Safety Standards

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Nuclear Safety Standards Commission (KTA)

KTA 3702 (06/2000)

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

(Notstromerzeugungsanlagen mit Dieselaggregaten in Kernkraftwerken)

This safety standard was previously issued in two parts, 06/80 and 06/91

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

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KTA SAFETY STANDARD

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Comments by the editor:

Taking into account the meaning and usage of auxiliary verbs in the German language, in this translation the following agreements are effective:

shall	indicates a mandatory requirement,
shall basically	is used in the case of mandatory requirements to which specific exceptions (and only those!) are permitted. It is a requirement of the KTA that these exceptions - other than those in the case of **shall normally** - are specified in the text of the safety standard,
shall normally	indicates a requirement to which exceptions are allowed. However, exceptions used shall be substantiated during the licensing procedure,
shall normally	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, 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) are applied, provided, no other requirements are superposed due to the specifics of the nuclear power plant.

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

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

1 Scope

This safety standard applies to 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 permissible 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) Individual diesel-generator unit

An individual diesel-generator unit is a power generating unit consisting of a diesel engine and a generator.

(5) Operating fuel tank

An operating fuel tank is the tank allocated to the individual diesel engine and installed between diesel engine and fuel storage tank.

(6) Fuel storage tank

A fuel storage tank is a tank designed for the storage of fuel on the power plant site.

3 Design

3.1 General Requirements

(1) Design and installation of all parts of the emergency power generating facility shall normally be such that proper maintenance and short repair times are possible. Unambiguous instructions shall be provided for operation, servicing and repair. The instructions of the manufacturers shall be taken into consideration.

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

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

3.2 Power Balance and Static Tolerances

3.2.1 General Requirements

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

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:

a) motoric power loads,

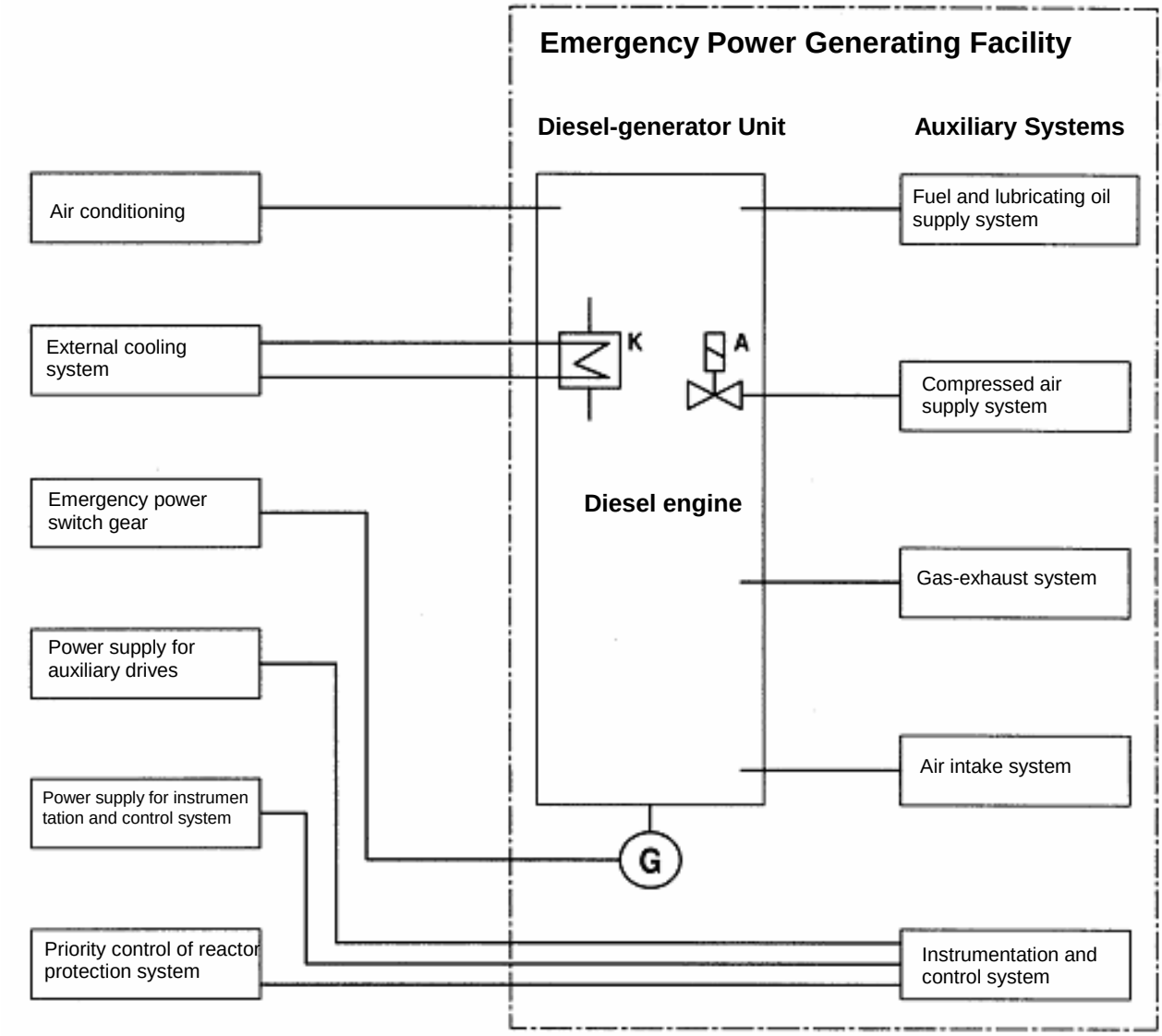
b) non-motoric power loads (e.g., rectifiers, heating systems, lighting systems),

c) non-uniform distribution of the power load to the individual trains,

d) switchable power loads and buses,

e) electrical transmission losses,

generator losses (degree of efficiency).



A : main startup valve
K : heat exchangers for water, charge air, oil
G : generator

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

(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 under 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 building 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

a) 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 under Section 3.3.2 are not exceeded under consideration of the transients 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 under 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 shall not exceed the vibrational fatigue resistance of the generator. When designing the diesel-generator unit, an agreement shall be reached between manufacturers of the diesel engine and the generator regarding the generator design or the additional measures regarding vibration isolation.

(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 under 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 an individual 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 under Sections 3.6.2, 3.6.3 and 3.6.4.

(2) In the case of indications regarding overstressing of components, wrong choice of materials or common mode failures, it shall be demonstrated that the failure cause has been removed.

3.6.2 Suitability of the Diesel Engine

(1) Only such diesel engines the suitability of which 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) A diesel engine may be assumed as being suitable if

a) a satisfactory service life is demonstrated by 15 identically designed diesel engines for a total of 7500 operating hours where two of the diesel engines shall account for at least 2000 operating hours each

and

b) a type test on this diesel engine type was successfully carried out in a test run over approximately 100 hours at the corresponding cylinder performance, this type test having been performed in accordance with one of the following regulations

ba) Germanischer Lloyd: GL 90 or

bb) International Railroad Association (Union International de Chemin de Fer) UIA-Code 623-2 VE or

bc) a type test of diesel engines as specified under Appendix D.

(3) Even if it cannot be shown that the requirements above are met, a diesel engine may yet be used, provided,

a) the satisfactory service life of the diesel engine line is demonstrated by 15 diesel engines for a total of 7500 operating hours where two diesel engines shall account for at least 2000 operating hours each,

and

b) a type test as specified under Appendix D was successfully performed on the diesel engines in the presence of an authorized expert (under Sec. 20 Atomic Energy Act).

(4) 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.

(5) 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.

(6) 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.

(7) 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.

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

(5) 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 and the Instrumentation and Control Systems

(1) The suitability of the auxiliary systems and the instrumentation and control 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 events) and these safety features are covered neither by type tests nor by the certified satisfactory service life, special suitability tests shall be performed.

3.7 Diesel Engine Requirements

3.7.1 Rated Continuous Power of the Diesel Engine

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

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 under Section 3.3.2 under consideration of the power load steps and power load acceptance times as specified under 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 and testing procedures.

(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 shall amount to at least 500 hours.

3.7.4 Coupling between Diesel Engine and Generator

The design of the coupling shall be in accordance with the stresses resulting from the overload power capacity of the diesel engine, from the short-circuit moment of the generator and the torsional vibrations from the analysis as specified under Section 3.4.

3.7.5 Overspeed Resistance of the Diesel Engine

The diesel engine including coupling shall be designed such 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) In the case of diesel engines with a rated continuous power larger than or equal to 800 kW, pressurized air starters with the compressed air acting on the pistons shall normally be used for reasons of reliability.

(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 permissible duty cycle of the electrical and mechanical components of the starter system shall at least be larger than three times the maximum startup time.

(4) 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.

(5) 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 charge-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.

(6) The requirements regarding corrosion resistance to be applied to the charge-air supply system specified under Section 3.9.2. shall also apply to the air-pressurized components of the starter system of the diesel engine up to the cylinder head.

3.7.7 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 cooling water,
c) uniform warm-up by means of a circulation pump,
d) provision of the working pressure for the regulators necessary during the run-up procedure.

(2) Only those pre-lubrication devices shall be used that cannot cause any damage from excessive lubrication.

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

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

(5) 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 supply in the oil pan of the diesel engine or in an associated lubricating oil tank shall be sufficient to ensure

operation of at least 10 hours without falling below the minimum level.

(2) Checking and replenishing the oil supply 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).

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 (motor 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.

(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. It shall be possible to monitor the coolant quality by the taking of samples.

(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.

3.7.11 Crankcase Ventilation and Crankcase Overpressure Protection

N o t e :
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 m^3, 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 under Section 3.2.3 plus the safety margin under Section 3.2.4.

(2) The generator and its excitation system shall be designed such that the static and dynamic tolerances as specified under 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 under 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) All auxiliary systems not attached to the diesel engine or to the generator which, however, are required for their proper function or for the supply of auxiliary media, are subject to the same safety requirements that apply to the diesel-generator unit, in particular with regard to the redundant train allocation and to the protection measures taken against failure inducing events within the nuclear power plant and against external events.

(2) The design, manufacture, assembly, commissioning and inspection of those auxiliary system components which, in case of their failure, would reduce the functional capability of the diesel-generator unit shall be subject to the same aspects of high-reliability and shall be subject to the same measures ensuring high quality that apply to the diesel-generator unit itself.

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

3.9.2 Charge-Air Supply System

(1) Each train of the emergency power generating facility shall be allocated to an individual charge-air supply tank and an individual charge-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 charge-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 under Section 3.7.6 para. 5 shall be adhered to. In the case that charge-air tanks are connected in parallel, check valves shall be installed in the feed and discharge lines of each tank.

(4) The capacity of the air-charge supply system shall be dimensioned such that rated pressure is reestablished within 45 minutes after the six startup procedures indicated under para. 3. 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.

(5) It shall be possible to replenish the charge-air supply independently of the individual train.

(6) The charge-air supply system shall be designed in accordance with the following requirements:

a) In the case that temperature fluctuations can lead to temperatures below the dew point, the components of the

charge-air supply system shall be manufactured from corrosion-resistant materials.

b) In the case that corrosion-resistant coatings (e.g. for tanks) are used to prevent corrosion, a demonstration of their suitability is required. It shall be ensured that no corrosion products from the compressor reach the tanks.

c) The piping and pipe connections shall be designed taking the possible vibrational stresses into account.

d) Water drains shall be provided at the lowest points of the pipes and of the charge-air tanks.

e) The charge-air supply system shall be protected such that the pressure does not exceed the design pressure.

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. A filter shall be installed upstream of the operating tank.

(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) Connections in the fuel lines shall be welded or provided with welded flanges. The fuel line between operating fuel tank and diesel engine shall routed with a falling gradient.

(13) The of 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 position of those dampers that must open up to supply the combustion air shall be monitored.

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

(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 may experience additional loading from constrained thermal expansion.

3.9.5 External Cooling Circuit

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

(2) The materials of the components of the external coolant circuits shall be coordinated with the quality and flow rate of the coolant such that impermissible corrosion and deposits will not occur.

(3) The external cooling circuits shall be designed such that maintenance measures can be performed.

3.9.6 Energy Supply for Instrumentation and Control Equipment and for Electrical Auxiliary Drives

(1) The instrumentation and control equipment as well the auxiliary drives required during startup of the diesel-generator unit shall be supplied by a non-interruptible emergency power facility.

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

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

(2) The planning and design of the emergency power generating facilities shall meet the following requirements:

a) The emergency power generating facility shall be designed such that maintenance measures can be performed.

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

c) The room of the control station shall normally be accessible other than from the turbine room.

3.11 Instrumentation and Control Systems

3.11.1 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 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 minute operation of the safety system without manual actions, this shall also apply to the associated emergency power generating facility.

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

(5) In the case that, in view of the process-technological tasks and the supplied power loads, the emergency power generating facilities are required to function only after a time period longer than one hour after failure of the station service facility, the automatic triggering of the starter may be replaced exclusively by manual actions.

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

3.11.2 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) A failure of the power supply from the station service facility shall be detected at every 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 startup signal shall be delayed such that operational voltage drops within the station service facility are bridged. The startup signal shall be stored for a sufficient duration to allow the switching commands 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 under Section 3.3.1.

(7) The run-up and power load-attaching program shall ensure that the requirements regarding testability as specified under 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 coast-down of the diesel engine shall normally be effected automatically.

(10) In all shutting-down phases, the emergency power generating facility shall remain available in case of a renewed failure of the station service facility.

3.11.3 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 as follows:

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 in a time-delayed alarm.

(4) The temperature sensors shall only be installed in stationary immersion shells.

(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:
Appendix A shows the required displays and alarms of an emergency power generating facility with standby diesel generator unit and a rated continuous power larger than 800 kW.

If diesel generator units with a rated continuous power smaller than or equal to 800 kW are used, it may be permissible to reduce the extent of the instrumentation.

Requirements regarding the design of the hazard alarm devices are specified in safety standard KTA 3501.

3.11.4 Protection

(1) Faults which may lead to damages in the vicinity of 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:
Appendix A shows the required displays and alarms of an emergency power generating facility with standby diesel-generator unit and a rated continuous power larger than 800 kW.

If diesel generator units with a rated continuous power rating smaller than or equal to 800 kW are used, it may be permissible to reduce the extent of the instrumentation.

(2) The protective devices initiating shutdown (S and S_V as listed in Appendix A column 6) shall be designed such that a 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) The high-priority protective devices shall be designed such that erroneous triggering is avoided with a high reliability. Thus, the trigger signals shall normally be formed by a 2-out-of-2 or a 2-out-of-3 circuit.

Notes:
Appendix B shows examples for the mechanical equipment protection of the diesel engine.
Appendix C shows examples for the mechanical equipment protection of the generator.

(7) A non-redundant design of the high-priority protective devices is permissible, provided, it is demonstrated that their failure is improbable to such degree that an erroneous shutdown of the emergency power generating facility due to their failure does not have to be considered.

Note:
This may apply, e.g., to current transformers or to mechanically actuated components of tachometers.

(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 shall be ensured both during insular operation as during 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.

3.12 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 inservice 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
No.	***Characteristic Value*** *(relative to the nominal value)*	***Formulaic Symbol***	***Unit***	***Value***
1	Range of speed adjustment (relative to nominal speed)	–	%	+ 2.5 to - (2.5 + δ_s)
2	Static speed adjustment (P-degree)	δ_s	%	4 to 5
3	Static width of frequency variation	β_f	%	± 1
4	Voltage control range	ΔU_S	%	+ 5 to - 5
5	Voltage accuracy	σ_G	%	± 2.5

Table 3-1: Static tolerances

1	2	3	4	5
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 decrease (frequency undershoot)	$f_{d,min}$	%	≤ 10
1.3	Triggering speed of the overspeed protection equipment	$n_{d,0}$	min^{-1}	≤ 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	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	Release of maximum load level	t_{UE}	s	≤ 1
4.2	Application of maximum load level	t_{UB}	s	≤ 1

Table 3-2: Dynamic tolerances

4 Documents to be Submitted for the Suitability Tests, Type Tests and Production Tests

4.1 General Requirements

(1) It shall be shown by documents to be reviewed by authorized experts (under Sec. 20 Atomic Energy Act) that the emergency power generating facilities are designed, fabricated, assembled, serviced, repaired and tested in accordance with the safety-related requirements.

(2) The review comprises the assessment of the documents on the design as specified under Section 4.2, on the component parts and components as specified under Sections 4.3 through 4.7, on the ability to carry out inservice inspections as specified under Section 4.8 and on the tests after repairs as specified under Section 4.9.

4.2 Documents on the Design of the Emergency Power Generating Facilities

Documents shall be submitted showing that the design of the emergency power generating facilities, including their auxiliary systems, is in accordance with the safety-related requirements. These documents shall include:

a) overview circuit diagram showing the circuitry of the emergency power generating facilities within the required electrical power supply of the safety-related power users,

b) description of the required redundancy of the emergency power generating facilities,

c) summary description of the required functional independence and separation, both spatial and with respect to fire protection, of the emergency power generating facilities regarding their design as separate trains that are non-intermeshed and spatially separated or protected from each other,

d) summary description of the required protection of the emergency power generating facilities against failure-initiating events inside the power plant,

e) summary description of the required protection of the emergency power generating facilities against external events, and of the coordination with the protection concept of the emergency-power supplied process-technological systems,

N o t e :
The documents under items a through e are only required to be submitted if they are not already part of the Safety Analysis Report.

f) power balances specifying for each train the individually required emergency power for the accidents to be considered and their chronological sequence. The power chosen for the generator set shall be specified, and the safety margins used shall be substantiated,

g) proof that the design of the emergency power generating facilities is in accordance with most unfavorable ambient conditions at the installation location,

h) specification of the power load attachment time, size, chronological sequence and time interval of the intended

power load steps and description of the coordination with the process-technological requirements,

i) specification of the characteristics regarding speed and voltage values of the emergency power generating facilities within the specified tolerances,

k) demonstration that the emergency power generating facilities will stay functional under consideration of the operation-related vibrations to be anticipated at the installation location and of the internal and external events to be taken into account,

l) assembly drawing of the emergency power generating facilities with its supports and the anchoring connections in the foundation,

m) general arrangement drawings of the buildings that house emergency power generating facilities and component arrangement drawings of the diesel generator units and their auxiliary systems, including the routing of pipes and cables as well as a summary description regarding arrangement and installation,

n) documents for operation, servicing and repairs.

o) The fire protection measures as well as the precautionary measures against human errors shall be demonstrated within the scope of the overall concept for the nuclear power plant.

4.3 Documents on the Diesel Engine

It shall be shown that the design of the diesel engine meets the safety-related requirements. This includes:

a) proof that the diesel engine is suited for its installation location and purpose of usage,

b) list of the drawing numbers of the main component parts with which it will be possible to verify that the diesel engine corresponds to the one used in the suitability test,

c) drawings of the engine (assembly drawing), of the torsionally elastic or mechanical clutches at the engine output, and of the base frame,

d) proof that the crankshaft was calculated and designed in accordance with the design requirements of one of the two classification institutions, either Germanischer Lloyd or Lloyd's Register of Shipping. A certificate issued by either of these institutions serves as such proof,

e) list of the technical data of the engine with special regard to the actual usage and intended power performance. The extent is specified in **Table 4-1**,

f) list of the tests and inspections planned for the engine within the scope of the production tests as specified under Section 5.2.

4.4 Documents on the Generator

It shall be shown that the design of the generator meets the safety-related requirements. This includes:

a) proof that the generator is suited for its installation location and purpose of usage,

b) proof that the generator corresponds to the one used in the suitability test,

Note:
A list of the drawing numbers of the main component parts or a systematic overview of the type designations and the serial numbers may, e.g., be used for this purpose.

c) drawings of the generator with its major dimensions, a description of the oil supply to the bearing, and a functional diagram of the excitation system,

d) list of the technical data of the generator with reference to the actual usage and the intended power performance; the extent is specified in **Table 4-2**,

e) proof of the design against damages during standstill in the case that roller bearings are used,

f) list of the tests and inspections planned for the generator within the scope of the tests as specified under Sections 5.3 and 5.4.

4.5 Documents on the Auxiliary Systems

It shall be shown that the design of the auxiliary systems meets the safety-related requirements. This includes:

a) proof that the auxiliary systems and their components are suited for their installation location and purpose of usage. This proof shall normally be submitted as a proof of satisfactory service life under comparable operating conditions and, if required, by supplementary suitability tests as specified under Section 5.5,

b) circuit diagrams with a summary description, indications of the measurement locations and a list of components for the

  ba) compressed-air system,

  bb) fuel system,

  bc) lubricating oil system,

  bd) air intake system and gas exhaust system,

  be) coolant system,

c) analytical proof that the components of the auxiliary systems are designed in accordance with the safety related requirements. These are, essentially:

  ca) dimensioning of the compressed-air supply and the compressed-air generating facility,

  cb) dimensioning of the fuel supply and the lubricating oil supply,

  cc) design of the heat exchangers,

d) drawings of tanks and heat exchangers as well as their anchoring and support structures; isometric views of pipes (larger than NW 80) including expansion joints and supports insofar as these are required for the proof of functional capability in the case of induced vibrations,

e) welding specifications for those components with weld connections directly required for the function of the auxiliary system.

f) list of the components of the auxiliary systems and of the tests planned within the scope of tests as specified under Sections 5.5 and 5.6.

4.6 Documents on the Instrumentation and Control Equipment

It shall be shown that the design of the instrumentation and control equipment meets the safety-related requirements. This includes:

a) summary description of the instrumentation and control equipment,

b) demonstration that the instrumentation and control equipment and their components are suited [for their installation location and purpose of usage],

This demonstration shall normally be submitted as a proof of satisfactory service life under comparable operating conditions and, if required, by supplementary suitability tests as specified under Section 5.7.

c) Function diagrams covering the
   ca) run-up and power loading procedure,
   cb) shut-down procedure,
   cc) monitoring and protective devices including indications regarding the displays,
   cd) alarm signals and protective shutdowns,
   ce) interlocks,
   cf) synchronization,

d) Measurement location data sheets,

e) Allocation list for the local control station,

f) A list of the technical data of the components of the instrumentation and control equipment. This shall normally include data for those components specified which are essential to the implementation of the functions shown in the function diagrams,

   Note:
   Insofar as the instrumentation and control equipment of the emergency power generating facilities is identical to that of other safety-related systems, it is sufficient to provide a reference to the technical data of the components of this instrumentation and control equipment that were submitted within the framework of the overall plant.

g) A list of the tests and inspections planned for the components of the instrumentation and control equipment in accordance with Section 5.8.

4.7 Documents on the Type Tests and Production Tests

Documents as specified under Sections 5.1 through 5.4, 5.6 and 5.8 shall be submitted, e.g., in form of a test list, which shall indicate the type and extent of the type tests and of the production tests, the testers and the participation of authorized experts. These documents require approval by the authorized expert (under Sec. 20 Atomic Energy Act).

4.8 Documents on Tests and Inspections During On-site Assembly, Commissioning and Inservice Inspection

Documents on tests and inspections during on-site assembly as specified under Section 6, during commissioning as specified under Section 7 and during inservice inspection as specified under Section 8 shall be submitted.

4.9 Documents on Tests During Repairs

In the case of a thorough overhaul or in the case of comparable repairs, documents shall be submitted, e.g., in form of a test list which shall indicate the type and extent of the tests ad inspections during repairs, the testers and the participation of authorized experts. These documents requires the approval by the authorized expert (under Sec. 20 Atomic Energy Act).

5 Suitability Tests, Type Tests and Production Tests

The suitability may be proven by showing a successful service life and by a type test performed in accordance with one of the following regulations

a) of Germanischer Lloyd or

b) of the International Railroad Association (Union International de Chemin de Fer) or

c) as specified under Section 5.1.

5.1 Type Test of the Diesel Engine

(1) The type test shall be performed in accordance with the requirements as specified in Appendix D or under Section 3.6.2 para. 5.

(2) The type test shall be carried out in the presence of an authorized expert (under Sec. 20 Atomic Energy Act).

(3) The type test shall meet the following general requirements:

a) A test run shall be carried out on a test stand for a duration of 100 hours in accordance with a specified test program, and once for each engine type (cf. **Table D-2**).

b) The type test shall be carried out on a design-identical engine type intended for use in nuclear power plants, together with all component parts of the auxiliary systems that are attached to, or are driven by, the engine. Insofar as the process instrumentation and the heat exchangers of the outer coolant circuit are part of the equipment of the test stand, they are exempted from this requirement. Engines are considered to be design-identical if their component parts are identical with respect to design, materials and fabrication and if equivalent quality assurance measures are taken. In the case of the functionally required component parts, any deviations from the proven fabrication series shall be specified and substantiated by proper references.

c) The manufacturer is permitted to repeat the type test in the case of a negative evaluation. Pre-requisites for repeating the type test are a detailed assessment of the damage, the agreement with respect to corrective actions by the authorized expert (under Sec. 20 Atomic Energy Act) and the removal of all identified defects.

d) The type test shall normally be carried out under the most unfavorable conditions of coolant and intake air permitted by the manufacturer.

e) Necessary deviations from the program of the type test shall be agreed upon between manufacturer and authorized expert (under Sec. 20 Atomic Energy Act) and shall be documented in the test report.

(4) The type test is considered successful if the following conditions are met:

a) the engine has achieved a total operating time of 100 hours under adherence to the power data specified in the test program,

b) the maximum permissible number of malfunctions specified under Section D 5 is not exceeded,

c) the results of the visual inspections specified under Section D.4 following the test run give no indications for the choice of wrong materials or for an overloading,

d) test records and measurement results of the test run indicate a positive result after their evaluation by the manufacturer and review by the authorized expert (under Sec. 20 Atomic Energy Act).

(5) A test report on the type test shall be prepared and signed by both the authorized expert (under Sec. 20 Atomic Energy Act) and the engine manufacturer. The authorized expert (under Sec. 20 Atomic Energy Act) issues a certificate on the successful performance of the type test.

1	Manufacturer	....
2	Type	.....
3	On-site power rating	
	Rated continuous power	..... kW bei ..... RPM
	Overload capacity	..... kW bei ..... RPM
4	Ambient conditions for power rating	
	Air pressure	..... Pa
	Intake air temperature before entry into the exhaust gas turbocharger	..... C°
	Intake air vacuum	max. ..... Pa
	Exhaust gas back pressure	max. ..... Pa
5	Nominal speed	..... RPM
6	Working cycle	.....
7	Type of construction	.....
8	Charge cycle	.....
9	Fuel injection	.....
10	Number of cylinders	.....
11	Cylinder bore	..... mm
12	Piston stroke	..... mm
13	Total displacement	..... dm^3
14	Compression ratio	.....
15	Mean effective piston pressure	
	at rated continuous power rating	..... MPa
	at overload	..... MPa
16	Firing order in direction of rotation	.....
17	Mean piston velocity at nominal speed	..... m/s
18	Ignition speed	..... to ..... RPM
19	Ambient air temperature	max. ..... °C
20	Type of cooling	.....
21	Amount of heat to be removed by coolant	
	at rated continuous power	..... MJ/h
	at overload capacity	..... MJ/h
22	Coolant operating temperature of the internal cooling system	
	before the engine	min. ...../max. ..... °C
	after the engine	min. ...../max. ..... °C
23	Amount of coolant in the internal cooling system	min. ..... m^3/h
24	Preheating temperature of coolant	min. ..... °C
25	Temperature of coolant	
	before the charge air cooler	max. ..... °C
	after the charge air cooler	max. ..... °C
26	Recirculating amount of coolant in the charge air cooling system	min. ..... m^3/h
27	Temperature of lubricating oil	
	before the engine	min. ...../max. ..... °C
	after the engine	min. ...../max. ..... °C
28	Consumption of lubricating oil at rated continuous power	max. ..... kg/h
29	Pressure of lubricating oil at nominal speed and operating temperature	min. ..... MPa
30	Exhaust air turbocharger	
	Manufacturer	.....
	Type	.....
	Speed	
	at rated continuous power	..... RPM
	at overload capacity	..... RPM
	Temperature of exhaust gas at outlet	
	at rated continuous power	..... °C
	at overload capacity	..... °C

Table 4-1: Technical data of the diesel engine

31	Charging pressure before cylinder	
	at rated continuous power	..... MPa
	at overload capacity	..... MPa
32	Specific fuel consumption at rated continuous power	.... g/kWh
33	Lubricating oil volume	max...../min. ..... dm^3
34	Coupling between motor and generator	
	Manufacturer	.....
	Type	.....
	Nominal torque	.... Nm
	Maximum permissible torque	..... Nm
35	Heat balance at rated continuous power	
	Effective power	..... MJ/h = ... %
	Power losses:	
	heat amount of engine coolant	..... MJ/h = ... %
	heat amount of lubricating oil	..... MJ/h = ... %
	heat amount of charge air	..... MJ/h = ... %
	heat amount of exhaust gas	..... MJ/h = ... %
	heat amount of radiation energy	..... MJ/h = ... %
	Total heat amount supplied by fuel	..... MJ/h = 100 %
36	Fuel injection pumps	
	Single of unit pumps	.....
	Manufacturer	.....
	Type	.....
	Start of injection before TDC in degrees of crankshaft angle	..... °
37	Fuel injection nozzles	
	Manufacturer	.....
	Type	.....
	Ejection pressure	.....MPa
38	Intake valves	
	Valve clearance	..... mm at ..... °C
	Intake opens before TDC in degrees of crankshaft angle	..... °
	Intake closes after TDC in degrees of crankshaft angle	..... °
39	Exhaust valves	
	Valve clearance	..... mm at ..... °C
	Exhaust opens before TDC in degrees of crankshaft angle	..... °
	Exhaust closes after TDC in degrees of crankshaft angle	.... °
40	Speed governor	
	Manufacturer	.....
	P-degree	from .....% to ....%
	Type	.....

Table 4-1: Technical data of the diesel engine (continued)

1	Manufacturer	.....
		.....
2	Type	.....
3	Nominal power	..... kVA
4	Nominal voltage	 V
5	Nominal current	..... A
6	Current overload capability for 15 s	.....-fold Nominal current
7	Power overload for 1 h (according diesel engine, Table 4-1 No. 3)	..... kVA
8	Nominal frequency	..... Hz
9	Number of phase	.....
10	Nominal speed	..... 1/min
11	Permissible overspeed	..... 1/min
12	Thermal grade	.....
13	Torque of inertia	..... kg m^2
14	Coil connection	.....
15	Power factor	.....
16	Nominal exciting voltage	 V
17	Nominal exciting current	..... A
18	efficiency at cos φ equal 0.8 and at	
	Generator power equal 1/4 nominal power	..... %
	Generator power equal 2/4 nominal power	..... %
	Generator power equal 4/4 nominal power	..... %
	Generator power equal 5/4 nominal power	..... %
19	Synchronous-reactance x_d (unsaturated)	..... %
20	Transient- reactance x'_d (saturated)	..... %
21	Subtransient- reactance x''_d (saturated)	..... %
22	Voltage adjustment range	from ..... % to ..... %
23	Steady short-circuit current	..... kA
24	Short-circuit current impulse	..... kA
25	Type of construction	.....
26	Type of bearing and lubrication	.....
27	Degree of protection	IP .....
28	Type of cooling	.....
29	Ambient temperature	..... °C
30	Permissible absolute altitude	..... m
31	Weight	..... kg

Table 4-2: Technical data of the generator

5.2 Production Test and Acceptance Test of the Diesel Engine

(1) A production test shall be performed on each diesel engine.

(2) Testing of the component parts shall be performed in accordance with the quality assurance requirements specified under Section 3.

(3) A list containing the component parts, the test procedures and type and extent of the test records shall be prepared for the production test. **Table 5-1** shows the extent of tests for a diesel engine with a rated continuous power larger than or equal to 800 kW. It is permissible to reduce the test extent in the case of large-scale-production diesel engines with a rated continuous power smaller than 800 kW.

(4) Prior to the acceptance test, the diesel engine shall be subjected to a running-in procedure in accordance with the program specified by the manufacturer.

(5) The acceptance test of the diesel engine at the manufacturing plant shall be carried out in accordance with a program demonstrating power values and essential technical data under defined boundary conditions. **Table 5-2** shows a minimum required extent of this test. Additions may be necessary, depending on the type of engine and the manufacturer.

5.3 Type Test of the Generator

(1) The tests specified in **Table 5-3** Column 3 shall be carried out as proof for the analytically determined characteristic values for a specific type of generator. They shall be carried out on one actual generator of this type and its excitation system.

(2) If the use of the generator and its excitation system in the nuclear power plant requires safety-related characteristics which are covered neither by the type test in accordance with **Table 5-3** Column 3 nor by an analytical proof, then an additional suitability test is required for these characteristics. This

shall be reviewed by the authorized expert (under Sec. 20 Atomic Energy Act).

5.4 Production Test of the Generator

(1) A production test shall be performed on each generator and its excitation system.

(2) Testing of the component parts of the generator and its excitation system shall be performed in accordance with the quality assurance requirements specified under Section 3.

(3) The minimum required extent of the production test is specified in **Table 5-3** Column 4.

5.5 Suitability Test for Components of the Auxiliary Systems

(1) If a satisfactory service life as specified under Section 4.5 item a cannot be proven for all components of the auxiliary systems, supplementary tests shall be carried out. An analytical proof of certain characteristics is permissible. In the case of equivalent requirements, a prototype test or type test of series-produced devices may serve as suitability certification.

Note:
The components concerned are, essentially, pump units, actuators, compressors and valves as well as filters, expansion joints, damping elements and heat exchangers.

(2) The type and extent of these suitability tests require the approval by the authorized expert (under Sec. 20 Atomic Energy Act). The power load and test runs of the diesel engine units as specified under Section 7.1 may be taken into account.

5.6 Production Tests of the Components of the Auxiliary Systems

(1) Testing of the components of the auxiliary systems shall be performed in accordance with the quality assurance requirements specified under Section 3.

(2) A list of the components shall be prepared for the production tests containing the test procedures and the type and extent of the test records.

(3) This list shall differentiate between components which are essential and those which are not essential to the functional capability of the emergency power generating facilities.

(4) For components which are essential to the functional capability of the emergency power generating facilities, the specification of test extents and documentation requires the approval of the authorized expert (under Sec. 20 Atomic Energy Act). In this context, the generally accepted engineering standards shall be used insofar as this applies to the components concerned.

Notes:
Table 5-4 indicates the generally accepted engineering standards.

The functional capability of all components is demonstrated within the framework of the tests as specified under Section 7.1.

(5) The records on the tests and inspections of those components essential to the functional capability of the emergency power generating facilities shall be submitted to the authorized expert (under Sec. 20 Atomic Energy Act).

5.7 Suitability Test for Components of the Instrumentation and Control Equipment

(1) If a complete proof of the demonstration of satisfactory service life as specified under Section 4.6 item b is not possible for components of the instrumentation and control equipment, supplementary tests shall be carried out. An analytical proof of certain characteristics is permissible. In the case of comparable requirements, a prototype test or type test of series-produced equipment may serve as the suitability certification.

Note:
Insofar as the instrumentation and control equipment of the emergency power generating facilities is identical to that of other safety-related systems, it is sufficient to reference the proofs of suitability of the components of this instrumentation and control equipment that were submitted within the framework of the overall plant

(2) Type and extent of these suitability tests require the approval by the authorized expert (under Sec. 20 Atomic Energy Act). The power load and test runs of the emergency power generating facilities as specified under Section 7.1 may be taken into account.

5.8 Production Tests of the Components of the Instrumentation and Control Equipment

(1) Testing of the instrumentation and control equipment shall be performed in accordance with the quality assurance requirements specified under Section 3.

(2) A list of the components of the instrumentation and control equipment shall be prepared for these production tests containing the test procedures and the type and extent of the test records.

(3) A specific test program shall be established for each type of component.

Component	*Tests and Examinations*															Le
	Tensile test	Notched bar impact test specimen	Folding test	Hardness test	Chemical analysis	Microstructural analysis	Crack test	Radiographic examination	Ultrasonic examination	Test of characteristic	Weight test	Heat setting test	Pressure test	Leak tightness test	Functional test	
Cylinder crankcase	○			○	○	○							Δ			a
Crankshaft bearing bolts	○			○	○		○									
Cylinder-head bolts	○			○	○		○									
Crankshaft bearing cover	○			○	○		○									
Crankshaft bearing shell			○			○		○								
Oil pan														○		c
Cylinder liner				○		○	○						Δ			
Crankshaft	Δ	Δ		Δ	Δ		Δ		○							b
Connecting rod	Δ	Δ		○	Δ		Δ				○					
Connecting-rod bearing liner			○			○		○								
Connecting-rod bolts	○			○	○		○									
Piston shaft	○			○	○						○					d
Piston head	○			○	○	○	○				○					
Piston rings					○											
Piston pins				○	○	○	○		○							
Cylinder head	○			○	○								Δ			e
Intake valves	○			○	○	○	○									f
Exhaust valves	○			○	○	○	○									f
Valve spring										○		○				
Rocker arm				○			○									
Camshaft				○	○	○	○									
Bumper				○	○	○										
Gears of the cog-wheel gearing				○												
Lubricating pump															○	g
Lubricating oil heat exchanger													Δ			h
Injection pump															○	
Injection pipe line	○		○		○								Δ			i
Injection valve															○	
Main starting valve					○								Δ		○	
Speed governor															○	
Pressurized air pipes	○				○	○							Δ			
Cooling water pump													Δ		○	
Exhaust gas turbocharger													Δ			k
Charge air cooler													Δ			
Coupling	○	○		○	○											b
Base frame	○				○											l

Materials and testing methods as well as extent of tests shall be specified dependent on the type of engine.
Inspection for adherence to dimensions and for cleanness are mandatory and, therefore, not individually specified.

Δ : Acceptance certificate “3.1.B“ (cf. DIN EN 10204 Sec. 3.1)
○ : Certificate “2.1“ of compliance with order as collective certificate for the entire engine (cf. DIN EN 10204 Sec. 2.1)

Note:
On account of the design of the diesel engine and the methods of fabrication it may become necessary to enlarge the extent of the tests and inspections or to apply other equivalent methods of testing. This applies, e.g., to the following:

a) Examination of the weld seams in the case of welded crankcases,
b) Unbalance check of crankcase and coupling (under consideration of rotational speed),
c) Chemical analysis and crack test on oil pans that are welded and subjected to engine forces,
d) Ultrasonic examination of the piston skirt of full skirt pistons, and crack test of the piston skirt of manufactured pistons,
e) Crack test of the cylinder head base plate,
f) Ultrasonic examination in the case of friction weld connections between valve disk and shaft,
g) Pressure test in the case of an external lubricating oil pump,
h) Hardness test, chemical analysis, microstructural examination and crack test in the case of lubricating oil heat exchangers with cooling elements in cast aluminum housings,
i) Eddy current examination of injection pipes made from austenitic materials,
k) Overspeed test of the exhaust gas turbochargers (under consideration of the design),
l) Crack test of those base frame welds that are subjected to loading stress.

Table 5-1: Extent of production tests of component parts of the diesel engine with a rated continuous power larger than 800 kW

1	**Specification of the Operating Media**		
1.1	Fuel		.....
1.2	Lubricating oil		.....
1.3	Coolant		.....
2	**On-site Operating Conditions**		
2.1	Intake air temperature upstream of engine		..... °C
2.2	Coolant temperature downstream of engine		..... °C
2.3	Charge-air coolant temperature upstream of cooler		..... °C
2.4	Altitude of site above mean sea level		..... m
2.5	Intake pressure loss upstream of exhaust turbocharger [1)]		..... Pa
2.6	Exhaust gas pressure downstream of exhaust turbocharger [1)]		..... Pa
2.7	Fuel temperature upstream of engine		..... °C
3	**Operating Power** (at conditions as under No. 2)		
3.1	Rated continuous power		..... kW at ..... RPM
3.2	Overload capacity (blocked output)		..... kW at ..... RPM
4	**Reduction of operating power** (effective braking power)		
4.1	2 h P		..... kW ..... RPM
4.2	Full-load governor test		
4.3	1 h P 110 % load	At a fixed position of controls for 100 % load as under No. 3.1 and for nominal rotational speed	
4.4	15 min P 75 % load		
4.5	15 min P 50 % load		
4.6	15 min P 25 % load		
4.7	15 min P 10 % load		
5	**Measurements**		
	Measurements and findings shall be registered in the test record. Operating values shall be read from the displays and recorded after 30 min, 60 min or at the end of the individual operating level. The lubricating oil consumption shall be determined during the test under item 4.1.		
6	**Functional Tests**		
6.1	Six startup cycles	Startup pressure	..... MPa
		Tank volume	 l
		Mean compressed air consumption per startup cycle	 l
6.2	Overspeed limiter		
6.3	Coastdown of exhaust gas turbocharger		
6.4	Safety shutdown of oil pressure		
6.5	Test of speed governor, determination of static change of speed (P-degree) and test of the speed adjustment device		
6.6	Test of the attached electrical devices		
6.7	Leak tightness test		
7	**Certification of Tests and Inspections:** The tests and inspections shall be certified by the manufacturer in an acceptance test record.		

[1)] The specified position of the throttle device shall be maintained during the entirel acceptance test.

Table 5-2: Acceptance test of the diesel engine

1	2	3	4
No.	***Type of Test or Inspection***	***To be performed during***	
		Type Test	***Production Test***
1	Overspeed test	X	X
2	Determination of the operating temperature from: heat-up test in case of idling and of short circuits	X	–
3	Recording of the loading characteristic	X	–
4	Recording of the no-load characteristic and measurement of the iron losses and friction losses	X	X
5	Recording of the short circuit characteristic (tri-pole short circuit) and measurement of the short circuit losses	X	X
6	Analytical determination of the efficiency on the basis of the individual losses	X	X
7	Overload test run	X	–
8	Impulse short-circuit test	X	–
9	Measurement of the DC resistance of the individual strands of the stator winding	X	X
10	Measurement of the DC resistance of the rotor winding	X	X
11	Check of the insulation resistance of the stator and rotor windings in the case of generators larger than 1 kV	X	X
12	Check of the rotary field and of the terminal marking	X	X
13	Checking the voltage equality of the strands	X	X
14	Winding test of the stator and rotor windings	X	X
15	Coastdown test to determine the moment of inertia	X	–
16	Impedance measurement	X	–
17	Zero phase-sequence impedance measurement	X	–
18	Check of running smoothness	X	X
19	Functional check of the excitation system	X	X

Table 5-3: Extent of the type and production tests of the generator

System / Component	***Tests and inspection performed in accordance*** [1)]
Compressed Air Supply System	
Pressure vessel and valve head	AD Standards Series, TRB Standards Series, DIN 6275, DIN 6276
Fittings, valves	AD Standards Series, DIN 3230-3
Pipe lines	AD Standards Series, DIN EN287-1, DIN EN 719, DIN EN 729-1 to DIN EN 729-4, DIN EN 25817, DIN 8564-1
Fuel and Lubricating Oil Supply System	
Operating and storage tanks	TRbF, DIN 6616, DIN 6625-1
Fittings, valves	TRbF, DIN 3230-3
Pipe lines	TRbF, DIN EN 287-1, DIN EN 719, DIN EN 729-1 to DIN EN 729-4, DIN EN 25817, DIN 8564-1
Coolant Supply System	
Cooling water surge tank	AD Standards Series, TRB Standards Series
Heat exchangers	AD Standards Series [2)], TRB Standards Series [2)]
Fittings, valves	AD Standards Series, DIN 3230-3
Pipe lines	AD Standards Series, DIN EN 287-1, DIN EN 719, DIN EN 729-1 to DIN EN 729-4, DIN EN 25817, DIN 8564-1
Intake and Exhaust Gas Systems	
Pipe lines	DIN EN 287-1, DIN EN 287-2, DIN EN 719, DIN EN 729-1 to DIN EN 729-4, DIN EN 25817, DIN 8564-1
Steel Structures for Supports	DIN 18 800-1, DIN 18 800-2, DIN 18 800-2/A1, DIN 18 800-3, DIN 18 800-3/A1, DIN 18 800-4, DIN 18 800-7

1) The type of certification (statement of compliance with the order, or acceptance test certificate in accordance with DIN EN 10204) shall be specified depending on the standards applied and materials used.

2) If a heat exchanger is part of a system with higher level test requirements these higher requirements shall be taken into consideration.

Table 5-4: Reference to the generally accepted technical standards which apply to the productions tests of component parts of the auxiliary system

6 Tests and Inspections During On-site Assembly

The tests and inspections shall normally ensure that thoseassembly conditions, installation conditions and assembly dimensions important to a reliable function of the emergency power generating facilities are adhered to. These tests include, essentially:

a) inspection of the components to ensure that they correspond to the documents and to identify any damage from transportation or storage,

b) verification of the finished product with regard to the design-reviewed documents (e.g. component arrangement drawings, isometric drawings of pipe lines, system circuit diagrams of the auxiliary systems),

c) verification with regard to adherence to assembly instructions (e.g. with respect to pretensioning torques, alignment, cleanliness, freedom of movement, insulation of the generator),

d) verification of assembly dimensions,

e) supervision of welding tasks.

7 Commissioning Tests

7.1 Tests and Inspections during Pre-nuclear Operation

7.1.1 General Requirements

(1) Prior to the first criticality of the power plant, acceptance and function tests shall be carried out to demonstrate that the specified safety requirements are met and that the emergency power generating facilities function properly.

(2) The operating time of each train of the emergency power generating facilities shall normally amount to 200 hours in the time period before first criticality of the power plant. If individual diesel generator units are operated longer than 200 hours, the additional time may be credited to the operating time of the other diesel generator units, provided, the individual trains of the emergency power generating facility are of identical design. However, the operating time of an individual diesel generator unit shall not be less than 150 hours.

(3) The required operating time shall be distributed over several runs in which at least 50 startup procedures shall be demonstrated for each train of the emergency power generating facilities in the time period before first criticality.

(4) The duration of test runs carried out under responsibility of the equipment manufacturer as well as the duration of the acceptance and function tests as specified under Sections 7.1.3 and 7.1.4 and the inservice inspections under Section 8 may be credited to the required operating times and startup procedures.

(5) The permissible idling times and minimum power loads specified by the manufacturer shall be adhered to.

(6) Malfunctions of the emergency power generating facilities shall be recorded.

(7) Any identified defects shall be removed. Depending on the type of defect, additional tests shall be performed. The type and extent of the additional tests shall be reviewed by the authorized expert (under Sec. 20 Atomic Energy Act) prior to the performance of the tests.

7.1.2 Verification of Adherence to the Requirements

(1) Tests and inspections shall be performed showing that the safety-related requirements of the emergency power generating facilities meet are met.

(2) These tests shall normally be carried out under a condition as realistic as possible. Insofar as a test with regard to protective limit values could present a danger to components of the emergency power generating facilities (e.g., test of the overspeed limiter) the actuation of these limit values may be simulated. The tests include:

a) verifying adherence to the static tolerances,

b) verifying the power load acceptance time, also with the lowest permissible temperatures of engine preheating,

c) verifying adherence to the dynamic tolerances with the maximum attached power load as specified,

d) verifying quiet running,

e) torsional vibration measurement

In the case of identically designed diesel generator units, the detailed evaluation of the torsional vibration measurement is required only for that diesel generator unit for which the least favorable values were measured,

f) testing the compressed air supply system,

g) testing the fuel and lubricating oil supply system,

h) testing the air supply system and the air intake and exhaust systems,

i) testing the coolant supply system,

k) testing the monitoring equipment,

l) testing the protective equipment,

p) testing the sound level at the diesel control station compartment,

q) testing the possibilities for manual actions, the synchronization, the reconnection of the emergency power supply system to the station service equipment from the local control station,

r) testing the interlocks,

s) testing the insulation of the generator bearing.

7.1.3 Power Load Operation of the Diesel Generator Units

(1) Within the operating time of each emergency power generating facility as specified under Section 7.1.1, the diesel generator unit shall be subjected to an uninterrupted power load operation of at least 24 hours. This shall include at least six hours at rated continuous power and one hour at overload power capacity. For one of a number of design-identical diesel generator units, this power load operation run shall be extended to 72 hours. The displays of safety-related measurement values shall be read and recorded.

(2) During these power load operation runs, special attention shall be paid to checking the cooling of the diesel engine and generator as well as the adequacy of the design of the internal and external cooling circuits.

7.1.4 Preliminary Emergency Power Tests

Preliminary emergency power tests shall be carried out to demonstrate the functional capability of the individual emergency power trains as well as the entire emergency power system. For these tests, all systems to be supplied by the emergency power system shall normally be available to serve as power loads. At least the following tests shall be carried out:

a) startup and power loading of each train of the emergency power generating facility by triggering the respective reactor protection signals,

b) parallel net operation of one emergency power generating facility and disconnection of the power supply from the associated train of the station service facility,

c) startup and power loading of all emergency power generating facilities by a simultaneous disconnection of the power supplies from the station service facility,

d) verifying that the inservice inspections can be carried out under consideration of the reactor protection system and the process-technological systems.

7.2 Tests During Initial Nuclear Startup Operation

(1) An emergency power supply test shall be carried out within the framework of the initial nuclear startup operation. This test shall be performed during partial power load operation of the reactor and shall be initiated by disconnecting the station service power supply. It shall be possible to operate the power plant for at least one hour under emergency power supply conditions.

(2) Prior to carrying out this emergency power supply test, all trains of the emergency power generating facilities shall normally have been subjected to inservice inspections to demonstrated their functional capability. The test shall be initiated only if all power grid feed-ins are available.

(3) During the emergency power supply test, the power loading of the components of the emergency power supply system (e.g. emergency power units, transformers, rectifiers, converters) shall normally be checked.

8 Inservice Inspections

8.1 General Requirements

(1) Inservice inspections shall be carried out to verify the continued functional capability of the emergency power generating facilities. These tests are normally not to be carried out simultaneously in several trains.

(2) In the case of a startup failures or failure during a test run, the test run shall be repeated following the identification of the cause and removal of the defect. If the cause cannot be clearly identified, a new test interval shall be specified as agreed upon by the authorized expert (under Sec. 20 Atomic Energy Act).

(3) Visual inspections of the emergency power generating facilities shall be carried out during the test runs specified under Sections 8.2 and 8.3.

8.2 Function Test Run

(1) The function test run shall include startup and power loading of the emergency power generating facility with a subsequent power load operation run in parallel net operation. The total duration of the test run shall normally be two hours. At the end of the test run during parallel net operation, the diesel generator unit shall normally be power loaded to at least 80 % of the rated continuous power for the duration of at least one hour.

(2) The function test run shall normally be performed in intervals of four weeks on each emergency power generating facility as well as prior to every startup of the power plant following a longer outage (e.g. refueling). The function test runs of redundant emergency power generating facilities shall normally be distributed evenly over the test interval (e.g. one test run of one train every week in case of a four-train emergency power generating facility). It is permissible to extend the test intervals, provided the extension is well-founded on operating experience.

(3) Triggering the startup and power loading program shall normally be effected by simulating the startup criterion. During these tests, all the protective equipment of the emergency power generating facilities shall normally be effective.

(4) Startup shall be triggered at least once a year by disconnecting the bus coupler between station service equipment and diesel generator bus.

(5) An insular operation shall subsequently be followed by a parallel-net operation.

(6) The execution of the commands issued by the startup and power loading program and the time sequence shall be recorded automatically and shall be verified with respect to any deviations from the specified times.

8.3 Test Run at Overload Power Capacity

Once every 12 months after a function test run as specified under Section 8.2 para. 1, each diesel generator unit shall be operated at overload power capacity for at least 30 minutes (e.g. one function test run of one train every three months in the case of a four-train diesel generator facility).

8.4 Testing the Instrumentation and Control Equipment

Instrumentation and control equipment the function of which is not tested in the course of the test runs shall be tested at regular intervals. The test intervals shall be coordinated with those of the other instrumentation and control equipment of the emergency power system. A test interval of four years shall normally not be exceeded (e.g. each year one train of a four-train emergency power generating facilities is tested).

8.5 Examination of the Operating Media

8.5.1 Fuel

(1) The adherence to the specified requirements of the fuel and the changes it undergoes in the fuel storage tanks shall be checked on representative samples

a) during the initial filling,

b) following each refill or new filling,

c) in intervals of six months.

(2) The fuel in the operating and storage tanks shall be replaced whenever the requirements for the fuel with respect to density, boiling behavior, viscosity, flash point, carbonization residues, ash content and water content are no longer met.

(3) In the case of replenishment or new filling of the fuel storage tanks, a material identification check shall be carried upon fuel delivery and prior to tanking the fuel; this check shall determine the following values:

a) visual evaluation (fuel shall be clear and free of solid impurities),

b) density,

c) flash point,

d) water content.

The fuel may only be tanked if the requirements regarding items a through d are met as specified.

(4) The fuel from the storage tanks shall be subjected to an aging test in yearly intervals. The original procedure shall repeatedly be used for comparison purposes. The results shall be evaluated by the fuel manufacturer and the authorized expert (under Sec. 20 Atomic Energy Act) with respect to continued storage and usability of the fuel. The test interval shall be reduced if necessary.

(5) Heating oil EL may be used as fuel only if the supplier can demonstrate that all requirements of this safety standard regarding diesel fuel are met.

8.5.2 Lubricating Oil

(1) Upon delivery, adherence to the values specified by the engine manufacturer shall be demonstrated, and a material identification check shall be carried out on each container.

(2) Analyses shall be carried out to determine whether or not an unscheduled oil change becomes necessary. These analyses include:

a) visual inspection for unusual water content prior to or during each test run,

b) half-yearly inspection in accordance with the regulations of the engine manufacturer, however, at least for

ba) undissolved substances,

bb) viscosity,

bc) flash point,

bd) water content,

be) base number (TBN - total base number).

The samples shall be taken from the running engine before the end of a test run.

8.5.3 Coolant of the Internal Cooling Circuit

(1) The specified values and the identity of the coolant shall be checked prior to each new filling.

(2) The regular operational surveillance shall be carried out in accordance with the regulations of the engine manufacturer. The following tests shall be performed:

a) determination of the concentration of the coolant additive,

b) measurement of the pH index.

A test interval of six months shall not be exceeded. In case corrosion protection oils are used in the coolant, this test interval shall normally be reduced to four weeks. The samples shall be taken during the test run either from the provided sample removal location or from a pipe with a high through flow.

9 Operation, Servicing and Repair

9.1 General Requirements

(1) Instructions shall be provided for operation, servicing and repair that are necessary for operating the emergency power generating facilities and for the control and mitigation of malfunctions and faults. In this connection, the regulations of the manufacturer shall normally be adhered to.

(2) Malfunctions and damages shall be removed without delay.

9.2 Operation

(1) One person shall be on duty during each shift who is qualified to carry out the following tasks:

a) inspection of operating emergency power generating facilities with respect to function and supply storage.

b) initiation of the clarification and removal of malfunctions and faults.

(2) The shut-down procedure of the emergency power generating facilities shall normally be initiated manually, however, only when the following conditions are met:

a) A supply of the emergency power bus bars shall be available from a power feed-in that is independent of the emergency power generating facilities.

b) The coolant of the internal cooling circuit shall normally have reached the equilibrium temperature.

(3) The shut-down procedure shall be carried out separately for each train.

(4) The idling time specified by the manufacturer for the diesel engine shall normally not be exceeded.

(5) After the maximum continuous operating time specified for the diesel generator unit has been exceeded it shall be subjected to extended servicing.

9.3 Servicing and Repair

(1) The diesel generator unit and auxiliary systems (e.g., coolers, pumps, compressors, tanks) shall be serviced in accordance with a written servicing schedule. In preparing the servicing schedule, the following shall be taken into account:

a) the safety requirements of the nuclear power plant,

b) the permissible times of non-availability of the emergency power generating facilities for servicing tasks,

c) the chronological staggering of the servicing of the individual trains of the emergency power generating facilities,

d) the servicing schedules of the component manufacturers,

e) the indications found in servicing comparable components.

(2) The fuel and lubricating oil storage tanks shall normally be drained of water once a year and shall be cleaned internally once every five years.

(3) The lubricating oil shall be changed in accordance with the regulations of the engine manufacturer. If the lubricating oil is not changed for a period longer than one year, the lubricating oil shall be subjected to tests regarding its quality that, in agreement with the engine manufacturer, are more extensive than specified under Section 8.5.2 para. 2 item b.

(4) Those parts listed in Tables 5-1, 5-3 and 5-4 that are replaced in the course of maintenance shall be subjected to documented tests as specified under Sections 5.2, 5.4, 5.6, 5.8 and 6.

(5) Those parts listed in Tables 5-1, 5-3 and 5-4 that are replaced in the course of maintenance and are modified with respect to the original configuration shall be subjected to documented suitability tests and production tests.

(6) Those parts listed in Tables 5-1, 5-3 and 5-4 that are overhauled in the course of maintenance shall be subjected to tests the extent of which shall be specified on an individual basis.

10 Tests Subsequent to Servicing or Repair

(1) After completion of servicing or repair tasks that have led to an interruption of functional operability, then the restoration to operability shall be demonstrated by means of a test. Depending on the type and extent of the parts or functions concerned, the test extent shall be specified in agreement with the authorized expert (under Sec. 20 Atomic Energy Act).

(2) After an interruption of functional operability resulting from servicing or repair, at least one function test run as specified under Section 8.2 shall be performed.

(3) After a basic overhaul of a diesel engine, power load operation runs shall be carried out on the facility for a total duration of 48 hours. At least 24 hours of these shall be carried out as a non-interrupted power load operation as specified under Section 7.1.3.

11 Testers

(1) The type and production tests as specified under Sections 5.1 through 5.4, 5.6 and 5.8 shall normally be carried out by plant experts of the manufacturer or under their responsibility. Authorized experts (under Sec. 20 Atomic Energy Act) or external experts shall be consulted if so specified in the test list.

(2) The tests and inspections during on-site assembly as specified under Section 6, the commissioning tests under Section 7, the inservice inspections under Section 8 and the tests subsequent to servicing and repair as specified under Section 10 shall be carried out by competent personnel specified by the licensee. Authorized experts (under Sec. 20 Atomic Energy Act) shall be consulted if so specified in the test list.

12 Test Certification and Documentation

(1) All tests carried out in accordance with this safety standard shall be certified. The test certifications shall contain the information necessary for the assessment and evaluation of the tests. This includes information on:

a) testing organization,

b) test object,

c) test extent,

d) type of test,

e) identification number of the testing instruction and, if applicable, also of the standard testing instruction,

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

g) test results,

h) confirmation of test performance, their results and evaluation by signature of the testers and, if participation was required, of the authorized expert (under Sec. 20 Atomic Energy Act).

(2) The servicing and repair as specified under Section 9.3 shall be documented.

Appendix A

Monitoring and Protective Shutdown of an Emergency Power Generating Facility with a Standby Diesel Generator Unit and a Rated Continuous Power Larger than 800 kW

1	2	3	4	5	6
No.	**System Component** Measurement value, criterion	**Monitoring** on-site	in local control station	in control room	**Protective shutdown** of diesel generator unit
1	**Diesel Generator Unit**				
1.1	Active power	–	A	A	–
1.2	Current	–	A	A	–
1.3	Voltage	–	A	A	–
1.4	Rotational speed	A	$\overline{M}$	SM1	$\overline{S}_V$
1.5	Frequency	–	A	A	–
1.6	Accumulated operating hours	–	A	–	–
1.7	Number of Startups	–	A	–	–
1.8	Level in collecting sump	–	$\overline{M}$	SM1	–
2	**Startup System, Charge-air Supply System**				
2.1	Pressure upstream of startup valve	A	$\underline{M}$	SM1	–
2.2	Compressor drive – failure mode (cf. No. 9.11)	–	M	M or SM2	–
3	**Fuel System, Fuel Supply System**				
3.1	Differential pressure of fuel filter on diesel engine	A	–	–	–
3.2	Differential pressure of fuel filter between storage tank and operating fuel tank	A	–	–	–
3.3	Level in storage tank	A or	A $\underline{M}$	SM1	–
3.4	Leakage of storage tank	–	M	SM1	–
3.5	Level in operating fuel tank	A or	A $\underline{M}$ $\underline{\underline{M}}$	SM1	–
3.6	Leakage of operating fuel tank	–	M	SM1	–
3.7	Electrical fuel-supply pump – failure mode (cf. No. 9.11)	–	M	M or SM2	–
4	**Lubricating Oil System**				
4.1	Level in oil pan or tank	A or	A $\underline{M}$	SM1 SM3	
4.2	Pressure of lubricating oil	A	$\underline{M}$ $\underline{\underline{M}}$	SM1 SM3	$\underline{\underline{S}}_V$
4.3	Differential pressure at oil filter	A	–	–	–
4.4	Temperature upstream of diesel engine	A	$\overline{M}$	SM1	–
4.5	Faulty pre-lubrication	-	M	SM1	–
5	**Cooling System of the Diesel Engine**				
5.1	Level in equalizing tank	A or	A $\underline{M}$	SM1 SM3 $\underline{\underline{S}}$	od. $\underline{\underline{S}}_V$
5.2	Temperature downstream of diesel engine	A	$\overline{M}$ $\overline{\overline{M}}$	SM1 SM3 $\overline{\overline{S}}_V$	od. $\overline{\overline{S}}$
5.3	Temperature upstream of diesel engine	A	–	–	–
5.4	Pressure downstream of pump	A	$\underline{M}$	SM1	–
5.5	Temperature of preheating system	(by No. 5.2)	$\underline{M}$	SM1	–
6	**Coolant Supply System**	The pressure upstream and temperature downstream of the cooler shall be monitored in the external cooling circuit with respect to permissible limit values			

1	2	3	4	5	6
No.	**System Component** Measurement value, criterion	**Monitoring** on-site	in local control station	in control room	**Protective shutdown** of diesel generator unit
7	**Air Supply System, Air Intake and Exhaust Facility**				
7.1	Charge air pressure	A	–	–	–
7.2	Exhaust gas collective temperature	A	$\overline{M}$	SM1	–
7.3	Engine room temperature	–	$\overline{M}$ $\underline{M}$	SM1	–
8	**Generator**				
8.1	Overcurrent during insular operation of the diesel generator unit, alternatively: differential voltage protection	–	$\overline{M}$	SM2 SM3	$\overline{S}_V$
8.2	Overcurrent during parallel net operation	–	$\overline{M}$	SM2	–
8.3	Reverse power during parallel net operation	–	$\overline{M}$	SM2 SM3	$\overline{S}$
8.4	Excitation fault	–	M	SM2	–
8.5	Winding temperature	–	A	–	–
9	**Emergency Power Switchgear and Instrumentation and Control Equipment**				
9.1	Generator bus voltage	–	–	A $\underline{M}$ [1] $\underline{\underline{M}}$ [2]	–
9.2	Generator bus frequency	–	–	A $\underline{M}$ [3]	–
9.3	Position of generator breaker	–	A	A	–
9.4	Position of bus coupler to station service facility	–	A	A	–
	Synchronization displays				
9.5	– Double voltage display	–	A	–	–
9.6	– Double frequency display	–	A	–	–
9.7	– Synchronoscope	–	A	–	–
9.8	Auxiliary voltages at control station	–	$\underline{M}$	SM2	–
9.9	Temperature control station	–	$\overline{M}$	SM1	–
9.10	Automatics switched off	–	A M	M or SM2	–
9.11	Fault mode of auxiliary drives	–	M	M or SM2	–

A : Display

M : Alarm
$\overline{M}$: at 1st upper limit value
$\overline{\overline{M}}$: at 2nd upper limit value
$\underline{M}$: at 1st lower limit value
$\underline{\underline{M}}$: at 2nd lower limit value

SM1: Collective alarm 1 “Mechanical Failure”
SM2: Collective alarm 2 “Electrical Failure”
SM3: Collective alarm 3 “Protective Shutdown of Diesel“

S : Protective shutdown without priority
$\overline{S}$: at 1st upper limit value
$\overline{\overline{S}}$: at 2nd upper limit value

S_V: Protective shutdown with priority
$\underline{S}_V$: at 1st lower limit value
$\underline{\underline{S}}_V$: at 2nd lower limit value
$\overline{S}_V$: at 1st upper limit value
$\overline{\overline{S}}_V$: at 2nd upper limit value

N o t e :
Depending on the design of the diesel-generator unit or of the associated auxiliary systems at may be necessary to expand the extent of the instrumentation. This is the case for, e.g., the following:
- admission of untreated water to charge-air cooler or lubrication-oil cooler (monitoring of temperature upstream of cooler)
- dampers for intake air, exhaust air, combustion air (monitoring of actual position)
- temperature of sleeve bearing of generator (display, alarm)
- controlled charge-air cooling (temperature downstream of charge-air cooler)
- measurement of exhaust gas temperature if this is provided for in operational monitoring

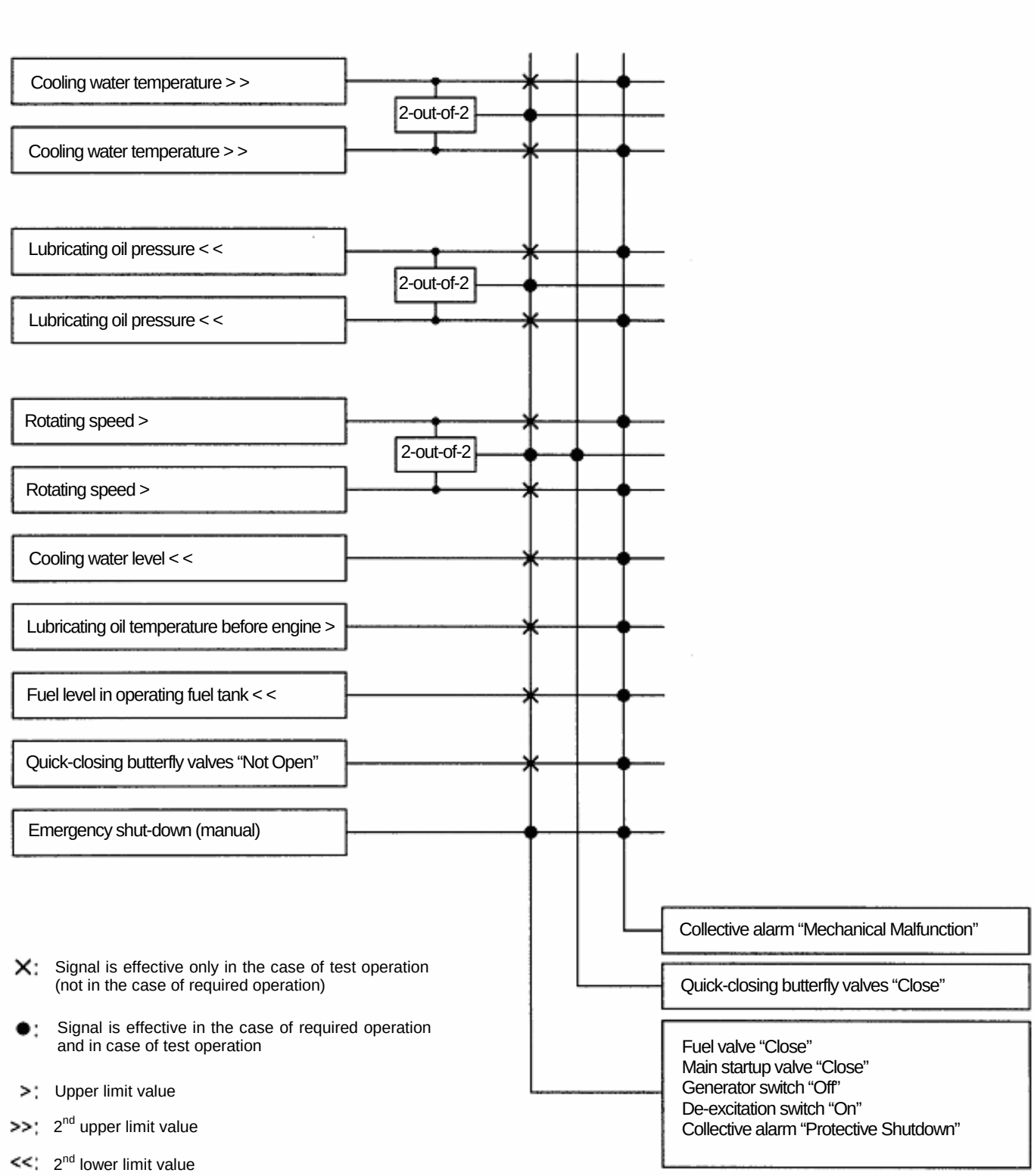
[1] $\underline{M}$ cf. Section 3.11.3 para. 3

[2] $\underline{\underline{M}}$ cf. Section 3.11.2 para. 3

[3] $\underline{M}$ cf. Section 3.11.2 para. 4

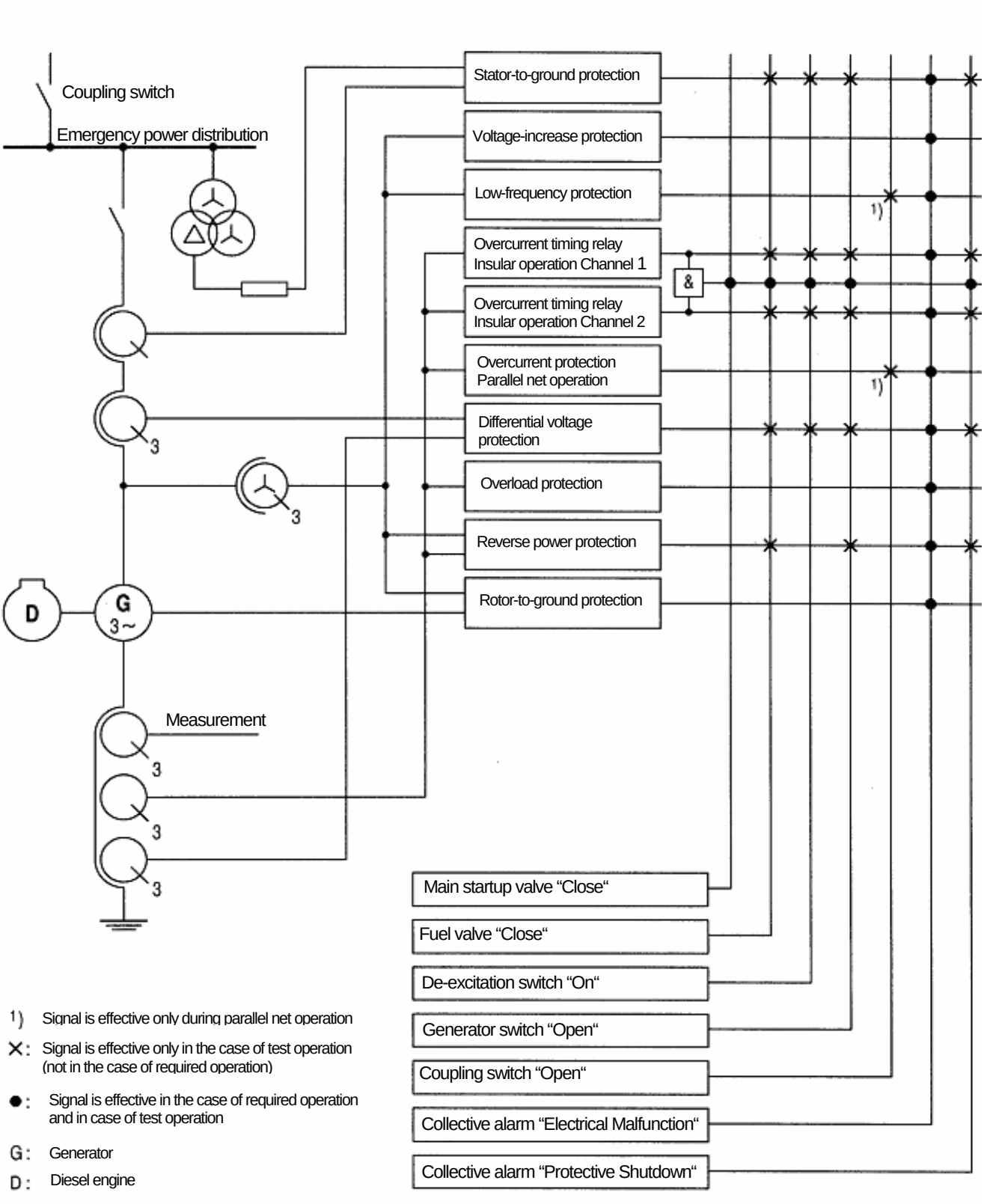
Appendix B

Design Example for the Equipment Protection of a Diesel Engine



Appendix C

Design Example for the Equipment Protection of a Generator



Appendix D

Type Testing of a Diesel Engine

D 1 Documents to be Submitted

(1) The following documents shall be submitted:

a) technical drawings
   aa) assembly drawing showing the main dimensions (length, width and height) with respect to the crankshaft axis,
   ab) longitudinal section and cross section for the engine series,

b) technical data as listed in **Table 4-1**,

c) system layout diagrams and summary description of the auxiliary systems of the diesel engine involved in the tests, including the demarcation regarding which components are part of the engine and which part of the test bench
   ca) lubricating oil system,
   cb) fuel system,
   cc) cooling system,
   cd) charge air system,
   ce) startup system,
   cf) diagram of measurement locations.

(2) The essential component parts of the diesel engine which are included in the extent of the type test shall be documented. This documentation shall make it possible to determine whether or not these component parts are similar to those of the diesel engine used in the nuclear power plant.

D 2 Measurement and Verification Tasks

D 2.1 Tasks Before the Test Run

Prior to the test run, the following checks and tests shall be carried out:

a) verification that measurement locations and their numbers are in agreement with those in the measurement location overview, in the measurement location list and the measurement record,

b) verification of the measurement equipment with respect to applicability and display accuracy as specified under Section D 2.6 paras. 2 and 3,

c) verification of the dynamometric brake as specified under Section D 2.6 para. 4,

d) taking of a sample from the fuel, lubricating oil and coolant as specified under Section D 2.5,

e) recording of the lubricating oil level at the beginning of the 100 hour test run (cf. Section D 2 4.3).

D 2.2 Tasks During the Test Run

The following tasks shall be carried out during the test run:

a) measurements and calculations as listed in **Table D-1** and their documentation.

b) continuous measurements during the test run as specified under Section D 2.6 para. 5,

c) taking of samples from the lubricating oil and coolant prior to the end of the test run.

D 2.3 Tasks after Ending the Test-Run

The following tasks shall be carried out after ending the test run:

a) inspection regarding general condition, cleanness and leak tightness,

b) recording of the lubricating oil level and calculation of the consumption as specified under Section D 2.4.3,

c) disassembly of the engine for visual inspection,

d) visual inspection of the engine components as specified under Section D 4.

D 2.4 Boundary Conditions for the Measurements

D 2.4.1 Measurement of the Power Rating

(1) The diesel engine shall be operated on the basis of actual power ratings; it is not permissible to apply conversion formulas.

(2) The temperatures of the intake air and the charge-air cooling water shall not be lower than 6 °C below the specified reference condition.

(3) The throttle devices shall be adjusted such that, at rated continuous power and nominal speed, the maximum values of intake pressure loss and exhaust gas back pressure for the specified reference condition are attained. This adjustment of the throttle device position shall be maintained during the entire test run.

D 2.4.2 Measurement of Fuel Consumption

The fuel consumption shall be measured only when constant operating values (pressure and temperature) are reached.

D 2.4.3 Measurement of Lubricating Oil Consumption

The method for measuring the lubricating oil consumption shall be specified taking the type of lubricating oil system into account. The oil level readings before and after the test run shall be performed under similar boundary conditions. The oil amounts replenished during the test run shall be noted in the measurement record.

D 2.5 Analysis of the Operating Media

(1) Samples from the fuel, lubricating oil and coolant shall be removed from the running engine and shall be marked and sealed in the presence of the authorized expert (under Sec. 20 Atomic Energy Act).

(2) Two samples shall be removed in each case. The first sample shall be analyzed and the second sample shall be kept until the results of this analysis are available. The results shall be included in the test report.

(3) On the basis of the samples taken prior to the beginning of the test run and at each fuel replenishment, the engine manufacturer shall demonstrate that the fuel provided is in accordance with his own regulations.

D 2.6 Measurement Instruments

(1) All measurement instruments shall be compiled in a list and numbered in correspondence with the measurement location list. The list shall permit the subsequent identification of the measurement instruments used and shall include information on the detection methods and processing of the measured values.

(2) The display accuracy shall be demonstrated for all employed measurement instruments by means of test or calibration certificates which shall not be older than four months.

(3) The display range shall normally be selected such that the display at nominal power rating and nominal speed does not lie within the first third of the scale.

(4) The error limits of the measurement circuits including display instruments shall not be larger than ± 1.5 % of the upper display value. The deviations determined during the static calibration of the dynamometric brake shall be plotted and this plot included in the test report.

(5) To achieve a continuous monitoring of the test run, the following measurement values shall be documented with recording measurement devices:

a) engine speed,

b) brake load,

c) exhaust gas temperature or coolant outlet temperature of the individual cylinders, insofar as the measurement is possible with standard procedures,

d) exhaust gas temperature in the collector downstream from the exhaust gas turbocharger if a measurement of the exhaust gas temperatures at the individual cylinders is not possible.

(6) Proper functioning of the recording measurement devices shall be tested in quarter-hourly intervals. The recording paper shall be marked when inserted or replaced.

(7) Interruptions or malfunctions of the recording measurement devices shall be reported to the authorized expert (under Sec. 20 Atomic Energy Act) and noted on the recording paper.

D 3 Execution of the Test Run

D 3.1 General Requirements

(1) The type test shall be carried out under the sole responsibility of the engine manufacturer. The test run shall be supervised by an authorized expert (under Sec. 20 Atomic Energy Act).

(2) If irregularities occur during the type test, both the authorized expert (under Sec. 20 Atomic Energy Act) and the head of type testing shall be notified.

(3) The operating behavior of the engine during the test run shall be observed, e.g. with respect to

a) startup,

b) control,

c) operating noise,

d) vibrations,

e) functioning of the auxiliary systems,

f) heating-up of essential components,

g) leakages,

h) ignition failures.

Any deviations from the normal state shall be recorded.

(4) The data supplied by the displays of the measurement devices or by digital printers shall be recorded in the measurement record.

(5) The accuracy of the registrations in the measurement records shall be confirmed by the signature of the authorized expert (under Sec. 20 Atomic Energy Act).

(6) No traces from lubricating oil, fuel, coolant and exhaust gas on the engine may be removed during the type test.

D 3.2 Startup Procedures

The engine shall be started six times at nominal pressure from the preheated condition using compressed air tanks of known contents. The average amount of air required in each startup procedure shall be determined.

D 3.3 100 Hour Test Run

(1) The test run shall be carried out without interruption in accordance with the program specified in **Table D-3**. Measurements shall be carried out every hour at rated continuous power and at overload power capacity and prior to a power load change to partial power load.

(2) The power load changes in the course of the test run shall be performed such that the run-up to higher power levels reaches 0.9 times the specified power load and the run-down to lower power 1.1 times the specified power load within no more than 15 seconds.

(3) At the end of the last power cycle, the function and the static speed adjustment (P-degree) of the speed governor shall be determined by releasing the braking equipment three times.

D 4 Visual Inspection of the Engine Parts

(1) After the test run and after disassembling the engine, the following parts shall be visually inspected by the authorized expert (under Sec. 20 Atomic Energy Act). The results of the visual inspection shall be included in the test report.

a) Crankcase

Condition of the bearing shell seats (working traces), correct fitting of the cylinder liners, condition of the water jacket and of the contact surfaces of one cylinder (pitting, fouling).

b) Cylinder liners

Condition of the working surfaces (scoring, wear, working traces, oil carbonization) and, on one cylinder liner, condition of the outer surfaces (pitting) and of the cylinder liner collar (running traces).

c) Pistons

Condition of the piston head and top land (wear, burning traces, oil carbonization), of the piston ring grooves (wear-in, gumming up), of the piston skirt (wear, pitting, pressure traces, formation of oil varnish) and of the piston pin bushings.

d) Piston pins

Running traces.

e) Piston rings

Condition of the rings in the grooves (loose or firm). Formation of burrs, wear condition, impact traces on the partition surfaces and working traces on the sliding surfaces.

f) Piston rods

Seats of the bearing shells (working traces), condition of the piston pin bushing.

g) Crankshaft

Condition of the shaft and crank journals, the flange cone and the shaft bearing seal.

h) Bearings of crankshaft and connecting rod

Condition of backing, faces and butt (working traces), running traces (condition of the working layer, scoring, detachments, crumbling, cracking).

i) Cylinder heads

Condition of the cylinder heads (crack formation), the valve seats and the valve stem guides (gumming up) and the cylinder head gaskets.

k) Intake valves and exhaust valves

Condition of the valve seats (pocketing or pitting), condition of the lower part of the stem (oil carbonization).

l) Injection nozzles

Ejection appearance, ejection pressure, post-ejection dribble, appearance regarding overheating (color and gumming up).

m) Injection pumps

Smooth running of the control rod, condition of the camshaft (in the case of unit control pumps).

n) Exhaust gas turbocharger

General condition (fouling, oil wetting), condition of bearings, condition of the turbine blades.

o) Gears

Surface appearance (pitting, unilateral or oblique wear), condition of bearings.

p) Camshafts

Condition of the control cams and the bearing locations.

q) Valve tappets and rocker arms

General condition.

r) Lubricating oil pump

General condition.

s) Water pump

General condition, in particular, of the bearings, the sealing rings and the pump wheel.

(2) Of the above-mentioned parts, one unit each shall be photographed. If it is required to confirm an evaluation, several units shall normally be photographed. The photographs shall be included in the test report.

(3) If any damage is suspected, additional tests shall be agreed upon.

D 5 Interruptions of the Test Run

(1) During the test run, only two interruptions due to malfunctions are permissible. The interruption caused by a malfunction shall not exceed 20 minutes before a restart, and the test-run conditions shall be restored within the shortest possible time. The duration of the interrupted section of the test program (cf. **Table D-2**) shall be extended by the duration of the interruption. Malfunctions are all events leading to an interruption of the test run as a result of defects or damages of parts and systems of the engine, provided, these are component parts of the diesel generator unit to be tested.

(2) Interruptions for external reasons which are not a result of defects of the tested diesel engine or of its auxiliary systems, rather are, e.g., caused by equipment of the test bench, shall not be considered as malfunctions. In the case of interruptions for external reasons, the continuation of the test run shall be agreed upon between manufacturer and authorized expert (under Sec. 20 Atomic Energy Act).

(3) Interruptions for external reasons shall be considered as malfunctions if the manufacturer uses the interruption to eliminate engine defects. The time invested for this purpose shall not exceed 20 minutes.

(4) Irrespective of the type of interruption, the test run shall normally not be interrupted more than a total of three times.

No.	Measurement Values, measured or calculated	During startup tests	During rated continuous power, overpower and partial power	During cyclic power loading
1	Engine speed	–	x	–
2	Brake load	–	x	–
3	Braking power (calculated)	–	x	–
4	Fuel, measured quantity [1]	–	x	–
5	Fuel, temperature	–	x	–
6	Fuel, flow stopping time[1]	–	x	–
7	Fuel, hourly consumption (calculated)	–	x	–
8	Fuel, specific consumption (calculated)	–	x	–
9	Fuel level indicator	–	x	–
10	Lubricating oil, pressure	–	x	–
11	Lubricating oil, temperature upstream of engine	x	x	–
12	Lubricating oil, temperature downstream of engine	x	x	–
13	Lubricating oil, replenished quantity	–	x	x
14	Coolant, temperature upstream of engine	x	x	–
15	Coolant, temperature downstream of engine	x	x	–
16	Intake air, temperature	x	x	–
17	Charge-air, temperature upstream of charge-air cooler	–	x	–
18	Coolant, temperature upstream of charge-air cooler	–	x	–
19	Charge-air, temperature downstream of charge-air cooler	–	x	–
20	Intake air, sub-atmospheric pressure	–	x	–
21	Charge-air, pressure downstream of charge-air cooler	–	x	–
22	Gas exhaust turbocharger, rotational speed	–	x	–
23	Gas exhaust, temperature downstream of gas exhaust turbocharger	–	x	–
24	Gas exhaust, temperature at cylinder outlet [2]	–	x [3]	–
25	Gas exhaust, pressure downstream of gas exhaust turbocharger	–	x	–
26	Gas exhaust, smoke index	–	x	–
27	Intake air, barometric pressure	x	x	–
28	Air consumption, startup (calculated)	x	–	–
29	Speed governor, P-degree	–	–	x
30	Maximum combustion pressure in the cylinder [2]	–	x [4]	–

1) In the case of an automatic evaluation, the recording of this measurement value is not required.
2) insofar as a measurement location is possible as a standard feature
3) continuous monitoring by observation or by limit value alarm
4) at the beginning and at the end of the rated continuous power run

Table D-1: Measurements and evaluations during the 100 hour test run

No.	Mode of Operation	Duration	Effective Power *in % of rated continuous power*	Remarks
1	Rated continuous power	80 h	100 %	All power loads shall be applied at a constant governor setting for the nominal speed at 100 % power load.
2	Overload power	1 h	110 %	
3	Rated power	2 h 30 min	100 %	
4	Partial power	2 h 30 min	75 %	
5	Partial power	2 h 30 min	50 %	
6	Partial power	2 h 30 min	25 %	
7	Cyclic power loads			
	5 x cycle	2 min 8 min	15 % 100 %	
8	5 x cycle	4 min 6 min	25 % 100 %	
9	18 x cycle	4 min 6 min	50 % 100 %	
10	26 x cycle	4 min 6 min	75 % 100 %	

Table D-2: Test program of the 100 hour test run

Appendix E

Regulations Referred to in this Safety Standard

Regulations referred to in this safety standard are only valid in the version cited below. Regulations which are referred to within these regulations are valid only in the version that was valid when the latter regulations were established or issued.

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, p. 814) as amended on July 15, 1985 (BGBl. I, p. 1565), most recently changed by law on April 6, 1998 (BGBl. I, p. 694)
GL 90	(07/87)	Guidelines for series-produced engines, Sec. 4 (Germanischer Lloyd AG)
UIC 623-2 VE	(07/97)	Qualification tests for diesel engines in vehicles Union International de Chemin de Fer (International Train Worker Association)