Prüfbericht-Nr.: *Test report no.*:	**CN269I4W 001**	**Auftrags-Nr.:** *Order no.*:	326172276	Seite 1 von 53 *Page 1 of 53*
Kunden-Referenz-Nr.: *Client reference no.*:	N/A	**Auftragsdatum:** *Order date:*	2026-02-04	
Auftraggeber: *Client*:	**Ningbo Veken New Energy Technology Co.,Ltd.** North Plant 1,Building 1, No.3,Gangxi Avenue,Western Bonded Zone, Ningbo 315800 ZHEJIANG P.R. CHINA			
Prüfgegenstand: *Test item*:	Lithium-ion Battery			
Bezeichnung / Typ-Nr.: *Identification / Type no.*:	VK-48V15Ah-13S3P; VK-48V30Ah-A-13S6P			
Auftrags-Inhalt: *Order content*:	cTÜVus Mark approval procedure			
Prüfgrundlage: *Test specification*:	ANSI/CAN/UL/ULC 2271: 2018			

Wareneingangsdatum: *Date of sample receipt*:	2026.02.27
Prüfmuster-Nr.: *Test sample no:*	See below
Prüfzeitraum: *Testing period*:	2026.02.27 - 2026.03.27
Ort der Prüfung: *Place of testing*:	See page 5
Prüflaboratorium: *Testing laboratory:*	TUV Rheinland (Shanghai) Co., Ltd.
Prüfergebnis*: *Test result*:*	Pass



erstellt von:
created by: X

Datum:
Date: 2026-04-22

Stellung / Position: Sachverständige(r)/Expert

genehmigt von:
authorized by: X

Ausstellungsdatum:
Issue date: 2026-04-22

Stellung / Position: Sachverständige(r)/Expert

Sonstiges / *Other*: This report is issued for cTÜVus Rheinland mark approval. The complete report includes the following attachments:
-Test report (53 pages); - Attachment 1: Equipment list (1 page); - Attachment 2: Photo documents (8 pages).

Zustand des Prüfgegenstandes bei Anlieferung: *Condition of the test item at delivery*: Prüfmuster vollständig und unbeschädigt *Test item complete and undamaged*

* Legende:	P(ass) = entspricht o.g. Prüfgrundlage(n)	F(ail) = entspricht nicht o.g. Prüfgrundlage(n)	N/A = nicht anwendbar	N/T = nicht getestet
** Legend:*	*P(ass) = passed a.m. test specification(s)*	*F(ail) = failed a.m. test specification(s)*	*N/A = not applicable*	*N/T = not tested*

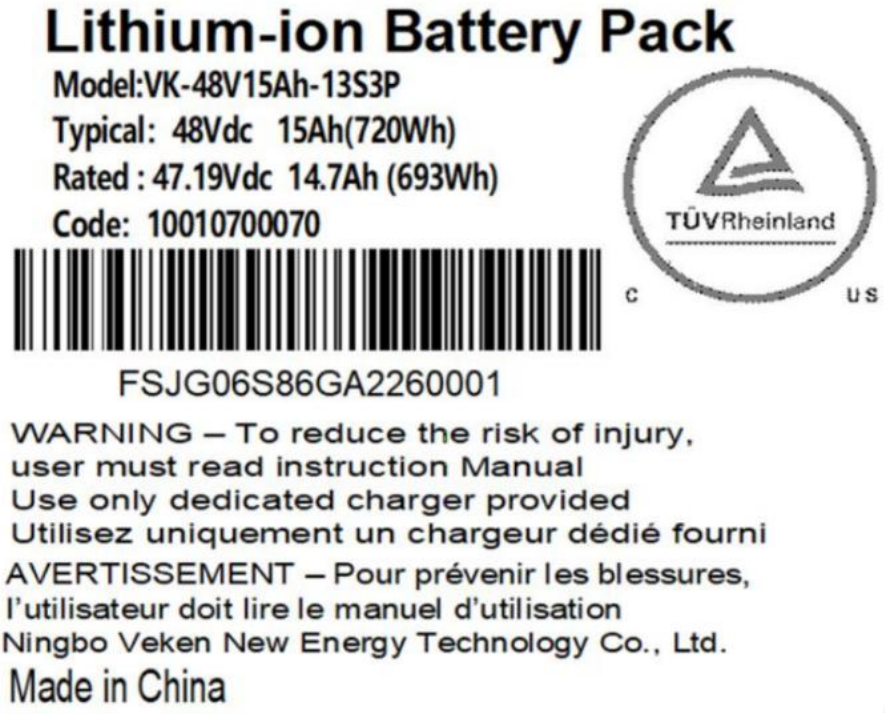
Dieser Prüfbericht bezieht sich nur auf das o.g. Prüfmuster und darf ohne Genehmigung der Prüfstelle nicht auszugsweise vervielfältigt werden. Dieser Bericht berechtigt nicht zur Verwendung eines Prüfzeichens.
This test report only relates to the above mentioned test sample. Without permission of the test center this test report is not permitted to be duplicated in extracts. This test report does not entitle to carry any test mark.

Absatz *Clause*	**Anforderungen - Prüfungen /** *Requirements - Tests*	**Messergebnisse – Bemerkungen/** *Measuring results - Remarks*	**Ergebnis** *Result*

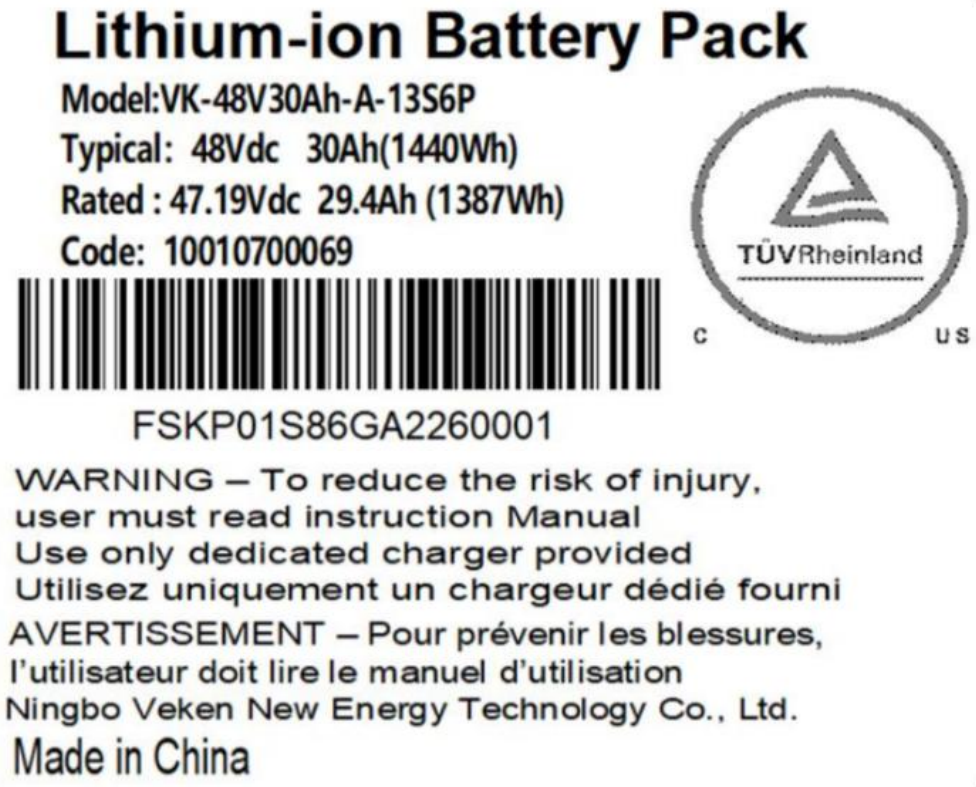
1	Alle eingesetzten Prüfmittel waren zum angegebenen Prüfzeitraum gemäß eines festgelegten Kalibrierungsprogramms unseres Prüfhauses kalibriert. Sie entsprechen den in den Prüfprogrammen hinterlegten Anforderungen. Die Rückverfolgbarkeit der eingesetzten Prüfmittel ist durch die Einhaltung der Regelungen unseres Managementsystems gegeben. Detaillierte Informationen bezüglich Prüfkonditionen, Prüfequipment und Messunsicherheiten sind im Prüflabor vorhanden und können auf Wunsch bereitgestellt werden. *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.*
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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. *Test clauses with remark of * are subcontracted to qualified subcontractors and descripted under the respective test clause in the report.* *Deviations of testing specification(s) or customer requirements are listed in specific test clause in the report.*
4	Die Entscheidungsregel für Konformitätserklärungen basierend auf numerischen Messergebnisen 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 bezueglich des Risikos durch diese Entscheidungsregel siehe ILAC G8:2019. *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.*

Test item particulars:	
Information about the product needed to establish a correct test program, such as product mobility, type of power connections and similar.	(Test item particulars are selected by the TRF Originator base on the requirements in the standard)
Designation ..... :	VK-48V15Ah-13S3P; VK-48V30Ah-A-13S6P
Trademark ..... :	N/A
Nominal voltage ..... :	47.19VDC
Rated capacity ..... :	14700mAh(VK-48V15Ah-13S3P); 29400mAh(VK-48V30Ah-A-13S6P)
Maximum charge voltage ..... :	54.6V
Maximum charge current ..... :	5A
End-of-discharge voltage ..... :	35.5V
Max Ambient Temperature ..... :	40°C (discharging), 40°C (charging)
Manufacturer's charge method ..... :	Charging the battery with 3A constant current and 54.6V constant voltage until the current reduces to 0.4A at ambient 25°C±3°C(VK-48V15Ah-13S3P) Charging the battery with 5A constant current and 54.6V constant voltage until the current reduces to 0.4A at ambient 25°C±3°C(VK-48V30Ah-A-13S6P)
Sample No. ..... :	See cover page
Possible test case verdicts:	
Test case does not apply to the test object ..... :	N(/A)
Test object does meet the requirement:	P(ass)
Test object does not meet the requirement ..... :	F(ail)
Testing:	
Date of receipt of test item ..... :	See cover page
Date(s) of performance of tests .... :	See cover page
General remarks: This report shall not be reproduced, except in full, without the written approval of the testing laboratory. The test results presented in this report relate only to the object tested. "(see remark #)" refers to a remark appended to the report. "(see appended table)" refers to a table appended to the report. Throughout this report a point is used as the decimal separator.	

Copy of marking plate



VK-48V15Ah-13S3P



VK-48V30Ah-A-13S6P

Summary of testing:

Test items of UL 2271:2018:

Clause(s)	Test(s)
23	Overcharge Test
24	Short Circuit Test
25	Overdischarge Test
26	Temperature Test
27	Imbalanced Charging Test
30	Vibration EnduranceTest
31	Shock Test
33	Drop Test
34	Mold Stress Relief Test
35	Handle Loading Test
36	Roll Over Test
38	Immersion Test
39	Water Exposure Test (IP code Rating)
40	Thermal Cycling Test
41	Label Permanence Test

Testing location:

All test except except for Clause 38, 40:

TÜV Rheinland (Shanghai) Co., Ltd. Kunshan Branch

No.38, Jingfan Road, Bacheng, Kunshan, Jiangsu, China

For Clause 38, 40:

TÜV Rheinland (Shenzhen) Co., Ltd.

1-5F, Block 5, No. 1100, Huanli Road, Yungu Community, Xinhu Street, Guangming District, Shenzhen, China

Description of the product:

The battery system(VK-48V15Ah-13S3P) is constructed with 39 (3P13S) lithium-ion cells, and has overcharge, overdischarge, oercurrent, over temperature protection circuit.

The battery system(VK-48V30Ah-A-13S6P) is constructed with 78 (6P13S) lithium-ion cells, and has overcharge, overdischarge, overcurrent, over temperature protection circuit.

VK-48V15Ah-13S3P and VK-48V30Ah-A-13S6P have same Circuit diagram.

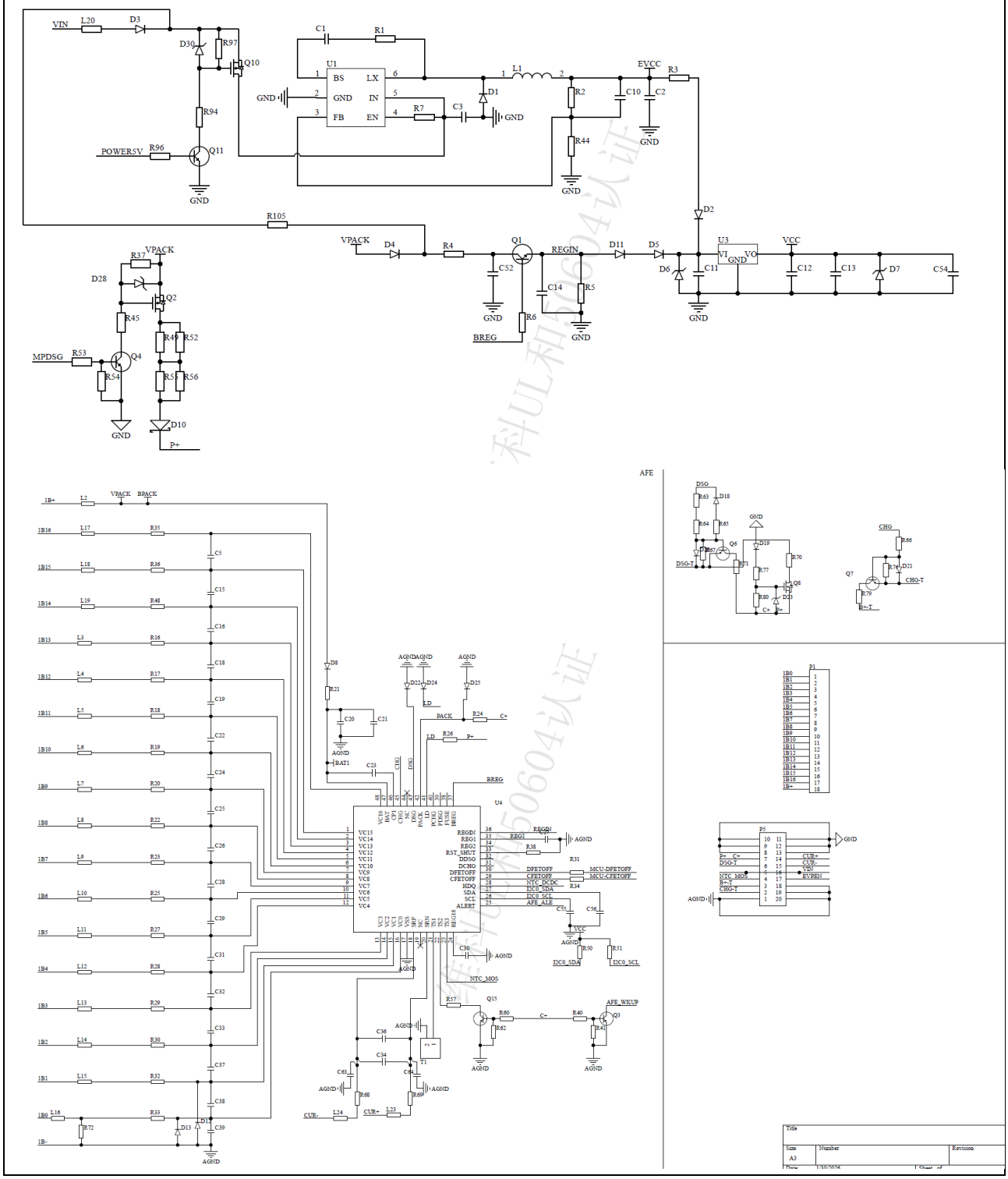
The key features of the cell and battery are shown as below:

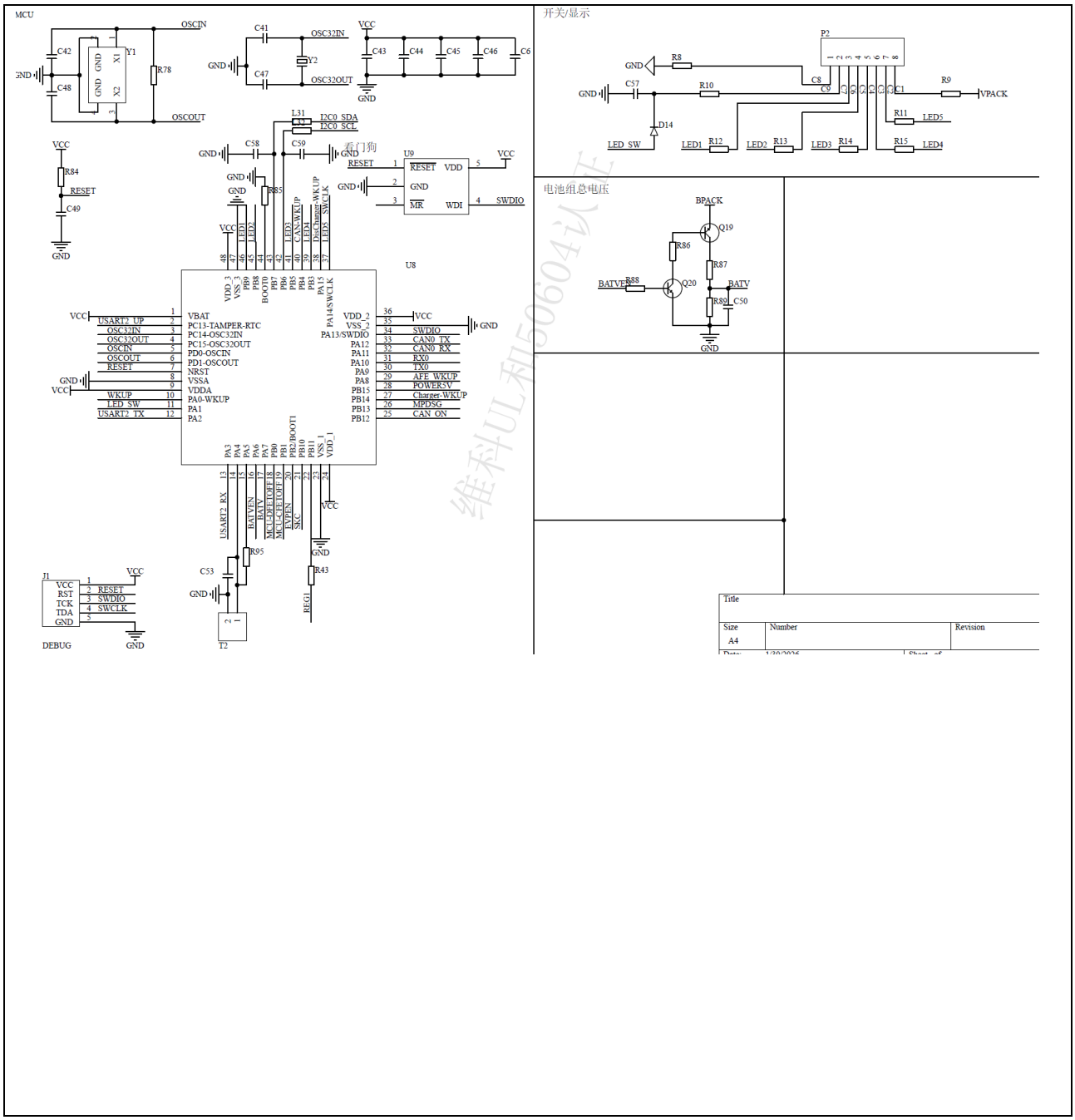
Product technical data			
Cell or battery	☒ Cell	☒ Battery System	
Model	INR21700-50G	VK-48V15Ah-13S3P	VK-48V30Ah-A-13S6P
Rated capacity	4900mAh	14700mAh	29400 mAh
Nominal voltage (V)	3.63	47.19	47.19
Maximum Charge Voltage (V)	4.25	54.6	54.6
Standard Charge Current (mA)	2450	3000	5000
Standard Discharge Current (mA)	980	5000	6000
Maximum Charge Current (mA)	4900	5000	5000
Maximum Discharge Current (mA)	9800	12000	24000
End-of-discharge voltage (V)	2.5	35.5	35.5
Charge temperature range (°C)	0°C to 45°C	0°C to 40°C	0°C to 40°C
Discharge temperature range (°C)	-20°C to 60°C	-20°C to 40°C	-20°C to 40°C
The manufacturer's maximum charge method at 25 ±5°C	--	Charging the battery with 3.0A constant current and 47.19V constant voltage until the current reduces to 0.104 A at ambient 25°C±5°C	Charging the battery with 5.0A constant current and 47.19V constant voltage until the current reduces to 0.104 A at ambient 25°C±5°C
IP Code Rating	--	IPX4	IPX4
Applicable to LEV type	--	☒ off road LEV ☐ on road LEV	☒ off road LEV ☐ on road LEV
Install type of EESAs	--	☐EESAs intended to be removable by the user. ☒EESA intended for service handling only	☐EESAs intended to be removable by the user. ☒EESA intended for service handling only
Mass	--	About 4±0.2kg	About 7±0.2kg
Pack Pattern	--	3P13S	6P13S

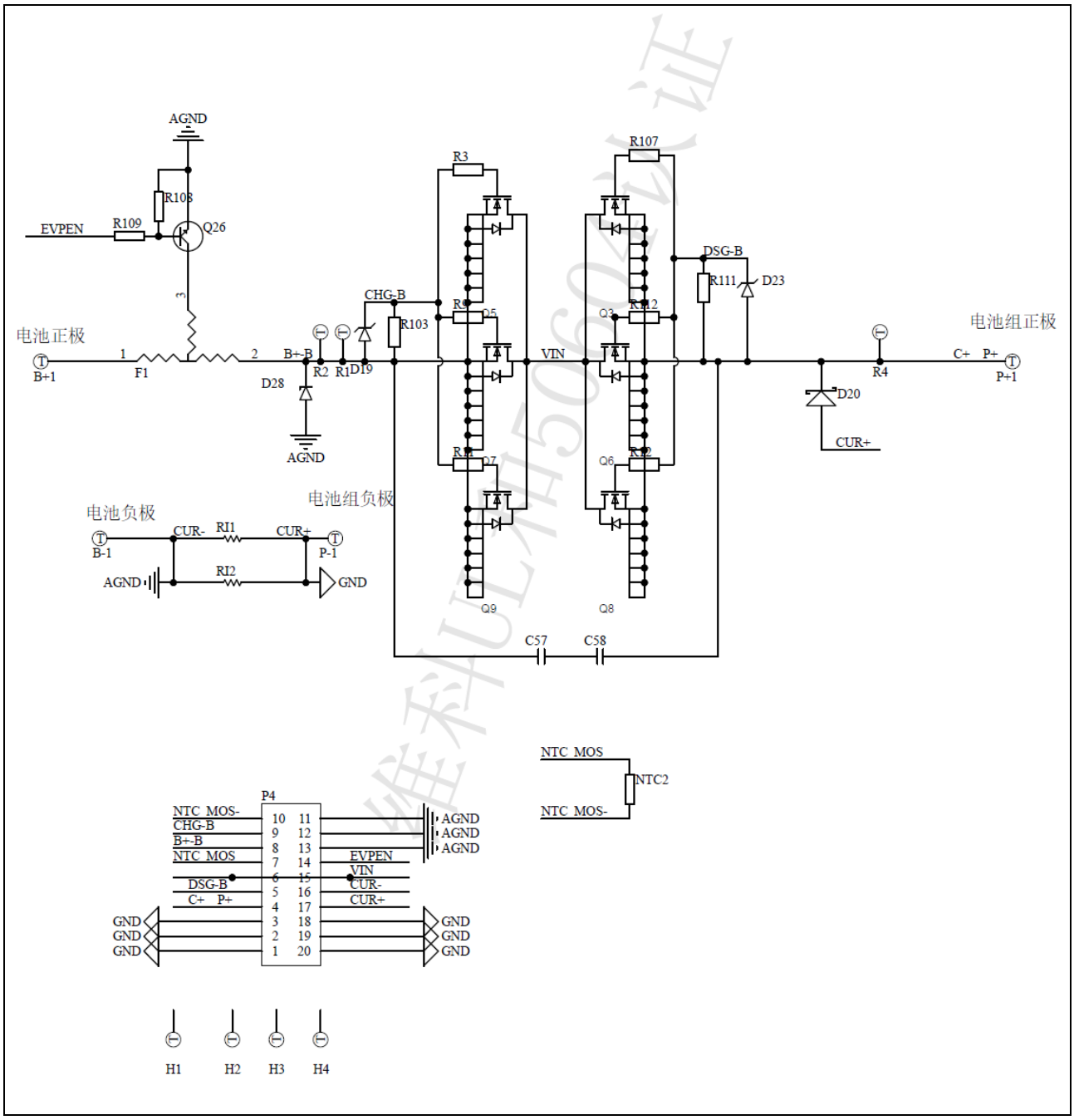
Factory location:

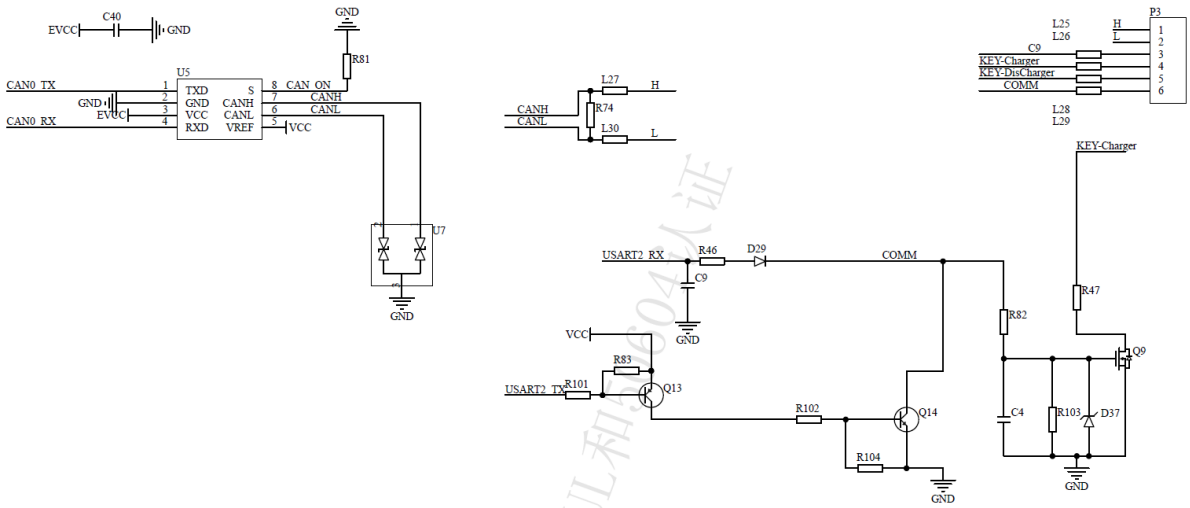
Ningbo Veken New Energy Technology Co.,Ltd.
North Plant 1,Building 1, No.3,Gangxi Avenue,Western Bonded Zone,
Ningbo 315800 ZHEJIANG P.R. CHINA

Circuit diagram:

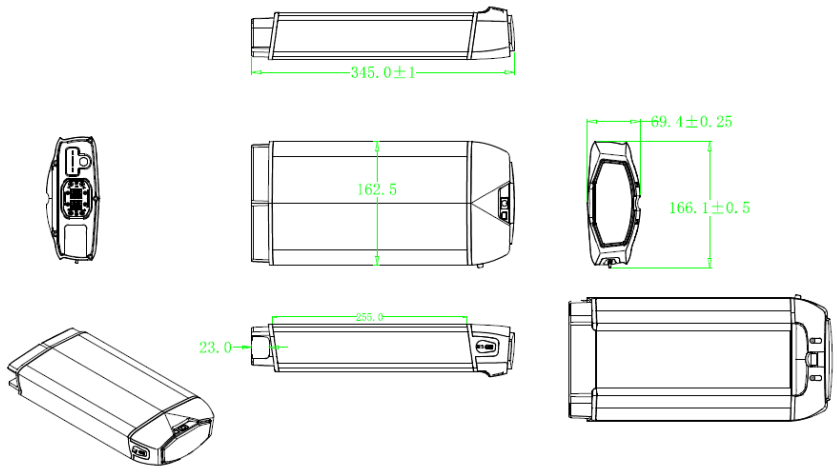



MCU
开关/显示
电池组总电压
Title
Size
A4
Number
Revision

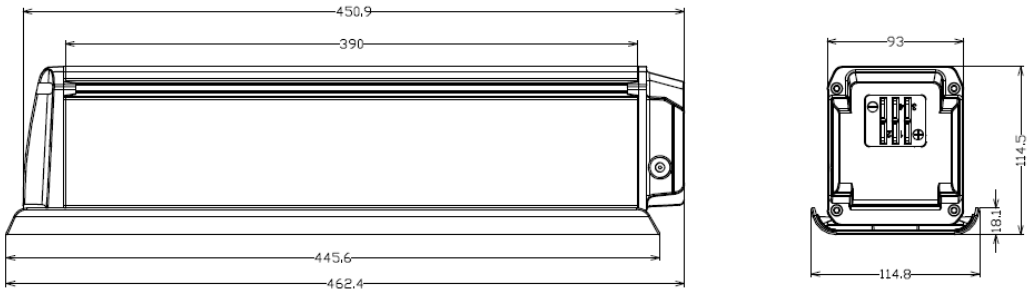

AGND
R108
EVPEN
R109
Q26
电池正极
B+1
F1
B+-B
D28
R2
R1
D19
CHG-B
R103
R3
R107
DSG-B
R111
D23
VIN
R4
D20
CUR+
电池组正极
C+ P+
P+1
电池负极
B-1
CUR-
RI1
CUR+
P-1
RI2
GND
电池组负极
Q9
Q8
C57
C58
NTC MOS
NTC2
NTC MOS-
P4
NTC MOS-
CHG-B
B+-B
NTC MOS
DSG-B
C+ P+
EVPEN
VIN
CUR-
CUR+
H1
H2
H3
H4



Dimension diagram (Unit: mm):



VK-48V15Ah-13S3P



VK-48V30Ah-A-13S6P

UL 2271			
Clause	Requirement + Test	Result - Remark	Verdict
INTRODUCTION			
1	**Scope**		P
2	**Components**		P
2.1	A component of a product covered by this Standard shall comply with the requirements for that component.	See Critical Components for details.	P
2.2	A component is not required to comply with a specific requirement that: a) Involves a feature or characteristic not required in the application of the component in the product covered by this standard; or b) Is superseded by a requirement in this standard.	See Critical Components for details.	P
3	**Units of Measurement**		P
4	**Undated References**		P
5	**Reference Publications**		P
6	**Glossary**		P
CONSTRUCTION			
7	**Non-Metallic Materials**		P
7.1	The materials employed for enclosures shall comply with the applicable enclosure requirements outlined in the Evaluation of Properties of Polymeric Materials, CAN/CSA-C22.2 No. 0.17 / Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, Path III of the Enclosure Requirements Table, except as modified by this standard.		N/A
7.2	Polymeric materials employed for enclosures shall have a minimum flame rating of V-1 in accordance with the Evaluation of Properties of Polymeric Materials, CAN/CSA-C22.2 No. 0.17 / Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94. *Exception: The enclosure may alternatively be evaluated to the 20 mm end product flame test in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.*		N/A
7.3	The following factors in (a) – (e) are taken into consideration when an enclosure employing nonmetallic materials is being judged. For a nonmetallic enclosure all of these factors are to be considered with respect to thermal aging. Dimensional stability of a polymeric enclosure is addressed by compliance to the mold stress relief test. Suitability to factors (a) – (e) below may be determined by the tests of this standard. a) Resistance to impact; b) Crush resistance; c) Abnormal operations;		N/A

UL 2271			
Clause	Requirement + Test	Result - Remark	Verdict
	d) Severe conditions; and e) Mold-Stress Relief Distortion.		
7.4	The polymeric materials employed for enclosures and insulation shall be suitable for anticipated temperatures encountered in the intended application. EESA enclosures shall have a Relative Thermal Index (RTI) with impact suitable for temperatures encountered in the application but no less than 80°C (176°F), as determined in accordance with the Evaluation of Properties of Polymeric Materials, CAN/CSA-C22.2 No. 0.17 / Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B.		P
7.5	The enclosure materials intended to be directly exposed to sunlight and rain in the end use application shall comply with the UV Resistance and the Water Exposure and Immersion tests in accordance with the Evaluation of Properties of Polymeric Materials, CAN/CSA-C22.2 No. 0.17 / Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.		N/A
7.6	Materials employed as electrical insulation in the assembly shall be resistant to deterioration that would result in an electrical shock, fire or other safety hazard. Compliance is determined by the tests of this standard. Materials employed for direct support of live parts at hazardous voltage, shall additionally meet the direct support insulation criteria outlined in the Material Property Considerations table in the Evaluation of Properties of Polymeric Materials, CAN/CSA-C22.2 No. 0.17 / Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C unless employed as part of a component that has been evaluated to a suitable component standard. Insulated wiring is subjected to the requirements outlined in Section 10.		P
7.7	Gaskets and Seals of the EESA relied upon for safety, shall be determined suitable for the environmental conditions and chemical substances they are anticipated to be exposed to in their end use.		P
8	**Metallic Parts Resistance to Corrosion**		N/A
8.1	Metal EESA enclosures shall be corrosion resistant. A suitable plating or coating process can achieve corrosion resistance.		N/A
8.2	Metallic EESA enclosures may be provided with an insulating liner to prevent shorting of live parts to the enclosure. If using an insulating liner for this purpose, the insulating liner shall consist of non-moisture absorbent materials that have a temperature rating suitable for temperatures within the pack during operation.		N/A

UL 2271			
Clause	Requirement + Test	Result - Remark	Verdict
8.3	Conductive parts in contact at terminals and connections shall not be subject to corrosion due to electrochemical action. Combinations above the line in Table B.1 of Annex B shall be avoided.		N/A
9	**Enclosures**	No enclosures, built-in battery to be evaluated in final system.	N/A
9.1	The enclosure of an EESA shall have the strength and rigidity required to resist the possible physical abuses that it will be exposed to during its intended use, in order to reduce the risk of fire or injury to persons.		N/A
9.2	A tool providing the mechanical advantage of a pliers, screwdriver, or similar tool, shall be the minimum mechanical capability required to open the enclosure.		N/A
9.3	Openings in the enclosure of an electric energy storage assembly shall be designed to prevent inadvertent access to hazardous parts as installed in the vehicle.		N/A
9.4	Openings in the enclosure shall be designed to prevent ingress of water as installed in the vehicle in accordance with intended use and IP rating in accordance with Standard for Degrees of Protection Provided by Enclosures (IP Code), IEC 60529 with a minimum rating of IPX3.		N/A
10	**Wiring and Terminals**		P
10.1	Wiring shall be insulated and acceptable for the purpose, when considered with respect to temperature, voltage, and the conditions of service to which the wiring is likely to be subjected within the equipment.		P
10.2	Internal wiring shall be routed, supported, clamped or secured in a manner that reduces the likelihood of excessive strain on wire and on terminal connections; loosening of terminal connections; and damage of conductor insulation. In safety critical circuits, for soldered terminations, the conductor shall be positioned or fixed so that reliance is not placed upon the soldering alone to maintain the conductor in position.	Internal wiring route, support, clamp and secured well.	P
10.3	Connections to the cells shall be made in a manner that does not result in damage to the cells or protection assembly. For example, connections made using high heat processes, such as solder, shall not be used on direct connections to the cell terminals without proper processes and controls as this could result in damage to the cell as a result of heat transfer during soldering. To prevent damage to cells or protective devices, connections between cells and electronic protective devices should be made using the connection sequences recommended by the protective device manufacturer.		P

UL 2271			
Clause	Requirement + Test	Result - Remark	Verdict
10.4	An EESA external terminal shall be designed to prevent inadvertent shorting. An external terminal shall be designed to prevent inadvertent misalignment or disconnection when installed in its end use vehicle.	The external terminal can prevent inadvertent misalignment or disconnection when installed in its end use vehicle.	P
10.5	For all EESAs, an external terminal for charging shall be designed to prevent an inadvertent shorting and misalignment and a reverse polarity connection. For EESAs that are intended for removal from the vehicle for external charging or replacement with a charged EESA, the external terminal for discharging shall be designed to prevent inadvertent shorting, a reverse polarity connection and a misalignment.		P
10.6	For EESAs that are intended for removal from the vehicle for external charging or replacement with a charged EESA by the user, the external terminal for discharging and any other external terminals with hazardous voltage shall be designed to prevent access by the user. Compliance is determined by use of the articulate test finger shown in Figure 2. The articulate test finger requirement does not apply to the manual disconnection for servicing device as outlined in 15.5.		N/A
10.7	The external terminals of an EESA intended for removal from the vehicle for charging, shall be evaluated to either the no load endurance test or endurance with load test as applicable to the end use application in accordance with the Standard for Plugs, Receptacles and Couplers for Electric Vehicles, UL 2251 without being subjected to the exposure to contaminants.		N/A
10.8	A hole by which insulated wires pass through an internal or external opening in the enclosure shall be provided with a smoothly rounded bushing or shall have smooth surfaces, free of burrs, fins, sharp edges, and the like, upon which the wires may bear, to prevent abrasion of the insulation.		P
10.9	Wiring for hazardous voltage shall be readily distinguishable from low voltage wiring harnesses through the use of orange colored insulation or orange wiring harness jacketing or covers. Internal wiring of hazardous voltage circuits that are not provided with orange wiring harness covers or jackets, shall also be colored primarily orange (i.e. solid orange or orange striped), or enclosed in junction boxes with hazardous voltage warning labels such as ISO No. 7010, No. W001 (i.e. lightning bolt within triangle).	No hazardous voltage inside the battery.	N/A
11	**Fuses**		P
11.1	Fuses used in an EESA shall be acceptable for current and voltage which are likely to be subjected.		P

UL 2271			
Clause	Requirement + Test	Result - Remark	Verdict
11.2	For user replaceable fuses, a fuse replacement marking shall be located adjacent to each fuse or fuse holder, or on the fuse holder, or in another location provided that it is obvious to which fuse the marking applies and giving the fuse ratings.		N/A
12	**Handles**		P
12.1	An integral handle(s) or other lifting mechanism used for picking the pack up shall be capable of supporting the weight of the pack without breakage of the handle, its securing means, or that part of the product to which the handle is attached. Compliance is determined by Section 35, Handle Loading Test.		P
13	**Electrical Spacings and Separation of Circuits**		N/A
13.1	Electrical circuits within the EESA at opposite polarity shall be provided with reliable physical spacing to prevent inadvertent short circuits (i.e. electrical spacings on printed wiring boards, physical securing of uninsulated leads and parts, etc.). Insulation suitable for the anticipated temperatures and voltages shall be used where spacings cannot be controlled by reliable physical separation.		N/A
13.2	Electrical spacings in circuits shall have the following minimum over surface and through air spacings as outlined in Table 13.1 or the spacings requirements outlined in the Standard for Information Technology Equipment Safety – Part 1: General Requirements, CAN/CSA-C22.2 No. 60950-1 / UL 60950-1, the clause for “Clearances, Creepage Distances and Distances Through Insulation”. *Exception No. 1: As an alternative to the spacing requirements of Table 13.1, the spacing requirements in the Standard for Insulation Coordination, CSA-C22.2 No. 0.2 / Standard for Insulation Coordination Including Clearances and Creepage Distances For Electrical Equipment, UL 840, may be used. For determination of clearances, a dc source such as a battery does not have an overvoltage category as outlined in the section for Components of the Standard for Insulation Coordination, CSA-C22.2 No. 0.2 / Standard for Insulation Coordination Including Clearances and Creepage Distances For Electrical Equipment, UL 840 unless charged through a source connected to a mains supply. The anticipated pollution degree is determined by the design and application of the electrical energy storage assembly or subassembly under evaluation.* *Exception No. 2: As an alternative to the clearance values outlined in the Standard for Information Technology Equipment Safety – Part 1: General Requirements, CAN/CSA-C22.2 No. 60950-1 / UL 60950-1, the clause for Clearances, Creepage Distances and Distances Through Insulation, the alternative method for determining minimum*	Below 60 Vdc.	N/A

UL 2271			
Clause	Requirement + Test	Result - Remark	Verdict
	clearances in the Annex for Alternative Method for Determining Minimum Clearances, Annex G, of the Standard for Information Technology Equipment Safety – Part 1: General Requirements, CAN/CSA-C22.2 No. 60950-1 / UL 60950-1 may be applied. *Exception No. 3: For electric energy storage assemblies where external leakage of liquid electrolyte may occur, the clearance and creepage distances of Clause 6.2 of the Standard for Electrically Propelled Road Vehicles – Safety Specifications – Part 1: On-board Rechargeable Energy Storage System (RESS), ISO 6469-1, applies.*		
13.3	There are no minimum spacings applicable to parts where insulating compound completely fills the casing of a compound or subassembly if the distance through the insulation, at voltages above 60 Vdc or above 30 Vrms is a minimum of 0.4-mm (0.02-in) thick for supplementary or reinforced insulation, and passes the Dielectric Voltage Withstand Test, Section 28 and the Isolation Resistance Test, Section 29. There is no minimum insulation thickness requirement for insulation of circuits at or below 60 Vdc or for basic or functional insulation. Some examples include potting, encapsulation, and vacuum impregnation.	Below 60 Vdc.	N/A
13.4	Conductors of circuits operating at different voltages shall be reliably separated from each other through the use of mechanical securements such as barriers or wire ties to maintain spacings requirements unless they are each provided with insulation acceptable for the highest voltage involved. An insulated conductor shall be reliably retained so that it cannot contact an uninsulated live part of a circuit operating at a different voltage.		P
14	**Insulation Levels and Protective Grounding**		P
14.1	Hazardous voltage circuits shall be insulated from accessible conductive parts and safety extra low voltage (SELV) circuits as outlined in 14.2 through the following: a) Basic insulation and provided with a protective grounding system for protection in the event of a fault of the basic insulation; or b) A system of double or reinforced insulation; or c) A combination of (a) and (b).	No hazardous voltage circuits.	N/A
14.2	Safety extra low voltage (SELV) circuits (i.e. circuits at or below 60 Vdc or 48 Vrms under normal and single fault conditions) that are insulated from accessible conductive parts through functional insulation only are considered accessible.	Below 60 Vdc.	P

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Clause	Requirement + Test	Result - Remark	Verdict
14.3	If relying upon a protective grounding system (i.e. grounding of an accessible metal enclosure), it shall comply with 14.4 – 14.6.	No protective grounding.	N/A
14.4	Parts of a protective grounding system shall be reliably secured in accordance with 10.5 and provided with good metal-to-metal contact of the grounded parts of the EESA to the vehicle. The impedance from the various bonding conductors and connections to the main ground terminal shall have a maximum resistance of 0.1 Ω. Compliance can be determined by measurement using an ohmmeter.		N/A
14.5	The main ground terminal of the protective earthing ground system shall be identified by one of the following: a) A green-colored, not readily removable terminal screw with a hexagonal head; b) A green-colored, hexagonal, not readily removable terminal nut; c) A green colored pressure wire connector; or d) The word “Ground” or the letters “G” or “GR” or the grounding symbol (IEC 60417, No. 5019 – upside down “tree” in circle) or otherwise identified by a distinctive green color.		N/A
14.6	Conductors, relied upon for the protective grounding and bonding system, shall be sized to handle intended fault current. If insulated, the insulation shall be green or green and yellow striped in color.		N/A
15	**Protective Circuit and Safety Analysis**		P
15.1	The EESA protective circuit shall maintain the cells within their normal operating region for charging and discharging through the life of the EESA. If normal limits are exceeded, the protective circuit shall limit or shut down the charging or discharging to prevent excursions beyond normal operating limits. Compliance is determined through a review of the pack and cell or electrochemical capacitor data including the safety analysis of 15.2 and through the testing of this standard.		P
15.2	An analysis of potential hazards (including a failure modes and effects analysis (FMEA)) shall be conducted on the EESA to determine that events that could lead to a hazardous condition have been identified and addressed through design or other means. Documents that can be used as guidance for the safety analysis include: a) The Standard for Analysis Techniques for System Reliability – Procedure for Failure Mode and Effects Analysis (FMEA), IEC 60812; b) The Standard for Fault Tree Analysis (FTA), IEC 61025;	FMEA report provided by manufacturer according to UL 991.	P

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Clause	Requirement + Test	Result - Remark	Verdict
	c) The Potential Failure Mode and Effects Analysis in Design (Design FMEA), Potential Failure Mode and Effects Analysis in Manufacturing and Assembly Processes (Process FMEA), SAE J1739; d) The Procedures for Performing a Failure Mode, Effects, and Criticality Analysis, MIL-STD-1629A; e) The Standard for Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems Part 1: General Requirements, IEC 61508-1, and all parts; f) The Standard for Safety of Machinery – Safety-Related Parts of Control Systems – Part 1: General Principles for Design, ISO 13849-1 and the Standard for Safety of Machinery – Safety- Related Parts of Control Systems – Part 2: Validation, ISO 13849-2.		
15.3	The analysis in 15.2 is utilized to identify anticipated faults in the system which could lead to a hazardous condition and the types and levels of protection provided to mitigate the anticipated faults. The analysis shall consider single fault conditions in the protection circuit/scheme as part of the anticipated faults.		P
15.4	When conducting the analysis of 15.2, active devices shall not be relied upon for critical safety unless: a) They are provided with a redundant passive protection device; or b) They are provided with redundant active protection that remains functional and energized upon loss of power/failure of the first level active protection; or c) They are determined to fail safe upon loss of power to the active circuit; or d) The protective circuit has been shown to comply with a minimum of IEC 61508 Safety Integrity Level (SIL) 2 or ISO 13849 Performance Level (PL) c.	ISO 13849 report provided.	P
15.5	Devices relied upon for critical safety as noted in 15.4 shall be tested for functionality in accordance with appropriate functional safety requirements unless already evaluated through the other tests of this standard. Functional safety criteria for EESAs can be found in one of the following standard as appropriate to the design of the electronic and software protection scheme: a) The Standard for Safety Tests for Safety-Related Controls Employing Solid-State Devices, UL 991 and the Standard for Software in Programmable Components, UL 1998; b) The Standard for Automatic Electrical Controls for Household and Similar Use – Part 1: General Requirements, CSA-E60730-1 / UL 60730-1; c) The Standard for Functional Safety of Electrical/Electronic/Programmable Electronic Safety-		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
	Related Systems Part 1: General Requirements, IEC 61508-1, and all parts; d) The Standard for Road Vehicles – Functional Safety – Part 1: Vocabulary, ISO 26262-1, and all parts; e) The Standard for Safety of Machinery – Safety-Related Parts of Control Systems – Part 1: General Principles for Design, ISO 13849-1 and the Standard for Safety of Machinery – Safety- Related Parts of Control Systems – Part 2: Validation, ISO 13849-2.		
15.6	A hazardous voltage EESA shall have a manual disconnect to prevent inadvertent access to hazardous voltage parts during servicing or during a collision. The manual disconnect shall: a) Disconnect both poles of the hazardous voltage circuit; b) Be accessible and able to be operated without the use of a tool in the event of a collision or during servicing; c) Require manual action to break the electrical connection; d) Ensure disconnection is physically verifiable and can include actual removal of the EESA from the vehicle or unplugging the EESA connector/plug; and e) When engaged (i.e. under disconnection), it does not create exposed conductors capable of becoming energized and is insulated to prevent a shock hazard during actuation.	No hazardous voltage.	N/A
15.7	If a hazardous voltage automatic disconnect device is provided to isolate accessible conductive parts from the hazardous voltage circuit of the EESA, it shall: a) Not be able to be reset automatically although it may be able to be reset deliberately upon clearing of the fault; b) Disconnect both poles of the hazardous voltage circuit; c) Be capable of handling full load disconnects of the hazardous voltage circuit that it is isolating; and d) Not result in a hazardous condition upon automatic actuation.	No hazardous voltage.	N/A
16	**Cells and Electrochemical Capacitors**		P
16.1	Cells and electrochemical capacitors shall be designed to safely withstand anticipated abuse conditions for vehicular applications.		P
16.2	Lithium ion and other lithium based cells shall comply with the requirements for secondary lithium cells in the Standard for Batteries for Use In Electric Vehicles, UL 2580/ULC-S2580.	Cell was evaluated with UL 2580.	P
16.3	Nickel metal hydride cells and other nickel based cells shall comply with the nickel cell requirements of the		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
	Standard for Batteries for Use In Electric Vehicles, UL 2580/ULC-S2580. *Exception: Nickel metal hydride cells and other nickel based cells that are sealed and formed as part of a monobloc battery, need only comply with the requirements of this standard as part of the assembled* *battery.*		
16.4	Sodium nickel metal chloride cells shall comply with the requirements for sodium beta battery cells outlined in Annex B of the Standard for Batteries For Use In Light Electric Rail (LER) Applications and Stationary Applications, UL 1973.		N/A
16.5	Batteries employing re-closable pressure release valves on the external enclosure of the battery (e.g. valve regulated lead acid batteries) or flame arresters on vented batteries, shall comply with the pressure release test or the flame arrester test of the Standard for Standby Batteries, UL 1989.		N/A
16.6	Electrochemical capacitors shall comply with the single capacitor requirements outlined in the Standard for Electrochemical Capacitors, UL 810A.		N/A
17	**Manufacturing and Production Line Testing**	Below 60 Vdc.	N/A
17.1	EESAs shall be subjected to 100% production screening as described in 17.2 and 17.3 to determine the acceptability of spacing, insulation and grounding system in production.		N/A
17.2	A dielectric withstand test as outlined in the Dielectric Voltage Withstand Test in Section 29 shall be conducted on 100% production of EESAs with working voltage exceeding 60 Vdc or 30 Vrms/42.4 Vpeak.		N/A
17.3	A continuity check of the grounding conductors using an ohmmeter or other method shall be conducted on 100% production employing protective grounding. The continuity check shall determine that the resistance of the protective grounding system does not exceed 0.1Ω.		N/A
17.4	Manufacturers of EESAs shall have documented production process controls in place that continually monitor and record the following key elements of the manufacturing process that can affect safety, and shall include measured parametric limits enabling corrective/preventative action to address defects (out of limit parameters) found affecting these key elements: a) Supply chain control; and b) Assembly processes.		N/A
PERFORMANCE			

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Clause	Requirement + Test	Result - Remark	Verdict
18	**General**		P
18.1	Unless indicated otherwise, batteries shall be fully charged to the maximum operating state of charge (MOSOC) in accordance with the manufacturer's specifications for conducting the tests in this standard. After charging and prior to testing, the batteries shall be allowed to rest for a maximum period of 8 h at 25±5°C (77±9°F).		P
18.2	Unless otherwise indicated, fresh samples representative of production are to be used for the tests described in this standard. The test program and number of samples to be used in each test is shown in Table 18.1.		P
18.3	All tests, unless noted otherwise, are conducted in a room ambient 25±5°C (77±9°F). Unless noted otherwise in the test method, the cooling systems or other auxiliary systems of the EESA may be allowed to operate during the test if they can affect the outcome of the test.		P
18.4	Temperature shall be measured using thermocouples consisting of wires not larger than 0.21 mm^2 (24 AWG) and not smaller than 0.05 mm^2 (30 AWG) connected to a potentiometer-type instrument. Temperature measurements are to be made with the measuring junction of the thermocouple held tightly against the component/location being measured. For those tests that require the sample to reach thermal equilibrium (also referred to as steady state conditions), thermal equilibrium is considered to be achieved if after three consecutive temperature measurements taken at intervals of 10% of the previously elapsed duration of the test but not less than 15 min, indicate no change in temperature greater than ±2°C (±3.6°F).		P
18.5	Where there is a specific reference to a single fault condition in the individual test methods, the single fault is to consist of a single failure (i.e. open, short or other failure means) of any component in the EESAs that could occur and affect the results of the test. This fault is implemented in conjunction with the test being conducted (i.e. overcharge, short circuit, etc.) or may be conducted as part of a verification of a protective circuit. A protective component determined to be reliable may remain in the circuit without being faulted. A reliable protective component is one that has been evaluated to its applicable component standard. See Annex A and 2.1. A protective circuit determined to be reliable is one that has been shown to comply with an appropriate functional safety standard per 15.5 with a safety level defined by a corresponding hazards and risk analysis.	Single fault condition applied on applicable test items.	P

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Clause	Requirement + Test	Result - Remark	Verdict
18.6	The tests contained in this standard may result in explosions, fire and emissions of flammable and/or toxic fumes as well as electric shock. It is important that personnel use extreme caution and follow local and regional worker safety regulations when conducting any of these tests and that they be protected from flying fragments, explosive force, and sudden release of heat and noise that could result from testing. The test area is to be well ventilated to protect personnel from possible harmful fumes or gases. As an additional precaution, the temperatures on surface of at least one cell/module within the DUT and the OCV of the DUT are to be monitored during the test for safety and information purposes. All personnel involved in the testing are to be instructed to never approach the DUT until temperatures are falling and have returned to within ambient temperatures.		P
18.7	Unless noted otherwise in the individual test methods, the tests shall be followed by a minimum 1-h observation time prior to concluding the test and temperatures are to be monitored in accordance with 18.6.		P
19	**Combustible Concentrations**		N/A
19.1	Where a system analysis indicates that venting/off gassing from cells or capacitors could result in combustible concentrations because of the system's chemistry (i.e. vented batteries) or design, the evaluation for combustible concentrations during the tests of this standard shall be determined through the methods outlined in 19.2. If it can be determined through examination of the cells after testing that they did not vent as a result of the test, the system is in compliance with these criteria.		N/A
19.2	For detection of potential flammable concentrations that may be emitted during testing, a gas monitor suitable for detecting 25% of the lower flammability limit of the evolved gases being measured. A minimum of two sampling locations where concentrations may occur such as at vent openings or vent ducts shall be used for taking measurements. *Exception: As an alternative to using gas detection measurement to determine if there are flammable concentrations, non-compliant tests results for fire may include an evaluation for potential flammable concentrations of vapors with the use of a minimum of two continuous spark sources. The continuous spark sources are to provide at least two sparks per second with sufficient energy to ignite natural gas (or sufficient energy to ignite the potential vapor if more energy is required for ignition than would be needed to ignite natural gas) and are to be located near anticipated sources of vapor such as vent openings or at the vent duct.*		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
19.3	Additional precautions shall be taken during tests requiring this analysis due to the potential for flammable gas concentrations that may occur within the test room or chamber.		N/A
20	**Tolerances**		P
20.1	Unless noted otherwise in the test methods, the overall accuracy of controlled or measured values when conducting testing in accordance with this standard shall be within following tolerances: a) ±1% for voltage; b) ±1% for current; c) ±2°C (±3.6°F) for temperatures at or below 200°C (392°F) and ±3% for temperatures above 200°C (392°F); d) ±0.1% for time; and e) ±1% for dimension.		P
21	**Post Test Cycle**		P
21.1	EESAs that are operational after the following tests shall be subjected to a minimum of one cycle of charging and discharging in accordance with the manufacturer's specifications to determine that there is no non-compliant results as outlined in Table 21.1 for that test: a) Electrical Tests – Overcharge, short circuit, overdischarge protection, imbalanced charging; b) Mechanical Tests – Vibration, shock, roll over, drop; c) Environmental Tests – Water exposure, and thermal cycling.		P
22	**Results Criteria**		P
22.1	See Table 21.1 for results criteria for tests outlined in this standard and Section 6 for definitions of the non-compliance results terms. See also individual tests methods for any additional details.		P
ELECTRICAL TESTS			
23	**Overcharge Test**		P
23.1	This test is intended to evaluate an DUT's ability to withstand an overcharge condition under a single fault in the charging control circuitry that could result in an overcharge condition.	See table 23 for detail.	P
23.2	A fully charged sample is to be discharged at a 0.2 C constant discharge rate or a higher discharge rate permitted by the manufacturer to the manufacturer's specified EODV. The DUT is then subjected to a constant current charging at the manufacturer's maximum specified charging rate and under a single fault condition in the circuitry that directly controls the charging line of the DUT that could lead to an		P

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Clause	Requirement + Test	Result - Remark	Verdict
	overcharge condition. Protective devices that have been determined reliable may remain in the circuit and circuits that have been determined reliable may remain active without being faulted as noted in 18.5. For information purposes, temperatures are to be monitored on the cell/module where temperatures may be highest.		
23.3	The test is to be continued until the voltage has reached 110% of the maximum specified voltage limit and monitored temperatures return to ambient or steady state conditions and an additional 2 h has elapsed, or explosion/fire occur. If the DUT is operational after the test, it shall be subjected to a minimum of one charge/discharge cycle at the manufacturer's maximum specified values. The test shall be followed by an observation period per 18.7.		P
23.4	At the conclusion of the observation period, the samples with hazardous voltage circuits shall be subjected to a Dielectric Voltage Withstand Test or Isolation Resistance Test (without humidity conditioning).	Without hazardous voltage circuits.	N/A
23.5	If a protective device in the circuit operates, the test is repeated at 90% of the trip point of the protection device or at some percentage of the trip point that allows charging for at least 10 min. Temperatures shall be measured on the DUT for monitoring purposes.		P
23.6	As a result of the overcharge test, any of the following results in (a) – (g) below are considered a non-compliant results. See also Table 21.1 and Section 22. a) E – Explosion; b) F – Fire; c) C – Combustible Concentrations (if applicable to technology); d) R – Rupture (enclosure); e) L – Electrolyte Leakage (external to enclosure); f) S – Electric shock hazard (resistance below isolation resistance limits or dielectric breakdown); g) P – Loss of protection controls.		P
24	**Short Circuit Test**		P
24.1	This test evaluates a DUT's ability to withstand a short circuit condition.	See table 24 for detail.	P
24.2	A fully charged sample of the DUT is to be short-circuited by connecting the positive and negative terminals of the sample with a circuit load having a total resistance of less than or equal to 20 mΩ.		P
24.3	Samples are to be subjected to an external short under a single fault condition in the protection circuit		P

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Clause	Requirement + Test	Result - Remark	Verdict
	of the DUT that could impact the external short. Protective devices that have been determined reliable may remain in the circuit and circuits that have been determined reliable may remain active without being faulted as noted in 18.5.		
24.4	The sample shall be discharged until the sample has returned to ambient temperature or fire or explosion occurs. Temperatures shall be measured on the DUT for monitoring purposes.		P
24.5	If the DUT is operational after the test, it shall be subjected to a minimum of one charge/discharge cycle at the manufacturer's maximum specified values. The test shall be followed by an observation period per 18.7.		P
24.6	If a protective device in the circuit operates, the test is repeated at 90% of the trip point of the protection device or at some percentage of the trip point that allows discharging for at least 10 min.		P
24.7	At the conclusion of the test and after cooling to near ambient, the samples that contain hazardous voltage circuits shall be subjected to a Dielectric Voltage Withstand Test or Isolation Resistance Test (without humidity conditioning).	Without hazardous voltage circuits.	N/A
24.8	As a result of the short circuit test, any of the following results in (a) – (g) below are considered a non-compliant result. See also Table 3 and Section 22. a) E – Explosion; b) F – Fire; c) C – Combustible Concentrations (if applicable to technology); d) R – Rupture (enclosure); e) L – Electrolyte Leakage (external to enclosure); f) S – Electric shock hazard (resistance below isolation resistance limits or dielectric breakdown); g) P – Loss of protection controls.		P
25	**Overdischarge Test**		P
25.1	This test is intended to evaluate a DUT's ability to withstand an overdischarge under protection circuitry fault condition.	See table 25 for detail.	P
25.2	The fully charged sample is to be subjected to a constant discharging current at the maximum discharging current specified by the manufacture under a single fault condition in the discharging circuit of the DUT that could lead to an overdischarge condition. Protective devices that have been determined reliable may remain in the circuit as noted in 18.5. Temperatures shall be measured on a cell/module for monitoring purposes.		P
25.3	The test is to be continued until the sample is fully discharged to a near zero voltage state or protective		P

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Clause	Requirement + Test	Result - Remark	Verdict
	devices remaining in the circuit operate, and the monitored temperatures return to ambient or steady state, or explosion and/or fire occurs. If the DUT is operational after the test, it shall be subjected to a minimum of one charge/discharge cycle at the manufacturer's maximum specified values. The test shall be followed by an observation period per 18.7.		
25.4	At the conclusion of the observation period, the samples with hazardous voltage circuits shall be subjected to an Isolation Resistance Test (without humidity conditioning) or a Dielectric Voltage Withstand Test.	Without hazardous voltage circuits.	N/A
25.5	As a result of the overdischarge test, any of the following results in (a) – (g) below are considered a non-compliant result. See also Table 21.1 and Section 22. a) E – Explosion; b) F – Fire; c) C – Combustible Concentrations (if applicable to technology); d) R – Rupture (enclosure); e) L – Electrolyte Leakage (external to enclosure); f) S – Electric shock hazard (resistance below isolation resistance limits or dielectric breakdown); g) P – Loss of protection controls.		P
26	**Temperature Test**		P
26.1	This test is conducted to determine whether or not the modules and their cells are being maintained within their specified operating limits during maximum charge and discharge conditions of the EESA. During this test, it shall also be determined as to whether or not temperature sensitive safety critical components and temperature sensitive materials in the DUT are being maintained within their temperature ratings based upon the maximum operating temperature limits of the DUT. Temperatures on accessible surfaces, which may be contacted by the user, are also monitored.	See table 26 for detail.	P
26.2	A fully discharged DUT (i.e. discharged to EODV) is to be conditioned within a chamber set to the upper limit charging temperature specifications of the EESA. After thermal stabilization in the chamber, the DUT is to be connected to a charging circuit input representative of anticipated maximum charging parameters. The DUT shall then be subjected to maximum normal charging while monitoring voltages and currents on cells/modules until it reaches the manufacturer's specified fully charged condition. Temperatures shall be monitored on temperature sensitive components including cells and on any user accessible surfaces.	Charging current: 5A Upper limit charging temperature: 40°C	P

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Clause	Requirement + Test	Result - Remark	Verdict
26.3	While still in the conditioning chamber, and after allowing temperatures to stabilize, the fully charged DUT shall then be discharged in accordance with the manufacturer's specifications down to the manufacturer's specified end of discharge condition while monitoring voltage and current on cells/modules until the DUT reaches its specified EODV. Temperatures shall be monitored on temperature sensitive safety critical components including cells and on any user accessible surfaces.	Discharging current: 12A (VK-48V15Ah-13S3P) 24A(VK-48V30Ah-A-13S6P) Upper limit discharging temperature: 40°C	P
26.4	The charge and discharge cycles are then repeated for a total of 5 complete cycles of charge and discharge.		P
26.5	During the temperature test, the voltage and current during discharge and charging of the component cells is monitored to determine that they are not outside of the specified cell manufacturer's operating region.		P
26.6	The manufacturer's specified limits (voltage, current and temperatures measured) shall not be exceeded during the charging and discharging cycles. Temperatures measured on components shall not exceed their specifications. See Tables 4 and 5 for surface and component temperature limits.		P
26.7	At the conclusion of the observation period, the samples with hazardous voltage circuits shall be subjected to an Isolation Resistance Test (without humidity conditioning) or a Dielectric Voltage Withstand Test.	Without hazardous voltage circuits.	N/A
26.8	As a result of the temperature test, any of the following results in (a) – (h) below are also considered a non-compliant result. See also Table 21.1 and Section 22. a) E – Explosion; b) F – Fire; c) C – Combustible Concentrations (if applicable to technology); d) R – Rupture (enclosure); e) L – Electrolyte Leakage (external to enclosure); f) V– Venting; g) S – Electric shock hazard (resistance below isolation resistance limits or dielectric breakdown); h) P – Loss of protection controls.		P
27	**Imbalanced Charging Test**		P
27.1	This test is to determine whether or not a DUT with series connected cells can maintain the cells within their specified operating parameters if it becomes imbalanced.		P
27.2	A fully charged DUT shall have all of its cells with the exception of one cell/cell block discharged to its specified fully discharged condition. The		P

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Clause	Requirement + Test	Result - Remark	Verdict
	undischarged cells shall be discharged to approximately 50% of its specified state of charge (SOC) to create an imbalanced condition prior to charging. For this test, protective devices that have been determined reliable may remain in the circuit and circuits that have been determined reliable may remain active without being faulted as noted in 18.5.		
27.3	The DUT shall then be charged in accordance with the manufacturer's specifications. The voltage of the partially charged cells shall be monitored during the charging to determine if its voltage limits are exceeded. If the DUT is operational after the test, it shall be subjected to a minimum of one charge/discharge cycle at the manufacturer's maximum specified values.	The cells voltage not exceeding 4.25V.	P
27.4	At the conclusion of the observation period, the samples with hazardous voltage circuits shall be subjected to an Isolation Resistance Test (without humidity conditioning) or a Dielectric Voltage Withstand Test.	Without hazardous voltage circuits.	N/A
27.5	The maximum voltage limit of the cells shall not exceed the manufacturer's specifications. In addition, any of the following results in (a) – (h) below are considered a non-compliant result. See also Table 21.1 and Section 22. a) E – Explosion; b) F – Fire; c) C – Combustible Concentrations (if applicable to technology); d) R – Rupture (enclosure); e) L – Electrolyte Leakage (external to enclosure); f) V– Venting; g) S – Electric shock hazard (resistance below isolation resistance limits or dielectric breakdown); h) P – Loss of protection controls.		P
28	**Dielectric Voltage Withstand Test**	No hazardous voltage circuits within the DUT.	N/A
28.1	This test is an evaluation of the electrical spacings and insulation at hazardous voltage circuits within the DUT.		N/A
28.2	Circuits at 60 Vdc or higher shall be subjected to a dielectric withstand voltage consisting of a dc potential of twice the rated voltage times 1.414. *Exception No. 1: An essentially sinusoidal ac potential of 60 Hz at twice rated voltage may be applied instead of the dc potential.* *Exception No. 2: For those circuits connected to an ac mains supply, the test voltage shall be an essentially ac potential of 60 Hz at 1,000 V plus twice the rated voltage. If using a dc potential, the test*		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
	voltage shall be 1.414 time the ac test potential value of 1,000 V plus twice the rated voltage. *Exception No. 3: Semiconductors or similar electronic components liable to be damaged by application of the test voltage may be bypassed or disconnected.*		
28.3	The test voltage is to be applied between the hazardous voltage circuits of the DUT and non-current carrying conductive parts that may be accessible.		N/A
28.4	The test voltage is also to be applied between the hazardous voltage charging circuit and the enclosure/accessible non-current carrying conductive parts of the DUT.		N/A
28.5	If the accessible parts of the DUT are covered with insulating material that may become live in the event of an insulation fault, then the test voltages are applied between each of the live parts and metal foil in contact with the accessible parts. The metal foil shall be wrapped tightly around and in intimate contact with the accessible part. The foil is to be drawn tightly across any opening in the enclosure or other accessible parts to form a flat plane across such opening. See Figure 28.1.		N/A
28.6	The test voltages shall be applied for a minimum of 1 min with the cells/modules disconnected to prevent charging during application of the voltage.		N/A
28.7	The test equipment shall consist of a 500 VA or larger capacity transformer, the output voltage, which is variable and which is essentially sinusoidal if using ac test method a dc output if using a dc test method. There is no trip current setting for the test equipment since the test is checking for insulation breakdown, which results in a large increase of current. Setting a trip current may result in a false failure of this test, as it may not be indicative of insulation breakdown. *Exception: A 500 VA or larger capacity transformer need not be used if the transformer is provided with a voltmeter that directly measures the applied output potential.*		N/A
28.8	There shall be no evidence of a dielectric breakdown (breakdown of insulation resulting in a short through insulation/arcing over electrical spacings) as evidenced by an appropriate signal from the dielectric withstand test equipment as a result of the applied test voltage. Corona discharge or a single momentary discharge is not regarded as a dielectric breakdown (i.e. insulation breakdown).		N/A
29	**Isolation Resistance Test**		N/A
29.1	Isolation resistance method for systems rated 120 V and above	Below 60V.	N/A

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Clause	Requirement + Test	Result - Remark	Verdict
29.1.1	This test is intended to determine that insulation provides adequate isolation of hazardous voltage circuits from accessible conductive parts of the DUT and that the insulation is non-hygroscopic.		N/A
29.1.2	The electric energy storage assembly shall be subjected to Isolation resistance test of Clause 6.1.3 of the Standard for Electrically Propelled Road Vehicles – Safety Specifications – Part 1: On-board Rechargeable Energy Storage System (RESS), ISO 6469-1, with the following exceptions in (a) and (b). The DUT is to be in the fully charged state for both (a) and (b): a) Testing is to be conducted with the DUT in the as-received condition (i.e. no humidity conditioning prior to measurements); and b) Testing is to be conducted after conditioning the DUT in accordance with the Standard for Environmental Testing – Part 2-30: Tests – Test Db: Damp Heat, Cyclic (12 h + 12 h Cycle), IEC 60068-2-30 using the following parameters: 1) Variant 1; 2) At maximum temperature of 55±2°C (131±3°F); and 3) 6 cycles.		N/A
29.1.3	For condition 29.1.2(b), the DUT shall be placed within the chamber so that it is oriented in the manner in which it will be installed in the vehicle. Upon completion of the 6th cycle the sample shall be subjected to a controlled recovery in accordance with Recovery, Clause 9, of the Standard for Environmental Testing – Part 2-30: Tests – Test Db: Damp Heat, Cyclic (12 h + 12 h Cycle), IEC 60068-2-30. The isolation resistance measurements shall be made within 30 min of completion of the controlled recovery phase.		N/A
29.1.4	For both (a) and (b) of 29.1.2, the isolation resistance divided by the maximum working voltage of the circuit under test, shall be at least 100 Ω/V for dc systems and 500 Ω/V for ac systems or combined ac and dc systems.		N/A
29.2	Isolation resistance method for systems rated below 120 V (insulation resistance method)	Below 60V.	N/A
29.2.1	This test is intended to determine that insulation of the DUT provides adequate isolation of hazardous voltage circuits from accessible conductive parts of the DUT and that the insulation is non-hygroscopic.	No hazardous voltage circuits within the DUT.	N/A
29.2.2	A DUT with accessible parts shall be subjected to an insulation resistance test between the positive terminal and accessible dead metal parts of a DUT. If the accessible parts of the DUT are covered with insulating material that may become live in the event		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
	of an insulation fault, then the test voltages are applied between each of the live parts and metal foil in contact with the accessible parts as shown in 28.5 and Figure 28.1.		
29.2.3	The insulation resistance shall be measured after a 60-s application with a high resistance voltmeter using a 500 Vdc potential applied for at least 1 min to the locations under test.		N/A
29.2.4	The test shall be repeated on a sample subjected to humidity conditioning in accordance with the Standard for Information Technology Equipment Safety – Part 1: General Requirements, CAN/CSA-C22.2 No. 60950-1 / UL 60950-1, Clause 2.9.2. Measurements shall be made with the sample still in the chamber.		N/A
29.2.5	The measured insulation resistance between the positive terminals and accessible parts of the DUT shall be at least 50,000Ω.		N/A
MECHANICAL TESTS			
30	**Vibration Endurance Test**		P
30.1	This test evaluates the DUT's ability to withstand vibration that may occur from its use in an LEV. The test shall be performed in accordance with the Standard for Electrically Propelled Road Vehicles – Test Specification for Lithium-Ion Traction Battery Packs and Systems – Part 1: High-Power Applications, ISO 12405-1, or in accordance with a test profile specified by the manufacturer and verified to the LEV application. *Exception: The test is to be carried out at room ambient without temperature variation.*	See table 30 for details.	P
30.2	The DUT shall be securely mounted to a vibration test platform in a manner similar to how it is mounted in the end use LEV. The DUT shall be subjected to a random vibration sequentially along three perpendicular axes as defined in Table 30.1.		P
30.3	The DUT shall be subjected to the vibration in each axis for 21 h if testing one sample, 15 h is testing two samples or 12 h if testing 3 samples. For each axis the frequency shall be varied from 5 Hz to 200 Hz with power spectral density (PSD) as outlined in the Table 30.1.	1 sample, 21 hours.	P
30.4	If the DUT is operational after the test, it shall be subjected to a minimum of one charge/discharge cycle at the manufacturer's maximum specified values. The test shall be followed by an observation period per 18.7.		P
30.5	At the conclusion of the observation period, the samples with hazardous voltage circuits shall be		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
	subjected to a Dielectric Voltage Withstand Test or Isolation Resistance Test (without humidity conditioning).		
30.6	As a result of the vibration endurance test, any of the following results in (a) – (g) below are considered a non-compliant result. See also Table 21.1 and Section 22. a) E – Explosion; b) F – Fire; c) C – Combustible Concentrations (if applicable to technology); d) R – Rupture (enclosure); e) L – Electrolyte Leakage (external to enclosure); f) S – Electric shock hazard (resistance below isolation resistance limits or dielectric breakdown); g) P – Loss of protection controls.		P
31	**Shock Test**		P
31.1	This test is intended to determine whether or not the DUT can withstand a mechanical shock that may occur when in use in an LEV.	See table 31 for details.	P
31.2	The fully charged sample is to be secured to the testing machine by means of a rigid mount, which supports all mounting surfaces of the sample. Temperatures on the center cell are monitored for information purposes. *Exception: For the test, the DUT may be mounted in a fixture representative of the mounting means used in the end use vehicle.*		P
31.3	The sample is to be subjected to mechanical shock testing with parameters as shown in Table 31.1 or according to a test profile determined by the customer and verified to the LEV application. The shocks are to be applied in all 6 spatial directions for prismatic DUT and 3 spatial directions for cylindrical DUT.		P
31.4	During the test the OCV of the sample and temperatures on the center cell(s/modules) may be monitored for information purposes.		P
31.5	If the DUT is operational after the test, it shall be subjected to a minimum of one charge/discharge cycle at the manufacturer's maximum specified values. The test shall be followed by an observation period per 18.7.		P
31.6	At the conclusion of the observation period, the samples with hazardous voltage circuits shall be subjected to a Dielectric Voltage Withstand Test or Isolation Resistance Test (without humidity conditioning).	Without hazardous voltage circuits.	N/A

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Clause	Requirement + Test	Result - Remark	Verdict
31.7	As a result of the shock test, any of the following results in (a) – (g) below are considered a non-compliant result. See also Table 3 and Section 22. a) E – Explosion; b) F – Fire; c) C – Combustible Concentrations (if applicable to technology); d) R – Rupture (enclosure); e) L – Electrolyte Leakage (external to enclosure); f) S – Electric shock hazard (resistance below isolation resistance limits or dielectric breakdown); g) P – Loss of protection controls.		P
32	**Crush Test**		N/A
32.1	This test is conducted to determine the DUT's ability to withstand a crush that could occur during a vehicle accident. This test is only applicable to on road LEVs such as scooters and motorcycles that could be involved in a vehicle crash.	Off road LEVs.	N/A
32.2	This test is conducted on a fully charged DUT.		N/A
32.3	A sample shall be crushed between a fixed surface and a ribbed test platen. The platen shall have semi-cylindrical intruders that have a 75-mm (2.95-in) radius and placed 30-mm (1.2-in) from one another across the face of the platen as shown in Figure 32.1.		N/A
32.4	The sample is to be subjected to a crushing force that deforms the DUT by 50% but no greater force than 1,000 times weight of the DUT or 100 kN, whichever comes first. The crushing force is to be applied at a rate of approximately 1.5 cm/s upon first contact with the sample. The crush is to be applied in each of 3 mutually perpendicular directions with the ribs centered on the sample in each direction of press. *Exception No. 1: DUTs with only 2 axes of symmetry, such as cylindrical designs are subjected to mutually perpendicular directions of press.* *Exception No. 2: The DUT may be installed in a protective framework representative of what is provided in the vehicle.*		N/A
32.5	Each sample shall only subject to one crush. The force shall be increase from zero to a maximum force value (i.e. 1,000 times the weight of the DUT or 100 kN) or when the maximum of 50% deformation is achieved, whichever comes first and then it is removed. Monitoring for information purposes per 18.6 should be conducted during the test.		N/A
32.6	At the conclusion of the observation period, the samples are examined for electrolyte leakage and samples with hazardous voltage circuits shall be subjected to a Dielectric Voltage Withstand Test or		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
	Isolation Resistance Test (without humidity conditioning).		
32.7	As a result of the crush test, any of the following results in (a) and (e) below are considered non-compliant results. See also Table 21.1 and Section 22. a) E – Explosion; b) F – Fire; c) C – Combustible Concentrations (if applicable to technology); d) L – Electrolyte Leakage (external to enclosure); e) S – Electric shock hazard (resistance below isolation resistance limits or dielectric breakdown);		N/A
33	**Drop Test**		P
33.1	**Drop test for EESAs intended to be removable by the user**	Not intended to be removable by the user	N/A
33.1.1	This test is intended to evaluate whether a hazard exists when a DUT is subjected to an inadvertent drop during lifting or handling by the user when charging or replacement, etc.		N/A
33.1.2	A fully charged DUT is to be dropped three times from a height of 1.0 ±0.01 m (39.4 ±0.4 in) to strike a flat concrete surface in a manner most representative of what would occur during lifting or handling of the DUT by the user. The concrete surface shall be at least 76-mm (3-in) thick and shall be large enough in area to cover the DUT. If the DUT is operational after the drop, it is to be subject to a minimum of one normal charge/discharge cycle in accordance with the manufacturer's specifications. The DUT shall be subjected to an observation period per 18.7 and then examined. Monitoring for information purposes per 18.6 should be conducted during the test. *Exception: DUTs employing plastic enclosures that are intended for use in 0°C (32°F) temperatures shall be conditioned for a minimum of 3 h at 0°C (32°F) [or temperature specified if lower than 0°C (32°F)] prior to conducting the drop test, which shall be conducted immediately after removing the samples from the cold conditioning.*		N/A
33.1.3	If the DUT is operational after the test, it shall be subjected to a minimum of one charge/discharge cycle at the manufacturer's maximum specified values. The test shall be followed by an observation period per 18.7.		N/A
33.1.4	After the examination, the DUTs shall be subjected to a Dielectric Voltage Withstand Test or Isolation Resistance Test (without humidity conditioning) if applicable.		N/A
33.1.5	There shall be no damage of the enclosure that would allow hazardous voltage parts to be accessed by use		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
	of the articulate test finger shown in Figure 9.1 and test pin shown in Figure 10.1.		
33.1.6	As a result of the drop test, any of the following results in (a) – (g) below are considered non-compliant. See also Table 21.1 and Section 22. a) E – Explosion; b) F – Fire; c) C – Combustible Concentrations (if applicable to technology); d) R – Rupture (enclosure); e) L – Electrolyte Leakage (external to enclosure); f) S – Electric shock hazard (resistance below isolation resistance limits or dielectric breakdown); g) P – Loss of protection controls.		N/A
33.2	**Drop test for EESAs intended for service handling only**		P
33.2.1	This test is intended to evaluate whether a hazard exists when a DUT is subjected to an inadvertent drop during installation or removal from the vehicle.		P
33.2.2	After being equilibrated at room temperature, a fully charged DUT is to be dropped from a minimum height of 1.0 m (3.3 ft) to strike a flat concrete surface in the position most likely to produce the adverse results and in a manner and height most representative of what would occur during maintenance and handling/removal of the DUT during servicing.		P
33.2.3	If only one drop test is performed, it shall not be a flat drop, and if one drop test is a flat drop, then at least one other test shall be performed that is not a flat drop.		N/A
33.2.4	The DUT is to be dropped a minimum of one time.		P
33.2.5	The concrete surface is to be at least 76-mm (3-in) thick and shall be large enough in area to cover the DUT.		P
33.2.6	The DUT shall be examined within a time frame of 6 – 24h after dropping. During the test, temperatures shall be monitored. If the DUT returns to or remains near ambient, a Dielectric Voltage Withstand Test or Isolation Resistance Test (without humidity conditioning) is to be conducted.		P
33.2.7	As a result of the drop test, any of the following results in (a) – (e) are considered non-compliant. See also Table 21.1 and Section 22. a) E – Explosion; b) F – Fire; c) C – Combustible Concentrations (if applicable to technology); d) L – Electrolyte Leakage (external to enclosure);		P

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Clause	Requirement + Test	Result - Remark	Verdict
	e) S – Electric shock hazard (resistance below isolation resistance limits or dielectric breakdown)		
34	**Mold Stress Relief Test**		P
34.1	This test is intended to evaluate whether any shrinkage or distortion exist on a molded or formed thermoplastic enclosure due to release of internal stresses caused by the molding or forming operation and result in the exposure of hazardous parts or reduction of electrical spacings.		P
34.2	The sample is to be placed in a full-draft circulating-air oven maintained at a uniform temperature of 70°C (158°F). The samples are to remain in the oven for 7 h. *Exception: If the maximum temperature, T, recorded on the DUT thermoplastic enclosure parts, obtained during the normal temperature test of Section 26 exceeds 60°C (140°F), then the oven temperature is to be maintained at a temperature equal to T +10°C (18°F).*	70°C, 7hours	P
34.3	To prevent hazards from overheating energized cells, samples shall be fully discharged prior to conditioning.		P
34.4	After careful removal from the oven, the sample shall be allowed to cool to room temperature and then examined. After the examination, the samples shall be subjected to a Dielectric Voltage Withstand Test or Isolation Resistance Test (without humidity conditioning).		N/A
34.5	There shall be no insulation breakdown during the Dielectric Voltage Withstand Test or the isolation resistance shall not be below the levels outlined in Section 29.	No hazardous voltage circuits within the DUT. Dielectric Voltage Withstand Test or Isolation Resistance Test no need to conduct.	N/A
34.6	There shall be no damage of the DUT enclosure that would allow hazardous voltage parts to be accessed by use of the articulate test finger shown in Figure 9.1 and the test pin shown in Figure 10.1.		P
35	**Handle Loading Test**		P
35.1	This test is intended to evaluate the strength of the handle(s) on a user removable EESA.		P
35.2	A force is to be applied on the handle in the intended carrying direction uniformly over a 75-mm (2.95-in) length at the center of the handle. The applied force shall be gradually increased from zero to four times the weight of the DUT in 5 – 10 s and then maintained at the level for 1 min.		P
35.3	If more than one handle is provided, the test force shall be determined by the percentage of the DUT weight sustained by each handle with the DUT in the intended carrying position. If a DUT weighing less		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
	than 25 kg (55.1 lbs) is provided with more than one handle and can be carried by only one handle, each handle shall be capable of withstanding a force based on the total weight of the DUT.		
35.4	There shall be no breakage of the handle, its securing means, or that part of the DUT to which the handle is attached.		P
36	**Roll Over Test**		P
36.1	This test is to evaluate whether or not a rotation of an EESA as might occur within an LEV that is turned over could lead to a hazardous condition. A sample of the electric energy storage assembly shall be subjected to a 360° rotation to simulate an overturned vehicle. *Exception: The sample may be mounted within a mounting fixture representative of the intended end use vehicle application.*		P
36.2	The fully charged sample shall be rotated at a continuous rate of 90°/15 s. Testing shall be conducted subjecting the sample to a 360° rotation in 3 mutually perpendicular different directions. DUTs with only 2 axes of symmetry, such as cylindrical designs are subjected to 2 mutually perpendicular directions of rotation. Monitoring for information purposes per 18.6 should be conducted during the test.		P
36.3	If the DUT is operational after the test, it shall be subjected to a minimum of one charge/discharge cycle at the manufacturer's maximum specified values. The test shall be followed by an observation period per 18.7.		P
36.4	At the conclusion of the observation period, the samples with hazardous voltage circuits shall be subjected to a Dielectric Voltage Withstand Test or Isolation Resistance Test (without humidity conditioning).	No hazardous voltage circuits within the DUT.	N/A
36.5	As a result of the roll over test, any of the following results in (a) – (g) below are considered non-compliant. See also Table 21.1 and Section 22. a) E – Explosion; b) F – Fire; c) C – Combustible Concentrations (if applicable to technology); d) R – Rupture (enclosure); e) L – Electrolyte Leakage (external to enclosure); f) S – Electric shock hazard (resistance below isolation resistance limits or dielectric breakdown); g) P – Loss of protection controls.		P
37	**Strain Relief Tests (Cord Anchorages)**		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
37.1	General		N/A
37.1.1	The strain relief tests are conducted on those EESAs that have exposed non-detachable cords or cables that may be subjected to pull in the end use vehicle.		N/A
37.2	Strain relief pull test		N/A
37.2.1	The purpose of this test is to determine if the strain relief means for a non-detachable accessible cord prevents damage or displacement upon being pulled.		N/A
37.2.2	One sample of the EESA or accessory provided with a strain relief shall withstand without damage to the cord or conductors and without displacement, a direct pull of 2 times the weight of the DUT but no greater than 156 N (35 lbf), applied to the cord for 1 min. Supply connections within the equipment are to be disconnected from terminals or splices during the test when applicable.		N/A
37.2.3	If the cord anchorage is mounted in polymeric enclosure material, the test is to be conducted after the mold stress test and after the sample has cooled to room temperature.		N/A
37.2.4	As a result of the pull force, there was no damage or displacement of internal connectors. Inner conductors may not elongate more than 2 mm (0.08 in) from the pre-test position.		N/A
37.3	Push-back test		N/A
37.3.1	The purpose of this test is to determine if the strain relief of a non-detachable accessible cord provides adequate protection to connections and prevents hazardous displacement of internal wiring and connections as a result of push back.		N/A
37.3.2	The DUT is to be tested in accordance with 37.3.3 and 37.3.4 without occurrence of any of the following conditions: a) Subjecting the supply cord to mechanical damage; b) Exposing the supply cord to a temperature higher than that for which it is rated; c) Reducing spacings (such as to a metal strain-relief clamp) below the minimum required values; or d) Damaging internal connections or components.		N/A
37.3.3	The non-detachable cord is to be held 25.4 mm (1 in) from the point where it emerges from the DUT and is then to be pushed back into the DUT. When a removable bushing, which extends further than 25.4 mm (1 in) is present it is to be removed prior to the test.		N/A
37.3.4	When the bushing is an integral part of the cord, then the test is to be carried out by holding the bushing. The cord is to be pushed back into the product in 25.4-mm (1-in) increments until the cord buckles or		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
	the force to push the cord into the product exceeds 26.7 N (6 lbf).		
37.3.5	The cord is to be manipulated to determine compliance with 37.3.2.		N/A
ENVIRONMENTAL TESTS			
38	**Immersion Test**		P
38.1	This test is intended for those electric energy storage assemblies that may be subjected to potential immersion in the LEV application. (i.e. underbody location). This test is conducted on a fully charged (i.e. MOSOC) DUT and is intended to determine its resistance to a hazardous condition as a result of a temporary immersion in water from flooding of a vehicle.		P
38.2	While the DUT is in its normal operating orientation and with switches/contactors in closed position, it shall be subjected to an immersion. The DUT is to be immersed in salt water (5% by weight NaCl in H_2O) at room temperature for a minimum of 2 h or until any visible reactions have stopped. The water depth is to be sufficient to completely submerge the DUT. *Exception: Testing may be conducted at the module level that is representative of the energy storage assembly.*		P
38.3	After removal from the water, the DUTs with hazardous voltage circuits shall be subjected to a Dielectric Voltage Withstand Test or Isolation Resistance Test (without humidity conditioning).	No hazardous voltage circuits within the DUT. Dielectric Voltage Withstand Test or Isolation Resistance Test no need to conduct.	N/A
38.4	As a result of the water immersion test, any of the following results in (a) – (c) below are considered a non-compliant result. See also Table 21.1 and Section 22. a) E – Explosion; b) F – Fire; c) S – Electric shock hazard (resistance below isolation resistance limits or dielectric breakdown);		P
39	**Water Exposure Test (IP Code Rating)**		P
39.1	This test is intended to evaluate the EESA's ability to withstand potential water exposure in its intended use such as cleaning, outdoor storage or use, etc., and is conducted in accordance with the test method outlined in 39.2.		P
39.2	A fully charged DUT (i.e. MOSOC) shall be subjected to a water exposure test in accordance with the Standard for Degrees of Protection Provided by Enclosures (IP Code), IEC 60529, Tests for protection against water indicated by the second characteristic numeral 3 (IPX3) unless the EESA is provided with a higher IP Code rating, in which case	Comply with IPX3 test.	P

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Clause	Requirement + Test	Result - Remark	Verdict
	the DUT shall be tested in accordance with its rating. Monitoring for information purposes per 18.6 should be conducted during the test.		
39.3	If the DUT is operational after the test, it shall be subjected to a minimum of one charge/discharge cycle at the manufacturer's maximum specified values. The test shall be followed by an observation period per 18.7.		P
39.4	At the conclusion of the observation period, the samples with hazardous voltage circuits shall be subjected to a Dielectric Voltage Withstand Test or Isolation Resistance Test (without humidity conditioning).	No hazardous voltage circuits within the DUT. Dielectric Voltage Withstand Test or Isolation Resistance Test no need to conduct.	N/A
39.5	As a result of the water exposure test, any of the following results in (a) – (g) below are considereda non-compliant result. See also Table 21.1 and Section 22. a) E – Explosion; b) F – Fire; c) C – Combustible Concentrations (if applicable to technology); d) R – Rupture (enclosure); e) L – Electrolyte Leakage (external to enclosure); f) S – Electric shock hazard (resistance below isolation resistance limits or dielectric breakdown); g) P – Loss of protection controls.		P
40	**Thermal Cycling Test**		P
40.1	This test determines the electrical EESA's ability to withstand exposure to rapidly changing environments such as when the vehicle is entering or exiting a heated garage after being in a cold environment, or during transport etc. without evidence of damage that could lead to a hazardous event.		P
40.2	A fully charged DUT (i.e. MOSOC) shall be subjected to the thermal shock test of the Standard for Electric and Hybrid Electric Vehicle Rechargeable Energy Storage System (RESS) Safety and Abuse Testing, SAE J2464, except that the temperature extremes are from 85 ±2°C to −40 ±2°C (185 ±3.6°F to −40 ±3.6°F). Monitoring for information purposes per 18.6 should be conducted during the test. *Exception: Testing may be conducted at the module level that is representative of the energy storage assembly.*		P
40.3	If the DUT is operational after the test, it shall be allowed to return to room ambient and then subjected to a minimum of one charge/discharge cycle at the manufacturer's maximum specified values. The test shall be followed by an observation period per 18.7.		P

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Clause	Requirement + Test	Result - Remark	Verdict
40.4	At the conclusion of the observation period, the samples with hazardous voltage circuits shall be subjected to a Dielectric Voltage Withstand Test or Isolation Resistance Test (without humidity conditioning).	No hazardous voltage circuits within the DUT. Dielectric Voltage Withstand Test or Isolation Resistance Test no need to conduct.	N/A
40.5	As a result of the thermal cycling test, any of the following results in (a) – (g) below considered a non-compliant result. See also Table 21.1 and Section 22. a) E – Explosion; b) F – Fire; c) C – Combustible Concentrations (if applicable to technology); d) R – Rupture (enclosure); e) L – Electrolyte Leakage (external to enclosure); f) S – Electric shock hazard (resistance below isolation resistance limits or dielectric breakdown); g) P – Loss of protection controls.		P
41	Label Permanence Test		P
41.1	The purpose of this test is to evaluate the permanence of an adhesive label that has not been subjected to a previous evaluation program.		P
41.2	An adhesive label secured to a surface representative of the end use application and is subjected to the following conditioning: a) The label sample is rubbed by hand for 15 s with a piece of cloth soaked with water; and b) The sample is again rubbed for 15 s with a piece of cloth soaked with petroleum spirit.		P
41.3	The petroleum spirit to be used for the test is an aliphatic solvent hexane having: a) A maximum aromatics content of 0.1% by volume; b) A kauributenol value of 29; c) An initial boiling point of approximately 65°C (149°F); d) A dry point of approximately 69°C (156.2°F); and e) A mass per unit volume of approximately 0.7 kg/l. *Exception: As an alternative, it is permitted to use a reagent grade hexane with a minimum of 85% as n-hexane.*		P
41.4	After the conditioning outlined in 41.2, the sample is to be examined for signs of damage including curing and to determine if the marking is still legible. The sample is also examined to determine if it can be removed by easily by hand from the surface the adhered surface.		P
41.5	As a result of the conditioning, the sample label shall remain legible, show no evidence of damage including curling and shall not be able to be able to be		P

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Clause	Requirement + Test	Result - Remark	Verdict
	easily removed by hand from the adhered surface.		
MARKINGS			
42	**General**		P
42.1	The markings required for compliance to this standard shall be legible and permanent such as etched, adhesive labels, etc. An adhesive-backed label shall comply with the requirements in the Standard for Marking and Labeling Systems, UL 969, for the intended exposure conditions and surface adhered to. *Exception: Adhesive labels may be alternately evaluated to the Label Permanence Test in Section 41.*	See clause 41.	P
42.2	EESAs are to be marked with the manufacturer's name, trade name, trademark or other descriptive marking which may identify the organization responsible for the product, part number or model number, and electrical ratings in volts dc and Ah or Wh, and chemistry.		P
42.3	Terminals shall be marked "positive" or "+" and "negative" or "−" or both to indicate polarity unless the terminal is keyed in a manner that prevents incorrect connections in the end use vehicle.	The terminal is keyed in a manner that prevents incorrect connections in the end use vehicle.	N/A
42.4	EESAs shall also be marked with the date of manufacture, which may be in the form of a code that does not repeat within 10 years.		P
42.5	EESAs shall be marked with charging instructions. An example of such markings would be the following or equivalent "Use Only (__) Charger". The marking shall be visible to the user, including after installation, if the EESA is not removed for charging. If applicable, the installation instructions shall indicate the need to include this charging marking on the external surface of the vehicle near the exposed charging connection. See 43.3. Additional markings are not required on the EESAs if the charger plugs and receptacles are uniquely keyed, and for vehicles that use communications between vehicle and charger or other methods to prevent charging by non-approved chargers.		P
42.6	All external terminals and connections shall be provided with identification and if applicable, polarity markings.		P
42.7	The point of connection to the charger earth grounding system shall be identified by the word "Ground" or the letters "G" or "GR" or the grounding symbol IEC 60417, No. 5019 (upside down tree within a circle) or otherwise identified by a distinctive green color. Any other grounding terminals shall also be identified in a manner that is distinctive from the main earth ground terminal for the charger system.	No earth grounding.	N/A

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Clause	Requirement + Test	Result - Remark	Verdict
42.8	The EESA that contains hazardous voltage circuits shall be marked with the following or be marked with the electric shock hazard symbol ISO 3864 No. 5036 (lightning bolt within a triangle). In Canada: In English: “Warning: Hazardous Voltage Circuits”; and In French: «Attention: Circuits à tension élevée» In the United States: In English: “Warning: Hazardous Voltage Circuits”.	No hazardous voltage circuits within the DUT.	N/A
42.9	EESAs shall be marked as follows or with the sign M002 of the Standard for Graphical Symbols Safety Colours and Safety Signs, Safety Signs Used in Workplaces and Public Area, ISO 7010, No. W001 (i.e., exclamation point in triangle). In Canada: In English: “WARNING – To reduce the risk of injury, user must read instruction Manual”; and In French: «AVERTISSEMENT – Pour prévenir les blessures, l’utilisateur doit lire le manuel d’utilisation» In the United States: In English: “WARNING – To reduce the risk of injury, user must read instruction manual”.		P
42.10	An EESA may or may not be marked with the minimum required IPX3 rating. EESAs marked with a higher IP rating than the minimally required rating of IPX3, shall comply with the requirements for that higher rating in accordance with Section 39.		N/A
INSTRUCTIONS			
43	**General**		P
43.1	An EESA shall be provided with complete instructions for installation and integration in the end use vehicle including instructions for how to secure the EESA in the end use vehicle to prevent movement and stress on connections and parts.	Provided in the instructions.	P
43.2	An EESA shall be provided with instructions for the proper use including charging and discharging, storage and disposal. These instructions shall include temperature limits, charging and discharging limits. Instructions for replacement of user replaceable fuses shall also be provided.	Provided in the instructions.	P
43.3	For EESAs that are not removed from the vehicle for charging and are intended to be used with a specific charger per 42.5, installation instructions shall indicate that a marking per 42.5 be located near the accessible charging port of the vehicle where the marking will be visible to the user charging the vehicle.		N/A

UL 2271			
Clause	Requirement + Test	Result - Remark	Verdict
43.4	An EESA intended for removal and charging outside of the vehicle shall be provided with instructions for the safe handling including removal and insertion into the vehicle and during charging and instructions for storage of fully charged EESA.		P
43.5	The following or equivalent marking shall be provided in the instructions: In Canada: In English: “WARNING – Risk of Fire and Electric Shock – No User Serviceable Parts”; and In French: «AVERTISSEMENT– Risque d’incendie et de choc électrique – Aucune des pièces ne peut être réparée par l’utilisateur» In the United States: In English: “WARNING – Risk of Fire and Electric Shock – No User Serviceable Parts”. *Exception No. 1: If EESA does not contain circuits above 60 Vdc or 30 Vrms/4.24 Vpeak, the instructions shall be replaced by the following or equivalent:* *In Canada:* *In English: “WARNING – Risk of Fire – No User Serviceable Parts”; and* *In French: «AVERTISSEMENT – Risque d’incendie – Aucune des pièces ne peut être réparée par l’utilisateur»* *In the United States:* *In English: “WARNING – Risk of Fire – No User Serviceable Parts”.* *Exception No. 2: Accessible fuse replacement or equivalent is allowed to be user replaced.*	Provided in the instructions.	P

UL 2271			
Clause	Requirement + Test	Result - Remark	Verdict

2.1	TABLE: Critical components information				P
Object/part no.	**Manufacturer/ trademark**	**Type/model**	**Technical data**	**Standard**	**Mark(s) of conformity[1)]**
Cell	SAMSUNG SDI CO LTD	INR21700-50G	3.63Vdc, 4900mAh	UL 2580 CAN/ULC-2580	MH62891
PCB	SHEN ZHEN TIE FA TECHNOLOGY LTD	TF-M	V-0, 130°C Min. thickness 0.6mm	UL 796 UL 94	E346897
Alt.	Interchangeable	Interchangeable	V-0, 130°C Min. thickness 0.6mm	UL 796 UL 94	UL approved
Protection IC (U4)	TI	BQ76952	Operating voltage: 4.7~85V Operation temperature range: -40 °C to +85 °C	--	Tested with appliance
MOSFET Discharge(Q3,Q6,Q8)	NCEPOWER	NCEP018N85LL	VDS=85V, VGS=±20V, ID =320A(TC=25°C), TJ, TSTG: -55 to 175°C	--	Tested with appliance
MOSFET charge (Q5,Q7,Q9)	NCEPOWER	NCEP018N85LL	VDS=85V, VGS=±20V, ID =320A(TC=25°C), TJ, TSTG: -55 to 175°C	--	Tested with appliance
MCU(U8)	GigaDevice	GD32F303C	Operation temperature range: -40 °C to +85 °C	--	Tested with appliance
Fuse(F1)	CYG Wayon Electronics Co., Ltd.	WPF45A10K-3P	Rated current: 45A, Operating voltage: 36-62V Operation temperature range:-25°C ~85°C	UL 248-1, UL 248-14	E311435
NTC (NTC1)	Murata	NCP18XH103F03RB	Resistance 10k Ohms at 25deg. C Resistance Tolerance+ / -1% B Value3380K at 25/50 deg. C B Value Tolerance+ /-1%	UL 1434	E137188

UL 2271					
Clause	Requirement + Test		Result - Remark		Verdict
			Operate temperature: -40°C ~125°C		
For VK-48V30Ah-A-13S6P					
Metal enclosure	Kunshan Shuo YiRui Intelligent Technology Co .,Ltd	SYRB207076-L390	6063, Aluminium Min. thickness 1.8mm	--	Test with applicance
Plastic enclosure	LG CHEM LTD	LUPOY GN5001RF(T)	PC+ABS thickness：min.1.5mm V-0, 80°C	UL746C	E67171
PVC	SHENZHEN GOLDEN OCEAN INDUSTRIAL DEVELOPMENT CO LTD	10-1000 PVC	600V, 105°C, Min. thickness:0.15mm V-0, 105°C	UL 224	E513299
Alt.	Interchangeable	Interchangeable	600V, 105°C, Min. thickness:0.15mm V-0, 105°C	UL 224	UL approved
Cell holder	FORMOSA CHEMICALS & FIBRE CORP PLASTICS DIV	AC310(+)	Material: PC+ABS, Min. thickness: 1.1mm, V-0, RTI 85°C	AC310(+)	E162823
Charge wires	DONGGUAN ZHONGZHEN NEW ENERGY TECHNOLOGY CO.,LTD	UL3135	200°C，20 AWG，600Vac	UL758	E355578
Alt.	Interchangeable	Interchangeable	200°C，20 AWG，600Vac	UL758	UL approved
Charge port	Hu Yi Te (Kunshan) Precision Electronics Co., Ltd.	311CM	42Vd.c, 5A	--	Tested with appliance
Plastic of charge port	SuZhou Hegengli Plastics Technology Co., Ltd.	PA66 A2G5	PA66+30%GF, UL94 V-0, 110°C	UL94	E480692
Plastic of discharge port	CHANG CHUN CHEMICAL(JIANGSU) CO LTD	4130-(Z)X	PBT Min. thickness:0.75mm V-0 140°C	IEC60695	E345326
For VK-48V15Ah-13S3P					
PVC	SHENZHEN GOLDEN OCEAN	10-1000 PVC	600V, 105°C,	UL 224	E513299

UL 2271					
Clause	Requirement + Test		Result - Remark		Verdict
	INDUSTRIAL DEVELOPMENT CO LTD		Min. thickness:0.15mm V-0, 105°C		
Alt.	Interchangeable	Interchangeable	600V, 105°C, Min. thickness:0.15mm V-0, 105°C	UL 224	UL approved
Charge wires	DONGGUAN ZHONGZHEN NEW ENERGY TECHNOLOGY CO.,LTD	1007	200°C， 20 AWG， 600Vac	UL758	E355578
Alt.	Interchangeable	Interchangeable	200°C， 20 AWG， 600Vac	UL758	UL approved
Metal enclosure	Kunshan Reention Electrical and Mechanical Co., Ltd	6063-T5	6063-T5, Aluminium Min. thickness 2,0mm	--	Tested with appliance
Plastic enclosure	FORMOSA CHEMICALS&FIBER CORP PLASTIC	AC3108	PC/ABS, V-0, 105°C, Min. thickness: 1,5 mm	UL746C	E162823
Cell holder	KINGFA SCI&TECH CO LTD	JH850	JH850 V-0, 60°C, Min. thickness: 2.5 mm	UL94	E171666
Charge port	Hu Yi Te (Kunshan) Precision Electronics Co., Ltd.	311CM	42Vd.c, 5A	--	Tested with appliance
Plastic of charge port	SuZhou Hegengli Plastics Technology Co., Ltd.	PA66 A2G5	PA66+30%GF, UL94 V-0, 140°C	UL94	E480692
Discharge port	Kunshan Reention Electrical and Mechanical Co., Ltd	6PIN	48V, 20A	--	Tested with appliance
Supplementary information: [1)] Components shall comply with all the applicable CSA Group and UL component standards.					

UL 2271			
Clause	Requirement + Test	Result - Remark	Verdict

23	TABLE: Overcharge Test		P
Sample No.		A004213493-001 (VK-48V15Ah-13S3P)	A004213493-014 (VK-48V30Ah-A-13S6P)
OCV before test (V)		41.90	41.90
Charge current (A)		5A	5A
Charge voltage (V)		60.06V	60.06V
OCV after test (V)		56.0	56.0
Device single faulted		Short circuit MOSFET (Q5) PIN S-D	Short circuit MOSFET (Q5) PIN S-D
Max Temperature (°C)			
Max temperature of cells		31.1	29.7
Ambient temperature		28.7	28.0
The DUT was operational after the test, it was subjected to a minimum of one charge/discharge cycle at the manufacturer's maximum specified values. Y or N?		☒Yes ☐No	☒Yes ☐No

24	TABLE: Short Circuit Test				P
Sample No.		A004213493-014 (VK-48V15Ah-13S3P)	A004213493-0015 (VK-48V30Ah-A-13S6P)	--	--
OCV before test (V)		53.5	53.4	--	--
Discharge current (A)		31.5	31.5	--	--
OCV after test (V)		39.24	39.77	--	--
Resistance of conductor (mΩ)		16.53	16.74	--	--
Device single faulted		short circuit MOSFET (Q3) PIN S-D	short circuit MOSFET (Q3) PIN S-D	--	--
Max Temperature (°C)					
Max temperature of cells		39.6	37.8	--	--
Battery enclosure		33.0	31.7	--	--
Ambient temperature		23.2	23.2	--	--

UL 2271				
Clause	Requirement + Test		Result - Remark	Verdict
DUT was operational after the test, it was subjected to a minimum of one charge/discharge cycle at the manufacturer's maximum specified values. Y or N?	☒Yes ☐No	☒Yes ☐No	--	--

25	TABLE: Overdischarge Test		P
Sample No.	A004213493-003 (VK-48V15Ah-13S3P)	A004213493-0016 (VK-48V30Ah-A-13S6P)	
OCV before test (V)	53.5	53.4	
Maximum discharging current (A)	12A	24A	
OCV after test (V)	32.79	32.80	
Device single faulted	short circuit MOSFET (Q3) PIN S-D	short circuit MOSFET (Q3) PIN S-D	
Max Temperature (°C)			
Max temperature of cells	29.3	29.2	
Battery enclosure	28.7	25.6	
Ambient temperature	20.5	20.5	
The DUT was operational after the test, it was subjected to a minimum of one charge/discharge cycle at the manufacturer's maximum specified values. Y or N?	☒Yes ☐No	☒Yes ☐No	

UL 2271			
Clause	Requirement + Test	Result - Remark	Verdict
26	**TABLE: Temperature Test**		**P**

Sample No.	A004213493-004(VK-48V15Ah-13S3P)		Limit (°C)
Location	Charging (°C)	Discharging (°C)	--
Ambient	40.1	40.1	--
PCB near U4	44.7	44.4	85
PCB near U8	44.8	44.6	85
PCB near Q3	44.6	43.6	175
PCB near Q6	44.4	43.4	175
PCB near Q8	44.6	44	175
PCB near Q5	44.4	44.3	175
PCB near Q7	44.4	44.1	175
PCB near Q9	44.3	43.9	175
PCB near F1	44.8	45.8	85
Discharging wires	43.6	41.4	200
Charging wires	42.9	40.4	200
Discharge Connector	42.4	40.4	110
Charge Connector	44	41.5	140
Battery case	43.4	42.2	105
Cell 1	44.9	48.5	60
Cell 2	44.3	48.5	60
Cell 3	45.4	47.8	60
Max Current measured on cell	1.66A	4A	4.9A/9.8A
Max Voltage measured on cell	4.20V	--	4.25V
Min Voltage measured on cell	--	3.085V	2.5V
Sample No.	A004213493-017 (VK-48V30Ah-A-13S6P)		Limit (°C)
Location	Charging (°C)	Discharging (°C)	--
Ambient	40.1	40	85
PCB near U4	42.2	44.2	85
PCB near U8	42.3	44.4	175

UL 2271			
Clause	Requirement + Test	Result - Remark	Verdict
PCB near Q3	42	43.2	175
PCB near Q6	41.9	43	175
PCB near Q8	42.1	43.5	175
PCB near Q5	42.9	44.6	175
PCB near Q7	41.9	44.4	175
PCB near Q9	41.8	44.4	85
PCB near F1	42.3	46.1	200
Discharging wires	41.1	41.7	200
Charging wires	40.4	40.2	140
Discharge Connector	40.3	40.5	110
Charge Connector	41.9	40.3	80
Battery case	41.2	42.3	70
Cell 1	42.6	46.7	60
Cell 2	43.7	47.7	60
Cell 3	44.1	49	60
Cell 4	43.8	48.8	60
Cell 5	43.8	47.4	60
Cell 6	42.6	46.2	60
Max Current measured on cell	0.83	4	4.9A/9.8A
Max Voltage measured on cell	4.2	--	4.25V
Min Voltage measured on cell	--	3.097	2.5V
Supplementary information: --			

27	**TABLE: Imbalanced Charging Test**		**P**
Sample No.		A004213493-005 (VK-48V15Ah-13S3P)	A004213493-018 (VK-48V30Ah-A-13S6P)
OCV before test (V)		41.22	41.31
OCV after test (V)		52.8	53.0
OCV of cell (max) (V)		4.193	4.199

UL 2271			
Clause	Requirement + Test	Result - Remark	Verdict

Device single faulted	Short circuit MOSFET (Q5) PIN S-D	Short circuit MOSFET (Q5) PIN S-D
Supplementary information: The DUT was operational after the test, it was subjected to a minimum of one charge/discharge cycle at the manufacturer's maximum specified values.	☒Yes ☐No	☒Yes ☐No

30	**TABLE: Vibration Endurance Test**		**P**
Sample No.(VK-48V15Ah-13S3P)	A004213493-007	A004213493-008	A004213493-009
OCV before test (V)	54.5	54.5	54.5
OCV after test (V)	54.4	54.5	54.5
Sample No. (VK-48V30Ah-A-13S6P)	A004213493-020	A004213493-021	A004213493-022
OCV before test (V)	54.5	54.5	54.5
OCV after test (V)	54.4	54.5	54.4
Supplementary information: The DUT was subjected to the vibration in each axis for ☒ 21h if testing 1pcs sample, or ☐ 15h if testing 2pcs samples, or ☐ 12h if testing 3pcs samples. ☒ The DUT was operational after the test, it was subjected to a minimum of one charge/discharge cycle at the manufacturer's maximum specified values.			

31	**TABLE: Shock Test**	**P**
Sample No.	A004213493-010 (VK-48V15Ah-13S3P)	A004213493-023 (VK-48V30Ah-A-13S6P)
OCV before test (V)	54.5	54.5
OCV after test (V)	54.5	54.5
Supplementary information: ☒ The DUT was operational after the test, it was subjected to a minimum of one charge/discharge cycle at the manufacturer's maximum specified values.		

32	**TABLE: Crush Test**		**N/A**
Sample No.	--	--	--
OCV before test (V)	--	--	--
Max Force applied (kN)	--	--	--

UL 2271			
Clause	Requirement + Test	Result - Remark	Verdict
Battery enclosure temperature	--	--	--
Supplementary information: --			

--End of Report--

Attachment 1: Equipment list

Produkte
Products

Test location:
TÜV Rheinland (Shanghai) Co., Ltd. Kunshan Branch
No.38, Jingfan Road, Bacheng, Kunshan, Jiangsu, China

	Eq. No.	Name	Manufacturer	Model No.	Date of Calibration	Date of next Calibration
☒	9077636	Battery Charge & Forced Discharge System	Beijing Dahua & Dingchen	DH1798-4 & DCL8006	2026.03.30	2027.03.29
☒	9073805	Temperature recorder	Graphtec Corp.	GL860	2026.01.16	2027.01.15
☒	9062988	multimeter	FLUKE	15B+	2026.03.05	2027.03.04
☒	9078508	External short-circuit currentTester	Readytek(shenzhen)Co.,Ltd	RJD-DL-HT-300AC5	2026.01.16	2027.01.15
☒	G1812625	Temperature Rise Recorder	Graphtec Corp.	GL840-M	2026.01.16	2027.01.15
☒	9079635	ITECH CTRONIC LOAD	ITECH	IT8512A+	2026.03.27	2027.03.26
☒	9076076	Climatic chamber	Readytek(shenzhen)Co.,Ltd	RJD-HLDT-408L	2026.03.06	2027.03.05
☒	9055792	Battery Charge & Discharge System	Chroma	17020	2025.09.23	2026.09.22
☒	9026566	Temperature recorder	Graphtec Corp.	GL840	2025.11.07	2026.11.06
☒	9061616	Thrust vertical shaking table	SuSshi Testing GroupCo.,Ltd	DC—2200-26/TBS-1000/	2025.08.04	2026.08.03
☒	9061656	Power battery test system	Neware technology limited.,Ltd	SC-225-CD-3	2026.01.15	2027.01.14
☒	9061617	Hydraulic impact test bench	SuSshi Testing GroupCo.,Ltd	CL-50	2025.08.04	2026.08.03
☒	9061606	Battery drop tester	Readytek(shenzhen)Co.,Ltd	RJD-DL-1500L-50K	2026.01.20	2027.01.19
☒	9061610	High-temperature ovens	Readytek(shenzhen)Co.,Ltd	RJD-VA-150N	2026.01.19	2027.01.18
☒	9082230	Battery flipping testing machine	高鑫	GX-5718-A100	2025.11.19	2026.11.18
☒	9067012	Alcohol spray	TB	--	--	--

Test location: TÜV Rheinland (Shenzhen) Co., Ltd.
1-5F, Block 5, No. 1100, Huanli Road, Yungu Community, Xinhu Street, Guangming District, Shenzhen, China

☒	G1824779	IP testing system	Dongguan Jianxin	JX1401	2025.07.08	2026.07.07
☒	2.064	Thermal cycling chamber	YinHe(ChongQing) Testing Equipment Co., Ltd.	KWGDS6025IIF	2026.03.06	2027.03.05
☒	2.082	Multimeter	Fluke	179C	2025.05.22	2026.05.21
☒	1.958	HEV Battery test system	DIGATRON	EVT300-0600-2x80Kw	2025.09.17	2026.09.16

*) Initial calibration or verification only

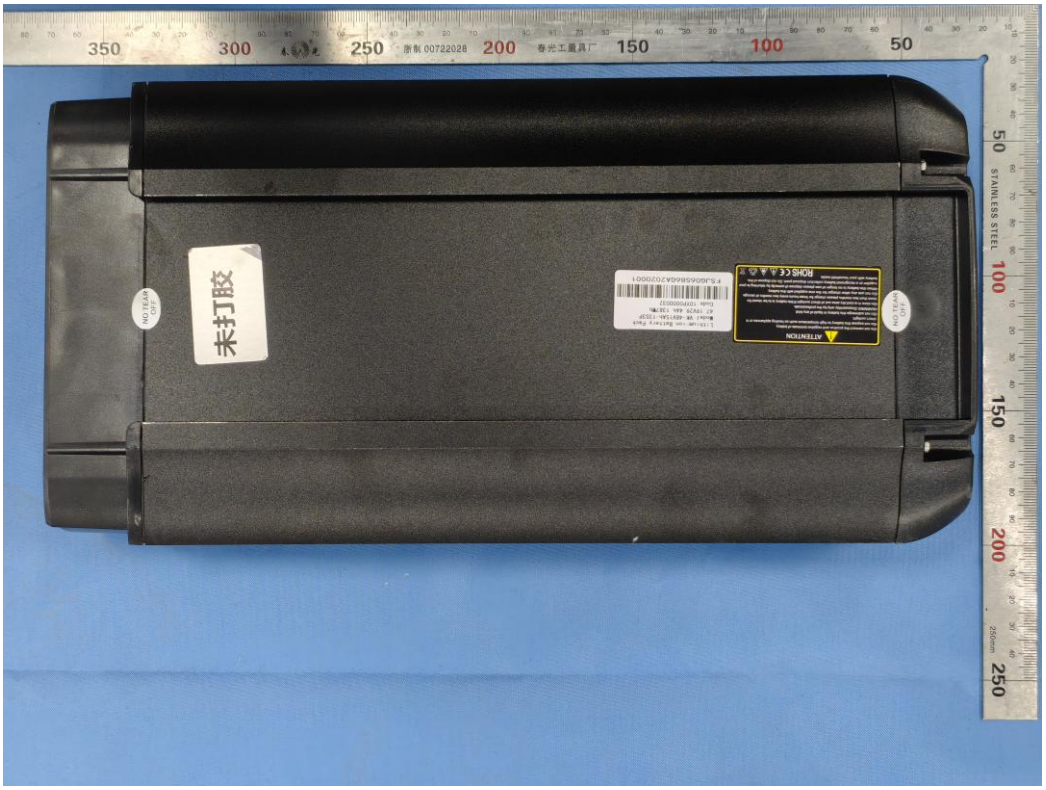


Figure 1: General View of battery (VK-48V15Ah-13S3P)

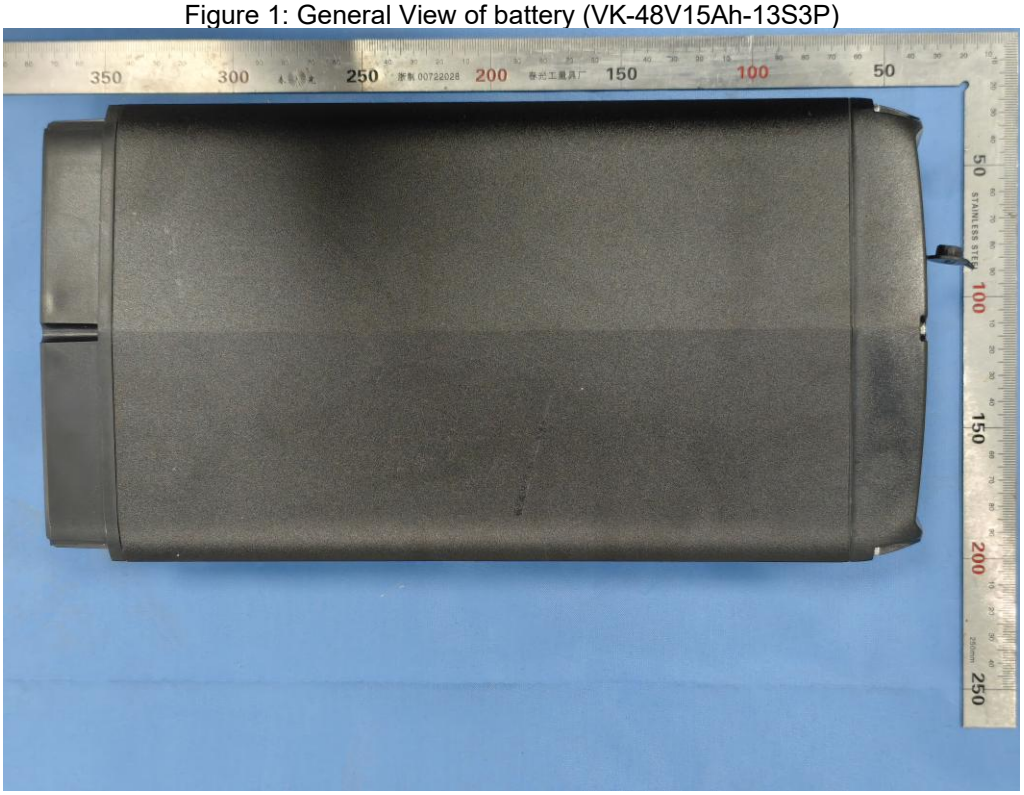


Figure 2: General View of battery (VK-48V15Ah-13S3P)

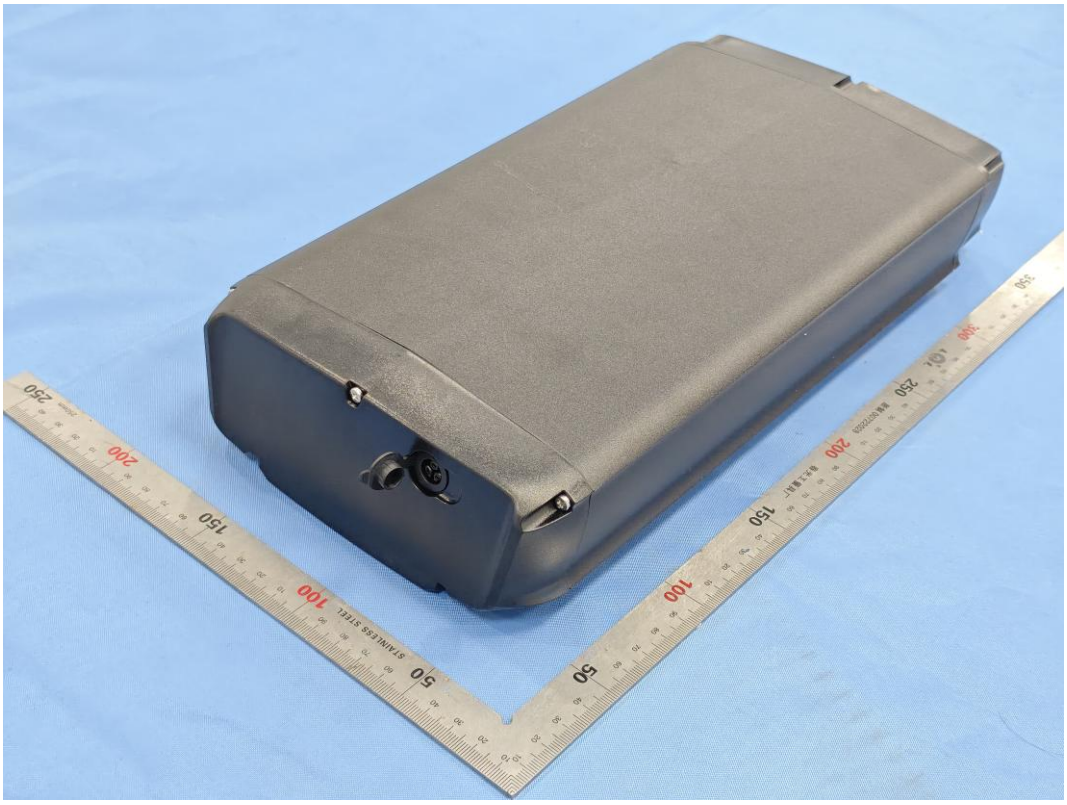


Figure 3: The charge port of battery (VK-48V15Ah-13S3P)



Figure 4: The discharge port of battery (VK-48V15Ah-13S3P)

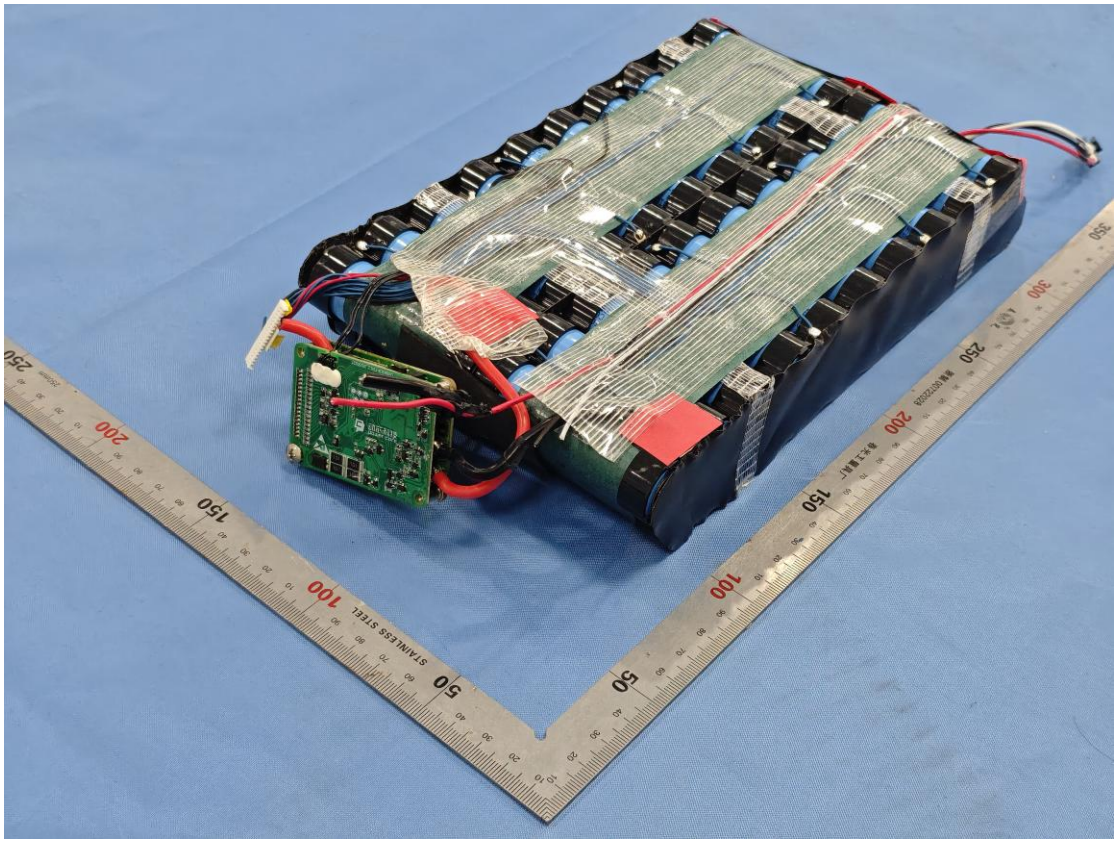


Figure 5: Interview of battery (VK-48V15Ah-13S3P)

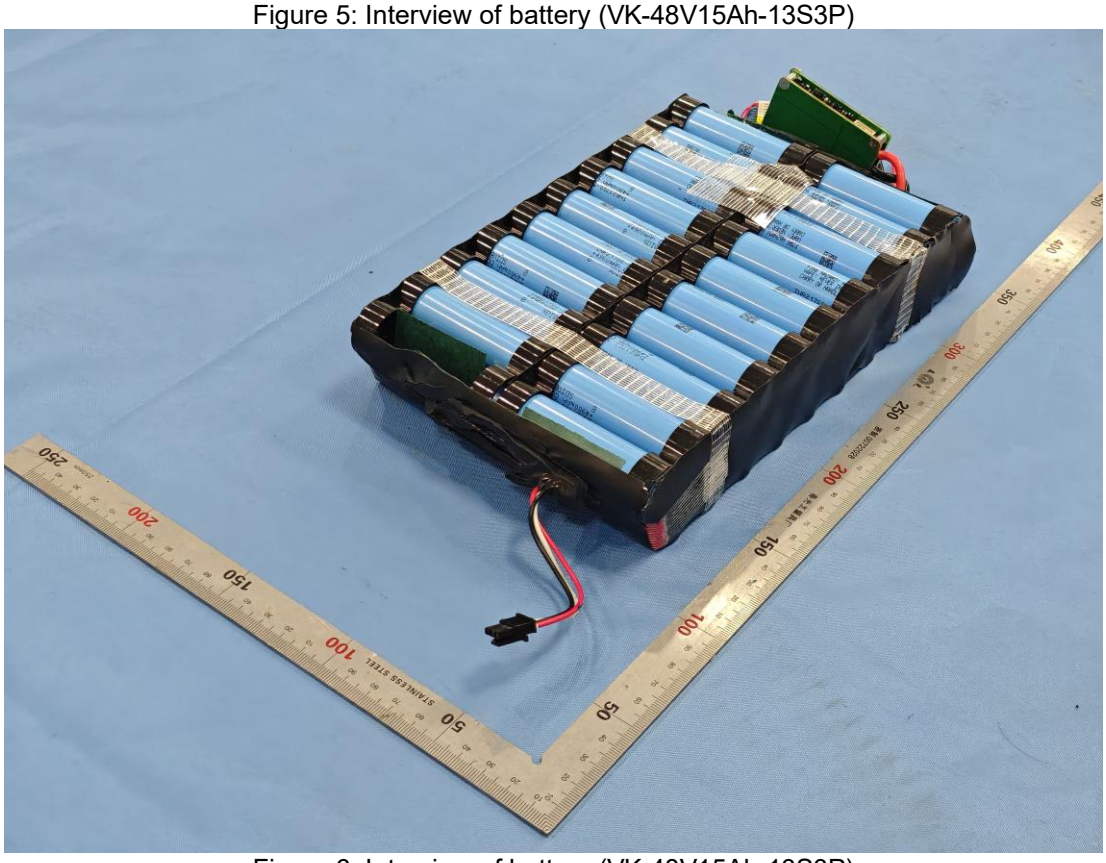


Figure 6: Interview of battery (VK-48V15Ah-13S3P)

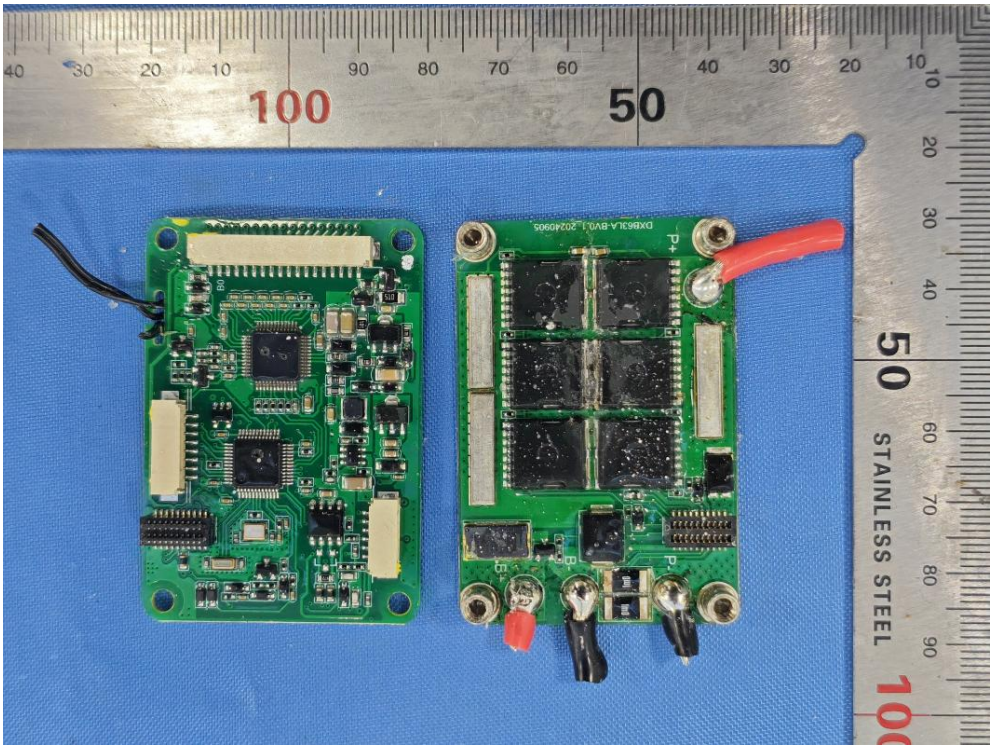


Figure 7: Front of pcb bord (VK-48V15Ah-13S3P)

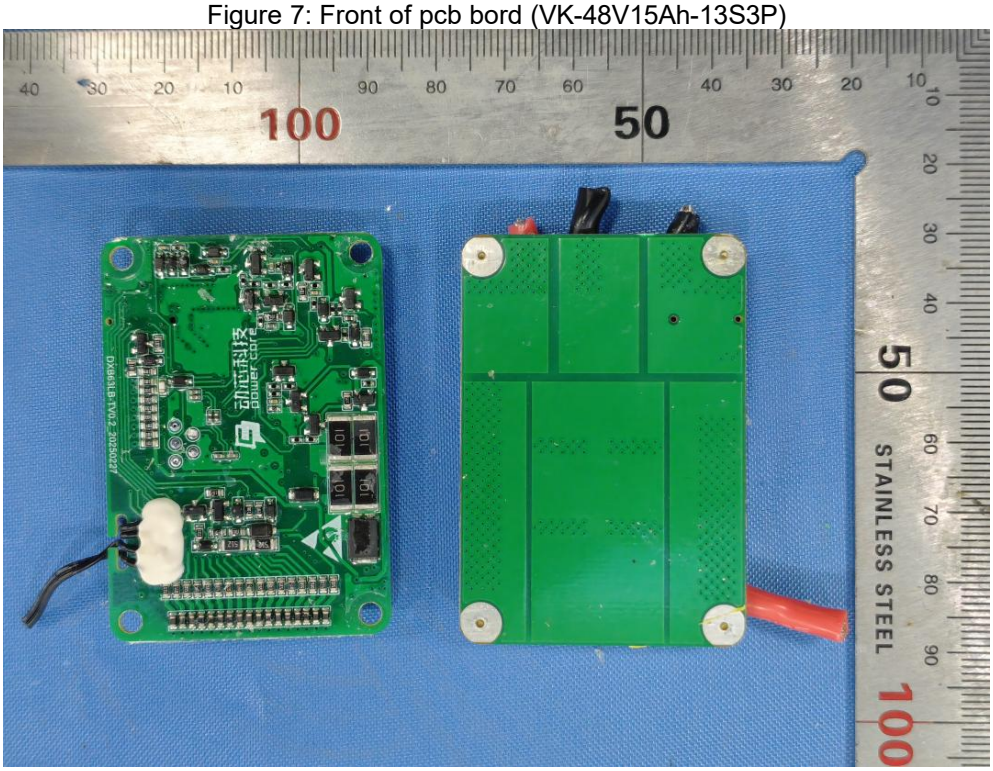


Figure 8: Reverse of pcb bord (VK-48V15Ah-13S3P)

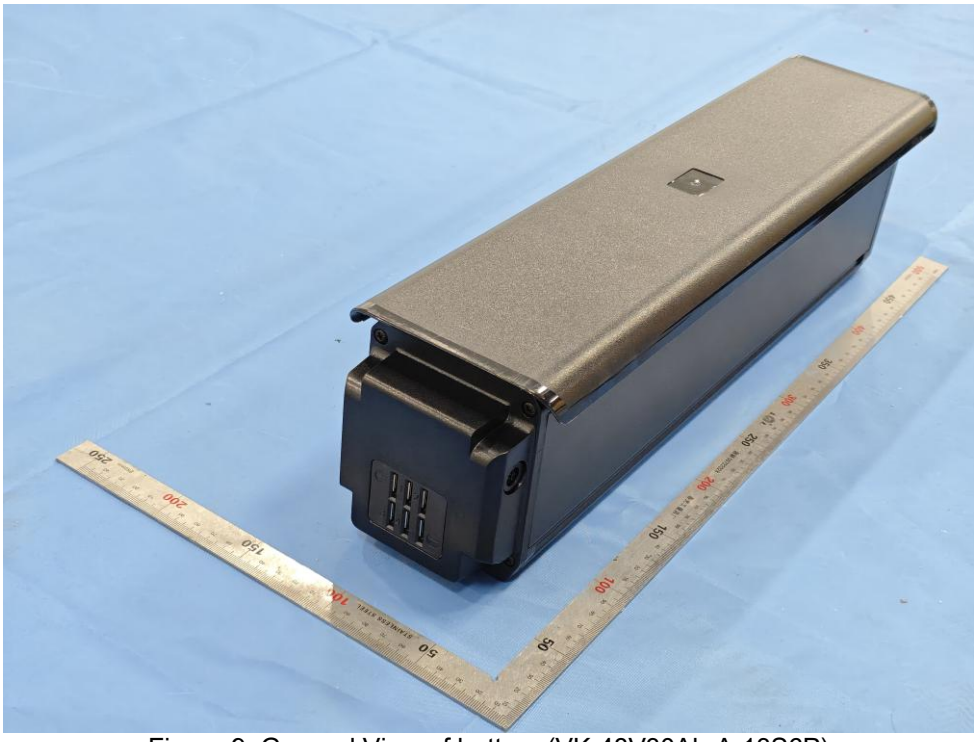


Figure 9: General View of battery (VK-48V30Ah-A-13S6P)

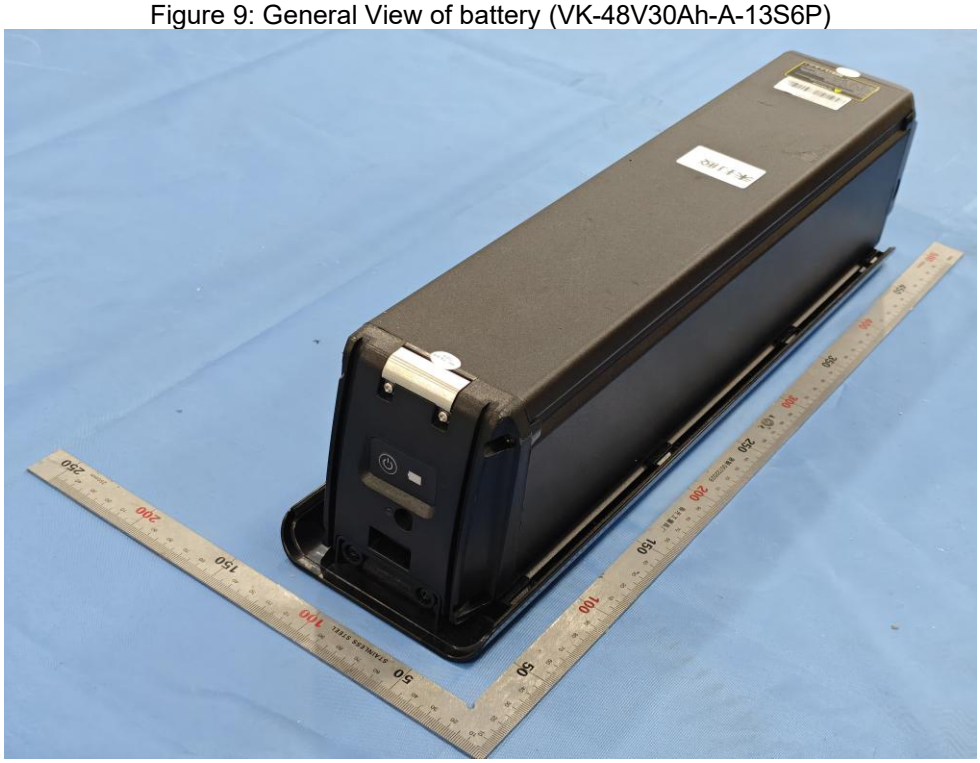


Figure 10: General View of battery (VK-48V30Ah-A-13S6P)

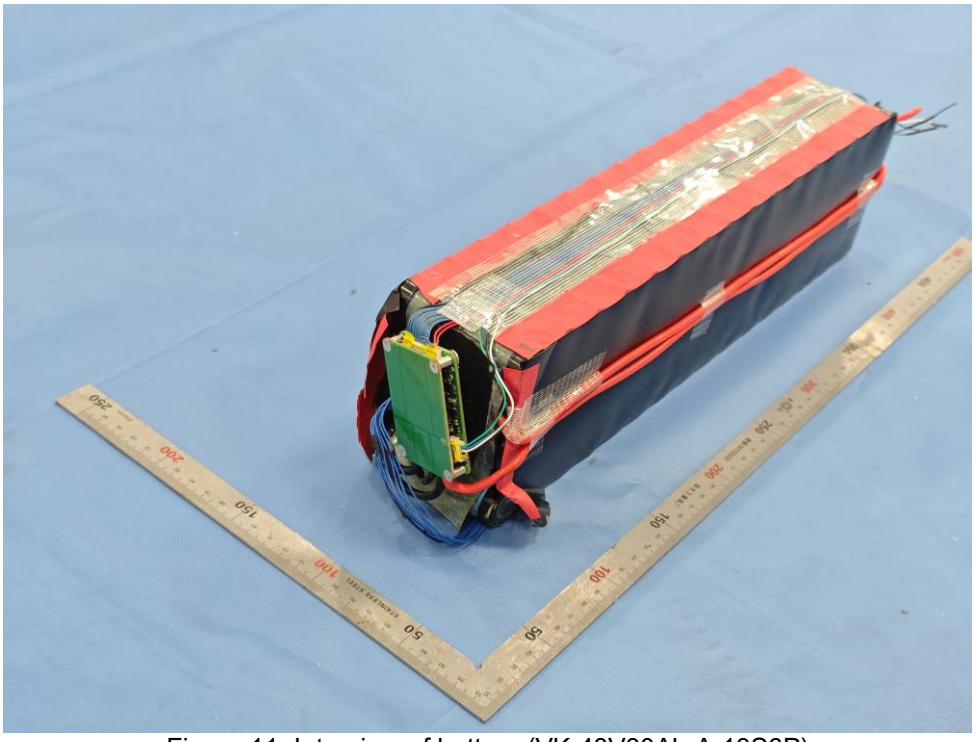


Figure 11: Interview of battery (VK-48V30Ah-A-13S6P)

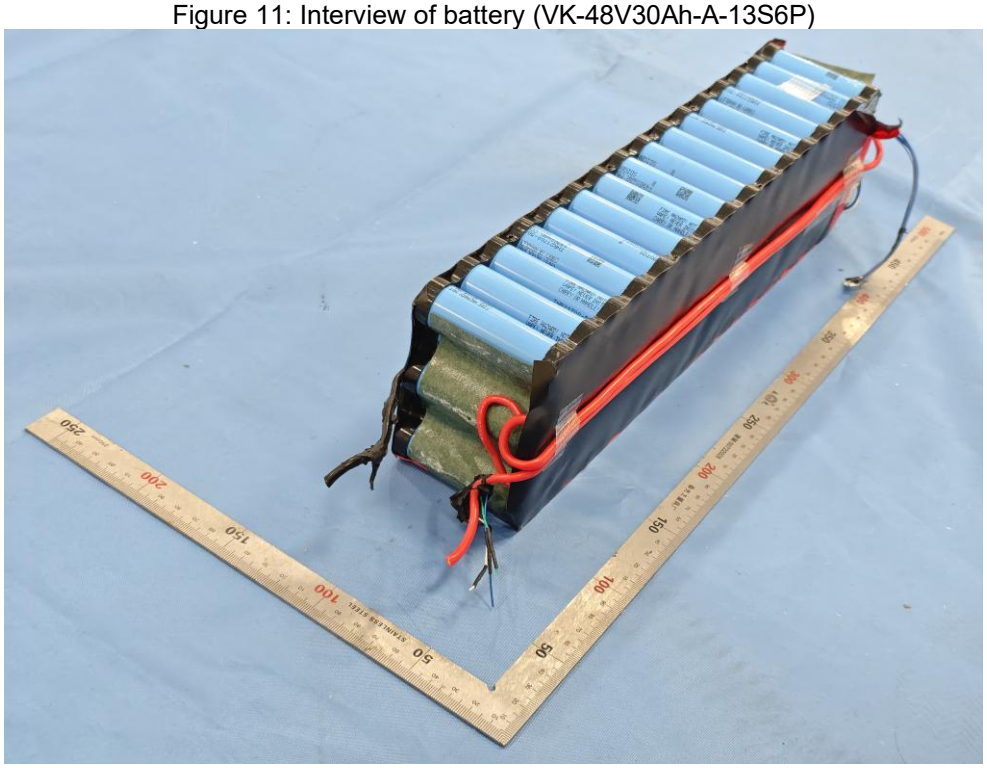


Figure 12: Interview of battery (VK-48V30Ah-A-13S6P)

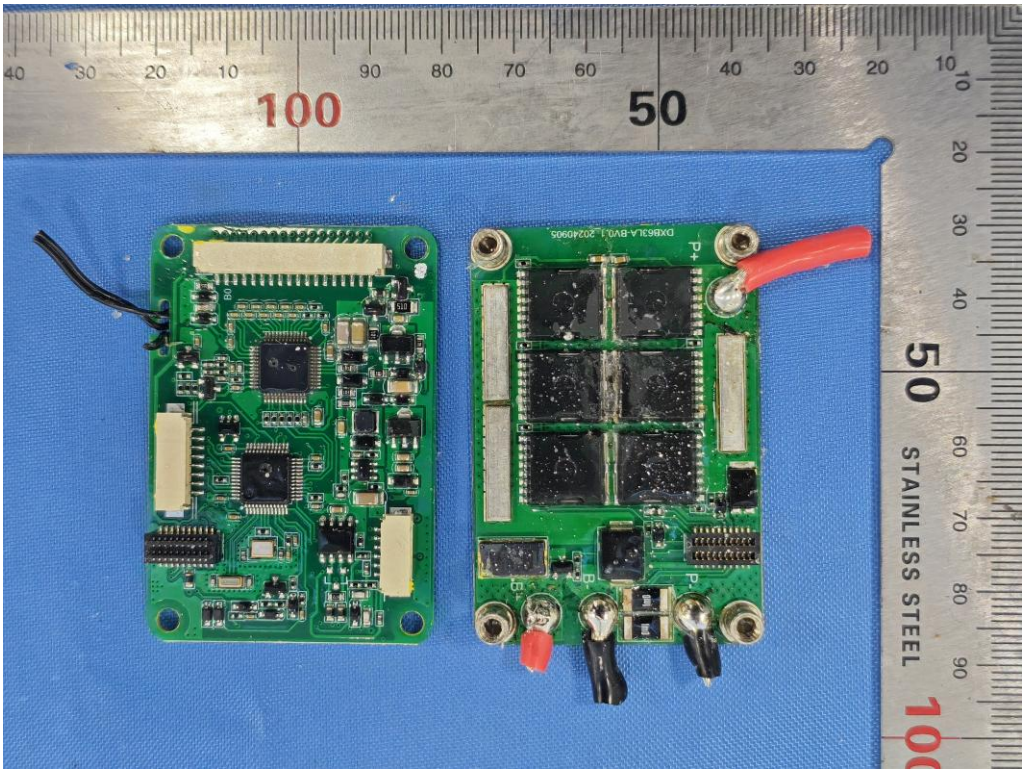


Figure 13: Front of pcb bord (VK-48V30Ah-A-13S6P)

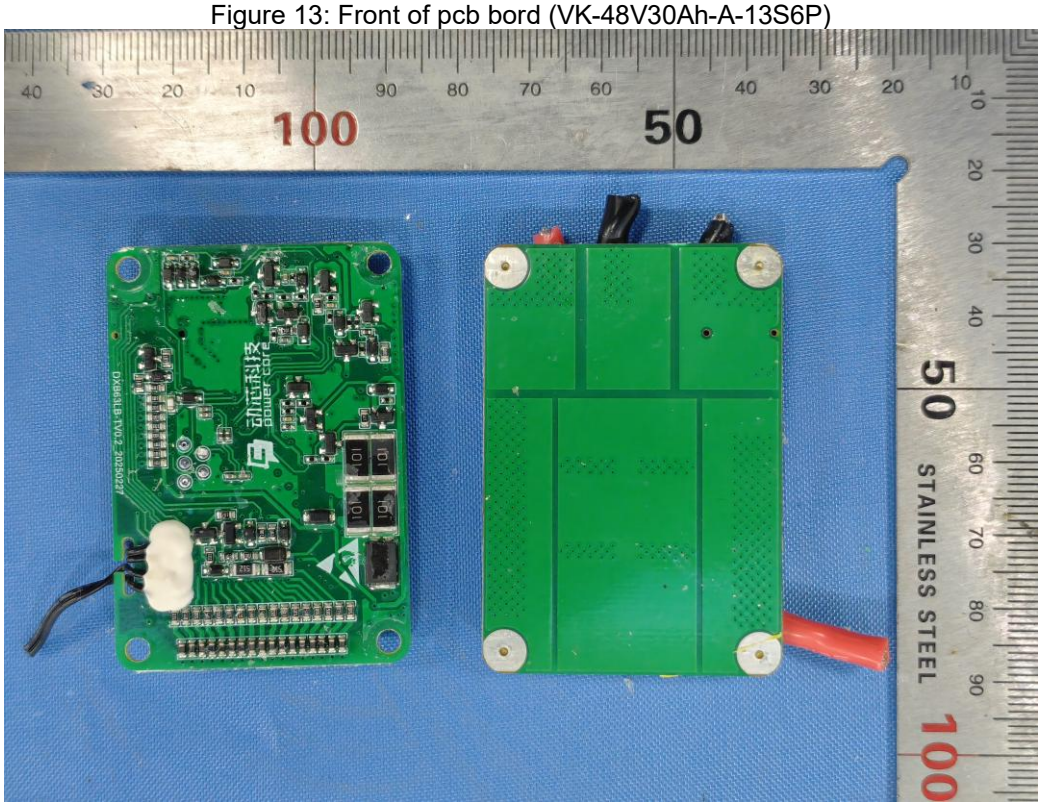


Figure 13: Front of pcb bord (VK-48V30Ah-A-13S6P)

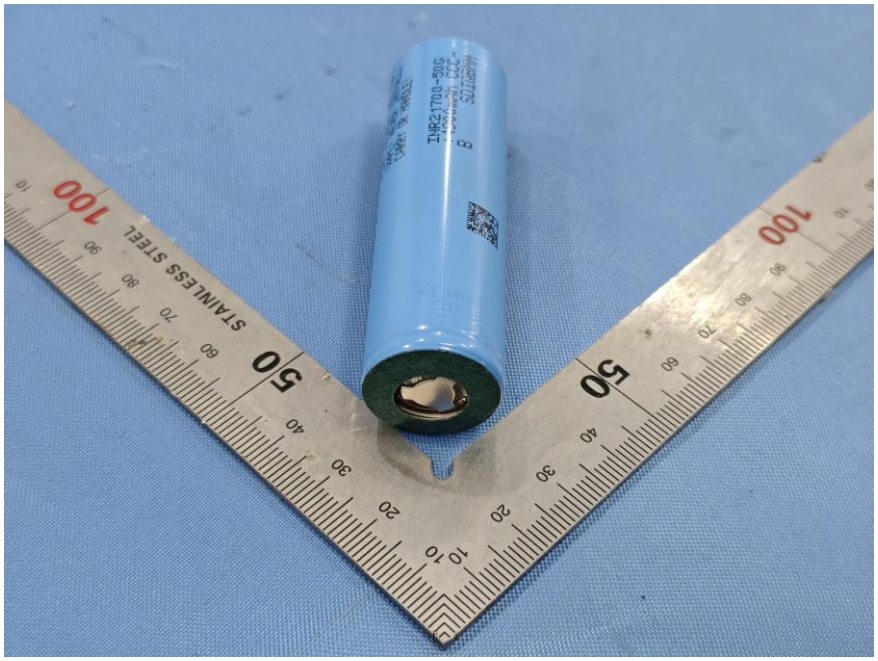


Figure 13: General view of battery cell