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Revision 2

Total number of pages =276

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Acton, MA 01720

Testing performed for:
BIRNS, Inc.
1720 Fiske Place
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SEISMIC QUALIFICATION REPORT FOR THREE BIRNS INC. LIGHTING UNITS MODELS 4702, 4726 AND 4634

Purchase Order No. 23093

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REVISION RECORD					
DATE	REVISION NUMBER	SEC/PAGE NUMBER	PARA NUMBER	CHANGES OR ADDITIONS	APPROVED BY
0----------FIRST-ISSUE----------11/26/2013					
12/4/2013	1	All		Changed footers to Revision 1	CRP 12/4/13 JM 12/4/13
		Cover		Changed to Revision 1 Changed total # of pages to 276	RRK 12/4/13
		Rev/1		Added revision record	
		3/1	Table	For item 1 replaced 47kg with 17.7kg For item 2 replaced 47kg with 16.3kg For item 3 added weight of approximately 4.5kg. Added Note 1	
12/13/2013	2	All		Changed footers to Revision 2	CRP 12/13/13 JM 12/13/13
		Cover		Changed to Revision 2	RC 12/13/13
		3/1	Note 1	Changed Appendix I to Appendix C (typo)	
		Appendix A	All	Replaced all drawings with latest issued by BIRNS	

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SECTION **PAGE No.'s**

1.0 QUALIFICATION PROGRAM SCOPE

The purpose of this report is to present the methodology, which was utilized to seismically qualify the BIRNS INC. lighting equipment listed in Section 3.0. The devices were seismically qualified to applicable sections of GE Specification No. 63.1030S, Revision 2 dated October, 2012. The applicable sections were paragraph 3.19 Seismic Requirements, Attachment G Lighting Fixtures Response Spectra Figures and Appendix A30 Seismic and Dynamic Qualification (Category 1).

This report documents the nuclear safety related seismic qualification of the equipment identified within Section 3.0 by receipt inspection, functional testing, and seismic qualification by means of dynamic testing.

Receipt inspection, functional testing and seismic testing of the items is addressed in Sections 6.0, 7.0 and 8.0 of this report, respectively. BIRNS INC. supplied the items and mounting fixtures to undergo the qualification effort. Seismic qualification consisted of performing the following:

Resonance Surveys

SRV Alone

OBE + SRV + LOCA

SSE + SRV + LOCA

Chugging (LOCA) Alone

Testing was conducted in accordance with the guidelines provided within IEEE Standard 344-1987 and the seismic margin requirements of IEEE 323 1974. Any pre-aging requirements prior to performance of seismic testing were the responsibility of BIRNS INC. to perform. Seismic qualification testing was performed as detailed within Section 8.0 of this report. Test levels established and duration of each type test performed encompassed the requirements contained within GE Specification No. 63.1030S, Revision 2.

1.0 QUALIFICATION PROGRAM SCOPE (continued)

All work conducted for this program was performed in accordance with the requirements of NTS Corporate Quality Policy Manual Revision 7, dated 9 October, 2012 ensuring the program's compliance to the applicable provisions of 10 CFR, Part 21 and Part 50, Appendix B.

2.0 APPLICABLE REFERENCE DOCUMENTS

2.1 Code of Federal Regulations, Title 10, Part 50, Appendix B, Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants.

2.2 Code of Federal Regulations, Title 10, Part 21, Reporting of Defects and Noncompliance.

2.3 NTS Corporate Quality Policy Manual Revision 7, dated 9 October, 2012.

2.4 Institute of Electrical & Electronics Engineers, Inc. Std. 344-1987, Recommended Practices for Seismic Qualification of Class 1E Equipment.

2.5 IEEE 323-1974, IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations.

2.6 GE Nuclear Energy Specification 63.1030S, Revision 2 dated October, 2012.

2.7 Regulatory Guide 1.100, June 1988, Seismic Qualification of Electric and Mechanical Equipment for Nuclear Power Plants.

2.8 Regulatory Guide 1.89, June 1984, Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants

2.9 NTS Test Procedure TP023710-14N, Revision 2 dated 20 September, 2013.

3.0 COMPONENT DESCRIPTION

The following equipment was supplied by BIRNS INC. to NTS for the purpose of qualification.

Item No.	Qty	Model Number	Description
01	1	4702	ELU Unit Power control System with two lamps attached. 41cm W x 10cm D x 53cm H Weight 17.7 kg approximately
02	1	4726	ELUA Unit Power control system only 38cm W x 9cm D x 33cm H Weight 16.3kg approximately
03	1	4634 (Incandescent)	ELUR Unit Just two lighting lamps attached to a plate (Incandescent lamps) Qty (2) 108.2mm diam. x 47mm D on plate Weight 4.5kg approximately
04	1	4634 (LED)	ELUR Unit Just two lighting lamps attached to a plate (Led lamps) Qty (2) 108.2mm diam. x 47mm D on plate

NOTE: Change of Procedure 001 contained within Appendix C was issued prior to the start of testing to add item 4 above. Operation and monitoring for this item will be the same as for Item 3.

NOTE-1 Above listed weights were provided by the BIRNS Inc.

4.0 CRITICAL CHARACTERISTICS

The critical characteristics were used as acceptance criteria to provide assurance that the items received were the items specified, that the items will perform their intended function, as well as ensure the test items functional integrity throughout seismic testing.

Critical characteristics that were verified are the following:

- Visual Configuration and Part Number verification.
- Digital photographs were taken of the test units during receipt inspection.
- Operability was verified before, during, and after seismic testing per Section 7.0 of this report

BIRNS INC. personnel on-site assisted by NTS perform the functional operability at the time of testing. The critical characteristics verification results were documented by BIRNS Inc.

5.0 PROGRAM SEQUENCE

The qualification program was conducted in the following sequence:

1) Receipt Inspection

2) Functional Testing

3) Seismic Testing

4) Post-Seismic Functional Testing

5) Test Report and Certificate of Seismic Qualification/Compliance

6.0 RECEIPT INSPECTION

The following narrative outlines the receipt inspection NTS performed.

6.1 Visual Damage Inspection

The items were inspected for visual damage and packaging.

Results

There was no damage to the items upon receipt inspection at NTS.

6.2 Documentation Review

The Bill of Material was checked to verify that the items received were the items required for this project.

Results

The item part numbers were in accordance with the customer's PO.

6.3 Visual Configuration

NTS took digital photos showing the configuration of the test items. Photos are made part of Section 8.0 of this report.

7.0 FUNCTIONAL TESTING

The test items were subjected to functional testing to verify operability before, during and after seismic testing. All test data acquired was recorded by BIRNS personnel.

Pre and Post Seismic Functional Test

1. 120VAC, 60Hz power was supplied to the 4702 and 4726 units. The 4726 unit was connected to the remote lights model 4634.
2. Verification that the lights were not illuminated was performed.
3. The test switch on the 4702 and 4726 units was pressed and held.
4. Verification that the lights illuminated was performed.
5. The test switch was released.
6. 120VAC power was removed.
7. Verification that the lights illuminated was performed.
8. 120VAC power was reapplied.
9. Verification that after a time out of approximately 15 minutes that the lights extinguished was performed.

Seismic Functional Testing

During the performance of each of the following test the units were operated as follows.

SRV Event

120VAC was initially supplied to the 4702 and 4726 units. Approximately half way thru the test the 120VAC power was removed during a run. Verification that the lights illuminated and remained illuminated for the second half of the test was performed.

OBE + SRV + LOCA Events

During the 1st and 2nd run, 120VAC power was applied to the 4702 and 4726 units and verification that no illumination of the lights occurred.

During the 3rd run, the 120VAC power to the 4702 and 4726 units was removed during the test and verification that the lights illuminated and remain illuminated was performed.

7.0 FUNCTIONAL TESTING (continued)

Seismic Functional Testing

OBE + SRV + LOCA Events

During the 4th and 5th run, 120VAC was not applied to units 4702 and 4726 and verification that the lights remained illuminated was performed.

SSE + SRV +LOCA Event

120VAC was initially supplied to the 4702 and 4726 units. Approximately 10 seconds into the run the 120VAC power was removed. Verification that the lights illuminated and remained illuminated for the remainder of the test was performed.

Chugging Event

120VAC was initially supplied to the 4702 and 4726 units. Approximately half way thru the test the 120VAC power was removed during a run. Verification that the lights illuminated and remained illuminated for the second half of the test was performed.

Results

The units operated as defined above.

8.0 SEISMIC TESTING

The objective of this testing was to subject the test units to seismic vibration to demonstrate their ability to withstand such vibration without evidence of mechanical damage, deterioration or loss of functional and mounting integrity prior to, during and after the simulated seismic events.

Seismic testing was performed in accordance with the guidelines and requirements of References 2.4 thru 2.8.

8.1 Test Mounting

The test units supplied by BIRNS INC. were mounted on a vertical bookend fixture with Unistrut hardware used to interface the test units to the vertical fixture plate. Mounting the units onto the Unistrut and the Unistrut to the steel fixture was per the Unistrut Mounting Configuration and Mounting on Steel Drawings contained in Appendix A of this report for each item. The fixtured test items were then securely attached to a hydraulic, piston-actuated, shaker table at the NTS Acton seismic test facility. Resonance surveys were done on the NTS single axis test system. All other testing was performed on the NTS independent tri-axial shaker table system within the limits of the simulator.

Control accelerometers were mounted at the base of the test fixture. A triax array of accelerometers was mounted on the top panel of the 4702 and 4726 units. The 4634 items had a triax array of accelerometers mounted to the supporting plate.

The seismic test fixture is a made from welded 3” square by ¼” wall thickness tubing. The front and rear of the fixture can accepted a 3’ x 5’ steel plate. For the purpose of this program the front side of the fixture was used having a ½” steel plated bolted to the three vertical support columns. The bolt pattern was every six inches up the columns. Hardware used was ½ x 13 socket head bolts. The base of the fixture has 3/8” thick angle iron welded on the outside edges and inside perimeters.

8.0 SEISMIC TESTING (continued)

8.1 Test Mounting

A hole pattern every 4 inches allows for bolting the these flanges to the triaxial shaker table platform using ½"x13 socket head bolts. The test specimens were arranged and conformed to the applicable mounting configuration drawings contained in Appendix A for Unistrut Mounting Configuration and for Mounting on Steel having welded Unistrut.

Unistrut channels welded to vertical plate
Front view of fixture

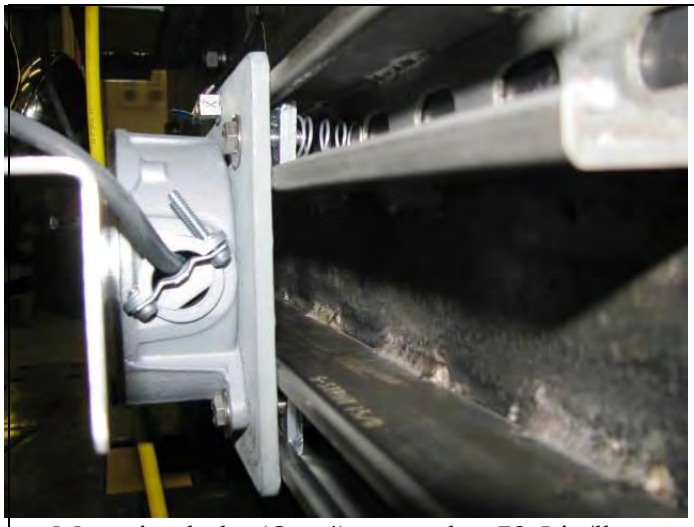
Rear view of fixture

4634 unit with incandescent lamps and Triax Accelerometer mounted

Triax accelerometer mounted on plate of 4634 unit

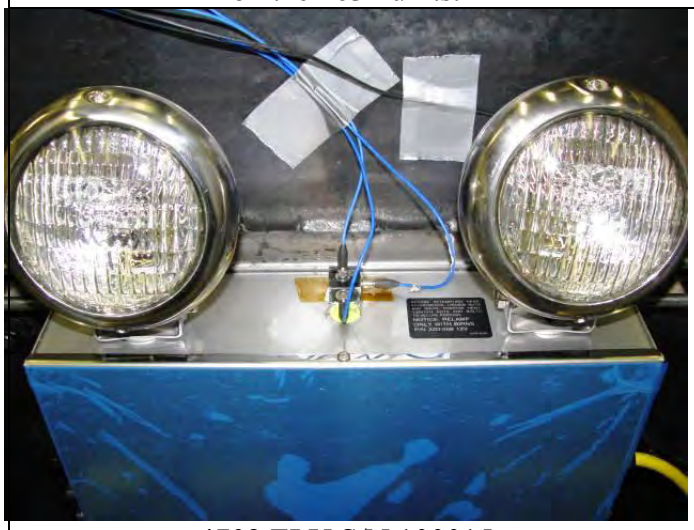
8.0 SEISMIC TESTING (continued)

8.1 Test Mounting

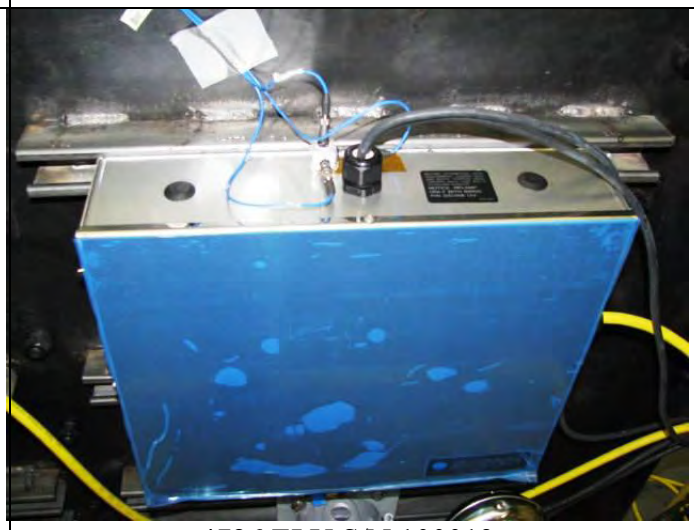


Mounting bolts (Qty 4) torqued to 78.5 in/lbs. on the 4634 units.

4634 unit with LED lamps



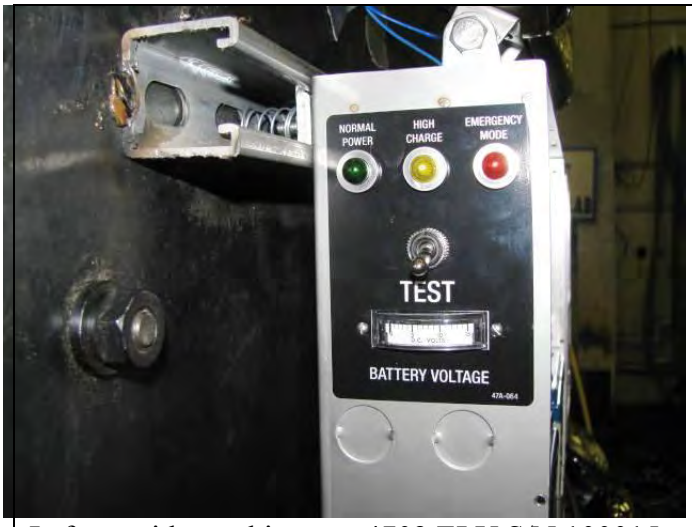
4702 ELU S/N 100015
With triax accelerometer array mounted on top



4726 ELU S/N 100013
With triax accelerometer array mounted on top

8.0 SEISMIC TESTING (continued)

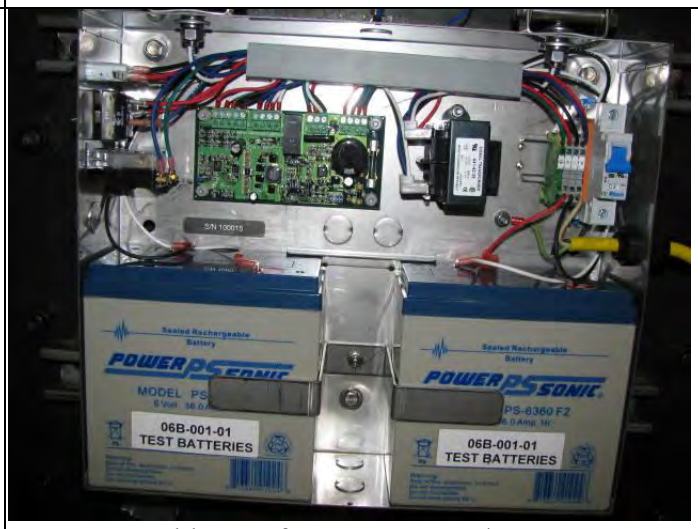
8.1 Test Mounting



Left top side markings on 4702 ELU S/N 100015

Left bottom side markings on 4702 ELU S/N 100015

Topside markings on 4702 ELU S/N 100015



Internal layout for 4702 ELU S/N 100015

8.0 SEISMIC TESTING (continued)

8.1 Test Mounting

Internal layout for 4726 ELU S/N 100013

4726 ELU S/N 100013 Unistrut mounting hardware 3 places, Torqued to 78.5 in/lbs.

8.2 Resonant Frequency Search

A resonant frequency search was performed in the range from 1 to 60Hz at an input excitation level of 0.2g peak. The input acceleration was controlled at all times by means of piezoelectric accelerometer.

Response accelerometers were mounted to the test item and used to monitor the response of the item for determination of any resonant frequencies. The input frequency was swept at a rate of one octave per minute. The resonant frequency searches were performed in each of three orthogonal axes. The test units were not functional during the surveys. X-Y plots of all accelerometers (Frequency versus G's) and transmissibility plots were generated and are contained within Appendix D of this report.

Results

No resonances of the test items were found. Amplification was seen at 49 hertz in the Front to Back axis and at 56 hertz in the Side to Side axis. This was the resonance of the test fixture being used.

8.0 SEISMIC TESTING (continued)

8.2 Resonant Frequency Search

Front to Back Axis Resonance Survey

Side to Side Axis Resonance Survey

Vertical Axis Resonance Survey performed on triax table

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8.3 Safety Relief Valve Testing (SRV)

The intent of this test was to subject the test item to vibratory loads that are imposed by normal plant induced vibration scenarios. Appendix A30 of GE Specification 63.1030S, Revision 2 defines the criteria for SRV testing. The curves are from GE Specification 63.1030S, Revision 2 Attachment G Figures 8 and 36.

The following pages contain the vertical, horizontal and combined RRS curves for the intended SRV envelope with the 10% margin added. Testing was performed to the combine curve of Figure 8-3.

8.0 SEISMIC TESTING (continued)

8.3 Safety Relief Valve Testing (SRV)

SRV testing consisted of meeting 1 event that has a minimum duration of 19 minutes with 8,400 stress cycles produced by 2,850 burst actuations. Each actuation consisted of a burst having a nominal duration of 0.4 seconds. Each actuation contained a minimum of 3 stress cycles.

The method for verifying the stress cycle count was from the time history of the burst actuation. A plot of the time history in each axis was obtained. A virtual horizontal line was drawn at the 50% point of the ZPA value. The number of cycles that exceed the 50% level were counted as stress cycles per actuation. For each burst credit only for 3 stress cycles was taken even if more stress cycles were present that met the 50% criteria. This was a conservative approach.

Upon verifying that the curves were enveloped at the required damping per actuation and that the required stress cycles per actuation were present, a total of 2,850 burst actuations were inputted continuously for a total duration of 19 minutes. Test inputs were random motion equalized at $1/6^{th}$ octave intervals. Response data was analyzed at $1/6^{th}$ octave intervals.

Spectrum plots and time history plots were produced at random times (approximately every 5 minutes) to verify the consistency of the run. Data plots were generated from the burst actuations performed at 610, 1425, 2280 and 2850 burst count. This data is contained within Appendix E of this report.

Table 8-0

Burst #	Appendix E
610	E-2 to E-10
1425	E-11 to E-19
2280	E-20 to E-28
2850	E-29 to E-37

8.0 SEISMIC TESTING (continued)

8.3 Safety Relief Valve Testing (SRV)

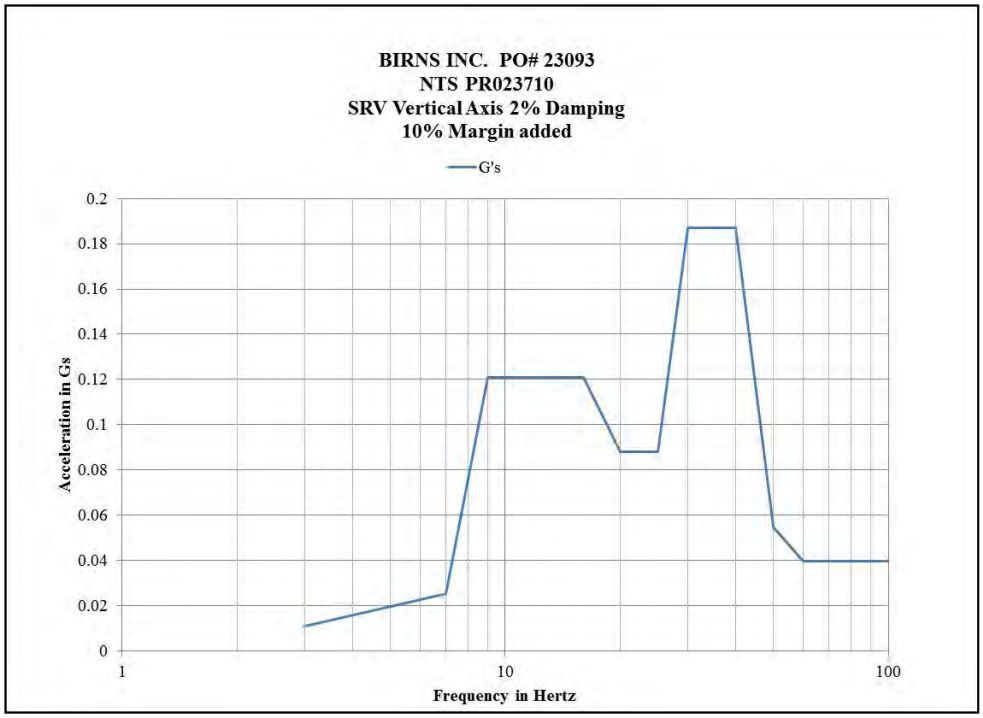
The 2% damping values with 10% margin added are shown on the following pages.

Table 8-1

SRV data points Vertical Axis
2% Damping

Frequency	G's	Frequency	G's
3	0.011	30	0.187
7	0.025	40	0.187
9	0.121	50	0.055
16	0.121	60	0.040
20	0.088	100	0.040
25	0.088		

Figure 8-1



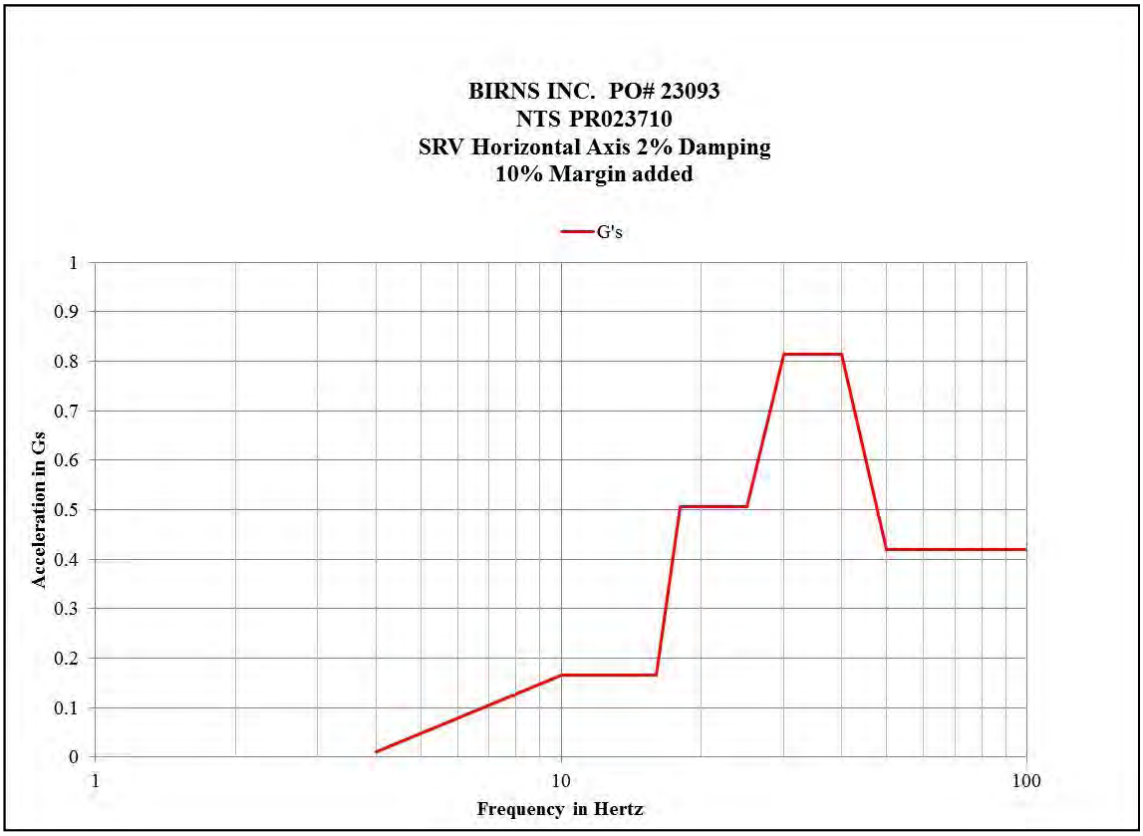
8.0 SEISMIC TESTING (continued)

8.3 Safety Relief Valve Testing (SRV)

Table 8-2
SRV data points Horizontal Axis
2% Damping

Frequency	G's	Frequency	G's
4	0.011	30	0.814
10	0.165	40	0.814
16	0.165	50	0.420
18	0.506	100	0.420
25	0.506		

Figure 8-2



8.0 SEISMIC TESTING (continued)

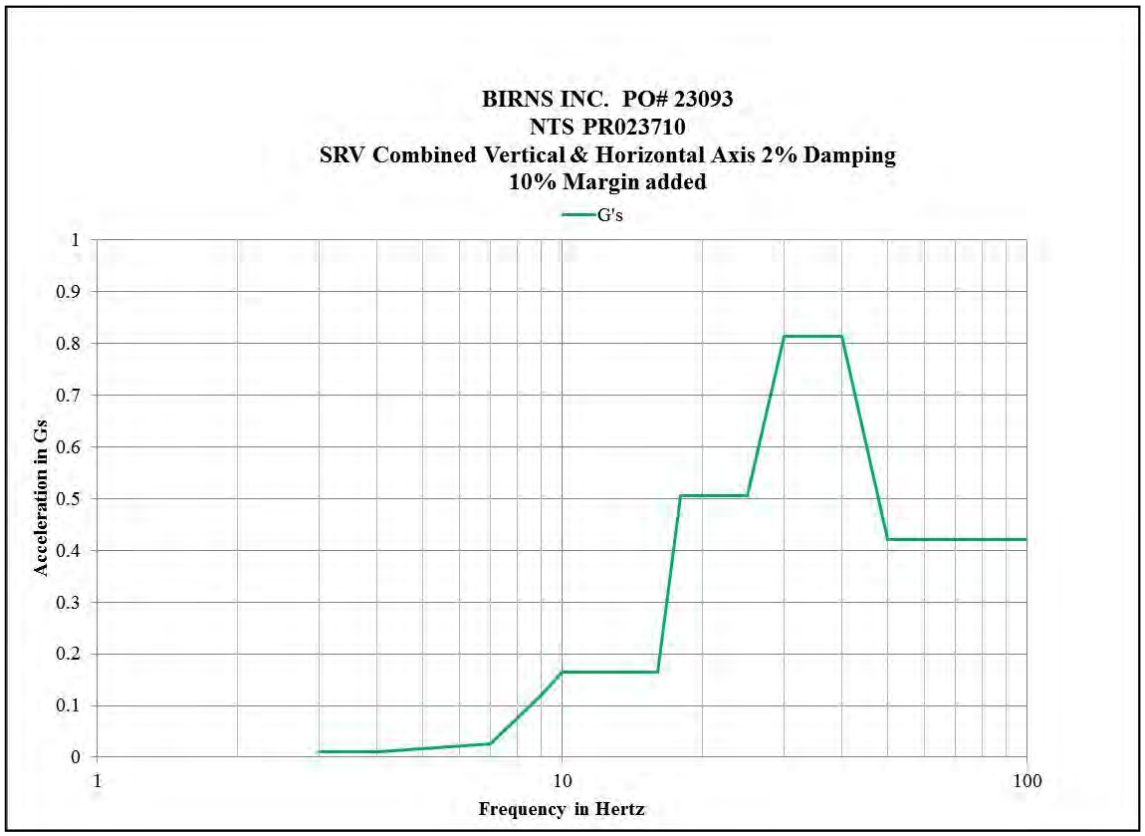
8.3 Safety Relief Valve Testing (SRV)

Table 8-3

SRV data points Combined Horizontal and Vertical Axis
2% Damping

Frequency	G's	Frequency	G's
3	0.011	18	0.506
4	0.011	25	0.506
7	0.025	30	0.814
9	0.121	40	0.814
10	0.165	50	0.420
16	0.165	100	0.420

Figure 8-3



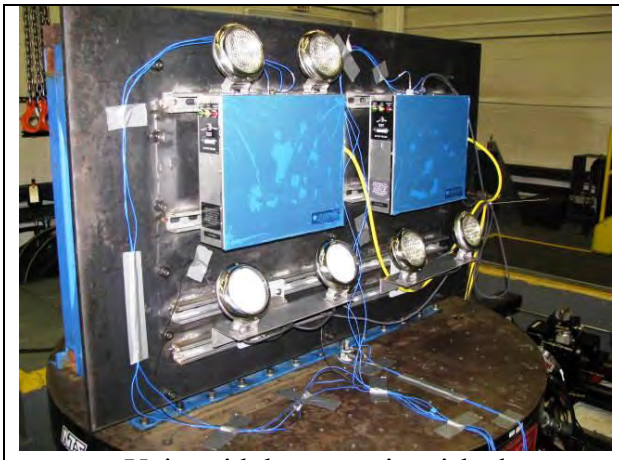
8.0 SEISMIC TESTING (continued)

8.3 Safety Relief Valve Testing (SRV)

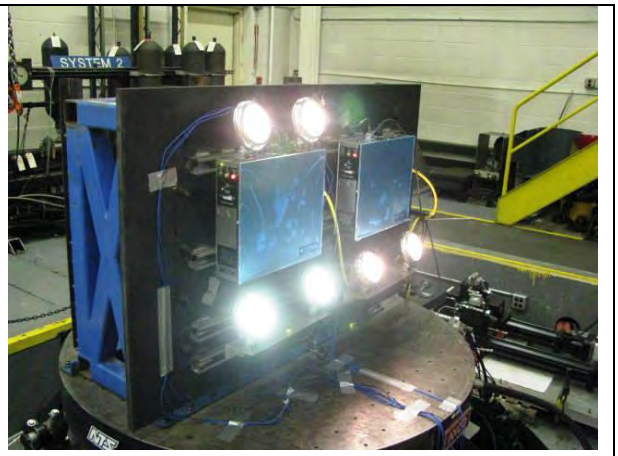
For the first 1425 burst actuations the 4702 and 4726 units had 120VAC applied. Verification that the lamps powered by each unit did not illuminate was performed. During the last 1425 burst actuations the 4702 and 4726 units had 120VAC removed. Verification that the lamps powered by each unit were illuminated was performed.

Results

All units functioned without any anomalies occurring. Post SRV testing was performed by BIRNS personnel with no discrepancies being noted.



Units with lamps extinguished



Units with lamps illuminated

8.4 OBE +LOCA +SRV Multi-Frequency Testing

NTS utilized the ANCO R-5 independent tri-axial table for performance of testing to this section. The tables and curves that follow were derived from GE Specification 63.1030S, Revision 2 Attachment G and have been taken at the 2% damping value with 10% margin added. These curves were then combined for a worst case RRS envelope in both the horizontal and vertical axis. The curves from Figures 8-10 and 8-16 were used for testing. The curves presented are as follows:

2% OBE Damping Curves

TP023710		GE Specification 63.1030S, Revision 2 Attachment G		
Figure #	Table #	Page	Figure	Axis
8-4	8-4	A30-3	M-1	OBE Horizontal
8-5	8-5	A30-14	B-4	OBE Horizontal
8-6	8-6	A30-15	B-5	OBE Horizontal
8-7	8-7	A30-19	B-1	OBE Horizontal
8-8	8-8	A30-21	RBSWPH-1	OBE Horizontal
8-9	8-9	Overlays of Figures 8-4 thru-8-9		OBE Horizontal
8-10	8-10	OBE Required Response Spectra		OBE Horizontal
8-11	8-11	A30-4	M-2	OBE Vertical
8-12	8-12	A30-16	B-6	OBE Vertical
8-13	8-13	A30-20	B-2	OBE Vertical
8-14	8-14	A30-22	RBSWPH-2	OBE Vertical
8-15	8-15	Overlays of Figures 8-11 thru-8-14		OBE Vertical
8-16	8-16	OBE Required Response Spectra		OBE Vertical

8.4 OBE +LOCA +SRV Multi-Frequency Testing

Figure 8-4

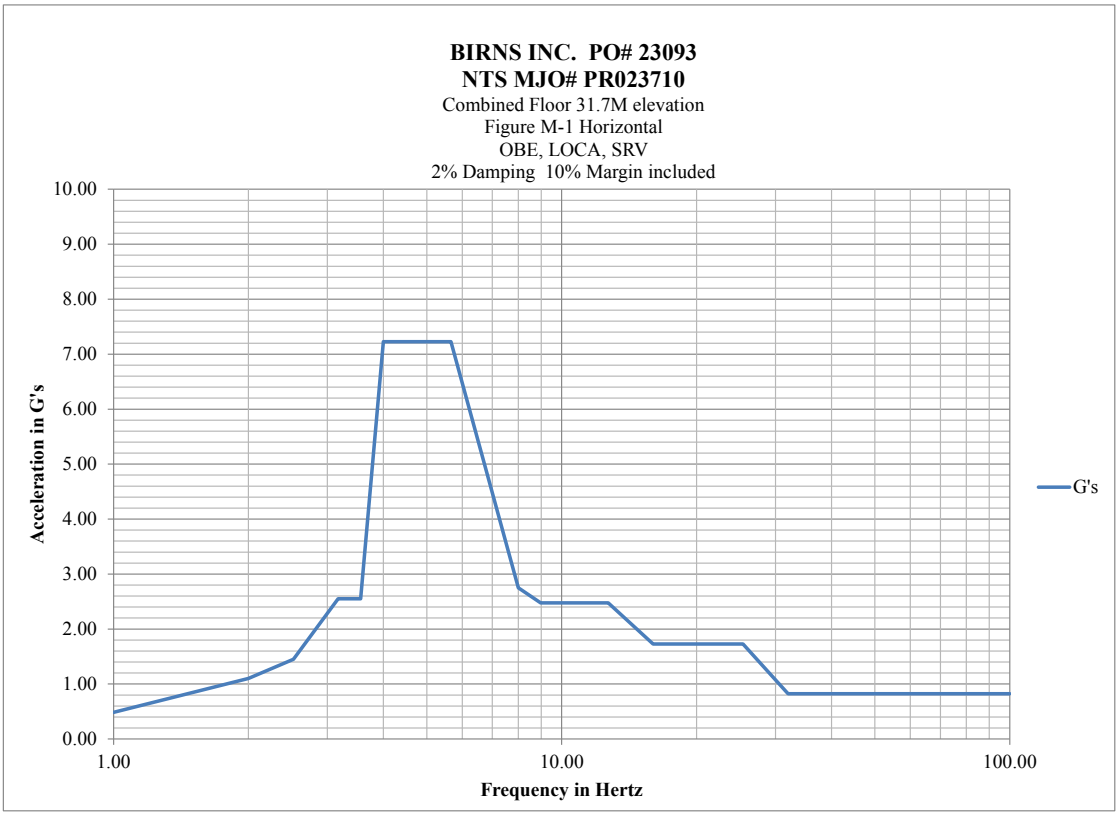


Table 8-4

Figure M-1 Horizontal 2% OBE, LOCA, SRV with 10% margin			
Combined Floor 31.7M elevation			
Frequency	G's	Frequency	G's
1.00	0.48	8.98	2.48
2.00	1.10	12.70	2.48
2.52	1.45	16.00	1.73
3.17	2.55	20.16	1.73
3.56	2.55	25.39	1.73
4.00	7.23	32.00	0.83
5.66	7.23	100.00	0.83
8.00	2.75		

8.0 SEISMIC TESTING (continued)

8.4 OBE +LOCA +SRV Multi-Frequency Testing

Figure 8-5

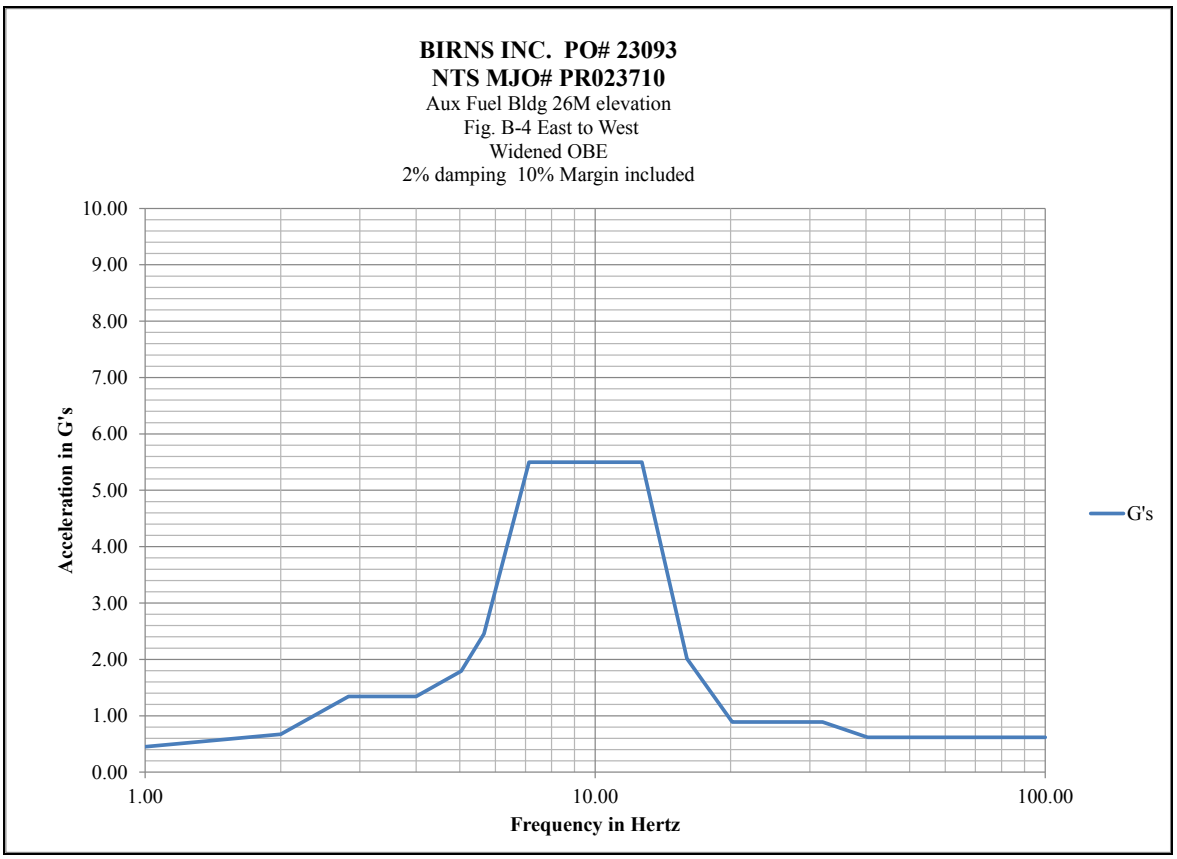


Table 8-5

Fig. B-4 East to West 2% Widened OBE with 10% margin			
Aux Fuel Bldg. 26M elevation			
Frequency	G's	Frequency	G's
1.00	0.45	12.70	5.50
2.00	0.67	16.00	2.01
2.83	1.34	20.16	0.89
4.00	1.34	32.00	0.89
5.04	1.79	40.32	0.62
5.66	2.45	100.0	0.62
7.13	5.50		

8.4 OBE +LOCA +SRV Multi-Frequency Testing

Figure 8-6

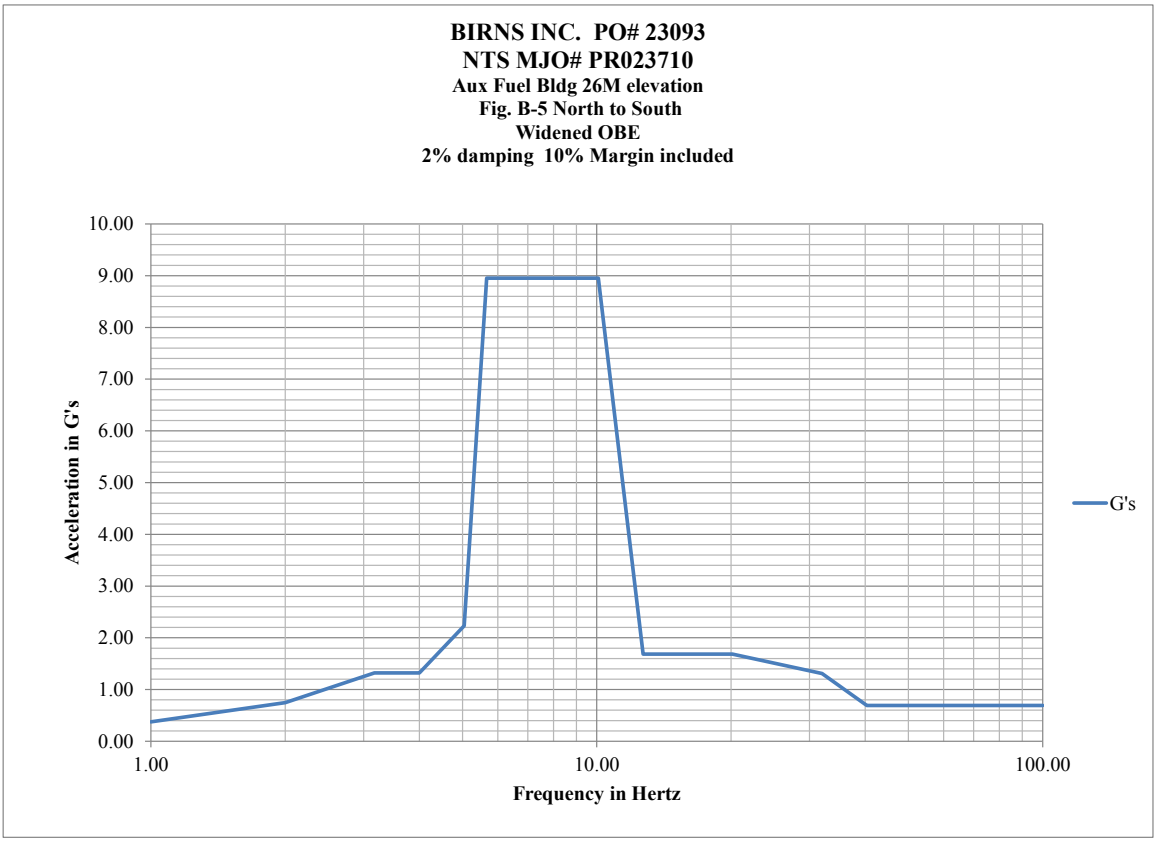


Table 8-6

Fig. B-5 North-South 2% Widened OBE			
Aux Fuel Bldg. 26M elevation			
Frequency	G's	Frequency	G's
1.00	0.37	12.70	1.68
2.00	0.75	16.00	1.68
3.17	1.32	20.16	1.68
4.00	1.32	32.00	1.31
5.04	2.23	40.32	0.69
5.66	8.95	100.0	0.69
10.08	8.95		

8.0 SEISMIC TESTING (continued)

8.4 OBE +LOCA +SRV Multi-Frequency Testing

Figure 8-7

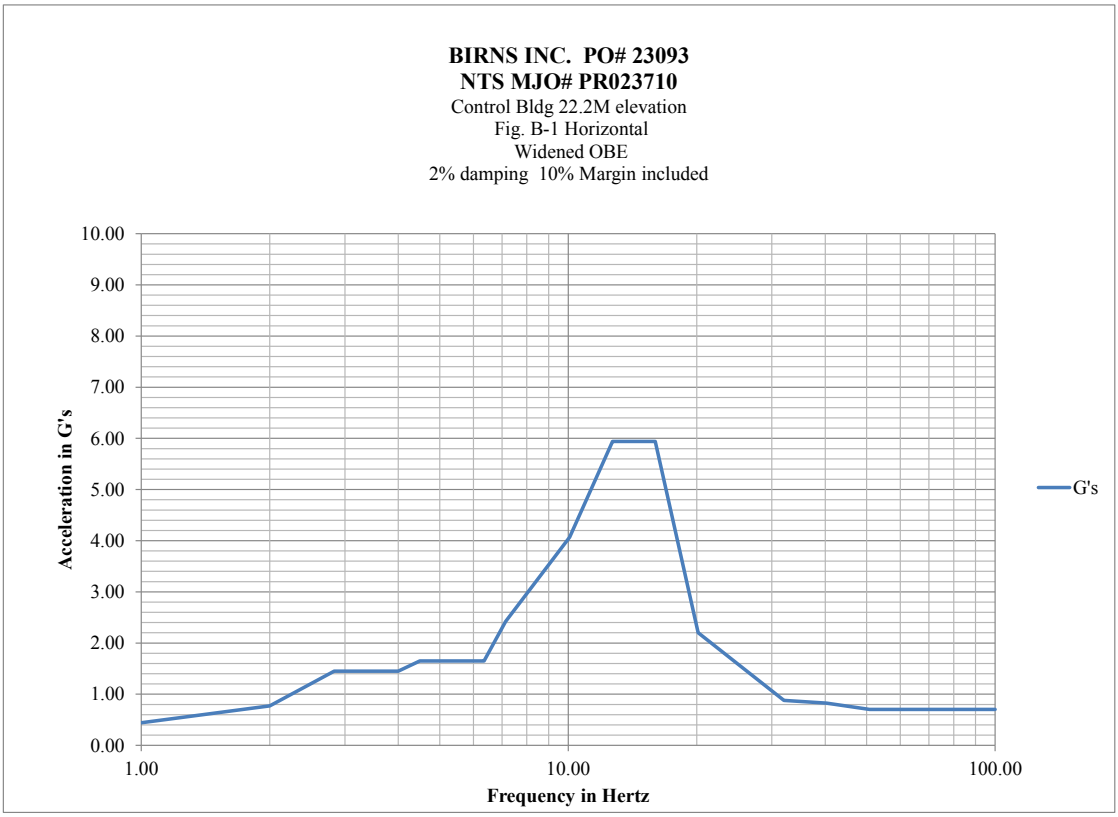


Table 8-7

Fig. B-1 Horizontal 2% Widened OBE with 10% margin			
Control Bldg. 22.2M elevation			
Frequency	G's	Frequency	G's
1.00	0.44	12.70	5.94
2.00	0.77	16.00	5.94
2.83	1.45	20.16	2.20
4.00	1.45	32.00	0.88
4.49	1.65	40.32	0.83
6.35	1.65	50.80	0.70
7.13	2.42	100.00	0.70
10.08	4.07		

8.0 SEISMIC TESTING (continued)

8.4 OBE +LOCA +SRV Multi-Frequency Testing

Figure 8-8

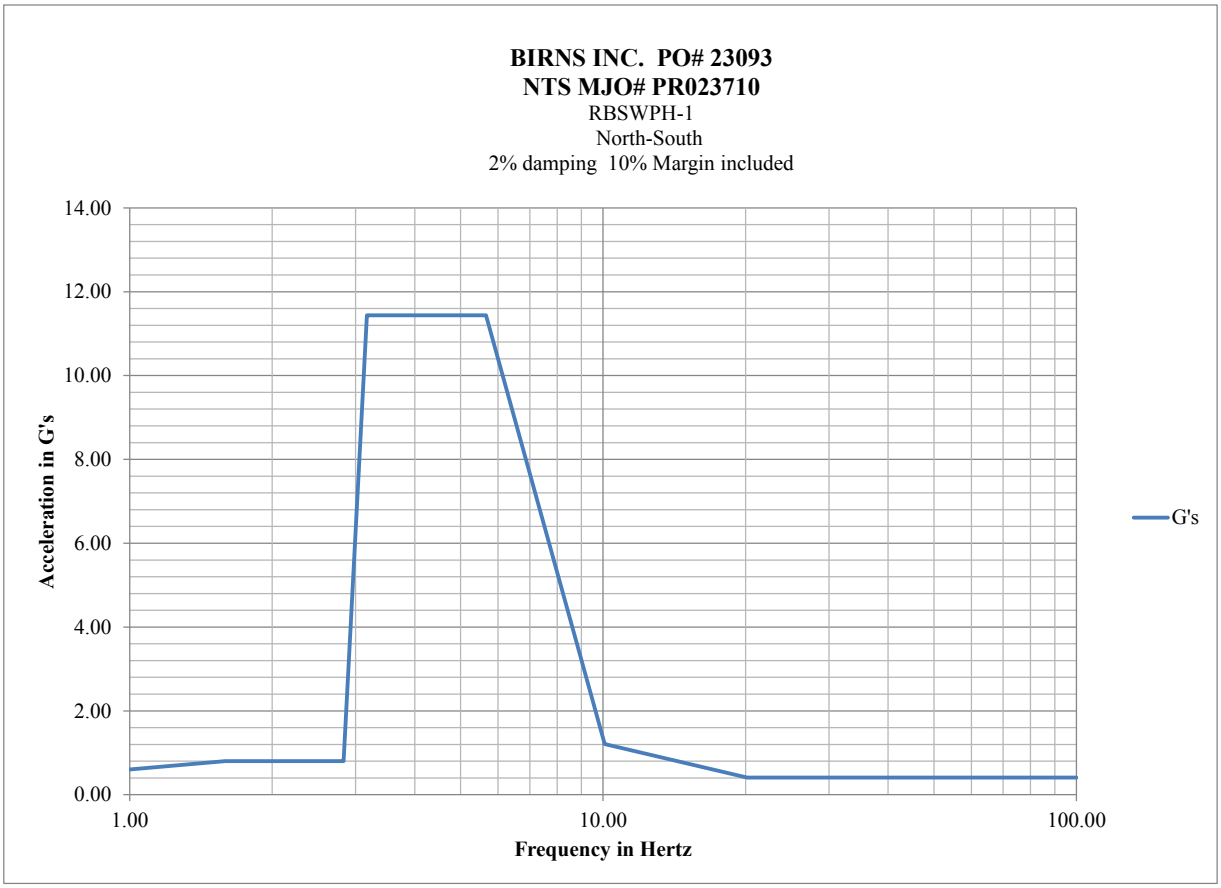
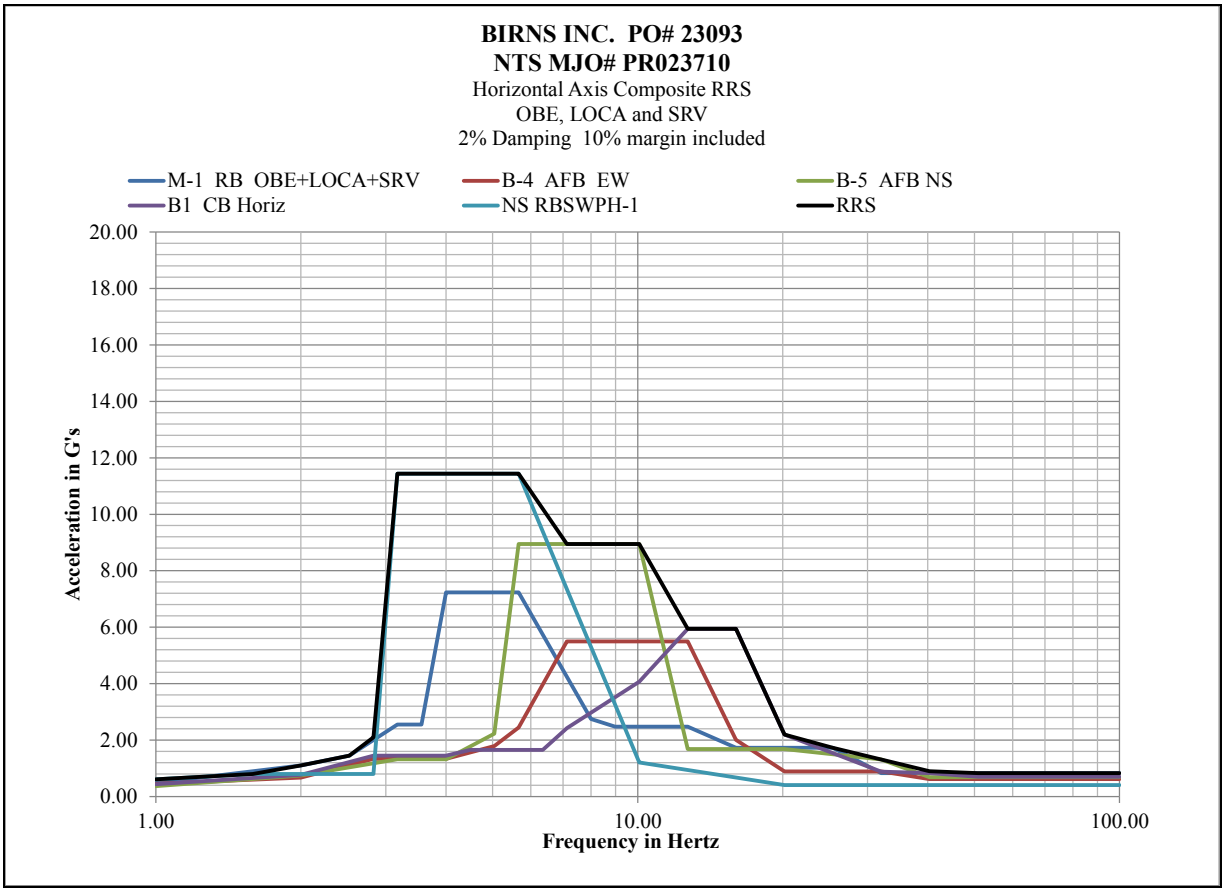


Table 8-8

Reactor Building Service Water Pump House			
RBSWPH-1 2% OBE with 10% margin			
North-South			
Frequency	G's	Frequency	G's
1.00	0.61	5.66	11.44
1.59	0.80	10.08	1.21
2.83	0.80	20.16	0.41
3.17	11.44	100.00	0.41

8.4 OBE +LOCA +SRV Multi-Frequency Testing

Figure 8-9



RB	Reactor Building
AFB	Auxiliary Fuel building
CB	Control Building
RBSWPH	Reactor Building Service Water Pump House

8.0 SEISMIC TESTING (continued)

8.4 OBE +LOCA +SRV Multi-Frequency Testing

Table 8-9

OBE at 2% Damping with 10% margin						
Horizontal Overlays RRS OBE ,LOCA, SRV						
Frequency	M-1 RB OBE+LOCA+SRV	B-4 AFB EW	B-5 AFB-NS	B-1 CB H	NS RBSWPH-1	RRS
1.00	0.48	0.45	0.37	0.44	0.61	0.61
1.59					0.80	0.80
2.00	1.10	0.67	0.75	0.77		1.10
2.52	1.45					1.45
2.83		1.34		1.45	0.80	2.10
3.17	2.55		1.32		11.44	11.44
3.56	2.55					
4.00	7.23	1.34	1.32	1.45		
4.49				1.65		
5.04		1.79	2.23			
5.66	7.23	2.45	8.95		11.44	11.44
6.35				1.65		
7.13		5.50		2.42		8.95
8.00	2.75					
8.98	2.48					
10.08			8.95	4.07	1.21	8.95
12.70	2.48	5.50	1.68	5.94		5.94
16.00	1.73	2.01		5.94		5.94
20.16		0.89	1.68	2.20	0.41	2.20
25.39	1.73					1.73
32.00	0.83	0.89	1.31	0.88		1.31
40.32		0.62	0.69	0.83		0.90
50.80				0.70		0.83
100.00	0.83	0.62	0.69	0.70	0.41	0.83

8.0 SEISMIC TESTING (continued)

8.4 OBE +LOCA +SRV Multi-Frequency Testing

Figure 8-10

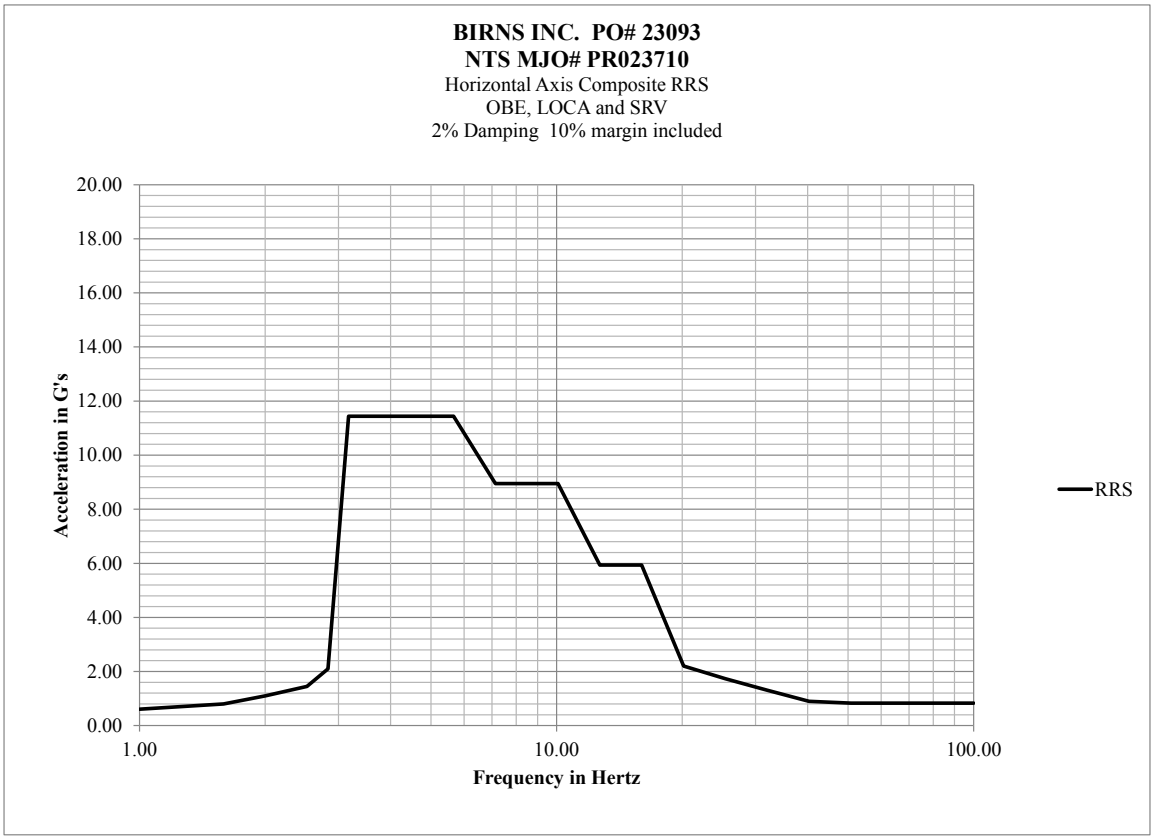


Table 8-10

OBE Horizontal RRS 2% Damping with 10% margin			
Frequency	G's	Frequency	G's
1.00	0.61	12.70	5.94
1.59	0.80	16.00	5.94
2.00	1.10	20.16	2.20
2.52	1.45	25.39	1.73
2.83	2.10	32.00	1.31
3.17	11.44	40.32	0.90
5.66	11.44	50.80	0.83
7.13	8.95	100.00	0.83
10.08	8.95		

8.0 SEISMIC TESTING (continued)

8.4 OBE +LOCA +SRV Multi-Frequency Testing

Figure 8-11

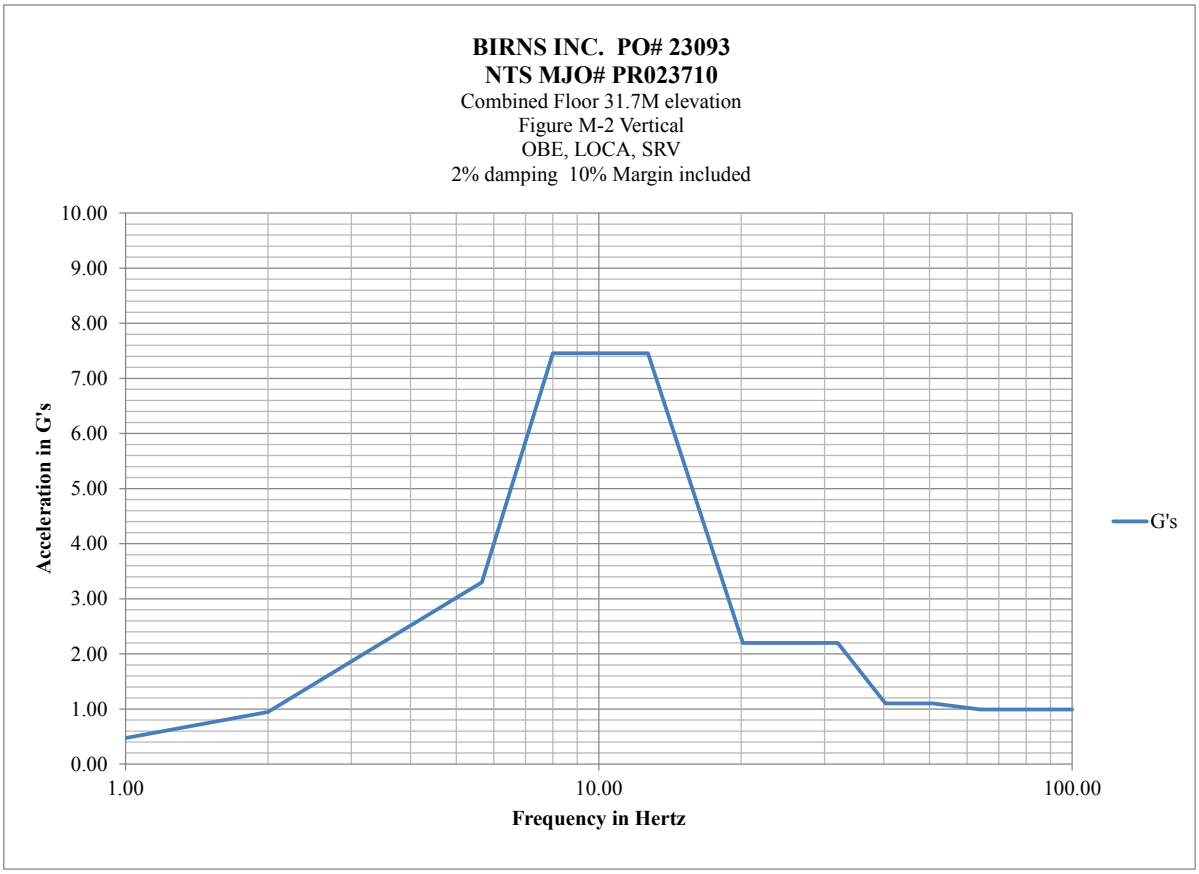


Table 8-11

Figure M-2 Vertical 2% OBE, LOCA, SRV with 10% margin			
Combined Floor 31.7M elevation			
Frequency	G's	Frequency	G's
1.00	0.47	32.00	2.20
2.00	0.95	40.32	1.10
5.66	3.30	50.80	1.10
8.00	7.46	64.00	0.99
12.70	7.46	100.00	0.99
20.16	2.20		

8.4 OBE +LOCA +SRV Multi-Frequency Testing

Figure 8-12

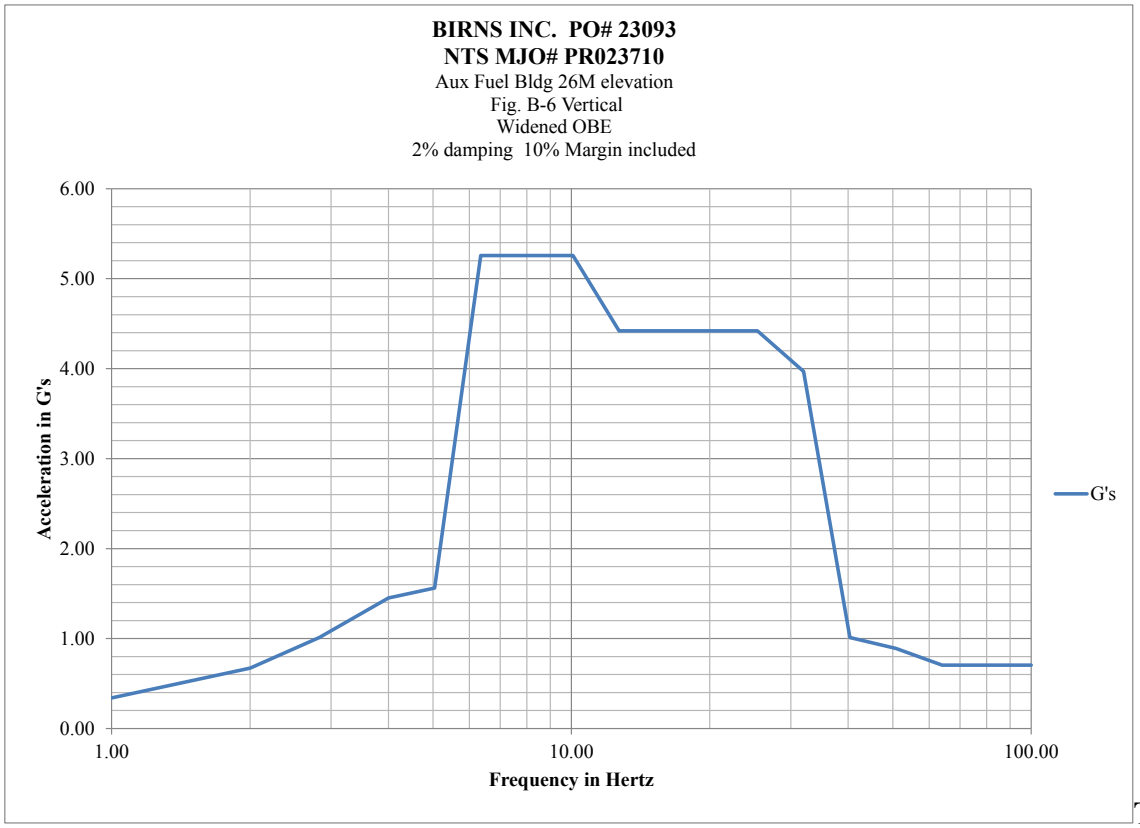


Table 8-12

Fig. B-6 Vertical 2% Widened OBE with 10% margin			
Aux Fuel Bldg. 26M elevation			
Frequency	G's	Frequency	G's
1.00	0.34	16.00	4.42
2.00	0.67	25.40	4.42
2.83	1.01	32.00	3.97
4.00	1.45	40.32	1.01
5.04	1.56	50.80	0.89
6.35	5.26	64.00	0.70
10.08	5.26	100.00	0.70
12.70	4.42		

8.4 OBE +LOCA +SRV Multi-Frequency Testing

Figure 8-13

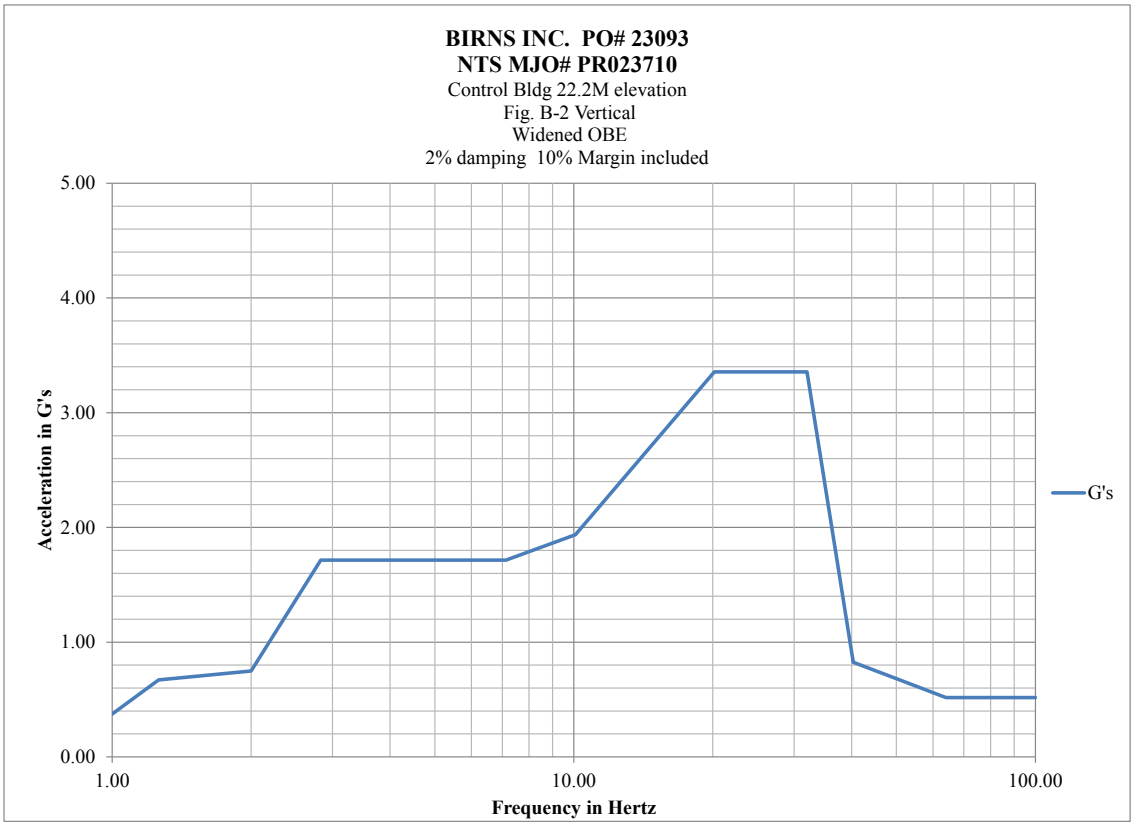


Table 8-13

Fig. B-2 Vertical 2% Widened OBE with 10% margin			
Control Bldg. 22.2M elevation			
Frequency	G's	Frequency	G's
1.00	0.37	20.16	3.36
1.26	0.67	32.00	3.36
2.00	0.75	40.32	0.83
2.83	1.72	50.80	0.67
7.13	1.72	64.00	0.52
10.08	1.94	100.00	0.52

8.5 OBE +LOCA +SRV Multi-Frequency Testing

Figure 8-14

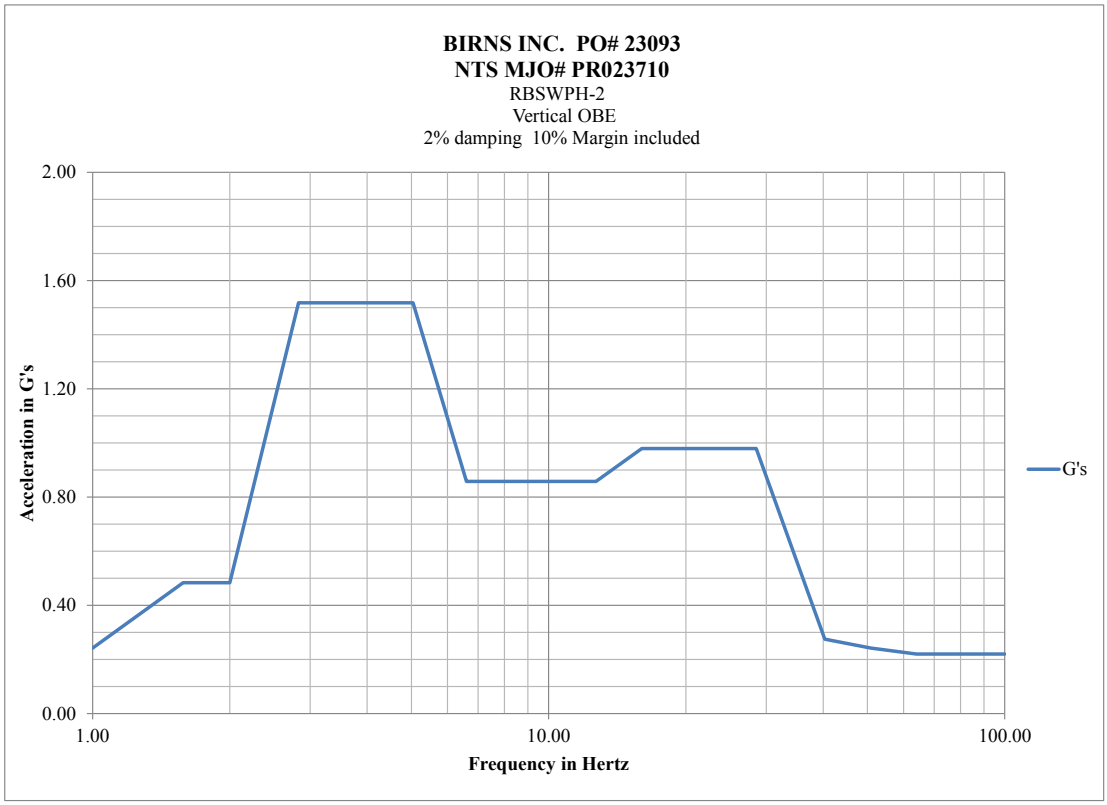


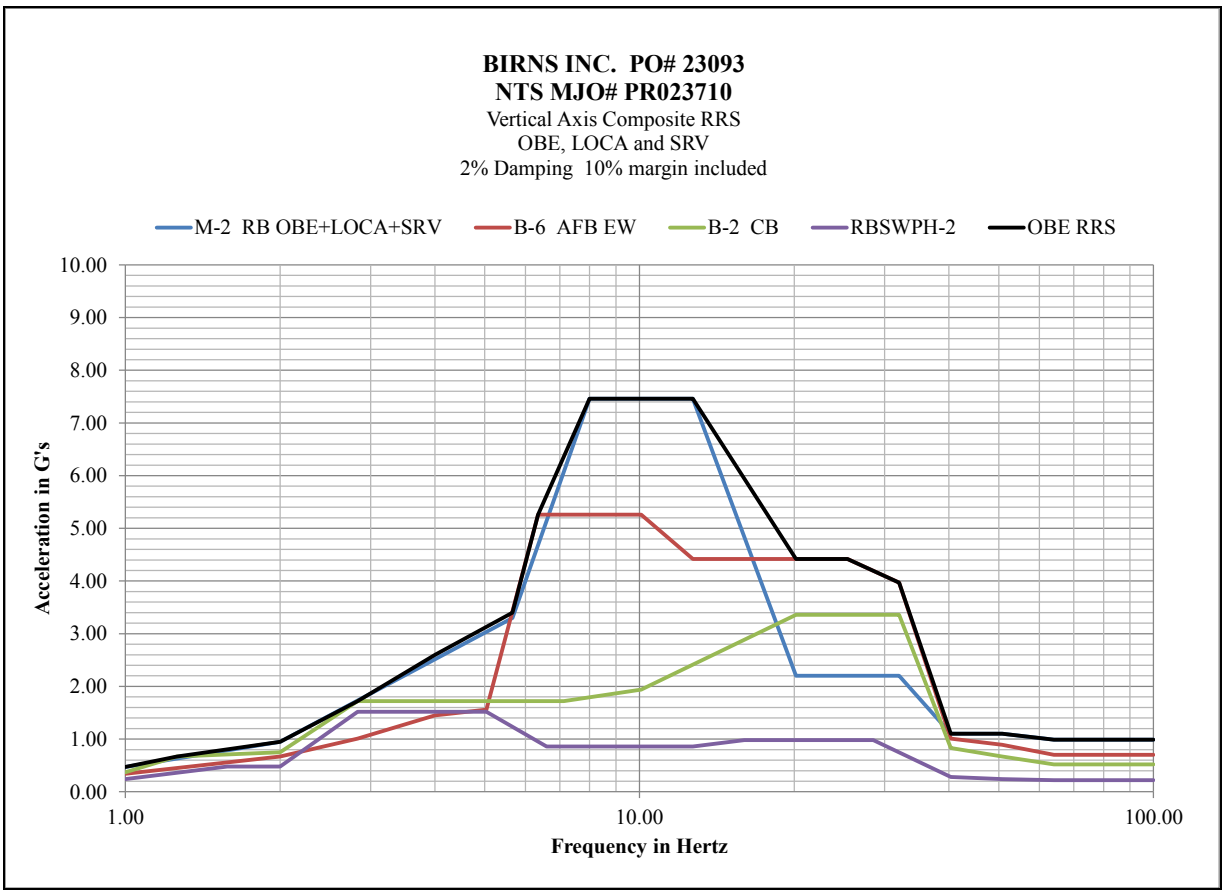
Table 8-14

Reactor Building Service Water Pump House			
RBSWPH-2 2% OBE with 10% margin			
Vertical			
Frequency	G's	Frequency	G's
1.00	0.24	16.00	0.98
41.58	0.48	28.51	0.98
2.00	0.48	40.32	0.28
2.83	1.52	50.80	0.24
5.04	1.52	64.00	0.22
6.60	0.86	100.00	0.22
12.70	0.86		

8.0 SEISMIC TESTING (continued)

8.4 OBE +LOCA +SRV Multi-Frequency Testing

Figure 8-15



RB	Reactor Building
AFB	Auxiliary Fuel building
CB	Control Building
RBSWPH	Reactor Building Service Water Pump House

8.4 OBE +LOCA +SRV Multi-Frequency Testing

Table 8-15

OBE at 2% Damping with 10% Margin					
Vertical Overlays OBE, LOCA, SRV					
Frequency	M-2 RB OBE+LOCA+SRV	B-6 AFB	B-2 CB	RBSWPH-2	OBE RRS
1.00	0.47	0.34	0.37	0.24	0.47
1.26			0.67		0.67
1.58				0.48	
2.00	0.95	0.67	0.75	0.48	0.95
2.83		1.01	1.72	1.52	1.72
4.00		1.45			2.60
5.04		1.56		1.52	
5.66	3.30				3.40
6.35		5.26			5.26
6.60				0.86	
7.13			1.72		
8.00	7.46				7.46
10.08		5.26	1.94		
12.70	7.46	4.42		0.86	7.46
16.00				0.98	
20.16	2.20		3.36		4.42
25.40		4.42			4.42
28.51				0.98	
32.00	2.20	3.97	3.36		3.97
40.32	1.10	1.01	0.83	0.28	1.10
50.80	1.10	0.89	0.67	0.24	1.10
64.00	0.99	0.70	0.52	0.22	0.99
100.00	0.99	0.70	0.52	0.22	0.99

8.0 SEISMIC TESTING (continued)

8.4 OBE +LOCA +SRV Multi-Frequency Testing

Figure 8-16

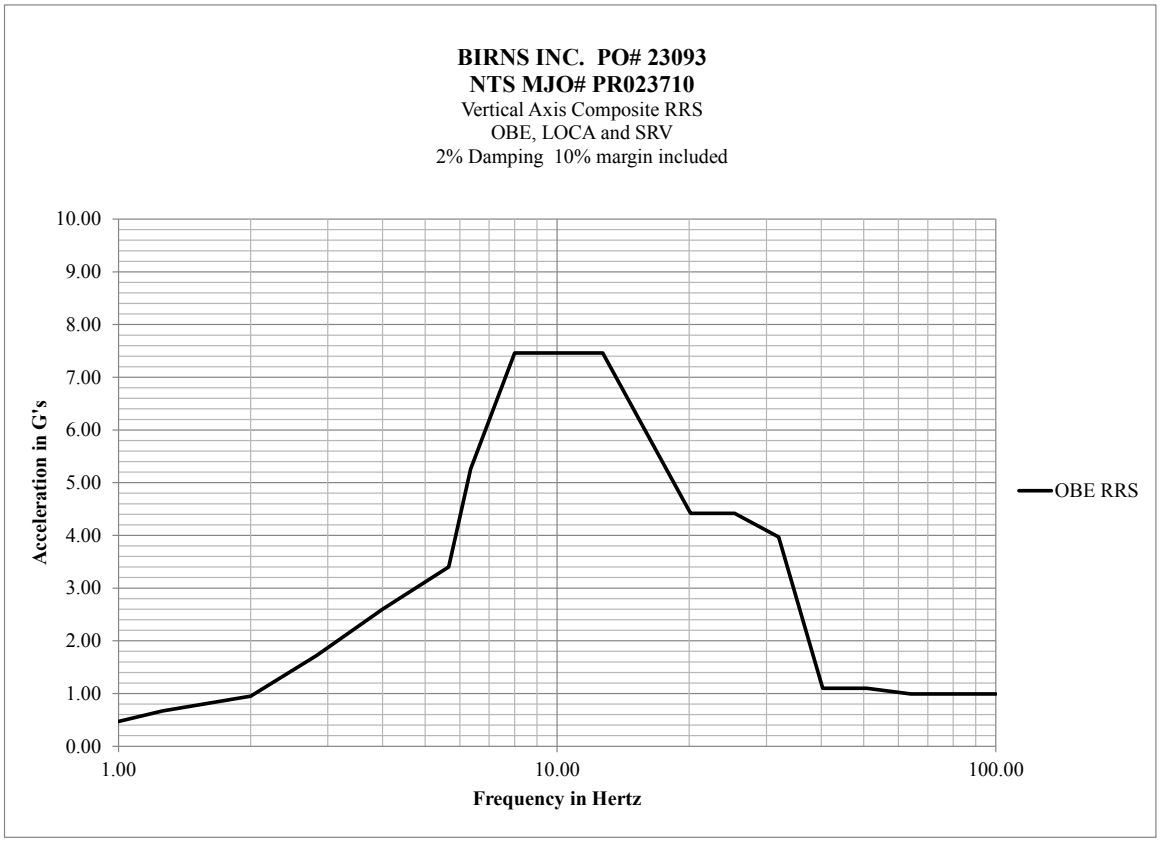


Table 8-16

OBE Vertical RRS 2% Damping with 10% margin			
Frequency	OBE RRS	Frequency	OBE RRS
1.00	0.47	12.70	7.46
1.26	0.67	20.16	4.42
2.00	0.95	25.40	4.42
2.83	1.72	32.00	3.97
4.00	2.60	40.32	1.10
5.66	3.40	50.80	1.10
6.35	5.26	64.00	0.99
8.00	7.46	100.00	0.99

8.0 SEISMIC TESTING (continued)

8.4 OBE +LOCA +SRV Multi-Frequency Testing

Table 8-16-A below list the actual spectrum acceleration values achieved for OBE #5 (Typical for each OBE run). At each 1/6th octave frequency the demand value for the horizontal and vertical directions is given versus the actual values achieved.

Table 8-16-A

OBE 5					
Frequency	**Horizontal Demand (G)**	**Front-Back (G)**	**Side-Side (G)**	**Vertical Demand (G)**	**Vertical (G)**
1.00	0.61	0.73	0.69	0.47	0.56
1.12	0.65	0.75	0.76	0.56	0.61
1.26	0.70	0.78	0.81	0.67	0.81
1.41	0.75	0.90	0.92	0.73	0.88
1.59	0.80	0.97	0.98	0.80	1.00
1.78	0.94	1.14	1.21	0.87	1.12
2.00	1.10	1.44	1.40	0.95	1.21
2.24	1.26	1.62	1.59	1.16	1.47
2.52	1.45	2.10	2.10	1.41	1.85
2.83	2.10	4.78	4.31	1.72	2.10
3.17	11.44	14.03	14.37	1.97	2.48
3.56	11.44	14.51	14.47	2.26	3.08
4.00	11.44	14.30	14.31	2.60	3.25
4.49	11.44	14.31	14.29	2.84	3.63
5.04	11.44	14.09	14.52	3.11	4.11
5.66	11.44	14.31	14.29	3.40	4.26
6.35	10.12	13.09	12.63	5.26	6.72
7.13	8.95	11.76	10.82	6.26	7.80
8.00	8.95	11.91	12.40	7.46	9.50
8.98	8.95	12.39	12.08	7.46	9.32
10.08	8.95	12.62	11.06	7.46	8.85
11.31	7.29	8.53	10.72	7.46	9.92
12.70	5.94	10.58	11.28	7.46	9.06
14.25	5.94	14.29	8.65	6.55	10.32
16.00	5.94	11.07	12.26	5.74	8.91
17.96	3.62	11.10	10.10	5.04	9.23
20.16	2.20	8.96	9.55	4.42	9.10
22.63	1.95	10.11	8.20	4.42	9.31
25.40	1.73	8.57	7.55	4.42	7.37
28.51	1.51	7.61	5.21	4.19	6.63
32.00	1.31	5.92	5.39	3.97	5.60
35.92	1.09	5.35	5.03	2.09	3.69
40.32	0.90	5.72	4.74	1.10	3.32
45.25	0.86	5.30	5.02	1.10	3.08
50.80	0.83	5.30	4.55	1.10	2.79
57.02	0.83	4.94	4.36	1.04	2.60
64.00	0.83	4.80	4.27	0.99	2.56
71.84	0.83	4.73	4.21	0.99	2.53
80.63	0.83	4.67	4.17	0.99	2.50
90.51	0.83	4.64	4.13	0.99	2.48
100.00	0.83	4.61	4.11	0.99	2.47

8.0 SEISMIC TESTING (continued)

8.4 OBE +LOCA +SRV Multi-Frequency Testing

Operation of the test units for each OBE run was performed as detailed in Table 8-16-B.

Table 8-16-B

Test# OBE #	Power to 4702 and 4726 units	4634 Incandescent 4634 LED Status	Appendix F Data
Test 5 OBE 1	120VAC	Off	F-2 to F-10
Test 6 OBE 2	120VAC	Off	F-11 to F-19
Test 7 OBE 3	120VAC to 0VAC	Off to On	F-20 to F-28
Test 8 OBE 4	0VAC	On	F-29 to F-37
Test 9 OBE 5	OVAC	On	F-38 to F-46

Results

All units functioned without any anomalies occurring. Post SRV testing was performed by BIRNS personnel with no discrepancies being noted.

8.0 SEISMIC TESTING (continued)

8.5 SSE+ SRV + LOCA Multi-Frequency Testing

NTS utilized the ANCO R-5 independent tri-axial table for performance of testing to this section. The tables and curves that follow were derived from GE Specification 63.1030S, Revision 2 Attachment G and have been taken at the 2% damping value with 10% margin added. These curves were then combined for a worst case RRS envelope in both the horizontal and vertical axis. The curves from Figures 8-23 and 8-29 were used for testing within the limitations of the triax table.

The SSE Horizontal curve (Figure 8-23) and SSE Vertical curve (Figure 8-29) could not be enveloped fully below 2 hertz due to limitations of the triax table. IEEE-344 1987 allows for this to occur providing there were no resonances below 5 hertz as long as the curve is met at 3.5 hertz and upwards. This criterion was met under this program.

The curves presented are as follows:

2% SSE Damping Curves

TP023710		GE Specification 63.1030S, Revision 2 Attachment G		
Figure #	Table #	Page	Figure	Axis
8-17	8-17	A30-5	N-1	SSE Horizontal
8-18	8-18	A30-11	A-4-	SSE Horizontal
8-19	8-19	A30-12	A-5	SSE Horizontal
8-20	8-20	A30-17	A-1	SSE Horizontal
8-21	8-21	A30-23	RBSWPH-3	SSE Horizontal
8-22	8-22	Overlays of Figures 8-17 thru-8-21		SSE Horizontal
8-23	8-23	SSE Required Response Spectra		SSE Horizontal
8-24	8-24	A30-6	N-2	SSE Vertical
8-25	8-25	A30-13	A-6	SSE Vertical
8-26	8-26	A30-18	A-2	SSE Vertical
8-27	8-27	A30-24	RBSWPH-4	SSE Vertical
8-28	8-28	Overlays of Figures 8-11 thru-8-14		SSE Vertical
8-29	8-29	OBE Required Response Spectra		SSE Vertical

8.5 SSE+ SRV + LOCA Multi-Frequency Testing

Figure 8-17

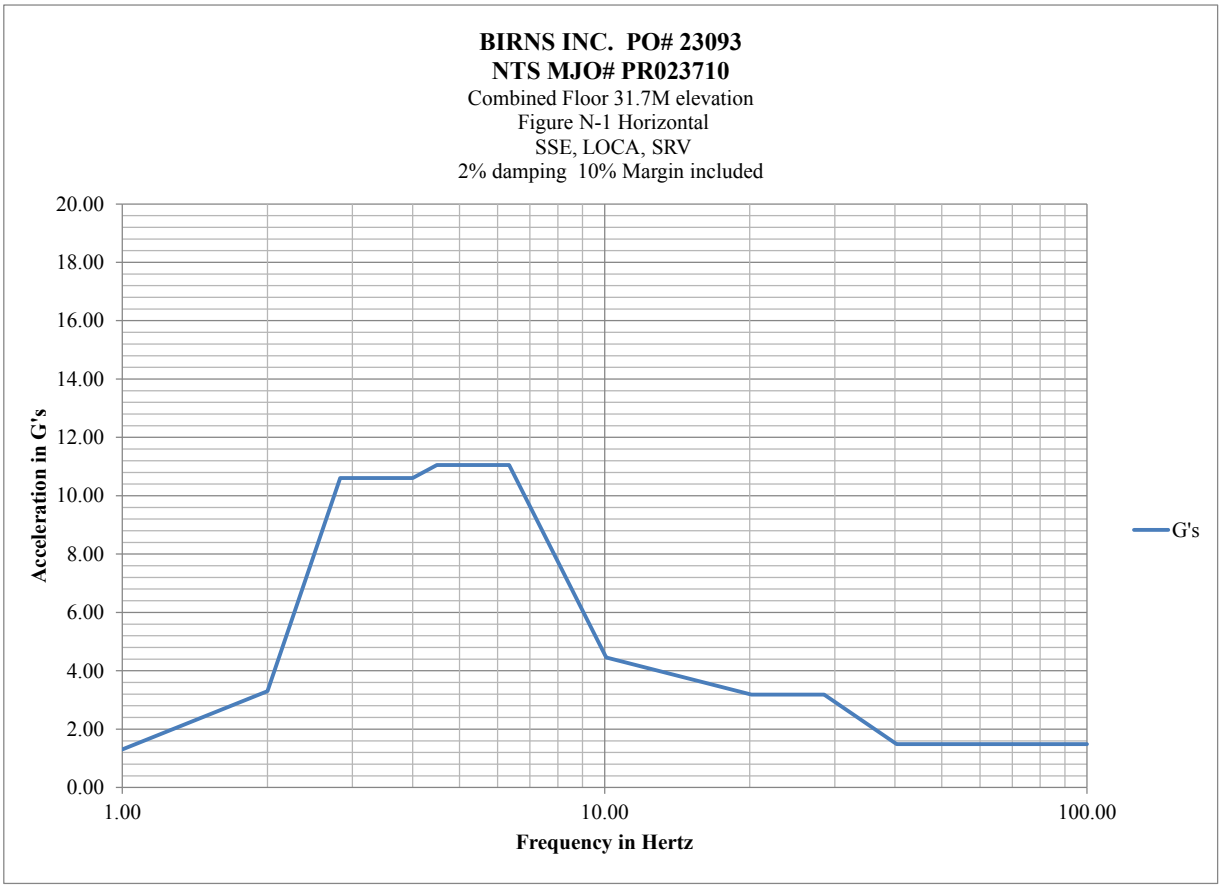


Table 8-17

Figure N-1 Horizontal 2% SSE, LOCA, SRV with 10% margin			
Combined Floor 31.7M elevation			
Frequency	G's	Frequency	G's
1.00	1.30	10.08	4.46
2.00	3.30	20.16	3.18
2.83	10.61	28.51	3.18
4.00	10.61	40.32	1.49
4.49	11.06	100.00	1.49
6.34	11.06		

8.5 SSE+ SRV + LOCA Multi-Frequency Testing

Figure 8-18

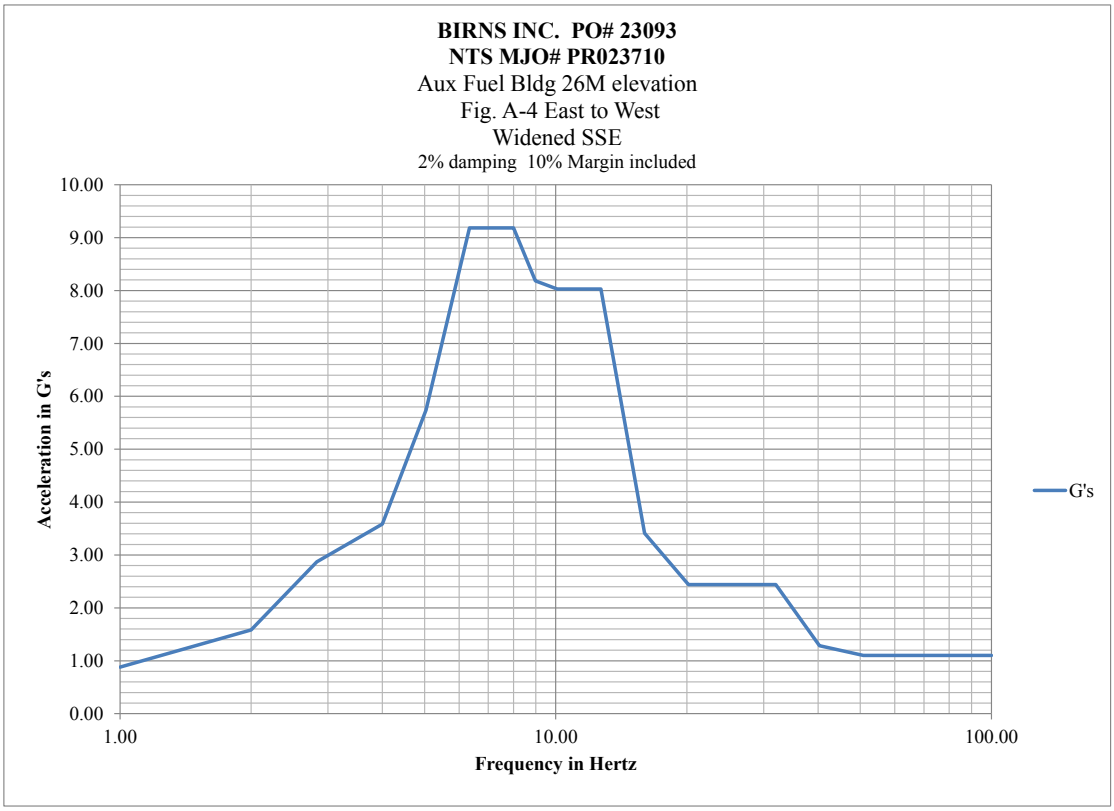


Table 8-18

Fig. A-4 East to West 2% Widened SSE with 10% margin			
Aux Fuel Bldg. 26M elevation			
Frequency	G's	Frequency	G's
1.00	0.88	10.08	8.03
2.00	1.58	12.70	8.03
2.83	2.87	16.00	3.41
4.00	3.59	20.16	2.44
5.04	5.74	32.00	2.44
6.34	9.19	40.32	1.29
8.00	9.19	50.80	1.10
8.98	8.18	100.00	1.10

8.5 SSE+ SRV + LOCA Multi-Frequency Testing

Figure 8-19

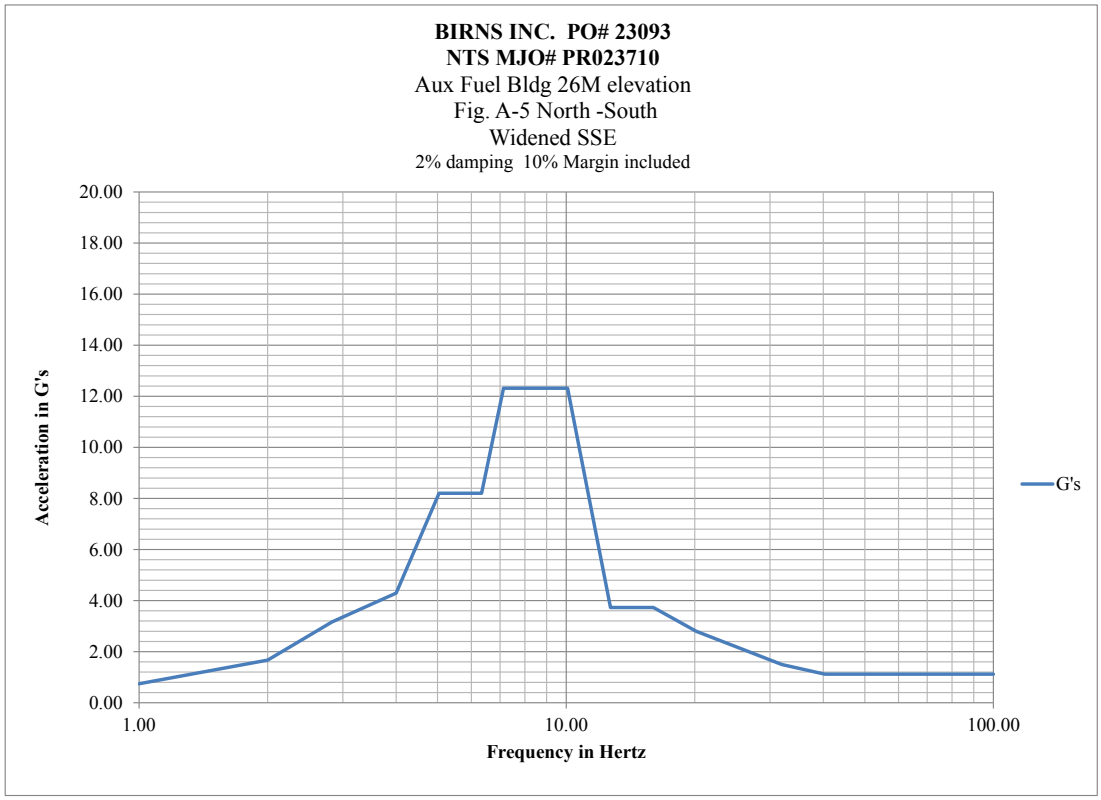


Table 8-19

Fig. A-5 North –South 2% Widened SSE with 10% margin			
Aux Fuel Bldg. 26M elevation			
Frequency	G's	Frequency	G's
1.00	0.75	10.08	12.32
2.00	1.67	12.70	3.73
2.83	3.17	16.00	3.73
4.00	4.29	20.16	2.79
5.04	8.21	32.00	1.50
6.34	8.21	40.32	1.12
7.13	12.32	50.80	1.12
8.98	12.32	100.00	1.12

8.5 SSE+ SRV + LOCA Multi-Frequency Testing

Figure 8-20

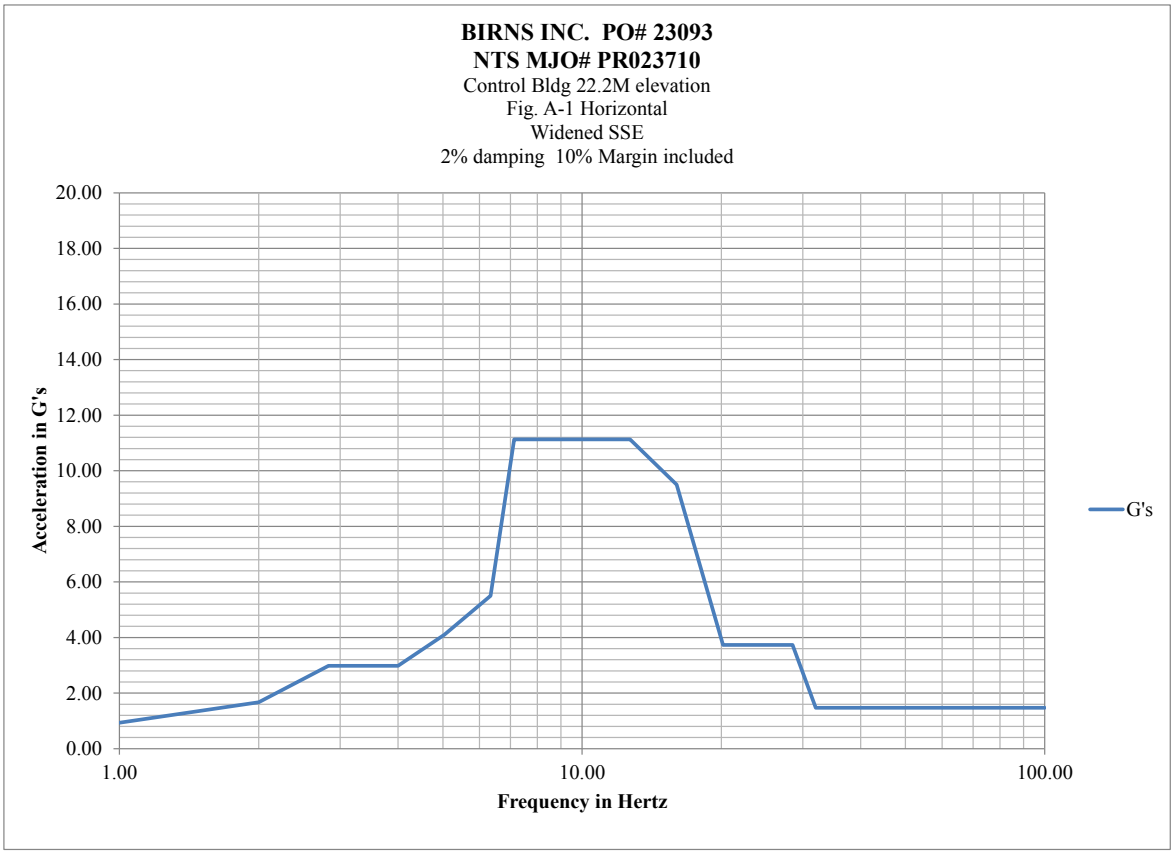


Table 8-20

Fig. A-1 Horizontal 2% Widened SSE			
Control Bldg. 22.2M elevation			
Frequency	G's	Frequency	G's
1.00	0.94	10.08	11.13
2.00	1.67	12.70	11.13
2.83	2.98	16.00	9.50
4.00	2.98	20.16	3.75
5.04	4.10	28.51	3.75
6.34	5.50	32.00	1.47
7.13	11.13	50.80	1.47
8.98	11.13	100.00	1.47

8.0 SEISMIC TESTING (continued)

8.5 SSE+ SRV + LOCA Multi-Frequency Testing

Figure 8-21

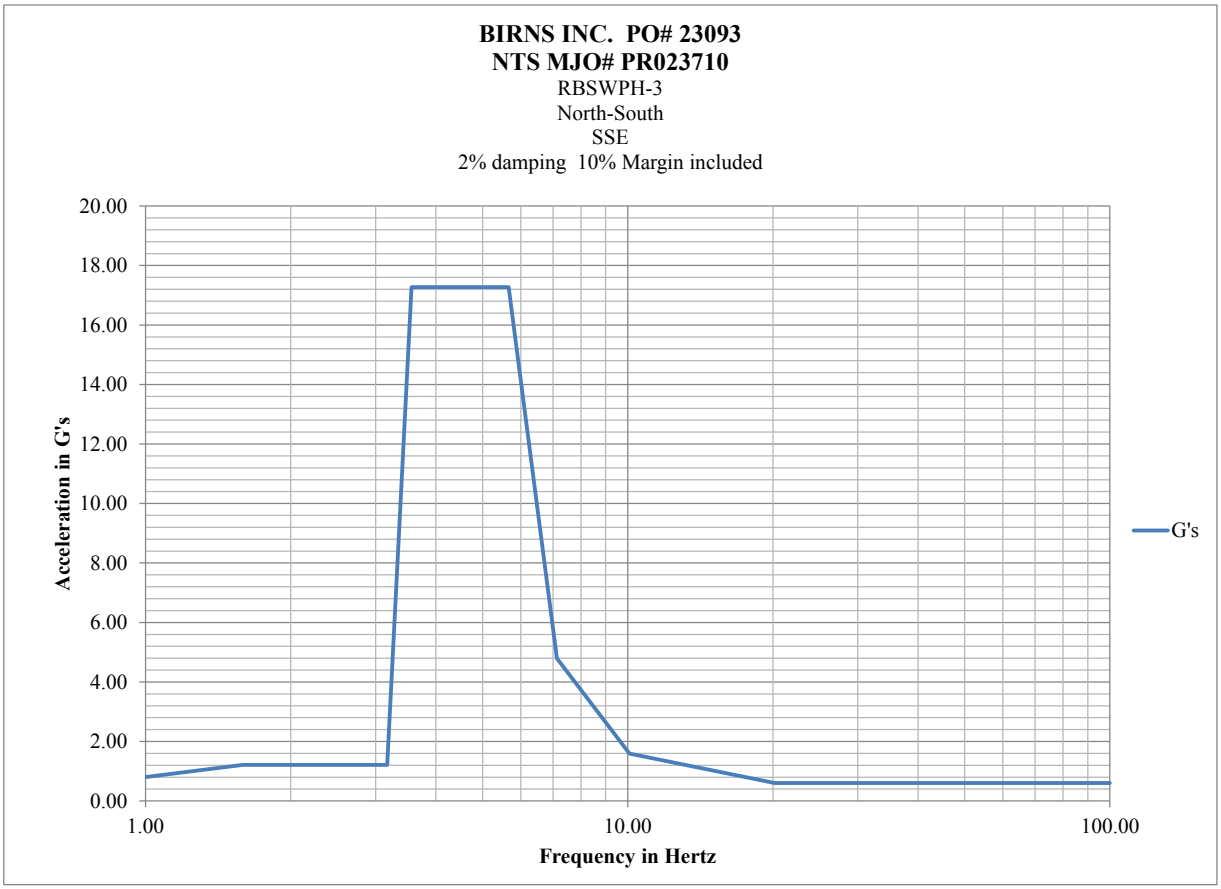


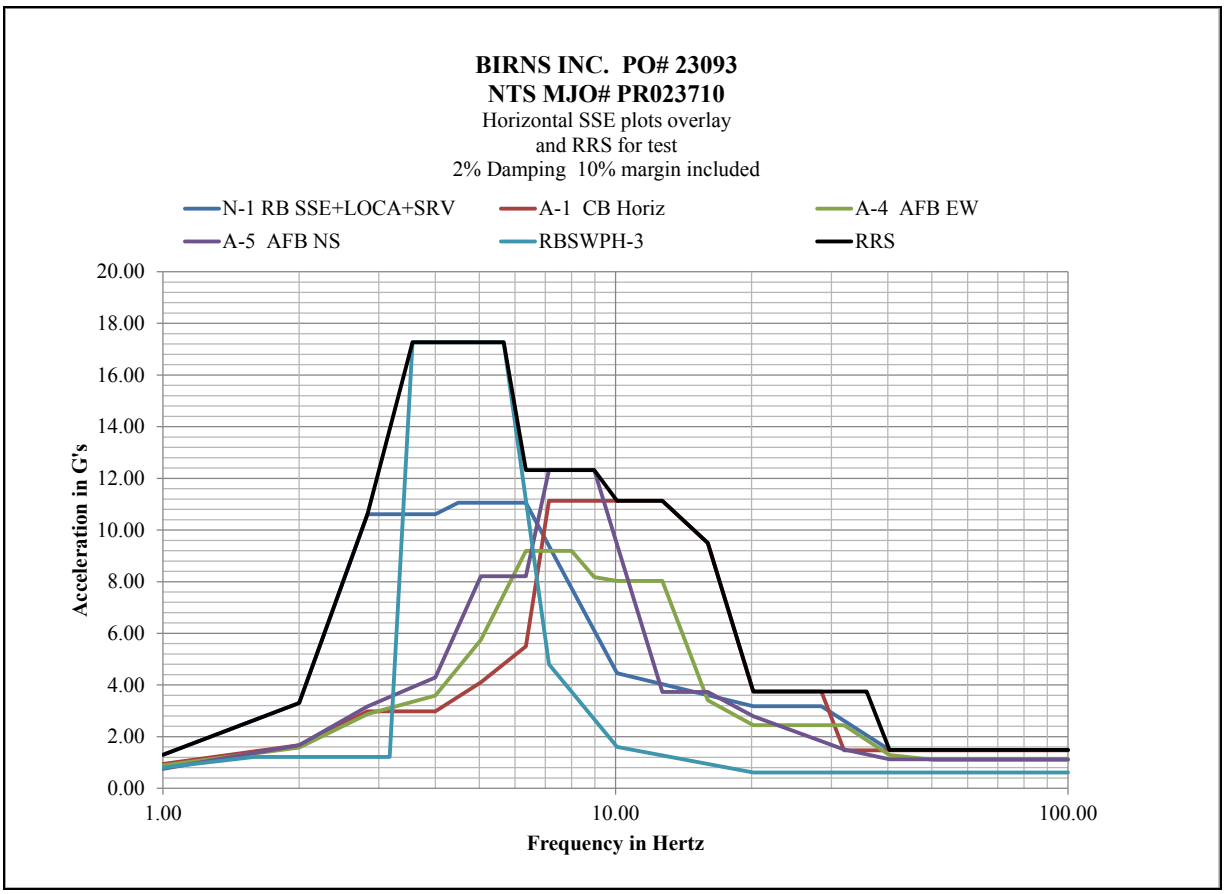
Table 8-21

Reactor Building Service Water Pump House			
North-South 2% SSE With 10% margin			
RBSWPH-3			
Frequency	G's	Frequency	G's
1.00	0.80	5.66	17.27
1.59	1.21	7.13	4.80
2.83	1.21	10.08	1.60
3.17	1.21	20.16	0.61
3.56	17.27	100.00	0.61

8.0 SEISMIC TESTING (continued)

8.5 SSE+ SRV + LOCA Multi-Frequency Testing

Figure 8-22



RB	Reactor Building
AFB	Auxiliary Fuel building
CB	Control Building
RBSWPH	Reactor Building Service Water Pump House

8.0 SEISMIC TESTING (continued)

8.5 SSE+ SRV + LOCA Multi-Frequency Testing

Table 8-22

SSE 2% Damping						
Horizontal Overlays SSE, LOCA, SRV						
Frequency	N-1 RB SSE+LOCA+SRV	A-1 CB Horiz	A-4 AFB EW	A-5 AFB NS	RBSWPH-3	RRS
1.00	1.30	0.94	0.88	0.75	0.80	1.30
1.59					1.21	
2.00	3.30	1.67	1.58	1.67		3.30
2.83	10.61	2.98	2.87	3.17		10.61
3.17					1.21	
3.56					17.27	17.27
4.00	10.61	2.98	3.59	4.29		
4.49	11.06					
5.04		4.10	5.74	8.21		
5.66					17.27	17.27
6.34	11.06	5.50	9.19	8.21		12.32
7.13		11.13		12.32	4.80	12.32
8.00			9.19			
8.98			8.18	12.32		12.32
10.08	4.46		8.03		1.60	11.13
12.70		11.13	8.03	3.73		11.13
16.00		9.50	3.41	3.73		9.50
20.16	3.18	3.75	2.44	2.79	0.61	3.75
28.51	3.18	3.75				
32.00		1.47	2.44	1.50		
35.92						3.75
40.32	1.49		1.29	1.12		1.49
50.80			1.10			
100.00	1.49	1.47	1.10	1.12	0.61	1.49

8.0 SEISMIC TESTING (continued)

8.5 SSE+ SRV + LOCA Multi-Frequency Testing

Figure 8-23

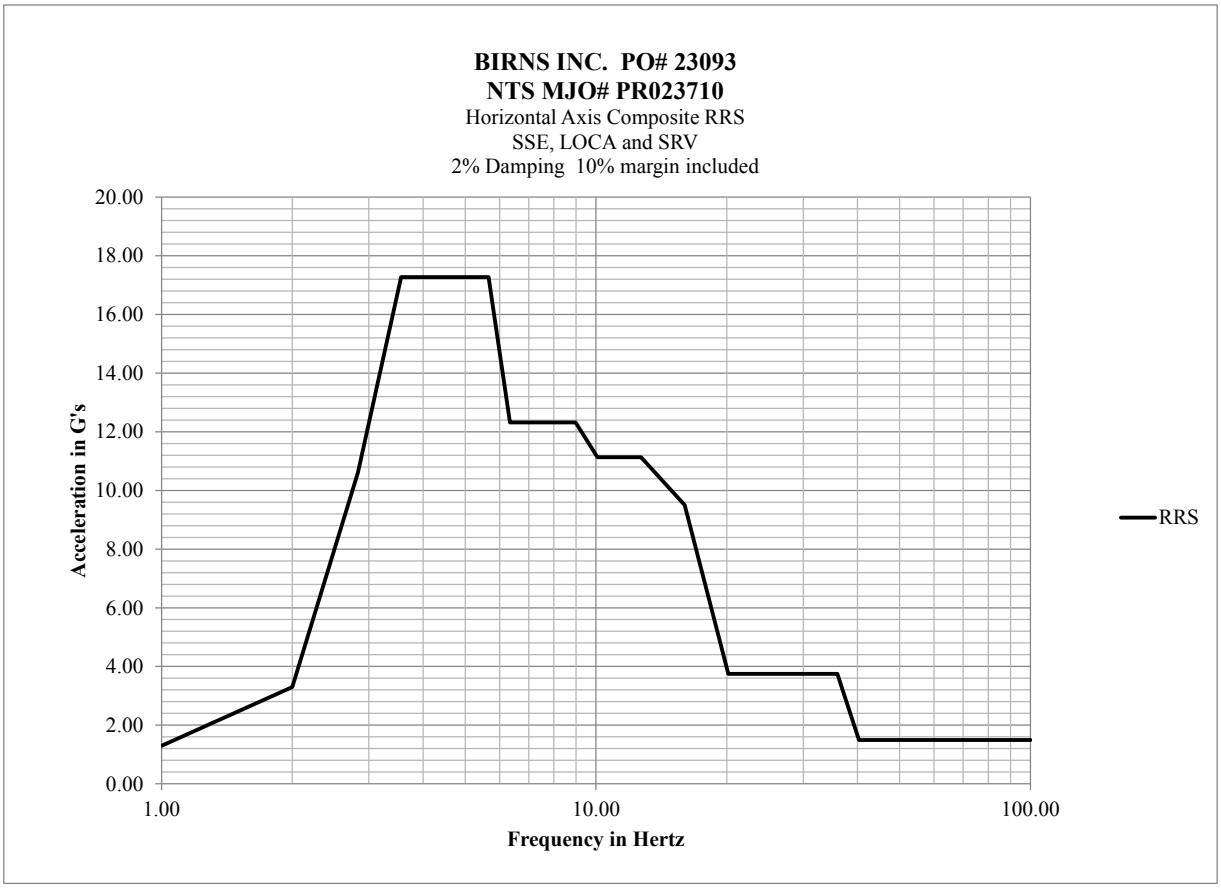


Table 8-23

SSE Horizontal RRS 2% Damping with 10% margin			
Frequency	G's	Frequency	G's
1.00	1.30	10.08	11.13
2.00	3.30	12.70	11.13
2.83	10.61	16.00	9.50
3.56	17.27	20.16	3.75
5.66	17.27	28.51	3.75
6.34	12.32	35.92	3.75
7.13	12.32	40.32	1.49
8.98	12.32	100.00	1.49

Input at 1 hertz limited to 0.6 g's.

8.0 SEISMIC TESTING (continued)

8.5 SSE+ SRV + LOCA Multi-Frequency Testing

Figure 8-24

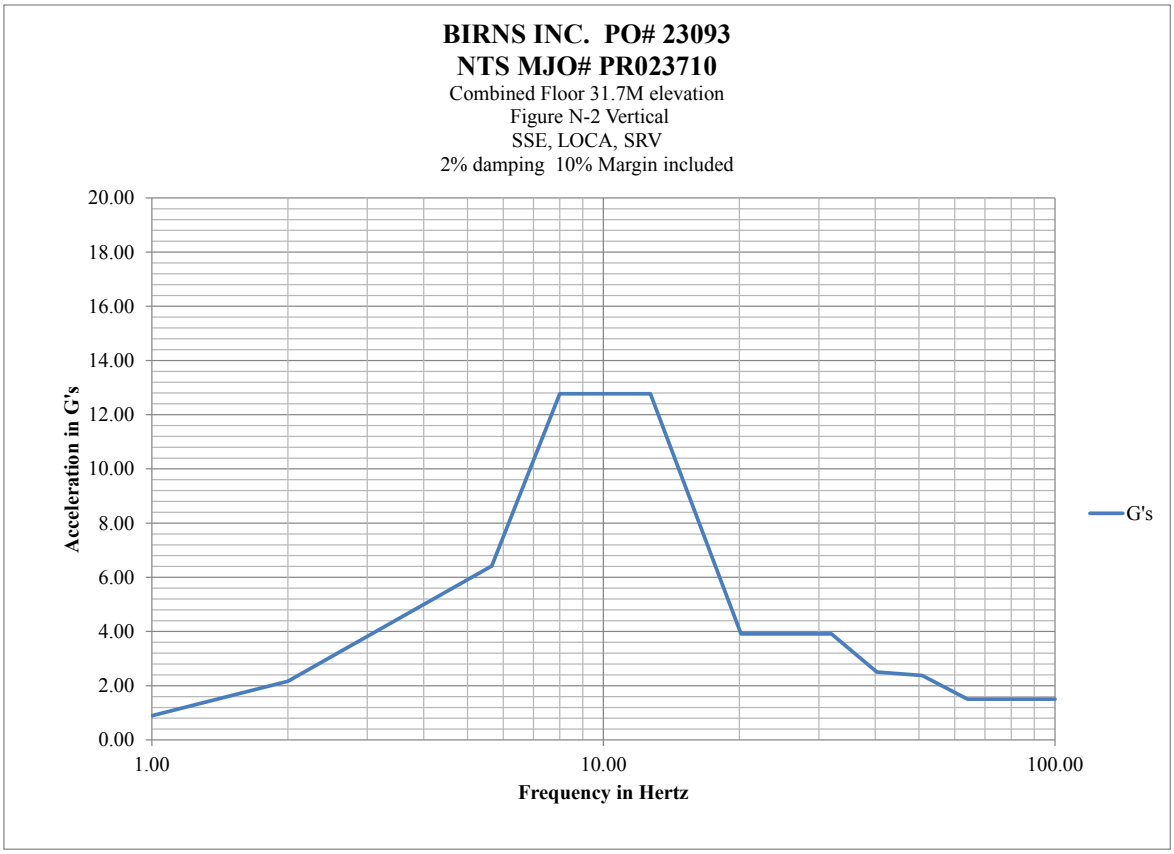


Table 8-24

Figure N-2 Vertical 2% SSE, LOCA, SRV with 10% margin			
Combined Floor 31.7M elevation			
Frequency	G's	Frequency	G's
1.00	0.89	32.00	3.91
2.00	2.16	40.32	2.51
5.66	6.42	50.80	2.38
8.00	12.77	64.00	1.51
12.70	12.77	100.0	1.51
20.16	3.91		

8.0 SEISMIC TESTING (continued)

8.5 SSE+ SRV + LOCA Multi-Frequency Testing

Figure 8-25

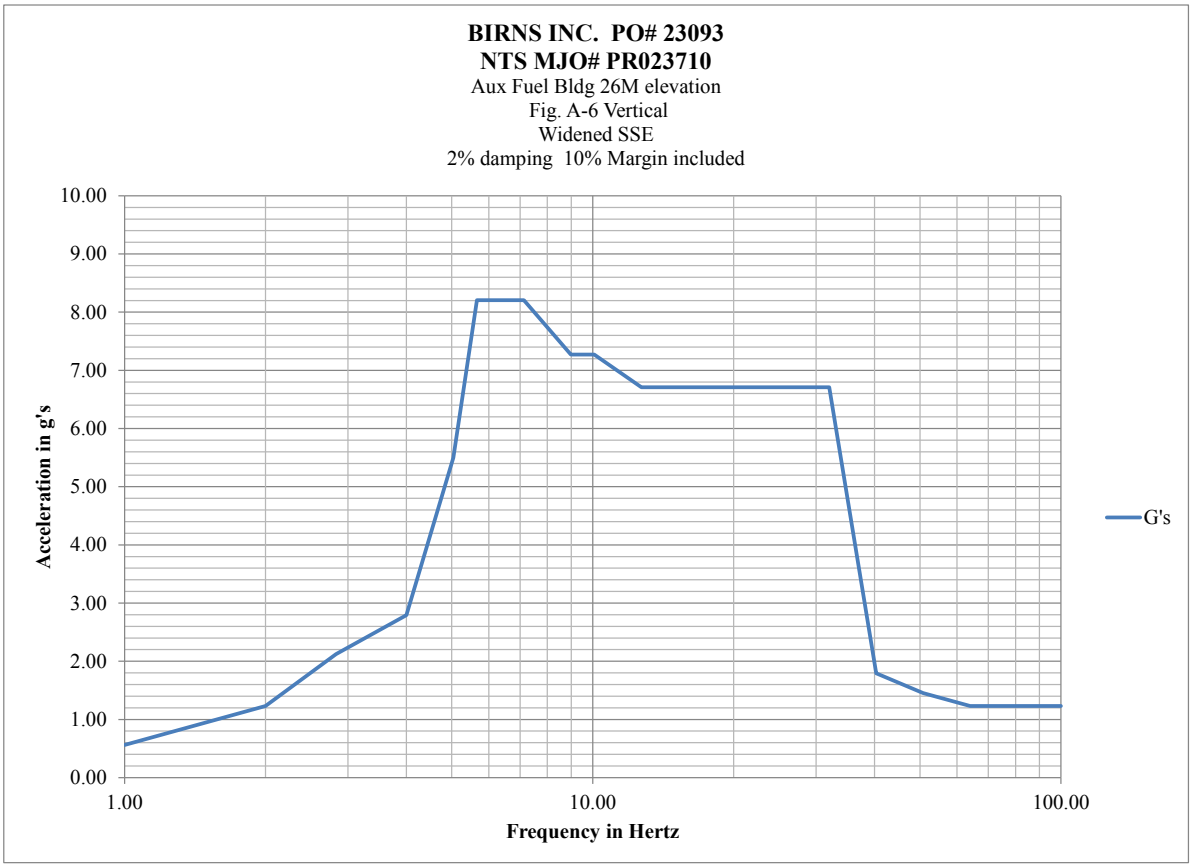


Table 8-25

Fig. A-6 Vertical 2% Widened SSE with 10% margin			
Aux Fuel Bldg. 26M elevation			
Frequency	G's	Frequency	G's
1.00	0.56	12.70	6.71
2.00	1.23	16.00	6.71
2.83	2.12	20.16	6.71
4.00	2.79	32.00	6.71
5.04	5.50	40.32	1.79
5.66	8.21	50.80	1.45
7.13	8.21	64.00	1.23
8.98	7.27	100.00	1.23
10.08	7.27		

8.5 SSE+ SRV + LOCA Multi-Frequency Testing

Figure 8-26

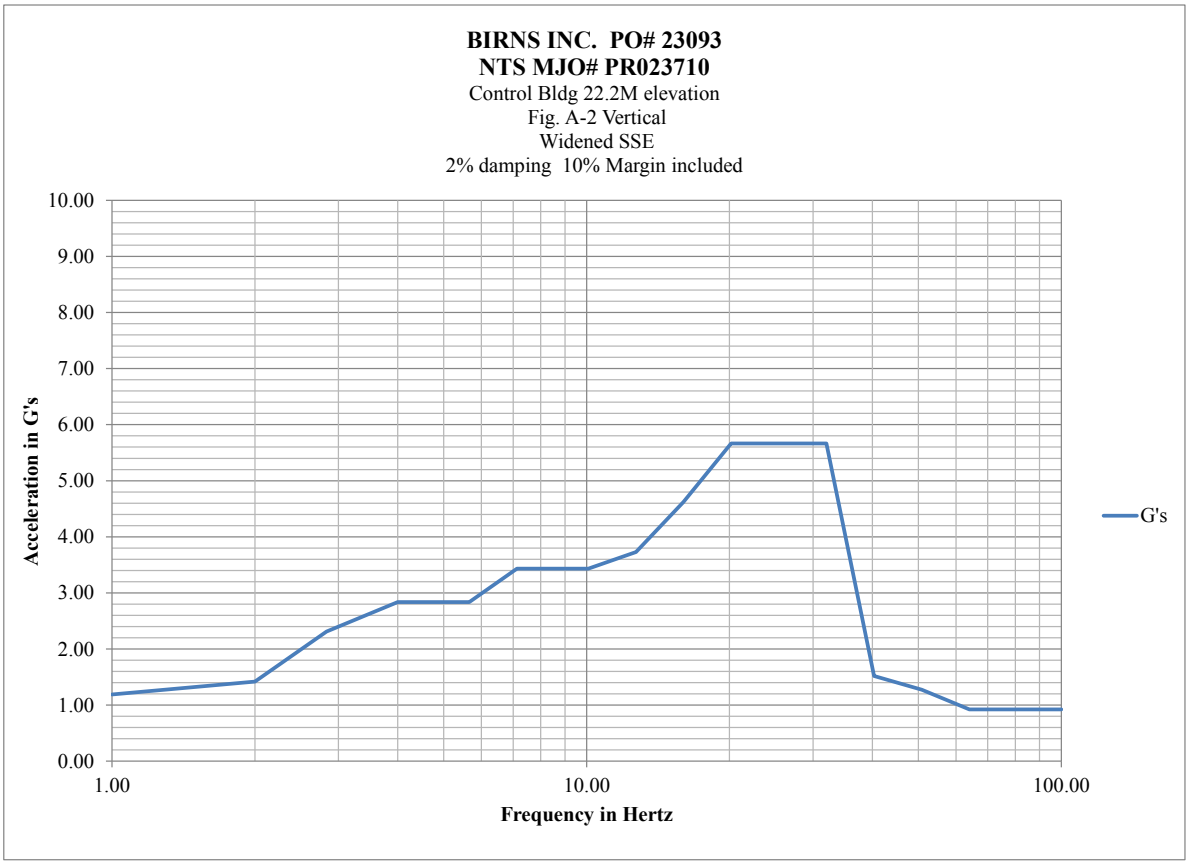


Table 8-26

Fig. A-2 Vertical 2% Widened SSE with 10% margin			
Control Bldg. 22.2M elevation			
Frequency	G's	Frequency	G's
1.00	1.19	12.70	3.73
2.00	1.42	16.00	4.62
2.83	2.31	20.16	5.67
4.00	2.84	32.00	5.67
5.04	2.84	40.32	1.52
5.66	2.84	50.80	1.28
7.13	3.43	64.00	0.92
8.98	3.43	100.00	0.92
10.08	3.43		

8.5 SSE+ SRV + LOCA Multi-Frequency Testing

Figure 8-27

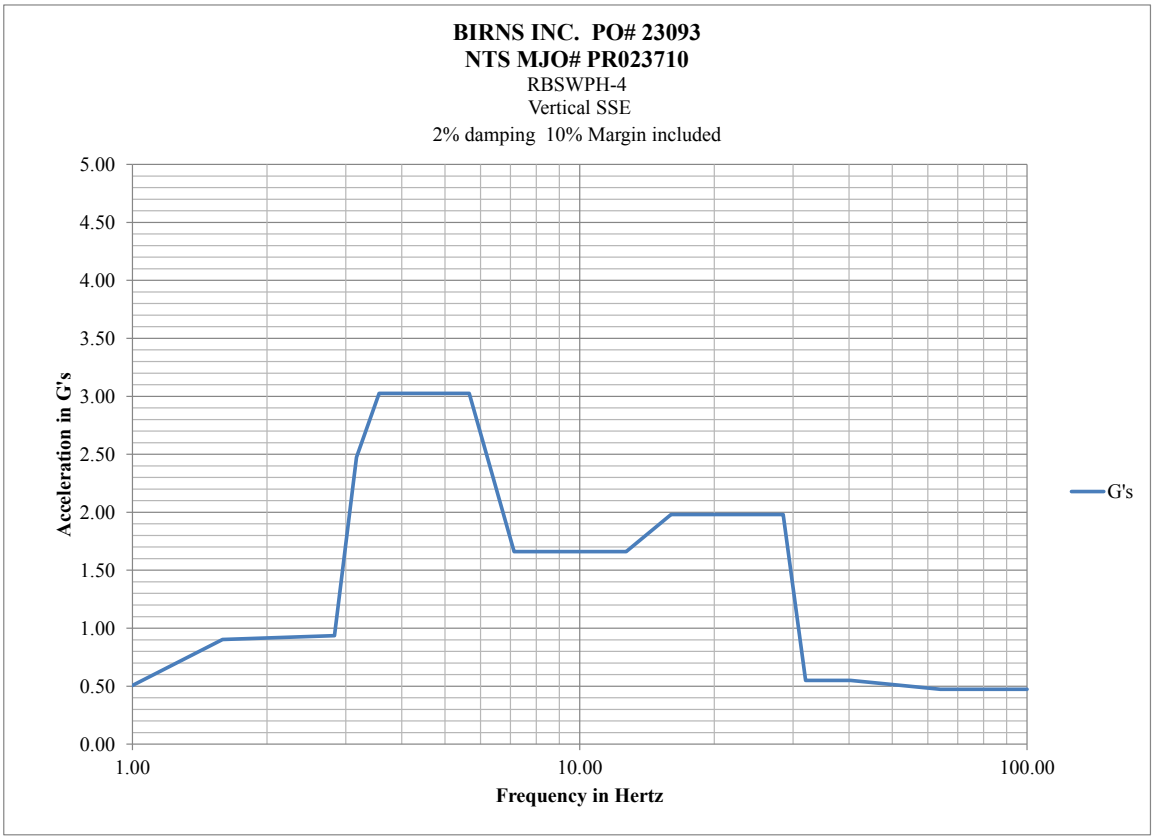
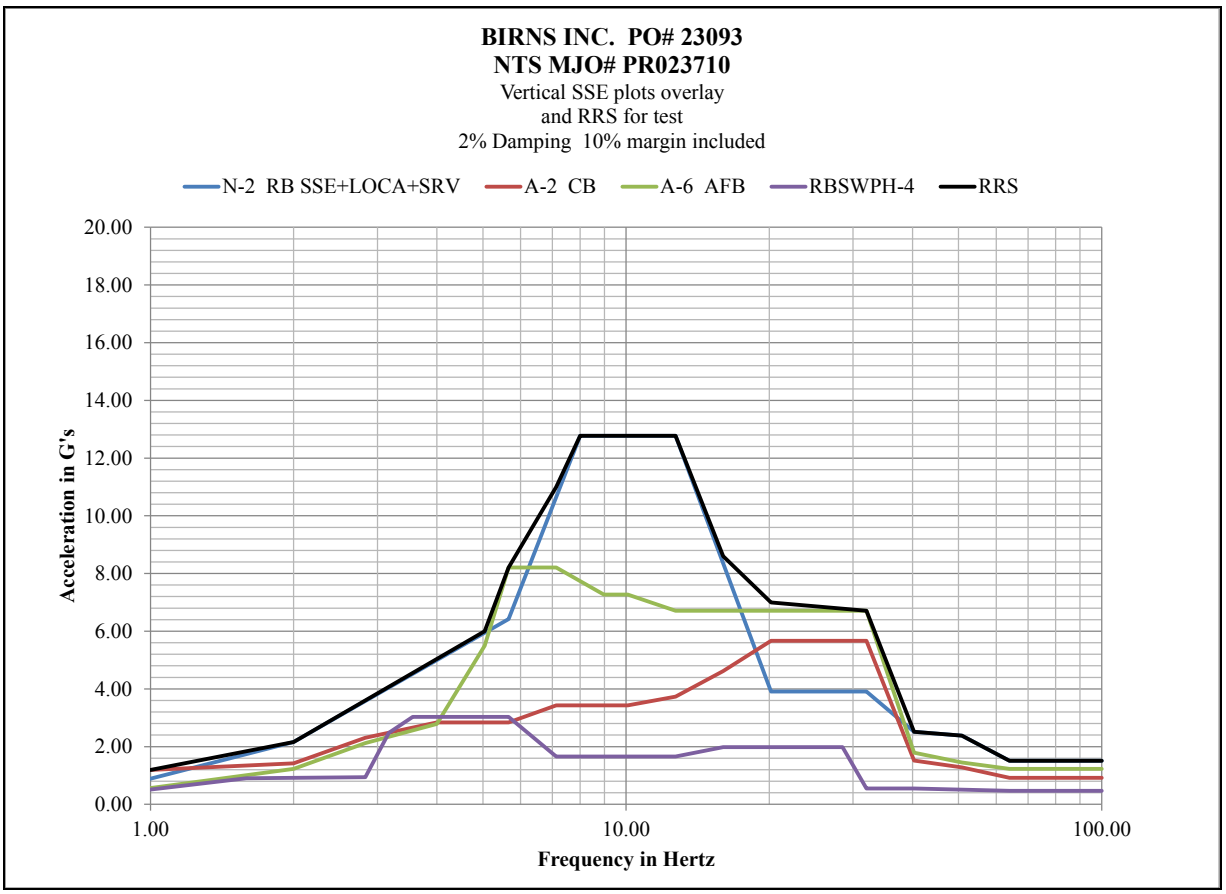


Table 8-27

Reactor Building Service Water Pump house			
RBSWPH-4 2% SSE With 10% margin			
Vertical			
Frequency	G's	Frequency	G's
1.00	0.51	12.70	1.66
1.59	0.90	16.00	1.98
2.83	0.94	28.51	1.98
3.17	2.48	32.00	0.55
3.56	3.03	40.32	0.55
5.66	3.03	64.00	0.47
7.13	1.66	100.00	0.47
12.70	1.66		

8.5 SSE+ SRV + LOCA Multi-Frequency Testing

Figure 8-28



RB	Reactor Building
AFB	Auxiliary Fuel building
CB	Control Building
RBSWPH	Reactor Building Service Water Pump House

8.5 SSE+ SRV + LOCA Multi-Frequency Testing

Table 8-28

SSE at 2% Damping with 10% margin					
Vertical SSE, LOCA, SRV					
Frequency	N-2 RB SSE+LOCA+SRV	A-2 CB	A-6 AFB	RBSWPH-4	RRS
1.00	0.89	1.19	0.56	0.51	1.19
1.59				0.90	
2.00	2.16	1.42	1.23		2.16
2.83		2.31	2.12	0.94	
3.17				2.48	
3.56				3.03	
4.00		2.84	2.79		
5.04			5.50		6.00
5.66	6.42	2.84	8.21	3.03	8.21
7.13		3.43	8.21	1.66	11.00
8.00	12.77				12.77
8.98			7.27		
10.08		3.43	7.27		
12.70	12.77	3.73	6.71	1.66	12.77
16.00		4.62		1.98	8.60
20.16	3.91	5.67			7.00
28.51				1.98	
32.00	3.91	5.67	6.71	0.55	6.71
40.32	2.51	1.52	1.79	0.55	2.51
50.80	2.38	1.28	1.45		2.38
64.00	1.51	0.92	1.23	0.47	1.51
100.00	1.51	0.92	1.23	0.47	1.51

8.0 SEISMIC TESTING (continued)

8.5 SSE+ SRV + LOCA Multi-Frequency Testing

Figure 8-29

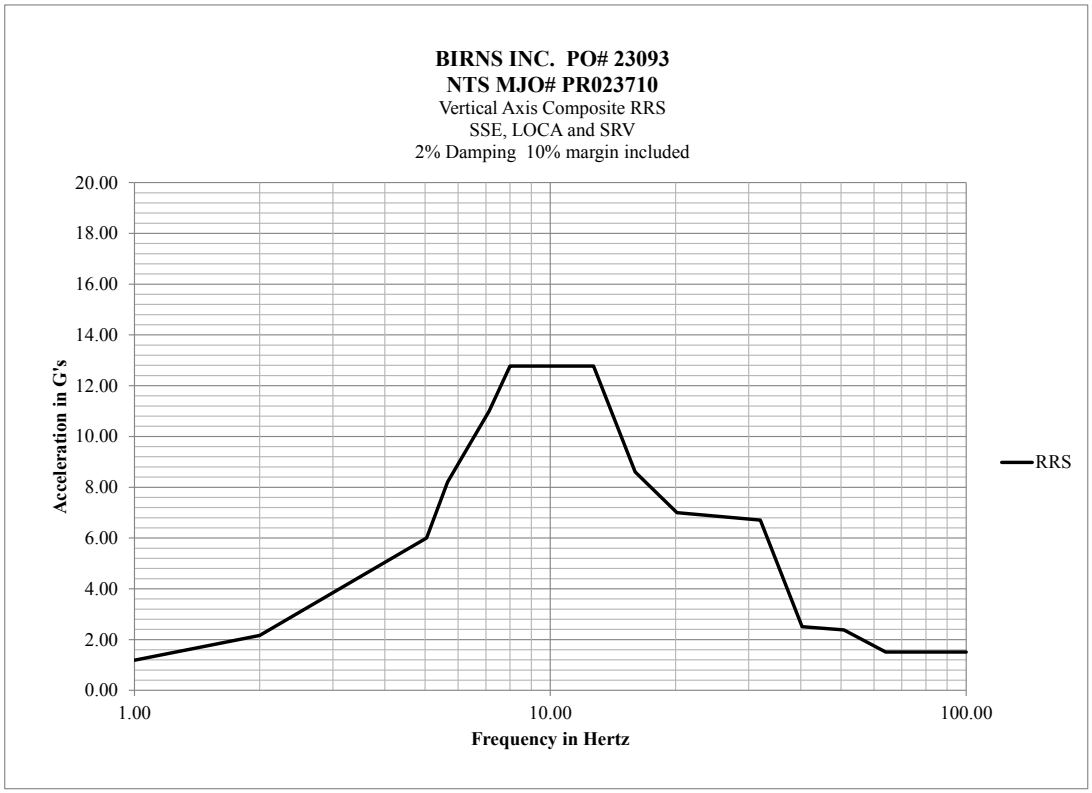


Table 8-29

SSE Vertical RRS 2% Damping with 10% margin			
Frequency	G's	Frequency	G's
1.00	1.19	16.00	8.60
2.00	2.16	20.16	7.00
5.04	6.00	32.00	6.71
5.66	8.21	40.32	2.51
7.13	11.00	50.80	2.38
8.00	12.77	64.00	1.51
12.70	12.77	100.0	1.51

Input at 1 hertz limited to 0.6 g's.

8.0 SEISMIC TESTING (continued)

8.5 SSE+ SRV + LOCA Multi-Frequency Testing

Table 8-29-A below list the actual spectrum acceleration values achieved for the SSE run. At each 1/6th octave frequency the demand value for the horizontal and vertical directions is given versus the actual values achieved.

Table 8-29-A

SSE					
Frequency	**Horizontal Demand (G)**	**Front-Back (G)**	**Side-Side (G)**	**Vertical Demand (G)**	**Vertical (G)**
1.00	0.60	0.64	0.65	0.60	0.71
1.12	0.80	0.92	0.92	0.74	0.87
1.26	1.06	1.24	1.24	0.92	1.05
1.41	1.41	1.66	1.67	1.14	1.30
1.59	1.87	2.21	2.15	1.41	1.69
1.78	2.48	2.94	2.92	1.74	2.05
2.00	3.30	3.93	3.88	2.16	2.62
2.24	4.87	5.71	5.86	2.45	2.89
2.52	7.18	8.57	8.47	2.79	3.16
2.83	10.59	12.55	12.49	3.17	3.64
3.17	13.54	15.82	16.16	3.60	4.19
3.56	17.27	20.22	20.46	4.09	4.93
4.00	17.27	20.43	20.41	4.65	5.56
4.49	17.27	20.70	20.30	5.28	6.75
5.04	17.27	20.54	20.61	6.00	7.33
5.66	17.27	19.84	20.79	8.20	9.06
6.35	12.32	14.15	14.28	9.50	10.07
7.13	12.32	15.09	15.01	10.99	13.04
8.00	12.32	15.90	15.85	12.77	15.16
8.98	12.32	18.40	15.37	12.77	16.09
10.08	11.13	17.84	17.47	12.77	14.96
11.31	11.13	17.01	18.20	12.77	15.50
12.70	11.13	18.61	21.06	12.77	19.00
14.25	10.28	20.62	20.74	10.48	15.44
16.00	9.50	16.47	15.60	8.60	15.50
17.96	5.97	18.46	18.32	7.76	16.32
20.16	3.75	15.08	13.62	7.00	13.09
22.63	3.75	18.74	12.93	6.93	11.51
25.40	3.75	13.92	11.66	6.85	9.69
28.51	3.75	10.79	11.48	6.78	10.67
32.00	3.75	10.84	9.88	6.71	9.24
35.92	3.75	9.32	9.96	4.10	6.70
40.32	1.49	9.35	7.89	2.51	5.91
45.25	1.49	8.21	7.01	2.44	4.47
50.80	1.49	7.78	6.74	2.38	4.10
57.02	1.49	7.52	6.58	1.90	3.98
64.00	1.49	7.35	6.47	1.51	3.90
71.84	1.49	7.23	6.39	1.51	3.84
80.63	1.49	7.14	6.33	1.51	3.79
90.51	1.49	7.08	6.28	1.51	3.76
100.00	1.49	7.03	6.25	1.51	3.73

8.0 SEISMIC TESTING (continued)

8.5 SSE+ SRV + LOCA Multi-Frequency Testing

During the SSE run the 120VAC supplied to the 4702 and 4726 units was removed. Verification that the lamps illuminated as a result of the power loss was performed.

Results

All units functioned without any anomalies occurring. Post SRV testing was performed by BIRNS personnel with no discrepancies being noted. Appendix G of this report pages G-2 thru G-10 contains the curves that were generated for the SSE qualification run.

8.6 Chugging Load Testing

The plots that follow contain the horizontal and vertical Chugging Load requirements based on 2% damping. The curves are from GE Specification 63.1030S, Revision 2 Attachment G Figures 66 and 94.

Figure 8-30

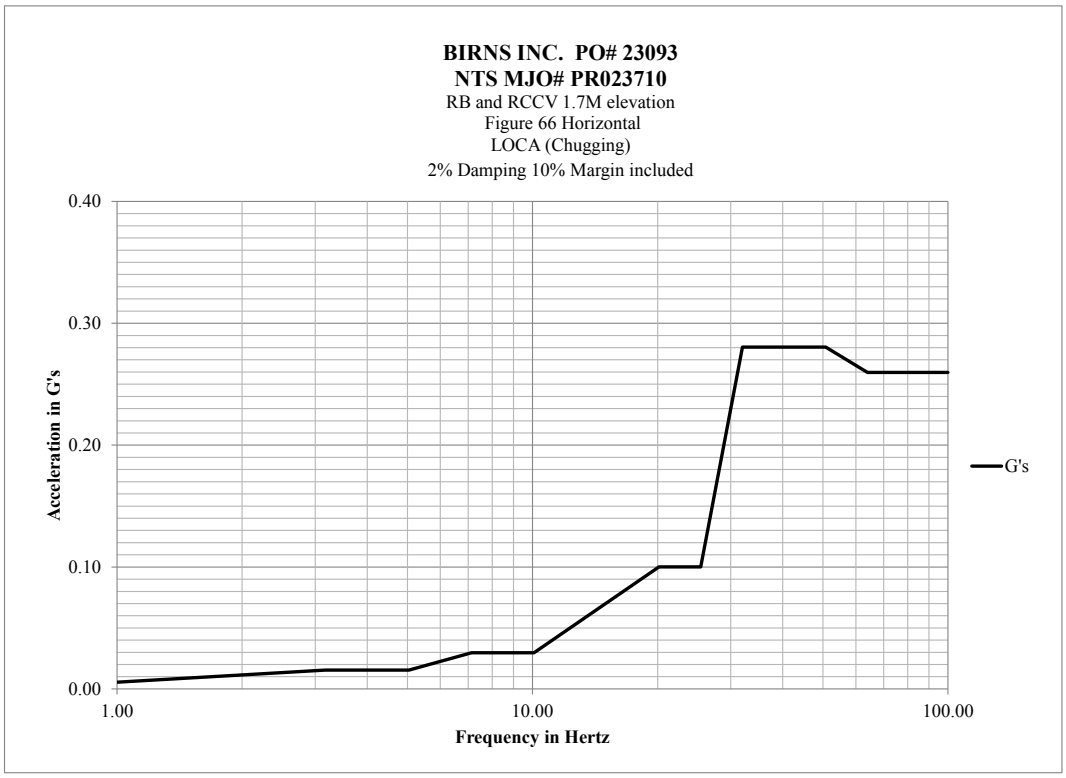


Table 8-30

Figure 66 Horizontal 2% LOCA With 10% margin			
RB and RCCV 1.7M elevation			
Frequency	G's	Frequency	G's
1.00	0.01	25.40	0.10
3.17	0.02	32.00	0.28
5.04	0.02	50.80	0.28
7.13	0.03	64.00	0.26
10.08	0.03	100.00	0.26
20.16	0.10		

8.0 SEISMIC TESTING (continued)

8.6 Chugging Load Testing

Figure 8-31

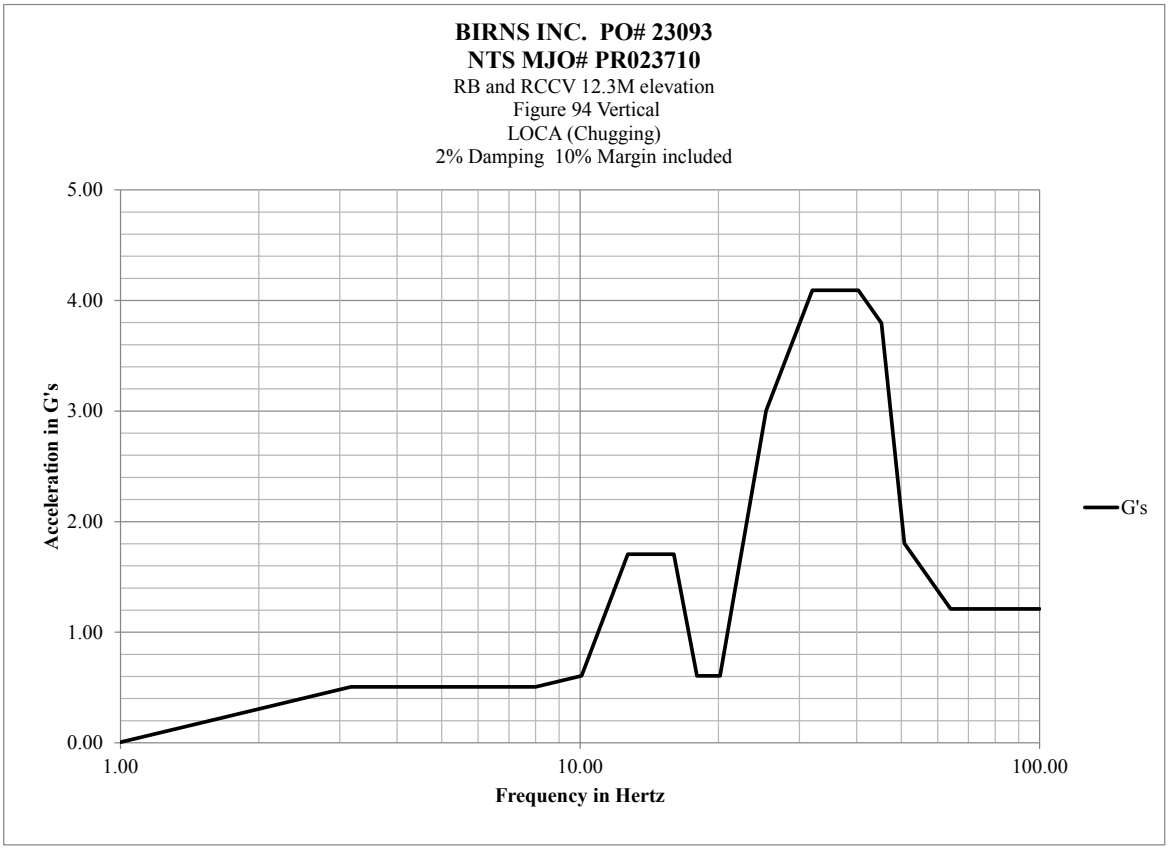


Table 8-31

Figure 94 Vertical 2% LOCA With 10% margin			
RB and RCCV 12.3M elevation			
Frequency	G's	Frequency	G's
1.00	0.01	25.40	3.00
3.17	0.51	32.00	4.09
8.00	0.51	40.32	4.09
10.08	0.61	45.25	3.80
12.70	1.71	50.80	1.80
16.00	1.71	64.00	1.21
17.96	0.61	100.00	1.21
20.16	0.61		

8.0 SEISMIC TESTING (continued)

8.6 Chugging Load Testing

Chugging testing consisted of meeting 1 event having a minimum duration of 19 minutes with 9,000 stress cycles produced by 1,140 burst actuations. Each actuation consisted of a burst having duration of 1.0 second. Each actuation contained a minimum of 8 stress cycle.

The method to verify the stress cycle count was from the time history of the burst actuation. A plot of the time history in each axis was obtained. A virtual horizontal line was drawn at the 50% point of the ZPA value. The number of cycles that exceed the 50% level were counted as stress cycles per actuation. For each burst credit only for 8 stress cycles was taken even if more stress cycles were present that met the 50% criteria. This was a conservative approach.

Upon verifying that the curves were enveloped at the required damping per actuation and that the required stress cycles per actuation were present, a total of 1,140 burst actuations were inputted continuously for a total duration of 19 minutes minimum. Test inputs were random motion equalized at $1/6^{th}$ octave intervals. Response data was analyzed at $1/6^{th}$ octave intervals.

Spectrum plots and time history plots were produced at random times (approximately every 5 minutes) to verify the consistency of the run. Data plots were generated from the burst actuations performed at 300, 570, 841 and 1140 burst.

Table 8-32

Burst #	Appendix H
300	H-2 to H-10
570	H-11 to H-19
841	H-20 to H-28
1140	H-29 to H-37

For the first 570 burst actuations the 4702 and 4726 units had 120VAC applied. Verification that the lamps powered by each unit did not illuminate was performed. During the last 570 burst actuations the 4702 and 4726 units had 120VAC removed. Verification that the lamps powered by each unit were illuminated was performed.

Results

All units functioned without any anomalies occurring. Post SRV testing was performed by BIRNS personnel with no discrepancies being noted.

8.0 SEISMIC TESTING (continued)

8.7 Seismic Simulators

NTS used the ANCO R-5 hydraulic, piston-actuated, independent-tri-axial shaker table at the NTS seismic test facility. This system was used for the SRV, OBE SSE and Chugging test.

The tri-axial shaker table system has three actuators arranged in a tripod configuration, allowing independent three-dimensional motion of the tripod apex (table center point) to be specified by applying the appropriate input signals to the actuator servo-valves. The use of this tri-axial table results in independent horizontal, transverse and vertical force components that are phase independent.

Independent tri-axial, pure-random, multiple frequency excitations was applied. Controlling the output of a ANCO triaxial controller composed the test input. This controller produced the three independent RRS curves in the 1 to 100 HZ frequency range. The resulting data was transferred through the ANCO shock spectrum synthesizer during the shaker table equalization process. In this manner, controlling the level of individual 1/6-octave interval frequencies shaped the required random test spectra.

Shaker table equalization was performed at the required damping value for each type of test being inputted. The test inputs were controlled such that the Test Response Spectra (TRS) from the control accelerometers envelop the appropriate Required Response Spectra (RRS) within the control limitations of the shaker system.

Control accelerometer outputs and response accelerometer outputs were analyzed online by a Data Acquisition System computer system at 1/6-octave intervals in the frequency bandwidth of 1 to 100 Hz and at the specified damping values. During the SSE runs the control accelerometer data was provided in both graphical form and spread sheet format of the spectrum values computed at 2% damping from 1-100Hz at the $1/6^{th}$ octave points. (See Table 8-16-A and Table 8-29-A.)

8.0 SEISMIC TESTING (continued)

8.8 Post-Seismic Functional Testing

Following completion of seismic testing, functional testing detailed in Section 7.0 was repeated to check for item operability. The test items were carefully inspected for any evidence of damage, degradation or loss of mounting integrity. This activity was performed by BIRNS personnel with NTS assisting as needed.

All units functioned without any anomalies occurring. The items were then packaged and returned to BIRNS, INC.

9.0 TEST EQUIPMENT REQUIREMENTS

All test equipment used on this program was verified prior to testing to assure that it was in calibration and that the parameters being measured were appropriate for the range on the measuring instrument.

Calibration is performed and verified on a routine basis using standards traceable to the National Institute of Standards and Technology (NIST). Calibration of equipment is performed in accordance with the NTS quality program.

A list of test equipment used and verification of the suitability of the measuring device is included on the following page.

11/6/13

PR023710

Wrk Cntr	Legacy ID	Group Name	Manufacturer	Model	Serial Number	Cal Intrvl	Cal Due	Cal Range/Accuracy/Assignment		Test Name
WC000490	AC1871	Controller (Vibration)	Vibration Research	8500	079CBB,038BFA, 0	12	8/1/2014	1 to 20 KHZ	Periodic Calibration Required	Seismic
WC000575	AC0815	Accelerometer (Seismic)	PCB Piezotronics	353B33	57976	12	1/10/2014	0.5 to 4000HZ	Periodic Calibration Required	Seismic
WC000576	AC2013	Accelerometer (Seismic)	PCB Piezotronics	353B33/ACS-4	111398	12	1/10/2014	0.5 to 4000HZ	Periodic Calibration Required	Seismic
WC000578	AC2015	Accelerometer (Seismic)	PCB Piezotronics	353B33/ACS-4	111400	12	1/10/2014	0.5 to 4000HZ	Periodic Calibration Required	Seismic
WC000580	AC0789	Accelerometer (Seismic)	PCB Piezotronics	353B33	53972	12	1/10/2014	0.5 to 4000HZ	Periodic Calibration Required	Seismic
WC000587	AC2055	Accelerometer (Seismic)	PCB Piezotronics	353B18	112157	12	5/13/2014	1HZ to 10KHZ	Periodic Calibration Required	Seismic
WC000593	AC3086	Accelerometer (Seismic)	PCB Piezotronics	353B33/ACS-4	142410	12	5/11/2014	0.5 to 4000HZ	Periodic Calibration Required	Seismic
WC000597	AC2057	Accelerometer (Seismic)	PCB Piezotronics	353B18	112067	12	5/11/2014	1HZ to 10KHZ	Periodic Calibration Required	Seismic
WC000601	AC2061	Accelerometer (Seismic)	PCB Piezotronics	353B18	112071	12	5/13/2014	1HZ to 10KHZ	Periodic Calibration Required	Seismic
WC000703	AC2328	Accelerometer (Seismic)	PCB Piezotronics	353B33/ACS-4	122105	12	7/19/2014	0.5 to 4000HZ	Periodic Calibration Required	Seismic
WC001194	AC2052	GeoBox (Seismic)	Vibration Research	VR8500	GB1086	12	8/2/2014		Periodic Calibration Required	Seismic
WC001251	AC0455	Hyd System (Seismic)	MTS Systems	458	648	0			No Periodic Calibration Required	Seismic
WC002307	AC0934	Wrench (Torque)	Proto	6062AB	WBC09860	12	12/12/2013	40 to 200 IN/LBS	Periodic Calibration Required	Seismic

PR023710

Wrk Cntr	Legacy ID	Group Name	Manufacturer	Model	Serial Number	Cal Intrvl	Cal Due	Cal Range/Accuracy/Assignment		Test Name
WC002352	AC2914	Accelerometer (Tri-Axial)	Dytran	3273A2	419	12	10/11/2014	1HZ to 10KHZ	Periodic Calibration Required	Seismic
WC002354	AC2915	Accelerometer (Tri-Axial)	Dytran	3273A2	417	12	5/13/2014	1HZ to 10KHZ	Periodic Calibration Required	Seismic
WC002355	AC2051	Accelerometer (Tri-Axial)	PCB Piezotronics	354B22/ACS -4T	4654	12	4/26/2014	0.5 to 7000HZ	Periodic Calibration Required	Seismic
WC002359	AC0824	Tri-Table (Quasi-Static)	ANCO	NONE	NONE	0		UP TO 5000LBS, SRS TO 3g	No Periodic Calibration Required	Seismic

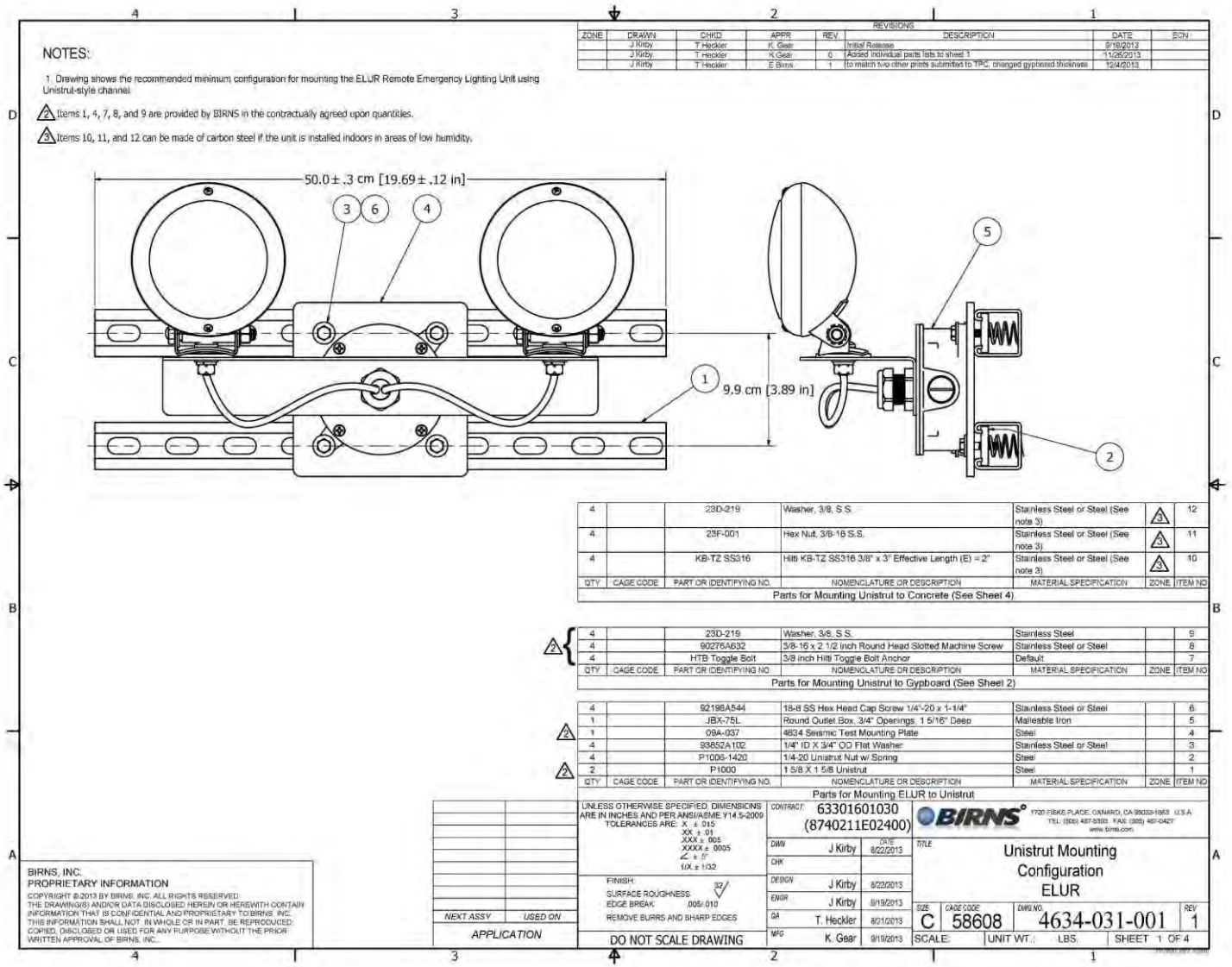
10.0 CONCLUSIONS

The items as identified within Section 3.0 of this report have successfully completed the seismic qualification program requirements. The devices were seismically qualified to applicable sections of GE Specification No. 63.1030S, Revision 2 dated October, 2012. The applicable sections were paragraph 3.19 Seismic Requirements, Attachment G Lighting Fixtures Response Spectra Figures and Appendix A30 Seismic and Dynamic Qualification (Category 1).

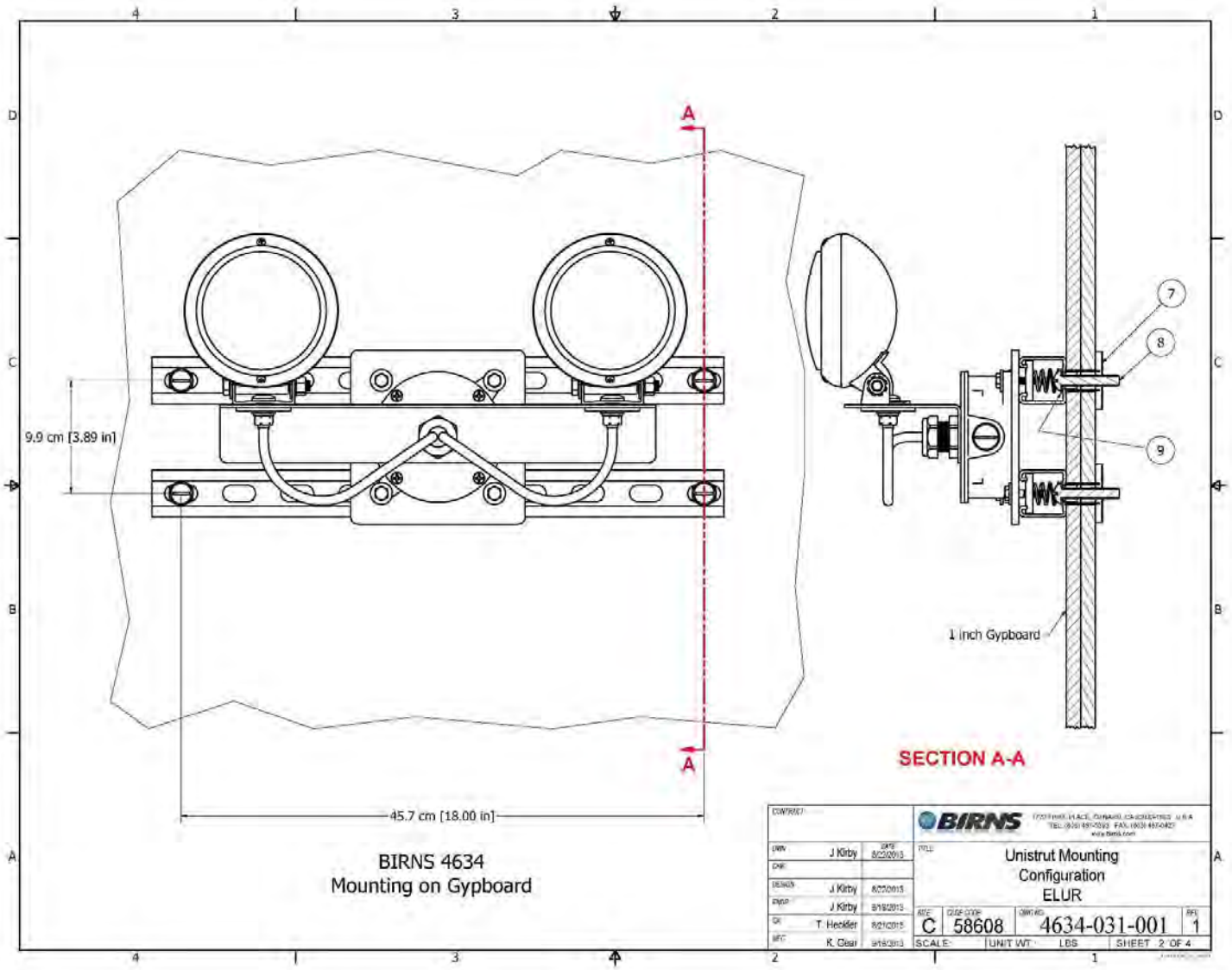
The items maintained structural integrity, functionality before during and after each series of testing performed. The items are considered qualified to IEEE 344 1987 and are suitable for nuclear safety related Class 1E use.

APPENDIX A

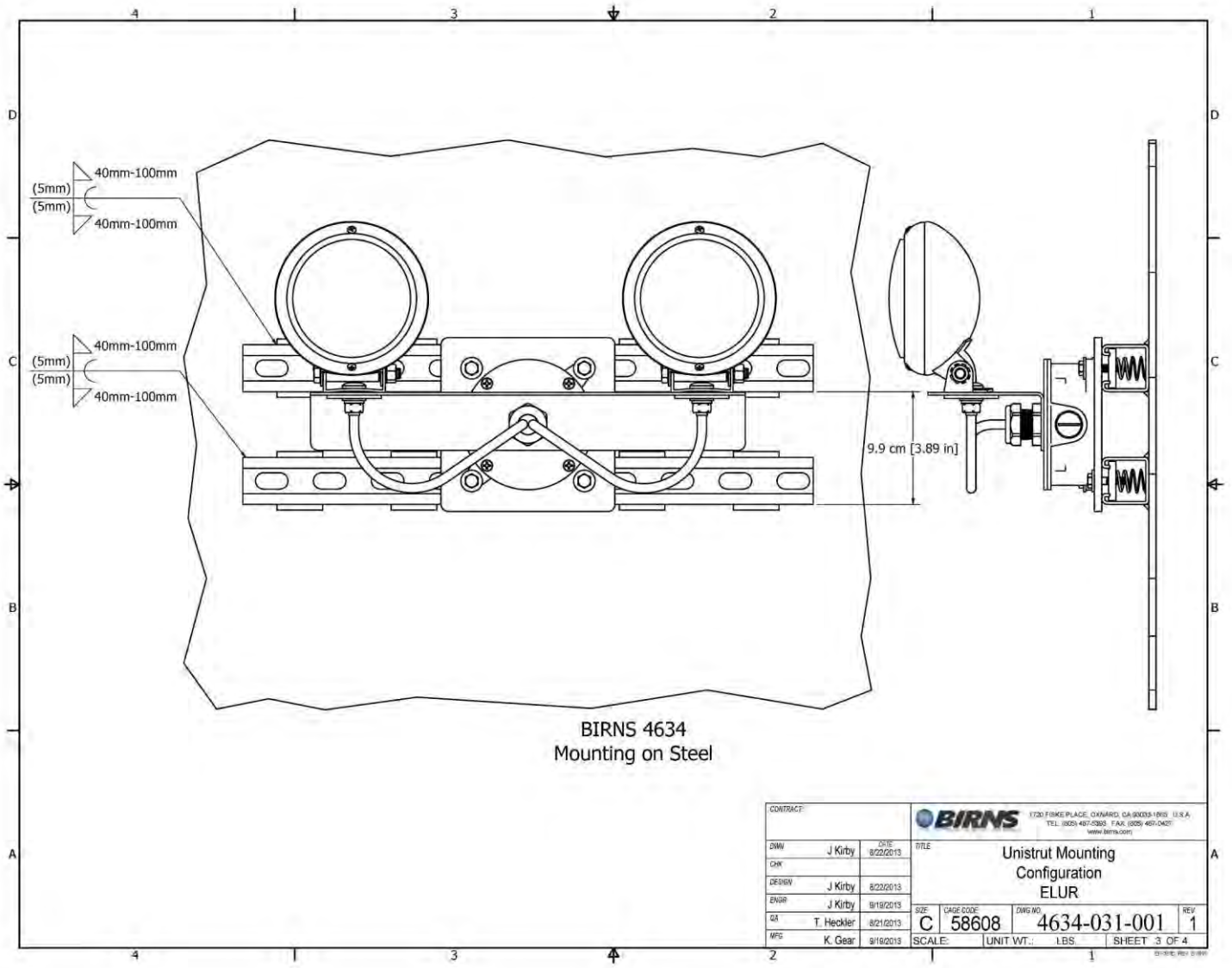
Mounting Drawings



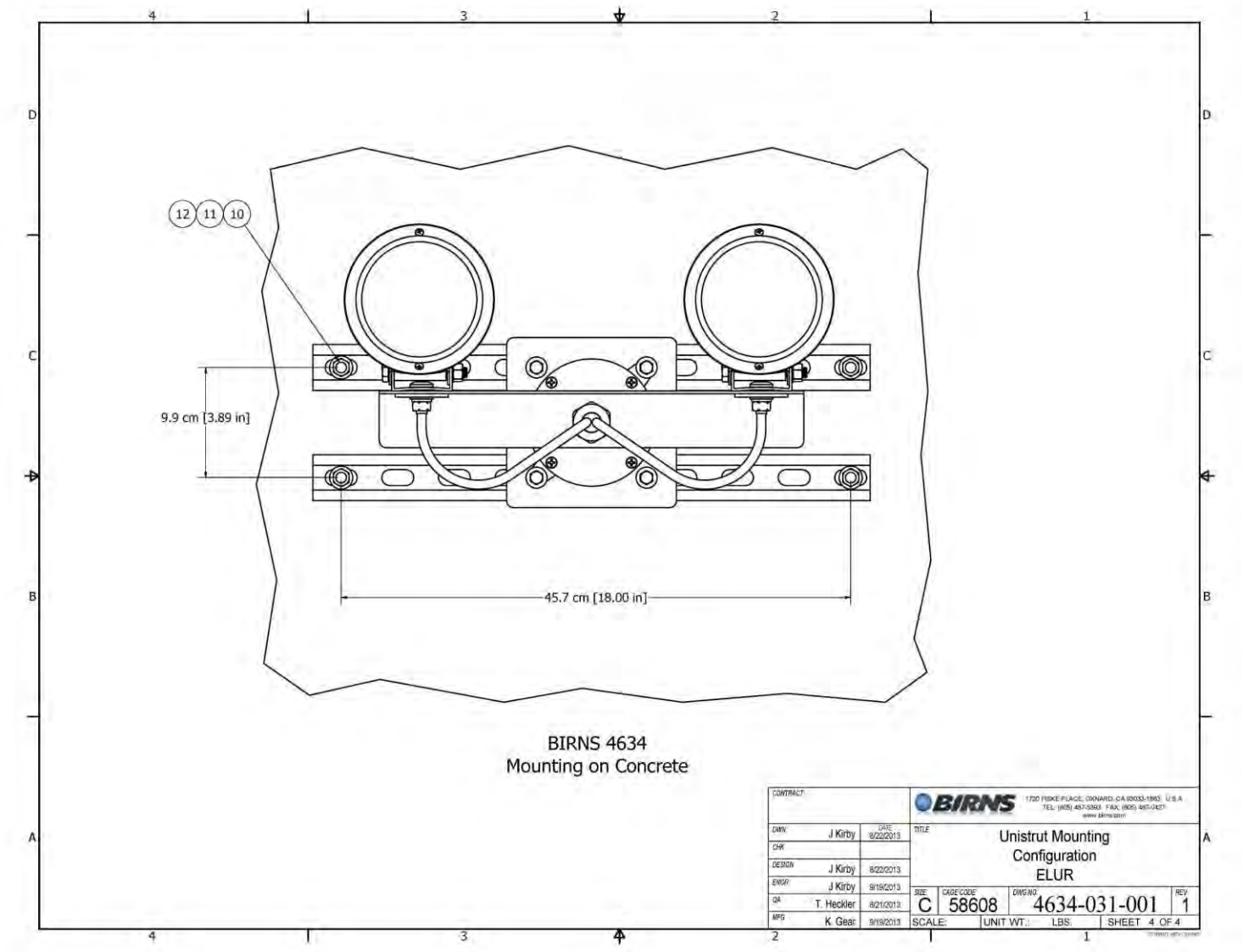
4634 Unistrut Mounting Configuration



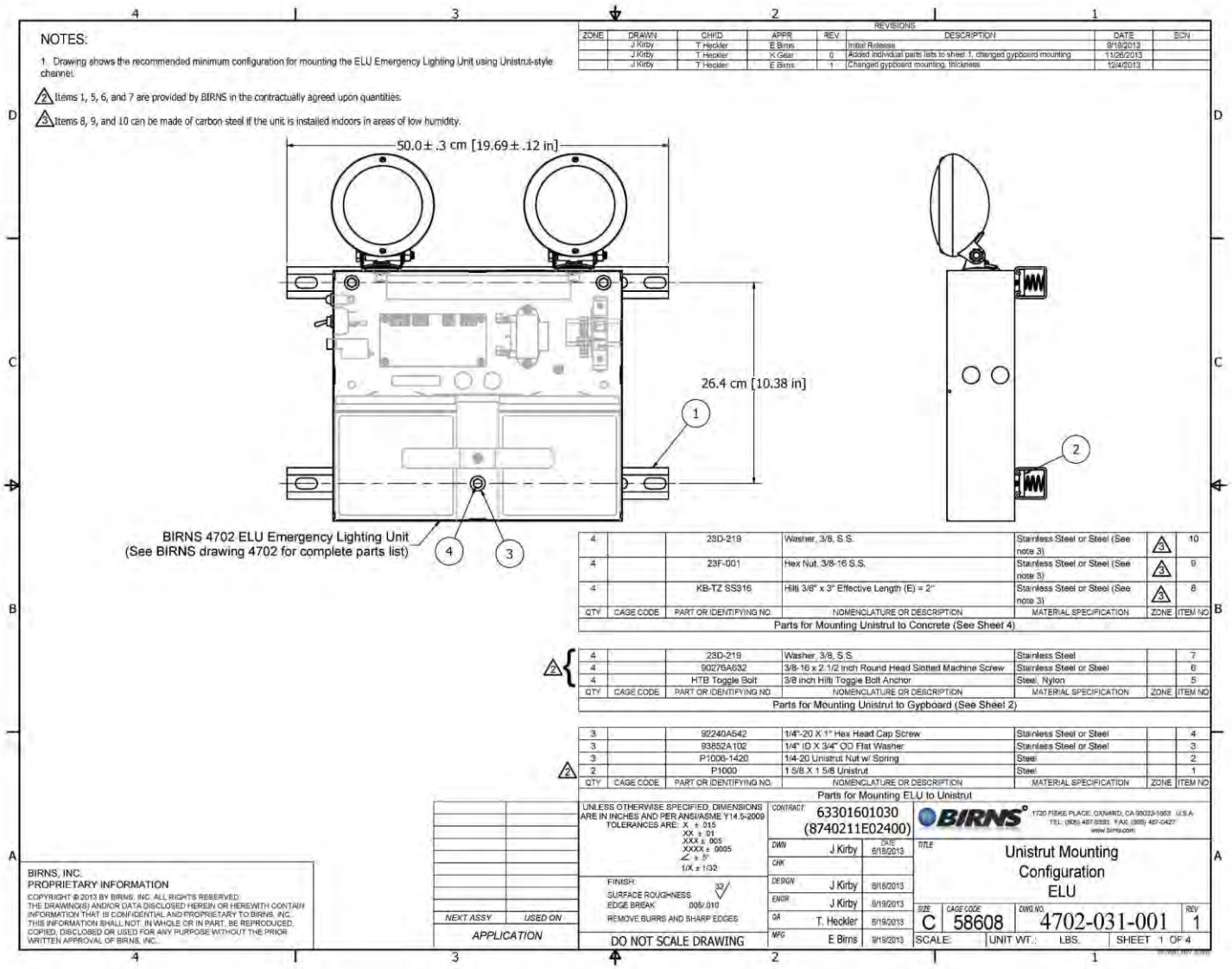
4634 Unistrut Mounting on Gypboard



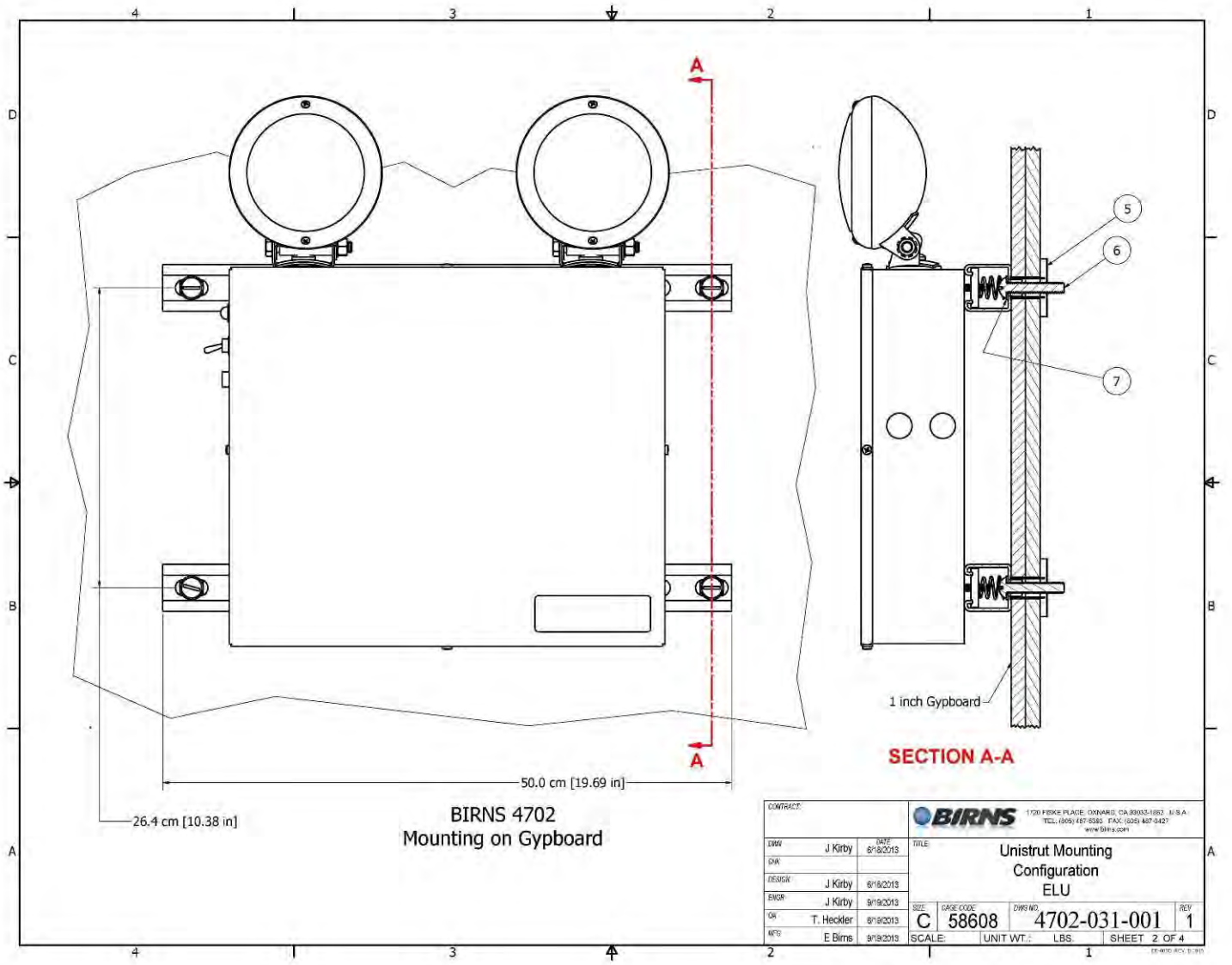
4634 Unistrut Mounting on Steel



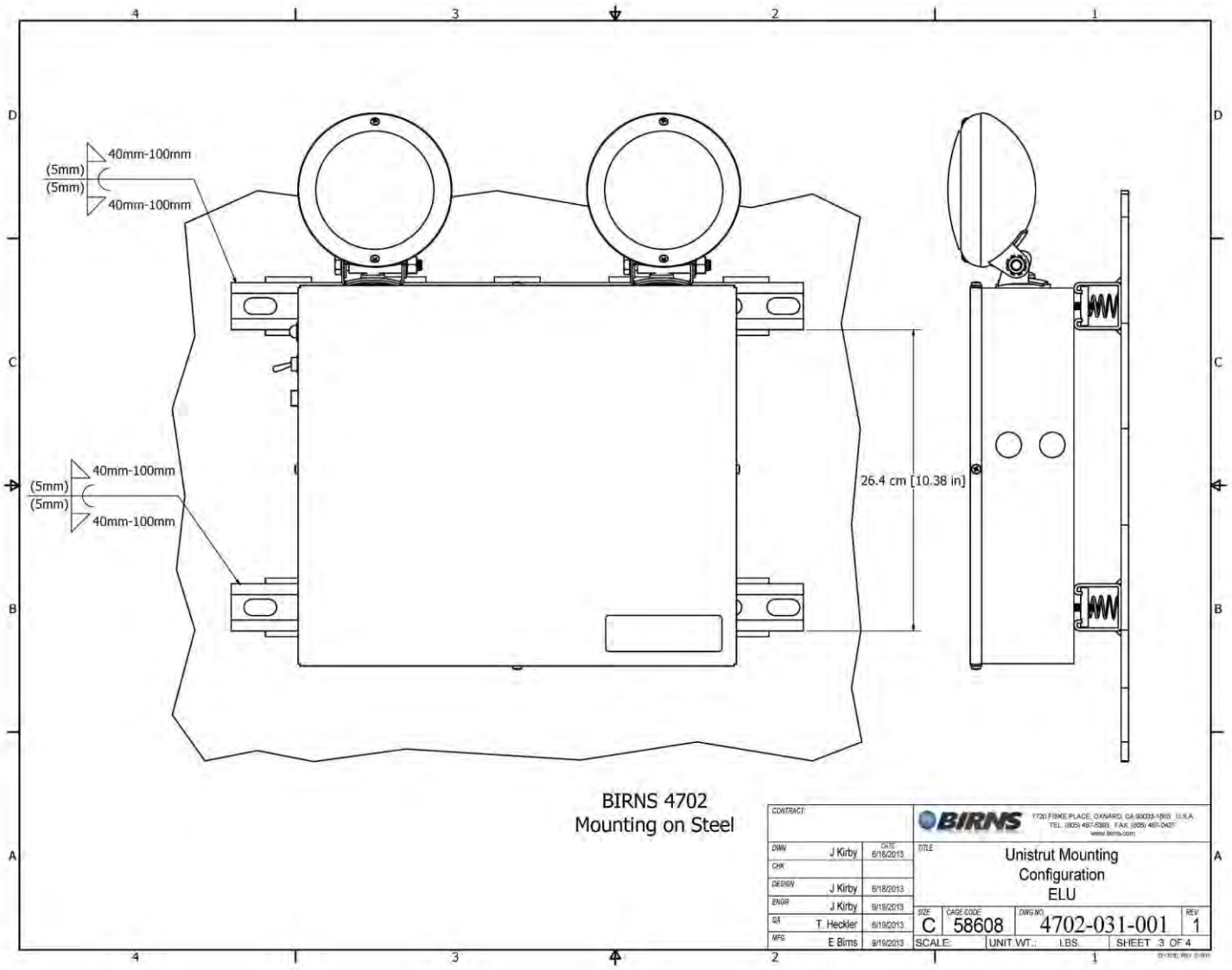
4634 Unistrut Mounting on Concrete



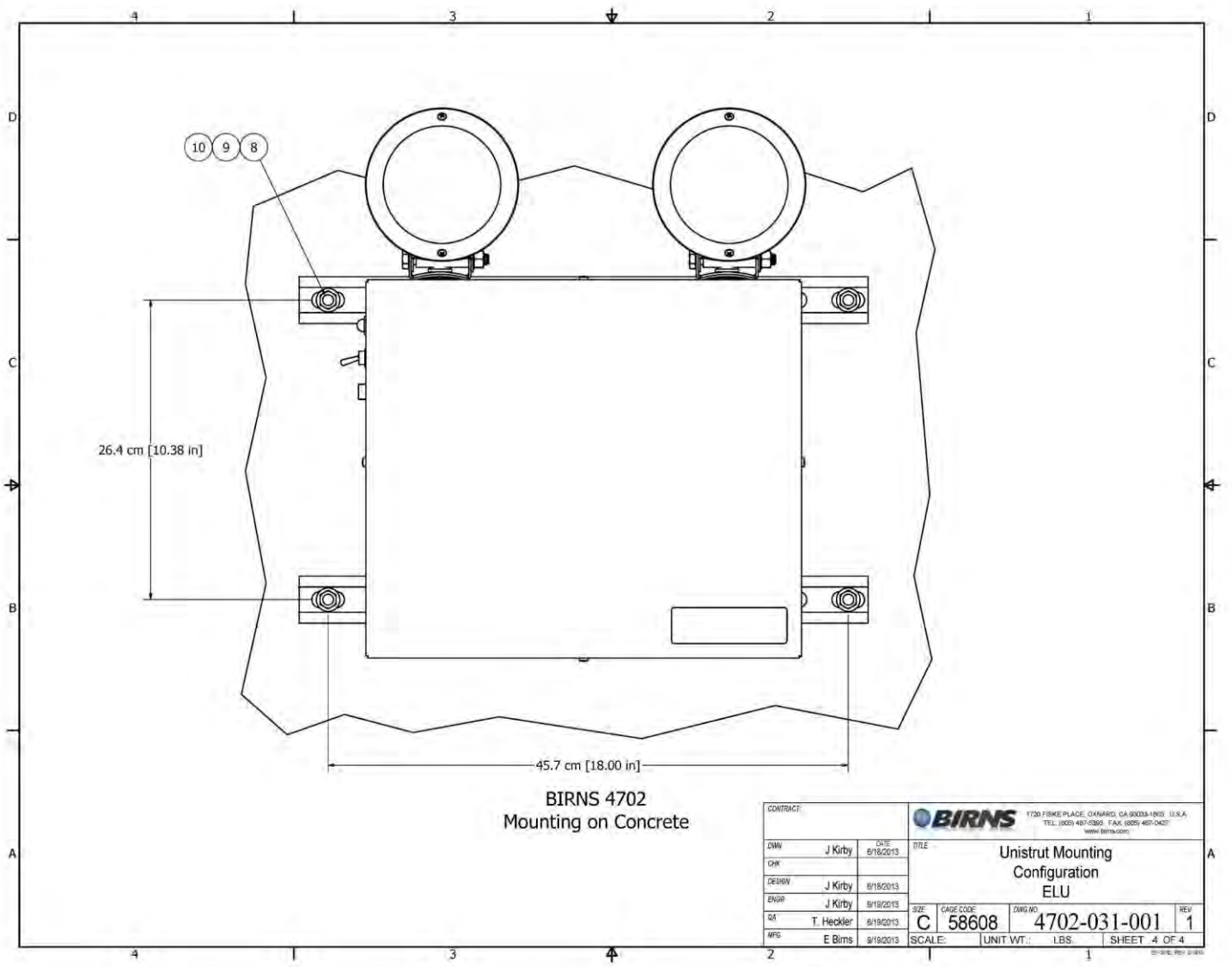
4702 Unistrut Mounting Configuration



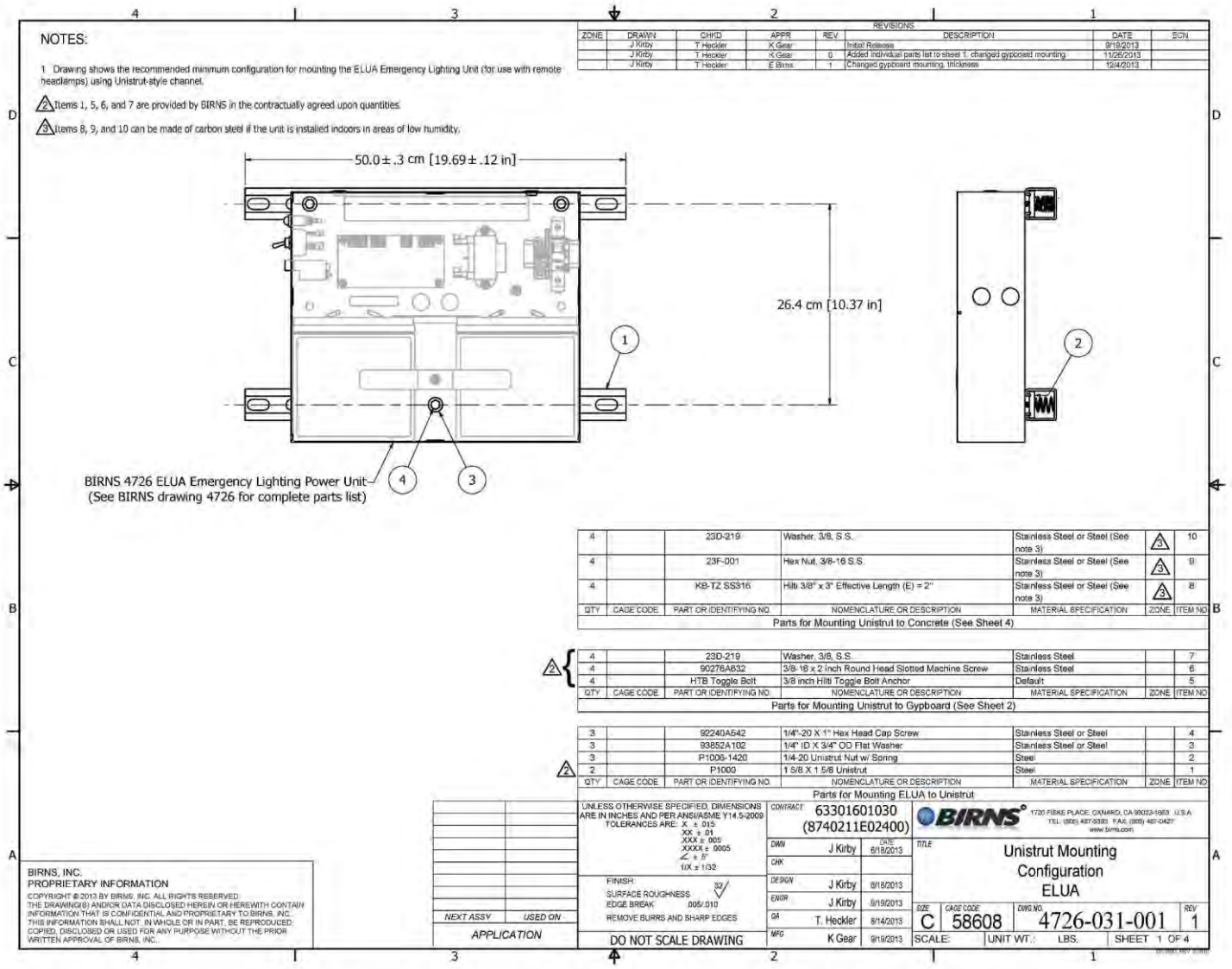
4702 Mounting on Gypboard



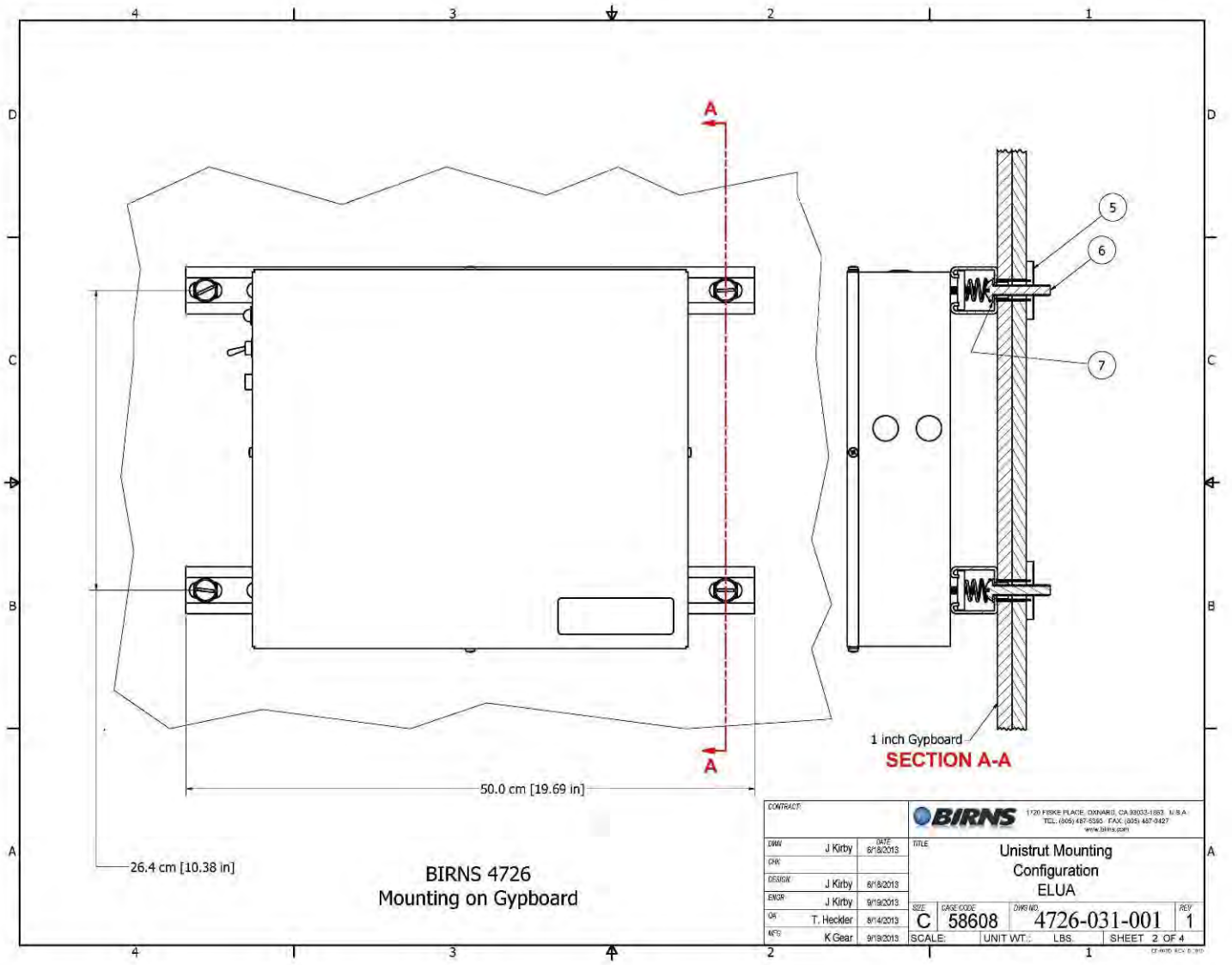
4702 Mounting on Steel



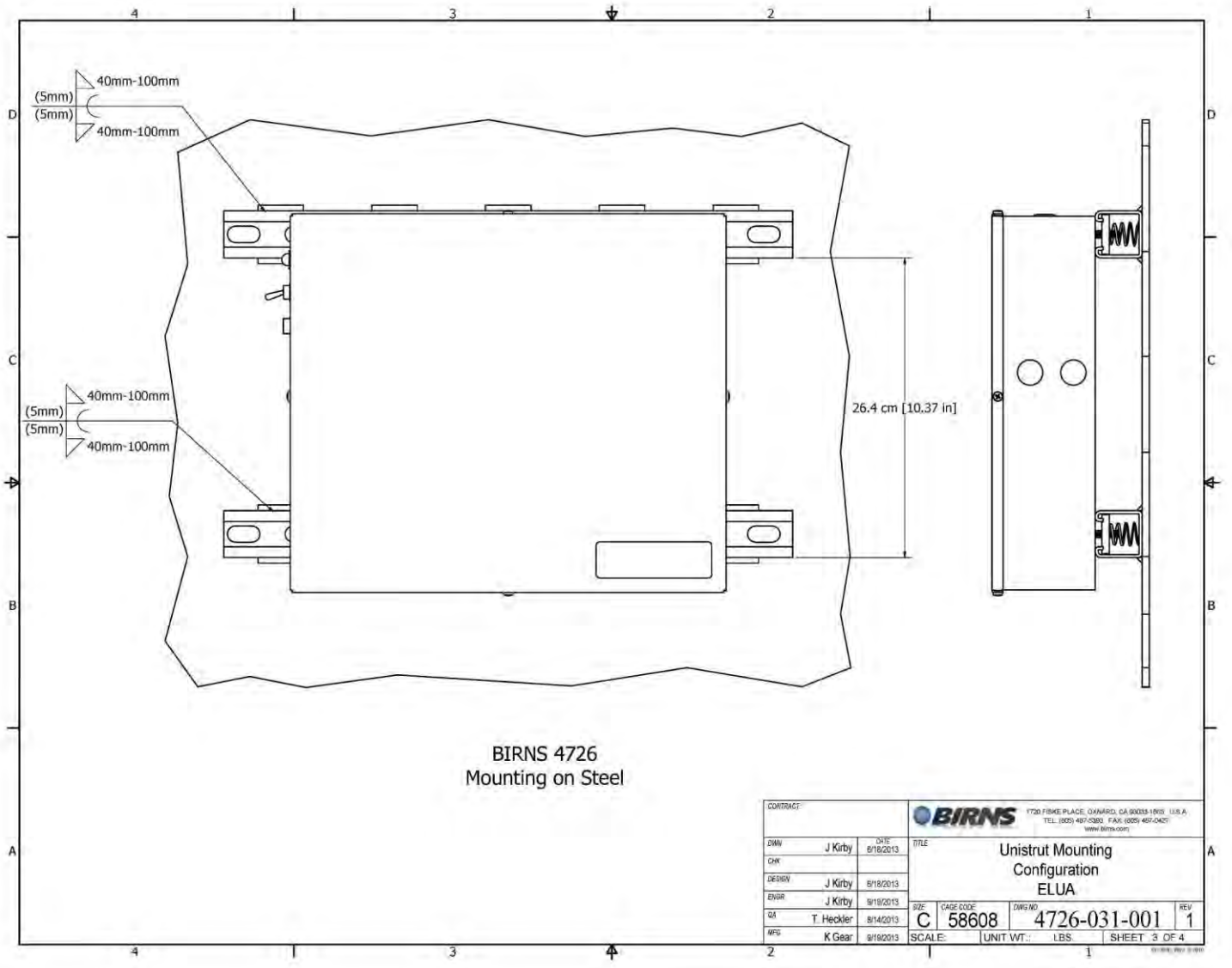
4702 Mounting on Concrete



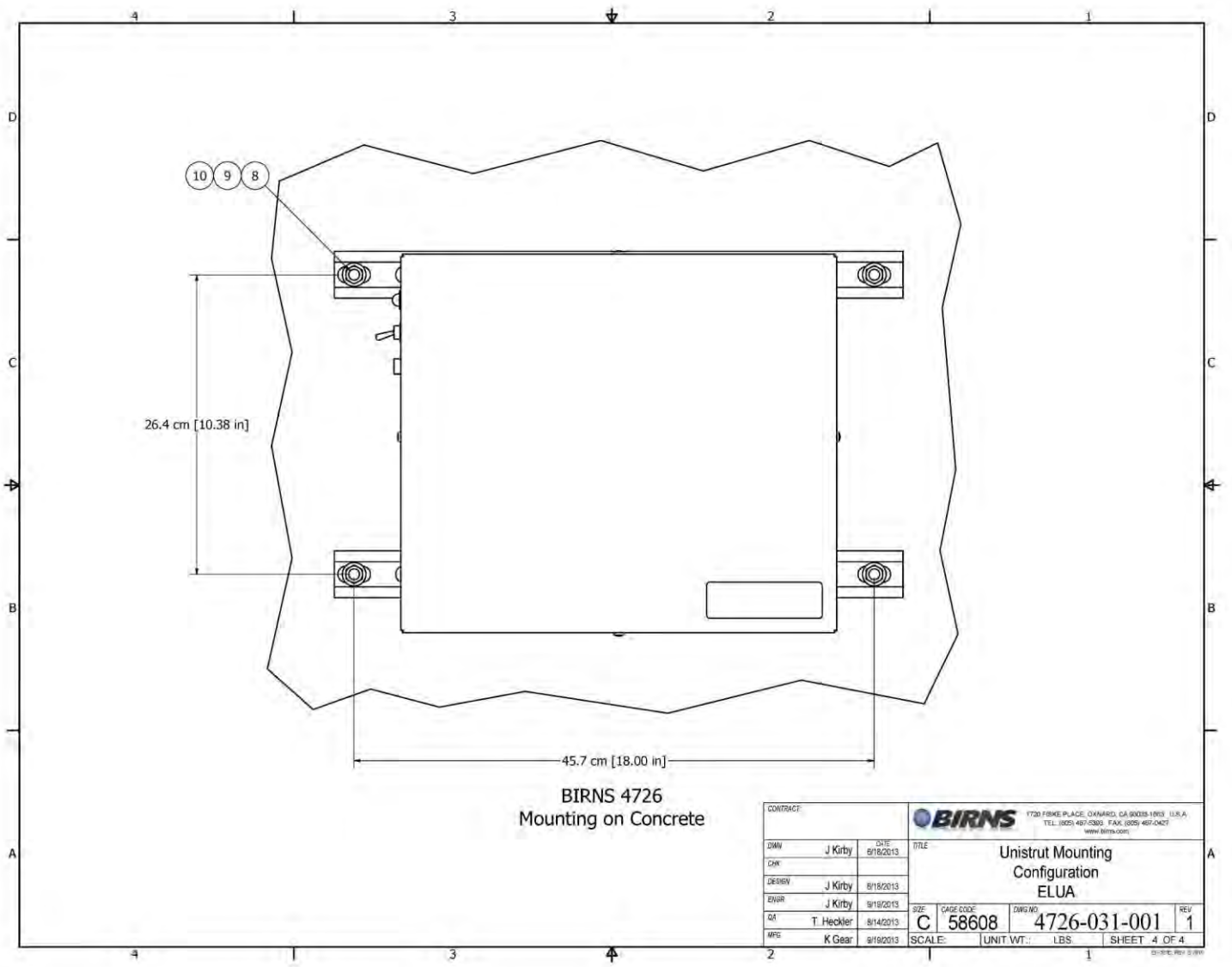
4726 Unistrut mounting Configuration



4726 Mounting on Gypboard



4726 Mounting on Steel



4726 Mounting on Concrete

APPENDIX B

Appendix A30 of GE Specification 63.1030S, Rev 2

Title:	SEISMICALLY QUALIFIED GUIDE LAMP LIGHTING FIXTURES	Document No 63.1030S Revision No 2

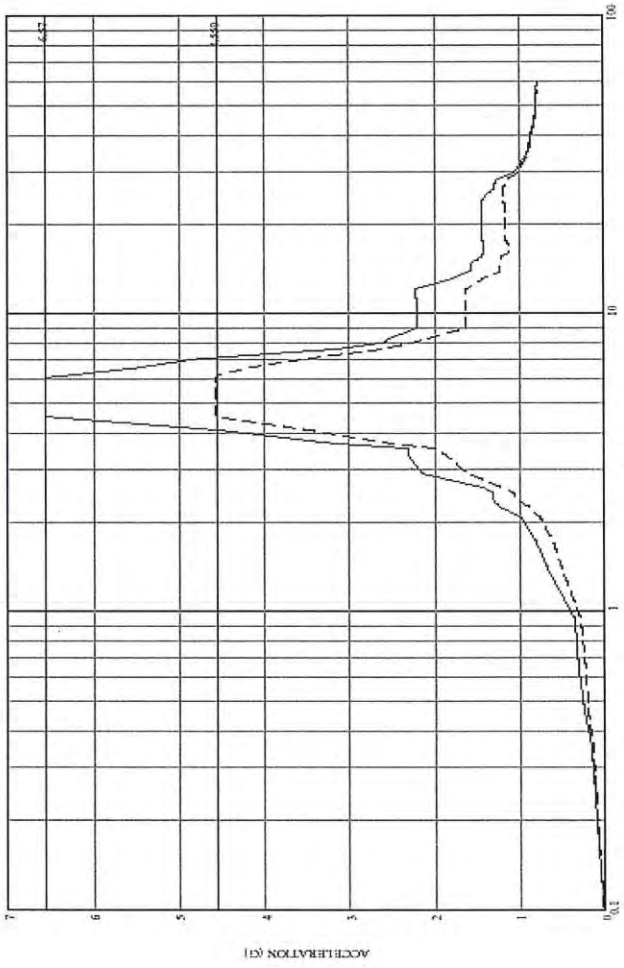


Figure M-1 Combined Floor Response Spectra - OBE + LOCA + SRV - Horizontal (Elevation 31.7M)

A30-3

Title:	SEISMICALLY QUALIFIED GUIDE LAMP LIGHTING FIXTURES	Document No 63.1030S Revision No 2

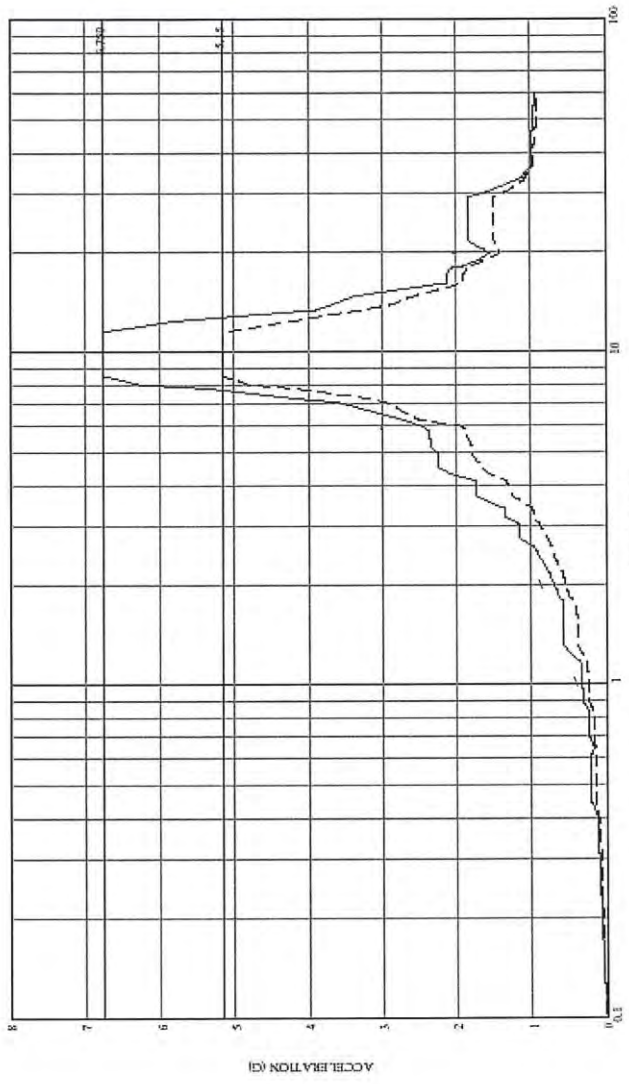


Figure M-2 Combined Floor Response Spectra - OBE + LOCA + SRV - Vertical (Elevation 31.7M)

A30-4

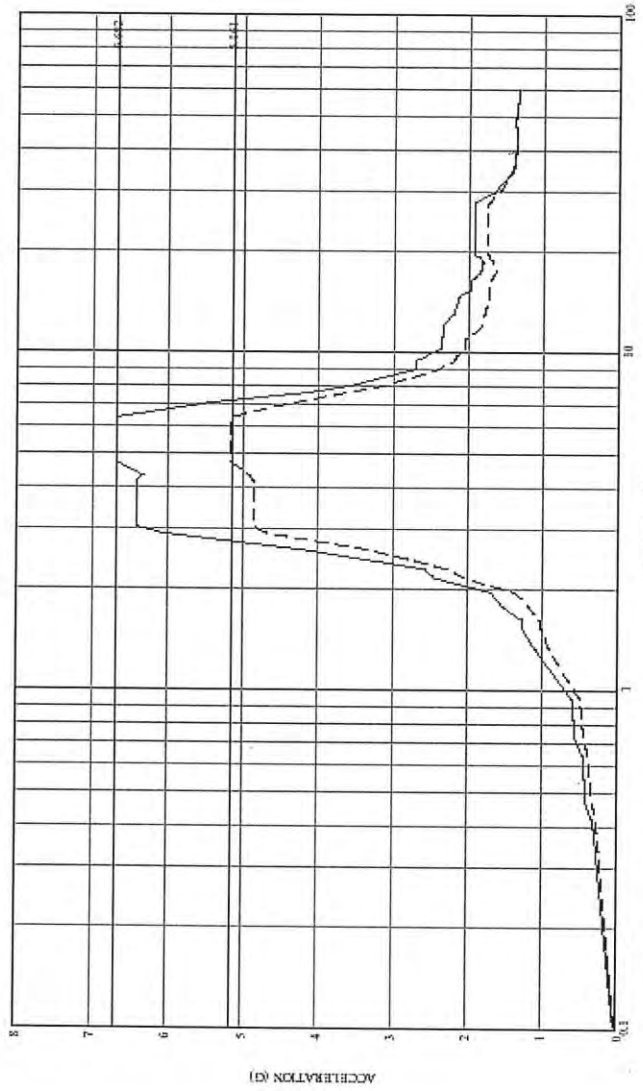


Figure N-1 Combined Floor Response Spectra - SSE + LOCA + SRV - Horizontal (Elevation 31.7M)

Title:	SEISMICALLY QUALIFIED GUIDE LAMP LIGHTING FIXTURES	Document No 63.1030S Revision No 2

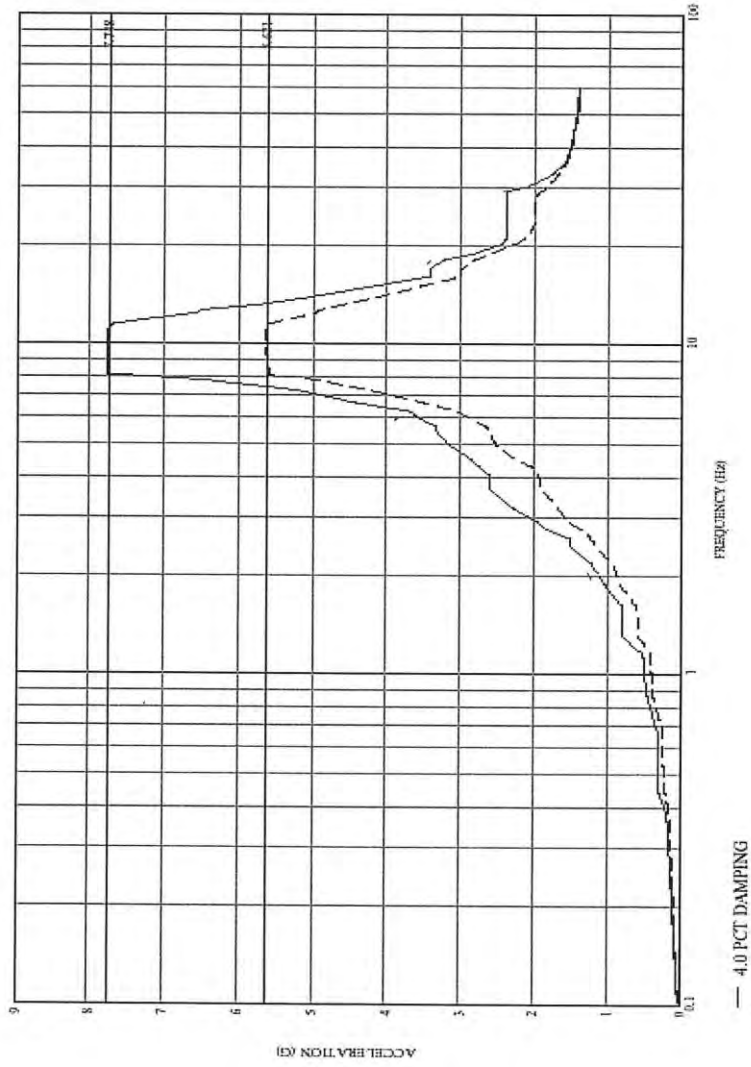


Figure N-2 Combined Floor Response Spectra - SSE + LOCA + SRV - Vertical (Elevation 31.7M)

A30-6

Title:	SEISMICALLY QUALIFIED GUIDE LAMP LIGHTING FIXTURES	Document No 63.1030S Revision No 2

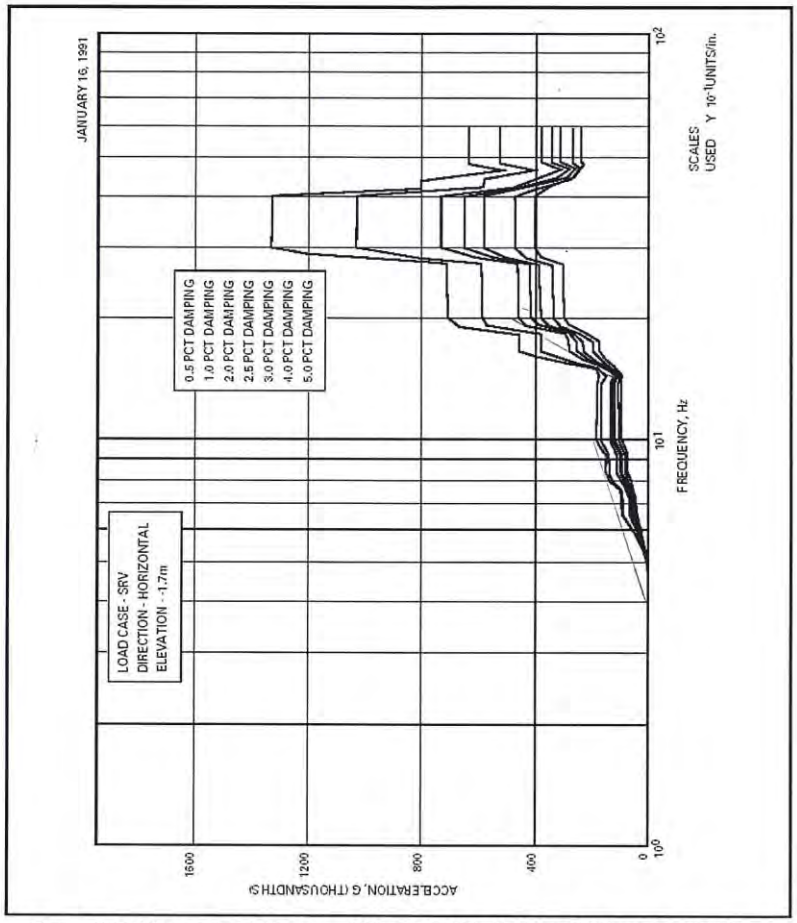


Figure 8 SRV Enveloped Spectra - RB and RCCV - Horizontal (Elevation -1.7M)

Title:	SEISMICALLY QUALIFIED GUIDE LAMP LIGHTING FIXTURES	Document No 63.1030S Revision No 2

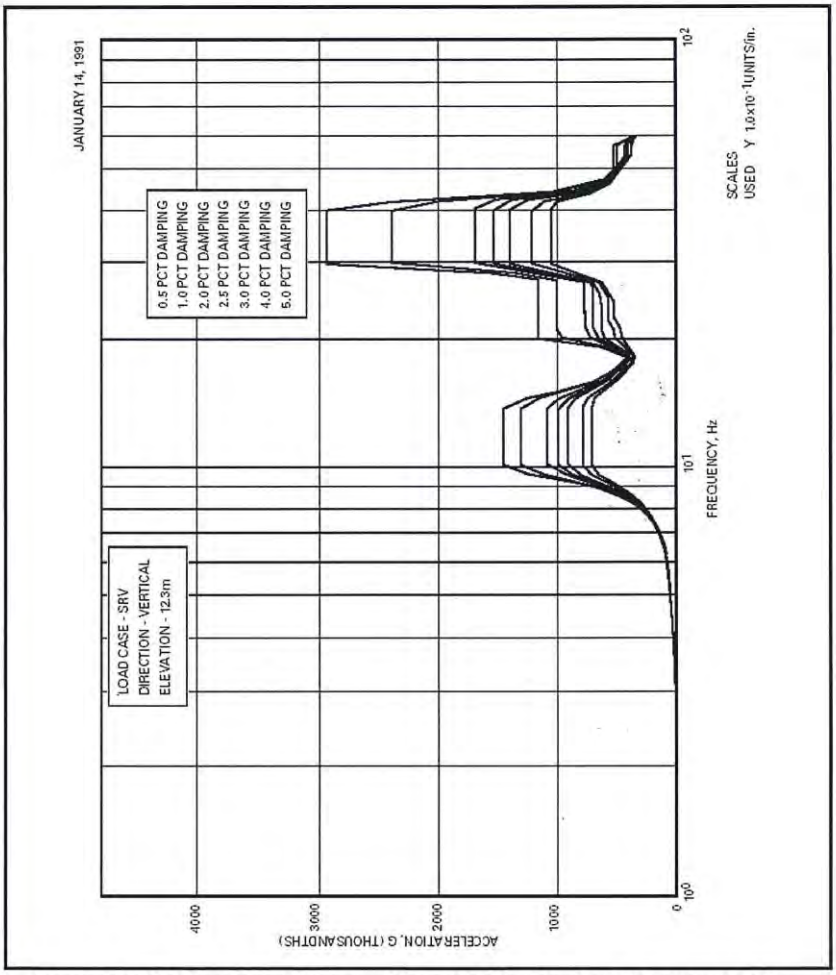


Figure 36 SRV Enveloped Spectra - RB and RCCV - Vertical (Elevation 12.3M)

A30-8

Title:	SEISMICALLY QUALIFIED GUIDE LAMP LIGHTING FIXTURES	Document No 63.1030S Revision No 2

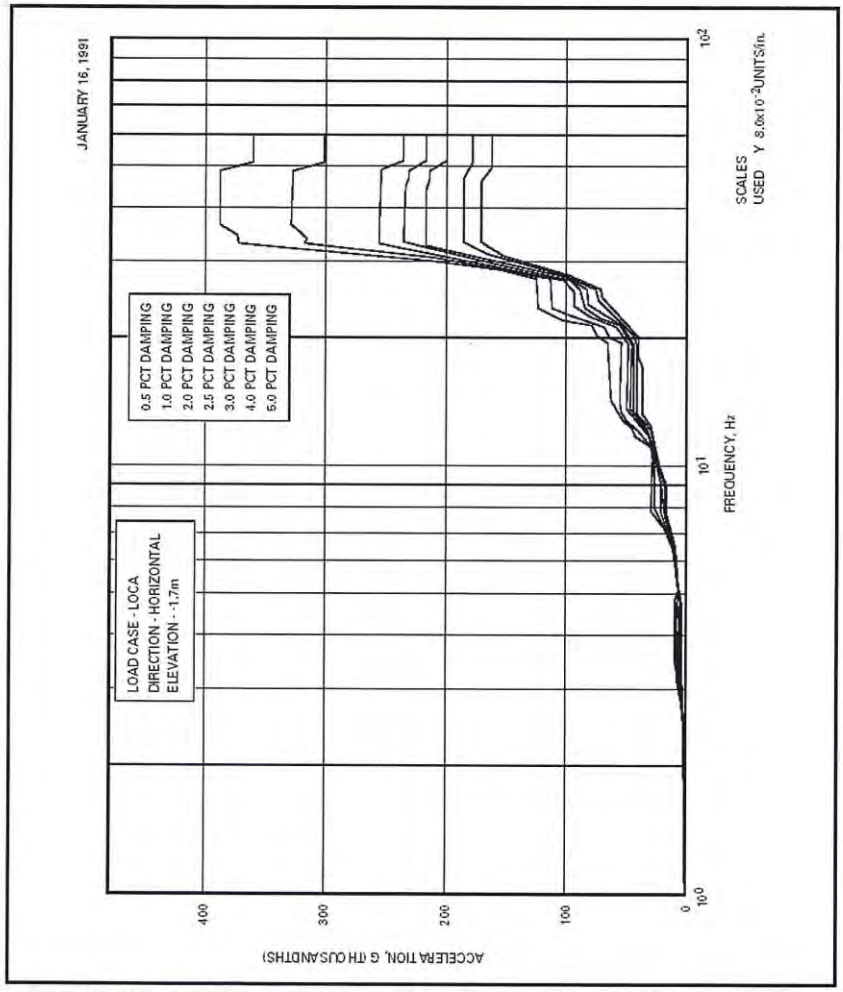


Figure 66 LOCA Enveloped Spectra - RB and RCCV - Horizontal (Elevation -1.7M)

Title:	SEISMICALLY QUALIFIED GUIDE LAMP LIGHTING FIXTURES	Document No 63.1030S Revision No 2

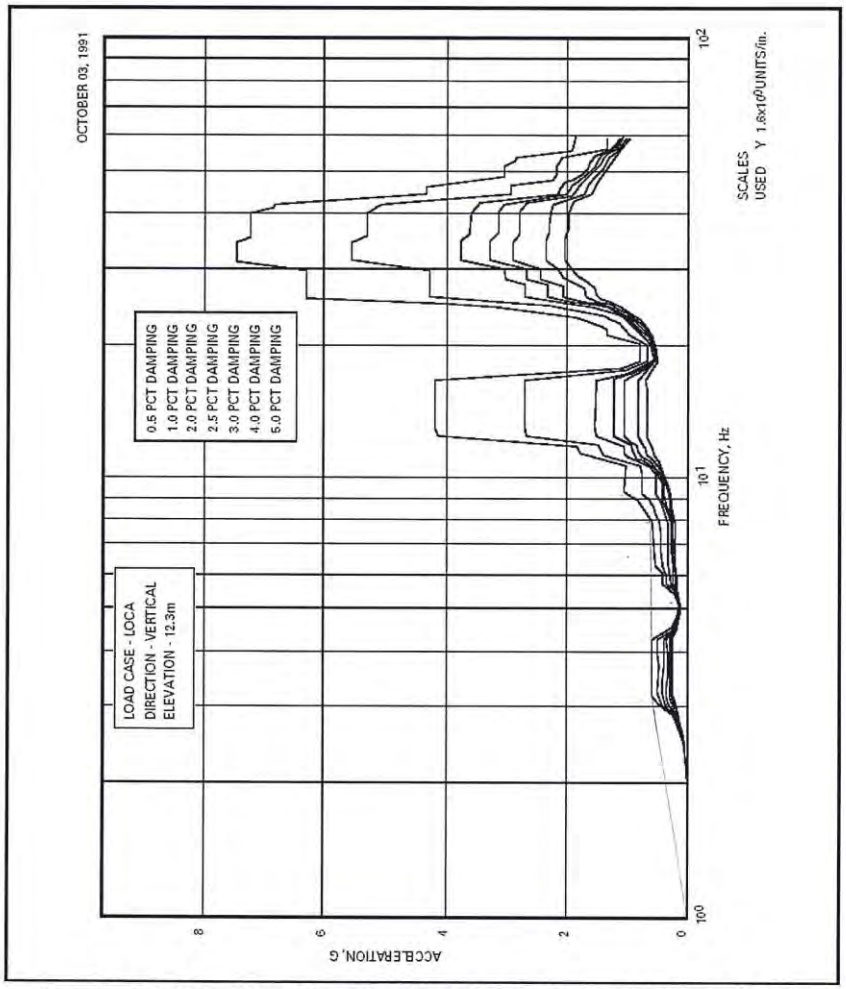


Figure 94 LOCA Enveloped Spectra - RB and RCCV - Vertical (Elevation 12.3M)

A30-10

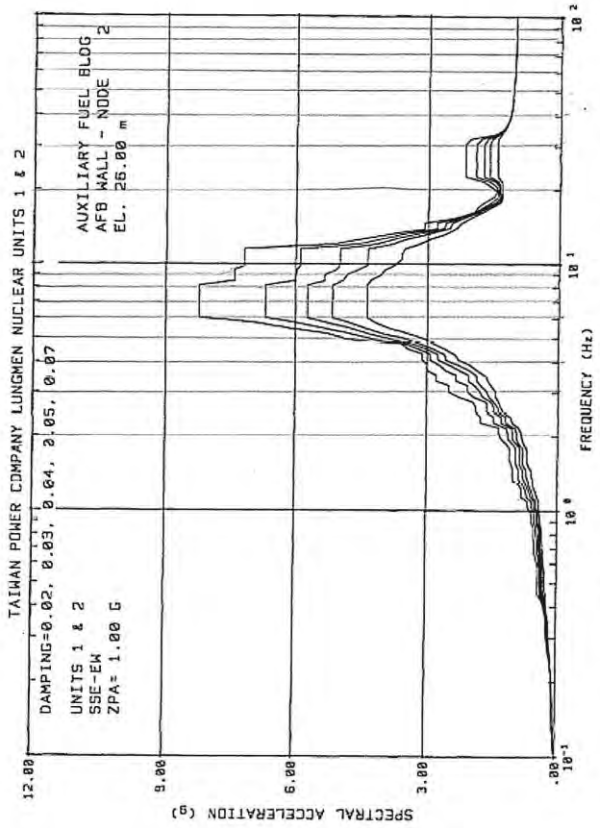


FIGURE A-4 WIGENED ENVELOPED FLOOR RESPONSE SPECTRA

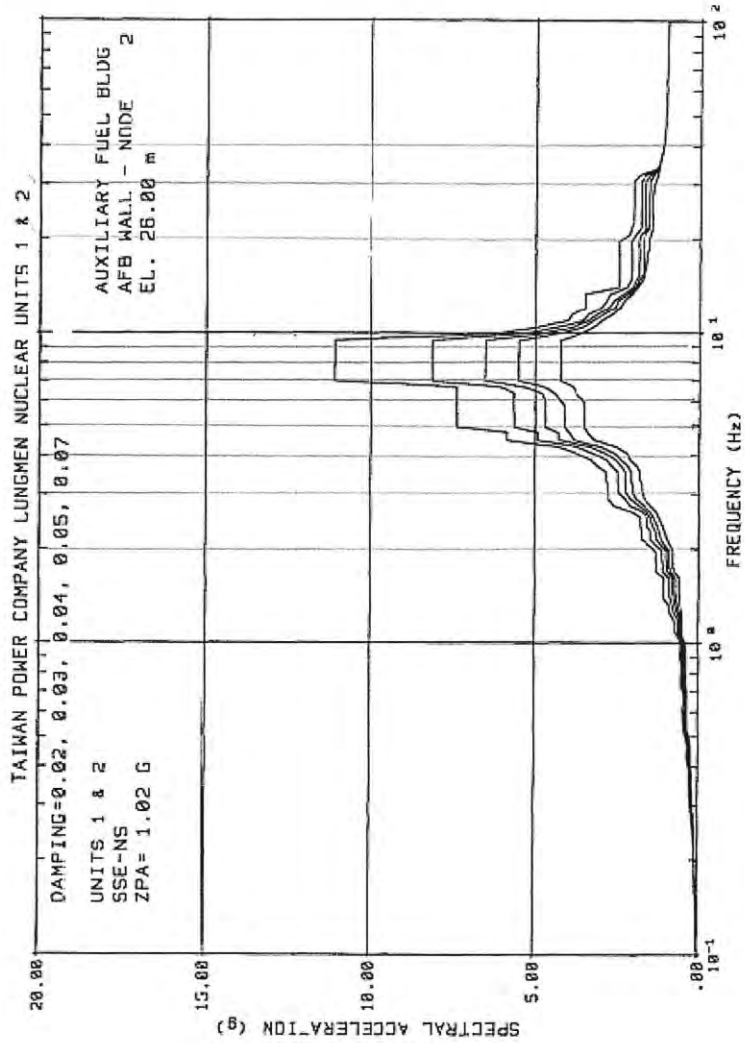


FIGURE A-5 WIDENED ENVELOPED FLOOR RESPONSE SPECTRA

Title:	SEISMICALLY QUALIFIED GUIDE LAMP LIGHTING FIXTURES	Document No 63.1030S Revision No 2

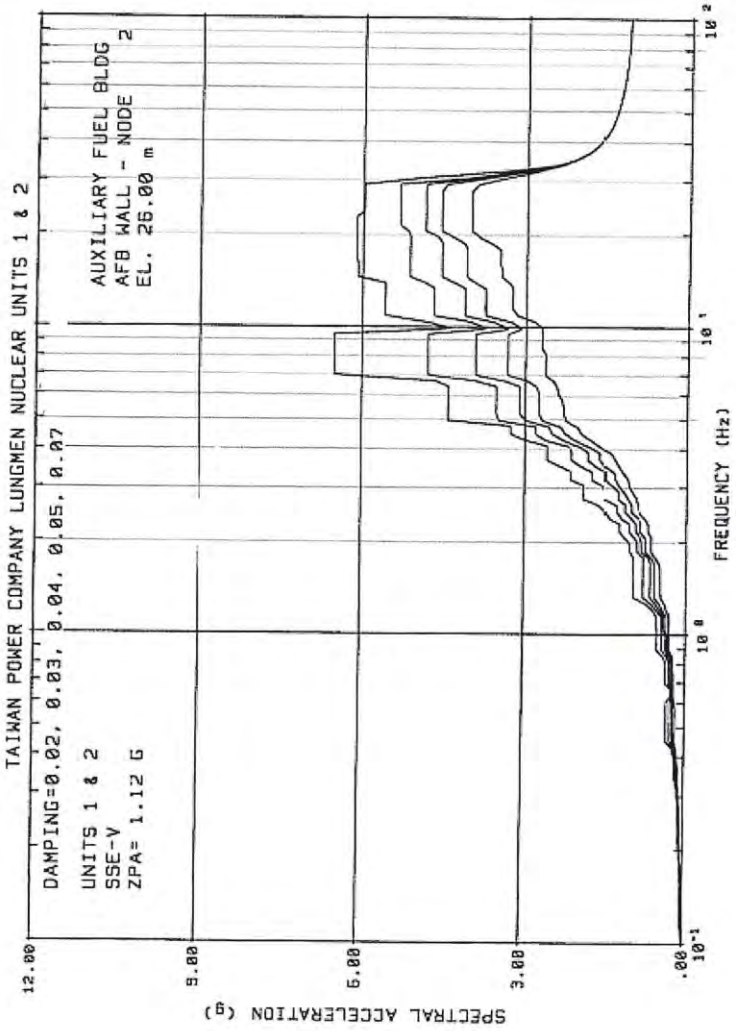


FIGURE A-6 WIDENED ENVELOPED FLOOR RESPONSE SPECTRA

A30-13

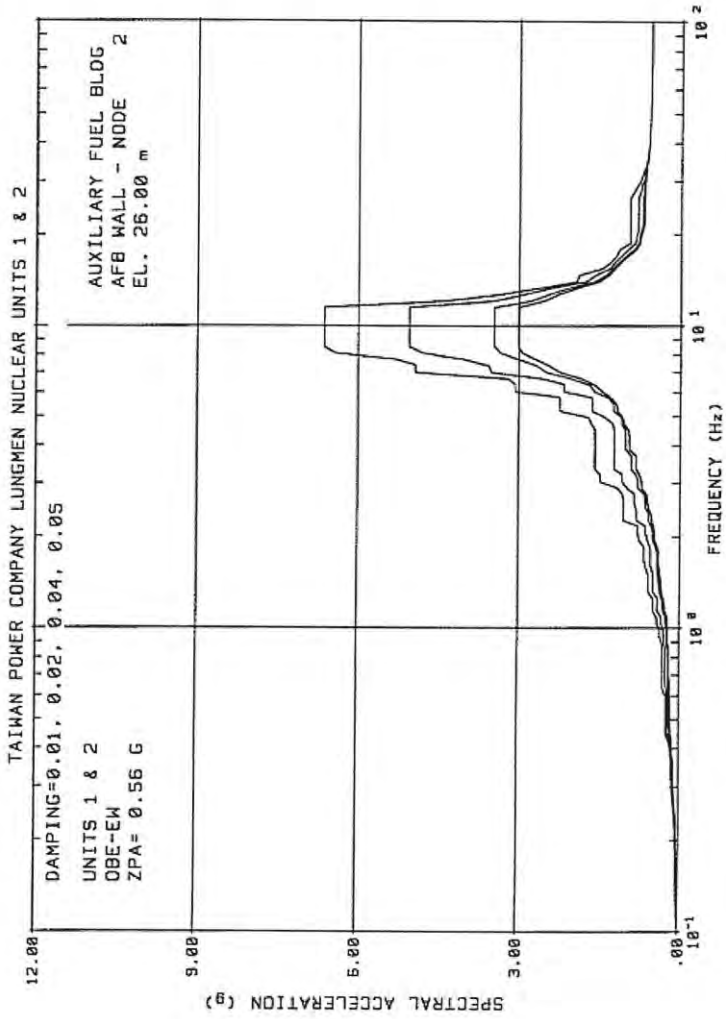


FIGURE B-4 WIDENED ENVELOPED FLOOR RESPONSE SPECTRA

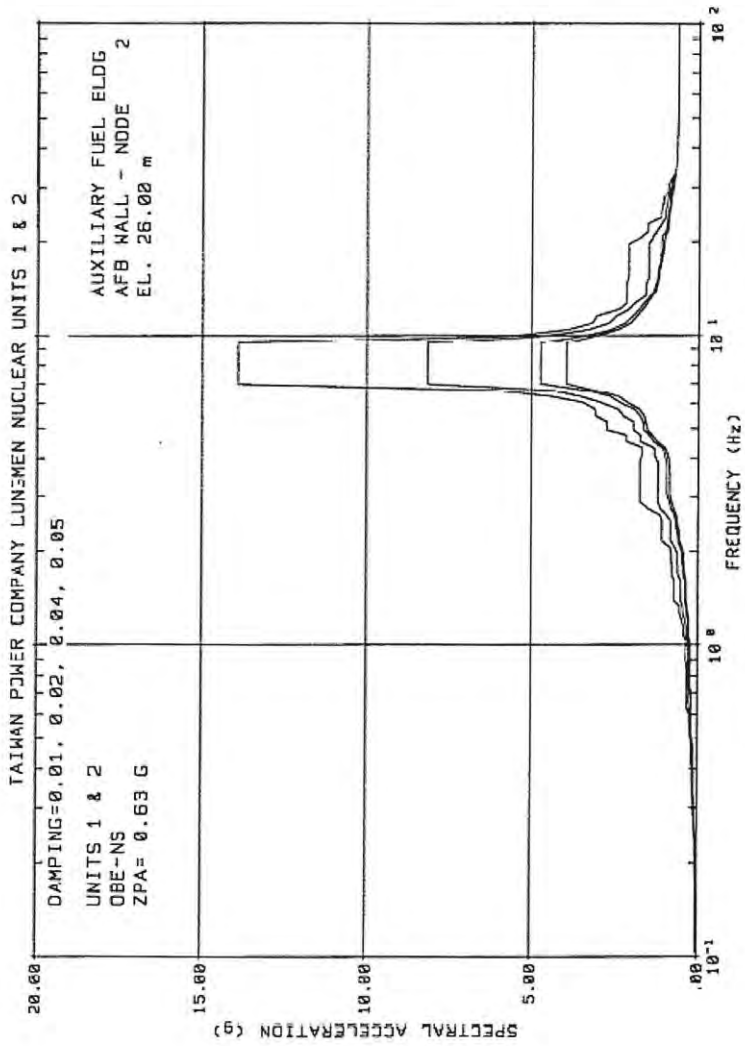


FIGURE B-5 WIDENED ENVELOPED FLOOR RESPONSE SPECTRA

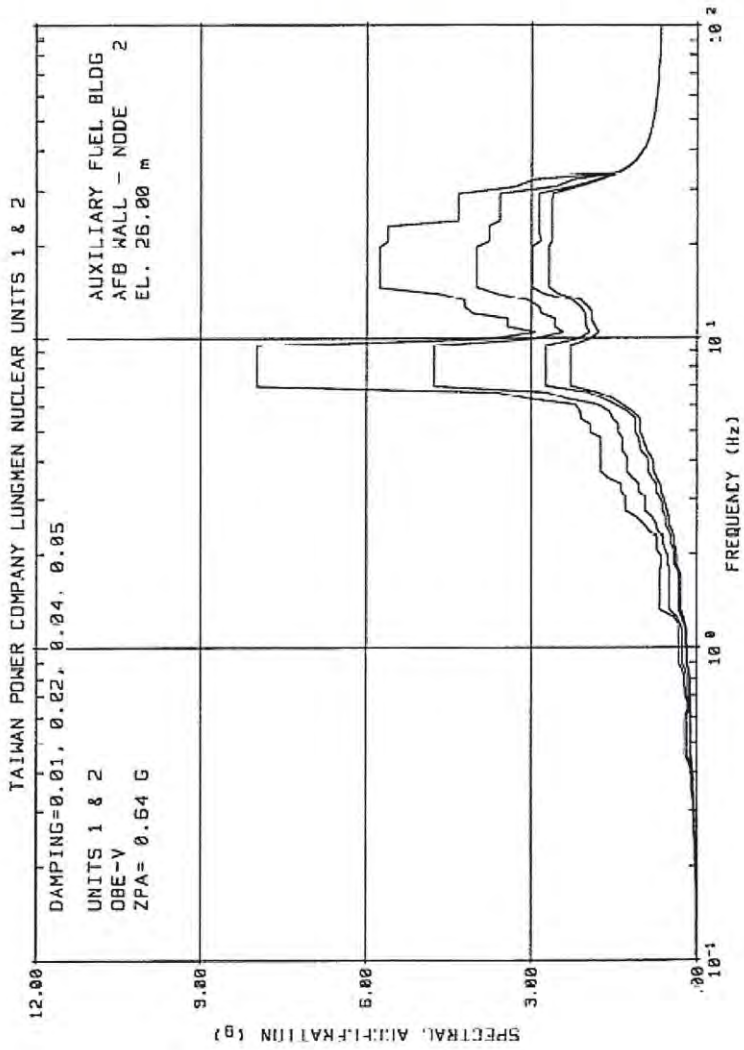


FIGURE B-6 WIDENED ENVELOPED FLOOR RESPONSE SPECTRA

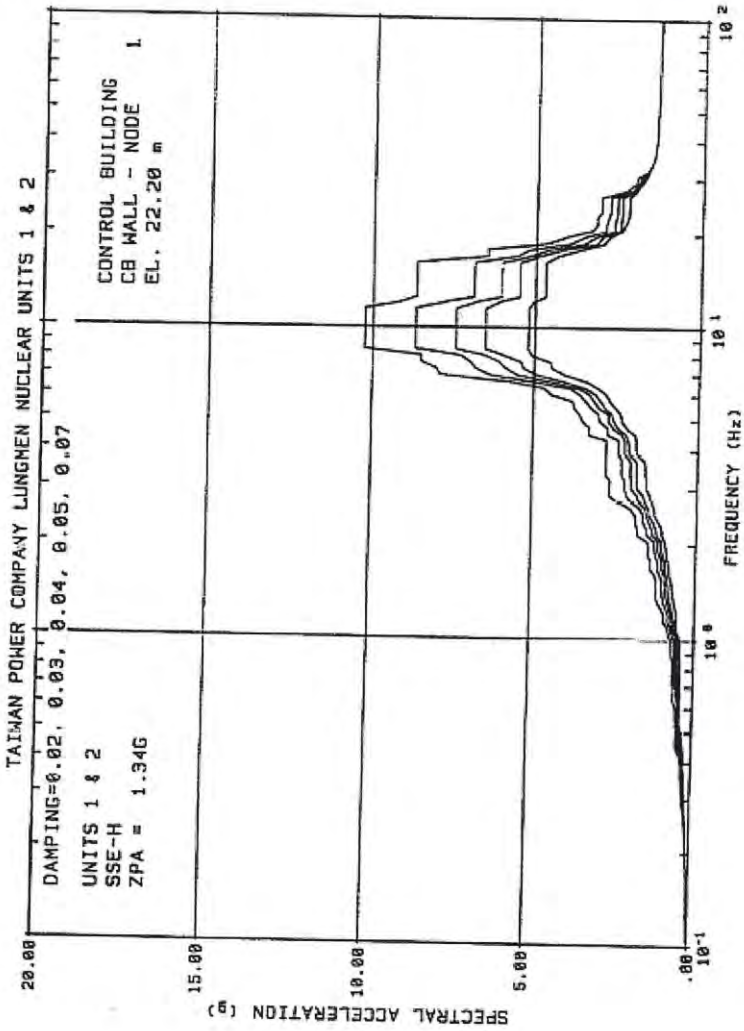


FIGURE A-1 WIDENED ENVELOPED FLOOR RESPONSE SPECTRA

Title:	SEISMICALLY QUALIFIED GUIDE LAMP LIGHTING FIXTURES	Document No 63.1030S Revision No 2

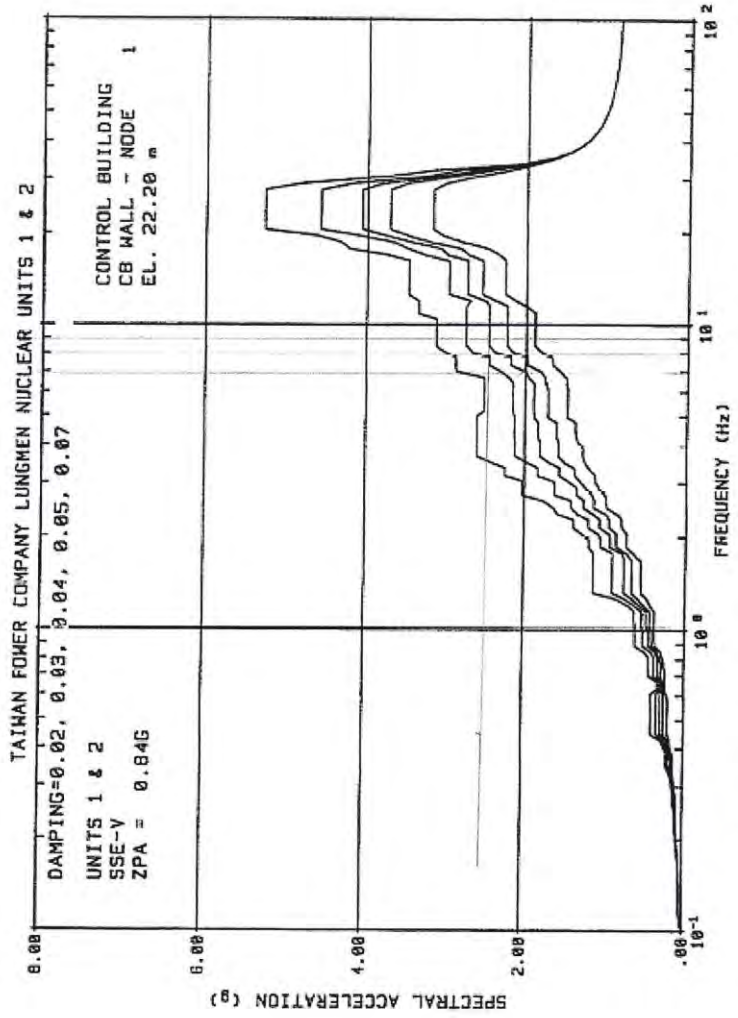


FIGURE A-2 WIDENED ENVELOPED FLOOR RESPONSE SPECTRA

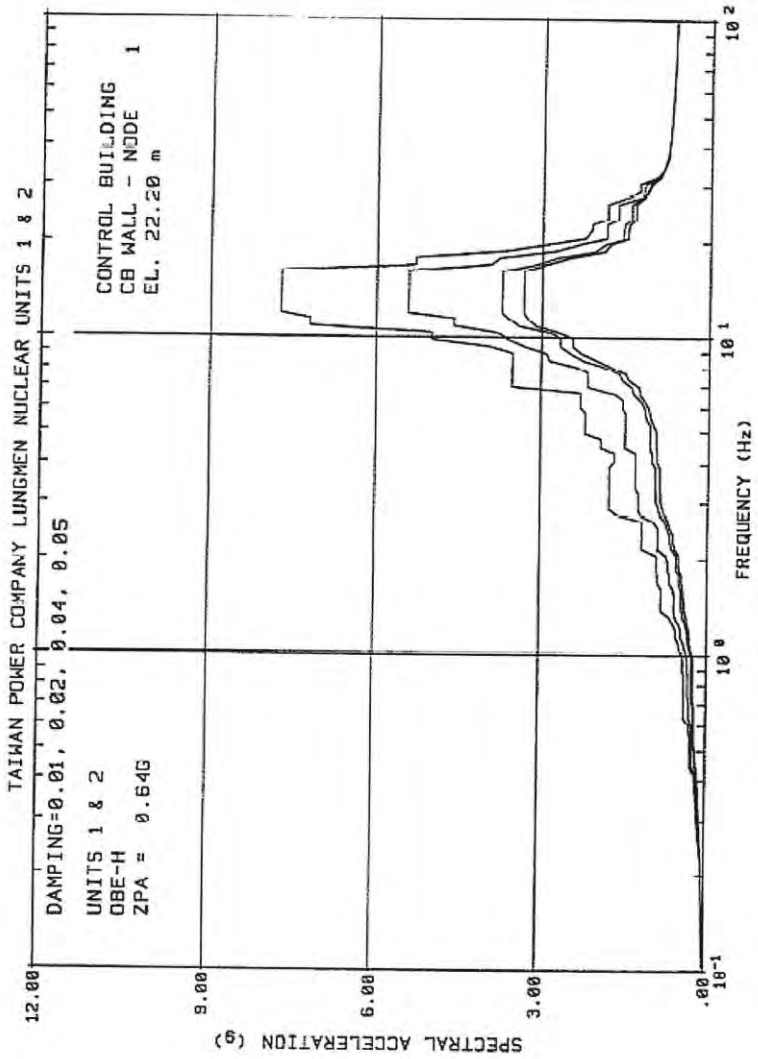


FIGURE B-1 WIDENED ENVELOPED FLOOR RESPONSE SPECTRA

A30-19

Title:	SEISMICALLY QUALIFIED GUIDE LAMP LIGHTING FIXTURES	Document No 63.1030S Revision No 2

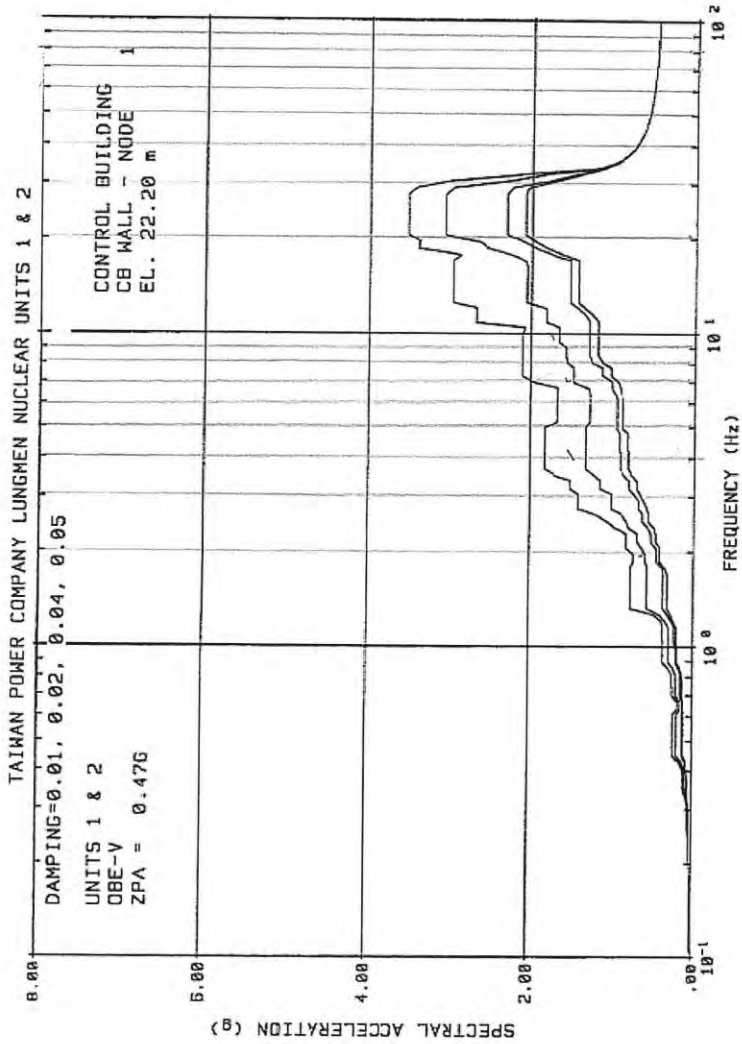
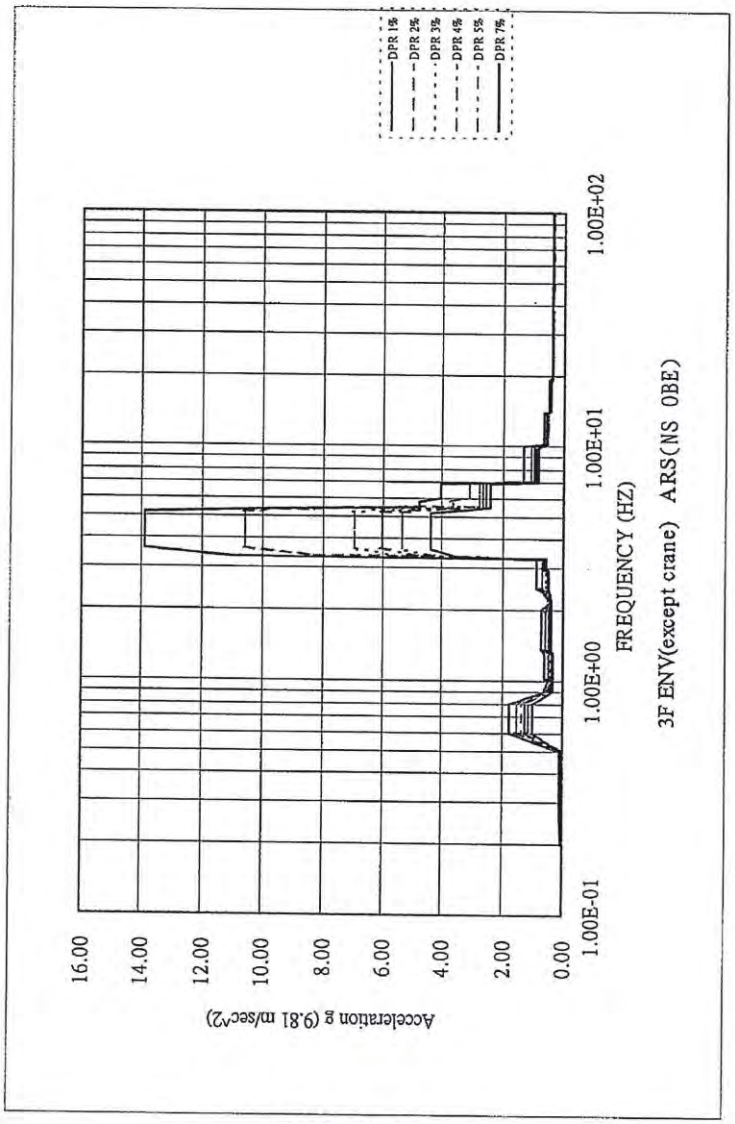


FIGURE B-2 WIDENED ENVELOPED FLOOR RESPONSE SPECTRA

A30-20

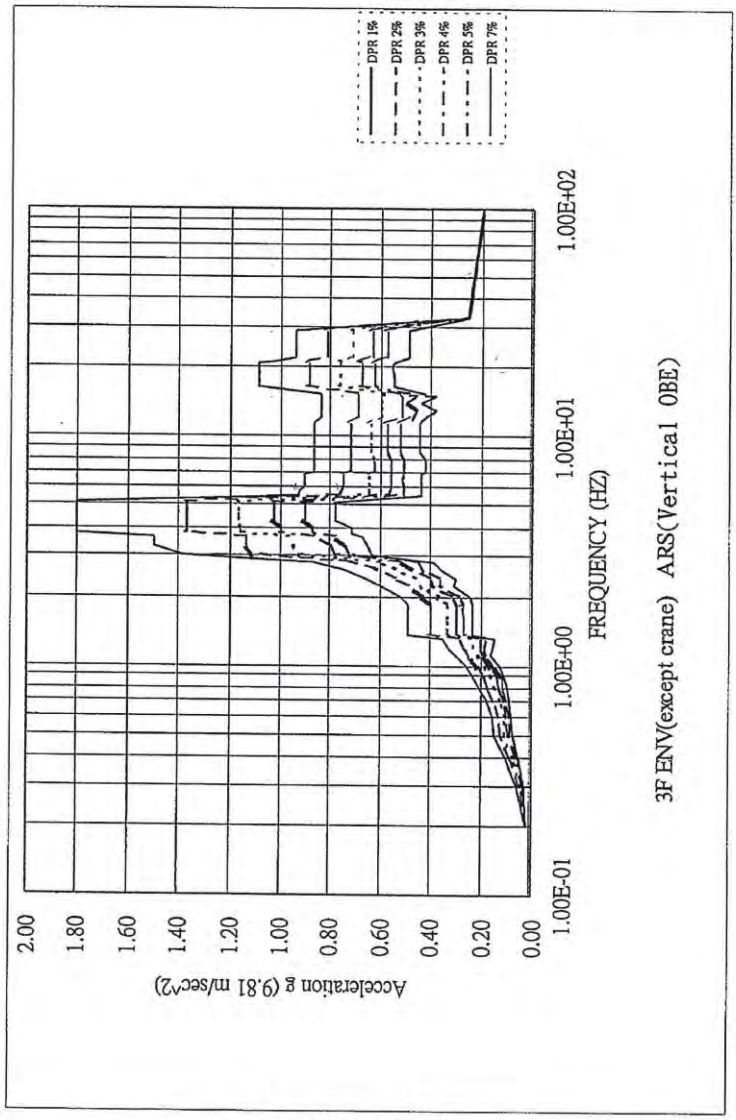
Title:	SEISMICALLY QUALIFIED GUIDE LAMP LIGHTING FIXTURES	Document No 63.1030S Revision No 2



RBSWPH-1

A30-21

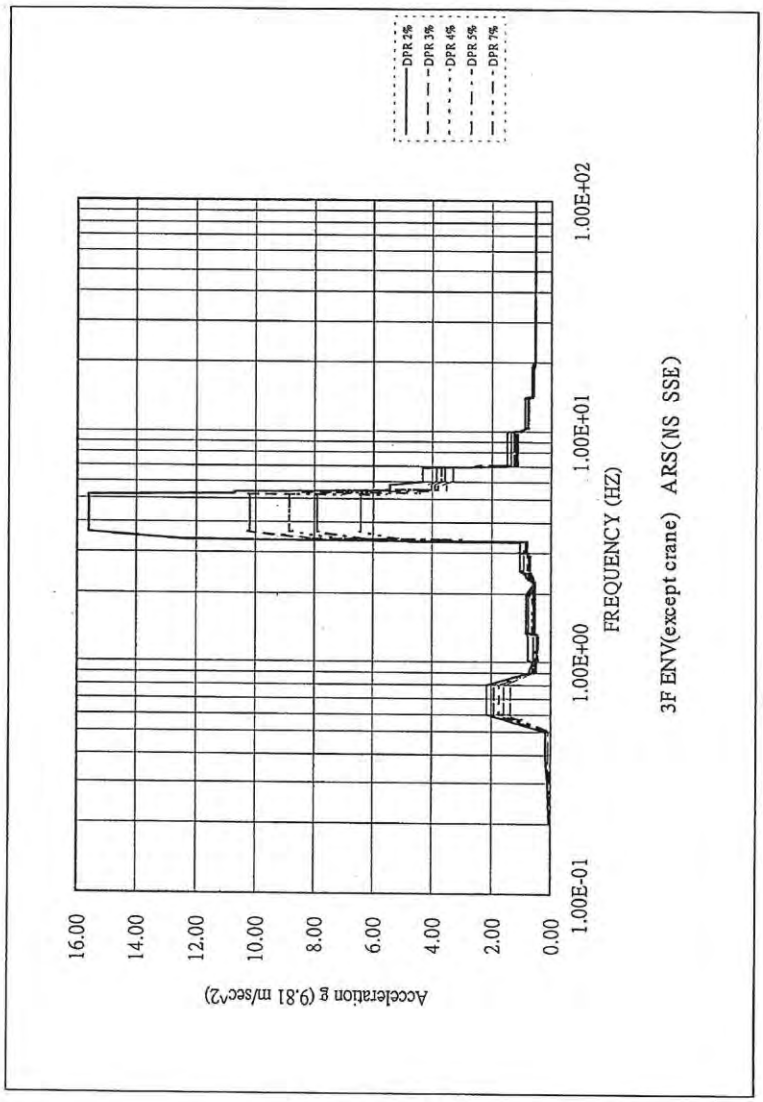
Title:	SEISMICALLY QUALIFIED GUIDE LAMP LIGHTING FIXTURES	Document No 63.1030S Revision No 2



RBSWPH-2

A30-22

Title:	SEISMICALLY QUALIFIED GUIDE LAMP LIGHTING FIXTURES	Document No 63.1030S Revision No 2



RBSWPH-3

A30-23

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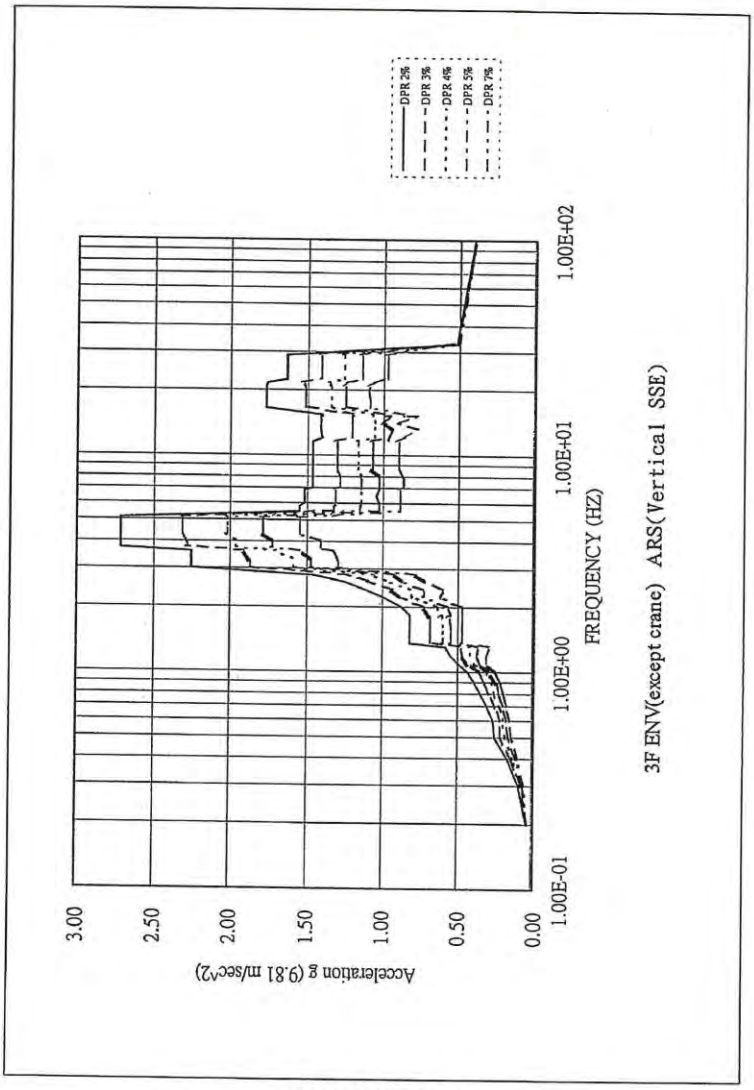


RBSWPH-4

A30-24

APPENDIX C

Change of Procedure #001

NTS
WE ENGINEER SUCCESS

CHANGE OF PROCEDURE

Job Number: PR023710-14N	**Date:** 28 October, 2013
Client: BIRNS Inc.	**COP Number:** 001

Charles R. Pilotte	**has authorized changes to the following specification:**
TP023706-14N	Revision 2 Section 3.0

DESCRIPTION OF CHANGE:

1) Add additional item for testing being two LED lamps used in Model 4710. Monitoring of device operation will be performed by BIRNS.

JUSTIFICATION FOR CHANGE:

1) Additional test item

NTS APPROVALS:

Project Manager *(Signature)*: Charles R Pilotte 10-28-13

Quality Representative *(Signature)*: David R Klug 10-28-13

Independent Review (Nuclear Only) Jonathan Mundrick 10/28/13

Government Representative *(Signature)*: N/A

Client Contact

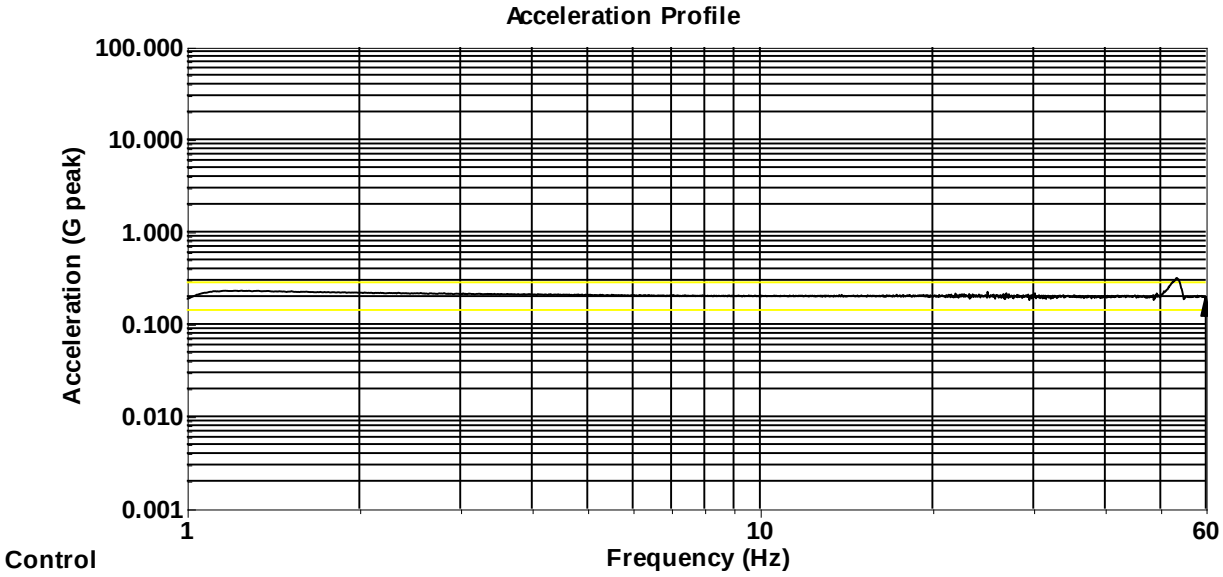
Client Authorization *(If available or required) at time of deviation]*:

Thomas Keckler Quality Manager 10/28/13
(Signature, Title, and Date)

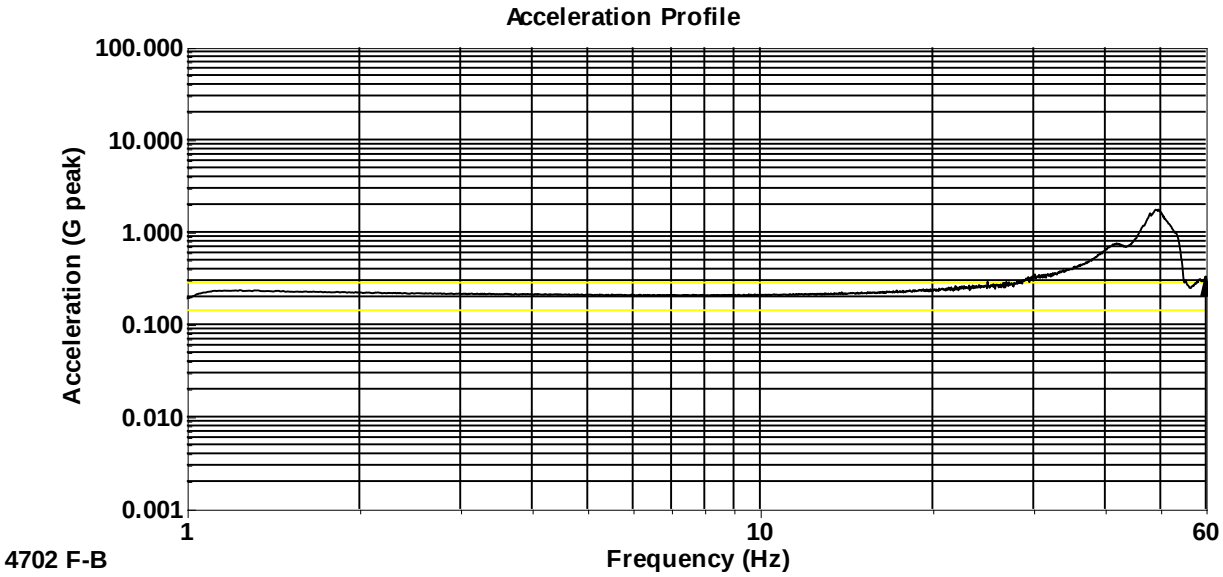
COR 23.0, REV. 0

APPENDIX D

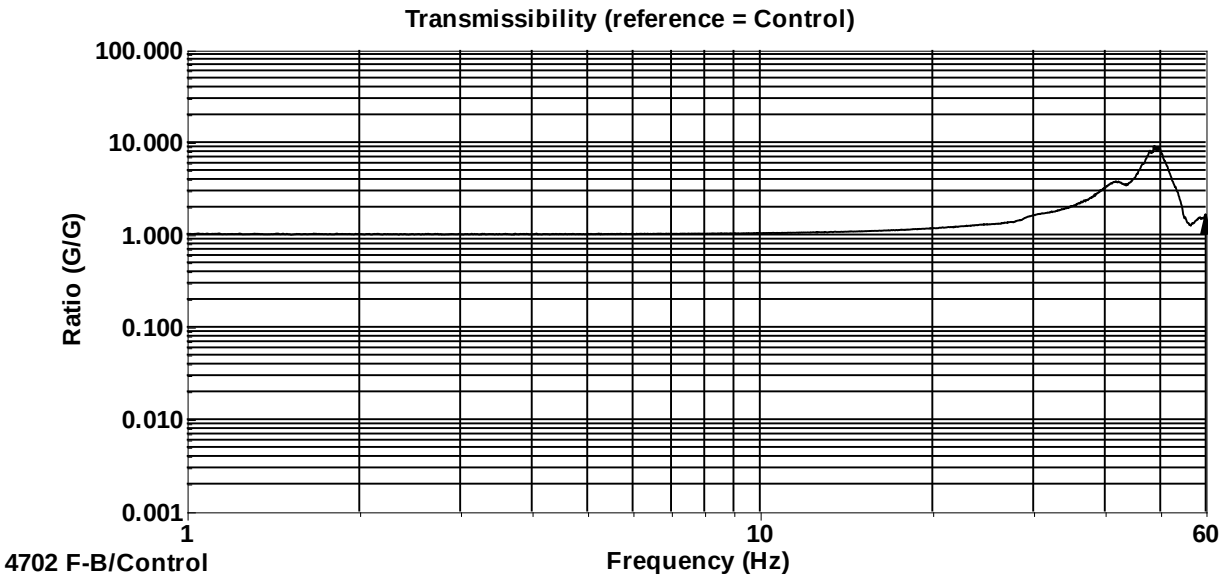
Resonance Survey Plots



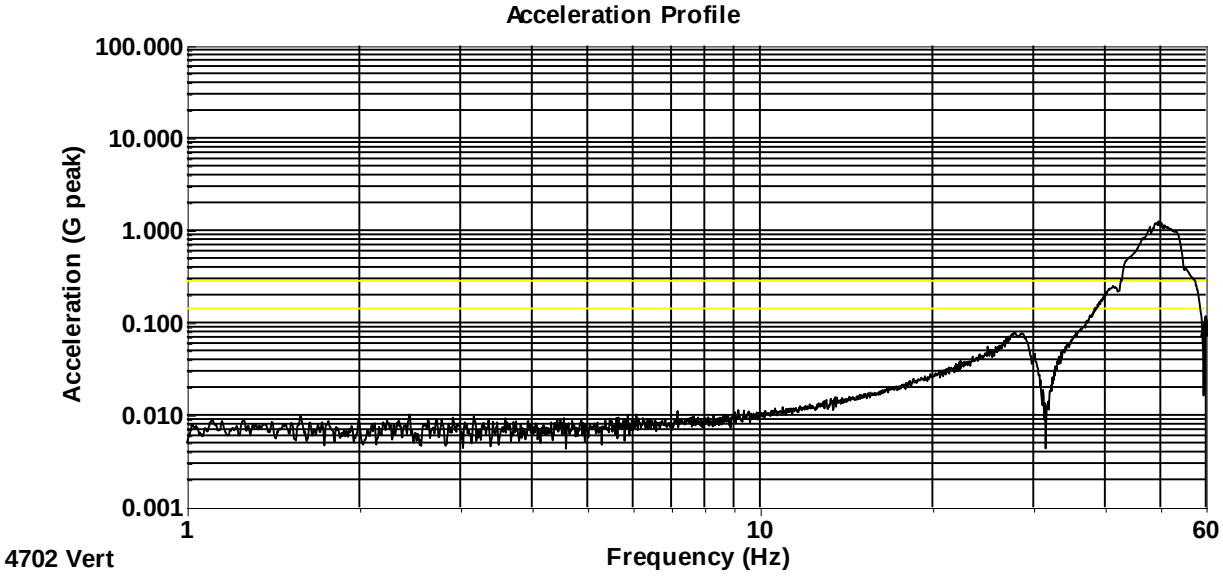
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 1 Front-Back Survey Oct 28, 2013 15:59:51
Control Accelerometer



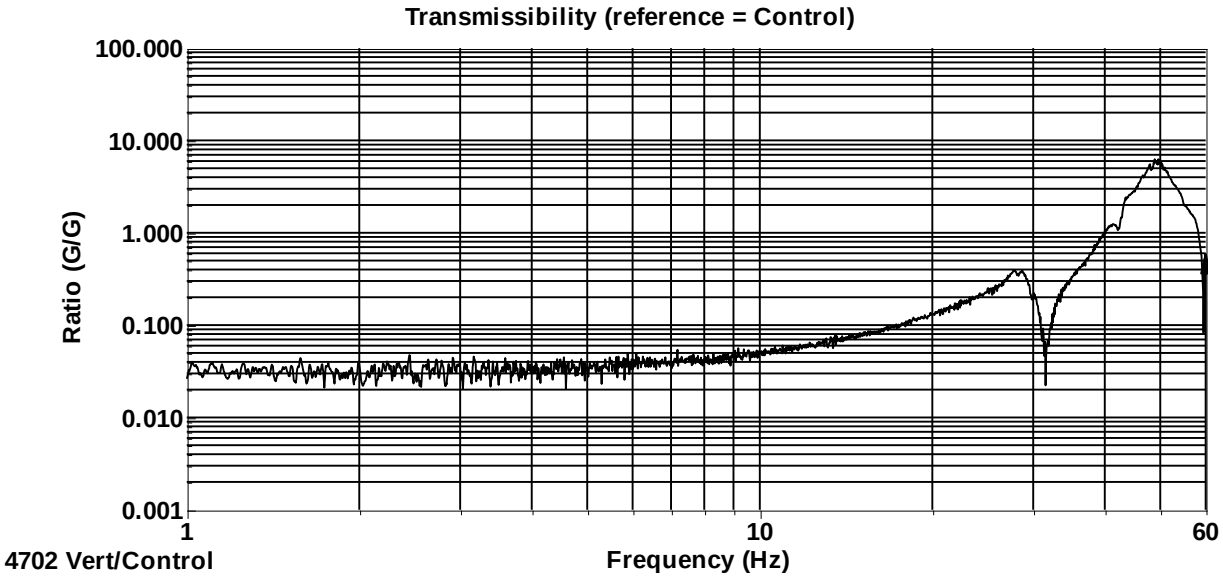
Front to Back Axis
Front to Back Response on 4702 unit



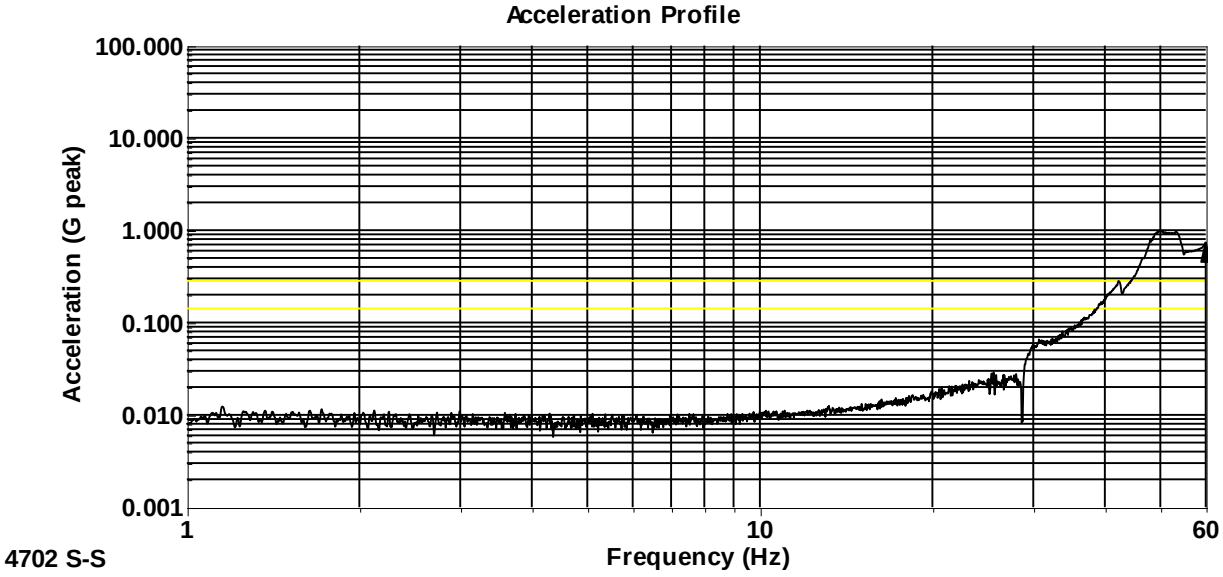
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 1 Front-Back Survey Oct 28, 2013 15:59:51
4702 Front to Back response versus Control
Amplification is the fixture resonance at 49Hz.



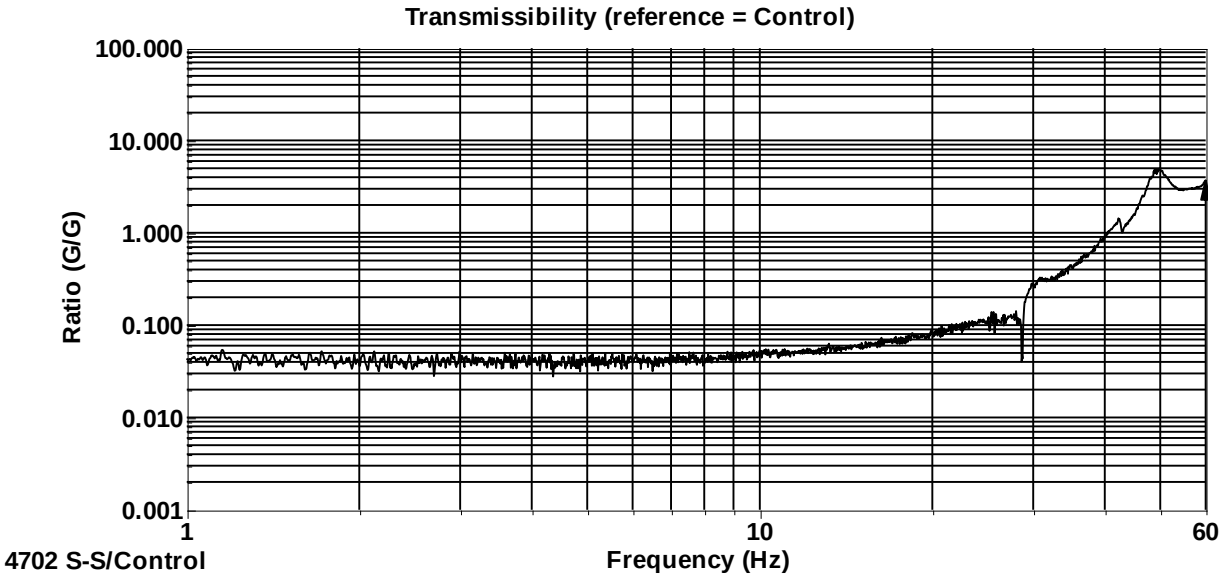
Front to Back Axis
Vertical Response on 4702 unit



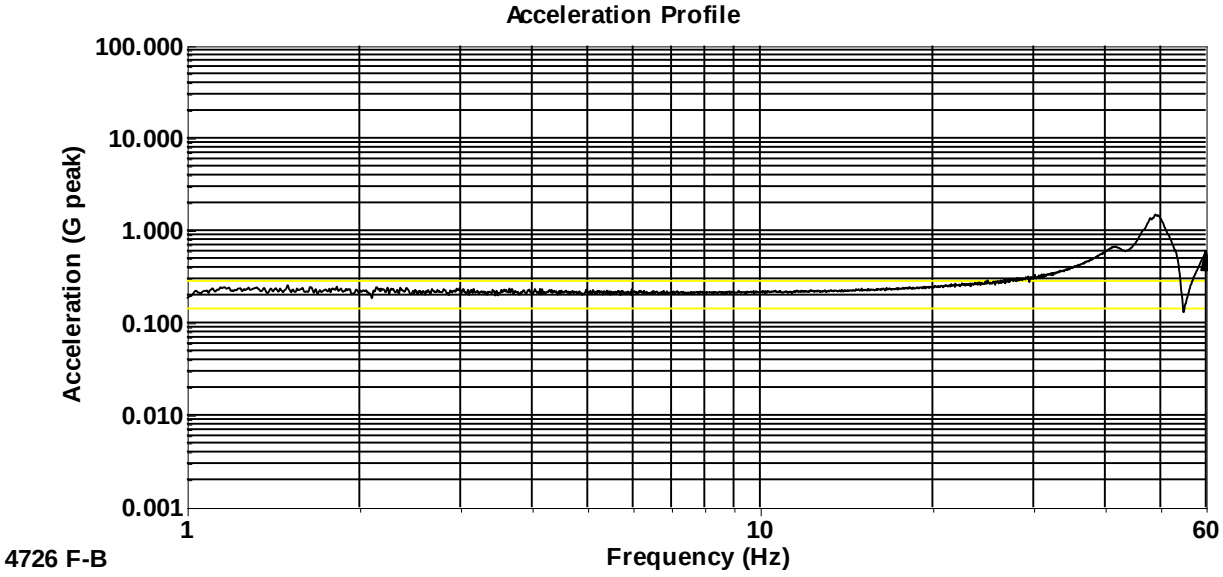
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 1 Front-Back Survey Oct 28, 2013 15:59:51
4702 Vertical response versus Control
Amplification is the fixture resonance at 49Hz.



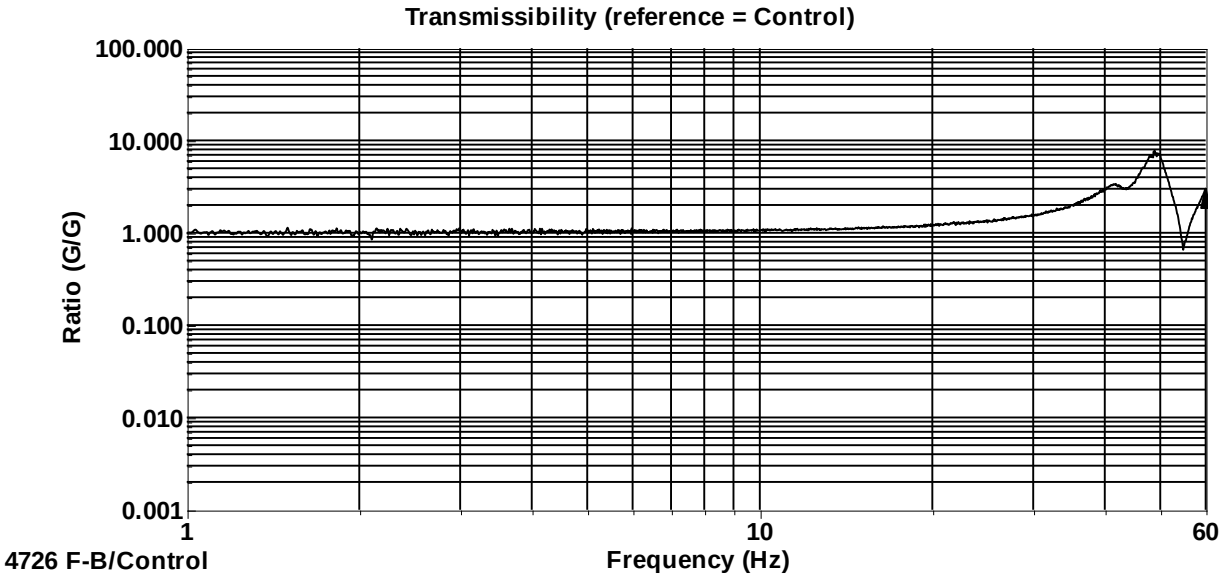
Front to Back Axis
Side to Side Response on 4702 unit



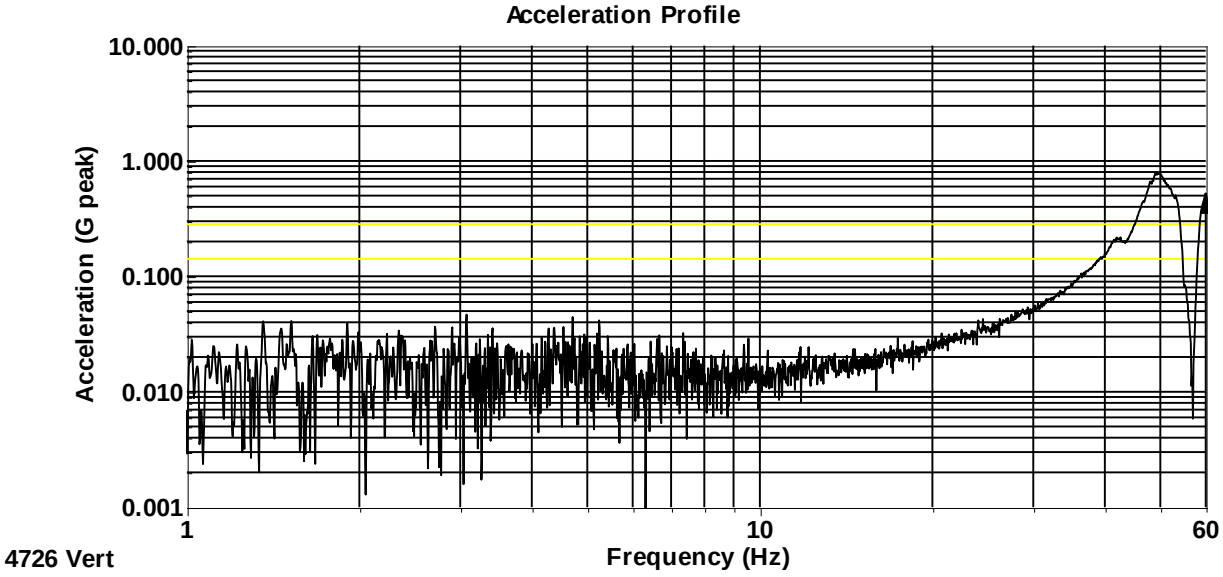
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 1 Front-Back Survey Oct 28, 2013 15:59:51
4702 Side to Side response versus Control
Amplification is the fixture resonance at 49Hz.



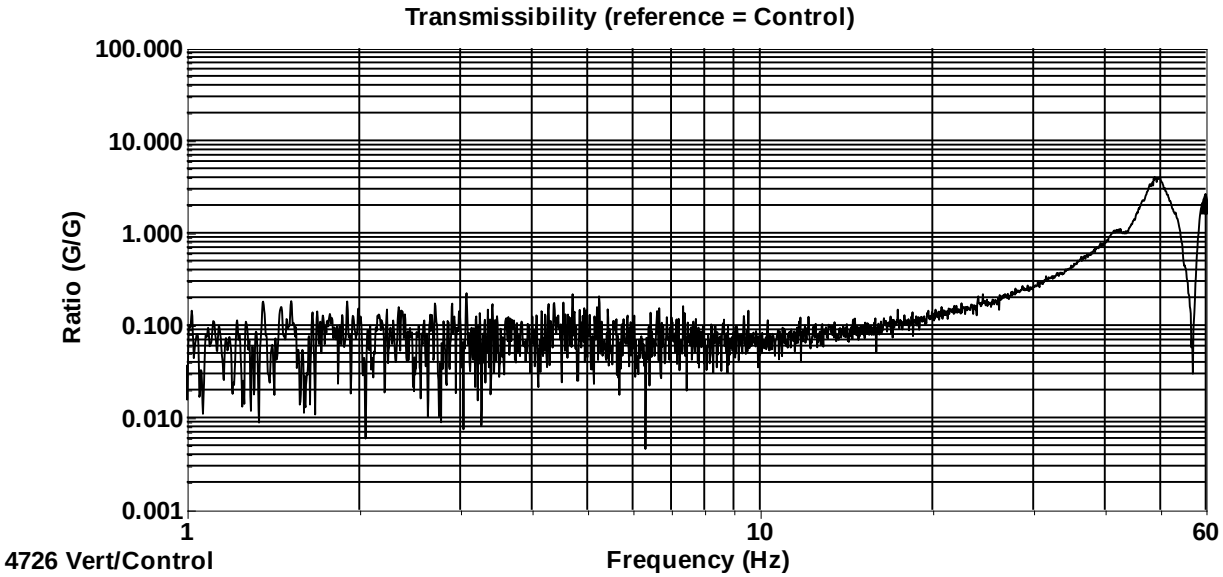
Front to Back Axis
Front to Back Response on 4726 unit



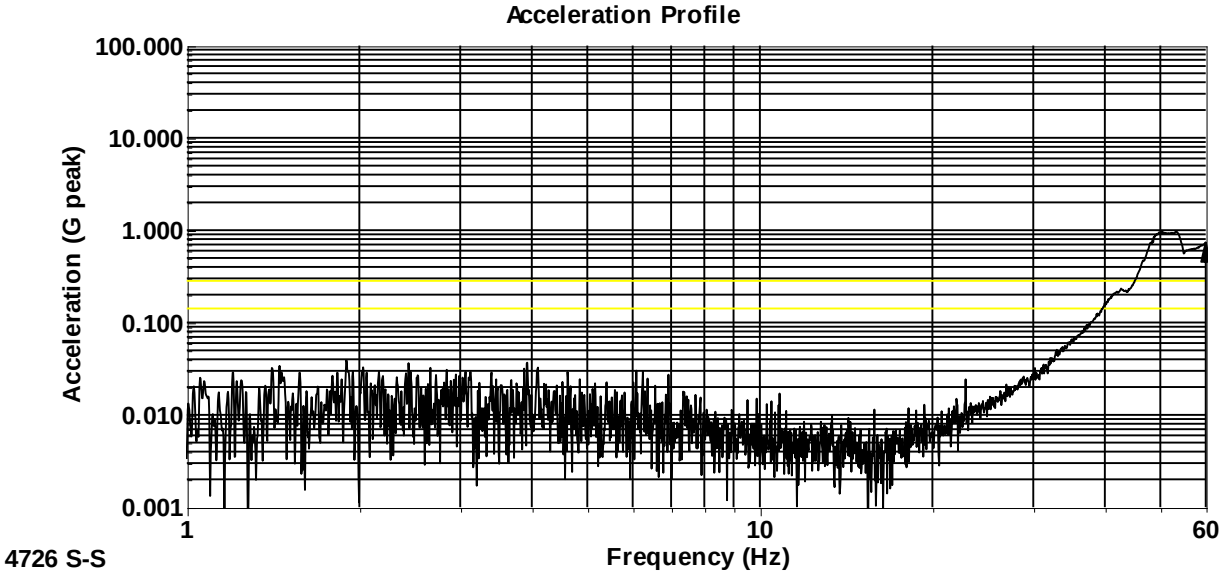
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 1 Front-Back Survey Oct 28, 2013 15:59:51
4726 Front to Back response versus Control
Amplification is the fixture resonance at 49Hz.



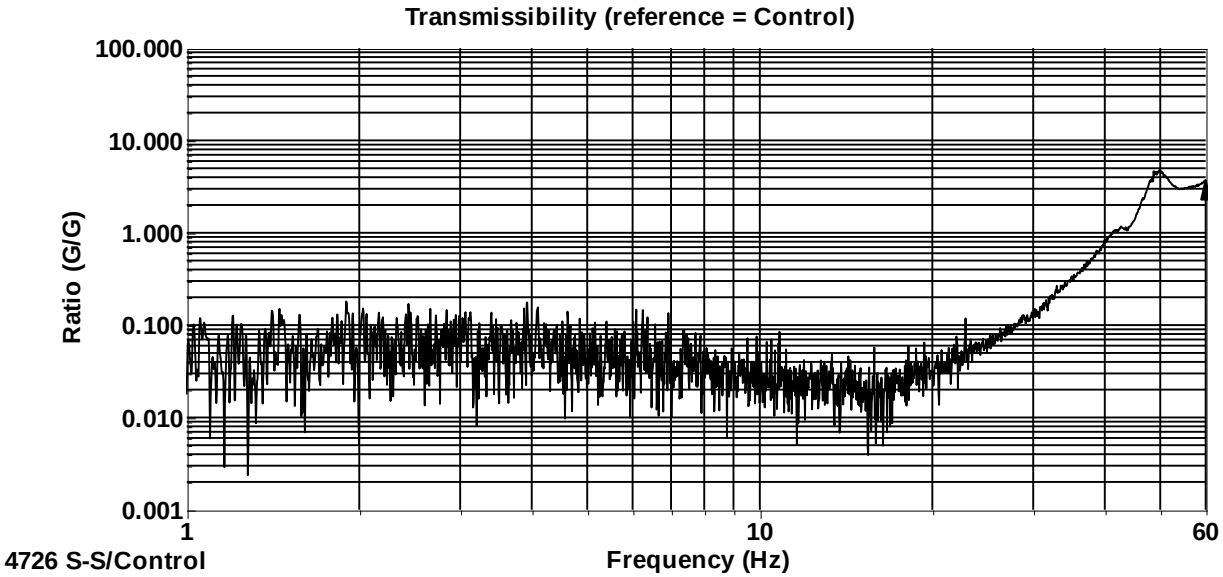
Front to Back Axis
Vertical Response on 4726 unit



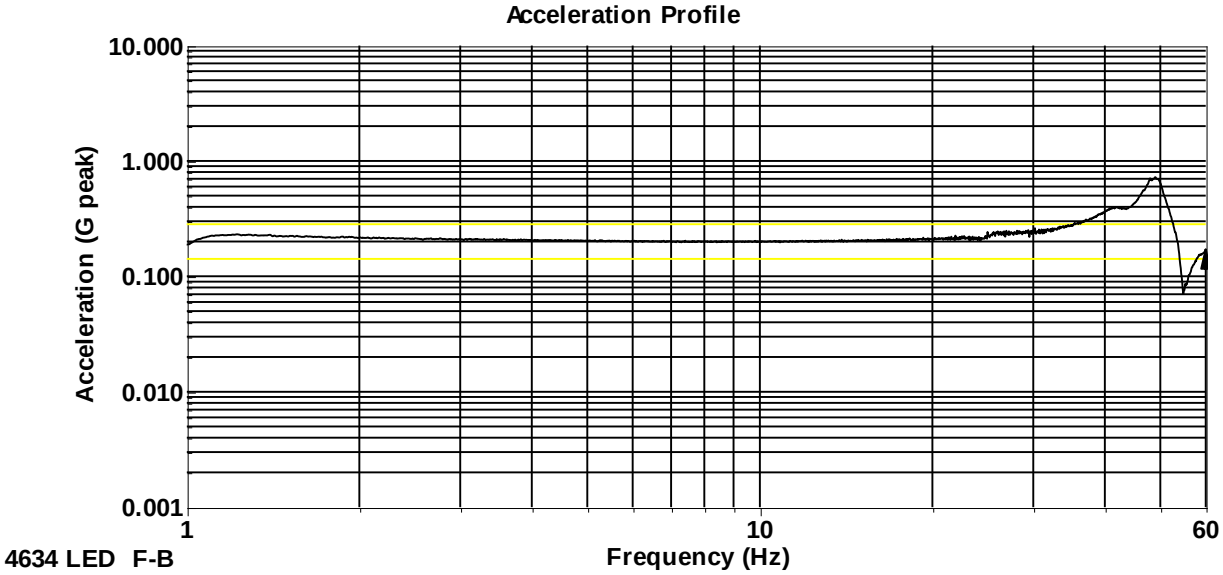
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 1 Front-Back Survey Oct 28, 2013 15:59:51
4726 Vertical response versus Control
Amplification is the fixture resonance at 49Hz.



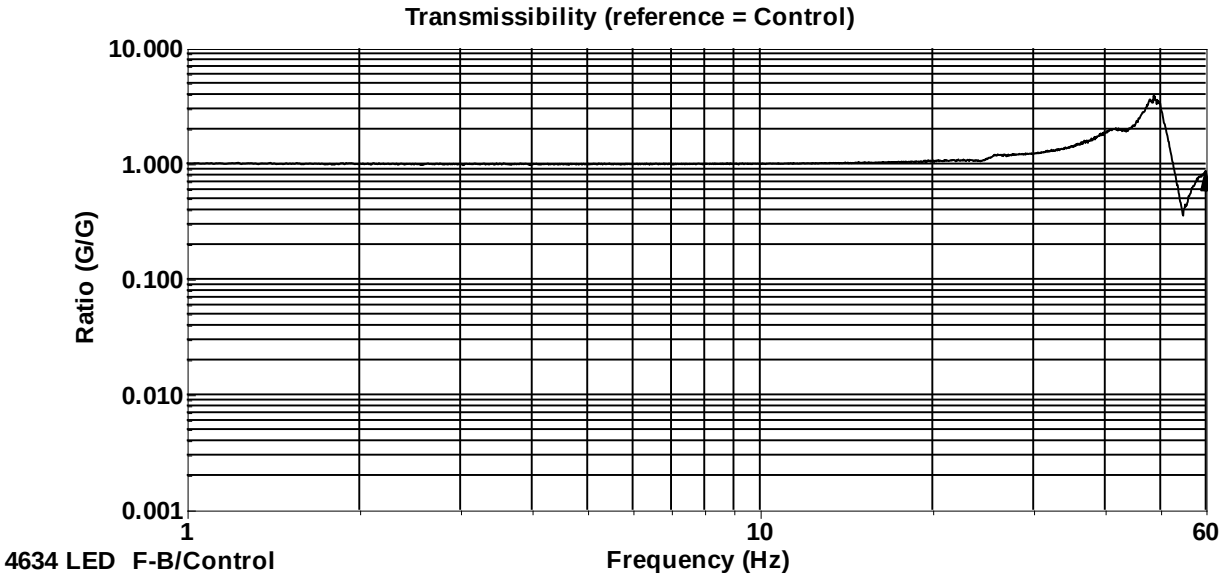
Front to Back Axis
Side to Side Response on 4726 unit



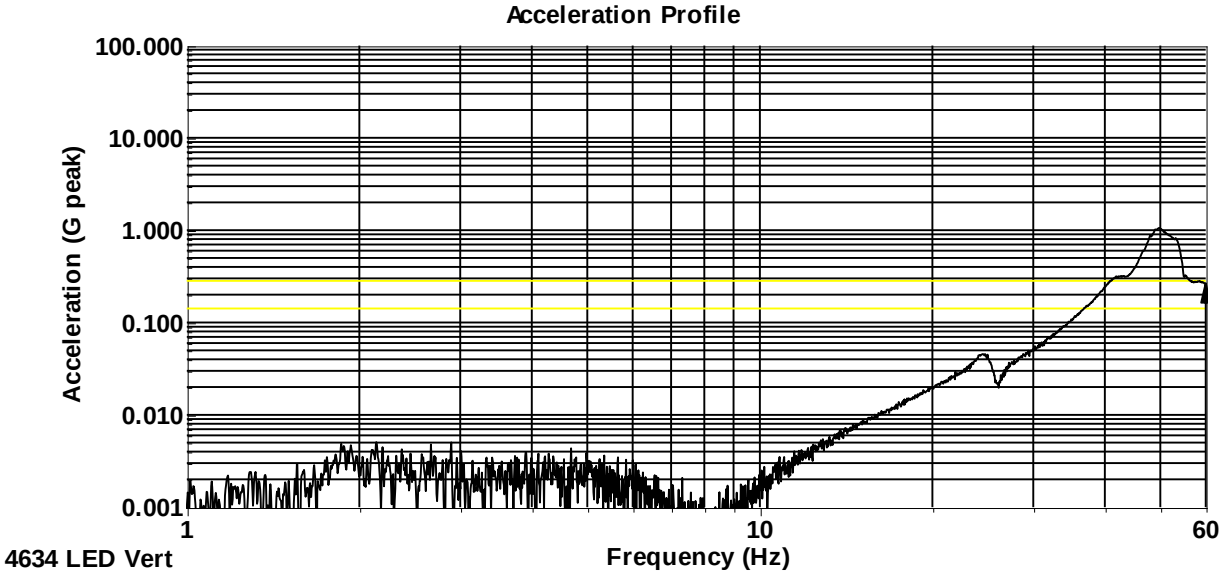
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 1 Front-Back Survey Oct 28, 2013 15:59:51
4726 Side to Side response versus Control
Amplification is the fixture resonance at 49Hz.



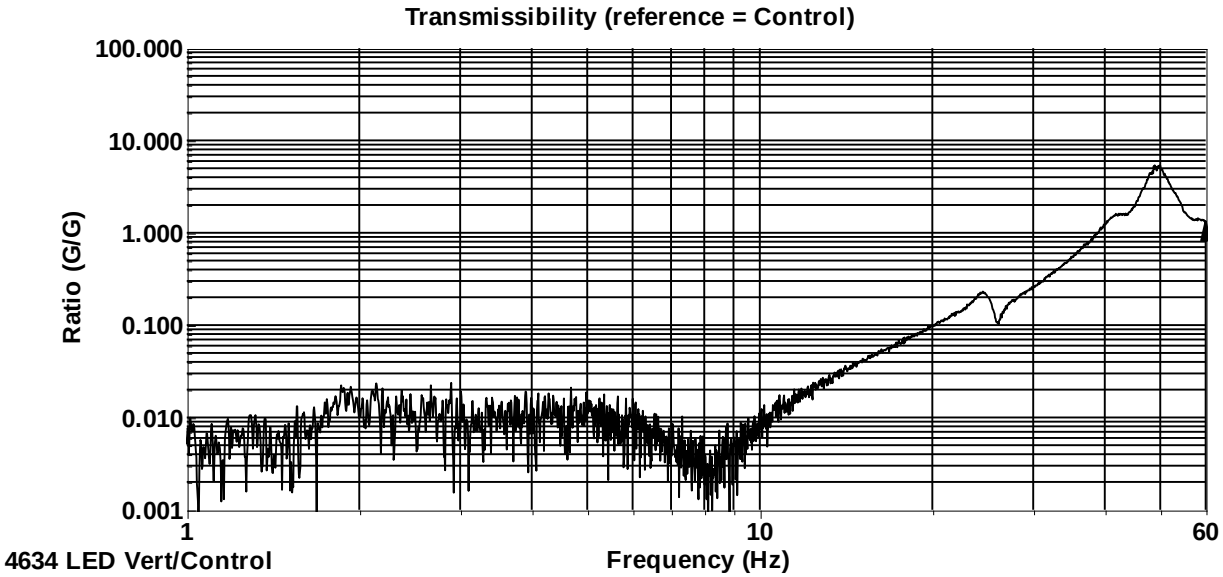
Front to Back Axis
Front to Back Response on 4634 LED unit



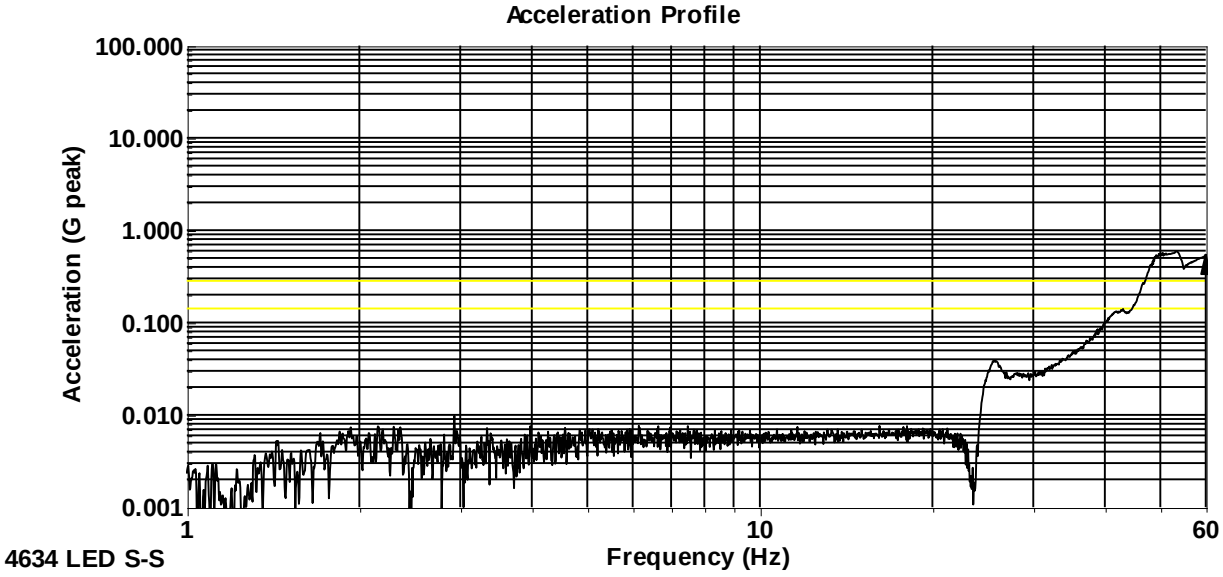
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 1 Front-Back Survey Oct 28, 2013 15:59:51
4634 LED Front to Back response versus Control
Amplification is the fixture resonance at 49Hz.



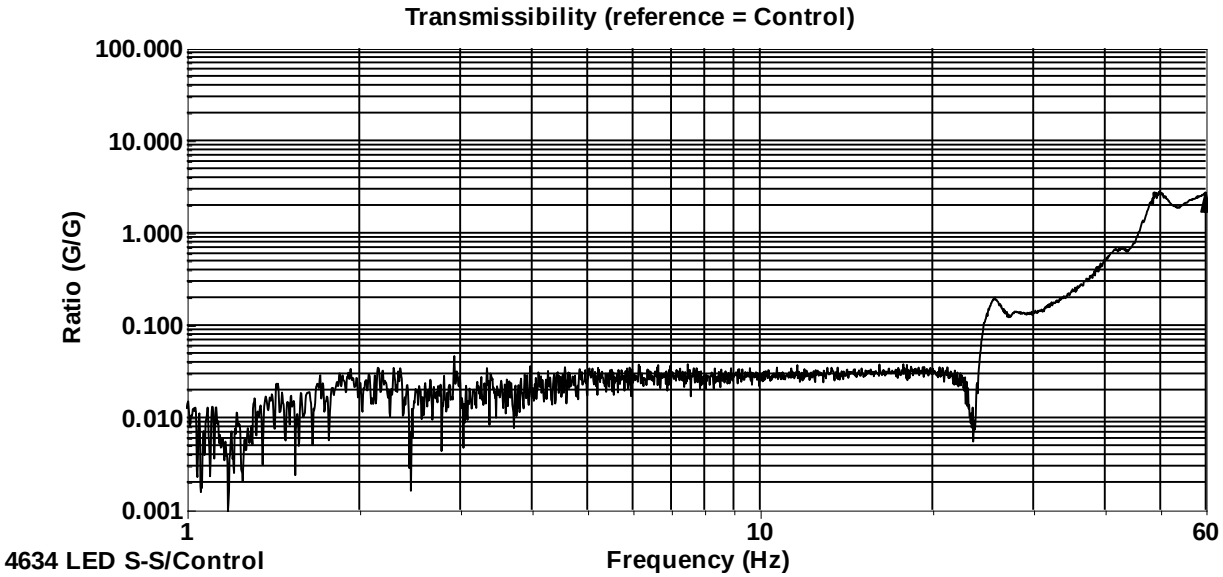
Front to Back Axis
Vertical Response on 4634 LED unit



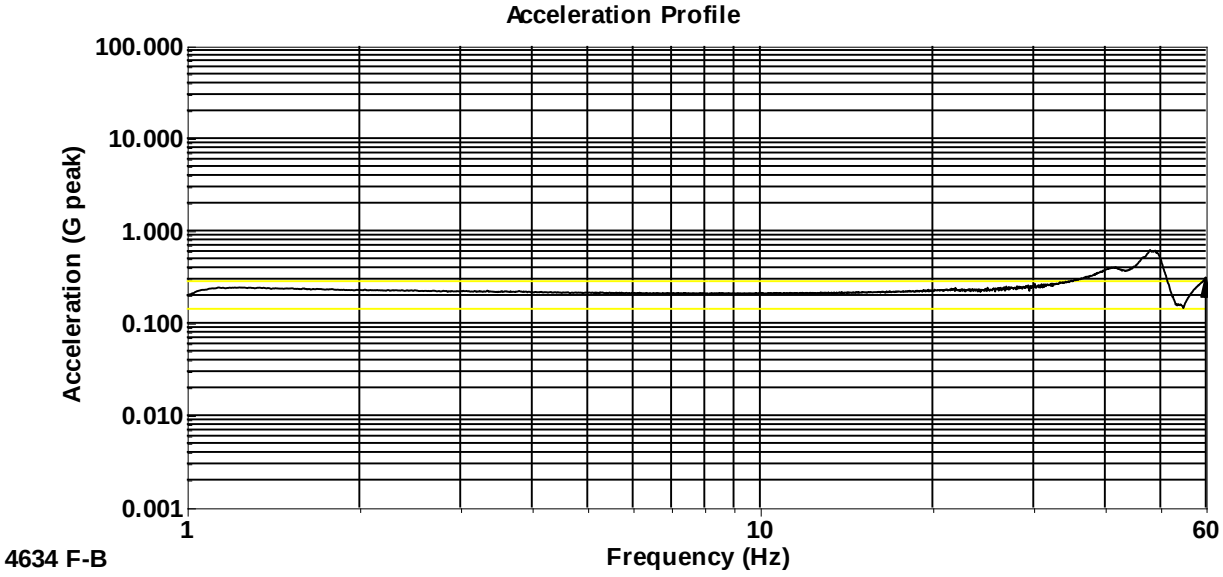
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 1 Front-Back Survey Oct 28, 2013 15:59:51
4634 LED Vertical response versus Control
Amplification is the fixture resonance at 49Hz.



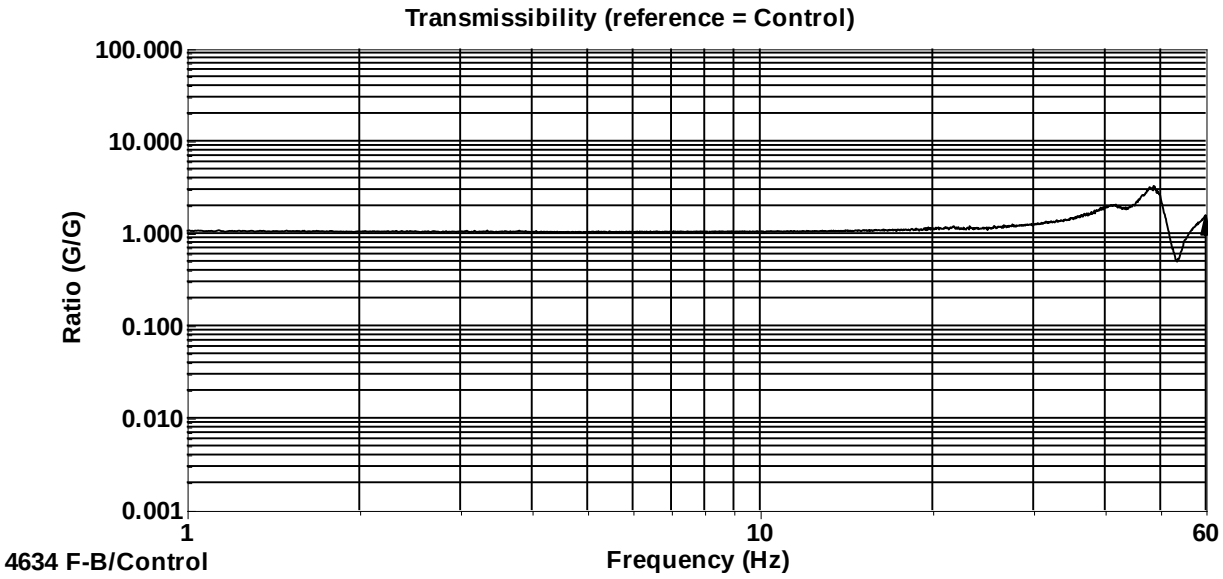
Front to Back Axis
Side to Side Response on 4634 LED unit



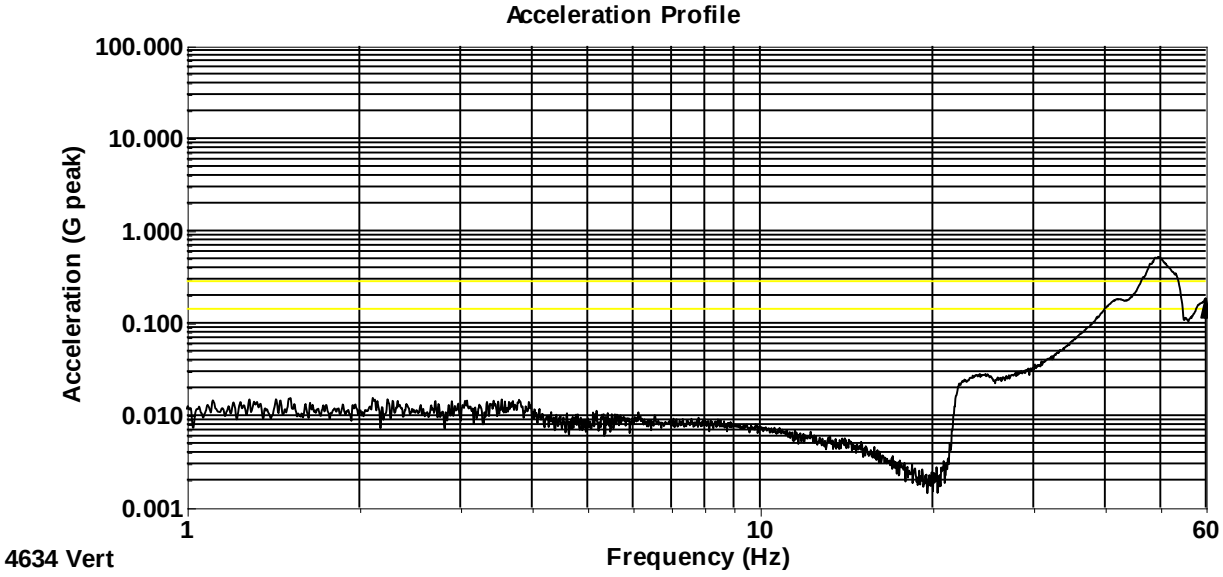
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 1 Front-Back Survey Oct 28, 2013 15:59:51
4634 LED Side to Side response versus Control
Amplification is the fixture resonance at 49Hz.



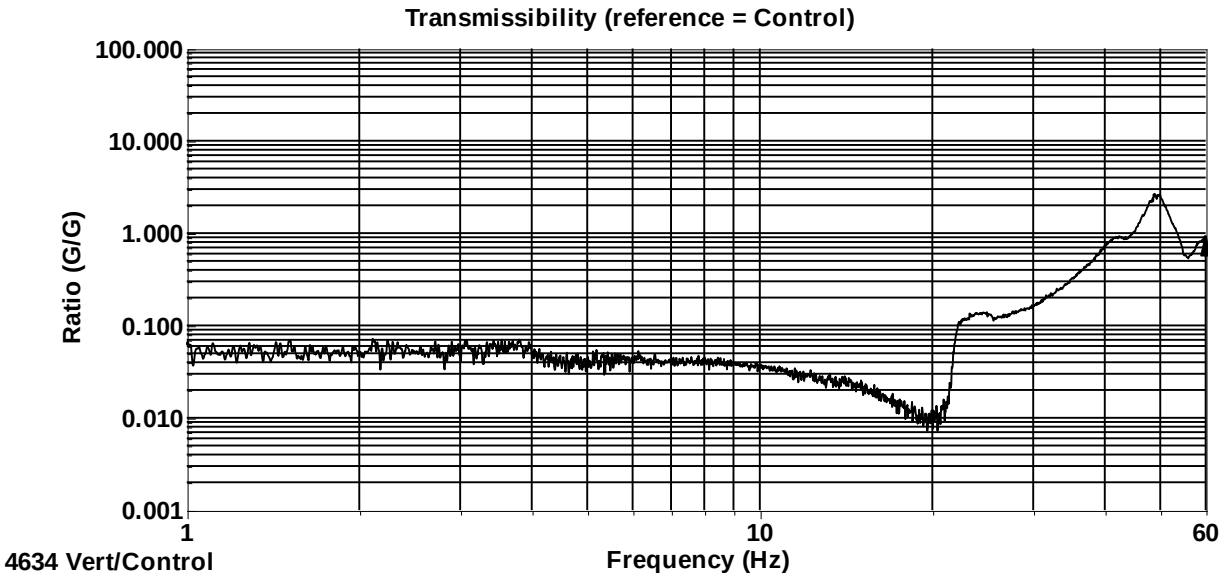
Front to Back Axis
Front to Back Response on 4634 Incandescent unit



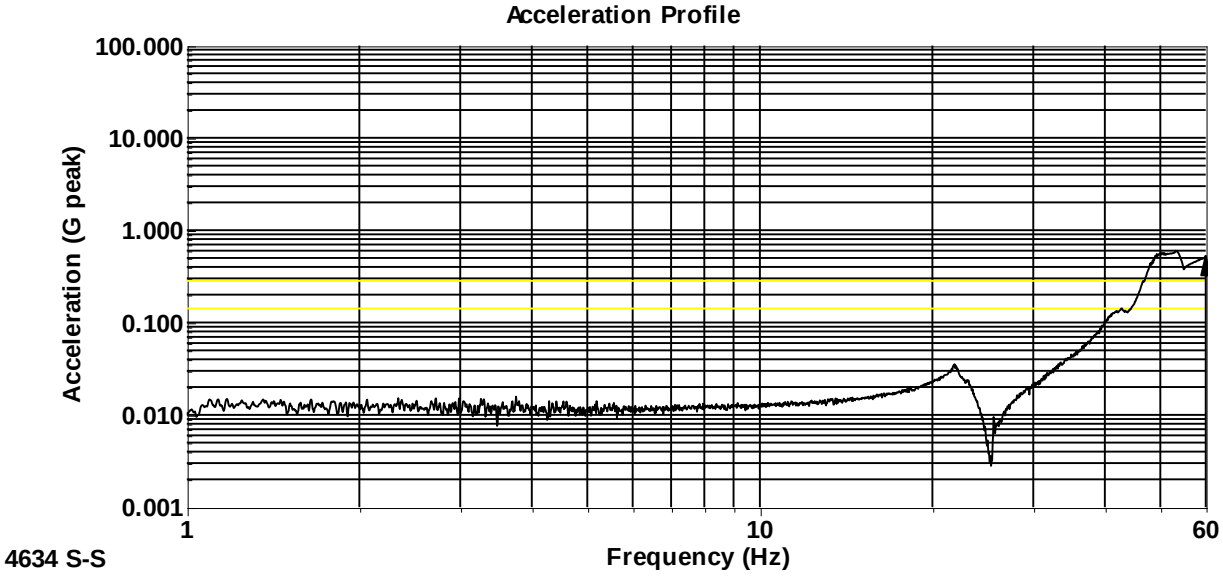
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 1 Front-Back Survey Oct 28, 2013 15:59:51
4634 Incandescent Front to Back response versus Control
Amplification is the fixture resonance at 49Hz.



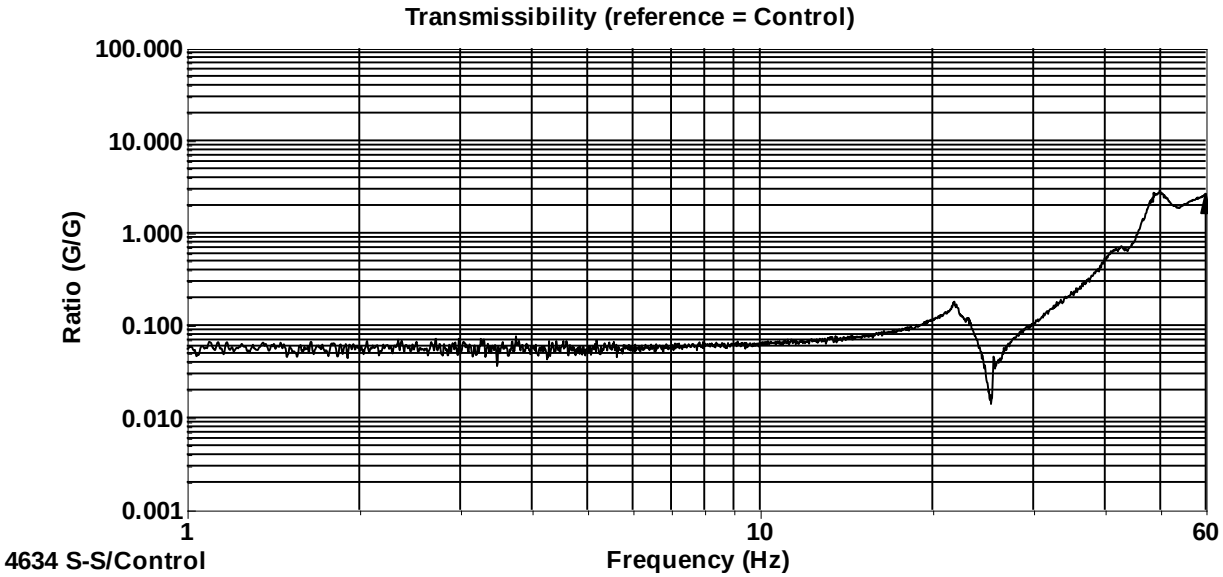
Front to Back Axis
Vertical Response on 4634 Incandescent unit



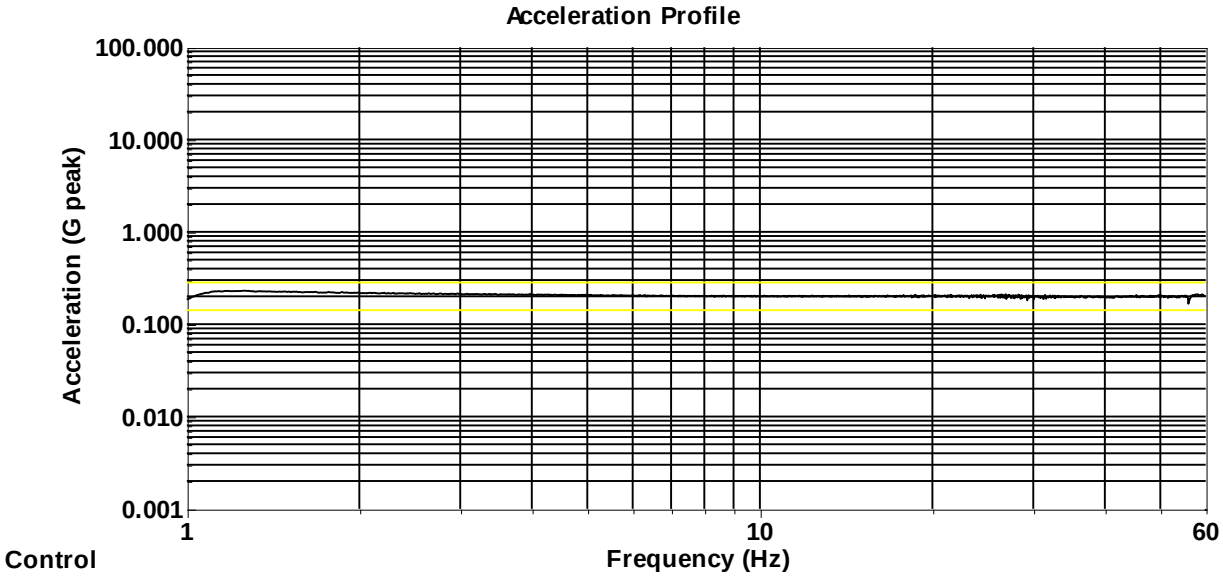
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 1 Front-Back Survey Oct 28, 2013 15:59:51
4634 Incandescent Vertical response versus Control
Amplification is the fixture resonance at 49Hz.



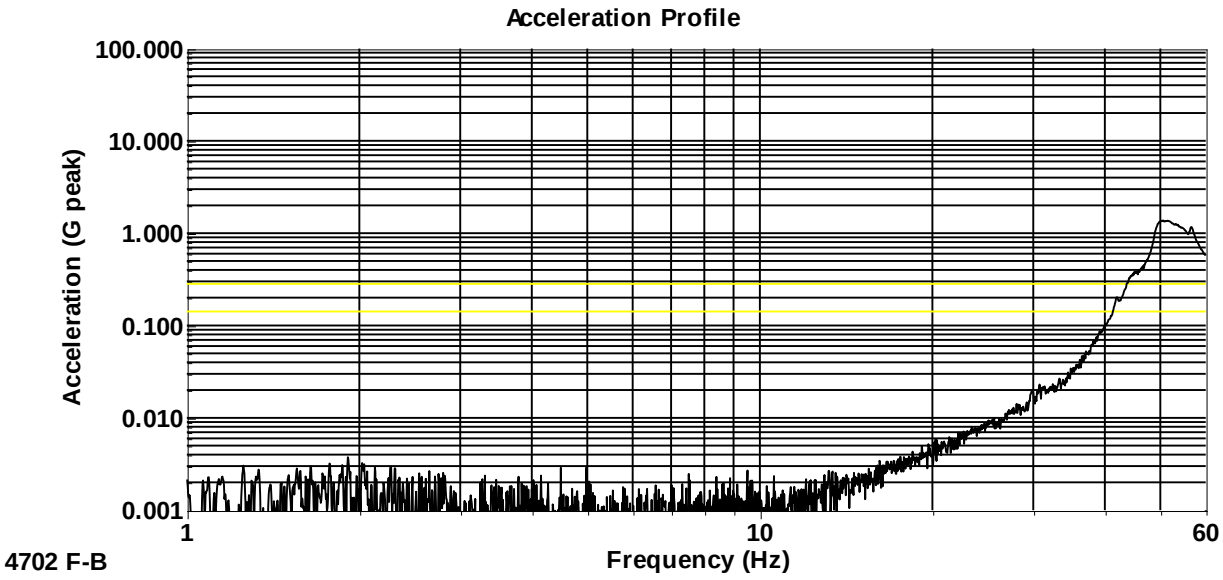
Front to Back Axis
Side to Side Response on 4634 Incandescent unit



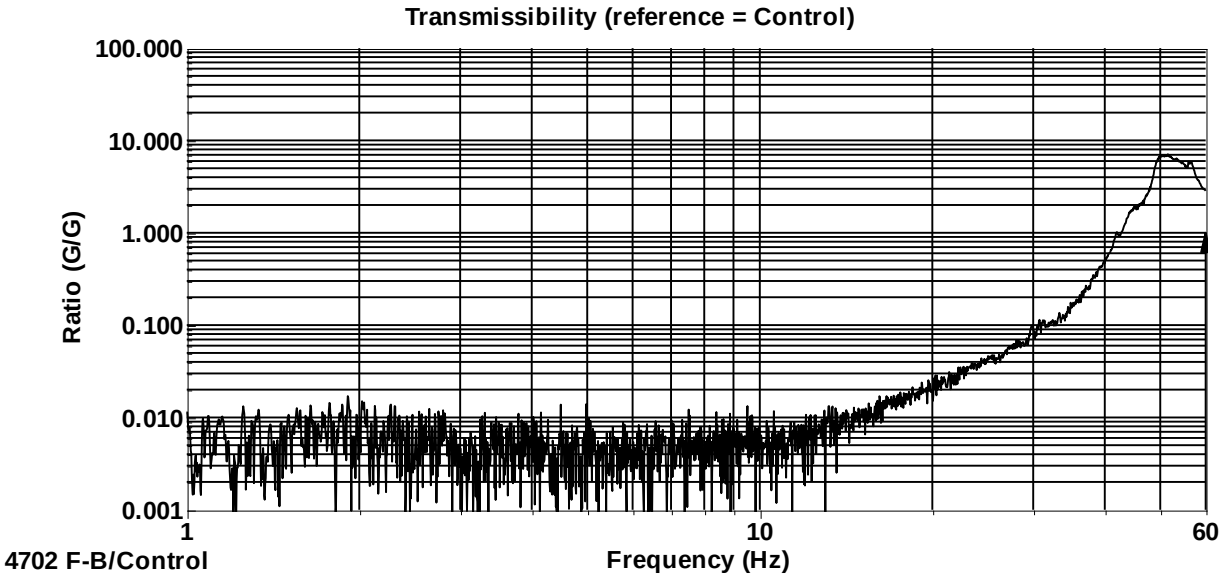
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 1 Front-Back Survey Oct 28, 2013 15:59:51
4634 Incandescent Side to Side response versus Control
Amplification is the fixture resonance at 49Hz.



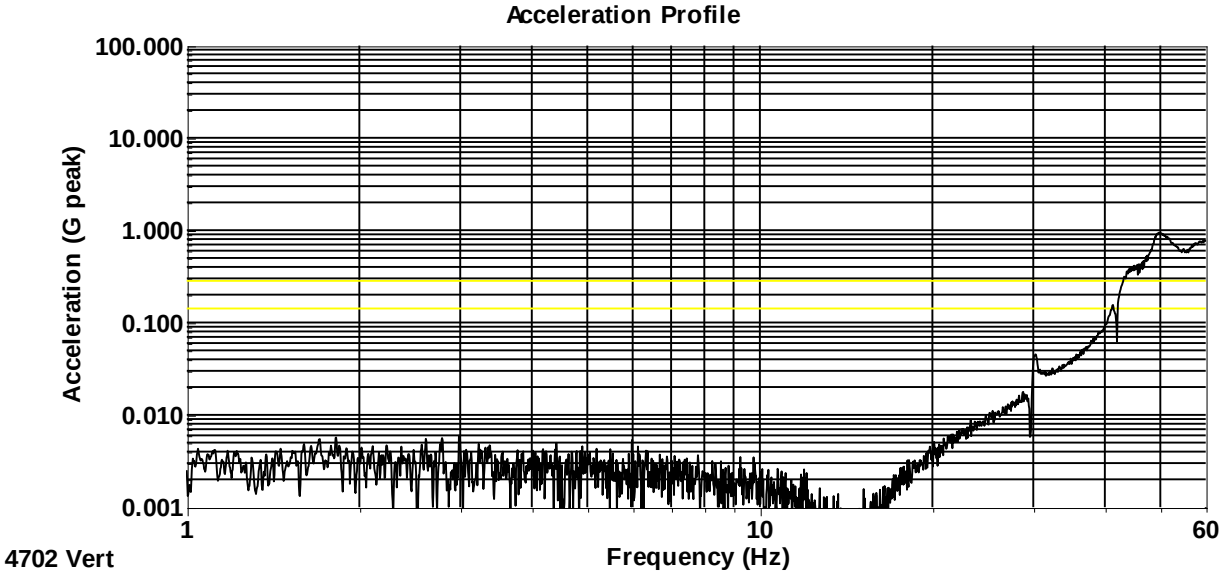
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 2 Side to Side Survey Oct 28, 2013 15:59:51
Control Accelerometer



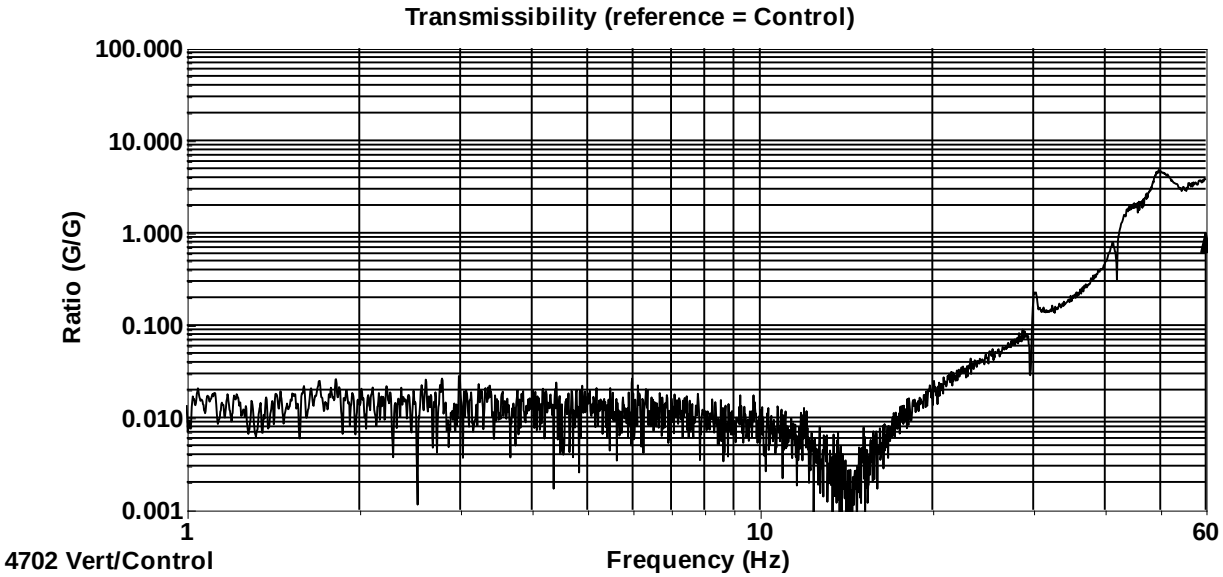
Side to Side Axis
Front to Back Response on 4702 unit



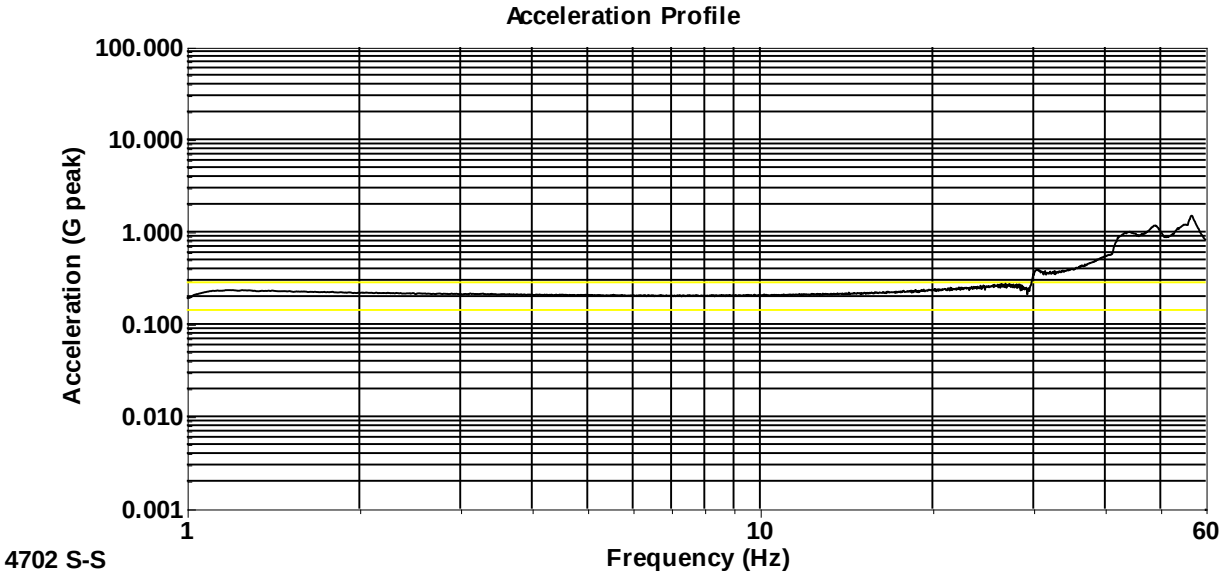
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 2 Side to Side Survey Oct 28, 2013 15:59:51
4702 Front to Back response versus Control
Amplification is the fixture resonance at 56Hz.



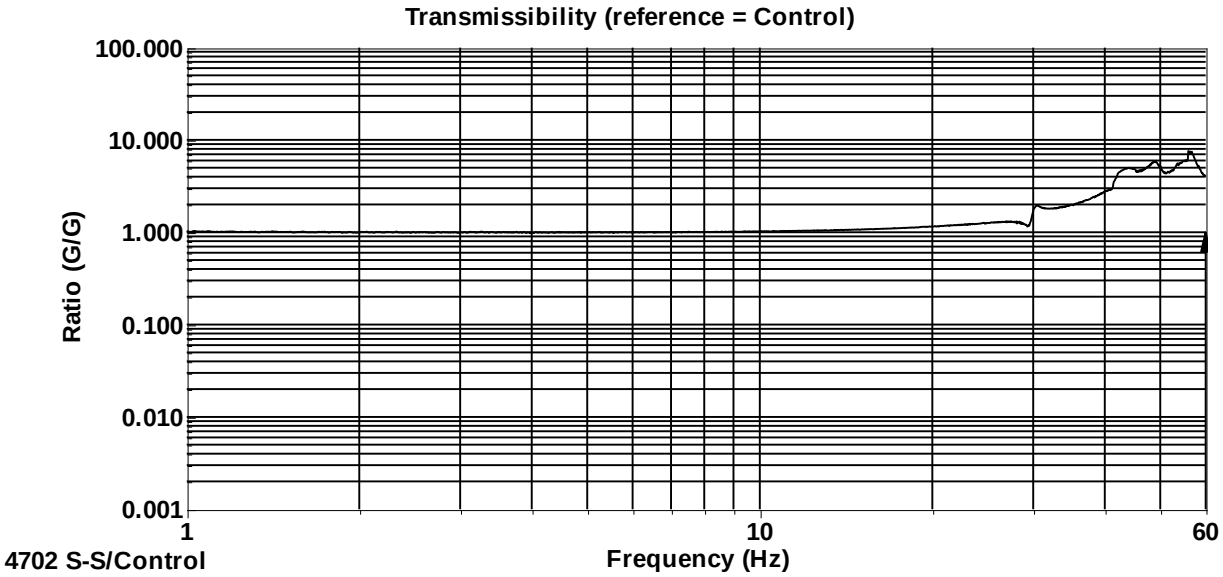
Side to Side Axis
Vertical Response on 4702 unit



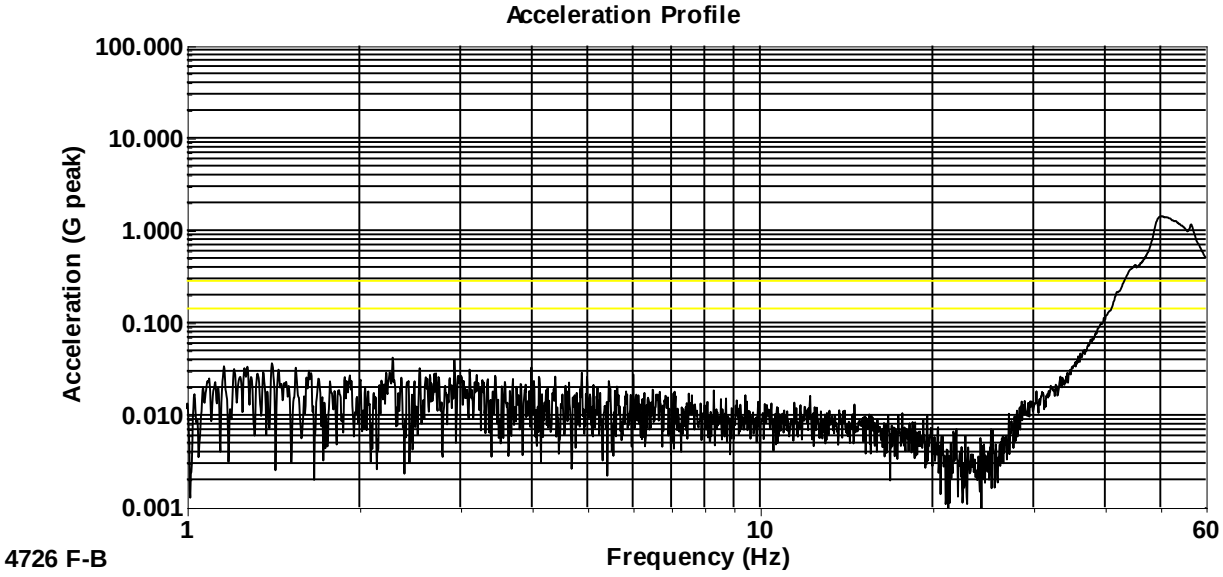
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 2 Side to Side Survey Oct 28, 2013 15:59:51
4702 Vertical response versus Control
Amplification is the fixture resonance at 56Hz.



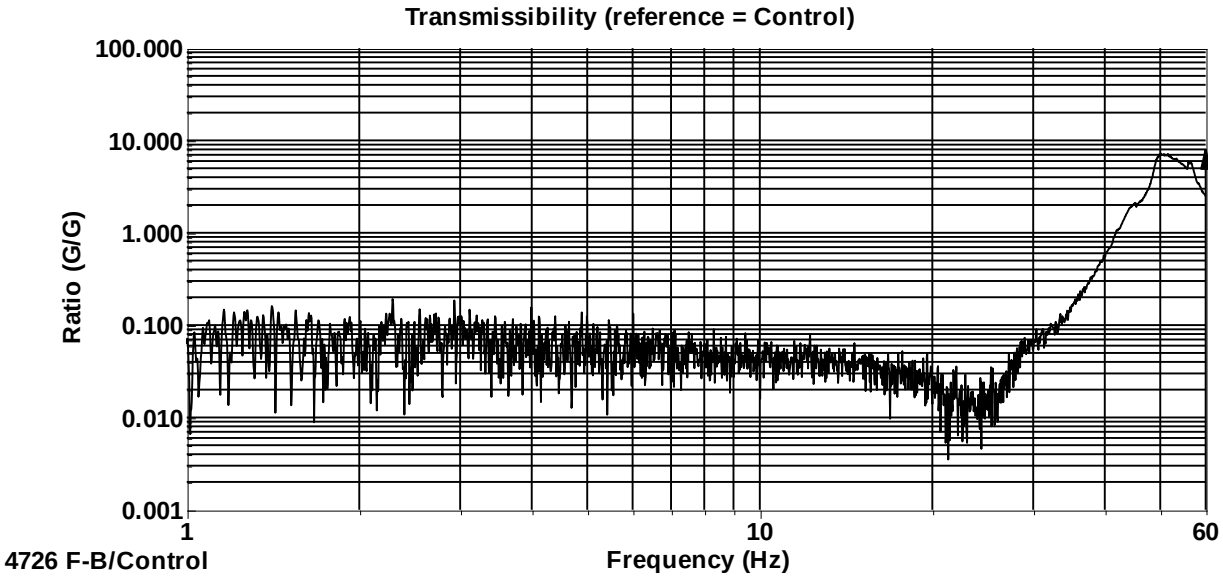
Side to Side Axis
Side to Side Response on 4702 unit



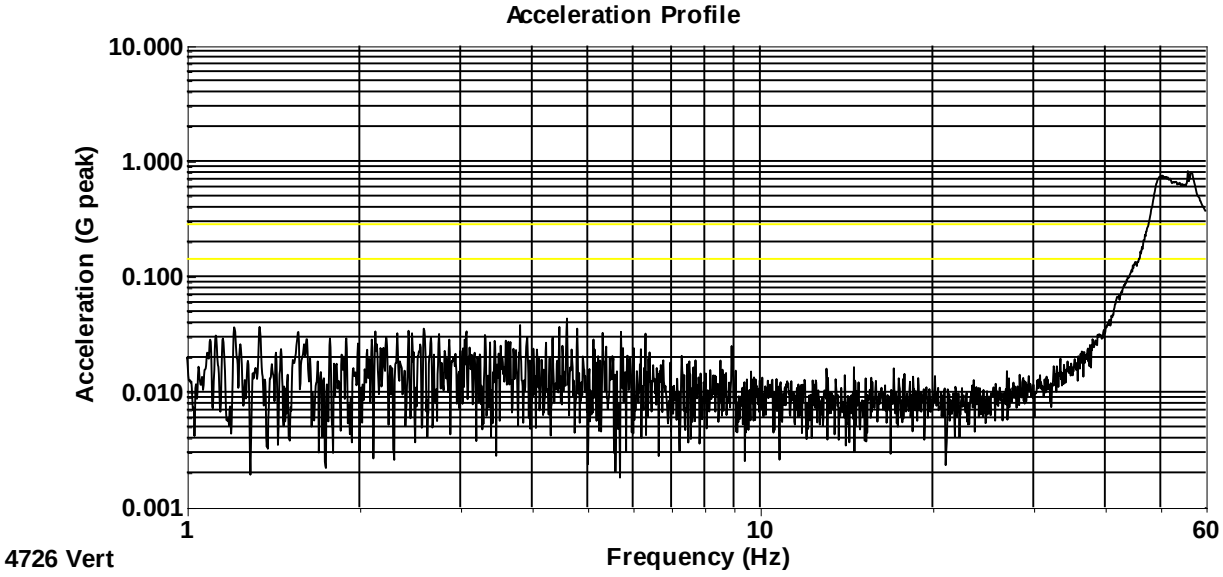
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 2 Side to Side Survey Oct 28, 2013 15:59:51
4702 Side to Side response versus Control
Amplification is the fixture resonance at 56Hz.



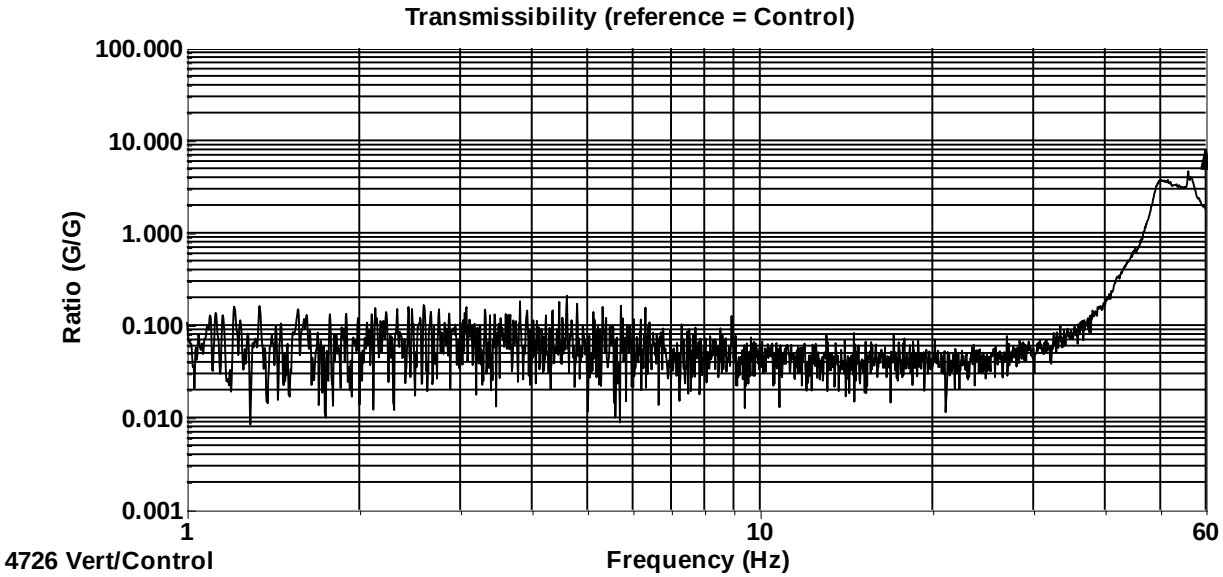
Side to Side Axis
Front to Back Response on 4726 unit



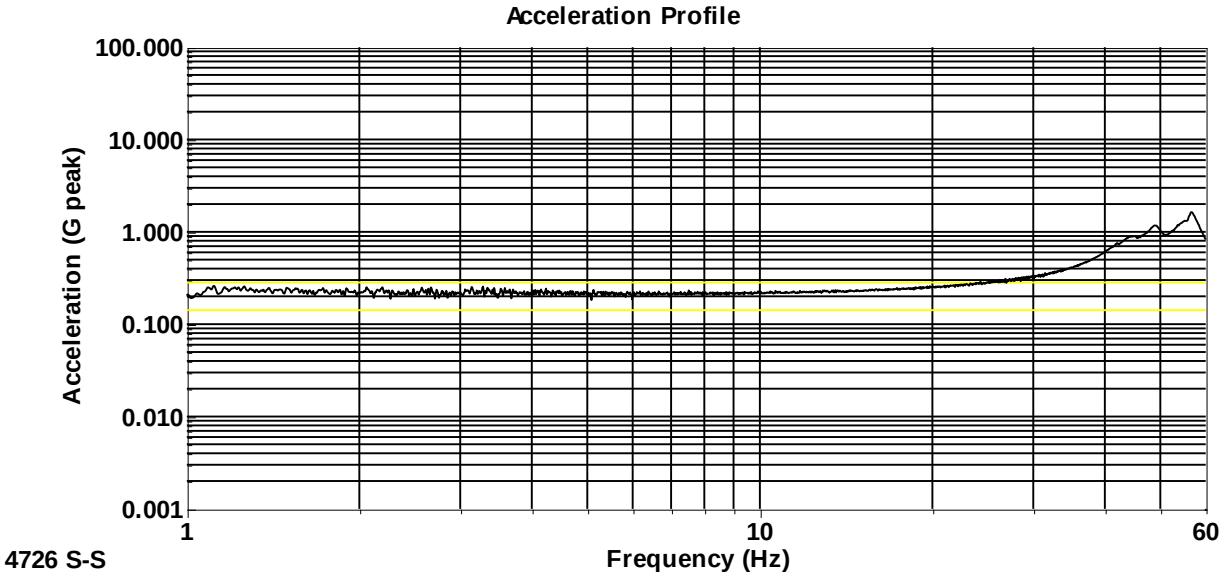
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 2 Side to Side Survey Oct 28, 2013 15:59:51
4726 Front to Back response versus Control
Amplification is the fixture resonance at 56Hz.



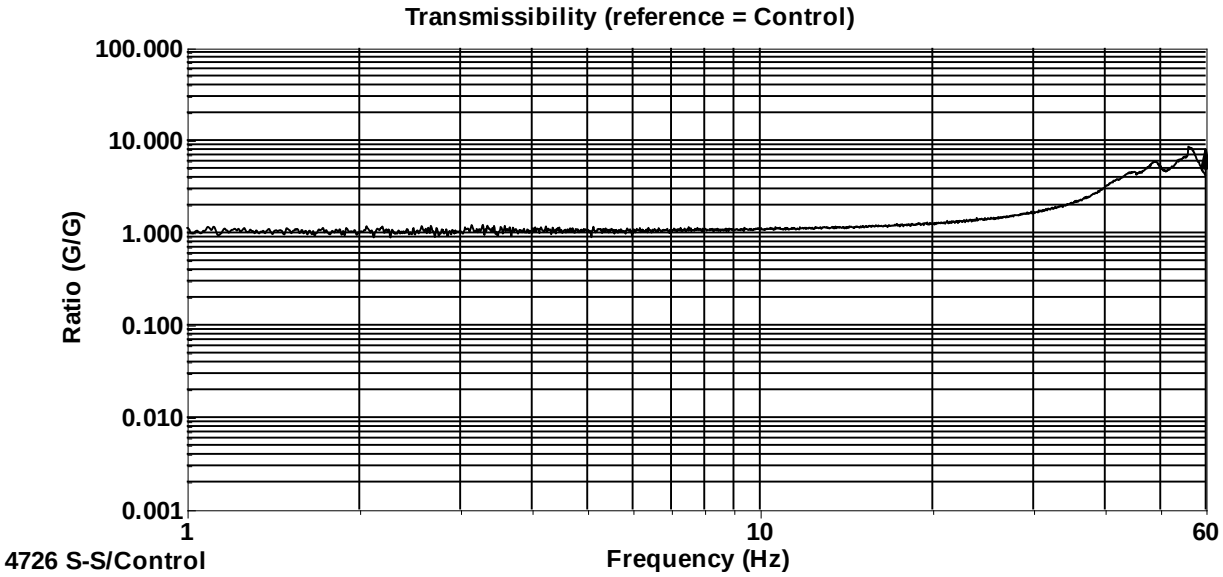
Side to Side Axis
Vertical Response on 4726 unit



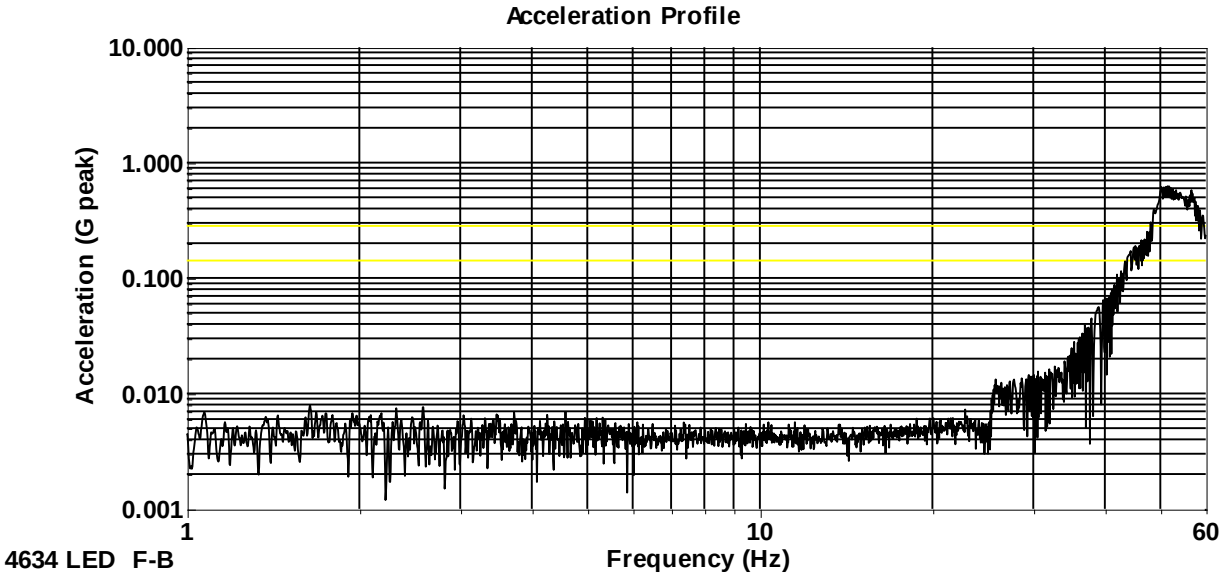
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 2 Side to Side Survey Oct 28, 2013 15:59:51
4726 Vertical response versus Control
Amplification is the fixture resonance at 56Hz.



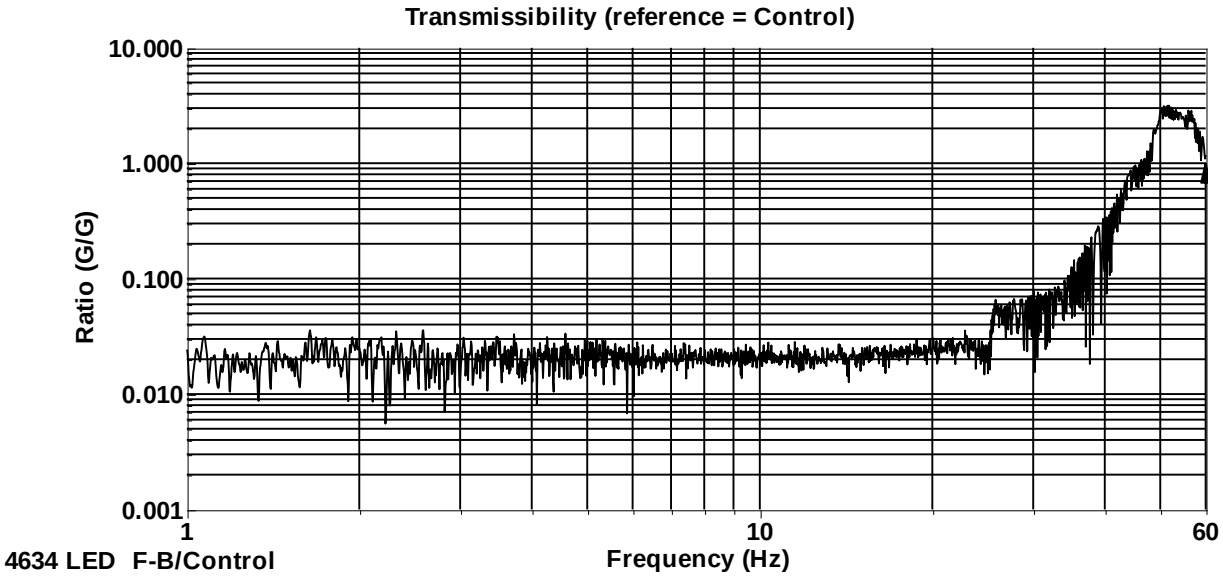
Side to Side Axis
Side to Side Response on 4726 unit



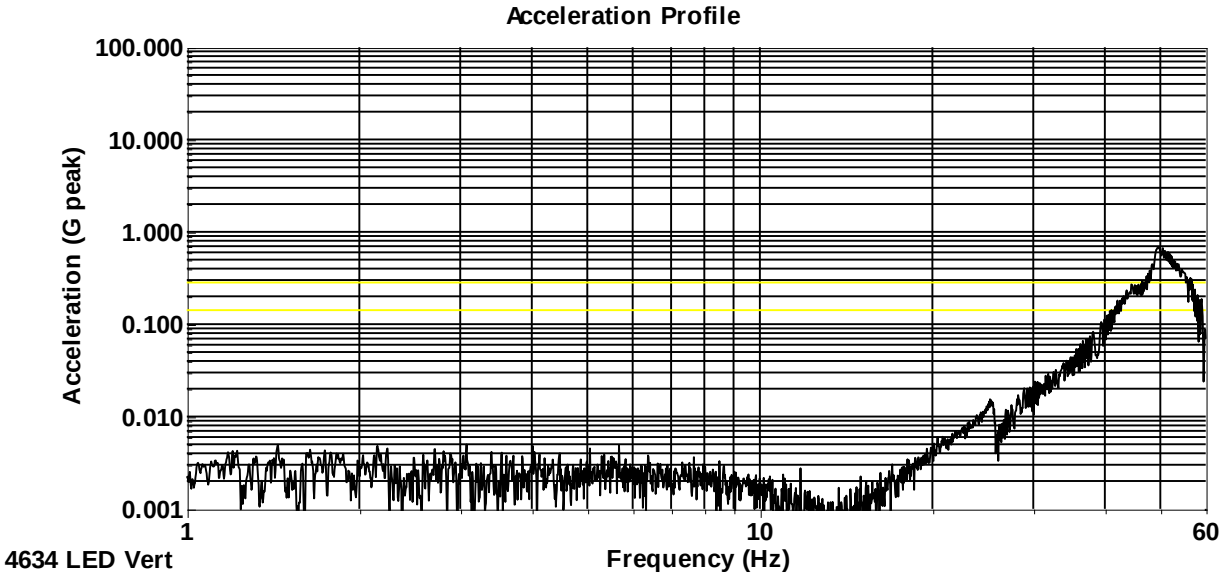
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 2 Side to Side Survey Oct 28, 2013 15:59:51
4726 Side to Side response versus Control
Amplification is the fixture resonance at 56Hz



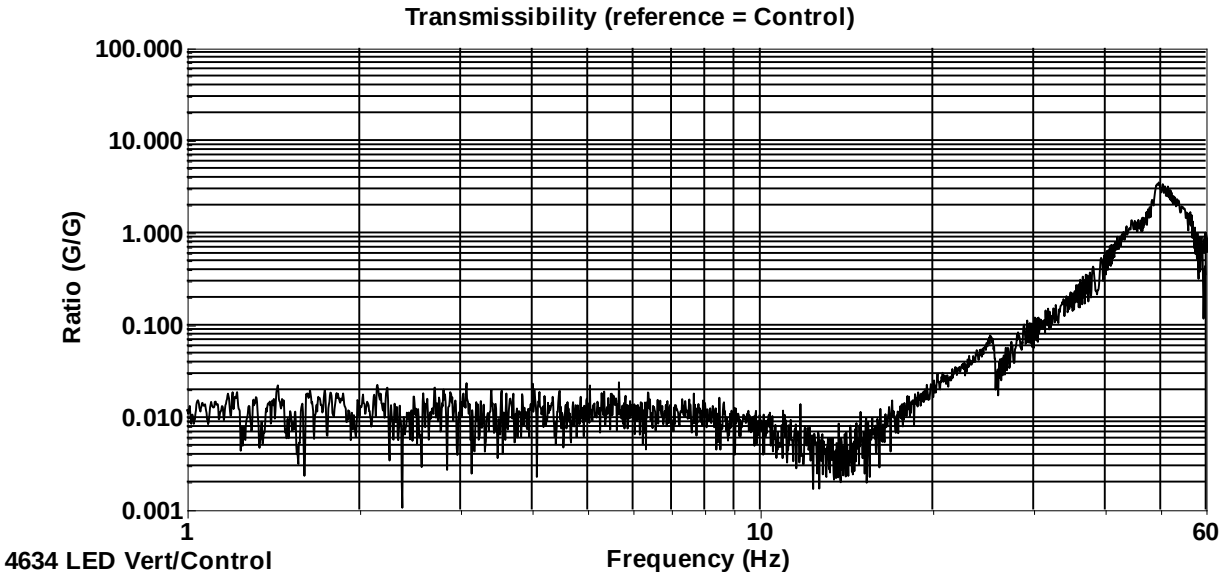
Side to Side Axis
Front to Back Response on 4634 LED unit



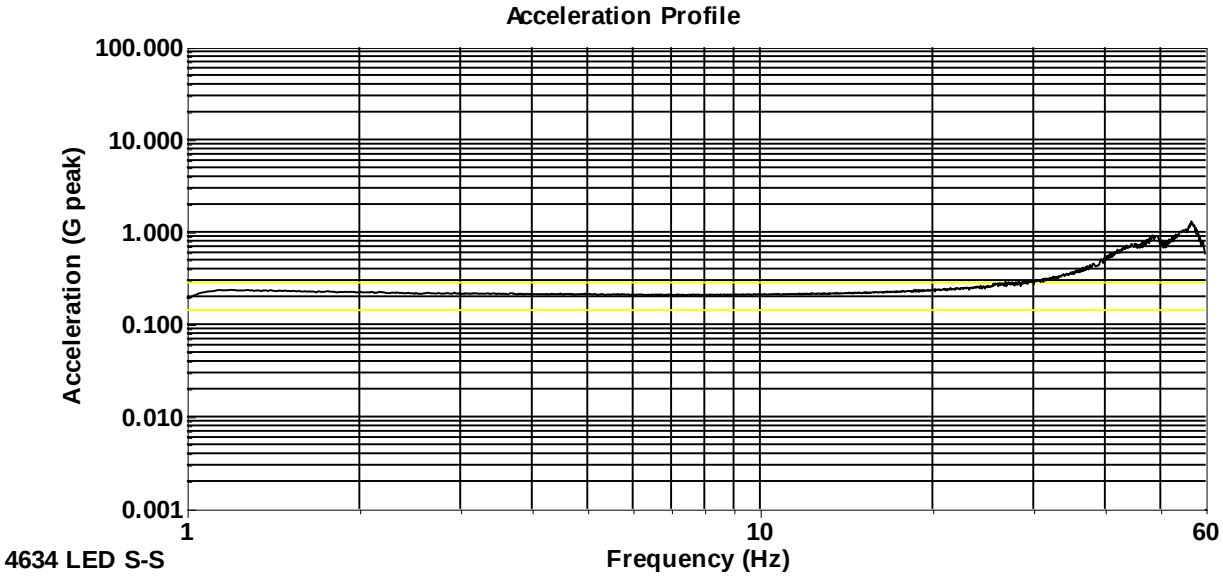
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 2 Side to Side Survey Oct 28, 2013 15:59:51
4634 LED Front to Back response versus Control
Amplification is the fixture resonance at 56Hz



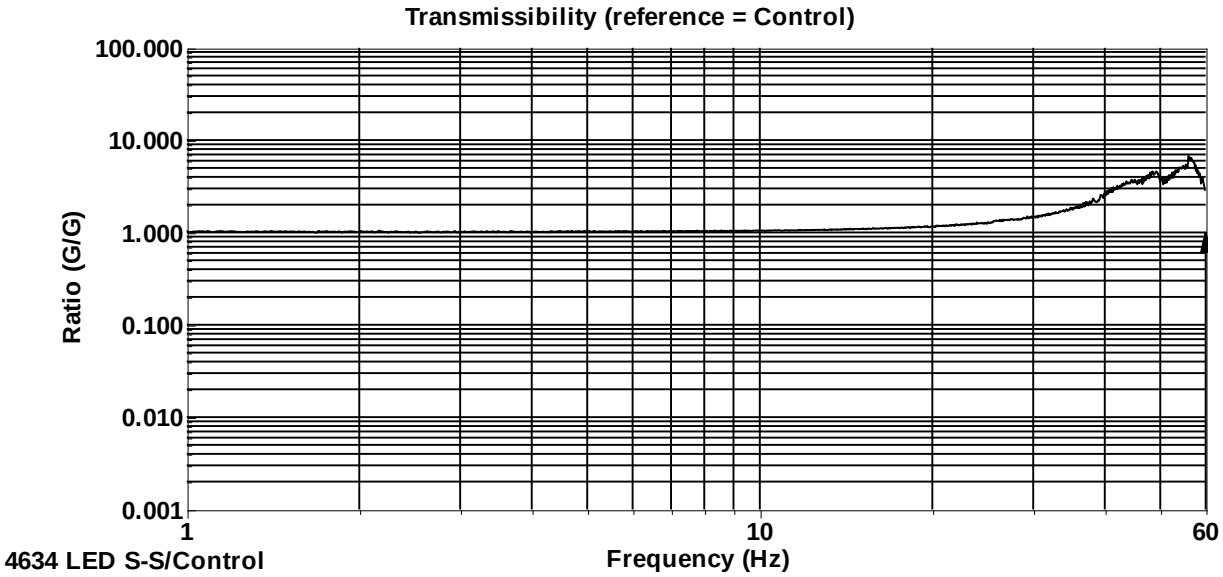
Side to Side Axis
Vertical Response on 4634 LED unit



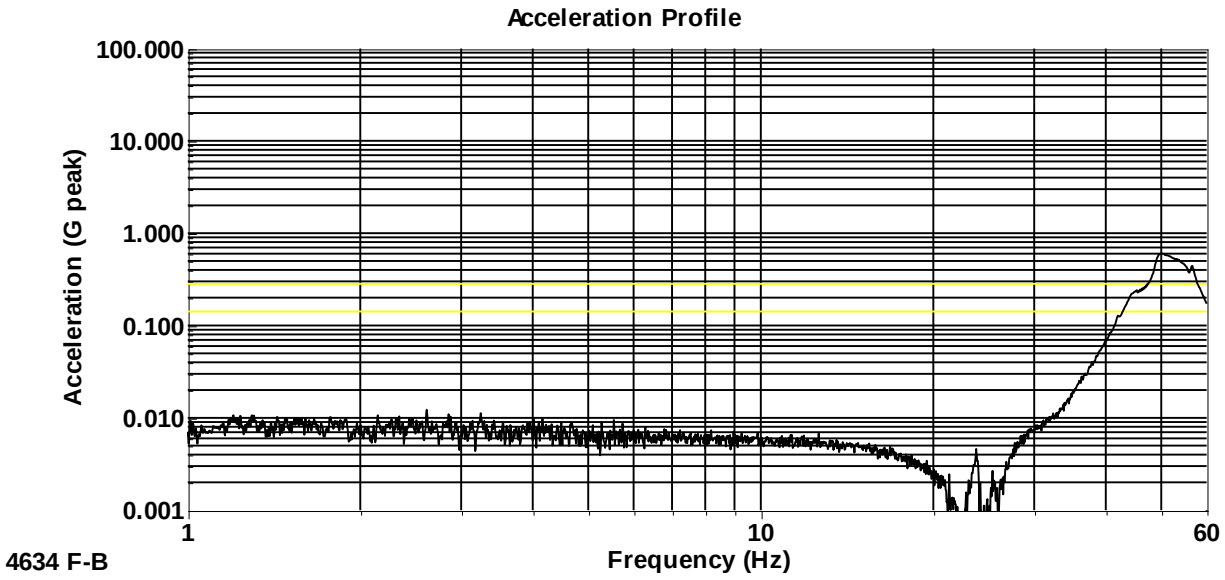
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 2 Side to Side Survey Oct 28, 2013 15:59:51
4634 LED Vertical response versus Control
Amplification is the fixture resonance at 56Hz



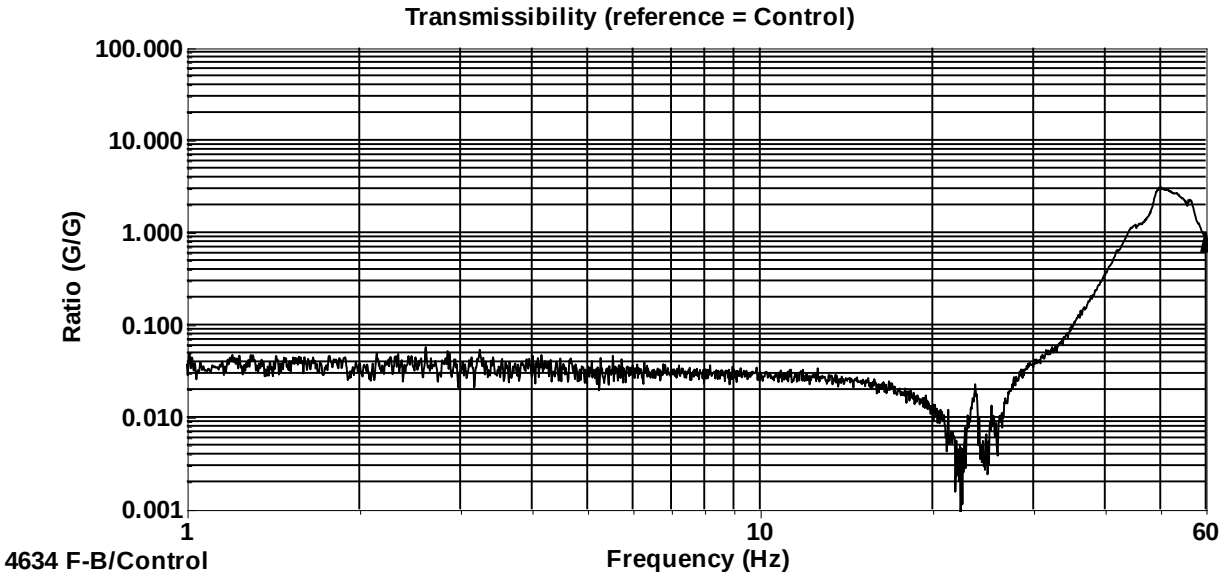
Side to Side Axis
Side to Side Response on 4634 LED unit



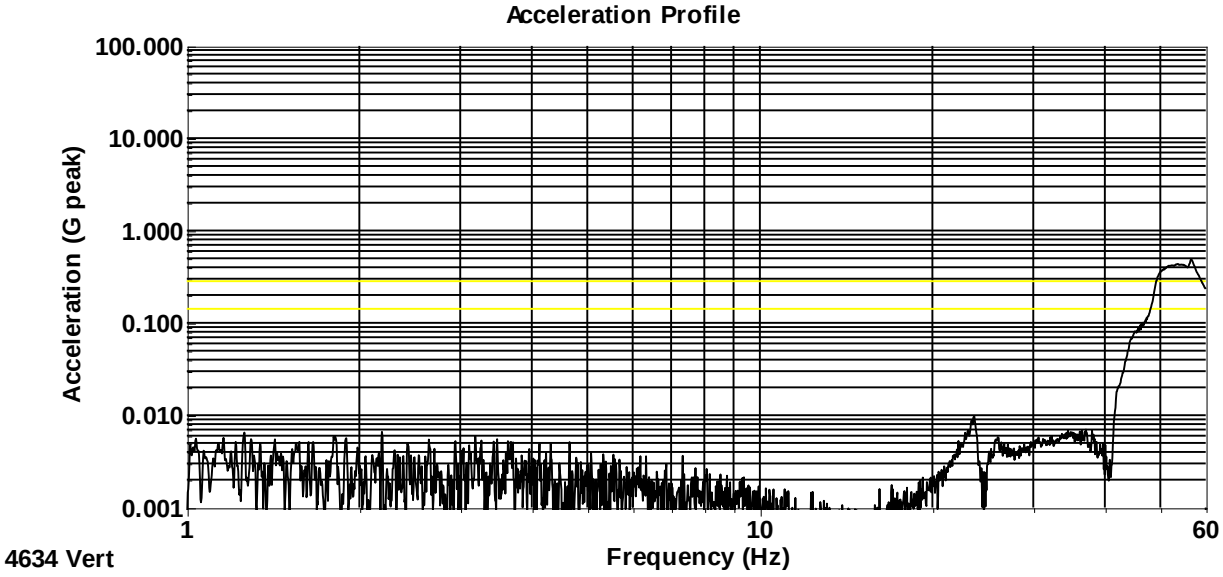
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 2 Side to Side Survey Oct 28, 2013 15:59:51
4634 LED Side to Side response versus Control
Amplification is the fixture resonance at 56Hz



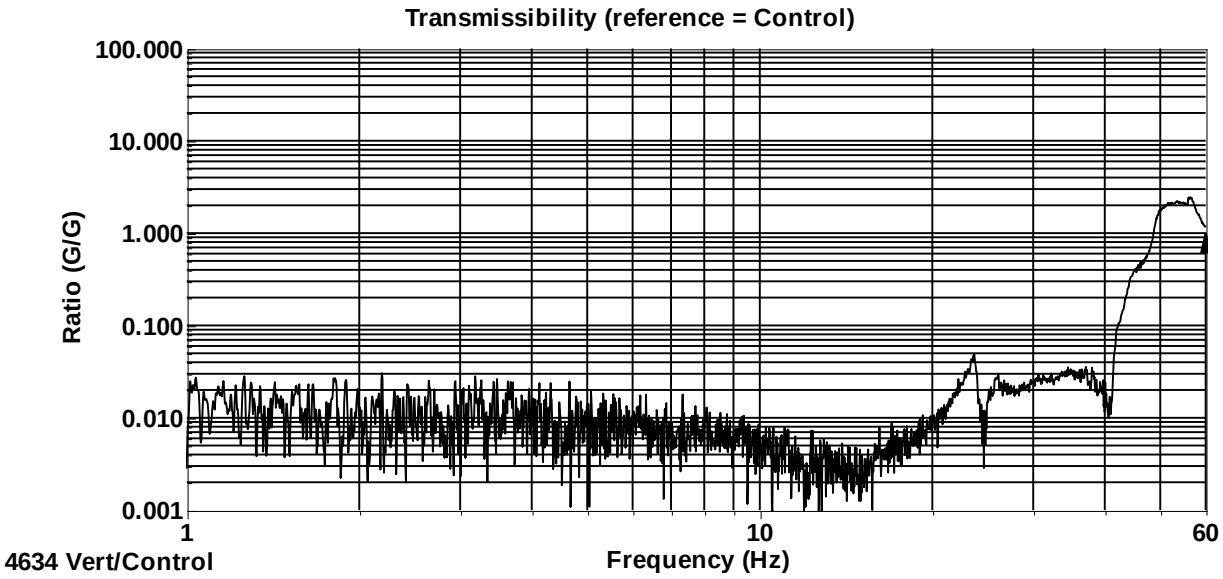
Side to Side Axis
Front to Back Response on 4634 Incandescent unit



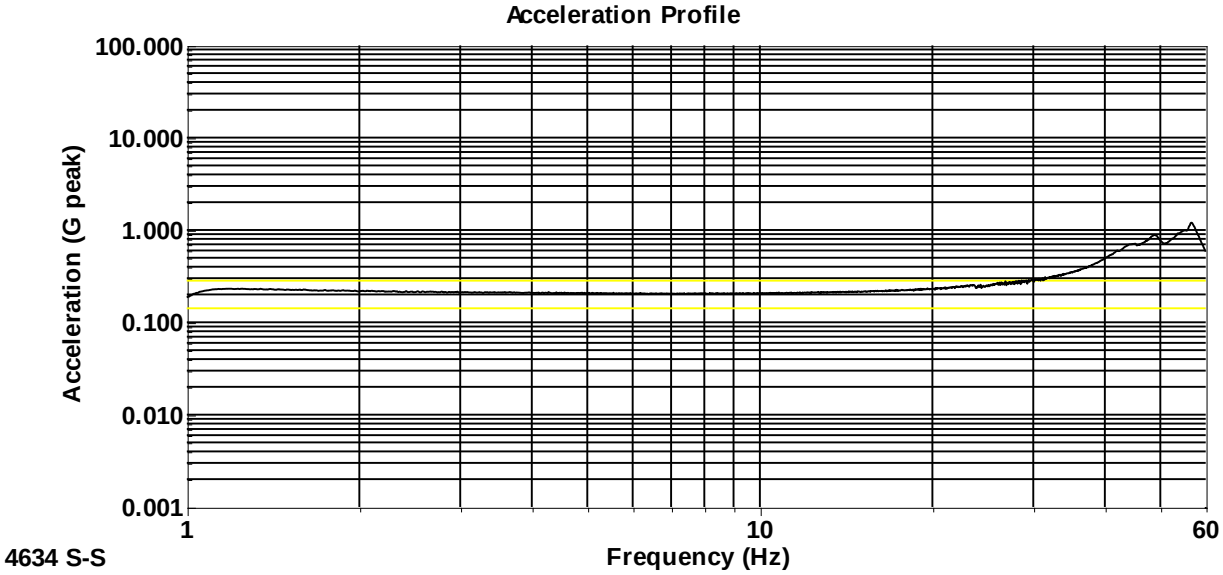
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 2 Side to Side Survey Oct 28, 2013 15:59:51
4634 Incandescent Front to Back response versus Control
Amplification is the fixture resonance at 56Hz



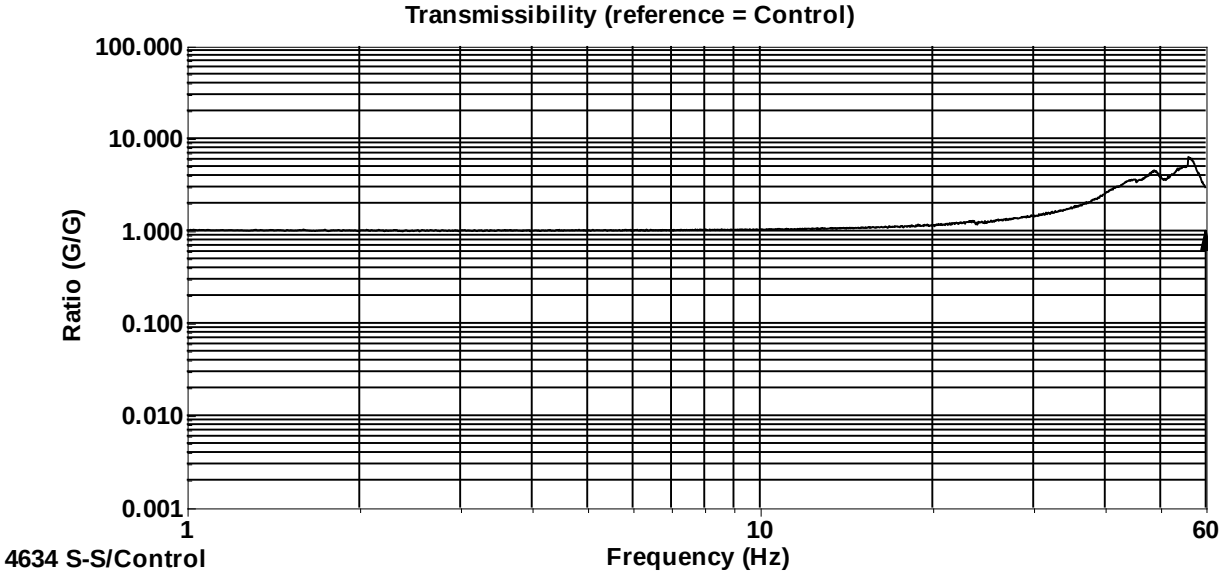
Side to Side Axis
Vertical Response on 4634 Incandescent unit



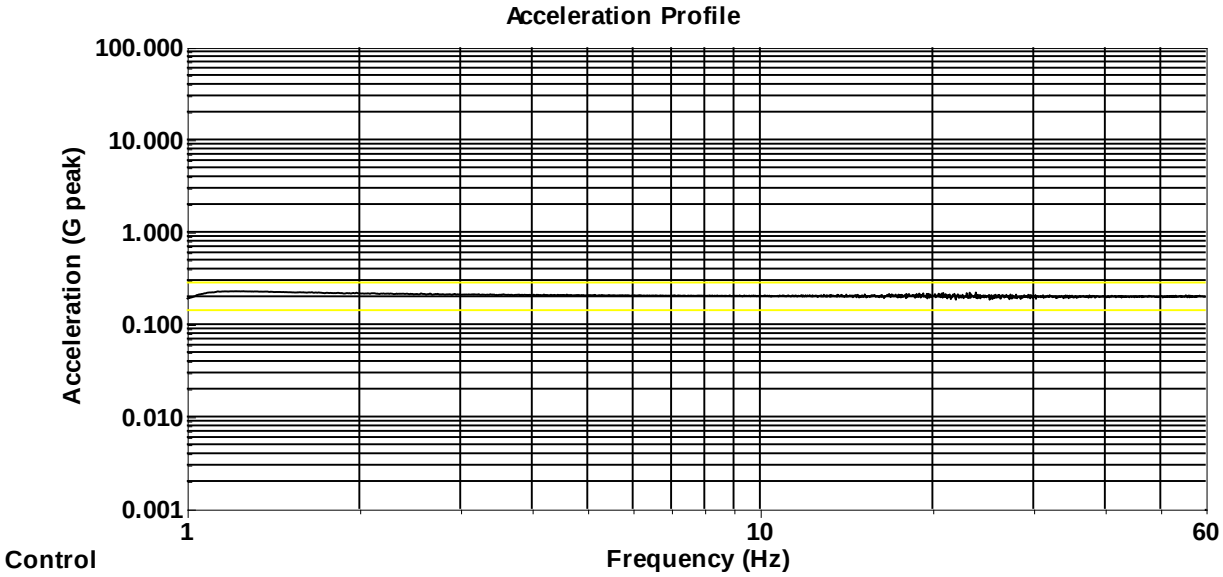
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 2 Side to Side Survey Oct 28, 2013 15:59:51
4634 Incandescent Vertical response versus Control
Amplification is the fixture resonance at 56Hz



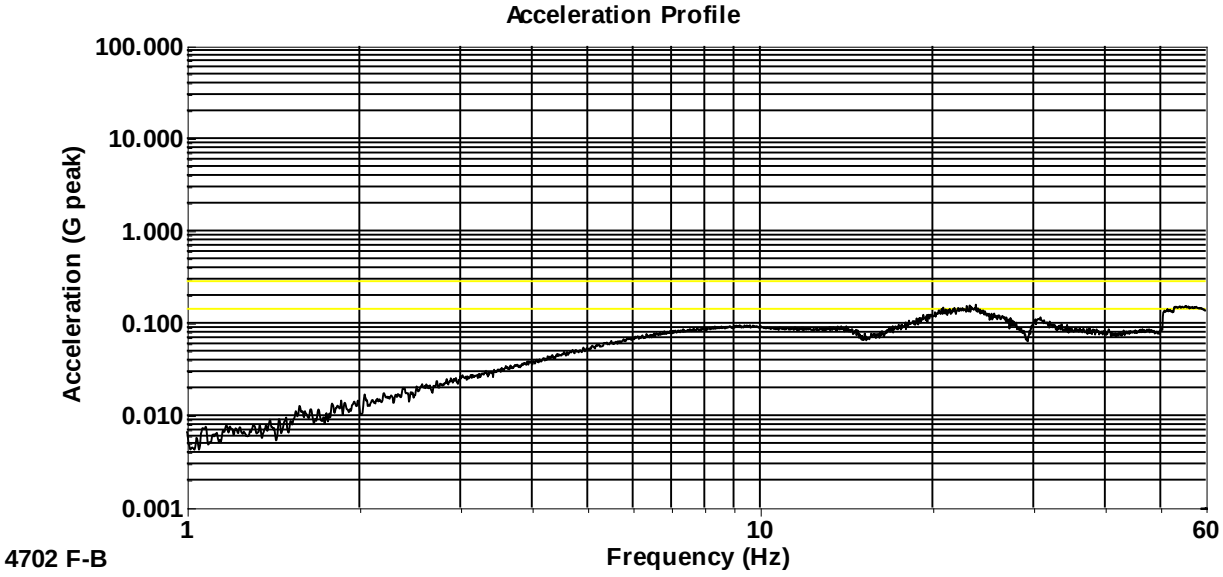
Side to Side Axis
Side to Side Response on 4634 Incandescent unit



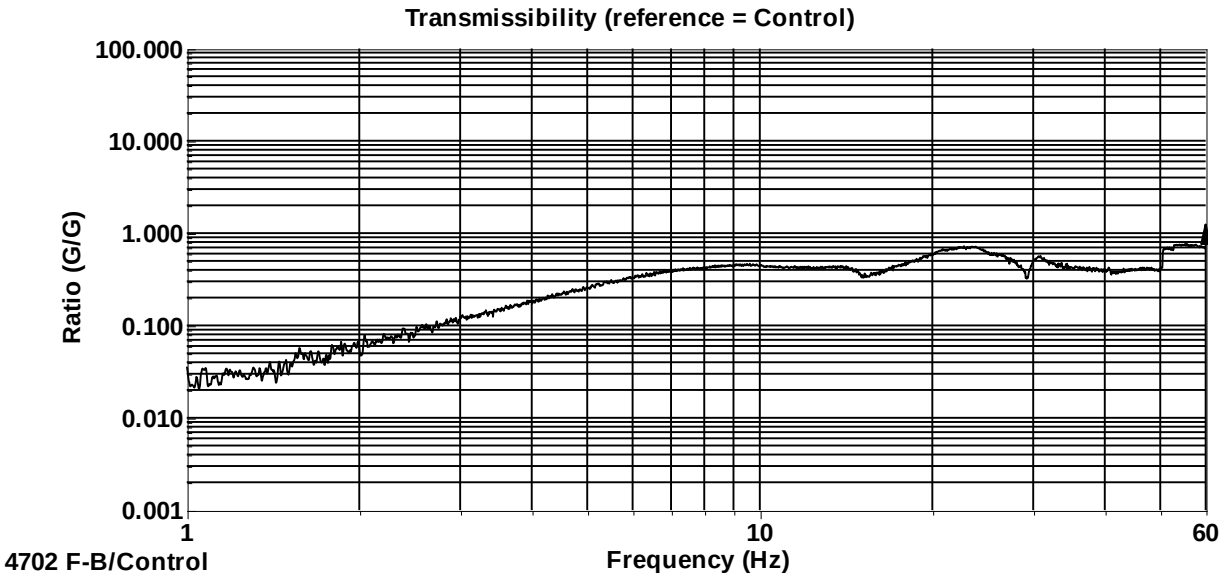
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 2 Side to Side Survey Oct 28, 2013 15:59:51
4634 Incandescent Side to Side response versus Control
Amplification is the fixture resonance at 56Hz



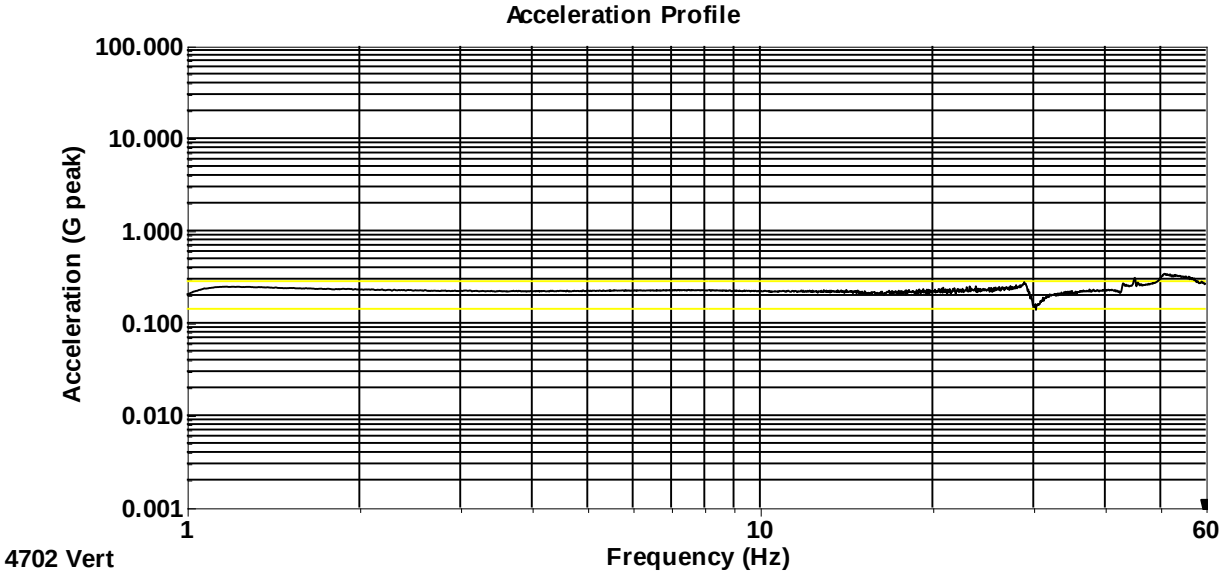
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 3 Vertical Survey Oct 28, 2013 15:59:51
Control Accelerometer



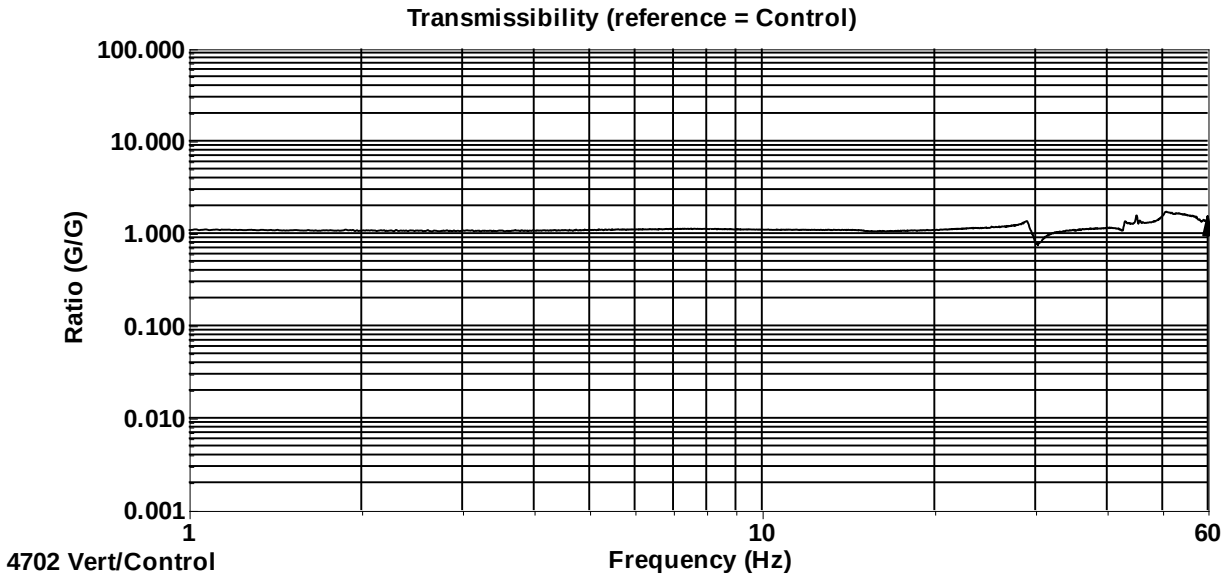
Vertical Axis
Front to Back Response on 4702 unit



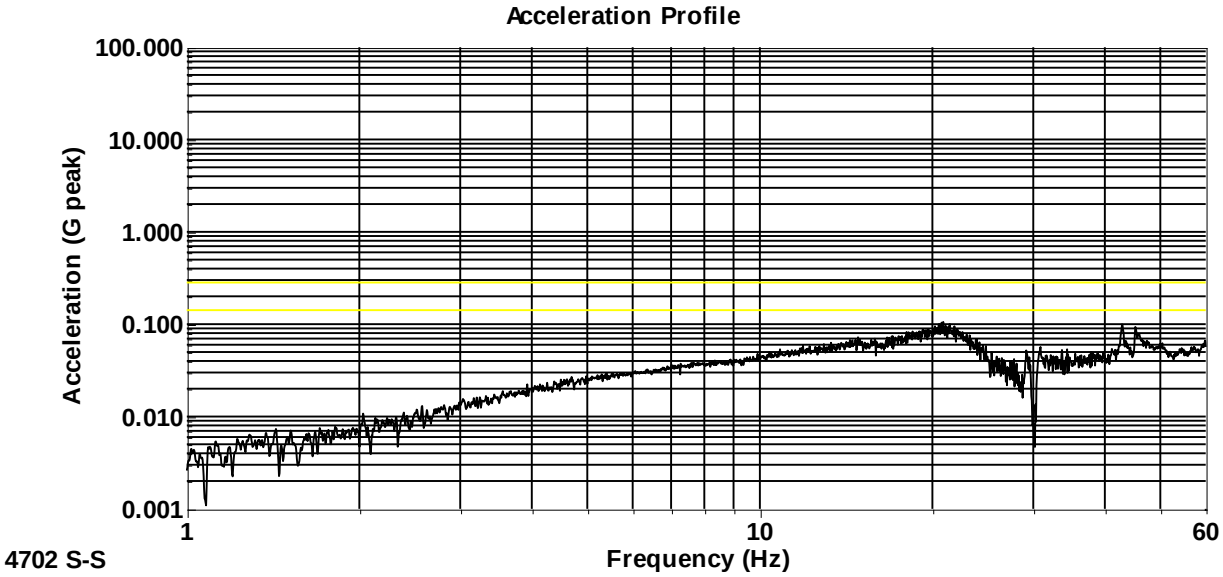
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 3 Vertical Survey Oct 28, 2013 15:59:51
4702 Front to Back response versus Control



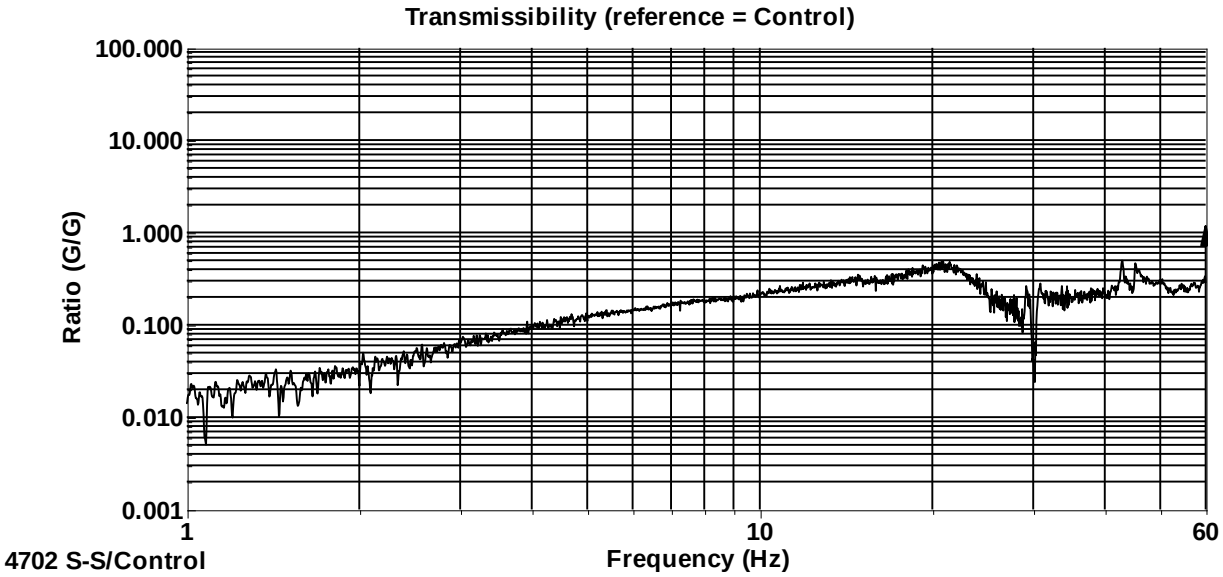
Vertical Axis
Vertical Response on 4702 unit



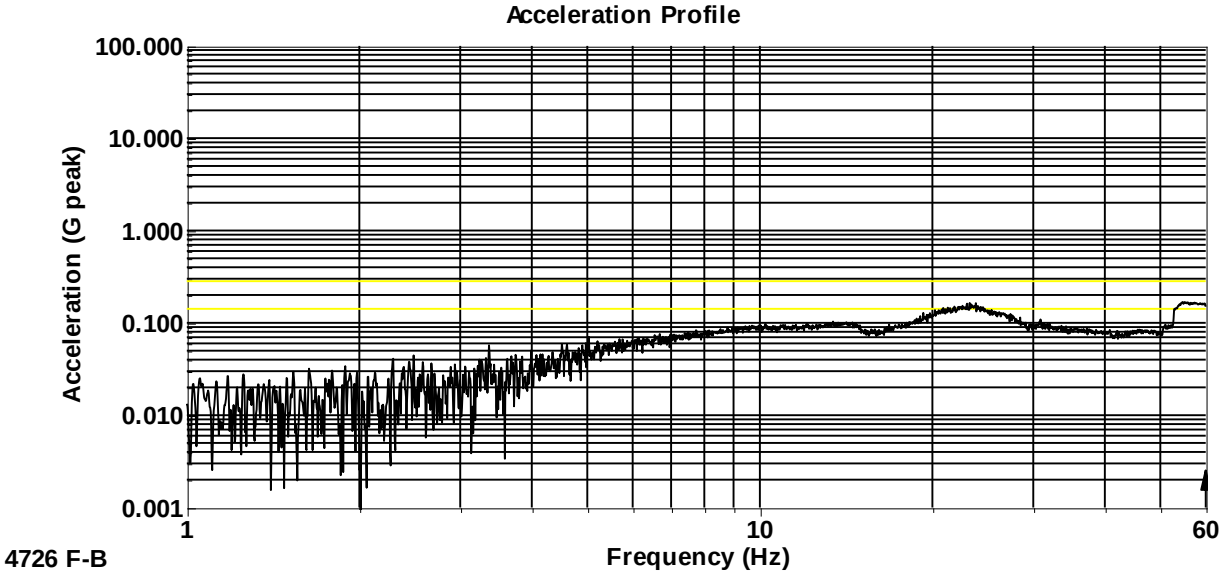
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 3 Vertical Survey Oct 28, 2013 15:59:51
4702 Vertical response versus Control



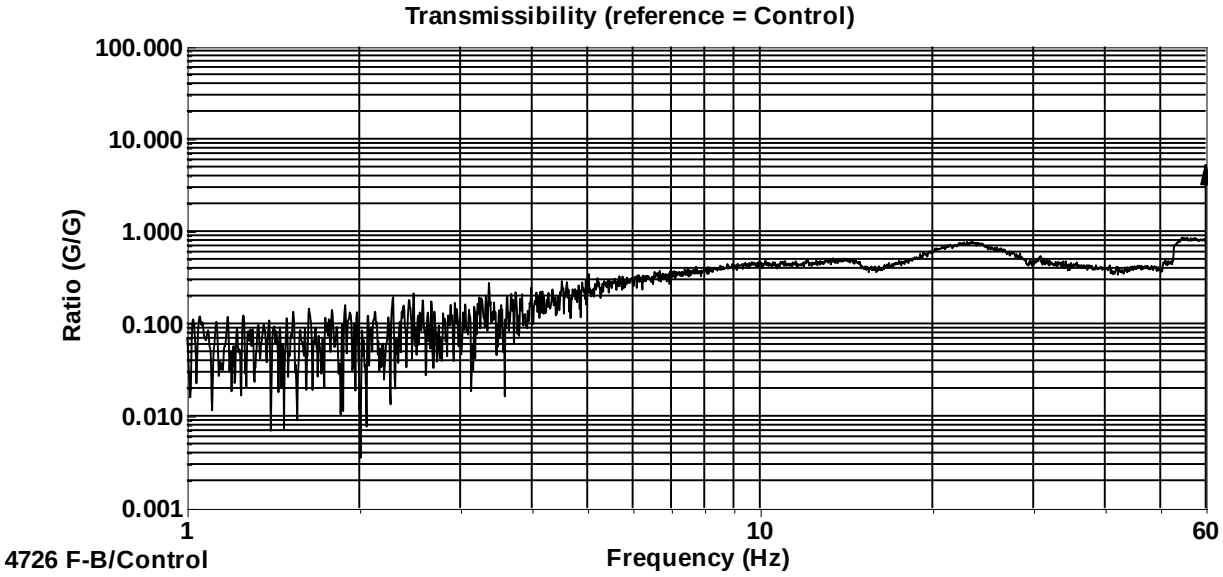
Vertical Axis
Side to Side Response on 4702 unit



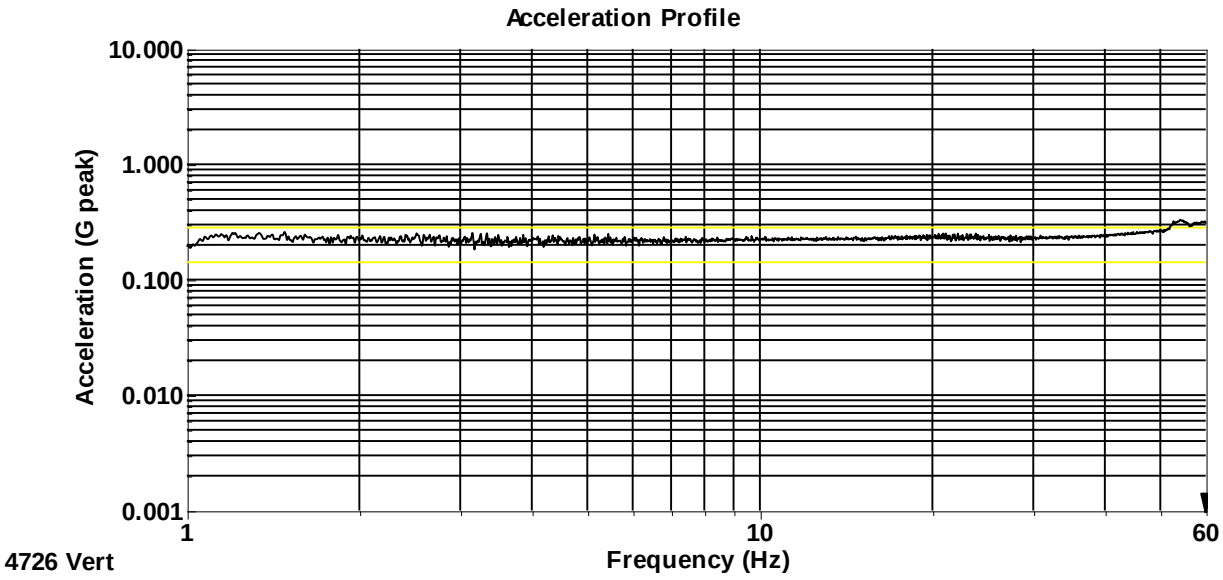
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 3 Vertical Survey Oct 28, 2013 15:59:51
4702 Vertical response versus Control



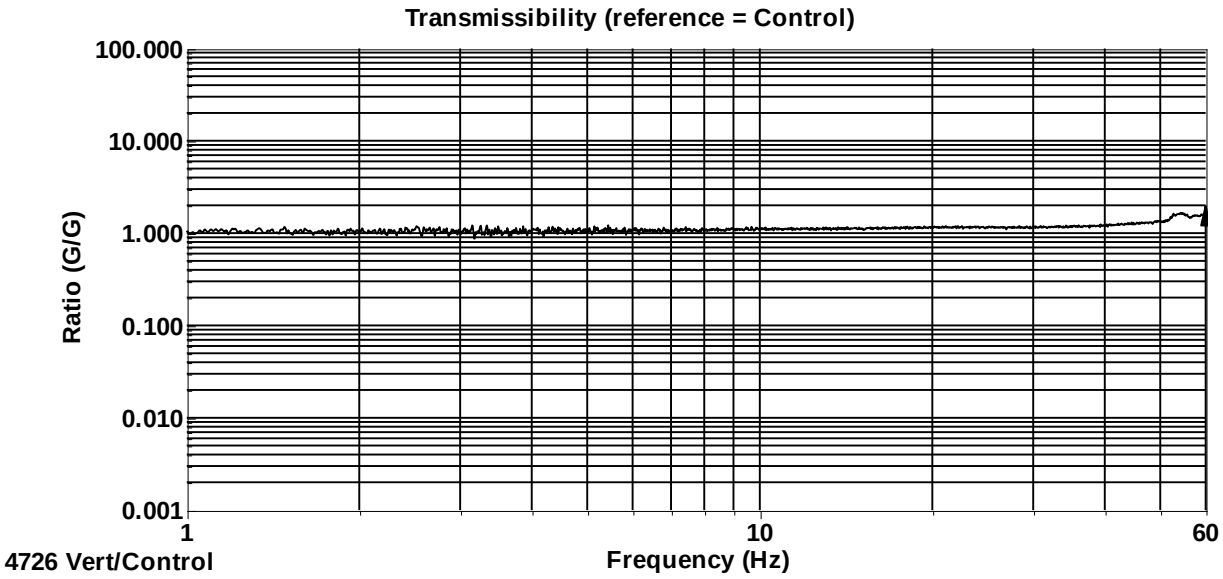
Vertical Axis
Front to Back Response on 4726 unit



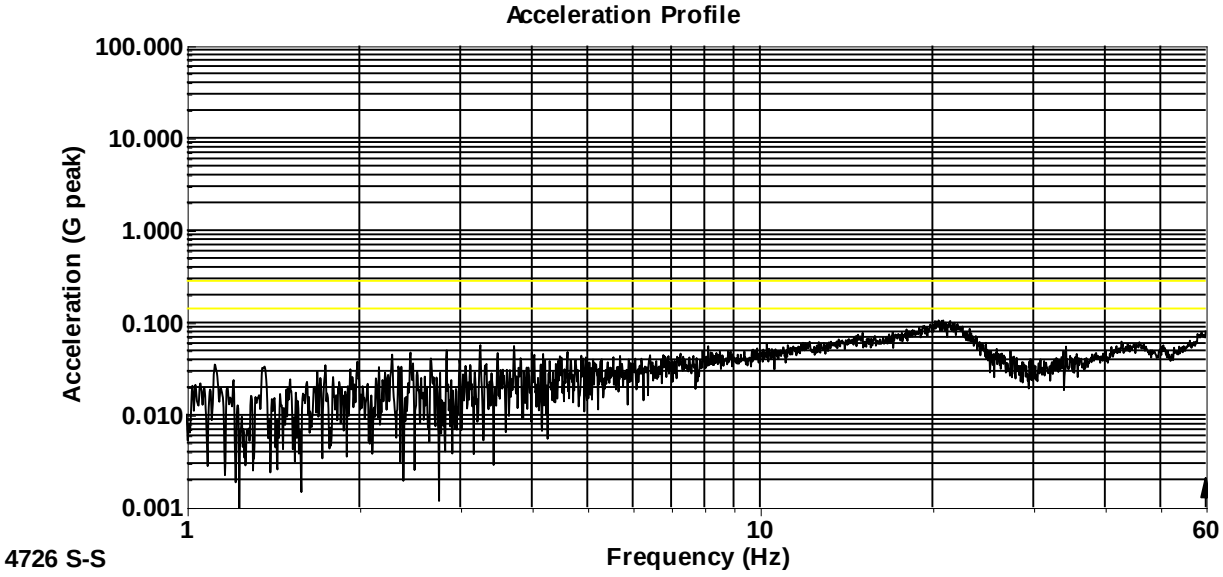
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 3 Vertical Survey Oct 28, 2013 15:59:51
4726 Front to Back response versus Control



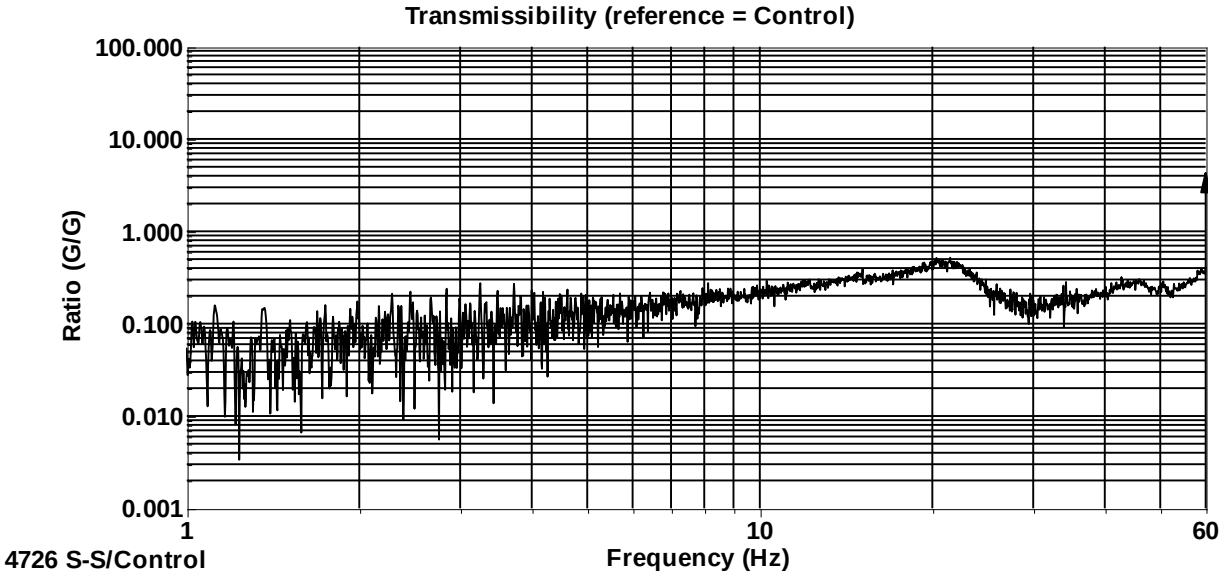
Vertical Axis
Vertical Response on 4726 unit



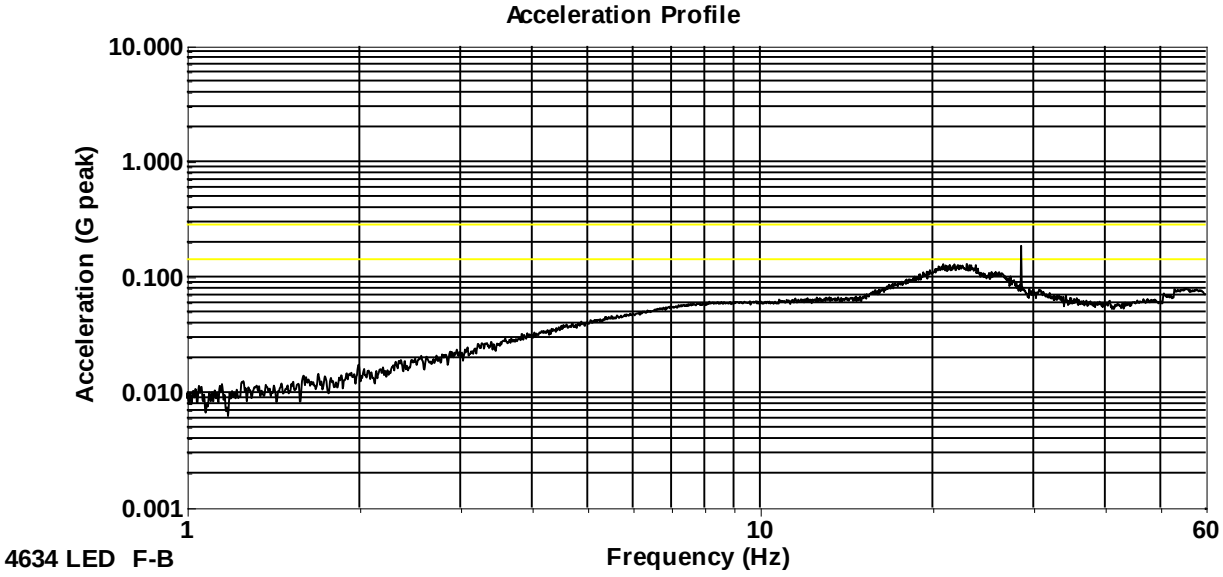
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 3 Vertical Survey Oct 28, 2013 15:59:51
4726 Vertical response versus Control



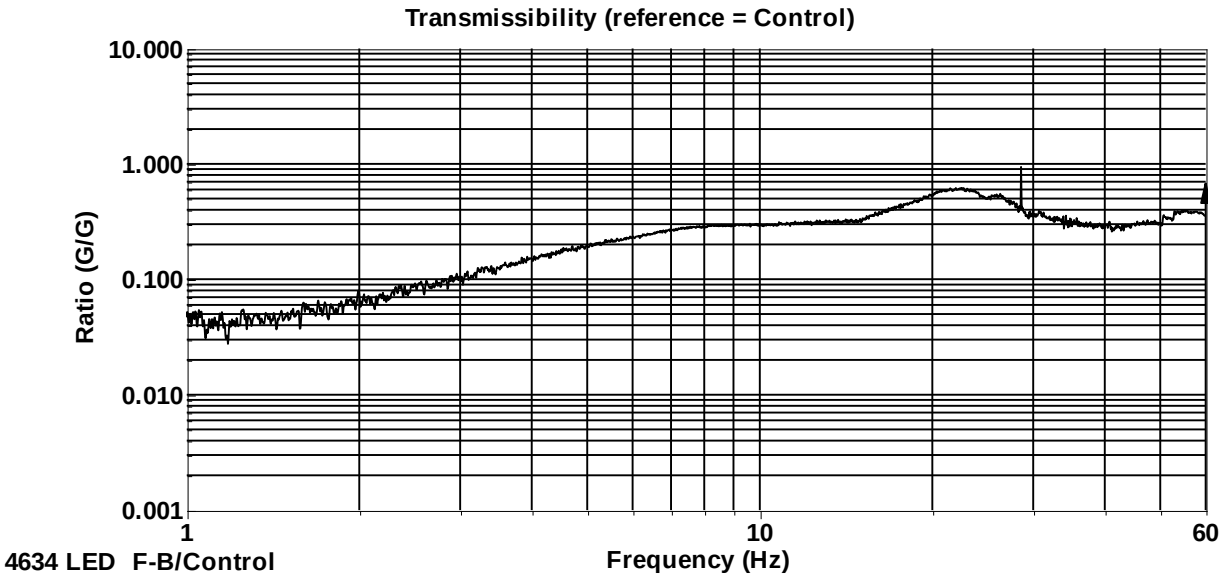
Vertical Axis
Side to Side Response on 4726 unit



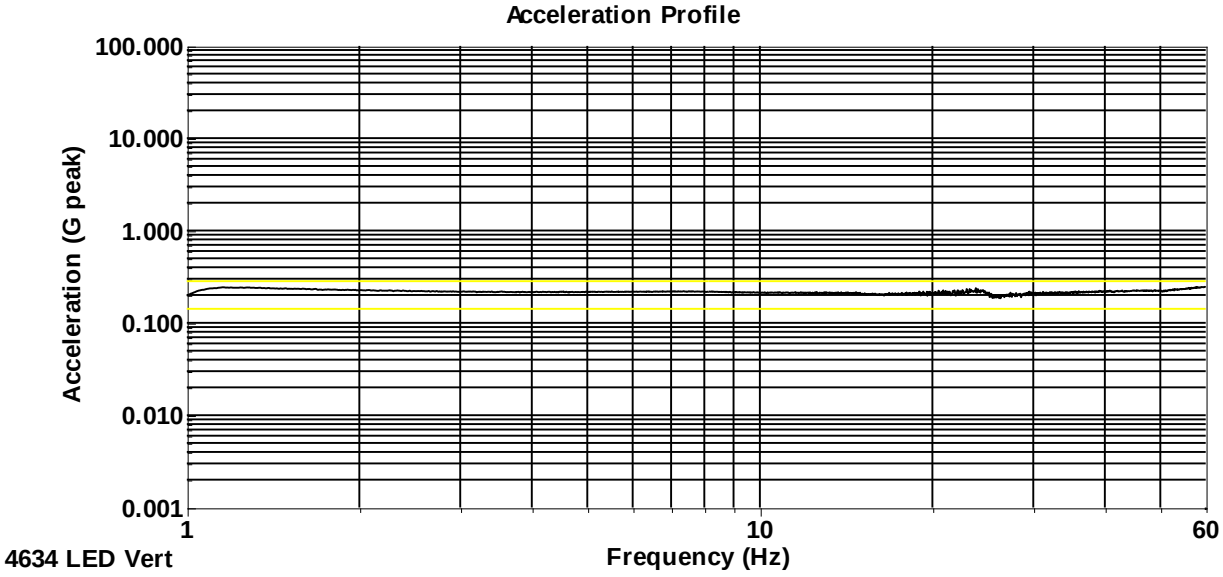
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 3 Vertical Survey Oct 28, 2013 15:59:51
4726 Side to Side response versus Control



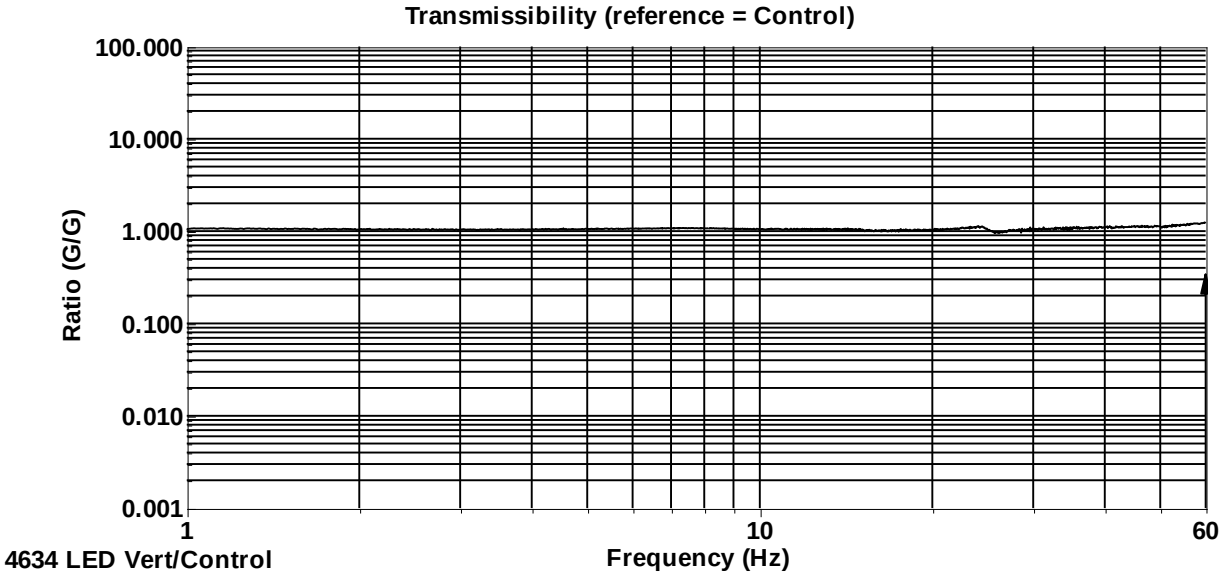
Vertical Axis
Front to Back Response on 4634 LED unit



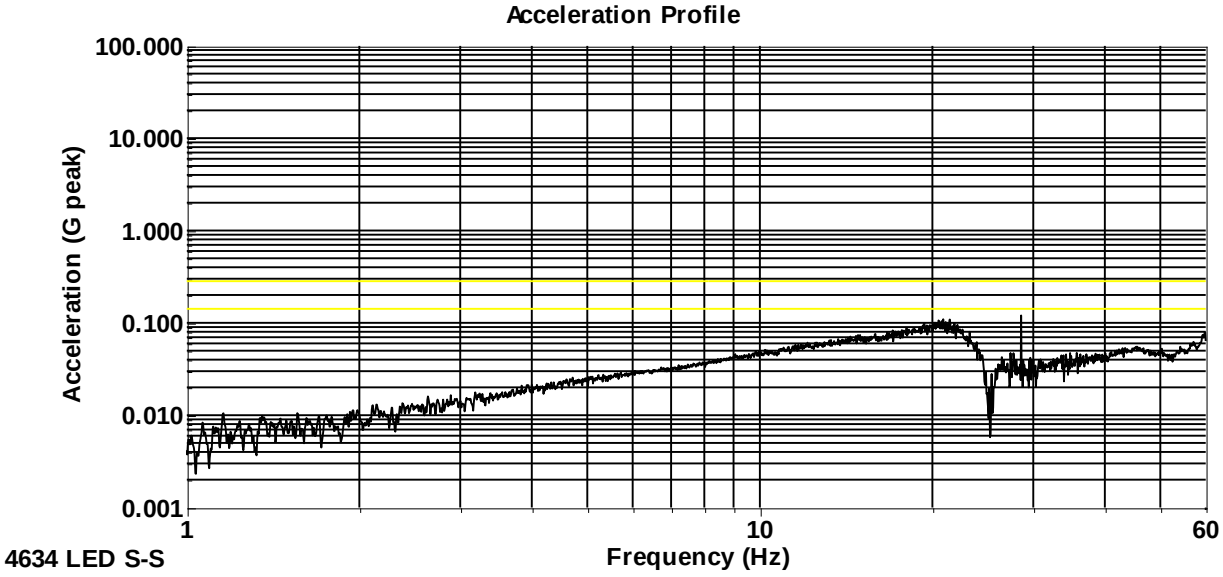
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 3 Vertical Survey Oct 28, 2013 15:59:51
4634 LED Front to Back response versus Control



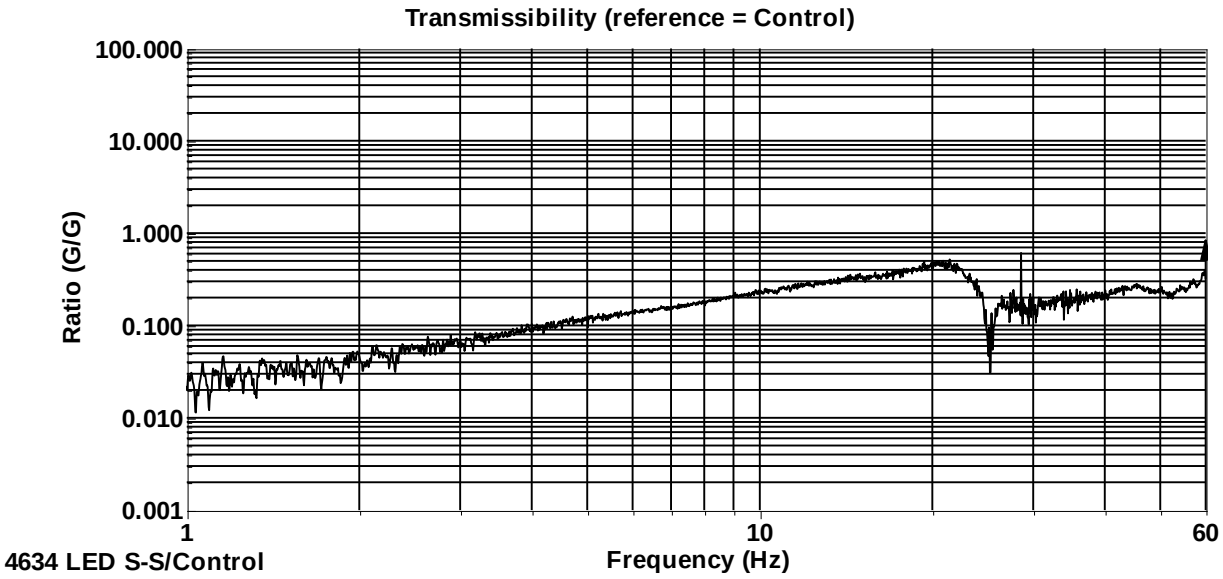
Vertical Axis
Vertical Response on 4634 LED unit



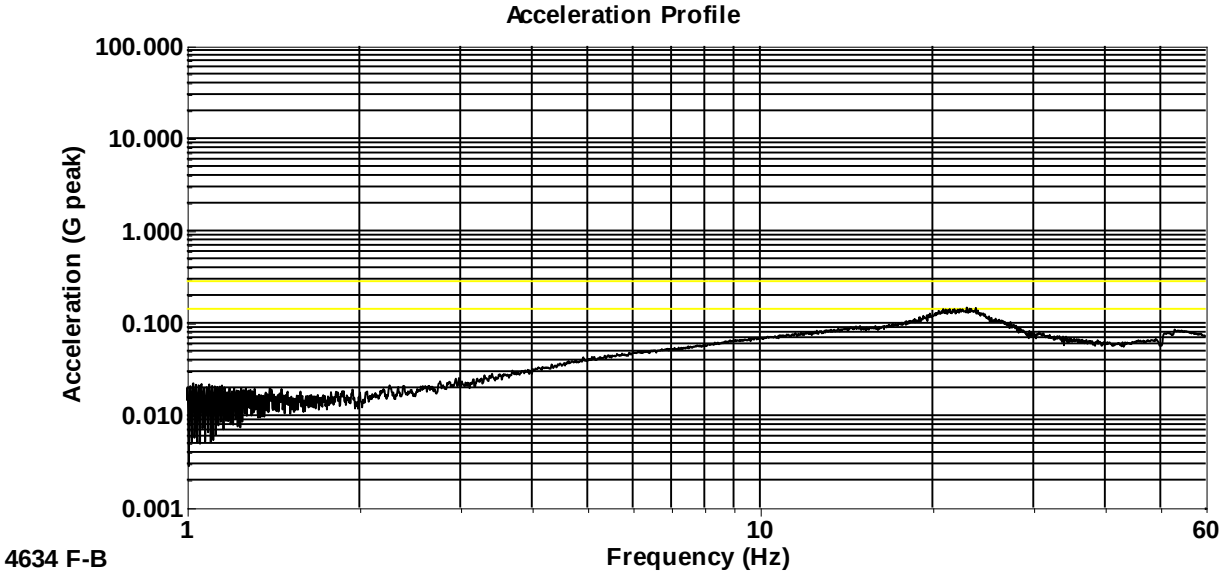
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 3 Vertical Survey Oct 28, 2013 15:59:51
4634 LED Vertical response versus Control



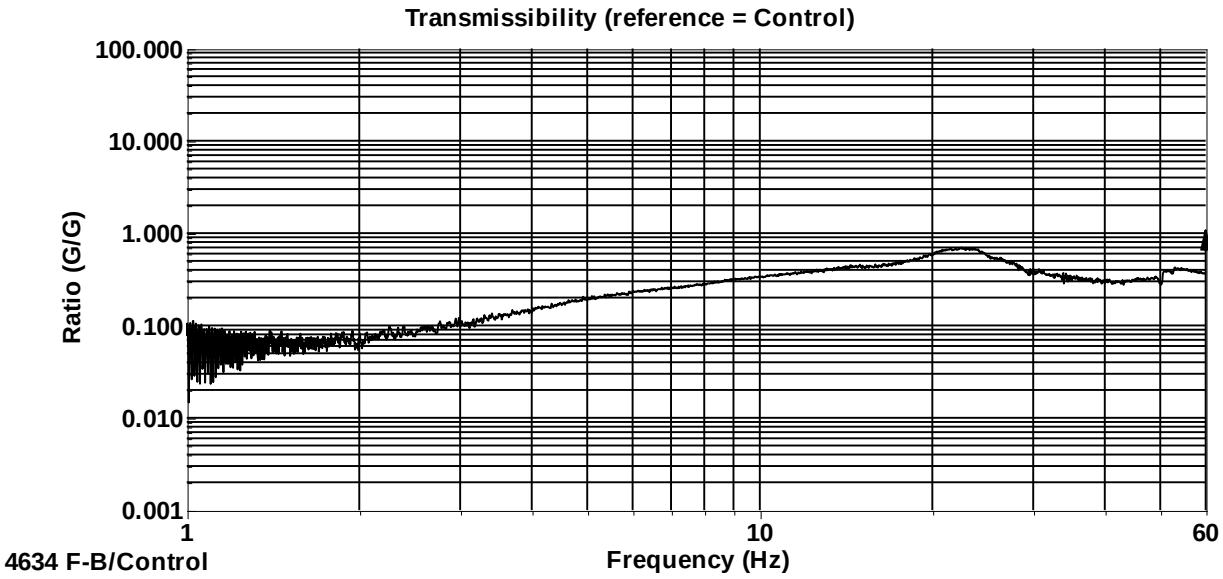
Vertical Axis
Side to Side Response on 4634 LED unit



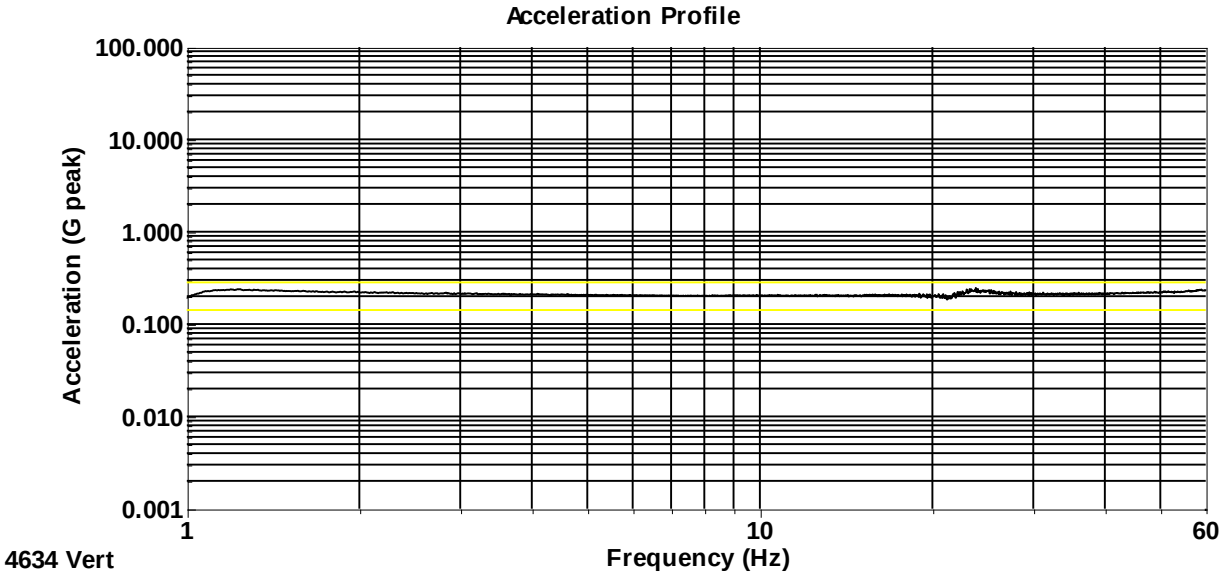
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 3 Vertical Survey Oct 28, 2013 15:59:51
4634 LED Side to Side response versus Control



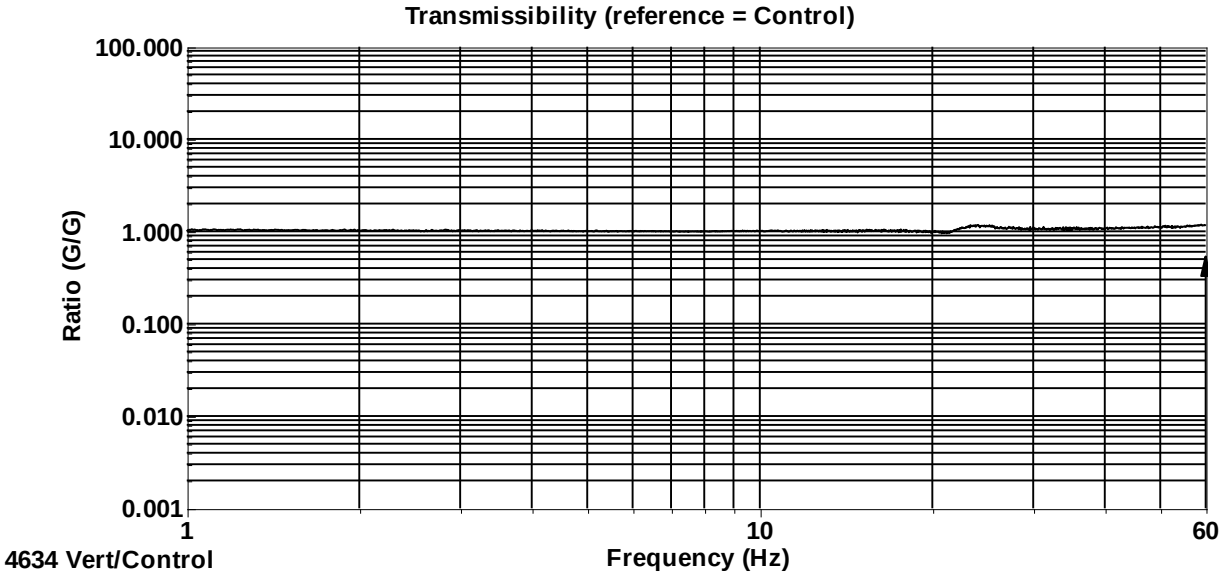
Vertical Axis
Front to Back Response on 4634 Incandescent unit



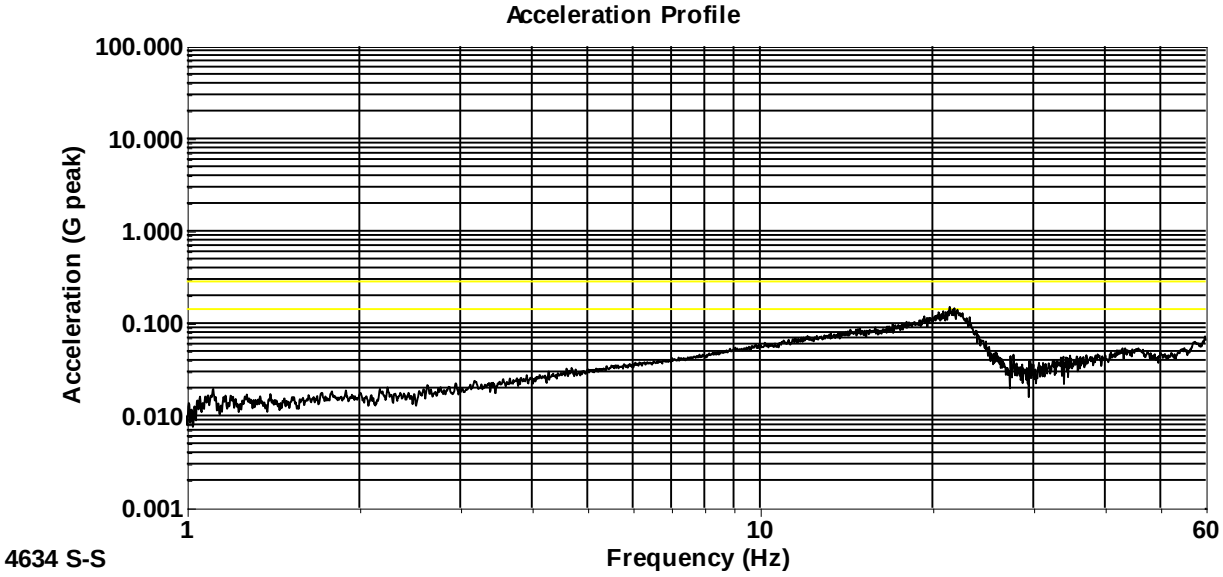
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 3 Vertical Survey Oct 28, 2013 15:59:51
4634 Incandescent Front to Back response versus Control



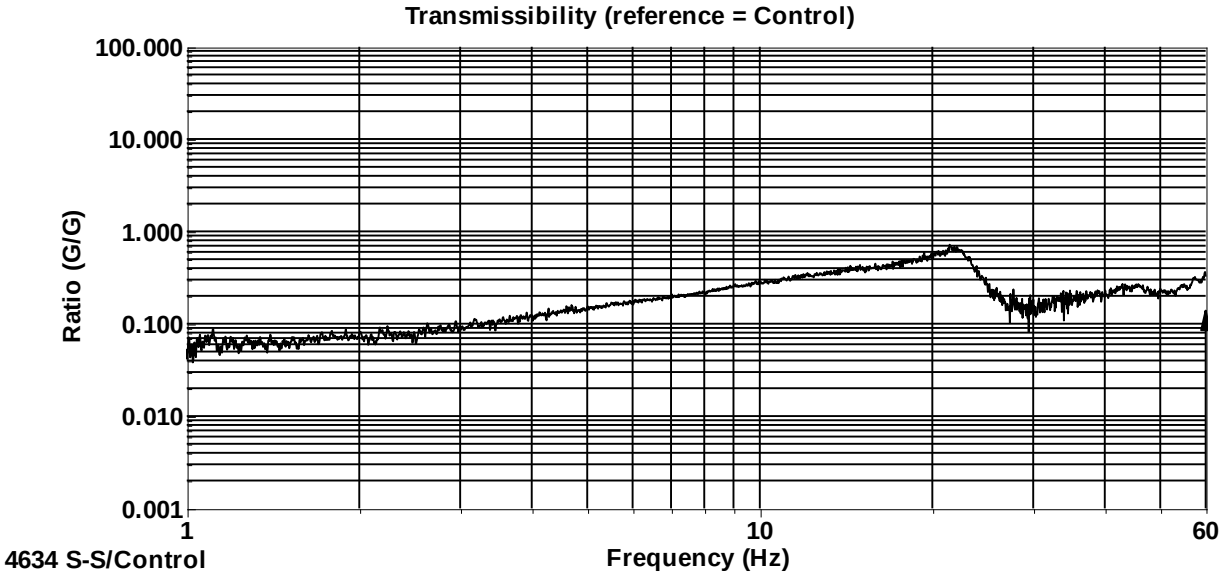
Vertical Axis
Vertical Response on 4634 Incandescent unit



BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 3 Vertical Survey Oct 28, 2013 15:59:51
4634 Incandescent Vertical response versus Control



Vertical Axis
Side to Side Response on 4634 Incandescent unit

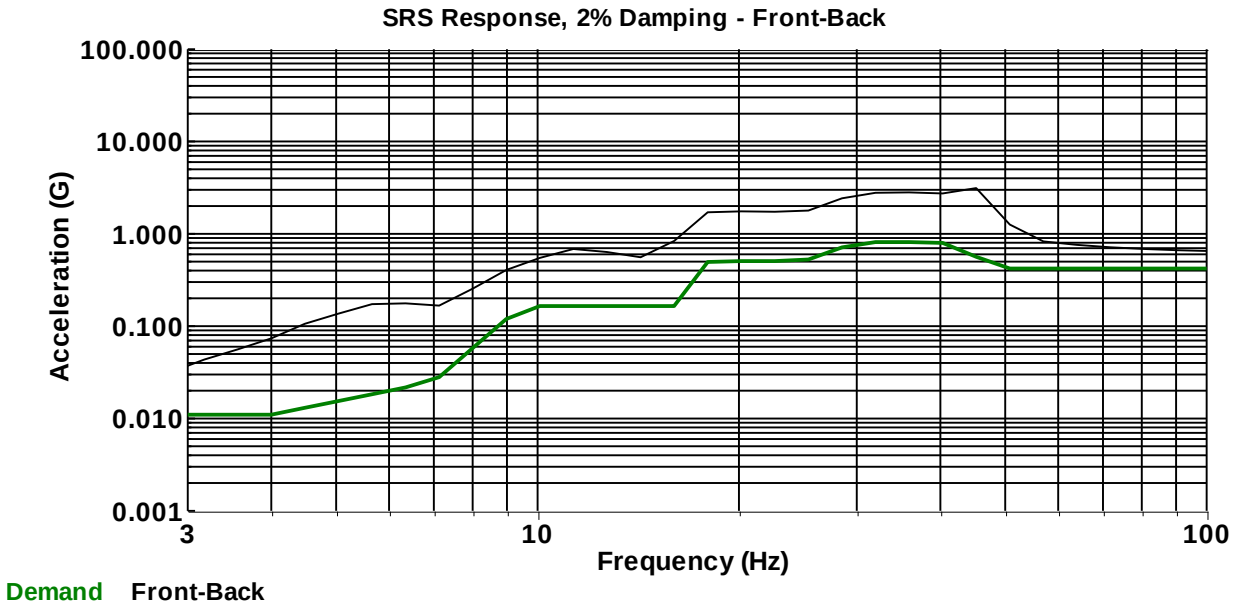


BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 3 Vertical Survey Oct 28, 2013 15:59:51
4634 Incandescent Side to Side response versus Control

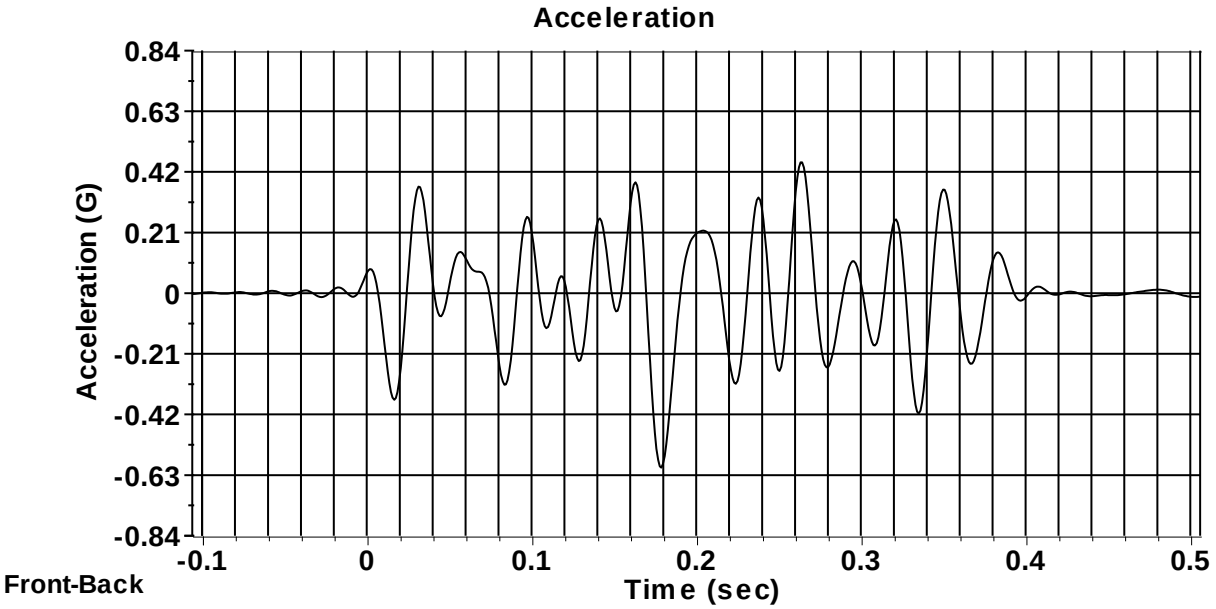
APPENDIX E

SRV Data Curves

ZPA: -0.6043 G

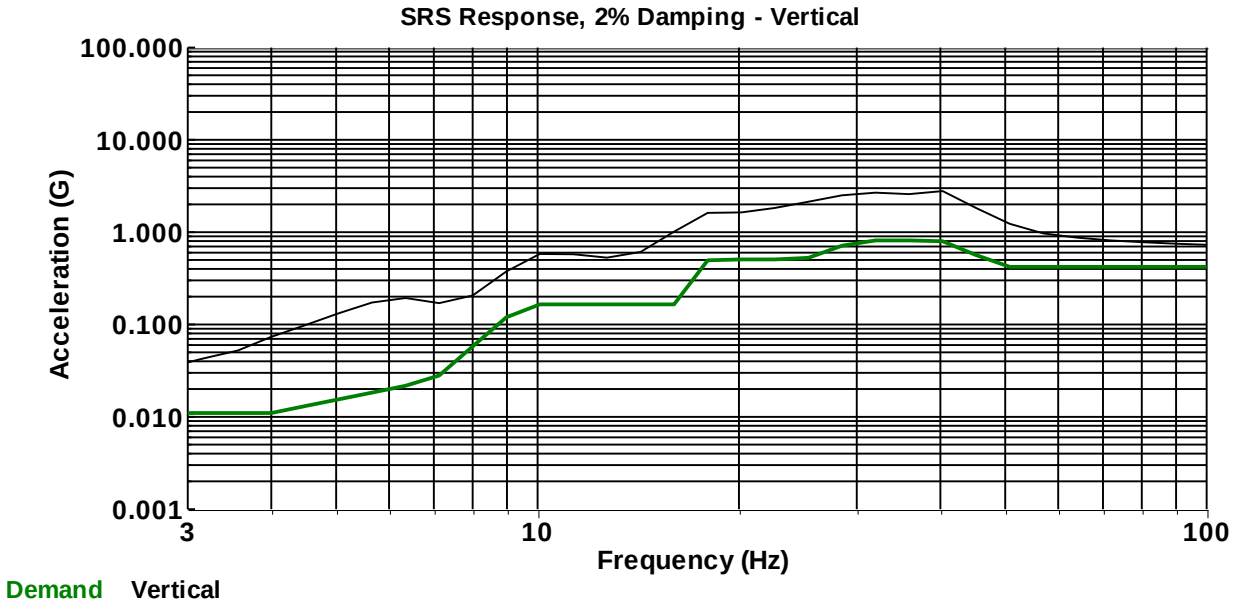


Front to Back Axis Control

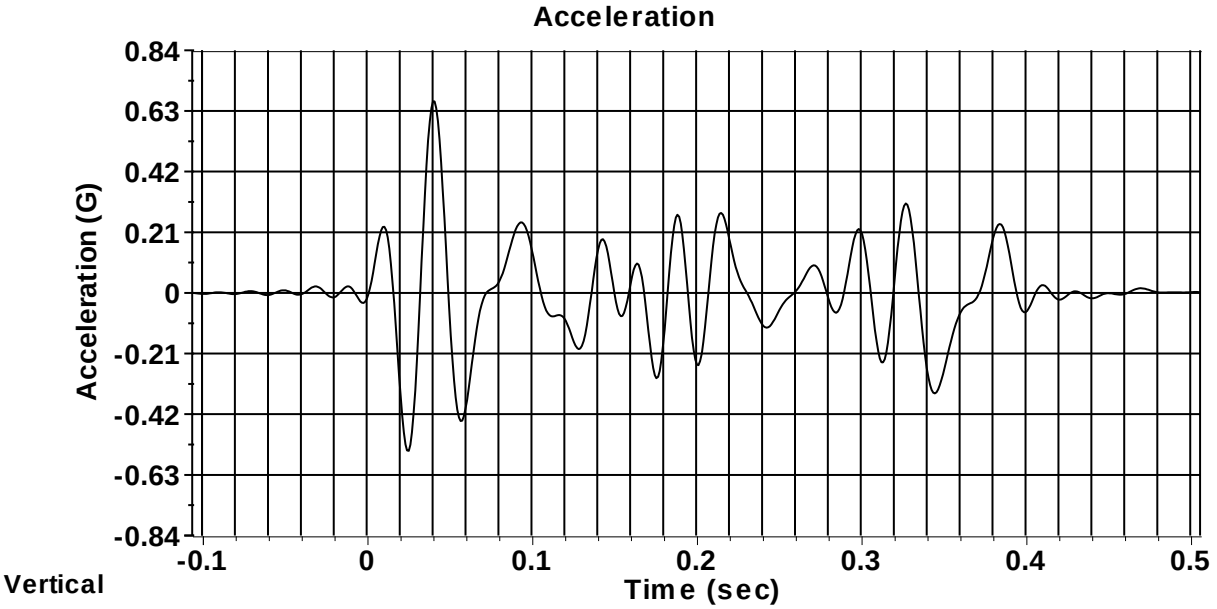


BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 4 Safety Relief Valve Testing (SRV) Oct 29, 2013 10:01:46
Pulse: 610 of 2850

ZPA: 0.6633 G

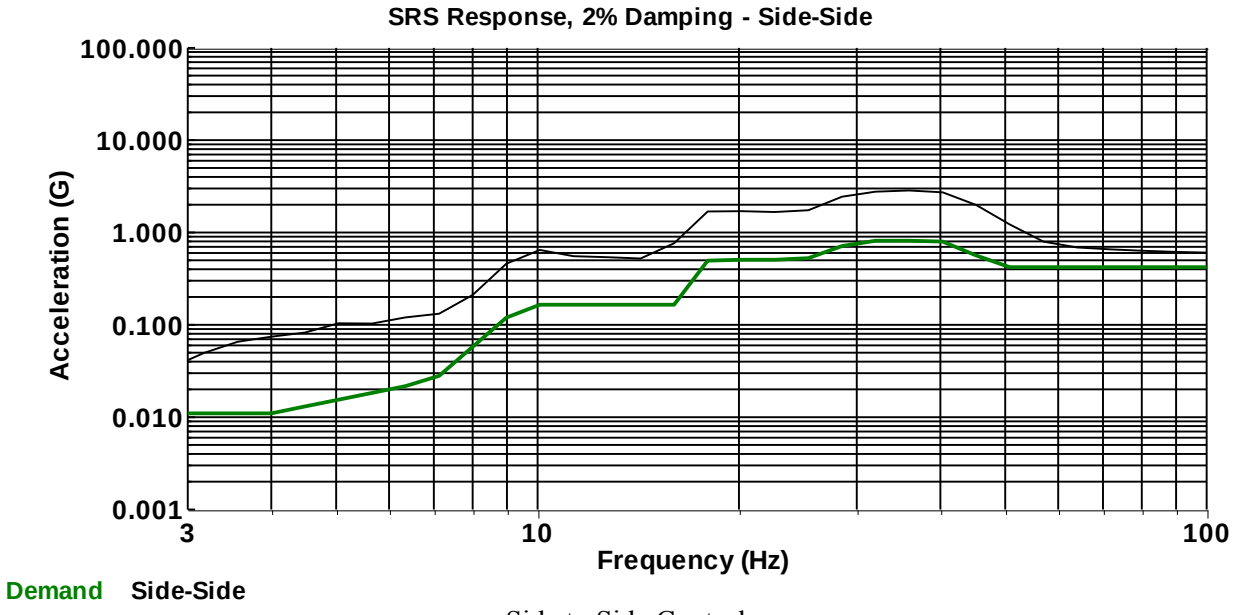


Vertical Axis Control

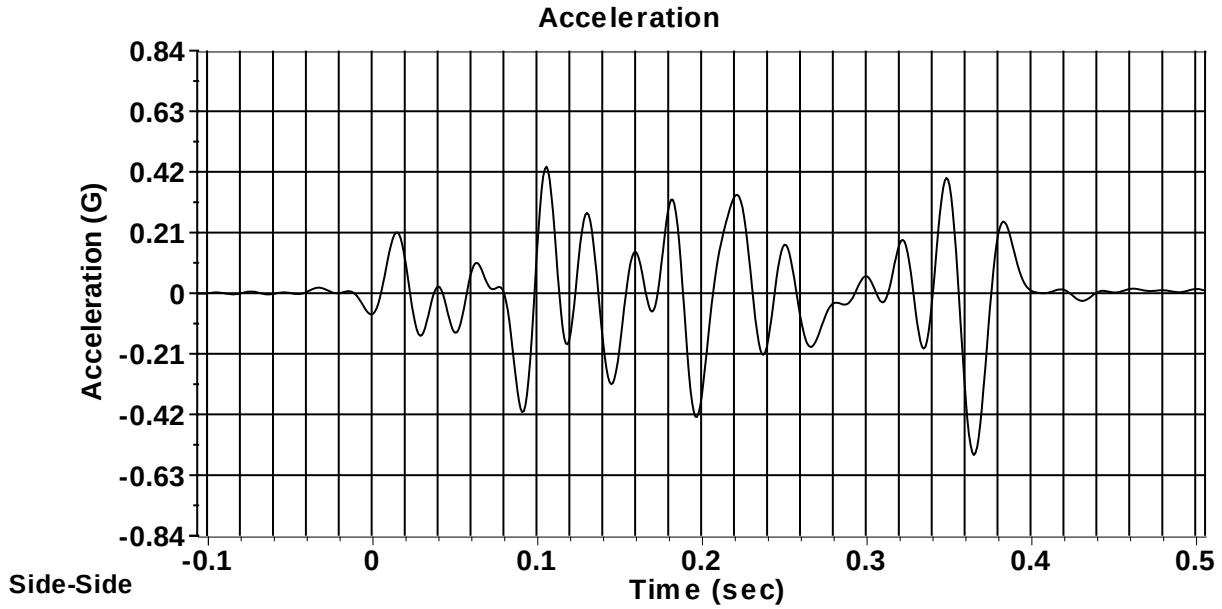


BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 4 Safety Relief Valve Testing (SRV) Oct 29, 2013 10:01:46
Pulse: 610 of 2850

ZPA: -0.5609 G

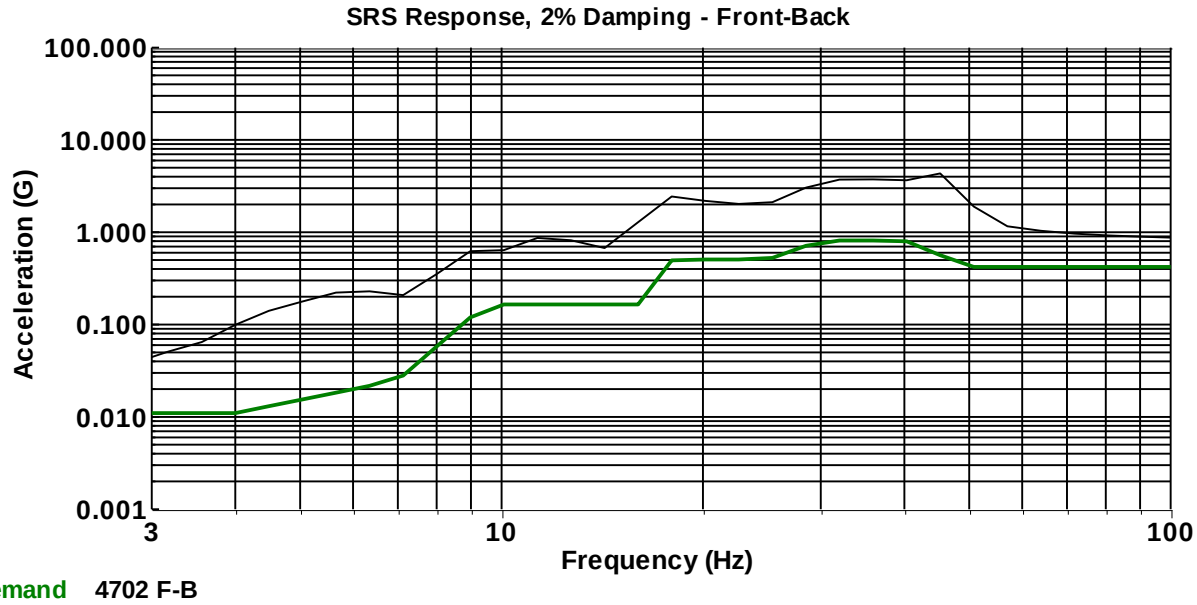


Side to Side Control



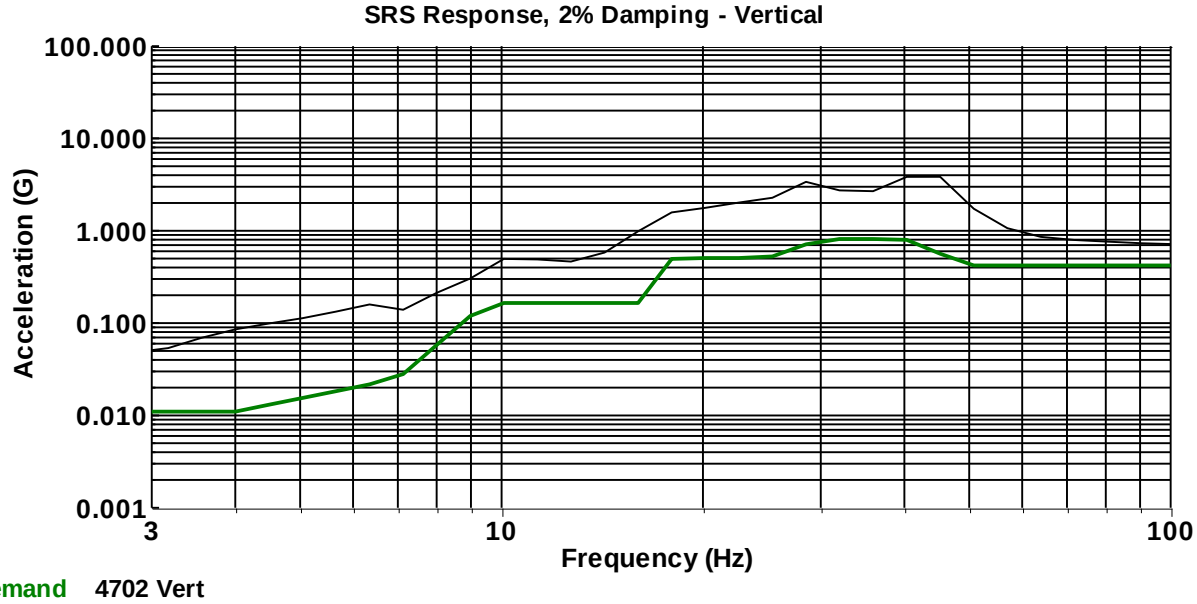
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 4 Safety Relief Valve Testing (SRV) Oct 29, 2013 10:01:46
Pulse: 610 of 2850

ZPA: -0.8075 G



4702 unit Front to Back Response

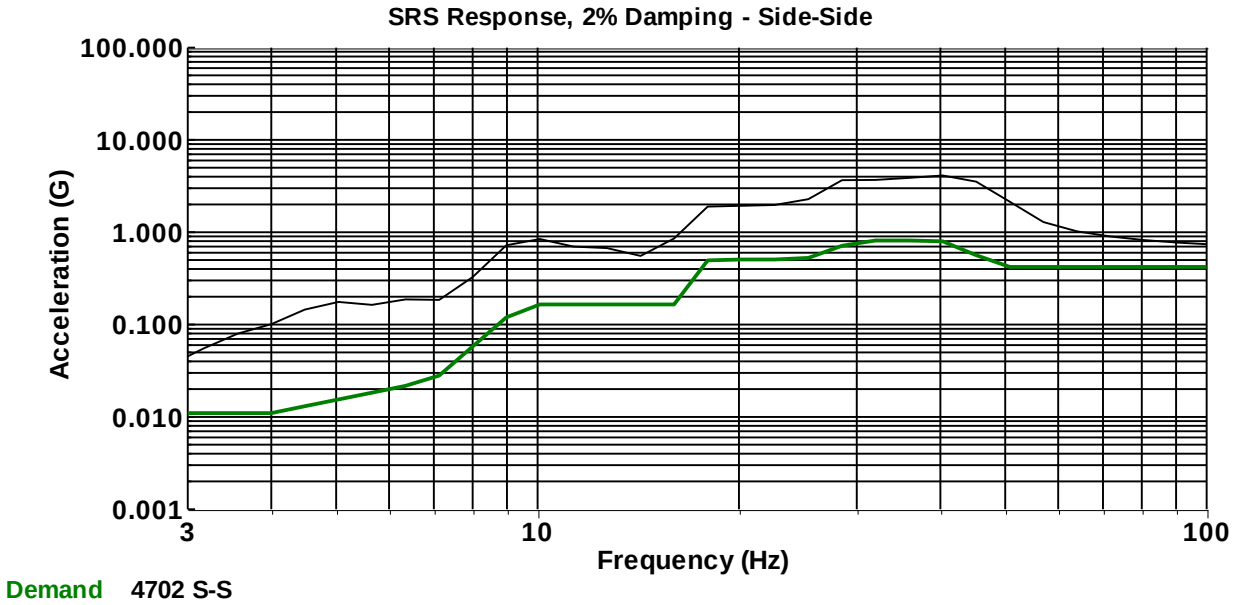
ZPA: 0.6512 G



4702 unit Vertical Response

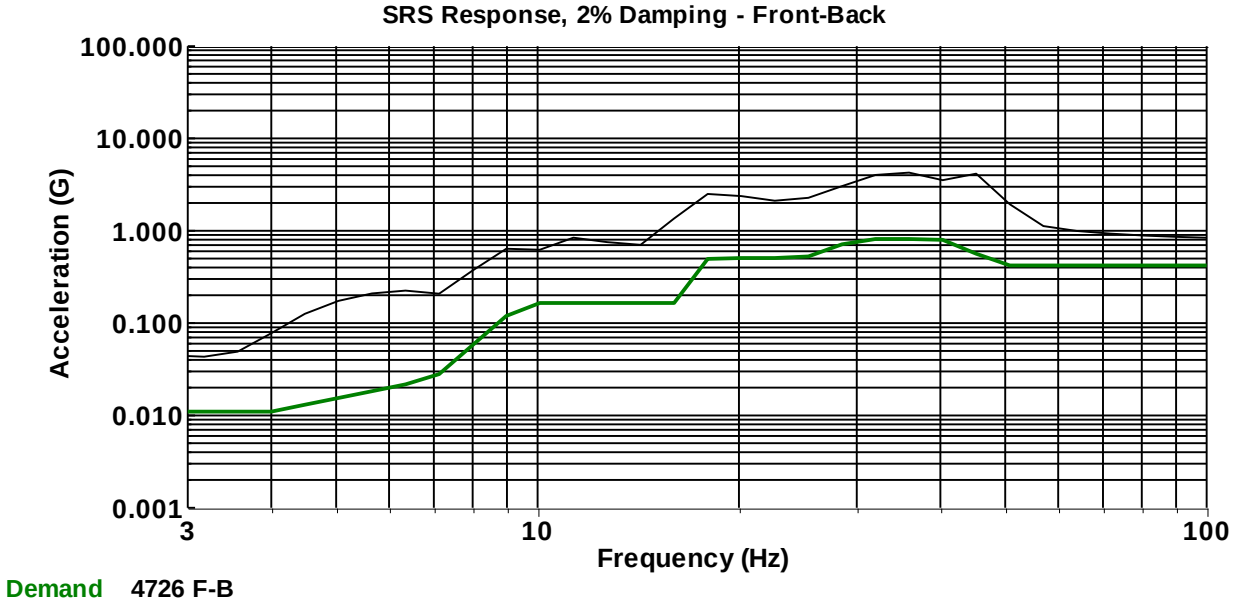
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 4 Safety Relief Valve Testing (SRV) Oct 29, 2013 10:01:46
Pulse: 610 of 2850

ZPA: -0.682 G



4702 unit Side to Side Response

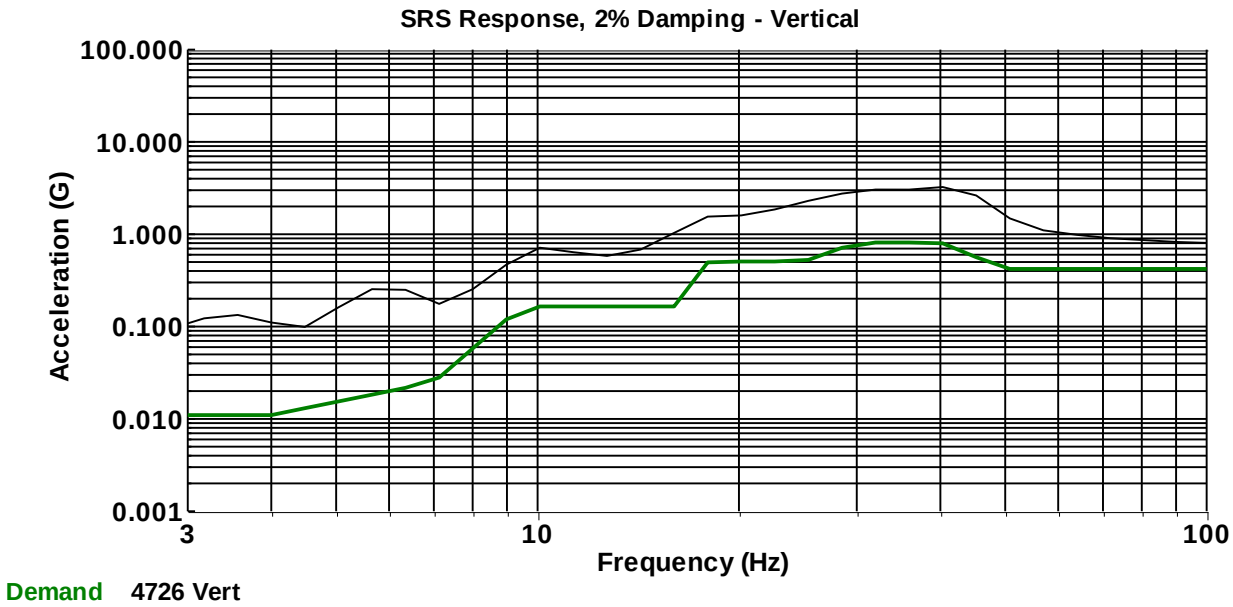
ZPA: -0.7751 G



4726 unit Front to Back Response

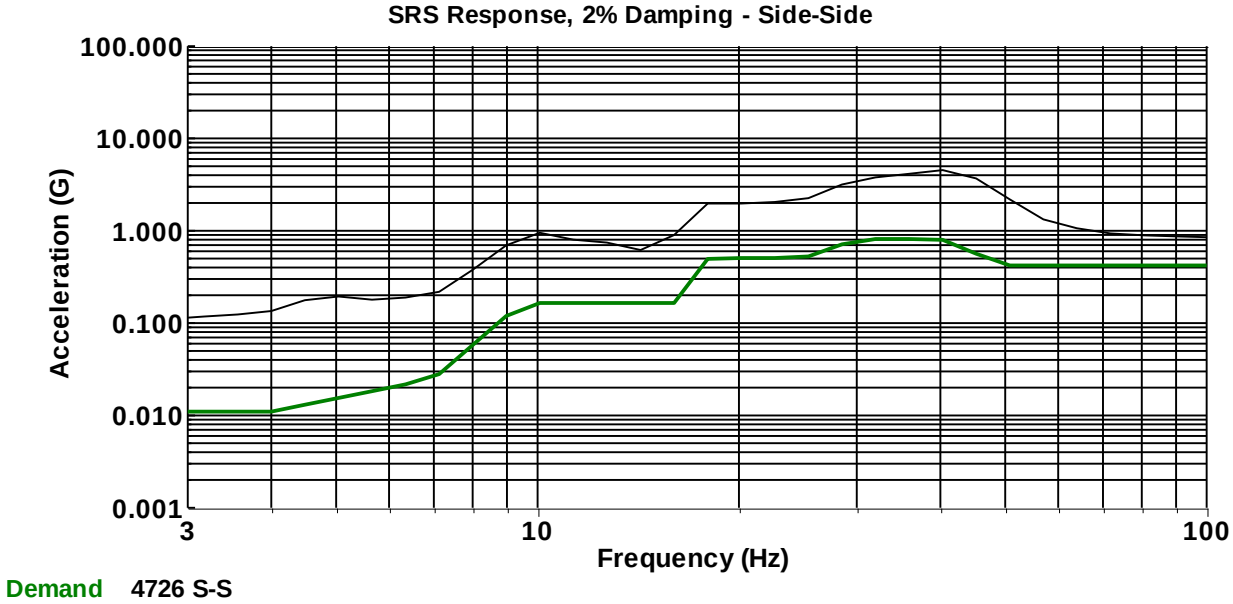
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 4 Safety Relief Valve Testing (SRV) Oct 29, 2013 10:01:46
Pulse: 610 of 2850

ZPA: 0.7241 G



4726 unit Vertical Response

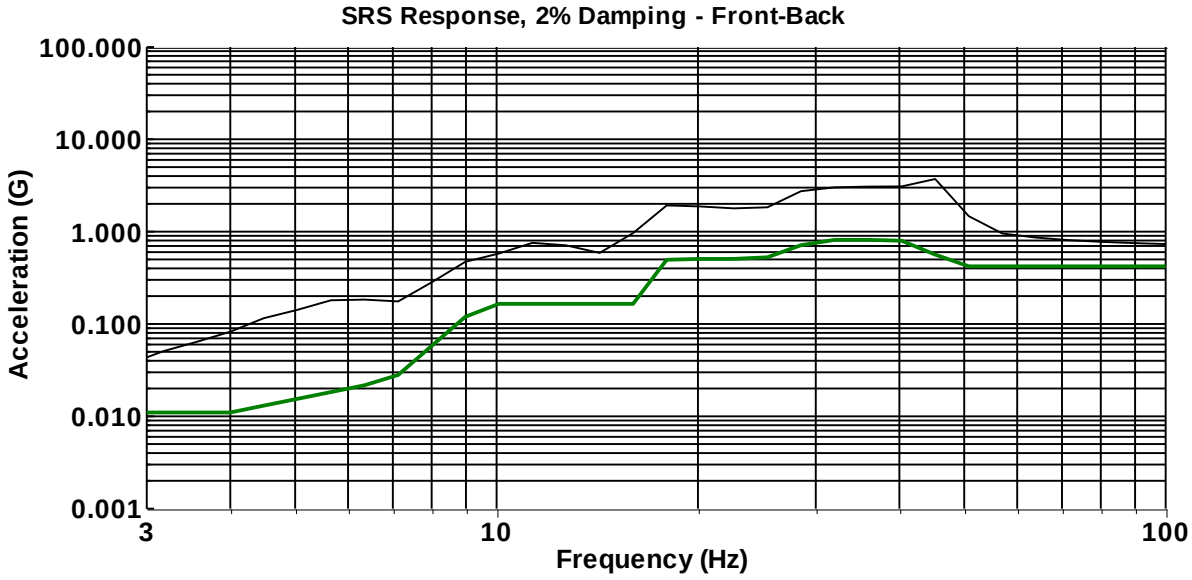
ZPA: -0.7898 G



4726 unit Side to Side Response

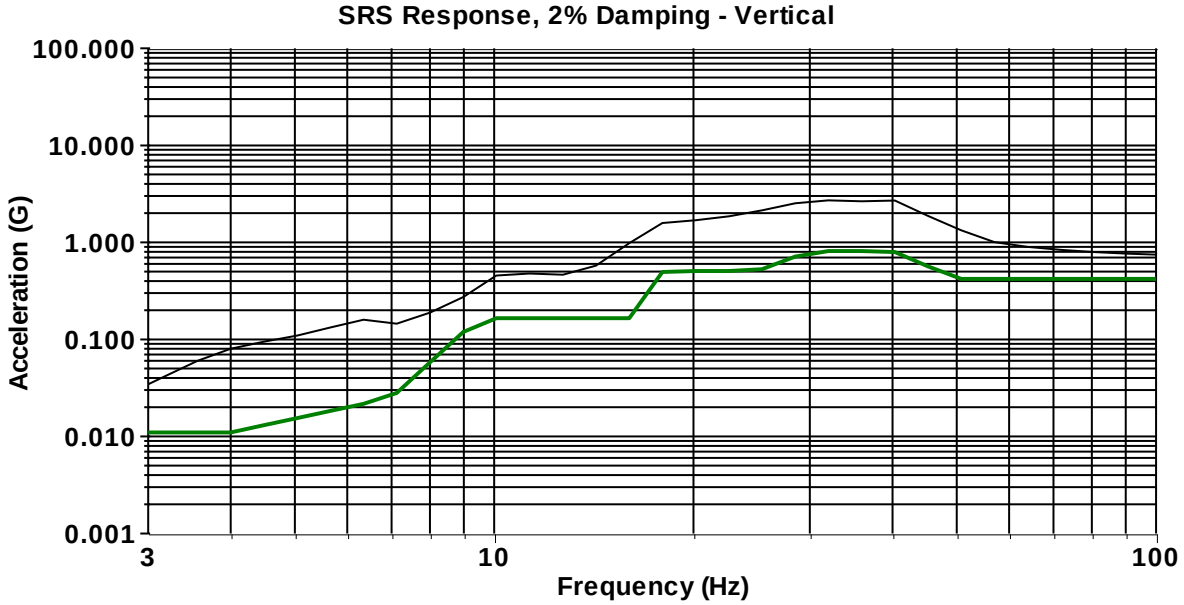
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 4 Safety Relief Valve Testing (SRV) Oct 29, 2013 10:01:46
Pulse: 610 of 2850

ZPA: -0.6755 G



4634 LED unit Front to Back Response

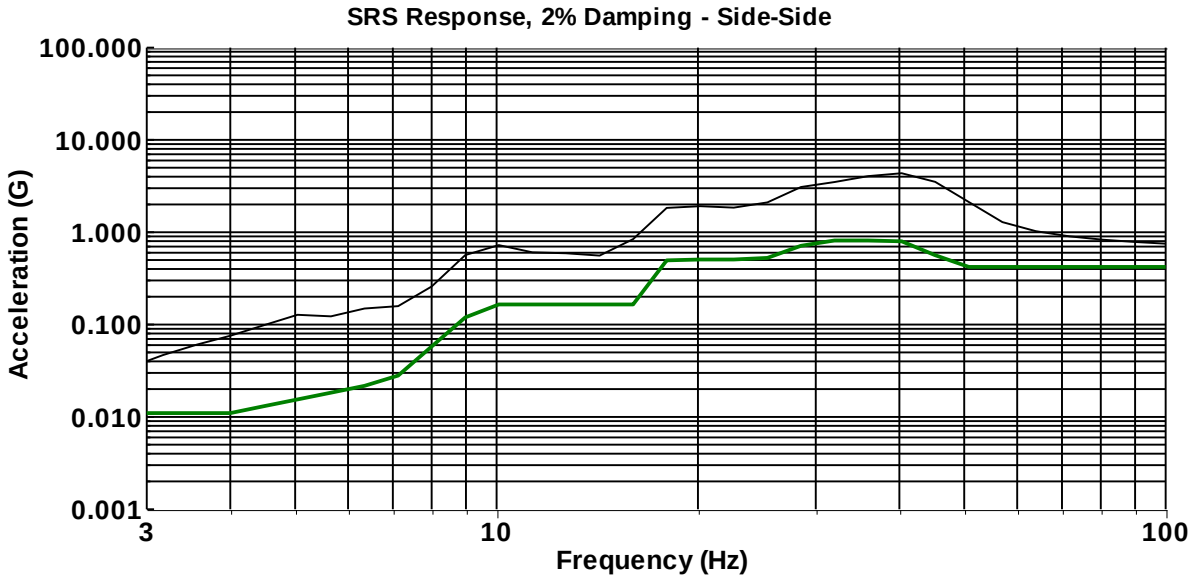
ZPA: 0.6764 G



4634 LED unit Vertical Response

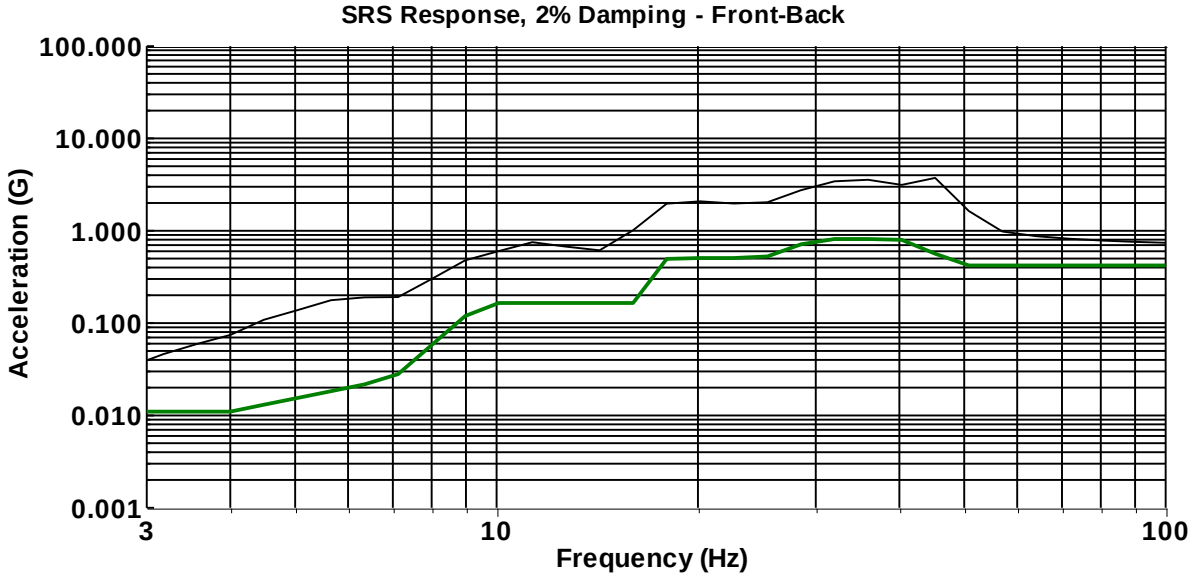
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 4 Safety Relief Valve Testing (SRV) Oct 29, 2013 10:01:46
Pulse: 610 of 2850

ZPA: -0.6776 G



4634 LED unit Side to Side Response

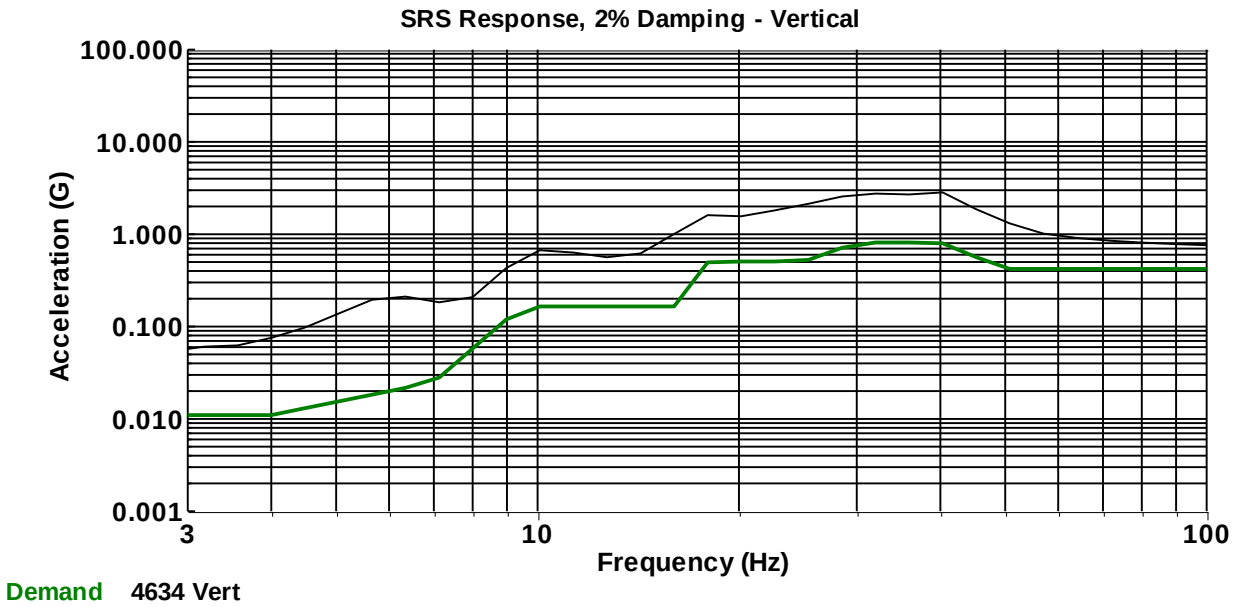
ZPA: -0.6812 G



4634 Incandescent unit Front to Back Response

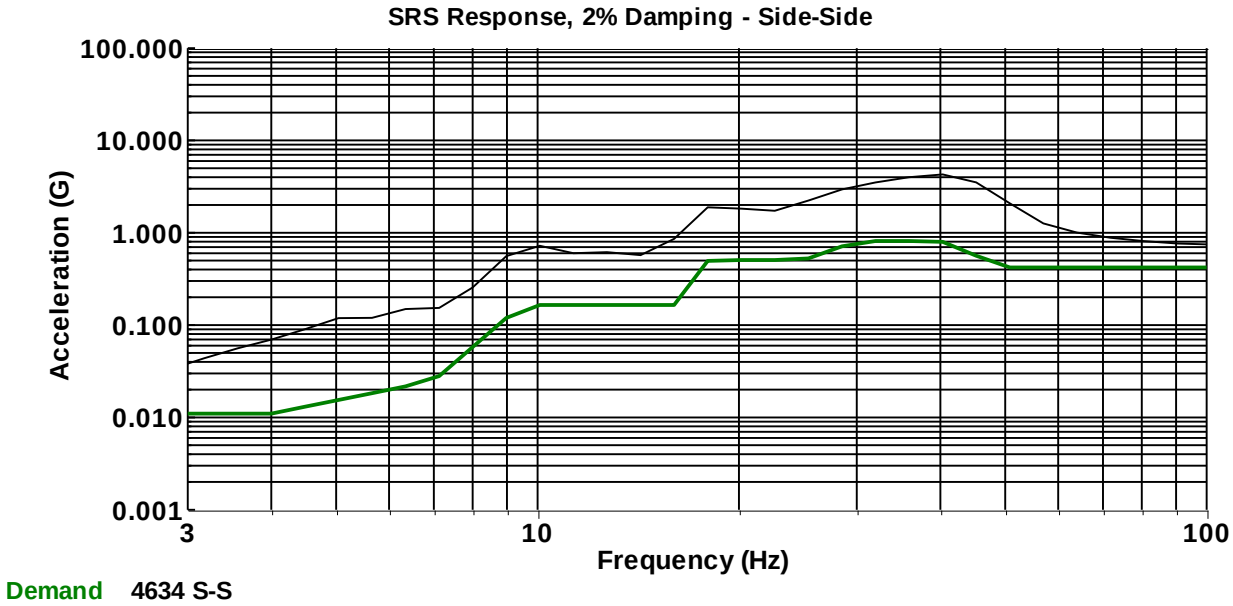
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 4 Safety Relief Valve Testing (SRV) Oct 29, 2013 10:01:46
Pulse: 610 of 2850

ZPA: 0.6887 G



4634 Incandescent unit Vertical Response

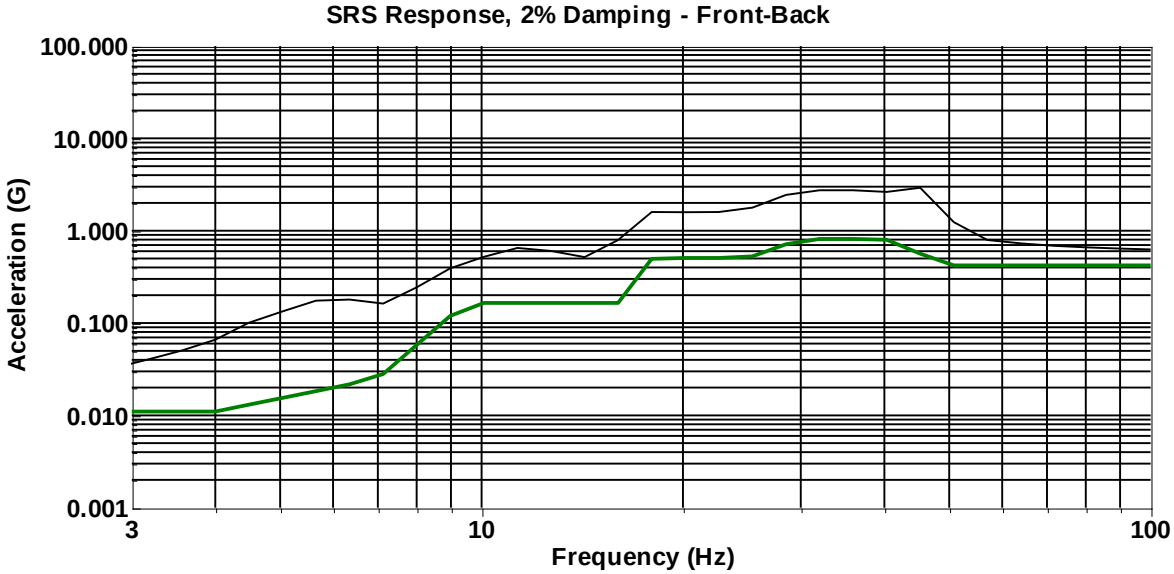
ZPA: -0.6916 G



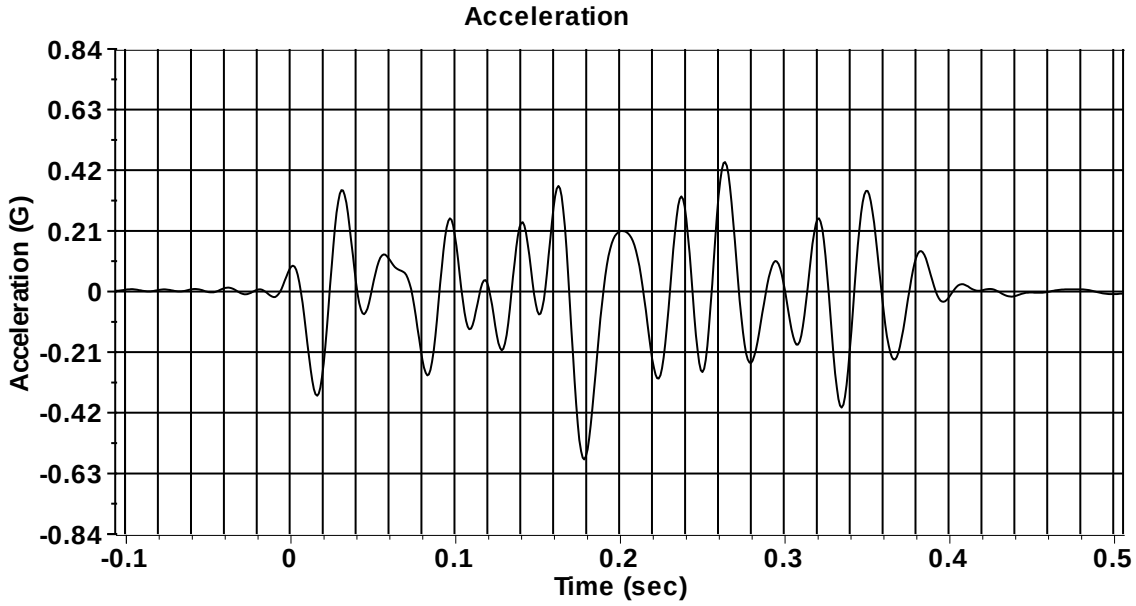
4634 Incandescent unit Side to Side Response

BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 4 Safety Relief Valve Testing (SRV) Oct 29, 2013 10:01:46
Pulse: 610 of 2850

ZPA: -0.5817 G

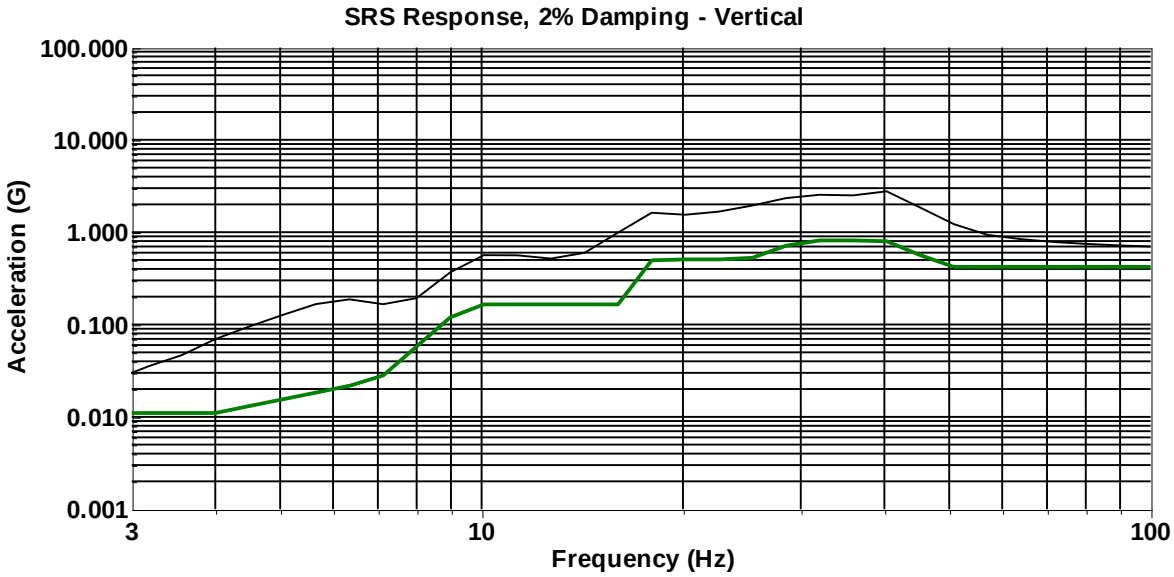


Front to Back Axis Control



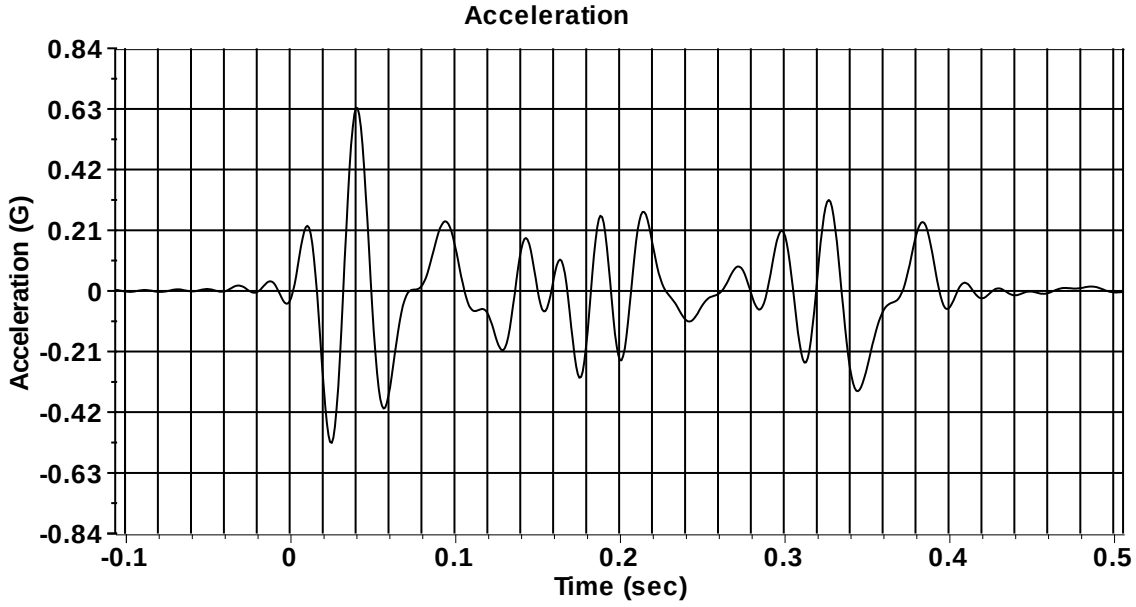
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 4 Safety Relief Valve Testing (SRV) Oct 29, 2013 10:47:10
Pulse: 1425 of 2850

ZPA: 0.634 G



Demand **Vertical**

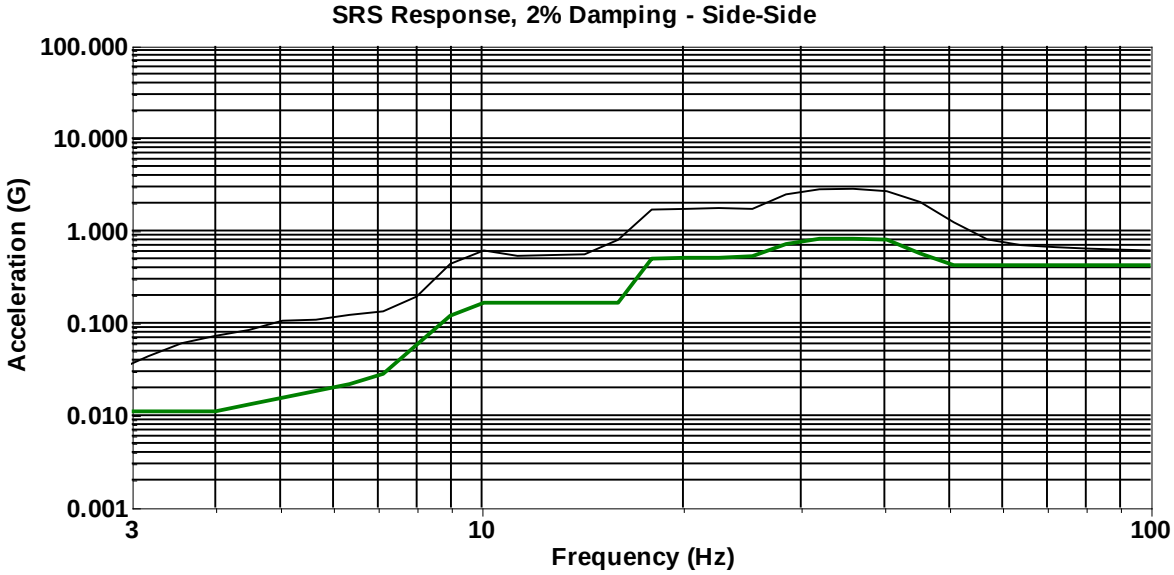
Vertical Axis Control



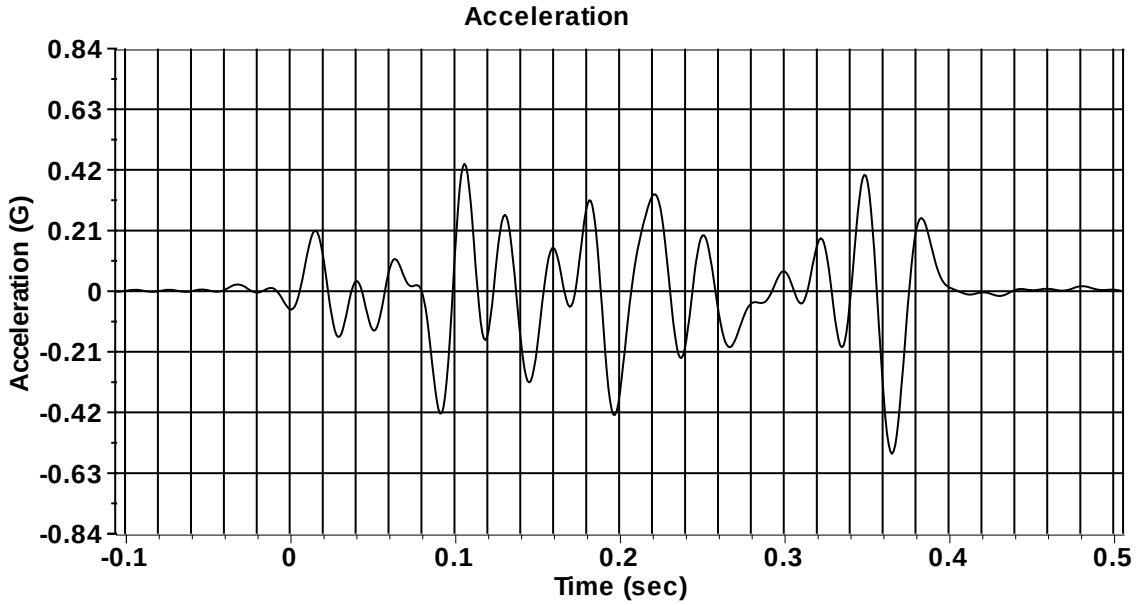
Vertical

BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 4 Safety Relief Valve Testing (SRV) Oct 29, 2013 10:47:10
Pulse: 1425 of 2850

ZPA: -0.5634 G

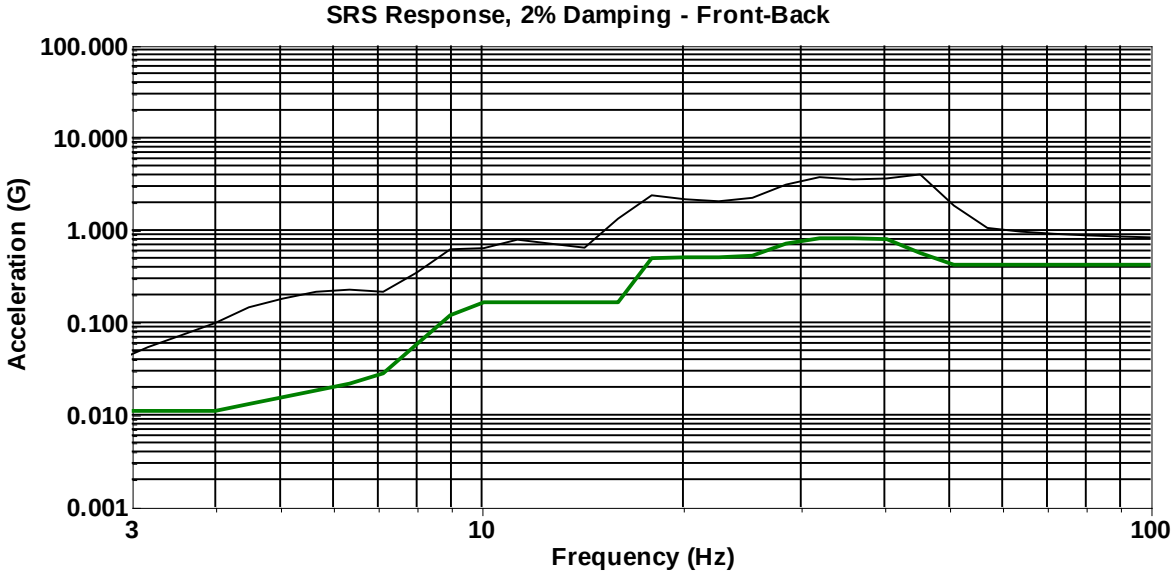


Side to Side Axis Control



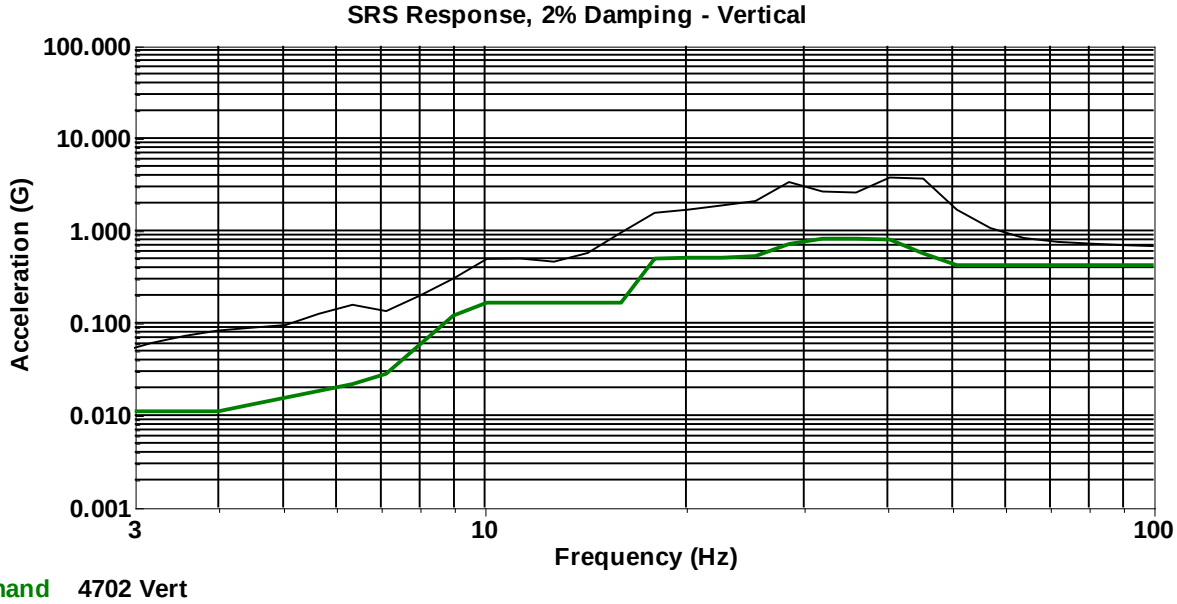
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 4 Safety Relief Valve Testing (SRV) Oct 29, 2013 10:47:10
Pulse: 1425 of 2850

ZPA: -0.771 G



4702 unit Front to Back Response

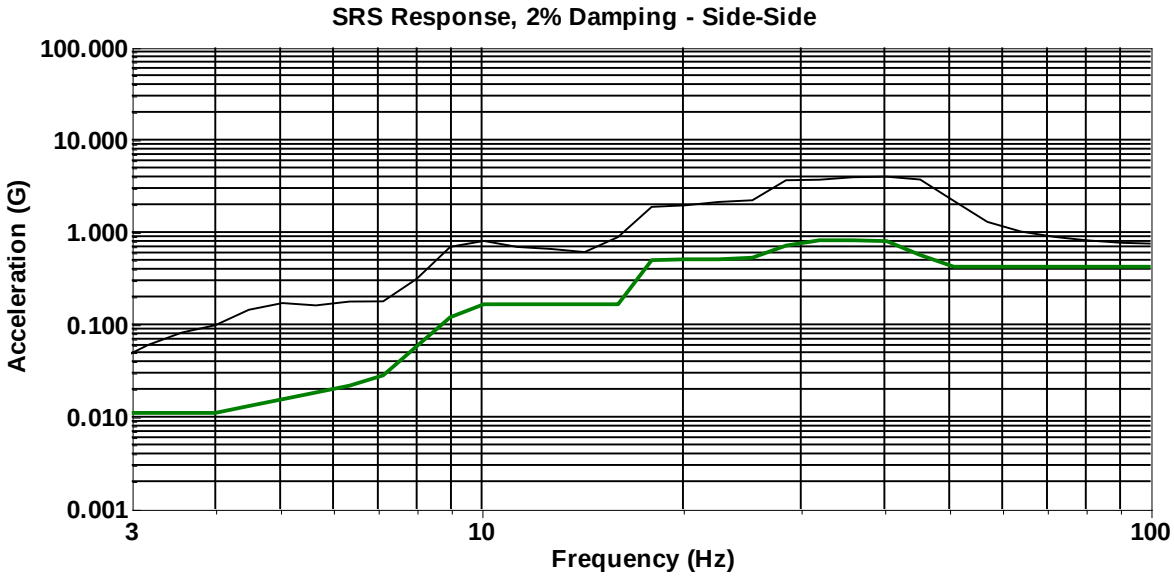
ZPA: 0.6141 G



4702 unit Vertical Response

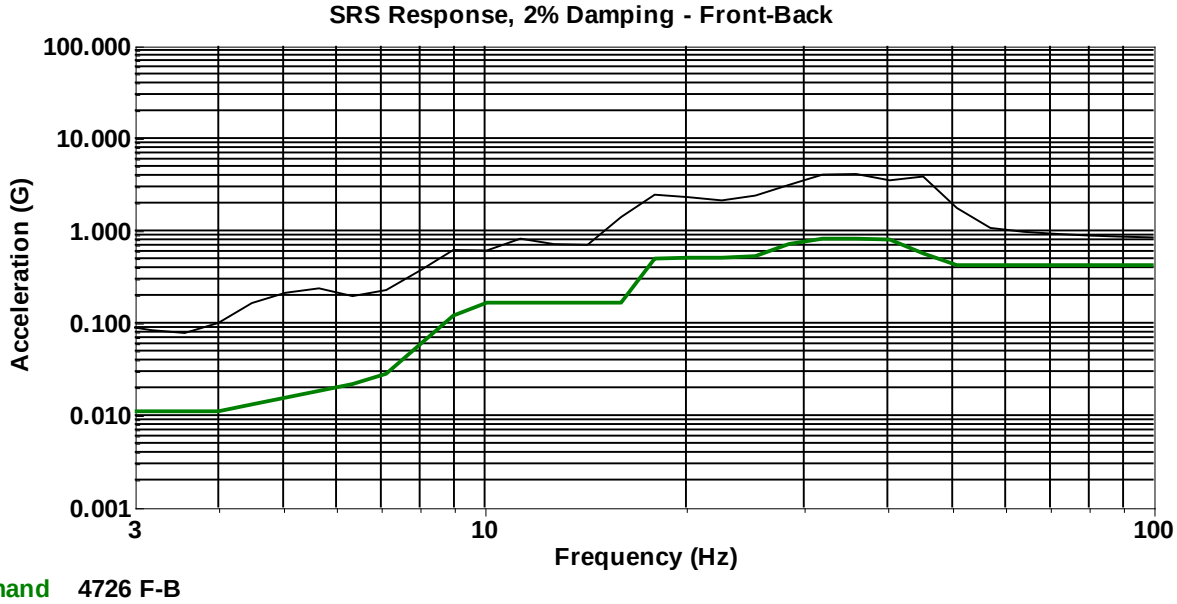
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 4 Safety Relief Valve Testing (SRV) Oct 29, 2013 10:47:10
Pulse: 1425 of 2850

ZPA: -0.696 G



4702 unit Side to Side Response

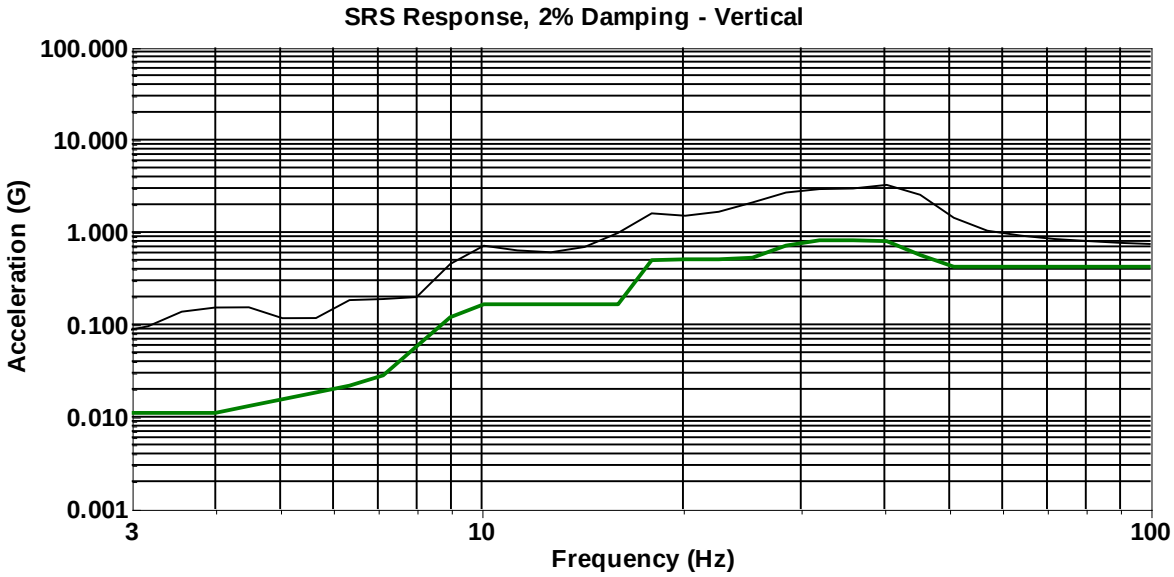
ZPA: -0.7795 G



4726 unit Front to Back Response

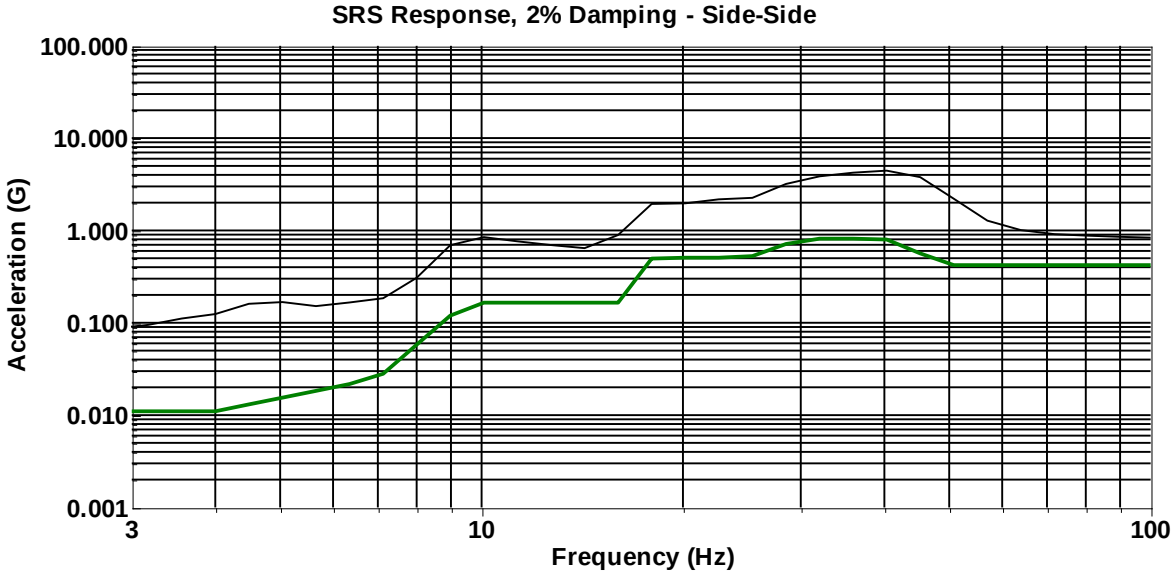
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 4 Safety Relief Valve Testing (SRV) Oct 29, 2013 10:47:10
Pulse: 1425 of 2850

ZPA: 0.6646 G



4726 unit Vertical Response

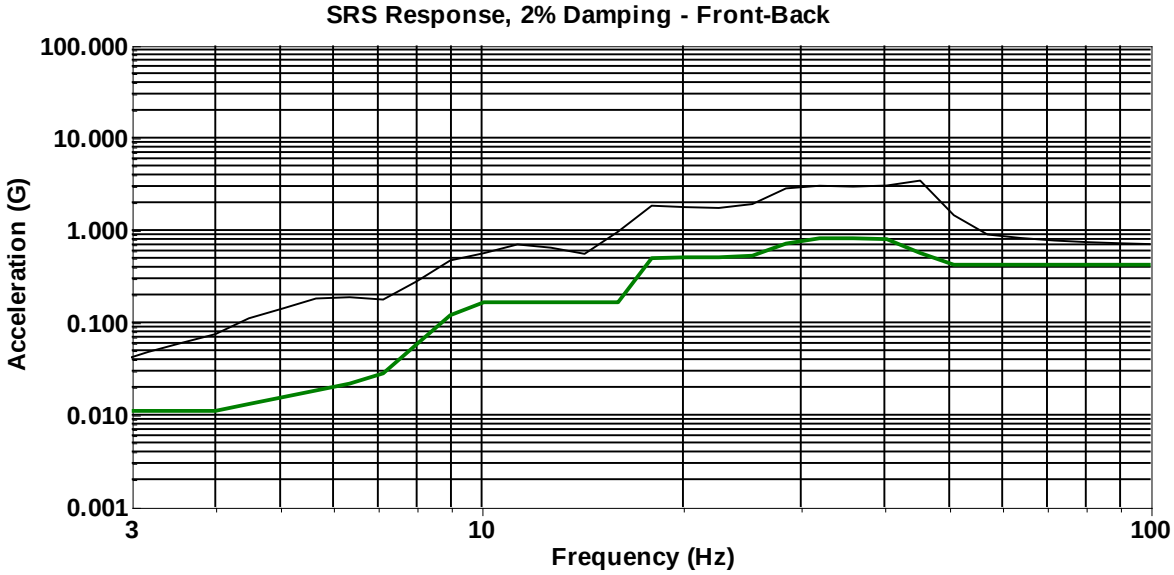
ZPA: -0.7706 G



4726 unit Side to Side Response

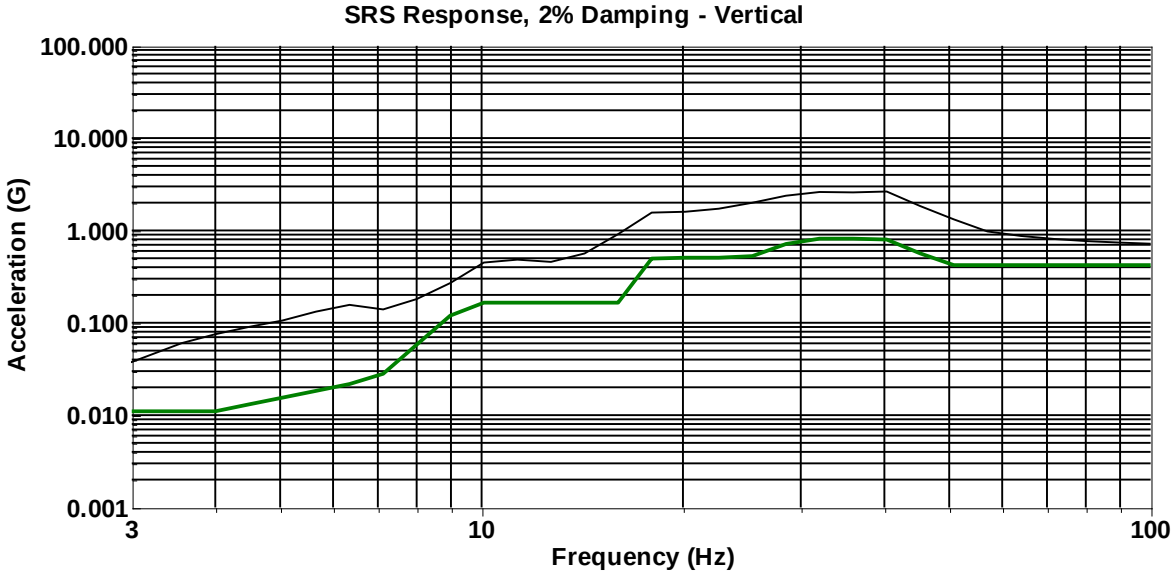
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 4 Safety Relief Valve Testing (SRV) Oct 29, 2013 10:47:10
Pulse: 1425 of 2850

ZPA: -0.6512 G



4634 LED unit Front to Back Response

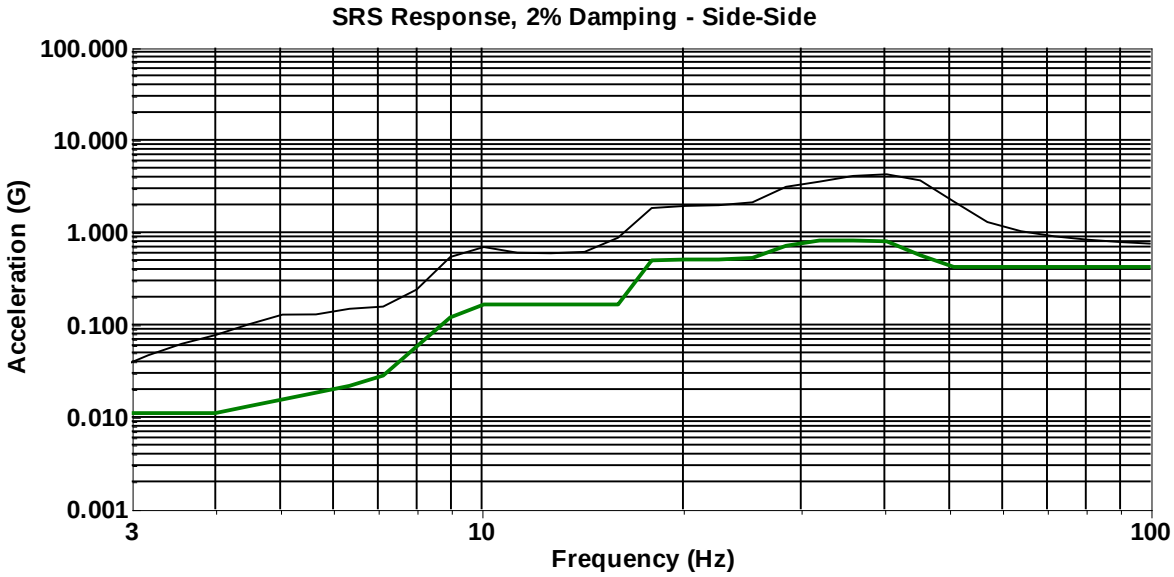
ZPA: 0.6493 G



4634 LED unit Vertical Response

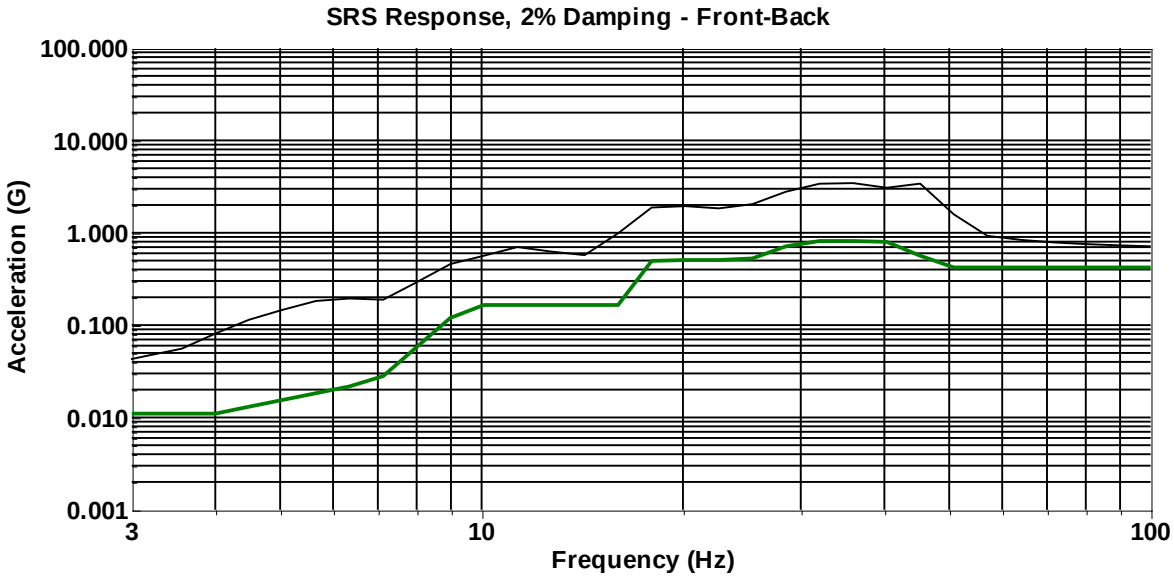
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 4 Safety Relief Valve Testing (SRV) Oct 29, 2013 10:47:10
Pulse: 1425 of 2850

ZPA: -0.6862 G



4634 LED unit Side to Side Response

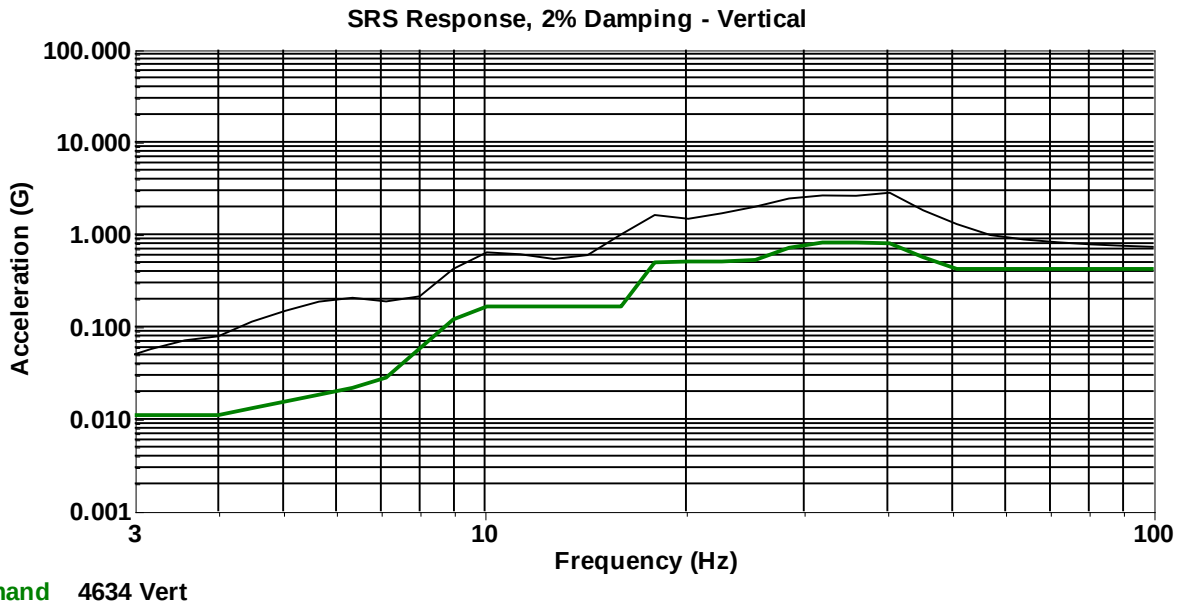
ZPA: -0.66 G



4634 Incandescent unit Front to Back Response

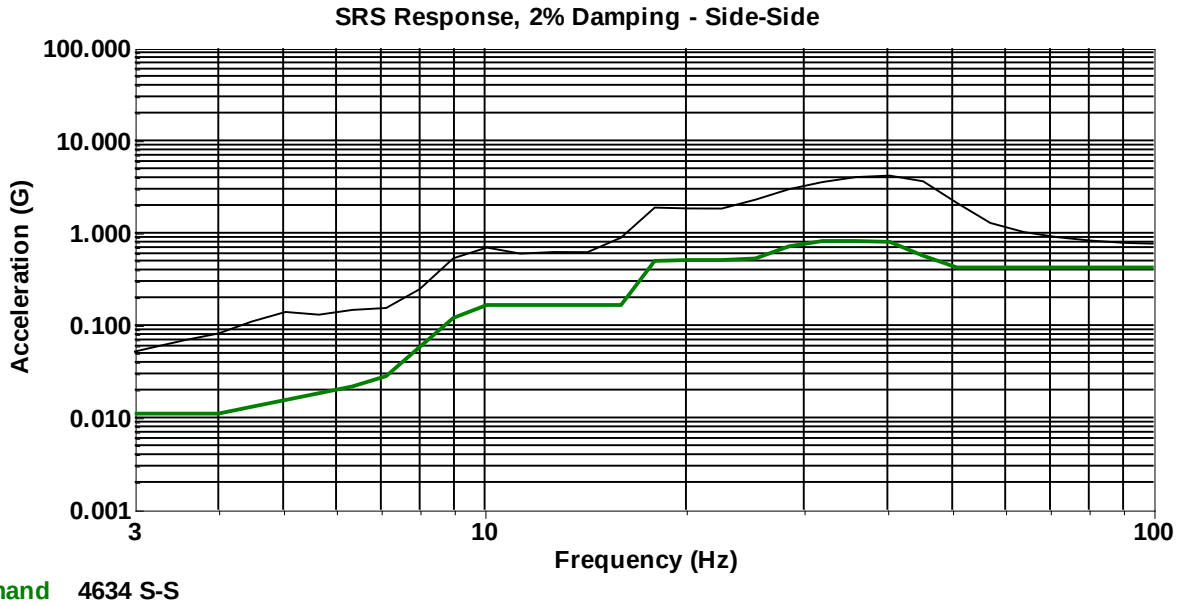
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 4 Safety Relief Valve Testing (SRV) Oct 29, 2013 10:47:10
Pulse: 1425 of 2850

ZPA: 0.6609 G



4634 Incandescent unit Vertical Response

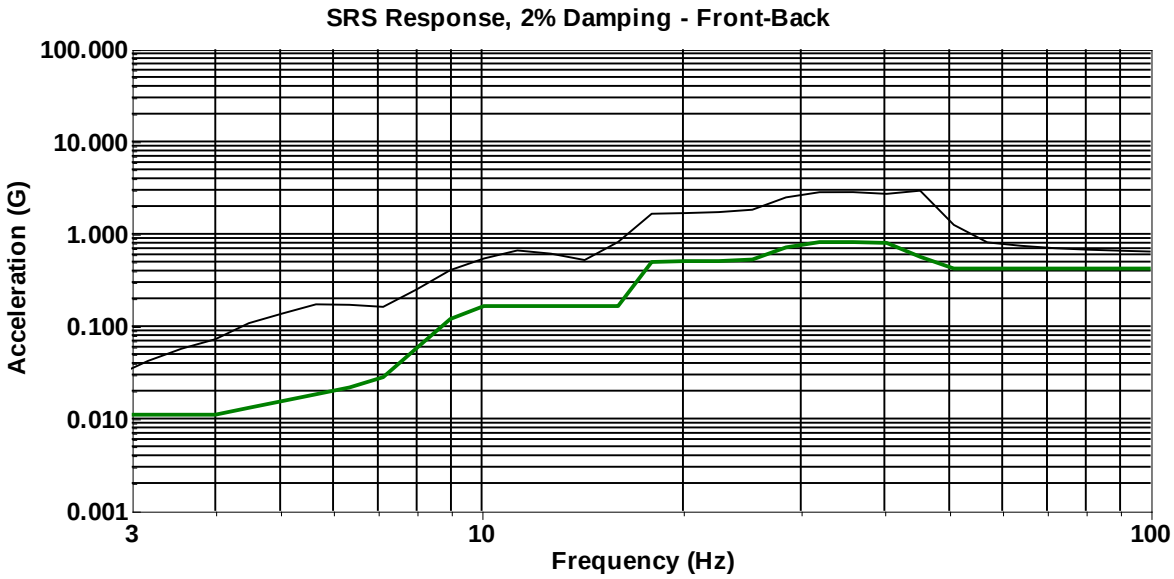
ZPA: -0.7037 G



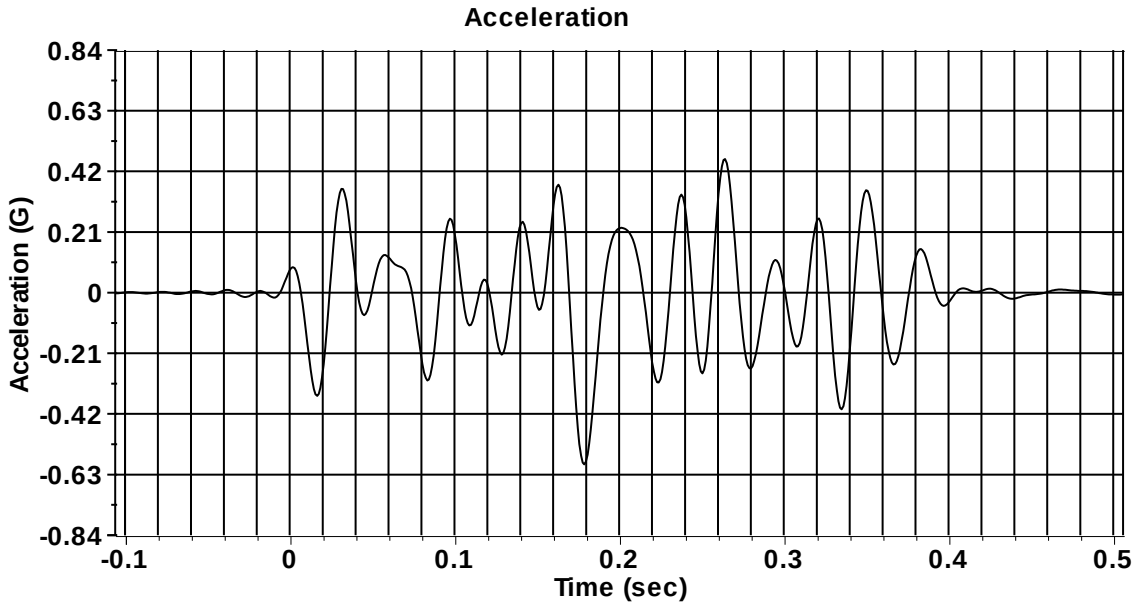
4634 Incandescent unit Side to Side Response

BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 4 Safety Relief Valve Testing (SRV) Oct 29, 2013 10:47:10
Pulse: 1425 of 2850

ZPA: -0.5953 G

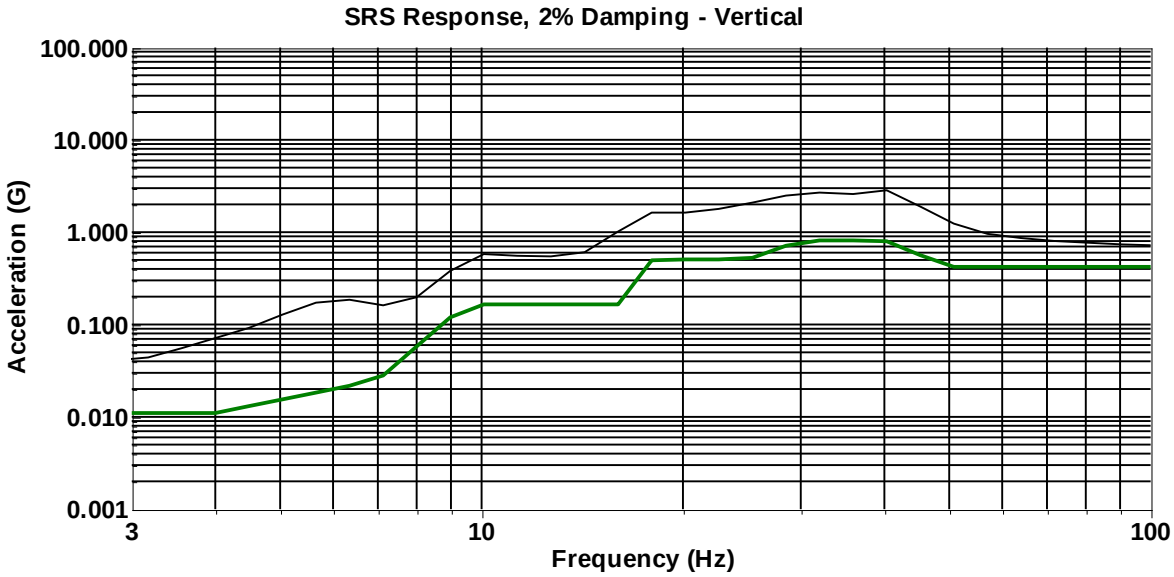


Front to Back Axis Control



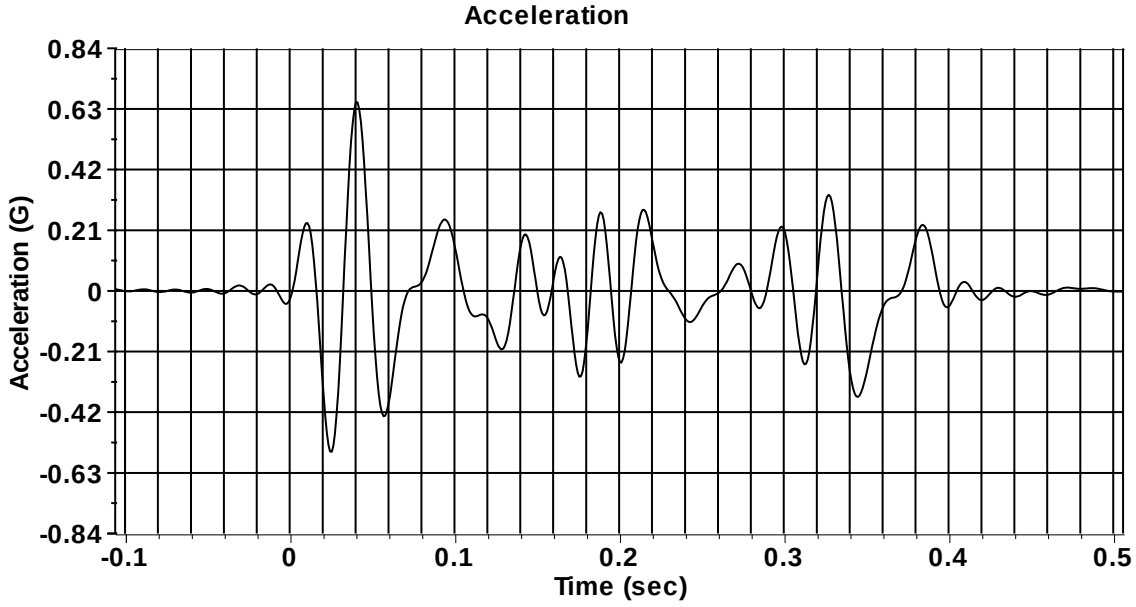
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 4 Safety Relief Valve Testing (SRV) Oct 29, 2013 11:52:23
Pulse: 2280 of 2850

ZPA: 0.6533 G



Demand **Vertical**

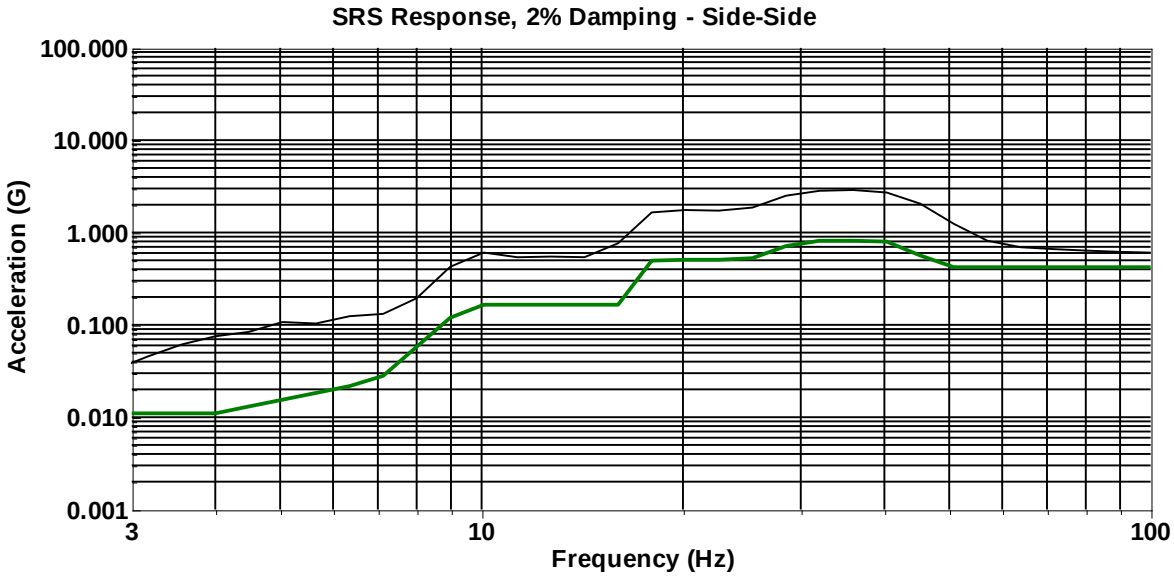
Vertical Axis Control



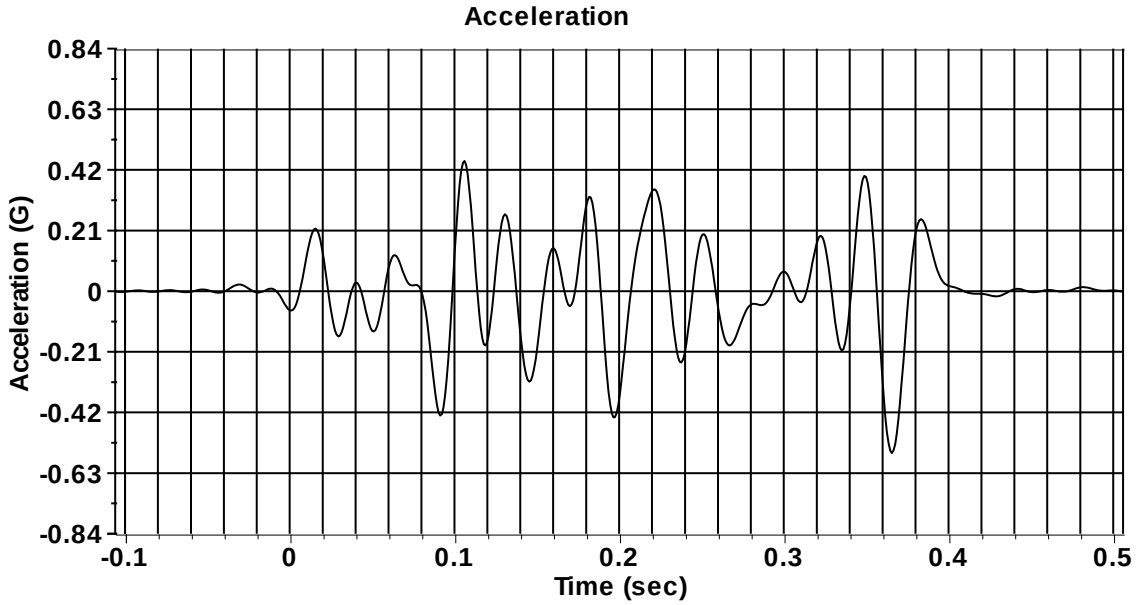
Vertical

BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 4 Safety Relief Valve Testing (SRV) Oct 29, 2013 11:52:23
Pulse: 2280 of 2850

ZPA: -0.5607 G

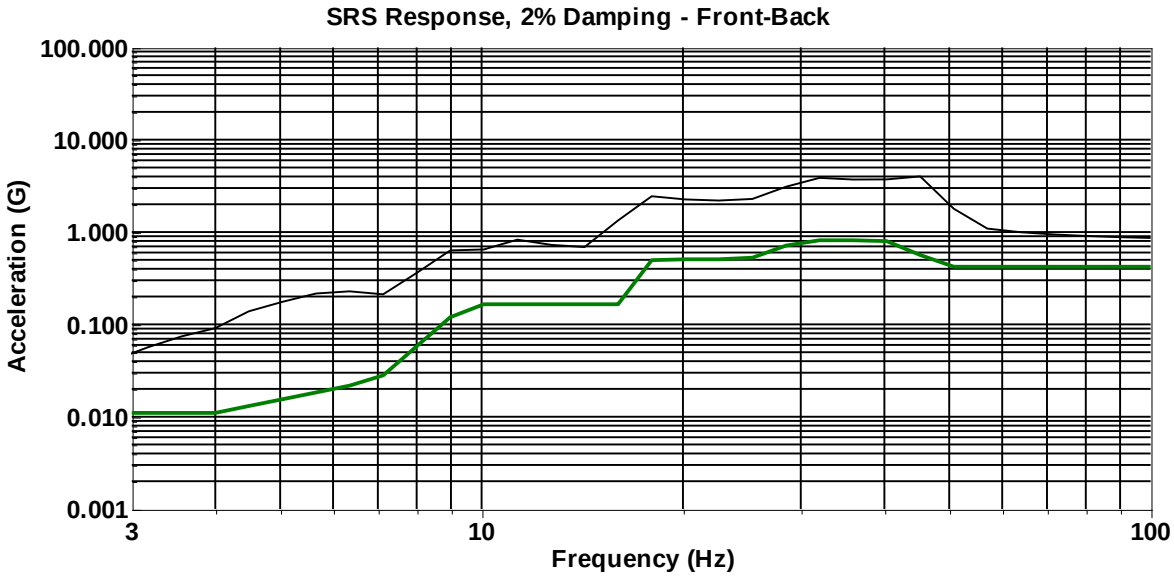


Side to Side Axis Control



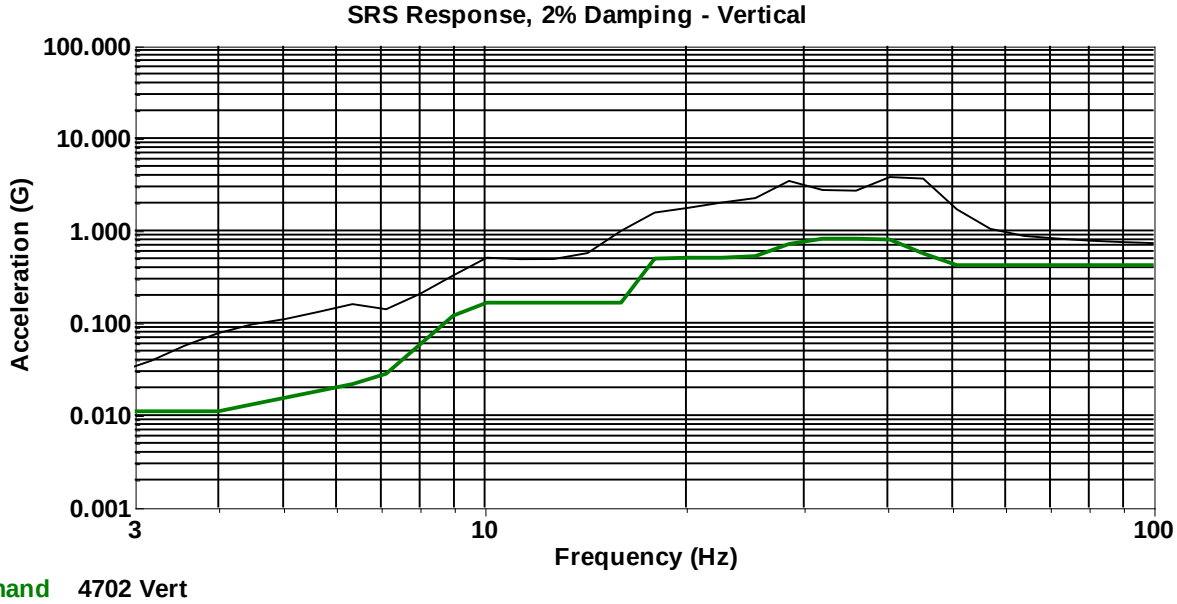
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 4 Safety Relief Valve Testing (SRV) Oct 29, 2013 11:52:23
Pulse: 2280 of 2850

ZPA: -0.7974 G



4702 unit Front to Back Response

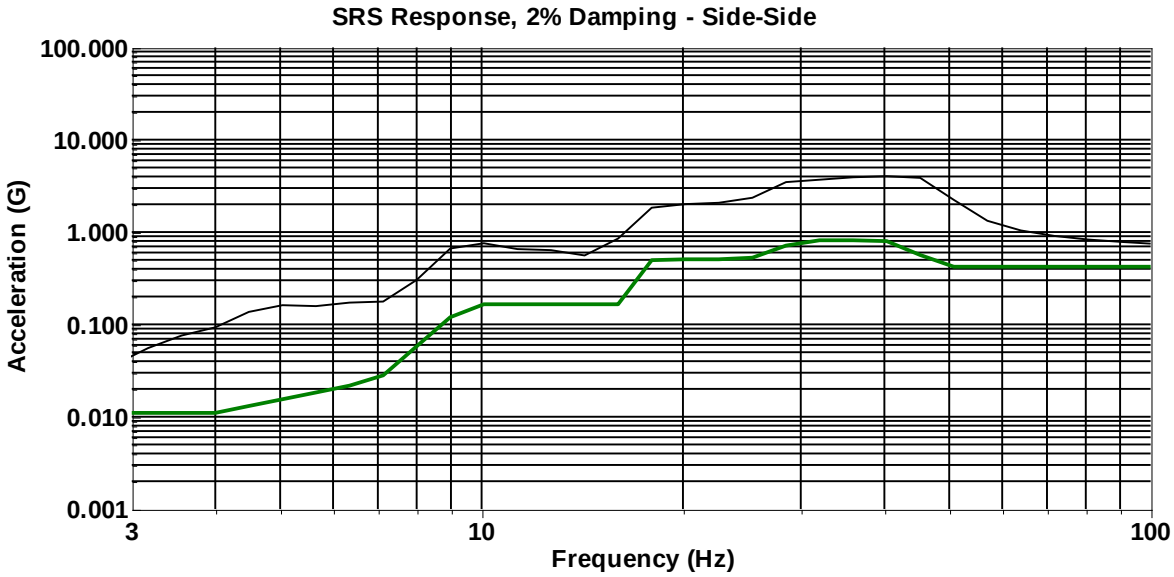
ZPA: 0.6605 G



4702 unit Vertical Response

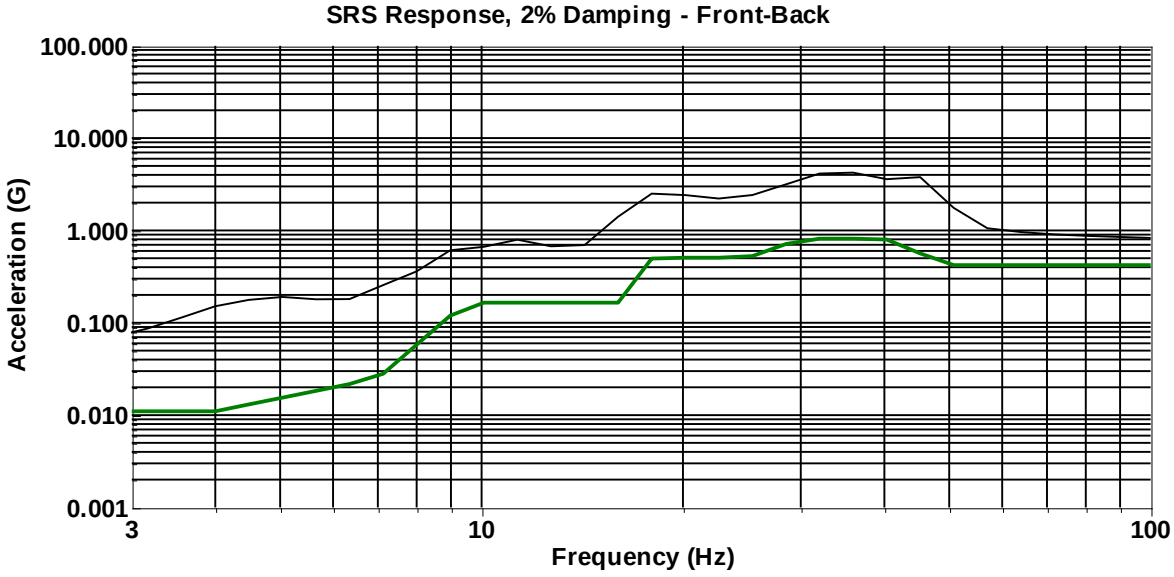
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 4 Safety Relief Valve Testing (SRV) Oct 29, 2013 11:52:23
Pulse: 2280 of 2850

ZPA: -0.6817 G



4702 unit Side to Side Response

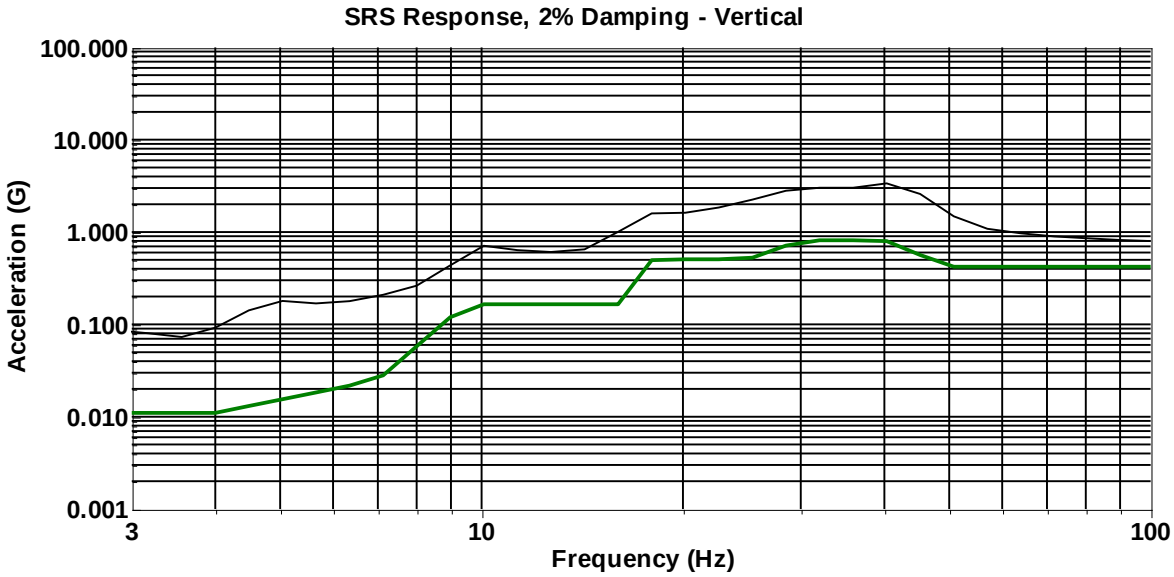
ZPA: -0.7687 G



4726 unit Front to Back Response

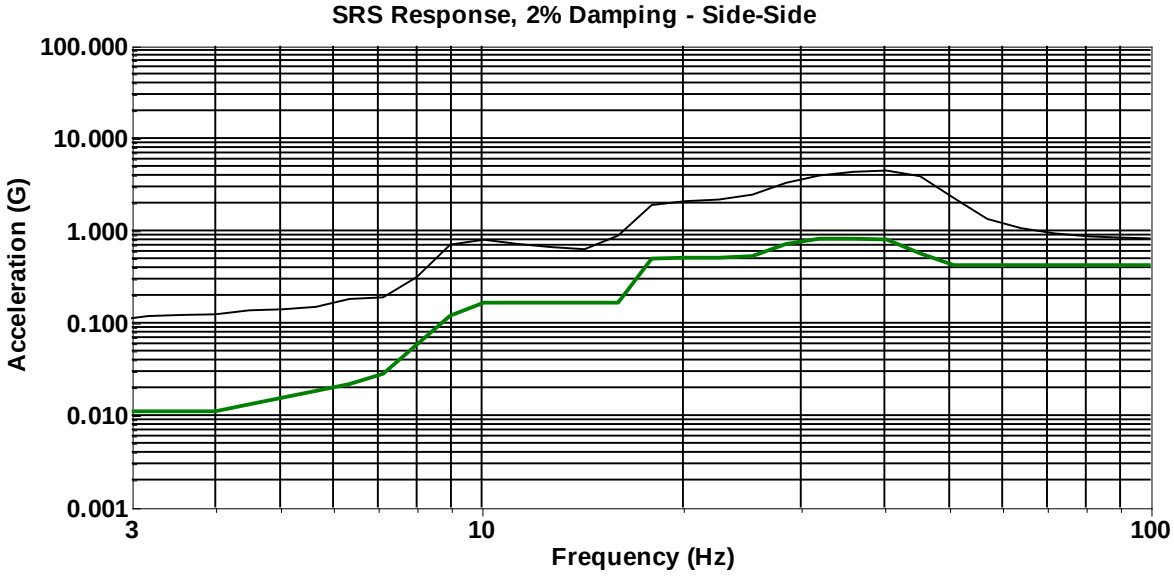
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 4 Safety Relief Valve Testing (SRV) Oct 29, 2013 11:52:23
Pulse: 2280 of 2850

ZPA: 0.7196 G



4726 unit Vertical Response

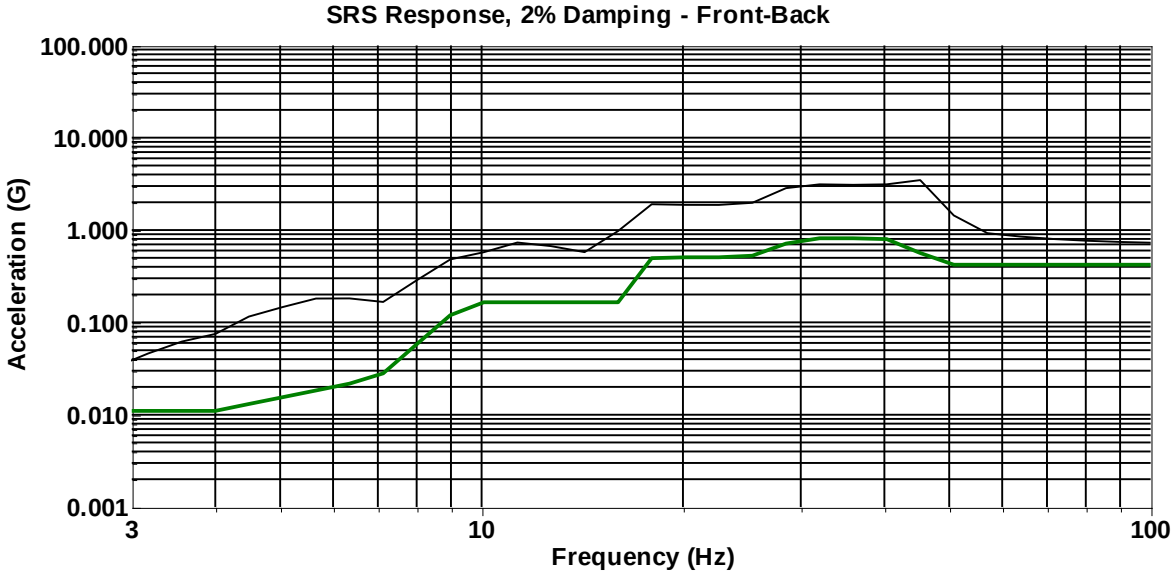
ZPA: -0.7538 G



4726 unit Side to Side Response

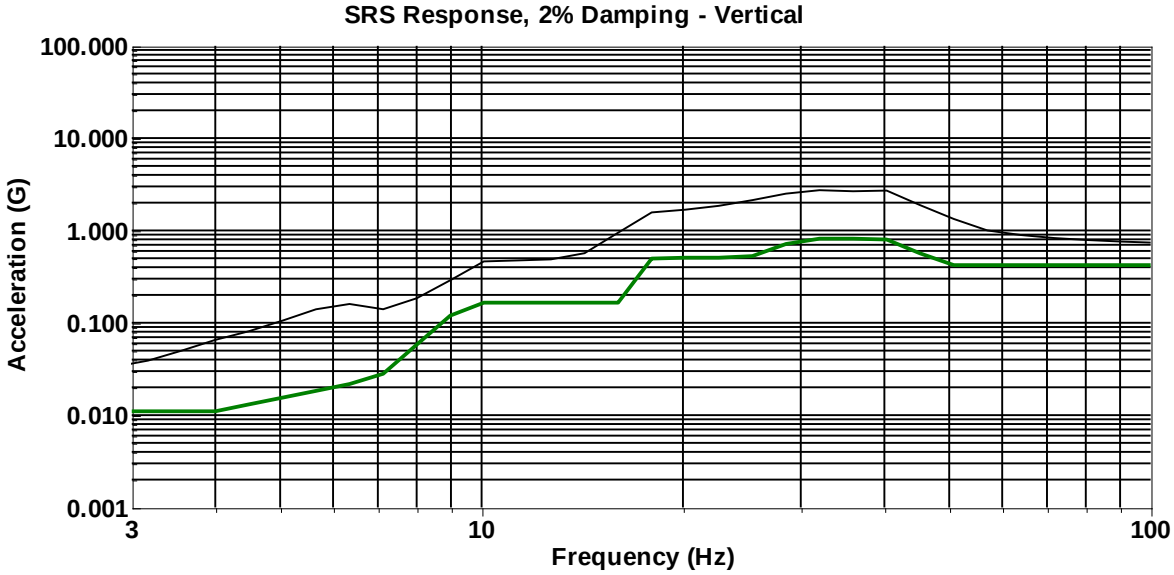
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 4 Safety Relief Valve Testing (SRV) Oct 29, 2013 11:52:23
Pulse: 2280 of 2850

ZPA: -0.6745 G



4634 LED unit Front to Back Response

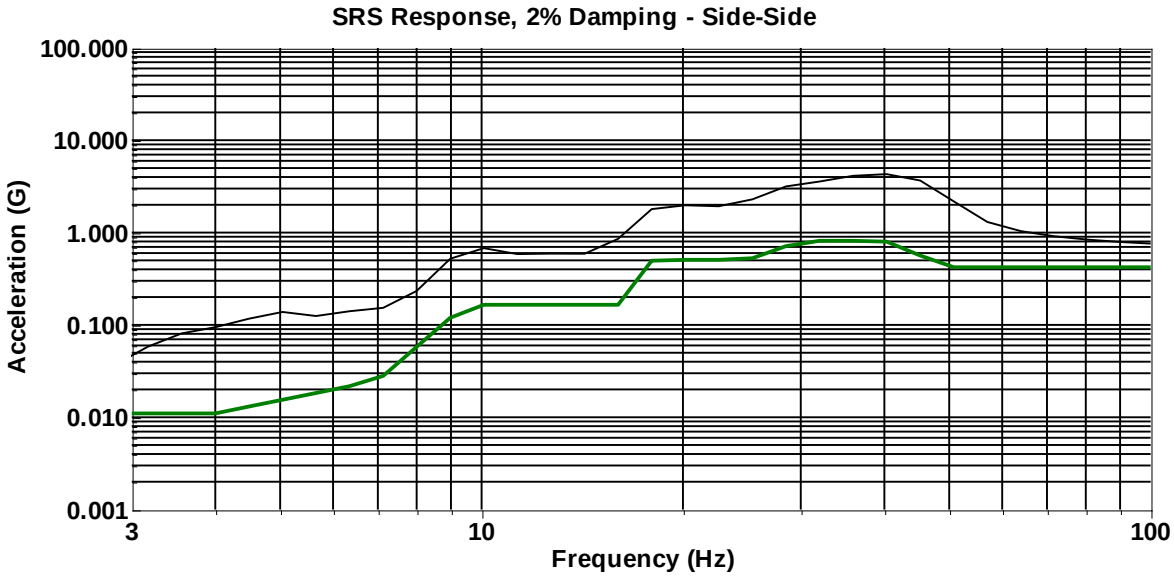
ZPA: 0.6694 G



4634 LED unit Vertical Response

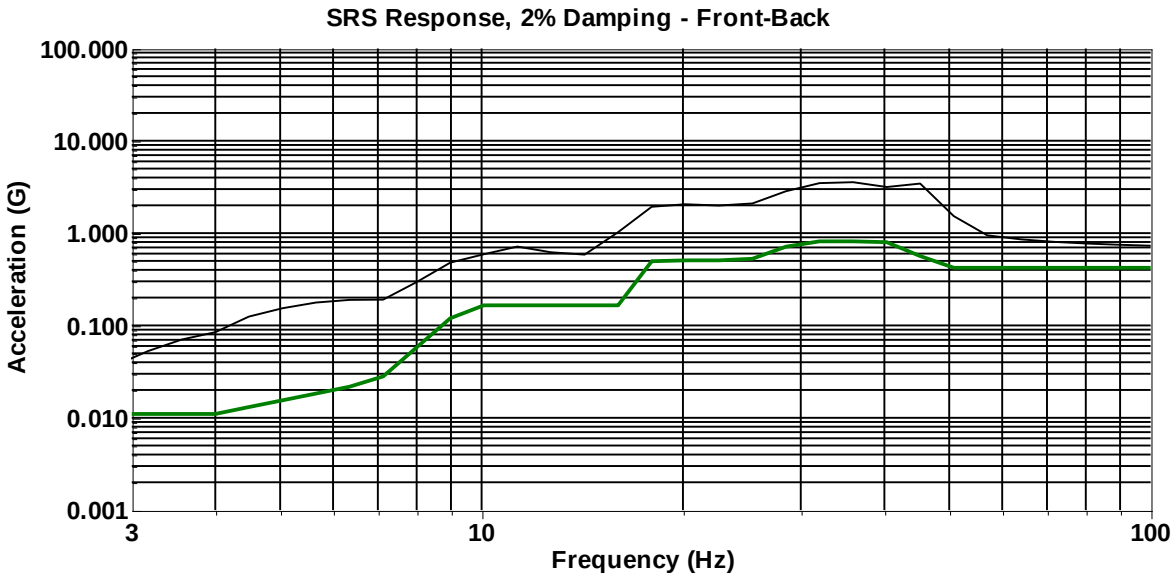
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 4 Safety Relief Valve Testing (SRV) Oct 29, 2013 11:52:23
Pulse: 2280 of 2850

ZPA: -0.6826 G



4634 LED unit Side to Side Response

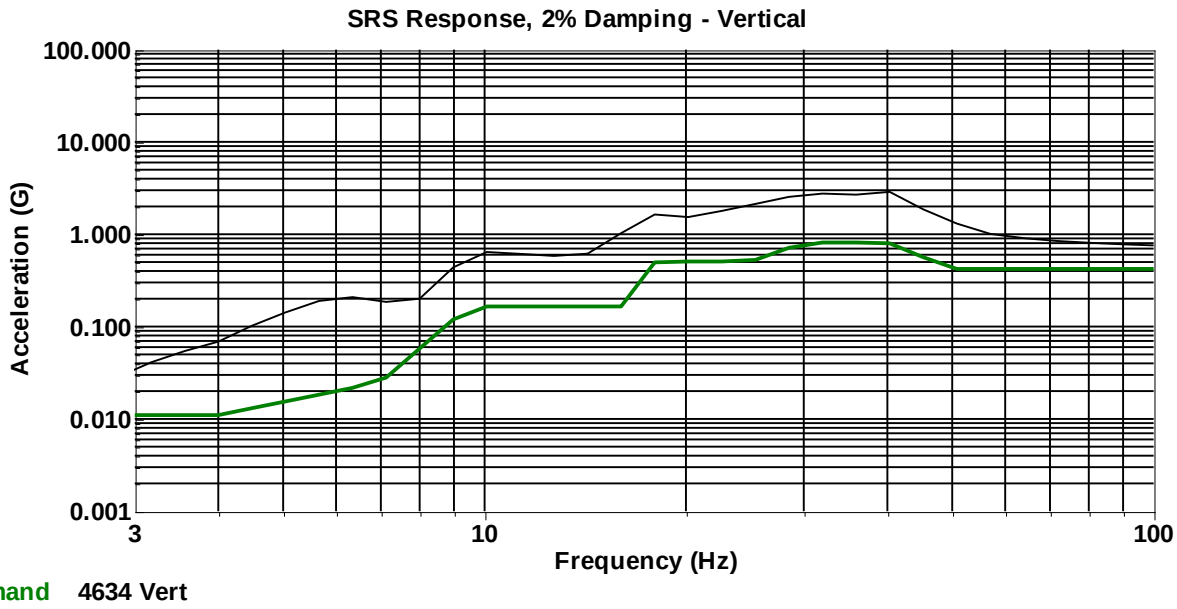
ZPA: -0.6766 G



4634 Incandescent unit Front to Back Response

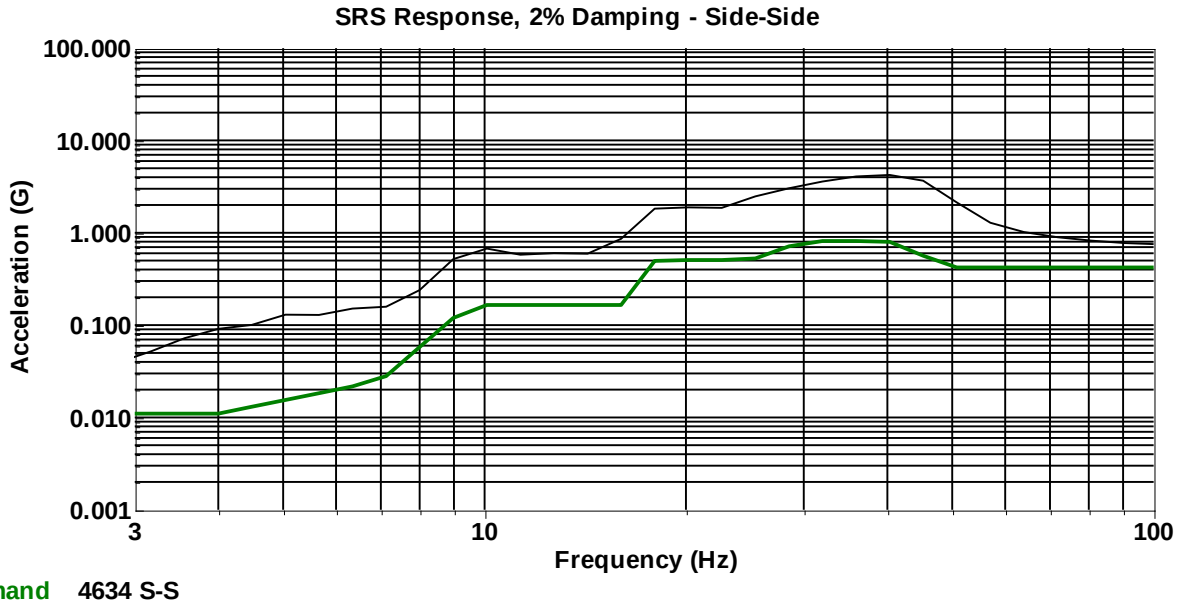
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 4 Safety Relief Valve Testing (SRV) Oct 29, 2013 11:52:23
Pulse: 2280 of 2850

ZPA: 0.6869 G



4634 Incandescent unit Vertical Response

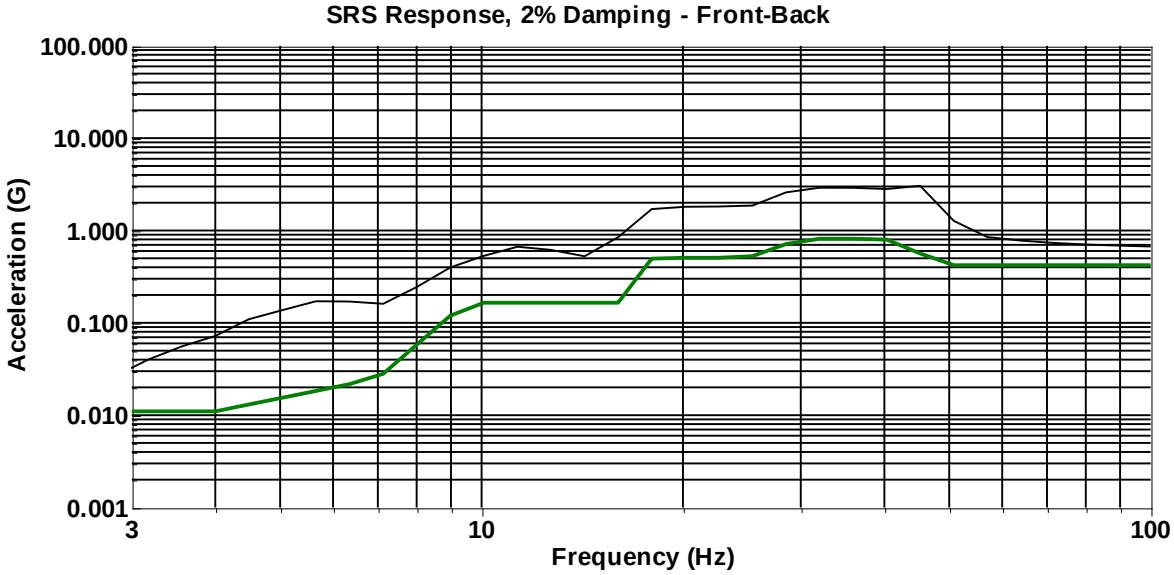
ZPA: -0.6941 G



4634 Incandescent unit Side to Side Response

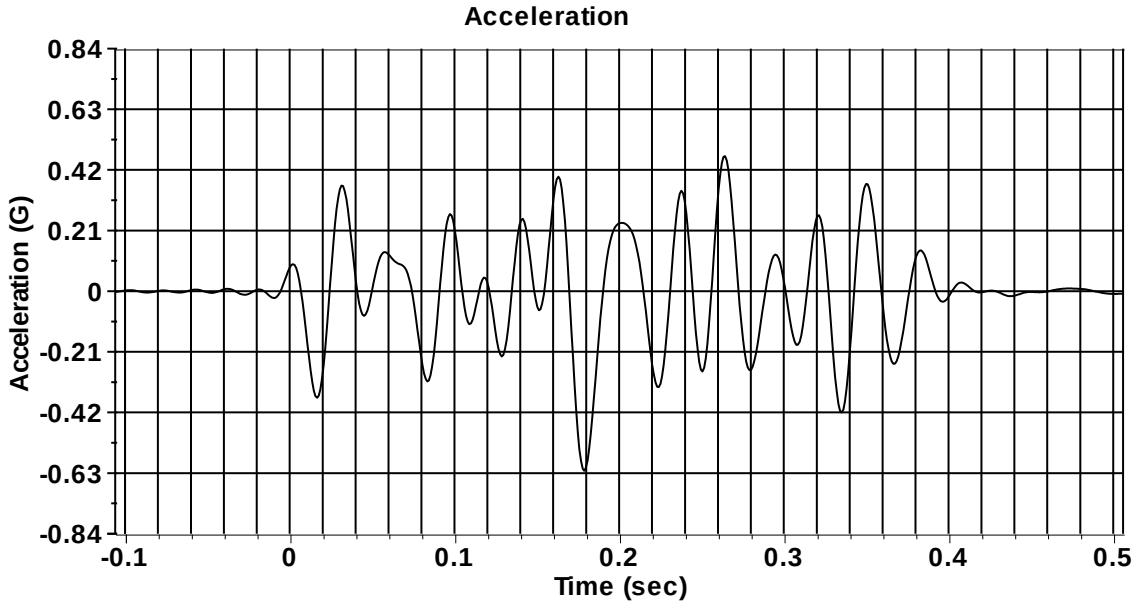
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 4 Safety Relief Valve Testing (SRV) Oct 29, 2013 11:52:23
Pulse: 2280 of 2850

ZPA: -0.622 G



Demand **Front-Back**

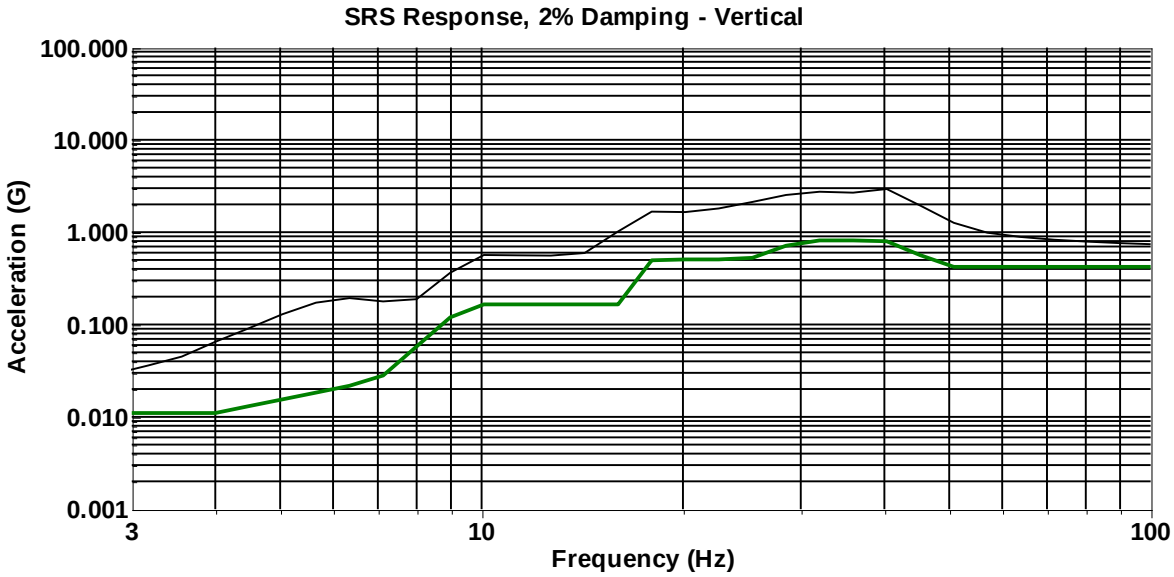
Front to Back Axis Control



Front-Back

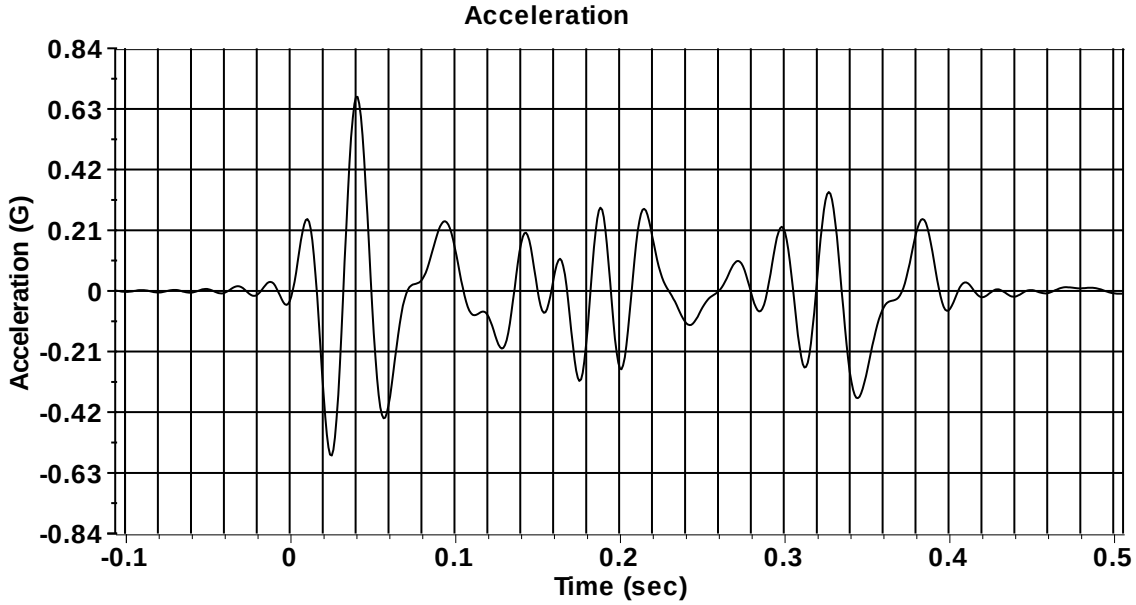
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 4 Safety Relief Valve Testing (SRV) Oct 29, 2013 12:25:46
Pulse: 2850 of 2850

ZPA: 0.6716 G



Demand **Vertical**

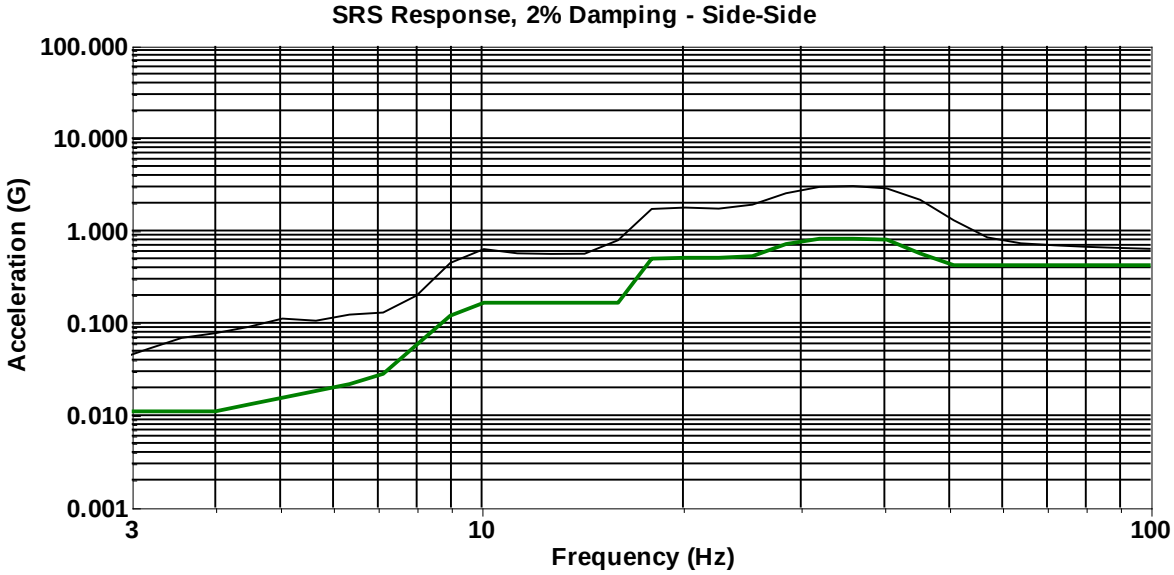
Vertical Axis Control



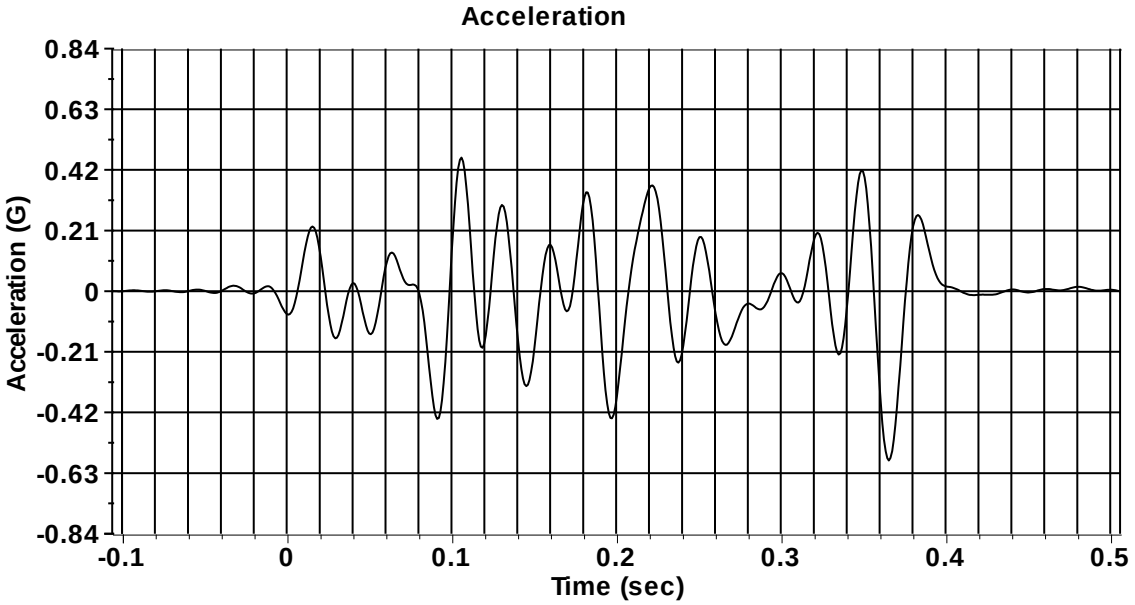
Vertical

BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 4 Safety Relief Valve Testing (SRV) Oct 29, 2013 12:25:46
Pulse: 2850 of 2850

ZPA: -0.5868 G

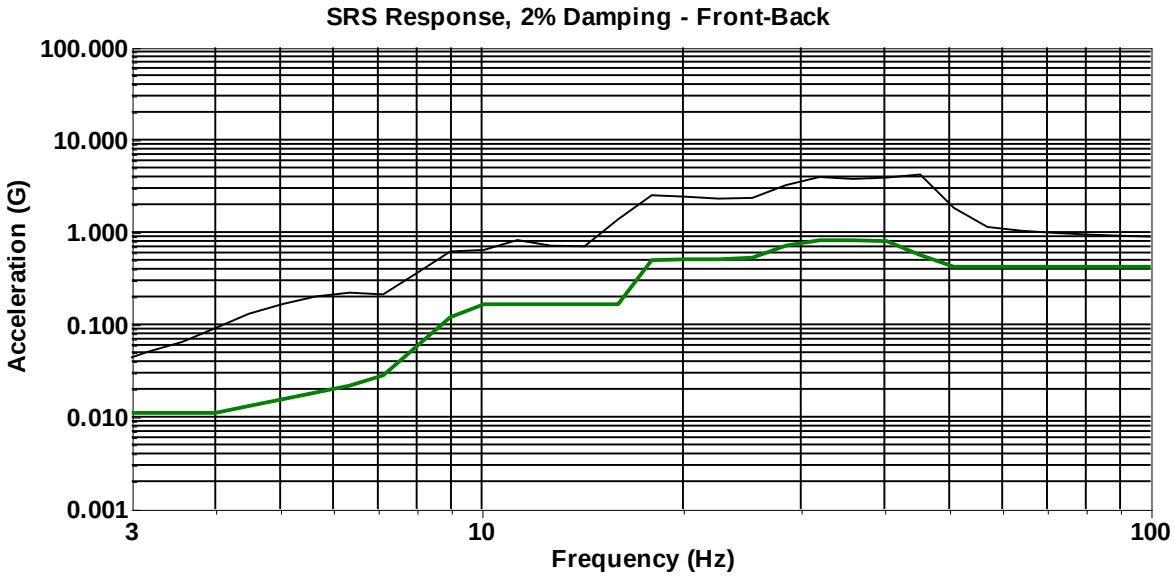


Side to Side Axis Control



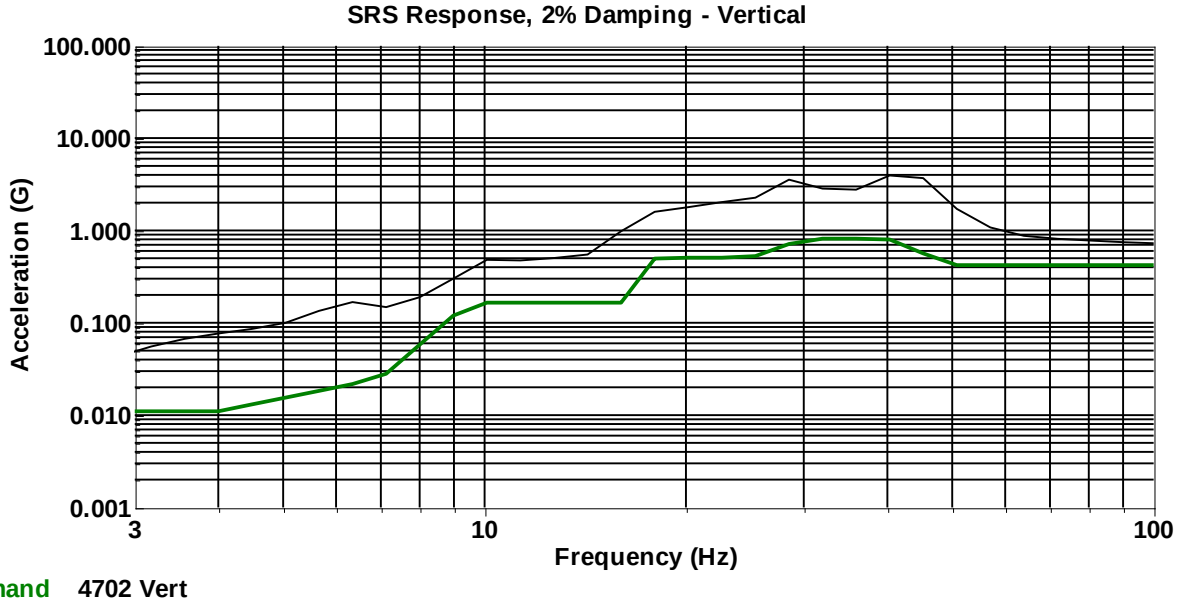
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 4 Safety Relief Valve Testing (SRV) Oct 29, 2013 12:25:46
Pulse: 2850 of 2850

ZPA: -0.8246 G



4702 unit Front to Back Response

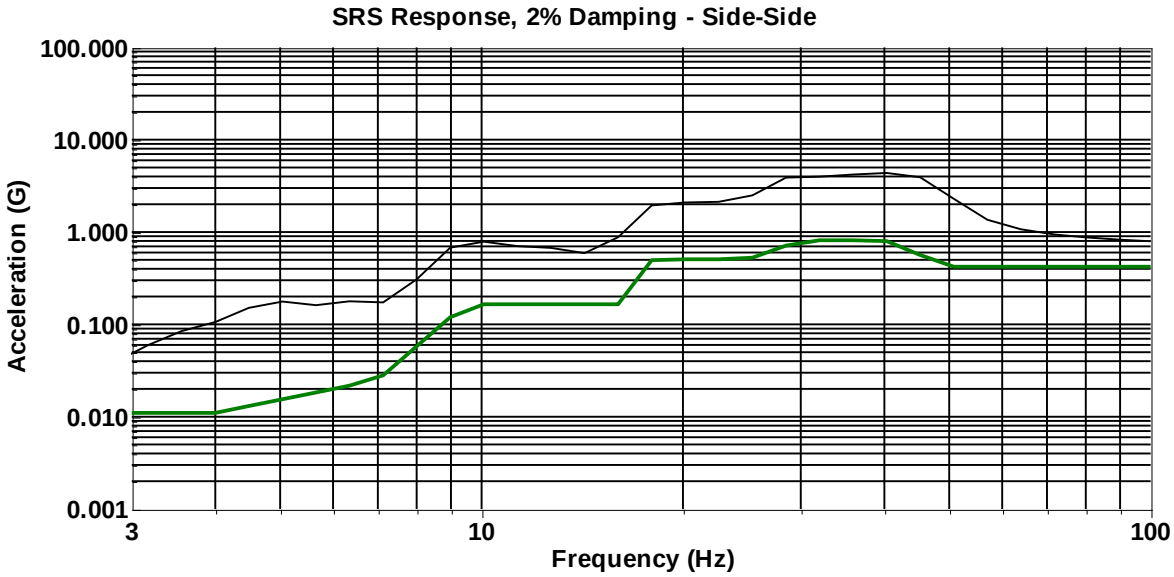
ZPA: 0.6585 G



4702 unit Vertical Response

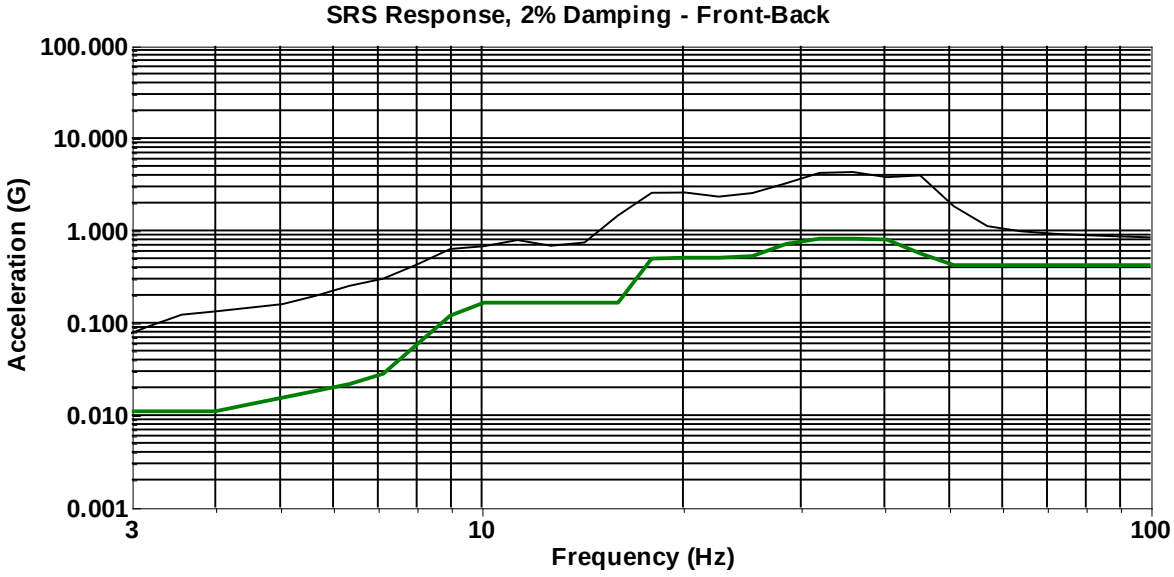
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 4 Safety Relief Valve Testing (SRV) Oct 29, 2013 12:25:46
Pulse: 2850 of 2850

ZPA: -0.7154 G



4702 unit Side to Side Response

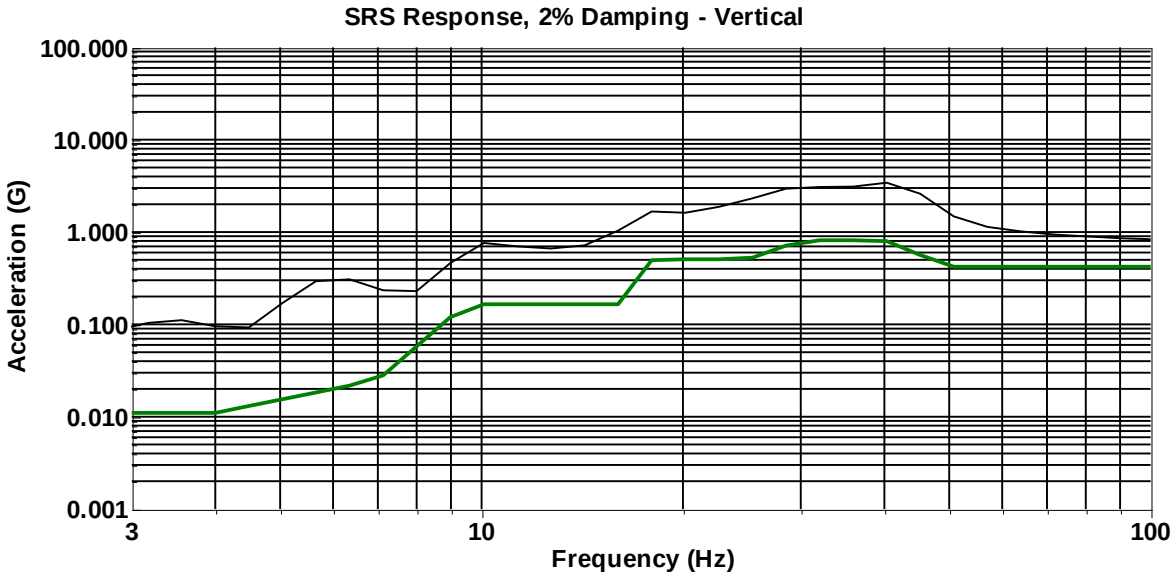
ZPA: -0.7788 G



4726 unit Front to Back Response

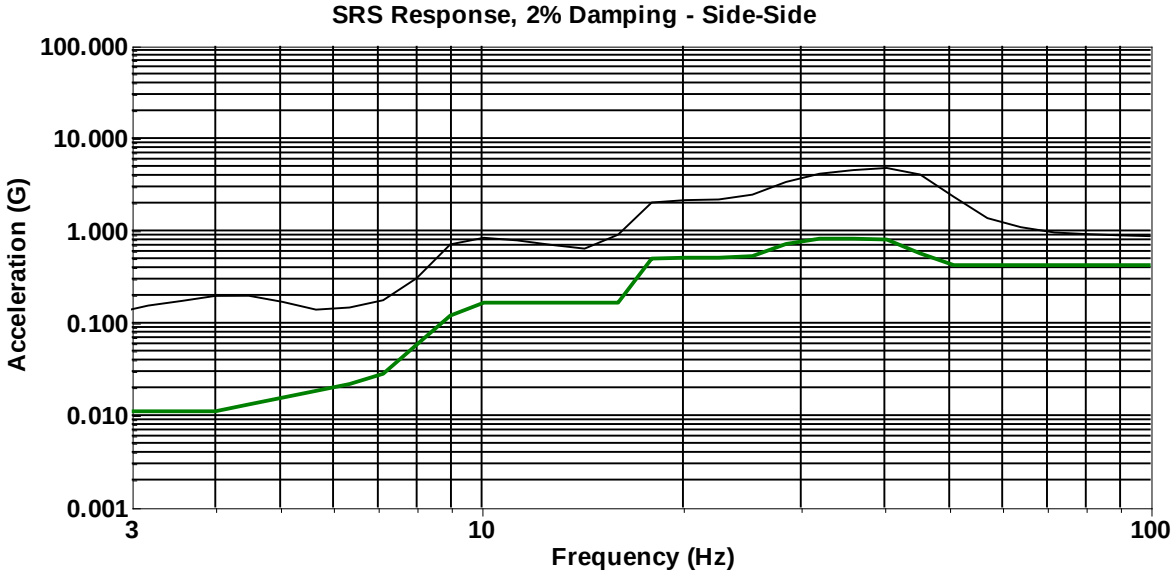
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 4 Safety Relief Valve Testing (SRV) Oct 29, 2013 12:25:46
Pulse: 2850 of 2850

ZPA: 0.7541 G



4726 unit Vertical Response

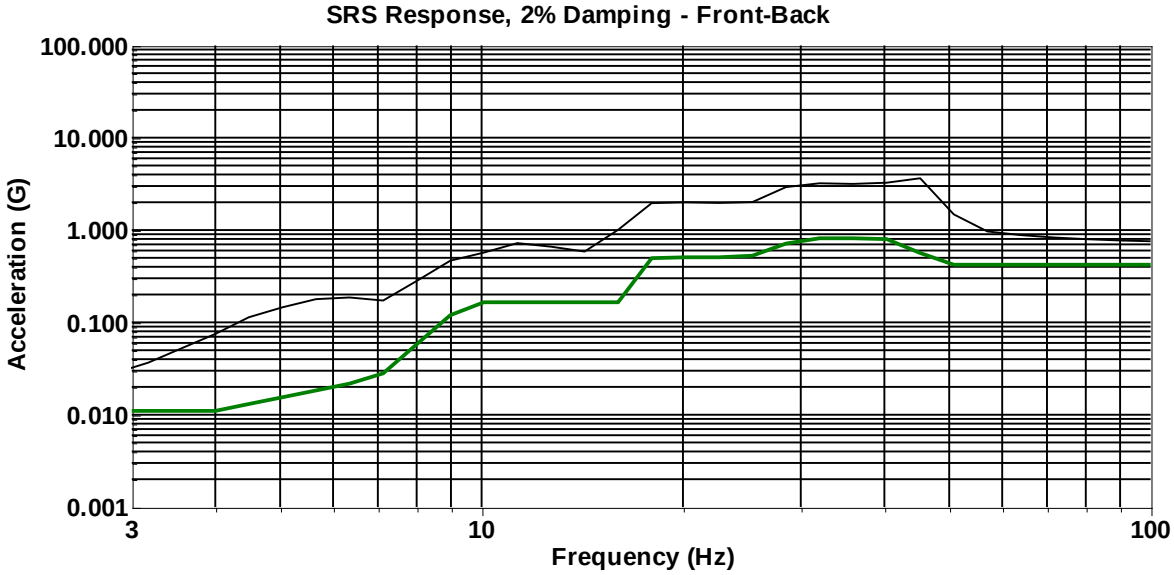
ZPA: -0.799 G



4726 unit Side to Side Response

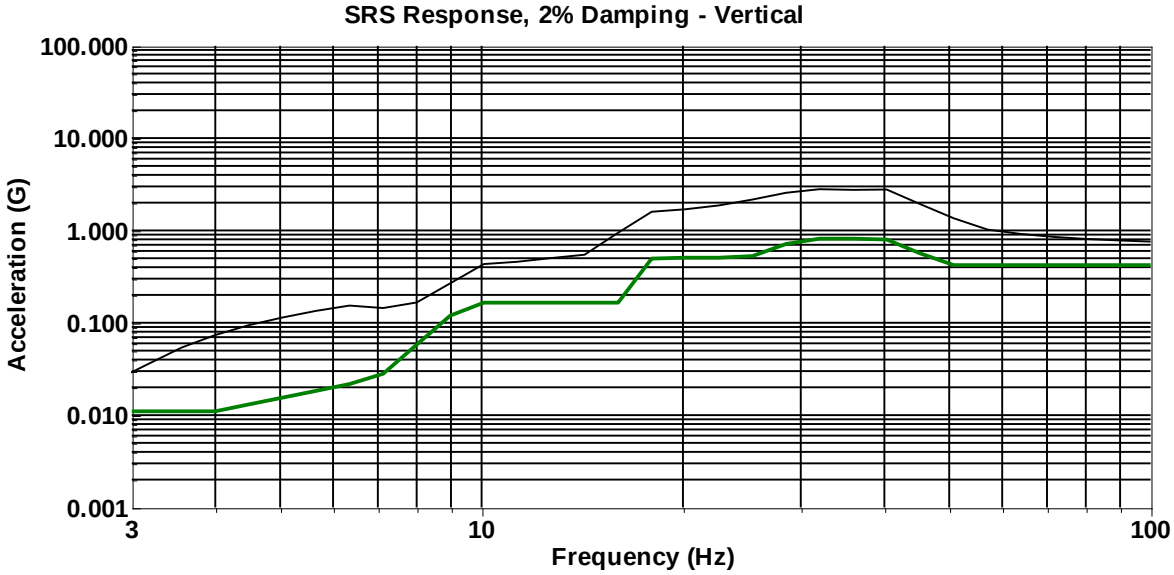
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 4 Safety Relief Valve Testing (SRV) Oct 29, 2013 12:25:46
Pulse: 2850 of 2850

ZPA: -0.6984 G



4634 LED unit Front to Back Response

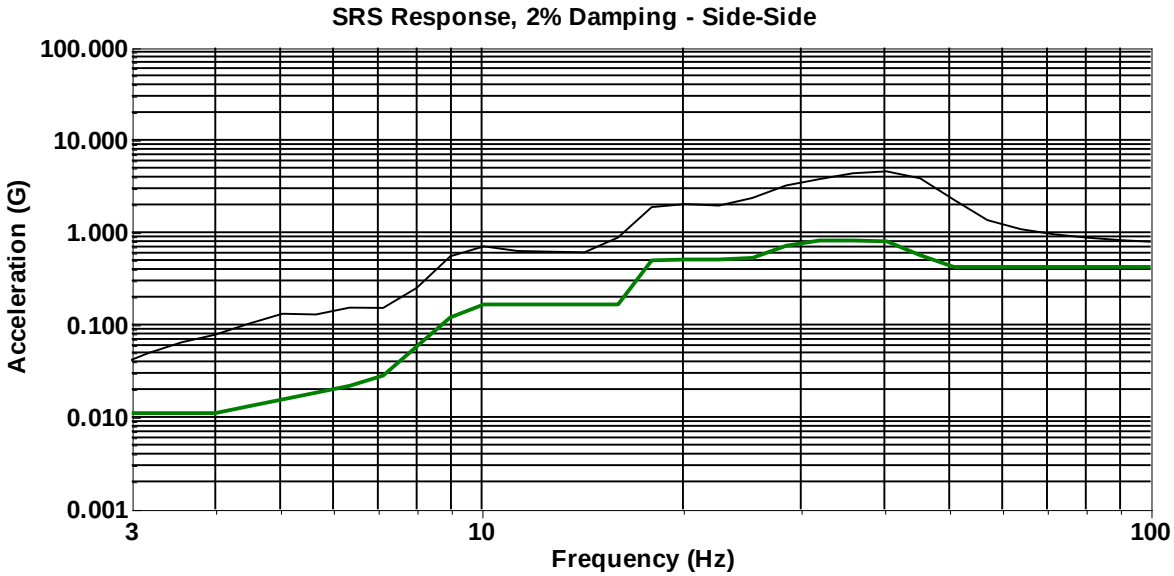
ZPA: 0.6871 G



4634 LED unit Vertical Response

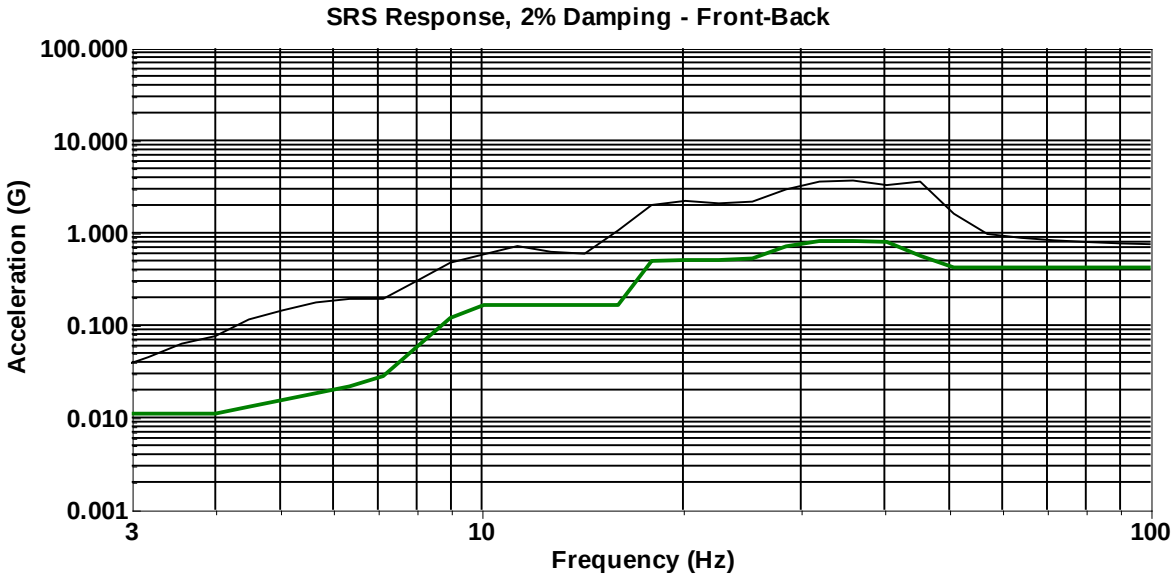
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 4 Safety Relief Valve Testing (SRV) Oct 29, 2013 12:25:46
Pulse: 2850 of 2850

ZPA: -0.7138 G



4634 LED unit Side to Side Response

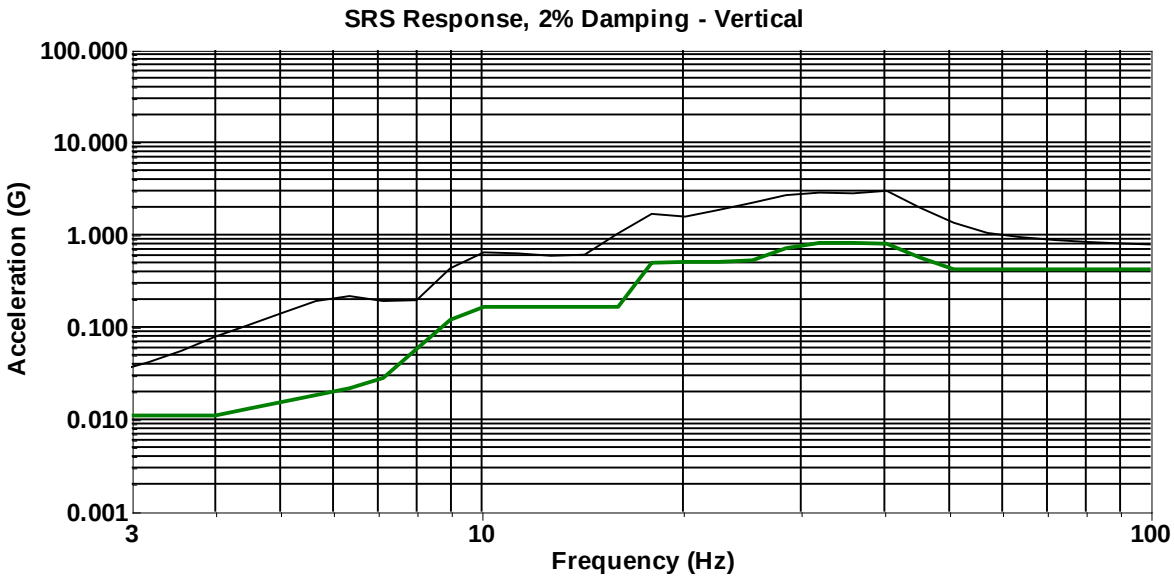
ZPA: -0.6956 G



4634 Incandescent unit Front to Back Response

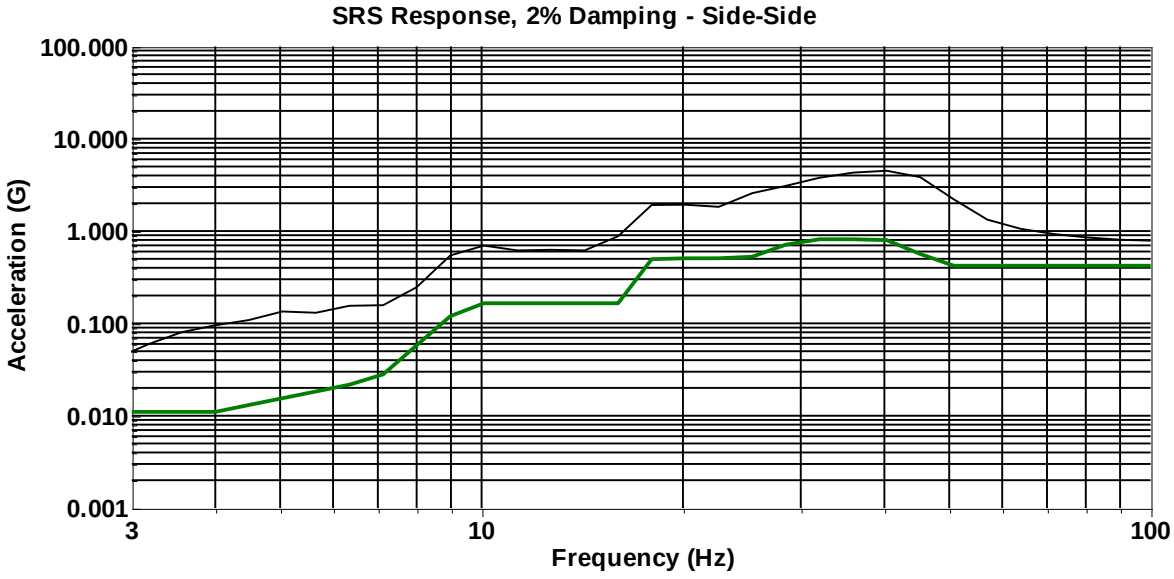
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 4 Safety Relief Valve Testing (SRV) Oct 29, 2013 12:25:46
Pulse: 2850 of 2850

ZPA: 0.7092 G



4634 Incandescent unit Vertical Response

ZPA: -0.7258 G



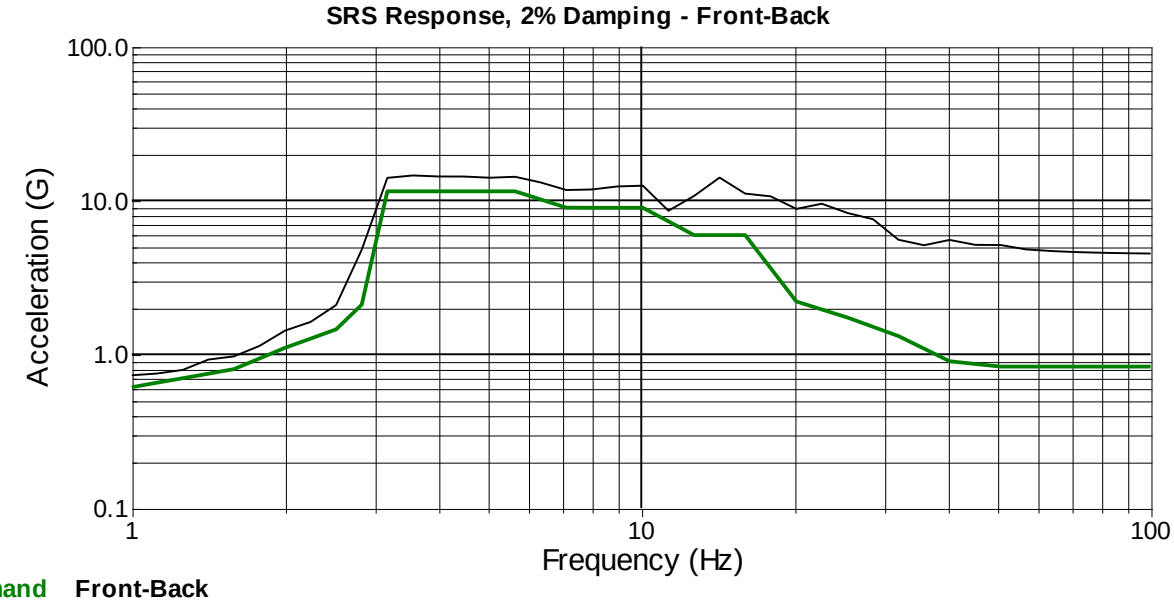
4634 Incandescent unit Side to Side Response

BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 4 Safety Relief Valve Testing (SRV) Oct 29, 2013 12:25:46
Pulse: 2850 of 2850

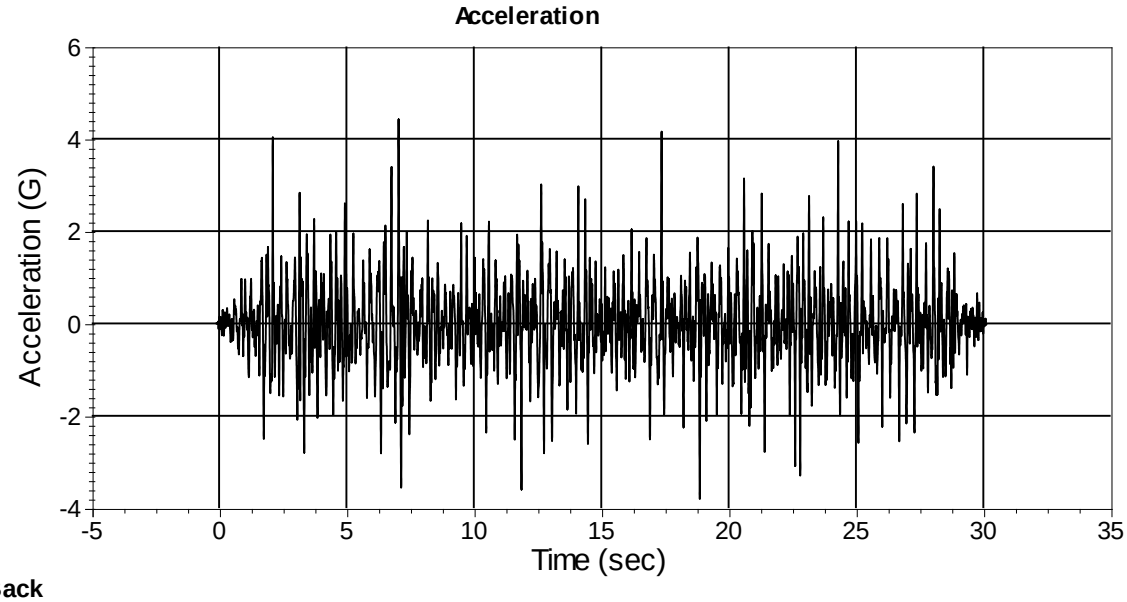
APPENDIX F

OBE +LOCA +SRV Data Curves

ZPA: 4.42 G

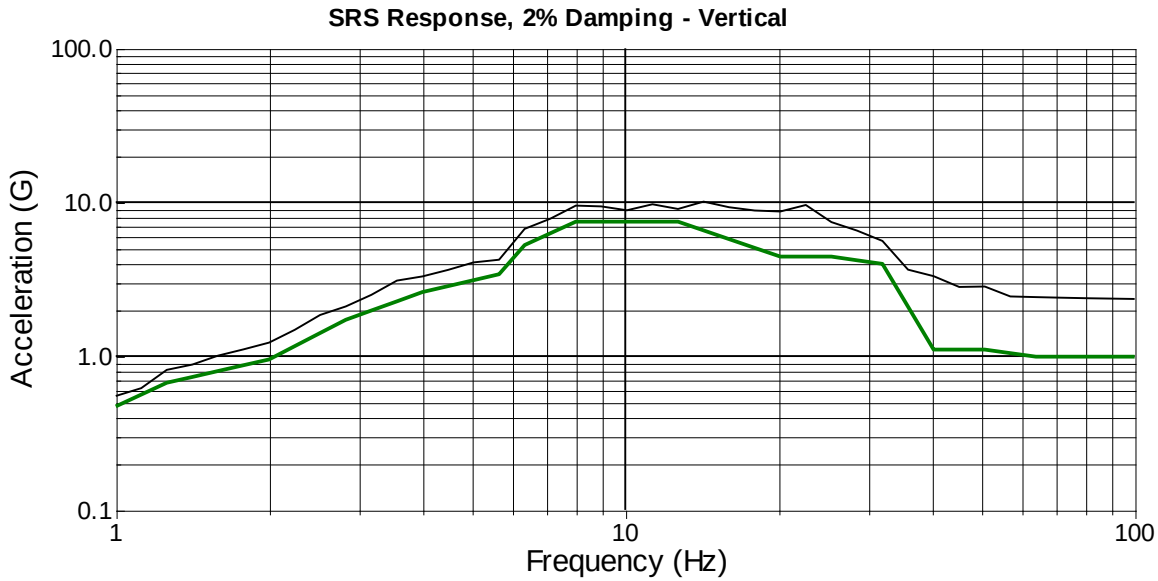


Front to Back Axis Control



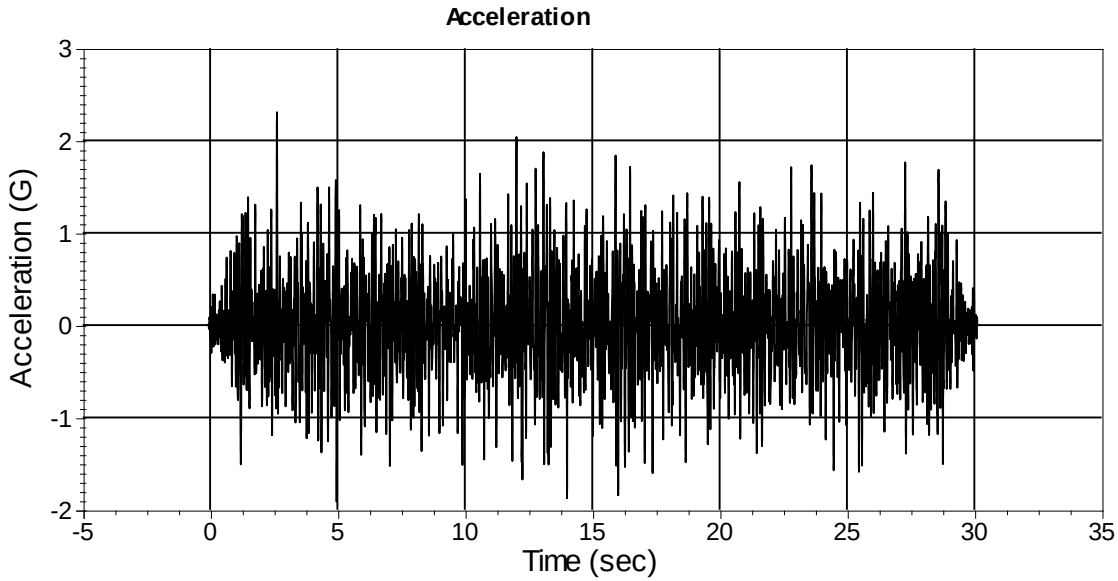
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 5 OBE 1
120AC Applied No Illumination Oct 29, 2013 13:18:02

ZPA: 2.306 G



Demand **Vertical**

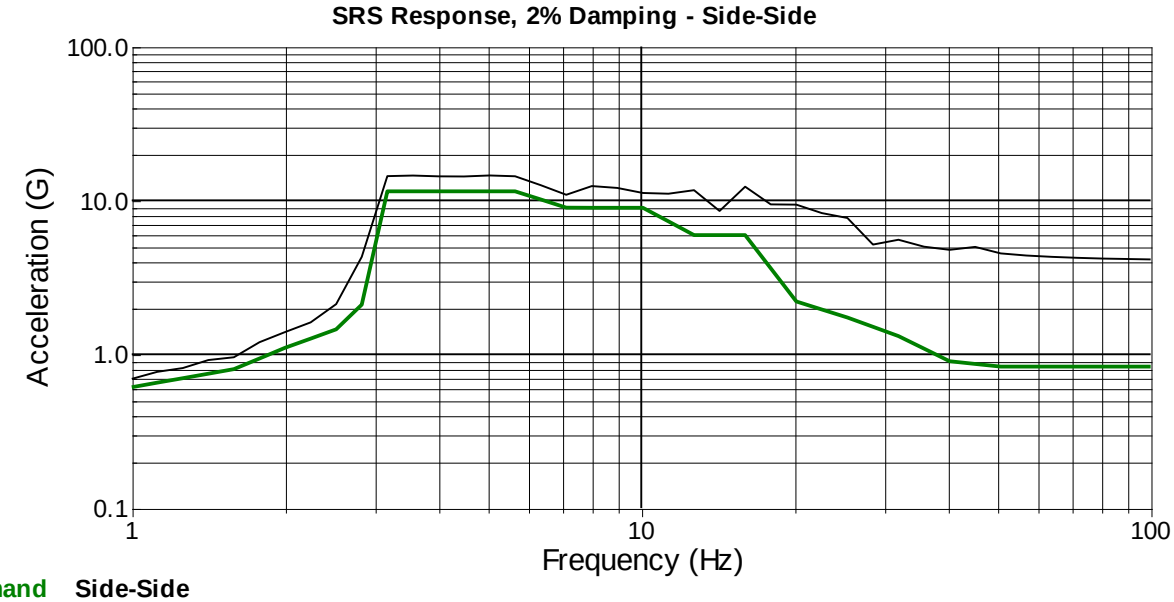
Vertical Axis Control



Vertical

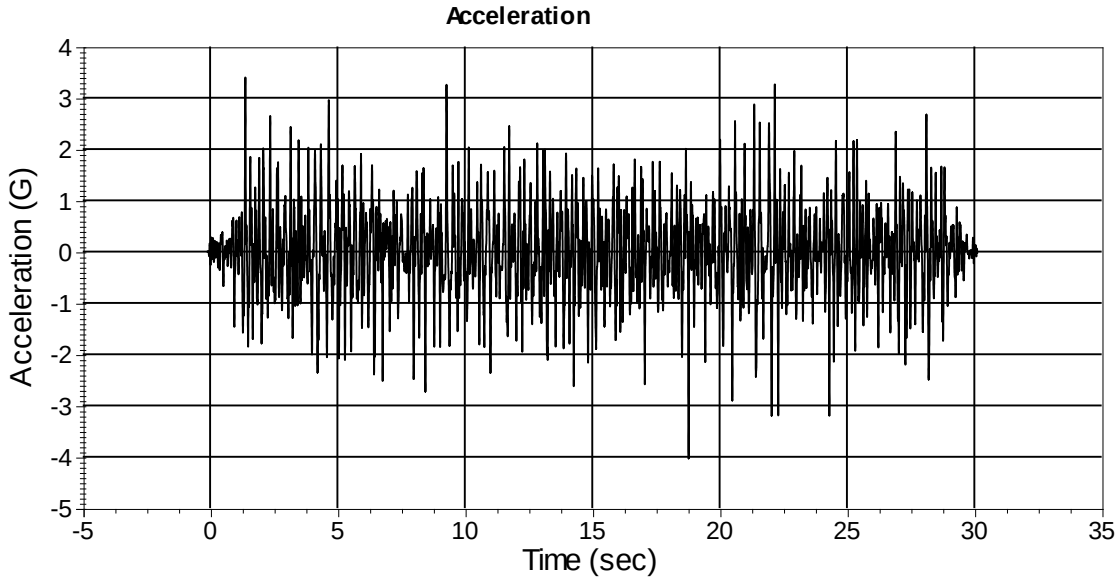
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 5 OBE 1
120AC Applied No Illumination Oct 29, 2013 13:18:02

ZPA: -4.033 G



Demand **Side-Side**

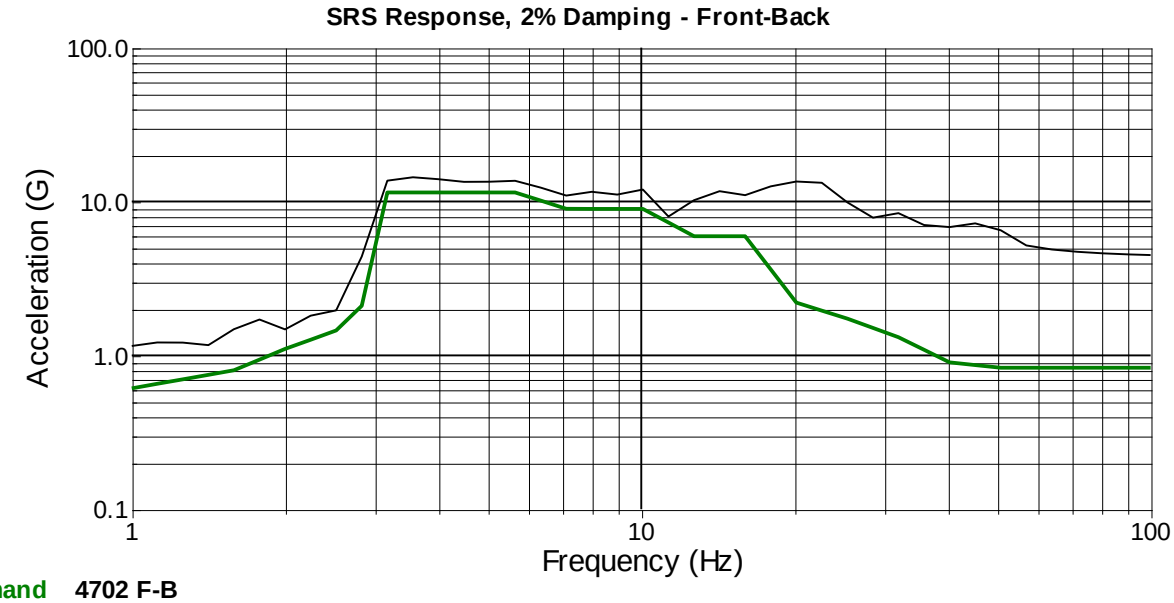
Side to Side Axis Control



Side-Side

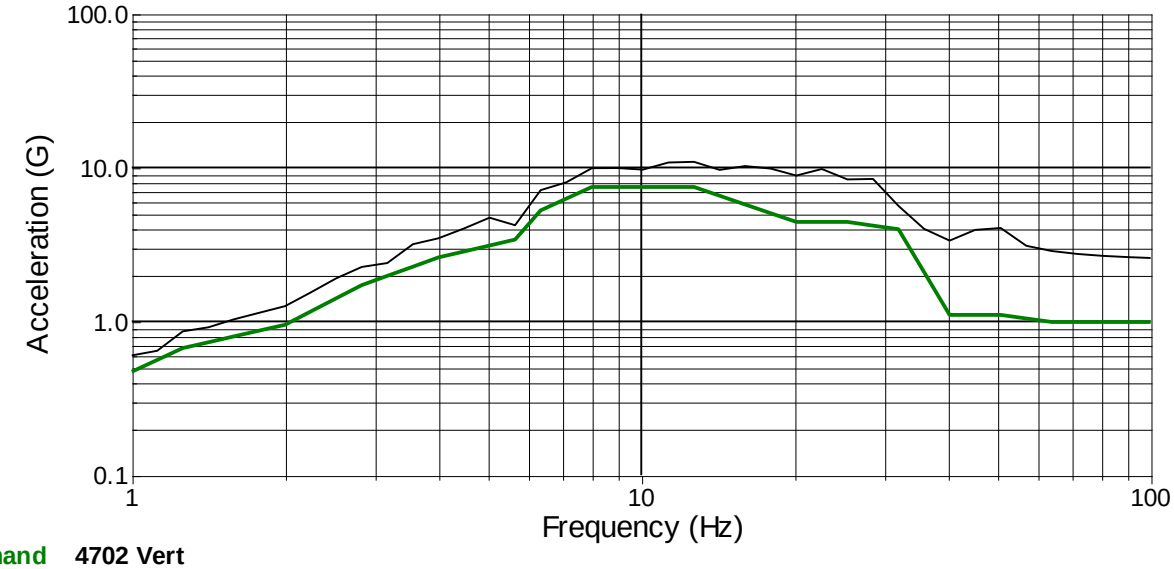
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 5 OBE 1
120AC Applied No Illumination Oct 29, 2013 13:18:02

ZPA: 4.311 G



4702 unit Front to Back Response

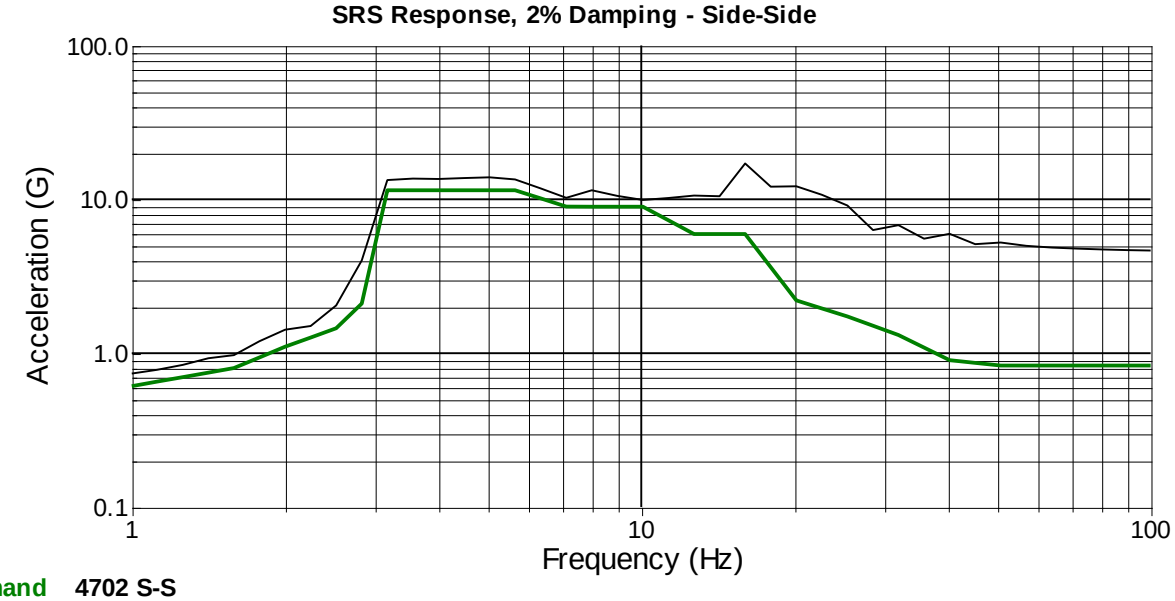
ZPA: 2.453 G



4702 unit Vertical Response

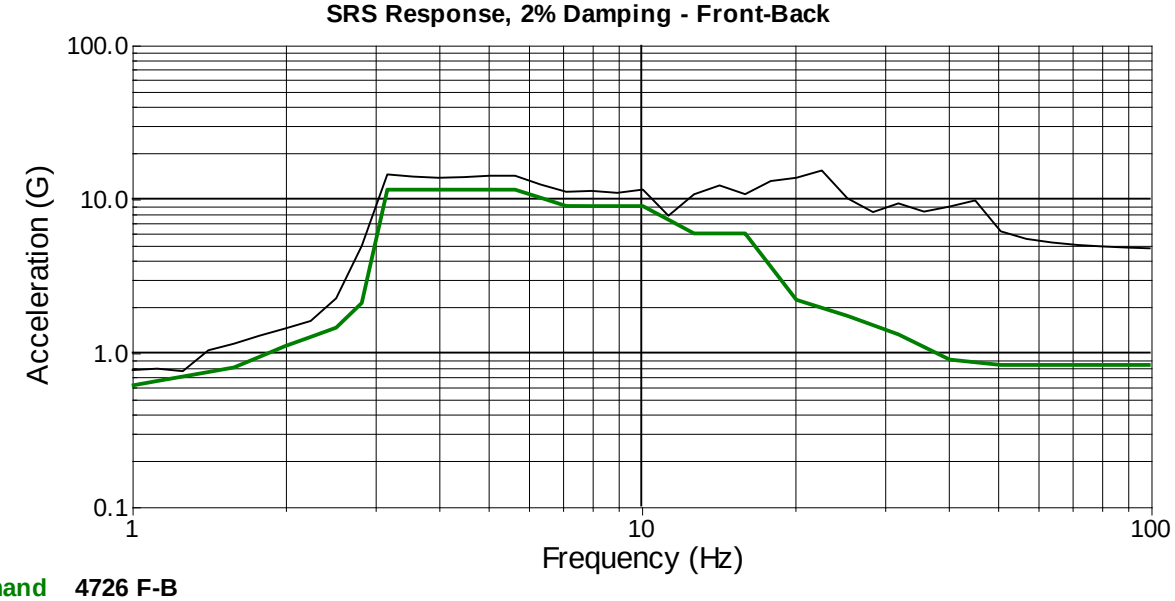
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 5 OBE 1
120AC Applied No Illumination Oct 29, 2013 13:18:02

ZPA: -4.514 G



4702 unit Side to Side Response

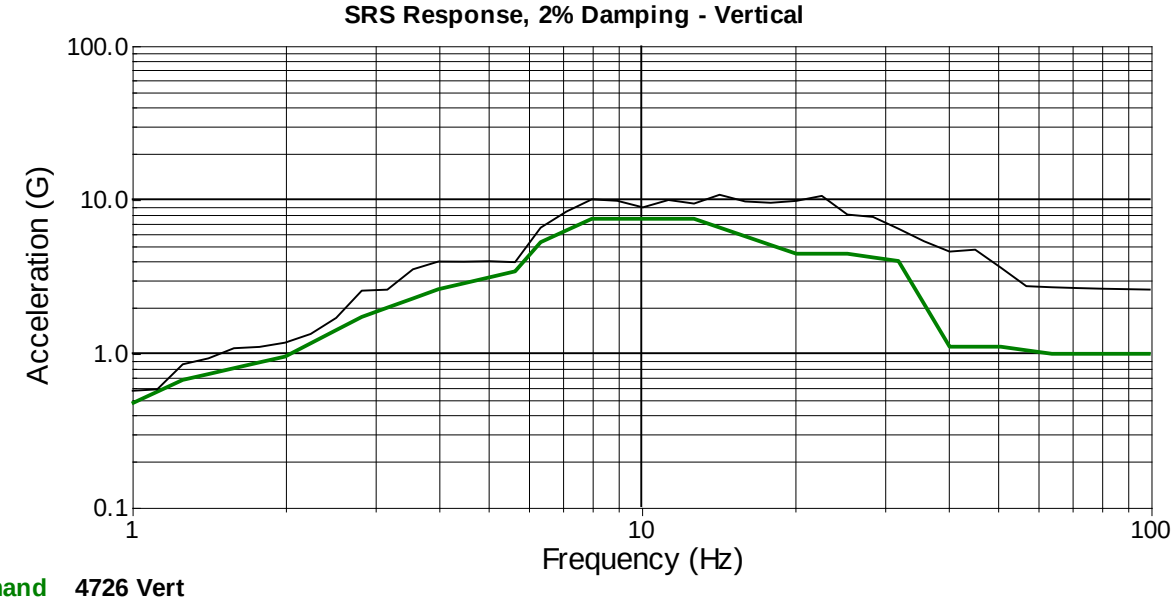
ZPA: 4.562 G



4726 unit Front to Back Response

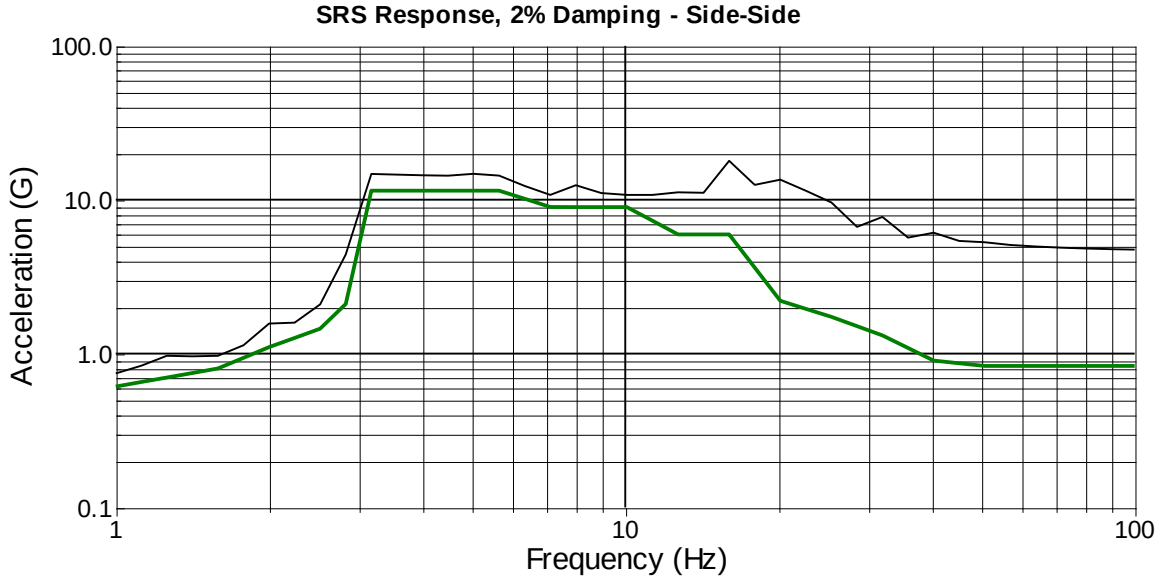
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 5 OBE 1
120AC Applied No Illumination Oct 29, 2013 13:18:02

ZPA: 2.534 G



4702 unit Vertical Response

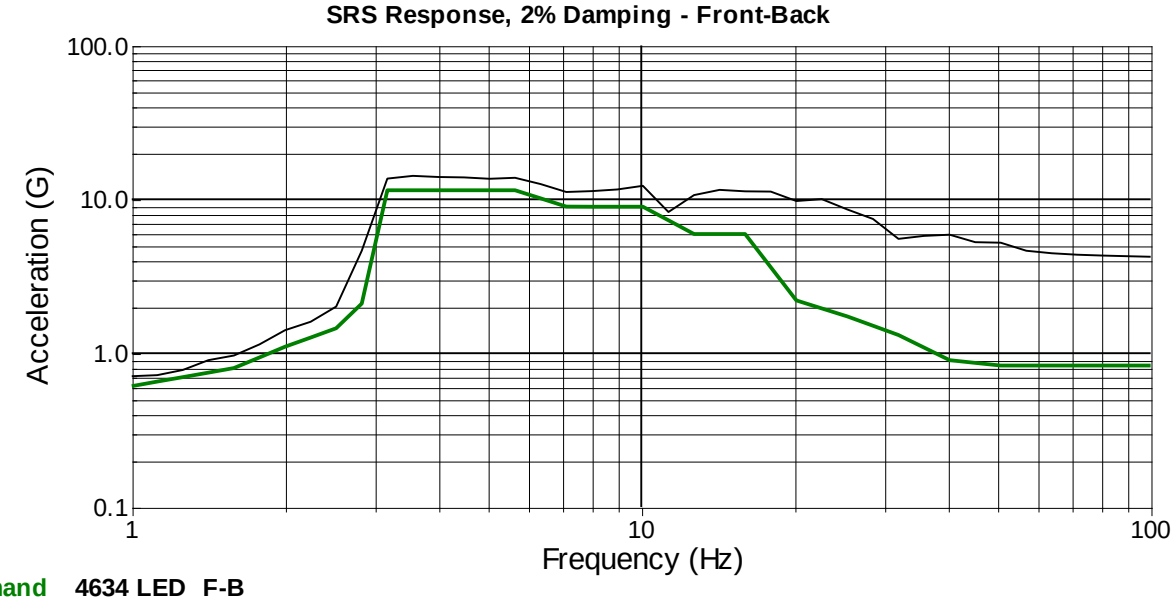
ZPA: -4.607 G



4702 unit Side to Side Response

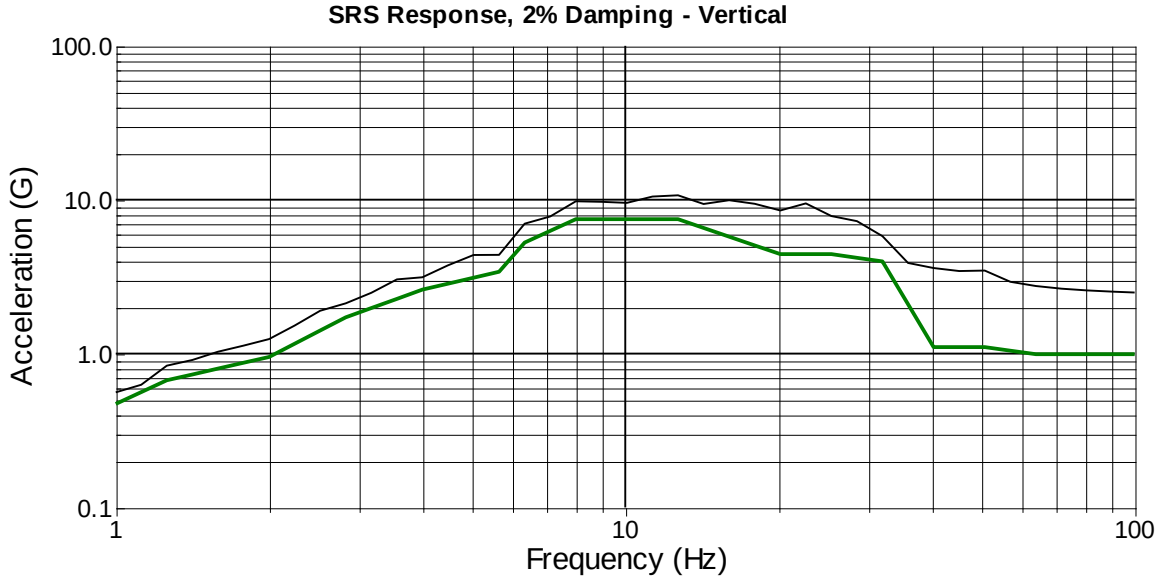
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 5 OBE 1
120AC Applied No Illumination Oct 29, 2013 13:18:02

ZPA: 4.13 G



4634 LED unit Front to Back Response

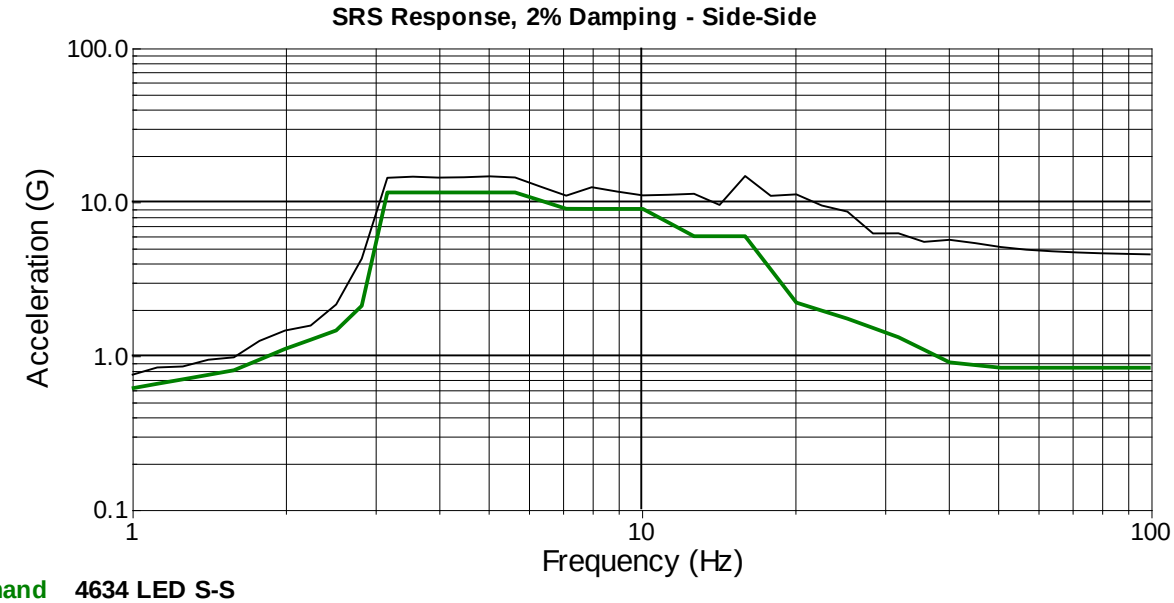
ZPA: 2.376 G



4634 LED unit Vertical Response

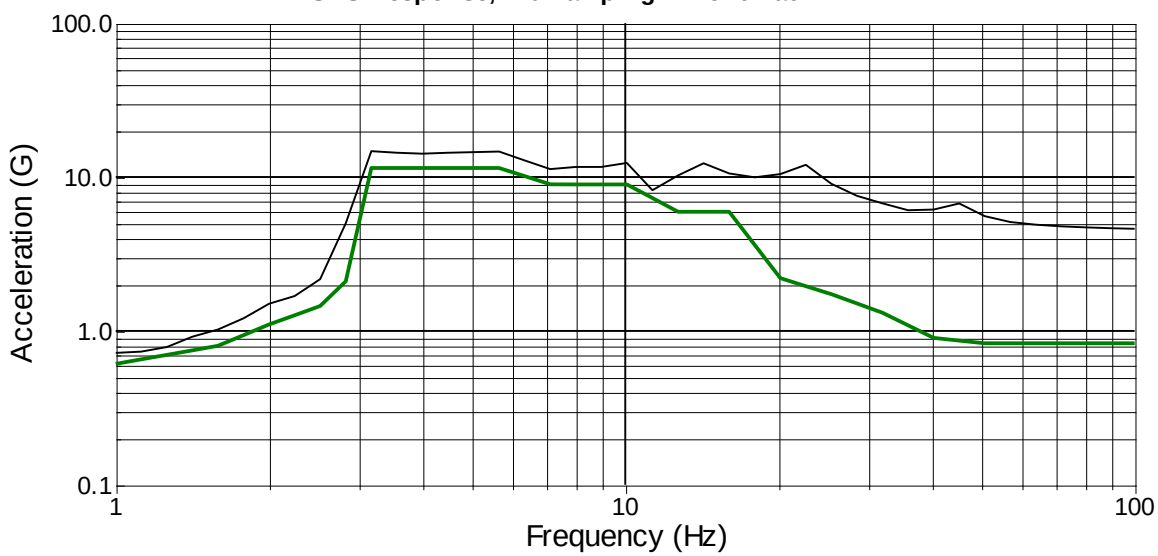
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 5 OBE 1
120AC Applied No Illumination Oct 29, 2013 13:18:02

ZPA: -4.415 G



4634 LED unit Side to Side Response

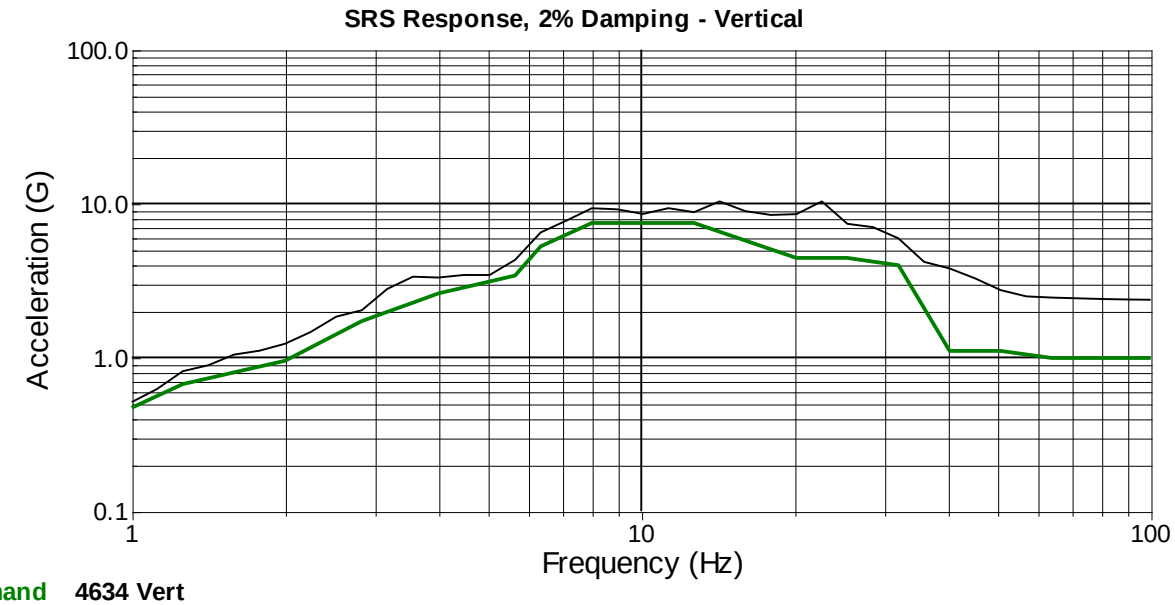
ZPA: 4.474 G



4634 Incandescent unit Front to Back Response

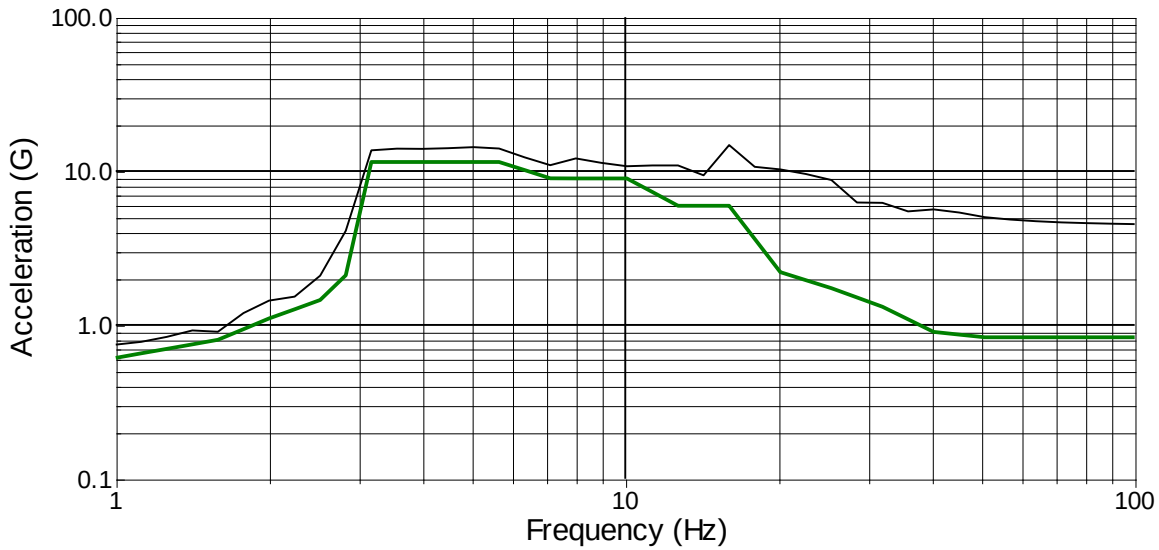
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 5 OBE 1
120AC Applied No Illumination Oct 29, 2013 13:18:02

ZPA: 2.318 G



4634 Incandescent unit Vertical Response

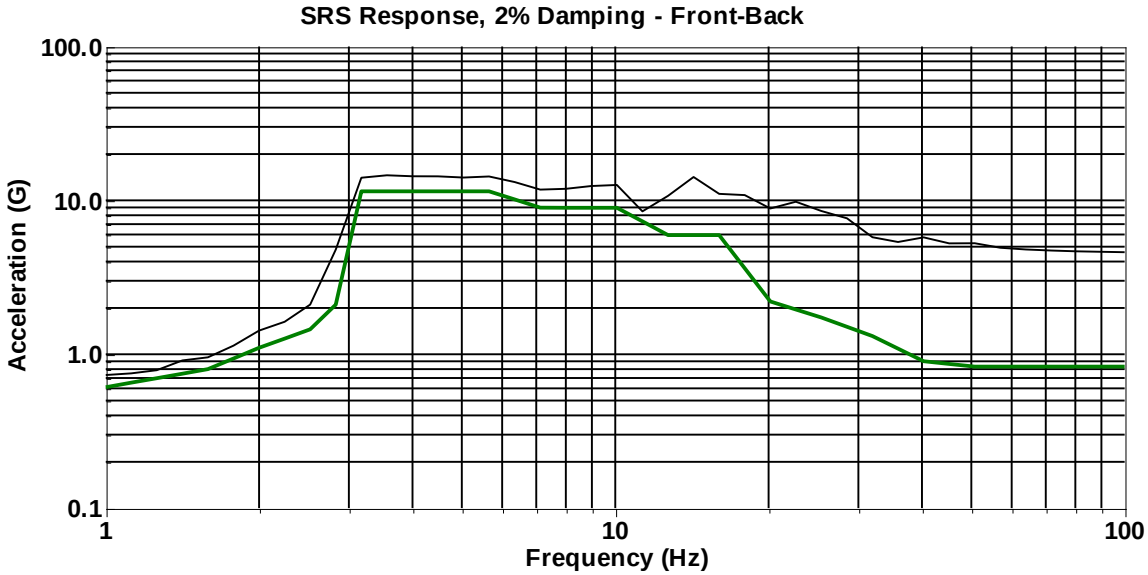
ZPA: -4.4 G



4634 Incandescent unit Side to Side Response

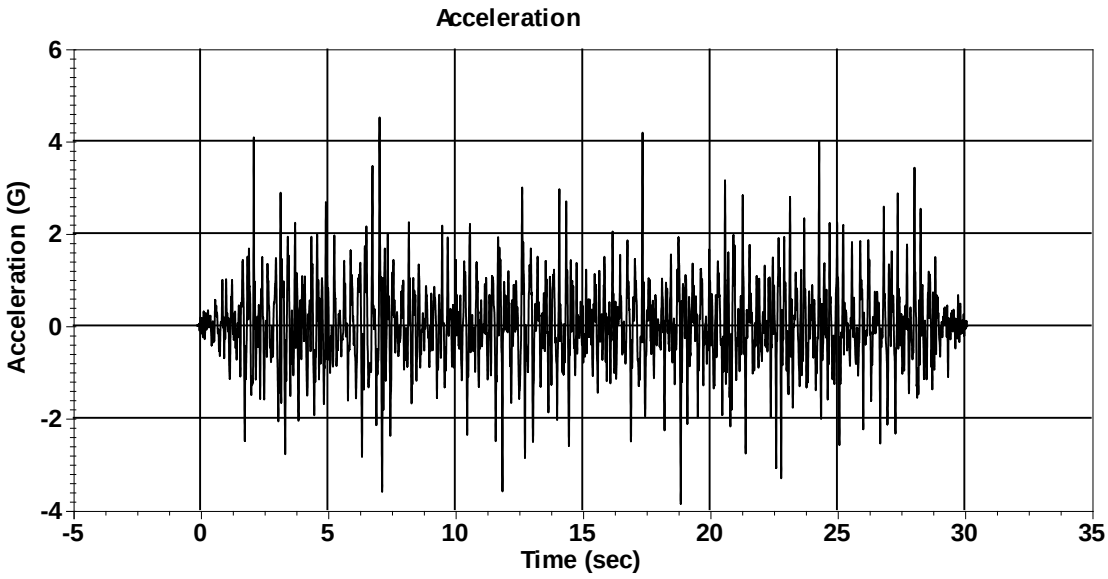
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 5 OBE 1
120AC Applied No Illumination Oct 29, 2013 13:18:02

ZPA: 4.506 G



Demand **Front-Back**

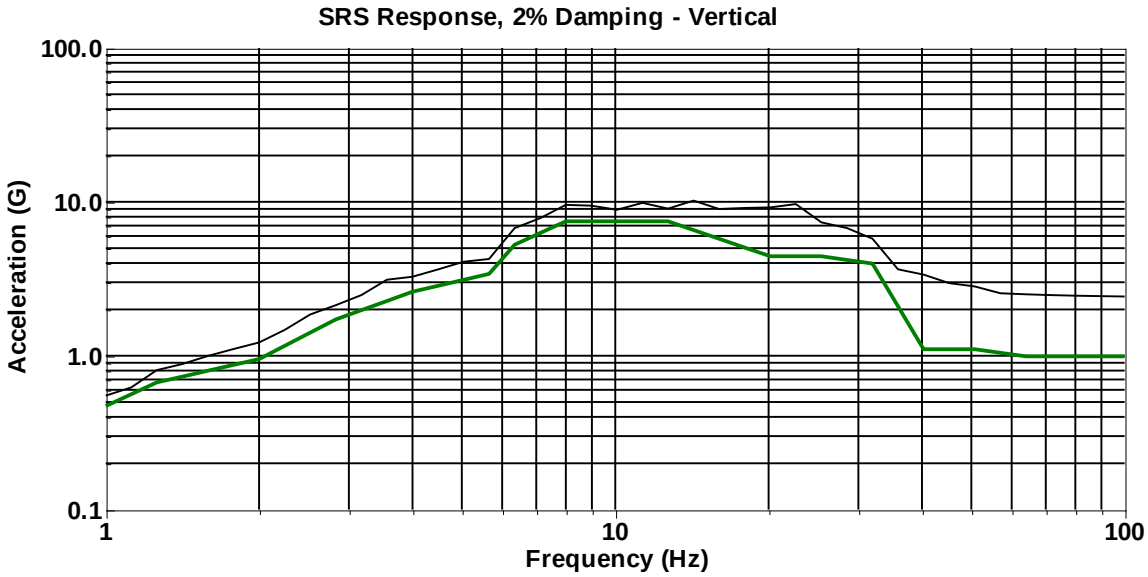
Front to Back Axis Control



Front-Back

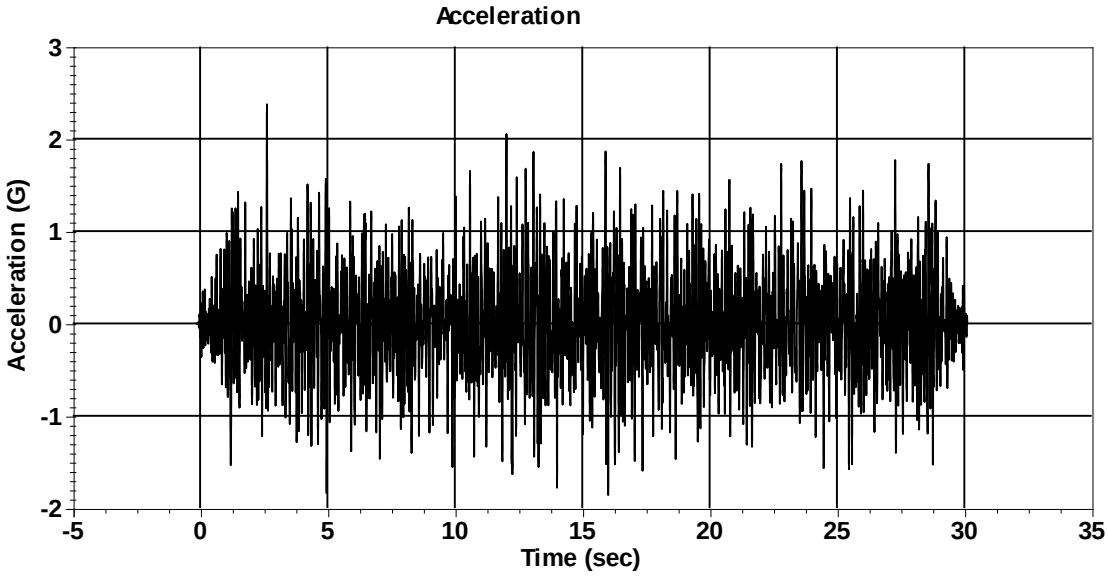
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634
Test# 6 OBE 2
120AC Applied No Illumination Oct 29, 2013 13:19:31

ZPA: 2.374 G



Demand **Vertical**

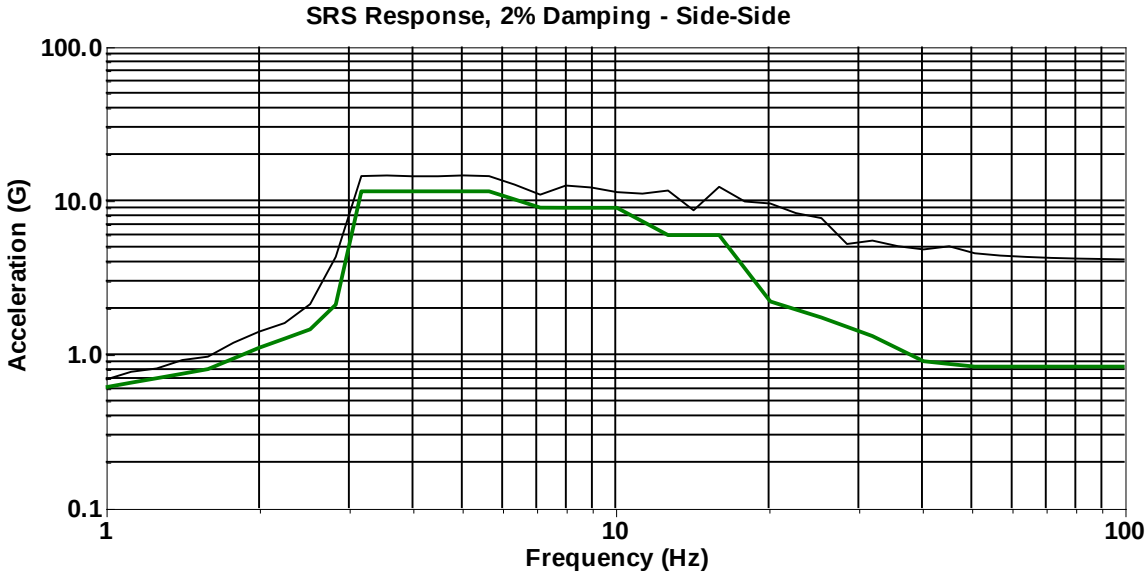
Front to Back Axis Control



Vertical

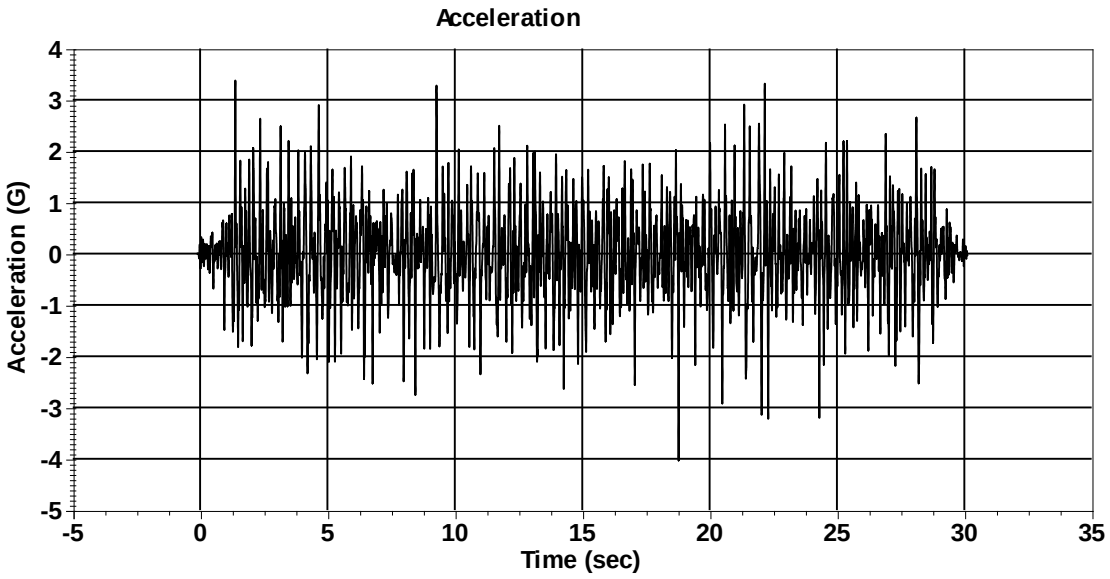
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634
Test# 6 OBE 2
120AC Applied No Illumination Oct 29, 2013 13:19:31

ZPA: -4.035 G



Demand **Side-Side**

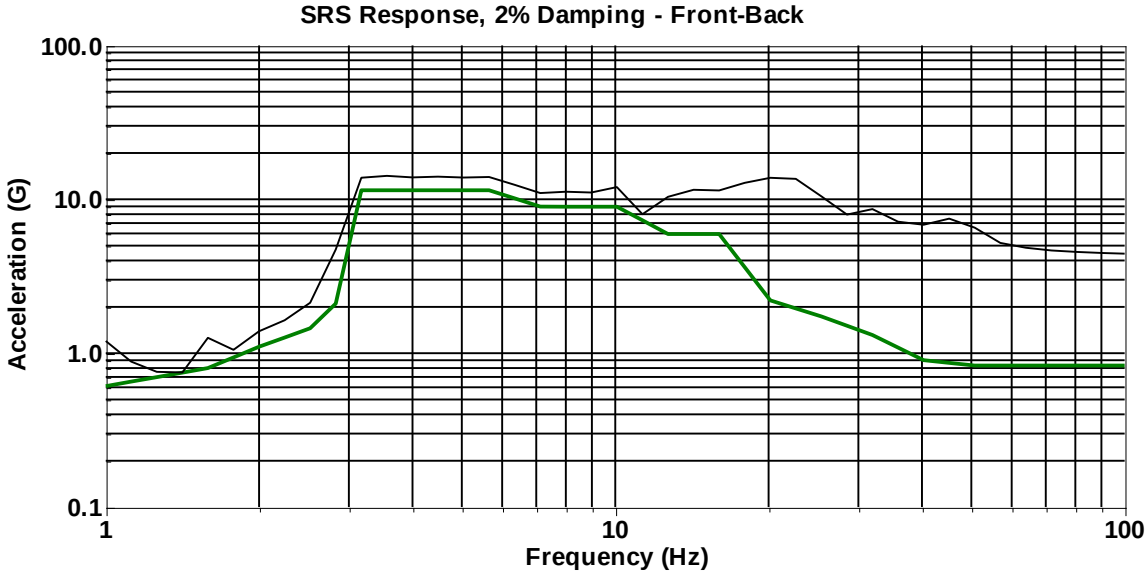
Side to Side Axis Control



Side-Side

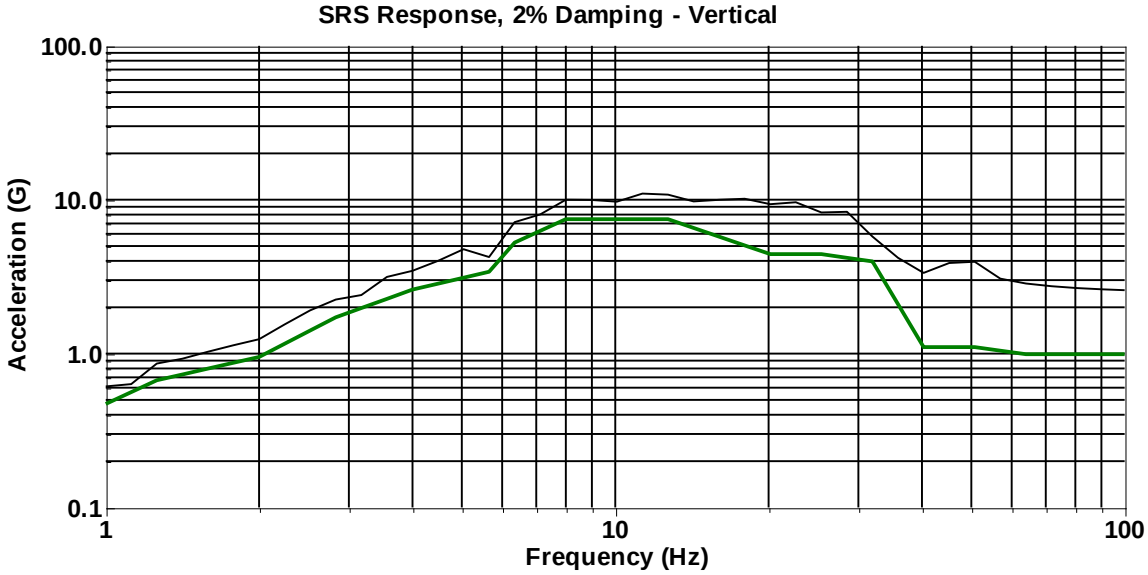
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634
Test# 6 OBE 2
120AC Applied No Illumination Oct 29, 2013 13:19:31

ZPA: 4.267 G



4702 unit Front to Back Response

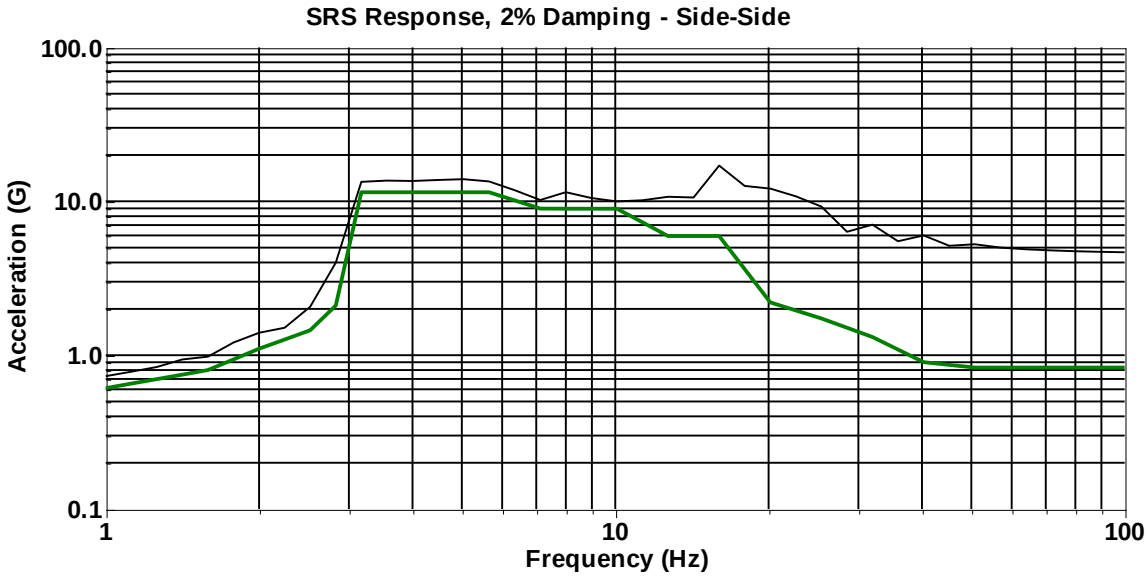
ZPA: 2.458 G



4702 unit Vertical Response

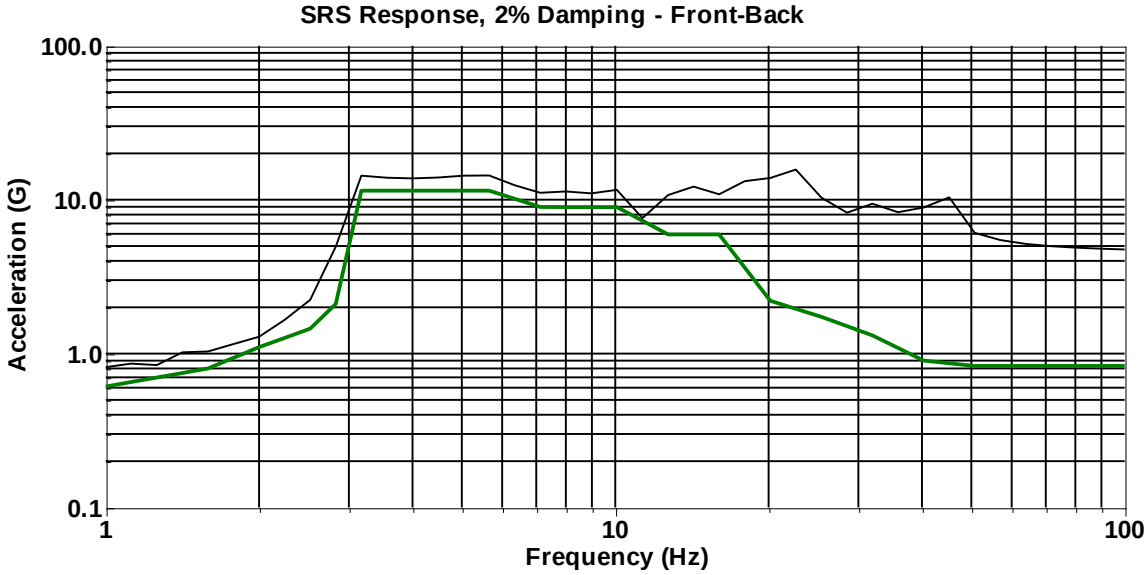
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634
Test# 6 OBE 2
120AC Applied No Illumination Oct 29, 2013 13:19:31

ZPA: -4.538 G



4702 unit Side to Side Response

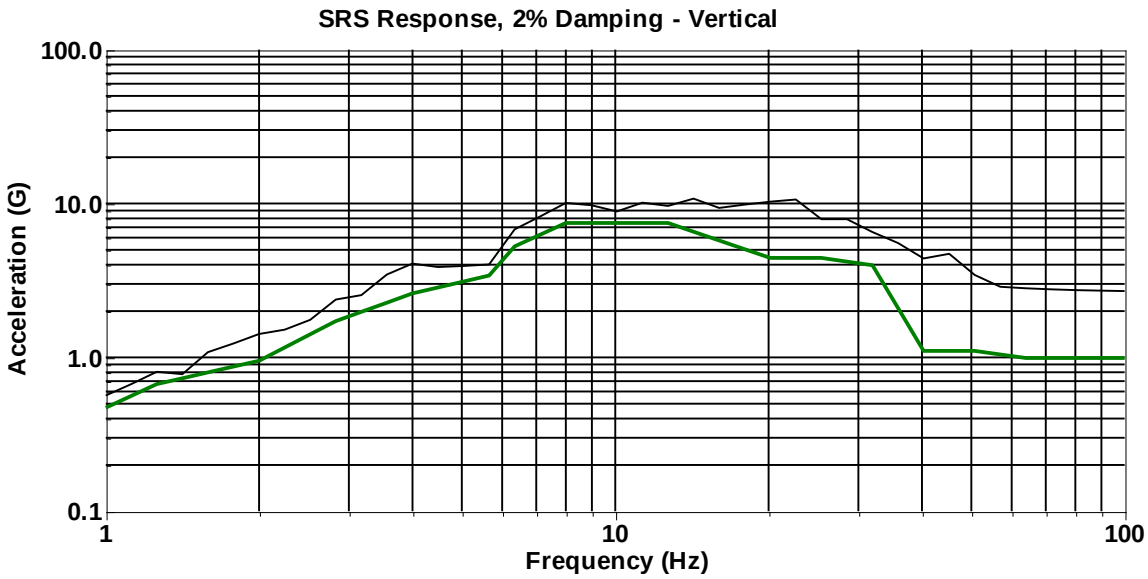
ZPA: 4.557 G



4726 unit Front to Back Response

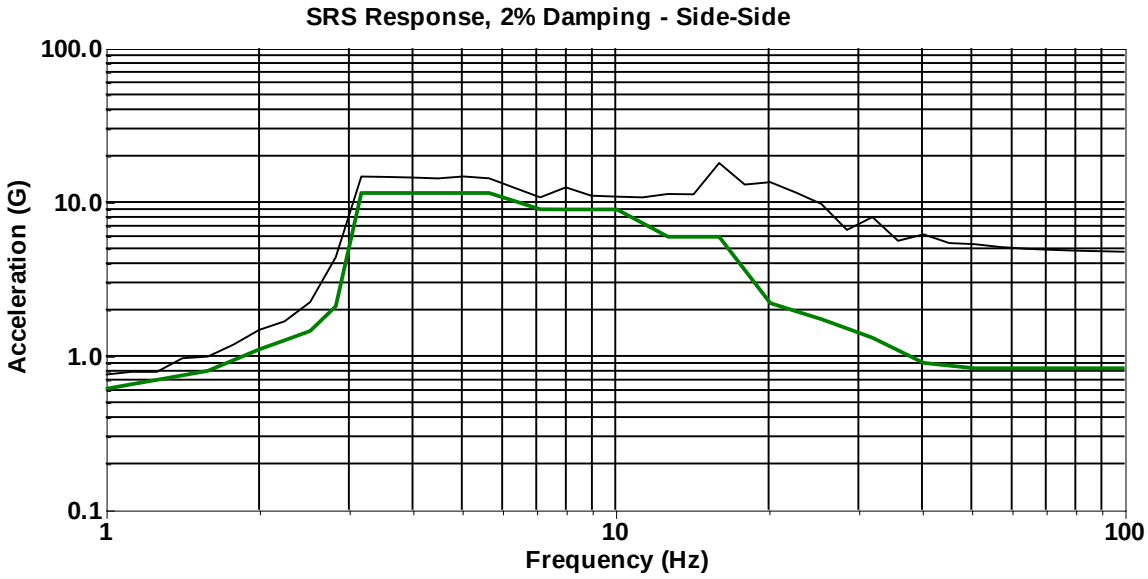
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634
Test# 6 OBE 2
120AC Applied No Illumination Oct 29, 2013 13:19:31

ZPA: 2.631 G



4726 unit Vertical Response

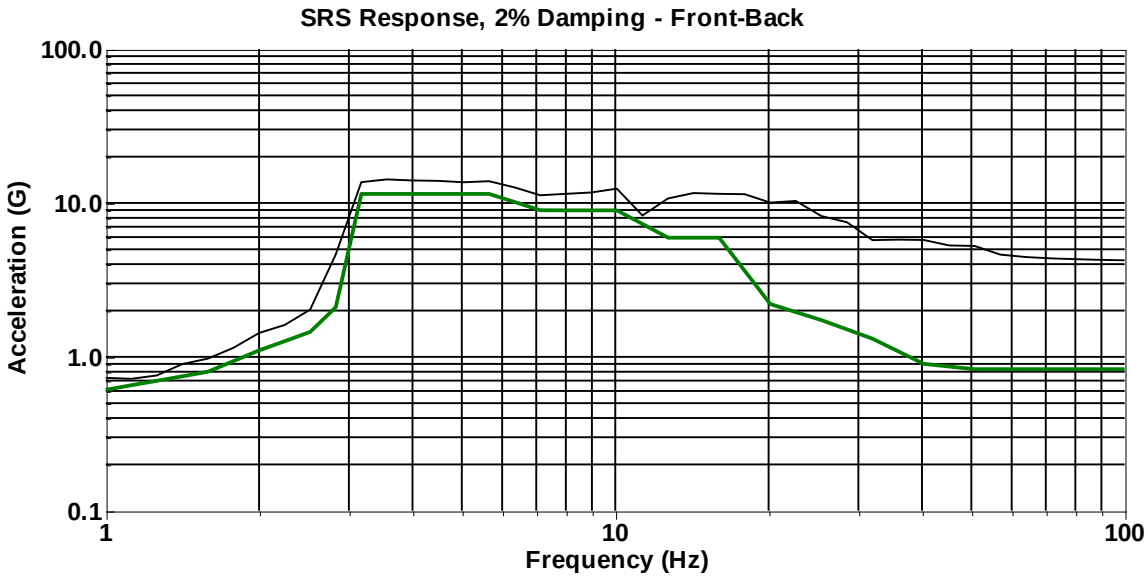
ZPA: -4.627 G



4726 unit Side to Side Response

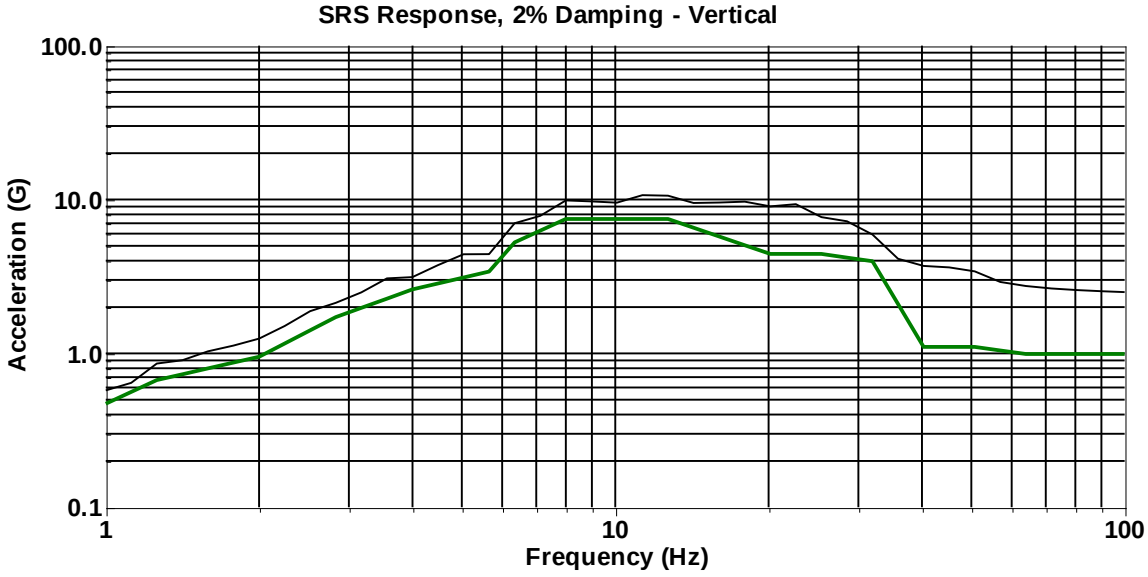
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634
Test# 6 OBE 2
120AC Applied No Illumination Oct 29, 2013 13:19:31

ZPA: 4.14 G



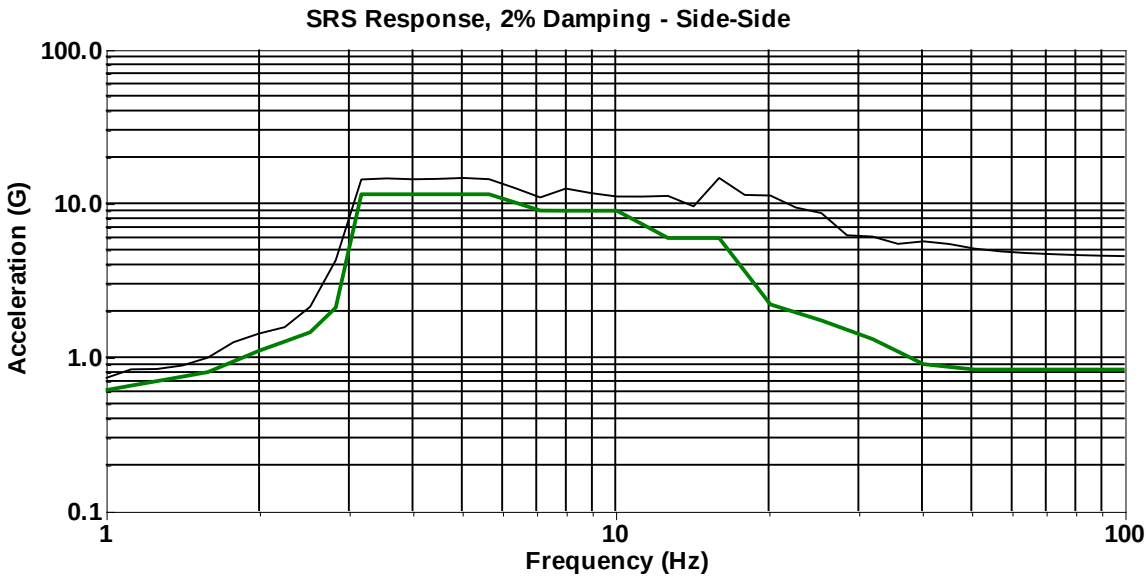
4634 LED unit Front to Back Response

ZPA: 2.388 G



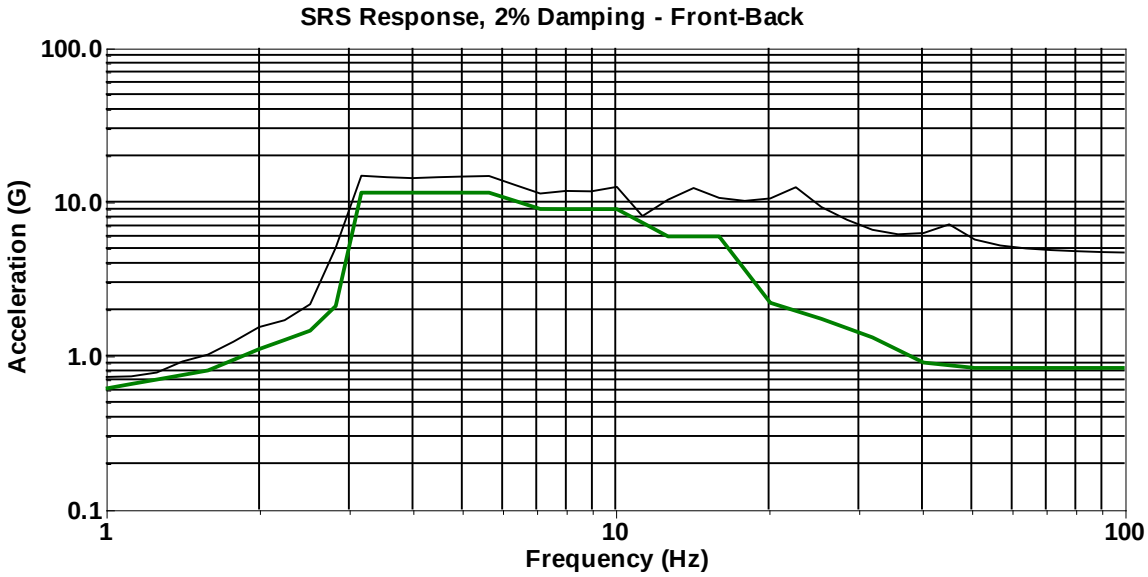
4634 LED unit Vertical Response

ZPA: -4.418 G



4634 LED unit Side to Side Response

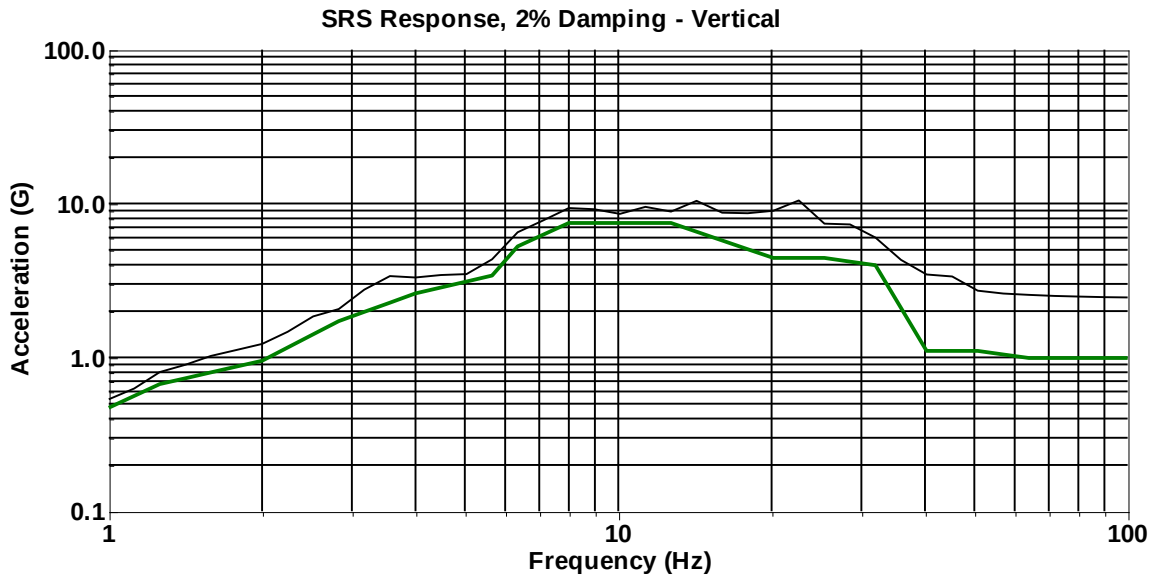
ZPA: 4.529 G



4634 Incandescent unit Front to Back Response

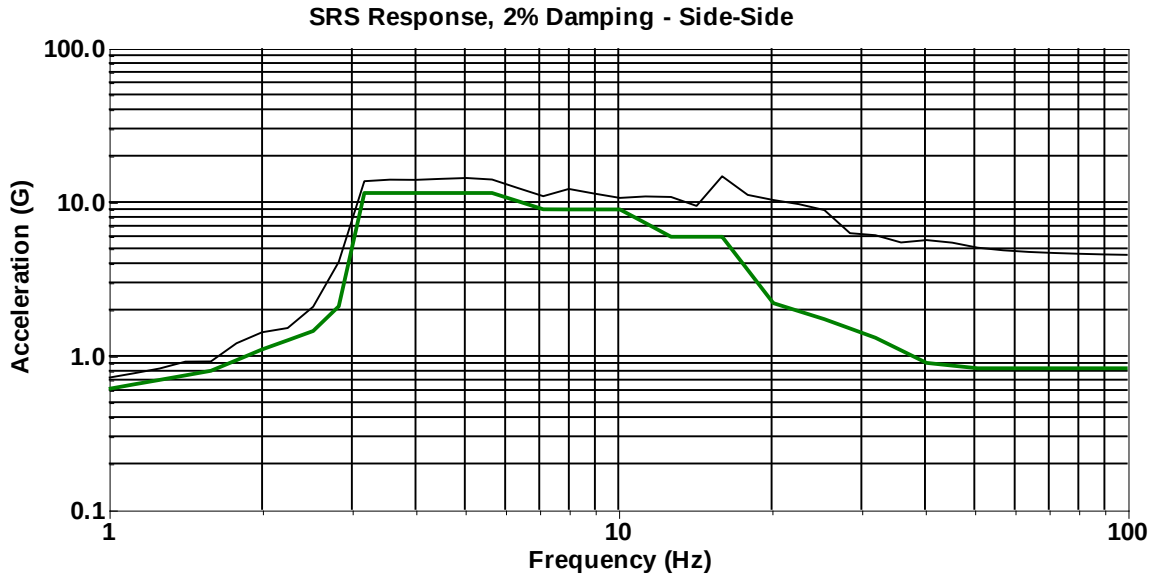
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634
Test# 6 OBE 2
120AC Applied No Illumination Oct 29, 2013 13:19:31

ZPA: 2.392 G



4634 Incandescent unit Vertical Response

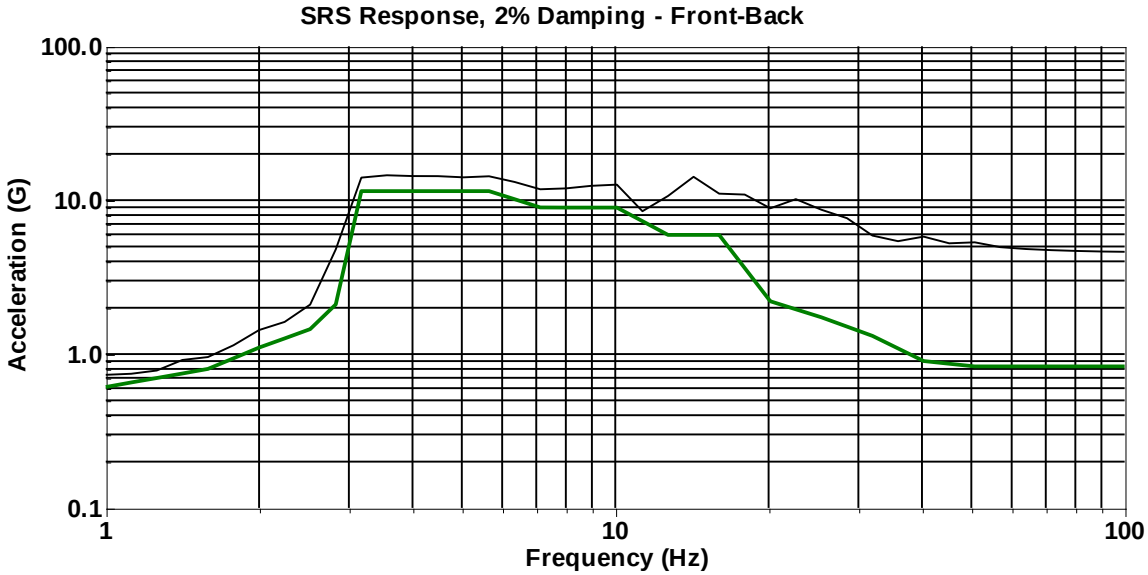
ZPA: -4.419 G



4634 Incandescent unit Side to Side Response

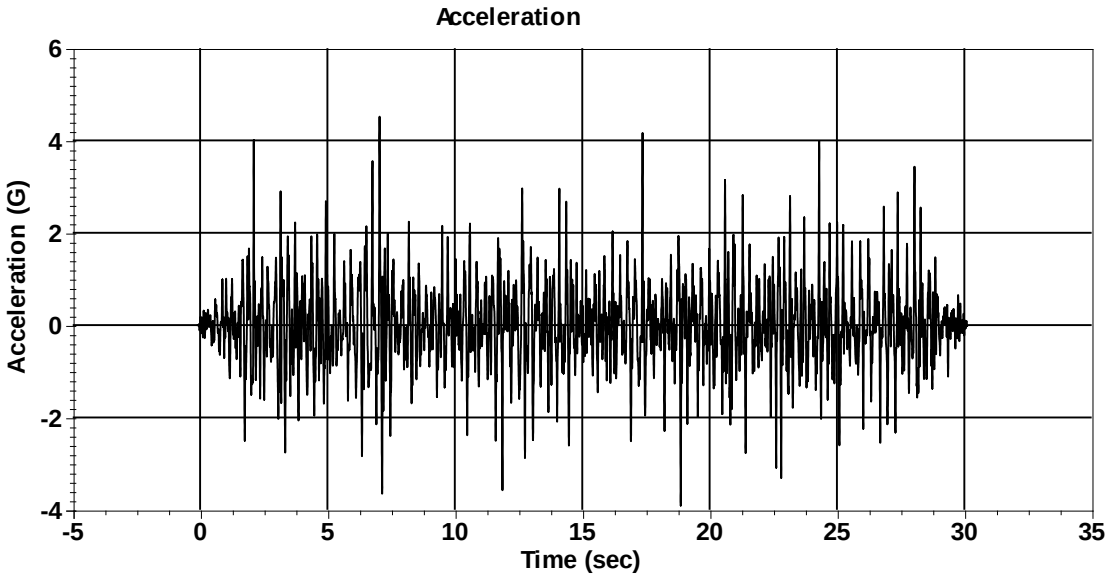
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634
Test# 6 OBE 2
120AC Applied No Illumination Oct 29, 2013 13:19:31

ZPA: 4.514 G



Demand **Front-Back**

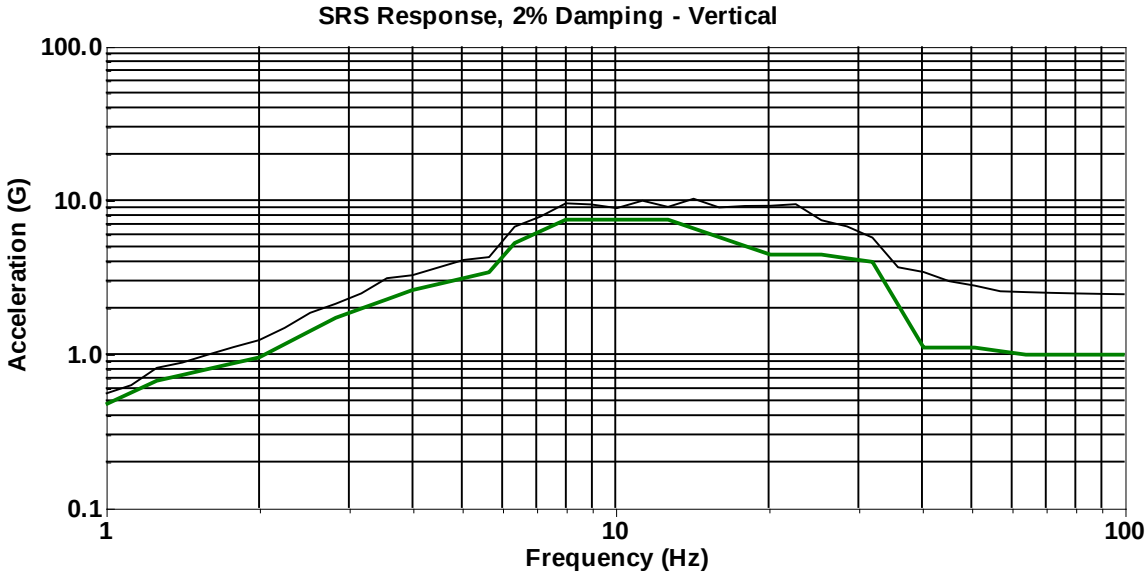
Front to Back Axis Control



Front-Back

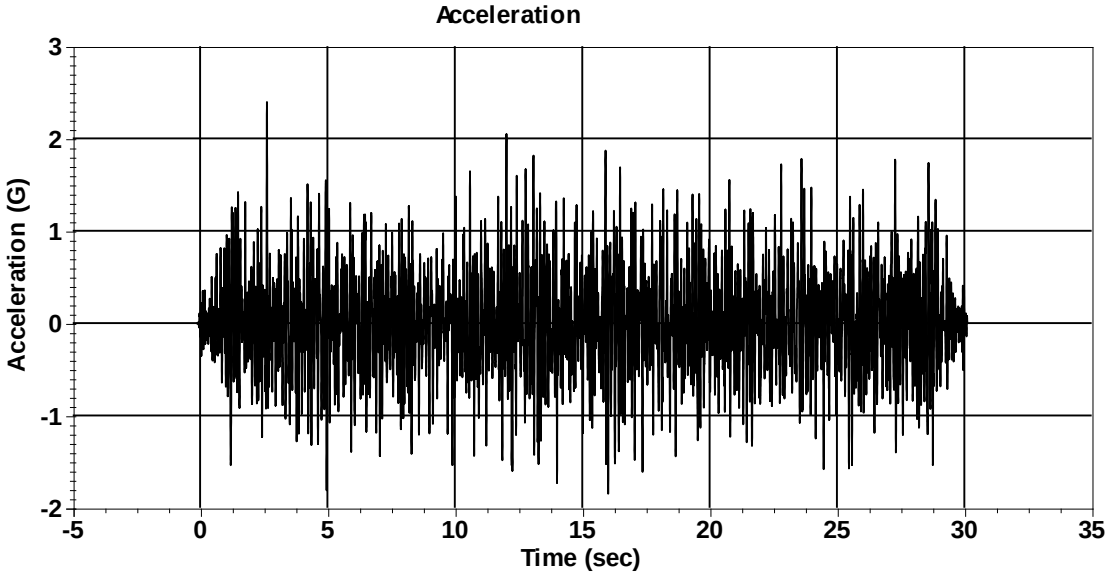
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634
Test# 7 OBE 3
120VAC removed during test, Lamps illuminated Oct 29, 2013 13:21:35

ZPA: 2.395 G



Demand **Vertical**

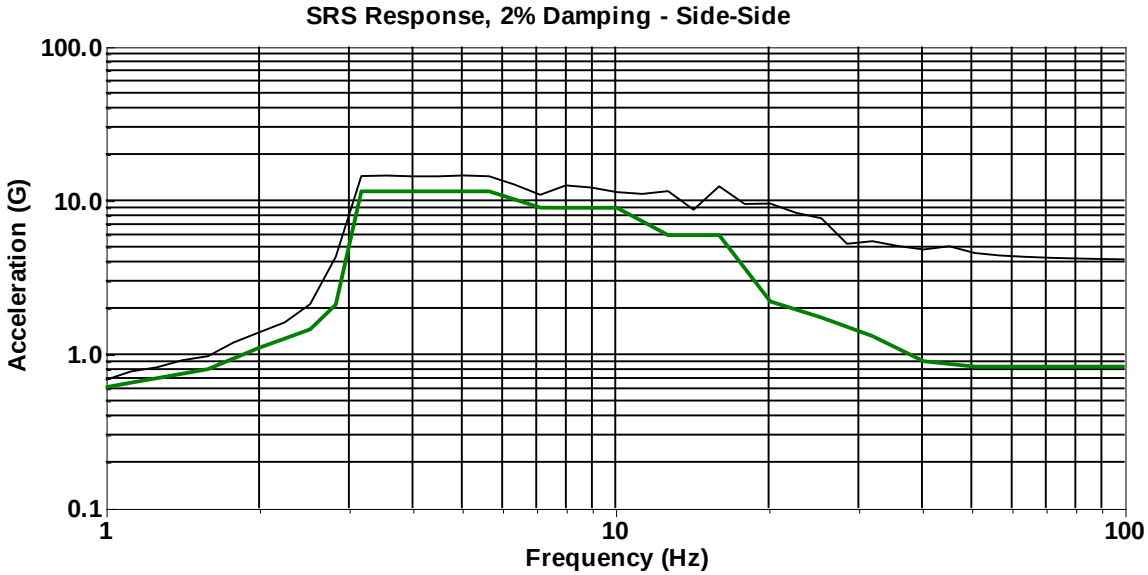
Vertical Axis Control



Vertical

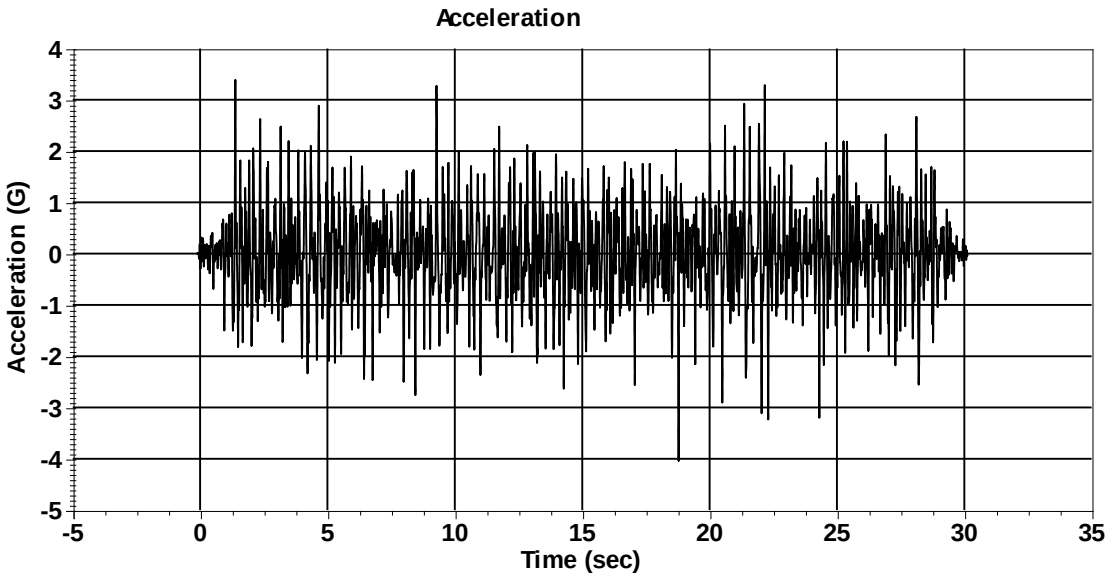
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634
Test# 7 OBE 3
120VAC removed during test, Lamps illuminated Oct 29, 2013 13:21:35

ZPA: -4.039 G



Demand **Side-Side**

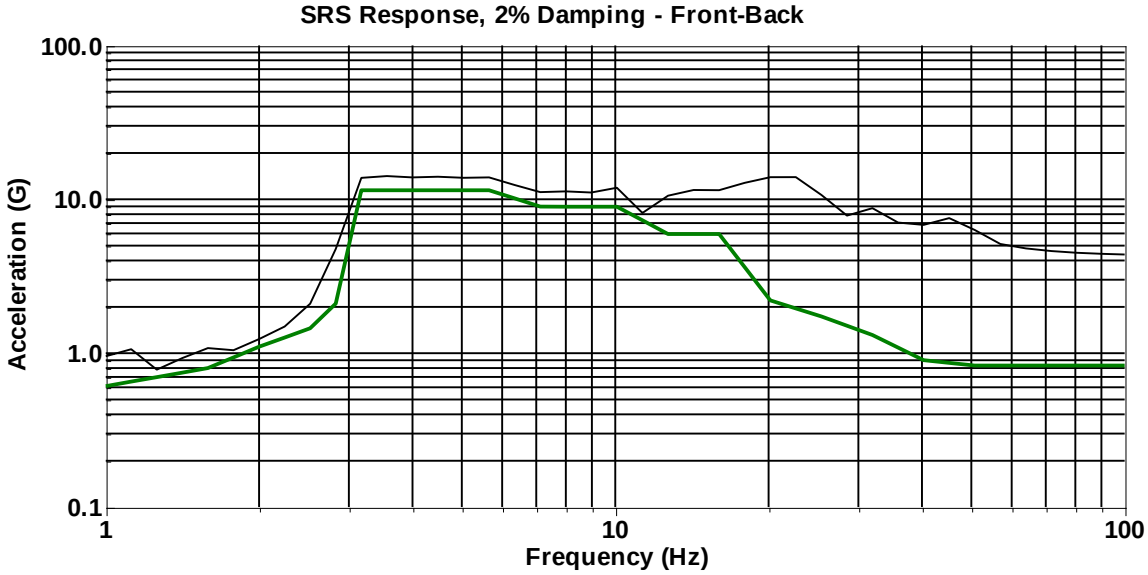
Side to Side Axis Control



Side-Side

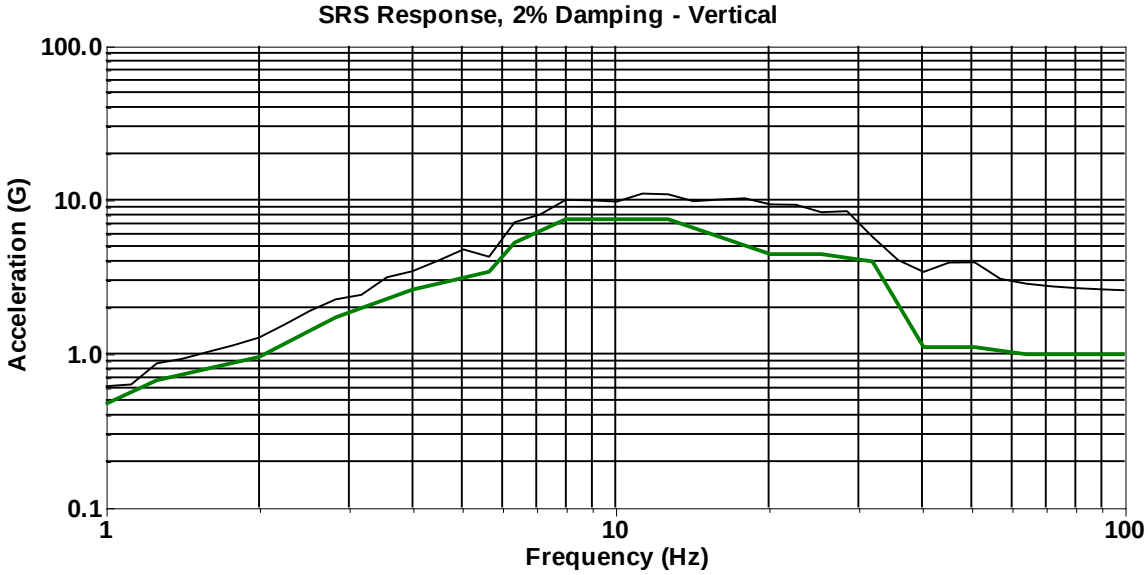
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634
Test# 7 OBE 3
120VAC removed during test, Lamps illuminated Oct 29, 2013 13:21:35

ZPA: 4.219 G



4702 unit Front to Back Response

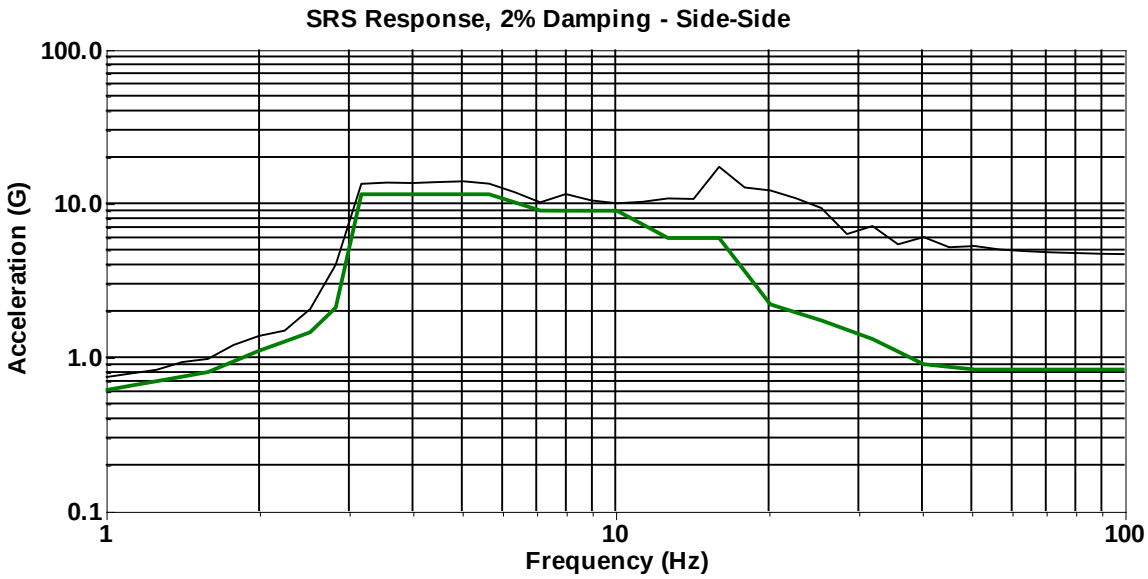
ZPA: 2.457 G



4702 unit Vertical Response

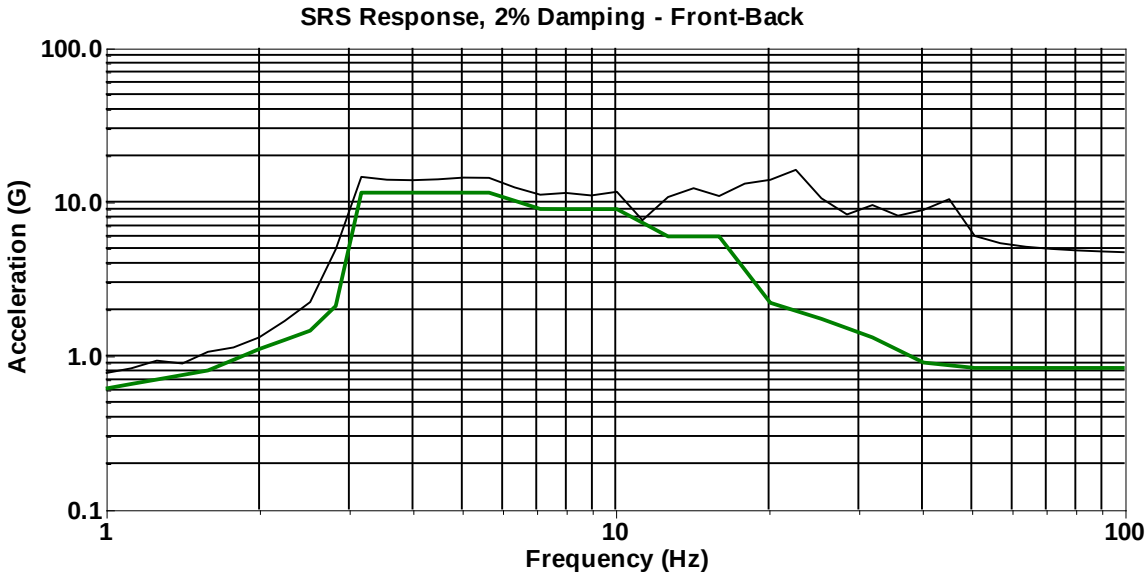
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634
Test# 7 OBE 3
120VAC removed during test, Lamps illuminated Oct 29, 2013 13:21:35

ZPA: -4.543 G



4702 unit Side to Side Response

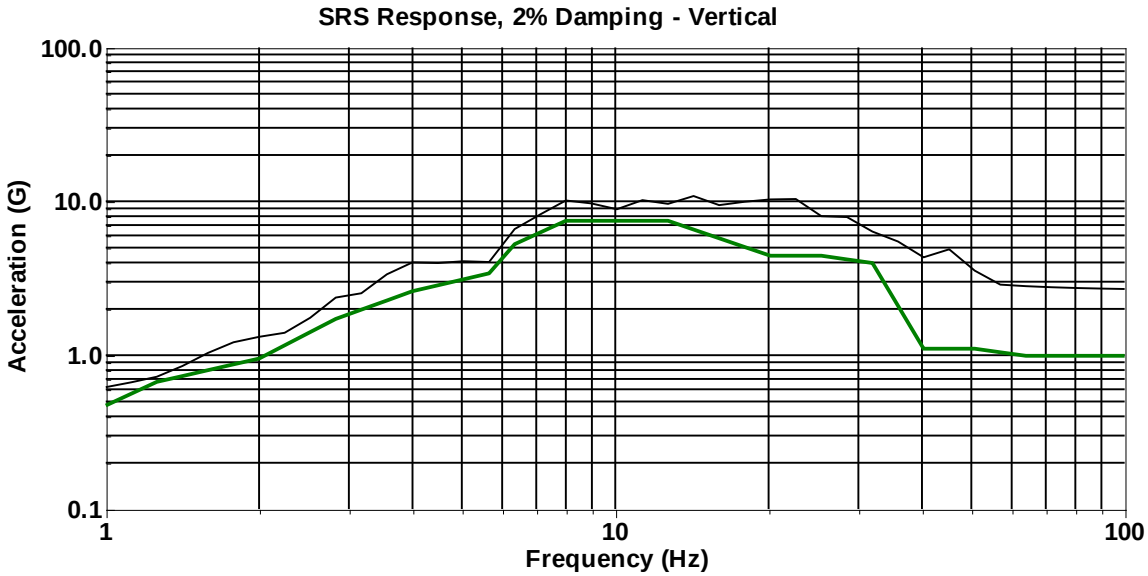
ZPA: 4.509 G



4726 unit Front to Back Response

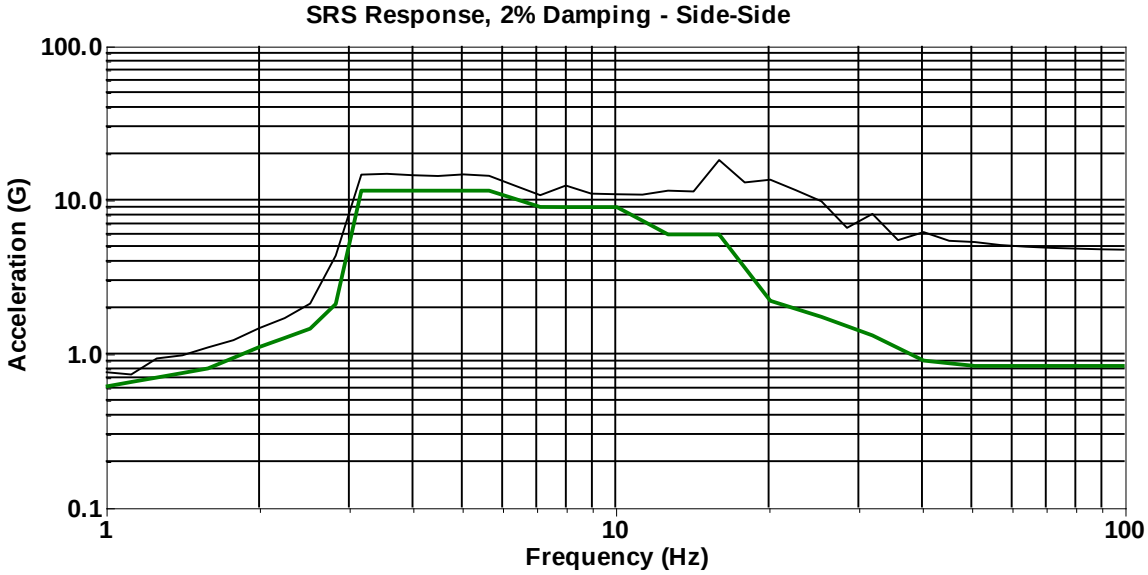
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634
Test# 7 OBE 3
120VAC removed during test, Lamps illuminated Oct 29, 2013 13:21:35

ZPA: 2.625 G



4726 unit Vertical Response

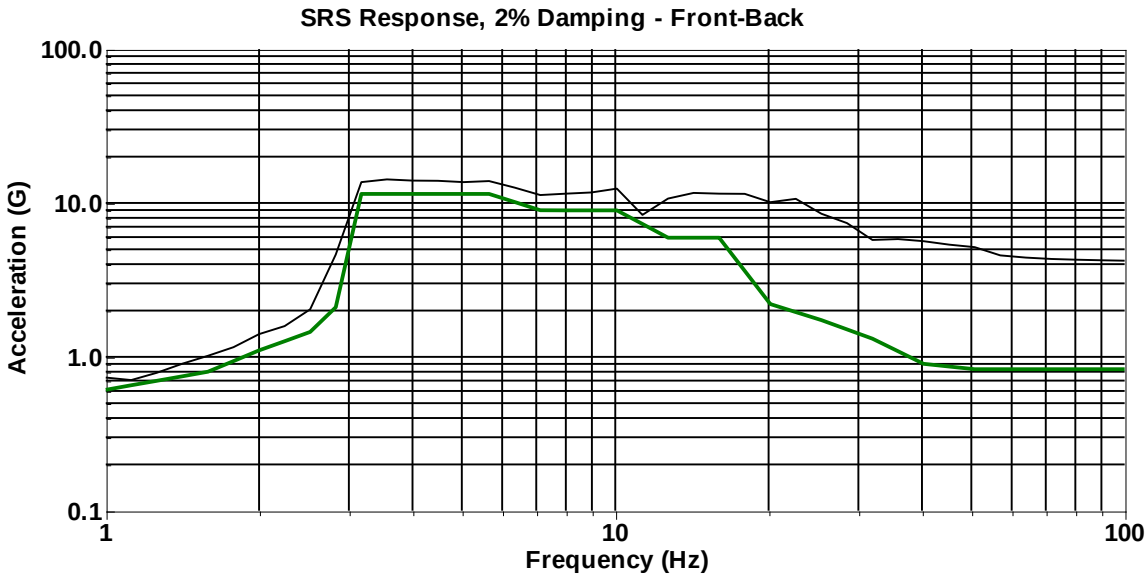
ZPA: -4.6 G



4726 unit Side to Side Response

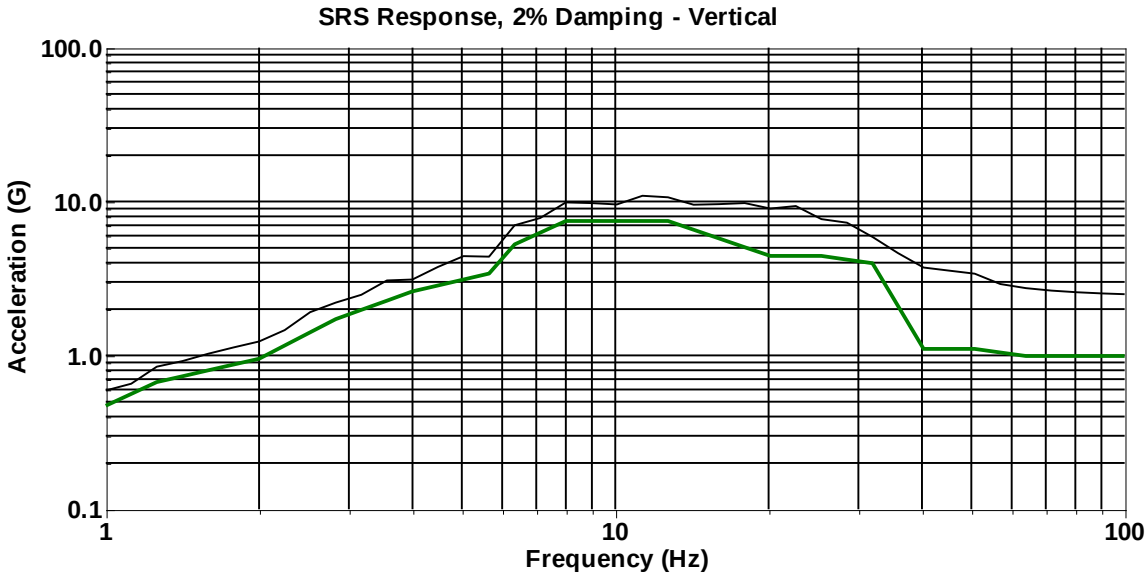
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634
Test# 7 OBE 3
120VAC removed during test, Lamps illuminated Oct 29, 2013 13:21:35

ZPA: 4.119 G



4634 LED unit Front to Back Response

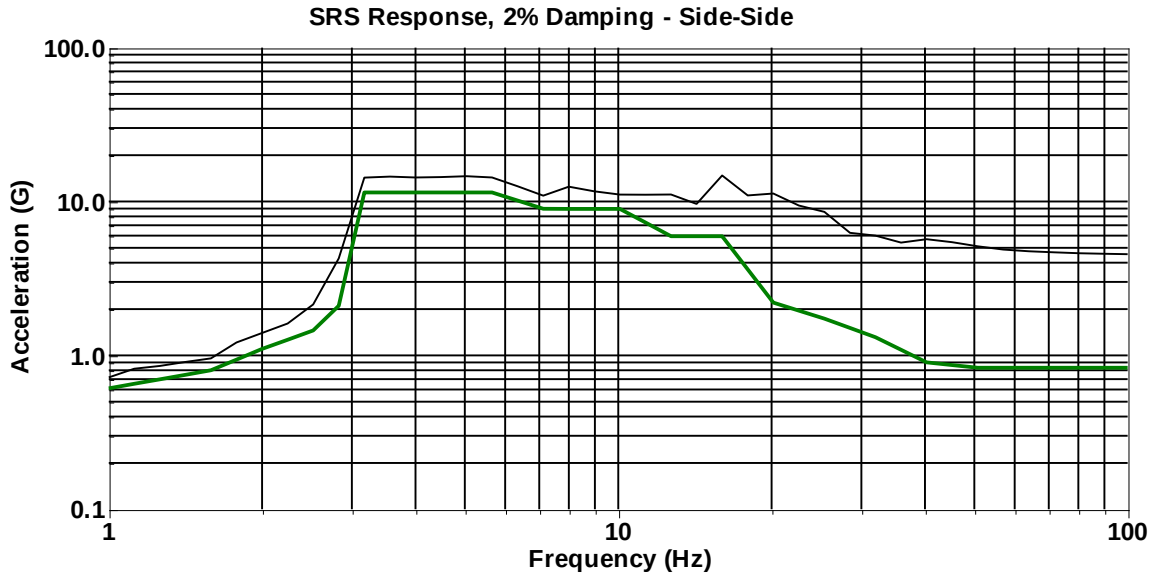
ZPA: 2.382 G



4634 LED unit Vertical Response

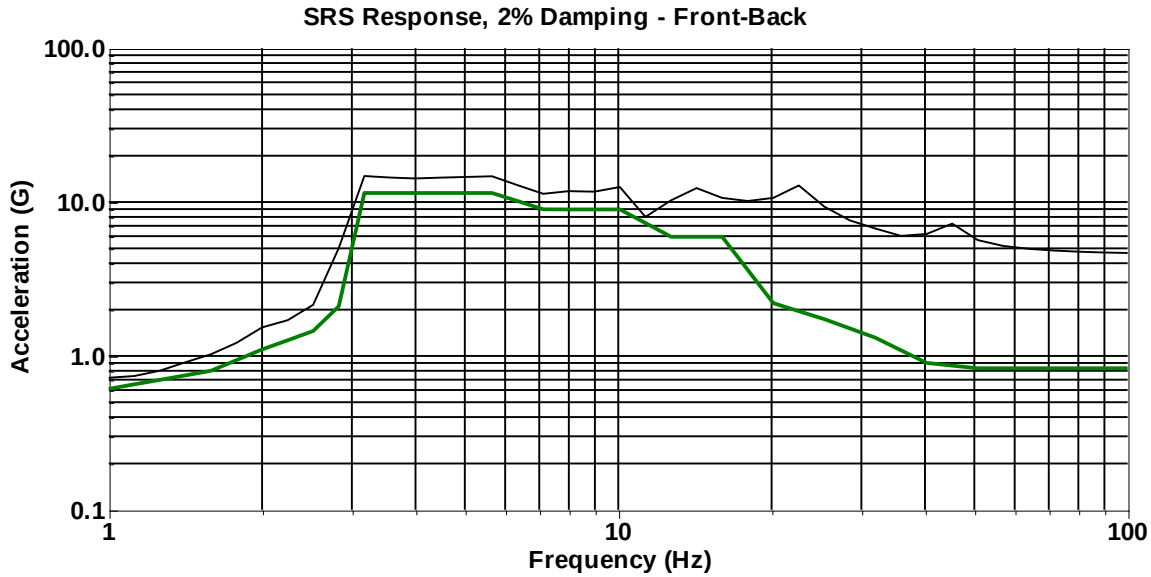
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634
Test# 7 OBE 3
120VAC removed during test, Lamps illuminated Oct 29, 2013 13:21:35
21:35

ZPA: -4.424 G



4634 LED unit Side to Side Response

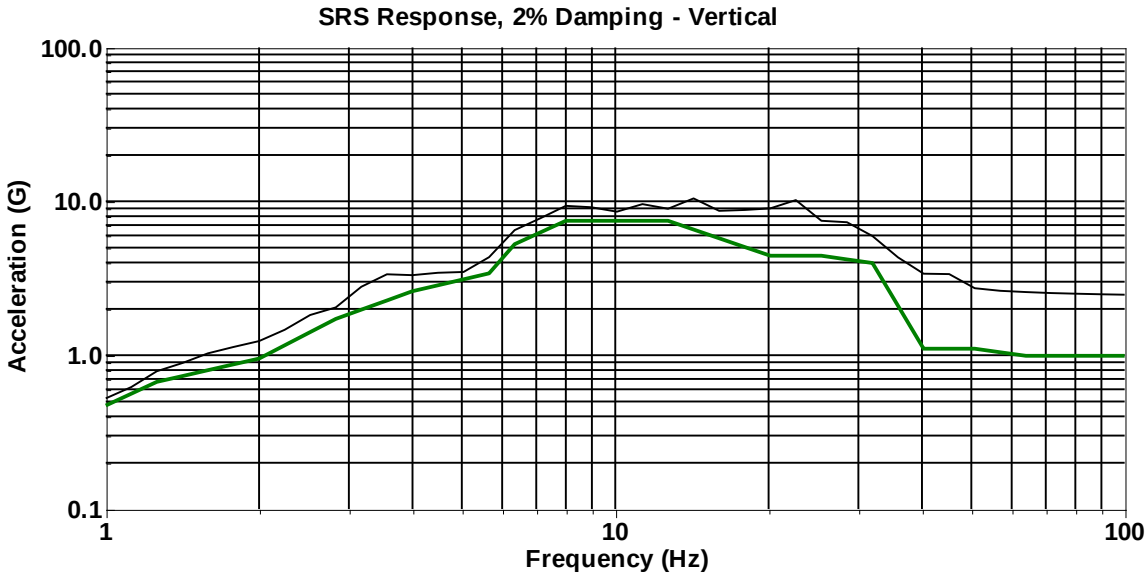
ZPA: 4.52 G



4634 Incandescent unit Front to Back Response

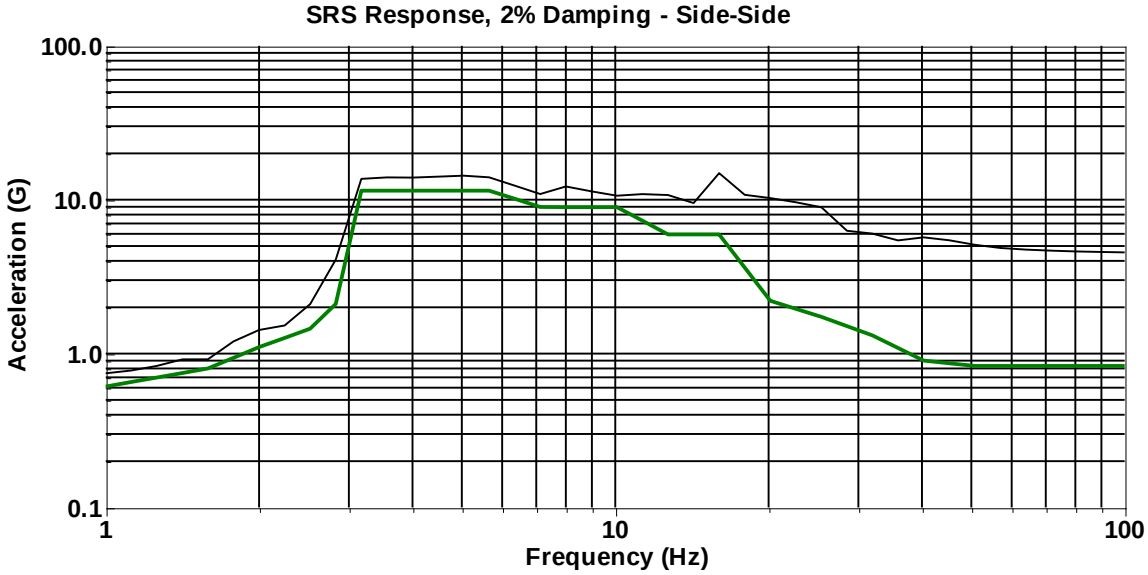
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634
Test# 7 OBE 3
120VAC removed during test, Lamps illuminated Oct 29, 2013 13:21:35

ZPA: 2.416 G



4634 Incandescent unit Vertical Response

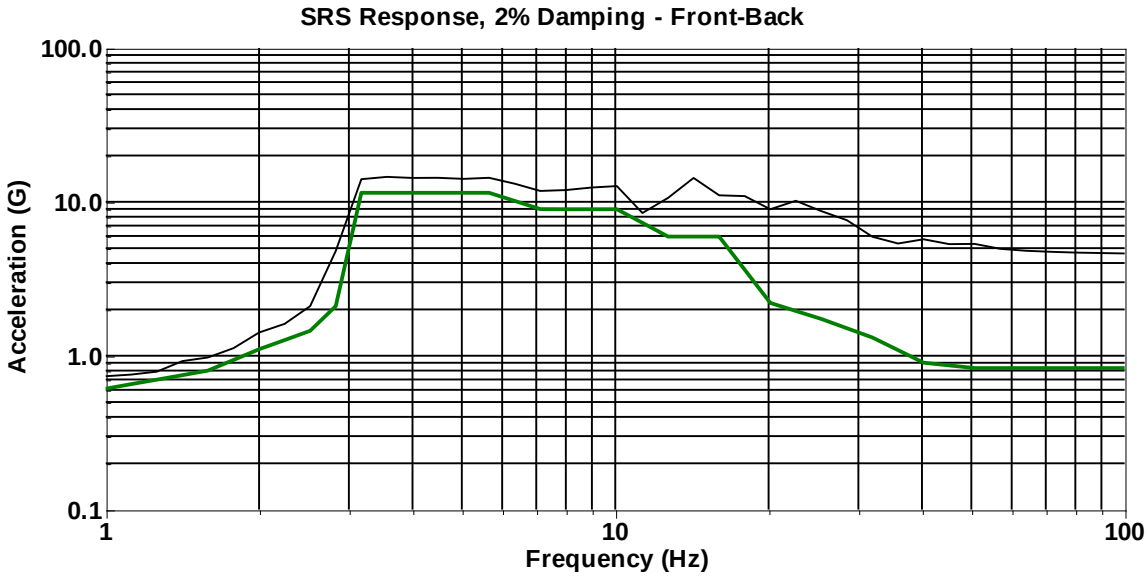
ZPA: -4.426 G



4634 Incandescent unit Side to Side Response

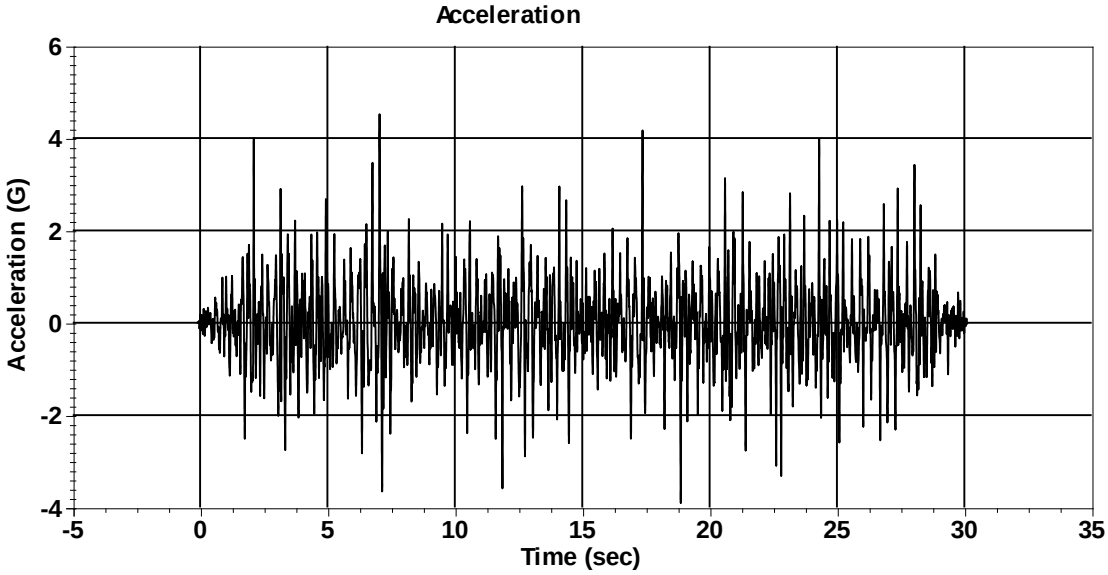
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634
Test# 7 OBE 3
120VAC removed during test, Lamps illuminated Oct 29, 2013 13:21:35

ZPA: 4.517 G



Demand **Front-Back**

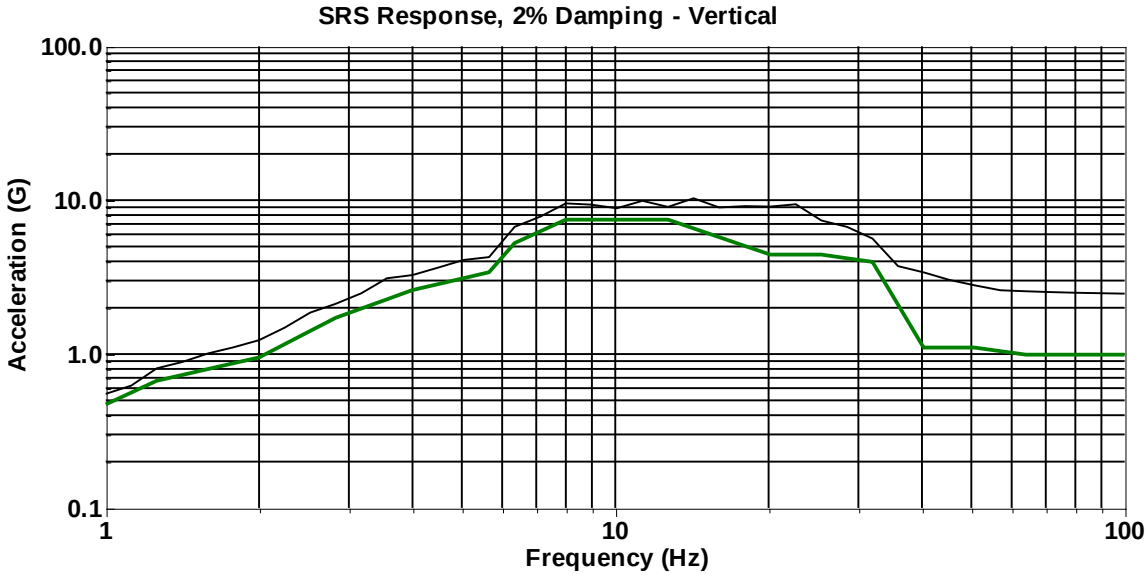
Front to Back Axis Control



Front-Back

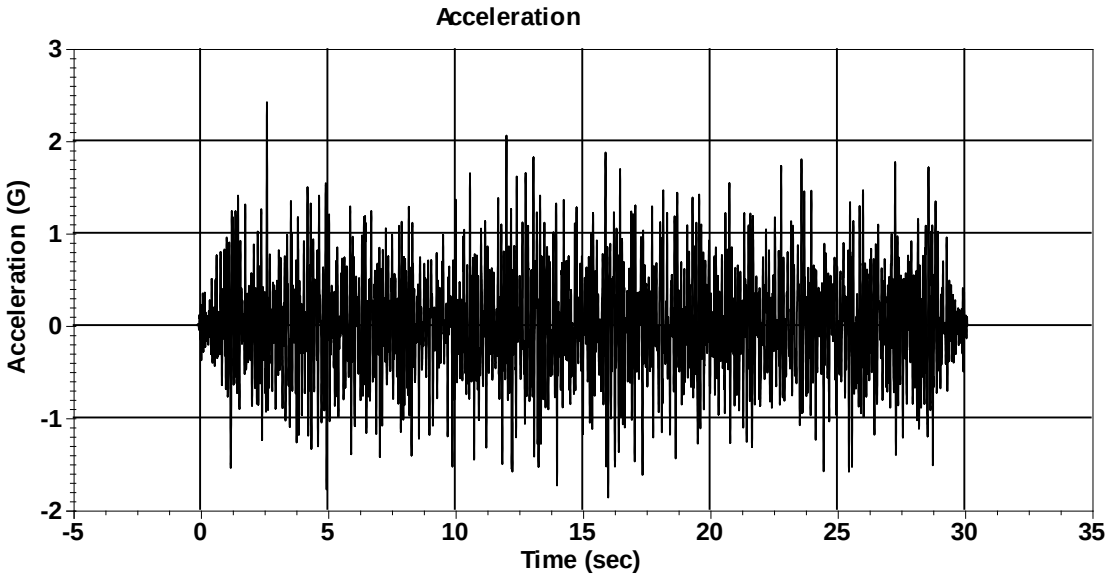
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 8 OBE 4
Lamps illuminated Oct 29, 2013 13:23:19

ZPA: 2.415 G



Demand **Vertical**

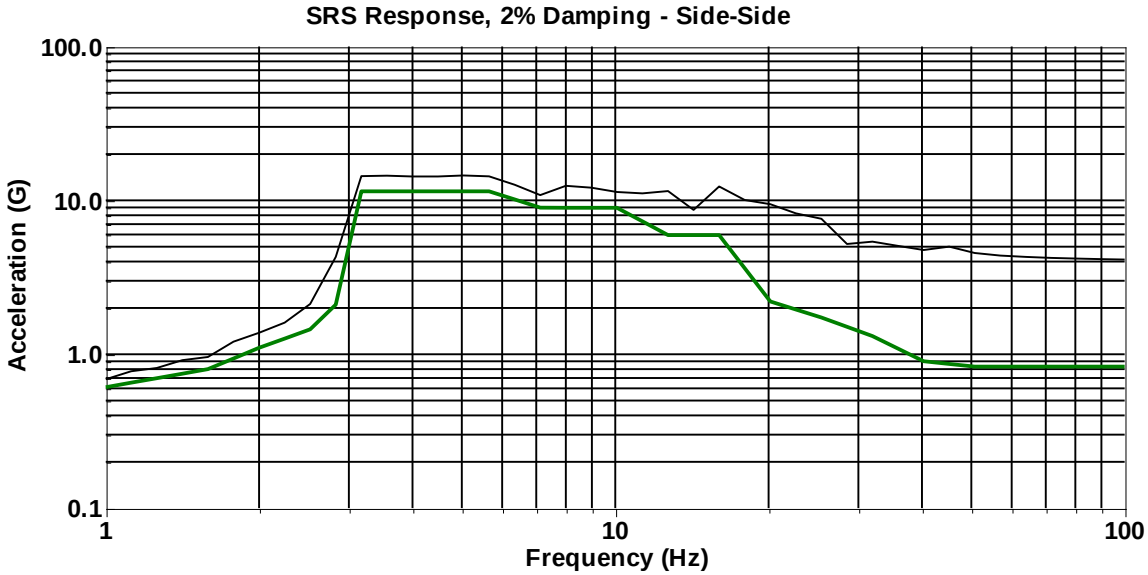
Vertical Axis Control



Vertical

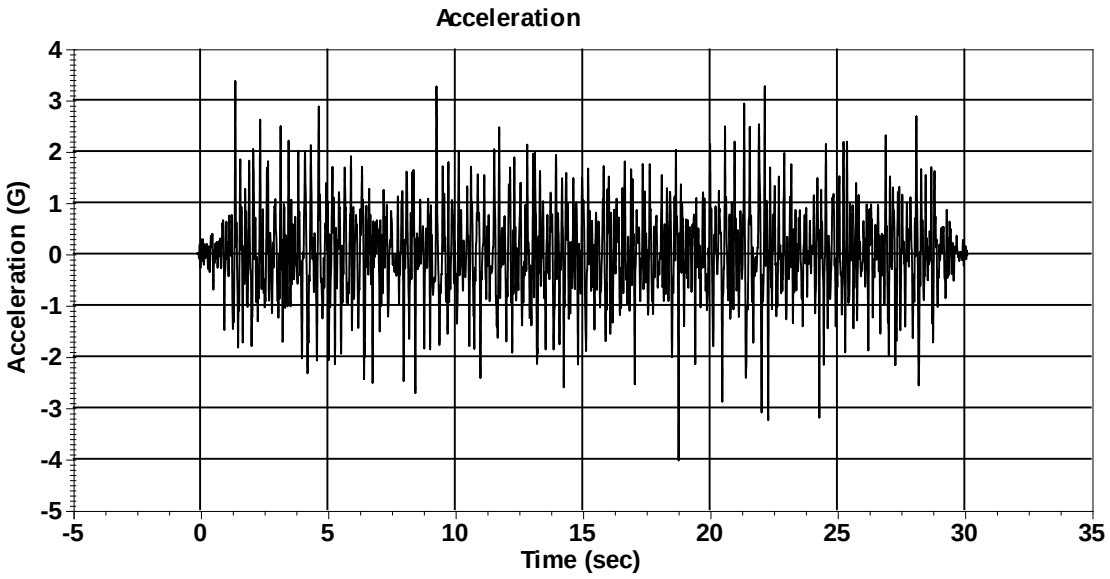
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 8 OBE 4
Lamps illuminated Oct 29, 2013 13:23:19

ZPA: -4.031 G



Demand **Side-Side**

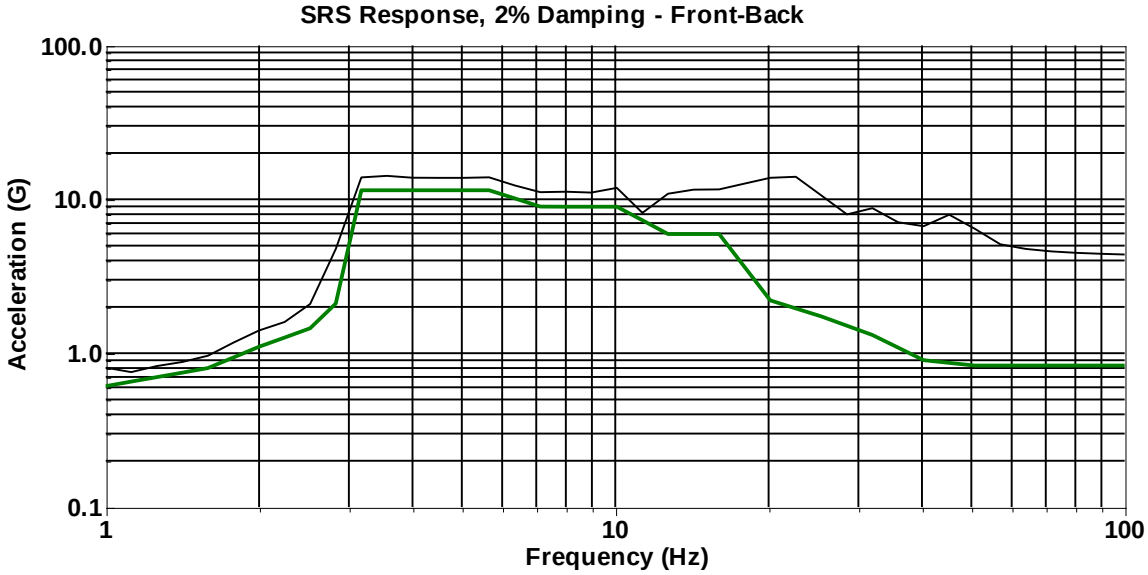
Side to Side Axis Control



Side-Side

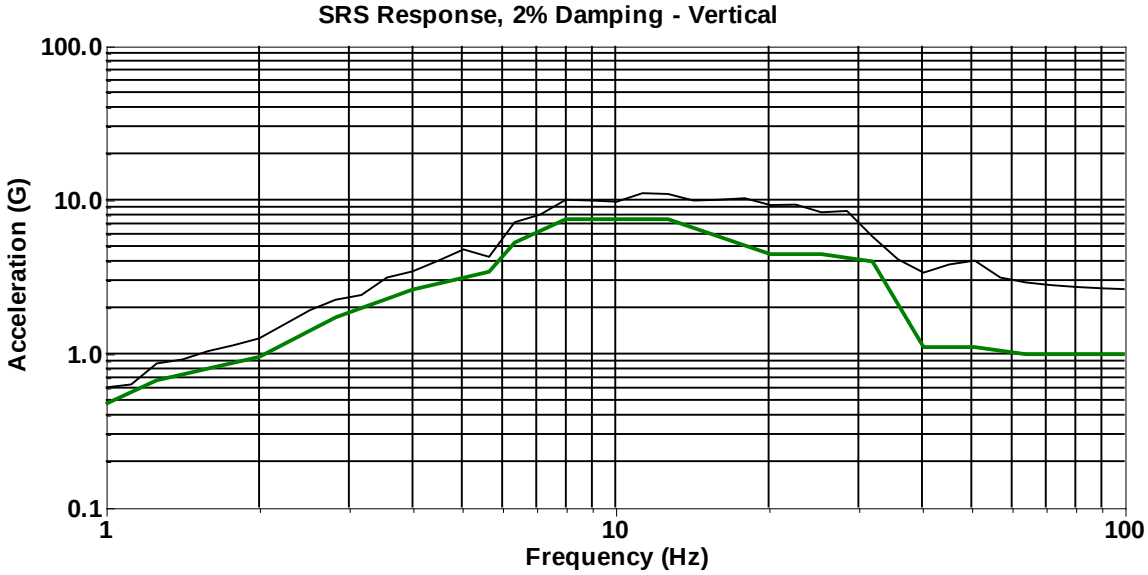
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 8 OBE 4
Lamps illuminated Oct 29, 2013 13:23:19

ZPA: 4.213 G



4702 unit Front to Back Response

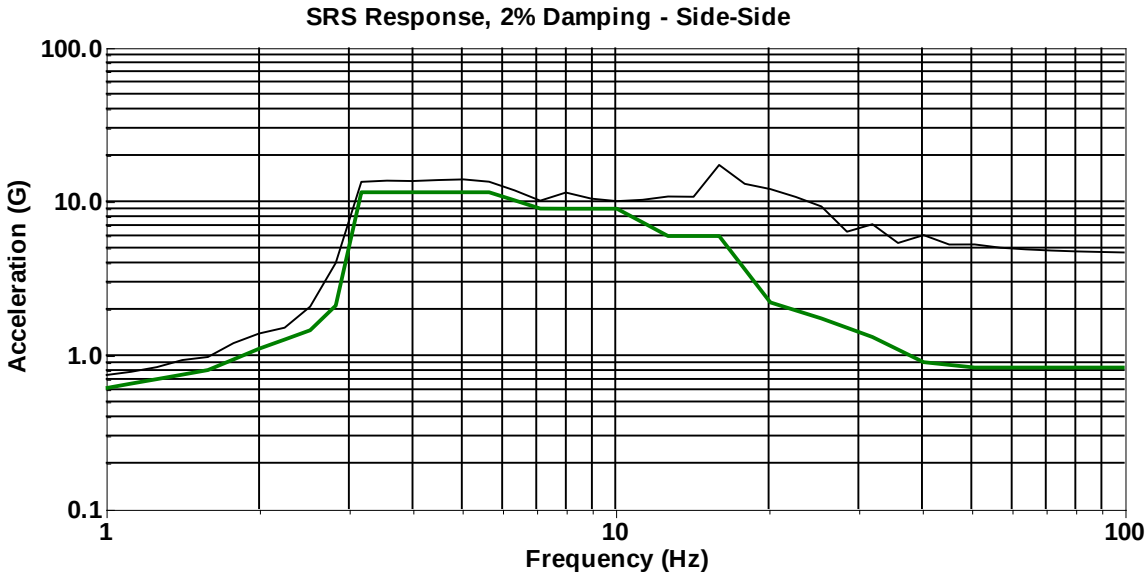
ZPA: 2.496 G



4702 unit Vertical Response

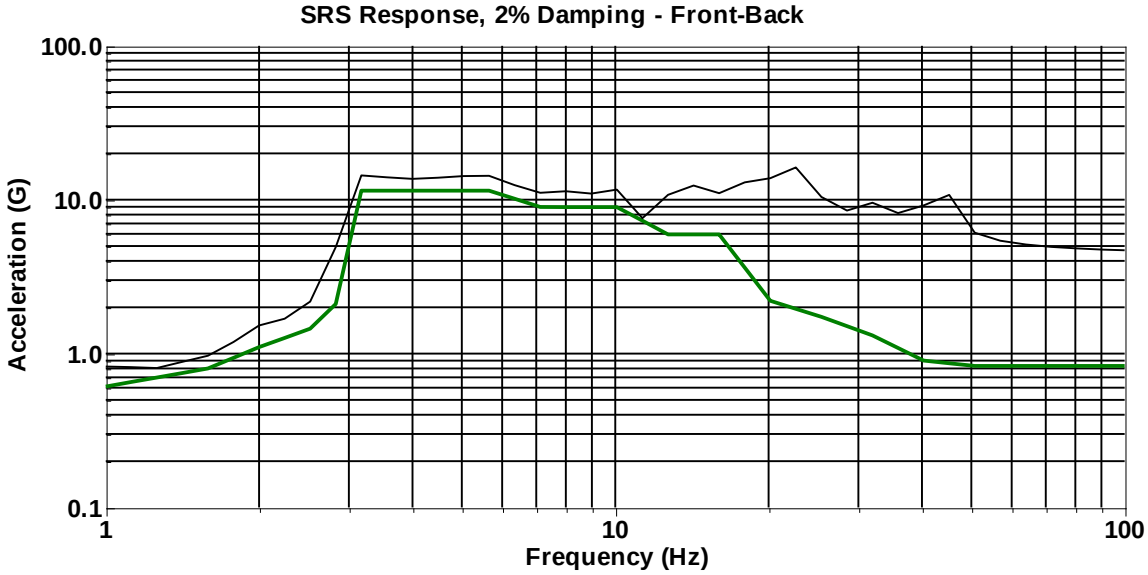
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 8 OBE 4
Lamps illuminated Oct 29, 2013 13:23:19

ZPA: -4.527 G



4702 unit Side to Side Response

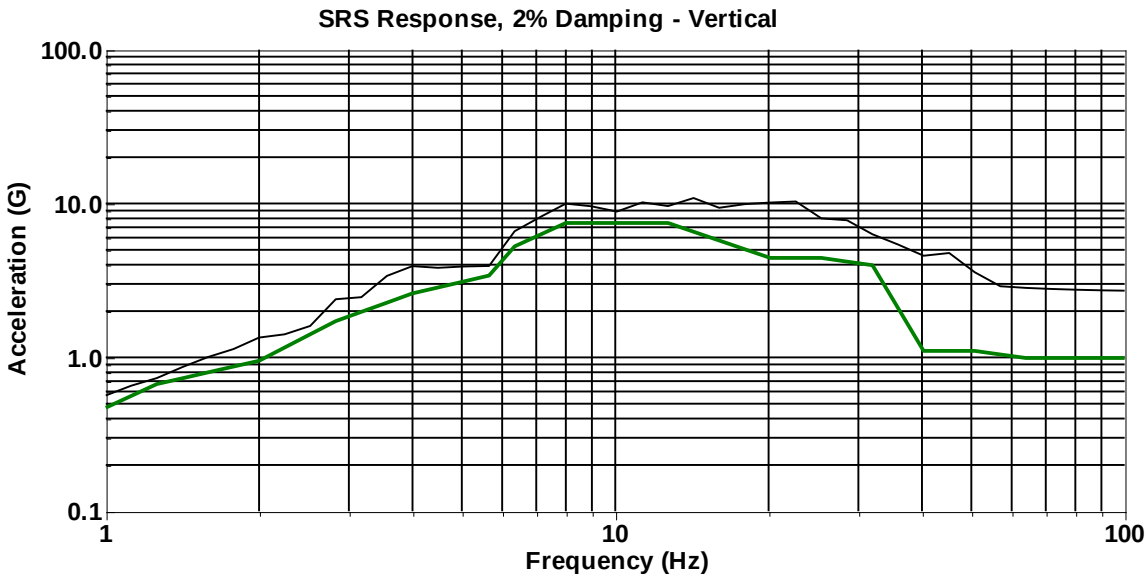
ZPA: 4.493 G



4726 unit Front to Back Response

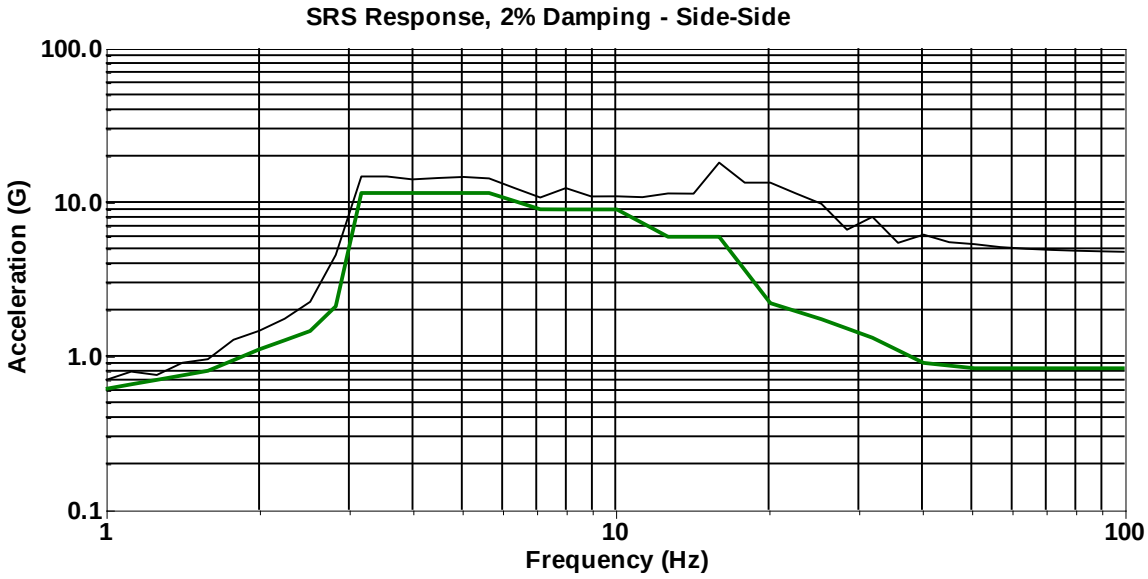
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 8 OBE 4
Lamps illuminated Oct 29, 2013 13:23:19

ZPA: 2.641 G



4726 unit Vertical Response

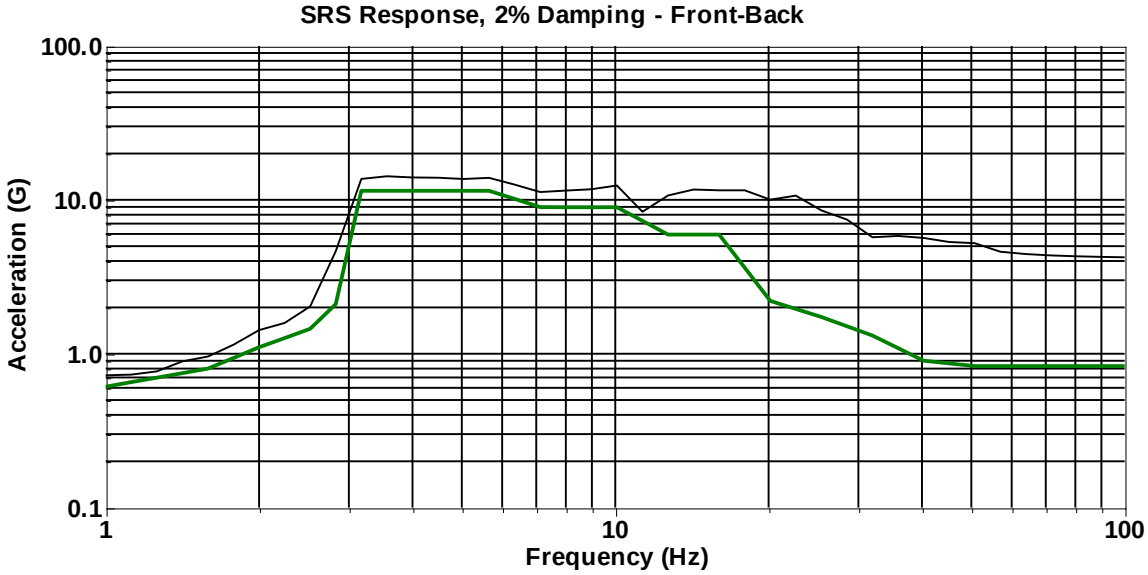
ZPA: -4.621 G



4726 unit Side to Side Response

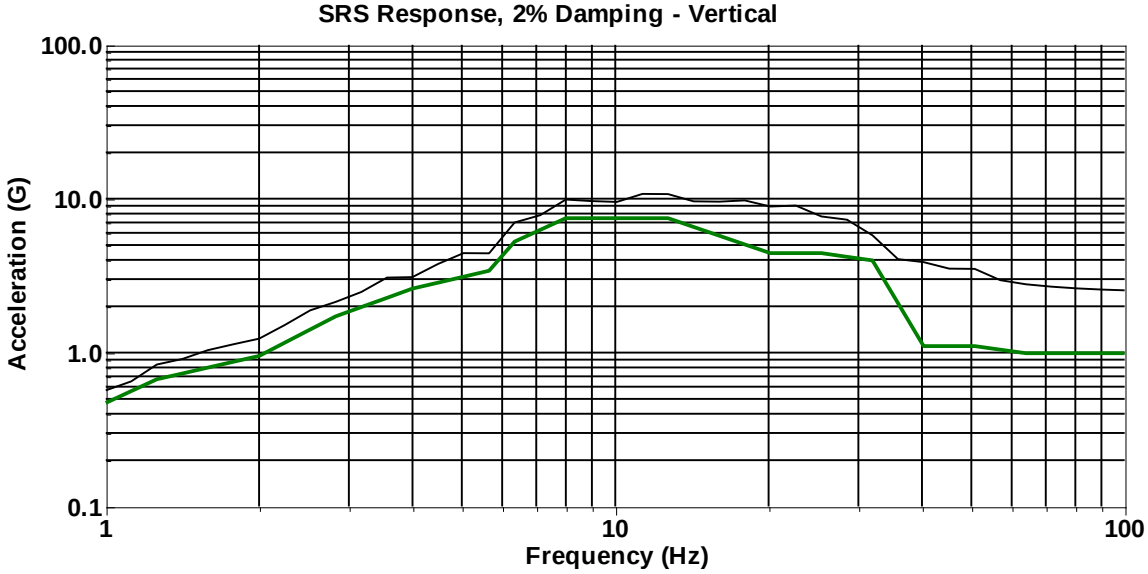
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 8 OBE 4
Lamps illuminated Oct 29, 2013 13:23:19

ZPA: 4.137 G



4634 LED unit Front to Back Response

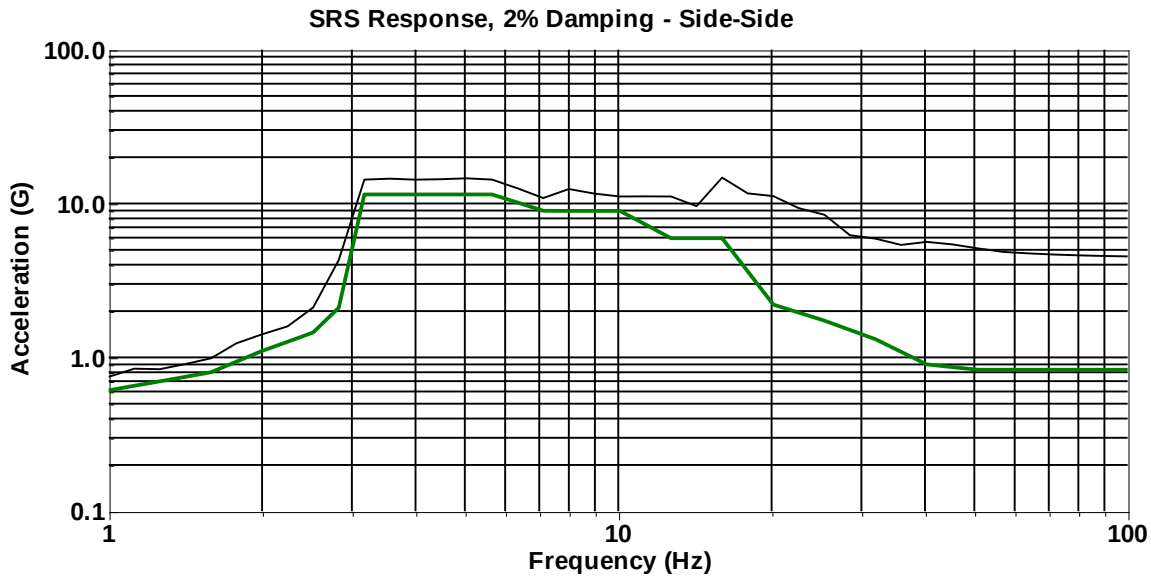
ZPA: 2.42 G



4634 LED unit Vertical Response

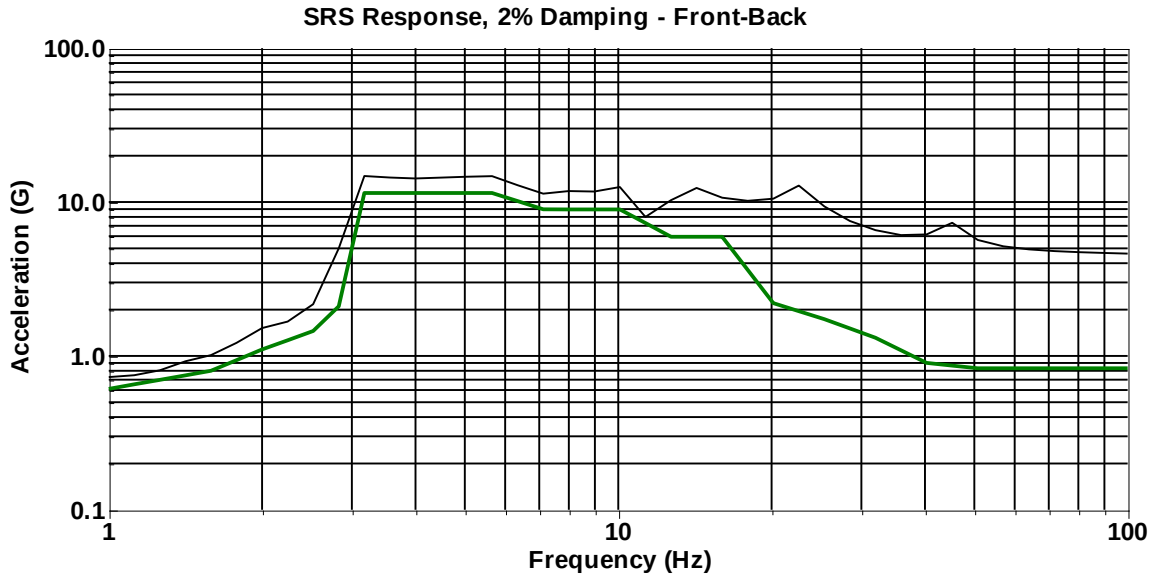
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 8 OBE 4
Lamps illuminated Oct 29, 2013 13:23:19

ZPA: -4.412 G



4634 LED unit Side to Side Response

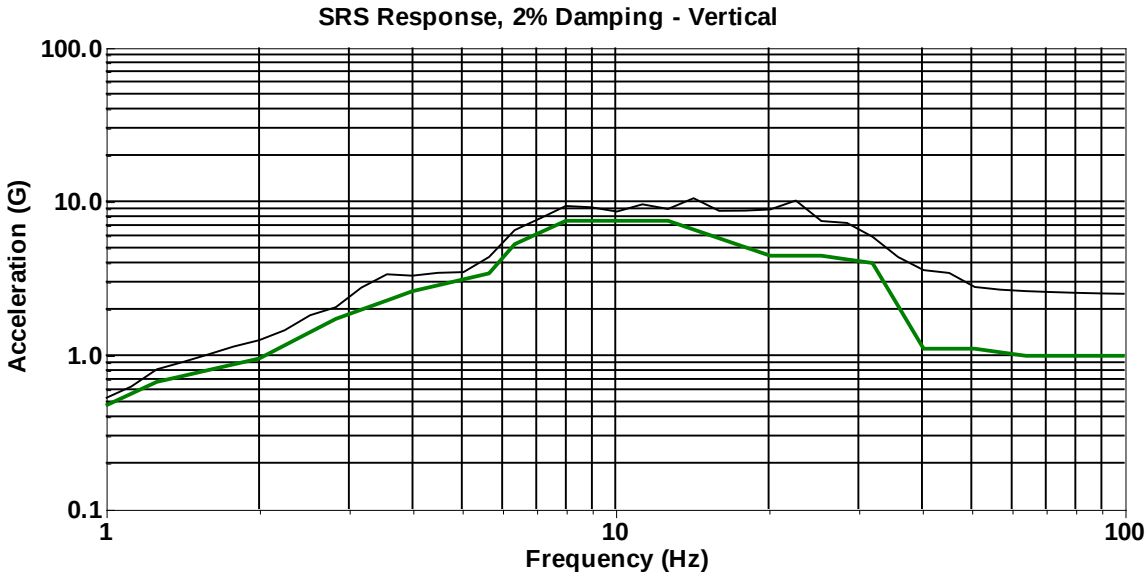
ZPA: 4.486 G



4634 Incandescent unit Front to Back Response

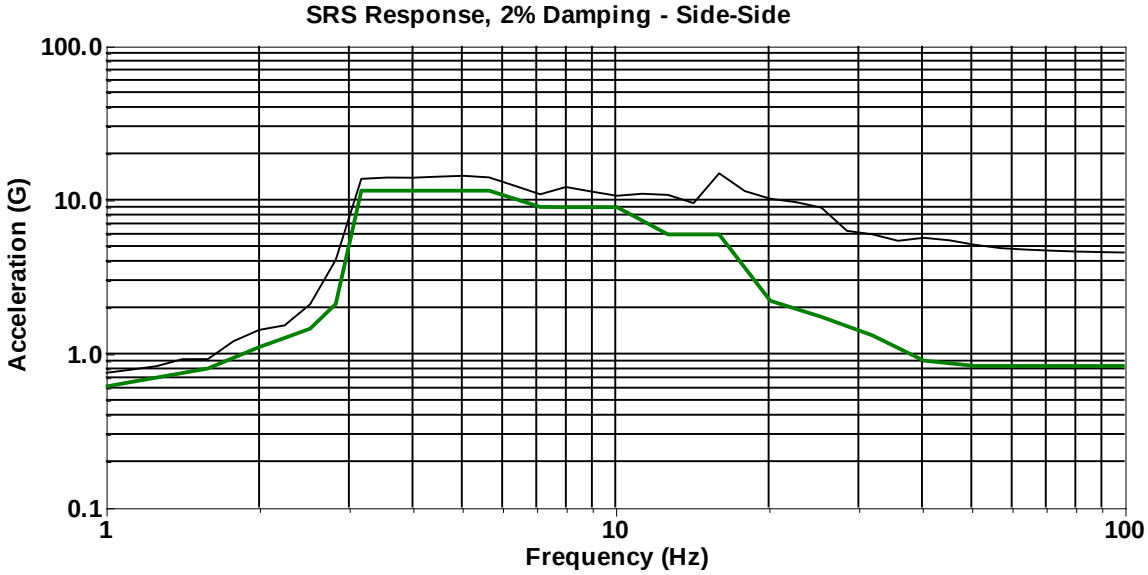
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 8 OBE 4
Lamps illuminated Oct 29, 2013 13:23:19

ZPA: 2.443 G



4634 Incandescent unit Vertical Response

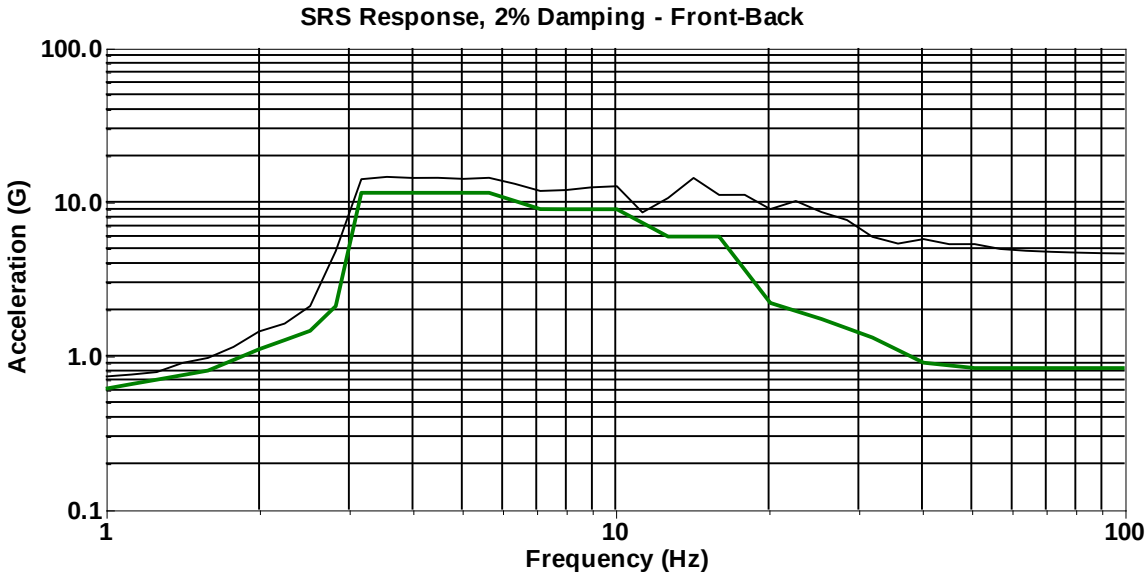
ZPA: -4.421 G



4634 Incandescent unit Side to Side Response

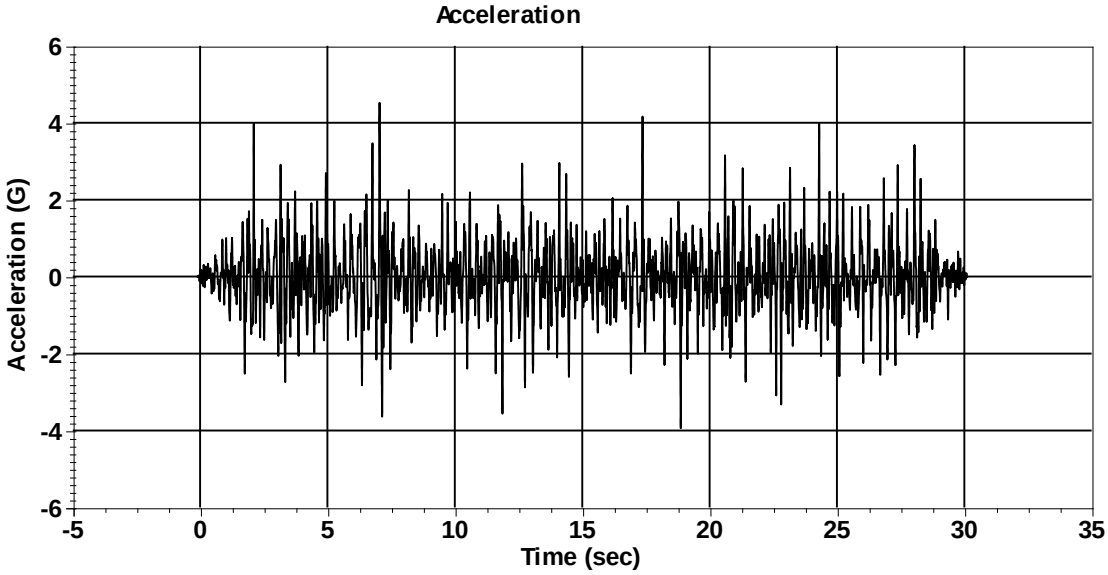
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 8 OBE 4
Lamps illuminated Oct 29, 2013 13:23:19

ZPA: 4.516 G



Demand **Front-Back**

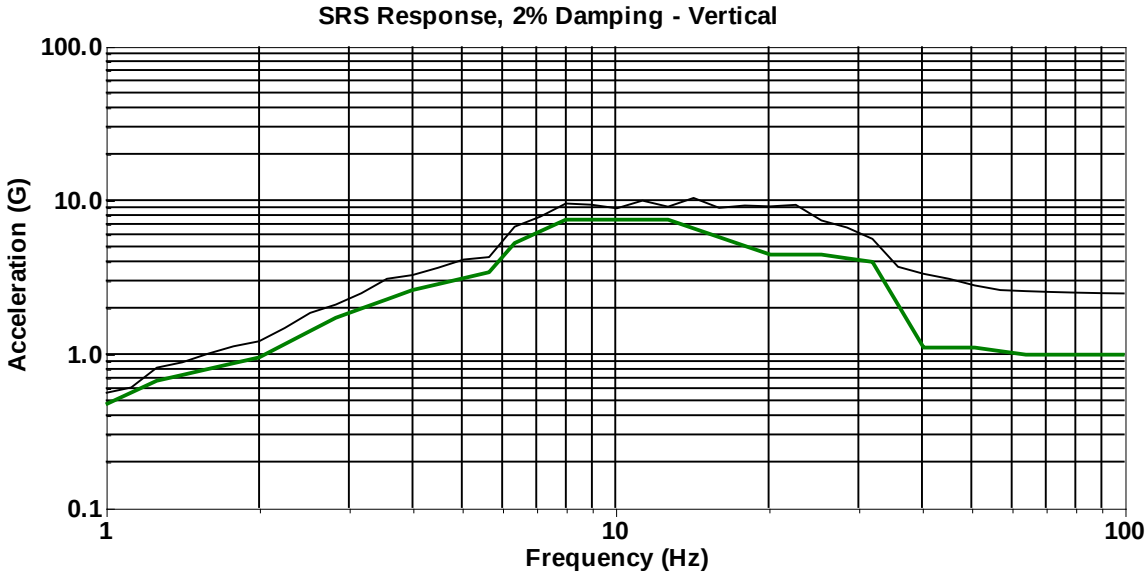
Front to Back Axis Control



Front-Back

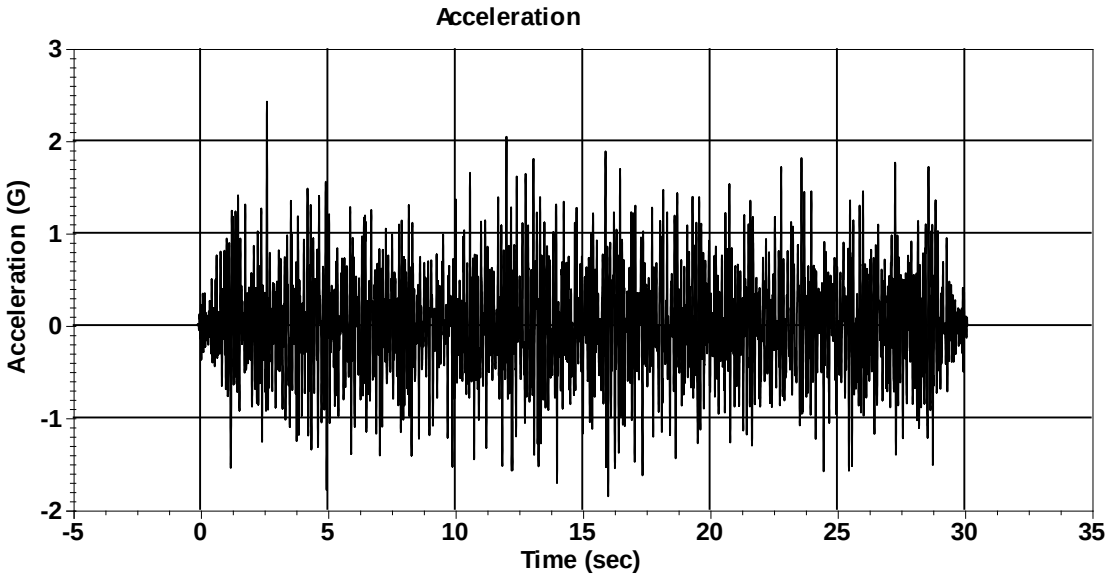
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634
Test# 9 OBE 5
Illumination Oct 29, 2013 13:24:45

ZPA: 2.419 G



Demand **Vertical**

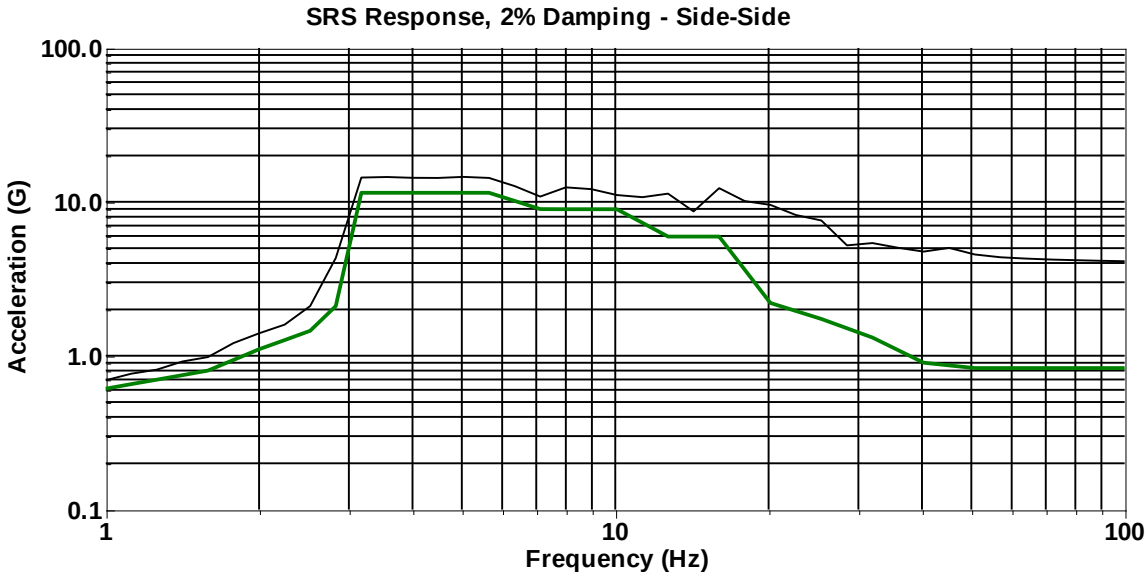
Vertical Axis Control



Vertical

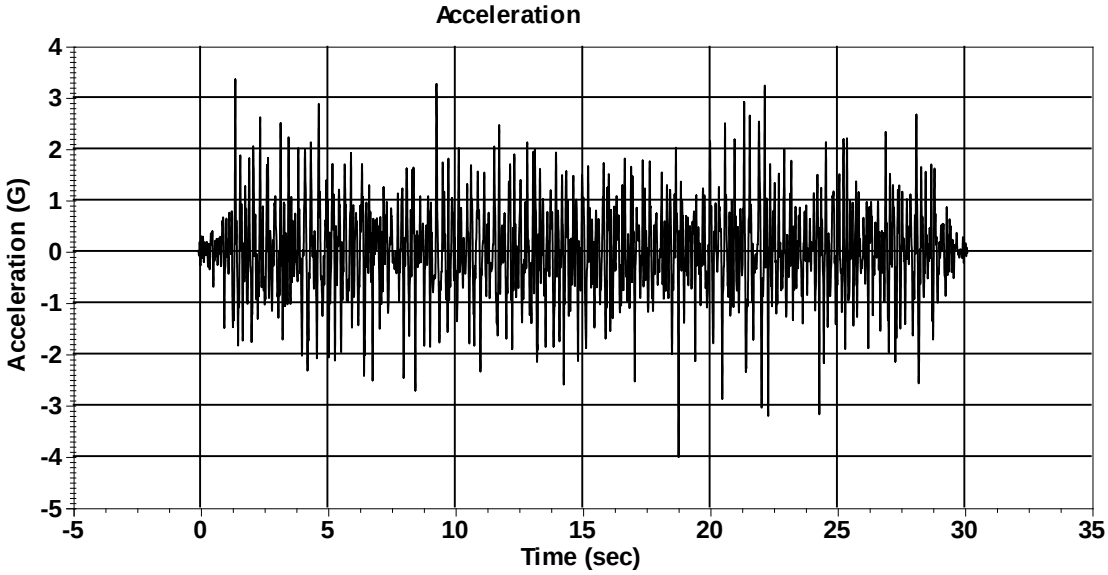
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634
Test# 9 OBE 5
Illumination Oct 29, 2013 13:24:45

ZPA: -4.02 G



Demand **Side-Side**

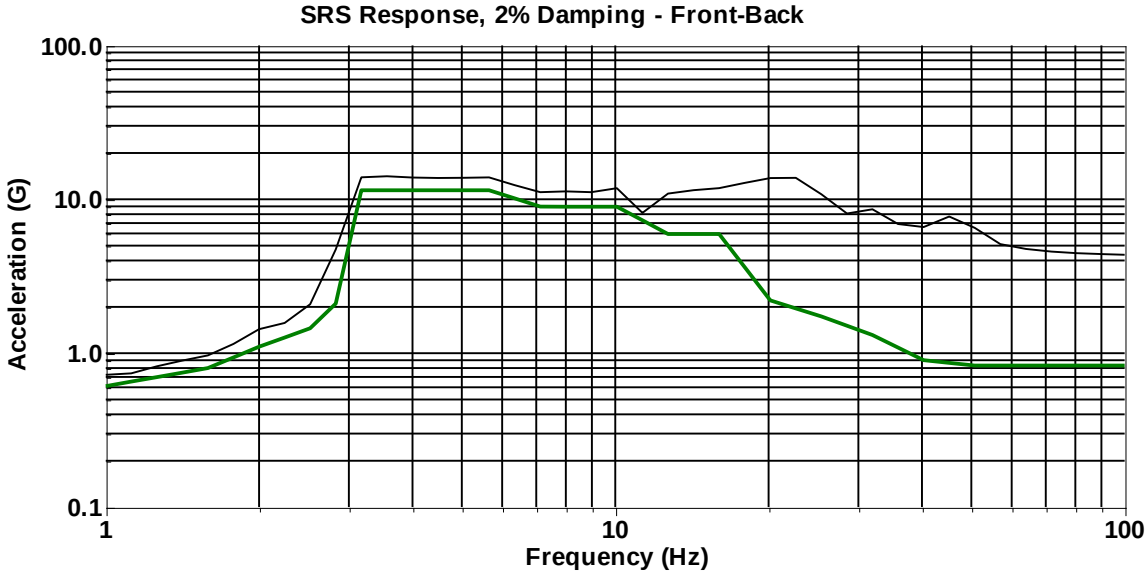
Side to Side Axis Control



Side-Side

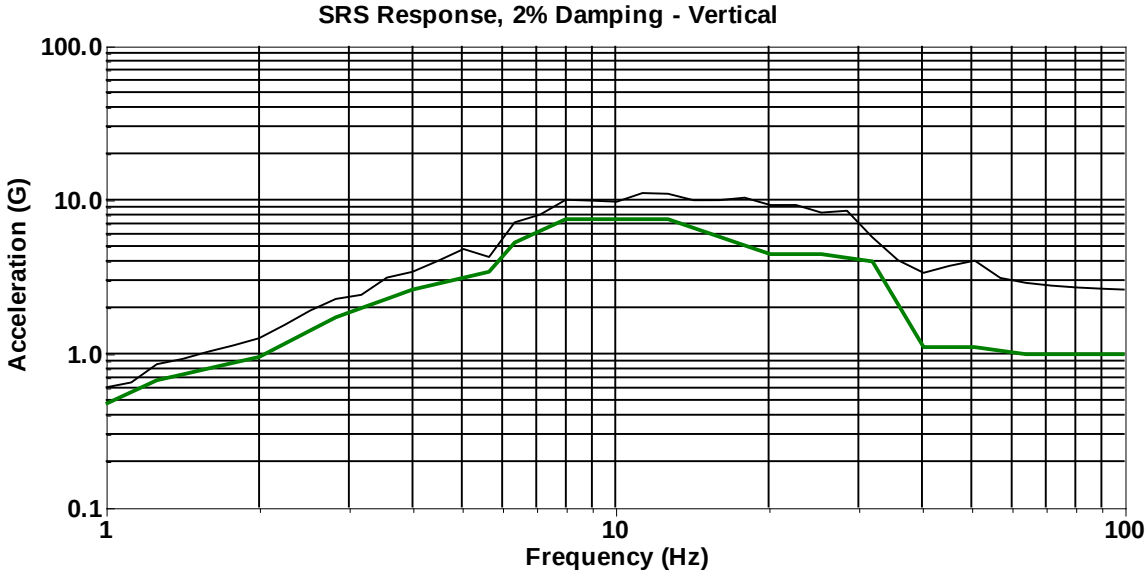
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634
Test# 9 OBE 5
Illumination Oct 29, 2013 13:24:45

ZPA: 4.196 G



4702 unit Front to Back Response

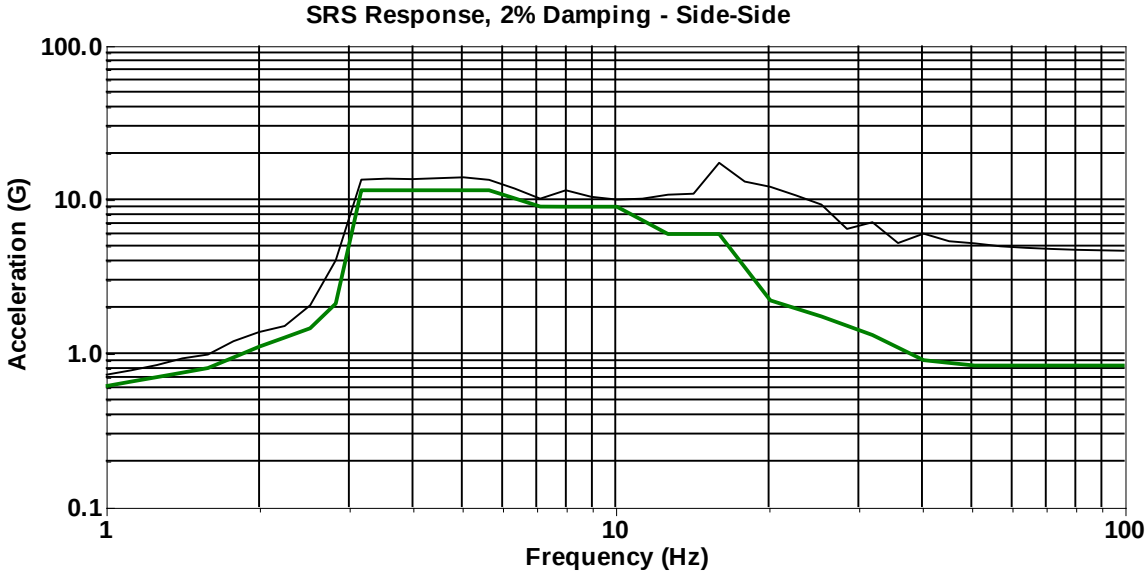
ZPA: 2.48 G



4702 unit Vertical Response

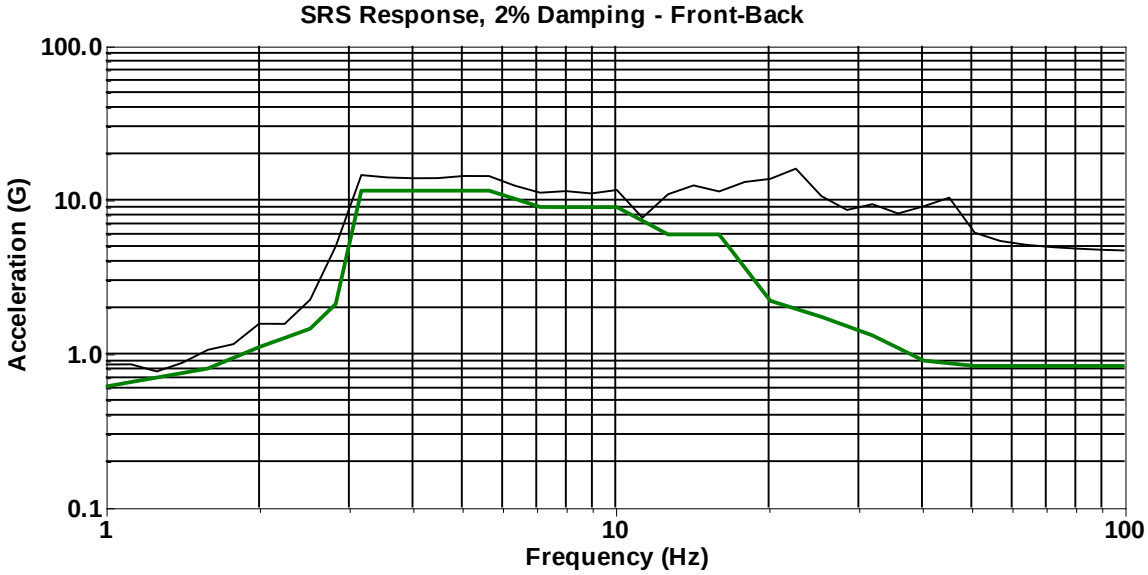
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634
Test# 9 OBE 5
Illumination Oct 29, 2013 13:24:45

ZPA: -4.508 G



4702 unit Side to Side Response

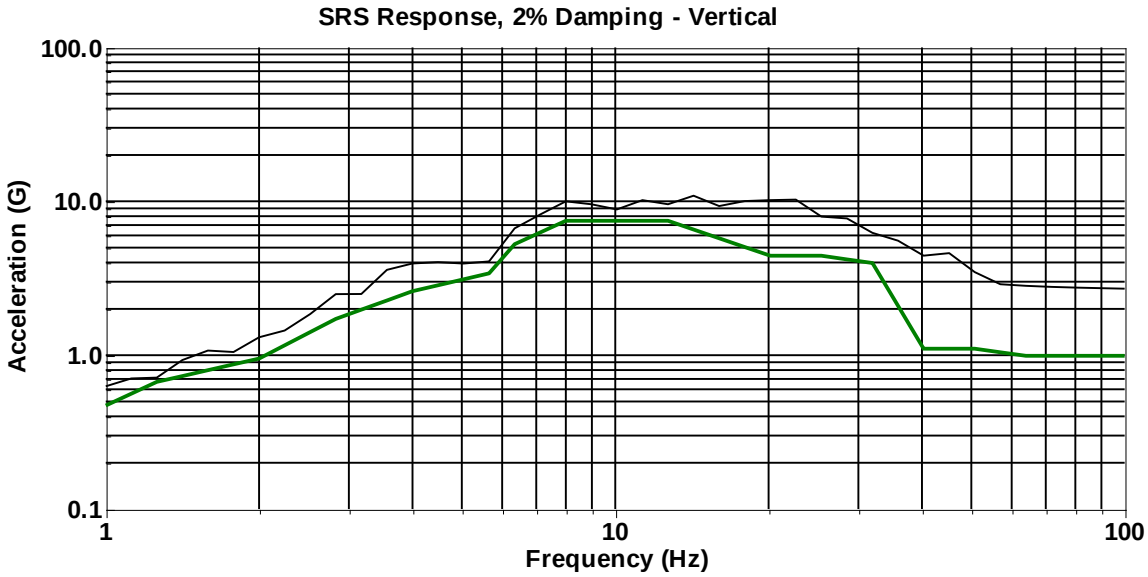
ZPA: 4.487 G



4726 unit Front to Back Response

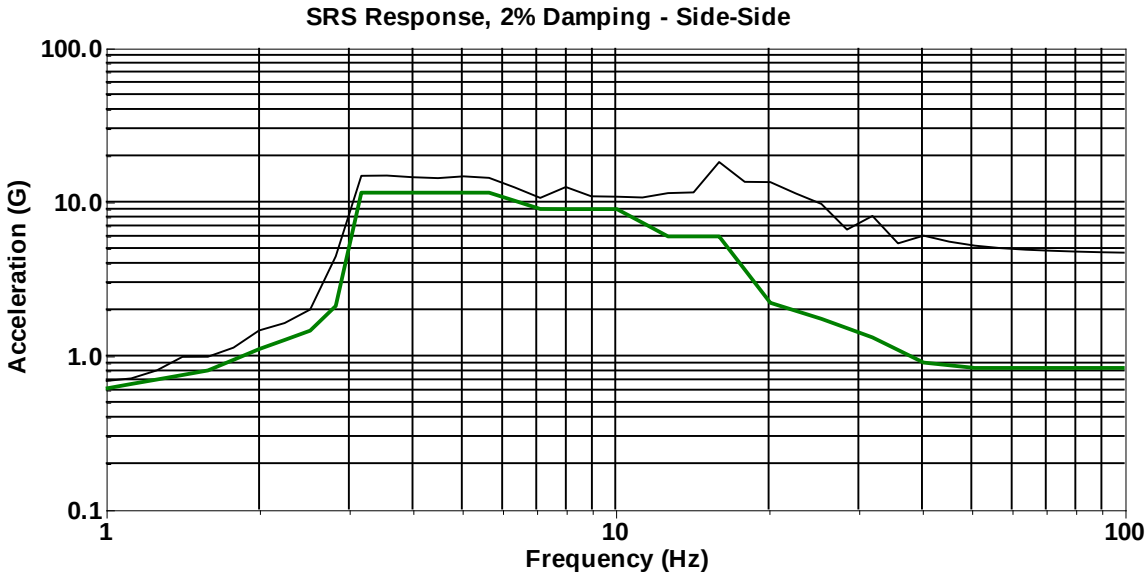
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634
Test# 9 OBE 5
Illumination Oct 29, 2013 13:24:45

ZPA: 2.637 G



4726 unit Vertical Response

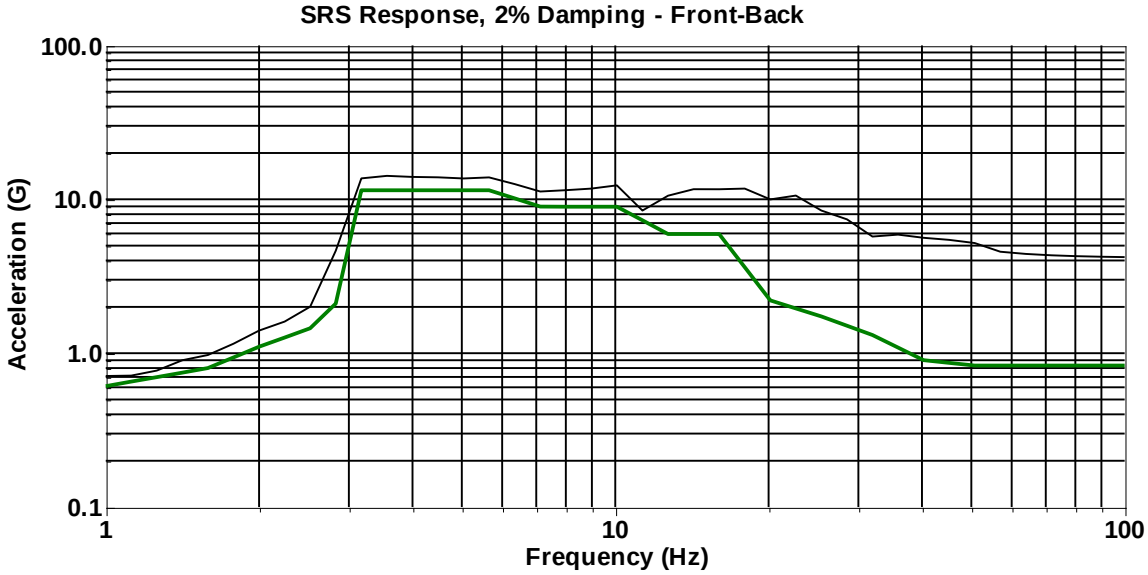
ZPA: -4.546 G



4726 unit Side to Side Response

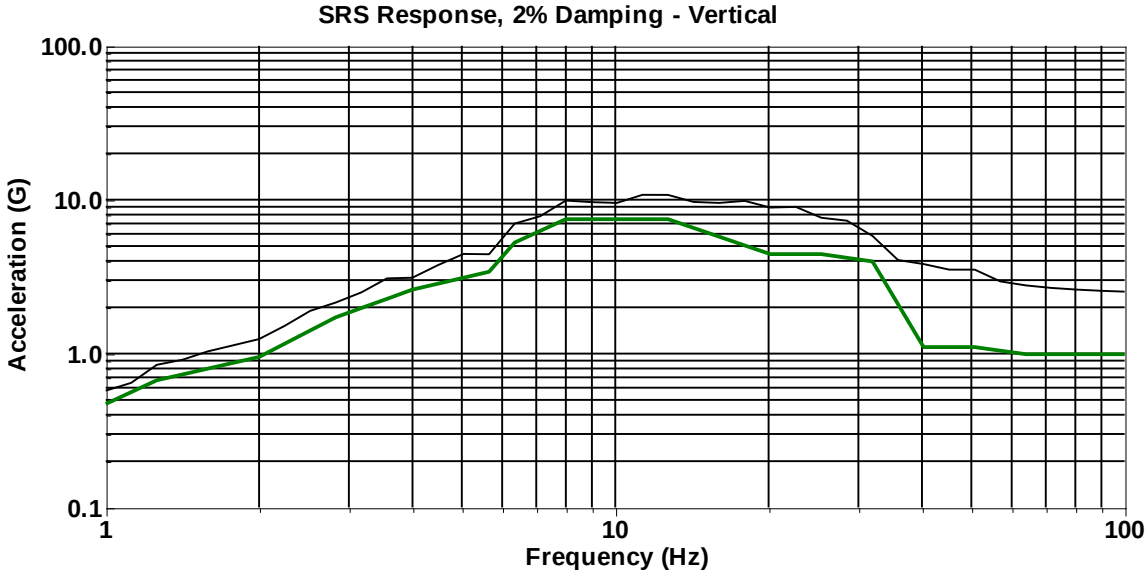
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634
Test# 9 OBE 5
Illumination Oct 29, 2013 13:24:45

ZPA: 4.117 G



4634 LED unit Front to Back Response

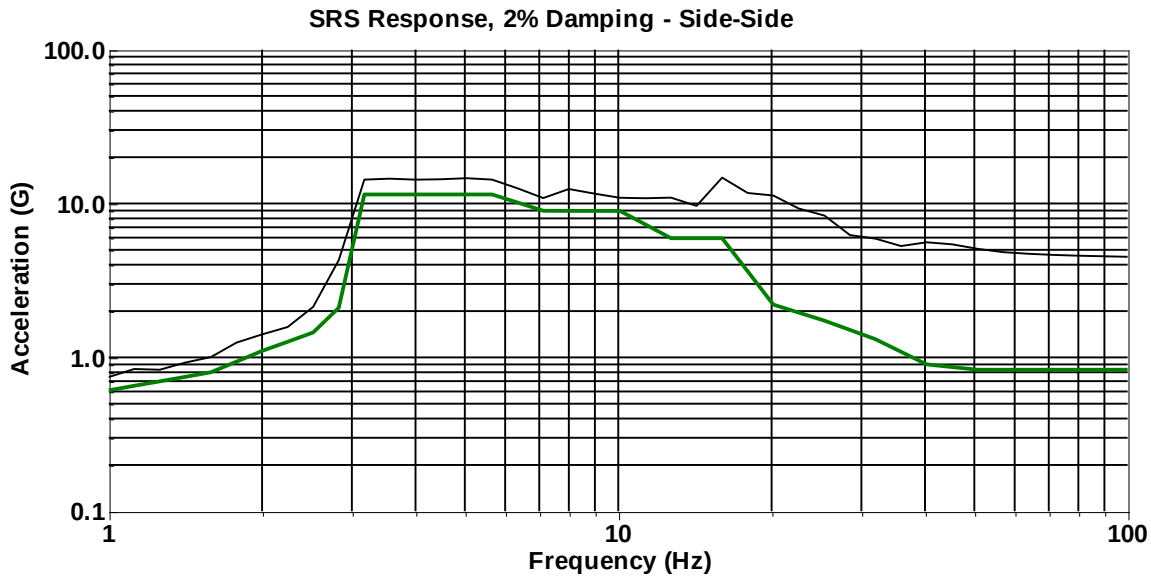
ZPA: 2.412 G



4634 LED unit Vertical Response

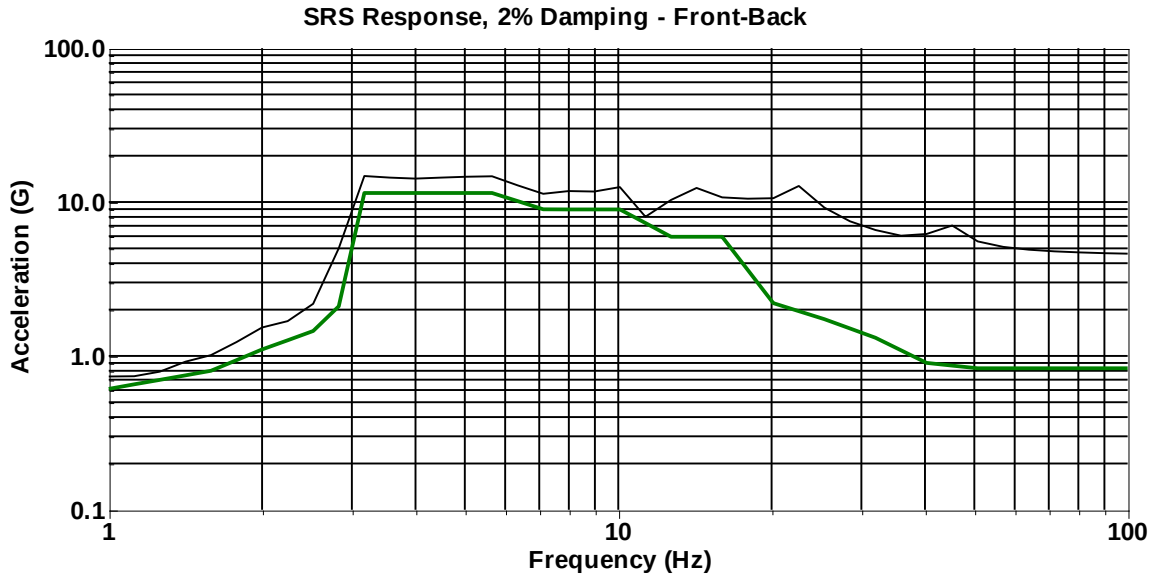
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634
Test# 9 OBE 5
Illumination Oct 29, 2013 13:24:45

ZPA: -4.392 G



4634 LED unit Side to Side Response

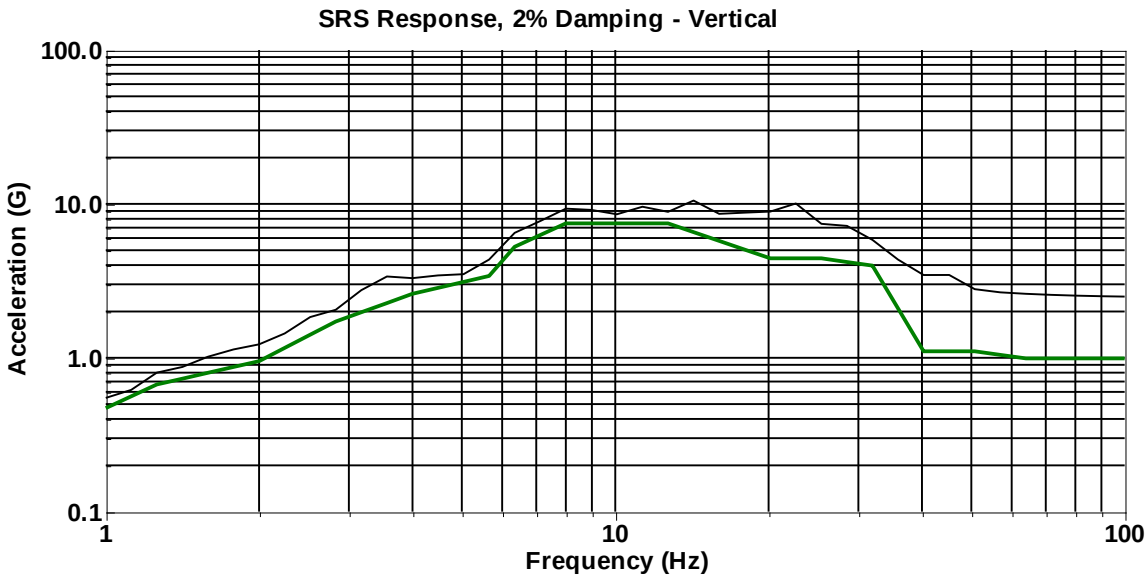
ZPA: 4.478 G



4634 Incandescent unit Front to Back Response

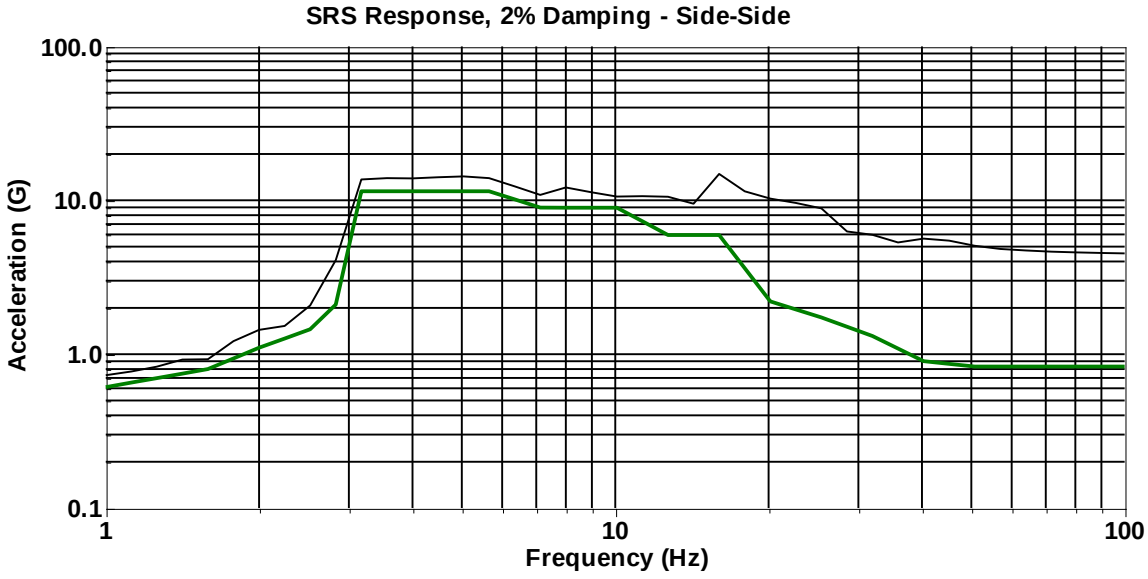
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634
Test# 9 OBE 5
Illumination Oct 29, 2013 13:24:45

ZPA: 2.437 G



4634 Incandescent unit Vertical Response

ZPA: -4.403 G



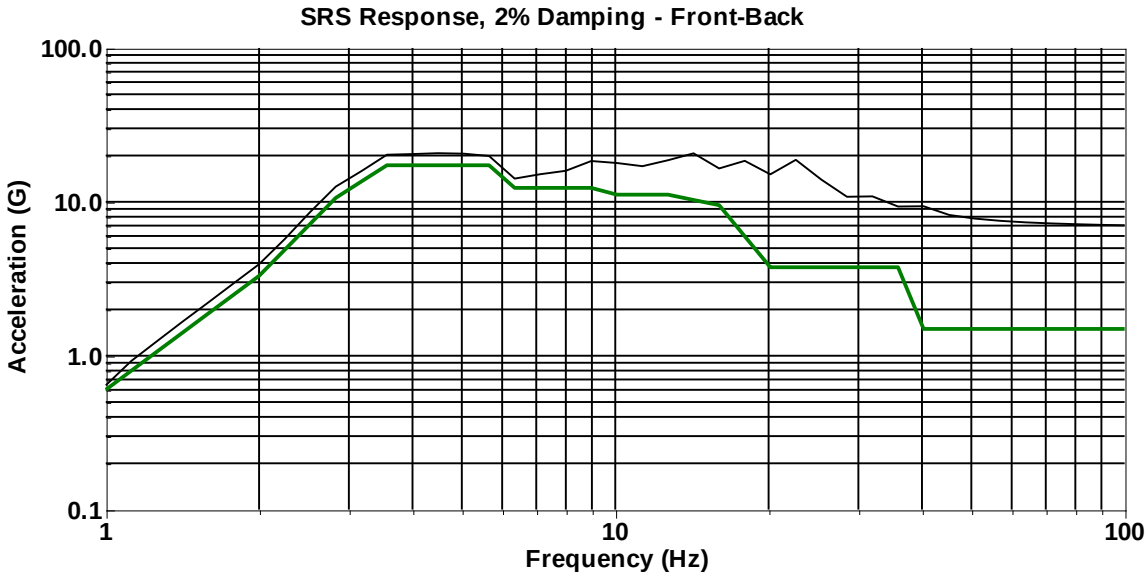
4634 Incandescent unit Side to Side Response

BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634
Test# 9 OBE 5
Illumination Oct 29, 2013 13:24:45

APPENDIX G

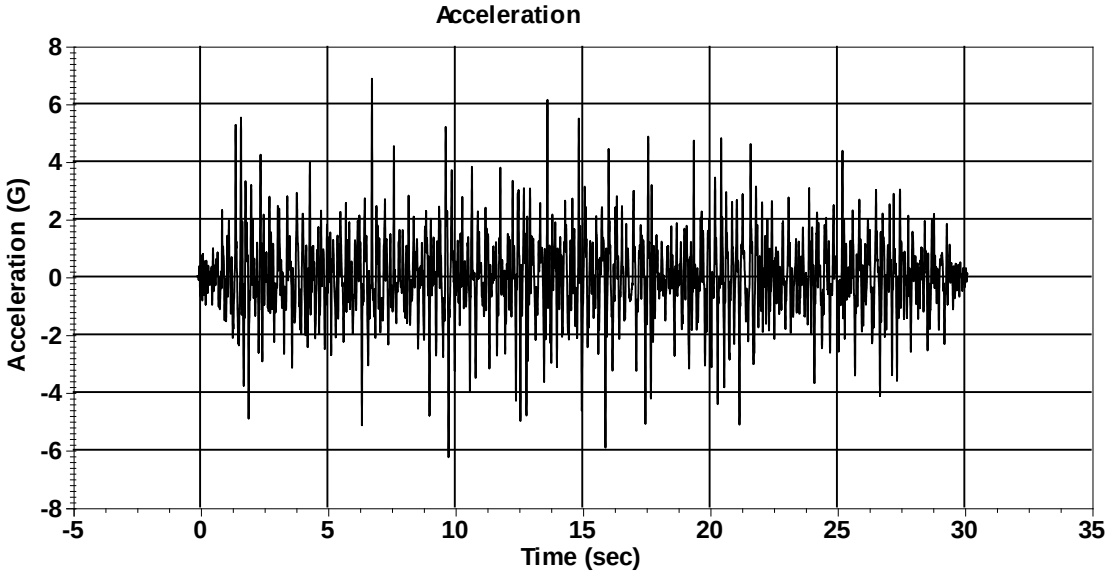
SSE+ SRV + LOCA Data Curves

ZPA: 6.856 G



Demand **Front-Back**

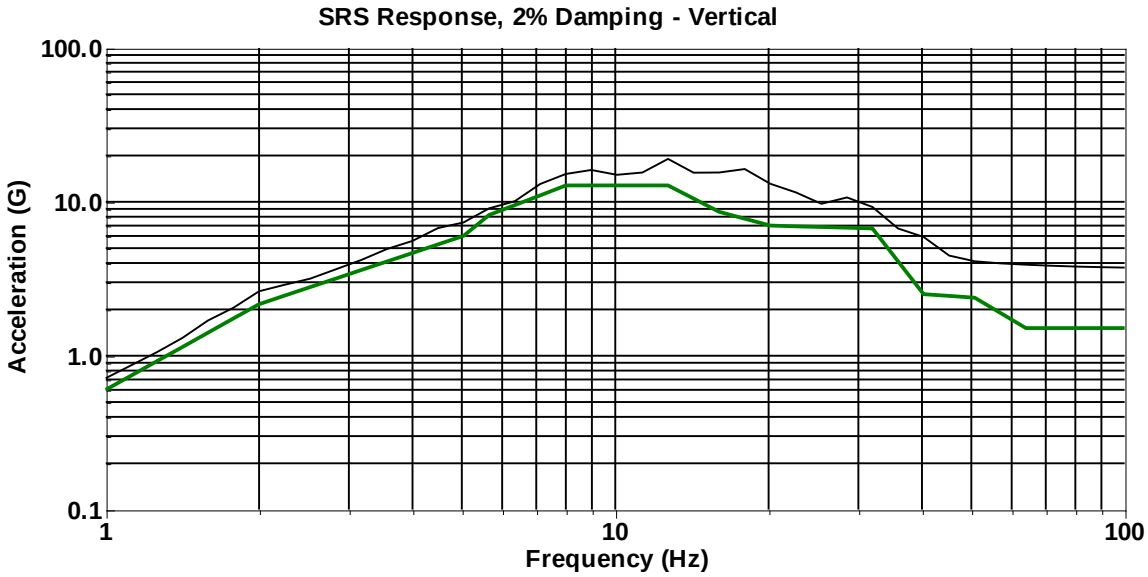
Front to Back Axis Control



Front-Back

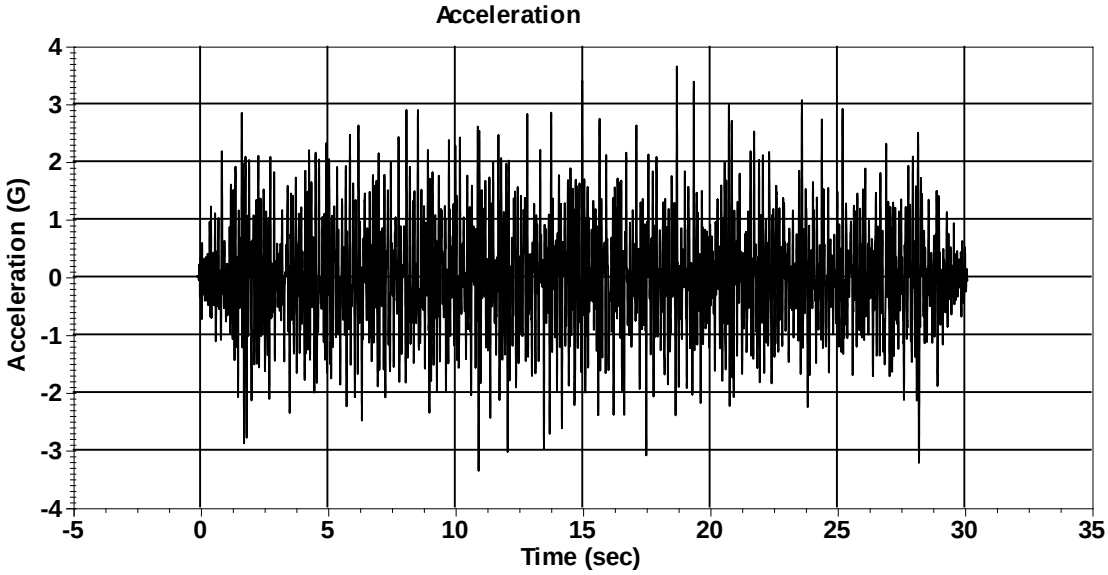
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 10 SSE
120VAC removed during test, Lamps illuminated Oct 29, 2013 13:45:48

ZPA: 3.64 G



Demand **Vertical**

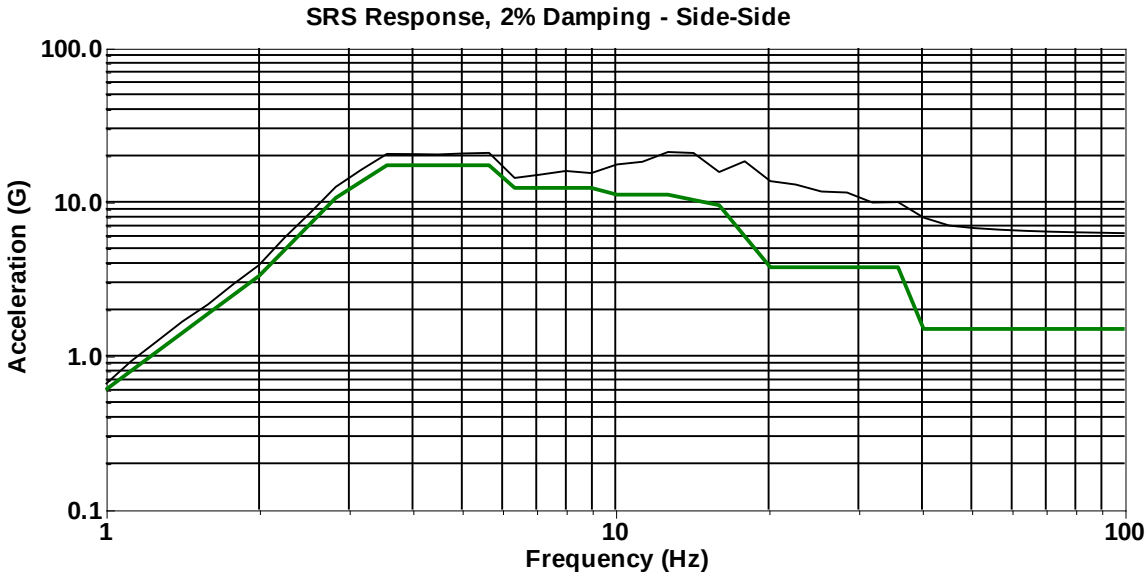
Vertical Axis Control



Vertical

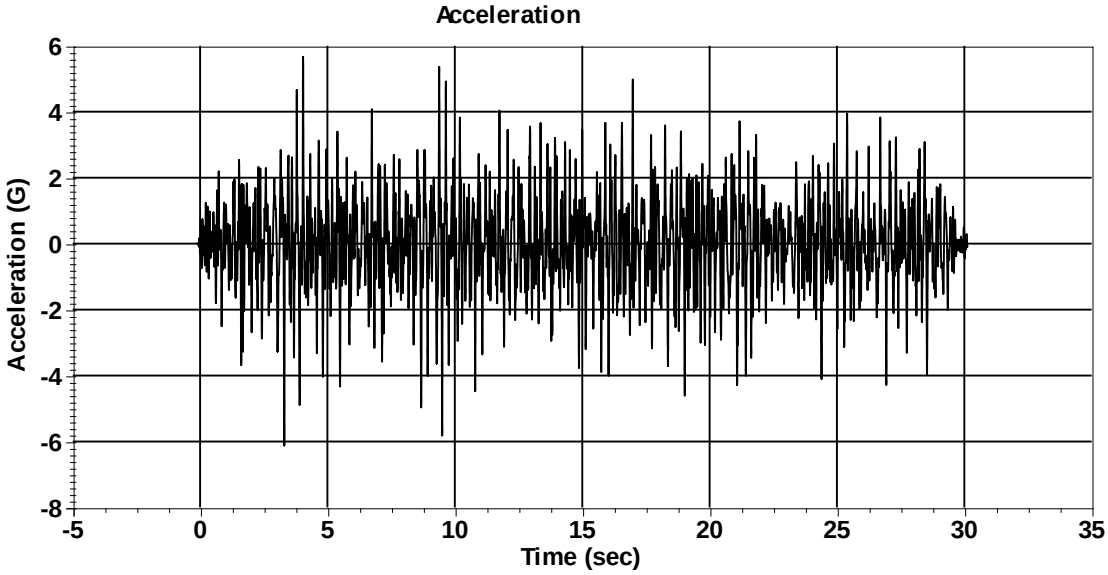
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 10 SSE
120VAC removed during test, Lamps illuminated Oct 29, 2013 13:45:48

ZPA: -6.124 G



Demand **Side-Side**

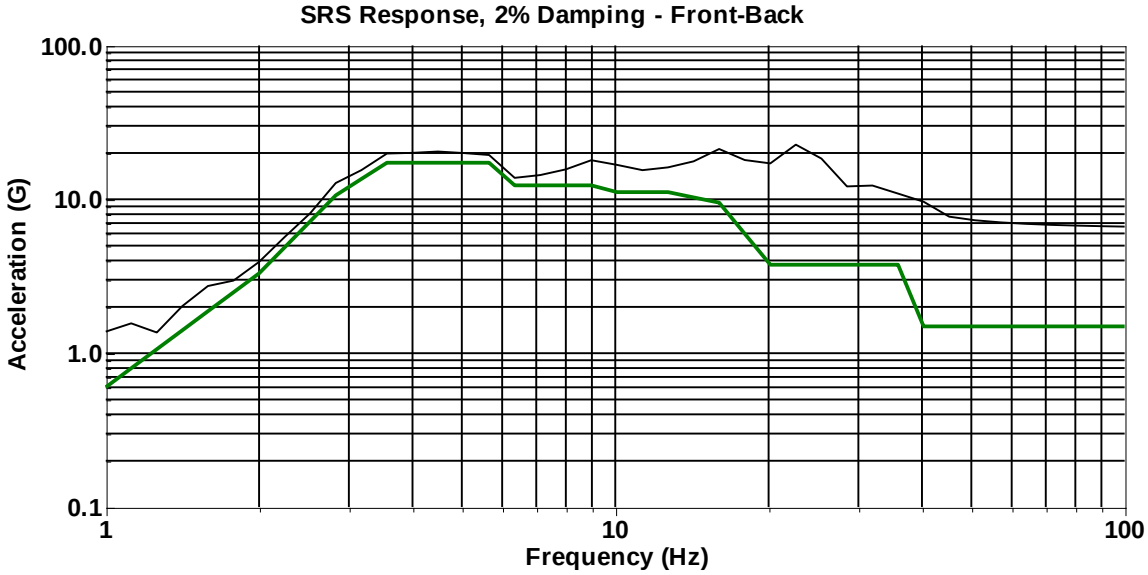
Side to Side Axis Control



Side-Side

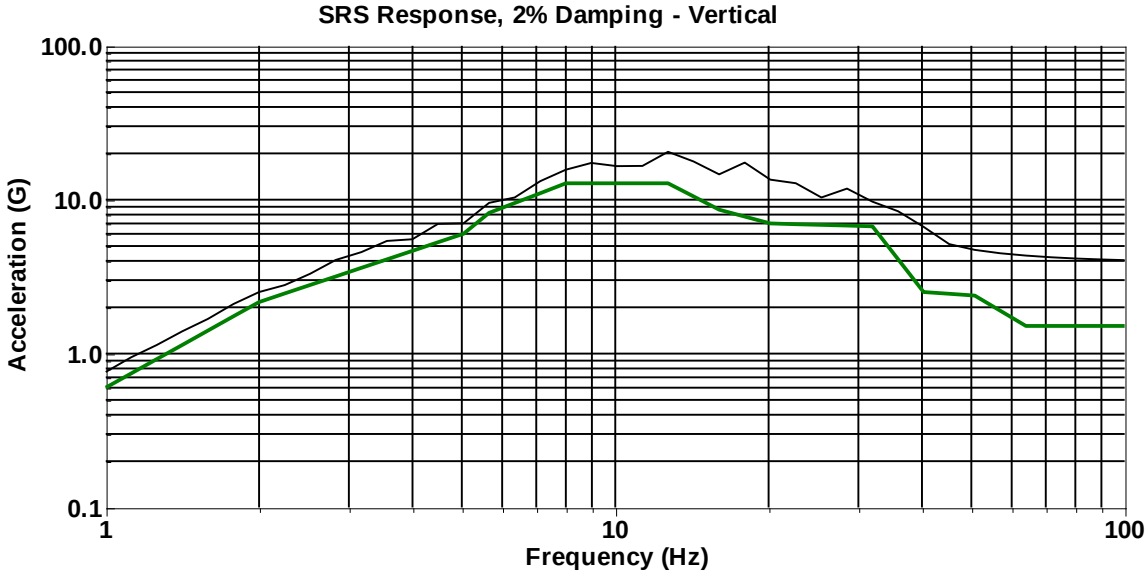
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 10 SSE
120VAC removed during test, Lamps illuminated Oct 29, 2013 13:45:48

ZPA: 6.479 G



4702 unit Front to Back Response

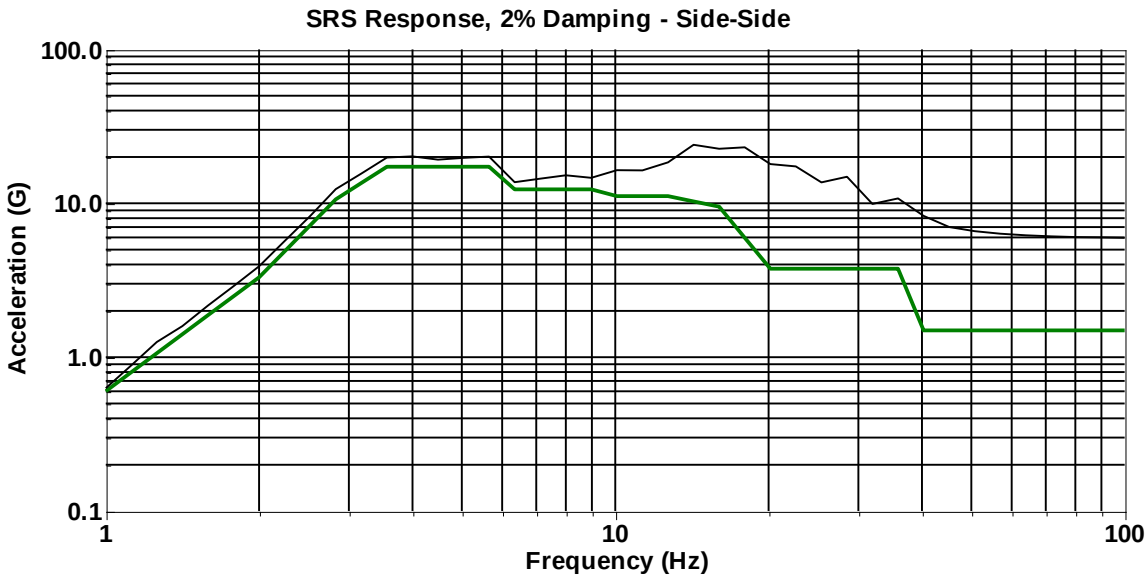
ZPA: 3.892 G



4702 unit Vertical Response

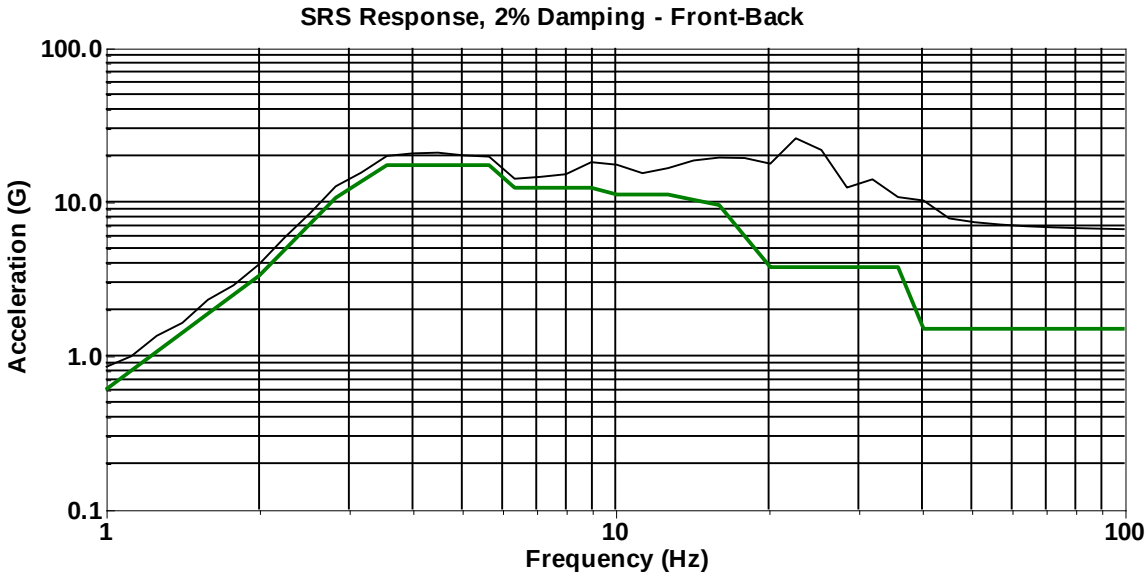
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 10 SSE
120VAC removed during test, Lamps illuminated Oct 29, 2013 13:45:48

ZPA: -5.844 G



4702 unit Side to Side Response

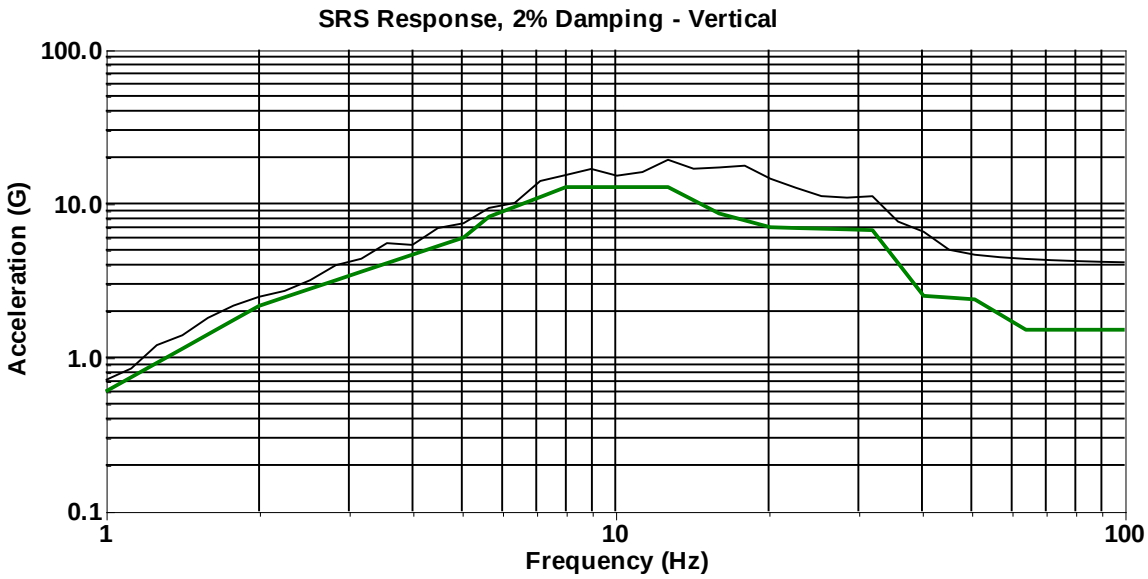
ZPA: -6.458 G



4726 unit Front to Back Response

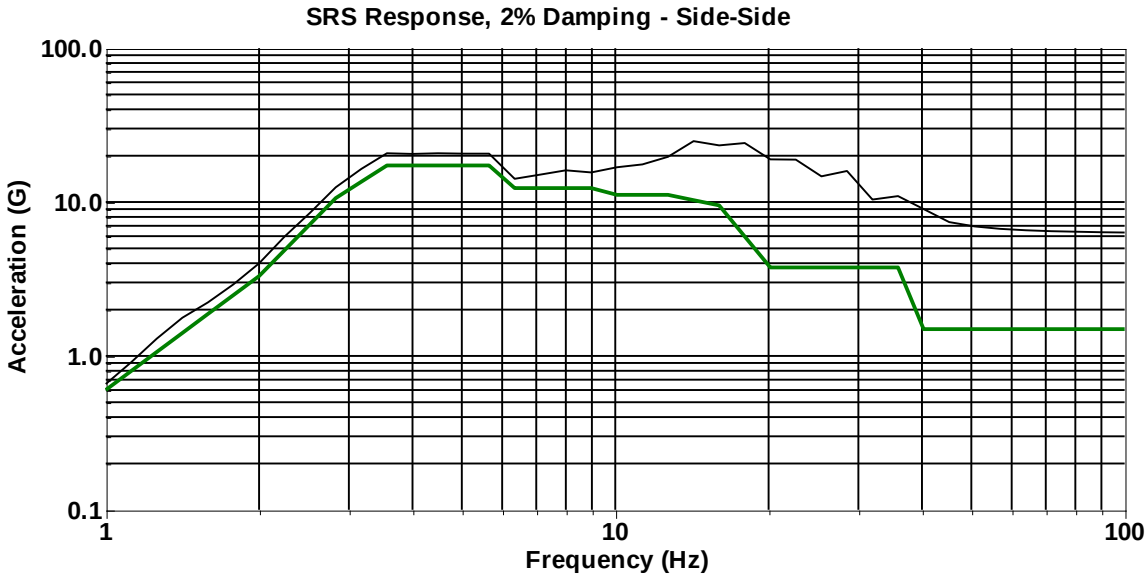
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 10 SSE
120VAC removed during test, Lamps illuminated Oct 29, 2013 13:45:48

ZPA: 4.029 G



4726 unit Vertical Response

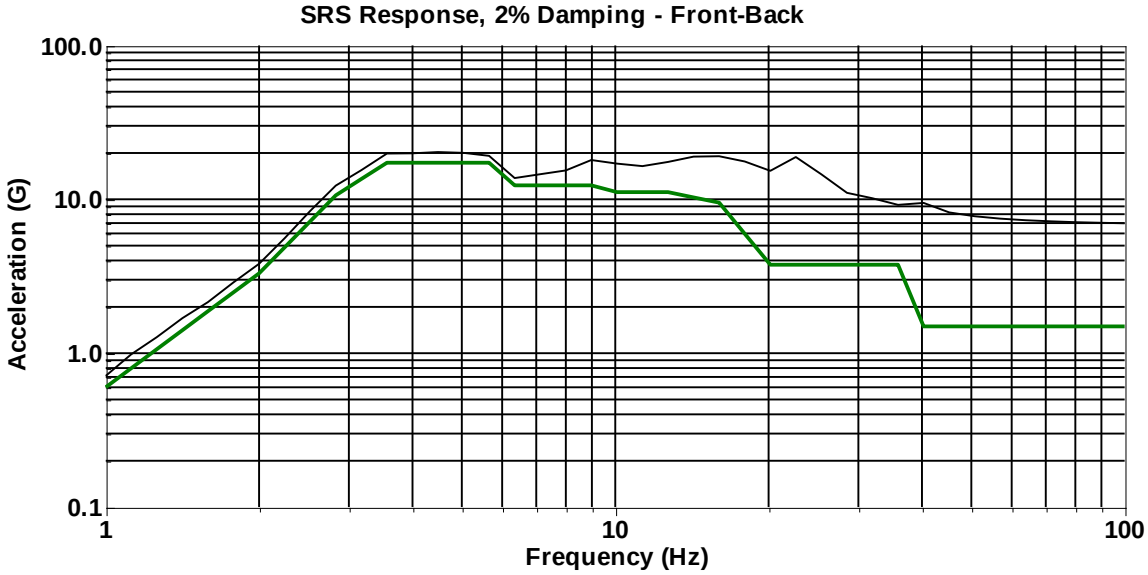
ZPA: -6.21 G



4726 unit Side to Side Response

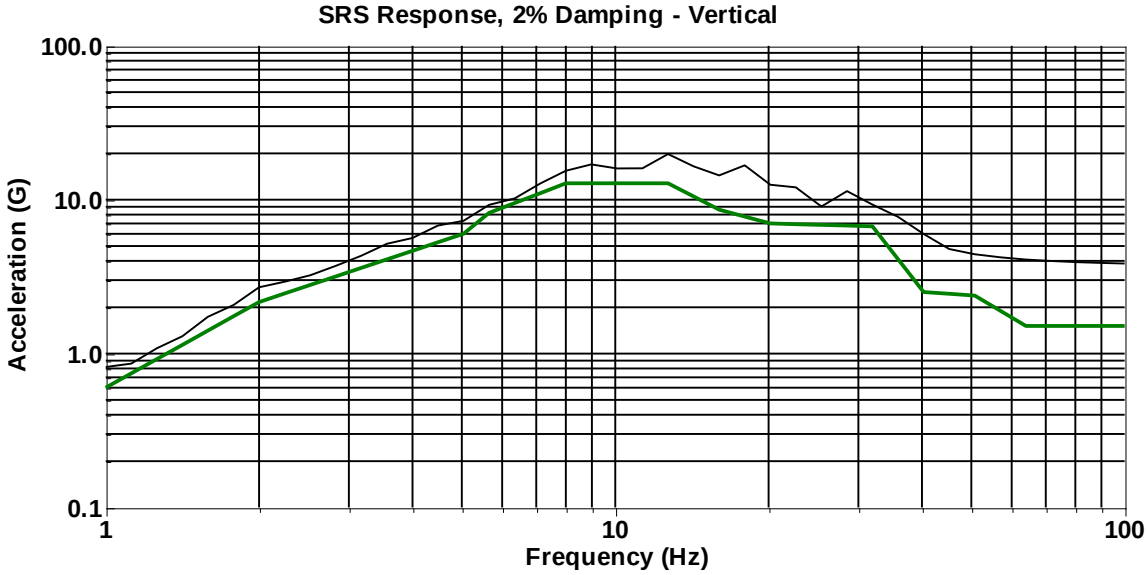
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 10 SSE
120VAC removed during test, Lamps illuminated Oct 29, 2013 13:45:48

ZPA: 6.797 G



4634 LED unit Front to Back Response

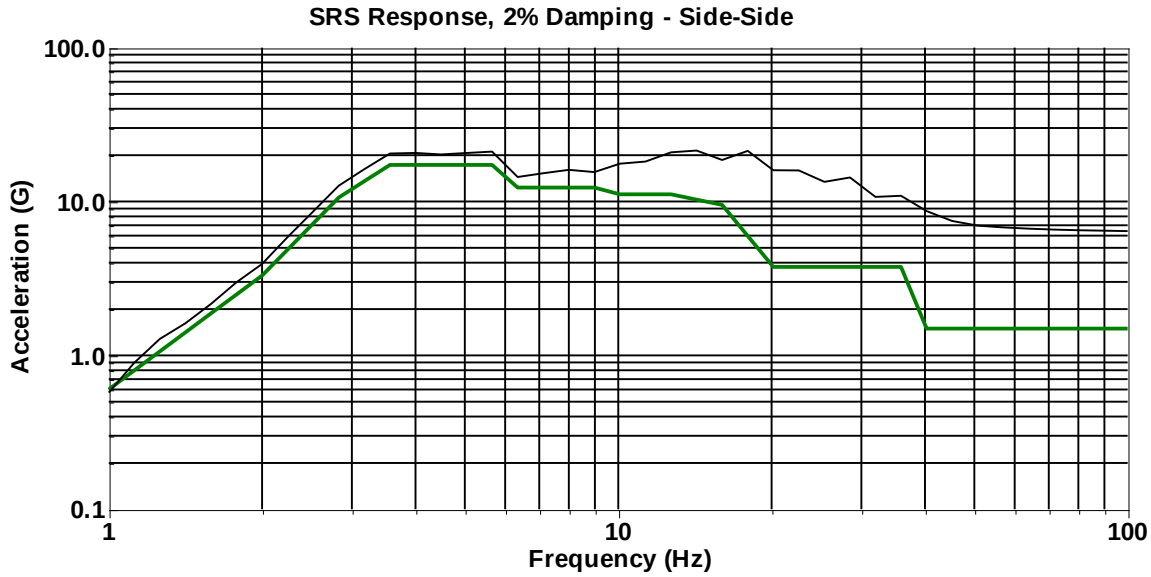
ZPA: 3.712 G



4634 LED unit Vertical Response

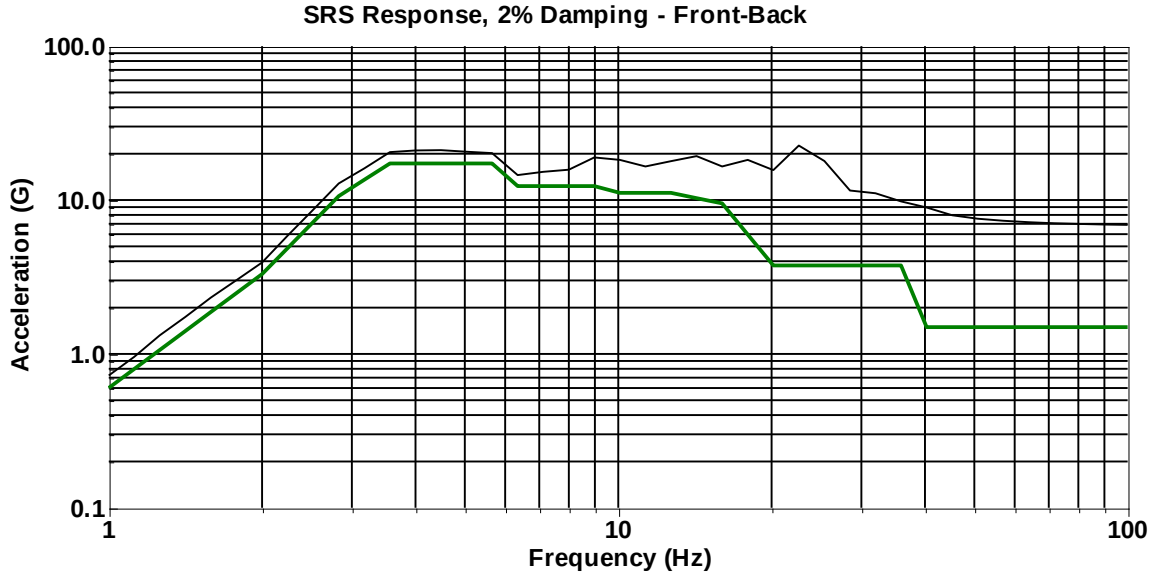
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 10 SSE
120VAC removed during test, Lamps illuminated Oct 29, 2013 13:45:48

ZPA: -6.284 G



4634 LED unit Side to Side Response

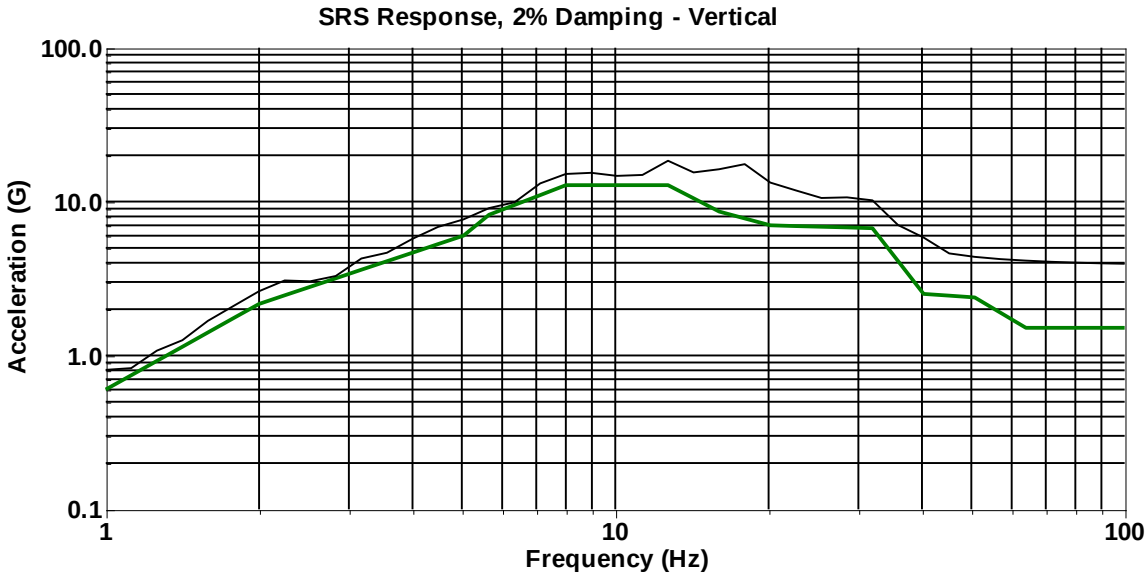
ZPA: 6.721 G



4634 Incandescent unit Front to Back Response

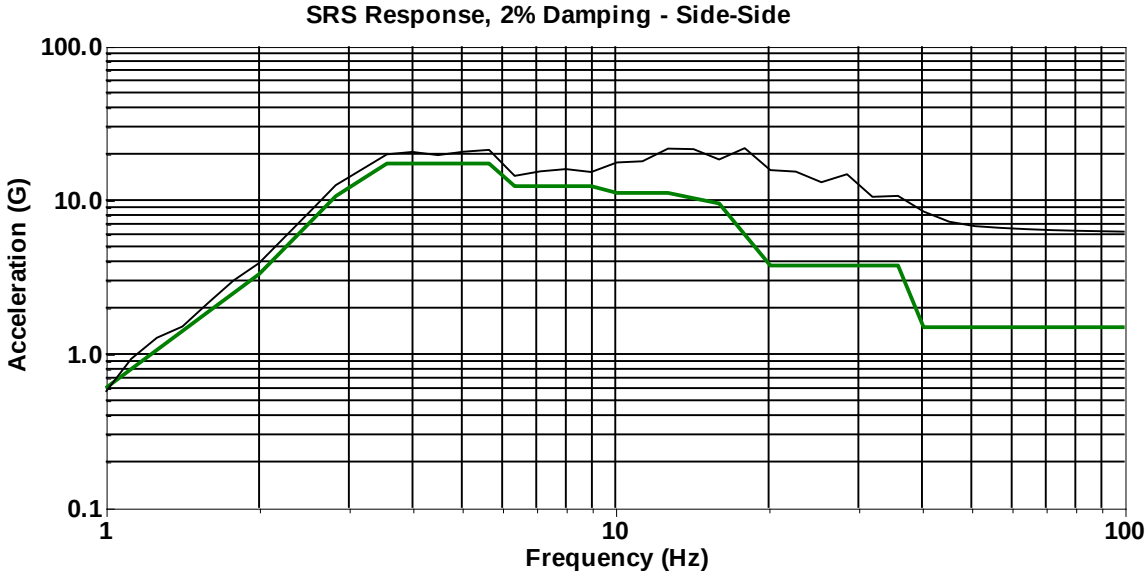
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 10 SSE
120VAC removed during test, Lamps illuminated Oct 29, 2013 13:45:48

ZPA: 3.833 G



4634 Incandescent unit Vertical Response

ZPA: -6.1 G



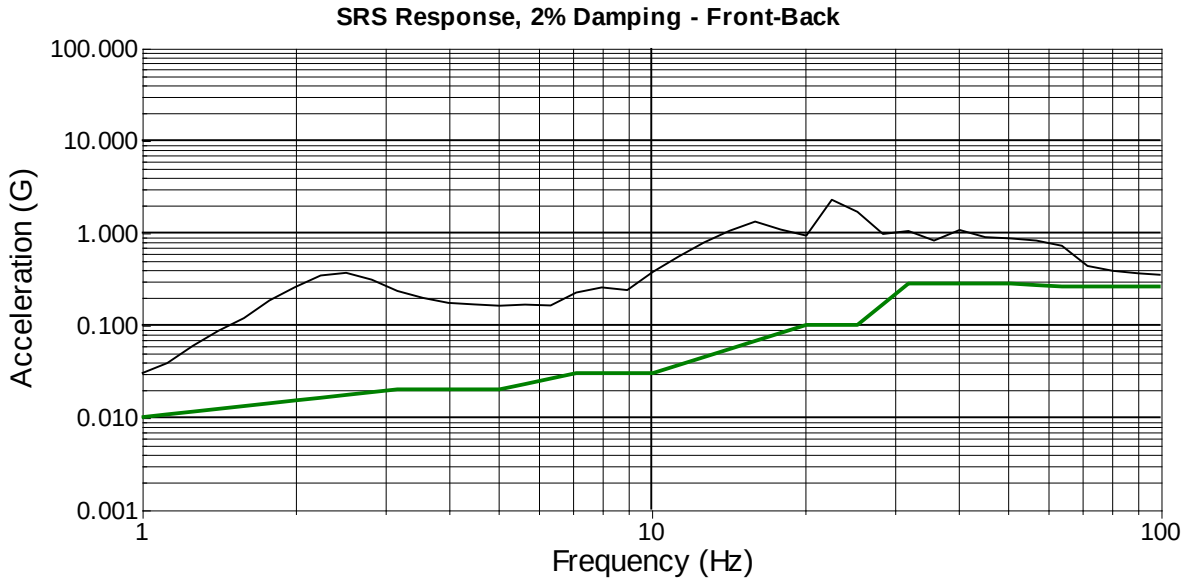
4634 Incandescent unit Side to Side Response

BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 10 SSE
120VAC removed during test, Lamps illuminated Oct 29, 2013 13:45:48

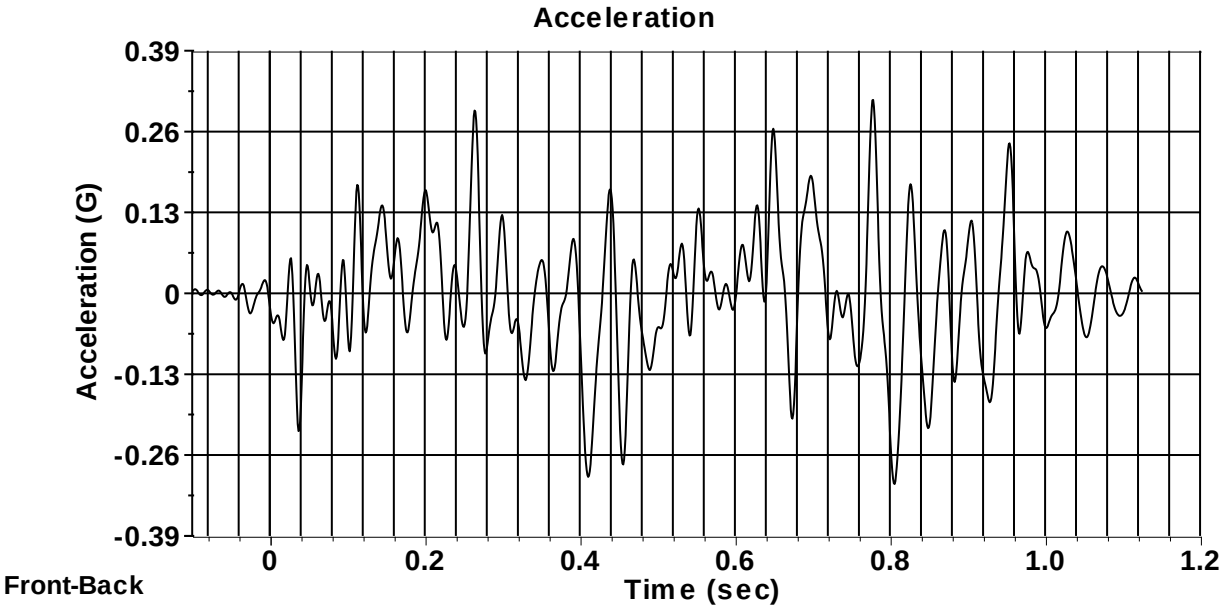
APPENDIX H

Chugging Data Curves

ZPA: 0.3109 G

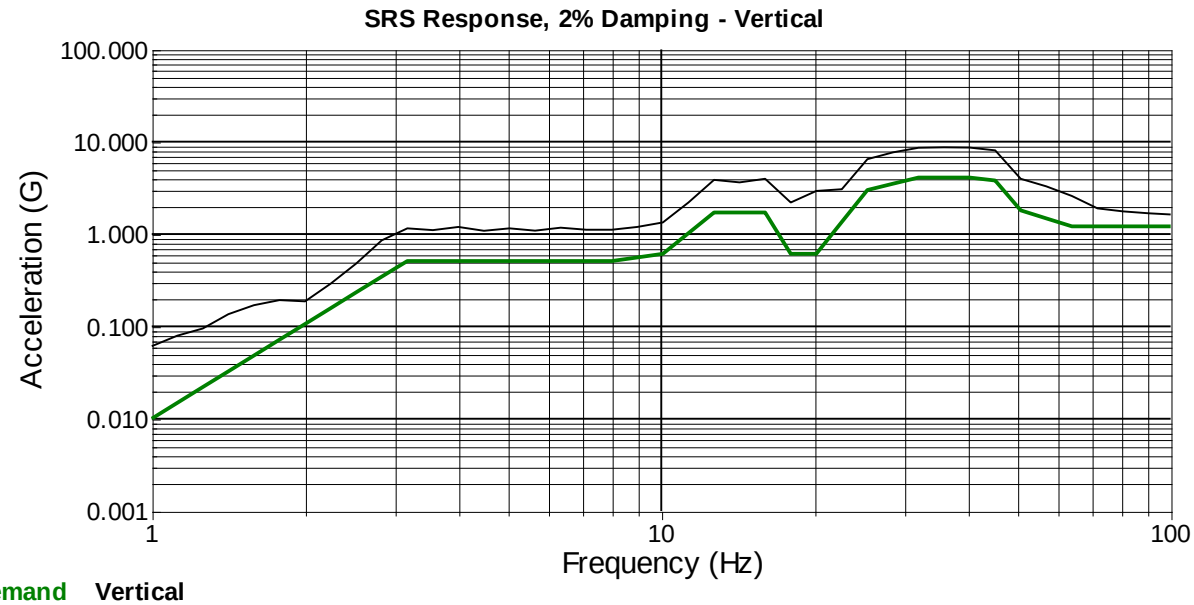


Front to Back Axis Control

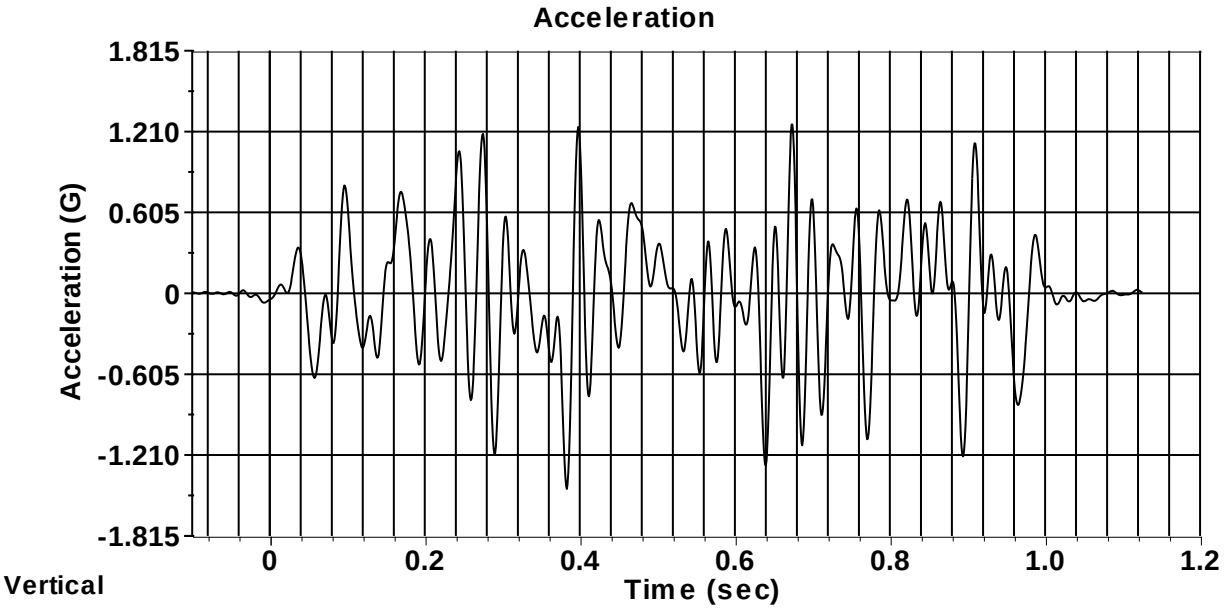


BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 11 Chugging Event Oct 29, 2013 14:17:32
Pulse: 300 of 1140

ZPA: -1.464 G

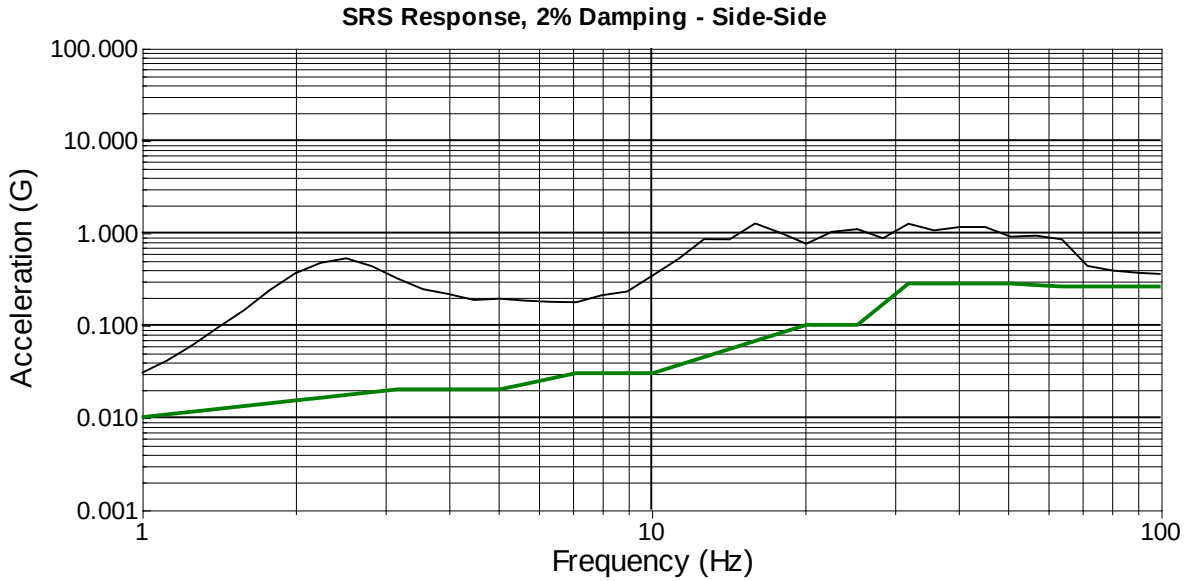


Vertical Axis Control

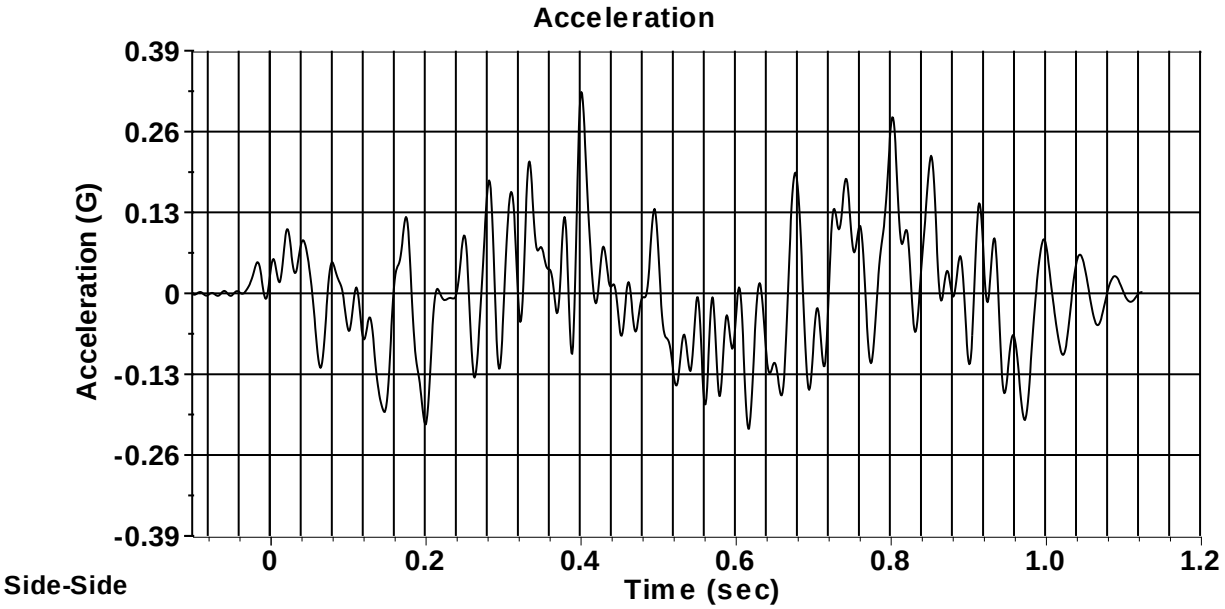


BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 11 Chugging Event Oct 29, 2013 14:17:32
Pulse: 300 of 1140

ZPA: 0.3235 G

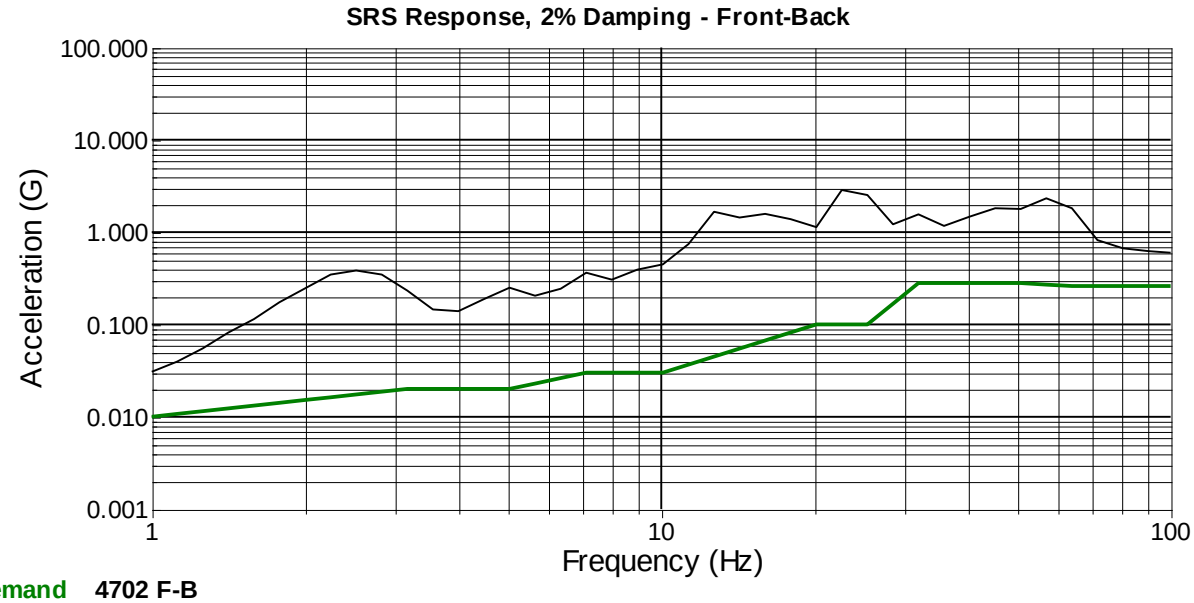


Side to Side Axis Control



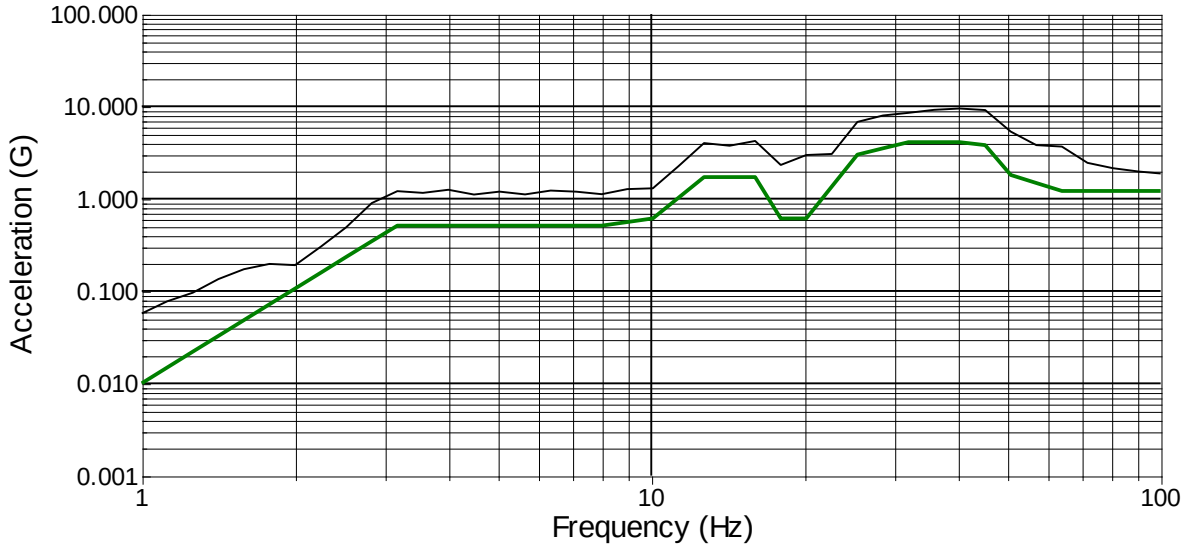
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 11 Chugging Event Oct 29, 2013 14:17:32
Pulse: 300 of 1140

ZPA: -0.5321 G



4702 unit Front to Back Axis Response

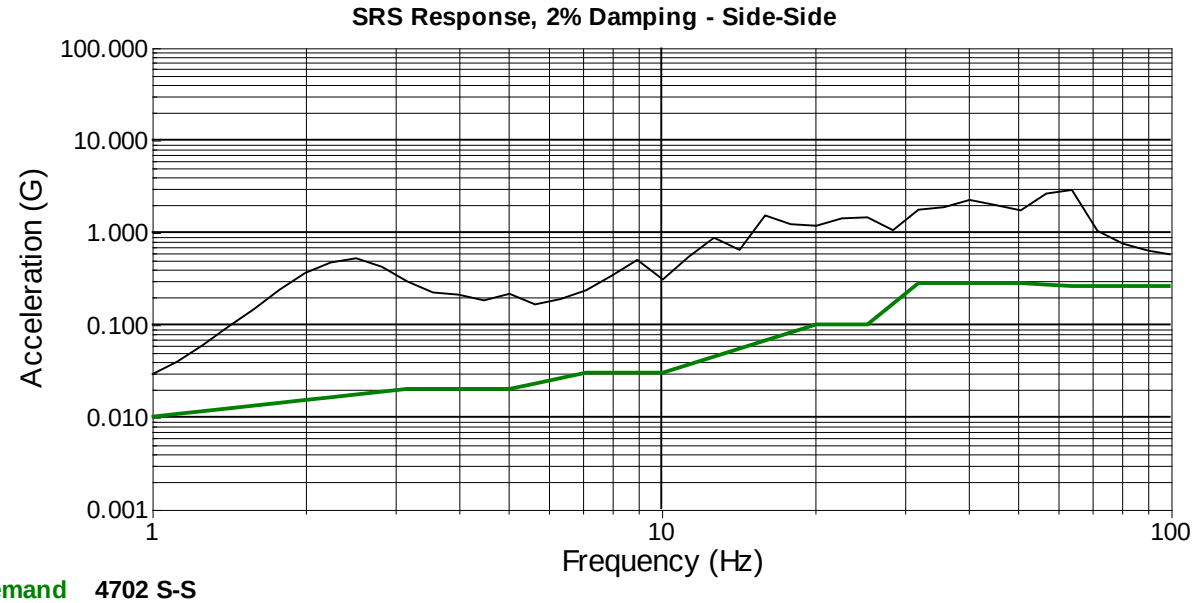
ZPA: 1.562 G



4702 unit Vertical Axis Response

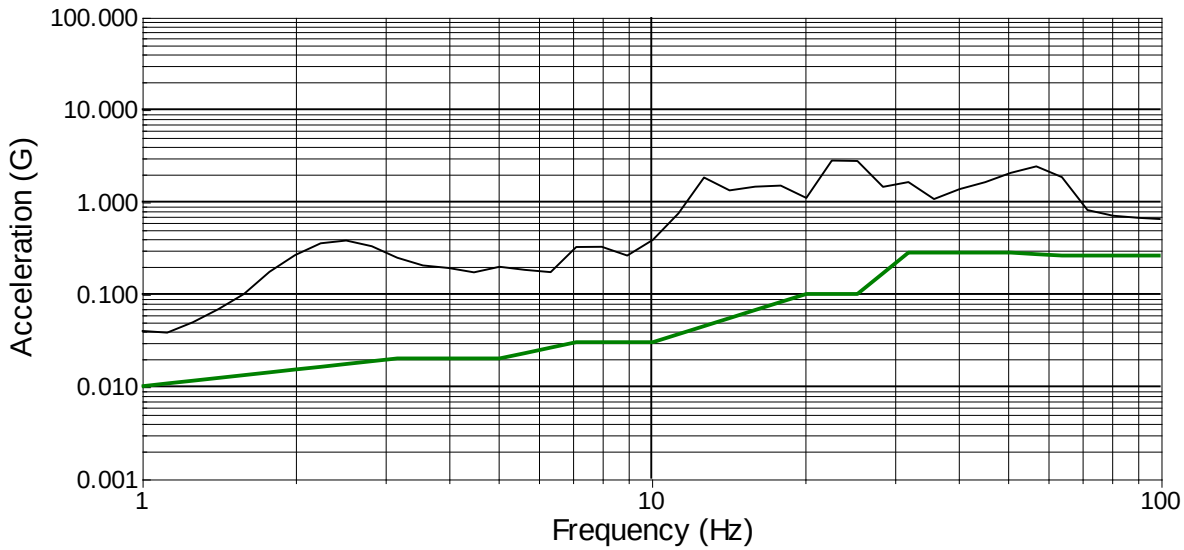
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 11 Chugging Event Oct 29, 2013 14:17:32
Pulse: 300 of 1140

ZPA: 0.4501 G



4702 unit Side to Side Axis Response

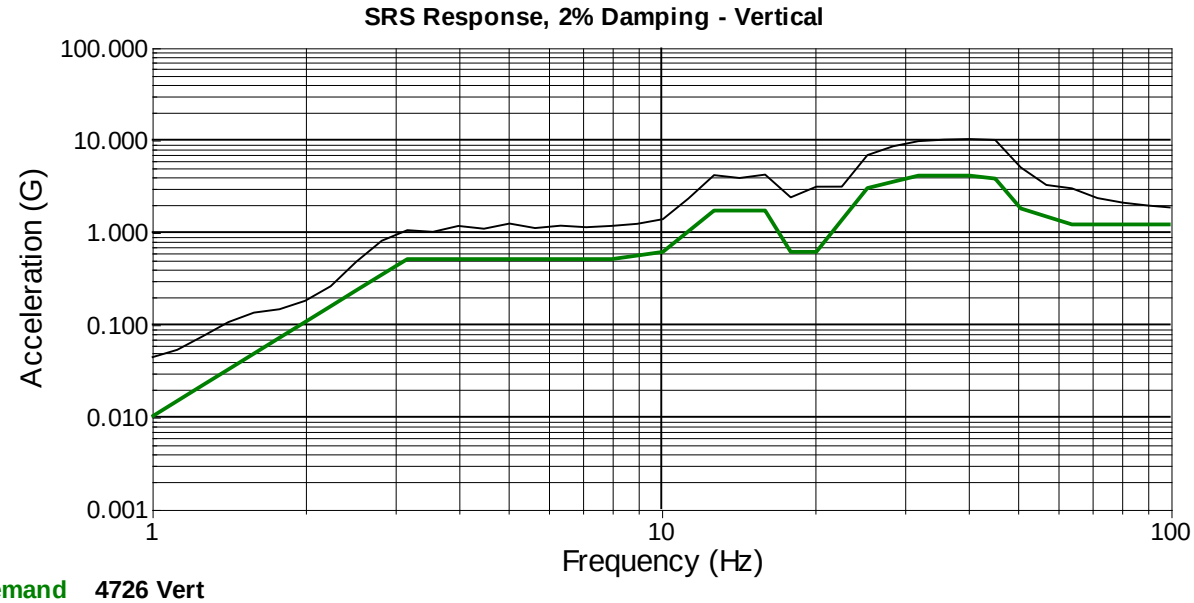
ZPA: -0.5893 G



4726 unit Front to Back Axis Response

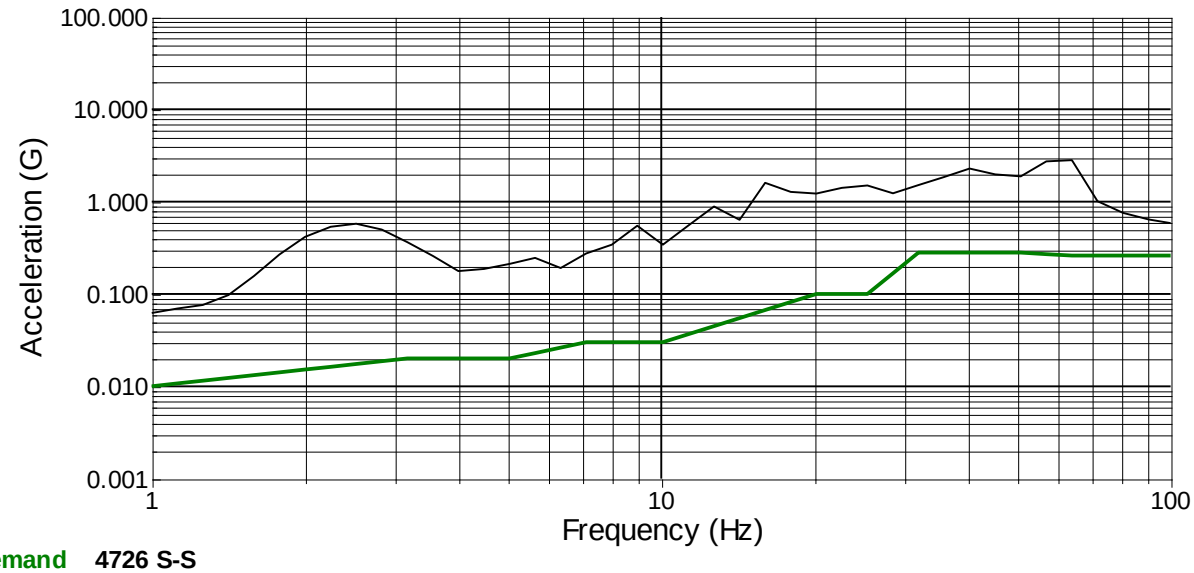
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 11 Chugging Event Oct 29, 2013 14:17:32
Pulse: 300 of 1140

ZPA: -1.604 G



4702 unit Vertical Axis Response

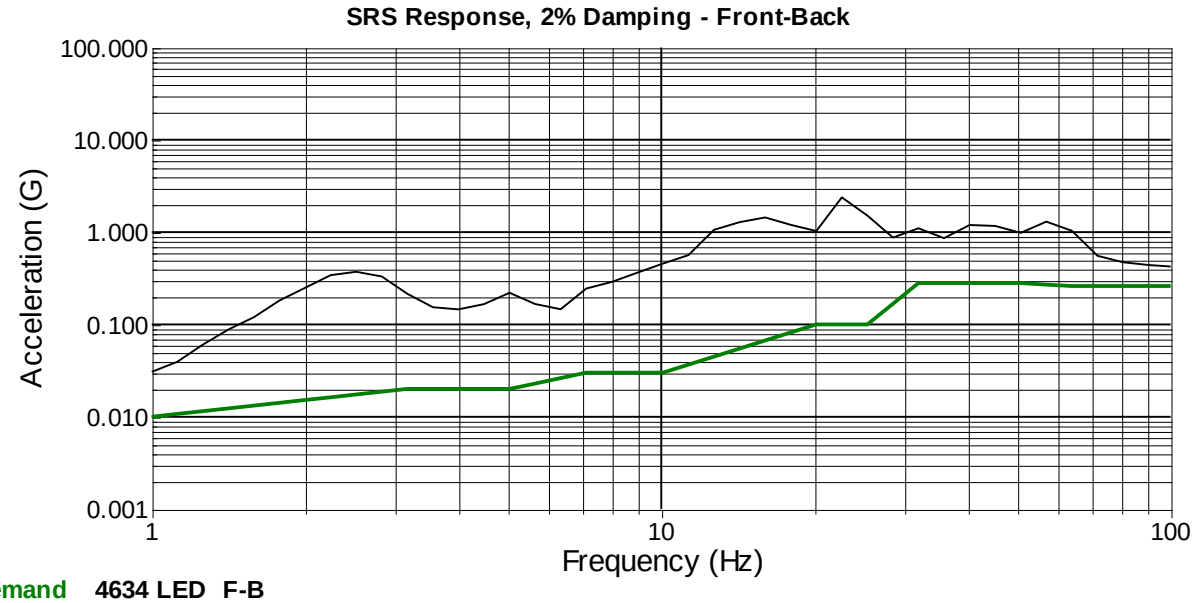
ZPA: 0.4457 G



4702 unit Side to Side Axis Response

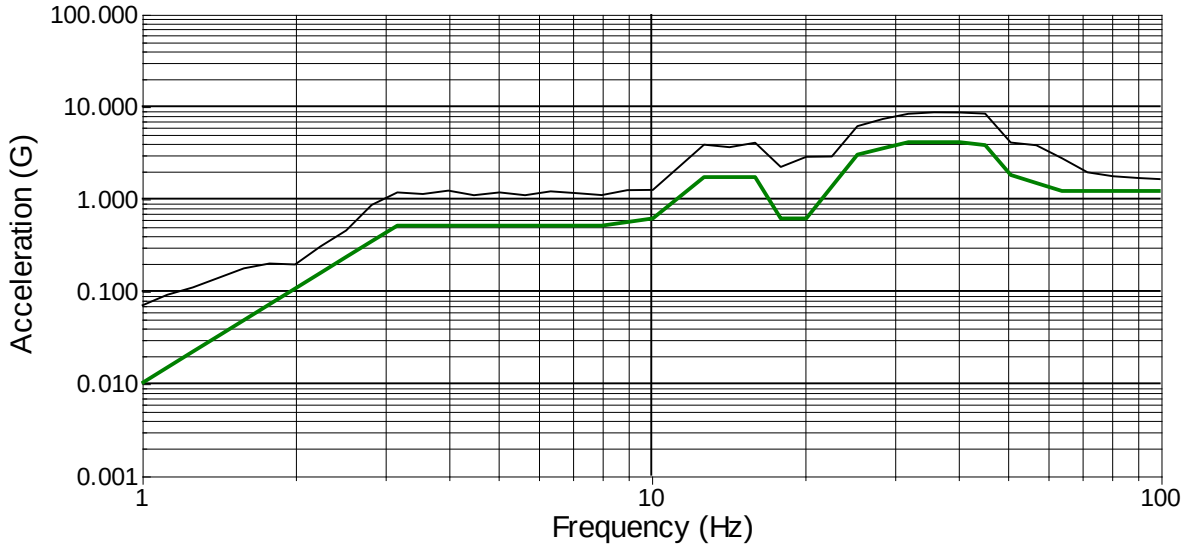
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 11 Chugging Event Oct 29, 2013 14:17:32
Pulse: 300 of 1140

ZPA: 0.3743 G



4634 LED unit Front to Back Axis Response

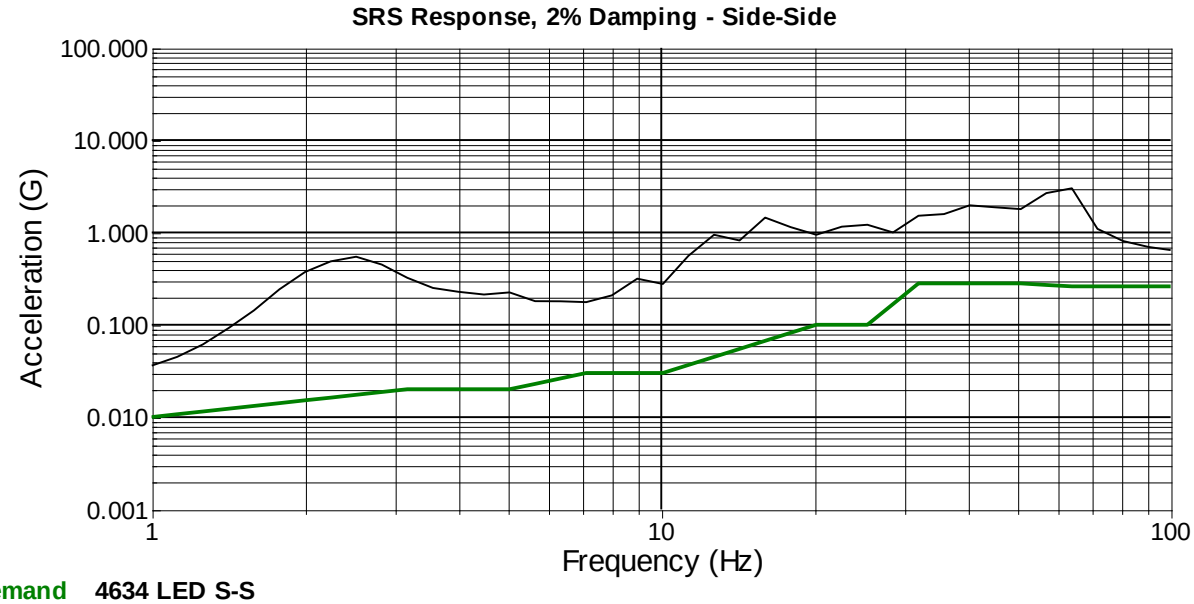
ZPA: -1.467 G



4634 LED unit Vertical Axis Response

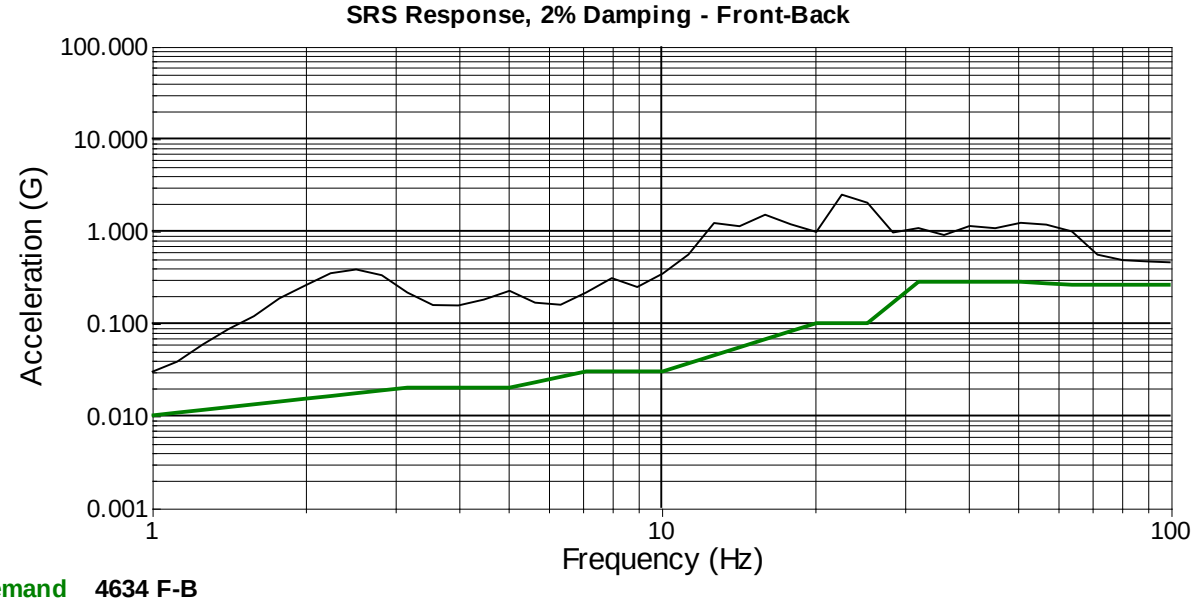
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 11 Chugging Event Oct 29, 2013 14:17:32
Pulse: 300 of 1140

ZPA: 0.5123 G



4634 LED unit Side to Side Axis Response

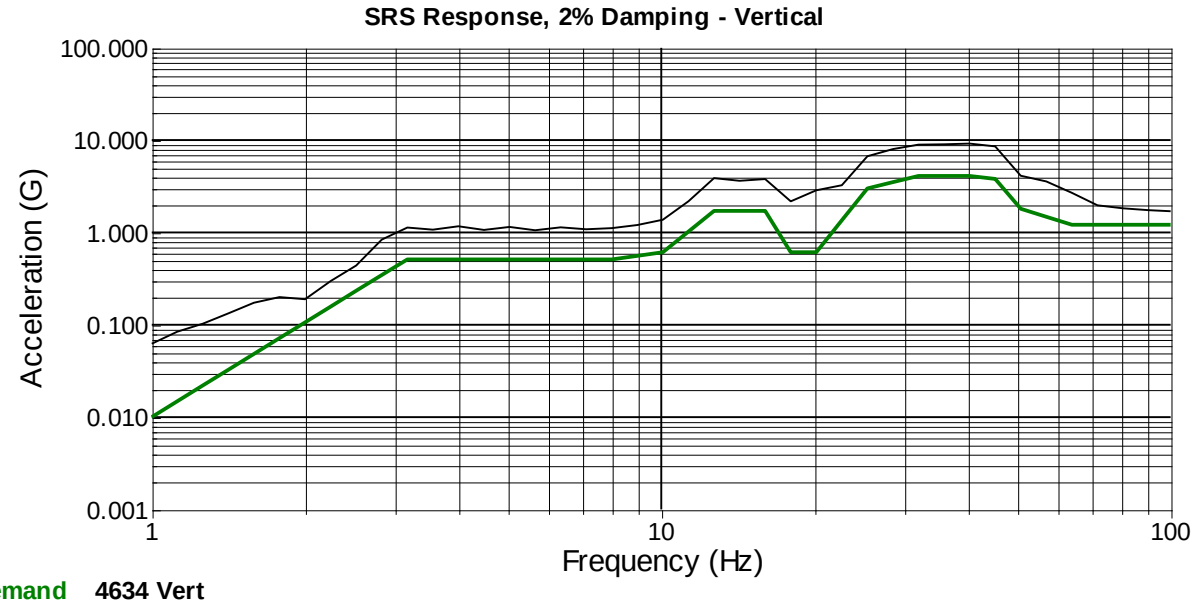
ZPA: -0.4258 G



4634 Incandescent unit Front to Back Axis Response

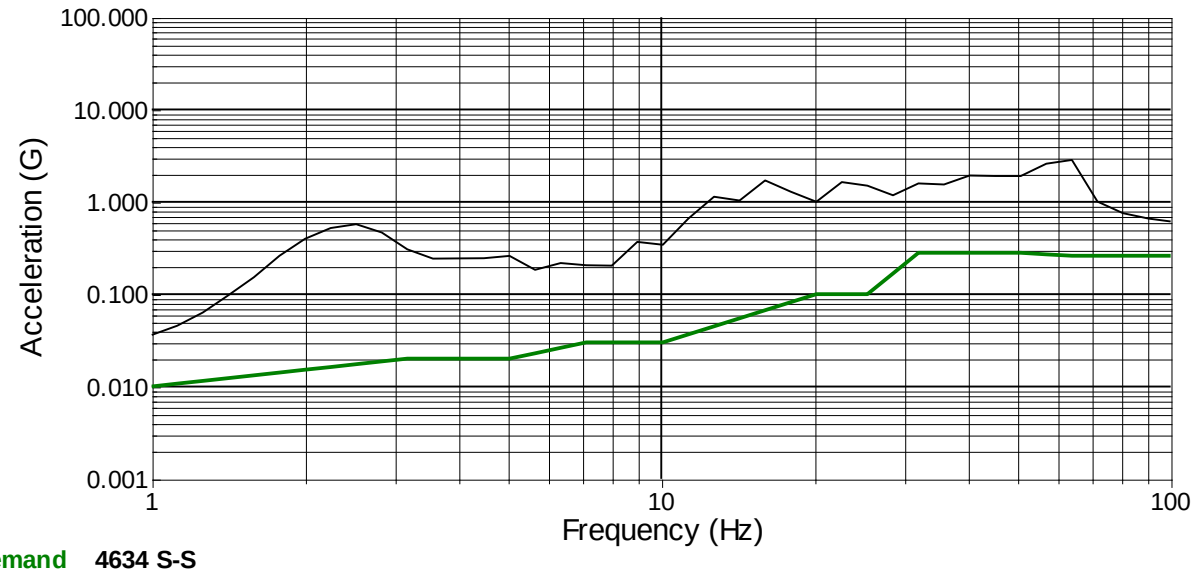
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 11 Chugging Event Oct 29, 2013 14:17:32
Pulse: 300 of 1140

ZPA: -1.525 G



4634 Incandescent unit Vertical Axis Response

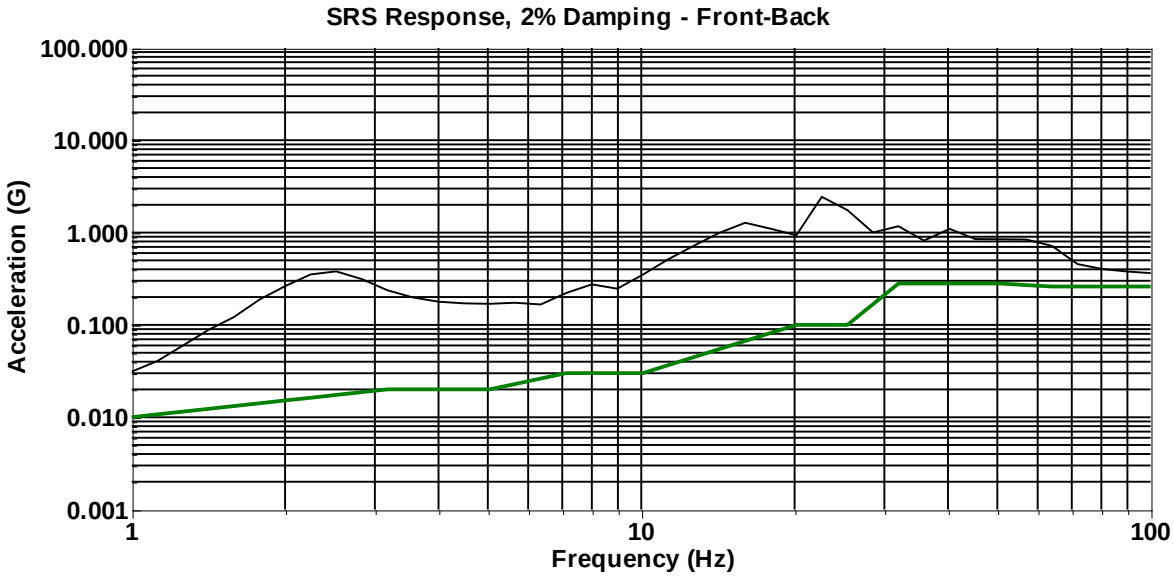
ZPA: 0.4911 G



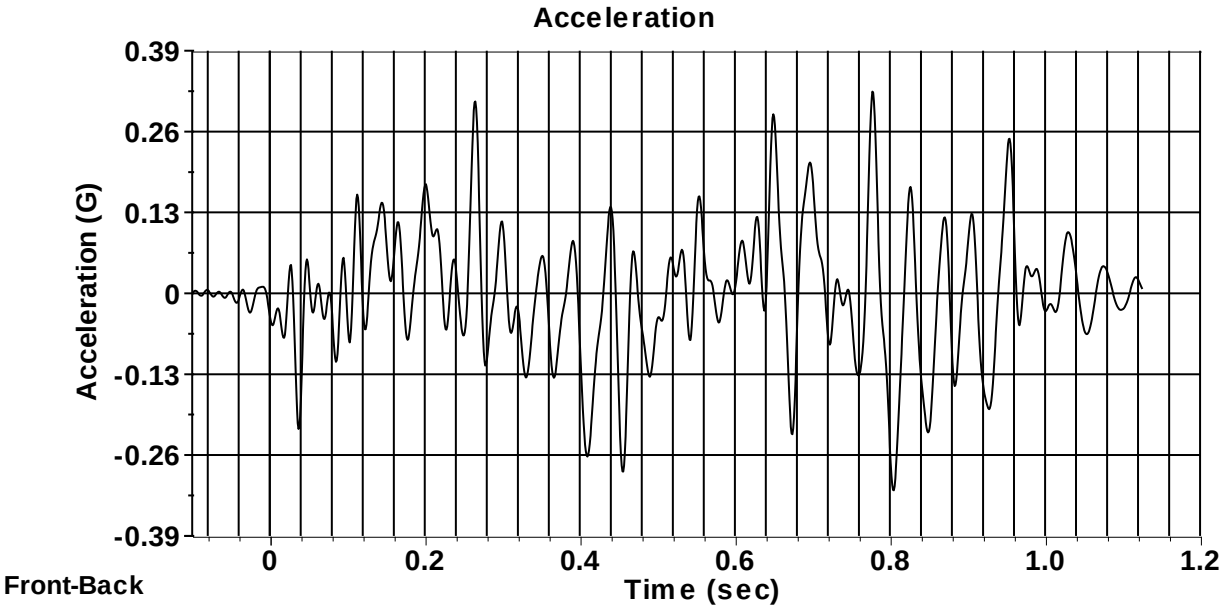
4634 Incandescent unit Side to Side Axis Response

BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 11 Chugging Event Oct 29, 2013 14:17:32
Pulse: 300 of 1140

ZPA: 0.3243 G

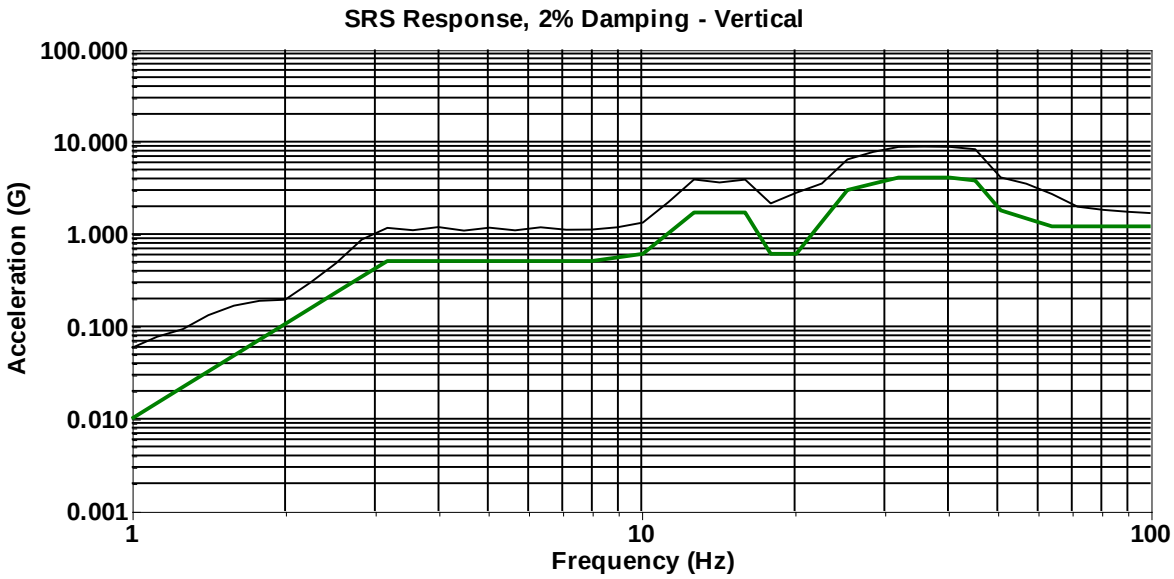


Front to Back Axis Control

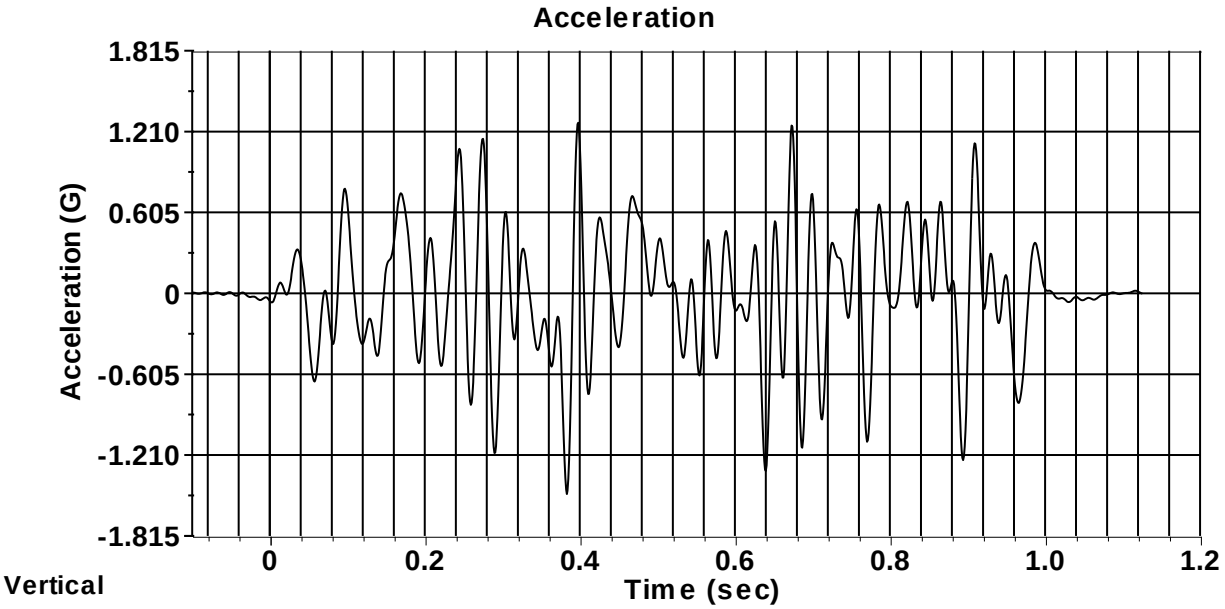


BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 11 Chugging Event Oct 29, 2013 14:48:34
Pulse: 570 of 1140

ZPA: -1.502 G

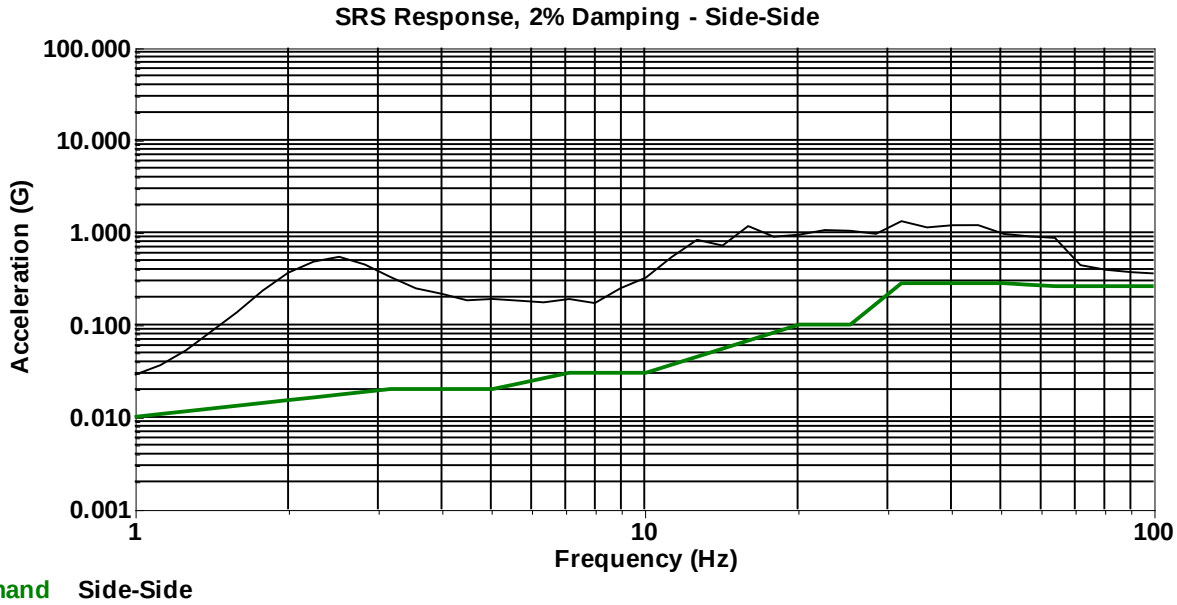


Vertical Axis Control

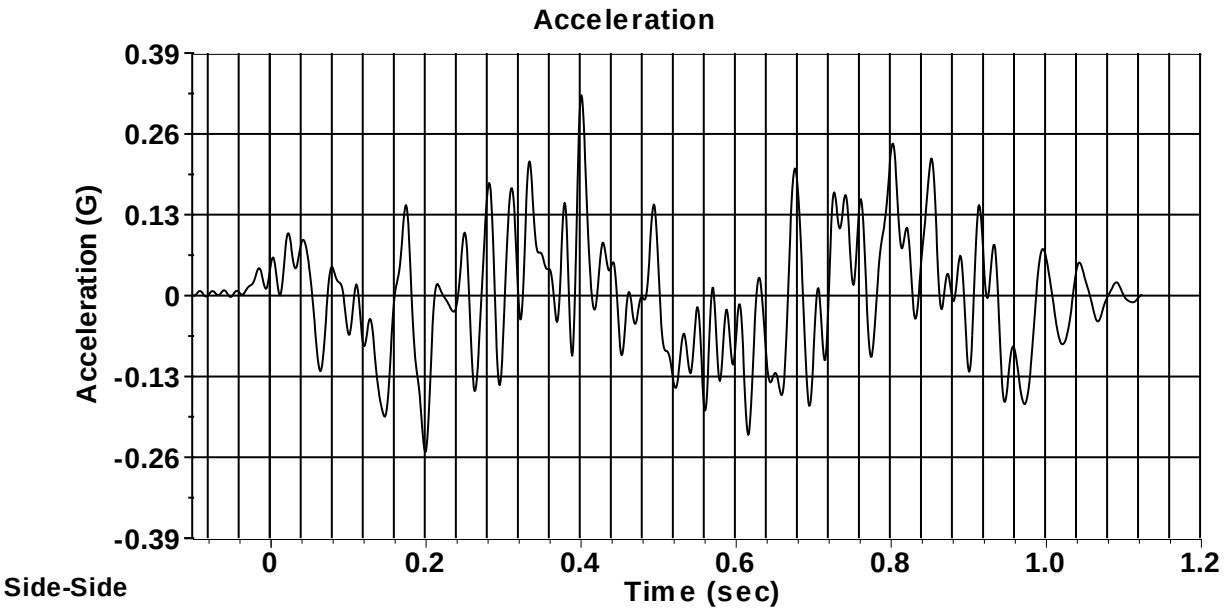


BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 11 Chugging Event Oct 29, 2013 14:48:34
Pulse: 570 of 1140

ZPA: 0.3221 G

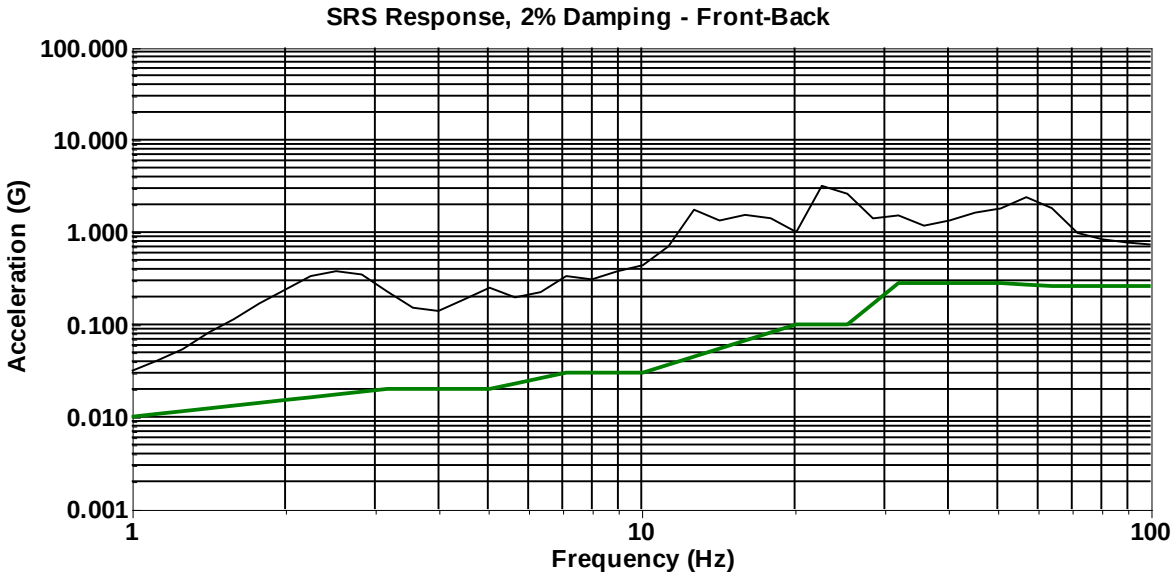


Side to Side Axis Control



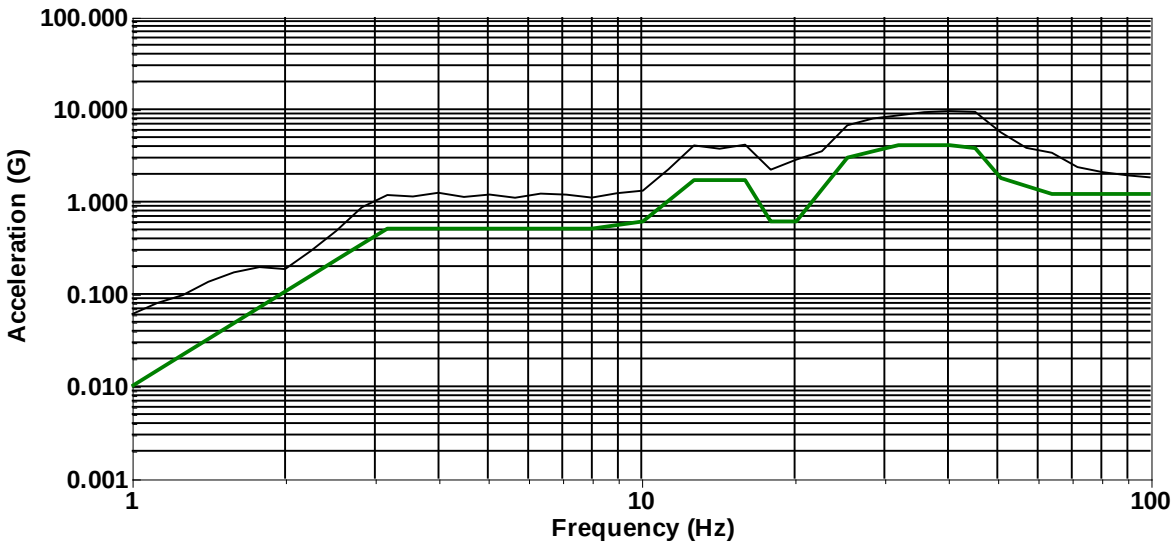
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 11 Chugging Event Oct 29, 2013 14:48:34
Pulse: 570 of 1140

ZPA: -0.6425 G



4702 unit Front to Back Axis Response

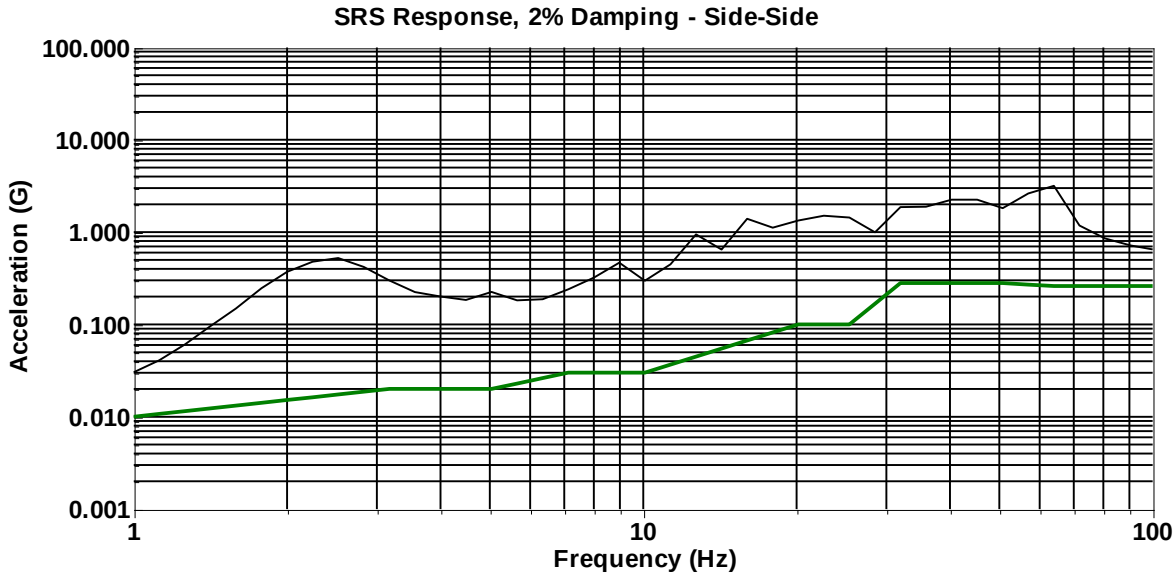
ZPA: 1.53 G



4702 unit Vertical Axis Response

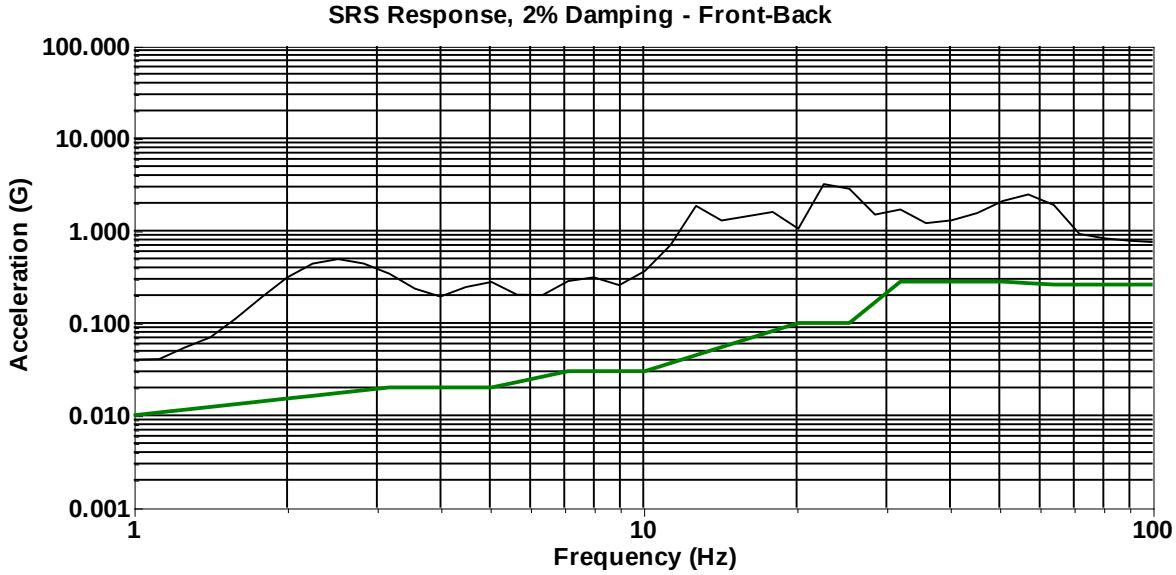
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 11 Chugging Event Oct 29, 2013 14:48:34
Pulse: 570 of 1140

ZPA: 0.4934 G



4702 unit Side to Side Axis Response

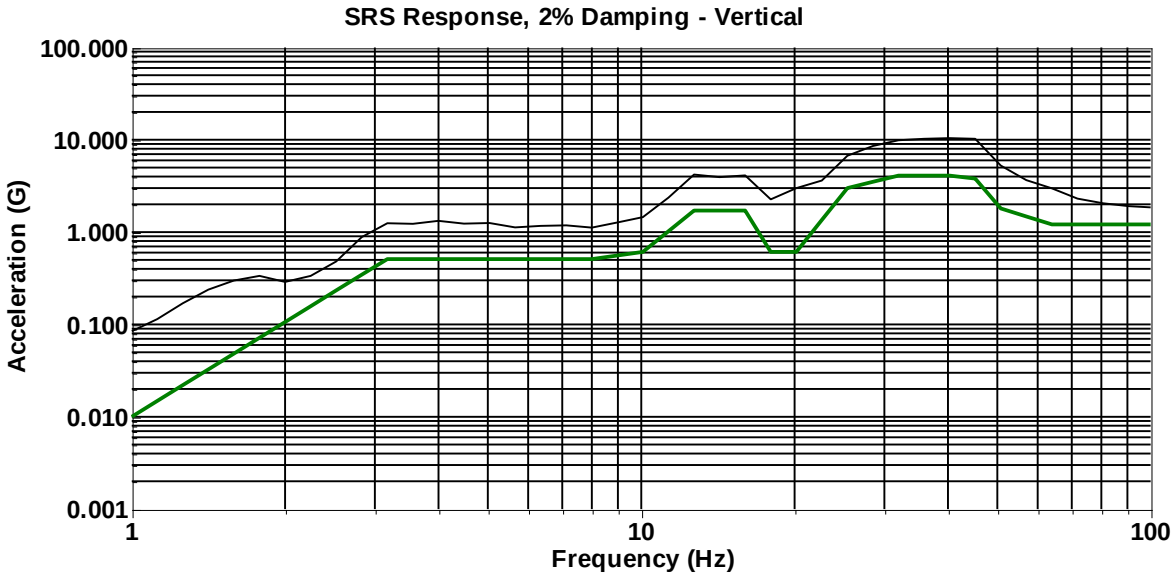
ZPA: -0.6787 G



4726 unit Front to Back Axis Response

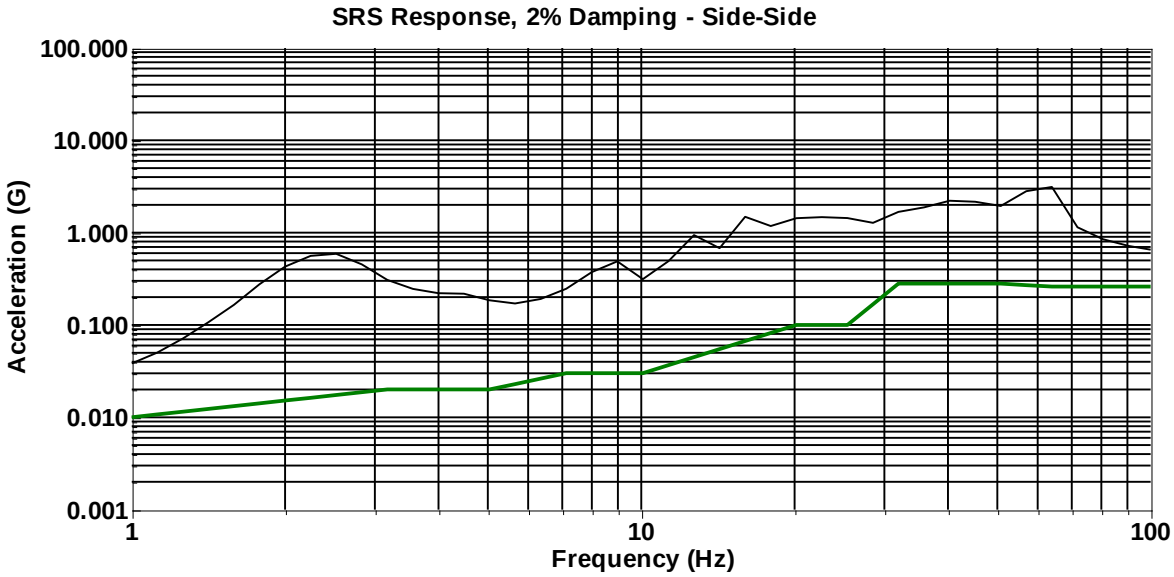
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 11 Chugging Event Oct 29, 2013 14:48:34
Pulse: 570 of 1140

ZPA: -1.657 G



4726 unit Vertical Axis Response

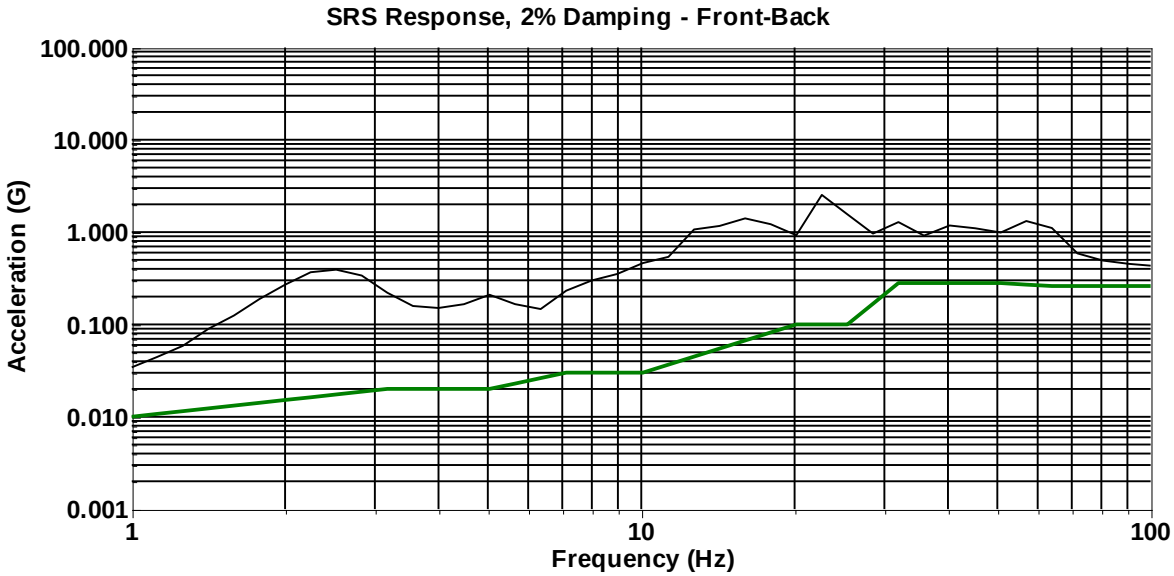
ZPA: 0.4833 G



4726 unit Side to Side Axis Response

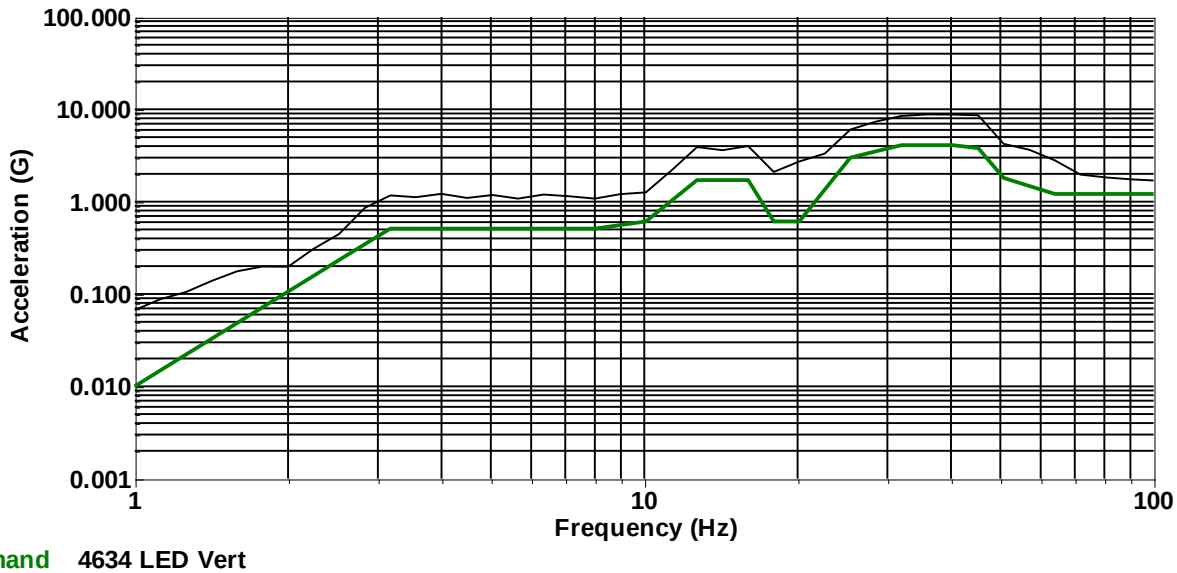
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 11 Chugging Event Oct 29, 2013 14:48:34
Pulse: 570 of 1140

ZPA: 0.3787 G



4634 LED unit Front to Back Axis Response

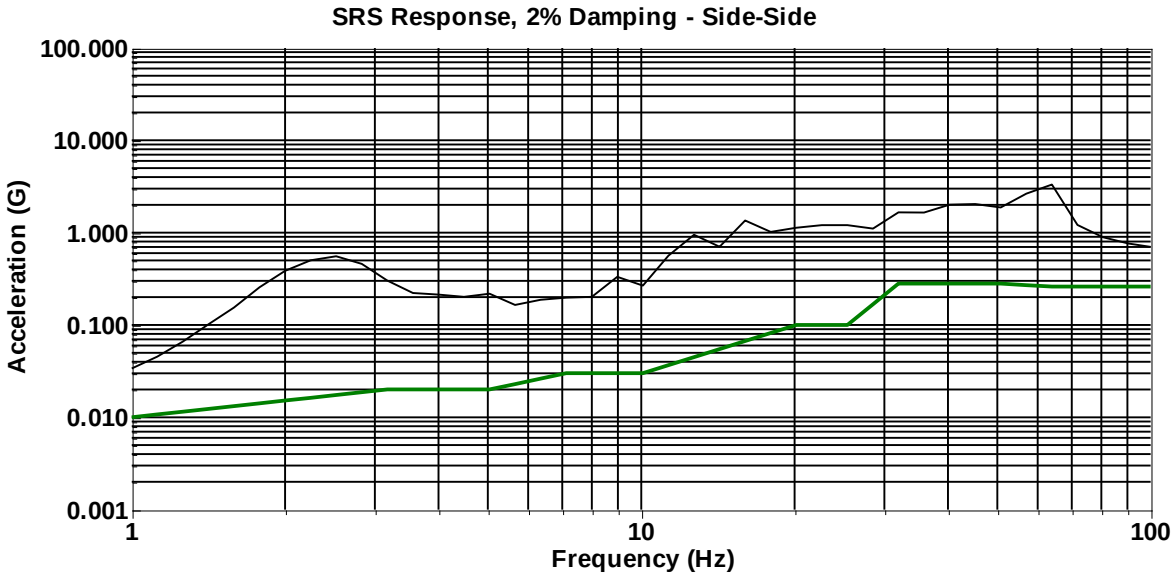
ZPA: -1.511 G



4634 LED unit Vertical Axis Response

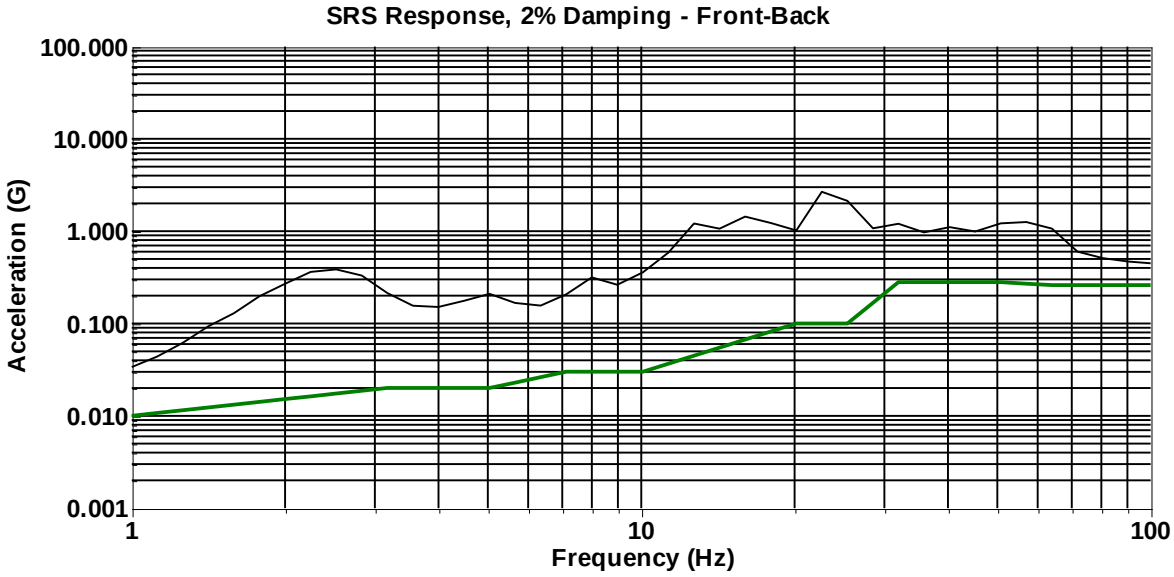
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 11 Chugging Event Oct 29, 2013 14:48:34
Pulse: 570 of 1140

ZPA: 0.5456 G



4634 LED unit Side to Side Axis Response

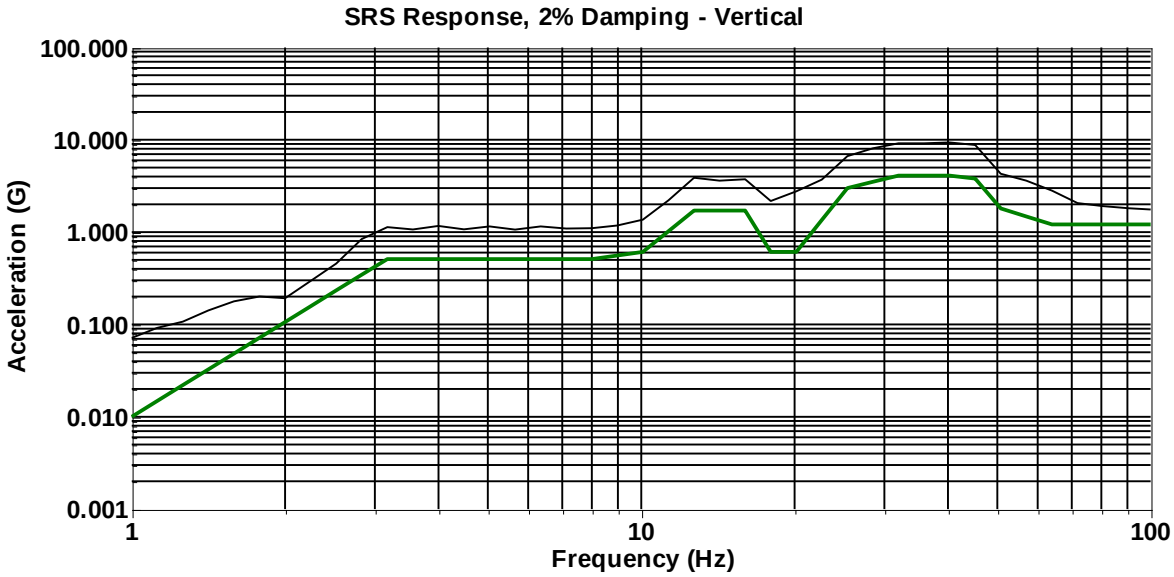
ZPA: -0.4123 G



4634 Incandescent unit Front to Back Axis Response

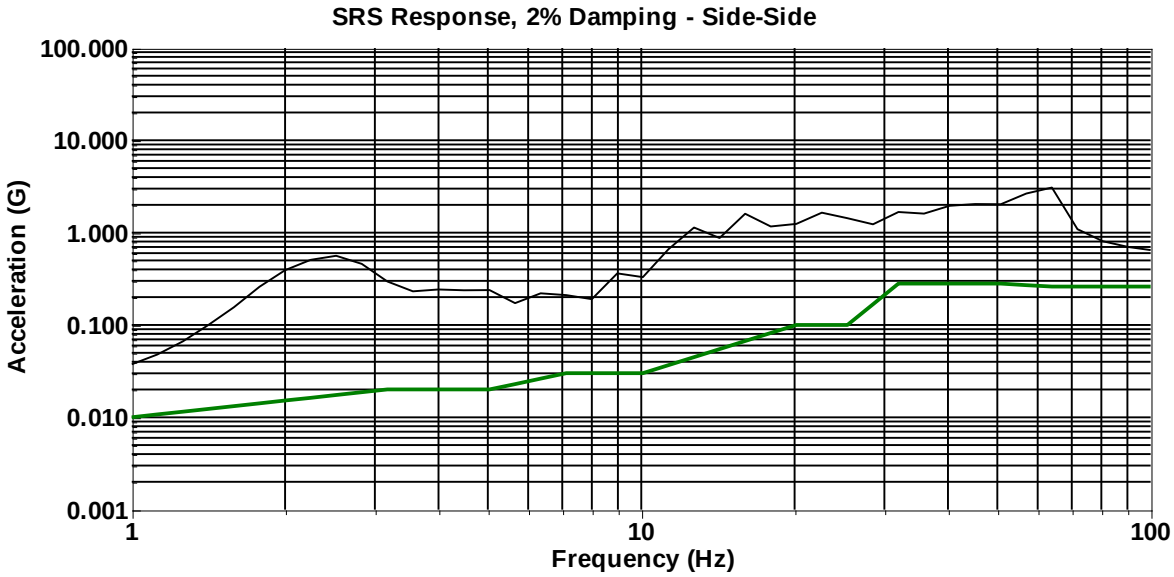
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 11 Chugging Event Oct 29, 2013 14:48:34
Pulse: 570 of 1140

ZPA: -1.567 G



4634 Incandescent unit Vertical Axis Response

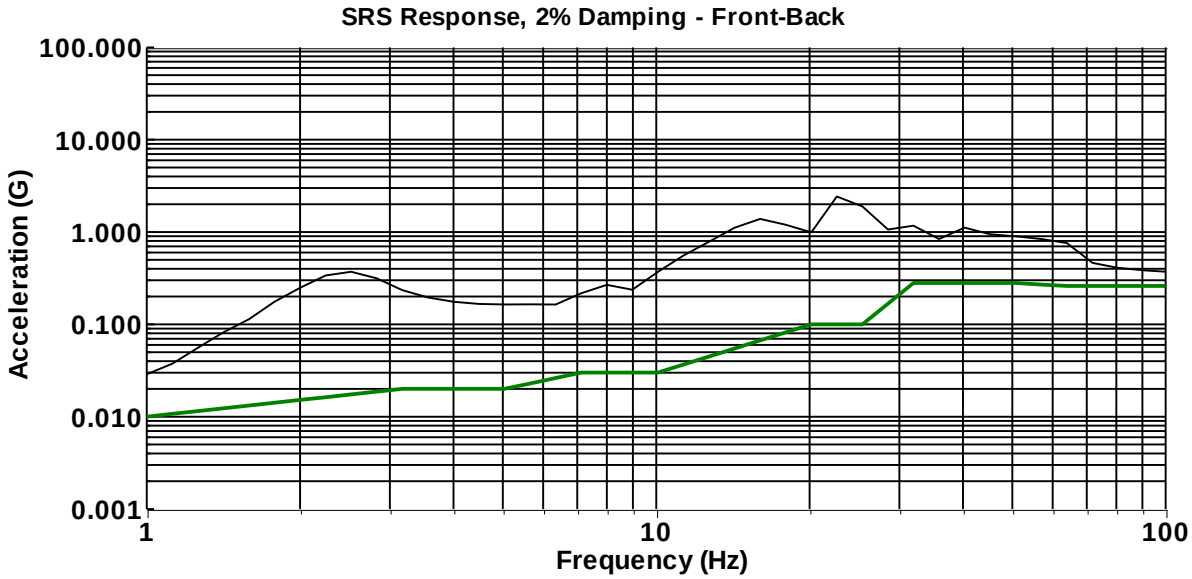
ZPA: 0.5153 G



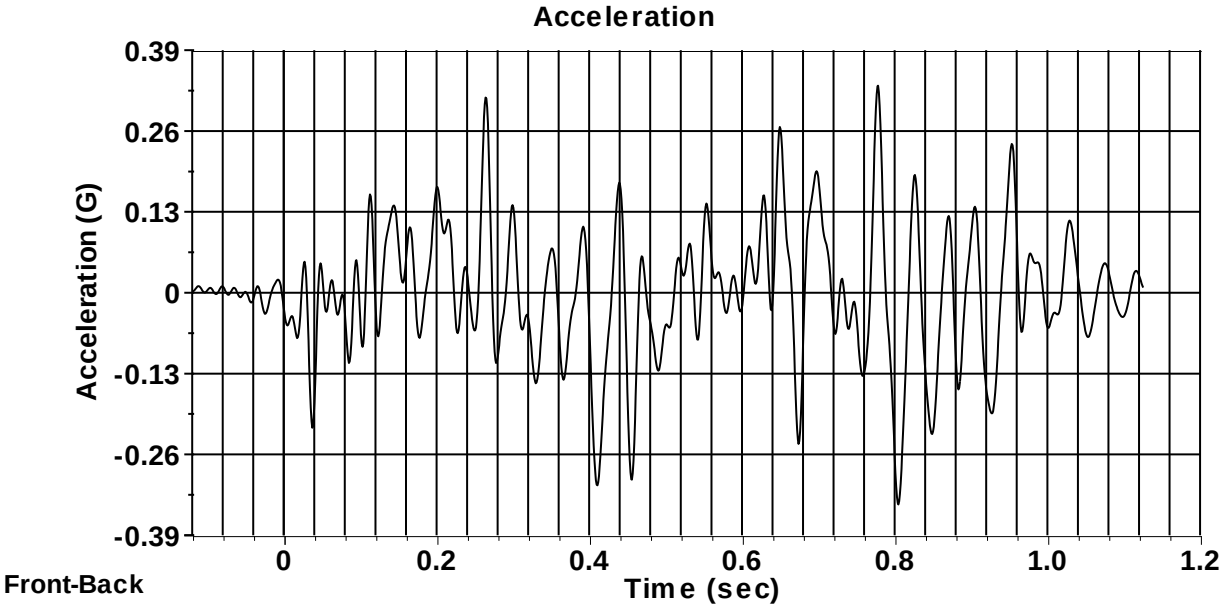
4634 Incandescent unit Side to Side Axis Response

BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 11 Chugging Event Oct 29, 2013 14:48:34
Pulse: 570 of 1140

ZPA: -0.3408 G

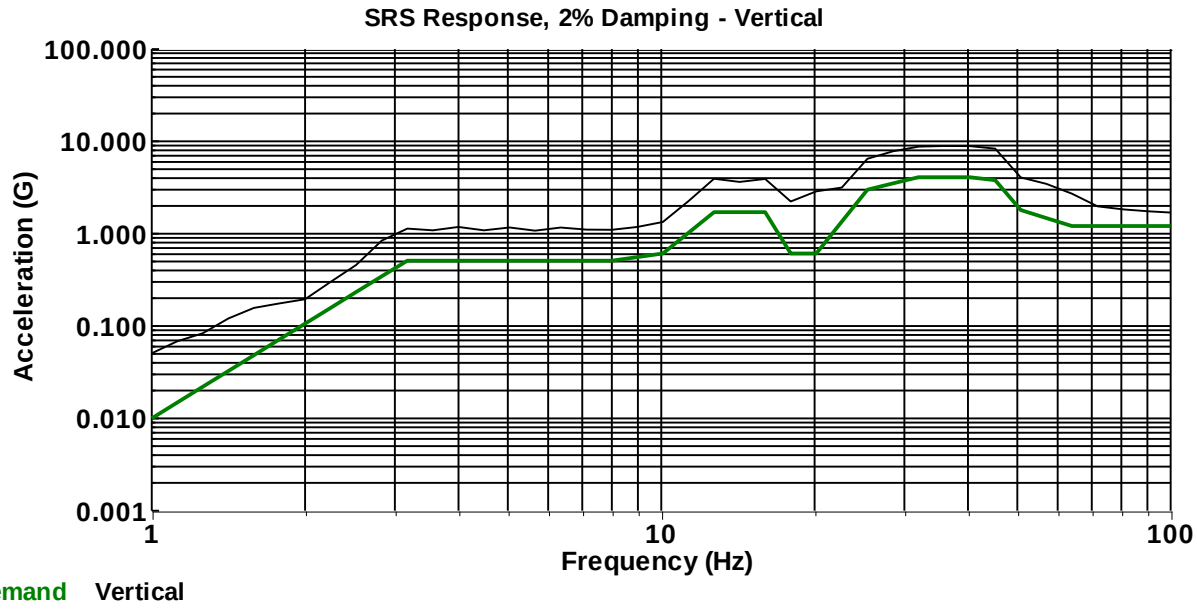


Front to Back Axis Control

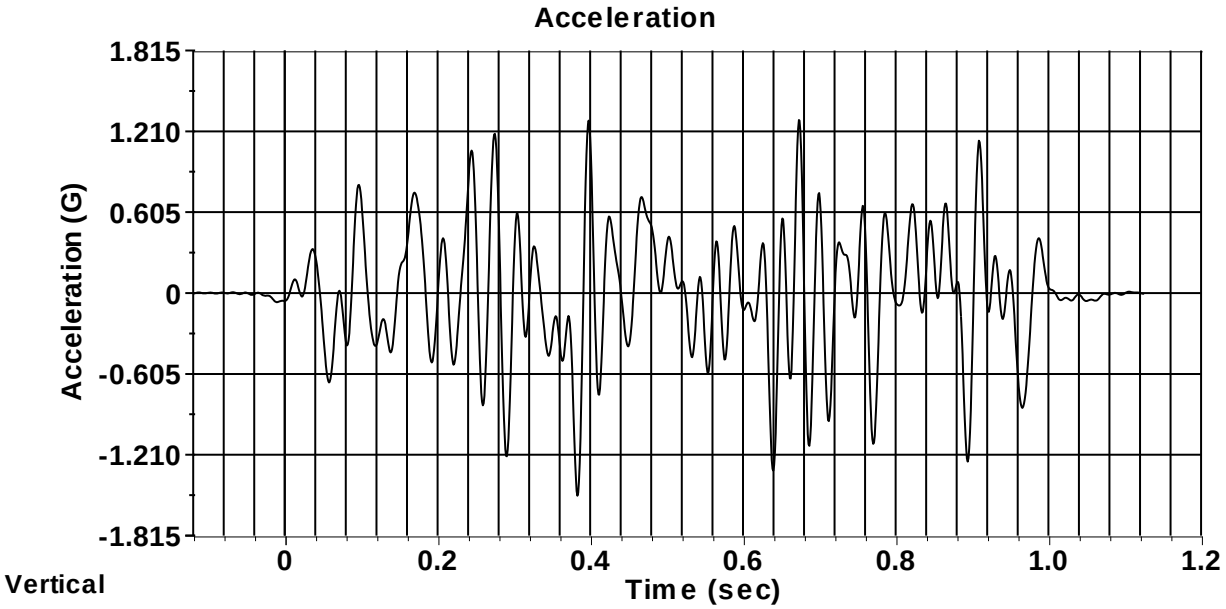


BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 11 Chugging Event Oct 29, 2013 15:22:50
Pulse: 841 of 1140

ZPA: -1.517 G

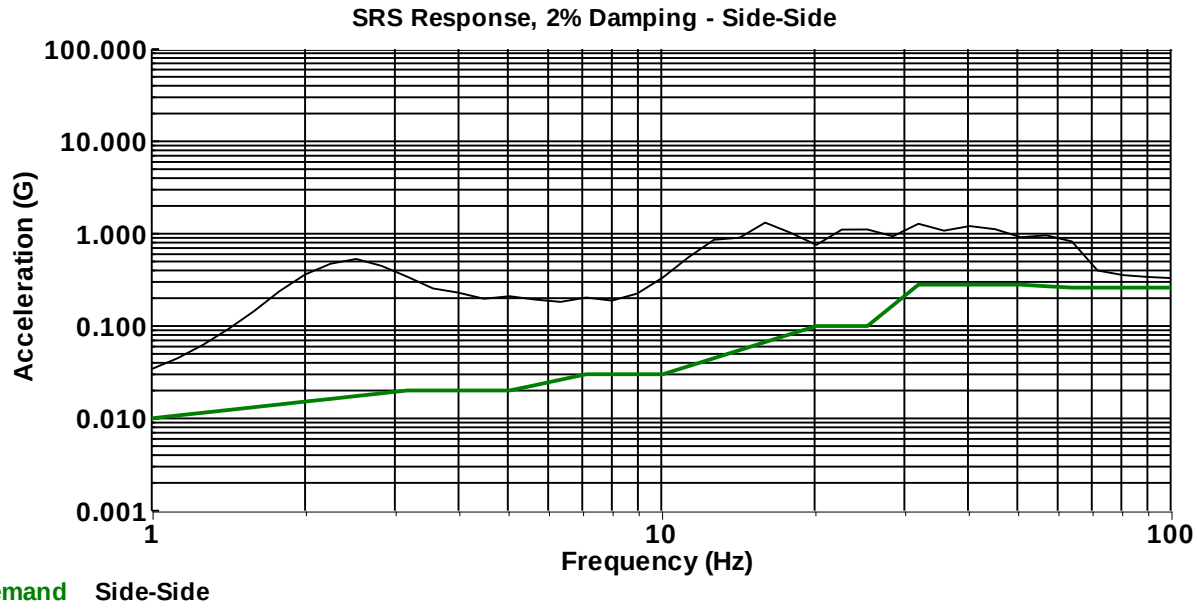


Vertical Axis Control

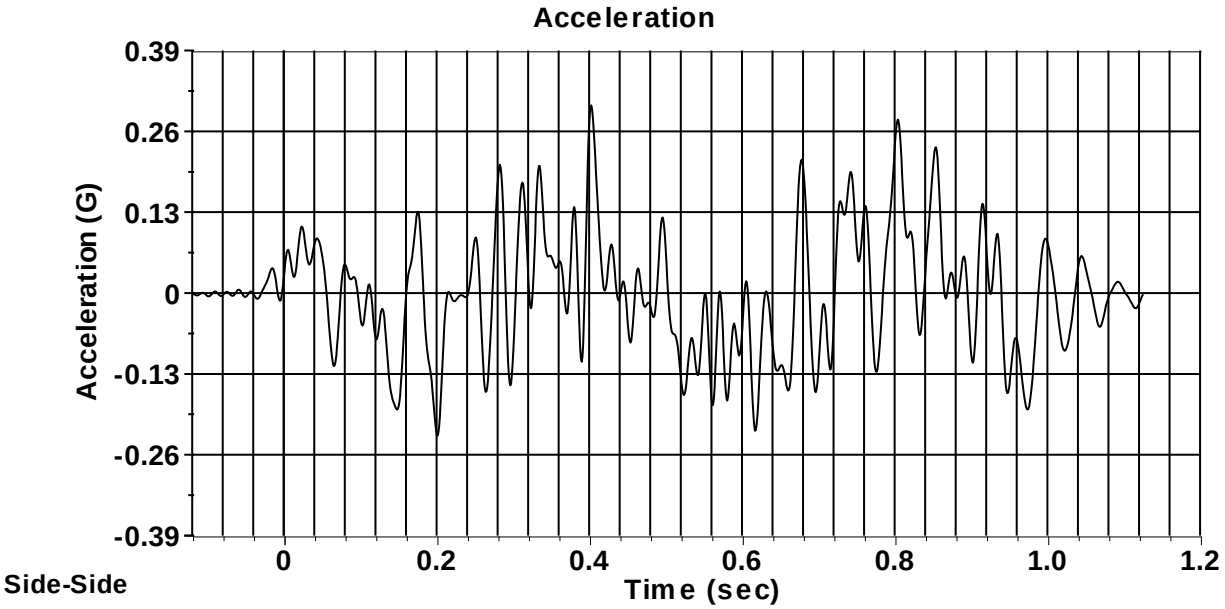


BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 11 Chugging Event Oct 29, 2013 15:22:50
Pulse: 841 of 1140

ZPA: 0.3016 G

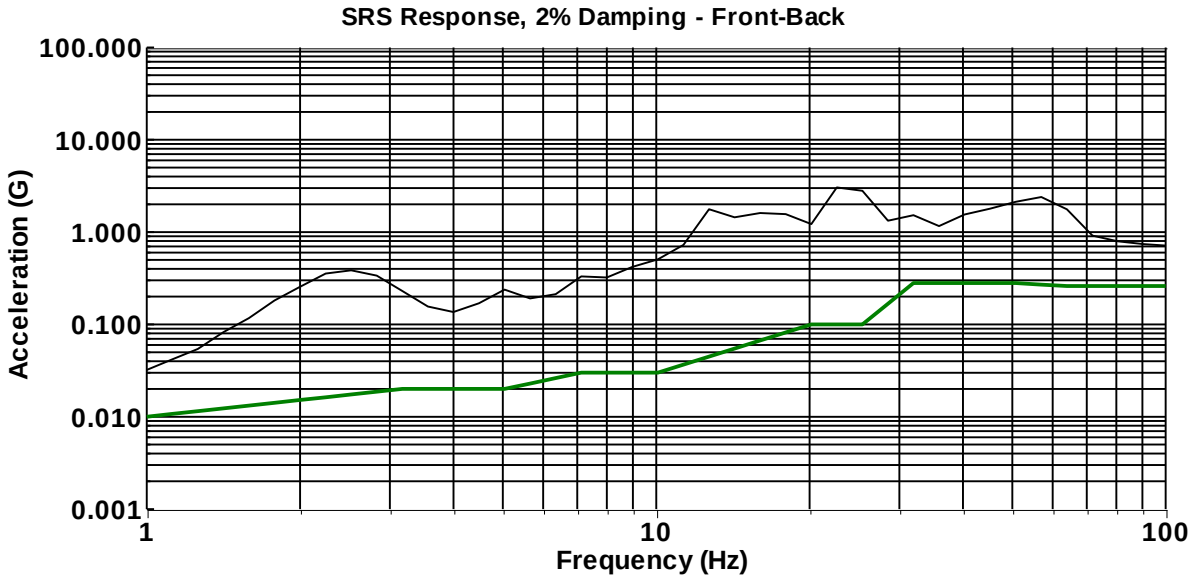


Side to Side Axis Control



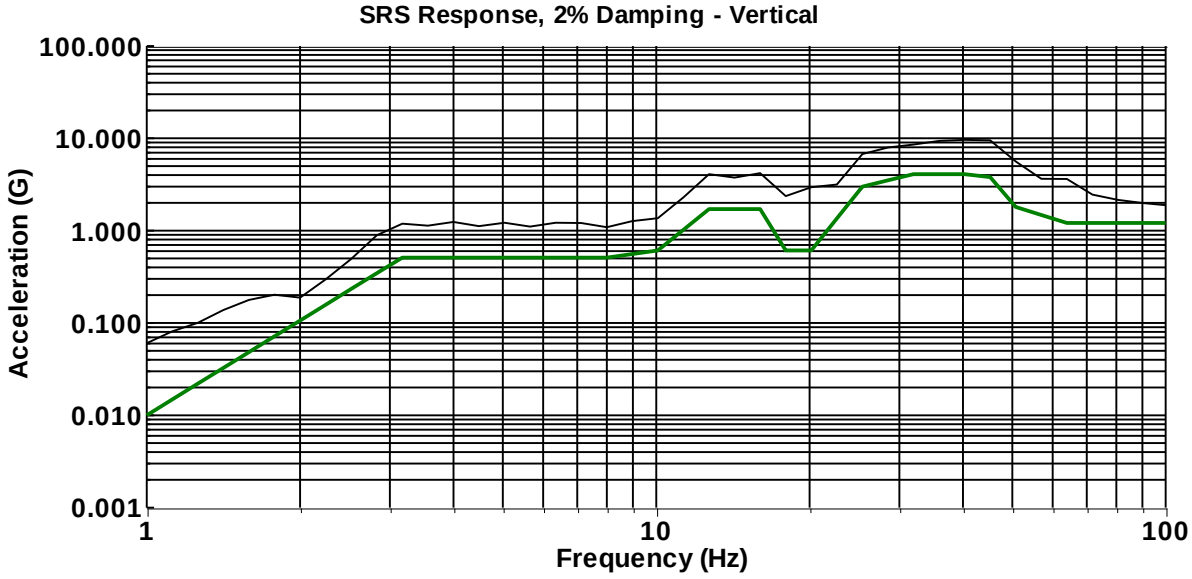
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 11 Chugging Event Oct 29, 2013 15:22:50
Pulse: 841 of 1140

ZPA: -0.6373 G



4702 unit Front to Back Axis Response

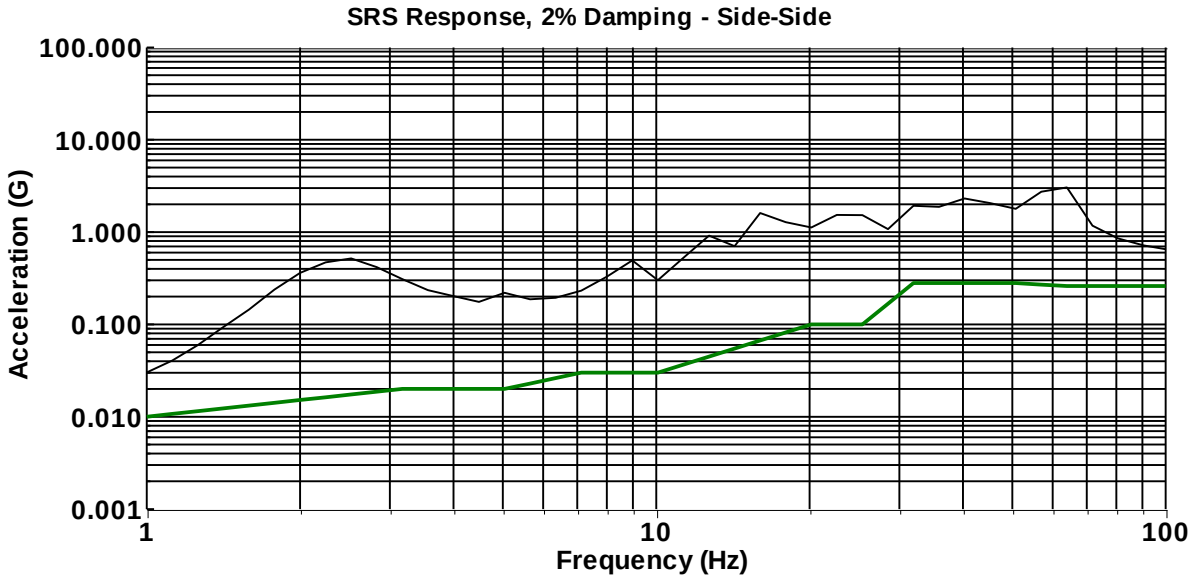
ZPA: 1.579 G



4702 unit Vertical Axis Response

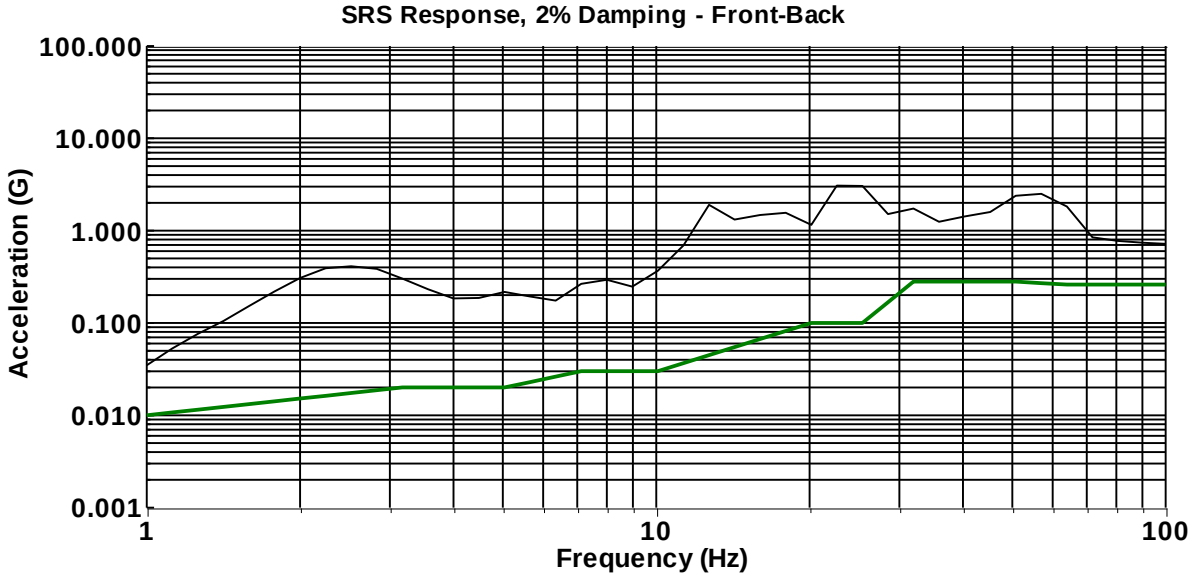
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 11 Chugging Event Oct 29, 2013 15:22:50
Pulse: 841 of 1140

ZPA: 0.4855 G



4702 unit Side to Side Axis Response

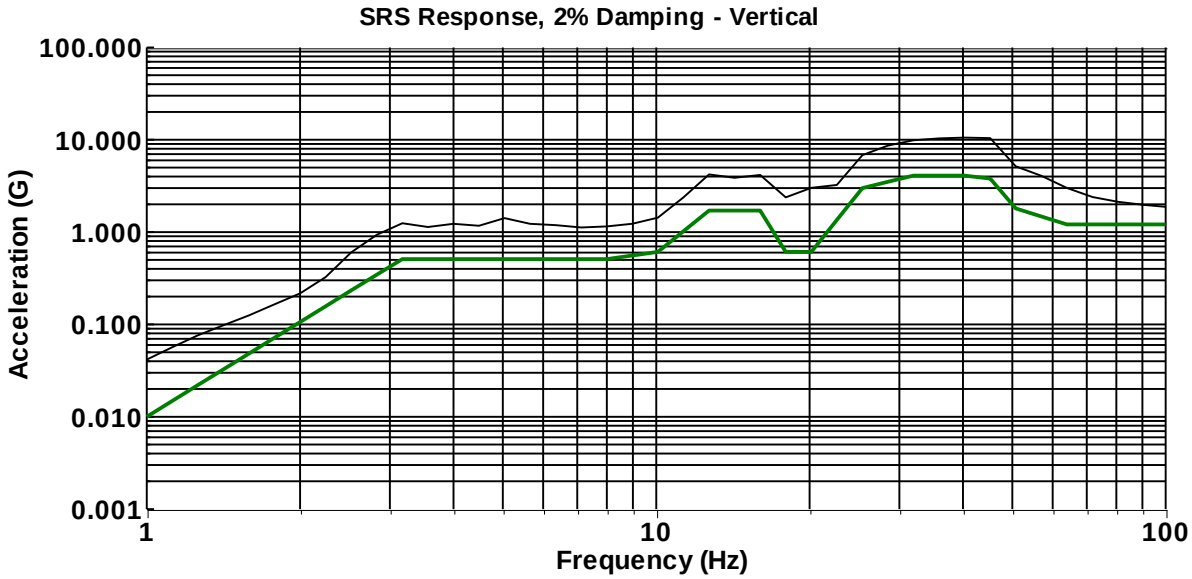
ZPA: -0.6621 G



4726 unit Front to Back Axis Response

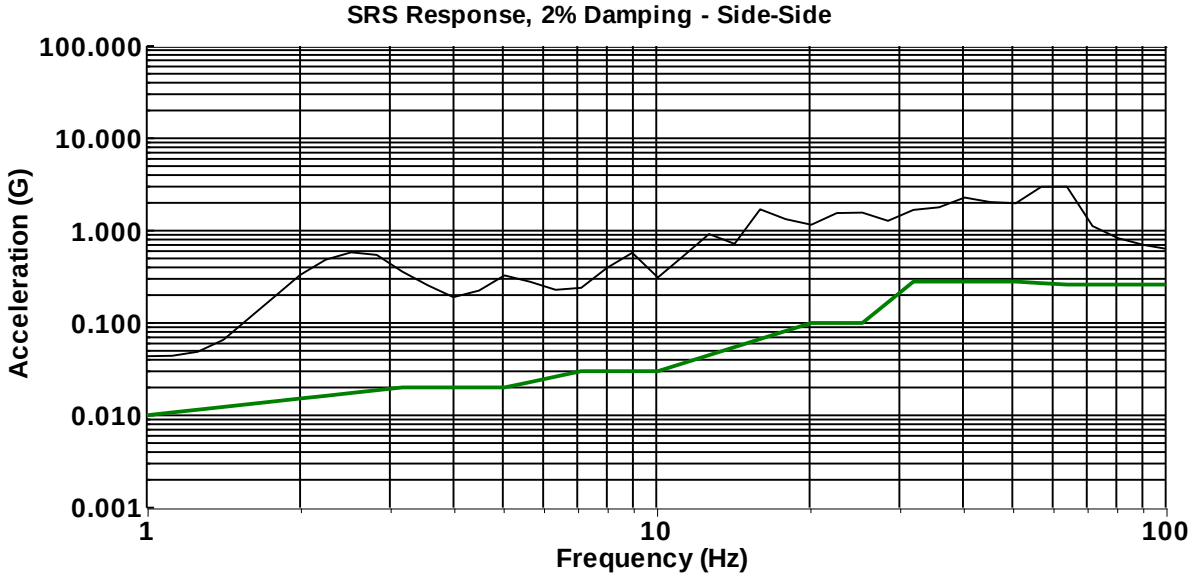
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 11 Chugging Event Oct 29, 2013 15:22:50
Pulse: 841 of 1140

ZPA: -1.621 G



4726 unit Vertical Axis Response

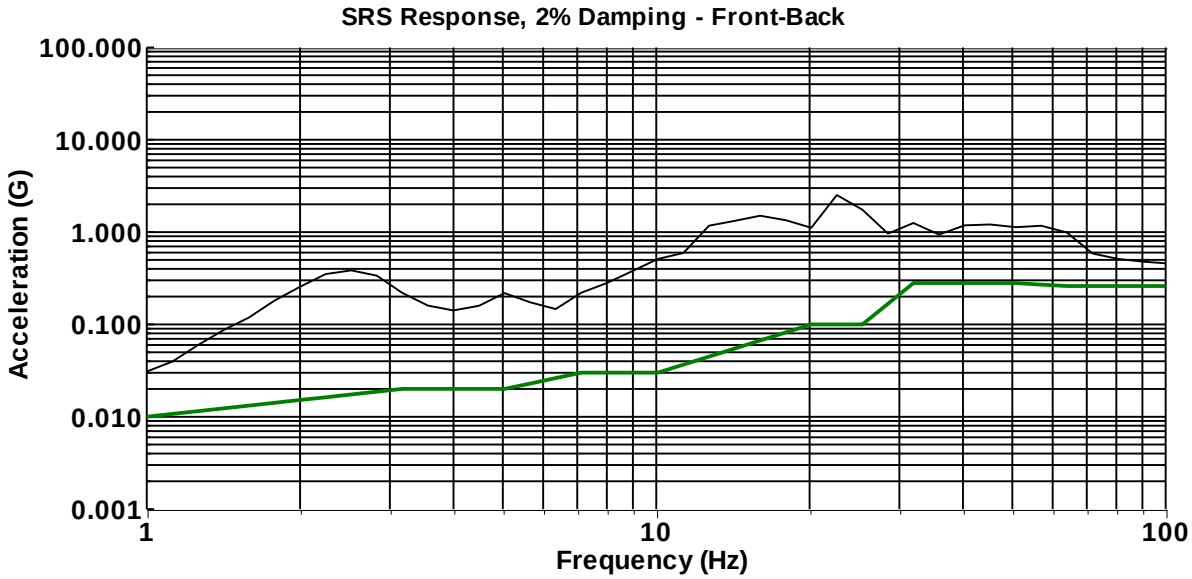
ZPA: 0.4652 G



4726 unit Side to Side Axis Response

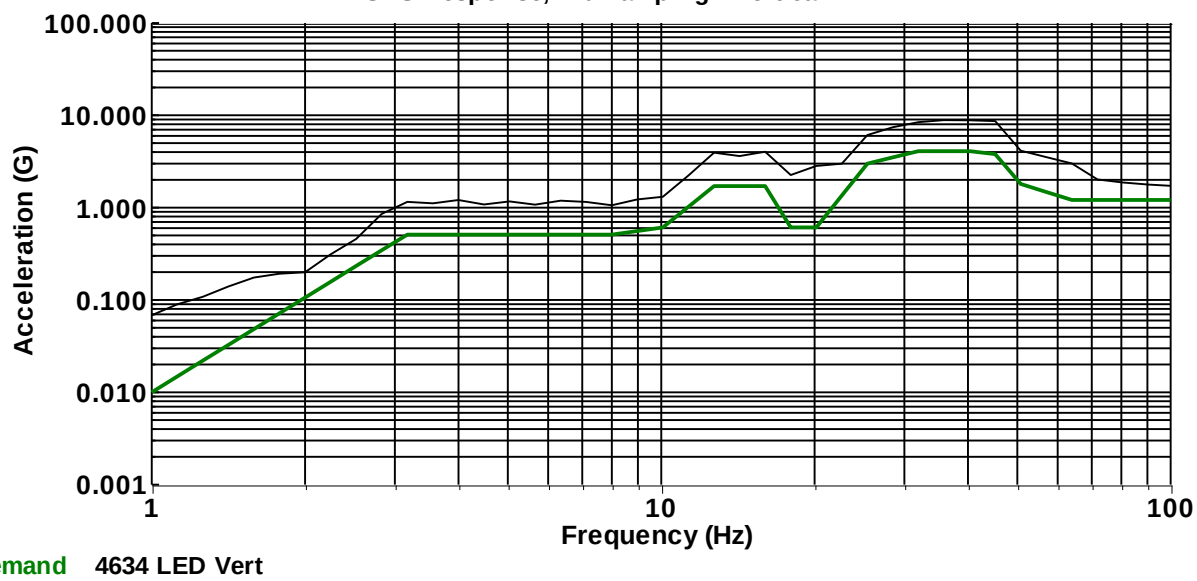
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 11 Chugging Event Oct 29, 2013 15:22:50
Pulse: 841 of 1140

ZPA: 0.4073 G



4634 LED unit Front to Back Axis Response

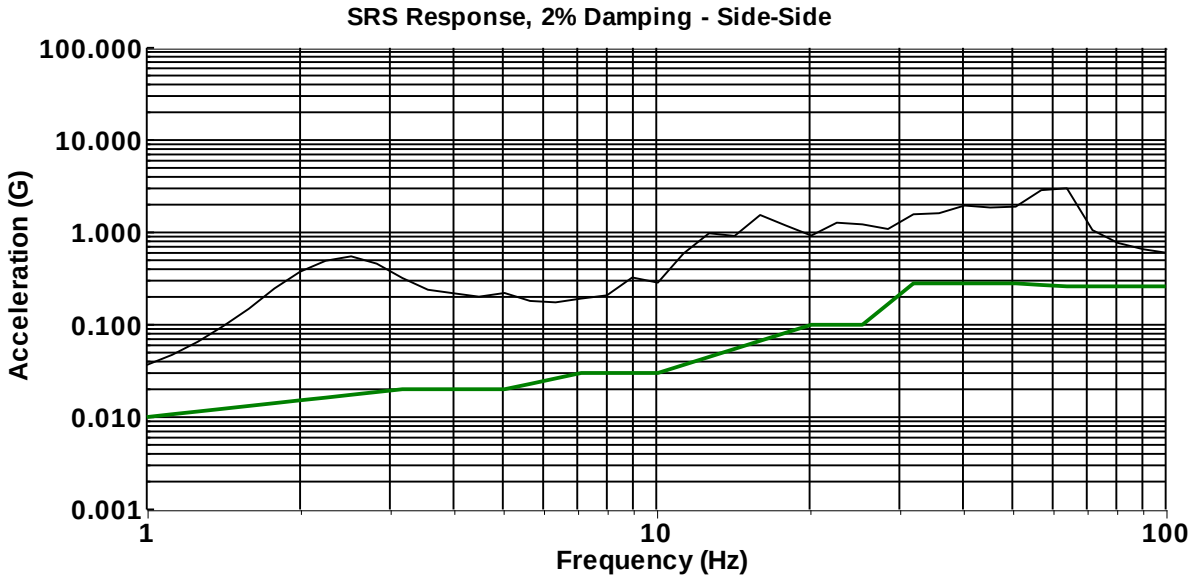
ZPA: -1.542 G



4634 LED unit Vertical Axis Response

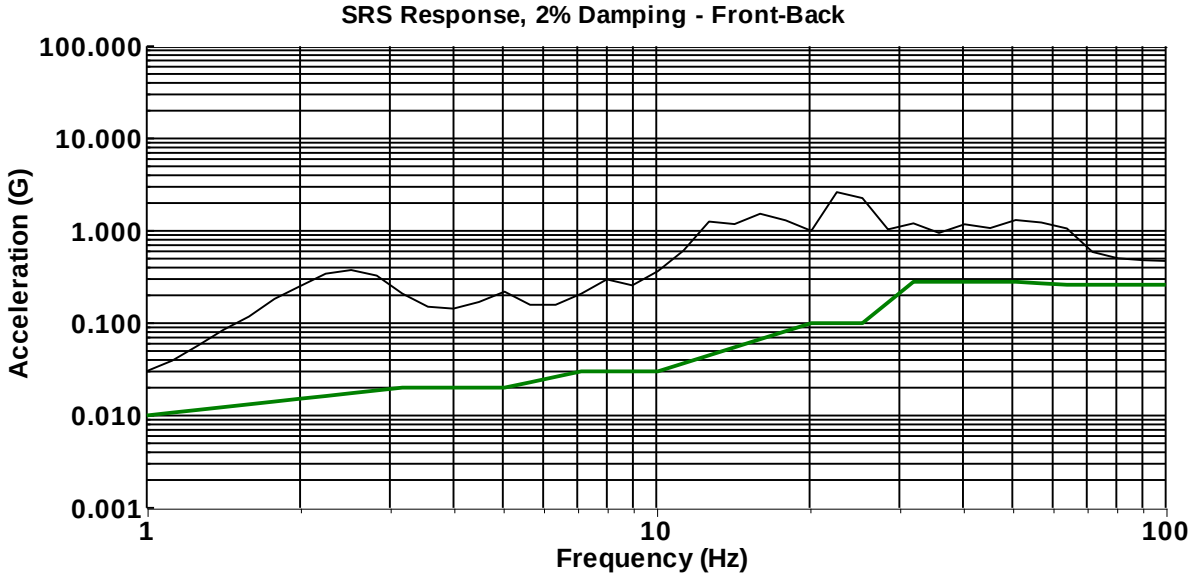
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 11 Chugging Event Oct 29, 2013 15:22:50
Pulse: 841 of 1140

ZPA: 0.4773 G



4634 LED unit Side to Side Axis Response

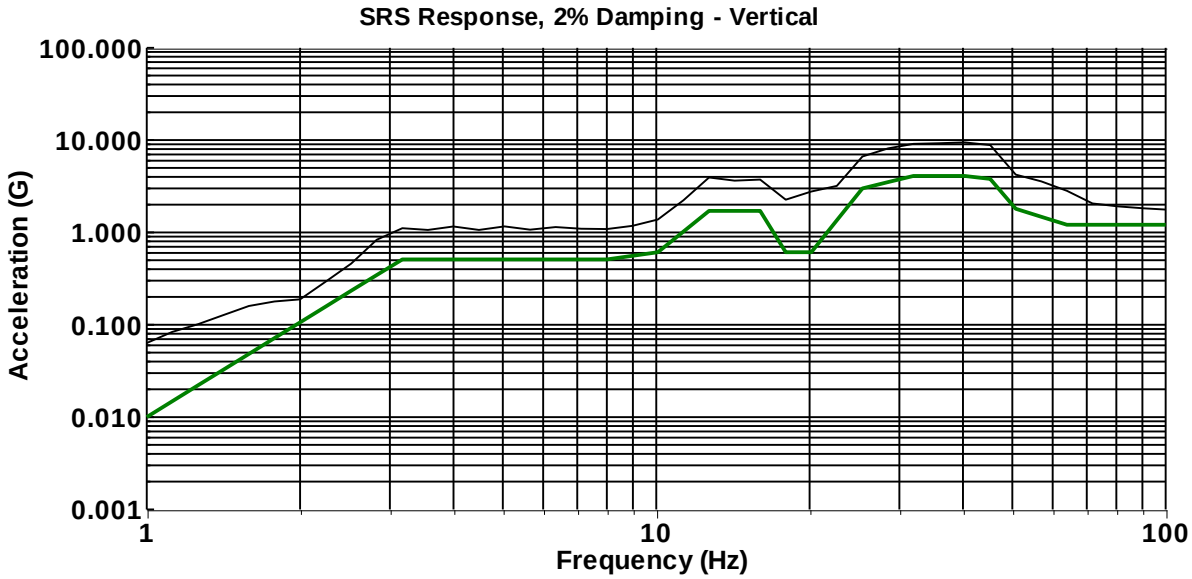
ZPA: -0.4426 G



4634 Incandescent unit Front to Back Axis Response

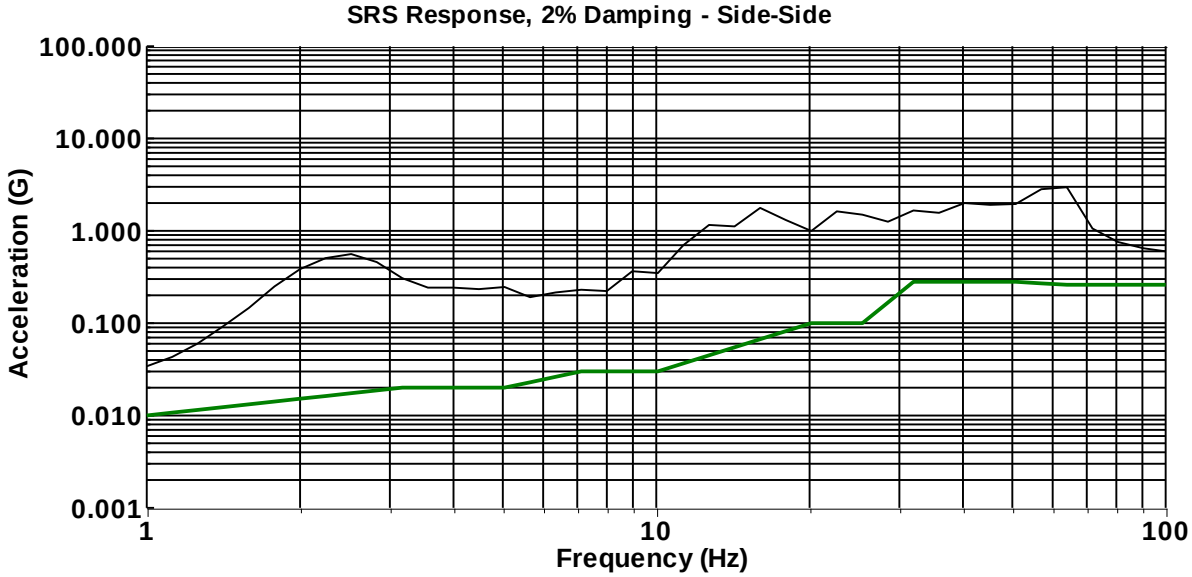
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 11 Chugging Event Oct 29, 2013 15:22:50
Pulse: 841 of 1140

ZPA: -1.584 G



4634 Incandescent unit Vertical Axis Response

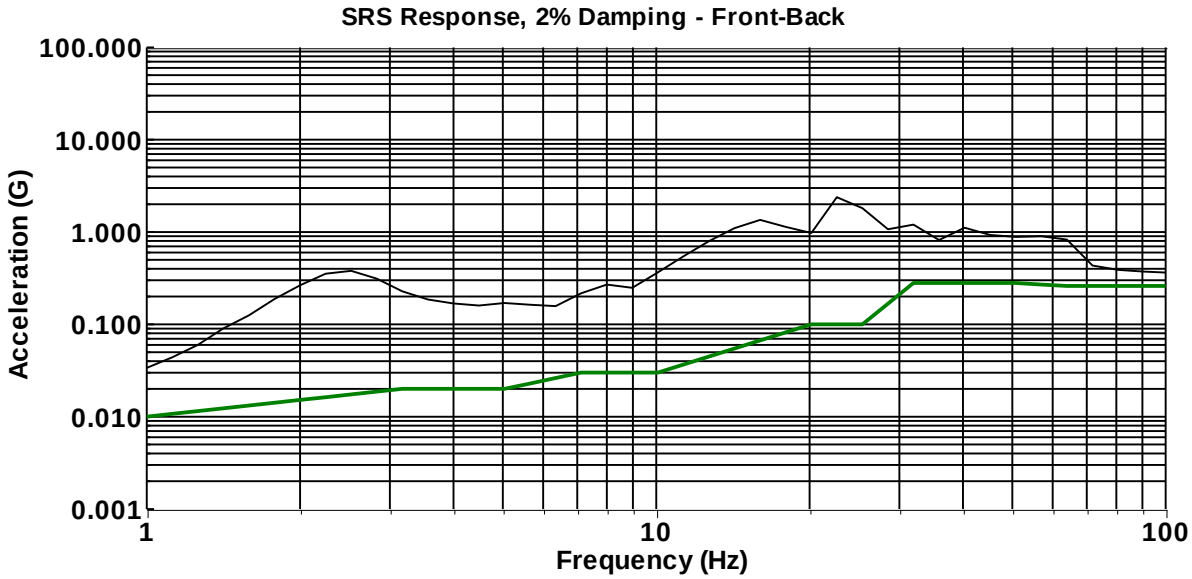
ZPA: 0.4737 G



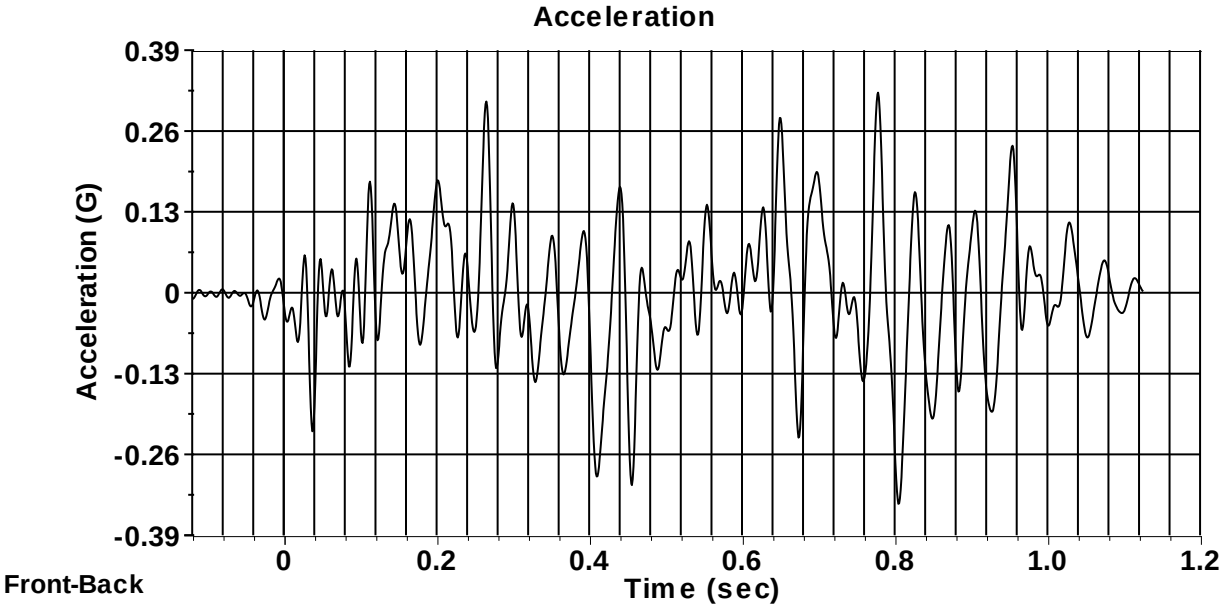
4634 Incandescent unit Side to Side Axis Response

BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 11 Chugging Event Oct 29, 2013 15:22:50
Pulse: 841 of 1140

ZPA: -0.3397 G

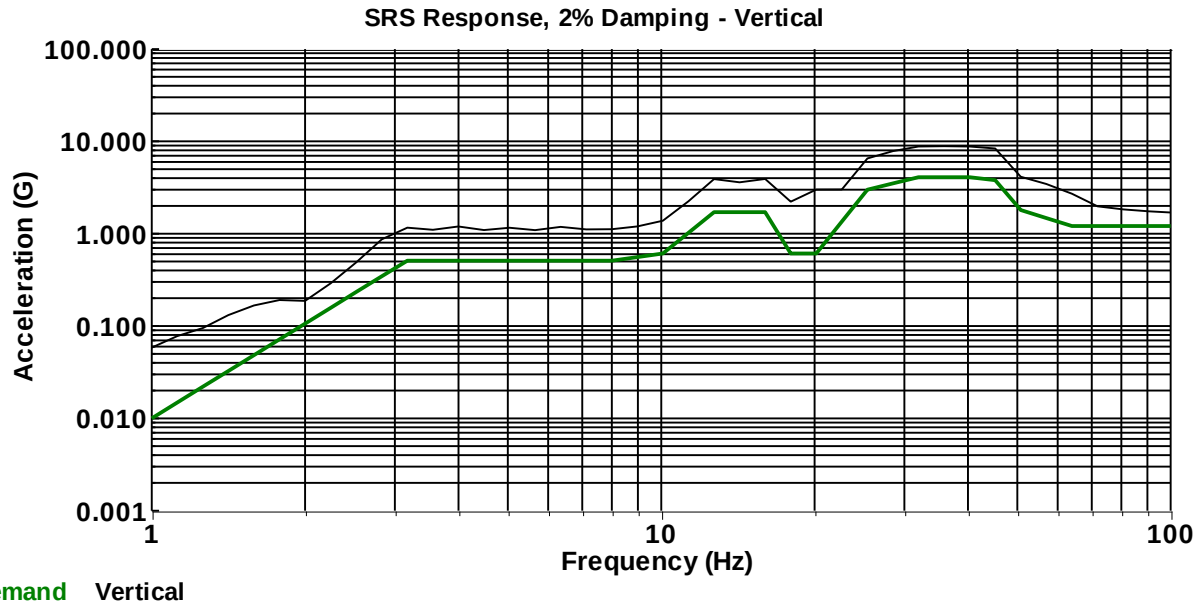


Front to Back Axis Control

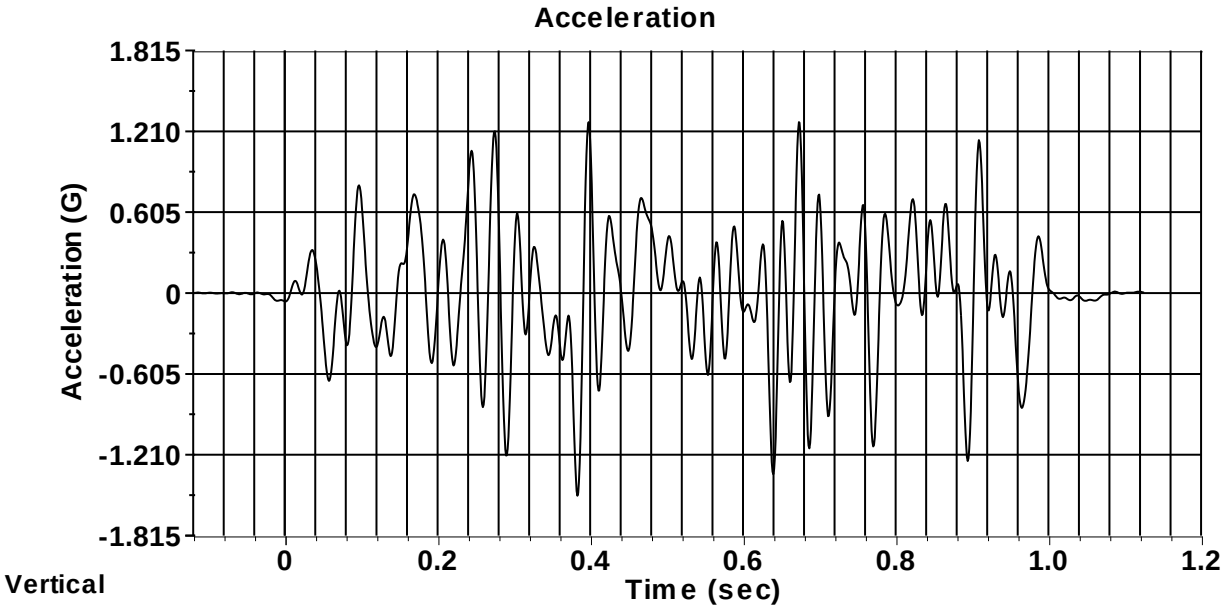


BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4762, 4634 LED, 4634 Incandescent
Test# 11 Chugging Event Oct 29, 2013 15:59:33
Pulse: 1140 of 1140

ZPA: -1.518 G

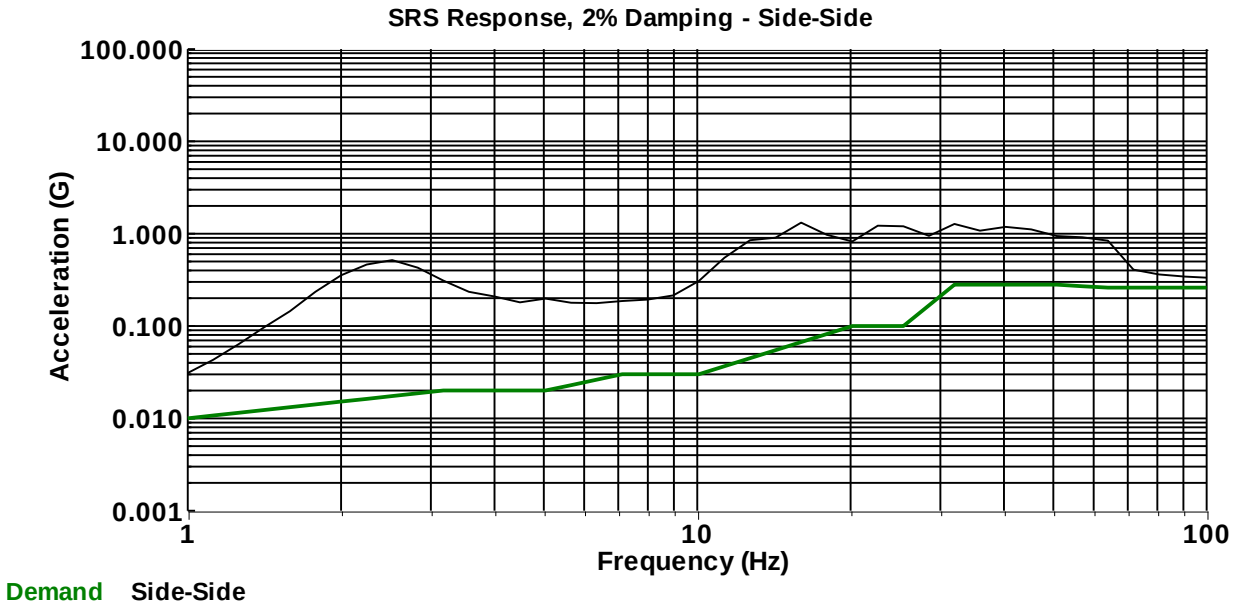


Vertical Axis Control

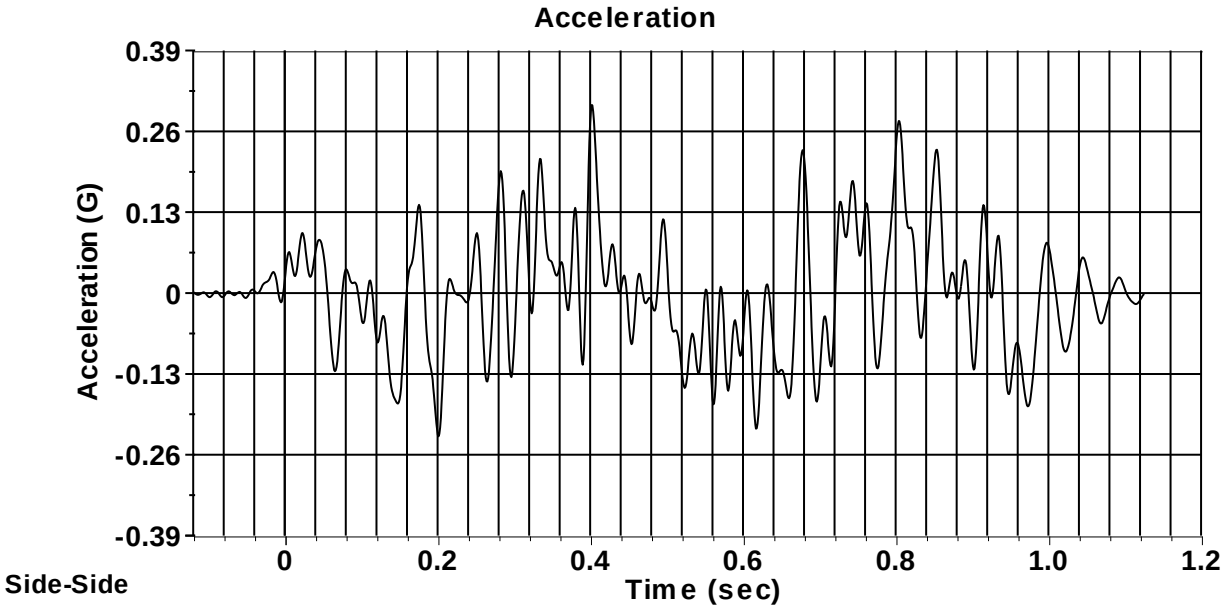


BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4762, 4634 LED, 4634 Incandescent
Test# 11 Chugging Event Oct 29, 2013 15:59:33
Pulse: 1140 of 1140

ZPA: 0.3022 G

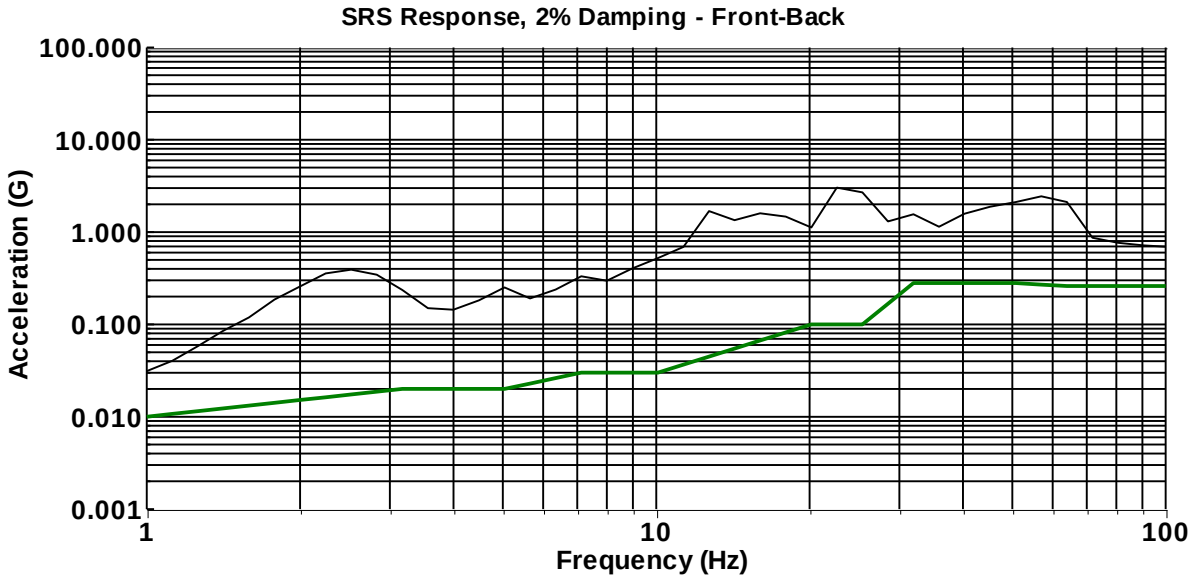


Side to Side Axis Control



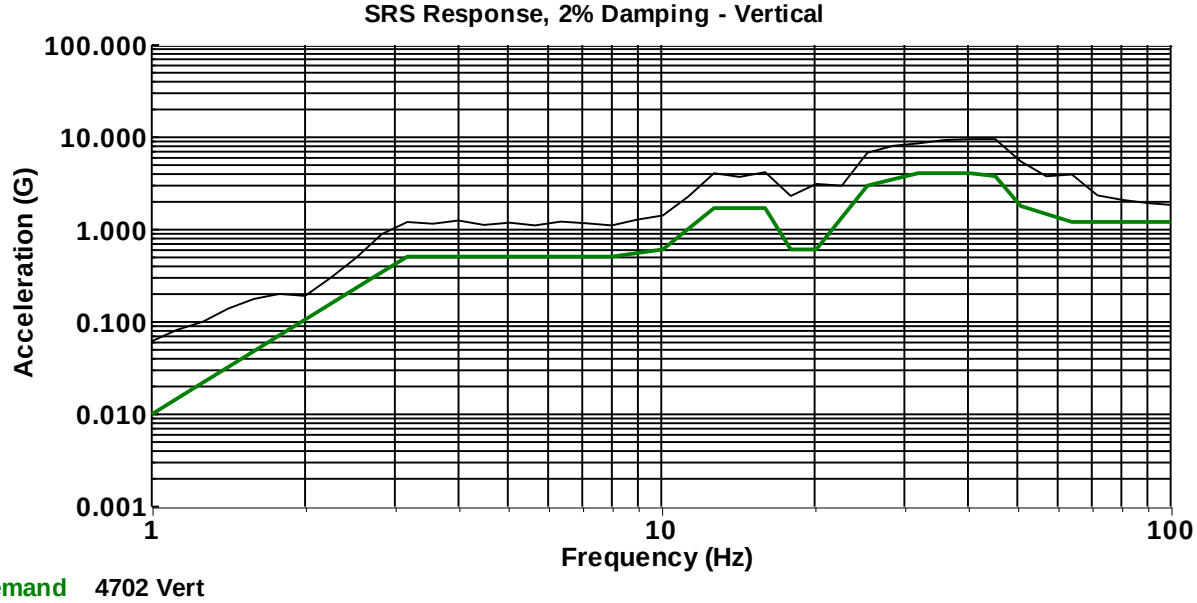
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4762, 4634 LED, 4634 Incandescent
Test# 11 Chugging Event Oct 29, 2013 15:59:33
Pulse: 1140 of 1140

ZPA: -0.623 G



4702 unit Front to Back Axis Response

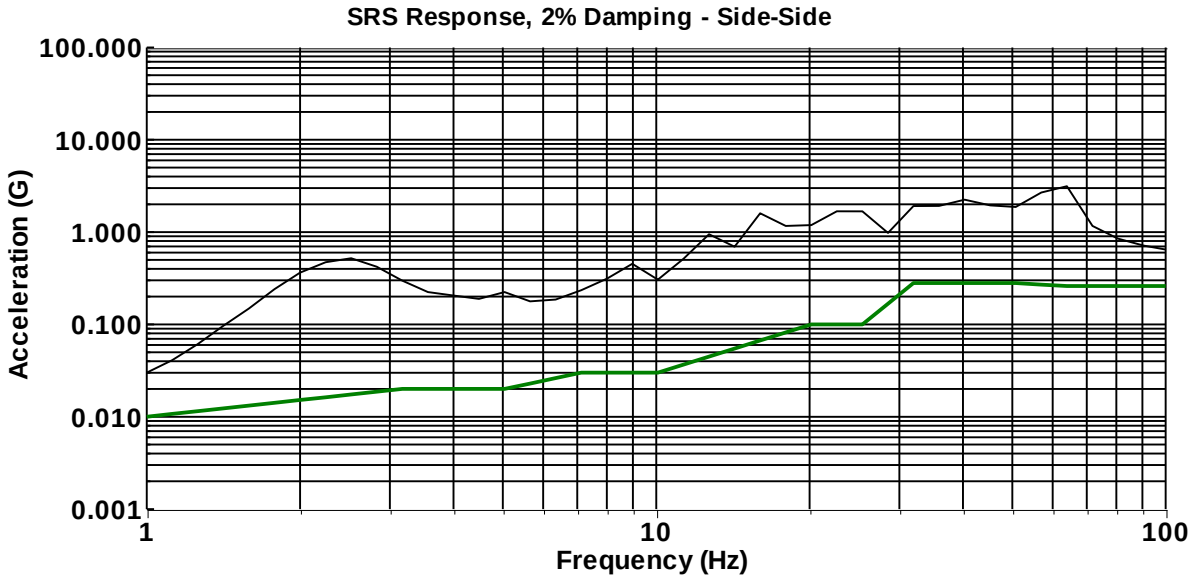
ZPA: -1.572 G



4702 unit Vertical Axis Response

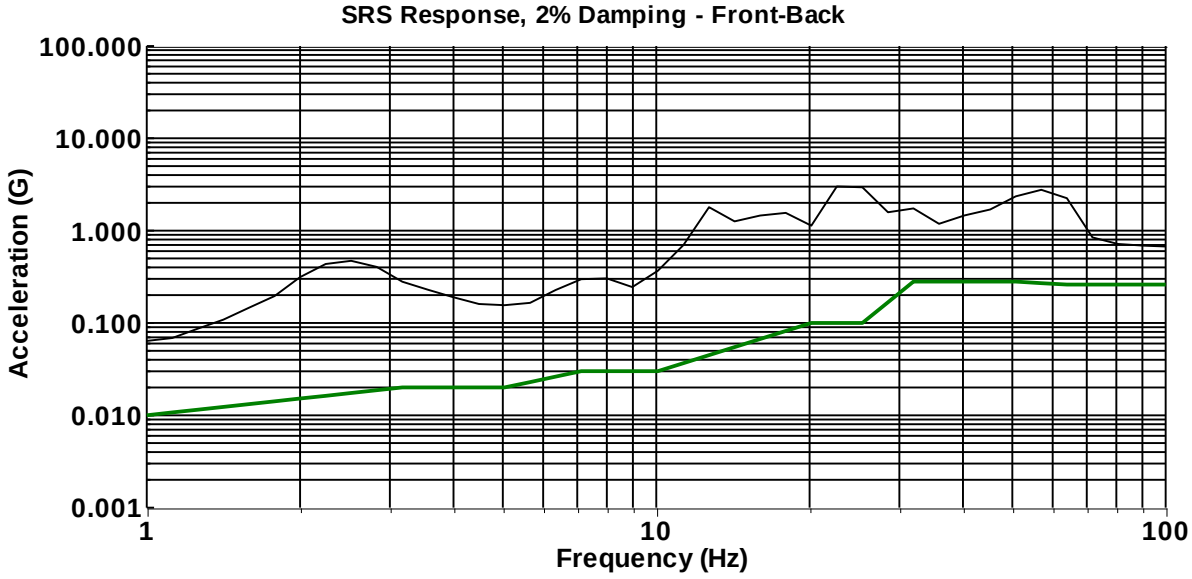
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 11 Chugging Event Oct 29, 2013 15:59:33
Pulse: 1140 of 1140

ZPA: -0.4673 G



4702 unit Side to Side Axis Response

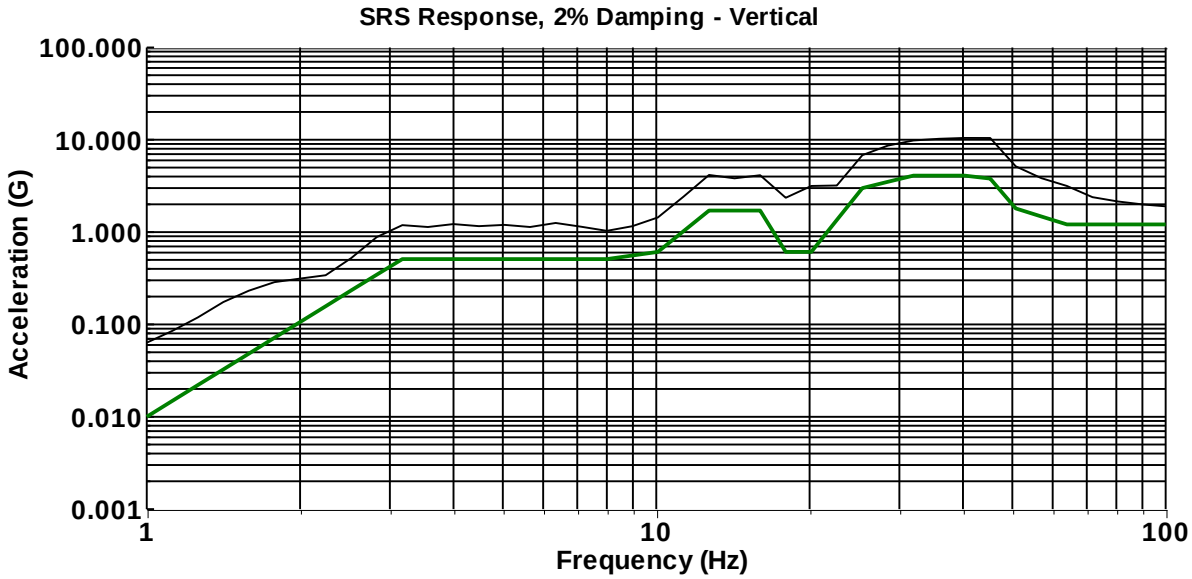
ZPA: -0.6204 G



4726 unit Front to Back Axis Response

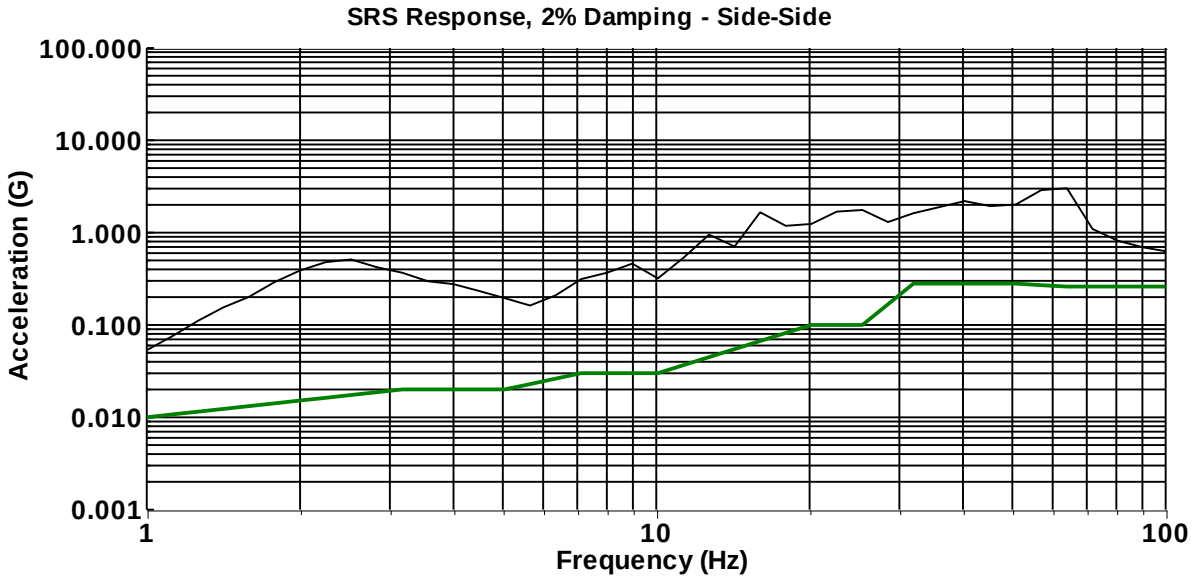
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 11 Chugging Event Oct 29, 2013 15:59:33
Pulse: 1140 of 1140

ZPA: -1.638 G



4726 unit Vertical Axis Response

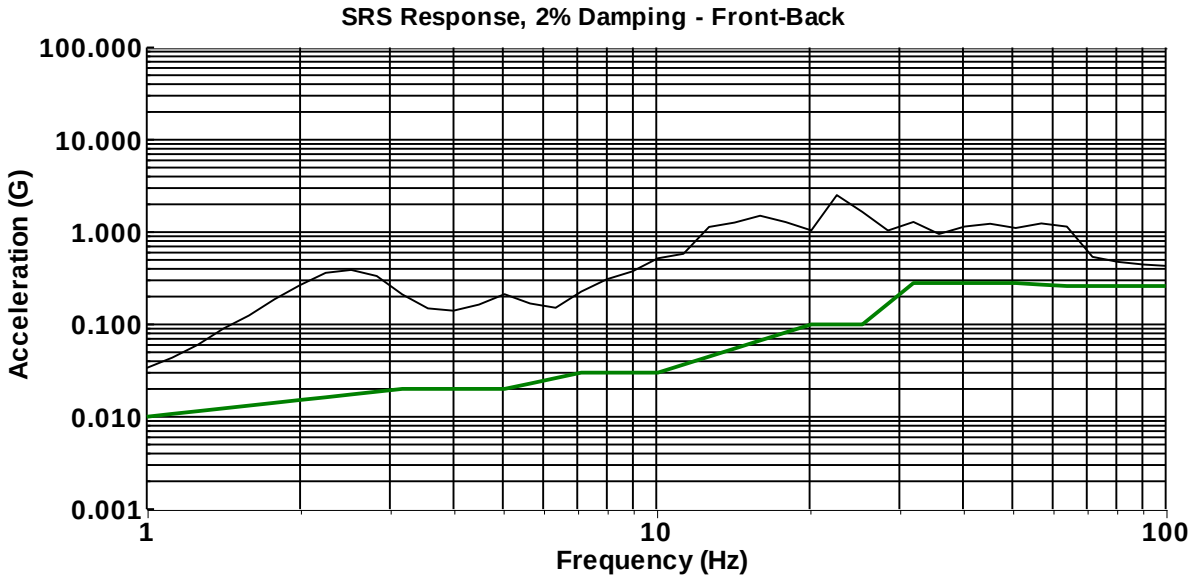
ZPA: 0.4645 G



4726 unit Side to Side Axis Response

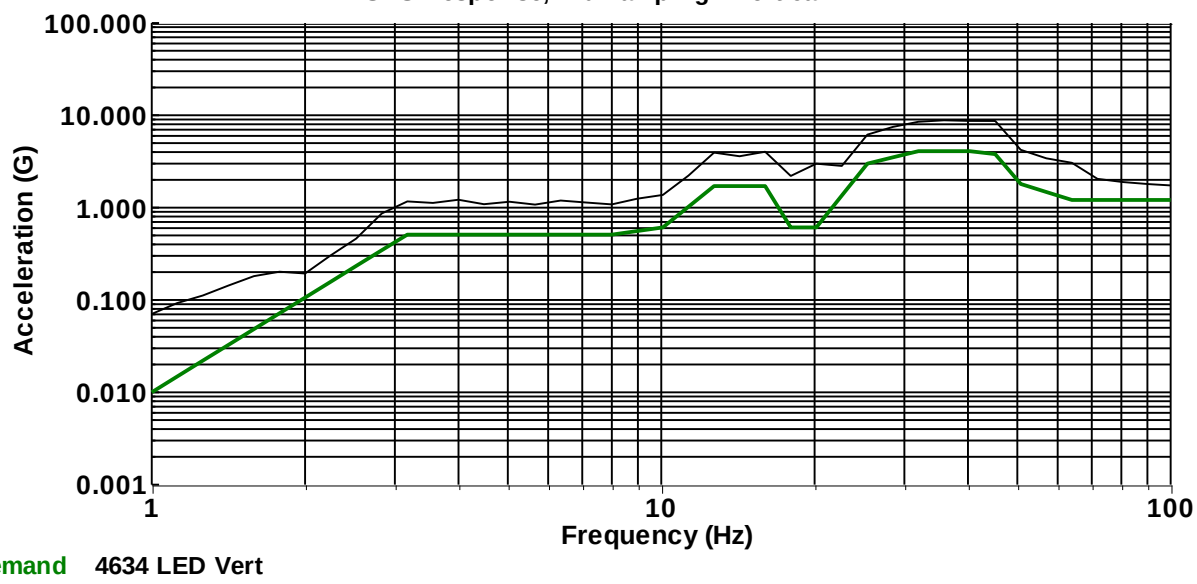
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 11 Chugging Event Oct 29, 2013 15:59:33
Pulse: 1140 of 1140

ZPA: 0.383 G



4634 LED unit Front to Back Axis Response

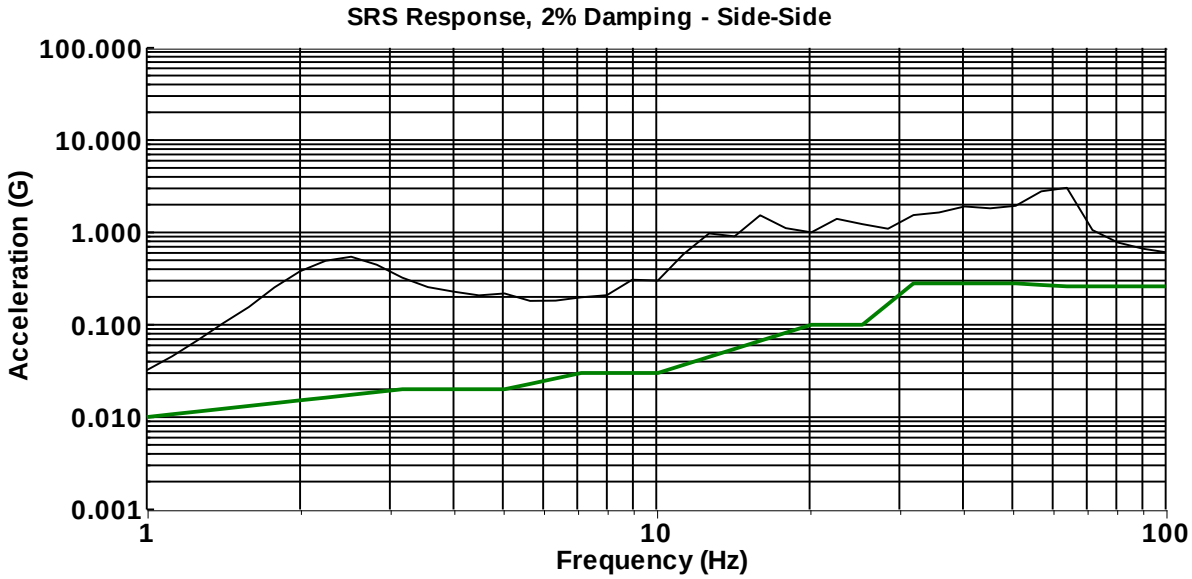
ZPA: -1.553 G



4634 LED unit Vertical Axis Response

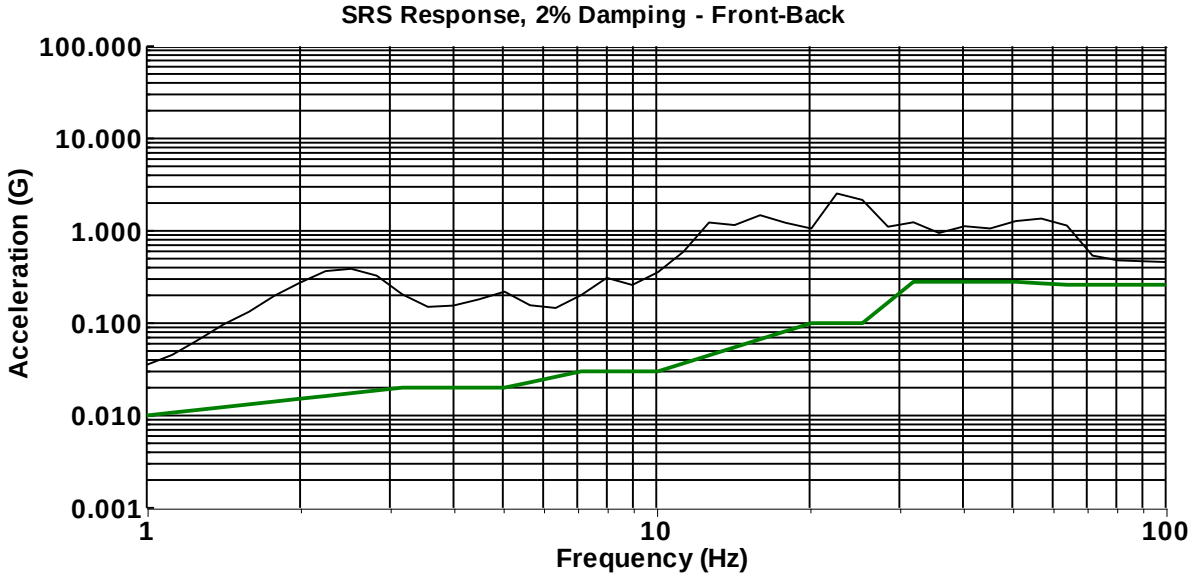
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 11 Chugging Event Oct 29, 2013 15:59:33
Pulse: 1140 of 1140

ZPA: 0.4835 G



4634 LED unit Side to Side Axis Response

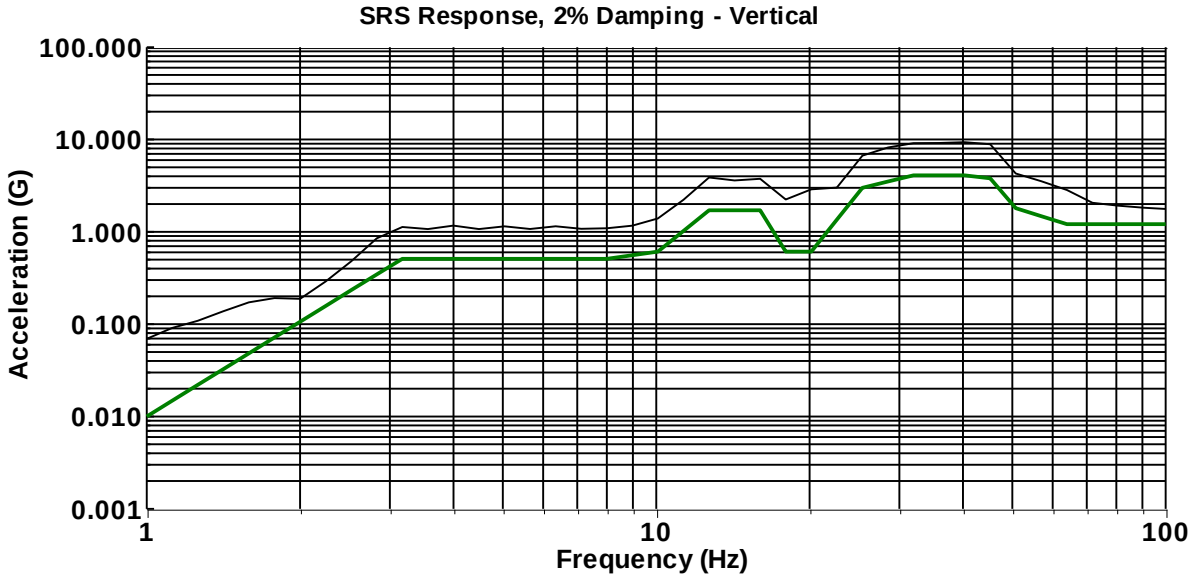
ZPA: -0.4339 G



4634 Incandescent unit Front to Back Axis Response

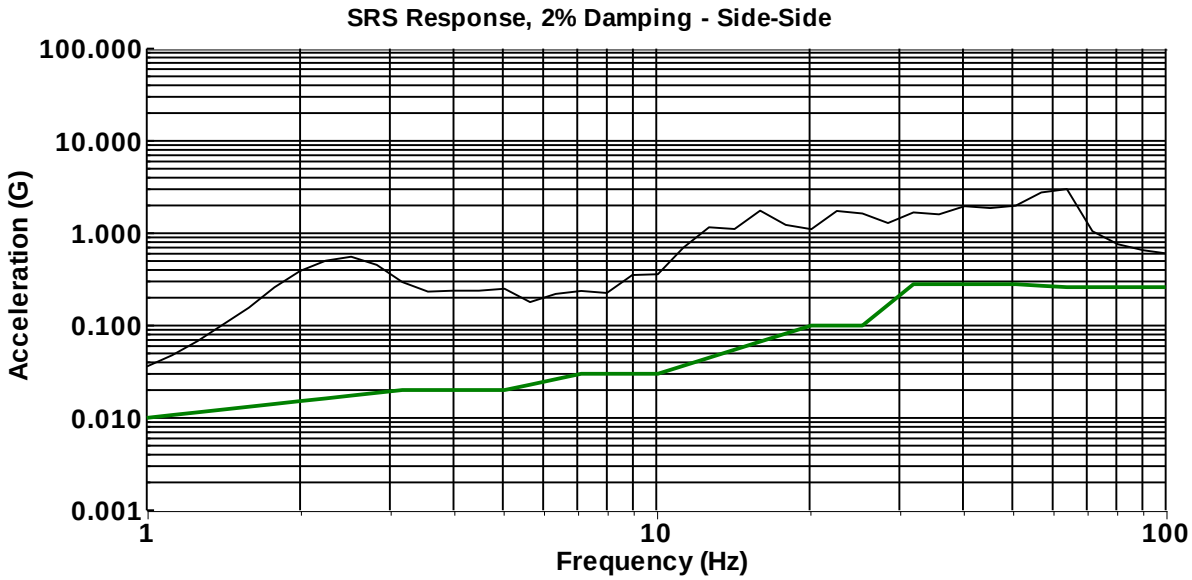
BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 11 Chugging Event Oct 29, 2013 15:59:33
Pulse: 1140 of 1140

ZPA: -1.582 G



4634 Incandescent unit Vertical Axis Response

ZPA: 0.4782 G



4634 Incandescent unit Side to Side Axis Response

BIRNS, Inc. PR023710-14N
Lighting Units Models 4702, 4726, 4634 LED, 4634 Incandescent
Test# 11 Chugging Event Oct 29, 2013 15:59:33
Pulse: 1140 of 1140

Appendix B

Evaluation and Qualification Review

Forell/Elsesser Engineers, Inc.

FORELL/ELSESSER ENGINEERS, INC.
Structural Engineers

December 13, 2013

Thomas Heckler
BIRNS, Inc.
1720 Fiske Place
Oxnard, CA 93033-1863

Re: Seismic Qualification Report TR023710-14N Revision 2
Lighting Units 4702, 4726, and 4634

Dear Mr. Heckler -

Forell/Elsesser has reviewed test report TR023710-14N Revision 2 prepared by National Technical Systems (NTS) and dated December 13, 2013. This testing was performed for the seismic qualification of three BIRNS, Inc. lighting systems for the Taiwan Power Company (TPC) Lungmen Nuclear Power Project.

The test report meets the project requirements established by technical specification 63.1030S, Revision 2, prepared by General Electric for TPC and dated October, 2012. The specification references IEEE-344-1987, and we are satisfied that the testing has been conducted in accordance with the guidelines provided within this standard. The lighting units maintained their structural integrity and functionality during and after the testing.

Based on our review of the testing, the BIRNS, Inc. lighting units are seismically qualified for the Lungmen Nuclear Power Project.

Please feel free to contact me 415-837-0700 with any questions.

Sincerely,

FORELL/ELSESSER ENGINEERS, INC.

Marco Scanu, SE
Principal

Appendix C

Concrete and Gypsum Board Calculations

STRUCTURAL CALCULATIONS

Analysis of Mounting Methods
for BIRNS Emergency Lighting Unit

for

Birns
1720 Fiske Place
Oxnard, Ca 93033-1863

12.2.13

December 2, 2013
Job No. 13-07-20

Laima B. Reeder, P.E.
4048 Ocean Drive
Oxnard, Ca. 93035
(805) 985-1700

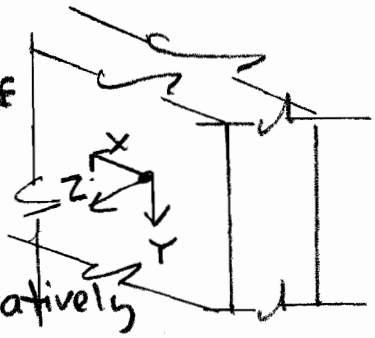
Table of Contents

WALL ANCHORAGE TO CONCRETE WALL

USE HILTI KB-TZ 3/8" ϕ W/ 2" EMBED
- HILTI PROFIS SOFTWARE
- ACI 349-01 DESIGN PROVISIONS B.3.6.3
- 4 CONNECTIONS PER LIGHT FIXTURE

WEIGHT = 39.05# USE 39#

LAMP IS A RIGID BODY THERFORE THE ZPA VALUE CAN BE USED.



ZPA OF RRS FOR SSE

H=1.6g , V=1.6g USE 2.0g conservatively

STATIC COEFFICIENT = 1.5

TENSION RATIO TO BE MULTIRIED BY 2

T_z= 39# x 2.0g x 1.5 x 2 / 4 = 59#

V_y= 39# x 2.0g x 1.5 / 4 = 29.3#

V_x= 39# x 2.0g x 1.5 / 4 = 29.3#

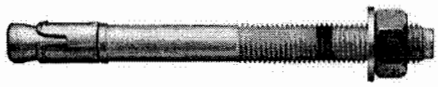
ZPA OF RRS FOR OBE

H=1.0g , V=0.8g THESE VALUES ARE LOWER THAN SSE. DESIGN TO BE BASED ON ZPA OF SSE

Company:	Laima B. Reeder, P.E.	Page:	1
Specifier:	Laima Reeder	Project:	Birns Lighting- ZPA SSE
Address:	4048 Ocean Drive, Oxnard, Ca 93035	Sub-Project I Pos. No.:	
Phone I Fax:	(805) 985-1700 |	Date:	12/2/2013
E-Mail:	reeder.lb@gmail.com		

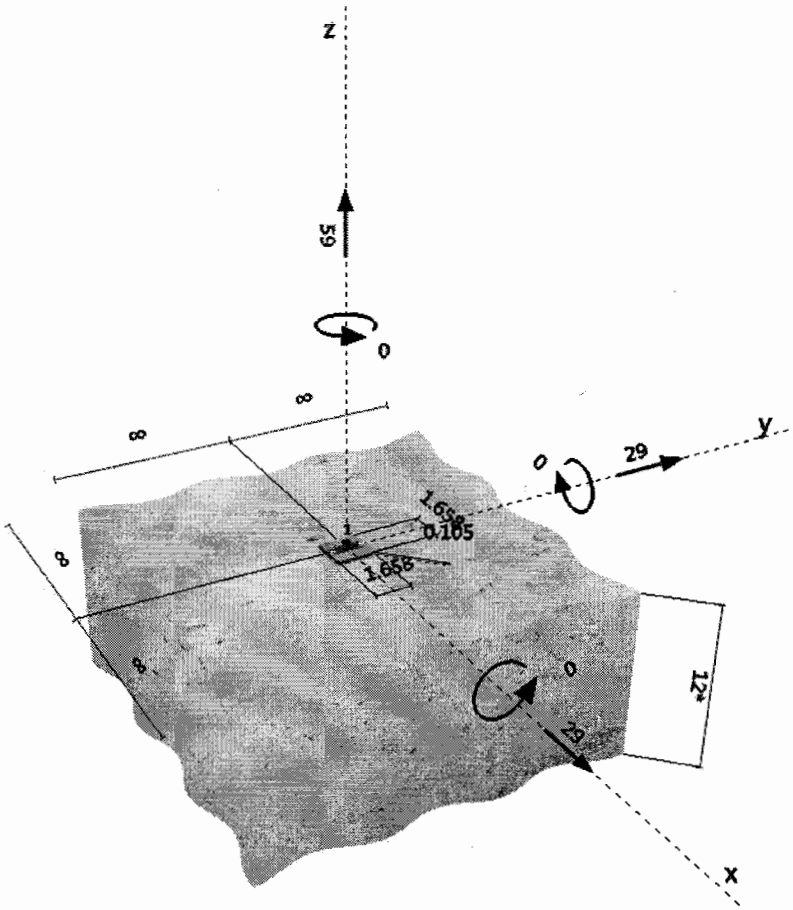
Specifier's comments:

1 Input data



Anchor type and diameter:	**Kwik Bolt TZ - CS 3/8 (2)**
Effective embedment depth:	h_{ef} = 2.000 in., h_{nom} = 2.313 in.
Material:	Carbon Steel
Technical Information:	Kwik Bolt TZ - CS Design Guide for ACI349-01, Appendix B
Issued I Valid:	- | -
Proof:	Design Provisions of ACI349-01, Appendix B
Stand-off installation:	e_b = 0.000 in. (no stand-off); t = 0.105 in.
Anchor plate:	l_x x l_y x t = 1.658 in. x 1.658 in. x 0.105 in.; (Recommended plate thickness: not calculated)
Profile:	Rectangular plates and bars (AISC); (L x W x T) = 0.250 in. x 1.000 in. x 0.000 in.
Base material:	cracked concrete, 4000, f_c' = 4000 psi; h = 12.000 in.
Reinforcement:	edge reinforcement: none or < No. 4 bar
Seismic loads (cat. C, D, E, or F)	yes
Anchor Design Option	B.3.6.3

Geometry [in.] & Loading [lb, in.lb]



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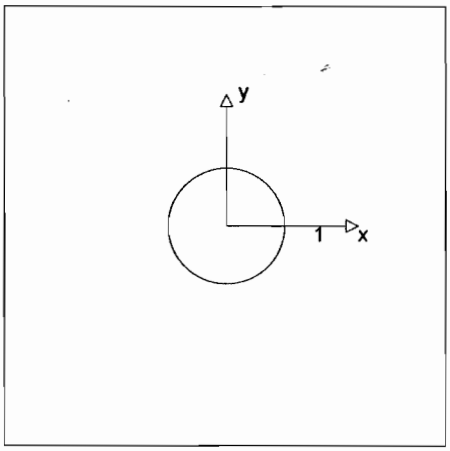
Specifier:	Laima Reeder	Project:	Birns Lighting- ZPA SSE
Address:	4048 Ocean Drive, Oxnard, Ca 93035	Sub-Project I Pos. No.:	
Phone I Fax:	(805) 985-1700 |	Date:	12/2/2013
E-Mail:	reeder.lb@gmail.com		

2 Load case/Resulting anchor forces

Load case: Design loads



Anchor reactions [lb]
Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	59	41	29	29

max. concrete compressive strain: - [‰]
max. concrete compressive stress: - [psi]
resulting tension force in (x/y)=(0.000/0.000): 59 [lb]
resulting compression force in (x/y)=(0.000/0.000): 0 [lb]

3 Tension load

	Load N_u [lb]	Capacity ϕN_n [lb]	Utilization $\beta_N = N_u/\phi N_n$	Status
Steel Strength*	59	5200	2	OK
Pullout Strength*	59	1021	6	OK
Concrete Breakout Strength**	59	1368	5	OK

* anchor having the highest loading **anchor group (anchors in tension)

3.1 Steel Strength

N_s = Design Guide value — refer to Kwik Bolt TZ - CS Design Guide
$\phi N_{steel} \geq N_u$ — ACI 349-01 Eq. (B-1)

Variables

n	A_{se} [in.^{2}]	f_{ut} [psi]
1	0.05	115000

Calculations

N_s [lb]
6500

Results

N_s [lb]	ϕ_{steel}	ϕN_s [lb]	N_u [lb]
6500	0.800	5200	59

3.2 Pullout Strength

$N_{pn} = N_{p,2500}$ — refer to Kwik Bolt TZ - CS Design Guide
$\phi N_{pn} \geq N_u$ — ACI 349-01 Eq. (B-1)

Variables

$N_{p,2500}$ [lb]
2270

Results

N_{pn} [lb]	$\phi_{concrete}$	$\phi_{nonductile}$	ϕN_{pn} [lb]	N_u [lb]
2270	0.750	0.600	1021	59

Company:	Laima B. Reeder, P.E.	Page:	3
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Address:	4048 Ocean Drive, Oxnard, Ca 93035	Sub-Project I Pos. No.:	
Phone I Fax:	(805) 985-1700 |	Date:	12/2/2013
E-Mail:	reeder.lb@gmail.com		

3.3 Concrete Breakout Strength

$N_{cb} = \left(\frac{A_N}{A_{N0}}\right) \psi_2 \psi_3 N_b$ ACI 349-01 Eq. (B-4a)

$\phi N_{cb} \geq N_u$ ACI 349-01 Eq. (B-1)

A_N see ACI 349-01R, Fig. RB.5.1

$A_{N0} = 9 h_{ef}^2$ ACI 349-01 Eq. (B-5)

$\psi_1 = \left(\frac{1}{1 + \frac{2 e'_N}{3 h_{ef}}}\right) \leq 1.0$ ACI 349-01 Eq. (B-7)

$\psi_2 = 0.7 + 0.3 \left(\frac{c_{min}}{1.5 h_{ef}}\right) \leq 1.0$ ACI 349-01 Eq. (B-8)

$N_b = k \sqrt{f'_c} h_{ef}^{1.5}$ ACI 349-01 Eq. (B-6a)

Variables

h_{ef} [in.]	$e_{1,N}$ [in.]	$e_{2,N}$ [in.]	c_{min} [in.]	ψ_3	k_{cr}	f'_c [psi]
2.000	0.000	0.000	∞	1.000	17	4000

Calculations

A_N [in.^{2}]	A_{N0} [in.^{2}]	$\psi_{1,1}$	$\psi_{1,2}$	ψ_2	N_b [lb]
36.00	36.00	1.000	1.000	1.000	3041

Results

N_{cb} [lb]	$\phi_{concrete}$	$\phi_{nonductile}$	ϕN_{cb} [lb]	N_u [lb]
3041	0.750	0.600	1368	59

Company:	Laima B. Reeder, P.E.	Page:	4
Specifier:	Laima Reeder	Project:	Birns Lighting- ZPA SSE
Address:	4048 Ocean Drive, Oxnard, Ca 93035	Sub-Project I Pos. No.:	
Phone I Fax:	(805) 985-1700 |	Date:	12/2/2013
E-Mail:	reeder.lb@gmail.com		

4 Shear load

	Load V_u [lb]	Capacity ϕV_n [lb]	Utilization $\beta_V = V_u/\phi V_n$	Status
Steel Strength*	41	1691	3	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength**	41	1368	3	OK
Concrete edge failure in direction **	N/A	N/A	N/A	N/A

* anchor having the highest loading **anchor group (relevant anchors)

4.1 Steel Strength

V_{seis} = Design Guide value refer to Kwik Bolt TZ - CS Design Guide

$\phi V_{steel} \geq V_u$ ACI 349-01 Eq. (B-2)

Variables

n	A_{se} [in.^{2}]	f_{ut} [psi]
1	0.05	115000

Calculations

V_s [lb]
2255

Results

V_s [lb]	ϕ_{steel}	ϕV_s [lb]	V_u [lb]
2255	0.750	1691	41

4.2 Pryout Strength

$V_{cp} = k_{cp}\left[\left(\frac{A_N}{A_{N0}}\right)\psi_2\,\psi_3\,N_b\right]$ ACI 349-01 Eq. (B-21)

$\phi V_{cp} \geq V_u$ ACI 349-01 Eq. (B-2)

A_N see ACI 349-01R, Fig. RB.5.1

$A_{N0} = 9\,h_{ef}^2$ ACI 349-01 Eq. (B-5)

$\psi_1 = \left(\frac{1}{1+\frac{2\,e_N'}{3\,h_{ef}}}\right) \leq 1.0$ ACI 349-01 Eq. (B-7)

$\psi_2 = 0.7 + 0.3\left(\frac{c_{min}}{1.5h_{ef}}\right) \leq 1.0$ ACI 349-01 Eq. (B-8)

$N_b = k\sqrt{f_c'}\,h_{ef}^{1.5}$ ACI 349-01 Eq. (B-6a)

Variables

k_{cp}	h_{ef} [in.]	$e_{1,N}$ [in.]	$e_{2,N}$ [in.]
1	2.000	0.000	0.000

c_{min} [in.]	ψ_3	k_{cr}	f_c' [psi]
∞	1.000	17	4000

Calculations

A_N [in.^{2}]	A_{N0} [in.^{2}]	$\psi_{1,1}$	$\psi_{1,2}$	ψ_2	N_b [lb]
36.00	36.00	1.000	1.000	1.000	3041

Results

V_{cp} [lb]	$\phi_{concrete}$	$\phi_{nonductile}$	ϕV_{cp} [lb]	V_u [lb]
3041	0.750	0.600	1368	41

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Phone I Fax:	(805) 985-1700 |	Date:	12/2/2013
E-Mail:	reeder.lb@gmail.com		

5 Combined tension and shear loads

β_N	β_V	ζ	Utilization $\beta_{N,V}$ [%]	Status
0.058	0.030	5/3	2	OK

$\beta_{NV} = \beta_N^{\zeta} + \beta_V^{\zeta} <= 1$

6 Warnings

- To avoid failure of the anchor plate the required thickness can be calculated in PROFIS Anchor. Load re-distributions on the anchors due to elastic deformations of the anchor plate are not considered. The anchor plate is assumed to be sufficiently stiff, in order not to be deformed when subjected to the loading!
- Checking the transfer of loads into the base material and the shear resistance are required in accordance with ACI349-01 or the relevant standard!
- ACI 349-01, Appendix B, Part B.3.6.1 requires the governing design strength of an anchor or group of anchors to be limited by ductile steel failure. If this is NOT the case, Part B.3.6.2 requires the attachment to be designed to undergo ductile yielding at a load level corresponding to anchor forces not greater than 75% of the controlling design strength. In lieu of B.3.6.1 and B.3.6.2, the minimum design strength of the anchors shall be multiplied by a reduction factor ($\phi_{nonductile}$) per B.3.6.3
- Pryout Strength can control the shear design if edge distances are large. When checking the Design Shear Strength per B.3.6.1, the Design Concrete Breakout Strength and the Design Pryout Strength will be multiplied by a factor 0.85 and compared to 0.65 N_s
- Please note that this PROFIS software is not produced or supplied under Hilti's 10CFR50, Appendix B compliant Nuclear Quality Program

Fastening meets the design criteria!

Company:	Laima B. Reeder, P.E.	Page:	6
Specifier:	Laima Reeder	Project:	Birns Lighting- ZPA SSE
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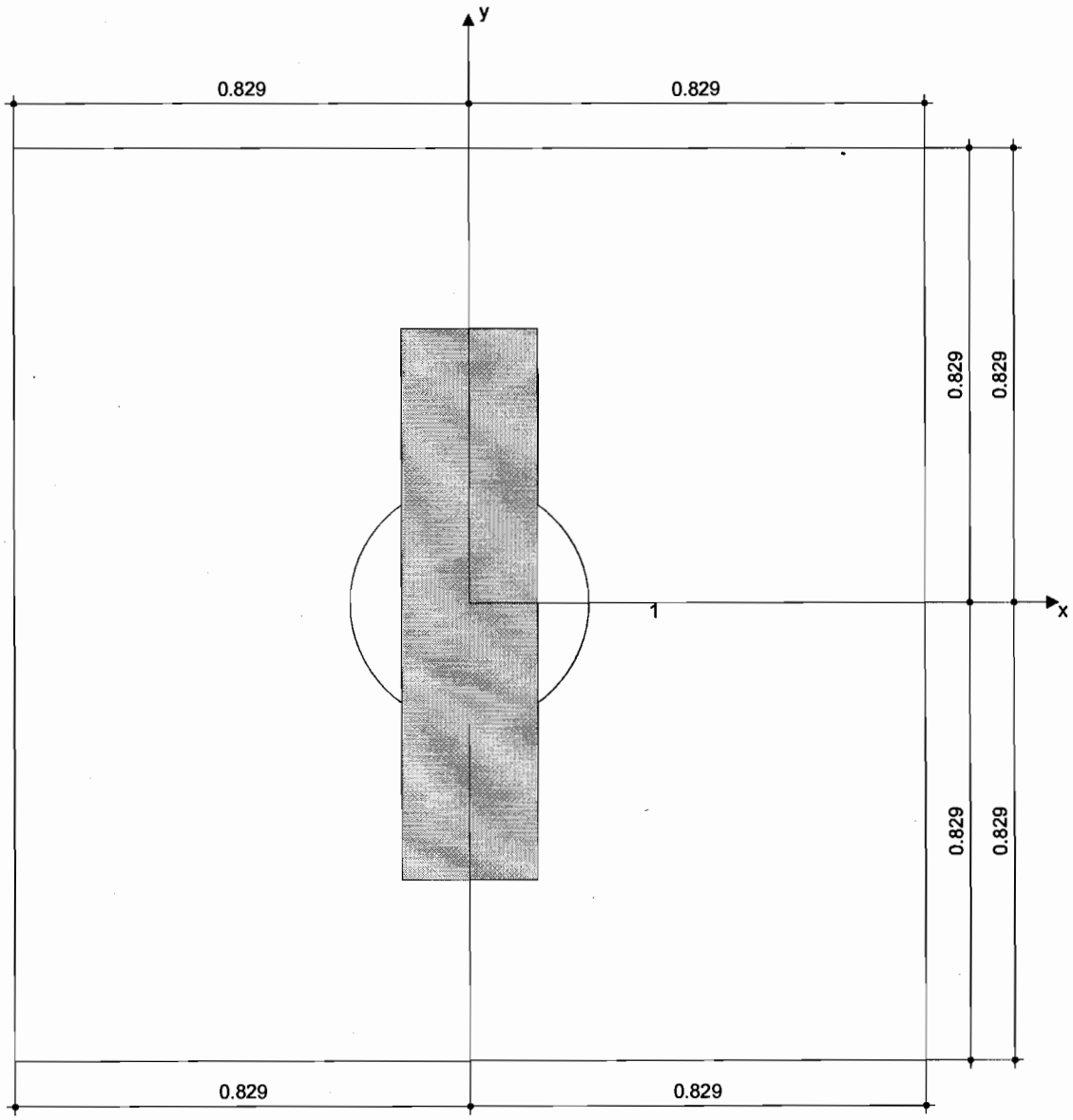
Phone I Fax:	(805) 985-1700 |	Date:	12/2/2013
E-Mail:	reeder.lb@gmail.com		

7 Installation data

Anchor plate, steel: -
Profile: Rectangular plates and bars (AISC); 0.250 x 1.000 x 0.000 in.
Hole diameter in the fixture: d_f = 0.438 in.
Plate thickness (input): 0.105 in.
Recommended plate thickness: not calculated
Cleaning: Manual cleaning of the drilled hole according to instructions for use is required.

Anchor type and diameter: Kwik Bolt TZ - CS, 3/8 (2)
Installation torque: 300.000 in.lb
Hole diameter in the base material: 0.375 in.
Hole depth in the base material: 2.625 in.
Minimum thickness of the base material: 5.000 in.



Coordinates Anchor in.

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	0.000	0.000	-	-	-	-

Company:	Laima B. Reeder, P.E.	Page:	7
Specifier:	Laima Reeder	Project:	Birns Lighting- ZPA SSE
Address:	4048 Ocean Drive, Oxnard, Ca 93035	Sub-Project I Pos. No.:	
Phone I Fax:	(805) 985-1700 |	Date:	12/2/2013
E-Mail:	reeder.lb@gmail.com		

8 Remarks; Your Cooperation Duties

- Any and all information and data contained in the Software concern solely the use of Hilti products and are based on the principles, formulas and security regulations in accordance with Hilti's technical directions and operating, mounting and assembly instructions, etc., that must be strictly complied with by the user. All figures contained therein are average figures, and therefore use-specific tests are to be conducted prior to using the relevant Hilti product. The results of the calculations carried out by means of the Software are based essentially on the data you put in. Therefore, you bear the sole responsibility for the absence of errors, the completeness and the relevance of the data to be put in by you. Moreover, you bear sole responsibility for having the results of the calculation checked and cleared by an expert, particularly with regard to compliance with applicable norms and permits, prior to using them for your specific facility. The Software serves only as an aid to interpret norms and permits without any guarantee as to the absence of errors, the correctness and the relevance of the results or suitability for a specific application.
- You must take all necessary and reasonable steps to prevent or limit damage caused by the Software. In particular, you must arrange for the regular backup of programs and data and, if applicable, carry out the updates of the Software offered by Hilti on a regular basis. If you do not use the AutoUpdate function of the Software, you must ensure that you are using the current and thus up-to-date version of the Software in each case by carrying out manual updates via the Hilti Website. Hilti will not be liable for consequences, such as the recovery of lost or damaged data or programs, arising from a culpable breach of duty by you.

Emergency Light Fixture
Job No. 13-07-20

WALL ANCHORAGE TO GYPBOARD

USE HILTI HTB TOGGLER BOLT 3.3.16

4 CONNECTIONS PER LIGHT FIXTURE
WEIGHT= 39.05# USE 39#
LAMP IS A RIGID BODY THEREFORE
THE ZPA VALUE CAN BE USED

ZPA OF RRS FOR SSE
H= 1.0g V= 1.0g USE 2.0g CONSERVATIVELY
STATIC COEFFICIENT = 1.5

$T = 2.0g \times 39\# \times 1.5/4_{ANCHORS} = \underline{29.3\#}$

ZPA OF RRS FOR OBE IS LOWER USE SSE.

3/8" TOGGLER BOLT - TENSION
1/2" DRYWALL= 35# > 29.3# O.K.
5/8" DRYWALL= 50# > 29.3# O.K.

$V = 2.0g \times 39\# \times 1.5/4_{ANCHORS} = 29.3\#$

3/8" TOGGLER BOLT - SHEAR
1/2" DRYWALL= 70# > 29.3# O.K.
5/8" DRYWALL= 105# > 29.3# O.K.

USE 4 - HILTI 3/8"ϕ TOGGLER BOLT PER LIGHT.

HTB TOGGLER® Bolt 3.3.16

3.3.16.1 Product Description

The Hilti HTB TOGGLER® Bolt fastening system consists of a metal channel threaded to accept a machine bolt, and unique plastic legs and locking cap for fastening in a wide range of hollow-wall materials.

Product Features

- Unique installation legs and locking cap facilitate fastening in wide range of drywall and hollow wall materials up to 2-1/4" thick
- One piece metal channel provides greater holding power
- Plastic pull ring assists in setting lock cap
- Anchor is adjustable for various base material thicknesses providing easier installation as well as minimizing inventory investment
- Remains mounted in the wall without screw for convenient handling, installation and reuse
- Available in stainless steel and carbon steel for different environments
- Comprehensive offering with and without machine screws

3/16" & 1/4" 3/8" & 1/2"

3.3.16.2 Material Specifications

Zinc plated metal channel material meets the requirements for AISI 1010 steel

3.3.16.3 Technical Data

HTB TOGGLER® Bolt Allowable Loads[1]

Toggler Bolt Size in.	Hole Dia. in.	1/2" Drywall		5/8" Drywall		Hollow Concrete Block	
		Tension lb (N)	Shear lb (N)	Tension lb (N)	Shear lb (N)	Tension lb (N)	Shear lb (N)
3/16	1/2	30 (133)	70 (311)	45 (200)	95 (423)	140 (623)	160 (712)
1/4	1/2	35 (155)	85 (378)	50 (222)	105 (467)	160 (712)	240 (1068)
3/8	3/4	35 (155)	70 (311)	50 (222)	105 (467)	200 (890)	380 (1690)
1/2	3/4	35 (155)	85 (378)	50 (222)	110 (489)	240 (1068)	420 (1868)

1 Based on using a safety factor of 4.0.

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3.3.16.4 Installation Instructions

Installation Instructions For Use (IFU) are included with each product package. They can also be viewed or downloaded on-line at www.us.hilti.com (US) and www.hilti.ca (Canada) -- "Service/Technical Info >> Technical Downloads >> Anchoring Systems". Because of the possibility of changes, always verify that downloaded IFU are current when used. Proper installation is critical to achieve full performance. Training is available on request. Contact Hilti Technical Services for applications and conditions not addressed in the IFU.

3.3.16.5 Ordering Information

Description	Machine Screw Dia. (In.)	Machine Screw Length (In.)	Bit Dia. (in.)[1]	Box Qty
HTB TOGGLER® Bolt 3/16" with SRH screw[1]	3/16	2-1/2	1/2	100
HTB TOGGLER® Bolt 3/16" with PFH screw[2]	3/16	2-1/2	1/2	100
HTB TOGGLER® Bolt 3/16" w/o screw[3]	3/16	–	1/2	100
HTB TOGGLER® Bolt 1/4" with SRH screw[1]	1/4	2-1/2	1/2	100
HTB TOGGLER® Bolt 1/4" with PFH screw[2]	1/4	2-1/2	1/2	100
HTB TOGGLER® Bolt 1/4" w/o screw[3]	1/4	–	1/2	100
HTB TOGGLER® Bolt 3/8" with SRH screw[1]	3/8	2-1/2	3/4	25
HTB TOGGLER® Bolt 3/8" w/o screw[3]	3/8	–	3/4	25
HTB TOGGLER® Bolt 1/2" with SRH screw[1]	1/2	2-1/2	3/4	25
HTB TOGGLER® Bolt 1/2" w/o screw[3]	1/2	–	3/4	25

1 Round Head (Combination Slotted/Phillips)

2 Phillips Flat Head

3 Machine screws not included

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