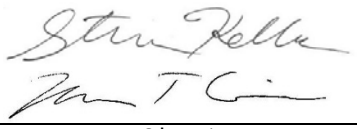
LABORATORY DATA PACKAGE

Number of pages in this package __41__ **[** including additional pages ____ **]**
(Fill in when using printed copy as record)

CLIENT INFORMATION	
Company Name	AQUION ENERGY INC
Address	32 39th St Pittsburgh, PA 15201 United States

AUDIT INFORMATION:			
[x**]** Description of Tests	Per Standard No. UL 1973	Edition	First, Issued Feb. 15, 2013
[x] Tests Conducted by +	Steve Keller Michael Greiner Printed Name	 Signature	
~~**[]** UL Staff conducting or witnessing testing~~ ~~(WTDP, TMP, WMT only)~~ ~~**[]** UL Staff supervising UL Staff in training~~ **[x]**Authorized Signatory (CTDP, TPTDP, TCP, PPP, SMT)	Jeremy LeGasse Printed Name	 2014-04-03 Signature. Include date for CTDP, TPTDP, TCP, PPP, WMT, TMP, SMT	
Reviewed and accepted by qualified Project Handler	Printed Name	Signature	

TESTS TO BE CONDUCTED:			
Test No.	Done+ ++	Test Name	**[]** Comments/Parameters **[]**Tests Conducted by ++
		GENERAL	
1	2014-01-13	OVERCHARGE TEST:	
2		OVERDISCHARGE PROTECTION	
3	2014-03-18	TEMPERATURE AND OPERATING LIMITS CHECK TEST	
4	2014-02-17	IMBALANCED CHARGING TEST	

Instructions -
+ - When all tests are conducted by one person, printed name and signature can be inserted here instead of including printed name and signature on each page containing data. Must indicate number of pages in the data package.
++ - When test conducted by more than one person, printed name and signature of person conducting the test can be inserted next to the test name instead of including printed name and signature on each page containing data. Test dates may be recorded here instead of entering test dates on the individual datasheet pages. Must indicate number of pages in the data package.

+++ - Use of this field is optional and may be employed differently. If used to include a date instead of entering the testing date on the individual datasheet pages, the date shall be the date the test was conducted.

Special Instructions -

Tables are provided on the data sheets for recording of maximum temperature data. Charts, printouts or additional data showing the maximum or stabilized temperatures had been reached shall be included with this package.

Ambient Conditions:

Unless specified otherwise in the individual Methods, the tests shall be conducted under the following ambient conditions. Confirmation of these conditions shall be recorded at the time the test is conducted.

Ambient Temperature, C	25 ± 5	Relative Humidity, %	N/A	Barometric Pressure, mBar	N/A

[x**]** No general environmental conditions are specified in the Standard(s) or have been identified that could affect the test results or measurements.

RISK ANALYSIS RELATED TO TESTING PERFORMANCE:

The following types of risks have been identified. Take necessary precautions. This list is not all inclusive.

[x**]** Electric shock	**[ ]** Radiation
[x**]** Energy related hazards	**[**x**]** Chemical hazards
[x**]** Fire	**[ ]** Noise
[x**]** Heat related hazards	**[ ]** Vibration
[ ] Mechanical	**[ ]** Other (Specify)__

TOLERANCES

Unless noted otherwise in the test methods, the overall accuracy of controlled or measured values when conducting testing in accordance with this standard, were within the following tolerances:

a) ±1% for voltage;
b) ±3% for current;
c) ±4% for watts;
d) ±2°C (±3.6°F) for temperature at or below 200°C (392°F), and ±3°C (±5.4°F) for temperature above 200°C (392°F);
e) ±0.1% for time;
f) ±1% for dimension.
g) ±3.1% for Ah;
h) ±4.1% for Wh;

Safety Precautions When Conducting Testing -

FOLLOW ALL BATTERY SOPS WHEN HANDLING, TESTING, STORING OR DISPOSING OF ELECTRIC ENERGY STORAGE SYSTEM (EESS) SAMPLES.

Review the test procedure carefully before testing. Identify in advance the possible hazards that mat occur as a result of each test and develop an action plan to address the hazards.

Follow appropriate procedures to prevent inadvertent shorting of battery, capacitor and cell terminals during handling, storage and disposal of EESSs. Follow MSDS sheets and battery handling SOPs when handling batteries and capacitors where there is evidence of electrolyte leakage.

Personnel should follow extreme caution when handling large format EESSs and executing the tests outlined in this document. To prevent injury, protective equipment and clothing should be utilized when handling EESSs and when conducting testing. Short-circuiting can lead to very hazardous currents, and large format EESSs may still be hazardous even in an uncharged condition. Nickel metal hydride batteries contain electrolyte consisting of potassium hydroxide, which is caustic and may cause skin burns.

EESS evaluated to these requirements may be at hazardous voltages and energy levels. Care should be taken when working with these EESSs, as electric shock hazards from handling hazardous voltage circuits can lead to serious injury and even death. When handling and testing hazardous voltage systems, appropriate personal protection equipment to prevent injuries should be used at all times.

At the conclusion of all testing, the EESSs samples should be dis-energized to prevent serious incidents that could occur with handling and storage of energized damaged/used samples if possible. After dis-energized tested samples, they should be stored in an isolated, safe location until ready for disposal in accordance with SOPs.

Some batteries are capable of exploding when subjected to battery tests. It is important that personnel be protected from the flying fragments, explosive force, fire and sudden release of heat and noise that results from such explosions. For protection, the testing should be conducted in a room separate from the observer or in an isolated protected test area.

Hydrogen or other harmful gas can be vented under certain stress conditions to these batteries. Care should be taken to protect personal from exposure to harmful gases and test areas should be designed to protect against inadvertent ignition of combustible concentrations of emitted gases. The test area is to be well ventilated to protect personnel from possible harmful fumes or gases.

As an additional precaution, the temperatures on the surface of the samples shall be monitored during the tests. All personnel involved in the testing of EESSs are to be instructed to never approach the DUT until temperatures are falling and are at safe levels.

IMPORTANT TEST PARAMETERS:

STACK:	
Stack Manufacturer	Aquion Energy Inc.
Stack Model	AE1
Cell Manufacturer	Aquion Energy Inc.
Cell Model	
Cell Configuration	7S/1P
Overcharge Voltage Protection	None
Over-discharging Voltage Protection:	None
PTC, Fuse or other current/thermal protection	None
Capacitance	2514F
Standard Charging Current	1.8A
Full State of Charge Voltage (SOC)	53.2Vdc
End of Charging Current	
Maximum Charging Current	6.0A
Maximum Charging Voltage	53.2Vdc
Standard Discharging Current/Load	1.8A
Nominal capacity (20 hr rate)	35Ah
End of Discharge Voltage (EODV)	27V
Maximum Discharge Current/Load	6.0A
Maximum Use Ambient	-5C to 45C
Standard Charge/Discharge Cycle time, minutes	
L x W x H, cm	83.3 x 30.7 x 32.5 cm
Weight, Kg	92Kg

Tested by: Steve Keller / Michael Greiner (Printed Name) (Signature) Date 2014-03-25

TEST LOCATION: (To be completed by Staff Conducting the Testing)
[]UL or Affiliate []WTDP []CTDP [X]TPTDP []TCP []PPP []WMT []TMP []SMT
Company Name: MGA Research Corporation
Address: 12790 Main RD Akron, NY 14001

TEST EQUIPMENT INFORMATION

[] UL test equipment information is recorded on Meter Use in UL's Laboratory Project Management (LPM) database.

[] UL test equipment information is recorded on <<insert location and local laboratory equipment system identification.>>

Inst. ID No.	Instrument Type	Test Number +, Test Title or Conditioning	Function/ Range	Last Cal. Date	Next Cal. Date
36.01-04	Multi meter	4,1	40MV to 1000V	2013-04-05	2014-04-05
36.08-05	Multi meter (DAS)	4,1	100mv to 1000v, -190°C - 1350°C	2013-06-17	2014-06-17
97.01-21	Shunt	4,1	25A/50mV	2013-07-11	2014-07-11
36.08-06	Multi meter (DAS)	3	100mv to 1000v, -190°C - 1350°C	2013-12-23	2014-12-23
97.01-19	Shunt	3	25A/50mV	2013-07-11	2014-07-11
17.07-01	Remote Controller	3	-80 to 190 C	2013-02-20	UWCE

+ - If Test Number is used, the Test Number must be identified on the data sheet pages or on the Data Sheet Package cover page.

The following additional information is required when using client's or rented equipment, or when a UL ID Number for an instrument number is not used. The Inst. ID No. below corresponds to the Inst. ID No. above.

Inst. ID No.	Make/Model/Serial Number/Asset No.
36.01-04	Fluke/ 83III/ 75860525

Steve Keller
Tested by: Michael Greiner Date 2014-03-25
Printed Name Signature

Inst. ID No.	Make/Model/Serial Number/Asset No.
36.08-05	Keithley/ 2700/ 0958442
97.01-21	Empro/ HA-25-50/ N/A
36.08-06	Keithley/ 2700/ 1031037
97.01-19	Empro/ HA-25-50/ N/A
17.07-01	Thermotron/ PRCH-S-S-AC/ 16000

Steve Keller
Tested by: Michael Greiner Date 2014-03-25
Printed Name Signature

TEST SAMPLE IDENTIFICATION:

The table below is provided to establish correlation of sample numbers to specific product related information. Refer to this table when a test identifies a test sample by "Sample No." only.

Sample Card No.	Date Received	[] Test No.+	Sample No.	Manufacturer, Product Identification and Ratings
S11131114 0002		1	8	Aquion Energy Inc. Salt Water Battery Rating: 53.2Vdc, 6.00A
S11131107 0001		3	7	Aquion Energy Inc. Salt Water Battery Rating: 53.2Vdc, 6.00A
S11131107 0003		4	9	Aquion Energy Inc. Salt Water Battery Rating: 53.2Vdc, 6.00A

+ - If Test Number is used, the Test Number or Numbers the sample was used in must be identified on the data sheet pages or on the Data Sheet Package cover page.

[] Sampling Procedure -

[] This document contains data using color and if printed, should be printed in color to retain legibility and the information represented by the color.

Steve Keller
Tested by: Michael Greiner Date 2014-03-25
Printed Name Signature

GENERAL

Unless indicated otherwise the device under test (DUT) shall be at the maximum operational state of charge (MOSOC), in accordance with the manufacturer's specifications, for conducting the tests in this standard. After charging and prior to testing, the samples shall be allowed to rest for a maximum period of 8 h at room ambient.

ROOM AMBIENT

All tests, unless noted otherwise, are conducted in a room ambient 25 ±5°C (77 ±9°F). Tests shall be conducted with the DUTs heated to normal operating temperatures unless indicated otherwise in the test.

THERMAL EQUILIBRIUM

For those tests that require the DUT to reach thermal equilibrium, thermal equilibrium is considered to be achieved if after three consecutive temperature measurements taken at intervals of 10% of the previously elapsed duration of the test but not less than 15 min, indicate no change in temperature greater than ±2°C (±3.6°F).

TEMPERATURE MEASUREMENTS

Thermocouples are to be attached to the central component cell or module during the system level tests in Sections 13 – 37. Temperatures shall also be measured on any components affected by temperature in the control circuit during the tests of Sections 17. Temperature shall be measured using thermocouples consisting of wires not larger than 24 AWG (0.21 mm2) and not smaller than 30 AWG (0.05 mm2) connected to a potentiometer-type instrument. Temperature measurements are to be made with the measuring junction of the thermocouple held tightly against the component/location being measured.

OBSERVATION PERIOD

Unless noted otherwise in the individual test methods, the tests shall be followed by a 1-h observation time prior to concluding the test and temperatures are to be monitored.

Steve Keller
Tested by: Michael Greiner Date 2014-03-25
Printed Name Signature

GENERAL (CONT'D):

SAMPLE REQUIREMENTS

Unless otherwise indicated, fresh samples (i.e. not more than 6 months old) representative of production are to be used for the system level tests described in Sections 13 - 37. The number of samples per test is shown in Table below.

Test	Section	Number of samples[a]
Electrical Tests		
Overcharge[c]	13	1
Short Circuit[c]	14	1
Overdischarge Protection[c]	15	1
Imbalanced Charging[c]	16	1
Temperature and Operating Limits Check[c]	17	1
Dielectric Voltage Withstand	18	1 Use Temperature Sample
Continuity	19	1 Use Temperature Sample
Failure of Cooling/Thermal Stability System	20	1
Working Voltage Measurements[e]	21	1
Locked-Rotor Test (Low Voltage D.C. Fans/Motors In Secondary Circuits)	22.1	b
Input	22.2	b
Leakage Current	22.3	b
Strain Relief	22.4	b
Push-Back Relief	22.5	b
Mechanical Tests		
Vibration (LER motive application)	23	1
Shock (LER motive application)	24	1
Crush[c] (LER motive application)	25	1
Static Force	26	1
Impact	27	1
Drop Impact (rack mounted module)[f]	28	1
Wall Mount Fixture/Handle Test[g]	29	1 (mounting fixture)
Mold Stress	30	1
Pressure Release	31	b
Start-to-Discharge	32	b

Tested by: Steve Keller / Michael Greiner Date 2014-03-25

Printed Name Signature

GENERAL (CONT'D)

Test	Section	Number of samples[a]
Environmental Tests		
Resistance to Moisture[c]	33	1
Thermal Cycling[c]	34	1
Salt Fog[c]	35	1
External Fire Exposure[c]	36	1
Internal Fire Exposure[c]	37	1
Material Tests		
20-mm end product flame test (LER motive applications)	5.1.1	[b]
(Note: not conducted if minimum V-1)		
Parts in contact with electrolyte	5.10.1	[d]
[a] At the agreement of the manufacturer, battery pack samples may be re-used for more than one test if not damaged in a manner that would affect test results.		
[b] Need only evaluate parts/area under test and not complete electric energy storage system.		
[c] Testing may be conducted on subassemblies if determined representative of the complete electric energy storage system.		
[d] Parts or samples in accordance with ASTM test methods.		
[e] This check of maximum working voltage values is needed when using the spacing criteria of Table 5.1.		
[f] This test is conducted on modules or subassemblies intended for field installation in rack-mount or similar equipment.		
[g] This test is conducted on EESS with wall-mount fixtures only.		

Steve Keller
Tested by: Michael Greiner Date 2014-03-25
Printed Name Signature

GENERAL (CONT'D)

DEFINITIONS CRITICAL TO TESTING -

DUT – Device Under Test

ELECTRIC ENERGY STORAGE SYSTEM (EESS) – Consists of a pack and external controls and circuitry related to the pack such as cooling systems, disconnects or protection devise external to the pack.

EXPLOSION – A violent release of energy that produces projectiles or a pressure wave from the DUT and results in DUT contents being forcibly expelled through a rupture in the enclosure or casing.

FIRE – The sustained combustion of the DUT's contents as evidenced by flame, heat and charring or other damage of materials.

LEAKAGE – A condition where liquid electrolyte escapes through the opening of a designed vent or through a rupture or crack or other unintended opening and is visible external to the DUT.

MOSOC – MAXIMUM OPERATING STATE OF CHARGE.

NORMAL OPERATING REGION – That region of voltage, current, and temperature within which a cell or electrochemical capacitor can safely be charged and discharged repetitively throughout its anticipated life. The manufacturer specifies these values, which are then used in the safety evaluation of the device and may vary as the device ages.

PROTECTIVE COMPONENTS, ACTIVE - Devices provided to prevent hazardous conditions that require electrical energy in order to operate. An example of an active control would be a battery management system (BMS).

PROTECTIVE COPONENTS, PASSIVE – Devices provided to prevent hazardous conditions that do not require electrical energy in order to operate. An example of a passive protective device would be a fuse.

RUPTURE – A mechanical failure of the DUT's enclosure/casing from either internal or external causes, that results in spillage and/or exposure of internal contents of the DUT, but does not result in projectiles and violent energy release, which occur during an explosion.

Tested by: Steve Keller / Michael Greiner Date 2014-03-25

Printed Name Signature

GENERAL (CONT'D):

SINGLE FAULT CONDITIONS - The single fault is to consist of a single failure (i.e. open, short or other failure means) of any component in the electrical energy storage system that could occur as identified in the system safety analysis and that could affect the results of the test.

TOXIC GAS RELEASE (For Crush Test for LER Application) – A release of vapor that results in a concentration in excess of the Emergency Response Planning Guidelines (ERPG) level 2. ERPG-2 defines this as: "The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action."

TOXIC GAS RELEASE (Other Than Crush Test) – A release of vapor that results in a concentration in excess of the Occupational Safety and Health Administration (OSHA) 8-h time-weighted-average (TWA) permissible exposure limit, which corresponds to the National Institute of Safety and Health (NIOSH) 10-h per day 40-h per week permissible exposure limit.

VENTING – A condition when the cell electrolyte and/or battery solvent is emitted as vapor, smoke or aerosol from a designed vent or through a sealing edge.

DETERMINATION OF POTENTIAL FOR FIRE HAZARD -

For detection of potential flammable concentrations that may be emitted during testing, a gas monitor suitable for detecting 25% of the lower flammability limit of the evolved gases being measured. A minimum of two sampling locations where concentrations may occur such as at vent openings or vent ducts shall be used for taking measurements.

Exception: A minimum of two continuous spark sources may be used instead of the spark sources. The continuous spark sources are to provide at least two sparks per second with sufficient energy to ignite natural gas and are to be located near anticipated sources of vapor such as vent openings or at the vent duct.

Additional precautions shall be taken during tests requiring this analysis due to the potential for flammable gas concentrations that may occur within the test room or chamber.

Tested by: Steve Keller / Michael Greiner Date 2014-03-25

Printed Name Signature

GENERAL (CONT'D):

DETERMINATION OF TOXIC EMISSIONS -

For those systems for which venting from cells or capacitors could result in the emission of toxic gases as determined by an analysis of the outgassed substances, the concentration of toxic gases during the destructive testing noted in the individual test shall be monitored using one of the sampling methods noted below.

a) The Standard Practice for Measuring the Concentration of Toxic Gases or Vapors Using Detector Tubes, ASTM D4490;

b) The Standard Practice for Measuring the Concentration of Toxic Gases or Vapors Using Length-of-Stain Dosimeters, ASTM D4599;

c) The OSHA Evaluation Guidelines for Air Sampling Methods Utilizing Spectroscopic Analysis; or

d) The NIOSH Manual of Analytic Methods.

To determine the concentration of toxic emissions, testing is to be conducted in a closed test chamber of known volume large enough to contain the DUT. Results obtained from continuous sampling the emissions during testing shall be scaled to estimate the anticipated exposure and concentration of toxic materials within either the passenger compartment of a light electric rail (LER) or the anticipated smallest room in which the system can be installed. For walk-in units, continuous monitoring shall also be conducted in the interior of the system enclosure. The results for stationary applications shall be further scaled to consider a 0.5 air changes per hour (ACH) ventilation rate. The 0.5 ACH represents allowable low ventilation rated for construction.

Steve Keller
Tested by: Michael Greiner Date 2014-03-25
Printed Name Signature

GENERAL (CONT'D):

TEST RESULTS -

Tests that result in one or more of the following conditions as noted in Table below shall be considered as non-compliant for the test.

Table 10.1
Non-compliant test results

Tests[a]	Non-compliant results
Overcharge	E, F, C, V, S, L, R, P
Short Circuit	E, F, C, V, S, L, R, P
Overdischarge Protection	E, F, C, V, S, L, R, P
Temperature and Operating Limits Check	E, F, S, L, R
Imbalanced Charging	E, F, C, V, S, L, R, P
Failure of Cooling/Thermal Stability System	E, F, C, V, S, L, R, P
Vibration (LER)	E, F, C, V, S, L, R, P
Shock (LER)	E, F, C, V, S, L, R, P
Crush (LER)	E, F, C, V
Static Force	E, F, C, V, S, L, R, P
Impact	E, F, C, V, S, L, R, P
Drop Impact	E, F, C, S, L, R, P
Thermal Cycling	E, F, C, V, S, L, R, P
Resistance to Moisture	E, F, C, V, S, L, R, P
Salt Fog	E, F, C, V, S, L, R, P
External Fire Exposure	E
Internal Fire Exposure[b]	E, F

Non-compliant Results Key:
E - Explosion
F - Fire
C - Combustible vapor concentrations
V - Toxic vapor release[c] (in buildings or LER passenger compartments)
S - Electric shock hazard (dielectric breakdown)
L - Leakage (external to enclosure of DUT)
R - Rupture (of DUT enclosure exposing hazardous parts as determined by IEC articulate probe with a force of 10N)
P - Loss of protection controls[d]

a For tests not listed here, only those compliance criteria noted in the tests method need be applied.
b During the internal fire exposure test, the internal fire shall not spread to outside of the DUT enclosure
c A toxic vapor release is a hazard if there is potential for persons to be exposed to it. See Determination Of Toxic Emissions in General section of this datasheet for definition for crush test and other test.
d Loss of protection controls - Failure of software and/or electronic controls, discrete control devices or other built-in electrical protection components relied upon for safety and that remain in the circuit during the test, to operate as intended.

Steve Keller
Tested by: Michael Greiner Date 2014-03-25
Printed Name Signature

GENERAL (CONT'D):

For the following tests, if the DUT is still operational after the test (a user replaceable fuse may be replaced or user resettable device such as an accessible circuit breaker, etc. reset), it shall be subjected to a minimum single charge/discharge cycle in accordance with the manufacturer's specifications.

Non-compliant results as outlined in Table 10.1 shall not occur during the charge/discharge cycle of a still operational DUT.

a) Overcharge;
b) Short Circuit;
c) Overdischarge Protection;
d) Imbalanced Charging;
e) Failure of Cooling/Thermal Stability System;
f) Vibration;
g) Shock;
h) Impact or Drop Impact;
i) Static Force;
j) Thermal Cycling;
k) Salt Fog; and
l) Resistance to Moisture.

Tested by: Steve Keller / Michael Greiner Date 2014-03-25

Printed Name Signature

OVERCHARGE TEST: UL1973, Sec. 13

METHOD

Tests were conducted at room ambient (i.e. 25 ± 5°C).

A fully discharged battery stack AE1 (i.e. discharged to the manufacturer's specified EODV) was subjected to an overcharge resulting from a single fault condition in the charging protection/control circuit of the system that could lead to an overcharge condition. The charging rate was the manufacturer's specified maximum charging rate, and the charging voltage was 110% of the maximum specified charging voltage of the DUT.

The test was continued until ultimate results occur followed by an observation period per "General – Observation" section of this datasheet. Ultimate results were considered to have occurred when one of the following occurs:

a) The sample charging was terminated by the protective circuitry whether it was due to voltage or temperature controls or if the DUT reaches 110% of its maximum specified charging voltage limit, or

b) DUT failure occurred as evidenced by explosion, fire or other identifiable non-compliant results per Table 10.1 in General - Test Result section of this datasheet.

[x**]** During the test, detection method as outlined in "General - Determination of Potential for Fire Hazard" Section of this datasheet was used to detect the presence of flammable concentrations.

~~**[ ]** During the test, venting of toxic releases was continuously monitored per "General - Determination of Toxic Emissions" Section of this datasheet.~~

If the DUT was operational after test it was subjected to a discharge and charging cycle in accordance with the manufacturer's specifications. An observation period was then conducted.

At the conclusion of the observation period, the samples was subjected to an "as received" dielectric voltage withstand test in accordance with Section 18 of UL1973. The DUT was examined for signs of rupture and evidence of leakage.

Tested by: Steve Keller / Michael Greiner Date 2014-03-25

Printed Name Signature

OVERCHARGE TEST (CONT'D): UL1973, Sec. 13

RESULTS

DUT Model	AE1
Mfr. Specified End of Discharge Voltage, Vdc	27 Vdc
Mfr. Specified Maximum Charge Current, A	6 A
Mfr. Specified Maximum Charge Voltage, Vdc	53.2 Vdc
110% of Maximum Charge Voltage, Vdc	58.52 Vdc

Sample No.	OCV at start of Test, Vdc	Fault Condition Imposed	Measured Maximum Charge Voltage, Vdc	Measured Maximum Charge Current, A	Max Temp Measured, °C	Dielectric Voltage Test, Brk/No Brk	Results
8	42.2	N/A	58.4	6.0	27.1	No Brk	1

Sample No.	Charge/ Discharge Cycle at end?	Combustible Concentration		~~Toxic Gas Concentration~~			
		≥ 25% LFL?	Spark Ignition?	~~Potential Toxic gas~~	~~Chamber Volume, m3~~	~~Measured concentration of toxic gas, ppm~~	~~OSHA TWAs Limit Values, ppm~~
8	Yes	NA	Yes				

Result Key
1 – Sample remained intact and operational (after fuses __ replaced and/or resettable devices __ reset)
2 – Sample remained intact but nonoperational
3 – Sample Vented
4 – Sample enclosure cracked or ruptured or leaked electrolyte
5 – Sample exploded
6 – Sample caught on fire
7 – Component Damaged _____ (identify component)
8 – Protector Operated _____ (identify protection)
9 – Other _____ (indicate result)

Tested by: Steve Keller / Michael Greiner Date 2014-03-25

Printed Name Signature

OVERCHARGE (CONT'D) UL1973, Sec. 13

There **[**~~was~~**]** **[**was no**]** evidence of fire or combustible concentrations, explosion.

There **[**~~was~~**]** **[**was no**]** evidence of external leakage or enclosure rupture.

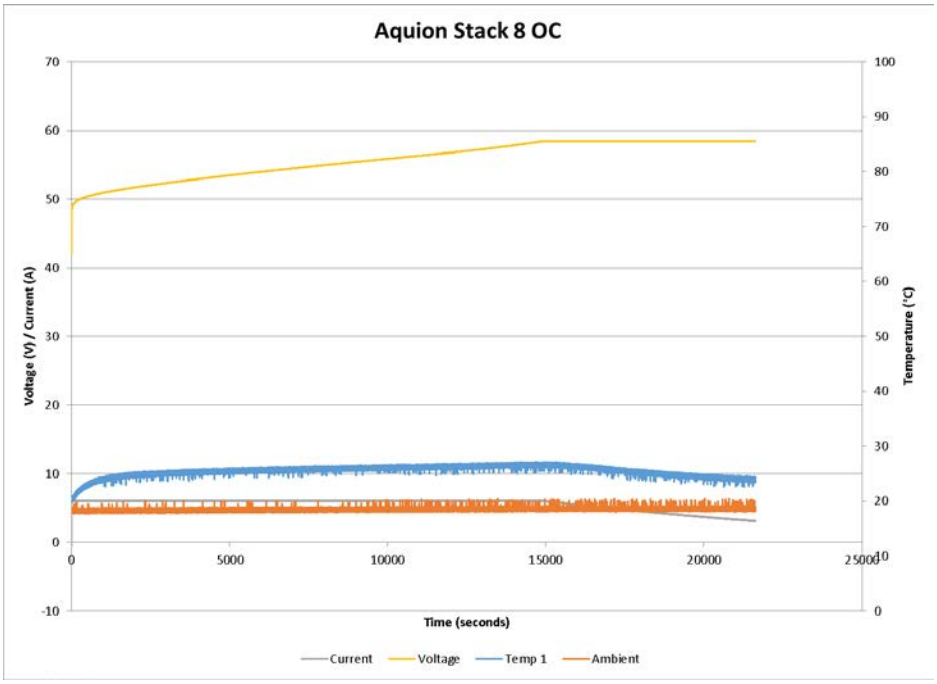
There **[**~~was~~**]** **[**was no**]** venting of vapors emitted from the opening other than the designated ventilation openings.

~~**[ ]** The toxic vapors emitted from the opening other than the designated ventilation openings **[**did**]** **[**did not**]** exceed OSHA TWAs.~~

There **[**~~was~~**]** **[**was no**]** evidence of dielectric breakdown.

[NA] There **[**was**]** **[**was no**]** failure of software and/or electronic controls, discrete control devices or other built-in electrical protection as a result of cycling an operational DUT.

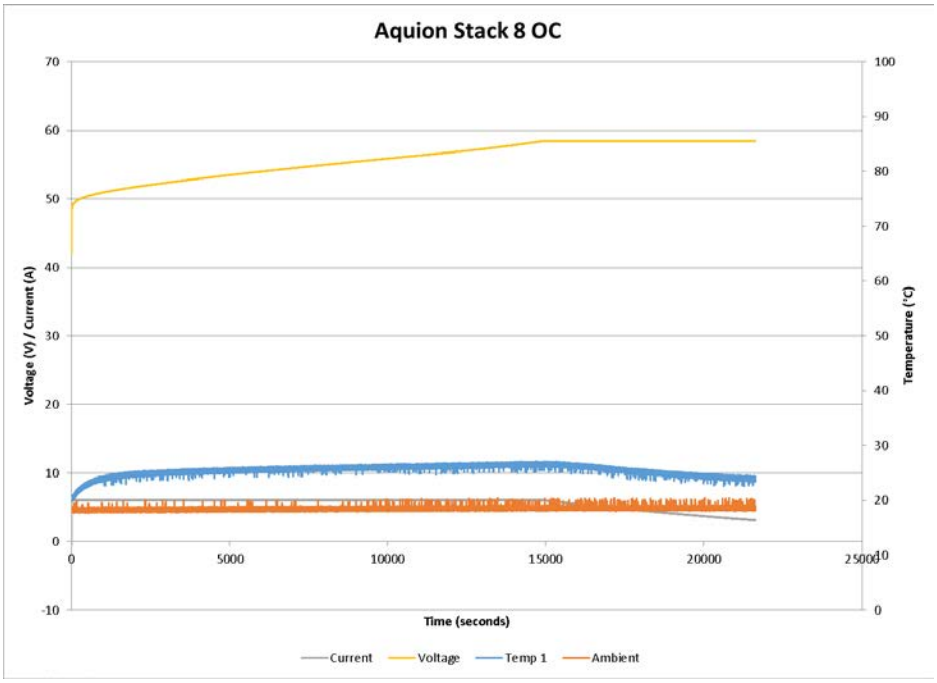
Test Date	2014-01-13
Ambient Temperature, °C	20.5
Relative Humidity, %	24



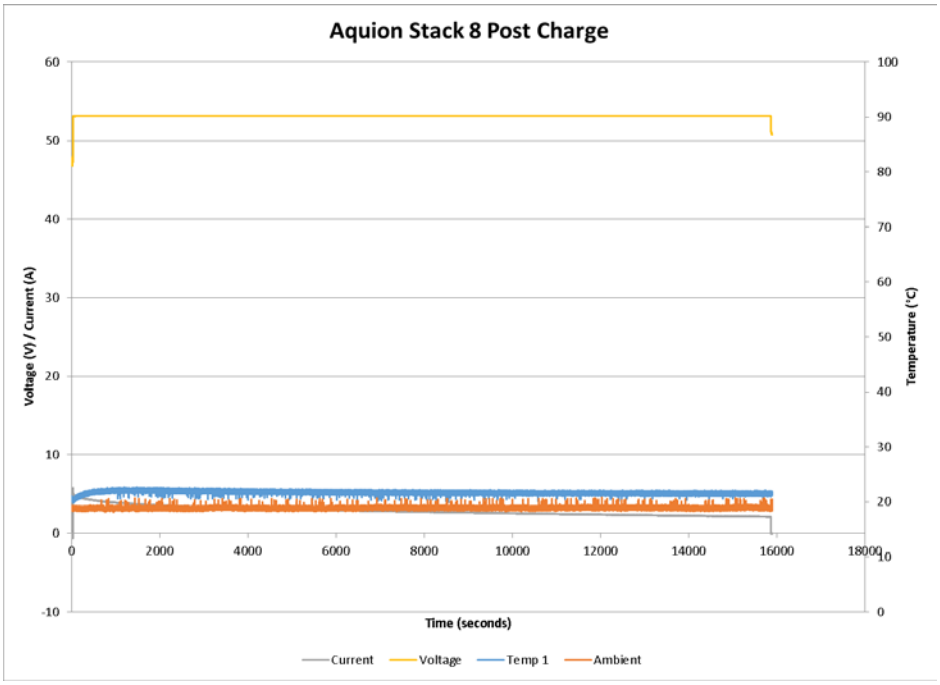
OC Test

Tested by: Steve Keller / Michael Greiner Date 2014-03-25

Printed Name Signature



Post Discharge



Post Charge

Tested by: Steve Keller / Michael Greiner Date 2014-03-25

Printed Name Signature

OVERDISCHARGE PROTECTION

UL 1973, Sec. 15

METHOD

This test was conducted on a fully charged battery stack (MOSOC) with all discharge protection circuitry for both temperature and minimum voltage connected to prevent irreparable cell damage.

Tests were conducted at room ambient (i.e. 25 ± 5°C).

The DUT was subjected to a constant discharging current/power that discharged the DUT at 95% of the passive protection device ratings for the DUT.

The test was continued until the passive protection device(s) were activated, or the minimum cell voltage/maximum temperature protection was activated.

[x**]** During the test, detection method as outlined in “General - Determination of Potential for Fire Hazard” Section of this datasheet was used to detect the presence of flammable concentrations.

~~**[ ]** During the test, venting of toxic releases was continuously monitored per “General - Determination Of Toxic Emissions” Section of this datasheet.~~

If the DUT was operational after the test it was subjected to a discharge and charging cycle in accordance with the manufacturer's specifications. An observation period was then conducted.

At the conclusion of the observation period, ~~the samples was subjected to an "as received" dielectric voltage withstand test in accordance with Section 18 of UL1973.~~ The DUT was examined for signs of rupture and evidence of leakage.

Tested by: Steve Keller / Michael Greiner Date 2014-03-25

Printed Name Signature

OVERDISCHARGE PROTECTION (CONT'D) UL 1973, Sec. 15

RESULTS

DUT Model:	AE1
MOSOC (% of SOC)	100%
Voltage at MOSOC, Vdc	53.2 Vdc
Passive protection device Mfr. and type	N/A
Passive protection device ratings, A	N/A
95% of passive protection rating, A	N/A

Sample No.	Initial OCV, V	Voltage at End of Test, Vdc	Measured Maximum Discharge current, A	Max Temp Measured °C	~~Dielectric Voltage Test, Brk/No Brk~~	Results
					N/A	

Sample No.	Charge/ Discharge Cycle at end?	Combustible Concentration		~~Toxic Gas Concentration~~			
		≥ 25% LFL?	Spark Ignition?	~~Potential Toxic gas~~	~~Chamber Volume, m3~~	~~Measured concentration of toxic gas, ppm~~	~~OSHA TWAs Limit Values, ppm~~

Result Key
1 – Sample remained intact and operational (after fuses __ replaced and/or resettable devices __ reset)
2 – Sample remained intact but nonoperational
3 – Sample Vented
4 – Sample enclosure cracked or ruptured or leaked electrolyte
5 – Sample exploded
6 – Sample caught on fire
7 – Component Damaged _____ (identify component)
8 – Protector Operated _____ (identify protection)
9 - Other _____ (indicate result)

Tested by: Steve Keller / Michael Greiner Date 2014-03-25

Printed Name Signature

OVERDISCHARGE PROTECTION (CONT'D) UL 1973, Sec. 15

There **[**was**]** **[**was no**]** evidence of fire or combustible concentrations, explosion.

There **[**was**]** **[**was no**]** evidence of external leakage, enclosure rupture.

There **[**was**]** **[**was no**]** venting of vapors emitted from the opening other than the designated ventilation openings.

~~**[ ]** The toxic vapors emitted from the opening other than the designated ventilation openings **[**did**]** **[**did not**]** exceed OSHA TWAs.~~

~~There **[**was**]** **[**was no**]** evidence of dielectric breakdown.~~

~~**[ ]** There **[**was**]** **[**was no**]** failure of software and/or electronic controls, discrete control devices or other built-in electrical protection as a result of cycling an operational DUT.~~

Test Date	
Ambient Temperature, °C	
Relative Humidity, %	

Tested by: Steve Keller / Michael Greiner Date 2014-03-25

Printed Name Signature

TEMPERATURE AND OPERATING LIMITS CHECK TEST

UL 1973, Sec. 16

METHOD

A fully discharged battery stack (i.e. discharged to EODV) was conditioned within a chamber set to the upper limit charging temperature specifications of the DUT.

After being stabilized at that temperature (refer to “General Section – Thermal Equilibrium” for temperature stable condition), the DUT was subjected to maximum normal charging while monitoring voltages and currents on modules until it reached the manufacturer’s specified fully charged condition. Temperatures were monitored on temperature sensitive components including cells.

While still in the conditioning chamber, the chamber temperature was set to the upper limit discharging temperature specifications of the DUT, and after allowing temperatures to stabilize (refer to “General Section – Thermal Equilibrium” for temperature stable condition), the fully charged DUT (MOSOC) was then discharged in accordance with the manufacturer’s specifications down to the manufacturer’s specified end of discharge condition while monitoring voltage and current on modules. Temperatures were monitored on temperature sensitive safety critical components including cells.

The charge and discharge cycles were then repeated for a total of 5 complete cycles of charge and discharge.

At the conclusion of the observation period, ~~the samples was subjected to an "as received" dielectric voltage withstand test in accordance with Section 18 of UL1973.~~ The DUT was examined for signs of rupture and evidence of leakage.

Tested by: Steve Keller / Michael Greiner Date 2014-03-25

Printed Name Signature

TEMPERATURE AND OPERATING LIMITS CHECK TEST (CONT'D) UL 1973, Sec. 16

RESULTS

DUT Model:	S111311070001		
Maximum Charging Current, A	6 A	Maximum Discharge Rate, A	6 A
Maximum Charging Voltage, Vdc	53.2 Vdc	End of discharge voltage, Vdc	27 V
End of Charging Current, A	1 A or 2 hours	Maximum Ambient Temperature for discharging, °C	45C
Maximum Ambient Temperature for charging, °C	45C		

Sample Number	S111311070001

Thermocouple Location	Max measured Temp during charging, °C	Max measured Temp during discharging, °C	Max Temp Limit, °C
Chamber Ambient	44.9221	44.8734	45
Cell casing (top)	45.0645	45.0445	
Cell casing (middle)	46.0158	45.8967	
Cell casing (bottom)	45.7879	45.6438	
Terminal covers	47.3776	47.4659	
Wiring near cell connection	46.9582	46.9230	
Wiring near connector connection	47.3383	47.0162	
APP connector body	50.1290	49.4456	

Tested by: Steve Keller / Michael Greiner Date 2014-03-25

Printed Name Signature

TEMPERATURE AND OPERATING LIMITS CHECK TEST (CONT'D) UL 1973, Sec. 16

Location of voltage measured	Max measured Voltage on module/cell, Vdc	Min measured voltage on module/cell, Vdc	Normal Operating range of module/cell, Vdc
Cell 1	7.3360	4.3779	53.2 - 27v
Cell 2	7.4118	4.4782	53.2 - 27v
Cell 3	7.3743	4.2731	53.2 – 27v
Cell 4	7.3867	4.6954	53.2 – 27v
Cell 5	7.3853	4.7815	53.2 – 27v
Cell 6	9.9134	-0.2700	53.2 – 27v
Cell 7	7.3968	4.7382	53.2 – 27v

Location of current measured	Max measured Current flow through module/~~cell~~, Vdc	Min measured Current flow through module/~~cell~~, Vdc	Normal Operating range of module/~~cell~~, Vdc
Module	5.8101	3.3104	6.00

Tested by: Steve Keller / Michael Greiner Date 2014-03-25

Printed Name Signature

TEMPERATURE AND OPERATING LIMITS CHECK TEST (CONT'D) UL 1973, Sec. 16

The normal operating limits (voltage, current at specified temperature) of the modules/cells **[**~~were~~**]** **[**were not**]** exceeded during charging and discharging.

Temperatures measured on cells, components and accessible surfaces **[**~~did~~**]** **[**did not**]** exceed their specifications.

There **[**~~was~~**]** **[**was no**]** evidence of fire or explosion.

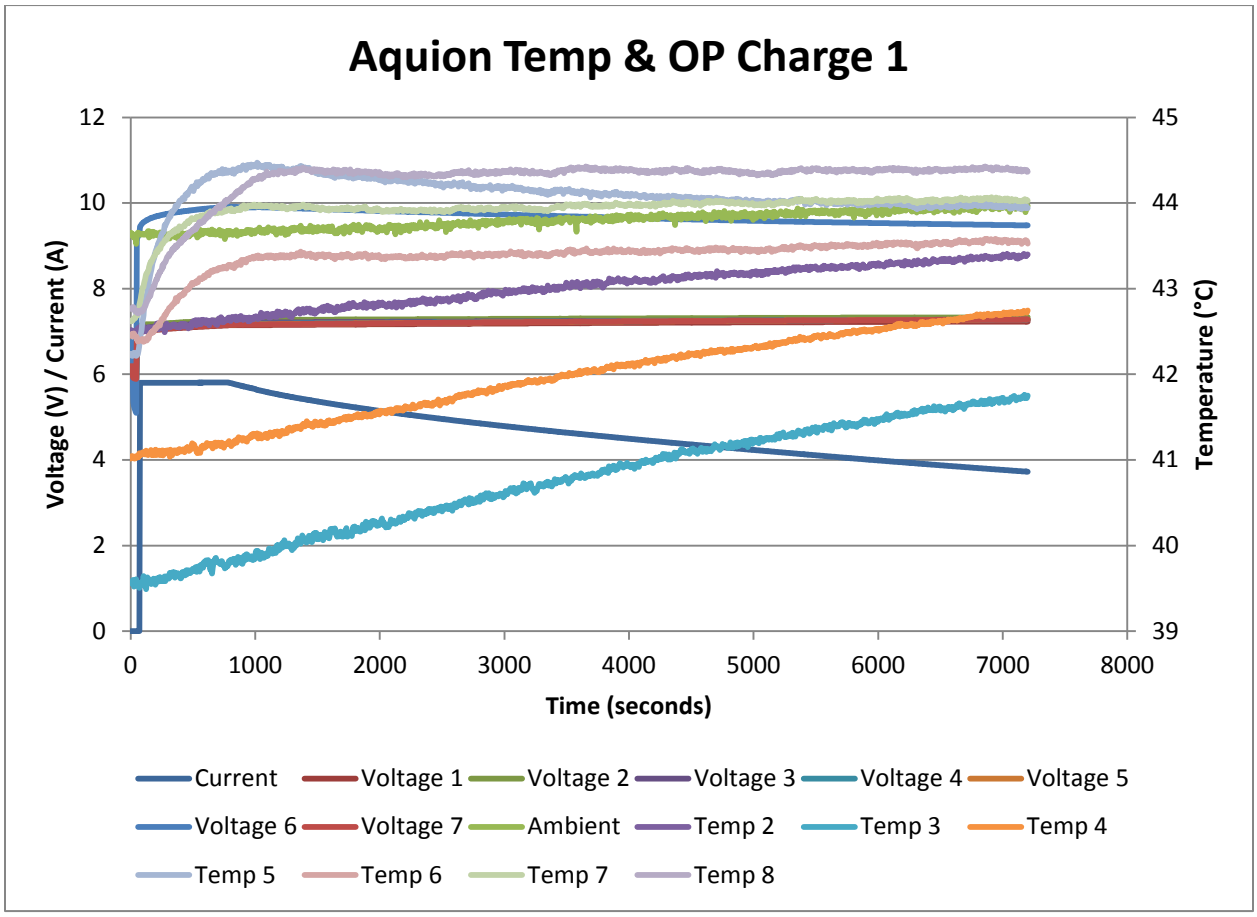
There **[**~~was~~**]** **[**was no**]** evidence of external leakage, enclosure rupture.

~~There [was] [was no] evidence of dielectric breakdown.~~

Test Date	2014-03-18
Ambient Temperature, °C	45 C
Relative Humidity, %	28.3

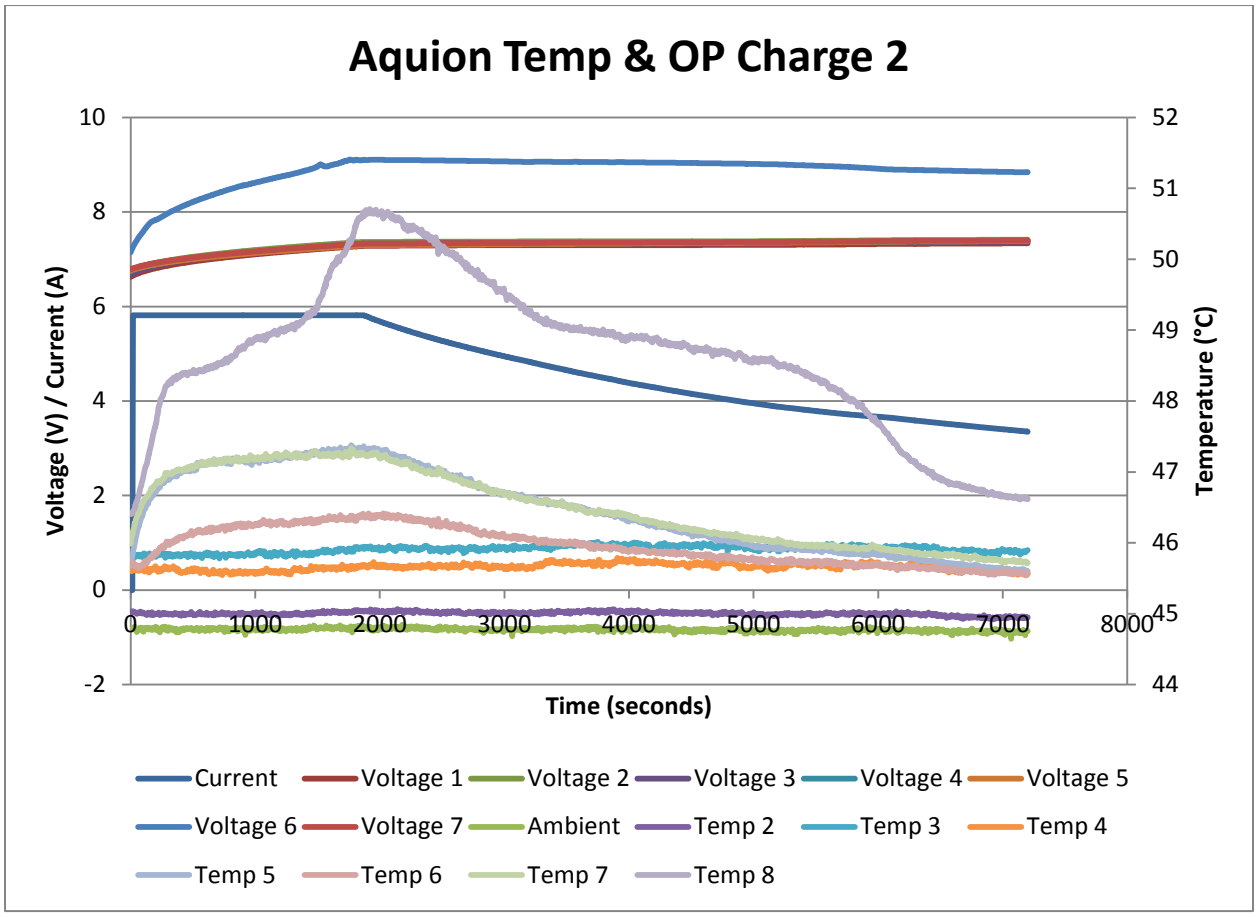
Tested by: Steve Keller / Michael Greiner Date 2014-03-25

Printed Name Signature



Tested by: Steve Keller / Michael Greiner Date 2014-03-25

Printed Name Signature



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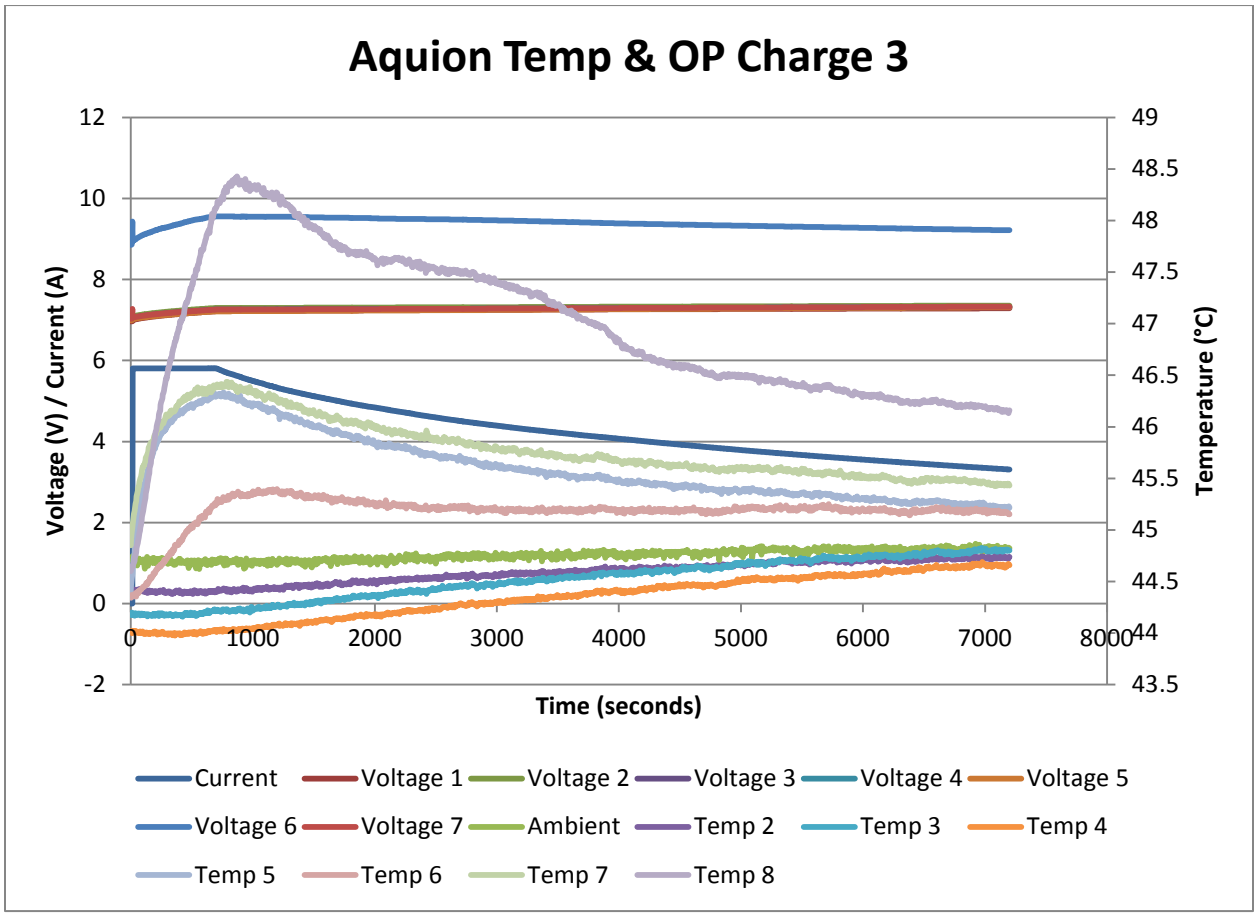

Tested by: Steve Keller / Michael Greiner Date 2014-03-25

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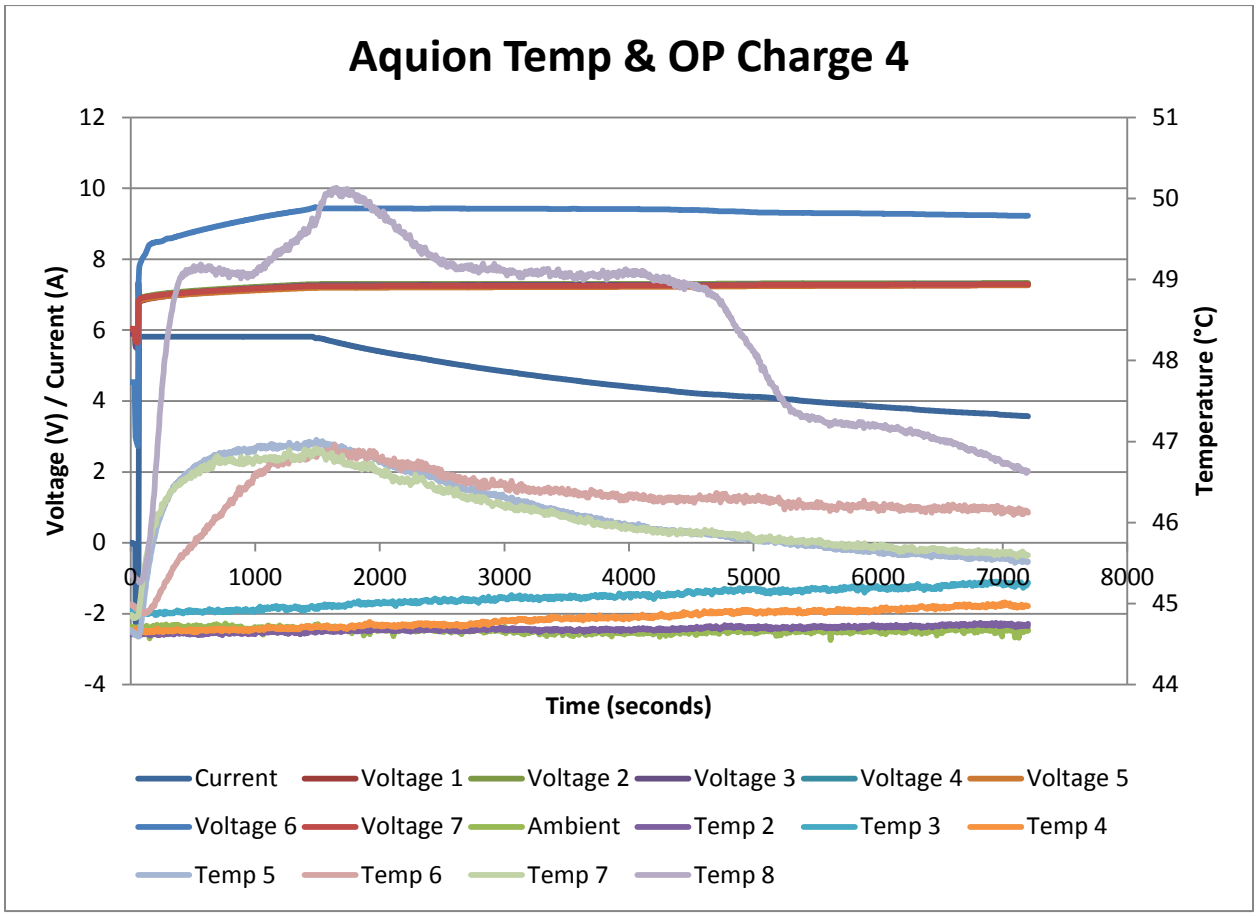

Tested by: Steve Keller / Michael Greiner Date 2014-03-25

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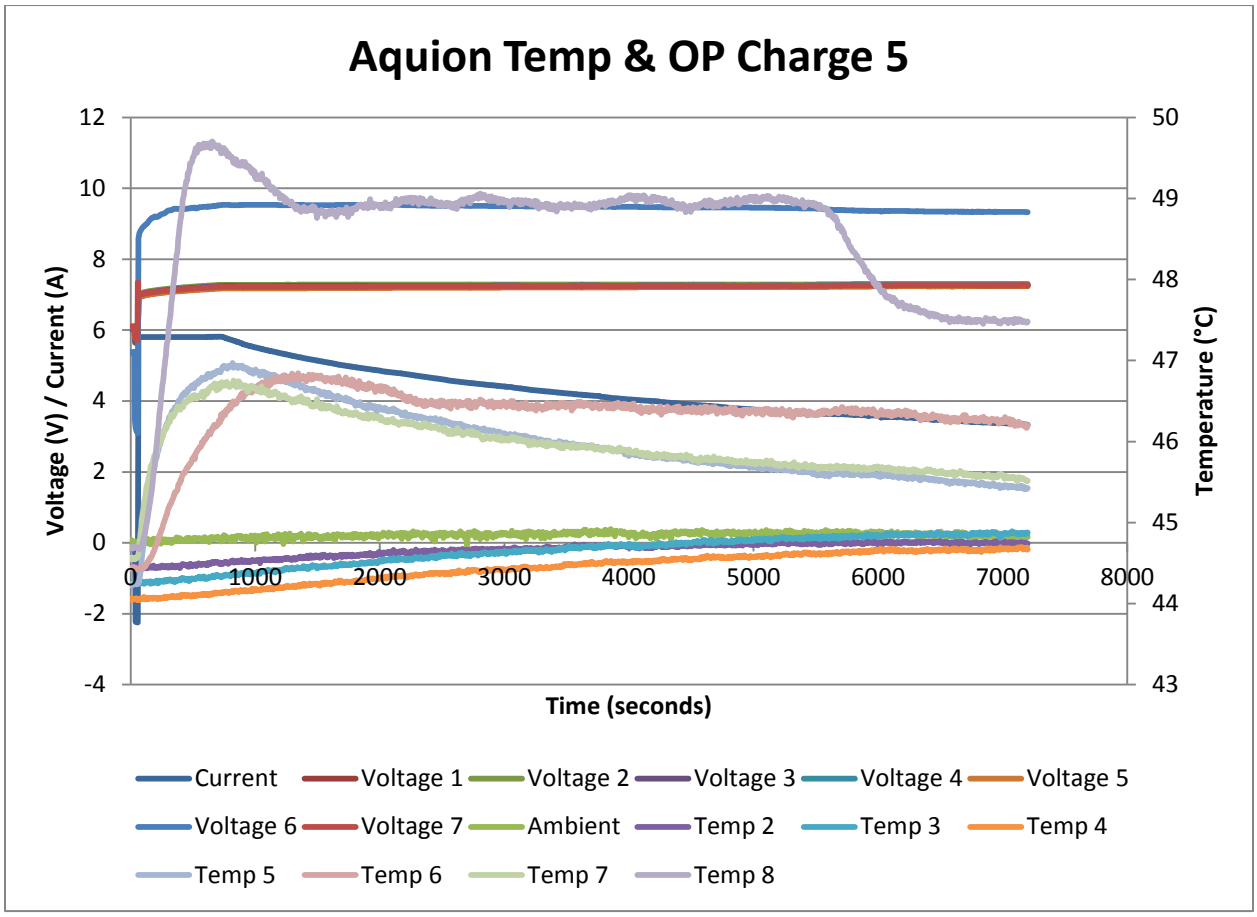

Tested by: Steve Keller / Michael Greiner Date 2014-03-25

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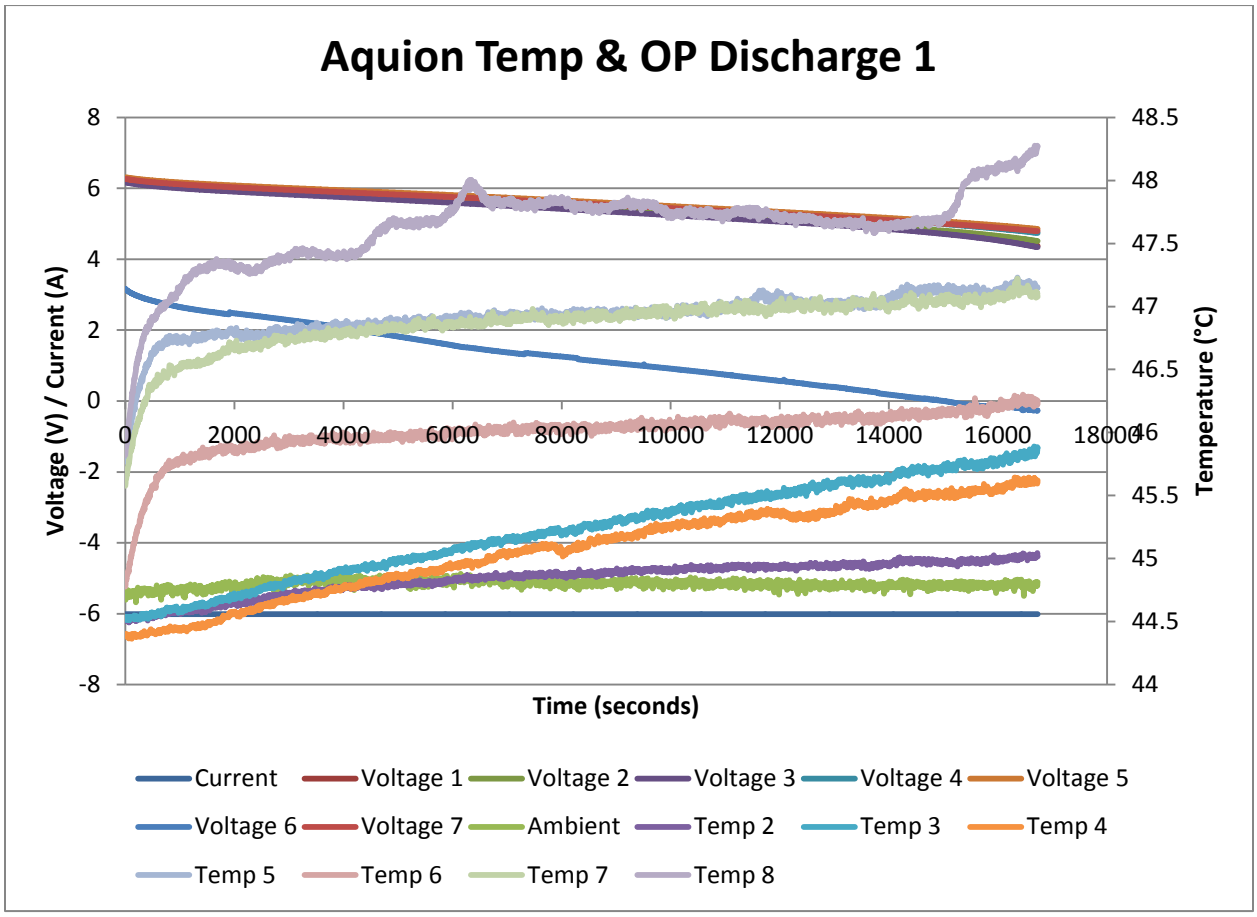
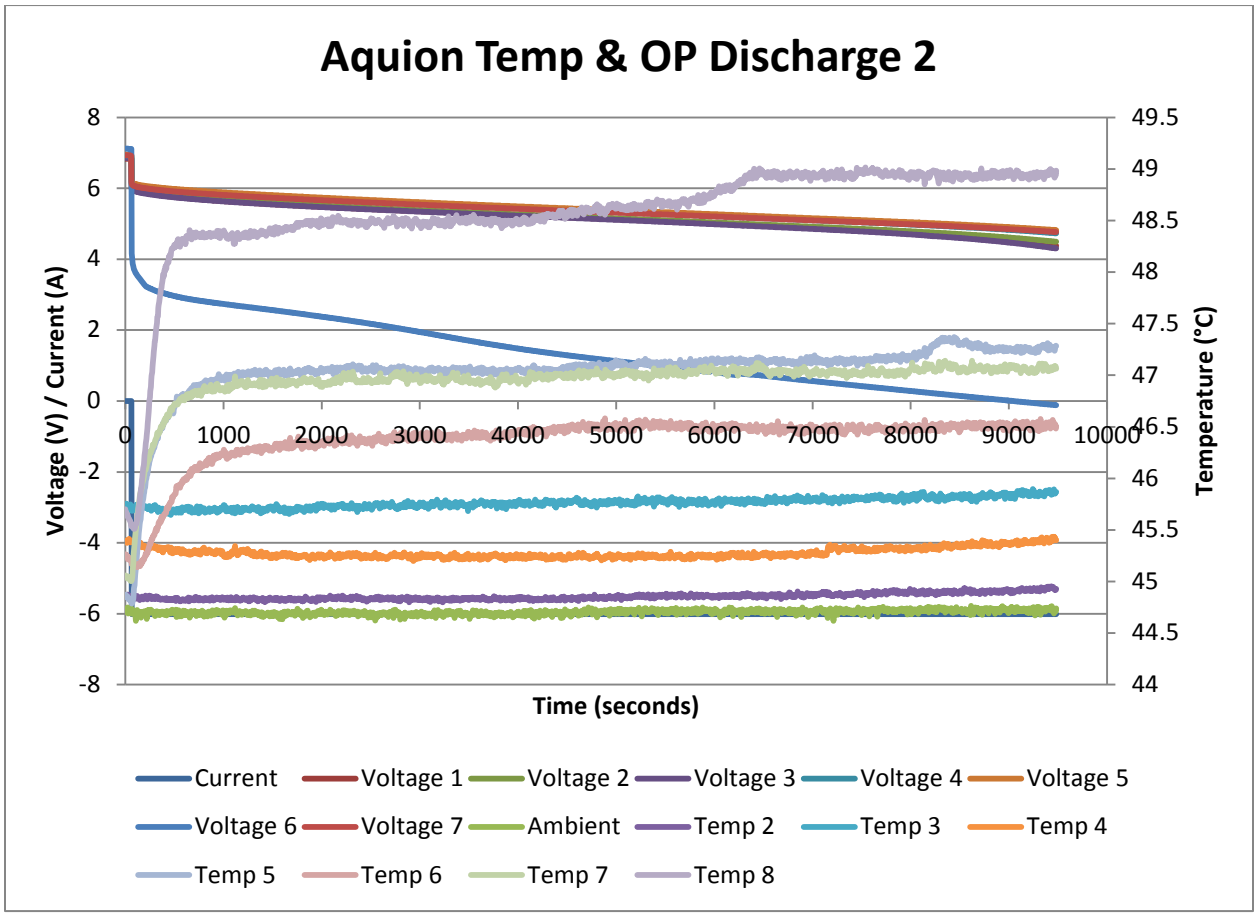


Tested by: Steve Keller / Michael Greiner Date 2014-03-25

Printed Name Signature



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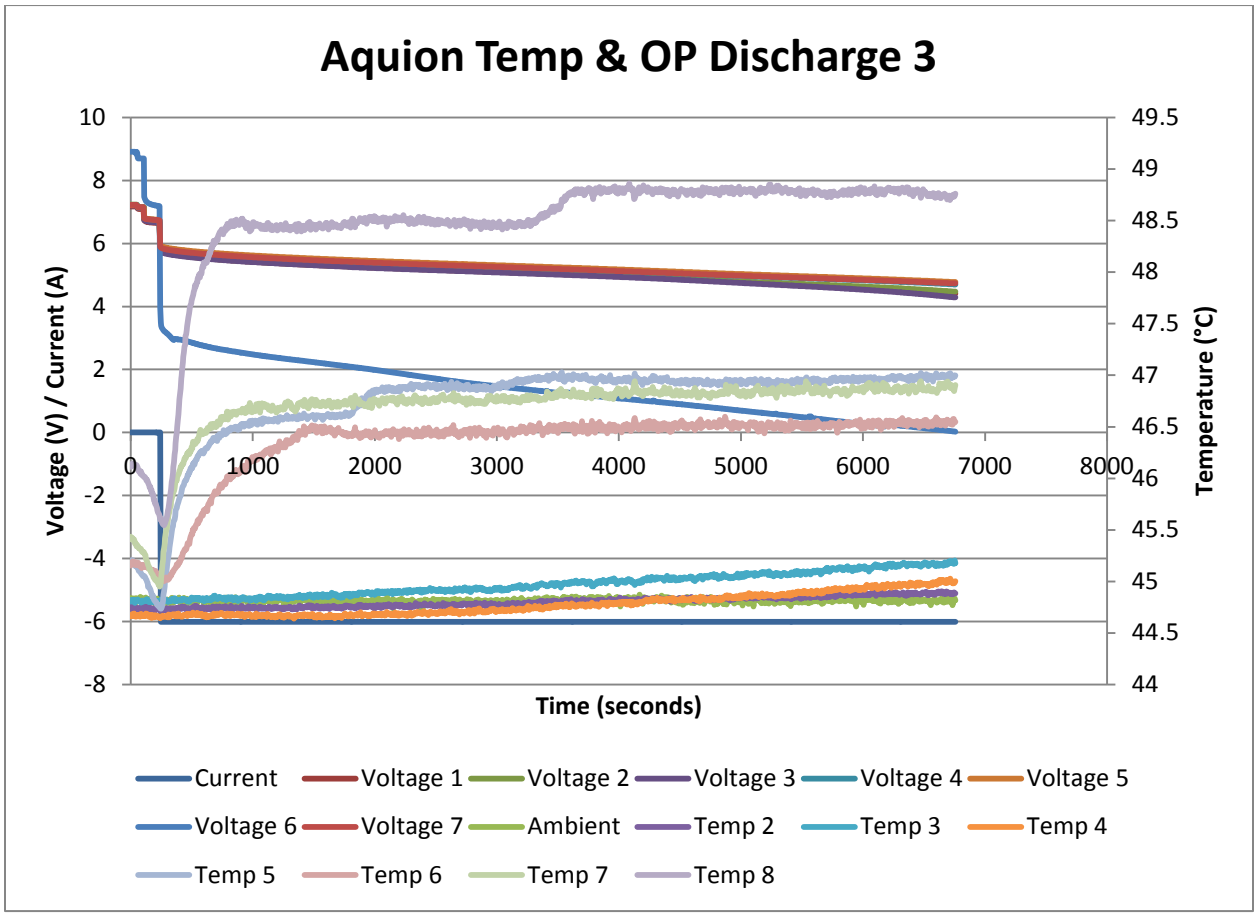

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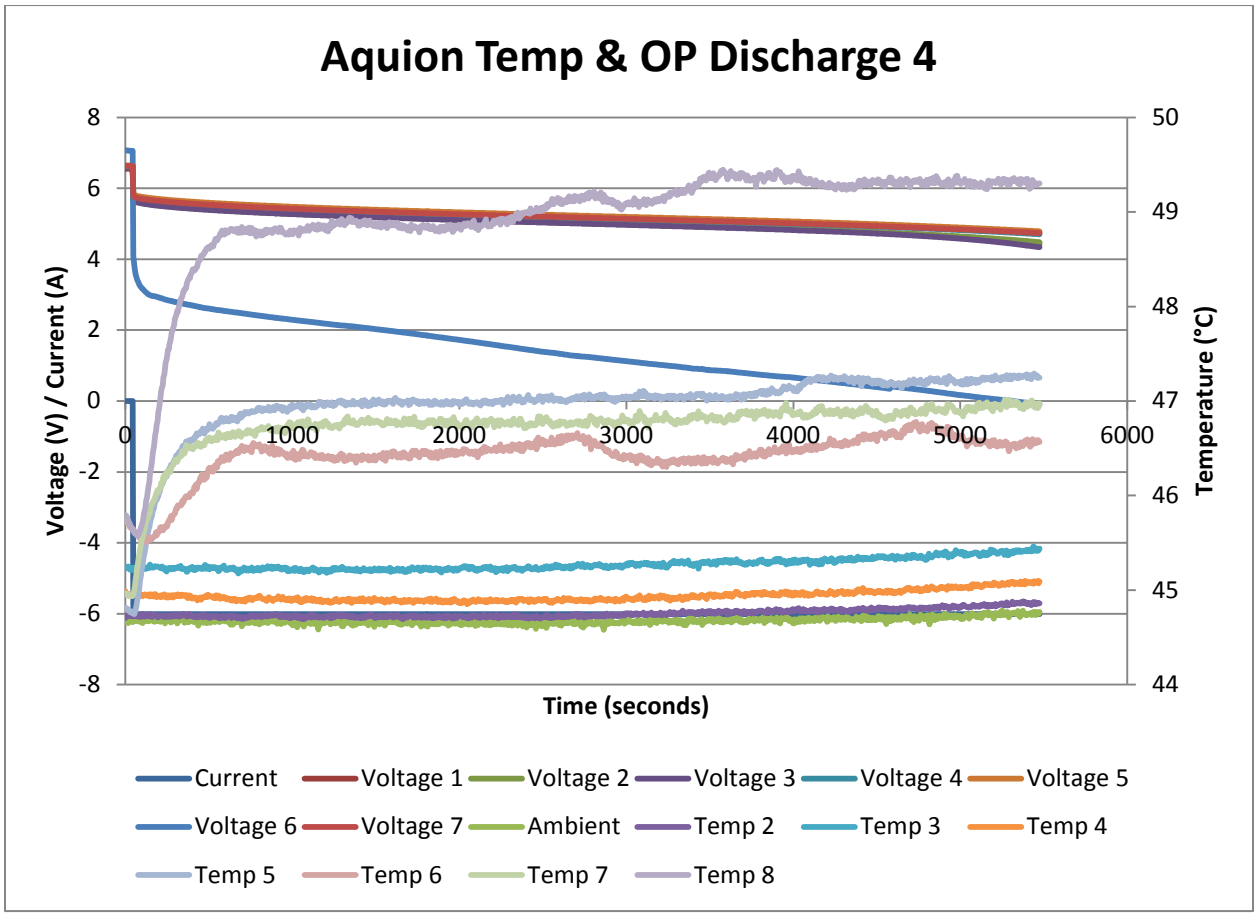

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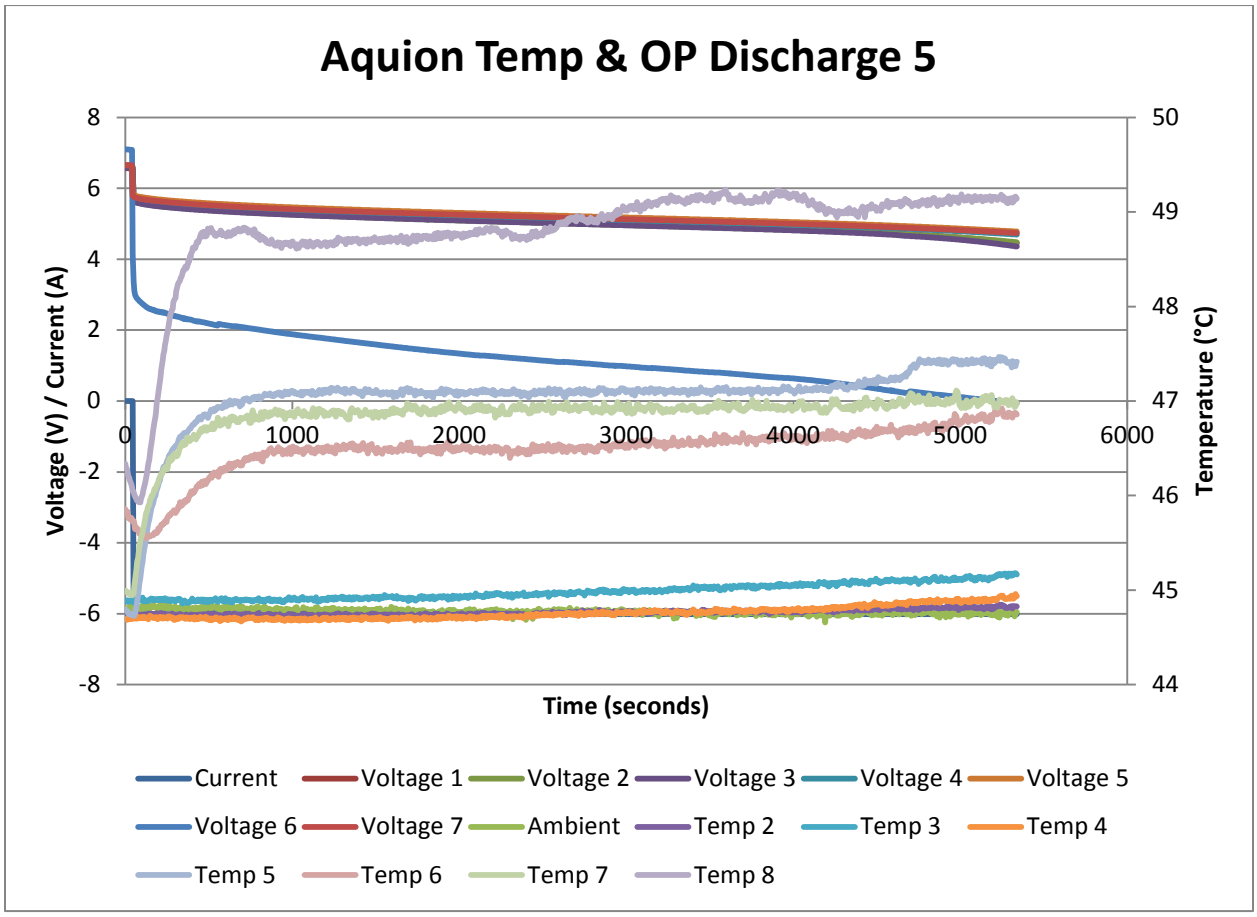

Tested by: Steve Keller / Michael Greiner Date 2014-03-25

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IMBALANCED CHARGING TEST

UL 1973, Sec. 17

METHOD

A fully charged battery stack was used for this test.

The DUT had all of its modules/cells with the exception of one discharged to its specified fully discharged condition. The undischarged module/cell was discharged to approximately 50% of its specified state of charge (SOC) to create an imbalanced condition prior to charging.

The DUT shall then be charged in accordance with the manufacturer’s maximum normal charging specifications. The voltage of the partially charged module/cell shall be monitored during the charging.

Tests were conducted at room ambient (i.e. 25 ± 5°C) and temperature was monitored on the partially charged module casing.

[x**]** During the test, detection method as outlined in “General - Determination of Potential for Fire Hazard” Section of this datasheet was used to detect the presence of flammable concentrations.

~~**[ ]** During the test, venting of toxic releases was continuously monitored per “General - Determination Of Toxic Emissions” Section of this datasheet.~~

If the DUT was operational after test it was subjected to a discharge and charging cycle in accordance with the manufacturer's specifications. An observation period was then conducted.

At the conclusion of the observation period, the samples was subjected to an "as received" dielectric voltage withstand test in accordance with Section 18 of UL1973. The DUT was examined for signs of rupture and evidence of leakage.

Tested by: Steve Keller / Michael Greiner Date 2014-03-25

Printed Name Signature

IMBALANCED CHARGING TEST (CONT'D) UL 1973, Sec. 17

RESULTS

DUT Model	AE1
Method to achieve 50% SOC of imbalanced module/cell	
Maximum Charge Voltage of DUT, Vdc	53.2 Vdc
Maximum Charge current of DUT, A	6 A
End of charge current of DUT, A	1 A or 2 hours
Mfr. specified maximum voltage limit of module/cell, Vdc	7.6 V per cell

Sample No	Initial OCV of partially charged module/cell, Vdc	Measured Maximum charge voltage, Vdc	Measured Maximum charge current, A	Measured Maximum Voltage on partially charged module/cell, Vdc	Measured Maximum Temp on partially charged module/cell, °C	~~Dielectric Voltage Test, Brk/No Brk~~	Results
9	6.51	53.5024	5.9688	8.2128	20.2962	N/A	1

Sample No.	Charge/ Discharge Cycle at end?	Combustible Concentration		~~Toxic Gas Concentration~~			
		≥ 25% LFL?	Spark Ignition?	~~Potential Toxic gas~~	~~Chamber Volume, m3~~	~~Measured concentration of toxic gas, ppm~~	~~OSHA TWAs Limit Values, ppm~~
9	Yes	No	Yes				

Result Key
1 – Sample remained intact and operational (after fuses __ replaced and/or resettable devices __ reset)
2 – Sample remained intact but nonoperational
3 – Sample Vented
4 – Sample enclosure cracked or ruptured or leaked electrolyte
5 – Sample exploded
6 – Sample caught on fire
7 – Component Damaged _____ (identify component)
8 – Protector Operated _____ (identify protection)
9 - Other _____ (indicate result)

Tested by: Steve Keller / Michael Greiner Date 2014-03-25

Printed Name Signature

IMBALANCED CHARGING TEST (CONT'D) UL 1973, Sec. 17

The maximum voltage limit of the module/cell **[**~~was~~**]** **[**was not**]** exceeded when charging an imbalanced DUT.

There **[**~~was~~**]** **[**was no**]** evidence of fire or combustible concentrations, explosion.

There **[**~~was~~**]** **[**was no**]** evidence of external leakage, enclosure rupture.

There **[**~~was~~**]** **[**was no**]** venting of vapors emitted from the opening other than the designated ventilation openings.

~~**[ ]** The toxic vapors emitted from the opening other than the designated ventilation openings **[**did**]** **[**did not**]** exceed OSHA TWAs.~~

~~There **[**was**]** **[**was no**]** evidence of dielectric breakdown.~~

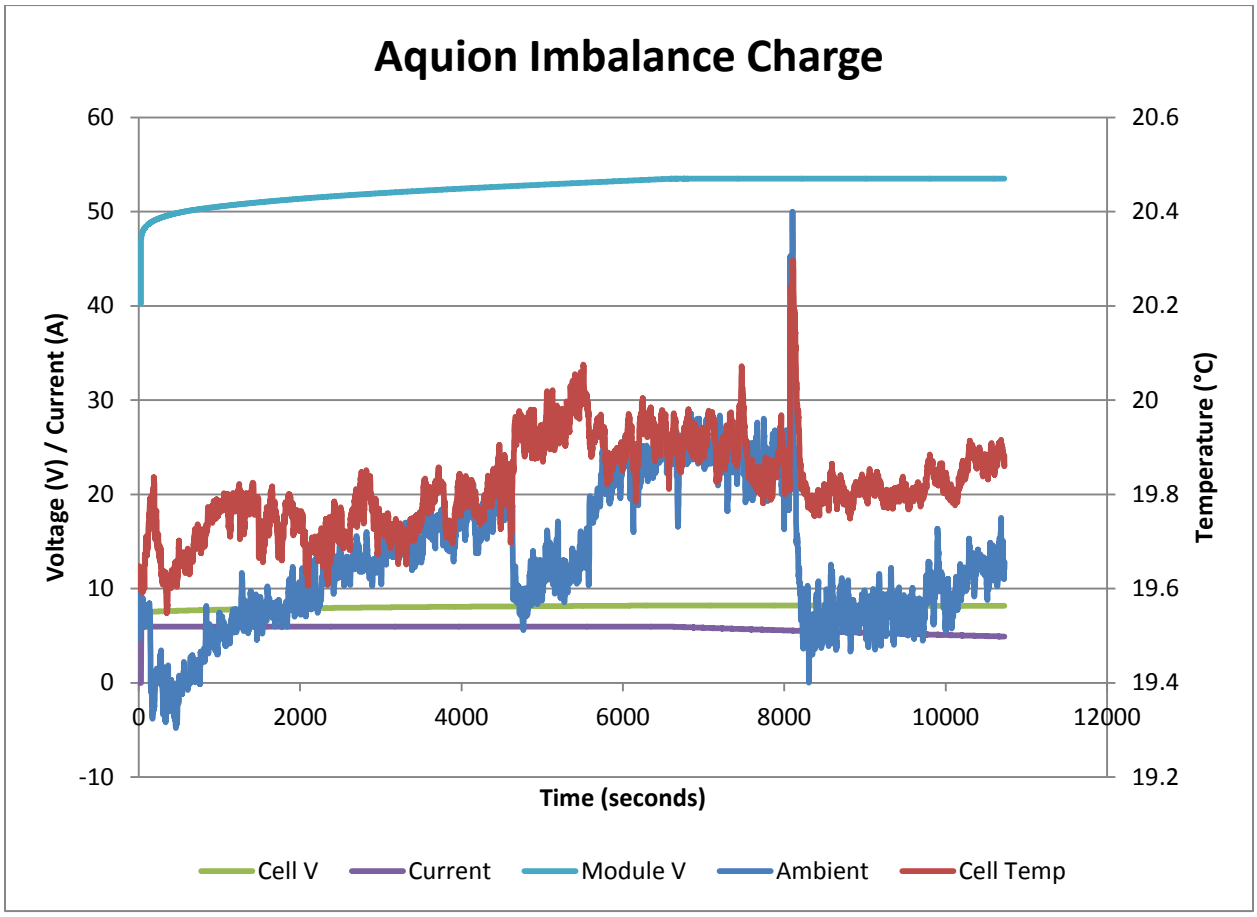
~~**[ ]** There **[**was**]** **[**was no**]** failure of software and/or electronic controls, discrete control devices or other built-in electrical protection as a result of cycling an operational DUT.~~

Test Date	2014-02-17
Ambient Temperature, °C	19.5
Relative Humidity, %	30

Note: Aquion Met the 2 hr Imbalance charge.

Tested by: Steve Keller / Michael Greiner Date 2014-03-25

Printed Name Signature



Tested by: Steve Keller / Michael Greiner Date 2014-03-25

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