



mga research corporation

Aquion Energy

Penetration, Ground Fault, Immersion, Flame Propagation, Roll-Over

TP033-04, TP030-02

C12T1-192




TEST REPORT


MGA REPORT NO.: C12T1-192
TESTS PERFORMED ON: August 6 - 10, 2012
TEST DESCRIPTION: Penetration, Ground Fault, Immersion, Flame
Propagation, Roll-Over
ITEM DESCRIPTION*: Lithium Batteries
PROCEDURE NUMBER: TP033-04, TP030-02

TEST LABORATORY: MGA Research Corporation
Technical Services Laboratory
12790 Main Road
Akron, NY 14001

SUBMITTED TO: Eric Weber
Aquion Energy
32 39th Street
Pittsburgh, PA 15201

REPORT WRITTEN BY: 
Michael Greiner: Director of Laboratory Operations

DATE: August 13, 2012

REPORT REVIEWED BY: 
Michael Capan: Quality Manager

DATE: August 13, 2012

*The results presented in this report relate only to the specified test items.

THIS REPORT SHALL ONLY BE REPRODUCED IN FULL, ANY PARTIAL REPRODUCTIONS MUST HAVE THE WRITTEN APPROVAL OF MGA RESEARCH CORPORATION



TABLE OF CONTENTS

C12T1-192

TABLE OF CONTENTS	3
1.0 TEST SUMMARY	4
2.0 PROGRAM	5
2.1 Penetration Testing	5
2.1.1 Test Requirements	5
2.1.2 Test Procedure	5
2.1.3 Test Results	5
2.2 Ground Fault Isolation (Non-A2LA)	5
2.2.1 Test Requirements	5
2.2.2 Test Procedure	5
2.2.3 Test Results	5
2.3 Water Immersion	6
2.3.1 Test Requirements	6
2.3.2 Test Procedure	6
2.3.3 Test Results	6
2.4 Flame Propagation (Non-A2LA)	6
2.4.1 Test Requirements	6
2.4.2 Test Procedure	6
2.4.3 Test Results	6
2.5 Roll-Over (Non-A2LA)	7
2.5.1 Test Requirements	7
2.5.2 Test Procedure	7
2.5.3 Test Results	7
TEST EQUIPMENT LIST	8
APPENDIX A	A-1
APPENDIX B	B-1

1.0 TEST SUMMARY

Test Conducted and Completion Date:	August 6 - 10, 2012
Test Conducted For:	Aquion Energy
Test Performed By:	Michael Greiner Nick Aplin Mike Capan
MGA File Number:	C12T1-192
Test Specification:	Penetration, Ground Fault, Immersion, Flame Propagation, Roll-Over SAE J2464, ASTM D149, UL 1973
Test Specimen Data:	Lithium Batteries Model: DM
Condition of Test Specimen upon Receipt:	Good
Condition of Test Specimen upon Completion:	Tested
Disposition of Test Items:	Upon completion of testing, test items were returned to Aquion Energy

2.0 PROGRAM

2.1 Penetration Testing

2.1.1 Test Requirements

As per SAE J2464 4.3.3.

2.1.2 Test Procedure

One (1) single battery stack was subjected to a nail penetration in accordance with SAE J2464 4.3.3.

2.1.3 Test Results

There was no visible damage as a result of the testing. The voltage did dropped slightly while penetrated. When the nail was removed, the voltage returned to normal levels.

See Appendix A for test data results.
See Appendix B for test photographs.

2.2 Ground Fault Isolation (Non-A2LA)

2.2.1 Test Requirements

As per ASTM D149

2.2.2 Test Procedure

Three (3) single battery stacks was subjected to a a ground fault isolation test in accordance with ASTM D149

2.2.3 Test Results

There was no visible damage as a result of the testing.

See Appendix B for test photographs.

2.3 Water Immersion

2.3.1 Test Requirements

As per SAE J2464 4.3.5

2.3.2 Test Procedure

One (1) single battery stack was subjected to an immersion test in accordance with SAE J2464 4.3.5. ASTM D 1141 simulated sea water was used for this test.

2.3.3 Test Results

There was no visible damage as a result of the test. Some discoloration was noticed in the water around the negative terminal. The battery voltage continually dropped, slightly, during testing.

See Appendix A for test data results.

See Appendix B for test photographs.

2.4 Flame Propagation (Non-A2LA)

2.4.1 Test Requirements

As per UL 1973.

2.4.2 Test Procedure

One (1) seven stack battery was subjected to a flame propagation test in accordance with UL 1973.

2.4.3 Test Results

The battery did sustain melting and burn damage during the 30 minute burn period. Many of the cell cavities opened, allowing salt water to escape during testing. This appeared to happen on at least the bottom four (4) cells in the pack.

Additionally, the wiring harness sustained damage and the cells were no longer electrically connected in series. This caused a complete drop in overall pack voltage to 0.0 V, as measured across the lowest cell and highest cell terminals.

At the conclusion of the flame propagation test, the battery was removed from direct flame. The battery immediately self-extinguished. There was no sign of rapid disassembly.

See Appendix A for test data results.

See Appendix B for test photographs.

2.5 Roll-Over (Non-A2LA)

2.5.1 Test Requirements

As per SAE J2464 4.3.4.

2.5.2 Test Procedure

Two (2) single battery stack was subjected to a roll-over test in accordance with SAE J2464 4.3.4.

2.5.3 Test Results

At the conclusion of the incremental roll testing, there were no signs of rapid disassembly, fire, or electrical isolation loss. There was no significant change in the cell weight or terminal voltage. Although there was an increase in all temperatures, T1-T6, this is attributed to a rise in ambient temperature.

See Appendix A for test data results.
See Appendix B for test photographs.

TEST EQUIPMENT LIST

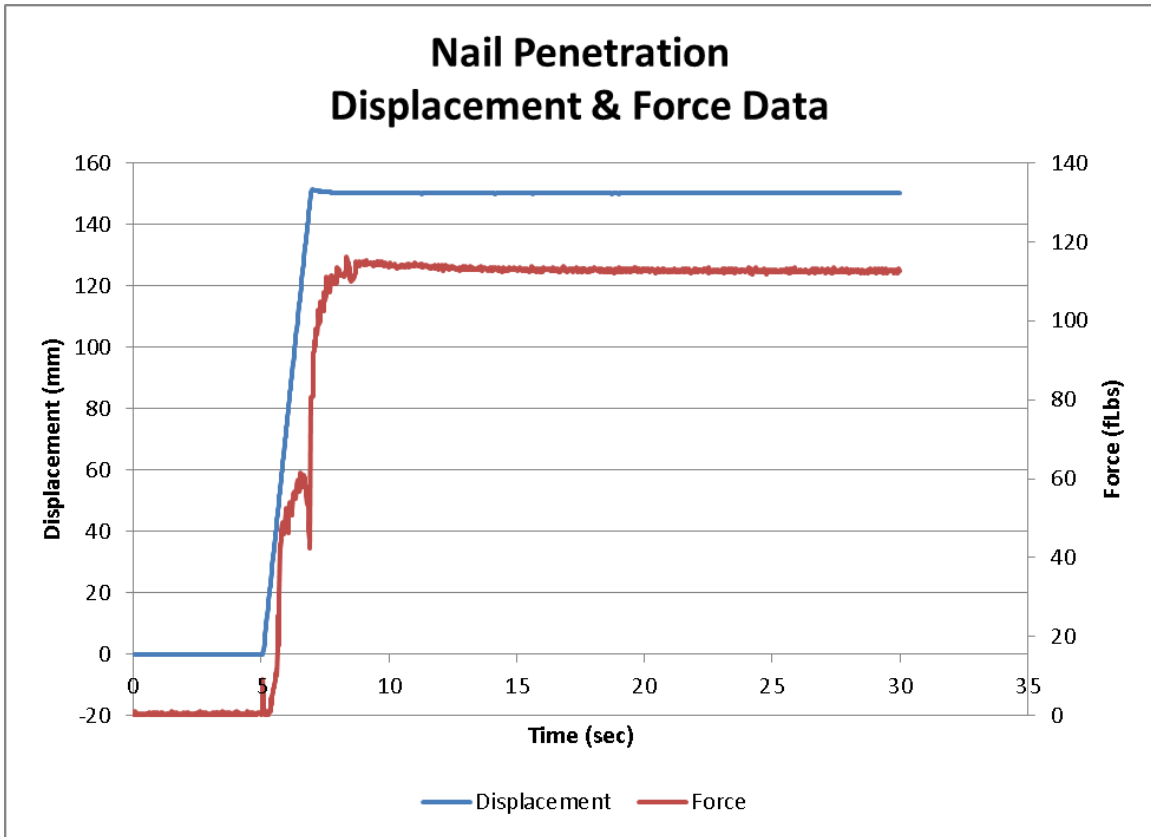
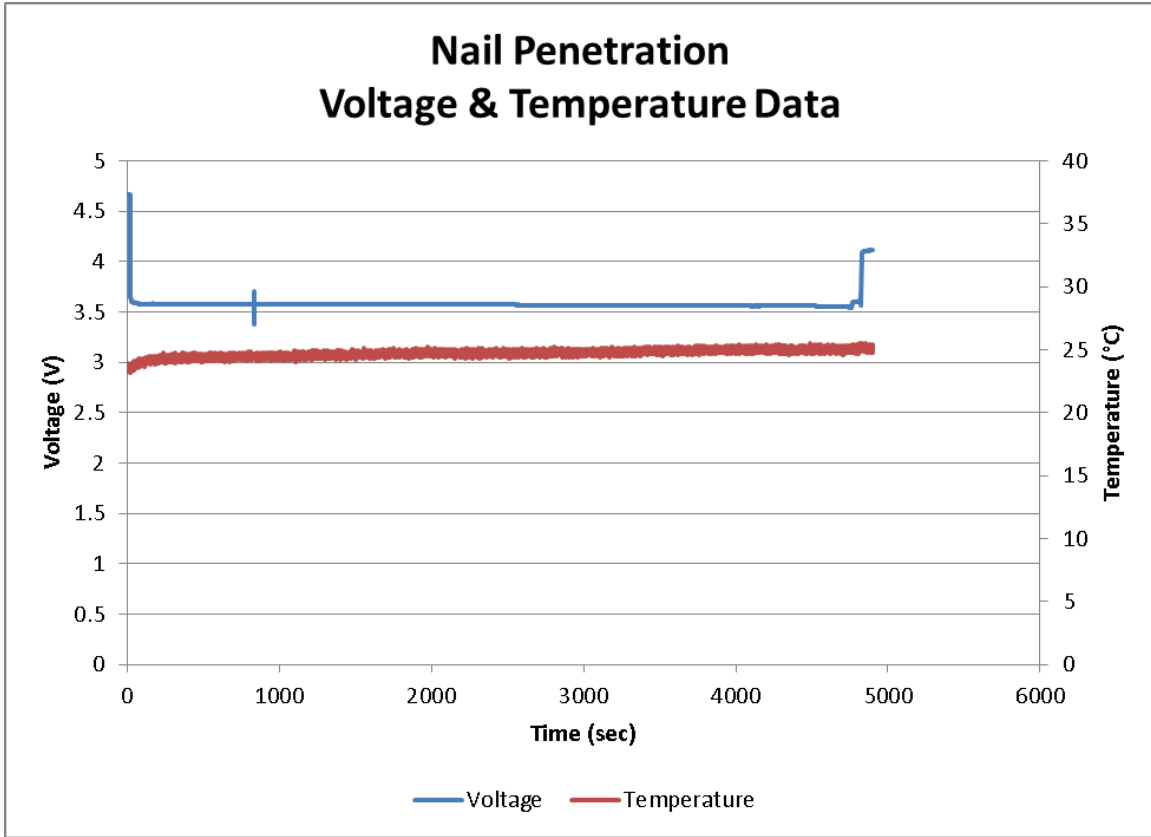
Item	Description	Manufacturer	Model No.	Serial No.	Cal Date	Date Due	MGA Ref
1	DAS	Keithley	2701	1381460	3-12-12	3-12-13	36.08-09
2	Load Cell	Interface	1210ACK-10K	276233A	8-29-11	8-29-12	01.01-06
3	Calipers	Mitutoyo	CD-6" CX	8435994	4-20-12	4-20-13	99.08-01
4	Dyelectric Tester	Slaughter	2515	3280209	9-29-11	9-29-12	56.02-01
5	DAS	Keithley	2701	1381460	3-12-12	3-12-13	36.08-09
6	DAQ	NI	NI9211 (A)	14F8AE9	11-2-11	11-2-12	MGA WI
7	Weight	Befour	P58060	0711RS1007	5-31-12	5-31-13	MGA WI
8	Length	Stanley	33-158	625	4-4-12	4-4-13	MGA WI
9	Angle	Digital Protractor	Pro 360	002	8-7-12	8-7-13	MGA WI

*UWCE – Use with calibrated equipment

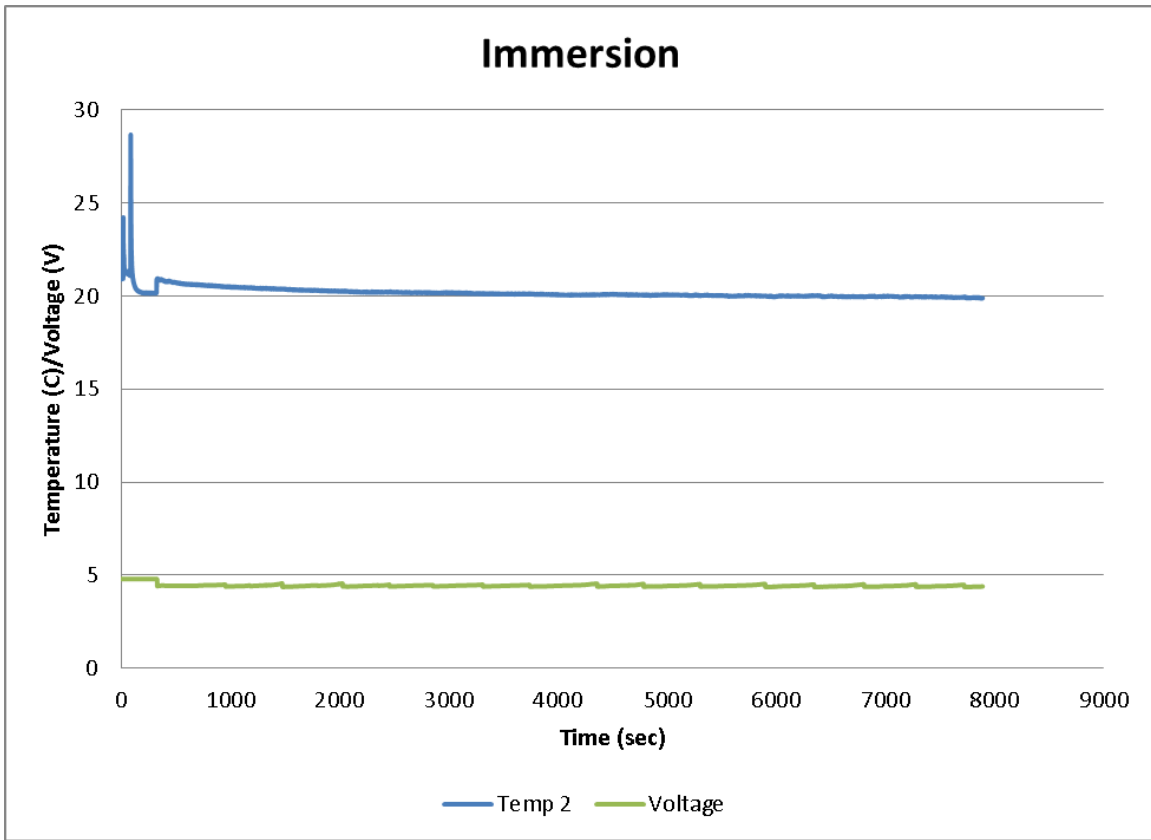
APPENDIX A

TEST DATA

Nail Penetration



Water Immersion



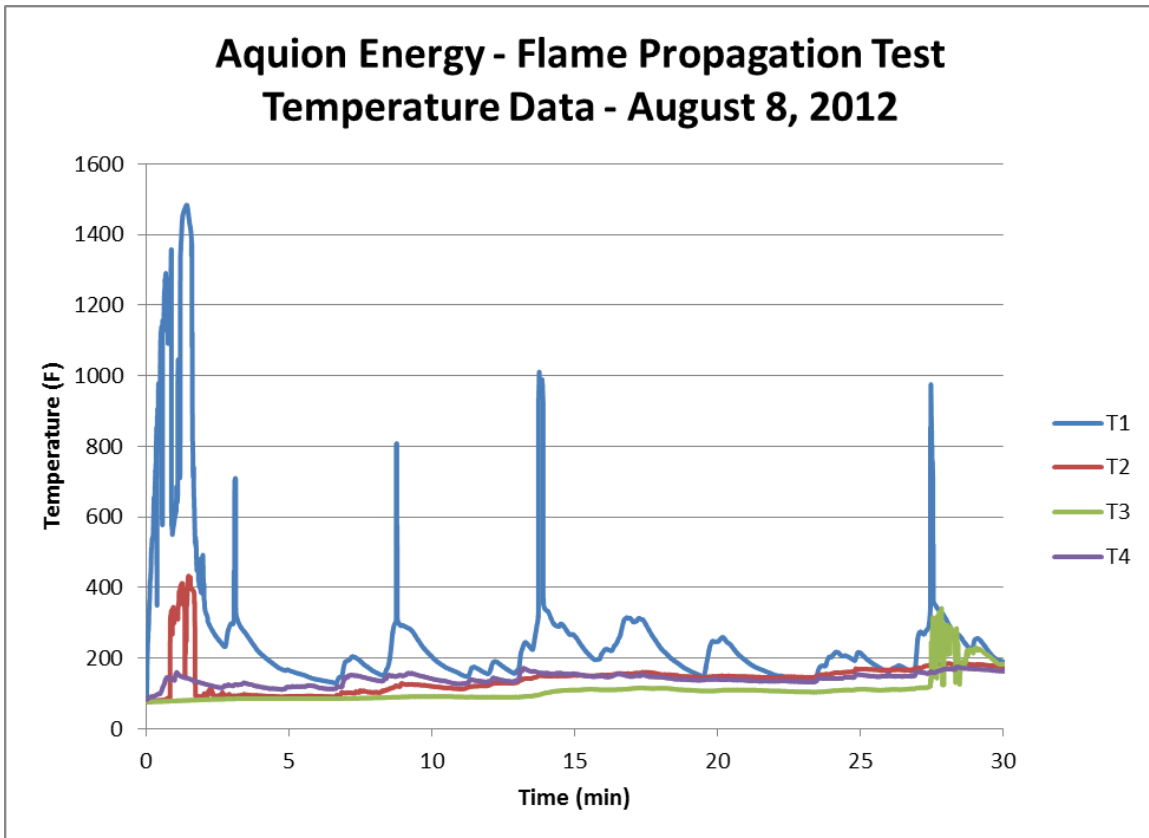
Flame Propagation

Pre-Test Weight (lb)	Post-Test Weight (lb)	Deviation (%)
201.9	193.5	4.16%

Table D1 – Test Weights

*NOTE: Both pre- and post-test weights include fixture

Pre-Test Voltage (V)	Post-Test Voltage (V)	Deviation (%)
11.28	0.00	100.00%



Roll-Over Cell 1

Pre-Test Weight (lb)	Post-Test Weight (lb)	Deviation (%)
24.2	24.2	0.00%

Table C1 – Incremental Roll Test Weights

Pre-Test Voltage (V)	Post-Test Voltage (V)	Deviation (%)
0.672	0.662	1.49%

Table C2 – Incremental Roll Test Voltage

Angle	Hold Time	T1	T2	T3	T4	T5	T6
0.0	1	88.5	91.0	91.5	93.0	99.0	100.0
31.2	1	-	-	-	-	-	-
62.0	1	-	-	-	-	-	-
90.0	1	-	-	-	-	-	-
118.6	1	-	-	-	-	-	-
149.0	1	-	-	-	-	-	-
180.0	1	-	-	-	-	-	-
209.4	1	-	-	-	-	-	-
238.2	1	-	-	-	-	-	-
270.0	1	-	-	-	-	-	-
301.2	1	-	-	-	-	-	-
332.4	1	-	-	-	-	-	-
360.0	60	91.5	95.5	95.5	97.0	100.0	100.0

Pre-Test Weight (lb)	Post-Test Weight (lb)	Deviation (%)
24.2	24.2	0.00%

Table C4 – Continuous Roll Test Weights

Pre-Test Voltage (V)	Post-Test Voltage (V)	Deviation (%)
0.662	0.654	1.21%

Table C5 – Continuous Roll Test Voltage

Time (min)	T1	T2	T3	T4	T5	T6
0	91.5	95.5	95.5	97.0	100.0	100.0
30	94.5	95.0	99.0	99.0	98.0	100.0

Roll-Over cell 2

Pre-Test Weight (lb)	Post-Test Weight (lb)	Deviation (%)
24.3	24.3	0.00%

Table B1 – Incremental Roll Test Weights

Pre-Test Voltage (V)	Post-Test Voltage (V)	Deviation (%)
0.682	0.672	1.47%

Table B2 – Incremental Roll Test Voltage

Angle	Hold Time	T1	T2	T3	T4	T5	T6
0.0	1	86.0	87.0	86.0	87.5	95.0	97.0
31.2	1	-	-	-	-	-	-
62.0	1	-	-	-	-	-	-
90.0	1	-	-	-	-	-	-
118.6	1	-	-	-	-	-	-
149.0	1	-	-	-	-	-	-
180.0	1	-	-	-	-	-	-
209.4	1	-	-	-	-	-	-
238.2	1	-	-	-	-	-	-
270.0	1	-	-	-	-	-	-
301.2	1	-	-	-	-	-	-
332.4	1	-	-	-	-	-	-
360.0	60	91.5	92.0	94.0	97.0	100.0	100.5

Pre-Test Weight (lb)	Post-Test Weight (lb)	Deviation (%)
24.3	24.3	0.00%

Table B4 – Continuous Roll Test Weights

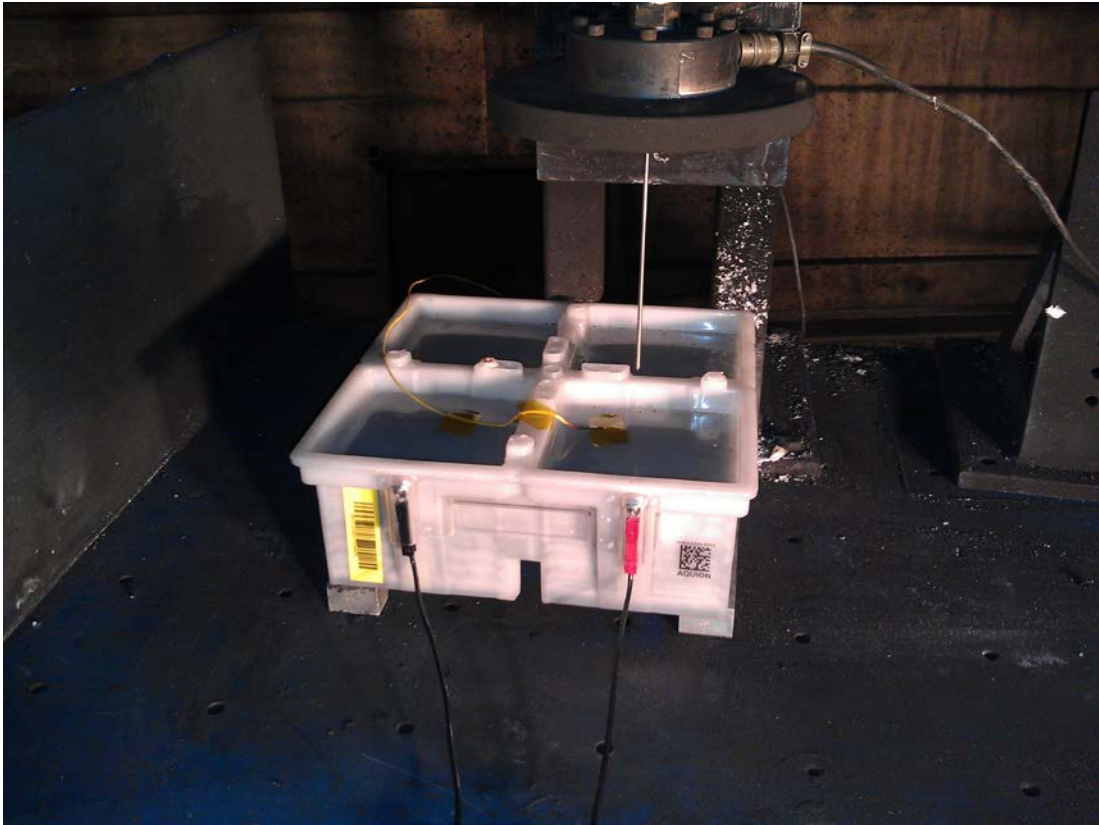
Pre-Test Voltage (V)	Post-Test Voltage (V)	Deviation (%)
0.672	0.666	0.89%

Table B5 – Continuous Roll Test Voltage

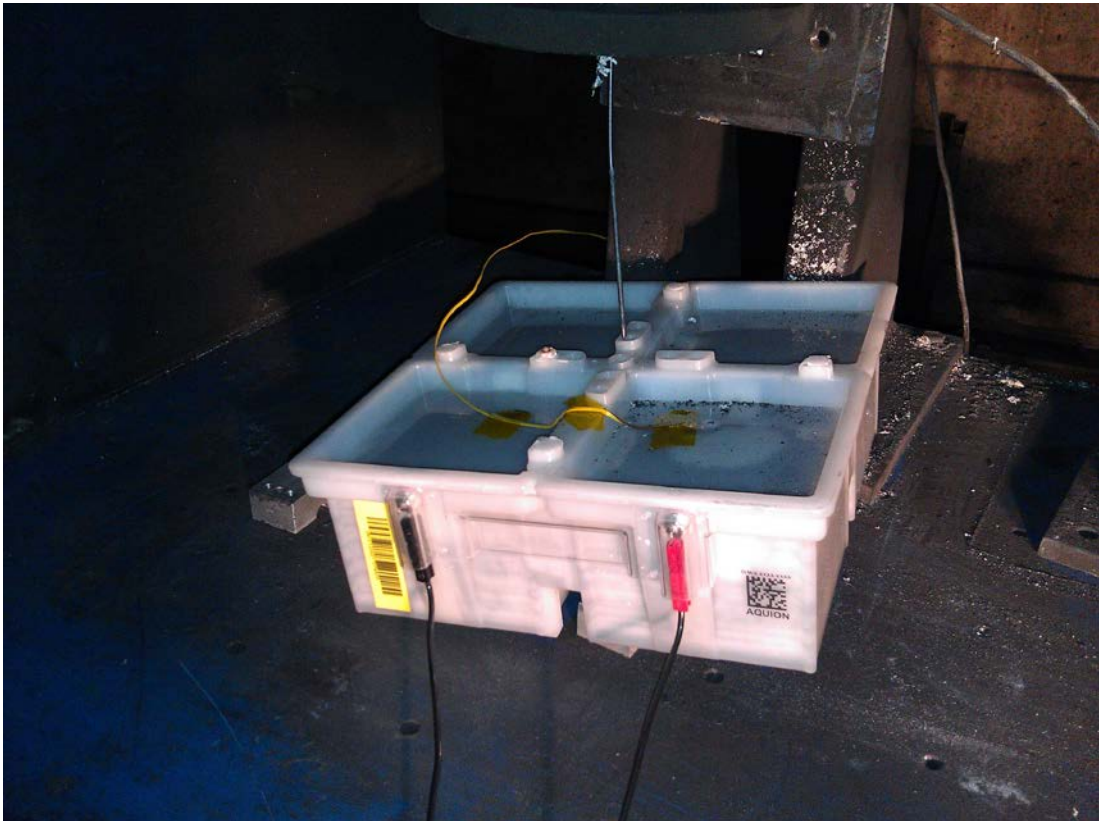
Time (min)	T1	T2	T3	T4	T5	T6
0	91.5	92.0	94.0	97.0	100.0	100.5
30	95.0	95.5	99.5	100.0	103.0	101.5

APPENDIX B

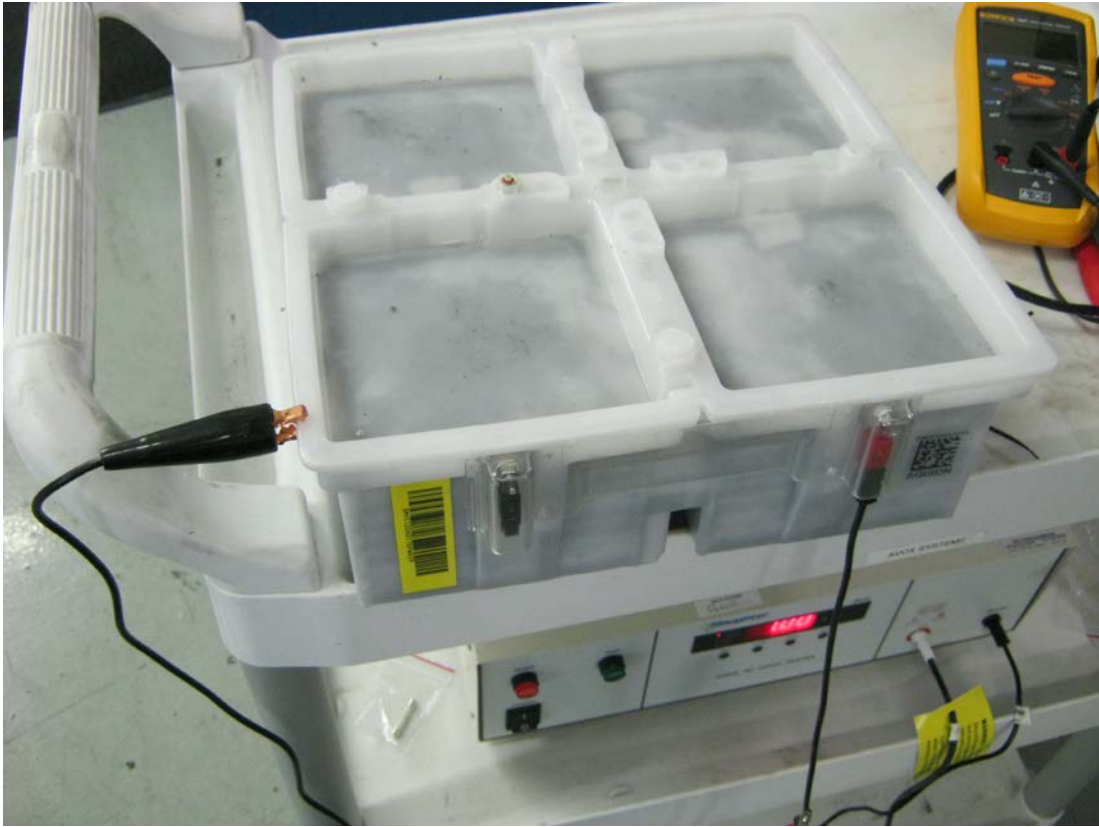
TEST PHOTOGRAPHS



Pre Nail Penetration



Post Nail Penetration



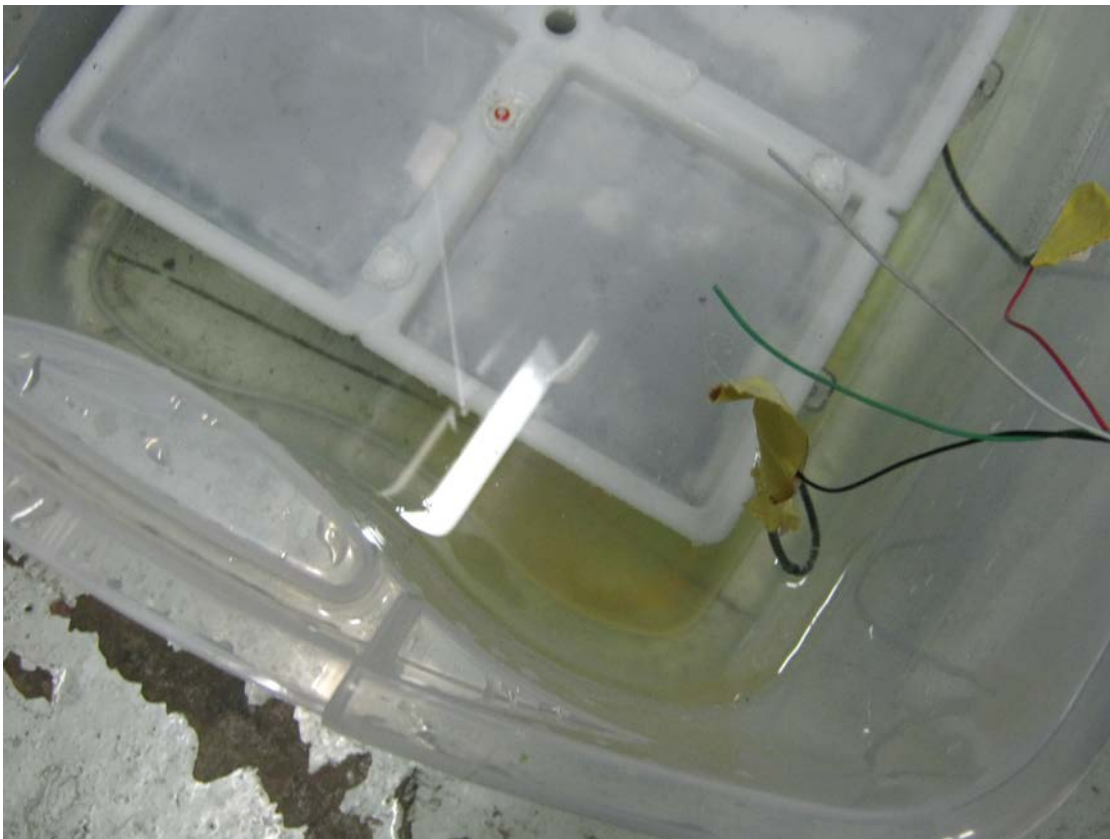
Ground Fault Isolation



Ground Fault Isolation



Pre Immersion



Post Immersion



Roll-Over Testing



Pre Flame Propagation



Post Flame Propagation