the fire protection requirements for being capable of achieving and maintaining safe shutdown and minimizing the likelihood of off-site radioactive releases, the requirements of section 1) of Article 3.2.5 will not be taken into account such that, outside the containment building, the redundant safe shutdown trains, including their associated circuits, must be located in different fire areas. In addition, their design shall minimize or eliminate the use of alternative or dedicated shutdown systems, except for the case of the main control room. Likewise, the execution of operator manual actions shall be avoided in case of a fire, and the use of fire-resistant coating in electrical raceways shall be minimized.

That means, for new design facilities, requirements for the separation of redundant trains of systems necessary to achieve and maintain the safe shutdown of the facility in case of fire must be achieved via fire area compartmentation and therefore no alternative configurations will be considered as equivalent of such separation required in the terms that were accepted for the existing facilities, also to ensure the alternative shutdown capacity.

3.10.3 Supplementary Information

The Law 15/1980 [SPN-02], creating the Nuclear Safety Council, explicitly states the faculty of the CSN at proposing and reviewing regulations, as well as elaborating and approving different kinds of mandatory rules related to nuclear and radioactive installations and to the activities associated with nuclear safety and radiological protection. In that sense, Law 15/1980 assigns to the CSN the function of proposing the necessary regulations on nuclear safety and radiation protection, as well as their reviews, for final approval. Furthermore, this article states that the CSN has the legal capacity to issue Instructions of the CSN (legally binding), Circulars, and Safety Guides on technical issues concerning nuclear installations and radioactive facilities and the activities related to the nuclear safety and radiation protection (under these terms, transport, emergency and security are also included). Therefore, the CSN elaborates rules (Instructions of the CSN and Safety Guides) which will become part of the Regulatory Framework on the subject under the scope of the rule.

The Board of the CSN set up a Regulation Commission in charge of promoting, supervising and coordinating the activity related to regulation development. The members of this commission consist of two Commissioners (acting as President and Vice-president of the Commission) and other members from both Technical Directorates and Secretariat. Besides CSN membership, the competent Ministry is represented in the Regulation Commission as well so that this Commission serves as a channel for coordinating and monitoring the activities regarding regulations and guides.

The CSN provides, within this legal framework, processes for establishing or adopting, promoting and amending regulations and guides. These processes involve compulsory consultation with interested parties and general public in the development of regulations and guides, taking into account internationally agreed standards and the feedback of relevant experience. Moreover, technological advances, research and development work, relevant operational lessons learned, and institutional knowledge are valuable tools in reviewing regulations and guides. The consideration of different kinds of foreign regulations (IAEA, OECD/NEA, Europe, etc.) is considered a strength, and it is important to mention that the CSN Creation Law includes provisions focused on foreign relationships that contains international agreements on the CSN´s responsibilities.

In Spain, the regulatory framework establishes the principles, requirements and associated criteria for safety upon which the regulatory judgements, decisions and actions are based. This framework has a hierarchical structure, as it is shown on next figure, starting with International Treaties (Conventions), and following top to bottom with Laws, mandatory regulations and Instructions and ending with Guides that contain acceptable technical approaches to comply with the regulations. Moreover, the competent Ministry and the CSN establish Limits and Conditions applicable to the license granted, and Complementary Technical Instructions for each installation, as a way to establish technical requirements about specific matters not included in other regulations (Figure 7).

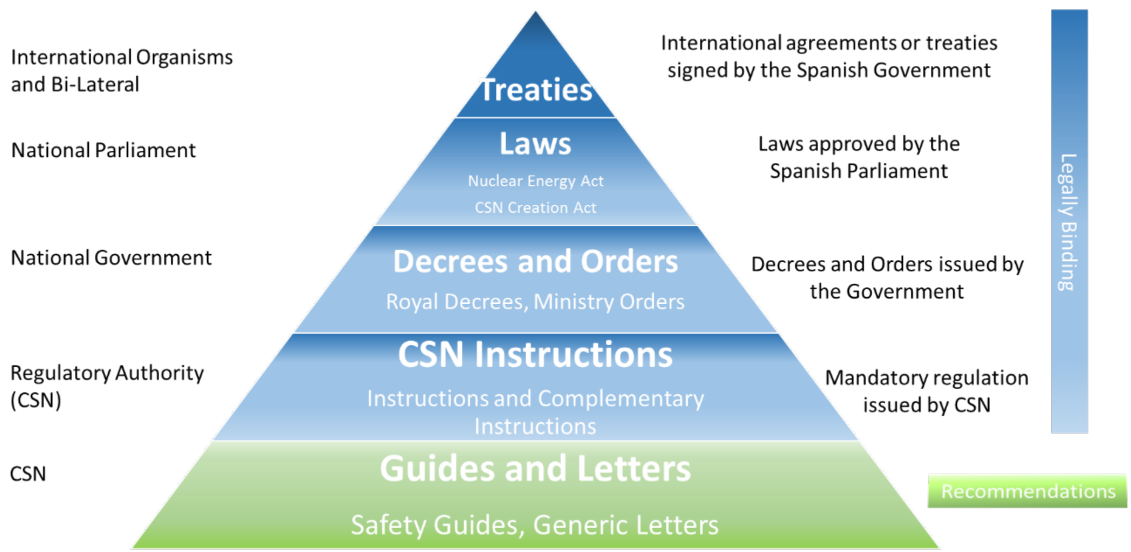

Figure 7 Hierarchical Pyramid of Nuclear Regulation in Spain

There are two main laws serving as the framework for the regulatory requirements and conditions:

- Law 25/1964, of 29th April, on Nuclear Energy [SPN-01],
- Law 15/1980, of 22nd April, creating the Nuclear Safety Council. [SPN-02].

The following Royal Decrees are also a relevant part of the Spanish nuclear regulatory framework:

- Royal Decree 1836/1999, of December 3rd, approving the Regulation on Nuclear and Radioactive Facilities (under review, BSS EU Directive) [SPN-03];

- Royal Decree 783/2001, of July 6th, which approves the Regulation on Sanitary Protection against Ionising Radiations (under review, BSS EU Directive);
- Royal Decree 146/2004, of June 25th, approving the basic Nuclear Emergency Plan.
- Royal Decree 1440/2010, of November 5th, approving the Statute of the Nuclear Safety Council.
- Royal Decree 1400/2018, of November 23rd, approving the Regulation on nuclear safety in nuclear facilities [SPN-04].

So far, there are 42 Instructions of the CSN; these legally binding documents develop Laws and Royal Decrees on nuclear safety, radiation protection, waste management, security and transport. In addition, there are more than 70 Safety Guides on different topics such as power reactors and nuclear power plants, fuel cycle installations, radiation protection, environmental radiological control, radioactive installation and devices, radioactive waste management, transport, security, natural radiation, etc. All Instructions of the CSN are available in English at the CSN website (https://www.csn.es/en/normativa-del-csn).

The most relevant regulations are provided in the following:

[SPN-01] The Nuclear Energy Act, Law 25/1964, of April 29th, 1964, https://www.boe.es/buscar/pdf/1964/BOE-A-1964-7544-consolidado.pdf, https://www.csn.es/documents/10182/1369702/Law+251964%2C+of+29th+of+April%2C+on+Nuclear+Energy (unofficial English version).

[SPN-02] The Law15/1980, of April 22nd, 1980, creating the Nuclear Safety Council, https://www.boe.es/buscar/pdf/1964/BOE-A-1964-7544-consolidado.pdf, https://www.csn.es/documents/10182/1369702/Law+Creating+the+Nuclear+Safety+Council (in official translation into English).

[SPN-03] The Royal Decree 1836/1999, of December 3rd, 1999, approving Regulation on Nuclear and Radioactive Facilities, https://www.boe.es/buscar/pdf/1999/BOE-A-1999-24924-consolidado.pdf, https://www.csn.es/documents/10182/1369702/Royal+Decree+1836-1999%2C+of+December+3rd%2C+approving+the+Regulation+on+Nuclear+and+Radioactive+Facilities (unofficial translation into English).

[SPN-04] Royal Decree 1400/2018, of November 23rd, 2018, Regulation on nuclear safety in nuclear facilities, https://www.boe.es/buscar/pdf/2018/BOE-A-2018-16041-consolidado.pdf.

[SPN-05] Instrucción de Seguridad IS-30 del CSN, sobre requisitos del programa de protección contra incendios en centrales nucleares, https://boe.es/boe/dias/2016/11/30/pdfs/BOE-A-2016-11342.pdf, https://www.csn.es/documents/10182/1348817/Instruction%20IS-30,%20Revision%202,%20of%20November%2016th%202016,%20on%20the%20requirements%20of%20the%20fire%20protection%20programme%20at%20nuclear%20power%20plants (unofficial English version).

[SPN-06] The Guia de Seguridad GS 1.19, Programa de Protección contra Incendios en Centrales Nucleares, https://www.csn.es/documents/10182/896572/GS+01-19+Requisitos+del+programa+de+protecci%C3%B3n+contra+incendios+en+centrales+nucleares.

3.11 <u>Sweden</u>

The regulatory information reflected in this section is current up to 2015.

3.11.1 Existing Reactors

Nuclear facilities in Sweden have to adhere both to conventional and specific nuclear fire protection regulations.

3.11.1.1 Nuclear Specific Regulations

The Act on Nuclear Activities (lagen (1984:3) om kärnteknisk verksamhet, also called kärntekniklagen), the Radiation Protection Act (strålskyddslagen (1988:220)) and the Ordinance with instructions for the Swedish Radiation Safety Authority (förordning (2008:452) med instruktion för Strålsäkerhetsmyndigheten) have been translated into English. The English versions of the acts and ordinances do not include changes that have been made after 2008.

When the Swedish nuclear reactors were designed there were no nuclear specific national fire protection requirement established. Instead the General Design Criteria 3 of Appendix A to 10 CFR 50 [NRC-01] were used as guidance along with general national building requirements. Today the nuclear specific regulations including fire protection are primarily:

- SSMFS 2008:1 [SSM-09], and
- SSMFS 2008:17 [SSM-09a].

SSMFS 2008:1 specifies amongst others that fire protection provisions in nuclear facilities must ensure that:

- The capacity of a facility's barriers and defense-in-depth system to prevent radiological accidents and mitigate the consequences in the event of an accident are analysed using deterministic methods before the facility is constructed or modified and taken into operation.
- The facilities are analysed using probabilistic methods in order to obtain as comprehensive a view as possible of safety.
- The Civil Protection Act (2003:778) [SWD-01] and the Civil Protection Ordinance (2003:789) [SWD-02] are used to specify the emergency preparedness.
- An emergency response plan that should cover all types of accidents for which the facility is designed as well as measures to mitigate the consequences of possible accident sequences which can occur in addition to this (combinations of events should be taken into account, such as fire or sabotage in combination with a radiological accident).
- Instructions of how to minimize combustible materials and ignition sources should be available. Instructions should also be available for inspection, maintenance and testing of fire protection measures (this is stated as a general advice in SSMFS 2011:3 [SWD-03] (not included in the English version of SSMFS 2008:1)).

SSMFS 2008:17 specifies amongst others that fire protection provisions in nuclear facilities have to ensure the following:

- The design of a facility is able to withstand a fire event and its consequences.
- Initiating fire events included in the deterministic safety analysis are divided into a limited number of event classes (based on an analyzed probability with which the event is expected to occur) with specified analysis assumptions and acceptance criteria.

- The facility in the event of fire (up to and including the event class improbable events) and a simultaneously single fault shall be able to reach a safe state with acceptance criteria according to the event classification.
- Reasonable technical and administrative measures are taken in order to counteract common cause failures in connection with design, manufacturing, installation, start-up, operation and maintenance of safety systems.
- The fire event are analyzed at all operating modes of the reactor. When analyzing fire as an initiating event, an additional fire need not be assumed in the facility.
- A fire that causes all equipment in a fire compartment to fail are assumed to occur, unless a fire hazard analysis can demonstrate that protection measures are sufficient to prevent the failure of redundant items important to safety.
- A fire event are postulated wherever a fire can effect equipment included in safety functions or other equipment used to take the facility to a safe state.
- When analyzing initiating events other than fire, which in turn can result in a fire, a fire should be assumed to occur as a possible consequential failure from the initiating event.
- When analyzing events other than fire, which in turn cannot result in a fire, a fire should nonetheless be assumed to occur no earlier than 12 hours after the initiating event. This sequence need not be combined with a single failure. This applies to initiating events up to and including the event class unanticipated events, apart from pipe breaks.
- Fire events that can threaten continued activity in the main control room are identified and an established action plan shall be available for dealing with such threats while maintaining reactor safety.

3.11.1.2 Conventional fire protection regulations

The following conventional fire protection regulations have to be considered when designing the fire protection:

1. Swedish Environmental Code (1998:808)
2. Civil Protection Act (2003:778)
3. Civil Protection Ordinance (2003:789)
4. Flammable and Explosive Goods Act (2010:1011)
5. Work Environment Act (1977:1160)
6. Work Environment Ordinance (1977:1166)
7. Planning and Building Act (2010:900)
8. Planning and Building Ordinance (2011:338)

The Swedish Environmental Code (1998:808) [SWD-04] for example includes requirement regarding handling with substances that can influence the environment negatively and can be needed to consider when designing confinement of leakage and/or firefighting water.

The Civil Protection Act (2003:778) [SWD-01] includes requirement regarding preparedness for accidents and the manual firefighting resources at a nuclear power plant shall be designed in accordance with this. A general advice for The Civil Protection Act (2003:778), chapter 2, paragraph 2 are given regarding documentation, inspection, maintenance and control of the fire protection measures.

The Flammable and Explosive Goods Act (2010:1011) [SWD-05] includes requirements regarding handling and storage of flammable liquids with a flashpoint not exceeding 100˚C and flammable gases that can be ignited 20ºC (also including handling of flammable gases in liquid phase such as LPG). Example of fire protection measure that can be needed to fulfil the requirements regarding flammable liquids and gases are fire compartmentation, containment of liquids and gas detection.

The Work Environment Act (1977:1160) [SWD-06] and Ordinance (1977:1166) [SWD-07] include requirements needed to be considered for fire fighter training, emergency lighting in work places and design of equipment according to ATEX.

The requirement resulting from the Planning and Building Act (2010:900) [SWD-08] and the Planning and Building Ordinance (2011:338) [SWD-09] regarding fire safety are specified in the building regulation, chapter 5 [SWD-11]. This regulation has altered since the Swedish reactors were built. The building regulation of today is therefore not mandatory for Swedish reactors in general. However, it is mandatory when making changes to the building structure, design or when changing the use of the building. The main purpose for the building regulation are evacuation safety.

According to the building requirements the fire protection shall be designed, developed and verified through simplified or analytical design. Simplified design means that the given general advices to the requirements shall be followed. Analytical design shall be used when the solutions according to the general advice are not suitable or if the building is too complex for simplified design to be used. General advice for analytical design is given in BBRAD (BFS 2011:27) [SWD-10].

Some design requirements according to building regulation relevant for nuclear application are summarized under “Supplementary material”.

3.11.1.3 Combining nuclear specific and conventional requirements on fire safety

The purpose of Figure 8 is to explain how the conventional and nuclear specific fire related requirements can be combined to result in a facility adapted fire protection.

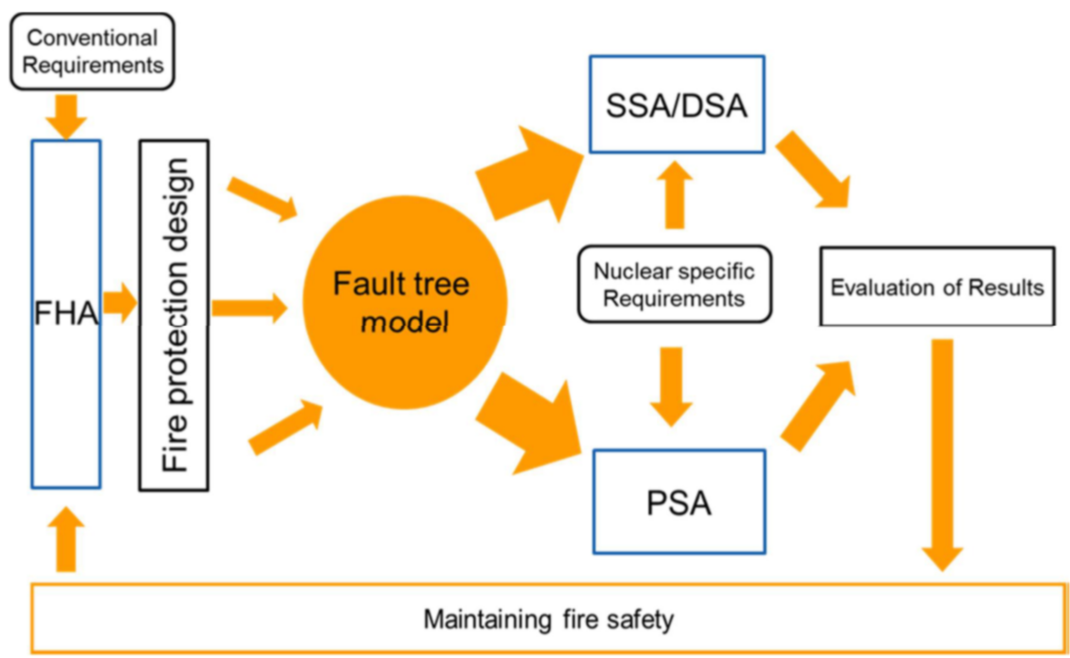

Figure 8 How Conventional and Nuclear Specific Fire Related Requirements can be Combined to Result in a Facility Adapted Fire Protection

The abbreviations in the figure are described below:

FHA:

A fire hazard analysis according to IAEA NS-G 1.7 [IAEA-04], section 3.24 can include detailed analysis of fire growth and consequence; a quality manual for fire engineering analysis has been produced by NBSG.

SSA/DSA:

Deterministic safety analysis (also called safe shutdown analysis) according to SSMFS 2008:1 [SSM-9], chapter 4, paragraph 1, and SSMFS 2008:17 [SSM-09a], paragraph 14 regarding fire corresponds to IAEA SSG-2 [IAEA-09] regarding fire.

PSA:

Probabilistic fire risk analysis according to SSMFS 2008:1, chapter 4, paragraph 1

- corresponds to PSA according to IAEA NS-G-1.7 [IAEA-04], paragraph 3.27,
- is used to prioritize and evaluate the effect of different fire protection features.

Maintaining fire safety:

Systematic fire protection work according to SRVFS 2004:3 [SWD-13]

- corresponds to the purpose of IAEA NS-G-2.1 [IAEA-00b] 1.4,
- fulfils SSMFS 2008:1 (including 2014:3), chapter 5, paragraph 2 regarding control of combustibles and ignition sources and inspection, maintenance and testing of fire protection measures.

To fulfil the demands of separation of redundant equipment and single failure as well as the demands of safe evacuation the resulting fire protection design can look like the following Figure 9 and Figure 10.

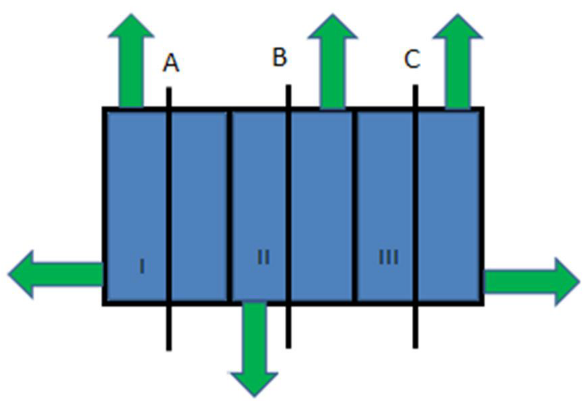

Figure 9 Need for Fire Compartments and Evacuation Routes when all Equipment in a Fire Compartment are Assumed to Fail during Fire - Sweden

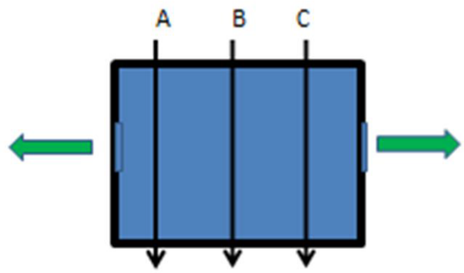

Figure 10 Need for Fire Compartments and Evacuation Routes when Analytical Fire Hazard Analysis can Demonstrate that Protection Measures are Sufficient to Prevent the Failure of Redundant Items Important to Safety - Sweden

3.11.2 New Reactors

There are no nuclear specific requirements established for new reactors in Sweden. The conventional fire related requirements are the same as stated for existing reactors.

3.11.3 Supplementary Information

A summary of the building requirements [SWD-11] regarding, fire compartmentation, safe evacuation, automatic fire alarm, suppression system is presented below.

3.11.3.1 Fire Compartmentation

Buildings should be divided into fire compartments to the extent that it creates sufficient time for evacuation and restricts the consequences of a fire (with simplified design not more than two floors and areas with specific fire load higher than 1600 MJ/m^2 shall be separated). Fire compartment classification may fully or partially be replaced by fire resistant installations.

The design of the fire compartment shall limit the spread of fire and smoke to the adjacent fire compartment over a specified time.

Separating structures in buildings in class Br1 should be designed for at least the fire resistance class given in the table below.

Table 1 Fire Resistance Class Requirement Related to Fire Load – Sweden

Structural element	Fire resistance class at fire load f (MJ/m^2)		
	f ≤ 800	F ≤ 1,600	F > 1,600
Separating structures in general, and building floors above basements	EI 60	EI 120 (EI 60*)	EI 240 (EI 120*)

* For buildings protected by an automatic water sprinkler system. *(BFS 2011:26).*

3.11.3.2 Safe Evacuation

Buildings shall be designed to ensure that there is an adequate time for evacuation during a fire. Adequate time for evacuation means that people who evacuate are not exposed to falling structural elements, high temperatures, high levels of heat radiation, toxic gases or reduced visibility that might impede evacuation to a safe location with sufficient certainty (BFS 2011:26) [SWD-11].

Spaces where people are present other than occasionally shall be designed with access to at least two independent escape routes. An escape route shall be an exit to a secure location (refers to a space in the open where fire and smoke cannot affect evacuated people) or a space in a building which leads from a fire compartment to such an exit (BFS 2011:26). The walking distance to the nearest escape route or to another fire compartment should not exceed a distance of 45 m in industrial buildings. In a space that is protected by an automatic extinguishing system, the walking distance may be increased by one third.

3.11.3.3 Automatic Fire Alarm

Automatic fire alarms shall be installed where this is necessary for the fire protection's design. The system shall be designed with the necessary properties that have the ability to detect fire reliably and give signals to the functions that depend on the alarm. The system shall be designed with sufficient coverage and shall activate quickly enough to ensure proper function.

The reliability and the ability of automatic fire alarms can be verified in accordance with Section 3 of the Swedish Fire Protection Association's publication, Regler för automatisk brandlarmsanläggning (automatic fire alarm installations), SBF 110:6 [SWD-12]. The components of a Rule for automatic fire alarm can be verified in accordance with the standard series SS-EN 54 [SIS-06] with properties tailored to suit their intended use.

3.11.3.4 Suppression Systems

If an automatic fire suppression system is essential for fire protection, the design shall be such that it has the capability to extinguish or control a fire over the appropriate time with high reliability.

The system shall activate quickly enough and shall be designed with sufficient coverage to ensure proper functionality.

The reliability and capability of automatic water sprinkler systems can be verified in accordance with SS-EN 12845 [SIS-04] and the standard series SS-EN 12259 [SIS-01]. For spaces in occupancy class 5C, the water source should consist of improved, doubled or combined water inlets as specified in 9.6.2 – 9.6.4 in SS-EN 12845.

The reliability and capacity of the water spray and deluge systems can be verified in accordance with SIS-CEN TS 14816 [SIS-09]. Other systems can be verified in accordance with SBF 120 (cf. BFS 2011:26 [SWD-11]).

[SIS-01] Swedish Standards Institute (SIS): Fixed firefighting systems - Components for automatic sprinkler and water spray systems, Series of Standards SS-EN 12259, 2001,.

[SIS-04] Swedish Standards Institute (SIS): Fixed firefighting systems - Automatic sprinkler systems - Design, installation and maintenance, Standard SS-EN 12845:2004, October 15, 2004.

[SIS-06] Swedish Standards Institute (SIS): Fire detection and fire alarm systems, Series of Standards SS-EN 54, 2006, https://www.notifier.se/filer/EN%2054%20STANDARDER.pdf.

[SIS-09] Swedish Standards Institute (SIS): Fixed firefighting systems – Water spray systems – Design, installation and maintenance, Technical Specification SIS-CEN TS 14816, February 26, 2009.

[SSM-09] Swedish Radiation Safety Authority (SSM): The Swedish Radiation Safety Authority's Regulations and General Advice concerning Safety in Nuclear Facilities, SSMFS 2008:1, ISSN 2000-0987, January 30, 2009, (latest version in Swedish only), https://www.stralsakerhetsmyndigheten.se/contentassets/e8ba282f8ef0461ca392137c9495f466/ssmfs-20081-the-swedish-radiation-safety-authoritys-regulations-concerning-safety-in-nuclear-facilities.

[SSM-09a] Swedish Radiation Safety Authority (SSM): The Swedish Radiation Safety Authority's Regulations concerning the Design and Construction of Nuclear Power Plants, SSMFS 2008:17, ISSN 2000-0987, January 30, 2009, https://www.stralsakerhetsmyndigheten.se/contentassets/ace5827a9cfc43fc9576fca14443da32/ssmfs-200817-the-swedish-radiation-safety-authoritys-regulations-concerning-the-design-and-construction-of-nuclear-power-reactors.

[SWD-01] Lag (2003:778) om skydd mot olyckor (Civil Protection Act), 20 November 2003, https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/lag-2003778-om-skydd-mot-olyckor_sfs-2003-778.

[SWD-02] Förordning (2003:789) om skydd mot olyckor (Civil Protection Ordinance), 20 November 2003, https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/forordning-2003789-om-skydd-mot-olyckor_sfs-2003-789.

[SWD-03] Föreskrifter om ändring i Strålsäkerhetsmyndighetens föreskrifter och allmänna råd (SSMFS 2008:1) om säkerhet i kärntekniska anläggningar, SSMFS 2011:3, 1 November 2011, https://www.stralsakerhetsmyndigheten.se/contentassets/6b6ce39b86b845c998cdc0062c07353e/ssmfs-20113-foreskrifter-om-andring-i-stralsakerhetsmyndighetens-foreskrifter-ssmfs-20081-om-sakerhet-i-karntekniska-anlaggningar.pdf.

[SWD-04] Miljöbalk (1998:808) (Swedish Environmental Code), 11 June 1998, https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/miljobalk-1998808_sfs-1998-808.

[SWD-05] Lag (2010:1011) om brandfarliga och explosiva varor (Flammable and Explosive Goods Act), 1 July 2010, https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/lag-20101011-om-brandfarliga-och-explosiva_sfs-2010-1011.

[SWD-06] Arbetsmiljölag (1977:1160) (Work Environment Act), 19 December 1977, https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/arbetsmiljolag-19771160_sfs-1977-1160.

[SWD-07] Arbetsmiljöförordning (1977:1166) (Work Environment Ordinance), 19 December 1977, https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/arbetsmiljoforordning-19771166_sfs-1977-1166.

[SWD-08] Plan- och bygglag (2010:900) (Planning and Building Act), 1 July 2010, https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/plan--och-bygglag-2010900_sfs-2010-900.

[SWD-09] Plan- och byggförordning (2011:338) (Planning and Building Ordinance), 31 March 2011, https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/plan--och-byggforordning-2011338_sfs-2011-338.

[SWD-10] The Swedish National Board of Housing, Building and Planning's general recommendations (BFS 2011:27) on the analytical design of a building's fire protection BBRAD, 18 June 2013, https://www.boverket.se/globalassets/publikationer/dokument/2013/bbrad-bfs-2011-27-tom-2013-12-english.pdf.

[SWD-11] The Swedish National Board of Housing, Building and Planning's building regulations – mandatory provisions and general recommendations, BBR, BFS 2011:6 with amendments up to BFS 2011:26, 10 October 2011.

[SWD-12] Swedish Fire Protection Association: Regler för automatisk brandlarmsanläggning (automatic fire alarm installations), SBF 110:6, 1 January 2001.

[SWD-13] Statens räddningsverk, Statens räddningsverks allmänna råd och kommentarer om systematiskt brandskyddsarbete, SRVFS 2004:3, ISSN 0283-6165, February 6, 2004, https://www.msb.se/contentassets/244bc5f1e438414eb6b58339cc58939e/statens-raddningsverks-allmanna-rad-och-kommentarer-om-systematiskt-brandskyddsarbete.pdf.

3.12 Switzerland

3.12.1 Existing Reactors

Figure 11 shows the structure of the legal framework for oversight of nuclear power plants in Switzerland and the bodies compete. According to Art. 90 of the Federal Constitution of the Swiss Confederation [SWT-01], the Confederation is responsible for legislation in the field of nuclear energy. Utilizing this competence, the Nuclear Energy Act [SWT-02] was created to regulate the peaceful use of nuclear energy, especially the safety of nuclear goods, nuclear installations and radioactive waste.

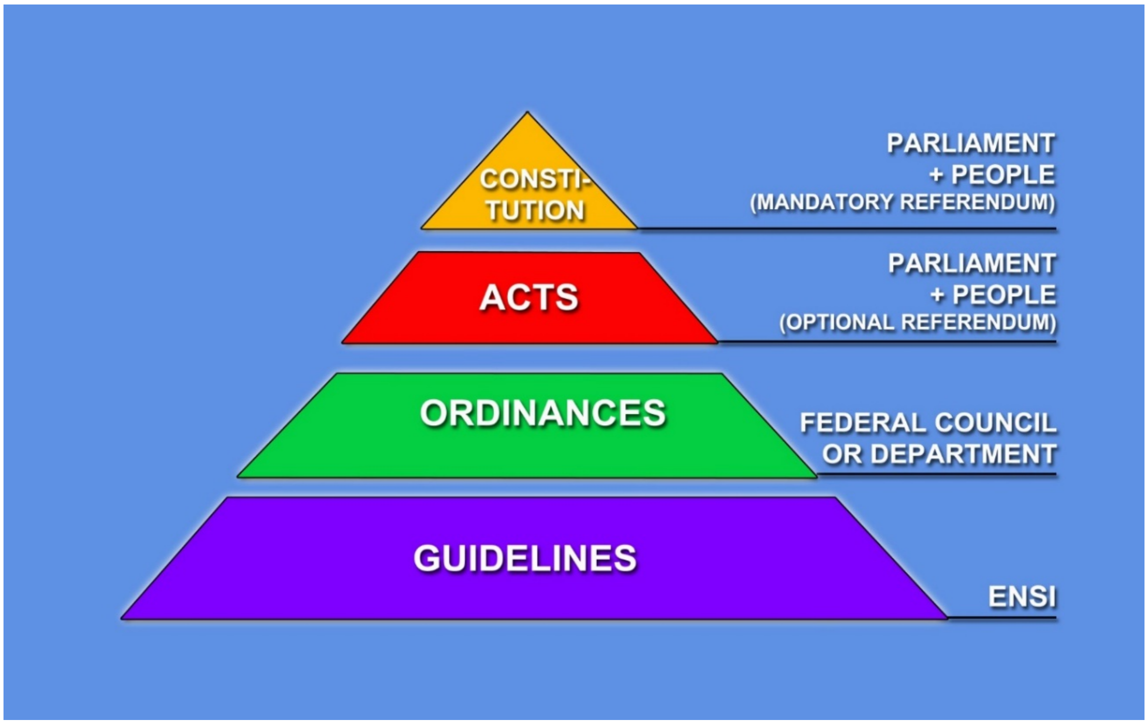

Figure 11 Regulatory Framework for Fire Protection in Switzerland

It establishes fundamental principles for safety and security, licensing processes for nuclear related facilities and activities, the regulatory apparatus and financial and governmental aspects. The accompanying Nuclear Energy Ordinance [SWT-03] establishes more detailed principles for nuclear safety and security for nuclear facilities, e.g., detailed requirements for licensing documents, requirements for the organization of a nuclear facility, requirements for assessment of safety and security analysis. The Nuclear Energy Ordinance explicitly names fire as a hazard to be considered in devising preventive and protective measures against accidents in nuclear installations. The hazard assumptions and associated evaluation criteria are defined in the Ordinance on the Hazard Assumptions and the Assessment of the Protection against Accidents in Nuclear Installations of the Federal Department of the Environment, Transport, Energy and Communications (DETEC) [SWT-04].

Requirements specifically related to radiological protection after incidents and accidents in nuclear installation derive from the Radiological Protection Act [SWT-05] and its implementing provisions in the Radiological Protection Ordinance [SWT-06].

The guideline HSK-R-50 “Requirements Important to Safety for Fire Protection in Nuclear Installations” [HSK-03] substantiates the implementation of the legal requirements. HSK-R-50 describes the fire protection goals and oversight processes and introduces high-level requirements on the performance of fire protection measures, such as the physical effects of fire to be considered. It also enumerates the documentation to be generated by the licensee, notably the fire protection conception, the fire protection plans and inventories of fire loads, the training schedule as well as the various procedures for firefighting and related operator actions. This guideline is currently being revised. Oversight on fire protection measures is provided by the designated cantonal authorities, especially the cantonal fire insurance institutions, which usually refer to regulations also applicable to non-nuclear facilities (Vereinigung Kantonaler Feuerversicherungen) [VKF-15].

The DETEC Ordinance on the Hazard Assumptions and the Assessment of the Protection against Accidents in Nuclear Installations specifies fires to be among the incidents and accidents to be considered in the safe shutdown analysis by the licensee. It subdivides design-base accidents into three categories according to their frequency with internal events less frequent than 10^{-6} a^{-1} being beyond-design-base accidents. The categories within the design base are connected to requirements regarding the nuclear defense-in-depth and barrier concepts as well as limits of the dose to the public provided in the Radiological Protection Ordinance. The Guideline ENSI-A01 “Requirements for Deterministic Accident Analysis for Nuclear Installations: Scope, Methodology and Boundary Conditions of the Technical Accident Analysis” [ENSI-18] provides the framework for the safe shutdown analysis of incidents and accidents of all kinds, including fires. In its newly released revision, there are also additional specific requirements on the interpretation of fire frequencies and the single failure criterion.

The Nuclear Energy Ordinance requires the development and use of a Probabilistic Safety Analysis (PSA) for all relevant operating modes of the Swiss nuclear power plants (NPPs). These requirements are further specified in two regulatory guidelines aimed at harmonizing the use and development of PSA.

Guideline ENSI-A05 “Probabilistic Safety Analysis (PSA): Quality and Scope” [ENSI-18a], defines the quality and scope on a plant-specific Level 1 and Level 2 PSA. The guideline specifies also the requirements on the probabilistic fire analysis including acceptable criteria on the screening of fire scenarios.

Guideline ENSI-A06 “Probabilistic Safety Analysis (PSA): Applications” [ENSI-15] formalizes the requirements for applying PSA to NPPs. It defines general principles for all PSA applications and the scope of mandatory PSA applications. With the aim of identifying potential plant improvements, this guideline specifies the evaluation of the safety level, the balance of risk contributors, plant modifications (including technical specifications) and operational experience. In case of a reportable event involving PSA-relevant systems, structures or components, such as a fire in the respective area would be, the incremental conditional core damage probability is to be reported.

3.12.2 New Reactors

Since licenses related to new power reactors are currently not being sought in Switzerland, ENSI has not formulated a recent position on fire protection in such installations.

3.12.3 Supplementary Information

[HSK-03] Hauptabteilung für die Sicherheit der Kernanlagen (HSK), Sicherheitstechnische Anforderungen an den Brandschutz in Kernanlagen, HSK-R-50/d, March 2003, https://www.ensi.ch/de/dokumente/richtlinie-hsk-r-50-deutsch.

[SWT-01] Swiss Confederation: Federal Constitution, 101, 18 April 1999, https://www.admin.ch/opc/en/classified-compilation/19995395.

[SWT-02] Federal Assembly of the Swiss Confederation, Nuclear Energy Act, 732.1, 21 March 2003,

https://www.admin.ch/opc/en/classified-compilation/20010233.

[SWT-03] Federal Council, Nuclear Energy Ordinance, 732.11, 10 December 2004, https://www.admin.ch/opc/en/classified-compilation/20042217.

[SWT-04] Federal Department of the Environment, Transport, Energy and Communications (DETEC), Verordnung des UVEK über die Gefährdungsannahmen und die Bewertung des Schutzes gegen Störfälle in Kernanlagen, 732.112.2, 17 June 2009,

https://www.admin.ch/opc/de/classified-compilation/20090231.

[SWT-05] Federal Assembly of the Swiss Confederation, Radiological Protection Act, 814.50, 22 March 1991,

https://www.admin.ch/opc/en/classified-compilation/19910045.

[SWT-06] Swiss Federal Council, Radiological Protection Ordinance, 814.501, 22 June 1994, https://www.admin.ch/opc/en/classified-compilation/19940157.

[VKF-15] Vereinigung Kantonaler Feuerversicherungen (VKF), Brandschutzvorschriften 2015, https://www.bsvonline.ch/de/vorschriften/?req=Norm_&anchor.

3.13 United Kingdom

The information contained herein was accurate at the end of July 2018 and applies to commercial nuclear power generating stations in the United Kingdom.

3.13.1 Existing Reactors

There is no difference in the legislative expectations placed on existing versus new reactors. The methods and details of analysis that would be acceptable to the Office for Nuclear Regulation (ONR) may be different at various life-cycle stages, as an existing reactor may be able to offer operating experience and feedback as an alternative to detailed analysis which may not be possible for a new-build facility.

The licence conditions place requirements on the licensee to collect operational experience through incident reporting arrangements and to undertake Periodic Safety Reviews (PSR) to ensure that the safety case remains current and informed.

When making judgements, ONR recognises that there may have been changes in the legislative framework and relevant good practice since the construction of existing reactors and that it may be unreasonable to require the dutyholder to implement the current expectations of modern standards. In such cases the dutyholder is required to provide a demonstration that the cost (in terms of time, money or trouble) is grossly disproportionate when compared to the risk reduction gained; i.e. that it may not be proportionate to implement changes to meet the same xpectations that new reactors would be expected to achieve.

3.13.1.1 Overview of Legislation

The legal framework for the nuclear industry in the UK is based on the Health and Safety at Work Act 1974 (HSWA74) [UK-01], the Energy Act 2013 (TEA13) [UK-02] and the Nuclear Installations Act 1965 (NIA65) [UK-03]. HSWA places duties on all employers, including those in the nuclear industry, to look after the health and safety of both their employees and the public. However, because of the particular hazards associated with the nuclear industry, including the potential for accidents to cause widespread harm and social disruption, further legislation is also in place, specifically the NIA65. Additionally, there are provisions for nuclear regulations to be made under TEA13, as well as specific regulations under HSWA74 such as the Ionizing Radiations Regulations 2017 (IRR17) [UK-04] and Radiation (Emergency Preparedness and Public Information) Regulations 2001 (REPPIR) [UK-05].

TEA13 was introduced to establish a legislative framework for delivering secure, affordable and low carbon energy. Part 3 of TEA13 establishes the Office for Nuclear Regulation (ONR) as a body corporate and sets out the purposes of the ONR. The Act confers a variety of powers and duties onto the ONR. These reflect a number of the roles which the ONR is to perform. Its primary role is to regulate the nuclear industry in the areas set out in its five purposes: nuclear safety, nuclear site health and safety, nuclear security, nuclear safeguards and transport.

The primary conventional fire safety legislation for the UK includes the Regulatory Reform (Fire Safety) Order 2005 in England and Wales [UK-06], the Fire Safety (Scotland) Regulations 2006 [UK-07] and the Fire Safety Regulations (Northern Ireland) 2010 [UK-08]. Supporting the legislation there are a number of British Standards which, though they do not apply on a nuclear site, they do remain part of the basis of relevant good practice; one of the relevant main standards is BS 9999:2017 “Code of practice for fire safety in the design, management and use of buildings” [UK-09].

Nuclear power plants (NPPs) are required under the NIA65 to hold a nuclear site license. The nuclear site license granted by ONR is a legal document, issued for the full life cycle of the facility. It contains site-specific information, such as the licensee's address and the location of the site and defines the number and type of installations permitted. Such installations include nuclear power stations, research reactors, nuclear fuel manufacturing and reprocessing, and the storage of radioactive matter in bulk.

A set of 36 Standard Conditions, covering design, construction, operation and decommissioning, is also attached to each license [UK-10]. These conditions require licensees to implement adequate arrangements to ensure compliance.

The UK operates a goal-setting approach to nuclear safety regulation and requires that the licensee or dutyholder demonstrate all risks are reduced so far as is reasonably practical (SFAIRP). Regulatory expectations are specified, and dutyholders are required to determine how best to achieve them and justify their chosen approach. This enables dutyholders to be innovative and flexible in how they achieve the high standards of nuclear safety and security required by implementing arrangements that meet their particular circumstances. It also strengthens accountability and encourages the adoption of relevant good practice and continuous improvement. The UK goal setting legal framework places the duty on the licensee to find the balance between nuclear and conventional safety requirements to comply with the law.

A key principle of the UK's approach is that nuclear licensees are required to build, operate and decommission nuclear sites in a way that ensures that risks are kept as low as reasonably practicable. This is referred to as the ALARP principle and requires licensees to demonstrate that they have done everything 'reasonably practicable' to reduce risks. This requires them to balance the level of risk posed by their activities against the measures needed to control that risk in terms of money, time or trouble. However, they do not have to take action if those measures would be grossly disproportionate to the level of risk averted.

3.13.1.2 Regulatory Fire Protection Expectations

The dutyholder is expected to have undertaken a systematic analysis of the hazards, potential consequences, fault progression and proposed protective measures for their installation. The safety case must demonstrate compliance with UK legislation, relevant regulations and the nuclear site licence conditions. In order to demonstrate that risks are ALARP, the dutyholder is expected to adopt relevant good practice.

ONR uses Safety Assessment Principles (SAPs) [ONR-14], together with supporting Technical Assessment Guides (TAGs) (which provide subject specific guidance and expectations), to guide their regulatory judgements when undertaking technical assessments of nuclear site licensees' safety submissions. The SAPs were revised in 2014 to take account of learning from the lessons from Fukushima and work by the International Atomic Energy Agency (IAEA), in particular the development of IAEA's design standard on the safety of nuclear power plants (SSR-2/1). [IAEA-16]. Underpinning these is the legal duty on licensees to reduce risks so far as is reasonably practicable.

The SAPs and TAGs are developed to provide a concise summary of principles and guidance that dutyholders are expected to apply. They are derived from:

- Interpretation of British law;
- Requirements and guides of the International Atomic Energy Agency (IAEA);
- Western European Nuclear Regulators Association (WENRA) Reference Levels ;
- NUREG – if relevant and in line with ONR expectations;
- British standards;

- Recognized industry practice.

The key TAGs addressing fire include: TAG-13 – External Hazards [ONR-18a] and TAG 14 – Internal Hazards [ONR-16a] with support from TAG-05 - Guidance on the Demonstration of ALARP (As Low As Reasonably Practicable) [ONR-18] and TAG-030 - Probabilistic Safety Analysis [ONR-16], where applicable.

ONR's regulatory expectation is that licensees should adopt a defense in depth, approach. This defense in depth should be secured by characteristics as near as possible to the top of the hierarchy of safety measures adopted in the design of the facilities against fire hazards with a focus on prevention, protection and mitigation.

Good engineering design should show that precedence has been given to fire prevention (e.g. minimization of combustible inventories) and also how the design ensures that fires should they occur would not lead to unacceptable consequences. This involves limiting the severity of any fires (e.g. by early detection and extinguishing, and by the provision of suitably rated fire barriers that prevent fire spread). For any severe fires which do arise, the consequences on nuclear safety relevant structures, systems and components (SSCs) should be limited by design (e.g. by provision of redundant safety measures in segregated fire compartments).

Compartments formed by the installation of fire barriers should be rated to withstand total combustion of the fire load in the compartment. Where this is not practical due to conflicts with other plant design requirements, separation of the items important to safety could be achieved using an appropriate combination of limited combustibles, separation by distance, local passive fire barriers and fire detection and suppression systems.

The safety case should provide reference to surveys of combustible substances undertaken, which should be systematic and demonstrably complete. Transient fire loads that could be introduced either during construction, outages or at power modes should also be identified. It should be noted that all combustible inventories, including transient and protected combustible loads can contribute to a fully developed fire and the overall fire load.

The results of the fire hazard identification process should be documented to provide a basis for the hazard analysis required. In particular, fire hazards to items important to safety that may arise due to the failure of barriers and escalating fires should be identified using an appropriate systematic methodology, and the results documented.

The potential for fire initiation and growth and the possible consequences on items important to safety should be determined as part of the fire hazard analysis with the following key purposes:

- Determine consequences to SSC and them withstand, determine if further separation, isolation and redundancy is required;
- Determine performance requirements of fire safety measures;
- Specify the capacity and capability of the fire detection systems and any other active fire protection provisions;
- Test fire hazard identification and design substantiation assumptions and limitations; and
- Determine consequential effects from fires – e.g. flooding, explosion, dropped loads, etc.

The analysis approach must adequately address the inherent uncertainty associated with fire initiation and progression, and any reliance placed on the reliability of fire protection or mitigation measures, for example:

- The analysis captures the outcome of design basis fires. Sensitivity studies may be required to establish the design basis fire.
- Generally, it should be expected that the analysis will be based on complete burn-out of all combustible loads including any protected loads.
- All SSCs in the fire compartment are lost in the fire.
- Fire analysis during maintenance operations, outages etc. should be developed and take into account the availability of fire barriers, status of doors/ hatches connecting different fire compartments etc.

Internal and external hazards, whilst usually assessed individually rarely occur in isolation. A single event may result in a number of hazards which occur simultaneously or in quick succession. Fire assessments will be expected to include reasonably foreseeable hazard combinations. There are three types of hazard combinations.

- Independent Hazards; when more than one internal and/or external hazard applies simultaneously. This can be the case, for example, of nominally frequent events such as internal fire and flooding when there is no causation link between them.
- Consequential Hazards: an internal or external hazard directly poses one or more additional hazards to plant and structures (e.g. an earthquake that causes a fire).
- Concurrent Hazards: a hazard or event results in multiple hazard(s), which occur simultaneously. An example of this would be an oil leak or flammable atmosphere leading to an explosion and or fire.

It is expected that the fire analysis should clearly identify the fire compartments and safety divisional areas of the design. It should also document the effects of fire scenarios on the nuclear safety relevant barriers and plant taking into account the most challenging plant state. Typical features of adequate fire analysis generally include the following:

- The bounding combustible inventory within each fire compartment;
- For each compartment, the scenarios identified to present the most significant threat to the fire compartment barriers;
- Fire modelling;
- The time-temperature profiles;
- Substantiation of claimed barriers;
- Sensitivity analysis should be undertaken to show that there are sufficient safety margins;
- Application of relevant good practice, codes and standards; and
- Local fire effects.

Some common characteristics of design features and considerations in the design of safety measures against fire are covered in detail within TAG-14 [ONR-16a].

The hazards arising from fires, where either single or multiple measures are designed to prevent their escalation, should be quantified and assessed to verify the adequacy of the measures for preventing fire spread and maintaining the integrity of the safety systems delivering fundamental safety functions. As part of the assessment, the safety measures should be allocated an appropriate safety category and safety classification to clearly identify their role in ensuring nuclear safety. The safety measures should be included in maintenance schedules and operating instructions, as appropriate. In particular, safety management procedures should be established for maintaining the integrity and reliability of fire barriers and any penetrations such as doors, cable and pipe conduit seals, heating, ventilation and air conditioning ducts and dampers, and the fire detection, alarm and extinguishing systems.

3.13.1.3 Post Fire Safe Shutdown Expectations

It is an expectation that licensees have adequate measures, plans and equipment in place to safely recover from fire scenarios. By determining an adequate and bounding design basis fire, the design basis accident analysis contained within the safety case derives a reactor management philosophy and engineered controls that will manage the identified risks.

It is a requirement of the nuclear site licence (licence condition 11) that the licensee will make and implement adequate emergency arrangements. REPPIR [UK-05] requires that the nuclear and radiological consequences of severe accidents be considered on the surrounding population and that appropriate protective measures be identified and implemented.

Recent learning from Fukushima has resulted in all licensees reconsidering their emergency preparedness and resilience using a stress test exercise. Understanding of outputs from the stress tests resulted in increased regulatory expectations for provision of on-site and off-site back-up emergency equipment; review of human capability claims and closer scrutiny of combined internal and external hazards, including fire.

The existing nuclear power generation capability in the UK is delivered by fifteen operating reactors made up of seven sites containing two Advanced Gas Reactors (AGRs) each and one NPP utilizing one pressurized water reactor (PWR). The durations of fault sequences leading to core melt are substantially longer for AGRs (up to one to two days) than for PWRs (up to three hours), allowing more time for operator intervention. The post fire safe shutdown expectations therefore vary a little for the two reactor types, this must be considered within the safety case.

3.13.2 New Reactors

Though there is no difference in the legislative expectations placed on existing versus new reactors, there is generally an expectation that the dutyholder will undertake an exhaustive safety analysis of their proposed installation and proactively demonstrate that modern standards have been met and that all reasonable measures have been taken to reduce risks so far as is reasonably practicable. This will generally be more onerous for the planned water-cooled reactors than is expected for the existing fleet.

As the UK legal framework is goal setting, the onus is on the dutyholder to consider all options and identify the most effective mechanisms to reduce risk; it is not sufficient to rely only on compliance with relevant standards.

ONR provides the Generic Design Assessment (GDA) process for proposed new reactors in the UK. This is a voluntary process that the UK government strongly encourages all prospective new licensees to follow. It takes place in advance of licensing and provides early guidance to help comply with UK legislation and demonstrate that management of risks is ALARP. This process provides advice on the licensability of a design before a potential licensee procures a site, thereby reducing financial risk to them.

GDA or assessments for new reactors will expect available operational experience of similar reactor designs already in operation elsewhere in the world to inform the current design and development of the safety case.

3.13.3 Supplementary Information

[ONR-14] Office for Nuclear Regulation (ONR): Safety Assessment Principles (SAPs) for Nuclear Facilities, 2014 Edition, Revision 0, November 2014, http://www.onr.org.uk/saps/index.htm.

[ONR-16] Office for Nuclear Regulation (ONR): Probabilistic Safety Analysis, Nuclear Safety Technical Assessment Guide NS-TAST-GD-030, Revision 5, June 2016, http://www.onr.org.uk/operational/tech_asst_guides/ns-tast-gd-030.pdf.

[ONR-16a] Office for Nuclear Regulation (ONR): Internal Hazards, Nuclear Safety Technical Assessment Guide NS-TAST-GD-014, Revision 4, September 2016, http://www.onr.org.uk/operational/tech_asst_guides/ns-tast-gd-014.htm.

[ONR-18] Office for Nuclear Regulation (ONR): Guidance on the Demonstration of ALARP (As Low as Reasonably Practicable), Nuclear Safety Technical Assessment Guide NS-TAST-GD-005, Revision 9, March 2018, http://www.onr.org.uk/operational/tech_asst_guides/ns-tast-gd-005.pdf.

[ONR-18a] Office for Nuclear Regulation (ONR): External Hazards, Nuclear Safety Technical Assessment Guide NS-TAST-GD-013, Revision 7, October 2018, http://www.onr.org.uk/operational/tech_asst_guides/ns-tast-gd-013.htm.

[UK-01] Health and Safety at Work Act 1974 (HSWA74), https://www.legislation.gov.uk/ukpga/1974/37.

[UK-02] The Energy Act 2013 (TEA13), http://www.legislation.gov.uk/ukpga/2013/32/contents/enacted.

[UK-03] Nuclear Installations Act 1965 (NIA65), https://www.legislation.gov.uk/ukpga/1965/57.

[UK-04] Ionizing Radiations Regulations 2017 (IRR17), http://www.legislation.gov.uk/uksi/2017/1075/contents/made.

[UK-05] Radiation (Emergency Preparedness and Public Information) Regulations 2001 (REPPIR), https://www.legislation.gov.uk/uksi/2001/2975/contents/made.

[UK-06] Regulatory Reform (Fire Safety) Order 2005, http://www.legislation.gov.uk/uksi/2005/1541/contents/made.

[UK-07] Fire Safety (Scotland) Regulations 2006, http://www.legislation.gov.uk/ssi/2006/456/contents/made.

[UK-08] Fire Safety Regulations (Northern Ireland) 2010, https://www.legislation.gov.uk/nisr/2010/325/contents/made.

[UK-09] BS 9999:2017: Code of practice for fire safety in the design, management and use of buildings, 2017.

[UK-10] Nuclear Site Licence Conditions, http://www.onr.org.uk/licensing.htm.

3.14 United States of America

3.14.1 Existing Reactors

The Code of Federal Regulations is a codification of the general and permanent rules published in the Federal Register by the Executive departments and agencies of the Federal Government. The Code of Federal Regulations includes the United States Nuclear Regulatory Commission's (NRC) Fire Protection Regulations. The following references contain the NRC requirements for fire protection in Nuclear Power Plants.

3.14.1.1 Overview

1. General Design Criteria 3 of Appendix A to 10 CFR 50 [NRC-01]
   a. Used in the 1970's prior to the Browns Ferry Fire of 1975, this document was used as justification by the U.S. Atomic Energy Commission (AEC) and U.S. NRC for acceptance of fire protection programs at nuclear power plants.
   b. It is based on very broad performance objectives.

2. 10 CFR 50.48 [NRC-04] and Appendix R [NRC-02]
   a. 10 CFR 50.48, Fire Protection, was issued in 1980 and contained broad performance requirements.
   b. Appendix R to 10 CFR 50 was also issued and provided specific and detailed requirements for addressing disputed issues.

3. 10 CFR 50.48(c) [NRC-09]
   a. This rule was established on 16 June 2004.
   b. Allows the voluntary adoption of risk-informed performance-based fire protection program in accordance with:
      i. NFPA 805, *Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants* [NFPA-01]

3.14.1.2 Supplementary Material

1. Appendix A to Part 50--General Design Criteria for Nuclear Power Plants- Criterion 3 Fire Protection [NRC-01]

Criterion 3 - Fire protection. Structures, systems, and components important to safety shall be designed and located to minimize, consistent with other safety requirements, the probability and effect of fires and explosions. Non-combustible and heat resistant materials shall be used wherever practical throughout the unit, particularly in locations such as the containment and control room. Fire detection and fighting systems of appropriate capacity and capability shall be provided and designed to minimize the adverse effects of fires on structures, systems, and components important to safety. Firefighting systems shall be designed to assure that their rupture or inadvertent operation does not significantly impair the safety capability of these structures, systems, and components.

2. § 50.48 Fire protection [NRC-03]

a. (1) Each holder of an operating license issued under this part or a combined license issued under part 52 of this chapter must have a fire protection plan that satisfies Criterion 3 of Appendix A to this part. This fire protection plan must:

   i. Describe the overall fire protection program for the facility;

   ii. Identify the various positions within the licensee's organization that are responsible for the program;

iii. State the authorities that are delegated to each of these positions to implement those responsibilities; and

iv. Outline the plans for fire protection, fire detection and suppression capability, and limitation of fire damage.

(2) The plan must also describe specific features necessary to implement the program described in paragraph (a)(1) of this section such as

i. Administrative controls and personnel requirements for fire prevention and manual fire suppression activities;

ii. Automatic and manually operated fire detection and suppression systems; and

iii. The means to limit fire damage to structures, systems, or components important to safety so that the capability to shut down the plant safely is ensured.

(3) The licensee shall retain the fire protection plan and each change to the plan as a record until the Commission terminates the reactor license. The licensee shall retain each superseded revision of the procedures for 3 years from the date it was superseded.

(4) Each applicant for a design approval, design certification, or manufacturing license under part 52 of this chapter must have a description and analysis of the fire protection design features for the standard plant necessary to demonstrate compliance with Criterion 3 of Appendix A to this part.

b. Appendix R to this part establishes fire protection features required to satisfy Criterion 3 of Appendix A to this part with respect to certain generic issues for nuclear power plants licensed to operate before January 1, 1979.

(1) Except for the requirements of Sections III.G, III.J, and III.O, the provisions of Appendix R to this part do not apply to nuclear power plants licensed to operate before January 1, 1979, to the extent that

i. Fire protection features proposed or implemented by the licensee have been accepted by the NRC staff as satisfying the provisions of Appendix A to Branch Technical Position (BTP) APCSB 9.5-1 [NRC-05] reflected in NRC fire protection safety evaluation reports issued before the effective date of February 19, 1981; or

ii. Fire protection features were accepted by the NRC staff in comprehensive fire protection safety evaluation reports issued before Appendix A to Branch Technical Position (BTP) APCSB 9.5-1 was published in August 1976 [NRC-04].

(2) With respect to all other fire protection features covered by Appendix R, all nuclear power plants licensed to operate before January 1, 1979, must satisfy the applicable requirements of Appendix R to this part, including specifically the requirements of Sections III.G, III.J, and III.O.

c. National Fire Protection Association Standard NFPA 805 [NFPA-01]

(1) *Approval of incorporation by reference.* National Fire Protection Association (NFPA) Standard 805, "Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants, 2001 Edition" (NFPA 805 [NFPA-01]), which is referenced in this section, was approved for incorporation by reference by the Director of the Federal Register pursuant to 5 U.S.C. 552(a) and 1 CFR part 51. Copies of NFPA 805 may be purchased from the NFPA Customer Service Department, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101 and in PDF format through the NFPA Online Catalog (*http://www.nfpa.org*) or by calling 1-800-344-3555 or (617) 770-3000. Copies are also

available for inspection at the NRC Library, Two White Flint North, 11545 Rockville Pike, Rockville, Maryland 20852-2738, and at the NRC Public Document Room, Building One White Flint North, Room O1-F15, 11555 Rockville Pike, Rockville, Maryland 20852-2738. Copies are also available at the National Archives and Records Administration (NARA). For information on the availability of this material at NARA, call (202) 741-6030, or go to: http://www.archives.gov/federal_register/code_of_federal_regulations/ibr_locations.html.

(2) *Exceptions, modifications, and supplementation of NFPA 805.* As used in this section, references to NFPA 805 are to the 2001 Edition [NFPA-01], with the following exceptions, modifications, and supplementation:

i. *Life Safety Goal, Objectives, and Criteria.* The Life Safety Goal, Objectives, and Criteria of Chapter 1 are not endorsed.

ii. *Plant Damage/Business Interruption Goal, Objectives, and Criteria.* The Plant Damage/Business Interruption Goal, Objectives, and Criteria of Chapter 1 are not endorsed.

iii. *Use of feed-and-bleed.* In demonstrating compliance with the performance criteria of Sections 1.5.1(b) and (c), a high-pressure charging/injection pump coupled with the pressurizer power-operated relief valves (PORVs) as the sole fire-protected safe shutdown path for maintaining reactor coolant inventory, pressure control, and decay heat removal capability (i.e., feed-and-bleed) for pressurized-water reactors (PWRs) is not permitted.

iv. *Uncertainty analysis.* An uncertainty analysis performed in accordance with Section 2.7.3.5 is not required to support deterministic approach calculations.

v. *Existing cables.* In lieu of installing cables meeting flame propagation tests as required by Section 3.3.5.3, a flame-retardant coating may be applied to the electric cables, or an automatic fixed fire suppression system may be installed to provide an equivalent level of protection. In addition, the italicized exception to Section 3.3.5.3 is not endorsed.

vi. *Water supply and distribution.* The italicized exception to Section 3.6.4 is not endorsed. Licensees who wish to use the exception to Section 3.6.4 must submit a request for a license amendment in accordance with paragraph (c)(2)(vii) of this section.

vii. *Performance-based methods.* Notwithstanding the prohibition in Section 3.1 against the use of performance-based methods, the fire protection program elements and minimum design requirements of Chapter 3 may be subject to the performance-based methods permitted elsewhere in the standard. Licensees who wish to use performance-based methods for these fire protection program elements and minimum design requirements shall submit a request in the form of an application for license amendment under § 50.90. The Director of the Office of Nuclear Reactor Regulation, or a designee of the Director, may approve the application if the Director or designee determines that the performance-based approach;

   a. Satisfies the performance goals, performance objectives, and performance criteria specified in NFPA 805 related to nuclear safety and radiological release;

   b. Maintains safety margins; and

c. Maintains fire protection defense-in-depth (fire prevention, fire detection, fire suppression, mitigation, and post-fire safe shutdown capability).

(3) *Compliance with NFPA 805.*

i. A licensee may maintain a fire protection program that complies with NFPA 805 as an alternative to complying with paragraph (b) of this section for plants licensed to operate before January 1, 1979, or the fire protection license conditions for plants licensed to operate after January 1, 1979. The licensee shall submit a request to comply with NFPA 805 in the form of an application for license amendment under § 50.90. The application must identify any orders and license conditions that must be revised or superseded and contain any necessary revisions to the plant's technical specifications and the bases thereof. The Director of the Office of Nuclear Reactor Regulation, or a designee of the Director, may approve the application if the Director or designee determines that the licensee has identified orders, license conditions, and the technical specifications that must be revised or superseded, and that any necessary revisions are adequate. Any approval by the Director or the designee must be in the form of a license amendment approving the use of NFPA 805 together with any necessary revisions to the technical specifications.

ii. The licensee shall complete its implementation of the methodology in Chapter 2 of NFPA 805 (including all required evaluations and analyses) and, upon completion, modify the fire protection plan required by paragraph (a) of this section to reflect the licensee's decision to comply with NFPA 805, before changing its fire protection program or nuclear power plant as permitted by NFPA 805.

(4) *Risk-informed or performance-based alternatives to compliance with NFPA 805.* A licensee may submit a request to use risk-informed or performance-based alternatives to compliance with NFPA 805. The request must be in the form of an application for license amendment under § 50.90 of this chapter. The Director of the Office of Nuclear Reactor Regulation, or designee of the Director, may approve the application if the Director or designee determines that the proposed alternatives:

i. Satisfy the performance goals, performance objectives, and performance criteria specified in NFPA 805 related to nuclear safety and radiological release;

ii. Maintain safety margins; and

iii. Maintain fire protection defense-in-depth (fire prevention, fire detection, fire suppression, mitigation, and post-fire safe shutdown capability).

d. *Reserved]. (As it is used to label a section of the U.S. Code or Code of Federal Regulations, the word 'reserved' means that the section has been saved as 'empty space' to be used later that is, that the section has been 'reserved' for later use)*

e. *[Reserved]. (As it is used to label a section of the U.S. Code or Code of Federal Regulations, the word 'reserved' means that the section has been saved as 'empty space' to be used later – that is, that the section has been 'reserved' for later use)*

f. *[Reserved]. (As it is used to label a section of the U.S. Code or Code of Federal Regulations, the word 'reserved' means that the section has been saved as 'empty space' to be used later – that is, that the section has been 'reserved' for later use)*

g. *Licensees that have submitted the certifications required under § 50.82(a)(1) shall maintain a fire protection program to address the potential for fires that could cause the* *release or spread of radioactive materials (i.e., that could result in a radiological hazard). A fire protection program that complies with NFPA 805 shall be deemed to be acceptable for complying with the requirements of this paragraph.*

(1) The objectives of the fire protection program are to

i. Reasonably prevent these fires from occurring;

ii. Rapidly detect, control, and extinguish those fires that do occur and that could result in a radiological hazard; and

iii. Ensure that the risk of fire induced radiological hazards to the public, environment and plant personnel is minimized.

(2) The licensee shall assess the fire protection program on a regular basis. The licensee shall revise the plan as appropriate throughout the various stages of facility decommissioning.

(3) The licensee may make changes to the fire protection program without NRC approval if these changes do not reduce the effectiveness of fire protection for facilities, systems, and equipment that could result in a radiological hazard, taking into account the decommissioning plant conditions and activities.

[65 FR 38190, June 20, 2000; 69 FR 33550, June 16, 2004; 72 FR 49495, Aug. 28, 2007]

3. Appendix R to Part 50 — Fire Protection Program for Nuclear Power Facilities Operating Prior to January 1, 1979 [NRC-02]

I. Introduction and Scope

This appendix applies to licensed nuclear power electric generating stations that were operating prior to January 1, 1979, except to the extent set forth in § 50.48(b) of this part. With respect to certain generic issues for such facilities it sets forth fire protection features required to satisfy Criterion 3 of Appendix A to this part.

Criterion 3 of Appendix A to this part specifies that "Structures, systems, and components important to safety shall be designed and located to minimize, consistent with other safety requirements, the probability and effect of fires and explosions."

When considering the effects of fire, those systems associated with achieving and maintaining safe shutdown conditions assume major importance to safety because damage to them can lead to core damage resulting from loss of coolant through boiloff.

The phrases "important to safety," or "safety-related," will be used throughout this Appendix R as applying to all safety functions. The phrase "safe shutdown" will be used throughout this appendix as applying to both hot and cold shutdown functions.

Because fire may affect safe shutdown systems and because the loss of function of systems used to mitigate the consequences of design basis accidents under postfire conditions does not per se impact public safety, the need to limit fire damage to systems required to achieve and maintain safe shutdown conditions is greater than the need to limit fire damage to those systems required to mitigate the consequences of design basis accidents. Three levels of fire damage limits are established according to the safety functions of the structure, system, or component:

Table 2 U.S. 10 CFR 50 Appendix R Fire Damage

Safety function	Fire damage limits
Hot Shutdown	One train of equipment necessary to achieve hot shutdown from either the control room or emergency control station(s) must be maintained free of fire damage by a single fire, including an exposure fire. (An exposure fire is a fire in a given area that involves either in situ or transient combustibles and is external to any structures, systems, or components located in or adjacent to that same area. The effects of such fire (e.g., smoke, heat, or ignition) can adversely affect those structures, systems, or components important to safety. Thus, a fire involving one train of safe shutdown equipment may constitute an exposure fire for the redundant train located in the same area, and a fire involving combustibles other than either redundant train may constitute an exposure fire to both redundant trains located in the same area.)
Cold Shutdown	Both trains of equipment necessary to achieve cold shutdown may be damaged by a single fire, including an exposure fire, but damage must be limited so that at least one train can be repaired or made operable within 72 hours using onsite capability.
Design Basis Accidents	Both trains of equipment necessary for mitigation of consequences following design basis accidents may be damaged by a single exposure fire.

The most stringent fire damage limit shall apply for those systems that fall into more than one category. Redundant systems used to mitigate the consequences of other design basis accidents but not necessary for safe shutdown may be lost to a single exposure fire. However, protection shall be provided so that a fire within only one such system will not damage the redundant system.

II. General Requirements

A. *Fire protection program*. A fire protection program shall be established at each nuclear power plant. The program shall establish the fire protection policy for the protection of structures, systems, and components important to safety at each plant and the procedures, equipment, and personnel required to implement the program at the plant site.

The fire protection program shall be under the direction of an individual who has been delegated authority commensurate with the responsibilities of the position and who has available staff personnel knowledgeable in both fire protection and nuclear safety.

The fire protection program shall extend the concept of defense-in-depth to fire protection in fire areas important to safety, with the following objectives:

1. To prevent fires from starting;
2. To detect rapidly, control, and extinguish promptly those fires that do occur;
3. To provide protection for structures, systems, and components important to safety so that a fire that is not promptly extinguished by the fire suppression activities will not prevent the safe shutdown of the plant.

B. *Fire hazards analysis*. A fire hazards analysis shall be performed by qualified fire protection and reactor systems engineers to (1) consider potential in situ and transient fire hazards; (2) determine the consequences of fire in any location in the plant on the ability to safely shut down the reactor or on the ability to minimize and control the release of radioactivity to the environment; and (3) specify measures for fire prevention, fire detection, fire suppression, and fire containment and alternative shutdown capability as required for each fire area containing structures, systems, and components important to safety in accordance with NRC guidelines and regulations.

C. *Fire prevention features*. Fire protection features shall meet the following general requirements for all fire areas that contain or present a fire hazard to structures, systems, or components important to safety.

1. In situ fire hazards shall be identified and suitable protection provided.

2. Transient fire hazards associated with normal operation, maintenance, repair, or modification activities shall be identified and eliminated where possible. Those transient fire hazards that cannot be eliminated shall be controlled and suitable protection provided.

3. Fire detection systems, portable extinguishers, and standpipe and hose stations shall be installed.

4. Fire barriers or automatic suppression systems or both shall be installed as necessary to protect redundant systems or components necessary for safe shutdown.

5. A site fire brigade shall be established, trained, and equipped and shall be on site at all times.

6. Fire detection and suppression systems shall be designed, installed, maintained, and tested by personnel properly qualified by experience and training in fire protection systems.

7. Surveillance procedures shall be established to ensure that fire barriers are in place and that fire suppression systems and components are operable.

D. *Alternative or dedicated shutdown capability*. In areas where the fire protection features cannot ensure safe shutdown capability in the event of a fire in that area, alternative or dedicated safe shutdown capability shall be provided.

III. Specific Requirements

A. *Water supplies for fire suppression systems*. Two separate water supplies shall be provided to furnish necessary water volume and pressure to the fire main loop.

Each supply shall consist of a storage tank, pump, piping, and appropriate isolation and control valves. Two separate redundant suctions in one or more intake structures from a large body of water (river, lake, etc.) will satisfy the requirement for two separated water storage tanks. These supplies shall be separated so that a failure of one supply will not result in a failure of the other supply.

Each supply of the fire water distribution system shall be capable of providing for a period of 2 hours the maximum expected water demands as determined by the fire hazards analysis for safety-related areas or other areas that present a fire exposure hazard to safety- related areas.

When storage tanks are used for combined service-water/fire-water uses the minimum volume for fire uses shall be ensured by means of dedicated tanks or by some physical means such as a vertical standpipe for other water service. Administrative controls, including locks for tank outlet valves, are unacceptable as the only means to ensure minimum water volume.

Other water systems used as one of the two fire water supplies shall be permanently connected to the fire main system and shall be capable of automatic alignment to the fire main system. Pumps, controls, and power supplies in these systems shall satisfy the requirements for the main fire pumps. The use of other water systems for fire protection shall not be incompatible with their functions required for safe plant shutdown. Failure of the other system shall not degrade the fire main system.

B. *Sectional isolation valves*. Sectional isolation valves such as post indicator valves or key operated valves shall be installed in the fire main loop to permit isolation of portions of the fire main loop for maintenance or repair without interrupting the entire water supply.

C. *Hydrant isolation valves*. Valves shall be installed to permit isolation of outside hydrants from the fire main for maintenance or repair without interrupting the water supply to automatic or manual fire suppression systems in any area containing or presenting a fire hazard to safety-related or safe shutdown equipment.

D. *Manual fire suppression*. Standpipe and hose systems shall be installed so that at least one effective hose stream will be able to reach any location that contains or presents an exposure fire hazard to structures, systems, or components important to safety.

Access to permit effective functioning of the fire brigade shall be provided to all areas that contain or present an exposure fire hazard to structures, systems, or components important to safety.

Standpipe and hose stations shall be inside PWR containments and BWR containments that are not inerted. Standpipe and hose stations inside containment may be connected to a high quality water supply of sufficient quantity and pressure other than the fire main loop if plant-specific features prevent extending the fire main supply inside containment. For BWR drywells, standpipe and hose stations shall be placed outside the dry well with adequate lengths of hose to reach any location inside the dry well with an effective hose stream.

E. *Hydrostatic hose tests*. Fire hose shall be hydrostatically tested at a pressure of 150 psi or 50 psi above maximum fire main operating pressure, whichever is greater. Hose stored in outside hose houses shall be tested annually. Interior standpipe hose shall be tested every three years.

F. *Automatic fire detection*. Automatic fire detection systems shall be installed in all areas of the plant that contain or present an exposure fire hazard to safe shutdown or safety-related systems or components. These fire detection systems shall be capable of operating with or without offsite power.

G. *Fire protection of safe shutdown capability*.

1. Fire protection features shall be provided for structures, systems, and components important to safe shutdown. These features shall be capable of limiting fire damage so that:

a. One train of systems necessary to achieve and maintain hot shutdown conditions from either the control room or emergency control station(s) is free of fire damage; and

b. Systems necessary to achieve and maintain cold shutdown from either the control room or emergency control station(s) can be repaired within 72 hours.

2. Except as provided for in paragraph G.3 of this section, where cables or equipment, including associated non-safety circuits that could prevent operation or cause maloperation due to hot shorts, open circuits, or shorts to ground, of redundant trains of systems necessary to achieve and maintain hot shutdown conditions are located within the same fire

area outside of primary containment, one of the following means of ensuring that one of the redundant trains is free of fire damage shall be provided:

a. Separation of cables and equipment and associated non-safety circuits of redundant trains by a fire barrier having a 3-hour rating. Structural steel forming a part of or supporting such fire barriers shall be protected to provide fire resistance equivalent to that required of the barrier;

b. Separation of cables and equipment and associated non-safety circuits of redundant trains by a horizontal distance of more than 20 feet with no intervening combustible or fire hazards. In addition, fire detectors and an automatic fire suppression system shall be installed in the fire area; or

c. Enclosure of cable and equipment and associated non-safety circuits of one redundant train in a fire barrier having a 1-hour rating, In addition, fire detectors and an automatic fire suppression system shall be installed in the fire area; Inside non-inerted containments one of the fire protection means specified above or one of the following fire protection means shall be provided:

d. Separation of cables and equipment and associated non-safety circuits of redundant trains by a horizontal distance of more than 20 feet with no intervening combustibles or fire hazards;

e. Installation of fire detectors and an automatic fire suppression system in the fire area; or

f. Separation of cables and equipment and associated non-safety circuits of redundant trains by a noncombustible radiant energy shield.

3. Alternative or dedicated shutdown capability and its associated circuits,1 independent of cables, systems or components in the area, room, zone under consideration should be provided:

a. Where the protection of systems whose function is required for hot shutdown does not satisfy the requirement of paragraph G.2 of this section; or

b. Where redundant trains of systems required for hot shutdown located in the same fire area may be subject to damage from fire suppression activities or from the rupture or inadvertent operation of fire suppression systems. In addition, fire detection and a fixed fire suppression system shall be installed in the area, room, or zone under consideration.

H. *Fire brigade*. A site fire brigade trained and equipped for fire fighting shall be established to ensure adequate manual fire fighting capability for all areas of the plant containing structures, systems, or components important to safety. The fire brigade shall be at least five members on each shift. The brigade leader and at least two brigade members shall have sufficient training in or knowledge of plant safety-related systems to understand the effects of fire and fire suppressants on safe shutdown capability. The qualification of fire brigade members shall include an annual physical examination to determine their ability to perform strenuous fire fighting activities. The shift supervisor shall not be a member of the fire brigade. The brigade leader shall be competent to assess the potential safety consequences of a fire and advise control room personnel. Such competence by the brigade leader may be evidenced by possession of an operator's license or equivalent knowledge of plant safety-related systems.

The minimum equipment provided for the brigade shall consist of personal protective equipment such as turnout coats, boots, gloves, hard hats, emergency communications equipment, portable lights, portable ventilation equipment, and portable extinguishers. Self-contained breathing apparatus using full-face positive-pressure masks approved by NIOSH

(National Institute for Occupational Safety and Health —approval formerly given by the U.S. Bureau of Mines) shall be provided for fire brigade, damage control, and control room personnel. At least 10 masks shall be available for fire brigade personnel. Control room personnel may be furnished breathing air by a manifold system piped from a storage reservoir if practical. Service or rated operating life shall be a minimum of one-half hour for the self-contained units.

At least a 1-hour supply of breathing air in extra bottles shall be located on the plant site for each unit of self-contained breathing apparatus. In addition, an onsite 6-hour supply of reserve air shall be provided and arranged to permit quick and complete replenishment of exhausted air supply bottles as they are returned. If compressors are used as a source of breathing air, only units approved for breathing air shall be used and the compressors shall be operable assuming a loss of offsite power. Special care must be taken to locate the compressor in areas free of dust and contaminants.

I. *Fire brigade training*. The fire brigade training program shall ensure that the capability to fight potential fires is established and maintained. The program shall consist of an initial classroom instruction program followed by periodic classroom instruction, fire fighting practice, and fire drills:

1. *Instruction*

a. The initial classroom instruction shall include:

(1) Indoctrination of the plant fire fighting plan with specific identification of each individual's responsibilities.

(2) Identification of the type and location of fire hazards and associated types of fires that could occur in the plant.

(3) The toxic and corrosive characteristics of expected products of combustion.

(4) Identification of the location of fire fighting equipment for each fire area and familiarization with the layout of the plant, including access and egress routes to each area.

(5) The proper use of available fire fighting equipment and the correct method of fighting each type of fire. The types of fires covered should include fires in energized electrical equipment, fires in cables and cable trays, hydrogen fires, fires involving flammable and combustible liquids or hazardous process chemicals, fires resulting from construction or modifications (welding), and record file fires.

(6) The proper use of communication, lighting, ventilation, and emergency breathing equipment.

(7) The proper method for fighting fires inside buildings and confined spaces.

(8) The direction and coordination of the fire fighting activities (fire brigade leaders only).

(9) Detailed review of fire fighting strategies and procedures.

(10) Review of the latest plant modifications and corresponding changes in fire fighting plans.

Note: Items (9) and (10) may be deleted from the training of no more than two of the non-operations personnel who may be assigned to the fire brigade.

b. The instruction shall be provided by qualified individuals who are knowledgeable, experienced, and suitably trained in fighting the types of fires that could occur in the plant and in using the types of equipment available in the nuclear power plant.

c. Instruction shall be provided to all fire brigade members and fire brigade leaders.

d. Regular planned meetings shall be held at least every 3 months for all brigade members to review changes in the fire protection program and other subjects as necessary.

e. Periodic refresher training sessions shall be held to repeat the classroom instruction program for all brigade members over a two- year period. These sessions may be concurrent with the regular planned meetings.

2. *Practice*

Practice sessions shall be held for each shift fire brigade on the proper method of fighting the various types of fires that could occur in a nuclear power plant. These sessions shall provide brigade members with experience in actual fire extinguishment and the use of emergency breathing apparatus under strenuous conditions encountered in fire fighting. These practice sessions shall be provided at least once per year for each fire brigade member.

3. *Drills*

a. Fire brigade drills shall be performed in the plant so that the fire brigade can practice as a team.

b. Drills shall be performed at regular intervals not to exceed 3 months for each shift fire brigade. Each fire brigade member should participate in each drill, but must participate in at least two drills per year.

A sufficient number of these drills, but not less than one for each shift fire brigade per year, shall be unannounced to determine the fire fighting readiness of the plant fire brigade, brigade leader, and fire protection systems and equipment. Persons planning and authorizing an unannounced drill shall ensure that the responding shift fire brigade members are not aware that a drill is being planned until it is begun. Unannounced drills shall not be scheduled closer than four weeks.

At least one drill per year shall be performed on a "back shift" for each shift fire brigade.

c. The drills shall be preplanned to establish the training objectives of the drill and shall be critiqued to determine how well the training objectives have been met. Unannounced drills shall be planned and critiqued by members of the management staff responsible for plant safety and fire protection. Performance deficiencies of a fire brigade or of individual fire brigade members shall be remedied by scheduling additional training for the brigade or members. Unsatisfactory drill performance shall be followed by a repeat drill within 30 days.

d. At 3-year intervals, a randomly selected unannounced drill must be critiqued by qualified individuals independent of the licensee's staff. A copy of the written report from these individuals must be available for NRC review and shall be retained as a record as specified in section III.I.4 of this appendix.

e. Drills shall as a minimum include the following:

(1) Assessment of fire alarm effectiveness, time required to notify and assemble fire brigade, and selection, placement and use of equipment, and fire fighting strategies.

(2) Assessment of each brigade member's knowledge of his or her role in the fire fighting strategy for the area assumed to contain the fire. Assessment of the brigade member's conformance with established plant fire fighting procedures and use of fire fighting equipment, including self-contained emergency breathing apparatus, communication equipment, and ventilation equipment, to the extent practicable.

(3) The simulated use of fire fighting equipment required to cope with the situation and type of fire selected for the drill. The area and type of fire chosen for the drill should differ from those used in the previous drill so that brigade members are trained in fighting fires in various plant areas. The situation selected should simulate the size and arrangement of a fire that could reasonably occur in the area selected, allowing for fire development due to the time required to respond, to obtain equipment, and organize for the fire, assuming loss of automatic suppression capability.

(4) Assessment of brigade leader's direction of the fire fighting effort as to thoroughness, accuracy, and effectiveness.

4. *Records*

Individual records of training provided to each fire brigade member, including drill critiques, shall be maintained for at least 3 years to ensure that each member receives training in all parts of the training program. These records of training shall be available for NRC review. Retraining or broadened training for fire fighting within buildings shall be scheduled for all those brigade members whose performance records show deficiencies.

J. Emergency lighting. Emergency lighting units with at least an 8-hour battery power supply shall be provided in all areas needed for operation of safe shutdown equipment and in access and egress routes thereto.

K. Administrative controls. Administrative controls shall be established to minimize fire hazards in areas containing structures, systems, and components important to safety. These controls shall establish procedures to:

1. Govern the handling and limitation of the use of ordinary combustible materials, combustible and flammable gases and liquids, high efficiency particulate air and charcoal filters, dry ion exchange resins, or other combustible supplies in safety-related areas.

2. Prohibit the storage of combustibles in safety-related areas or establish designated storage areas with appropriate fire protection.

3. Govern the handling of and limit transient fire loads such as combustible and flammable liquids, wood and plastic products, or other combustible materials in buildings containing safety-related systems or equipment during all phases of operating, and especially during maintenance, modification, or refueling operations.

4. Designate the onsite staff member responsible for the inplant fire protection review of proposed work activities to identify potential transient fire hazards and specify required additional fire protection in the work activity procedure.

5. Govern the use of ignition sources by use of a flame permit system to control welding, flame cutting, brazing, or soldering operations. A separate permit shall be issued for each area where work is to be done. If work continues over more than one shift, the permit shall be valid for not more than 24 hours when the plant is operating or for the duration of a particular job during plant shutdown.

6. Control the removal from the area of all waste, debris, scrap, oil spills, or other combustibles resulting from the work activity immediately following completion of the activity, or at the end of each work shift, whichever comes first.

7. Maintain the periodic housekeeping inspections to ensure continued compliance with these administrative controls.

8. Control the use of specific combustibles in safety-related areas. All wood used in safety-related areas during maintenance, modification, or refueling operations (such as lay-down

blocks or scaffolding) shall be treated with a flame retardant. Equipment or supplies (such as new fuel) shipped in untreated combustible packing containers may be unpacked in safety-related areas if required for valid operating reasons. However, all combustible materials shall be removed from the area immediately following the unpacking. Such transient combustible material, unless stored in approved containers, shall not be left unattended during lunch breaks, shift changes, or other similar periods. Loose combustible packing material such as wood or paper excelsior, or polyethylene sheeting shall be placed in metal containers with tight-fitting self-closing metal covers.

9. Control actions to be taken by an individual discovering a fire, for example, notification of control room, attempt to extinguish fire, and actuation of local fire suppression systems.

10. Control actions to be taken by the control room operator to determine the need for brigade assistance upon report of a fire or receipt of alarm on control room annunciator panel, for example, announcing location of fire over PA system, sounding fire alarms, and notifying the shift supervisor and the fire brigade leader of the type, size, and location of the fire.

11. Control actions to be taken by the fire brigade after notification by the control room operator of a fire, for example, assembling in a designated location, receiving directions from the fire brigade leader, and discharging specific fire fighting responsibilities including selection and transportation of fire fighting equipment to fire location, selection of protective equipment, operating instructions for use of fire suppression systems, and use of preplanned strategies for fighting fires in specific areas.

12. Define the strategies for fighting fires in all safety-related areas and areas presenting a hazard to safety-related equipment. These strategies shall designate:

a. Fire hazards in each area covered by the specific prefire plans.

b. Fire extinguishants best suited for controlling the fires associated with the fire hazards in that area and the nearest location of these extinguishants.

c. Most favorable direction from which to attack a fire in each area in view of the ventilation direction, access hallways, stairs, and doors that are most likely to be free of fire, and the best station or elevation for fighting the fire. All access and egress routes that involve locked doors should be specifically identified in the procedure with the appropriate precautions and methods for access specified.

d. Plant systems that should be managed to reduce the damage potential during a local fire and the location of local and remote controls for such management (e.g., any hydraulic or electrical systems in the zone covered by the specific fire fighting procedure that could increase the hazards in the area because of overpressurization or electrical hazards).

e. Vital heat-sensitive system components that need to be kept cool while fighting a local fire. Particularly hazardous combustibles that need cooling should be designated.

f. Organization of fire fighting brigades and the assignment of special duties according to job title so that all fire fighting functions are covered by any complete shift personnel complement. These duties include command control of the brigade, transporting fire suppression and support equipment to the fire scenes, applying the extinguishant to the fire, communication with the control room, and coordination with outside fire departments.

g. Potential radiological and toxic hazards in fire zones.

h. Ventilation system operation that ensures desired plant air distribution when the ventilation flow is modified for fire containment or smoke clearing operations.

i. Operations requiring control room and shift engineer coordination or authorization.

j. Instructions for plant operators and general plant personnel during fire.

L. *Alternative and dedicated shutdown capability*.

1. Alternative or dedicated shutdown capability provided for a specific fire area shall be able to (a) achieve and maintain subcritical reactivity conditions in the reactor; (b) maintain reactor coolant inventory; (c) achieve and maintain hot standby conditions for a PWR (hot shutdown for a BWR); (d) achieve cold shutdown conditions within 72 hours; and (e) maintain cold shutdown conditions thereafter. During the postfire shutdown, the reactor coolant system process variables shall be maintained within those predicted for a loss of normal a.c. power, and the fission product boundary integrity shall not be affected; i.e., there shall be no fuel clad damage, rupture of any primary coolant boundary, of rupture of the containment boundary.

2. The performance goals for the shutdown functions shall be:

a. The reactivity control function shall be capable of achieving and maintaining cold shutdown reactivity conditions.

b. The reactor coolant makeup function shall be capable of maintaining the reactor coolant level above the top of the core for BWRs and be within the level indication in the pressurizer for PWRs.

c. The reactor heat removal function shall be capable of achieving and maintaining decay heat removal.

d. The process monitoring function shall be capable of providing direct readings of the process variables necessary to perform and control the above functions.

e. The supporting functions shall be capable of providing the process cooling, lubrication, etc., necessary to permit the operation of the equipment used for safe shutdown functions.

3. The shutdown capability for specific fire areas may be unique for each such area, or it may be one unique combination of systems for all such areas. In either case, the alternative shutdown capability shall be independent of the specific fire area(s) and shall accommodate postfire conditions where offsite power is available and where offsite power is not available for 72 hours. Procedures shall be in effect to implement this capability.

4. If the capability to achieve and maintain cold shutdown will not be available because of fire damage, the equipment and systems comprising the means to achieve and maintain the hot standby or hot shutdown condition shall be capable of maintaining such conditions until cold shutdown can be achieved. If such equipment and systems will not be capable of being powered by both onsite and offsite electric power systems because of fire damage, an independent onsite power system shall be provided. The number of operating shift personnel, exclusive of fire brigade members, required to operate such equipment and systems shall be on site at all times.

5. Equipment and systems comprising the means to achieve and maintain cold shutdown conditions shall not be damaged by fire; or the fire damage to such equipment and systems shall be limited so that the systems can be made operable and cold shutdown can be achieved within 72 hours. Materials for such repairs shall be readily available on site and procedures shall be in effect to implement such repairs. If such equipment and systems used prior to 72 hours after the fire will not be capable of being powered by both onsite and offsite electric power systems because of fire damage, an independent onsite power system

shall be provided. Equipment and systems used after 72 hours may be powered by offsite power only.

6. Shutdown systems installed to ensure postfire shutdown capability need not be designed to meet seismic Category I criteria, single failure criteria, or other design basis accident criteria, except where required for other reasons, e.g., because of interface with or impact on existing safety systems, or because of adverse valve actions due to fire damage.

9. 7. The safe shutdown equipment and systems for each fire area shall be known to be isolated from associated non-safety circuits in the fire area so that hot shorts, open circuits, or shorts to ground in the associated circuits will not prevent operation of the safe shutdown equipment. The separation and barriers between trays and conduits containing associated circuits of one safe shutdown division and trays and conduits containing associated circuits or safe shutdown cables from the redundant division, or the isolation of these associated circuits from the safe shutdown equipment, shall be such that a postulated fire involving associated circuits will not prevent safe shutdown. An acceptable method of complying with this alternative would be to meet Regulatory Guide 1.75 position 4 related to associated circuits and IEEE Std 384-1974 (Section 4.5) where trays from redundant safety divisions are so protected that postulated fires affect trays from only one safety division.

M. *Fire barrier cable penetration seal qualification*. Penetration seal designs must be qualified by tests that are comparable to tests used to rate fire barriers. The acceptance criteria for the test must include the following:

1. The cable fire barrier penetration seal has withstood the fire endurance test without passage of flame or ignition of cables on the unexposed side for a period of time equivalent to the fire resistance rating required of the barrier;

2. The temperature levels recorded for the unexposed side are analyzed and demonstrate that the maximum temperature is sufficiently below the cable insulation ignition temperature; and

3. The fire barrier penetration seal remains intact and does not allow projection of water beyond the unexposed surface during the hose stream test.

N. *Fire doors*. Fire doors shall be self-closing or provided with closing mechanisms and shall be inspected semiannually to verify that automatic hold-open, release, and closing mechanisms and latches are operable. One of the following measures shall be provided to ensure they will protect the opening as required in case of fire:

1. Fire doors shall be kept closed and electrically supervised at a continuously manned location;

2. Fire doors shall be locked closed and inspected weekly to verify that the doors are in the closed position;

3. Fire doors shall be provided with automatic hold-open and release mechanisms and inspected daily to verify that doorways are free of obstructions; or

4. Fire doors shall be kept closed and inspected daily to verify that they are in the closed position. The fire brigade leader shall have ready access to keys for any locked fire doors. Areas protected by automatic total flooding gas suppression systems shall have electrically supervised self-closing fire doors or shall satisfy option 1 above.

O. *Oil collection system for reactor coolant pump*. The reactor coolant pump shall be equipped with an oil collection system if the containment is not inerted during normal operation. The oil collection system shall be so designed, engineered, and installed that failure will not lead to fire during normal or design basis accident conditions and that there is reasonable assurance that the system will withstand the Safe Shutdown Earthquake. See Regulatory Guide 1.29—"Seismic Design Classification" paragraph C.2.

Such collection systems shall be capable of collecting lube oil from all potential pressurized and unpressurized leakage sites in the reactor coolant pump lube oil systems. Leakage shall be collected and drained to a vented closed container that can hold the entire lube oil system inventory. A flame arrester is required in the vent if the flash point characteristics of the oil present the hazard of fire flashback. Leakage points to be protected shall include lift pump and piping, overflow lines, lube oil cooler, oil fill and drain lines and plugs, flanged connections on oil lines, and lube oil reservoirs where such features exist on the reactor coolant pumps. The drain line shall be large enough to accommodate the largest potential oil leak.

[45 FR 76611, Nov. 19, 1980; 46 FR 44735, Sept. 8, 1981, as amended at 53 FR 19251, May 27, 1988; 65 FR 38191, June 20, 2000; 77 FR 39907, Jul. 6, 2012]

3.14.2 New Reactors

New reactor designs integrate fire protection requirements, including the protection of safe shutdown capability and the prevention of radiological release, into the planning and design phase for the plant. In addition, new reactor designs should minimize or eliminate the use of alternative/dedicated shutdown systems and should only rely on such systems when it is not feasible to provide the required protection for redundant safe shutdown systems, such as in the main control room.

3.14.2.1 Overview

1. General Design Criteria (GDC) 3 of Appendix A to 10 CFR 50 [NRC-01]
   GDC 3 addresses fire protection requirements and specifies, in part, that (1) systems, structures and components (SSCs) important to safety must be designed and located to minimize the probability and effects of fires and explosions, (2) non-combustible and heat-resistant materials must be used wherever practical, and (3) fire detection and suppression systems must be provided to minimize the adverse effects of fires on SSCs important to safety.
2. 10 CFR 50.48(a) [NRC-04]
   The fire protection program for new reactor plants are subject to 10 CFR 50.48(a) and the criteria for enhanced fire protection.
3. Regulatory Guide 1.189 [NRC-07]
   a. Enhanced Fire Protection Criteria: “New reactor designs should ensure that safe shutdown can be achieved assuming that all equipment in any one fire area will be rendered inoperable by fire and that re-entry into the fire area for repairs and operator actions is not possible. The control room should be evaluated to ensure that the effects of fire do not adversely affect the ability to achieve and maintain safe shutdown. New reactors should provide fire protection for redundant shutdown systems in the reactor containment building that will ensure, to the extent practicable, that one shutdown division will be free of fire damage. Additionally, new reactor designs should ensure that smoke, hot gases, or the fire suppressant will not migrate into other fire areas to the extent that they could adversely affect safe-shutdown capabilities, including operator actions”
   b. *Passive Plant Safe Shutdown Condition*: “The passive decay heat removal systems should be capable of achieving and maintaining 215.6 ºC (420 ºF) or below for non-LOCA events. This safe shutdown condition is predicated on demonstration of acceptable passive safety system performance.”

3.14.3 Supplementary Information

[NRC-01] United States Nuclear Regulatory Commission (NRC): 10 CFR 50 Domestic Licensing of Production and Utilization Facilities; 10 CFR 50.48 Fire Protection, August 2007, Appendix A to Part 50 – General Design Criteria for Nuclear Power Plants, (updated) January 1, 2011, https://www.nrc.gov/reading-rm/doc-collections/cfr/part050/part050-appa.html.

[NRC-02] United States Nuclear Regulatory Commission (NRC): 10 CFR 50 Domestic Licensing of Production and Utilization Facilities; 10 CFR 50.48 Fire Protection, Appendix R to 10 CFR Part 50, "Fire Protection Program for Nuclear Power Facilities Operating Prior to January 1, 1979", updated 2017, https://www.nrc.gov/reading-rm/doc-collections/cfr/part050/part050-appr.html.

[NRC-04] United States Nuclear Regulatory Commission (NRC): 10 CFR 50 Domestic Licensing of Production and Utilization Facilities; 10 CFR 50.48 Fire Protection, August 2007, http://www.nrc.gov/reading-rm/doc-collections/cfr/part050/part050-0048.html.

[NRC-05] United States Nuclear Regulatory Commission (NRC): Appendix A to Branch Technical Position (BTP) APCSB 9.5-1, Guidelines for Fire Protection for Nuclear Power Plants, 1976, http://www.nrc.gov/reading-rm/doc-collections/nuregs/brochures/, br0361/s1/apcsb95-1.pdf.

[NRC-07] United States Nuclear Regulatory Commission (NRC), Office of Nuclear Reactor Regulation: Fire Protection for Nuclear Power Plants, Regulatory Guide 1.189, Rev. 2, Washington, DC, USA, October 2009, https://www.nrc.gov/docs/ML0925/ML092580550.pdf.

4 REGULATORY QUESTIONAIRE

4.1 General Comparisons

In order to provide a uniform comparison between the high-level regulations on a country by country basis, a simplified questionnaire intended to capture the larger themes and prevailing practices of many countries with regard to fire safety regulatory schemes was provided to the National Coordinator(s) of each country. The four questions asked and the respective responses from the 14 FIRE Database Project member countries are provided in the following paragraphs.

4.2 Regulation Questionnaire Form

The following survey has been answered by all FIRE Database Project member countries in order to document the regulatory information in a simple manner.

4.2.1 Questions about the use of FIRE PSA (PRA) in FIRE member countries

Q.1 Are the NPP fire protection regulations in your country based on prescriptive (deterministic) principles or performance-based risk-informed methods?

Q.2 Are Fire PRAs used to support license applications?

Q.3 How does the regulator inspect and ensure the quality of the Fire PRA supporting the license amendment?

Q.4 If Fire PRAs are being developed and applied, what methodological guidance is being used and what issues/limitations have been identified, if any, with these methods?

4.2.2 High Level Questionnaire Summary Results

Table 3 FIRE Member Countries - High Level Questionnaire Summary Results

Country	Prescriptive / Risk-Informed	PSA Supports Licensing Actions	Methodology Framework
Belgium	Prescriptive & risk-informed	Yes	NUREG/CR-6850 [NRC-08]
Canada	Prescriptive & risk-informed	Yes	NUREG/CR-6850 [NRC-08]
Czech Republic	Prescriptive & risk-informed	Yes	NUREG/CR-6850 [NRC-08]
Finland	Prescriptive & risk-informed	Yes	Partially applied NUREG/CR-6850 [NRC-08]
France	Prescriptive & Risk-Informed	Yes	INB order [FRA-02]
Germany	Prescriptive & risk-informed; however,	Yes	German PSA Guide [BMU-05] and Supporting Technical Documents on PSA

Country	Prescriptive / Risk-Informed	PSA Supports Licensing Actions	Methodology Framework
	traditionally mainly prescriptive		Methods and Data [FAK-05], [FAK-05a], [FAK-16]
Japan	Prescriptive	No	NUREG/CR-6850 [NRC-08]
Korea	Prescriptive	No	NUREG/CR-6850 [NRC-08]
The Netherlands	Prescriptive & risk-informed	Yes	NUREG/CR-6850 [NRC-08]
Spain	Prescriptive & risk-informed	Only under performance-based methodology accepted as a valid way to meet fire protection regulation requirements	NUREG/CR-6850 [NRC-08]
Sweden	Prescriptive	Yes	Not directly, but influenced by NUREG/CR-6850 [NRC-08]
Switzerland	Prescriptive & risk-informed	Yes	ENSI-A05 [ENSI-18a]
United Kingdom	Prescriptive & risk-informed	To a limited extent; for new reactors, Fire PSA would be expected prior to operation	ONR SAPs and the ONR TAG on PSA, NS-TAST-GD-030 (TAG-030) - Probabilistic Safety Analysis [ONR-16]
United States	Prescriptive & risk-informed	Yes	NUREG/CR-6850 [NRC-08]

4.3 Survey Responses

4.3.1 Belgium

Q.1 Are the NPP fire protection regulations in your country based on prescriptive (deterministic) principles or performance-based risk-informed methods?

Both; Royal Decree (RD) of 30/11/2011 transposes the WENRA 2008 Safety Reference Levels in the Belgian regulatory framework. Art. 17.3 of the RD requires that a deterministic fire risk analysis has to be performed in order to demonstrate that safety objectives are met, fire protection systems are properly designed and that all administrative provisions were correctly identified. In addition, Art. 32.2 requires that a fire probabilistic risk analysis (Fire PRA) to be performed to complement the deterministic risk analysis, for power reactors only.

Q.2 Are Fire PRAs used to support license applications?

Because new nuclear installation must comply with the Royal Decree of 30/11/2011, Fire PSA can be considered as a requirement for a license application of new nuclear power reactors (Fire PSA is not required for other type on nuclear installations, such as research reactors). However, there is currently no plan for a license application of nuclear power reactor.

Q.3 How does the regulator inspect and ensure the quality of the Fire PRA supporting the license amendment?

The Belgian regulatory body, nuclear safety authority and TSO, ensures an on-line review of the execution of the Fire PSA study, this includes establishment of the methodology, compliance with the guidance and justification of potential deviations, as well as the analysis and discussion of the results, including CDF quantification and physical improvement to the fire safety of the installation.

Q.4 If Fire PRAs are being developed and applied, what methodological guidance is being used and what issues/limitations have been identified, if any, with these methods?

NUREG/CR-6850 is used as the methodological guidance for Fire PSA in Belgium. This is not enforced by the Belgian regulation but acknowledged by the regulatory body as the state-of-the-art methodology to be followed. Licensees may propose some deviation from this methodological framework, which has to be reviewed and accepted by the regulatory body.

4.3.2 Canada

Q.1 Are the NPP fire protection regulations in your country based on prescriptive (deterministic) principles or performance-based risk-informed methods?

In Canada the regulations for fire protection is based on prescriptive (deterministic) and risk-informed assessment principals. The licensee' Power Reactor Operating Licence (PROL) includes a license condition under Safety and Control Area of Emergency Management and Fire Protection: "The licensee shall implement and maintain a fire protection program". The fire Protection program is required to meet Canadian Standards Association (CSA) N293-12 "Fire protection for nuclear power plants" [CSA-12]. CSA N293 can be thought of as an objective based standard (consistent with the Canadian Building and Fire code approach). CSA N293 permits the use of performance-based approaches but does not prescribe in similar fashion to NFPA 805 [NFPA-01] a risk-based fire protection program. CSA N293 establishes the fire protection requirements for the design construction, commissioning, operation, and decommissioning of nuclear power plants to address the fire protection goals and objectives. CSA N293 requirements include:

- Design requirements (e.g., fire detection and alarm system, fire suppression, fire resistance rating of building structures, building materials, egress);
- Operational requirements (e.g., control of ignition sources, ITM of fire protection features, control of flammable, combustible materials);
- Fire Protection Program requirements;
- Fire safety assessment requirements (e.g., code compliance, fire hazard assessments, fire safe shutdown analysis); and
- Fire response and decommissioning.

Q.2 Are Fire PRAs used to support license applications?

Yes. The licensee' Power Reactor Operating Licence (PROL) includes a license condition with regard to "Safety Analysis" and the licensees are required to comply with regulatory document

REGDOC-2.4.2 “Probabilistic Safety Assessment (PSA) for Nuclear Power Plants” [CNSC-14a]. REGDOC-2.4.2 requires the PSA to include both internal and external events.

Q.3 How does the regulator inspect and ensure the quality of the Fire PRA supporting the license amendment?

PSA for internal and external events are required to meet the requirement of the regulatory document REGDOC-2.4.2 “Probabilistic Safety Assessment (PSA) for Nuclear Power Plants” [CNSC-14a]. This regulatory document requires the licensees to seek CNSC acceptance of the PSA methodology before the conduct of the PSA. This provides CNSC staff assurance that the PSA is developed according to an accepted methodology. In addition, CNSC staff use ASME/ANS PRA Standard, CSA N290.17.17 “Probabilistic safety assessment for nuclear power plants” [CSA-17], NUREG (e.g., NUREG/CR-6850 [NRC-08] for fire) IAEA documents (such as SSG-3 [IAEA-10], SSG-4 [IAEA-10a], IAEA-TECDOC-1135 [IAEA-00d], and IAEA-TECDOC-1229 [IAEA-01]) to review the quality of Fire PSA.

Q.4 If Fire PRAs are being developed and applied, what methodological guidance is being used and what issues/limitations have been identified, if any, with these methods?

The methodology used for Fire PSA for the Canadian nuclear power plants is generally developed based on NUREG/CR-6850 methodology [NRC-08]. The limitation is the applicability of fire data/ fire initiating event frequencies, definition of fire zones given the difference in CANDU design and layout, fire scenario modelling (e.g., oil, hydrogen, multi-cable tray scenarios) and the whole site multi-unit PSA issues.

4.3.3 Czech Republic

Q.1 Are the NPP fire protection regulations in your country based on prescriptive (deterministic) principles or performance-based risk-informed methods?

Until 2016, fire legislation was based on prescriptive principals. The new Atomic Act – Act No. 263/2016 Coll and related SÚJB Decree No. 162/2016 Coll., “Requirements for safety assessment under the Atomic Act” require the use the fire protection regulations based both on prescriptive and probabilistic methods.

Q.2 Are Fire PRAs used to support license applications?

Yes, complete Level 1 and limited scope Level 2 PSA (Fire PSA is included like internal hazards) for power operation as well as for low power and shutdown plant operational states) or applications are used in the frame of regulatory oversight in addition to deterministic analyses.

Q.3 How does the regulator inspect and ensure the quality of the Fire PRA supporting the license amendment?

PSA is reviewed by independent review team during the Periodic Safety Reviews (PSR). The methodology and criteria for chapter 6 (PSA evaluation) were developed in UJV Rez. PSR is performed every ten years (PSR 30 - last revision at the Dukovany NPP was made in 2015 and PSR 20 – last revision at the Temelin NPP was made in 2018).

At the Dukovany NPP the IPERS mission took place in 1998, focusing on first level PSA study, in order to assess the study and propose specific proposals for its improvement. At present, this activity builds IAEA TSR-PSA review team. Last mission was performed at NPP Dukovany in 2016. Some recommendations were also concerned to quality and scope of Fire PSA. All recommendations were analyzed in detail and adopted recommendations were included into the PSA model and documents.

At the Temelin NPP a mission on the PSA study took place in 1995 and 1996. The mission concluded that Temelín NPP carefully adopted PSA methodology and the results confirmed a high level of power plant safety in spite of conservative assumptions. In 2003, the IPSART mission re-examined the previous verifications and focused in detail on updated models of probabilistic safety assessment of the current design and operation of the power plant. The visit of IAEA TSR-PSA review team is in plan.

In addition, the Czech regulatory body, NPPs and TSO ensure an on-line review of the execution of the Fire PSA study, this includes establishment of the methodology, compliance with the guidance.

Q.4 If Fire PRAs are being developed and applied, what methodological guidance is being used and what issues/limitations have been identified, if any, with these methods?

Fire PSA is implemented like one of internal hazard into PSA by UJV Rez. The used approach is based on NUREG/CR-6850 [NRC-08]. For some aspects (for example – quantification of spurious signals probability) the support of another guidelines is partially used (NUREG/CR-7150 [NRC-16], NEI 00-01 [NEI-05].

The issues we have could be the effective selection of the most important combination of spurious signals (multi-cable tray scenarios) leading to inadvertent behavior of equipment (how to cut off most insignificant combinations and still stay on the conservative side), smoke impact on electronics, uncertainty of fires in the I&C cabinet rooms and MCR (only the spatial separation of redundant lines), modelling of large fires in one compartment (oil fire in turbine hall) and influence on steel construction (pillars, beams), hot gas layer phenomena.

4.3.4 Finland

Q.1 Are the NPP fire protection regulations in your country based on prescriptive (deterministic) principles or performance-based risk-informed methods?

In Finland the regulations for fire protection is based on prescriptive (deterministic) principles. STUK YVL Guide B.8 [FIN-19].

- It shall be demonstrated by means of the containment fire hazard analysis that, despite containment fires, the reactor can be shut down and cooled, and residual heat can be removed without compromising containment integrity.
- It shall be demonstrated by a fire hazard analysis of the control room that control of the necessary safety functions can be executed in the event of a fire in the control room or in any other fire compartment.
- In connection with the design of the I&C systems of the nuclear power plant, the influence of fires on the functioning of safety significant I&C systems shall be analyzed, including the effects of fire-induced temperature rise and combustion gases on equipment and the reflection of disturbances and failures thereof on the execution of safety functions.

Q.2 Are Fire PRAs used to support license applications?

Yes, per STUK YVL Guide A.7 (PRA) [FIN-20] PRA is mandatory (full scope PRA Level 1 & 2; power operation as well as low power and shutdown modes).

Q.3 How does the regulator inspect and ensure the quality of the Fire PRA supporting the license amendment?

International review guidelines were partially utilized, when STUK developed own review guideline for the whole PRA. The electronic PRA models are also provided to STUK for review and to be able to perform quantification by STUK (e.g. sensitivity and uncertainty analyses). Under the review of Fire-PRAs, small and medium scale fire research has been ordered by a

TSO (VTT) especially considering cable fires and I&C cabinet fires. Fire simulations have also been ordered by VTT considering cable fires, I&C cabinet fires and large oil pool fires. The outcome of VTT's work has been taken into account when updating Fire PRAs. As stated in the YVL Guide A.7 (items 501, 506, and 508):

- STUK oversees the licensee's risk management by reviewing the associated documents, models, analyses, guidelines and applications and by performing verification analyses. STUK makes inspection visits to nuclear power plants and organisations involved in the implementation of the PRA. STUK may commission work supporting the review of the PRA from external expert organisations.
- STUK reviews in the extent necessary the updates to the PRA and its applications submitted for information during the nuclear power plant's operation and, where necessary, makes a decision on them. Always in connection with a Periodic Safety Review, STUK performs an extensive review of the adequacy of the PRA and its applications.
- In reviewing the PRA and its applications, STUK qualitatively and quantitatively assesses the adequacy of the quality and scope of the power utility's PRA and its applications.
  - The qualitative review assesses whether the data, methods and their results are justified and acceptable and checks the modelling of i.e. initiating events, safety systems, auxiliary systems and operator actions.
  - The quantitative review assesses the most important numerical results, the computation of accident sequences and the associated uncertainty and sensitivity analyses.

Q.4 If Fire PRAs are being developed and applied, what methodological guidance is being used and what issues/limitations have been identified, if any, with these methods?

Fire PRA was started in Finland in the 1980's utilizing available international fire data and some foreign Fire PRAs as examples. EPRI/NUREG reports (fire frequencies) have been partially utilized when the Fire PRAs have been developed further through the years. In most cases conservative assumptions are applied: fire may impact all vulnerable equipment inside the compartment (no further modelling). Some expert judgements on fire propagation (also utilizing fire event data or experimental fire test results) have been applied. Fire simulations have been done for the most important compartments only (e.g. cable fires, I&C cabinet fires and large oil pool fire in the turbine hall).

Especially severe fire events around the world are important to realize possible consequences of fires and to avoid optimistic assumptions/limitations (e.g. to realize possible scope of direct, indirect and consequential failures).

STUK does not specify methodologies to be used for PRA.

Smoke impact on electronics is a potential uncertainty issue considering fires in the I&C cabinet rooms.

4.3.5 France

Q.1 Are the NPP fire protection regulations in your country based on prescriptive (deterministic) principles or performance-based risk-informed methods?

The order laying down general rules for Basic Nuclear Installation (BNI), said Order of 7 February, 2012 setting the general rules relative to basic nuclear installations [FRA-

02],was published in the Official Journal on 7 February 2012. It is a major element of this approach. This includes in particular the French law rules corresponding to international best practices. The provisions of the order BNI are mainly dealing in the organization and responsibilities of the Basic Nuclear Installation operators, demonstration nuclear safety, nuisance control and their impact on health and the environment, waste management and the preparation and management of emergency situations.

The ASN resolution No 2014-DC-0417 of 28th January 2014 concerning the rules applicable to BNI with regard to management of fire risks [FRA-03] concerning the rules applicable to BNI with regard to management of fire risks is applicable since 1st July 2014.

Q.2 Are Fire PRAs used to support license applications?

Yes, in France, the licensee may use PSA to complete the nuclear safety demonstration, but he must have first a deterministic approach. By instance, EDF has used PSA to support his demonstration about the EPR.

Q.3 How does the regulator inspect and ensure the quality of the Fire PRA supporting the license amendment?

EDF Fire PSA is reviewed by IRSN during the Periodic Safety Reviews. IRSN also develops independent focused Fire PSA, which allows to compare results and main assumptions.

Q.4 If Fire PRAs are being developed and applied, what methodological guidance is being used and what issues/limitations have been identified, if any, with these methods?

EDF and IRSN Fire PSA methods are inspired by NUREG/CR-6850 [NRC-08] recommended methods. Specific methodological aspects were adapted by IRSN/EDF in order to better fit specific needs (for example to focus the Fire PSA on specific aspects, human errors evaluation taking into account fire procedures; etc.) or operating experience (for example, fire spreading probability assessment, cable fire initiation, etc.).

4.3.6 Germany

Q.1 Are the NPP fire protection regulations in your country based on prescriptive (deterministic) principles or performance-based risk-informed methods?

The NPP fire protection regulations in Germany are both, however traditionally the regulation is mainly prescriptive.]

The most recent German nuclear regulations, the so-called “Safety Requirements for Nuclear Power Plants [BMU-15] covering also (in a separate Appendix) internal hazards such as plant internal fires are in general prescriptive based on deterministic safety principles. However, these requirements also include probabilistic safety assessment supplementing the deterministic assessment. The subordinate nuclear fire protection standards KTA-2101, Part 1 to 3 [KTA-15], [KTA-15a], [KTA-15b] are again mainly prescriptive, but use probabilistic arguments and evidence given by risk-informed approaches.

Q.2 Are Fire PRAs used to support license applications?

Yes, either complete Level 1 Fire PSA (for power operation as well as for low power and shutdown plant operational states) or application case based probabilistic studies are used in the frame of regulatory oversight in addition to deterministic analyses. The main benefit of such analyses is to compare e.g. the existing situation in a plant and to demonstrate if and in how far a proposed modification (not only of plants SSC but also of procedures or both) will increase or decrease the plant safety with respect to fires.

Q.3 How does the regulator inspect and ensure the quality of the Fire PRA supporting the license amendment?

On behalf of the local state regulatory body in charge of nuclear oversight of the plant under investigation experts from the corresponding technical expert/safety organization(s), such as TÜV and/or GRS review the Fire PSA carried out by the licensee or its consultants in detail, performing as far as necessary also own calculations. These reviews are based on the German PSA Guide [BMU-05] and its technical supplements on PSA methods and data [FAK-05], [FAK-05a], [FAK-16] considering also international guidance, e.g. from IAEA [IAEA-10].

Q.4 If Fire PRAs are being developed and applied, what methodological guidance is being used and what issues/limitations have been identified, if any, with these methods?

For Fire PSA to be carried out in Germany, in particular in the frame of the Periodic Safety Reviews (PSR), the German PSA Guide [BMU-05] and its Supporting Technical Documents on PSA Methods and Data [FAK-05], [FAK-05a], [FAK-16] are used providing state-of-the-art guidance on Fire PSA methods and data to be used. These guidance documents do not provide detailed guidance in how far detailed fire modelling needs to be performed and which fire simulation codes are suitable for the scenarios to be investigated in detail. However, uncertainty and sensitivity analyses have to be carried out, e.g. by the GRS code SUSA, in order to give indications on the level of conservatism of the Fire PSA.

4.3.7 Japan

Q.1 Are the NPP fire protection regulations in your country based on prescriptive (deterministic) principles or performance-based risk-informed methods?

The regulations are prescriptive. NRA has established the NRA Ordinance on Standards for the Location, Structures and Equipment of Commercial Power Reactors Article 8 (Design Considerations against Fire) [JPN-04] for fire protection. As for Article 8, the nuclear reactor facilities shall be designed such that their safety will not be impaired by fire considering protective measures for preventing, detecting and fire suppression, and mitigating its effect, independently. These protective measures shall also be designed such as not to impair the required functions of SSCs with safety functions as a result of their failure or malfunction.

Q.2 Are Fire PRAs used to support license applications?

No. Fire PRAs are not used.

Q.3 How does the regulator inspect and ensure the quality of the Fire PRA supporting the license amendment?

Fire PRAs are not used to support the license amendment.

Q.4 If Fire PRAs are being developed and applied, what methodological guidance is being used and what issues/limitations have been identified, if any, with these methods?

Examples of guidance are provided in the following; however, how to use it is not yet decided at present.

- Fire PRA Guide for Japanese nuclear industry developed by Nuclear Risk Research Center (NRRC) of Central Research Institute of the Electric Power Industry (CRIEPI),
- Implementation standard concerning the internal fire probabilistic risk assessment of nuclear power plants developed by the Atomic Energy Society of Japan,
- EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities (NUREG/CR-6850, EPRI 101-1989, Volumes 1 and 2), developed by U.S. NRC [NRC-08].

4.3.8 Korea

Q.1 Are the NPP fire protection regulations in your country based on prescriptive (deterministic) principles or performance-based risk-informed methods?

The NPP fire protection regulations in Korea are prescriptive.

Fire protection regulations for NPPs in Korea are based on a prescriptive regulatory guideline, KINS/RG-N10.06 (Fire protection in Nuclear Power Plants) [KOR-06], which includes comprehensive requirements related to fire protection plan with fire hazard / fire safe shutdown analysis. NFPA 803 [NFPA-98] and NFPA 804 [NFPA-15] are used as a regulatory requirement /plant-specific license condition by KINS/RG-N10.06 [KOR-06]. After approval of implementing NFPA 805 [NFPA-01], one-point exemption for a specific requirement of fire protection is accepted by regulatory body, Nuclear Safety and Secure Commission, using performance-based risk-informed methods, NFPA 805.

Q.2 Are Fire PRAs used to support license applications?

The results or insight of Fire PRA are not yet used to support license applications in Korea, but Fire PRA are only performed as a regulatory process of Periodic Safety Review and severe accident policy in Korea.

Q.3 How does the regulator inspect and ensure the quality of the Fire PRA supporting the license amendment?

The detailed method to ensure the quality of Fire PRA is not yet established in Korea. But international requirements such as NUREG and IAEA documents will be used to establish the guideline for reviewing Fire PRA submittal. Plant walk-down and a few sample verification reviews for Fire PRA model will be included in detailed method in Korea.

Q.4 If Fire PRAs are being developed and applied, what methodological guidance is being used and what issues/limitations have been identified, if any, with these methods?

NUREG/CR-6850 (EPRI 1011989) [NRC-08] methods will be used as the baseline methodological guidance in Korea.

4.3.9 The Netherlands

Q.1 Are the NPP fire protection regulations in your country based on prescriptive (deterministic) principles or performance-based risk-informed methods?

The NPP fire protection regulations in the Netherlands are both, prescriptive and performance-based. There is a uniform regulatory approach harmonizing all parts of fire protection standards, based mainly on (prescriptive) deterministic requirements also considering probabilistic requirements, for the assessment of reliability.

Q.2 Are Fire PRAs used to support license applications?

Yes; the licensee includes a license condition with regard to “Safety Analysis” and the licensees are required to comply with IAEA documents for Probabilistic Safety Assessment for Nuclear Power Plants [IAEA-10], [IAEA-10a]. The Borssele NPP has also a full scope Level 3 Probabilistic Safety Assessment (PSA) which includes internal and external hazard initiators.

Q.3 How does the regulator inspect and ensure the quality of the Fire PRA supporting the license amendment?

Licensees are requested to carry out the Periodic Safety Review (PSR) to incorporate the state-of-the-art knowledge into the plant design, operation and maintenance activities. A review of operational safety aspects must be performed once every two years, whilst a more comprehensive safety review must be conducted once every ten years.

Upon request of ANVS, in-depth international team reviews are also carried out by bodies such as the IAEA (OSART, Fire Safety, IPSART [NED-12], [NED-13], etc.). ANVS carries out inspections or team audits from time to time. In addition, the Borssele nuclear plant itself carries out self-assessments at regular intervals and invites others like WANO to perform assessments.

Q.4 If Fire PRAs are being developed and applied, what methodological guidance is being used and what issues/limitations have been identified, if any, with these methods?

NUREG/CR-6850 [NRC-08] is used as the methodological guidance for Fire PSA in the Netherlands. This is not enforced by the regulation but acknowledged by the regulatory body. Development of probabilistic-logic model and implementation of quantitative calculations are performed using the software WinNUPRA 4.0 [SCI-06] applying event/fault tree methodology.

4.3.10 Spain

Q.1 Are the NPP fire protection regulations in your country based on prescriptive (deterministic) principles or performance-based risk-informed methods?

The regulations in Spain are prescriptive/both.

Currently, Safety Instruction IS-30 [SPN-05] is the regulatory standard for fire protection in nuclear power plants and is a deterministic regulation endorsing 10 CFR 50.48 [NRC-04], [NRC-07] requirements. However, the IS-30 itself includes the statement that some of its provisions may be accomplished under risk-informed performance-based analysis carried out under a methodology accepted by the regulator, i.e. the NFPA-805 [NFPA-01]. This approach requires a license amendment application from the licensee.

Q.2 Are Fire PRAs used to support license applications?

Fire PRAs for all operation modes are required in all power stations. Additionally, for licensees who have used these analyses in support of their performance-based applications to meet IS-30 [SPN-05] provisions these PSA’s are required to meet the NUREG/CR-6850 methodology [NRC-08] or at power operating mode.

Q.3 How does the regulator inspect and ensure the quality of the Fire PRA supporting the license amendment?

The review process is under a step-by-step implementation of standardized quality features, as ASME/ANS RA-Sa-2009 [ANS-09] shows. On top of that, RG 1.200 [NRC-12] is used as a guidance to determine the quality level of the PSA. Additionally, CSN performs an independent review of the Fire PRA. In this process, particular attention is given to the conclusions from the peer-review process from an independent expert panel that is also required to plants transitioning to NFPA 805 [NFPA-01].

Q.4 If Fire PRAs are being developed and applied, what methodological guidance is being used and what issues/limitations have been identified, if any, with these methods?

As answered above, NUREG/CR-6850 [NRC 08] is being adopted as the standard Fire PRA methodology.

4.3.11 Sweden

Q.1 Are the NPP fire protection regulations in your country based on prescriptive (deterministic) principles or performance-based risk-informed methods?

The NPP fire protection regulations in Sweden are prescriptive (deterministic).

SSMFS 2008:17 [SSM-09a-] specifies amongst others that fire protection provisions in nuclear facilities have to ensure that:

- the design of a facility are able to withstand a fire event and its consequences;
- fire events included in the deterministic safety analysis are divided into a limited number of event classes with specified analysis assumptions and acceptance criteria.

SSMFS 2008:1 [SSM-09] specifies amongst others that fire protection provisions in nuclear facilities have to ensure that the capacity of a facility's barriers and defense-in-depth system to prevent radiological accidents and mitigate the consequences in the event of an accident are analyzed using deterministic methods before the facility is constructed or modified and taken into operation.

Q.2 Are Fire PRAs used to support license applications?

Yes, SSMFS 2008:1 [SSM-09] specifies that in addition to deterministic analyses the facility shall be analyzed using probabilistic methods in order to obtain as comprehensive view as possible of safety. Consequently, fire needs to be included in the scope of the licensees´ PSAs.

Q.3 How does the regulator inspect and ensure the quality of the Fire PRA supporting the license amendment?

SSM reviews the PSAs rather briefly. SSM make sure that the licensees have the necessary conditions (competence, suitability, adequate time and resources etc.) needed to ensure the quality.

Q.4 If Fire PRAs are being developed and applied, what methodological guidance is being used and what issues/limitations have been identified, if any, with these methods?

SSM does not require use of a specific guide or method. The used methods are conservative and bounding (room based, all equipment assumed to fail). The licensees state that parts of the Fire PSA methods are influenced by NUREG/CR-6850 [NRC-08].

4.3.12 Switzerland

Q.1 Are the NPP fire protection regulations in your country based on prescriptive (deterministic) principles or performance-based risk-informed methods?

The regulations in Switzerland are prescriptive.

Fire protection in nuclear installations in Switzerland is governed by guideline HSK-R-50 "Requirements Important to Safety for Fire Protection in Nuclear Installations" [HSK-03], and rules on the detailed arrangements of fire protection measures are developed by the cantonal fire insurers. However, Fire PSA is a mandatory part of the Level 1 and Level 2 PSAs for developed for NPPs. The applications of the risk measures developed, include among others, restrictions on their total magnitude and requirements for a balanced risk profile. These provisions limit the permissible risk of fire to nuclear safety, even though they may not specifically target fire.

Q.2 Are Fire PRAs used to support license applications?

There are applications of CDF, FDF and LERF for license amendments such as changes of SSCs or revisions of Technical Specifications with regard to completion times and permissible maintenance configurations during operation. While these do not imply specific requirements regarding fire protection, the Fire PSA does constitute an integral part of the PSAs performed to derive those risk measures, so any effect of fire risk in licensing applications needs to be addressed.

Q.3 How does the regulator inspect and ensure the quality of the Fire PRA supporting the license amendment?

ENSI reviews the PSAs of the NPPs in their entirety in the context of the PSRs due once in a decade. Where the licensee chooses to implement significant changes in the modelling, these are typically reviewed directly after their submittal. Thus, at the time of submittal of license amendment request only model changes directly related to the proposed amendment need to be reviewed.

Q.4 If Fire PRAs are being developed and applied, what methodological guidance is being used and what issues/limitations have been identified, if any, with these methods?

All PSAs for Swiss NPPs are developed according to guideline ENSI-A05 [ENSI-18a]. As far as development and modelling of scenarios is concerned, licensees are free in their choice of methodology provided that the suggested solution ensures a level of quality as required in the guideline ENSI-A05 [ENSI-18a]. Most of the licensees opt for NUREG/CR-6850 [NRC-08] and the more recent work under the auspices of EPRI and the U.S.NRC to clarify and update the guidance.

4.3.13 United Kingdom

Q.1 Are the NPP fire protection regulations in your country based on prescriptive (deterministic) principles or performance-based risk-informed methods?

The NPP fire regulations in the United Kingdom (UK) are both, prescriptive and performance-based.

NFPA 805 [NFPA-01] is not used as a regulatory requirement or for licensing basis in the UK. In general, the UK looks toward both British Standards and to a goal setting risk-informed method for NPP fire protection regulation.

Some aspects of fire safety on an NPP, such as those which relate to conventional fire safety may have some prescriptive elements. Where nuclear fire and conventional fire safety clash, the consequences and risks are compared, and measures put in place to ensure all fire risks are reduced so far as is reasonably practical (SFAIRP). An analogous term, as low as reasonably practicable (ALARP), is frequently used in the nuclear context.

UK regulation is primarily goal setting in nature and requires that the licensee demonstrate ALARP through adoption of relevant good practice (RGP) and any other risk reduction methods as may be applicable.

The primary conventional fire safety legislation for the UK includes the Regulatory Reform (Fire Safety) Order 2005 [UK-06] in England and Wales, the Fire Safety (Scotland) Regulations 2006 [UK-07] and the Fire Safety Regulations (Northern Ireland) 2010 [UK-08].

The Office for Nuclear Regulation (ONR) establishes guidance in the form of published Safety Assessment Principles (SAPs) and Technical Assessment Guides (TAGs).

ONR SAPs expect the use of risk-based approaches but do not prescribe a risk-based fire protection program as specified in NFPA 805 [NFPA-01]. Relevant British Standards, which may be prescriptive in nature, are used as a baseline for conventional fire safety aspects from which RGP is determined.

Q.2 Are Fire PRAs used to support license applications?

To a limited extent: the station safety reports prepared at the time of licensing for the more modern UK NPPs have PSAs (probabilistic safety assessments) that include risk estimates for hazards, including fire. These have been maintained throughout station life.

The older AGR (advanced gas cooled reactors) include an estimate of the risk from fire and are not modern Fire PSAs, but a probabilistic representation of the deterministic safety case.

Nevertheless, a pilot Fire PSA was carried out for one of the AGRs in the middle 2000s. This was extensive and included cable tracing and confirmation of the fire zones and their interfaces and penetrations. It was carried out against current IAEA Fire PSA guidance. The exercise gave some learning points but was largely confirmatory of the soundness of the deterministic fire safety case.

New build reactors are expected to produce a PSA consistent with modern standards, including a Fire PSA. This is often developed before construction but must be before operation.

In general, evidence that relevant good practice has been adopted with respect to the NUREG guidance, Fire PSA standard or the ONR TAG on PSA, NS-TAST-GD-030 (TAG-030) - Probabilistic Safety Analysis [ONR-16] must support license applications. Other TAGs which relate to fire aspects include: NS-TAST-GD-013 (TAG-13) – External Hazards [ONR-16a] and NS-TAST-GD-014 (TAG 14) – Internal Hazards [ONR-18a].

It is not the intention of Appendix 1 of TAG-030 to prescribe specific methods and approaches for conducting PSA for NPPs. Dutyholders may choose to use alternative methods to those covered in this Appendix as long as they are shown to lead to equally valid outcomes. In cases where the PSA or specific areas of it have been undertaken using alternative approaches, ONR will review on a case-by-case basis and judge each on its own merits.

The site license conditions give a legal framework which can be drawn on in assessment and are, in general, set out in the form of requiring the licensee to make adequate arrangements, in the interests of safety, to secure certain objectives. The principal license conditions (LCs) relevant to PSA are LC14, LC23, LC27 and LC28.

LC14 requires the licensee to make and implement adequate arrangements for the production and assessment of safety cases. Normally, the licensee's safety case will need to contain PSA as well as deterministic analysis.

LC23 requires that the safety case identifies the conditions and limits necessary in the interest of safety. The SAPs, which convey ONR's expectations, state that design basis and beyond design basis analysis should apply an appropriate combination of engineering, deterministic and probabilistic methods.

ONR expects that PSA will contribute to the identification of suitable and sufficient safety mechanisms, devices and circuits, as required by LC27 and provide a significant input for LC28 in identifying plant that may affect safety for which regular, systematic examination, inspection, maintenance and testing will be required.

When preparing modifications to the existing safety cases in areas relevant to fire hazards, licensees have looked at the effect on nuclear risks - in some cases by using their PSA as a tool to show the effect on risks.

The methods and details of analysis that would be acceptable to ONR may be different at various life-cycle stages, as an existing facility may be able to offer operating experience and feedback as an alternative to detailed analysis which is not possible for a new-build facility.

Q.3 How does the regulator inspect and ensure the quality of the Fire PRA supporting the license amendment?

The ONR carries out an assessment of the Fire PRA submitted to determine whether it meets national and international standards and guidance as identified in Appendix 1 – Assessment Expectations for Review of PSAs for Nuclear Power Plants of ONR TAG-030 [ONR-16] (this includes IAEA and NUREG standards). Additional guidance is provided by ONR TAG-014 – Internal Hazards [ONR-16a], and TAG-013 – External Hazards [ONR-18a].

Q.4 If Fire PRAs are being developed and applied, what methodological guidance is being used and what issues/limitations have been identified, if any, with these methods?

Methodological guidance is provided in ONR TAG-030 - Probabilistic Safety Analysis [ONR-16], which includes reference to International Atomic Energy standards and other international guidance. Additional guidance is provided by ONR TAG-014 – Internal Hazards[ONR-16a], and TAG-013 – External Hazards [ONR-18a].

Due to the option of using alternate methods, one challenge is the determination of the equivalency of an alternate method to the listed accepted methods within Appendix 1 – Assessment Expectations for Review of PSAs for Nuclear Power Plants of TAG-030 [ONR-16].

One issue with some methods is determining initiating event frequencies for different types of fire events. Evidence of incorporation of learning from previous PSAs can be a challenge when determining the adequacy of a Fire PSA.

4.3.14 United States of America

Q.1 Are the NPP fire protection regulations in your country based on prescriptive (deterministic) principles or performance-based risk-informed methods?

The NPPs have the option of using either type of fire protection regulations in the United States:

- **Prescriptive (deterministic) -** The NRC uses regulation to ensure U.S. nuclear power plants are safe. Since the deterministic fire protection requirements were established, no fires have challenged safe shutdown. Every plant must have a fire protection plan that satisfies 10 CFR Part 50, Appendix A [NRC-01], Criterion 3 and 10 CFR 50.48(a) [NRC-09]. The fire protection plan must outline the overall fire protection program, installed fire protection systems, and the means to ensure that the reactor can be safely shutdown in the event of a fire.

  Plants that were licensed before January 1, 1979 were also subject to the prescriptive requirements of 10 CFR 50.48(b) and Appendix R [NRC-02]. Plants that were licensed after January 1, 1979 typically followed the same prescriptive requirements to demonstrate conformance with the fire protection regulations. These requirements were based on an assumed serious fire, where generic criteria were established for all plants. In cases where these requirements were not practical, or there was a more favourable approach to achieving an equivalent level of safety, applicants and licensees sought alternatives, typically through specific exemptions and amendments.

  For example, one of the prescriptive requirements related to the fire protection requirements for safe shutdown capability. This regulation requires that one train of systems necessary to achieve and maintain hot shutdown is free of fire damage. The regulation prescribes that the trains will have:

  - a three-hour barrier between them,
  - 20' of separation, automatic fire suppression, and fire detection, or
  - a one-hour barrier between them, automatic fire suppression, and fire detection.

- **Risk Informed -** In 2004, the NRC amended its fire protection requirements in 10 CFR 50.48 to add 10 CFR 50.48(c) [NRC-09] to allow licensees to adopt, on a voluntary basis, the 2001 edition of the National Fire Protection Association Standard 805, "Performance-Based Standard for Fire Protection for Light-Water Reactor Electric

Generating Plants" (NFPA 805 [NFPA-01]), in lieu of their existing fire protection licensing basis. This approach offers plants the opportunity to use a new and scientifically sound way of reducing fire risks further.

NFPA 805 is part of an NRC effort to incorporate risk information into the agency's regulations and enhance safety. The risk-informed performance-based approach considers risk insights as well as other factors to better focus attention and resources on design and operational issues according to their importance to safety. This approach relies on a required outcome rather than requiring a specific process or technique to achieve that outcome. It allows licensees to focus their fire protection activities on the areas of greatest risk.

NFPA 805 enables leveraging the state-of-the-art in fire protection evaluation techniques to maintain and enhance safety. It establishes a fundamental fire protection program and design requirements for fire protection systems and features, including prevention, fire detection and suppression, and safe shutdown. It allows nuclear safety performance criteria to be satisfied by using both fire modelling and quantitative fire risk evaluation. By using this approach, resources can be focused on higher risk areas.

Q.2 Are Fire PRAs used to support license applications?

Yes, Fire PRAs are used to support license applications.

Q.3 How does the regulator inspect and ensure the quality of the Fire PRA supporting the license amendment?

The NRC reviews the transition plan and schedules. If the plans and schedules are approved, the licensee then submits a license amendment request (LAR) that requests use of a NFPA 805 [NFPA-01] licensing basis. The staff reviews the LAR and writes a safety evaluation report approving or disapproving the license amendment. Throughout the transition period, the NRC has the ability to grant the licensee enforcement discretion, which means that the licensee will not receive violations for those potential non-compliances found during the transition that are not of high safety-significance.

The NRC typically allows a licensee up to three years to submit the LAR to transition to NFPA 805 [NFPA-01]. During the transition and subsequent LAR review period, the NRC continues to monitor individual licensee actions to address plant-specific fire protection technical issues through its Reactor Oversight Process (ROP) (**https://www.nrc.gov/reactors/operating/oversight.html)**.

Q.4 If Fire PRAs are being developed and applied, what methodological guidance is being used and what issues/limitations have been identified, if any, with these methods?

One of the primary tools used to support Fire PRAs in the United States was developed by the NRC Office of Nuclear Regulatory Research (RES) and the Electrical Power Research Institute (EPRI). NUREG/CR-6850/EPRI 1011989, "EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities" published in 2005 [NRC-08] and Supplement 1 to NUREG/CR6850 and EPRI 1011989 published in 2009 [NRC-13] document Fire PSA methods, tools, and data to support risk assessments and discusses methods to perform fire risk analyses. The methodologies presented in these two documents have been enhanced and updated by recent NUREG publications including but not limited to:

– NUREG/CR-7150 (JACQUE-FIRE), EPRI 1026424 - Joint Assessment of Cable Damage and Quantification of Effects from Fire; Volumes 1-3 [NRC-16];

– NUREG/CR-7010 (CHRISTI-FIRE) - Cable Heat Release, Ignition, and Spread in Tray Installations During Fire [NRC-23];

- NUREG/CR-7100 (DESIREE-Fire) - Direct Current Electrical Shorting in Response to Exposure Fire [NRC-17];
- NUREG/CR-6931 (CAROLFIRE) - Cable Response to Live Fire [NRC-10];
- NUREG-1824 and NUREG-1824 Supplement 1; EPRI 3002002182 - Verification and Validation of Selected Fire Models for Nuclear Power Plant Applications [NRC-24];
- NUREG/CR-7114 - A Framework for Low Power/Shutdown Fire PRA [NRC-19];
- NUREG-1921, EPRI 1023001 - Fire Human Reliability Analysis Guidelines [NRC-18];
- NUREG-2169; EPRI 3002002936 - Nuclear Power Plant Fire Ignition Frequency and Non-Suppression Probability Estimation Using the Updated Fire Events Database [NRC-22];
- NUREG/CR-7197 (HELEN-FIRE) - Heat Release Rates of Electrical Enclosure Fires, Final Report [NRC-25];
- NUREG-2178, EPRI 3002005578 (RACHELLE-FIRE) - Refining And Characterizing Heat Release Rates From Electrical Enclosures During Fire — Volume 1: Peak Heat Release Rates and Effect of Obstructed Plume [NRC-30];
- NUREG-2180 (DELORES-VEWFIRE); - Determining the Effectiveness, Limitations, and Operator Response for Very Early Warning Fire Detection Systems in Nuclear Facilities [NRC-27];
- NUREG-1934; EPRI 1023259 - Nuclear Power Plant Fire Modelling Analysis Guidelines (NPP FIRE MAG) [NRC-29];
- NUREG-2178; EPRI 3002016052 (RACHELLE-FIRE) - Refining and Characterizing Heat Release Rates From Electrical Enclosures During Fire — Volume 2: Fire Modelling Guidance for Electrical Cabinets, Electric Motors, Indoor Dry Transformers, and the Main Control Board [NRC-30];
- NUREG-2230; EPRI 3002016051 – Methodology for Modelling Fire Growth and Suppression Response for Electrical Cabinet Fires in Nuclear Power Plants [NRC-31];
- NUREG-2232; EPRI 3002015997 - Heat Release Rate and Fire Characteristics of Fuels Representative of Typical Transient Fire Events in Nuclear Power Plants [NRC-32];
- NUREG-2233; EPRI 3002016054 - Methodology for Modelling Transient Fires in Nuclear Power Plant Fire Probabilistic Risk Assessment [NRC-33].

These documents provide methods, tools and data for use in a PRA model however do not become part of a licensing basis until they are used and approved by the AHJ during a license amendment request (LAR) and subsequent reviews prior to the issuance of a safety evaluation report.

Additional guidance on PSA quality is provided in Regulatory Guide 1.174 [NRC-15] and Regulatory Guide 1.200, “An Approach for Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities,” dated February 2004, [NRC-12]. In addition, The American Nuclear Society (ANS) issued a standard [ANS-09] for evaluating the technical adequacy of each plant’s fire risk assessment for regulatory applications. The ANS standard is intended to provide the necessary information for determining the technical adequacy of the licensee’s fire risk analyses for regulatory applications.

NFPA 805 [NFPA-01] requires that the PSA approach, methods, and data must be acceptable to the authority having jurisdiction (AHJ). In the case of the United States, the AHJ is the U.S. NRC. This regulatory position provides guidance with respect to acceptability of the approaches, methods and data used for the PSA approach. Additional guidance for the PSA approach is provided by NEI 04-02 [NEI 05a], including Sections 5.1.3, 5.3.4, J.4, and J.5.

Licensees should justify that the methods that the NRC finds acceptable for use in meeting NFPA 805 [NFPA-01] requirements are appropriate for each specific application. These analyses may use screening methods or more complex quantitative PSA methods, depending on the specific conditions of the scenario being evaluated. When licensees choose to rely on information in an internal events-based PSA model to quantify risk associated with fires, they should review the analysis to ensure that the model addresses applicable NFPA 805 requirements, including the engineering analysis requirements in Section 2.4.2 of NFPA 805. Based on the review, the licensee should modify its internal events-based PSA model, as necessary, to meet applicable NFPA 805 requirements.

5 CONCLUSIONS AND RECOMMENDATIONS

Based on the contributions by the Organisation for Economic Co-operation and Development/Nuclear Energy Agency (OECD/NEA) Fire Incidents Records Exchange (FIRE) Database Project, member countries' significant efforts and resources have been allocated to the regulatory programs associated with fire protection regulations. Many countries ensure that the requirements of the country-specific regulation are met and the fire protection codes and standards are followed by implementing a fire protection program for all operational stages of the facilities. The fire protection program demonstrates that fire protection measures are implemented in a controlled, coordinated, and effective manner to protect the health and safety of people and the environment from fire events.

In recent years, a significant amount of work has been initiated into regulatory activities based on a risk-informed approach and the development of new regulatory structures to take advantage of this advancement.

5.1 General Conclusions

This Topical Report presents at a high level the processes and methods each country undertakes to meet specific regulatory goals related to fire safety. It highlights that the 14 FIRE member countries employ various defense-in-depth approaches for ensuring nuclear safety and that the plant can be safely shut down in the event of a fire.

This Topical Report provides a valuable tool to the members of the OECD/NEA FIRE Database Project to aid in the development of future Topical Reports. It can, for instance, be used in supporting the currently ongoing investigations with respect to fire brigade effectiveness and implementation strategies including country-specific approaches to fire brigade and fire suppression techniques. Details include to investigate if and in how far according to the national fire safety regulations in place professional onsite versus offsite fire brigades are used and evaluate challenges and impact on non-suppression probabilities for the two approaches. A unified source for information on regulatory requirements allows for effective searching for the regulatory source materials from each member country and compiling relevant information to inform future Topical Reports.

One general conclusion from the survey questionnaire is that a wide range of countries are using both some form of prescriptive as well as risk-informed methodological approaches to carry out their regulatory framework related to fire safety. The general trend among member countries is moving towards using Fire PSA as a tool for gaining valuable risk insights regardless of regulatory framework guidelines. This trend supports the conclusions from several investigations of the level of maturity for Fire PSA that more recently (cf. [NEA 19]) has amongst others been an area of interest of the OECD/NEA Committee on the Safety of Nuclear Installations (CSNI) Working Group on Risk Assessment (WGRISK).

5.2 Recommendations to the FIRE Database Project

High-quality PSA reviews in member countries largely rely on online plant inspections, sensitivity and uncertainty studies, and various international standards to ensure the assumptions and quality meet corresponding member country standards. These inspections were generally conforming to various international standards such as the International Atomic Energy Agency (IAEA) guidelines and further guidance documents such as the American Society of Mechanical Engineers /American Nuclear Society PRA Standards, NUREG publications, and various methodologies for peer reviews. The complexity of Fire PSA methodologies is clearly highlighted through the level of effort described in the quality review responses. Review of plant-specific Fire PSA methodology assumptions and model choices has been shown to require substantial resources.

In the future, the FIRE Database may be extended as a mechanism for efficient feedback on fire event experience including the development of additional measures for prevention and oversight activities. In addition, the Database may be used to focus on events that document failures of fire protection features to be used as a data source reliability. It may also be used for reviewing observations and findings from inspections of nuclear power plant fire protection programs.

Updates of the Topical Report are to be foreseen in case of changes in the national standards and regulations of FIRE Database Project member countries.

5.3 Recommendations to CSNI and CNRA

This Topical Report provides an overview on the range of fire-related regulations in a broad sample of OECD/NEA members countries representative for different types of reactors and fire safety programs in place. Many of the results and insights of this activities reflect the actual progress in the expert community dealing with fire hazards considering from various fire incidents in OECD/NEA member countries. This also underlines the value of operating experience information to decisionmakers.

Based on the aforementioned insights, it is recommended to the CSNI and the Committee for Nuclear Regulatory Activities to

(1) Consider supporting further joint Working Group or Database Project activities concerning lessons from major operational incidents aiming on enhancing the regulations by operational feedback.

(2) More generally, continue to support efforts to increase interactions between the FIRE Database Project, in particular with the Working Group on Operating Experience and WGRISK, but also with other relevant OECD/NEA Working Groups.

(3) Encourage and facilitate cooperation with the IAEA on related activities to address the challenges of fire-related guidance and decision-making.

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APPENDIX A
GERMAN NUCLEAR FIRE AND EXPLOSION STANDARDS KTA 2101.1-3 AND KTA 2103

Safety Standards

of the
Nuclear Safety Standards Commission (KTA)

KTA 2101.1 (2015-11)

Fire Protection in Nuclear Power Plants
Part 1: Basic Requirements

(Brandschutz in Kernkraftwerken
Teil 1: Grundsätze des Brandschutzes)

The previous version of this safety standard was issued in 2000-12

If there is any doubt regarding the information contained in this translation, the German wording shall apply.

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KTA SAFETY STANDARD

November 2015	**Fire Protection in Nuclear Power Plants** **Part 1: Basic Requirements**	KTA 2101.1

Previous versions of the present safety standard: 1985-12 (Banz No. 33a of February 18,1986)
2000-12 (Banz No. 106 a of June 9, 2001 corrected in BAnz No. 239 of December 21, 2007

Contents

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Comments by the Editor:

Taking into **account** the meaning and usage of auxiliary verbs in the German language, in this translation the following agreements are effective:

shall	indicates a mandatory requirement,
shall basically	is used in the case of mandatory requirements to which specific exceptions (and only those!) are permitted. It is a requirement of the KTA that these exceptions - other than those in the case of **shall normally** - are specified in the text of the safety standard,
shall normally	indicates a requirement to which exceptions are allowed. However, exceptions used shall be substantiated during the licensing procedure,
should	indicates a recommendation or an example of good practice,
may	indicates an acceptable or permissible method within the scope of the present safety standard.

Basic Principles

(1) The safety standards of the Nuclear Safety Standards Commission (KTA) have the task of specifying those safety-related requirements which shall be met with regard to precautions to be taken in accordance with the state of science and technology against damage arising from the construction and operation of the plant (Sec. 7, para. (2), subpara. (3) Atomic Energy Act - AtG) in order to attain the protective goals specified in AtG and the Radiological Protection Ordinance (StrlSchV) and further detailed in the Safety Requirements for Nuclear Power Plants (SiAnf) and the SiAnf-Interpretations.

(2) The Safety Requirements for Nuclear Power Plants (SiAnf) Appendix 3 "Internal and external events as well as external hazards" states among others that protective measures against fires inside the nuclear power plant must be provided. The basic requirements regarding fire protection measures are detailed in the present safety standard. The fire protection of civil structures (also called "building structures" or "structural components") is detailed in safety standard KTA 2101.2 and the fire protection of mechanical and electrical components in safety standard KTA 2101.3. All three parts of the safety standard series KTA 2101 must be considered in the planning and execution of fire protection measures. Explosion protection is dealt with in safety standard KTA 2103 and is not subject of the present safety standard.

(3) The following aspects are considered that can influences the occurrence, the propagation and the effects of a fire:

a) fire loads and ignition sources,

b) structural and equipment-related features,

c) possibilities for fire detection and alarms and firefighting.

(4) In this context, corresponding technical and organizational measures are specified. The extent and quality of the measures and the extent of the tests and inspections are determined according to their significance in respect to the fire protection goals specified under Section 1.

(5) The present safety standard is prepared based on the assumption that the building codes, fire protection laws and fire protection regulations of the individual German states (Länder), the German Workplace Ordinance, the German Accident Prevention Regulations (UVV) of the trade unions and other public law regulations are complied with. If the specifics of the nuclear power plant require deviations from laws, ordinances or other public law regulations or from the German Accident Prevention Regulations, then, in each individual case, the particular procedures specified in these regulations regarding deviations and exemptions must be followed.

(6) Certain requirements regarding fire protection are also specified in the following safety standards:

KTA 1201	Requirements for the Operating Manual
KTA 1301.1	Radiation Protection Considerations for Plant Personnel in the Design and Operation of Nuclear Power Plants; Part 1: Design
KTA 1301.2	Radiation Protection Considerations for Plant Personnel in the Design and Operation of Nuclear Power Plants; Part 2: Operation
KTA 1402	Integrated Management Systems for the Safe Operation of Nuclear Power Plants
KTA 1403	Ageing Management in Nuclear Power Plants
KTA 2103	Explosion Protection in Nuclear Power Plants with Light Water Reactors (General and Case-specific Requirements)
KTA 2207	Flood Protection for Nuclear Power Plants
KTA 2501	Structural Waterproofing of Nuclear Power Plants
KTA 3301	Residual Heat Removal Systems of Light Water Reactors
KTA 3403	Cable Penetrations Through the Reactor Containment Vessel
KTA 3501	Reactor Protection System and Monitoring Equipment of the Safety System
KTA 3601	Ventilation Systems in Nuclear Power Plants
KTA 3602	Storage and Handling of Fuel Assemblies and Associated Items in Nuclear Power Plants with Light Water Reactors
KTA 3604	Storage, Handling and Plant-internal Transport of Radioactive Substances in Nuclear Power Plants (with the Exception of Fuel Assemblies)
KTA 3605	Treatment of Radioactively Contaminated Gases in Nuclear Power Plants with Light Water Reactors
KTA 3701	General Requirements for the Electrical Power Supply in Nuclear Power Plants
KTA 3702	Emergency Power Generating Facilities with Diesel Generator Units in Nuclear Power Plants
KTA 3705	Switchgear Facilities, Transformers and Distribution Networks for the Electrical Power Supply of the Safety System in Nuclear Power Plants
KTA 3904	Control Room, Remote Shutdown Station and Local Control Stations in Nuclear Power Plants

(7) Requirements regarding quality assurance are specified in the following safety standards:

KTA 1401	General Requirements Regarding Quality Assurance
KTA 1404	Documentation During the Construction and Operation of Nuclear Power Plants

(8) Requirements regarding alarm facilities and lightning protection facilities are specified in the following safety standards:

KTA 2206	Design of Nuclear Power Plants Against Damaging Effects from Lightning
KTA 3901	Communication Means for Nuclear Power Plants

1 Scope

(1) This safety standard applies to nuclear power plants with light water reactors.

(2) It applies – during building-internal and building-external fires – in all operating phases to

a) the protection of plant components, the function of which are designed and necessary to meet the protective goals and radiological safety goals in accordance with SiAnf, Sec. 2.3 and Sec. 2.5, and which must be maintained, i.e.,

  aa) control of reactivity,

  ab) cooling of fuel assemblies,

  ac) confinement of radioactive materials, and

  ad) limitation of radiation exposure,

  as well as to

b) the protection of personnel working in the plant.

2 Definitions

Note:

Any terms identically defined in the conventional standards (cf. Basic Principles, para. (5)) are not included in the present safety standard.

(1) Acceptance and function test

The acceptance and function test is the testing and assessment of the construction of components and systems including the necessary auxiliary, supply and power systems as well as their functional behavior, these tests being performed within the framework of the accompanying inspections.

(2) Civil structure

A civil structure (also called “structural component” or “building structure”) is a ground-connected structure manufactured from construction products (e.g., building materials, structural elements).

(3) Plant component

A plant component is a structural, mechanical, electrical or process technological or other technical part of a power plant. Synonymous terms: equipment, system.

(4) Plant-internal fire

A plant-internal fire is a fire inside or outside of buildings on the power plant site.

(5) Fire compartment

A fire compartment is the region of the building between outer or inside walls which are designed as fire walls extending over all stories of the building.

(6) Firefighting sub-compartment

Firefighting sub-compartmenst (also called “firefighting sections”) are subsections of fire compartments that, because of an increased fire hazard or for the protection of equipment of the safety system and the emergency system or for the protection of persons are partitioned off by structural elements with a sufficient fire resistance capability such that a fire propagation to, or inadmissible fire effects on, other subsections or separated subsections is prevented.

(7) Fire load density

The fire load density is the sum of the fire loads in a room or a group of rooms divided by the respective floor space.

(8) Fire hazard

A fire hazard is understood to be the possibility of a fire damage without a specific requirement regarding damage extent and probability of occurrence.

(9) Fire hazard analysis (FHA)

A fire hazard analysis is a systematic deterministic analysis for the assessment of a possible threat to the safety of the power plant due to fire as well as of the existing fire protection measures regarding the required protective goals.

(10) Fire Load

The fire load is the combustion energy of combustible materials. It corresponds to the factorial product of mass and calorific value (net combustion heat).

(11) Fire load, protected

A fire load is considered as being protected if it is contained either in a closed system or otherwise enclosed, e.g., in a container. The term “protected fire load” is used exclusively when determining the required fire resistance time of components.

Note:

The determination of the required fire resistance time of structural elements is detailed in Appendix A of safety standard KTA 2101.2. Protected fire loads are further detailed in DIN 18230-1. This term is delimited by the term “encapsulation”, cf. definition (21).

(12) Fire protection, defensive

The defensive fire protection comprises technical firefighting measures for combating dangers to life, health and property caused by a fire.

(13) Fire protection, equipment-related

The equipment-related fire protection comprises components and equipment for fire detection and firefighting, for heat and smoke removal as well the fire protection measures for ventilation systems. The equipment-related fire protection also includes the associated controls and media supplies.

Note:

The equipment-related fire protection measures are not part of the safety system. However, according to the comments relating to the AtSMV (Nuclear Safety Officer and Reporting Ordinance), the fire protection equipment in all structural components containing safety-related systems and components do belong to the other safety-related systems and components.

(14) Fire protection, structural

Structural fire protection comprises building materials and structural elements that, due to their fire behavior and fire resistance prevent the occurrence and propagation of fire and ensure the usability of the rescue routes.

Note:

The structural fire protection measures are not part of the safety system. However, according to the comments relating to the AtSMV (Nuclear Safety Officer and Reporting Ordinance), the fire protection equipment in all civil structures containing safety-related systems and components do belong to the other safety-related systems and components.

(15) Fire protection, operational

The operational fire protection supports the structural and equipment-related fire protection. It serves to prevent the occurrence and propagation of fire and to uphold the usability of the rescue routes, to perform self-help measures in the event of fire and to support the fire department.

(16) Fire protection concept

A fire protection concept is a protective-goal oriented overall assessment of the structural, the equipment-related, the operational and the defensive fire protection measures and their mutual effectiveness.

(17) Equipment

The term “equipment” is considered a synonymous term for “plant component”.

(18) Event

An event is an incident that may impair the safety of a power plant.

N o t e :

These also include internal and external events in accordance with SiAnf.

(19) Postulated event

A postulated event is an incident that may actuate sequential events and that is used as basis for the safety-related design of a nuclear power plant.

(20) Functional capability

Functional capability is the ability of equipment to perform the prescribed task by performing corresponding mechanical, electrical or other functions. Integrity may be considered as such a function.

(21) Encapsulation

Encapsulation is a measure to protect combustible materials or individual equipment such that, in the event of fire within or outside of the encapsulation, an ignition of the materials is prevented, or the equipment is not inadmissibly damaged by the fire. Depending on the requirements, this measure may be implemented with or without a defined fire resistance time.

N o t e :

The term “encapsulation” is delimited by the term “protected fire load”, cf. definition (11).

(22) Rescue route

Rescue routes serve to support the self-rescue and emergency rescue of persons. Rescue routes lead from any place in the room into the open or into a protected area. They also serve as fire access routes for the fire department.

(23) Authorized expert

Authorized expert is an expert person or organization consulted in accordance with Atomic Energy Act, Sec. 20, by the licensing or supervisory authority.

(24) Airlock antechamber

An airlock antechamber is a room provided for the protection of persons before the entrance to the personnel airlock (in accordance with safety standard KTA 3402) in the containment vessel of a pressurized water reactor. It is a protected area.

(25) Safety system

The safety system comprises all equipment that have the task of protecting the facility from an inadmissible event and, when a design basis accident occurs, of keeping the effects on the facility, on the environment and on the plant personnel within specified limits.

(26) System

The term “system” is considered a synonymous term for “plant component”.

(27) Design review

Design review is the assessment of the original or changed documents prepared for manufacturing (e.g., plans, written instructions, drawings, calculations or proofs) with regard to their fulfilling legal directives and the requirements specified in standards.

(26) Ignition Sources

An ignition sources is a permanently or temporarily available possibility in an area of the plant which could release the amount of ignition energy required to ignite the existing combustible material.

(27) Random Failure

The random failure is a failure which occurs statistically independent of failures of other similar equipment.

3 Basic Requirements

3.1 General Requirements

(1) It shall be ensured that the fire protection goals specified under Section 1 are not endangered by plant-internal fires and their subsequent effects. This requires providing the following fire protection measures:

a) structural fire protection measures,

b) equipment-related fire protection measures,

c) operation fire protection measures, and

d) defensive fire protection measures.

These fire protection measures shall be specified and documented in a graduated fire protection concept as specified under Section 3.5

(2) To prevent the occurrence and propagation of a fire, fire loads and potential ignition sources shall be reduced to the minimum necessary for the safe operation (as a fire prevention measure).

(3) In this context, unavoidable fire loads shall

a) be – as far as this is structurally and operationally possible for the respective equipment – physically separated from unavoidable potential ignition sources such that a combustion of these fire loads is prevented,

b) be physically separated such that persons present in secured areas (e.g., necessary staircases or airlock antechambers) are not endangered.

c) basically, be physically separated such that the safety system and the emergency system cannot be inadmissibly affected. If such a physical separation is not possible due to system-technological or usage-related requirements, other fire protection measures with an equivalent level of protection shall be provided.

(4) In case of the presence of unavoidable fire loads that cannot be encapsulated, measures shall normally be taken to minimize smoke development (e.g., proper choice of materials).

(5) With regard to the fire hazard analysis specified under para. (8), data shall be gathered on the fire load in each compartment. These data may neglect the fire loads from permanently installed floorings, decontaminable coatings and fire protection coatings as well as negligible fire loads (e.g., flange gaskets, identification labels, paint coatings of technological components). In addition, potential ignition sources shall be identified (e.g., hot components, open switch gear).

(6) Protected fire loads shall be indicated separately in the fire hazard analysis specified under para. (8).

(7) The fire protection measures shall fulfill the requirements specified under Section 3.4 under consideration of the design principles specified under Section 3.2.

(8) A fire hazard analysis (FHA) shall be performed as specified under Section 3.6.

3.2 Design Principles

3.2.1 Fire loads

(1) Basically, only non-combustible building materials shall be used. Exempted are combustible building materials that are unavoidable for reasons of their technical purpose.

(2) Unavoidable combustible building materials shall basically be flame retardant. Exempted are “normally flammable” building materials that are unavoidable for reasons of their technical purpose.

(3) With regard to limiting the flammability, the decontaminable coatings and fire protection coatings shall at least meet the requirements of the “normally flammable” building material class.

(4) Basically, only non-combustible materials shall be used. Exempted are combustible materials that are unavoidable for reasons of their technical purpose.

Note:

Unavoidable combustible materials that are considered to be negligible fire loads are, e.g., flange gaskets, identification labels, paint coatings of technological components.

(5) In their fabricated state, the fire behavior of combustible materials should be comparable to flame retardant building materials.

(6) Inside the containment of light water reactors only such insulation materials of cables shall basically be used that would counteract rapid fire propagation and that, in the event of fire, do not release any corrosive combustion gases. Exemptions are admissible where special electrical requirements (e.g., measurement cables) or special mechanical requirements (e.g., flexibility) must be met. In the case of large assemblies of cables inside the containment that do not have the above characteristics, additional fire protection measures shall be provided.

(7) Basically, only non-combustible operating materials shall be used. Exempted are control fluids and lubricating materials as well as other combustible operating materials that are unavoidable for reasons of their technical purpose.

3.2.2 Occurrence of fire

(1) An ignition of the existing fire loads shall basically be taken into consideration. Exempted are encapsulated fire loads, provided, it is demonstrated that the encapsulation remains functional in the event of fire and the combinations specified under Section 3.3.

Note:

The assumption of the ignition of combustible materials serves to determine the maximum fire effects and, in turn, to determine the required fire resistance time of enclosing structural elements of fire compartment and firefighting sub-compartments. This assumption is not a boundary condition for the fire-development related accident analyses.

(2) Also exempted from the assumption under para. (1) are the combinations under Section 3.3, provided, plausibility considerations show that the combustible material cannot be ignited by the potential ignition sources.

(3) No fires need to be assumed within areas rendered inert, e.g., inerted BWR containment. The conditions of the de-inerting phase shall be considered.

3.2.3 Fire effects

(1) If the function (including equipment-related fire protection) of plant components or parts of civil structures is required even in the event of fire, the fire effects may be demonstrated based on suitable analytic or experimental procedures or based on analogy or plausibility considerations.

(2) The following fire effects shall be considered:

a) heat development in the fire area,

b) heat development outside of the fire area,

c) development and spreading of smoke,

d) flying sparks, burning droplets, and

e) increasing pressure in the fire area.

(3) The proof of fire effects shall at least take the following boundary conditions into consideration:

a) fire loads (even the protected fire loads or taking encapsulation into account),

b) area geometry and type of structural elements,

c) heat sinks and heat sources,

d) ventilation conditions, and

e) possibilities for fire detection and alarms and firefighting under consideration of the sequential development of the fire.

3.2.4 Fire during operating phases with a shutdown reactor

(1) The fire protection measures shall be reviewed with regard to whether they need to be modified or supplemented during this plant condition (modified requirements regarding functionality of safety equipment, additional combustible materials or a change of their location, possible ignition sources during repair work, changed number of personnel).

(2) The additional fire loads usually present during operating phases with a shutdown reactor shall be taken into consideration in selecting the fire protection measures and in performing the fire hazard analysis as specified under Section 3.6.

3.3 Combination of a fire with another event

3.3.1 General requirements

(1) Combinations of a fire with another event shall be assumed if the combined events are in causal relationship or if the simultaneousness of the events must be taken into consideration based on the occurrence probability and extent of damage.

(2) Combinations of a fire with another event shall be considered exclusively with respect to achieving the fire-protection goal specified under Section 1 para. (2) item a). Fire protection measures shall be provided for the considered combinations unless it can be shown that effective and reliable preventive measures have already been installed.

Note:

This requirement details the damage extent indicated above under para. 3.3.1 (1).

(3) It is necessary to distinguish between the following combination types:

a) Combination of causally related events:

aa) Fire and a subsequent event, and

bb) Postulated event and a subsequent fire

b) Combination of causally unrelated events:
Postulated event and causally unrelated fire.

3.3.2 Combination of causally related events

3.3.2.1 Fire and a subsequent event

(1) The following combinations of a fire with a subsequent event shall be considered:

a) Fire and the subsequent failure of components:

aa) Failure (including a high-energy failure) of electrical components and equipment.

ab) Failure of mechanical components (e.g., fast rotating parts, prestressed springs).

ac) Failure (including a high-energy failure) of pressurized pipes and pressure vessels, the inherent failure of which cannot be ruled out.

aca) In the case of pressure vessels, pressurized components and plant components, the inherent failure of which can be ruled out because their quality characteristics, or the failure type of which is limited, measures shall be taken to prevent a fire near these vessels or plant components, or protective measures against the effects from fire events shall be installed, or it shall be demonstrated that, in the event of fire, those quality characteristics ruling out a failure or limiting a failure type are not inadmissibly impaired.

Note:

Such pressure vessels and pressurized components in pressurized water reactors are, e.g., reactor pressure vessel, steam generator, pressurizer, main coolant pumps and accumulators, and, in boiling water reactors, the reactor pressure vessel and the fast shutdown (scram) vessel. The respective plant components are, e.g., the containment, safety-related supports and structural plant components as well as the fuel pool for spent fuel assemblies. Such quality characteristics may be, e.g., utilization of the maximum stress. Limiting a failure type is achieved by, e.g., the basic-safety design in accordance with SiAnf.

acb) In the case of pressure vessels, pressurized components and plant components the inherent failure of which cannot be ruled out, basically, measures shall be taken either to prevent a fire, or to protect these pressure vessels, pressurized components and plant components against the effects from fire events. Alternatively, measures may be provided for the protection of the safety system against the simultaneous effect of a fire and the resultant events from the pressure vessels, pressurized components and plant components caused by the fire.

b) Fire and a resultant plant-internal explosion including radiolysis gas reactions in systems and components.

3.3.2.2 Postulated event and a resultant fire

The following combinations of a postulated event with a resultant fire shall be considered:

a) Component failures and a subsequent fire:

aa) High-energy failures (e.g., electric arcs) of electrical components and equipment (e.g., switch yards, transformers and high-voltage cables).

ab) High-energy failures of mechanical components (e.g., fast rotating parts, prestressed springs).

ac) High-energy failures of pressurized pipes and pressure vessels, the inherent failure of which cannot be ruled out. In this context, if steam is released no occurrence of a fire needs to be postulated.

b) Plant-internal explosion and a subsequent fire:

A plant-internal explosion, the subsequent fire of which inadmissibly affects safety functions shall be prevented. The prevention of safety functions being inadmissibly affected is considered achieved if the requirements in accordance with safety standard KTA 2103 are met.

c) Earthquakes and a subsequent fire:

ca) Inside civil structures which, because of their safety-related significance, shall be designed against earthquakes in accordance with KTA 2201.1, it shall be ensured that effects of a fire resulting from the earthquake are limited to such a degree that the specified normal functions of safety equipment are not inadmissibly affected. This requirement is considered as met if the equipment which, on losing integrity would release combustible materials or could cause ignition, are designed to resist the design-basis earthquake by choosing suitable materials and a proper mechanical design. If a fire cannot be excluded, structure-related fire protection measures shall be installed to ensure the individual safety functions required after an earthquake. If this is not possible due to system-technological or usage-related requirements, an equivalent protection level shall be ensured by the installation of equipment-related fire protection measures (e.g., a fire detection and alarm system) or by a combination of these measures.
The aforementioned structural and equipment-related fire protection measures themselves shall be designed against the design-basis earthquake by choosing suitable materials and a proper mechanical design. Due to the short strong-quake duration in Germany it may be presumed that a subsequent fire will only become effective after the earthquake has subsided.

cb) Insofar as the plant has been designed for a design-basis earthquake with a maximum intensity, I, of VI on the EMS-98 scale (European Macroseismic Scale), it may be assumed that the structural and equipment-related fire protection measures will be available even without sustaining the special design measures.

d) Lightning effects and subsequent fire:
A fire resulting from lightning effects which inadmissibly affects safety functions shall be prevented. The prevention of safety functions being inadmissibly affected is considered achieved if the requirements in accordance with safety standard KTA 2206 are fulfilled.

3.3.3 Combination of unrelated events

(1) Basically, no measures need to be provided for the combination of a presumed fire and the occurrence of an unrelated event.

Note:

This requirement is based on the assumption that

a) the probability of occurrence of such combinations is less than 1×10^{-5} per year,
b) such combinations are prevented by suitable precautionary measures, or
c) the unrelated event will not inadmissibly affect the fire prevention measures.

(2) Measures do have to be provided for the combination of a presumed fire with one of the following presumed events:

a) plant-internal flooding,
b) plant-internal or external electromagnetic events (except lightning),
c) earthquakes (including subsequent effects),
d) flood (high water), or
e) additional site-specific external events.

(3) Within one week from the occurrence of an event specified under para. (2), the fire protection measures necessary for achieving the fire protection goal specified under Section 1, para. (2), item a), in case of such a combination shall

either be again made available or shall be replaced by other suitable measures.

Note:

By observing the waiting period of one week, the probability of occurrence of the combination fire with the events specified under para. (2) is reduced to less than 1 × 10^{-5} per year.

(4) It is a valid presumption for the combination of a fire with an event specified under para. (2) above, that the measures specified under para. (3) can be provided within one week.

3.4 Requirements for Fire Protection Measures

3.4.1 General requirements

(1) Structural fire protection measures shall be given priority over equipment-related fire protection measures. If the structural measures cannot be provided to the extent that, in the event of fire, the required protection is ensured, additional equipment-related measures shall be provided regarding the early fire detection and alarms (e.g., installation of fire detectors), firefighting (e.g., installation of stationary fire extinguishing systems), or heat and smoke removal.

(2) Structural and equipment-related fire protection measures shall be designed such that, in the event of fire, their function required is ensured despite the fire effects specified under Section 3.2.3.

(3) With respect to the combinations specified under Section 3.3 it shall be checked how far the other event may inadmissibly affect the required functions of the structural and equipment-related fire protection measures and, thus, make it necessary to provide further measures.

(4) If for safety-related reasons additional requirements have to be met by the structural or equipment-related fire protection measures (e.g., radiation protection requirements), then the fire protection functions shall be assessed also regarding these additional requirements (e.g., sufficient shielding).

(5) The fire protection measures described in the fire protection concept shall be realized in a professional way and shall permanently remain functional. In the case of modification of the plant the retroactive effects on the fire protection measures shall be considered.

Note:

Requirements regarding accompanying inspections are dealt with in Section 7.3 and regarding inservice inspections in Section 7.4.

3.4.2 Requirements for rescue routes

(1) Rescue routes shall be established inside the buildings.

(2) The rescue routes shall be protected against effects from fire events such that they can be used sufficiently long for self-rescue and the rescue of other persons, and that they can be used for required safety-related manual actions by the personnel.

(3) Equipment and measures regarding early fire detection and fire alarms as well as for issuing of escape or evacuation orders shall be provided such that, in the event of fire, persons can reach a protected area or escape into the open and that persons can be rescued from outside.

Note:

Requirements for alarm equipment are detailed in safety standard KTA 3901.

3.4.3 Requirements concerning equipment of the safety system and of the emergency system

(1) All equipment necessary to achieve the goals specified under Section 1 para. (2) item a) subitems aa) through ad) shall be designed to be able to fulfill their required safety-related tasks even in the event of fire.

Note:

Whether a plant shutdown becomes necessary after a fire-related failure of safety system equipment is not within the scope of the present safety standard.

(2) It shall basically be ensured that, in the event of fire in one redundancy, all redundants in the other redundancies remain functional. If this is not possible due to system-technological or usage-related requirements, a failure of redundants due to the fire in the not from the fire affected redundancies is admissible, provided, achievement of the goals specified under Section 1, para. (2), item a), subitems aa) through ad), is ensured with the remaining safety functions.

Note:

The terms “redundancy” and “redundants” are defined in SiAnf.

(3) The failure of non-redundant equipment caused by fire is admissible, provided, achievement of the goals specified under Section 1, para. (2), item a), subitems aa) through ad), is ensured with the remaining safety functions.

(4) The anchors and supports of components of the safety system or components of the emergency system and components, the fire-related failure of which would lead to an inadmissible impairment of safety system equipment as specified under para. (1) shall be designed or protected considering the expected fire effects specified under Section 3.2.3.

(5) The entirety of fire protection measures shall ensure that the fire protection goal specified under Section 1, para. (2), item a), is achieved in the event of fire even in case of a random failure of a single structural or equipment-related fire protection measure.

(6) If the measures specified in safety standards KTA 2101.2 and KTA 2101.3 are observed, no random failure (single failure) within an individual fire protection measure needs to be assumed in the fire protection design.

(7) Regarding the combinations specified under Section 3.3, no random failure of structural or equipment-related fire protection measures needs to be assumed.

(8) If the performance of safety-related tasks of the equipment of the safety system or the emergency system requires particularly important fire protection measures, the reliability of these fire protection measures shall be ensured by extraordinary measures to be specified in each individual case. The particular importance of the individual fire protection measures and the resulting reliability requirements shall be determined.

Note:

These particularly fire protection measures are, e.g., extended tests, stationary fire extinguishing systems instead of manual firefighting, automatic instead of manual actuation of the fire extinguishing systems.

3.5 Fire Protection Concept

3.5.1 General requirements

A fire protection concept shall be drawn up and documented. Any modifications of the plant shall be assessed regarding their retroactive effect on the actual fire protection concept, and the fire protection concept shall be updated accordingly.

3.5.2 Objective and extent

(1) The fire protection concept shall comprise all individual measures within the framework of the structural or equipment-related fire protection as well as of the defensive and operational fire protection. In this context, the individual fire protection measures and their interaction shall be described

and as far as necessary demonstrated with regard to achieving the fire protection goals specified under Section 1.

Note:

An exemplary structure of a fire protection concept is presented in Appendix B (informative).

(2) The following shall be considered in the fire protection concept:

a) its utilization,
b) the fire hazard,
c) the possible extent of damage due to fire,
d) the possible combinations specified under Section 3.3, and
e) all operating phases.

3.6 Fire Hazard Analysis

3.6.1 General requirements

To check whether the fire protection goal specified under Section 1, para. (2), item a), is achieved considering the measures described in the fire protection concept, and whether the design principles specified under Section 3.2 are observed, a fire hazard analysis shall be drawn up and documented. The fire hazard analysis shall be kept up-to-date.

3.6.2 Extent

(1) The fire hazard analysis shall contain adaptions regarding the respective operating phases.

(2) In the fire hazard analysis, it shall be presumed that a fire will occur wherever combustible materials are temporarily or permanently stored and the ignition of which is possible.

(3) It may be assumed that only one fire at a time will occur.

(4) For each fire assumed, the fire hazard analysis shall also consider the possibilities for fire propagation.

(5) The combinations specified under Section 3.3 shall be considered.

4 Structural Fire Protection

4.1 General Requirements

The structural fire protection measures include, e.g.,

a) utilization of non-combustible or, at least, flame retardant building materials (cf. Section 3.2.1),
b) design regarding the fire resistance capability of structural elements,
c) construction of fire compartments and firefighting sub-compartments,
d) encapsulation (cf. Section 3.2.2), and
e) establishment of rescue routes (cf. Section 3.4.2),

Note:

Detailed requirements concerning these points are specified in safety standard KTA 2101.2.

4.2 Fire Behavior of Structural Elements

(1) Supporting, strengthening and enclosing structural elements of sections with space-enclosing functions shall be designed regarding their sufficient fire resistance capability such that, in case of demand, their failure due to fire does not need to be assumed.

(2) The sufficient fire resistance capability shall be demonstrated for the fire effects to be presumed as specified under Section 3.2.3.

(3) Regarding the combinations specified under Section 3.3, it shall be checked in how far it is possible that the other events can inadmissibly impair the required function of the respective structural fire protection measures and, therefore, necessitate that additional measures are taken.

4.3 Fire Protective Physical Separation

(1) The individual civil structures shall be constructed as fire compartments from structural elements with a sufficient fire resistance capability, or they shall be physically separated from each other by a sufficient distance to counteract a propagation of fire.

(2) Regarding necessary openings in the outer walls, it shall be ensured that a propagation of fire from one fire compartment to another is prevented. Appropriate protective measures shall be specified for each individual case.

(3) On-site fire loads outside of buildings shall be separated from the civil structures by structural elements with a sufficient fire resistance capability, or they shall be separated from each other by a sufficient distance.

(4) The distances between civil structures or the distances between fire loads outside of the civil structures are considered to be sufficient if a propagation of fire due to the fire effects specified under Section 3.2.3 is not to be expected.

(5) Provided, the requirements regarding a fuel fire from a plane crash in accordance with SiAnf, Appendix 3, are fulfilled, no further measures are required regarding building-external fires in connection with the combinations specified under Section 3.3.

(6) The inside of civil structures shall basically be designed in the form of fire compartments. If system-technological or usage-related requirements either make it necessary to go beyond the fire compartment size basically prescribed by the building code or make it impossible for individual structural elements to fully meet the fire protection requirements approved by the building inspection, then, to achieve comparable protection conditions, additional fire protection measures as specified under Sections 5 or 6 shall be provided.

Note:

Typical examples for these exceptions are the reactor building, reactor auxiliary building, turbine building of boiling water reactors, nuclear services building.

(7) The individual fire compartments shall basically be subdivided as single-story firefighting sub-compartments by structural elements with a sufficient fire resistance capability. In case, due to system-technological or usage-related requirements, it is necessary to construct multi-story firefighting sub-compartments, then, to achieve comparable protection conditions, additional fire protection measures as specified under Sections 5 or 6 shall be provided.

(8) Penetrations of cable installations as well as openings in enclosing structural elements between fire compartments and firefighting sub-compartments shall basically be partitioned off with a sufficient fire resistance capability. The fire resistance capability of the fire shields shall correspond to the fire resistance of the separating structural elements. It is admissible that in the event of fire the openings close automatically or that the closures are opened up for the duration of pressure equalization. In case, due to system-technological or usage-related requirements (e.g., pressure equalization openings), it is not possible to install such partitions, then additional fire protection measure shall be provided as specified

under Sections 5 and 6 to achieve comparable protection conditions.

(9) Compartment areas with considerable fire loads (e.g. large assemblies of cables in cable compartments, fuel storage compartments for the emergency power diesel generator) shall basically be physically separated by structural elements with a sufficient fire resistance capability. In case, due to system-technological or usage-related requirements, a physical separation is not possible, then, to achieve comparable protection conditions, additional fire protection measures as specified under Sections 5 or 6 shall be provided.

(10) Redundant equipment of the safety system or redundant emergency systems shall basically be physically separated by structural elements with a sufficient fire resistance capability such that the requirements specified under Section 3.4.3, para. (2), are met. In case, due to system-technological or usage-related requirements, this is not possible then other suitable fire protection measure shall be provided to achieve a comparable protection condition (e.g., physical separation by sufficient distance, encapsulation, function-sustaining cable systems, fire extinguishing systems, or a combination of these measures).

(11) If a fire protective physical separation is the only measure ensuring the functional capability of the safety system equipment in the event of fire, then the room isolation (including stability) by the necessary structural elements shall be demonstrated considering the fire effects specified under Section 3.2.3 as well as the additional requirements stemming from the analyses of the combinations specified under Section 3.3.

Note:

Aside from the ceilings and walls, the necessary structural elements also include fire shields and the closing elements for the openings in these structural elements.

5 Equipment-Related Fire Protection

5.1 General Requirements

(1) The equipment-related fire protection measures include

a) equipment for fire detection, fire signaling and fire alarms,

b) firefighting equipment, and

c) ventilation systems and equipment for heat and smoke removal.

(2) In context with the equipment-related fire protection measures including their triggering and actuation, the freedom from retroaction with required safety functions shall be ensured even considering the combinations specified under Section 3.3.

(3) If firefighting measures are required to ensure functional capability of the equipment of the safety system and the emergency system in the event of fire, the functional capability of the required equipment-related fire protection measures shall be demonstrated considering the fire effects specified under Section 3.2.3 and the requirements specified under Section 3.3.

5.2 Equipment for Fire Detection, Fire Signaling and Fire Alarms

(1) A fire detection and alarm system (also called "fire alarm facility") shall be provided regarding early fire detection and fire signaling. The number and location of the fire detectors shall be chosen taking the following aspects into account:

a) fire load density,

b) location of combustible material in the rooms,

c) fire behavior of the combustible material (flame propagation and smoke development),

d) room geometry and ventilation conditions,

e) safety-related importance of the monitored systems and components,

f) protection of personnel (ensuring their rescue), and

g) criteria for actuating the fire protection equipment.

(2) The fire detection and alarm system shall normally ensure localizing the fire and shall normally ensure a corresponding display at the local fire detection centers (also called "local fire alarm centers").

(3) The necessary display and control equipment for the fire detection and alarm system shall be installed in the control room. At least one group annunciation of the fire detection and alarm system shall be installed in the control room within the visual range of the personnel.

(4) Regarding fire detection and alarm systems in civil structures that also contain equipment of the emergency system, optical and acoustical group alarms for fires and for failures of the fire detection and alarm system shall additionally be installed in the remote shutdown station.

(5) Equipment and measures shall be provided regarding the alarming in the event of fire.

Note:

Requirements for alarm equipment are detailed in safety standard KTA 3901.

(6) It is admissible to manually trip the equipment for alarming in the event of fire. In this case, one actuation point shall be located in the control room.

5.3 Firefighting Equipment

5.3.1 Firefighting water supply

(1) An amply dimensioned firefighting water main loop system shall be installed for the supply of firefighting water to the hydrants and to the wall hydrants in civil structures as well as to the stationary water-based fire extinguishing systems.

(2) Regarding the firefighting water supply, either a natural source of water such as rivers, streams, lakes, or an artificial source of water such as firefighting water ponds, water wells or vessels with sufficient quantities of water shall be available.

(3) Hydrants or wall hydrants shall be located such that a fire on the plant site or in the civil structures can be manually combatted.

(4) All civil structures accommodating equipment of the safety system or of the emergency system shall be provided with wet firefighting water mains. It shall be ensured that, in the case of water release due to a loss of integrity of such mains, the required functional capability of the equipment of the safety system or of the emergency system is retained.

(5) Redundant pumps with an emergency power backup or a net-independent power supply and a pressurizing system shall be provided for the firefighting water supply system. The fire pumps shall be spatially separated (by a sufficient distance) or shall be protected such that the failure of an individual pump or an individual supply line to the firefighting water main loop system will not lead to a failure of the required water flow rate in case of demand.

(6) In case of pressure loss in the firefighting water system, the firewater pumps shall be switched on line automatically. It shall be possible to monitor and operate the pumps from the control room. It shall normally only be possible to manually switch off the pumps.

(7) It shall be possible to reopen the containment vessel penetration valves of the firefighting water supply system after their closure was triggered by the reactor protection system.

(8) Any equipment and auxiliary means shall be kept available that are required for setting up an additional firefighting water supply (e.g., to feed water into the firefighting water main loop system or into civil structures).

5.3.2 Fire extinguishing systems

(1) In the case of existing fire loads that can lead to any inadmissible fire effects as specified under Section 3.2.3 (e.g., effects on enclosing structural elements, on equipment of the safety system or the emergency system), stationary fire extinguishing systems shall be installed, or equivalent fire protection measures shall be provided.

(2) Stationary fire extinguishing systems shall also be installed wherever manual firefighting would lead to an inadmissible endangerment of the firefighting personnel due to difficult accessibility, high local dose rates or insufficient smoke removal.

(3) In the case of cables with insulating materials to counteract fire propagation and that in the event of fire do not emit any corrosive fire gases and in case of encapsulated cables and cable ways that in the event of fire are not required to continue functioning, it shall be demonstrated in the individual case whether stationary fire extinguishing systems may be dispensed with.

(4) Stationary fire extinguishing systems shall basically be triggered automatically. Remotely controlled or on-site manually triggered fire extinguishing systems are admissible, provided, the possible fire effects specified under Section 3.2.3 can be kept under control up to the moment when these fire extinguishing systems become effective.

(5) When assessing an automatic actuation, the disadvantages of erroneous actuation shall be taken into consideration (e.g., failure of safety-related equipment, erroneous triggering in case of steam leakage, contamination of the firefighting water and the effects of the fire extinguishing agent on parts with high surface temperatures.

(6) In case massive quantities of water during the fire extinguishing procedure must be accounted for (e.g. in the case of spray-water extinguishing systems), possibilities for removing the water, if necessary by means of mobile pumps, shall be available. Firefighting water from the controlled area shall basically be discharged only under controlled conditions and after a detailed assessment of its radioactivity. Exceptions are permissible in the case of temporarily established controlled areas, provided, no release of radioactive substances is to be expected.

5.4 Ventilation Systems and Equipment for Heat and Smoke Removal

5.4.1 General requirements

(1) With regard to fire, the ventilation systems shall meet the requirements specified in safety standard KTA 3601 and, as far as necessary to achieve the fire protection goals specified in Section 1, shall also meet requirements regarding

a) preventing the spreading of smoke and radioactivity,

b) continuing a possibly necessary ventilation of non-affected redundancies,

c) preventing smoke accumulation in necessary staircases and airlock antechambers,

d) allowing a manual firefighting, and

e) removing of smoke and heat.

Note:

These ventilation systems are as itemized below or consist of a combination thereof:

a) operational ventilation systems, i.e.,

   aa) facilities for the operational heat removal in areas not affected by the fire,

   ab) facilities for sustaining a sub-atmospheric pressure,

   ac) facilities for ventilating the control room and the remote shutdown station, and

   ad) facilities for the removal of heat transmitted from neighboring redundant regions in the event of fire.

b) heat and smoke removal systems, and

c) facilities for the prevention of smoke accumulation in necessary staircases.

(2) Ventilation systems that are intended to be used in the event of fire, shall be designed such that equipment of the safety system and of the emergency system are not inadmissibly affected and persons are not endangered by the fire.

5.4.2 Requirements for ventilation systems

(1) When designing ventilation systems, the following points shall be taken into consideration:

a) radiation protection issues (e.g., sustaining sub-atmospheric pressure during accidents, preventing the spreading of radioactivity), and

b) sustaining the functional capability of the safety system and of the emergency systems.

(2) In the event of fire, a spreading of smoke and radioactivity into non-affected areas shall be prevented.

(3) In the case of redundant equipment of the safety system or of the emergency system, the redundancies of which are separated from each other by structure-related fire protection measures, the associated ventilation systems shall be arranged and constructed such that a fire of one redundancy does not affect the functionality of the other redundant equipment.

(4) The air supply to the control room and the remote shutdown station shall be ensured even in the case of a fire in directly adjacent fire sub-compartments. This does not apply to a fire in a ventilation system itself that supplies the control room or the remote shutdown station.

Note:

In the event of a fire in this ventilation system, a continued operation of the control room and remote shutdown station can be ensured by manual means.

(5) The ventilation equipment for ensuring a secure containment (e.g., quick-closing valves in the containment vessel) should be located and protected such that even in the event of fire it will be possible to close one valve in each of the ventilation ducts.

Note:

In this context, it does not need to be presumed that simultaneous fires occur both inside and outside of the containment vessel.

(6) Any penetration of smoke and hot fumes from a fire through the ventilation systems into the individual civil structures that house equipment of the safety system or the emergency systems shall be prevented.

5.4.3 Equipment for heat and smoke removal

5.4.3.1 Equipment for heat and smoke removal from civil structures outside of the controlled area

Measures for the heat and smoke removal or equivalent measures shall be provided for civil structures outside of the controlled area wherever fire loads are present that can lead to inadmissible fire effects (e.g., on enclosing structural elements or on equipment of the safety system) as specified under Section 3.2.3.

5.4.3.2 Equipment for heat and smoke removal from civil structures within the controlled area

(1) A smoke removal from civil structures within the controlled area is basically admissible, provided, this is necessary for firefighting and to rescue people and it is carried out via the paths designated for the discharge of radioactive substances during specified normal operation.

Note:

A large-volume smoke removal from within the reactor building is not feasible regarding the control and mitigation of a loss-of coolant accident.

(2) A heat and smoke removal via other than the specified normal operation discharge paths (e.g. via the smoke and heat dissipation dampers to the outside) from those areas which are separated from the controlled area regarding fire protection and ventilation (e.g., necessary staircases) as well as from the turbine building (of a BWR) is admissible, provided, these areas have been demonstrated to be radiologically irrelevant.

5.4.3.3 Keeping necessary staircases or airlock antechambers free of smoke

In the event of fire, the necessary staircases and airlock antechambers shall be kept at low smoke levels.

Note:

It may become necessary, within the reactor building, that the ventilation must be switched off for safety-related reasons and that as a result the necessary staircases or airlock antechambers cannot be kept entirely clear of smoke.

5.5 Displays and Controls of Equipment Relevant to Fire Protection

(1) The remote controls and displays for the feedback and malfunction signals of equipment relevant to fire protection (e.g., position signals of the fire dampers, operation of ventilation systems with fire protection functions, of equipment relevant to fire protection and fire extinguishing systems), shall be installed in the control room and to the necessary extent in the remote shutdown station, unless superordinate requirements call for their installation in separate local control stations. At least one optical and one acoustical group alarm of each individual fire-protection equipment shall be installed in the control room.

Note:

Equipment-related reasons (e.g., ventilation technology, flooding, pressure equalization) may lead to additional requirements regarding feedback signals.

(2) The displays and signals of process-technological systems and components that monitor the function of systems and component and, additionally, fulfill fire-protection tasks (e.g., monitoring the bearing temperature of pumps or motors, leakage monitoring, Buchholz relays) shall be correlated to the monitoring equipment of these systems and components considering process-technological aspects.

6 Operational Fire Protection Measures and Defensive Fire Protection

6.1 General Requirements

(1) Operational fire protection measures shall be taken that counteract any development of fires.

Note:

Requirements in this context are specified under Sections 3.1 and 3.2.

(2) By regulating the responsibilities as well as by creating suitable operating documents proper measures shall be provided such that, in the event of fire, timely and goal-oriented defensive measures can be triggered and can be performed.

(3) Suitable precautions and measures regarding defensive fire protection shall be taken that are necessary regarding firefighting as well as regarding the control and mitigation of the fire effects specified under Section 3.2.3.

6.2 Operational Fire Protection

6.2.1 Fire protection officer

(1) In each nuclear power plant one suitably trained person shall be appointed as fire protection officer. Organizationally, this person shall have the right to report directly to the plant management.

(2) The duties of this person shall, particularly, include the supervision regarding compliance with fire prevention measures, e.g., with regard to storage of combustible materials or the execution of welding tasks. In addition, the fire protection officer shall take part in the regular fire drills and participate in the creation and regular review of

a) the fire protection concept specified under Section 3.5,

b) the plant-internal fire protection regulation specified under Section 6.2.2,

c) the fire protection plans specified under Section 6.2.3, and

d) the deployment plans for the fire department specified under Section 6.2.4.

(3) The fire protection officer shall be enabled to acquire the initial and continued training required for the respective tasks under consideration of the plant-operational issues.

6.2.2 Plant-internal fire protection regulation

A plant-internal fire protection regulation shall be drawn up as part of the operating manual in accordance with safety standard KTA 1201 specifying the measures for fire prevention and firefighting as well as the substitute measures in situations where the structural and equipment-related fire protection measures are not available; also included shall be regulations regarding conduct of personnel in the event of fire.

6.2.3 Fire protection plans

(1) Fire protection plans shall be drawn up that shall contain at least the following information:

a) space usage and fire-protection-related partitions,

b) areas monitored by automatic fire detectors,

c) areas where stationary fire extinguishing systems are installed,

d) areas for which heat and smoke removal equipment are available,

e) arrangement of rescue routes, and

f) locations of respirators intended for self-rescue and the rescue of others.

(2) The fire protection plans shall be kept up-to-date.

6.2.4 Deployment plans for the fire department

(1) Regarding orientation and situation assessment in the event of fire, the plant fire brigade specified under Section 6.3.1 together with the authorized public bodies shall establish plans for the deployment of the fire department that

shall detail the plant site and civil structures. These plans shall include at least the following information that is necessary for the tactical maneuvers by the fire department.

(2) The general layout plan of the plant site shall show at least

a) the location of the civil structures together with their plant-specific names and their number of floor levels,
b) the connection of the plant site to public traffic areas as well as the public traffic areas directly adjoining the plant site,
c) the access roads including barriers, streets and road ways on the site, the staging and free movement areas for the fire department, the no-entry areas, the route restrictions and the fenced-in areas,
d) the firefighting water supply locations (e.g., hydrants, vessels, open water bodies) together with their capacity as well as the locations for feeding fire extinguishing agents into rising mains and fire extinguishing systems,
e) the main entrance ways for the fire department, the designated gathering points and the dangerous areas including the controlled areas, and
f) the location of the depots for auxiliary equipment and materials for the fire department.

(3) The plans of the floor levels of civil structures shall show at least

a) the plant-specific name of the floor level shown and what the level is used for,
b) the permanently established boundaries of the controlled areas and exclusion areas,
c) the firewalls and other room-enclosing walls including specification of their respective fire resistance,
d) the fire and smoke-related room isolating devices as well as the openings without fire isolating devices in other room-enclosing ceilings and walls,
e) the entrances and exits, the elevators for the fire department and other elevators as well as the staircases and stairs (including travel direction and reachable floor levels),
f) the operating locations for fire protection and operational facilities that must be operated by the fire department within the framework of hazard mitigation,
g) the firefighting water taps in rising mains (wet or dry) and the regions with stationary fire extinguishing systems together with information on the fire suppression agents as well as the locations of central controls or local supply points,
h) the location and number of compressed-gas containers and pressure vessels,
i) information on existing dangerous, including radioactive, substances,
j) the rooms and areas of building engineering facilities for heating, ventilation, power supply as well as electrical operation rooms, and
k) the warnings regarding rooms and areas where specific fire suppression agents may not be used, or which may not be accessed.

(4) The plans for the deployment of the fire department shall be kept up to date. On copy of the plans for the deployment of the external fire brigade shall be available in the control room, in the remote shutdown station, at the main gate as well as with the plant fire brigade.

6.2.5 Special requirements for rescue routes

(1) Rescue routes shall always be kept feely accessible.

(2) Within the containment vessel and within so-called trapped rooms, operating-phase related suitable respirators shall be provided for the flight. The number of respirators and their locations shall be based on the required hazard assessment.

6.2.6 Areas and fire access routes for the fire department

In preparation for the deployment of the fire department, the necessary staging and free movement areas for fire engines, for the readying of equipment and the planning of rescue and firefighting missions as well as the necessary fire department access routes and entry points shall be prepared and kept freely accessible.

Notes:

(1) Detailed requirements are specified in safety standard KTA 2101.2.

(2) Main access routes of the fire department are the rescue routes required as specified under Section 3.4.2.

6.3 Defensive Fire Protection

6.3.1 Plant fire brigade

(1) For the purpose of firefighting, a sufficiently effective plant fire brigade shall be established, equipped and sustained in accordance with local State laws (*Landesrecht*).

(2) The commander of the plant fire brigade shall not be part of the responsible shift personnel.

(3) Technical communication measures shall be available at the deployment site.

6.3.2 Fire Extinguishers

For the initial-response firefighting, suitable fire extinguishers in sufficient number shall be placed at well accessible locations.

Note:

Detailed requirements are specified in safety standard KTA 2101.3.

7 Tests and Inspections

7.1 General Requirements

(1) Before the construction or modifications of structural and equipment-related fire protection measures, the measures shall be evaluated regarding their safety-related importance, their effectiveness and their design. In this context, documents in accordance with statutory provisions shall be made available that will enable the assessment and demonstration of the appropriate design, construction and function of the measures as well as their freedom from retroaction.

(2) To ensure the necessary quality characteristics, construction supervision shall be provided, and assembly tests performed, during the construction or modifications of structural and equipment-related fire protection measures.

(3) An acceptance and function test shall be performed to prove that the construction or modifications of structural and equipment-related fire protection measures have been completed, that the functioning of these measures is ensured and that they do not have inadmissible retroactive effects on the plant.

(4) In the course of regular operation, regular and, in suitable time intervals recurring, inservice inspections shall performed to demonstrate that the individual test object continuous to meet the specified quality characteristics and that sufficient provisions are available to ensure that these quality

characteristics will continue to be met until the next inservice inspection.

7.2 Inspections in Accordance with Statutory Provisions

(1) Before the construction or modifications of structural and equipment-related fire protection measures, the following documents may be required for inspection in accordance with statutory provisions:

a) fire protection concept,

b) fire protection plans,

c) lists of the existing fire loads correlated to the individual rooms,

d) listing of the intended potential ignition sources including the safety-related assessment regarding those plant components possibly affect by a fire,

e) description and related documentation for building elements and building types required by the building inspection (e.g., general approval under construction supervision legislation, general certification under construction supervision legislation, marks of conformity with declaration of performance – CE- and Ü-marks),

f) description of the ventilation systems with details regarding schematics, technical drawings, controls concept and – insofar as required – ventilation rates,

g) description of the heat and smoke removal facilities as well as proof of their proper design,

h) description of the fire extinguishing systems as well as proof of their proper design,

i) description of the fire detection and alarm systems as well as proof of their adequate design,

j) schematic of the staging areas for the fire department.

(2) These documents shall be reviewed to ensure that they are complete, mutually compatible and that the designs they incorporate are suited to the respective functions.

7.3 Accompanying Inspections

(1) The accompanying inspections include:

a) design reviews,

b) construction supervision and assembly testing, and

c) acceptance and function tests.

(2) The required tests and inspections are specified in **Table 7-1**. Type and extent of the tests depend on the specific circumstances of the plant and shall be specified for the individual case. The test instructions for the acceptance and functional testing shall be made available early before the date of testing.

Note:

The term "early" is understood to mean a time span that is sufficient for a coordination between the parties involved.

7.3.1 Design reviews

Design reviews shall be performed as specified in **Table 7-1**.

7.3.2 Construction supervision and assembly testing

(1) The building materials and structural elements shall be checked during construction and assembly. It shall also be checked whether the plant components and equipment are fabricated and erected in accordance with the reviewed documents.

(2) Insofar as the manufacture of the structural materials, structural elements, plant components and equipment is already subject to tests in the manufacturing plant and is properly documented, no additional tests are required.

7.3.3 Acceptance and function tests

(1) Acceptance and function tests shall be performed as specified in **Table 7-1.**

(2) During acceptance testing, the completeness of the fire protection measures shall be checked.

(3) After repairs and modifications, acceptance and function tests of the respective structural elements, plant components and equipment shall be repeated to the necessary extent.

7.4 Inservice Inspections

(1) The type of tests and the testing intervals of the licensee regarding inservice inspections shall basically be as specified in **Table 7-2**. The licensee shall ensure that the tests and inspections are properly performed. Insofar as suitability certificates require shorter testing intervals, these intervals shall be specified in each individual case.

(2) When specifying other testing intervals than those listed in **Table 7-2,** the experience from inservice inspections as well as the specific design characteristics and quality assurance measures required in nuclear power plants shall be taken into consideration.

Note:

Deviations from the testing intervals specified in **Table 7-2** are checked within the nuclear licensing procedure.,

(3) If, for reasons of, e.g., limited accessibility, these tests can only be performed during reactor shutdown (e.g., refueling or maintenance), a prolongation of the testing interval is permissible.

Note:

Deviations from the testing intervals specified in **Table 7-2** are checked within the nuclear licensing procedure.

(4) In accordance with safety standard KTA 1202, testing instructions shall be drawn up for the individual test objects listed in **Table 7-2**. These shall specify, particularly, the plant-related and equipment-related individual testing steps.

Note:

Details of the test requirements are contained, e.g., in the approvals under construction supervision legislation, in the function certificates or in the relevant standards and guidelines.

(4) The existing combustible materials shall be subjected to inservice inspections regarding correspondence with the approved fire protection concept specified under Section 3.5. Within the framework of the fire protection inspection walk-through after every maintenance, it shall be checked and documented that the additionally introduced fire loads have been properly removed.

7.5 Removal of Deviations

The licensee shall ensure that any deviations determined during testing are removed.

7.6 Documentation

(1) Test records shall be drawn up as proof of the performance of the tests and inspections specified under Section 7.4. These test records shall, particularly, contain an assessment of the test results, the detected deviations, any necessary time limits for the removal of deviations and the signature of the tester and the date of the test.

Note:

Respective details are specified in safety standards KTA 1202 and KTA 1404.

(2) The test records of the inservice inspections shall be kept in safe storage by the licensee.

No.	Test Object	Design Review 1)	Construction Supervision / Assembly Testing	Acceptance and Function Tests
1	Structural Materials	X	X	–
2	Room-Isolating Structural Elements with Fire-Protection Related Requirements			
2.1	Walls, ceilings and support structures	X	X	X
2.2	Fire shields for cables and pipes	X	X	X
2.3	Fire protection closures (e.g., doors, hatches)	X	X	X
2.4	Other isolating elements (e.g., joints, glass windows)	X	X	X
3	Fire Protection Measures for Mechanical and Electrical Components			
3.1	Special measures regarding separation of redundancies (e.g., encapsulation, coating systems, heat insulation)	X	X	X
3.2	Measures regarding reducing the fire hazard of components (e.g., oil pans, splatter protection, special protection of cables)	X	X	X
3.3	Cable facilities with integrated functional integrity	X	X	X
4	Smoke Removal Systems, (exclude are mechanical smoke extractors)	X	X	X
5	Fire Detection and Alarm Systems	X	X	X
6	Fire Protection Measures for Ventilation Systems			
6.1	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	X	X	X
	b) ventilation systems to keep necessary staircases and airlock antechambers free of smoke	X	X	X
6.2	Fire protection dampers and smoke removal dampers including the corresponding controls and signaling	X	X	X
6.3	Fire resistant ventilation and smoke removal ducts (excluded are concrete ducts)	X	X	X
7	Firefighting Water Supply	X	X	X
8	Fire Extinguishing System	X	X	X
9	Mobile Fire Extinguishers Inside Civil Structures	X	–	X
10	Mobile Auxiliary Equipment Inside Civil Structures for the Fire Department	X	–	X
11	Markings and Accessibility of Rescue Routes	–	–	X

X Tests by authority or authorized expert.

– No tests required. In case this applies to the column Acceptance and Function Tests, the respective acceptance test record shall be created during assembly testing.

1) Insofar as components with a certification of functionality (e.g., with a general building inspection approval) exist, only these approval certificates need to be presented.

Table 7-1: Testers and test objects regarding initial testing

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		

Table 7-2: Test objects and testing intervals of inservice inspections

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

Table 7-2: Test objects and testing intervals of inservice inspections (Continuation)

Appendix A

Regulations Referred to in the Present Safety Standard

(Regulations referred to in the present safety standard are valid only in the versions cited below. Regulations which are referred to within these regulations are valid only in the version that was valid when the latter regulations were established or issued.)

AtG		Act on the peaceful utilization of atomic energy and the protection against its hazards (Atomic Energy Act – AtG) of December 23, 1959, revised version of July 15, 1985 (BGBl. I, p. 1565), most recently changed by Article 307 of the Act of August 31, 2015 (BGBl. I 2015, No. 35, p. 1474)
AtSMV	(2010-06)	Ordinance on the nuclear safety officer and the reporting of accidents and other events (Nuclear Safety Officer and Reporting Ordinance - AtSMV) of October 14, 1992 (BGBl. I 1992, No. 48) most recently changed by Article 1 of the of the Ordinance of June 8, 2010 (BGBl. I, p. 755)
BetrSichV	(2015-02)	Ordinance updating the requirements for work protection during use of work tools and hazardous substances (Article 1, Ordinance on industrial safety and protection of health using work tools (Industrial Safety and Health Ordinance (BetrSichV)) most recently changed by Article 2 of the updated Hazardous Materials Ordinance of February 3, 2015 (BGBl. I, p. 49)
StrlSchV	(2012-02)	Ordinance on the protection from damage by ionizing radiation (Radiological Protection Ordinance – StrlSchV) of July 20, 2001 (BGBl. I, p. 1714; 2002 I, p. 1459), most recently changed by Article 5 of the Act of December 11, 2014 (BGBl. I, p. 2010)
SiAnf	(2015-03)	Safety requirements for nuclear power plants of November 22, 2012, revised version of March 3, 2015 (BAnz AT of March 30, 2015 B2)
SiAnf Interpretations	(2015-03)	Interpretations of the safety requirements for nuclear power plants of November 22, 2012, revised version of March 3, 2015 (BAnz AT of March 30, 2015 B3)
KTA 1201	(2009-11)	Requirements for the Operating Manual
KTA 1202	(2009-11)	Requirements for the Testing Manual
KTA 1301.1	(2012-11)	Radiation Protection Considerations for Plant Personnel in the Design and Operation of Nuclear Power Plants; Part 1: Design
KTA 1301.2	(2014-11)	Radiation Protection Considerations for Plant Personnel in the Design and Operation of Nuclear Power Plants; Part 2: Operation
KTA 1401	(2013-11)	General Requirements Regarding Quality Assurance
KTA 1402	(2012-11)	Integrated Management Systems for the Safe Operation of Nuclear Power Plants
KTA 1403	(2010-11)	Ageing Management in Nuclear Power Plants
KTA 1404	(2013-11)	Documentation During the Construction and Operation of Nuclear Power Plants
KTA 2101.2	(2015-11)	Fire Protection in Nuclear Power Plants; Part 2: Fire Protection of Civil Structures
KTA 2101.3	(2015-11)	Fire Protection in Nuclear Power Plants; Part 3: Fire Protection of Mechanical and Electrical Plant Components
KTA 2103	(2015-11)	Explosion Protection in Nuclear Power Plants with Light Water Reactors (General and Case-Specific Requirements)
KTA 2201.1	(2011-11)	Design of Nuclear Power Plants Against Seismic Events; Part 1: Principles
KTA 2206	(2009-11)	Design of Nuclear Power Plants Against Damaging Effects from Lightning
KTA 2207	(2004-11)	Flood Protection for Nuclear Power Plants
KTA 2501	(2010-11)	Structural Waterproofing of Nuclear Power Plants
KTA 3301	(2015-11)	Residual Heat Removal Systems of Light Water Reactors
KTA 3402	(2014-11)	Airlocks on the Reactor Containment of Nuclear Power Plants - Personnel Airlocks
KTA 3403	(2010-11)	Cable Penetrations Through the Reactor Containment Vessel
KTA 3501	(2015-11)	Reactor Protection System and Monitoring Equipment of the Safety System
KTA 3601	(2005-11)	Ventilation Systems in Nuclear Power Plants

KTA 3602	(2003-11)	Storage and Handling of Fuel Assemblies and Associated Items in Nuclear Power Plants with Light Water Reactors
KTA 3604	(2005-11)	Storage, Handling and Plant-internal Transport of Radioactive Substances in Nuclear Power Plants (with the Exception of Fuel Assemblies)
KTA 3605	(2012-11)	Treatment of Radioactively Contaminated Gases in Nuclear Power Plants with Light Water Reactors
KTA 3701	(2014-11)	General Requirements for the Electrical Power Supply in Nuclear Power Plants
KTA 3702	(2014-11)	Emergency Power Generating Facilities with Diesel Generator Units in Nuclear Power Plants
KTA 3705	(2013-11)	Switchgear Facilities, Transformers and Distribution Networks for the Electrical Power Supply of the Safety System in Nuclear Power Plants
KTA 3901	(2013-11)	Communication Means for Nuclear Power Plants
KTA 3904	(2007-11)	Control Room, Remote Shutdown Station and Local Control Stations in Nuclear Power Plants

DIN VDE 0833-1	(2014-10)	Alarm systems for fire, intrusion and hold-up - Part 1: General requirements
DIN 18230-1	(2010-09)	Structural fire protection in industrial buildings - Part 1: Analytically required fire resistance time

Appendix B (informative)

Content and Structure of a Fire Protection Concept for Nuclear Power Plants

B 1 Basics

(1) The fire protection concept of a nuclear power plant comprises the individual measures regarding

– structural fire protection,
– equipment-related fire protection,
– operational fire protection, and
– defensive fire protection.

(2) Under consideration of, particularly,

– the plant-related risks,
– the fire risks,
– the extent of damages to be expected, and
– the safety-related significance of expected damages,

the fire protection concept describes the measures and their interconnections with regard to achieving the protective goals of the building codes and the goals specified in Section 1. Thus, the fire protection concept presents a goal-oriented overall assessment of the fire protection for the respective power plant. In addition to the goals mentioned above, further protection goals may become significant for the fire protection concept (e.g., any derived from other public law regulations as well as from requirements by the designer, the constructors, the operator or the insurer of the power plant).

(3) The fire protection concept must be correlated to the individual case. In this context, any necessary deviations and simplifications regarding building codes and the requirements of nuclear safety standards shall be identified and assessed.

(4) In the procedures of creating, updating or amending and documenting the fire protection concept, the requirements in accordance with safety standard KTA 1401 shall be observed.

(5) When preparing the fire protection concept, proof is required that for a specified time span

– the function of the safety system equipment, or
– the function of structural or equipment-related fire protection measures (e.g., stability of load-carrying and supporting structural elements, accessibility of rescue routes, possibility of an effective firefighting)

is ensured despite effects from fire events; this proof may be achieved by applying validated procedures of fire protection engineering considering all-embracing input data and assumptions.

(6) For each individual case

– the applied validated procedures,
– the all-embracing simplifying assumptions made in the procedure,
– the all-embracing input data used in the procedure, particularly, the fire hazard scenarios,
– the resulting uncertainties of the results (e.g., due to uncertain or variable input data as well as due to uncertainties of the assumptions and modelling)

shall be completely, comprehensibly and verifiably described and assessed in the fire protection concept.

B 2 Scope of the Fire Protection Concept

(1) The fire protection concept serves as the basis for the documentation and assessment of fire protection within

– the nuclear licensing and surveillance procedures,
– the licensing procedures under building code,
– the fire safety inspections by official fire protection departments.

(2) Regarding operational concerns, the fire protection concept serves as the basis for

– the technical planning, construction and coordination by the different trade disciplines,
– the acceptance tests and inservice inspection,
– the planning and execution of modifications to the power plant,
– the risk assessment under private law,
– the organization of the operational fire protection, and
– the fire action planning for the defensive fire protection.

(3) In addition, the fire protection plan can be used for the training of external and internal proper personnel.

B 3 Content of the Fire Protection Concept

The fire protection concept shall normally contain the assessment details regarding the partial aspects cited in the following sections even if these reveal that no respective measures are necessary.

B 3.1 General Requirements

B 3.1.1 Description of the power plant

– Description of the location of the power plant including naming site-related positive factors (e.g., proximity to the fire department) and site-related risks (e.g., neighboring establishments with higher fire and explosion hazards).
– Description of the accessibility of the plant site from public roadways (e.g., entrances, access routes).
– Description of the on-site civil structures including specifying the locally present equipment-related hazards (e.g., controlled areas, open plant components under voltage, storage or usage of hazardous materials).

B 3.1.2 Assessment criteria

– Description of the current state of planning and the legal basis (State Civil Ordinance, Atomic Energy Act).
– Description and assessment of the goals (cf. Section B 1).
– Description of the operating phases considered in the fire protection concept.

B 3.2 Requirements Regarding Fire Protection

– Building-specific description of those fire events and their combinations to be considered including their correlation to the operating phases.
– System-specific description of the equipment of the safety system and the safety functions including the fire-protection-specific requirements including their correlation to the operating phases, events and combination of events (e.g., in tabular form).

B 3.3 Fire Hazards and Major Risk Factors

– Building-specific description and assessment of the fire hazards and ignition sources including their correlation to the operating phases.

– Building-specific description and assessment of the special fire risks including their correlation of effects to the operating phases.

B 3.4 Fire Protection Measures

B 3.4.1 Structural fire protection

– Description of the fire behavior of the building materials and structural elements.
– Description of the fire resistance time of structural elements (e.g., stability, room isolation, separation).
– Description of the fire resistance time of closures for openings in fire compartment enclosing structural elements.
– Building-specific description of the arrangement of fire compartments and other fire-protection related subsections.
– Description of the arrangement and construction of smoke-control compartments (e.g., smoke barriers, smoke protection doors).
– Description of the entrances to civil structures when coming from the plant site.
– Description of the rescue routes and their construction.
– Building-specific data regarding the design of structural fire protection measures against those fire events and their combinations to be considered.
– Building-specific data and assessment regarding the deviations and simplifications.

B 3.4.2 Equipment-related fire protection

– Description of the fire detection and alarm systems including the building-specific naming of the monitored areas, of the fire hazard characteristics and the fire protection measures to be triggered.
– Description of the sequential handling of fire alarms,
– Description of the alarm equipment including the description of the actuation and functional behavior.
– Description of firefighting water supply and the retention of firefighting water.
– Description of the technical fire protection equipment such as wet rising mains, wall hydrants, pressurizer facility, semi-stationary fire extinguishing systems and firewater supply points for the fire department.
– System-related description of the stationary fire extinguishing systems naming the type of fire extinguishing system and the protected areas as well as the description of the controls and signals.
– System-related description of the ventilation systems
  a) for the prevention of a fire-related spreading of smoke and radioactivity,
  b) for the continued ventilation of redundancies not affected by the fire,
  c) for keeping rescue routes free of smoke,
  d) for facilitating manual firefighting, and
  e) for the removal of fire-related heat,

  naming the respective system types and describing their triggering and signaling in the event of fire.
– Specification of the protected areas for the heat and smoke removal equipment.
– Description of how functions of the fire protection measures are sustained including the backup power supply.
– Description of the lightning and over-voltage protection facilities (in accordance with safety standard KTA 2206).
– Description of the safety and emergency lighting.
– Building-specific information regarding the elevators (e.g., controls in the event of fire, emergency call response, elevators for the fire department).
– Building-specific information regarding the design of the technological and constructional fire protection measures against those fire events and their combinations to be considered.
– Building-specific information regarding the deviations and simplifications including their assessment.

B 3.4.3 Operational fire protection

– Description of the fire protection measures.
– Information regarding the tasks of the fire protection officer and of the plant fire brigade commander as well as regarding their organizational positions within the plant.
– Information regarding the integration of radiation protection.
– Information regarding the plant-internal alarm regulation and fire protection regulation (in accordance with safety standard KTA 1201).
– Information regarding the fire protection plans and the deployment plans for the fire department.
– Information regarding the rescue plans as well as the marking of rescue routes and safety equipment.
– Description of the areas for the fire department (staging and free movement areas)
– Information regarding initiating and documenting the required design reviews, construction supervision, assembly testing, acceptance and function tests as well as in-service inspections.
– Information on the plant-internal regulations regarding those fire events and their combinations to be considered.
– Description and assessment of whether the requirements regarding operational fire protection are met.

B 3.4.4 Defensive fire protection

– Information regarding the preparatory measures for firefighting (e.g., specifying the areas in which restrictions regarding the use of certain fire extinguishing agents exist or in which firefighting may only be carried out under certain operating conditions).
– Information regarding the establishment of a plant fire brigade.
– Information regarding the staffing and technical equipment of the plant fire brigade as well as its response time.
– Information regarding the external fire departments that can be requested as support for the plant fire brigade as well as their collaboration in regular fire drills.
– Information regarding the collaboration of external fire departments in the event of fire and naming the central engagement points for these fire departments.
– Description of the building-specific telecommunication facilities that can be used in the event of fire by the fire fighters of the collaborating fire departments.
– Information regarding provision of small fire extinguishing equipment (fire extinguishers) and regarding the training of personnel in the handling of these small fire extinguishers.
– Information regarding ensuring the defensive fire protection for those fire events and their combinations to be considered.
– Description and assessment regarding whether the requirements of the defensive fire protection are met.

B 3.4.5 Interaction of fire protection measures

– Description and assessment of whether the fire protection requirements are met, especially, regarding the interaction of the individual measures, thereby ensuring the goals specified under Section B 1.

B 4 Applying and Updating the Fire Protection Concept

In order to properly apply and update the fire protection measures specified in the fire protection concept, a smooth interaction during construction and the considered operating phases (e.g., including larger modification measures, maintenance and extended shutdown periods) may require that

– special fire protection measures are specified according to the construction progress or the operating phase,

– the responsibilities and duties are defined (e.g., construction supervisor, fire protection specialist, construction firm, contractor),

– the qualification of each construction firms is described, and

– information regarding proper execution is presented (e.g., the required certifications).

Safety Standards

of the

Nuclear Safety Standards Commission (KTA)

KTA 2101.2 (2015-11)

Fire Protection in Nuclear Power Plants
Part 2: Fire Protection of Civil Structures

(Brandschutz in Kernkraftwerken
Teil 2: Brandschutz an baulichen Anlagen)

The previous version of this safety
standard was issued in 2000-12

If there is any doubt regarding the information contained in this translation, the German wording shall apply.

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KTA SAFETY STANDARD

November 2015	Fire Protection in Nuclear Power Plants Part 2: Fire Protection of Civil Structures	KTA 2101.2

Previous version of the present safety standard: 2000-12 (BAnz No. 106 a of June 9, 2001, corrected in BAnz No. 239 of December 21, 2007)

Contents

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Comments by the Editor:

Taking into account the meaning and usage of auxiliary verbs in the German language, in this translation the following agreements are effective:

shall	indicates a mandatory requirement,
shall basically	is used in the case of mandatory requirements to which specific exceptions (and only those!) are permitted. It is a requirement of the KTA that these exceptions - other than those in the case of **shall normally** - are specified in the text of the safety standard,
shall normally	indicates a requirement to which exceptions are allowed. However, exceptions used shall be substantiated during the licensing procedure,
should	indicates a recommendation or an example of good practice,
may	indicates an acceptable or permissible method within the scope of the present safety standard.

Basic Principles

(1) The safety standards of the Nuclear Safety Standards Commission (KTA) have the task of specifying those safety-related requirements which shall be met with regard to precautions to be taken in accordance with the state of science and technology against damage arising from the construction and operation of the plant (Sec. 7, para. (2), subpara. (3) Atomic Energy Act - AtG) in order to attain the protective goals specified in AtG and the Radiological Protection Ordinance (StrlSchV) and further detailed in the Safety Requirements for Nuclear Power Plants (SiAnf) and the SiAnf-Interpretations.

(2) The Safety Requirements for Nuclear Power Plants (SiAnf), Appendix 3 "Internal and external events as well as external hazards", states among others that protective measures against fires inside the nuclear power plant must be provided. The basic requirements regarding fire protection measures are detailed in the safety standard KTA 2101.1. The fire protection of civil structures (also called "building structures" or "structural components") is detailed in the present safety standard and the fire protection of mechanical and electrical components in safety standard KTA 2101.3. All three parts of the safety standard series KTA 2101 must be considered in the planning and execution of fire protection measures.

Note:

The additionally relevant safety standards of the KTA are specified in safety standard KTA 2101.1.

(3) The present safety standard is prepared based on the assumption that the building codes, fire protection laws and fire protection regulations of the individual German states (Länder), the German Workplace Ordinance, the German Accident Prevention Regulations (UVV) of the trade unions and other public law regulations are complied with. If the specifics of the nuclear power plant require deviations from laws, ordinances or other public law regulations or from the German Accident Prevention Regulations, then, in each individual case, the particular procedures specified in these regulations regarding deviations and exemptions must be followed.

1 Scope

This safety standard applies to nuclear power plants with light water reactors.

Note:

Further scope-related specifications are detailed in safety standard KTA 2101.1.

2 Definitions

Notes:

(1) Applicable definitions are specified in safety standard KTA 2101.1.

(2) In specifying requirements for the structural material classes as well as for the fire resistance time, the present safety standard uses the terminology introduced by the building inspectorate (cf. DIBt-BRL "List of Building Regulations").

3 Design of Structural Fire Protection Measures

3.1 Certification Procedure

(1) It shall be proven that the structural fire protection measures will withstand the fire effects determined in accordance with safety standard KTA 2101.1, Sec. 3.2.3, without losing their fire protection function (e.g., stability, room isolation).

Note:

A simplified procedure specific to nuclear power plants that is used for determining the required fire resistance time of structural fire protection measures is presented in the informative Appendix A. The fire resistance classes for the intended structural elements can be deduced from these fire resistance times.

(2) In case the requirements specific to nuclear power plants go beyond requirements specified by the building inspectorate, the respective proofs may be provided analytically, experimentally, by analogy or by plausibility considerations.

(3) In the case of an analytical proof it is permissible to use simplified analysis procedures.

Note:

Analysis procedures are specified, e.g., in the fire protection sections of the Eurocodes that comply with the building inspectorate regulations.

(4) Experimental proofs shall be presented for special structural elements that, in addition to requirements regarding fire resistance, must also fulfill requirements specific to nuclear power plants.

(5) Any analogy consideration shall be based on referential results of experimental or analytical proofs that were performed for comparable constructions (e.g., type of construction, building materials, dimensions) and for comparable loadings (e.g., temperature effects, operational loading, additional loading regarding design basis accidents).

(6) Plausibility considerations may be presented to prove that structural measures designed for other load cases can also be considered for ensuring safety in the event of fire.

3.2 Fire Events under Consideration of Additional Requirements and of Combinations with Other Events

(1) If additional design requirements as specified in safety standard KTA 2101.1, Sec. 3.4.1 para. (4), must be considered (e.g., regarding radiation protection, gas leak tightness, lower temperature increases on the far side of the fire) then the determination of the fire resistance of the components shall be based also on these requirements. The proof guidelines and proof criteria established by the building inspectorate shall be applied analogously under consideration of the above requirements. It is admissible to use the certification procedures specified under Section 3.1 in these cases.

(2) Structural fire protection measures, the function of which must be ensured for the event combinations specified in safety standard KTA 2101.1, Sec. 3.3, shall be designed accordingly.

(3) Those structural fire protection measures, the fire protection function of which must be ensured even after an earthquake, shall be designed for the earthquake effects determined as specified in KTA 2201.1, provided that the intensity of the design-basis earthquake is higher than VI (EMS-98 - European Macroseismic Scale). The proofs regarding fire and earthquake may be performed independently of each other.

4 Location and Accessibility of Buildings

4.1 General Requirements

(1) Buildings shall be arranged taking operational and, additionally, the following requirements into consideration:

a) the fire protective physical separation by the distances between buildings,

b) the rapid and safe rescue of persons in the event of fire, and

c) the access points for the firefighting missions.

(2) The requirements in accordance with DIN 14090 shall basically be applied and additionally those specified under Sections 4.2 through 4.5.

4.2 Access Roads

(1) All surface areas on the plant site that are used for vehicular traffic shall basically be designed at least as a fire department staging area in accordance with DIN 14090. Exceptions are admissible in the case of remote vehicular surface areas (e.g., parking lots), provided, they are is insignificant regarding accessing buildings or plant components. In case they have a reduced load-carrying capacity they shall be marked accordingly.

(2) Buildings with safety-related systems and plant components shall basically be accessible via two independent access roads that are at least 6 meters wide. Exceptions are admissible in the case of access roads to remote buildings that have a low fire load density (e.g., auxiliary service water pump building).

(3) In the case of plant-engineering related bottlenecks, the width of the access roads may be reduced to a minimum of 3.5 meters. However, the length of such bottlenecks shall be limited to a maximum of 40 meters.

4.3 Access Points

It can happen that access points dedicated to rescue and firefighting missions are locked for security reasons. It is, therefore, mandatory that these doors can be opened from the outside and can be arrested in the open position. The same applies to plant-internal access points of enclosed building areas.

Note:

Requirements regarding the blocking of entry points are detailed in Section 7.1.

4.4 Fire Department Staging Areas

The fire department staging areas in accordance with DIN 14090 may be part of the width of access roads, provided, a width of at least 5 meters next to the staging area remains available for the access road.

4.5 Free Movement Areas

(1) Regarding rescue and danger aversion missions, a free movement area of at least 7 meters by 40 meters shall be assigned in front of each of the necessary access points of the buildings. The distance between the free movement area and the respective access points shall normally not exceed 25 meters.

(2) The free movement areas in accordance with DIN 14 090 may be part of the width of access roads, provided, a width of at least 3 meters next to the free movement area remains available for the access road.

(3) Walk ways or other similar surfaces bordered by curb stones may be integrated up to a width of 2 meters into the free movement area.

5 Fire Compartments and Firefighting Sub-Compartments

5.1 Fire Compartments

If system-technological or usage-related requirements make it necessary for the size of a fire compartment to exceed the size basically specified by building regulations, the required fire protection shall be ensured by compensatory measures (e.g., by creating firefighting sub-compartments (also called “firefighting sections”) as specified under Section 5.2, by additional plant-engineering related fire protection measures, or by a combination of these measures).

Note:

This applies, e.g., to the reactor building and to the turbine building of boiling water reactors.

5.2 Firefighting Sub-Compartments

(1) The following areas shall be designed as firefighting sub-compartments:

a) rooms for electronic data processing equipment and their conduit rooms,

b) rooms for switch gear and their conduit rooms,

c) rooms for electronic equipment and their conduit rooms,

d) rooms for emergency power generation systems and their fuel depots, and for redundancies of the emergency power supply systems,

e) rooms for redundant safety-related systems and plant components,

f) rooms with storage vessels and facilities for lubrication oil, turbine oil and other combustible fluids,

g) cable ducts and cable wells, insofar as they are not part of a room,

h) cable floors,

i) pool for new fuel assemblies,

j) rooms for transformers with combustible fluids inside of buildings,

k) rooms for the external oil supply (e.g., oil storage vessels including their auxiliary equipment). In the case of boiling water reactors, this room shall be located outside of the control rod drive room.

l) rooms in which more than 3 m^3 of activated charcoal are stored,

m) rooms for fuel oil storage tanks,

n) rooms for the conditioning of combustible waste material including the respective storage rooms.

(2) In addition, the following areas shall normally be constructed as firefighting sub-compartments:

a) rooms for the fuel oil day tanks,

b) storage rooms for closed containers for combustible radioactive substances,

c) rooms in which up to 3 m^3 of activated charcoal are stored.

(3) Walk-in pipe or cable ducts that are longer than 50 meters shall basically be subdivided into, as far as possible, equal-length firefighting sub-compartments. If the ducts do not contain any combustible materials or if they are equipped with a stationary fire extinguishing system, then a subdivision is required only if a duct is longer than 100 meters. When creating the subdivisions, personnel protection shall be taken into consideration.

(4) The control room together with its functional areas and the associated cable floor shall be constructed to be at least one firefighting sub-compartment. The document area and the personnel rest area shall be separated from the control room by fire resistant building elements out of non-combustible building materials. Any other rooms directly accessible from the control room shall normally be separated by fire retardant building elements out of non-combustible building

materials. The doors into the control room shall normally be constructed to be smokeproof.

(5) The emergency control center including annex room and the associated cable floor shall be constructed as at least one firefighting sub-compartment to be at least fire resistant and constructed out of non-combustible building materials.

5.3 Measures Regarding Neighboring Buildings and Building Corners

5.3.1 Neighboring buildings

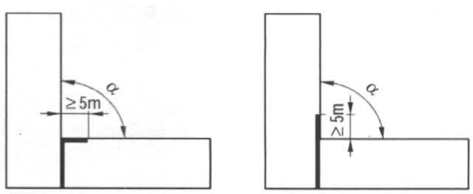
If the distance between buildings is smaller than 5 meters, at least one of the opposing external walls shall be designed as a fire wall.

N o t e :

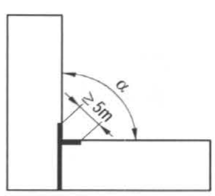
Requirements applying to fire walls are specified in the DIBt-BRL "List of Building Regulations".

5.3.2 Building corners

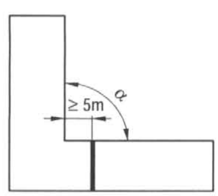
If building components that meet under an angle, α, smaller than or equal to 120 degrees must be separated by a fire wall, the building corner shall be designed as shown in **Figure 5-1.**



The fire wall at the inside corner shall be extended in either of the two directions to a length ≥ 5 meters.



The fire wall shall be extended in both directions.



The fire wall shall be located at a distance of ≥ 5 meters away from the inside corner.

Figure 5-1: Building corners

5.3.3 Roofs of lower buildings or building components

(1) Roof levels or roofs of lower building components or of neighboring lower buildings that are closer than 5 meters from external walls of larger building parts or buildings shall basically be designed to be at least fire resistant and constructed out of non-combustible building materials. This requirement is fulfilled in the case of those roofs, the load-carrying roof shell of which are constructed out of mineral building materials (e.g., concrete).

(2) The measures under para. (1) are not required if the neighboring external wall of the higher building is constructed as a fire wall.

6 Structural Elements Enclosing Fire Compartments and Firefighting Sub-Compartments

6.1 Structural Elements Enclosing Fire Compartments

(1) All structural elements for enclosing fire compartments – including their supports and bracing structures – shall be designed to be at least fire resistant and constructed out of non-combustible building materials

(2) Walls that enclose fire compartments toward adjacent buildings or building parts shall basically be designed as continuous fire walls. If the functional and operational use of the building so requires, it is admissible to use overlapping instead of continuous fire walls, provided, the fire walls are designed to be at least fire resistant and constructed out of non-combustible building materials. These walls shall be constructed together with basically hermetically closed ceilings having at least the same fire resistance. If system-technology necessitates openings in these ceilings, these openings shall be locked shut as if they were openings in fire walls.

(3) If operating activities in a fire compartment lead to an increased fire risk (e.g., higher fire load densities, difficult accessibility) or if the fire compartment serves as protection for equipment of the safety system, the structural elements specified under paras. (1) and (2) may be required to have a higher fire resistance capability. Proof of these measures shall be performed as specified under Section 3.

6.2 Structural Elements Enclosing Firefighting Sub-Compartments

(1) The walls and ceilings that separate firefighting sub-compartments – including their support structures and bracing structures – shall basically be designed to be fire resistant and constructed out of non-combustible building materials. Higher fire resistance classes may be required, and lower fire resistance classes may be admissible. Higher requirements would apply if they are necessary

a) due to an increased fire risk (e.g., higher fire load densities, difficult accessibility), or
b) for the protection of equipment of the safety system.

Lower requirements regarding the fire resistance require individual proofs.

(2) Walls shall basically meet the requirements of fire walls regarding impact resistance. Exceptions are admissible, e.g., for rooms that are directly accessible from the control room as well as for the separating elements of room areas without safety-related equipment.

6.3 Closing Elements for Openings in Enclosing Structural Elements of Fire Compartments and Firefighting Sub-Compartments

6.3.1 General requirements

(1) Closing elements of openings in enclosing structural elements of fire compartments include, e.g.,

a) fire protection closing elements (fire protection doors and gates),
b) windows,
c) fire dampers,
d) fire shields of cables,
e) fire shields of pipes, and
f) joint sealants.

N o t e :

Requirements for the fire shields of cable penetrations in the reactor containment vessel are detailed in safety standard KTA 3403, Sec. 4.7.

(2) The fire resistance time of the closing elements of openings shall basically be the same as the required fire resistance time of the enclosing structural elements. Exceptions are admissible for firefighting sub-compartments, provided, a proof is presented as specified under Section 3.1.

(3) Insofar as the closing elements of openings must, in addition to fire protection, meet requirements regarding

a) radiation protection,

b) leak tightness,

c) mechanical stability with respect to external events and plant-internal design basis accidents, or

d) plant security,

and which, therefore, might lead to a reduction of the fire resistance capability of a structural element, then the fire protection shall be ensured by other equivalent measures.

(4) The function of the fire shields of pipe penetrations shall be demonstrated both for the fire event and for the loading under specified normal operation.

6.3.2 Special requirements regarding earthquakes

In the case of cable penetrations, the fire protection functions of which, as specified in Section 3.2 para. (3), must be demonstrated to be ensured even after an earthquake, the relative deformation of the fire shield of the cable in direction of the cable penetration caused by the dynamic earthquake loading shall be limited by constructional means (e.g. fixed-point placement) to such a level that the fire resistance time of the fire shield is not inadmissibly reduced.

6.4 Measures to Counter Fire Flashover Between External Structural Elements

6.4.1 External walls

(1) External walls shall consist of non-combustible building materials. This also applies to barrage structures, the outer-wall glazing and cladding including their mounting elements and insulating materials, however, not to the sealants, protective coatings, flashings and sun protection devices.

(2) External walls including their openings shall be designed to be fire resistant if any fire loads (e.g., combustible materials regularly stored or placed on the plant site outside of buildings) are not stored or placed at a sufficient distance away from the buildings.

Note:

Sufficient distances are specified under Section 6.4.3 as well as, e.g., in TRGS 510.

6.4.2 Roofs

(1) The support structure of the roofs and the roof insulation shall consist of non-combustible building materials.

(2) Roof openings belonging to different fire compartments or firefighting sub-compartments shall be no closer to each other than 5 meters if these openings are unprotected from a standpoint of fire protection.

6.4.3 Structural fire protection measures for open-air transformers

(1) The distance between open-air transformers shall basically be as specified in DIN EN 61936-1. Otherwise, the open-air transformers shall be separated by walls that are designed as specified in accordance with DIN EN 61936-1.

(3) Adjacent open-air transformers filled with more than 1000 liters of combustible isolating fluids that are closer to each other than specified in accordance with DIN EN 61936-1 shall be protected from each other by walls that are fire resistant and constructed of non-flammable structural materials and that are dimensioned in accordance with DIN EN 61936-1, however, with the minimum dimensions as follows:

Height: extending beyond the top edge of the transformer vessel including the expansion vessel – at least 1.0 meters

Depth: extending forward and, in the case of a freestanding installation, also to the back – at least 1.5 meters

(3) Building walls that border on open-air transformers filled with combustible isolating fluids shall be designed as fire walls if the distance to the transformers is less than specified in accordance with DIN EN 61936-1.

(4) These walls shall extend, vertically, at least 5 meters above the height of the top edge of the transformer vessel including the expansion vessel or up to an equivalent ceiling above the transformer and, horizontally, at least to a length of 5 meters beyond either side of the transformer outer dimension.

6.5 Encapsulation

6.5.1 Encapsulations with sustained functional integrity

All structural elements serving as encapsulation with sustained functional integrity shall – including their supports and bracing structures – have a sufficient fire resistance capability. They shall normally be designed to be at least fire resistant and constructed out of non-combustible building materials.

Note:

A typical encapsulation with sustained functional integrity is, e.g., a channel made from calcium-silicate slabs with a defined fire resistance time that has the approval of the building inspectorate.

6.5.2 Encapsulations without sustained functional integrity

The suitability of encapsulations without a defined fire resistance time shall be proven by the procedures specified under Section 3.1 (e.g., plausibility proof).

Note:

An encapsulation without sustained functional integrity is, e.g., a sheet metal channel without a defined fire resistance time.

7 Rescue Routes

7.1 General Requirements

(1) For reasons of security, doors along rescue routes may be blocked for a limited time. For these cases, the possibilities for rescuing and firefighting missions shall be regulated on a plant-specific basis.

(2) These doors shall carry a sign warning of the possible blocking and indicating the plant-specific regulations.

7.2 Necessary Staircases

(1) The walls and ceilings of the necessary staircases shall be designed to be at least fire resistant and constructed out of non-combustible building materials.

(2) Closing elements of openings from the necessary staircases to adjacent rooms shall basically be designed to be fire resistant and smoke proof. A lower fire resistance class or non-smokeproof doors are admissible for those closing elements of openings to rooms with an area not exceeding

200 m² and with a low fire risk. In these exceptional cases, the closing elements shall be constructed to be at least fire retardant, leak tight and self-closing.

(3) Basically, no requirements are specified regarding fire resistance and smoke leakage for openings in necessary staircases that lead to the outside. Where the necessary staircases are located in front of the external wall of buildings, an angle is created to the outside wall. In this case the distance to unprotected openings shall be equal to the safety distance specified under Section 5.3.2.

(4) Supporting structural elements of stairs shall be designed to be fire resistant.

7.3 Airlock Antechambers

(1) The walls and ceilings of airlock antechambers as well as closing elements of openings in these civil structures shall basically be constructed to be fire resistant and constructed out of non-combustible building materials

(2) In well-founded cases (e.g., due to a low fire risk), lower fire resistance times are admissible for closing elements of openings.

(3) Doors and dampers shall be constructed to be self-closing and doors, additionally, to be smokeproof.

8 Ventilation Systems, Heat and Smoke Removal Equipment

8.1 General Requirements

(1) In the case that fire dampers are installed in ventilation systems that, in accordance with safety standard KTA 3601, must be leak tight, these fire dampers shall not have inadmissible adverse effects on the leak tightness of the system.

(2) Leak tight ventilation systems with fire protection requirements shall be designed such that the recurrent leakage tests in accordance with safety standard KTA 3601 can be performed. These tests shall not have any lasting adverse effects on fire protection.

8.2 Requirements for Ventilation Systems

(1) Pipes, adapter fittings, ducts and channels of ventilation conduits shall basically be designed to be constructed of non-combustible materials. In case corrosive gasses (e.g. from battery rooms and laboratories) need to be removed, exceptions are permissible, provided, the structural materials used are at least flame retardant.

(2) In case ventilation facilities have the combined function of operational ventilation and heat and smoke removal, then the requirements regarding the temperature and pressure resistance for the individual structural elements of the ventilation systems shall be specified under consideration of the mixture temperature that can occur in the ventilation ducts. The suitability of the ventilation system regarding heat and smoke removal shall be demonstrated.

(3) If ventilation ducts of the required system for ventilating the control room lead through other fire compartments or fire-fighting sub-compartments, they shall be constructed to be at least fire resistant.

8.3 Equipment for Heat and Smoke Removal

Smoke removal conduits and smoke removal dampers shall be designed in accordance with DIN 18232-5. The design shall basically be based on the temperature class F600. Deviations are admissible, provided, it is proven that

a) the smoke will cool off along the smoke removal conduits, or

b) lower temperatures are expected inside the fire compartment or area.

8.4 Ventilation Measures for the Necessary Staircases

(1) The necessary staircase shall basically be equipped with openings for smoke removal. If this is impossible for plant-engineering related reasons, powered systems shall be provided that counteract the penetration of smoke into the necessary staircases or that can remove possibly penetrated smoke from the necessary staircases. Regarding the reactor containment vessel, the special plant-engineering related features shall be taken into consideration.

(2) The inlet and exhaust ducts of the powered systems, as far as they are routed outside of the necessary staircases, shall be constructed to be as fire resistant as the respective fire-endangered building.

(3) Any powered smoke removal from other areas shall not direct smoke into the necessary staircase and airlock antechambers.

Appendix A (informative)

Simplified Validation Procedure for Determining the Required Fire Resistance Time of Structural Fire Protection Measures

A 1 Basic Data for the Validation Procedure

The simplified validation procedure described in the following may be used for determining the fire resistance time of structure-related fire protection measures (also refer to [1] and [2]).

It shall be observed that this validation procedure may not be intermixed with other analytical procedures.

Basic data for this validation procedure are room-specific lists identifying their geometry, the mass and calorific values of the contained combustible materials, as well as the ventilation conditions caused by openings that, in the event of fire, may regularly or irregularly be in the open position, or the ventilation conditions caused by a forced ventilation with a specified volume flow rate.

Specifically, the following input parameters are required:

a) room area, A [m²],

b) room height, H [m],

c) sum of natural ventilation openings, A_V [m²],

d) input air flow rate of forced ventilation, $\dot{V}_{zu}$ [m³/h],

e) masses, M_i in kg, of the unprotected combustible materials (e.g., oil, cables) as well as their calorific values, H_{ui} in kWh/kg,

f) masses, M_j in kg, of combustible materials protected against ignition by being enclosed in containments, closed systems or other enclosures (e.g., intumescent coating in the case of cables).

The criterion for the expected fire loading of structural elements in the natural course of a fire event is the fire duration, $t_ä$, that is equivalent to the standard fire loading (uniform-temperature-time-curve) in accordance with DIN 4102-2; the fire duration, $t_ä$, is determined following the procedure described in DIN 18230-1 as dependent on a theoretical fire load density, q_R.

A 2 Theoretical Fire Load Density, q_R

The theoretical fire load density, q_R in kWh/m², is calculated from the individual masses, M_i, the calorific values, H_{ui}, and the combustion efficiencies, X_i, of the unprotected combustible materials as well as from the corresponding values M_j, H_{uj} and X_i of the protected combustible materials and, if applicable, considering the energy losses, ΔQ_W, caused by heat sinks.

$$q_R = (Q_u + Q_g - \Delta Q_W) / A \qquad \text{(A 2-1)}$$

where

Q_u : sum of unprotected fire loads, [kWh],
$Q_u = \Sigma (M_i \times H_{ui} \times X_i)$ (A 2-2)

Q_g : sum of protected fire loads, [kWh],
$Q_g = \Sigma (M_j \times H_{uj} \times X_j \times \psi_j)$ (A 2-3)

ΔQ_W : sum of energy losses, [kWh], caused by heat sinks as specified under Section A 4

Applicable values for the average combustion efficiencies, X_i, of combustible materials are listed in **Table A 2-1**. Specific combustion efficiencies listed in [3] may be used in individual cases.

State	Average Combustion Efficiency X
gaseous	1.0
fluid	0.9
solid	0.8

Table A 2-1: Applicable simplified combustion efficiencies

The combustible materials that are protected by containing them in closed systems or other enclosures may be reduced by applying combination coefficients, ψ_j. The following values may be assumed without detailed validation

$$\psi_j = 0.8 \qquad \text{(A 2-4)}$$

for the largest individual protected fire load

$$\psi_j = 0.55 \qquad \text{(A 2-5)}$$

for other protected fire loads

The consideration of energy losses caused by heat sinks is an iterative procedure. The initial step is to assume that $\Delta Q_W = 0$; the further analytical procedure is presented in Section A 4.

A 3 Equivalent Fire Duration, $t_ä$

Under consideration of the actual room height, H, and ventilation conditions inside the fire compartment or area, the equivalent fire duration, $t_ä$ [min], is determined as dependent on the theoretical fire load density, q_R, from equations (A 2-1) through (A 2-3) as follows:

$$t_ä = t_{ä,0} \times f_H \times f_{Av} \qquad \text{(A 3-1)}$$

where

$t_{ä,0}$: basic value of the equivalent fire duration [min] for a most unfavorable ventilation and a room height H_{ref} = 2.5 meters

f_H : correction factor for other room heights, H

f_{Av} : correction factor for the actual ventilation conditions

Note:

The correction factor, f_{Av}, shall be determined for planned and unplanned ventilation conditions.

The basic value for $t_{ä,0}$ can be extracted from the value diagrams of **Figure A 3-1** or **Figure A 3-2** (same content with different plotting scales).

The value diagrams of **Figure A 3-1** and **Figure A 3-2** distinguish between the following cases:

a) uniformly distributed fire load:
fire extends over the entire room,

b) non-uniformly distributed fire load:
fire is limited to a larger partial area of the room,

c) point-source fire load:
entire fire load is on fire in a localized area.

In case of a non-uniformly distributed fire load, the higher equivalent fire duration shown in **Figure A 3-1** and **Figure A 3-2** is applicable only for those areas where a non-uniformly distributed fire load or a point-source fire load is expected. For other areas, the equivalent fire duration of a uniformly distributed fire load shall be applied.

The correction factor, f_H, for a room height other than the reference room height, H_{ref}, shall be calculated using equation (A 3-2):

$$f_H \left[\frac{H_{ref}}{H}\right]^{0.3} \wedge \qquad \text{(A 3-2)}$$

The correction factor, f_{Av}, for the actual ventilation condition can be read out from **Figure A 3-3** as dependent on the relative effective overall surface area of the openings, $A_{V,eff}/A$:

$$f_{Av} = f(A_{V,eff} / A) \qquad \text{(A 3-3)}$$

where

$$A_{V,eff} = A_V + \dot{V}_{zu}/2200, \text{ [m}^2\text{]} \qquad \text{(A 3-4)}$$

A_V : overall surface area, [m²]
of the vertical openings in the enclosing walls

$\dot{V}_{zu}$: supplied volumetric air rate, [m³/h]
in the case of an available forced ventilation

Without further considerations, this procedure is applicable only for a relative effective overall surface area of the openings, $A_{V,eff}/A$, up to 3 %.

A 4 Consideration of Heat Sinks

The influence on the expected fire effects of the energy losses to available heat sinks inside the fire compartment or area, such as

a) structural concrete elements in addition to the enclosing structural elements (e.g., partition walls, support columns), Q_B,

b) structural steel elements (e.g., bearing and support structures, shells), Q_S,

c) large-volume vessels for fluids, Q_F,

may be taken into consideration as the overall energy loss, ΔQ_W, in equation (A 2-1). In this context,

$$\Delta Q_W = \Sigma Q_{W,i} \qquad \text{(A 4-1)}$$

where

$Q_{W,i} = Q_B$, Q_S or Q_F, [kWh]

The energy losses, $Q_{W,i}$ may generally be determined as follows:

$$Q_{W,i} = M_W \times c_{p,W} \times (\overline{T}_{SW} - T_O) / (3.6 \times 10^6) \qquad \text{(A 4-2)}$$

where

M_W : mass, [kg], of the component

$c_{p,W}$: specific heat capacity, [J/(kg×K)], of the component

$\overline{T}_{SW}$: calorific mean temperature, [°C], of the component

T_O : operating temperature, [°C], of the component

The calorific mean temperature, $\overline{T}_{SW}$, can be extracted from **Figure A 4-1** dependent on the previously calculated (without heat sinks) equivalent fire duration, $t_ä$, (without heat sinks) and on the flock parameter, σ_W

$$\sigma_W = \left(\frac{\alpha_W}{\rho_W \times c_{p,W}}\right) \times \left(\frac{A_W}{V_W}\right) \quad \text{[s}^{-1}\text{]} \qquad \text{(A 4-3)}$$

where

A_W: fire-affected surface area, [m²], of the structural element

V_W: volume [m³] of the structural element

A_W/V_W: profile factor, [m⁻¹], (analogous to A_m/V in accordance with DIN EN 1993-1-2)

α_W: heat transfer coefficient. [W/(m²×K)]

ρ_W: density, [kg/m³], of the structural element

$c_{p,W}$: specific heat capacity, [J/(kg×K)], of the structural element

The thermal characteristics of the materials to be considered can be extracted from **Table A 4-1.**

Material	α_W W/(m²×K)	ρ_W kg/m³	$c_{p,W}$ J/(kg×K)
concrete	20	2200	879
steel	20	7850	600
water	–	1000	4182
oil	–	910	1880

Table A 4-1: Thermal characteristics of different materials

Instead of extracting the calorific mean temperature from **Figure A 4-1**, this parameter may be determined by applying equation (A 4-4)

$$\overline{T}_{SW} = T_g\left[1-\exp\left(-s_w \times 60 \times t_ä\right)\right] \qquad \text{(A 4-4)}$$

where

σ_W: flock parameter, [s⁻¹],
calculated from equation (A 4-3)

$t_ä$: equivalent fire duration, [min],
determined in the initial step without ΔQ_W

T_g : hot-gas temperature, [°C],
of the standardized fire after a fire duration of $t_ä$

$$T_g = RT + 345 \times \log(8 \times t_ä + 1) \qquad \text{(A 4-5)}$$

where

RT : room temperature, [°C], at the start of the fire

The calculation of energy losses, Q_F, to vessels filled with fluids is based on the weighted mean values of the density, $\overline{\rho}_F$, and of the specific heat capacity $\overline{c}_{p,F}$:

$$\overline{\rho}_F = \mu_{BE} \times \rho_{BE} + \mu_{FL} \times \rho_{FL} \qquad \text{(A 4-6)}$$

$$\overline{c}_{p,F} = \mu_{BE} \times c_{p,BE} + \mu_{FL} \times c_{p,FL} \qquad \text{(A 4-7)}$$

where

$c_{p,BE}$: specific heat capacity, [J/(kg×K)], of the vessel wall

$c_{p,FL}$: specific heat capacity, [J/(kg×K)], of the fluid

ρ_{BE}: density, [kg/m³], of the vessel wall

ρ_{FL} : density, [kg/m³], of the contained fluid

$$\mu_{BE} = \frac{M_{BE}}{M_{ges}} ; \mu_{FL} = \frac{M_{FL}}{M_{ges}} \quad \text{(A 4-8)}$$

where

$$M_{BE} = A_F \times d_{BE} \times \rho_{BE} \quad \text{(A 4-9)}$$

$$M_{FL} = V_F \times \rho_{FL} \times h/100 \quad \text{(A 4-10)}$$

$$M_{ges} = M_{BE} + M_{FL} \quad \text{(A 4-11)}$$

and the vessel parameters are

A_F: surface area, [m²],

d_{BE}: wall thickness, [m],

V_F: volume, [m³],

h: average filling, [%],

A 5 Required Fire Resistance Time, erf t_f

The required fire resistance time, erf t_f in minutes, of the structure-related fire protection measures is determined by multiplying the equivalent fire duration, $t_ä$, with the safety factor, γ:

$$\text{erf } t_f = \gamma \times t_ä \quad \text{(A 5-1)}$$

The safety factor, γ, shall be extracted from **Table A 5-1** under consideration of the significance of the structural elements to be dimensioned, of the provided fire protection measures and of the basic ventilation conditions.

Fire Fighting Category	Ventilation	Safety Factor, γ, for Fire Safety Class		
		SKb 3	SKb 2	SKb 1
A	p	1.45	1.10	0.70
	u	0.85	0.50	0.50
B	p	1.35	1.00	0.60
	u	0.80	0.50	0.50
C	p	1.10	1.00	0.50
	u	0.50	0.50	0.50
D	p	0.75	0.50	0.50
	u	0.50	0.50	0.50
p : planned u : unplanned				

Table A 5-1: Safety factor, γ, for the design of structure-related fire protection measures in nuclear power plants

With respect to the effectiveness of firefighting missions, the following four categories are differentiated between:

a) Category A: manual firefighting missions after on-site clarification of the situation; action begins more than 10 min after occurrence of the fire.

b) Category B: manual firefighting missions by on-site personnel; action begins less than 10 min after occurrence of the fire.

c) Category C: stationary fire extinguishing system, manually triggered; action begins less than 10 min after occurrence of the fire.

d) Category D: stationary fire extinguishing system; automatically triggered or manually triggered on site or triggered in the control room immediately after the fire alarm; action begins less than 2 min after occurrence of the fire.

With respect to ventilation, it shall be differentiated between planned (p) and unplanned (u) ventilation conditions. In case of the planned ventilation,

a) all openings (including doors) that stand open in the event of fire,

b) the leakage openings in the enclosing structural elements, and

c) the available forced ventilation that would continue to be in operation in the event of fire

are considered.

In case of the unplanned ventilation,

a) open doors that, regularly, would be closed in the event of fire, or

b) continued operation of a forced ventilation that, regularly, would be shut down, and additionally,

c) leakage openings specified above under planned ventilation.

are considered.

Notes:

(1) The forced ventilation mentioned under planned ventilation also comprises such forced ventilation, the shutdown or isolation of which in the event of fire is not specified unambiguously, e.g., in the plant-internal fire protection regulation.

(2) An unplanned forced ventilation may, if applicable, be the fire-related failure of, or unplanned air release from, compressed air systems in the fire compartment or area.

Regarding the design of structural elements, they shall be correlated to one of the following three fire safety classes, SKb 1 through SKb 3:

a) SKb 1: subordinate structural elements with fire resistance requirements, e.g., parts of the secondary support structure,

b) SKb 2: closing elements of openings, or fire shields of cable or pipe penetrations through separating structural elements,

c) SKb 3: structural elements separating fire compartments or firefighting sub-compartments (e.g., also physical separations of redundancies) or that support separating structural elements, as well as all structural elements of the major support structure.

Note:

The structural elements are correlated to the fire safety classes in accordance with MIndBauRL and DIN 18230-1 which present additional details. Particularly in existing power plants, a downgrading by one fire safety class (e.g., SKb 3 to Skb 2) is admissible, provided, the required safety level is ensured by other means (e.g., additional organizational fire protection measures).

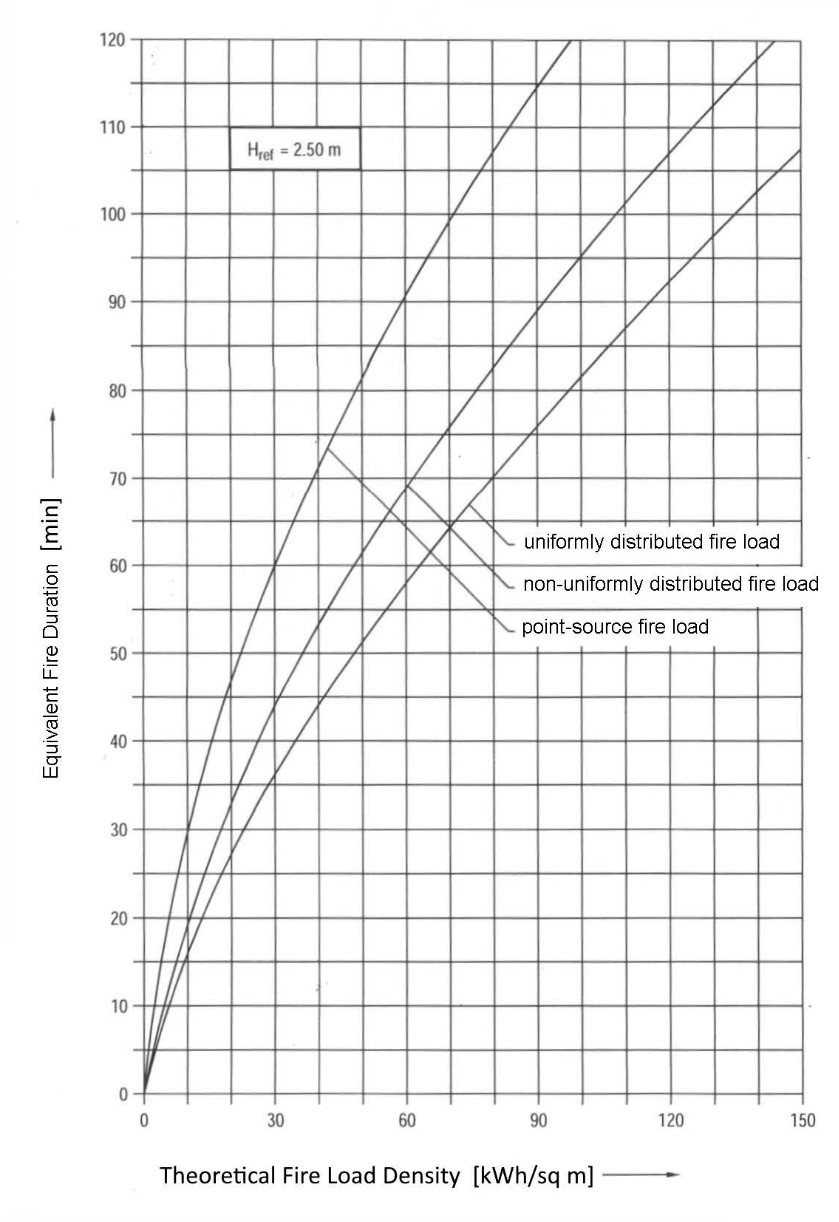


Figure A 3-1: Basic equivalent fire duration, $t_{ä,0}$, as a function of the theoretical fire load density, q_R

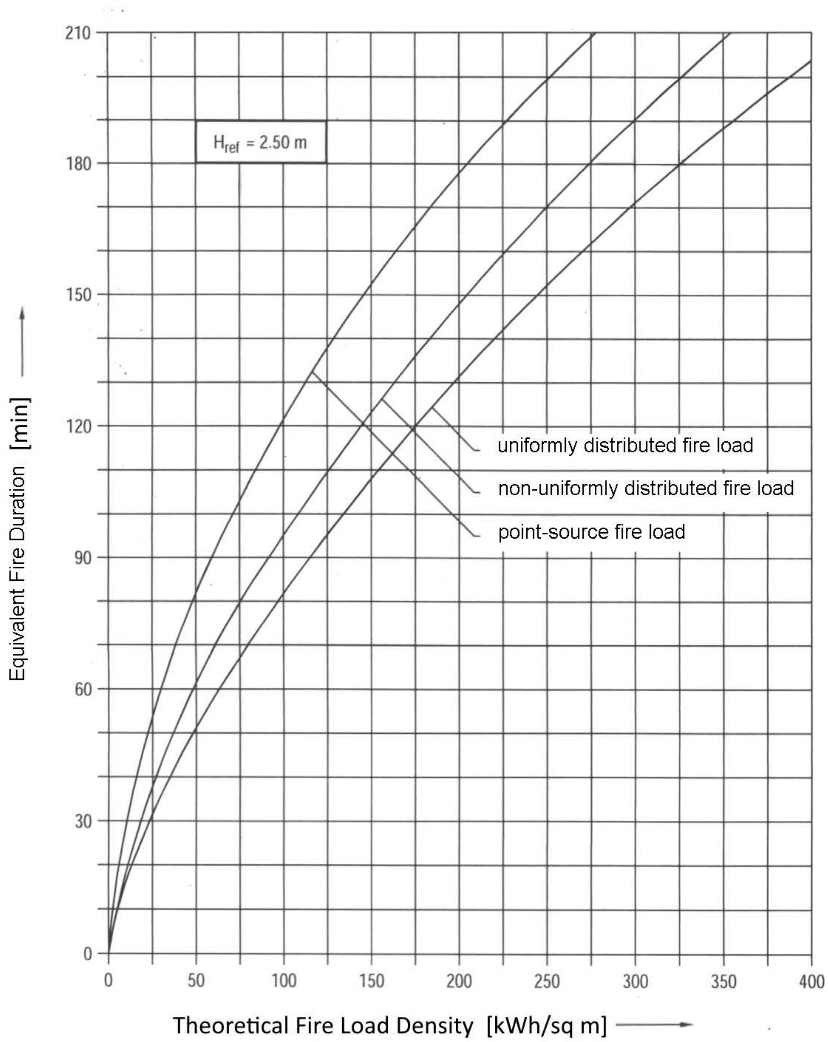


Figure A 3-2: Basic equivalent fire duration, $t_{a,0}$, as a function of the theoretical fire load density, q_R

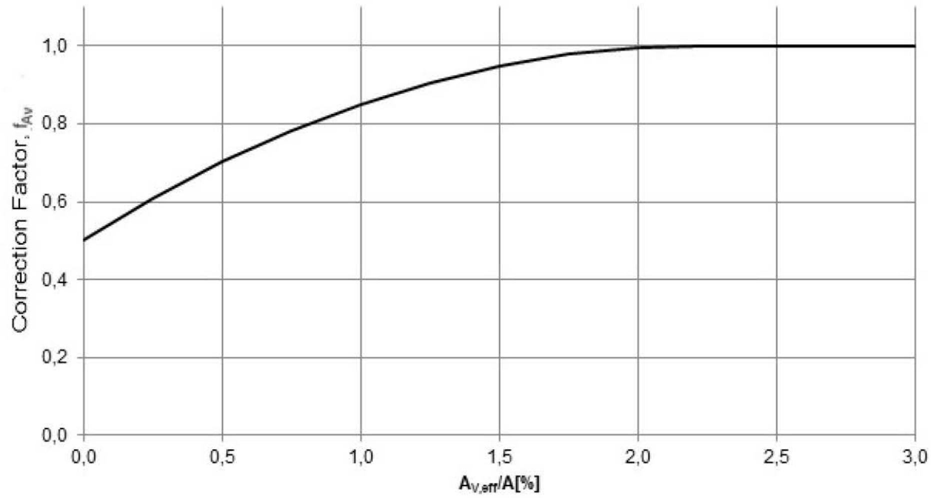


Figure A 3-3: Correction factor, f_{Av}, as a function of the relative effective overall surface of the openings, $A_{V,eff}/A$

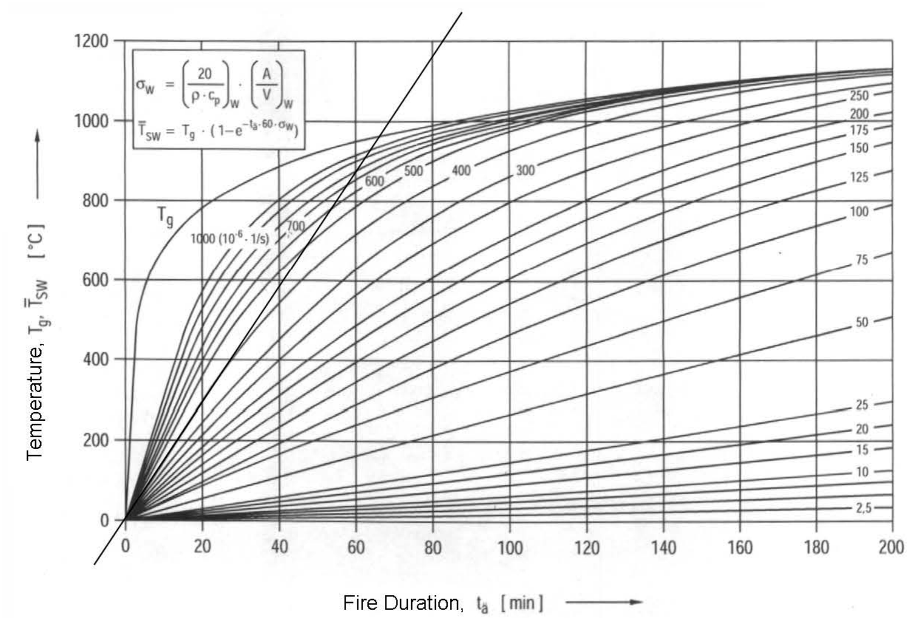


Figure A 4-1: Calorific mean temperature, $\overline{T}_{SW}$, as a function of fire duration, $t_ä$ and flock parameter σ_W

Literature

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[2] Forell, B.
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[3] Tewarson, A.
Generation of heat and gaseous, liquid, and solid products in fires. In: DiNenno, P. J. et al. (Hrsg.). The SFPE handbook of fire protection engineering. 4th Ed. S. 3-109 bis 3-194. Quincy, Massachusetts 2008

Appendix B

Regulations Referred to in the Present Safety Standard

(Regulations referred to in the present safety standard are valid only in the versions cited below. Regulations which are referred to within these regulations are valid only in the version that was valid when the latter regulations were established or issued.)

AtG		Act on the peaceful utilization of atomic energy and the protection against its hazards (Atomic Energy Act – AtG) of December 23, 1959, revised version of July 15, 1985 (BGBl. I, p. 1565), most recently changed by Article 307 of the Act of August 31, 2015 (BGBl. I 2015, No. 35, p. 1474)
StrlSchV		Ordinance on the protection from damage by ionizing radiation (Radiological Protection Ordinance – StrlSchV) of July 20, 2001 (BGBl. I, p. 1714; 2002 I, p. 1459), most recently changed by Article 5 of the Act of December 11, 2014 (BGBl. I, p. 2010)
SiAnf	(2015-03)	Safety requirements for nuclear power plants of November 22, 2012, revised version of March 3, 2015 (BAnz AT of March 30, 2015 B2)
SiAnf Interpretations	(2015-03)	Interpretations of the safety requirements for nuclear power plants of November 22, 2012, revised version of March 3, 2015 (BAnz AT of March 30, 2015 B3)
KTA 2101.1	(2015-11)	Fire Protection in Nuclear Power Plants; Part 1: Basic requirements
KTA 2101.3	(2015-11)	Fire Protection in Nuclear Power Plants; Part 3: Fire Protection of Mechanical and Electrical Plant Components
KTA 2201.1	(2011-11)	Design of Nuclear Power Plants Against Seismic Events; Part 1: Principles
KTA 3403	(2010-11)	Cable Penetrations Through the Reactor Containment Vessel
KTA 3601	(2005-11)	Ventilation Systems in Nuclear Power Plants
DIN 4102-2	(1977-09)	Fire Behavior of Building Materials and Building Components; Building Components; Definitions, Requirements and Tests
DIN 14090	(2003-05)	Areas for the fire brigade on premises
DIN 18230-1	(2010-09)	Structural Fire Protection in Industrial Buildings - Part 1: Analytically Required Fire Resistance Time
DIN 18232-5	(2012-11)	Smoke and heat control installations - Part 5: Powered smoke exhaust systems; requirements, design
DIN EN 1993-1-2	(2010-12)	Eurocode 3: Design of steel structures - Part 1-2: General rules - Structural fire design; German version EN 1993-1-2:2005 + AC:2009
DIN EN 61936-1, VDE 0101-1	(2014-12)	Power installations exceeding 1 kV a.c. - Part 1: Common rules (IEC 61936-1:2010, modified + Cor.:2011 + A1:2014); German version EN 61936-1:2010 + AC:2011 + AC:2013 + A1:2014
MIndBauRL	(2014-07)	Exemplary guideline for the structural fire protection in industrial buildings (*Muster-Industriebaurichtlinie - MindBauRL*)
TRGS 510	(2013-01)	Technical standards for hazardous materials (TRGS): Storage of hazardous material in mobile vessels

Safety Standards

of the

Nuclear Safety Standards Commission (KTA)

KTA 2101.3 (2015-11)

Fire Protection in Nuclear Power Plants
Part 3: Fire Protection of Mechanical and Electrical Plant Components

(Brandschutz in Kernkraftwerken
Teil 3: Brandschutz an maschinen- und elektrotechnischen Anlagen)

The previous version of this safety standard was issued in 2000-12

If there is any doubt regarding the information contained in this translation, the German wording shall apply.

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KTA SAFETY STANDARD

November 2015	**Fire Protection in Nuclear Power Plants Part 3: Fire Protection of Mechanical and Electrical Plant Components**	KTA 2101.3

Previous version of the present safety standard: 2000-12 (BAnz No. 106 a of June 9, 2001, corrected in BAnz No. 239 of December 21, 2007)

Contents

PLEASE NOTE: Only the original German version of the present safety standard represents the joint resolution of the 35-member Nuclear Safety Standards Commission (Kerntechnischer Ausschuss, KTA). The German version was made public in Bundesanzeiger (BAnz) of January 8, 2016.
Copies of the German versions of KTA safety standards may be mail-ordered through Wolters Kluwer Deutschland GmbH (info@wolterskluwer.de). Downloads of the English translations are available at the KTA website: www.kta-gs.de

All questions regarding this English translation should please be directed to:

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Comments by the Editor:

Taking into account the meaning and usage of auxiliary verbs in the German language, in this translation the following agreements are effective:

shall	indicates a mandatory requirement,
shall basically	is used in the case of mandatory requirements to which specific exceptions (and only those!) are permitted. It is a requirement of the KTA that these exceptions - other than those in the case of **shall normally** - are specified in the text of the safety standard,
shall normally	indicates a requirement to which exceptions are allowed. However, exceptions used shall be substantiated during the licensing procedure,
should	indicates a recommendation or an example of good practice,
may	indicates an acceptable or admissible method within the scope of the present safety standard.

Basic Principles

(1) The safety standards of the Nuclear Safety Standards Commission (KTA) have the task of specifying those safety-related requirements which shall be met with regard to precautions to be taken in accordance with the state of science and technology against damage arising from the construction and operation of the plant (Sec. 7, para. (2), subpara. (3) Atomic Energy Act - AtG) in order to attain the protective goals specified in AtG and the Radiological Protection Ordinance (StrlSchV) and further detailed in the Safety Requirements for Nuclear Power Plants (SiAnf) and the SiAnf-Interpretations.

(2) The Safety Requirements for Nuclear Power Plants (SiAnf) Appendix 3 "Internal and external events as well as external hazards" states among others that protective measures against fires inside the nuclear power plant must be provided. The basic requirements regarding fire protection measures are detailed in the safety standard KTA 2101.1. The fire protection of structural components is detailed in safety standard KTA 2101.2 and the fire protection of mechanical and electrical components in the present safety standard. All three parts of the safety standard series KTA 2101 must be considered in the planning and execution of fire protection measures.

Note:

The additionally relevant KTA safety standards are specified in safety standard KTA 2101.1.

(3) The present safety standard is prepared based on the assumption that the building codes, fire protection laws and fire protection regulations of the individual German states (Länder), the German Workplace Ordinance, the German Accident Prevention Regulations (UVV) of the trade unions and other public law regulations are complied with. If the specifics of the nuclear power plant require deviations from laws, ordinances or other public law regulations or from the German Accident Prevention Regulations (UVV), then, in each individual case, the particular procedures specified in these regulations regarding deviations and exemptions must be followed.

1 Scope

This safety standard applies to nuclear power plants with light water reactors.

Note:

Further scope-related specifications are detailed in safety standard KTA 2101.1.

2 Definitions

Note:

Applicable definitions are specified in safety standard KTA 2101.1.

3 Fire Protection Measures for Mechanical and Technical Components and Facilities

3.1 General Requirements

Insofar as the measures specified under Sections 3.2 and 3.3 cannot be applied to the extent necessary to ensure the required protection in the event of fire, additional measures shall be specified regarding fire detection (e.g., by installing additional fire detectors) and regarding firefighting (e.g., by installing stationary fire extinguishing systems).

3.2 Fire Prevention Measures

3.2.1 Components containing combustible liquid or gaseous materials

(1) Hot parts in close proximity to components containing combustible materials shall basically be avoided. If this is not possible due to system-technological or usage-related requirements, measures shall be introduced to avoid an ignition of leakages (e.g., thermal insulation, double concentric pipe, encapsulation, local extraction).

(2) Oil and fuel supplies shall be designed such that their fluids cannot leak onto any plant components with a surface temperature higher than 200 °C.

(3) The systems containing combustible liquid or gaseous operating materials shall normally be provided with equipment for leakage detection (e.g., filling level monitors in case of liquid materials, pressure monitors in case of gaseous materials) and, if applicable, for the draining of leakages.

(4) Vessels containing larger amounts of combustible fluids shall be provided with collecting facilities. The volume of the collecting facilities shall be specified considering the maximum possible non-isolatable leakage amount of the largest individual vessel and, in the case of stationary water-based fire extinguishing systems, also of the accumulated firefighting agent.

Note:

Vessels containing larger amounts are, e.g., vessels of the external oil supply as well as the fuel oil tanks of the emergency power generating facilities.

(5) Combustible materials escaping from safety valves shall be safely drained off.

(6) It is not admissible to use cutting ring fittings for pressure-retaining pipes containing combustible liquid or gaseous materials.

3.2.2 Pumps

(1) In the case of an external lubricant supply, the amount of oil from leakages shall be minimized. In this context, measures for monitoring the oil level or oil pressure shall be provided. As soon as the amount of supplied oil falls below a minimum value to be specified, the oil supply shall automatically be shut off.

(2) In the case reactor coolant pumps and associated motors are provided with an integrated oil supply, the pumps shall be equipped with a collecting facility for the entire oil amount of the largest individual supply vessel.

(3) In the case of integrated oil supplies with cooling equipment inside the oil tank, the level in the oil tank shall be monitored. When the maximum admissible level is reached, the cooling water supply to the oil cooler shall be shut off.

(4) The oil supply lines of the reactor coolant pumps shall be designed against external events considering safety standard KTA 2101.1 Sec. 3.3. This shall basically also apply to the oil tank including the auxiliary equipment. In the case of an external oil supply, the oil tank including the auxiliary equipment in the same room does not need to be designed against external events, provided, it is demonstrated that the structural elements separating the firefighting sub-compartment of the oil tank compartment remain functional even after an external event and that the oil collection pan continues to be leak tight.

(5) In the case of reactor coolant pumps with an external oil supply, the design shall incorporate constructional measures that will prevent an uncontrolled release of oil.

3.2.3 Emergency power generating facilities

The fuel oil storage tank of each redundancy shall, and the fuel oil day tank of each redundant element shall normally, be located in individual firefighting sub-compartments apart from the diesel generator units.

Note:

Additional requirements regarding fire protection of emergency power generating facilities are specified in safety standard KTA 3702.

3.2.4 Turbine of a BWR

(1) The pressurized oil supply lines including the respective return lines shall be routed in separate channels to the turbine deck.

(2) The control fluid used for the turbine control system shall normally be flame retardant.

3.2.5 Gas treatment systems

(1) The design of gas treatment systems of power plants with boiling water reactors shall incorporate measures that will prevent the occurrence of a fire, that will ensure an early fire detection and that will limit the extent of the fire. In this context, the following equipment shall normally be installed:

a) at least one pre-adsorber, the size of which is limited to the operationally necessary volume of activated charcoal,

b) a carbon-monoxide detector at the exit port of the pre-adsorber, the alarm of which shall be displayed in the control room.

   Note:

   As specified in safety standard KTA 3904, the control room annexes are considered as part of the control room.

c) input ports for inerting gaseous fire suppression agents, and

d) individual isolating devices for the pre-adsorbers.

(2) The gas treatment systems of power plants with pressurized water reactors shall be designed such that they can be operated under a protective gas atmosphere.

(3) In the rooms of the adsorbers with activated charcoal, combustible materials are admissible only in such amounts as are necessary for the operation of these adsorbers.

(4) The vessels of adsorbers with activated charcoal filters shall be manufactured of non-combustible materials.

3.2.6 Refrigeration plants

Non-combustible refrigerants shall normally be used.

3.2.7 Storage and handling of combustible radioactive wastes, residual substances and auxiliary equipment

(1) Combustible radioactive wastes, residual substances and auxiliary equipment shall be collected in non-combustible and lockable containers. Combustible radioactive fluids shall be collected separately. The containers shall be marked with appropriate danger symbols. The containers shall normally be stored in a ventilated room until further treatment of the wastes and residual substances or until reuse of the auxiliary equipment.

(2) When storing such materials, the creation of combustible gases that can lead to an inadmissible release of radioactive materials shall be prevented, even under consideration of autoxidation. If the creation of combustible gases cannot be precluded, safety standard KTA 2103 shall be considered.

3.2.8 Insulation materials

(1) The insulation of pipes and components shall basically consist of non-combustible materials.

(2) For cold-temperature insulations it is admissible to use combustible foam isolation materials or combustible auxiliary materials, provided,

a) the insulation material is flame retardant, or

b) after installation, the insulation material used

   ba) is comparable to flame retardant building materials,

   bb) is protected from direct flames by a sheet metal encasement and

   bc) it is proven that inside the insulation a sustained fire is not possible.

(3) In the vicinity of oil and fuel supplies, the heat insulations shall be sufficiently protected such that, in case of leakages, these fluids will not penetrate into the insulation materials. This can be achieved, e.g., by baffles or sheet metal encasements.

3.3 Measures for Limiting the Fire Impact

3.3.1 Containment vessel

(1) The containment vessel integrity shall be ensured in the event of fire. Therefore, any fire loads that could endanger the integrity of the containment vessel shall basically be avoided. Admissible exceptions are those fire loads that are protected by structural and equipment-related fire protection measures.

(2) The measures specified in para. (1) shall also ensure that heat effects on one side of the containment wall will not cause a transfer of the fire to the other side of the wall.

(3) The airlocks and airlock antechambers shall be kept free of any fire loads that are not necessary for the operation of the airlocks or for the protection of personnel.

3.3.2 Storage of combustible or combustion-promoting operating materials and of pressurized gas bottles

Note:

Requirements regarding explosion protection in nuclear power plants with light-water reactors are detailed in safety standard KTA 2103.

(1) It is not admissible to store combustible or combustion-promoting gases in areas containing safety-related plant components.

(2) The storage of combustible or combustion-promoting gases inside the controlled area shall be limited to the operationally necessary amount.

(3) The storage of combustible fluids or other combustible or combustion-promoting materials in areas containing safety-related plant components is basically inadmissible. Exempted is the storage of the amount of diesel fuel specified in safety standard KTA 3702 as well as the necessary amount of operating materials and the operating materials contained in the systems.

(4) The provision and use of combustible or combustion-promoting operating materials shall be limited to the operationally necessary amounts and time.

(5) It is not admissible to store combustible fluids together with other combustible or combustion-promoting materials.

(6) The storage or provision of pressurized gas bottles, even for non-combustible gases, in the vicinity of massive fire loads is basically inadmissible. Exempted is the provision of

pressurized gas bottles for small fire extinguishing systems and for equipment protection systems.

3.3.3 Storage for new fuel assemblies

(1) Neither the pipe lines carrying combustible materials, nor cables and power lines nor combustible materials not required for the operation of the storage facility shall be led through, or stored in, the storage room.

(2) In the storage room, only such fire suppressants shall be used for firefighting for which the criticality analysis specified in safety standard KTA 3602, Sec. 3.1.2.1, has confirmed that they will not cause criticality. The accordingly admissible fire suppressants shall be specified in the operating manual and listed at the access points to the storage room.

3.3.4 Components containing liquid or gaseous combustible or combustion-promoting materials

(1) It shall be ensured, that components containing combustible or combustion-promoting liquid or gaseous materials will not release these materials in case of fire.

(2) Basically, only non-combustible materials may be used for these components. Excepted are sealants, provided, they are protected from a direct flame exposure in the event of fire. Combustible hoses shall normally be designed to be fully metal encased.

4 Fire Protection Measures for Electrical Operating Agents and Equipment

4.1 General Requirements

(1) The proper choice of materials and protective equipment shall assure a low risk of occurrence of fire and of fire propagation in electrical equipment and their operating agents.

(2) Redundant electrical facilities and their operating agents shall be protected from each other, either by structural elements having a sufficient fire resistance capability, by their physical separation (e.g., sufficient distance) or by the encapsulation of combustible materials, such that a fire cannot lead to the failure of an inadmissible number of redundant equipment.

4.2 Terminal Boxes

Predetermined breaking points shall be arranged on the terminal boxes of high-voltage motors such that escaping gases from electric arcs are guided onto the motor housing on which the boxes are mounted.

4.3 Control Rooms and Rooms for Switch Gear and for Instrumentation and Control Equipment

(1) No cable ducts or large assemblies of cables other than those required for the function of the switch gear itself are admissible in those regions which, considering electric arc effects, are within the specified minimum distance between switch gear and the adjacent walls or plant components.

(2) Switch gear and the instrumentation and control equipment shall be housed in metal cabinets.

4.4 Cables and Cable Routing

(1) Cables and electrical conduits ("cables" for short, in the following) of the fire protection equipment for a fire compartment or firefighting sub-compartment shall basically be designed or routed such that, in the event of a fire in this fire compartment or fire sub-compartment, the function of the corresponding fire protection equipment is ensured. The only admissible exceptions are those cases where the function of the fire protection equipment has already been performed at the time of cable destruction and a later functioning of this equipment is not required anymore.

(2) The use of fire shields for cables with a shield thickness larger than 50 cm, the use of intumescent materials or cable bandages requires demonstrating that the mechanical and electrical characteristics of the cables and their connection points are maintained. The heat dissipation from the cables shall not be inadmissibly impaired.

(3) Pipe lines that are conduit to combustible materials may not be routed in cable ducts.

(4) In the case of cables that are required to counteract rapid fire propagation and that, in the event of fire, may not give off corrosive combustion gases, it shall be demonstrated that their fire behavior (e.g., low fire propagation, free of halogens, flame retardant, self-fire-extinguishing behavior, corrosiveness of the combustion gases, combustion gas density). This may be demonstrated in accordance with the standards DIN EN 50267-2-2, DIN EN 60332-3-22, DIN EN 60332-3-23, DIN EN 60332-3-24 and DIN EN 61034-2.

(5) For cables (including cable mounting elements) of systems, the function of which must be ensured even in the event of fire, a sustained function capability of the cables shall be demonstrated for the required time span.

4.5 Electric Heaters

(1) Mobile electric heaters shall be protected against inadmissible self-heating.

(2) In case electric heaters are used as stationary installations it shall be ensured that there is sufficient distance to combustible materials and that there is an unhindered dissipation of heat. In the case of mobile electric heaters this shall be ensured by administrative measures.

5 Equipment for Fire Detection and Alarm Systems

5.1 General Requirements

(1) Only certified components shall be used for the fire detection and alarm systems. The proper interaction of all components shall be demonstrated by system approvals.

(2) If fire detection and alarm systems are located inside structural components which, due to their safety-related significance, must be designed against a design basis earthquake that has an intensity, I, higher than VI (EMS-98 – European Macroseismic Scale), then these fire detection and alarm systems shall normally be designed as specified in safety standard KTA 2201.4 with the earthquake effects to be determined as specified in safety standard KTA 2201.1.

(3) Fire detection and alarm systems, the function of which must be ensured after event combinations as specified in safety standard KTA 2101.1, Sec. 3.3, shall be designed for the effects from the events to be combined. If the event combination involves an earthquake with subsequent fire and the design basis earthquake has an intensity, I, higher than VI (EMS-98), then these fire detection and alarm systems shall be designed as specified in safety standard KTA 2201.4 for the earthquake effects determined as specified in safety standard KTA 2201.1.

5.2 Transmission Routes, Detector Groups

(1) Each redundancy shall be equipped with its individual detector group. A failure affecting multiple redundancies of the detector groups shall be prevented by a corresponding arrangement and design of the transmission routes.

(2) If stationary fire extinguishing systems are triggered by automatic fire detectors, then the actuation of each fire extinguishing system in its fire extinguishing area requires a two-out-of-two dependency of the detector alarms.

(3) The fire detectors of a specific detector group shall normally all be placed either inside or outside of the permanent exclusion areas in accordance with StrlSchV.

(4) Measures shall be taken to ensure that those fire alarms from areas that are inaccessible during specific operating conditions will not become inoperative due to operational effects (e.g., radiation) until the next possible accessibility.

Note:

This can be ensured by shielding the fire detectors, by installing aspirating smoke detectors, or by multiple available detector groups.

5.3 Extent of Fire Detectors and their Arrangement

(1) The scope of protection of the fire detection and alarm system shall basically be classified as Category 1 in accordance with DIN 14675 (Full Protection). For those areas that shall not be monitored, the admissibility shall be demonstrated by a fire hazard analysis.

(1) Automatic fire detectors are required in the following areas or in areas with the following equipment:

a) switch gear, dc-dc converters,
b) cabinets for instrumentation and control equipment,
c) telecommunications centers,
d) process computers,
e) transformers located in structural components,
f) stationary battery facilities,
g) diesel units including the fuel oil supply,
h) large assemblies of cables (e.g., cable cellars, cable ducts, cable wells, conduit rooms, cable floors),
i) not-continuously-manned control stations (this includes, e.g., the areas behind the control panels, furthermore, the local control stations, the remote shutdown station and the control room annexes),
j) storage for new fuel assemblies,
k) area for the storage and handling of combustible radioactive wastes in the waste storage facility,
l) other areas for the storage of combustible materials, e.g., fuel oil depot,
m) decontamination room,
n) hot workshop,
o) oil-lubricated components with an oil reservoir or oil supply system (e.g., on the turbo-generator set in BWR, on the reactor coolant pumps, on the feed water pumps, on the main condensate pumps, on the safety injection pumps, on the high-pressure feed pumps),
p) central air conditioning facilities including, if applicable, filter compartments and air ducts of air-recirculation systems,
q) other important and fire endangered rooms that are inaccessible during plant operation.

(3) Rooms equipped with sprinkler facilities shall be monitored by automatic fire detectors.

(4) In the case of room areas monitored by automatic fire detectors for the control equipment of fire extinguishing systems, it is admissible to dispense with additional monitoring by the fire detection and alarm system. However, at least one of these automatic fire detectors in each detector group shall submit their fire and malfunction alarms also to the local fire alarm center. The necessary components of the control equipment necessary for fire detection and alarm shall meet the requirements of Section 5.1.

(5) The number and arrangement of manual fire detectors (not the automatic fire detectors) shall be specified for each individual case.

5.4 Arrangement of the Local Fire Alarm Centers, of the Display and Control Panels

(1) At least one display and control panel of the fire detection and alarm system shall be installed in the control room or in a room directly accessible from the control room.

(2) One display and control panel shall additionally be installed in the remote shutdown station. This control and display panel shall display at least the fire and malfunction alarms of the detector groups that monitor plant regions containing equipment of the emergency systems.

(3) If the display and control panels of the local fire alarm centers are installed in a room directly accessible from the control room, then one optical and one acoustical group alarm each shall be shown in the control room signaling malfunction of the fire detection and alarm system or a fire. A failure of a display and of a control panel shall be displayed in conjunction with the malfunction group alarm.

(4) In the case of a serial display of the fire alarms, the group display shall be supplemented by an additional summaric display serving as information on the queued alarms.

(5) In order to increase availability, the fire detection and alarm system shall normally comprise a network of decentralized fire alarm centers. The fire and malfunction alarms shall be transmitted to the superordinate fire alarm center via two transmission routes that shall be independent of each other.

(6) Malfunctions in local fire alarm centers shall not lead to a simultaneous erroneous actuation of fire protection equipment in different redundancies unless it is demonstrated that erroneous actuations are harmless from the standpoint of safety.

(7) Two copies of the floor plans shall be made available in the control room showing the alarm areas, the location of the automatic and non-automatic detectors, the access routes and locations of firefighting equipment. Furthermore, instructions for the correct behavior in case of fire alarms as well as descriptions regarding malfunctions of the fire detection and alarm system shall be provided. Regarding the detector groups specified under para. (2), one copy of these floor plans shall be provided in the remote shutdown station.

Note:

The tactical mission data for the fire department is contained in the deployment plans for the fire department as specified in safety standard KTA 2101.1.

(8) In case the fire alarms require manual measures, then the displays of the fire detection and alarm system, the floor plans and instructions specified under para. (7) shall be ergonomically coordinated such that a fast and unambiguous identification of the affected regions and the actuating elements of the control equipment is possible.

5.5 Arrester Systems for Fire Barriers

(2) The arrester systems of those fire barriers that must be kept open for safety-related reasons shall meet the following additional requirements:

a) The power for the arrester systems shall normally be supplied from the uninterruptible emergency power supply facility.

b) In case an uninterruptible emergency power supply is not used, then possible power interruptions (e.g., during a bus switch-over or during diesel start-up) shall be bridged by an energy storage system such that this interruption will not lead to an actuation of the arrester system in the time span until emergency power is again effective. Other functions shall not be affected by this energy storage system.

c) The position “NOT OPEN” of the fire barriers shall be signaled as specified in safety standard KTA 2101.1, Sec. 5.5.

6 Firefighting Equipment

6.1 General Requirements

(1) The equipment for firefighting include

a) the firefighting water supply,

b) the fire extinguishing systems,

c) the mobile fire extinguishing equipment.

(2) Firefighting equipment, the function of which must be ensured after event combinations as specified in safety standard KTA 2101.1, Sec. 3.3, shall be designed for the effects from the events to be combined. If the event combination involves an earthquake with subsequent fire and the design basis earthquake has an intensity, I, higher than VI (EMS-98), then this firefighting equipment shall be designed as specified in safety standard KTA 2201.4 for the earthquake effects determined as specified in safety standard KTA 2201.1.

6.2 Firefighting Water Supply

6.2.1 General requirements

(1) The design of the pumps and dimensions of the firefighting water main loop system shall be based on the firefighting water demand (i.e., 100%) which results from the stationary fire extinguishing system with the largest as-designed water supply inside or outside of the buildings (e.g., sprinkler systems, spray-water or foam firefighting systems) plus an added water demand of 1600 liters/min (e.g., for hydrants and wall hydrants). The overall supply of available water shall allow a flow rate of at least 3200 liters/min.

(2) With the exception of the coolant water intake civil structure as well as cable and pipe penetrations, any structural components containing equipment of the safety system or of the emergency systems shall be connected to the firefighting water main loop system by at least two connection point. Each connection point to the firefighting water main loop system shall be equipped with an isolation device to allow interrupting the supply from the firefighting water main loop system on the inside of the structural component.

(3) The dimensions of these connection points shall be based on the valve station of the fire extinguishing system inside the structural component with the largest as-designed water flow rate plus an added amount of 800 l/min.

(4) In case the firefighting water is supplied entirely from tanks or firefighting water pools, the following requirements shall be met:

a) The supply shall cover the firefighting water demand (100%) specified under para. (1) for the duration of at least one hour.

b) The useable water supply shall, however, amount to at least 600 m^3.

c) If the water is supplied entirely from tanks, the number and capacity of these tanks shall be such that 100% of the water supply specified under items a) and b) will be available even if one tank is unavailable.

d) In case of specified normal operation of the firefighting water supply system, it shall be possible for the water supply (100%) to be refilled within 8 hours.

(5) With regard to creating an additional firefighting water supply for mobile firefighting, firefighting water removal points for fire pumps of the fire department shall be installed at suitable locations (e.g., water intake structure, cooling tower dish). From this location it shall be possible to create a connection to the supply inlet of the firefighting water main loop system.

(6) In structural components containing equipment of the safety system or of the emergency systems, additional feed-in possibilities for mobile firefighting (800 l/min) shall be installed to enable the fire department to provide firefighting water in case of a failure of the outside firefighting water supply system.

(7) The pipe system of the firefighting water supply system shall basically be designed for the firefighting water quality available at the plant site. Alternatively, the pipe system in its operationally readied state may be filled with water that shall be harmless to the pipe system with respect to corrosion.

(8) If the pipe system of the fire extinguishing system is not designed for the firefighting water quality available at the plant site and in its operationally readied state is, therefore, filled with water that shall be harmless to the pipe system with respect to corrosion, then the following requirements shall be met:

a) Regarding fire drills of the plant fire brigade that include tapping firefighting water from the firefighting water main loop system, a firefighting water flow rate of 600 liters/min shall be sustained for at least 15 min. During fire drills it should be avoided that river water or water of a similarly low quality gets into the pipe system of the firefighting water supply.

b) In the case that, during a firefighting mission or for other reasons, river water or water of a lower quality has gotten into the pipe system, then the affected pipes, branches, valves, fittings and nozzles shall be flushed and subsequently refilled with water that shall be harmless with respect to corrosion.

(9) Any suspended matter contained in the water shall not cause functional disturbances in the firefighting water supply.

Note:

This can be achieved by flushing the firefighting water supply lines.

(10) The use of water wells as firefighting water supply is admissible, provided, their silting is prevented.

Note:

This can be ensured, e.g., by a continuous operational water removal.

(11) To protect against flooding, it is admissible to install active isolating devices in firefighting water pipes leading to structural components that, under normal conditions, are closed. It shall be possible to open these active isolating devices from the control room. Proper measures shall be taken to sustain the pressure in the pipe systems that are shutoff.

(12) Given a sufficient flooding capacity, firefighting water ingress may, alternatively, be limited by correspondingly qualified instrumentation and control equipment.

(13) The retention of firefighting water shall be dimensioned in accordance with pertinent conventional guidelines and observing the protective goals.

6.2.2 Hydrants, wall hydrants

(1) Hydrants shall be installed on the plant site in the direct vicinity of the buildings with a distance between hydrants of about 60 meters but no more than 80 meters. The hydrants shall, preferably, be located close to the access points of the buildings or close to other openings that are suitable to be used for firefighting missions in the buildings. The placement of hydrants shall normally be oriented along the free movement areas for the fire department.

(2) Wall hydrants shall be suitable for operations by the fire department. They shall, preferably, be located close to the staircases and shall normally be supplied by wet supply lines.

(3) In those areas where fires of fluids are possible (e.g., turbines or areas where diesel fuel is present), the wall hydrants shall, additionally, be equipped with firefighting equipment for fires of fluids.

6.2.3 Design of the firefighting water pipe lines

(1) The firefighting water pipe lines shall be dimensioned such that, for operation of the fire extinguishing system designed for the largest as-designed water flow rate in the respective area, a flow pressure of at least 0.3 MPa is available at the most unfavorable water hydrant.

(2) The water velocity shall normally not exceed 10 m/sec in pipe lines and 5 m/sec in the valves and fittings.

(3) The firefighting water pipe lines shall be routed such that they are protected against frost.

(4) The firefighting water pipe lines shall be routed such that leakages will not adversely affect the function of more than one redundancy of the safety-related equipment.

(5) The chemical suitability of the firefighting water pipe lines as well as associated valves and fittings shall be demonstrated.

Note:

Regarding the chemical suitability in case of using river water or similar water qualities, the requirements under Section 6.2.1 para. (7) shall be considered.

6.3 Fire Extinguishing Systems

6.3.1 General requirements

(1) Stationary, automatically actuated fire extinguishing systems shall be installed for the oil-filled high-power transformers of the main off-site power connection (e.g., generator transformers) and of the auxiliary power branch-off (e.g., station transformers) specified in safety standard KTA 3701. This requirement also applies to standby mains transformers if a fire-related inadmissible impairment of adjacent buildings and facilities cannot be precluded.

Note:

Suitable for the actuation are, e.g., Buchholz relays, differential relays or temperature sensitive triggering systems.

(2) Stationary fire extinguishing systems shall normally be installed in the following rooms or in rooms with the following equipment:

a) turbine oil tanks and turbine oil channels,
b) fuel oil storage for diesel units where supply tanks and fuel oil day tanks are inside buildings,
c) reactor coolant pumps including oil tanks,
d) not encapsulated large assemblies of cables (e.g., in cable ducts, conduit rooms and cable floors),
e) not encapsulated large fire loads in areas difficult for manual firefighting (e.g., poor accessibility, high local dose rate, insufficient smoke removal),
f) waste treatment and storage of radioactive combustible materials,
g) electronic data processing facilities.

(3) The suitability of the fire extinguishing systems shall be demonstrated for the individual application. The fire extinguishing systems may basically be planned and designed in accordance with generally accepted engineering standards. Admissible exceptions are related to the actuation, power supply, firefighting water supply and tests as specified in this section.

Note:

Generally accepted engineering standards are, e.g., DIN, Comité Européen des Assurances (CEA), National Fire Protection Association (NFPA).

(4) In areas of the storage and handling of radioactive materials, precautionary measures shall be taken to prevent a spreading of radioactivity by the fire suppression agents.

(5) In the controlled area, the entire firefighting water shall be retained inside the controlled area.

6.3.2 Water-based fire extinguishing systems

(1) Stationary water-based fire extinguishing systems are, e.g.,

a) stationary and semi-stationary spray-water extinguishing systems,
b) stationary and semi-stationary fine-spray-water extinguishing-systems,
c) fogging fire extinguishing systems,
d) sprinkler systems,
e) variants of these fire extinguishing systems regarding propellant gases or inert gases.
f) foam firefighting systems.

(2) In the case of oil-containing components and systems, each individual case shall be evaluated to prove that a simultaneous actuation of multiple fire extinguishing systems in the same firefighting sub-compartment is not necessary.

(3) In the rooms and areas protected by water-based fire extinguishing systems, the fire suppression agent shall either be collected or be drained off in a controlled and harmless manner.

(4) In the case of oil fuel supply facilities protected by water-based fire extinguishing systems, the positioning area of the oil supply shall be designed such that the water-oil mixture of one fire extinguishing process shall either be collected or be drained off in a controlled and harmless manner. Measures shall be provided that the accumulated water-oil mixture of the fire extinguishing process can be drained off in a controlled way after the fire extinguishing process.

6.3.3 Gas-based fire extinguishing systems

(1) Gas-based fire extinguishing systems are, e.g.,

a) CO_2 fire extinguishing systems,
b) inert-gas fire extinguishing systems,
c) fire extinguishing systems with halogenated hydrocarbons.

(2) Any damage to the pressure vessels including associated valves and fittings of gas-based fire extinguishing systems shall not have inadmissibly adverse effects on safety-related plant components.

(3) In case of the actuation of an area-protecting fire extinguishing system, the fire extinguishing area shall be isolated. Unless other measures prevent an inadmissible pressure increase in the fire extinguishing area, the pressure relief equipment shall be kept open during the gas inflow process. To prevent the fire extinguishing gas concentration from prematurely falling below effective values, the pressure relief equipment shall be closed after termination of the gas inflow process.

Note:

An isolated fire extinguishing area is not one that is closed off in accordance with building regulations but rather one where the fire dampers or fire barriers are closed.

(4) The pressure relief related gas overflows from a fire extinguishing system may be directed into adjacent rooms or areas, provided, that this does not have any inadmissible safety-related effects, that any danger to personnel is excluded and that the enclosing structural elements of these rooms or plant areas are not inadmissibly impaired. In the case fire extinguishing systems are actuated inside the controlled area, the pressure relief related gas overflows may only be directed into rooms of the controlled area.

(5) Gas-based fire extinguishing systems for the control room and rooms directly accessible from there shall basically only be actuated manually. An automatic actuation of gas firefighting systems is admissible if the control room personnel can remain in the control room after actuation.

Note:

The protection of personnel is of utmost importance in the control room and in rooms directly accessible from there. It can be assumed that an immediate actuation of the gas-based fire extinguishing system is ensured by the personnel continuously present in the control room.

6.3.4 Controls of the fire extinguishing systems

(1) The triggering controls of the fire extinguishing systems shall be designed such that they cannot be inadmissibly impaired by the fire they are to mitigate. In the case of electrical controls, the power needed for the controls shall be ensured even if the regular power grid fails.

(2) In the case of a non-automatic actuation, it shall be ensured that actuation occurs early and reliably. The respective actuation criteria and instructions for a manual actuation of the fire extinguishing systems shall be included in the operating manual. The actuation criteria shall be specified for each individual case.

Note:

Such criteria pertain to, e.g., the triggering of the fire detection and alarm system, the visual check using the plant's television system, the failure or malfunction alarms.

(3) A manual actuation of the fire extinguishing system shall normally be provided that is independent of the remote actuation or of the automatic actuation.

(4) Preventive measures to avoid any erroneous actuation of the fire extinguishing systems shall be provided.

Note:

Such preventive measures are, e.g., in the case automatic actuations are triggered from fire detectors, the logical connection of two fire detector groups, or actuation controls that are based on the load current principle.

(5) In well substantiated cases, the effective running time of spray-water extinguishing systems may be limited to no less than 5 minutes.

(6) The actuation of a fire extinguishing system shall be annunciated in the control room as specified in safety standard KTA 2101.1, Sec. 5.5.

(7) Sprinkler systems only need to fulfill paras. (1), (4) and (6).

6.4 Mobile Fire Extinguishing Equipment

(1) Instead of portable fire extinguishers, it is admissible to also provide part of the fire suppression agent amount required in accordance with ASR A2.2 in mobile equipment (no more than 50 kg).

(2) The choice and deployment of mobile fire extinguishing equipment in electrical equipment requires the additional consideration of DIN VDE 0132.

Note:

The fire suppression agents shall be chosen taking possible impairments, e.g., to electrical and electronic components into consideration.

7 Ventilation Systems, Equipment for Heat and Smoke Removal

7.1 General Requirements

(1) To prevent the spreading of smoke, those air-recirculation systems serving more than one firefighting sub-compartment shall be equipped with smoke controls that would automatically switch the air-recirculation systems over to an external air and exhaust air operating mode. From the control room it shall be possible to reset this automatic switch-over. This requirement does not apply to the air-recirculation cooling systems in the controlled area.

(2) The fire compartment or firefighting sub-compartment concerned shall be isolated by a remotely controlled closing of the fire dampers.

(3) Those ventilation systems and the equipment for heat and smoke removal, the function of which must be ensured after event combinations as specified in safety standard KTA 2101.1, Sec. 3.3, shall be designed for the effects from the events to be combined. If the event combination involves an earthquake with a subsequent fire and an intensity of the design basis earthquake, I, higher than VI (EMS-98), then these ventilation systems and the equipment for heat and smoke removal shall be designed as specified in safety standard KTA 2201.4 for the earthquake effects determined as specified in safety standard KTA 2201.1.

7.2 Ventilation Systems

(1) Those ventilators of ventilation systems, the function of which must be ensured in the event of fire, are not required to be redundant alone for reasons of fire protection.

(2) In case ventilation systems are equipped with filter systems, it shall be ensured that they are not inadmissibly impaired by the loads from, e.g., temperature, pressure, fire by-products or fire suppression agents.

Note:

In this context and considering, e.g., the radiation exposition expected in the direct vicinity, peripheral deflectors can be provided surrounding the filter system.

7.3 Equipment for Heat and Smoke Removal

(1) The individual measures for heat and smoke removal as well as the required time for the removal of smoke and the required air volume flows shall be specified for each individual case dependent on the local conditions. At least the following aspects shall be considered:

a) location of the room or area,

b) possibility of air supply or air exhaust using the ventilation facilities,

c) objective of smoke removal (e.g., enabling rescue or mobile firefighting operations), or

d) restrictions for reasons of radiation protection (e.g., low external air and exhaust air volume flows).

(2) The smoke removal air volume flow may not be interrupted during in time frame specified for the removal of smoke (e.g., by the closing of fire dampers, by constrictions in mufflers, by the clogging up of filters).

(3) The inlet air volume flow required for the smoke removal shall be ensured. In the case of powered smoke removal, it is admissible that the required inlet air volume flow is also supplied from the inlet air to an air conditioning and ventilation system of the respective room. In this context, after closing the possibly provided inlet-air-oriented fire dampers, continued operation of the heat and smoke removal system is only admissible if the developing pressure differences are not inadmissibly high.

7.4 Preventing Smoke Ingress into Necessary Staircases and Airlock Antechambers

7.4.1 General requirements

(1) Smoke ingress into necessary staircases and airlock antechambers shall be prevented (e.g. by thinning down or removal of the smoke) by providing either

a) equipment for natural venting, or

b) powered airing and venting systems.

Note:

Natural venting is not suitable, e.g., in radiologically relevant regions of the controlled area, in regions without a sufficient number of openings to the outside, or where plant security requires that doors are kept closed.

(2) The opening of equipment for smoke removal in staircases of the controlled area shall be displayed and logged in the control room as specified in safety standard KTA 2101.1, Sec. 5.5.

7.4.2 Equipment for natural venting

Natural venting may basically not be used in staircase regions that are below ground level. Exception are admissible when connecting to sub-ground levels in which the smoke ingress is expected to be minimal.

7.4.3 Powered airing and venting facilities for the dilution of smoke

(1) The powered airing and venting facilities for regions outside of the inner compartments of the reactor building shall be designed such that a sufficient smoke dilution is achieved for the assumed duration of self-rescue operations. The air exchange rate shall be specified for each individual case.

Notes:

a) A self-rescue operation is generally assumed to take up to 15 minutes.

b) By the antechambers and air locks located between the fire compartment or area and the rescue route, the requirements of the powered airing and venting facilities regarding dilution of smoke may be reduced.

(2) The air flow shall be guided such that it purges the necessary staircases and airlock antechambers along their entire lengths.

(3) The supply of the amount of air required for the dilution of smoke shall be ensured by an additional ventilation system or by utilizing the air supply branched off from other areas.

(4) The opening force at the doors shall be limited such that, when deploying powered airing and venting facilities for the dilution of smoke, opening the doors does not require auxiliary means.

7.4.4 Necessary staircases and airlock antechambers inside inner compartments of the reactor building of a PWR

(1) In the event of fires inside inner compartments of the reactor building of a pressurized water reactor, the entire inlet air flow of normal operation shall, as far as possible, normally be available for the airing of staircases and airlock antechambers.

Notes:

a) The inlet air flow is limited by the fact that openings penetrating the containment must be kept small. The inlet air flow shall be specified for each individual case.

b) It is possible that ventilation systems inside the inner compartments of the reactor building must be shut off for safety-related reasons, thereby limiting the smoke dilution in the necessary staircases and airlock antechambers.

(2) During maintenance and the expected conditions inside the reactor building (e.g., unlocked and open doors of personnel airlocks, a significant increase in the number of persons), the air supply to the necessary staircases and airlock antechambers shall be increased in the event of fire. The requirements shall be specified for each individual case. In this context, limitations for reasons of radiation protection shall be considered.

(3) The necessary control actions regarding paras. (1) and (2) shall be performed from the control room.

7.5 Controls, Displays, Power Supplies

7.5.1 Controls for fire dampers and smoke exhaust dampers

(1) If fire dampers for reasons of preventing the spreading of smoke must be closed before the soft-solder triggering occurs (e.g., to protect rescue routes or to protect sensitive components), these fire dampers shall be provided with an actuation control that is independent of the soft-solder triggers.

(2) Normally, the independent actuation specified under para. (1) shall basically be triggered automatically by smoke detectors. If safety-related reasons command that an automatic actuation is inadmissible, remote actuations shall be provided at least from one well accessible local control station or from the control room.

(3) If safety-related reasons command that fire dampers are actuated only in the event of fire and must, otherwise, remain in the “OPEN” position, the controls of the fire dampers shall be designed such that no erroneous actuation must be assumed (e.g., thermal actuation of the fire dampers, or triggering controls based on the load current principle), or technical administrative measures shall be provided by which these fire dampers can be opened within a specified time frame.

(4) In case air conditioning and ventilation systems are also employed for heat and smoke removal, it shall be ensured that, even under the room temperatures expected in case of demand, the controls of necessary fire dampers and smoke exhaust dampers is maintained.

(5) In order to prevent an unintended closing of the air inlet dampers caused by reversed currents of hot combustion gases, the controls for the smoke exhaust dampers shall be designed such that these dampers open automatically when a fire damper in the air exhaust duct closes.

7.5.2 Controls of heat and smoke removal systems

Early smoke detection and the design or arrangement of the switching and control equipment shall be such that, in case of demand, the proper functioning of the heat and smoke removal systems is ensured. This applies, particularly, to the case where components catch fire that are in the same room with the switching and control equipment.

7.5.3 Position indicators, signals

(1) Fire dampers shall send out at least the following feedback signals:

a) a feedback signal of the position of the individual fire damper which is sent to the corresponding local control station. As specified in safety standard KTA 2101.1, Sec. 5.5, corresponding group signals shall be sent from these local control stations to the control room.

   Note:

   The feedback signal may indicate the position of the individual fire damper (CLOSED or NOT OPEN or both). In this context, regarding ventilation aspects or explosion protection aspects may become relevant.

b) a feedback signal of the individual fire damper which is sent to the control room – required in case further measures are to be performed by the control room personnel.

(2) At least the following feedback signals shall be displayed at the corresponding local control station and, as specified in safety standard KTA 2101.1, Sec. 5.5, as a group signal in the control room:

a) the operation of ventilation systems with fire protection functions, and

b) the closing of the fire protection barriers which, for reasons of ventilation, are in the open position during normal operation.

(3) The "OPEN" position of smoke exhaust dampers shall be displayed at the corresponding local control station.

7.5.4 Routing of triggering and signaling cables and of other controls-related transmission devices

(1) Cables required for triggering and feedback signaling shall basically meet the requirements specified under Section 4.4.

(2) In deviation of para. (1), it is admissible to route the cables required for feedback signaling through the room to be protected, provided, in the event of fire, no control action is derived from these feedback signals.

7.5.5 Controls for ventilators

(1) Ventilators used exclusively for keeping the rescue routes free from smoke shall be equipped with on-site controls for their manual actuation. In staircases, it shall, additionally, be possible to trigger these ventilators either remotely from the control room or automatically by smoke detectors.

(2) The local control points shall basically be located at the access points to the rescue routes and, in the case of staircases, at least at the top and bottom levels as well as at the exit level. Only one control point, namely at the exit level, is sufficient if the ventilators are automatically triggered.

(3) Ventilators used for heat and smoke removal shall be equipped with on-site controls for their manual actuation. It shall, additionally, be possible to trigger these ventilators either remotely from the control room or automatically by smoke detectors. It shall be ensured that during startup of the smoke removal ventilator the corresponding smoke exhaust damper is already open or that it can still be opened during operation of the ventilator.

(4) A buildup of inadmissible pressures (e.g., due to insufficient inlet air) that could lead to a failure of the structural elements shall be prevented.

7.5.6 Power supply

(1) A reliable power supply shall be provided for the ventilation systems and equipment under Section 7. The auxiliary power supply specified in safety standard KTA 3701, Sec. 2, para. (1), may be considered as sufficiently reliable.

(2) The ventilation systems and the equipment for heat and smoke removal specified under Section 7.1, para. (3) shall, additionally, be connected to the emergency power supply.

(3) All controls and displays of the ventilation systems and the equipment for heat and smoke removal specified under Section 7.1, para. (3) shall be connected to the uninterruptible emergency power supply.

(4) It shall be ensured for ventilation systems with specified functions in the event of fire, that the power supply (e.g., cables and their routing, including controls) is maintained for the required duration of the respective function.

7.6 Design of Special Systems or Components

7.6.1 Activated charcoal filters and high-efficiency particulate air filters

(1) Filter shells shall be constructed of non-combustible materials (cf. safety standard KTA 2101.1, Sec. 3.2.1 para. (3)).

(2) Tightly closing ventilation dampers shall be arranged before and after filter units with activated charcoal. These ventilation dampers shall be designed to be triggered from the control room. Smoke detectors shall be installed in the duct on the inlet air side of the first ventilation damper. A fire damper shall be installed before the filter if smoke temperatures above 100 °C can occur due to local conditions (e.g., duct length, mixture temperature, fire load, ingression of fire).

(3) If the exhaust air system is used for the removal of smoke then it shall be possible to bypass the activated charcoal filters and high-efficiency particulate air filters.

(4) In order to be able to detect a fire in the activated charcoal filters, alarm devices (e.g., carbon monoxide measuring devices) shall be installed between the filters and ventilation dampers. The alarms shall be displayed in the control room.

Note:

In non-flow-through filter systems, a buildup of the carbon monoxide concentration that can lead to false alarms must be expected.

(5) In rooms housing activated charcoal filters and high-efficiency particulate air filters, combustible materials are admissible only in such amounts as are required for regular operation of these filters and ventilation systems.

(6) Requirements for mobile filter systems shall be specified for each individual case.

7.6.2 Accident filtration systems

(1) It is not admissible to use accident filtration systems (exhaust-air filtration facilities as specified in safety standard KTA 3601, Sec. 5.2.3) for the removal of smoke. The requirements specified under Section 7.6.1, paras. (2) through (4) do not apply to accident filtration facilities.

(2) Safety-related reasons command that accident filtration systems that are triggered by the reactor protection system may not be equipped with fire dampers. In these cases, a fire and smoke transmission into other fire compartments shall be prevented by a proper type and routing of the ducts.

Note:

The thick-walled air ducts penetrating through structural plant components with fire protection functions may be protected by enclosing the ducts with fire shields like those used for fire-protected steel pipe penetrations.

Appendix A

Regulations Referred to in the Present Safety Standard

(Regulations referred to in the present safety standard are valid only in the versions cited below. Regulations which are referred to within these regulations are valid only in the version that was valid when the latter regulations were established or issued.)

AtG		Act on the peaceful utilization of atomic energy and the protection against its hazards (Atomic Energy Act – AtG) of December 23, 1959, revised version of July 15, 1985 (BGBl. I, p. 1565), most recently changed by Article 307 of the Act of August 31, 2015 (BGBl. I 2015, No. 35, p. 1474)
StrlSchV		Ordinance on the protection from damage by ionizing radiation (Radiological Protection Ordinance – StrlSchV) of July 20, 2001 (BGBl. I, p. 1714; 2002 I, p. 1459), most recently changed by Article 5 of the Act of December 11, 2014 (BGBl. I, p. 2010)
SiAnf	(2015-03)	Safety requirements for nuclear power plants of November 22, 2012, revised version of March 3, 2015 (BAnz AT of March 30, 2015 B2)
SiAnf Interpretations	(2015-03)	Interpretations of the safety requirements for nuclear power plants of November 22, 2012, revised version of March 3, 2015 (BAnz AT of March 30, 2015 B3)
KTA 2101.1	(2015-11)	Fire Protection in Nuclear Power Plants; Part 1: Basic requirements
KTA 2101.2	(2015-11)	Fire Protection in Nuclear Power Plants; Part 2: Fire Protection of Civil Structures
KTA 2103	(2015-11)	Explosion Protection in Nuclear Power Plants with Light Water Reactors (General and Case-Specific Requirements)
KTA 2201.1	(2011-11)	Design of Nuclear Power Plants Against Seismic Events; Part 1: Principles
KTA 2201.4	(2012-11)	Design of Nuclear Power Plants Against Seismic Events; Part 4: Components
KTA 3601	(2005-11)	Ventilation Systems in Nuclear Power Plants
KTA 3602	(2003-11)	Storage and Handling of Fuel Assemblies and Associated Items in Nuclear Power Plants with Light Water Reactors
KTA 3701	(2014-11)	General Requirements for the Electrical Power Supply in Nuclear Power Plants
KTA 3702	(2014-11)	Emergency Power Generating Facilities with Diesel-Generator Units in Nuclear Power Plants
KTA 3904	(2007-11)	Control Room, Remote Shutdown Station and Local Control Stations in Nuclear Power Plants
DIN 14675	(2012-04)	Fire detection and fire alarm systems - Design and operation
DIN EN 50267-2-2 VDE 0482-267-2-2	(1999-04)	General testing procedures for the behavior of cables and insulated conduits under fire conditions – Testing the gases created when burning the materials of cables and insulated conduits – Part 2-2: Test procedures; Determining the acidity level of the gases from the materials by measuring their pH value and conductivity German version EN 50267-2-2:1998
DIN EN 60332-3-22 VDE 0482-332-3-22	(2010-08)	Tests on electric and optical fiber cables under fire conditions - Part 3-22: Test for vertical flame spread of vertically-mounted bunched wires or cables - Category A (IEC 60332-3-22:2000 + A1:2008); German version EN 60332-3-22:2009
DIN EN 60332-3-23 VDE 0482-332-3-23	(2010-08)	Tests on electric and optical fiber cables under fire conditions - Part 3-23: Test for vertical flame spread of vertically-mounted bunched wires or cables - Category B (IEC 60332-3-23:2000 + A1:2008); German version EN 60332-3-23:2009
DIN EN 60332-3-24 VDE 0482-332-3-24	(2010-08)	Tests on electric and optical fiber cables under fire conditions - Part 3-24: Test for vertical flame spread of vertically-mounted bunched wires or cables - Category C (IEC 60332-3-24:2000 + A1:2008); German version EN 60332-3-24:2009
DIN EN 61034-2 VDE 0482-1034-2	(2014-11)	Measurement of smoke density of cables burning under defined conditions - Part 2: Test procedure and requirements (IEC 61034-2:2005 + A1:2013); German version EN 61034-2:2005 + A1:2013
DIN VDE 0132	(2015-10)	Firefighting and technical assistance in or near electrical installations
ASR A2.2	(2012-11)	Technical workplace regulations – Measures to prevent fires

Safety Standards

of the

Nuclear Safety Standards Commission (KTA)

KTA 2103 (2015-11)

Explosion Protection in Nuclear Power Plants with Light Water Reactors (General and Case-Specific Requirements)

(Explosionsschutz in Kernkraftwerken mit Leichtwasserreaktoren – allgemeine und fallbezogene Anforderungen)

The previous version of this safety standard was issued in 2000-06

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KTA SAFETY STANDARD

November 2015	Explosion Protection in Nuclear Power Plants with Light Water Reactors (General and Case-Specific Requirements)	KTA 2103

Previous versions of the present safety standard: 1989-06 (BAnz No. 229a of December 7, 1989)
2000-06 (BAnz No. 231a of December 8, 2000)

Contents

PLEASE NOTE: Only the original German version of the present safety standard represents the joint resolution of the 35-member Nuclear Safety Standards Commission (Kerntechnischer Ausschuss, KTA). The German version was made public in Bundesanzeiger (BAnz) of January 8, 2016 (Corrigendum: December 19, 2017).
Copies of the German versions of KTA safety standards may be mail-ordered through Wolters Kluwer Deutschland GmbH (info@wolterskluwer.de). Downloads of the English translations are available at the KTA website: www.kta-gs.de

All questions regarding this English translation should please be directed to:

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Comments by the Editor:

Taking into account the meaning and usage of auxiliary verbs in the German language, in this translation the following agreements are effective:

shall	indicates a mandatory requirement,
shall basically	is used in the case of mandatory requirements to which specific exceptions (and only those!) are permitted. It is a requirement of the KTA that these exceptions - other than those in the case of **shall normally** - are specified in the text of the safety standard,
shall normally	indicates a requirement to which exceptions are allowed. However, exceptions used shall be substantiated during the licensing procedure,
should	indicates a recommendation or an example of good practice,
may	indicates an acceptable or permissible method within the scope of the present safety standard.

Basic Principles

(1) The safety standards of the Nuclear Safety Standards Commission (KTA) have the task of specifying those safety-related requirements which shall be met with regard to precautions to be taken in accordance with the state of science and technology against damage arising from the construction and operation of the plant (Sec. 7, para. (2), subpara. (3) Atomic Energy Act - AtG) in order to attain the protective goals specified in AtG and the Radiological Protection Ordinance (StrlSchV) and further detailed in the Safety Requirements for Nuclear Power Plants (SiAnf) and the SiAnf-Interpretations.

(2) In accordance with SiAnf, Annex 3, protective measures must be provided to counter fires and explosions in a nuclear power plant. Fire protection in Nuclear Power Plants is dealt with in the safety standard series KTA 2101 and is, therefore, not within the scope of the present safety standard.

(3) The present safety standard presumes that the German Industrial Safety Ordinance (BetrSichV) and the Hazardous Substances Ordinance (GefStoffV) together with the associated technical standards (TRBS and TRGS) are observed. Furthermore, it is assumed that the regulations of the German Social Accident Insurance (DGUV), and that standard DIN EN 60079-10-1 as well as other regulations under public law are observed. Detailed information on the zone-classification of potentially explosive areas are contained in the collection of examples of standard DGUV 113-001. Exceptions are admissible in well-founded cases.

(4) To meet the objectives of explosion protection in nuclear power plants with light water reactors, the present safety standard specifies such explosion protection measures that will help to sustain the safety-related tasks of plant components including the structural components under consideration that the precautionary measures under para. (2) are taken. In this context, technical and administrative measures are specified. The extent and quality of these measures as well as the associated inspection effort are dependent on the importance of the explosion protection with regard to achieving the protective goals and radiological safety goals in accordance with SiAnf, Secs. 2.3 and 2.5.

1 Scope

(1) This safety standard shall be applied to nuclear power reactors with light-water reactors.

(2) It deals with the protection from explosions and their detrimental effects. It shall be applied under all operation phases for the protection of equipment and structural components, the specified normal function of which serve to

a) safely shut down the reactor and keep it in a shutdown condition,

b) remove the residual heat, and

c) prevent a release of radioactive substances.

Note:

By applying this safety standard, the protection of personnel working in the power plant is ensured (cf. Basic Principles, para. (3)).

(3) This safety standard shall be applied to explosion hazards from substances that are able to generate an explosive atmosphere or other explosive mixtures if these substances can be brought to, or penetrate into, the nuclear power plant site or if they can be created inside or outside of buildings on the nuclear power plant site.

(4) This safety standard does not apply to protective measures against explosion hazards that may occur

a) when handling substances in accordance with SprengG, Sec. 1, para. 1,

b) when releasing ignitable gases or vapors outside of the nuclear power plant site; excepted are the requirements specified in Section 5 of this safety standard regarding the deployment of gas warning equipment,

c) due to hydrogen released during a beyond-design-basis accident, or

d) due to disruptive actions or another interference by third parties that involve explosive materials.

Note:

Details in the context of para. (4) are dealt with in GL SEWD LWR.

2 Definitions

(1) Work place

A work place is a local area designated for a specific work procedure even if more than one person is involved.

(2) Atmosphere, explosive

Explosive atmosphere is an explosive mixture under atmospheric conditions admixed with air. Atmospheric conditions are characterized by an overall pressure between 0.8 bar and 1.1 bar and a mixture temperature between - 20 °C and + 60 °C as well as an oxygen content of no more than 20.95 % by volume.

(3) Atmosphere, dangerously explosive

A dangerously explosive atmosphere is an explosive atmosphere that occurs in such an amount (hazardous amount) that special protective measures are needed to maintain the protection of the safety and health of working personnel or other persons.

(4) Area, potentially explosive

A potentially explosive area is an area in which a dangerously explosive atmosphere can occur. An area in which an explosive atmosphere cannot occur in such amounts that special protective measures would be required is not considered to be a potentially explosive area. Regarding the definition of “potentially explosive areas within zones”, cf. GefStoffV and technical standards TRBS 2152, Part 2 / TRGS 722.

(5) Provision of ignitable gases and flammable liquids

The provision of ignitable gases and flammable liquids means making these materials available for the anticipated task (not for longer than 24 hours) at or near the work place in the required amounts.

Note:

Provision in itself does not comprise the actual storage (cf. Definition (18)). Additional information regarding the term “ignitable” can be found in the European regulation EG 1272/2008 (CLP-VO).

(6) Explosion

Explosion is a sudden oxidation reaction or decomposition reaction with an increase of temperature, of pressure or of both.

(7) Explosion protection

Explosion protection comprises all measures taken for the protection from the hazards caused by explosions.

(8) Explosion protection, structural

Structural explosion protection comprises structural measures that limit the effects of an explosion to an extent that they can be considered as harmless (cf. GefStoffV, Sec. 11, and technical standard TRBS 2152, Part 4).

(9) Liquids, flammable

Flammable liquids – for the purpose of the present safety standard – are all liquids with a flash point lower or equal to 100 °C; these include, especially, ignitable, highly ignitable, or extremely ignitable liquids with a flash point lower or equal to 55 °C.

(10) Gases, ignitable

Ignitable gases – for the purpose of the present safety standard – are all gases and gas mixtures that have an explosive range in air near 20 °C and a standard pressure of 1.013 bar and that are marked as Hazard Class 2.2 with hazard warnings H220 or H221 in accordance with EG 1272/2008 (CLP-VO).

(11) Mixture, explosive

An explosive mixture is a mixture of flammable gases, vapors, mists or dusts in which, after ignition has occurred, the combustion process spreads to the entire unburned mixture.

(12) Mixture, dangerously explosive

A dangerously explosive mixture is an explosive mixture that occurs in such an amount (hazardous amount) that special protective measures are needed to maintain the health and safety of working personnel or other persons. Other explosive mixtures – for the purpose of the present safety standard – are all dangerously explosive mixtures that are not categorized as dangerously explosive atmospheres.

(13) Equipment groups and equipment categories

Equipment groups and equipment categories categorize equipment and protective systems relative to their degree of freedom from ignition sources in accordance with 11thProdSV.

(14) Maintenance

Maintenance encompasses the entirety of measures to maintain and restore the required condition as well as to determine and assess the actual condition.

Note:

Maintenance is subdivided into inspection, servicing, and repairs.

(15) Nuclear power plant site

The nuclear power plant site is the tract of land within corresponding boundaries that belongs to the single-unit or multi-unit nuclear power plant.

Note:

The nuclear power plant site – for the purpose of the present safety standard – extends to all facilities inside the outer security area but not to the generally accessible areas such as information center, outdoor switchyard and parking lots.

(16) Storage depots and storage equipment

Storage depots – for the purpose of the present safety standard – are buildings, areas or rooms inside or outside of the buildings that meet specific requirements regarding the protection of working personnel or other persons and that are intended for storing hazardous substances and that meet the requirements in accordance with technical standard TRGS 510. This also includes storage equipment such as containers or cabinets that meet the requirements in accordance with technical standard TRGS 510 as well as safety cabinets in accordance with technical standard TRGS 510, Appendix 3.

(17) Storage facilities

Storage facilities – for the purpose of the present safety standard – are rooms or areas with the exception of gas stations inside or outside of buildings that are intended for storing stationary or transportable containers for flammable, highly flammable or extremely flammable liquids.

(18) Storing

In accordance with GefStoffV, Sec. 2, para. 5, storing means safe keeping for later (self) use as well as for a disposal to others. Storing includes the provision for transport if the transport does not occur within 24 hours after the provision or on the following workday. If this workday is a Saturday, the period expires at the end of the following workday.

(19) Standard state (regarding volume data of gases)

The volume of gases in the standard state is its volume at 1.013 bar and 0 °C.

3 General Requirements

3.1 Basic Principles of Explosion Protection

(1) In accordance with GefStoffV, the explosion protection shall be ensured by measures ranked as follows:

1. Preventing the formation of dangerously explosive mixtures (cf. technical standard TRBS 2152, Part 2).
2. Avoiding the ignition of dangerously explosive mixtures (avoiding effective ignition sources, cf. technical standard TRBS 2152, Part 3).
3. Incorporating structural design measures for fire protection that limit the effects of an explosion to an extent that they can be considered as harmless (cf. technical standard TRBS 2152, Part 4).

Note:

This ranked procedure is well suited– in conformance with SiAnf, Annex 3, Sec 3.2.9.1 – to achieve the goals laid down in the present safety standard under Basic Principals, para. (4).

(2) The operator of the nuclear power plant shall, in accordance with GefStoffV, Secs. 6 and 11, perform a risk assessment regarding explosion hazards. If, regarding the requirements of GefStoffV, Secs. 6 and 11, the formation of a dangerously explosive atmosphere cannot be ruled out, the necessary protective measures shall be specified in course of a risk assessment in accordance with BetrSichV, Sec. 3, and an explosion protection document shall be crafted. The explosion hazards shall be assessed in accordance with technical standards TRBS 1111 and TRBS 2152 with its Parts /TRGS 720 ff. In the case of other dangerously explosive mixtures, the procedure followed shall be analogous to the one described in GefStoffV, particularly its Appendix 1, No. 1.

Note:

The risk assessment and the explosion protection document may be presented as one document.

(3) Substances that can lead to the formation of an explosive atmosphere or other explosive mixtures may only be stored in storage facilities or storage equipment intended for this purpose. Only limited amounts of these substances may be made available outside of these storage facilities and storage equipment. After completion of the work task with these substances, they shall be returned to the storage facilities or storage equipment without delay.

(4) If, during certain operating conditions of the power plant, functions of the safety systems are not needed or needed only in parts (e.g., during maintenance procedures), deviations from the requirements of the present safety standard are admissible, provided, even in case of an explosion, the respectively needed function of the safety system cannot be inadmissible affected. Maintenance in power plants shall carried out in accordance with technical standards TRBS 1112 and TRBS 1112, Part 1.

(5) The non-availability of equipment and protective systems as well as of safety, surveillance and control devices that deal with explosion protection shall be dealt with by plant-specific measures to be specified and executed with the objective of ensuring the continued protection of the power plant (e.g., during non-availability of air-mixing ventilators in the turbine building, of ventilation systems of battery compartments, or of gas-measurement equipment in the central hydrogen supply facility).

(6) The fire protection dampers and ventilation dampers in potentially explosive areas shall trigger an alarm “NOT OPEN” in the control room area when ventilation is needed for reasons of explosion protection.

3.2 Avoiding Effective Ignition Sources

(1) In accordance with technical standard TRBS 2152, Part 3, effective ignition sources shall be avoided in potentially explosive areas and anywhere an explosive atmosphere may possibly develop (e.g., during servicing and repair tasks).

(2) In these areas suitable explosion-protected equipment in accordance with BetrSichV, Sec. 9, para. (4), shall be used. The suitability of explosion-protected equipment shall be certified for their use in dangerously explosive atmospheres and shall be classified by the equipment manufacturer to a specific equipment category.

(3) Furthermore, ignition sources shall be avoided in areas with dangerously explosive atmospheres that may be caused by plant components and activities of personnel. In this context, the guidelines in accordance with technical standard TRBS 2152, Part 3, shall be observed.

(4) Ignition sources shall also be avoided in areas with other dangerously explosive mixtures (e.g., radiolysis gas). Explosion-protected equipment certified for use in dangerously explosive atmospheres and classified by the equipment manufacturer to a specific equipment category need an additional certification if they are to be used in these areas. The suitability of this equipment for use in areas with other dangerously explosive mixtures shall be separately demonstrated.

3.3 Combinations of the Explosion Event with Another Event

3.3.1 General requirements

(1) Combinations of an explosion with another event shall be assumed if

a) the events are causally interconnected, or

b) a simultaneity of the events must be assumed based on its probability and the extent of damages.

(2) Combinations of an explosion with another event shall be analyzed exclusively in terms of achieving the goals laid down in Basic Principals, para. (4), of the present safety standard. Associated necessary measures shall be provided.

(3) The following combinations shall be differentiated between:

a) Combination of causally dependent events:

aa) explosion and a resultant event, and

ab) an assumed event and a resultant explosion

and

b) Combination of independent events:

An assumed event and an independent explosion.

3.3.2 Combination of causally dependent events

3.3.2.1 Explosion and a resultant event

The following combinations of an explosion with a resultant event shall be analyzed:

a) Explosion and a resultant fire

It shall be prevented that a fire caused by a plant-internal explosion can have inadmissibly adverse effects on the respectively needed function of the safety system.

Explosions shall not cause damages in fire protection equipment to such an extent that the goals laid down in Basic Principals, para. (4), of the present safety standard are endangered.

Note:

Fire protection requirements are detailed in safety standard series KTA 2101.

b) Explosion and resultant component failure

Unless the component is designed against effects from a plant-internal explosion, a component failure caused by the explosion and that could potentially adversely affect the respectively needed function of the safety system shall be analyzed.

3.3.2.2 An assumed event and a resultant explosion

The following combinations of an assumed event with a resultant explosion shall be analyzed:

a) Plant-internal fire and a resultant explosion

Occurrence of an inadmissible effect on the respectively needed function of the safety system may be ruled out, provided, the requirements specified in the safety standard series KTA 2101 are observed.

b) Component failure and a resultant explosion

All components shall basically be designed such that, even if they fail, this will not lead to an explosion.

If an explosion cannot be ruled out, the protection of the respectively needed function of the safety system shall be ensured. In so far as this is not possible due to system-engineering or usage-related requirements, an equivalent protection condition shall be achieved by applying appropriate measures or a combination of these measures.

c) Earthquake and a resultant explosion

Equipment of the explosion protection and the plant components specified in Sections 3 and 4 shall be designed against the design basis earthquake in accordance with safety standard KTA 2201.1, or it shall be demonstrated that, in case of an explosion, the respectively needed function of the safety system is ensured.

d) Lightning event and a resultant explosion

A lightning-caused explosion that could have inadmissibly adverse effects on the respectively needed function of the safety system shall be prevented. An inadmissible adverse effect on the respectively needed function of the safety system may be ruled out, provided, the requirements specified in the safety standard KTA 2206 are observed.

e) Protective measures shall be established for events that, independent of power plant operation, create a dangerously explosive atmosphere outside of safety-related buildings (e.g., transportation accidents), thus, preventing ingress of this atmosphere into the buildings.

3.3.3 Combinations of independent events

Combinations of independent events shall be assumed whenever the simultaneity of the events is established. The simultaneity of the explosion event with an independent event shall be assumed if this is deemed necessary based on the probability analysis.

Notes:

1. Simultaneity – for the purpose of the present safety standard – also considers long-term events (e.g., high water) and the possibly still effective resultant events from the explosion.
2. A sufficiently small probability of occurrence may be assumed if the event combinations occur with a probability of less than $1x10^{-5}$ per annum.

4 Case-Specific Requirements

4.1 Storing and Bottling of Flammable Liquids

(1) Flammable liquids may be stored only in storage facilities intended for this purpose that shall meet applicable rules and regulations. When storing flammable liquids with a flash point lower than or equal to 55 °C in transportable containers the regulation in accordance with technical standard TRGS 510 shall be met. When storing them in stationary vessels or tanks the regulation in accordance with technical standard TRGS 509 shall be met. Supplements and additional requirements are specified in the following paragraphs.

(2) Flammable liquids with a flash point lower than or equal to 55 °C shall be stored in a storage depot only up to an amount of 1000 liters and only in vessels with a capacity not larger than 200 liters. It is not admissible to store flammable liquids with a flash point lower than or equal to 55 °C in compartments with equipment of the safety system and in compartments where an explosion could have inadmissibly adverse effects on the respectively needed function of the safety system.

(3) Flammable liquids in containers with a capacity larger than 1 liter may be stored and handled only if the containers fulfill the regulations in accordance with GGVSEB; other containers larger than 1 liter are not admissible without a protective enclosure.

(4) Flammable liquids with a tendency of dangerous self-disintegration (e.g., unstable substances such as two-component epoxy resins or two-component polyurethanes) may only be stored in separate storage facilities outside of the controlled area. It is not admissible to store any flammable liquids that have a tendency for explosive reactions (e.g., nitromethane).

(5) A hazardous substances inventory in accordance with GefStoffV, Sec. 6, shall be available. In this context, all vessels containing flammable liquids with a flash point lower than or equal to 55 °C in amounts larger than 30 liters that are supplied to, and removed from, storage depots shall be documented. In intervals of no more than one year, a written inventory shall be crafted and the appropriate condition of the storage depots and containers – including those outside of storage depots – shall be checked.

(6) Residual quantities of flammable liquids with a flash point lower than or equal to 55 °C that are not needed anymore in a controlled area shall be immediately removed from this controlled area; the removal shall be documented. Flammable liquids with a flash point lower than or equal to 55 °C needed inside a controlled area are admissible only in amounts up to 100 liters and only if stored in a storage depot or compartment for storage equipment in accordance with technical standard TRGS 510. The storage depots or compartments for storage equipment shall be chosen such that in case of fire or an explosion no mutual interaction can occur. Regarding the hazardous substances inventory for these storage depots or compartments for storage equipment, the requirements under para. (5) shall be applied.

(7) Containers for flammable liquids with a flash point lower than or equal to 55 °C may be refilled only in the following suitable areas:

a) bottling stations or emptying stations in accordance with technical standard TRGS 509,

b) storage compartments that are also certified as a bottling or emptying station in accordance with technical standard TRGS 509,

c) laboratory fume hoods designed to be protected against explosions.

4.2 Provision and Deployment of Flammable Liquids

(1) The provision and deployment of flammable liquids is subject to the pertinent regulations in accordance with GefStoffV and BetrSichV as well as the associated technical standards TRGS and TRBS. Supplements and additional requirements are specified in the following paragraphs.

Note:

The term deployment comprises all activities associated with processing and any other handling, not however, activities associated with storing and bottling (cf. Section 4.1).

(2) It is not admissible to provide or deploy flammable liquids that have a tendency for explosive reactions (e.g., nitromethane).

(3) In a controlled area and in areas containing equipment of the safety system as well as in areas in which an explosion could have inadmissibly adverse effects on the respectively needed function of the safety system, the provision and deployment of flammable liquids with a flash point lower than or equal to 55 °C and of liquids, the maximum working temperature of which lies over or closely (i.e., up to 5 K for pure substances and up to 15 K for mixtures) under the flash point of the liquid (cf. technical standards TRBS 2152 Part 1 / TRGS 721), shall be limited to the amount necessary for the work task over a period of 24 hours as follows:

a) The amounts provided per work place may not exceed 50 liters and, for simultaneous use, not more than10 liters at this work place; however, the overall amount deployed in a fire-fighting sub-compartment may not exceed 50 liters.

b) Work tasks with such liquids (e.g., surface treatments) shall only be performed in conjunction with the use of a technical ventilation. The effectiveness of the technical ventilation shall be demonstrated by qualified persons, e.g., using gas detectors.

c) The accumulation of a dangerously explosive atmosphere or other dangerously explosive mixtures shall be limited both in space and time by the measures specified under Section 3.1.

d) No pipe lines are admissible that carry such liquids.

(4) Outside of a laboratory, the provision and deployment specified under para. (3) is admissible only if based on a written work order. This work order shall also specify the necessary protective measures (e.g., ventilation, avoidance of ignition sources, deployment of gas detectors). In the case of multiple work places of this kind, they may not endanger each other. After work completion, the residuals of such liquids, including

waste material incorporating such liquids, shall be removed without delay.

(5) Deviating from para. (3), larger amounts may be deployed, provided, a risk assessment specific to the individual case was performed and respective protective measures were specified.

4.3 Gas Stations and Mobile Tank Facilities

(1) Stationary gas stations and mobile tank facilities including the associated refilling equipment shall be located more than 30 meters away from the air inlet ducts of the ventilation systems and from the entrances to, and exits from, buildings.

(2) The amount of gasoline stored on the nuclear power plant site shall be limited to 1000 liters. Deviating this requirement, larger amounts may be deployed, provided, a risk assessment specific to the individual case was performed and respective protective measures were specified.

4.4 Hydraulic and Lubrication Oils

Note:

Additional requirements for oil supply systems are detailed in safety standard KTA 2101.3.

(1) Oil supply systems shall be constructed and operated such that, in the case of a leakage, the occurrence of explosive mixtures of oil mists, oil vapors and oil solutions of gases with air are prevented or are at least restricted to a level such that the respectively needed function of the safety system cannot be inadmissible affected.

(2) In the case of oil supply systems with an operating overpressure less than or equal to 10 bar, the requirement specified under para. (1) is considered fulfilled if the oil is suited for the intended purpose and if the oil coast-down temperature (i.e., the oil outlet temperature seeping from the component that caused the heating up of the oil) shall not exceed 60 % of the flash point (measured in °C) of the respective oil.

(3) In the case of oil supply systems with an operating overpressure higher than 10 bar, the requirement specified under para. (1) is considered fulfilled if, in addition to the requirements specified under para. (2), the following requirements are also met:

a) In regular intervals to be specified (depending on the individual test results and the accessibility), the oils shall be analyzed with respect to their suitability. The results of these analyses shall be documented in writing.

b) In order to restrict possible leakages (from, e.g., pipes, valves), the use of screw connections and connections with plane flanges shall basically be avoided. In the case of unavoidable connections of this type, the formation of larger oil mist clouds from spray jets shall be prevented by installing shields such as baffle sheets, baffle discs or baffle pipes.

4.5 Storing and Bottling of Ignitable Gases

4.5.1 General requirements

(1) The construction and operation of the gas depots and their distribution networks shall meet the requirements in accordance with BetrSichV and GefStoffV. The handling of ignitable gases in stationary and transportable pressure equipment is subject to the European guidelines GL 97/23/EG (PED) and GL 2010/35/EU (TPED) and the revised appendices ADR. Furthermore, the requirements in accordance with technical standards TRGS 407, TRBS 3145/TRGS 725 and TRBS 3146/TRGS 726 shall be met. The storing of ignitable gases in nonstationary pressure equipment shall meet the requirements in accordance with technical standard TRGS 510.

(2) The storage amounts for ignitable gases specified in the present safety standard apply to rooms above ground level; a storage below ground level shall meet the requirements in accordance with technical standard TRGS 510.

(3) Basically, no ignitable gases with a tendency of dangerous self-disintegration or of explosion-like reactions (e.g., the chemically instable gases listed in Table II of DGUV 100-500, Sec. 2.33) are admissible on the nuclear power plant site; the exception is acetylene, provided, it is handled as specified under Section 4.5.2, para. (8) and, for laboratories, as specified under Section 4.6.5.

Note:

Sec. 2.33 of DGUV 100-500 was retracted the end of 2004. Nevertheless, the standard is still available.

(4) Ignitable gases shall basically be stored in a central gas depot in accordance with technical standard TRGS 510 and as specified under Section 4.5.2; exceptions regarding other types of storage are specified under Section 4.5.3.

(5) The central gas depot specified under Section 4.5.2 and the other depots specified under Section 4.5.3 shall not be located in rooms in which an explosion could have inadmissibly adverse effects on the respectively needed function of the safety system.

(6) Gas depots shall not be located in the immediate vicinity of the air inlet ducts of buildings that contain equipment of the safety system.

(7) Gas supply lines shall basically not be led through rooms that contain equipment of the safety system; excepted are necessary feed lines, provided, they are designed such that the respectively needed function of the safety system cannot be inadmissible affected.

4.5.2 Central gas depot

(1) All hydrogen-supply-related transportable pressure equipment shall basically be stored in the central gas depot; exceptions are the emergency supply for generator cooling (cf. Section 4.6.1) and the hydrogen supply for laboratories and workshops (cf. Section 4.5.3).

(2) Transportable pressure equipment may neither be refilled nor repaired inside the central gas depot. These tasks may be performed only in special rooms.

(3) The only ignitable gases that may be stored in the central gas depot are hydrogen, methane, propane and butane as well as acetylene and ignitable forming gases, provided, the following volumetric and other limitations are observed.

(4) The following shall be applied to storing hydrogen in pressure equipment:

Overall, no more than 5000 m^3 (standard state) in transportable pressure equipment with an individual capacity of up to 50 liters.

(5) The following shall be applied to the storing of hydrogen in stationary pressure equipment:

a) Of the maximum allowed amount specified under para. (4), a maximum amount of up to 2500 m^3 (standard state) may be stored in one or more spatially neighboring stationary pressure equipment.

b) The (stationary) pressure equipment shall be located at a safety distance of 50 meters away from the outer walls of buildings that contain equipment of the safety system and away from such equipment on the outside as well as from the air inlet ducts of the ventilation systems. This safety distance shall be measured from the outside wall of the pressure equipment. The same safety distance applies to the pressure vessel vehicle during the refilling process.

c) Structures with a tamping effect shall be avoided in the immediate vicinity of stationary pressure equipment.

(6) The following shall be applied to the storing of methane:

No more than 500 m^3 (standard state) in transportable pressure equipment with an individual capacity of up to 50 liters.

(7) The following shall be applied to the storing of propane and butane:

No more than 220 kg (in pressurized liquid form) in transportable pressure equipment with an individual capacity of up to 30 liters.

(8) The following shall be applied to the storing of acetylene:

No more than 50 transportable pressure equipment with an individual capacity of up to 40 liters per bottle.

(9) The following shall be applied to the storing of ignitable forming gases:

No more than 100 transportable pressure equipment with an individual capacity of up to 50 liters per bottle.

4.5.3 Gas depots for laboratories and workshops

(1) Gas depots may be provided for the ignitable gases in transportable pressure equipment that are needed in laboratories and workshops if this is necessary for operational reasons (e.g., long transportation routes).

(2) The requirements specified under Sections 4.5.1 and 4.5.2 shall be fulfilled.

(3) The maximum admissible number of transportable pressure equipment shall be adapted to cover the number of bottles required for one day plus needed reserves.

4.6 Provision and Deployment of Ignitable Gases

4.6.1 Cooling system of the generator

(1) The cooling system of the generator and the associated hydrogen supply facility, aside from fulfilling the general requirements of explosion protection, need to meet the requirements under para. (13) only, if the goals laid down in Basic Principals, para. (4), of the present safety standard are inadmissibly affected.

(2) The design, construction and operation of the hydrogen supply facility including the employed components shall fulfill the requirements in accordance with BetrSichV and technical standards TRBS 2152/TRGS 720 ff as well as DIN EN 60034-3 (VDE 0530 Part 3). Soft solder shall be avoided.

Note:

Additional requirements regarding design, construction and operation of these systems are specified in VGB-S 165.

(3) The pipes and valves used in the hydrogen supply facility shall be suited for the contact with hydrogen and for the expected pressure (at least pressure stage PN 10). Cast iron valves are not admissible. If copper, brass or bronze are used for pipes and connections, any ammonia impurities in the hydrogen shall be prevented. The hydrogen supply pipe line from the central gas depot to the generator hydrogen supply system shall be designed and constructed to permanently be technically leak-proof in accordance with technical standards TRBS 2152, Part 2/ TRGS 722.

Note:

Additional requirements regarding design and construction of these pipe lines are specified in VGB-R 503 M, IGC DOC 15/06E and DGUV 113-001.

(4) No flanges shall normally be mounted in the hydrogen supply line located inside of building structures. If they are unavoidable, it shall be demonstrated that they are permanently technically leak-proof in accordance with technical standards TRBS 2152, Part 2/ TRGS 722. If this demonstration fails, the hazards shall be assessed, and respective measures taken (e.g., flushing by a sufficiently large air flow such that any possibility for the formation of a dangerously explosive atmosphere is prevented).

(5) The hydrogen discharged from the central hydrogen supply facility shall be continuously monitored by a suitable measuring equipment (e.g. a flow meter or a volumetric flow monitor); this discharge is made up of a volume of hydrogen released in an uncontrolled way and of a volume of hydrogen constantly discharged over time in a controlled way.

(6) Regarding functional safety of the hydrogen measurement function, this monitoring equipment shall comply with Safety Integration Level SIL 1 or higher. The evaluation may be performed in accordance with DIN EN 61511-1. Following the principles of that standard, the specified SIL Level may also be attained by deploying redundant service-proved components or SIL-certified components. If deployed in potentially explosive areas, the monitoring equipment shall meet the requirements in accordance with European guideline GL 2014/34/EU.

(7) The following shall be applied to monitoring:

a) Whenever an upper limit value is exceeded, the hydrogen make-up shall automatically be interrupted from outside of the turbine building.

b) The interruption shall trigger an alarm in the control room.

c) The upper limit value set point of the monitoring equipment as specified under item a) shall be created as the sum of the measured controlled release and the maximum admissible uncontrolled leakage amount of the hydrogen make-up volume from the generator and its auxiliary equipment.

d) In accordance with DIN EN 60034-3 (VDE 05030 Part 3), the maximum admissible uncontrolled leakage amount shall be specified as 18 m^3 (standard state) in 24 hours.

e) The sum of the measured controlled release of hydrogen volumes shall not exceed 250 liters (standard condition) in one hour.

f) The volume required for filling or refilling hydrogen (e.g., in order to adapt the gas pressure in the generator to changed load conditions) shall not be included when determining whether the limit value specified under item a) has been met.

g) An alarm shall be triggered upon failure of the power supply of the monitoring equipment, and the failure shall be repaired without delay.

(8) Basically, in the vicinity of the generator and its auxiliary equipment, the formation of a dangerously explosive atmosphere (e.g., hydrogen/air mixture) at possible leakage points shall be prevented by flushing with a sufficiently large air flow. In the case of permanently technically sealed plant component, no release or leakage and, thus, no forming of dangerously explosive mixtures need to be assumed.

(9) The ventilation of the individual rooms of the turbine building shall be designed in accordance with DIN EN 60034-3 (VDE 0530, Part 3) observing the therein specified room-volume limits. No closed-off, unventilated hollow spaces are admissible in rooms where a hydrogen leakage can possibly occur.

(10) Electrical equipment shall be so arranged or constructed that, in case of a short circuit, neighboring equipment of the hydrogen supply will not be damaged.

(11) The following shall be applied to the emergency hydrogen supply:

a) In order to ensure the hydrogen supply to the generator, the gas losses of which during normal operation are replenished from the central hydrogen depot, it is admissible to provide a stationary installation in the turbine building for use as an emergency hydrogen supply in case of malfunctions; the necessary pressurized hydrogen cylinders shall be brought into the turbine building only when needed and, then, only temporarily.

b) In the pressurized hydrogen cylinder battery specified under item a), up to eight pressurized hydrogen cylinders with a capacity of 50 liters each may be linked to a single manifold by means of connecting elbows. However, only two of the connected pressurized hydrogen cylinders may be used simultaneously for supplying hydrogen. Free connections shall be isolated by means of high-pressure intermediate valves.

c) Whenever the generator facility is supplied from a pressurized hydrogen cylinder battery, the number of emptied bottles shall be used to check whether or not the uncontrolled release of hydrogen is larger than 18 m^3 (standard state) in 24 hours. If this limit value is exceeded, the procedure to be followed shall be in accordance with DIN EN 60034-3 (VDE 0530 Part 3).

d) The replacement of pressurized hydrogen cylinders shall be documented in writing.

(12) The continuous hydrogen supply to reduce the oxygen in the cooling water of the generator windings shall be automatically interrupted outside of the turbine building whenever the amount of hydrogen make-up exceeds the nominal value by 20 %. This nominal value shall be limited to 500 liters per hour (standard state). An exceeding of this nominal value shall trigger an alarm in the control room.

(13) In case of a malfunction, the hydrogen shall rapidly be removed from the generator coolant water by remote controls (the discharge time shall normally be less than 10 min) and shall be safely released to the atmosphere (rapid H_2-discharge from generator). The integrity of the turbine building shall not be endangered by possible blast waves from an explosion at the H_2-discharge points.

4.6.2 Hydrogen for the recombination of oxygen

Note:

Hydrogen is used in a recombiner to reduce the oxygen present in the exhaust gas system and is also used for the gassing of the primary coolant.

(1) Supplying hydrogen to the exhaust gas system and to the primary coolant supply of pressurized and boiling water reactors and to the volume control system of pressurized water reactors shall be carried out in accordance with the pertinent rules and regulations; in particular, BetrSichV and the associated technical standard TRBS 2152 and its parts /TRGS 720 ff shall be fulfilled.

(2) The hydrogen supply lines shall be designed in accordance with DGUV 100-500, Sec. 2.33. The test pressure of the pipe lines shall be equal to 1.5 times the maximum operating pressure.

(3) Flanges shall normally not be built into the hydrogen supply lines. If they are unavoidable, it shall be demonstrated that they are permanently technically leak-proof in accordance with technical standards TRBS 2152, Part 2/ TRGS 722. If this demonstration fails, the hazards shall be assessed, and respective measures taken (e.g., flushing by a sufficiently large air flow such that any possibility for the formation of a dangerously explosive atmosphere is prevented).

(4) The hydrogen discharged from the central gas depot shall be continuously monitored within the hydrogen supply and distribution system by suitable monitoring equipment (e.g., a volumetric flow monitor). Whenever the volumetric flow of hydrogen exceeds its nominal value by 20 %, the supply shall be automatically interrupted outside of the reactor building, outside of the reactor auxiliary building or of the turbine building. However, the volumetric flow shall not be exceeded by more than 300 liters per hour. An exceeding of this aforementioned flow limits shall trigger an alarm in the control room.

(5) Regarding functional safety of the hydrogen measurement function, this monitoring equipment shall comply with Safety Integration Level SIL 1 or higher. The evaluation may be performed in accordance with DIN EN 61511-1. Following the principles of that standard, the specified SIL Level may also be attained by deploying redundant service-proved components or SIL-certified components. If deployed in potentially explosive areas, the monitoring equipment shall meet the requirements in accordance with European guideline GL 2014/34/EU.

4.6.3 Counter gases for the monitoring of radioactivity

(1) Gas flow counters used for measuring radioactivity shall be designed in accordance with the pertinent rules and regulations. Supplements and additional requirements are specified in the following paragraphs.

(2) The gas flow counters shall basically be operated with an argon/methane mixture in a volumetric ratio of 90 to 10 or with non-ignitable gas mixtures. Exceptions are admissible in the case of:

a) radioactivity measurements in laboratories,

b) mobile measurement devices, provided, the counter gas volume in each measurement device does not exceed

   ba) 100 liters in the case of gaseous methane (standard state),

   bb) 200 milliliters in the case of liquid propane,

   bc) 200 milliliters in the case of liquid butane.

c) mobile measurement devices for determining the tritium content of the room atmosphere, provided, they are not deployed in rooms with a free volume less than 50 m^3 and the volume of the methane in the pressure equipment does not exceed 3 m^3 (standard state).

d) stationary measurement devices in which, due to their location and due to the intrinsic volume limitation of the device, an explosion cannot have inadmissibly adverse effects on the respectively needed function of the safety system.

4.6.4 Fuel gases for welding, cutting and related work procedures

(1) The work with fuel gases shall be subject to requirements in accordance with DGUV 113-004 and DGUV 100-500, Sec. 2.26, para. 3.8. Supplemental and additional requirements are specified in the following paragraphs.

(2) When working with fuel gases in rooms with safety-related plant components and in rooms in which an explosion could have inadmissibly adverse effects on the respectively needed function of the safety system, only single cylinder units shall normally be used, the number of which shall be kept as low as necessary. Only one burner tool may be attached to a single cylinder unit. The single cylinder units shall be removed from these rooms after completion of the task or in case of a longer interruption of the task (e.g., at night).

(3) In individual cases, autogenous welding in the reactor building is admissible, provided, the corresponding work permit states the location, time and plant condition and no more than five work places are simultaneously in action.

4.6.5 Ignitable gases and oxidizing agents in laboratories

(1) When working with ignitable gases and oxidizing agents in laboratories, the requirements in accordance with TRGS 526 shall be met. Supplements and additional requirements are specified in the following paragraphs.

Note:

Requirements regarding a fire-protective structural separation are detailed in safety standard KTA 2101.2.

(2) Laboratories shall not be located in rooms from which an explosion could have inadmissibly adverse effects on the respectively needed function of the safety system.

(3) If gases are supplied from the central gas depot specified in Section 4.5.2, the volumetric flow of ignitable gases shall be monitored by measurement equipment. Whenever the volumetric flow of ignitable gases exceeds the specified nominal value by 20 %, the supply shall be automatically interrupted.

(4) Regarding functional safety of the hydrogen measurement function, this monitoring equipment shall comply with Safety Integration Level SIL 1 or higher. The evaluation may be performed in accordance with DIN EN 61511-1. Following the principles of this standard, the specified SIL Level may also be attained by deploying redundant service-proved components or SIL-certified components. If deployed in potentially explosive areas, the monitoring equipment shall meet the requirements in accordance with European guideline GL 2014/34/EU.

4.7 Stationary Batteries or Battery Facilities

(1) The requirements of safety standard KTA 3703 and DIN EN 50272-2 (VDE 0510-2) shall be applied to the design, construction and operation of stationary batteries or battery facilities. The following additional requirements shall be fulfilled as far as explosion protection is concerned.

(2) In battery facilities – excepted are facilities that exclusively house gastight batteries – an accumulation of dangerously explosive mixtures in the battery rooms shall be prevented by a technical (artificial) ventilation; furthermore, the danger of ignition in the direct vicinity of the hydrogen source of the batteries shall be prevented by technical and administrative measures.

(3) To ensure sufficient air circulation, the function of the air-conditioning and ventilation system shall be monitored by technical or administrative measures. In this context, the air flow shall be monitored, or at least the following measures shall be taken:

a) monitoring the branch-off circuitry for the ventilator motors in the associated switch gear,

b) monitoring the speed of belt driven ventilators at the ventilator side, and

c) periodic function test of the ventilation system.

(4) The permissible interruption time, t_0, of the technical (artificial) ventilation of the battery room shall be calculated from equation (4-1):

$$t_0 = \frac{V_r * f}{Q} \qquad (4\text{-}1)$$

where

t_0 : (in hours) – permissible interruption time in which, under the assumption of a uniform distribution, the volume fraction of hydrogen in volume, V_r, may increase by 0.8 % by volume.

Note:

0.8 % by volume corresponds to one fifth of the lower explosion limit of hydrogen in air.

V_r : (in m³) – air volume of those room sections in which the released hydrogen can mix with air when an interruption of the technical (artificial) ventilation occurs.

Q : (in m³/h) – minimum value of the volumetric air flow, to be calculated in accordance with DIN EN 50272-2 (VDE 0510-2), Sec. 8.2, with a factor s = 5 and under consideration of the amperage, I, of the charging current.

f : numeric value 5 or 1. The numeric value, f, depends on the value of the amperage, I, of the charging current used in calculating the volumetric air flow, Q, as follows:

a) f = 5 if the value of the amperage used is in accordance with DIN EN 50272-2 (VDE 0510-2), Table 1.

b) f = 1 if the amperage used is equal to the actually existing charging current.

(5) Precautions shall be taken to ensure that within the admissible interruption time, t_0, as calculated from equation (4-1), the performance of effective alternative measures is possible (e.g., repair of the ventilation, construction and activation of a replacement ventilation, opening of the fire protection dampers and ventilation dampers).

(6) In the case of a charging operation with voltages above the compensating charge voltage, it shall be checked, prior to manual switching at the rectifier unit, that the ventilation system is in operation as required in accordance with KTA 3703. During such charging operation this check shall be repeated in intervals that are equal to the admissible interruption time, t_0, as calculated from equation (4-1) for operation at the respective charging current strength.

4.8 Precaution Against Radiolysis Gas

(1) The possible hazards from an accumulation of radiolysis gas shall be determined within the framework of a risk assessment. This analysis of diverse effects of potential radiolysis gas reactions and of possible countermeasures shall be carried out with the goal of ensuring the necessary protective measures against damages. The risk assessment shall be performed in the following three steps:

a) All plant-specific areas with a potential for inadmissible radiolysis gas accumulations shall be systematically recorded.

b) Each of these recorded areas shall be analyzed regarding the maximum adverse effects that could result from a radiolysis gas reaction (e.g., blast waves, fragments, jet forces, reaction forces).

c) Protective measures shall be specified for each of the recorded areas. The quality requirements for these measures regarding their prevention of radiolysis reactions shall be specified according to the safety levels associated with the potential event. Passive measures shall be given preference over active measures.

(2) The systematic recording of these areas shall normally be carried out on a plant-specific basis. Experience and insight of other operating utilities shall normally be considered. Areas that are endangered with regard to radiolysis accumulations are those areas of systems

a) that during specified normal operation contain reactor coolant steam,

b) that under abnormal operating conditions will carry, or be exposed to, reactor coolant steam,

c) that border unto areas that conduct reactor coolant steam, i.e., that are separated from these areas by closed valves or inside heat exchangers (seepage of radiolysis gas in case of leakages),

d) that are directly connected to reactor coolant steam areas (e.g., feedwater tank, feedwater system, condensate system), especially, those areas where steam condensation can lead to the accumulation of radiolysis gas.

(3) The recorded system areas shall be inspected for “stagnant” media. The accumulation of radiolysis gas can be safely excluded only if turbulent flow prevails.

(4) The radiolysis gas reaction shall be assumed to occur in form of a detonation. A differing assumption is admissible, provided, it is individually certified. Due to the low limit value of the ignition energy, an ignition mechanism or ignition source shall always be assumed to be present. It shall be assumed that the radiolysis reaction will lead to loss of integrity of the component involved. A differing assumption is admissible, provided, an integrity proof is presented. This integrity proof shall take the deflagration-to-detonation transitions (DDT), the pre-compactions and reflected shock waves that may lead to higher peak pressures than the pressure of the detonation itself (Chapman-Jouguet condition) into consideration. This analysis of the maximum adverse effects shall normally encompass the effects on the plant, the systems and bordering components.

(5) Every assumed radiolysis reaction shall be correlated to a specific safety level. The measures for preventing inadmissible radiolysis gas reactions shall be specified dependent on the possible adverse effects. Examples for measures aimed at avoiding, mitigating and preventing radiolysis gas reactions are listed in the (informative) **Appendix A**. These measures may be correlated to graded quality requirements regarding safety against failure. The effectiveness of the measures introduced shall be continuously monitored and checked by inservice inspections (cf. Section 6, para. (8)).

4.9 Gaseous Waste Facilities (Gas Treatment Systems)

4.9.1 General requirements

Note:

Plant engineering measures and measure regarding monitoring and functional controls are dealt with in safety standard KTA 3605 (Treatment of Radioactively Contaminated Gases in Nuclear Power Plants with Light Water Reactors). Additional associated fire protection measures are dealt with in safety standard KTA 2101.3 (Fire Protection of Mechanical and Electrical Plant Components).

(1) Any of the possible gaseous waste sources specified in safety standard KTA 3605, Tables 3-1 and 3-2, Nos. A and B respectively, can also contain radiolysis gas. The gaseous waste facilities shall be constructed and operated such that the occurrence of explosive mixtures is prevented or at least limited to such degree that, in case of an explosion, the respectively needed function of the safety system cannot be inadmissible affected.

(2) The control equipment shall be constructed to comply with the Safety Integration Level (SIL) that corresponds to the safety significance of the equipment.

(3) Regarding functional safety of the hydrogen measurement function, this monitoring equipment shall comply with Safety Integration Level SIL 1 or higher. The evaluation may be performed in accordance with DIN EN 61511-1. Following the principles of this standard, the specified SIL Level may also be attained by deploying redundant service-proved components or SIL-certified components. If deployed in potentially explosive areas, the monitoring equipment shall meet the requirements in accordance with European guideline GL 2014/34/EU.

4.9.2 Boiling water reactors

(1) In case of a boiling water reactor, the radiolysis gases described in Section 4.8 are separated from the water-steam circuit, predominantly, in the condenser and are led to the gas treatment system that is directly connected to the condenser. All other gaseous waste sources with radiolysis gas (e.g., steam injection of stuffing boxes, vapor space of the feedwater tank) shall preferably be injected into the condenser. If gaseous waste sources with radiolysis gas are injected into the exhaust air facility it shall be demonstrated that the exhaust gas is not explosive anymore after being thinned down with the exhaust air.

(2) The throughput volumes of the exhaust gas shall be measured and monitored. If the actual throughput falls below the specified throughput, additional measures shall be taken to prevent the development of an explosive mixture.

4.9.3 Pressurized water reactors

In the case of a pressurized water reactor, the primary coolant is gassed with hydrogen; in addition, additional radiolysis gases are created. These gases are removed from the coolant in the primary coolant degasification system, in its treatment and storage systems as well as in the volume control surge tank. Therefore, the named plant components shall be connected to the gas treatment system in order to remove these gases.

4.10 Preventing Explosive Hydrogen Mixtures Inside the Containment Vessel

4.10.1 General requirements

To prevent a hydrogen explosion or a hydrogen fire inside the containment vessel during specified normal operation (levels of defense 1 and 2 in accordance with SiAnf) as well as in case of events of level of defense 3, a distance of 0.5 % by volume to the lower explosion limit of hydrogen (4.0 % by volume hydrogen in air) shall be maintained at all times. All hydrogen-creating sources shall be considered.

Notes:

1. The requirements to be considered when determining the creation and release of hydrogen in case of a loss-of-coolant accident are detailed in SiAnf, Annex 5, Appendix 1.
2. Measures against hydrogen released during event sequences that exceed design limit values are not within the scope of the present safety standard (e.g., inertisation of the containment vessel, filtered pressure relief).

4.10.2 Monitoring the hydrogen concentration in rooms of the containment vessel after a loss-of-coolant accident

(1) Measurement equipment shall be installed that, even under the conditions expected to prevail after a loss-of-coolant accident, a reliable chronological determination of the hydrogen distribution is ensured in the mainly concerned areas of the containment vessel. In this context, the (ambient) conditions in the containment vessel at the measurement points shall be considered (e.g., temperature, pressure, humidity).

(2) Regarding functional safety of the hydrogen measurement function, this monitoring equipment shall comply with Safety Integration Level SIL 1 or higher. The evaluation may be performed in accordance with DIN EN 61511-1. Following the principles of this standard, the specified SIL Level may also be attained by deploying redundant service-proved components or SIL-certified components.

Note:

A gas detector has Safety Integration Level SIL 1 if it is type tested and approved in accordance with DIN EN 50271 (including Section 4.8).

(3) Based on suitable analysis procedures, measurement locations shall be specified and operated that enable a reliable monitoring of the hydrogen concentration.

4.10.3 Preventing explosive hydrogen concentrations in the containment vessel after a loss-of-coolant accident

(1) The following principles shall be applied to the measures and equipment for preventing explosive hydrogen concentrations in the containment vessel after a loss-of-coolant accident:

a) If the analyses show that hydrogen concentrations in the containment vessel may locally exceed the lower explosion limit, equipment shall be installed by which a sufficient forced mixing in the containment vessel is ensured.

b) If the analysis of the overall hydrogen concentration shows that reaching the explosion limit cannot be prevented over a long period without taking measures for the reduction of hydrogen, the following requirements shall be met:

ba) The reduction rate of the recombination equipment shall be such that, at all times, the overall hydrogen concentration stays under the explosion limit.

bb) The recombination equipment shall be designed such that their reliable availability and function are ensured even under the conditions expected to prevail in the containment vessel at the time when operation of this equipment is necessary.

(2) Active measures shall be actuated at the moment the hydrogen concentration reaches 3.5 % by volume. A manual actuation is admissible.

(3) Within the framework of analyzing accident mitigation, it is not admissible to consider flushing the containment vessel (i.e., feeding air into, and releasing air from, the containment vessel) as a measure for reducing the overall hydrogen concentration.

5 Protection Against the Penetration of Ignitable Gases and Vapors from the Outside – Deployment of Gas Warning Equipment

Note:

This section deals with the deployment of gas warning equipment as protection against ignitable gases and vapors penetrating from the outside (cf. GL Blast Waves). However, the questions as to when and under what conditions their deployment will become necessary are not dealt with in the present safety standard.

(1) If ignitable gases and vapors set free outside of the nuclear power plant site have to be prevented from penetrating into the buildings via the ventilation system, then measures in accordance with TRBS 2152 Part 2 / TRGS 722 shall be taken. Supplements and additional requirements are specified in the following paragraphs.

(2) A gas warning equipment shall be deployed.

(3) The gas warning equipment shall be chosen in accordance with of TRBS 2152, Part 2 / TRGS 722 Sec. 2.5.1, para. (3), regarding the suitability of its functional measurement capability and functional safety under the expected deployment conditions. The gas warning equipment shall be type tested and approved for the measurement function and the functional safety for each gas to be detected in accordance with European guideline GL 2014/34/EU, Equipment Group II, Category 1 or 2. With regard to functional safety it can, therefore, be assumed that the gas warning equipment (the gas detectors) corresponds to at least Safety Integration Level SIL 1; the classification of the entire gas warning equipment (e.g., due to redundant design, to automatic measures) shall be specified on a plant-specific basis.

Note:

A gas detector has Safety Integration Level SIL 1 if it is type tested and approved in accordance with DIN EN 50271 (including Section 4.8).

(4) The measuring detectors of the gas warning equipment shall be located such that a timely alarming and triggering of switching measures can occur. This means that the measuring detectors shall be located either directly in front of the inlet opening of the air supply duct or at a suitable distance even as far away as the plant site security fence.

(5) The decisive factors regarding the timely alarming and triggering of the switching measures are:

a) the distance of the gas path, s_G, between the location of the measuring detector and the location of the first effective isolation device of the ventilation system in the building to be protected,

b) the time span, t_G, required by the gas/air mixture to travel along the gas path, s_G,

c) the time span, t_S, between triggering the gas alarm and isolation of the ventilation system,

d) the adjustment time, t_x, i.e., the time span between the occurrence of a sudden change from clean air to test gas or vice versa at the gas detector input and the time when the specified portion, x, of the maximum display is reached for the test gas. The x corresponds to the value of the alarm threshold (% of lower explosion limit (UEG)) specified in para. (7). The adjustment time of the respective measuring component used shall be the one specified by the manufacturer of the gas detector. In case more than one ignitable gas is involved, the safety analysis shall be based on the longest adjustment time.

(6) The sum of time span, t_S, and adjustment time, t_x, of the gas warning equipment shall be compared to the time span, t_G. The following relation shall be fulfilled:

$$t_x + t_S \leq t_G \qquad (6\text{-}1)$$

(7) The alarm thresholds of the gas warning equipment shall basically be adjusted to a value between 10 % and 20 % of the lower explosion limit (UEG) of the gas mixture to be expected. With regard to specific applications, these alarm thresholds shall be set, on one hand, to be low enough that, when exceeded, the respective protective measure will early on become effective. On the other hand, the setting shall be high enough to avoid false alarms. If the adjustment time, t_x, of the gas warning equipment was certified in a safety report as t_{30} or t_{40}, it is admissible to set the alarm thresholds to the values 30 % or 40 % of the lower explosion limit (UEG). In these cases, the value t_x in relation (6-1) shall be replaced by t_{30} or t_{40}.

(8) Switching measures that are executed to interrupt the air supply to the building to be protected shall be triggered whenever a gas alarm is triggered from at least two separate measurement detectors.

6 Tests and Inspections

Notes:

1. Requirements regarding the quality of testing measures are detailed in safety standard KTA 1401.
2. Requirements regarding the testing manual are detailed in safety standard KTA 1202.

(1) The tests and inspections of work materials and technical measures in potentially explosive areas to be performed prior to commissioning and after modifications requiring testing as well as the inservice inspections shall be carried out in accordance with BetrSichV.

(2) Explosion-protected equipment and protective systems as well as safety, surveillance and control devices in accordance with European guideline GL 2014/34/EU that are intended for use in dangerously explosive atmospheres are systems to be

monitored and to be inspected in accordance with BetrSichV. TRBS 1201, Part 1, shall be observed.

(3) In accordance with BetrSichV, it shall be checked whether the tests and inspections prior to commissioning or after a modification requiring testing must be performed by an Approved Inspection Agency (ZÜS).

(4) Equipment and protective systems as well as safety, surveillance and control devices that are deployed in regions where other explosive mixtures (e.g., radiolysis gas) can occur shall be subjected by the operating utility under its own responsibility to inservice inspections with special regard to their orderly condition. The same applies to repairs.

(5) Commissioning tests and inservice inspections of gas treatment systems shall be performed as specified in safety standard KTA 3605, Tables 6-1 and 6-2.

(6) In addition to the testing requirements in accordance with BetrSichV, the following items shall be tested and inspected in intervals to be specified by the operating utility:

a) the storage depots and provision locations for substances that can generate other dangerously explosive mixtures (e.g., chemical depots with epoxy resins) – to be tested and inspected for their orderly condition,

b) the gas warning equipment in accordance with BGI 518 with explosion protection functions that are located outside of explosion-endangered areas – to be tested, e.g., for compliance with Section 5, and

c) the gas detectors with explosion protection functions that are located outside of explosion-endangered areas (e.g., for monitoring the hydrogen volume flow from the central hydrogen supply facility) – to be tested and inspected for their orderly condition and functional capability.

(7) In individual cases, exceptions to existing legal provisions regarding the construction and operation of facilities requiring tests and inspections subject to ProdSG may be declared by the licensing authorities in accordance with AtG, Sec. 8, para. (3).

(8) Inservice inspections shall be specified that demonstrate the sustained effectiveness of the measures specified in Section 4.8 for the prevention of radiolysis gas reactions (e.g., tests of the catalysts).

7 Instructions

All persons handling substances on the nuclear power plant site that can generate an explosive atmosphere or other explosive mixtures or who work, or are present, in potentially explosive areas shall be properly instructed regarding the specific aspects of explosion protection.

Note:

Additional information regarding maintaining the knowledge of the competent persons are detailed in BetrSichV and in TRBS 1203.

8 Documentation

The documentation shall contain written reports on:

a) the results of the explosion risk assessments performed for the protection of the function of the safety system (i.e., risk assessment and explosion protection documentation in accordance with BetrSichV and GefStoffV) including the protective measures applied,

b) the results of the tests and inspection specified under Section 6, and

c) the instructions specified under Section 7.

Appendix A (informative)

Example Table for Radiolysis Gas Precaution

Measures	For Avoiding, Mitigating and Preventing Events at the Levels of Defense:
Regular manually operated flushings; effectiveness monitoring by continuous temperature measurements that trigger alarms when limits are exceeded or failures occur.	1 / 2
Catalyst or thermally controlled venting; monitoring the effectiveness by discontinuous measurements is admissible.	1 / 2
Flushing line with valves; valve interlocks in the open position; valve position check before startup; effectiveness test by measurements during startup.	1 / 2
Catalyst; effectiveness monitoring by continuous temperature measurements that trigger alarms when limits are exceeded or failures occur.	3
Operational measurements to prove that an accumulation is prevented by physical effects (e.g., convection, diffusion, gas transport in the condensate); effectiveness monitoring by continuous temperature measurements that trigger alarms when limits are exceeded or failures occur.	3
Flushing line with valves; valve interlocks in the open position; valve position check before startup; effectiveness test by continuous measurements during operation.	3
Structural protective measures that reduce the effects to a lower level of defense	3

Table A-1: Examples for measures with the objective of avoiding, mitigating and preventing radiolysis gas reactions

Note:

Table 4-1 is an extract of the RSK-Recommendation of July 10, 2003; the recommendation contains additional information and requirements for precautionary measures against radiolysis gas, also with regard to the level of defense 4.

Appendix B

Regulations Referred to in the Present Safety Standard

(Regulations referred to in the present safety standard are valid only in the versions cited below. Regulations which are referred to within these regulations are valid only in the version that was valid when the latter regulations were established or issued.)

AtG		Act on the peaceful utilization of atomic energy and the protection against its hazards (Atomic Energy Act – AtG) of December 23, 1959, revised version of July 15, 1985 (BGBl. I, p. 1565), most recently changed by Article 307 of the Act of August 31, 2015 (BGBl. I 2015, No. 35, p. 1474)
ProdSG		Act on the provision and marketing of products (Product Safety Act – ProdSG), of November 11, 2011
SprengG		Act on explosive substances (Explosive Substances Act – SprengG) of September 13, 1976 (BGBl. I, p. 2737), revised version made public April 17,1986, most recently changed by the Act July 23, 1998 (BGBl. I, p. 1530)
StrlSchV		Ordinance on the protection from damage by ionizing radiation (Radiological Protection Ordinance – StrlSchV) of July 20, 2001 (BGBl. I, p. 1714; 2002 I, p. 1459), most recently changed by Article 5 of the Act of December 11, 2014 (BGBl. I, p. 2010)
BetrSichV		Ordinance on the safety and health protection when using work materials (Industrial Safety Ordinance – BetrSichV) of February 3, 2015 (BGBl. I, p. 49)
GefStoffV		Ordinance on the protection from Hazardous Substances (Hazardous Substances Ordinance – GefStoffV), of November 26, 2010 (BGBl. I, p. 1643), most recently changed by Article 2 of the Ordinance of February 3, 2015 (BGBl. I, p. 49)
GGVSEB		Ordinance on the transport of dangerous goods by road, rail and inland waterways (GGVSEB), of June 17, 2009 (BGBl. I, p. 1389) most recently changed by Article 1 of the Ordinance of March 4, 2011 (BGBl. I, p. 347)
11^{th}ProdSV		Eleventh ordinance regarding the Product Safety Act (Explosion Protection Ordinance – 11^{th} ProdSV), Article 21 of the Act on Reforming the Equipment and Product Safety Law of November 8, 2011, (BGBl. I, No. 57, p. 2178)
EG 1272/2008 (CLP-VO)		Regulation (EC) No. 1272/2008 of the European parliament and of the council of December 16, 2008, on classification, labelling and packaging of substances and mixtures (CLP-VO)
SiAnf	(2015-03)	Safety requirements for nuclear power plants of November 22, 2012, revised version of March 3, 2015 (BAnz AT of March 30, 2015 B2)
SiAnf-Interpretations	(2015-03)	Interpretations of the safety requirements for nuclear power plants of November 22, 2012, revised version of March 3, 2015 (BAnz AT of March 30, 2015 B3)
KTA 1202	(2009-11)	Requirements for the Testing Manual
KTA 1401	(2013-11)	General Requirements Regarding Quality Assurance
KTA 2101.1	(2015-11)	Fire Protection in Nuclear Power Plants; Part 1: Basic Requirements
KTA 2101.2	(2015-11)	Fire Protection in Nuclear Power Plants; Part 2: Fire Protection of Structural Components
KTA 2101.3	(2015-11)	Fire Protection in Nuclear Power Plants; Part 3: Fire Protection of Mechanical and Electrical Plant Components
KTA 2206	(2009-11)	Design of Nuclear Power Plants Against Damaging Effects from Lightning
KTA 3605	(2012-11)	Treatment of Radioactively Contaminated Gases in Nuclear Power Plants with Light Water Reactors
KTA 3703	(2012-11)	Emergency Power Facilities with Batteries and AC/DC Converters in Nuclear Power Plants
EG 1272/2008 (CLP-VO)	(2008-12)	Regulation (EC) No. 1272/2008 of the European parliament and of the council of December 16, 2008, on classification, labelling and packaging of substances and mixtures (CLP-VO)

ADR	(2013-01)	Appendix of the publication of the Appendices A and B of the European agreement of September 30, 1957 on the international transportation of dangerous goods by road (ADR) in the version of January 1, 2013
BGL 518 (T023)	(2012-04)	German Social Accident Insurance (DGUV), Trade Union Information: Gas detectors for explosion protection – Deployment and operation
DGUV 113-001 (prev.: BGR 104)	(2014-03)	German Social Accident Insurance (DGUV) (previous Trade Union Standard): Explosion protection standards (EX-RL); Collection of technical standards for the prevention of hazards from explosive atmospheres, including collection of examples for the classification of the hazardous areas into zones
DGUV 113-004 (prev.: BGR 117-1)	(2008-09)	German Social Accident Insurance (DGUV) (previous Trade Union Standard): Vessels, silos and narrow spaces; Part 1: Working in vessels, silos and narrow spaces
DGUV 100-500 (prev.: BGR 500)	(2008-04)	German Social Accident Insurance (DGUV) (previous Trade Union Standard): Operating with work materials
IGC DOC 15/06E	(2006)	European Industrial Gases Association AISBL Gaseous hydrogen stations; Revision of Doc 15/96 and Doc 15/05
DIN EN 50271	(2011-04)	Electrical apparatus for the detection and measurement of combustible gases, toxic gases or oxygen - Requirements and tests for apparatus using software and/or digital technologies; German version prEN 50271:2010
DIN EN 50272-2 (VDE 0510 Part 2)	(2001-12)	Safety requirements for secondary batteries and battery installations - Part 2: Stationary batteries; German version EN 50272-2:2001
DIN EN 60034-3 (VDE 0530 Part 3)	(2009-03)	Rotating electrical machines - Part 3: Specific requirements for synchronous generators driven by steam turbines or combustion gas turbines and for synchronous compensators (IEC 60034-3:2007); German version EN 60034-3:2008
DIN EN 60079-10-1 (VDE 0165)	(2014-11)	Explosive atmospheres - Part 10-1: Classification of areas - Explosive gas atmospheres (IEC 31J/234/CDV:2014); German version FprEN 60079:2014
DIN EN 61511-1 (VDE 0810 Part 1)	(2005-05)	Functional safety - Safely instrumented systems for the process industry sector - Part 1: Framework, definitions, system, hardware and software requirements (IEC 61511-1:2003 + Corrigendum 2004); German version EN 61511-1:2004
GL Blast Waves	(1976-08)	Guideline for the protection of nuclear power plants against pressure waves from chemical reactions by means of the design of nuclear power plants with regard to strength and induced vibrations and by means of the adherence to safety distances; made public by BMI on August 1, 1976 (RS I 4 – 513 145/1 - (GMBl. S. 442))
GL SEWD LWR	(1995-12)	Guideline for the protection of nuclear power plants with light-water reactors against disruptive actions or other interference by third parties (SEWD RL LWR) ; made public by BMU on December 6, 1995 (RS I 3 – 513 13151 - 6/14 VS-nfD)
GL 2010/35/EU (TPED)	(2010-06)	Directive 2010/35/EU of the European Parliament and of the Council of June 16, 2010 on transportable pressure equipment (TPED)
GL 97/23/EG (PED)	(1997-05)	Directive 97/23/EU of the European Parliament and of the Council of May 29, 1997 on pressure equipment (PED)
GL 2014/34/EU	(2014-02)	Directive 2014/34/EU of the European Parliament and of the Council of February 26, 2014 on the harmonisation of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres
RSK-Recommendation	(2003-07)	Recommendation of Reactor Safety Commission, 364th RSK Session on July 10,2003: General requirements for measures to prevent inadmissible radiolysis gas reactions
TRBS 1111	(2006-12)	Technical Standards for Operating Safety; Hazard assessment and safety related evaluation (BAnz No. 232a, p. 7, of December 1, 2006)
TRBS 1112	(2010-10)	Technical Standards for Operating Safety; Maintenance (GMBl. 2010, No. 60, p. 1219, of October 14, 2010)
TRBS 1112 Part 1	(2010-05)	Technical Standards for Operating Safety; Risk of an explosion during and from maintenance tasks – Assessment and protective measures (GMBl. 2010, No. 29, p. 615, of May 12, 2010)

TRBS 1201	(2012-08)	Technical Standards for Operating Safety; Test and examination of work material and of systems to be monitored (BAnz No. 232a, p. 11, of December 9, 2006), the revised version of August 2012 (GMBl. 2012, No. 45, p. 864, of October 17, 2012)
TRBS 1201 Part 1	(2006-09)	Technical Standards for Operating Safety / Technical Standards for Hazardous Substances; Tests and inspections of plants in potentially explosive areas and checking work places in potentially explosive areas, of September 2006 (BAnz No. 232a, p. 20 of December 12, 2006)
TRBS 1203	(2012-04)	Technical Standards for Operating Safety; Competent persons (GMBl. 2010, No. 29, p. 627), the revised version of April 2012 (GMBl. 2012, No. 21, p. 386)
TRBS 2152 / TRGS 720	(2006-03)	Technical Standards for Operating Safety (TRBS)/ Technical Standards for Hazardous Substances (TRGS); Dangerously explosive atmosphere; General requirements, of March 2006 (BAnz No. 103, p. 4, of June 2, 2006)
TRBS 2152 Part 1 / TRGS 721	(2006-03)	Technical Standards for Operating Safety (TRBS)/ Technical Standards for Hazardous Substances (TRGS); Dangerously explosive atmosphere; Assessment of the explosion risk, of March 2006 (BAnz No. 103, p. 8, of June 2, 2006)
TRBS 2152 Part 2 / TRGS 722	(2012-05)	Technical Standards for Operating Safety (TRBS)/ Technical Standards for Hazardous Substances (TRGS); Preventing or limiting dangerously explosive atmosphere, of March 2006 (BAnz No. 103, p. 11, of June 2, 2006), the revised version of May 2012 (GMBl. 2012, No. 22, p. 398)
TRBS 2152 Part 3	(2009-11)	Technical Standards for Operating Safety; Dangerously explosive atmosphere; Preventing the ignition of a dangerously explosive atmosphere, of November 2009 (GMBl. 2009, No. 77, p. 1583)
TRBS 2152 Part 4	(2012-04)	Technical Standards for Operating Safety; Measures of structural explosion protection limiting the effects of an explosion to an extent that they can be considered as harmless – Dangerously explosive atmosphere, of April 2012 (GMBl. 2012, No. 21, p. 387)
TRBS 3145 / TRGS 725	(2013-06)	Technical Standards for Operating Safety / Technical Standards for Hazardous Substances; Transportable compressed-gas containers – filling, storing, plant-internal transport, emptying, of June 2013 (GMBl. 2013, No. 41/42, p. 803)
TRBS 3146 / TRGS 726	(2014-04)	Technical Standards for Operating Safety / Technical Standards for Hazardous Substances; Stationary pressure equipment for gasses, of April 2014 (GMBl. 2014, No. 28/29, p. 606)
TRGS 407	(2013-06)	Technical Standards for Hazardous Substances; Handling of gasses – Risk assessment (GMBl. 2013, No. 41/42, p. 814-844), the revised version of June 2013 (GMBl. 2013, No. 63, p. 1263)
TRGS 509	(2014-09)	Technical Standards for Hazardous Substances; Storing of liquid and solid hazardous substances in stationary containers as well as filling and emptying facilities of transportable containers, of September 2014 (GMBl. 2014, No. 66/67, p. 1346-1400)
TRGS 510	(2013-01)	Technical Standards for Hazardous Substances; Storing hazardous substances in transportable containers, of January 2013 (GMBl. 2013, No. 22, p. 446, of May 15, 2013), in the revised version of November 2014 (GMBl. 2014, No. 65, p. 1346)
TRGS 526	(2008-02)	Technical Association for Generation and Storage of Power and Heat (VGB Power Tech), Standard; Laboratories
VGB-S 165	(2014-07)	Technical Association for Generation and Storage of Power and Heat (VGB Power Tech), Standard; Recommendations for the improvement of H2 safety in hydrogen-cooled generators
VGB-R 503 M	(2002-09)	Technical Association for Generation and Storage of Power and Heat (VGB Power Tech); Guideline for the internal piping of the turbine generator

NRC FORM 335 (12-2010) NRCMD 3.7 U.S. NUCLEAR REGULATORY COMMISSION **BIBLIOGRAPHIC DATA SHEET** *(See instructions on the reverse)*	1. REPORT NUMBER (Assigned by NRC, Add Vol., Supp., Rev., and Addendum Numbers, if any.) **NUREG/IA-0519**
2. TITLE AND SUBTITLE **Survey of Member Countries' Nuclear Power Plant Fire Protection Regulations by the OECD Nuclear Energy Agency (NEA) Fire Incidents Records Exchange (FIRE) Database Project – Topical Report No. 2**	3. DATE REPORT PUBLISHED MONTH: **August** YEAR: **2020** 4. FIN OR GRANT NUMBER
5. AUTHOR(S) Nicholas B. Melly, Thomas H. Aird, Mark Henry Salley	6. TYPE OF REPORT Technical 7. PERIOD COVERED (Inclusive Dates)

8. PERFORMING ORGANIZATION - NAME AND ADDRESS (If NRC, provide Division, Office or Region, U. S. Nuclear Regulatory Commission, and mailing address; if contractor, provide name and mailing address.)

Organisation for Economic Co-operation and Development (OECD)
Nuclear Energy Agency (NEA)
Committee on the Safety of Nuclear Installations (CSNI)
Paris, France

9. SPONSORING ORGANIZATION - NAME AND ADDRESS (If NRC, type "Same as above", if contractor, provide NRC Division, Office or Region, U. S. Nuclear Regulatory Commission, and mailing address.)

Division of Risk Analysis
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

10. SUPPLEMENTARY NOTES

11. ABSTRACT (200 words or less)

Nations establish and authorize agencies with the responsibility to protect the health and safety of the public and the environment by licensing and regulating Nuclear Power Plants (NPP). Unwanted accidental fires have been shown to be a major risk to NPP safety. Fire protection regulations built on defense-in-depth principles have been established in each country to minimize this risk. The purpose of this report is to collect and share the fire protection regulations and strategies used in different countries to ensure reactor safety. The report is built by each member country assembling their major fire protection regulations, with all the regulations translated in the common language of English. Additionally, there is an international trend for regulations to evolve from prescriptive requirements to risk-informed performance-based requirements. This report includes that information where applicable. The completed report now provides a single reference where countries can review and contrast their NPP fire protection regulations with other member countries. Through international cooperation in projects such as this research effort, each member country may discover new insights and ideas for their NPP fire protection regulations.

12. KEY WORDS/DESCRIPTORS (List words or phrases that will assist researchers in locating the report.)	13. AVAILABILITY STATEMENT
Fire Risk Fire safety Regulations Fire protection Nuclear Energy Agency Committee on the Safety of Nuclear Installations Organisation for Economic Co-operation and Development OECD	unlimited 14. SECURITY CLASSIFICATION *(This Page)* unclassified *(This Report)* unclassified 15. NUMBER OF PAGES 16. PRICE

Printed on recycled paper

Federal Recycling Program

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, DC 20555-0001

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NUREG/IA-0519

Survey of Member Countries' Nuclear Power Plant Fire Protection Regulations by the OECD Nuclear Energy Agency (NEA) Fire Incidents Records Exchange (FIRE) Database Project – Topical Report No. 2

August 2020