

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)

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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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Fire Protection in Nuclear Power Plants Part 1: Basic Requirements

KTA 2101.1

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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 the Federal Gazette (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

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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 influence 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-compartment (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.

Note:

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.

Note:

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 re-

quired 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: