HMD23LR001

HAZARDOUS MATERIALS GROUP ATTACHMENT

Attachment 8

Lucid Motors Battery Examination Results

Final

Lucid Battery Testing Protocol
NTSB Investigation HMD23LR002

1. Purpose:
   The group examination will be a non-invasive, non-destructive examination of the accident batteries. The purpose of the examination is to survey the battery cells for indications of thermal runaway before the trailer fire.

2. Work Location: Lucid Motors facility (Lucid 1HQ), bunker, 7373 Gateway Boulevard, Newark, CA 94560

3. Test/examinations to be performed during group examination. The examination will include the following:

    a. Receive remnants from event at Lucid HQ Newark, CA.
        i. Photo document receipt of batteries at Lucid HQ.
        ii. Move batteries to secure, controlled access location at Lucid HQ, and photo document location.
    b. In a controlled access area, perform visual inspection of batteries inside each container.
        i. Note: given the large number of battery cells, not all batteries will be inspected. Approximately 660 cells will be examined.
        ii. Bulk visual inspection of the batteries will occur at this stage.
        iii. Any abnormal indications from visual inspection will be pulled from the container for further review.
        iv. Record the size, damage characteristics, the presence of moisture/liquid/condensation on the interior of all batteries (if possible).
            1. Excel spreadsheet will be the primary method of data collection and attributes. Photos taken will be captured in a Word document.
    c. The down-selected battery cells from above will have:
        i. Detailed visual inspection, focusing on top-vent vs side-split indications.
        ii. Voltage measurements made via a DMM (digital multi-meter), to provide further indication of whether battery cells directly went into full thermal runaway; or rather were exposed to thermal runaway of other battery cells.
        iii. Record observations of top-vent vs. side-split indications and voltage measurements.
    d. Other non-battery cell related components will be reviewed individually.
        i. Any non-battery cell related components that are still intact will be visually inspected for any abnormal conditions.

ii. Visual inspection will verify that the components are in an as acceptable a condition as possible given the event as confirmed from the Lucid quality checks and packaging confirmation prior to leaving Lucid manufacturing facility.

e. All measurements, observations and notes will be captured in field notes generated by Lucid Motors. Contents of notes will be presented for review to the Hazardous Materials Group.

f. A report with findings and conclusions of the battery examination will be generated by Lucid Motors and be reviewed by the Hazardous Materials Group.

4. Site Safety:
    a. Lithium batteries that have been damaged pose a risk of ignition and fire, and may contain high voltage exposure, therefore personnel safety must be determined by Lucid Safety Manager and, at a minimum, consider the following:
        i. Appropriate PPE: Appropriate protective gear to be worn during the examination.
        ii. Thermal gun or camera to be continuously monitoring for any rise in temperature that could lead to a smoke or fire event during the examination.
        iii. Appropriate fire extinguisher for trained personnel to use if a smoke or fire event occurs during the examination.
        iv. Proper egress.

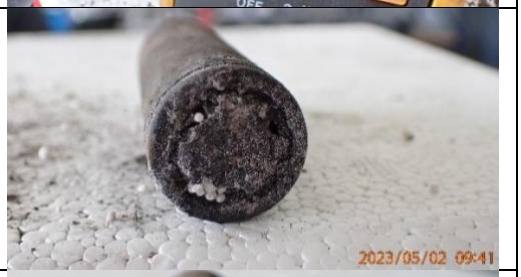
Executive Summary

Two Lucid battery packs were among the cargo burned in a fire in a FedEx truck near Monahan, Texas. Cells from the battery packs were recovered from the cargo debris and packed and shipped by Environmental Restoration to Lucid headquarters in Newark, California, for inspection. The damage observed from the inspected cells is not consistent with the fire originating inside of the battery pack, based upon comparison with the results of previous battery safety testing.

Procedure For Inspection of Incident Cells

The cells were stored in a total of 14 Barrels. From Barrels One to Five, one in every twenty cells was sampled. In this span, repetitive damage characteristics were seen; because of this, and in the interest of time, one in every fifty cells from Barrel Six onward was sampled.

Below are definitions of the damage intensities (characteristics) and an example of each.

0	no damage – cell has voltage and no visible defects	
1	top cap intact – cell has no voltage and minor visible defects	
2	partial jellyroll ejection – cell has no voltage and jellyroll has partially ejected from one end of the cell	

3	full jellyroll ejection – cell has no voltage as entire jellyroll has ejected outside the can	
4	small side rupture – cell has no voltage, and the side of the battery cell can has ruptured. Identified with a small crack along the battery cell can.	
5	large side rupture - cell has no voltage, and the side of the battery cell can has ruptured. Identified with a large crack along the battery cell can.	Not seen during inspection
6	can open – cell has no voltage and entire side of battery cell has ruptured open. Jellyroll can be seen.	

Table 1 - Damage Characteristics of Battery Cells

Observations/Results for Incident Cells

Below are the occurrences of each damage characteristic and the corresponding percentage among all samples.

Damage Intensity	Count	%
0	2	0.50%
1	303	75.75%
2	77	19.25%
3	7	1.75%
4	7	1.75%
5	0	0.00%
6	4	1.00%
Total	400	100.00%

Table 2: Incident Cell Damage Intensity Distribution

Most cells either had top cap intact or partial jellyroll ejection as their failure modes; this is to be expected, as these batteries are designed to vent and eject materials from the top cap area.

Below is a list of some anomalies seen during the analysis:

- Across all sampled cells, there were two cells with residual voltage left, both slightly > 0.6V; these cells had CID (Current Interrupt Device) activation.
- A metal ring, suspected to be foreign to the packs, was found in the barrels.
- There were fourteen unbreakable clusters among all sampled cells.
- One half-module was found with the module plastic, PCBA, and cells mostly intact.
- Two cells out of all sampled cells were potential candidates for evidence of high voltage arcing, based on the size of the holes on the cells. They were cell 35 (upper) and cell 270 (lower). Please see the pictures below.

Figure 1 – Sampled Cell #35 – Potential Candidate of High Voltage Arcing

Figure 2 – Sampled Cell #270 – Potential Candidate of High Voltage Arcing

Lucid Safety Team Previous Test Campaign Results

Propagation Tests

The Lucid battery safety and abuse testing team has performed multiple battery module and pack level thermal runaway propagation tests to validate performance of battery safety features and ensure battery packs are safe. Both the module level and the pack level tests used the same battery cell type. The module level tests were performed with 70% SOC cells, which was the nearest the total energy from Lucid testing related to the incident. The pack level tests are performed with 100% SOC (state of charge) cells, which is higher than the battery SOC in this incident.

Below is the module level test cell failure mode pie chart. The trial (sample size: one every three cells) that has the most "Top Cap Intact" failure mode was chosen to find similarity between the previous test and the incident. Comparison of Table 3, below, to Table 2, above, shows the test trial had a much higher percentage of side rupture cells (20%) than the incident (1.75%).

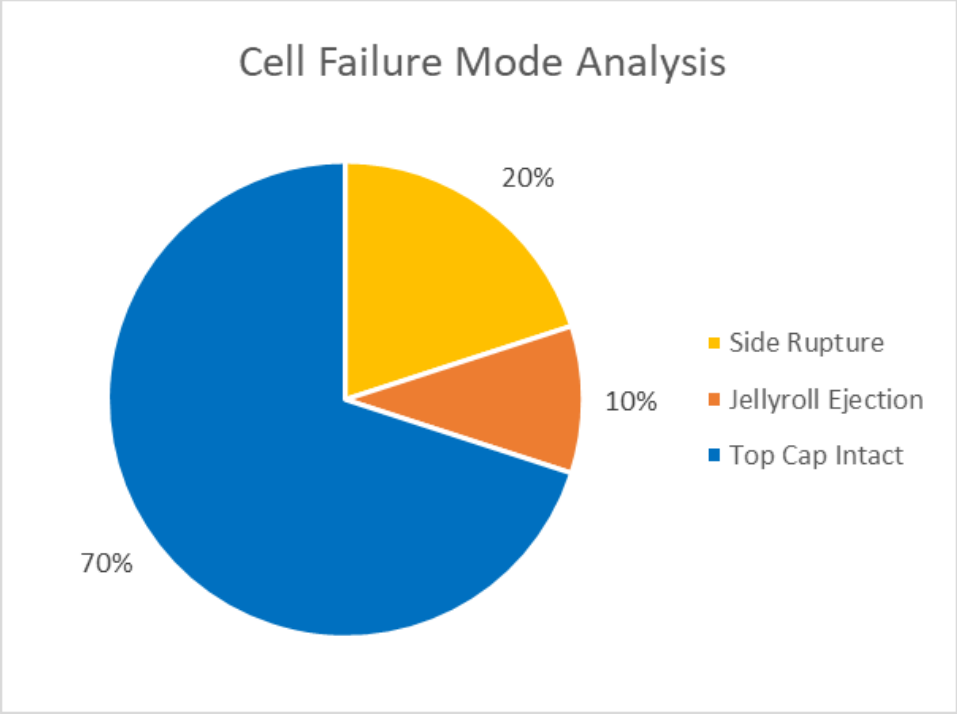


Table 3: Propagation Test Damage Intensity Distribution

For the pack level test performed previously (100% SOC), as part of Lucid safety testing, the battery pack is more structurally intact compared to the incident packs, regardless of the cover type. Pack test images reviewed with NTSB staff show that test packs with both steel covers and SMC covers remained more intact than the incident battery packs.

Arc Initiated Tests

Lucid had also performed a pack level thermal runaway test initiated by high voltage arcing. Figure 3 below shows the picture of a cell impacted by high voltage arcing. There is clearly melted steel can material deposited on the cell can body.

Figure 3 - Arc-Initiated Test Cell - not seen in incident - shown for reference

Compared to cell 35 of the incident, this cell from the previous arc-initiated test had a less defined cell opening and more binding between the steel can body and the unburned jellyroll inside.

Conclusions

From the cells' perspective, among all the sampled incident cells, 95% have either top cap intact or partial jellyroll ejection, which are considered as the intended cell failure modes. In previous thermal runaway experiments initiated within test battery modules/packs, conducted by Lucid teams, more severe cell failure modes were observed than in the incident cells. From the pack perspective, the external cover of the incident pack was severely damaged. In previous thermal runaway experiments, the battery pack covers were more intact than was observed in the incident pack covers. These comparisons indicate the damage to the incident batteries is not consistent with initiation of a fire within the battery packs.