Number of pages in this package _13_ ~~[including additional pages ____]~~
~~(Fill in when using printed copy as record)~~

CLIENT INFORMATION	
Company Name	Samsung Sdi Co Ltd
Address	467 BEONYEONG-RO SEOBUK-GU CHEONAN-SI, CHUNGCHEONGNAM-DO 31086, REPUBLIC OF KOREA

AUDIT INFORMATION:				
Description of Tests	Per Standard No.	UL 1642	Edition/ Revision Date	Fifth/ 2015-06-23
		~~UL 2580~~		~~Third/ 2020-04-01~~
[X] Tests Conducted by[1]	Dick Wu			
[ ] UL Staff conducting or witnessing testing (WTDP, CTF Stage 1 or 2 only) **[ ]** UL Staff supervising UL Staff in training				
[ ]Authorized Signatory (CTDP, TPTDP, TCP, PPP, CTF Stage 3 or 4)	Printed Name		Signature. Include date for CTDP, TPTDP, TCP, PPP, CTF Stage 3 or 4	
Reviewed and accepted by qualified Project Handler	SunMe Lee Printed Name		SunMe Lee Signature	

TESTS TO BE CONDUCTED:

Test No.	Done[3]	Test Name	**[X]** Comments/Parameters **[ ]** Tests Conducted by[2] **[ ]** Link to separate data files[4]
1	X	HEATING TEST:	INR21700-50E++* Capacity: 4900mAh Sample 1~5 is charged at upper temperature limit+5 (65°C) to upper limit charging voltage 4.25V

* Note: '++' mark placed after model name means that tested cell may have an optional single alphanumeric suffix or blank in commercial use.

Instructions -
1 - When all tests are conducted by one person, name can be inserted here instead of including name on each page containing data.

2 - When test conducted by more than one person, name of person conducting the test can be inserted next to the test name instead of including name on each page containing data. Test dates may be recorded here instead of entering test dates on the individual datasheet pages.
3 - Use of this field is optional and may be employed differently. If used to include a date instead of entering the testing date on the individual datasheet pages, the date shall be the date the test was conducted.
4 – Link to separate data files for a test can be inserted here. The link must be to a server that is accessible to UL staff, that provides for backup, required retention periods and a path, including file name, that does not change and result in a broken link. Not applicable to DAP.

Special Instructions -

[X] Unless specified otherwise in the individual Methods, the tests shall be conducted under the following ambient conditions. Confirmation of these conditions shall be recorded at the time the test is conducted.

Ambient Temperature, °C	20±5	Relative Humidity, %	±	Barometric Pressure, mBar	±

[ ] No general environmental conditions are specified in the Standard(s) or have been identified that could affect the test results or measurements.

RISK ANALYSIS RELATED TO TESTING PERFORMANCE:

The following types of risks have been identified. Take necessary precautions. This list is not all inclusive.

[X] Electric shock	**[ ]** Radiation
[ ] Energy related hazards	**[X]** Chemical hazards
[X] Fire	**[ ]** Noise
[X] Heat related hazards	**[ ]** Vibration
[ ] Mechanical	**[X]** Other (Specify)__Explosion

Top off Parameters:

The following parameters shall be utilized in order to “top off” the cell so that it is in the fully charged state prior to testing.

Model	Top Off Parameters		
	Charge Voltage, Vdc	Charge Current, mA	Cut Off Current*/~~Time,~~ mA/~~min,~~
INR21700-50E++	4.2V	2450mA	98mA
* - If not provided, standard value is 0.05C.			

Ambient Conditions:

Unless specified otherwise in the individual Methods, the tests shall be conducted under the following ambient conditions. Confirmation of these conditions shall be recorded at the time the test is conducted.

Ambient Temperature, °C	Relative Humidity, %	Barometric Pressure, mBar
20 ± 5	N/A	N/A

Tables are provided on the data sheets for recording of maximum temperature data. Attach temperature chart when temperature variation during the course of measurement is greater than 5 °C.

Safety Precautions When Conducting Testing -_

Follow all battery SOPs when handling, testing, storing or disposing of battery samples. Follow appropriate procedures to prevent inadvertent shorting of battery and cell terminals during handling, storage and disposal of batteries. Follow MSDS sheets and battery SOPs when handling batteries where there is evidence of electrolyte leakage.

Some lithium batteries are capable of exploding when subjected to battery tests. It is important that personnel be protected from the flying fragments, explosive force, fire and sudden release of heat and noise that results from such explosions.

The test area is to be well ventilated to protect personnel from possible harmful fumes or gases that may be emitted during battery testing.

As an additional precaution, the temperatures on the surface of the battery casings shall be monitored during testing with the exception of the projectile test. All personnel involved in the testing of lithium batteries are to be instructed never to approach a lithium battery while the surface temperature exceeds 90°C (194°F) and not to touch the lithium battery while the surface temperature exceeds 45°C (113°F)

For protection, the projectile test is to be conducted in a room separate from the observer.

When testing large format lithium cells such as large liquid cathode primary cells or large lithium ion cells (i.e. ≥ 10 Ah), the cells shall be isolated during testing as noted in the test methods to prevent an out of control event due to multiple cell failures.

IMPORTANT TEST PARAMETERS:	
CELL:	
Cell Manufacturer	Samsung SDI Co Ltd
Cell Model	INR21700-50E++
Cell Type	Rechargeable Lithium Ion Cylindrical
PTC or other current/ thermal protection	N/A
Capacity	4900mAh
Standard Charging Current	2450mA
Standard Full Charging Voltage	4.2Vdc
End of Charging Current	98mA
Maximum Charging Current	4900mA
Maximum Charging Voltage	4.6Vdc
Standard Discharging Current	980 mA
End Point Voltage	2.5 Vdc
Maximum Discharge Current	12500mA
Charging Temperature Range	0~60℃
Discharging Temperature Range	-20~60℃
Upper Limit Charging Voltage	4.25Vdc
Upper charging Temp limit(T3)	60℃
Lower charging Temp limit(T2)	0℃

[ ] PTC Specification Sheet Attached. Includes PTC information such as the manufacturer, PTC model designation, electrical ratings, dimensions, I hold, current trip limit, time to trip, and reference resistance.

TEST LOCATION: (To be completed by Staff Conducting the Testing)					
[X]UL or Affiliate	[ ]WTDP	[ ]CTDP	[]TPTDP	[]TCP	[]PPP
	[]CTF Stage 1	[]CTF Stage 2	[]CTF Stage 3	[]CTF Stage 4	
Company Name:	UL-CCIC Company Limited Guangzhou Branch				
Address:	Electronic Building, Parage Electronic Industrial Park, No.8 Nanyun Er Road, Guangzhou Science Park, Guangzhou 510670, China				

TEST EQUIPMENT INFORMATION

[X] UL test equipment information is recorded on Meter Use.

[ ] UL test equipment information is recorded on <<insert location and local laboratory equipment system identification.>>

Inst. ID No.	Instrument Type	Test Number +, Test Title or Conditioning	Function/Range	Last Cal. Date	Next Cal. Date
N/A	N/A	N/A	N/A	N/A	N/A

+ - If Test Number is used, the Test Number must be identified on the data sheet pages or on the Data Sheet Package cover page.

The following additional information is required when using client’s or rented equipment, or when a UL ID Number for an instrument number is not used. The Inst. ID No. below corresponds to the Inst. ID No. above.

Inst. ID No.	Make/Model/Serial Number/Asset No.
N/A	N/A

TEST SAMPLE IDENTIFICATION:

The table below is provided to establish correlation of sample numbers to specific product related information. Refer to this table when a test identifies a test sample by "Sample No." only.

Sample Card No.	Date Received	[X] Test No.+	Sample No.	Manufacturer, Product Identification and Ratings
5240878	2022-08-15	1	5240878-S1-5240878-S5	SAMSUNG SDI CO LTD, Rechargeable Lithium Ion cell, Cylindrical, INR21700-50E++, 4900mAh, Vmax=4.6Vdc, Ic=4900mA

+ - If Test Number is used, the Test Number or Numbers the sample was used in must be identified on the data sheet pages or on the Data Sheet Package cover page.

[ ] Sampling Procedure -

[X] This document contains data or information using color and if printed, should be printed in color to retain legibility and the information represented by the color.

GENERAL

Top Off Voltage– The manufacturer's recommended maximum voltage. This is the open circuit voltage for the fully charged condition. For lithium ion batteries, the typical value, unless noted otherwise, is 4.2Vdc.
Prior to conducting testing on secondary cells, the cells shall be topped off in accordance with the manufacturer's specified fully charged condition.

PROTECTIVE DEVICES

The following are typical protective devices that may be utilized as protection for lithium cells and batteries against an external overload/overcharge or overheating condition. These devices may be internal or external to the cell or battery:

Positive Temperature Coefficient (PTC) – A resettable thermally sensitive semiconductor resistor that exhibits a significant nonlinear increase in resistance with an increasing temperature over its R/T curve. The PTC requires removal of power from the circuit in order to reset.

Fuse – A non-resettable protective device, which opens a circuit during, specified overcurrent conditions by means of a current responsive element.

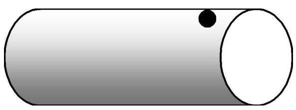
Fusible Tab/Connections – a cell tab or external lead that operates in a manner similar to a thermal link.

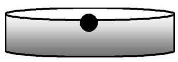
Thermal Link – A non-resettable protective device incorporating a thermal element which will open a circuit once only when exposed for a sufficient length of time to a temperature in excess of that which it has been designed.

Circuit Interrupt Device (CID) - An internal cell protection mechanism that interrupts the cell circuit (opens) due to pressure build up within the cell.

THERMOCOUPLES

Temperatures were measured by thermocouples consisting of wires not larger than 24 AWG (0.21 mm^2) and not smaller than 30 AWG (0.05 mm^2). The temperature measurements on the batteries were made with the measuring junction of the thermocouple held tightly against the outer casing of the battery.





HEATING TEST: UL 1642, 17

METHOD

The batteries were subjected to the Heating Test in accordance with Sec. 17 of the Standard for Lithium Batteries, UL 1642, Fifth Edition.

Prior to conducting the testing, two sets of five lithium ion cell samples are to be fully discharged (i.e. to the manufacturer's specified end point voltage) and then placed in a test chamber and conditioned for 1 to 4 h (5 samples at the upper charging temperature limit and 5 samples at the lower charging temperature limit of the operating region). While still in the test chamber set at the temperature limits, the samples are charged (5 samples at the upper charging temperature limit and 5 samples at lower charging temperature limit) at the specified maximum charging current and upper limit charging voltage, using a constant voltage charging method. Charging is continued until the charge current is reduced to the specified end of charge conditions (i.e. 0.05 times the charge current).

After the precondition, the ten samples were heated in a gravity convection or circulating air oven with an initial temperature of 20 ± 5°C (68 ± 9°F). The temperature of the oven was raised at a rate of 5 ± 2°C (9 ± 3.6°F) per minute to a temperature of 130 ± 2°C (266 ± 3.6°F) and remained for 10 minutes at that temperature before the test was discontinued. The samples were allowed to return to room temperature of 20 ± 5°C (68 ± 9°F) and examined.

[ ] For batteries specified for temperatures above 100°C (212°F), the upper limit conditioning temperature was increased from 130 ± 2°C to 30 ± 2°C (86 ± 3.6°F) above the manufacturer's maximum specified temperature for a maximum upper limit conditioning temperature of **[** °C**]**/**[**170 ± 2°C (338 ± 3.6°F)**]**.

During the test, samples were placed on an insulating surface and separated so that they were not touching each other or the chamber walls.

For safety, a thermocouple was placed on the cell casing to monitor temperatures during the test in accordance with the thermocouple section of the datasheet package. Samples shall not be handled until they have reached safe temperatures (example ± 10°C from ambient).

Note to Technician: Safety Information - See safety information at beginning of data package prior to testing including information regarding testing of larger cells.

HEATING TEST: (CONT'D) UL 1642, 17

Tested by:	Dick Wu	Test Date:	2022-08-25, 2022-08-26

Precondition					
Model	Chemistry	Upper Charging Voltage, Vdc	Maximum Charging Current, A	Upper charging Temp, C	Lower charging Temp, C
INR21700-50E++	NCA	4.25	4.900	60 (Tested at 65)	--

RESULTS

Sample No: 5240878-S1

Measured initial test ambient Temperature, °C	20.5
Measured Max. test chamber Temperature, °C	130.5
Measured room ambient Temperature, °C	20.7

Sample No: 5240878-S2-5240878-S3

Measured initial test ambient Temperature, °C	20.9
Measured Max. test chamber Temperature, °C	130.5
Measured room ambient Temperature, °C	21.2

Sample No: 5240878-S4-5240878-S5

Measured initial test ambient Temperature, °C	21.1
Measured Max. test chamber Temperature, °C	130.2
Measured room ambient Temperature, °C	20.8

[ ] large cell, should be isolated when tested.

Sample No.	Cell Condition	Open Circuit Voltage, V dc	Measured Maximum Cell Casing Temperature, °C	Comments
5240878-S1	E	4.198	135.5	1
5240878-S2	E	4.201	134.6	1
5240878-S3	E	4.198	135.7	1
5240878-S4	E	4.200	136.1	1
5240878-S5	E	4.203	136.5	1

Comments Key	Cell Condition Key
(1) Sample remained intact (did not explode or catch fire)	(A) Fully Charged fresh samples
(2) Sample bulged (3) Sample vented	(B) One half discharged
(4) Sample opened and leaked electrolyte	(C) Completely discharged
(5) Sample exploded (6) Sample caught on fire	(D) Fully Charged after preconditioning (Charge-discharged cycled)
(7) Sample smoldered without flame	(E) Preconditioned at the upper temperature limit
(8) Other	(F) Preconditioned at the lower temperature limit

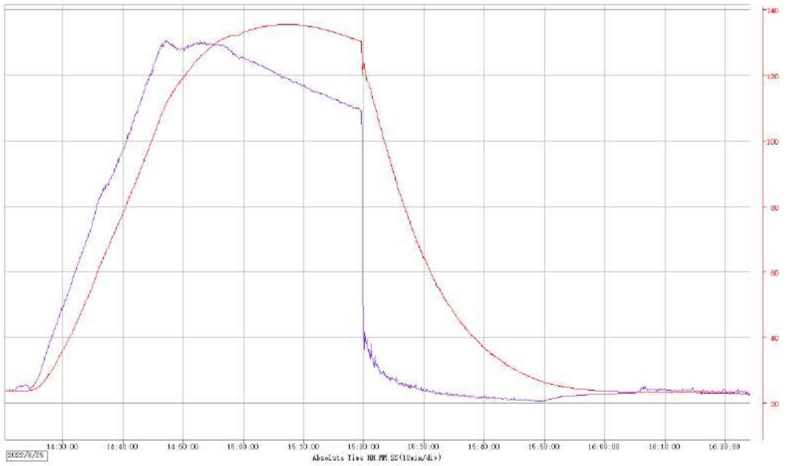
Note to Technician: Safety Information - See safety information at beginning of data package prior to testing including information regarding testing of larger cells.

The samples ~~[exploded or caught fire]~~ **[**did not explode or catch fire**]**.

Statistical Report

Test name:	HEATING TEST			Tester:	Dick Wu	Start time:	2022/08/25 14:20:25
Product type:	INR21700-50E++	Sample No.:	5240878-S1	Sampling period:	5 second	Stop time:	2022/08/25 16:24:05
Project No.:	4790502997	File No.:	MH21015	Normalize Temp. to:	25.0	Duration:	0Day 02h:03m
Test category:	N/A	Termination condition:		Manual stop			

Trend:



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Statistical table:

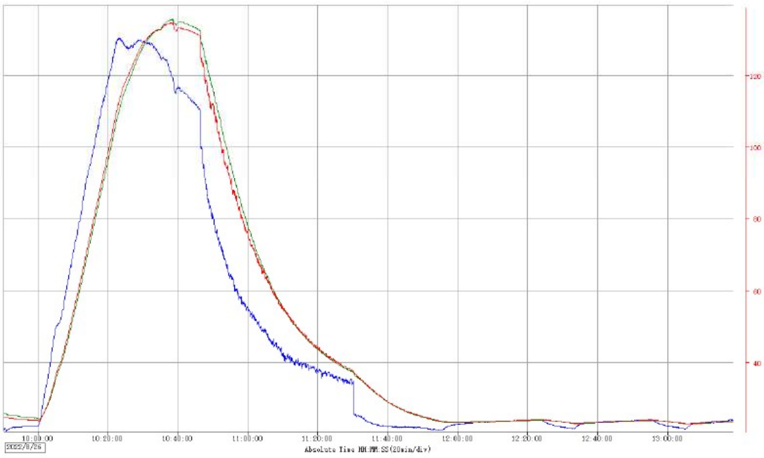
No.	Color	Device	CH No.	Measure Point	Amb CH	Max	Time	Min	Time	Start Amb.1	Start Amb.2	Start Amb.3	Amb.1	Amb.2	Amb.3	Start	Final	Max Temp. Rise	Normalize	Normalize	Stable Temp.1	Stable Temp.2	Stable Temp.3
-		Group01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1		GUZ-LE-DL038	CH001	C1		135.5	8/25/2022 3:07:25 PM	22.7	8/25/2022 4:23:10 PM	23.9	22.6	23.8	118.1	119.0	118.7	23.7	22.7	16.9	41.9	42	-	-	-
4		GUZ-LE-DL038	CH006	ambient 3	V	130.5	8/25/2022 2:47:20 PM	20.5	8/25/2022 3:49:00 PM	-	-	-	-	-	-	23.8	22.5	-	-	-	-	-	-

Sample No.	5240878-S1
Ch Name	CH001

Dick Wu/2022-08-25

Statistical Report

Test name:	HEATING TEST_001			Tester:	Dick Wu	Start time:	2022/08/26 09:50:20
Product type:	INR21700-50E++	Sample No.:	5240878-S2-5240878-S3	Sampling period:	5 second	Stop time:	2022/08/26 13:18:40
Project No.:	4790502997	File No.:	MH21015	Normalize Temp. to:	25.0	Duration:	0Day 03h:28m
Test category:	N/A	Termination condition:		Manual stop			
Trend:							



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Statistical table:

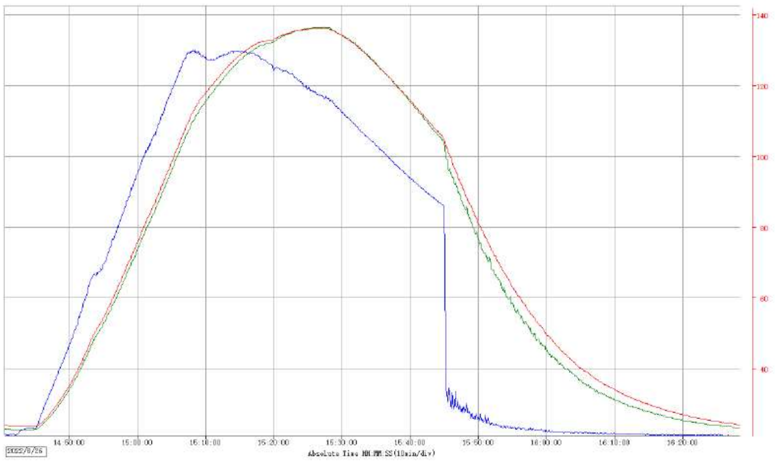
No.	Color	Device	CH No.	Measure Point	Amb CH	Max	Time	Min	Time	Start Amb 1	Start Amb 2	Start Amb 3	Amb 1	Amb 2	Amb 3	Start	Final	Max Temp Rise	Normalize	Normalize	Stable Temp.1	Stable Temp.2	Stable Temp.3
-		Group01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1		GUZ-LE-DL038	CH001	C1		134.6	8/26/2022 10:37:50 AM	22.9	8/26/2022 1:05:05 PM	21.2	21.2	21.6	121.1	120.9	121.6	24.9	23.6	13.4	38.4	38	-	-	-
2		GUZ-LE-DL038	CH002	C2		135.7	8/26/2022 10:38:45 AM	22.8	8/26/2022 1:05:35 PM	21.2	21.2	21.6	118.9	118.7	120.7	25.9	23.4	16.3	41.3	41	-	-	-
3		GUZ-LE-DL038	CH004	Ambient 1	V	130.5	8/26/2022 10:23:20 AM	20.9	8/26/2022 9:51:00 AM	-	-	-	-	-	-	21.2	24.0	-	-	-	-	-	-

Sample No.	5240878-S2	5240878-S3
Ch Name	CH001	CH002

Dick Wu/2022-08-26

Statistical Report

Test name:	HEATING TEST_002			Tester:	Dick Wu	Start time:	2022/08/26 14:40:30
Product type:	INR21700-50E++	Sample No.:	5240878-S4-5240878-S5	Sampling period:	5 second	Stop time:	2022/08/26 16:28:15
Project No.:	4790502997	File No.:	MH21015	Normalize Temp. to:	25.0	Duration:	0Day 01h:47m
Test category:	N/A	Termination condition:		Manual stop			
Trend:							



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Statistical table:

No.	Color	Device	CH No.	Measure Point	Amb. CH	Max	Time	Min	Time	Start Amb.1	Start Amb.2	Start Amb.3	Amb.1	Amb.2	Amb.3	Start	Final	Max Temp. Rise	Normalize	Normalize	Stable Temp.1	Stable Temp.2	Stable Temp.3
-		Group01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1		GUZ-LE-DL038	CH001	C1		136.1	8/26/2022 3:25:55 PM	23.7	8/26/2022 2:42:05 PM	21.5	21.4	21.9	118.4	119.5	119.5	24.0	24.2	17.0	42.0	42	-	-	-
2		GUZ-LE-DL038	CH002	C2		136.5	8/26/2022 3:27:15 PM	22.7	8/26/2022 2:41:35 PM	21.5	21.4	21.9	116.7	118.0	117.5	22.9	23.4	19.1	44.1	44	-	-	-
3		GUZ-LE-DL038	CH004	Ambient 1	V	130.2	8/26/2022 3:08:20 PM	21.1	8/26/2022 4:26:55 PM	-	-	-	-	-	-	21.5	21.1	-	-	-	-	-	-

Sample No.	5240878-S4	5240878-S5
Ch Name	CH001	CH002

Dick Wu/2022-08-26

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