

Safety Standards

of the
Nuclear Safety Standards Commission (KTA)

KTA 3703 (2022-11)

**Emergency Power Facilities with Batteries
and AC/DC Converters in Nuclear Power Plants**

(Notstromerzeugungsanlagen mit Batterien
und Gleichrichtergeräten in Kernkraftwerken)

Previous versions of this safety standard
were issued in 1999-06 and 2012-11

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

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Emergency Power Facilities with Batteries and AC/DC Converters in Nuclear Power Plants

KTA 3703

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PLEASE NOTE: Only the original German version of this safety standard represents the joint resolution of the 35-member Nuclear Safety Standards Commission (Kerntechnischer Ausschuss, KTA). The German version was made public in the Federal Gazette (Bundesanzeiger) on July 25, 2023. Copies of the German versions of the KTA safety standards may be mail-ordered through the Wolters Kluwer Deutschland GmbH (info@wolterskluwer.de). Downloads of the English translations are available at the KTA website (<http://www.kta-gs.de>).

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

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Comments by the Editor:

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

shall	indicates a mandatory requirement,
shall basically	is used in the case of mandatory requirements to which specific exceptions (and only those!) are permitted. It is a requirement of the KTA that these exceptions - other than those in the case of shall normally - are specified in the text of the safety standard,
shall normally	indicates a requirement to which exceptions are permissible. However, exceptions used shall be substantiated during the licensing procedure,
should	indicates a recommendation or an example of good practice,
may	indicates an acceptable or permissible method within the scope of this safety standard.

Basic Principles

(1) The safety standards of the Nuclear Safety Standards Commission (KTA) have the task of specifying those safety-related requirements which shall be met with regard to precautions to be taken in accordance with the state of science and technology against damage arising from the construction and operation of the plant (Sec. 7, para. (2), subpara. (3) Atomic Energy Act - AtG) in order to attain the protective goals specified in the AtG, the Radiation Protection Act (StrlSchG) and the Radiation Protection Ordinance (StrlSchV) as well as further detailed in the Safety Requirements for Nuclear Power Plants (SiAnf) and the Interpretations of the SiAnf.

(2) Based on the Safety Requirements and their interpretations, the safety standards KTA 3701 through KTA 3705 specify the requirements for the energy supply of the safety system.

(3) In the present safety standard, it is presumed that the conventional requirements and standards (e.g., the German Occupational Accident Prevention Regulations, DIN Standards and VDE Regulations) are met unless other safety-related requirements are specified on account of the specifics of nuclear power plants.

(4) The present safety standard contains the special requirements for emergency power generation facilities with batteries and rectifier units. Superordinate requirements for the electrical power supply in nuclear power plants are specified in KTA 3701. The latter also includes requirements for the electronic modules of rectifier units.

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

(6) The requirements for emergency power facilities with converters in nuclear power plants are specified in KTA 3704.

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

(8) The KTA safety standards consider the emergency power facilities as ending at the connection terminals of the individual power loads. Requirements for the power loads are, therefore, specified in the component-specific safety standards KTA 3501 and KTA 3504.

(9) The basic requirements regarding quality assurance are specified in KTA 1401.

(10) The requirements regarding explosion protection in nuclear power plants with light water reactors are specified in KTA 2103.

(11) The requirements regarding the seismic design of mechanical and electrical components in nuclear power plants are specified in KTA 2201.4.

1 Scope

This safety standard applies to emergency power generation facilities with vented lead-acid batteries and rectifier units (referred to in the following as 'battery facilities') in stationary nuclear power plants.

Note :

Figure 1-1 is a graphic representation of the scope.

2 Definitions

(1) Stand-by parallel operation of battery facilities

The stand-by parallel operation of battery facilities is a parallel

operation where the battery delivers electrical current only when the supply from the rectifier unit is not available.

(2) Discharge time period

The discharge time period is the time period between the begin of discharge until the minimum permissible battery cell voltage, U_{Zmin} , is reached.

Note :

The minimum permissible battery cell voltage, U_{Zmin} , is specified in Section 4.5.2.2.

(3) Battery, vented

A vented battery consists of battery cells where the cover of each cell has one or more vent openings through which the produced gasses can escape.

(4) Parallel operation of battery facilities

The parallel operation of battery facilities is an operation mode where the power load, the rectifier unit, and the battery are continuously connected in parallel.

3 General Requirements

(1) The design of the battery facilities, the switch gear, the distribution facilities and the DC power loads shall be coordinated such that the static and dynamic supply voltage limits permissible for the power loads will not be exceeded.

(2) The effects of failure-inducing events inside the battery facilities on the nuclear power plant shall be analyzed with respect to their permissibility.

Note :

In the system design, one assumes, e.g., that a failure-inducing event (e.g., short circuit) can cause a failure of one train of the DC power supply and, thereby, a failure of the power loads (e.g., magnetic valves) that are supplied from a single power source.

4 Design

4.1 Circuit Design Concept and Supply of the Power Loads

(1) When specifying the circuit design concepts due consideration shall, in particular, be given to the redundancy of the supplied power loads and the effects of component failures in the battery facilities on the reliability of the supplied power loads.

(2) Battery facilities supplying train-oriented power loads shall be designed as consisting of functionally and spatially separated trains.

(3) Regarding the power supply of rectifier units and power loads one of the following circuit design concepts shall normally be chosen:

a) One rectifier unit for each train of the battery facility. The connection of the rectifier unit to the diesel emergency power facility of the same train. Supply of the power loads of one train from the associated train of the battery facility, or supply of the power loads of one train from the associated train and from a neighboring train of the battery facility (e.g., **Figure 4-1**).

b) Two rectifier units for each train of the battery facility. Connection of the first rectifier unit to the diesel emergency power facility of the same train, connection of the second rectifier unit to the diesel emergency power generator of a neighboring train. In this case, each one of the rectifier units shall be designed for 100 % of the electrical current requirements of the train. The power loads of the individual trains shall be supplied only from the associated train of the battery facility (e.g., **Figure 4-2**).

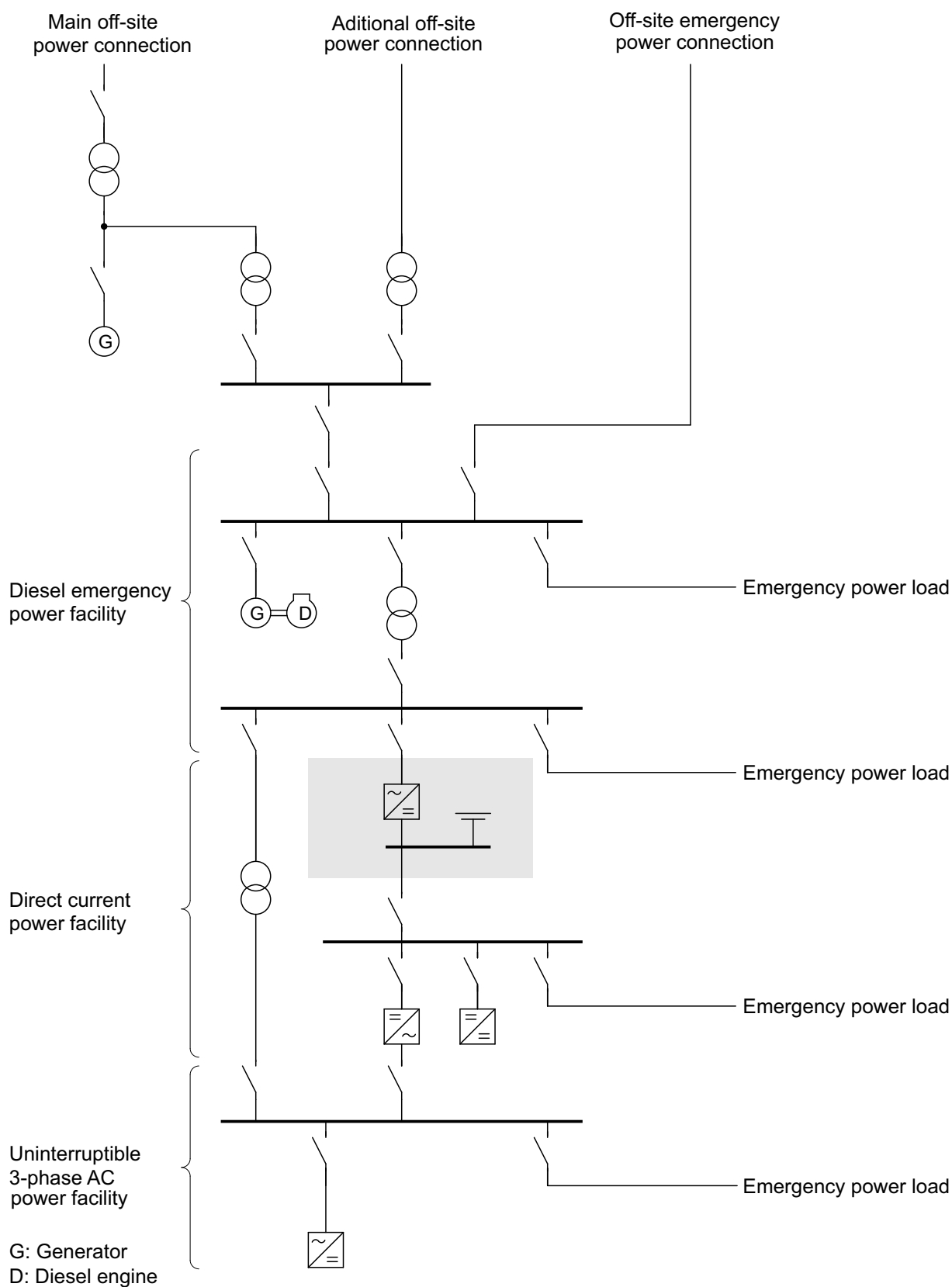


Figure 1-1: Scope of this safety standard (grayed area)

(4) When choosing a diode-decoupled dual supply for the power load as specified in Section 4.2, para. 3, item a) or a dual supply on the rectifier side as specified in Section 4.2, para. 3, item b), the connections to the neighboring train shall be designed such that none of the failure possibilities to be considered can cause more than one train to fail.

4.2 Circuit Design of the Battery Facilities

(1) The following points shall be considered in specifying the circuit design of battery facilities:

- a) Nominal voltage of the system,
- b) Failure detection and failure removal,
- c) Requirements from the connected power loads,
- d) Physical extent of the circuit,
- e) Isolation possibility,
- f) Lightning protection, and
- g) Overvoltage protection.

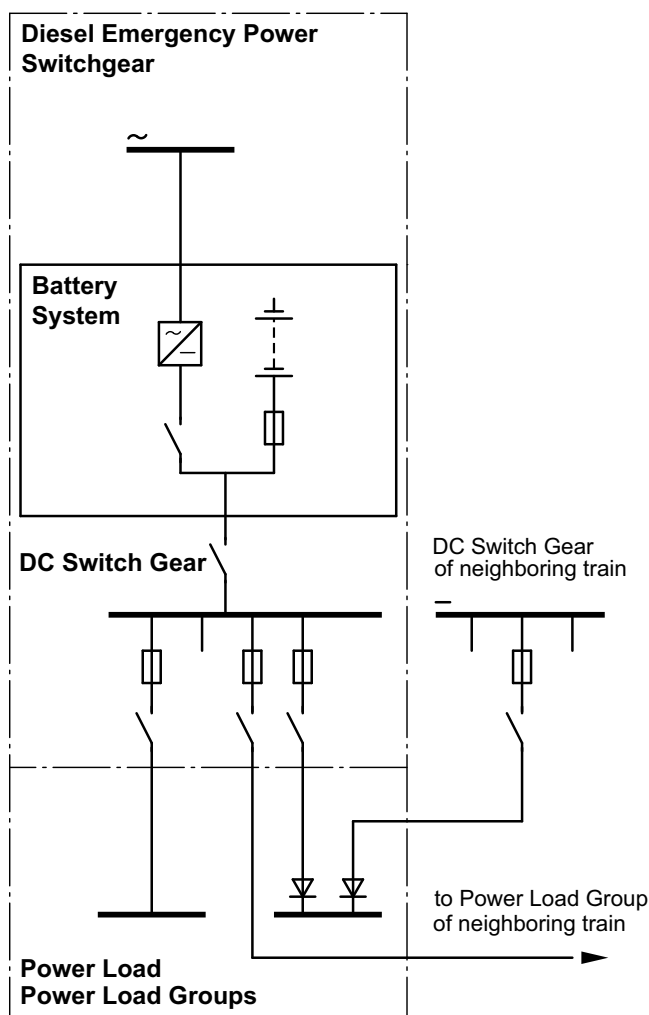


Figure 4-1: Example of a circuit concept for one train of a battery facility with one rectifier unit per train, with singly supplied and dually supplied power loads (cf. Section 4.1, para. (3) item a))

(2) If a DC circuit is operated in a grounded condition, the battery facility shall meet the following requirements:

- a) The cross-section of the grounded conductor between battery, rectifier unit, and DC switchgear shall be equal to the cross-section of the non-grounded conductor. The grounded conductor shall not be fused.
- b) In case of centralized grounding, the DC circuit shall be grounded at a mutual connecting point.

- c) In case of decentralized grounding, the DC circuit shall be grounded at the instrumentation and control cabinets, and at the desks and panels of the control room.
- d) The M-conduit should not be grounded, neither in the battery facility nor in the DC switchgear.

Note:

In the case of a decentralized grounding, this will prevent operating currents from partially flowing through the grounding facility between power loads and switchgear.

(3) If a DC circuit is operated in a non-grounded condition, the battery facilities shall meet the following requirements:

- a) The condition of the insulation shall be continuously monitored. It shall be possible to identify the locations of ground shorts.
- b) In the case of battery facilities where the power loads are supplied through diode decouplers, a voltage doubling from a possible dual ground short shall be prevented.

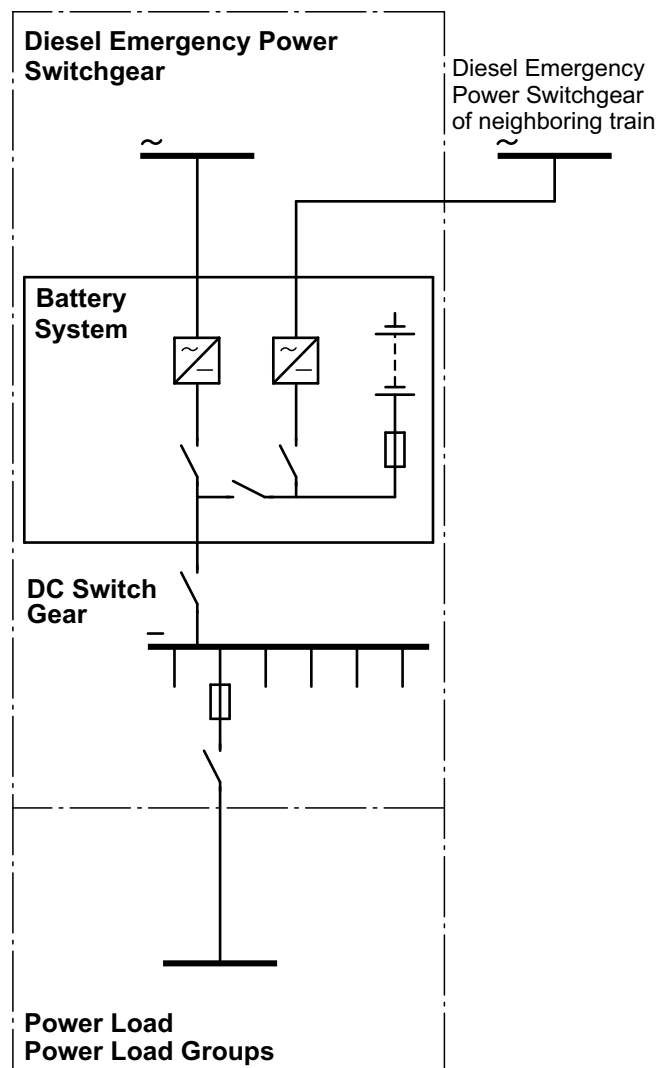


Figure 4-2: Example of the circuit concept for one train of a battery facility with two rectifier units per train and with singly supplied power loads (cf. Section 4.1, para. (3) item b))

4.3 Detailed Electrical Current Balance and Limit Values

4.3.1 General requirements

The electrical current requirements of the power loads shall be determined separately for each train taking into account the operating cases and design basis accidents to be considered

for the nuclear power plant as well as the chronological sequence. In this context, all electrical currents of those power loads that can be connected to one train during the operating cases and design basis accidents to be considered shall be determined as a function of time.

4.3.2 Determination of the electrical current requirements

(1) Prior to designing the battery facilities, a detailed balance of the power-load currents shall be established in the form of a current-versus-time diagram both for the discharge time periods specified in Section 4.3.4 of each equipment arrangement of a train as well as for each load case to be considered. In this context, the following independent load cases shall be taken into account:

- a) Dead-voltage interval upon failure of the station service equipment (startup period of the diesel generator plus the time required for reconnecting the rectifier units): In this interval, the battery may supply the power loads of the associated train as well as of the dually supplied power loads in a neighboring train.
- b) Discharge of the battery over the specified discharge time period: As specified in Section 4.3.4, it shall be assumed that in each train the battery supplies all train-specific power loads.

Note :

Dually supplied power loads of a neighboring train which must be supplied after the zero-voltage phase in case of a non-availability of a rectifier unit are considered in the design of the rectifier units (cf. Section 4.5.3.1).

(2) The two mutually independent load cases specified in para. (1), items a) and b) may be introduced sequentially when establishing the current-versus-time diagram.

(3) The detailed balance of the power-load currents shall contain:

- a) Electrical current requirements of all power loads which can be supplied from the respective train of the battery facility during the load cases specified in para. (1), items a) and b).
- b) Static and dynamic load changes, and
- c) Electrical transmission losses.

(4) In the case of intermittently operated power loads or power load groups, the power-load currents shall be multiplied by a simultaneity factor to be specified. This simultaneity factor may be different for different loading cases. In cases where, for procedural reasons, the electrical actuation operation will occur at the same point in time, the simultaneity factor shall be set equal to 1.

(5) Load changes shall be included in the design of the battery and the rectifier unit such that the limit values specified in Section 4.3.5 are observed.

4.3.3 Safety margin of the electrical current requirements

A safety margin shall be added to the determined electrical current requirements. This safety margin shall amount to at least 10 % of the electrical current requirements determined at the begin of the erection of the battery buildings. These reserves shall not be completely used up by any plant design changes.

4.3.4 Discharge time period

(1) The discharge time period shall be specified in accordance with the requirements from process technology and power supply equipment. The discharge time period shall not be shorter than two (2) hours.

(2) The discharge time period shall be specified for each battery of a train under the assumption that this one battery alone must deliver the entire electrical current required in accordance with the current-versus-time diagram specified in Section 4.3.2 plus the safety margin specified in Section 4.3.3.

4.3.5 Limit Values

(1) The design of the battery facilities, of the corresponding protection and monitoring equipment and of the cable network shall be coordinated such that the limit values permissible for the power loads are not exceeded even under the most unfavorable ambient conditions and the largest operational load conditions during specified normal operation or during design basis accidents.

Note :

The operation related load conditions considered in this context are, e.g., load shedding to station service, station service switch-over and offsite power transients.

(2) For the standby parallel operation of the battery and rectifier unit, the limit values of the rectifier unit shall meet the requirements specified in **Table 4-1** and under the following para. (3).

(3) With regard to the limit values of the DC output voltage of the parallel operated rectifier unit, the following requirements apply in addition the consideration of the output voltage dependency on the float charge voltage as specified in Section 4.5.3.2, para. (1):

- a) The upper static limit value shall be specified as a function of the maximum voltage permanently permissible at the power loads of the systems to be supplied and shall be considered in specifying the number of battery cells as specified in Section 4.5.2.1.
- b) The upper dynamic limit values shall be specified as a function of the short-time overvoltage permissible at the power loads of the systems to be supplied.
- c) The limit values and time delays of the protection and monitoring equipment shall normally be specified such that operational transients on the AC end (e.g., due to the startup of powerful motors or load shedding) will not cause the rectifier unit to shut down. However, if continued operation of the rectifier unit would cause impermissible overvoltages at the DC end, it may be necessary to briefly interrupt the electrical current supply from the rectifier unit.
- d) In the case of parallel operation, it is not necessary to specify the lower static and dynamic limit values of the DC output voltage of the rectifier unit.

Note :

The requirements for the design of the battery specified in Section 4.6.2 apply (also) to these cases.

(4) If a short-duration stand-alone operation of the rectifier unit is required (e.g., for the revision of a battery during plant outage), the corresponding limit values for the DC end of the rectifier unit shall be specified.

4.4 Qualification

4.4.1 Qualification of the battery facility

(1) The qualification of the battery facility with regard to its utilization in nuclear power plants shall be verified as specified in Sections 4.4.2 and 4.4.3.

(2) If the utilization in nuclear power plants requires additional safety related characteristics, which cannot be verified by the type tests specified in Section 5.2 nor by the certified satisfactory service life, then additional qualification tests shall be carried out for these components.

No.	Characteristic Parameters	Limit Values		cf. Footnotes
		upper	lower	
1	AC End			a
1.1	Connection voltage relative to U_N , the nominal voltage			
1.1.1	Static voltage deviation	$0.9 U_N$	$1.1 U_N$	
1.1.2	Dynamic voltage change	$0.8 U_N$	$1.15 U_N$	b
1.2	Connection frequency relative to f_N , the nominal frequency			
1.2.1	Static frequency deviation	$0.95 f_N$	$1.05 f_N$	
1.2.2	Dynamic frequency change	$0.90 f_N$	$1.15 f_N$	
2	DC End			c
2.1	Float charge voltage ($U_{LE} = n \times U_{ZLE}$) Static condition during standby parallel operation in the load range up to 100 % of the nominal DC current, I_{dN}	$0.99 U_{LE}$	$1.01 U_{LE}$	d
2.2	Frequency band width of the superimposed alternating voltages, $U_{ÜSS}$	< 300 Hz	$0.05 U_d$	e
		≥ 300 Hz	$0.10 U_d$	
a Limit values at the connection terminals of the rectifier unit				
b Whenever the upper limit value of $1.15 U_N$ is exceeded, the rectifier unit shall be shut down (see Table 4-2 , No. 1.1) and shall be automatically restarted as soon as a permissible voltage value (e.g., $1.10 U_N$) is reached.				
c Limit values at the connection terminals of the battery				
d Limit values apply to the tolerance band width of the static values of the connection voltage (No. 1.1.1) and of the connection frequency (No. 1.2.1)				
e Only in the case of 24 V-battery facilities				

Table 4-1: Limit values for the design of the rectifier unit

(3) Type and extent of the qualification test shall be specified in agreement with the proper nuclear authority or with an authorized expert appointed in Section 20 AtG by this authority. In this context, the periods of operation of the battery facility before the first criticality of the nuclear power plant may be taken into account.

4.4.2 Qualification of the battery

- (1) A battery may be assumed as being qualified, provided,
- a type test as specified in Section 5.2.1 has been successfully carried out on this cell type, and
 - the certified satisfactory service life is demonstrated by the operation of 10 batteries with similarly built battery cells, each battery having been subjected to at least three operating years under comparable operating conditions.
- (2) In case of any indications with respect to overstressed components, to choice of wrong materials or to other common-mode failures, it shall be verified that the failure cause has been rectified.
- (3) Battery cells shall be considered as being similarly built if their essential component parts are alike with respect to design, materials, and manufacturing, and their quality assurance is equivalent.
- (4) If the certified satisfactory service life cannot be demonstrated on similarly built battery cells, a separate verification is permissible in well substantiated cases for the individual differing component parts.

4.4.3 Qualification of the rectifier unit

- (1) A rectifier unit may be assumed as being qualified, provided,

- a type test as specified in Section 5.2.2 has been successfully carried out on this type of rectifier unit, and
- the certified satisfactory service life is demonstrated by the operation of 10 rectifier unit of this fabrication series, with each unit having been subjected to at least three operating years under comparable operating conditions.

(2) In case of any indications with respect to overstressed components, to choice of wrong materials or to other common-mode failures, it shall be verified that the failure cause has been rectified.

(3) Rectifier units shall be considered as being part of the same fabrication series if, considering the graded nominal electrical current level, they are constructed on the basis of a similar design concept and if they are similar with respect to circuitry, controls, and monitoring.

(4) If the rectifier units to be installed in the nuclear power plant have individual component parts that are different from the fabrication series used for demonstrating the certified satisfactory service life, a separate verification is permissible in well substantiated cases for these component parts.

4.5 Design of the Battery Facility

4.5.1 Design of the system

(1) The design of the system with its individual components (batteries, rectifier units, connections between batteries and rectifiers, fuses, switching devices) shall be based on the detailed electrical current balance established for the current in each train as specified in Section 4.3.

(2) The design of all components shall be coordinated with respect to their electrical-current-conducting capability and their thermal and dynamic short-to-ground resistance and shall be designed for the maximum load cases.

4.5.2 Design of the battery

4.5.2.1 Determining the number of battery cells

The number of battery cells shall be determined from the static upper limit value of the float charge voltage per battery cell, U_{ZLEmax} , and from the continuously permissible maximum voltage at the power load, U_{Vmax} , by applying the following equation

$$n \leq \frac{U_{Vmax} + \Delta U_{min}}{U_{ZLEmax}} \quad (4-1)$$

Nomenclature:

n	[-]	number of battery cells (cf. Section 4.5.2.1)
U_{Vmax}	[V]	continuously permissible maximum voltage level at the power load
ΔU_{min}	[V]	minimum possible voltage drop between battery terminal and power load
U_{ZLEmax}	[V]	static upper limit value of the float charge voltage per battery cell ($U_{ZLEmax} = 1.01 U_{ZLE}$)
U_{ZLE}	[V]	average float charge voltage per battery cell

Note:

A usual value for U_{ZLE} is 2.23 V.

4.5.2.2 Determination of the battery capacity

(1) The battery capacity shall be determined on the basis of the current-versus-time diagram plus the safety margin respectively specified in Sections 4.3.2 and 4.3.3.

(2) While discharging, the static and dynamic loads shall not cause the battery voltage to drop below the minimum voltage level, U_{Vmin} , continuously permissible for the power load. The minimum cell voltage, U_{Zmin} , is specified by the following equation

$$U_{Zmin} \geq \frac{U_{Vmin} + \Delta U_{max}}{n} \quad (4-2)$$

Nomenclature:

U_{Zmin}	[V]	lowest voltage of the single battery cell
U_{Vmin}	[V]	continuously permissible minimum voltage level at the power load
ΔU_{max}	[V]	maximum possible voltage drop between battery terminal and power load
n	[-]	number of battery cells (cf. Section 4.5.2.1).

When specifying ΔU_{max} and U_{Zmin} the following shall be taken into account:

- all series-connected maximum voltage drops between the battery terminals and the terminals of the power loads (e.g., diodes, cables, shunts, fuses),
- the maximum electrical current drawn by the power loads (startup current of motors and DC/AC inverters, load variations during control procedures, ambient temperatures), and
- the momentary voltage reduction occurring when a fully charged battery begins to be discharged.

(3) The nominal capacity shall be chosen such that within the specified battery discharge period the minimum voltage specified in para. (2) is maintained taking both the current-versus-time diagram (cf. Section 4.3) and the capacity characteristic of the employed cell type into account. In this context, an ageing-induced reduction of the capacity shall also be taken into account. The nominal battery capacity shall normally be determined based on an electrolyte temperature of 20 °C.

(4) The battery design shall be based on a specified capacity limit value, K_{limit} , up to which limit the requirements specified

in para. (3) shall be met. K_{limit} is indicative for the minimum required capacity reserve and it is a criterion for the in-service inspections specified in **Table 5-3**. This design limit value shall be specified not to be lower than 80 % of the nominal battery capacity.

4.5.2.3 Requirements for the battery casing

(1) Only transparent battery casings shall be used.

(2) In the case semi-crystalline plastics are employed, the battery casings shall be tempered.

4.5.3 Design of the rectifier unit

4.5.3.1 Nominal electrical current

(1) The design of the rectifier unit shall be based on the electrical current requirements determined for the power loads of the associated train and for the dually supplied power loads of a neighboring train plus the safety margin (cf. Section 4.3.3). The rectifier unit shall cover these electrical current requirements; however, current peaks (e.g., caused by the start-up of motors) do not need to be considered in the design of the rectifier unit, provided, the corresponding capacity-drain from the battery is negligible.

(2) The rectifier unit shall be able to deliver a recharging current in addition to the electrical current requirements of the associated train. The recharging current to be considered shall amount to at least the ten-hour discharge current, I_{10} , of the battery.

(3) A parallel operation of two rectifier units supplied from the same train of the diesel generator facility is permissible, provided, each unit is designed for at least 50 % of the electrical current requirements. In this context, the requirements of Section 4.3.5 shall be met.

4.5.3.2 DC output voltage

(1) The DC output voltage of the rectifier unit, U_d , shall be adjusted such that the float charge voltage at the battery is maintained under consideration of the static limit values and the voltage drop.

The following applies

$$U_d = n \times U_{ZLE} (1 \pm 0.01) + \Delta U_B \quad (4-3)$$

Nomenclature:

U_d	[V]	DC output voltage of the rectifier unit
n	[-]	number of battery cells (as specified in Section 4.5.2.1)
U_{ZLE}	[V]	average float charge voltage per battery cell
ΔU_B	[V]	voltage drop along the connection between rectifier unit and battery

(2) When specifying the DC output voltage, dynamic loads lower than the nominal electrical current of the rectifier unit shall also be taken into account in order that these occasional loads will not cause a reduction of the available capacity nor of the discharge time period.

Note:

In this context, it may be necessary to adjust the float charge voltage to be higher than the usual value of 2.23 V per battery cell.

(3) Manual switching shall be possible for charging the battery at voltages higher than the float charge voltage specified in para. (1) (e.g., boost-charge operation). Technical measures shall ensure that the adjustment to higher voltages can only be carried out when the corresponding power loads have been shut down.

4.5.3.3 Structural considerations

- (1) The spatial arrangement of the terminal regions of the AC end and the DC end shall be such that no vagabond voltages can occur during construction and testing activities.
- (2) The spatial arrangement of the individual components shall be such that they can be quickly exchanged.

4.5.4 Connection between battery, rectifier unit, and switchgear

In addition to their spatial separation, the arrangement of the batteries and rectifier units shall meet the following requirements:

- a) The connections between battery, rectifier unit and switchgear shall be designed to be short.
- b) The connecting point between battery, rectifier unit, and switchgear shall normally be located in close proximity to the battery.
- c) One separator including the fuses for the battery shall be located outside of the battery room, however, in close proximity to the battery.

- d) The conductors from the battery terminals to the fuses shall be routed such that they are short-circuit and earth fault proof. Therefore, no short circuits need to be considered in this area.

4.5.5 Short-circuit resistance

All components of the battery facility shall, basically, be designed for the mechanical and thermal loads from the maximum possible short-circuit currents. As specified in Section 4.5.4, item d), no short circuits need to be assumed between the battery terminals and the battery fuses.

4.6 Instrumentation and Control Equipment

4.6.1 General requirements

The instrumentation and control equipment for the operation, surveillance, and protection of battery facilities shall correspond to the train design and the train correlation of the battery facilities.

1	2	3	4	5
No.	Measurand / Criterion	Monitoring		Protective Shutdown
		On Site	Main Control Room	
1	Rectifier Unit	at the rectifier unit		
1.1	Connection AC voltage (limit value specified in Table 4-1 No. 1.1.2)	$\underline{M}$ $\overline{M}$	SM	$\underline{S}^{4)}$ $\overline{S}^{4)}$
1.2	Output DC voltage	A $\overline{M}$ $\underline{M}$	SM	$\overline{S}^{2) 1)}$ $\underline{S}^{1)}$
1.3	Output current	A	—	—
1.4	Short-circuit protection (specified in Section 4.7.3, para. (2))	M	SM	S
1.5	Frequency band width (limit value specified in Table 4-1 No. 2.2)	$\overline{M}^{3)}$	SM ³⁾	$\overline{S}^{3)}$
1.6	Fuse surveillance (thyristor fuses, control circuit fuses)	M	SM	S
1.7	Failure of a rectifier unit during parallel operation	M	SM	—
1.8	Failure of a rectifier unit of the ± 24 V facilities	M	SM	S ⁵⁾
2	Battery	at the battery facility		
2.1	Monitoring for a disruption inside the battery and between the battery and rectifier unit	M	M	—
2.2	Battery current	A	—	—
A : display M : alarm SM : collective alarm, upset condition of the rectifier unit A delay of the collective alarm is permissible (e.g., startup of the Diesel facility) $\overline{M}$: alarm, upper limit value $\underline{M}$: alarm, lower limit value 1) It is permissible to briefly interrupt the electrical current supply of the rectifier unit (cf. Section 3.5, para. (3) item c)). 2) With a time delay 3) Only in the case of 24 V battery facilities 4) Short-period shutdown with automatic startup after return of the AC voltage within the permissible limits 5) Shutdown of both associated rectifier units provided this is required for the protection of the power loads S : protective shutdown $\overline{S}$: protective shutdown, upper limit value 1 $\underline{S}$: protective shutdown, upper limit value 2 $\underline{S}$: protective shutdown, lower limit value				

Table 4-2: Display, alarms and protective shutdowns for one train of a battery facility

4.6.2 Monitoring

(1) Monitoring equipment shall be provided that indicates, by displays and alarms, the state of the functional readiness, the operating condition, and any exceedance of limit values.

(2) The monitoring equipment shall be arranged to meet the requirements of operation, servicing and repair and shall normally be separated according to

- a) the displays and single alarms at the rectifier unit,
- b) the displays and single alarms at the battery-feeder cabinet
- c) displays and group alarms in the main control room.

(3) The arrangement of the displays and alarms shall enable establishing the operational condition of the battery facility. In this context, it is permissible to place a group display on the front side of the rectifier unit cabinet and to place the individual displays on the modules inside of the cabinet. Train-oriented collective alarms shall normally be directed to the main control room.

(4) The required alarm displays for monitoring one train of a battery facility are listed in Columns 3 and 4 of **Table 4-2**.

(5) The group displays in the control room shall be treated as Class I alarms, and the individual alarms as Class II alarms, provided, they can be followed back to their origin.

Note :

The requirements regarding the different classes of alarms are specified in KTA 3501.

4.6.3 Protection

(1) Protection equipment shall be provided for the detection of failures and defects in and around the battery facility and for effecting the necessary circuit shutdowns. In this context, the shutting down of short-circuit currents shall maintain the selectivity between the battery fuses and the short-circuit protection measures in the branch circuits of the DC switchgear. In this context, the minimum short-circuit currents at the end of the specified battery discharge period shall also be maintained. Regarding a single train of a battery facility, the necessary protection shutdowns are listed in **Table 4-2**, Column 5. Additional protection shutdowns shall be evaluated with regard to their necessity and reliability.

(2) In case of short circuits within the range of the rectifier unit up to and including the bus of the DC switchgear, protection equipment shall be provided to shut down the rectifier unit unless the electrical current limiter of the rectifier unit can prevent a reaction of the rectifier unit fuses.

Note :

Such protection equipment detects, e.g., an undervoltage at the output end of the rectifier unit.

(3) If a single fuse cannot protect against particular electrical current levels, it is permissible to use parallel fuses. In this case, in order to achieve a uniform current distribution, the following requirements shall be met:

- a) same make of the fuses.
- b) same type of the fuses,
- c) same nominal values of the fuses, as well as
- d) same electric resistance in the parallel branches leading to and away from the fuses.

(4) The limit values and time delays of the protection shut-down in the case of an overvoltage on the DC side of the rectifier unit (cf. **Table 4-2**, No. 1.2) shall be coordinated with the design values specified for an overvoltage of the supplied power loads.

(5) In the case of a diode-decoupled power supply to the power load, the overvoltage protection equipment for the DC side of the rectifier units shall be designed such that shut-down of a faulty rectifier unit is ensured even in case of a single failure within the overvoltage protection equipment.

4.7 Testability

(1) The instrumentation and control equipment of the battery facility shall normally be designed such that the in-service inspections specified in Section 5.7 can be carried out without manipulation of the circuitry.

(2) Preinstalled test sockets shall be provided that allows connecting the discharging device required for the capacity test to the battery facility.

4.8 Location and Placement

(1) The location of the battery rooms and the placement of the batteries and rectifier units within these rooms shall correspond to the redundant train correlation of the battery facilities and shall take the design basis accidents and external events to be considered for the individual battery facility into account.

Note :

In the case of spatially limited events (e.g., aircraft crash), a correspondingly large spatial separation between the trains may be sufficient, provided, loss of one train is permissible.

(2) The design of the battery facilities shall take the following requirements into account:

- a) In the case the batteries employed are not gas-tight, the rectifier units shall normally be placed outside of the battery rooms with due consideration of the basic requirement of short lengths of the interconnections.
- b) The temperature in the battery room shall normally be kept between 18 °C and 25 °C.

(3) Due consideration shall be given to good accessibility for servicing, visual inspection and repairs as well as to good transportation possibilities for the components of the battery facility.

5 Tests and Inspections

5.1 Required Documents

(1) The proper nuclear authority or an authorized expert appointed in Section 20 AtG by this authority shall be presented with documents verifying that the battery facilities were designed, fabricated, installed and tested in accordance with the safety related requirements.

(2) Test and examination procedures shall be established in agreement with the proper nuclear authority or an authorized expert appointed in Section 20 AtG by this authority, in as far as this safety standard does not specify detailed testing requirements.

5.2 Type Testing

5.2.1 Battery

(1) It shall be verified that each battery type was subjected to a type test in accordance with **Table 5-1**. The type tests shall be carried out on six battery cells of each battery cell type.

(2) If necessary with regard to the individual application, it shall be verified that the batteries will withstand the induced vibrations within the framework of specified requirements. In case of the battery cells, a vibration test shall be used for this verification. In case of the battery rack, an analytical verification is permissible. Vibration tests on other batteries comparable with regard to their vibration characteristics may be used for this verification.

No.	Type of Test
1	Capacity
2	Suitability for float charging
3	Durability during the discharging and charging cycles
4	Charge conservation
5	Short-circuit current and internal resistance
Note: The type test procedure is specified, e.g., in DIN EN 60896-11	

Table 5-1: Extent of the type tests on vented battery cells (cf. Section 5.2.1)

(3) During the vibration test, the battery circuit shall be monitored for changes in their electrical resistance. For the vibration test, the battery cells may be filled with a substitute electrolyte, e.g., with water of a sufficient conductivity. After the conclusion of the vibration tests, the test object shall be examined and the mechanical integrity of the functionally significant parts evaluated.

(4) The vibration test shall normally be carried out together with the battery casings which shall have been prestressed to represent the intended duration of battery life. Prestressing is not required, provided, the vibration test is performed with loading values that are at least 50 % higher than the values to be expected from induced vibrations at the place of installation.

(5) The test reports of these tests shall be presented to the proper nuclear authority or to an authorized expert appointed in Section 20 AtG by this authority.

5.2.2 Rectifier unit

(1) It shall be verified that each rectifier unit type was subjected to a type test in accordance with **Table 5-2**.

(2) If necessary with regard to the individual application, it shall be verified that the rectifier units will withstand the induced vibrations within the framework of specified requirements. Vibration tests on other rectifier units comparable with regard to their vibration characteristics may be used for this verification.

(3) The test reports of these tests shall be presented to the proper nuclear authority or to an authorized expert appointed in Section 20 AtG by this authority.

Tests	Type Test	Routine Test
Insulation test ⁵⁾	X	X
Low-load and function test ⁵⁾	X ²⁾	X ¹⁾
Test at nominal electrical current level ⁵⁾	X	X
Determination of losses ⁵⁾	X	
Temperature rise test ⁵⁾	X	X
Determination of the power factor at the reference point	X	
Test of auxiliary equipment ⁵⁾	X	X
Test of the valve control equipment ⁵⁾	X	X
Test of the protection and monitoring equipment ⁵⁾	X	X
Electromagnetic compatibility (cf. Section 5.3)	X	
Recording of the output characteristic	X	X
Determination of the frequency range of the superimposed alternating voltage	X	
Determination of the dynamic behavior	X ^{3) 4)}	
¹⁾ In this context, the voltage behavior at the output of the rectifier unit shall also be checked for the most unfavorable dynamic voltage changes at the input end that is to be expected in the facility. It is sufficient to perform this test on one rectifier unit of each type. ²⁾ Test is to be performed at 0.9, 1.0 und 1.1 times the input nominal voltage ³⁾ With a sudden load change from the nominal electrical current level (I_N) to one half of the nominal electrical current level ($0.5 I_N$) and from one half of the nominal electrical current level ($0.5 I_N$) to the nominal electrical current level (I_N) ⁴⁾ The static and dynamic behavior of the parameters at the DC side upon a change of the parameters at the AC side shall be verified for the limit values specified in Table 4-1 . This verification of the behavior upon dynamic frequency changes may be performed analytically or by physical tests on the individual modules. ⁵⁾ Note: The execution of the tests are specified, e.g., in DIN EN 60146-1-1.		

Table 5-2: Extent of the type tests and routine tests on the rectifier units (cf. Sections 5.2.2 and 5.4.2)

5.3 Electromagnetic Compatibility Test (ECT) of the Rectifier Unit

(1) The immunity of the rectifier unit to electromagnetic circuit-, field- and contact-related interferences to be expected during specified normal operation and during design basis accidents at the place of installation shall be verified.

(2) It shall be verified that the electromagnetic field- and circuit-related interference emissions of the rectifier units will not impermissibly influence other equipment or components at the place of installation

Note:

The test accuracy levels and the limit values can be specified, e.g., in accordance with generic EMC standards DIN EN 61000-6-2 and DIN EN 61000-6-4.

(3) The test reports of these tests shall be presented to the proper nuclear authority or to an authorized expert appointed in Section 20 AtG by this authority.

5.4 Routine Tests

5.4.1 Battery

(1) For each battery cell type six battery cells connected in series shall be subjected to the following routine tests:

- a) The actual capacity of the battery cells to be tested shall be determined; in this context, the discharge procedure shall be preceded by a float charge operation.
- b) After a preceding float charge operation, the fully charged battery cells shall be discharged following the current-versus-time diagram specified in Section 4.3.2 plus the added safety margin specified in Section 4.3.3 until the minimum permissible cell voltage ($6 \times U_{Zmin}$) is reached. In this context is the following shall be verified:
 - ba) The voltage drop at the onset of discharge (voltage delay) shall not reach the minimum permissible voltage ($6 \times U_{Zmin}$) when discharged with the initial value of the specified current-versus-time diagram.
 - bb) The minimum permissible voltage ($6 \times U_{Zmin}$) shall not be reached within the specified discharge period when discharged in accordance with the specified current-versus-time diagram.
 - bc) The design value of the capacity reserve as specified in Section 4.5.2.2, para. (4) shall be maintained even for the expected aging-related capacity reduction.

(2) The routine test of the battery shall be finalized by evaluating a mixture sample of the electrolyte in accordance with DIN 43530-2, Section 7.3, to check that the permissible amount of impurities is not exceeded. If a battery contains battery cells from different production lots, the impurities shall be determined separately for each lot. Whenever the impurities of the operating acid exceed the limit values in accordance with DIN 43530-2, Table 4, the further steps shall be decided together with the proper nuclear authority or with an authorized expert appointed in Section 20 AtG by this authority.

Note:

The result of this test for permissible impurities of the electrolyte is the baseline value regarding the retest specified in Section 5.7.2, para. (8).

(3) The test reports of these tests shall be presented to the proper nuclear authority or to an authorized expert appointed in Section 20 AtG by this authority.

5.4.2 Rectifier unit

(1) It shall be verified that each rectifier unit was subjected to the routine tests listed in **Table 5-2**.

(2) The test reports of these tests shall be presented to the proper nuclear authority or an authorized expert appointed in Section 20 AtG by this authority

5.5 Tests and Inspections during On-site Construction

Tests and inspections shall be performed during on-site construction that shall normally ensure that the requirements pertaining to construction, installation and assembly conditions and the assembly measurements essential to a reliable function of the battery facility are met. These tests shall include, in particular:

- a) Inspection of the components regarding their identity with respect to the documents and regarding damages from transport or storage,
- b) Inspection of the final construction regarding its correspondence with the valid documents (e.g. component arrangement drawings), and
- c) Inspection regarding compliance with the assembly instructions (e.g., handling of acids, free movement, cleanliness).

5.6 Tests and Inspections during Commissioning

5.6.1 Battery

(1) The following commissioning tests shall be performed on each battery:

- a) The electrolyte level and the external condition of the battery shall be checked by visual inspection.
- b) The battery voltage shall be measured during the float charge operation
(required value $U_{LE} = n \times U_{ZLE} (1 \pm 0.01)$).
- c) The cell voltages during the float charge operation shall be measured. The cell voltage of one battery cell shall not vary by more than $+0.1 \text{ V}$ or -0.05 V with respect to the required value (e.g., 2.23 V).
- d) After a preceding float charge operation, the battery capacity shall be determined as basis measurement (K_{basis}) for the in-service inspections; in this context, the discharge sequence shall normally be started no earlier than one hour and no later than 24 hours after the charging operation. The discharge current for this capacity test shall be chosen based on the electrical current possible with the discharge equipment that is provided for the capacity test during in-service inspections as specified in Section 5.7.2, para. (4); however, the discharge current shall normally not be higher than the three-hourly nor lower than the ten-hourly discharge currents (I_3 and I_{10} , respectively). Discharging shall be continued until the final discharge voltage specified by the battery manufacturer for the chosen discharge current is reached. This capacity test shall be used to determine the actual capacity and to verify that, as a minimum, the capacity specified by the manufacturer for the discharge current is achieved.
- e) The electrolyte densities and the cell voltages shall be measured at least at the beginning and at the end of the discharge sequence specified in item d).
- f) The cell connectors shall be tested for incorrectly high transition resistances.
- g) The function of the battery circuit monitoring (cf. Table 4-2, No. 2.1) shall be tested.

(2) The function of the ventilation system of the battery rooms shall be tested.

5.6.2 Rectifier unit

(1) The following commissioning tests shall be performed on each rectifier unit:

- a) function tests of the instrumentation and control equipment, and
 - b) tests of the operating mode switchover and the interlocks, e.g., for boost-charge operation.
- (2) It shall be verified within the framework of the commissioning tests of the nuclear power plant that the rectifier units meet the requirements specified in Section 4.3.5, para. (3), item c).

5.7 In-service Inspections

5.7.1 General requirements

In-service inspections shall be performed to ascertain that the functional capability of the battery facilities is maintained. These in-service inspections shall normally not be performed simultaneously in the different trains.

5.7.2 In-service Inspections of the Battery

(1) The following tests and inspections shall be performed in monthly intervals:

- a) Visual inspections shall be performed with regard, in particular, to the electrolyte level, to damages of the battery casing and to battery pole corrosion.

Note:

The visual inspections can also be extended to include checking for sludge formation and exfoliation, even if these effects do not require immediate action.

- b) The float charge voltage shall be tested.
- c) The room temperature and the function of the ventilation system shall be checked.
- d) The electrolyte density shall basically be tested in monthly intervals on at least 10 % of the battery cells and, additionally, in those cells where the cell voltage had been too low in previous tests.
- e) The monthly 10 % measurement of the electrolyte density (item d)) may be dispensed with, provided, the cell voltages and the overall voltage of the battery are monitored continuously and, provided, the limit values and requirements specified in para. (2) are met. The technical equipment technology used for these voltage measurements shall not detrimentally affect the reliability of the battery supply.

(2) A test of all battery cells regarding cell voltage and electrolyte density shall be performed during float charge operation. A testing interval of 12 months shall normally not be exceeded. If the cell voltage of one battery cell varies by more than + 0.1 V or - 0.05 V from the required value (e.g., 2.23 V), the following steps shall be taken:

- a) If the electrolyte density of the battery cell differs from the value averaged over all battery cells by an amount still permissible according to the manufacturer specifications, this battery cell shall be included in the monthly electrolyte density tests specified in para. (1), item d).
- b) If the electrolyte density of the battery cell differs from the value averaged over all battery cells by an amount not permissible according to the manufacturer specifications, the further steps shall be arranged in agreement with the proper nuclear authority or with an authorized expert appointed in Section 20 AtG by this authority.

(3) Capacity tests shall be performed during float charge operation in testing intervals not exceeding five years. These tests shall normally be performed in a staggered time sequence, e.g., one train per year.

(4) The recurrent capacity tests shall be performed at the same discharge current as the one used for the capacity test specified in Section 5.6.1, para. (1), item d). For the evaluation of the capacity tests, the percentage limit value specified in Section 4.5.2.2, para. (4), shall be set in relation to the capacity which the battery manufacturer has specified for the chosen discharge current, I_n , and which corresponds to the nominal capacity, K_n (e.g., K_5). In the following text of this safety standard, this limit value will be referred to as K_{limit} .

(5) Depending on the capacity determined by an in-service inspection, K_{test} , and its relation to the limit value of the capacity, K_{limit} , or to its relation to the capacity determined in the basis test during commissioning, K_{basis} , or to its relation to the capacity related to the discharge current, K_n , corresponding to the nominal capacity, the individual measures to be taken shall be those specified in **Table 5-3**. In the case of unexpected capacity losses, their causes shall be determined.

(6) In the case of parallel battery fuses, the uniformity of the electrical current distribution shall be tested. This test shall normally be performed in conjunction with the recurrent capacity tests.

Results of the recurrent capacity test	Subsequent charge-up to full capacity and repeat of the capacity test	Result of the 2 nd capacity test (recurrent test)	Required measures to be taken
$K_{test} > 105 \% K_{limit}$ and $K_{test} > 90 \% K_n$	not required	—	none
$K_{test} \leq 105 \% K_{limit}$ or $K_{test} \leq 90 \% K_n$	required	$K_{test} \geq 110 \% K_{limit}$ and $K_{test} \geq 90 \% K_n$	none
		$K_{test} < 110 \% K_{limit}$ or $K_{test} < 90 \% K_n$	inspection interval shall be shortened
		$K_{test} < 105 \% K_{limit}$	battery shall be replaced
$K_{test} < 80 \% K_{basis}$	required	$K_{test} \geq 80 \% K_{basis}$	none
		$K_{test} < 80 \% K_{basis}$	inspection interval shall be shortened

Table 5-3: Evaluation criteria for the recurrent capacity tests

(7) The cell connectors shall be tested for incorrectly high transition resistances. This test shall normally be performed in conjunction with the recurrent capacity tests.

(8) After the initial recurrent capacity test of a battery, the test for impermissible impurities of the electrolyte specified in Section 5.4.1, para. (2), shall be repeated. Depending on the test results, the need for, and the point in time of, additional checks shall be arranged in agreement with the proper nuclear authority or with an authorized expert appointed in Section 20 AtG by this authority.

5.7.3 In-service inspections of the rectifier unit and of the battery circuit monitoring equipment

In-service inspections shall be performed regarding the function of the power unit and of those parts of the instrumentation and control equipment whose function is not continuously monitored during operation. The inspection intervals shall be coordinated with those of the other instrumentation and control equipment of the emergency power system. An inspection interval of four years (e.g., one train per year in the case of a four-train battery facility) shall normally not be exceeded.

5.8 Tests and Inspections after Maintenance or Repair

(1) Upon completion of maintenance or repair activities that have led to a disruption of the functional readiness, a test shall be performed to verify that the functional readiness has been restored. Depending on the type and extent of the parts or functions involved, and as arranged in agreement with the proper nuclear authority or with an authorized expert appointed in Section 20 AtG by this authority, a function test shall be performed.

(2) If the maintenance and repair activities have required the installation of component parts that differ from the original configuration, the suitability of these component parts shall be verified.

5.9 Testers

(1) The tests and inspections specified in Sections 5.2, 5.3 and 5.4 shall normally be carried out by plant experts or under

their responsible supervision. In well-substantiated cases, the individual tests shall be arranged in agreement with the proper nuclear authority or with an authorized expert appointed in Section 20 AtG by this authority

(2) The tests and inspections specified in Sections 5.5 through 5.8 shall be carried out in agreement with the proper nuclear authority or with an authorized expert appointed in Section 20 AtG by this authority

5.10 Test Reports

All tests and inspections performed shall be verified by test reports. These test reports shall contain all information necessary for the evaluation and assessment of the tests and inspections.

This information includes:

- a) Organizational unit performing the test,
- b) Test object,
- c) Extent of test,
- d) Type of test,
- e) Identification number of the test and examination procedure and, if applicable, of the standardized test and examination procedure.
- f) Performance of test (e.g., required and actual date of testing, testing interval, testing equipment used),
- g) Test results (e.g., testing goal achieved, non-conformances, measures were taken or necessary), and
- h) Confirmation of the test performance, of the test results and of the test assessment by the person in charge.

6 Operation, Maintenance, and Repair

(1) Instructions with respect to operation, maintenance (including cleaning) and repair procedures shall be established on the basis of the manufacturer specifications.

(2) If the battery is charged-up with a voltage impermissible for the power loads, then all power loads shall be disconnected from the battery.

Appendix A

Nomenclature Used in this Safety Standard

f_N	nominal connection frequency of the rectifier unit
I_{dN}	nominal direct current of the rectifier unit
I_n	n-hourly discharge current
K_{basis}	basis value of the battery capacity during commissioning for in-service inspections
K_{limit}	limit value of the battery capacity (cf. Section 5.7.2 para. (4))
K_n	battery capacity corresponding to the nominal battery capacity when discharged with the electrical current I_n
K_{test}	battery capacity determined during in-service inspections (cf. Section 5.7.2)
n	number of battery cells (cf. Section 4.5.2.1)
U_d	DC output voltage of the rectifier unit
U_{LE}	float charge voltage of the battery
U_N	nominal connection AC voltage of the rectifier unit
$u_{\text{ÜSS}}$	frequency band width of the alternating voltages superimposed on the direct current
U_{Vmax}	maximum voltage level continuously permissible at the power load
U_{Vmin}	minimum voltage level continuously permissible at the power load
U_{ZLE}	average float charge voltage per battery cell
U_{Zmin}	lowest voltage of the single battery cell (cf. Section 4.5.2.2, para. (2))
U_{ZLEmax}	static maximum limit value of the float charge voltage per battery cell
ΔU_B	voltage drop along the connection between rectifier unit and battery
ΔU_{max}	maximum possible voltage drop between battery contacts and power load
ΔU_{min}	minimum possible voltage drop between battery contacts and power load

Appendix B

Regulations Referred to in this Safety Standard

(Regulations referred to in this safety standard are valid only in the versions 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.)

AtG		Act on the Peaceful Utilization of Atomic Energy and the Protection against its Hazards (Atomic Energy Act) Atomic Energy Act in the version promulgated on July 15, 1985 (BGBl. I, p. 1565), most recently changed by article 1 of the act dated December 4, 2022 (BGBl. I, p. 2153)
StrSchG		Act on the Protection against the Harmful Effect of Ionising Radiation (Radiation Protection Act - StrlSchG) Radiation Protection Act of June 27, 2017 (BGBl. I, p. 1966), most recently changed by the promulgation of January 3, 2022 (BGBl. I, p. 15)
StrlSchV		Ordinance on the Protection against the Harmful Effects of Ionising Radiation (Radiation Protection Ordinance - StrlSchV) Radiation Protection Ordinance of November 29, 2018 (BGBl. I, p. 2034, 2036), most recently changed by article 1 of the ordinance dated October, 2021 (BGBl. I p. 4645)
SiAnf	(2015-03)	Safety Requirements for Nuclear Power Plants (SiAnf) of November 22, 2012, amended version of March 3, 2015 (BAnz AT 30.03.2015 B2), most recently changed as promulgated by BMUV on February 25, 2022 (BAnz AT 15.03.2022 B3)
Interpretations of SiAnf	(2015-03)	Interpretations of the safety requirements for nuclear power plants of November 22, 2012, of November 29, 2013 (BAnz AT 10.12.2013 B4), changed on March 3, 2015 (Banz AT of March 30, 2015 B3)
KTA 1401	(2017-11)	General requirements regarding quality assurance
KTA 2103	(2015-11)	Explosion protection in nuclear power plants with light water reactors (General and case-specific requirements)
KTA 2201.4	(2012-11)	Design of nuclear power plants against seismic events; Part 4: Components
KTA 3501	(2015-11)	Reactor protection system and monitoring equipment of the safety system
KTA 3504	(2022-11)	Electrical drive mechanisms of the safety system in nuclear power plants
KTA 3701	(2014-11)	General requirements for the electrical power supply in nuclear power plants
KTA 3702	(2022-11)	Emergency power generating facilities with diesel-generator units in nuclear power plants
KTA 3704	(2022-11)	Emergency power facilities with static and rotary converters in nuclear power plants
KTA 3705	(2022-11)	Switchgear facilities, transformers and distribution networks for the electrical power supply of the safety system in nuclear power plants
DIN 43530-2	(1987-10)	Accumulators; electrolyte and refilling water; electrolyte for lead acid batteries
DIN EN 60146-1-1 (VDE 0558-11)	(2011-04)	Semiconductor converters - General requirements and line commutated converters – Part 1-1: Specification of basic requirements (IEC 60146-1-1:2009); German version EN 60146-1-1:2010
DIN EN 60896-11	(2003-07)	Stationary lead-acid batteries - Part 11: Vented types; General requirements and methods of test (IEC 60896-11:2002); German version EN 60896-11:2003
DIN EN 60896-11 Corrigendum 1	(2006-03)	Stationary lead-acid batteries - Part 11: Vented types - General requirements and methods of test; (IEC 60896-11:2002); German version EN 60896-11:2003, Corrigenda to DIN EN 60896-11:2003-07
DIN EN IEC 61000-6-2 (VDE 0839-6-2)	(2019-11)	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity standard for industrial environments (IEC 61000-6-2:2016); German version EN IEC 61000-6-2:2019
DIN EN IEC 61000-6-4 (VDE 0839-6-4)	(2020-09)	Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments (IEC 61000-6-4:2018); German version EN IEC 61000-6-4:2019