

Prüfbericht-Nr.: CN24G3KM 001 <i>Test report no.:</i>		Auftrags-Nr.: 326054735 <i>Order no.:</i>		Seite 1 von 38 Page 1 of 38	
Kunden-Referenz-Nr.: 2513995 <i>Client reference no.:</i>		Auftragsdatum: 2024-09-25 <i>Order date:</i>			
Auftraggeber: Suzhou RCT Power Energy Technology Co., Ltd <i>Client:</i>		5.1.2e China			
Prüfgegenstand: C&I Energy Storage System Battery Rack <i>Test item:</i>					
Bezeichnung / Typ-Nr.: RACK-233L1D-IEC-20,RACK-233L1D-UL-20 <i>Identification / Type no.:</i> RACK-233L1D-IEC-21,RACK-233L1D-UL-21					
Auftrags-Inhalt: Test Report <i>Order content:</i>					
Prüfgrundlage: IEC 60730-1:2022 Annex H <i>Test specification:</i> UL 60730-1:2022 Annex H					
Wareneingangsdatum: 2024-10-20 <i>Date of sample receipt:</i>					
Prüfmuster-Nr.: Engineer Sampling <i>Test sample no.:</i>					
Prüfzeitraum: 2024-10-20 - 2024-12-17 <i>Testing period:</i>					
Ort der Prüfung: See others <i>Place of testing:</i>					
Prüflaboratorium: TÜV Rheinland (Shanghai) Co., Ltd. <i>Testing laboratory:</i>					
Prüfergebnis*: Pass <i>Test result*:</i>					
geprüft von: tested by: 5.1.2e		genehmigt von: authorized by: 5.1.2e			
Datum: Date: 2024-12-18		Ausstellungsdatum: Issue date: 2024-12-18			
Stellung / Position: Project Engineer		Stellung / Position: Authorizer			
Sonstiges / <i>Other:</i> Place of testing is at Unit 01, 02, Building B, Jiangsu P.R. China.		5.1.2e 5.1.2e 5.1.2e, Suzhou,			
Zustand des Prüfgegenstandes bei Anlieferung: <i>Condition of the test item at delivery:</i>		Prüfmuster vollständig und unbeschädigt <i>Test item complete and undamaged</i>			
* Legende: P(ass) = entspricht o.g. Prüfgrundlage(n) F(ail) = entspricht nicht o.g. Prüfgrundlage(n) N/A = nicht anwendbar N/T = nicht getestet * Legend: P(ass) = passed a.m. test specification(s) F(ail) = failed a.m. test specification(s) N/A = not applicable N/T = not tested					
Dieser Prüfbericht bezieht sich nur auf das o.g. Prüfmuster und darf ohne Genehmigung der Prüfstelle nicht auszugsweise vervielfältigt werden. Dieser Bericht berechtigt nicht zur Verwendung eines Prüfzeichens. This test report only relates to the above mentioned test sample. Without permission of the test center this test report is not permitted to be duplicated in extracts. This test report does not entitle to carry any test mark.					

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Test report no.:

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Anmerkungen
Remarks

1	Alle eingesetzten Prüfmittel waren zum angegebenen Prüfzeitraum gemäß eines festgelegten Kalibrierungsprogramms unseres Prüfhauses kalibriert. Sie entsprechen den in den Prüfprogrammen hinterlegten Anforderungen. Die Rückverfolgbarkeit der eingesetzten Prüfmittel ist durch die Einhaltung der Regelungen unseres Managementsystems gegeben. Detaillierte Informationen bezüglich Prüfkonditionen, Prüfequipment und Messunsicherheiten sind im Prüflabor vorhanden und können auf Wunsch bereitgestellt werden. <i>The equipment used during the specified testing period was calibrated according to our test laboratory calibration program. The equipment fulfils the requirements included in the relevant standards. The traceability of the test equipment used is ensured by compliance with the regulations of our management system. Detailed information regarding test conditions, equipment and measurement uncertainty is available in the test laboratory and could be provided on request.</i>
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3	Prüfklausel mit der Note * wurden an qualifizierte Unterauftragnehmer vergeben und sind unter der jeweiligen Prüfklausel des Berichts beschrieben. Abweichungen von Prüfspezifikation(en) oder Kundenanforderungen sind in der jeweiligen Prüfklausel im Bericht aufgeführt. <i>Test clauses with remark of * are subcontracted to qualified subcontractors and described under the respective test clause in the report. Deviations of testing specification(s) or customer requirements are listed in specific test clause in the report.</i>
4	Die Entscheidungsregel für Konformitätserklärungen basierend auf numerischen Messergebnissen in diesem Prüfbericht basiert auf der "Null-Grenzwert-Regel" und der "Einfachen Akzeptanz" gemäß ILAC G8:2019 und IEC Guide 115:2021, es sei denn, in der auf Seite 1 dieses Berichts genannten angewandten Norm ist etwas anderes festgelegt oder vom Kunden gewünscht. Dies bedeutet, dass die Messunsicherheit nicht berücksichtigt wird und daher auch nicht im Prüfbericht angegeben wird. Zu weiteren Informationen bezüglich des Risikos durch diese Entscheidungsregel siehe ILAC G8:2019. <i>The decision rule for statements of conformity, based on numerical measurement results, in this test report is based on the "Zero Guard Band Rule" and "Simple Acceptance" in accordance with ILAC G8:2019 and IEC Guide 115:2021, unless otherwise specified in the applied standard mentioned on Page 1 of this report or requested by the customer. This means that measurement uncertainty is not taken in account and hence also not declared in the test report. For additional information to the resulting risk based of this decision rule please refer to ILAC G8:2019.</i>



TEST REPORT IEC/UL 60730-1 Automatic electrical controls for household and similar use Controls using software	
Report Number.:	CN24G3KM 001
Date of issue	See cover page
Total number of pages	See cover page
Name of Testing Laboratory preparing the Report.....:	See cover page
Applicant's name	See cover page
Address	See cover page
Test specification: Standard	
Test procedure.....	
Non-standard test method.....: N/A	
Test Report Form No.....:	IEC60730_1i_SOFTWARE
Test Report Form(s) Originator.....:	TÜV Rheinland (Shanghai) Co., Ltd.
Master TRF	2023-11
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General disclaimer: The test results presented in this report relate only to the object tested. The authenticity of this Test Report and its contents can be verified by contacting the NCB, responsible for this Test Report.	

Test Item description	See cover page	
Trade Mark		
Manufacturer	See cover page	
Model/Type reference	See cover page	
Ratings	See copy of marking label and model list	
Software module(s) and associated version(s)	HW version: SCH_BMU-B30-64-504_V1.4, SCH_BCU-B30-201_V1.3 SW Version: V13.81.5.1	
Responsible Testing Laboratory (as applicable), testing procedure and testing location(s):		
☐ CB Testing Laboratory:		
Testing location/ address.....:		
Tested by (name, function, signature).....:		
Approved by (name, function, signature)....:		
☐ Testing procedure: CTF Stage 1:		
Testing location/ address.....:		
Tested by (name, function, signature).....:		
Approved by (name, function, signature)....:		
☐ Testing procedure: CTF Stage 2:		
Testing location/ address.....:		
Tested by (name + signature)		
Witnessed by (name, function, signature) .:		
Approved by (name, function, signature)....:		
☐ Testing procedure: CTF Stage 3:		
☐ Testing procedure: CTF Stage 4:		
Testing location/ address.....:		
Tested by (name, function, signature).....:		
Witnessed by (name, function, signature) .:		
Approved by (name, function, signature)....:		
Supervised by (name, function, signature) :		

List of Attachments (including a total number of pages in each attachment):

- Attachment 1 - FMEA and fault insert testing
- Attachment 2 - Electrical clearance and creepage distance

Summary of compliance with National Differences (List of countries addressed):

N/A

Copy of marking plate:

The artwork below may be only a draft. The use of certification marks on a product must be authorized by the respective NCBs that own these marks.

For Battery System:

Rechargeable Lithium-Ion Battery Rack		RCT power
Product Name: C&I Energy Storage System Battery Rack Model: RACK-233L1D-IEC-20 Battery Designation: IFpP/73/175/208/[((13S)4S)5S]E/-10+40/90 Nominal Voltage: 832 Vd.c. Rated Capacity: 280 Ah Rated Energy: 232960 Wh Operating Voltage Range: 715~928.2Vd.c. Maximum Charging Power: 116480W Maximum Discharging Power: 116480W Ingress Protection: IP20 / Battery Pack IP67 Protection Class: I Operating Temperature Range: -20~45°C Icc / Icp, mr: 15kA with fuse / 8000A@1500Vd.c. (L/R≤2ms)		
    		
Suzhou RCT Power Energy Technology Co., Ltd Add: Unit 01 and 02, Building B 5.1.2e 5.1.2e 5.1.2e Suzhou, Jiangsu, P.R. China		

Label for model: RACK-233L1D-IEC-20

Rechargeable Lithium-Ion Battery Rack		RCT power
Product Name: C&I Energy Storage System Battery Rack Model: RACK-233L1D-IEC-21 Battery Designation: IFpP/73/175/208/[((13S)4S)5S]E/-10+40/90 Nominal Voltage: 832 Vd.c. Rated Capacity: 280 Ah Rated Energy: 232960 Wh Operating Voltage Range: 715~928.2Vd.c. Maximum Charging Power: 116480W Maximum Discharging Power: 116480W DCDC Input/Output: 832V, 1.5A / 24V, 12.5A Ingress Protection: IP20 / Battery Pack IP67 Protection Class: I Operating Temperature Range: -20~45°C Icc / Icp, mr: 15kA with fuse / 8000A@1500Vd.c. (L/R≤2ms)		
    		
Suzhou RCT Power Energy Technology Co., Ltd Add: Unit 01 and 02, Building B 5.1.2e 5.1.2e 5.1.2e Suzhou, Jiangsu, P.R. China		

Label for model: RACK-233L1D-IEC-21

Rechargeable Lithium-Ion Battery Rack



Product Name: C&I Energy Storage System Battery Rack
 Model: RACK-233L1D-UL -20
 Battery Designation: IFpP/73/175/208/[((13S)4S)5S]E/-10+40/90
 Nominal Voltage: 832 Vd.c.
 Rated Capacity: 280 Ah
 Rated Energy: 232960 Wh
 Operating Voltage Range: 715~928.2Vd.c.
 Maximum Charging Power: 116480W
 Maximum Discharging Power: 116480W
 Ingress Protection: IP20 /Battery Pack IP67
 Protection Class: I
 Operating Temperature Range: -20~45°C
 Icc / Icp, mr: 15kA with fuse / 8000A@1500Vd.c. (L/R≤2ms)



Suzhou RCT Power Energy Technology Co., Ltd

Add: Unit 01 and 02, Building B, No. 28 5.1.2e 5.1.2e t, Suzhou, Jiangsu, P.R. China

Label for model: RACK-233L1D-UL-20

Rechargeable Lithium-Ion Battery Rack



Product Name: C&I Energy Storage System Battery Rack
 Model: RACK-233L1D-UL -21
 Battery Designation: IFpP/73/175/208/[((13S)4S)5S]E/-10+40/90
 Nominal Voltage: 832 Vd.c.
 Rated Capacity: 280 Ah
 Rated Energy: 232960 Wh
 Operating Voltage Range: 715~928.2Vd.c.
 Maximum Charging Power: 116480W
 Maximum Discharging Power: 116480W
 DCDC Input/Output: 832V, 1.5A /24V, 12.5A
 Ingress Protection: IP20 /Battery Pack IP67
 Protection Class: I
 Operating Temperature Range: -20~45°C
 Icc / Icp, mr: 15kA with fuse / 8000A@1500Vd.c. (L/R≤2ms)

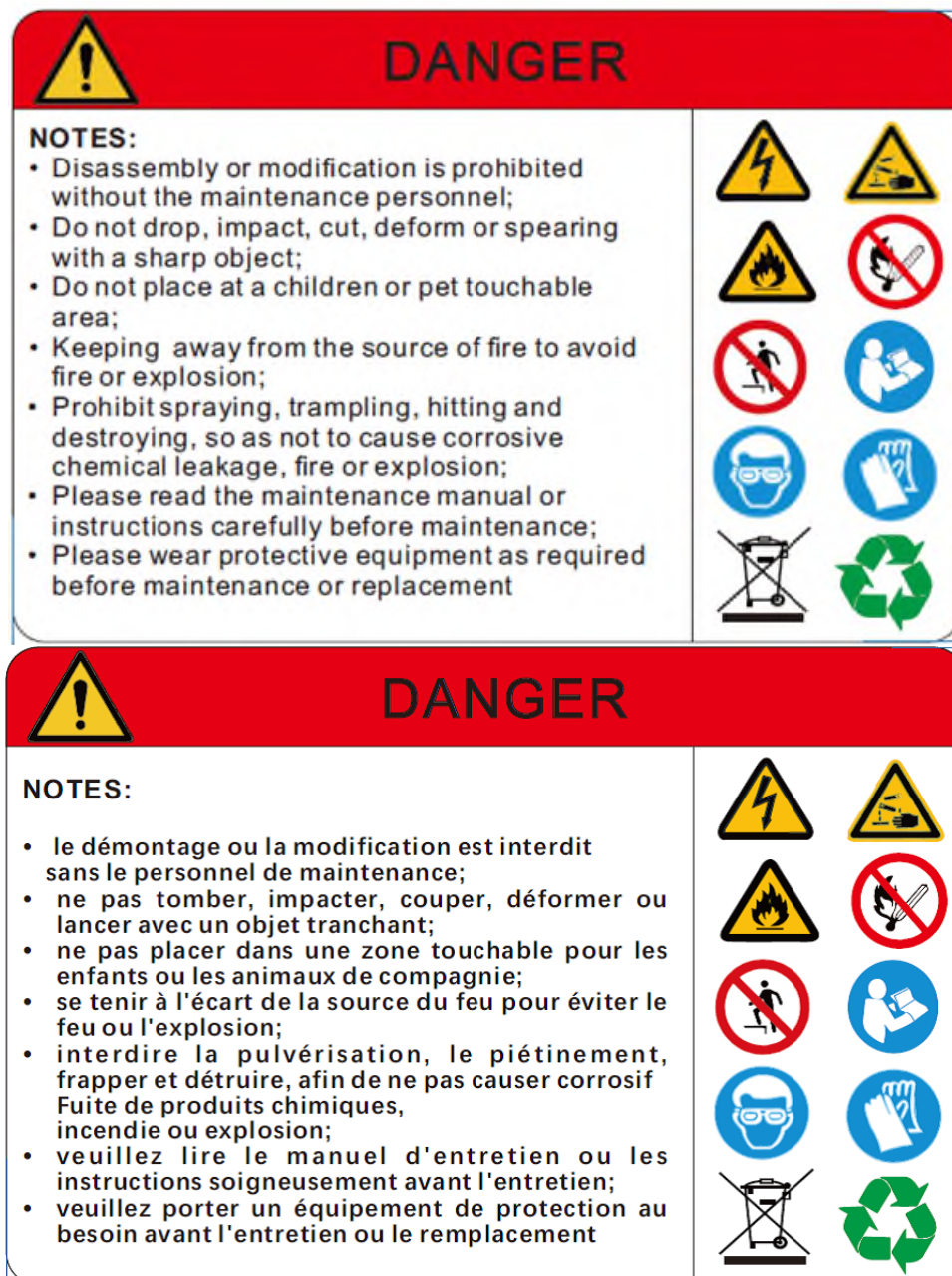


Suzhou RCT Power Energy Technology Co., Ltd

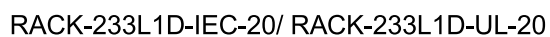
Add: Unit 01 and 02, Building B, No. 28 5.1.2e 5.1.2e t, Suzhou, Jiangsu, P.R. China

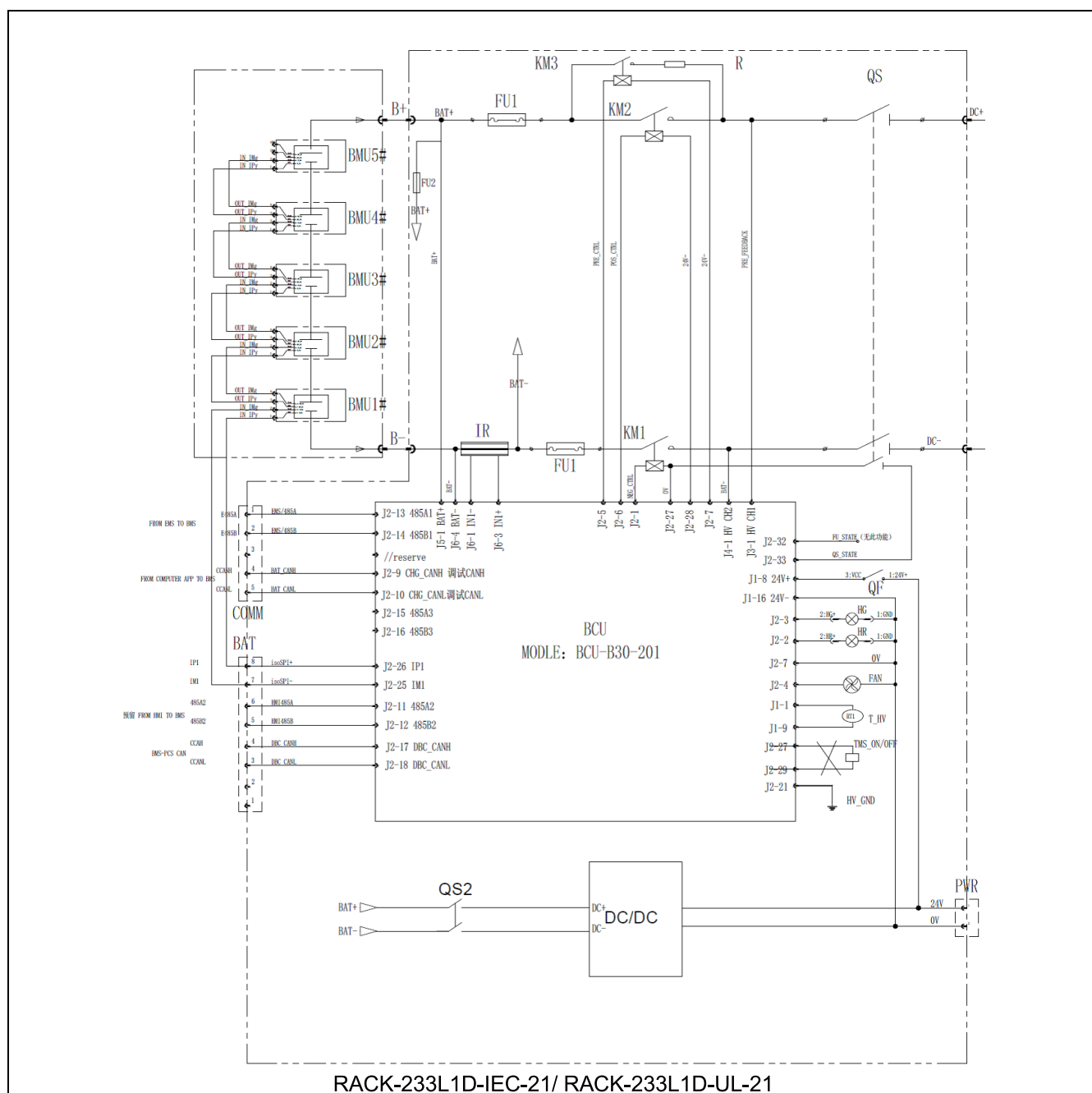
Label for model: RACK-233L1D-UL-21

Warning label:



TEST ITEM PARTICULARS:	
Manufacturer's specified maximum operating ambient:	45°C
POSSIBLE TEST CASE VERDICTS:	
- test case does not apply to the test object.....:	N/A
- test object does meet the requirement	P (Pass)
- test object does not meet the requirement	F (Fail)
TESTING:	
Date of receipt of test item.....:	See cover page
Date (s) of performance of tests.....:	See cover page
GENERAL REMARKS:	
"(See Enclosure #)" refers to additional information appended to the report. "(See appended table)" refers to a table appended to the report. This Test Report is only applicable to controls using software. This TRF is to be used in conjunction with the IEC 60730-1, Edition 5.1 Test Report. Throughout this report a ☐ comma / ☒ point is used as the decimal separator. When differences exist; they shall be identified in the General product information section.	
Name and address of factory (ies)	Suzhou RCT Power Energy Technology Co., Ltd 5.1.2e Street, Suzhou, Jiangsu P.R. China
GENERAL PRODUCT INFORMATION:	
<u>Product Description:</u> This product is used for Energy Storage System. The EUTs described in this report are two models of LFP lithium-ion battery energy storage systems which include one control box and five battery packs in series connection. The difference between them is that the Control box of model RACK-233L1D-IEC-21/RACK-233L1D-UL-21 have a DC/DC module and the Control box of model RACK-233L1D-IEC-20/RACK-233L1D-UL-20 do not have a DC/DC module. The battery module is constructed with 52 battery cells in series. And it contains one BMU board for measuring and collecting the cell parameters and uploading the information of cell voltage and temperature to BCU in control box. The battery system has overcharge, over-discharge, over current and short-circuits proof circuit. The electronic circuits and software controls for the battery system relied upon protective functions of the battery management system which have been evaluated in accordance with IEC/UL 60730-1 Annex H. The EUT is indoor type. The insulation between the DC circuit and the metal enclosure is basic insulation. The insulation between the DC circuit and communication circuit is reinforced insulation or double insulation. OVC II considered for the rack, it shall be isolated from an OVC III supply source through an isolated transformer or protected in a manner that prevents transient overvoltage conditions in end use. The Ingress Protection (IP) rating of the EUT is IP20 and the Pollution Degree (PD) of it is PD 2, which specified by the manufacturer. The equipment has been evaluated according to IEC 62477-1:2012+A1:2017, EN 62477-1+A11+A1 +A12:2021 and UL1973:2022. Block diagram as below:	





The main features of the cell and battery system are shown as below:

	Cell	Module
Product	Rechargeable Li-ion Cell	Rechargeable Li-ion Battery
Type/model	GSP71173204F	POWER CESS PACK 47L1D2
Cell Capacity [Ah]	280	280

Cell Quantity	1	52
Battery structure	-	1P52S
Nominal voltage [V]	3.2	166.4
Rated capacity [Wh]	896	46592
Upper limit charging voltage [V]	3.65	183.76
Recommend charging current [A]	140	140
Maximum charging current [A]	280	175.7
Recommend discharging current [A]	140	140
Maximum discharging current [A]	280	175.7
Discharge cut-off voltage [V]	2.5	137.6
Temperature range for charging [°C]	0 to 60°C	0 to 45°C
Temperature range for discharging [°C]	-20 to 60	-20 to 45°C
Temperature threshold for protection	-	50°C
Overcharge protected voltage supply by battery system	-	≥3.63V /Cell
Recommend charging method by manufacturer	At constant power 448W until the voltage reaches 3.65V	At constant power 23.296kW till any one cell voltage reaches 3.63V
Dimension [mm]	(71.7±0.8) *(173.9±0.8) *(207.2±0.8) T*W*H(mm) without terminal	243mm(H)*810mm(W)*1130mm(D)
Weight [kg]	(5.55±0.3) kg	332.5 ± 5Kg
Ingress Protection (IP)	-	IP67
Protective Class	-	I
Cooling type	-	Liquid cooling
Altitude [m]	-	2000

	Battery system	
Product	C&I Energy Storage System Battery Rack	
Type/model	RACK-233L1D-IEC-20/ RACK-233L1D-UL-20	RACK-233L1D-IEC-21/ RACK-233L1D-UL-21
Component	Control box (Without DCDC) + Battery pack*5	Control box (With DCDC) + Battery pack*5
DC-DC port Input	-	250-1500 V, 1.5 A
DC-DC port Output	-	24V, 12.5A

Cell Capacity [Ah]	280
Cell Quantity	260
Battery structure	((13S)4S)5S
Operating voltage range [Vd.c.]	715-928.2
Nominal voltage [V]	832
Rated capacity [Wh]	232960
Recommend Current [A]	140
Maximum charging and discharging current [A]	175.7
Maximum charging and discharging power [kW]	116.48
Recommend charging method by manufacturer	At constant power 116.48kW till any one cell voltage reaches 3.63V
Recommend discharging method by manufacturer	Discharging with constant power 116.48kW to any one cell discharge cut-off voltage 2.55V
Over voltage category	OVC II
Temperature range for charging [°C]	Charge: 0 to 45
Temperature range for discharging [°C]	Discharge: -20 to 45
Temperature threshold for protection[°C]	50
Overcharge protected voltage supply by battery system	≥3.63V /Cell
Dimension [mm]	1220*930*1835
Weight [kg]	1960
Installation Type	Floor standing
Pollution degree	2
Ingress Protection (IP)	IP20 (Battery Pack IP67)
Protective Class	I
Cooling type	Liquid cooling
Altitude[m]	2000
Additional application considerations – (Considerations used to test a component) – N/A	

DESCRIPTION OF SAFETY FUNCTION(S)

	Safety function 1 – Voltage protection function	
	Software protection	Hardware protection
Description	If the maximum voltage of a cell in the system is higher than the safe battery usage threshold and the duration reaches the threshold, both relays will be disconnected, and fault will be reported. If the minimum voltage of a cell in the system is lower than the safe battery usage threshold and the duration reaches the threshold, both relays will be disconnected, and fault will be reported.	-
Input	Cell voltage	-
threshold value	Overvoltage: 3.63V Low voltage: 2.53V	-
Response time	5 s	-
Output	MCU switch off both relays	-

	Safety function 2 – Temperature protection function	
	Software protection	Hardware protection
Description	If the maximum temperature of a cell in the system is higher than the safe battery usage threshold during charging or discharging, and the duration reaches the threshold, both relays will be disconnected, and fault will be reported. If the minimum temperature of a cell in the system is lower than the safe battery usage threshold during charging or discharging, and the duration reaches the threshold, both relays will be disconnected, and fault will be reported.	-
Input	Cell temperature	-
threshold value	Over temperature for charging: 55°C Low temperature for charging: 0°C Over temperature for discharging: 55°C Low temperature for discharging: -20°C	-
Response time	5 s	-
Output	MCU switch off both relays	-

	Safety function 3 – Current protection function	
	Software protection	Hardware protection

Description	If the maximum current of the system is higher than the safe battery usage threshold during charging or discharging, and the duration reaches the threshold, both relays will be disconnected, and fault will be reported.	Fuse (INTERRUPTING CAPACITY: 250,000 A at 1500V DC, Time Constant: $\leq 4\text{ms}$) is assembled in positive circuit.
Input	Charging/discharging current	Charging/discharging current
threshold value	Charging/discharging current: 205A	-
Response time	5 s	-
Output	MCU switch off both relays	Break of fuse, and the charging/discharging loop is disconnected.

IEC/UL 60730-1 Annex H			
Clause	Requirement + Test	Result - Remark	Verdict
H.5	Information in addition to Table 1 provided:		P
	H.3 - Software sequence documentation; clause: H.9.12.2.9; method: X	Considered.	P
	H.4 - Program documentation; clause: H.9.12.2.9, H.9.12.2.11; method: X		P
	H.5 - Software fault analysis; clause: H.9.1.2, 13.1.3; method: X		P
	H.6 - Software class(es) and structure; This information is not required for class A controls; clause: H.9.12.2, H.9.12.3, H.13.2.2.1, H.13.2.3.1; method: D		P
	H.7 - Analytical measures and fault/error control techniques employed; clause: H.3.17.10 H.9.12.2.6; method: X		P
	H.8 - Software fault/error detection time(s) for controls with software Classes B or C; clause: H.2.17.10, H.11.12.2.6; method: X		P
	H.9 - Control response(s) in case of detected fault/error; clause: H.9.12.2.7; method: X		P
	H.10 – Controls subjected to a second fault analysis and declared condition as a result of the second fault; clause H.13.2.3; method: X		P
	H.11 - Fault reaction time; clause H.3.22.2, H.13.2.2.2, H.13.2.2.3, H.13.2.3.2, H.13.2.3.3, H.13.2.4.2, H.13.2.4.3; method: X		P
	H.12 - Class or classes of control function(s), clause H.13.2.2, H.13.2.3; method: X		
	a – For controls declared as entirely class A, the requirements H.3, H.4, H.5, H.7, H.8 and H.9 of Table H.1 are exempted. For controls with software classes B or C, information shall be provided only for the safety-related segments of the software. Information on the non-safety related segments shall be sufficient to establish that they do not influence the safety-related segments.....		P

IEC/UL 60730-1 Annex H			
Clause	Requirement + Test	Result - Remark	Verdict
	b – The software sequence shall be documented and, together with the operating sequence of table requirement 46, shall include a description of the control system philosophy, the control flow, data flow and the timings.:		P
	c - Safety-related data and safety-related segments of the software sequence, the malfunction of which could result in non-compliance with the requirements of Clause 13, 19, 24 and H.25 shall be identified. This identification shall:		P
	– Included the operating sequence		P
	– Software fault analysis was related to the hardware fault analysis in Clause H.13.2.....:		P
	e - Programming documentation was supplied in a programming design language declared by the manufacturer		P
	f – Different software classes applied to different control functions		P
	g - Measures declared are chosen by manufacturer from the requirements of Clauses H.9.12.1.2 to H.9.12.2.4 inclusive.....:		P
H.9	Constructional requirements		P
H.9.12	Controls using software		P
	Controls using software were so constructed that the software did not impair control compliance with the requirements of this standard		P
H.9.12.1	Requirements for the architecture		P
H.9.12.1.1	Control functions with software class B or C use measures to control and avoid software-related faults/errors in safety-related data and safety-related segments of the software, as detailed in H.9.12.1.2 to H.9.12.3 inclusive.	Class B considered	P
H.9.12.1.2	Structure for control functions with software class B or C		
H.9.12.1.2.1	Control functions with software class C have one of the following structures:		N/A
	– single channel with periodic self-test and monitoring (H.3.16.7)	Class B	N/A

IEC/UL 60730-1 Annex H			
Clause	Requirement + Test	Result - Remark	Verdict
	– dual channel (homogenous) with comparison (H.3.16.3)		N/A
	– dual channel (diverse) with comparison (H.3.16.2)		N/A
H.9.12.1.2.2	Control functions with software class B have one of the following structures:		P
	– single channel with functional test (H.3.16.5)	Used	P
	– single channel with periodic self-test (H.3.16.6)	Used	P
	– dual channel without comparison (H.3.16.1)	Not used	N/A
H.9.12.1.3	Other structure permitted with equivalent level of safety to those in H.9.12.1.2 :		P
H.9.12.2	Measures to control faults/errors		P
H.9.12.2.1	Redundant memory with comparison provided on two areas of the same component: data stored in different formats		P
H.9.12.2.2	Software class C using dual channel structures with comparison: additional fault/error detection means		N/A
H.9.12.2.3	Software class B or C: means for recognition and control of errors in transmission to external safety-related data paths: Means took into account errors of data, addressing, transmission timing and sequence of protocol		P
H.9.12.2.4	For control with software class B or C, the manufacturer shall provide, within the control, measures to address the fault/errors in safety-related segments and data indicated in Table H.2 and declared in Table H.1, requirement H.5.		P
H.9.12.2.5	Measures others than those specified in H.9.12.2.4 are permitted if they can be shown to satisfy the requirements listed in Table H.2.		P
H.9.12.2.6	Software fault/error detection:		P
	– occur not later than declared time(s), Table H.1, requirement H.8		P

IEC/UL 60730-1 Annex H			
Clause	Requirement + Test	Result - Remark	Verdict
	– acceptability of declared time(s): evaluated during fault analysis of the control		P
H.9.12.2.7	For controls with functions, classified as Class B or C, detection of fault/error:		P
	– results in the response declared in Table H.1, requirement H.9		P
	– for Class C: independent means capable of performing this response provided		N/A
H.9.12.2.8	Class C, dual channel structure, loss of dual channel capability: deemed to be an error		N/A
H.9.12.2.9	Software referenced:		P
	– to relevant parts of the operating sequence		P
	– to the associated hardware functions		P
H.9.12.2.10	Labels used for memory locations are unique		N/A
H.9.12.2.11	Software protected from user alteration of safety-related segments and data		P
H.9.12.2.12	Software and safety-related hardware under its control is initialized to and terminates at a declared state, Table H.1, requirement H.4		P
H.9.12.3	Measures to avoid errors		P
H.9.12.3.1	For controls with software class B or C the measures shown in Figure H.1 to avoid systematic faults are applied		P
	Other methods utilized that incorporate disciplined and structured processes including design and test phases		P
H.9.12.3.2	Specification		P
H.9.12.3.2.1	Software safety requirements		P
H.9.12.3.2.1.1	The specification of the software safety requirements includes:		P

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Clause	Requirement + Test	Result - Remark	Verdict
	- A description of each safety related function to be implemented, including its response time(s): - functions related to the application including their related software classes - functions related to the detection, annunciation and management of software or hardware faults		P
	A description of interfaces between software and hardware		P
	A description of interfaces between any safety and non-safety related functions		P
H.9.12.3.2.2	Software architecture		P
H.9.12.3.2.2.1	The description of software architecture include the following aspects:		P
	Techniques and measures to control software faults/errors (refer to H.9.12.2)		P
	Interactions between hardware and software		P
	Partitioning into modules and their allocation to the specified safety functions		P
	Hierarchy and call structure of the modules (control flow)		P
	Interrupt handling		P
	Data flow and restrictions on data access		P
	Architecture and storage of data		P
	Time based dependencies of sequences and data		P
H.9.12.3.2.2.2	The architecture specification is verified against the specification of the software safety requirements by static analysis		P
H.9.12.3.2.3	Module design and coding		P
H.9.12.3.2.3.1	Software is suitably refined into modules. Software module design and coding are implemented in a way that is traceable to the software architecture and requirements. The module design specified:		P

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Clause	Requirement + Test	Result - Remark	Verdict
	– function(s)		P
	– interfaces to other modules		P
	– data		P
H.9.12.3.2.3.2	Software code is structured		P
H.9.12.3.2.3.3	Coded software is verified against the module specification, and the module specification is verified against the architecture specification by static analysis		P
H.9.12.3.2.4	Design and coding standards		P
	Program design and coding standards is used during software design and maintenance		P
	Coding standards		—
	– specified programming practice		P
	– proscribed unsafe language features		P
	– specify procedures for source code documentation		P
	– specify data naming conventions		P
H.9.12.3.3	Testing		P
H.9.12.3.3.1	Module design (software system design, software module design and coding)		P
H.9.12.3.3.1.1	A test concept with suitable test cases is defined based on the module design specification.		P
H.9.12.3.3.1.2	Each software module is tested as specified within the test concept		P
H.9.12.3.3.1.3	Test cases, test data and test results are documented		P
H.9.12.3.3.1.4	Code verification of a software module by static means includes such techniques as software inspections, walk-throughs, static analysis and formal proof		P

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Clause	Requirement + Test	Result - Remark	Verdict
	Code verification of a software module by dynamic means includes functional testing, white-box testing and statistical testing		P
H.9.12.3.3.2	Software integration testing		P
H.9.12.3.3.2.1	A test concept with suitable test cases is defined based on the architecture design specification		P
H.9.12.3.3.2.2	The software is tested as specified within the test concept		P
H.9.12.3.3.2.3	Test cases, test data and test results are documented		P
H.9.12.3.3.3	Software validation		P
H.9.12.3.3.3.1	A validation concept with suitable test cases is defined based on the software safety requirements specification		P
H.9.12.3.3.3.2	The software is validated with reference to the requirements of the software safety requirements specification as specified within the validation concept		P
	The software is exercised by simulation or stimulation of:		P
	• input signals present during normal operation		P
	• anticipated occurrences		P
	• undesired conditions requiring system action		P
H.9.12.3.3.3.3	Test cases, test data and test results are documented		P
H.9.12.3.4	Other Items		P
H.9.12.3.4.1	Equipment used for software design, verification and maintenance was qualified appropriately and demonstrated to be suitable for purpose in manifold applications		P
H.9.12.3.4.2	Management of software versions: All versions are uniquely identified for traceability		P
H.9.12.3.4.3	Software modification		P

IEC/UL 60730-1 Annex H			
Clause	Requirement + Test	Result - Remark	Verdict
H.9.12.3.4.3.1	Software modifications are based on a modification request which details the following:		P
	the hazards which may be affected		P
	the proposed change		P
	the reasons for change		P
H.9.12.3.4.3.2	An analysis is carried out to determine the impact of the proposed modification on functional safety.		P
H.9.12.3.4.3.3	A detailed specification for the modification is generated including the necessary activities for verification and validation, such as a definition of suitable test cases		P
H.9.12.3.4.3.4	The modification is carried out as planned		P
H.9.12.3.4.3.5	The assessment of the modification is carried out based on the specified verification and validation activities.		P
H.9.12.3.4.3.6	All details of modification activities are documented		P
H.9.12.3.5	For class C control functions: One of the combinations (a–p) of analytical measures given in the columns of table H.10 is used during hardware development.....	Class B	N/A
H.9.12.4	Remotely actuated control functions		N/A
H.9.12.4.2.3.1	Communication of Safety Related Data – Transmission – Safety relevant data is transmitted authentically concerning:		N/A
	– data corruption		N/A
	– address corruption		N/A
	– wrong timing or sequence		N/A
	Data variation or corrupted data did not lead to an unsafe state		N/A
	Before transmitted data was used it was ensured that data corruption, address corruption and wrong timing or sequence are addressed using the measures as given in Annex H.		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
	The following failure modes are addressed		—
	– permanent “auto-sending” or repetition,		N/A
	– interruption of data transfer		N/A
H.9.12.4.2.3.2	Access to data exchange		N/A
	Adequate hardware/software measures are taken to prevent unauthorized access to the control functions (class B and C; operating data, configuration parameters and/or software modules)		N/A
	Access to data exchange of class B control function or class C control function related operating data through public networks, has appropriate cryptographic techniques implemented.		N/A
H.9.12.4.2.3.3	For class B and class C software revisions the requirements of H.9.12.3 and hardware configuration management are applied and the control maintains its protective functions		N/A
H.9.12.4.5	Software Download and Installation		N/A
	Software updates provided by the manufacturer and transmitted to the control via remote communication were checked prior to its use:		N/A
	– against corruption through communication ensuring Hamming distance 3 for software class B, or Hamming distance 4 for software class C;		N/A
	– that the software version is compatible with the hardware version of the control according to the version management documentation.		N/A
	The software which performs the above mentioned checks had measures to control the fault/error conditions specified in H.9.12.2.		N/A
H.9.12.4.5.2	In case of software download via remote communication, the cryptographic techniques in H.9.12.4.6 were provided. In addition to the requirements in H.9.12.4.6, identification procedures were provided for the software packages.		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
	The cryptographic techniques employed were part of the control, did not rely upon part of the router or similar data transmission device itself, and were performed prior to transmission.		N/A
H.9.12.4.5.3	Each update of software had provisions for authorization by the user and a version ID number which were accessible.		N/A
H.9.12.4.5.4	The installation of class B software or class C software was permitted during and after which the software installation process the control remained in compliance with the requirements of this standard.		N/A
H.9.12.4.6	Cryptographic techniques		N/A
	In cases where class B control function or class C control function related operating data, configuration parameters and/or software modules were transmitted over a public network, and/or where software updates were provided by the manufacturer via remote communication, cryptographic techniques were employed.		N/A
H.13	Fault assessment on electronic circuits		P
H.13.2	Protection against internal faults to ensure functional safety		P
H.13.2.1	Design and construction requirements		P
H.13.2.1.1	Fault avoidance and fault tolerance		P
	Controls incorporating control functions of class B or C are designed according to H.13.2 taking into account the failure modes of Table 14 and H.9.12 for software		P
	Systematic errors are avoided		P
	Random faults are dealt with by a proper system configuration		P
	Functional analysis of the application resulted in a structured design with:		P
	– Control flow		P
	– Data flow		P

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Clause	Requirement + Test	Result - Remark	Verdict
	– Time related functions required by the application		P
	For custom-chips special attention was made to minimize systematic errors		P
	System configuration was failsafe or:		P
	Incorporated components with direct safety-critical functions guarded by safeguards that cause a completely independent safety shut-down in accordance to H.9.12 software class B or C		P
	- safeguards are built into hardware and,		P
	- safeguards are supplemented by software		P
	Time slot monitoring is sensitive to both an upper and a lower limit of the time interval.		P
	Faults resulting in a shift of the upper and/or lower limit are taken into account.		P
	In a class C control function when a single fault in a primary safeguard can render the safeguard inoperative, a secondary safeguard is provided		N/A
	The reaction time of the secondary safeguard is in accordance with Clause H.13.2.3.		P
H.13.2.1.2	Documentation		P
	The documentation was based on H.9.12.3		P
H.13.2.2	Class B control function		P
H.13.2.2.1	Design and construction requirements		P
	Software complies with software class B		P
H.13.2.3	Class C control function		N/A
H.13.2.3.1	Design and construction requirements		N/A
	Software complies with software class C		N/A
H.13.2.5	Circuit and construction evaluation		P
H.13.2.5.3	Assessment		P

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Clause	Requirement + Test	Result - Remark	Verdict
	Only the safety related software (software class B and C) as identified according to H.13.2.1.2 were subjected to further assessment		P
H.25	Electromagnetic compatibility (EMC) requirements – Immunity		P
H.25.1	General requirements	Considered in CN24MTDJ 001 001	P
	Electronic controls shall be so constructed as to: - withstand the effects of mains-borne perturbations		P
	- electromagnetic phenomena which can occur in normal use		P
H.25.2	Particular requirements for integrated and incorporated controls with type 2 action		N/A
	For integrated and incorporated controls with type 2 action, compliance is checked by H.25.5 and any other tests of Clause H.25 which are declared in Table H.1, requirement H.1.		N/A
H.25.3	Sample requirement		P
	A separate sample, as submitted, may be used for each test. At the option of the control manufacturer, multiple tests can be performed on a single sample.		P
H.25.4	Harmonics and interharmonics including mains signalling at AC power port, low frequency immunity tests		P
	The control is subjected to mains signals in accordance with IEC 61000-4-13, test level class 2 being applicable.		P
	During the test, the control is supplied with rated voltage. The test levels for Class 2 environment according to IEC 61000-4-13:2002, IEC 61000-4-13/AMD1:2009 and IEC 61000-4-13/AMD2:2015, Tables 1 to 4 shall be applied at the AC power port of the EUT. The control is tested under the test conditions as specified in the specific control standard.		P
	The following tests are performed in accordance with IEC 61000-4-13:2002, IEC 61000-4-13/AMD1:2009 and IEC 61000-4-13/AMD2:2015, Figure 1a for Class 2 environment:		P
	- "Harmonic combination" (IEC 61000-4-13:2002, IEC 61000-4-13/AMD1:2009 and IEC 61000-4-13/AMD2:2015, 8.2.1);		P

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Clause	Requirement + Test	Result - Remark	Verdict
	- "Meister curve" (IEC 61000-4-13:2002, IEC 61000-4-13/AMD1:2009 and IEC 61000-4-13/AMD2:2015, 8.2.4).		P
H.25.5	Voltage dips, voltage interruptions and voltage variations in the power supply network		P
	The control shall tolerate voltage dips voltage interruptions and voltage variations in the power supply network.		P
H.25.5.1	Voltage dips and interruptions		P
H.25.5.1.1	Test levels for voltage dips and interruptions		P
	The test values in Table H.13 shall be applied to all the test levels		P
H.25.5.1.2	Test procedure for voltage dips and interruptions		P
	The test apparatus and procedures shall be as described in IEC 61000-4-11. During the test, the control shall be initially operated at its rated voltage.		P
H.25.5.2	Voltage variation test		P
	- verify the immunity of the control against voltage change taking place over a short period which can occur due to a change of load or stored energy in local power networks.		P
H.25.5.2.1	Test levels for voltage variations		P
	The test values in Table H.14 shall be applied to all the test levels.		P
H.25.5.2.2	Test procedure		P
	The test apparatus and procedures shall be as described in IEC 61000-4-11.		P
H.25.6	Test of influence of voltage unbalance		P
H.25.6.1	The influence of unbalance in a three-phase voltage system on equipment sensitive to this kind of interference shall be investigated.		P
H.25.6.2	Test voltage characteristics		P

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Clause	Requirement + Test	Result - Remark	Verdict
	A power frequency three-phase voltage shall be applied to the control with the specified unbalance factor.		P
H.25.6.3	Test equipment/test generator		P
	The test arrangement shall consist of three single-phase auto-transformers, whose outputs are regulated individually, or the like.		P
H.25.6.4	Test level		P
	The test shall be carried out with an unbalance factor of 2 %.		P
H.25.7	Test of the influence of DC in AC networks		P
H.25.8	Surge immunity test		P
	The control shall tolerate voltage surges on the mains supply and relevant signal terminals.		P
	The tests as detailed in Table H.15 shall be applied.		P
	The test apparatus and procedure shall be as described in IEC 61000-4-5.		P
H.25.9	Electrical fast transient/burst immunity test		P
	The control shall tolerate fast transient bursts on the mains supply and on the signal lines.		P
	The tests shall be applied as specified in Table H.16.		P
	The test apparatus and test procedures shall be as described in IEC 61000-4-4.		P
H.25.10	Electrostatic discharge test		P
	This test is carried out in accordance with IEC 61000-4-2.		P
	The test values shall be applied to test level 3.		P
H.25.11	Radio-frequency electromagnetic field immunity		P
H.25.11.2.1	At minimum, the test levels in Table H.17 shall be applied.		P

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Clause	Requirement + Test	Result - Remark	Verdict
H.25.11.2.2	This test shall be carried out in accordance with IEC 61000-4-6.		P
H.25.11.3	The control shall tolerate high-frequency signals on the mains supply and relevant signal terminals.		P
H.25.11.3.1	Test levels for immunity to radiated electromagnetic fields shall be applied in accordance with Table H.18.		P
H.25.11.3.2	This test shall be carried out in accordance with IEC 61000-4-3.		P
H.25.12	Test of influence of supply frequency variations		P
	The test values in Table H.20 shall be applied.		P
	The test apparatus and procedures shall be as described in IEC 61000-4-28.		P
H.25.13	Power frequency magnetic field immunity test		P
H.25.13.1	The controls which are susceptible to magnetic field such as controls which use Hall-effect devices shall tolerate power-frequency magnetic fields.		P
H.25.13.2	The test levels shall be applied in accordance with Table H.21.		P
H.25.13.3	The control is supplied at rated voltage. Test equipment, test set-up and test procedure shall be in accordance with IEC 61000-4-8. The control is tested under the test conditions as specified in the relevant part 2.		P
H.25.14	Evaluation of compliance		P
H.25.14.1	After completion of all the tests of H.25.4 through H.25.13, the sample(s) shall meet the requirements of Clause 6, Clause 11 and 19.5.		P
H.25.14.2	The control shall meet the following:		P
	- the requirements of 19.14 or		P
	- the output(s) and functions shall be as declared in Table H.1, requirements H.1 and H.2.		P

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Clause	Requirement + Test	Result - Remark	Verdict
H.25.14.3	Different outputs and functions can be declared by the manufacturer after testing at test level 2, or test level 3, if relevant. Part 2 may specify particular criteria after each of these tests.		P
H.25.14.4	In cases where the compliance criteria is not specified for the control, the control shall comply with one of the following criteria:		P
	a) normal performance with no loss of protective functions and control is within specification or declared limits;		P
	b) loss of protective function within declared limits;		P
	c) loss of protective function with safety shut-down.		P

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Clause	Requirement + Test	Result - Remark	Verdict

TABLE H.1 – MEASURES TO ADDRESS FAULT/ERRORS (Software Class B) Software of MCU			
Component	Fault / Error	Declared measures	Verdict
1. CPU	-	-	-
1.1 Registers	Stuck at	Periodical self-test	P
1.3 Program counter	Stuck at	Periodical self-test	P
2. Interrupt handling and execution	No interrupt	Periodical self-test	P
	Too frequent interrupt	Periodical self-test	P
3. Clock	Wrong frequency (for quartz synchronized clock: harmonics/ sub-harmonics only)	Periodical self-test	P
4. Memory	-	-	-
4.1 Invariable memory	All single bit faults	Periodical self-test	P
4.2 Variable memory	DC fault	Periodical self-test and POST	P
4.3. Addressing (relevant to variable and invariable memory)	Stuck at	The same as item 4.1 and 4.2.	P
5. Internal data path	-	-	-
5.1 Data	Stuck at	Covered by item 1-4.	P
5.2 Addressing	Wrong address	Covered by item 1-4.	P
6. External communication	-	-	-
6.1 Data	Hamming distance 3	Periodical self-test	
6.2 Addressing	Wrong address	Periodical self-test	
6.3 Timing	Wrong point in time	Periodical self-test	
	Wrong sequence	Periodical self-test	
7. Input/output periphery	-	-	-
7.1 Digital I/O	Fault conditions specified in Cl.H.27	Periodical self-test	
7.2 Analog I/O	-	-	-
7.2.1 A/D and D/A-converter	Fault conditions specified in Cl. H.27	Periodical self-test	

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Clause	Requirement + Test	Result - Remark	Verdict
7.2.2 Analog multiplexer	Wrong addressing	N/A No such part	N/A
9. Custom chips e.g. ASIC, GAL, gate array	Any output outside the static and dynamic functional specification	N/A No such part	N/A

Attachment 1 - FMEA and fault insert testing

SN	Function	Compon ent	Failure Mode Failure Mode	Effect Analysis				Diagnostic technique and measure
				Safe	Dangerous detectable	Dangerous undetectable	No Effect	
BMU								
1	Power Supply	R73	O-C	-	√	-	-	Both relay+ & relay- are disconnected.
2	Cell voltage sampling	Fu4 BAT13A	O-C	-	√	-	-	Both relay+ & relay- are disconnected.
		C22	S-C	-	√	-	-	Both relay+ & relay- are disconnected.
3	Commun ication	RT12	O-C	-	√	-	-	Both relay+ & relay- are disconnected.
		RIS1	O-C	-	√	-	-	Both relay+ & relay- are disconnected.
4	TEMPER ATURE voltage sampling	R47	O-C	-	√	-	-	Both relay+ & relay- are disconnected.
		C101	S-C	-	√	-	-	Both relay+ & relay- are disconnected.
BCU								
1	Power Supply	LM1	O-C	-	√	-	-	Both relay+ & relay- are disconnected.
		CPW3	S-C	-	√	-	-	Both relay+ & relay- are disconnected.
2	communi cation	RA33	O-C					Both relay+ & relay- are disconnected.
		R11	O-C	-	√	-	-	Both relay+ & relay- are disconnected.
		UA2 PIN10& PIN11	S-C	-	√	-	-	Both relay+ & relay- are disconnected.
3	Current sampling	RV1	O-C	-	√	-	-	Both relay+ & relay- are disconnected.
		CV7	S-C	-	√	-	-	Both relay+ & relay- are disconnected.
		CV6	S-C	-	√	-	-	Both relay+ & relay- are disconnected.
4	MOS	QHL1	S-C, then simulate V/I/T fault	-	√	-	-	Both relay+ & relay- are disconnected.
		QHL9	S-C, then simulate V/I/T fault	-	√	-	-	Both relay+ & relay- are disconnected.
5	RELAY	RELAY+	S-C, then simulate V/I/T fault	-	√	-	-	Both relay+ & relay- are disconnected.
		RELAY-	S-C, then simulate V/I/T fault	-	√	-	-	Both relay+ & relay- are disconnected.
6	MOS	C127	O-C	-	√	-	-	Both relay+ & relay- are disconnected.

		RHL21	S-C	-	√	-	-	Both relay+ & relay- are disconnected.
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Attachment 2 - Electrical clearance and creepage distance

TABLE: clearance and creepage distance measurements						P
Clearance cl and creepage distance dcr at/of:	System / Impulse voltage (V)	U r.m.s. (V)	Required cl (mm) (Altitude 2000m)	cl (mm)	Required dcr (mm)	dcr (mm)
Control box						
DC+ to DC- (FI)	4000	832	3.0	See below	8.4	See below
-at DC connector	-	-	-	35.0	-	35.0
-at DC bus	-	-	-	40.0	-	40.0
Battery circuit to PE (BI)	4000	832	3.0	See below	8.4	See below
-at DC connector	-	-	-	15.0	-	20.0
- at Contactor	-	-	-	35.0	-	35.0
-at Fuse+/-	-	-	-	21.0	-	21.0
-at Busbar	-	-	-	36.0	-	36.0
Battery Pack						
DC+ to DC- (FI)	4000	832	3.0	See below	8.4	See below
-at Battery Terminal	-	-	-	>30	-	>15
Battery circuit to PE (BI)	4000	832	3.0	See below	8.4	See below
-at Battery terminal	-	-	-	13.5	-	>15.0
-at Cell	-	-	-	11.0	-	>15.0
BMU Board						
Battery circuit to PE (BI)	4000	832	3.0	See below	4.2*	See below
-at H1	-	-	-	8.0	-	8.0
-at H2	-	-	-	8.0	-	8.0
Battery circuit to communication circuit (RI)	6000	832	5.5	See below	8.4*	See below
-at T1	-	-	-	13.4	-	15.3
-at T2	-	-	-	13.4	-	15.3
CMU Board						
DC+ to DC- (FI)	4000	832	3.0	See below	8.4*	See below
-at Battery Terminal J1	-	-	-	7.5	-	>8.0

Battery circuit to PE (BI)	4000	832	3.0	See below	8.4*	See below
-at H5	-	-	-	8.5	-	>8.5
-at R1004	-	-	-	8.5	-	>8.5
Battery circuit to communication circuit (RI)	4000	832	3.0	See below	8.4*	See below
-between R1004 and J5	-	-	-	14.0	-	14.0
-at TR3 and J3	-	-	-	20.2	-	>20.0
Circuits Definition:						
Communication Circuits: DVC-A			Battery Circuits: DVC-C			
Control Circuits: DVC-C						
Legend						
Note(s): VMAX (V) = 832Vd.c, Battery circuit = O.V.C II. PD = PD2. *Material Group >600V						

- End of Test Report -

Legenda toegepaste uitzonderingsgrondslagen

In dit document zijn gegevens definitief geanonimiseerd op grond van:

Wet	Artikel	Omschrijving	Pagina's
Wet open overheid	Art. 5.1 lid 2 sub e	De eerbiediging van de persoonlijke levenssfeer	1, 6, 7, 9
Wet open overheid	Art. 5.1 lid 2 sub f	De bescherming van andere dan in het eerste lid, onderdeel c, genoemde concurrentiegevoelige bedrijfs- en fabricagegegevens	10
Burgerlijk wetboek 6	Art. 6:230b BW	Dit gegeven hoeft volgens art. 6:230b BW alleen verstrekt te worden aan de afnemer van de verleende diensten.	8, 22