EUROPEAN COMMISSION
JOINT RESEARCH CENTRE

Directorate C - Energy, Transport and Climate (Petten)
Energy Storage

Petten, 08 November 2022

JRC replies to the questions received from the Informal Working Group members at the 24th GTR EVS meeting on the presentation "Gas emissions from thermal runaway and propagation of Li-ion battery cells in short stack and module experiments"

(EVS24-E1TP-0401 [EC]Gas emissions from thermal runaway .pdf)

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Colour code:
Black – question
Blue – JRC reply

1. from OICA - Gérald CREPEAU:

Why AEGL 2 60 minutes and not AEGL 2 10 minutes please?

We are considering including AEGL-2 10 min and 20 min in order to reflect different realistic scenarios with passengers being exposed for different period of time (shorter=being able to escape but still exposed to released gases or longer=being trapped in the car).

2. from Brian Engle; Amphenol:

How many cells vented in each configuration?

All of them at different time (sequentially)

Were the cells weighed before and after the test to determine mass release of each cell?

Yes, the weight loss was measured. For details please refer to JRC's presentation, given at the 20th GTR EVS meeting EVS20-E1TP-0500 [EC]Progress on thermal propagation testing.pdf (slide 22).

3. from shashi kuppa:

This is a very good systematic study. Why is it that average concentration of some gases goes down for some gases when the DUT size increases?

Is it because the CO and CO2 emission are much greater for larger DUTs and so though there are significant emissions of other gases, their concentration is lowered?

Research on gas emissions and their dynamics is ongoing and from the data JRC obtained there may be at least two possible reasons for this observation: dilution effect and lower amount of some gases produced for larger DUTs. Indeed, CO and CO_2 emissions are much greater for larger DUTs, contributing to the dilution (please see Annex I below). Also, both ceramic nail penetration and rapid heating trigger thermal runaway initiation, with higher temperatures developing in the cell with TRIM heater, leading to the higher concentrations of CO, H_2, PH_3. This can be a manifestation of a higher rate of thermal decomposition process in this case (please see Annex I-II below).

But that doesn't mean these gases won't pose health risk because they are still of a quantity harmful to health, correct?
The exposure to gases in concentrations above AEGL-2 is harmful to human health since this causes irreversible effects.

4. from Tobias Kaufmann FEV:
Thank you for that detailed presentation.
A question for curiosity: how did you assure that the gas sampling was representative for the gases released during the test?
The gas sampling method was strictly the same regardless of DUT size.
The parameters (position of the DUT on the table, position of the sampling probe for gas analyses, room where experiments were performed, the analysing equipment and the sampling frequency) were the same, facilitating a direct comparison among the experiments. For details please refer to the JRC's presentation, given at the 24th GTR EVS meeting EVS24-E1TP-0401 [EC]Gas emissions from thermal runaway .pdf (slide 05).

Can the variations of gas concentrations in different experiments be clearly be associated with the trigger method, i.e. can fluctuations just due to different gas trajectories be excluded?
Please see our reply to the previous question.

5. from CN-Hao Weijian:
Thank you! Very impressive work. We also pay attention to the potential toxic affect of gas generated from the traction battery. Compared with gas component, the concentration of some certain toxic gas is more important to evaluate the toxic effect to the occupants. you compared this toxic gas concentration to the AEGL. We just consider that did this concentration could reflect the real scenario for the occupants sit in the car?
We are considering including AEGL-2 10 min and 20 min in order to reflect different realistic scenarios with passengers being exposed for different period of time (shorter=being able to escape but still exposed to released gases or longer=being trapped in the car).

6. from shashi kuppa:
Will JRC be publishing reports of this research effort and the TP test method presented yesterday? It would be very helpful.
It is our intention to disseminate the results.

Annex I

Gas analysis overview - FTIR (online) / GC (offline)

Impact of the initiation test on gas emission

				FTIR online			
				CO2 vol%	CO ppm	TOC ppm	HF ppm
5-cell stack	vertical/ML17	TRIM	Test #6	0.13	182.6	545	7.4
5-cell stack	vertical/ML17	TRIM	Test #11	0.32	199	615	13.7
5-cell stack	horizontal/ML17	TRIM	Test #14	0.15	88.2	351	7.1
5-cell stack	horizontal	TRIM	Test #15	0.18	53	182	10.2
5-cell stack	vertical	TRIM	Test #10				
5-cell stack	vertical	CNP	Test #2	0.6	65.5	72	19.7
5-cell stack	vertical/ML17	CNP	Test #3	0.42	78.7	191	13.1
5-cell stack	vertical/ML17	CNP	Test #16	0.2	28.7	53	8.0
10s2p module	horizontal	TRIM	Test #12	1.18	309	284	25.7
10s2p module	horizontal	TRIM	Test #13	1.91	531	372	29.7

				sampling GC off line		
				CO2 vol%	CO ppm	H2 ppm
5-cell stack	vertical/ML17	TRIM	Test #11	**0.5**	238	376
5-cell stack	horizontal/ML17	TRIM	Test #14	0.2	116	165
5-cell stack	horizontal	TRIM	Test #15	0.2	58	82
5-cell stack	vertical	TRIM	Test #10	**0.6**	140	240
5-cell stack	vertical	CNP	Test #2	0.9	74	34
5-cell stack	vertical/ML17	CNP	Test #3	0.6	85	73
5-cell stack	vertical/ML17	CNP	Test #16	**0.4**	**41**	**20**
10s2p module	horizontal	TRIM	Test #12	**1.3**	**354**	**130**
10s2p module	horizontal	TRIM	Test #13	**2.0**	**535**	**136**

average ca. 20-30 min

10

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Annex II

		5-cell stack			5-cell stack			
unit		Test #2	Test #3	Test #16	Test #10	Test #11	Test #14	Test #15
cell size	Ah	5s 40Ah	5s 40Ah	5s 40Ah	5s 40Ah	5s 40Ah	5s 40Ah	5s 40Ah
test condition		Nail penetration	Nail penetration	Nail penetration	Canadian heater	Canadian heater	Canadian heater	Canadian heater
volume of test room	l	free room 100 m3	free room 100 m3	free room 100 m3	free room 100 m3	free room 100 m3	free room 100 m3	free room 100 m3
mat between cells		no	yes	yes	no	yes	yes	no
CO_2	vol %	0.9	0.6	0.4	0.6	0.5	0.2	0.2
O_2	vol %	20.4	20.7	20.6	20.4	20.5	21.4	20.8
N_2	vol %	77.8	77.8	78.1	78.0	78.0	77.4	78.1
Ar	vol %	0.9	0.9	0.9	0.9	0.9	0.9	0.9
H_2	ppm	34	73	20	240	376	165	82
CO	ppm	74	85	41	140	238	116	58
Phosphin PH_3	mg/m^3	<0,0142	<0,0142	<0,0142	0.0355	0.0355	<0,0142	<0,0142
Formaldehyde:	µg/m^3	<100	<100	<100	<100	148*	226	202
Acetaldehyde:	µg/m^3	4080	6840	3540	19200	32200	17500	8780
Propionaldehyde:	µg/m^3	802	526	<100	830	994	476	210
Butyraldehyde:	µg/m^3	188	180	<100	442	574	<100	<100
Valeraldehyde:	µg/m^3	306	184	228	538	590	298	210
Methane:	vol %	<0,1	<0,1	<0,1	<0,1	<0,1	<0,1	<0,1
Ethane:	vol %	<0,0005	<0,0005	<0,0005	<0,0005	0.001	<0,0005	<0,0005
Ethene:	vol %	<0,0005	0.002	<0,0005	0.005	0.010	0.005	0.002
Ethyne:	vol %	<0,0005	<0,0005	<0,0005	<0,0005	<0,0005	<0,0005	<0,0005
Propane:	vol %	<0,0005	<0,0005	<0,0005	<0,0005	<0,0005	<0,0005	<0,0005
Propene:	vol %	<0,0005	<0,0005	<0,0005	<0,0005	0.001	<0,0005	<0,0005
Propine:	vol %	<0,0005	<0,0005	<0,0005	<0,0005	<0,0005	<0,0005	<0,0005