Committee of Experts on the Transport of Dangerous Goods and on the Globally Harmonized System of Classification and Labelling of Chemicals

4 July 2019

Sub-Committee of Experts on the Transport of Dangerous Goods
Fifty-fifth session
Geneva, 1-5 July 2019
Item 4 (b) of the provisional agenda
Electric storage systems:
hazard-based system for classification of lithium batteries

Report of the lunchtime working group on hazard-based classification of lithium batteries and cells (2-3 July 2019)

Transmitted by the expert from France and COSTHA on behalf of the informal working group

Background

1. The participants briefly discussed the current status of the work being conducted in the IWG:

(a) Propagation – focused on reactions between cells but propagations within batteries must still be discussed.

(b) Flowchart – draft testing flowchart has been developed. Movement through the flowchart is based on results of tests

(i) propagating or no propagation

(ii) gas generation

(iii) fire

(iv) …

(v) Eventual exit from flowchart would decide classification based on significance of hazard

(c) The IWG created a draft test methodology for tests. The general parameters of the procedure are reproduced in INF.5, Annex 2

(d) Two teleconferences were held in Spring 2019 to finalize testing protocols using the same model cells and test procedures between different testing laboratories.

(e) Next IWG meeting is scheduled for October 7-9 in Dallas, Texas, USA. The main purpose of the meeting is to share testing results.

Discussion

2. RECHARGE explained that there were problems encountered during the conference calls.

(a) The tests have not started yet because there was some concern over particular details of the test methodology. It was perceived by some that all laboratories must follow the exact methodology.

(b) The Lunchtime Working Group (LWG) advised that an exact and detailed methodology is not necessary as long as defined elements identified in paragraph 6 are maintained.

3. The Chairman explained that during the 55th Session, the participants could address the identified problems with testing so that laboratories can have test results to discuss in October 2019.

(a) It was also suggested that how the data will be reviewed/analyzed could be discussed.

(b) INF.5, Annex 2, Test Methodology (f) indicated that variations of testing methods were welcomed as the results may be useful to determine future refinements to the test methods. Detailed test methodology at this stage would limit laboratories to be able to conduct the tests based on their experience with similar tests. Instead, specific data points were determined to be more critical during this testing event.

4. The LWG suggested the testing has 2 goals:

(a) reproducibility of the test

(b) identifying the variations that are possible.

(c) The Chairman reminded the group the current testing is designed not to identify a reproducible test, but instead to do testing and collect data so that the results of the tests can be used to define a reproducible test method. Data needs to be collected, even in a non-perfect way, so that the IWG has data to make future decisions. Without the data, opinions are driving decisions.

5. The group concluded the tests need to be conducted with the current guidance on the tests as listed in INF.5, Annex 2. A laboratory is encouraged to collect all the additional parameters used to prepare the cell for the test (method for attaching cells, location of heating element, alternate ways of initiation), but questions about the methods should not prevent testing.

Conclusion

6. The LWG agreed it was important to provide clear guidance on the testing methodology and acceptable flexibility in conducting the tests.

(a) It is legitimate to have differences between protocols during this stage of the testing. Laboratories may also coordinate with identical protocols. ***But the lack of a detailed coordinated protocol should not prevent testing initiation.***

(b) For the purposes of this test protocol, identical pouch cells and identical cylindrical cells will be provided. The test protocol shall be followed for each type of battery. Sufficient number of cells will be provided to conduct three (3) tests on each type. The cells will be tested as received (except for charging), and no individual cell shall be tested more than once.

(c) Methodology to be followed must include:

(i) Test shall include 2 cell types of identical design, chemistry, state of charge, manufacturer. PRBA will provide specific manufacturer and model number for use during the tests.

(ii) The test set-up should avoid heat dissipation (thermal insulation). Experience of gained from testing should be collected and shared with the testing results.

(iii) Initiation method must be from an external heat source. Alternate initiation methods may be conducted in addition to external heat sources for purposes of comparison. Details of initiation method must be collected and described in report.

(iv) 6 cells placed in a row in an arrangement per drawings developed previously in the IWG. Cells must be in contact with each other.

(v) Cells must be at 100 % state of charge.

(vi) Each time a test is repeated, a new set of cells are to be used.

(vii) Cells should be tested as received (jacket or cover should not be removed)

(viii) Cells must be of the design provided to all laboratories. Additional cell designs may be used in a separate, additional test.

(ix) Results should be shared in a way that protects confidentiality of the manufacturer.

(d) Testing setup must be fully described so that methodology may be compared to other testing configurations.

(i) Variations of testing methods, such as type of heater or placement of heat source, could be presented using the same data collection points. Future proposals regarding different testing methods would only be considered if data presented is comparable using the same methods.

(ii) All labs should do the common testing as previously described on provided cells but are free to perform extra tests at different SOC, batteries chemistry, geometry etc… if they care about illustrating different points.

(e) Data points to be collected include:

(i) Temperature of initiation of trigger cell

(ii) max temperature of each cell

(iii) temperature of initiation of transfer cell

(iv) max temperature of runaway

(v) max temperature of the overall pack temperature

(vi) time to propagate from the moment of cell reacting to an adjacent cell reaction

(vii) voltage and weight of cell before and after test

(viii) volume/identification of gas production – optional understanding that not all laboratories have the ability to collect.

(f) An example data report is provided in Annex 1.

(g) The standard test protocols with drawings is provided as Annex 2.

Next Steps

7. Timetable

(a) Laboratories will have a conference call to confirm the objectives and methodology (placement of thermocouple for example) as soon as possible.

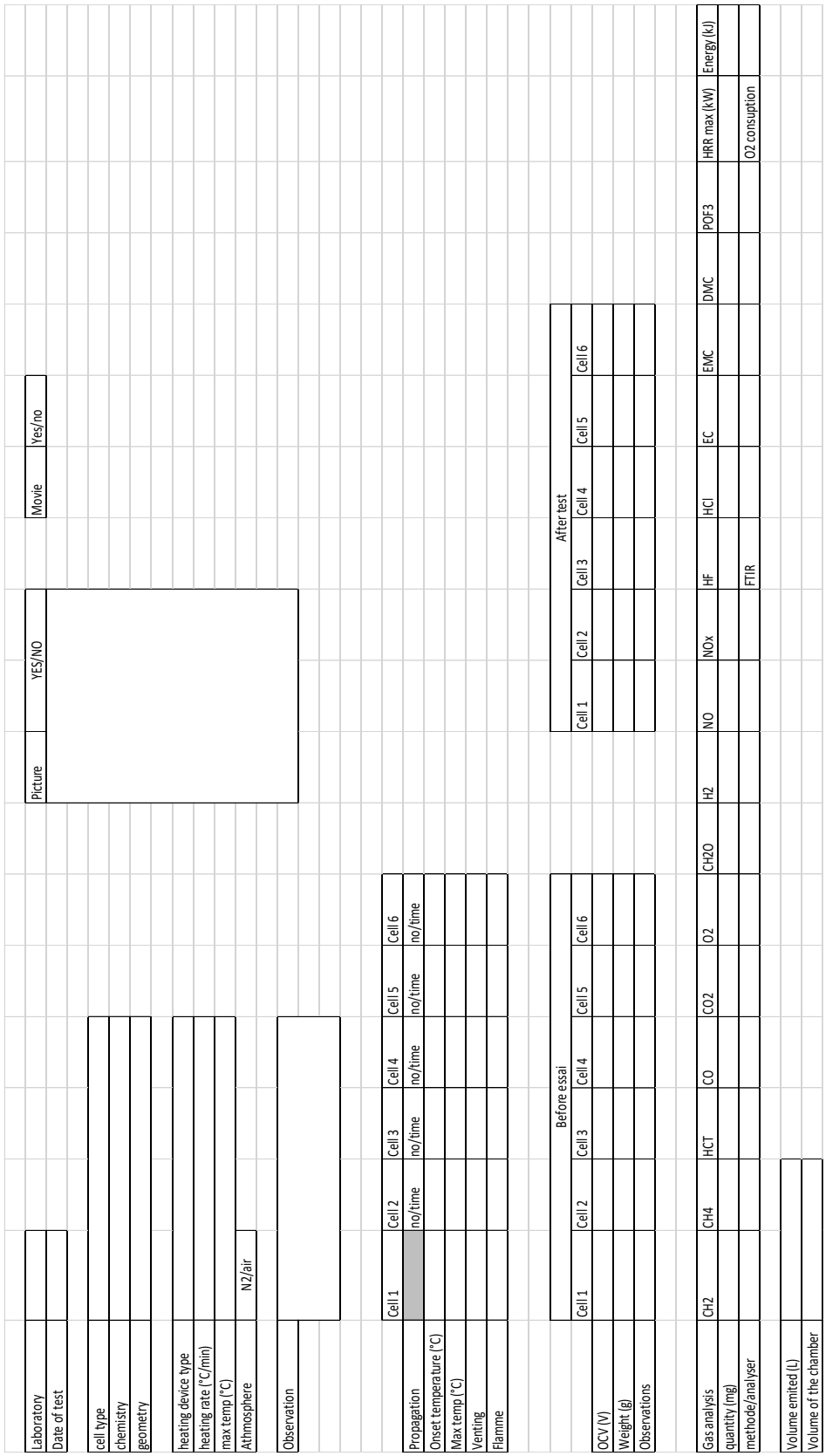
(b) PRBA will ship cells to laboratories by the end of July.

(c) Testing should be conducted in August and September.

(d) However, laboratories need to start testing by September 15 at the latest. Expectation is that testing should take up to 2 weeks.

(e) Test reports should be supplied to PRBA/RECHARGE by 1 October 2019.

Annex 1


Laboratory
Date of test
Picture
YES/NO
Movie
Yes/no
cell type
chemistry
geometry
heating device type
heating rate (°C/min)
max temp (°C)
Athmosphere
N2/air
Observation
Cell 1
Cell 2
Cell 3
Cell 4
Cell 5
Cell 6
Propagation
no/time
Onset temperature (°C)
Max temp (°C)
Venting
Flamme
Before essai
OCV (V)
Weight (g)
Observations
Gas analysis
quantity (mg)
methode/analyser
CH2
CH4
HCT
CO
CO2
O2
CH2O
H2
NO
NOx
HF
HCl
EC
EMC
DMC
POF3
HRR max (kW)
Energy (kJ)
After test
FTIR
O2 consuption
Volume emited (L)
Volume of the chamber

Annex 2

Background:

18650's

- Test Series 1: All labs
- Test Series 2a: Labs without gas analysis
- Test Series 2b: Labs with gas analysis

Pouch

- Test Series 1: All labs
- Test Series 2a: Labs without gas analysis
- Test Series 2b: Labs with gas analysis

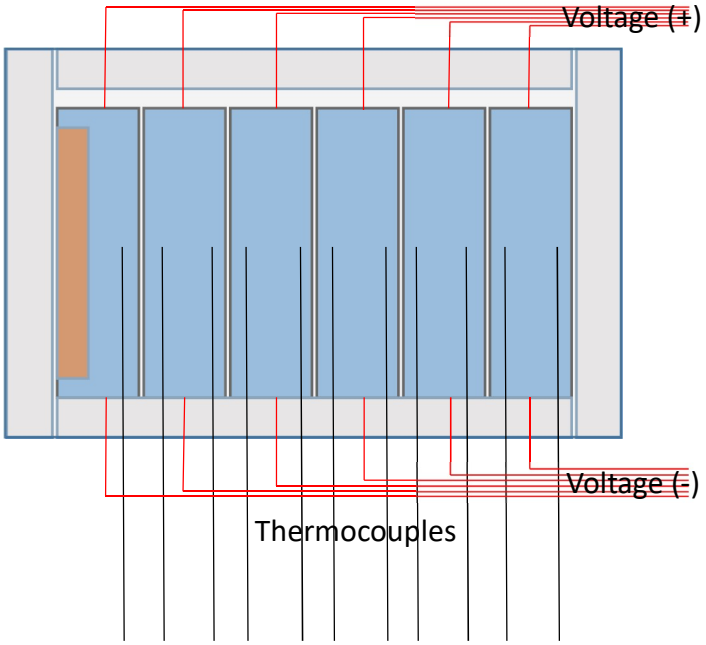
Test Series 1, All Labs:

Experimental Setup:

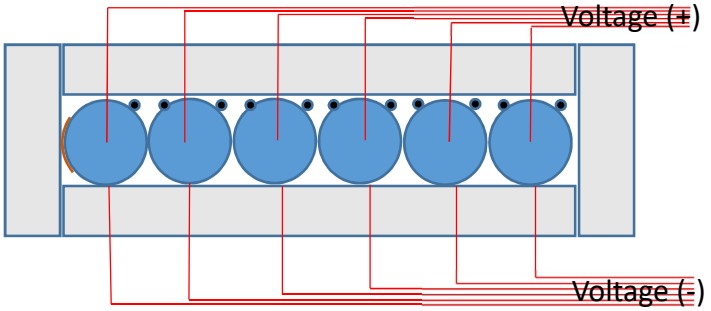
- Six (6) 18650 cells, 100% SoC
- Parallel configuration (not electrically connected)
- 1 T/C on first cell, 2 T/C on each remaining cell
- Voltage measurement on each cell
- Insulation on all sides

Experimental Procedure:

- Cells are touching each other
- Attach thermocouples at mid-height of cells at 1:30 and 10:30 positions as shown below
- Collect temperature and voltage data at 1Hz.
- Heat 1st cell at 20C/min
- Turn heater off when first cell goes into thermal runaway (temperature jump above 200C)
- Repeat Test Three (3) times



Side View



Top View

Test Series 2a, Labs without Gas Analysis:

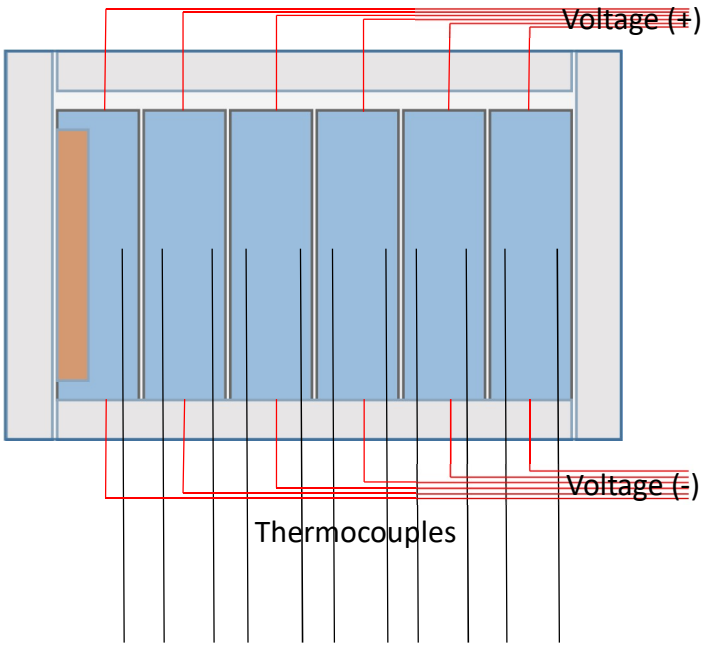
Experimental Setup:

- Six (6) 18650 cells per test at SoC according to grayed regions in table below (4 tests).
- Parallel configuration (not electrically connected)
- 1 T/C or first cell, 2 T/C on each remaining cell
- Voltage measurement on cell
- Insulation on all sides

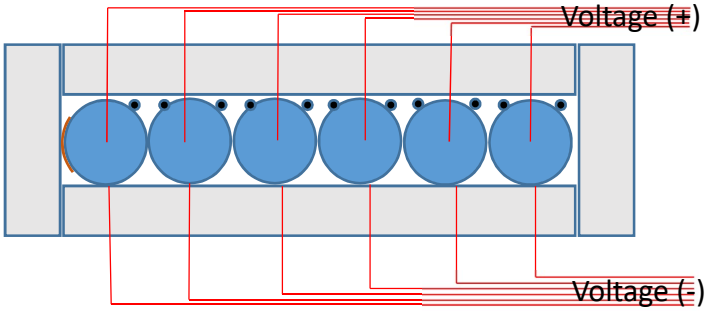
Experimental Procedure:

- Cells are touching each other
- Attach thermocouples at mid-height of cells at 1:30 and 10:30 positions as shown below
- Collect temperature and voltage data at 1Hz.
- Heat cells according to table below
- Turn heater off when cell goes into thermal runaway (temperature jump above 200C)
- Each test is performed once

	30% SoC	50% SoC	70% SoC	100% SoC
5 C/min				
20 C/min				



Side View



Top View

Test Series 2b, Labs with Gas Analysis:

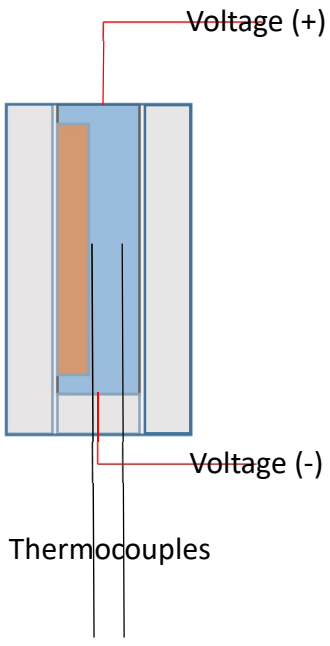
Experimental Setup:

- One (1) 18650 cell per test at SoC according to grayed regions in table below (10 tests).
- Two (2) T/C on cell
- Voltage measurement on cell
- Insulation on all sides except top

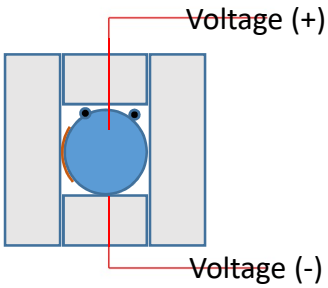
Experimental Procedure:

- Attach thermocouples at mid-height of cells at 1:30 and 10:30 positions as shown below
- Collect temperature and voltage data at 1Hz.
- Heat cells according to table below
- Turn heater off when cell goes into thermal runaway (temperature jump above 200C)
- Each test is performed once
- Measure volume of gas
- Measure composition of gas

	30% SoC	50% SoC	70% SoC	100% SoC
5 C/min				
10 C/min				
15 C/min				
20 C/min				



Side View



Top View

Pouch

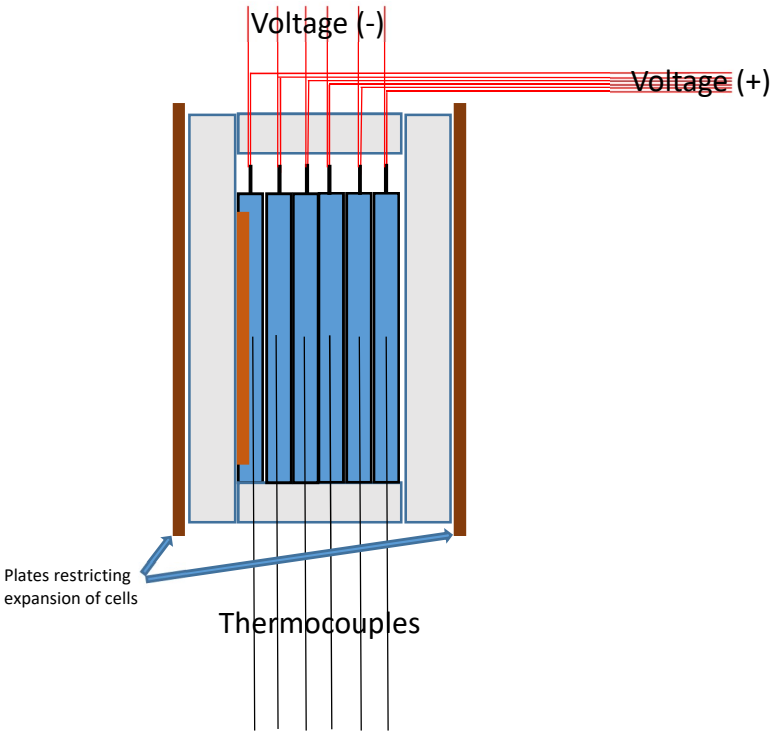
Test Series 1, All Labs:

Experimental Setup:

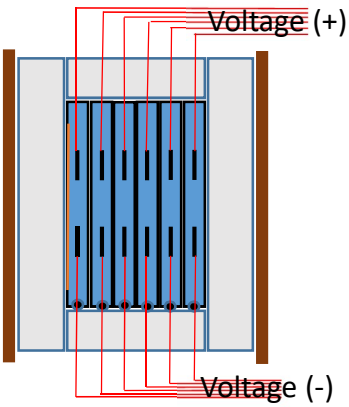
- Six (6) pouch cells, 100% SoC
- Parallel configuration (not electrically connected)
- 1 T/C on each cell
- Voltage measurement on each cell
- Insulation on all sides
- Two rigid steel plates to sandwich the configuration together to prevent expansion.

Experimental Procedure:

- Cells are touching each other
- Attach thermocouple at mid-height at edge of cell.
- Collect temperature and voltage data at 1Hz.
- Heat 1st cell at 20C/min
- Turn heater off when first cell goes into thermal runaway (temperature jump above 200C)
- Repeat Test Three (3) times



Side View



Top View

Test Series 2a, Labs without Gas Analysis:

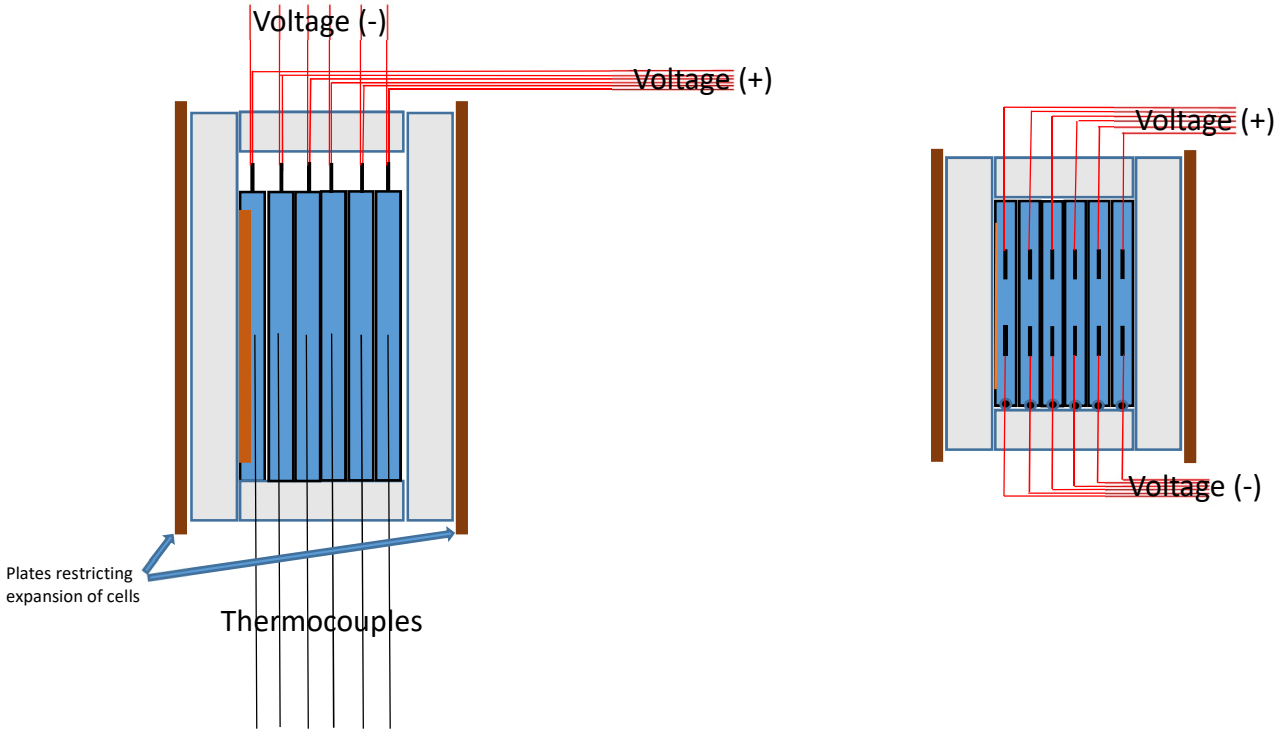
Experimental Setup:

- Six (6) pouch cells per test at SoC according to grayed regions in table below (4 tests).
- Parallel configuration (not electrically connected)
- 1 T/C on each cell
- Voltage measurement on each cell
- Insulation on all sides
- Two rigid steel plates to sandwich the configuration together to prevent expansion.

Experimental Procedure:

- Cells are touching each other
- Attach thermocouple at mid-height at edge of cell.
- Collect temperature and voltage data at 1Hz.
- Heat cells according to table below
- Turn heater off when cell goes into thermal runaway (temperature jump above 200C)
- Each test is performed once

	30% SoC	50% SoC	70% SoC	100% SoC
5 C/min				
20 C/min				



Side View

Top View

Test Series 2b, Labs with Gas Analysis:

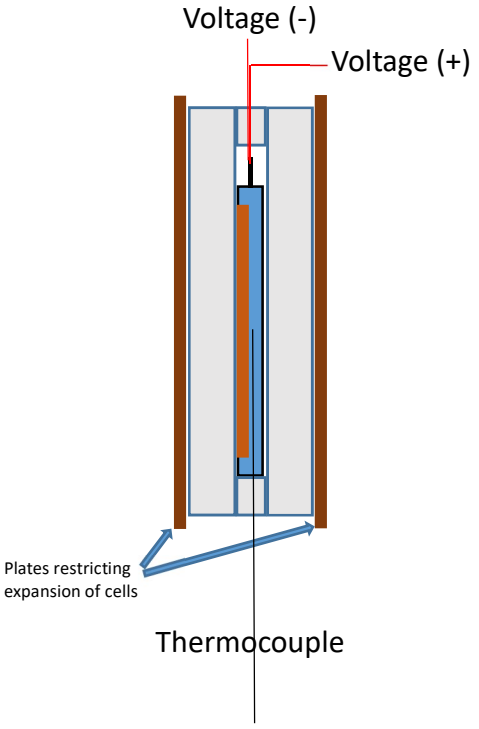
Experimental Setup:

- One (1) pouch cell per test at SoC according to grayed regions in table below (10 tests).
- Two (2) T/C on cell
- Voltage measurement on cell
- Insulation on all sides except top

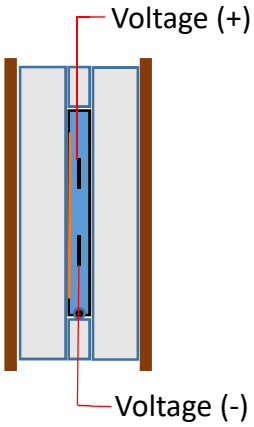
Experimental Procedure:

- Attach thermocouple at mid-height at edge of cell.
- Collect temperature and voltage data at 1Hz.
- Heat cells according to table below
- Turn heater off when cell goes into thermal runaway (temperature jump above 200C)
- Each test is performed once
- Measure volume of gas
- Measure composition of gas

	30% SoC	50% SoC	70% SoC	100% SoC
5 C/min				
10 C/min				
15 C/min				
20 C/min				



Side View



Top View

18650 and Pouch

General notes:

1. Type K thermocouples,
2. Wiring doesn't matter since voltage readings require minimal current,
3. Insulation with thermal conductivity less than .2W/mK. Insulation must not melt or decompose at temperatures below 800C. (superwool, kaowool)
4. Any size heater tape. Cartridge heaters must be less than .25" diameter and no longer than the cell.
5. Heater controller capable of heating the cell at the target rate within 2C. The 1 minute average must be within 2C of the target.
6. Voltage at 1Hz recording rate. Accurate to .01V
7. Starting temperature of all cells: 20C +-5C
8. Record ambient starting temperature in the lab.
9. If not in chamber: no forced airflow over the cells. i.e. wind, hvac, fans, etc.
10. If a cell ejects its core, rerun the test and record event.
11. If a cell has a sidewall rupture, rerun the test and record event.
12. Clean chamber between each test since battery soot is conductive and can lead to faulty temperature and voltage measurements.
13. Cells oriented vertically
14. If extra cells are available, repeat tests from 2a or 2b randomly.

If in chamber:

15. Allow chamber to cool to 20C +-5C before taking gas measurement to properly determine volume.
16. After allowing the cells to cool, add 2-5psi N2 to mix the gasses before sampling.
17. Record pressure at 1Hz