AQUION ENERGY

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Re: Aquion AHI Battery Safety Assessment

Aquion has developed an Aqueous Hybrid Ion Rechargeable Battery for use in residential, commercial, and industrial energy applications. Historical use of lead acid batteries for such applications has led to environmentally-unfriendly practices for storage and disposal as well as inefficient battery performance when deep-cycled. Aquion's Aqueous Hybrid Ion Rechargeable Battery was designed specifically to permit recharging and deep-cycle discharging at high frequencies without degeneration; all while delivery a safe and environmentally-friendly materials.

The Aqueous Hybrid Ion Rechargeable Battery is constructed using a plastic housing containing a stack of electrochemical cells. Each cell includes an anode and cathode along with a separator to prevent internal short circuit, and a liquid electrolyte. Electrodes are constructed of Lithium Manganese Oxide ($LiMn_2O_4$) and $NaTi_2(PO_4)_3$ and the electrolyte is a Sodium Sulfate (Na_2SO_4) solution. Unlike many lithium ion batteries, the reversible reaction in the Aqueous Hybrid Ion Rechargeable Battery involves intercalation/deintercalation of sodium ions from the water-based, brine electrolyte. Individual batteries can be stacked and connected to scale up the battery to the needed power specifications of a given energy requirement. Nominal voltage of the individual cells within the battery is 1.2 V, and each battery has 4 cells and a nominal discharge energy of 220 Wh.

The design of the battery is provided in the US Patent US 8,298701B2, dated 12/30/2012 provided as Attachment 1. A safety data sheet for the article is included as Attachment 2.
Testing In February 2013, the battery has been successfully tested in accordance with UL1973 standards and the results indicate that batteries are able to be operated safely. These tests included:

- Overcharge
- Over-discharge Protection
- Temperature and Operating Limits Check Test
- Imbalanced Charging Test

The battery was successful in all tests and did not create excessive heat, explosion, or fire during any of the tests. The full test report is included as Attachment 3.

The battery was also subjected to abuse testing in late 2013/early 2014. These tests included:

- Drop Impact
- Vibration
- Altitude
- Salt Fog
- Sand/Dust
- Shock
- Nail Penetration

- Crush
- Roll-over
- Emersion
- Thermal Cycling
- Overcharge

The battery successfully passed all tests and did not generate excessive heat, explosion, or fire during any of the tests. The full abuse testing report is included as Attachment 4.

To demonstrate a worst case situation for the battery, one (1) seven stack battery was subjected to a flame propagation test which is part of the UL1973 testing regime. The battery is exposed to a flame for a 30-minute burn period after which the flame is removed. The battery sustained damage to the plastic housing which resulted in the electrolyte (salt water) being liberated. However, the non-flammable nature of the electrolyte served to extinguish the fire, and once the battery was removed from the flame, the battery self-extinguished. Results from the Flame Propagation test are included in the report in Attachment 5.

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