

Report Details

Products tested	VCCR300-xx
Products Description	300W DC-DC power supply.
Design Phase	3 – Verification
Product Serials	P/N: VCCR300-24, S/N: 2328CXX0001 P/N: VCCR300-36, S/N: 2328CXX0002
Test Goals	Test according to: MIL-STD-810G: Method 514.6, Procedure I (General Vibration) Category 4 (Trucks & Trailers, Composite wheeled vehicle), Figure 514.6C-3, Non-Operational MIL-STD-810G: Method 514.6, Procedure I (General Vibration) Category 7 (Aircraft, Jet cargo), Figure 514.6C-5 General exposure, Non-Operational MIL-STD-810G: Method 514.6, Procedure I (General Vibration) Category 24, (All, Minimum integrity) Figure 514.6E-1, Non-Operational IEC60068-2-6: Sine, 10 – 500 Hz, 3 axes, 1 oct/min., 10 cycles each axis, Operational IEC60068-2-64: Random, 5 – 500 Hz, 3 axes, 30 min, Operational & Non-Operational IEC60068-2-27: Half sine, 3 axes, 3 positive & 3 negative, 30 min, Operational & Non-Operational
Test dates	13 th July to 9 th August 2023
Report date	14 th August 2023

Authorisation

Jorge Almendros

14/8/23

Test performed by (Print)

Date

Brian McDonald

14/8/23

Test report written by (Print)

Date

1. Objective

Vibration and Shock testing is part of the test requirements to comply with MIL-STD-810G & IEC60068-2 standards. The objective of this report is to show compliance with the requirements of the following tests.

- MIL-STD-810G: Method 514.6, Procedure I (General Vibration) Category 4 (Trucks & Trailers, Composite wheeled vehicle), Figure 514.6C-3, Non-Operational.
- MIL-STD-810G: Method 514.6, Procedure I (General Vibration) Category 7 (Aircraft, Jet cargo), Figure 514.6C-5 General exposure, Non-Operational.
- MIL-STD-810G: Method 514.6, Procedure I (General Vibration) Category 24, (All, Minimum integrity) Figure 514.6E-1, Non-Operational.
- IEC60068-2-6: Sine, 10 – 500 Hz, 3 axes, 1 oct/min., 10 cycles each axis, Operational.
- IEC60068-2-64: Random, 5 – 500 Hz, 3 axes, 30 min, Operational & Non-Operational.
- IEC60068-2-27: Half sine, 3 axes, 3 positive & 3 negative, 30 min, Operational & Non-Operational.

2. Executive summary

Performance tests were carried out on a number of product samples at the Vox Power R&D laboratory and the results recorded. The units were then shipped to a specialist external laboratory to perform the vibration and shock test according to the relevant MIL-STD-810G and IEC60068 standards. The samples were then returned to the Vox Power R&D laboratory and the performance tests were repeated and compared with the original results. A visual inspection was also carried out to ensure no mechanical damage had occurred during testing.

The details of the performance tests before and after testing are shown in appendix 1.

The details of the visual inspection are shown in appendix 2.

The details of the vibration and shock testing are shown in appendix 3.

3. Conclusions

The performance test results for the tested samples before and after the vibration and shock test show no variation in performance.

The visual inspection shows no issues for the VCCR300-24 with S/N 2328CXX0001

The visual inspection shows the following issue in VCCR300-36 with S/N 2328CXX0002,

- Capacitors C15 and C16 leads broke. The issue resulted in the parts being loose inside of the unit potentially causing the voltage drops observed in Figure 48 of Appendix 3. The same issue was not observed in the 24V unit. An analysis showed that the coating in the 24V unit had bonded C15 and C16 together giving them increased stability.

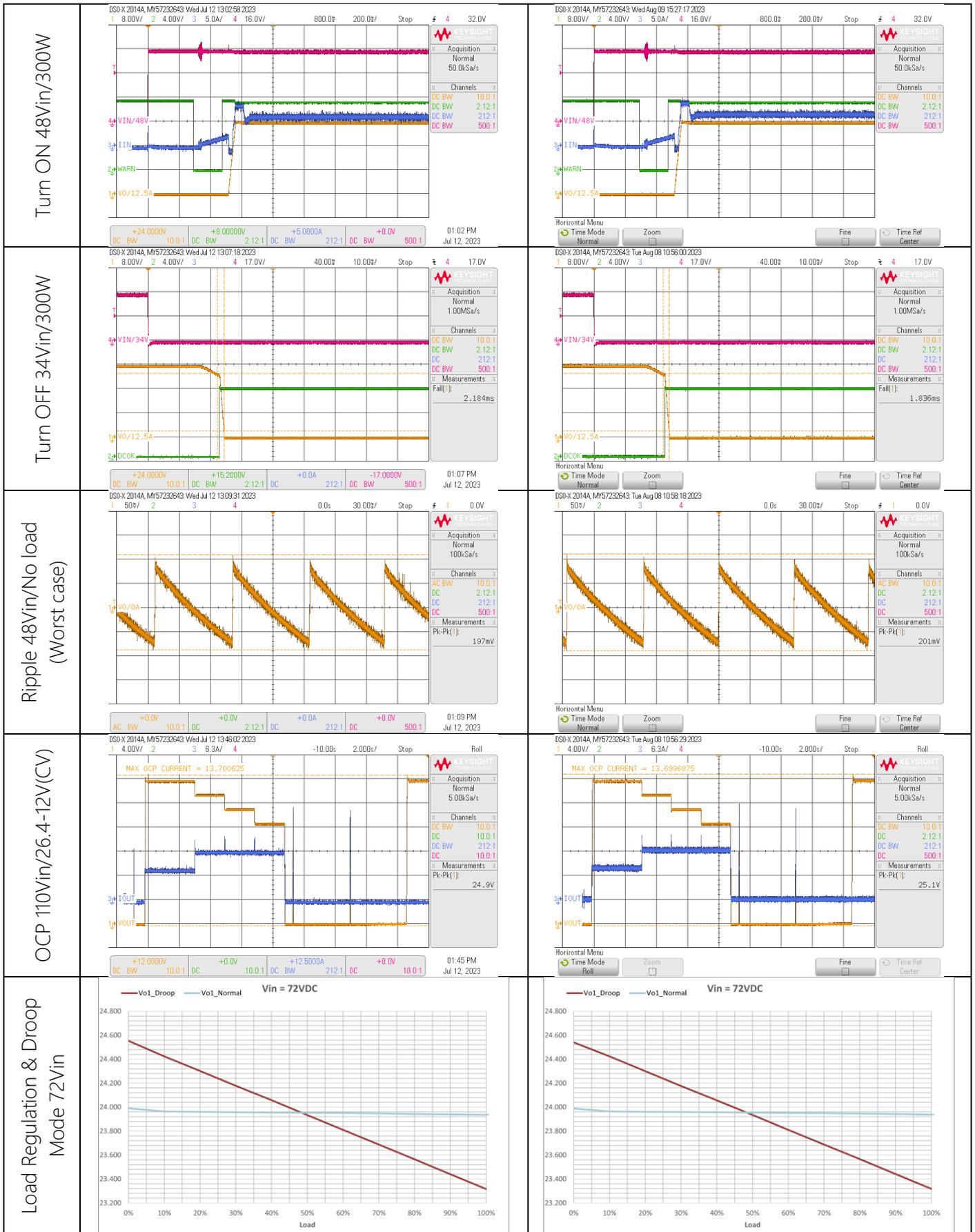
It can be concluded that the vibration and shock test was passed successfully subject to correct bonding between C15 and C16.

Refer to ECO-ENG-1329 for detailed information about the implemented corrective actions.

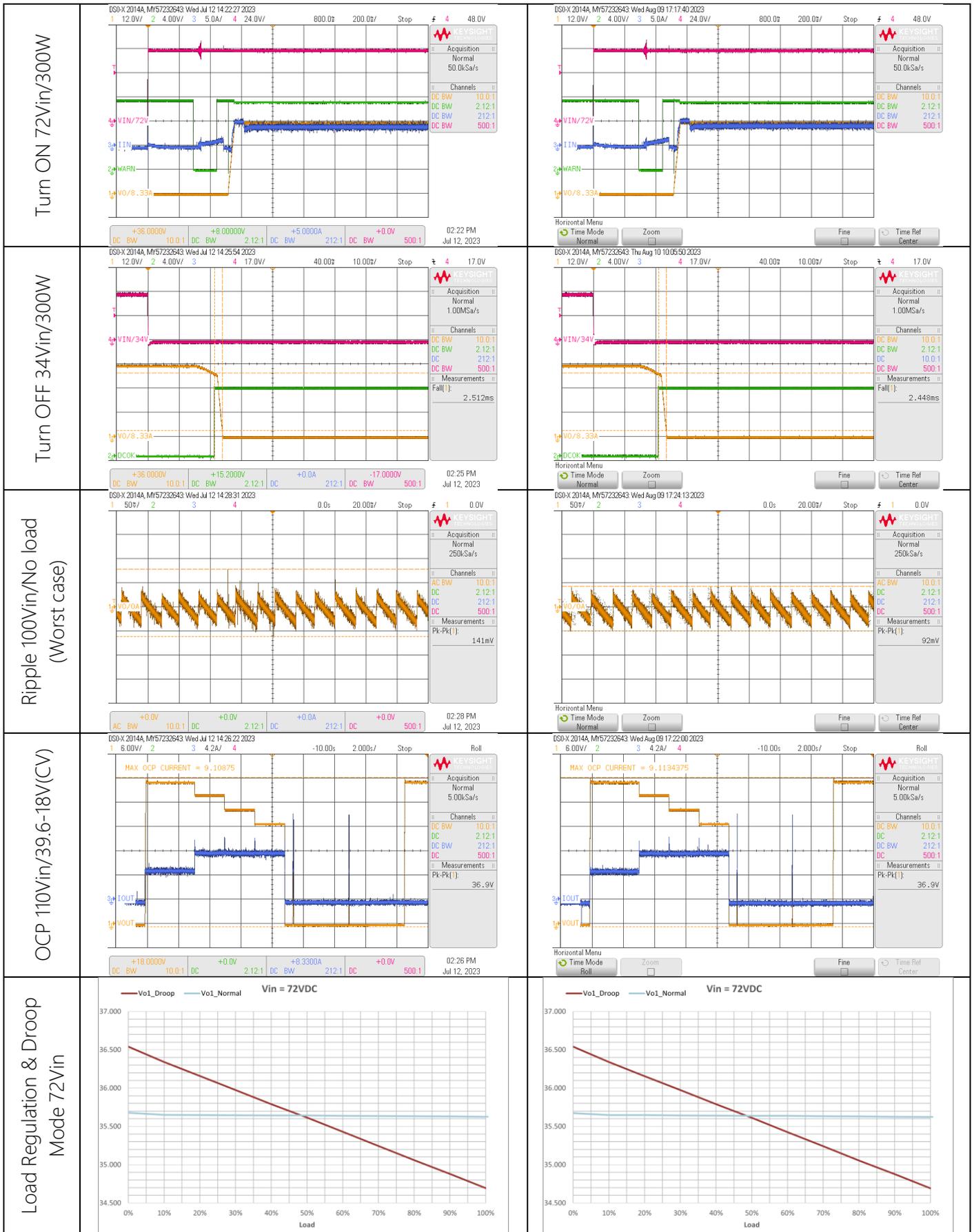
Appendix 1 - Performance Test Results

VCCR300-24 Engineering Sample, S/N: 2328CXX0001

Test	Before Vibration & Shock Test	After Vibration & Shock Test
Efficiency		
Power Loss		
Holdup 100Vin/15ms		
Rise Time 96Vin/300W		
Transient 25-75%/48Vin		

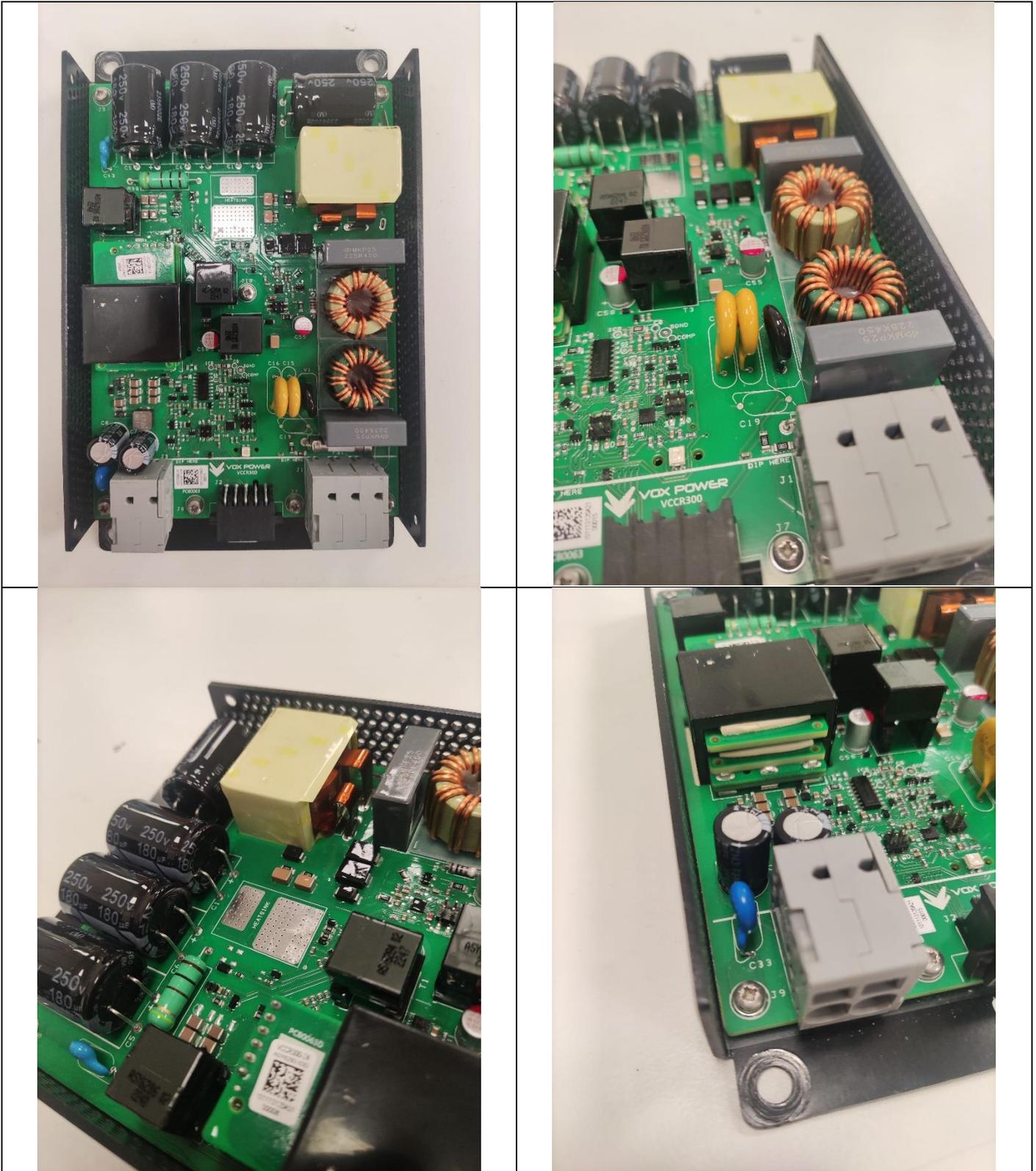


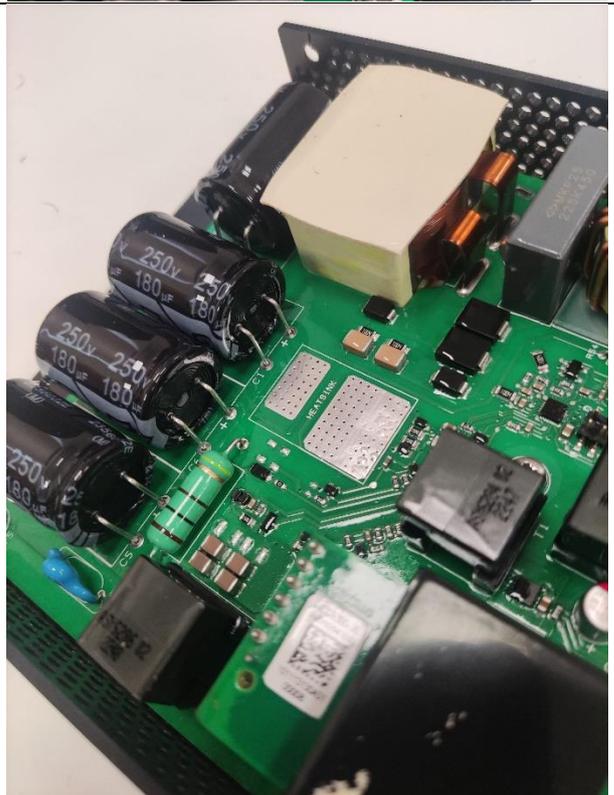
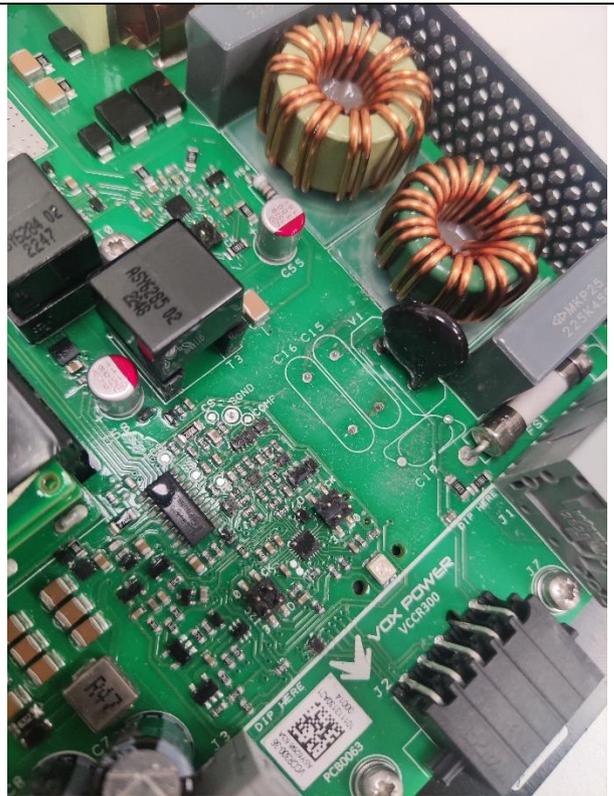
Test	Before Vibration & Shock Test	After Vibration & Shock Test
Efficiency		
Power Loss		
Holdup 100Vin/15ms		
Rise Time 96Vin/300W		
Transient 25-75%/48Vin		



Appendix 2 - Visual Inspection

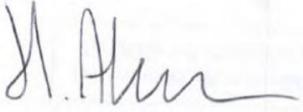
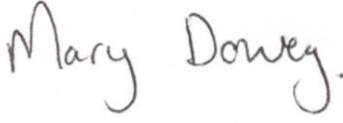
VCCR300-24 Engineering Sample, S/N: 2328CXX0001





Appendix 3 – Vibration and Shock Test

**VIBRATION AND SHOCK TEST REPORT FOR VOX POWER
IN COMPLIANCE WITH
MIL-STD-810G METHOD 514.6 CATEGORY 4, 7 & 24: RANDOM VIBRATION
IEC60068-2-6: SINUSOIDAL VIBRATION
IEC60068-2-64: RANDOM VIBRATION
IEC60068-2-27: SHOCK**

Author: (Name)	Author: (Signature)	Date:
Hayley Alcorn		2023-08-11
Approver: (Name)	Approver: (Signature)	Date:
Mary Dowey		2023-08-11

 Resonate TESTING LIMITED A NACELLE GROUP COMPANY	Test Report Vibration and shock	Record No: RTL00535 D0017 Rev No: 1 2023-08-11 Document Status: Approved
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CONTRACT INFORMATION

Customer:	Vox Power
PO Number:	PO: 11316
Contact Name:	Brian McDonald
Customer Address:	Unit 2, Redcow Interchange Estate, Ballymount, Dublin, Ireland
Test Specimen:	P/N: VCCR300-24, S/N: 2328CXX0001 P/N: VCCR300-36, S/N: 2328CXX0002
Specimen Receipt Date:	2023-07-20
Date of Test:	2023-07-24 to 2023-08-02
Date of Report:	Iss 01: 2023-08-11
Test Method to be Used:	MIL-STD-810G: Method 514.6, Procedure I (General Vibration) Category 4 (Trucks & Trailers, Composite wheeled vehicle), Figure 514.6C-3. MIL-STD-810G: Method 514.6, Procedure I (General Vibration) Category 7 (Aircraft, Jet cargo), Figure 514.6C-5 General exposure MIL-STD-810G: Method 514.6, Procedure I (General Vibration) Category 24, (All, Minimum integrity) Figure 514.6E-1 IEC60068-2-6: Sine,10 – 500 Hz, 3 axes, 1 oct/min., 10 cycles each axis IEC60068-2-64: Random, 5 – 500 Hz, 3 axes, 30 min, Operational & Non-Operational IEC60068-2-27: Half sine, 3 axes, 3 positive & 3 negative, 30 min, Operational & Non-Operational
Any Deviation from Test Method:	None
Results summary:	Testing was carried out as per customer's specification without witnessing. No determination on the pass/fail of the test specimens has been made.
Customer onsite representatives:	None
<p>All testing is carried out in compliance with the requirements and specifications detailed above, and the results apply to the specimens tested. Opinions and interpretations are not given by Resonate Testing Ltd.</p> <p>Testing was carried out on these test specimens only and provides no verification for the performance of other items in the same batch, or production run.</p>	

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1 Test Specimen

Customer Description:	Conduction cooled power supply VCCR300 series
Customer Unique ID:	P/N: VCCR300-24, S/N: 2328CXX0001 P/N: VCCR300-36, S/N: 2328CXX0002
Condition on receipt:	Suitable for testing

Testing was carried out on these test specimens only and provides no verification for the performance of other items in the same batch, or production run.

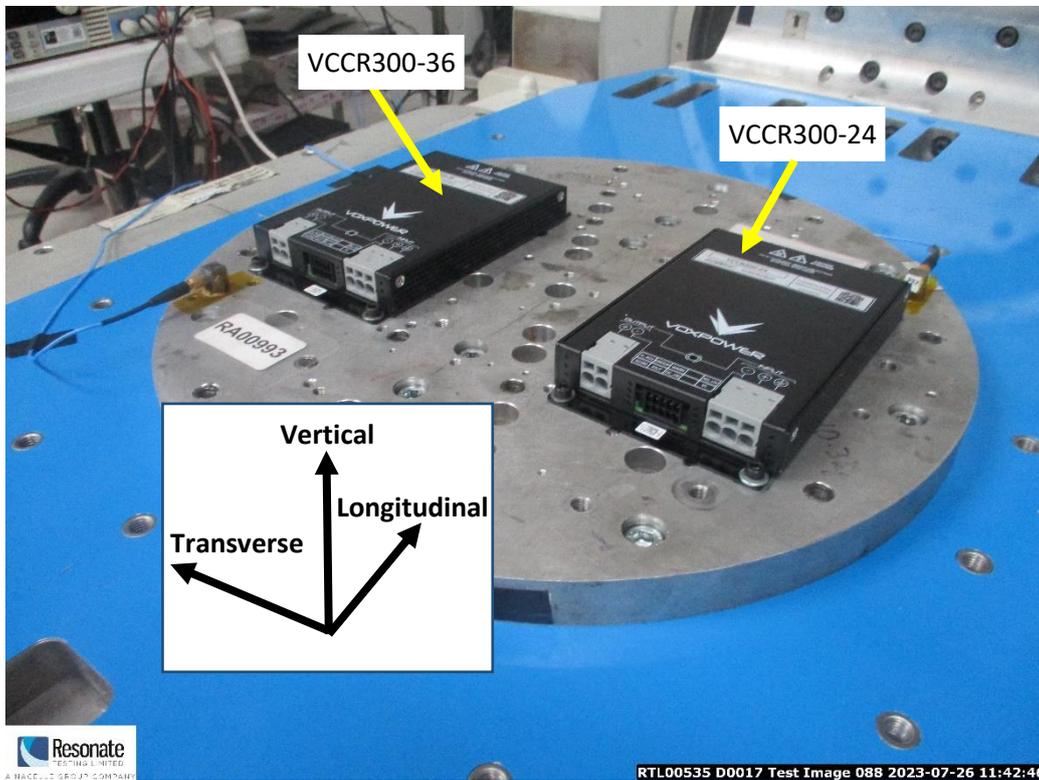


Figure 1: Test specimen and principal axis directions

2 Test Specification

2.1 General

Testing was carried out in accordance with the customers' requirements as specified in:

Document reference:	<p>Testing was carried out in compliance with:</p> <p>MIL-STD-810G: Method 514.6, Procedure I (General Vibration) Category 4 (Trucks & Trailers, Composite wheeled vehicle), Figure 514.6C-3.</p> <p>MIL-STD-810G: Method 514.6, Procedure I (General Vibration) Category 7 (Aircraft, Jet cargo), Figure 514.6C-5 General exposure</p> <p>MIL-STD-810G: Method 514.6, Procedure I (General Vibration) Category 24, (All, Minimum integrity) Figure 514.6E-1</p> <p>IEC60068-2-6: Sine, 10 – 500 Hz, 3 axes, 1 oct/min., 10 cycles each axis</p> <p>IEC60068-2-64: Random, 5 – 500 Hz, 3 axes, 30 min, Operational & Non-Operational</p> <p>IEC60068-2-27: Half sine, 3 axes, 3 positive & 3 negative, 30 min, Operational & Non-Operational</p>
Date of receipt:	Received via email from Brian McDonald on Thursday 2023-06-29 at 15:55

2.2 Environmental Conditions

The test was carried out under standard laboratory conditions:

Temperature: +15 to +35°C.

Relative Humidity: Not greater than 85%.

Ambient Pressure: 84 to 107 kPa (equivalent to +5,000 to -1,500 ft) (+1525 to -460m).

2.3 Test Specification

2.3.1 MIL-STD-810G: Method 514.6, Procedure I (General Vibration) Category 4 (Trucks & Trailers, Composite wheeled vehicle), Figure 514.6C-3

A random vibration test was carried out in accordance with MIL-STD-810G Method 514.6 Procedure I Category 4 Composite wheeled vehicle vibration exposure in all three orthogonal axes shown in Figure 2 and Table 1. The required levels were applied to their specified axis for a duration of **120 minutes** and the test specimens were **non-operational** during the test.

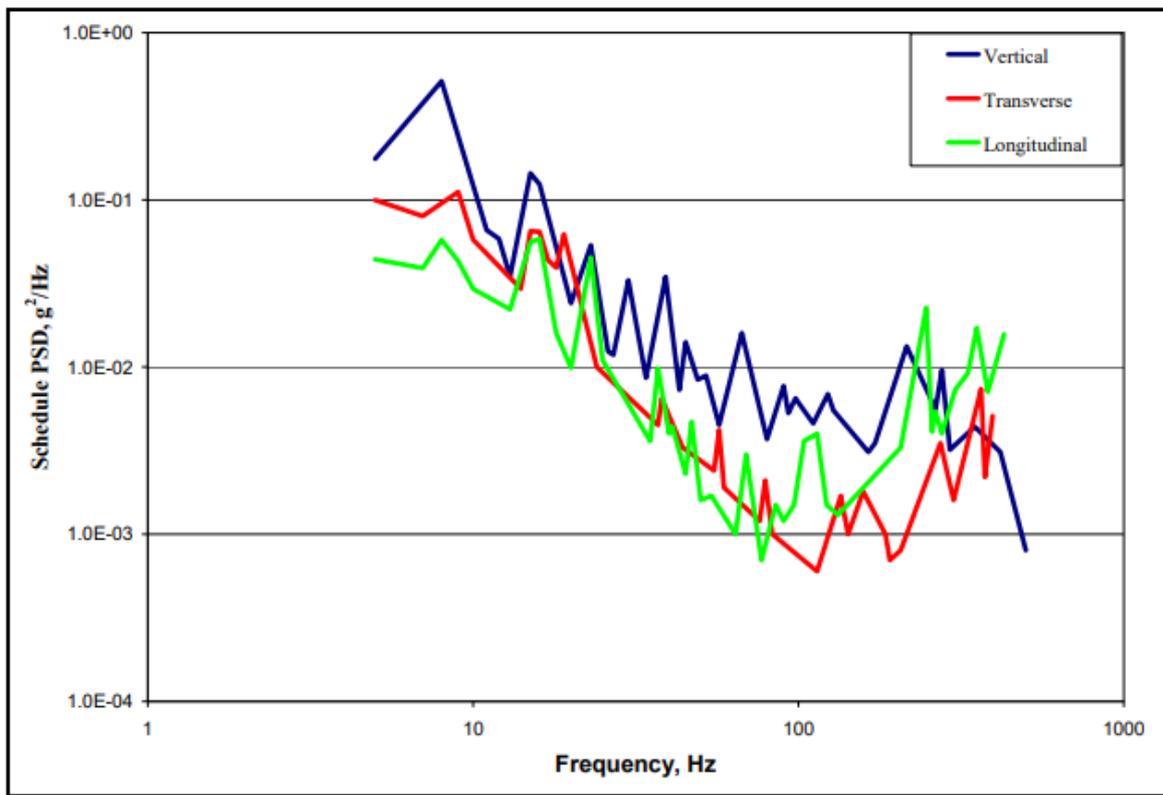


Figure 2: 514.6C-3 – Category 4 - Composite wheeled vehicle vibration exposure

Table 1: Break points for Figure 2

Vertical		Transverse		Longitudinal	
Frequency, Hz	PSD, g ² /Hz	Frequency, Hz	PSD, g ² /Hz	Frequency, Hz	PSD, g ² /Hz
5	0.1759	5	0.0998	5	0.0441
8	0.5120	7	0.0799	7	0.0390
11	0.0660	9	0.1115	8	0.0576
12	0.0585	10	0.0577	9	0.0430
13	0.0348	14	0.0294	10	0.0293
15	0.1441	15	0.0651	13	0.0221
16	0.1237	16	0.0646	15	0.0558
20	0.0241	17	0.0436	16	0.0585
23	0.0536	18	0.0393	18	0.0160
26	0.0124	19	0.0622	20	0.0099
27	0.0118	24	0.0100	23	0.0452
30	0.0331	37	0.0045	25	0.0110
34	0.0086	38	0.0065	35	0.0036
39	0.0347	44	0.0033	37	0.0098
43	0.0073	55	0.0024	40	0.0040
45	0.0141	57	0.0042	41	0.0044
49	0.0084	59	0.0019	45	0.0023
52	0.0089	76	0.0012	47	0.0047
57	0.0045	79	0.0021	50	0.0016
67	0.0160	83	0.0010	54	0.0017
80	0.0037	114	0.0006	64	0.0010
90	0.0077	135	0.0017	69	0.0030
93	0.0053	142	0.0010	77	0.0007
98	0.0065	158	0.0018	85	0.0015
99	0.0063	185	0.0010	90	0.0012
111	0.0046	191	0.0007	97	0.0015
123	0.0069	206	0.0008	104	0.0036
128	0.0055	273	0.0035	114	0.0040
164	0.0031	300	0.0016	122	0.0015
172	0.0035	364	0.0074	132	0.0013
215	0.0133	374	0.0022	206	0.0033
264	0.0056	395	0.0051	247	0.0226
276	0.0096	500	0.0012	257	0.0041
292	0.0032	rms = 1.48 g	264	0.0054	
348	0.0044		276	0.0040	
417	0.0031		303	0.0073	
500	0.0008		332	0.0092	
rms = 2.24 g			353	0.0172	
			382	0.0071	
			428	0.0157	
			500	0.0016	
			rms = 1.90 g		

2.3.2 MIL-STD-810G: Method 514.6, Procedure I (General Vibration) Category 7 (Aircraft, Jet cargo), Figure 514.6C-5 General exposure

A random vibration test was carried out in accordance with MIL-STD-810G Method 514.6 Procedure I (General Vibration) Category 7 (Aircraft, Jet cargo) in all three orthogonal axes shown in Figure 3 and Table 2. The required levels were applied to their specified axis for a duration of **120 minutes per axis** and the test specimens were **non-operational** during the test.

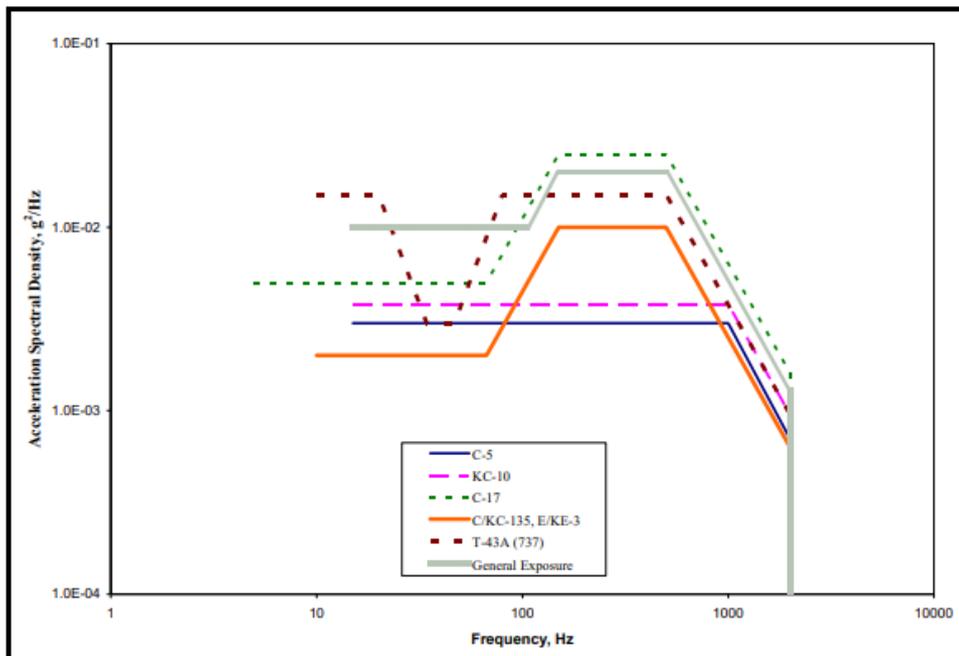


Figure 3: 514.6C-5. Category 7 - Jet aircraft cargo vibration exposure

Table 2: Break points for Figure 3

General Exposure		
Hz	g^2/Hz	dB/Oct
15	0.01	
105.94	0.01	
		6
150	0.02	
500	0.02	
		-6
2000	1.3E-3	
rms = 4.02 g		

2.3.3 MIL-STD-810G: Method 514.6, Procedure I (General Vibration) Category 24, (All, Minimum integrity) Figure 514.6E-1

A random vibration test was carried out in accordance with MIL-STD-810G Method 514.6 Procedure I Category 24 General Minimum Integrity exposure shown in Figure 4. The required levels were applied to their specified axis for duration of **60 minutes per axis** and the test specimens were **non-operational** during the test.

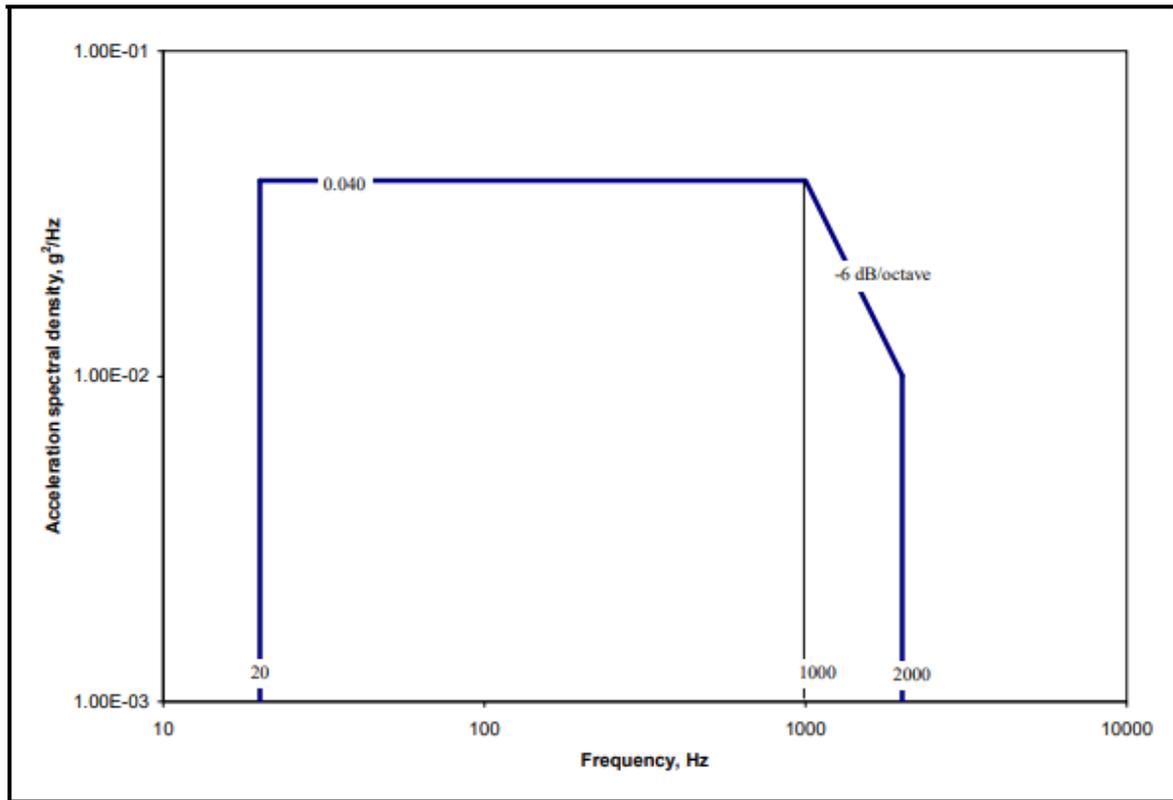


Figure 4: Category 24- General minimum integrity exposure

2.3.4 IEC60068-2-6: Sine Vibration Operational

A Sine Vibration test was carried out in accordance with IEC60068-2-6. The required levels were applied to all three axes in accordance with the parameters in Table 3. The test specimens were **operational** during the test.

Table 3: Sine vibration levels

Frequency Range	Sweep Rate	Number of Cycles per axis	Acceleration (g)
10-500Hz	1 Oct/min	10	2

2.3.5 IEC60068-2-64: Random Vibration Operational

A random vibration test was carried out in accordance with IEC60068-2-64. The required levels were applied to their specified axis in accordance with Table 4. **VCCR300-24 was operational** and **VCCR300-36 was non-operational** during the test.

Table 4: Random vibration levels operational

Frequency Range	Duration	g^2/Hz Level	grms Level
5-500Hz	30 mins	0.0122	2.46

2.3.6 IEC60068-2-64: Random Vibration Non-Operational

A random vibration test was carried out in accordance with IEC60068-2-64. The required levels were applied to their specified axis in accordance with Table 5. The test specimens were **non-operational** during the test.

Table 5: Random vibration levels non-operational

Frequency Range	Duration	g^2/Hz Level	grms Level
5-500Hz	30 mins	0.02	3.15

2.3.7 IEC60068-2-27: Mechanical Shock, Operational

A shock test was carried out in accordance with IEC60068-2-27. The required levels were applied to their specified axis in accordance with Table 6 and the tolerances in Figure 5. **VCCR300-24 was operational** and **VCCR300-36 was non-operational** during the test.

Table 6: Operational shock levels

Pulse shape	Peak (g)	Duration (ms)	No. of shocks
Half-Sine	30	18	3 positive & 3 negative

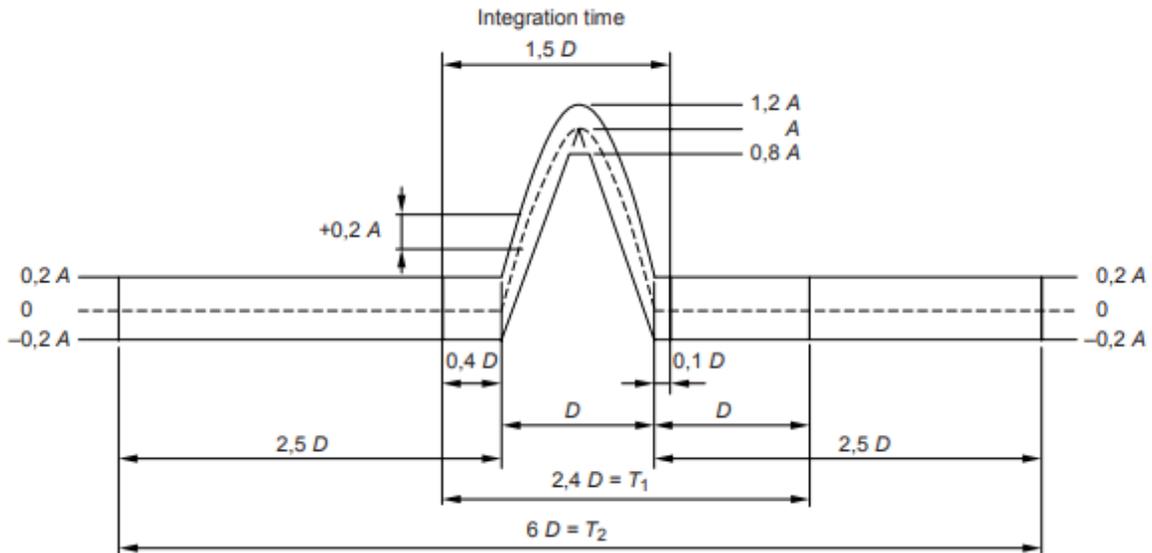


Figure 5: IEC 60068-2-27 Half-sine tolerances

2.3.8 IEC60068-2-27: Mechanical Shock, Non-Operational

A shock test was carried out in accordance with IEC60068-2-27. The required levels were applied to their specified axis in accordance with Table 7 and the tolerances in Figure 5. The test specimens were **non-operational** during the test.

Table 7: Non-operational shock Levels

Pulse shape	Peak (g)	Duration (ms)	No. of shocks
Half-Sine	50	11	3 positive & 3 negative

3 Test Equipment and Instrumentation

3.1 Test Laboratory

Laboratory Address:	Resonate Testing Limited Unit 1 Bridge Technology Park Carnagat Lane Carnagat Newry BT35 8XF
Test Technician:	Hayley Alcorn, Conor Barry
Customer Onsite representatives:	None

3.2 Test Equipment

Testing was carried out using the equipment outlined in the following specification (See Table 8).

Table 8: Vibration equipment specification

Shaker			
	Manufacturer:	IMV Corporation	
	Model:	EM2605	
	Frequency range:	5-2600 Hz	
	Serial No:	51000167	
	Max. Force:	Sine	54 kN
		Random	54 kN rms
		Shock	112 kN
	Max. Acceleration:	Sine	857 m/s ²
		Random	600 m/s ²
		Shock	1777 m/s ²
Max. Velocity:	Sine	2.4 m/s	
	Shock	3.5 m/s	
Max. Displacement:	Sine (peak to peak)	100 mm	

3.3 Fixturing

The test specimens were fixed so that the vibration motion was parallel to each of their three major orthogonal axes. The test specimens were attached to the test fixture as shown in Figure 6 using four M5 bolts with washers and torqued to 6.6 Nm.

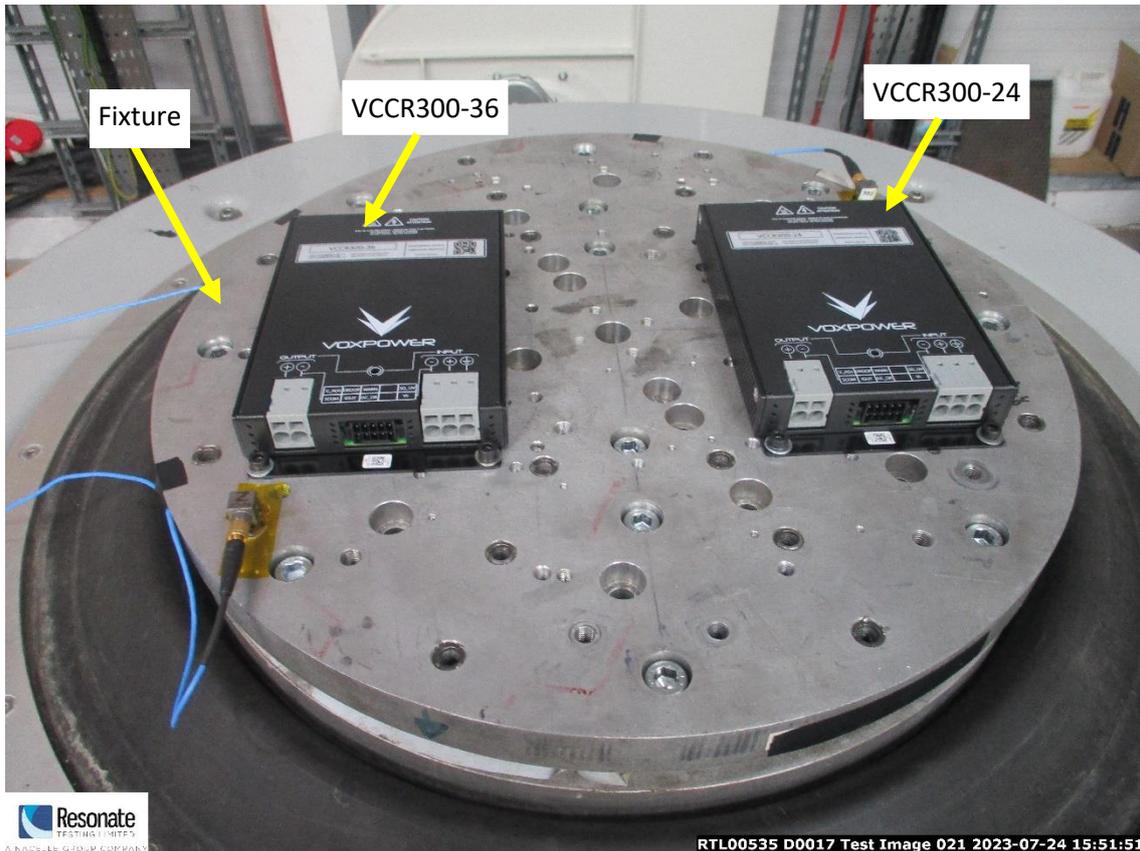


Figure 6: Representative attachment of test specimens to fixture

3.4 Test Instrumentation

3.4.1 Control Accelerometers

The control accelerometers were attached to the test fixture as near as practicable to the test specimen's mounting locations for each axis of test, shown in Figure 7. RA00992 was used as the control accelerometer for the shock tests.

Where more than one accelerometer has been used, the average of the accelerometer signals has been used for control. APSD plots are given to demonstrate that the control levels meet the test level requirements – See Section 5.

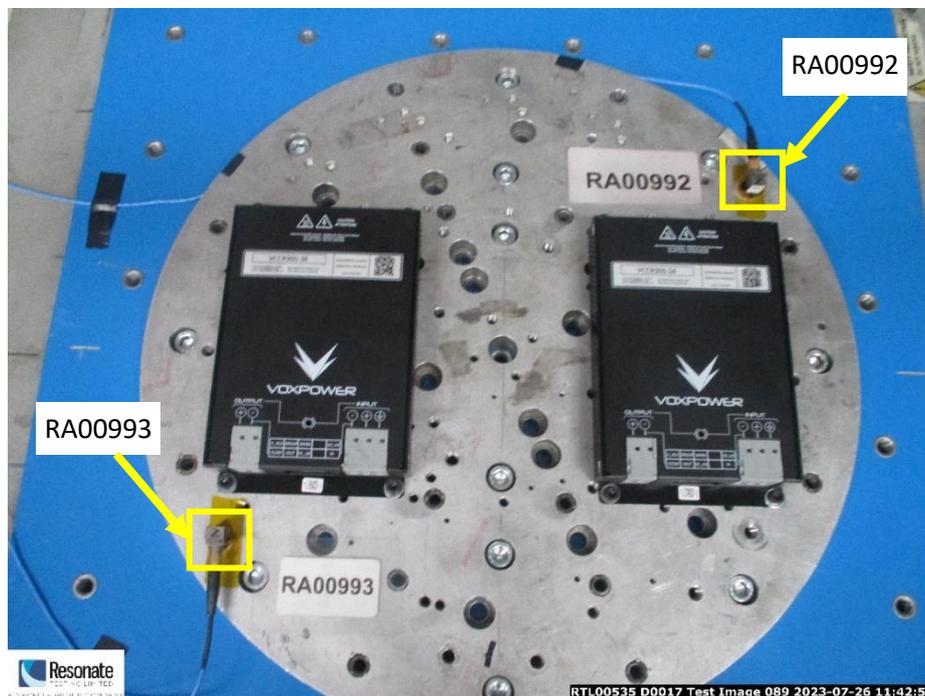


Figure 7: Location of control accelerometers – Location for all axes [RA00992 and RA00993]

3.4.2 Traceability

All equipment has been calibrated as required using standards traceable to National or International standards.

Table 9: List of instrumentation used

Ref No:	Serial No:	Use	Type:	Cal Status:	Cal Expiry:	Accuracy %
RA00085	51000167	Control	Controller	Calibrated	2023-11-02	± 1.88
RA00992	LW306210	Control	Tri-axial	Calibrated	2024-05-09	± 1.65
RA00993	LW306211	Control	Tri-axial	Calibrated	2024-05-09	± 2.87
RA00631	KEBBH26	Monitoring output voltage	Datalogger	Calibrated	2024-04-25	± 0.07

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4 Procedure

Each test specimen was subjected to a suite of tests in each of its principal axes in accordance with the test specification and in the following order:

1. MIL-STD-810G Procedure I Category 4 (Trucks & Trailers, Composite Wheeled Vehicle) Non-Operational
2. MIL-STD-810G Procedure I Category 7 (Aircraft, Jet Cargo) Non-Operational
3. MIL-STD-810G Procedure I Category 24 (Minimum Integrity) Non-Operational
4. IEC60068-2-6 Sine Vibration Operational
5. IEC60068-2-64 Random Vibration Operational
6. IEC60068-2-64 Random Vibration Non-Operational
7. IEC60068-2-27 Shock Operational
8. IEC60068-2-27 Shock Non-Operational

During the operational tests for the VCCR300-24, the electronic load was connected and turned on and the voltage was monitored throughout the duration of the tests. During the operational tests for the VCCR300-36 and the longitudinal sine test for VCCR300-24, the units were powered up and the voltage was monitored throughout the duration of the tests.

Photographs of the test setup in each axis are shown in Figure 8 to Figure 11.

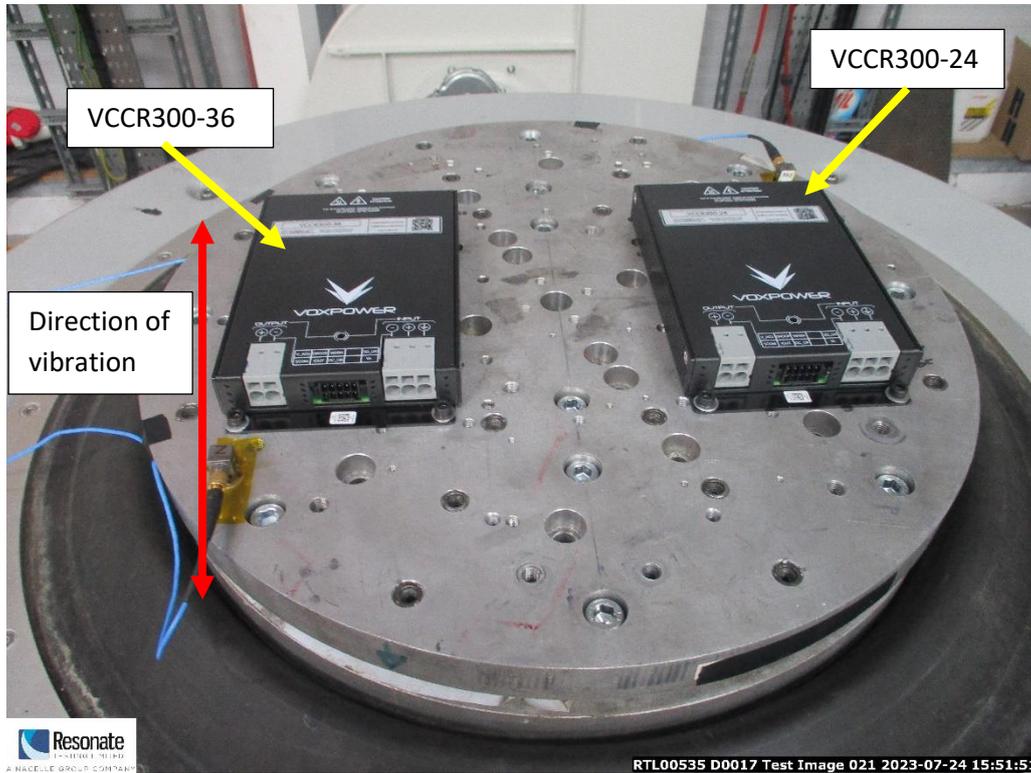


Figure 8: Vertical axis non-operational test set-up

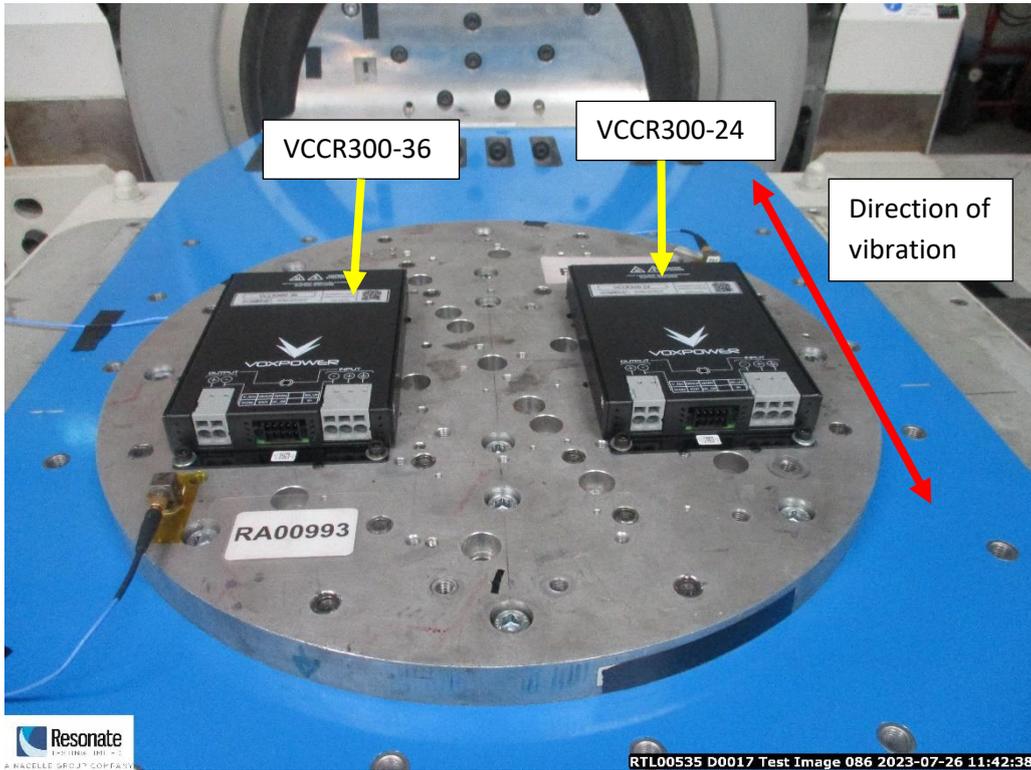


Figure 9: Longitudinal axis non-operational test set-up

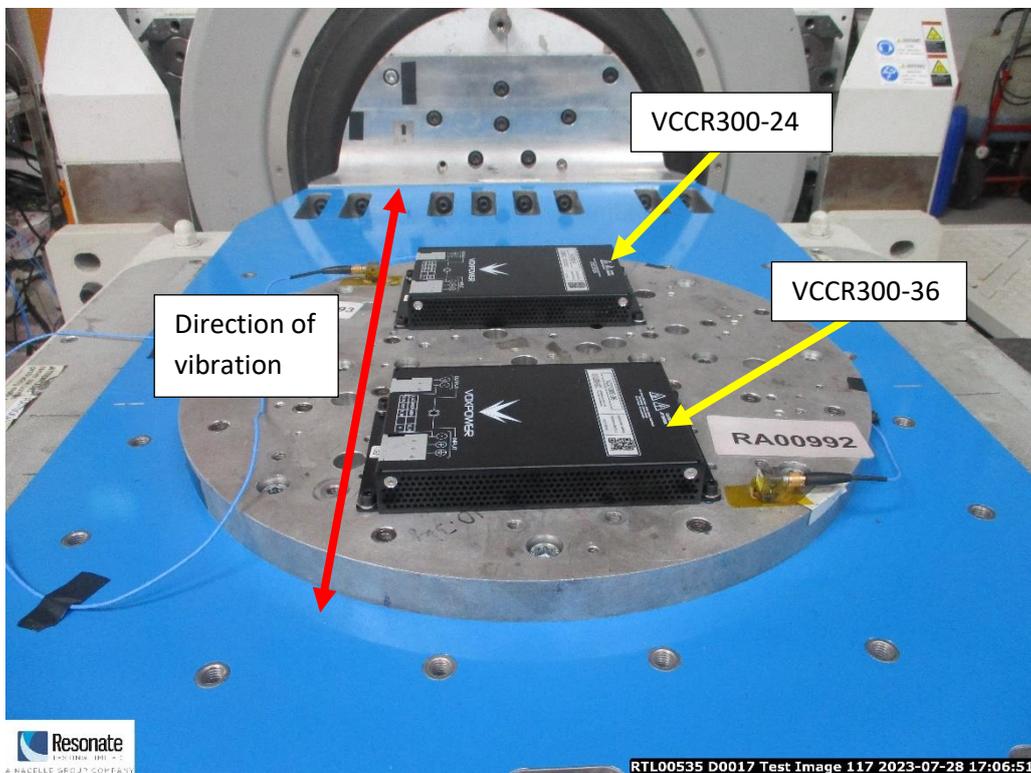


Figure 10: Transverse axis non-operational test set-up

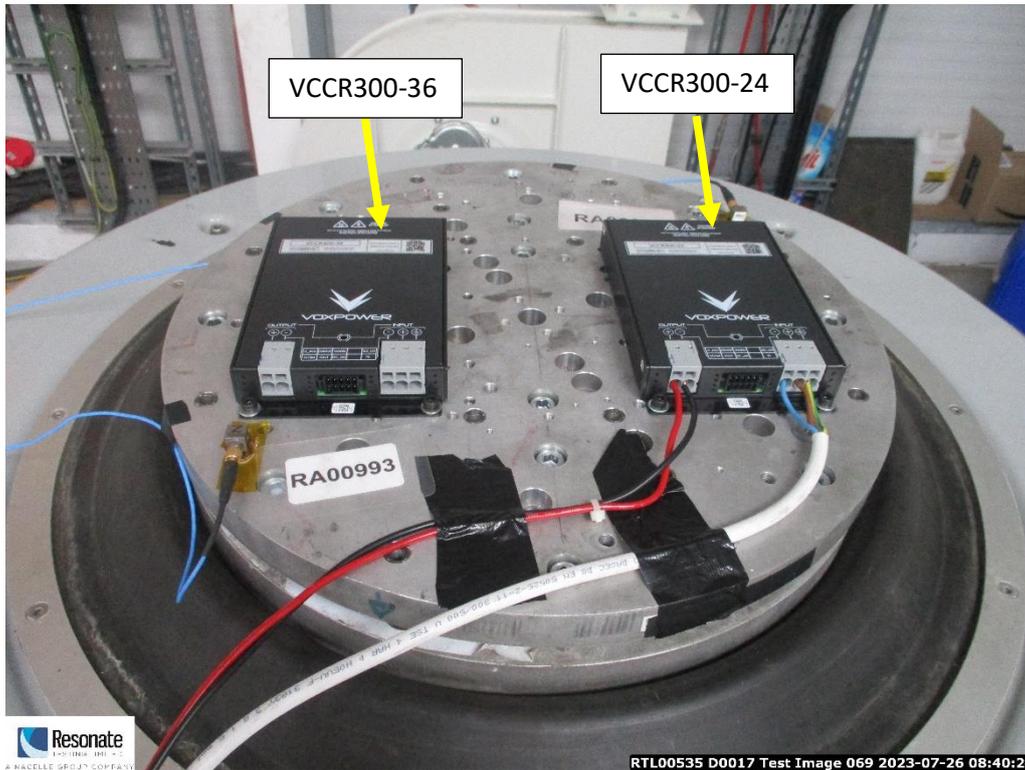


Figure 11: Representative set-up for monitoring voltage during operational testing

5 Test Results

The test specimens completed the vibration tests in accordance with the required test methods in each of the three orthogonal axes.

Test statuses and control references are captured in Table 10 to Table 28. Vibration control spectra from the random vibration tests are shown in Figure 12 to Figure 56.

Table 10: Vibration test status – MIL-STD 810G Category 4 random vibration

	Vertical axis	Longitudinal axis	Transverse axis
Start	24/07/2023 15:07:25	26/07/2023 11:46:39	28/07/2023 17:12:16
End	24/07/2023 17:53:05	26/07/2023 13:47:23	28/07/2023 19:13:07
Status	Excitation is completed. (Test time is completed.)	Excitation is completed. (Test time is completed.)	Excitation is completed. (Test time is completed.)
Reference	2.2793 g rms	1.9111 g rms	1.4932 g rms
Response	2.2783 g rms	1.9095 g rms	1.4962 g rms
Elapsed time	02:00:00	02:00:00	02:00:00
Alarm	OK	OK	OK
Abort	OK	OK	OK

Table 11: Vertical test control reference - MIL-STD 810G Category 4 random vibration

Control Reference				
Acceleration	2.279 g rms			
Velocity	0.326 m/s rms			
Displacement	8.206 mm rms			
Break point PSD				
No.	Frequency(Hz)	Level/Slope		
1	5.00	0.1759	g2/Hz	
2	8.00	0.5120	g2/Hz	
3	11.00	6.600e-2	g2/Hz	
4	12.00	5.850e-2	g2/Hz	
5	13.00	3.480e-2	g2/Hz	
6	15.00	0.1441	g2/Hz	
7	16.00	0.1237	g2/Hz	
8	20.00	2.410e-2	g2/Hz	
9	23.00	5.360e-2	g2/Hz	
10	26.00	1.240e-2	g2/Hz	
11	27.00	1.180e-2	g2/Hz	
12	30.00	3.310e-2	g2/Hz	
13	34.00	8.600e-3	g2/Hz	
14	39.00	3.470e-2	g2/Hz	
15	43.00	7.300e-3	g2/Hz	
16	45.00	1.410e-2	g2/Hz	
17	49.00	8.400e-3	g2/Hz	
18	52.00	8.900e-3	g2/Hz	
19	57.00	4.500e-3	g2/Hz	
20	67.00	1.600e-2	g2/Hz	
21	80.00	3.700e-3	g2/Hz	
22	90.00	7.700e-3	g2/Hz	
23	93.00	5.300e-3	g2/Hz	
24	98.00	6.500e-3	g2/Hz	
25	99.00	6.300e-3	g2/Hz	
26	111.00	4.600e-3	g2/Hz	
27	123.00	6.900e-3	g2/Hz	
28	128.00	5.500e-3	g2/Hz	
29	164.00	3.100e-3	g2/Hz	
30	172.00	3.500e-3	g2/Hz	
31	215.00	1.330e-2	g2/Hz	
32	264.00	5.600e-3	g2/Hz	
33	276.00	9.600e-3	g2/Hz	
34	292.00	3.200e-3	g2/Hz	
35	348.00	4.400e-3	g2/Hz	
36	417.00	3.100e-3	g2/Hz	
37	500.00	8.000e-4	g2/Hz	
Tolerance				
Abort upper(dB) Abort lower(dB) Abort A.B.W. (Hz) Alarm upper(dB) Alarm lower(dB) Alarm A.B.W. (Hz)				
-3.00	6.00	-6.00	0.00	3.00
Extended tolerance(0 items)				

Table 12: Longitudinal test control reference - MIL-STD 810G Category 4 random vibration

Control Reference			
Acceleration	1.911 g rms		
Velocity	0.144 m/s rms		
Displacement	3.617 mm rms		
Break point PSD			
No.	Frequency(Hz)	Level/Slope	
1	5.00	4.410e-2	g2/Hz
2	7.00	3.900e-2	g2/Hz
3	8.00	5.760e-2	g2/Hz
4	9.00	4.300e-2	g2/Hz
5	10.00	2.930e-2	g2/Hz
6	13.00	2.210e-2	g2/Hz
7	15.00	5.580e-2	g2/Hz
8	16.00	5.850e-2	g2/Hz
9	18.00	1.600e-2	g2/Hz
10	20.00	9.900e-3	g2/Hz
11	23.00	4.520e-2	g2/Hz
12	25.00	1.100e-2	g2/Hz
13	35.00	3.600e-3	g2/Hz
14	37.00	9.800e-3	g2/Hz
15	40.00	4.000e-3	g2/Hz
16	41.00	4.400e-3	g2/Hz
17	45.00	2.300e-3	g2/Hz
18	47.00	4.700e-3	g2/Hz
19	50.00	1.600e-3	g2/Hz
20	54.00	1.700e-3	g2/Hz
21	64.00	1.000e-3	g2/Hz
22	69.00	3.000e-3	g2/Hz
23	77.00	7.000e-4	g2/Hz
24	85.00	1.500e-3	g2/Hz
25	90.00	1.200e-3	g2/Hz
26	97.00	1.500e-3	g2/Hz
27	104.00	3.600e-3	g2/Hz
28	114.00	4.000e-3	g2/Hz
29	122.00	1.500e-3	g2/Hz
30	132.00	1.300e-3	g2/Hz
31	206.00	3.300e-3	g2/Hz
32	247.00	2.260e-2	g2/Hz
33	257.00	4.100e-3	g2/Hz
34	264.00	5.400e-3	g2/Hz
35	276.00	4.000e-3	g2/Hz
36	303.00	7.300e-3	g2/Hz
37	332.00	9.200e-3	g2/Hz
38	353.00	1.720e-2	g2/Hz
39	382.00	7.100e-3	g2/Hz
40	428.00	1.570e-2	g2/Hz
41	500.00	1.600e-3	g2/Hz
Tolerance			
Abort upper (dB)	Abort lower (dB)	Abort A.B.W. (Hz)	Alarm upper (dB) Alarm lower (dB) Alarm A.B.W. (Hz)
6.00	-6.00	0.00	3.00
-3.00	0.00		
Extended tolerance(0 items)			

Table 13: Transverse test control reference - MIL-STD 810G Category 4 random vibration

Control Reference				
Acceleration	1.493 g rms			
Velocity	0.202 m/s rms			
Displacement	5.320 mm rms			
Break point PSD				
No.	Frequency(Hz)	Level/Slope		
1	5.00	9.980e-2	g2/Hz	
2	7.00	7.990e-2	g2/Hz	
3	9.00	0.1115	g2/Hz	
4	10.00	5.770e-2	g2/Hz	
5	14.00	2.940e-2	g2/Hz	
6	15.00	6.510e-2	g2/Hz	
7	16.00	6.460e-2	g2/Hz	
8	17.00	4.360e-2	g2/Hz	
9	18.00	3.930e-2	g2/Hz	
10	19.00	6.220e-2	g2/Hz	
11	24.00	1.000e-2	g2/Hz	
12	37.00	4.500e-3	g2/Hz	
13	38.00	6.500e-3	g2/Hz	
14	44.00	3.300e-3	g2/Hz	
15	55.00	2.400e-3	g2/Hz	
16	57.00	4.200e-3	g2/Hz	
17	59.00	1.900e-3	g2/Hz	
18	76.00	1.200e-3	g2/Hz	
19	79.00	2.100e-3	g2/Hz	
20	83.00	1.000e-3	g2/Hz	
21	114.00	6.000e-4	g2/Hz	
22	135.00	1.700e-3	g2/Hz	
23	142.00	1.000e-3	g2/Hz	
24	158.00	1.800e-3	g2/Hz	
25	185.00	1.000e-3	g2/Hz	
26	191.00	7.000e-4	g2/Hz	
27	206.00	8.000e-4	g2/Hz	
28	273.00	3.500e-3	g2/Hz	
29	300.00	1.600e-3	g2/Hz	
30	364.00	7.400e-3	g2/Hz	
31	374.00	2.200e-3	g2/Hz	
32	395.00	5.100e-3	g2/Hz	
33	500.00	1.200e-3	g2/Hz	
Tolerance				
Abort upper(dB) Abort lower(dB) Abort A.B.W. (Hz) Alarm upper(dB) Alarm lower(dB) Alarm A.B.W. (Hz)				
-3.00	6.00	-6.00	0.00	3.00
Extended tolerance(0 items)				

Table 14: Vibration test status – MIL-STD 810G Category 7 random vibration

	Vertical axis	Longitudinal axis	Transverse axis
Start	25/07/2023 08:40:59	26/07/2023 13:50:08	31/07/2023 08:42:57
End	25/07/2023 10:42:04	26/07/2023 15:51:14	31/07/2023 10:44:04
Status	Excitation is completed. (Test time is completed.)	Excitation is completed. (Test time is completed.)	Excitation is completed. (Test time is completed.)
Reference	4.0114 g rms	4.0114 g rms	4.0114 g rms
Response	4.0154 g rms	4.0171 g rms	4.0179 g rms
Elapsed time	02:00:00	02:00:00	02:00:00
Alarm	OK	OK	OK
Abort	OK	OK	OK

Table 15: Test control reference - MIL-STD 810G Category 7 random vibration

Control Reference			
Acceleration	4.011 g rms		
Velocity	0.043 m/s rms		
Displacement	0.277 mm rms		
Break point PSD			
No.	Frequency (Hz)	Level/Slope	
1	15.00	1.000e-2	g ² /Hz
2	105.94	1.000e-2	g ² /Hz
3	150.00	6.00	dB/octave
4	500.00	2.000e-2	g ² /Hz
5	2000.00	-6.00	dB/octave
Tolerance			
Abort upper (dB) Abort lower (dB) Abort A.B.W. (Hz) Alarm upper (dB) Alarm lower (dB) Alarm A.B.W. (Hz)			
-3.00	6.00	-6.00	5.00 3.00
Extended tolerance (0 items)			

Table 16: Vibration test status – MIL-STD 810G Category 24 random vibration

	Vertical axis	Longitudinal axis	Transverse axis
Start	25/07/2023 10:44:25	26/07/2023 15:52:45	31/07/2023 10:47:32
End	25/07/2023 11:45:22	26/07/2023 16:53:41	31/07/2023 11:48:31
Status	Excitation is completed. (Test time is completed.)	Excitation is completed. (Test time is completed.)	Excitation is completed. (Test time is completed.)
Reference	7.6985 g rms	7.6985 g rms	7.6985 g rms
Response	7.7170 g rms	7.7163 g rms	7.7164 g rms
Elapsed time	01:00:00	01:00:00	01:00:00
Alarm	OK	OK	OK
Abort	OK	OK	OK

Table 17: Test control reference - MIL-STD 810G Category 24 random vibration

Control Reference			
Acceleration	7.699 g rms		
Velocity	0.071 m/s rms		
Displacement	0.350 mm rms		
Break point PSD			
No.	Frequency (Hz)	Level/Slope	
1	20.00	4.000e-2	g2/Hz
2	1000.00	4.000e-2	g2/Hz
3	2000.00	-6.00	dB/octave
Tolerance			
Abort upper (dB)		Abort lower (dB)	Abort A.B.W. (Hz)
Alarm upper (dB)	Alarm lower (dB)	Alarm A.B.W. (Hz)	
-3.00	6.00	0.00	-6.00
			0.00
			3.00
Extended tolerance (0 items)			

Table 18: Vibration test status – IEC60068-2-6 Sine vibration operational (VCCR300-24)

	Vertical axis	Longitudinal axis	Transverse axis
Start	25/07/2023 13:25:00	27/07/2023 08:53:46	31/07/2023 13:09:09
End	25/07/2023 15:18:03	27/07/2023 10:46:50	31/07/2023 15:02:13
Status	Excitation is completed. (Test time is completed.)	Excitation is completed. (Test time is completed.)	Excitation is completed. (Test time is completed.)
Reference	2.0 g 0-p	2.0 g 0-p	2.0 g 0-p
Response	1.9996 g 0-p	1.9998 g 0-p	1.9994 g 0-p
Elapsed time	01:52:54	01:52:55	01:52:55
Alarm	OK	OK	OK
Abort	OK	OK	OK

Table 19: Vibration test status – IEC60068-2-6 Sine vibration operational (VCCR300-36)

	Vertical axis	Longitudinal axis	Transverse axis
Start	25/07/2023 16:22:46	26/07/2023 17:06:07	31/07/2023 15:14:48
End	25/07/2023 18:15:51	26/07/2023 18:59:11	31/07/2023 17:07:52
Status	Excitation is completed. (Test time is completed.)	Excitation is completed. (Test time is completed.)	Excitation is completed. (Test time is completed.)
Reference	2.0 g 0-p	2.0 g 0-p	2.0 g 0-p
Response	1.9994 g 0-p	1.9997 g 0-p	1.9998 g 0-p
Elapsed time	01:52:54	01:52:54	01:52:55
Alarm	OK	OK	OK
Abort	OK	OK	OK

Table 20: Test control reference - IEC60068-2-6 Sine vibration operational

Control Reference	
Sweep mode	Log
Sweep direction	Forward-double
Sweep rate	1.0 octave/min [5.644min/single-sweep]
Sweep pause time	0:00:00
Test time	By double sweep counts 10 double-sweep
Internal record	Normal
Manual	Not operate
Sweep profile	
Frequency range	10.00 <==> 500.00 Hz
Acc.	2.0 g 0-p (10.00 <==> 500.00 Hz)
Tolerance	
	Abort Alarm
Upper limit	6.00 dB 3.00 dB
Lower limit	[-6.00 dB] [-3.00 dB]
Sweep rate segment	None

Table 21: Vibration test status - IEC60068-2-64 Random operational

	Vertical axis	Longitudinal axis	Transverse axis
Start	26/07/2023 08:51:14	28/07/2023 14:46:58	02/08/2023 09:02:47
End	26/07/2023 09:22:21	28/07/2023 15:17:51	02/08/2023 09:33:34
Status	Excitation is completed. (Test time is completed.)	Excitation is completed. (Test time is completed.)	Excitation is completed. (Test time is completed.)
Reference	2.4605 g rms	2.4605 g rms	2.4605 g rms
Response	2.4676 g rms	2.4682 g rms	2.4707 g rms
Elapsed time	00:30:00	00:30:00	00:30:00
Alarm	OK	OK	OK
Abort	OK	OK	OK

Table 22: Test control reference - IEC60068-2-64 Random operational

Control Reference	
Acceleration	2.461 g rms
Velocity	0.084 m/s rms
Displacement	1.847 mm rms
Break point PSD	
No.	Frequency (Hz) Level/Slope
1	5.00 1.220e-2 g ² /Hz
2	500.00 1.220e-2 g ² /Hz
Tolerance	
Abort upper (dB) Abort lower (dB) Abort A.B.W. (Hz) Alarm upper (dB) Alarm lower (dB) Alarm A.B.W. (Hz)	
-3.00	6.00 0.00 -6.00 0.00 3.00
Extended tolerance (0 items)	

 <p>Resonate TESTING LIMITED A NACELLE GROUP COMPANY</p>	<p>Test Report</p> <h1>Vibration and shock</h1>	<p>Record No: RTL00535 D0017 Rev No: 1 2023-08-11 Document Status: Approved</p>
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Table 23: Vibration test status - IEC60068-2-64 Random non-operational

	Vertical axis	Longitudinal axis	Transverse axis
Start	26/07/2023 09:29:54	28/07/2023 15:22:20	02/08/2023 09:37:57
End	26/07/2023 10:00:37	28/07/2023 15:53:09	02/08/2023 10:08:46
Status	Excitation is completed. (Test time is completed.)	Excitation is completed. (Test time is completed.)	Excitation is completed. (Test time is completed.)
Reference	3.1504 g rms	3.1504 g rms	3.1504 g rms
Response	3.1383 g rms	3.1657 g rms	3.1673 g rms
Elapsed time	00:30:00	00:30:00	00:30:00
Alarm	OK	OK	OK
Abort	OK	OK	OK

Table 24: Test control reference - IEC60068-2-64 Random non-operational

Control Reference			
Acceleration	3.150 g rms		
Velocity	0.108 m/s rms		
Displacement	2.365 mm rms		
Break point PSD			
No.	Frequency (Hz)	Level/Slope	
1	5.00	2.000e-2	g ² /Hz
2	500.00	2.000e-2	g ² /Hz
Tolerance			
Abort upper (dB) Abort lower (dB) Abort A.B.W. (Hz) Alarm upper (dB) Alarm lower (dB) Alarm A.B.W. (Hz)			
-3.00	6.00	-6.00	0.00 3.00
Extended tolerance (0 items)			

Table 25: Test status - IEC60068-2-27 Shock operational

	Vertical axis	Longitudinal axis	Transverse axis
Start	26/07/2023 10:10:36	28/07/2023 16:03:59	02/08/2023 10:34:00
End	26/07/2023 10:13:18	28/07/2023 16:06:04	02/08/2023 10:36:04
Status	Excitation is completed. (Test time is completed.)	Excitation is completed. (Test time is completed.)	Excitation is completed. (Test time is completed.)
Reference	+/- 30.0 g	+/- 30.0 g	+/- 30.0 g
Alarm	OK	OK	OK
Abort	OK	OK	OK

Table 26: Test control reference - IEC60068-2-27Shock operational

Reference		
Reference waveform type	Classical Shock	
Waveform type	Half-sine	
Sampling frequency	2048.00 Hz	
Peak amplitude	30.0 g	
Pulse width	18.0 ms	
Pulse position	0.0 %	
Rest time:Pre-pulse	0.0 ms	
Rest time:Post-pulse	0.0 ms	
Tolerance type	IEC (JIS C) 60068-2-27	
Compensation wave	Asymmetry	
Compensation wave type	Type4	
Peak level:Pre-pulse	90.0 %	
Peak level:Post-pulse	90.0 %	
Total length	249.5117 ms (512 points)	
	Min.	Max.
Acceleration	-4.9097 g	30.0 g
Velocity	-1.6761 m/s	1.6760 m/s
Displacement	-21.9060 mm	18.5431 mm

Table 27: Test status - IEC60068-2-27 Shock non-operational

	Vertical axis	Longitudinal axis	Transverse axis
Start	26/07/2023 10:10:36	28/07/2023 16:11:53	02/08/2023 10:41:28
End	26/07/2023 10:13:18	28/07/2023 16:13:53	02/08/2023 10:43:25
Status	Excitation is completed. (Test time is completed.)	Excitation is completed. (Test time is completed.)	Excitation is completed. (Test time is completed.)
Reference	+/- 50.0 g	+/- 50.0 g	+/- 50.0 g
Alarm	OK	OK	OK
Abort	OK	OK	OK

Table 28: Test control reference - IEC60068-2-27 Shock non-operational

Reference		
Reference waveform type	Classical Shock	
Waveform type	Half-sine	
Sampling frequency	2560.00 Hz	
Peak amplitude	50.0 g	
Pulse width	11.0 ms	
Pulse position	0.0 %	
Rest time:Pre-pulse	0.0 ms	
Rest time:Post-pulse	0.0 ms	
Tolerance type	IEC (JIS C) 60068-2-27	
Compensation wave	Asymmetry	
Compensation wave type	Type4	
Peak level:Pre-pulse	90.0 %	
Peak level:Post-pulse	90.0 %	
Total length	199.6094 ms (512 points)	
	Min.	Max.
Acceleration	-8.2020 g	50.0 g
Velocity	-1.7142 m/s	1.7140 m/s
Displacement	-13.2874 mm	12.4265 mm

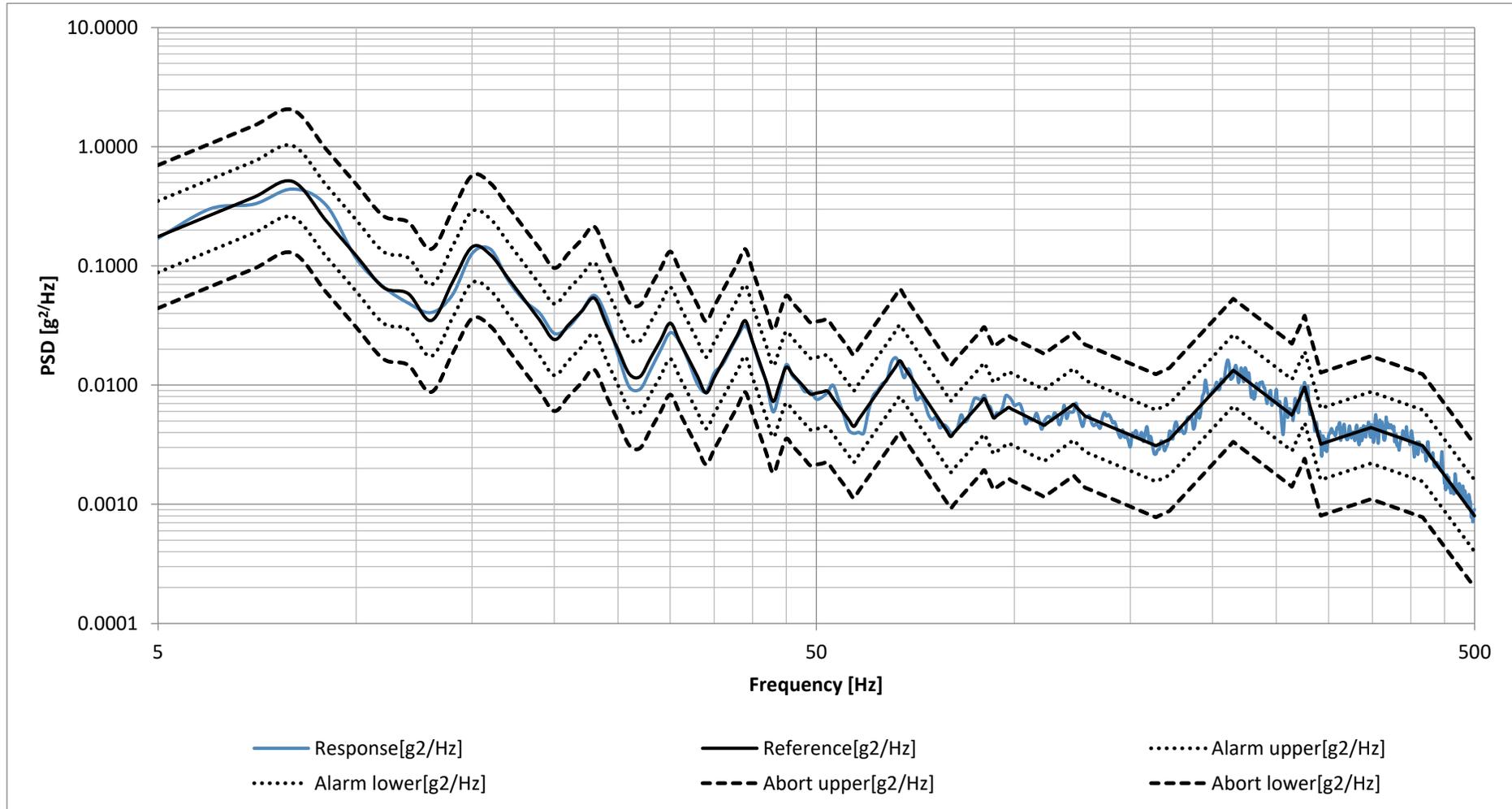


Figure 12: Vertical axis MIL-STD 810G category 4 random vibration

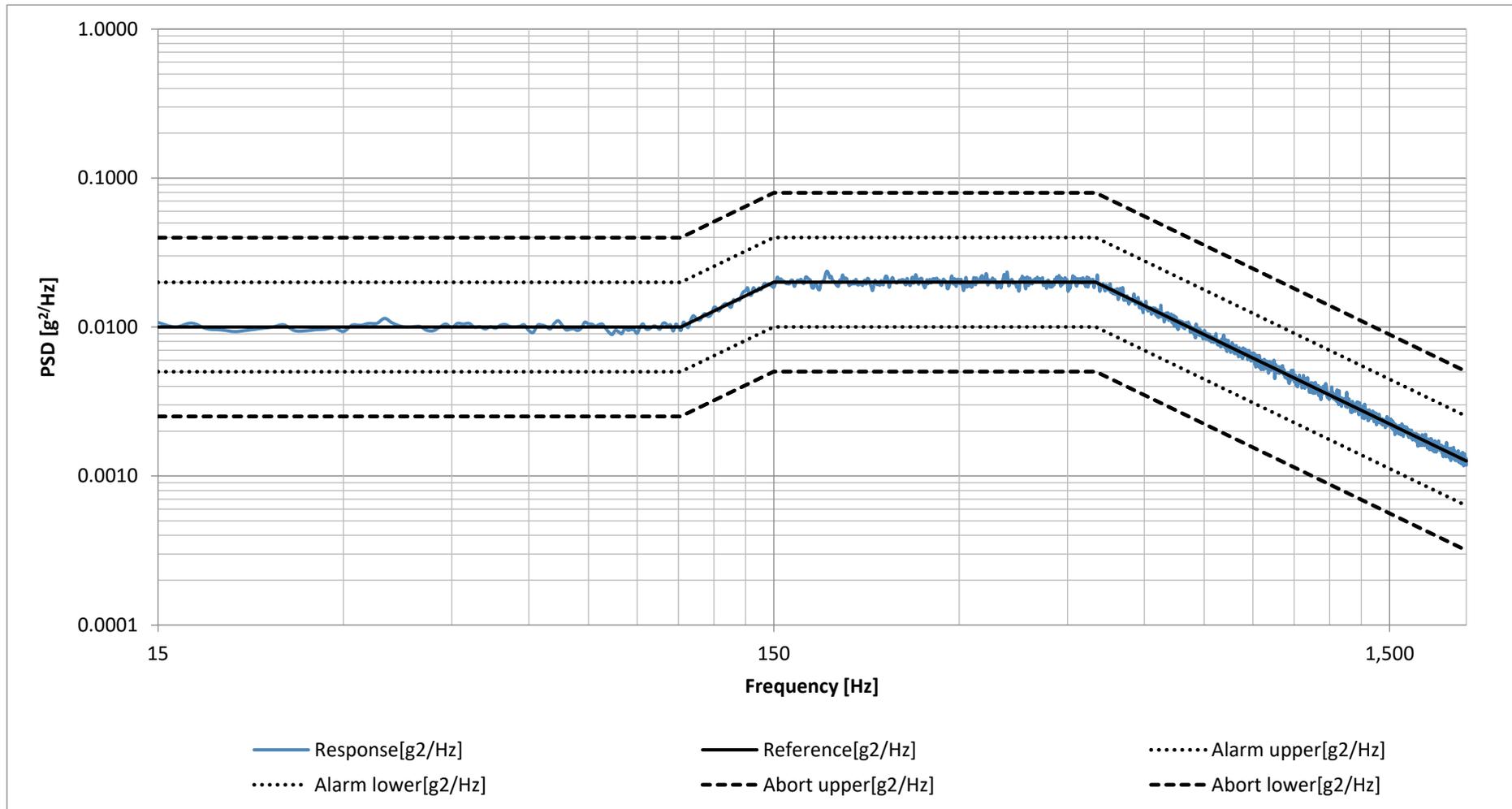


Figure 13: Vertical axis MIL-STD 810G category 7 random vibration

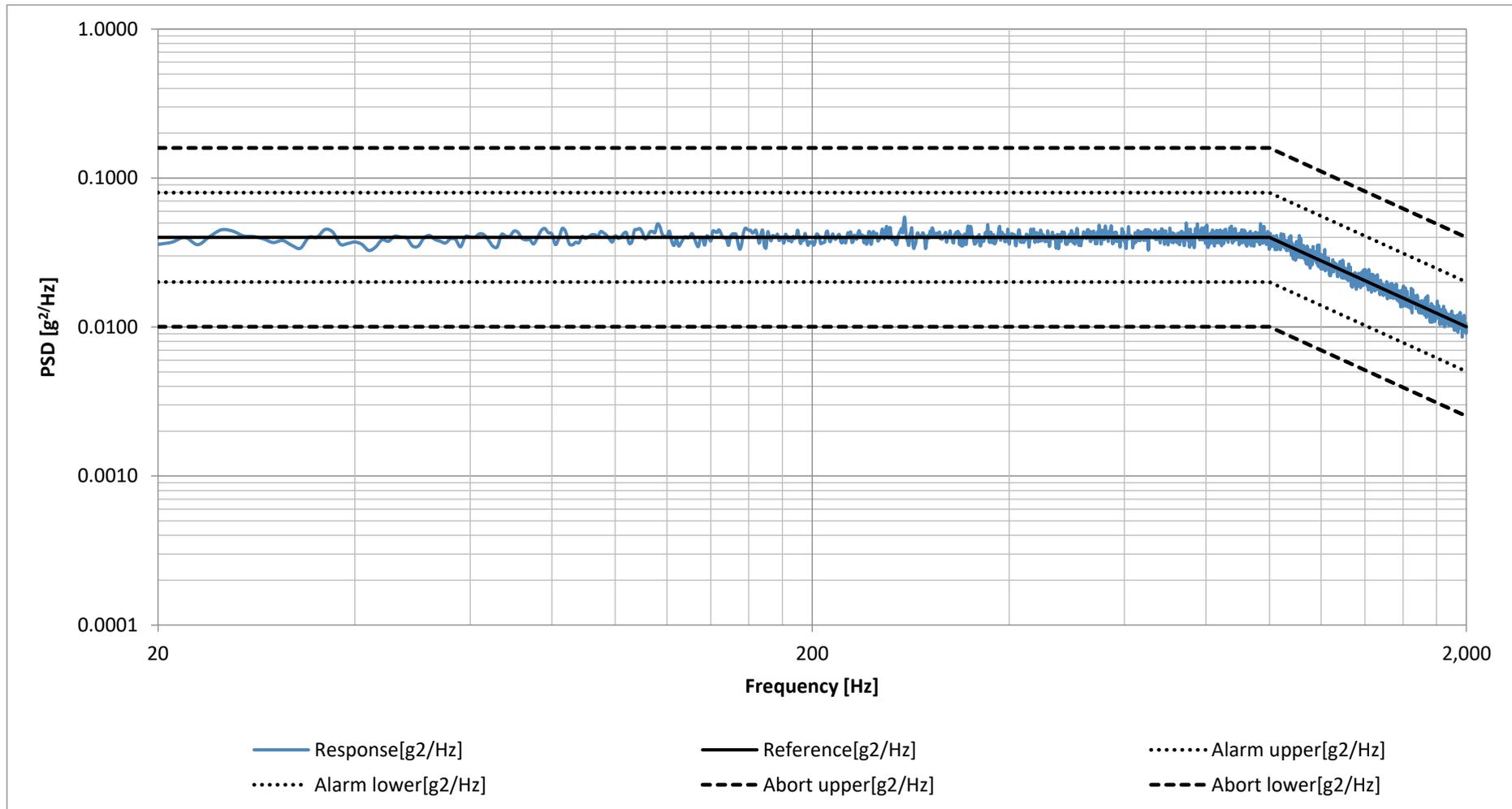


Figure 14: Vertical axis MIL-STD 810G category 24 random vibration

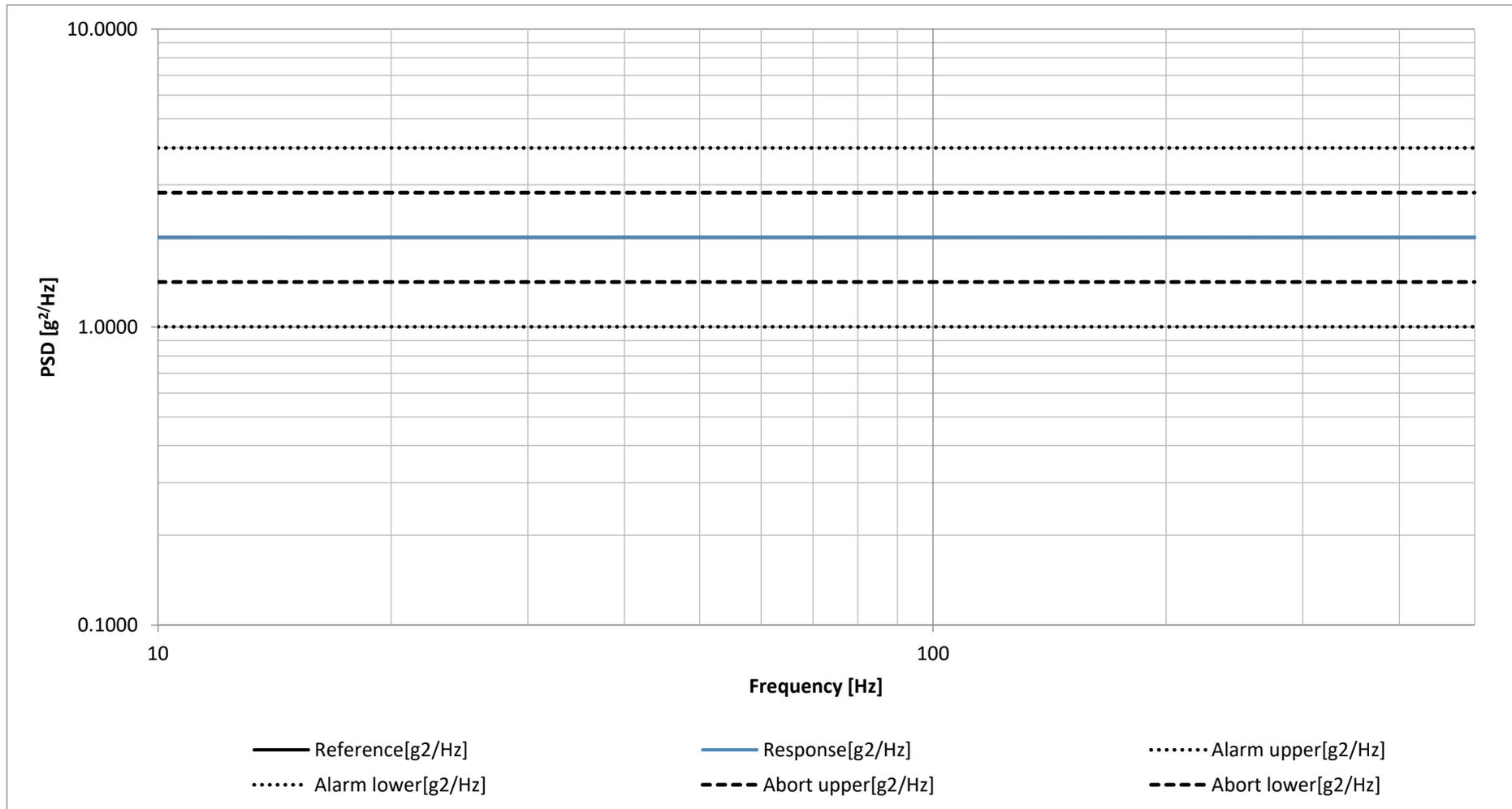


Figure 15: Vertical axis IEC60068-2-6 sine vibration operational (VCCR300-24)

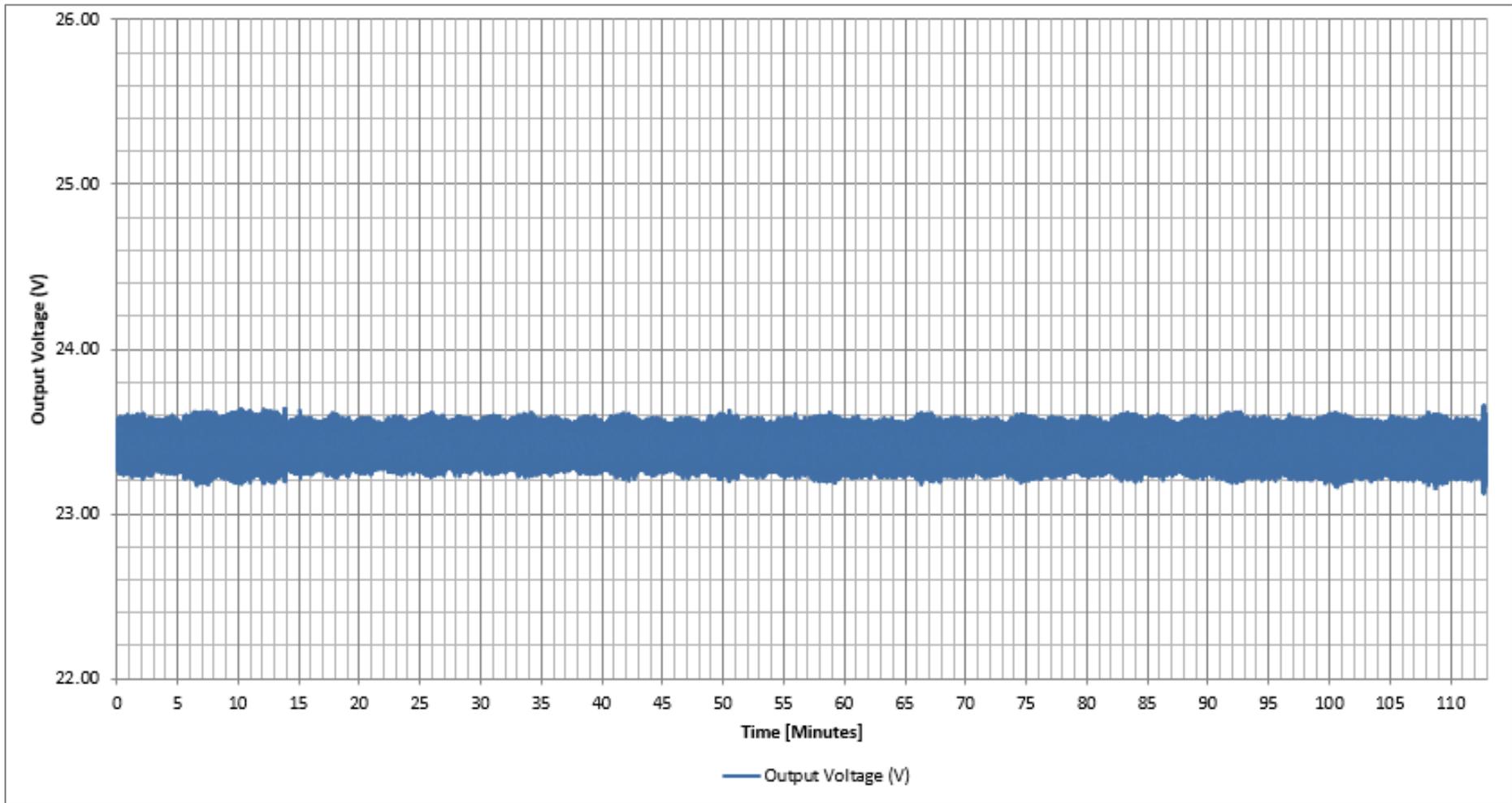


Figure 16: Output voltage during vertical sine vibration (VCCR300-24)

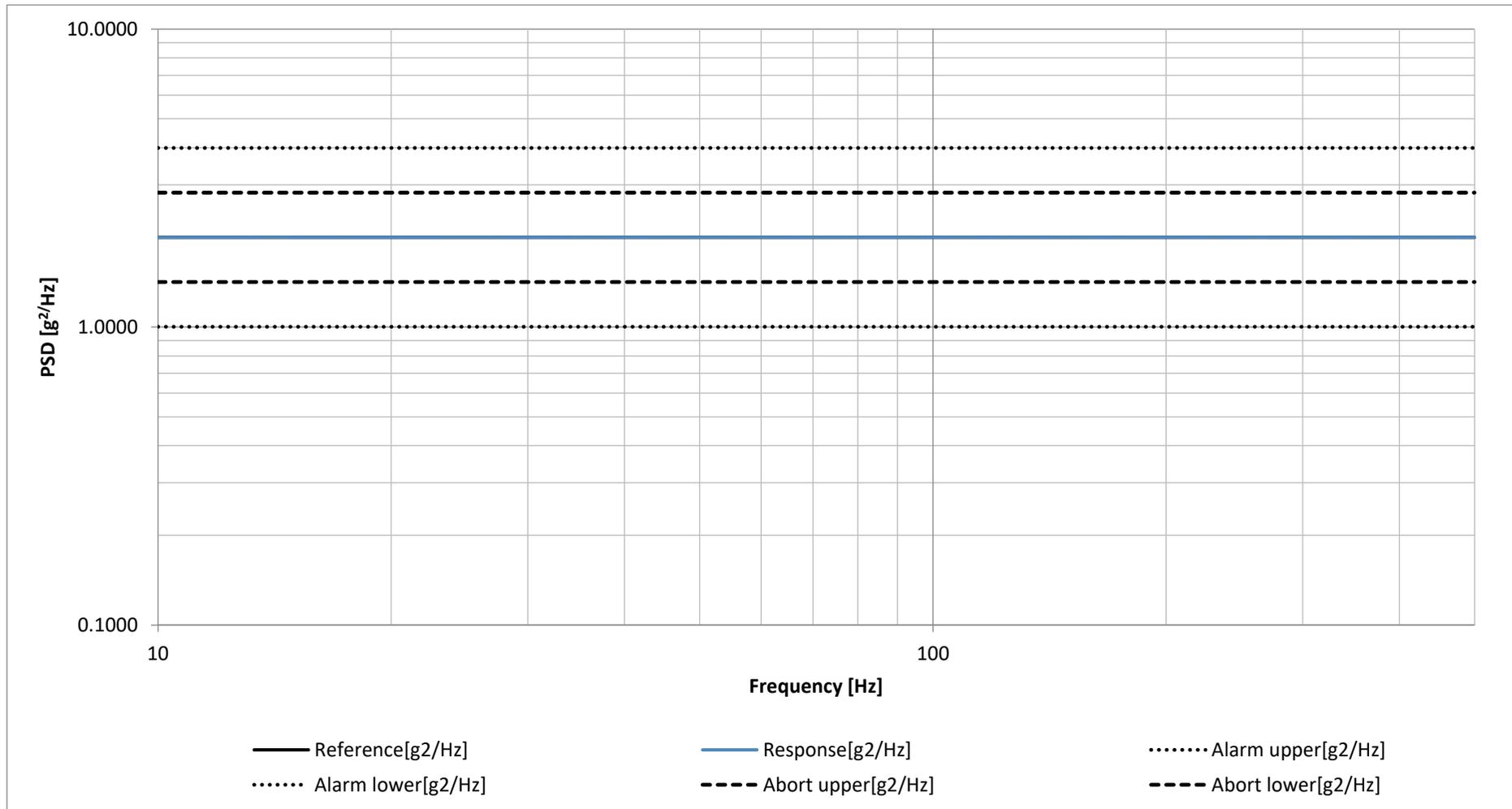


Figure 17: Vertical axis IEC60068-2-6 sine vibration operational (VCCR300-36)

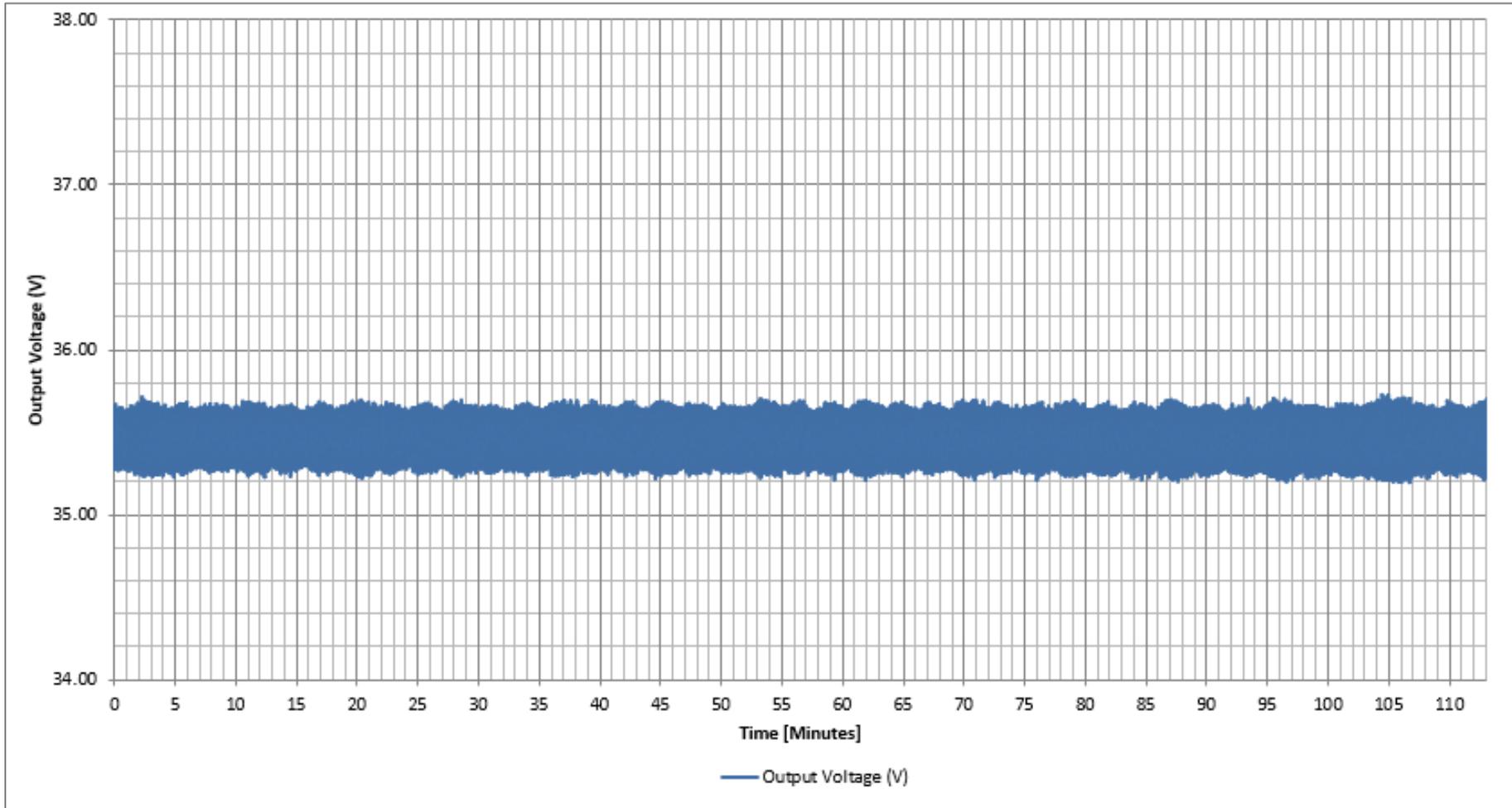


Figure 18: Output voltage during vertical sine vibration (VCCR300-36)

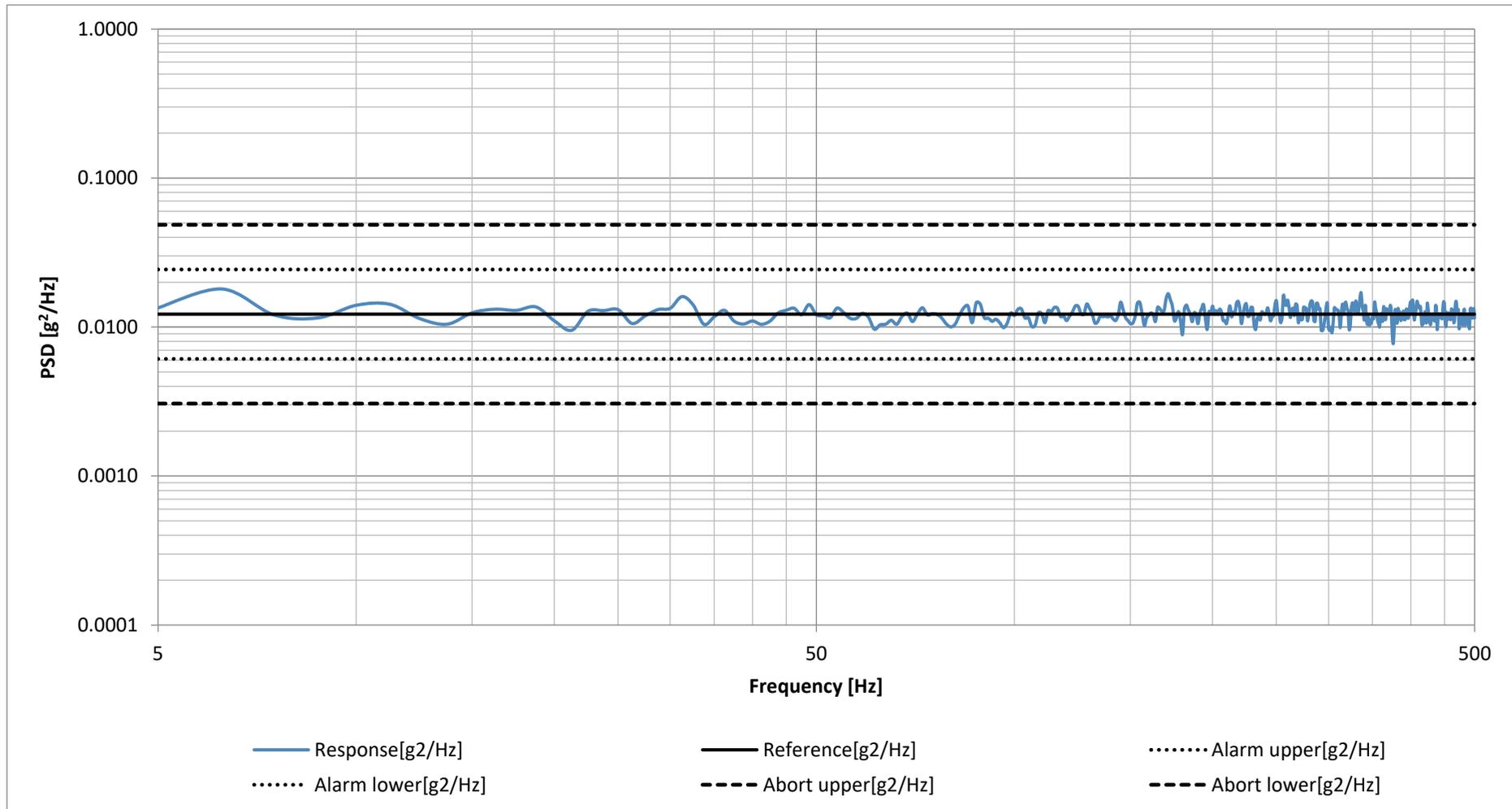


Figure 19: Vertical axis IEC60068-2-64 random operational

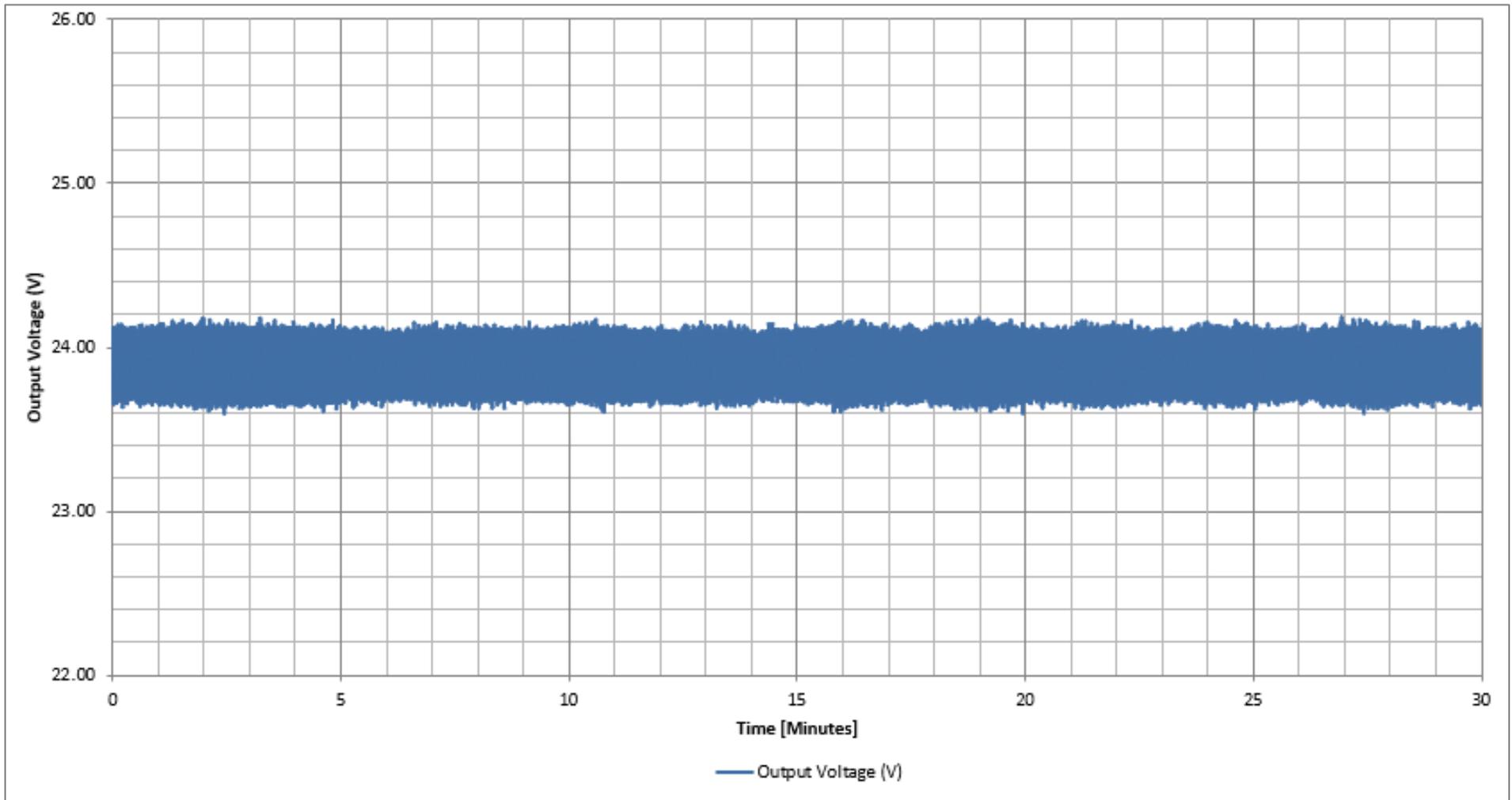


Figure 20: Output voltage during vertical axis IEC60068-2-64 random operational (VCCR300-24)

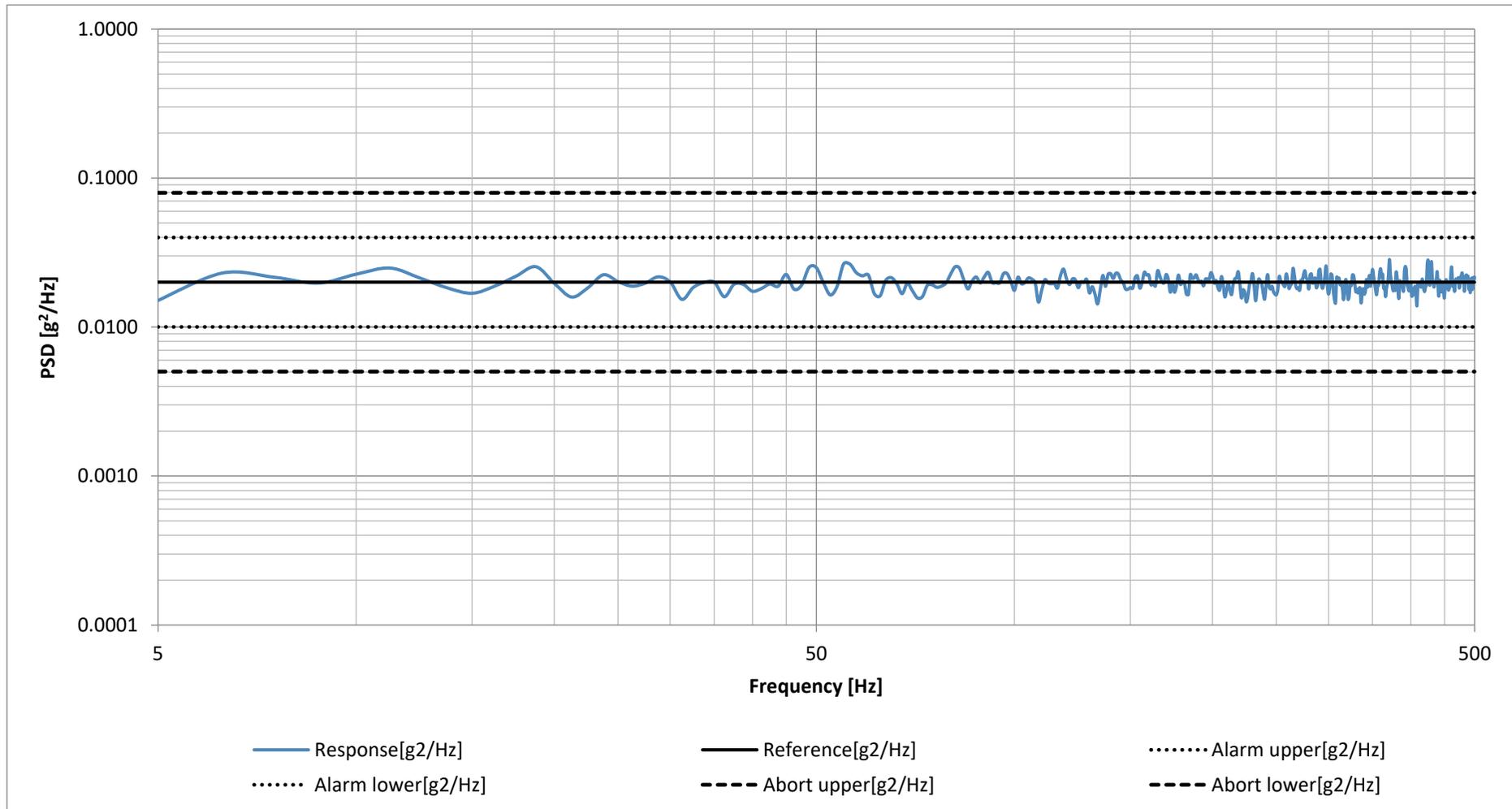


Figure 21: Vertical axis IEC60068-2-64 random non-operational

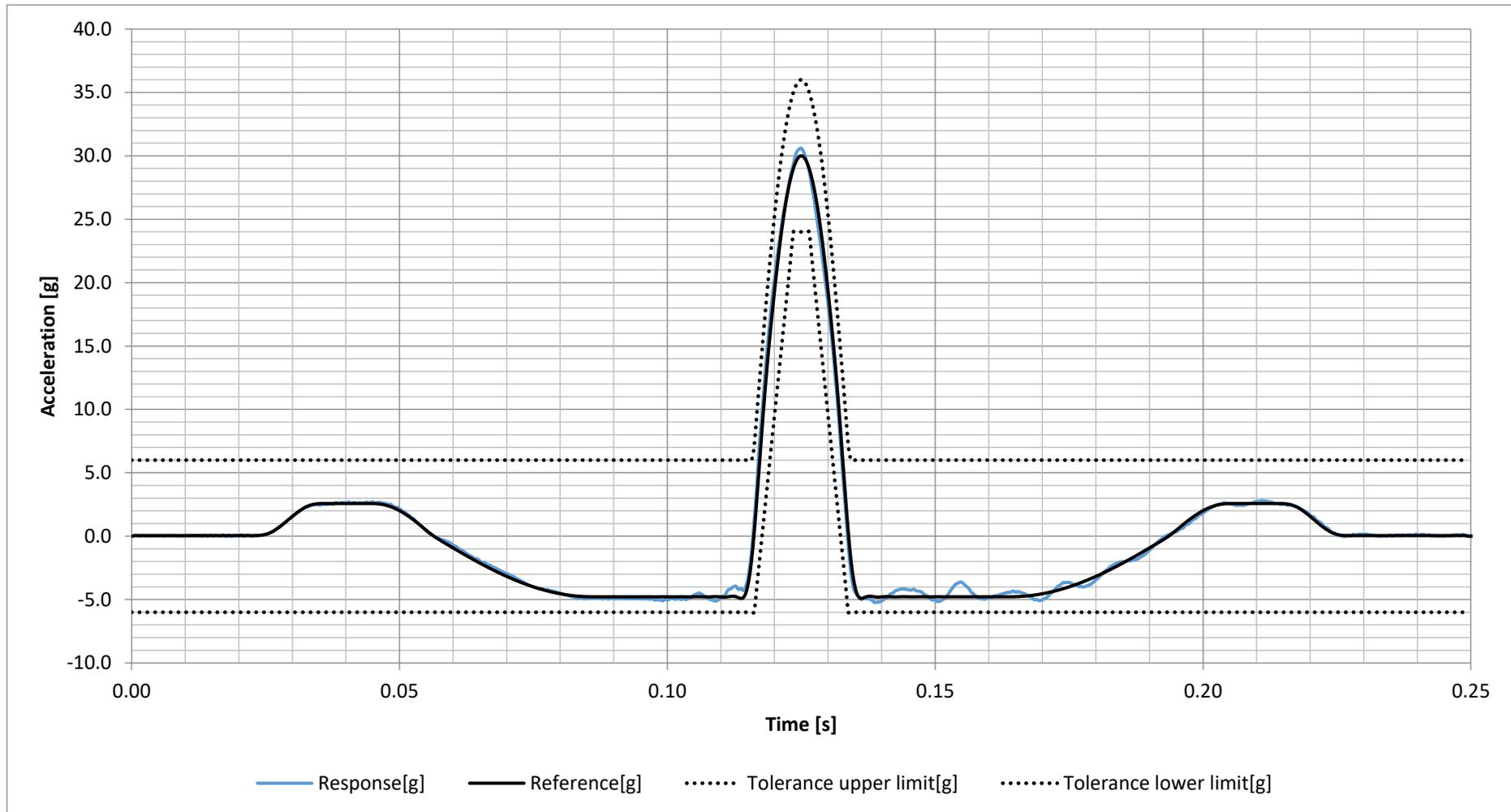


Figure 22: Operational IEC60068-2-27 positive shock test response - Shock 1 of 6 – Vertical axis

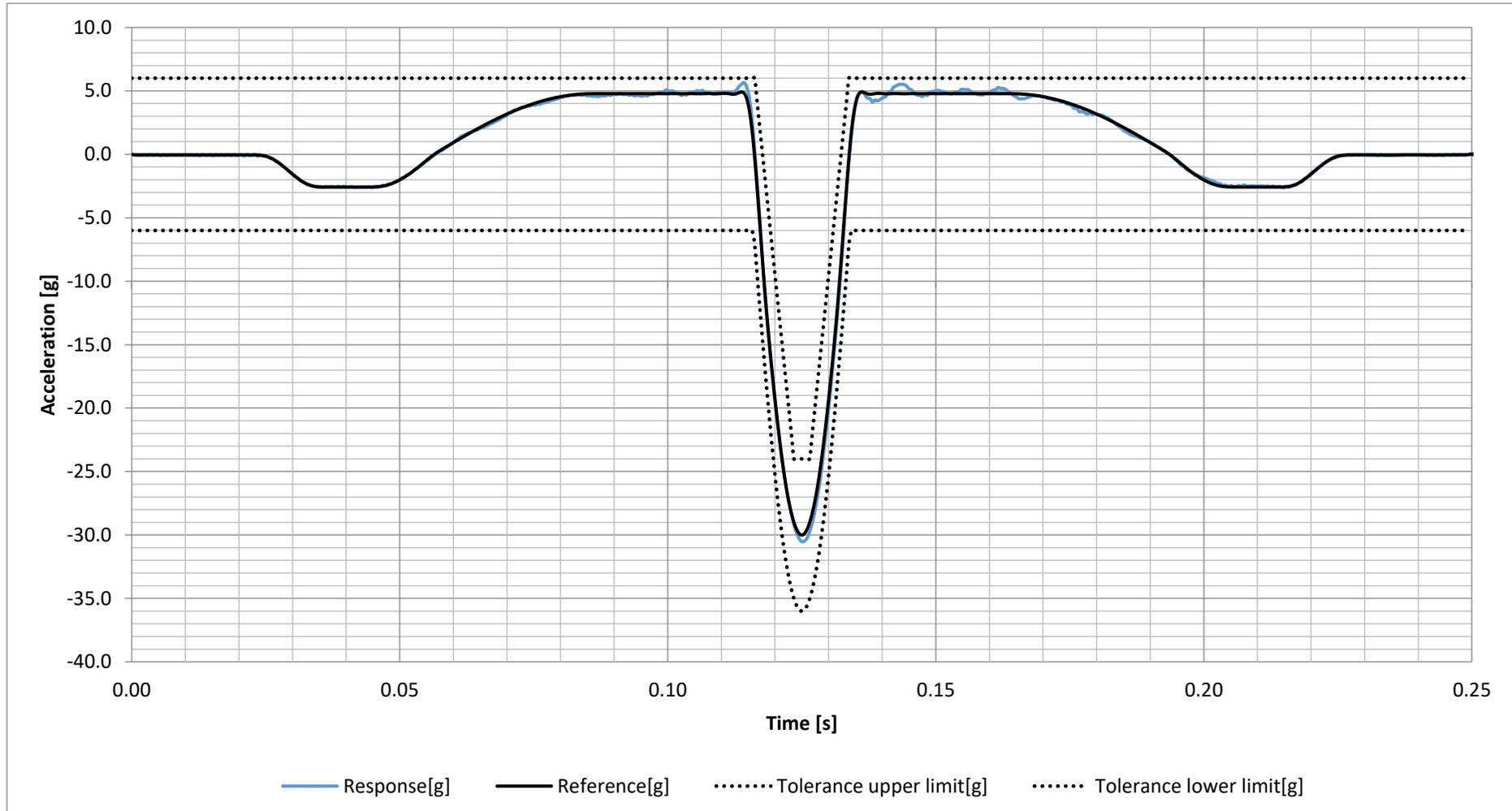


Figure 23: Operational IEC60068-2-27 negative shock test response - Shock 6 of 6 – Vertical axis

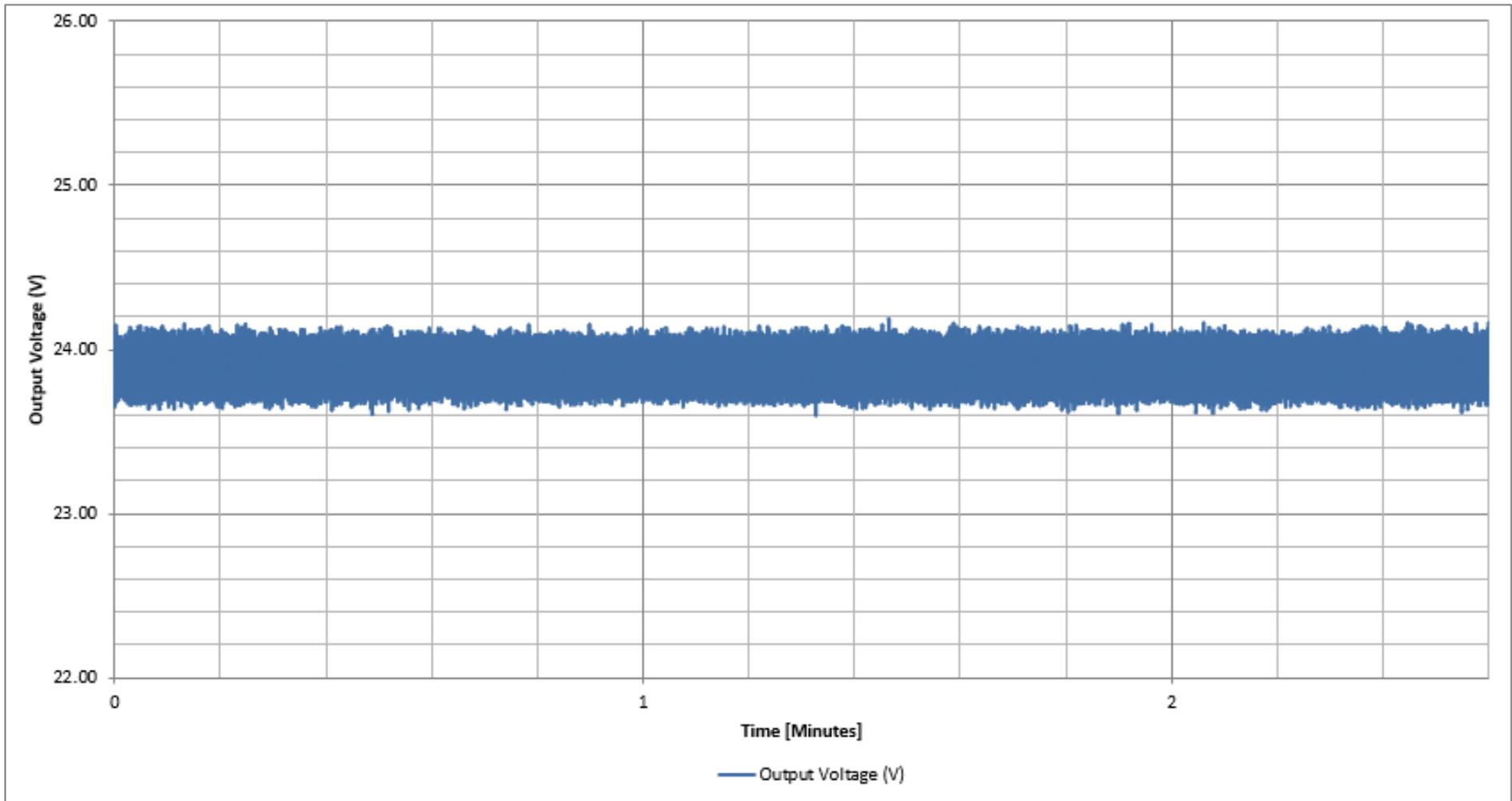


Figure 24: Output voltage during vertical axis IEC60068-6-27 shock operational (VCCR300-24)

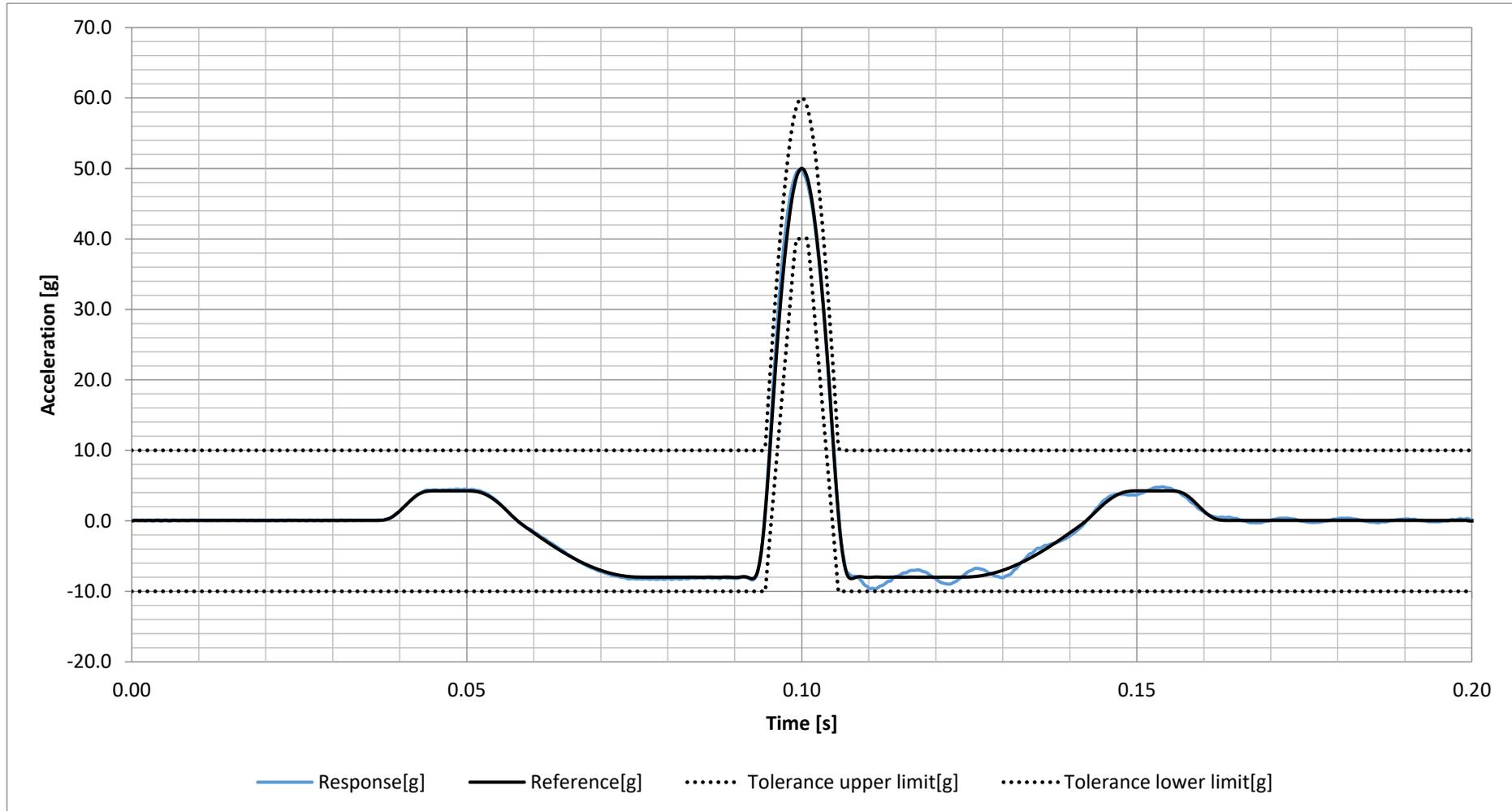


Figure 25: Non-operational IEC60068-2-27 positive shock test response - Shock 1 of 6 – Vertical axis

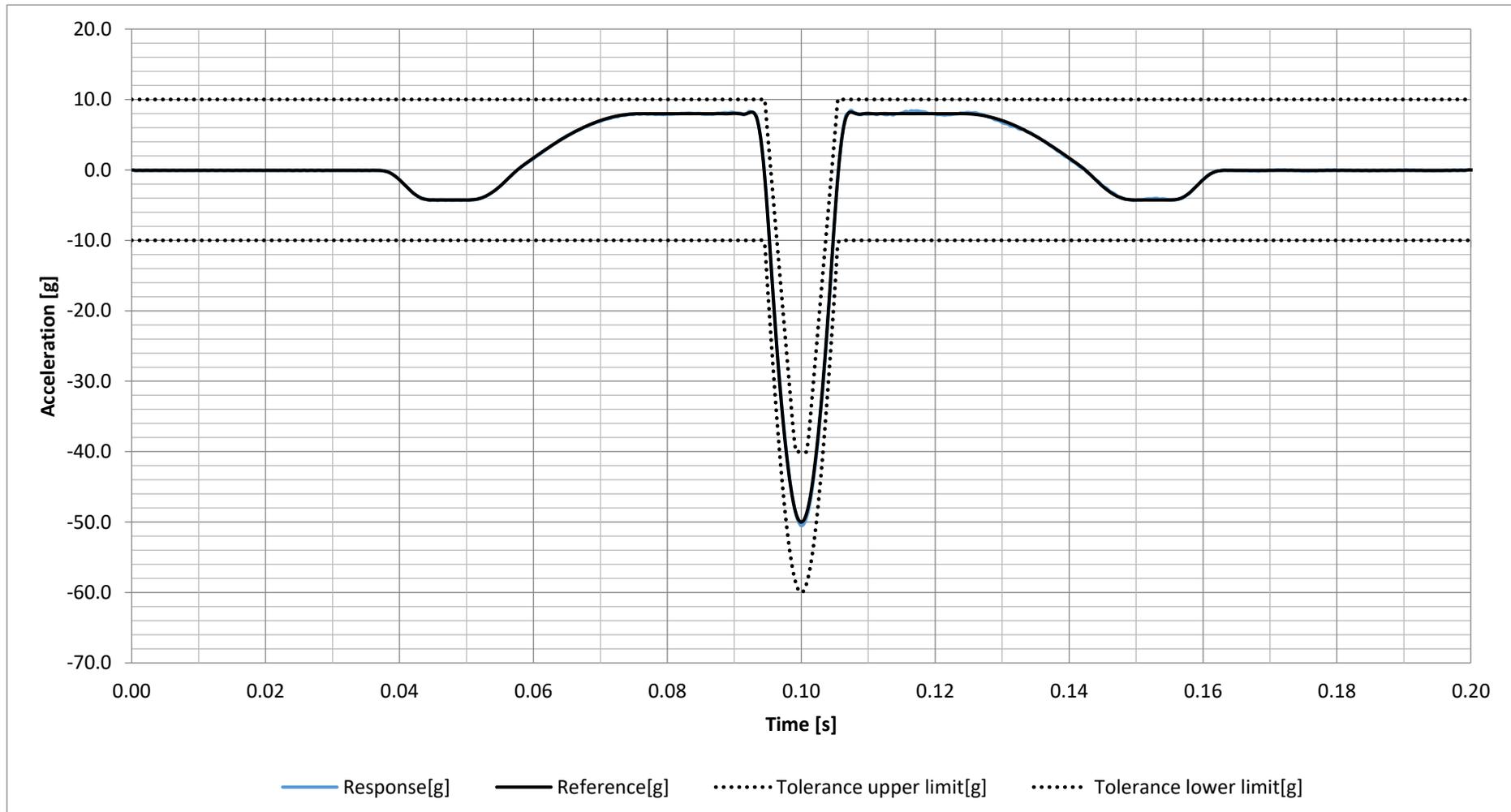


Figure 26: Non-operational IEC60068-2-27 negative shock test response - Shock 6 of 6 – Vertical axis

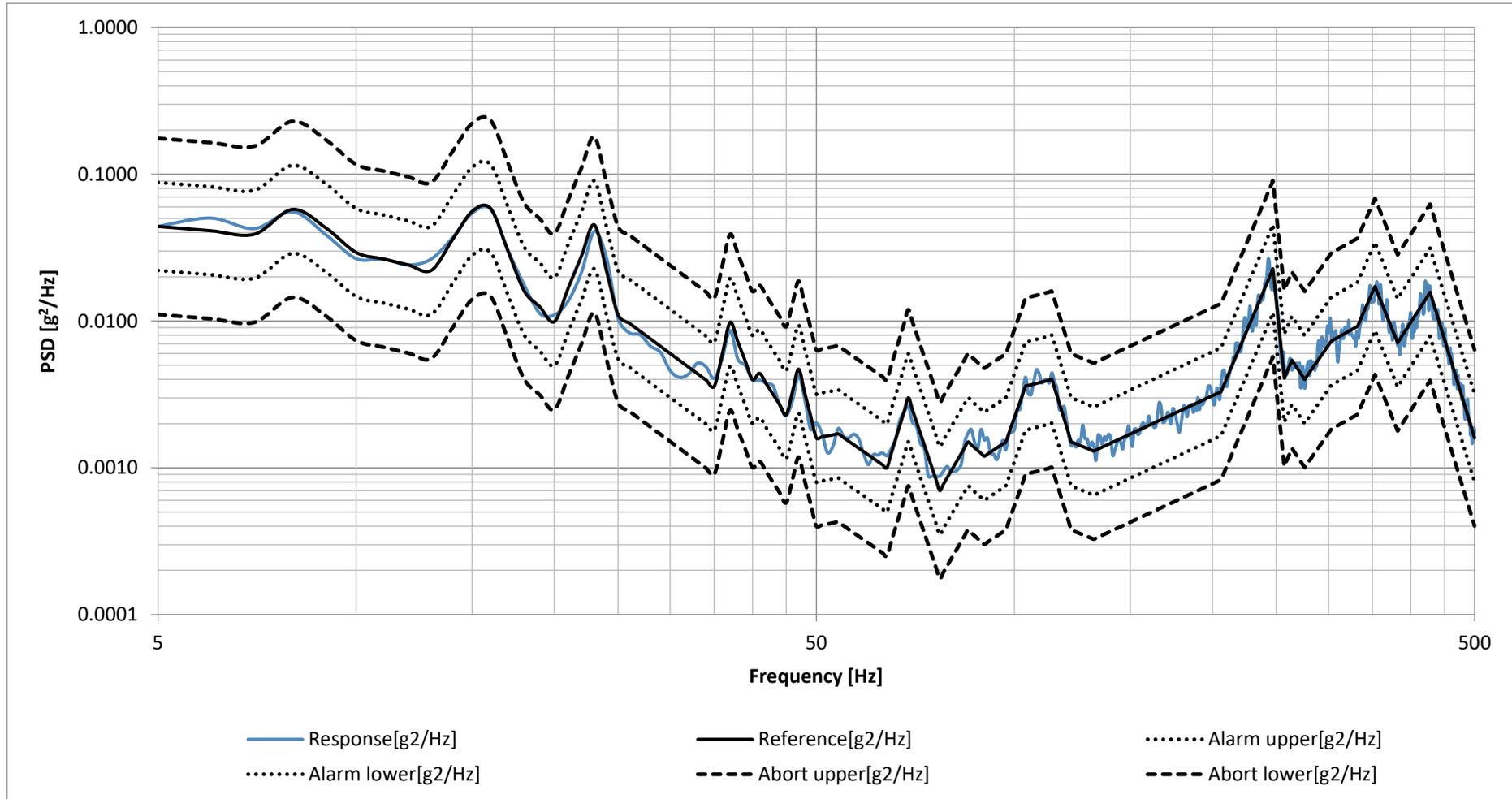


Figure 27: Longitudinal axis MIL-STD 810G category 4 random vibration

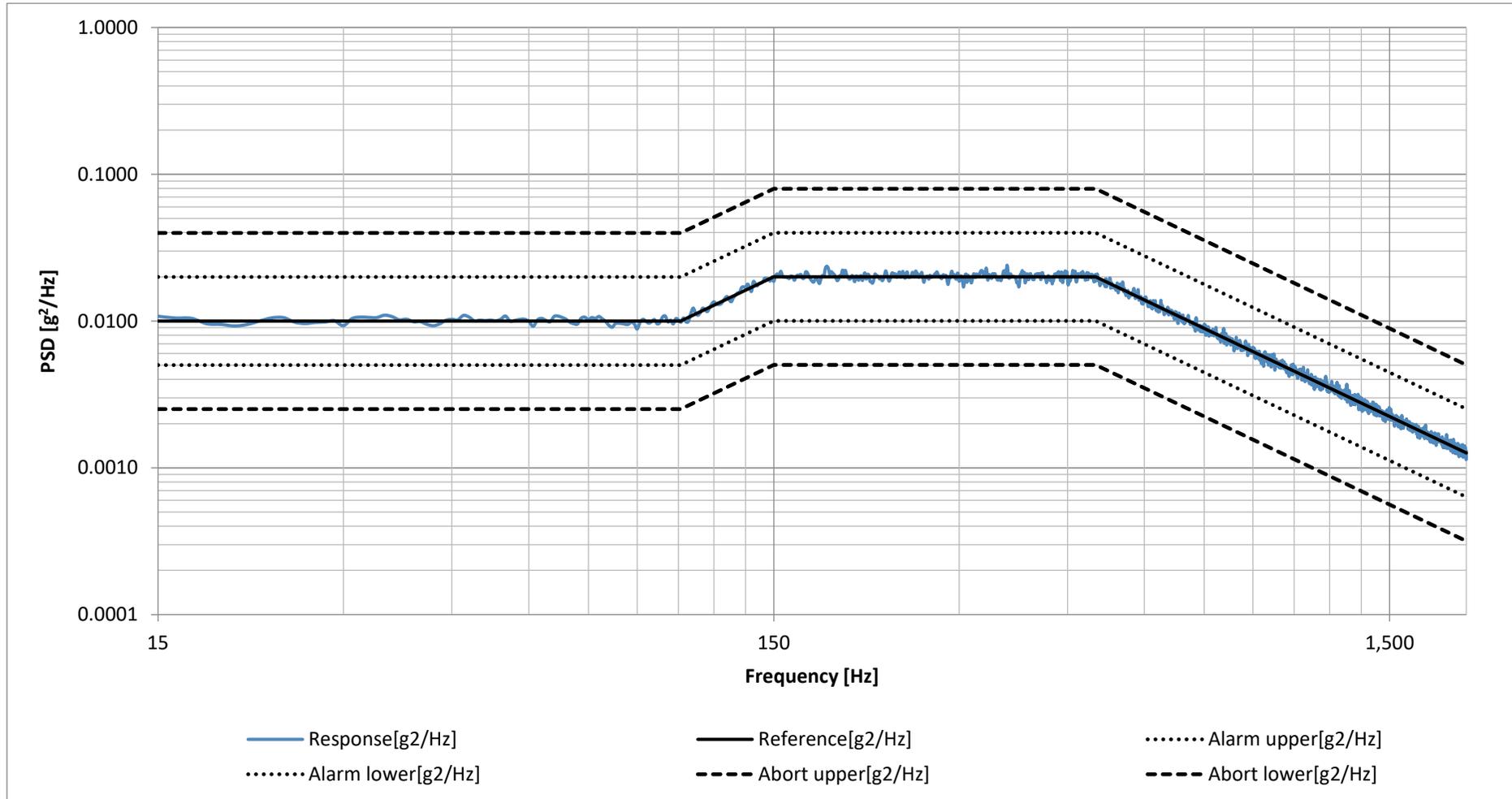


Figure 28: Longitudinal axis MIL-STD 810G category 7 random vibration

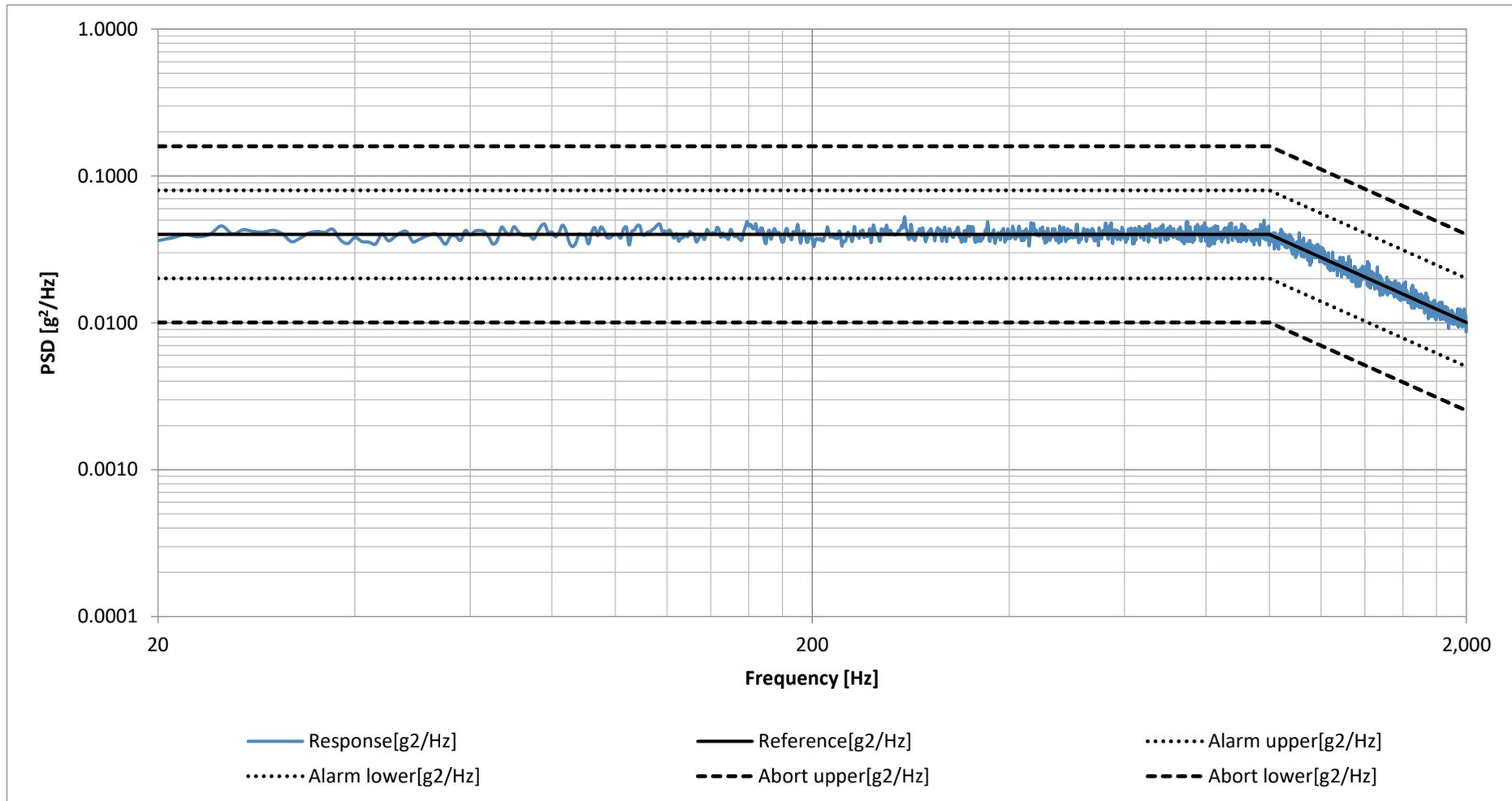


Figure 29: Longitudinal axis MIL-STD 810G category 24 random vibration

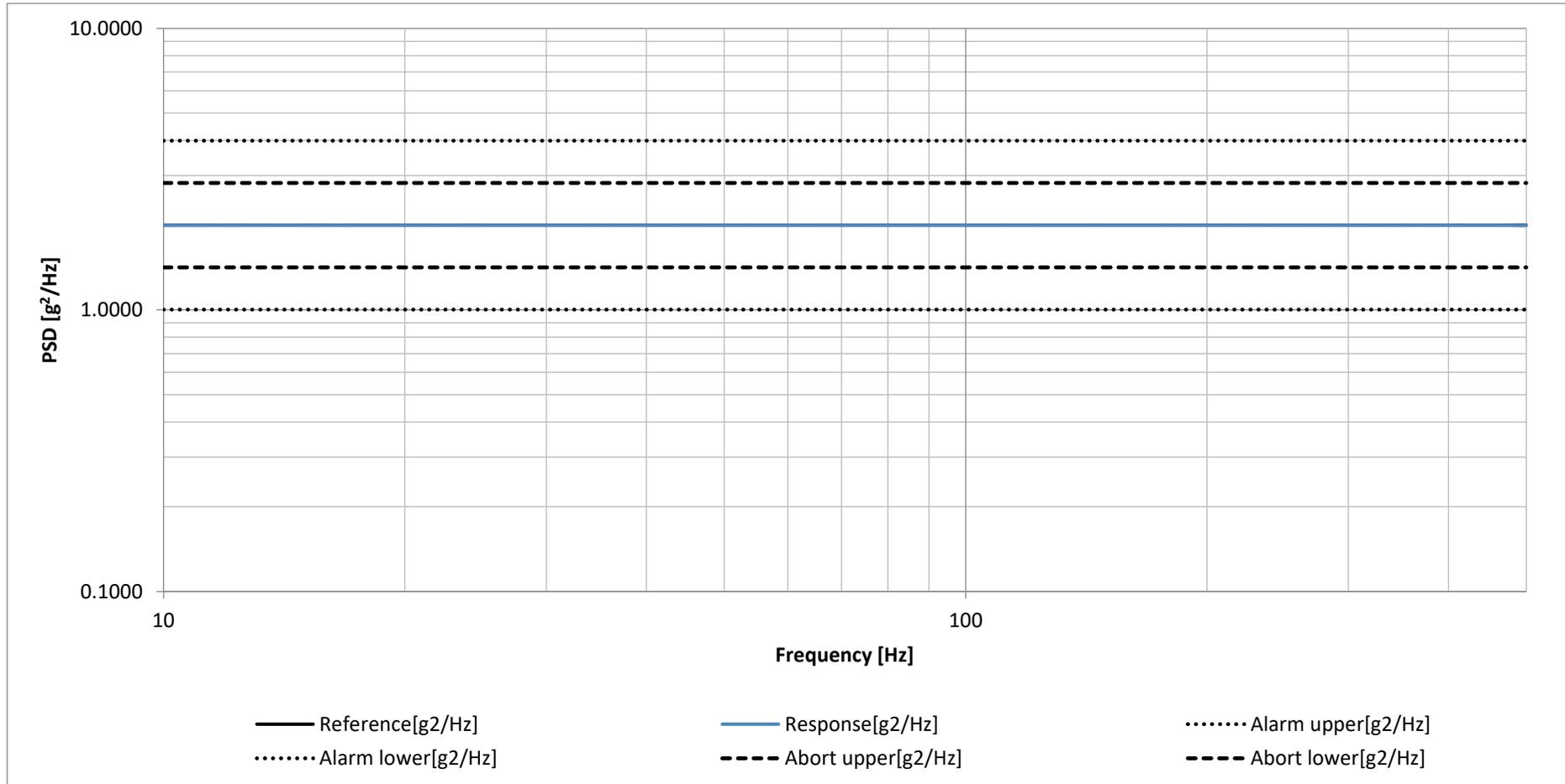


Figure 30: Longitudinal axis IEC60068-2-6 sine vibration operational (VCCR300-24)

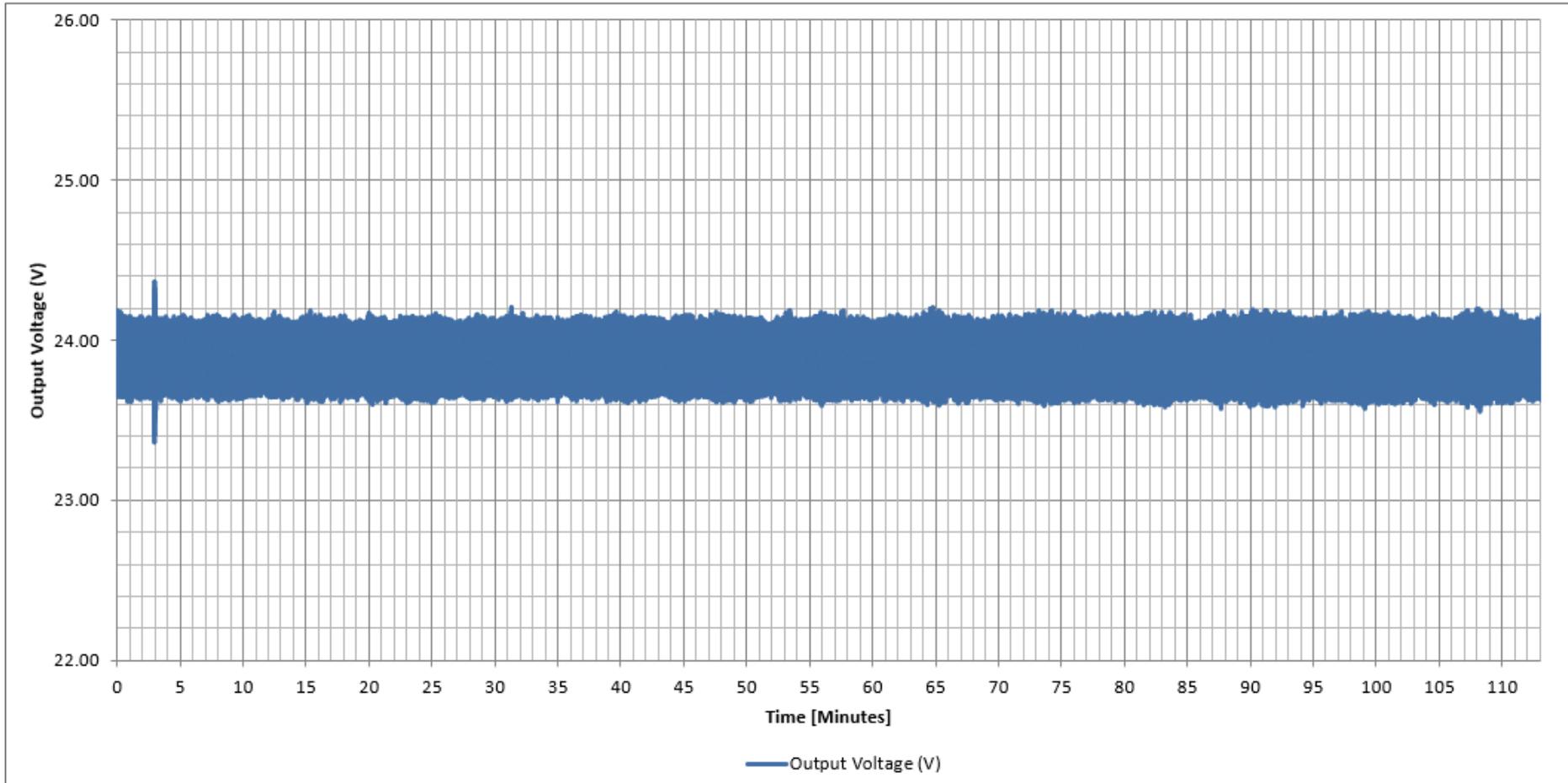


Figure 31: Output voltage during longitudinal sine vibration (VCCR300-24)

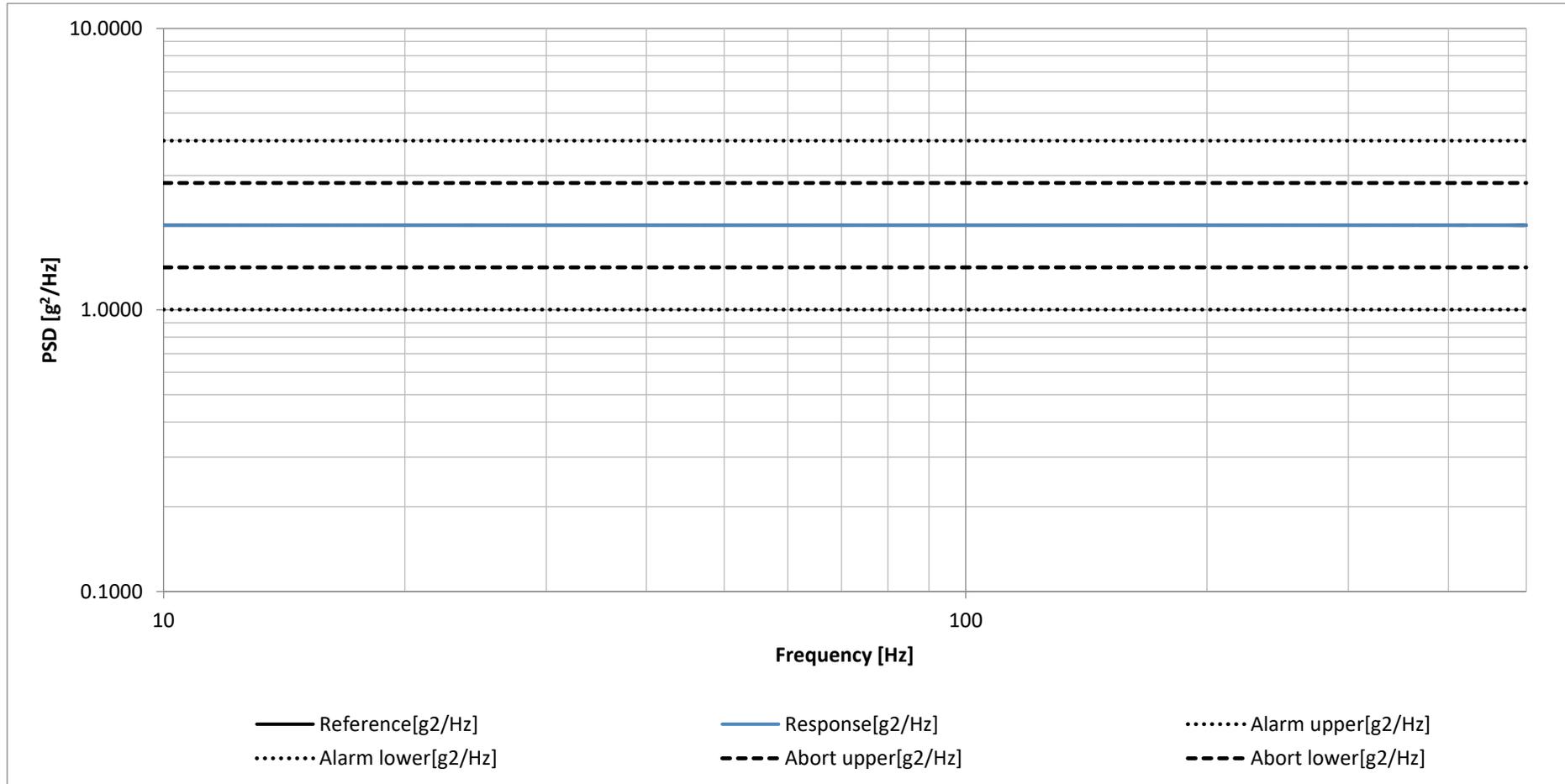


Figure 32: Longitudinal axis IEC60068-2-6 sine vibration operational (VCCR300-36)

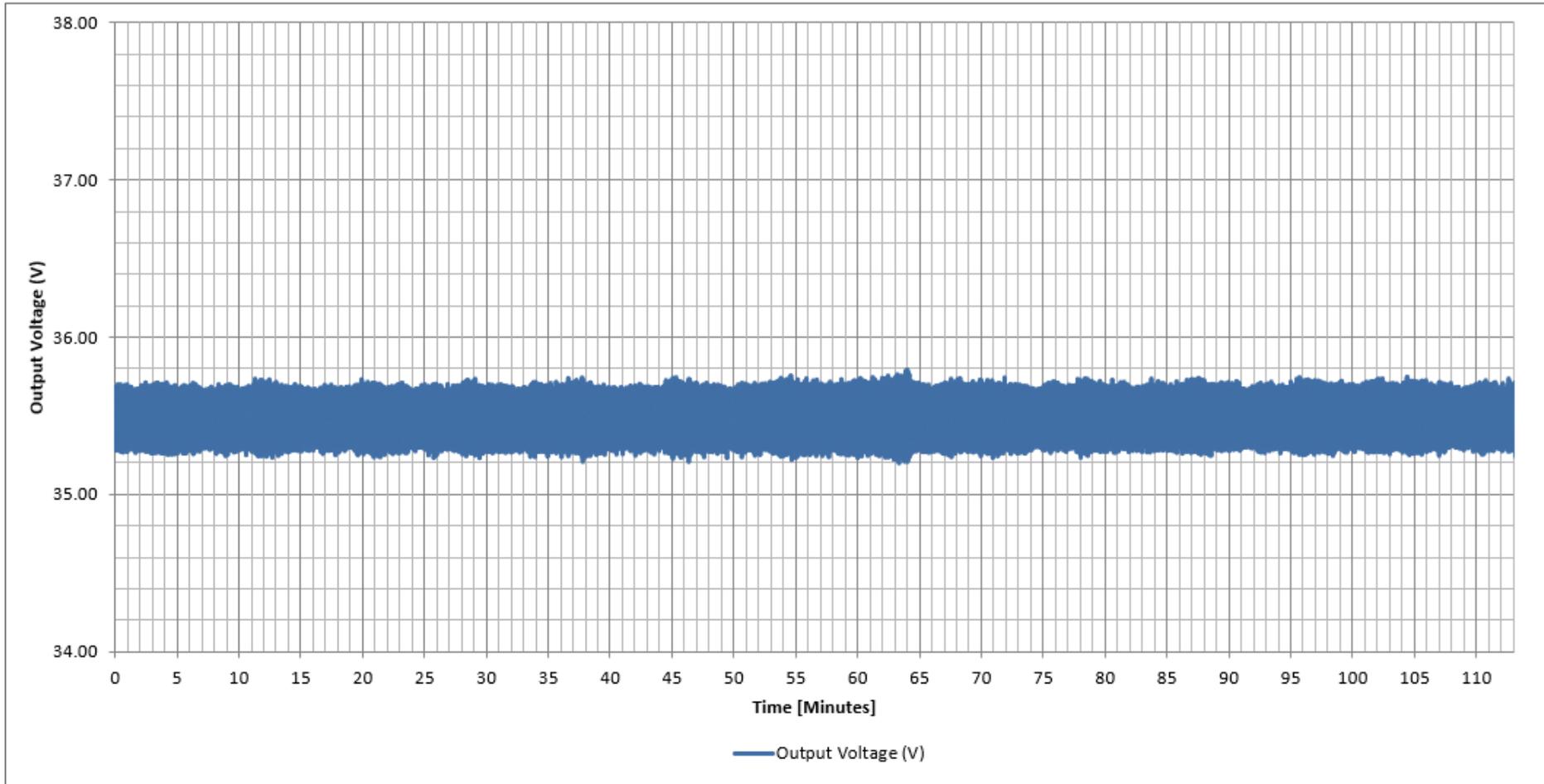


Figure 33: Output voltage during longitudinal sine vibration (VCCR300-36)

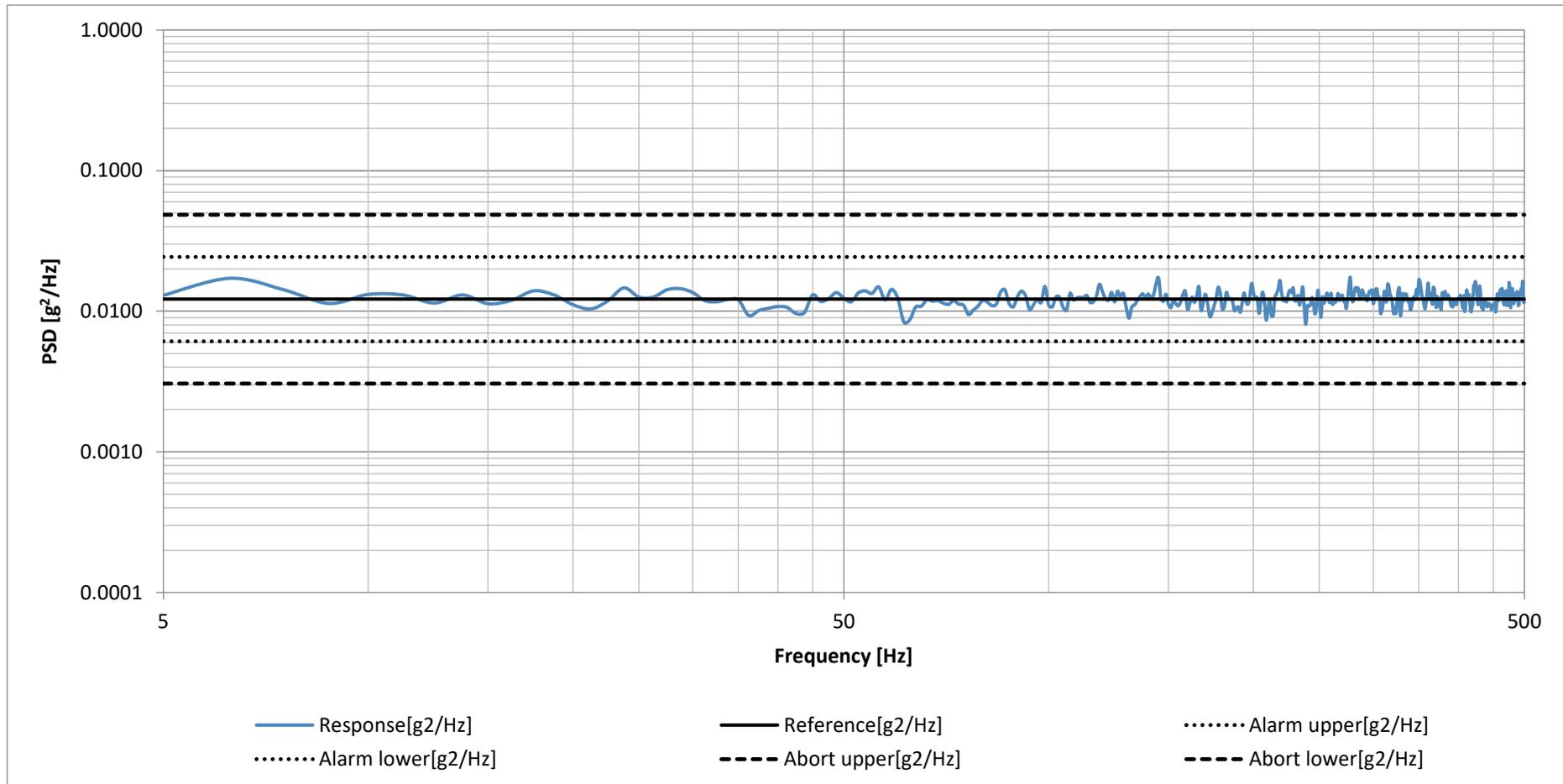


Figure 34: Longitudinal axis IEC60068-2-64 random operational

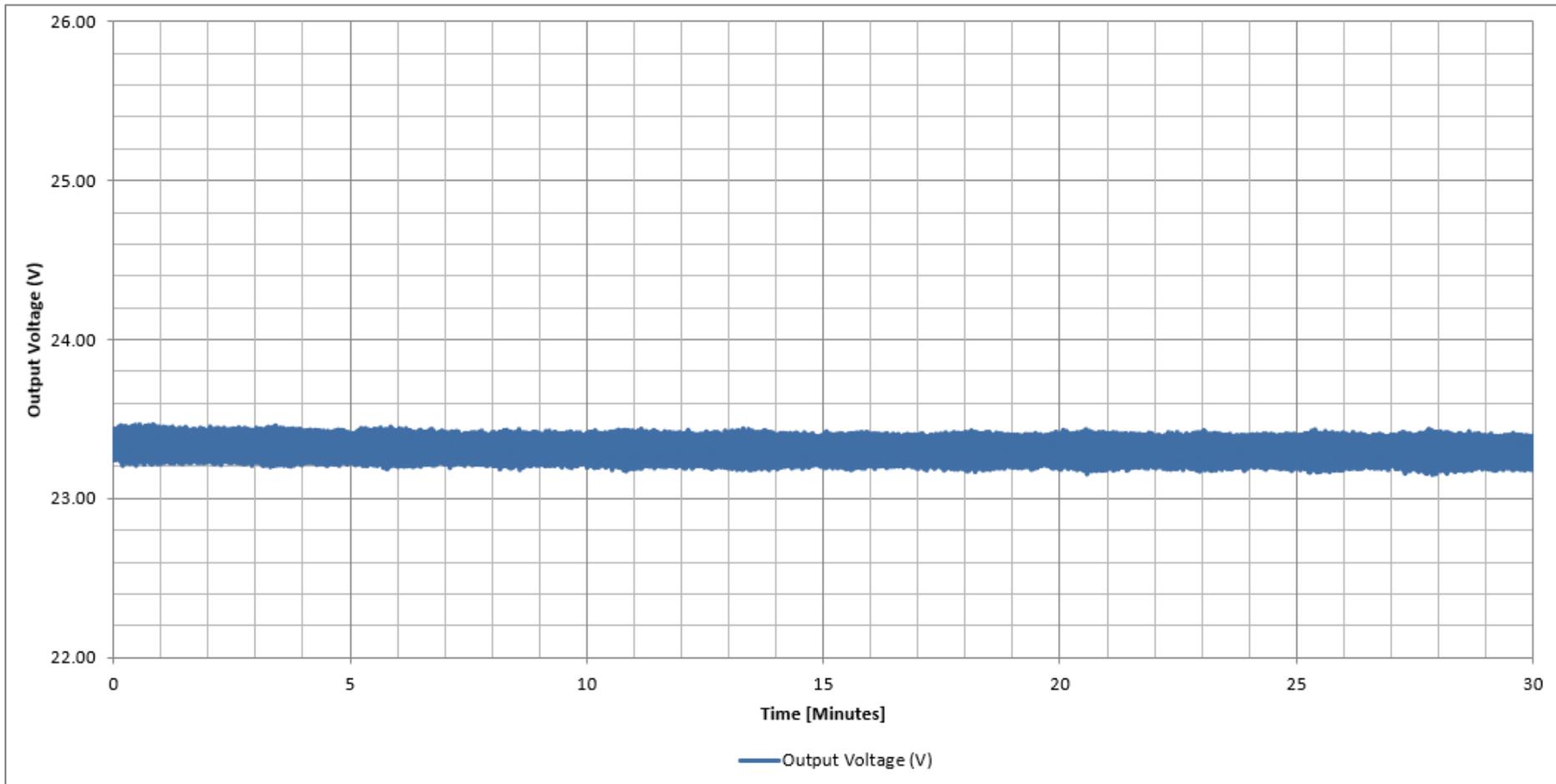


Figure 35: Output voltage during longitudinal axis IEC60068-2-64 random operational (VCCR300-24)

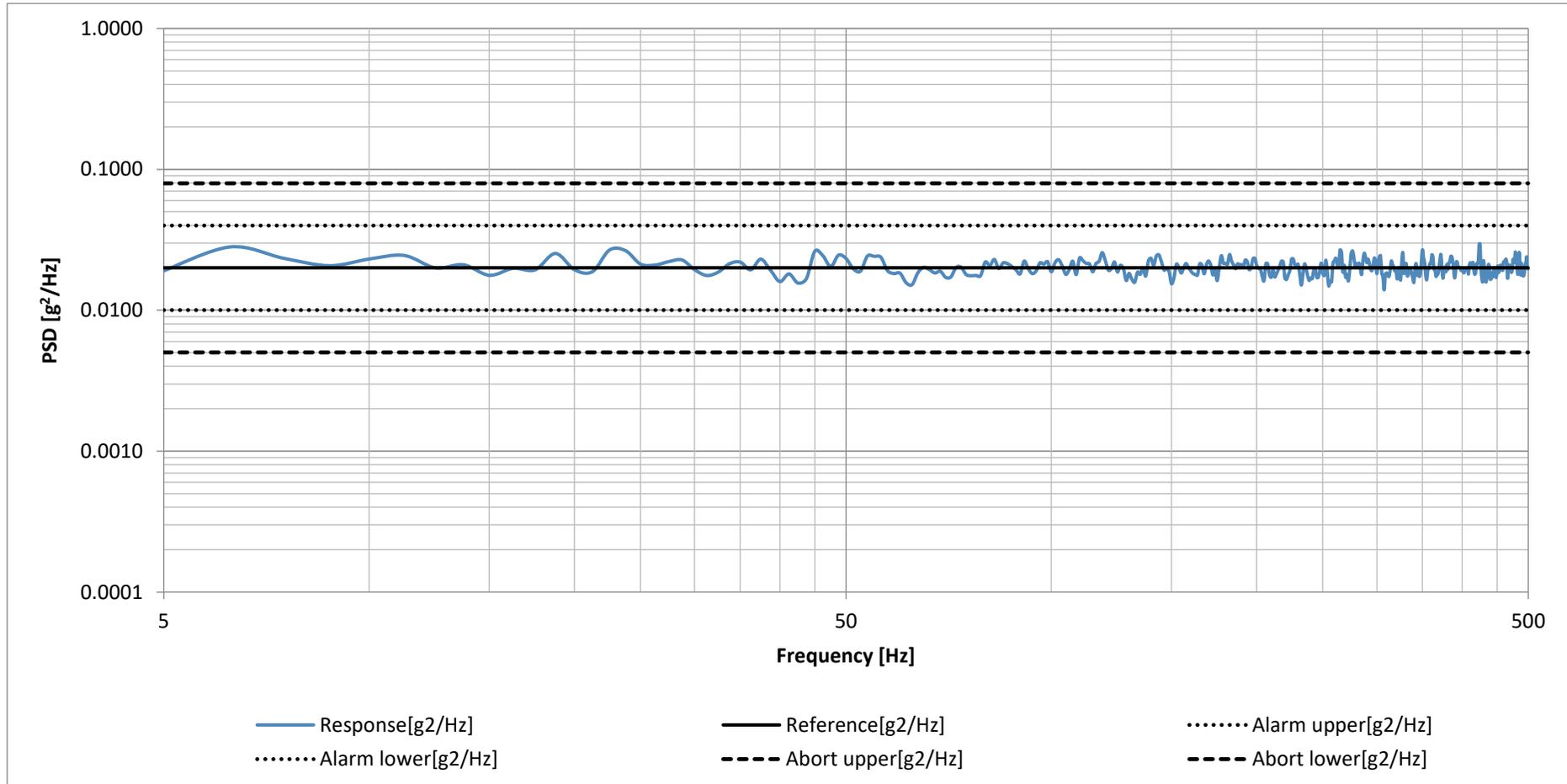


Figure 36: Longitudinal axis IEC60068-2-64 random non-operational

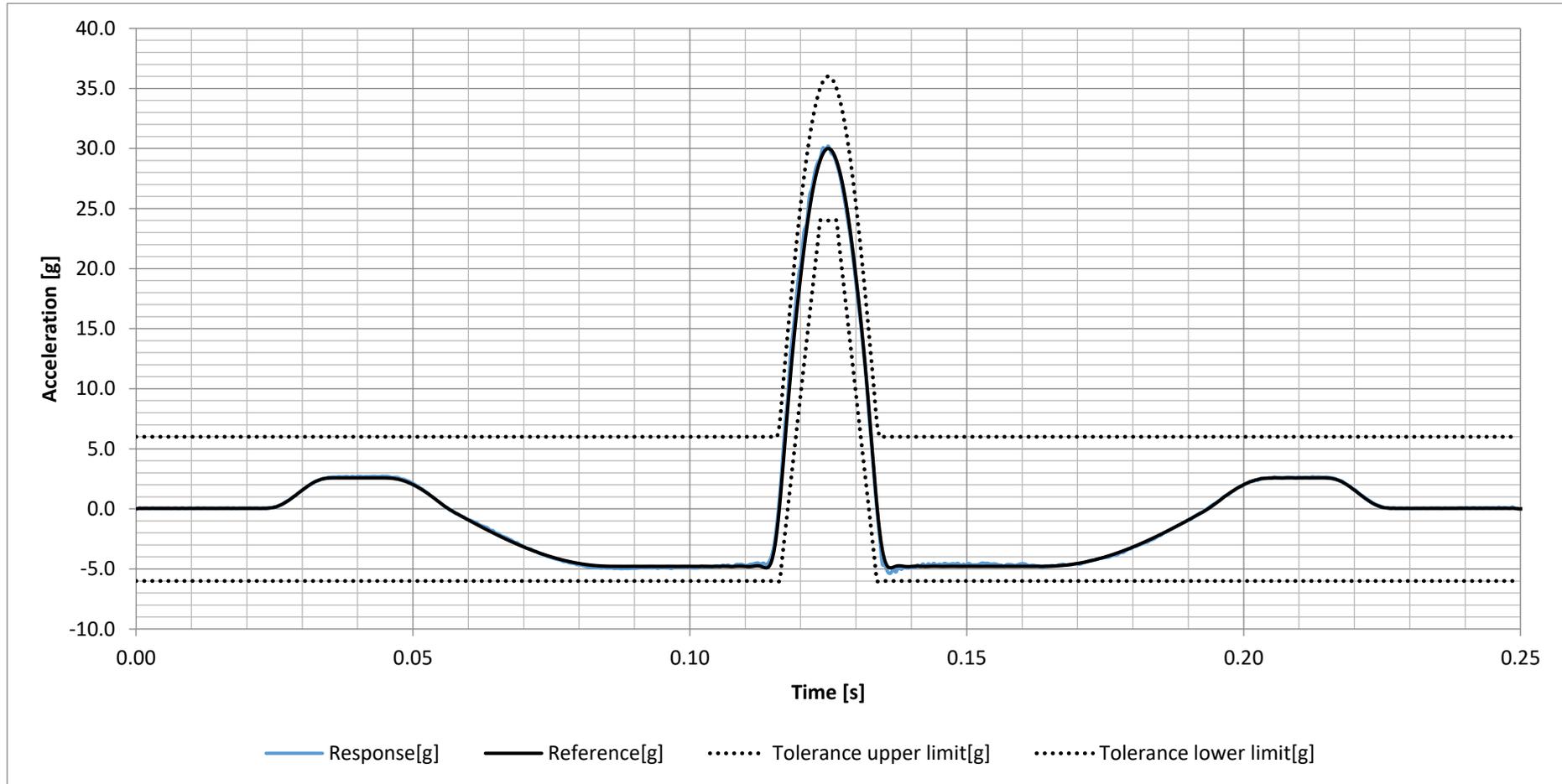


Figure 37: Operational IEC60068-2-27 positive shock test response – Shock 1 of 6 – Longitudinal axis

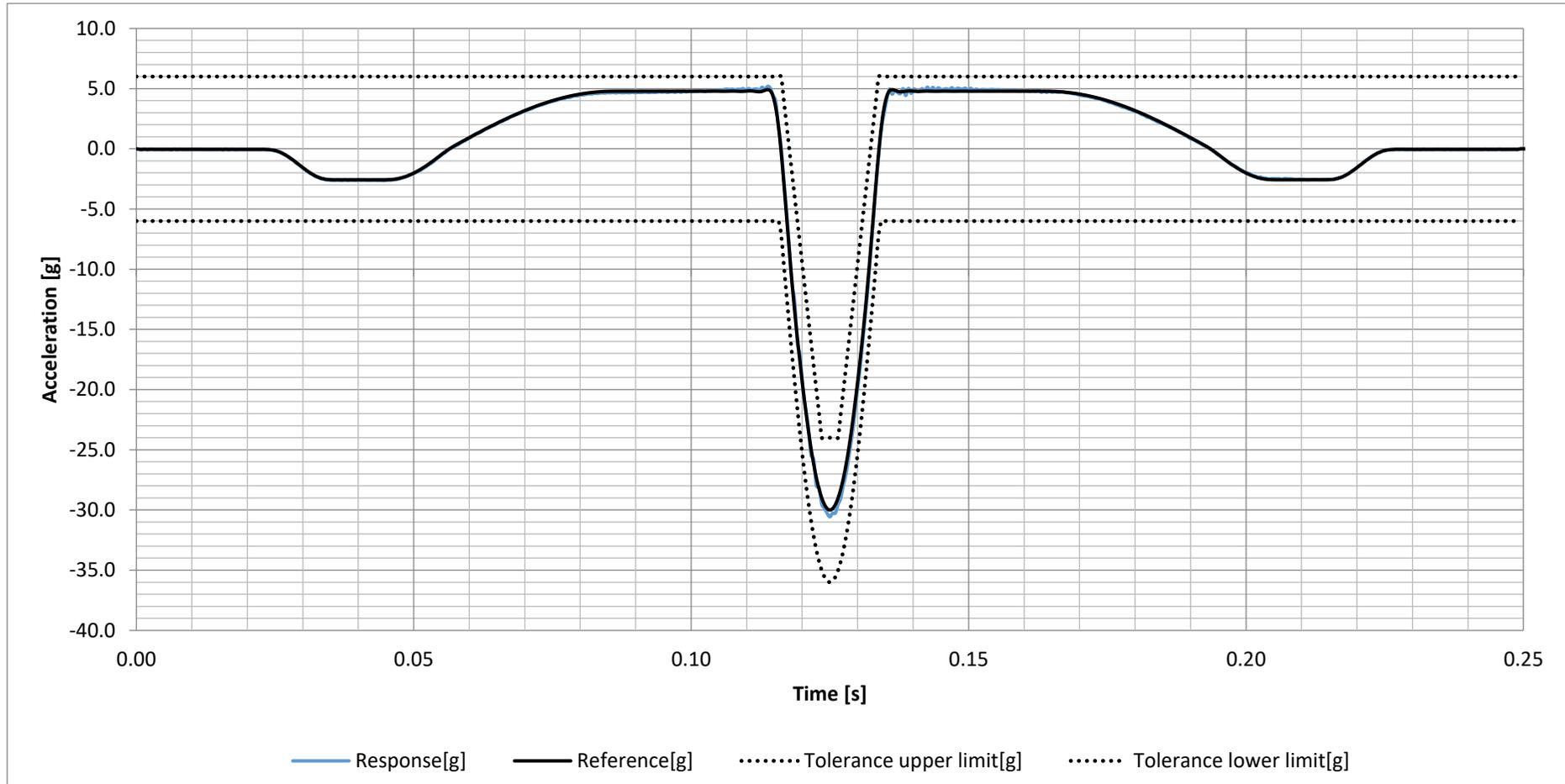


Figure 38: Operational IEC60068-2-27 negative shock test response - Shock 6 of 6 – Longitudinal axis

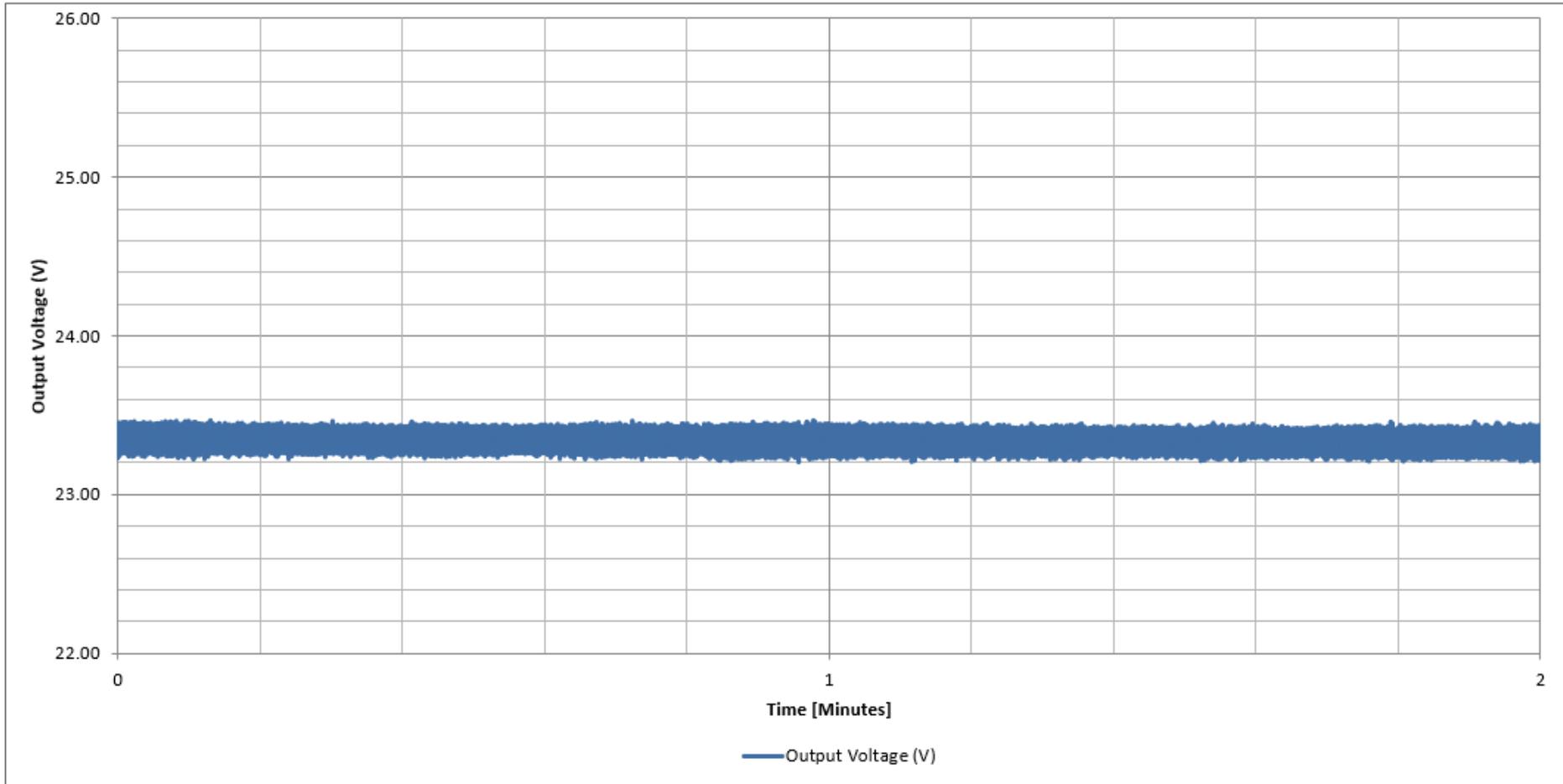


Figure 39: Output voltage during longitudinal axis IEC60068-2-27 shock operational (VCCR300-24)

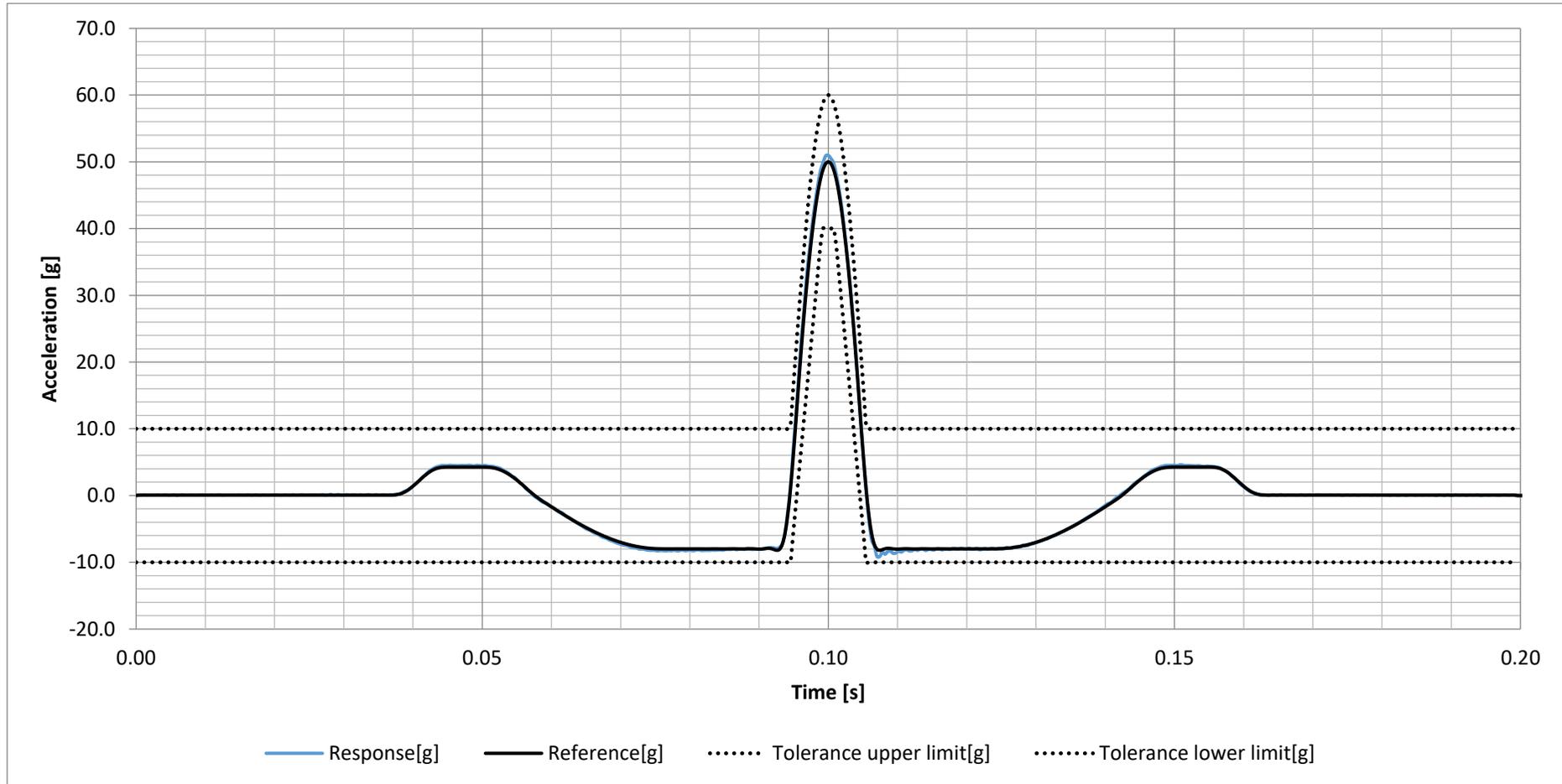


Figure 40: Non-operational IEC60068-2-27 positive shock test response - Shock 1 of 6 – Longitudinal axis

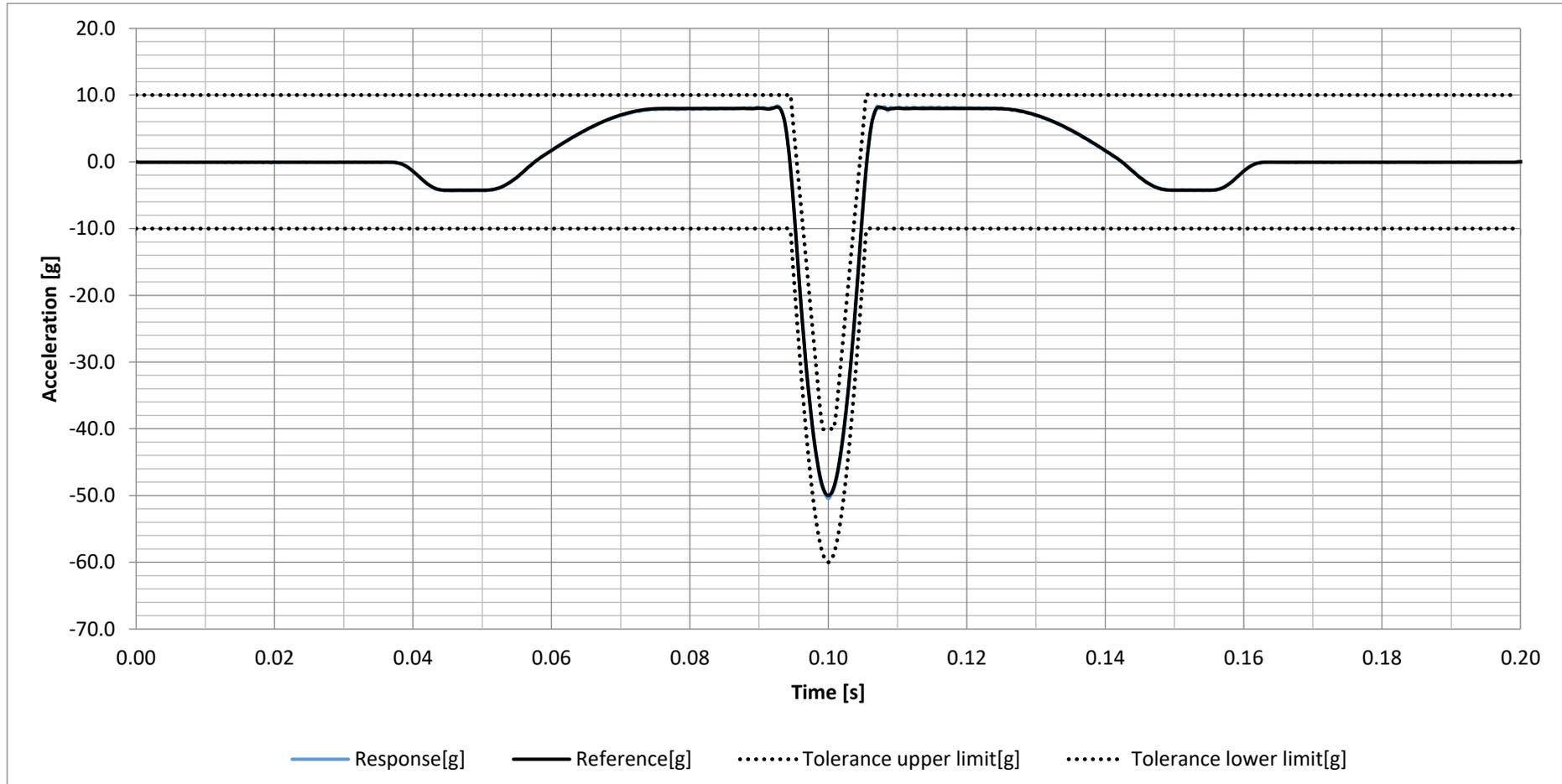


Figure 41: Non-operational IEC60068-2-27 negative shock test response - Shock 6 of 6 – Longitudinal axis

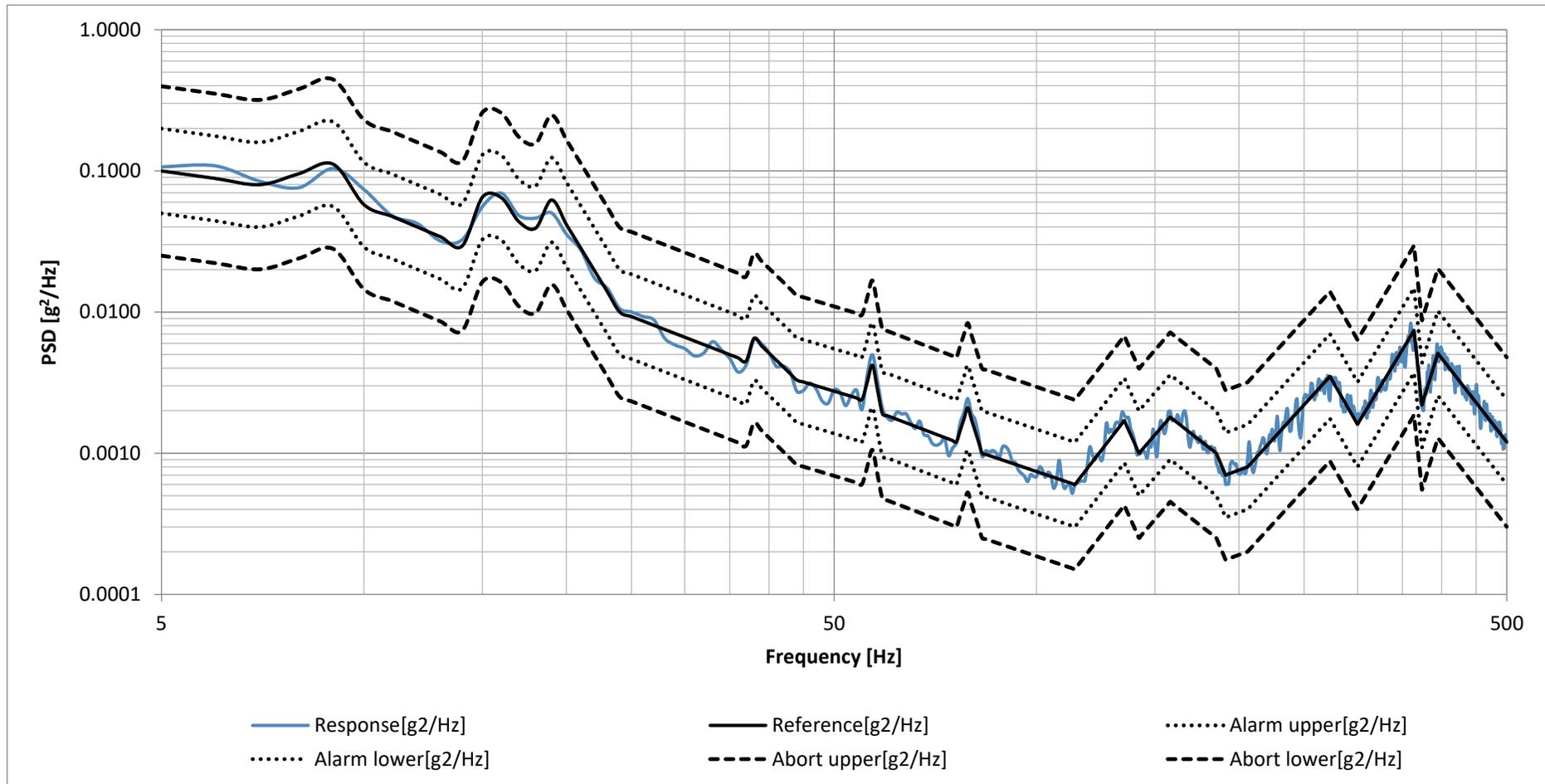


Figure 42: Transverse axis MIL-STD 810G category 4 random vibration

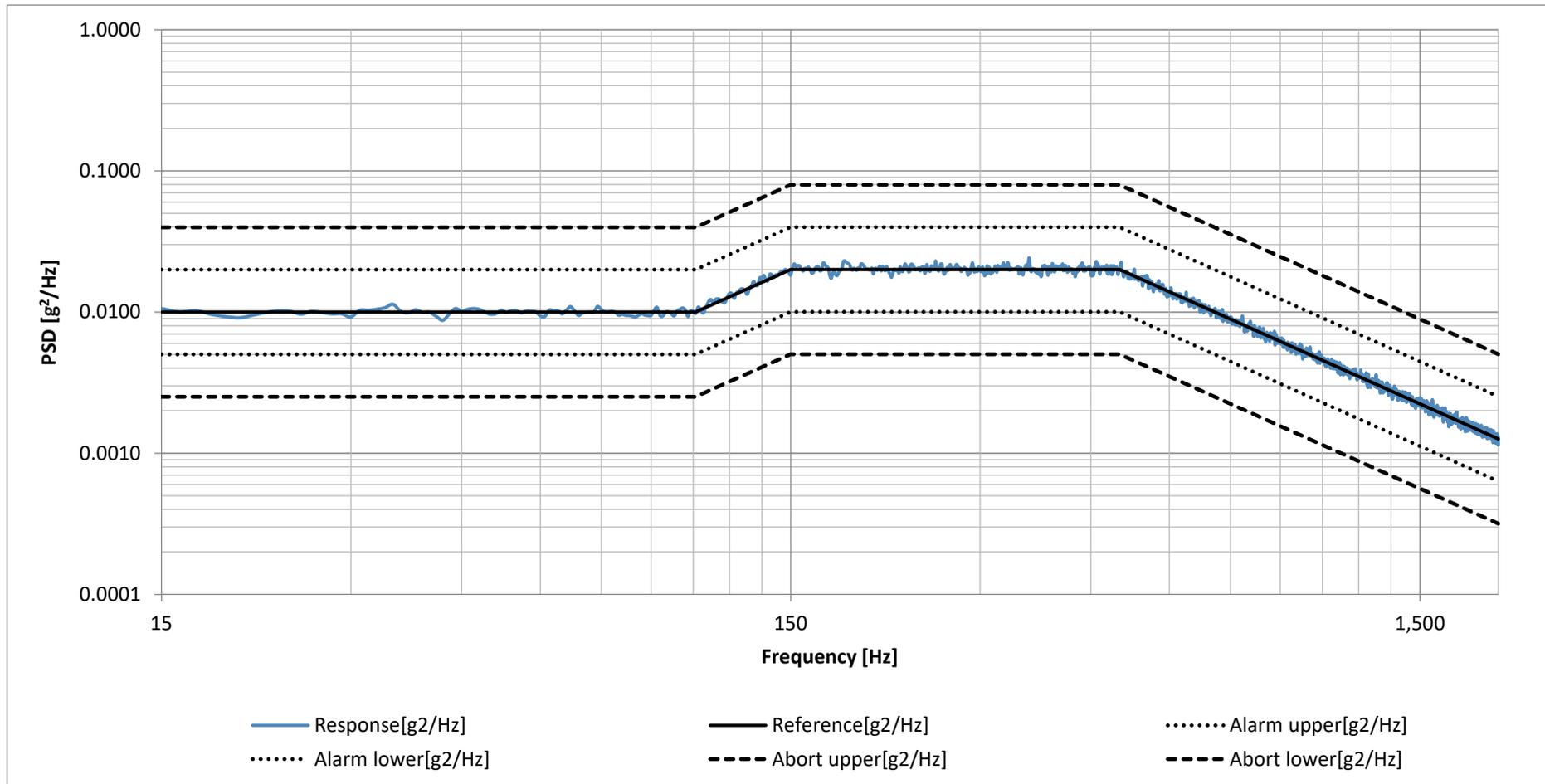


Figure 43: Transverse axis MIL-STD 810G category 7 random vibration

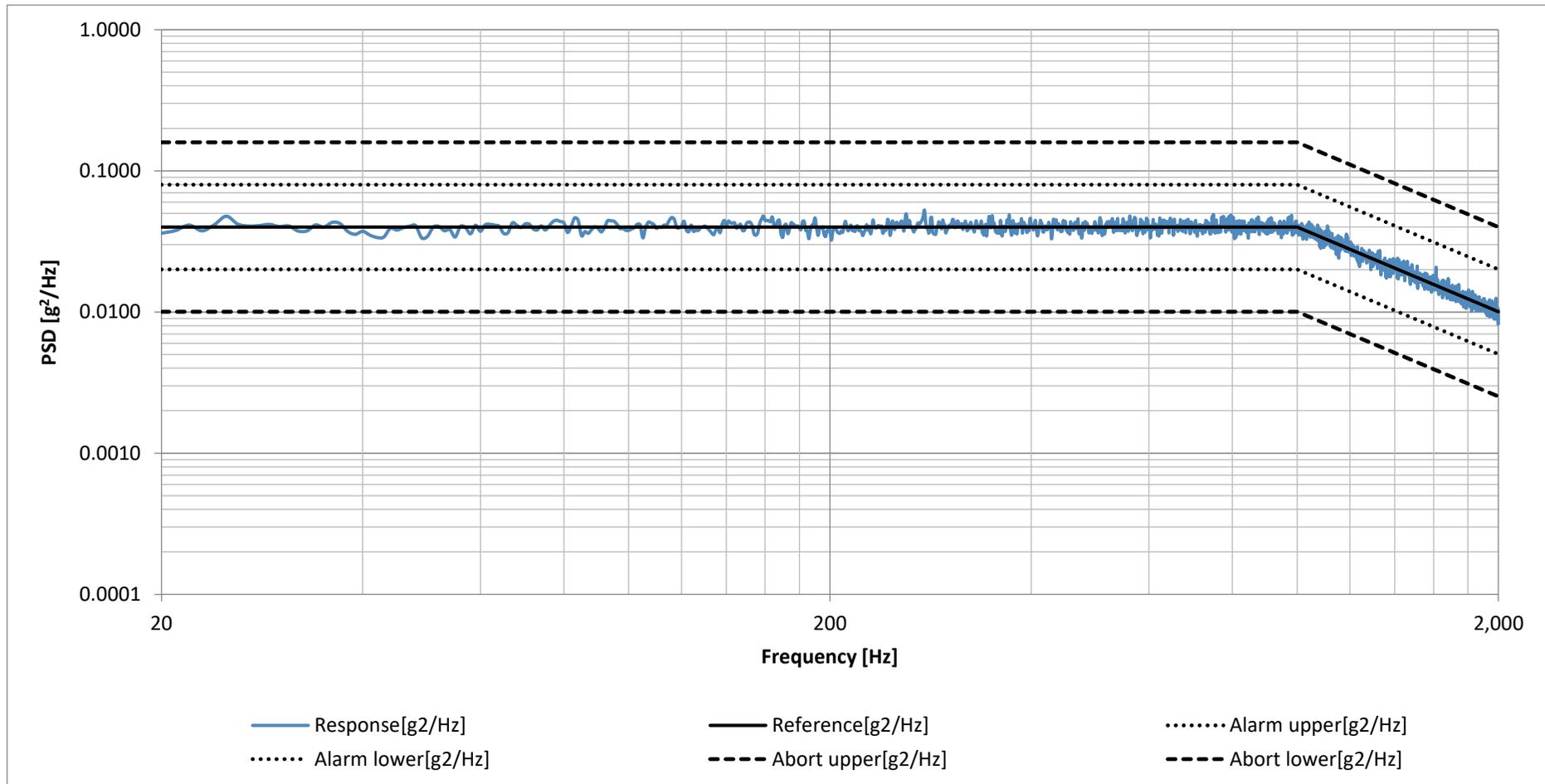


Figure 44: Transverse axis MIL-STD 810G category 24 random vibration

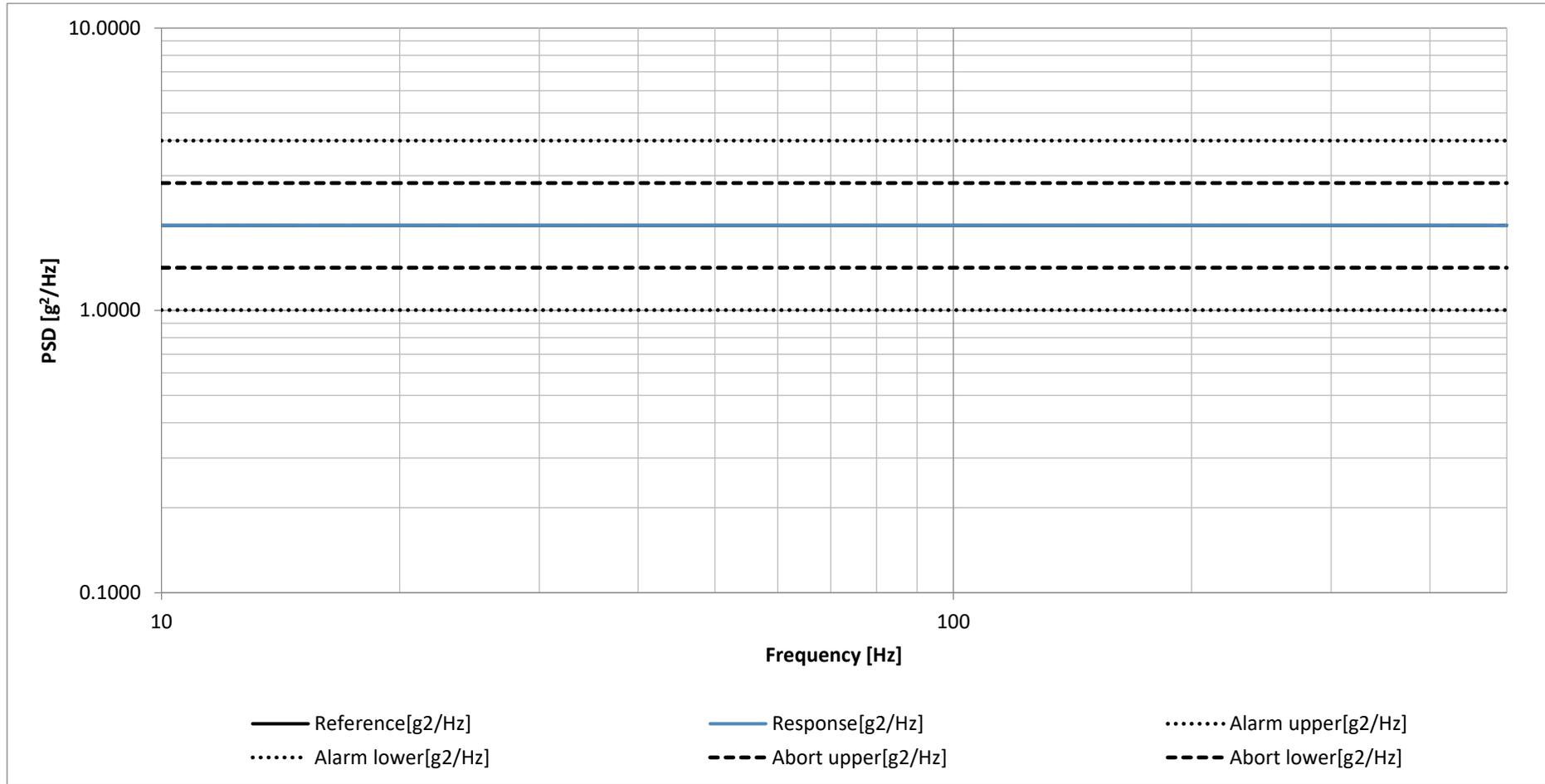


Figure 45: Transverse axis IEC60068-2-6 sine vibration operational (VCCR300-24)

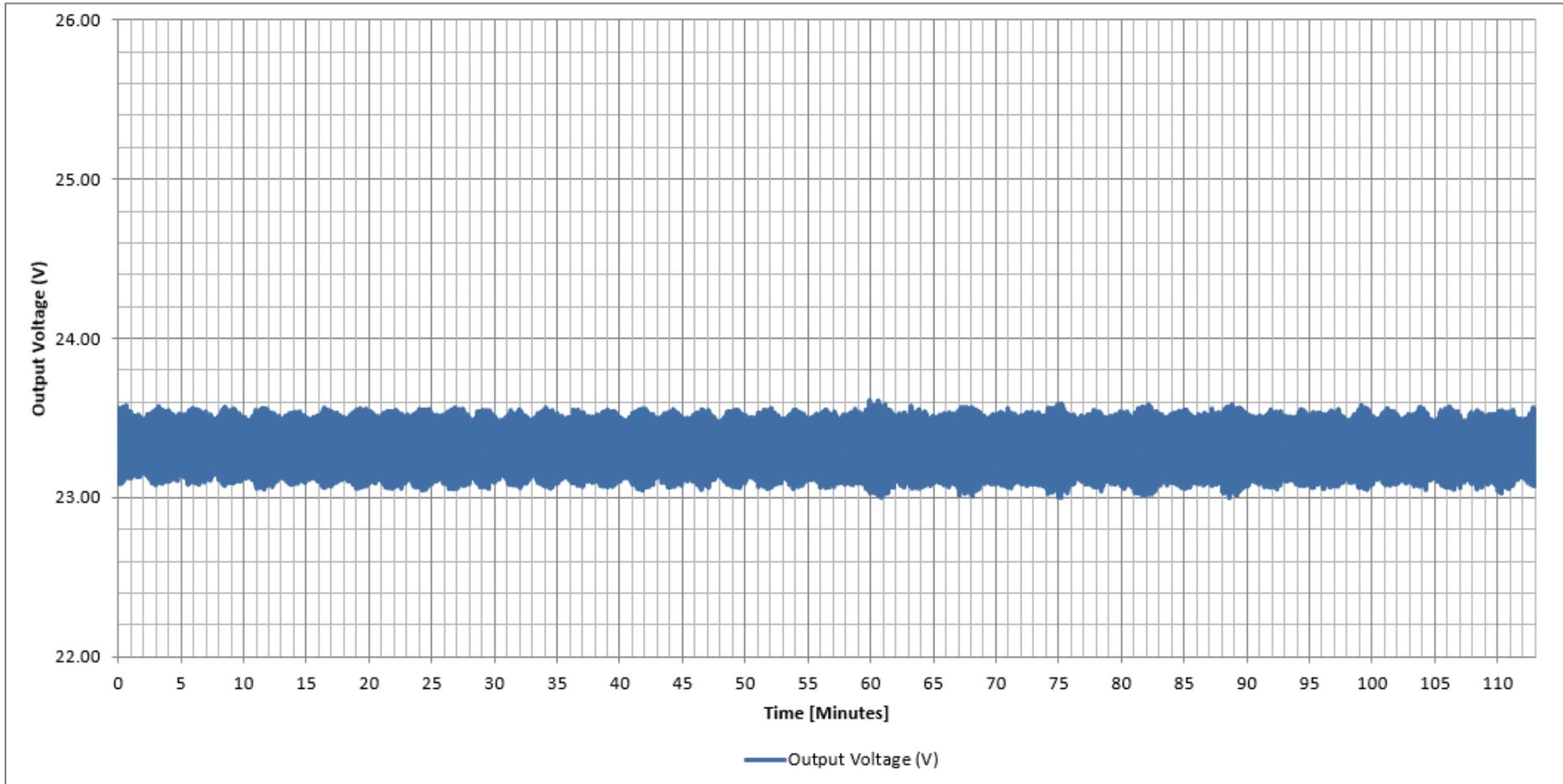


Figure 46: Output voltage during transverse sine vibration (VCCR300-24)

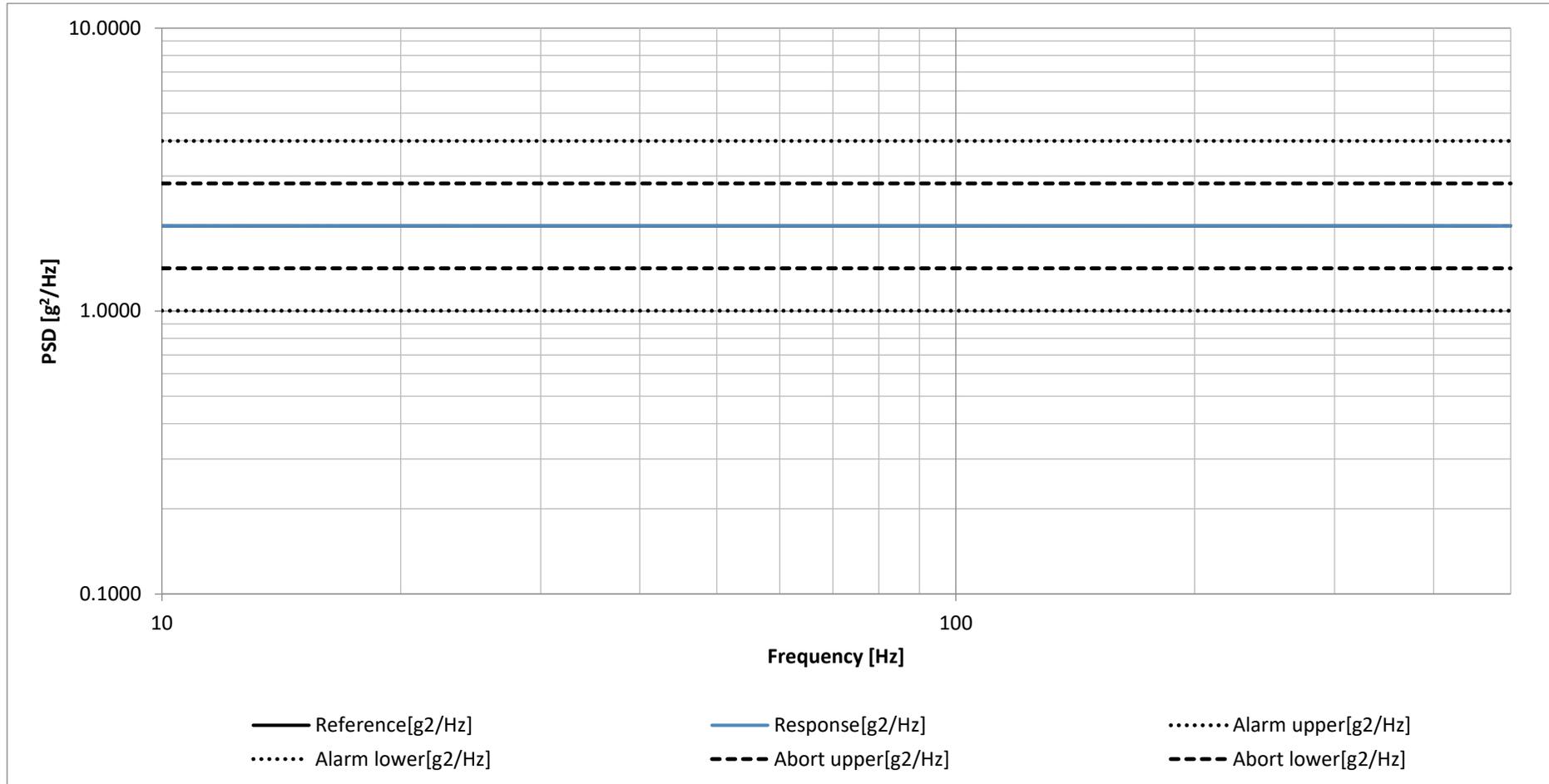


Figure 47: Transverse axis IEC60068-2-6 sine vibration operational (VCCR300-36)

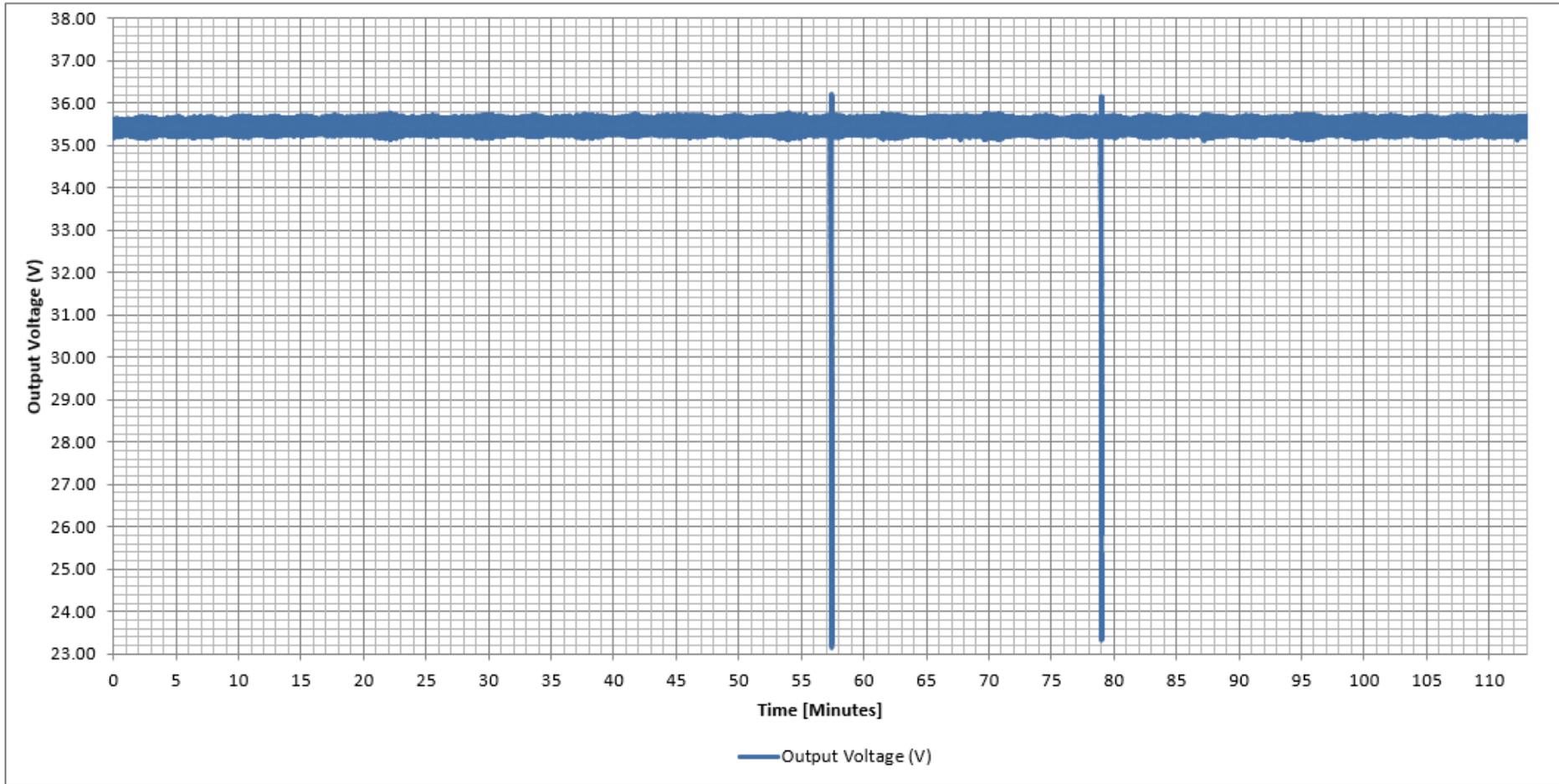


Figure 48: Output voltage during transverse sine vibration (VCCR300-36)

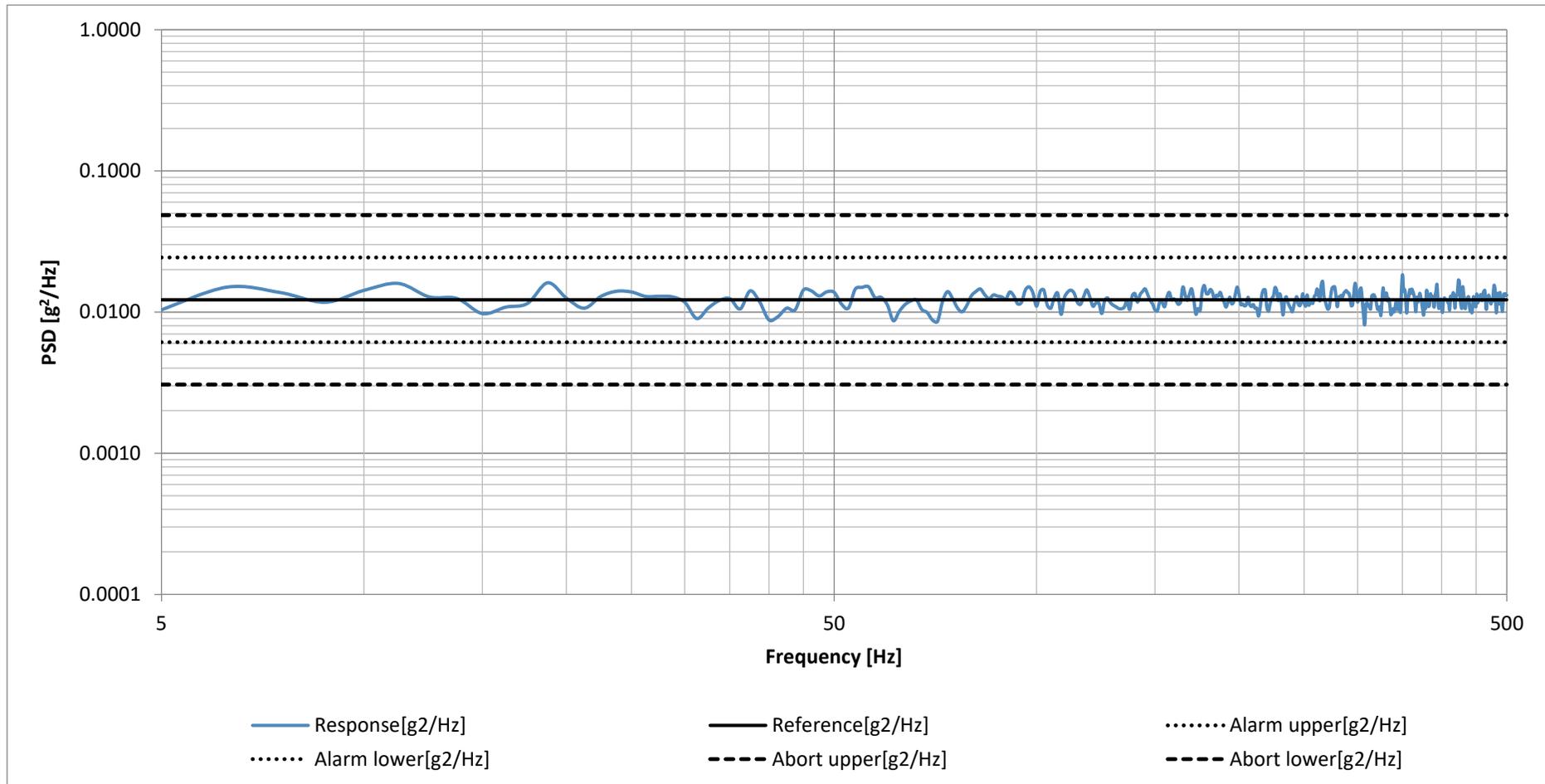


Figure 49: Transverse axis IEC60068-2-64 random operational

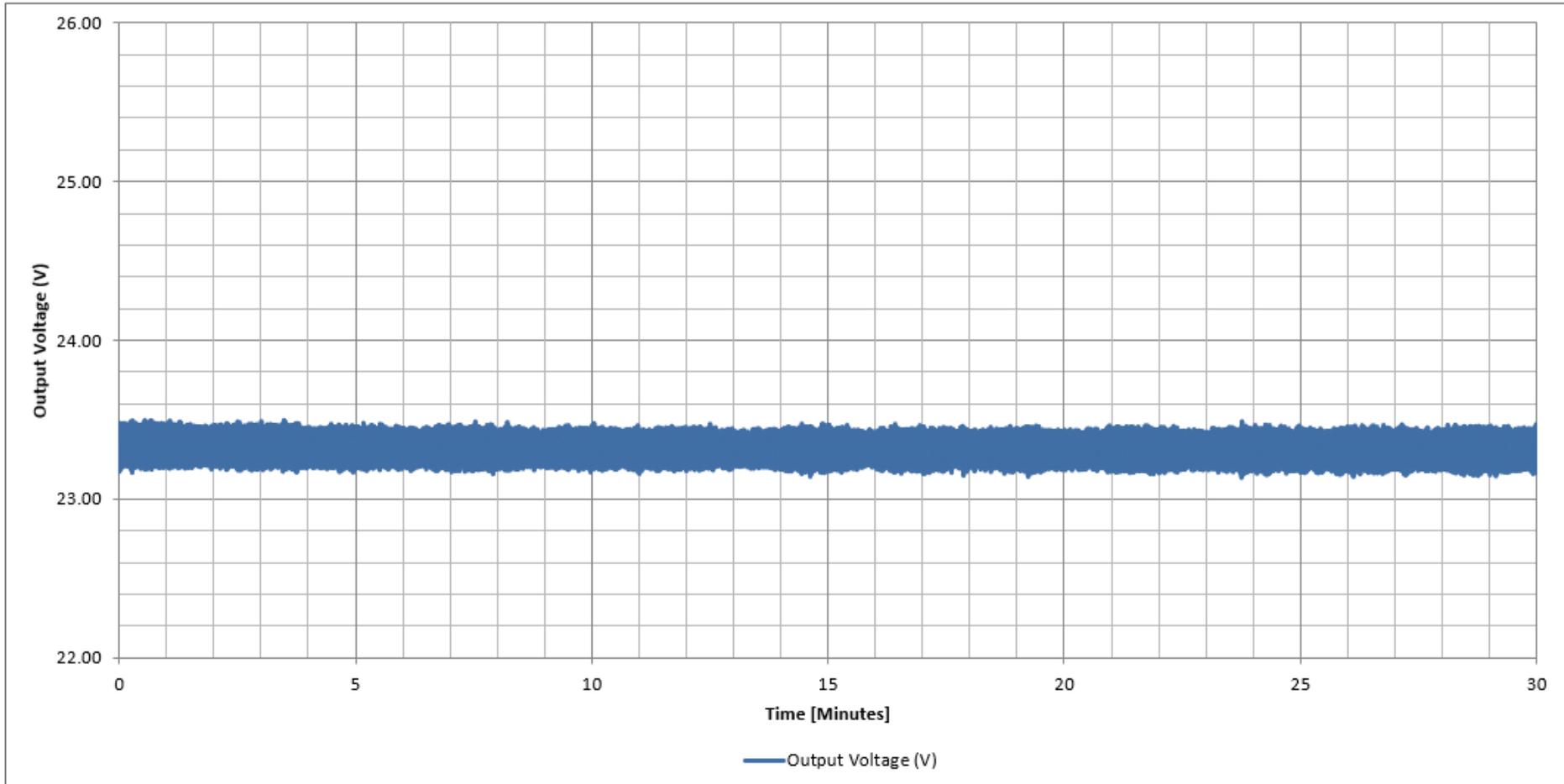


Figure 50: Output voltage during transverse axis IEC60068-2-64 random operational (VCCR300-24)

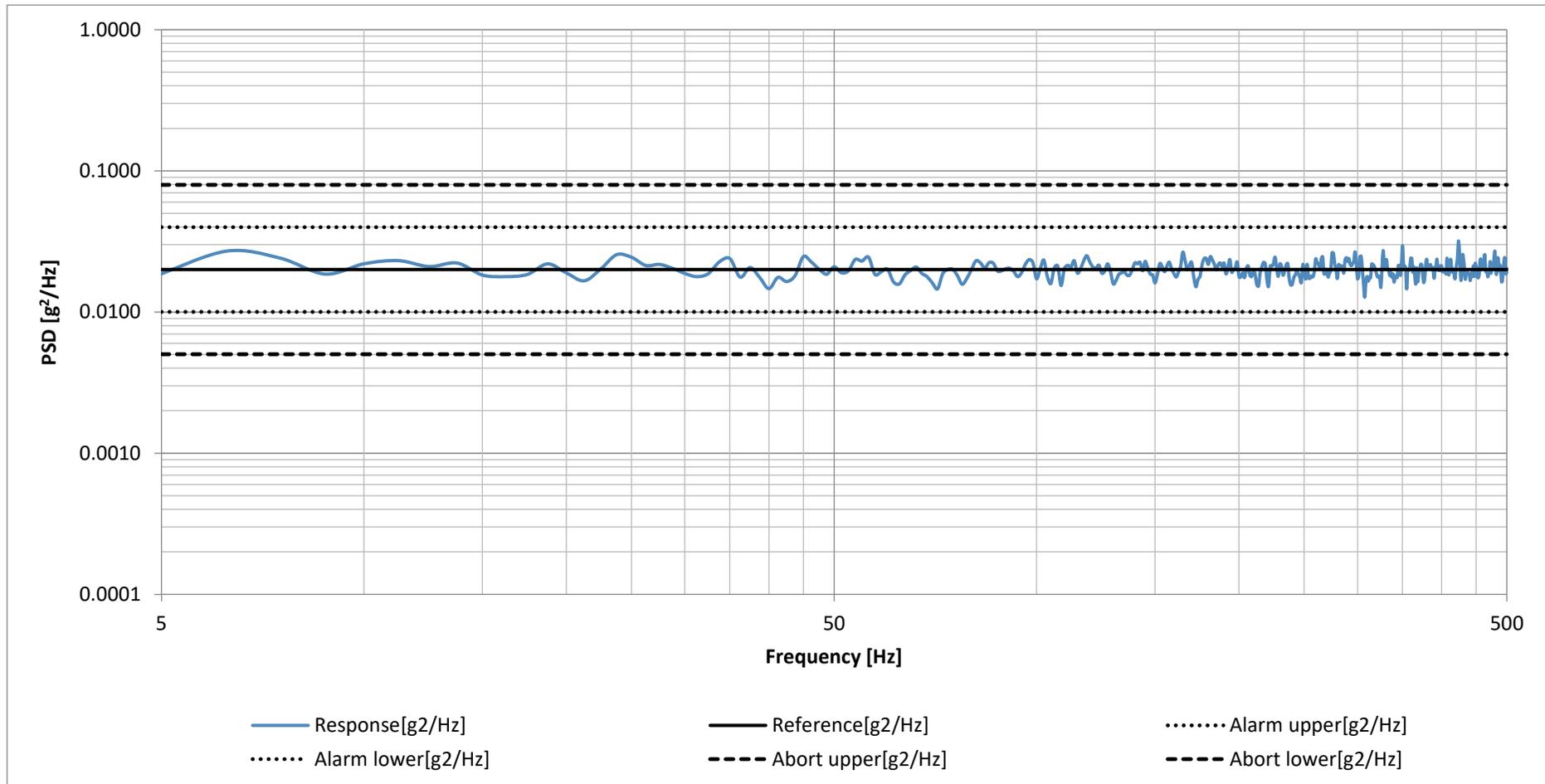


Figure 51: Transverse axis IEC60068-2-64 random non-operational

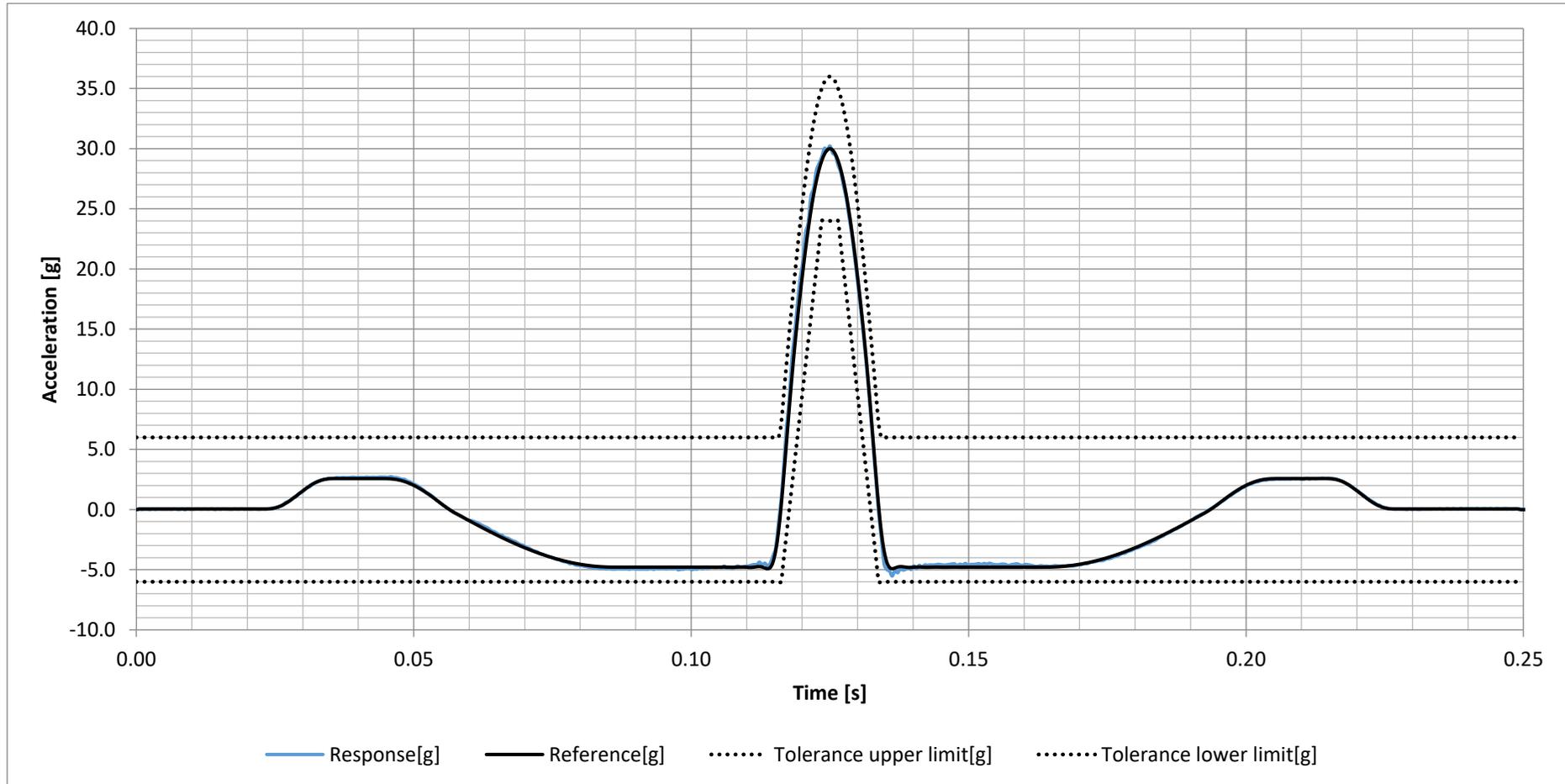


Figure 52: Operational IEC60068-2-27 positive shock test response - Shock 1 of 6 – Transverse axis

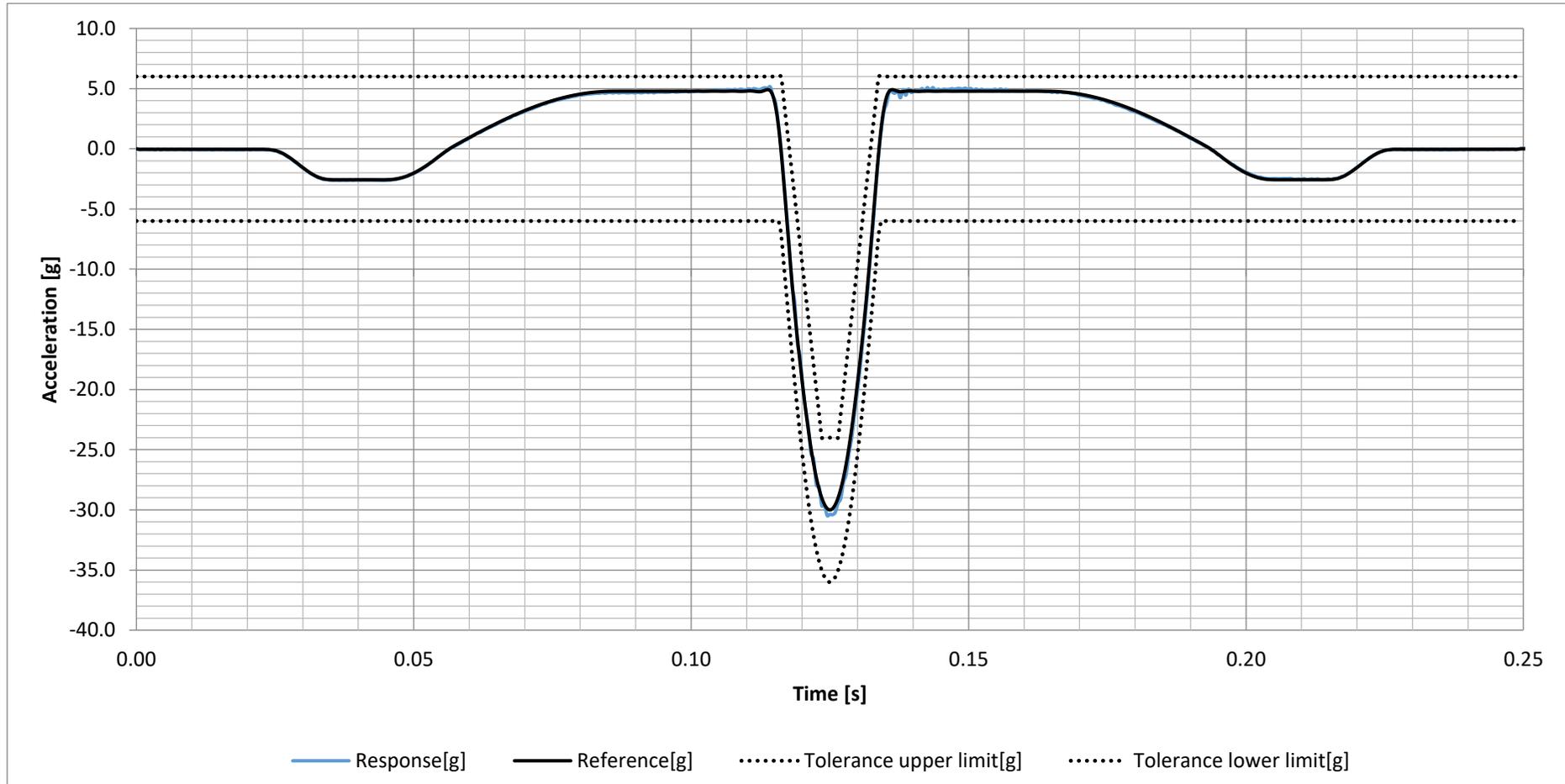


Figure 53: Operational IEC60068-2-27 negative shock test response - Shock 6 of 6 – Transverse axis

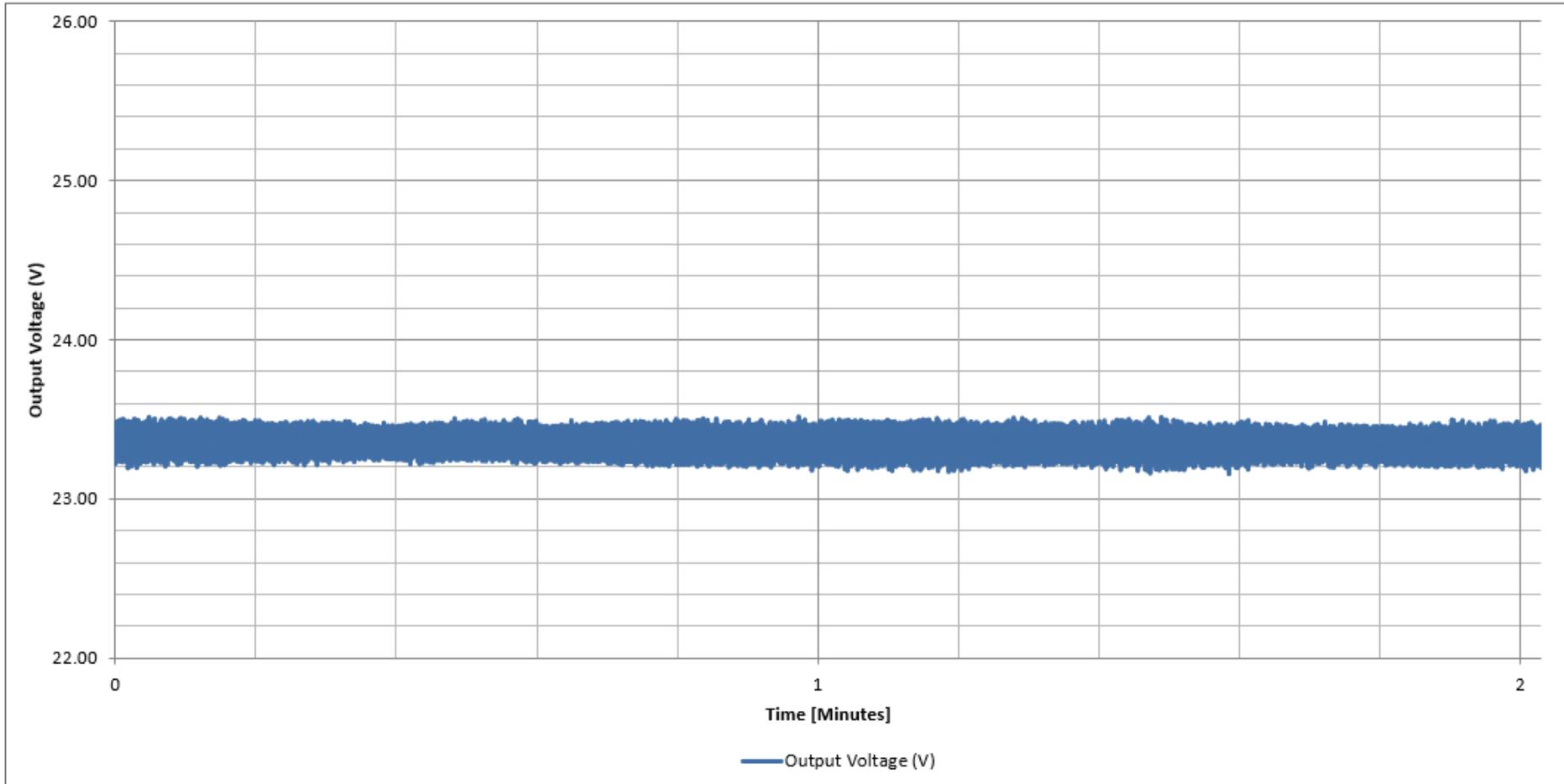


Figure 54: Output voltage during transverse axis IEC60068-2-27 shock operational (VCCR300-24)

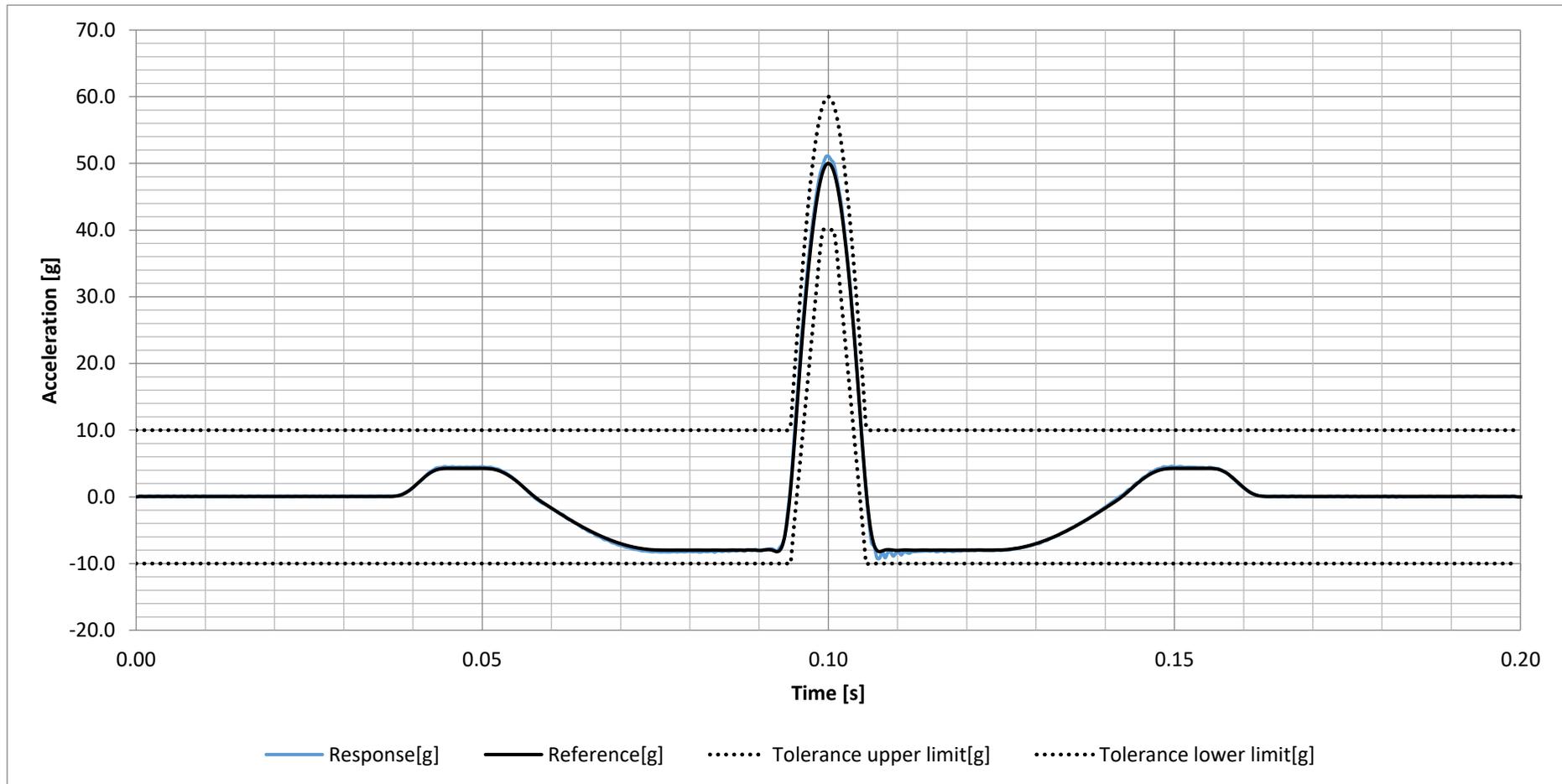


Figure 55: Non-operational IEC60068-2-27 positive shock test response - Shock 1 of 6 – Transverse axis

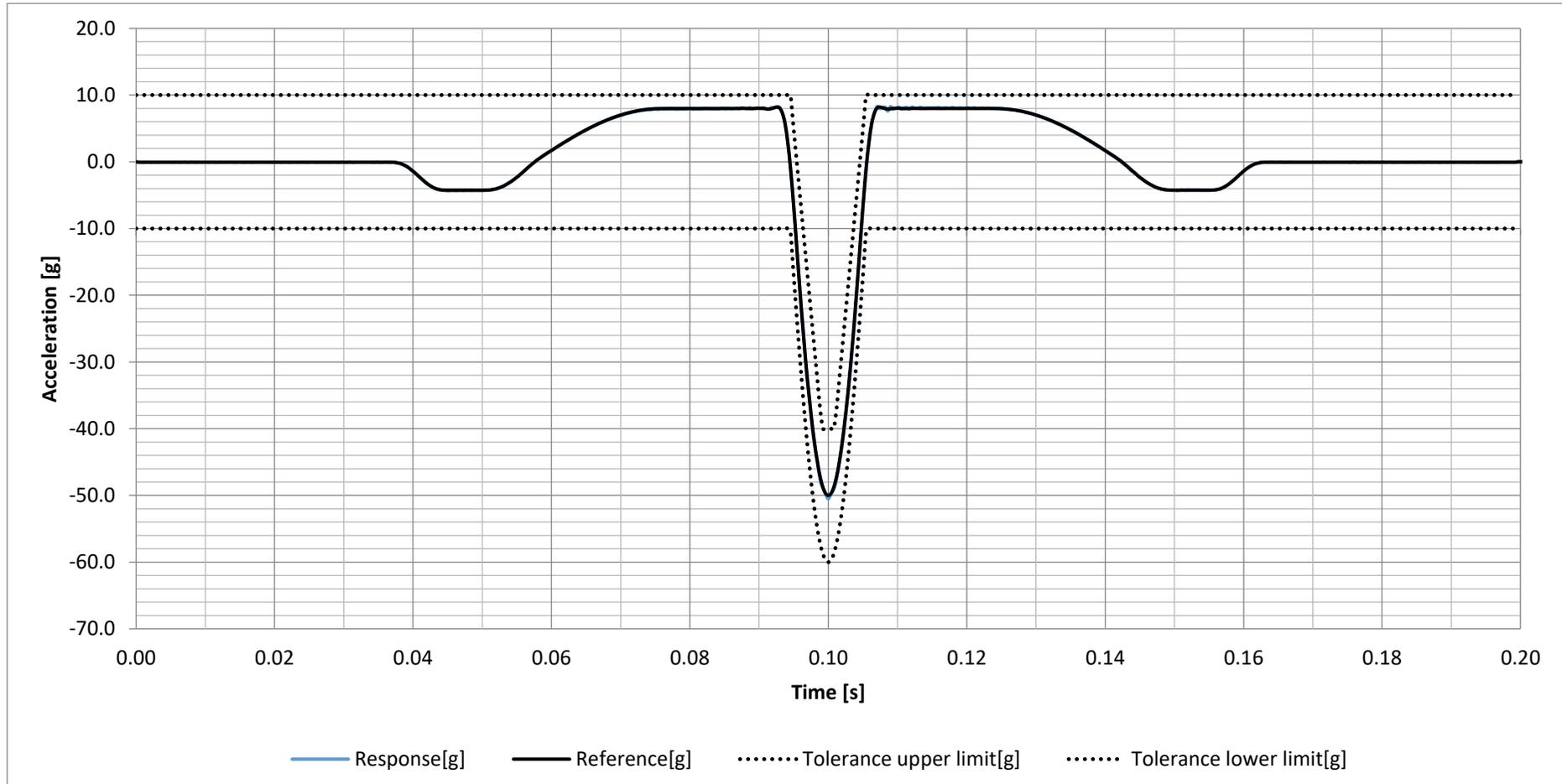


Figure 56: Non-operational IEC60068-2-27 negative shock test response - Shock 6 of 6 – Transverse axis

 <p>Resonate TESTING LIMITED A NACELLE GROUP COMPANY</p>	<p>Test Report</p> <p>Vibration and shock</p>	<p>Record No: RTL00535 D0017 Rev No: 1 2023-08-11 Document Status: Approved</p>
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6 Quality Assurance

Our technical competence and quality control arrangements are in accordance with the conditions of our quality management system.

7 Summary

A suite of vibration tests was carried out in all three orthogonal axes in accordance with IEC 60068 and MIL-STD-810G in the following order:

1. MIL-STD-810G Procedure I Category 4 (Trucks & Trailers, Composite Wheeled Vehicle)
2. MIL-STD-810G Procedure I Category 7 (Aircraft, Jet Cargo)
3. MIL-STD-810G Procedure I Category 24 (Minimum Integrity)
4. IEC 60068-2-6 Sine Vibration Operational
5. IEC 60068-2-64 Random Vibration Operational
6. IEC 60068-2-64 Random Vibration Non-Operational
7. IEC 60068-2-27 Shock Operational
8. IEC 60068-2-27 Shock Non-Operational

The plots of the control spectra have been provided to show that the test requirements have been adhered to. Output voltage plots from each operational test have also been provided.

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End of Report