Reaffirmed: 11/04

Safety Standards

of the
Nuclear Safety Standards Commission (KTA)

KTA 3701 (6/99)

General Requirements for the Electrical Power Supply in Nuclear Power Plants

(Übergeordnete Anforderungen an die
elektrische Energieversorgung in Kernkraftwerken)

The previous version of this safety standard was issued June 1997

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

Editor:

KTA-Geschaeftsstelle c/o Bundesamt fuer Strahlenschutz (BfS)

Willy-Brandt-Str. 5 • 38226 Salzgitter • Germany

Telephone +49-5341/885-(0) 901 • Telefax +49-5341/885-905

KTA SAFETY STANDARD

June 1999	General Requirements for the Electrical Power Supply in Nuclear Power Plants	KTA 3701

The previous version, June 1997, of this safety standard was issued in BAnz No. 187a on October 8, 1997.

CONTENTS

Fundamentals 1
1 Scope 1
2 Definitions 1
3 General Requirements 2
4 Emergency Power System 2
4.1 Boundaries of the Emergency Power System 2
4.2 Basic Requirements 2
4.3 Protection against Failure-initiating Events within the Emergency Power System 3
4.4 Protection against Failure-initiating Events within the Nuclear Power Plant 3
4.5 Protection against External Events 3
4.6 Redundancy 3
4.7 Functional Independence 3
4.8 Spatial Separation 3
4.9 Power Balances 3
4.10 Interruption and Delay Times 3
4.11 Initiation and Termination of Emergency Power Operation 4
4.12 Protection 4
4.13 Testability 4
4.14 Monitoring 4
4.15 Operation and Maintenance 4
4.16 Quality Assurance and Inspections of the Emergency Power System 4
5 Connections Between the Units of a Multi-Unit Nuclear Power Plant 5
5.1 Basic Conditions 5
5.2 Basic Requirements 5
5.3 Circuit Design Concept 6
5.4 Protection 6
5.5 Monitoring and Interlocking 6
5.6 Quality Assurance, Tests and Inspections 6
6 Additional Requirements for the Connections to Emergency Power Facilities Between Units of a Multi-Unit Nuclear Power Plant 6
6.1 General Requirements 6
6.2 Functional Independence 6
6.3 Spatial Separation 6
6.4 Switching on of Electrical Power Connections 6
6.5 Disconnection of Electrical Power Connections 6
Annex A Examples of Electrical Circuit Concepts for the Electrical Power Supply of a Nuclear Power Plant 7
Annex B Boundaries of an Emergency Power System 10
Annex C Offsite Power Connections and Station Service Facility 11
Annex D Examples of the Design of Power Connections Between the Nuclear Power Plant Units 12
Annex E Regulations Referred to in this Safety Standard 15
Annex F Literature(informative) 15

PLEASE NOTE: Only the original German version of this safety standard represents the joint resolution of the 50-member Nuclear Safety Standards Commission (Kerntechnischer Ausschuss, KTA). The German version was made public in Bundesanzeiger No. 243b on December 23, 1999. Copies may be ordered through the Carl Heymanns Verlag KG, Luxemburger Str. 449, 50939 Koeln, Germany (Telefax +49-221-94373603).

All questions regarding this English translation should please be directed to:

KTA-Geschaeftsstelle c/o BfS, Willy-Brandt-Str. 5, 38226 Salzgitter, Germany

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, the 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 this safety standard.

Fundamentals

(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 the damage arising from the construction and operation of the facility (Sec. 7 para. 2 subpara. 3 Atomic Energy Act), in order to attain the protection goals specified in the Atomic Energy Act and Radiological Protection Ordinance (StrlSchV) and which are further detailed in "Safety Criteria for Nuclear Power Plants" and in "Guidelines for the Assessment of the Design of PWR Nuclear Power Plants against Incidents pursuant to Sec. 28 para. 3 of the Radiological Protection Ordinance (StrlSchV) – Incident Guidelines".

(2) Based on Criterion 7.1 "Emergency Power Supply" of the Safety Criteria, the nuclear safety standards KTA 3701 through KTA 3705 specify the requirements for the power supply of power loads important to safety.

(3) This KTA safety standard takes the research results [1] through [3] on the reliability of emergency power diesel facilities into account.

(4) In this KTA safety standard it is presumed that the conventional requirements and standards (for instance the German Occupational Accident Prevention Regulations, DIN Standards and VDE Regulations) are met unless other requirements are specified due to the specifics of nuclear power plant.

(5) This KTA safety standard contains the general requirements for the electrical power supply of the power loads important to safety in nuclear power plants. Additional general requirements for the grid extending beyond the scope of this safety standard are contained in the recommendation by the Reactor Safety Commission from November 23, 1988, "Final Report on the Results from the Safety Review of the Nuclear Power Plants in the Federal Republic of Germany by the RSK" [2].

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

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

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

(9) The requirements for switchyards, transformers and distribution networks for the electrical power supply of the safety system in nuclear power plants are specified in safety standard KTA 3705.

(10) The KTA safety standards consider the emergency power facilities as ending at the connection terminals of the individual power loads. Requirements for the power loads are, therefore, specified in the following special equipment related safety standards

KTA 3501 Reactor Protection System and Surveillance Equipment of the Safety System

and

KTA 3504 Electrical Drives of the Safety System in Nuclear Power Plants.

(11) The requirements regarding fire protection will be specified in safety standard KTA 2101.3 "Fire Protection in Nuclear Power Plants; Part 3: Mechanical and Electrical Components".

(12) The requirements regarding lightning protection are specified in safety standard KTA 2206 "Design of Nuclear Power Plants against Lightning Effects".

(13) The requirements regarding cable penetration are specified in safety standard KTA 3403 "Cable Penetrations through the Reactor Containment Vessel".

(14) The basic requirements regarding quality assurance are specified in safety standard KTA 1401 "General Requirements Regarding Quality Assurance".

(15) The documents on the electrical power supply of power loads important to safety that must be presented for review in the nuclear licensing procedure are specified in "Collation of Information Required for Review in the Nuclear Licensing and Supervisory Procedure of Nuclear Power Plants (ZPI), Sec. 3.P" as published in Bundesanzeiger No. 6a on Jan. 11, 1983.

1 Scope

This safety standard specifies the general requirements for the electrical power supply of the power loads important to safety in stationary power plants.

2 Definitions

(1) Station service facility

The station service facility is the entirety of those plant components that serve to supply power to 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 electrical loads necessary for operation of a power plant unit and for supplying the emergency power system.

(3) Main offsite power connection

The main offsite power connection is the power connection between nuclear power plant and offsite power grid by which the nuclear power plant unit delivers, and can also draw, electrical power.

(4) Main offsite power connection, two-fold

A two-fold main offsite power connection is a main offsite power connection which, with regard to electrical function and protection consists of two separate connections between power plant and offsite power grid.

(5) Offsite power connection

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

(6) Emergency power facility

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

(7) Emergency grid connection

An emergency grid connection is an offsite power connection by which electrical power can be drawn for the supply of emergency power loads.

(8) Emergency power system

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

(9) Emergency power load

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

(10) Emergency power supply

The emergency power supply is the power supply of emergency power loads from emergency power generating facilities.

(11) Uninterruptible emergency power supply

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

(12) 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.

3 General Requirements

Note:
Annex A shows examples for the circuitry design concept of the electrical power supply of a nuclear power plant. Annex C deals with the offsite power connections and the station service facility.

(1) At least two offsite power supply possibilities shall be available for the electrical power supply of a nuclear power plant unit with respect to heat removal while sustaining the main heat sink.

Note:
The terminology “heat removal while sustaining the main heat sink” implies heat removal using power loads (systems) that are connected to the station service facility.

(2) The following power sources shall be available for the electrical power supply of the power loads important to safety in a nuclear power plant unit:

a) the power supply from the main generator of the nuclear power plant,

b) two power supplies from the offsite power grid,

c) the emergency power system with its emergency power generating facilities on the site of the power plant, and

d) one power supply installation that is independent from the emergency power generating facilities of the power plant.

Note:
A suitable power supply installation is, for instance, the offsite power connection.

(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) A power demand from the emergency power generating facilities is permitted only if the possibilities in accordance with paragraph 2 items a) and b) of an electrical power supply for the power loads important to safety are simultaneously not available. However, the power demand to one train of the emergency power generating facility is permitted for the purpose of testing,

(5) The electrical power supply of the power loads important to safety 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 reliability of the electrical power supply of the power loads important to safety shall be demonstrated taking all components and auxiliary systems of the electrical power supply into consideration.

4 Emergency Power System

4.1 Emergency Power Boundaries

The emergency power system comprises all electrical components and equipment between the feed breakers and the connection terminals of the station service facility and the offsite power supply on one side and those of the emergency power loads on the other side.

Note:
Annex B shows an example for the boundaries of the emergency power system.

4.2 Basic Requirements

(1) All power loads important to safety of a nuclear power plant unit shall be connected to emergency power facilities. These shall, in particular, be those loads required to safely shutdown the reactor, to keep it in the shutdown condition, to remove the residual heat and to prevent any impermissible release of radioactive substances.

(2) The emergency power switchyards shall at all times be kept energized such that the emergency power loads can draw their power from the station service facility or from an offsite grid connection and, in case the aforementioned power supplies fail, from the emergency power generating facilities.

(3) In the design of the emergency power facilities the consideration of a simultaneous failure both of the onsite and of the offsite power supply shall be superposed with one of the design basis accidents or one of the external events considered in the design of the nuclear power plant.

(4) The design of the emergency power facilities shall ensure that the electrical conditions of the corresponding power loads are fulfilled even under the most unfavorable ambient conditions and under any operation and accident related loading.

Note:
The electrical conditions for the supply of the power loads include, in particular, the allowed tolerances of voltage, current or frequency both in the static and in the dynamic range.

(5) A sufficient power production and operational availability of the emergency power system shall be ensured over the entire operating life of the nuclear power plant.

4.3 Protection against Failure Initiating Events within the Emergency Power System

(1) The emergency power system shall be designed, constructed and operated such that failure initiating events within the emergency power system and within the corresponding emergency power loads will not prevent the required emergency power supply when demanded. The following failure initiating events within the emergency power system shall be taken into consideration:

a) random failures of components of the emergency power system (these are single failures that shall be covered by redundancies in accordance with Section 4.6)

and

b) common cause failures, such as multiple failures occurring simultaneously or in short succession of each other, that have a common cause within the system itself.

(2) The effects of common cause failures in the emergency power system shall be analyzed. Depending on the results of these analyses, additional measures shall be taken to reduce the probability of occurrence of common cause failures or to reduce their effects.

4.4 Protection against Failure-initiating Events within the Nuclear Power Plant

The emergency power system shall be designed, constructed and operated such that failure-initiating events within the nuclear power plant will not prevent the required emergency power supply when demanded. The failure-initiating events within the nuclear power plant that shall be taken into consideration are, e.g., fire or pipe rupture.

4.5 Protection against External Events

The emergency power facilities shall be protected against the same external events as the process engineering systems whose power loads are supplied by these emergency power facilities and which must remain functional during and after the particular external event. The protection concept of the emergency power facilities against external events shall be coordinated with the protection concept of the corresponding process engineering system. In case individual trains of the emergency power system fail due to external events, the remaining trains shall have sufficient power with respect to the control and mitigation of design basis accidents.

4.6 Redundancy

The circuit design concepts of the process engineering systems and of the corresponding emergency power facilities shall be coordinated with each other such that the redundancy of the emergency power generation and distribution systems corresponds to the redundancy of the process engineering systems. The emergency power system shall also fulfill its function during test or repair procedures with a simultaneous occurrence of a single failure, provided this requirement also applies to the corresponding process engineering system. In the overall analysis of a design basis accident, the occurrence of a single failure and the repair case shall be assumed once in the entirety of the equipment and facilities available for the control and mitigation of the accident.

4.7 Functional Independence

(1) The emergency power system shall consist of redundant non-interconnected trains each of which has individual feed-ins as well as individual emergency power generating facilities, cable race ways and auxiliary systems and is, therefore, functionally independent.

(2) In exceptional cases emergency power loads may be supplied from more than one train of an emergency power facility, provided, the required reliability of the supplied system can only be achieved in this way and, provided, it is demonstrated for the individual case that the reliability of the emergency power system is not impermissibly reduced as a result of this measure. These power connections shall be designed such that no more than one train will fail for any failure possibility to be considered.

4.8 Spatial Separation

The redundant trains of the emergency power facilities shall be spatially separated or protected from each other such that failure-inducing events in one train cannot affect other trains and, also, that a single, plant internal failure-inducing event cannot lead to the failure of more than one train.

4.9 [Emergency] Power Balances

(1) Power balances shall be prepared taking all accidents (design basis accidents) of the accident analysis of the nuclear power plant into consideration. This applies in particular to:

a) failure of the station service power supply and of the main grid power supply without a simultaneous failure within the process engineering systems,

b) failure of the station service power supply and of the main grid power supply occurring simultaneously with one of the considered design basis accidents in the process engineering systems,

c) failure of the station service power supply and of the main grid power supply simultaneously with one of the considered external events.

(2) The power demand shall be determined individually for each train.

(3) In addition to each of the electrical power loads supplied by the emergency power facilities, all of the machines directly driven by the emergency power generators shall be included in these power balances.

(4) In preparing the power balances, the sequentially different power requirements in the course of the individual accident sequence to be considered shall be taken into consideration.

(5) The power balances shall reflect the static operational range and transient conditions.

(6) The power balances shall contain a safety margin. Uncertainties in the design and changes to be anticipated in the project design concept shall be considered in accordance with the planning stage of the project.

Note:
Component specific safety margins are specified in safety standards KTA 3702 through KTA 3705.

4.10 Interruption and Delay Durations

(1) For every emergency power load the time period shall be established for the maximum permitted duration of interruption or delay after a failure of the station service power supply or of the main grid supply until the supply from the emergency power generation facilities sets in. Correspondingly grouped power loads shall be assigned to the respective emergency power facilities.

(2) The equipment of these emergency power facilities shall be designed such that the maximum permitted duration for interruption and delay are not exceeded.

Note:
The maximum permitted interruption and delay durations are a result of the design basis accident analysis of the individual power plant.

4.11 Initiation and Termination of Emergency Power Operation

(1) The emergency power operation shall be initiated when the power supply of the corresponding emergency power busses from the station service facility fails or when the tolerances for voltage or frequency permitted for the power load are exceeded.

Note:
The requirements for generating and processing the signals for initiating emergency power operation are specified in safety standards KTA 3702 and KTA 3501.

Emergency power operation is given, e.g., when the corresponding emergency power generator supplies the individual train.

(2) The emergency power facilities shall be designed such that, for a period of at least 30 minutes after demand, no manual actions are required for the operation of the emergency power facilities.

(3) If the control and mitigation of design basis accidents requires a longer time period than 30 minutes without manual actions, this requirement shall also apply to the corresponding emergency power facilities.

(4) The emergency power operation should be terminated when the supply from the station service facility or from a suitable other source is again reliably available.

4.12 Protection

The engineered protection equipment in the emergency power system shall be designed such that defects or failures are reliably detected, that the necessary disconnections are performed and erroneous actuations from operational transients are prevented. An actuation of the protection equipment shall initiate appropriate alarms.

Note:
Component specific requirements are specified in safety standards KTA 3702 through KTA 3705.

4.13 Testability

(1) The equipment of the emergency power supply system shall be designed such that a periodical and complete inspection is possible during unit shutdown and, if required for reliability reasons, also during normal operation.

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

(3) Defects or failures occurring during tests and inspections in the train tested shall not cause defects or failures in other trains [of the emergency power system].

4.14 Monitoring

The equipment in the emergency power supply shall be monitored by measurements and alarms with respect to their functional condition in order to ascertain operability and the operating condition.

4.15 Operation and Maintenance

(1) All components of the emergency power supply should be designed with respect to the possibility of getting a clear overview, of easy maintenance and of short repair times, e.g. by accessibility and exchangeability.

(2) For operation, maintenance and repair unambiguous instructions shall be available. The respective manufacturer specifications should be taken into consideration.

(3) Functional degradations and damages shall be removed without delay.

(4) Should a random failure including sequential failures occur during repair work within the emergency power system and the remaining part cannot fulfill its safety function, then the reactor plant shall be brought into a safe condition.

Note:
A safe condition can be achieved, e.g., by immediate repair or by shutting down the reactor plant. In those cases where the repair work can be concluded faster than a reactor plant shutdown, preference shall be given to immediate repair.

4.16 Quality Assurance and Inspections of the Emergency Power System

4.16.1 General Requirements

The quality assurance of the components of the emergency power system shall be demonstrated.

Note:
The general requirements for quality assurance are specified in KTA 1401. The component specific requirements regarding quality assurance are specified in safety standards KTA 3702 through KTA 3705.

4.16.2 Design Review

With respect to the design review by the authorized experts (under Sec. 20 Atomic Energy Act), documented proof shall be provided that the electrical components, electrical modules and systems have been designed, tested and assembled in accordance with the requirements important to safety.

4.16.3 Qualification Certification, Type Tests and Piece Tests

(1) After completion of the development of the component, type tests shall be performed on fabrication samples to demonstrate the essential characteristics of the component. A type test, e.g. in accordance with VDE-Provisions, is acceptable as valid demonstration.

(2) If the deployment in nuclear power plants requires safety characteristics which cannot be demonstrated by the type-testing, such as resistance to design basis accident conditions and to seismic events, then special validation tests shall be performed.

(3) Piece tests shall be performed with the goal of detecting material and fabrication defects. They, basically, shall be performed on each piece of the delivered lot. In the case of series produced items tests on random samples are permitted due to the general statistical safety involved.

(4) A piece test performed in accordance with VDE-Provisions is adequate, provided the application in the nuclear power plant does not require the assurance of additional safety characteristics. Otherwise, expanded piece tests shall be performed.

4.16.4 Commissioning Tests

Commissioning tests shall be performed on-site to demonstrate the fulfillment of the specified safety requirements and the function of the electrical power supply in their interaction with the process engineering systems and the instrumentation and control equipment. The commissioning tests should be performed under the most realistic conditions possible.

4.16.5 Inservice Inspections

Regular inservice inspections shall be performed to ascertain that the operability of the electrical power supply is maintained. They shall be performed during operation or shutdown of the nuclear power plant in specified time intervals; these time intervals are obtained from reliability considerations and from a mutual coordination with the functional tests of the corresponding process engineering systems.

4.16.6 Testing after Maintenance or Repair

(1) After completion of any maintenance and repair work which had required an interruption of operability, this operability shall be demonstrated by a corresponding test.

(2) Should the installation of modified equipment become necessary, this equipment must have successfully passed the tests in accordance with Section 4.16.3.

4.16.7 Test Specifications

Test specifications shall be provided which specify the individual tests and inspections corresponding to the different test types. Additionally, the required means and equipment and the preparations for testing and inspection shall be specified.

4.16.8 Testers

(1) The type tests in accordance with Section 4.16.3 shall be demonstrated by test documents to the authorized experts (under Sec. 20 Atomic Energy Act). The validation tests in accordance with Section 4.16.3 shall be performed by or in the presence of authorized experts (under Sec. 20 Atomic Energy Act).

(2) The piece tests in accordance with Section 4.16.3 shall be performed by plant experts. Additionally, it shall be specified in the course of the design review, which of the tests in accordance with Section 4.16.3 shall be carried out in the presence of authorized experts (under Sec. 20 Atomic Energy Act).

(3) The commissioning tests in accordance with Section 4.16.4 shall be carried out in the presence of, or in agreement with, authorized experts (under Sec. 20 Atomic Energy Act).

(4) The regular inservice inspections in accordance with Section 4.16.5 and tests after maintenance or repair in accordance with Section 4.16.6 shall be performed by the power utility in agreement with or in the presence of the authorized experts (under Sec. 20 Atomic Energy Act).

4.16.9 Proof of Tests

(1) To demonstrate the performance of tests and inspections, test records shall be kept that shall contain all data necessary for the evaluation of the respective test or inspection. This shall include:

a) performing institutions,

b) test object,

c) extent of test,

d) type of test,

e) identification number of the test specification and, if applicable, of the standard test specification,

f) performance of the test (scheduled and actual date of the test),

g) test results,

h) confirmation of the performance, results and evaluation of the test by signature of the tester, and in case the authorized expert (under Sec. 20 Atomic Energy Act) took part, also his signature.

(2) The tests and inspections in accordance with Section 4.16.3 shall be verified by certificates.

5 Connections Between the Units of a Multi-Unit Nuclear Power Plant

5.1 Basic Conditions

(1) The use of electrical power connections between the three-phase alternating current power facilities of the plant units are permitted provided they are carried out with the goal of

a) preventing start-ups of emergency power generators during planned shut-downs in the station service equipment (maintenance),

b) reducing the operating time of emergency power generators during demanded operation,

c) achieving an equivalent power feed-in in case of an unavailability of emergency power facilities during required operation of these emergency power facilities.

(2) No electrical power connections should be planned between DC busses of neighboring nuclear plant units.

(3) DC power loads may be supplied from DC power facilities of neighboring nuclear power plant units, provided the feed-in is reliably de-coupled.

5.2 Basic Requirements

(1) Electrical power connections between nuclear power plant units shall be designed for the electrical power to be transmitted. The tolerances of current, voltage and frequency shall meet the requirements of the individual power loads.

Note:
Annex D shows examples for the design of power connections between nuclear power plant units.

(2) Only one type of design should be used for the connections between nuclear power plant units,.

(3) The electrical power to be supplied to other nuclear power plant units shall be taken into consideration when

designing station service facilities, emergency power generating and emergency power distribution facilities.

(4) The electrical power connections between switchyards of nuclear power plant units shall be designed and operated such that they do not determine the non-availability of the power supply for the power loads important to safety in the individual nuclear power plant units.

5.3 Circuit Design Concept

(1) The circuit design concept of the station service switchyard of neighboring nuclear power plant units shall match the (redundancy) subdivision of these facilities.

(2) The circuit design concept of electrical power connections between the emergency power switchyard of neighboring nuclear power plant units shall be in accordance with the train design concept of the emergency power facilities; this also applies to the electrical power connections between the station service switchyard of one nuclear power plant unit and the emergency power switchyard of another nuclear power plant unit.

(3) It shall be possible to disconnect the electrical power connections between nuclear power plant units at either end.

5.4 Protection

The individual electrical power connections between nuclear power plant units shall be equipped with engineered protection equipment that shall be designed such that the selectivity within each nuclear power plant unit is maintained.

5.5 Monitoring and Interlocking

(1) At each nuclear power plant unit, the switching and load conditions shall be displayed for those parts of the electrical power connections that are part of this nuclear power plant unit.

(2) Impermissible switching conditions shall, preferably, be prevented by technical measures and supplementary administrative measures.

(3) Signal links between the plant units shall be galvanically decoupled.

5.6 Quality Assurance, Tests and Inspections

5.6.1 General Requirements

The quality assurance of the power connections between the units of a multi-unit nuclear power plant shall be demonstrated.

Note:
The general requirements for quality assurance are specified in KTA 1401.

5.6.2 Commissioning Tests and Inspections

Commissioning tests and inspections shall be performed to demonstrate that the specified requirements are met. The commissioning tests and inspections should be performed under conditions that are as realistic as possible.

6 Additional Requirements for the Connections to Emergency Power Facilities Between the Units of a Multi-Unit Nuclear Power Plant

6.1 General Requirements

The electrical power connections between the emergency power switchyards of neighboring nuclear power plant units and between the electrical power connections between the station service switchyard of one nuclear power plant unit and the emergency power switchyard of another nuclear power plant unit shall meet the requirements of Section 5 and, additionally, of Sections 6.2 through 6.5.

6.2 Functional Independence

Electrical power connections to emergency power switchyards shall be designed such that none of the failure possibility to be considered can lead to the failure of more than one train of the emergency power system in each nuclear power plant unit.

6.3 Spatial Separation

The electrical power connection trains between emergency power switchyards of neighboring nuclear power plant units shall be either spatially separated or protected from each other such that events in one train cannot affect any other electrical power connection train and that a single plant-internal failure-inducing event will not lead to the failure of more than one train of the electrical power connection.

6.4 Switching on of Electrical Power Connections

(1) The switching on of electrical power connections should be performed by manual actions only. The switching on of more than one electrical power connection shall be carried out sequentially one train after another.

(2) Emergency power generation facilities of neighboring nuclear power plant units should not be operated in parallel via electrical power connections.

(3) Synchronization and short-duration parallel operation of emergency power generators of one nuclear power plant unit with the power from another nuclear power plant unit is permissible if required to achieve an interruption-free switchover.

6.5 Disconnecting of Connections to Other Nuclear Power Plant Units

In case of initiating signals requesting emergency power operation in one train of an individual nuclear power plant unit, the electrical power connections from the emergency power switchyard of this train to other nuclear power plant units shall be disconnected automatically.

Annex A
Examples of Electrical Circuit Design Concepts for the Electrical Power Supply of a Nuclear Power Plant

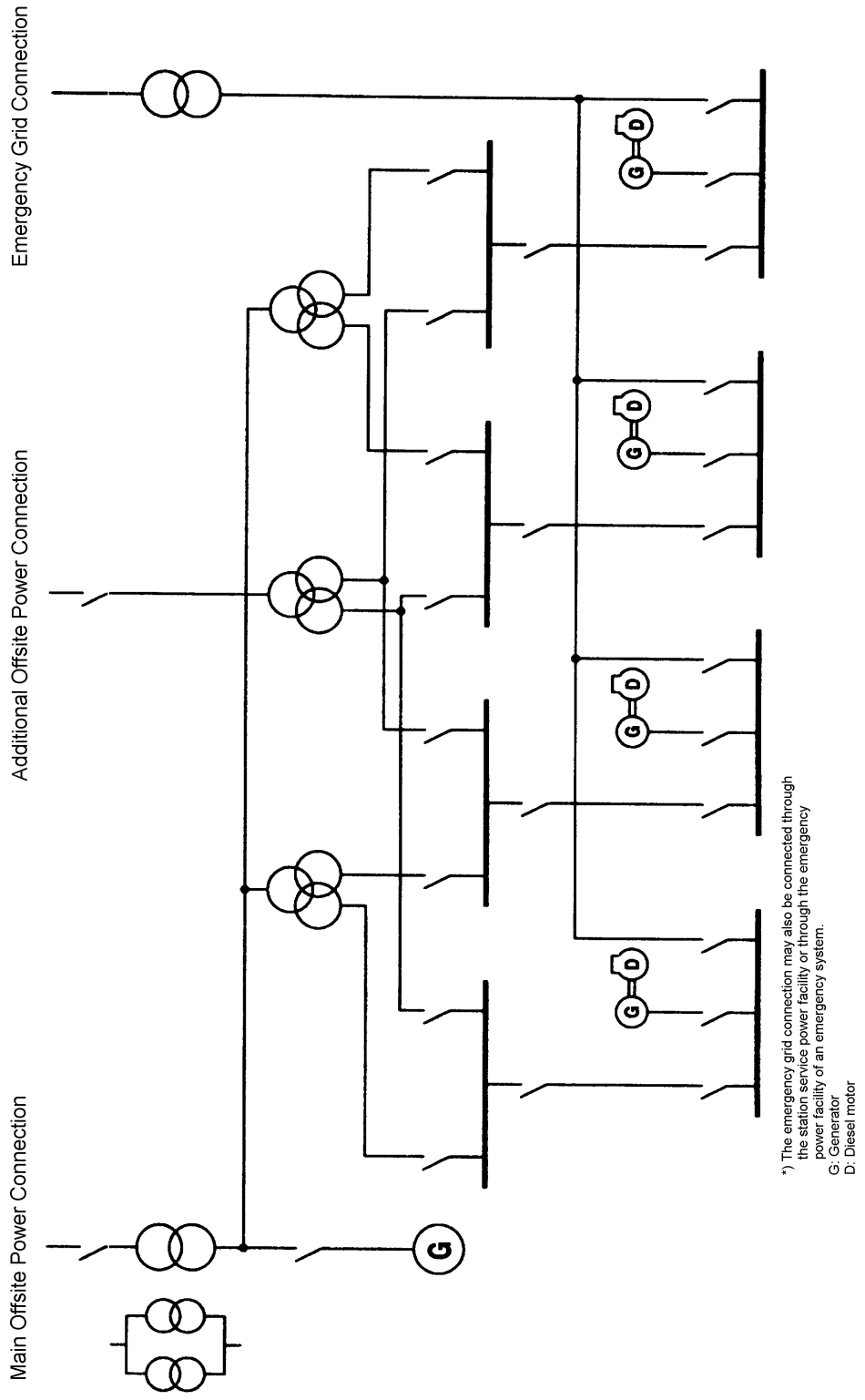

Figure A-1: Example of the electrical circuit for a nuclear power plant with one main offsite, one additional offsite and one emergency grid connection

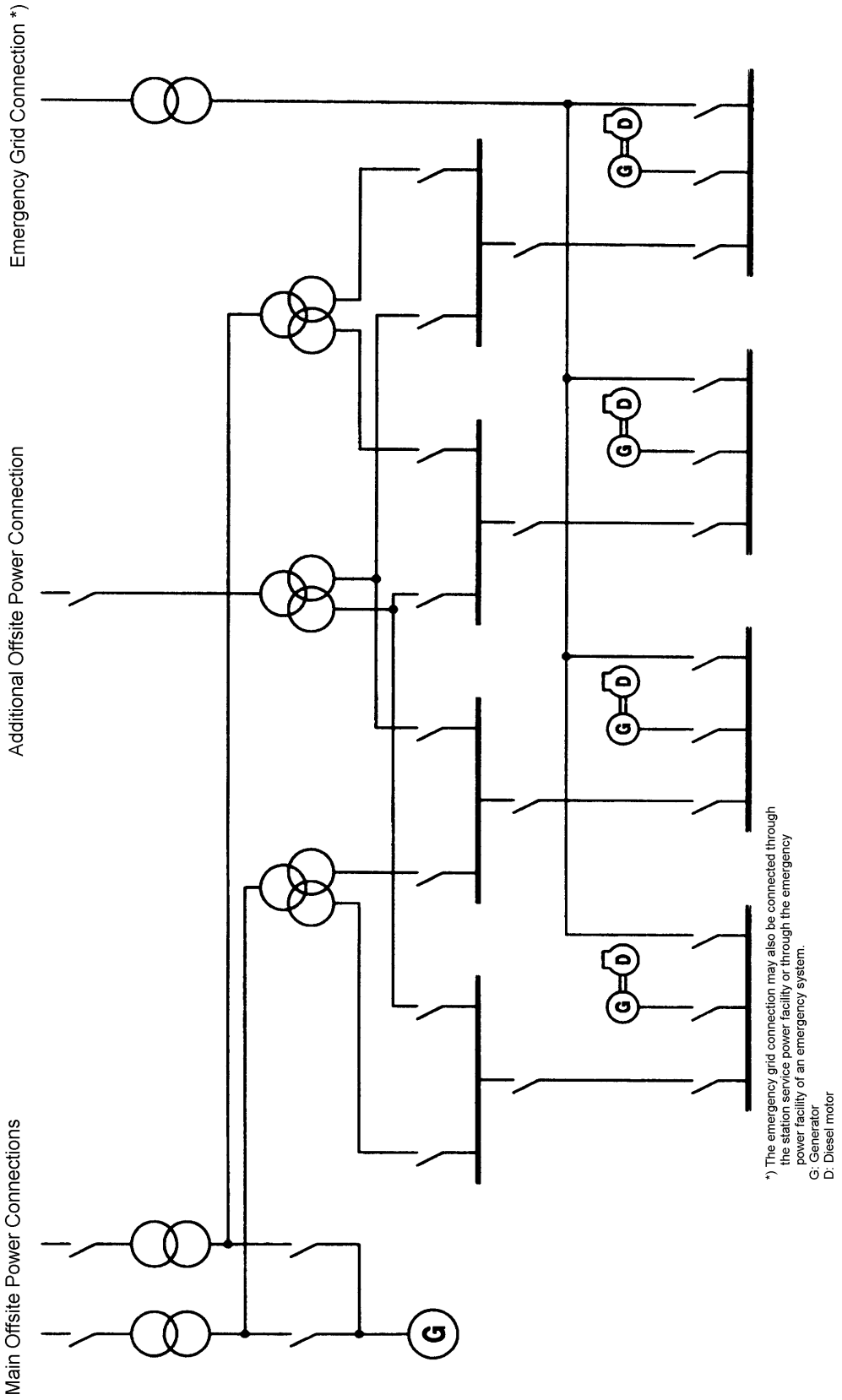

Figure A-2: Example of the electrical circuit for a nuclear power plant with a twofold main offsite, one additional offsite and one emergency grid connection

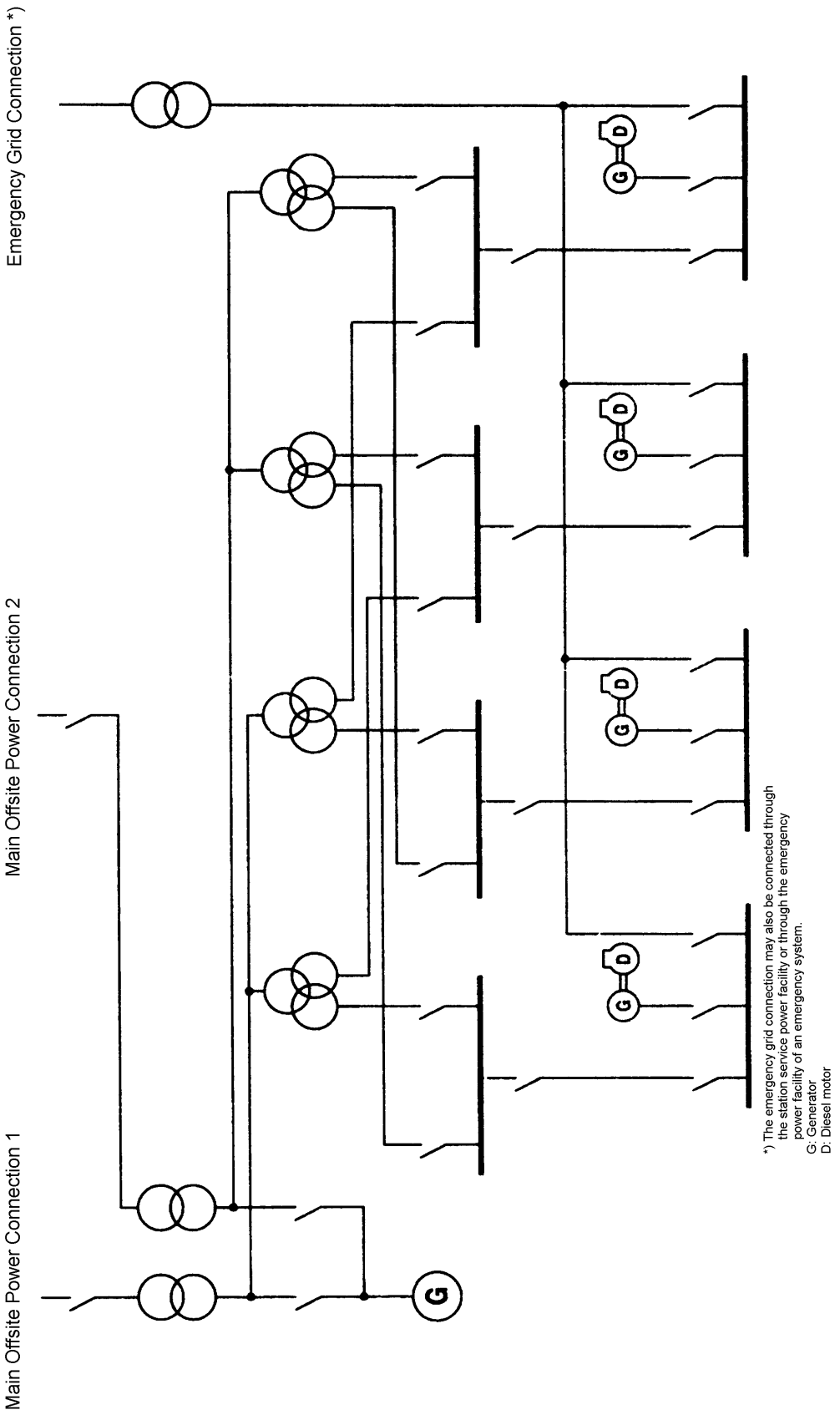

Figure A-3: Example of the electrical circuit for a nuclear power plant with two main offsite power connections and one emergency grid connection

Annex B
Emergency Power System Boundaries

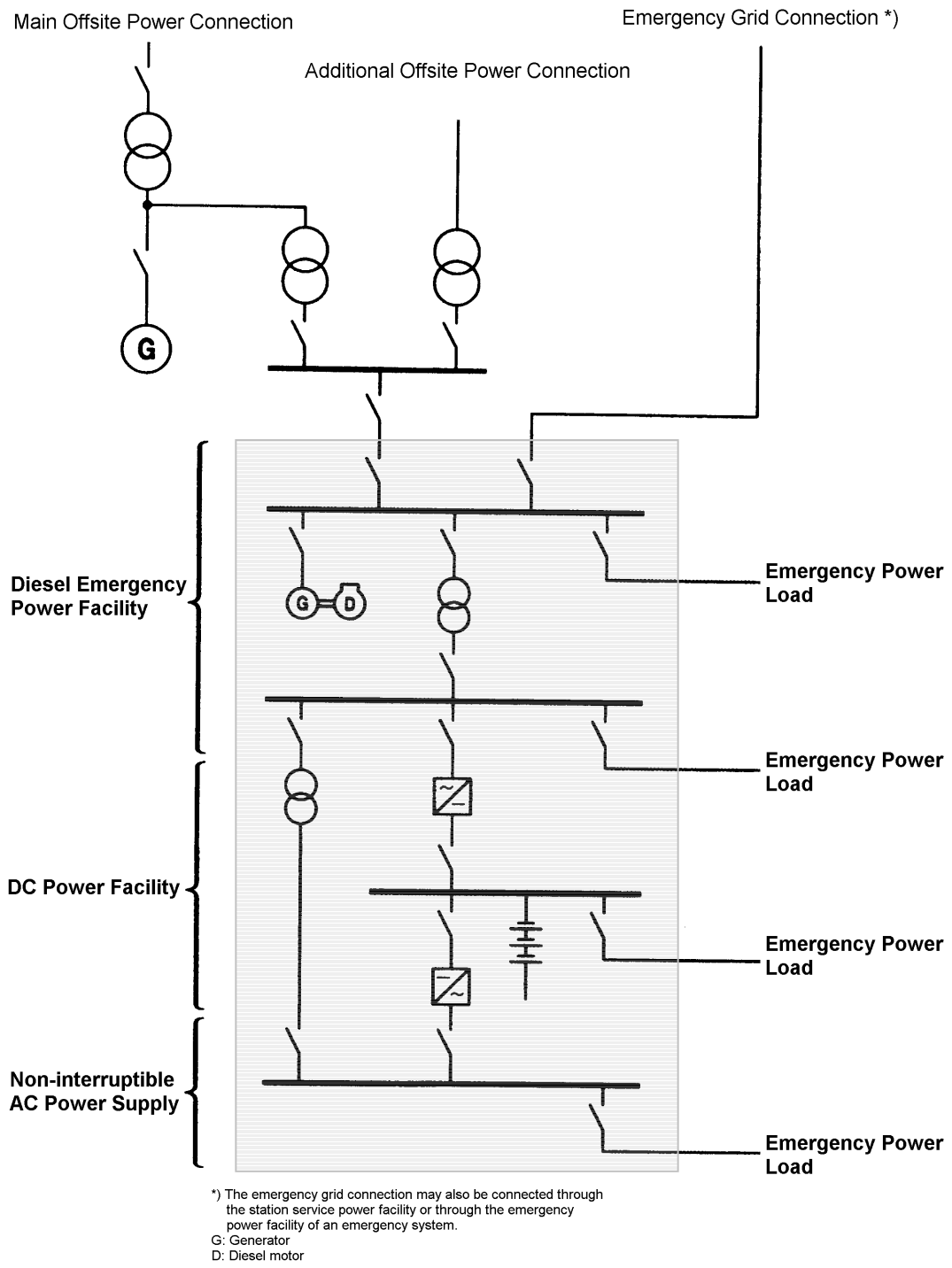

Figure B-1: Schematic representation of the boundaries of an emergency power system (shown for one train)

Annex C
Offsite Power Connections and Station Service Facility

C 1 General Requirements

C 1.1 Requirements Regarding Design Concepts of Electrical Circuits

(1) The electrical circuitry and spatial arrangement of offsite power connections and the station service facility shall be designed such that no single failure inducing event inside the nuclear power plant or within the electrical power supply in the nuclear power plant or in the vicinity of the offsite power connections could cause a long-term failure of all grid supply possibilities. Such a failure inducing event and subsequent mechanical damages, e.g. power pylon or cable breaks, shall not lead to a mechanical failure of all of the offsite power connections in accordance with Section 3 para. (2) items a) and b).

(2) Equipment shall be available which will automatically shut the plant unit down to the level of station service power (load shedding to station service power) when the plant unit becomes disconnected from the offsite grid.

C 1.2 Connections between Station Service Facility or Offsite Power Supply and Emergency Power System

(1) All connections between the station service facility or the offsite power supply and the emergency power system shall be designed such that they will be automatically disconnected in case of a failure of the station service and offsite power supply possibilities. The equipment for reconnecting the newly available station service facility or newly available offsite power supply shall be designed such that each train of the emergency power system can be individually reconnected.

(2) No unavoidable interference from the offsite power connections or the station service facility, e.g. overvoltage or short-circuit to ground, shall cause any common cause failure in the emergency power system.

C 1.3 Testability

(1) The equipment for the electrical power supply of the power loads important to safety shall be designed such that a periodical and complete inspection can be performed during shutdown of the plant unit and, if so required for reasons of reliability, also during normal operation.

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

C 1.4 Monitoring

The equipment for the electrical power supply of the power loads important to safety shall be monitored by measurements and alarms with respect to functional values in order to ascertain their functional availability and their operating condition.

C 2 Offsite Power Connections

C 2.1 Offsite Power Boundaries

(1) A main offsite power connection shall be considered as comprising all electrical and technical equipment between the low-voltage terminal of the main transformer and the bus terminals of the circuit breakers in the offsite grid switchyard of the particular offsite power connection.

(2) A additional offsite power connection shall be considered as comprising all electrical and technical equipment between the circuit breakers in the station service facility and the bus terminals of the circuit breakers in the offsite grid switchyard of the particular offsite power connection.

(3) An emergency power connection shall be considered as comprising all electrical and technical equipment between the circuit breakers in the station service facility or in emergency power facilities and the bus terminals of the circuit breakers in the offsite grid switchyard of the particular offsite power connection or of a power source that is independent of the emergency power system of the nuclear power plant.

C 2.2 Design

(1) Each one of the two offsite power supply possibilities in accordance with Section 3 para. (2) item b shall be able to supply all trains of the emergency power system.

> Note:
> Only such offsite power connections that are functionally separated from each other and are decoupled by protective circuits shall be considered as an offsite power supply possibility.

(2) The offsite power supply possibilities in accordance with Section 3 para. (2) item b and d shall be decoupled by protective circuits.

(3) The offsite power supplies in accordance with Section 3 para. (2) item b should be connected either to separate offsite power grid switchyard or to different voltage levels.

(4) The additional offsite power supply shall be designed such that it can deliver sufficient power to shut down the nuclear power plant unit while sustaining the main heat sink.

(5) Additional offsite power supplies may be mutually used by several nuclear power plant units. A mutually used offsite power supply shall be designed such that it can deliver sufficient power to simultaneously shut down all connected nuclear power plant units while sustaining the main heat sinks.

(6) The emergency grid connection and its feeder locations in the nuclear power plant shall be designed such that at least that amount of power can be drawn that is required for one residual heat removal train of the nuclear power plant unit including all necessary instrumentation and control as well as auxiliary equipment.

> Note:
> With respect to the power required for residual heat removal, no superposition of a further design basis accident, e.g. loss-of-coolant accident, is considered.
> In nuclear power plants with emergency residual heat removal systems, one train of the emergency heat removal system may be sufficient for residual heat removal.

(7) Emergency grid supplies may be mutually used by several nuclear power plant units. A mutually used emergency grid supply shall be designed such that it can deliver sufficient power as specified in accordance with para. (6) to simultaneously remove the residual heat in all connected nuclear power plant units.

(8) At least one connection to the grid, for instance the emergency grid connection, shall be designed as a cable connection in the direct vicinity of the nuclear power plant.

C 2.3 Connecting with, and Repairing Offsite Power Connections

(1) The additional offsite power source shall be connected automatically in case of demand. The initiation limit values and time delay of this automatically switched connection shall be chosen and coordinated with the emergency power generation facilities such that no unnecessary connections to the emergency power generation facilities will occur.

(2) It should be possible to manually connect the emergency grid supply when required. An automatic connection is permissible, provided the emergency grid supply is designed for the maximum power of the automatically connected power loads.

(3) The repair of any failed offsite power source shall be initiated without delay.

C 2.4 Possibilities for Power Supply in Case of External Events

If it cannot be precluded that external events would cause the simultaneous failure of all offsite power connections it is required that an offsite power connection be repaired or another power supply be established within less than three days. This power supply shall deliver at least the amount of electrical power required for the residual heat removal of the nuclear power plant unit including all the necessary instrumentation and control as well as auxiliary equipment. In the case of multi-unit power plants the electrical power shall be sufficient for supplying the corresponding energy in every one of the nuclear power plant units.

C 3 Operation and Maintenance

(1) Design and arrangement of all plant components belonging to the electrical power supply of the power loads important to safety should be such that a clear overview, easy servicing and short repair times are made possible, e.g. by accessibility and exchangeability.

(2) Unambiguous instructions for operation and maintenance shall be available that are required for specified normal operation of the plant and for the control and mitigation of design basis accidents.

(3) System malfunctions and failures shall be repaired without delay.

C 4 Quality Assurance and Testing of Equipment Important to Safety of the Station Service Facility

C 4.1 General Requirements

The quality assurance of the electrical power supply of the power loads important to safety shall be demonstrated.

Note:
The general requirements for quality assurance are specified in KTA 1401.

C 4.2 Commissioning Tests and Inspections

Commissioning tests and inspections shall be performed to demonstrate the functionality of the electrical power supply in conjunction with the plant and with the process-engineering systems and the instrumentation and control systems.

Annex D
Examples of the Design of Power Connections Between the Nuclear Power Plant Units

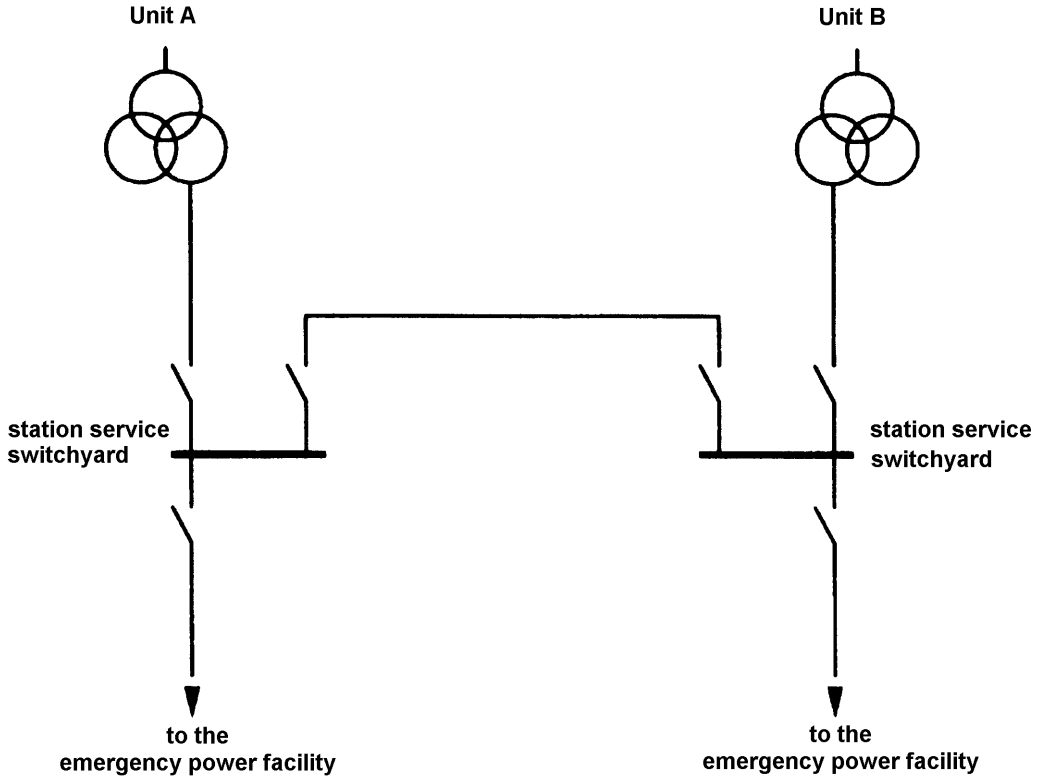

Figure D-1: Example of a power connection between station service switchyards of two nuclear power plant units (schematic representation for one train)

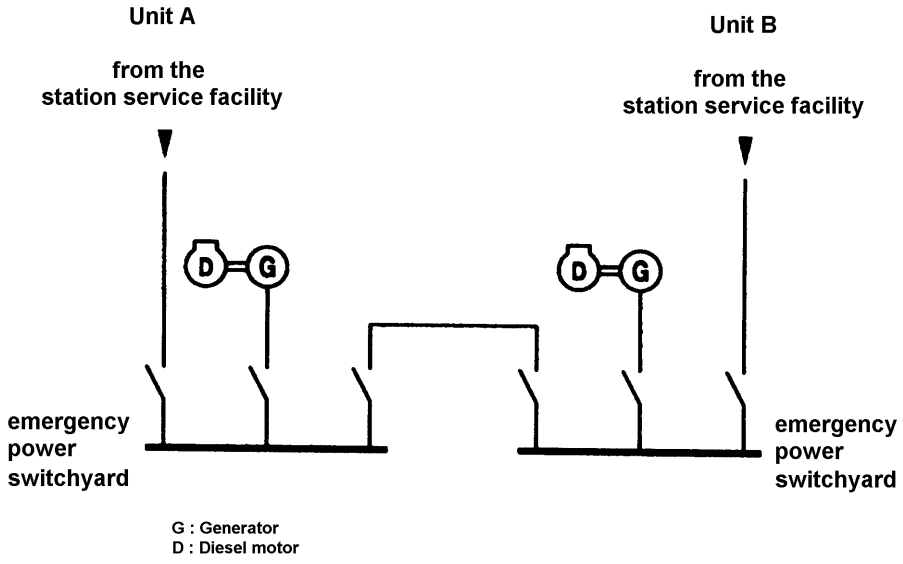

Figure D-2: Example of a power connection between emergency power switchyards of two nuclear power plant units (schematic representation for one train)

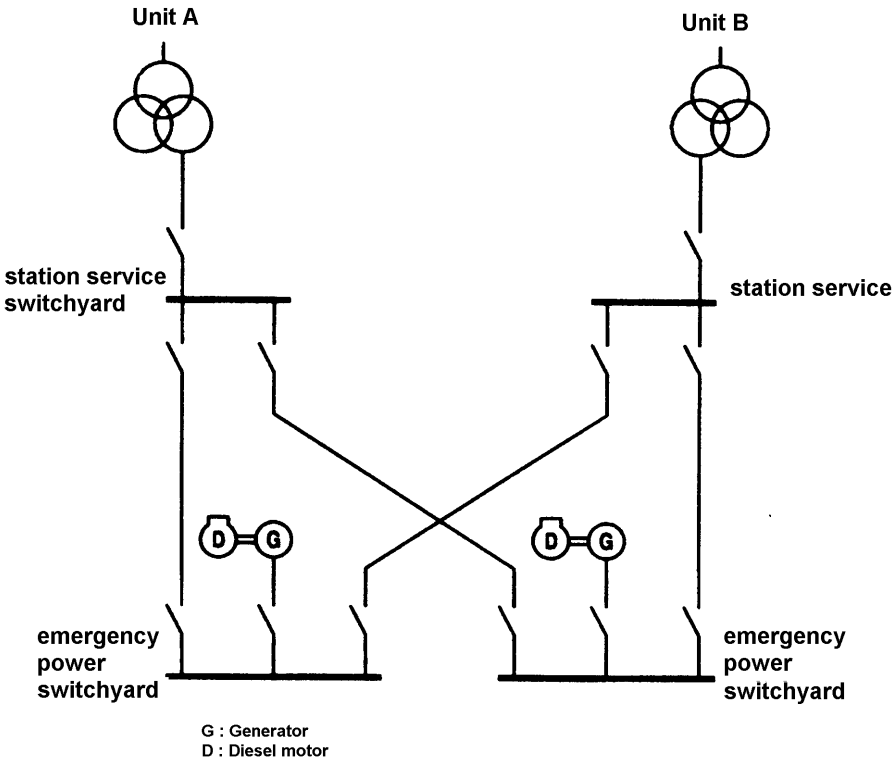

Figure D-3: Example of a power connection between station service switchyards and emergency power switchyards of two nuclear power plant units (schematic representation for one train)

Annex E
Regulations Referred to in this Safety Standard

Atomic Energy Act	Act on the Peaceful Utilization of Atomic Energy and the Protection against its Hazards (Atomic Energy Act) of December 23, 1959 (BGBl I, Page 814) as Amended and Promulgated on July 15, 1985 (BGBl I, Page 1565) last Amendments by the Act of April 6, 1998 (BGBl I Page 694)

Annex F
Literature
(strictly informative)

[1] Statistical Investigation of the Reliability of Diesel Generators in German Nuclear Power Plants. VdTÜV Leitstelle Kerntechnik. Verlag TÜV Rheinland, Köln 1983.

[2] Final Report of the Results of the Safety Review of the Nuclear Power Plants in the Federal Republic of Germany by the Reactor Safety Commission.
Recommendations of the Reactor Safety Commission (RSK) of November 23, 1988.
Bundesanzeiger No. 47a of March 8, 1989.

[3] Evaluation of Operating Experience Regarding the Reliability of Emergency Power Diesel Generators in German Nuclear Power Plants.
Final Report GRS-A-1736 (November 1990). M. Maqua (Author). Report Series on Reactor Safety and Radiological Protection BMU-1991- .