



1049 Triad Court
Marietta, Georgia 30062

(770) 423-1400
Fax # (770) 424-6415

VIBRATION QUALIFICATION TESTING

Prepared for

OPTIMA EPS
1775 MCLEOD DRIVE
LAWRENCEVILLE, GA 30043

Prepared by _____
Mike Reid, Materials Testing

Reviewed by _____
David Common, Materials Testing

This report may not be reproduced except in full without the written approval of ATS.

This report represents interpretation of the results obtained from the test specimen and is not to be construed as a guarantee or warranty of the condition of the entire material lot. If the method used is a customer provided, non-standard test method, ATS does not assume responsibility for validation of the method.

*Professional Engineers and Scientists
Design • Consulting • Testing and Inspection*

*Members in AAFS, ACS, ANSI, ASM, ASME, ASNT, ASQ, ASTM, AWS, BOMA, FSCT, IAAI, IWCA, NACE, NCSL, NFPA, SAFS, TAPPI
GEORGIA SOCIETY OF PROFESSIONAL ENGINEERS, NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS*

*In the state of North Carolina, Engineering Services will be provided by ATS Engineering, PLLC or a properly licensed subcontractor
In the state of New York, Engineering Services will be provided by Neville W. Sachs, P.E., PLLC or a properly licensed subcontractor*



MATERIALS TEST REPORT

Ref. D201449

Date: October 01, 2013

Page 1 of 15

Subject

Vibration testing on an equipment shelf system

Materials

One (1) shelf

Objective and Background

Applied Technical Services, Inc. was requested by Optima EPS to apply the following requirements to the supplied shelf system:

- AREMA C&S Manual, Part 11.5.1, Section D.4 (Vibration) and D.5 (Shock), Class I
- Profile from IEC 61373-1999, Category 1, Class B (Vibration and Shock)

Test Procedure

The sample was bolted to an electrodynamic shaker table as illustrated in Figures 1-3.

- AREMA C&S Manual, Part 11.5.1, Section D.4 (Vibration) and D.5 (Shock), Class I

AREMA® C&S Manual
Part 11.5.1 **2009**
Table 1151-1 (Continued)

Parameter	Condition	Class F (Vehicle Exterior Axle Mounted)	Class G (Vehicle Exterior Truck Mounted)	Class H (Vehicle Exterior Platform Mounted)	Class I (Vehicle Interior Platform Mounted)	Class J (Vehicle Interior Cab)
Temperature	Operating Minimum	-40F (-40C)	-40F (-40C)	-40F (-40C)	-40F (-40C)	-13F (-25C)
	Maximum	+158F (+70C)	+158F (+70C)	+158F (+70C)	+158F (+70C)	+158F (+70C)
Storage	Minimum	-87F (-55C)	-87F (-55C)	-87F (-55C)	-87F (-55C)	-87F (-55C)
	Maximum	+185F (+85C)	+185F (+85C)	+185F (+85C)	+185F (+85C)	+185F (+85C)
Relative Humidity (%) Non-condensing	Operating	0	0	0	0	40
	Minimum	95	95	95	95	45
	Storage	0	0	0	0	5
	Maximum	95	95	95	95	95
Vibration	5-10 Hz	---	---	0.5" p-p	0.3" p-p	0.2" p-p
	10-200 Hz	---	---	2.5 g p	1.5 g p	1.0 g p
	200 - 1000 Hz	---	---	2.5 g p	---	---
	5-20 Hz	0.9" p-p	0.5" p-p	---	---	---
Mechanical Shock (11ms)	Shipping	10 g p	10 g p	10 g p	10 g p	10 g p
	Operating	100 g p	20 g p	10 g p	10 g p	5 g p
EMI (µV/m)	50 kHz-88 MHz	---	---	150	150	150
	88-216 MHz	---	---	250	250	250
	216-1000 MHz	---	---	350	350	350
Dielectric Strength	Volts RMS	3000	3000	3000 2000	3000 2000	2000
Abrasive Environment	Salt, rain, sand, hail, dust, contaminants	Yes	Yes	Yes	Yes	No



MATERIALS TEST REPORT

Ref. D201449

Date: October 01, 2013

Page 2 of 15

1. Sinusoidal vibration

The sinusoidal vibration profiles shown in Figures 4-6 were applied to the unit along each mutually perpendicular axes (Longitudinal, Transverse, Vertical) for a duration of 1 hour/axis.

The following breakpoints were implemented:

5Hz-10Hz: 0.3" peak to peak displacement

10Hz-200Hz: 1.5G peak acceleration

2. Shock

A 10G peak, 11ms pulse width, terminal sawtooth waveform was applied along each direction.

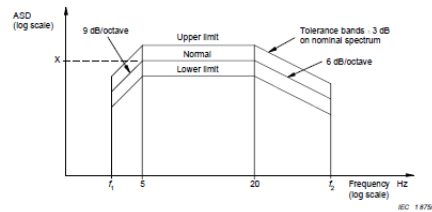
Figure 7 shows the corresponding acceleration time history.

The structural integrity of the assembly submitted for testing by Optima EPS remained intact upon completion of the AREMA C&S test, Part 11.5.1, Sections D.4 and D.5.

- Profiles from IEC 61373-1999, Category 1, Class B

61373 © IEC:1999

- 37 -



when mass	<500 kg:	$f_1 = 5 \text{ Hz}$	$f_2 = 150 \text{ Hz}$
when mass	>500 kg < 1 250 kg:	$f_1 = \frac{1\,250}{\text{mass}} \times 2 \text{ Hz}$	$f_2 = \frac{1\,250}{\text{mass}} \times 80 \text{ Hz}$
when mass	>1 250 kg:	$f_1 = 2 \text{ Hz}$	$f_2 = 80 \text{ Hz}$

	Vertical	Transverse	Longitudinal
Functional test ASD level (m/s ²) ² /Hz	0,0298	0,0060	0,0144
RMS value m/s ² 5 Hz to 150 Hz	1,00	0,45	0,70
Long life test ASD level (m/s ²) ² /Hz	1,857	0,366	0,901
RMS value m/s ² 5 Hz to 150 Hz	7,9	3,5	5,5

NOTE 1 - For items with test frequencies less than 5 Hz the r.m.s. levels will be higher than those quoted above.
 NOTE 2 - For items with test frequencies less than 150 Hz the r.m.s. levels will be lower than those quoted above.
 NOTE 3 - If frequencies above f_2 are known to exist they may be included, the amplitude being established by extending the 6 dB/octave decay line until it intersects the maximum frequency required. In such cases the r.m.s. levels will be increased.

Figure 2 - Category 1 - Class B - Body-mounted - ASD spectrum

Table 3 - Test severity, pulse shape and direction

Category	Orientation	Peak acceleration A, m/s ²	Nominal duration τ, ms
1	Vertical	30	30
Class A and class B	Transverse	30	30
	Longitudinal	50	30
2	Bogie mounted	All	18
3	Axle mounted	All	6

NOTE - See figure 6 for pulse shape details.



MATERIALS TEST REPORT

Ref. D201449 **Date:** October 01, 2013 **Page** 3 **of** 15

1. Random vibration

The random vibration profiles shown in Figures 8-10 were applied to the unit along each mutually perpendicular axes (Longitudinal, Transverse, Vertical) for a duration of 5 hours/axis (Long Life test).

2. Shock

With the assembly oriented along the transverse and vertical axes, Three (3) 3G peak, 30ms pulse width, ½-sine waveform shocks were applied along each direction. Figure 11 shows the corresponding acceleration time history.

The longitudinal axes was subjected to Three (3) 5G peak, 30ms pulse width, ½-sine waveform shocks (see Figure 12)

The structural integrity of the assembly submitted for testing by Optima EPS remained intact upon completion of the random vibration profiles and mechanical shock severities from IEC 61373-1999, Category 1, Class B.

Equipment used

Shaker: ATS-01343, Calibration due date: 11/20/2013

Accelerometer: ATS-1716 K, Calibration due date: 01/09/2014

Accelerometer: ATS-1716 S, Calibration due date: 01/09/2014



MATERIALS TEST REPORT

Ref. D201449

Date: October 01, 2013

Page 4

of

15



Figure 1: View of the test setup – Longitudinal Direction



MATERIALS TEST REPORT

Ref. D201449

Date: October 01, 2013

Page 5

of

15



Figure 2: View of the test setup – Transverse Direction



MATERIALS TEST REPORT

Ref. D201449

Date: October 01, 2013

Page 6

of

15



Figure 3: View of the test setup – Vertical Direction



MATERIALS TEST REPORT

Ref. D201449

Date: October 01, 2013

Page 7

of

15



Figure 4: AREMA profile – Sinusoidal vibration – Longitudinal Direction



MATERIALS TEST REPORT

Ref. D201449

Date: October 01, 2013

Page 8

of

15



Figure 5: AREMA profile – Sinusoidal vibration – Transverse Direction



MATERIALS TEST REPORT

Ref. D201449

Date: October 01, 2013

Page 9

of

15



Figure 6: AREMA profile – Sinusoidal vibration – Vertical Direction



MATERIALS TEST REPORT

Ref. D201449

Date: October 01, 2013

Page 10 of 15

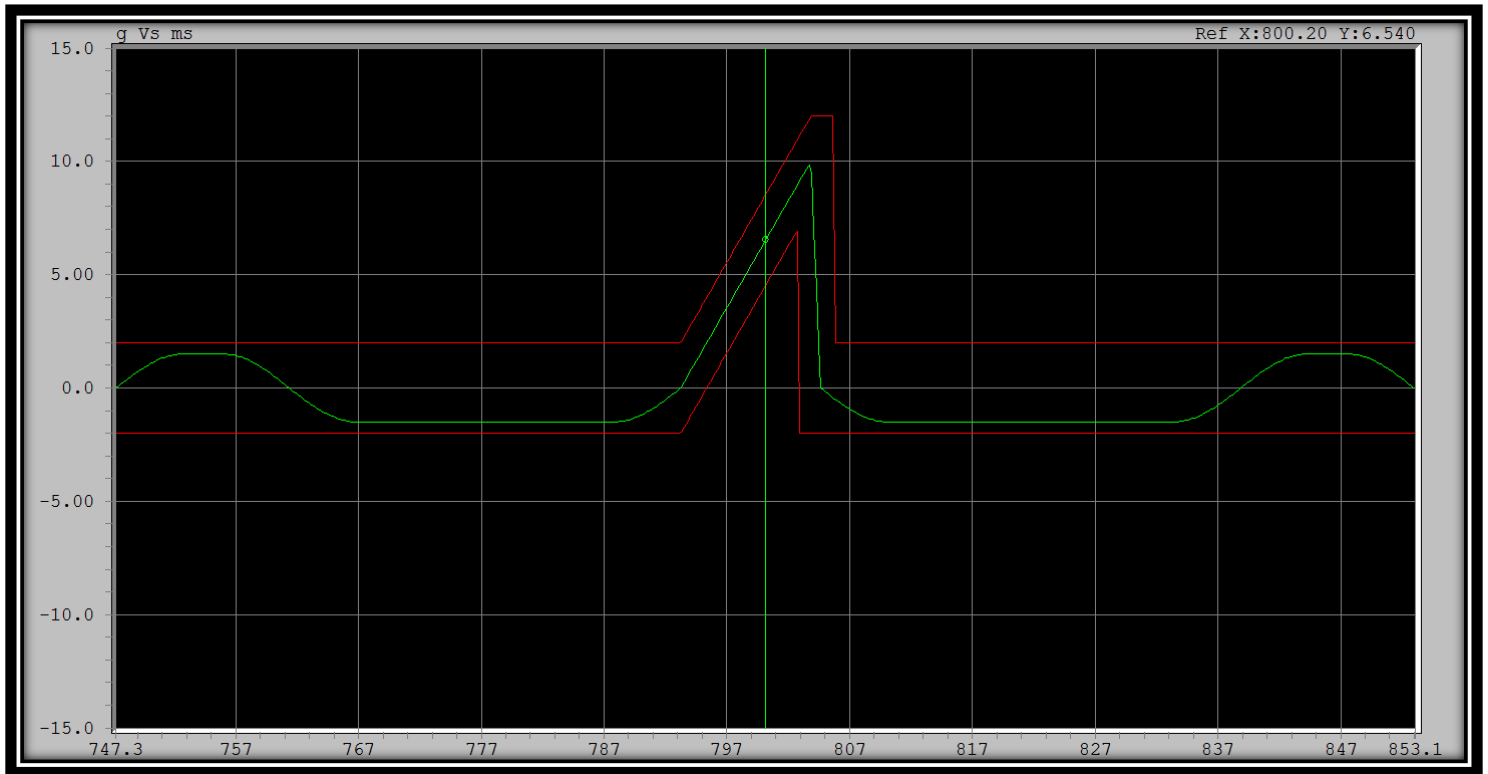


Figure 7: AREMA – 10G, 11ms, Terminal Sawtooth



MATERIALS TEST REPORT

Ref. D201449

Date: October 01, 2013

Page 11 of 15

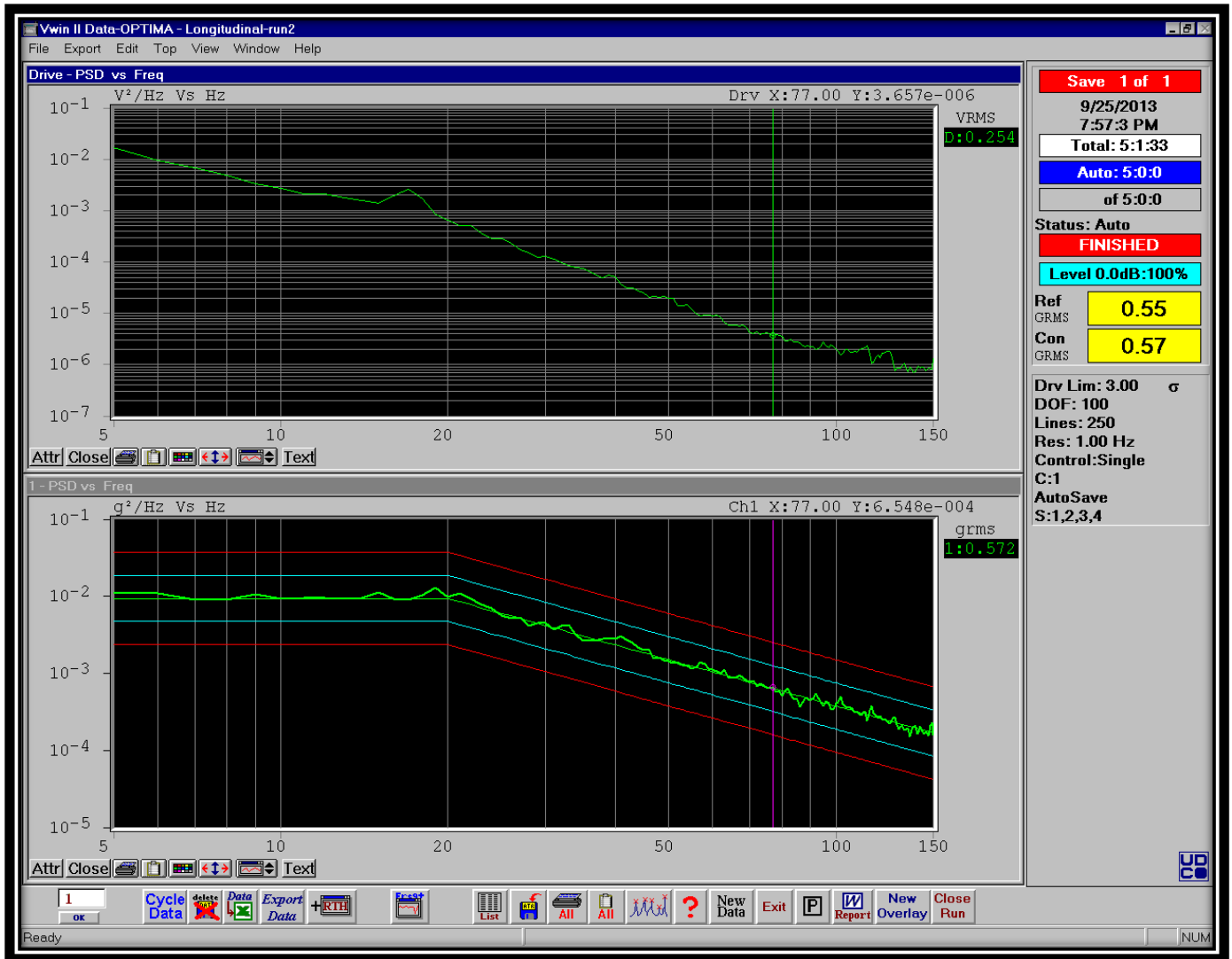


Figure 8: IEC profile – Random vibration – Longitudinal Direction



MATERIALS TEST REPORT

Ref. D201449

Date: October 01, 2013

Page 12 of 15

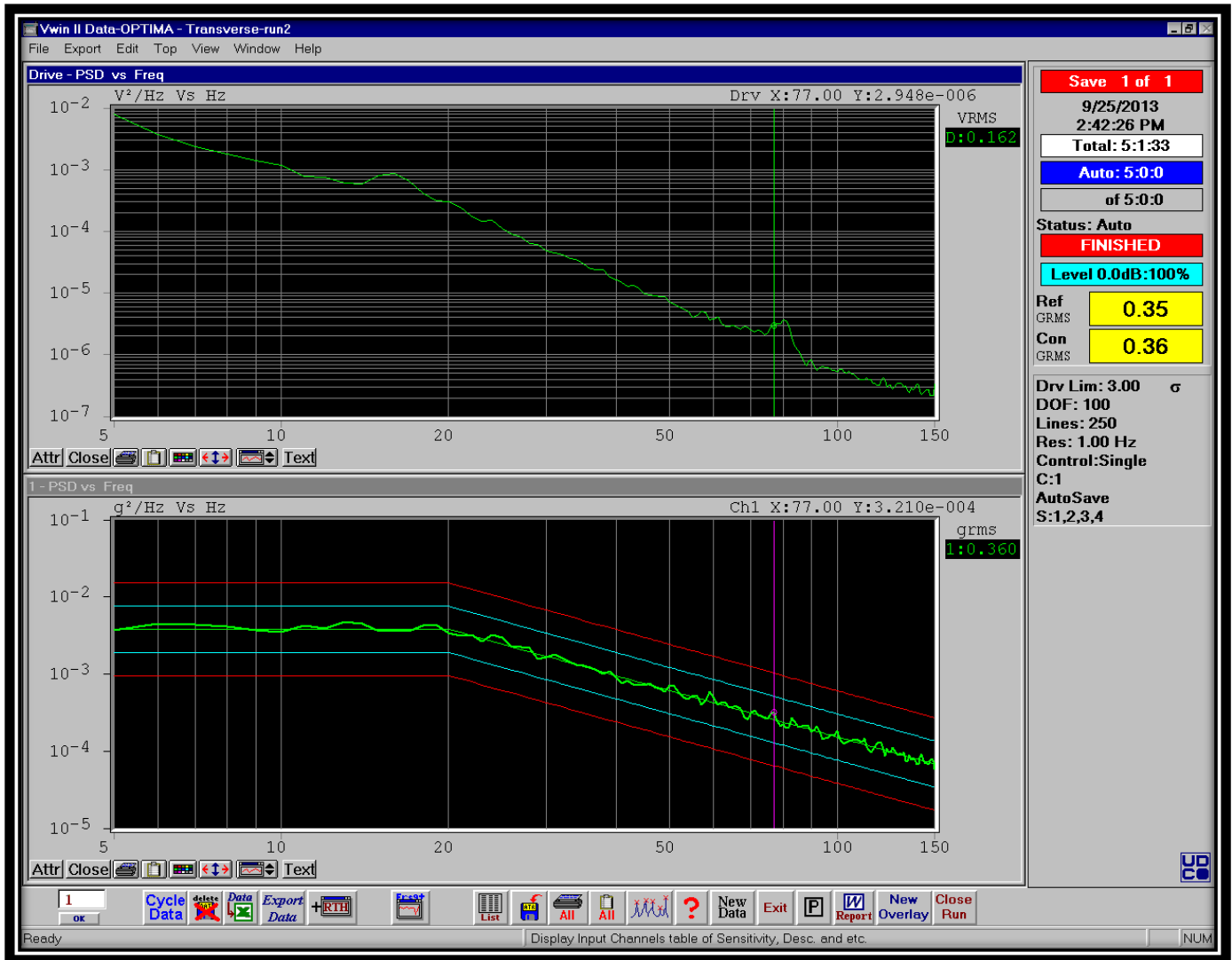


Figure 9: IEC profile – Random vibration – Transverse Direction



MATERIALS TEST REPORT

Ref. D201449

Date: October 01, 2013

Page 13 of 15

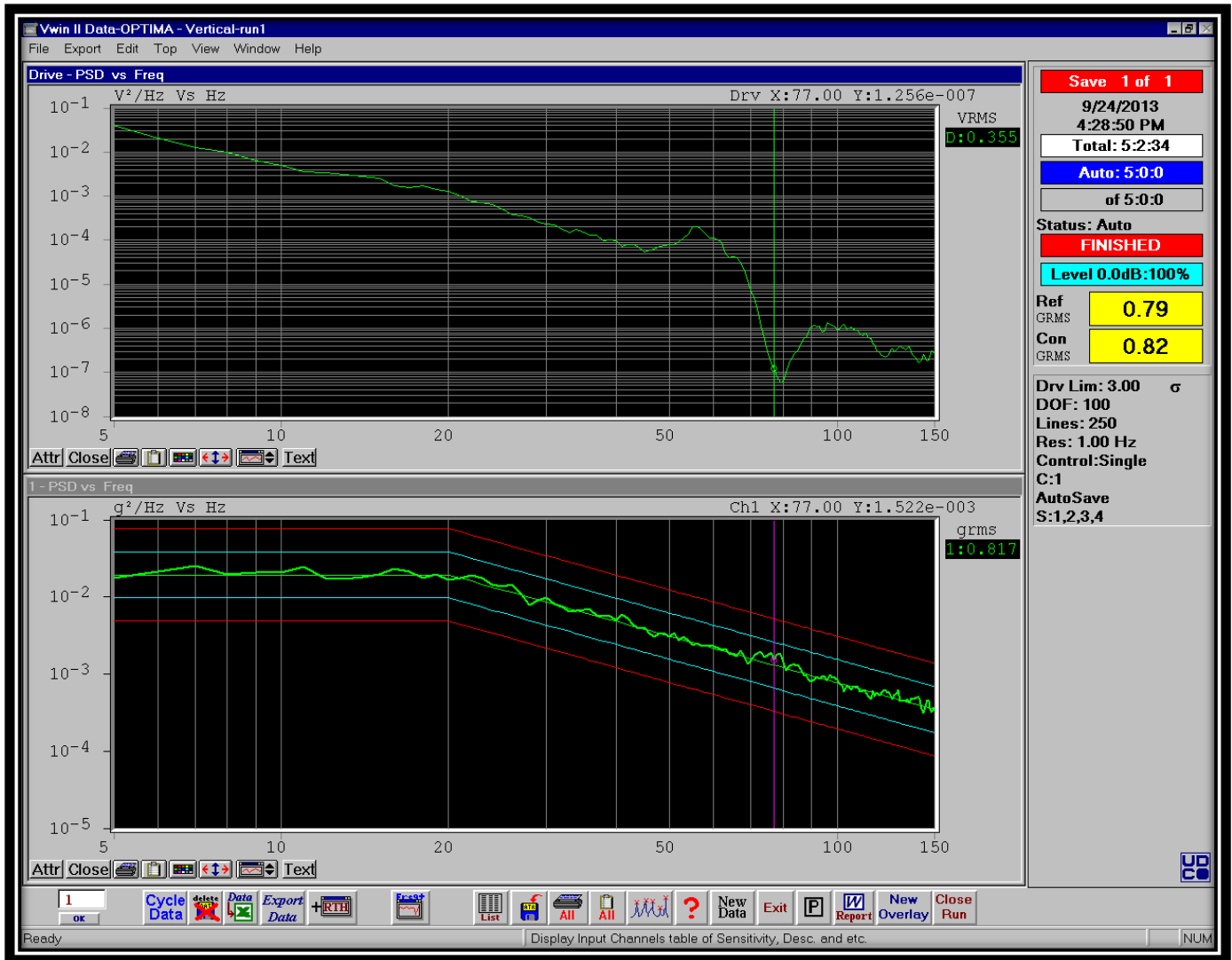


Figure 10: IEC profile – Random vibration – Vertical Direction



MATERIALS TEST REPORT

Ref. D201449

Date: October 01, 2013

Page 14 of 15

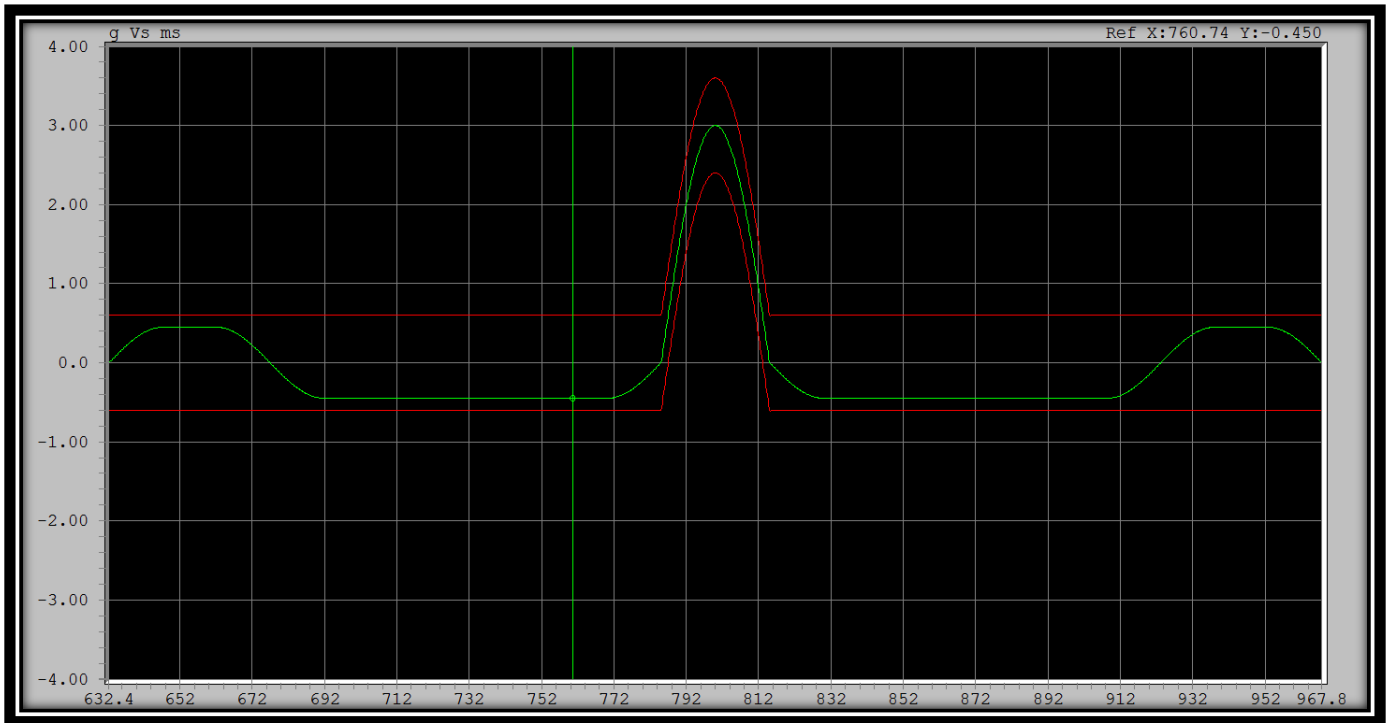


Figure 11: IEC – 3G, 30ms, 1/2-Sine



MATERIALS TEST REPORT

Ref. D201449

Date: October 01, 2013

Page 15 of 15

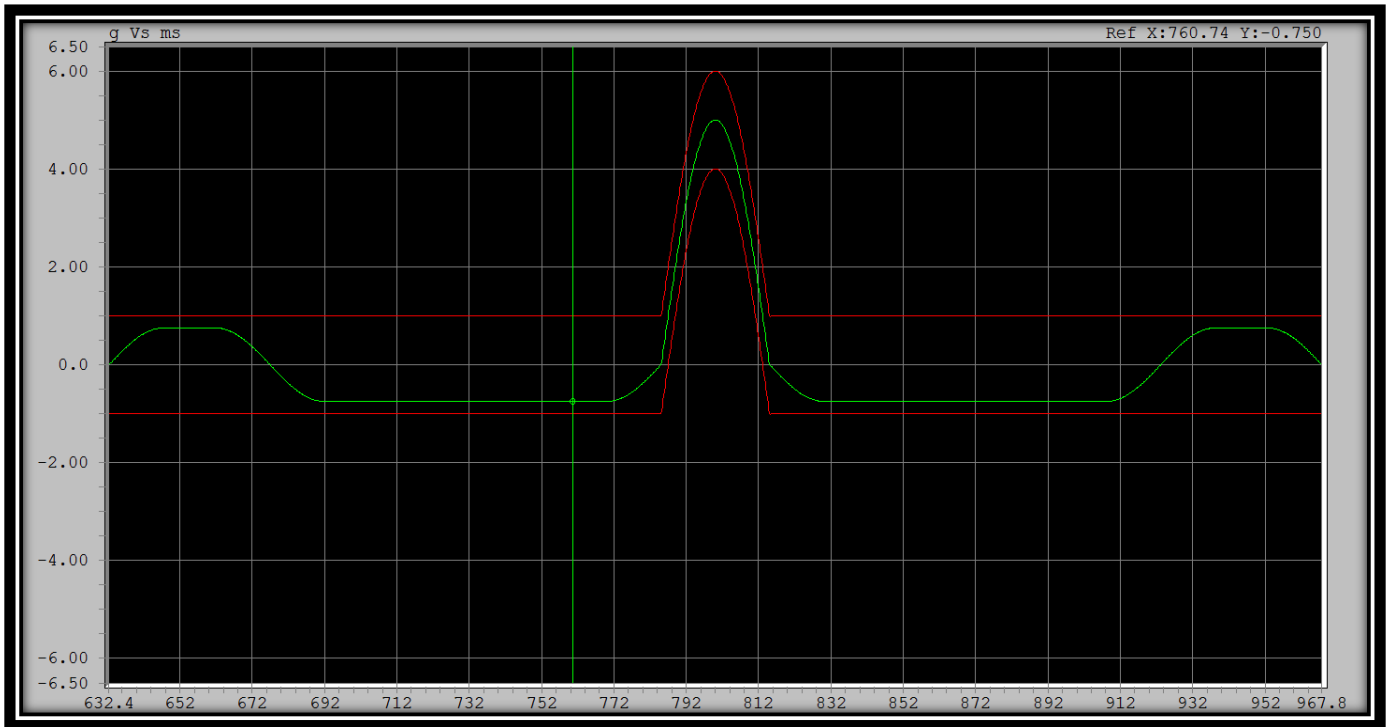


Figure 12: IEC – 5G, 30ms, 1/2-Sine