



DLS CONFORMITY ASSESSMENT, INC
200 E. Marquardt Drive
Wheeling, IL 60090 USA
Voice 847-537-6400
Fax 847-947-8651
www.dlsemc.com

ENVIRONMENTAL TEST REPORT

ATOM and ION

Test Conducted For:
Jordan Heintz
Churchill Navigation
5660 Airport Blvd #101
Boulder, CO 80301

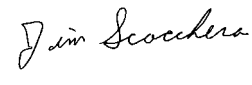
PROJECT #:	16CA131
DATE TESTING STARTED:	03/17/2017
DATE TESTING COMPLETED:	08/04/2017
EUT(s) SUBMITTED:	Quantity: Three (3) ATOM and Four (4) ION EUT's ATOM – Model 1.1 Mission Computer ION – Model 1.7 Cockpit Video Recorder Serial Numbers: ATOM – 160020, 160021, 160055 ION – 110098, 110100, 110101, 110129

Prepared by: Thomas Komorowski
Mark A. Haynes

Signature: 

Mark A. Haynes

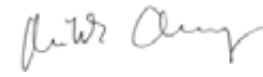
Reviewed By: Jim Scocchera

Signature: 

Tests Conducted By: Mark A. Haynes

Signature: *Mark A. Haynes*

Approved By: Mitch Gaudyn

Signature: 

Date: 09/18/2017

Revision Level: Initial

NOTICE: "This test report relates only to the items tested and must not be used by the client to claim product endorsement by D.L.S. Conformity Assessment, Inc. or any agency of the U.S. Government"

COPYRIGHT NOTICE: This report must not be reproduced (except in full) without the approval of D.L.S. Conformity Assessment, Inc. © Copyright 1983-2017 D.L.S. Conformity Assessment, Inc.



Table of Contents

REFERENCE DOCUMENTS	8
INTRODUCTION.....	8
TEST FACILITY.....	8
TEST ITEMS	8
TEST RESULTS SUMMARY	9
GROUND SURVIVAL LOW & SHORT TIME OPERATING LOW TEMPERATURE TESTS.....	12
TEST DATE	12
EQUIPMENT UNDER TEST (EUT).....	12
TEST SPECIFICATION.....	12
REQUIREMENTS.....	12
PROCEDURE.....	12
TEST RESULTS	13
EQUIPMENT USED	13
PHOTOS	14
Test Title.....	14
EUT's in Environmental Test Chamber.....	15
EUT's in Environmental Test Chamber – Close Up	16
TEST DATA	17
Ground Survival Low and Short Time Operating Low Temperature Test Profile	17
OPERATING LOW TEMPERATURE TEST.....	18
TEST DATE	18
EQUIPMENT UNDER TEST (EUT).....	18
TEST SPECIFICATION.....	18
REQUIREMENTS.....	18
PROCEDURE.....	18
TEST RESULTS	19
EQUIPMENT USED	19
PHOTOS	20
(See Ground Survival Low Photos for Setup).....	20
TEST DATA	21
Operating Low Temperature Test Profile	21
GROUND SURVIVAL HIGH & SHORT TIME OPERATING HIGH TEMPERATURE TESTS	22
TEST DATE	22
EQUIPMENT UNDER TEST (EUT).....	22
TEST SPECIFICATION.....	22
REQUIREMENTS.....	22
PROCEDURE.....	22
TEST RESULTS	23
EQUIPMENT USED	23
PHOTOS	24
(See Ground Survival Low Photos for Setup).....	24
TEST DATA	25
Ground Survival High and Short Time Operating High Temperature Test Profile	25



OPERATING HIGH TEMPERATURE TEST	26
TEST DATE	26
EQUIPMENT UNDER TEST (EUT).....	26
TEST SPECIFICATION.....	26
REQUIREMENTS.....	26
PROCEDURE.....	26
TEST RESULTS.....	27
EQUIPMENT USED	27
PHOTOS	28
(See Ground Survival Low Photos for Setup).....	28
TEST DATA	29
Operating High Temperature Test Profile.....	29
TEMPERATURE VARIATION TEST	30
TEST DATES	30
EQUIPMENT UNDER TEST (EUT).....	30
TEST SPECIFICATION.....	30
REQUIREMENTS.....	30
PROCEDURE.....	30
TEST RESULTS	31
EQUIPMENT USED	31
PHOTOS	32
(See Ground Survival Low Photos for Setup).....	32
TEST DATA	33
Temperature Variation Test - Cycle 1.....	33
Temperature Variation Test - Cycle 2.....	34
ALTITUDE TEST	35
TEST DATE	35
EQUIPMENT UNDER TEST (EUT).....	35
TEST SPECIFICATION.....	35
REQUIREMENTS.....	35
PROCEDURE.....	35
TEST RESULTS	36
EQUIPMENT USED	36
PHOTOS	37
Test Title.....	37
EUT's in Altitude Chamber	38
EUT's in Altitude Chamber – Close Up	39
TEST DATA	40
Altitude Test Profile.....	40
DECOMPRESSION TEST	41
TEST DATE	41
EQUIPMENT UNDER TEST (EUT).....	41
TEST SPECIFICATION.....	41
REQUIREMENTS.....	41
PROCEDURE.....	41
TEST RESULTS	42
EQUIPMENT USED	42



PHOTOS	43
Test Title	43
EUT's in Pressure Chamber	44
EUT's in Pressure Chamber – Close Up	44
TEST DATA	45
EUT's at 8,000 Ft.	45
EUT's at 45,000 Ft.	45
Decompression Test Profile	46
OVERPRESSURE TEST	47
TEST DATE	47
EQUIPMENT UNDER TEST (EUT)	47
TEST SPECIFICATION	47
REQUIREMENTS	47
PROCEDURE	47
TEST RESULTS	47
EQUIPMENT USED	48
PHOTOS	49
Test Title	49
Overpressure Test Setup	50
TEST DATA	51
Overpressure Test Measurement	51
HUMIDITY TEST	52
TEST DATES	52
EQUIPMENT UNDER TEST (EUT)	52
TEST SPECIFICATION	52
REQUIREMENTS	52
PROCEDURE	52
TEST RESULTS	53
EQUIPMENT USED	53
PHOTOS	54
Test Title	54
Humidity Chamber	55
EUT's In Humidity Chamber	56
TEST DATA	57
Humidity Test Data 03/20/2017 – 03/22/2017	57
VIBRATION TESTS	58
TEST DATES	58
EQUIPMENT UNDER TEST (EUT)	58
TEST SPECIFICATION(s)	58
REQUIREMENTS	58
PROCEDURE	59
TEST RESULTS	59
EQUIPMENT USED	59
REPRESENTATIVE PHOTOS	61
Vibration in X Axis	61
Vibration in Y Axis	62
Vibration in Z Axis	63
Accelerometer Locations in X Axis – Part 1	64

Accelerometer Locations in X Axis – Part 2.....	65
Accelerometer Locations in Y Axis – Part 1.....	66
Accelerometer Locations in Y Axis – Part 2.....	67
Accelerometer Locations in Z Axis	68
TEST DATA	69
X-AXIS	69
Category S, Curve B Pre Sine Resonance Sweep in X Axis.....	69
Category S, Curve B Vibration in X Axis.....	70
Category S, Curve B Post Sine Resonance Sweep in X Axis	71
Category S, Curve C Pre Sine Resonance Sweep in X Axis	72
Category S, Curve C Vibration in X Axis.....	73
Category S, Curve C Post Sine Resonance Sweep in X Axis	74
Category S, Curve L Vibration in X Axis.....	75
Category S, Curve M Vibration in X Axis	76
Category R, Curve B Pre Sine Vibration in X Axis	77
Category R, Curve B Vibration in X Axis	78
Category R, Curve B1 Vibration in X Axis	79
Category R, Curve B Post Sine Vibration in X Axis	80
Category U2, Pre Curve F Vibration in X Axis	81
Category U2, Curve F1 Vibration in X Axis.....	82
Category U2, Post Curve F Vibration in X Axis.....	83
Y AXIS.....	84
Category S, Curve B Pre Sine Vibration in Y Axis	84
Category S, Curve B Vibration in Y Axis.....	85
Category S, Curve B Post Sine Vibration in Y Axis.....	86
Category S, Curve C Pre Sine Vibration in Y Axis	87
Category S, Curve C Vibration in Y Axis.....	88
Category S, Curve C Post Sine Vibration in Y Axis.....	89
Category S, Curve L Vibration in Y Axis.....	90
Category S, Curve M Vibration in Y Axis.....	91
Category R, Curve B Pre Sine Vibration in Y Axis	92
Category R, Curve B Vibration in Y Axis	93
Category R, Curve B1 Vibration in Y Axis	94
Category R, Curve B Post Sine Vibration in Y Axis	95
Category U2, Pre Curve F Vibration in Y Axis	96
Category U2, Curve F1 Vibration in Y Axis.....	97
Category U2, Post Curve F Vibration in Y Axis.....	98
Z AXIS	99
Category S, Curve B Pre Sine Vibration in Z Axis	99
Category S, Curve B Vibration in Z Axis.....	100
Category S, Curve B Post Sine Vibration in Z Axis	101
Category S, Curve C Pre Sine Vibration in Z Axis	102
Category S, Curve C Vibration in Z Axis.....	103
Category S, Curve C Post Sine Vibration in Z Axis	104
Category S, Curve L Vibration in Z Axis	105
Category S, Curve M Vibration in Z Axis	106
Category R, Curve B Pre Sine Vibration in Z Axis	107
Category R, Curve B Vibration in Z Axis.....	108
Category R, Curve B1 Vibration in Z Axis.....	109
Category R, Curve B Post Sine Vibration in Z Axis.....	110
Category U2, Pre Curve F Vibration in Z Axis.....	111
Category U2, Curve F1 Vibration in Z Axis.....	112
Category U2, Post Curve F Vibration in Z Axis	113
OPERATIONAL SHOCK TEST	114

TEST DATES	114
EQUIPMENT UNDER TEST (EUT).....	114
TEST SPECIFICATION.....	114
REQUIREMENTS.....	114
PROCEDURE.....	114
TEST RESULTS.....	115
EQUIPMENT USED	115
PHOTOS	116
(See Vibration Photos for Setup and Test Orientations)	116
TEST DATA	117
1st Positive 6 g 11 msec Operating Shock Pulse in X Axis	117
2nd Positive 6 g 11 msec Operating Shock Pulse in X Axis	118
3rd Positive 6 g 11 msec Operating Shock Pulse in X Axis.....	119
1st Negative 6 g 11 msec Operating Shock Pulse in X Axis.....	120
2nd Negative 6 g 11 msec Operating Shock Pulse in X Axis	121
3rd Negative 6 g 11 msec Operating Shock Pulse in X Axis	122
1st Positive 6 g 11 msec Operating Shock Pulse in Y Axis	123
2nd Positive 6 g 11 msec Operating Shock Pulse in Y Axis	124
3rd Positive 6 g 11 msec Operating Shock Pulse in Y Axis.....	125
1st Negative 6 g 11 msec Operating Shock Pulse in Y Axis.....	126
2nd Negative 6 g 11 msec Operating Shock Pulse in Y Axis	127
3rd Negative 6 g 11 msec Operating Shock Pulse in Y Axis	128
1st Positive 6 g 11 msec Operating Shock Pulse in Z Axis.....	129
2nd Positive 6 g 11 msec Operating Shock Pulse in Z Axis	130
3rd Positive 6 g 11 msec Operating Shock Pulse in Z Axis	131
1st Negative 6 g 11 msec Operating Shock Pulse in Z Axis	132
2nd Negative 6 g 11 msec Operating Shock Pulse in Z Axis.....	133
3rd Negative 6 g 11 msec Operating Shock Pulse in Z Axis.....	134
CRASH SAFETY (IMPULSE) TEST	135
TEST DATES	135
EQUIPMENT UNDER TEST (EUT).....	135
TEST SPECIFICATION.....	135
REQUIREMENTS.....	135
PROCEDURE.....	135
TEST RESULTS.....	136
EQUIPMENT USED	136
PHOTOS	137
(See Vibration Photos for Setup and Test Orientations)	137
TEST DATA	138
Positive 20 g 11 msec Crash Safety Impulse in X Axis	138
Negative 20 g 11 msec Crash Safety Impulse in X axis.....	139
Positive 20 g 11 msec Crash Safety Impulse in Y Axis.....	140
Negative 20 g 11 msec Crash Safety Impulse in Y Axis.....	141
Positive 20 g 11 msec Crash Safety Impulse in Z Axis.....	142
Negative 20 g 11 msec Crash Safety Impulse in Z Axis	143
CRASH SAFETY (SUSTAINED) TEST	144
TEST DATE	144
EQUIPMENT UNDER TEST (EUT).....	144
TEST SPECIFICATION.....	144
REQUIREMENTS.....	144



DLS CONFORMITY ASSESSMENT, INC
200 E. Marquardt Drive
Wheeling, IL 60090 USA
Voice 847-537-6400
Fax 847-947-8651
www.dlsemc.com

PROCEDURE.....	144
TEST RESULTS.....	145
EQUIPMENT USED	145
PHOTOS	146
EUT's in Axis 1 (Forward)	146
EUT's in Axis 2 (Right).....	147
EUT's in Axis 3 (Aft)	148
EUT's in Axis 4 (Left).....	149
EUT's in Axis 5 (Down).....	150
EUT's in Axis 6 (Up).....	151
TEST DATA	152
20 g's in Axis 1 (Forward).....	152
20 g's in Axis 2 (Right)	153
20 g's in Axis 3 (Aft).....	154
20 g's in Axis 4 (Left).....	155
20 g's in Axis 5 (Down).....	156
20 g's in Axis 6 (Up)	157
EXPLOSIVE ATMOSPHERE TEST	158
TEST DATE	158
EQUIPMENT UNDER TEST (EUT).....	158
TEST SPECIFICATION.....	158
REQUIREMENTS.....	158
PROCEDURE.....	158
TEST RESULTS.....	159
EQUIPMENT USED	159
PHOTOS	160
EUT's in Chamber	160
Test Setup	161
TEST DATA	162
Explosive Atmosphere Test Profile	162
TEST ITEM DISPOSITION.....	163
PERSONNEL	163
REPORT DISTRIBUTION	163
REVISIONS TO REPORT	163



DLS CONFORMITY ASSESSMENT, INC
200 E. Marquardt Drive
Wheeling, IL 60090 USA
Voice 847-537-6400
Fax 847-947-8651
www.dlsemc.com

REFERENCE DOCUMENTS

- RTCA DO-160G, Environmental Conditions and Test Procedures for Airborne Equipment, hereafter referred to as RTCA DO-160G

INTRODUCTION

Churchill Navigation contracted test services for environmental testing with DLS CA. This report documents the preparations, set-up and methods for testing of the EUT's (Equipment Under Test) described in the table below.

Testing was performed between 03/17/2017 and 08/04/2017. The tests that were performed are listed in the table below. All testing was performed at and under the control of DLS Conformity Assessment, Inc., 200 E. Marquardt Drive, Wheeling, IL 60090. DLS is an ISO/IEC 17025:2005 accredited test lab.

TEST FACILITY

Testing was performed by DLS CA at its laboratory facility located at 200 E. Marquardt Drive, Wheeling, IL 60090.

TEST ITEMS

DLS CA received the EUT's described in the Test Results Summary table, starting on or before 03/17/2017. Each EUT was examined visually prior to testing and was found to have no visible defects.

TEST RESULTS SUMMARY

Test Name	EUT	Test Summary	Test Result
Ground Survival Low & Short Time Operating Low Temperature	Quantity: One (1) Model: ION SN: 110100 Quantity: One (1) Model: ATOM SN: 160020	RTCA DO-160G, Section 4.5.1 Category A1	Conforms
Operating Low Temperature	Quantity: One (1) Model: ION SN: 110101 Quantity: One (1) Model: ATOM SN: 160020	RTCA DO-160G, Section 4.5.2 Category A1	Conforms
Ground Survival High & Short Time Operating High Temperature	Quantity: One (1) Model: ION SN: 110100 Quantity: One (1) Model: ATOM SN: 160020	RTCA DO-160G, Section 4.5.3 Category A1	Conforms
Operating High Temperature	Quantity: One (1) Model: ION SN: 110100 Quantity: One (1) Model: ATOM SN: 160020	RTCA DO-160G, Section 4.5.4 Category A1	Conforms
Temperature Variation	Quantity: One (1) Model: ION SN: 110100 Quantity: One (1) Model: ATOM SN: 160020	RTCA DO-160G, Section 5.3.1 Category C	Conforms
Altitude	Quantity: One (1) Model: ION SN: 110101 Quantity: One (1) Model: ATOM SN: 160020	RTCA DO-160G, Section 4.6.1 Category A1	Conforms
Decompression	Quantity: One (1) Model: ION SN: 110101 Quantity: One (1) Model: ATOM SN: 160020	RTCA DO-160G, Section 4.6.2 Category A1	Conforms

Overpressure	Quantity: One (1) Model: ION SN: 110101 Quantity: One (1) Model: ATOM SN: 160020	RTCA DO-160G, Section 4.6.3 Category A1	Conforms
Humidity	Quantity: One (1) Model: ION SN: 110098 Quantity: One (1) Model: ATOM SN: 160021	RTCA DO-160G, Section 6.3.1 Category A	Conforms
Vibration	Quantity: One (1) Model: ION SN: 110129 Quantity: One (1) Model: ATOM SN: 160055	RTCA DO-160G, Section 8 Cat R – Curves B & B1 Cat S – Curves B, C, L & M Cat U2 – Curves F & F1	Conforms
Operational Shock	Quantity: One (1) Model: ION SN: 110129 Quantity: One (1) Model: ATOM SN: 160055	RTCA DO-160G, Section 7.2.1 Category B	Conforms
Crash Safety (Impulse)	Quantity: One (1) Model: ION SN: 110129 Quantity: One (1) Model: ATOM SN: 160055	RTCA DO-160G, Section 7.3.1 Category B	Conforms
Crash Safety (Sustained)	Quantity: One (1) Model: ION SN: 110129 Quantity: One (1) Model: ATOM SN: 160055	RTCA DO-160G, Section 7.3.3 Category B	Conforms
Explosive Atmosphere	Quantity: One (1) Model: ION SN: 110100 Quantity: One (1) Model: ATOM SN: 160020	RTCA DO-160G, Section 9.6.2 Category E	Conforms



DLS CONFORMITY ASSESSMENT, INC
200 E. Marquardt Drive
Wheeling, IL 60090 USA
Voice 847-537-6400
Fax 847-947-8651
www.dlsemc.com

TEST REQUIREMENTS – (Applicable Documents)

Testing of the EUT items were conducted in accordance to:

- 1) RTCA DO-160G

If applicable, the Customer provided data sheets and instructions for recording of operational testing throughout the testing.

- ☐ Yes (Customer provided documents - See Appendix A and B)
- ☒ No (No documents provided by Customer)

GROUND SURVIVAL LOW & SHORT TIME OPERATING LOW TEMPERATURE TESTS

TEST DATE

03/17/2017

EQUIPMENT UNDER TEST (EUT)

Quantity: One (1)

Model: ION

Serial Number: 110100

Quantity: One (1)

Model: ATOM

Serial Number: 160020

TEST SPECIFICATION

RTCA DO-160G, Section 4.5.1 Category A1

REQUIREMENTS

Each EUT shall undergo Ground Survival Low and Short Time Operating Low Temperature testing per RTCA DO-160G, Section 4.5.1 Category A1. There shall be no physical or electrical failures that prevent each EUT from being operated.

PROCEDURE

RTCA DO-160G, Section 4.5.1 Category A1

- 1) Place EUT's inside test chamber and place thermocouples to measure chamber and EUT surface temperatures.
- 2) Setup both EUT's and conduct the standard compliance check.
- 3) With each EUT not operating and at ambient pressure, stabilize the EUT temperature at the ground survival low temperature (-55°C) for 3 hours. Continue maintaining the test chamber air temperature at this temperature for a minimum of 3 additional hours.
- 4) With each EUT not operating, increase temperature to -40°C at a minimum rate of $2^{\circ}\text{C}/\text{minute}$.
- 5) Maintain each EUT at -40°C for at least 30 minutes.
- 6) At -40°C , operate and monitor each EUT for at least 30 additional minutes.
- 7) Remove power from each EUT and return the EUT temperature to room ambient conditions.
- 8) Examine both EUT's and record any physical abnormalities.
- 9) Conduct a post-test standard compliance check.



DLS CONFORMITY ASSESSMENT, INC
200 E. Marquardt Drive
Wheeling, IL 60090 USA
Voice 847-537-6400
Fax 847-947-8651
www.dlsemc.com

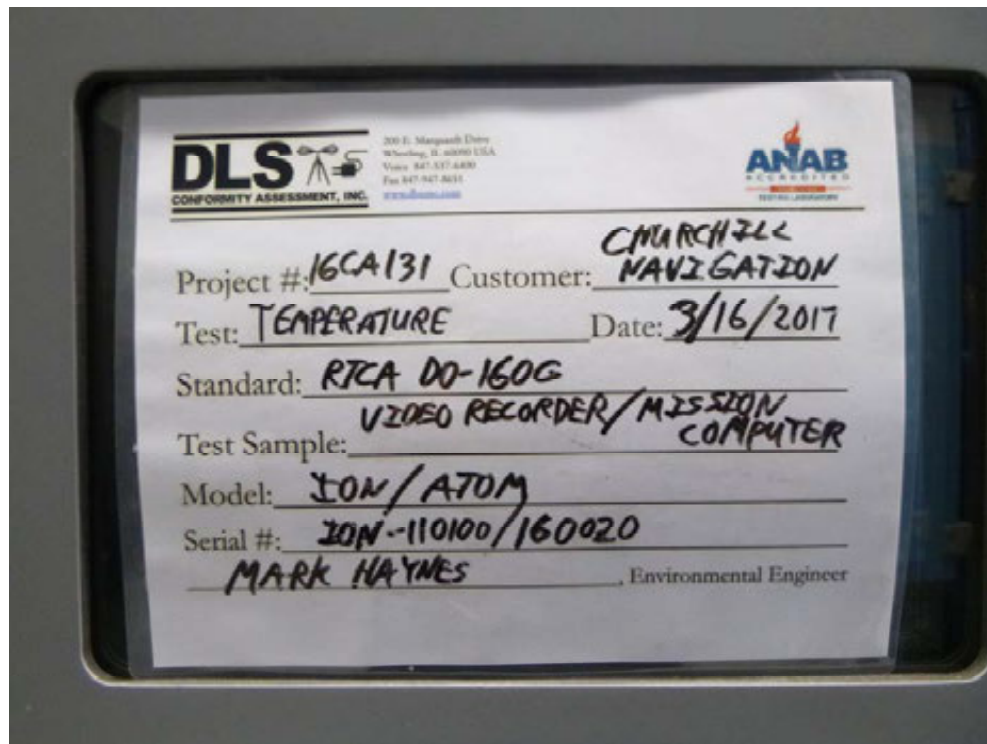
TEST RESULTS

Both units conformed to testing. No physical damage was noted to any unit. Each unit passed a post-performance test.

EQUIPMENT USED

Equipment	Manufacturer	DLS Lab Number	Model#	Date Calibrated	Calibration Due Date
Environmental Chamber	Test Equity	229	3007C	N/A	Verified w/Calibrated Data Acquisition Unit
Data Acquisition Unit	Agilent Technologies	223	34970A	12/27/2016	12/27/2017

PHOTOS



Test Title

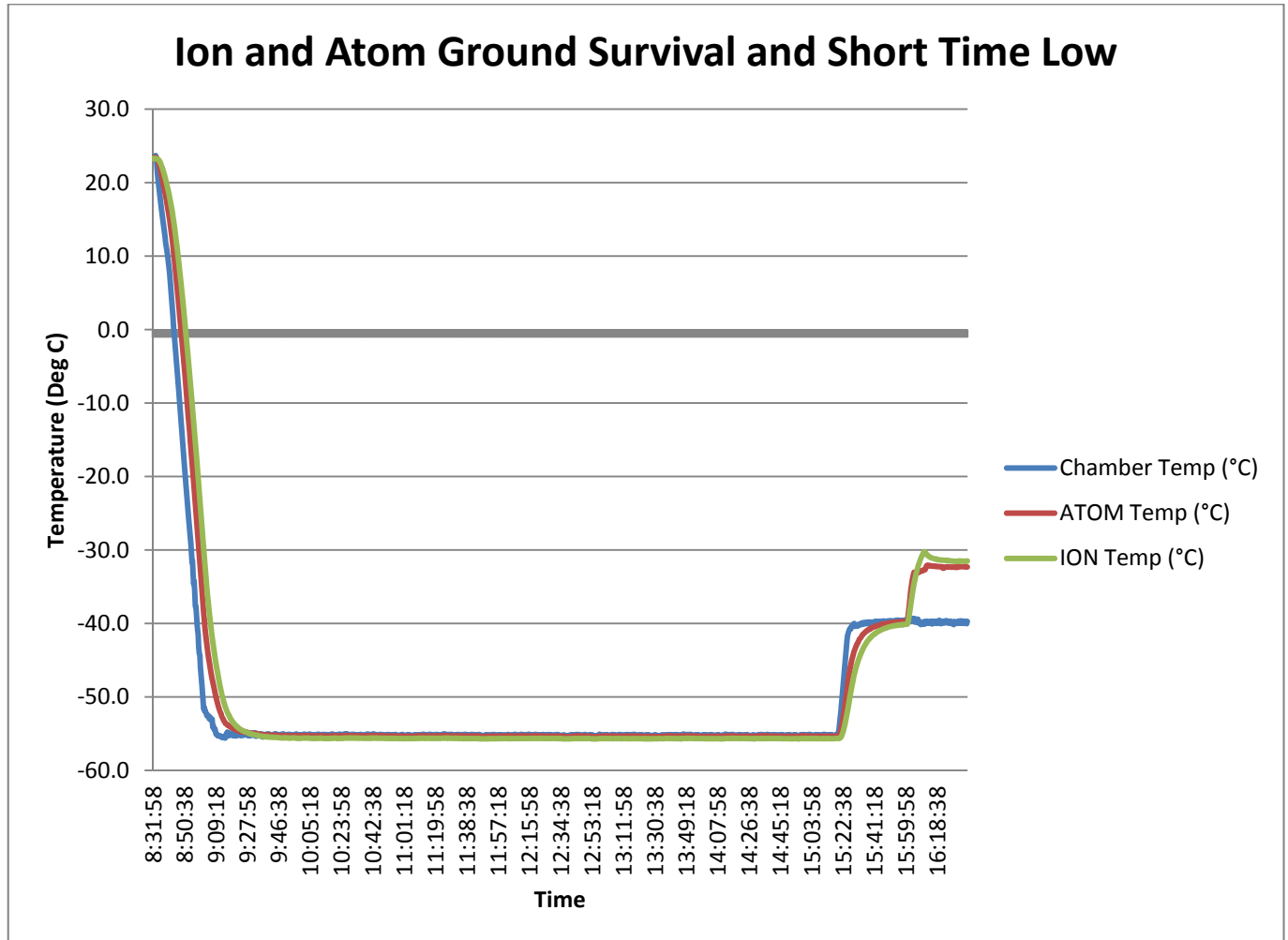


EUT's in Environmental Test Chamber



EUT's in Environmental Test Chamber – Close Up

TEST DATA



Ground Survival Low and Short Time Operating Low Temperature Test Profile



OPERATING LOW TEMPERATURE TEST

TEST DATE

03/30/2017

EQUIPMENT UNDER TEST (EUT)

Quantity: One (1)

Model: ION

Serial Number: 110101

Quantity: One (1)

Model: ATOM

Serial Number: 160020

TEST SPECIFICATION

RTCA DO-160G, Section 4.5.2 Category A1

REQUIREMENTS

Each EUT shall undergo Operating Low Temperature testing per RTCA DO-160G, Section 4.5.2 Category A1. There shall be no physical or electrical failures that prevent each EUT from being operated.

PROCEDURE

RTCA DO-160G, Section 4.5.2 Category A1

- 1) Place both EUT's inside the test chamber and place thermocouples to measure chamber and EUT surface temperatures.
- 2) With each EUT operating and at ambient pressure, stabilize the chamber temperature at the low operating temperature (-15°C) for 2 hours.
- 3) Continue maintaining the test chamber air temperature at -15°C for a minimum of 2 additional hours. During this time, monitor the performance for each EUT.
- 4) Remove power from each EUT and return the chamber temperature to room ambient conditions.
- 5) Examine each EUT and record any physical abnormalities.
- 6) Conduct a post-test standard compliance check.



DLS CONFORMITY ASSESSMENT, INC
200 E. Marquardt Drive
Wheeling, IL 60090 USA
Voice 847-537-6400
Fax 847-947-8651
www.dlsemc.com

TEST RESULTS

Both units conformed to testing. No physical damage was noted to any unit. Each unit passed a post-performance test.

EQUIPMENT USED

Equipment	Manufacturer	DLS Lab Number	Model#	Date Calibrated	Calibration Due Date
Environmental Chamber	Test Equity	229	3007C	N/A	Verified w/Calibrated Data Acquisition Unit
Data Acquisition Unit	Agilent Technologies	223	34970A	12/27/2016	12/27/2017

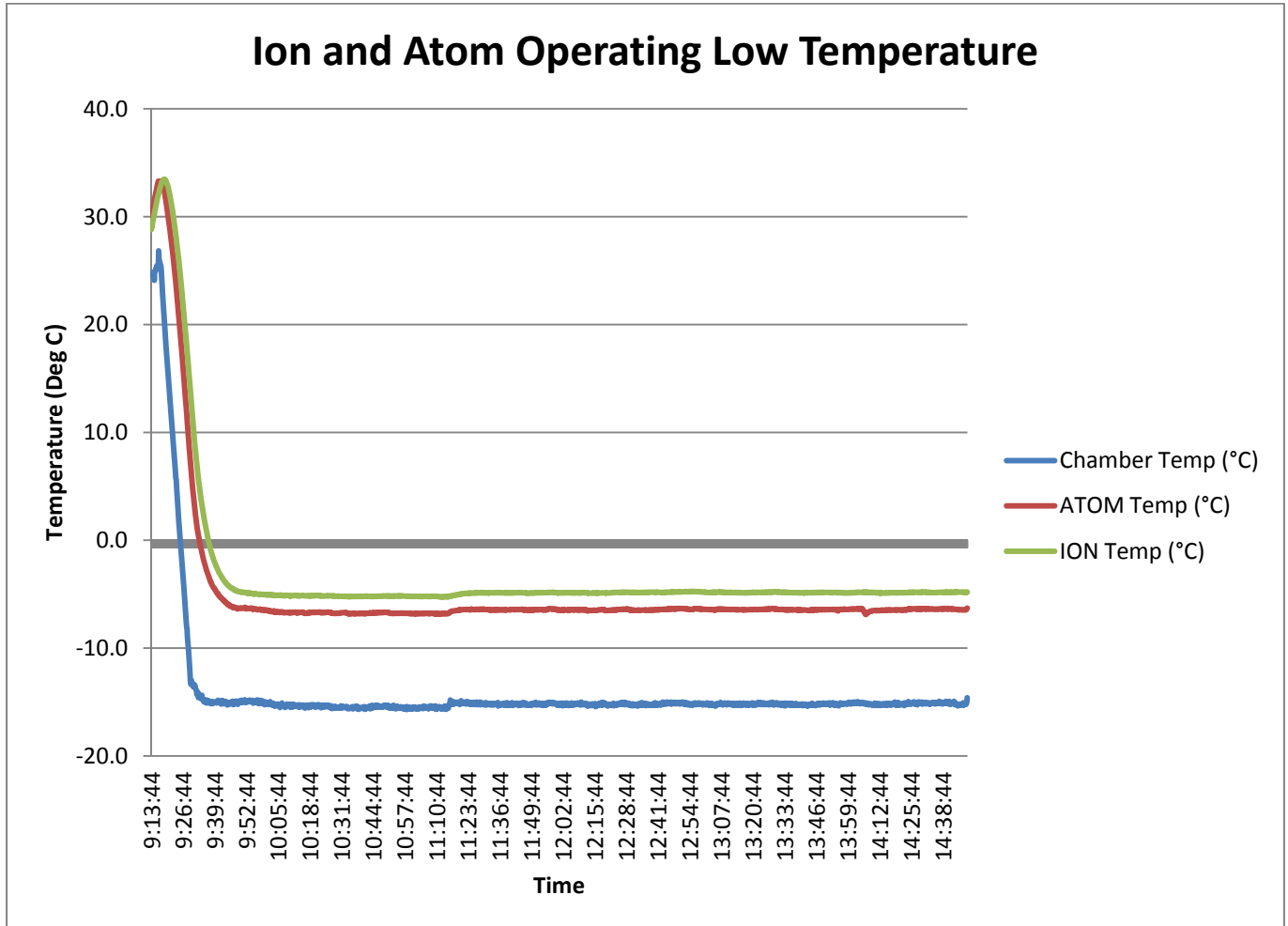


DLS CONFORMITY ASSESSMENT, INC
200 E. Marquardt Drive
Wheeling, IL 60090 USA
Voice 847-537-6400
Fax 847-947-8651
www.dlsemc.com

PHOTOS

(See Ground Survival Low Photos for Setup)

TEST DATA



Operating Low Temperature Test Profile

GROUND SURVIVAL HIGH & SHORT TIME OPERATING HIGH TEMPERATURE TESTS

TEST DATE

04/12/2017

EQUIPMENT UNDER TEST (EUT)

Quantity: One (1)

Model: ION

Serial Number: 110100

Quantity: One (1)

Model: ATOM

Serial Number: 160020

TEST SPECIFICATION

RTCA DO-160G, Section 4.5.3 Category A1

REQUIREMENTS

Each EUT shall undergo Ground Survival High and Short Time Operating High Temperature testing per RTCA DO-160G, Section 4.5.3 Category A1. There shall be no physical or electrical failures that prevent each EUT from being operated.

PROCEDURE

RTCA DO-160G, Section 4.5.3 Category A1

- 1) Place both EUT's inside the test chamber and place thermocouples to measure chamber and EUT surface temperatures.
- 2) Setup each EUT and conduct the standard compliance check.
- 3) With the EUT's not operating and at ambient pressure, stabilize the EUT temperature at the ground survival high temperature (+85°C) for 3 hours.
- 4) Continue maintaining the test chamber air temperature at this temperature (+85°C) for a minimum of 3 additional hours.
- 5) With the EUT's still not operating, reduce the EUT temperature to the short-time operating high temperature (+70°C) at a minimum rate of 2°C/minute.
- 6) After the EUT's stabilize at +70°C for 30 minutes, apply power and operate each EUT for at least 30 additional minutes, while monitoring their operation.
- 7) Remove power from each EUT and return the chamber temperature to room ambient conditions.
- 8) Examine each EUT and record any physical abnormalities.
- 9) Conduct a post-test standard compliance check.



DLS CONFORMITY ASSESSMENT, INC
200 E. Marquardt Drive
Wheeling, IL 60090 USA
Voice 847-537-6400
Fax 847-947-8651
www.dlsemc.com

TEST RESULTS

Both units conformed to testing. No physical damage was noted to any unit. Each unit passed a post-performance test.

EQUIPMENT USED

Equipment	Manufacturer	DLS Lab Number	Model#	Date Calibrated	Calibration Due Date
Environmental Chamber	Test Equity	229	3007C	N/A	Verified w/Calibrated Data Acquisition Unit
Data Acquisition Unit	Agilent Technologies	223	34970A	12/27/2016	12/27/2017

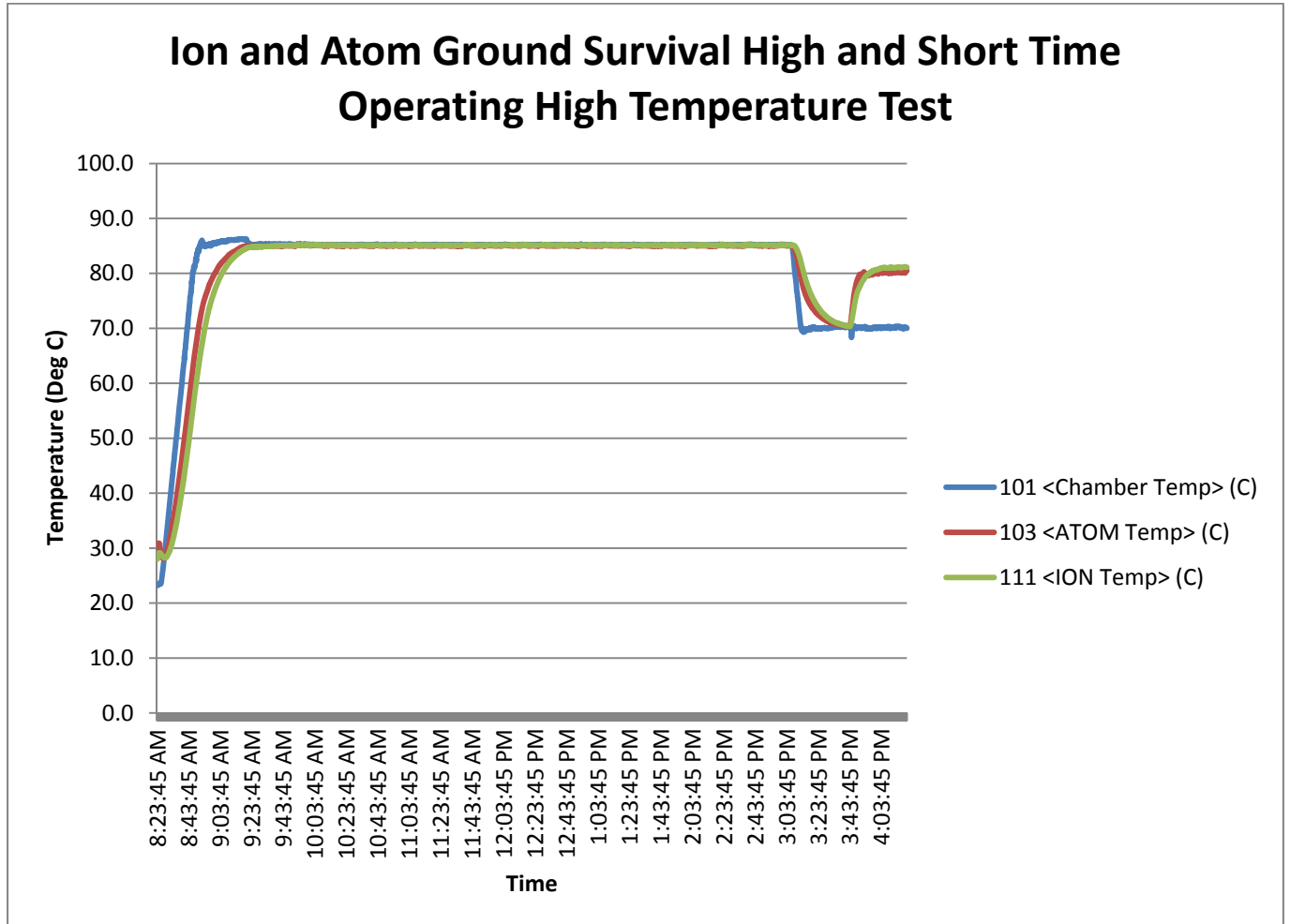


DLS CONFORMITY ASSESSMENT, INC
200 E. Marquardt Drive
Wheeling, IL 60090 USA
Voice 847-537-6400
Fax 847-947-8651
www.dlsemc.com

PHOTOS

(See Ground Survival Low Photos for Setup)

TEST DATA



Ground Survival High and Short Time Operating High Temperature Test Profile



OPERATING HIGH TEMPERATURE TEST

TEST DATE

04/11/2017

EQUIPMENT UNDER TEST (EUT)

Quantity: One (1)

Model: ION

Serial Number: 110100

Quantity: One (1)

Model: ATOM

Serial Number: 160020

TEST SPECIFICATION

RTCA DO-160G, Section 4.5.4 Category A1

REQUIREMENTS

Each EUT shall undergo Operating High Temperature testing per RTCA DO-160G, Section 4.5.4 Category A1. There shall be no physical or electrical failures that prevent each EUT from being operated per customer's post-test requirements.

PROCEDURE

RTCA DO-160G, Section 4.5.4 Category A1

- 1) Place both EUT's inside the test chamber and place thermocouples to measure chamber and EUT surface temperatures.
- 2) Setup each EUT and conduct the standard compliance check.
- 3) With the EUT's operating, stabilize the chamber temperature at the operating high temperature (+55°C) for 2 hours.
- 4) Continue maintaining the test chamber air temperature at 55°C for a minimum of 2 additional hours.
- 5) During this time, monitor the performance of each EUT.
- 6) Remove power from each EUT and return the chamber temperature to room ambient conditions.
- 7) Examine each EUT and record any physical abnormalities.
- 8) Conduct a post-test standard compliance check.



DLS CONFORMITY ASSESSMENT, INC
200 E. Marquardt Drive
Wheeling, IL 60090 USA
Voice 847-537-6400
Fax 847-947-8651
www.dlsemc.com

TEST RESULTS

Both units conformed to testing. No physical damage was noted to any unit. Each unit passed a post-performance test.

EQUIPMENT USED

Equipment	Manufacturer	DLS Lab Number	Model#	Date Calibrated	Calibration Due Date
Environmental Chamber	Test Equity	229	3007C	N/A	Verified w/Calibrated Data Acquisition Unit
Data Acquisition Unit	Agilent Technologies	223	34970A	12/27/2016	12/27/2017

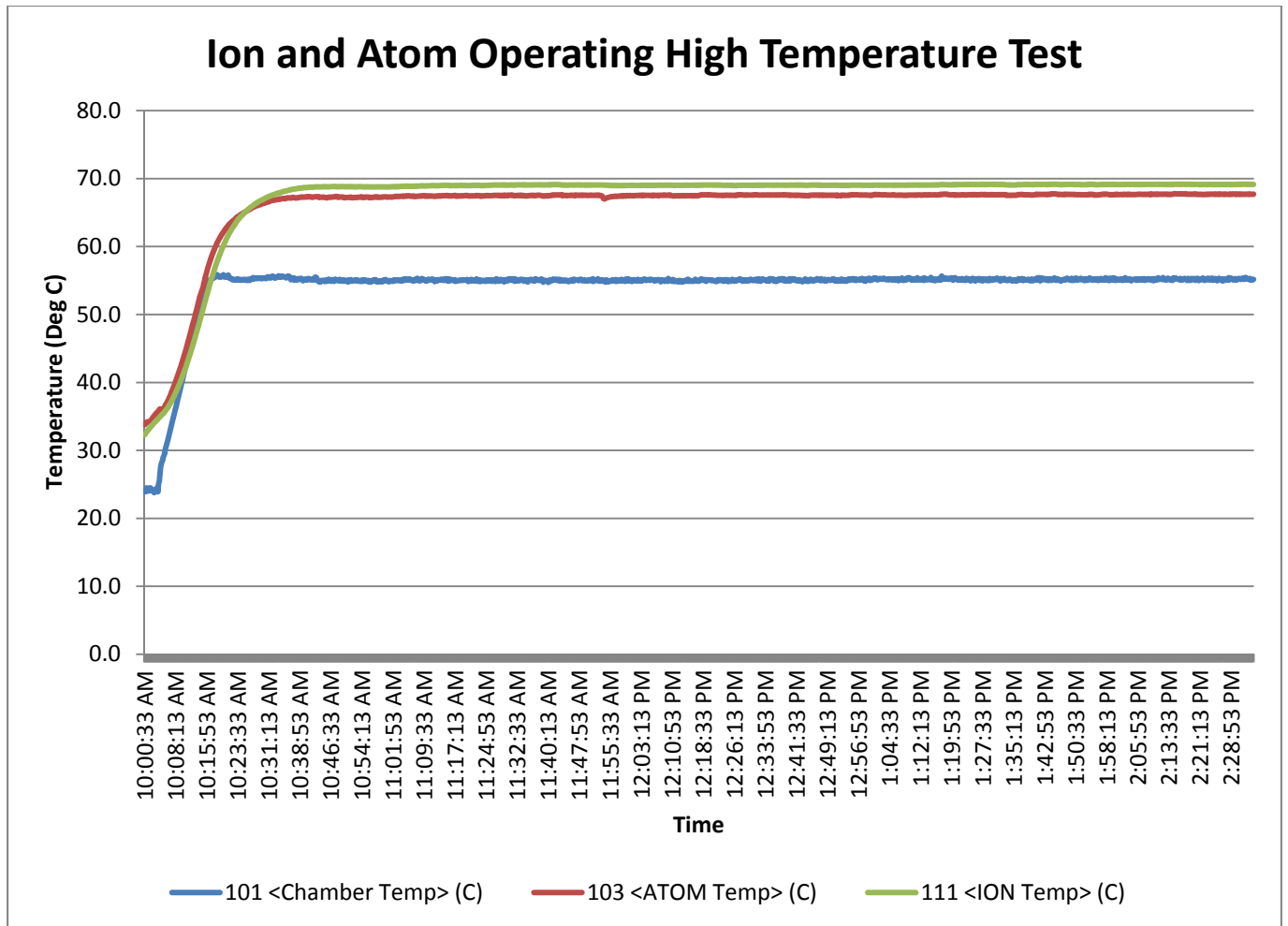


DLS CONFORMITY ASSESSMENT, INC
200 E. Marquardt Drive
Wheeling, IL 60090 USA
Voice 847-537-6400
Fax 847-947-8651
www.dlsemc.com

PHOTOS

(See Ground Survival Low Photos for Setup)

TEST DATA



Operating High Temperature Test Profile

TEMPERATURE VARIATION TEST

TEST DATES

04/18/2017 – 04/20/2017

EQUIPMENT UNDER TEST (EUT)

Quantity: One (1)

Model: ION

Serial Number: 110100

Quantity: One (1)

Model: ATOM

Serial Number: 160020

TEST SPECIFICATION

RTCA DO-160G, Section 5.3.1 Category C

REQUIREMENTS

Each EUT shall undergo Temperature Variation testing per RTCA DO-160G, Section 5.3.1 Category C. There shall be no physical or electrical failures that prevent each EUT from being operated per customer's post-test requirements.

PROCEDURE

RTCA-DO-160G, Section 5.3.1 Category C

- 1) At ambient pressure, apply power to each EUT and ramp down at a minimum of 2 C/minute to the appropriate operating low temperature (-15°C) while monitoring the operation of each EUT.
- 2) Allow the chamber to stabilize at -15°C for at least 2 hours.
- 3) Raise the temperature in the chamber towards the operating high temperature (+55°C) at a minimum of 2 C/minute while monitoring the operation of each EUT and permit the temperature to stabilize at this temperature for at least 2 hours.
- 4) Remove power to the EUT's and re-apply it after at least 2 minutes.
- 5) With the EUTs still operating, decrease the temperature at a minimum of 2 C/minute to the appropriate operating low temperature (-15°C) while monitoring the operation of each EUT.
- 6) Allow the EUT's to stabilize at this temperature (-15°C) for a period of not less than 2 hours.
- 7) While still at -15°C, operate the EUT's for at least an additional hour.
- 8) While still at -15°C, remove power to the EUT's and re-apply it after at least 30 minutes.
- 9) Return chamber temperature to site ambient.
- 10) Repeat steps 1 thru 9 above for one additional cycle (for a total of 2 cycles).
- 11) Perform post-test functional check.



DLS CONFORMITY ASSESSMENT, INC
200 E. Marquardt Drive
Wheeling, IL 60090 USA
Voice 847-537-6400
Fax 847-947-8651
www.dlsemc.com

TEST RESULTS

On conclusion of temperature variation testing, all units were functional. Both units conformed to testing. No physical damage was noted to any unit. Each unit passed a post-performance test.

EQUIPMENT USED

Equipment	Manufacturer	DLS Lab Number	Model#	Date Calibrated	Calibration Due Date
Environmental Chamber	Test Equity	229	3007C	N/A	Verified w/Calibrated Data Acquisition Unit
Data Acquisition Unit	Agilent Technologies	223	34970A	12/27/2016	12/27/2017

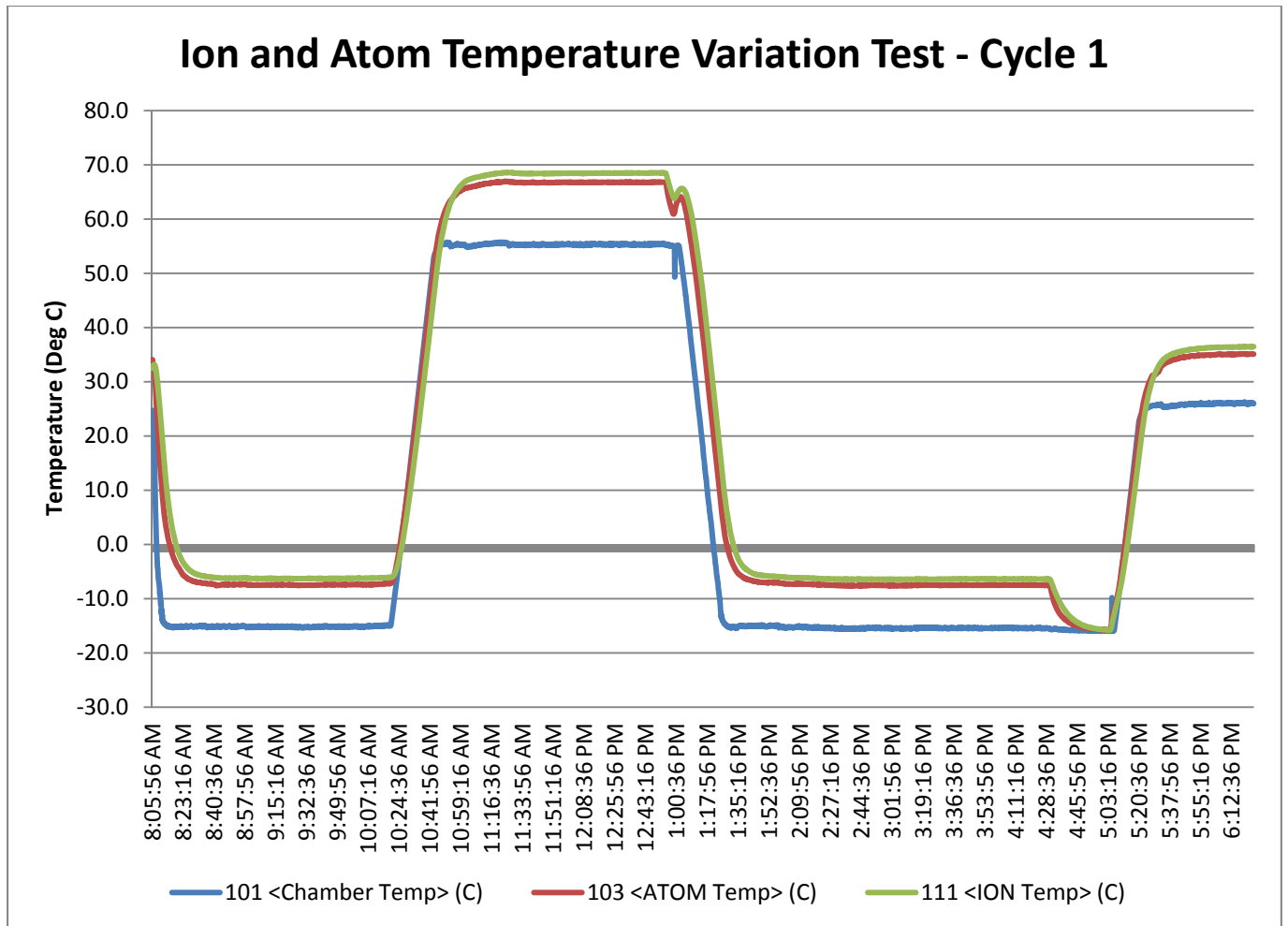


DLS CONFORMITY ASSESSMENT, INC
200 E. Marquardt Drive
Wheeling, IL 60090 USA
Voice 847-537-6400
Fax 847-947-8651
www.dlsemc.com

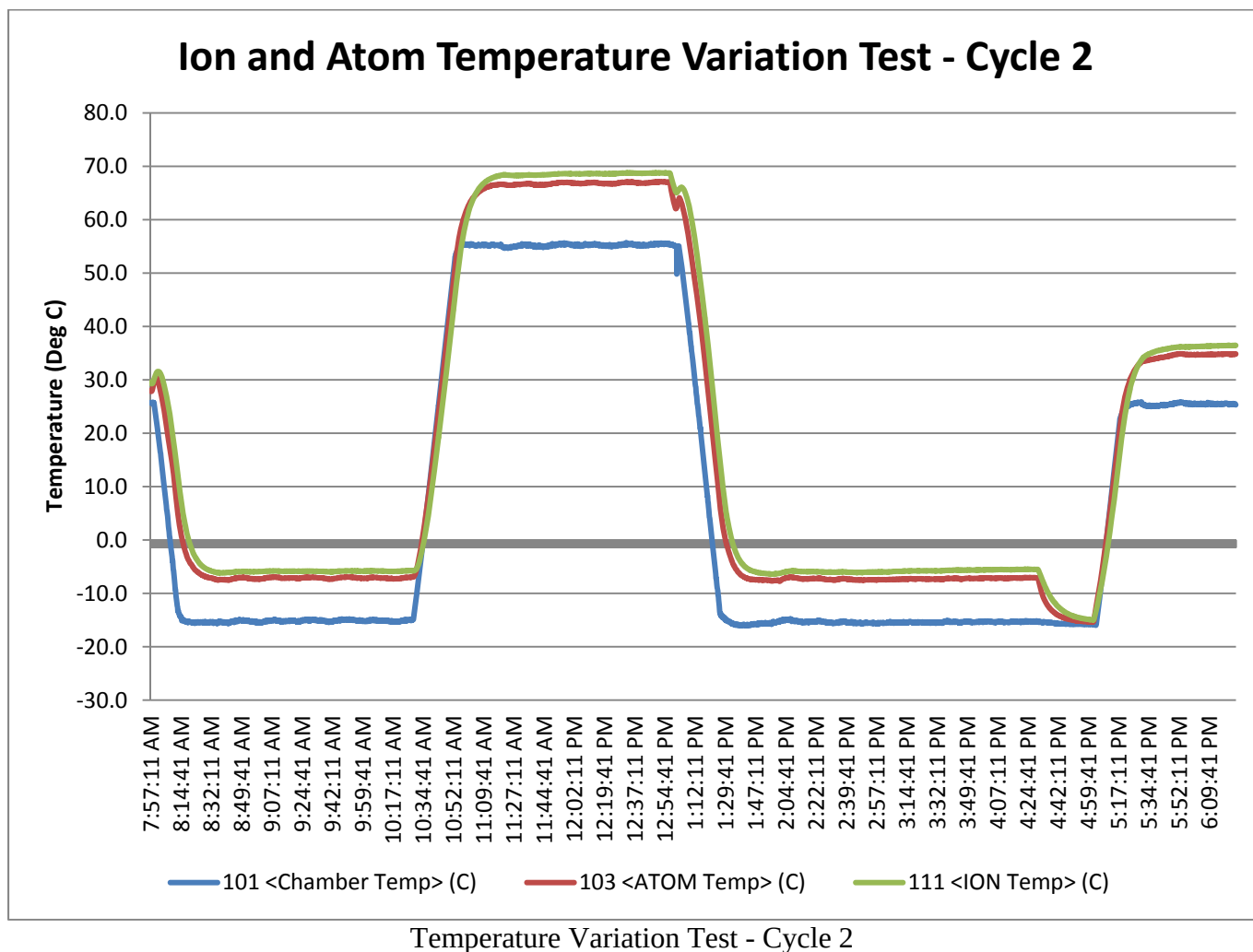
PHOTOS

(See Ground Survival Low Photos for Setup)

TEST DATA



Temperature Variation Test - Cycle 1



ALTITUDE TEST

TEST DATE

04/24/2017

EQUIPMENT UNDER TEST (EUT)

Quantity: One (1)

Model: ION

Serial Number: 110101

Quantity: One (1)

Model: ATOM

Serial Number: 160020

TEST SPECIFICATION

RTCA DO-160G, Section 4.6.1 Category A1

REQUIREMENTS

Each EUT shall undergo Altitude testing per RTCA DO-160G, Section 4.6.1 Category A1. Each EUT shall withstand altitudes up to 15,000 ft. (429.0 Torr) for a period of two hours plus a stabilization period at room ambient temperature. Each EUT will be operated at its maximum duty cycle during testing. There shall be no physical or electrical failures that prevent each EUT from being operated per customer's post-test requirements.

PROCEDURE

RTCA DO-160G, Section 4.6.1 Category A1

- 1) Place both EUT's inside the test chamber and measure the chamber temperature.
- 2) Setup each EUT and conduct the standard compliance check.
- 3) Close door and seal chamber.
- 4) With EUT's powered on, decrease the chamber's pressure to the equivalent of 15,000 ft. (429.0 Torr).
- 5) Allow each test EUT to stabilize at chamber ambient temperature.
- 6) Maintain chamber conditions for a minimum of two hours while monitoring the operation of each EUT.
- 7) Remove power from both test EUT's.
- 8) Increase chamber air pressure and temperature back to site ambient.
- 9) Examine both EUT's and record any physical abnormalities.



DLS CONFORMITY ASSESSMENT, INC
200 E. Marquardt Drive
Wheeling, IL 60090 USA
Voice 847-537-6400
Fax 847-947-8651
www.dlsemc.com

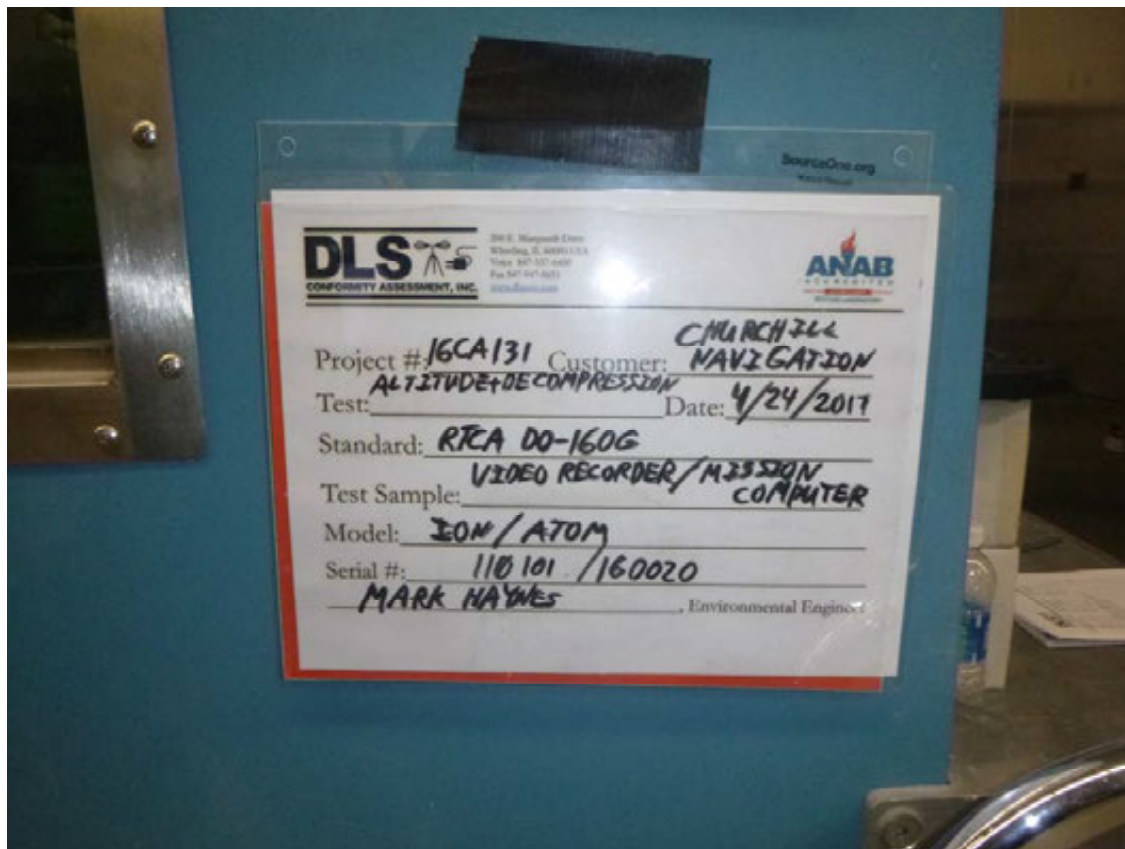
TEST RESULTS

Both units conformed to testing. No physical damage was noted to any unit. Each unit passed a post-performance test.

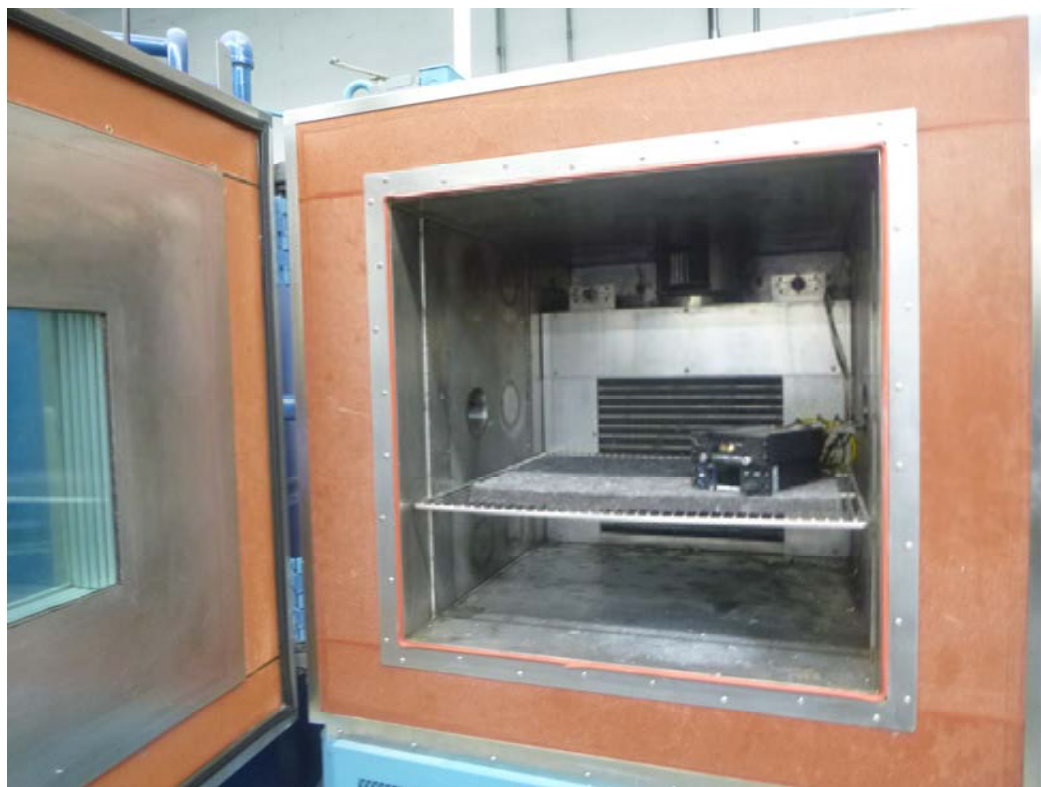
EQUIPMENT USED

Equipment	Manufacturer	DLS Lab Number	Model#	Date Calibrated	Calibration Due Date
Altitude Chamber	Lunaire (Tenney)	187	15.6ST	N/A	Verified w/Calibrated Chart Recorder
Chart Recorder	Honeywell	200	DR45AT	10/25/2016	10/25/2017
Data Acquisition Unit	Agilent Technologies	222	34970A	12/27/2016	12/27/2017

PHOTOS



Test Title

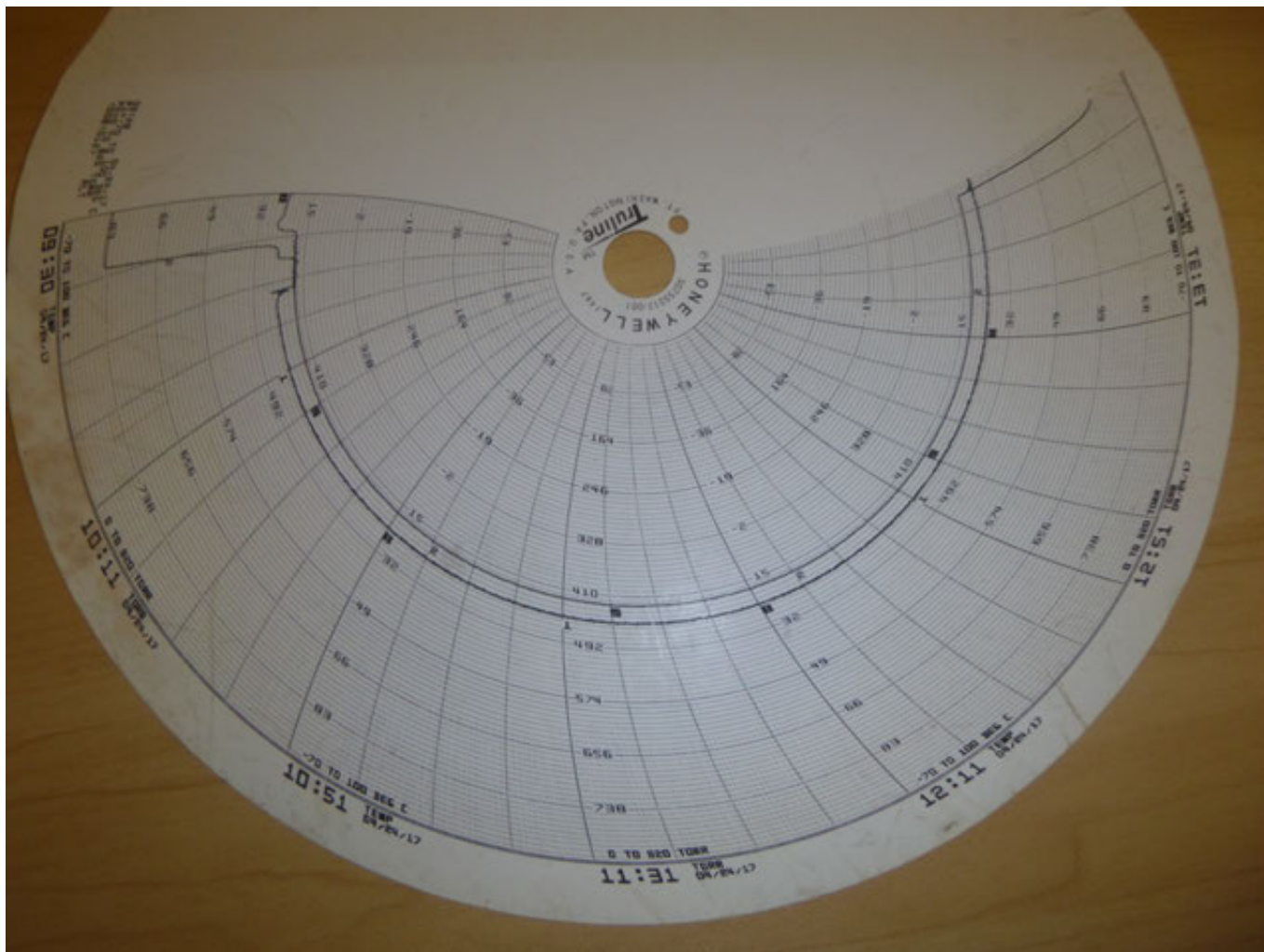


EUT's in Altitude Chamber



EUT's in Altitude Chamber – Close Up

TEST DATA



Altitude Test Profile

DECOMPRESSION TEST

TEST DATE

04/25/2017

EQUIPMENT UNDER TEST (EUT)

Quantity: One (1)

Model: ION

Serial Number: 110101

Quantity: One (1)

Model: ATOM

Serial Number: 160020

TEST SPECIFICATION

RTCA DO-160G, Section 4.6.2 Category A1

REQUIREMENTS

Each EUT shall undergo Decompression testing per RTCA DO-160G, Section 4.6.2 Category A1. Each EUT shall withstand decompression from 8000 ft (752.6 mbars) to 45,000 ft (148.4 mbars) in a period of less than 15 seconds at room ambient temperature. Each EUT will be operated at its maximum duty cycle. There shall be no physical or electrical failures that prevent each EUT from being operated per customer's post-test requirements.

PROCEDURE

RTCA DO-160G, Section 4.6.2 Category A1

- 1) Place both EUT's inside the pressure chamber and monitor the chamber temperature and pressure.
- 2) Apply power to each EUT and monitor the operation of each EUT throughout the entire test.
- 3) With power applied to each EUT, adjust the chamber pressure to 752.6 mbars (+8,000 feet) and chamber ambient temperature, then allow the chamber to stabilize.
- 4) Rapidly adjust the chamber pressure to 148.4 mbars (+45,000 feet) within fifteen (15) seconds maximum.
- 5) With power applied to each EUT, maintain the 148.4 mbars (+45,000 feet) pressure for ten (10) minutes minimum.
- 6) Adjust the chamber pressure and temperature to ambient conditions.
- 7) Allow each EUT to stabilize and perform a standard compliance check.
- 8) Examine both EUT's and record any physical abnormalities.



DLS CONFORMITY ASSESSMENT, INC
200 E. Marquardt Drive
Wheeling, IL 60090 USA
Voice 847-537-6400
Fax 847-947-8651
www.dlsemc.com

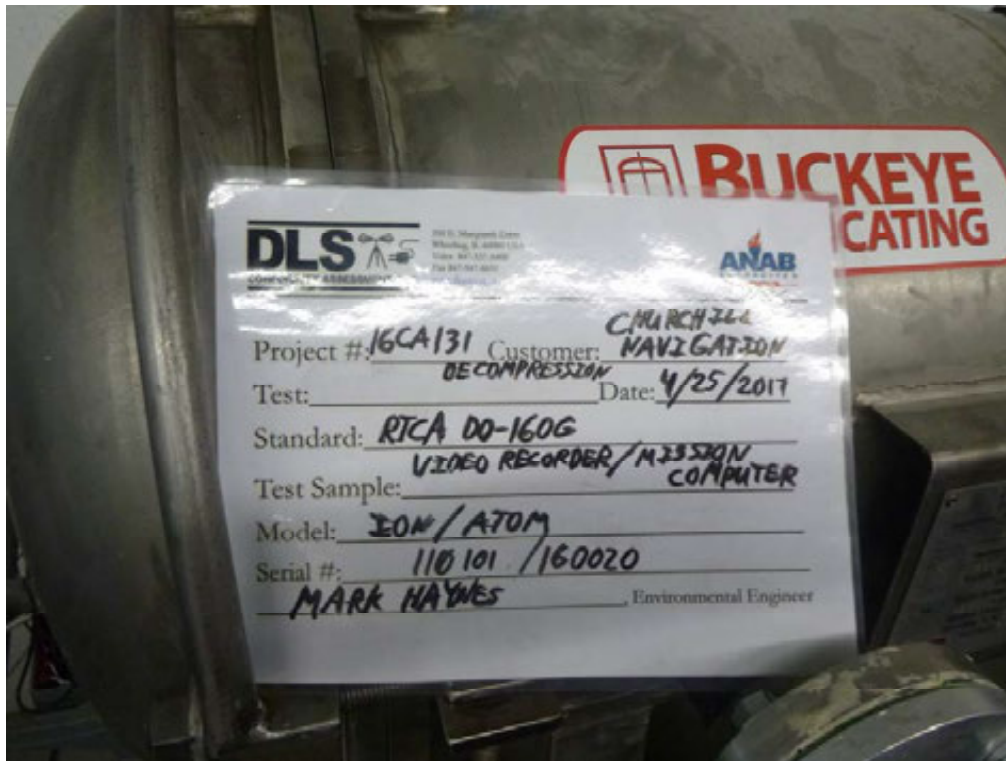
TEST RESULTS

Both units conformed to testing. No physical damage was noted to any unit. Each unit passed a post-performance test.

EQUIPMENT USED

Equipment	Manufacturer	DLS Lab Number	Model#	Date Calibrated	Calibration Due Date
Altitude Chamber	Lunaire (Tenney)	187	15.6ST	N/A	Verified w/Calibrated Chart Recorder
Temperature & Pressure Probe	Omega Engineering	207	iBTHX-W-5	01/09/2017	01/09/2018
Chart Recorder	Honeywell	200	DR45AT	10/25/2016	10/25/2017
Data Acquisition Unit	Agilent Technologies	222	34970A	12/27/2016	12/27/2017
Timer	Cole Parmer	252	CP47469	03/17/2017	03/17/2018
Pressure Chamber	Buckeye	253	31964	N/A	Verified w/Calibrated Temperature & Pressure Probe

PHOTOS



Test Title



EUT's in Pressure Chamber



EUT's in Pressure Chamber – Close Up

TEST DATA

Temperature

26.5 °F

Pressure

749.0 mbar

Humidity

27.4 %

Dewpoint

43.8 °F

EUT's at 8,000 Ft.

Temperature

31.4 °F

Pressure

145.0 mbar

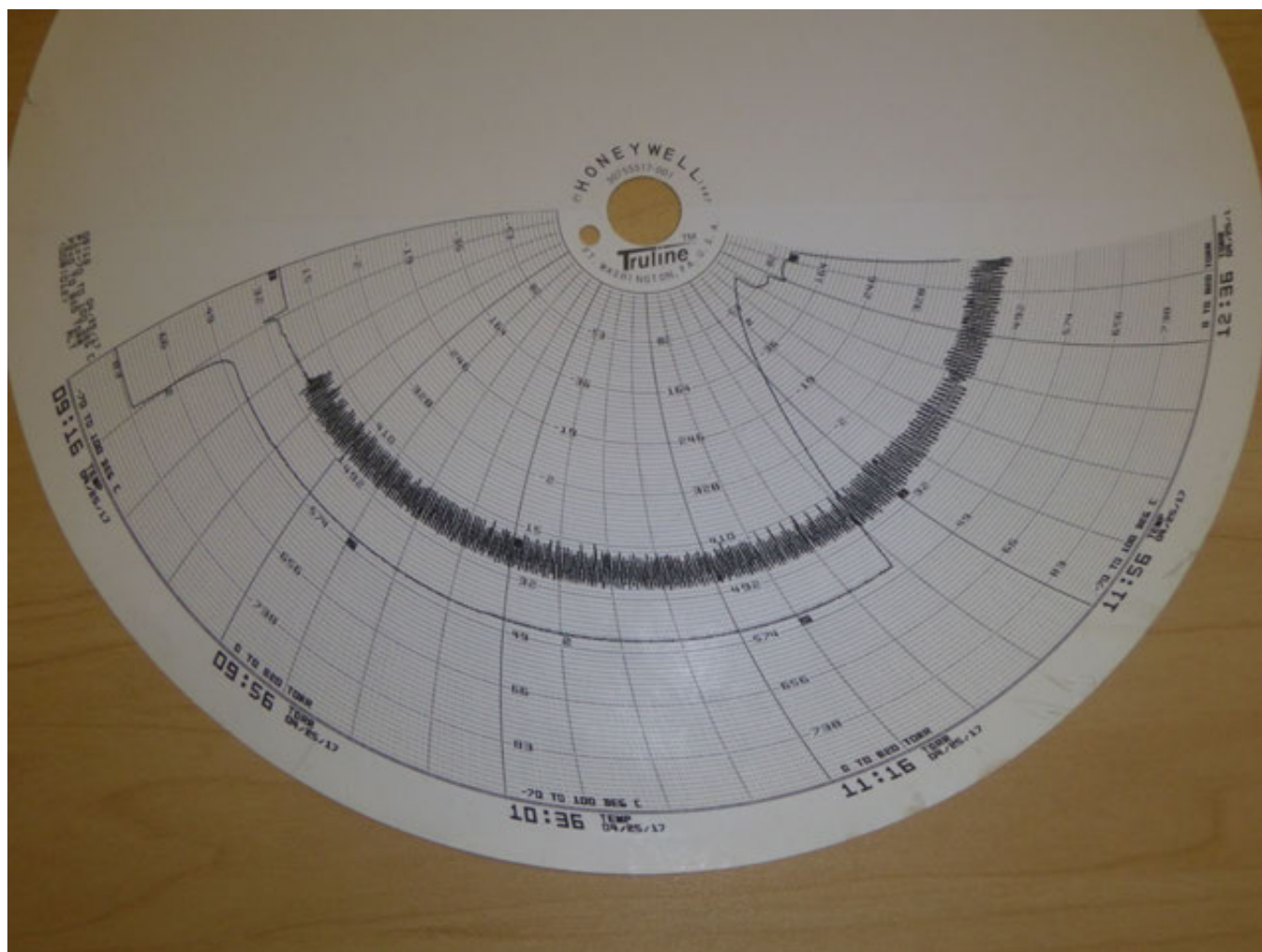
Humidity

5.0 %

Dewpoint

10.3 °F

EUT's at 45,000 Ft.



Decompression Test Profile



OVERPRESSURE TEST

TEST DATE

04/25/2017

EQUIPMENT UNDER TEST (EUT)

Quantity: One (1)

Model: ION

Serial Number: 110101

Quantity: One (1)

Model: ATOM

Serial Number: 160020

TEST SPECIFICATION

RTCA DO-160G, Section 4.6.3 Category A1

REQUIREMENTS

Each EUT shall undergo Overpressure testing per RTCA DO-160G, Section 4.6.3 Category A1. Each EUT shall withstand overpressure of -15,000 ft. (170 kPa or 10.0 PSIG) at ambient temperatures. Each EUT was not operated during test. There shall be no physical or electrical failures that prevent each EUT from being operated per customer's post-test requirements.

PROCEDURE

RTCA DO-160G, Section 4.6.3 Category A1

- 1) Perform the standard compliance check.
- 2) At ambient temperature with both EUT's not operating, adjust the chamber pressure to 10.0 PSIG (-15,000 feet).
- 3) Maintain the 10.0 PSIG (-15,000 feet) pressure for ten (10) minutes minimum.
- 4) Adjust the chamber pressure to ambient conditions.
- 5) Allow both EUT's to stabilize and perform a standard compliance check.
- 6) Examine each EUT and record any physical abnormalities.

TEST RESULTS

Both units conformed to testing. No physical damage was noted to any unit. Each unit passed a post-performance test.

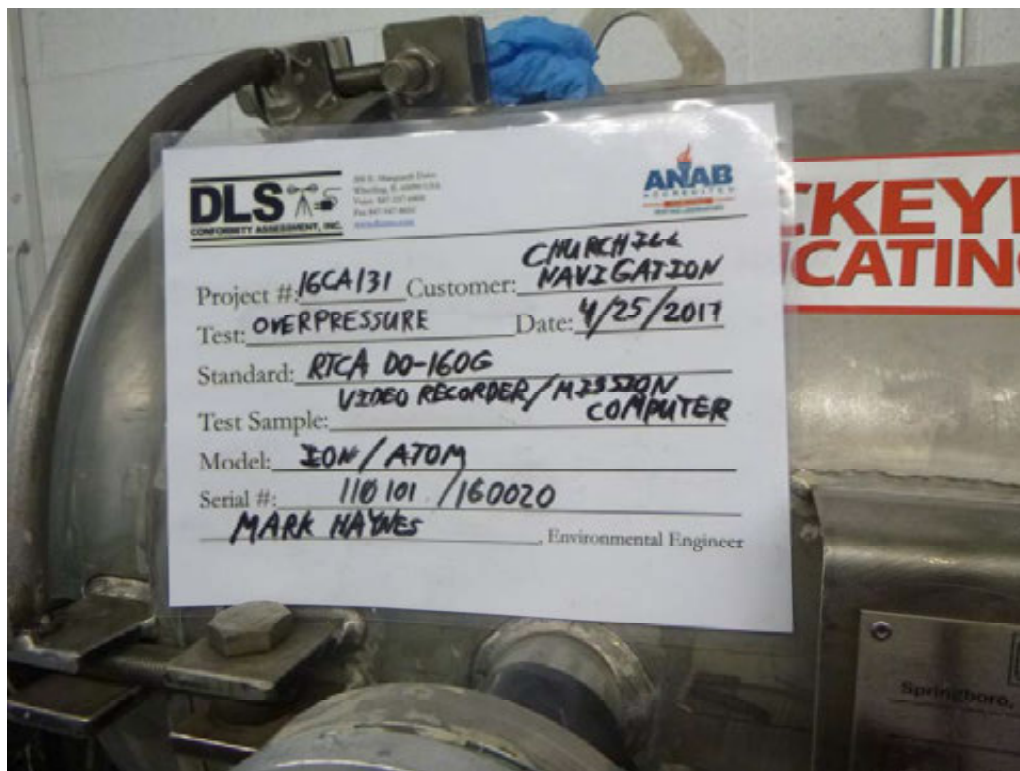


DLS CONFORMITY ASSESSMENT, INC
200 E. Marquardt Drive
Wheeling, IL 60090 USA
Voice 847-537-6400
Fax 847-947-8651
www.dlsemc.com

EQUIPMENT USED

Equipment	Manufacturer	DLS Lab Number	Model#	Date Calibrated	Calibration Due Date
Pressure Gauge	CECOMP	211	F16B200PSIG	10/31/2016	10/31/2017
Pressure Chamber	Buckeye	253	31964	N/A	Verified w/Calibrated Pressure Gauge
Timer	Cole Parmer	252	CP47469	03/17/2017	03/17/2018

PHOTOS



Test Title



Overpressure Test Setup

TEST DATA



Overpressure Test Measurement

HUMIDITY TEST

TEST DATES

03/20/2017 – 03/22/2017

EQUIPMENT UNDER TEST (EUT)

Quantity: One (1)

Model: ION

Serial Number: 110098

Quantity: One (1)

Model: ATOM

Serial Number: 160021

TEST SPECIFICATION

RTCA DO-160G, Section 6.3.1 Category A

REQUIREMENTS

Each EUT shall be exposed to Humidity per RTCA-DO-160G, Section 6.3.1 Category A. There shall be no physical or electrical failures that prevent each EUT from being operated per customer's post-test requirements.

PROCEDURE

RTCA-DO-160G, Section 6.3.1 Category A

1. Stabilize both EUT's at +38 °C (± 2 °C) and 85% (± 4 %) relative humidity.
2. Over a two (2) hour period (± 10 minutes), raise the chamber temperature to +50 °C (± 2 °C) and increase the relative humidity to 95% (± 4 %).
3. Maintain the chamber temperature at +50 °C (± 2 °C) with the relative humidity at 95% (± 4 %) for six (6) hours minimum.
4. During the next sixteen (16) hour period (± 15 minutes), decrease the chamber temperature gradually to 38 °C (± 2 °C) or lower. During this period, keep the relative humidity as high as possible and do not allow it to fall below 85%.
5. Steps 2 through 4 constitute one cycle. Repeat these steps until a total of two (2) cycles (48 hours of exposure) have been completed.
6. At the end of the exposure period, remove both EUT's from the test chamber and drain off (do not wipe) any condensed moisture.
7. Within one (1) hour after the two (2) cycles are completed, perform a post-environment functional test on each EUT.
8. Perform an external visual inspection.



DLS CONFORMITY ASSESSMENT, INC
200 E. Marquardt Drive
Wheeling, IL 60090 USA
Voice 847-537-6400
Fax 847-947-8651
www.dlsemc.com

TEST RESULTS

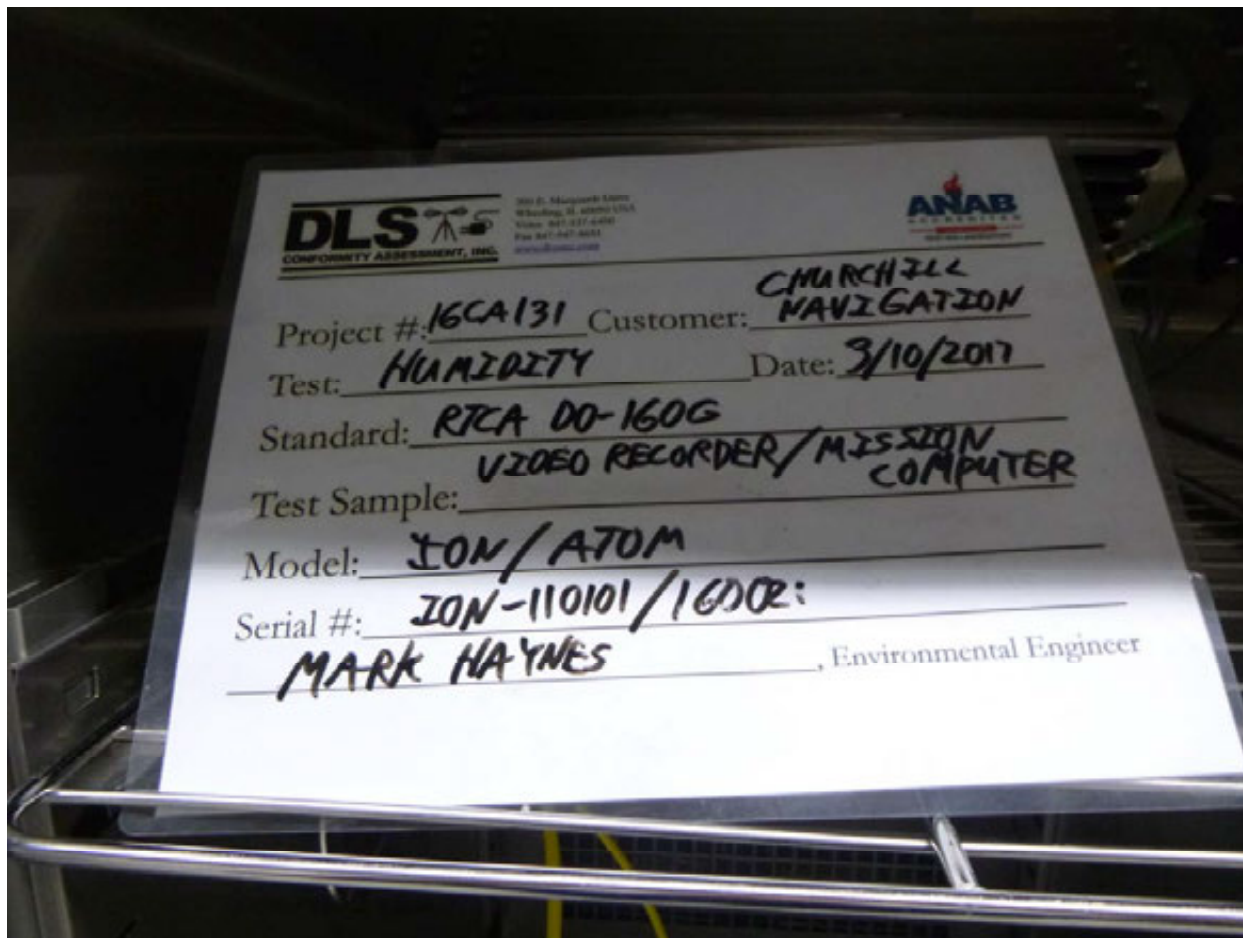
The EUT's functioned as required upon the completion of testing. Both units conformed to testing. No physical damage was noted to any unit. Each unit passed a post-performance test.

EQUIPMENT USED

Equipment	Manufacturer	DLS Lab Number	Model#	Date Calibrated	Calibration Due Date
Humidity Chamber	Espec	238	ESL-2CA	Verified with calibrated Humidity/Temperature Probe	
Humidity Chamber	Espec	188	ENX60-6CAL	05/02/2016	05/02/2017
Humidity / Temperature Probe	Vaisala	N/A	L3420067	04/21/2016	04/21/2017
Data Acquisition Unit	Agilent	223	34970A	12/27/2016	12/27/2017
Backup Data Acquisition Unit	MicroDAQ	285	EL-USB-2-LCD+	No Calibration Required	

PHOTOS

Test Title



DLS  200 E. Marquardt Drive
Wheeling, IL 60090 USA
Voice 847-537-6400
Fax 847-947-8651
www.dlsemc.com

ANAB ACCREDITED

Project #: 16CA131 Customer: CHURCHILL NAVIGATION
Test: HUMIDITY Date: 3/10/2017
Standard: RCA DO-160G
Test Sample: VIDEO RECORDER/MISSION COMPUTER
Model: ION/ATOM
Serial #: ION-110101/160R:
MARK HAYNES, Environmental Engineer

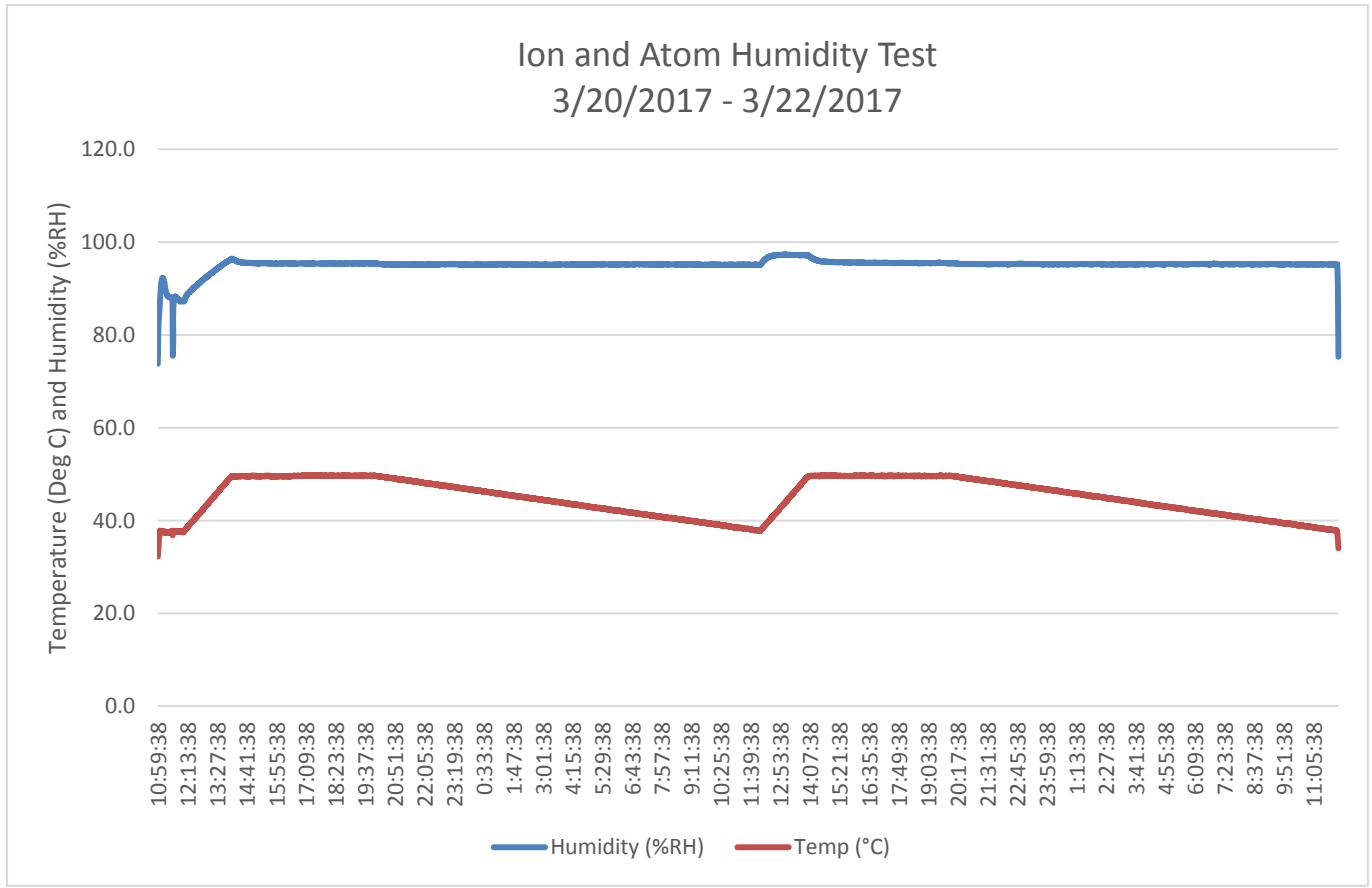
Humidity Chamber



EUT's In Humidity Chamber



TEST DATA



Humidity Test Data 03/20/2017 – 03/22/2017



VIBRATION TESTS

TEST DATES

07/26/2017 – 08/02/2017

EQUIPMENT UNDER TEST (EUT)

Quantity: One (1)

Model: ION

Serial Number: 110129

Quantity: One (1)

Model: ATOM

Serial Number: 160055

TEST SPECIFICATION(s)

RTCA DO-160G, Section 8, Category R - Curves B & B1,

Category S - Curves B, C, L & M

Category U2 - Curves F & F1

REQUIREMENTS

Each EUT shall be exposed to Vibration per RTCA DO-160G, Section 8, Category R – Curves B & B1, Category S – Curves B, C, L & M, and Category U2 – Curves F & F1. There shall be no failure of any EUT or mounting bracket. All equipment shall remain in place. There shall be no physical or electrical failures that prevent each EUT from being operated per customer's post-test requirements.

Category R, Curve B & B1 Details:

Pre-Sine Sweep (0.5 g-PK sine scan, 10 to 2000 Hz)

Vibration (10 minutes, Curve B Frequency & Levels - Fig. 8-1)

Vibration (3 hours, Curve B1 Frequency & Levels - Fig. 8-4)

Post-Sine Sweep (0.5 g-PK sine scan, 10 to 2000 Hz)

Category S, Curve B Details:

Pre-Sine Sweep (0.5 g-PK sine scan, 10 to 2000 Hz)

Vibration (1 hour, Curve B Frequency & Levels - Fig. 8-1)

Post-Sine Sweep (0.5 g-PK sine scan, 10 to 2000 Hz)

Category S, Curve C Details:

Pre-Sine Sweep (0.5 g-PK sine scan, 10 to 2000 Hz)

Vibration (1 hour, Curve C Frequency & Levels - Fig. 8-1)

Post-Sine Sweep (0.5 g-PK sine scan, 10 to 2000 Hz)

Category S, Curve L Details:

Vibration (1 hour, Curve L Frequency & Levels - Fig. 8-3)

Category S, Curve M Details:

Vibration (1 hour, Curve M Frequency & Levels - Fig. 8-3)

Category U2, Curve F & F1 Details:

Vibration (Pre Sweep, Curve F Frequency & Levels - Fig. 8-7)

Vibration (3 hours, Curve F1 Frequency & Levels - Fig. 8-7)

Vibration (Post Sweep, Curve F Frequency & Levels - Fig. 8-7)

PROCEDURE

RTCA DO-160G, Section 8, Categories R, S & U2

- 1) Perform a standard compliance check.
- 2) Mount both EUT's to the provided vibration fixture.
- 3) Fasten vibration fixture in axis of test.
- 4) Attach a control accelerometer parallel to the axis of excitation.
- 5) Attach a response accelerometer to each EUT parallel to the axis of excitation as shown in photos section below.
- 6) Apply specified power to both EUT's and verify operation.
- 7) Conduct each part of the vibration profile in the 1st axis; monitor/record the control and response plot.
- 8) Monitor the operation of each EUT throughout each vibration test.
- 9) Mount the EUT's in each of the other 2 orthogonal axes and repeat the steps above.
- 10) Examine each EUT and record any physical abnormalities.
- 11) Repeat the above steps for each category/curve.

TEST RESULTS

Both units conformed to all testing. No physical damage was noted to any unit. Each unit passed a post-performance test.

EQUIPMENT USED

Equipment	Manufacturer	DLS Lab Number	Model#	Date Calibrated	Calibration Due Date
Accelerometer	Dytran	268	3333M2T	11/16/2016	11/16/2017
Accelerometer	Dytran	152	3225F1T	09/28/2016	09/28/2017
Accelerometer	Dytran	161	3049E1	05/12/2017	05/12/2018



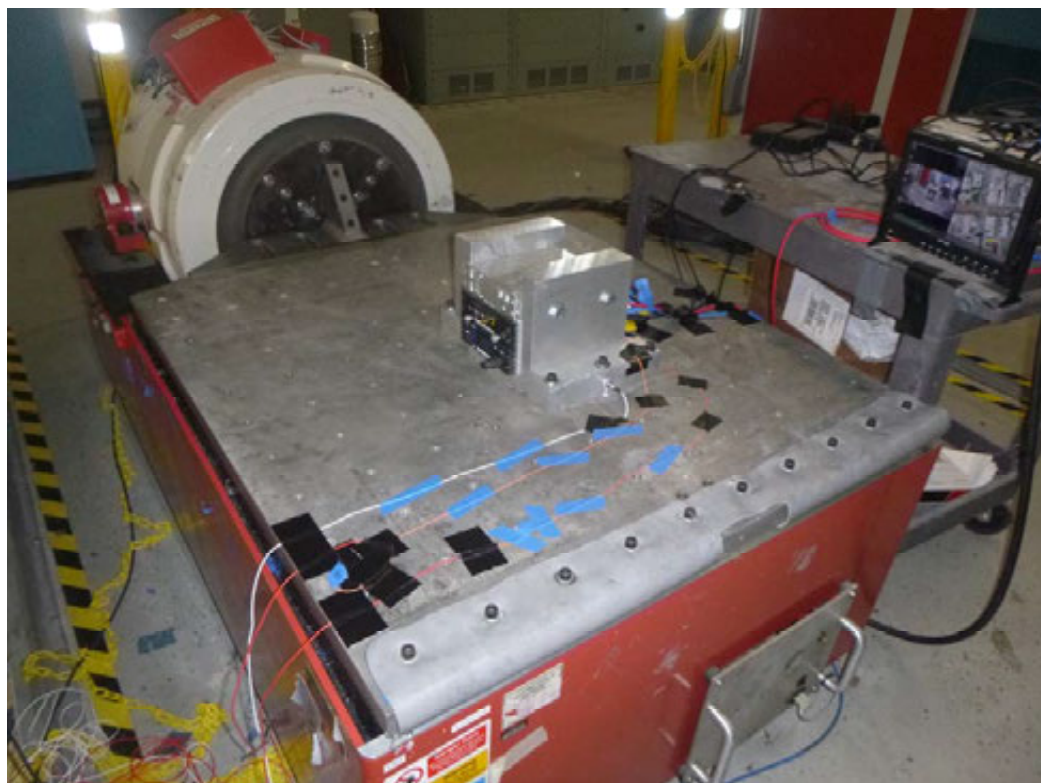
DLS CONFORMITY ASSESSMENT, INC
200 E. Marquardt Drive
Wheeling, IL 60090 USA
Voice 847-537-6400
Fax 847-947-8651
www.dlsemc.com

Accelerometer	Dytran	154	3225F1T	08/09/2016	08/09/2017
Accelerometer	Dytran	159	3049E1	06/16/2017	06/16/2018
Electrodynamic Shaker	LDS	183	V850-440	N/A	Verified w/Calibrated Accelerometers
Vibration Controller	Vibe Research Corp	165	VR9500	09/20/2016	09/20/2017

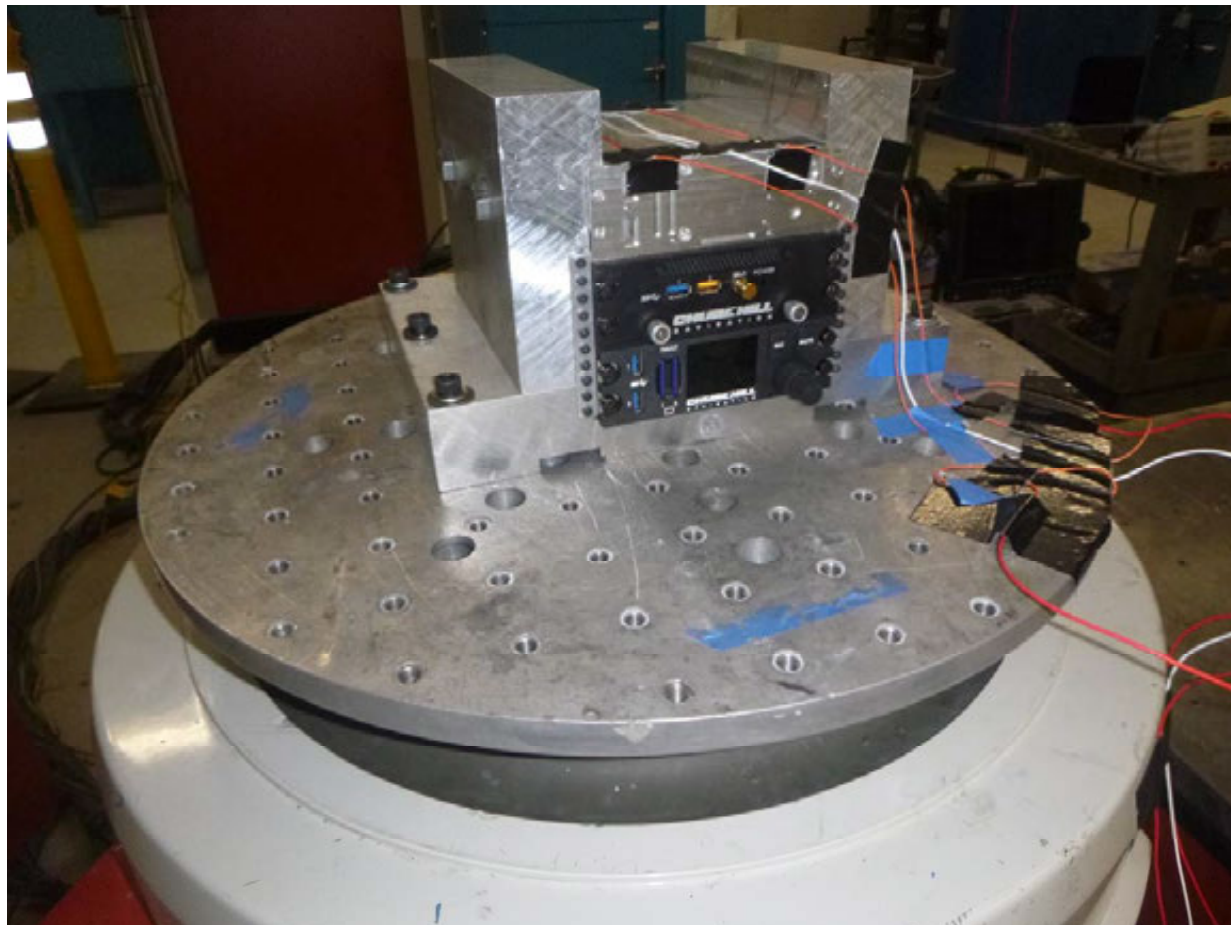
REPRESENTATIVE PHOTOS



Vibration in X Axis



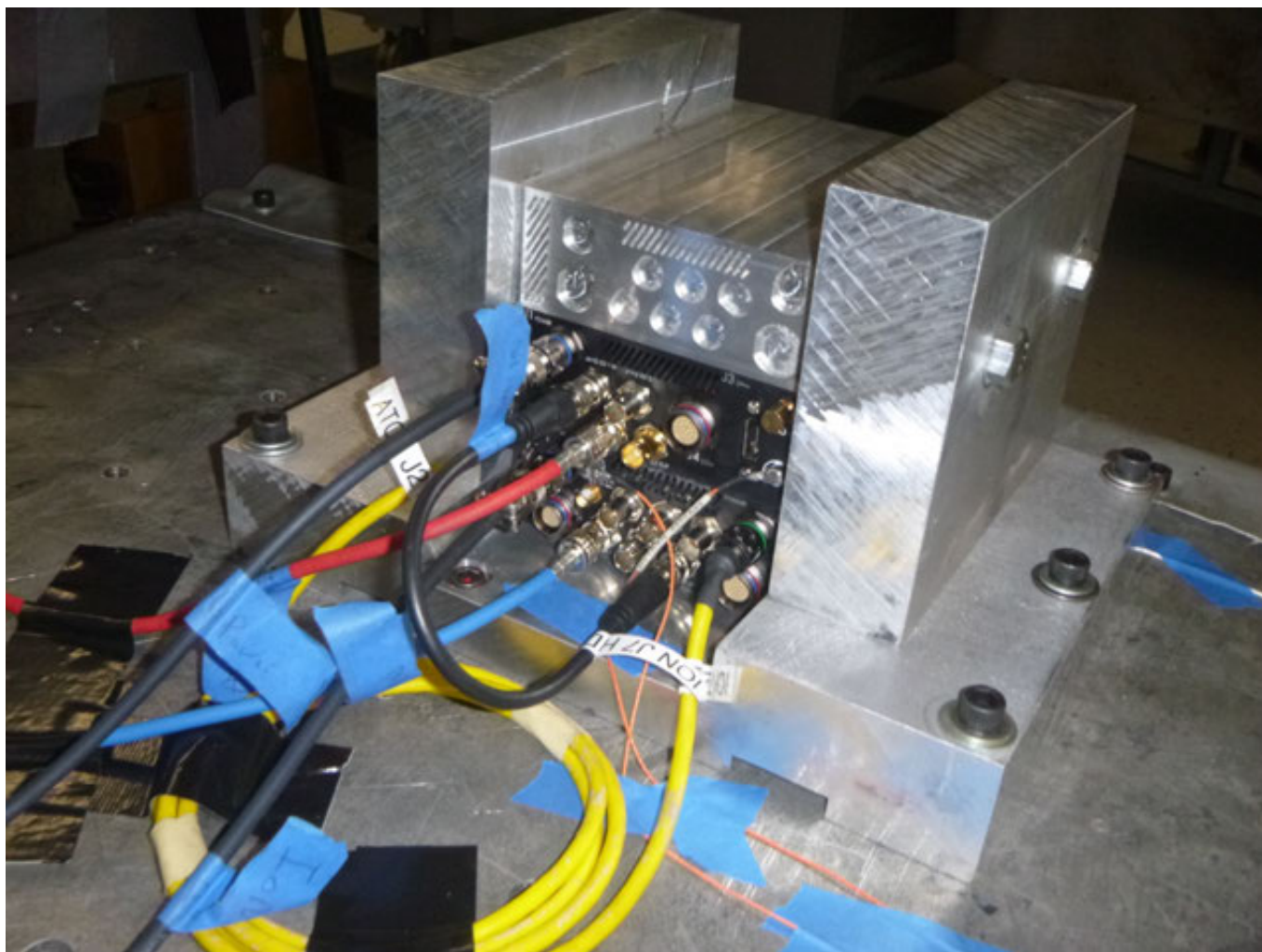
Vibration in Y Axis



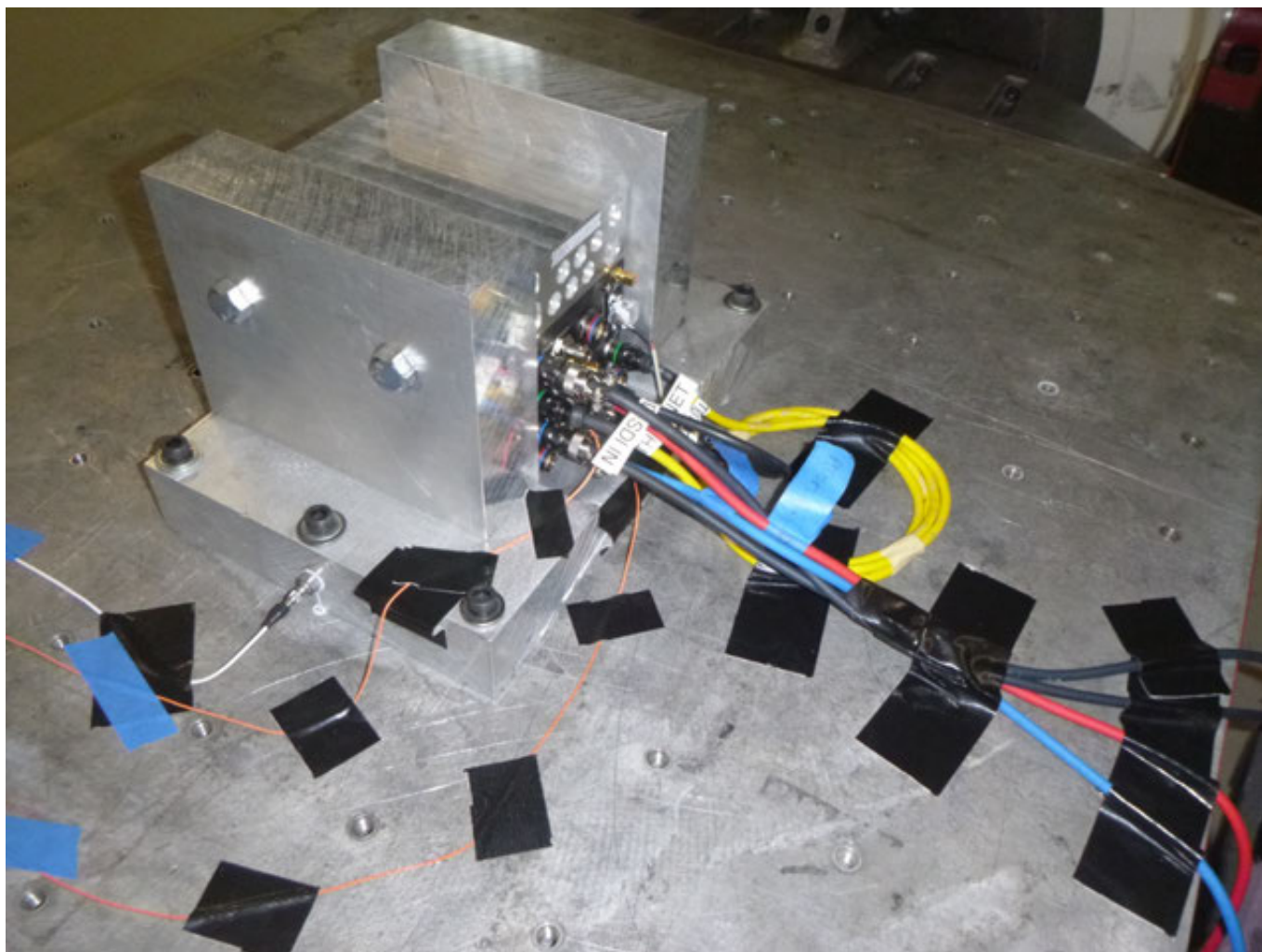
Vibration in Z Axis



Accelerometer Locations in X Axis – Part 1



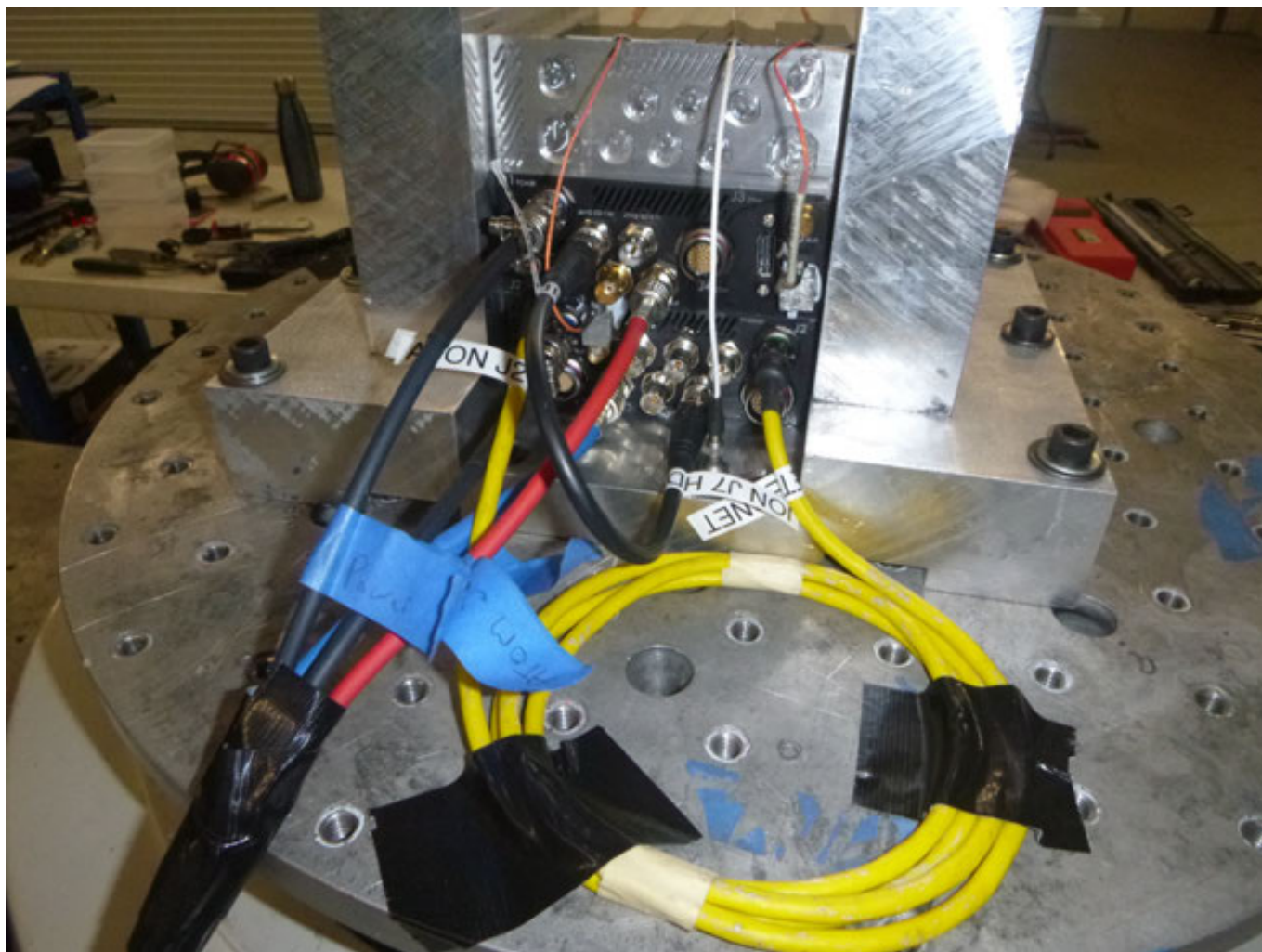
Accelerometer Locations in X Axis – Part 2



Accelerometer Locations in Y Axis – Part 1

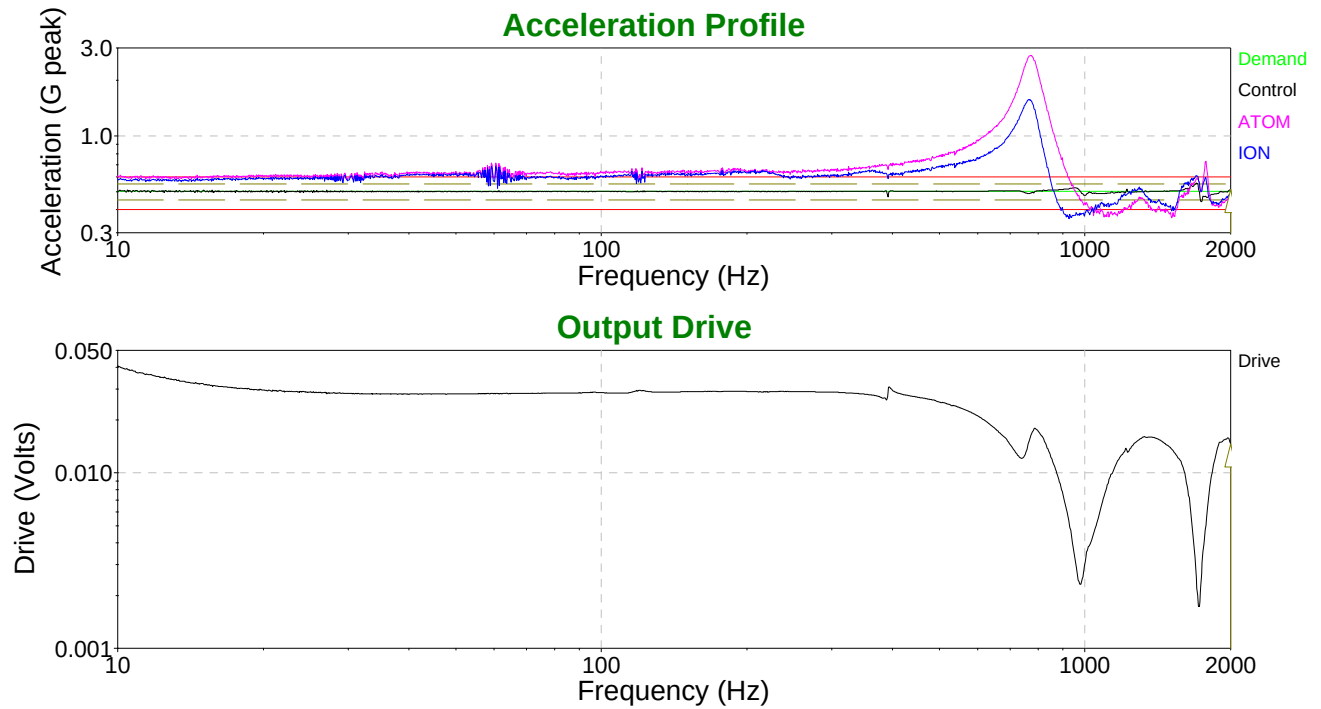


Accelerometer Locations in Y Axis – Part 2

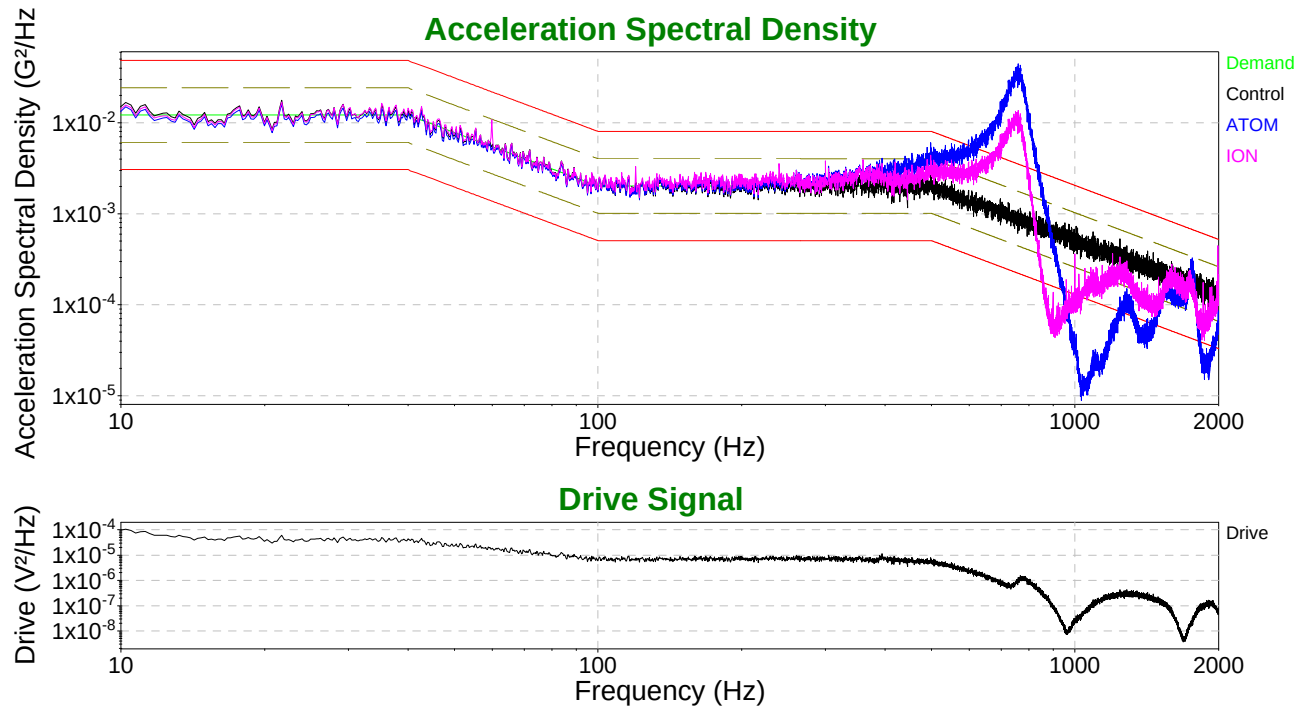


Accelerometer Locations in Z Axis

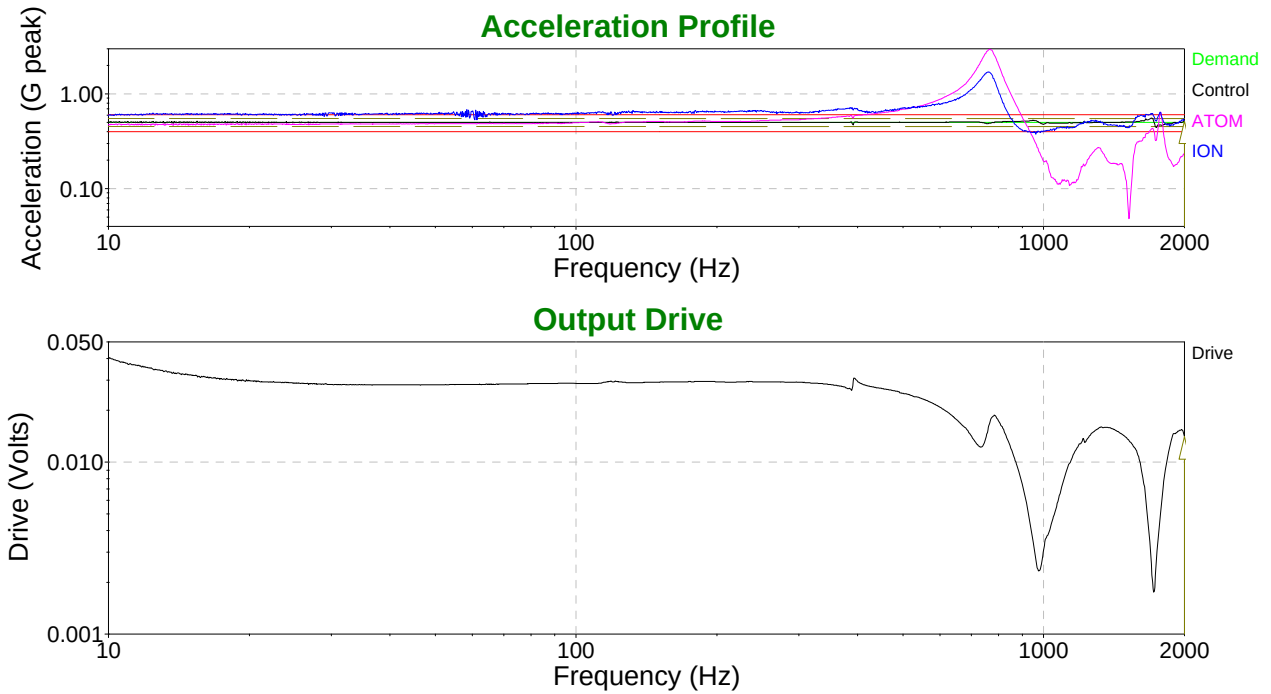
TEST DATA
X-AXIS



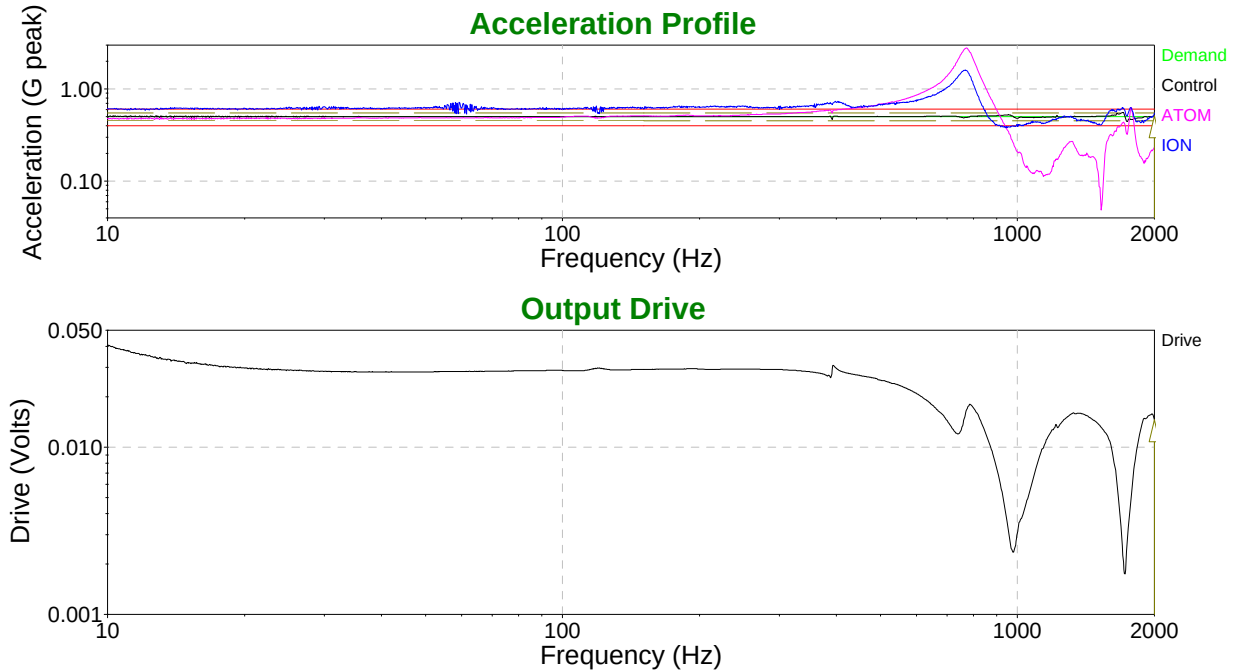
Category S, Curve B Pre Sine Resonance Sweep in X Axis



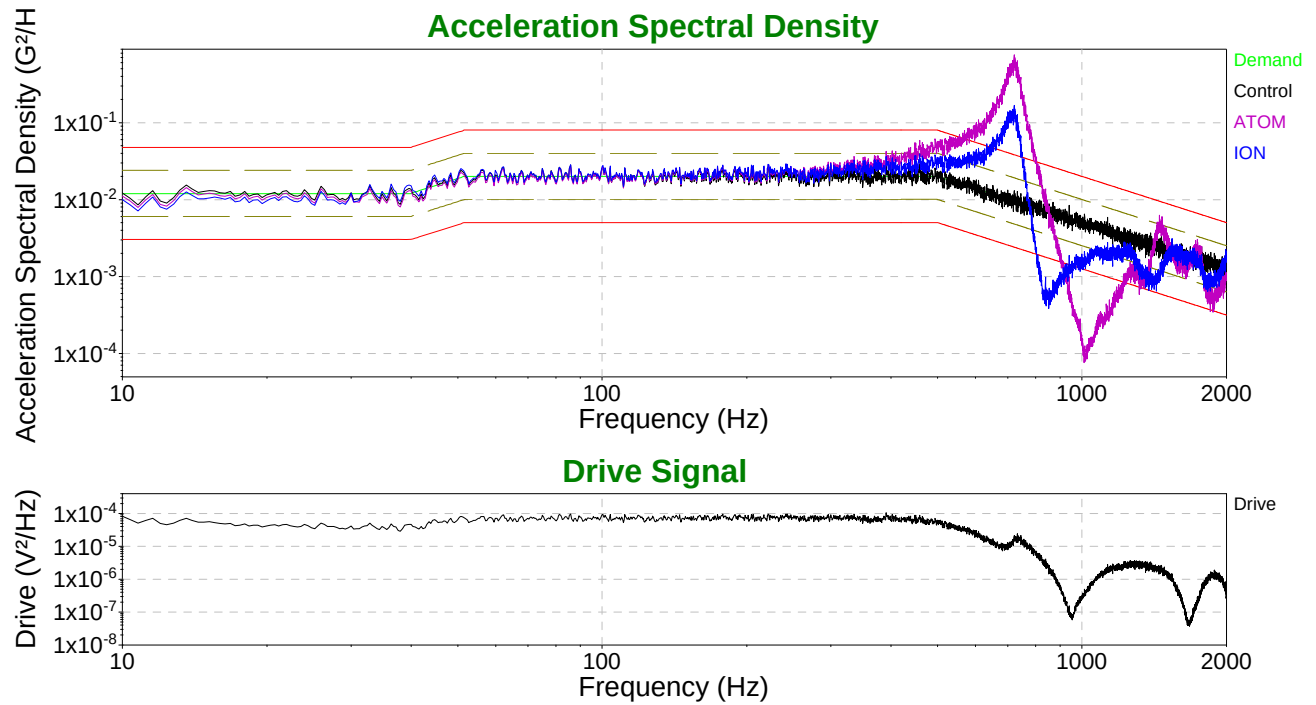
Category S, Curve B Vibration in X Axis



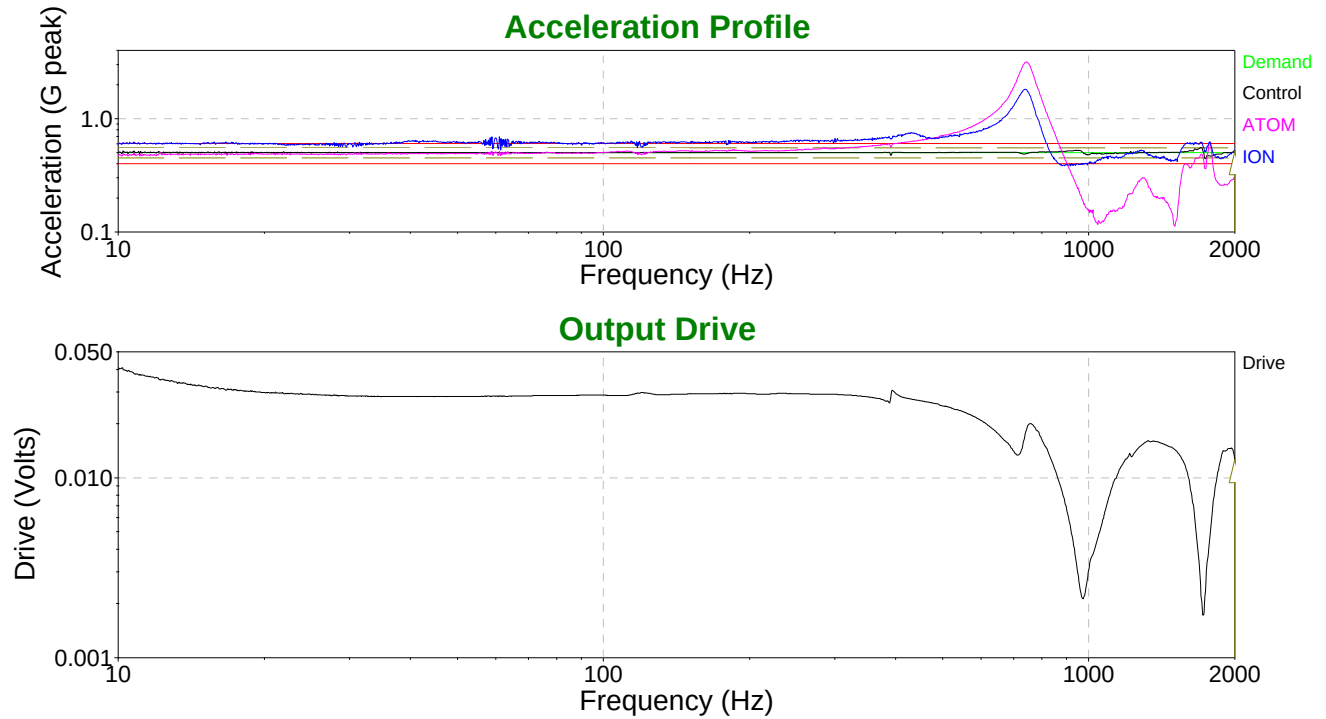
Category S, Curve B Post Sine Resonance Sweep in X Axis



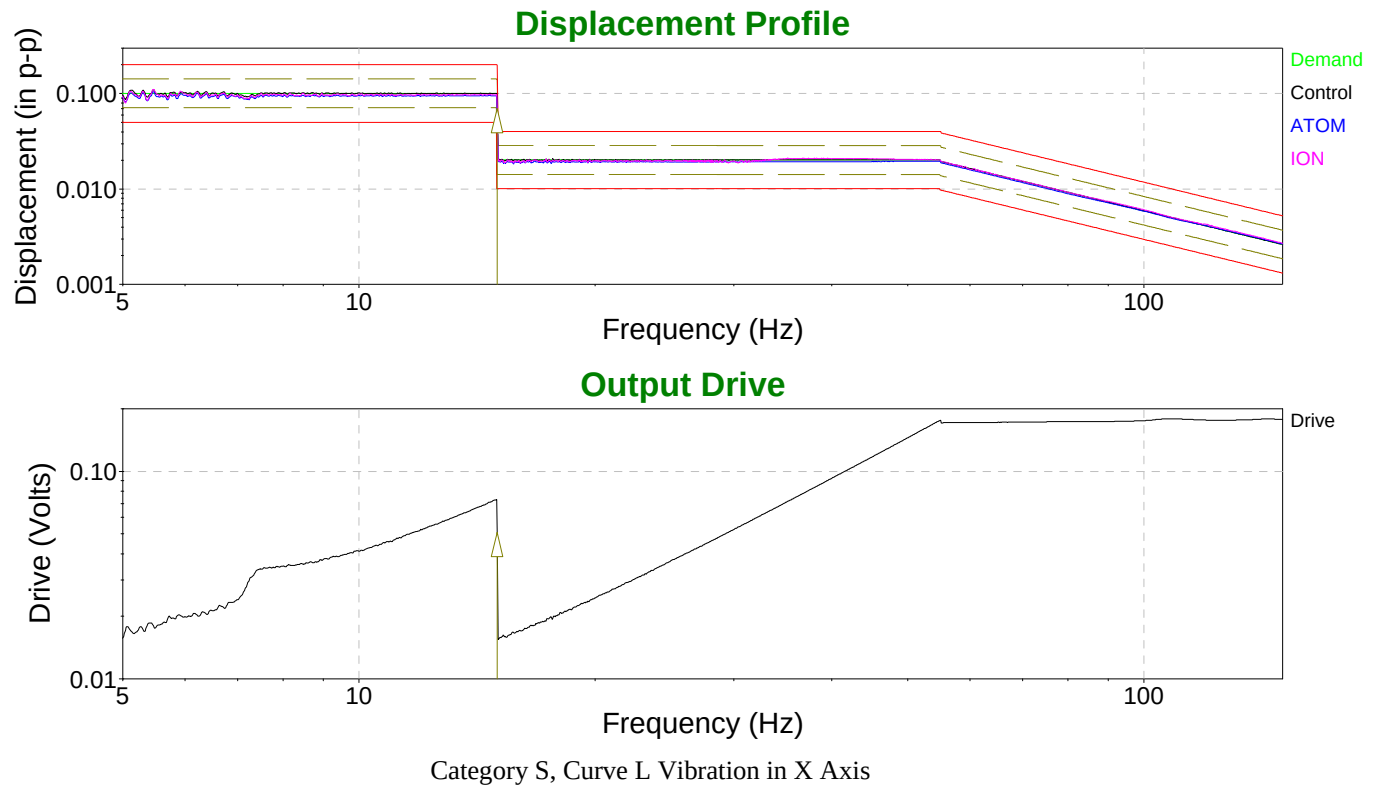
Category S, Curve C Pre Sine Resonance Sweep in X Axis

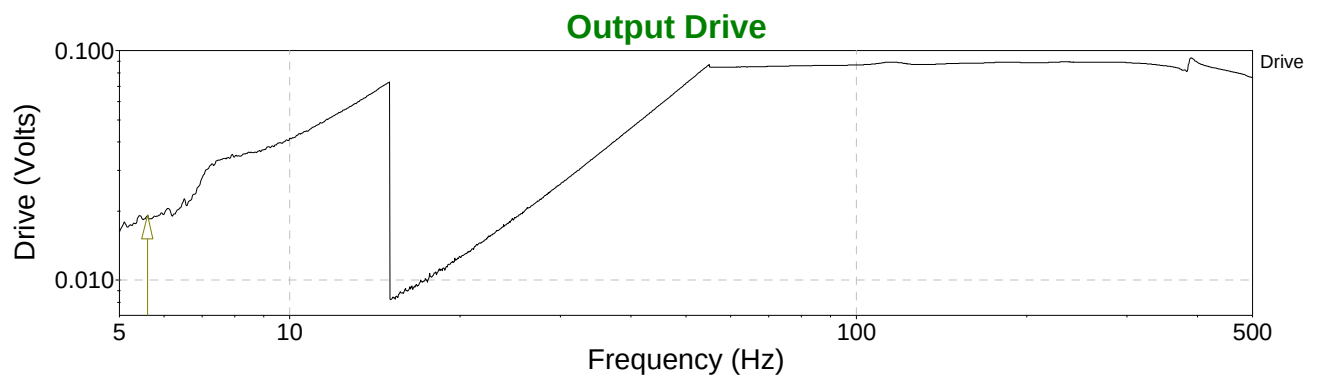
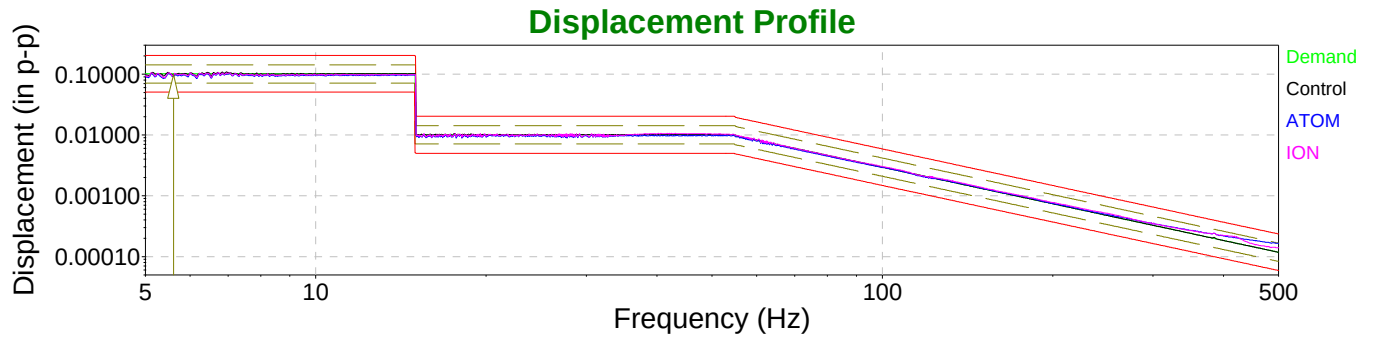


Category S, Curve C Vibration in X Axis

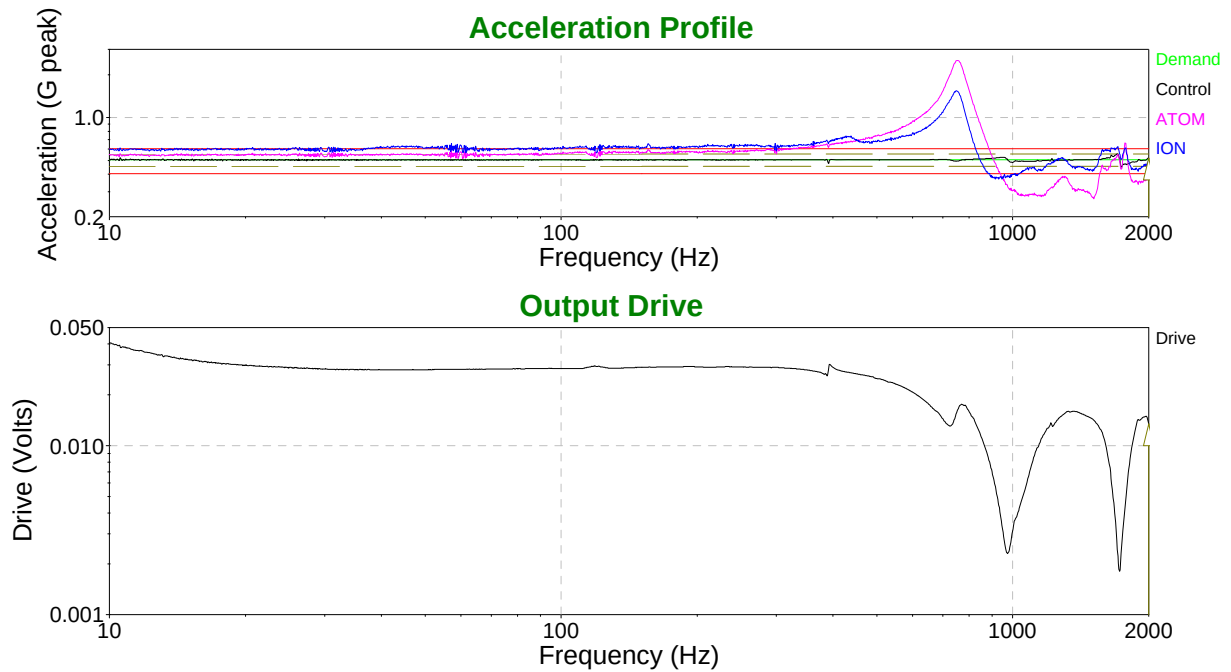


Category S, Curve C Post Sine Resonance Sweep in X Axis

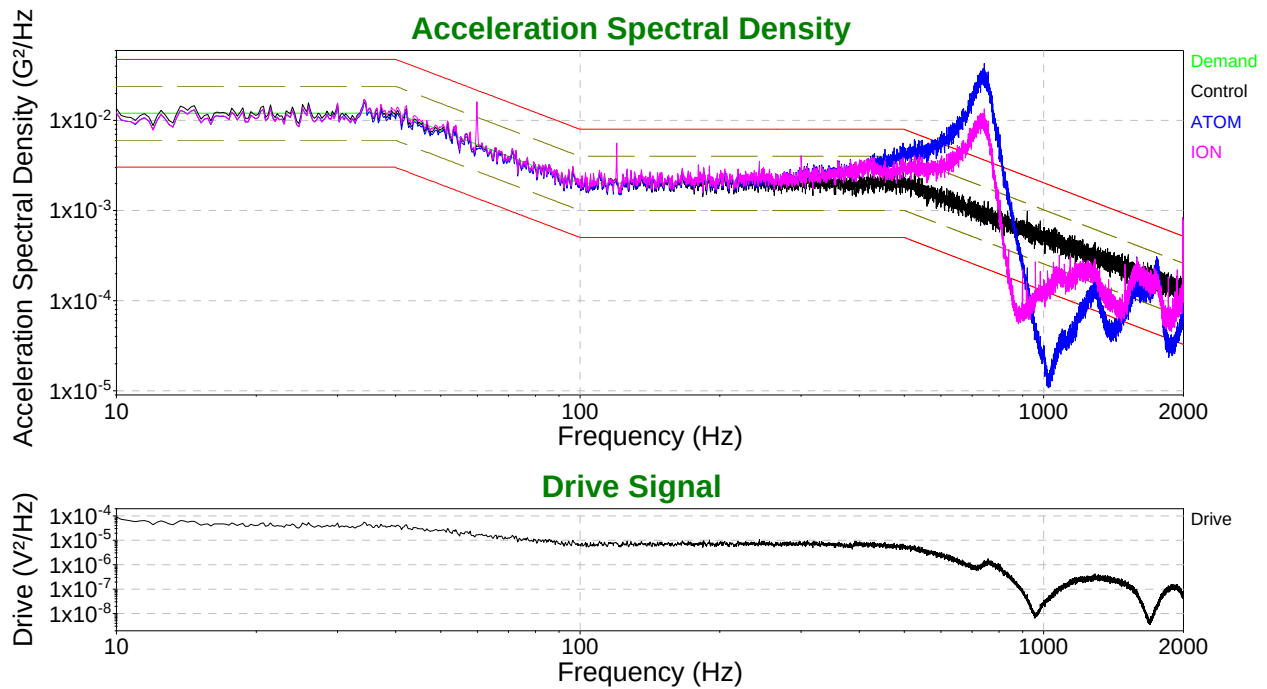




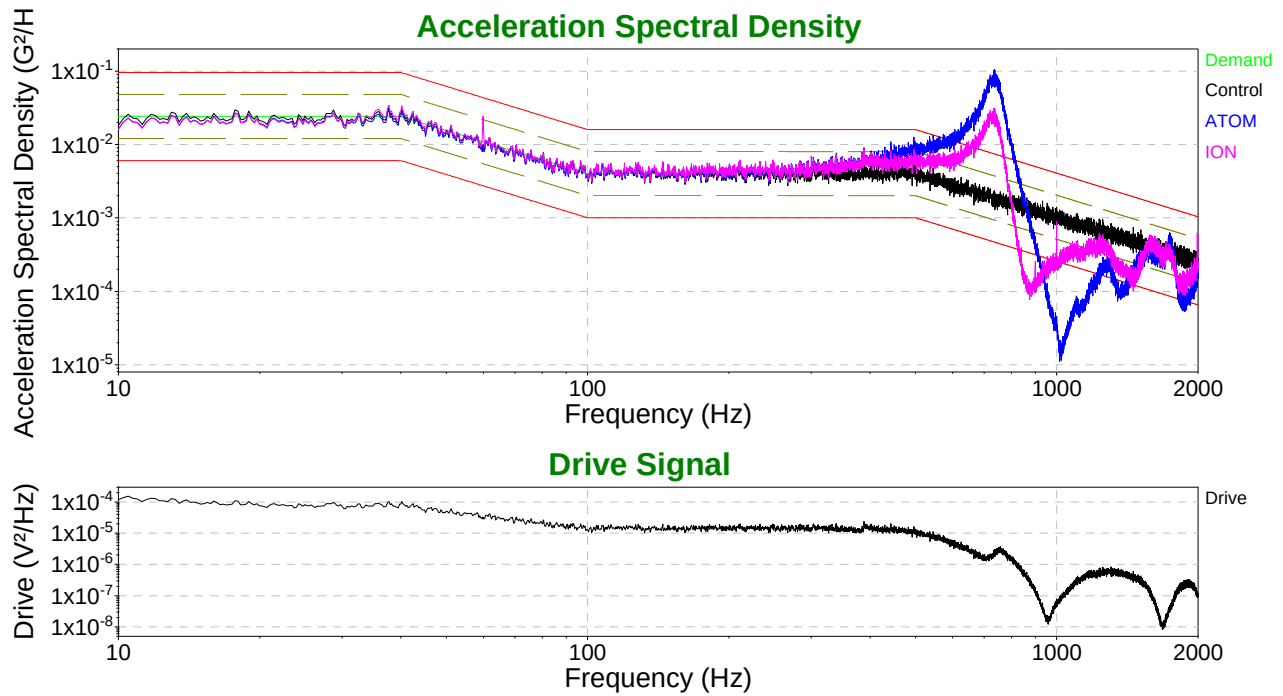
Category S, Curve M Vibration in X Axis



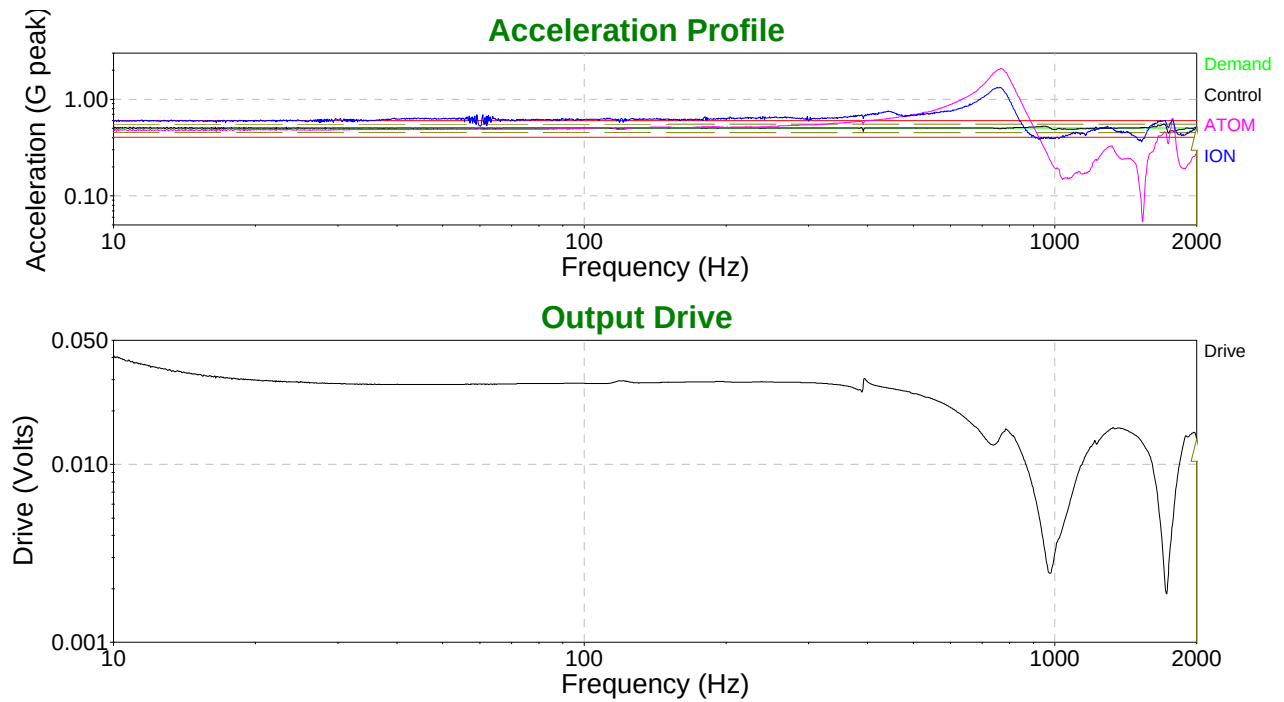
Category R, Curve B Pre Sine Vibration in X Axis



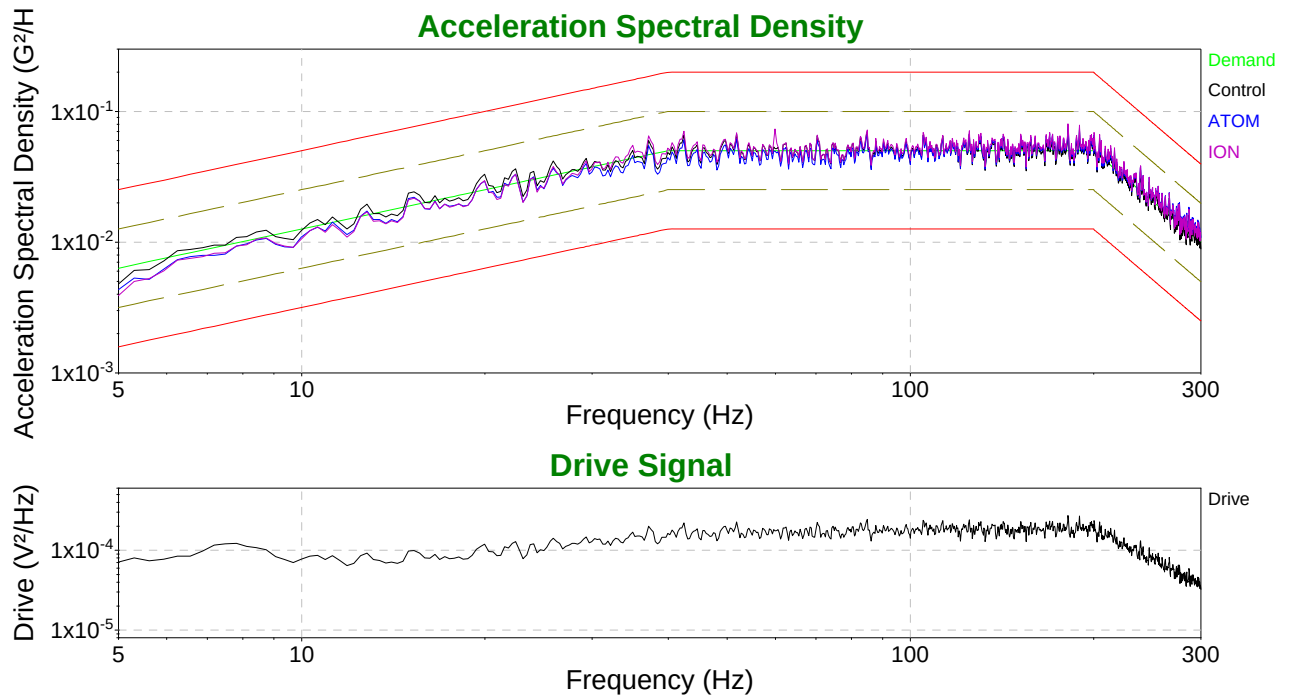
Category R, Curve B Vibration in X Axis



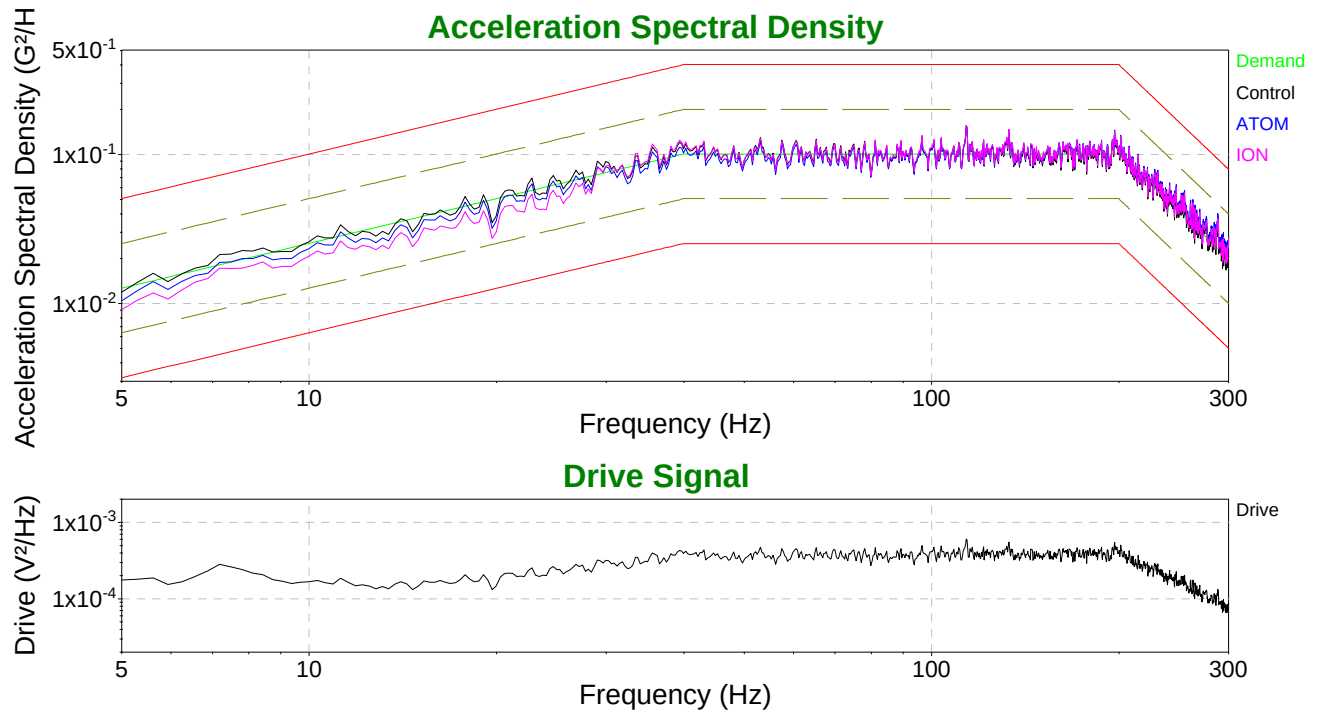
Category R, Curve B1 Vibration in X Axis



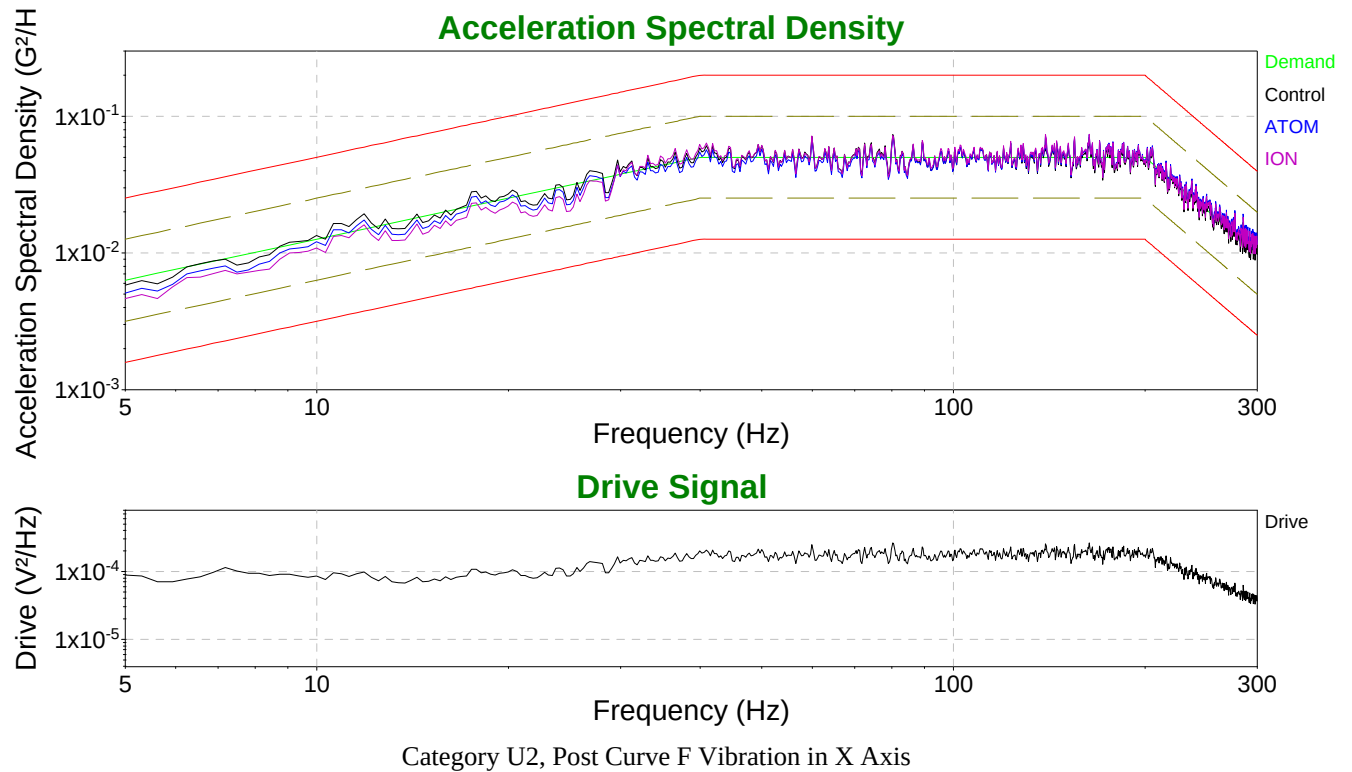
Category R, Curve B Post Sine Vibration in X Axis

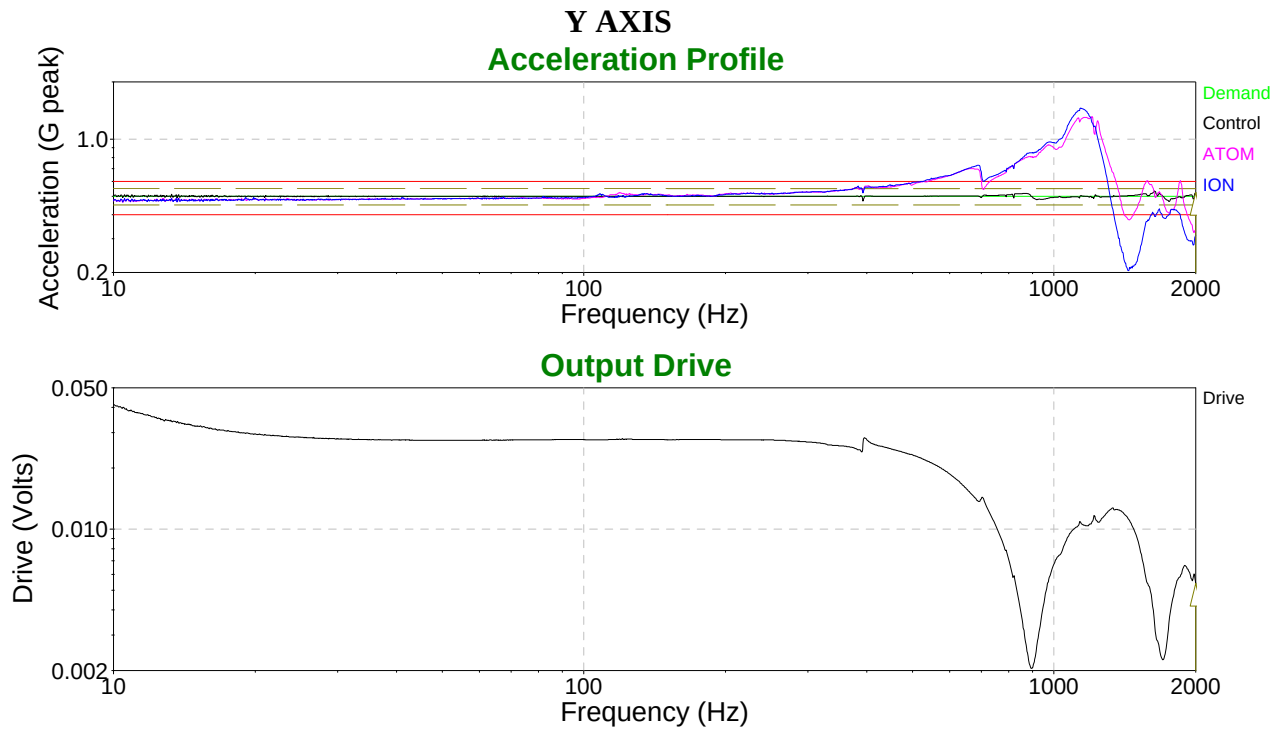


Category U2, Pre Curve F Vibration in X Axis

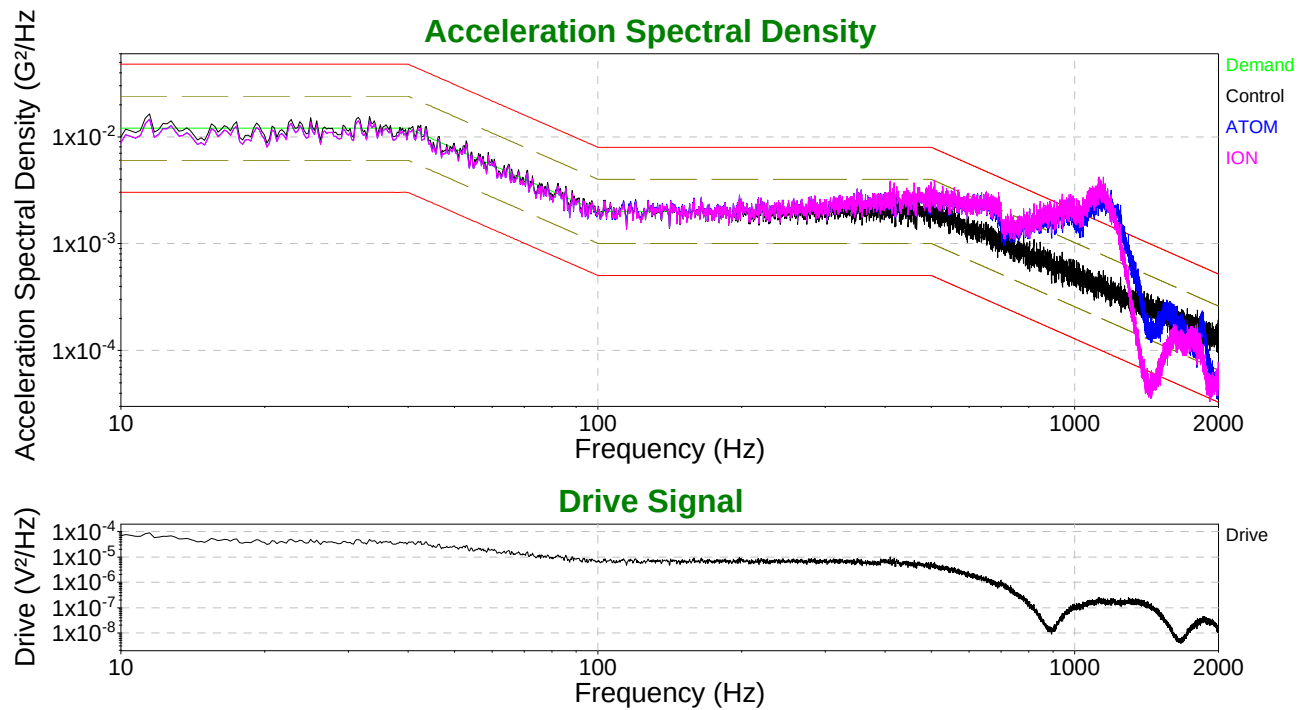


Category U2, Curve F1 Vibration in X Axis

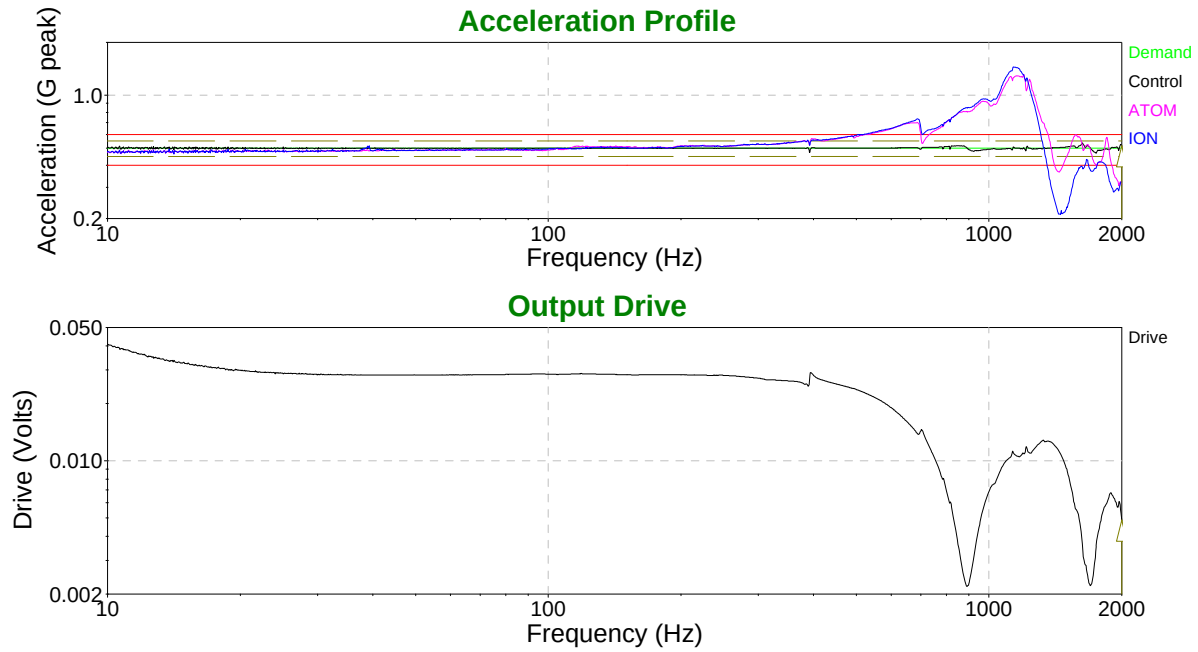




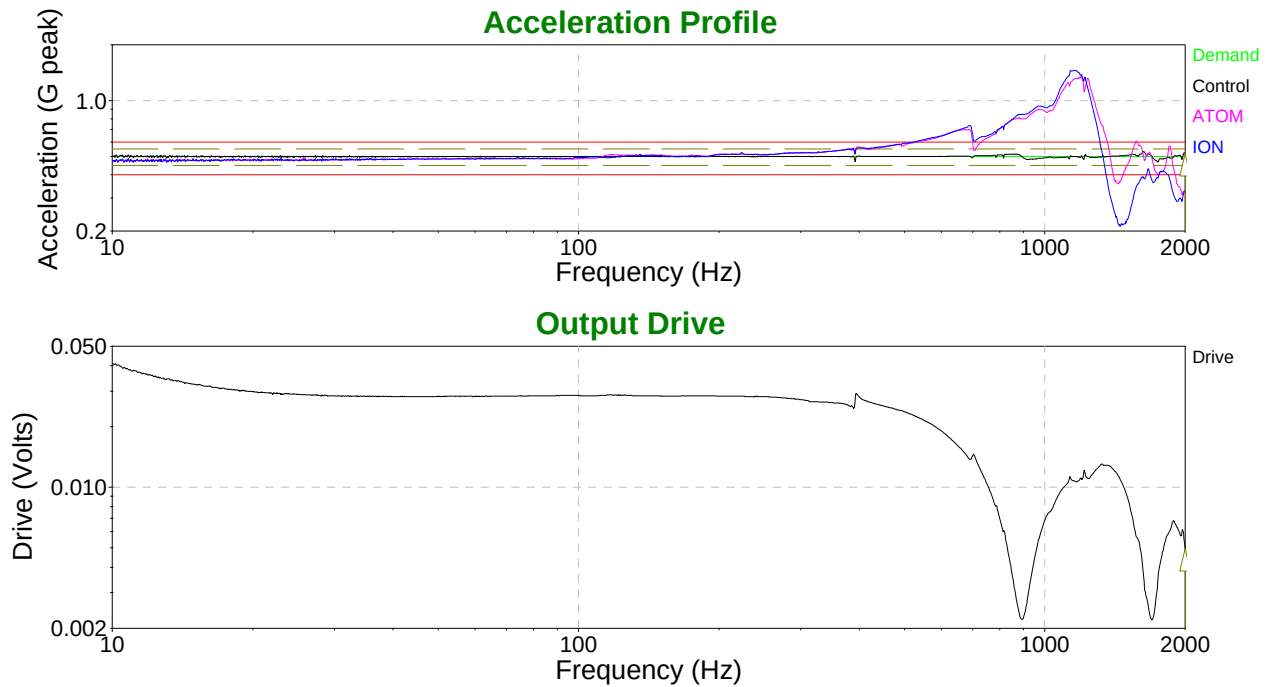
Category S, Curve B Pre Sine Vibration in Y Axis



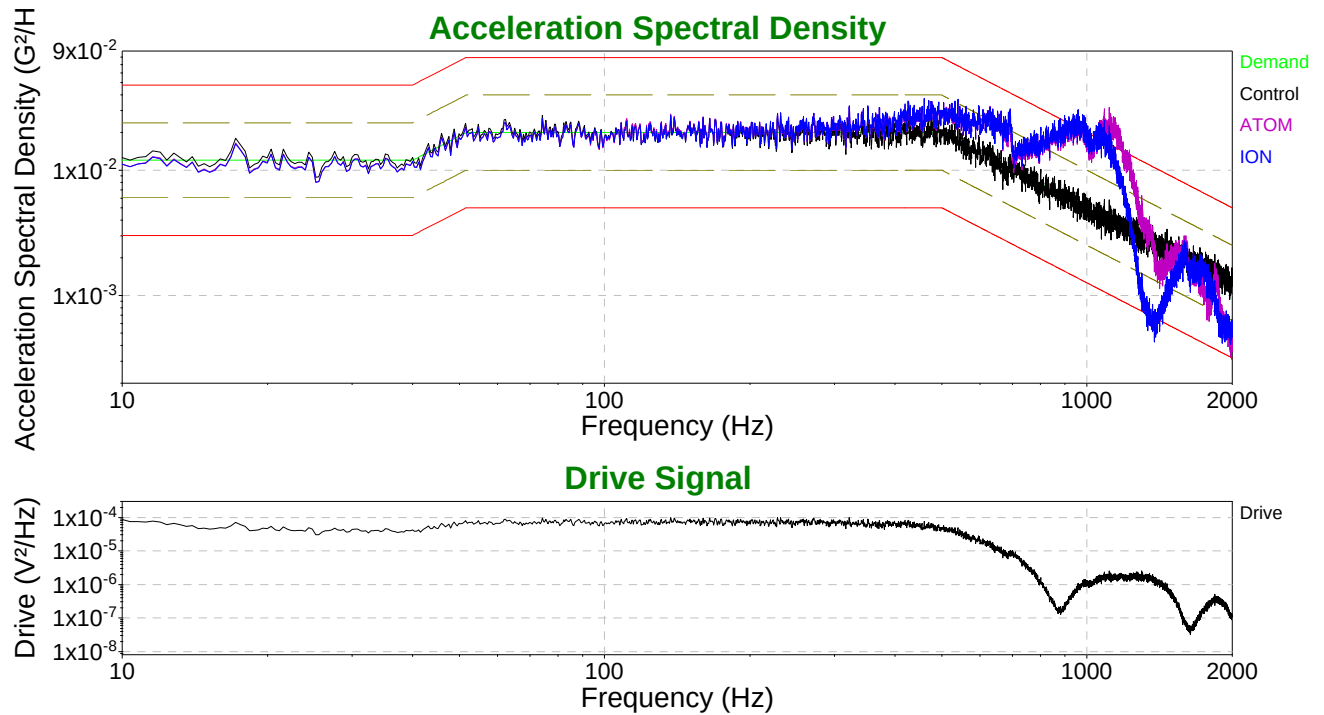
Category S, Curve B Vibration in Y Axis



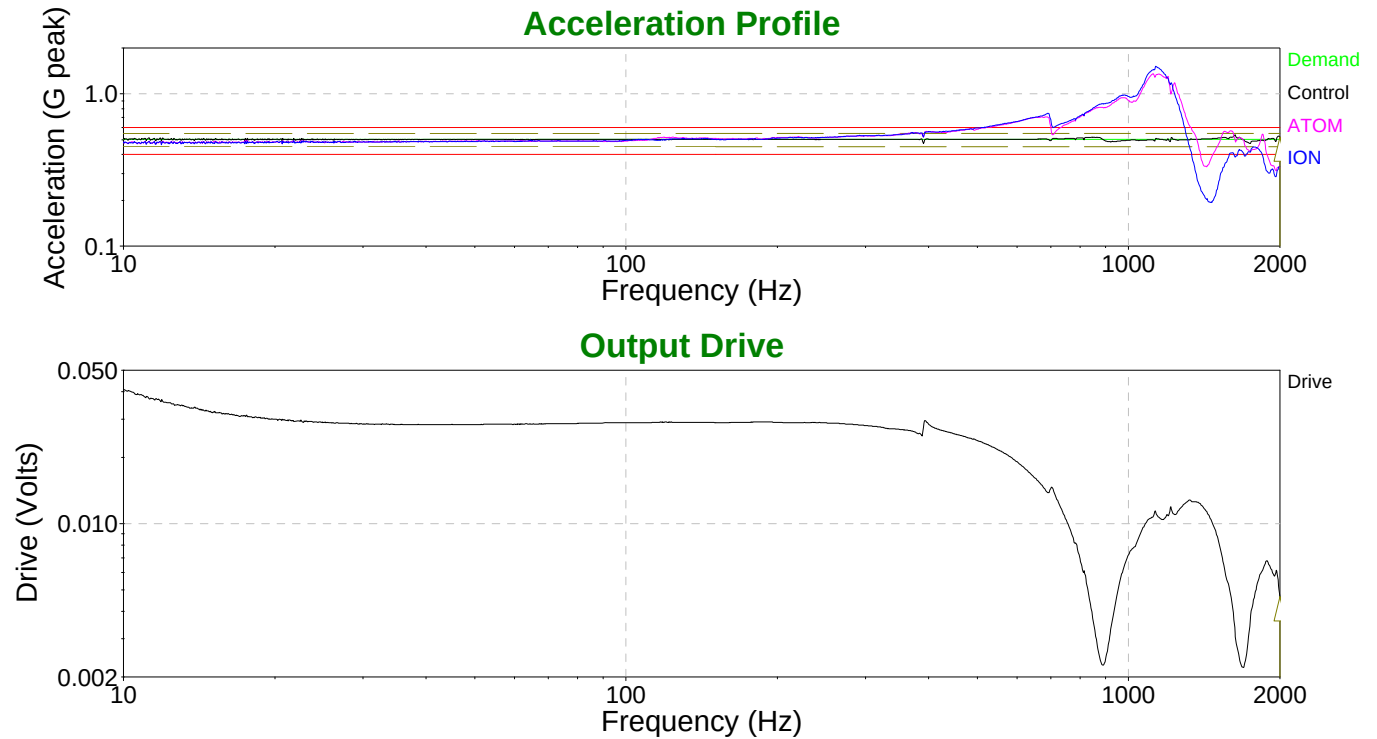
Category S, Curve B Post Sine Vibration in Y Axis



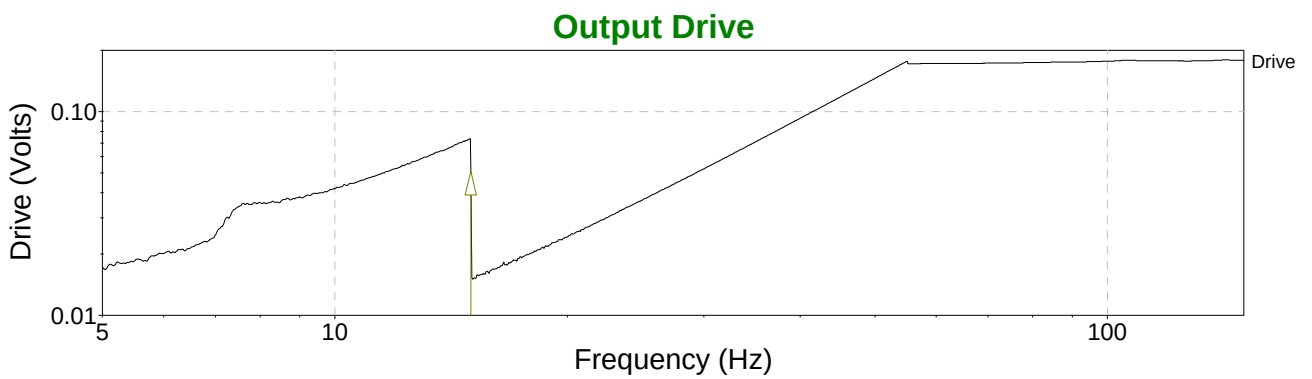
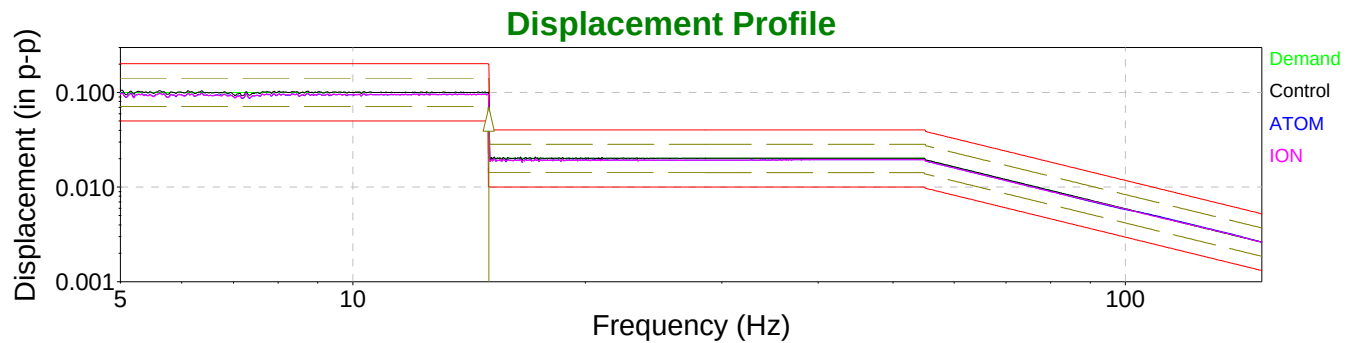
Category S, Curve C Pre Sine Vibration in Y Axis



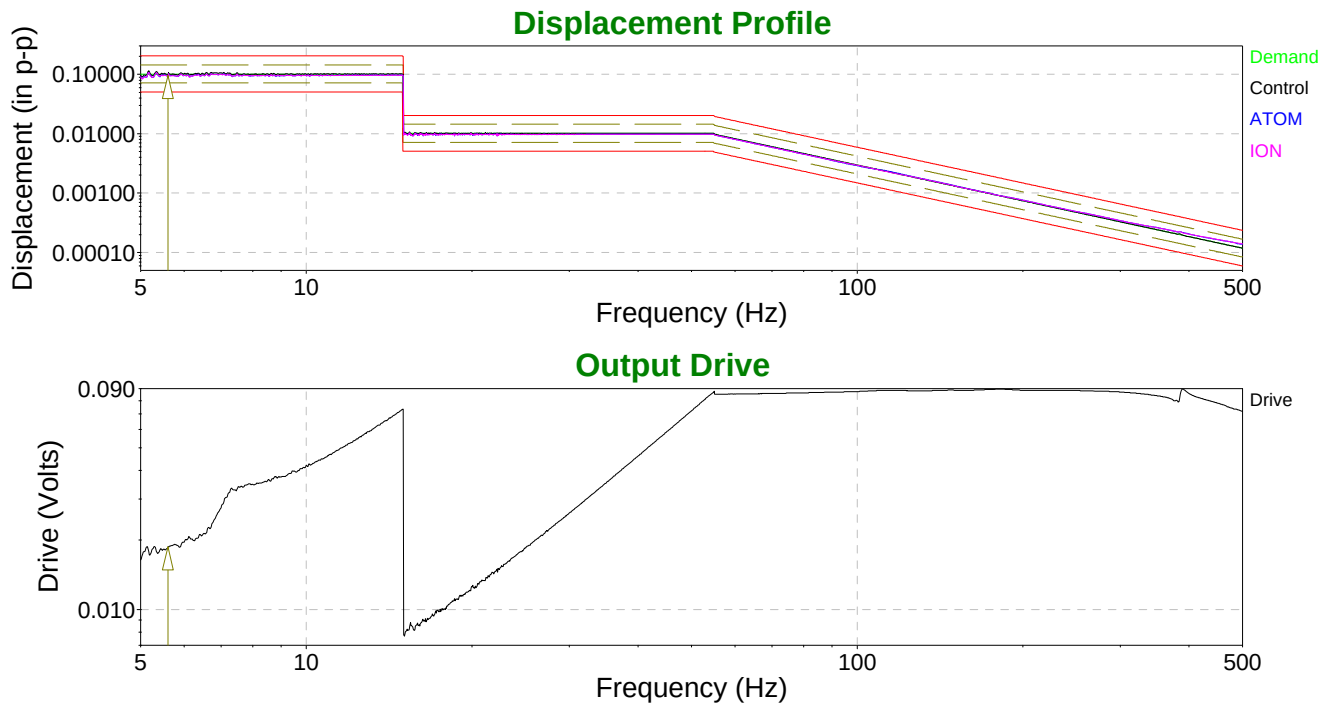
Category S, Curve C Vibration in Y Axis



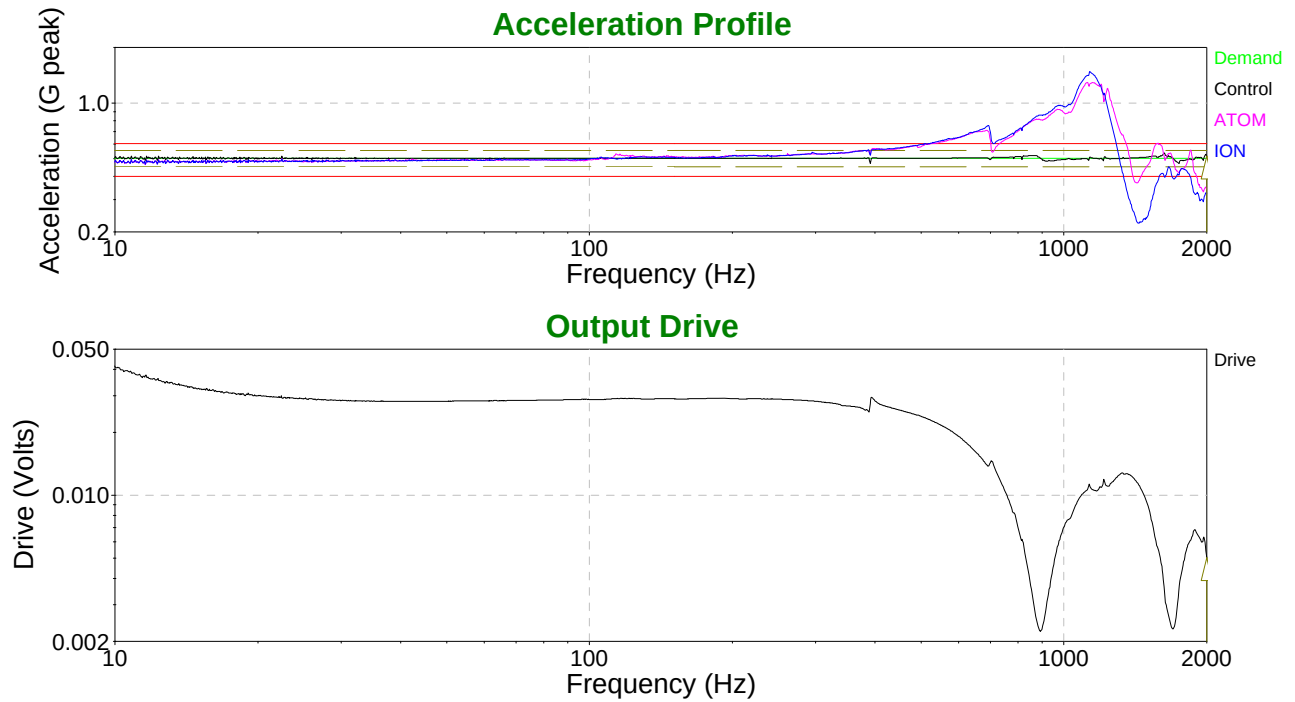
Category S, Curve C Post Sine Vibration in Y Axis



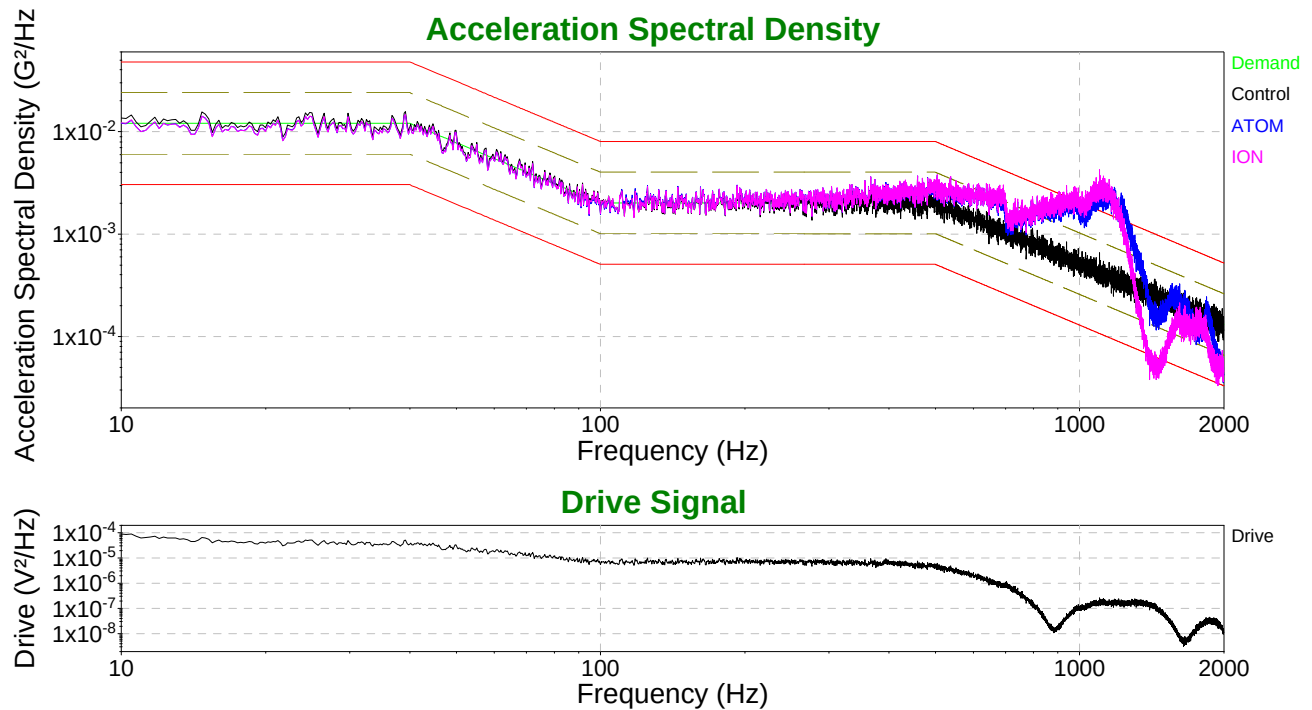
Category S, Curve L Vibration in Y Axis



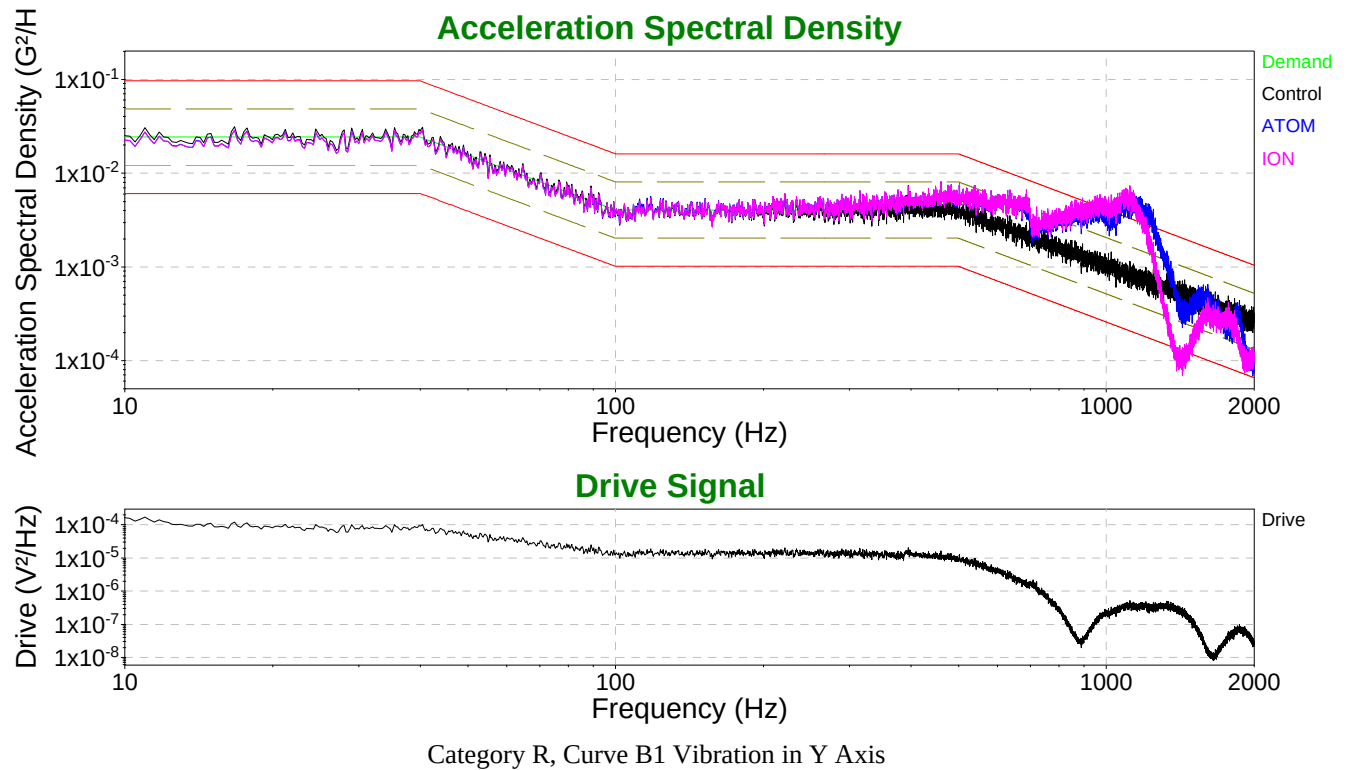
Category S, Curve M Vibration in Y Axis

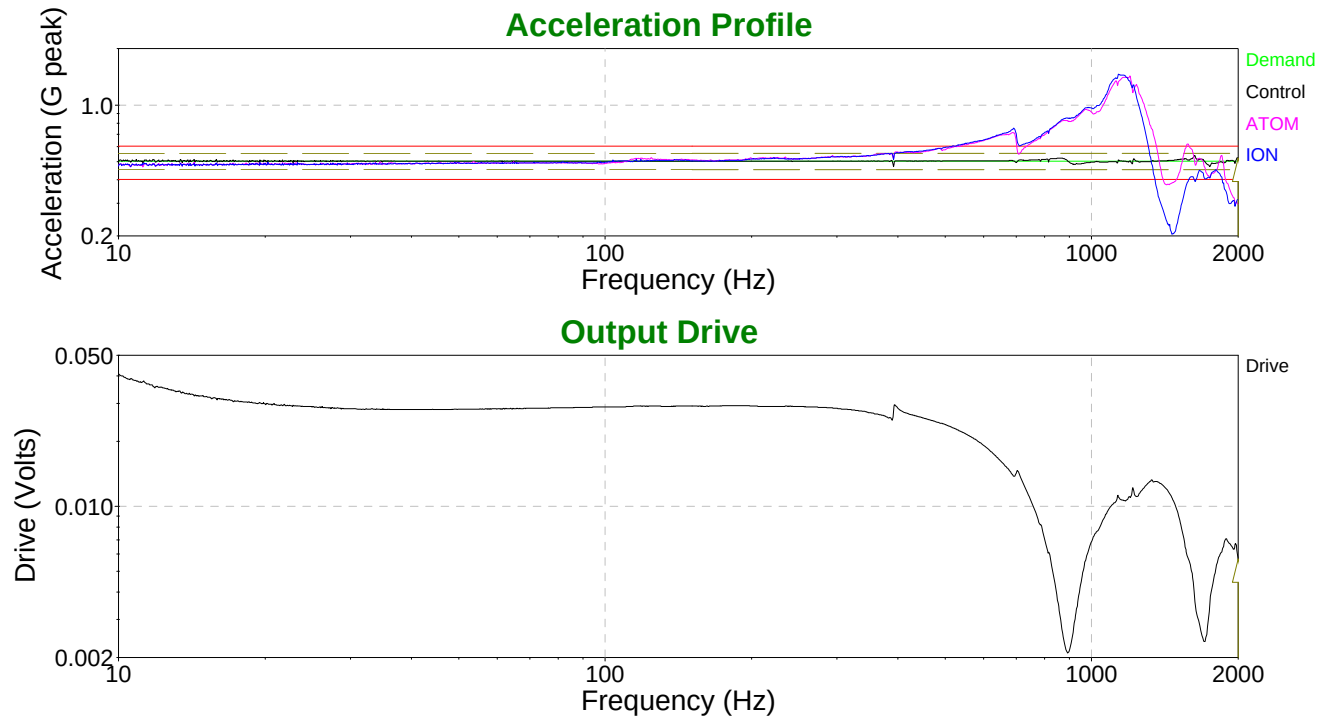


Category R, Curve B Pre Sine Vibration in Y Axis

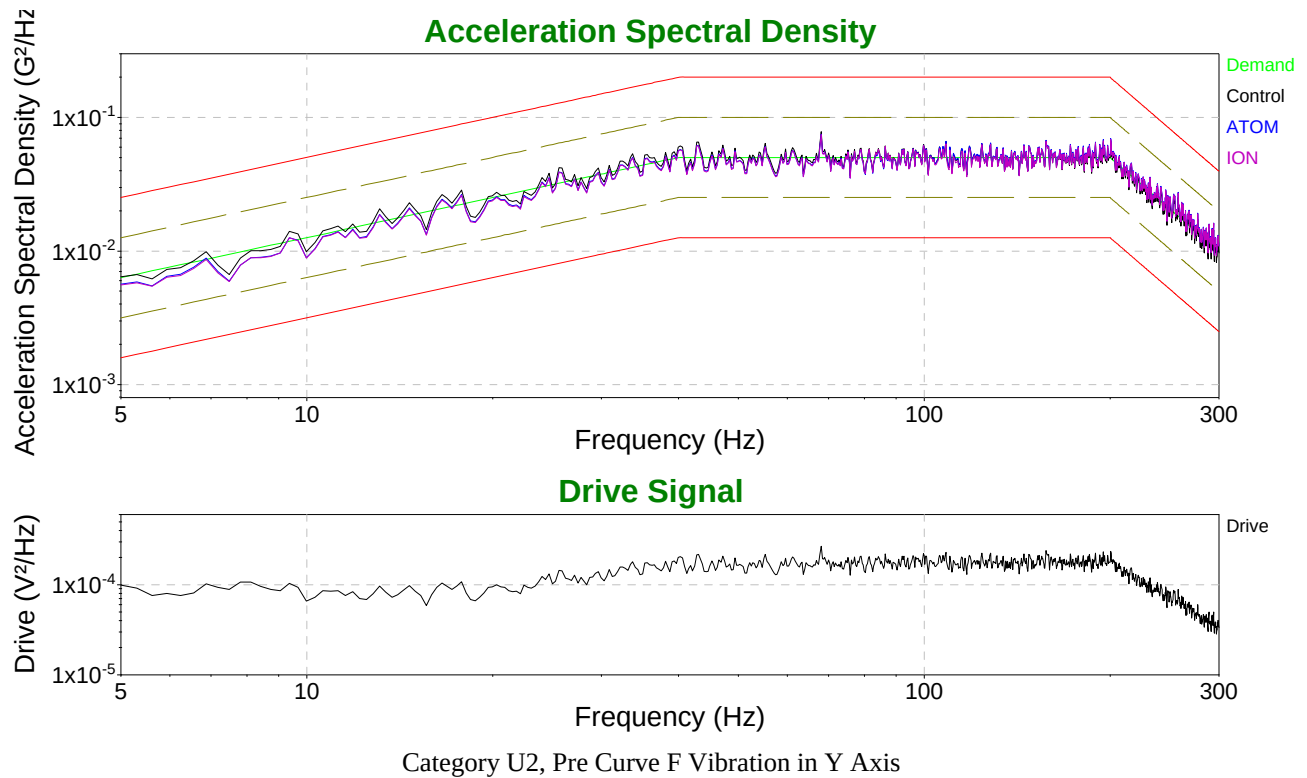


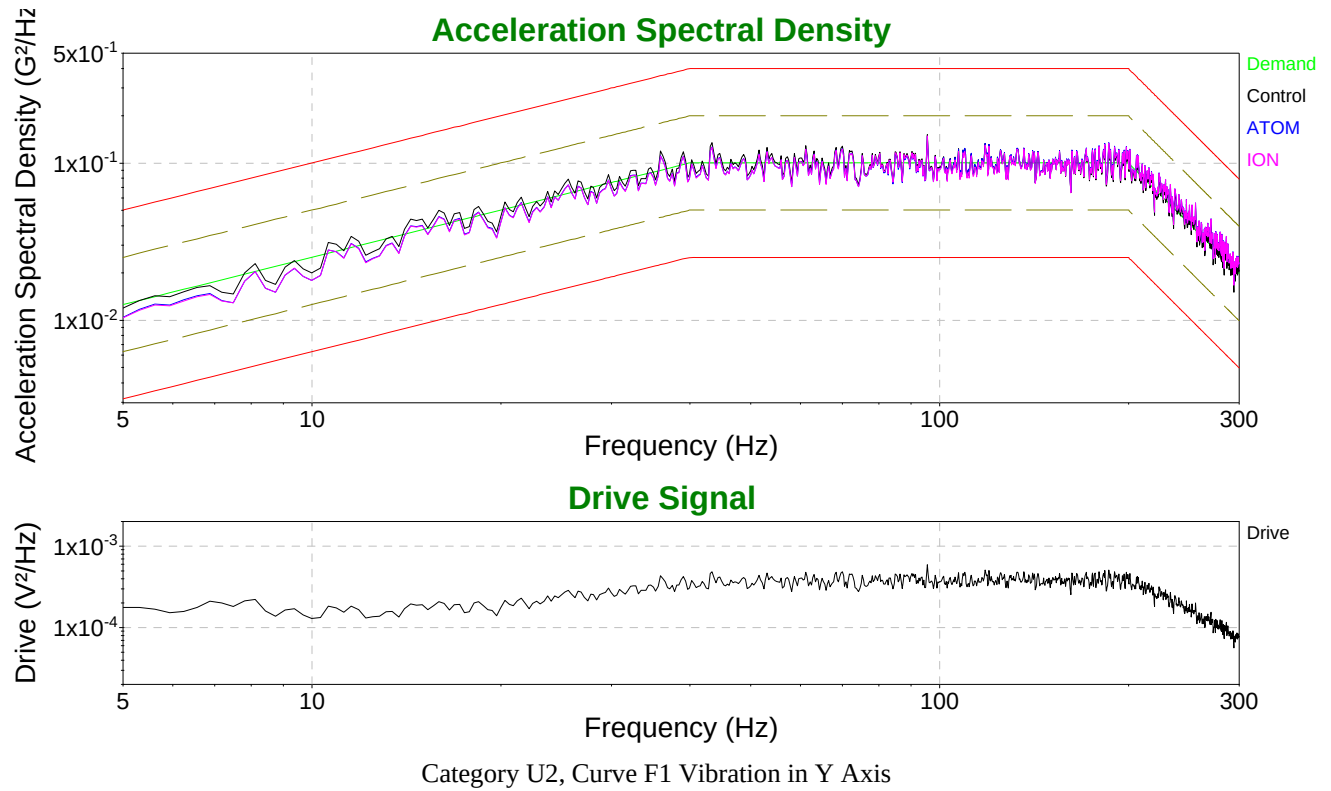
Category R, Curve B Vibration in Y Axis

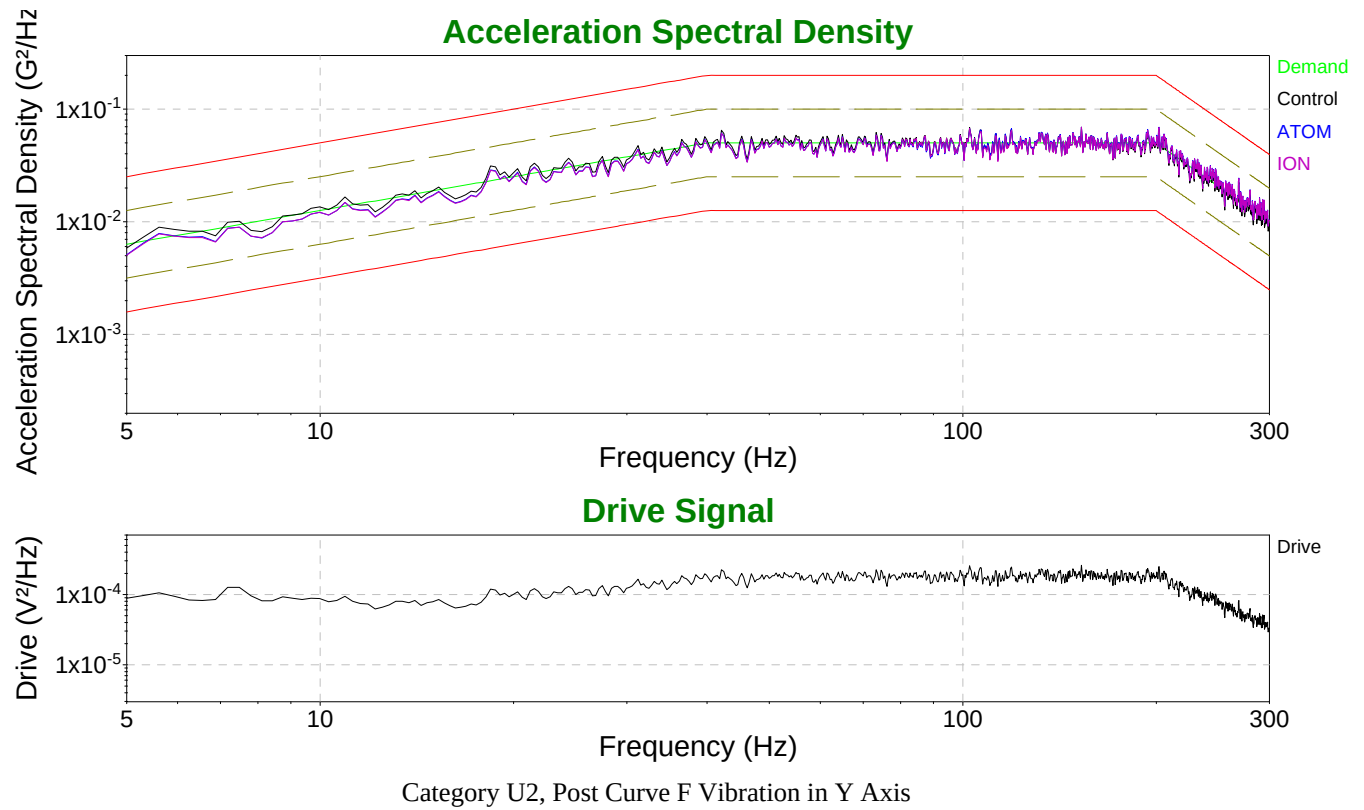




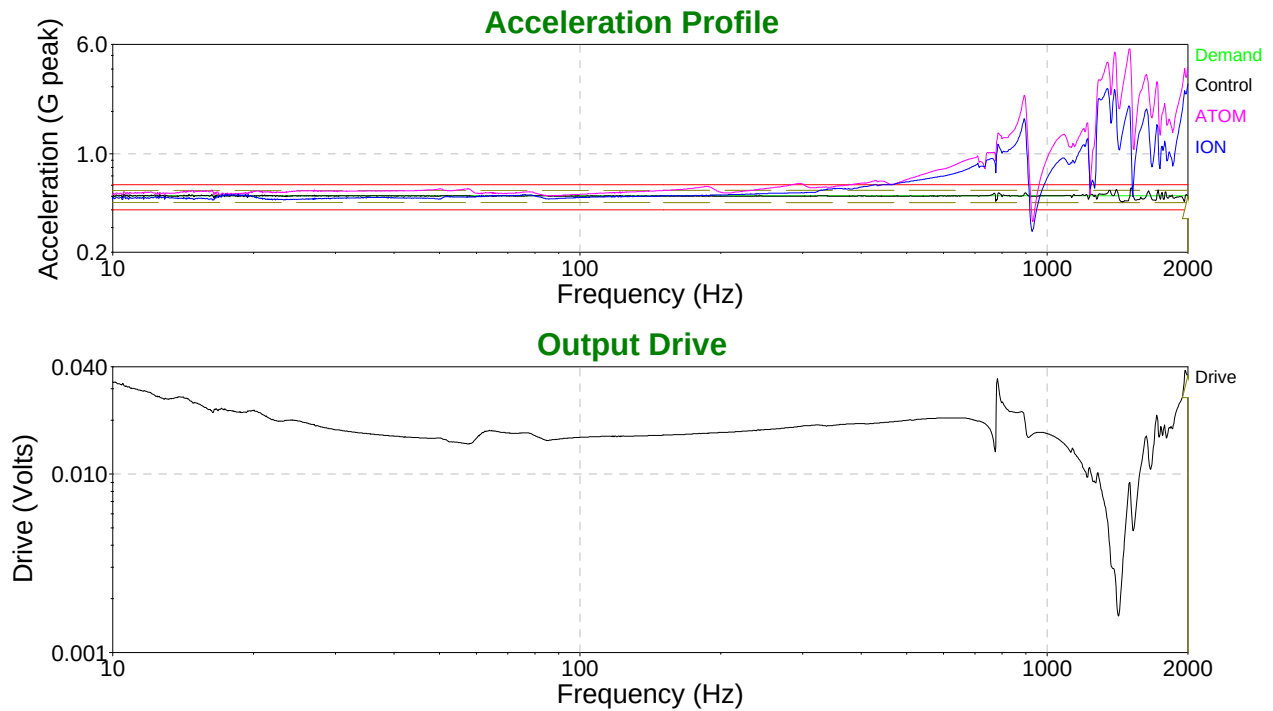
Category R, Curve B Post Sine Vibration in Y Axis



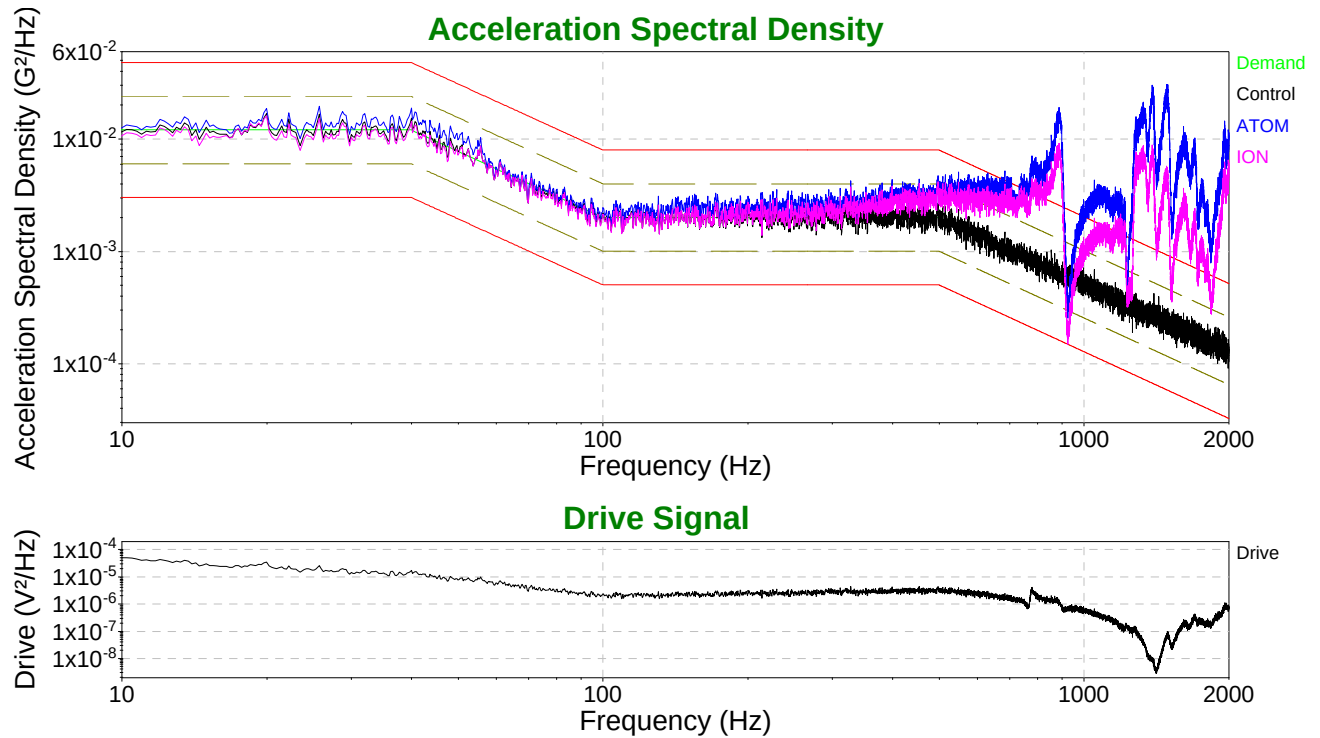




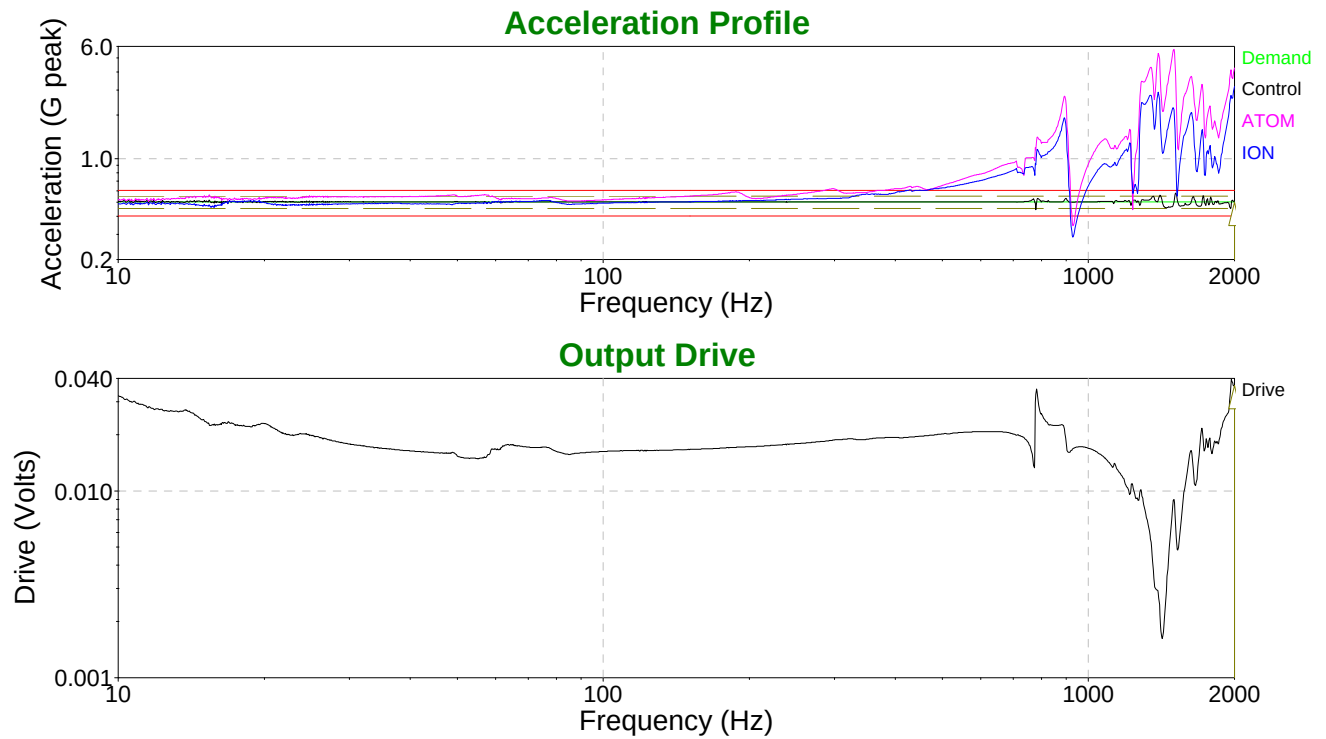
Z AXIS



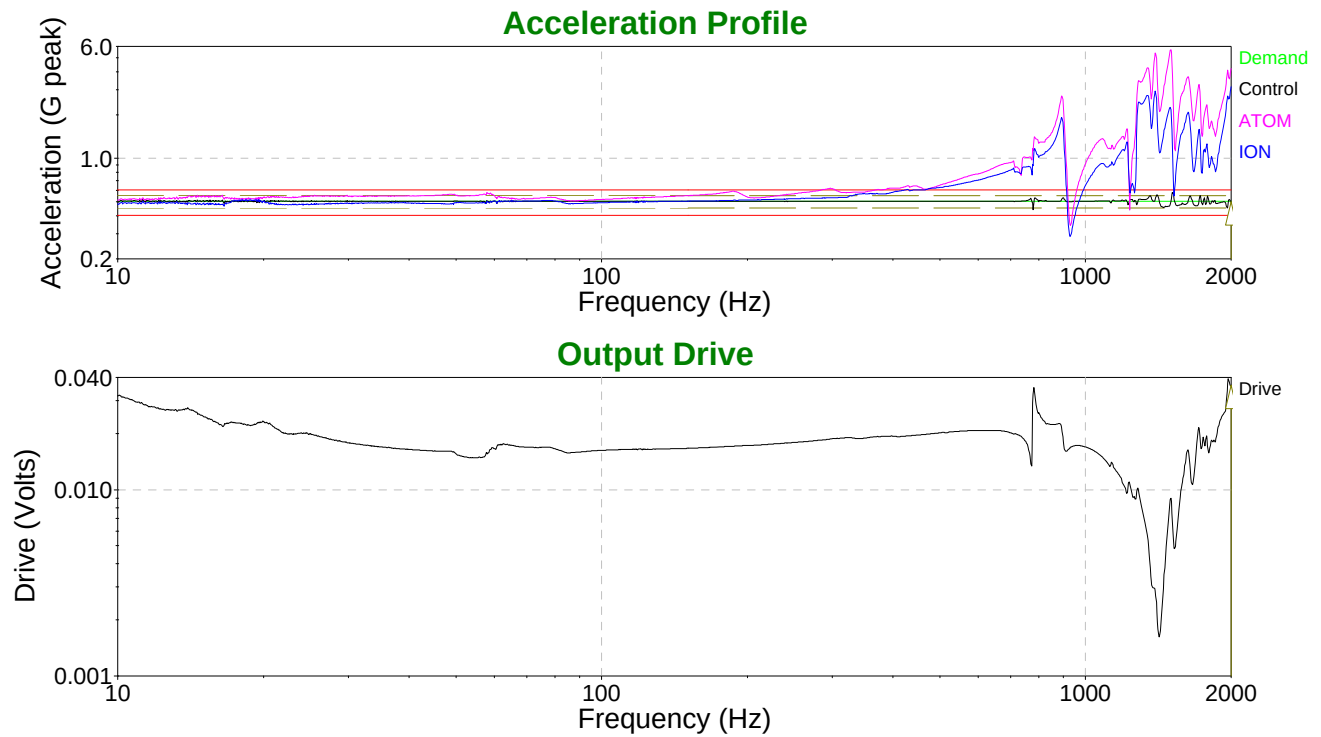
Category S, Curve B Pre Sine Vibration in Z Axis



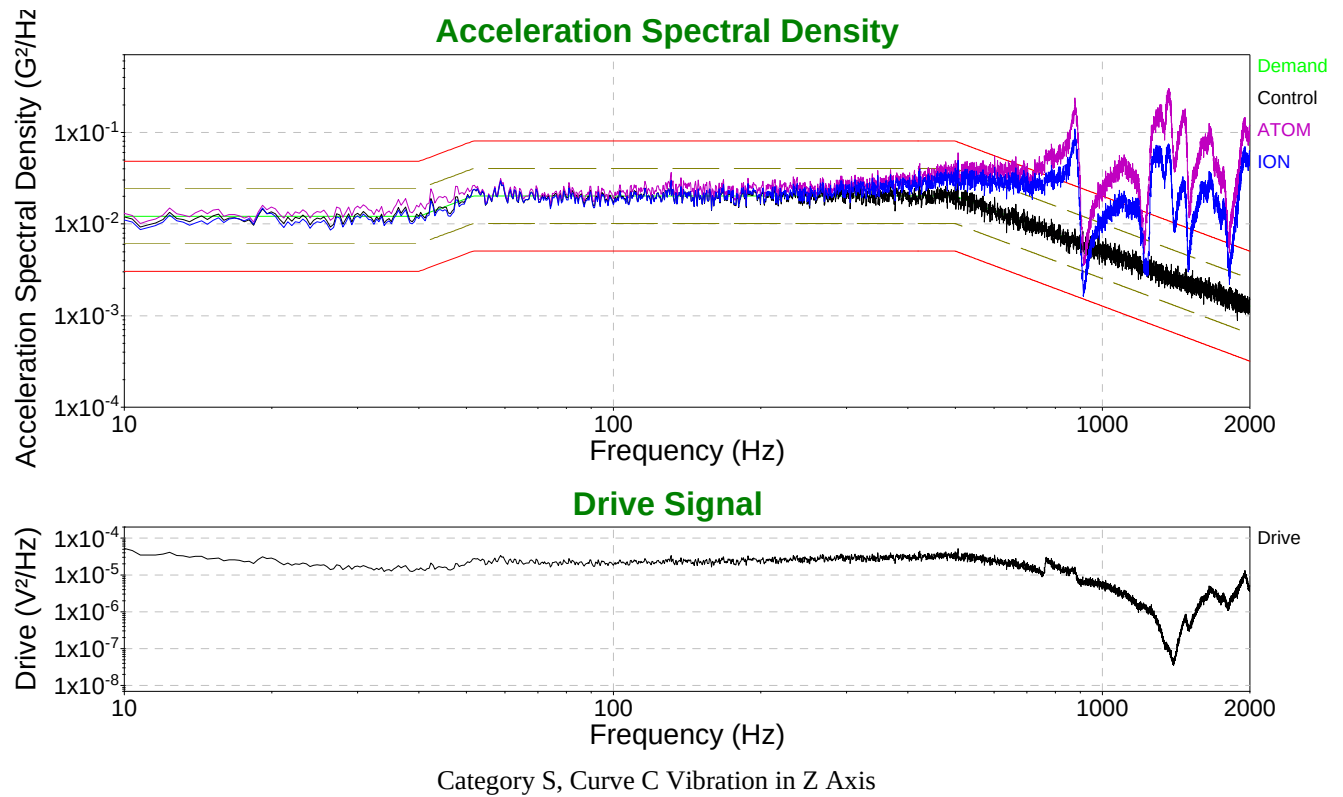
Category S, Curve B Vibration in Z Axis

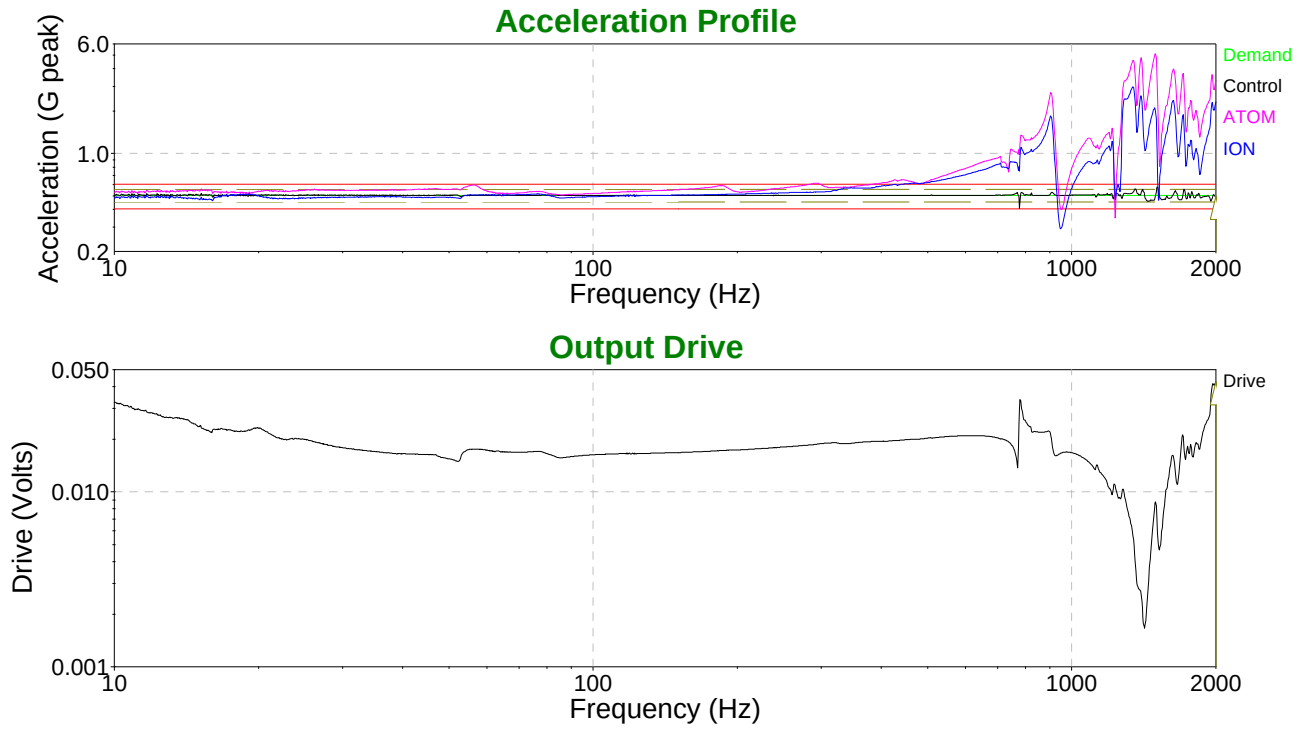


Category S, Curve B Post Sine Vibration in Z Axis

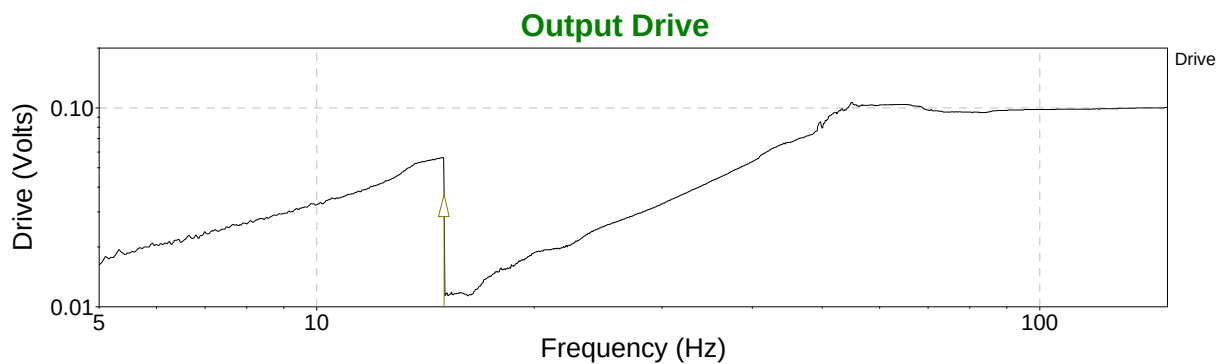
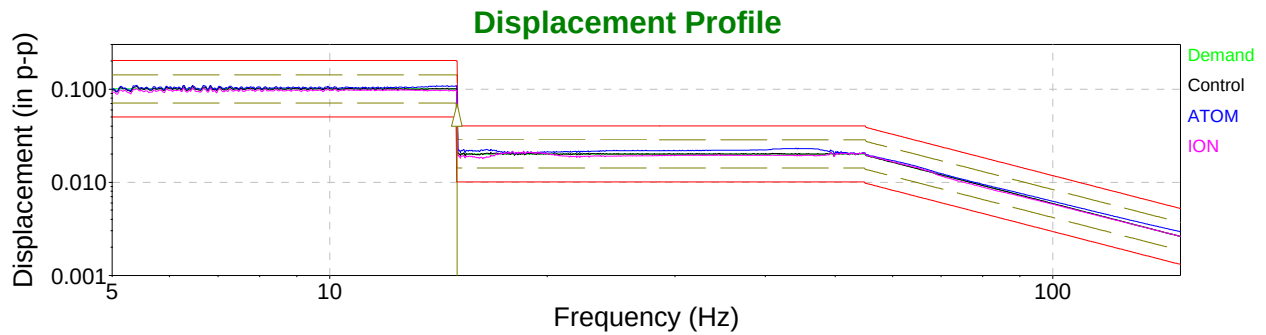


Category S, Curve C Pre Sine Vibration in Z Axis

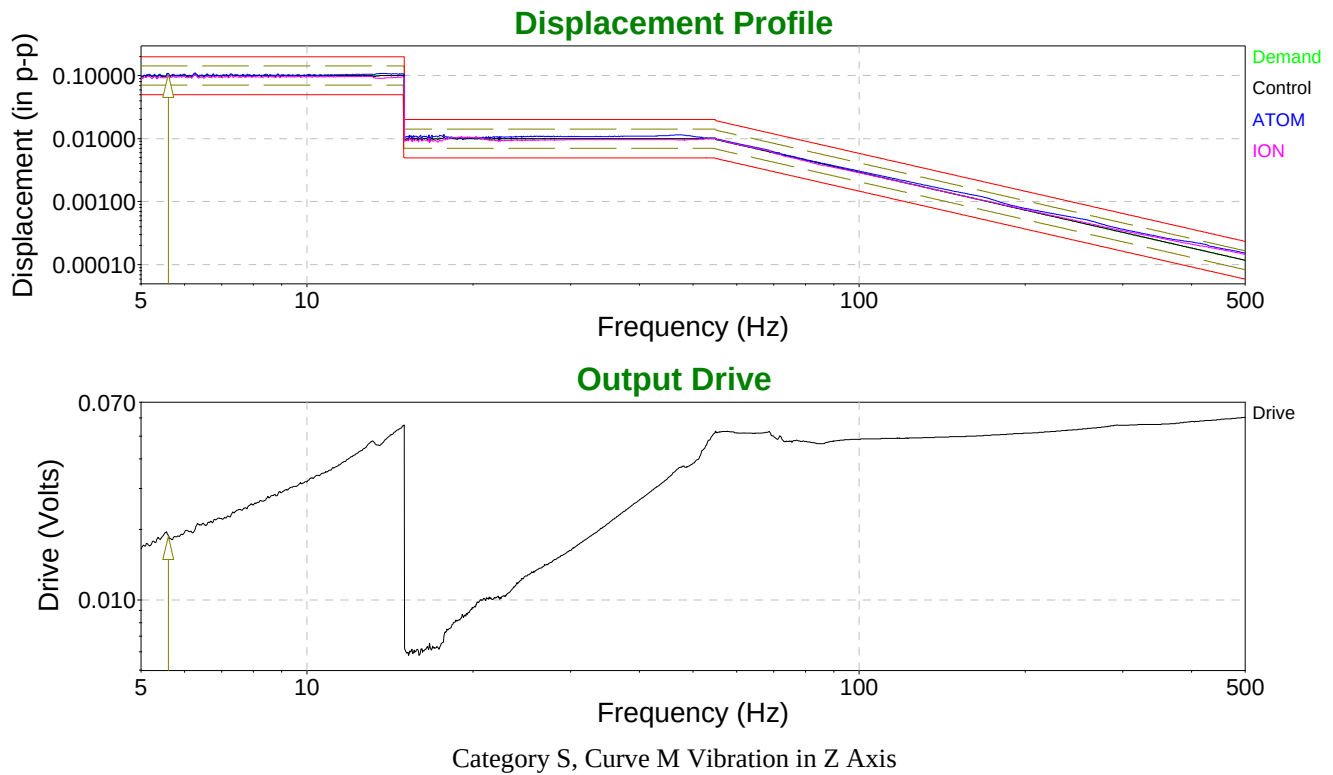


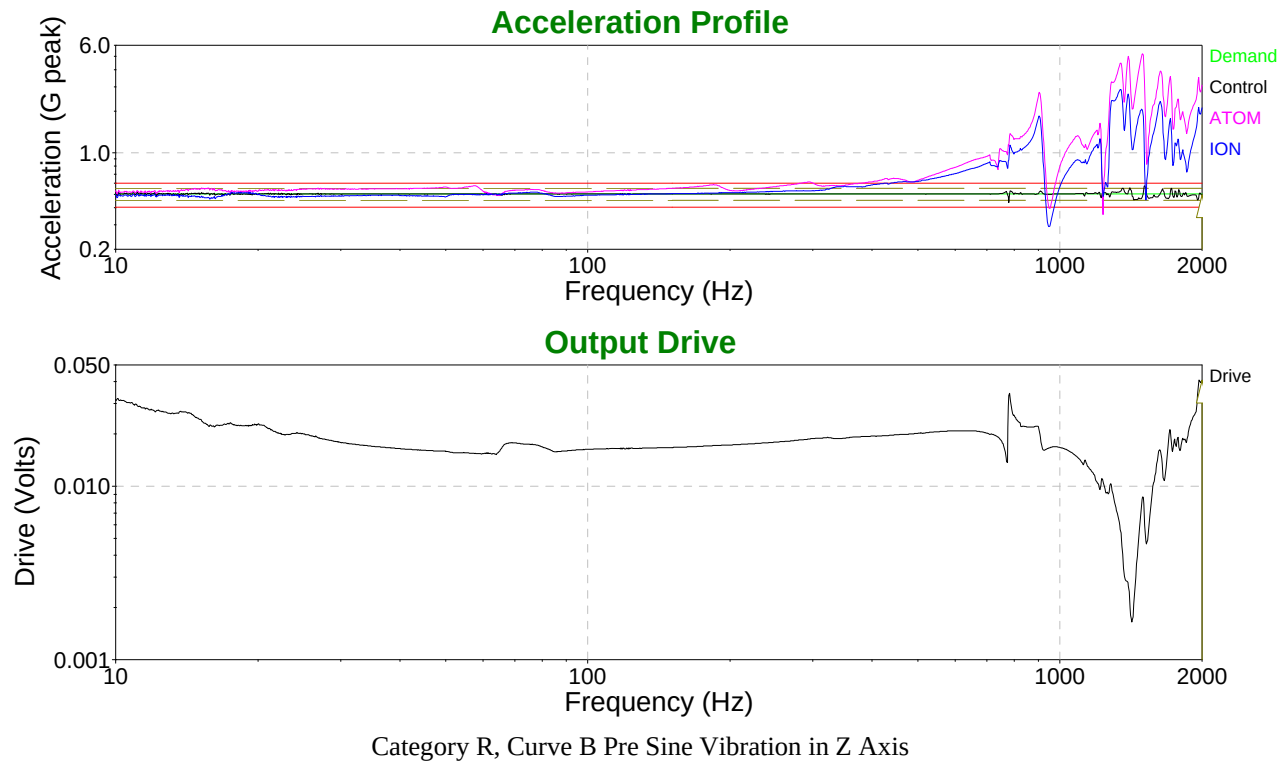


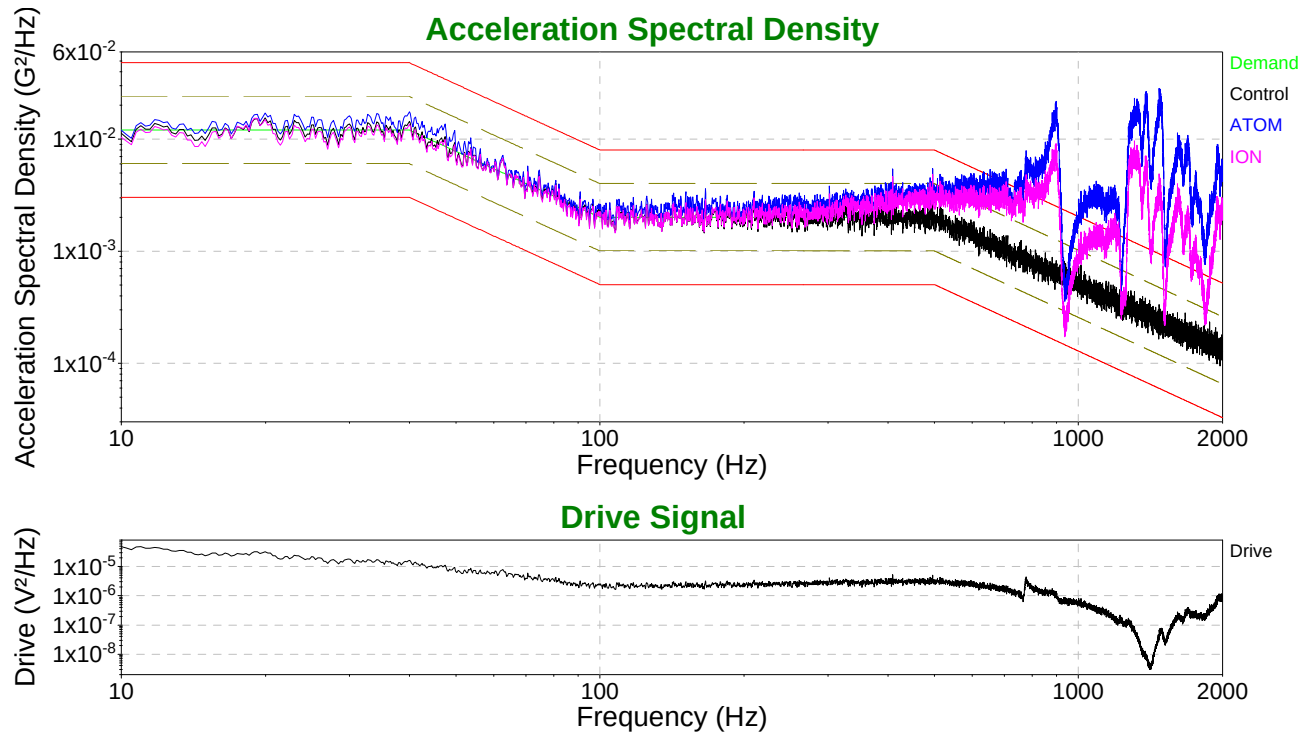
Category S, Curve C Post Sine Vibration in Z Axis



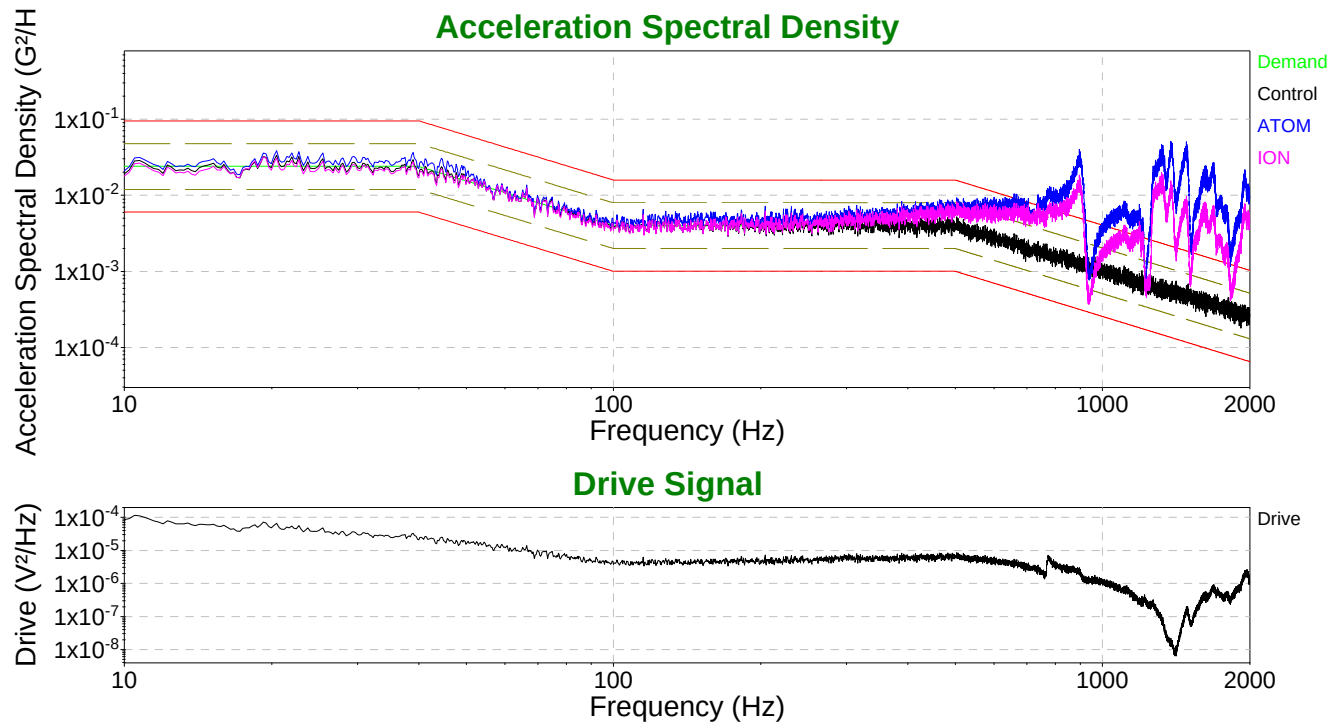
Category S, Curve L Vibration in Z Axis



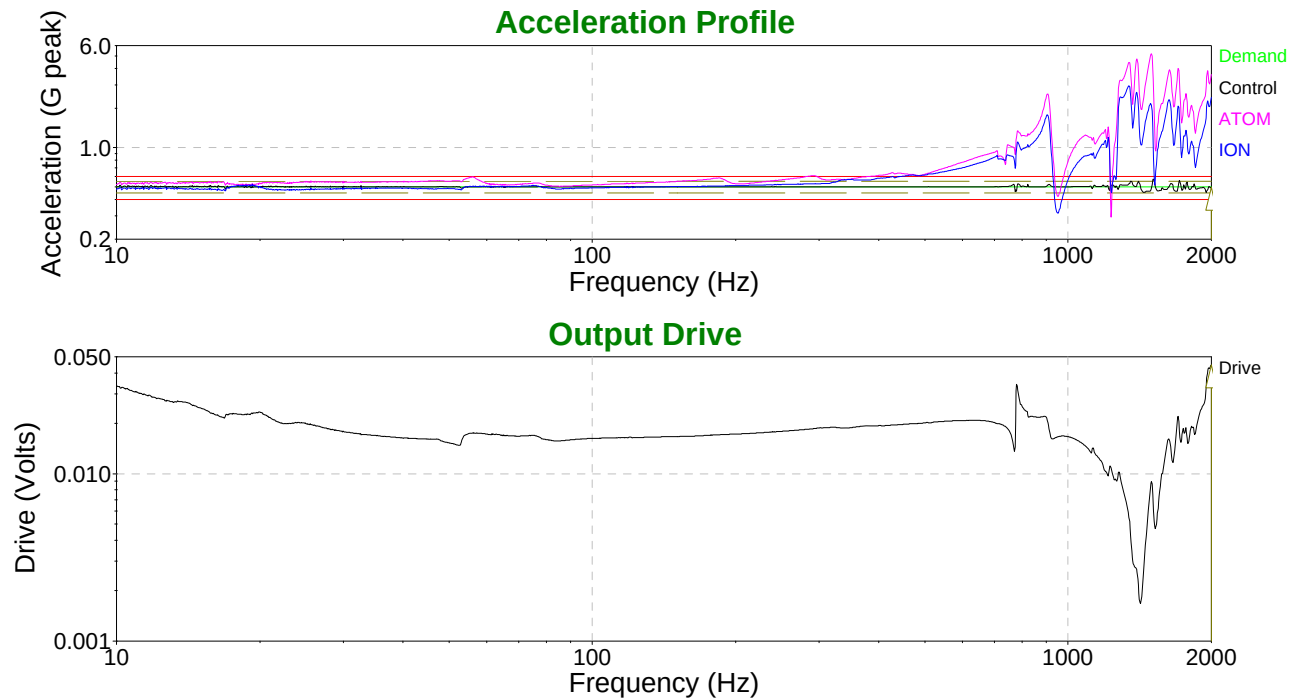




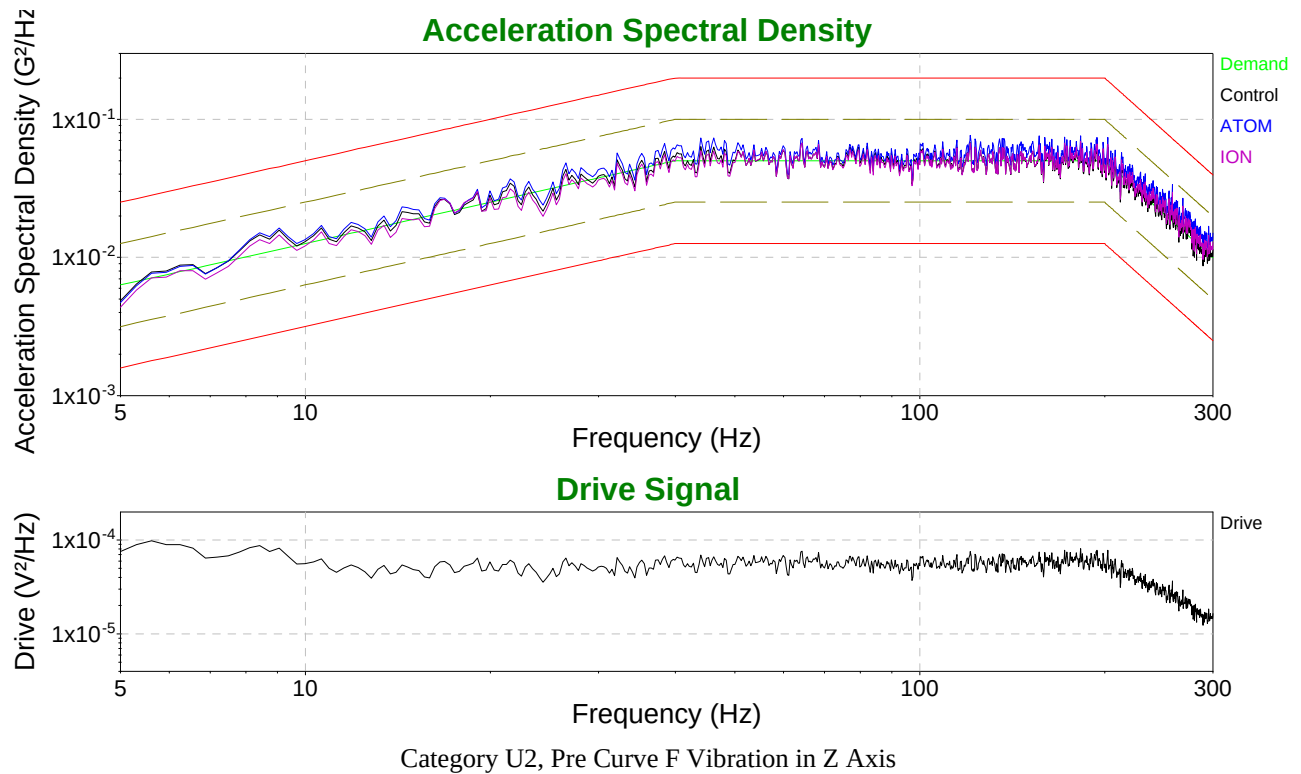
Category R, Curve B Vibration in Z Axis

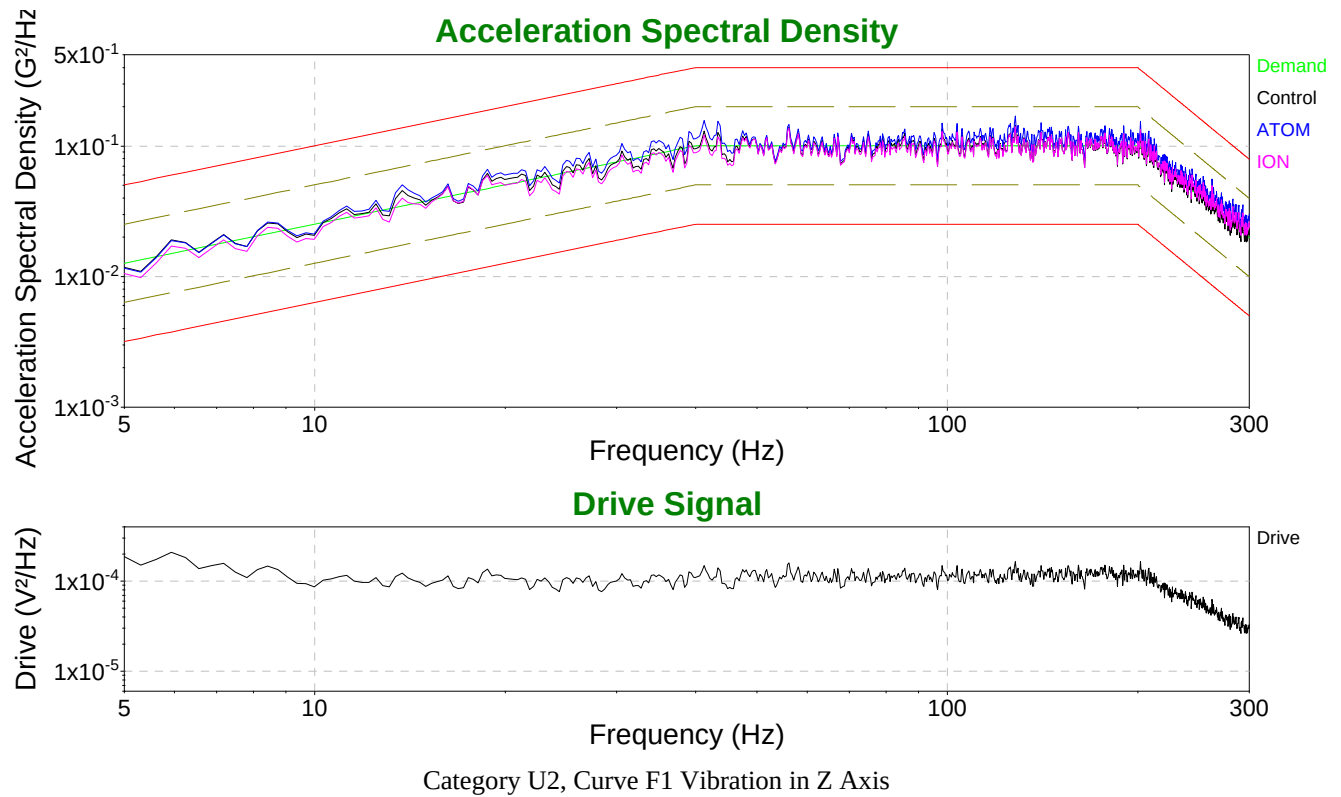


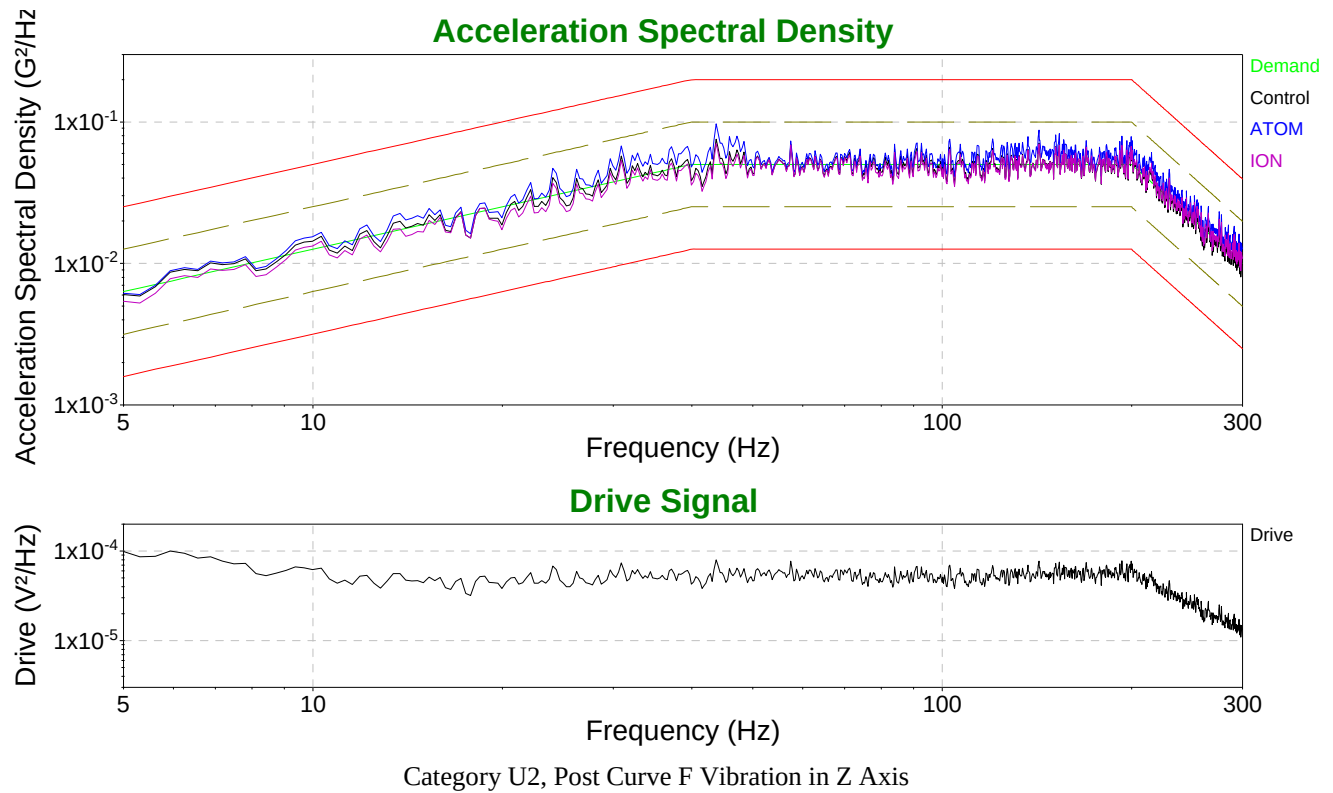
Category R, Curve B1 Vibration in Z Axis



Category R, Curve B Post Sine Vibration in Z Axis







OPERATIONAL SHOCK TEST

TEST DATES

07/28/2017 - 08/02/2017

EQUIPMENT UNDER TEST (EUT)

Quantity: One (1)

Model: ION

Serial Number: 110129

Quantity: One (1)

Model: ATOM

Serial Number: 160055

TEST SPECIFICATION

RTCA DO-160G, Section 7.2.1 Category B

REQUIREMENTS

Each EUT shall undergo Operational Shock testing per RTCA DO-160G, Section 7.2.1 Category B. There shall be no failure of any EUT or mounting bracket. All equipment shall remain in place. There shall be no physical or electrical failures that prevent each EUT from being operated per customer's post-test requirements.

PROCEDURE

RTCA DO-160G, Section 7.2.1 Category B

- 1) Perform a standard compliance check.
- 2) Mount both EUT's to the provided shock fixture.
- 3) Fasten shock fixture in axis of test.
- 4) Attach a control accelerometer parallel to the axis of excitation.
- 5) Attach a response accelerometer to each EUT parallel to the axis of excitation.
- 6) Apply specified power to each EUT and monitor operation throughout this test.
- 7) Start the shock profile of 3 positive and 3 negative impulses of 6g, 11ms sawtooth in the 1st axis, monitor/record the control and response plot.
- 8) Perform the standard compliance check.
- 9) Mount both EUT's in the 2nd orthogonal axis and repeat the steps above.
- 10) Mount both EUT's in the 3rd orthogonal axis and repeat the steps above.
- 11) Perform the post-test verification.
- 12) Examine each EUT and record any physical abnormalities.



DLS CONFORMITY ASSESSMENT, INC
200 E. Marquardt Drive
Wheeling, IL 60090 USA
Voice 847-537-6400
Fax 847-947-8651
www.dlsemc.com

TEST RESULTS

Both units conformed to all testing. No physical damage was noted to any unit. Each unit passed a post-performance test.

EQUIPMENT USED

Equipment	Manufacturer	DLS Lab Number	Model#	Date Calibrated	Calibration Due Date
Accelerometer	Dytran	268	3333M2T	11/16/2016	11/16/2017
Accelerometer	Dytran	152	3225F1T	09/28/2016	09/28/2017
Accelerometer	Dytran	161	3049E1	05/12/2017	05/12/2018
Accelerometer	Dytran	154	3225F1T	08/09/2016	08/09/2017
Accelerometer	Dytran	159	3049E1	06/16/2017	06/16/2018
Electrodynamic Shaker	LDS	183	V850-440	N/A	Verified w/Calibrated Accelerometers
Vibration Controller	Vibe Research Corp	165	VR9500	09/20/2016	09/20/2017

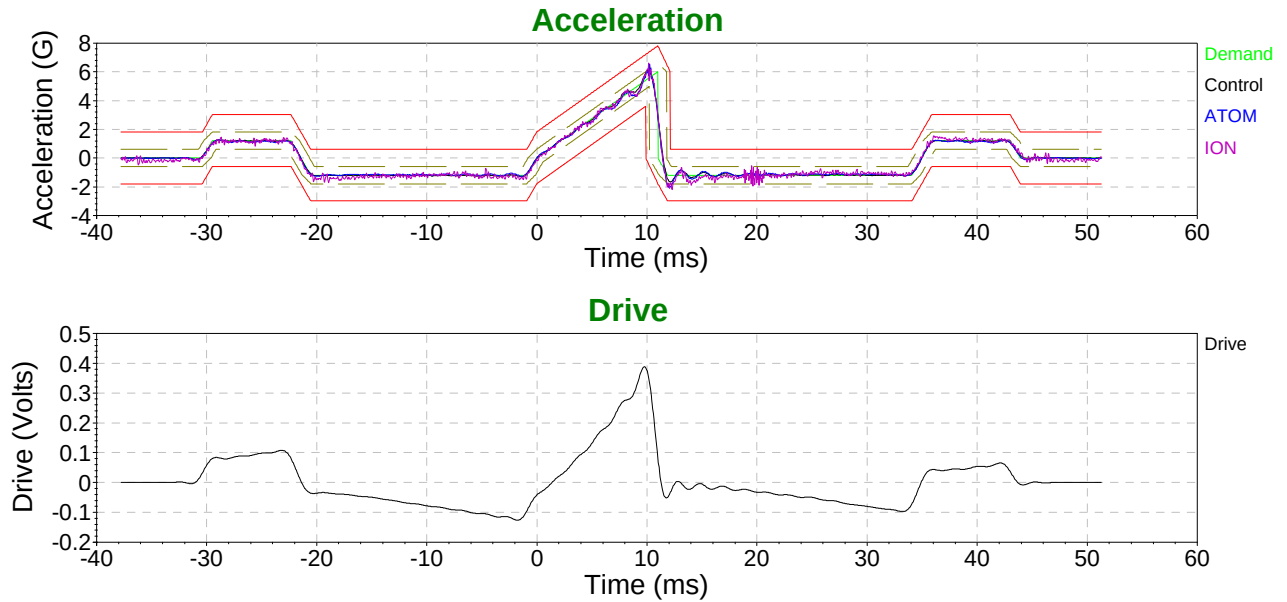


DLS CONFORMITY ASSESSMENT, INC
200 E. Marquardt Drive
Wheeling, IL 60090 USA
Voice 847-537-6400
Fax 847-947-8651
www.dlsemc.com

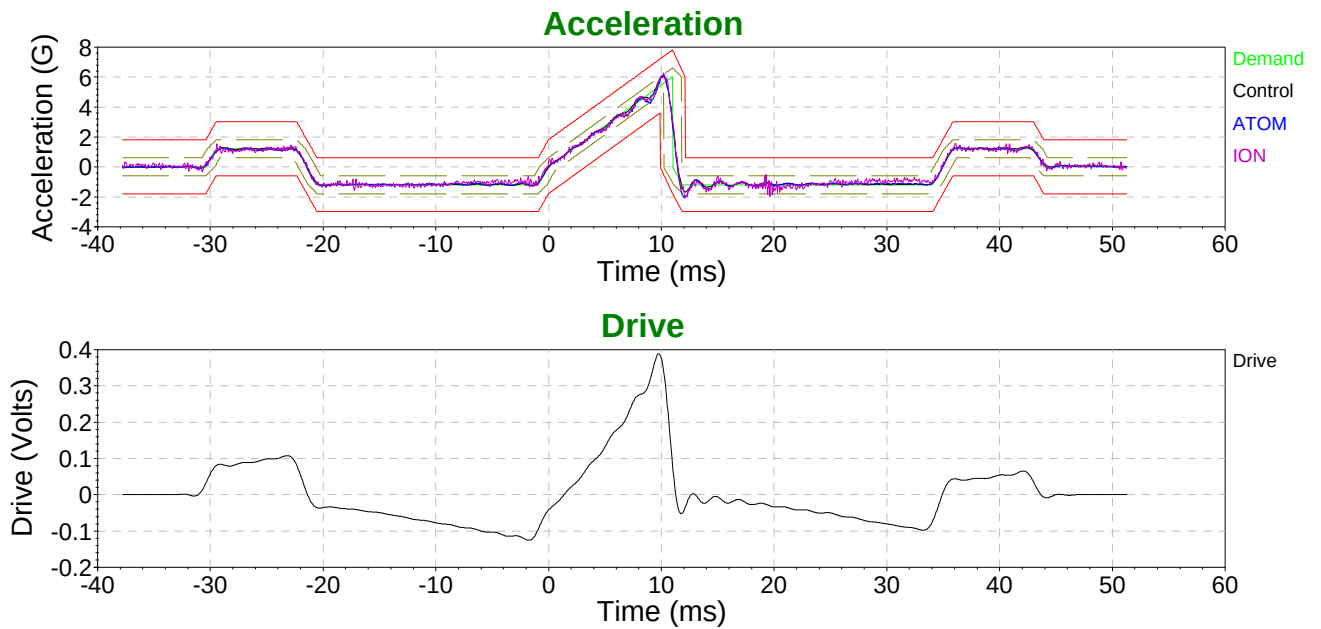
PHOTOS

(See Vibration Photos for Setup and Test Orientations)

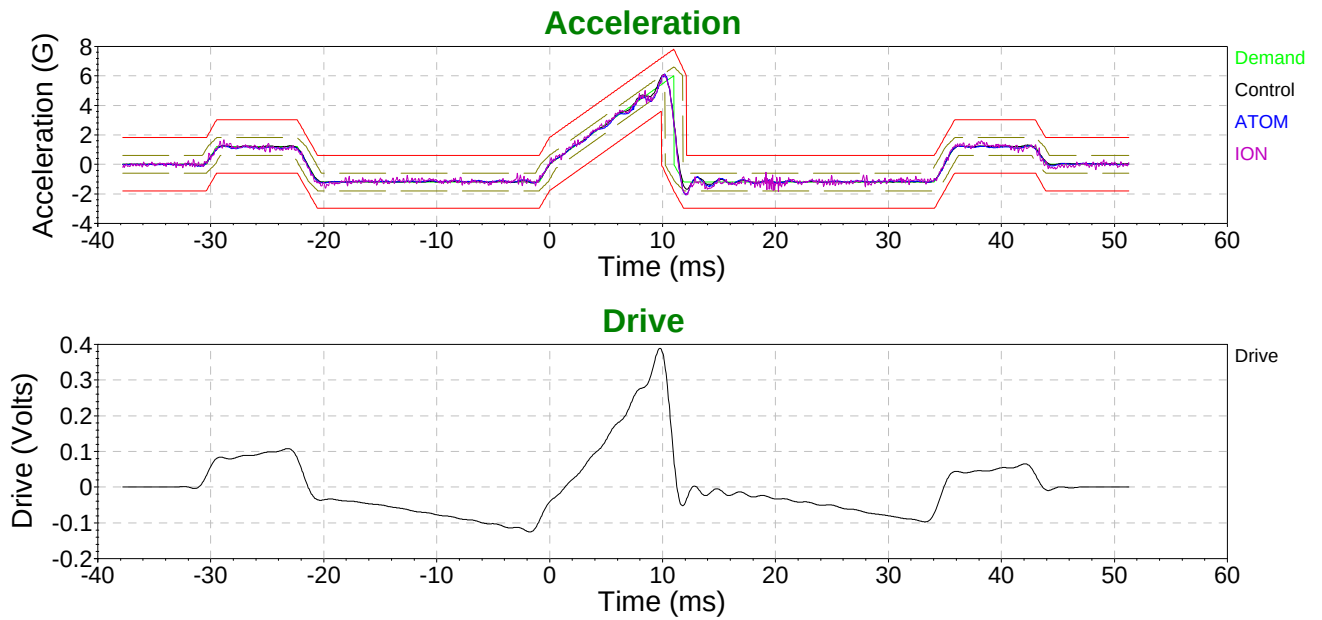
TEST DATA



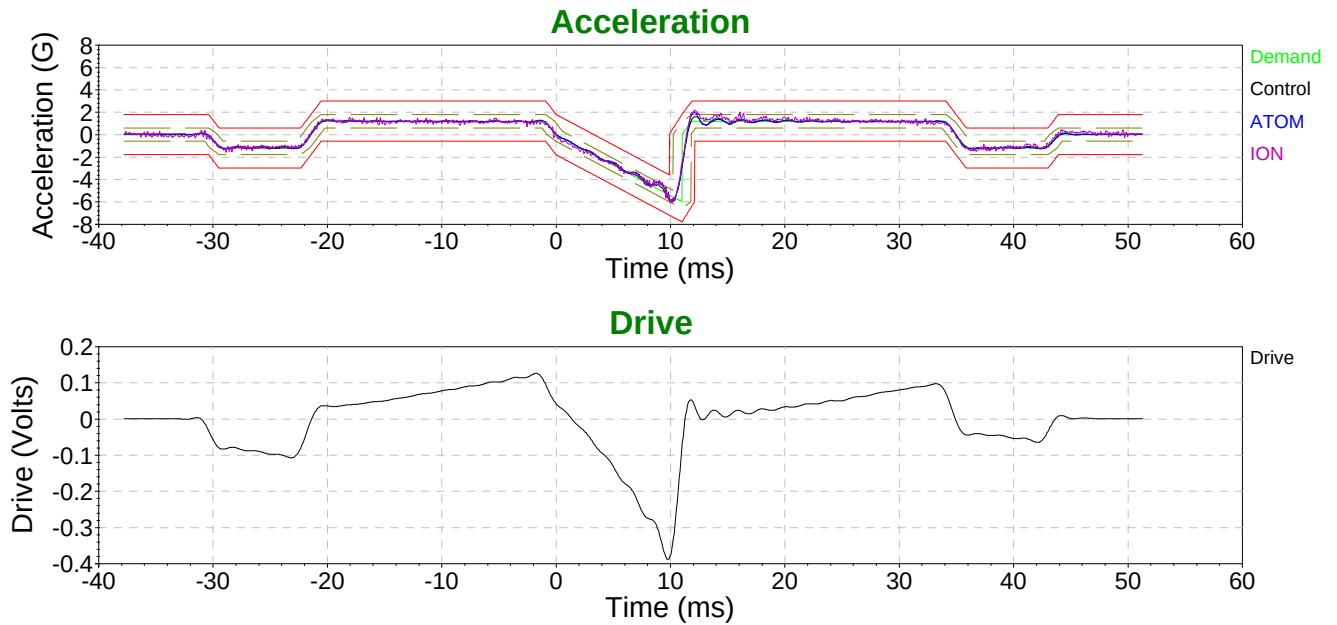
1st Positive 6 g 11 msec Operating Shock Pulse in X Axis



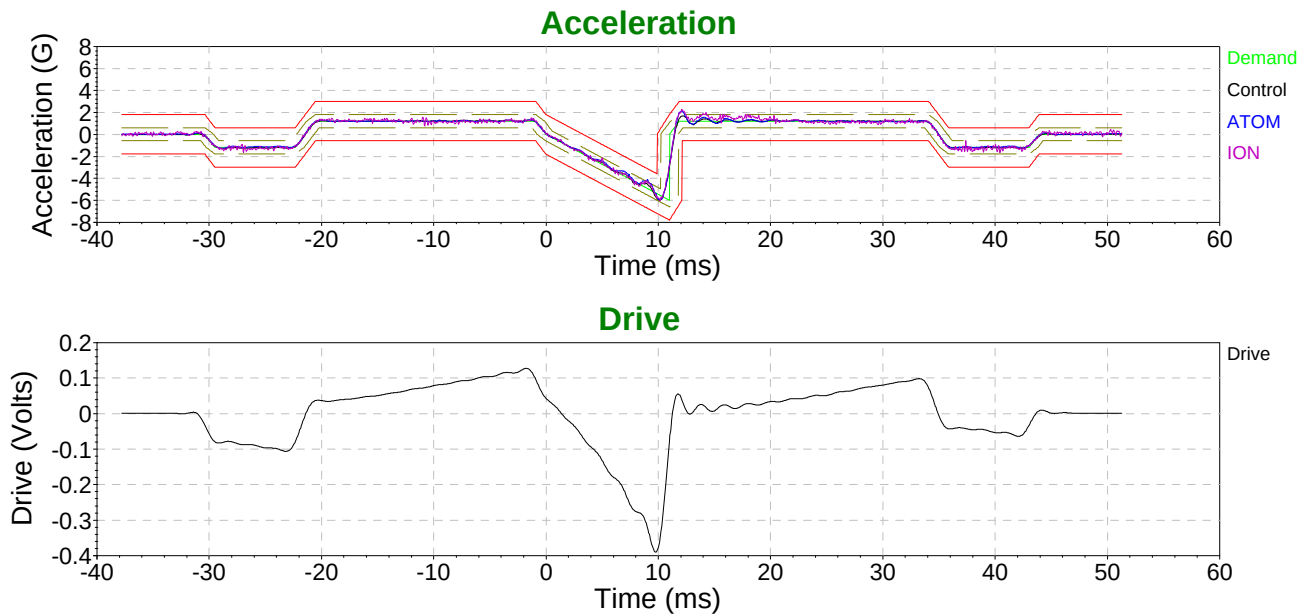
2nd Positive 6 g 11 msec Operating Shock Pulse in X Axis



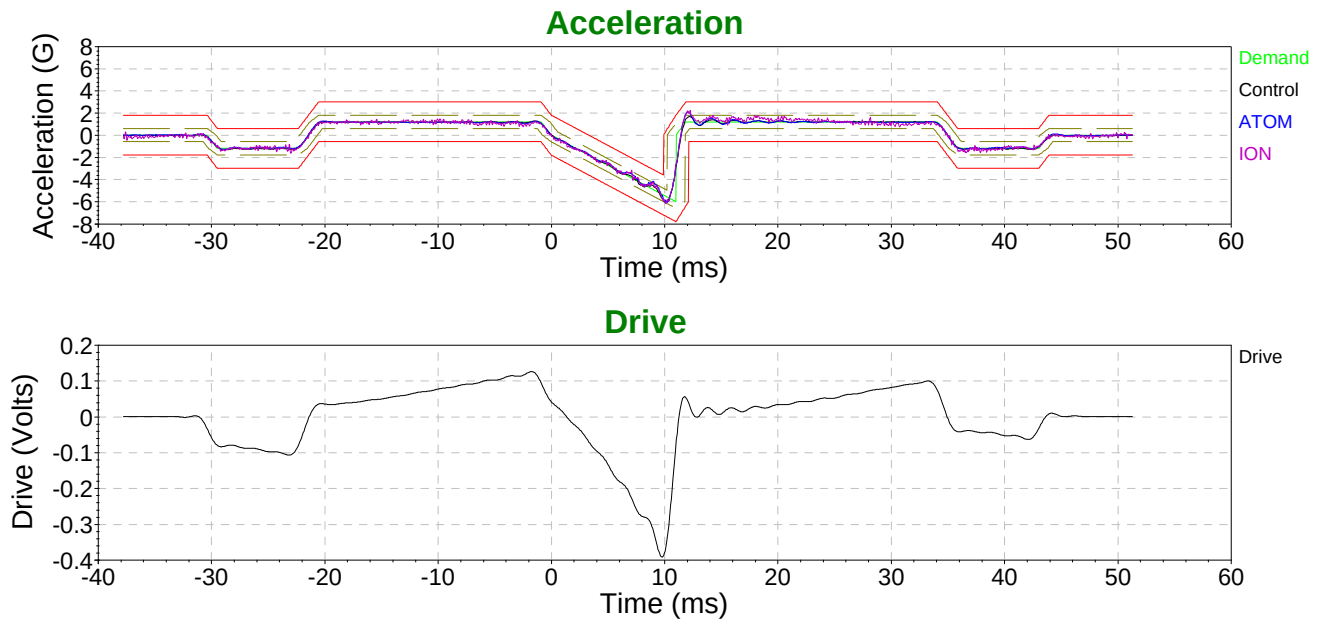
3rd Positive 6 g 11 msec Operating Shock Pulse in X Axis

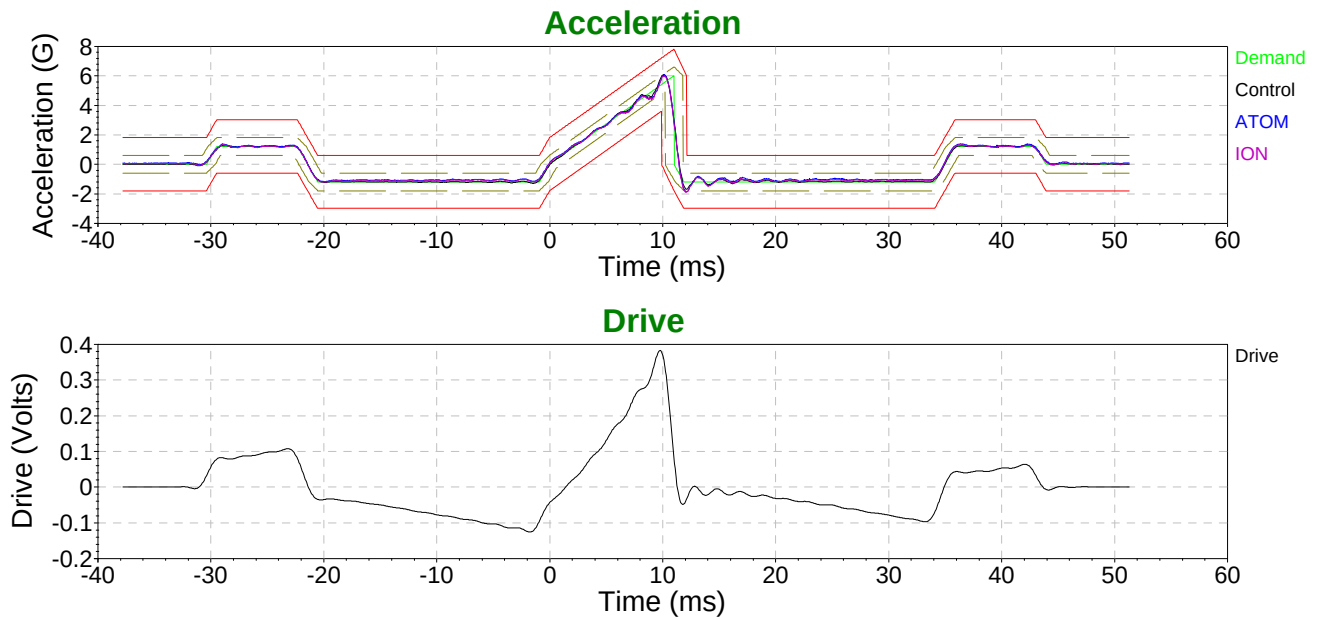


1st Negative 6 g 11 msec Operating Shock Pulse in X Axis

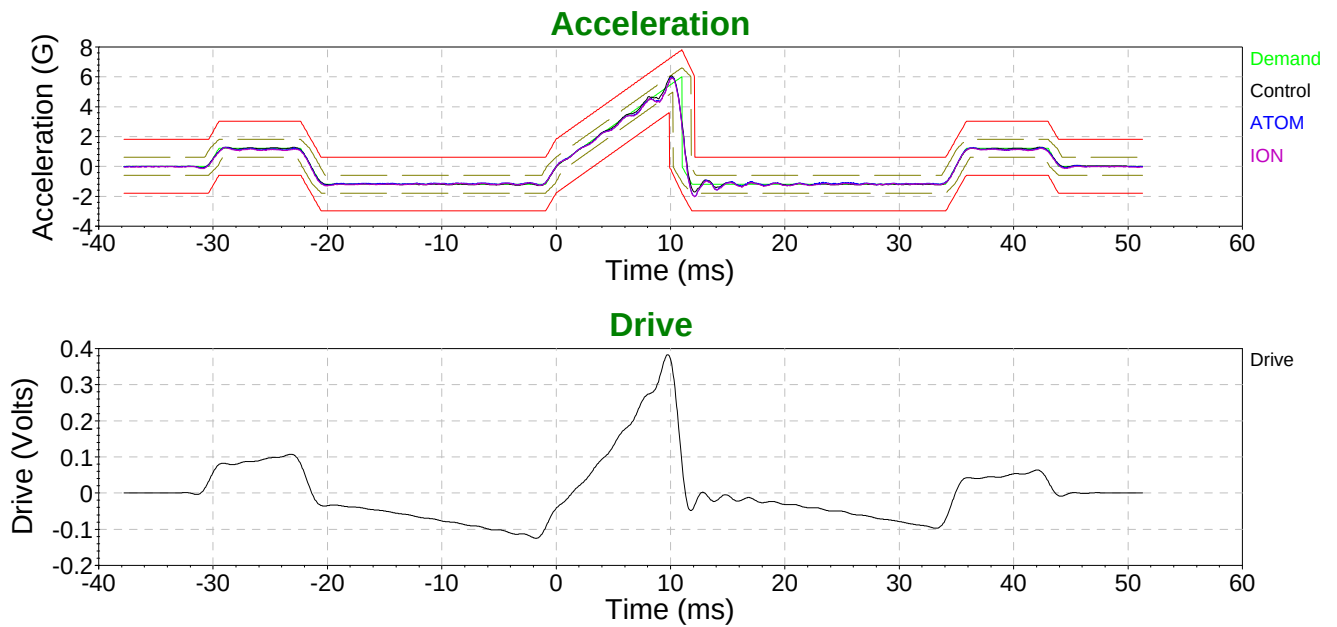


2nd Negative 6 g 11 msec Operating Shock Pulse in X Axis

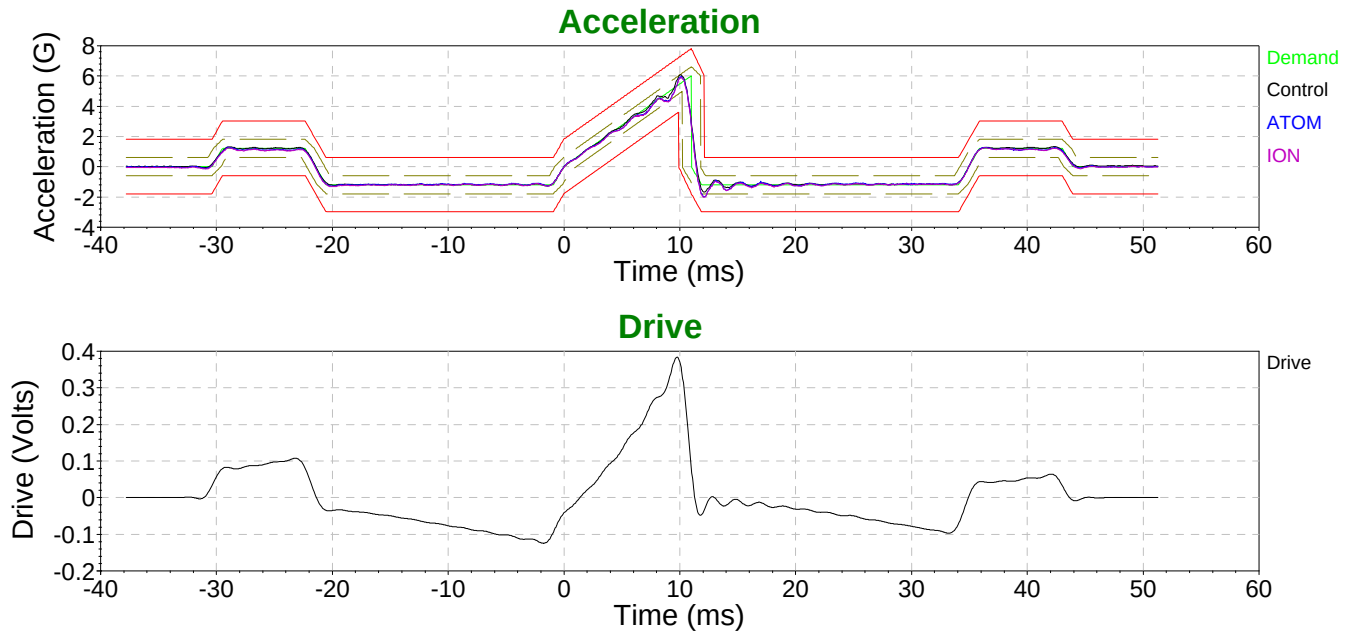




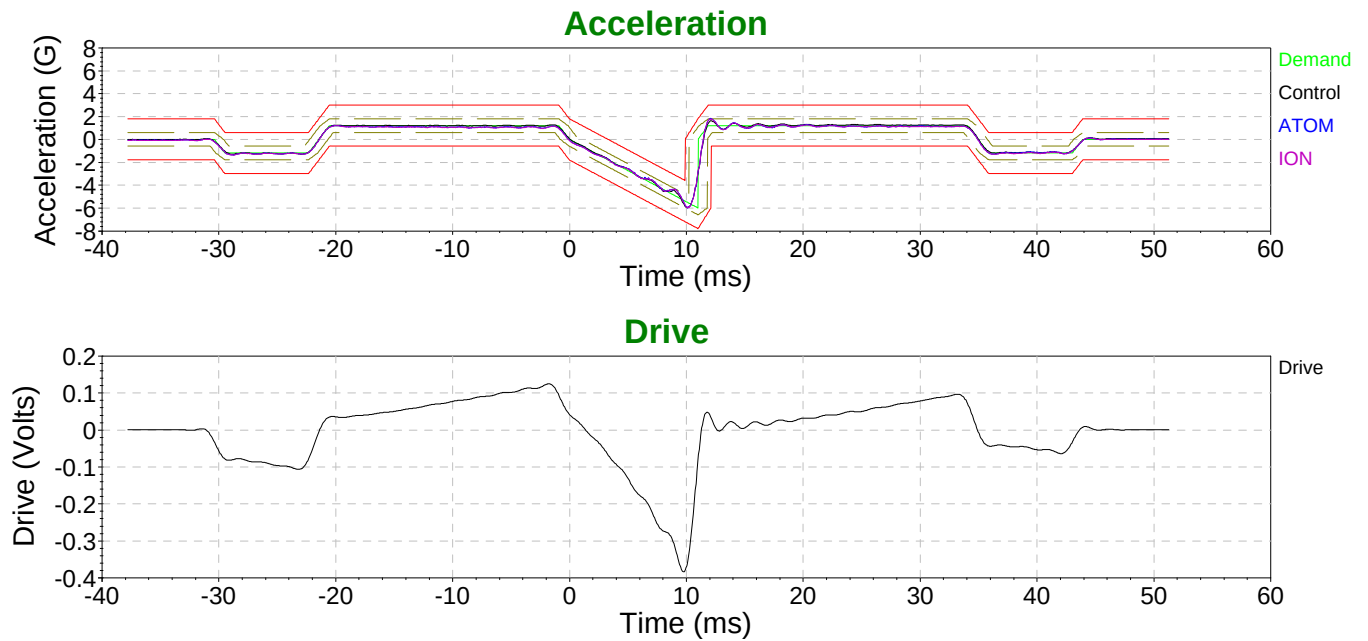
1st Positive 6 g 11 msec Operating Shock Pulse in Y Axis



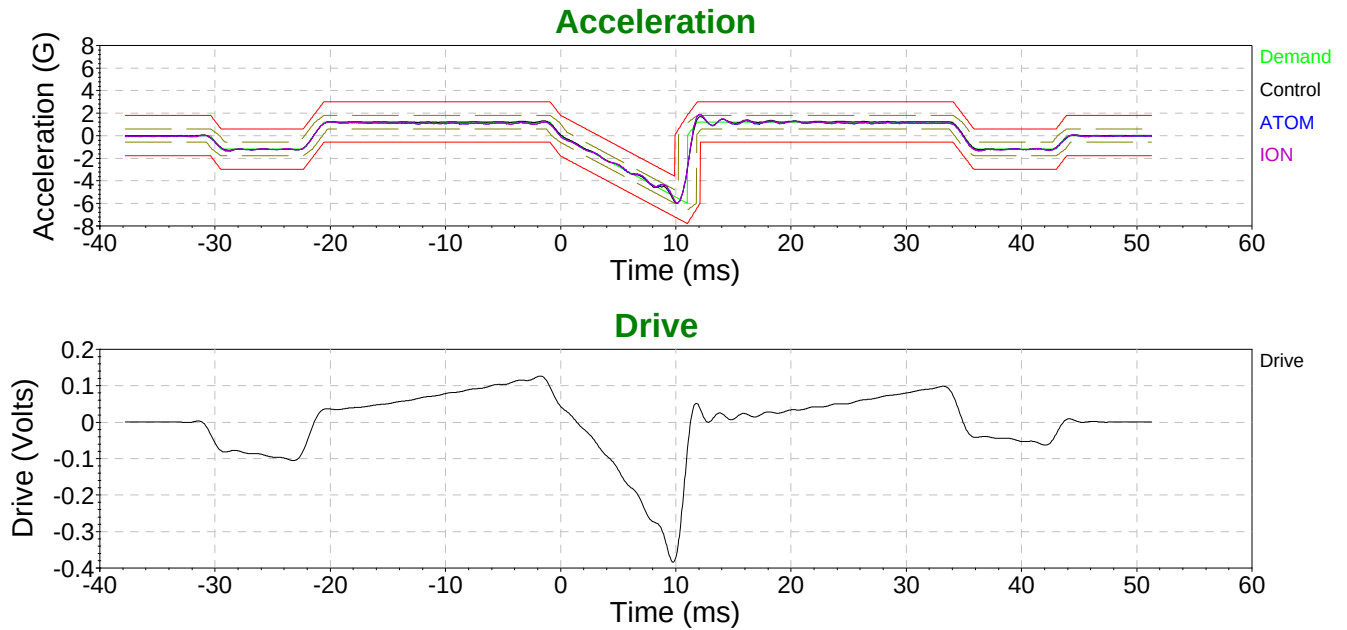
2nd Positive 6 g 11 msec Operating Shock Pulse in Y Axis



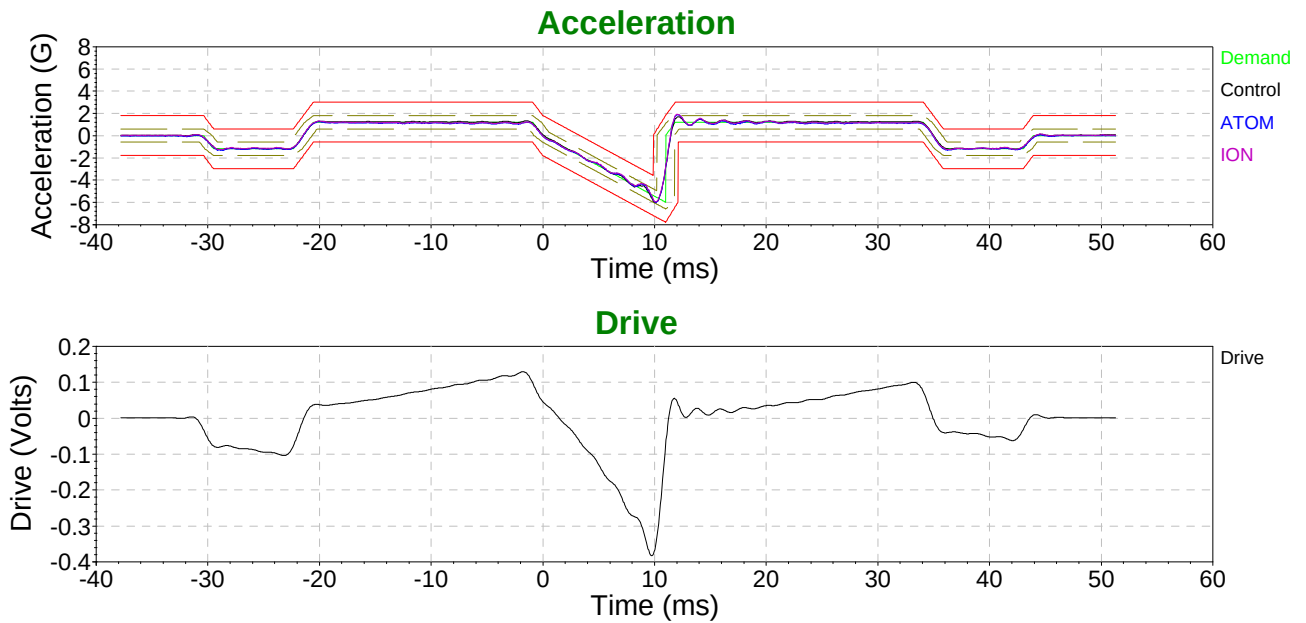
3rd Positive 6 g 11 msec Operating Shock Pulse in Y Axis



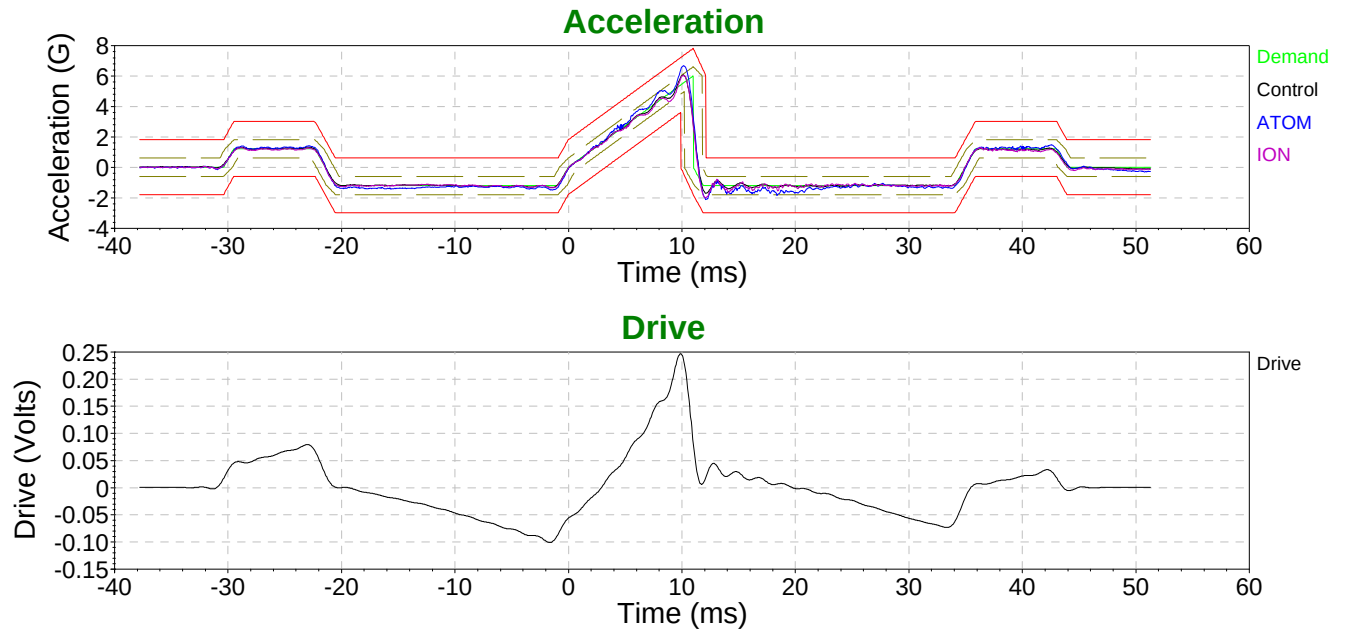
1st Negative 6 g 11 msec Operating Shock Pulse in Y Axis

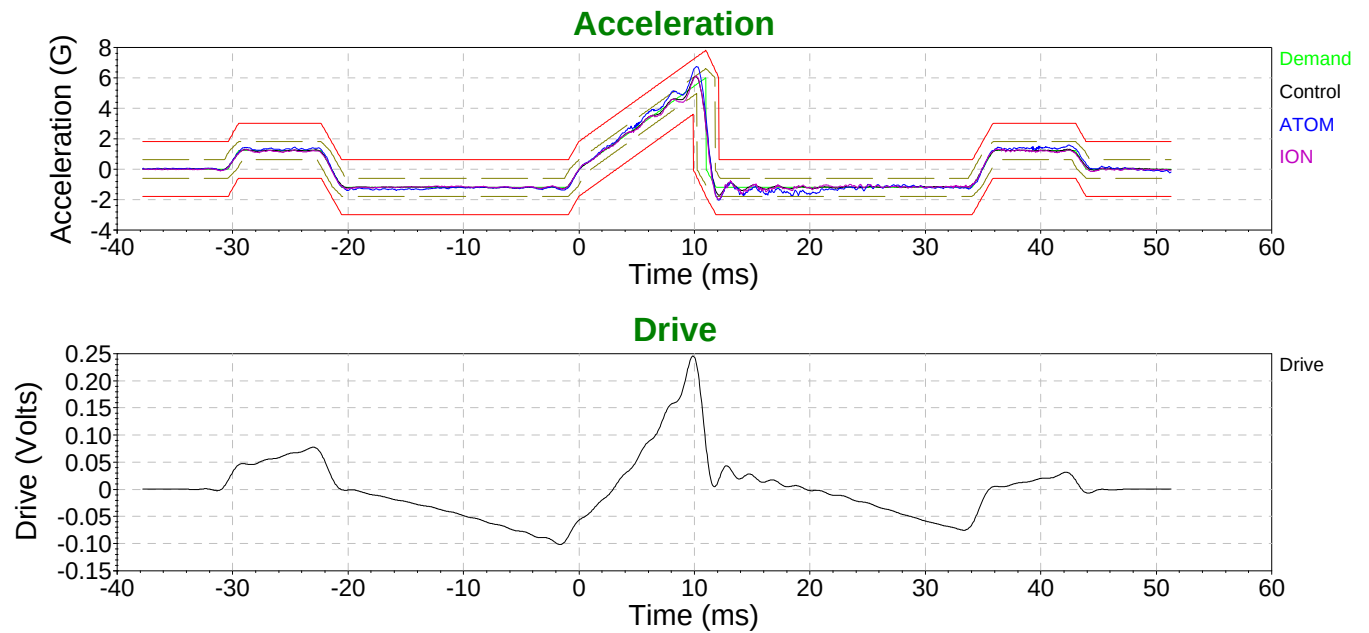


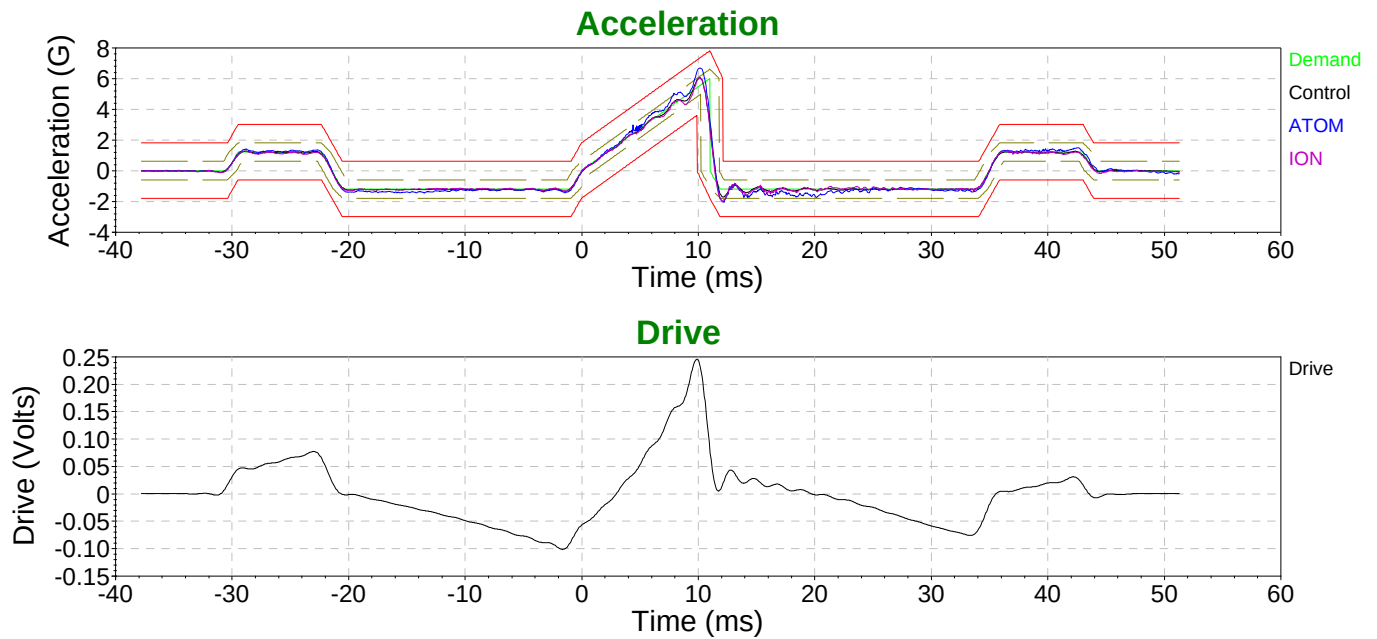
2nd Negative 6 g 11 msec Operating Shock Pulse in Y Axis

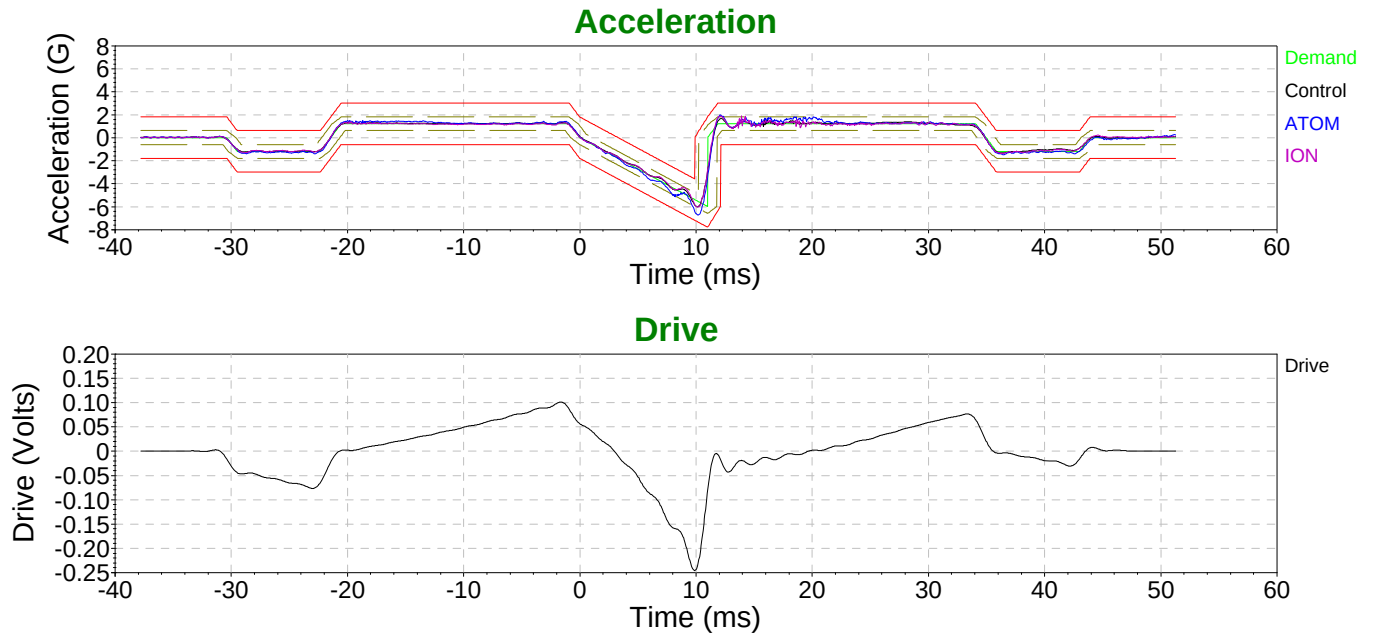


3rd Negative 6 g 11 msec Operating Shock Pulse in Y Axis

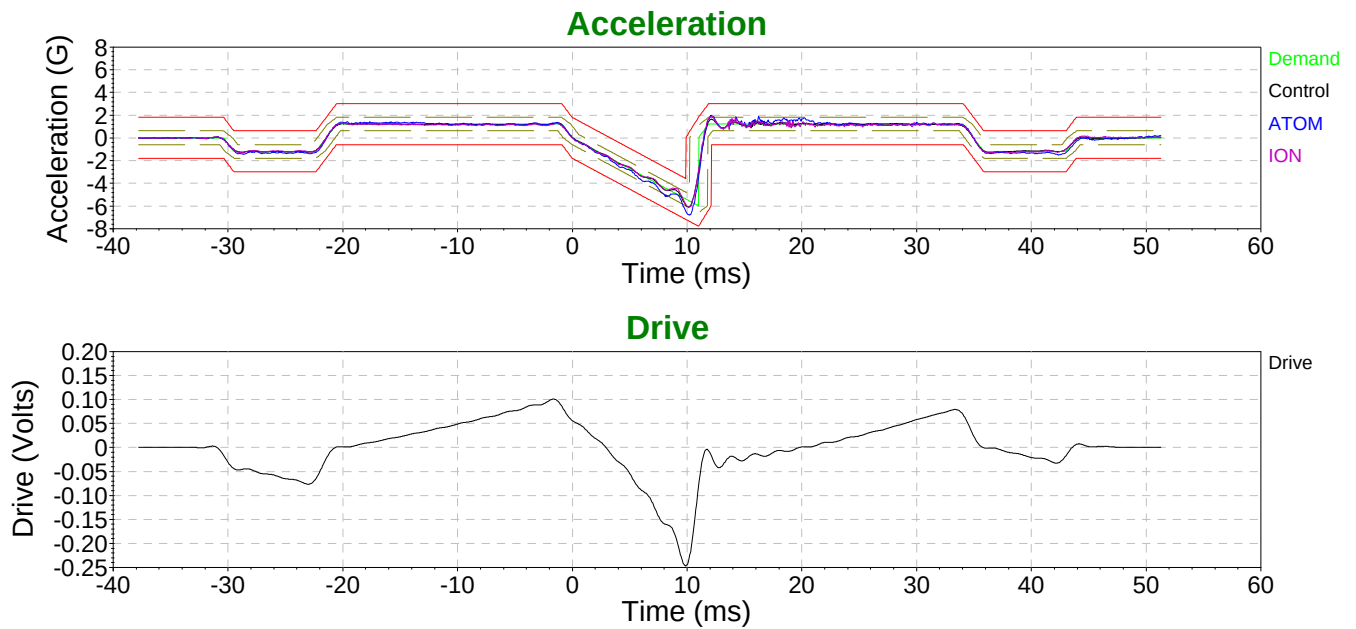




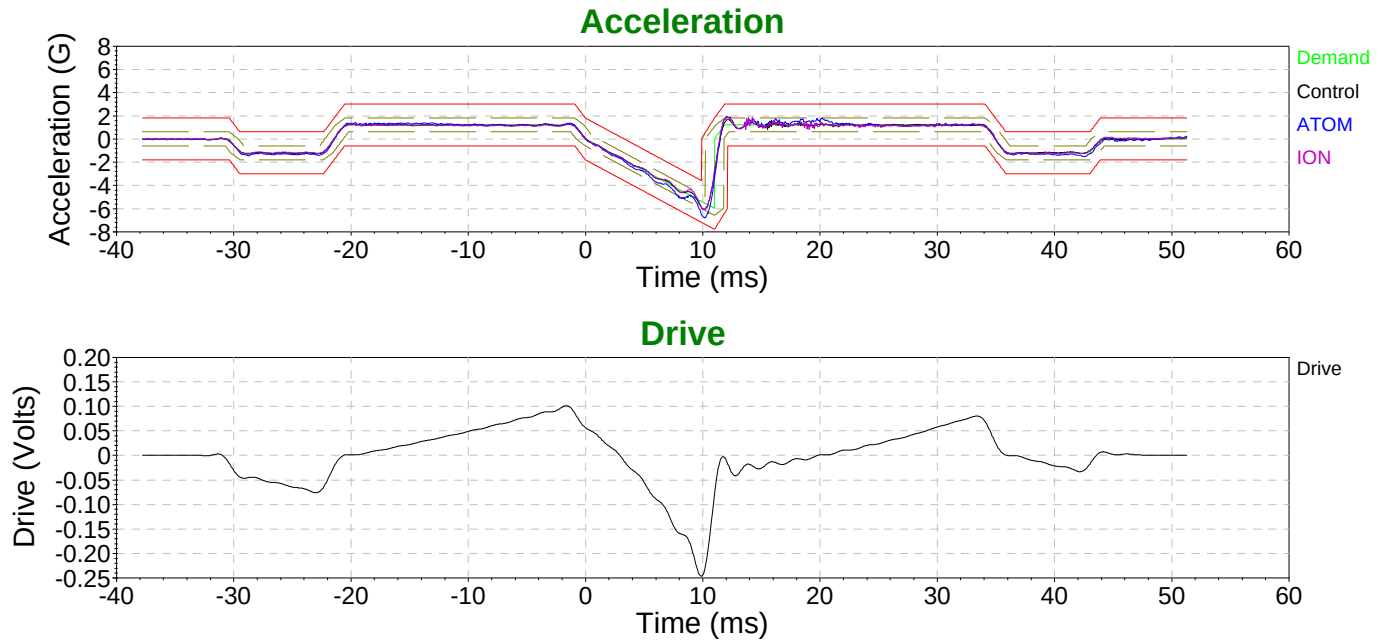




1st Negative 6 g 11 msec Operating Shock Pulse in Z Axis



2nd Negative 6 g 11 msec Operating Shock Pulse in Z Axis



3rd Negative 6 g 11 msec Operating Shock Pulse in Z Axis

CRASH SAFETY (IMPULSE) TEST

TEST DATES

07/28/2017 - 08/02/2017

EQUIPMENT UNDER TEST (EUT)

Quantity: One (1)

Model: ION

Serial Number: 110129

Quantity: One (1)

Model: ATOM

Serial Number: 160055

TEST SPECIFICATION

RTCA DO-160G, Section 7.3.1 Category B

REQUIREMENTS

Each EUT shall undergo Crash Safety (Impulse) testing per RTCA DO-160G, Section 7.3.1 Category B. There shall be no failure of any EUT or mounting bracket. All equipment shall remain in place. There shall be no physical or electrical failures that prevent each EUT from being operated per customer's post-test requirements.

PROCEDURE

RTCA DO-160G, Section 7.3.1 Category B

- 1) Mount both EUT's to the provided shock fixture.
- 2) Fasten shock fixture in Axis of test.
- 3) Attach a control accelerometer parallel to the axis of excitation.
- 4) Attach a response accelerometer to each EUT parallel to the axis of excitation.
- 5) Start the shock profile of 1 positive and 1 negative impulses of 20g, 11ms sawtooth in the 1st axis, monitor/record the control and response plot.
- 6) Mount both EUT's in the 2nd orthogonal axis and repeat the steps above.
- 7) Mount both EUT's in the 3rd orthogonal axis and repeat the steps above.
- 8) Examine each EUT and record any physical abnormalities.



DLS CONFORMITY ASSESSMENT, INC
200 E. Marquardt Drive
Wheeling, IL 60090 USA
Voice 847-537-6400
Fax 847-947-8651
www.dlsemc.com

TEST RESULTS

Both units conformed to all testing. No physical damage was noted to any unit. Each unit passed a post-performance test.

EQUIPMENT USED

Equipment	Manufacturer	DLS Lab Number	Model#	Date Calibrated	Calibration Due Date
Accelerometer	Dytran	268	3333M2T	11/16/2016	11/16/2017
Accelerometer	Dytran	152	3225F1T	09/28/2016	09/28/2017
Accelerometer	Dytran	161	3049E1	05/12/2017	05/12/2018
Accelerometer	Dytran	154	3225F1T	08/09/2016	08/09/2017
Accelerometer	Dytran	159	3049E1	06/16/2017	06/16/2018
Electrodynamic Shaker	LDS	183	V850-440	N/A	Verified w/Calibrated Accelerometers
Vibration Controller	Vibe Research Corp	165	VR9500	09/20/2016	09/20/2017

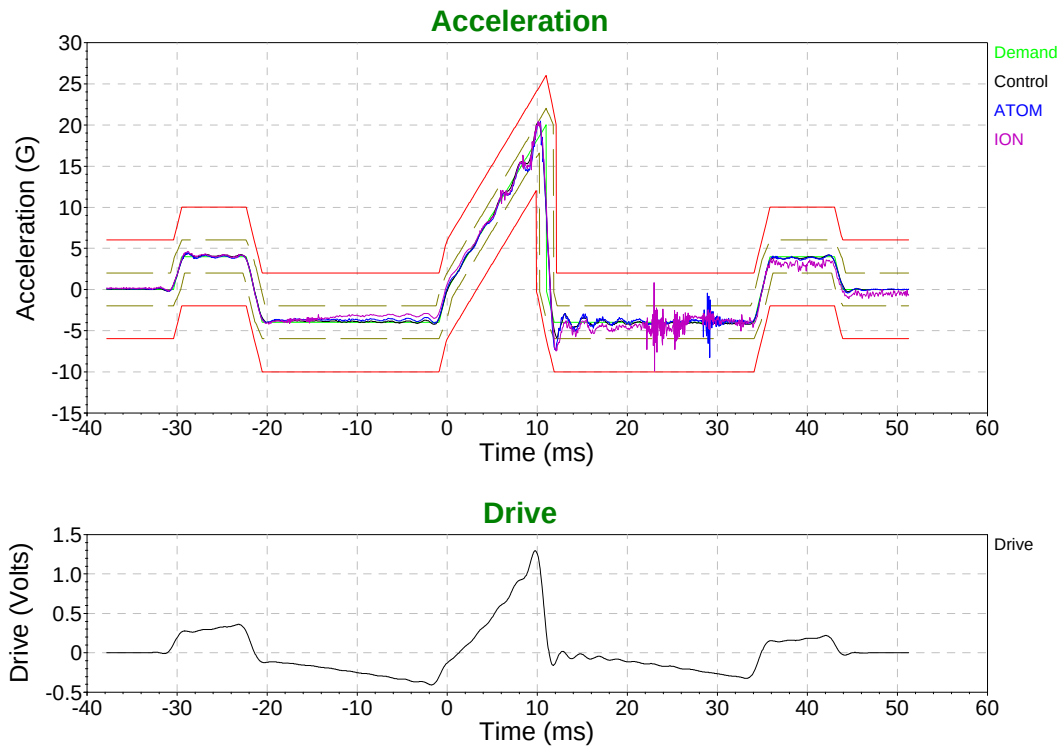


DLS CONFORMITY ASSESSMENT, INC
200 E. Marquardt Drive
Wheeling, IL 60090 USA
Voice 847-537-6400
Fax 847-947-8651
www.dlsemc.com

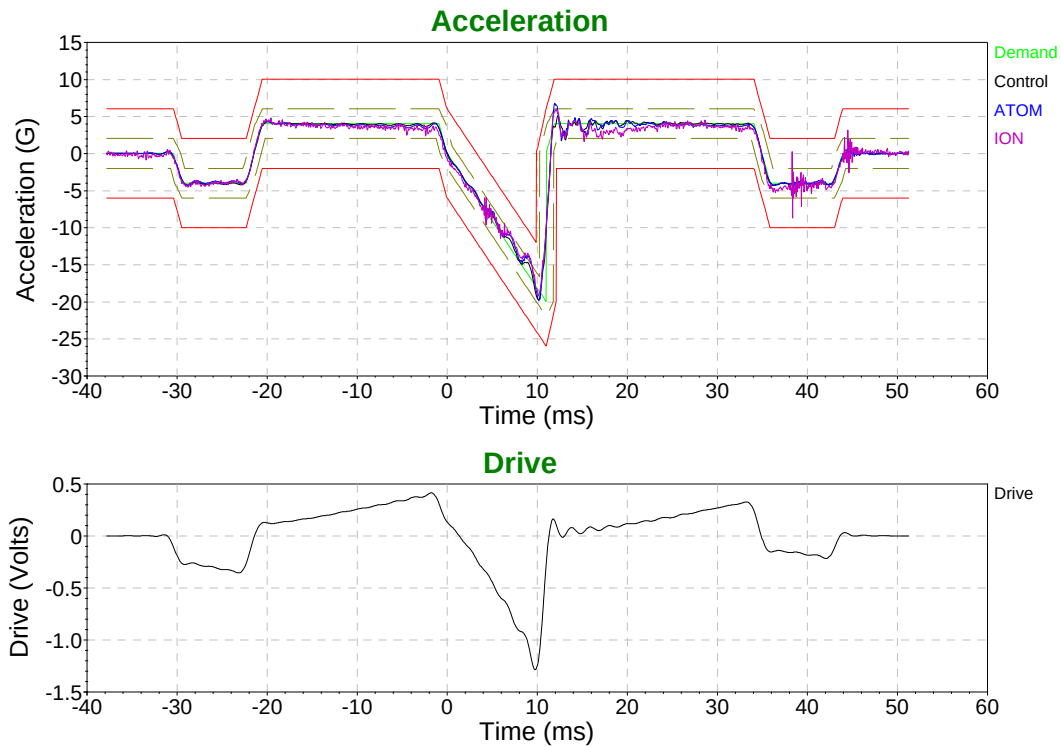
PHOTOS

(See Vibration Photos for Setup and Test Orientations)

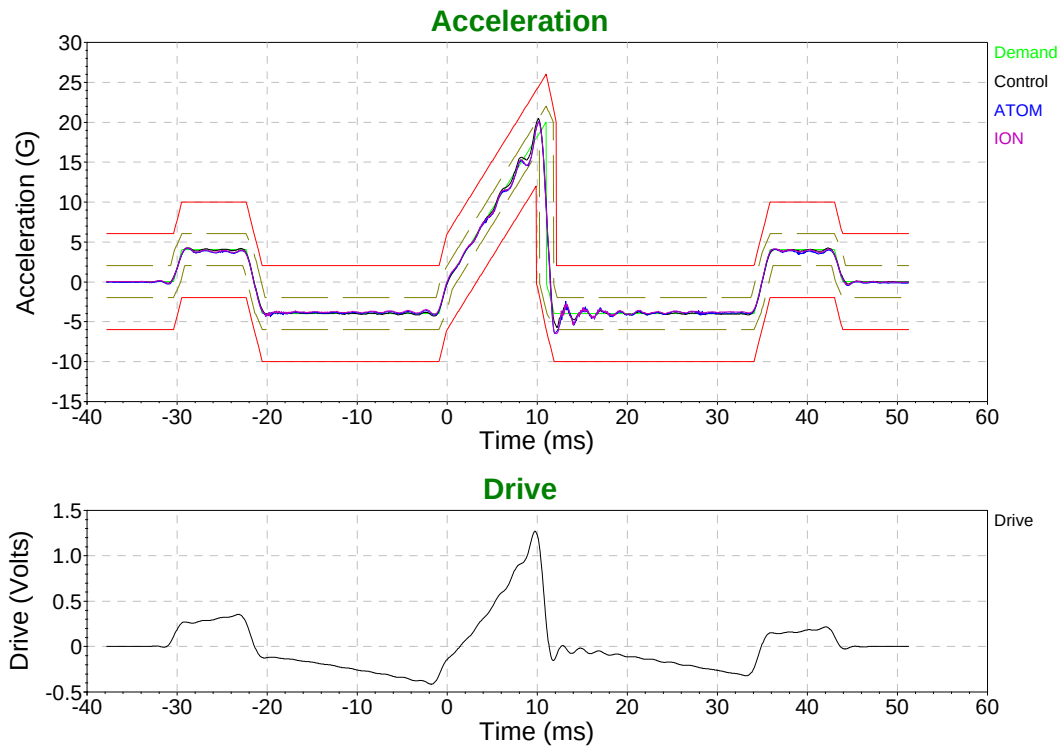
TEST DATA



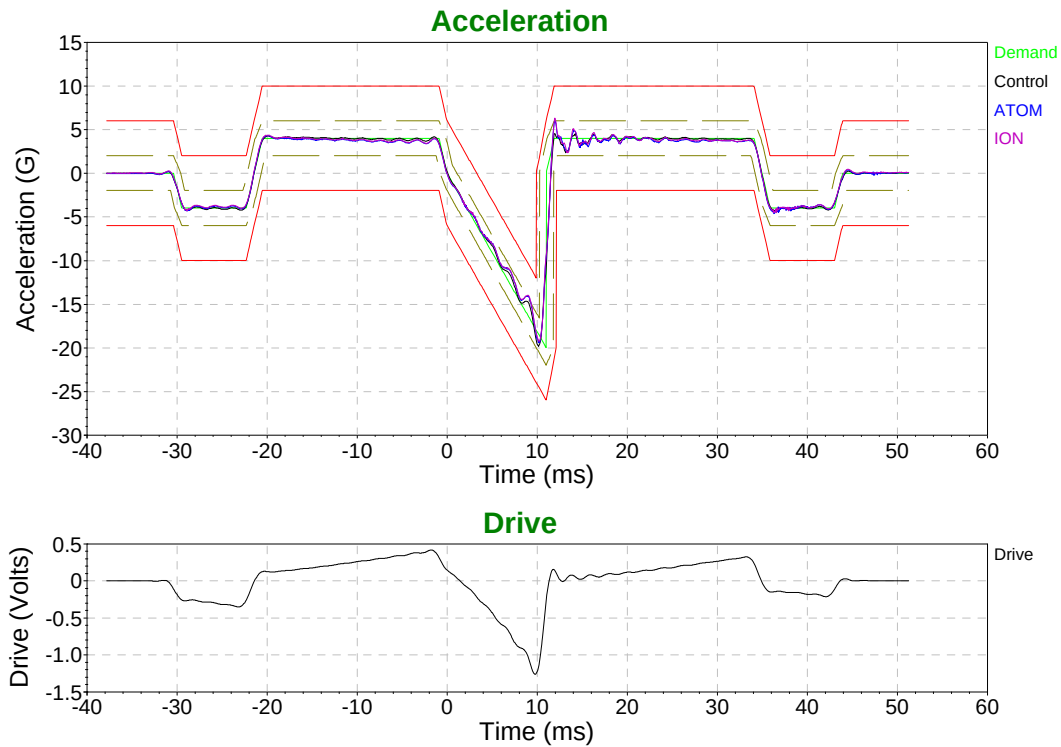
Positive 20 g 11 msec Crash Safety Impulse in X Axis



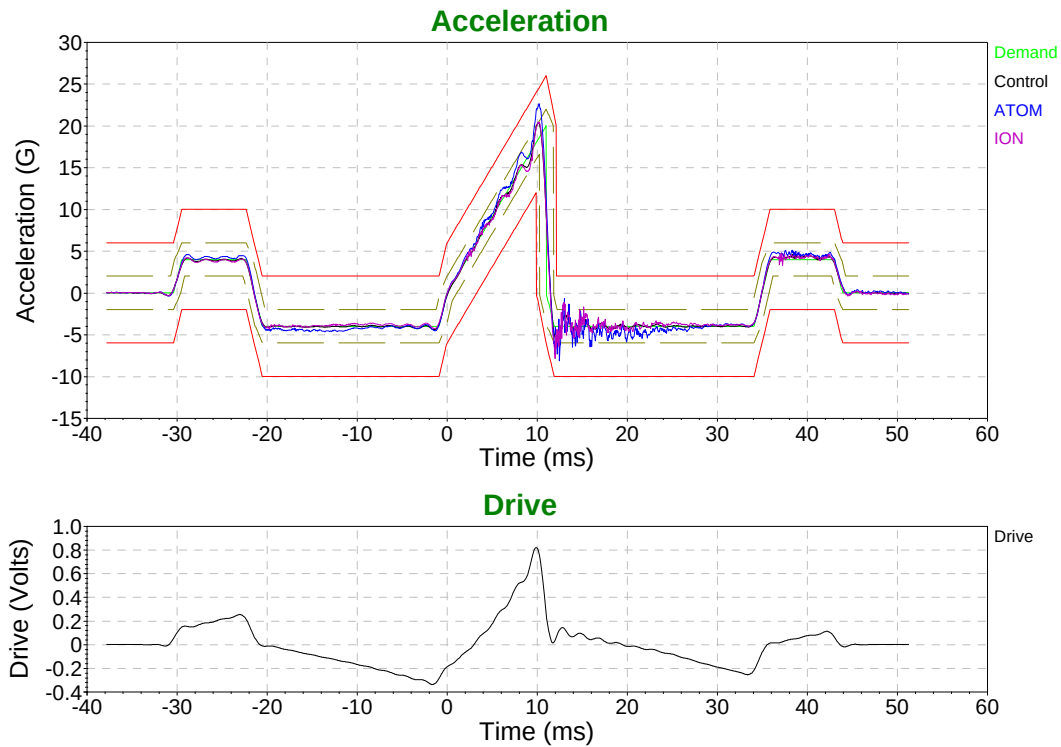
Negative 20 g 11 msec Crash Safety Impulse in X axis



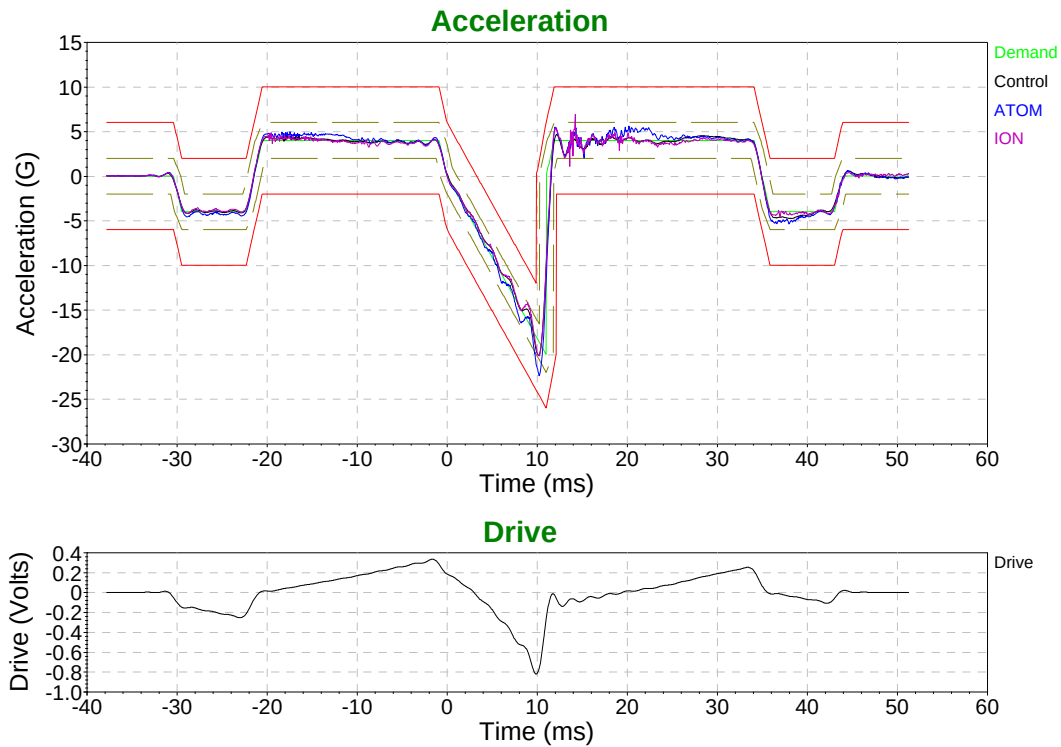
Positive 20 g 11 msec Crash Safety Impulse in Y Axis



Negative 20 g 11 msec Crash Safety Impulse in Y Axis



Positive 20 g 11 msec Crash Safety Impulse in Z Axis



Negative 20 g 11 msec Crash Safety Impulse in Z Axis



CRASH SAFETY (SUSTAINED) TEST

TEST DATE

08/04/2017

EQUIPMENT UNDER TEST (EUT)

Quantity: One (1)

Model: ION

Serial Number: 110129

Quantity: One (1)

Model: ATOM

Serial Number: 160055

TEST SPECIFICATION

RTCA DO-160G, Section 7.3.3 Category B

REQUIREMENTS

Each EUT shall undergo Crash Safety (Sustained) testing per RTCA DO-160G, Section 7.3.3 Category B. There shall be no failure of the EUT or mounting bracket. All equipment shall remain in place. There shall be no physical or electrical failures that prevent each EUT from being operated per customer's post-test requirements.

PROCEDURE

RTCA DO-160G, Section 7.3.3 Category B

- 1) Mount both EUT's to the supplied mounting fixture.
- 2) Fasten the mounting fixture to the arm of the centrifuge in axis of test.
- 3) Counter balance the opposite arm of the centrifuge with the appropriate weight.
- 4) Attach an accelerometer parallel to the axis of acceleration with special attention given to the center of gravity of each EUT.
- 5) Begin ramping the centrifuge up to 20g's.
- 6) Maintain 20g's for a minimum of 3 seconds.
- 7) Stop the test and ramp the centrifuge back to zero g's.
- 8) Examine each EUT and record any physical abnormalities.
- 9) Mount both EUT's in the 2nd orthogonal axis and repeat the steps 2 through 8 above.
- 10) Mount both EUT's in the 3rd orthogonal axis and repeat the steps 2 through 8 above.
- 11) Mount both EUT's in the 4th orthogonal axis and repeat the steps 2 through 8 above.
- 12) Mount both EUT's in the 5th orthogonal axis and repeat the steps 2 through 8 above.
- 13) Mount both EUT's in the 6th orthogonal axis and repeat the steps 2 through 8 above.



DLS CONFORMITY ASSESSMENT, INC
200 E. Marquardt Drive
Wheeling, IL 60090 USA
Voice 847-537-6400
Fax 847-947-8651
www.dlsemc.com

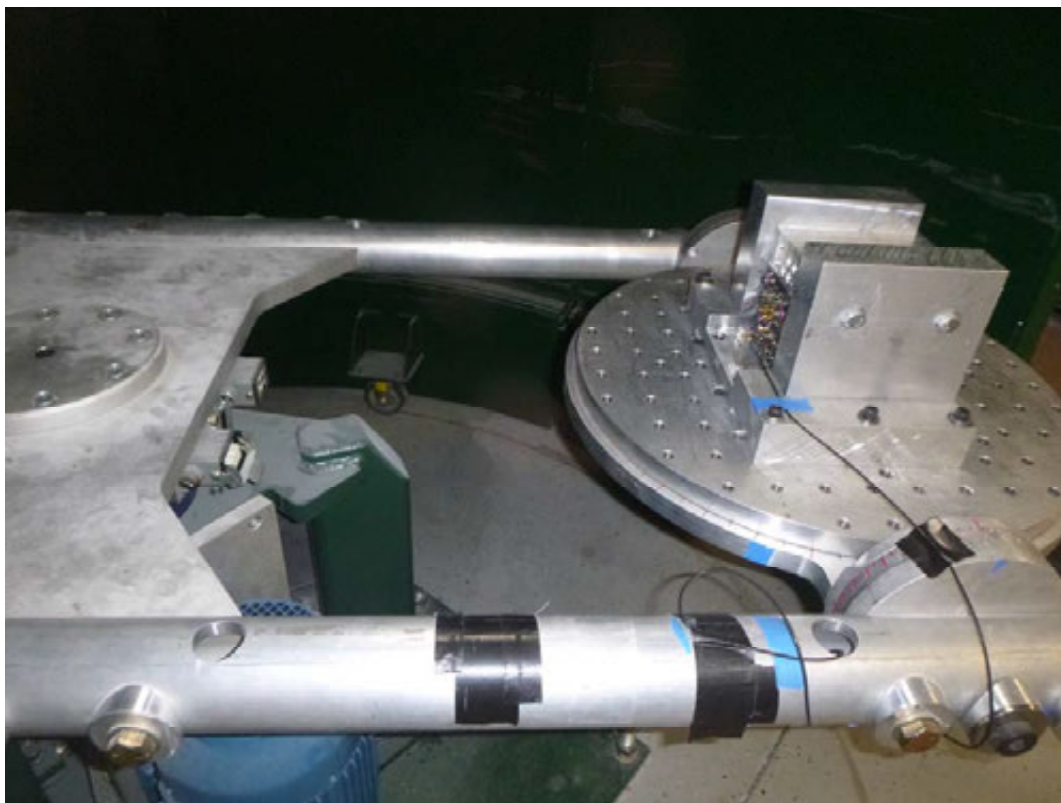
TEST RESULTS

Both units conformed to all testing. No physical damage was noted to any unit. Each unit passed a post-performance test.

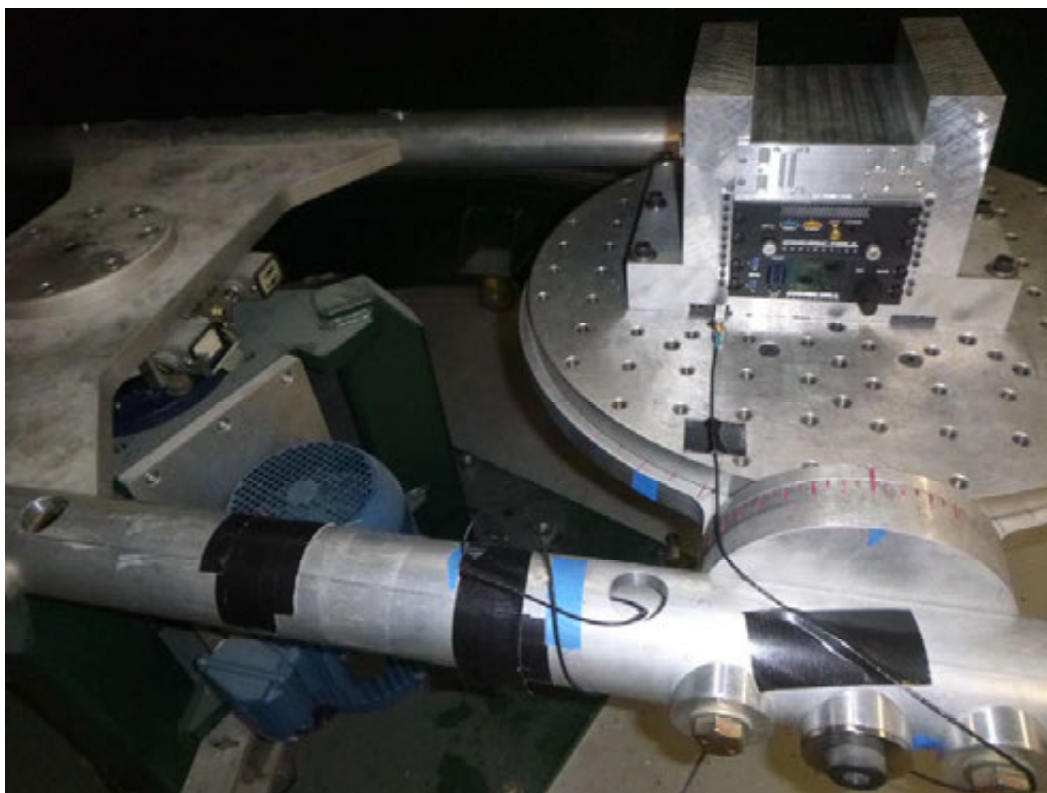
EQUIPMENT USED

Equipment	Manufacturer	DLS Lab Number	Model#	Date Calibrated	Calibration Due Date
Centrifuge	VST	215	CAT10HP	N/A	Verified w/Calibrated Accelerometer
Accelerometer	Dytran	227	7500A6	04/19/2017	04/19/2018
Signal Conditioner	Dytran	194	4010	09/28/2016	09/28/2017

PHOTOS



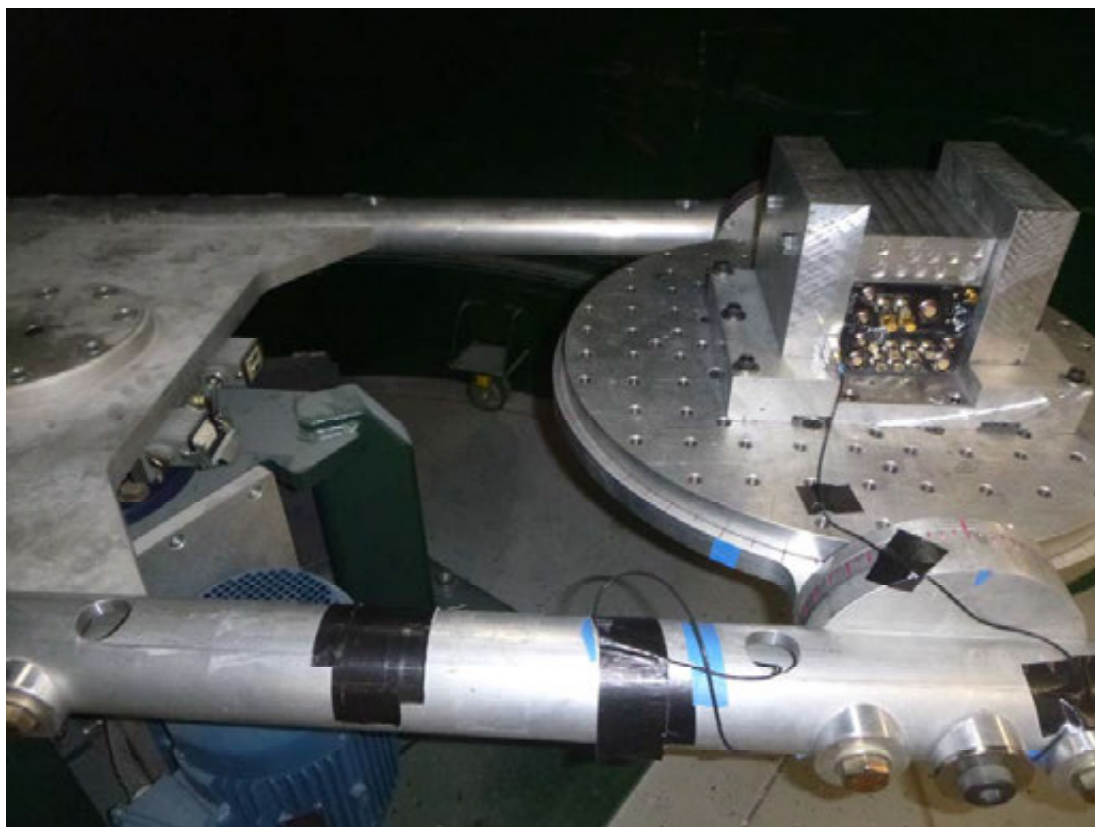
EUT's in Axis 1 (Forward)



EUT's in Axis 2 (Right)



EUT's in Axis 3 (Aft)



EUT's in Axis 4 (Left)



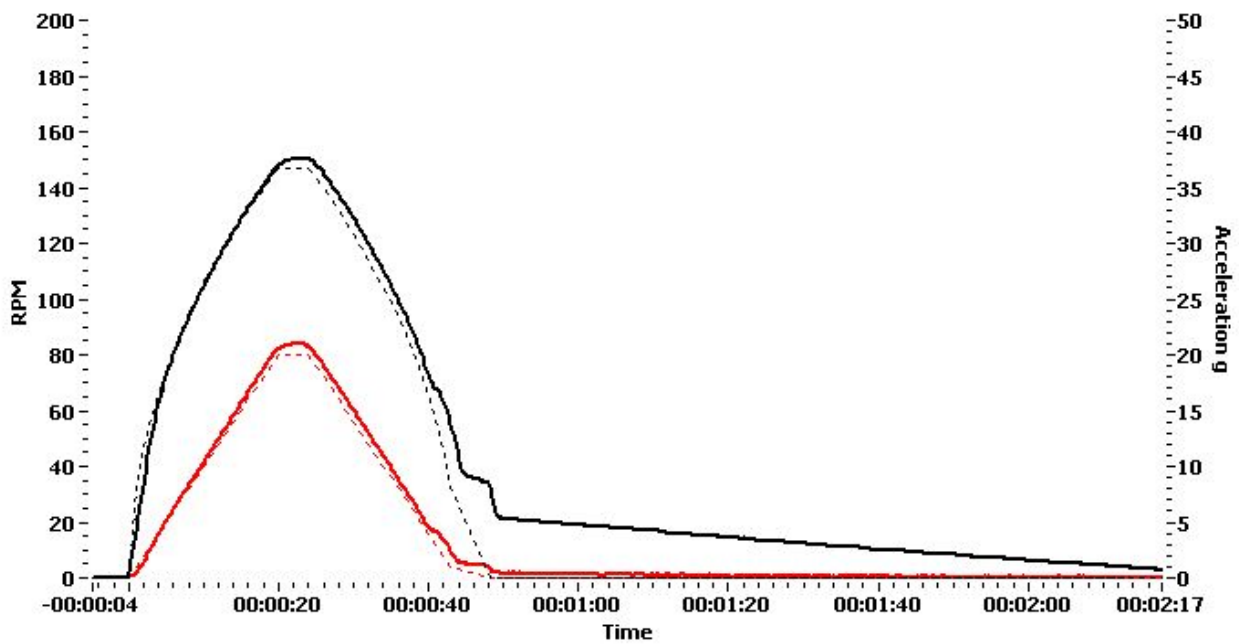
EUT's in Axis 5 (Down)



EUT's in Axis 6 (Up)

TEST DATA

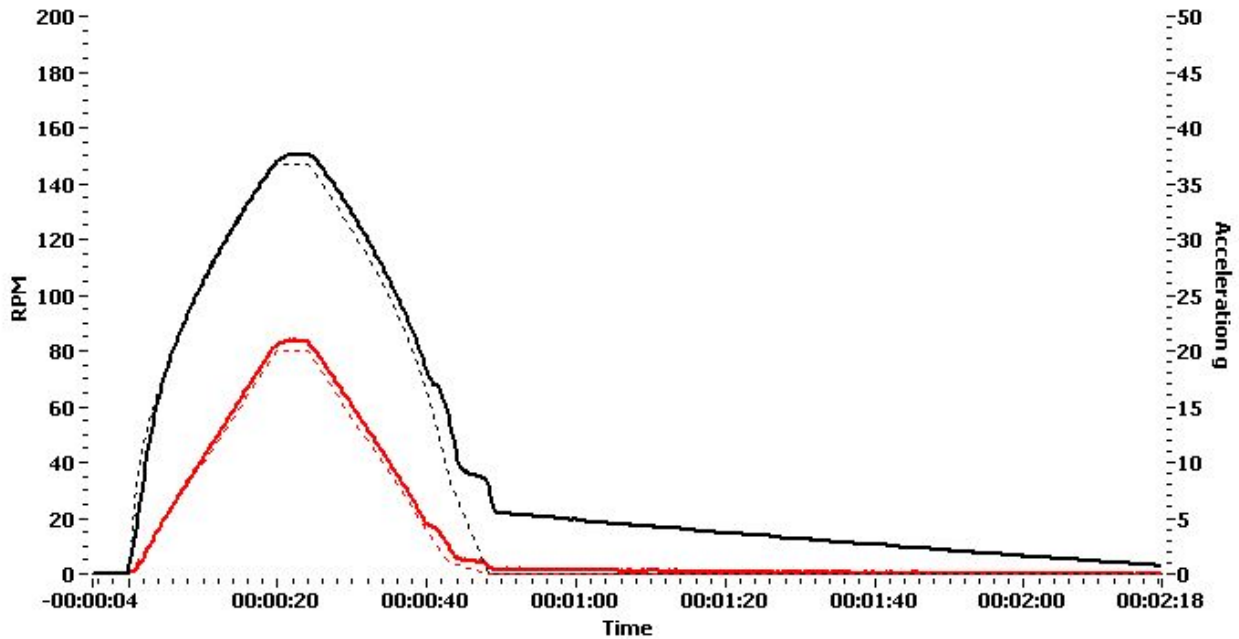
Red Line = Acceleration (g)
Black Line = RPM



20 g's in Axis 1 (Forward)

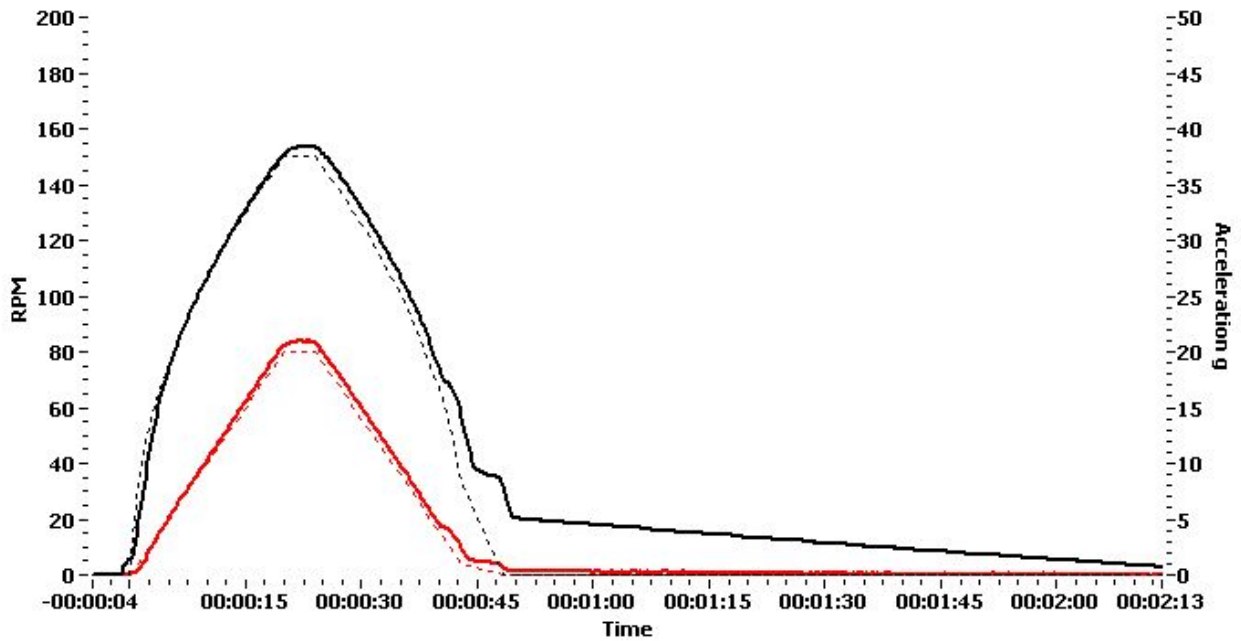
Red Line = Acceleration (g)

Black Line = RPM



20 g's in Axis 2 (Right)

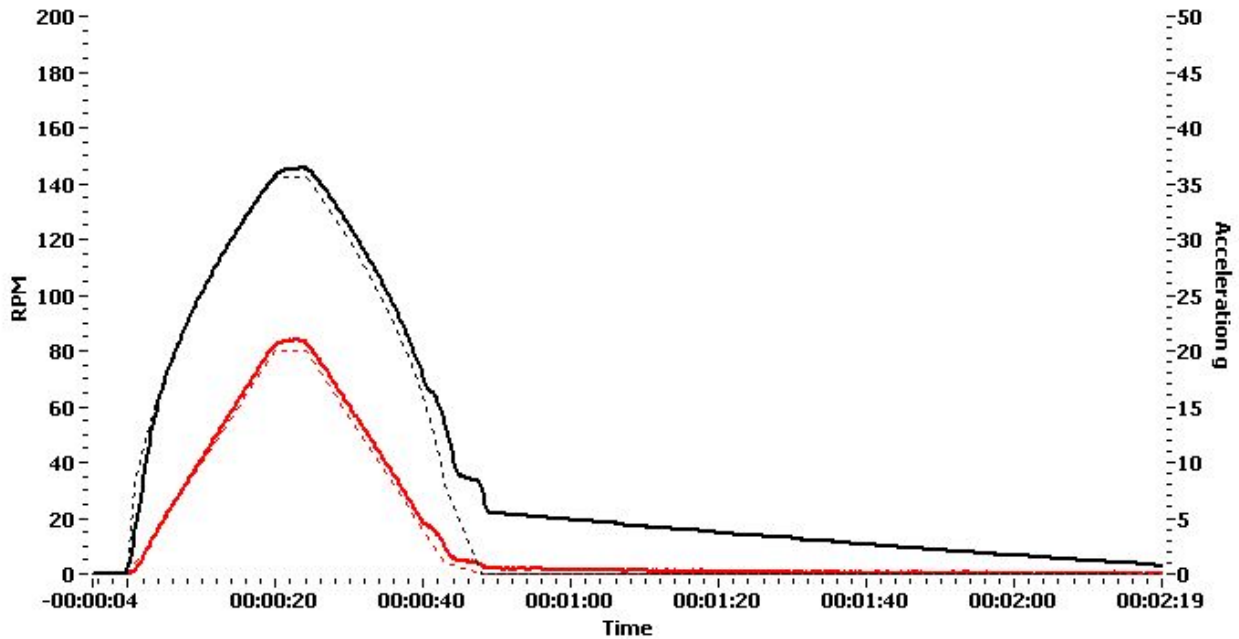
Red Line = Acceleration (g)
 Black Line = RPM



20 g's in Axis 3 (Aft)

Red Line = Acceleration (g)

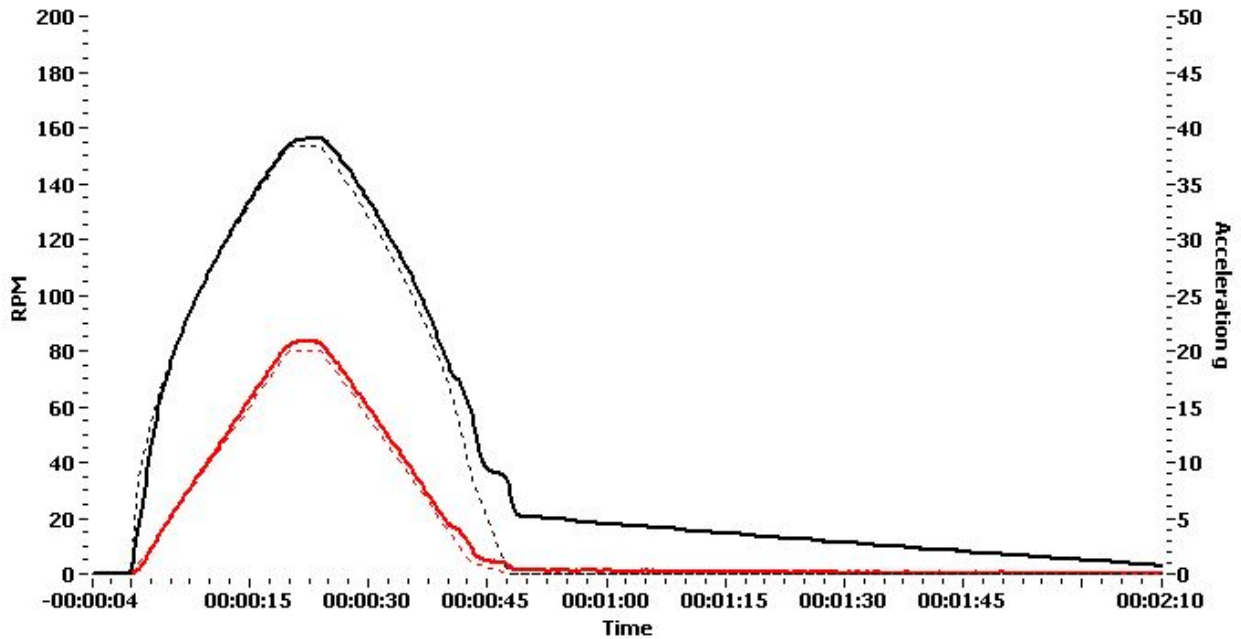
Black Line = RPM



20 g's in Axis 4 (Left)

Red Line = Acceleration (g)

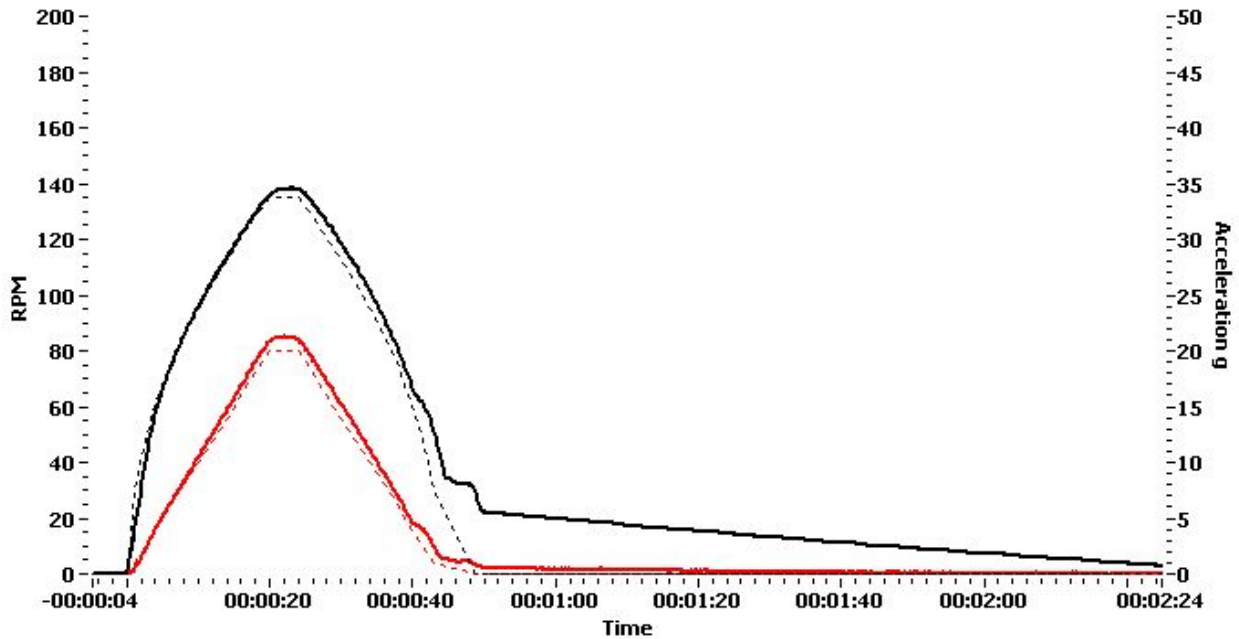
Black Line = RPM



20 g's in Axis 5 (Down)

Red Line = Acceleration (g)

Black Line = RPM



20 g's in Axis 6 (Up)



EXPLOSIVE ATMOSPHERE TEST

TEST DATE

05/01/2017

EQUIPMENT UNDER TEST (EUT)

Quantity: One (1)

Model: ION

Serial Number: 110100

Quantity: One (1)

Model: ATOM

Serial Number: 160020

TEST SPECIFICATION

RTCA DO-160G, Section 9.6.2 Category E

REQUIREMENTS

Each EUT shall be exposed to Explosive Atmosphere as per RTCA DO-160G, Section 9.6.2 Category E, using the Non-Ignition Test. There shall be **NO** explosion caused by any EUT. If an explosion results, the EUT shall have failed the test and further tests need not be conducted.

PROCEDURE

RTCA DO-160G, Section 9.6.2 Category E

1. Seal the Test chamber and raise the ambient Temperature within to the maximum Operating High Temperature given in Table 4-1. The temperature of the test chamber and the chamber walls shall be permitted to rise to within 11°C of the chamber ambient air, prior to the introduction of the explosive mixture, to prevent condensation of the explosive medium.
2. Introduce the required quantity of fuel (paragraph 9.4.4) into the chamber. Circulate the test atmosphere for at least three (3) mins. to allow for complete vaporization of fuel and the development of a homogenous mixture.
3. At this time, actuate all electrical contacts of the test items. Continuously operate the test items throughout this period and make/break all electrical contacts as frequently as deemed practicable.
4. If no explosion occurs as a result of the test item operation, verify the potential explosiveness of the air-vapor mixture by igniting a sample of the mixture with a spark gap or glow plug.



DLS CONFORMITY ASSESSMENT, INC
200 E. Marquardt Drive
Wheeling, IL 60090 USA
Voice 847-537-6400
Fax 847-947-8651
www.dlsemc.com

TEST RESULTS

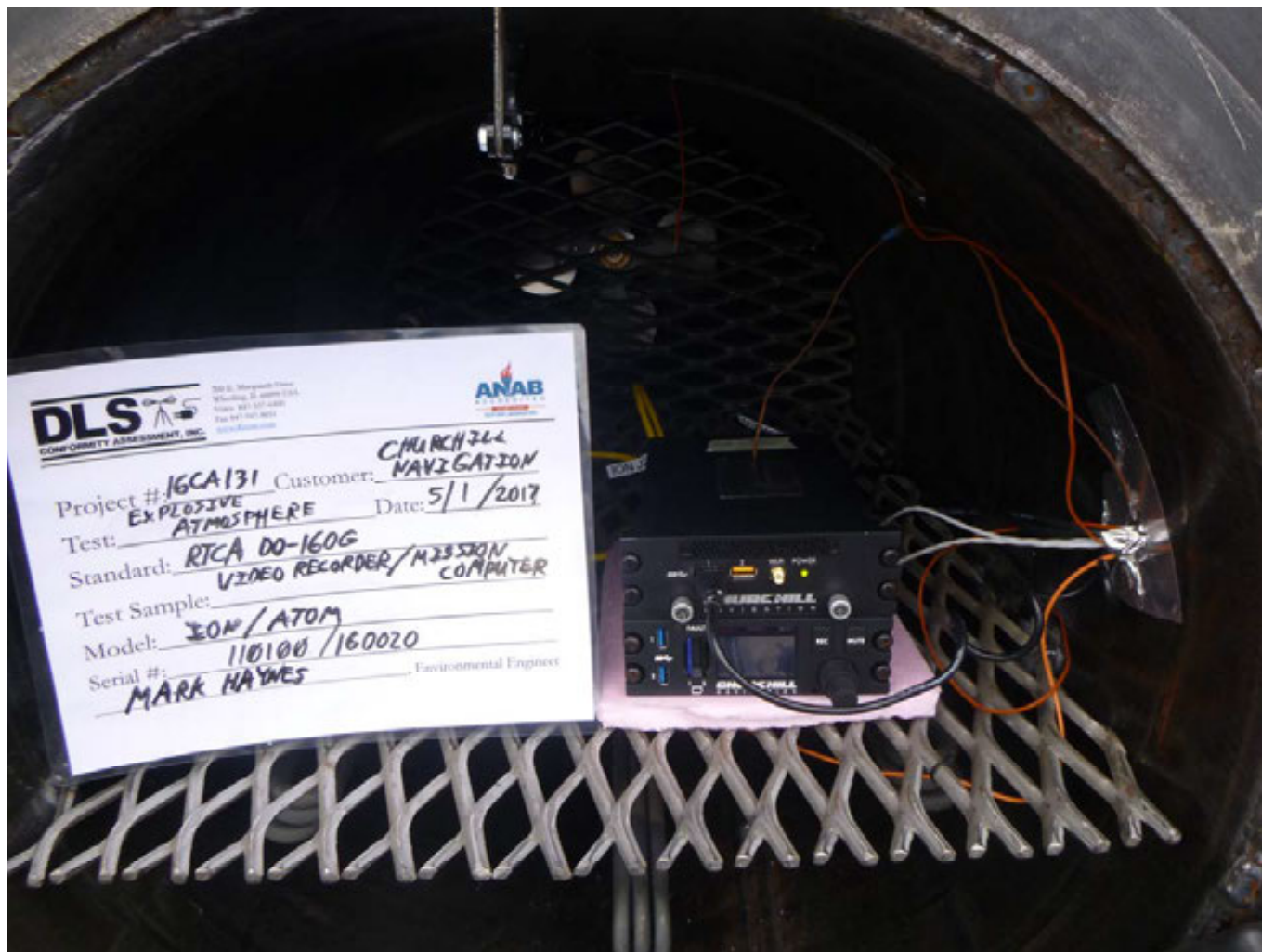
Both EUT's were placed in the chamber, sealed and an air-vapor mixture added. Each EUT was then powered on and off for 3 minutes as per instructions. After 3 minutes the units **DID NOT** cause an explosion. The air-vapor mixture was then tested and a successful explosion occurred. Both EUT's conformed to the applicable test requirements detailed above.

EQUIPMENT USED

Equipment	Manufacturer	Lab Number	Model#	Date Calibrated	Calibration Due Date
Chamber	DLS	295	DLS001	Verified with calibrated Data Acquisition Unit & Gas Meter	
Data Acquisition Unit	Agilent	251	34970A	07/18/2016	07/18/2017
Gas Meter	GDS	296	GDS-58NXP	12/05/2016	12/05/2017
Timer	Cole-Parmer	231	CP47470	03/17/2017	03/17/2018

PHOTOS

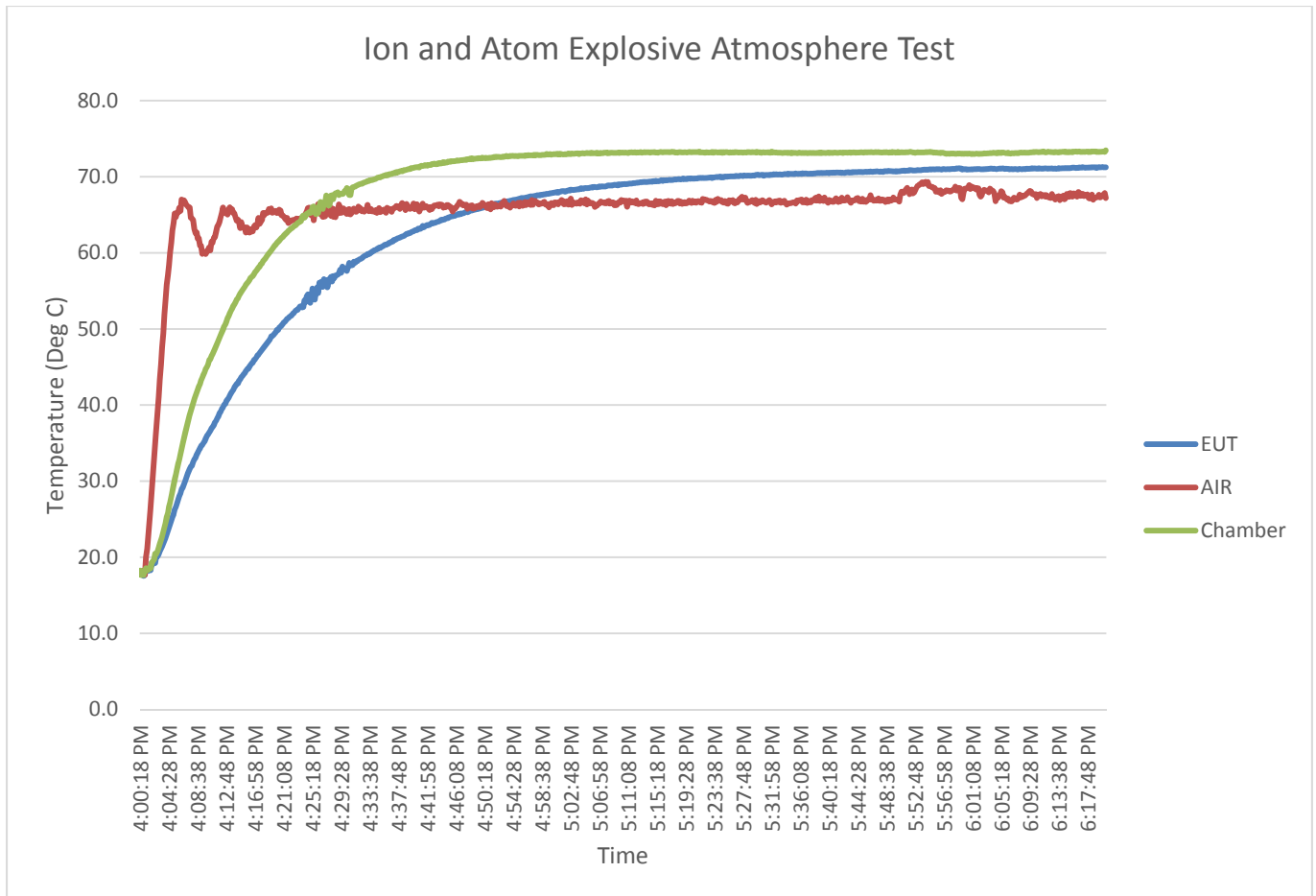
EUT's in Chamber



Test Setup



TEST DATA



Explosive Atmosphere Test Profile



DLS CONFORMITY ASSESSMENT, INC
200 E. Marquardt Drive
Wheeling, IL 60090 USA
Voice 847-537-6400
Fax 847-947-8651
www.dlsemc.com

TEST ITEM DISPOSITION

Samples will be returned to Churchill Navigation

PERSONNEL

DLS Conformity Assessment, Inc.,
Mark A. Haynes
Thomas Komorowski

REPORT DISTRIBUTION

Jordan Heintz
Churchill Navigation
5660 Airport Blvd #101,
Boulder, CO 80301

REVISIONS TO REPORT

Revision: Initial Release