



Controllers for Diesel Motors

Requirements and test methods

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VdS Guidelines for water extinguishing systems

Controllers for Diesel Motors

Requirements and test methods

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1 General

1.1 Scope

These Guidelines specify requirements and test methods for controllers for diesel motors (hereafter referred to as controllers) in sprinkler, water spray and foam extinguishing systems (hereafter referred to as extinguishing systems).

1.2 Description

The controls and monitors the starting and stopping of a pump powered by a diesel motor, designed for extinguishing systems, for regulating the charging of the starter batteries and the operating parameters of the diesel motor. In addition, connection devices and switching, control and indicating equipment for sub-assemblies can be provided, which are required for maintaining the operational readiness of the extinguishing system. These may include the following:

- tank filling pump;
- booster pump for the pipework of the extinguishing system;
- air compressor;
- supply outlet for heaters or heating bands of low capacity (max. 3kW) to keep the sprinkler equipment room or small parts of the pipework frost-free;
- motorised valves;
- sewage pump belonging to the extinguishing system;
- lighting of the sprinkler equipment room;
- ventilation of the sprinkler equipment room;
- monitoring and control panel;
- cooling liquid pre-heating units;
- blind controls;
- ventilators;
- solenoid valves.

1.3 System requirement

If a flow rate is delivered by more than one pump, each pump shall have its own controller. The pump shall operate at full capacity within 15s of the beginning of the starting cycle.

1.4 Recognised codes of practice

The controller shall comply with the recognised codes of practice. These include the regulations published by VDE Verband der Elektrotechnik Elektronik Informationstechnik e.V. (Association for Electrical, Electronic & Information Technologies), e.g. DIN VDE 0100 "Regulations for installing low voltage systems" and DIN EN 60439-1 (VDE 0660-500) "Low voltage controller combinations" Part 1: "Type-tested and partially type-tested combinations", the accident prevention regulations by Berufsgenossenschaft der Feinmechanik und Elektrotechnik (Employers' Liability Insurance Association of Precision Engineering and Electrical Engineering) BGV A3 "Electrical systems and equipment".

1.5 Type series

1.5.1 Controllers of one type series

Type series are controllers with the same circuit diagram. One type series may include different control voltages and different connection voltages. Each control voltage and connection voltage shall be clearly identifiable in the type designation and comprehensively documented in the technical documentation. Equipment with control voltage related and connection voltage related dimensioning can be adjusted to each control voltage and connection voltage within one type series.

1.5.2 Controllers of different type series

Different type series imply that the controllers have different:

- monitoring.

1.5.3 Ancillary equipment

If one power range is provided for the individual ancillary equipments, the appropriate electrical equipment and cables shall be rated for maximum power.

The wiring protection equipment, e.g. fuse inserts, circuit breakers, motor protection switches and thermal motor protection equipment, e.g. overload protection relays, shall be adjusted to the effective power rating of the consumer.

1.6 Approval

The controllers are tested and approved in the configuration submitted. If the configuration for sub-assemblies is reduced, a renewal of the approval is not necessary. Extensions shall be submitted for testing. Controller cabinets of one type series can be combined into one approval. Controller cabinets of different type series will get separate approvals for each series.

1.7 Validity

These Guidelines will come into force on February 1, 2011. They supersede VdS Guidelines for water extinguishing systems – Controllers for diesel motors – Requirements and test methods – VdS 2100-22 : 1987-02.

Note: The validity of existing approvals may be extended according to the approval period of the respective approval for another 4 years until January 31, 2011.

2 Normative references

These Guidelines incorporate dated or undated references to other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to these Guidelines only when incorporated in them by amendment or revision. For undated references the latest edition of the publication referred to applies.

BGV A3 Accident prevention regulations for electrical installations and equipment

DIN 41773-1 Static power convertors, semiconductor rectifier equipment with IU-characteristics for charging of lead-acid batteries, Guidelines

DIN 41773-2 Static power convertors, semiconductor rectifier equipment with IU-characteristics for charging of nickel-cadmium batteries, Guidelines

DIN 5032-7 Light measurement classifications for illuminance and brightness measurement instruments

DIN EN 50130-4 (VDE 0830-1-4) Alarm systems – Part 4: Electromagnetic compatibility, Product family standard: Immunity requirements for components of fire, intruder and social alarm systems

DIN EN 54-2 Fire detection and fire alarm systems – Part 2: Control and indicating equipment

DIN EN 54-3 Fire detection and fire alarm systems – Part 3: Fire alarm devices – Sounders

DIN EN 60068-1 Environmental testing – Part 1: General and guidance

DIN EN 60068-2-1 Environmental testing – Part 2: Tests; Test A: Cold

DIN EN 60068-2-30 Environmental testing – Part 2-30: Tests; Test Db: Damp heat, cyclic (12 + 12 hours)

DIN EN 60068-2-6 Environmental testing – Part 2: Tests; Test Fc: Vibration, sinusoidal

DIN EN 60068-2-75 Environmental testing – Part 2: Tests; Test Eh: Hammer tests

DIN EN 60068-2-78 Environmental testing – Part 2-78: Tests; Test Cab: Damp heat, steady state

DIN EN 60529 (VDE 0470-1) Protection class housing (IP code)

DIN EN 60695-2-10 (VDE 0471-2-10) Fire hazard testing – Part 2-10: Glowing/hot-wire based test methods – Glow wire apparatus and common test procedure

DIN EN 60695-2-11 (VDE 0471-2-11) Fire hazard testing – Part 2-11: Glowing/hot-wire based test methods – Glow wire flammability test method for end products

DIN EN 61672-1 Electroacoustics – Sound level meters – Part 1: Specifications

DIN EN 61672-2 Electroacoustics – Sound level meters – Part 2: Pattern evaluation tests

IEC 60695-2-2 Needle-flame test

VdS CEA 4001 Guidelines for sprinkler systems, Planning and installation

3 Definitions

3.1 Disabled condition

The signal “Disabled condition” is given when, after automatic start-up, the pump is disabled manually via push buttons while the starting command of at least one pressure switch for automatic pump start is still present.

3.2 **[$I_{\max a}$] Output load current**

Output load current $I_{\max a}$ is the maximum permanent load current specified by the manufacturer.

3.3 **[$I_{\max b}$] Output load current**

Output load current $I_{\max b}$ is the maximum short-term load current specified by the manufacturer. If the manufacturer has not specified $I_{\max b}$, $I_{\max a}$ shall be applied.

3.4 **[$U_{b \max}$] End-of-charge voltage**

$U_{b \max}$ is the end-of-charge voltage of the battery.

3.5 **[$U_{b \min}$] End-of-discharge voltage**

$U_{b \min}$ is the end-of-discharge voltage of the battery.

3.6 **[U_n] Nominal voltage**

U_n is the nominal voltage of the public power supply network or a similar network.

3.7 **[U_{fault}] Fault control voltage**

U_{fault} is the control voltage to be specified by the manufacturer, at which a fault is signalled and the diesel motor can still be started correctly (6 tries).

4 Requirements

4.1 Marking

Controllers shall be marked at the front with the following information:

- name of manufacturer;
- type designation;
- year of construction;
- enclosure rating acc. DIN EN 60529;
- approval number;
- control voltage (12 V / 24 V);
- battery capacity;
- battery type;
- mains voltage/mains frequency;
- connected load.

The marking shall be non-detachable, permanent and well legible.

One copy of the circuit documents shall be supplied with each controller.

4.2 Configuration and design

4.2.1 Controller cabinet

The cabinet of the controller shall be made of metal.

The enclosure rating of the cabinet of the controller, equipment and cable entries in the walls and doors of the controller shall be at least IP 54.

Battery chargers installed next to the batteries shall have at least the same enclosure rating as the controller.

According to the operating conditions higher enclosure ratings may be required.

4.2.3 Cable entries and terminals

For external connections separate terminals shall be provided. Where possible by the nominal sizes of the terminals, series terminals shall be used. The incoming power supply can also be connected directly to the main switch (e.g. fuse switch).

Cables and lines shall lead into the controller from the bottom side.

One terminal should be connected to one conductor only. The connection of two or more conductors is permitted only if the terminals are designed for this purpose.

4.2.4 Immunity to heat and fire

The controller shall be constructed such that it can neither cause a fire nor contribute to fire spread.

Plastic insulating components shall be resistant to heat and fire.

The requirements are fulfilled if the tests of 5.11.7 have a positive result.

4.2.4 Equipment

Switches, contactors, relays, protective equipment (fuses etc.) shall be fitted inside the controller cabinet. It shall be possible to operate any operating elements from the front side, indicators shall be readable from the front side. Sounders can be fitted either inside or at the front.

4.2.5 Operating conditions

The controller shall function in a temperature range between -5°C and +40°C and with deviations from the mains nominal voltage between +10% and -15%.

4.2.6 Control transformer

A control transformer may be fitted in the control circuit for voltage adjustment.

The short-term power of the control transformer shall be at least as great as the pick-up power and holding power of the contactors and consumers which have been or are being activated simultaneously when the pump starts.

The continuous power of the control transformer shall be at least as great as the sum of the holding powers of all contactors and consumers activated simultaneously.

As the additional stray fields of a star-star circuit (Yy) mainly close via ferromagnetic construction parts (e.g. transformer tanks), a loading of the output neutral conductor 2N is permitted at 10% of the nominal current only. This is due to the additional losses dissipated as heat.

For protective equipment for the control transformer see 4.2.8.

4.2.7 Remote control panel

The controller may have provision for the connection of a remote control panel.

With a remote control panel the function and functional condition of the controller can be controlled while located elsewhere.

Open or short circuits in cables or lines to the remote control panel shall not affect the function of the pump.

At least the following control elements and indicators shall be provided:

- ON and OFF push button for pump;
- optical light indicators “Operation”, “Fault” and “Disabled condition” of pump.

Indicators shall be in accordance with 4.2.11 and control elements with 4.2.10. They should be wired with separate cables and lines between remote control panel and controller.

The cross sections and maximum lengths of these cables and lines shall be specified in the documentation.

Cables and lines to the control elements for activating and deactivating the pump shall be monitored for open and short circuit. Open and short circuit shall be indicated as faults in accordance with 4.2.11, but shall not enable or disable the pump.

The requirements are fulfilled, if the tests of 5.6 are passed.

4.2.8 Protective equipment

Mains connection and control circuit shall be secured by means of a line protection fuse.

The nominal current of the line protection fuse for the control circuit shall be rated such that during continuous operation, switch-on or return of the supply voltage of the controller no unintended activation occurs.

Protective equipment for the control transformer upon overload shall only lead to the indication of faults in accordance with 4.2.11, but not to disablement. The adjustment of the protective equipment for the control transformer shall be specified in the circuit diagram and in the documentation (control transformers may be battery chargers).

Protective equipment for protecting the control transformer in case of short circuit shall not be fitted.

Note: This does not apply to upstream line protection fuses.

Faults of the diesel motor such as lack of oil pressure, excess temperature etc. shall not disable the diesel motor, but shall be indicated. This does not apply to the overspeed monitoring when used with an electronic speed changer.

Note: It is permitted to have overvoltage protection upstream of the main fuse inside the controller (only by agreement with the controller manufacturer) or outside the controller. In this case the cable to the overvoltage protection equipment shall be short circuit proof and short circuit protected, or else it shall be so dimensioned that it is protected by the upstream fuse.

If overvoltage protection is fitted in a separate cabinet at the same place of installation as the controller, the separate cabinet provided for overvoltage protection shall fulfil the requirements for the controller cabinet (see 4.2.1 and 4.2.2).

4.2.9 Wiring

Multi-wire, fine-wire and extra fine-wire plastic-insulated conductors according to the specified operating voltages shall be used, at least in design H05V-R (multi-wire conductors), H05V-K (fine-wire conductors) and H05V-S (extra fine-wire conductors).

The minimum cross section for:

- main circuits is 1,5 mm² Cu
- control/auxiliary circuits is 1,0 mm² Cu

Power rails are also permitted inside the controller.

The wiring shall be well arranged in wiring ducts or similar systems. This does not apply to terminal ends.

Insulated conductors shall not touch bare active parts of other potential or sharp edges; they shall be fixed appropriately.

The connecting lines of movable parts shall have plastic protective tubes or similar.

Cables and lines shall have no mends or soldering points between two terminals. The soldering of terminal ends is not permitted.

4.2.10 Operating elements

It shall be possible to activate and deactivate the pump and the sub-assemblies (sub-assemblies whose control is inside the controller) individually via push buttons at the controller.

For sub-assemblies which may be switched on and switched off both manually and automatically via threshold value sensors the additional requirements of 4.3.2 apply.

For resetting audible indications a push button shall be provided. The visible indication shall remain until the fault has been rectified.

For push buttons the following colours shall be used:

green or white Pump "ON"; Electrical consumers "ON"

red	Pump "OFF";	Electrical consumers "OFF"
black	Sounder "OFF"	
black	Lamp test	

The push buttons "Pump OFF", "Electrical consumers OFF" and "Sounder OFF" shall not be latching.

4.2.11 Indicators

The functional conditions "Pump ready for operation", "Operation of pump" and "Disabled condition of pump" shall be indicated visibly, fault warnings visibly and audibly. The visible indication shall remain until the fault has been rectified, even if the push button "Sounder OFF" has been operated.

4.2.11.1 Indications

Indications shall be given with steady light in the following manner:

- mains voltage ON: (white)
- operation of pump: (white)
- disabled condition of pump: (blue)
- fault of diesel motor:
(lack of oil pressure, motor excess temperature,
overspeed, lack of fuel, adjustment fuel valve): (yellow)
- fault of battery voltage: (yellow)
- false start (after 6 unsuccessful tries): (yellow)
- failure of mains voltage: (yellow)
- failure of control voltage: (yellow)
- fault of programme flow: (yellow)
- fault of contactor lines: (yellow)

If existent:

- operation of sub-assemblies: (white)
- disabled condition of automatically
operated sub-assemblies: (blue)
- fault of sub-assemblies: (yellow)
- water level in pump priming tank
sunk to 2/3 of normal level: (yellow)

The fault warnings (yellow) may be combined to one indication.

The indicators shall be clearly arranged and unambiguously marked (e.g. labelling, symbols).

The medium service life of the indicators (e.g. lamps, LEDs) shall be at least 5000 hours. One control element shall be provided for testing the indicators.

Indications shall be legible at an ambient light intensity up to 500lx, measured by means of a measuring device in accordance with DIN 5032-7 Class B at an angle up to 22,5° from a line through the centre of the active indicator perpendicular to its mounting surface at a distance of 3m.

The sound level of sounders measured by means of a sound level meter in accordance with DIN EN 61572-1 and -2 under free field conditions in accordance with DIN EN 54-3 at a distance of 1m from the controller shall be at least 75dB (A).

4.2.11.2 Transmission of signals

For the transmission of signals representing functional conditions, potential-free contacts (at least one N/O contact and one N/C contact or one changeover contact) shall be provided as follows:

Pump (individual indications):

- mains voltage ON;
- response of a pressure switch;
- operation of pump (at least two N/O contacts and two N/C contacts or two changeover contacts shall be provided);
- fault of pump (general fault warning);
- disabled condition of pump.

Sub-assemblies (at least as general indication) for the following functional conditions:

- operation;
- disabled condition (with automatically operated sub-assemblies);
- fault (motor monitoring equipment).

Pump priming tank (individual indication):

- water level in pump priming tank sunk to 2/3 of normal level.

Additional signals (individual indication):

- fault of transmission paths in accordance with 4.3.5.1 and
- fault of mains and control voltage in accordance with 4.3.5.2.

4.2.11 Measuring equipment

The following shall be provided:

for each starter battery

- voltage meter, at least class 1,5 for measurement of battery voltage;
- current meter, at least class 1,5 for measurement of charging current;

for the diesel motor

- oil pressure gauge for measurement of oil pressure;
- thermometer for indication of cooling water temperature or cylinder temperature;
- revolution counter for measurement of revolution speed;

- service hour counter (shall indicate the service hours even after power failure).

4.3 Function

4.3.1 Pump control

The controller shall be able to activate the pump (diesel motor) automatically (pressure switch) and manually (push button); the nominal capacity of the pump shall be reached within 15s from activation. During operation, even after the response of motor monitoring equipment, the pump shall be disabled only manually (push button) (manual disable device).

To start the pump automatically, two series-connected pressure switches shall be fitted with contacts opening in case of pressure loss, or two parallel-connected pressure switches with contacts closing in case of pressure loss. The pressure switches shall be connected via two separate lines (contactor lines). The lines can be joint inside the controller.

For the connection of two pressure switches for an automatic pump start separate terminals shall be provided for each line.

Only one auxiliary connector with a pick-up power of 100VA maximum shall be triggered.

A fault on a contactor line shall not cause failure of another line and thus prevent the starting command.

Pressure switch and manual push button activate the automatic starting process. Even if during start-up of the starter motor the pressure switch is not operated for a short period of time or even permanently, the automatic starting process shall continue until the diesel motor starts.

The operating sequence of the automatic starting device shall allow 6 start attempts of (5 – 10s) each with a pause of 10s maximum. The starting device shall return automatically to the quiescent condition and be mains-independent, i.e. the automatic start and the functionality of the pump shall not depend on other power sources than the motor and appropriate batteries.

After each start attempt there shall be an automatic switchover to the other battery. The control voltage shall be tapped from the two batteries simultaneously. The inputs shall be separated such that one battery cannot affect the other.

4.3.2 Sub-assemblies

It shall be possible to switch on and switch off sub-assemblies manually (manual operation). They can also be switched on and switched off automatically via threshold value sensors (automatic operation). It shall be possible to select the mode of operation by selector switch without zero position or by push button. In the latter case the mode of operation shall be indicated visibly.

Upon manual disablement in automatic operation the signal "Disabled condition" shall be given as long as an automatic starting command is present.

4.3.3 Manual emergency starting device

The emergency starting device shall comprise an emergency start push button and one start relay for each battery. These start relays shall be independent of the start

relays for the automatic starting device. The push buttons shall have a cover. They shall directly operate the start relays.

4.3.4 Disable device

When the diesel motor is disabled via a solenoid, this shall be enabled for the disabling process (stop solenoid).

4.3.5 Monitoring

4.3.5.1 Transmission paths

In controllers of monitored extinguishing systems, the control circuits (pressure switch lines etc.) routed outside the controller for the pump required for extinguishing operation and for automatically operated sub-assemblies, shall be monitored for open and short circuit. Open and short circuit shall be indicated as a fault in accordance with 4.2.11.

A fault of the monitoring equipment for the contactor lines for automatic start shall not prevent the automatic starting command (pressure switch). This may be achieved e.g. by assigning one monitoring equipment each, including power supply unit, to each contactor line. Each monitoring equipment shall have a selective pre-fuse for the superordinate fuse.

4.3.5.2 Mains and control voltage

The mains voltage shall be monitored for failure, the control voltage for voltage drop. Failure of the "mains voltage" and voltage drop of the control voltage to a specific value U_{fault} specified by the manufacturer shall be indicated in accordance with 4.2.11.

The monitoring of the control voltage circuit for the pump shall include the control fuses.

4.4 Battery chargers

Each starter battery shall have its own permanently connected and fully automatic constant voltage charger. It shall be possible to remove one of the chargers while the other remains in operation.

Chargers for lead-acid batteries shall supply a charging voltage of $2,25V \pm 0,05V$ per cell. The nominal charging voltage shall be adjusted to local conditions (climatic conditions, regular maintenance etc.). A quick-charger for charging at higher voltage shall be provided which shall not exceed 2,7V per cell. The charging power shall be between 3,5% and 7,5% of the 10h capacity of the battery.

Chargers for nickel-cadmium batteries shall supply a charging voltage of $1,445V \pm 0,025V$ per cell. The nominal charging voltage shall be adjusted to local conditions (climatic conditions, regular maintenance etc.). A quick-charger for charging at higher voltage shall be provided which shall not exceed 1,75V per cell. The charging power shall be between 25% and 167% of the 5h capacity of the battery.

Alternatively to the recharging and trickle charging of each battery set, a charger with IU characteristic in accordance with DIN 41773-1, DIN 41773-2 may be used. The charger shall be able to charge a lead battery discharged to final voltage at I_{10} or a nickel-cadmium battery discharged to final voltage at I_5 with mains nominal

voltage - 15% within 24h to 80% of their nominal capacity. The nominal charging voltage shall be adjusted to local conditions (climatic conditions, regular maintenance etc.).

Note: The charger should be so rated and dimensioned that the nominal charging voltage is within the battery manufacturer's specifications for the ambient temperature range of -5°C to +40°C.

During operation of the diesel motor at least one set of batteries shall additionally be charged by the alternator.

5 Tests

5.1 Atmospheric conditions for tests

Unless stated otherwise in the respective test procedure, all tests shall be carried out after the specimens have adapted to the following standard atmospheric conditions in accordance with DIN EN 60068-1:

- a) Temperature: (15 to 35)°C;
- b) Relative air humidity: (25 to 75)%;
- c) Air pressure: (86 to 106)kPa.

Note: If variations of these parameters significantly influence the measurements, such variations should be limited to a minimum during a test series which is considered as one test for one specimen.

5.2 Mounting

The specimens shall be mounted by their normal means of mounting in accordance with the manufacturer's specifications. In case of more than one possible way of mounting, the most unfavourable shall be chosen for each test.

5.3 Tolerances

The tolerances for the environmental test values apply as specified in the relevant referenced standards (e.g. the relevant part of standard series DIN EN 60068), unless specified otherwise. If a requirement or test procedure does not specify any tolerance or deviation limits, deviation limits of $\pm 5\%$ shall apply.

5.4 Pre-test and identification

It is checked whether the controller complies with the description in the technical documentation (drawings, parts lists, functional descriptions, operating, maintenance and installation instructions) and fulfils the requirements of these guidelines.

5.5 Functional tests

The specified functions of the controller in accordance with Cl. 4 are tested at 0,85-fold and 1,1-fold nominal voltage and at the upper and lower battery supply voltages U_{fault} and U_{bmax} .

Afterwards, the controller is operated for 12 hours each at 0,85-fold and 1,1-fold nominal voltage and at an ambient temperature of $(25 + 5)^\circ\text{C}$ with the cabinet closed. The functional safety shall not be impaired and the operating temperature shall not be

higher than that specified in the relevant requirements or manufacturer’s specifications.

5.5.1 Charger

The function of the chargers is tested at 0,85-fold and then at 1,1-fold mains voltage.

5.5.1.1 Electrical connection

- a) The specimen shall be connected to the mains supply and to a battery with maximum capacity;
- b) All inputs and outputs shall be connected to lines and devices or dummy loads in accordance with the maximum load specified by the manufacturer.

5.5.1.2 Functional tests

The test comprises all tests specified in Table 1 with the relevant voltage combinations and output currents. The output voltages shall be measured, the test results shall be recorded.

In tests 1 and 2 the heat development shall be measured at all components with high power dissipation, e.g. transformers, rectifiers and voltage regulators, and the measurements shall be recorded.

Table 1

Test	Mains voltage	Battery condition	Output load current	Object	Test duration (hours)
1	$U_n +10\%$	$U_{b \text{ min}}$	$I_{\text{max a}}$	no overheating	4
2	$U_n -15\%$	$U_{b \text{ min}}$	$I_{\text{max a}}$	power data within specifications, no overheating	4
3	mains disconnected	U_{fault}	$I_{\text{max b}}$	fault signal, load test with starter simulation	
4	U_n	battery disconnected		indication battery fault	
5	$U_n +10\%$	$U_{b \text{ max}}$	$I_{\text{min.}}$	output voltage within specifications	

5.5.1.3 Test requirements

The output voltages measured in accordance with 5.5.1.2 and the test results shall not exceed the range specified by the manufacturer.

In tests 1 and 2 of 5.5.1.2 the temperatures shall not exceed the maximum temperatures specified by the manufacturer of the respective component.

5.5.2 Test of charger and motor starter batteries

5.5.2.1 Test procedure

Estimation of the charging behaviour in connection with tests 1 and 2 of Table 1,

with the charger being loaded not only with the operating current required for the controller, but also with constant load $I_{\max a}$ at the charging output for 4 hours. If it is possible to supply $I_{\max a}$ for this period of time without overheating, it is estimated by calculation whether the maximum battery capacity specified by the manufacturer can be charged.

In case of any difficulties due to the constantly high long-term loading, the test can be carried out as follows:

The battery is discharged to its final voltage at a discharge current of $I_d = C/20$ amp for lead batteries or $I_d = C/10$ amp for nickel-cadmium batteries, with C being the nominal capacity of the battery in ampere hours as specified by the battery manufacturer. For other battery types deviating discharge currents may be required. (The battery shall be provided by the controller supplier.)

The battery is charged for 72 hours by means of the respective charger at mains nominal voltage (U_n). During this time it shall be ensured that the charger only supplies the charging current for the battery and the required operating current for the operational diesel controller.

Note: This current value should be specified by the manufacturer.

The battery is again discharged to its final voltage at the discharge current specified above, and the discharge time (T_1) in hours is measured.

The battery is again charged for 24 hours at $U_n -15\%$. During this time it shall be ensured that the charger only supplies the charging current for the battery and the required operating current for the operational diesel controller.

Note: This current value should be specified by the manufacturer.

The battery is again discharged to its final voltage at the discharge current specified above. The discharge time (T_2) in hours is measured.

5.5.2.2 Test requirements

The product of discharge time T_1 and discharge current I_d shall not fall below the nominal capacity C of the battery.

The product of discharge time T_2 and discharge current I_d shall not fall below 0,8 x the nominal capacity C of the battery.

5.6 Functional test of remote control panel

The functional test of the control elements and lines is carried out at 0,85-fold and 1,1-fold nominal voltage.

Lines are tested to determine at which line resistances a fault warning is given. For this purpose, the line resistance is changed from $0 \Omega \rightarrow \infty$ simulating open wire and from $\infty \rightarrow 0 \Omega$ simulating short circuit by means of serial or parallel resistances.

At a line resistance not yet resulting in a fault warning, the controller shall function correctly when control elements are operated.

5.7 Software test

If the controller comprises switching or control devices with software, a software test shall be carried out on the basis of Cl. 13 of DIN EN 54-2, provided that the software has been programmed by the applicant or on behalf of the applicant. The software test is not required, if the software contained in the hardware is only parameterised.

5.8 Environmental class

The environmental tests specified in 5.11 apply to indoor installation with wall-mounted controllers.

In case of special operating conditions or outdoor installation, additional tests agreed with the manufacturer shall be carried out.

5.9 Indoor installation

The ambient temperature shall not exceed +40°C.

The lower limit of the ambient temperature shall not fall below -5°C.

Occasional moderate condensation due to temperature variation shall be taken into account.

5.10 Special operating conditions

In locations with high air humidity and greatly varying temperatures, destructive condensation inside the controller shall be prevented by appropriate measures (ventilation and/or internal heating, breathers etc.). The specified protection type shall be adhered to.

5.11 Environmental tests

5.11.1 Table of environmental tests

Table 2

Environmental test	Test procedure – Reference	Conditioning
Cold (operational)	Test assembly and test procedure acc. DIN EN 60068-2-1 Test Ab	Temperature: $(-5 \pm 3)^\circ \text{C}$ Duration: 16 h
Damp heat, cyclic (operational)	Test assembly and test procedure acc. DIN EN 60068-2-30 Test cycle Variant 1 and regulated recovery conditions	Low temperature: $(25 \pm 3)^\circ \text{C}$ High temperature: $(40 \pm 2)^\circ \text{C}$ Relative air humidity: a) at low temp. $\geq 95\%$ b) at high temp. $(93 \pm 3)\%$ Number of cycles: 2
Damp heat, steady state (endurance)	Test assembly and test procedure acc. DIN EN 60068-2-78 Test Cab	Temperature: $(40 \pm 2)^\circ \text{C}$ Relative air humidity: $(93 \pm 3)\%$ Duration: 21 days
Vibration, sinusoidal (operational)	Test assembly and test procedure acc. DIN EN 60068-2-6 Test Fc	Frequency range: (10 to 150) Hz Acceleration: $4,9 \text{ ms}^{-2}$ ($0,5 g_n$) Number of axes: 3 Sweep rate: $1 \text{ octave min}^{-1}$ Number of cycles: 1 per axis
Vibration, sinusoidal (endurance)	Test assembly and test procedure acc. DIN EN 60068-2-6 Test Fc	Frequency range: (10 to 150) Hz Acceleration: $9,81 \text{ ms}^{-2}$ ($1,0 g_n$) Number of axes: 3 Sweep rate: $1 \text{ octave min}^{-1}$ Number of cycles: 20 per axis
Impact (operational)	Test assembly and test procedure acc. DIN EN 60068-2-75 Test Eh	Impact energy: $(0,5 \pm 0,04) \text{ J}$ Number of impacts per point: 3
Electromagnetic compatibility *1		
Electrostatic discharge (operational)	Test procedure acc. DIN EN 50130-4	Test voltages: Air discharges: 2, 4 and 8 kV Contact discharges: 2, 4 and 6 kV Polarity: positive and negative Number of discharges per point at each voltage and polarity: 10 Interval between discharges: $\geq 1 \text{ s}$

Radiated electromagnetic fields (operational)	Test procedure acc. DIN EN 50130-4	Frequency range: (80-2000) MHz Field strength: 10 V/m 30 V/m in the range 890-960 MHz Modulation: Amplitude: 80 %, 1 kHz, sinusoidal, Duration at least: 3 s
Conducted disturbances induced by electromagnetic fields (operational)	Test procedure acc. DIN EN 50130-4	Frequency range: (0,15 – 100) MHz Voltage level (EMF) U _o : 140 dB μ V (10 V) Modulation: Amplitude:80 %, 1 kHz, sinusoidal
Fast transient bursts (operational)	Test procedure acc. DIN EN 50130-4	Test voltages: 2,0 kV for mains voltage supply lines 1,0 kV for DC low voltage supply lines and other input/output, signal, data and control lines Polarity: + and - Conditionings per polarity: 1 Duration per conditioning: 1 minute (+0,2; -0)
Slow high energy voltage surges (operational)	Test procedure acc. DIN EN 50130-4	Coupling mode AC mains voltage lines: line-line: 0,5 and 1 kV line-ground: 0,5; 1 and 2 kV Signal and low voltage lines: line-ground: 0,5 and 1 kV Polarity: + and - Minimum number of surges at each polarity, voltage, coupling mode and line: AC mains voltage lines: 20 Signal and low voltage lines: 5
Mains supply voltage dips and short interruptions	Test procedure acc. DIN EN 50130-4	30 % voltage dip for: 0,5; 1; 5 and 10 periods 60 % voltage dip for: 0,5; 1; 5; 10 periods 100 % voltage dip for: 0,5; 1; 5 periods For all voltage dips the following applies: Number of dips per period: 3 Interval between dips: \geq 10 s

*1 only if the controller contains equipment with electronic circuits. Equipment with electronic circuits in which all elements are passive (e.g. diodes, resistors, varistors, capacitors, overvoltage suppressors, restrictors) need not be tested.

5.11.2 State of the specimen during conditioning

Operational tests: During the conditioning period the specimen is connected to its supply and monitoring equipment.

Endurance tests: During the conditioning period the specimen is not powered.

5.11.3 Measurements during conditioning

Operational tests: The specimen shall be monitored during the conditioning period to detect any deviations from the quiescent condition. During the last hour of conditioning in the tests Cold, Damp heat steady state, and during the last half hour of the high-temperature phase of the last cycle of Damp heat cyclic the functional test specified in 5.11.6 shall be carried out.

5.11.4 Final measurements

Operational and endurance tests: After the conditioning periods and a recovery period of at least 1h in standardised laboratory conditions the functional test of 5.11.6 shall be carried out.

5.11.5 Requirements

During the conditioning period, the specimen shall remain in the quiescent condition, unless the functional test requires any change of the functional condition.

During the functional test the specimen shall function correctly within the manufacturer's specifications.

5.11.6 Functional test

A load (dummy load) agreed with the manufacturer shall be switched on by the controller at the applied nominal voltage.

5.11.7 Resistance to excessive heat and fire

If resistance tests to excessive heat and fire for plastic parts such as housings of components, covers etc. are not specified in the relevant device regulations or if no test certificates by the manufacturer have been submitted, these parts shall be subjected to the following test procedures:

DIN EN 60695-2-10 and DIN EN 60695-2-11

Insulating parts fixing current-carrying parts shall pass the Glowing wire test at a test temperature of 960°C.

Any other insulating parts including those used for fixing the protective conductor shall fulfil the requirements of the Glowing wire test at a temperature of 650°C.

For small parts another test shall be selected (e.g. Needle-flame test acc. IEC 60695-2-2). The same procedure may be applied for other practical reasons, when the metal proportion of a part is great in comparison with the insulating proportion.

If the test cannot be carried out with a complete part, it is permitted to:

- cut out a part that includes the part to be tested, or
- cut an opening into a complete part to achieve access for the glowing wire, or
- entirely remove the part to be tested and test it separately.

The test has been passed if

- any flames or glowing have been extinguished within 30s and
- the tissue paper pad has not ignited.

If during application of the glowing wire the specimen emits flames, further needle-flame tests in accordance with IEC 60695-2-2 may have to be carried out to test those parts affected by the flames.

5.12 Other tests

Where required due to special constructions or new manufacturing processes, additional tests shall be carried out by agreement with the manufacturer.