Venting of Gases Test for ElectricVehicles

China

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Background

——Safety of consumers is the top priority in the development of new energy vehicle industry

——Thermal runaway of traction batteries usually accompanied by a large amount of vented gas

——The vented gas contains a variety of toxic and combustible components, which threaten the safety of drivers, passengers and rescue workers.

Background

Standardization requirements of GTR

In general, the venting phenomena of lithium-ion battery cells are separated in two cases: (a) associated with combustion and/or decomposition of electrolyte, and (b) only caused by vaporisation of the electrolyte. In case of condition (b), the amount of the gases is considered as less significant to pose additional risk to the occupants. In case of condition (a), the emissions from the cells may increase the risk to vehicle occupants if they are exposed to such substances.

Extensive research has shown that gases generated in and vented from Li-ion batteries typically include carbon dioxide (CO_2), carbon monoxide (CO), hydrogen (H_2), oxygen (O_2), light C1-C5 hydrocarbons, e.g. methane and ethane, and fluorine-containing compounds such as hydrogen fluoride (HF) and fluoro-organics such as e.g. ethyl fluoride.

The informal working group examined the feasibility to establish a robust and repeatable method to verify the occurrence of venting and the potential exposure of vehicle occupant to the gases caused by venting condition (a) associated with combustion and/or decomposition of electrolyte, in the in-use test. **Several ideas from Japan, JRC and OICA were discussed but no suitable method, other than visual technique, was found at this stage for verifying the occurrence of venting as a basis for assessing the influence of venting gases to vehicle occupants.**

At the moment, venting is not adopted as a requirement for tests addressing safety of REESS post-crash. Assessment of potential safety risks of this requires more research to evaluate whether limits for emissions are required, for which species and which technique can be used to measure these. It was not possible to research and analyse this in Phase 1. Therefore, it will be considered in Phase 2 of this Regulation.

——Excerpt from the Global Technical Regulations on Electric Vehicle Safety （2018）

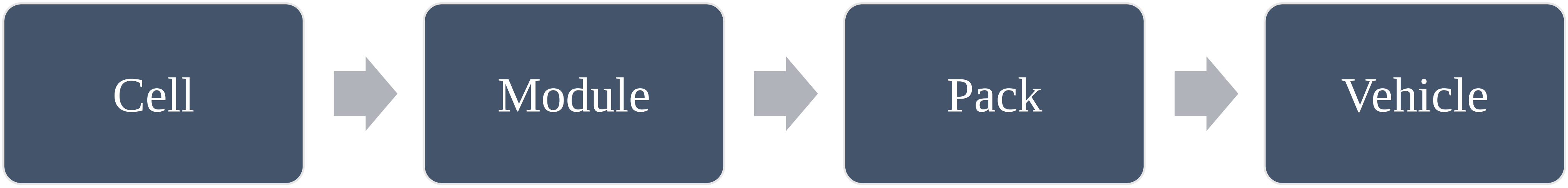
Background

——In Phase 2, JRC and other organizations shared some explorations in battery toxic gas analysis.

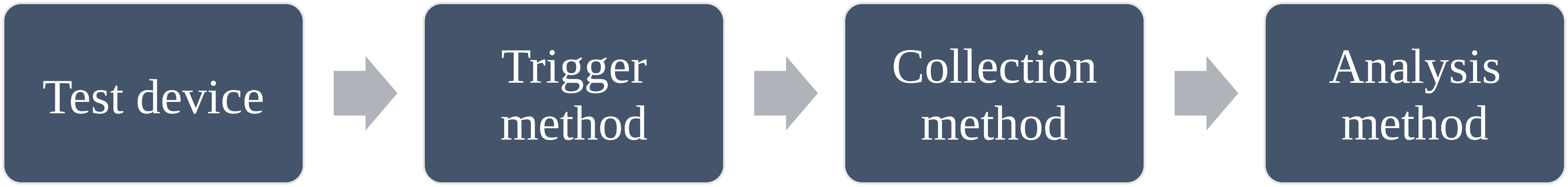
——China also attaches great importance to research on the safety of toxic gas from traction batteries, and believes that the current research focus should be to propose a unified, repeatable, easy to implement method that can evaluate the impact of battery gas production on occupants.

Research Framework

Establish a multi-level gas production test method from cell to module, pack and vehicle



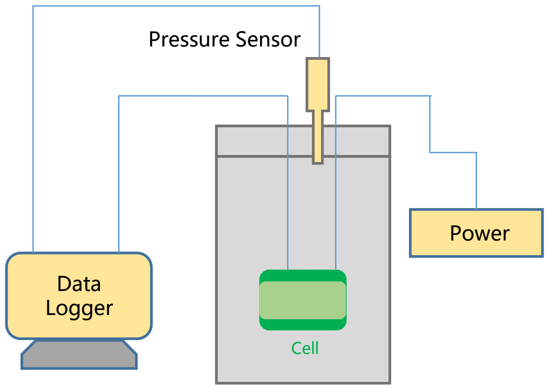
Key points including test device, thermal runaway trigger method, gas collection method, gas analysis method.



Research progress--Cell level test

Sealed container method

Procedure	Remark
• Cell to be tested	• The cell is at 100%SOC • The ambient temperature is RT
• To be sealed in the tank	• Tightness test • Test atmosphere: Nitrogen (N_2 content＞99%) or air atmosphere
• Trigger thermal runaway	• Heat-trigger: Heating the cell with 600W heating plate to thermal runaway • Overcharging-trigger (To be developed) • Nail-trigger (To be developed)
• Gas sampling	• Collect the gas after equilibrium
• Test results	• Gas maximum volume • Gas flow rate • Gas composition



$$P_1V = n_1RT_1 \qquad n = n_2 - n_1$$
$$P_2V = n_2RT_2 \qquad V = n * V_m$$

→ Maximum volume: V

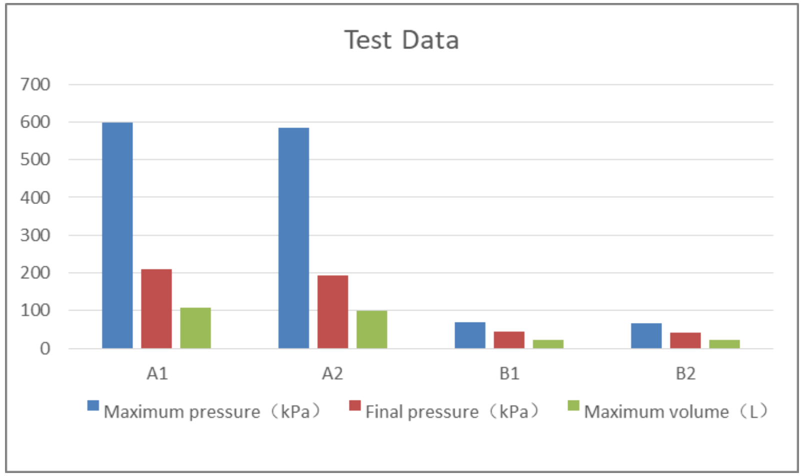
$$\triangle V = (P_{i+\Delta t} - Pi) * V/P$$

→ Gas flow rate $v = \Delta V/\Delta t$

Research progress--Cell level test

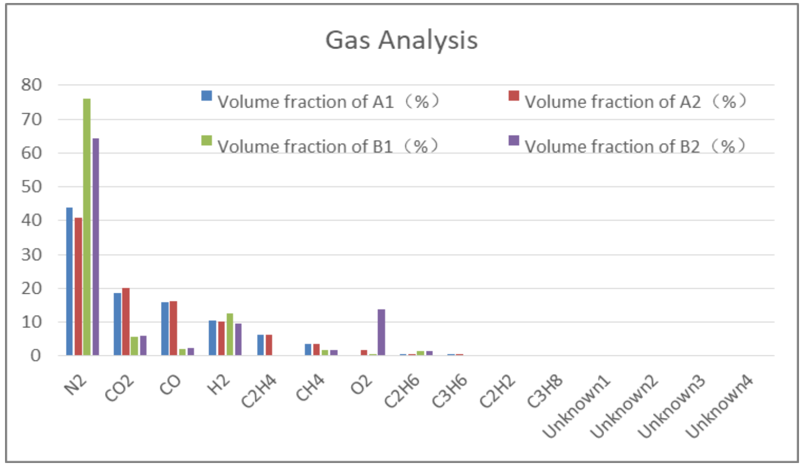
Test Data

System	Atmosphere	Sample number	Maximum pressure (kPa)	Final pressure (kPa)	Maximum volume
NCM	N_2	A1	597.74	209.76	109.1
	Air	A2	584.88	193.58	100.7
LFP	N_2	B1	68.10	43.8	22.2
	Air	B2	65.46	42.2	21.3



Gas Analysis

No.	Gas composition	Volume fraction of A1（%）	Volume fraction of A2（%）	Volume fraction of B1（%）	Volume fraction of B1（%）
1	N_2	43.76	40.72	76.03	64.26
2	CO_2	18.46	19.95	5.49	6.07
3	CO	15.88	16.10	2.10	2.32
4	H_2	10.30	10.22	12.40	9.66
5	C_2H_4	6.22	6.20	0.10	0.34
6	CH_4	3.37	3.48	1.58	1.61
7	O_2	0.33	1.59	0.41	13.78
8	C_2H_6	0.56	0.58	1.41	1.38
9	C_3H_6	0.52	0.55	0.01	0.01
10	C_2H_2	0.09	0.09	0.29	0.23
11	C_3H_8	0.07	0.08	0.03	0.05
12	Unknown1	0.19	0.18	0.15	0.22
13	Unknown2	0.14	0.14	/	0.16
14	Unknown3	0.06	0.07	/	/
15	Unknown4	0.05	0.05	/	/



Cell level test method is mature, and the cost is relatively low;
Difficult to evaluate the impact of battery gas production on occupants.

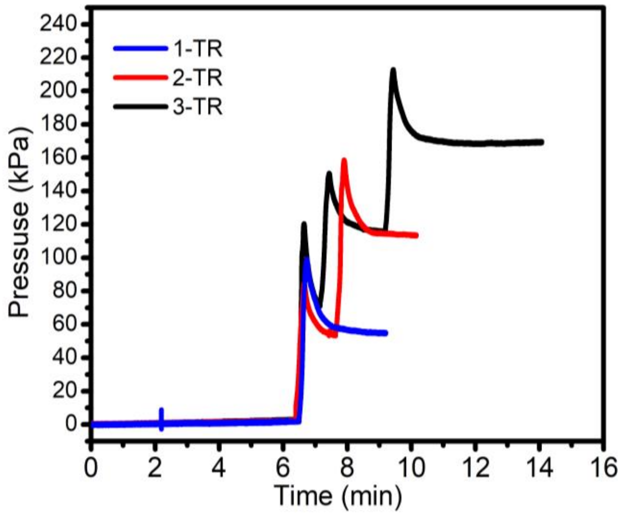
Research progress--module & battery pack level

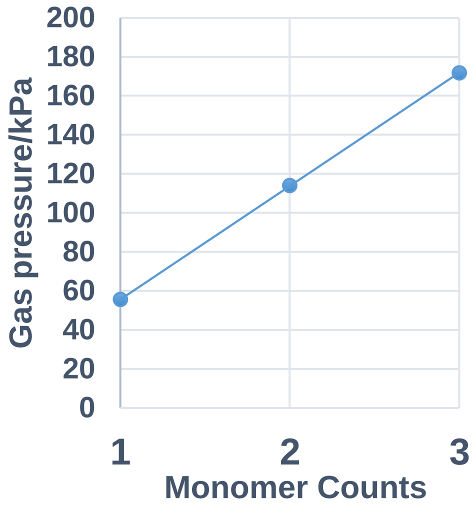
Validity verification of cell result multiplication (CRM) method

——Through the validation test of 40Ah NCM811 samples, the gas production of 1, 2 and 3 strings of battery samples was tested respectively, and the gas pressure results were compared;

——The gas pressure of the three tests has a linear relationship, and the gas composition is almost the same;

——The CRM method is feasible at the module level, while the harness and shell combustion gas need to be considered at the battery pack level, which needs to be further studied.





△P(kPa)	1st	2nd	3rd	Sum
single	55.53	/	/	55.53
double	53.19	60.78	/	113.97
triple	67.71	50.65	53.41	171.77

Module testing requires higher equipment. In order to further calculate the module data from a cell, it is planned to carry out more strings simulation verification in the later period.

Next plan

Standardization requirements of GTR

——Cell: Further study the impact of SOC, gas sampling location, consistency, etc. on test results;

——Module: Manufacture a gas generation test device that adapts to the size of the module;

——Vehicle: Carry out the vehicle-level thermal runaway test, and place the real-time gas detection device inside the vehicle. This test can best evaluate the impact of gas production on occupants, but the cost of the test is high.