



Prüfbericht-Nr.: <i>Test report no.:</i>	CN26ZZER 001	Auftrags-Nr.: <i>Order no.:</i>	326187889 P02413495	Seite 1 von 43 Page 1 of 43
Kunden-Referenz-Nr.: <i>Client reference no.:</i>	2089836	Auftragsdatum: <i>Order date:</i>	2026-05-21	
Auftraggeber: <i>Client:</i>	Pylon Technologies Co., Ltd. No.300, Miaoqiao Road, Kangqiao Town, Pudong New Area, 201315 SHANGHAI, P.R. CHINA			
Prüfgegenstand: <i>Test item:</i>	LFP Lithium Ion Energy Storage Battery System			
Bezeichnung / Typ-Nr.: <i>Identification / Type no.:</i>	RM-15, RM-22, RM-30, RM-37, RM-45, RM-52, RM-60, RM-67, RM-75 RM-15-Pro, RM-22-Pro, RM-30-Pro, RM-37-Pro, RM-45-Pro, RM-52-Pro, RM-60-Pro, RM-67-Pro, RM-75-Pro			
Auftrags-Inhalt: <i>Order content:</i>	TÜV Bauart-mark approval			
Prüfgrundlage: <i>Test specification:</i>	VDE-AR-E 2510-50:2017 2Pfg 2698/08.19			
Wareneingangsdatum: <i>Date of sample receipt:</i>	2026-07-15			
Prüfmuster-Nr.: <i>Test sample no.:</i>	A004336299-001~ A004336299-003			
Prüfzeitraum: <i>Testing period:</i>	2026-07-15 - 2026-08-13			
Ort der Prüfung: <i>Place of testing:</i>	See page 11 for details			
Prüflaboratorium: <i>Testing laboratory:</i>	TÜV Rheinland (Shanghai) Co., Ltd.			
Prüfergebnis*: <i>Test result*:</i>	Pass			
geprüft von: tested by: Yashi Zhang		genehmigt von: authorized by: Scola Chen		
Datum: Date: 2026-08-28		Ausstellungsdatum: Issue date: 2026-08-28		
Stellung / Position:	Sachverständige(r)/Expert	Stellung / Position:	Sachverständige(r)/Expert	
Sonstiges / <i>Other:</i>	See the following pages for General product information and comment.			
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. <i>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.</i>				

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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.</i> <i>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 115:2023, 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 115:2023, 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>

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Produktbeschreibung Product description

1	Produktdetails <i>Product details</i>	See model list
2	Maße / Gewicht <i>Dimensions / Weight</i>	See model list
3	Bedienelemente <i>Operating elements</i>	See model list
4	Verwendete Materialien <i>Used materials</i>	See model list
5	Sonstiges <i>Other:</i>	-Attachment 1: Photo Documentation (14 pages)
6	Prüflaboratorium: Name of Testing Laboratory preparing the Report:	TÜV Rheinland (Shanghai) Co., Ltd. 1/F., Building 10, & No.153, 165, 177, 179, 189, Lane 777, Guangzhong West Road, Jing'an District, Shanghai, China

1. 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.



PYLONTECH

LFP Lithium Ion Energy Storage Battery System

Model	Max.Charging/Discharging Current	Energy	Weight	Nominal Voltage/ Charge Voltage
RM-15	50A	15.0kWh	136kg	147.2V/163.3Vd.c.
RM-22	50A	22.5kWh	194kg	220.8V/244.95Vd.c.
RM-30	50A	30.0kWh	252kg	294.4V/326.6Vd.c.
RM-37	50A	37.5kWh	310kg	368.0V/408.25Vd.c.
RM-45	50A	45.0kWh	368kg	441.6V/489.9Vd.c.
RM-52	50A	52.5kWh	426kg	515.2V/571.55Vd.c.
RM-60	50A	60.0kWh	484kg	588.8V/653.2Vd.c.
RM-67	50A	67.5kWh	542kg	662.4V/734.85Vd.c.
RM-75	50A	75.0kWh	600kg	736.0V/816.5Vd.c.

SN: _____

Pylon Technologies Co., Ltd | www.pylontech.com.cn | Address: No.300, Miaoguo Road, Kangqiao Town, Pudong New Area, Shanghai 201318, China
The place of manufacture: Intersection of Daqianqun Road and Gaocheng Road, Economic Development Zone, Hebei County, Hebei, Anhui Province 231205, China

DANGER DANGER HIGH DC VOLTAGE INSIDE
DANGER HAUTE TENSION À L'INTÉRIEUR
DANGER ARC FLASH & SHOCK HAZARD
DANGER D'ARC ÉLECTRIQUE ET DE RISQUE D'ÉLECTROCUTION

- Do not disconnect, disassemble or repair by yourself.
Ne pas débrancher, désassembler ou réparer soi-même.
- Do not drop, deform, impact, cut or spear with a sharp object.
Ne pas échapper, déformer, frapper, couper ou transpercer avec un objet pointu.
- Do not place near open flame or incinerate.
Ne pas placer près des flammes nues ou incinérer.
- Do not sit or put heavy things on battery.
Ne pas s'asseoir ou mettre des objets lourds sur la batterie.
- Keep away from moisture or liquid.
Tenir loin de l'humidité ou de tout liquide.
- Keep out of reach of children, animals or insects.
Garder hors de la portée des enfants, des animaux ou des insectes.
- Contact your supplier within 24 hours if anything failure happens.
Contactez votre fournisseur dans les 24 heures en cas de panne.

Label for RM-15, RM-22, RM-30, RM-37, RM-45, RM-52, RM-60, RM-67, RM-75



PYLONTECH

LFP Lithium Ion Energy Storage Battery System

Model	Max.Charging/Discharging Current	Energy	Weight	Nominal Voltage/ Charge Voltage
RM-15-Pro	50A	15.0kWh	136kg	147.2V/163.3Vd.c.
RM-22-Pro	50A	22.5kWh	194kg	220.8V/244.95Vd.c.
RM-30-Pro	50A	30.0kWh	252kg	294.4V/326.6Vd.c.
RM-37-Pro	50A	37.5kWh	310kg	368.0V/408.25Vd.c.
RM-45-Pro	50A	45.0kWh	368kg	441.6V/489.9Vd.c.
RM-52-Pro	50A	52.5kWh	426kg	515.2V/571.55Vd.c.
RM-60-Pro	50A	60.0kWh	484kg	588.8V/653.2Vd.c.
RM-67-Pro	50A	67.5kWh	542kg	662.4V/734.85Vd.c.
RM-75-Pro	50A	75.0kWh	600kg	736.0V/816.5Vd.c.

SN: _____

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DANGER HAUTE TENSION À L'INTÉRIEUR
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Ne pas échapper, déformer, frapper, couper ou transpercer avec un objet pointu.
- Do not place near open flame or incinerate.
Ne pas placer près des flammes nues ou incinérer.
- Do not sit or put heavy things on battery.
Ne pas s'asseoir ou mettre des objets lourds sur la batterie.
- Keep away from moisture or liquid.
Tenir loin de l'humidité ou de tout liquide.
- Keep out of reach of children, animals or insects.
Garder hors de la portée des enfants, des animaux ou des insectes.
- Contact your supplier within 24 hours if anything failure happens.
Contactez votre fournisseur dans les 24 heures en cas de panne.

Label for RM-15-Pro, RM-22-Pro, RM-30-Pro, RM-37-Pro, RM-45-Pro, RM-52-Pro, RM-60-Pro, RM-67-Pro, RM-75-Pro

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Produktbeschreibung Product description

Registration



Manual



PYLONTECH Rechargeable Li-ion Battery

Model:	RMB70100	Battery Category	Industrial Battery
Part Number:		Chemistry:	LiFePO ₄ /LiPF ₆ /Graphite
Rated Energy/Capacity:	7.5kWh/102Ah	Hazardous Substances:	/
Nominal Voltage:	73.6Vd.c.	Usable Fire-extinguishing Agent:	A/B/C/F
Charge Voltage:	81.65Vd.c.	Critical Raw Materials:	Li>0.1%
Max.Charging/Discharging Current:	50A	Weight:	58kg

SN: _____ Date of Manufacture: _____







Pylon Technologies Co., Ltd | www.pylontech.com.cn | Address: No.300, Miaogao Road, Kangqiao Town, Pudong New Area, Shanghai 201315, China
The place of manufacture: Intersection of Daqianshan Road and Gaocheng Road, Economic Development Zone, Feixi County, Hefei, Anhui Province 231299, China

DANGER DANGER HIGH DC VOLTAGE INSIDE
DANGER HAUTE TENSION A L'INTERIEUR
DANGER ARC FLASH & SHOCK HAZARD
DANGER D'ARC ELECTRIQUE ET DE RISQUE D'ELECTROCUTION

-  Do not disconnect, disassemble or repair by yourself.
Ne pas débrancher, désassembler ou réparer soi-même.
-  Do not drop, deform, impact, cut or spear with a sharp object.
Ne pas échapper, déformer, frapper, couper ou transpercer avec un objet pointu.
-  Do not place near open flame or incinerate.
Ne pas placer près des flammes nues ou incinérer.
-  Do not sit or put heavy things on battery.
Ne pas s'asseoir ou mettre des objets lourds sur la batterie.
-  Keep away from moisture or liquid.
Tenir loin de l'humidité ou de tout liquide.
-  Keep out of reach of children, animals or insects.
Garder hors de la portée des enfants, des animaux ou des insectes.
-  Contact your supplier within 24 hours if anything failure happens.
Contactez votre fournisseur dans les 24 heures en cas de panne.

Label for Battery Pack RMB70100(Without heating function)

Registration



Manual



PYLONTECH Rechargeable Li-ion Battery

Model:	RMB70100-Pro	Battery Category	Industrial Battery
Part Number:		Chemistry:	LiFePO ₄ /LiPF ₆ /Graphite
Rated Energy/Capacity:	7.5kWh/102Ah	Hazardous Substances:	/
Nominal Voltage:	73.6Vd.c.	Usable Fire-extinguishing Agent:	A/B/C/F
Charge Voltage:	81.65Vd.c.	Critical Raw Materials:	Li>0.1%
Max.Charging/Discharging Current:	50A	Weight:	58kg

SN: _____ Date of Manufacture: _____







Pylon Technologies Co., Ltd | www.pylontech.com.cn | Address: No.300, Miaogao Road, Kangqiao Town, Pudong New Area, Shanghai 201315, China
The place of manufacture: Intersection of Daqianshan Road and Gaocheng Road, Economic Development Zone, Feixi County, Hefei, Anhui Province 231299, China

DANGER DANGER HIGH DC VOLTAGE INSIDE
DANGER HAUTE TENSION A L'INTERIEUR
DANGER ARC FLASH & SHOCK HAZARD
DANGER D'ARC ELECTRIQUE ET DE RISQUE D'ELECTROCUTION

-  Do not disconnect, disassemble or repair by yourself.
Ne pas débrancher, désassembler ou réparer soi-même.
-  Do not drop, deform, impact, cut or spear with a sharp object.
Ne pas échapper, déformer, frapper, couper ou transpercer avec un objet pointu.
-  Do not place near open flame or incinerate.
Ne pas placer près des flammes nues ou incinérer.
-  Do not sit or put heavy things on battery.
Ne pas s'asseoir ou mettre des objets lourds sur la batterie.
-  Keep away from moisture or liquid.
Tenir loin de l'humidité ou de tout liquide.
-  Keep out of reach of children, animals or insects.
Garder hors de la portée des enfants, des animaux ou des insectes.
-  Contact your supplier within 24 hours if anything failure happens.
Contactez votre fournisseur dans les 24 heures en cas de panne.

Label for Battery Pack RMB70100-Pro(With heating function)

Importer:

Telephone:

Address:

Importer marking

Note: The "+, -" markings provide on the surface of product, manufacture factory traceability provided in SN code.

Produktbeschreibung Product description

2. General product information:

Product Description:

- 1- The LFP Lithium Ion Energy Storage Battery System is used for energy storage system, comprising a Control box and a quantity of battery packs.
- 2- The Battery Pack (RMB70100, RMB70100-Pro) consists of 23 cells structured with 23S, also provide the fuse, the BMU board and related connection parts, the BMU board is used for measuring and collecting the cell parameters of each pack.

The difference between RMB70100 and RMB70100-Pro is RMB70100-Pro is equipped with heating function.

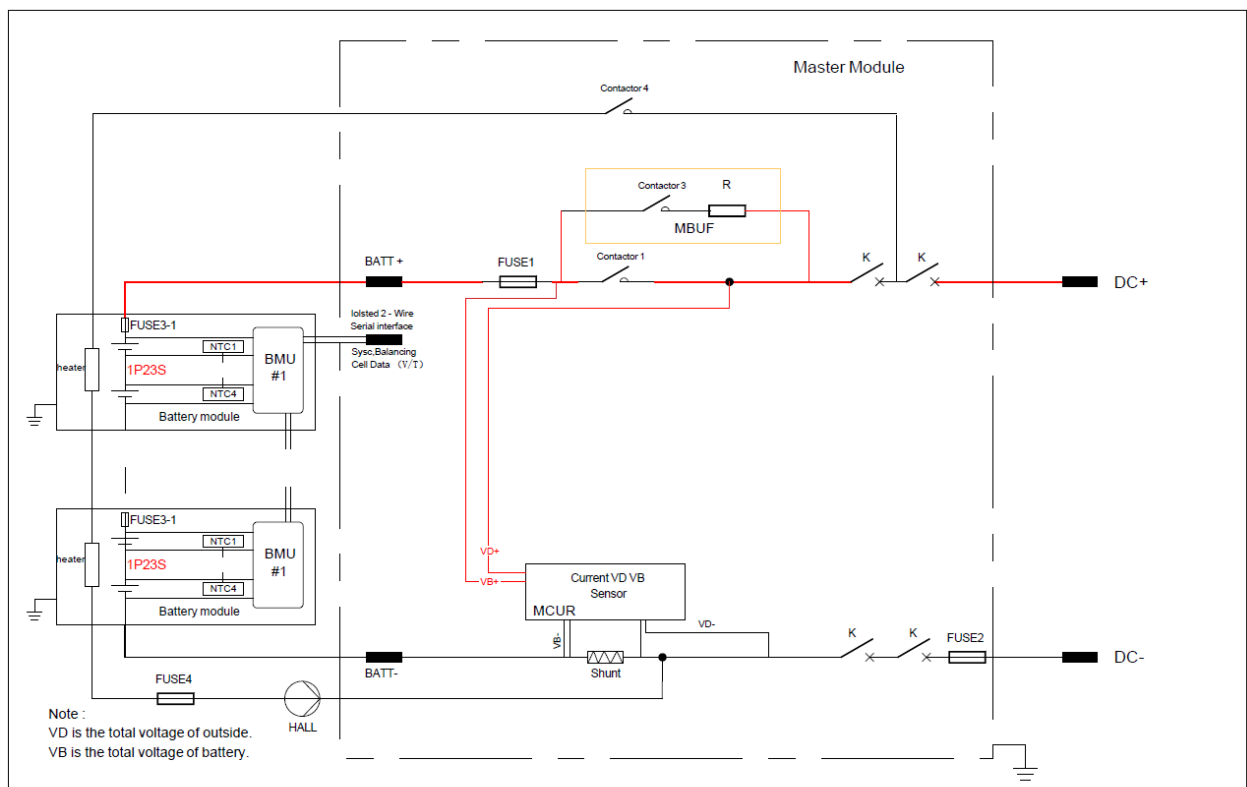
- 3- For RM-XX series and RM-XX-Pro series, the difference between models is only the number of battery packs in series connection and related parameters. Refer to the model list for details.

The difference between RM-XX series and RM-XX-Pro series is only: RM-XX-Pro series is equipped with heating function.

- 4- The battery system has overcharge, over-discharge, over current and short-circuits proof circuit. The electronic circuits and software controls for the battery system replied upon protective functions of the battery management system which have been evaluated in accordance with ISO 13849-1.

- 5- The IP rating of LFP Lithium Ion Energy Storage Battery System is IP65, and the Pollution Degree is considered as PD 2 inside, which specified by the manufacturer.

Circuit Block diagram:



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Produktbeschreibung
Product description

Model list:

Product name	Lithium-Ion Rechargeable Cell	Rechargeable Li-ion Battery Pack	
Type /model	IFP50160116-102Ah	RMB70100	RMB70100-Pro
Nominal voltage	3.2Vd.c.	73.6Vd.c.	
Rated capacity	102Ah	102Ah	
Rated energy	326.4Wh	7.5kWh	
Charging voltage declared by manufacturer	3.65Vd.c.	81.65Vd.c.	
Upper limit charging voltage	3.9Vd.c.	83.95Vd.c.	
Maximum continuous charging current	102A	50A(55 A@15min)	
Maximum continuous discharging current	255A	50A(55 A@15min)	
Discharging cut off voltage	2.5Vd.c.	See table 1	
Lower limit discharging voltage	2.0Vd.c.	See table 1	
Standard charging temperature range	0°C to 65°C	1°C to 55°C	-20°C to 55°C
Standard discharging temperature range	-30°C to 65°C	-10°C to 55°C	-20°C to 55°C
Standard charging method by manufacturer	Charging the cell with 20.4A constant current until to 3.65V, then constant voltage 3.65V until charging current reduces to 5.1A	-	
Charging method for internal short-circuit test	Charging the cell with 102A constant current until to 3.9V, then constant voltage 3.9V until charging current reduces to 5.1A	-	
Dimension	T× W×H: (49.9±0.5)mm×(160±0.8)mm×(118.5±0.5)mm	W×D×H: 770mm*380mm*170mm	
Weight	(1970±30)g	58 ± 2kg	
Ingress protection	-	IP65	
Protection class	-	Class I	
Operating altitude range	-	≤4000m	

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Produktbeschreibung
Product description

Model list for system:

Product name	LFP Lithium Ion Energy Storage Battery System			
Type /model	RM-15	RM-22	RM-30	RM-37
Nominal voltage [V]	147.2	220.8	294.4	368.0
Rated capacity [Ah]	102			
Rated energy [kWh]	15.0	22.5	30.0	37.5
Charging voltage declared by manufacturer	163.3V	244.95V	326.6V	408.25V
Maximum continuous charging current [A]	50A(55 A@15min)			
Maximum continuous discharging current [A]	50A(55 A@15min)			
Standard charging temperature range [°C]	1°C to 55°C			
Standard discharging temperature range [°C]	-10°C to 55°C			
Dimension [mm](W*H*D)	770mm* 380mm*550mm	770mm* 380mm*720mm	770mm* 380mm*890mm	770mm* 380mm*1060mm
Weight [kg]	136	194	252	310
Ingress protection	IP65			
Protection class	Class I			
Operating altitude range	≤4000m			

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Produktbeschreibung

Product description

Product name	LFP Lithium Ion Energy Storage Battery System				
Type /model	RM-45	RM-52	RM-60	RM-67	RM-75
Nominal voltage [V]	441.6	515.2	588.8	662.4	736.0
Rated capacity [Ah]	102				
Rated energy [kWh]	45.0	52.5	60.0	67.5	75.0
Charging voltage declared by manufacturer	489.9	571.55	653.2	734.85	816.5
Maximum continuous charging current [A]	50A (55 A@15min)				
Maximum continuous discharging current [A]	50A (55 A@15min)				
Standard charging temperature range [°C]	1°C to 55°C				
Standard discharging temperature range [°C]	-10°C to 55°C				
Dimension [mm](W*H*D)	770mm*380mm*1230mm	770mm*380mm*1400mm	770mm*380mm*1570mm	770mm*380mm*1740mm	770mm*380mm*1910mm
Weight [kg]	368	426	484	542	600
Ingress protection	IP65				
Protection class	Class I				
Operating altitude range	≤4000m				

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Produktbeschreibung

Product description

Product name	LFP Lithium Ion Energy Storage Battery System			
Type /model	RM-15-Pro	RM-22-Pro	RM-30-Pro	RM-37-Pro
Nominal voltage [V]	147.2	220.8	294.4	368.0
Rated capacity [Ah]	102			
Rated energy [kWh]	15.0	22.5	30.0	37.5
Charging voltage declared by manufacturer	163.3V	244.95V	326.6V	408.25V
Maximum continuous charging current [A]	50A (55 A@15min)			
Maximum continuous discharging current [A]	50A (55 A@15min)			
Standard charging temperature range [°C]	-20°C to 55°C*			
Standard discharging temperature range [°C]	-20°C to 55°C			
Dimension [mm](W*H*D)	770mm* 380mm*550mm	770mm* 380mm*720mm	770mm* 380mm*890mm	770mm* 380mm*1060mm
Weight [kg]	136	194	252	310
Ingress protection	IP65			
Protection class	Class I			
Operating altitude range	≤4000m			
Note*: with heating function. Heating is only started when the battery temperature is ≤ the set opening temperature (Minimum opening temperature is 0).				

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Produktbeschreibung
Product description

Product name	LFP Lithium Ion Energy Storage Battery System				
Type /model	RM-45-Pro	RM-52-Pro	RM-60-Pro	RM-67-Pro	RM-75-Pro
Nominal voltage [V]	441.6	515.2	588.8	662.4	736.0
Rated capacity [Ah]	102				
Rated energy [kWh]	45.0	52.5	60.0	67.5	75.0
Charging voltage declared by manufacturer	489.9	571.55	653.2	734.85	816.5
Maximum continuous charging current [A]	50A (55 A@15min)				
Maximum continuous discharging current [A]	50A (55 A@15min)				
Standard charging temperature range [°C]	-20°C to 55°C*				
Standard discharging temperature range [°C]	-20°C to 55°C				
Dimension [mm](W*H*D)	770mm*380mm*1230mm	770mm*380mm*1400mm	770mm*380mm*1570mm	770mm*380mm*1740mm	770mm*380mm*1910mm
Weight [kg]	368	426	484	542	600
Ingress protection	IP65				
Protection class	Class I				
Operating altitude range	≤4000m				
Note*: with heating function. Heating is only started when the battery temperature is ≤ the set opening temperature (Minimum opening temperature is 0).					

Table 1:

Rate of constant current (C)	[0~0.002]	[0.002~0.01]	[0.01~0.03]	[0.03~0.05]	[0.05~0.1]	[0.1~0.2]	[0.2~0.3]	[0.3~0.4]	[0.4~0.5]	[0.5~0.55]
Temperature (°C)										
[-20~-15]	3.083	3.044	2.889	2.500	2.500	2.500	2.500	2.500	2.500	2.500
[-15~-10]	3.083	3.044	2.889	2.500	2.500	2.500	2.500	2.500	2.500	2.500
[-10~-5]	3.083	3.044	2.889	2.500	2.500	2.500	2.500	2.500	2.500	2.500
[-5~0]	3.082	3.056	2.954	2.699	2.500	2.500	2.500	2.500	2.500	2.500
[0~5]	3.082	3.069	3.017	2.886	2.689	2.500	2.500	2.500	2.500	2.500
[5~10]	3.082	3.075	3.048	2.981	2.880	2.698	2.500	2.500	2.500	2.500
[10~15]	3.082	3.078	3.062	3.021	2.960	2.864	2.676	2.588	2.500	2.500
[15~20]	3.081	3.078	3.067	3.038	2.994	2.950	2.848	2.753	2.658	2.579
[20~25]	3.081	3.078	3.068	3.043	3.005	2.982	2.930	2.870	2.810	2.751
[25~30]	3.081	3.079	3.072	3.054	3.027	3.009	2.976	2.943	2.910	2.873
[30~35]	3.081	3.079	3.072	3.054	3.028	3.015	2.991	2.971	2.951	2.926
[35~40]	3.081	3.079	3.072	3.055	3.028	3.018	3.002	2.988	2.974	2.960
[40~47.5]	3.080	3.078	3.072	3.055	3.028	3.018	3.004	2.993	2.981	2.970
[47.5~55]	3.080	3.078	3.072	3.055	3.028	3.018	3.006	2.997	2.988	2.979

Note: For Battery pack and System, the discharge protection voltage of cell is determined based on the current and temperature.

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Produktbeschreibung

Product description

3. Place of testing:

TÜV Rheinland (Shanghai) Co., Ltd

No.177/ 178, Lane 777, Guangzhong West Road, Jing'an District, Shanghai, China

4. Name and address of factory:

Factory 1

Jiangsu Pylon Battery Co., Ltd.

No.7, Keyan 3rd Road, Yizheng Economic Development Zone Yangzhou 211400, JIANGSU P.R.CHINA

Factory 2

Anhui Pylon Technologies Co., Ltd.

Intersection of Daqianshan Road and Gaocheng Road, Economic Development Zone, Feixi County , Hefei, 231299, ANHUI P.R.CHINA

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4	Risk assessment and methodology for functional safety		
4.1	Risk assessment		
	a) risk analysis b) risk evaluation c) risk reduction The reliability of the implemented risk reduction measures shall meet the functional safety requirements.	Considered	P ☒ F ☐ N/A ☐ N/T ☐
	Functional safety requirements shall be assessed in accordance with at least one of the standards listed below: 1) IEC 61508 or 2) ISO 26262-2; 3) ISO 13849-1:2016-06; 4) IEC 62061:2005 + A1:2012 + A2:2015.	ISO 13849-1	P ☒ F ☐ N/A ☐ N/T ☐
	Risks remaining after risk assessment shall be indicated in the instructions for the operator. Additionally, suitable information shall be given on how to control the remaining risks.		P ☒ F ☐ N/A ☐ N/T ☐
	Based on the system conditions and the risk assessment, the manufacturer shall define a safety integrity level for the safety critical components (HW/SW) and the BESS paths. The construction requirements resulting from the intended level shall be met.		P ☒ F ☐ N/A ☐ N/T ☐
4.2	Requirements		
	The methodology and documentation of the risk assessment is evaluated to ensure that all risks are eliminated or reduced to an appropriate level. In addition to the mere documentation inspection, the risk reduction measures are verified under practical conditions.		P ☒ F ☐ N/A ☐ N/T ☐
	For this purpose, the constructional and functional safety shall be tested as follows.		P ☒ F ☐ N/A ☐ N/T ☐
	Furthermore, risks or weak points identified as a result of functional safety considerations may lead to extended testing. This is intended to determine the hazard level and the verification of the safety of the BESS under practical conditions.		P ☒ F ☐ N/A ☐ N/T ☐
5	General requirements		
5.1	CE marking		
	When placing the BESS on the market, the manufacturer is obliged to observe the (German) Product Safety Act (de: Produktsicherheitsgesetz) which includes the CE marking. The requirements are for example: a) electromagnetic compatibility (EMC, de: EMV); b) Low Voltage Directive (list of harmonized standards); c) RED telecommunications terminal equipment (as applicable);	Considered	P ☒ F ☐ N/A ☐ N/T ☐

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	e) RoHS prohibition of substances (Restriction of certain Hazardous Substances Directive); f) WEEE disposal of waste electrical and electronic equipment); g) Eco Design Directive. Verification is carried out by checking the EC conformity declaration of the manufacturer.		
5.2	Electromagnetic compatibility (EMC)		
	Compliance with the protection objectives regarding electromagnetic compatibility shall be demonstrated in accordance with the current European Directive. This can be achieved using the list of harmonized standards in the Official Journal of the European Union. Standards to be applied to BESS intended for household and business applications are, for example: – IEC 61000-6-1:2005; – IEC 61000-6-3:2006 + A1:2010.	IEC 61000-6-2 & IEC 61000-6-4, refer to EMC report: CN26K4XV 001	P ☒ F ☐ N/A ☐ N/T ☐
5.3	Low Voltage Directive (LVD)		
	Compliance with the protection objectives of the current European Low Voltage Directive (LVD) shall be demonstrated. This can be achieved using the list of harmonized standards in the Official Journal of the European Union. Depending on the use and condition of the BESS and its installed components, these can be, for example: – IEC 62368-1:2014, mod. + Cor.:2015 – IEC 60529:1989 + A1:1999 + A2:2013	Electrical safety is assessed acc. to EN 62477-1. Report No.:CN26OHTG 001.	P ☒ F ☐ N/A ☐ N/T ☐
5.4	Inverter/converter		
	Where inverters and/or converters are components of a BESS, they shall conform to the following: – IEC 62109-1 or – IEC 62477-1	Only DC battery system.	P ☐ F ☐ N/A ☒ N/T ☐
5.5	Grid integration		
	If the storage system is intended to be connected to the low voltage grid in Germany, reference shall be made to the following documents: a) VDE-AR-N 4105; b) VDE-AR-E 2510-2	No such part. Only DC battery system.	P ☐ F ☐ N/A ☒ N/T ☐
6	Constructional safety requirements		
6.1	General requirements		
	The hazards of table 1 shall be considered in the construction of a BESS as a complete system.		P ☒ F ☐ N/A ☐ N/T ☐
6.2	Tests		
6.2.1	General		
	Tests for which the number of test samples is not indicated shall be conducted using one test sample. The tests are type tests.		P ☒ F ☐ N/A ☐

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			N/T ☐
6.2.2	Insulation resistance test		
6.2.2.1	Test objective		
	The test is used to measure the insulation resistance between active conductors and the protective conductor connected to earth or the electrical ground. The test is used to measure the insulation resistance between the active conductors and the protective conductor connected to earth or the electrical ground.		P ☒ F ☐ N/A ☐ N/T ☐
6.2.2.2	Test procedure		
	Depending on the type and application of the BESS, the insulation resistance test is conducted as follows:		P ☒ F ☐ N/A ☐ N/T ☐
	1) testing at system level;		P ☐ F ☐ N/A ☒ N/T ☐
	1.1) AC coupled systems shall be subjected to all-pole testing at the point of connection to the household grid according to DIN VDE 0100-600 (VDE 0100-600). During each test run (L/PE, N/PE, L/N), the complete current circuit between the connection point and the inverter is tested; any switching and disconnecting elements in the AC circuit shall be closed and fuses shall be put in place.		P ☐ F ☐ N/A ☒ N/T ☐
	1.2) DC coupled systems are tested as described in 1.1) with their switching and disconnecting elements closed and fuses in place, but with the following modification: When measuring the insulation resistance between the DC contacts and the protective conductor potential of the system, the polarity of the test voltage shall be observed. For measurements between the positive terminal of the battery and the ground, the negative terminal of the test equipment shall be connected to the positive terminal of the battery. The positive terminal of the test equipment is connected to the protective conductor potential of the battery accordingly (see Figure 1). For measurements between the negative terminal of the battery and the ground, on the other hand, the positive terminal of the test equipment shall be connected to the negative terminal of the battery. The negative terminal of the test equipment is connected to the protective conductor potential of the battery accordingly. For both tests, the complete current circuit between the connection point and the cells shall be tested. For the purpose of testing between the positive and the negative terminal, the current circuit shall be disconnected at the point closest to the cells by means of the dedicated switching, disconnecting or fuse elements (in order to ensure that the test voltage is not applied to the cells).		P ☐ F ☐ N/A ☒ N/T ☐

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	1.3) Hybrid systems provided with AC and DC charging/discharging interfaces shall be tested in accordance with 1.1) on the AC side and with 1.2) on the DC side.		P ☐ F ☐ N/A ☒ N/T ☐
	2) testing conducted at pack and module levels; The insulation resistance of systems with a modular structure where subcomponents are DC coupled and disconnected from the system for installation, maintenance, transport or disassembly purposes is tested in accordance with 1.2).		P ☒ F ☐ N/A ☐ N/T ☐
	For all tests, the voltage level depends on the equipment under test (according to Table 3) with a minimum value of 500 V DC.		P ☒ F ☐ N/A ☐ N/T ☐
6.2.2.3	Requirements		
	For all measurements, an insulation resistance of at least 100 Ω /V in relation to the final charge voltage of the battery shall be reached. The level of the relative and the absolute value of insulation resistance as well as the tested measurement path shall be documented. The leakage current shall not exceed 10 mA. Where systems are provided with an insulation monitor, it shall be disconnected during testing. Alternatively, external testing of the insulation resistance may be conducted during the dead times while the insulation monitor is not taking any measurements. In both cases, the insulation monitor shall not influence the test result.	See table 6.2.2	P ☒ F ☐ N/A ☐ N/T ☐
6.2.3	Dielectric strength test		
6.2.3.1	Purpose		
	The test is used to check the clearances and creepage distances between the active conductors and the protective conductor potential.		P ☒ F ☐ N/A ☐ N/T ☐
	The insulation resistance shall be checked before and after each dielectric strength test in order to preclude successive damages to the test object.		P ☒ F ☐ N/A ☐ N/T ☐
	Testing is only required for test objects rated as dangerous to touch both during normal operation and in case of a single fault of the disconnecting element in accordance with DIN EN 61010-1 (VDE 0411-1), 6.3.		P ☒ F ☐ N/A ☐ N/T ☐
6.2.3.2	Test procedure		
	First, the insulation resistance test shall be conducted.		
	This shall be followed by the dielectric strength test. The level of the test voltages is determined by: – the altitude of the BESS: according to the manufacturer's specification; – the pollution degree: according to the manufacturer's specification; – the overvoltage category: depending on the type of inverter (if provided) and on the possible DC connection of supplies (e.g. PV); – the operating voltage of the equipment under test: according to the manufacturer's specification;		P ☒ F ☐ N/A ☐ N/T ☐

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	– the degree of insulation (basic insulation or double/reinforced insulation).		
	After the dielectric strength test is completed, the insulation resistance measurement shall be repeated. The test voltages shall be determined in accordance with the applicable product safety standard. If differing test voltages are derived, the higher value shall be applied.		P ☒ F ☐ N/A ☐ N/T ☐
6.2.3.3	Requirements		
	After conduction of each test, the compliance criteria in accordance with the applied relevant standard shall be met.	See table 6.2.3	P ☒ F ☐ N/A ☐ N/T ☐
6.2.4	Internal short-circuit (propagation test)		
6.2.4.1	Purpose		
	Objective of the test is to verify that the effects of the propagation of hazardous cell reactions to adjacent surrounding cells or components are limited by design. Verification shall be conducted by propagation testing in accordance with Figure 2 which is evaluated according to the type of BESS.		P ☒ F ☐ N/A ☐ N/T ☐
6.2.4.2	Test procedure		
	a) Test object: <i>Description of the test object preparation:</i>	Battery pack	P ☒ F ☐ N/A ☐ N/T ☐
	b) Procedure <i>Description of the test applied test procedure:</i>	See 6.2.6	P ☒ F ☐ N/A ☐ N/T ☐
	c) Measurement methods: <i>Description of applied measurement method:</i>	heating	P ☒ F ☐ N/A ☐ N/T ☐
	d) End of test: <i>Description of the sample condition:</i>	No external fire from the battery system or no battery case rupture.	P ☒ F ☐ N/A ☐ N/T ☐
6.2.4.3	Requirements		
	Depending on the type of the BESS, different passing criteria apply: – single solutions (small storage systems with a single closed case for cell blocks and higher-level system components); – stackable BESS (systems with their modules stacked directly on top of or directly beside one another (e.g. 19" modules within a rack)), see 6.2.6. The results of both options shall be taken into account in the risk evaluation. If applicable, further measures for minimizing risk shall be derived from this and verified.		P ☒ F ☐ N/A ☐ N/T ☐
6.2.5	Propagation test: single solutions		
6.2.5.1	Purpose		
	In case of single solutions, type related propagation of the cell defects described in 6.2.4 to adjacent cells,		P ☐ F ☐ N/A ☒ N/T ☐

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	components or the system cannot be precluded. In case of burning of the cell or the storage system, the fire shall not propagate to the surrounding environment.		
6.2.5.2	Test procedure		
	Testing shall be conducted according to 6.2.4.		P ☐ F ☐ N/A ☒ N/T ☐
6.2.5.3	Requirements		
	Component verification: For the purpose of fire protection, each single module shall be equipped with a fire protection enclosure in accordance with DIN EN 62368-1 (VDE 0868-1), M 4.3, 6.4.8. The fire protection enclosure may be the secondary lithium battery itself or that of the device in which the secondary lithium battery is contained. The presence of this fire protection enclosure shall be demonstrated by means of the test report, by visual inspection of the relevant materials or by submitting the data sheet of the secondary lithium battery.		P ☐ F ☐ N/A ☒ N/T ☐
	Test verification: Hazards (liquid electrolyte, fire, explosion or ejected parts) shall not propagate beyond the system boundaries (except vented gases which are considered separately in 7.10.3).		P ☐ F ☐ N/A ☒ N/T ☐
6.2.6	Propagation test: stackable BESS		
6.2.6.1	Purpose		
	For stackable solutions, hazards as described in 6.2.4 shall be limited to a permissible area. Cell defects shall propagate neither from module to module nor from module to system level.		P ☒ F ☐ N/A ☐ N/T ☐
6.2.6.2	Test procedure		
	Testing shall be conducted according to 6.2.4 (see also Figure 3).		P ☒ F ☐ N/A ☐ N/T ☐
6.2.6.3	Requirements		
	Component verification: For the purpose of fire protection, each single module shall be equipped with a fire protection enclosure in accordance with DIN EN 62368-1 (VDE 0868-1), M 4.3, 6.4.8. The fire protection enclosure may be the one of the secondary lithium battery itself or that of the device in which it is contained. The presence of this fire protection enclosure shall be demonstrated by means of the test report or visual inspection of the relevant materials or by submitting the data sheet of the secondary lithium battery.		P ☒ F ☐ N/A ☐ N/T ☐
	Test verification: – Cell defects shall only propagate within the module in which the thermal instability of the cell was intentionally caused. – A propagation from this module to an adjacent module	No external fire from the battery system, no battery case rupture	P ☒ F ☐ N/A ☐ N/T ☐

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	shall be precluded by testing (see above). – Hazards (liquid electrolyte, fire, explosion or ejected parts) shall not propagate beyond the system boundaries (except vented gases which are considered separately in 7.10.3).		
7	Functional safety requirements		
7.1	Battery management system (BMS)		
	For safety reasons, the battery management system (BMS) shall ensure compliance with the permissible operating range of the cell. This requires the monitoring of at least the following parameters at least the following parameters: 1) voltage of each cell/cell block; 2) current of the battery system; 3) temperature of the cells.	Considered	P ☒ F ☐ N/A ☐ N/T ☐
7.2	Software requirements		
	Where safety-related functions are represented in the BMS entirely by software-based functions, the software shall be designed as safety-related software. This requires compliance with the requirements described in Clause 4. Where application specific standards exist, they shall be applied.	Evaluated.	P ☒ F ☐ N/A ☐ N/T ☐
7.3	Plausibility of voltage measurement		
7.3.1	Purpose		
	The test is used to check the plausibility of the voltage values determined by the BMS. The uncertainty of the BMS voltage measurement resulting from the test shall be taken into account for the evaluation of subsequent tests.		P ☒ F ☐ N/A ☐ N/T ☐
7.3.2	Test procedure		
	For carrying out the test, the battery system shall be set to its normal operating condition at room temperature (BMS active, charge/discharge circuit closed). Afterwards, the following measured voltage values shall be recorded simultaneously: – voltage of three cells, randomly (BMS, test rig); or – voltage of three cell blocks, randomly (BMS, test rig).		P ☒ F ☐ N/A ☐ N/T ☐
7.3.3	Requirements		
	The following parameters shall be documented: – uncertainty of the BMS cell/cell block voltage measurement; – measurement uncertainty of the calibrated test rig. The determined uncertainties shall be taken into account in the subsequent tests (for voltage-relevant requirements).	See table 7.3	P ☒ F ☐ N/A ☐ N/T ☐
7.4	Detection of non-disconnectable switching elements		
7.4.1	Purpose		
	The test is used to check the function for detection of defective (non-disconnectable) switching elements such as electromechanical disconnecting elements or semi-conductors.		P ☒ F ☐ N/A ☐ N/T ☐
7.4.2	Test procedure		
	1) simulation of non-disconnectable switching elements under conditions of disconnection under load		P ☒ F ☐

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	2) Switching-on in the presence of a non-disconnectable switching element		N/A ☐ N/T ☐
7.4.3	Requirements		
	If a fault under load occurs, the BESS shall interrupt the charging/discharging process by means of the next higher or an equal disconnecting element of the safety chain. Disconnecting elements which are externally triggered by the BESS via communication paths shall also be effective in case of a failure of the communication path (see 7.10.1). The BESS shall prevent automatic reconnection of the charge/discharge circuit in the presence of a nondisconnectable disconnecting element. The BESS shall not switch on again unless a skilled person has been consulted and the fault has been eliminated.	There are two contactors in the control box. The non-disconnectable fault of contactor can be detected. The charging or discharging process can be interrupted by another contactor when one contactor is fault. The EUT can't switch on automatically unless the skilled person is involved and the fault has been eliminated.	P ☒ F ☐ N/A ☐ N/T ☐
7.5	Open-circuit detection of sensing line		
7.5.1	Purpose		
	The test is used to check the correct function of the open-circuit detection of sensing lines.		P ☒ F ☐ N/A ☐ N/T ☐
7.5.2	Test procedure		
	For carrying out the test, the battery system shall be set to its normal operating condition at room temperature (BMS active, charge/discharge circuit closed). Then, an exemplary interruption shall be simulated in the sensing lines dedicated to the following functions: 1) voltage measurement on cell/cell block; 2) current measurement; 3) temperature measurement. After interruption of the sensing line and the resulting reaction of the BESS, the simulated fault shall be eliminated and the BESS reset to its initial condition. The test shall be repeated for each of the functions listed above.		P ☒ F ☐ N/A ☐ N/T ☐
7.5.3	Requirements		
	The BMS shall interrupt the load circuit in time before the operating range of the cell is exceeded.	The charging or discharging process is interrupted in time. the operating range of the cell is not exceeded.	P ☒ F ☐ N/A ☐ N/T ☐
7.6	Checking the interlocking function for lockout		
	The interlocking function check is conducted and evaluated at system level in accordance with DIN EN 62040-1 (VDE 0558-510), 5.6.		P ☒ F ☐ N/A ☐ N/T ☐
7.7	Functional test for load reduction (derating)		
7.7.1	Purpose		
	For the safe operation of the battery system, it shall be ensured at all times that the operating range of the cell indicated by its manufacturer is not exceeded (see also informative Annex A). The objective of the following test is to check the correct function of the BMS in reducing the load during normal operation.		P ☒ F ☐ N/A ☐ N/T ☐

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	The objective is to demonstrate compliance with the threshold values for load reduction in the charge/discharge direction in relation to temperature and time as defined by the cell manufacturer.		
7.7.2	Test procedure		
	Prior to the test, the battery system is stored at room temperature for at least 12 h. Subsequently, the storage system shall be set to its normal operating condition and subjected to a current profile which represents a charging and discharging process under maximum load. During this, the test rig simulates the control behavior of a charge controller/inverter for the BMS. The inverter incorporated in the system may be alternatively used as a power source/sink. Possible ways of checking the current and voltage limits at different cell temperatures are as follows: – software simulation of temperature values; – hardware simulation of temperature values (e.g. by replacing existing temperature sensors with potentiometers or equivalent); – checking the limit values at the respective ambient temperatures following a homogenization period of at least 12 h with the BMS in the inactive condition. Throughout the duration of the test, the following measured values shall be recorded: – battery voltage upstream/downstream of fuse links or disconnecting devices (BMS), if applicable; – battery voltage downstream of the disconnecting elements (test rig); – overall battery current (test rig, BMS); – single cell voltages (BMS)/cell block voltages (BMS); – temperatures (BMS, test rig).		P ☒ F ☐ N/A ☐ N/T ☐
7.7.3	Requirements		
	For carrying out the test, it is assumed that a specification of the cell is provided by its manufacturer. This shall contain at least information on the following properties: – constant charge/discharge current ($I_{\text{const,chr}}$, $I_{\text{const,dchr}}$); – charge/discharge current as a function of time ($I_{\text{chr}}(t)$, $I_{\text{dchr}}(t)$); – charge/discharge current as a function of temperature ($I_{\text{chr}}(T)$, $I_{\text{dchr}}(T)$). In addition, the following requirements shall be met: – measurement and documentation of the numerical values and the recording rate for battery voltage, battery current, single cell voltages (or cell block voltage) and temperatures of the equipment under test; – the battery system shall not exceed at any point of the current profile the operating range of the cell defined by its manufacturer.		P ☒ F ☐ N/A ☐ N/T ☐
7.8	Functional test with exceeding the operating range limits		
	For the safe operation of the energy storage system and the battery, the operating range for voltage, temperature and current shall not be exceeded (see informative Annex A).		P ☒ F ☐ N/A ☐ N/T ☐

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	For the safe operation of the battery system, it shall be ensured at all times that the operating range of the cell indicated by its manufacturer is not exceeded (see also informative Annex A). The following tests shall be used to check the BMS for its correct function and reaction in case a fault of a charger/inverter occurs.		
7.8.1	Checking the voltage monitoring under conditions of overcharge		
7.8.1.1	Purpose		
	The test for monitoring the voltage of the system under conditions of induced overcharge shall be conducted in accordance with E DIN EN 62619 (VDE 0510-39):2014-04, 9.2.25).		P ☒ F ☐ N/A ☐ N/T ☐
7.8.1.2	Test procedure		
	The test for monitoring the voltage of the system under conditions of induced overcharge shall be conducted in accordance with E DIN EN 62619 (VDE 0510-39):2014-04, 9.2.2.		P ☒ F ☐ N/A ☐ N/T ☐
7.8.1.3	Requirements		
	In addition to the requirements described in E DIN EN 62619 (VDE 0510-39):2014-046), the following applies: – the BESS shall interrupt the charging process at the latest when the maximum cell voltage is reached; – the following values shall be used for the evaluation: 1) the final charge voltage specified by the cell manufacturer; 2) the maximum cell voltage determined by the BMS at the point of the charging process being interrupted by opening of the charge/discharge circuit; 3) the measurement uncertainty of the BMS determined according to 7.1.	See table 7.8.1	P ☒ F ☐ N/A ☐ N/T ☐
7.8.2	Checking the voltage monitoring under conditions of deep/forced discharge		
7.8.2.1	Purpose		
	The test shall be used to check the behavior of the battery system in case of exceeding the minimum cell voltage defined by the cell manufacturer. Distinction is made between the following two cases: 1) deep discharge: one or more cell voltages (OCV) drop below a minimum permissible value without discharge by means of a charger/inverter (e.g. self-discharge); 2) forced discharge: one or more cell voltages (CCV) drop below a minimum permissible value when the discharge amount is exceeded by the charger/inverter (e.g. communication fault between BMS and inverter).		P ☒ F ☐ N/A ☐ N/T ☐
7.8.2.2	Test procedure		
	When conducting the test, the battery system is discharged to the final discharge voltage and then set to its normal operating condition (BMS active, charge/discharge circuit closed) at room temperature. Next, the voltage change of a cell shall be simulated. This can be achieved by software simulation or by electrical tapping of the single cell voltage measurement. In both cases, a uniformly decreasing single cell voltage is simulated to the BMS. The voltage characteristic starts with the measured actual cell voltage before the test. Then, the voltage shall be decreased successively until a reaction of the BMS		P ☒ F ☐ N/A ☐ N/T ☐

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	occurs. The voltage change is stopped, when, due to the opening of the charge/discharge circuit, the battery system automatically opens the load circuit or the lower limit of the cell voltage is exceeded by more than 10 %.		
	If automatic shutdown does not occur when the minimum cell voltage is exceeded, the test is to be considered as failed and is terminated. If the system shutdown occurs at the latest when the minimum cell voltage is reached, the test is continued. The manipulated cell voltage is then increased uniformly to 10 % more than its minimum value. When the value returns to within the operating range of the cell, the charge/discharge circuit shall remain open (no automatic restart). Throughout the test duration, the following measured values shall be recorded: – battery voltage upstream and downstream of the disconnecting elements/devices (BMS); – battery voltage downstream of the disconnecting elements (test rig); – single cell voltages (BMS, including the voltage of the simulated/manipulated cell).		P ☒ F ☐ N/A ☐ N/T ☐
7.8.2.3	Requirements		
	The values indicated in the test procedure shall be measured and documented. Interruption of the imaginary discharging process shall be ensured by automatically opening the charge/discharge circuit (e.g. disconnecting elements) at the latest when the minimum final discharge voltage of the cell defined by its manufacturer is exceeded. Furthermore, the manufacturer shall provide technical measures to ensure that a restart requires consultation of a skilled person. NOTE Cell blocks consisting of cells in parallel connection can be used representatively for conducting the described test.	See table 7.8.2	P ☒ F ☐ N/A ☐ N/T ☐
7.8.3	Checking the current monitoring		
7.8.3.1	Purpose		
	The BESS shall prevent that the maximum permissible charge/discharge current of a cell is exceeded. The following test shall demonstrate the functionality of current monitoring used by the BESS to interrupt the charging/discharging process even before the safe operating range limits of the cell are exceeded.		P ☒ F ☐ N/A ☐ N/T ☐
7.8.3.2	Test procedure		
	It is assumed that the operating range limits of the BMS are set lower than those of the cell. Therefore, if the operating range permitted by the BMS is exceeded, the charge/discharge circuit shall be opened before the limits of the cell are exceeded. – charging/discharging procedure: The procedure for charging/discharging with overcurrent shall correspond to the operating ranges of the BMS and the cell. Figure 4 shows an example of the		P ☒ F ☐ N/A ☐ N/T ☐

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	combination of the operating ranges of the cell and the BMS		
	This results in the following test options: a) checking the current monitoring within the permanently permissible range of charge/discharge current (1): b) checking the current monitoring within the time-limited charge/discharge current range (2): Throughout the duration of the tests, at least the following values shall be measured and recorded: – battery current (test rig, BMS); – BMS signals for performance control (addressed to test rig); – temperatures (BMS, test rig).		P ☒ F ☐ N/A ☐ N/T ☐
7.8.3.3	Requirements		
	The BMS shall open the charge/discharge circuit in both the charging and the discharging case at the latest when the safe operating range of the cell is exceeded.	See table 7.8.3	P ☒ F ☐ N/A ☐ N/T ☐
7.8.4	Checking the temperature monitoring under conditions of an excessively high temperature		
7.8.4.1	Purpose		
	The test shall be used to check the reaction of the battery system in case the maximum operating temperature defined by the manufacturer is exceeded.		P ☒ F ☐ N/A ☐ N/T ☐
7.8.4.2	Test procedure		
	The maximum operating temperature of the BESS is determined by the maximum cell temperature defined by the manufacturer at which the cell is still free of safety-critical damages. Where $T_{max, cell, Betrieb} \geq T_{max, system, Betrieb}$ The corresponding lower temperature shall be used as the test temperature. With the BMS in the inactive condition, the battery system is preconditioned to the test temperature minus 5 K for at least 12 h.		P ☒ F ☐ N/A ☐ N/T ☐
	Throughout the duration of the tests, the following measured values shall be recorded: – battery voltage upstream and downstream of the disconnecting elements or devices (BMS); – battery voltage downstream of the disconnecting elements (test rig); – single cell voltages/cell block voltages (BMS); – temperatures (BMS, test rig).		P ☒ F ☐ N/A ☐ N/T ☐
7.8.4.3	Requirements		
	The values indicated in the test procedure shall be measured and documented. The system shall automatically stop the charging/discharging process at the latest when the maximum temperature for safe operation of the cell is exceeded. The ambient temperature measured by the test rig shall be used as the parameter for evaluating the temperature threshold for disconnection. Even in case of a communication fault or of a malfunction of the charger/inverter, it shall be ensured that the battery system is disconnected in time.	See table 7.8.4	P ☒ F ☐ N/A ☐ N/T ☐

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	After the first time the temperature exceeds the maximum cell temperature and falls below it, the system shall not automatically restart. Restart of the battery system shall require consultation of a skilled person.		
7.8.5	Checking the temperature monitoring under conditions of excessively low temperature		
7.8.5.1	Purpose		
	The test shall be used to check the reaction of the battery system in case the minimum temperature of the system defined by the manufacturer is exceeded.		P ☒ F ☐ N/A ☐ N/T ☐
7.8.5.2	Test procedure		
	For this purpose, the minimum system temperature depends on the minimum cell temperature for safe operation defined by the manufacturer. Where $T_{min, cell, Betrieb} \geq T_{min, system, Betrieb}$ The corresponding higher temperature shall be used as the test temperature.		P ☒ F ☐ N/A ☐ N/T ☐
	Two methods may be applied for testing: a) Actual ambient temperatures: Throughout the duration of the tests, the following measured values shall be recorded: • battery voltage upstream and downstream of the disconnecting elements or devices (BMS); • battery voltage downstream of the disconnecting elements (test rig); • single cell voltages (BMS); • temperatures (BMS, test rig). b) Simulated ambient temperatures: As an alternative to method a), the actual ambient temperatures of the climatic chamber are replaced by: • manipulation of the temperature sensors of the BESS; • software simulation; • other procedures.	Actual ambient temperature	P ☒ F ☐ N/A ☐ N/T ☐
7.8.5.3	Requirements		
	The values indicated in the test procedure shall be measured and documented. The system shall automatically interrupt the charge/discharge circuit at the latest when the minimum temperature for safe operation of the cell is exceeded. The ambient temperature measured by the test rig shall be used as the parameter for evaluating the temperature threshold for disconnection. In case of a communication fault or of a malfunction of the charger/inverter, it shall also be ensured that the battery system is disconnected in time.	The system interrupts the charging/discharge circuit. And the temperature for safe operation of the cell is not exceeded.	P ☒ F ☐ N/A ☐ N/T ☐
7.9	Checking the BMS measurands		
7.9.1	Checking the current measurement		
7.9.1.1	Purpose		
	On the one hand, the test shall be used to check the accuracy of the system-integrated current measurement sensors. On the other hand, the BMS measurement method for determining the current is to be checked in combination with the charger.		P ☒ F ☐ N/A ☐ N/T ☐
7.9.1.2	Test procedure		

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	The current profiles recorded in accordance with 7.7 shall be used to check the current measurements. For this purpose, the measurement deviation is evaluated with respect to the measurement paths: – overall battery current measured by the test rig (calibrated); – overall battery current measured by the BMS. In order to check the plausibility of current measurements in combination with the inverter, representative charging/discharging of the BESS (or a module) with 1C is carried out. The plausibility of the current measurement shall be checked with respect to the measurement paths: – overall battery current measured by the test rig via shunt (measurement resistance, calibrated); – overall battery current measured by the BMS.		P ☒ F ☐ N/A ☐ N/T ☐
7.9.1.3	Requirements		
	By measuring the current including associated tolerances, it shall be ensured that the maximum permissible current of the components under load is not exceeded at any time (including ripple currents (information provided by the manufacturer)). The BMS shall use an appropriate measurement method (sampling rate, calculation) to measure the charger currents with sufficient accuracy in order to ensure that the maximum permissible current of the components under load is not exceeded at any time (including ripple currents (information provided by the manufacturer)).	See table 7.9.1	P ☒ F ☐ N/A ☐ N/T ☐
7.9.2	Checking the temperature measurement		
7.9.2.1	Purpose		
	The test shall be used to check the accuracy and function of the system-integrated temperature measurement (sensory equipment and temperature models, if any).		P ☒ F ☐ N/A ☐ N/T ☐
7.9.2.2	Test procedure		
	Plausibility of the temperature measurement is checked in two steps: 1) First, the uncertainty of the system-integrated temperature measurement shall be evaluated in relation to the temperature values measured by the test rig using the temperature profiles described in 7.8.4 and 7.8.5. The measurements are conducted after the preconditioning period of 12 h. The measurement uncertainty shall be calculated with respect to the measurement paths: a) temperatures (at all system levels, as applicable) measured by the BMS; b) ambient temperature of the equipment under test measured by the test rig (calibrated); c) temperature of the equipment under test measured by the test rig (calibrated);		P ☒ F ☐ N/A ☐ N/T ☐
	2) Secondly, the dynamic recording of the internal temperature measurement values is evaluated (thermal coupling of sensors with the components to be measured or dynamic characteristics of the temperature		P ☒ F ☐ N/A ☐ N/T ☐

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	measurement circuit). The required thermal behavior of the battery shall be derived from the test described in 7.7. This requires thermal preconditioning of the system which is then subjected to a current profile leading to, for example, overheating of the cells. The measurement uncertainty shall be calculated with respect to the two measurement paths: a) temperatures (at all system levels, as applicable) measured by the BMS; b) temperature of the equipment under test measured by the test rig (calibrated); The equipment under test shall be prepared for both steps of the procedure.		
7.9.2.3	Requirements		
	The tolerances for BMS temperature measurements determined in Step 1 shall be taken into account when evaluating the functionality of the BMS (7.7). Step 2 shall demonstrate that the position and mechanical connection of the internal temperature sensors enable sufficiently accurate determination of temperature-critical components. For this purpose, the temperatures of safety-critical components shall always be correctly determined even when they are under electrical load. This means that the values measured by the BMS shall be within the operating range of the cell while taking into account the tolerance derived from Step 1.	See table 7.9.2	P ☒ F ☐ N/A ☐ N/T ☐
7.10	Reaction to failure of components or communication		
	A malfunction may lead to failure of safety-critical components such as: a) inverter/charger; b) BMS; c) safety controller (redundant BMS or monitoring unit); d) CSC (cell supervising circuit).		P ☒ F ☐ N/A ☐ N/T ☐
7.10.1	Communication failure		
7.10.1.1	Purpose		
	Failure of communication between two components representing safety-related functions by their interaction for measuring, controlling or regulating purposes shall not lead to an unsafe state. This also applies to the communication with components intended to be connected to and used with the BESS (e.g. connection of the BESS to already existing inverters/chargers).		P ☒ F ☐ N/A ☐ N/T ☐
7.10.1.2	Test procedure		
	For carrying out the test, the battery system shall be set to its normal operating condition at room temperature (BMS active, charge/discharge circuit closed). Then, the BESS shall be charged/discharged. This can be achieved by using the dedicated inverter/charger. Alternatively, the BESS can be charged/discharged by using a test rig simulating the behavior of either the dedicated or any suitable inverter/charger by means of software. During loading, a failure of the communication between the BMS and the inverter/charger shall be induced (e.g.		P ☒ F ☐ N/A ☐ N/T ☐

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	by hardware-induced disconnection of the communications paths). The test shall be stopped as soon as the BESS interrupts the charging/discharging process by opening the charge/discharge circuit or, at the latest, when the permissible operating range limits of the BESS are exceeded. In case the BESS interrupts the current flow due to the operating range of the BESS being exceeded, communication with the inverter/charger is restored. The charging/discharging process shall be continued by means of the test rig for a further 30 s. Then, the test is completed. The test shall be repeated with the safety-related communication paths mentioned in 7.10 as shown in Figure 5.		
7.10.1.3	Requirements		
	The communication connections shall meet the safety requirements in accordance with the safety class specified in the risk analysis. In case of a safety-related communication failure, the BESS shall interrupt charging/discharging processes by opening the charge/discharge circuit at the latest when the permissible operating range limits are exceeded.	The system interrupts the charging/discharge circuit when communication failure. And the temperature for safe operation of the cell is not exceeded.	P ☒ F ☐ N/A ☐ N/T ☐
7.10.2	Component failure		
7.10.2.1	Purpose		
	Failure of a component representing safety-related functions by measuring, controlling or regulating shall not lead to an unsafe state. This also applies to components intended to be connected to and used with the BESS (e.g. connection of the BESS to an already existing inverter/charger).		P ☒ F ☐ N/A ☐ N/T ☐
7.10.2.2	Test procedure		
	For carrying out the test, the battery system shall be set to its normal operating condition at room temperature (BMS active, charge/discharge circuit closed). Then, the BESS shall be charged/discharged. This can be achieved by using the dedicated inverter/charger. Alternatively, the BESS can be charged/discharged by using a test rig simulating the behavior of either the dedicated or any suitable inverter/charger by means of software. During loading, a failure of the BMS shall be simulated. An appropriate method shall be chosen which results in a reversible failure of the BMS, for example: – temporary overheating of the BMS μ C by means of an external heat source; – applying a temporary overvoltage at the supply voltage of the BMS μ C; – shutdown/disturbance of the BMS clockwatch/heartbeat; – software simulation.		P ☒ F ☐ N/A ☐ N/T ☐
7.10.2.3	Requirements		
	The following requirements shall be met: – documentation of the component failure method;	See table 7.10.2	P ☒ F ☐

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	– in case of failure of a safety-related component, the BESS shall interrupt the charging/discharging processes by opening the charge/discharge circuit at the latest when the permissible limits of the operating range are exceeded.		N/A ☐ N/T ☐
7.10.3	Cell/cell block failure		
7.10.3.1	Purpose		
	In case of a defective cell or a cell block, the BESS shall switch into a safe state. The BESS shall inform and warn the user according to the type of defect, thereby enabling the user to escape from the hazard zone in time.		P ☒ F ☐ N/A ☐ N/T ☐
7.10.3.2	Test procedure		
	Procedure for cell/cell block failure test: 1) Activating an electrical, mechanical or electromechanical intracellular protective function BESS operation may continue if – the CID/OSD has electrically disconnected the cell safely from the rest of the storage system. – the CID/OSD has electrically disconnected the cell safely from the rest of the storage system without damaging any surrounding cells/components (e.g. by release of liquid/gaseous electrolyte, temperature rise in adjacent cells). – the reduced number of cells is detected by the BMS and the operating range for further charging/discharging processes is adjusted accordingly. 2) Increasing the cell temperature causing a temperature rise in the adjacent (healthy) cells in excess of the permissible operating range – Shutdown, no automatic restart. 3) Leakage of liquid electrolyte – Liquid electrolyte shall not be released from the storage system (containment device). – In case a short-circuit occurs as a successive fault, activating of the fuse link(s), opening of the charge/discharge circuit.		P ☒ F ☐ N/A ☐ N/T ☐
7.10.3.3	Requirements		
	The following requirements shall be met: Re 1) verification of the correct function of the CID/OSD by practical testing (e.g. according to 8.4.1, Overcharge) or testing by an accredited testing laboratory; Re 2) verification of the correct function of the temperature monitoring by practical testing (e.g. according to 7.8.4, Checking the temperature monitoring) or testing by an accredited testing laboratory; Re 3) visual inspection and, if applicable, verification of the correct function of the short-circuit protection device by practical testing (e.g. according to 8.1, External short-circuit) or testing by an accredited testing laboratory; Re 4) verification of the correct function of the warning device and annunciator by practical testing (e.g. according to 6.2.4, Internal short-circuit (propagation test)) or testing by an accredited testing laboratory.		P ☒ F ☐ N/A ☐ N/T ☐
	4) Venting of gaseous electrolyte 5) Burning of the cell, spark formation and ignition of vented gas mixtures		P ☒ F ☐ N/A ☐

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	6) Explosion of the cell – Visual-auditory warning of the user in accordance with DIN EN 981, message category DANGER – urgent rescue or protective measures. Available characteristic for the ON phase: – sweeping, – bursts, – alternating pitch (two or three frequency steps). NOTE Urgency can be implied by rapid temporal pattern: – continuous or alternating ON/OFF; – alternating ON/OFF; – continuous or alternating ON/OFF; – any danger signal shall have a temporal pattern clearly differentiated from EMERGENCYEVACUATION (see DIN EN 981, Table 1).		N/T ☐
8	Reasonably foreseeable misuse		
8.1	External short-circuit		
8.1.1	External short-circuit test		
	This test is intended to check the safety of the BESS in case of an external short-circuit. It shall be verified at two levels of testing that safety is ensured: 1) cell level or cell block level: safety of the single cell or the parallel-connected cells (short-circuit path excluding external overcurrent protection device) (see 8.1.2); 2) module/pack/system level: correct function of the overcurrent protection device and correct design of the electric paths in one or more cells, modules or battery packs, in serial or parallel connection (short-circuit path including overcurrent protection device) (see 8.1.3). The test according to 1) may be omitted provided external short-circuit at cell level or cell block level can be precluded by one of the following measures: a) the construction of the cell or cell block meets the requirements regarding double/reinforced insulation; b) no changes are made to the construction of the single cells or cell blocks on the operating site of the BESS (e.g. installation, disassembly, maintenance). The requirement according to a) is satisfied throughout the lifecycle phases of installation, operation (maintenance) and disassembly.		P ☒ F ☐ N/A ☐ N/T ☐
8.1.2	Cell or cell block		
	External short-circuit testing at cell level or cell block level shall be conducted and evaluated in accordance with E DIN EN 62619 (VDE 0510-39):2014-04 while taking into account the following deviations: – the impedance of the entire shorted circuit, including terminals/terminal leads, measuring resistor and short-circuit switch, shall be $\leq 5 \text{ m}\Omega$; – the test object is preconditioned to the maximum operating temperature of the BESS as indicated by the manufacturer. Cells shall be subjected to thermal preconditioning for at least 6 h and cell blocks for at least 12 h.		P ☒ F ☐ N/A ☐ N/T ☐

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8.1.3	Module, pack, battery system		
8.1.3.1	Purpose		
	The correct function of the short-circuit protection device is verified at module level, pack level and system level. This requires prompt interruption of the short-circuit current by the protective device in order to prevent resulting damage to the equipment under test. Where an overcurrent protection device is not provided at module level, the short-circuit current rating shall be checked at the next higher level, i.e. pack level. Where an overcurrent protection device is not provided at pack level, the short-circuit current rating shall be checked at the next higher level, i.e. battery system level. Prerequisite for conducting the test is the presence of an overcurrent protection device (at least at system level) on the one hand and a protection concept documented by the manufacturer on the other.		P ☒ F ☐ N/A ☐ N/T ☐
8.1.3.2	Test procedure		
	The equipment under test is preconditioned to 100 % SOC and preheated to the maximum operating temperature of the BESS indicated by the manufacturer for at least 12 h. Then, the equipment under test shall be set to its normal operating condition (disconnecting elements closed, BMS active). The short-circuit with an impedance of 20 (+0/-10) mΩ is switched on within one second and maintained until one of the following criteria applies: – the overcurrent/short-circuit protection device has interrupted the short-circuit path and thereby the current supply; – an unsafe state occurs preventing the remaining test sequence (hazardous overheating, venting of gaseous electrolyte, fire, etc.)		P ☒ F ☐ N/A ☐ N/T ☐
	The following applies to short-circuit application: – at module level or pack level (if a protection device is provided at this level): • between the main terminals (charge/discharge circuit between positive and negative terminal); • between shunt terminals (e.g. separate charge circuit between positive and negative terminal). – at system level; • between the main terminals (charge/discharge circuit between positive and negative terminal); • between shunt terminals (e.g. separate charge circuit between positive and negative terminal); • between the main terminals of the battery system and the inverter; • in direct vicinity of fuse links of the battery system, as far as accessible.		P ☒ F ☐ N/A ☐ N/T ☐
8.1.3.3	Requirements		
	The following requirements shall be met: – the equipment under test shall neither exhibit any signs of fire or flames nor explode; – measurement and documentation of the values described in the test procedure;		P ☒ F ☐ N/A ☐ N/T ☐

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	– evaluation of shut-down times of the overcurrent protection device(s) taking into account the measured current and voltage values; – evaluation of the insulating resistance in accordance with 6.2.2.		
8.2	Drop test		
8.2.1	Purpose		
	It is assumed that the BESS and/or its component parts (incorporating cells) for purposes of a) installation; b) servicing/maintenance; c) repair; or d) disassembly are handled above the ground level and outside their transport packaging. This results in the risk of free fall and impact from transport or handling height. Even in case of such an impact, the safety of the BESS and its component parts shall be ensured such that the BESS and/or its component parts do not present any direct hazard.		P ☒ F ☐ N/A ☐ N/T ☐
8.2.2	Test procedure		
	The following test methods shall be applied according to the respective weight of the equipment under test (can be conducted on a test object or single test objects, according to previous damage):		P ☒ F ☐ N/A ☐ N/T ☐
	1) test object having a weight of ≤ 50 kg: At the beginning of the test, the insulation resistance of the test object is measured. Afterwards, the test object is suspended from a device having a height of ≥ 1 m above the flat ground (concrete, covered with a metal plate, if applicable) and orientated. Then, a free fall under controlled conditions is initiated using a releasing device. Care shall be taken that the test object maintains its position and orientation until its impact on the ground. After the impact, the insulation resistance is measured again and the test object is subjected to visual inspection. The test sequence is repeated until 3 different falling orientations have been simulated. These are e.g. – 30° impact onto the edge of the shortest side length; – 30°/30° impact onto one corner; – perpendicular impact onto one front or rear panel or onto one side equipped with terminals. Generally, the 3 falling orientations shall be chosen such that the most severe damage of the test object is to be expected. 2) Test objects having a weight ≥ 50 kg: At the beginning of the test, the insulation resistance of the test object is measured. Then, the test is conducted in accordance with E DIN EN 62619 (VDE 0510-39):2014-04, 8.2.3.27). After the impact, the insulation resistance is measured again. Having been subjected to those two test methods, the test object shall remain under observation until no	Battery Module: 59kg, the drop height is 0.05m; control box: 15.1 kg, the drop height is 0.1m;	P ☒ F ☐ N/A ☐ N/T ☐

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	further changes of the hazardous situation are to be expected.		
8.2.3	Requirements		
	Regarding 8.2.2, the following applies: – no fire, no explosion; – no venting; – no hazardous surface temperatures; – no ejected parts that may lead to injury of bystanders; – no direct access to active parts above the protective low voltage.		P ☒ F ☐ N/A ☐ N/T ☐
8.3	Impact test		
8.3.1	Purpose		
	Where cells or cell blocks for purposes of a) installation; b) servicing/maintenance; c) repair; or d) disassembly are handled outside their transport packaging, this presents not only the risk of free fall (see 8.2) but also the risk of unintended crushing (i.e. mechanical impact) (e.g. collision during replacement of cells). The test shall be used to demonstrate that an impact on one component (cell or cell block) does not lead to a hazard in its direct surrounding.	Cell evaluated with IEC 62619	P ☒ F ☐ N/A ☐ N/T ☐
8.3.2	Test procedure		
	Crushing (mechanical impact) shall be simulated by using the following test procedure. 1) E DIN EN 62619 (VDE 0510-39):2014-04, 8.2.28) Impact (at cell/cell block level).		P ☒ F ☐ N/A ☐ N/T ☐
8.3.3	Requirements		
	See E DIN EN 62619 (VDE 0510-39):2014-04, 8.2.28).		P ☒ F ☐ N/A ☐ N/T ☐
8.4	Thermal misuse		
	Thermal misuse is tested and evaluated in accordance with E DIN EN 62619 (VDE 0510-39):2014-04, 8.2.28) at cell/cell block level. Alternatively, conformity may be confirmed by testing carried out by an accredited test laboratory.		P ☒ F ☐ N/A ☐ N/T ☐
8.4.1	Overcharge		
	The overcharge test is conducted and evaluated in accordance with E DIN EN 62619 (VDE 0510-39):2014-04, 8.2.58) at cell/cell block level. Alternatively, conformity may be confirmed by testing carried out by an accredited test laboratory.	Cell evaluated with IEC 62619	P ☒ F ☐ N/A ☐ N/T ☐
8.4.2	Forced discharge		
	The forced discharge test is conducted and evaluated in accordance with E DIN EN 62619 (VDE 0510-39):2014-04, 8.2.68) at cell/cell block level. Alternatively, conformity may be confirmed by testing carried out by an accredited test laboratory.	Cell evaluated with IEC 62619	P ☒ F ☐ N/A ☐ N/T ☐
9	Safety during transport		
	For both the cells and the modules of a battery system, the tests according to UN 38.3 of the currently valid	UN 38.3 evaluated	P ☒ F ☐

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	edition of the United Nations Recommendations on the Transport of Dangerous Goods, Manual of Tests and Criteria, shall be complied with and conformity shall be demonstrated. For road transport, particular attention shall be paid to special provisions and the current legislation relating to dangerous goods, in particular of the currently valid edition of the European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR). This also applies to batteries "for disposal" or "for recycling". Other national transport regulations may be applicable.		N/A ☐ N/T ☐
10	Inspection of markings		
10.1	Crossed-out wheeled bin		
	Manufacturers placing a battery energy storage system on the market are obliged to observe the BattG (2006/66/EC) or the ElektroG (2012/19/EU) specifying the marking with the symbol. According to the type of BESS, the requirements regarding the positioning of the marking as presented can be derived.		P ☒ F ☐ N/A ☐ N/T ☐
	Type of BESS for which the following applies:		
	1) – Subgroups of equipment installed in separate enclosures and locally separated from each other (e.g. battery module(s), inverter/converter, smart meter) – Subgroups of equipment that can be safely split up by the end user, e.g. by load free pulling of plugs 2) – Subgroups of equipment installed in separate enclosures which are assembled to the final equipment in a shared enclosure on site by the end user (e.g. stackable solution, see also 6.2.6) 3) – BESS as a single equipment containing subgroups together with the battery in a shared enclosure thus forming a unit which cannot be split up or opened by the end user (e.g. single solution)		P ☒ F ☐ N/A ☐ N/T ☐
10.2	Marking and designation		
	A marking inspection in accordance with DIN EN 62620 (VDE 0510-35):2015-09, Clause 5, shall be ensured (visual inspection). The presence of markings shall be documented.		P ☒ F ☐ N/A ☐ N/T ☐
11	Documentation requirements		
	It shall be ensured that the BESS documentation contains the following indications provided by the manufacturer: – instructions for the correct operation including information on controls and indicators; – instructions for behavior in case of a fault; – hazard warnings, residual risks resulting from risk assessment; – information on the installation site under consideration of the environmental impacts, such as • installation height, safety distances and position; • ambient temperature and humidity;		P ☒ F ☐ N/A ☐ N/T ☐

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	• pollution degree (IP protection); • risk of external fire; • radiation; • vibration; • corrosive gases and liquids; • escape routes; • markings; – information on safe transport; – contact information of skilled persons responsible in a service case; – contact information of disposal companies responsible in case of disposal. Conformity is verified by inspection of documents (visual inspection).		
12	Fire/explosion		
	Used reference: gen. safety objective no. 6.4.3 of „Safety guideline – Li-ion Home Storage Systems“ Version 1.0 Issue: 11/2014 According to BATSO 02 chapter 2.2 test 1 based on EN 14470 (a validation of the housing is sufficient), see as well VDE-AR-2510-2 chapter 5.2.3 1. The system is according to the functional safety not allowed to be switched on again after the temperature of the cell T_{max} (in accordance to the manufacturer specification) was exceeded, even if the maximum temperature is below the temperature required in BATSO. 2. N.n (CID) 3. Housing or installation site F30 or restricted installation conditions (VDE-AR-2510-2, 5.2.3), Including consideration of the required warnings. 4. BATSO 02, Test 7 (modified without thermal runaway)		P ☒ F ☐ N/A ☐ N/T ☐
13	Flash/electrical surge		
	Used reference: gen. safety objective no. 6.4.4 of „Safety guideline – Li-ion Home Storage Systems“ Version 1.0 Issue: 11/2014 According to DIN EN 62109-1 chapter 14.7: To be considered " c) short-term temporary overvoltages which can occur transiently in electrical installations between network cable and ground: This temporary overvoltages can last up to 5 s and can reach values 1200 V over the external phase voltage of the grid measured against the neutral conductor." see chapter 7.3.7.2 isolation between the current circuit and the environment see chapter 7.5.2.2 value and type of the testing voltage description of the test and chart for helping to choose the voltage. An overload is connected to the specimen through a pulse generator (AC voltage according to chart 18: 1100V) and is to be maintained for 60 s minimum. The set voltage has to be reached within 5 s. There should be no voltage flash over the air.		P ☒ F ☐ N/A ☐ N/T ☐
14	Corrosion		

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	Used reference: gen. safety objective no. 6.5.7 of „Safety guideline – Li-ion Home Storage Systems“ Version 1.0 Issue: 11/2014 According to BATSO 02 chapter 2.1.2 as far as the manufacturer does not exclude the use in a corrosive environment.		P ☒ F ☐ N/A ☐ N/T ☐
15	Gases (like in agriculture)		
	Used reference: gen. safety objective no. 6.5.7 of „Safety guideline – Li-ion Home Storage Systems“ Version 1.0 Issue: 11/2014) According to BATSO 02 chapter 2.1.3 as far as the manufacturer does not exclude the use in an environment with harmful gases.		P ☒ F ☐ N/A ☐ N/T ☐
16	Flooding		
	Used reference: gen. safety objective no. 6.5.7 of „Safety guideline – Li-ion Home Storage Systems“ Version 1.0 Issue: 11/2014 According to BATSO 02 chapter 2.2 test 3 as far as the manufacturer does not exclude the use and installation below the backflowlevel and/or with the risk of flooding and restrict the installation conditions. Note: The system is according to the functional safety not allowed to turn on again after a flooding.		P ☒ F ☐ N/A ☐ N/T ☐

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**ZUSATZ-DOKUMENTATION
ADDITIONAL DOCUMENTATION**

Cell Operating window specified by the cell manufacture

NO.	condition	Temperature (°C)	Voltage (V)	Power/ Current	Duration (s)
1	Charge temperature	0~65	-	≤102A	-
2	Discharge temperature	-30~65	-	≤255A	-
3	Charge at high temperature	>65	-	0	-
4	Discharge at high temperature	>65	-	0	-
5	Charge at low temperature	<0	-	0	-
6	Discharge at low temperature	<-30	-	0	-
7	Charging	-	3.9	-	-
8	Discharging	-	2.5	-	-
9	Upper limit charging voltage	-	3.9	-	-

System Operating window specified by the manufacture

NO.	condition	Temperature (°C)	Voltage (V)	Power/ Current*	Duration (s)
1	Charge temperature	1 to 55	-	≤55A@15min	-
2	Discharge temperature	-10 to 55	-	≤55A@15min	-
3	Over temperature of charge	60	-	-	4±0.5s
4	Over temperature of discharge	60	-	-	4±0.5s
5	Under temperature of charge	0	-	-	4±0.5s
6	Under temperature of discharge	0	-	-	4±0.5s
7	Over voltage of cell	-	3.65	-	2±0.5s
8	Under voltage of cell	-	See tabel 1	-	2±0.5s
9	Charge Overcurrent	-	-	65A	0.5s
10	Discharge Overcurrent	-	-	65A	0.5s

Note: For RM-XX series.

System Operating window specified by the manufacture

NO.	condition	Temperature (°C)	Voltage (V)	Power/ Current*	Duration (s)
1	Charge temperature	-20 to 55	-	≤55A@15min	-
2	Discharge temperature	-20 to 55	-	≤55A@15min	-
3	Over temperature of charge	60	-	-	4±0.5s
4	Over temperature of discharge	60	-	-	4±0.5s
5	Under temperature of charge	0	-	-	4±0.5s
6	Under temperature of discharge	0	-	-	4±0.5s
7	Over voltage of cell	-	3.65	-	2±0.5s
8	Under voltage of cell	-	See tabel 1	-	2±0.5s
9	Charge Overcurrent	-	-	65A	0.5s
10	Discharge Overcurrent	-	-	65A	0.5s

Note: For RM-XX-Pro series.

6.2.2	Insulation resistance test			Pass
	Part	Test voltage	Insulation resistance	Limit
	Battery- to PE(enclosure)	500Vd.c.	>1000MΩ	81.7 kΩ
	Battery+ to PE(enclosure)	500Vd.c.	>1000MΩ	81.7 kΩ

Note: Tested was conducted on RM-15.

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6.2.3	Dielectric strength test			Pass
Position	Test Voltage (V)	Leakage current (mA)	Result (Pass/Fail)	
Battery + to PE(enclosure)	2120Vd.c.	0	Pass	
Battery - to PE(enclosure)	2120Vd.c.	0	Pass	
Battery + to Communication	4240Vd.c.	0	Pass	
Battery - to Communication	4240Vd.c.	0	Pass	

Note: Tested on one control box and one battery pack.

7.3	Plausibility of voltage measurement						Pass
Sample No.	Type (Cell/ Cell Block)	Current (A)	Cell Voltage measured by BMS (V)	Measurement Range of voltage of BMS (V)	Cell Voltage measured by test bench (V)	Accuracy of test bench (V)	Calculated Accuracy of BMS (V)
Charging							
Cell 2	Cell	50.0	3.489	0~5.0	3.491	0.001	-0.002
Cell 3	Cell	50.0	3.460	0~5.0	3.462	0.001	-0.002
Cell 4	Cell	50.0	3.492	0~5.0	3.494	0.001	-0.002
Discharging							
Cell 1	Cell	50.0	3.019	0~5.0	3.021	0.001	-0.002
Cell 2	Cell	50.0	2.907	0~5.0	2.908	0.001	-0.0001
Cell 4	Cell	50.0	2.900	0~5.0	2.901	0.001	-0.0001

Note: Tested was conducted on RM-15.

7.8.1	Checking the voltage monitoring under conditions of overcharge		Pass
Item	Value		
	exceeded voltage applied on the battery system	exceeded voltage applied on the cell	
Upper voltage specified by manufacture (V)	167.9 (3.65 per Cell*23*2)	-	
Trip value of BMS (V)	159.8 (max cell 3.657)	No	
Limit of Trip value (V)	179.4 (3.9 per Cell*23*2)	-	
Measure accuracy of BMS (V)	0.001	-	

Note: Tested was conducted on RM-15.

7.8.2	Checking the voltage monitoring under conditions of deep/forced discharge				Pass
Lower cell voltage limit specified by manufacture (V):		2.50			
Threshold value of low voltage protection of CELL (V):		Test temperature: 34.3°C, Current: 49.8A, Cell voltage protection value: 2.951V			
Step	Battery voltage before the separation devices by BMS (V)	Battery voltage after the separation devices by BMS (V)	Battery voltage after the separation devices by test bench (V)	Single cell voltage by BMS (V)	Operation state (operate /shutdown /Restart /No restart)
Initial state	152.2	152.2	-	Min 3.328	Operate
Trip value	137.6	137.6	-	Min 2.950	Shutdown
Value after trip	0	0	-	Min 2.992	No restart
re-commission condition	☐ automatic restart ☒ only restarted by a specialist				

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Note: Tested was conducted on RM-15.

7.8.3	Checking the current monitoring			Pass
Test Item		Test a) Charging	Test b) Discharging	Limit
Initial state				
Battery voltage by test bench (V)	-	-	-	
Battery voltage by BMS(V)	130.7	148.5	115.0/179.4	
BMS signals for power control	-	-	-	
Current (A)	55.0	55.0	Charging:102 Discharging: 255	
Temperature by BMS (°C)	26.7	25.1	Charging:65, Discharging:65	
Temperature by test bench (°C)	-	-	-	
Current change				
Change Ratio of Current (A/s)	0.5	0.5	-	
Trip value				
Battery voltage by test bench (V)	-	-	-	
Battery voltage by BMS(V)	131.8	130.7	115.0/179.4	
BMS signals for power control	Charge overcurrent	Discharge overcurrent	-	
Current (A)	66.0	66.0	Charging:102 Discharging: 255	
Temperature by BMS (°C)	27.2	26.6	Charging:65, Discharging:65	
Temperature by test bench (°C)	-	-	-	
The Operating window of cell exceeded?		☐ Yes ☒ No		
Note: Tested was conducted on RM-15.				

7.8.4	Checking the temperature monitoring under conditions of an excessively high temperature			Pass
T _{max, cell, operation} (°C)			65	
T _{max, system, operation} (°C)			60	
Duration of pre-condition (h)			12	
Item		Initial state	Trip state	Limit
Battery voltage before separation devices by BMS (V)		136.6	151.1	115.0/179.4
Battery voltage after separation devices by BMS (V)		136.6	151.1	115.0/179.4
Battery voltage after separation devices by test bench (V)		-	-	-
Cell/Cell block voltage by BMS		3.014	3.297	2.50/3.90
Temperature by BMS (°C)		53.6	60.0	65
Temperature by test bench (°C)		53.5	60.9	65
The Operating window of cell exceeded during test?			☐ Yes	☒ No
The battery system reconnected automatically after temperature recover?			☐ Yes	☒ No
Note: Tested was conducted on RM-15.				

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7.8.5	Checking the temperature monitoring under conditions of excessively low temperature - charge state		Pass
T _{min, cell, operation} (°C)		Charging state: 0	
T _{min, system, operation} (°C)		Charging state: 0	
Duration of pre-condition (h)		12	
Item	Initial state	Trip state	Limit
Battery voltage before separation devices by BMS (V)	143.9	149.2	115.0/179.4
Battery voltage after separation devices by BMS (V)	143.9	149.2	115.0/179.4
Battery voltage after separation devices by test bench (V)	-	-	-
Cell/Cell block voltage by BMS(V)	3.164	3.267	2.50/3.90
Temperature by BMS (°C)	7.3	0	0
Temperature by test bench (°C)	7.4	0.3	0
The Operating window of cell exceeded during test?		☐ Yes ☒ No	
Note: Tested was conducted on RM-15.			

7.8.5	Checking the temperature monitoring under conditions of excessively low temperature - discharge state		Pass
T _{min, cell, operation} (°C)		Discharging state: -30	
T _{min, system, operation} (°C)		Discharging state: -20	
Duration of pre-condition (h)		12	
Item	Initial state	Trip state	Limit
Battery voltage before separation devices by BMS (V)	148.9	132.6	115.0/179.4
Battery voltage after separation devices by BMS (V)	148.9	132.6	115.0/179.4
Battery voltage after separation devices by test bench (V)	-	-	-
Cell/Cell block voltage by BMS(V)	3.250	2.878	2.50/3.90
Temperature by BMS (°C)	-14.5	-21.0	-30
Temperature by test bench (°C)	-13.9	-21.8	-30
The Operating window of cell exceeded during test?		☐ Yes ☒ No	
Note: Tested was conducted on RM-15.			

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7.9.1	Checking the current measurement				Pass
Item	Current measured by test bench (A)	Current measured by BMS (A)	Accuracy of test bench (A)	Measurement range of Current of BMS (A)	Calculated accuracy of BMS (A)
Charge at 1A	0.997	1.033	±0.001	-312.5~+312.5	-0.036
Charge at 5A	5.001	5.023	±0.001	-312.5~+312.5	0.022
Charge at 10A	10.002	10.003	±0.001	-312.5~+312.5	0.001
Charge at 15A	14.997	14.980	±0.001	-312.5~+312.5	-0.017
Charge at 20A	19.999	19.959	±0.001	-312.5~+312.5	-0.04
Charge at 25A	25.002	24.937	±0.001	-312.5~+312.5	-0.065
Charge at 30A	29.999	29.916	±0.001	-312.5~+312.5	-0.083
Charge at 35A	34.998	34.899	±0.001	-312.5~+312.5	-0.099
Charge at 40A	39.998	39.879	±0.001	-312.5~+312.5	-0.119
Charge at 45A	45.003	44.975	±0.001	-312.5~+312.5	-0.128
Charge at 50A	49.997	49.860	±0.001	-312.5~+312.5	-0.137
Charge at 55A	54.840	54.996	±0.001	-312.5~+312.5	0.156
Discharge at 1A	1.002	1.036	±0.001	-312.5~+312.5	0.034
Discharge at 5A	5.001	5.022	±0.001	-312.5~+312.5	0.021
Discharge at 10A	10.004	9.995	±0.001	-312.5~+312.5	-0.009
Discharge at 15A	15.003	14.973	±0.001	-312.5~+312.5	-0.03
Discharge at 20A	20.001	19.959	±0.001	-312.5~+312.5	-0.042
Discharge at 25A	24.996	24.935	±0.001	-312.5~+312.5	-0.061
Discharge at 30A	29.996	29.918	±0.001	-312.5~+312.5	-0.078
Discharge at 35A	34.996	34.900	±0.001	-312.5~+312.5	-0.096
Discharge at 40A	39.997	39.875	±0.001	-312.5~+312.5	-0.122
Discharge at 45A	44.996	44.875	±0.001	-312.5~+312.5	-0.121
Discharge at 50A	50.000	49.845	±0.001	-312.5~+312.5	-0.155
Discharge at 55A	54.999	54.841	±0.001	-312.5~+312.5	-0.158
Calculation					
1).Upper current limit of BMS (A)			Charging: 55@15min, discharging: 55@15min		
2).maximum permissible current of Cell/Cell block (A)			Charging: 102, discharging: 255		
Value 1) less than Value 2)?			☒ Yes ☐ No		
Note: Tested was conducted on RM-15.					

7.9.2	Checking the temperature measurement				Pass
		Value by BMS (°C)	Value by test bench (°C)	Measurement Range of BMS (°C)	Measurement deviation (°C)
High temperature	Cell 1	60.3	59.7	-40 ~ +125	0.6
	Cell 2	59.1	59.4	-40 ~ +125	-0.3
	Cell 3	59.8	59.7	-40 ~ +125	0.1
	Cell 4	60.2	59.7	-40 ~ +125	0.5
low temperature	Cell 1	-19.8	-20.2	-40 ~ +125	0.4
	Cell 2	-19.6	-18.7	-40 ~ +125	-0.9
	Cell 3	-21.8	-19.9	-40 ~ +125	-1.9
	Cell 4	-20.4	-20.7	-40 ~ +125	0.3
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7.10.2		TABLE: Component failure						Pass
		ambient temperature (°C)				25.0		—
No.	component No.	fault	test voltage (V)	test time	fuse No.	fuse cur- rent (A)	Result	
1.	Power Supply	R139 O-C	839.5	10 min	-	-	Power supply was lost, the relay disconnected, and the charging process stopped	
2.		L8 O-C	839.5	10 min	-	-	Power supply was lost, the relay disconnected, and the charging process stopped	
3.		C717 S-C	839.5	10 min	-	-	Power supply was lost, the relay disconnected, and the charging process stopped	
4.	Communication	R505 O-C	839.5	10 min	-	-	Low-voltage and low-temperature faults were reported, the relay was disconnected, and the charging process stopped	
5.		R504 S-C	839.5	10 min	-	-	Low-voltage and low-temperature faults were reported, the relay was disconnected, and the charging process stopped	
6.		R287 O-C	839.5	10 min	-	-	Low-voltage and low-temperature faults were reported, the relay was disconnected, and the charging process stopped	
7.		R228 O-C	839.5	10 min	-	-	The current sampling IC fault was reported, the relay was disconnected, and the charging process stopped	
8.	Current sampling	R1 O-C	839.5	10 min	-	-	Overcurrent was reported, the relay was disconnected, and the charging process stopped.	
9.		C1 S-C	839.5	10 min	-	-	The capacitor used for absorbing high-frequency noise, no effect on safety function.	
10.	Total voltage sampling	R25 O-C	839.5	10 min	-	-	System error and Voltage fault were reported, the relay was disconnected, and the charging process stopped.	
11.		C7 S-C	839.5	10 min	-	-	System error and Voltage fault were reported, the relay was disconnected, and the charging process stopped.	

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12.	RELAY	Q155 S-C	839.5	10 min	-	-	Injection fault before charging/discharging, relay error was reported, system failed the self check.
13.		Feedback voltage at the coil end of the contactor O-C	839.5	10 min	-	-	Injection fault before charging/discharging, relay error was reported, system failed the self check.
14.		P+ S-C, then simulate V//T fault	839.5	10 min	-	-	The negative relay was disconnected, the discharge circuit was stopped, and the system lock was triggered.
15.		N- S-C, then simulate V//T fault	839.5	10 min	-	-	The positive relay was disconnected, the discharge circuit was stopped, and the system lock was triggered.
16.	MCU	Y1 S-C&O-C	839.5	10 min	-	-	The relay was disconnected, the discharge circuit was stopped.
17.	LOCK FUNCTION	V//T	839.5	10 min	-	-	Normal operation.
18.	Power Supply of BMU	R537 O-C	839.5	10 min	-	-	The relay was disconnected, the discharge circuit was stopped, and the system lock was triggered.
19.		C147 S-C	839.5	10 min	-	-	The relay was disconnected, the discharge circuit was stopped.
20.	Cell voltage sampling of BMU	R129 (BAT1) O-C	839.5	10 min	-	-	The voltage acquisition fault was reported, the relay was disconnected, and the discharge circuit was stopped.
21.		C34 (BAT2) S-C	839.5	10 min	-	-	The voltage acquisition fault was reported, the relay was disconnected, and the discharge circuit was stopped.
22.	CELL TEMPERATURE sampling	R148 (NTC1) O-C	839.5	10 min	-	-	The over-temperature fault was reported, the relay was disconnected, and the discharge circuit was stopped.
23.		C44 (NTC2) S-C	839.5	10 min	-	-	The over-temperature fault was reported, the relay was disconnected, and the discharge circuit was stopped.

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24.		D63 (NTC3) S-C	839.5	10 min	-	-	The over-temperature fault was reported, the relay was disconnected, and the discharge circuit was stopped.
25.	Communication of BMU	L11 PIN1-2 S-C	839.5	10 min	-	-	The relay was disconnected, the discharge circuit was stopped.
26.		R478 O-C	839.5	10 min	-	-	The relay was disconnected, the discharge circuit was stopped.
Note(s): In Fault column, s-c=short circuit, o-c=open circuit. The unit passed electric strength test after single fault test above. The test was conducted on RM-75							

- End of Report -