45000 Helm Street
Suite 150
Plymouth Twp., MI 48170

Telephone: 734-582-2900
Facsimile: 734-582-2901
www.intertek.com

Test Report for:

Electro-Sensors, Inc.
Attn: Mr. Kris Paxton

UN 38.3 BATTERY TESTING
Lithium Thionyl Chloride Battery Packs
Model Name: Battery Pack (19Ah 7Vdc)
Part Number: 800-012020

Client PO No.: P000061293

Scott Souter	Nick Diamond
Associate Engineer	Sr. Associate Engineer
February 9, 2015	
Report No.: 101925975DET-001	Page 1 of 31

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TEST VERIFICATION OF CONFORMITY

TEST METHOD: UN Manual of Tests and Criteria "Recommendations on the Transport of Dangerous Goods," section 38.3 "Lithium Batteries"
Document number ST/SG/AC.10/11/Rev.5, Amend 1
Revision #: 5th Edition, Amendment 1
Effective Date: April 2012

SAMPLE DESCRIPTION: Eight (8) Lithium Thionyl Chloride Battery Packs
MODEL NAME: Battery Pack (19Ah 7Vdc)
PART NUMBER: 800-012020

MANUFACTURER: Electro-Sensors, Inc.

SPECIFICATION SECTIONS T1 through T5:
Eight (8) Lithium Thionyl Chloride Battery Packs; PN: 800-012020; sample numbers:

Undischarged
- SN 1
- SN 2
- SN 3
- SN 4

Discharged
- SN 5
- SN 6
- SN 7
- SN 8

Condition of Test Sample: Production

DATE RECEIVED: 12/15/2014
DATES TESTED: 12/23/2014 through 02/09/2015

RESULT SUMMARY: The tested samples met the test requirements. See below breakout for tests performed.

Specification Section	Test Description	Results
T1	Altitude	Conforms
T2	Thermal Shock	Conforms
T3	Vibration	Conforms
T4	Shock	Conforms
T5	External Short Circuit	Conforms

Scott Souter	Nick Diamond
Associate Engineer	Sr. Associate Engineer
February 9, 2015	
Report No.: 101925975DET-001	

Attn: Mr. Kris Paxton
Electro-Sensors, Inc.
6111 Blue Circle Drive
Minnetonka, MN 55343
Phone: (952) 945-2868
E-mail Address: kpaxton@electro-sensors.com

DATE RECEIVED: 12/15/2015
DATE TESTED: 12/23/2014 through 02/09/2015

WORK REQUESTED / APPLICABLE DOCUMENTS:

Per the client's request and in accordance with UN 38.3 and our quotation number 500542488, dated 09/24/2014; perform Battery Testing as described below:

- T1 Test – Altitude Simulation
- T2 Test – Thermal Test
- T3 Test – Vibration
- T4 Test – Shock
- T5 Test – External Short Circuit

DESCRIPTION OF TEST SAMPLES:

Eight (8) Lithium Thionyl Chloride Battery Packs; PN: 800-012020

SPECIFICATION SECTIONS T1 through T5:
Eight (8) Lithium Thionyl Chloride Battery Packs; PN: 800-012020; sample numbers:

Undischarged
- SN 1
- SN 2
- SN 3
- SN 4

Discharged
- SN 5
- SN 6
- SN 7
- SN 8

Condition of Test Sample: Production

EQUIPMENT LIST:

Asset	Description	Manufacturer	Model	Serial
160454	MULTIMETER	Fluke	Fluke-12	68892051
376-003	PRECISION BALANCE	A&D COMPANY	GF-4000	T0338281
160808	DATA ACQUISITION / SWITCH UNIT	AGILENT	34970A	US37046210
160272	DC POWER SUPPLY	AMREL	LPS101	392663
161279	ALTITUDE CABINET	ENTELA	N/A	N/A
161279.1	PRESSURE TRANSDUCER FOR ALTITUDE CABINET 0-30 PSI	FAIRCHILD INDUSTRIAL	TA870212A	366027
162188	CONTROLLER	ENVIROTRONICS	SYSTEM PLUS SPRMTD	D11570303
162188.1	F4 CONTROLLER	WaTLOW	F4DHKKKK01RG	018908
162188p	ENVIRONMENTAL CHAMBER	ENVIROTRONICS	SSH32c-ac	01046091
160468	MULTIMETER	Fluke	12	68151007
375-033	ACCELEROMETER	PCB	320C15	13576
161132.2	VIBE CONTROLLER COMPUTER	HEWETT PACKARD	PAVILION S5-1224	3CR2250020W
375-041	VIBRATION CONTROLLER	VIBRATION RESEARCH	VR9500	9513397E
376-002	ICP SHOCK SENSOR	PCB	350B04	44164
375-042	VIBRATION CONTROLLER	VIBRATION RESEARCH	VR9500	951394BE
161197	SHOCK MACHINE (asset for controller is 375-042)	AVCO	SM-220 MP	HP-0011
161294	ENVIRONMENTAL CHAMBER - NO HUMIDITY	THERMOTRON	S-1.2c	22607
162044	DATA ACQUISITION / SWITCH UNIT	AGILENT	34970A	MY41018030
161342	SWITCHING POWER SUPPLY	BK PRECISION	1692	S940035793
162085	CURRENT SHUNT	EMPRO	HA-50-100	none
162086	CURRENT SHUNT	EMPRO	HA-50-100	none
162089	CURRENT SHUNT	EMPRO	HA-50-100	none
162095	CURRENT SHUNT	EMPRO	HA-50-100	none
160843	DATA ACQUISITION / SWITCH UNIT	AGILENT	34970A	MY41003793

****Sample of Equipment List shown above.**

T1 – ALTITUDE SIMULATION

Date Received: 12/15/2014
Date(s) Tested: 12/23/2014

Description of Samples:
Eight (8) Lithium Thionyl Chloride Battery Packs; PN: 800-012020; sample numbers:

Undischarged
- SN 1
- SN 2
- SN 3
- SN 4

Discharged
- SN 5
- SN 6
- SN 7
- SN 8

Purpose:
This test simulates air transport under low-pressure conditions.

Test Procedure:
Prior to testing the voltage and mass were measured on each sample. The samples were then placed into an altitude cabinet, stored at a pressure of 11.6 kPa or less for six (6) hours at ambient temperature. After testing, the voltage and mass were measured on each sample.

Acceptance Criteria:
Cells and batteries meet this requirement if there is no mass loss, no leakage, no venting, no disassembly, no rupture and no fire and if the open circuit voltage of each test cell or battery after testing is not less than 90% of its voltage immediately prior to this procedure. The requirement relating to voltage is not applicable to test cells and batteries at fully discharged states.

Results:
The test samples conformed to the acceptance criteria; there was no mass loss, no leakage, no venting, no disassembly, no rupture, no fire and the open circuit voltage of each test sample after testing was not less than 90% of its voltage immediately prior to this procedure.

T1 - Altitude Simulation								
Sample No.	Pre Conditioning Cycles	Voltage Pre Test (VDC)	Voltage Post Test (VDC)	%Change (Not Greater Than 10%)	Weight Pre Test (Grams)	Weight Post Test (Grams)	%Change (Not Greater Than 0.1%)	Meets requirement
1	Charged	7.02	6.96	0.85	353.92	353.9	0.01	Pass
2	Charged	6.99	6.95	0.57	357.96	357.94	0.01	Pass
3	Charged	7.01	6.99	0.29	361.47	361.46	0.00	Pass
4	Charged	7.00	6.98	0.29	359.87	359.86	0.00	Pass
5	Discharged	7.02	7.01	0.14	361.86	361.86	0.00	Pass
6	Discharged	7.03	7.04	-0.14	360.9	360.88	0.01	Pass
7	Discharged	7.00	6.99	0.14	358.73	358.71	0.01	Pass
8	Discharged	7.06	6.99	0.99	358.51	358.49	0.01	Pass

Appendix:
Appendix A – Photograph
Appendix B – Altitude Test Graph

Disposition of Test Samples:
At the completion of testing, the samples continued to T2 – Thermal Testing.

T2 – THERMAL TEST

Date Received: 12/15/2014
Date(s) Tested: 12/23/2014 through 12/30/2014

Description of Samples:
Eight (8) Lithium Thionyl Chloride Battery Packs; PN: 800-012020; sample numbers:

Undischarged
- SN 1
- SN 2
- SN 3
- SN 4

Discharged
- SN 5
- SN 6
- SN 7
- SN 8

Purpose:
This test assesses cell and battery seal integrity and internal electrical connections. The test is conducted using rapid and extreme temperature changes.

Test Procedure:
Prior to testing the voltage and mass were measured on each sample. The samples were placed into an environmental chamber and stored for six (6) hours at 72°C, followed by storage for six (6) hours at a temperature of -40°C. The maximum time interval between test temperature extremes was 30 minutes. This procedure was repeated 10 times, after which all samples were stored for 24 hours at ambient temperature. After testing the voltage and mass were measured on each sample.

Acceptance Criteria:
Cells and batteries meet this requirement if there is no mass loss, no leakage, no venting, no disassembly, no rupture and no fire and if the open circuit voltage of each test cell or battery after testing is not less than 90% of its voltage immediately prior to this procedure. The requirement relating to voltage is not applicable to test cells and batteries at fully discharged states.

Results:
The test samples conformed to the acceptance criteria; there was no mass loss, no leakage, no venting, no disassembly, no rupture, no fire and the open circuit voltage of each test sample after testing was not less than 90% of its voltage immediately prior to this procedure.

T2 - Thermal Test								
Sample No.	Pre Conditioning Cycles	Voltage Pre Test (VDC)	Voltage Post Test (VDC)	%Change (Not Greater Than 10%)	Weight Pre Test (Grams)	Weight Post Test (Grams)	%Change (Not Greater Than 0.1%)	Meets requirement
1	Charged	6.96	7.14	-2.59	353.9	353.81	0.03	Pass
2	Charged	6.95	7.16	-3.02	357.94	357.87	0.02	Pass
3	Charged	6.99	7.16	-2.43	361.46	361.36	0.03	Pass
4	Charged	6.98	7.16	-2.58	359.86	359.76	0.03	Pass
5	Discharged	7.01	7.18	-2.43	361.86	361.78	0.02	Pass
6	Discharged	7.04	7.17	-1.85	360.88	360.79	0.02	Pass
7	Discharged	6.99	7.16	-2.43	358.71	358.64	0.02	Pass
8	Discharged	6.99	7.20	-3.00	358.49	358.42	0.02	Pass

T2 – THERMAL TEST (cont'd)

Appendix:
Appendix A – Photograph
Appendix C – Thermal Test Graph

Disposition of Test Samples:
At the completion of testing, the samples continued to T3 – Vibration Testing.

T3 – VIBRATION TEST

Date Received: 12/15/2014
Date(s) Tested: 01/09/2015 through 01/14/2014

Description of Samples:
Eight (8) Lithium Thionyl Chloride Battery Packs; PN: 800-012020; sample numbers:

Undischarged
- SN 1
- SN 2
- SN 3
- SN 4

Discharged
- SN 5
- SN 6
- SN 7
- SN 8

Purpose:
This test simulates vibration during transport.

Test Procedure:
Prior to testing the voltage and mass were measured on each sample. The samples were firmly secured to the platform of the vibration machine without distorting the packs in such a manner as to faithfully transmit the vibration. The test samples were subjected to sinusoidal waveform with a logarithmic sweep between 7 Hz and 200 Hz and back to 7 Hz traversed in 15 minutes. This cycle was repeated 12 times for a total of three (3) hours for each of the three (3) mutually perpendicular mounting positions of the sample. One of the directions of vibration must be perpendicular to the terminal face.

The logarithmic frequency sweep is as follows: from 7 Hz a peak acceleration of 1g is maintained until 18 Hz is reached. The amplitude is then maintained at 0.8mm (1.6mm total excursion) and the frequency increased until a peak acceleration of 8g occurs (approximately 50 Hz). A peak acceleration of 8g is then maintained until the frequency is increased to 200 Hz. After testing the voltage and mass were measured on each sample.

Acceptance Criteria:
Cells and batteries meet this requirement if there is no leakage, no venting, no disassembly, no rupture and no fire and if the open circuit voltage of each test cell or battery after testing is not less than 90% of its voltage immediately prior to this procedure. The requirement relating to voltage is not applicable to test cells and batteries at fully discharged states.

Results:
The test samples conformed to the acceptance criteria; there was no leakage, no venting, no disassembly, no rupture and no fire and the open circuit voltage of each test cell or battery after testing was not less than 90% of its voltage immediately prior to this procedure. The requirement relating to voltage is not applicable to test cells and batteries at fully discharged states.

T3 - Vibration								
Sample No.	Pre Conditioning Cycles	Voltage Pre Test (VDC)	Voltage Post Test (VDC)	%Change (Not Greater Than 10%)	Weight Pre Test (Grams)	Weight Post Test (Grams)	%Change (Not Greater Than 0.1%)	Meets requirement
1	Charged	7.14	7.07	0.98	353.81	353.81	0.00	Pass
2	Charged	7.16	7.03	1.82	357.87	357.89	-0.01	Pass
3	Charged	7.16	7.02	1.96	361.36	361.36	0.00	Pass
4	Charged	7.16	7.01	2.09	359.76	359.76	0.00	Pass
5	Discharged	7.18	7.09	1.25	361.78	361.77	0.00	Pass
6	Discharged	7.17	7.11	0.84	360.79	360.77	0.01	Pass
7	Discharged	7.16	7.09	0.98	358.64	358.62	0.01	Pass
8	Discharged	7.20	7.09	1.53	358.42	358.43	0.00	Pass

T3 – VIBRATION TEST (cont'd)

Appendices:
Appendix A – Photographs
Appendix D – Vibration Plots

Disposition of Test Samples:
At the completion of testing, the samples continued to T4 – Shock Test.

T4 – SHOCK TEST

Date Received: 12/15/2014
Date(s) Tested: 01/15/2015 through 01/15/2015

Description of Samples:
Eight (8) Lithium Thionyl Chloride Battery Packs; PN: 800-012020; sample numbers:

Undischarged
- SN 1
- SN 2
- SN 3
- SN 4

Discharged
- SN 5
- SN 6
- SN 7
- SN 8

Purpose:
This test simulates possible impacts during transport.

Test Procedure:
Prior to testing the voltage and mass were measured on each sample. The samples were secured to the testing machine by means of a rigid mount with support on all mounting surfaces of each test battery. Each sample was subjected to a half-sine shock with a peak acceleration of 150G's with a pulse duration of six (6) milliseconds. Each sample was subjected to three (3) shocks in the positive direction followed by three (3) shocks in the negative direction of the three mutually perpendicular mounting positions. After testing the voltage and mass were measured on each sample.

Acceptance Criteria:
Cells and batteries meet this requirement if there is no leakage, no venting, no disassembly, no rupture and no fire and if the open circuit voltage of each test cell or battery after testing is not less than 90% of its voltage immediately prior to this procedure. The requirement relating to voltage is not applicable to test cells and batteries at fully discharged states.

Results:
The test samples conformed to the acceptance criteria; there was no leakage, no venting, no disassembly, no rupture and no fire and the open circuit voltage of each test cell or battery after testing was not less than 90% of its voltage immediately prior to this procedure. The requirement relating to voltage is not applicable to test cells and batteries at fully discharged states.

T4 - Shock								
Sample No.	Pre Conditioning Cycles	Voltage Pre Test (VDC)	Voltage Post Test (VDC)	%Change (Not Greater Than 10%)	Weight Pre Test (Grams)	Weight Post Test (Grams)	%Change (Not Greater Than 0.1%)	Meets requirement
1	Charged	7.07	7.02	0.71	353.81	353.82	0.00	Pass
2	Charged	7.03	7.01	0.28	357.89	357.91	-0.01	Pass
3	Charged	7.02	7.02	0.00	361.36	361.37	0.00	Pass
4	Charged	7.01	7.03	-0.29	359.76	359.78	-0.01	Pass
5	Discharged	7.09	7.08	0.14	361.77	361.78	0.00	Pass
6	Discharged	7.11	7.09	0.28	360.77	360.79	-0.01	Pass
7	Discharged	7.09	7.08	0.14	358.62	358.63	0.00	Pass
8	Discharged	7.09	7.10	-0.14	358.43	358.44	0.00	Pass

T4 – SHOCK TEST (cont'd)

Appendices:
Appendix A – Photographs
Appendix E – Mechanical Shock Plots

Disposition of Test Samples:
At the completion of testing, the samples continued to T5 – External Short Circuit Testing.

T5 – EXTERNAL SHORT CIRCUIT TEST

Date Received: 12/15/2014
Date(s) Tested: 01/15/2015 through 02/09/2015

Description of Samples:
Eight (8) Lithium Thionyl Chloride Battery Packs; PN: 800-012020; sample numbers:

- SN 1
- SN 2
- SN 3
- SN 4
- SN 5
- SN 6
- SN 7
- SN 8

Purpose:
This test simulates an external short circuit.

Test Procedure:
The samples were temperature stabilized until the external case temperature reached 55°C ± 2°C and then the samples were subjected to a short circuit condition with a total external resistance of less than 0.1 Ohm at 55°C ± 2°C. This short circuit condition continued for one (1) hour after the sample's external case temperature returned to 55°C ± 2°C. The samples were observed for a further six (6) hours for the test to be concluded.

Acceptance Criteria:
Cells and batteries meet this requirement if their external temperature does not exceed 170°C and there is no disassembly, no rupture and no fire within six hours of this test.

Results:
The test samples conformed to the acceptance criteria; at the completion of testing the cells and batteries external temperature did not exceed 170°C and there was no disassembly, no rupture or fire within six hours of this test.

- Prior to completing T5 – External Short Circuit, SN 1 OCV = 0.0V at ~35°C and greater. SN 1 was shipped back to Electro-Sensors, and upon inspection, a cell tab was found to have been broken away from near the weld point to the cell terminal. The diagnosis, per Kris Paxton, is that the cell tab broke because it was overstressed and weakened when the pack had been reworked to replace the cable grommet with a PVC bushing. The cable grommet was part of the original design, but all samples were returned to Electro-Sensors for new samples with the new PVC bushing.
- On December 11, 2014, per phone discussion between Nick Diamond, Scott Souter, and Kris Paxton, Electro-Sensors would build 8 new test samples with PVC bushing. At that time, Electro-Sensors was low on cells which resulted in some test samples being built from battery packs originally installed with the cable grommet.

T5 – EXTERNAL SHORT CIRCUIT TEST

Appendices:
Appendix A – Photograph
Appendix F – External Short Circuit Graphs

Disposition of Test Samples:
At the completion of testing, the samples were sent back to the client.

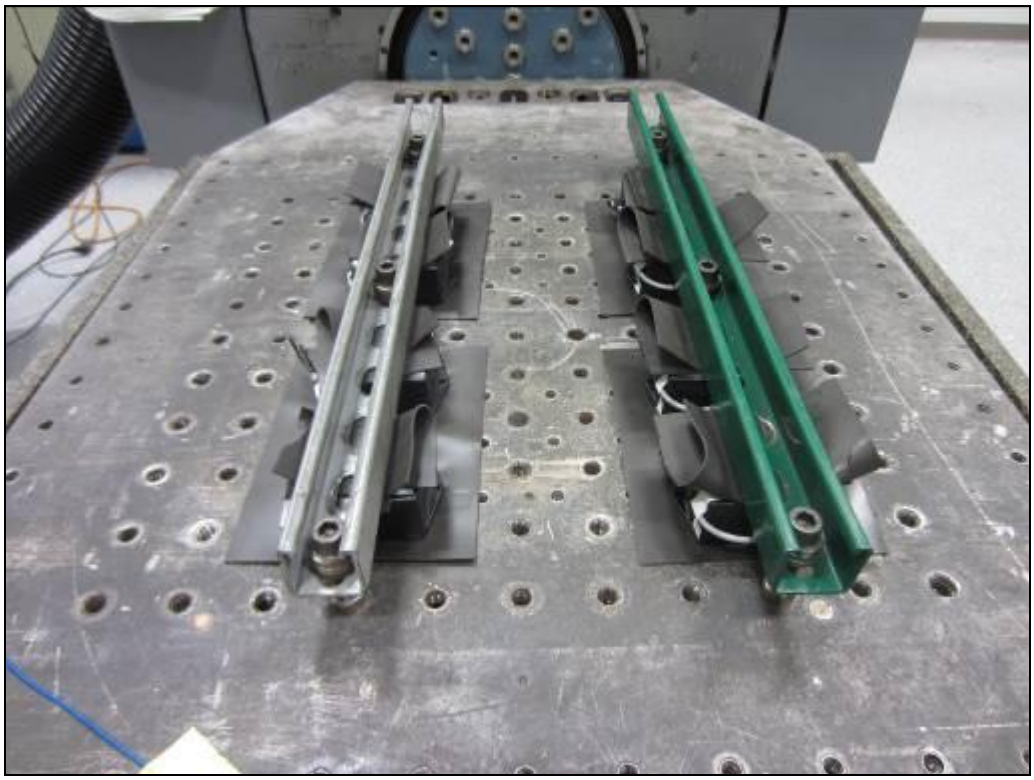
APPENDIX A – PHOTOGRAPHS
T1 – Altitude Test

Photograph 1: Altitude Simulation Setup

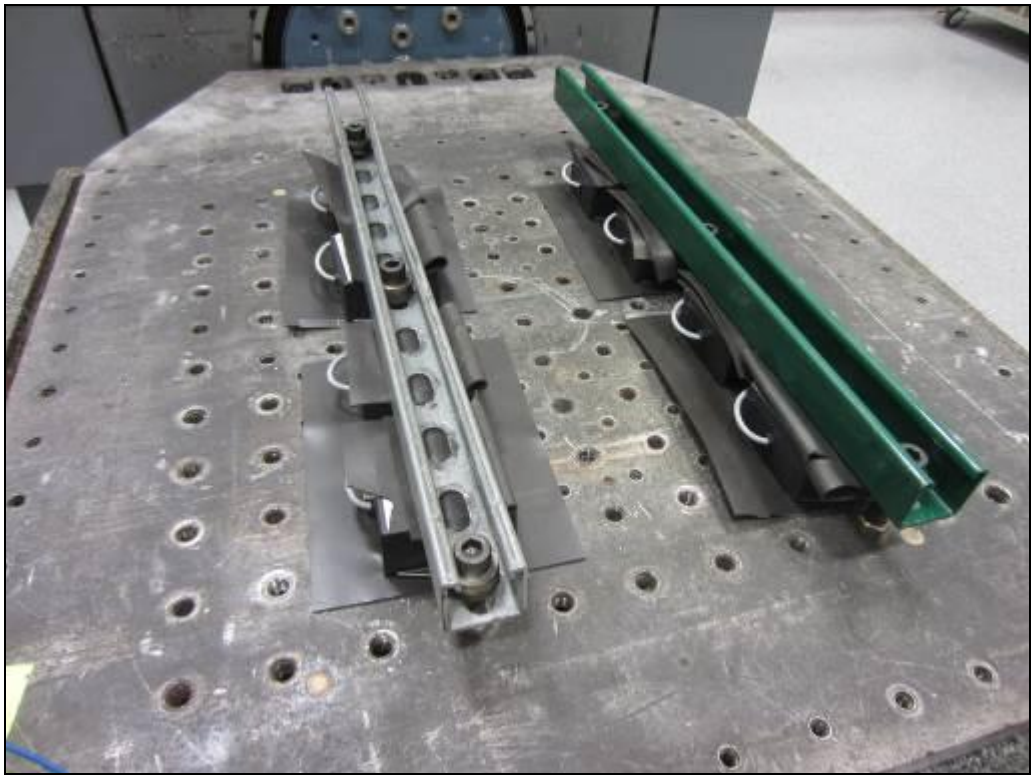
APPENDIX A – PHOTOGRAPHS (cont'd)
T2 – Thermal Shock Test

Photograph 2: Thermal Test Setup

APPENDIX A – PHOTOGRAPHS (cont'd)
T3 – Vibration Test

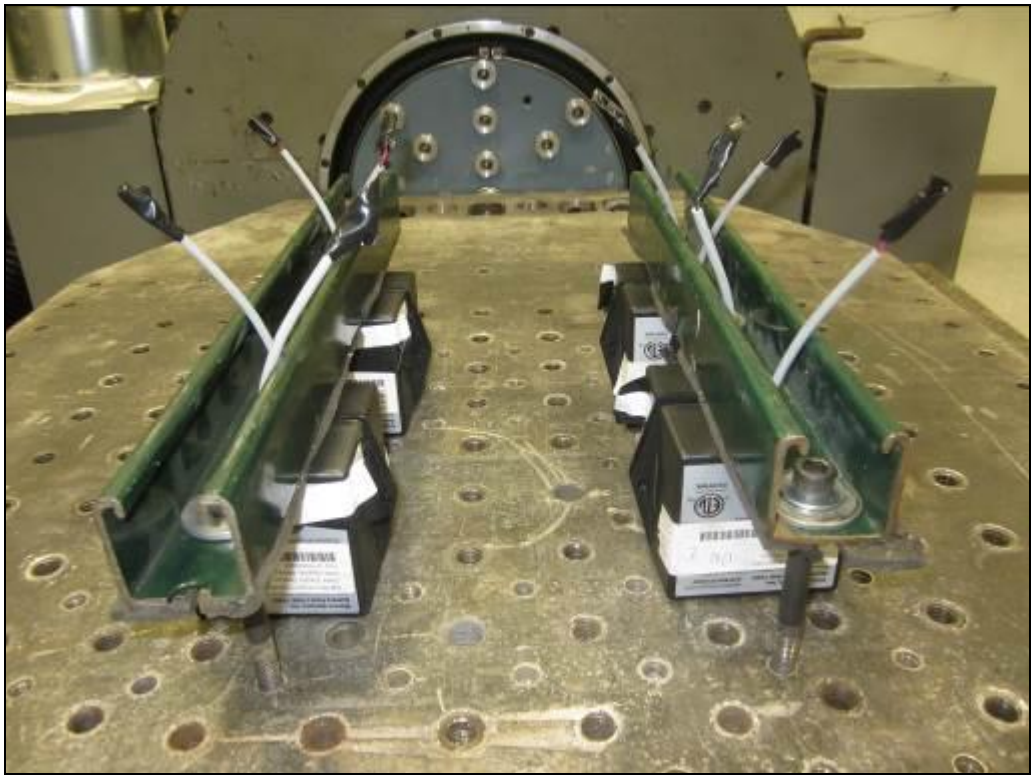


Photograph 3: Vibration Test Setup – Fore/Aft Direction



Photograph 4: Vibration Test Setup – Lateral Direction

APPENDIX A – PHOTOGRAPHS (cont'd)
T3 – Vibration Test



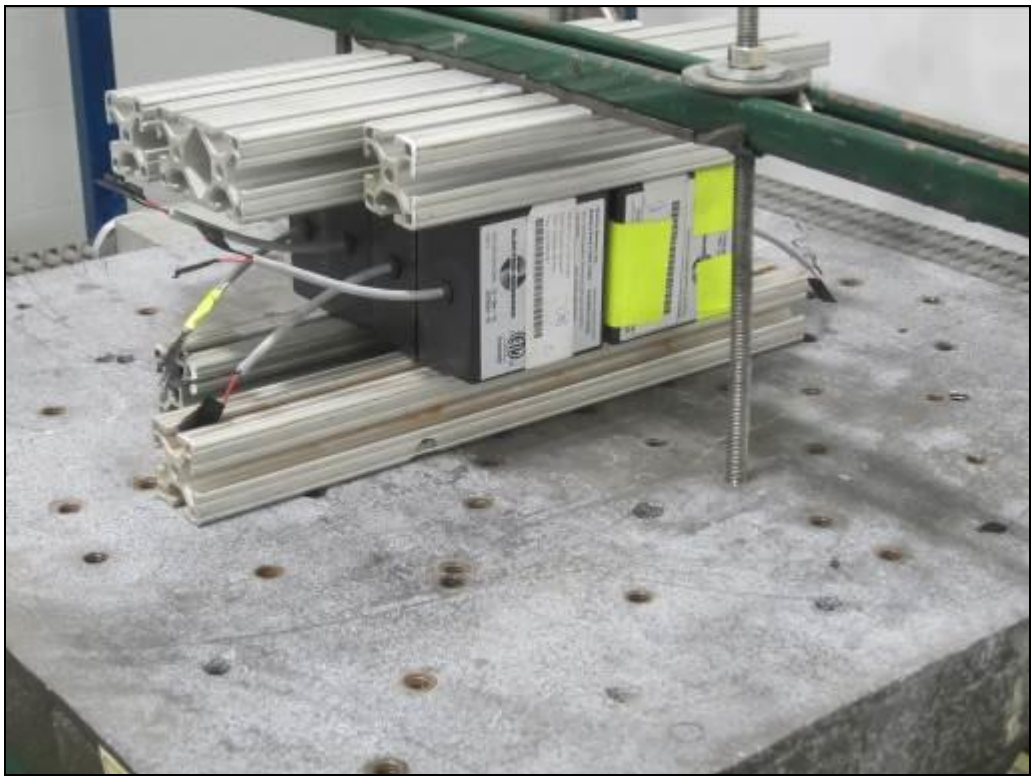
Photograph 5: Vibration Test Setup – Vertical Direction

APPENDIX A – PHOTOGRAPHS (cont'd)
T4 – Shock Test

Photograph 6: Shock Test Setup –Fore/Aft, Positive Direction

Photograph 7: Shock Test Setup – Fore/Aft, Negative Direction

APPENDIX A – PHOTOGRAPHS (cont'd)
T4 – Shock Test



Photograph 8: Shock Test Setup – Lateral, Positive Direction

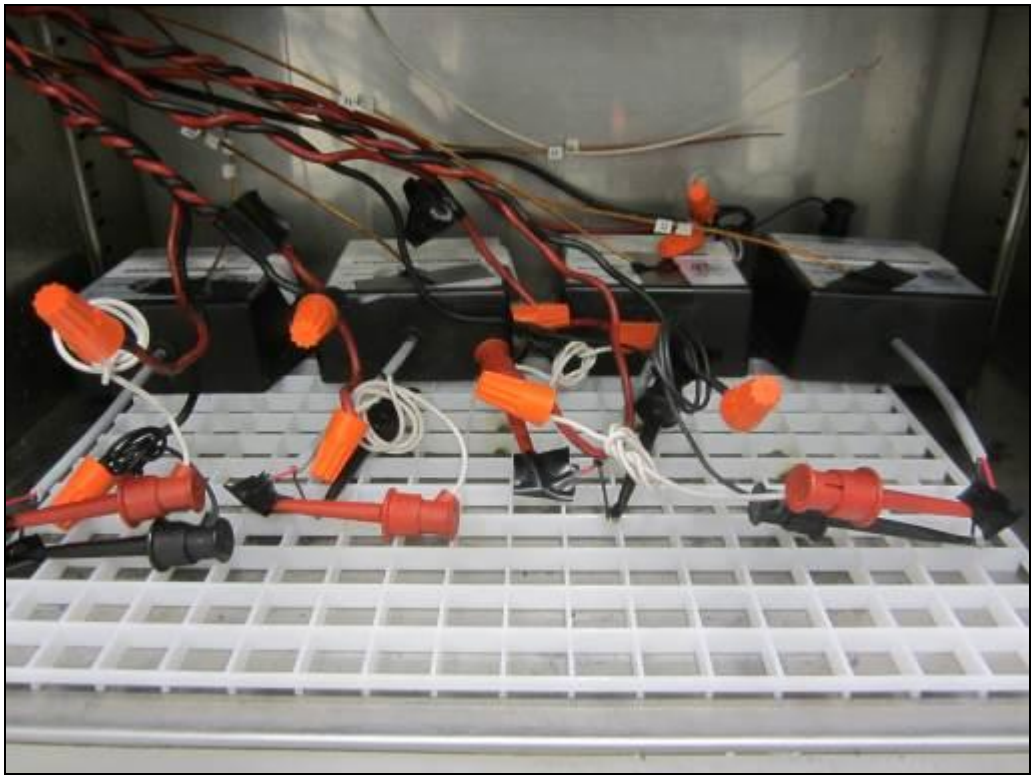
Photograph 9: Shock Test Setup – Lateral, Negative Direction

APPENDIX A – PHOTOGRAPHS (cont'd)
T4 – Shock Test

Photograph 10: Shock Test Setup – Vertical, Positive Direction

Photograph 11: Shock Test Setup – Vertical, Negative Direction

APPENDIX A – PHOTOGRAPHS (cont'd)
T5 – External Short Circuit



Photograph 12: External Short Circuit Test Setup

APPENDIX B – ALTITUDE SIMULATION GRAPH

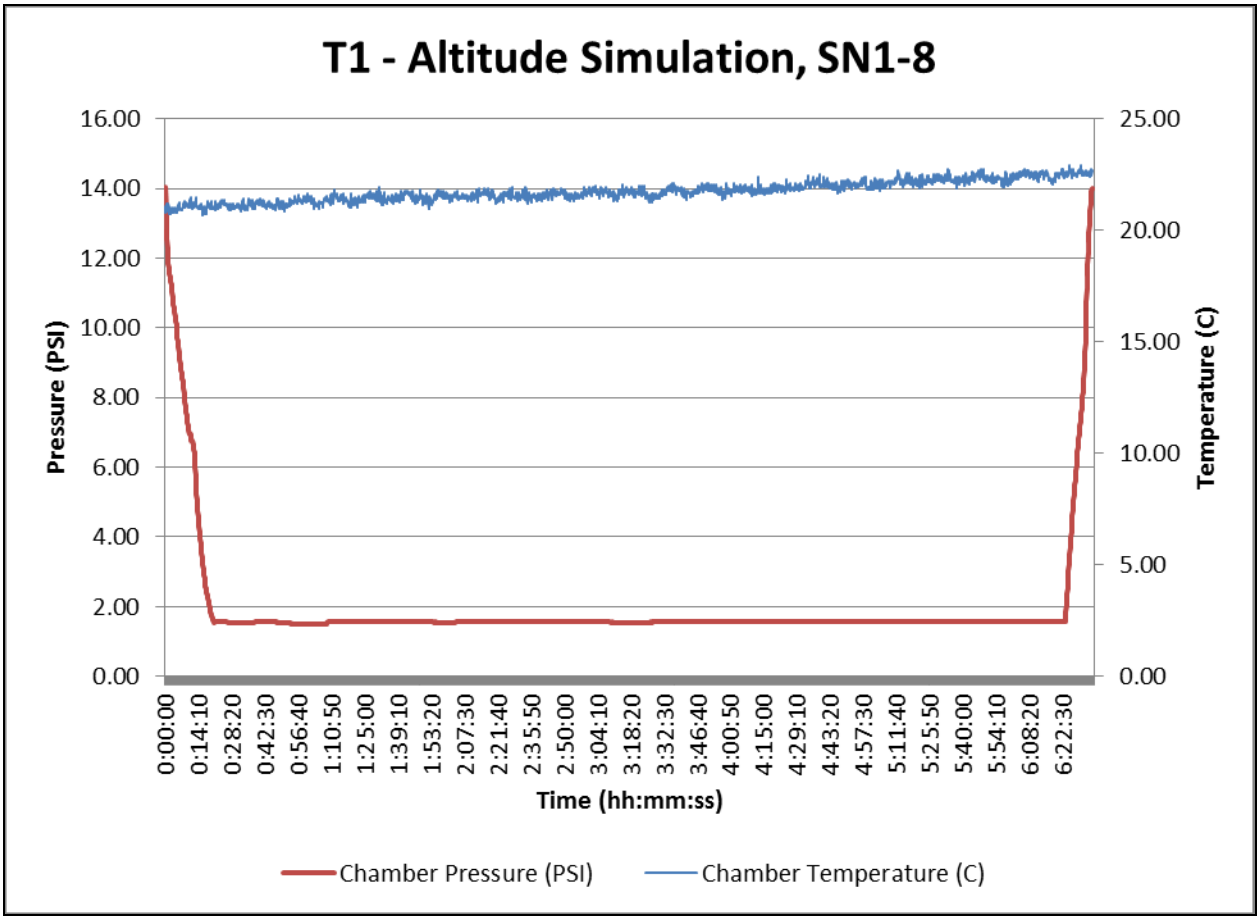


Figure 1: Altitude Simulation Graph; SN 1 – 8

APPENDIX C – THERMAL TEST GRAPH

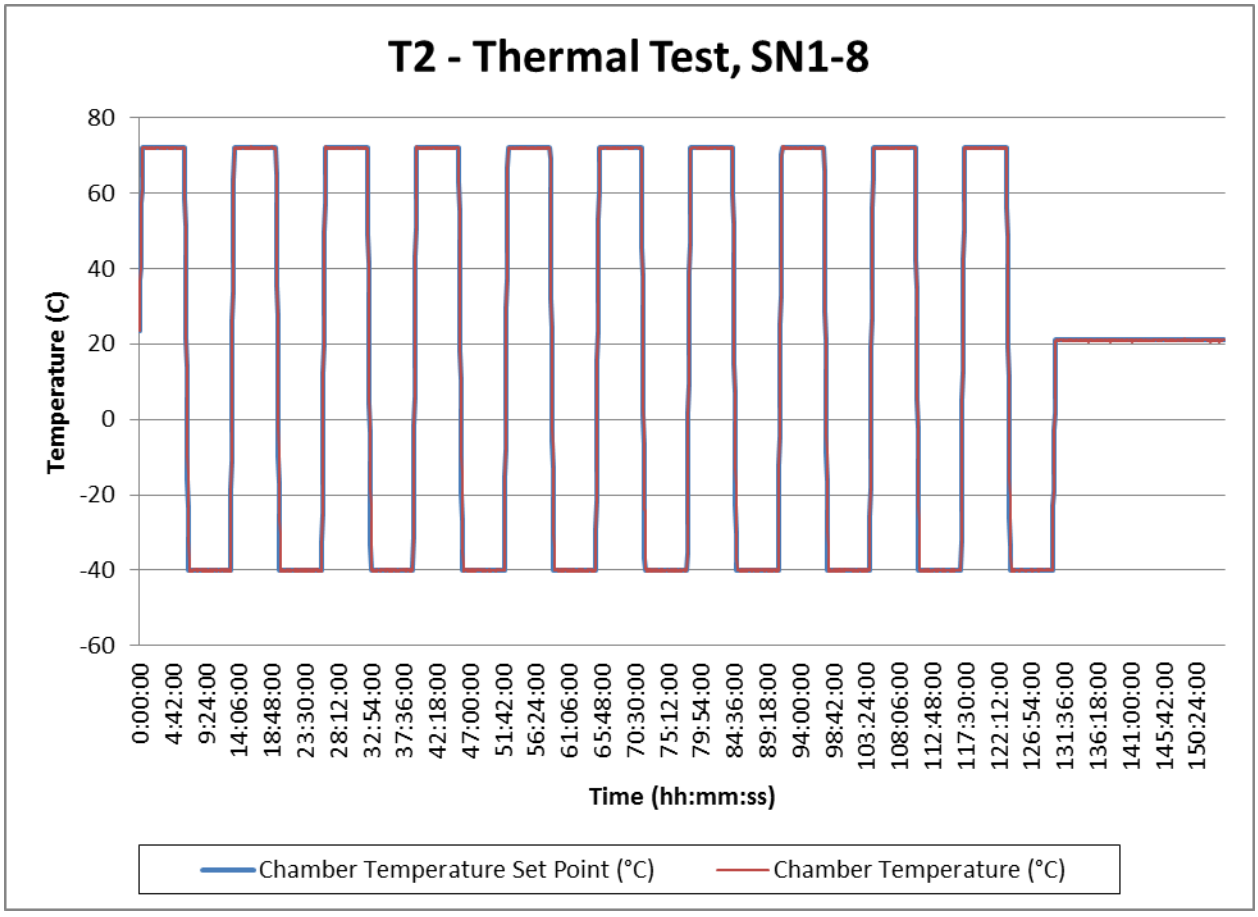


Figure 2: Thermal Test Graph; SN 1 – 8

APPENDIX D – VIBRATION PLOTS

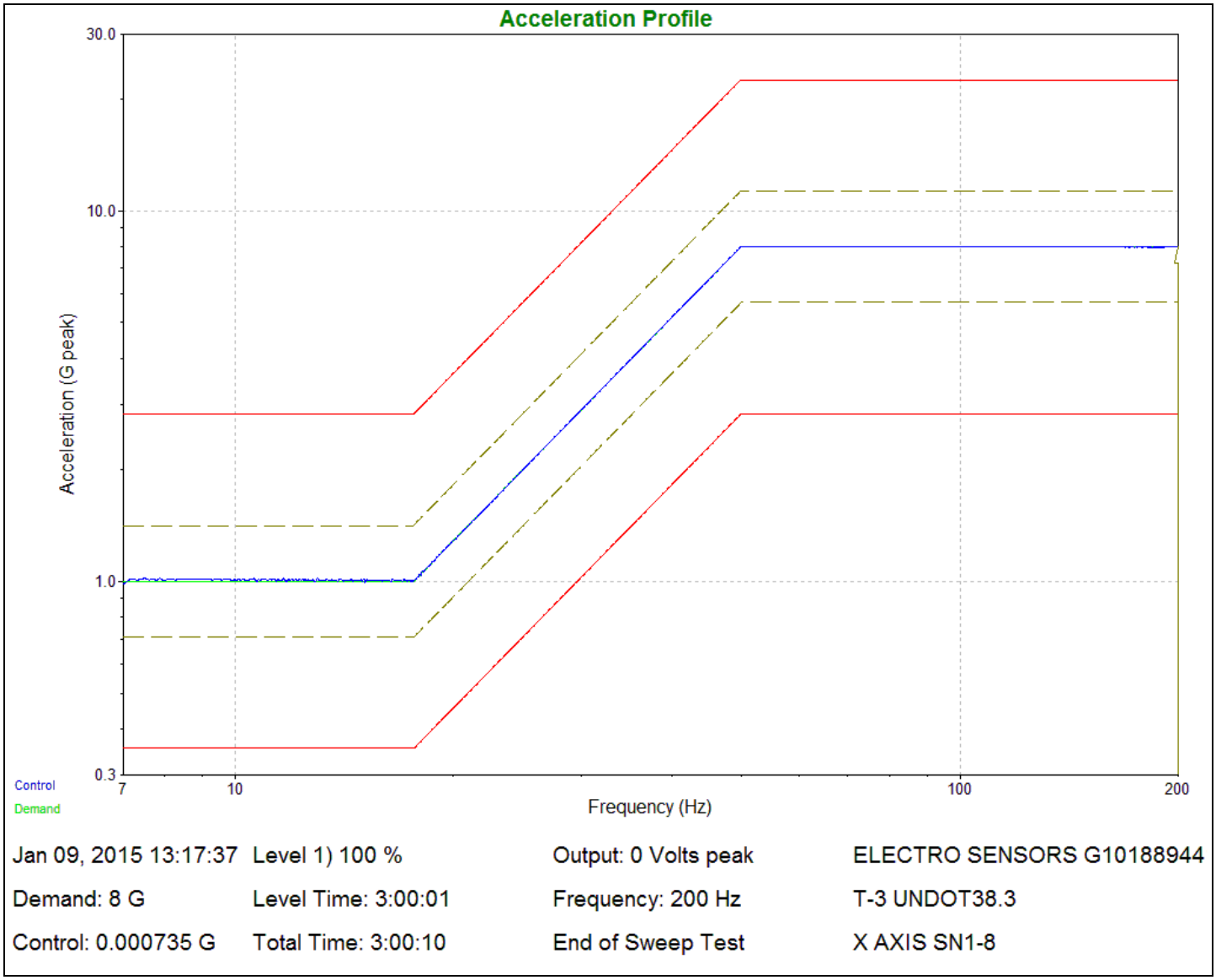


Figure 3: Vibration Plot – Fore/Aft Direction; SN 1 – 8

APPENDIX D –VIBRATION PLOTS (cont'd)

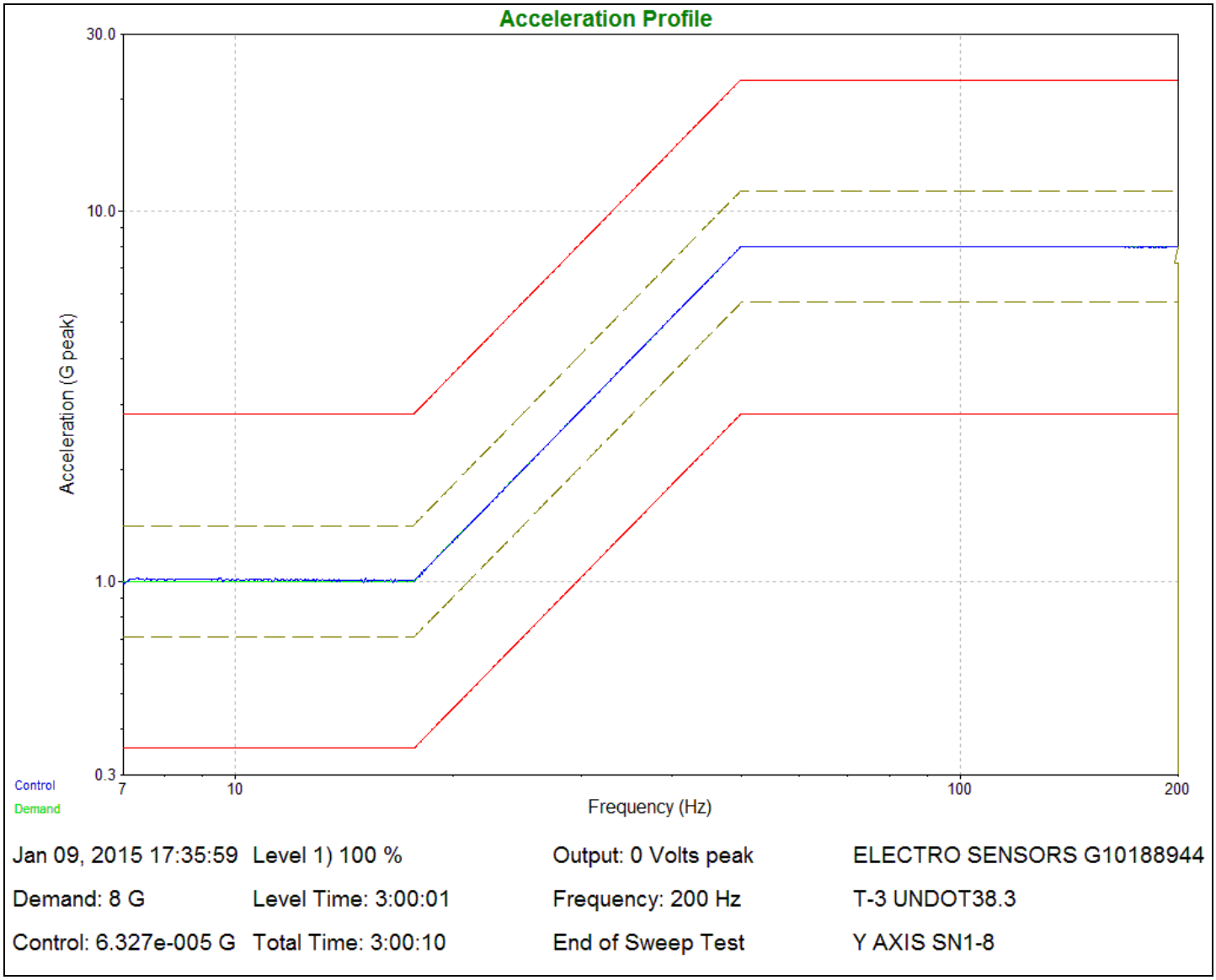


Figure 4: Vibration Plot – Lateral Direction; SN 1 – 8

APPENDIX D –VIBRATION PLOTS (cont'd)

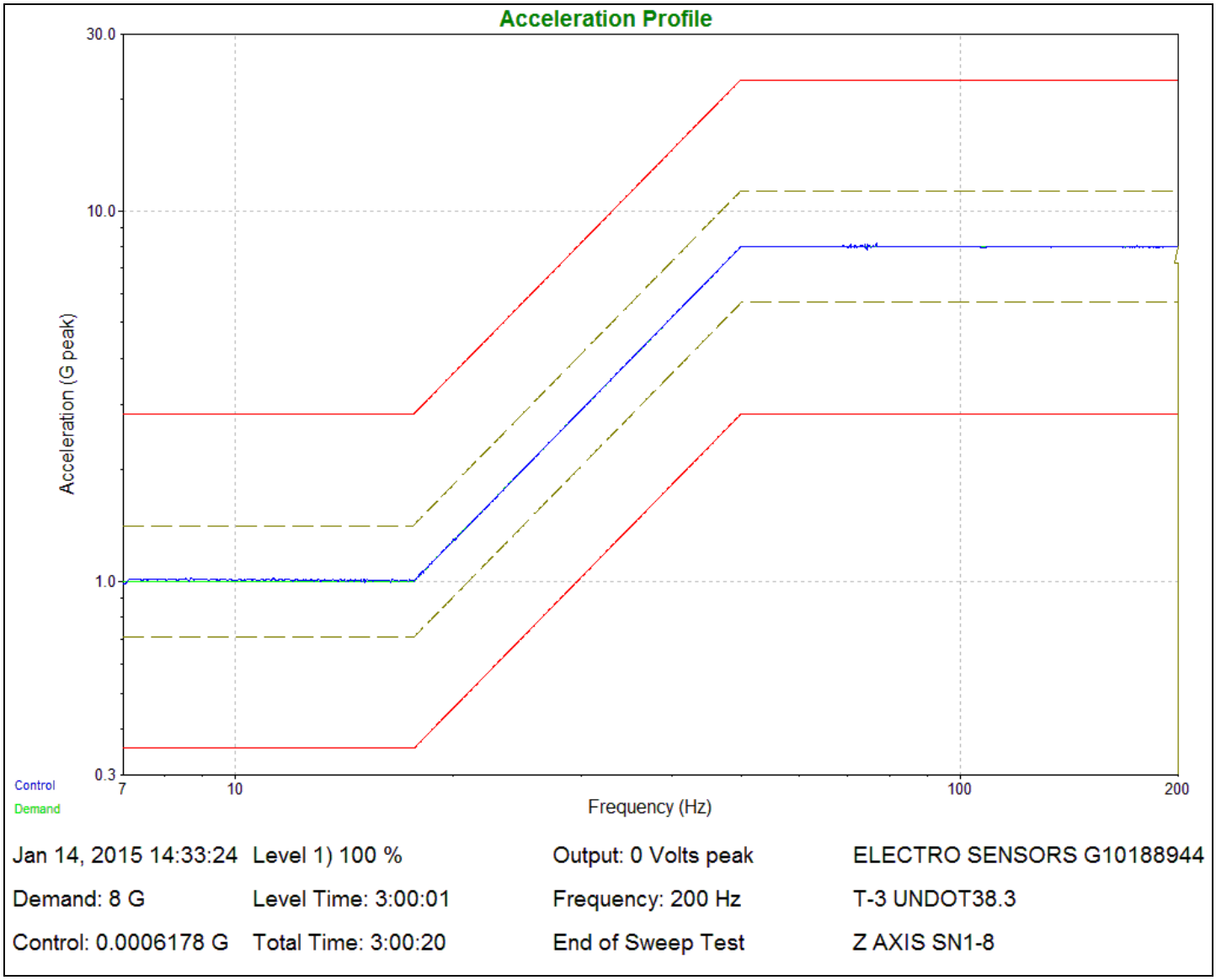


Figure 5: Vibration Plot – Vertical Direction; SN 1 – 8

APPENDIX E – MECHANICAL SHOCK PLOTS

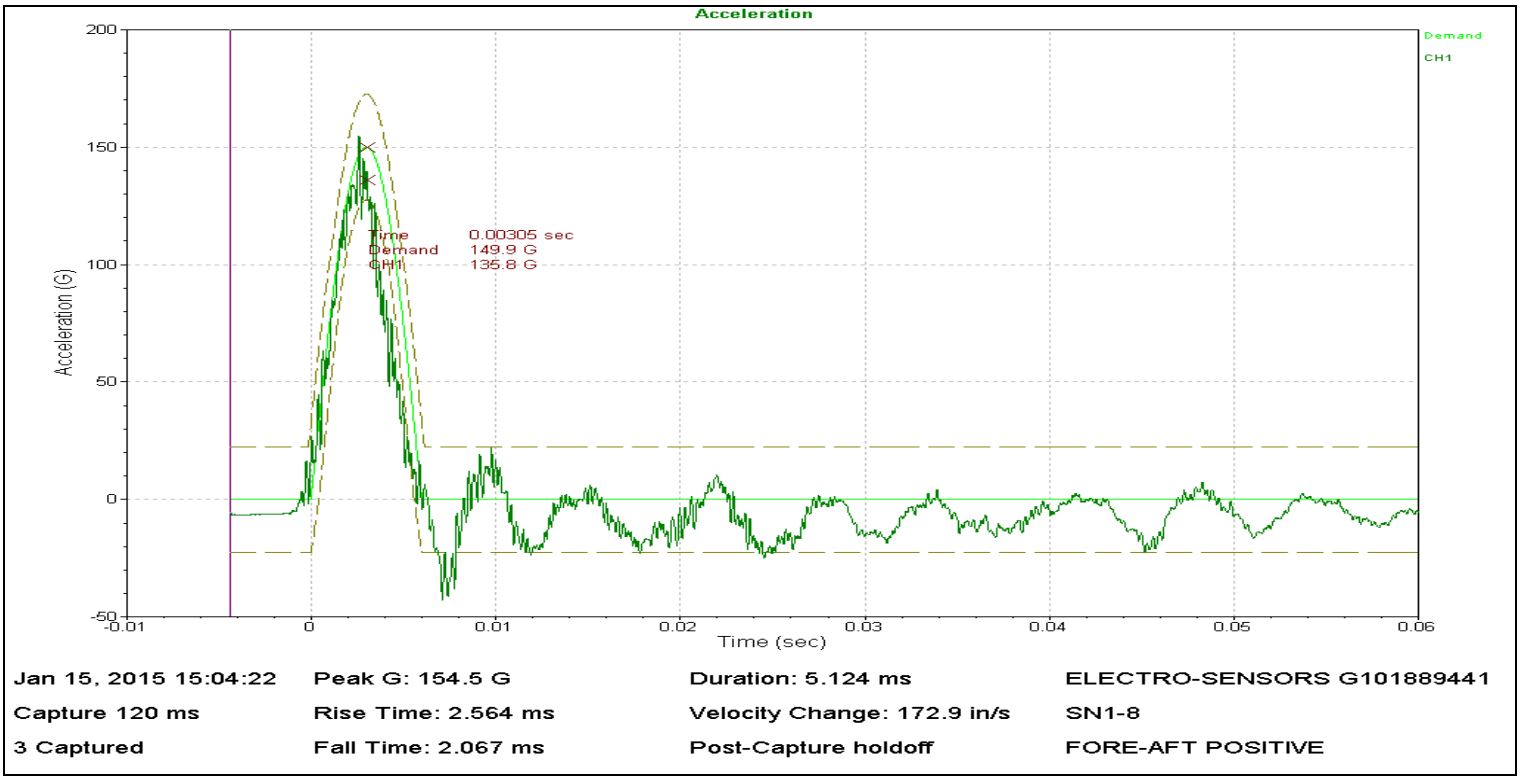


Figure 6: Shock Plot –Fore/Aft, Positive Direction; SN 1 – 8

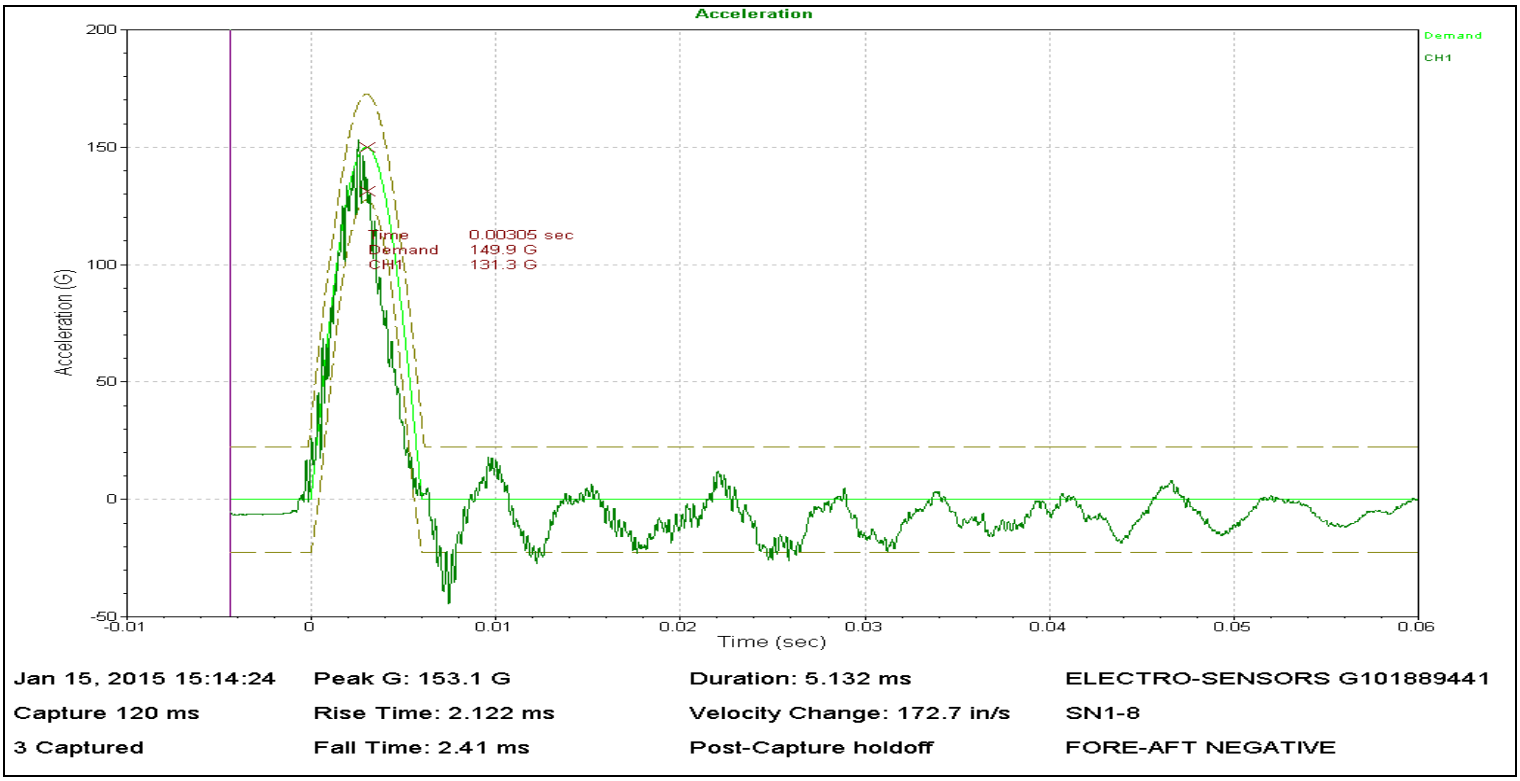


Figure 7: Shock Plot –Fore/Aft, Negative Direction; SN 1 – 8

APPENDIX E – MECHANICAL SHOCK PLOTS (cont'd)

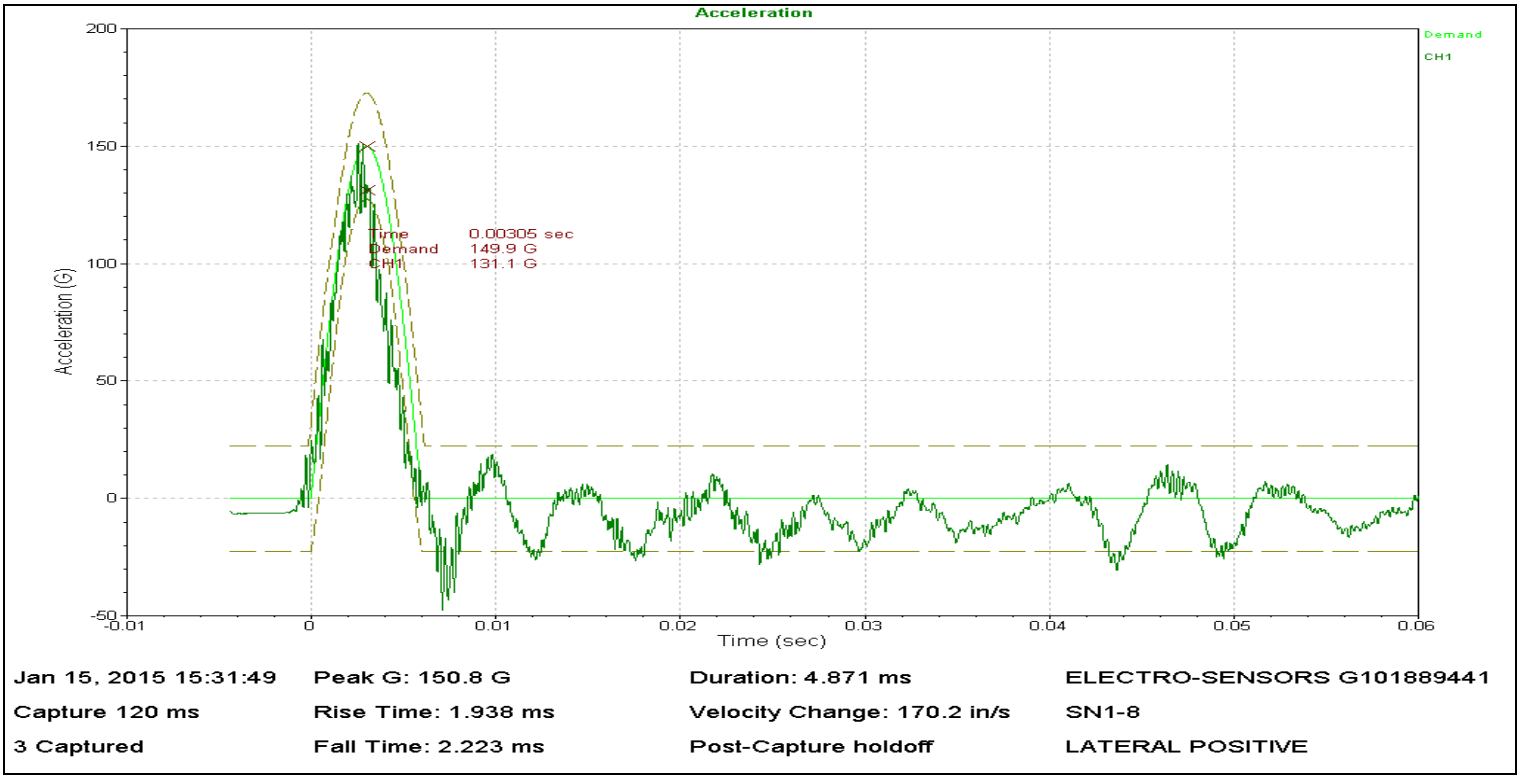


Figure 8: Shock Plot – Lateral, Positive Direction; SN 1 – 8

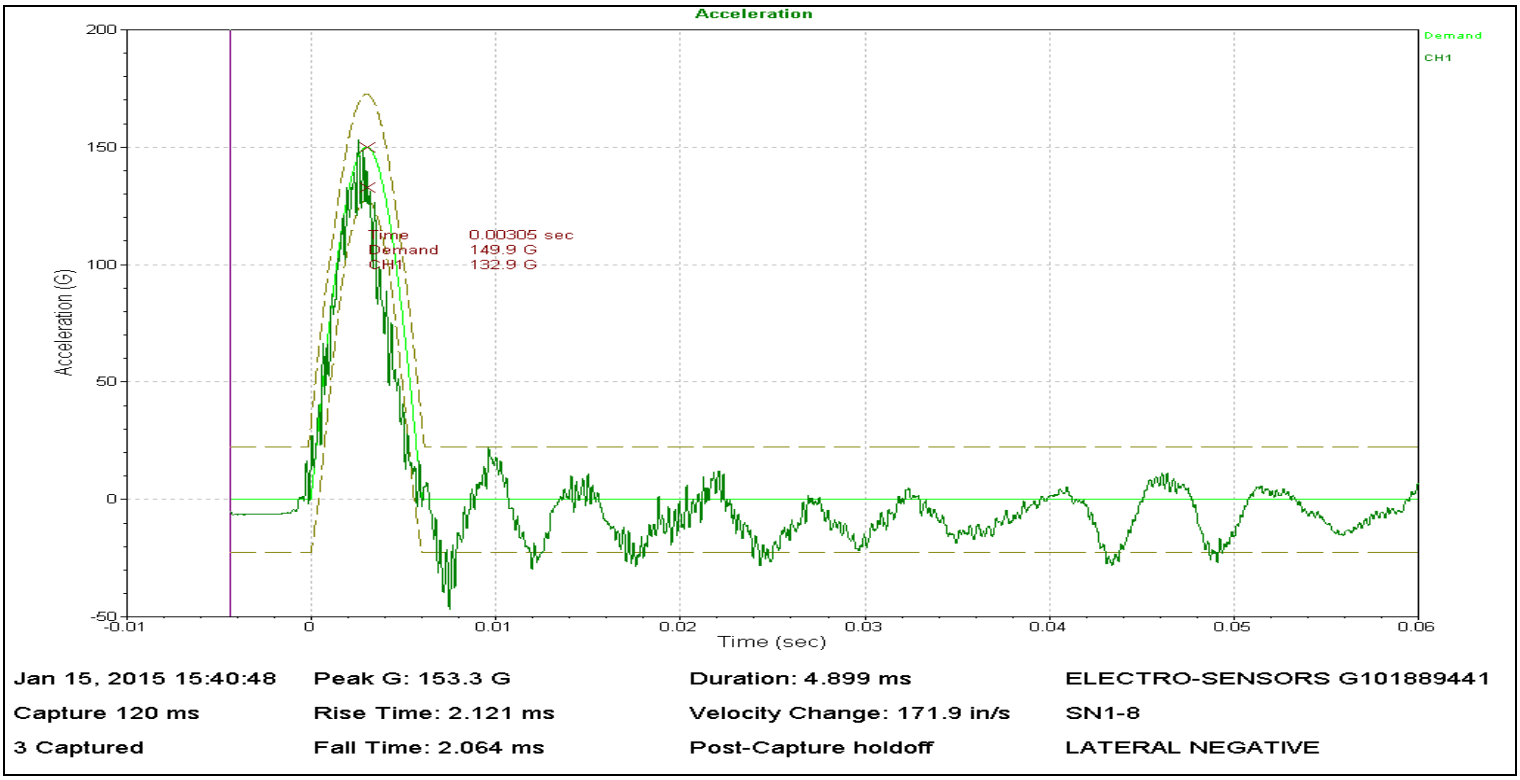


Figure 9: Shock Plot – Lateral, Negative Direction; SN 1 – 8

APPENDIX E – MECHANICAL SHOCK PLOTS (cont'd)

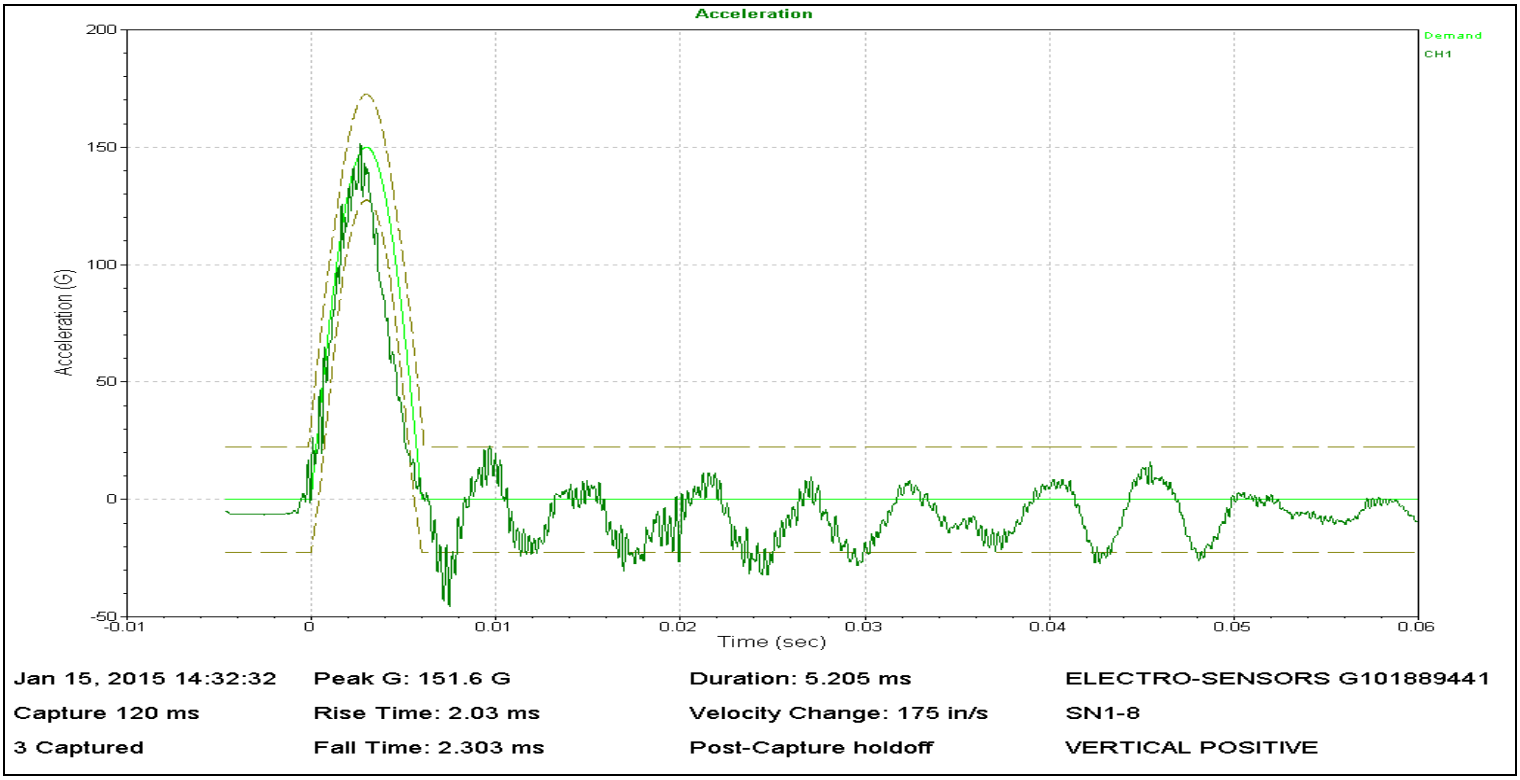


Figure 10: Shock Plot – Vertical, Positive Direction; SN 1 – 8

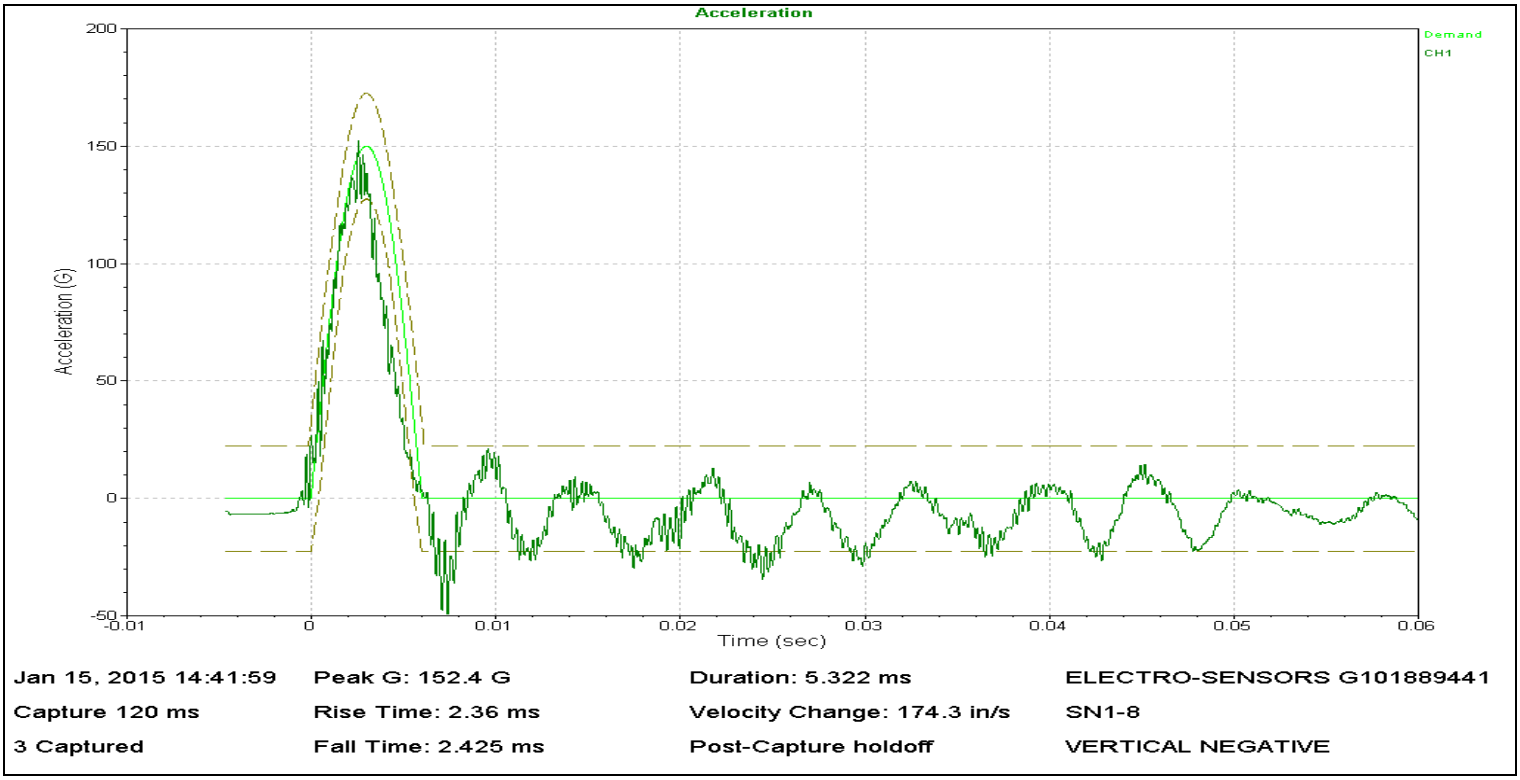


Figure 11: Shock Plot – Vertical, Negative Direction; SN 1 – 8

APPENDIX F – EXTERNAL SHORT CIRCUIT GRAPHS

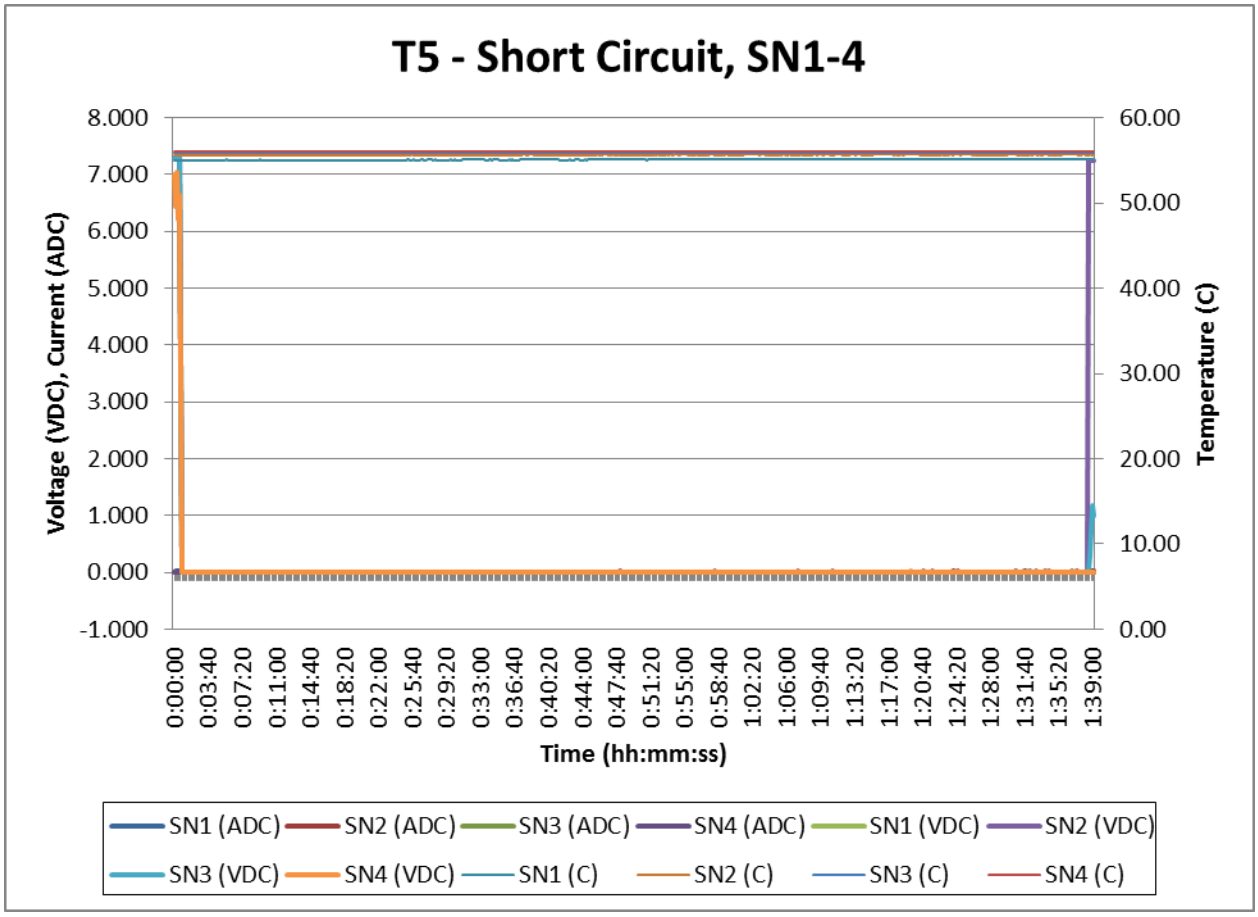


Figure 12: External Short Circuit Graph – Voltage / Temperature vs. Time, SN 1 – 4

APPENDIX F – EXTERNAL SHORT CIRCUIT GRAPHS (cont'd)

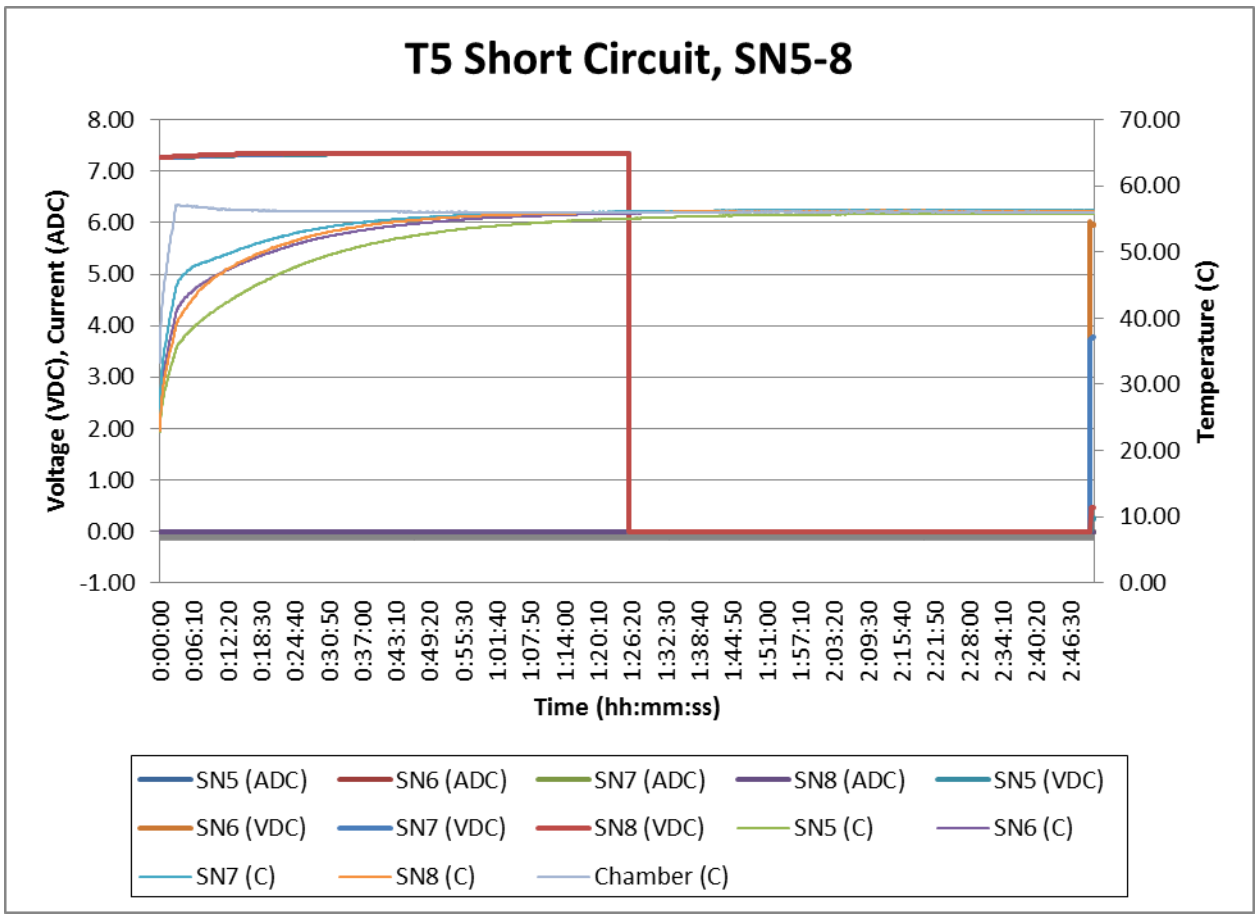


Figure 13: External Short Circuit Graph – Voltage / Temperature vs. Time, SN 5 – 8