Certificate of Compliance

Certificate: 80119076 **Master Contract:** 302690

Project: 80119076 **Date Issued:** 2023-05-26

Issued To: **Energie Volthium inc.**
2600 Boulevard Ford #100
Chateauguay, Quebec J6J 4Z2
Canada

The products listed below are eligible to bear the CSA Mark shown with adjacent indicators 'C' and 'US' for Canada and US or with adjacent indicator 'US' for US only or without either indicator for Canada only.

Issued by: Elly Ai
Elly Ai

C US

PRODUCTS

CLASS - C370112 - BATTERY SYSTEM for use in Stationary Applications
CLASS - C370182 - BATTERY SYSTEM FOR USE IN STATIONARY APPLICATIONS Certified to US Standards

Battery module for Use in Stationary Electrical Energy Storage Application, Lithium-ion, the Model name and Electrical Ratings are noted as below:

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Table 1: Manufacturer Specified Battery Module Electrical Ratings:

Battery Module Model	Battery Module Rating				Battery Cell Model	BMS Model
	Nominal Voltage, Vdc	Rated Capacity, kWhr	Battery Pack configuration	Enclosure IP/Type Rating		
51.2-100-R-H-C	51.2	5.12	16S-1P	IP 20	IFP27175200A-100Ah	16S150A-EES-BMS
51.2-200-R-H-C	51.2	10.24	16S-2P	IP 20	IFP27175200A-100Ah	16S150A-EES-BMS

Table 2: Manufacturer's Specified Charging Parameters for Battery Module:

Battery System Model	Operating Temperature Range, °C(#)	Normal Charging Voltage, Vdc	Normal Charging Current, A	Maximum Charging Voltage, Vdc	Maximum Charging Current, A
51.2-100-R-H-C	-5 to 45	56	50	57	100
51.2-200-R-H-C	-5 to 45	56	75	57	125

Table 3: Manufacturer Specified Discharging Parameters for Battery Module:

Battery Module Model	Operating Temperature Range, °C	Normal Discharging Current, A	Discharging Cut-off Voltage, Vdc	Maximum Discharging Current, A
51.2-100-R-H-C	-20 to 50	100	44.8	125
51.2-200-R-H-C	-20 to 50	100	44.8	125

Model Difference:
1. Model 51.2-100-R-H-C and 51.2-200-R-H-C employed the same BMS and other components except the configuration, enclosure dimensions and connector (P+, P-).
2. Model 51.2-100-R-C is identical to 51.2-100-R-H-C except 51.2-100-R-C has no heating function. Model 51.2-200-R-C is identical to 51.2-200-R-H-C except 51.2-200-R-C has no heating function.

Conditions of Acceptability:

1. The battery module with its intended BMS model 16S150A-EES-BMS has been tested according to the functional-safety requirements of ANSI/CAN/UL-1973:2022, Third Edition. Solid state circuits and software controls relied upon as the primary safety protection, have been evaluated to by CSA Group to meet requirement of this standard. Any change to the BMS including to its software and electronic controls required additional evaluation by CSA Group.
2. The enclosure was evaluated only to establish an IP rating of IP20 with the Standard for Degrees of Protection Provided by Enclosure (IP Code) IEC 60529.
3. Product was evaluated for indoor use and shall avoid being used in moisture environment, and not being used near marine environments.

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4. Further evaluation for Resistance of Moisture and/or Salt Fog shall be required for the battery module intended to be used in the end product where moisture and/or salt fog condition were applied.

5. Further evaluation for Static Force, Impact test shall be required for battery system enclosure where the module will be installed.
6. Corrosion due to electrochemical action is to be determined for conductive parts in contact with terminals when subjecting to the installation of the end products.
7. Equipment Application Location: Stationary
8. Access Location: Operator Accessible.
9. The installation was not evaluated. The battery system shall be installed in accordance with NFPA 70 or CSA C22.1 (Canadian Electric Code) or other applicable installation code.
10. Overvoltage Category(OVC): 2
11. Pollution Degree(PD): 2
12. Altitude for Operation: Up to 2000 m.

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Certificate: 80119076
Project: 80119076

Master Contract: 302690
Date Issued: 2023-05-26

APPLICABLE REQUIREMENTS

ANSI/CAN/UL 1973:2022, Third Edition - Batteries for Use in Stationary and Motive Auxiliary Power Applications

MARKINGS

See CSA Report

Notes:

Products certified under Class C370112, C370182 have been certified under CSA's ISO/IEC 17065 accreditation with the Standards Council of Canada (SCC). www.scc.ca

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Supplement to Certificate of Compliance

Certificate: 80119076 **Master Contract:** 302690

The products listed, including the latest revision described below, are eligible to be marked in accordance with the referenced Certificate.

Product Certification History

Project	Date	Description
80119076	2023-05-26	Original Certification for Battery module for used in Energy Storage System, Model 51.2-100-R-H-C, 51.2-100-R-C, 51.2-200-R-H-C, 51.2-200-R-C to ANSI/CAN/UL-1973:2022 under CSA APT program. (c CSA us mark)

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Descriptive Report and Test Results

MASTER CONTRACT: 302690
REPORT: 80119076
PROJECT: 80119076

Edition 1: May 26, 2023; Project 80119076 - Kunshan
Prepared By: Elly Ai
Authorized By: Joseph Zhou

Contents:

PRODUCTS

CLASS - C3701 12 - BATTERIES - Battery System for use in Stationary Applications
CLASS - C3701 82 - BATTERIES - Battery System for use in Stationary Applications - Certified to US Standards

Lithium-ion Battery Module for use in stationary application, Model 51.2-100-R-H-C, 51.2-100-R-C, 51.2-200-R-H-C, 51.2-200-R-C

Electrical Ratings:

Battery Module Model	Battery Module Rating				Battery Cell Model	BMS Model
	Nominal Voltage, Vdc	Rated Capacity, kWhr	Battery Pack configuration	Enclosure IP/Type Rating		
51.2-100-R-H-C	51.2	5.12	16S-1P	IP 20	IFP27175200A-100Ah	16S150A-EES-BMS
51.2-200-R-H-C	51.2	10.24	16S-2P	IP 20	IFP27175200A-100Ah	16S150A-EES-BMS

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Manufacturer's Specified Charging Parameters for Battery Module

Battery System Model	Operating Temperature Range, °C(#)	Normal Charging Voltage, Vdc	Normal Charging Current, A	Maximum Charging Voltage, Vdc	Maximum Charging Current, A
51.2-100-R-H-C	-5 to 45	56	50	57	100
51.2-200-R-H-C	-5 to 45	56	75	57	125

Manufacturer's Specified Discharging Parameters for Battery System

Battery Module Model	Operating Temperature Range, °C	Normal Discharging Current, A	Discharging Cut-off Voltage, Vdc	Maximum Discharging Current, A
51.2-100-R-H-C	-20 to 50	100	44.8	125
51.2-200-R-H-C	-20 to 50	100	44.8	125

Functional safety:

Battery Module Model	Standard Used	Safety Rating	Software/ Firmware version	Software/ firmware checksum	Configuration file version/checksum
51.2-200-R-H - C Master MCU	Annex H of UL 60730-1 or CAN/CSAE60730-1	Class B	V21R06	0xD9CB	-

Products listed above have also been verified for functional safety CSA Group under project 80119078, issued on 2023-05-26.

Separable Accessories and Controls Electrical Ratings:

Input Voltage, Vac or Vdc	Frequency, Hz	Number of Phase	Input Current, A	Input Power, Watts
N/A	N/A	N/A	N/A	N/A

Other Rating:

Battery Module Model	Enclosure rating	Maximum short circuit current and duration rating
51.2-100-R-H-C	IP20	1800A, 6ms
51.2-200-R-H-C	IP20	2400A, 6ms

Model Difference:
1. Model 51.2-100-R-H-C and 51.2-200-R-H-C employed the same BMS and other components except the configuration, enclosure dimensions and connector (P+, P-).
2. Model 51.2-100-R-C is identical to 51.2-100-R-H-C except 51.2-100-R-C has no heating function. Model 51.2-200-R-C is identical to 51.2-200-R-H-C except 51.2-200-R-C has no heating function.

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Conditions of Acceptability:

1. The battery module with its intended BMS model 16S150A-EES-BMS has been tested according to the functional-safety requirements of ANSI/CAN/UL-1973:2022, Third Edition. Solid state circuits and software controls relied upon as the primary safety protection, have been evaluated to by CSA Group to meet requirement of this standard. Any change to the BMS including to its software and electronic controls required additional evaluation by CSA Group.
2. The enclosure was evaluated only to establish an IP rating of IP20 with the Standard for Degrees of Protection Provided by Enclosure (IP Code) IEC 60529.
3. Product was evaluated for indoor use and shall avoid being used in moisture environment, and not being used near marine environments.
4. Further evaluation for Resistance of Moisture and/or Salt Fog shall be required for the battery module intended to be used in the end product where moisture and/or salt fog condition were applied.

5. Further evaluation for Static Force, Impact test shall be required for battery system enclosure where the module will be installed.
6. Corrosion due to electrochemical action is to be determined for conductive parts in contact with terminals when subjecting to the installation of the end products.
7. Equipment Application Location: Stationary
8. Access Location: Operator Accessible.
9. The installation was not evaluated. The battery system shall be installed in accordance with NFPA 70 or CSA C22.1 (Canadian Electric Code) or other applicable installation code.
10. Overvoltage Category(OVC): 2
11. Pollution Degree(PD): 2
12. Altitude for Operation: Up to 2000 m.

APPLICABLE REQUIREMENTS

ANSI/CAN/UL 1973:2022, Third Edition - Batteries for Use in Stationary and Motive Auxiliary Power Applications

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MARKINGS

The manufacturer is required to apply the following markings:

- Products shall be marked with the markings specified by the particular product standard.
- Products certified for Canada shall have all Caution and Warning markings in both English and French.

Additional bilingual markings not covered by the product standard(s) may be required by the Authorities Having Jurisdiction. It is the responsibility of the manufacturer to provide and apply these additional markings, where applicable, in accordance with the requirements of those authorities.

The products listed are eligible to bear the CSA Mark shown with adjacent indicators 'C' and 'US' for Canada and US (indicating that products have been manufactured to the requirements of both Canadian and U.S. Standards) or with adjacent indicator 'US' for US only or without either indicator for Canada only.

The markings shall be legibly and permanently marked with:

a) The products listed are eligible to bear the CSA Mark shown with adjacent indicators ‘C’ and ‘US’ for Canada and US.
b) Batteries shall be marked with the manufacturer’s name, trade name, trademark, CSA master contract number “302690” or other descriptive marking which may identify the organization responsible for the product.
c) Part number or Model number; as specified in product section above.
d) Electrical ratings in volts dc and capacity in Ampere-hours or Watt-hours and chemistry; as specified in product section above.
e) The electric energy storage system terminals shall be marked to indicate whether they are positive (+) or negative (-).
f) Enclosure IP Code /Type rating; as specified in product section above.
g) Electric energy storage systems shall also be marked with the date of manufacture, which may be in the form of a code that does not repeat within 20 years.
h) Cautionary marking indicating to read all instructions before installation, operation and maintenance of the system. This marking may be in the form of the symbol(s) for example: the Standard for Graphical Symbols for Use on Equipment – Index and Synopsis, ISO 7000, “caution” Symbol No. 434 (exclamation point inside triangle) followed by the “read instruction manual” Symbol No. 790 (open book). If using symbols, their meaning shall be explained in the instruction manual.
i) Warning marking indicating risk of electrocution near hazardous voltage battery terminals.
j) Software/Firmware version is displayed on the battery GUI when the following key sequence is activated.

The software version is displayed by checking with following key sequence:
1. Using CAN communication cable, follow user manual to connect PC with product.
2. Turn on product, using GUI software (Windows OS based) to connect to product
3. Follow user manual of GUI, to check the current firmware version of product.

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Nameplate adhesive label material approval information:

Label (INT): UL 969 and CSA-C22.2 No. 0.15 approved adhesive material (PGDQ2/8. MH16411).
Manufacturer: 3M COMPANY
Model: 7815
Applicable Surface: Polybutylene terephthalate
Temperature rating: -40℃~150 °C.

Refer to Att.1 figure 1~4 for detailed marking of the battery module.

DOCUMENTATION

N/A for module level.

ALTERATIONS

1. Marking and Documentation as listed above.

FACTORY TESTS

Manufacturers of battery systems shall have documented production process controls in place that continually monitor the following key elements of the manufacturing process that can affect safety, and shall include corrective/preventative action to address defects found affecting these key elements:
a) Supply chain control; and
b) Assembly processes.

1. Active Controls Utilized Function Check

Battery systems shall be subjected to 100 % production screening to determine that any active controls utilized for safety are functioning.

Exception: This check of the safety controls can be conducted on subassemblies or components of the system before final assembly.

2. Dielectric Voltage Withstand Test

N/A, circuit not exceeding 60Vdc.

3. Continuity Check

A continuity check of the grounding system using a milli ohmmeter or other method, shall be conducted on 100 % production employing protective grounding. The continuity check shall determine that measurements made on any two points of the grounding system do not exceed 0.1 Ω.

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SPECIAL INSTRUCTIONS FOR FIELD SERVICES

1. Component descriptions marked with either the "(INT)" or "(INT*)" identifiers may be substituted with other components providing the requirements specified under the notes in the "Description" are complied with.

2. The software version could be verified by PC communication interface (See Att1 figure 3 for details), it shall be verified to be the same as that recorded in the functional safety report that is referenced in the 'Contents' section.

COMPONENT SPECIAL PICKUP

1. Component descriptions marked with the identifier "(CT)" are subject to annual pickup and Conformity Testing.

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DESCRIPTION

Notes:

1. Component Substitution
   a) Critical components (those identified by mfr name, cat no), which are NOT identified with either "INT" or "INT*" are not eligible for substitution without evaluation and report updating
   b) The term "INT" means a "Certified" and/or "Listed" (or a "Recognized" and/or "Accepted") component may be replaced by one "Certified" and/or "Listed" by another certification organization accredited by the appropriate accreditation body or scheme requirements to the correct standard, for the same application; providing the applicable country identifiers are included and requirements in item "d" below are complied with.
   c) The Term "(INT*)" means a "Recognized" and/or "Accepted" component may be replaced by a component that is CSA Certified. The applicable country identifiers shall be included, the requirements in item "d" below as well as any "conditions of suitability" for the component (as recorded in this descriptive report) shall be complied with;
   d) Components which have been substituted, must be of an equivalent rating, configuration (size, orientation, mounting) and the applicable minimum creepage and clearance distances are to be maintained from live parts to bonded metal parts and secondary parts.
   e) Substitution of a "Certified" and/or "Listed" component with a component that is "Recognized" or "Accepted" is not permitted without evaluation and report updating.
   f) Substitution of a "Recognized" and/or "Accepted" component by one that is not CSA Certified is not permitted without a proper evaluation as well as a report update because the Conditions of Acceptance of the original component may be different than the Conditions of Acceptance of the substitute component.

General

51.2-100-R-H-C, 51.2-200-R-H-C were lithium-ion rechargeable battery modules, which are functioned with its intended BMS board, model 16S150A-EES-BMS, and will be used in energy storage systems for stationary applications.

The module construction and critical components were indicated below:

TABLE: Critical components information

Object / part No.	Manufacturer/ trademark	Type / model	Technical data	Standard	Mark(s) of conformity
Battery Module	Energie Volthium Inc	51.2-100-R-H-C	Nominal voltage 51.2V, rated capacity: 5.12kWh	UL1973 3rd	CSA/UL
Battery Module	Energie Volthium Inc	51.2-200-R-H-C	Nominal voltage 51.2V, rated capacity: 10.24kWh	UL1973 3rd	CSA/UL
-Metal Enclosure	Interchangeable	Interchangeable	Material: Cold rolled mild steel strip Thickness: 1.2 mm min, Detailed dimension see Att.3, ILL.1 & 2	--	Test in module

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-Connector Receptacle (J6 for P-&J7 for P+) (for model 51.2-200-R-H-C)	SHENZHEN CONNECTION ELECTRONIC CO LTD	ACTB135	120 °C, Wire type: Cu, 600V, 310A.	UL 1059, CSA-C22.2 No. 158	UL/cUL (E304128)
-Connector Receptacle (J6 for P-&J7 for P+) (for model 51.2-100-R-H-C)	AMPHENOL CORP	C10-730189-( ) 0 ( ) ( )	105 °C, 1000 Vdc max, 200 A max.	UL 1977, CSA-C22.2 No. 182.3	UL/cUL (E115497)
-Cell	Hefei Gotion High-tech Power Energy Co., Ltd.	IFP27175200 A-100Ah	Li-ion (LFP), prismatic 3.2Vdc, 100Ah	ANSI/CAN/UL 1973	cUL/UL (CSA 80067600)
-Busbar connected cells	Interchangeable	Interchangeable	Material Al, 2mm thickness Detailed dimensions see Att.3 ILL. 7 to 11	--	Test in module
-Busbar connected terminals	Interchangeable	Interchangeable	Material Cu 2mm thickness Detailed dimensions see Att.3 ILL. 12	--	Test in module
-Miniature circuit breaker	SHANGHAI LIANGXIN ELECTRICAL CO LTD	NDB1	240 Vac, 125A	UL 1077 CSA-C22.2 No. 235	cUL/UL (E300669)
-Enclosure of circuit breaker	KINGFA SCI & TECH CO LTD	PET-RG305	Min. Thk. 0.75mm, 130°C, V-0	UL 94 UL 746 CSA-C22.2 No. 0.17	cUL/UL (E171666)
-Shunt trip	SHANGHAI LIANGXIN ELECTRICALCO LTD	MX+OF	48V, 2A	UL 1077 CSA C22.2 No. 235-04	cUL/UL (E300669)
-Switch button	Yueqing Hengpai Electronics Co., Ltd.	--	12V, 5Pin, 300mm	--	--
-CAN connector for signal	BOOMELE	RJ45-B	Metal, 125Vdc, 1.5A, Temperature: -10°C to 70°C	--	--
-Battery handle	Dongguan Jinfulong Technology Co., Ltd.	--	Stainless steel, Diameter: 10mm	--	Test in module

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-Cell holder	FORMOSA CHEMICALS & FIBRE CORP PLASTICS DIV	AC310(+)	Min. Thickness: 2.3mm, V-2, 85°C	UL 746 UL 94 CSA-C22.2 No. 0.17	cUL/UL (E162823)
-Power wire (Connect to P+&P- Port) Red & Black	PUTIAN DUORONG OPTICS ELECTRONIC CO LTD	1015	7AWG, V-2, 105°C, 600Vac	UL 758 CSA-C22.2 No. 210	cUL/UL (E334567)
-Signal wire	DONGGUAN DANYANG ELECTRONIC WIRE CO LTD	1430	24AWG, V-2, 105°C, 300Vac	UL 758 CSA-C22.2 No. 210	cUL/UL (E332522)
-Insulation Tube	CHANGYUAN ELECTRONICS GROUP CO LTD	CB-300	VW-1, 105°C, 300V	UL 224 CSA-C22.2 No. 198.1 (2021)	cUL/UL (E180908)
-Epoxy board (Between cells, only for model 51.2-200-R-H-C)	SHENZHEN WANHEXING ELECTRONICS CO LTD	WHX-M1	V-0, 130°C, 162mm*172mm*3mm	UL 796 CAN/CSA-C22.2 No. 0.17	cUL/UL (E339171)
-Aluminum alloy board between cells (for model 51.2-100-R-H-C)	Interchangeable	Interchangeable	Aluminum alloy, W*L*T: 162mm*172 mm *3mm, Weight: 0.23kg/pcs, 14pcs used	--	--
-SPCC board with Zn coating outside the cell block (for model 51.2-100-R-H-C)	Interchangeable	Interchangeable	SPCC board with Zn coating, W*L*T: 172*162*2mm, Weight: 315.11g/pcs, 4pcs used	--	--
-NTC (on busbar for cell temp.)	SHENZHEN SUNLORD ELECTRONICS CO LTD	SNGR1103F3435FB	R25: 10000Ω, Tmoa: 200°C, B25/85: 3435K	UL 1434 CSA 60730-1	cUL/UL (E352242)
-Heater (3pcs)	Shenzhen Zhongli Electronic Co. Ltd.	(245+20)*162 MM	56V, 224W (3 in series), -40°C~130°C, covered with silicone film	--	--
Charging current limit circuit board: Hardware Version: V1.0 Mounting: located on the top of the main BMS board for limit the charging current Refer to Att.3 ILL.3&4 for details					

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-PWB(INT)	Interchangeable	Interchangeable	Rated 130 °C, V-0, min. 0.1mm	UL 796 CAN/CSA-C22.2 No. 0.17	cUL/UL
-IC (U1)	TEXAS INSTRUMENTS	TL494I	Operating Temperature: -40°C to 85°C, V_{CC}: 41V	--	--
-MOSFET (M1)	HOOYI SEMICONDUCTOR	HY3010D	V_{DSS}: 100V， V_{GSS}: ±25V, T_J, T_{STG}: -55°C to 175°C	--	--
MOSFET (M4, M5)	ST	STP15810	V_{DS}: 100V, V_{GS}: ±20V, T_J, T_{STG}: -55°C to 175°C, I_D: 110A	--	--
BMS Main board: Hardware Version: V1.0 Mounting: located in the front of the module for cell temperature, voltage, current detecting and protection for over-charging, over-discharging, over-current, over or under temperature, cell balance for both cells and battery module. Refer to Att.3 ILL.4-5 for detailed layout and components.					
-PWB(INT)	Interchangeable	Interchangeable	Rated 130 °C, V-0, min. 0.1mm	UL 796 CAN/CSA-C22.2 No. 0.17	cUL/UL
-AFE IC (U1)	Panasonic	AN49503	V_{VBAT}: -0.3V to 99V, Operating junction temperature: -40°C to 125°C	--	--
-MCU IC (U6)	MICROCHIP	PIC18F66K22	Operating voltage range: 1.8V to 5.5V, Working frequency：DC 64 MHz	--	--
-CAN IC (U11)	Microchip	MCP2515	Temperature Ranges Supported: Industrial: 40°C to 85°C, Operates from 2.7V to 5.5V	--	--
-MOSFET (M1, M2, M3, M4, M5, M6, M7, M8, M9, M10, M11, M12, M13, M14, M15, M16)	Wuxi NCE Power Co., Ltd	NCEP023N10LL	V_{DS}: -100V, V_{GS}: ±20V, I_D: 300A, T_J, T_{STG}: -55°C to 175°C	--	--
-DC/DC module power supply (U5)	Mornsun	B1205S-1WR3	VDC: 5V, Operating Temperature: -40°C to 105°C	--	--

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-MOSFET (M17)	HOOYI SEMICONDUCTOR	HY3010D	VDSS: 100V，VGSS: ±25V, TJ, TSTG: -55°C to 175°C	--	--
-Optical Isolators (U2, U12, U20)	LITE-ON Technology Corp.	LTV-217	IF: 5mA, VCE: 5V, Operating Temperature: -55°C to 110°C	UL 1577 CSA Component Acceptance Service Notice No. 5A	cUL/UL (E113898)
PWB (Output board)	Interchangeable	Interchangeable	130°C, V-0, Min: 0.2mm	UL 796 CAN/CSA-C22.2 No. 0.17	cUL/UL
Sense resistor (FL1 to FL10)	Interchangeable	Interchangeable	1mΩ, 2W	--	--

Safety functions

Delta Electronics, Inc agrees to inform CSA Group of any software changes with reference to the model(s) tested in this report and to obtain CSA approval before incorporating the new software version. The submittor is requested to submit documentation to confirm the nature and scope of the software changes. CSA will confirm whether the changes impact safety and will perform any additional evaluation and/or testing as required.

The safety functions covered by this report are:

Function	Trigger condition	Deviation	Delay time
OVP Overvoltage protection (Cell)	Cell > 3.63V	±0.01V	2 s
UVP Undervoltage protection (Cell)	Cell < 2.3V	±0.01V	2 s
OCP-C Overcurrent protection (Charging) for model 51.2-200-R-H-C	Current > 155A	±5A	10 s
OCP-C Overcurrent protection (Charging) for model 51.2-100-R-H-C	Current > 101A	±5A	10 s
OCP-D Overcurrent protection (Discharging) for model 51.2-200-R-H-C	Current > 155A	±5A	30 s
OCP-D Overcurrent protection (Discharging) for model 51.2-100-R-H-C	Current > 125A	±5A	30 s
OTP-C Over-temperature protection (Charging)	Cell Temper. > 55°C	±2°C	2 s
OTP-D Over-temperature protection (Discharging)	Cell Temper. > 60°C	±2°C	2 s
UTP-C Under-temperature protection (Charging)	Cell Temper. <-5°C	±2°C	2 s
UTP-D Under-temperature protection (Discharging)	Cell Temper. <-20°C	±2°C	2 s

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TEST HISTORY

Project 80119076

Original certification for battery module, model 51.2-100-R-H-C, 51.2-100-R-C, 51.2-200-R-H-C, 51.2-200-R-C to ANSI/CAN/UL 1973 3rd edition.

Tests conducted on model 51.2-200-R-H-C & 51.2-100-R-H-C could cover those on model 51.2-100-R-C & 51.2-200-R-C respectively after evaluation.

The following tests were conducted in the test facilities noted below under CSA APT program with an acceptable test result.

Test Lab: Dongguan BALUN Technology Co., Ltd
Address: Room 104, Building 3, Sohovark Industrial Incubation Park, Songshan Lake Zone, Dongguan, GuangDong Province, P. R. China 523808

List of applicable Tests

Possible test case verdicts:

Test case does not apply to the test object: N/A
Test object does meet the requirement: P (Pass)
Test object does not meet the requirement: F (Fail)
Test Waived: W (Waived)

Section	Test	Comment	Verdict
15	Overcharge	Test model: 51.2-200-R-H-C	P
16	High Rate Charge		P
17	Short Circuit		P
18	Overload Under Discharge		P
19	Overdischarge Protection		P
20	Temperature and Operating Limits Check		P
21	Imbalanced Charging		P
22	Dielectric Voltage Withstand	Waived, <60V	W
23	Continuity	Test model: 51.2-200-R-H-C & 51.2-100-R-H-C	P
24	Failure of Cooling/Thermal Stability System	Considered in battery system Cabinets	N/A
25	Working Voltage Measurements	No Booster circuit, using Mfr. specified max charging voltage limit of EUT.	N/A
26.1	Locked-Rotor Test (Low Voltage D.C. Fans/Motors In Secondary Circuits)	No Rotor applicated	N/A
26.2	Input	No mains connected circuit	N/A
26.3	Leakage Current	No mains connected circuit	N/A
26.4	Strain Relief	No non-detachable accessible cord provided	N/A

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Section	Test	Comment	Verdict
26.5	Push-Back Relief	No non-detachable accessible cord provided	N/A
26.6	Low Voltage Transformer Evaluation	No low voltage transformer applied	N/A
27.2	Electrostatic Discharge	--	P
27.3	Radio-Frequency Electromagnetic Field	--	P
27.4	Fast Transient/Burst Immunity	--	P
27.5	Surge Immunity	--	P
27.6	Radio-Frequency Common Mode	--	P
27.7	Power Frequency Magnetic Field	--	P
27.8	Operational Verification	--	P
28	Vibration (LER Motive and VAP Applications)	Stationary Applications	N/A
29	Shock (LER Motive and VAP Applications)	Stationary Applications	N/A
30	Crush (LER Motive and VAP Applications)	Stationary Applications	N/A
31	Static Force	Test model: 51.2-200-R-H-C	P
32	Impact	Test model: 51.2-200-R-H-C	P
33	Drop Impact (rack mounted module)	Test model: 51.2-200-R-H-C and 51.2-100-R-H-C	P
34	Wall Mount Fixture/Handle Test	Test model: 51.2-200-R-H-C	P
35	Mold Stress	Metallic Enclosure	N/A
36	Pressure Release	Li-ion Battery System	N/A
37	Start-to-Discharge	Li-ion Battery System	N/A
38	Thermal Cycling (LER Motive and VAP Applications)	Stationary Applications	N/A
39	Resistance to Moisture	Considered on battery system cabinets	N/A
40	Salt Fog	Not intended for used in marine area	N/A
41	External Fire Exposure	UL1973 Certified cell	N/A
42	Single Cell Failure Design Tolerance	Test model: 51.2-200-R-H-C & 51.2-100-R-H-C	P
Annex E E2	Preconditioning and Capacity Check	Test on 10 cells	P

Construction Review:

Construction review performed with satisfactory results.

---End of Report---

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Laboratory Test Data - UL 9540A Checklist and Test Result (Module Level)

ORIGINAL TEST DATA

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Master Contract:	302690	Model:	51.2-100-R-H-C	Page number 1 of 22
Project / Network:	80119081	Description:	Li-ion Battery Module	

Standard(s): ANSI/CAN/UL 9540A:2019 Fourth Edition, Dated November 12, 2019 - Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems

Testing Laboratory Name:	CCIC-CSA International Certification Co., Ltd. Kunshan Branch
Address:	Building 8, Tsinghua Science Park, No. 1666 Zu chongzhi Rd (S), Kunshan, Jiangsu (215347)
Testing Program:	**Custom Test** : Cover Latter ☐, Testing Only ☒

If tests were performed at another facility, then described below:

Testing Laboratory Name:	Shanghai Huahui Testing Co. Ltd.
Address:	No. 158, Changbangcun Road, Fengxian District, Shanghai, China
Facility Qualification Number:	N/A

	As above / or describe otherwise
Customer:	Energie Volthium inc.
Address:	2600 Boulevard Ford #100 Chateauguay, Quebec J6J 4Z2 Canada

Tested By: Zhang Hao, Technician (Huahui)
Name, Title

Zhang Hao — 2023-03-01
Signature — *Date (YYYY-MM-DD)*

☒ **Reviewed by:** Elly Ai(T)/Joseph Zhou, Certifier
☒ **Witnessed by:**
Name, Title

Elly Ai Joseph Zhou — 2023-03-01
Signature — *Date (YYYY-MM-DD)*

Version6.1 : 2022-02-08

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Master Contract:	302690	Model:	51.2-100-R-H-C	Page number 2 of 22
Project / Network:	80119081	Description:	Li-ion Battery Module	

Cell Level Test Summary	
Name of test laboratory perform cell level testing:	CCIC-CSA International Certification Co., Ltd. Kunshan Branch
Unique identification of test report:	Project No. 80067595
Standard and its edition used for testing:	UL 9540A 4th Edition, Section 7, November 12, 2019
Manufacturer:	Hefei Gotion High-tech Power Energy Co., Ltd.
Brand name / Trademark:	--
Model number:	IFP27175200A-100Ah
Nominal cell voltage, (V)	3.2
Cell capacity, (Ah)	100
Cell chemistry:	LFP
Physical format of cell:	Prismatic
Approximate dimension, (mm)	T*W*H: (27.2±0.5)mm*(175.4±0.3)mm*(200.3±0.3)mm
Mass, (g)	2022±60g
Method used to initiate thermal runaway:	Film heater
Average temperature at which cell first vented excluding gas collection sample, (°C)	188.1
Average temperature prior to thermal runaway excluding gas collection sample, (°C)	258.65
Flammable gas generation, (Liter)	--
Total gas generation, (Liter)	66.8
Lower flammability limit (LFL) at ambient temperature (25 ± 5°C), (%)	6.6
Lower flammability limit (LFL) at average gas vent temperature, (%)	5.6
Burning velocity, (Cm/Sec)	83.6
Maximum pressure P_{max}, (Mpa)	1.57
Gas composition:	CO_2(34.13%), CO(7.40%), H_2(48.26%), CH_4(4.20%), C_2H_4(2.76%), C_2H_2(0.13%), C_2H_6(0.87%), C_3H_8(0.55%), C_3H_6(0.58%), C_4 Total(1.13%)

The results relate only to the items tested.
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Master Contract:	302690	Model:	51.2-100-R-H-C	Page number 3 of 22
Project / Network:	80119081	Description:	Li-ion Battery Module	

Module Level Test Summary	
Manufacturer:	Energie Volthium inc.
Brand name / Trademark:	Volthium Energy
Model number:	51.2-100-R-H-C
Nominal voltage rating, (V)	51.2Vdc
Nominal capacity rating, (Ah)	100Ah
Approximate dimension, (mm)	435*465*222 (L*W*H)
Module certification available? (Yes/No)	Yes
Module evaluated with its associated BESS? (Yes/No)	Yes
Standard(s) used to certify product:	UL 1973 3rd edition
Certification organization name and its certificate number:	CSA, report No. 80119076
Module enclosure material:	Metallic
Electrical configuration of cell in module:	16s-1p
Number of cells in module:	16
Method used to initiate thermal runaway:	Flexible Film Heaters
Number of cells used for initiating thermal runaway:	1 (cell 5)
Number of cells exhibited thermal runaway within module:	6 (cell 3, 4, 5, 6, 7, 8)
Cell to cell propagation condition:	From cell 5 to cell 3, 4, 6, 7, 8
Peak chemical heat release rate, (kW)	N/A, no fire ignited
Flammable gas generation, (Liter)	182
Total gas generation, (Liter)	221
Weight loss, (%)	2.8
Gas composition:	CO (5.4%), CO_2 (17.6%), H_2 (0%), THC (76.9%)
Additional Information:	N/A

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Laboratory Test Data – UL 9540A Checklist and Test Result

ORIGINAL TEST DATA

The results relate only to the items tested.
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Master Contract:	301698	Model:	IFP27175200A-100Ah	Page number 1 of 32
Project / Network:	80067595	Description:	Li-ion cell, LFP	

Standard(s): UL9540A:2019 Fourth Edition, Dated November 12, 2019 - Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems

Testing Laboratory Name:	CCIC-CSA International Certification Co., Ltd. Kunshan Branch				
Address:	Building 8, Tsinghua Science Park, No. 1666 Zu chongzhi Rd (S) , Kunshan, Jiangsu (215347)				
Testing Program:	**Custom Test:**	Cover Letter	X	Testing Only	
	Note: Mark " X " in applicable test program block				

If tests were performed at another facility, then described below:

Testing Laboratory Name:	Hefei Gotion High-tech Power Energy Co.,Ltd.
Address:	No.599,Daihe Road, Xinzhan District, Hefei, Anhui 230012, China
Facility Qualification Number:	N/A

	As above / or describe otherwise
Customer:	Hefei Gotion High-tech Power Energy Co.,Ltd.
Address:	No.599,Daihe Road, Xinzhan District, Hefei, Anhui 230012, China

Tested By: Gang Tang (Gotion)
Name, Title

Gang Tang — 2021-06-18
Signature — *Date (YYYY-MM-DD)*

☒ **Reviewed by:** Cheney Chen (CSA Group)
☒ **Witnessed by:**
Name, Title

Cheney Chen — 2021-06-29
Signature — *Date (YYYY-MM-DD)*

Version4 : 01/25/2021

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Product Details	
Test Request:	☒ Cell Level Testing ☐ Module Level Testing ☐ Unit Level Testing ☐ Installation Level Testing
Manufacturer	☒ Cell: Hefei Gotion High-tech Power Energy Co.,Ltd. ☐ Module: ☐ Unit:
Brand name / Trademark	☒ Cell: N/A ☐ Module: ☐ Unit:
Model Number	☒ Cell: IFP27175200A-100Ah ☐ Module: ☐ Unit:
Date of receipt of test sample(s)	2020-12-20 (YYYY-MM-DD)
Cell/Battery Type	Lithium Ion, LFP
Approximate Dimension (mm)	☒ Cell: T*W*H: (27.2±0.5)mm*(175.4±0.3)mm*(200.3±0.3)mm ☐ Module: ☐ Unit:
Mass (g)	☒ Cell: 2022±60g ☐ Module: ☐ Unit:
DUT Sample/Serial Number	☒ Cell: see cell sample ☐ Module: ☐ Unit:
DUT Nominal Voltage Rating (V)	☒ Cell: 3.2Vdc ☐ Module: ☐ Unit:
DUT Nominal Charge Capacity Rating (Ah)	☒ Cell: 100Ah ☐ Module: ☐ Unit:
Fire Mitigation Strategies: (For installation level testing)	☐ Water: ☐ Other (Specify): ☒ N/A
Additional Information	N/A

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Master Contract:	301698	Model:	IFP27175200A-100Ah	Page number 3 of 32
Project / Network:	80067595	Description:	Li-ion cell, LFP	

THE TESTING SPECIFIED IN THIS PROCEDURE IS INHERENTLY DANGEROUS

DO NOT ATTEMPT TO PERFORM THIS TEST UNLESS YOU HAVE BEEN PROPERLY TRAINED REGARDING SAFELY WORKING WITH THE HAZARDS INVOLVED

Important Test Consideration:

- As some batteries expose in test described above, it is important that personnel be protected from the flying fragments, explosive force, and sudden release of heat, chemical burns, and noise resulting from such explosions. The test area is to be well ventilated to protect personnel from possible harmful fumes or gases.
- Temperature of the surface of the battery casing shall be monitored during the tests described above. All personnel involved in the testing of batteries are to be instructed never to approach a battery until the surface temperature returns to ambient temperature.
- Test shall be conducted in separate room or equipped with an adequate safety barrier separating the test area from observer.

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UL 9540 A – Definition

-"BATTERY ENERGY STORAGE SYSTEM (BESS)" - Stationary equipment that receives electrical energy and then utilizes batteries to store that energy to supply electrical energy at some future time. The BESS, at a minimum consists of one or more modules, a power conditioning system (PCS), battery management system (BMS) and balance of plant components.

NOTE: For flow battery systems the energy is stored within one or more electrolyte storage tanks.

a) INITIATING BATTERY ENERGY STORAGE SYSTEM UNIT (INITIATING BESS) – A BESS unit which has been equipped with resistance heaters in order to create the internal fire condition necessary for the installation level test (Section 9).
b) TARGET BATTERY ENERGY STORAGE SYSTEM UNIT (TARGET BESS) – The enclosure and/or rack hardware that physically supports and/or contains the components that comprise a BESS. The target BESS unit does not contain energy storage components, but serves to enable instrumentation to measure the thermal exposure from the initiating BESS.

-"BATTERY SYSTEM" - Is a component of a BESS and consists of one or more modules typically in a rack configuration, controls such as the BMS and components that make up the system such as cooling systems, disconnects and protection devices.

-"CELL" - The basic functional electrochemical unit containing an assembly of electrodes, electrolyte, separators, container, and terminals. It is a source of electrical energy by direct conversion of chemical energy.

-"DUT" - Device under test.

-"ELECTRICAL RESISTANCE HEATERS" - Devices that convert electrical energy supplied from a laboratory source into thermal energy.

-"END OF DISCHARGE VOLTAGE (EODV)" - The manufacturer's specified minimum voltage level during discharge.

-"ENERGY RESERVOIR" - The solution which stores the active energy in the flow battery energy storage system. This can be in the form of one electrolyte, two electrolytes, or one electrolyte with solid metal particles.

-"FLEXIBLE FILM HEATERS" - Electrical resistance heaters of a film, tape or otherwise thin sheet like construction that easily conform to the surface of cells.

-"FLOW BATTERY" - A battery technology that stores its active materials in the form of one or more electrolytes (with or without solid metal particles) within one or more storage tanks, and when operating, the electrolytes are transferred between the reactor (battery stacks) and the storage tanks

NOTE 1: Three commercially available flow battery technologies are zinc air, zinc bromine and vanadium redox.

NOTE 2: Unlike a fuel cell system, a flow battery is a closed system and has no net consumption of fuel.

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-"MAXIMUM SURFACE TEMPERATURE END POINT" - The final hold temperature measured on the cell case after conducting the thermal ramp when using the external heater method to achieve thermal runaway of the cell.

-"MODULE" - A subassembly that is a component of a BESS that consists of a group of cells or electrochemical capacitors connected either in a series and/or parallel configuration (sometimes referred to as a block) with or without protective devices and monitoring circuitry.

-"MONOBLOC" - A battery design with a common case containing one or more internal cells, electrolyte, a vent or pressure relief valve assembly, intercell connections and hardware. A typical example of a common monobloc battery is an SLI lead acid battery.

-"NON-RESIDENTIAL USE" - Intended for use in commercial, industrial or utility owned locations.

-"RESIDENTIAL USE" - In accordance with this standard, intended for use in one or two family homes and townhomes and individual dwelling units of multi-family dwellings.

-"STATE OF CHARGE (SOC)" - The available capacity in a BESS, pack, module or cell expressed as a percentage of rated capacity.

-"THERMAL RUNAWAY" - The incident when an electrochemical cell increases its temperature through self-heating in an uncontrollable fashion. The thermal runaway progresses when the cell's generation of heat is at a higher rate than the heat it can dissipate. This may lead to fire, explosion and gas evolution.

-"UNIT" - A frame, rack or enclosure that consists of a functional BESS which includes components and subassemblies such as cells, modules, battery management systems, ventilation devices and other ancillary equipment.

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Master Contract:	301698	Model:	IFP27175200A-100Ah	Page number 6 of 32
Project / Network:	80067595	Description:	Li-ion cell, LFP	

ANSI/CAN/UL 9540A:2019 Fourth Edition, Dated November 12, 2019 - Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems

Section	Requirement	Test (T) / Waive (W) / Not App. (N/A)	Comments
5	General		
5.1	Cell	T	Test Conducted
5.1.1	The cells associated with the BESS were tested.	---	Chemistry: Lithium Iron Phosphate (LFP) Physical Format: Prismatic Capacity (Ahr): 100 Energy (Whr): 320 Nominal Voltage (Vdc): 3.2 Approximate Dimension (mm): T*W*H: (27.2±0.5)mm*(175.4±0.3)mm*(200.3±0.3)mm Weight (g): 2022±60g
5.1.2	Cells associated with the BESS comply with UL 1973	---	See Attachment CSA Certificate of Cell_80067600 for cell certificate complying UL 1973 provided by manufacturer.
5.1.3	Cell level test report	---	See cell level test section below
5.2	Module	N/A	Module testing not requested by manufacturer
5.2.1	The module associated with the BESS were tested.	---	Module testing not requested by manufacturer
5.2.2	Modules associated with the BESS comply with UL 1973	---	Module testing not requested by manufacturer
5.2.3	Module level test report	---	Module testing not requested by manufacturer
5.3	Battery energy storage system unit	N/A	BESS testing not requested by manufacturer
5.3.1	BESS were tested.	---	BESS testing not requested by manufacturer
5.3.2	BESS comply with UL 9540	---	BESS testing not requested by manufacturer
5.3.3	Fire detection and suppression systems	---	BESS testing not requested by manufacturer
5.3.4	BESS test report	---	BESS testing not requested by manufacturer
5.4	Flow Batteries	N/A	EUT is not flow battery
5.4.1		---	EUT is not flow battery

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Master Contract:	301698	Model:	IFP27175200A-100Ah	Page number 7 of 32
Project / Network:	80067595	Description:	Li-ion cell, LFP	

Section	Requirement	Test (T) / Waive (W) / Not App. (N/A)	Comments
5.4.2	Flow battery comply with UL 1973	---	EUT is not flow battery
5.4.3	Flow battery thermal runaway determination level test report	---	EUT is not flow battery

Attachments		
No.	**Name**	**Page**
1	CSA Certificate of Cell_80067600	3

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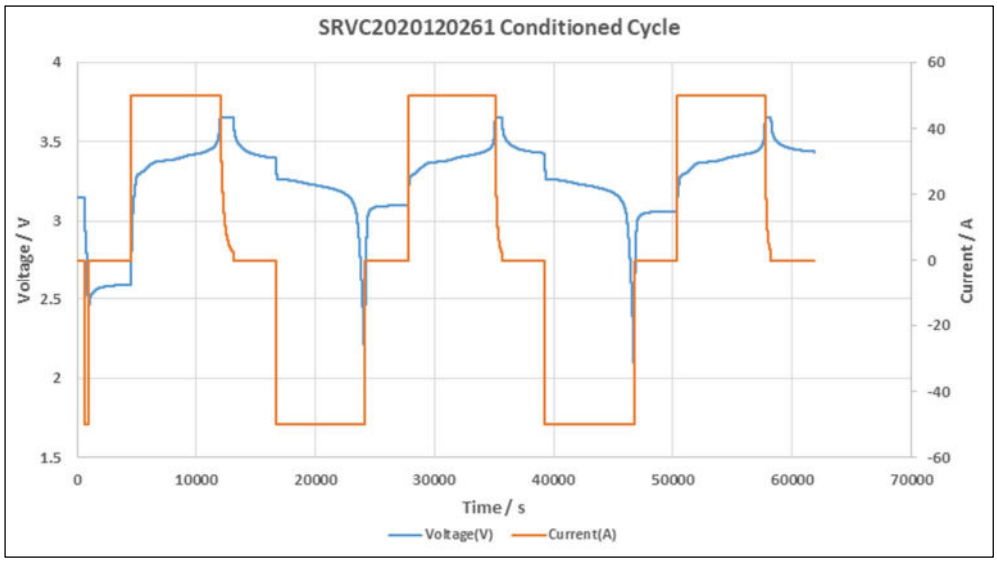
Master Contract:	301698	Model:	IFP27175200A-100Ah	Page number 8 of 32
Project / Network:	80067595	Description:	Li-ion cell, LFP	

ANSI/CAN/UL 9540A:2019 Fourth Edition, Dated November 12, 2019 - Section 7 Cell Level Testing

Section	Requirement	Comments
7	Cell Level Testing	
7.1	Test document effective methods for cell thermal runaway in a repeatable manner.	
7.2	Sample	
	Cell Sample conditioned for minimum 2 charge (100% SOC) - discharge (Specified end of discharge voltage) cycle as per manufacturer specified method.	Manufacturer recommended charge/discharge method: Charging Procedure: CC-CV Charging Voltage (V): 3.65 Charging Current (A): 50 Charging End Condition (A): 2.5 Discharging Procedure: CC Discharging Current (A): 50 End of Discharge Voltage (V): 2.0
	Total 5 fresh cell samples were visual checked before charging, and then subjected to a cycle of predischarge-charge-discharge-charge-discharge, and then final charged. The charge and discharge parameter were conducted in accordance with the manufacturer's cell specifications noted in clause 7.2 in page 8, cells were considedred fully charged by verifying the charge capacity at the end of the final charge cycle. See plot 1~5 for the charging profiles.	



Plot 1- Cell precondition data, Cell No. #1 (SRVC2020120261)

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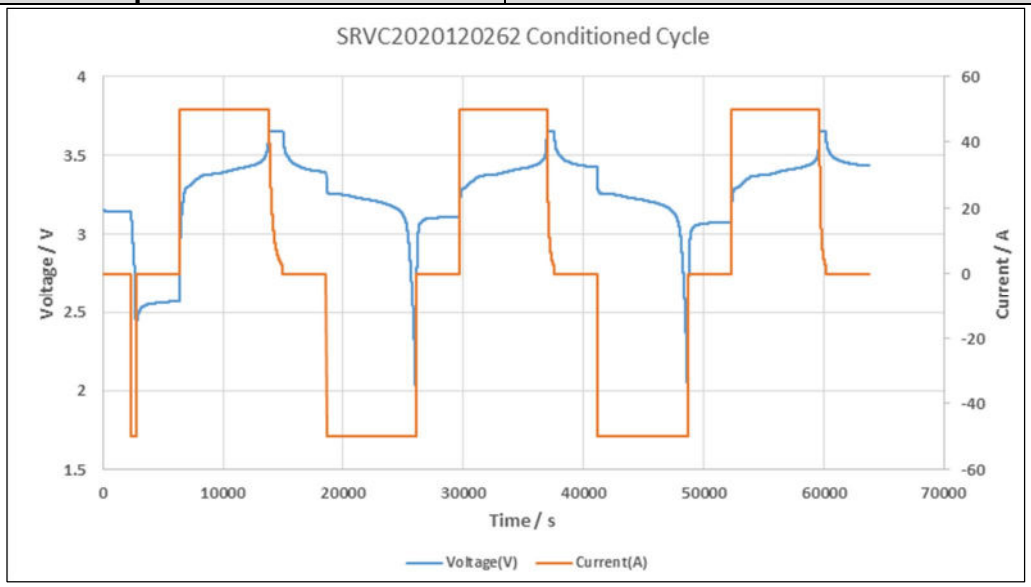
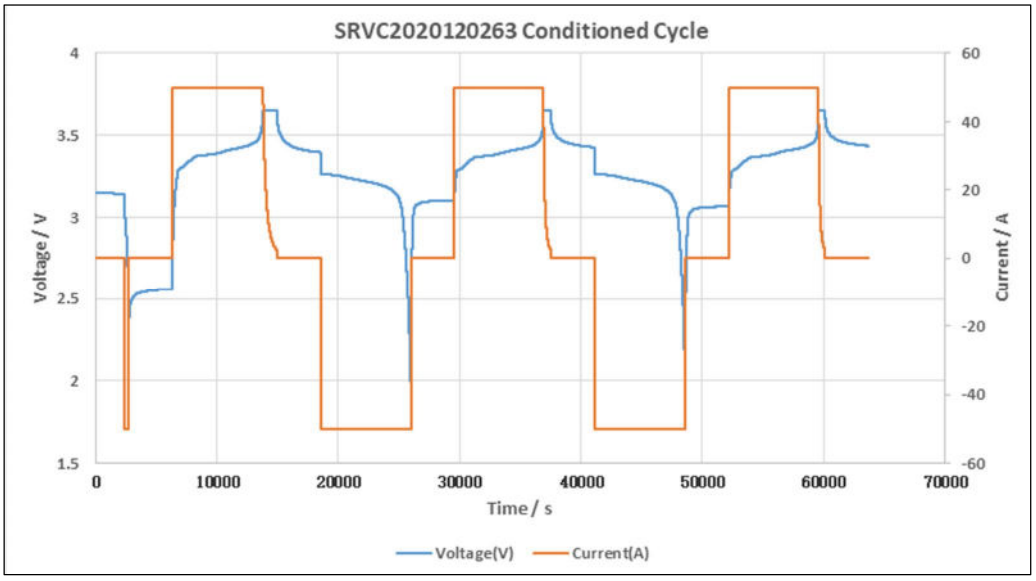
Master Contract:	301698	Model:	IFP27175200A-100Ah	Page number 9 of 32
Project / Network:	80067595	Description:	Li-ion cell, LFP	

Section	Requirement	Comments



Plot 2- Cell precondition data, Cell No. #2 (SRVC2020120262)



Plot 3- Cell precondition data, Cell No. #3 (SRVC2020120263)

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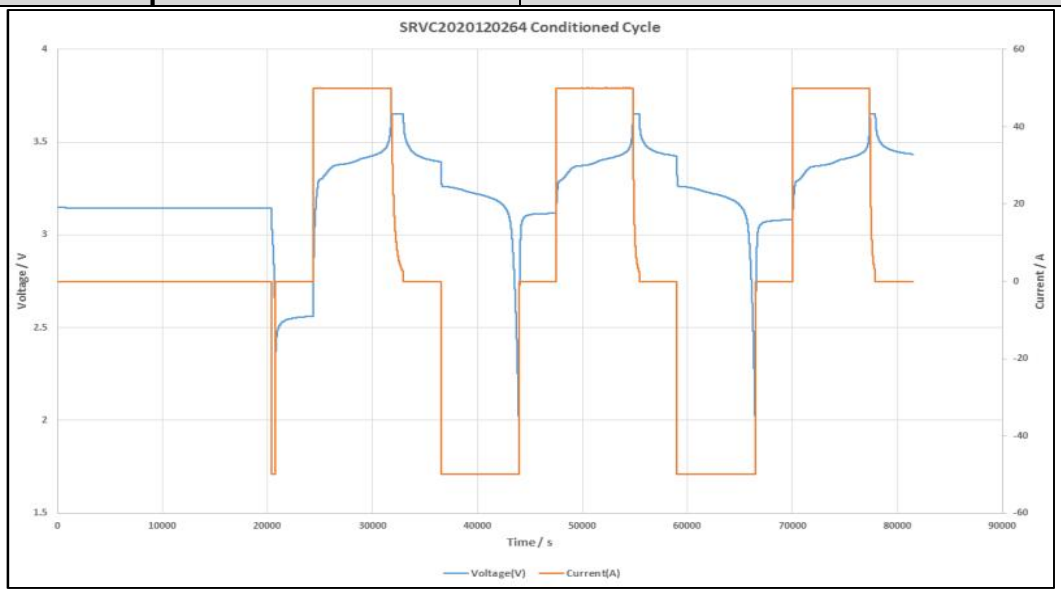
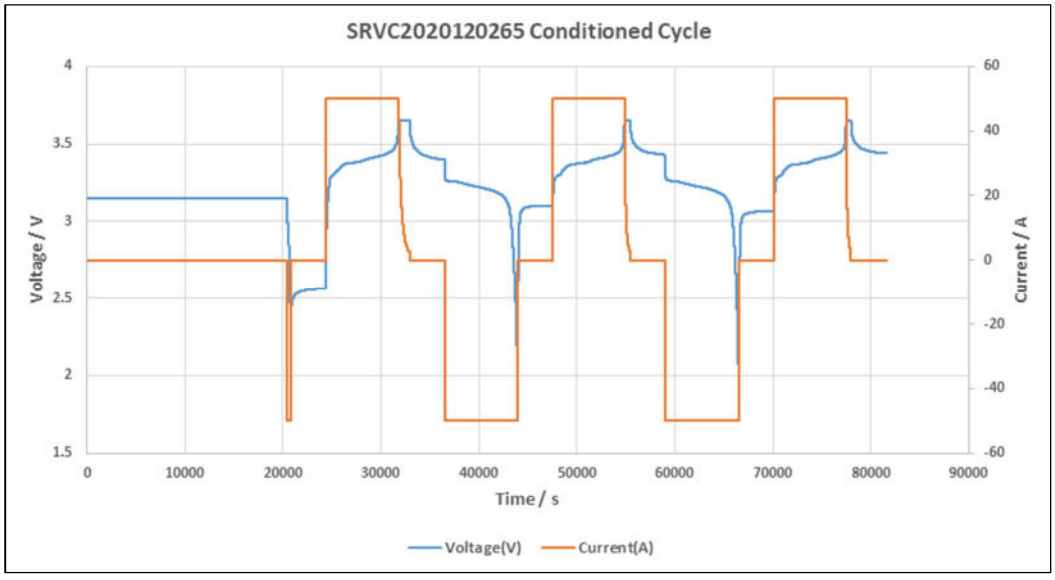
Master Contract:	301698	Model:	IFP27175200A-100Ah	Page number 10 of 32
Project / Network:	80067595	Description:	Li-ion cell, LFP	

Section	Requirement	Comments



Plot 4- Cell precondition data, Cell No. #4 (SRVC2020120264)



Plot 5- Cell precondition data, Cell No. #5 (SRVC2020120265)

During conditioning a relationship between open circuit voltage and SOC shall be determined through measurement of voltage and SOC

Sample Number	Cell charge capacity after final	Open Circuit Voltage after final

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Section	Requirement	Comments
		<table><tr><th></th><th>charge cycle (Ahr)</th><th>charge cycle (Vdc)</th></tr><tr><td>SRVC2020120261</td><td>104.096</td><td>3.437</td></tr><tr><td>SRVC2020120262</td><td>104.151</td><td>3.434</td></tr><tr><td>SRVC2020120263</td><td>104.187</td><td>3.436</td></tr><tr><td>SRVC2020120264</td><td>103.503</td><td>3.435</td></tr><tr><td>SRVC2020120265</td><td>103.884</td><td>3.439</td></tr></table>
	Cells under test are functional after charge discharge cycle.	☒ Conformed
	Ambient temperature during cell conditioning and during test……..……:	Temperature(ºC): 24.0 to 26.0 Humidity (% RH): 60% to 65%
	The tested cells have 100% SOC at the start of the test. The samples were allowed to stabilize for a minimum of one hour and a maximum of 8 h before the start of the test.	<table><tr><th>Sample Number</th><th>Final charge end time (Date and Time)</th><th>Test Start time (Date and Time)</th></tr><tr><td>SRVC2020120261</td><td>2020/12/29 7:34:41</td><td>2020/12/29 14:15:18</td></tr><tr><td>SRVC2020120262</td><td>2020/12/24 7:12:25</td><td>2020/12/24 14:32:06</td></tr><tr><td>SRVC2020120263</td><td>2020/12/25 7:36:32</td><td>2020/12/25 14:54:24</td></tr><tr><td>SRVC2020120264</td><td>2020/12/26 12:05:05</td><td>2020/12/26 16:12:00</td></tr><tr><td>SRVC2020120265</td><td>2020/12/27 12:50:55</td><td>2020/12/27 15:44:24</td></tr></table>
	Cells with flexible laminate casings - Constrained during the test in the manner that simulates the constraint in the BESS module to prevent excessive swelling during the test	☒ Conformed Prismatic, metal enclosure Li-ion cell
7.3	Ambient temperature during cell conditioning and during test……..……:	Temperature(ºC): 22.0 to 26.3 Humidity (% RH): 61% to 69%

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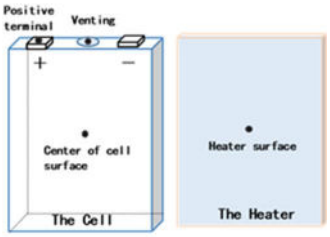
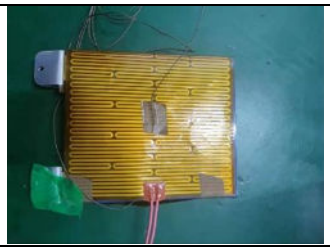
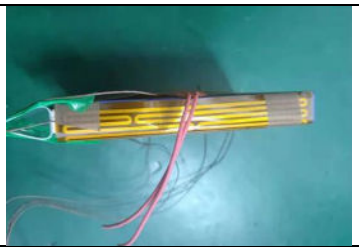
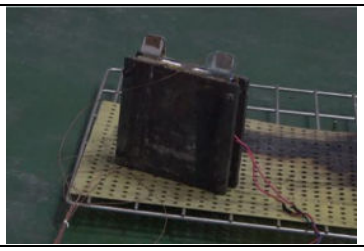
Master Contract:	301698	Model:	IFP27175200A-100Ah	Page number 12 of 32
Project / Network:	80067595	Description:	Li-ion cell, LFP	

Section	Requirement	Comments
	Propensity of cell to exhibit thermal runaway demonstrated by externally applied film heater	☒ Conformed Flexible thin film heater was used to exhibit thermal runaway testing simulation.
	See Figures indicated below for the heater and its instrument locations for testing setup：	
	 Fig 1a Top view of the DUT	 Fig 1b Side view of the DUT
	 Fig 2 thermocouple location	
	 Fig 3a heater instrumented on the cell	 Fig 3b heater instrumented on the cell
	 Fig 4 Completely cell assembly	
	Surface heating rate maintained at 4°C (7.2°F) to 7°C (12.6°F) per minute	☒ Conformed
	Alternate method used to exhibit thermal runaway	External heating method using flexible thin film heaters for testing.
	Monobloc battery treated as an individual cell for this testing.	☐ Conformed Li-ion cells.
	For Li-ion cells, the surface temperature hold point shall be between 5°C (9°F) and 15°C (27°F) greater than the melting temperature of the cell separator material.	See below.
	If melting temperature of the cell separator material is not available, temperature of film heater can be increased contiously without holding at certain temperature until thermal runaway as defined in standard observed.	☒ Conformed Temperature of film heater was increased contiously without holding at certain temperature.

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Section	Requirement	Comments
	Thermal runaway is not achievable by heating.	See above.
	Another external heating method used for thermal runaway.	☐ Conformed See above.
	Temperature measurement recorded using thermocouple junction formed from 24-gauge or smaller Type-K thermocouple wire.	☒ Conformed 30 AWG type K thermocouple with fiber glass sheath was used for temperature measurement, the thermocouple location was noted as below: - Positive terminal - Venting - Center of cell surface - Heater surface - Center of cell surface - Ambient Refer to Fig.2 for the thermocouple instrument location.
	The thermocouple located below the heater film at the center of the cell surface is used for temperature measurement at which 1. Cell case vents due to internal pressure rise. 2. Cell exihibits thermalrunaway.	☒ Conformed
	With other stress methods, it will be necessary to continue applying the stress until thermal runaway occurs.	☐ Conformed See above
	Rapid increase in temperature observed during testing.	☒ Conformed

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Section	Requirement	Comments

Section 7.2	TABLE: Determination of thermal runaway methodology				
Sample No	**Open Circuit Voltage Before Test (Vdc)**	**Cell Failure method**	**Cell Surface Temperature at which gases are first vented (ºC)**	**Cell Surface Temperature prior to thermal runaway (ºC)**	**Location of Maximum Temperature prior to thermal runaway**
SRVC2020120262	3.572	Thin film heating	190.6	260.8	Cell surface under heater
SRVC2020120263	3.504	Thin film heating	186.4	264.0	Cell surface under heater
SRVC2020120264	3.417	Thin film heating	187.4	260.9	Cell surface under heater
SRVC2020120265	3.423	Thin film heating	188.0	248.9	Cell surface under heater
Average measurement	N/A	N/A	188.1	258.65	N/A

Supplementary information:

Thermal Runaway Verification

Thermal runaway was forced on all four cells using external heating method. 1 flexible thin film heater, rated 10ohm resistance and 480W heating power, was wrapped on the two larger surfaces and the two narrow surfaces of the cell, with K type thermocople wires located in page 13 for testing. The heating rate was maintained within 4~7°C by adjusting the input current of the heaters, the average cell temperature at point of venting and the onset temperature of thermal runaway was noted in the above table in page 14.

Thermal Runaway Test Results Demonstrated by External Heating

Table below indicated the thermal runaway test results for cell SRVC2020120262 (#2):

Table 1 Thermal Runaway Test Results	
Test Date and Time	2020/12/24 14:32:06
Venting Time(hh:mm:ss)	15:12:21
Venting Temperature/ºC	190.6
Thermal Runaway Time(hh:mm:ss)	15:23:01
Thermal Runaway Temperature/ºC	260.8

Plot 6 shows the surface temperature measured during the test, cell venting and thermal runaway was observed, visual inspection for cell samples before and after tests was conducted, Figure 5a)~5c)

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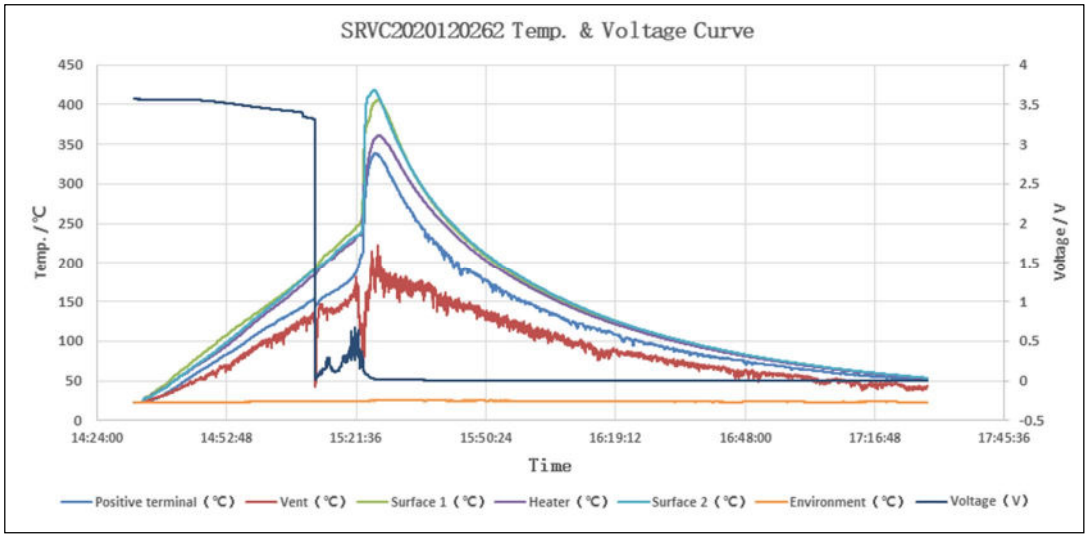
indicates indicates the sample forced venting and during thermal runaway, Figure 6a)~6b) indicates the samples after thermal runaway.



Plot 6 Surface Temperature and Voltage Measured on Cell No. #2

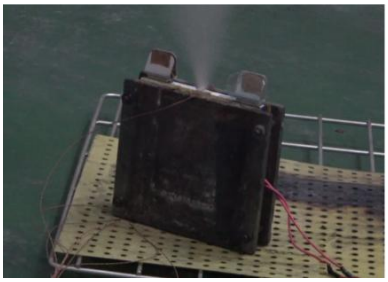


Fig 5a cell first vent

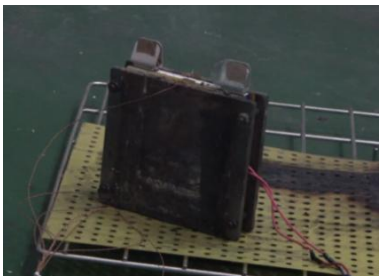


Fig 5b cell after vent

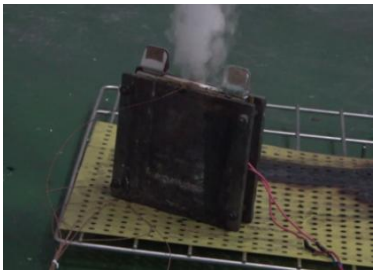


Fig 5c cell during TR

Fig. 6a cell after testing

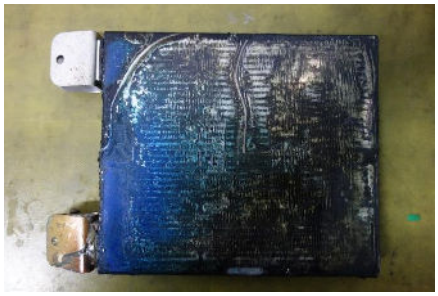


Fig. 6b cell after testing

Table below indicated the thermal runaway test results for cell SRVC2020120263(3#):

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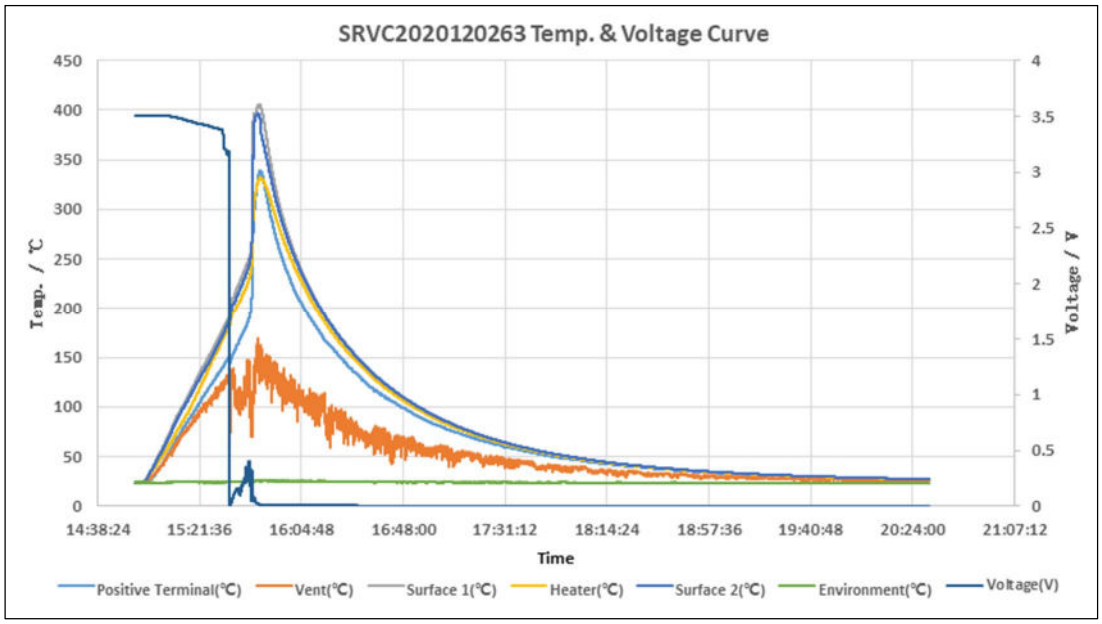
Section	Requirement	Comments

Table 2 Thermal Runaway Test Results	
Test Date and Time	2020/12/25 14:54:24
Venting Time(hh:mm:ss)	15:33:57
Venting Temperature/ºC	186.4
Thermal Runaway Time(hh:mm:ss)	15:43:41
Thermal Runaway Temperature/ºC	264.0

Plot 7 shows the surface temperature measured during the test, cell venting and thermal runaway was observed, visual inspection for cell samples before and after tests was conducted, Figure 7a)~7c) indicates indicates the sample forced venting and during thermal runaway, Figure 8a)~8b) indicates the samples after thermal runaway.



Plot 7 Surface Temperature and Voltage Measured on Cell No. #3

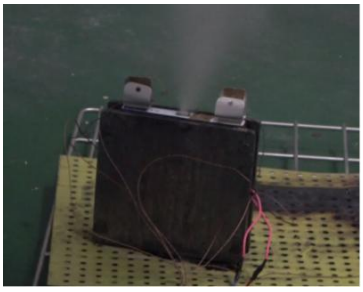


Fig 7a cell first vent

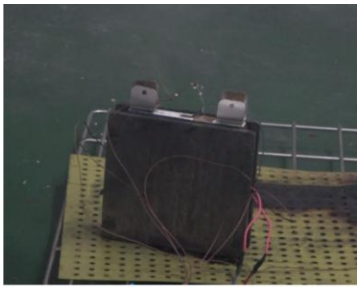


Fig 7b cell after vent

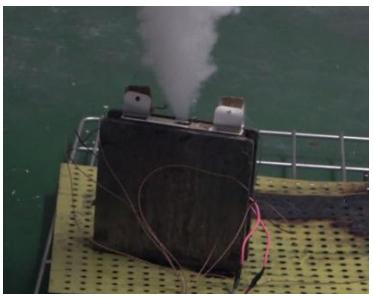


Fig 7c cell during TR

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Section	Requirement	Comments

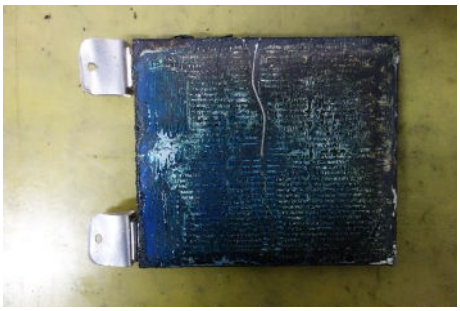

Fig 8a cell after test

Fig 8b cell after test

Table below indicated the thermal runaway test results for cell SRVC2020120264(4#):

Table 3 Thermal Runaway Test Results	
Test Date and Time	2020/12/26 16:12:00
Venting Time(hh:mm:ss)	16:55:16
Venting Temperature/ºC	187.4
Thermal Runaway Time(hh:mm:ss)	17:06:41
Thermal Runaway Temperature/ºC	260.9

Plot 8 shows the surface temperature measured during the test, cell venting and thermal runaway was observed, visual inspection for cell samples before and after tests was conducted, Figure 9a)~9c) indicates indicates the sample forced venting and during thermal runaway, Figure 10a)~10b) indicates the samples after thermal runaway.

The results relate only to the items tested.
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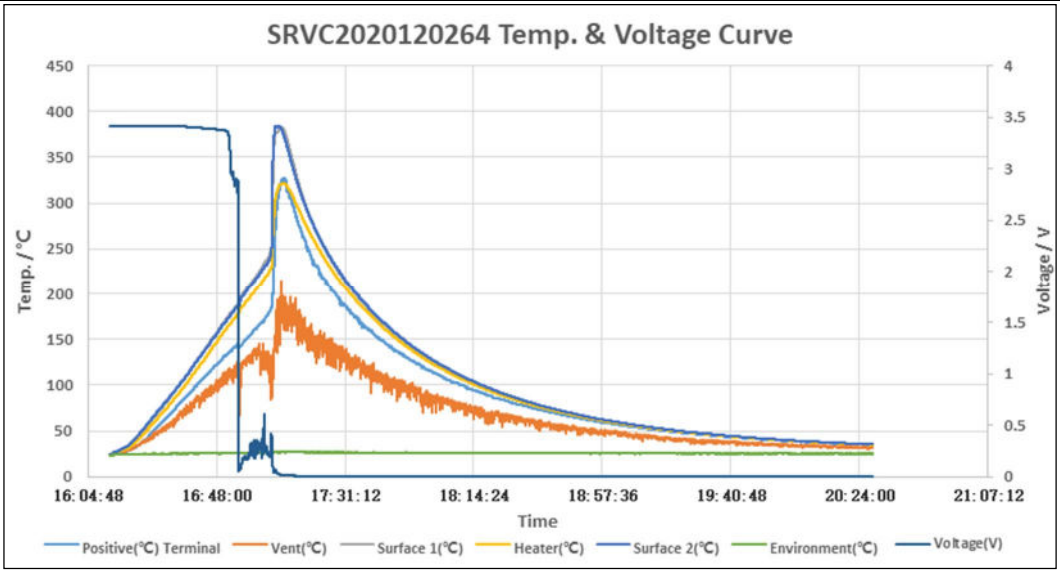

Plot 8 Surface Temperature and Voltage Measured on Cell No. #4

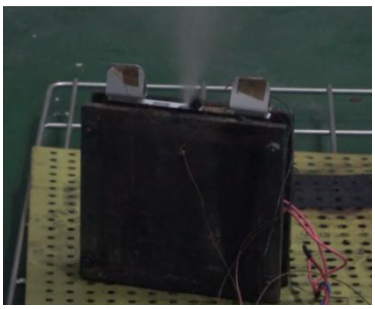

Fig 9a cell first vent

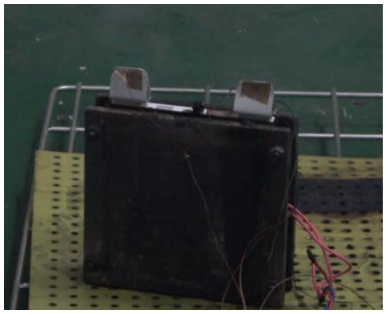

Fig 9b cell after vent

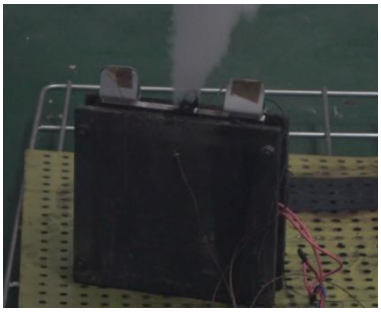

Fig 9c cell during TR

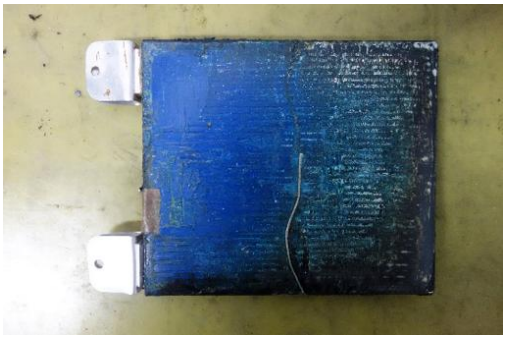

Fig 10a cell after test

Fig 10b cell after test

Table below indicated the thermal runaway test results for cell SRVC2020120265(5#):

The results relate only to the items tested.
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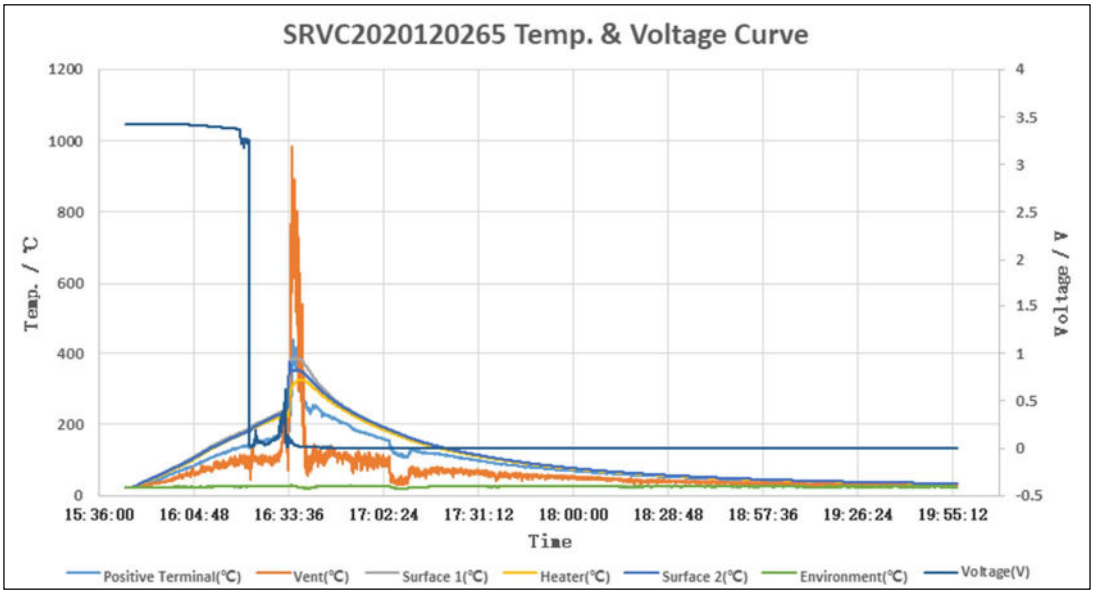
Section	Requirement	Comments

Table 4 Thermal Runaway Test Results	
Test Date and Time	2020/12/27 15:44:24
Venting Time(hh:mm:ss)	16:21:35
Venting Temperature/°C	188.0
Thermal Runaway Time(hh:mm:ss)	16:33:31
Thermal Runaway Temperature/°C	248.9

Plot 9 shows the surface temperature measured during the test, cell venting and thermal runaway was observed, visual inspection for cell samples before and after tests was conducted, Figure 11a)~11c) indicates indicates the sample forced venting and during thermal runaway, Figure 12a)~12b) indicates the samples after thermal runaway.



Plot 9 Surface Temperature and Voltage Measured on Cell No. #5

Fig 11a cell first vent

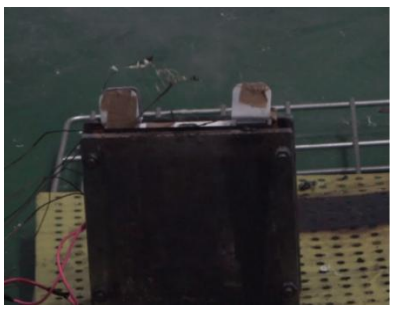


Fig 11b cell after vent

Fig 11c cell during TR

The results relate only to the items tested.
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Section	Requirement	Comments

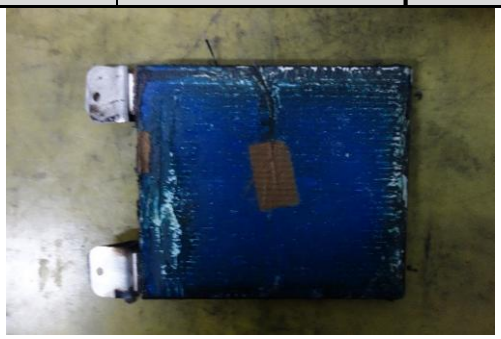

Fig 12a cell after test

Fig 12b cell after test

Weight Loss Measurement

The weight of the DUT before and after test was measured, and the results was recorded as below:

Sample No.	Weight before testing(g)	Weigh after testing(g)	Weight Loss(g)
SRVC2020120262	2082.5	1655.9	426.6
SRVC2020120263	2077.1	1649.1	428.0
SRVC2020120264	2070.2	1651.6	418.6
SRVC2020120265	2074.2	1652.4	421.8
SRVC2020120261	2080.6	1657.4	423.2

Date Start: 20/12/23 (YY/MM/DD)
Date End: 20/12/29 (YY/MM/DD)

7.4	Cell vent gas composition test	
	Cell vent gas generated and captured inside an 82-L (21.7-gal) pressure vessel; or	☒ Conformed See below
	Other known volume chamber.	☒ Conformed. Pressure Vessel Volum (L): 58.2
	Cell vent gas composition determined using following method.	
	1. Gas Chromatography (GC) with detection techniques for quantifying component gases, or	☒ Conformed Gas Chromatography (GC) with detector TCD and FID for quantifying component gases.
	2. Equivalent gas analysis techniques	☒ Conformed See above

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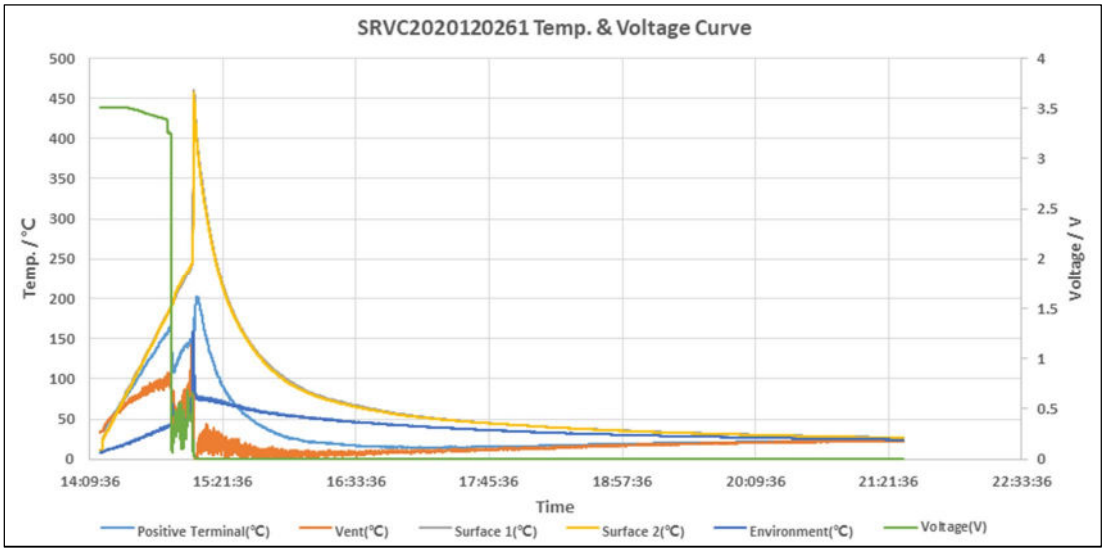
	Hydrogen gas was measured with a sensor capable of measuring in excess of 30% by volume.	☒ Conformed GC-TCD was used for quantifying Hydrogen gases, which was able to capture hydrogen gas in excess of 30% by volume.
	lower flammability limit of the cell vent gas shall be determined in accordance with ASTM E918, testing at both ambient and cell vent temperatures.	☒ Conformed LFL of the cell vented gas was evaluated in accordance to the standard ASTME918 at both ambient and cell vent temperature.
	Gas burning velocity in accordance with the Method of Test for Burning Velocity Measurement of Flammable Gases Annex in ISO 817.	☒ Conformed See test results noted below
	P_{max} in accordance with EN 15967	☒ Conformed See test results noted below
	 Plot 10 Surface Temperature and Voltage Measured on Cell No. #1	

The results relate only to the items tested.
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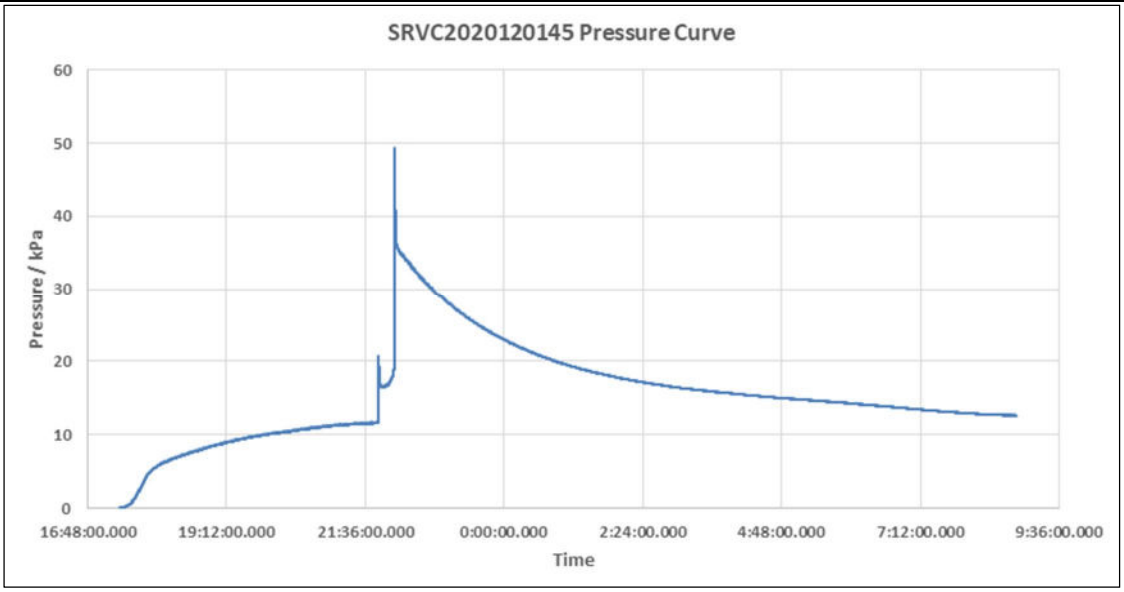

Plot 11 Pressure VS time for Cell No. #1 inside the vessel

Fig. 13 Vessel for gas collection

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Section	Requirement	Comments
	 Fig. 14a cell after test	 Fig. 14b cell after test

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Section 7.4	**TABLE: Cell vent gas composition test**
Sample No	SRVC2020120261
Open Circuit Voltage Before Test (Vdc):	3.425
Cell Failure Method:	External heating using thin film heater
Pressure Vessel Volume (liter):	58.2L
An Initial Condition of Atmospheric Pressure (kPa):	0.091kPa (relative pressure)
An Initial Condition of Oxygen by Volume (%):	0.26%
LFL limit at Ambient Temperature (%):	6.6% at 22(±2) ºC and 101(±3)kPa
LFL limit at Cell Vent Temperature (%):	5.6% at 188(±4) ºC and 101(±4)kPa
Gas Burning Velocity (cm/sec):	0.836m/s at room temperature and atmospheric pressure.
P_{max} (kPa):	1.57MPa at 26(±3) ºC and 101(±3)kPa

Gas Composition

Gas Component	Gas Type	Volume Released (After thermal runaway) (Milliliters)
Methane	Hydrocarbons	1543.08
Ethylene	Hydrocarbons	1015.36
Acetylene	Hydrocarbons	46.76
Ethane	Hydrocarbons	320.64
Propane	Hydrocarbons	200.4
Propylene	Hydrocarbons	213.76
C4*	Hydrocarbons	414.16
Carbon Dioxide	Carbon Containing	12545.04
Carbon Monoxide	Carbon Containing	2718.76
Hydrogen	-	17742.08
Total Hydrocarbons (% propane)	Hydrocarbon	3754.16

Note: C4* include n-C4H10, N-C4H8, C4H6, trans-C4H8, cis-C4H8, where N-C4H8 makes up the maximum volume concentration in the total C4* gases.

The results relate only to the items tested.
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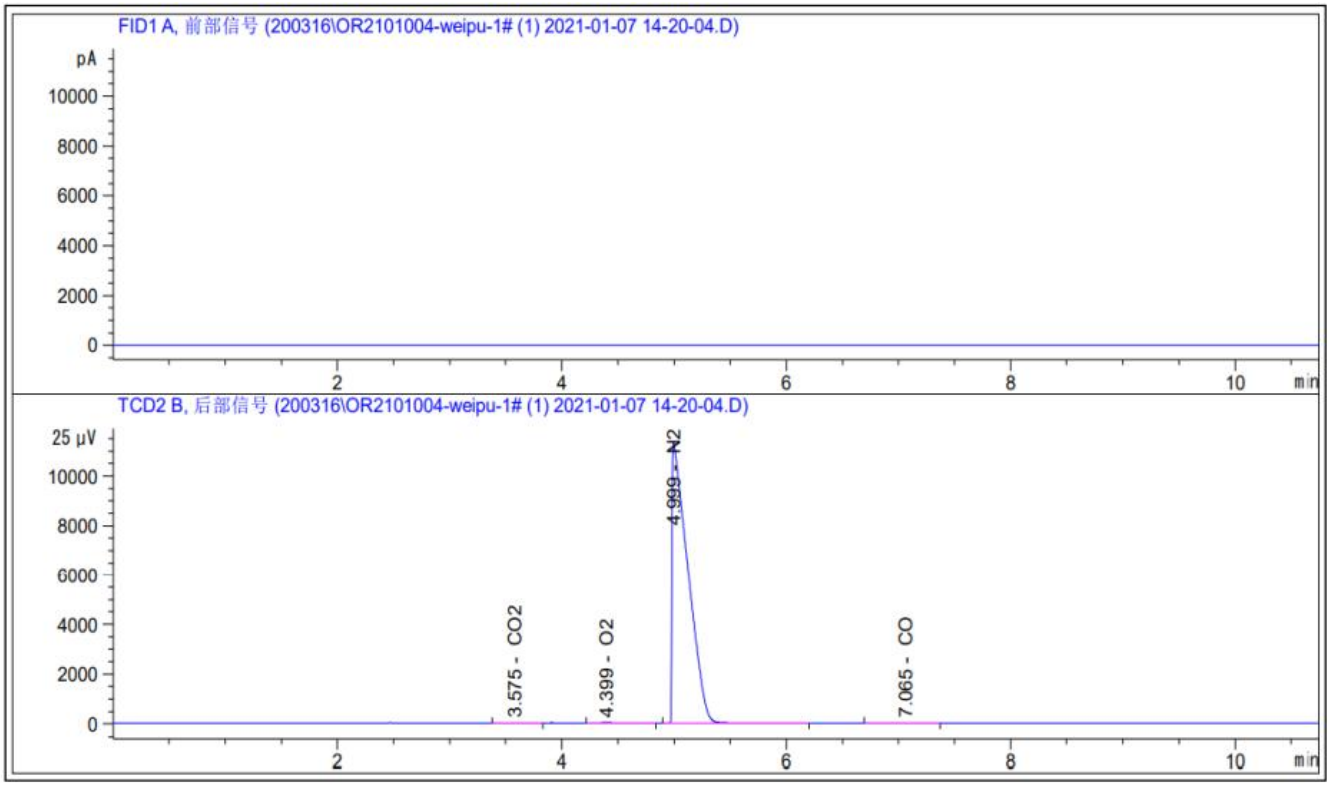
Supplementary information:

One fully charged cell sample SRVC2020120261 was forced into thermal runaway using the same method as the cell thermal runaway verification, test was conducted in an 58.2 L pressure vessel. Temperature and voltage for the cell was monitored, the gases released was collected and analyzed, the result was noted as below:



Plot 12 GC Spectrum for gas composition collected before test

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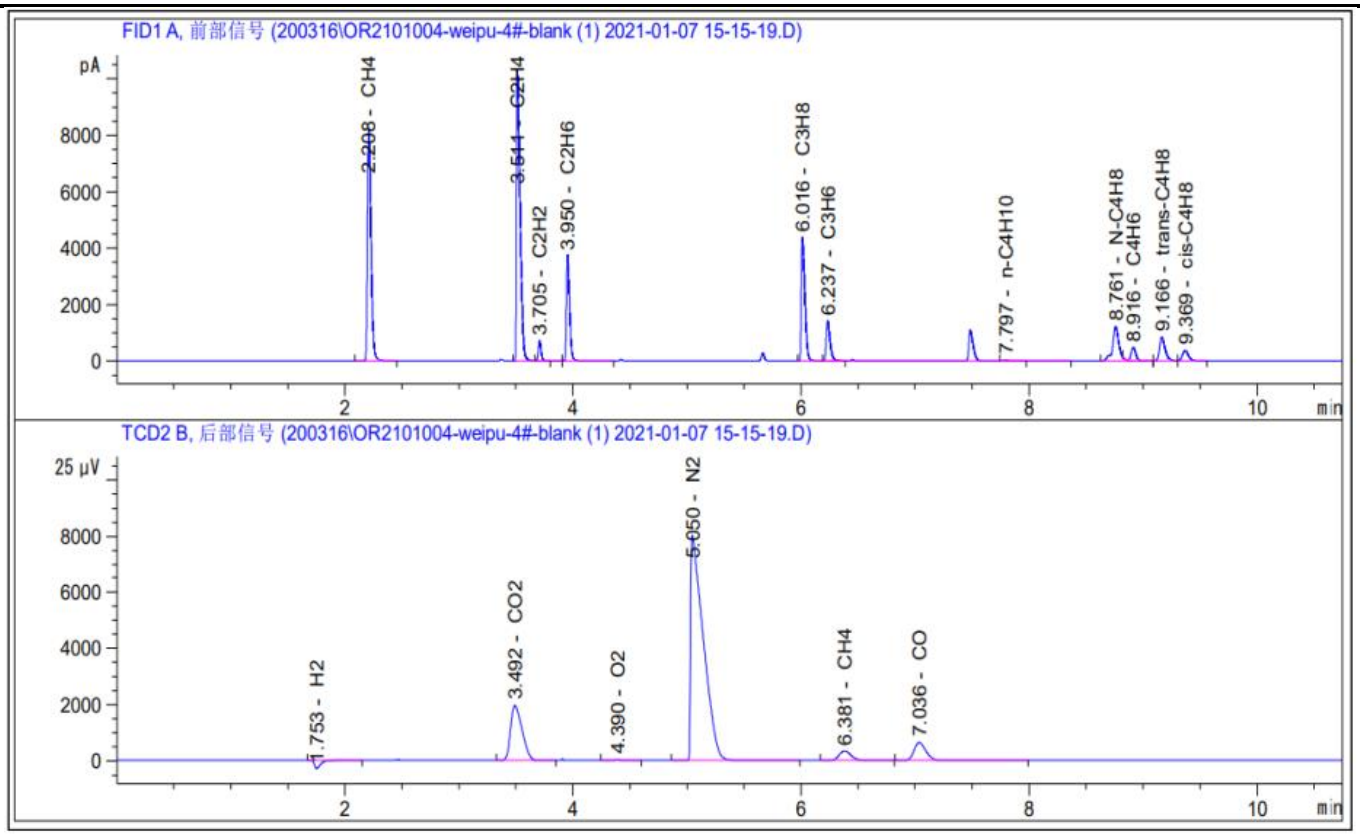

Plot 13 GC Spectrum for gas composition collected during test

Gas quantification including O2 and N2:

Gas Sample No.	21014020-2	
Gas Component	Chemical Fomula	Concentration, %
Oxygen	O2	0.13%
Nitrogen	N2	44.86%
Carbon Dioxide	CO2	18.78%
Carbon Monoxide	CO	4.07%
Hydrogen	H2	26.56%
Methane	CH4	2.31%
Ethylene	C2H4	1.52%
Acetylene	C2H2	0.07%
Ethane	C2H6	0.48%
Propane	C3H8	0.30%
Propylene	C3H6	0.32%
C4*	See Note	0.62%
Note: C4* include n-C4H10, N-C4H8, C4H6, trans-C4H8, cis-C4H8, where N-C4H8 makes up the maximum volume concentration in the total C4* gases.		

The results relate only to the items tested.
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Gas quantification excluding O2 and N2:

Gas Sample No.	20212901-2	
Gas Component	Chemical Fomula	Concentration, %
Carbon Dioxide	CO2	34.13%
Carbon Monoxide	CO	7.40%
Hydrogen	H2	48.26%
Methane	CH4	4.20%
Ethylene	C2H4	2.76%
Acetylene	C2H2	0.13%
Ethane	C2H6	0.87%
Propane	C3H8	0.55%
Propylene	C3H6	0.58%
C4*	See Note	1.13%
Note: C4* include n-C4H10, N-C4H8, C4H6, trans-C4H8, cis-C4H8, where N-C4H8 makes up the maximum volume concentration in the total C4* gases.		

Approximately 55.01% of the gas mass is accounted for in the testing, the remainder of the gases are air components (N2, O2), which makes up 44.99% by volume.

Synthesis method was used for preparing the gas mixtures in accordance with the above gas composition and concentration identified.

Total Gas Volume Released(L): approximately 66.8L(STP)

Lower Flammability Level Testing

The results for lower flammability level testing was conducted in accordance with the requirement of ASTM E918: 2019 at both ambient and cell venting temperature, and the results were indicated as below:
Measured LFL at ambient: 6.6% at 22(±2)ºC and 101(±3)kPa
Measured LFL at venting temperature: 5.6% at 188(±4)ºC and 101(±4)kPa

Test data for Gas mixture LFL at ambient temperature:

The results relate only to the items tested.
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No.	c_s [%]	T_i [℃]	p_i [kPa]	p_{ex} [kPa]	p_{ex}/p_i	Ignition?
1	6.9	21.6	103.7	114.1	1.10	Y
2	6.7	21.0	101.0	111.1	1.10	Y
3	6.5	21.1	101.1	103.3	1.02	N
4	6.5	22.0	100.8	103.3	1.02	N
5	6.5	23.4	102.1	105.8	1.04	N

Result	L_1=6.7%, L_2=6.5%, LFL=6.6% at 22(±2)℃ and 101(±3)kPa .
Remark	The symbols used in this Attached Table are defined as below: L_1 ——The minimum sample concentration that gives flame propagation; L_2 ——The maximum sample concentration that does not give flame propagation; LFL is expressed as: LFL = $(L_1 + L_2)/2$ It is considered explosion occurred, if $p_{ex}/p_i \geq 1.07$.

Test data for Gas mixture LFL at venting temperature: 188(±4)ºC:

The results relate only to the items tested.
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No.	c_s [%]	T_i [℃]	p_i [kPa]	p_{ex} [kPa]	p_{ex}/p_i	Ignition?
1	5.9	188.1	104.3	120.6	1.16	Y
2	5.7	184.6	103.5	117.5	1.14	Y
3	5.5	191.9	101.1	103.2	1.02	N
4	5.5	189.2	104.7	105.5	1.01	N
5	5.5	189.6	103.5	108.5	1.05	N

Result	L_1=5.7%, L_2=5.5%, LFL=5.6% at 188(±4)℃ and 101(±4)kPa .
Remark	The symbols used in this Attached Table are defined as below: L_1 ——The minimum sample concentration that gives flame propagation; L_2 ——The maximum sample concentration that does not give flame propagation; LFL is expressed as: LFL = $(L_1 + L_2)/2$ It is considered explosion occurred, if $p_{ex}/p_i \geq 1.07$.

Gas Burning Velocity Test:

Gas burning velocity test was conducted in a glass vessel(Internal diameter: 40mm, Length: 150mm), the equipment was verified using the refrigerant R32 before testing the gas mixtures. Gas mixture test results and test data was indicated as below:
Su =0.836m/s at room temperature and atmospheric pressure.

The results relate only to the items tested.
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No.	c_s [%]	S_s [m/s]	a_f/A_f /	S_u [m/s]
1.	20.1	0.900	0.483	0.434
2.	23.0	1.125	0.554	0.623
3.	24.0	1.425	0.486	0.692
4.	25.0	1.800	0.464	0.836
5.	26.0	1.650	0.479	0.791
6.	27.1	1.500	0.496	0.743
7.	28.0	1.500	0.480	0.720
8.	30.1	1.275	0.473	0.602

Result	S_u= 0.836 m/s at room temperature and atmosphere pressure.
Remark	The symbols used in this report are defined as below except otherwise defined: S_s —— Flame propagation speed, a_f —— Cross-sectional area of flame bottom, A_f —— Flame surface area, S_u is calculated as $S_u = S_s \times \frac{a_f}{A_f}$. Refer to ISO 817-2014, Article C.5.1.1. The total relative uncertainty of the burning velocity measurements as described in this International Standard is estimated between 7 % and 10 % and is due: a) primarily to uncertainties in the flame front area calculation (65 % of the total uncertainty), and b) the flame propagation speed measurement (35 % of the total uncertainty).

Maximum Explosion Pressure Testing

Test was conducted in a 5L closed sphere test vessel, using fuse wire as the ignition system, in accordance with the requirement of EN 15967:2011, the test results and test data was noted in below table:
Pmax=1.57MPa at 26(±3) ºC and 101(±3)kPa

The results relate only to the items tested.
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序号 No.	c_s [%]	$p_{ex,1}$ [MPa]	$p_{ex,2}$ [MPa]	$p_{ex,3}$ [MPa]	$p_{ex,4}$ [MPa]	$p_{ex,5}$ [MPa]	p_{mean} [MPa]
1.	15.0	0.433	/	/	/	/	0.433
2.	21.0	1.153	0.933	0.762	1.107	/	0.989
3.	22.0	1.223	0.930	0.977	/	/	1.043
4.	23.0	1.091	1.015	1.174	0.812	1.284	1.075
5.	24.0	1.336	1.024	1.336	1.573	1.304	1.315
6.	25.0	1.553	1.349	1.404	1.311	0.966	1.316
7.	25.2	1.072	1.362	1.070	1.203	1.250	1.191
8.	26.0	0.988	0.665	0.786	1.224	1.095	0.951
9.	28.0	0.878	0.934	0.847	/	/	0.886
10.	30.0	0.670	0.807	/	/	/	0.739

Attached Table 10 (continued) is on the next page.

The results relate only to the items tested.
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Master Contract:	301698	Model:	IFP27175200A-100Ah	Page number 32 of 32
Project / Network:	80067595	Description:	Li-ion cell, LFP	

序号 No.	c_s [%]	p_{lowest} [MPa]	$p_{highest}$ [MPa]	p_{mean} [MPa]	$p_{ex,max}$ [MPa]
1.	21.0	0.762	1.153	0.989	1.15
2.	22.0	0.930	1.223	1.043	1.22
3.	23.0	0.812	1.284	1.075	1.28
4.	24.0	1.024	1.573	1.315	1.57
5.	25.0	0.966	1.553	1.316	1.55
6.	25.2	1.070	1.362	1.191	1.36
7.	26.0	0.665	1.224	0.951	1.22
8.	28.0	0.847	0.934	0.886	0.93
9.	30.0	0.670	0.807	0.739	0.81

Reference Information for the Results

Content of flammable substance	24.0% volume
Smallest flammable substance content increment	0.2% volume
Maximum explosion pressure	1.57MPa

Result	p_{max}=1.57MPa at 26(±3)℃ and 101(±3)kPa.
Remark	The symbols used in this report are defined as below except otherwise defined: $p_{ex,n}$ —— p_{ex} in different trials at a certain concentration, $p_{ex,max}$ ——The maximum value of all the $p_{ex,n}$ at a certain concentration, p_{mean} ——The average value of all the $p_{ex,n}$ at a certain concentration, p_{lowest} ——Lowest explosion pressure in 5 (resp. 3) tests, $p_{highest}$ ——Highest explosion pressure in 5 (resp. 3) tests. p_{max} is expressed as the maximum value of $p_{ex,max}$.

Date Start: 21/01/05 (YY/MM/DD)
Date End: 21/06/02 (YY/MM/DD)

End of Report….