3.5 Smoke release rate measurement

3.5.1 Test method

The light transmission in the calorimeter's exhaust duct was measured using a white light source and photo detector for the duration of the test.

The smoke release rate was calculated as follows:

$$SRR = 2.303\left(\frac{V}{D}\right)Log_{10}\left(\frac{I_o}{I}\right)$$

Where:

SRR = Smoke release rate (m^2/s)

V = Volumetric exhaust duct flow rate (m^3/s)

D = duct diameter (m)

I_o = Light transmission signal of clear (pre-test) beam (V)

I = Light transmission signal during test (V)

The whole smoke release rate measurement system were self-checked using calibrated light filter before test.

3.5.2 Test result

Peak smoke release rate SRR: 0.821m²/s

Total smoke release TSR: 118.0m²

Figure 10 SRR curve

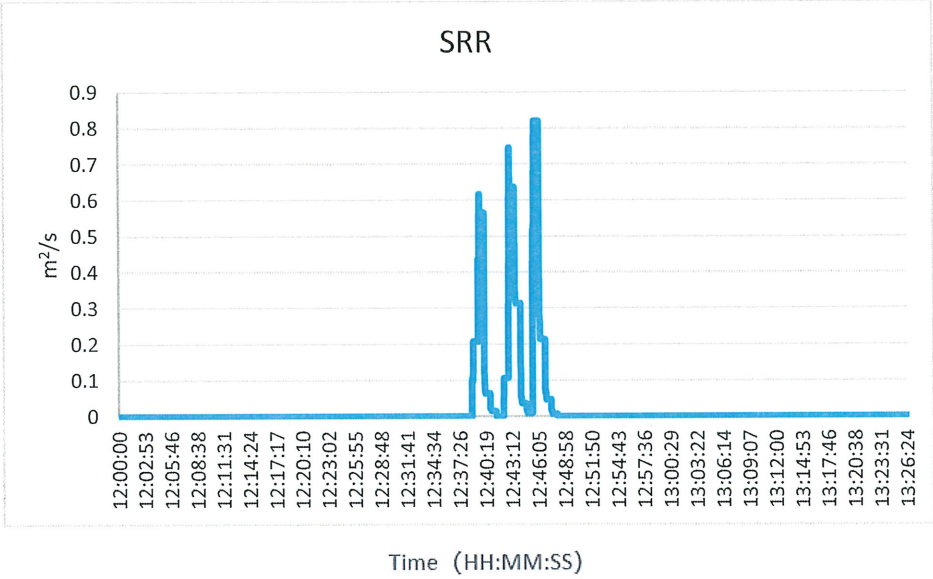
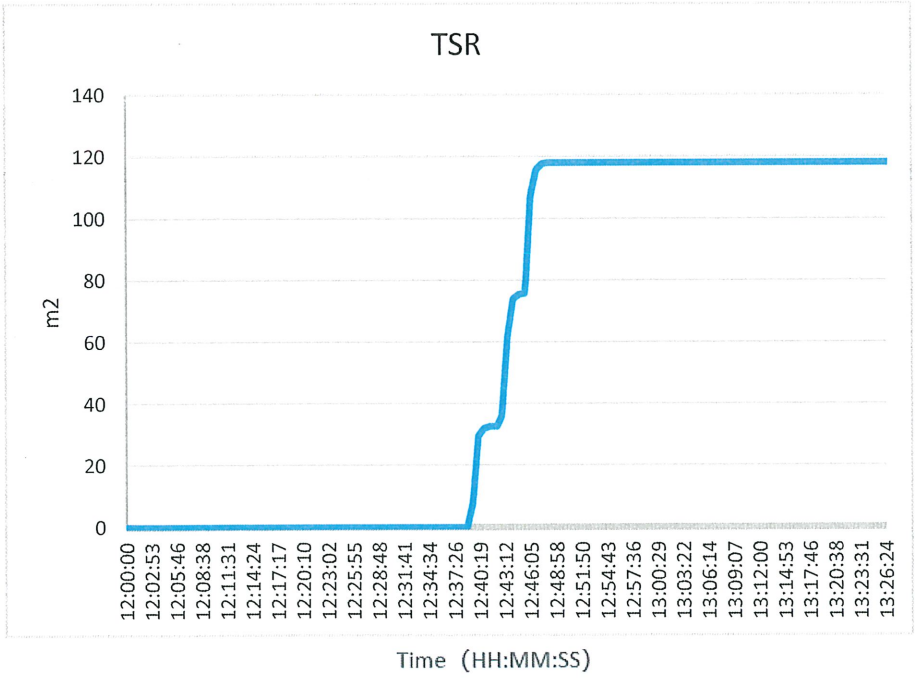


Figure 11 TSR curve



3.6 Gas generation measurement

3.6.1 Test method

The composition, velocity and temperature of the vent gases were measured within the calorimeter's exhaust duct.

Gas composition were measured using a Fourier-Transform Infrared Spectrometer with a resolution of 0.5 cm^{-1} and a path length of 5.1 m within the calorimeter's exhaust duct.

The hydrocarbon content of the vent gas was measured using flame ionization detection.

Hydrogen gas was measured with a palladium-nickel thin-film solid state sensor.

Composition, velocity and temperature instrumentation were collocated with heat release rate calorimetry instrumentation

3.6.2 Total gas release

The flow rates of various gases were integrated over the test duration and the total cumulative volume of gas calculated for the total test duration were presented in below table.

Gas type	Gas components		Total volume of gas (L)
Hydrocarbon species	Methane	CH_4	20.570
	Ethylene	C_2H_4	13.594
	Ethane	C_2H_6	1.787
	Propylene	C_3H_6	2.581
	Propane	C_3H_8	0.824
Hydrogen halide species	Hydrogen Fluoride	HF	0.872
Others	Carbon Monoxide	CO	33.852
	Carbon Dioxide	CO_2	77.634
	Hydrogen (Electrochemical) For reference only	H_2	160.97**
	Hydrogen (Palladium nickel thin film solid state sensor)	H_2	Below detectable limit*

	Carbonyl Sulfide	COS	0.464
	Oil as octane	/	1.362
	Dimethyl carbonate	$C_3H_6O_3$	36.830
	Ethyl methyl carbonate	$C_4H_8O_3$	16.244
	Methanol	CH_3OH	/
Total Hydrocarbons (equivalent to C_3H_8, measured by FID)			101.04

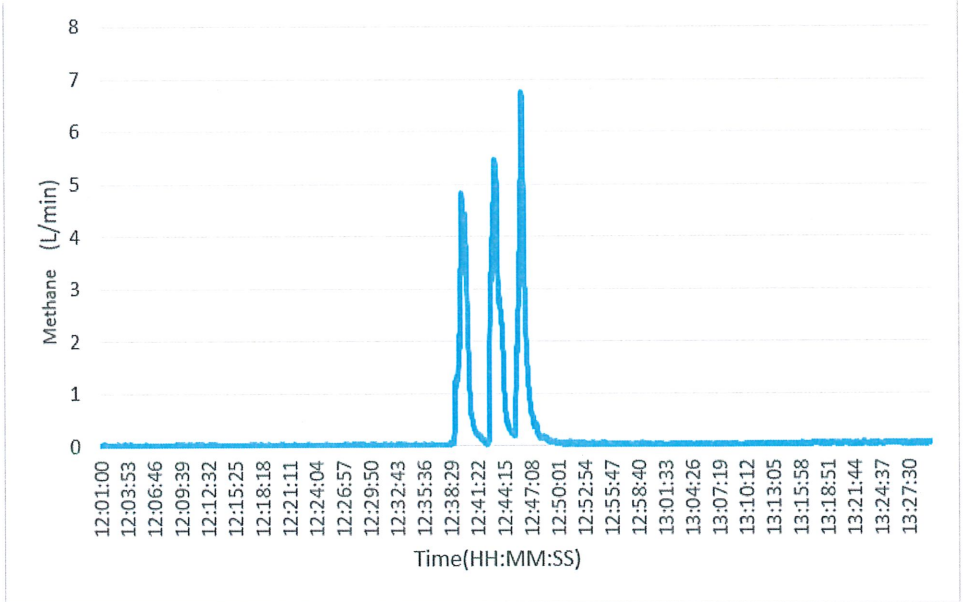
* = The volume of hydrogen released by a single cell after thermal runaway referred to the cell UL 9540A report is about 64.8L. However, it should be noted that the gas production of a single cell in the current test environment is not exactly equivalent to the gas production of the cell level test, because the test environment is not the same.

** = As there are some factor sensors which can affect the accuracy of hydrogen gas measurements, such as the accuracy for gas voltage signal, airflow rates, and environmental variables, the 160.97L in only for reference.

3.6.3 Gas components

Concentration of different gas components were present according to gas species classification in Figures 12 to 16. Average flow rate was 2.09 m^3/s during test.

Figure 12 Hydrocarbon species:



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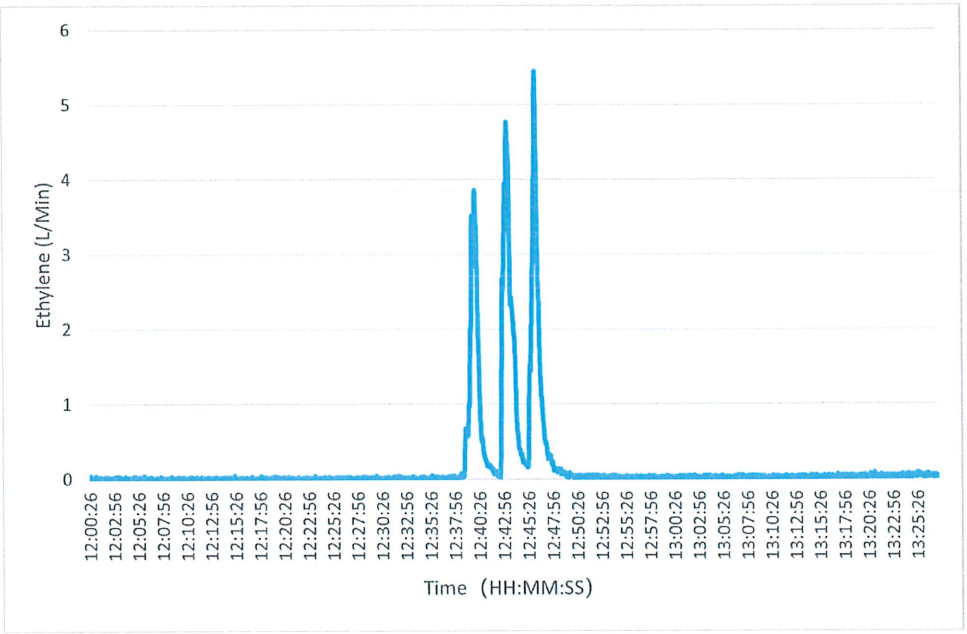
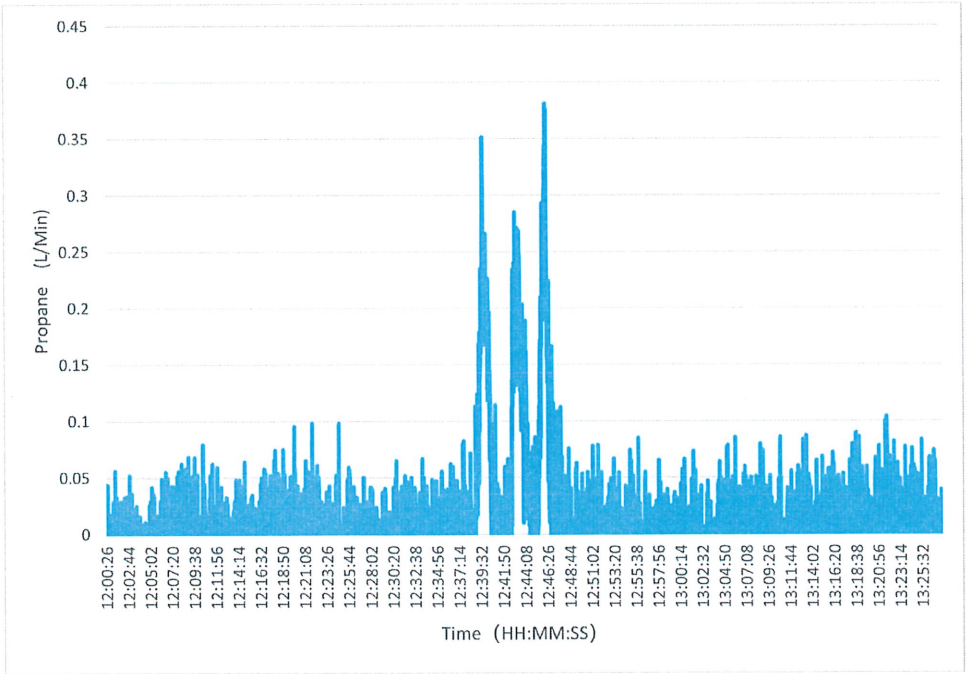




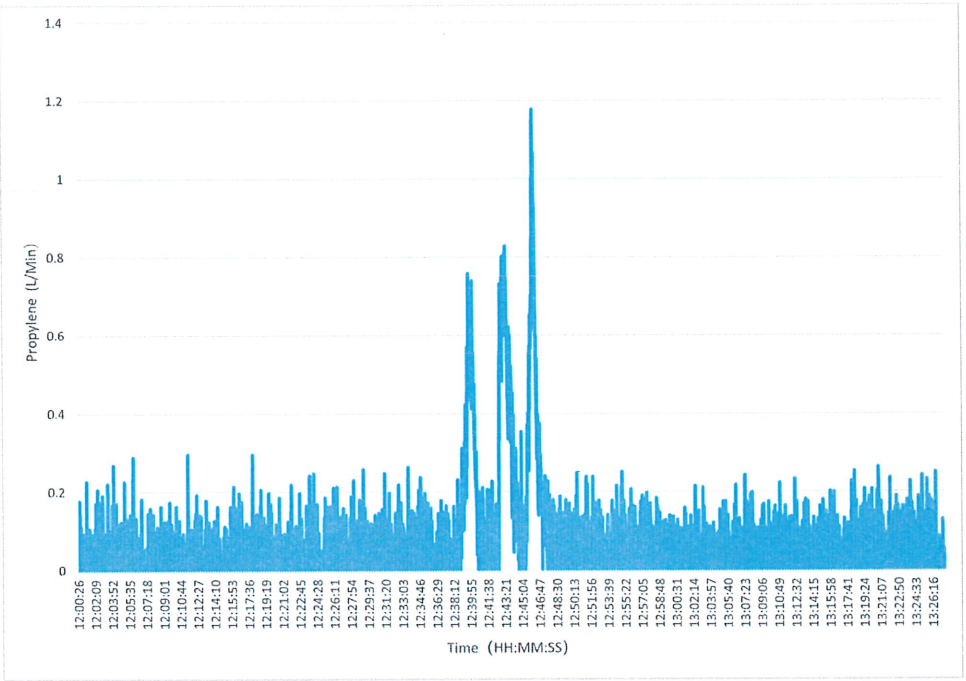


Figure 13 Hydrogen halide species:

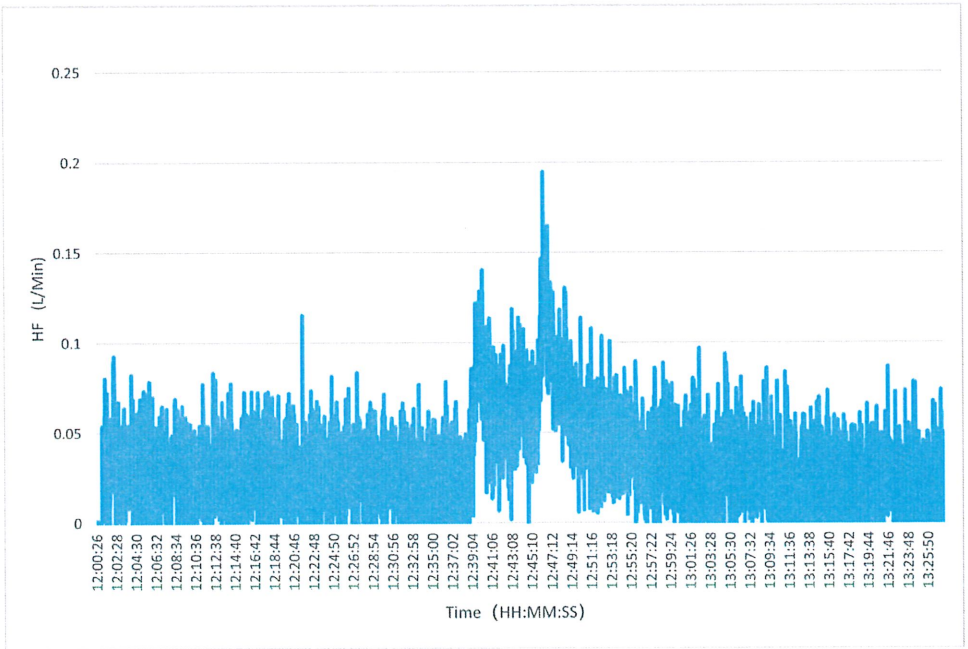
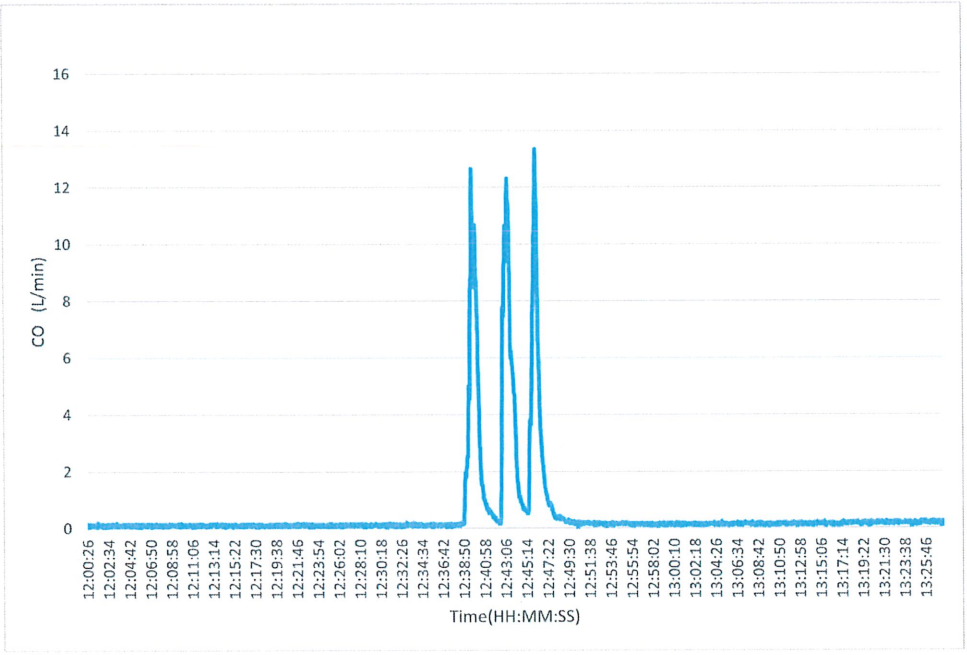


Figure 14 CO, CO2 concentration:



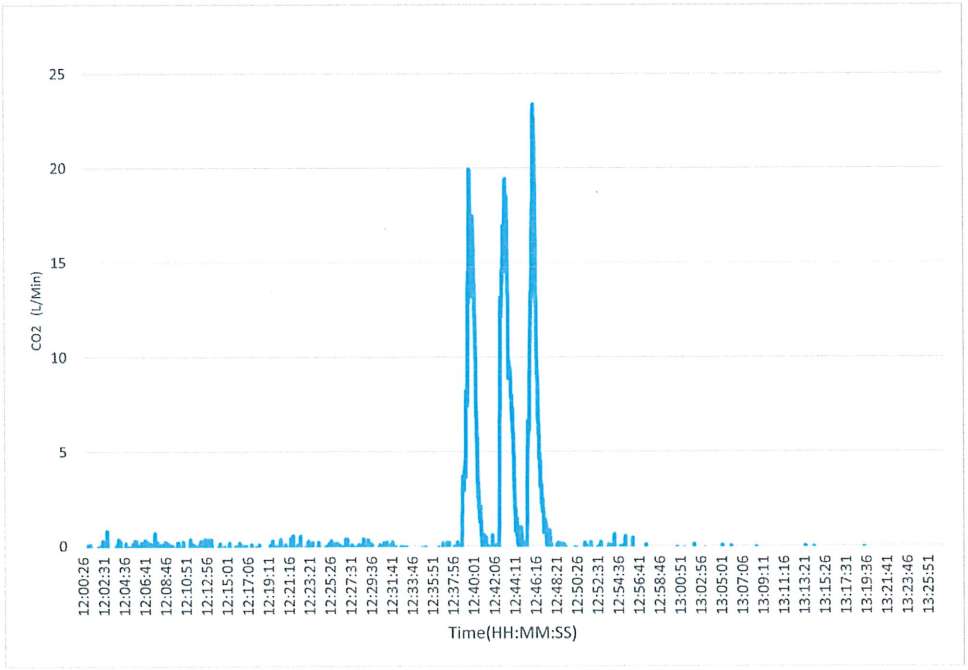


Figure 15 Total Hydrocarbons (equivalent to C3H8, measured by FID):

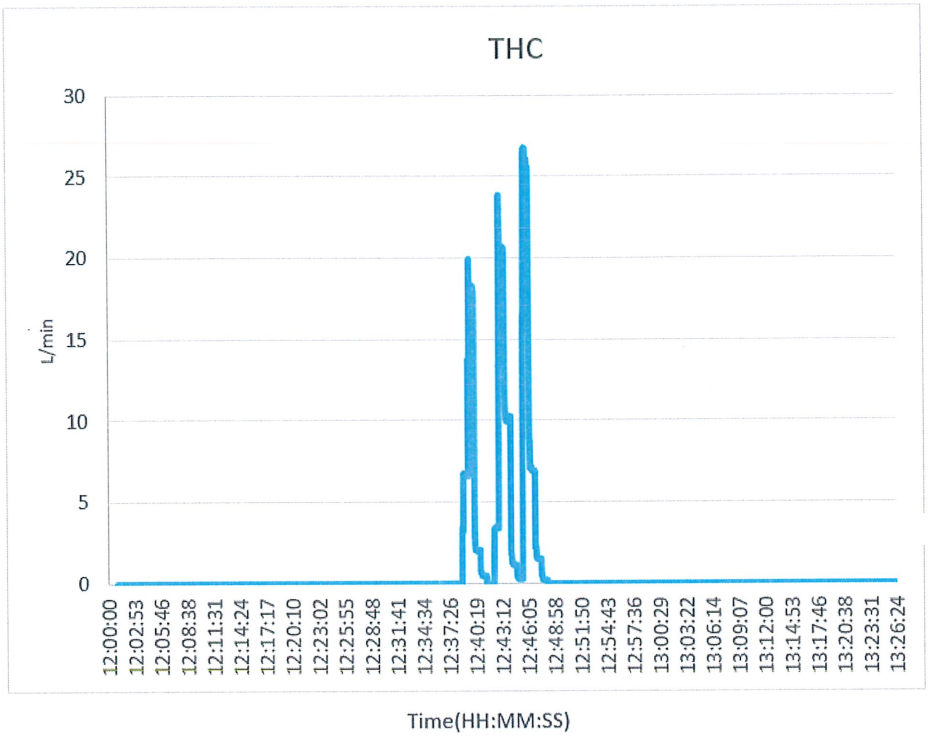
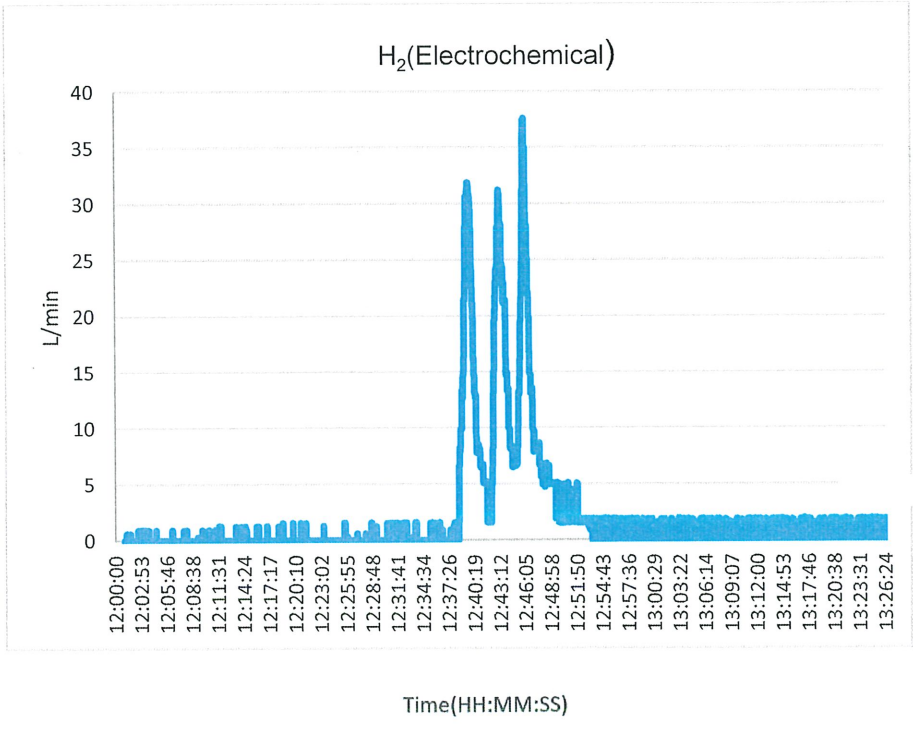
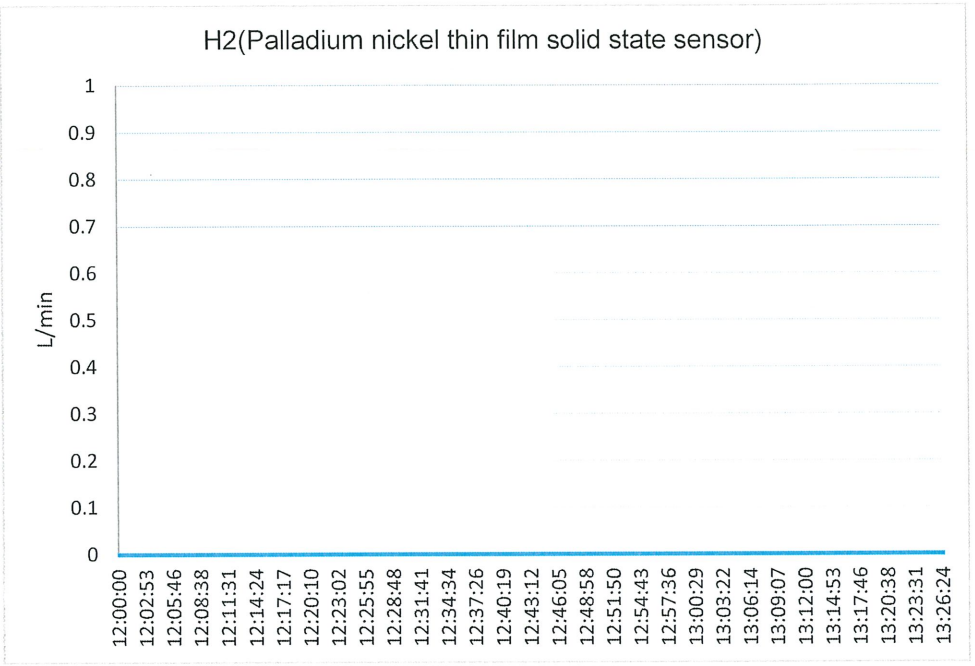


Figure 16 Others:




H2(Palladium nickel thin film solid state sensor)
L/min
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
12:00:00
12:02:53
12:05:46
12:08:38
12:11:31
12:14:24
12:17:17
12:20:10
12:23:02
12:25:55
12:28:48
12:31:41
12:34:34
12:37:26
12:40:19
12:43:12
12:46:05
12:48:58
12:51:50
12:54:43
12:57:36
13:00:29
13:03:22
13:06:14
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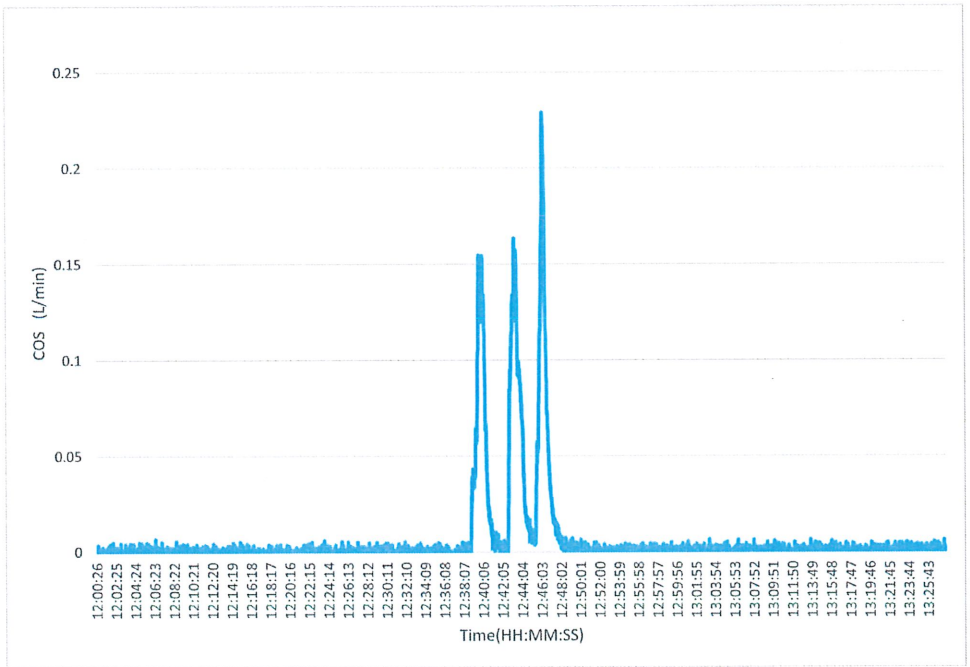
13:14:53
13:17:46
13:20:38
13:23:31
13:26:24
Time(HH:MM:SS)


COS (L/min)
0.25
0.2
0.15
0.1
0.05
0
Time(HH:MM:SS)

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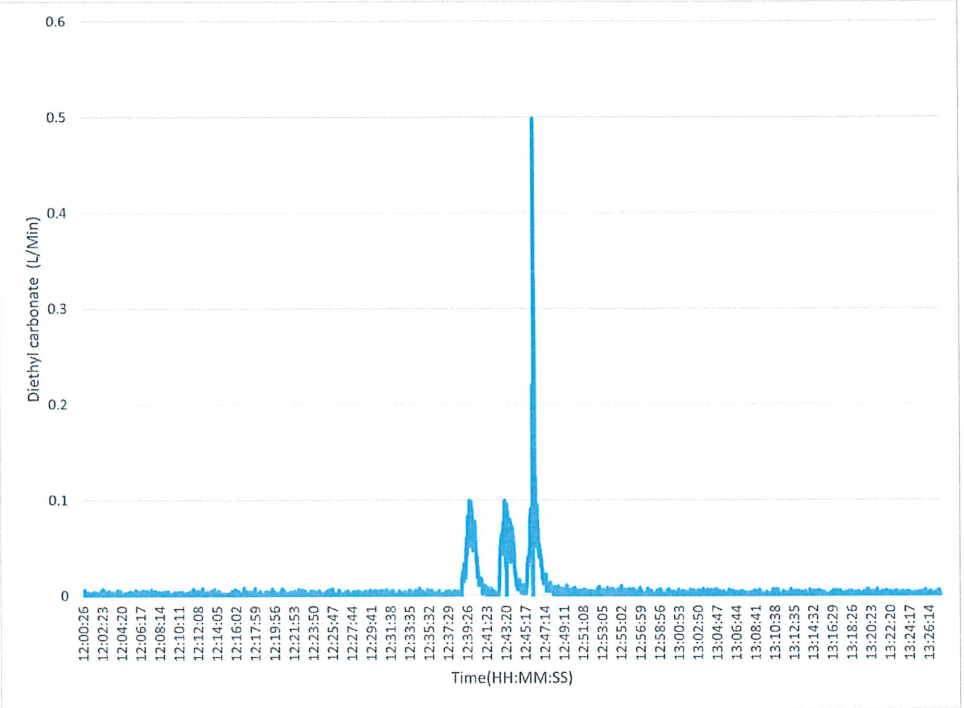

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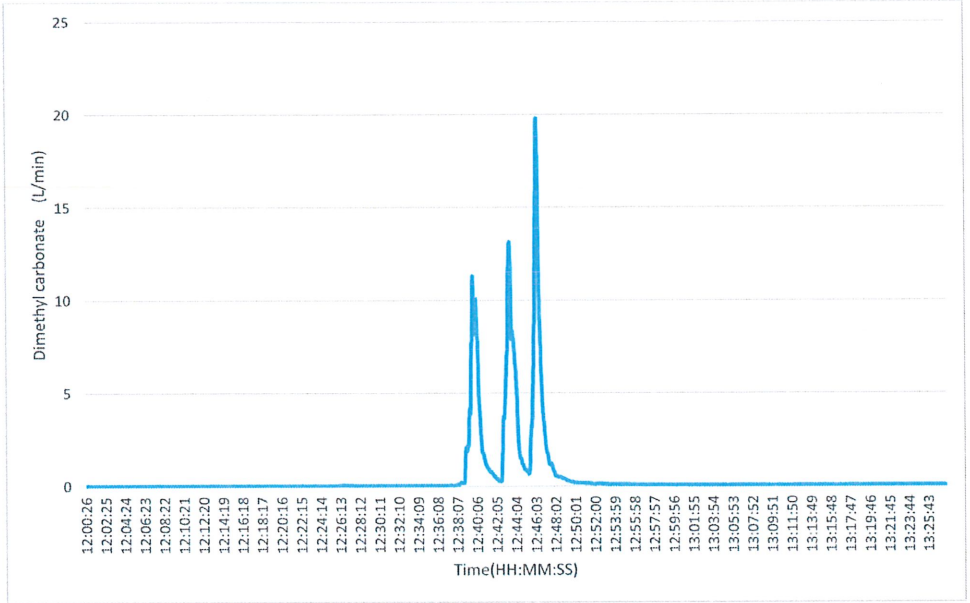

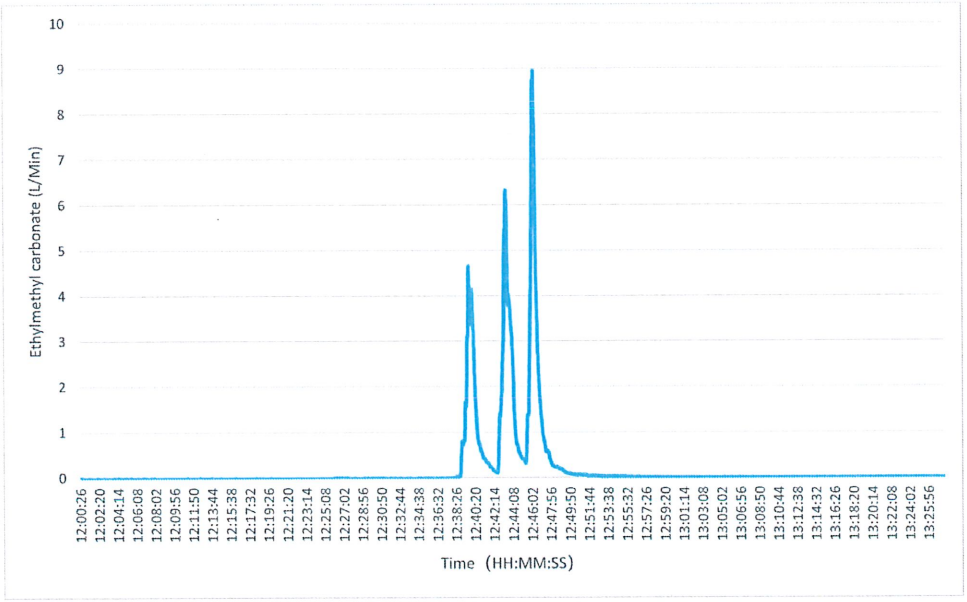

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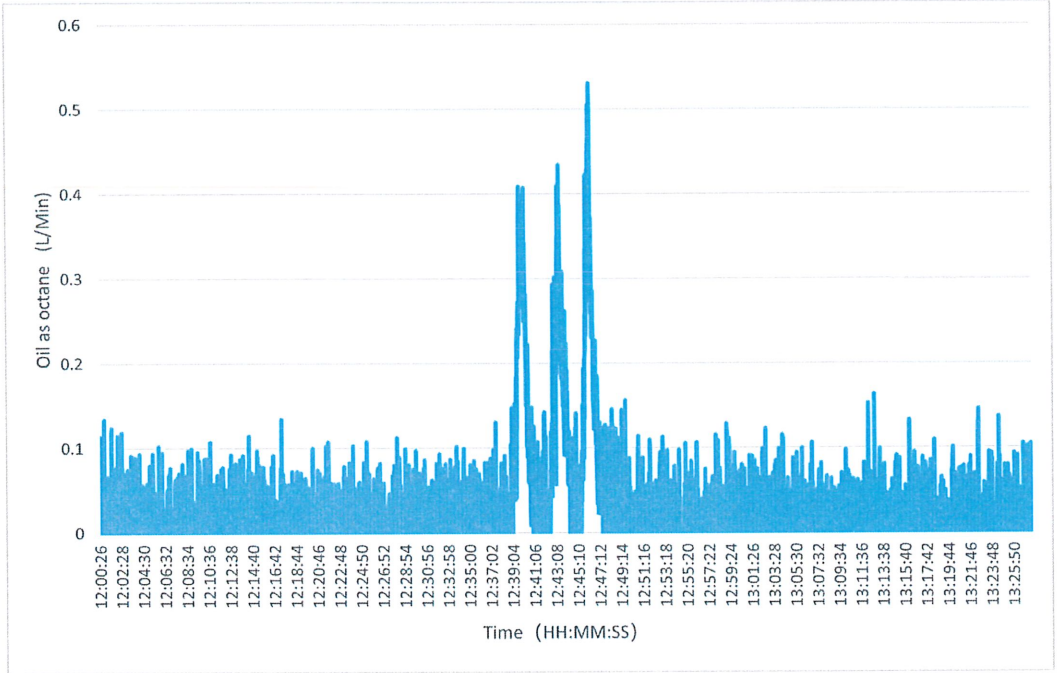
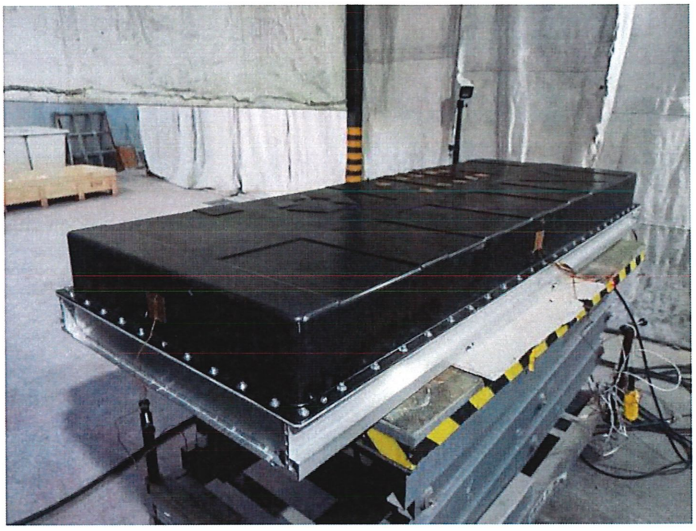
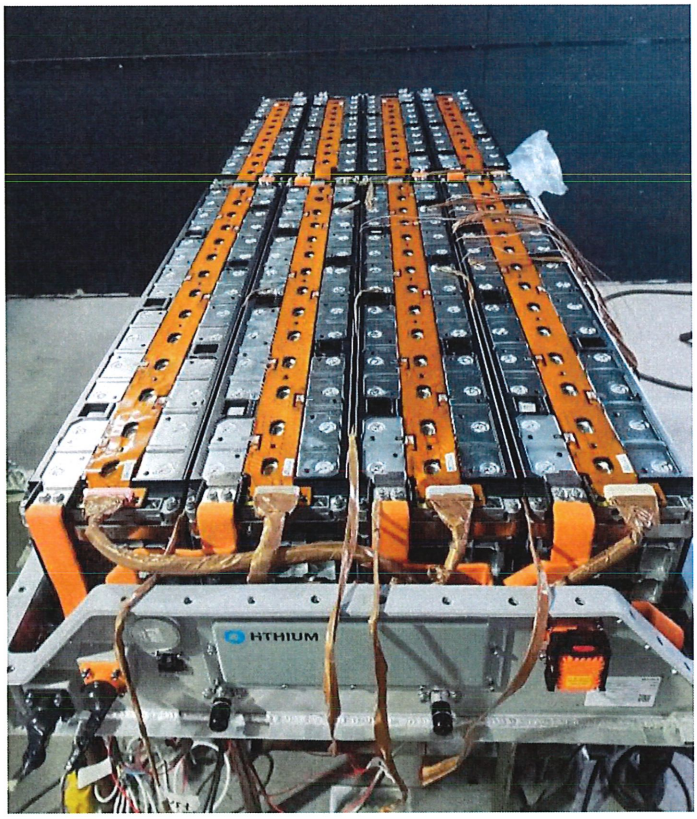


3.7 Photos

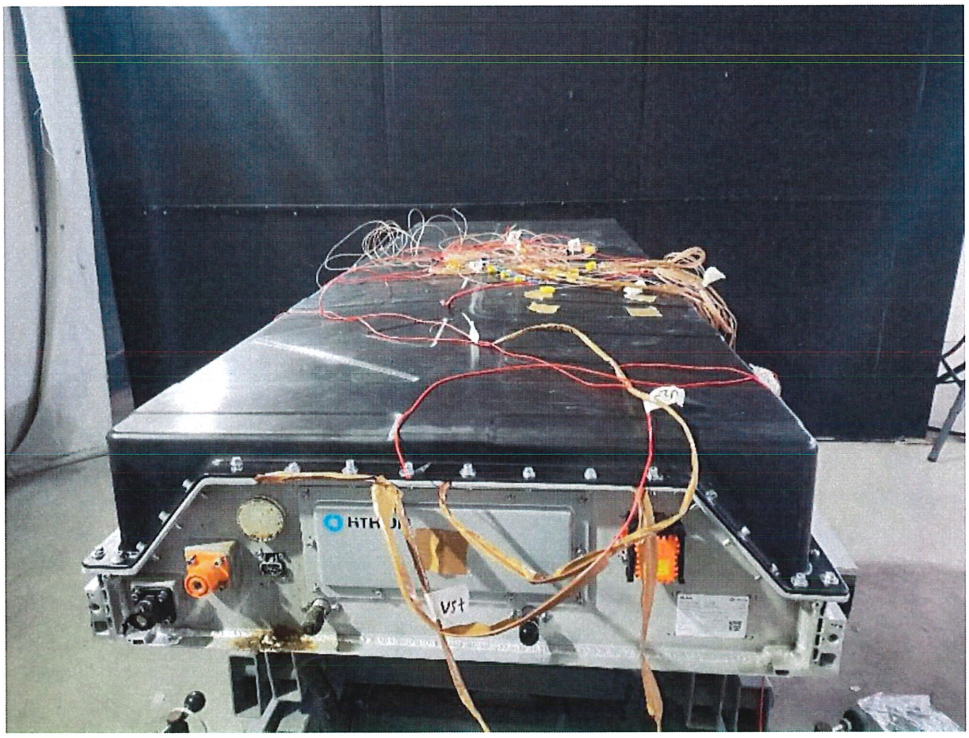
Module before test

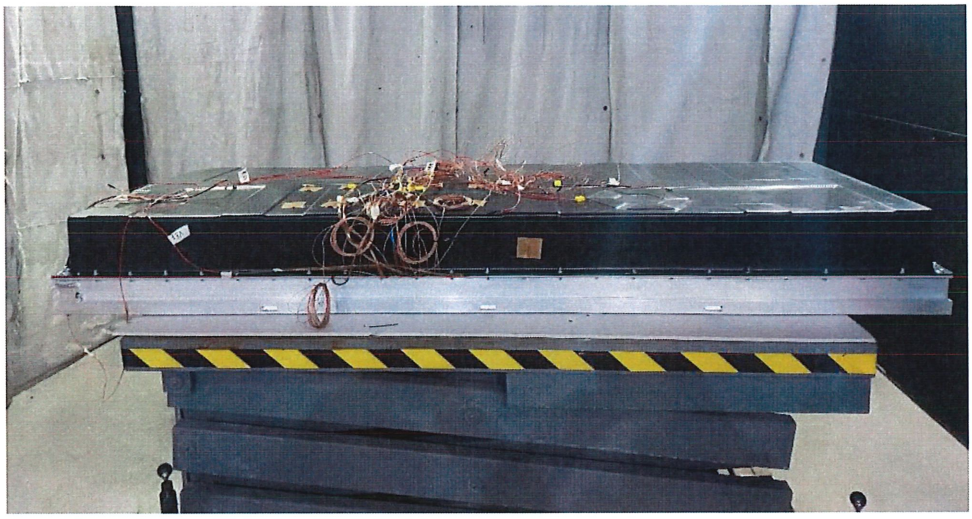


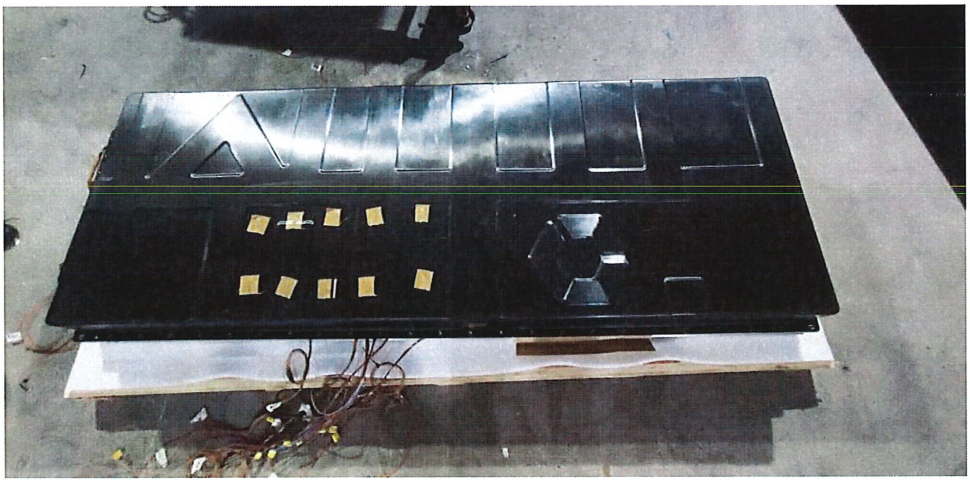

HTHIUM

Smoke release during test

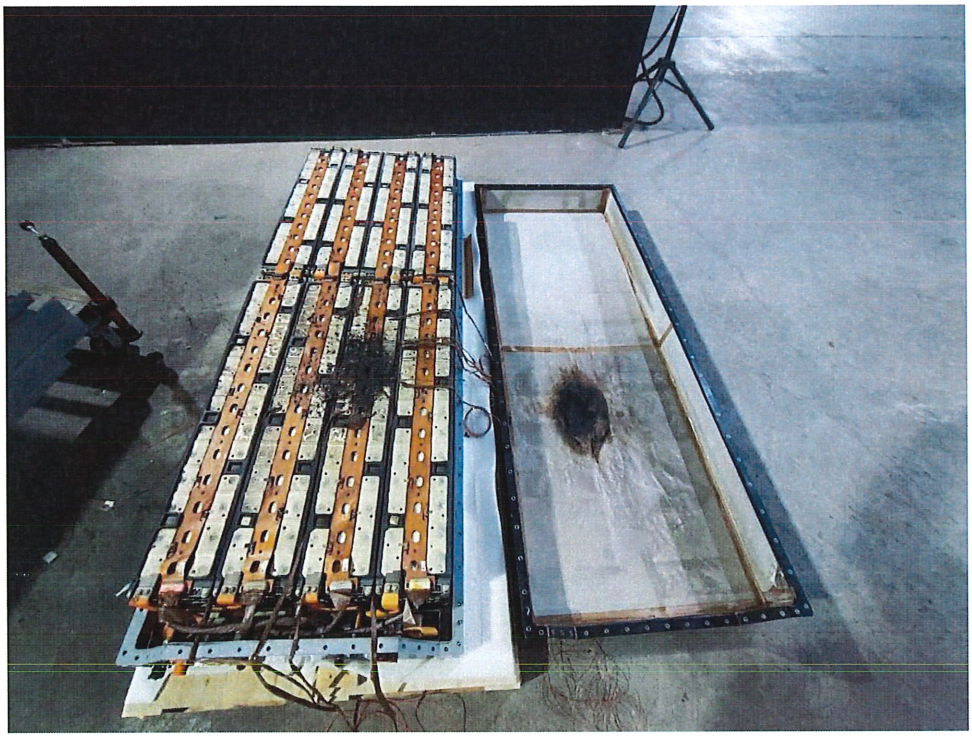
Sample after test

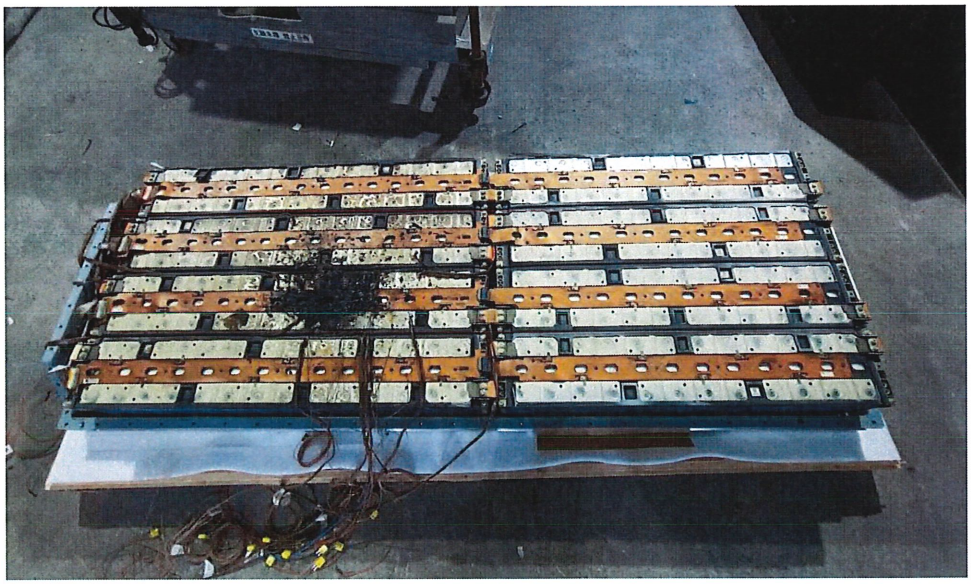






Damage of the internal components





3.8 List of test and measurements instruments:

No.	Equipment	Model	Rating	Inventory no.	Last Cal. date
1	Ambient temperature and humidity	COS-03	0°C ~50°C, 30%RH~95%RH	D-ZNDW23052402	2023.05.24
2	Data acquisition equipment	LR8450-01	0~1100°C	0221-0704-06	2023.10.19
3	Electronic scale	OCS-2t/1kg	1kg~2000kg	0221-0704-10	2023.11.19
4	Paramagnetic oxygen analyser	AO2020	Oxygen measurement: 6.02%vol~24%vol; Hydrogen concentration: 1%~3%; Carbon monoxide: 0.2%~0.8%; Carbon dioxide concentration: 2%~8%	0221-0704-03	2023.03.06
5	Velocity probe	DYM3	800~1060hPa	D-ZNDW23032210	2023.03.10
7	Fourier-Transform Infrared Spectrometer	MULTIGAS 6030	Methane, propane, acetylene concentration: 100μmol/mol~1000μmol/mol; Carbon monoxide concentration: 0.2%~0.8%	0221-0704-08	2023.03.06
9	Palladium-nickel thin-film solid state sensor	HY-OPTIMA-2720	Range: 0.4%~5.0%	0221-0704-01	2023.03.20
10	Flame ionization detector	AO2040	Methane concentration: 100μmol/mol~500μmol/mol	0221-0704-04	2023.03.06
11	Thermopile	TJ120-CAXL-116U-80	0~300°C	0221-0704-31	2023.10.22

Remark: Calibration of equipment is valid for 1 year.

End of Test Report