

Safety Standards

of the

Nuclear Safety Standards Commission (KTA)

KTA 3701 (2014-11)

General Requirements for the Electrical Power Supply in Nuclear Power Plants

(Übergeordnete Anforderungen an die elektrische Energieversorgung in Kernkraftwerken)

The previous versions of this safety standard were issued in 1997-06 and 1999-06.

If there is any doubt regarding the information contained in this translation, the German wording shall apply.

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General Requirements for the Electrical Power Supply in Nuclear Power Plants

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PLEASE NOTE: Only the original German version of this 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) of January 15, 2015.

Copies of the German version may be mail-ordered through the Wolters Kluwer Deutschland GmbH (info@wolterskluwer.de). Downloads of the English translations are available at the KTA website (<http://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 objective to specify safety-related requirements, compliance of which provides the necessary precautions in accordance with the state of the art in science and technology against damage arising from the construction and operation of the facility (Sec. 7 para. 2 subpara. 3 Atomic Energy Act - AtG) in order to achieve the fundamental safety functions specified in the Atomic Energy Act and the Radiological Protection Ordinance (StrlSchV) and further detailed in the Safety Requirements for Nuclear Power Plants as well as in the Interpretations of the Safety Requirements for Nuclear Power Plants.

(2) The safe enclosure of radioactive materials present in nuclear reactor plants necessitates the realization of an in-depth, multi-level technical safety concept (Defense in Depth). The present safety standard specifies the multi-level safety requirements for the measures and equipment of the electrical power supply in nuclear power plants.

(3) Based on SiAnf and the SiAnf-Interpretations, safety standards KTA 3701 through KTA 3705 specify requirements for the power supply of the safety-related power loads.

(4) The documents required in the nuclear licensing procedure for the electrical power supply of safety-related power loads are specified in ZPI, the collation of information required to be presented in the nuclear licensing and supervisory procedure for nuclear power plants.

(5) In the present safety standard, it is presumed that conventional requirements and technical standards (e.g. Accident Protection Requirements, DIN-Standards, VDE-Regulations) are adhered to under consideration of the safety-related requirements specific to nuclear power plants.

(6) The present safety standard contains the general requirements for the electrical power supply of the safety-related power loads in nuclear power plants.

(7) Requirements for emergency power generating facilities with diesel generator units in nuclear power plants are specified in safety standard KTA 3702.

(8) Requirements for emergency power generating facilities with batteries and rectifier units in nuclear power plants are specified in safety standard KTA 3703.

(9) Requirements for emergency power generating facilities with rotary converters and static inverters in nuclear power plants are specified in safety standard KTA 3704.

(10) Requirements for switchgears, transformers and distribution networks for the electrical power supply of the safety system in nuclear power plants are specified in safety standard KTA 3705.

(11) Requirements for ensuring a sustained resistance to a loss-of-coolant-accident of the electrical components and the components in the instrumentation and controls of operating nuclear power plants are specified in safety standard KTA 3706.

(12) KTA safety standards establish that the emergency power facilities end at the connection terminals of the power loads. Therefore, the requirements for the power loads are detailed in component-specific safety standards, namely KTA 3501 and KTA 3504.

(13) Requirements regarding fire protection of mechanical and electrical plant components are specified in safety standard KTA 2101.3.

(14) Requirements regarding lightning protection are specified in safety standard KTA 2206.

(15) Requirements regarding cable penetration through the reactor containment vessel are specified in safety standard KTA 3403.

(16) General requirements regarding quality assurance are specified in safety standard KTA 1401.

(17) Requirements regarding the testing manual are specified in safety standard KTA 1202.

(18) Requirements regarding the design of mechanical and electrical components in nuclear power plants against seismic events are specified safety standard KTA 2201.4.

1 Scope

The general requirements specified in this safety standard apply to the electrical power supply of those equipment in nuclear power plants that perform functions of safety-related significance during normal and abnormal plant operation and also during the control of design basis accidents.

Note:

The requirements for the equipment of the electrical power supply (e.g., regarding their circuit design concepts and design) differ according to safety-related significance of the supplied equipment. Accordingly, the present safety standard deals with the "Offsite power connections and station service facility" and the "Emergency power system" in separate sections.

2 Definitions

(1) Station service facility

The station service facility is the entirety of those plant components that serve to supply the connected power loads and to feed power into the emergency power system.

(2) Station service power

The station service power is the electrical power required for supplying the power loads necessary for the operation of a power plant unit and for supplying the emergency power system.

(3) Functional separation of offsite power connections

Offsite power connections are considered as functionally separated if neither of the two connections can influence each other through direct coupling. This requires, among others, a net topology that makes it possible for a nearby redundant power source to supply at least one of the two offsite power connections.

(4) Main offsite power connection

A main offsite power connection is the power connection through which the nuclear power plant unit delivers electrical power to, and can also draw electrical power from, the offsite power grid. The main offsite power connection comprises all electrical equipment between the low-voltage terminals of the main transformer and the busbar terminals of the power switch in the grid switchgear.

(5) Main offsite power connection, two-part

A two-part main offsite power connection is a main offsite power connection which, regarding electrical function and protection, consists of two separate interconnections between power plant and offsite power grid.

(6) Offsite power connection

An offsite power connection is an interconnection between the power plant and offsite power grid by which electrical power can be transmitted.

(7) Emergency power facility

An emergency power facility is the combination of a specific emergency power generating facility including all plant components that are necessary for the (emergency power) supply of the corresponding power loads.

(8) Emergency power operation

Emergency power operation implies that the power for the train is supplied by the respective emergency power facility.

(9) Emergency power (grid) connection

An emergency power connection is an offsite power connection by which electrical power can be drawn for the supply of emergency power loads. The emergency power connection comprises all electrical equipment between the power switches in the station service facility or in the emergency power facilities and the busbar terminals of the power switch in the grid switchgear or in an energy source independent of the emergency power system of the nuclear power plant.

(10) Emergency power system

The emergency power system is the entirety of the different emergency power facilities – different regarding power generation and task – in a nuclear power plant.

(11) Emergency power load

An emergency power load is a power load that is supplied from an emergency power facility.

(12) Supplying emergency power

Supplying emergency power means supplying the emergency power loads from emergency power generating facilities.

(13) Uninterruptible emergency power supply

An uninterruptible emergency power supply is an emergency power supply where the power supply from the emergency power facility sets in without interruption in case of failure of the power supply from the station service facility or from the offsite power connections.

(14) Additional offsite power connection

An additional offsite power connection is an offsite power connection from which at least that amount of electrical power can be drawn that is necessary for shutting down the nuclear power plant while sustaining the main heat sink. The additional offsite power connection comprises all electrical equipment between the power switches in the station service facility and the busbar terminals of the power switch in the grid switchgear.

(15) Station service switchover (short-term, long-term switchover)

A station service switchover is the switchover of the electrical station service supply from the main offsite power connection to the additional offsite power connection. Two cases are distinguished between:

a) Short-term switchover

This is a switchover with an interruption time no more than a few milliseconds. A short-term switchover is performed when the voltages at the main offsite and additional offsite power connections – regarding amplitude, frequency, phasing and phase sequence – are identical or insignificantly different within a specified tolerance range.

b) Long-term switchover

This is a switchover with an interruption time of a few seconds. A long-term switchover is performed when the voltages at the main offsite and additional offsite power connections – regarding amplitude, frequency, phasing and phase sequence – are larger than admissible for a short-term switchover. The switchover may be carried out depending

on the residual voltage, i.e., only after the lessening voltage in the station service facility falls below a lower limit value, or it may be carried out after a preset time limit.

3 General Requirements

(1) For the electrical power supply of a nuclear power plant unit regarding heat removal while sustaining the main heat sink at least two offsite grid supply possibilities shall be available.

Note:

The terminology "heat removal while sustaining the main heat sink" implies heat removal using power loads that are connected to the station service facility.

(2) The following power supply possibilities shall be available for the electrical power supply of the safety-related power loads in a nuclear power plant unit:

- a) the main generator of the nuclear power plant,
- b) two offsite grid connections,
- c) emergency power facilities with diesel generator units and with batteries on the nuclear power plant site, and
- d) one emergency power (grid) connection or one power supply facility that is independent of the emergency power generating facilities of the nuclear power plant.

Note:

The term "emergency Power (grid) connection" is used in the following to reference both of these power supply possibilities.

Note:

Appendix A shows examples of circuit design concepts for the electrical power supply of a nuclear power plant.

(3) In a multi-unit nuclear power plant, each nuclear power plant unit shall be equipped with an individual emergency power system that is assigned to that one plant unit alone.

(4) Power may be demanded from the emergency power generating facilities only if the possibilities specified under para. (2), items a) and b), for supplying electrical power to safety-related power loads are not simultaneously available. However, a power demand from one train of the emergency power generating facility is admissible for testing purposes.

(5) The electrical power supply to the safety-related power loads shall be designed to be of such reliability that this supply is not the determining factor of the unavailability of the supplied systems.

(6) The electromagnetic compatibility of components shall be demonstrated dependent on their safety-related significance.

(7) The reliability of the electrical power supply of safety-related power loads shall be demonstrated. In this context, all components and auxiliary systems of the electrical power supply shall be taken into account.

4 Offsite Power Connections and Station Service Facility

4.1 General Requirements

4.1.1 Requirements for the circuit design concepts

(1) The circuitry and spatial arrangement of the offsite power connections and the station service facility shall be such that a single failure initiating event inside the nuclear power plant or a single failure initiating event within the electrical power supply of the nuclear power plant or near the offsite power connections cannot cause a longer failure of all offsite grid supply possibilities. Such a failure initiating event and its mechanical sequential damages (e.g., broken mast, cable breakage) shall not lead to a mechanical failure of all of the power supply connections specified under Section 3, para. (2), items b) and d).

(2) Equipment shall be installed that, in case of a separation of the power plant unit from the offsite power grid, would automatically cause a switchover of the power plant unit to station service power (load shedding to station service power).

4.1.2 Interconnections of the offsite power connections or the station service facility with the emergency power system

(1) Interconnections of the offsite power connections or the station service facility with the emergency power system shall be designed such that they are automatically disconnected in case of failure of the plant unit's onsite and offsite grid supply possibilities. The equipment for reconnecting to the re-available offsite power connections or station service facility shall be designed such that each redundant train of the emergency power system can individually be reconnected.

(2) Unavoidable operational influences (e.g., from switching operations or ground shorts in the station service facility) shall not cause any systematic failures in the emergency power system.

(3) Externally or internally caused failure-related electrical transients or fault conditions (e.g., voltage drop, overvoltage, consequences of a phase failure, short-circuits, lightning effects on power lines) shall not lead to any inadmissible impairments of safety-related equipment. The respective proof may be performed experimentally or by simulation.

4.1.3 Testability

(1) The equipment of offsite power connections and the station service facility that serve to supply the emergency power system shall be designed such that they can be checked regularly and completely during a power plant unit shutdown and, as far as necessary for reliability reasons, also during normal operation.

(2) Tests and inspections shall not prevent necessary protective actions.

4.1.4 Monitoring

The equipment of the offsite power connections and station service facility that serve to supply the emergency power system shall be monitored by measurements and signals regarding their functional capability and operating condition.

4.2 Offsite Grid Supply Possibilities

4.2.1 Design

(1) Each one of the two offsite grid supply possibilities specified under Section 3, para. (2), item b), shall by itself be able to supply all trains of the emergency power system.

(2) The offsite grid supply possibilities specified under Section 3, para. (2), items b) and d), shall be functionally separated and protectively decoupled from each other.

(3) The offsite power grid connections specified under Section 3, para. (2), item b), shall normally be connected to different voltage levels. If this is not possible due to the grid conditions near the nuclear power plant, the offsite power sources shall at least be connected to separate switchgears and protectively decoupled from each other.

(4) The additional offsite power grid connection shall be designed such that it can enable shutdown of the nuclear power plant unit while sustaining the main heat sink. The dynamic loadings from a long-term switchover during a design basis accident shall be taken into account.

(5) In case of demand, the additional offsite power connections shall be automatically connected. The triggering criteria

and triggering limit values and the time delays for these automatic connections shall be specified in coordination with the emergency power generating facilities such that the emergency power generating facilities are not unnecessarily connected. The design of the station service switchover shall normally be such that, both, a short-term switchover as well as a long-term switchover can be performed.

(6) The additional offsite power connections may be mutually used by several nuclear power plant units. A mutually used additional offsite power connection shall be designed such that it can enable the simultaneous shutdown of all supplied nuclear power plant units while sustaining the main heat sinks.

(7) The emergency power (grid) connection and its power supply points in the nuclear power plant shall be designed such that – regarding residual heat removal of the nuclear power plant unit – the minimum electrical power required for supplying one residual heat removal train including all necessary instrumentation, control and auxiliary equipment is made available.

Notes:

(1) Regarding the required electrical power for the residual heat removal, no additional superposed design basis accident (e.g., loss-of-coolant accident) need be assumed.

(2) In the case of nuclear power plants with emergency residual heat removal systems, one emergency residual heat removal train may be sufficient for residual heat removal.

(8) The emergency power (grid) connections shall normally allow for their manual connection in a demand case. An automatic connection is admissible, provided, the power of the emergency power (grid) connection is designed for the maximum automatically connectable power load.

(9) Emergency power (grid) connections may be mutually used by multiple nuclear power plant units. The power of the mutually used emergency power (grid) connection shall be designed for a simultaneous residual heat removal of all connected nuclear power plant units and the power specified under para. (7).

(10) At least one interconnection to the offsite grid (e.g., the emergency power (grid) connection) shall, in the near vicinity of the nuclear power plant, be constructed as a ground-buried cable connection.

4.2.2 Measures upon failures of the offsite power supplies

(1) The repair of failed offsite net connections shall be initiated without delay.

(2) In case of external hazards a simultaneous failure of the main and additional offsite power connections in the near vicinity of the nuclear power plant cannot be ruled out; thus, it is necessary that, within three days, either one offsite net connection shall be repaired, or another supply possibility made available.

(3) The electrical power of the supply possibilities specified under para. (2) shall be sufficient for removing the residual heat and for preventing any inadmissible release of radioactive materials. In case of multi-unit power plants, the corresponding electrical power shall be sufficient for all nuclear power plant units.

4.3 Operation and Maintenance

(1) All components of the electrical power supply of safety-related power loads shall normally be designed and arranged with regard to enabling a clear overview, easy maintenance and short repair times (e.g., by accessibility and exchangeability).

(2) Unambiguous instructions for the operation and maintenance shall be available. The respective manufacturer specifications shall be taken into account.