



9800 Martel Road  
Lenoir City, TN 37772

Model

**PAC45 System**

Part Number

050-045-XXXX

Audio Control Panel/ Digital Audio Intercom System with Multi-Talker  
IntelliAudio® Processing

Technical Standard Order

**Environmental Testing Report**

**TSO C139A**

RTCA, Inc. /DO-160G

002-145-0160

Date: 2/22/19

Revision: New

# PAC45-SYSTEM RTCA DO-214A/DO-160G Test Plan

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2.5.1 Temperature and Altitude .....	4
2.5.1.1 Short Time Operating Low, Ground Survival Low-Temperature Test and Operating Low-Temperature Test .....	4
2.5.1.3 Operating High-temperature Tests.....	8
2.5.1.4 Altitude Tests.....	8
2.5.2 Temperature Variation .....	11
2.5.3 Humidity .....	12
2.5.4 Shock Tests .....	15
2.5.4.1 Operational Shocks.....	15
2.5.4.2 Crash Safety Shocks .....	16
2.5.5 Vibration Tests.....	18
2.5.6 Magnetic Effect Test .....	24
2.5.7 Power Input Tests .....	24
2.5.7.1 Normal Operating Conditions.....	24
DO-160G §16.6.1.2 Ripple Voltage DC.....	25
2.5.7.2 Abnormal Operating Conditions (dc) §16.6.2. ....	30
Low Voltage operation in accordance with DO-160G, §16.6.2.2. ....	30
Abnormal Surge Voltage (DC) DO-160G §16.6.2.4 .....	33
2.5.8 Voltage Spike Conducted Test (17.4).....	34
2.5.9 Audio Frequency Conducted Interference .....	36
2.5.10 Induced Signal Susceptibility Test.....	39
2.5.11 Radio Frequency Susceptibility Test (Radiated and Conducted) .....	40
2.5.11.1 Steady State RF Interference .....	41
2.5.11.2 Momentary RF Interference Test .....	41
2.5.12 Emission of Radio Frequency Energy Test .....	41
2.5.13 Lightning Induced Transient Susceptibility .....	44
2.5.14 Final Distortion test – Not Applicable to Audio Panels.....	45
2.5.15 Push-to-Talk Switch Life – Not Applicable to Audio Panels .....	45
2.5.16 Electrostatic Discharge .....	45
Appendix A Reports and Precision Test Equipment .....	45

*Table of Figures*

Figure 1 -Ground Survival Low Temperature and Short Term Operating Low temperature test .....5

Figure -2 - Low-Operating Temperature test.....6

Figure 3 - High survival and high short term operating tests .....7

Figure 4 - Operating High Temperature tests (PAC45-SYSTEM) .....8

Figure 5 Altitude test setup .....10

Figure 6 - Temperature Variation test parameters .....11

Figure 7 - Temperature testing setup .....11

Figure 8 PAC45-SYSTEM System EUT Humidity tests .....14

Figure 9 - PAC45-SYSTEM under vibration test .....20

Figure 10 Frequency and Vibration level (Curve M) .....21

Figure 11 - Random Helicopter Vibration .....22

Figure 12 Vibration test Curves, Helicopter Category U2 .....22

Figure 13 - Normal Operating Voltage Definitions .....24

Figure 14 Test results for Ripple Test DO-160G §16.6.1.2.....26

Figure 15 - Power Interruption Results DO-160G §16.6.1.3(b) .....27

Figure 16 - Power Interruption Results DO-160G §16.6.1.3(c) .....27

Figure 17 - Double Interruption Results DO-160G §16.6.1.3(d) .....28

Figure 18 – Normal Surge Voltage Results DO-160G §16.6.1.4.....29

Figure 19 - Engine Starting Voltage Test Results .....30

Figure 20 - Abnormal Voltage test, §16.6.2 .....31

Figure 21 – Momentary Undervoltage Operation Results DO-160G §16.6.2.3 .....33

Figure 22 - Results of Abnormal Surge Voltage DO-160G §16.6.2.4 .....34

Figure 23 Example Voltage Spike Generator test setup: .....34

Figure 24 Voltage Spike Waveform .....35

Figure 25 - Voltage Spike Results (DO-160G §17.4).....36


Figure 26 Emissions and susceptibility testing .....40

Figure 27 - EUT arrangement -Radiated susceptibility .....41

Figure 28 - Conducted Emission levels – power leads .....42

Figure 29 – Conducted Emissions - Cable Bundles .....43

Figure 30 - Radiated Emissions .....44

	<p align="center"><b>PAC45 Environmental Conditions Test Report RTCA DO-160G</b></p>	<p align="right">Document: 002-145-0160 Date: 2/22/19 Revision: new</p>
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The PAC45-SYSTEM System was tested in accordance with RTCA DO-214A §2.5, and the applicable sections of RTCA DO-160G.

NOTE: The PAC45-SYSTEM System was tested end to end such that each component received all of the environmental conditions, and any failure to function in accordance with the DO-214A Minimum Operating Performance specification would be detected. Audio stimulus from microphone or receiver audio passed through all adapters or impedance accessories and the output was measured to be within the allowable tolerance.

The PAC45 System Components include

Model Number	Part Number Tested	Serial Number Tested	Description
HUB45R	050-045-4101	BNXH01013	Audio Controller Hub for PAC45
CTL45	050-045-5201	E004	Control Head for PAC45
PSA210	050-230-0000	APSA1001	Remote Speaker Amplifier
HSA13	050-213-0001	E007	Low Impedance Microphone Adapter

## 2.5.1 Temperature and Altitude

The PAC45-SYSTEM was tested to meet the requirements of Category F1, *Equipment intended for installation in non-pressurized but controlled temperature locations on an aircraft and operated at altitudes up to 55,000 MSL.*

### 2.5.1.1 Short Time Operating Low, Ground Survival Low-Temperature Test and Operating Low-Temperature Test

The equipment was subjected to the test conditions as specified in RTCA DO-160G, Section 4.0.

Test Conditions, Low temperature:

Condition	DO-160G §4.5 F1
Operating Low Temperature	-20° C
Short Time Operating Low	-40° C
Ground Survival Low Temperature	-55° C

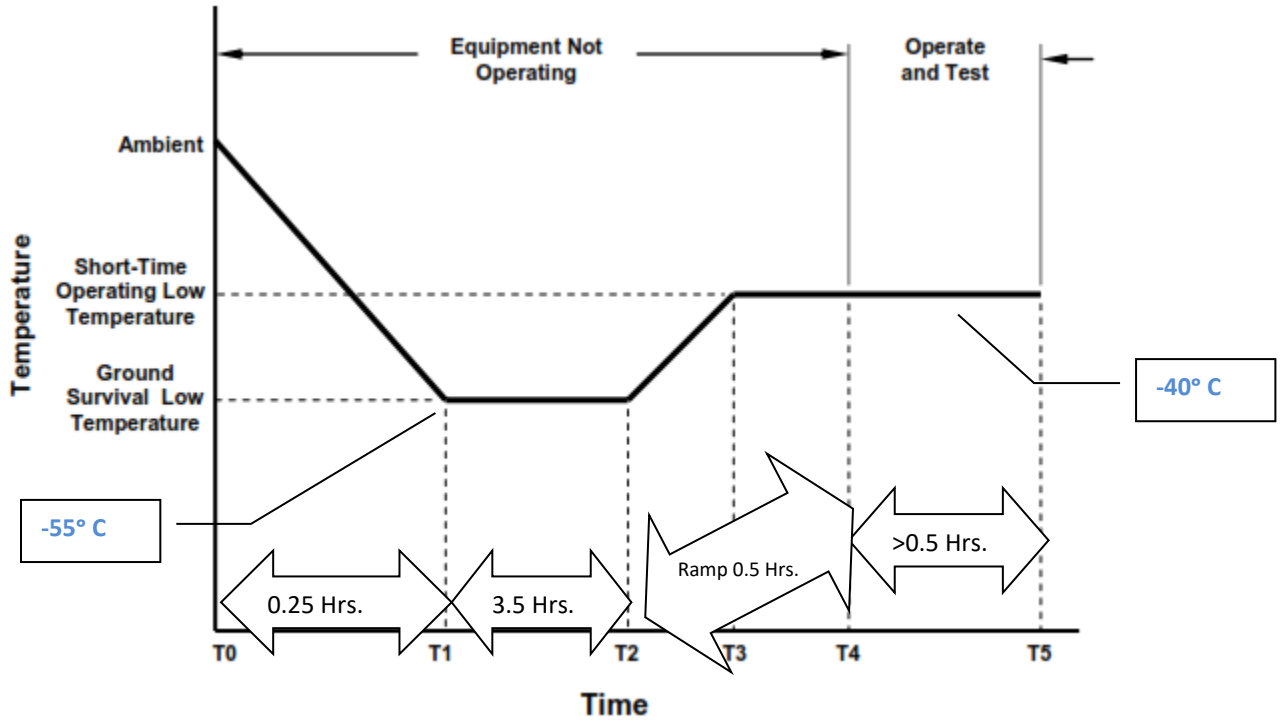


Figure 1 -Ground Survival Low Temperature and Short Term Operating Low temperature test

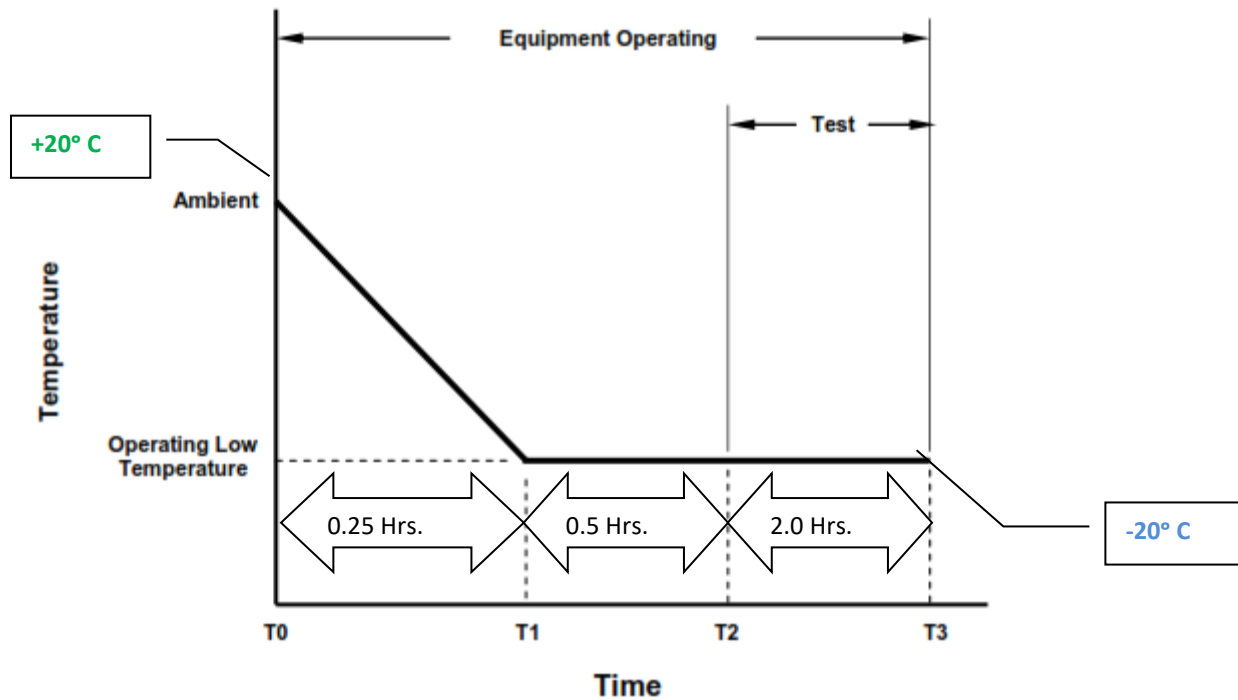


Figure -2 - Low-Operating Temperature test

During the tests, the following requirements were met:

1. Paragraph 2.4.3 - Distortion Characteristics (<1% THD)
2. Paragraph 2.4.8 - Compression (NOT applicable)
3. Subparagraph 2.4.11.1 - Audio Noise Without Signal (-56 dB to -65 dB)
4. Paragraph 2.4.15 - Listening Test satisfactory

2.5.1.2 Ground Survival High-Temperature Test and Short-Time Operating High- Temperature Test

The equipment was subjected to the test conditions as specified in RTCA DO-160G, Section 4.5.

Test conditions – High Temperature:

Condition	§ 4.5 F1
Operating High Temperature	+55°C
Short Time Operating Hi	+70° C
Ground Survival Hi Temperature	+85° C

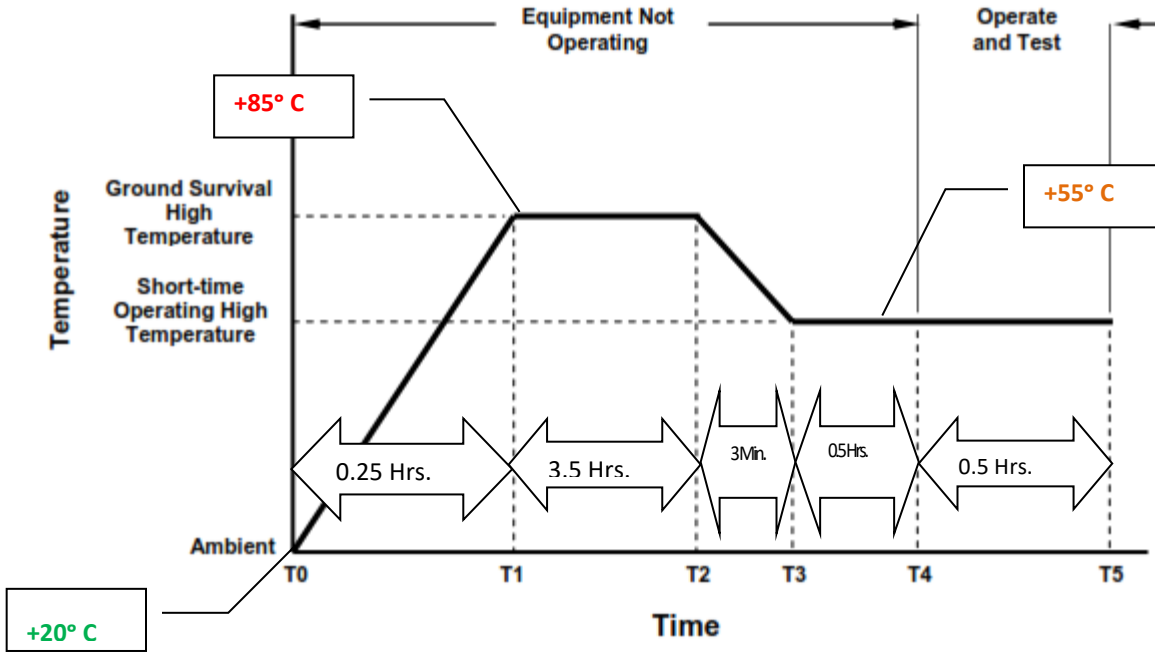


Figure 3 - High survival and high short term operating tests

During the test, the following requirements were met:

1. Paragraph 2.4.3 - Distortion Characteristics (<1% THD)
2. Subparagraph 2.4.1 1.1 - Audio Noise Without Signal (-56 to -64 dB, typical)
3. Paragraph 2.4.15 - Listening Test (Sound quality normal)
4. All mechanical devices operated satisfactorily. (Test OK).

### 2.5.1.3 Operating High-temperature Tests

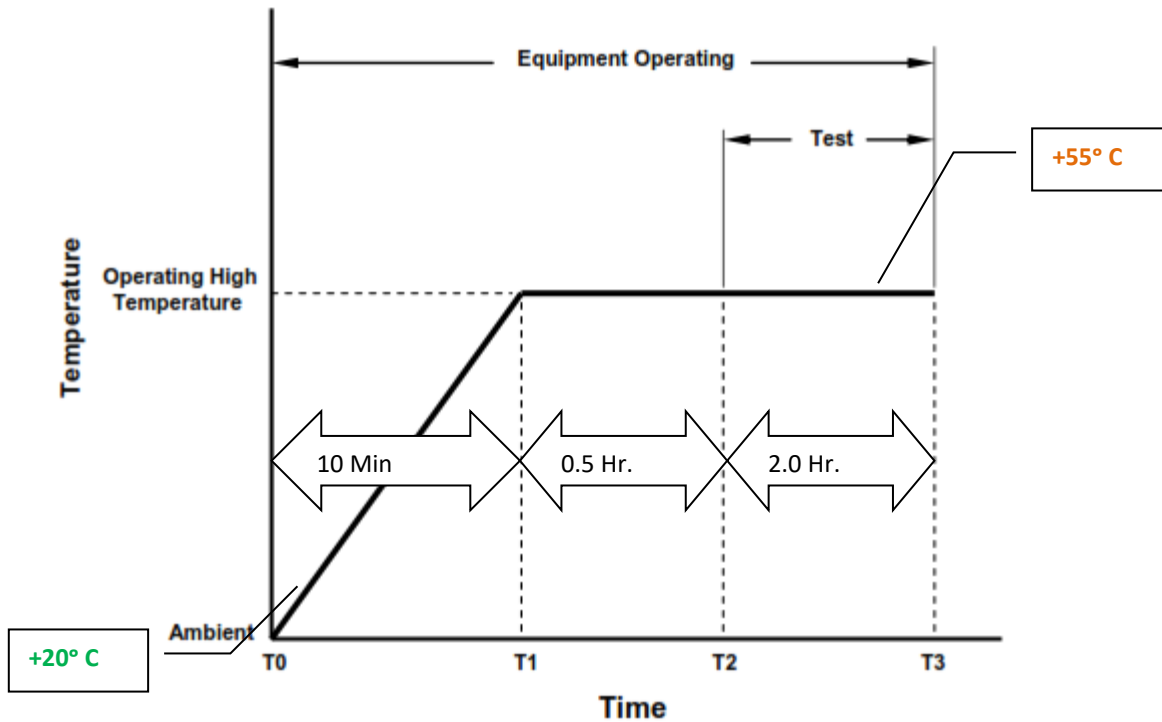


Figure 4 - Operating High Temperature tests (PAC45-SYSTEM)

The equipment was subjected to the test conditions as specified in RTCA DO-160G, Section 4.0. The following tests were satisfactory”

5. Paragraph 2.4.3 - Distortion Characteristics (<1% THD)
6. Subparagraph 2.4.1 1.1 - Audio Noise Without Signal (-56 to -4 dB, typical)
7. Paragraph 2.4.15 - Listening Test (Sound quality normal)
8. All mechanical devices operated satisfactorily. (Test OK).

### 2.5.1.4 Altitude Tests

The equipment was subjected to the test conditions as specified in RTCA DO-160G, Section 4.6.1.

The EUT was installed in altitude chamber. The test harness with the following signals was available outside the pressure chamber:

1. COM 1 input
2. Unswitched 1 input
3. Pilot Mic input
4. Pilot headphone output

In addition, headsets and speaker were inside the chamber and could be monitored during the tests.



Pressure inside the chamber was decreased to 2.69 in Hg (55,000'). The EUT was Operating at 100% duty cycle for the entire period for 2 hours, after reaching the altitude, and monitoring the test requirements. Tested the following parameters satisfactorily:

1. Paragraph 2.4.3 - Distortion Characteristics: Measured 0.5%THD
2. Subparagraph 2.4.1 1.1 - Audio Noise Without Signal -55 dB
3. Paragraph 2.4.15 - Listening Test Satisfactory.



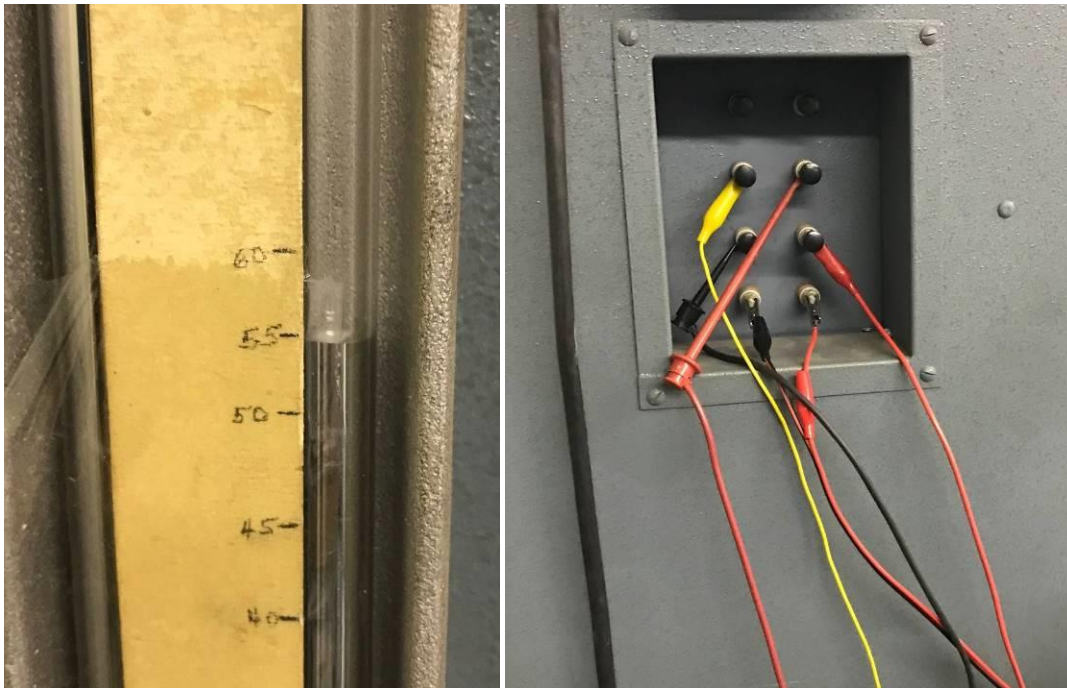


Figure 5 Altitude test setup

### 2.5.2 Temperature Variation

The unit was tested in accordance with RTCA DO-160G §5.0, Category B, 5°/minute: *For equipment in a non-temperature or partially temperature controlled internal section of the aircraft.*

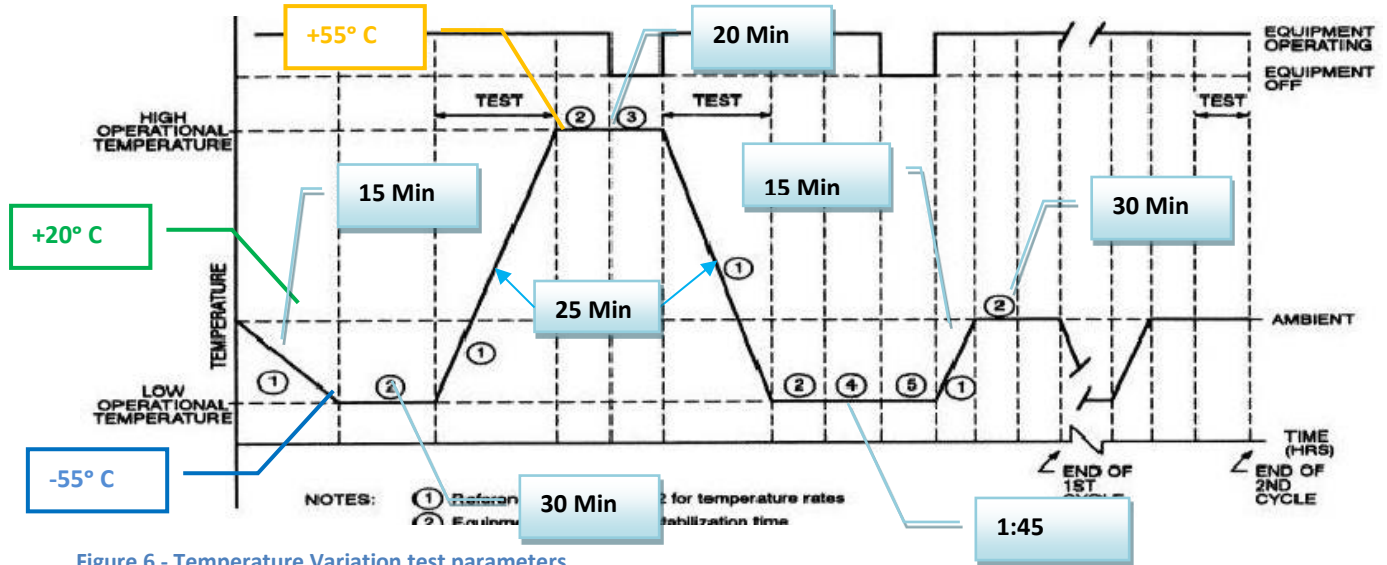


Figure 6 - Temperature Variation test parameters

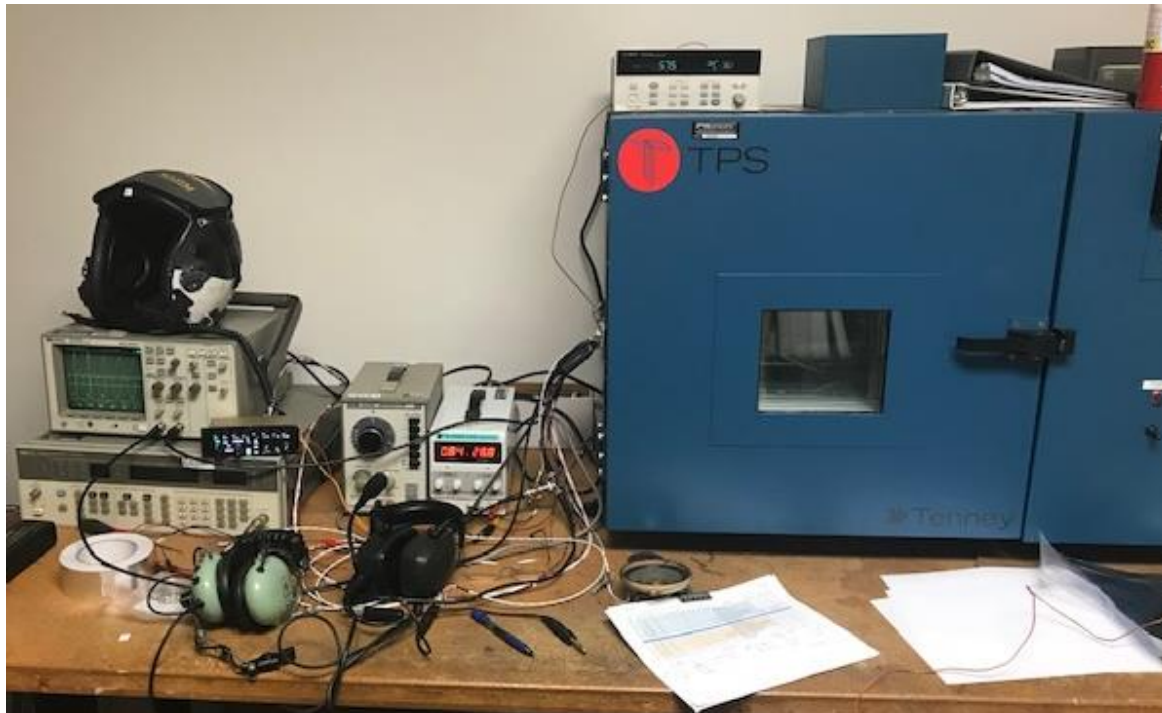


Figure 7 - Temperature testing setup

The equipment was subjected to the test conditions as specified in RTCA DO-160G, Section 5.0, Category B, *for equipment in a non-temperature or partially temperature controlled internal section of the aircraft.* Two complete cycles of the temperature variation applied.

During the testing portion of the variation, the following requirements were met

9. Paragraph 2.4.3 - Distortion Characteristics (<1% THD)
10. Subparagraph 2.4.1 1.1 - Audio Noise Without Signal (-56 to -64 dB, typical)
11. Paragraph 2.4.15 - Listening Test (Sound quality normal)
12. All mechanical devices operated satisfactorily. (Test OK).

### 2.5.3 Humidity

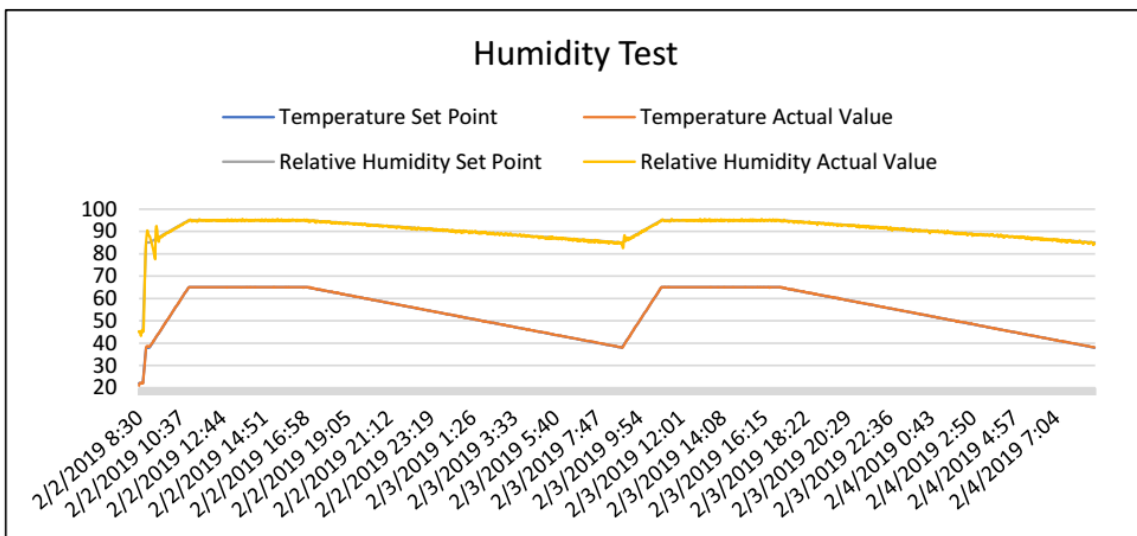
Humidity tests were conducted in accordance with DO-160G, § 6.0, Category A, Standard Humidity.

1. Stabilized the PAC45-SYSTEM at 38±2 °C and 85±4 % RH.
2. Over a two-hour period, ± 10 minutes, raised the chamber temperature to 50±2 °C and humidity to 95±4 % RH.
3. Maintain the chamber temperature at 50±2 °C and humidity at 95±4 % RH for six hours minimum.
4. During the next 16-hour period, ± 15 minutes, decrease the temperature gradually to 38±2 °C or lower. During this period, keep the humidity as high as possible and do not allow it to fall below 85 % RH.
5. Repeat steps 2, 3, and 4 for a total of two cycles (48 hours of exposure).
6. Step 7: Immediately following the warm-up the following requirements were met:
  1. Paragraph 2.4.3 - Distortion Characteristics: <0.5% THD
  2. Paragraph 2.4.7 – Crosstalk -50 dBm
  3. Subparagraph 2.4.1 1.1 - Audio Noise Without Signal -55 dBm
  4. Paragraph 2.4.15 - Listening Test OK
  5. All mechanical devices shall operate satisfactorily. OK





Figure 8 PAC45-SYSTEM System EUT Humidity tests



The PAC45-SYSTEM Complies with DO-214A, §2.5.3 and RTCA DO-160G §6.0 for Standard Humidity Category A.

## 2.5.4 Shock Tests

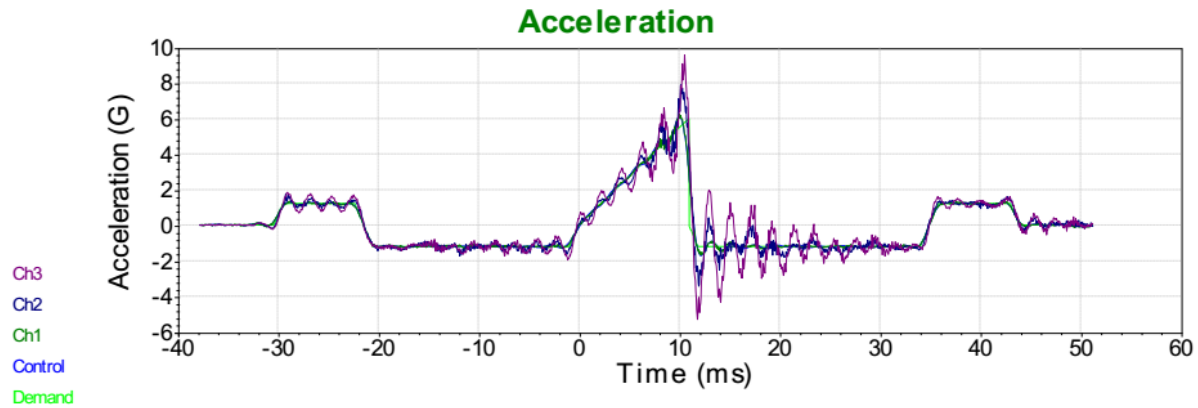
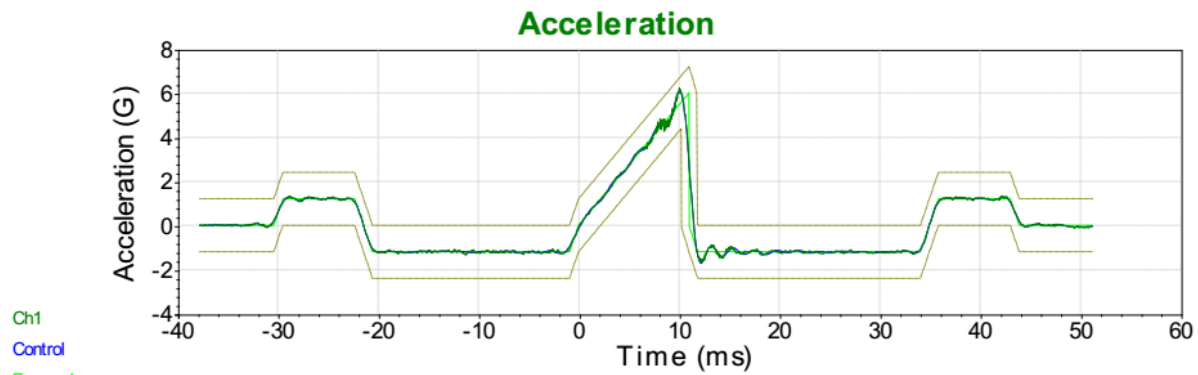
Shock tests were in accordance with DO-160G, § 7.0, Category B, standard operational and crash safety, and combined with vibration testing, and conducted in all three axis.

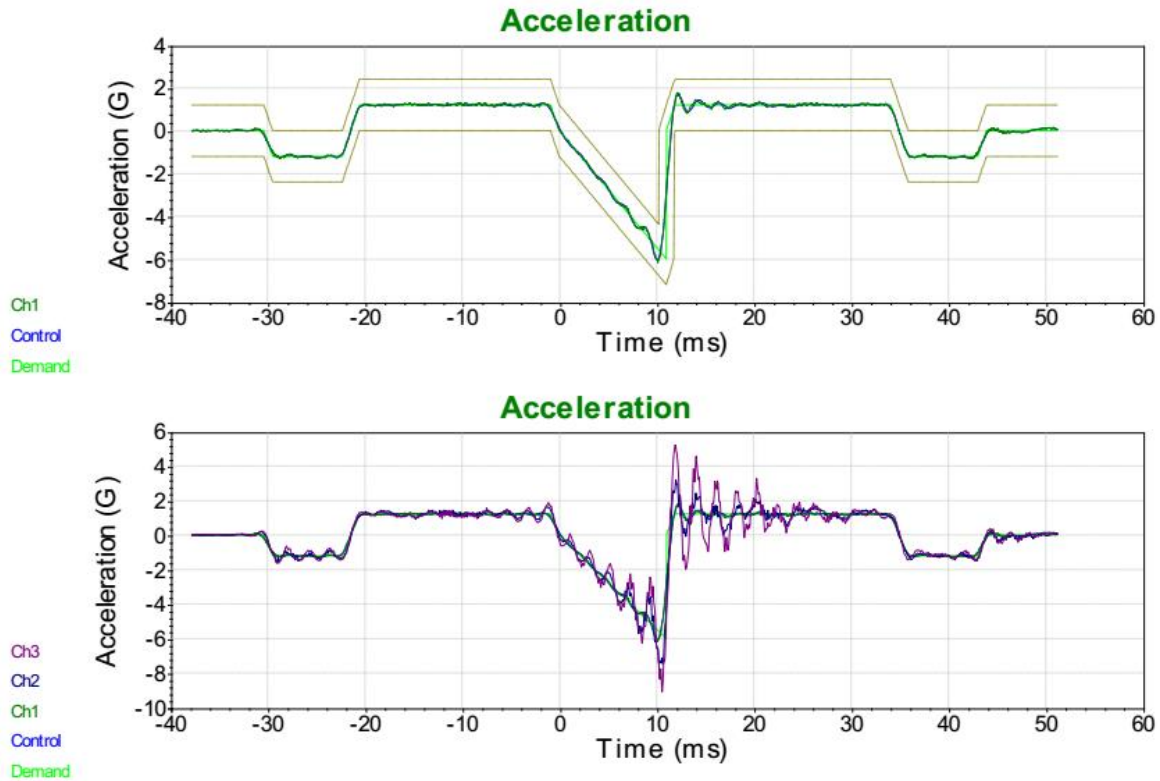
### 2.5.4.1 Operational Shocks

The EUT was subjected to a shock of 6 g for 11ms, in all three axes.

After the test, the following requirements were met:

1. Paragraph 2.4.3 - Distortion Characteristics
2. Subparagraph 2.4.1 1.1 - Audio Noise Without Signal
3. Paragraph 2.4.15 - Listening Test
4. All mechanical devices shall operate satisfactorily.





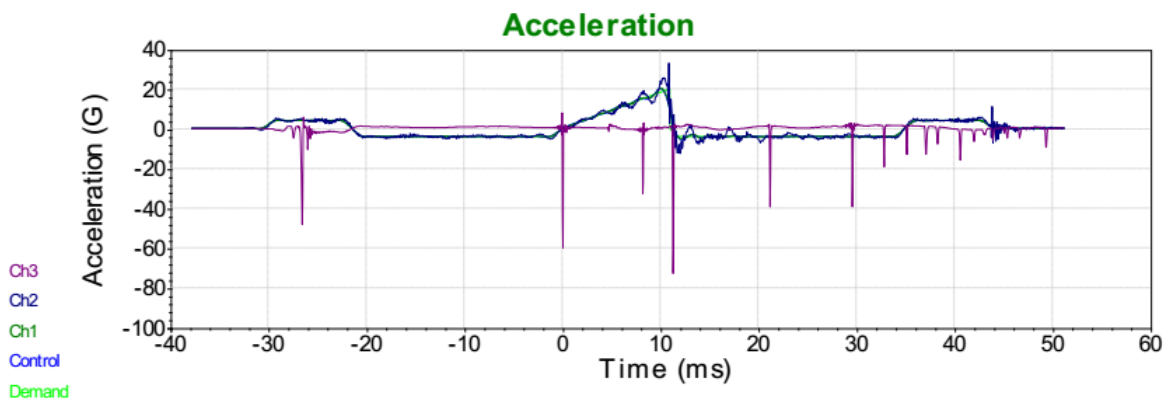
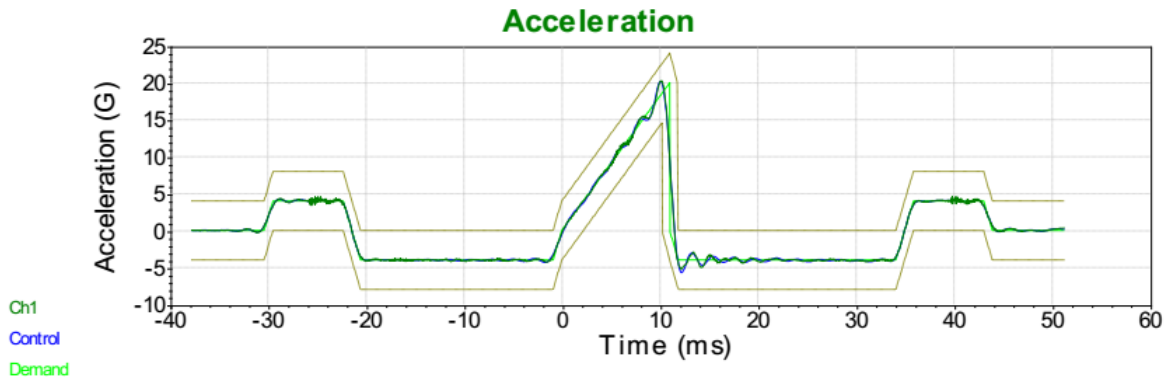
#### 2.5.4.2 Crash Safety Shocks

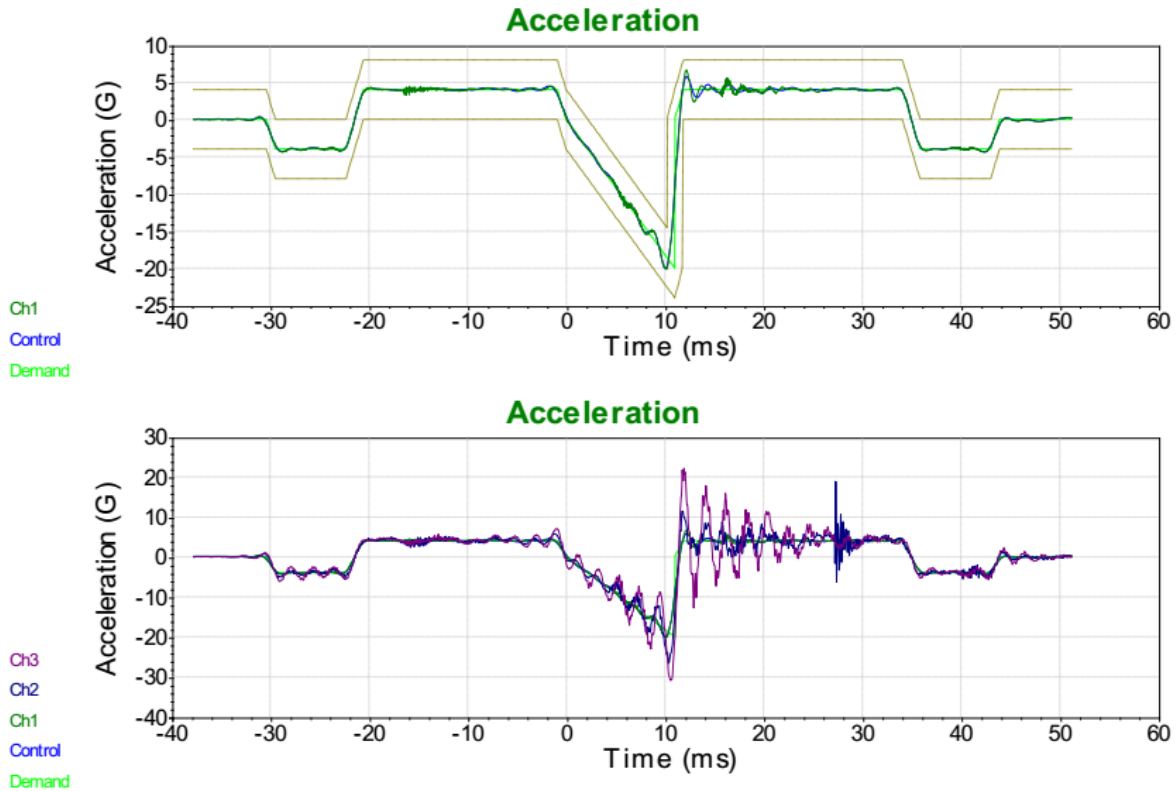
The EUT was subjected to a shock of 20 g for 11ms, in all three axes.

After the test, the following requirements were met:

5. The equipment remained in its mounting, and no parts of the equipment or its mounting became detached and free of the equipment.







## 2.5.5 Vibration Tests

The equipment was subjected to the test conditions as specified in RTCA DO-160G, Section 8.0, Vibration test, Category S Standard Vibration Test (§8.2.1).

With the PAC45-SYSTEM EUT operating, applied vibration (Curve M from 5 Hz to 500 Hz) for 60 minutes, while monitoring the accelerometers for response at selected location.

During the Performance level vibration, verify the EUT meets the following requirements:

1. Paragraph 2.4.1 – Rated output power
2. Subparagraph 2.4.1 1.1 - Audio Noise Without Signal
  - a. **During** the vibration, the noise was not more than -30 dB from the rated output.
  - b. **Following** the test, the Audio Noise without signal shall be at least -50 dB below the rated output
3. Paragraph 2.4.15 - Listening Test

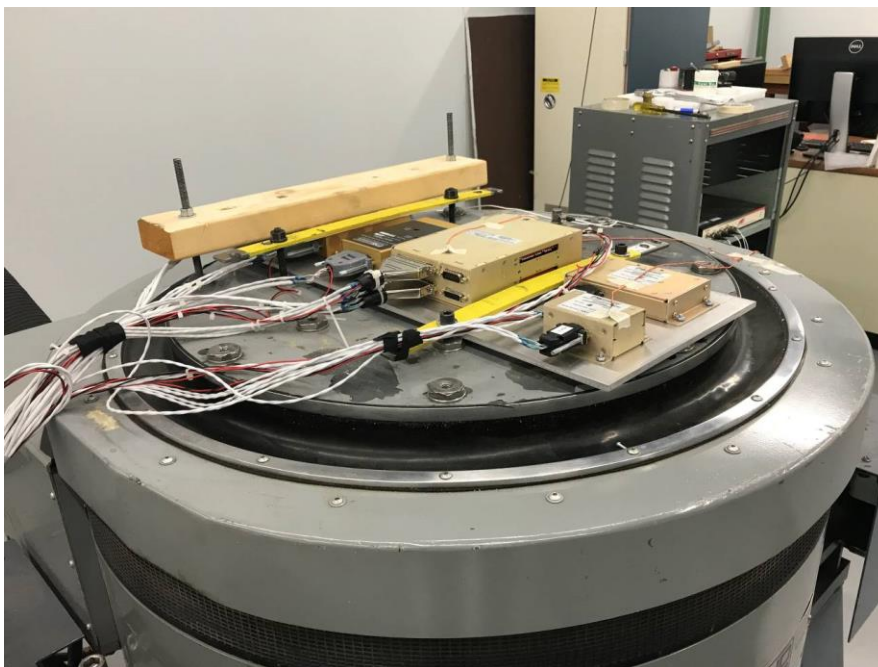
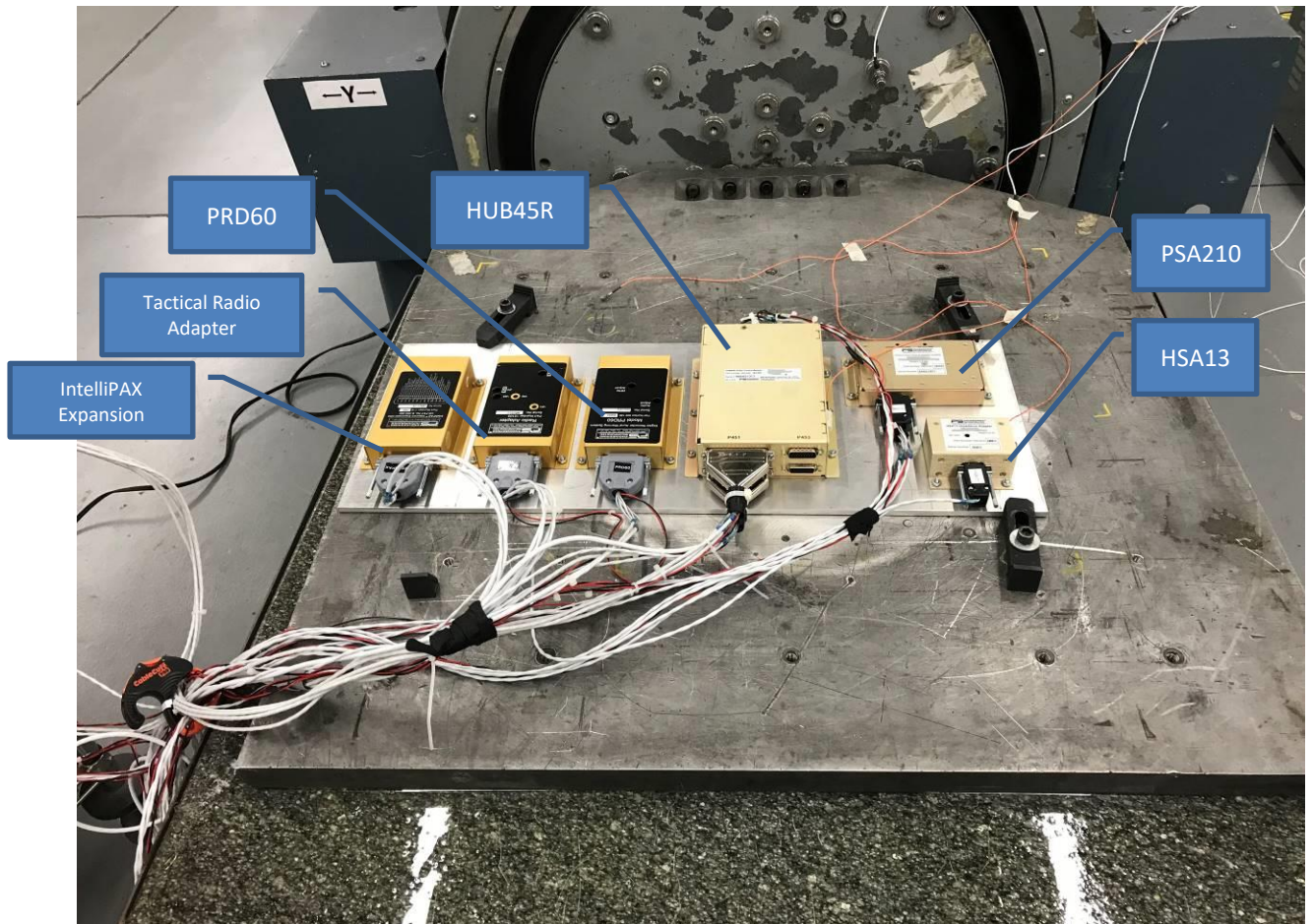
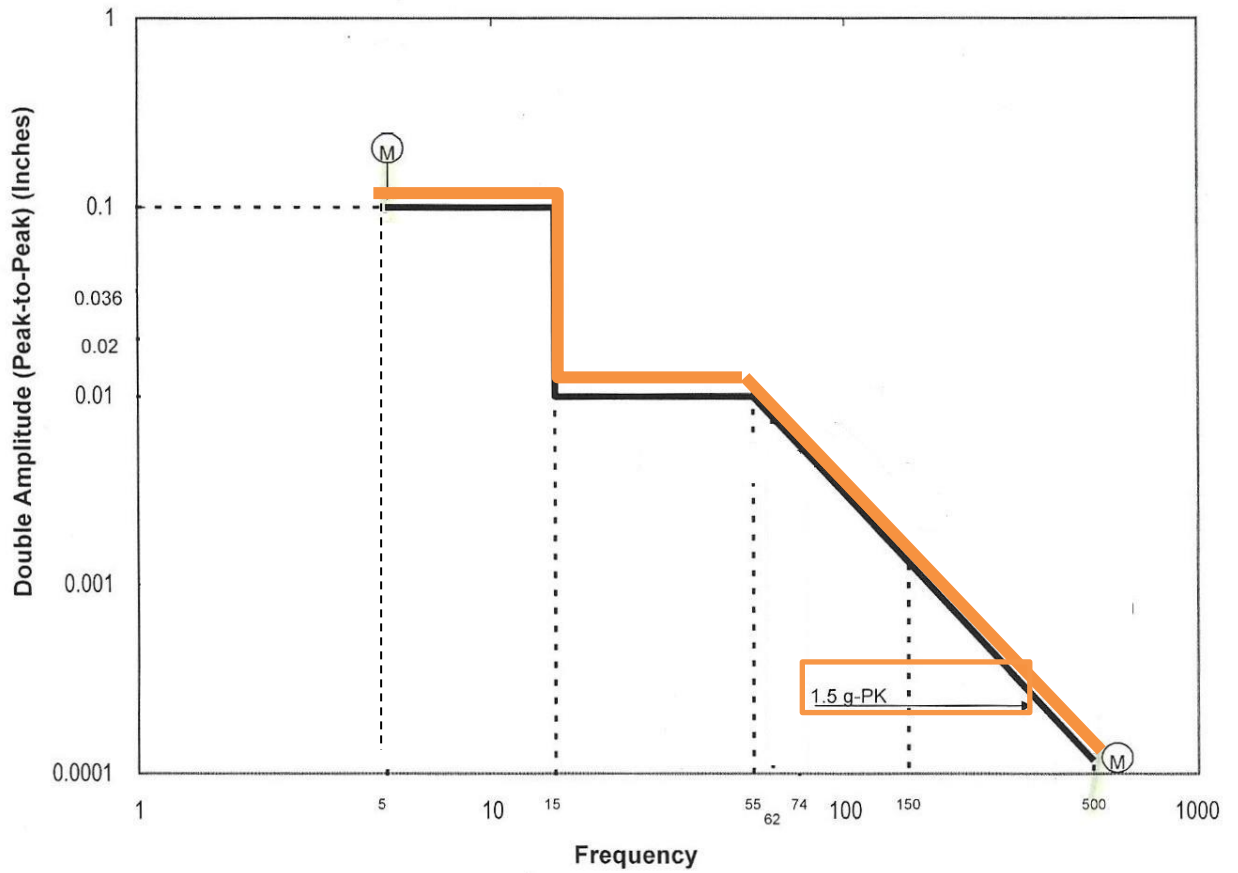
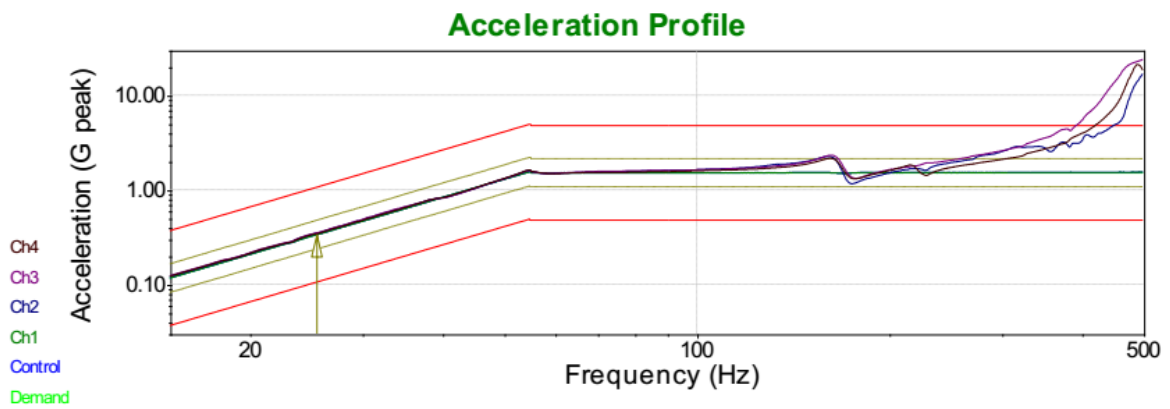
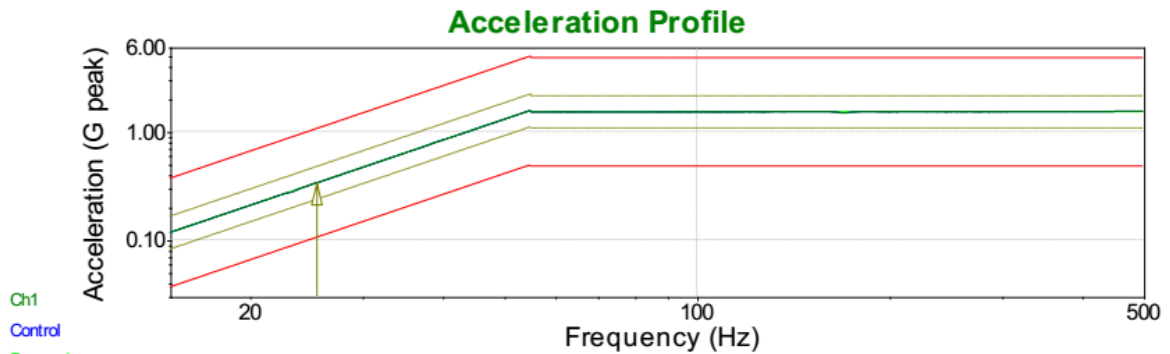


Figure 9 - PAC45-SYSTEM under vibration test





*Breakpoint table*

Start Freq.	Amplitude	End Freq.	Amplitude
15 Hz	0.01 in	55 Hz	0.01 in
55 Hz	1.5 G	500 Hz	1.5 G

*Current Measurements:*

Demand: 0.01 in at 25.53 Hz	Ch1: 0.332 G
Control: 0.332 G	Ch2: 0.3439 G
Control Vel.: 0.0203 m/s	Ch3: 0.346 G
Control Disp.: 0.009967 in	Ch4: 0.3396 G

Drive voltage: 0.1175 Volts peak  
 System gain is 0.3538 Volts/G (Max system gain limit = 10 Volts/G)

*Channel Measurements:*

	Accel	Velocity	Displacement
Ch1	0.332 G	0.0203 m/s	0.009966 in
Ch2	0.3439 G	0.0203 m/s	0.009966 in
Ch3	0.346 G	0.02115 m/s	0.01038 in
Ch4	0.3396 G	0.02077 m/s	0.01019 in

**Figure 10 Frequency and Vibration level (Curve M)**

Following the successful Fixed Wing tests, the EUT was then subjected to vibration in accordance with RTCA DO-160G, §8.8.3.

The equipment was subjected to the test conditions as specified in RTCA DO-160G, Section 8.0, Vibration test, Category U2 Random Test Procedure (§8.8.3) Unknown helicopter frequencies

With the PAC45 EUT operating, applied performance-level vibration (Curve F from 5 Hz to 300 Hz) for 15 minutes, while monitoring the accelerometers for response at selected location.

During the Performance level vibration, verify the EUT meets the following requirements:

1. Paragraph 2.4.1 – Rated output power
2. Subparagraph 2.4.1 1.1 - Audio Noise Without Signal
  - a. **During** the vibration, the noise was not more than -30 dB from the rated output.
  - b. **Following** the test, the Audio Noise without signal shall be at least -50 dB below the rated output
3. Paragraph 2.4.15 - Listening Test

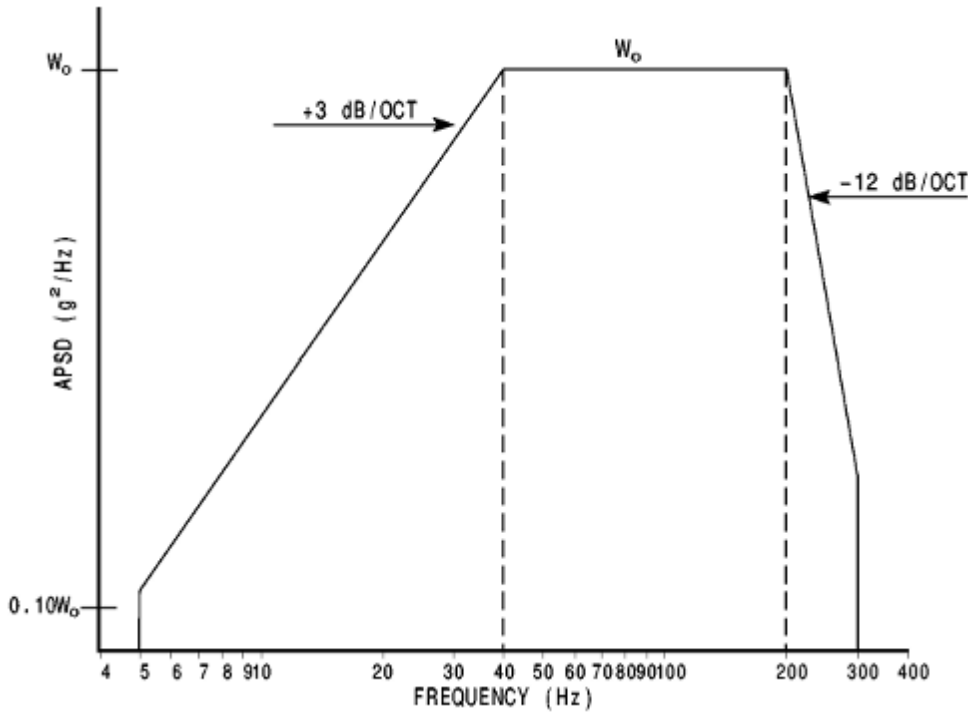
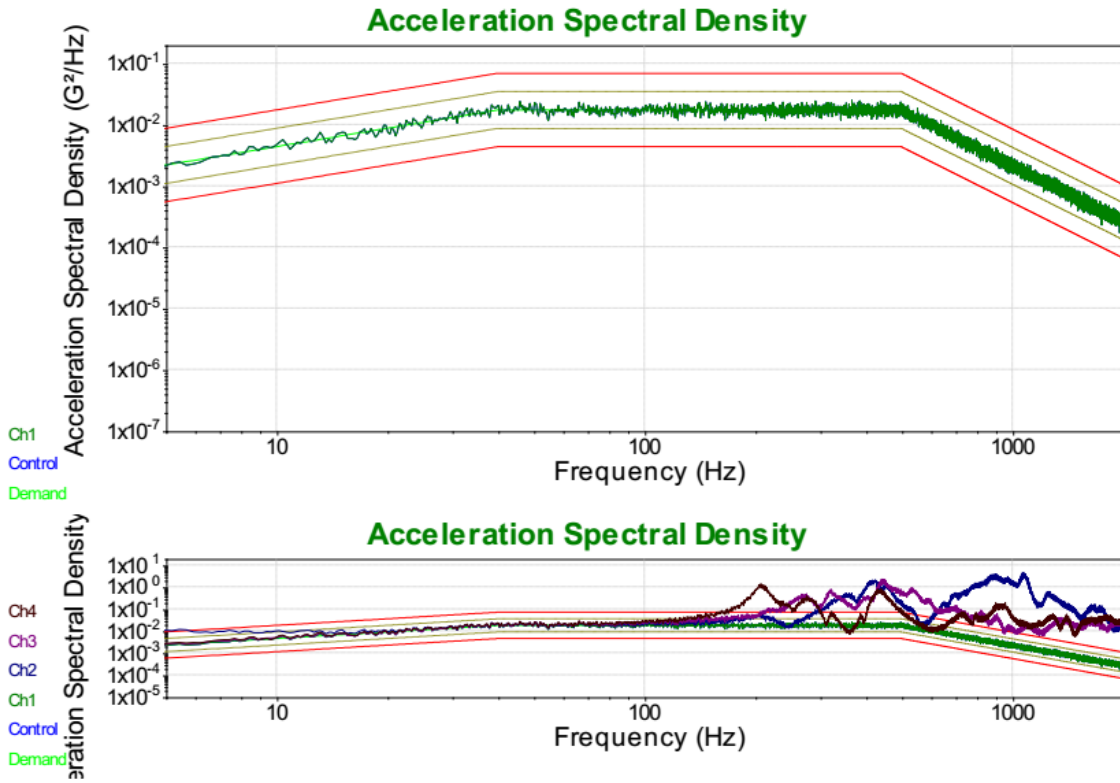


Figure 11 - Random Helicopter Vibration

Test	Test Category	W <sub>0</sub>	G <sub>rms</sub>
Performance	F	0.05	3.37
Endurance	F1	0.10	4.76

Figure 12 Vibration test Curves, Helicopter Category U2

Frequency	W <sub>0</sub>
5 Hz	0.126
40 Hz	1.0
200 Hz	1.0
300 Hz	0.199



*Breakpoint table*

Frequency	G <sup>2</sup> /Hz	dB/Octave
5 Hz	0.00214	3
40 Hz	0.017	0
200 Hz	0.017	0
500 Hz	0.017	-9.077
2000 Hz	0.00026	

*Channel Measurements:*

	(Overall)	(InBand)
Ch1	3.488 G RMS	3.486 G RMS
Ch2	30.91 G RMS	30.67 G RMS
Ch3	14.86 G RMS	14.41 G RMS
Ch4	14.62 G RMS	11.18 G RMS

## 2.5.6 Magnetic Effect Test

The equipment was subjected to the test conditions as specified in RTCA DO-160G, Section 15, Category Z, and shall not deflect a compass needle more than 1° at 0.3 meters distance. This category is intended for equipment located  $\geq 0.3$  meter from a compass or flux gate magnetometer.

## 2.5.7 Power Input Tests

### 2.5.7.1 Normal Operating Conditions

The equipment was subjected to the applicable test conditions as specified in RTCA DO-160G, Section 16.0, for **Category Z** (28 VDC systems).

Applies to 28 V DC equipment that may be used on all other types of aircraft electrical systems applicable to these standards is identified as Category Z. Category Z shall be acceptable for use in lieu of Category A or Category B.

Examples of this category are dc systems supplied from variable speed generators where:

- a. The DC supply does not have a battery floating on the DC bus, or
- b. The control or protective equipment may disconnect the battery from the DC bus, or
- c. The battery capacity is small compared with the capacity of the DC generators.

#### Manual Reset:

Manual Reset is the act of cycling all power to the EUT from on to off back to on to clear a fault condition or EUT latch up. Entering data into the EUT after a test, such as a power interrupt, is not considered to be a Manual Reset unless otherwise specified in applicable equipment performance standards.

### 16.3 Emergency Electrical System Operation

Emergency electrical system operation is defined as the condition of the electrical system during flight when the primary electrical system becomes unable to supply sufficient or proper electrical power, thus requiring the use of an independent source(s) of emergency power which is limited in power output capabilities.

#### *2.5.7.1 Normal Operating Conditions (dc) §16.6.1.*


Average Value DC Voltage Definitions:

	Normal	
	28 V System	14 V System
Maximum	30.3 VDC	15.1 VDC
Nominal	27.5 VDC	13.8 VDC
Minimum	22.0 VDC	11.0 VDC
Emergency	18.0 VDC	9.0 VDC

**Figure 13 - Normal Operating Voltage Definitions**

1. Operated the PAC45-SYSTEM EUT at maximum duty cycle (headphones fully loaded with signal) for 30 minutes with primary power adjusted to **maximum** voltage (32.2 VDC). Confirm the following:
2. Then operate at **nominal** voltage (27.5 VDC) for 1 minute



	<b>PAC45 Environmental Conditions Test Report RTCA DO-160G</b>	Document: 002-145-0160 Date: 2/22/19 Revision: new
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3. Then adjusted to **minimum** (22.0 VDC) voltage and operate for 30 minutes. Test the EUT to determine compliance with requirements as modified by DO-214A:
  - a. Paragraph 2.4.1 – Output Rated Power, NLT – 3DB
  - b. Paragraph 2.4.3 - Distortion Characteristics <20%
  - c. Subparagraph 2.4.1 1.1 - Audio Noise Without Signal -50 dB
  - d. Paragraph 2.4.15 - Listening Test - Remains Intelligible
4. Finally, operate the equipment with primary power adjusted to **emergency** voltage (18.0 VDC).
5. Test the EUT to determine compliance with requirements as modified by DO-214A, Table 2-1:
  - a. Paragraph 2.4.1 – Output Rated Power, NLT – 6 dB
  - b. Paragraph 2.4.3 - Distortion Characteristics <30%
  - c. Subparagraph 2.4.1 1.1 - Audio Noise Without Signal -40 dB
  - d. Paragraph 2.4.15 - Listening Test - Remains Intelligible
6. Finally, operate the equipment with primary power adjusted to **emergency** voltage (9.0 VDC).
  - a. During the test, the following requirements shall be met:
    - i. Degradation of performance is tolerable provided the equipment will resume normal operation when power input is returned to normal operating conditions.
    - ii. The gradual reduction to zero of the primary power voltage(s) for DC operated equipment shall produce no evidence of the presence of fire or smoke or permanent damage to the equipment.
  - b. After the test, the following requirements shall be met.
    - i. DC-operated equipment shall operate satisfactorily within one second of returning primary power voltage(s) to normal after testing to low voltage conditions. The one-second time period specified *does not include the time required for the operation of automatic self-test.*
  - c. Subparagraph 2.4.1 1.1 - Audio Noise Without Signal -50 dB
  - d. Paragraph 2.4.15 - Listening Test - Remains Intelligible
  - e. Subparagraph 2.4.11.1 - Audio Noise Without Signal

#### DO-160G §16.6.1.2 Ripple Voltage DC

Ripple Voltages shall be < 4V p-p from 22 to 32 VDC, and < 2 Vp-p for input less than 22 VDC

- b. Requirements related to ripple frequency components:

Refer to the paragraph 18.3.1 of subsection 18.3.

*Note: Categories R, B, Z and Z defined in section 18 correspond respectively to categories A, B, D and Z as defined in section 16*

Output	Test	Data	200Hz-1kHz	1kHz-15kHz		
Pilot Headset	Power Output	Vout (Vrms)	6.20	6.20	100% power	

Output	Test	Data	200Hz-1kHz	1kHz-15kHz	
(COM 1)	Distortion THD+N	@ 300 Hz (%)	0.3	0.3	10% power
		@ 1000 Hz (%)	0.3	0.3	
		@ 6000 Hz (%)	0.4	0.4	
	Frequency Response 300Hz-6kHz	Vmin (Vrms)	4.32	4.38	50% Power
		Vmax (Vrms)	4.37	4.40	
		Deviation	Change (dB)	0.10	
	Output Noise	Vout (mVrms)	8.00	8.00	
		Level (dB)	-57.0	-57.0	
	Listening Test		GOOD	GOOD	
	Pilot CVR (COM 1)	Power Output	Vout (Vrms)	2.8	2.8
Distortion THD+N		@ 300 Hz (%)	0.2	0.2	30% power
		@ 6000 Hz (%)	0.2	0.2	
Frequency Response 300Hz-6kHz		Vmin (Vrms)	1.70	1.80	50% Power
		Vmax (Vrms)	1.80	2.00	
Deviation		Change (dB)	0.50	0.92	
Output Noise		Vout (mVrms)	16.00	16.00	
		Level (dB)	-55.0	-55.0	(Relative to 2Vrms)
Listening Test			GOOD	GOOD	
Pilot Speaker (COM 1)		Power Output	Vout (Vrms)	6.32	6.32
	Distortion THD+N	@ 300 Hz (%)	0.3	0.3	30% power
		@ 6000 Hz (%)	0.5	0.5	
	Frequency Response 300Hz-6kHz	Vmin (Vrms)	3.50	3.50	50% Power
		Vmax (Vrms)	4.50	4.50	
	Deviation	Change (dB)	2.18	2.18	
	Output Noise	Vout (mVrms)	0.90	0.90	
		Level (dB)	-53.0	-53.0	(Relative to 2Vrms)
	Listening Test		GOOD	GOOD	

Figure 14 Test results for Ripple Test DO-160G §16.6.1.2

**DO-160G §16.6.1.3 Momentary Power Interruptions**

The EUT was subjected to momentary power interruptions as described in RTCA DO-160G§16.6.1.3(b) *Requirement for Equipment with Digital Circuits*, with the results in table below.

Transient Voltage (VDC)	Transient Duration (ms)	Observation during Transient	Results after Transient
0	2	Slight pop in headset, intercom/system works	Good, all systems work
14	13	Slight pop in headset, intercom/system works	Good, all systems work

Transient Voltage (VDC)	Transient Duration (ms)	Observation during Transient	Results after Transient
4.2	29	Slight pop in headset, intercom/system works	Good, all systems work
2.8	55	Pop in headset, intercom/system works	Good, all systems work
1.4	80	System powered up, no intercom/system	Good, all systems work
0	105	System powered up, no intercom/system	Good, all systems work
0	205	System powered up, no intercom/system	Good, all systems work
0	1005	System powered up, no intercom/system	Good, all systems work
22.4	14	Slight pop in headset, intercom/system works	Good, all systems work
14	35	Slight pop in headset, intercom/system works	Good, all systems work
0	70	Pop in headset, intercom/system works	Good, all systems work
4.2	93	System powered up, no intercom/system	Good, all systems work
104	120	System powered up, no intercom/system	Good, all systems work
0	220	System powered up, no intercom/system	Good, all systems work
0	1020	System powered up, no intercom/system	Good, all systems work
18.2	38	Slight pop in headset, intercom/system works	Good, all systems work
16.8	37	Slight pop in headset, intercom/system works	Good, all systems work
9.8	53	Pop in headset, intercom/system works	Good, all systems work
0	30	Slight pop in headset, intercom/system works	Good, all systems work

**Figure 15 - Power Interruption Results DO-160G §16.6.1.3(b)**

Although the EUT reverted automatically into fail-safe when power was interrupted for longer periods it always returned to normal operation without loss of data or manual reset required.

The EUT was subjected to momentary power interruptions of 50ms and one second, as described in RTCA DO-160G§16.6.1.3(c) *Requirement for All Equipment*, with the results in table below.

Transient Voltage (VDC)	Transient Duration (ms)	Observation during Transient	Results after Transient
0	50	Failsafe	Good
0	50	Failsafe	Good
0	50	Failsafe	Good
0	50	Failsafe	Good
0	50	Failsafe	Good
0	1000	Failsafe	Good
0	1000	Failsafe	Good
0	1000	Failsafe	Good
0	1000	Failsafe	Good
0	1000	Failsafe	Good

**Figure 16 - Power Interruption Results DO-160G §16.6.1.3(c)**

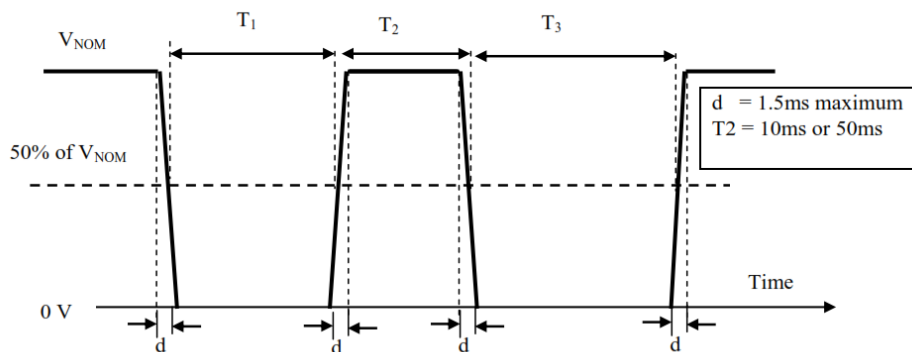
Although the EUT reverted automatically into fail-safe when power was interrupted for longer periods it always returned to normal operation without loss of data or manual reset required.

**Double Interrupt per DO-160G §16.6.1.3(d)**

Apply the input voltage test conditions as shown in the figure below. The tests were performed with a T<sub>2</sub> duration of 10 ms, and again with a T<sub>2</sub> duration of 50 ms.

Monitor the PAC45-SYSTEM performance during and after the test application.

The PAC45-SYSTEM shall not require reentry of information that is normally stored.



Vin	Transient	Observation during Transient	Results after Transient	
28	2ms	No changes to the front panel, ICS works	Good	Slight pop in headset at each transient
	10ms	No changes to the front panel, ICS works	Good	
	25ms	No changes to the front panel, ICS works	Good	
	50ms	No changes to the front panel, ICS works	Good	

**Figure 17 - Double Interruption Results DO-160G §16.6.1.3(d)**

Although the EUT reverted automatically into fail-safe when power was interrupted for longer periods it always returned to normal operation without loss of data or manual reset required.

**Normal Surge Voltage per DO-160G §16.6.1.4**

The PAC45-SYSTEM EUT was operated for five minutes at 28VDC. Then increased the input voltage to 50 VDC for 50 ms. Reduce back to 28 VDC for five seconds, repeated two more times.

Output	Test	Data	During	After		
Pilot Headset (COM 1)	Power Output	Vout (Vrms)	6.20	6.20	100% power	
		@ 300 Hz (%)	0.30	0.29	10% power	
		@ 1000 Hz (%)	0.22	0.24		
		@ 6000 Hz (%)	0.28	0.30		
	Distortion THD+N					50% Power
	Frequency Response	Vmin (Vrms)	4.37	4.37		
		Vmax (Vrms)	4.40	4.40		
		Change (dB)	-0.50	-0.50		
	Output Noise	Vout (mVrms)	10.000	10.000		
		Level (dB)	-56.0	-56.0		
Listening Test		GOOD	GOOD			

Pilot CVR (COM 1)	Power Output	Vout (Vrms)	2.80	2.8	100% power
	Distortion	@ 300 Hz (%)	0.24	0.24	10% power
	THD+N	@ 1000 Hz (%)	0.23	0.25	
		@ 6000 Hz (%)	0.23	0.24	
	Output Noise	Vout (mVrms)	15.00	16	50% Power
	Level (dB)	-55.0	-55		
Listening Test		GOOD	GOOD		
Pilot Speaker (COM 1)	Power Output	Vout (Vrms)	6.32	6.32	100% power
	Distortion	@ 300 Hz (%)	0.25	0.25	10% power
	THD+N	@ 1000 Hz (%)	0.40	0.4	
		@ 6000 Hz (%)	0.40	0.4	
	Output Noise	Vout (mVrms)	1.40	1.4	50% Power
	Level (dB)	-53.0	-53		
Listening Test		GOOD	GOOD		

Figure 18 – Normal Surge Voltage Results DO-160G §16.6.1.4

During and following application of surge voltages, verified the PAC45-SYSTEM meets requirements: **DO-214A**:

- a. Paragraph 2.4.1 – Output Rated Power,
- b. Paragraph 2.4.3 - Distortion Characteristics
- c. Subparagraph 2.4.1 1.1 - Audio Noise Without Signal
- d. Paragraph 2.4.15 - Listening Test

#### Engine Starting Under Voltage (DC) Per DO-160G §16.6.1.5

Decreased the input voltage from 28 VDC to 10 VDC and then slowly increase the voltage back to 20 VDC over 35 seconds (equivalent to 0.3 V per second). Then returned to 28VDC.

**During** application of the starting voltage, verify that the PAC45-SYSTEM meets the modified DO-214A requirements:

- a. Paragraph 2.4.1 – Output Rated Power, NLT – 3DB
- b. Paragraph 2.4.3 - Distortion Characteristics <20%
- c. Subparagraph 2.4.1 1.1 - Audio Noise Without Signal -50 dB
- d. Paragraph 2.4.15 - Listening Test - Remains Intelligible

**Following** application of starting voltages, verify the PAC45-SYSTEM meets requirements: **DO-214A**:

- a. Paragraph 2.4.1 – Output Rated Power,
- b. Paragraph 2.4.3 - Distortion Characteristics
- c. Subparagraph 2.4.1 1.1 - Audio Noise Without Signal
- d. Paragraph 2.4.15 - Listening Test

Output	Test	Data	28VDC	
Pilot Headset (COM 1)	Power Output	Vout (Vrms)	6.20	100% power
	Distortion	@ 300 Hz (%)	0.29	10% power
	THD+N	@ 1000 Hz (%)	0.31	
		@ 6000 Hz (%)	0.35	
	Frequency Response	Vmin (Vrms)	4.35	50% Power
	300Hz-6kHz	Vmax (Vrms)	4.38	
	Deviation	Change (dB)	-0.50	
Output Noise	Vout (mVrms)	10.000		

		Level (dB)	-57.0	
	Listening Test			GOOD
Pilot CVR (COM 1)	Power Output	Vout (Vrms)	2.80	100% power
	Distortion THD+N	@ 300 Hz (%)	0.25	10% Power
		@ 1000 Hz (%)	0.24	
		@ 6000 Hz (%)	0.25	
	Output Noise	Vout (mVrms)	14.00	50% Power
Level (dB)		-55.0		
	Listening Test			GOOD
Pilot Speaker (COM 1)	Power Output	Vout (Vrms)	6.32	100% power
	Distortion THD+N	@ 300 Hz (%)	0.25	10% power
		@ 1000 Hz (%)	0.35	
		@ 6000 Hz (%)	0.38	
	Output Noise	Vout (mVrms)	1.30	50% Power
Level (dB)		-54.0		
	Listening Test			GOOD

Figure 19 - Engine Starting Voltage Test Results

### 2.5.7.2 Abnormal Operating Conditions (dc) §16.6.2.

Voltage at Equipment Terminals	28 V dc
Maximum	32.2 V
Minimum	20.5 V

#### Low Voltage operation in accordance with DO-160G, §16.6.2.2.

Operated the PAC45-SYSTEM EUT for one minute at 28 VDC, then reduced to 20 VDC and operated for one minute. Then reduced the voltage to zero over at least 10 minutes. Returned to 28 VDC, and tested the unit in accordance with DO-214A


After the test, the following requirements were met.

- a. The PAC45-SYSTEM EUT shall operate satisfactorily within one second of retuning voltage to 28VDC after testing to low voltage conditions. The one second time period specified does not include the time required for the automatic self-test.
- b. Paragraph 2.4.3 - Distortion Characteristics
- c. Subparagraph 2.4.11.1 - Audio Noise Without Signal
- d. Paragraph 2.4.15 - Listening Test

Output	Test	Data	32.2VDC	27.5VDC	22VDC	18VDC	
Pilot Headset (COM 1)	Power Output	Vout (Vrms)	6.2	6.2	6.2	6.2	100% power
	Distortion THD+N	@ 300 Hz (%)	0.28	0.30	0.30	0.32	10% power
		@ 1000 Hz (%)	0.30	0.38	0.37	0.36	
		@ 6000 Hz (%)	0.35	0.44	0.39	0.40	

Output	Test	Data	32.2VDC	27.5VDC	22VDC	18VDC	
	Frequency Response 300Hz-6kHz Deviation	Vmin (Vrms)	4.38	4.38	4.38	4.38	50% Power
		Vmax (Vrms)	4.40	4.40	4.40	4.4	
		Change (dB)	0.04	0.04	0.04	0.04	
	Output Noise	Vout (mVrms)	8.0	8.0	8.0	8.0	
		Level (dB)	-56.0	-57.0	-57.0	-57	
	Listening Test		GOOD	GOOD	GOOD	GOOD	
Pilot CVR (COM 1)	Power Output	Vout (Vrms)	2.8	2.8	2.8	2.8	100% power
	Distortion THD+N	@ 300 Hz (%)	0.22	0.22	0.18	0.12	10% power
		@ 1000 Hz (%)	0.19	0.18	0.15	0.15	
		@ 6000 Hz (%)	0.20	0.21	0.22	0.16	
	Frequency Response 300Hz-6kHz Deviation	Vmin (Vrms)	1.70	1.64	1.69	1.682	50% Power
		Vmax (Vrms)	1.99	1.99	1.90	1.9	
		Change (dB)	2.47	2.47	2.47	2.47	
Output Noise	Vout (mVrms)	16.00	16.00	16.00	16		
	Level (dB)	-55.0	-55.0	-55.0	-55		
Listening Test		GOOD	GOOD	GOOD	GOOD		
Pilot Speaker (COM 1)	Power Output	Vout (Vrms)	6.32	6.32	6.32	6.32	100% power
	Distortion THD+N	@ 300 Hz (%)	0.25	0.25	0.45	0.8	10% power
		@ 1000 Hz (%)	0.42	0.30	0.45	0.42	
		@ 6000 Hz (%)	0.45	0.50	0.50	0.45	
	Frequency Response 300Hz-6kHz Deviation	Vmin (Vrms)	3.46	3.46	3.46	3.46	50% Power
		Vmax (Vrms)	4.60	4.60	4.60	4.60	
		2.47	2.47	2.47	2.47	2.47	
	Output Noise	Vout (mVrms)	0.90	0.90	0.90	0.90	
		Level (dB)	-52.0	-52.0	-52.0	-52.0	
	Listening Test		GOOD	GOOD	GOOD	GOOD	

Figure 20 - Abnormal Voltage test, §16.6.2

	<b>PAC45 Environmental Conditions Test Report RTCA DO-160G</b>	Document: 002-145-0160 Date: 2/22/19 Revision: new
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Operated the PAC45-SYSTEM EUT at 28 VDC (nominal), and then reduced the input to 12.0 VDC for 7 seconds. Then back to Nominal and tested.

Following the undervoltage condition, the following requirements were met:

Degradation of performance is tolerable provided the equipment will resume normal operation when power input is returned to normal operating conditions.

The gradual reduction to zero of the primary power voltage(s) for DC operated equipment shall produce no evidence of the presence of fire or smoke or permanent damage to the equipment.

After the test, the following requirements were met.

- e. The PAC45-SYSTEM EUT shall operate satisfactorily within one second of retuning voltage to 28VDC after testing to low voltage conditions. The one second time period specified does not include the time required for the automatic self-test.
- f. Paragraph 2.4.3 - Distortion Characteristics
- g. Subparagraph 2.4.11.1 - Audio Noise Without Signal
- h. Paragraph 2.4.15 - Listening Test



Output	Test	Data	Results	
Pilot Headset (COM 1)	Power Output	Vout (Vrms)	3.89	100% power
	Distortion THD+N	@ 300 Hz (%)	0.79	10% power
		@ 1000 Hz (%)	0.80	
		@ 6000 Hz (%)	0.62	
	Output Noise	Vout (mVrms)	8.30	50% Power
		Level (dB)	-58.0	
Listening Test			Good	
CVR (COM 1)	Power Output	Vout (Vrms)	2	100% power
	Distortion HD+N	@ 300 Hz (%)	0.40	10% power
		@ 1000 Hz (%)	0.17	
		@ 6000 Hz (%)	0.38	
	Output Noise	Vout (mVrms)	6.30	50% Power
		Level (dB)	-50.0	
	Listening Test			Good

Figure 21 – Momentary Undervoltage Operation Results DO-160G §16.6.2.3

**Abnormal Surge Voltage (DC) DO-160G §16.6.2.4**

Operated the PAC45-SYSTEM EUT for five minutes at 28VDC. Then increased the input voltage to 80 VDC for 100 ms. then reduced the voltage to 48VDC for 1 second.

Repeated two more times at 10-second intervals. Reduced back to 28 VDC. Following application of surge voltages, verified the PAC45-SYSTEM met requirements: **DO-214A:**

- a. Paragraph 2.4.1 – Output Rated Power,
- b. Paragraph 2.4.3 - Distortion Characteristics
- c. Subparagraph 2.4.1 1.1 - Audio Noise Without Signal
- d. Paragraph 2.4.15 - Listening Test

Output	Test	Data	48V/1sec	80V/100ms	
Pilot Headset (COM 1)	Power Output	Vout (Vrms)	6.20	6.20	100% power
	Distortion THD+N	@ 300 Hz (%)	0.30	0.30	10% power
		@ 1000 Hz (%)	0.30	0.30	
		@ 6000 Hz (%)	0.30	0.30	
	Output Noise	Vout (mVrms)	10.00	10.00	50% Power
		Level (dB)	-57.0	-57.0	
Listening Test			GOOD	GOOD	
Pilot CVR (COM 1)	Power Output	Vout (Vrms)	2.80	2.8	100% power
	Distortion THD+N	@ 300 Hz (%)	0.25	0.25	10% power
		@ 1000 Hz (%)	0.25	0.25	

		@ 6000 Hz (%)	0.25	0.25	
	Output Noise	Vout (mVrms)	14.00	14	50% Power
		Level (dB)	-55	-55	
	Listening Test		GOOD	GOOD	
Pilot Speaker (COM 1)	Power Output	Vout (Vrms)	6.32	6.32	100% power
	Distortion THD+N	@ 300 Hz (%)	0.36	0.36	10% power
		@ 1000 Hz (%)	0.36	0.36	
		@ 6000 Hz (%)	0.36	0.36	
	Output Noise	Vout (mVrms)	1.30	1.3	50% Power
		Level (dB)	-55.0	-55	
Listening Test		GOOD	GOOD		

Figure 22 - Results of Abnormal Surge Voltage DO-160G §16.6.2.4

### 2.5.8 Voltage Spike Conducted Test (17.4)

The equipment shall be subjected to the applicable test conditions as specified in RTCA DO-160G, Section 17.4. The PAC45-SYSTEM was tested to the requirements of **Category B (48 Volts)**, where a lower standard of protection against damage from voltage spikes is required.

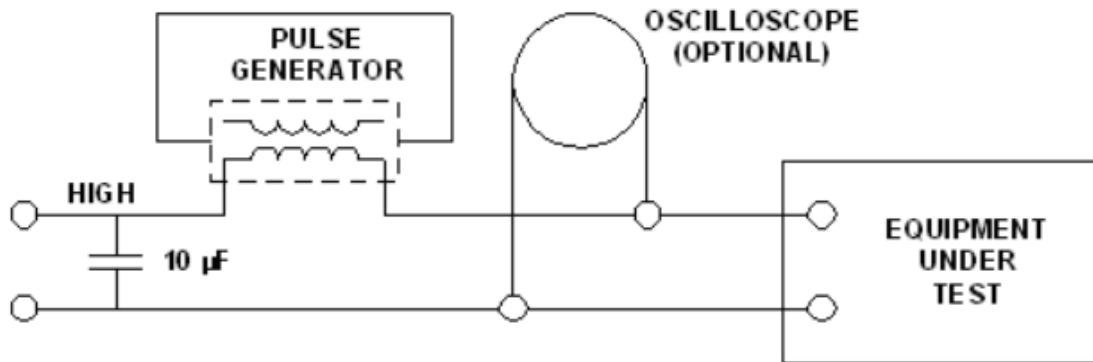
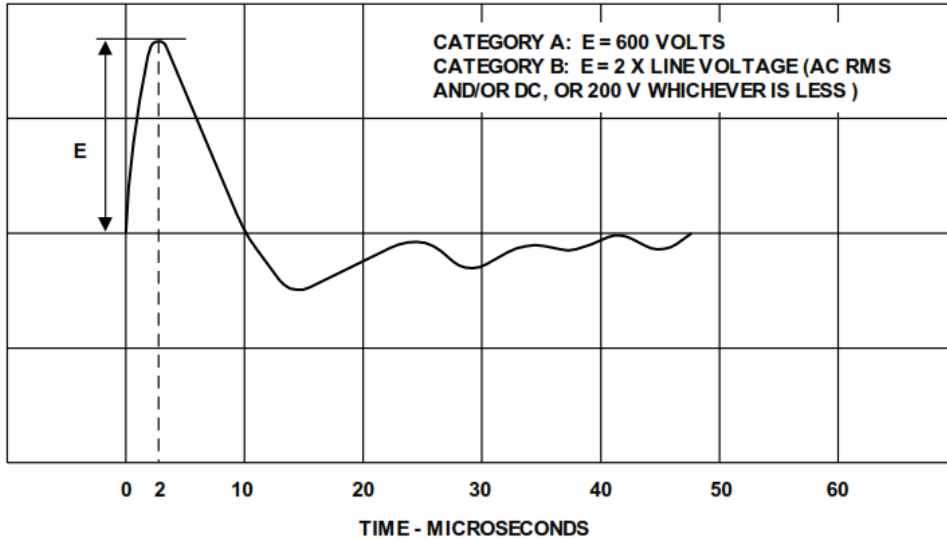


Figure 23 Example Voltage Spike Generator test setup:



**Figure 24 Voltage Spike Waveform**

With the equipment under test disconnected, the transient wave shape shall be verified to be in accordance with Figure 7.

With the PAC45-SYSTEM operating at its 28 VDC apply to the primary power input a series of positive and negative spikes shown in Figure 7. App power connection inputs were tested simultaneously. Apply a minimum of 50 positive polarity transients within a period of one minute.

Repeat the application with 50 negative polarity transients within a one minute period. The time between positive and negative transient applications is left to the discretion of the tester. Repeat the test for each operating mode or function of the equipment.

Output	Test	Data	Results	
Pilot Headset (COM 1)	Power Output	Vout (Vrms)	6.20	100% power
	Distortion THD+N	@ 300 Hz (%)	0.30	10% power
		@ 1000 Hz (%)	0.30	
		@ 6000 Hz (%)	0.30	
	Output Noise	Vout (mVrms) Level (dB)	4.35 -57.0	50% Power
Listening Test	Good			
Pilot CVR (COM 1)	Power Output	Vout (Vrms)	2.80	100% power
	Distortion THD+N	@ 300 Hz (%)	0.25	10% power
		@ 1000 Hz (%)	0.25	
		@ 6000 Hz (%)	0.25	
Output Noise	Vout (mVrms)	14.00	50% Power	

Output	Test	Data	Results	
		Level (dB)	-55.0	
	Listening Test	Good		
Pilot Speaker (COM 1)	Power Output	Vout (Vrms)	6.31	100% power
	Distortion	@ 300 Hz (%)	0.35	10% power
	THD+N	@ 1000 Hz (%)	0.35	
		@ 6000 Hz (%)	0.35	
	Output Noise	Vout (mVrms)	1.30	50% Power
		Level (dB)	-55.0	
	Listening Test	Good		

Figure 25 - Voltage Spike Results (DO-160G §17.4)

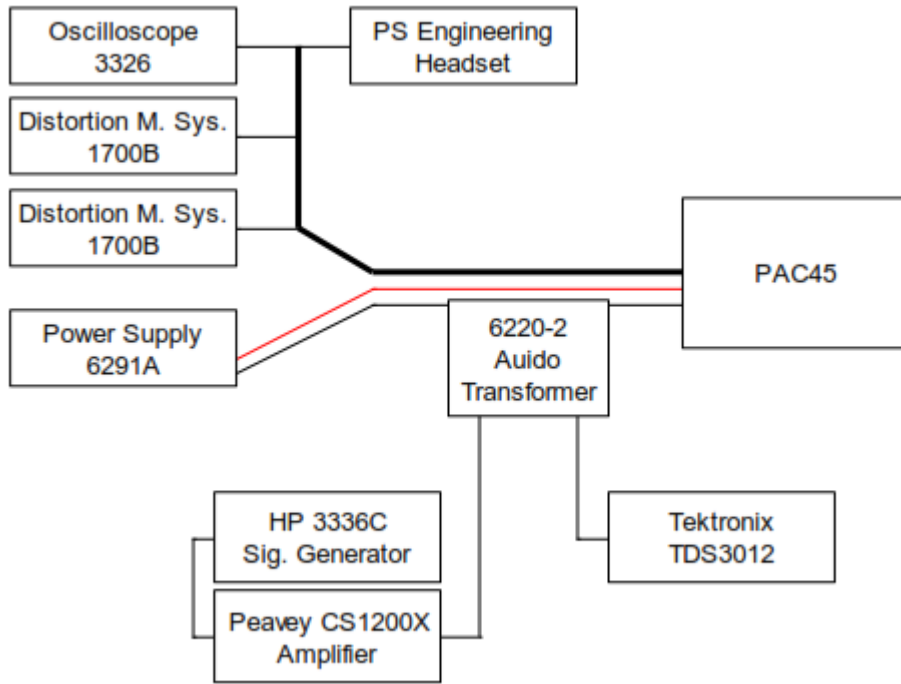
After the test, verified the requirements of DO-214A are met:

- a. Paragraph 2.4.3 - Distortion Characteristics
- b. Subparagraph 2.4.1 1.1 - Audio Noise Without Signal -50 dB
- c. The PAC45-SYSTEM shall continue to operate electrically and mechanically without degradation of performance.

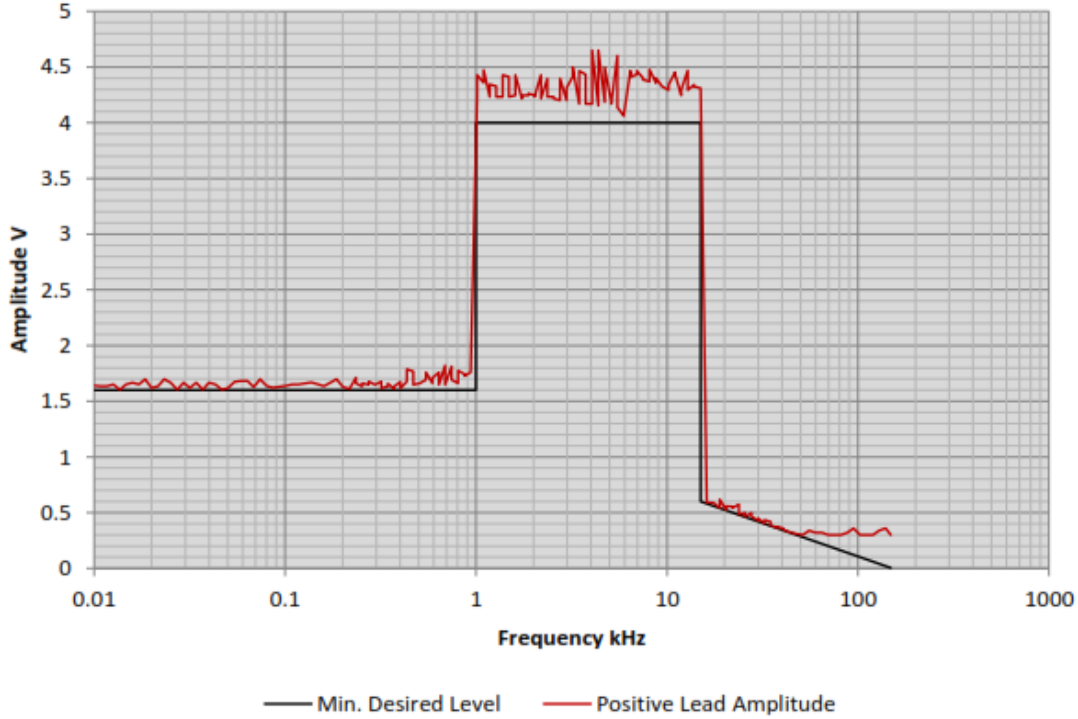
### 2.5.9 Audio Frequency Conducted Interference

The equipment was subjected to the applicable test conditions as specified in RTCA DO-160G, Section 18.0, Category Z.

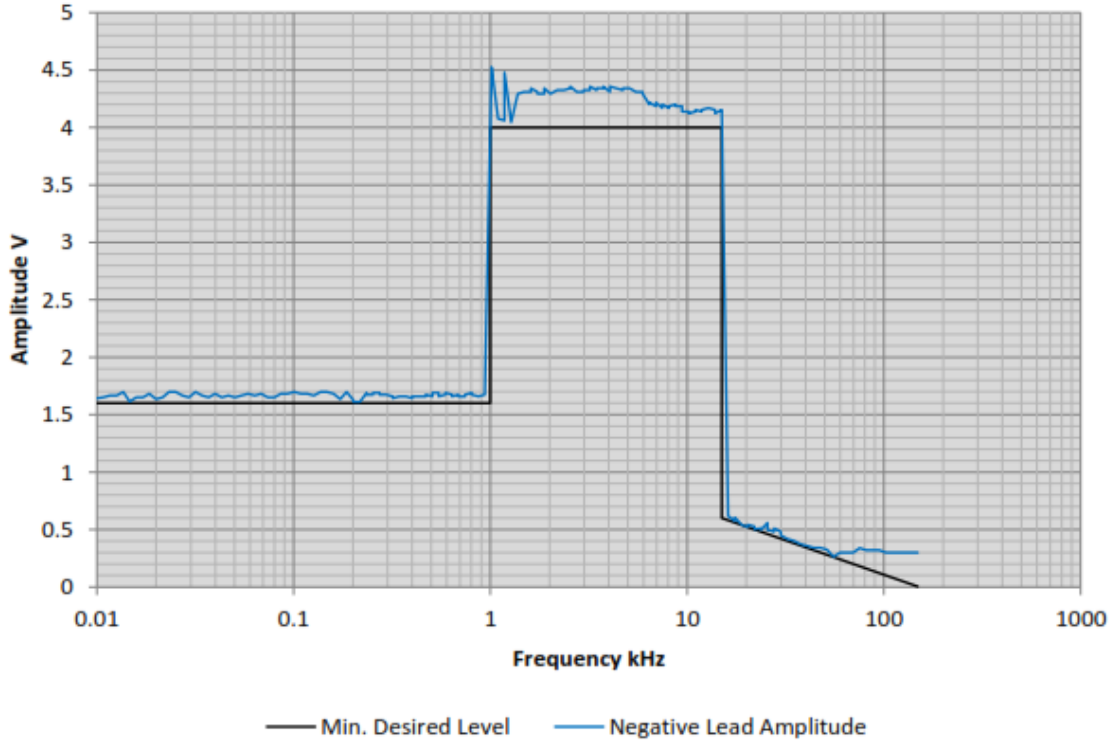
The equipment was arranged as shown:



### DO-160G / Positive Lead



### DO-160G / Negative Lead



During the application of the test signals, the PAC45-SYSTEM EUT was monitored and continued to meet the requirements of DO214A, § 2.4.1 1.1 - Audio Noise Without Signal -50 dB

The PAC45-SYSTEM meets the requirements of RTCA DO-214A §2.5.9(c), Audio Frequency Conducted Susceptibility Test.

#### 2.5.10 Induced Signal Susceptibility Test

The equipment was subjected to the applicable test conditions as specified in RTCA DO-160G, Section 19.0.

During the application of the test signals, the PAC45-SYSTEM EUT was monitored and continued to meet the requirements of DO214A, § 2.4.1 1.1 - Audio Noise Without Signal -50 dB, as the induced signal level did not exceed -50dB,.

NOTE: The EUT was configured with shielded cable in accordance with the installation instructions.

The PAC45-SYSTEM meets the requirements of RTCA DO-214A §2.5.9(c), Audio Frequency Conducted Susceptibility Test.



Figure 26 Emissions and susceptibility testing

### 2.5.11 Radio Frequency Susceptibility Test (Radiated and Conducted)

The equipment was subjected to the applicable test conditions as specified in RTCA DO-160G, Section 20, Category R.



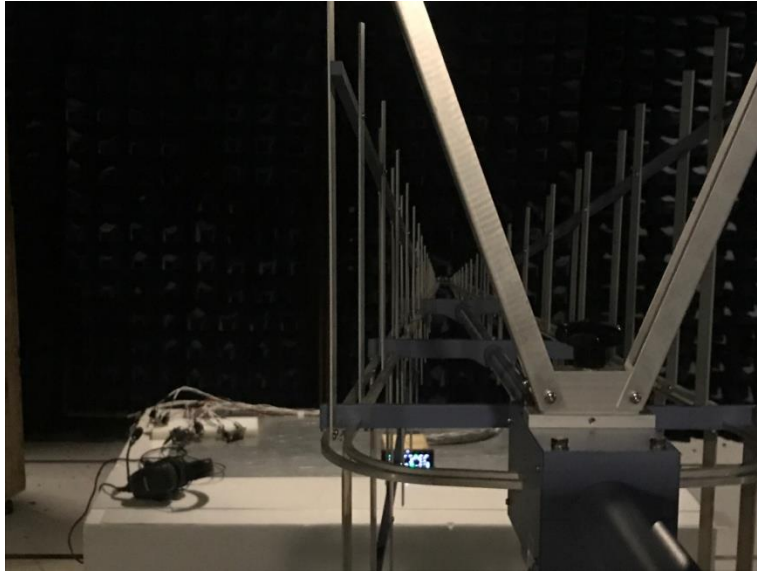


Figure 27 - EUT arrangement -Radiated susceptibility

#### 2.5.11.1 Steady State RF Interference

#### 5.5.11.2 Momentary RF Interference Test

### 2.5.12 Emission of Radio Frequency Energy Test

The equipment was subjected to the applicable test conditions as specified in RTCA DO-160G, Section 21, Category P.

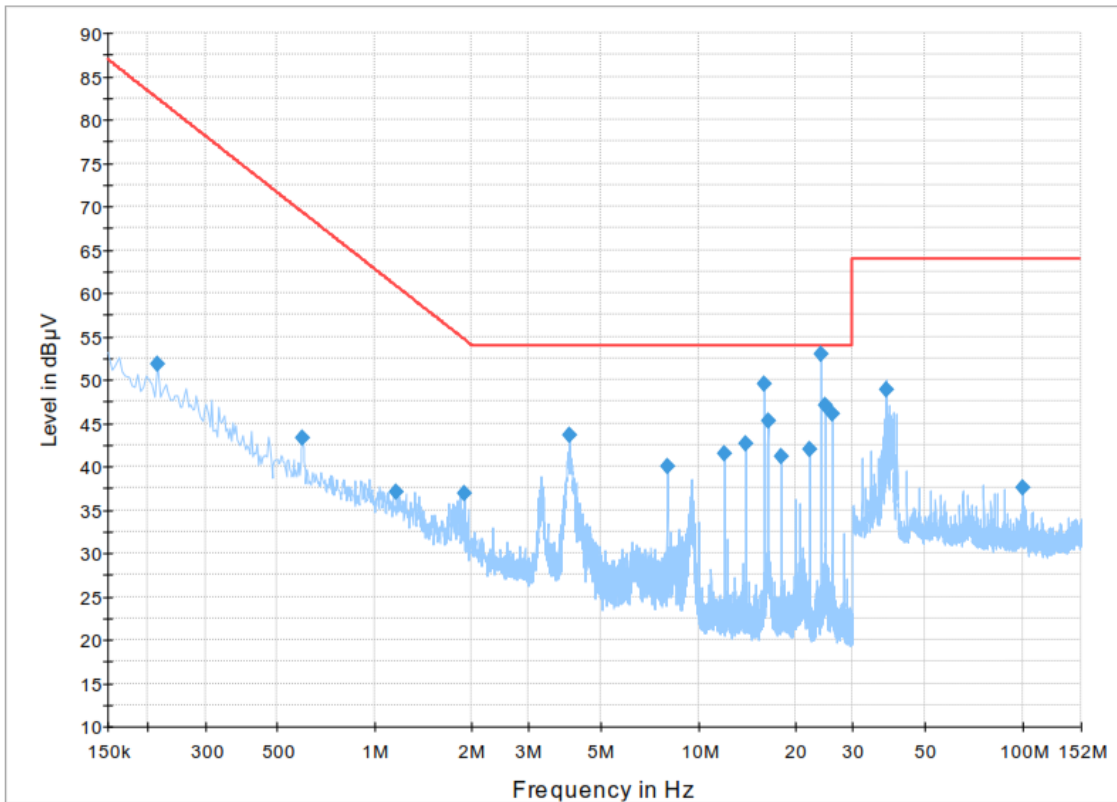


Figure 28 - Conducted Emission levels – power leads

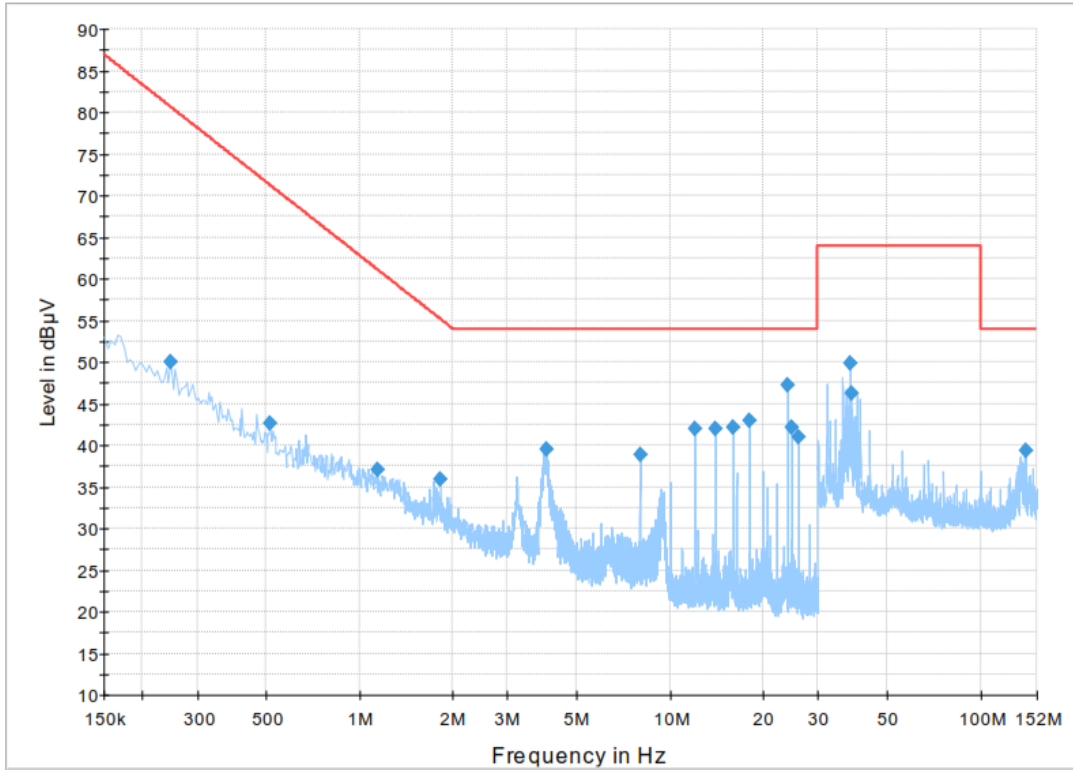
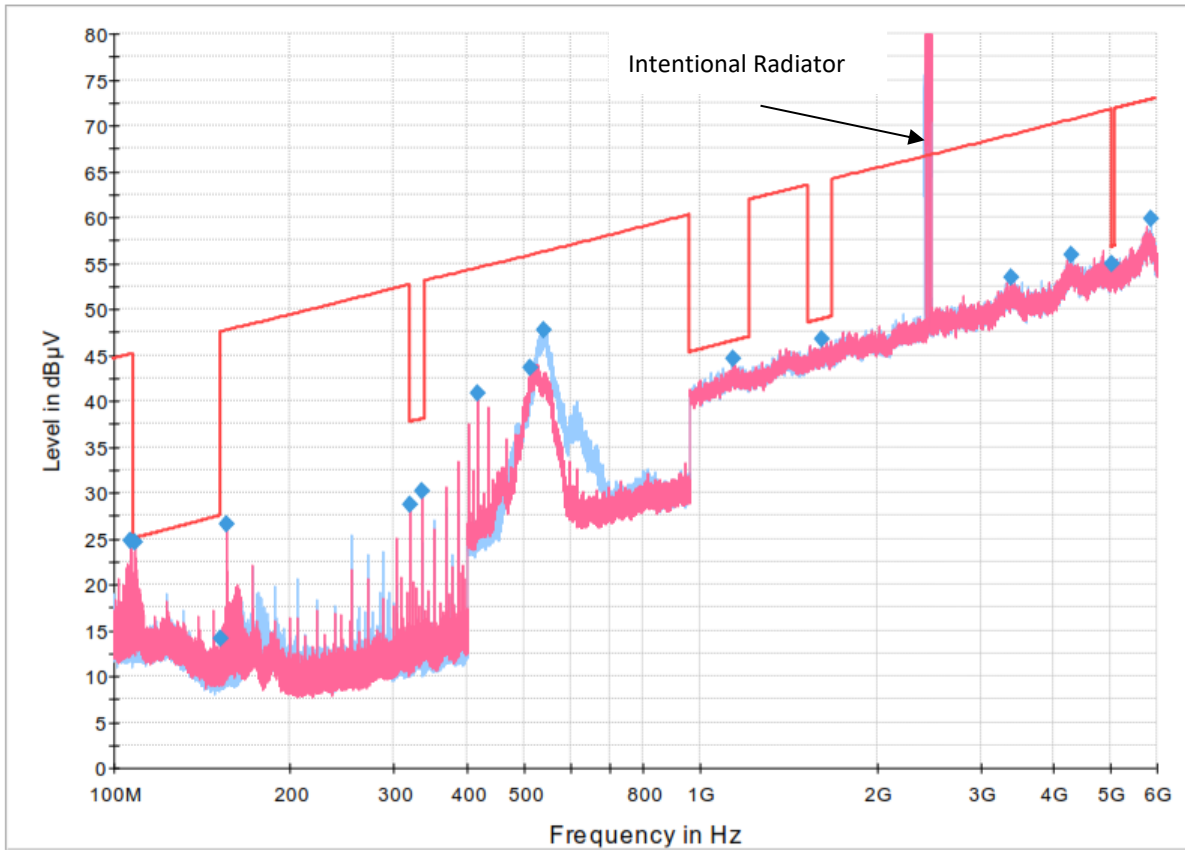


Figure 29 – Conducted Emissions - Cable Bundles



**Figure 30 - Radiated Emissions**

Note, the 2 GHz spike is the result of the Bluetooth<sup>®</sup> radio, when the test equipment set to store the signals over time, and will not actually be detectable in operation. The storage was used to ensure that the Bluetooth was in operation.


The requirements of DO-160G, §21, Category R (Conducted Emissions) and R (Radiated Emissions) are met.

### **2.5.13 Lightning Induced Transient Susceptibility**

The equipment was subjected to the applicable test conditions as specified in RTCA DO-160G, Section 22, Category A3J33. After the application of the transients, the EUT continued to meet specifications, including:

- a. Paragraph 2.4.3 - Distortion Characteristics
- b. Subparagraph 2.4.1 1.1 - Audio Noise Without Signal
- c. Paragraph 2.4.15 - Listening Test

*The PAC45-SYSTEM meets the requirements of DO-214A, §2.5.13 (c) and RTCA DO-160G §22, Category A3J33*

	<p style="text-align: center;"><b>PAC45 Environmental Conditions Test Report RTCA DO-160G</b></p>	<p style="text-align: right;">Document: 002-145-0160 Date: 2/22/19 Revision: new</p>
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### 2.5.14 Final Distortion test – Not Applicable to Audio Panels

### 2.5.15 Push-to-Talk Switch Life – Not Applicable to Audio Panels

### 2.5.16 Electrostatic Discharge

The equipment was subjected to the applicable test conditions as specified in RTCA DO-160G, Section 25 Category A.

The EUT was subjected to 15,000 volts, positive and negative, air discharge, applied 10 times to each knob, button, switch and human contact point.

- Point #1, EUT Chassis
- EUT Connector back shells

After the exposure, the PAC45-SYSTEM continued to meet requirements:

- a. Paragraph 2.4.15 - Listening Test
- b. The PAC45-SYSTEM shall continue to operate electrically and mechanically without degradation of performance.

*The PAC45-SYSTEM meets the requirements of DO-214A, §2.5.16 (c) and RTCA DO-160G §25, Category A*

## Appendix A Reports and Precision Test Equipment

All of the test equipment used by Global Test Laboratories and PS Engineering for credit testing was in current calibration.

Details of the test performed and test equipment at Global testing Laboratories is linked here.

The Test equipment used by PS Engineering is linked here.