

Safety Standards

of the
Nuclear Safety Standards Commission (KTA)

KTA 3702 (2022-11)

Emergency Power Generating Facilities with Diesel-Generator Units in Nuclear Power Plants

(Notstromerzeugungsanlagen mit Diesellaggregaten
in Kernkraftwerken)

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

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Emergency Power Generating Facilities with Diesel-Generator Units in Nuclear Power Plants

KTA 3702

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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) on July 25, 2023. Copies of the German versions of the KTA safety standards 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>).

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

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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 permissible. 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 this 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 the AtG, the Radiation Protection Act (StrlSchG) and the Radiation Protection Ordinance (StrlSchV) as well as further detailed in the Safety Requirements for Nuclear Power Plants (SiAnf) and the Interpretations of the SiAnf.

(2) Based on the Safety Requirements and their interpretations this safety standard specifies the requirements for emergency power generating facilities with diesel-generator units.

(3) This safety standard was set up under the assumption that the conventional regulations and standards (e.g. German Accident Prevention Regulations, DIN standards and VDE regulations) will be applied, in consideration of the specifics of the safety requirements for nuclear power plants.

(4) General requirements applying to the electrical power supply in nuclear power plants are specified in safety standard KTA 3701.

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

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

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

(8) Requirements for the fire protection of mechanical and electrical components are specified in safety standard KTA 2101.3.

(9) Requirements for Design of Components in Nuclear Power Plants against Seismic Events are specified in safety standard KTA 2201.4

(10) Requirements for the reactor protection system and monitoring system of the safety system are specified in safety standard KTA 3501.

(11) Requirements for Electrical Drive Mechanisms of the Safety System in Nuclear Power Plants are specified in safety standard KTA 3504

(12) General requirements for the quality assurance in nuclear power plants are specified in safety standard KTA 1401.

(13) Requirements for Ageing Management in Nuclear Power Plants are specified in safety standard KTA 1403.

(14) Requirements for Control Room, Remote Shutdown Station and Local Control Stations in Nuclear Power Plants are specified in safety standard KTA 3904.

1 Scope

This safety standard applies to stationary emergency power generating facilities with diesel-generator units (referred to in this safety standard text as 'emergency power generating facility') in stationary nuclear power plants.

Note:

The boundaries of an emergency power generating facility are shown in **Figure 1-1**.

2 Definitions

(1) Standby diesel-generator unit

A standby diesel-generator unit is a power generating unit driven by a diesel engine which, upon demand, will take over the power supply to a power load after a voltage interruption.

(2) Continuous operating time of diesel engine

The continuous operating time of the diesel engine is the manufacturer-approved uninterrupted running time for a specified power load cycle over a given time until a scheduled maintenance takes place with the diesel engine at standstill.

(3) Rated continuous power of diesel engine

The rated continuous power of the diesel engine is the highest power the diesel engine when used for an emergency power unit, can continuously supply at nominal speed and specified ambient conditions.

(4) Diesel-generator unit

A diesel-generator unit is a power generating unit consisting of a diesel engine, coupling and a generator mounted on a common base frame / foundation

(5) Operating fuel tank

An operating fuel tank is a tank allocated to the individual diesel engine, which supplies the engine directly with fuel.

(6) Fuel storage tank

A fuel storage tank is a stationary tank designed for the storage of fuel that supplies the operating fuel tank.

3 Design

3.1 General Requirements

(1) For the design of the unit and its auxiliary systems, all expected operational and incident-related loads on site and conceivable internal and external hazards shall be taken into account. For this purpose, the documents shall be submitted according to Section 4.2 and 3.10.

(2) Design and installation of all parts of the emergency power generating facility shall normally be such that proper maintenance in accordance with requirements and short repair times are possible. Unambiguous instructions shall be provided for operation, servicing, and repair. The instructions of the manufacturers shall be followed.

(3) The emergency power generating facilities for nuclear power plants shall normally employ standby diesel-generator units.

(4) It shall be demonstrated that the components of the emergency power generating facilities are quality-assured.

(5) The emergency diesel generator units of the emergency power generation systems in nuclear power plants shall be spatially separated and arranged train-by-train.

3.2 Power Balance and Static Tolerances

3.2.1 General Requirements

The emergency power requirement shall be determined by each train taking into account the design basis accidents to be considered and the corresponding accident sequences. Hereby, the power requirements of all power loads that can be connected to one train in case of the individual design basis accident considered shall be determined.

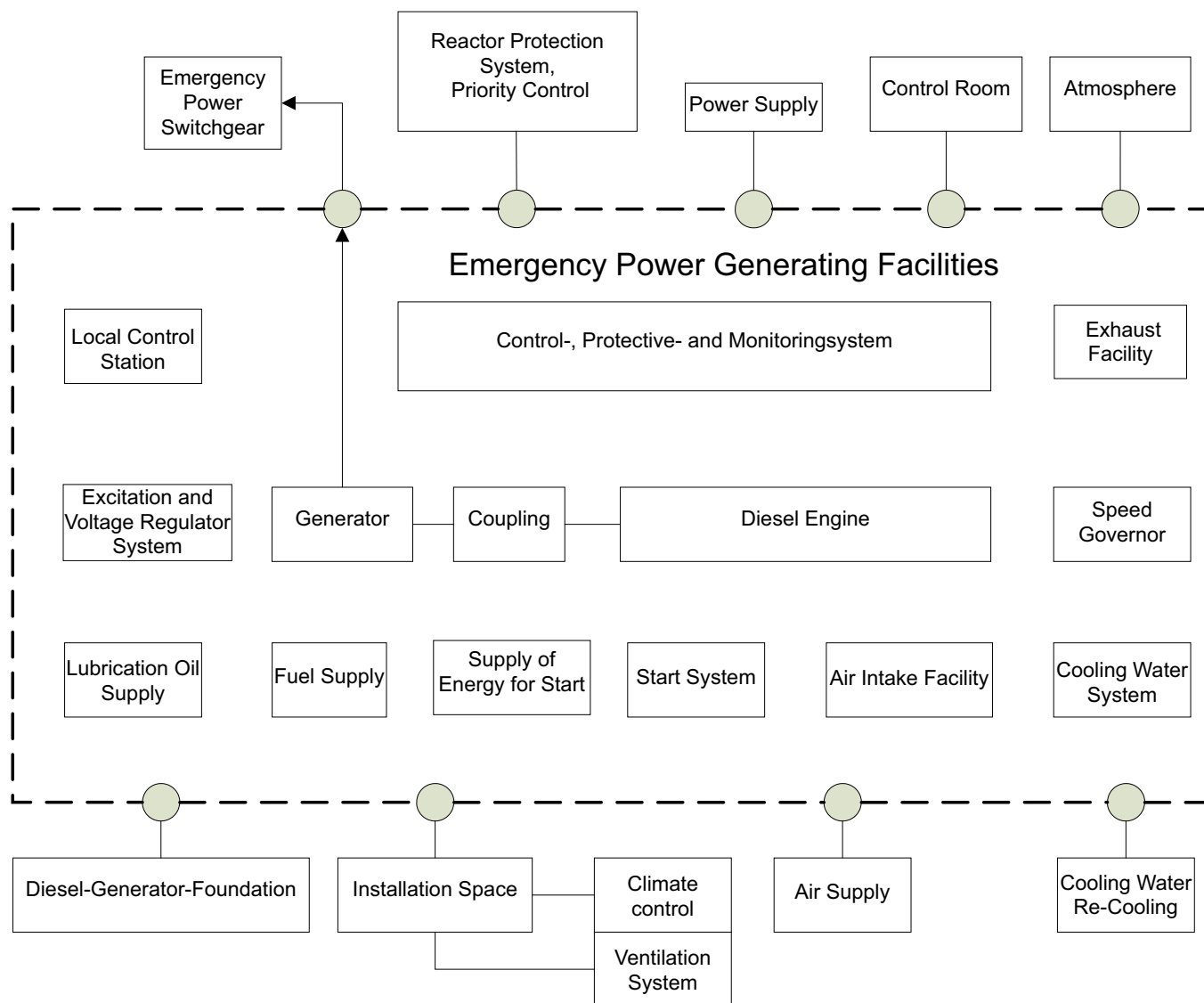


Figure 1-1: Boundaries of the emergency power generating facility

3.2.2 Determination of the Active Power

(1) In order to determine the diesel engine power rating, the active power shall be assessed in detail for each train. This detailed assessment shall take into account:

- motoric power loads,
- non-motoric power loads (e.g., rectifiers, heating systems, lighting systems),
- non-uniform distribution of the power load to the individual trains,
- switchable power loads and buses,
- electrical transmission losses
- generator losses (degree of efficiency).

(2) In the case of motoric power loads, the power balance shall include the power requirement of each drive or drive group on the shaft divided by their individual degree of efficiency.

(3) In the case of intermittently operated drives or drive groups (short-time or interrupted operation), the power balance shall include the rated electrical power multiplied by simultaneity factors. If an actuation can occur at the same point in time, a simultaneity factor of 1 is required.

3.2.3 Determination of the Apparent Power

In order to specify the generator rating, the balance of apparent power shall be determined for each train. This requires dividing

the active power of the power loads or power load groups determined as specified in Section 3.2.2 by their individual power factors.

3.2.4 Safety Margin of the Power Balance

A safety margin shall be added to the maximum power determined from the power balances. At the start of the construction of the emergency power generation facility the safety margin shall be equal to at least 10 %.

3.2.5 Static Tolerances

In the static operating range of up to 100 % rated continuous power, the tolerances for speed and voltage characteristics specified in **Table 3-1** shall not be exceeded.

3.3 Power Load Steps and Dynamic Tolerances

3.3.1 Power Load Steps and Power Load Acceptance Times

Under consideration of the accident analysis, the tolerances of the power-load specific design data, the viable power load acceptance time and the power load acceptance behavior of the diesel engines used, the size, sequence and time intervals of the power load steps of each train shall be specified such that

- the process-technologically required sequence and maximum permissible power interruption for the safety related power loads are adhered to,

- b) the permissible dynamic tolerances as specified in Section 3.3.2 are not exceeded, taking the transients into account when the power loads are connected or disconnected and
- c) the connection of power loads can be enabled by a simply structured program code. The program code shall be suited to trigger the emergency power supply at any point in time during the accident sequence.

3.3.2 Dynamic Tolerances

In the case of power load changes up to the overload power capacity specified in Section 3.7.2, the dynamic tolerances of the speed and voltage characteristics specified in **Table 3-2** shall not be exceeded.

3.4 Quiet-run Tolerances

(1) The vibrations transmitted from the diesel-generator unit to the structure and from the diesel engine to the generator shall be limited within the rotational speed adjustment range as follows:

- a) The vibrational power loads transmitted from the diesel-generator unit to the civil structure shall not exceed 3 % of the static power load.
- b) The vibrations transmitted from the diesel engine to the generator - superposed by the vibrations caused by the generator itself - shall not exceed the vibration speed of the generator.

Note:

Vibration speeds may be defined e.g. in accordance with ISO 8528-9.

(2) A torsional vibration analysis shall be carried out for the torsional vibration system of diesel engine, coupling and generator to demonstrate that the vibration range does not include any critical values. This requires taking spark failures of one cylinder into account.

3.5 Power Rating and Number of the Diesel-generator Units in each Train

(1) The statically required power rating shall be specified on the basis of the power balance determined for each train (Sections 3.2.2 and 3.2.3) including the safety margin (Section 3.2.4). The power rating of the diesel-generator unit shall be chosen such that it meets the dynamic tolerances as specified in Section 3.3.2 taking the unit's mass moment of inertia into account. The design of the diesel-generator unit shall be based on the most unfavorable ambient conditions at the installation site.

(2) Each train shall normally be provided with one diesel-generator unit.

3.6 Suitability

3.6.1 Suitability of the Emergency Power Generating Facility

(1) The suitability of the emergency power generating facility for use in nuclear power plants shall be demonstrated by a certified satisfactory service life and by type tests as specified in Sections 3.6.2 to 3.6.5.

3.6.2 Suitability of the Diesel Engine

(1) Only such diesel engines, for which the suitability can be demonstrated by a certified satisfactory service life and by type tests, shall be used in the emergency power generation facilities [of nuclear power plants].

(2) The suitability of the diesel engine is deemed proven if:

- a) a satisfactory service life is demonstrated by 15 diesel engines of the same series for a total of 7500 operating hours

whereby two of the diesel engines shall perform for at least 2000 operating hours each and

b) by a type test of diesel engines as specified in Appendix D.

(3) When using a diesel engine of lower power rating and speed, a type test may be regarded as successful if the components and parts relevant to engine operation are of the same design as those of the type-tested diesel engine.

(4) In the case of large-scale-production diesel engines for which considerably more operational experience is available than required under this safety standard, both the type and extent of the type test may be specified differently from the detailed requirements of this safety standard.

(5) If the satisfactory service life of individual components or auxiliary systems justifiably cannot be demonstrated by testing diesel engines of the same design, a separate proof for these components [or auxiliary systems] is permissible.

(6) If the use in nuclear power plants requires additional safety features (e.g., a design to withstand external events) and these safety features are covered neither by type tests nor by the certified satisfactory service life, special suitability tests shall be provided.

3.6.3 Suitability of the Generator

(1) Prerequisite for the use of a generator [in a nuclear power plant] is that it is part of a production series with a certified satisfactory service life.

(2) The service life of a generator production series may be considered as successfully demonstrated if at least 15 generators of this production series are in use.

(3) The generator type shall have successfully been subjected to a type test.

(4) If the use in nuclear power plants requires additional safety features (e.g., a design to withstand external events) and these safety features are covered neither by type tests nor by the certified satisfactory service life, special suitability tests shall be performed.

3.6.4 Suitability of the Auxiliary Systems

(1) The suitability of the auxiliary systems shall be demonstrated. A satisfactory service life shall normally have been demonstrated under comparable operating conditions for the components used.

(2) If the use in nuclear power plants requires additional safety features (e.g., a design to withstand external hazards) and these safety features are covered neither by type tests nor by the certified satisfactory service life, special suitability tests shall be performed.

3.6.5 Suitability of the Instrumentation and Control Systems

(1) The suitability of the instrumentation and control systems shall be demonstrated. The satisfactory service life of the components used shall normally have been demonstrated under comparable operating conditions

Note:

Requirements for complex electronic components are demanded in KTA 3701 Section 5.16.3.

(2) If the use in nuclear power plants requires additional safety features (e.g. a design to withstand external hazards) and these safety features are covered neither by type tests nor by the certified satisfactory service life, special suitability tests shall be performed.

3.6.6 Suitability of operating media

Only operating media authorized by the component manufacturers (e.g. fuel, lubricating oil or coolant) shall be used. The

interactions and compatibilities of supplies with the components shall be observed.

3.7 Diesel Engine Requirements

3.7.1 Rated Continuous Power of the Diesel Engine

(1) The rated continuous power of the diesel engine shall amount to at least the sum of the required static active power as specified in Section 3.2.2, including the safety margin in Section 3.2.4.

(2) If the diesel engine is directly coupled with further components (e.g. pumps), the power requirements of the additional components shall be included in the calculation of continuous power.

3.7.2 Overload Power Capacity of the Diesel Engine

(1) The overload power capacity of a diesel engine shall be specified such that it is sufficient to comply with the dynamic tolerances as specified in Section 3.3.2 under consideration of the power load steps and power load acceptance times as specified in Section 3.3.1. The overload power capacity shall amount to at least 110 % of the rated continuous power as specified in Section 3.7.1. The overload power capacity may not be used to meet the static power requirements during emergency power operation; it shall, however, be provided for the duration of one hour for the performance certification.

(2) The quantity of injected fuel shall be limited such that the specified overload power capacity cannot be exceeded.

3.7.3 Continuous Operating Time of the Diesel Engine

The continuous operating time of the diesel engine and of the components relevant to engine function authorized by the manufacturer shall amount to at least 500 hours.

3.7.4 Minimal Permissible Power of the Diesel Engine

The load shall basically not fall below the manufacturer's specified minimum permissible power in accordance with Table 4-1 for prolonged periods.

Note:

In the event of temporary reduction below the specified level, the manufacturer's specifications are taken into account.

3.7.5 Overspeed Resistance of the Diesel Engine

The diesel engine including coupling shall be designed in such a way that the speed $n_{d,0}$ specified in **Table 3-2** No. 1.3 may be exceeded for a short time following the response of the overspeed limiting device.

3.7.6 Starter System of the Diesel Engine

(1) On diesel engines, pressurized air starters using compressed air acting on the pistons or a pneumatic starter on the flywheel shall basically be used.

(2) In the case of electrical starters equipped with individual, train-oriented starter batteries, all instrumentation and control devices fed by these batteries and used during the starting procedure, e.g. the controls, shall be power regulated to account for the voltage drop during the starting procedure.

(3) The electrical actuation controls of the starter system shall close automatically following successful startup (i.e., ignition speed is exceeded). In case of an unsuccessful startup, the starter system shall be shut down after a specified time limit such that, with regard to the alarm limit-value of low-pressure in the compressed air supply system (see Section 3.9.2) or of low-voltage of the starter batteries, a sufficient energy supply remains for two successful starting procedures.

(4) The permissible duty cycle of the electrical and mechanical components of the starter system shall be at least three times longer than the duration up to time-limited shutoff.

(5) The starter system shall, in addition to the electrical actuation controls, be equipped with a manual actuation device. The manual device shall not prevent an electrical actuation.

(6) The requirements regarding the corrosion resistance of the charge-air supply system specified in Section 3.9.2 shall also apply to the air-pressurized components of the starter system.

3.7.7 Conditions for and Facilitation of Startup

(1) To ensure proper run-up and to provide for an immediate power loading, the following measures shall be taken already to be effective during standstill of the diesel engine:

- a) preheating of the cooling water and the lubricating oil up to the specified minimum values,
- b) automatic temperature control of the preheating of cooling water,
- c) uniform warm-up by means of a circulation pump,

3.7.8 Diesel Engine Fuel System

(1) The diesel engine fuel system shall be installed or shielded such that leakages are prevented from coming into contact with components having surface temperatures above 220 °C. The high-pressure fuel lines shall be double-walled with leakage drain and detection or shall be provided with an equivalent shielding.

(2) Cutting ring screw connections in pressure-containing fuel lines are not permissible. Only metallic seals shall be used for connections in fuel injection lines.

(3) The autofrettage of high pressure lines shall be provided.

(4) All fuel lines shall be installed and fastened such that no damage can be caused by vibrations.

(5) Fuel booster pumps upstream of the injection pump shall normally be mechanically driven by the diesel engine.

(6) Filters shall be provided between operating fuel tank and injection pump. It shall be possible to clean the filters without shutting down the diesel-generator unit.

3.7.9 Lubricating Oil System

(1) The oil reservoir of the diesel engine shall be sufficient to ensure autonomous operation for at least 10 hours without falling below the minimum level.

(2) Checking and replenishing the oil supply as well as sampling shall be possible during operation of the diesel-generator unit.

(3) The lubricating oil system of the diesel engine shall be installed or shielded such that leakages are prevented from coming into contact with components having surface temperatures above 220 °C.

(4) The lubricating oil system of the diesel engine shall be provided with a filter system. The filter system shall be designed such, that a cleaning will not become necessary within the time specified for continuous operation, or that it can be carried out without shutting down the diesel-generator unit. Any filter fouling shall be displayed (cf. Appendix A No. 4.3).

(5) The working pressure of controllers, which are required during the run-up process, shall be provided.

(6) Only such pre-lubrication equipment shall be used, that can cause no damage through over-lubrication.

3.7.10 Cooling System of the Diesel Engine

(1) An internal and an external cooling circuit shall be provided to cool the diesel engine. The internal cooling circuit of

pre-charged diesel engines (charge-air compression) may consist of two separate circuits (engine circuit and charge-air circuit). The external circuit may be cooled by a liquid coolant or by atmospheric air.

(2) The design of the heat exchanger shall be based on the most unfavorable values of temperature, pressure, and coolant flow rate in the external circuit. A safety margin of at least 10 % shall be applied to the analytically required capacity of the heat exchanger, taking the most unfavorable conditions into account. If fouling of the outer coolant circuit cannot be precluded, an additional margin of safety shall be applied on the capacity of the heat exchanger. For all circuits, the thermal characteristics of the used coolant shall be taken into account.

(3) The coolant in the internal circuit shall comply with the regulations of the engine manufacturer and shall be compatible with the materials used in the cooling circuit. A possibility of sampling shall be available to ensure the coolant quality.

(4) It shall be ensured that, following a failure-related shutdown of the diesel engine from the full-power-load condition, a subsequently performed renewed startup is not prevented by the shutdown limit value of the coolant temperature. This requirement does not apply in the case that this coolant temperature limit value is the cause of the failure-related shutdown of the diesel engine.

(5) In case of failure of the temperature control system, a manually controlled emergency operation of the diesel engine shall normally be possible.

(6) The alarm limit value in accordance with line no. 5.5 in Appendix A shall be chosen so that a period of at least 30 minutes is available for taking the necessary manual measures before the coolant preheating temperature specified by line 26 in **Table 4.1** is reached.

3.7.11 Crankcase Ventilation and Crankcase Overpressure Protection

Note:

Requirements for the design of safety devices are specified in the Guide Lines of Germanischer Lloyd.

(1) The crankcase ventilation shall be designed such that contaminants are prevented from entering the crankcase.

(2) In the case of diesel engines with a cylinder diameter larger than or equal to 200 mm or with a crank case volume larger than or equal to 0.6 m³, safety devices against overpressure in the crankcase shall be installed.

3.8 Requirements for the Generator

(1) The rated power of the generator shall be equal to at least the sum of the apparent power requirement specified in Section 3.2.3 plus the safety margin in Section 3.2.4.

(2) The generator and its excitation system shall be designed such that the static and dynamic tolerances as specified in Sections 3.2.5 and 3.3.2 are not exceeded at rated power. The overload power capacity shall be equal to at least that of the diesel engine as specified in Section 3.7.2. The maximum possible power load unbalance shall be taken into account.

(3) Magnitude and duration of the continuous short-circuit current shall enable a selective triggering of the protective devices associated with the connected emergency power facilities. The reactances shall be chosen such that the permissible dynamic voltage changes specified in **Table 3-2** are not exceeded in the case of power load changes.

3.9 Requirements for Auxiliary Systems

3.9.1 Superordinate Requirements

(1) The reliability of auxiliary systems whose function is required for the designed start and operation of the diesel engine

or the generator and the reliability of the diesel engine or the generator shall match. For the design of these auxiliary systems, the following shall be considered:

- The auxiliary systems are subject to the same safety-related requirements as the diesel engine and the generator itself.
- The quality of the components in auxiliary systems shall be at least equal to the quality of the diesel engine and the generator.

Note:

Quality requirements are specified in KTA 1401.

(2) The design and construction shall provide for maintenance measures.

3.9.2 Supply of Energy for Start

3.9.2.1 Start Compressed Air Supply

(1) Each train of the emergency power generating facility shall be allocated to an individual compressed air supply tank and an individual compressed air supply system.

(2) The air pressure upstream of the main starter valve shall be continuously monitored and shall lead to an alarm when it falls below the limit value for automatic triggering of the compressed air supply system.

(3) Under consideration of the alarm limit value in para. 2, the charge-air supply of each diesel-generator unit shall be dimensioned such, that six consecutive automatic startup procedures would be possible. Furthermore, the dimensioning requirement as specified in Section 3.7.6 para. 5 shall be adhered to. In the case that compressed air tanks are connected in parallel, check valves shall be installed in the feed and discharge lines of each tank.

(4) If compressed air from the compressed air supply is needed for other tasks (e.g. for pneumatic controls), this shall be taken into account in the design of the compressed air generating system.

(5) The capacity of the compressed air supply system shall be dimensioned such that after six startup operations indicated under para. 3, re-filling at a nominal pressure in about 45 min is possible. The air compressor shall be switched on and off automatically depending on the pressure in the tanks. Possible isolation devices between the tanks and the starter valve shall be monitored or mechanically interlocked in the open position.

(6) It shall be possible to replenish the compressed air supply independently of the individual train.

(7) The compressed air supply system shall be designed in accordance with the following requirements:

- The air-pressurized components of the compressed air supply system shall be manufactured from corrosion-resistant materials.
- The properties of the compressed air provided by the start compressed air supply (e.g. moisture, oil content, freedom from particles etc.) shall meet the specifications for reliable operation of the manufacturer of the diesel engine and of the manufacturer of the components of the start compressed air supply.
- The design of the piping, pipe connections, and pipe carrier shall also take into account the operational vibration loads caused by the compressor.
- Water drains shall be provided at the lowest points of the pipes and of the charge-air tanks.
- The compressed air system shall be protected in such a way that the pressure does not exceed the design pressure.

3.9.2.1 Electrical Start-Energy-Supply

(1) The starter battery capacity per diesel generator shall be designed in such way, that six sequenced automatic successful starting procedures are possible.

(2) Design, suitability, and testing shall be coordinated plant-specifically with the experts after 11 (3).

3.9.3 Fuel and Lubricating Oil Supply System

(1) The fuel shall be stored in an individual storage tank for each train of the emergency power generating facility from which it shall be pumped to the corresponding operating fuel tank.

(2) A leakage indicator shall be installed in the case of a double-walled fuel tank or of a single-walled fuel tank with collecting sump.

(3) It shall be possible to drain the water from the lowest point of each tank by suction from the top. Fuel extraction lines shall be installed at a sufficient height above the tank base.

(4) The operating fuel tank allocated to each train of the emergency power generating facility shall be installed at a point higher than the fuel booster pump on the diesel engine. An overflow to the storage tank shall be provided. The operating fuel tank shall be dimensioned such that the lowest permissible fuel level is sufficient for two hours of full-power-load operation.

(5) If the fuel level falls below the minimum value, an alarm shall be initiated (cf. Appendix A No. 3.5).

(6) The fuel storage tank and the operating fuel tank shall be dimensioned such that enough fuel can be stored for a 72 hour long operation of the emergency power generating facilities.

(7) The fuel required for a 24 hour long operation of an emergency power generating facility shall be stored individually for each train. The fuel required for an additional 48 hour long operation of all emergency power generating facilities may be stored on the site of the nuclear power plant.

(8) If individual diesel generator units are allocated to process-technological subsystems that fulfill their function in a shorter period of time, a fuel inventory for this shorter time period is sufficient.

(9) If the fuel inventory falls below the required quantity, an alarm shall be initiated (cf. Appendix A No. 3.3).

(10) The fuel supply system between fuel storage tank and operating tank shall ensure that the operating tank is refilled automatically. For this purpose, two switchable fuel-supply pumps and filters shall be installed.

(11) The fuel pump for refilling the operating tank shall be designed for a capacity of at least 110 % of the fuel consumption at overload power capacity. Self-charging pumps shall be installed; these shall normally pump continuously during operation of the diesel engine.

(12) The fuel supply from the operating tank to the diesel engine shall be designed in such a way that the diesel engine shall be safely supplied with fuel without the need for any auxiliary equipment and accidental draining of the fuel line and the operating tank is prevented. Connections in the fuel lines shall basically be welded or provided with welded flanges.

(13) The lubricating oil for the diesel-generator units shall be stored in sufficient quantity to correspond to the stored amount of the diesel fuel, regarding storage areas and storage depletion periods.

3.9.4 Air Supply System, Air Intake and Gas Exhaust Systems

(1) In specifying the necessary air supply for each train of the emergency power generating facility, the combustion air required for the diesel engine and the cooling air required for the diesel-generator units shall be taken into account. The design of the air supply system shall be based on the most unfavorable values of the air temperature at the installation site.

(2) Air intake and gas exhaust systems shall be designed such that mutual influences are prevented, in particular, an

air-side short circuit. Each diesel engine shall be provided with a separate gas exhaust line.

(3) Air intake, ventilation and heating systems shall be designed such that the required startup and operating temperature conditions for the diesel-generator unit and its auxiliary systems are not exceeded at the most unfavorable ambient temperatures.

(4) The safety function of those dampers that must open up to supply the combustion air shall be ensured and monitored.

(5) The air intake line of the diesel engine shall be provided with air filters.

(6) Gas exhaust lines shall be insulated and encased such that the surface temperature does not exceed 200 °C. It shall be ensured that neither fuel nor lubricating oil can penetrate into the insulation.

(7) Neither the gas exhaust lines nor the turbocharger shall be exposed to impermissible loads due to constrained thermal expansion.

3.9.5 External Cooling Circuit

(1) The design shall be based on the most unfavorable values for temperature, pressure, and throughput of the cooling medium.

(2) The materials of the components of the external coolant circuits shall be matched to the characteristics of the cooling media and cooling media flow rate in such a way that impermissible corrosion and deposits will not occur.

3.9.6 Energy Supply for Instrumentation, Control and Electrical Equipment

(1) The instrumentation, control and electrical equipment required during startup of the diesel-generator unit shall be supplied by the direct current power facility for reasons of reliability.

(2) The power required for the instrumentation, control and electrical systems shall be supplied from the associated individual train. If required for reasons of reliability, an additional possibility for supplying power shall be provided.

(3) Cables and pipes in the vicinity of the emergency power generating facilities shall be designed or protected such that they will withstand the actual power loading (e.g., from fuel, oil, temperatures, and vibrations).

(4) The main cable ways shall be routed away from heated pipe lines as well as from pipe lines with combustible media.

3.10 Diesel Generator Unit

The design of the diesel generator unit shall depend on the load arising from the operation of the diesel engine, the overload power capacity of the diesel engine, the load from the generator, the torsional vibration calculation and the external loads. In addition, a superposed load according to Table 3-3 shall be taken into account.

3.11 Local Control Station

(1) Each emergency power generating facility shall be provided with an individual control station.

(2) The constructional planning and design of the control station shall meet the following requirements:

a) The control station shall be located in a separate room near the diesel-generator unit; the sound level at the control station shall not exceed 80 dB (A).

b) The control station shall be accessible other than from the turbine room. The turbine room shall be observable from the control station.

Note:

Further requirements on the local control station are regulated in KTA 3904.

Superposition of Loads ¹⁾											
Line No.	Loads										Verification of (F → I → S) ²⁾
	Dead Load	Mains Parallel Operation	Isolated Operation	2-Phase Short Circuit	3-Phase Short Circuit	Faulty Synchronization	Ignition Failure at Nominal Power	Design Basis Earthquake (DBE)	Explosion Pressure Wave (EPW)	Aircraft Crash (AC)	
1	X	X	-	-	-	-	-	-	-	-	F
2	X	-	X	-	-	-	-	-	-	-	F
3	X	-	X	X	-	-	-	-	-	-	F
4	X	-	X	-	X	-	-	-	-	-	F
5	X	X	-	-	-	X	-	-	-	-	S
6	X	X	-	-	-	-	X	-	-	-	F
7	X	-	X	-	-	-	-	X	-	-	F
³⁾ 8	X	-	-	-	-	-	-	-	X	-	F ⁴⁾
³⁾ 9	X	-	-	-	-	-	-	-	-	X	F ⁴⁾
¹⁾ if necessary, additional plant-specific loads and their superpositions shall be complemented ²⁾ Function (F) contain Integrity (I) and Stability (S), Integrity (I) contains Stability (S) ³⁾ applied if required by the design concept of the system ⁴⁾ Verification of Function (F) after the event, if required by the design concept of the facility											

Table 3-3: Combinations of the load cases as specified by their design

3.12 Instrumentation and Control Systems

3.12.1 Functional Requirements

(1) The instrumentation and control systems for startup, run-up, operation, protection, monitoring, shutdown and test run of an emergency power generating facility shall correspond to the train allocation and shall be included in the protection measures against failure inducing events, which were specified for the emergency power generating facility itself.

(2) The instrumentation and control systems of each individual train of the emergency power generating facility shall normally be combined in one local control station.

(3) Partial controls shall normally be provided for partial tasks. These are, e.g., the coast-down and shutdown of the diesel-generator unit, the automatic parallel grid connection to the station service power grid during test runs or associated reconnection, the preheating, pre-lubrication and charge-air production.

(4) In the case of required operation, run-up procedures and enabling the connection of power loads shall be effected automatically. During subsequent operation of the emergency power generating facility, manual actions shall not be required for at least 30 minutes. In the case that control and mitigation of design basis accidents requires a longer than 30 minutes operation of the safety system without manual actions, this shall also apply to the associated emergency power generating facility.

Note:

In the case of emergency power generating facilities in emergency systems, this period of time may, e.g., amount to 10 hours.

(5) If, in view of the process-technological tasks and the supplied power loads, the emergency power generating facilities are only required to function after a time period that is more than one hour after failure of the station service facility, the emergency power generating facilities shall normally be started and loaded by manual actions instead of the automatic triggering of the starter.

Note:

In the case that the function of emergency power generating facilities is required only towards the end of the battery discharge time, this time period may amount to, e.g., two hours.

3.12.2 Initiation and Termination of Emergency Power Operation

(1) Emergency power operation shall be initiated whenever the power supply from the station service facility fails or is outside of the permissible tolerances for voltage and frequency specified for the emergency power loads.

(2) The function of the power supply from the station service facility shall be detected at every emergency diesel generator bus by monitoring the voltage and, as a second triggering criterion, by monitoring the frequency. The signal shall normally be formed by a 2-out-of-3 circuit.

(3) The initiating limit value from a voltage drop shall be specified in accordance with the design of the plant; however, it shall normally be specified not lower than 80 % of the rated motor voltage at the diesel-generator bus.



(4) The initiation limit value from a frequency drop shall be specified in accordance with the design of the plant; however, it shall normally be specified not lower than 47.2 Hz.

(5) Under consideration of the permissible power load acceptance times, the triggering startup signal shall be delayed in such a way that short-term limit value stimulation can be bridged by voltage and frequency variations in the auxiliary system. The startup signal shall be stored for long enough to allow the switching commands for startup and the power loading program to be carried out.

(6) Following the run-up of the emergency power generating facility, the power loads shall be attached such that sequence and intervals of the power load steps are adhered to as specified in Section 3.3.1.

(7) The run-up and power load-attaching program shall ensure that the requirements regarding testability as specified in Section 3.12 can be met.

(8) The startup, operation, and shutdown of the emergency power generating facility shall be possible by manual actions from the local control station.

(9) It shall be possible to manually initiate the switch-back from the emergency power generating facility to the station service facility. The parallel grid connection of the emergency power generating facility to the station service facility and the coastdown of the diesel engine shall normally be done automatically.

(10) After shutting-down, the emergency power generating facility shall be available again immediately in case of a renewed failure of the station service facility.

3.12.3 Monitoring

(1) Monitoring devices shall be provided and coordinated with the design of the emergency power generating facility such that displays and hazard alarms will indicate operational availability, operational state and the exceeding of any limit values.

(2) The monitoring devices shall be arranged according to the requirements of operation, servicing and repair and shall normally be subdivided locally into:

- a) displays at the site of the emergency power generating facility,
- b) displays and hazard alarms at the local control station,
- c) displays and collective alarms in the control room.

(3) A voltage drop at the diesel-generator bus down to below 95 % of the rated motor voltage shall initiate a time-delayed alarm.

(4) If immersion sleeves are used for temperature sensors, they shall be permanently installed.

(5) A clear arrangement of the displays and alarms shall allow for a differentiated determination of individual values at the local control station. The condition and fault related alarms transmitted to the control room shall normally be grouped together for each train.

(6) The group alarms transmitted to the control room shall be designed as Class I alarms. The individual hazard alarms transmitted to the local control station shall be designed as Class II alarms, provided, their origin can be localized.

Notes:

- (1) Appendix A shows the required displays and alarms of an emergency power generating facility with standby diesel generator unit.
- (2) Requirements regarding the design of the alarm devices are specified in safety standard KTA 3501.

3.12.4 Protection

(1) Faults which may lead to damages the emergency power generating facility shall be detected by the mechanical-equipment protection or the electrical protective devices and shall initiate any necessary shutdown.

Notes:

- (1) Appendix A shows the required displays and alarms of an emergency power generating facility with standby diesel-generator unit.
- (2) In addition to the protective shutdowns listed in Annex A, plant-specific protective shutdowns may be required according to KTA 3501.
- (2) The protective devices initiating shutdown (S and S_v as listed in Appendix A column 6) shall be designed in such a way that reliable triggering is ensured and any erroneous response avoided.
- (3) It shall be possible to test the protective devices initiating shutdown.
- (4) All protective devices shall normally be effective during a test run of an emergency power generating facility.
- (5) In case of a required operation of the emergency power generating facility, only the high-priority protective devices (S_v as listed in Appendix A column 6) shall remain effective. The response of the protective devices shall be displayed, even if they are not triggered due to the higher priority of a signal from the reactor protection system.
- (6) A single fault of the priority protection devices (S_v) shall not lead to an erroneous initiation or failure of the respective protection criterion (e.g. oil pressure <min). The priority protection devices shall be multi-channelled (e.g. 2-out-of-3 circuit). The high reliability of each individual protection channel shall be ensured by taking appropriate measures such as sufficient redundancy and self-monitoring or "fail-safe" behavior.

Notes:

- (1) Appendix B shows examples for the mechanical equipment protection of the diesel engine.
- (2) Appendix C shows examples for the mechanical equipment protection of the generator.
- (7) A single-channel design of the high-priority protective devices with current transformers or mechanically actuated components of tachometers is permitted, if their certified satisfactory service life is demonstrated.
- (8) In designing the protective devices, the following shall be considered as far as the interaction between the electrical protection of the emergency power generating facility and the protection of the emergency power facility and station service facility is concerned:
 - a) The selectivity of the emergency power facility protection shall be ensured both during insular operation and parallel net operation (during test runs).
 - b) In the case of parallel net operation (during test runs), the protective devices shall normally operate such that the emergency power facility is continually supplied either from the station service facility or from the emergency power generating facility. Thus, it shall normally be such that during parallel net operation either the reverse power protection (upon shutdown of the diesel engine) initiates opening of the generator circuit breaker, or the overcurrent protection (upon failure of the station service facility) opens the bus couplers to the station service facility sequentially in advance of the generator circuit breaker.

3.13 Testability

(1) The functional capability of the diesel facility shall be testable even during operation of the nuclear power plant.

(2) The sensors of the instrumentation and control equipment shall normally be easily accessible and shall be testable without having to be disassembled.

(3) In order to achieve a sufficient power loading of each emergency power generating facility, a synchronization possibility with an automatic parallel switching device shall normally be installed.

(4) A possible failure of the station service facility during a function test run shall not prevent continued operation of the emergency power generating facility.

(5) As far as the extent, sequence and boundary conditions are concerned, the periodic in-service inspections shall normally largely correspond to the requirements in case of an accident-related failure of the supply from the station service facility. A complete testing of the signal path shall be possible by disconnecting the bus coupler between station service bus and diesel-generator bus.

(6) With respect to recording and evaluation of the inspection sequence, at least the power, voltage, and frequency shall normally be determined for the emergency power generating facility. The execution of the commands issued by the startup and power loading program as well as their chronological sequence shall be recorded automatically.

1	2	3	4	5
Line No.	Characteristic Value (relative to the nominal value)	Formulaic Symbol	Unit	Value
1	adjustment range of idle speed (in percent of nominal speed)	—	%	+ 2.5 to - (2.5 + δ_s)
2	Static speed adjustment (P-degree)	δ_s	%	0 to 5
3	Static width of frequency variation	β_f	%	± 1
4	Voltage control range ¹⁾	ΔU_S	%	+ 5 to - 5
5	Voltage accuracy	σ_G	%	± 2.5
¹⁾ For the emergency operation, a fixed adjustment is permitted if it can be load-related proven in practical tests.				

Table 3-1: Static tolerances

1	2	3	4	5
Line No.	Characteristic Value (characteristic percentage values are relative to the nominal values)	Formulaic Symbol	Unit	Value
1	Dynamic Speed Deviation			
1.1	maximum transient frequency increase	$f_{d,max}$	%	<15
1.2	maximum transient frequency drop (frequency undershoot)	$f_{d,min}$	%	≤ 10
1.3	Triggering speed of the overspeed protection device	$n_{d,0}$	min^{-1}	$\leq 1.2 n_N$
2	Frequency Adjustment Time			
2.1	Release of maximum load level	t_{nE}	s	≤ 2
2.2	Application of maximum load level	t_{nB}	s	≤ 2
2.3	Frequency tolerance band (according to P-degree of the speed governor)	α_n	%	± 5
3	Dynamic Voltage Variation at the Generator Terminals (under consideration of startup currents of asynchronous motors, however without transient direct current elements)			
3.1	Transient voltage deviation during power level decrease (+)	σ_{DE}	%	≤ 20
3.2	Transient voltage deviation during power level increase (-)	σ_{DB}	%	≤ 15
4	Voltage Adjustment Time			
4.1	Removal of relevant load stage	t_{UE}	%	60 ¹⁾
4.2	Application of relevant load stage	t_{UB}	%	60 ¹⁾
¹⁾ Within 60% of the time interval between two successive load stages				

Table 3-2: Dynamic tolerances