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TESTING REPORT AND DATA ANALYSIS FOR 30-GALLON POLY DRUM

Test Date: August 2025

Apparatus

- Battery packs
- K-type thermocouples
- Kapton heaters
- BK Precision DAS-220
- 3M Fire Barrier Sealant
- DC power supply
- AkkuGrain
- 16AWG wires
- 30-gallon poly drum

Software

- Sefram Viewer

Pack Prep

- Each pack was deconstructed for the heating element to be placed directly onto the cells.
- The heating element was placed on one cell of each pack to engage thermal runaway. Figure 1 illustrates the same.
- After the heating element was set up, the positive and negative sides of the battery pack were located, and wires were soldered onto the connectors for voltage supply during testing.
- After the heater wires were installed on the battery pack, the pack was resealed in original packaging if possible.

Cell Specifications

Type: 18650

Chemistry: Nickel Manganese Cobalt Oxide (NMC)

Number of cells in 1 pack: 84

Battery pack: 52V 20Ah (2 identical packs per drum)

Average voltage at 100% SOC: 4.2V; Nominal Voltage: 3.7V; Energy per pack: 1040 Wh.

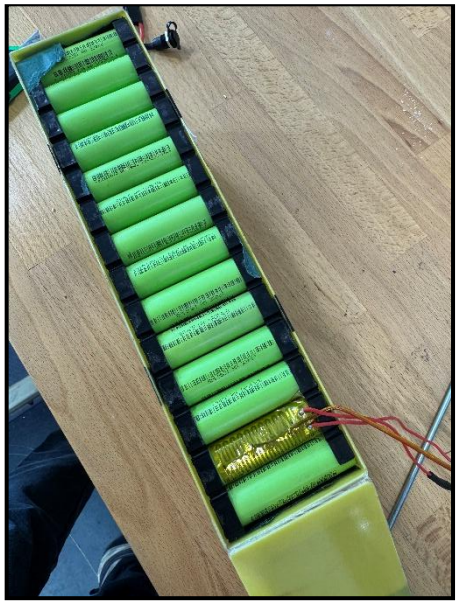


Figure 1

TEST 1

30-gallon poly drum prep

- A small hole was first drilled onto the bottom of the container to run wires and the thermocouples out during the test. The hole was then sealed with a high temperature sealant from the inside as well as the outside.
- The gasket was also removed from the lid to allow for gases to vent from the container.
- The 30-gallon poly drum was pre-filled with approximately 3 inches of AkkuGrain at the base before the first battery was placed in the container. Figure 2 illustrates the same.

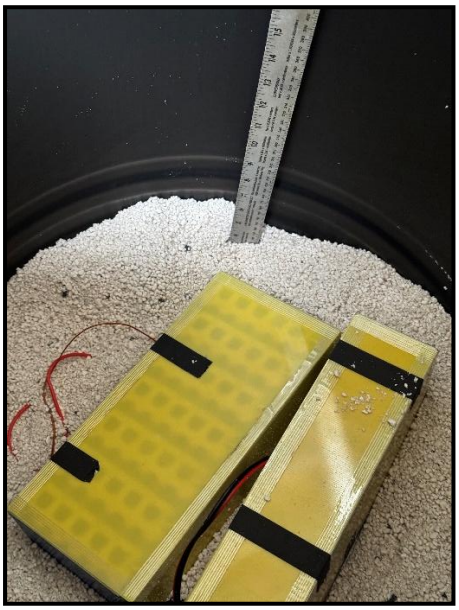


Figure 2

- Figure 3 shows the placement of the first pack. AkkuGrain was filled to the level of the first pack. Following this, approximately 3 inches of AkkuGrain was filled between each of the other two packs.
- Total energy used: 2080 Wh.

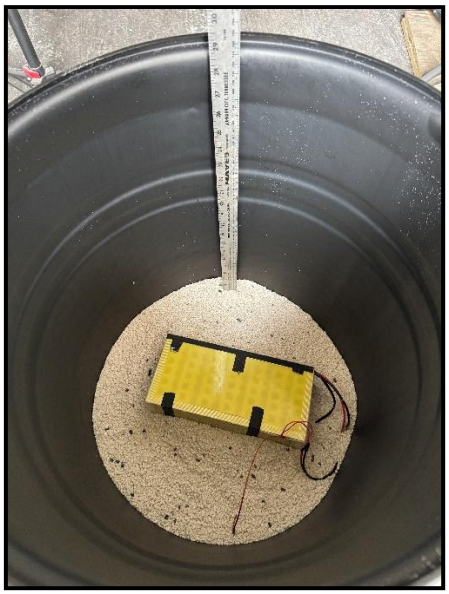
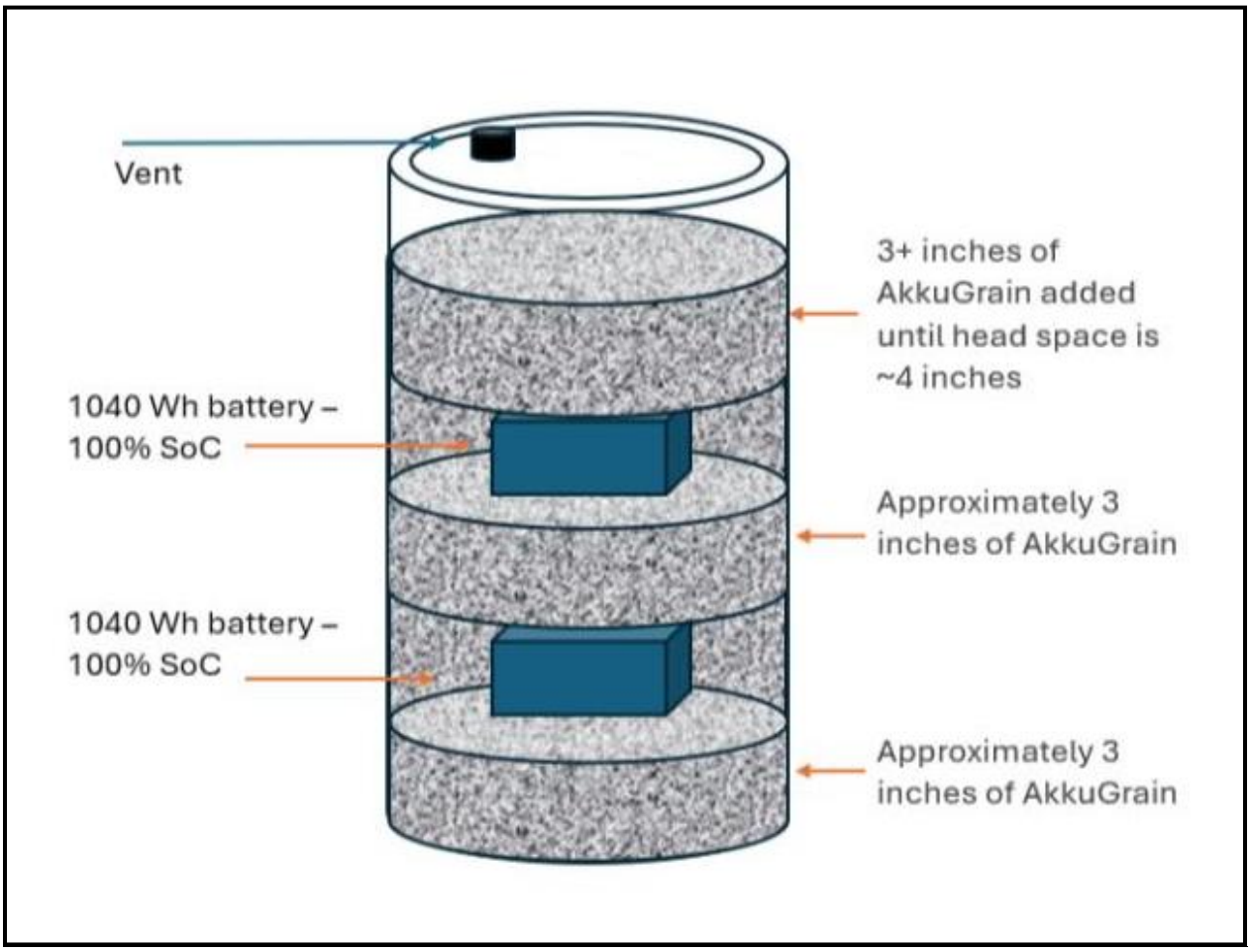


Figure 3

- Figure 4 shows the poly drum was then filled with AkkuGrain to approximately 4 inches from the top.

Figure 4



The above graphic illustrates the placement of the battery packs and the AkkuGrain within the drum.

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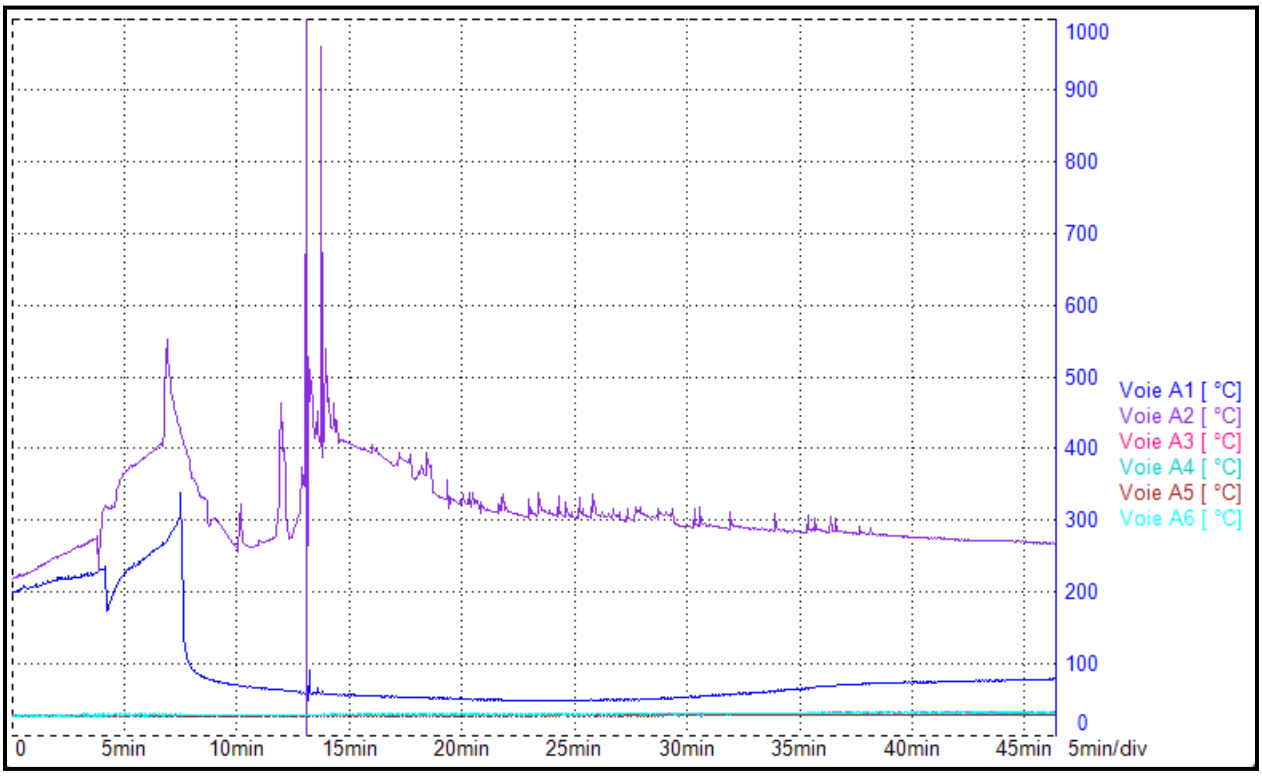
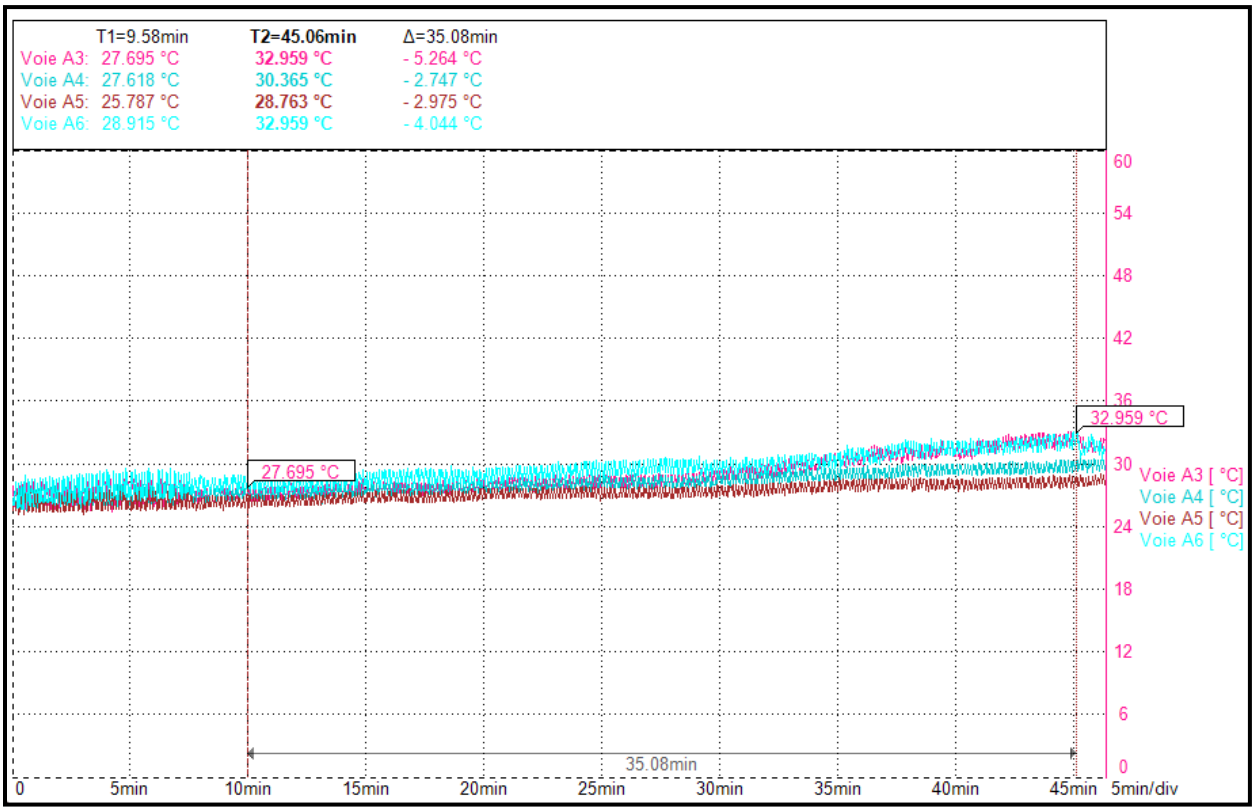
Test Data Analysis





- The graph illustrates all the temperatures measured during the test. From the legend, A1 and A2 are the temperatures of the cells intentionally set into thermal runaway for the top and the bottom pack respectively. A4 is the lid temperature and A3, A5 and A6 are the temperatures of the sidewall of the 30-gallon poly drum.
- In the graph, the temperatures for the top pack rise above 300°C (enough to put cells into thermal runaway) and the bottom pack well above 600°C. The initial temperature peaks indicate the very first thermal runaway events for each battery pack inside the drum at around 330°C for top pack and about 550°C for the bottom pack as well.
- The room temperature at the time of the test was recorded to be 32°C.
- The max temperatures recorded during the test:
    1. A3 (Bottom of drum) was 32.96°C
    2. A4 (Lif of drum) was 30.37°C
    3. A5 & A6 (Sides of drum, mounted 180° from each other) was 32.96°C.

The aftermath of test 1

Observations

- No deformation or bulking of the lid was observed.
- Vent was intact (aftermath picture) and believed to be functioning.
- No flames present during the duration of test.
- AkkuGrain was observed to be clean.

Conclusion:

Based on the above test observations, it can be concluded that the test was successful.

TEST 2

30-gallon poly drum prep

- A small hole was first drilled onto the bottom of the container to run wires and the thermocouples out during the test. The hole was then sealed with a high temperature sealant from the inside as well as the outside.
- The gasket was also removed from the lid to allow for gases to vent from the container.
- The 30-gallon poly drum was pre-filled with approximately 3 inches of AkkuGrain at the base. Another bag of AkkuGrain was filled in before placing the first battery pack. Figure 7 illustrates the same.

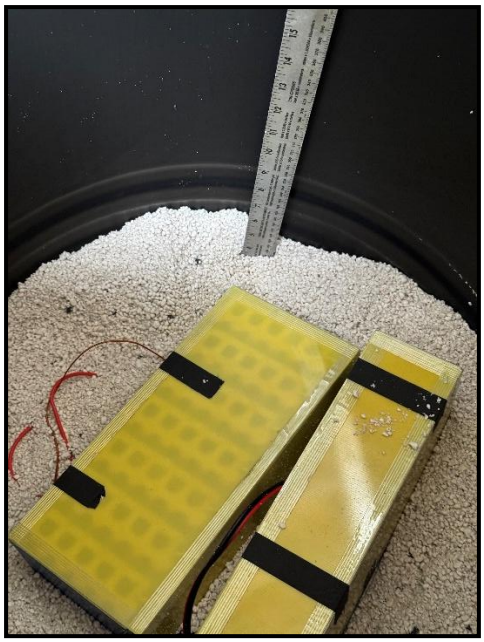


Figure 7

- Figure 8 shows the placement of the second pack. AkkuGrain was filled to the level of the first pack. Following this, approximately 3 inches of AkkuGrain was filled between the two packs.
- Total energy used: 2080 Wh.

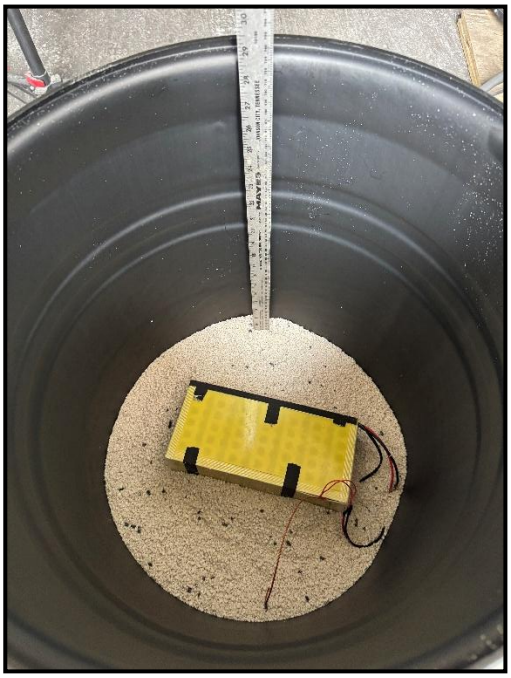


Figure 8

- Figure 9 shows the poly drum was then filled with AkkuGrain to approximately 4 inches from the top.

Figure 9

Test Data Analysis

- Figure 10 illustrates all the temperatures measured during the test. From the legend, A1and A2 are the temperatures of the cells intentionally set into thermal runaway (top and the bottom pack respectively). A3 is the lid temperature and A4, A5 and A6 are the temperatures of the sidewall of the 30-gallon poly drum.

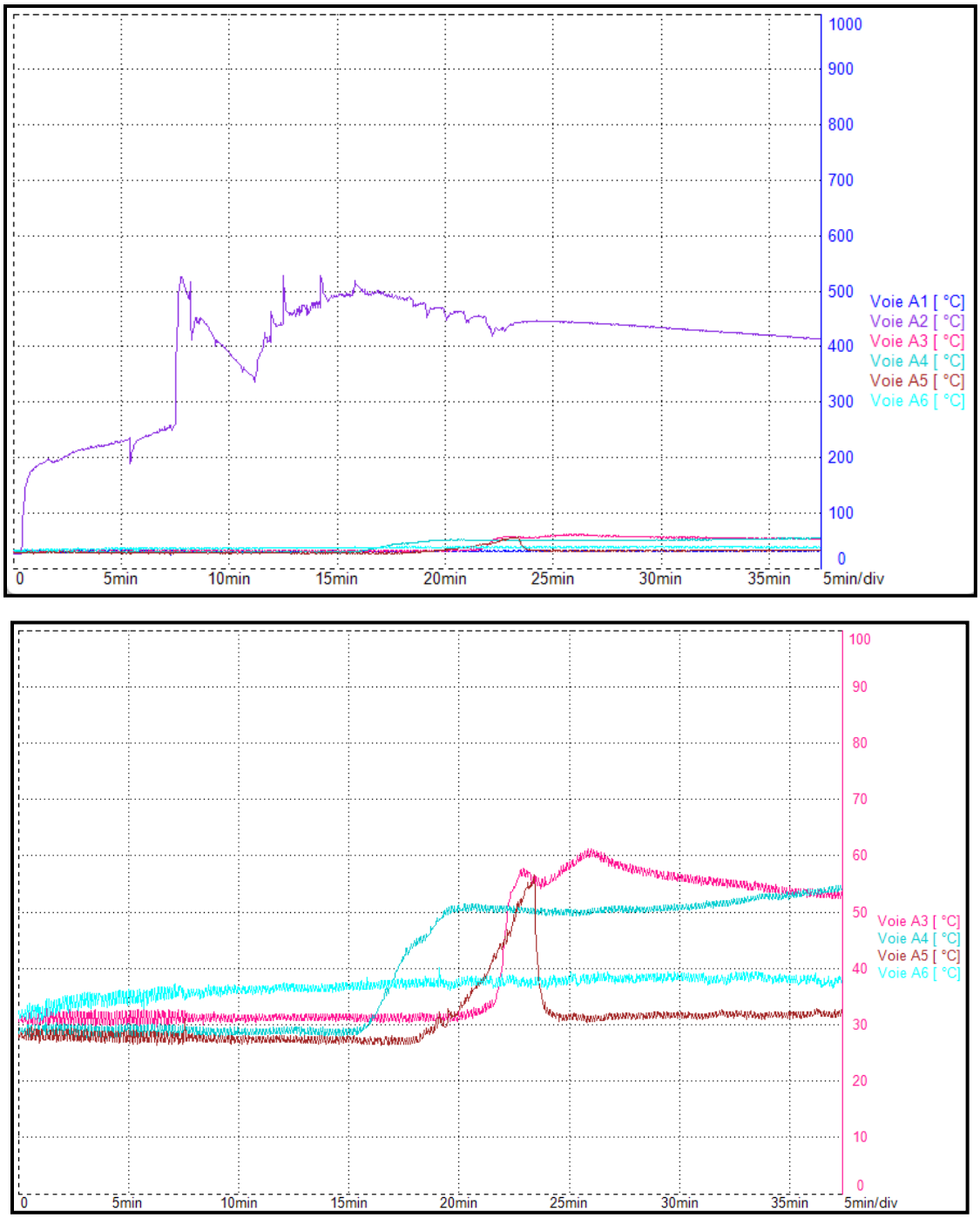


Figure 10

- In Figure 10, the temperatures of the top pack rise well above 500°C at the time of thermal runaway. Unfortunately, the bottom pack thermocouple (A2) failed and couldn't read any data.
- The room temperature at the time of the test was recorded to be 32°C.
- The max temperatures recorded during the test:

  • A3 (Lid of drum) was 53.83°C.

  • A4 & A5 (Sides of drum, mounted 180° from each other) was 55.45°C.

  • A6 & (Bottom of drum) was 39.38°C.

The aftermath of test 2

Observations

- Deformation or bulking of the lid was observed (aftermath pictures of test 2 above), lid remained secured and intact.
- Vent was observed to be exposed to elevated heat temperatures but functional.
- No flames present during the duration of test.

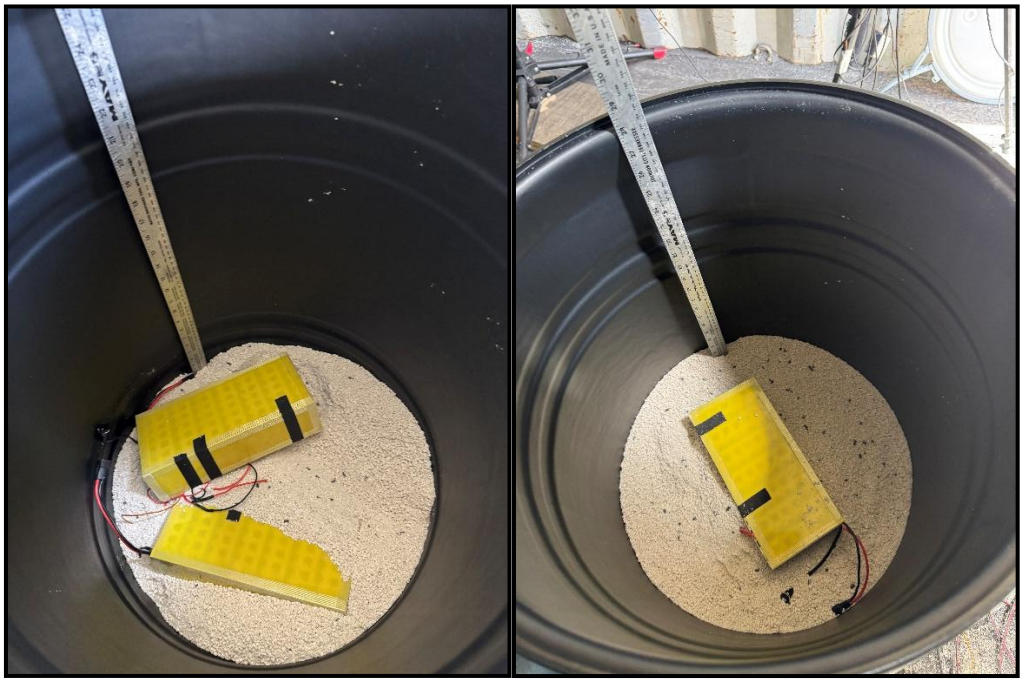
Conclusion:

Based on the above test observations, it can be concluded that the test was successful.

TEST 3

30-gallon poly drum prep

- The same procedure was followed for test 3. Following are the pictures of the preparation of test 3.
- Total energy used: 2080 Wh.



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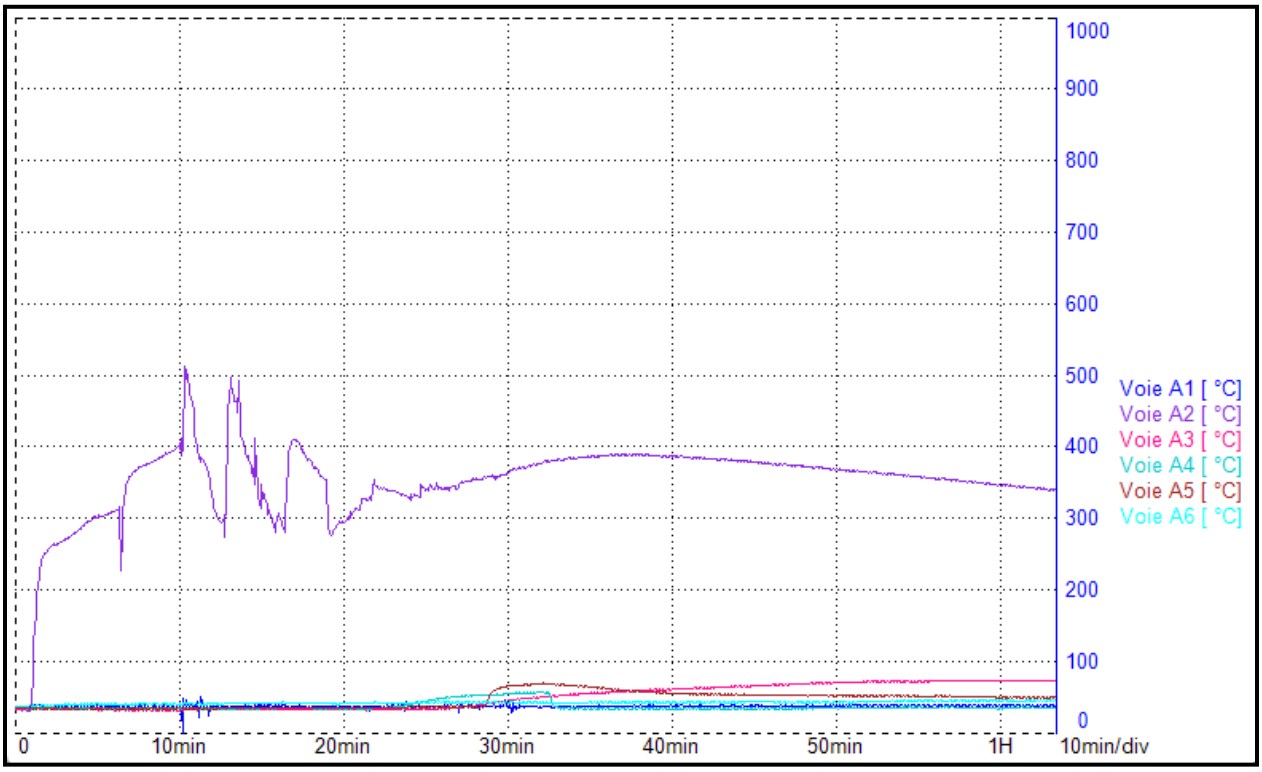
Test Data Analysis

- Figure 11 illustrates all the temperatures measured during the test. From the legend, A1and A2 are the temperatures of the cells intentionally set into thermal runaway (top and the bottom pack respectively). A3 is the lid temperature and A4, A5 and A6 are the temperatures of the sidewall of the 30-gallon poly drum.



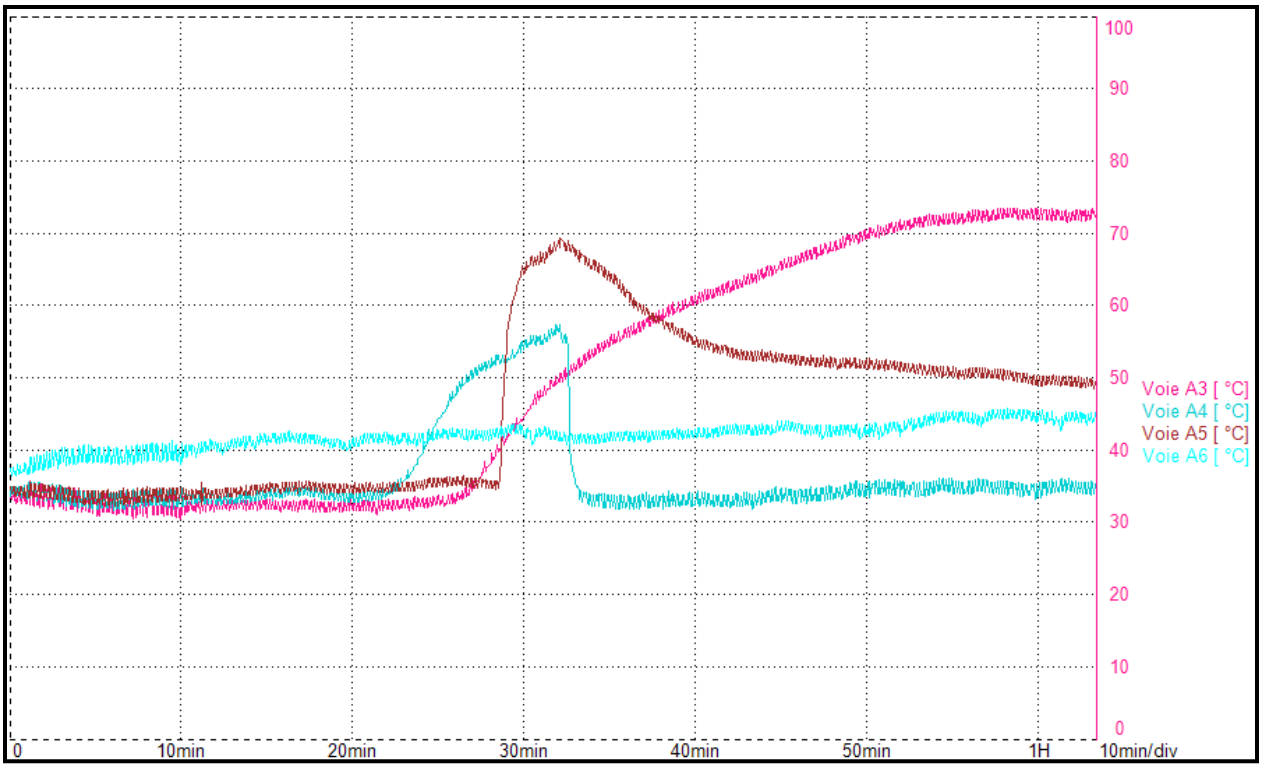


Figure 11

- The temperatures of the top pack rise above 500°C at the time of thermal runaway. Similar to test 2, the thermocouple (A1) failed for the top pack.
- The room temperature of the time of the test was recorded to be 32°C.
- The max temperatures recorded during the test:

  • A3 (Lid of drum) was 73.55°C.

  • A4 & A5 (Sides of drum, mounted 180° from each other) was 35.96°C and 49.98°C respectively.

  • A6 & (Bottom of drum) was 46.01°C.

The aftermath of test 3

Observations

- Deformation or bulking of the lid was observed (aftermath pictures of test 3 above), the lid remained secured and intact.
- Signs of moisture/residue from the AkkuGrain extinguishing the thermal runaway were present at the locking mechanism of the drum lid.
- Vent was observed to be intact and functional.
- No flames present during duration of test.

Conclusion:

Based on the above test observations, it can be concluded that the test was successful.

Summary of results:

Test 1: Battery Pack Energy (100% SoC) – 2,080 Wh

- Cells detonated into thermal runaway and propagated to other cells.
- Drum lid temperatures recorded at 32.96°C
- Drum body temperatures recorded max temperature of 32.96°C
- Drum base temperatures recorded max temperature of 30.37°C
- No flame or projectiles observed outside the drum.
- No deformation observed to the drum.

Test 2: Battery Pack Energy (100% SoC) – 2,080 Wh

- Cells detonated into thermal runaway and propagated to other cells.
- Drum lid temperatures recorded a max temperature of 53.83°C
- Drum body temperatures recorded max temperature of 55.45°C
- Drum base temperatures recorded max temperature of 39.38°C
- No flame or projectiles observed outside the drum.
- Deformation to the lid was noticed, lid remained intact to the drum.

Test 3: Battery Pack Energy (100% SoC) – 2,080 Wh

- Cells detonated into thermal runaway and propagated to other cells.
- Drum lid temperatures recorded max temperature of 73.55°C
- Drum body temperatures recorded max temperature of 69.86°C
- Drum base temperatures recorded max temperature of 46.01°C
- No flame or projectiles observed outside the drum.
- Deformation to the lid was noticed, lid remained intact to the drum.