VIBRATION RESEARCH

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AEROSPSACE & DEFENCE | VIBRATION & SHOCK TESTING

TEST STANDARDS – CONSISTENT & REPEATABLE TESTS

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AEROSPSACE & DEFENCE | VIBRATION & SHOCK TESTING

TEST STANDARDS – CONSISTENT & REPEATABLE TESTS

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Country Manager –
Vibration Research (UK)

AEROSPACE AND DEFENCE TESTING STANDARDS (VIBRATION AND SHOCK)

CONTENTS

TEST STANDARDS

NATO STANDARD

STANAG 4370
(AECTP 400)

NATIONAL DEFENCE STANDARDS
(INCLUDING MOST MILITARY AIRCRAFT)

USA
Mil Std 810
Method 514 & 516

UK
Def Stan 00-35
Test M1 and M3

France
GAM EG 13

AEROSPACE / COMMERCIAL AIRCRAFT

USA
RTCA - DO160
Section 8 & 7

Europe
EUROCAE / ED-14
Section 8 & 7

COMMERCIAL STANDARDS

International (IEC 60068 & IEC 60721)

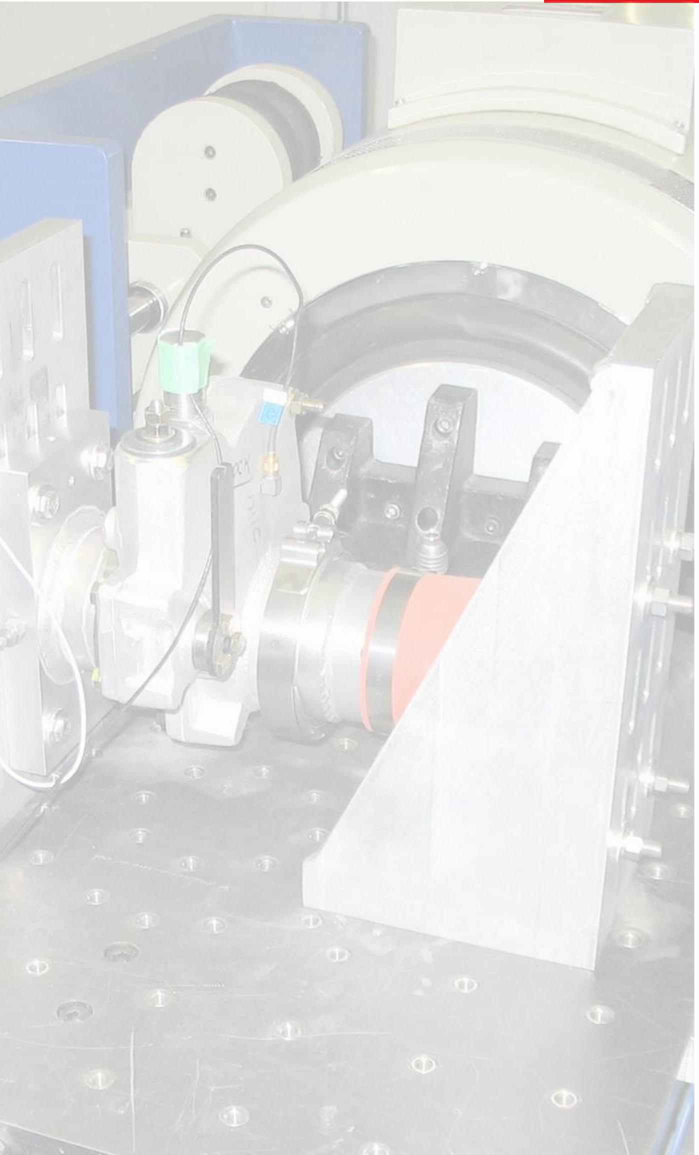
Random	Sine	Shock
ISO 60068-2-64	60068-2-6	60068-2-27

(Severities within many IEC ISO Standards)

THERE ARE MANY OTHER STANDARDS ASSOCIATED WITH OTHER SPECIFIC INDUSTRIES

(E.G. THE SPACE SECTOR) BUT MANY WILL HAVE THEIR ROOTS IN THESE STANDARDS OR REFER TO THESE STANDARDS / OR USE THE CONTROLS / TOLERANCES / PARAMETERS

TEST STANDARDS – WHY WE NEED THEM?



REPEATABLE METHODS

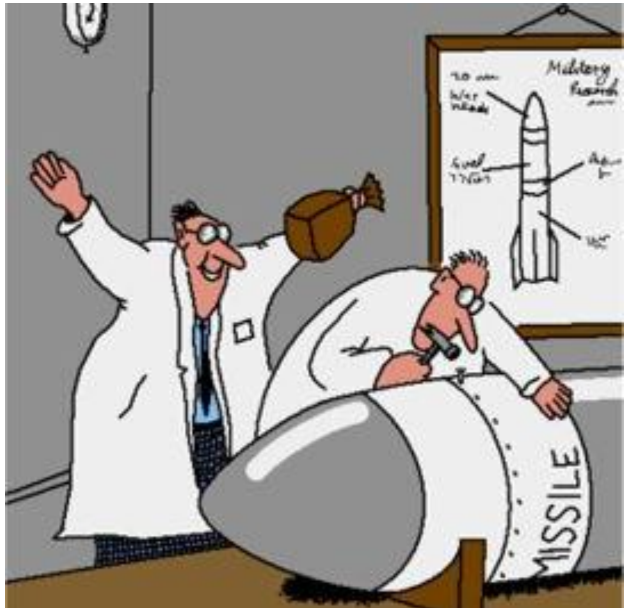
- results obtained in one laboratory or by one test engineer should be reproduceable within another laboratory / by another test engineer

*Items **must not** go bang when we don't want them to.....*

ADEQUATE TEST SEVERITIES

– not too severe but severe enough

*....but **must** go bang when we need them to."*



VIBRATION RESEARCH

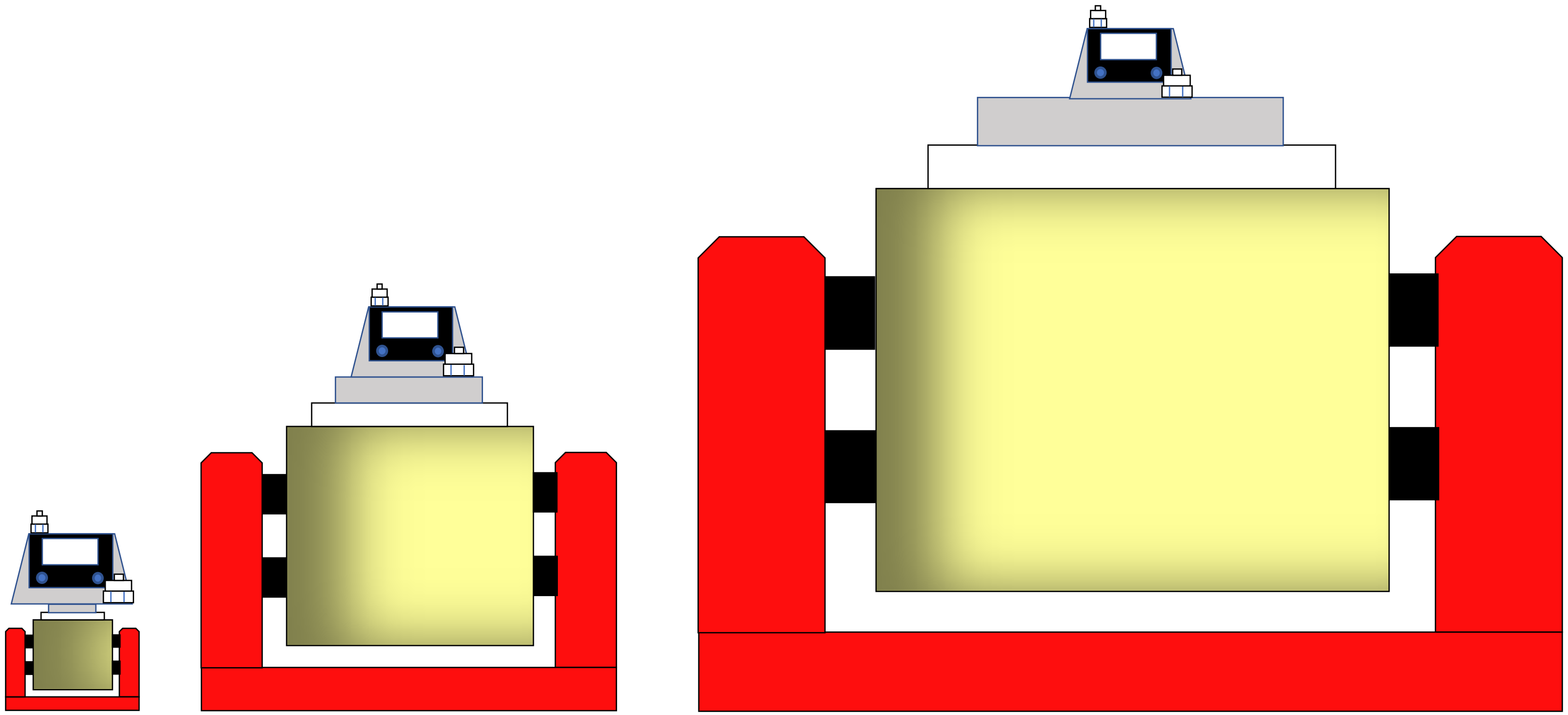
GENERAL TEST CONTROLS

- **CONTROL POSITION(S)**
  - WHERE TO APPLY THE SPECIFIED TEST AMPLITUDE
- **MEASUREMENT POSITIONS**
  - ADDITIONAL MEASUREMENT POSITIONS
- **CONTROL STRATEGIES / AVERAGING**
  - AVERAGE / MAXIMUM / EXTERMAL / WEIGHTED AVERAGE
- **MOTION CONTROLS**
  - PARALLEL MOTION – CROSS AXIS MOTION
- **LIMITING / NOTCHING**
  - ADVANCED TEST LIMITING AND NOTCHING

GENERAL TEST CONTROLS

HOW TO ACHIEVE CONSISTANT AND REPEATABLE RESULTS

- How do we ensure all tests would produce the same outcome?



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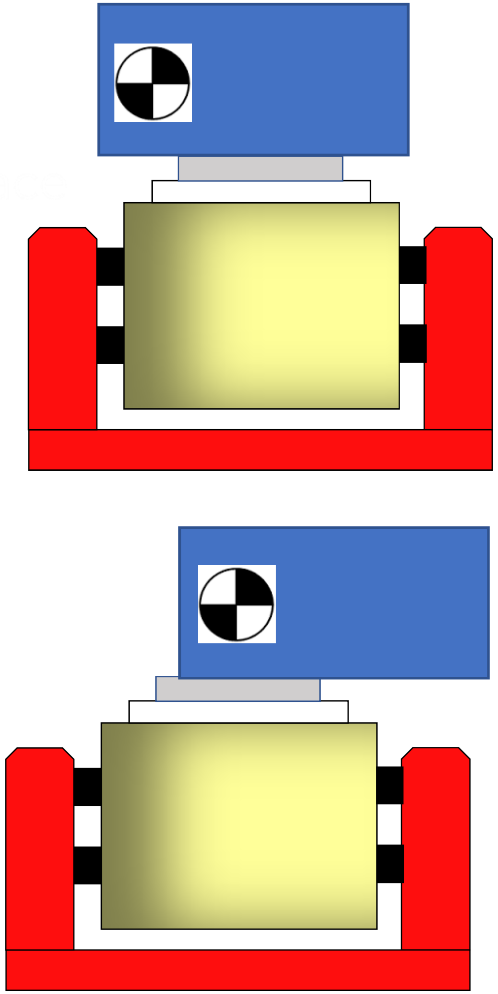

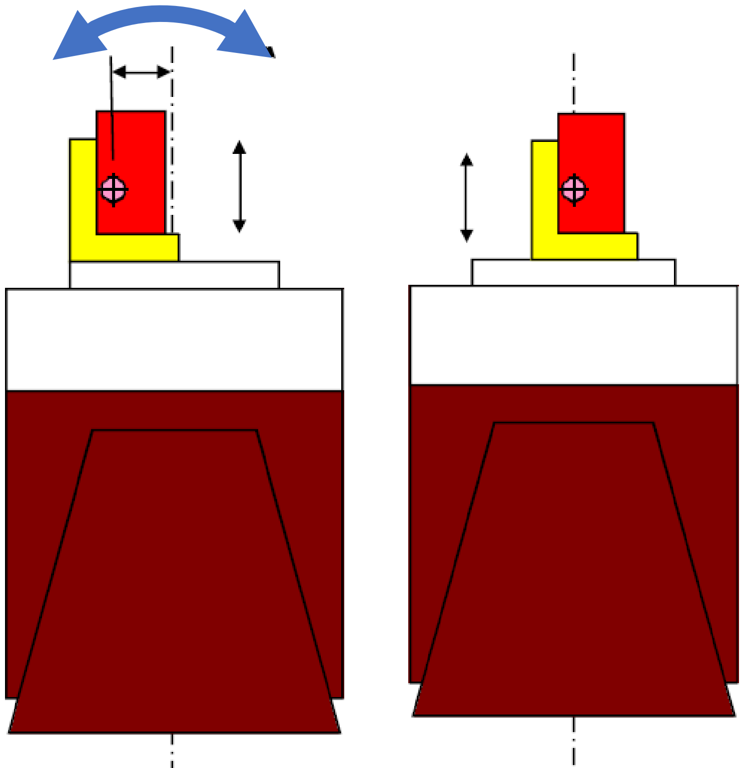

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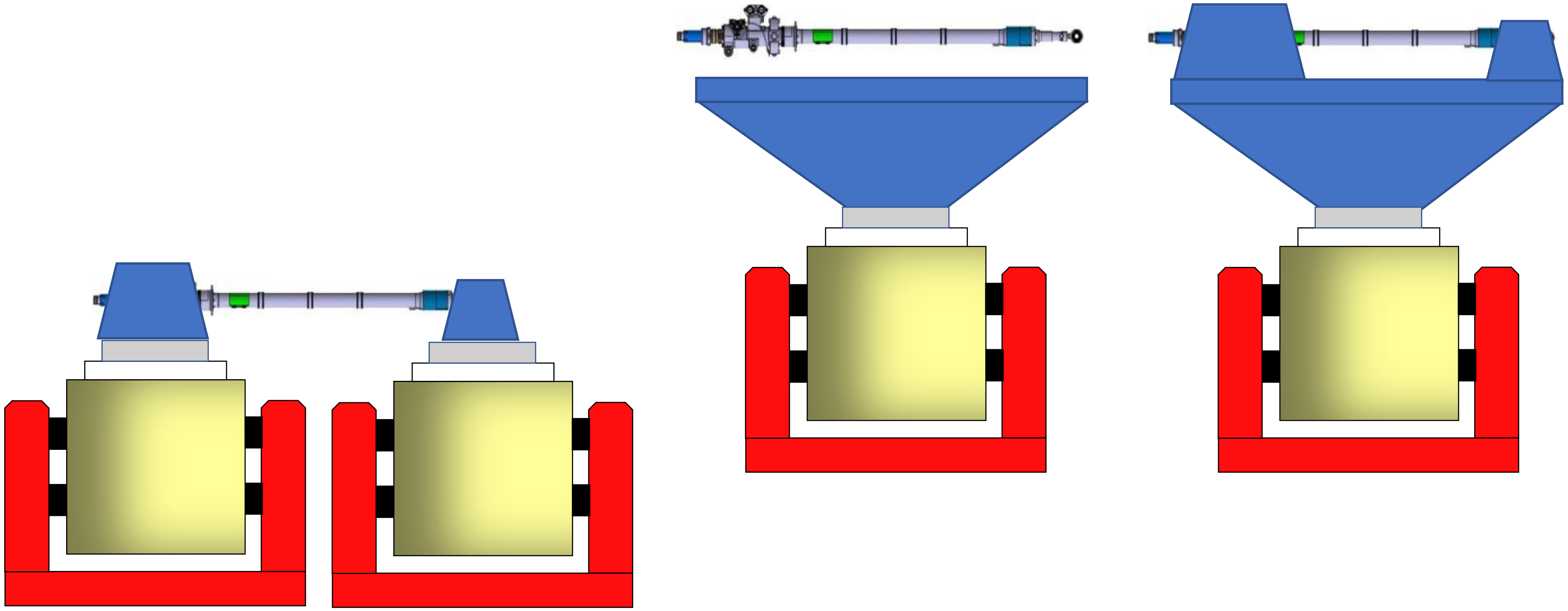

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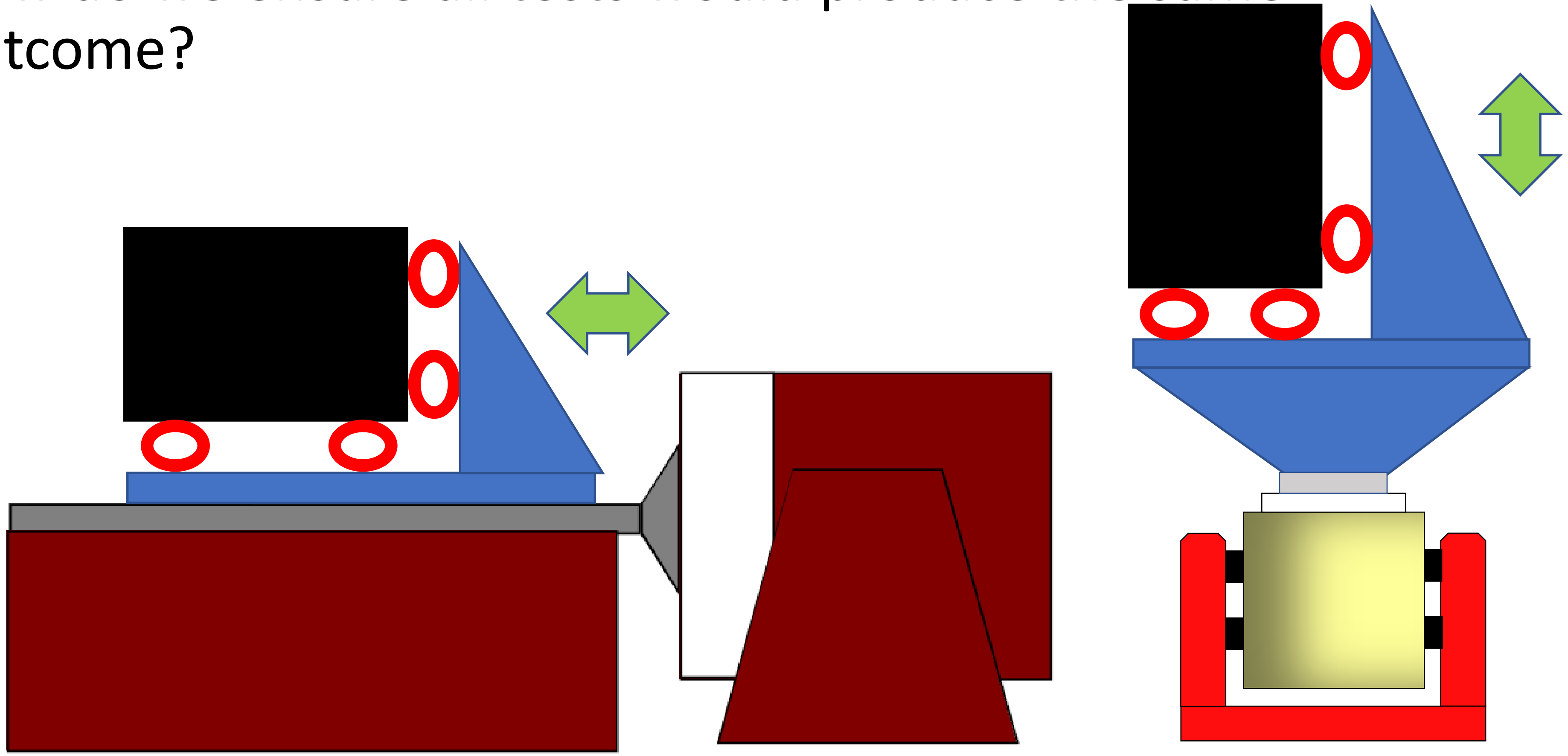

GENERAL TEST CONTROLS

CONTROL AND MEASUREMENT LOCATIONS TERMINOLOGY

Measurement Locations Terminology Used:

Fixing Points

Fixture / Test Item Interface

Measurement Points

Response Points

Check Points

Reference Point

(single –point control)

Fictitious Reference Points

(multipoint control)

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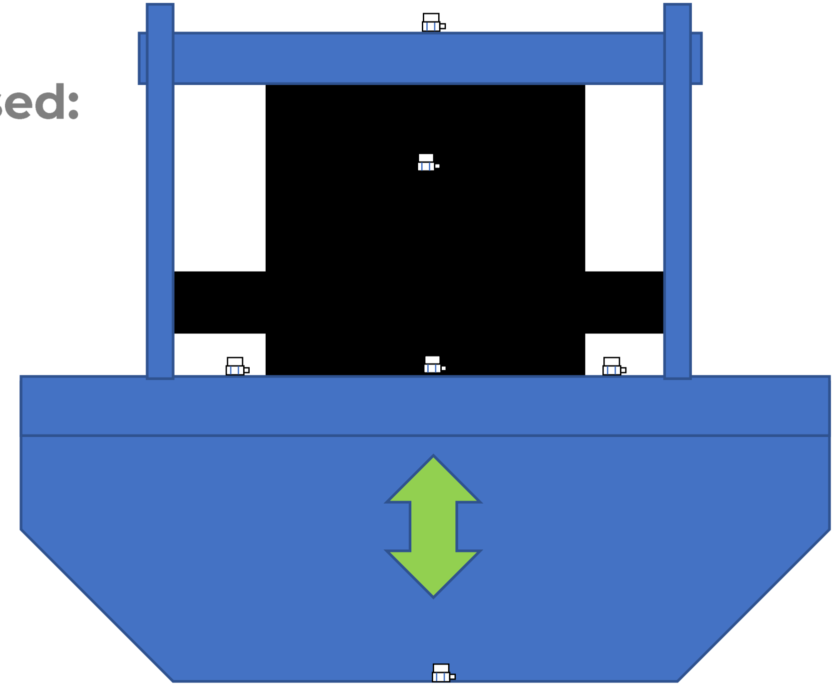

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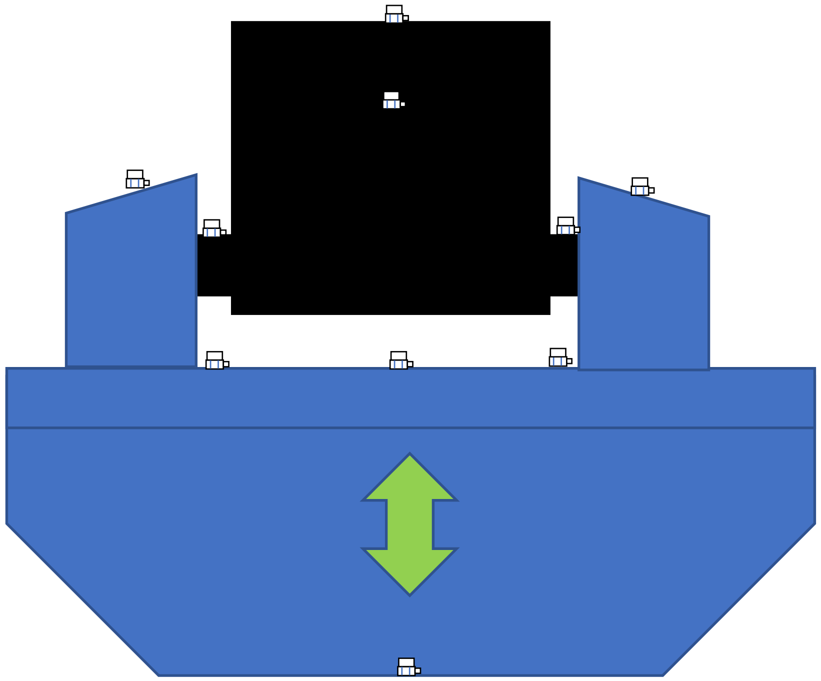

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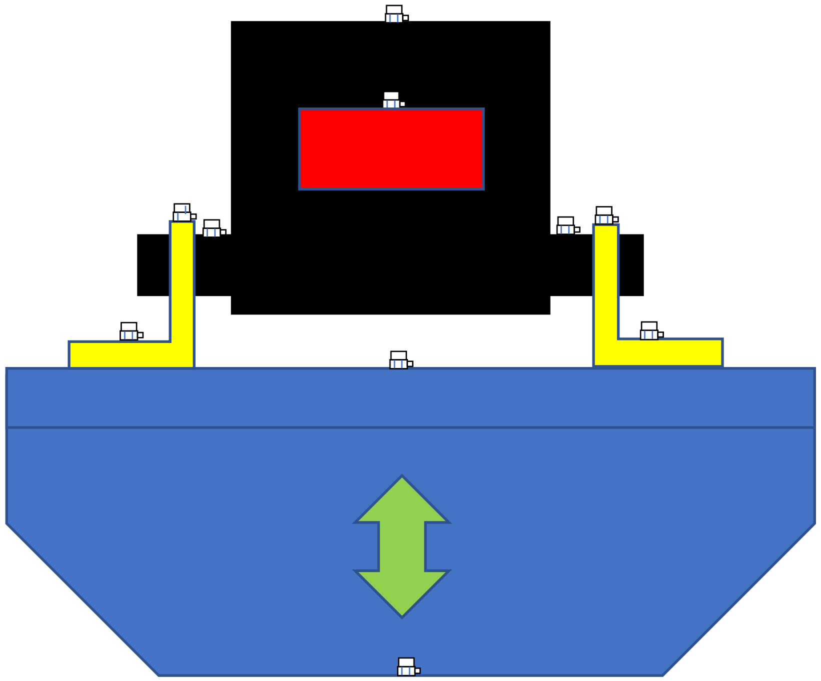

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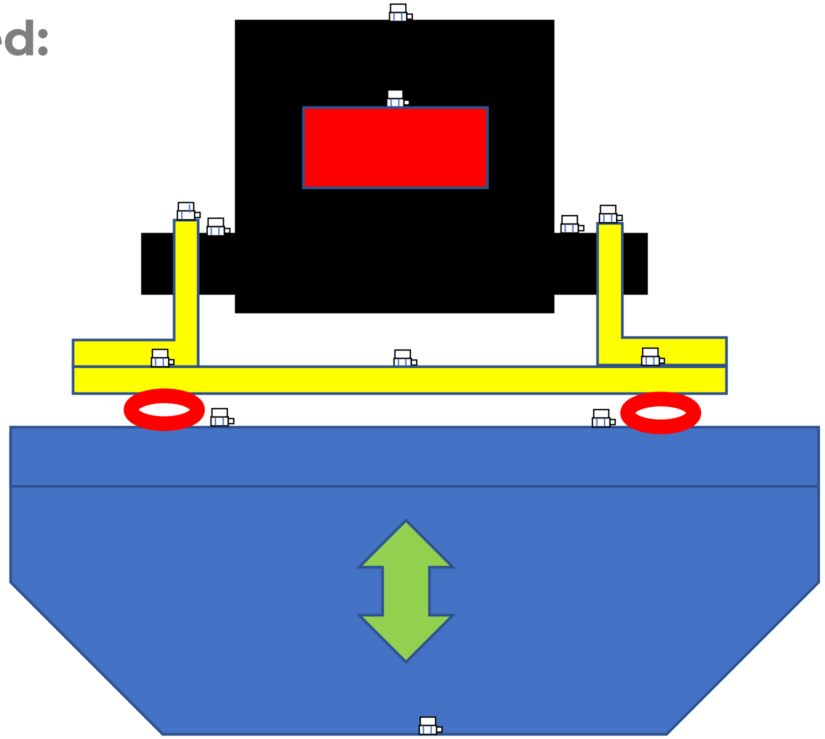


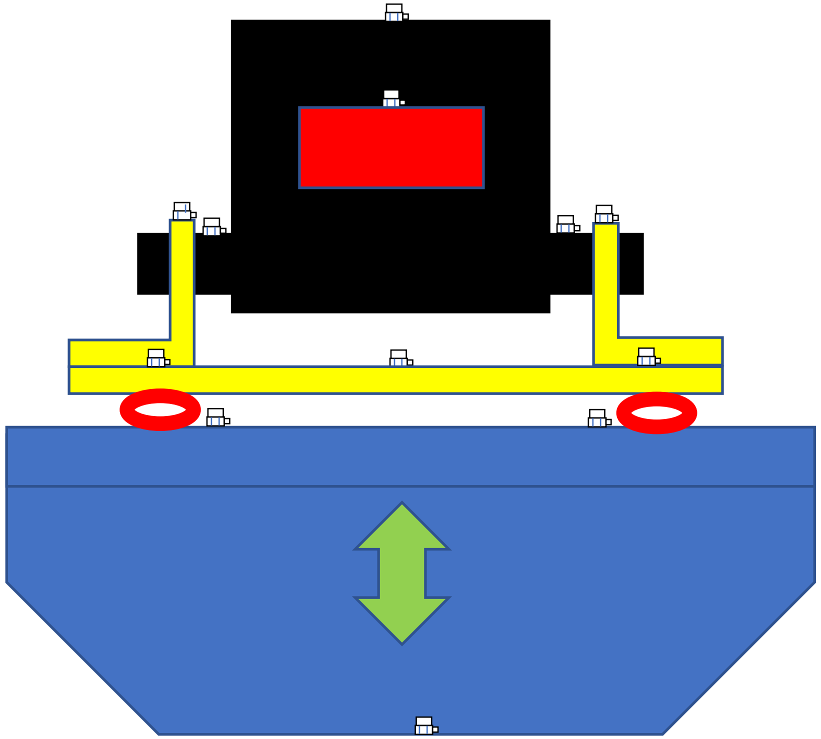
CONTROL AND MEASUREMENT LOCATIONS

CONTROL AND MEASUREMENT LOCATIONS TERMINOLOGY

Control Strategy Terminology Used:

- **Singlepoint / Multi point Control**

- **Averaging Strategies**
  - Athematic Average – Average of multiple checkpoint locations
  - Weighted Averaging where a weighting factor is applied to individual locations before averaging
  - Extremal – computed from the Maximum (or Minimum) extreme value for each checkpoint location



VIBRATION RESEARCH

CONTROL AND MEASUREMENT LOCATIONS

CONTROL STRATEGIES

Control Types

Input Control

Response Control

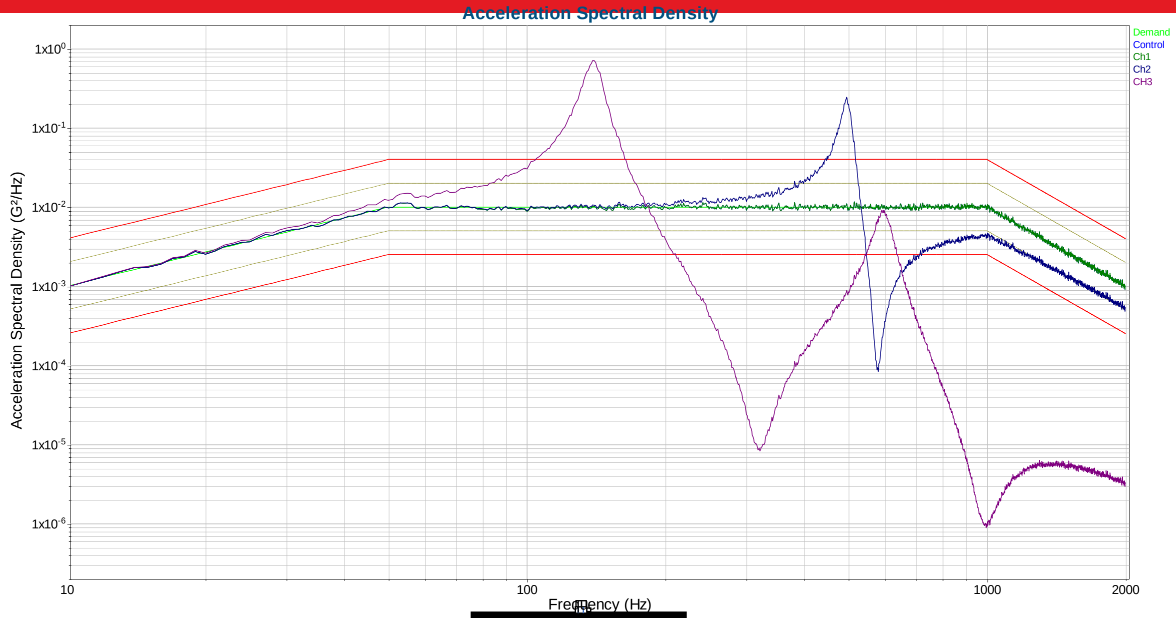
Single Reference Control

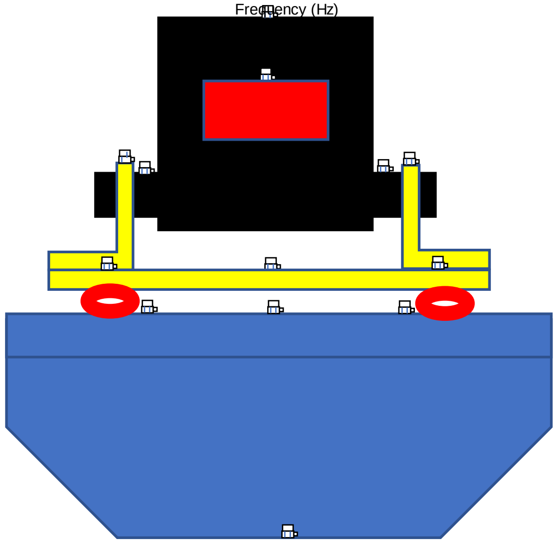
Multiple Reference Control

Limit Control

- Limiting / Notching
- Superseding (Boosting)

Equipment System Limits





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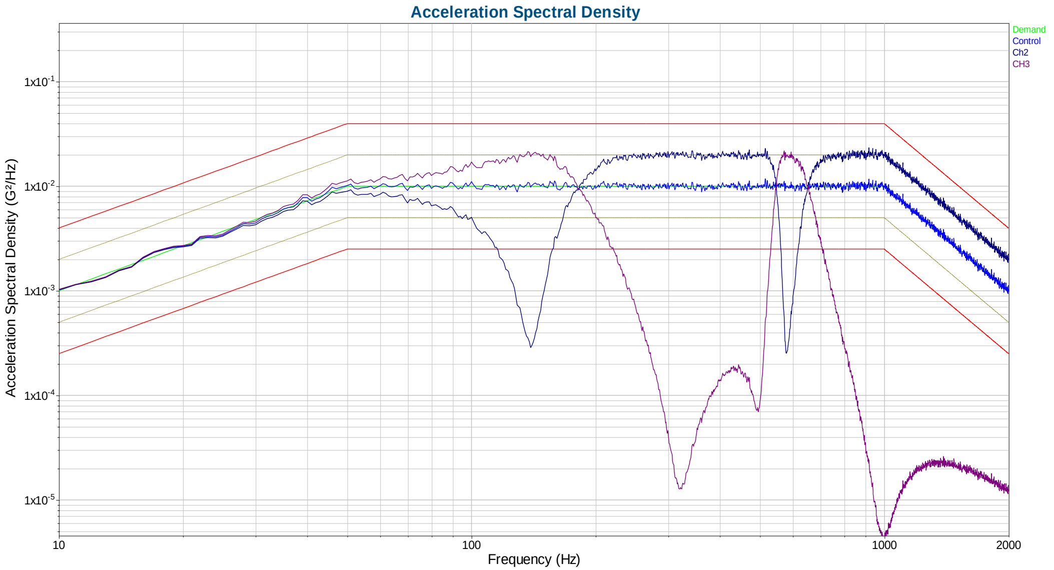

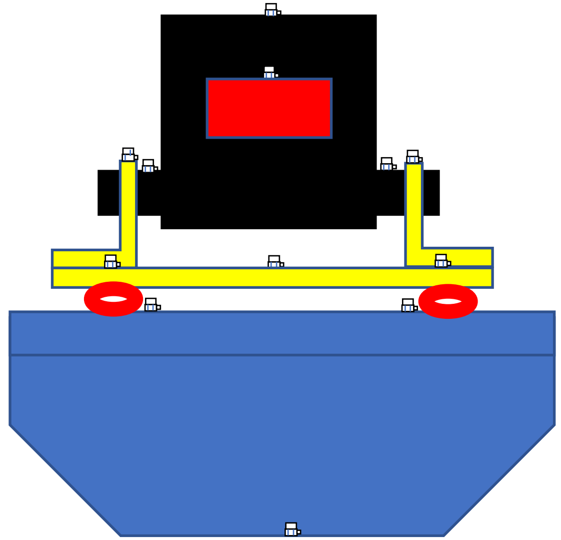

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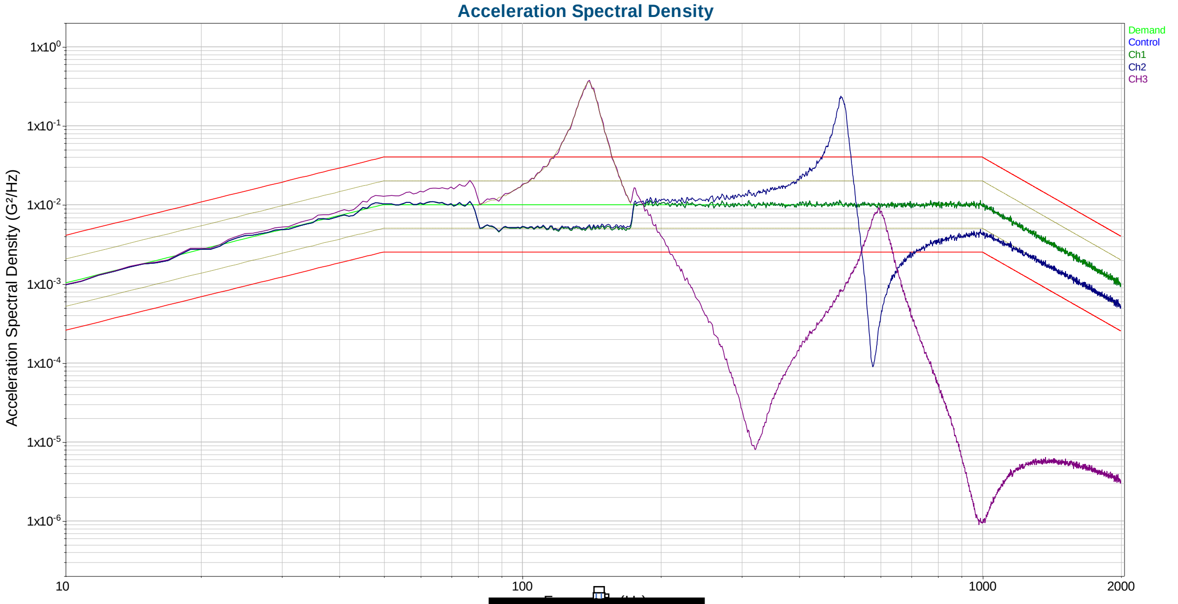
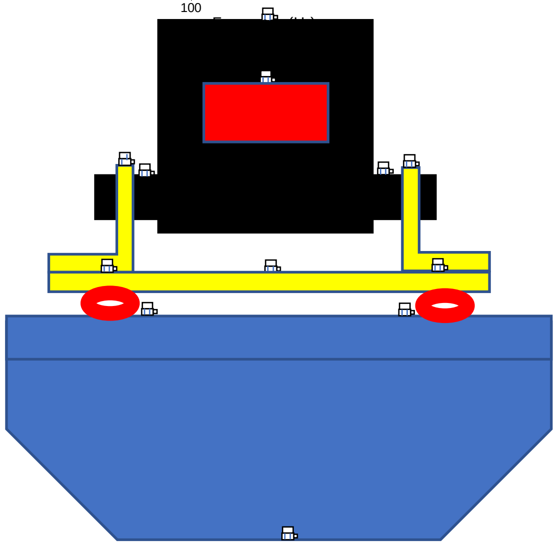
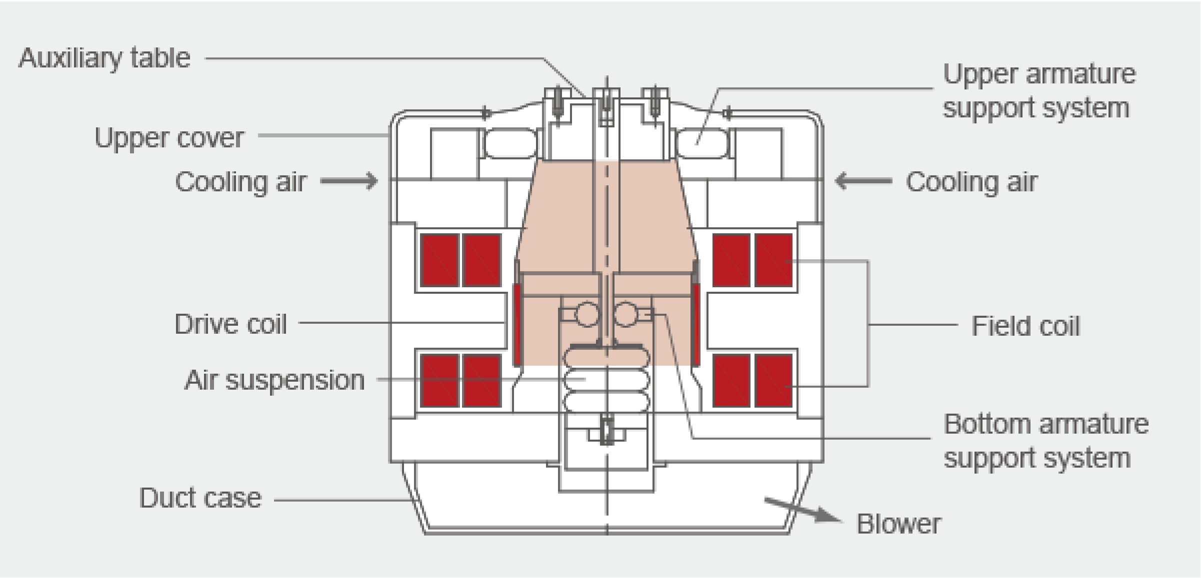




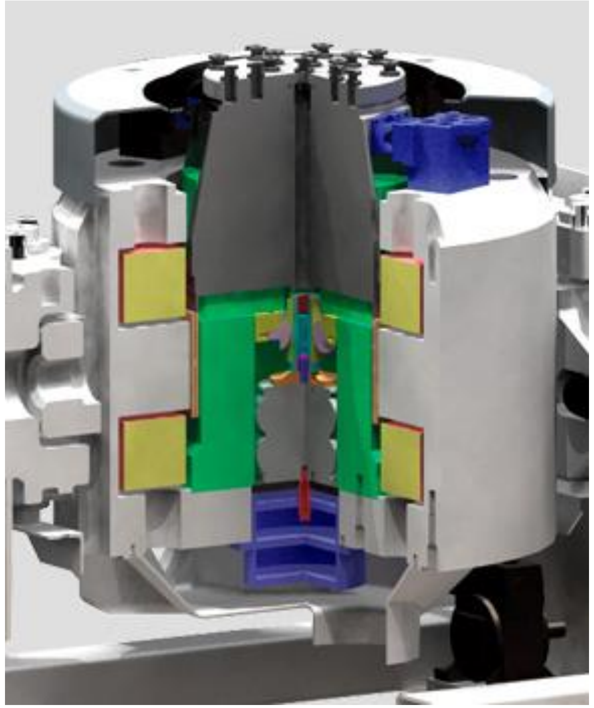
GENERAL CONTROLS – MOTION CONTROL

Single Axis Testing

The motion induced by the vibration generator should be such that the fixing points of the test item move substantially parallel to the axis of excitation.



What Does This Mean With Regard to Our Shaker System?



WHAT CHECKS SHOULD WE MAKE ON CROSS AXIS ACCELERATIONS?

MIL-STD-810
ENVIRONMENTAL ENGINEERING CONSIDERATIONS AND LABORATORY TESTS

Standard	Summary of Standard	Additional Notes
Mil Std 810H	Less than 50% below 500 Hz Less than 100% above 500 Hz	If exceeded, source shall be identified and addressed
Mil Std 810G	Less than 45% of the drive axis (20% for the Spectral Density)	Frequency reference removed! If exceeded, source shall be identified and addressed
Mil Std 810F	Less than 45% of the drive axis any frequency (20% for the Spectral Density)	Also contains a note that cross axis spectral density often has high narrow peaks. Consider tailoring cross-axis tolerances
Mil Std 810E	NO REQUIREMENT	
Mil Std 810D	NO REQUIREMENT	

CROSS AXIS ACCELERATIONS

DEF STAN 00-35

Environmental Handbook for Defence Materiel - Part 3 Environmental Test Methods

Standard	Summary of Requirement	Additional Notes
DEF STAN 00-35 Issue 5 (2017)	Less than 50% below 500 Hz Less than 100% above 500 Hz The out of axis overall RMS should not exceed 50% of the specified in-axis vibration	If exceeded, source shall be identified and addressed
DEF STAN 00-35 Issue 4 (2006)	**Random** - spectral content less than specified in-axis and out of axis overall RMS should not exceed 50% **Sine** - Less than 50% below 500 Hz Less than 100% above 500 Hz	Cross Axis to be checked prior to conducting the test. At some frequencies or on large or high mass items – cross axis or rotational motion in excess of requirements shall be monitored and stated in the test report

CROSS AXIS ACCELERATIONS

RTCA DO-160
EUROCAE ED-14
Environmental Conditions and Test Procedures For Airborne Equipment

Standard	Summary of Requirement	Additional Notes
RTCA DO-160G Section 8 (2010)	No specific requirement. “Motion should be parallel and fixture rigid and symmetrical”	The test tolerances / control parameters do not seem to have been updated since 1997. However, there may be additional guidance within DO-357 – User Guide Supplement to DO-160G
RTCA DO-160F Section 8 (2007)		
RTCA DO-160E Section 8 (2007)		
RTCA DO-160D Section 8 (1997)		

CROSS AXIS ACCELERATIONS

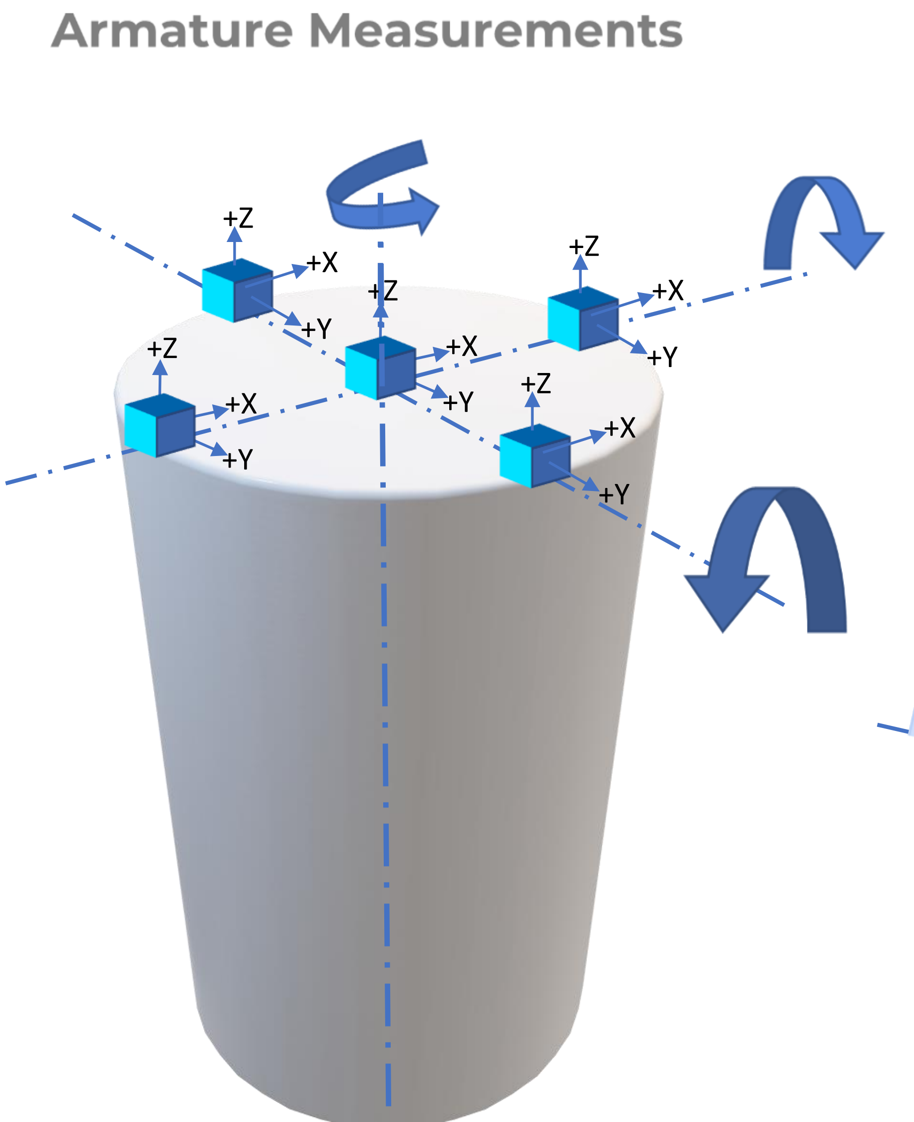
BS EN 60068-2-64

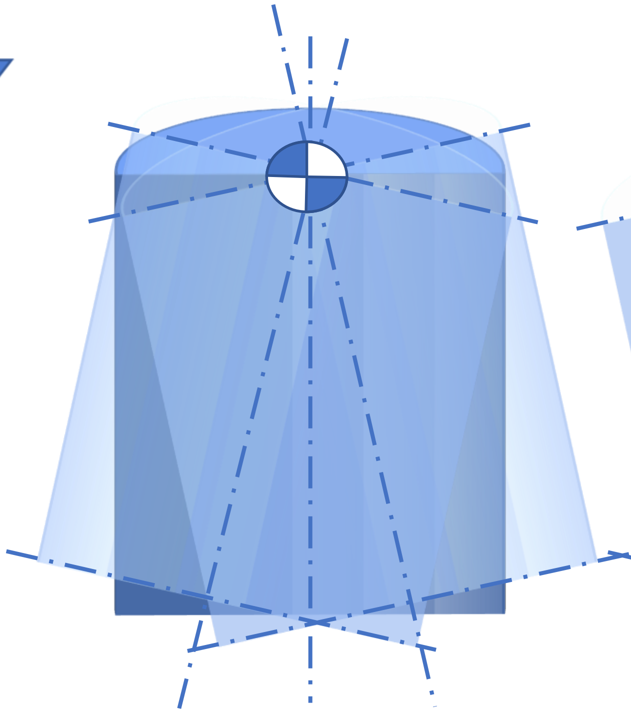
Environmental Conditions and Test Procedures For Airborne Equipment

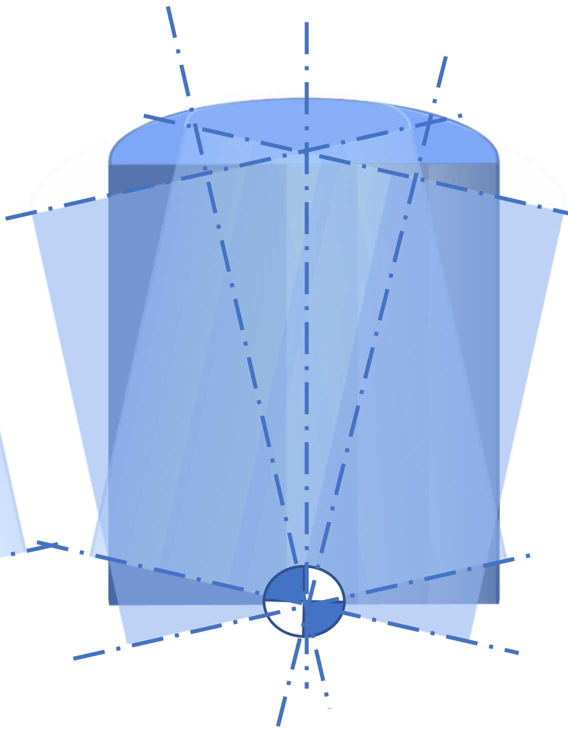
Standard	Summary of Requirement	Additional Notes
BS EN 60068-2-64:2008	Motion of fixing points to be in phase and amplitude rectilinear to direction of excitation. Less than 50% below 500 Hz Less than 100% above 500 Hz The out of axis overall RMS should not exceed 50% of the specified in-axis vibration	At some frequencies or with large-size or high-mass specimens, it may be difficult to achieve these values. Also, in those cases where the relevant specification requires severities with a large dynamic range, it may also be difficult to achieve these. In such cases, the relevant specification shall state which of the following requirements applies: a) any cross-axis motion in excess of that given above shall be stated in the test report; b) cross-axis motion which is known to offer no hazard to the specimen need not be monitored

SHAKER ARMATURE ROTATIONAL MOTIONS (ARMATURE GUIDANCE SYSTEMS)

MOTION CONTROLS

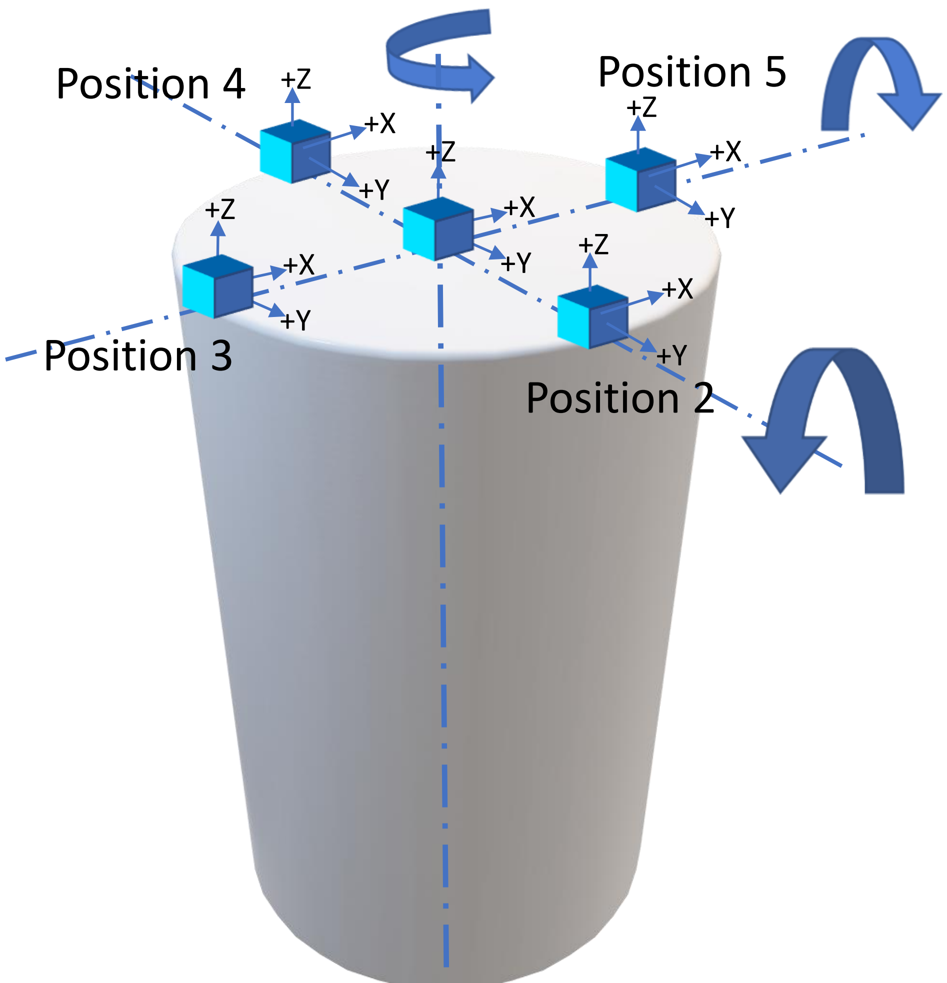






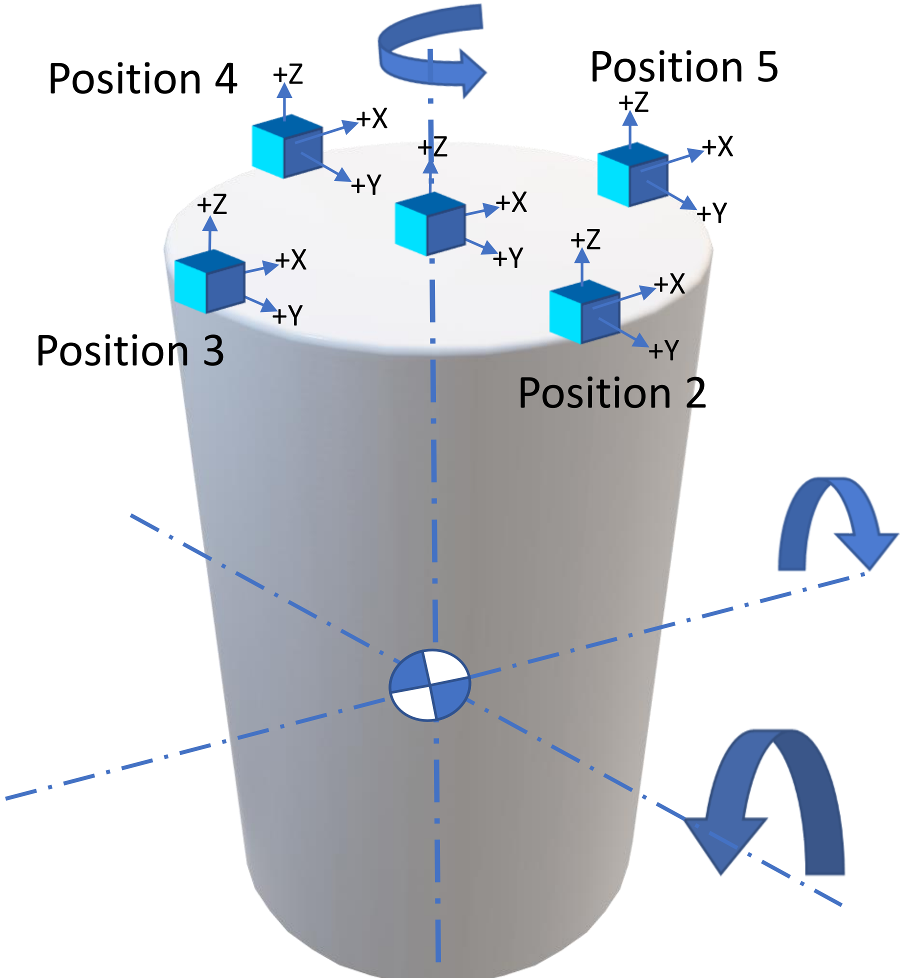
RIGID ROTATIONAL MOTIONS OF SHAKER ARMATURE (ARMATURE GUIDANCE SYSTEM)

Armature Measurements



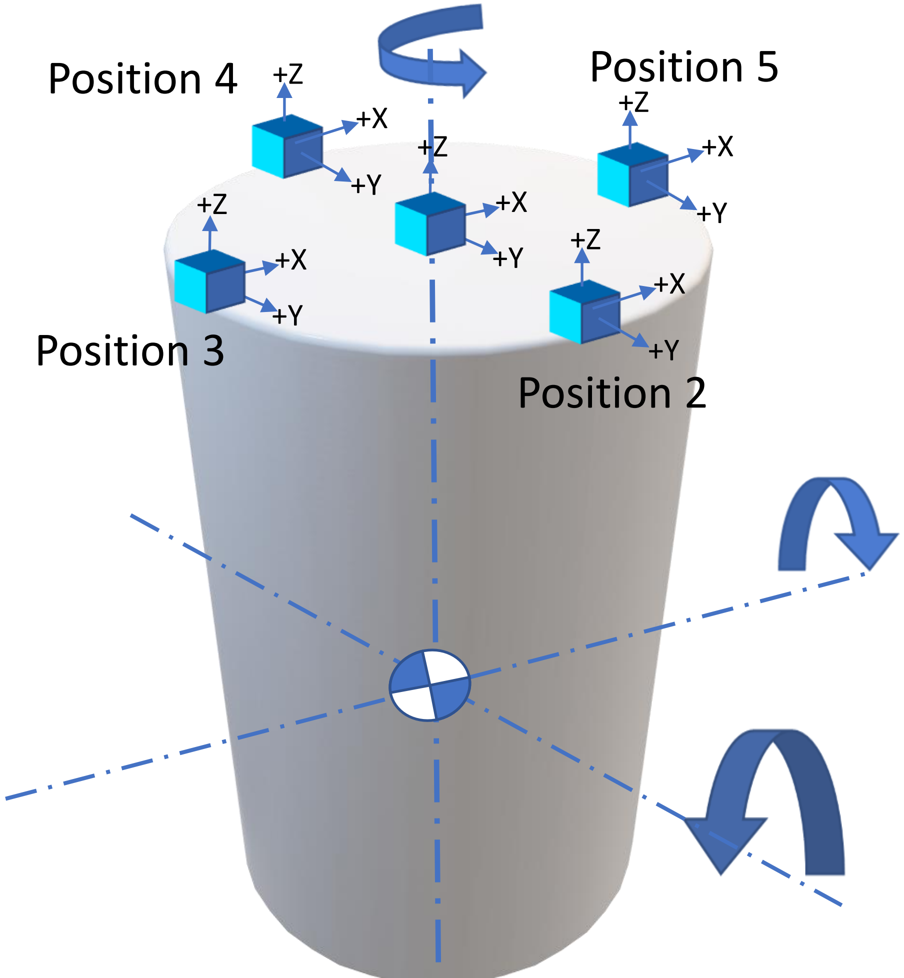
Motion	Measurement Position				
	1	2	3	4	5
Rotation Around Z Axis	-	+X Axis	+ Y Axis	-X Axis	-Y Axis
Rotation About Y Axis	-	-	-Z Axis	-	+Z Axis
Rotation About X Axis	-	-Z Axis	-	+Z Axis	-

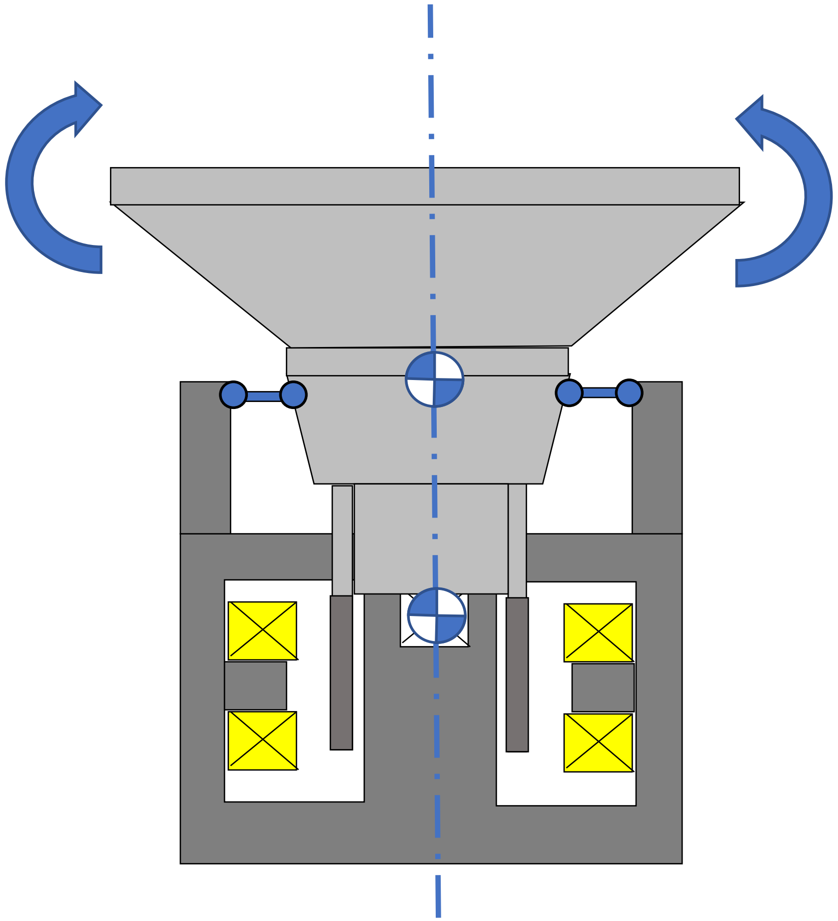
RIGID ROTATIONAL MOTIONS OF SHAKER ARMATURE (ARMATURE GUIDANCE SYSTEM)



Motion	Measurement Position				
	1	2	3	4	5
Rotation Around Z Axis	-	+X Axis	+ Y Axis	-X Axis	-Y Axis
Rotation About X Axis	+Y Axis	+Y Axis -Z Axis	-Z Axis	+ Y Axis + Z Axis	+Z Axis
Rotation About Y Axis	-X Axis		-X Axis +Z Axis		-X Axis -Z Axis

RIGID ROTATIONAL MOTIONS OF SHAKER ARMATURE (ARMATURE GUIDANCE SYSTEM)

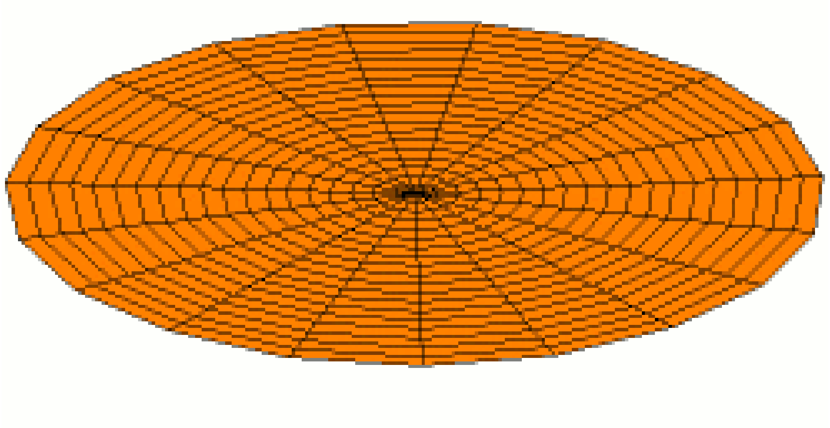


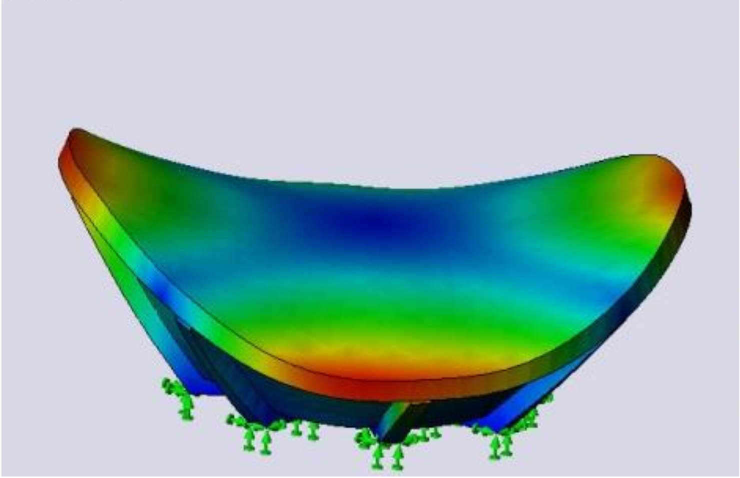


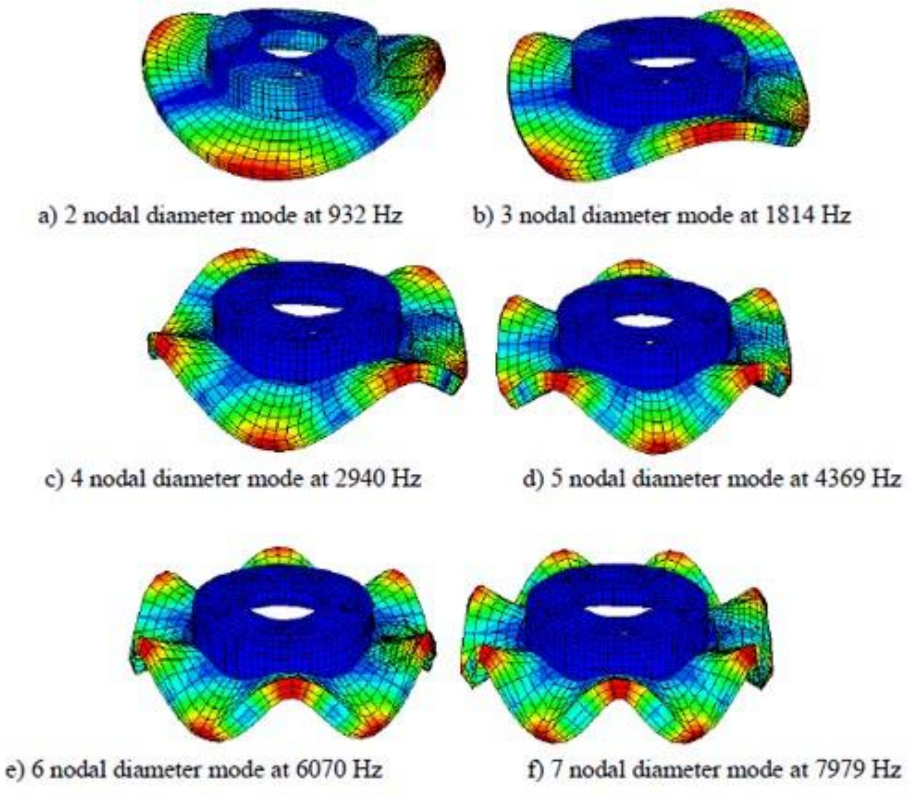
ARMATURE / FIXTURE MODE SHAPES AFFECTS ON CROSS AXIS

Diaphragming of the Armature and Resonance of the Fixture can lead to large cross axis motion at specific frequencies

Watch For Phase Shifts in Your Measurement Channels





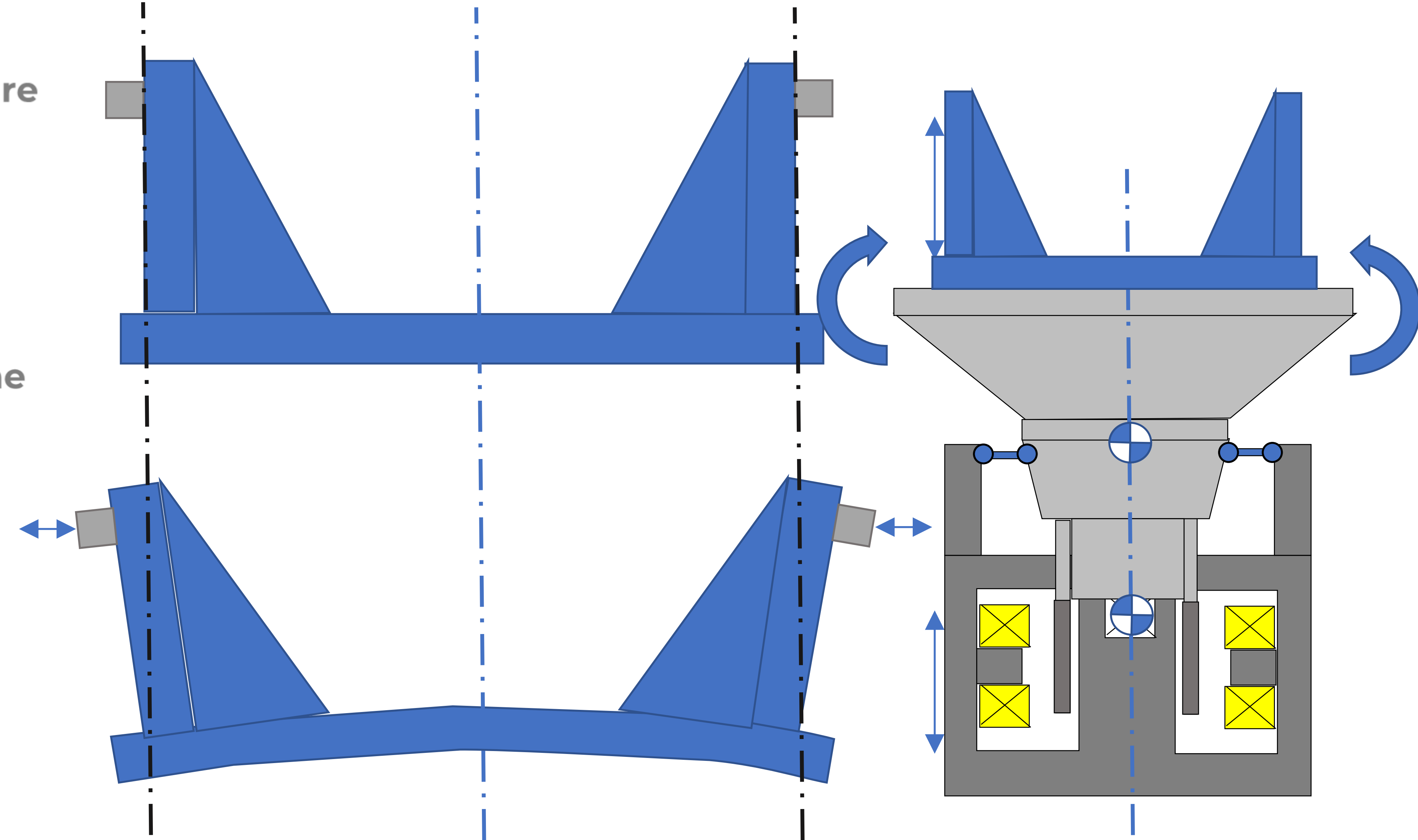

a) 2 nodal diameter mode at 932 Hz
b) 3 nodal diameter mode at 1814 Hz
c) 4 nodal diameter mode at 2940 Hz
d) 5 nodal diameter mode at 4369 Hz
e) 6 nodal diameter mode at 6070 Hz
f) 7 nodal diameter mode at 7979 Hz

ARMATURE / FIXTURE MODE SHAPES AFFECTS ON CROSS AXIS

Armature and Fixture Resonances and Mode Shapes

Diaphragming of the Armature and Resonance of the Fixture can lead to large cross axis motion

Watch For Phase Shifts in Your Measurement Channels



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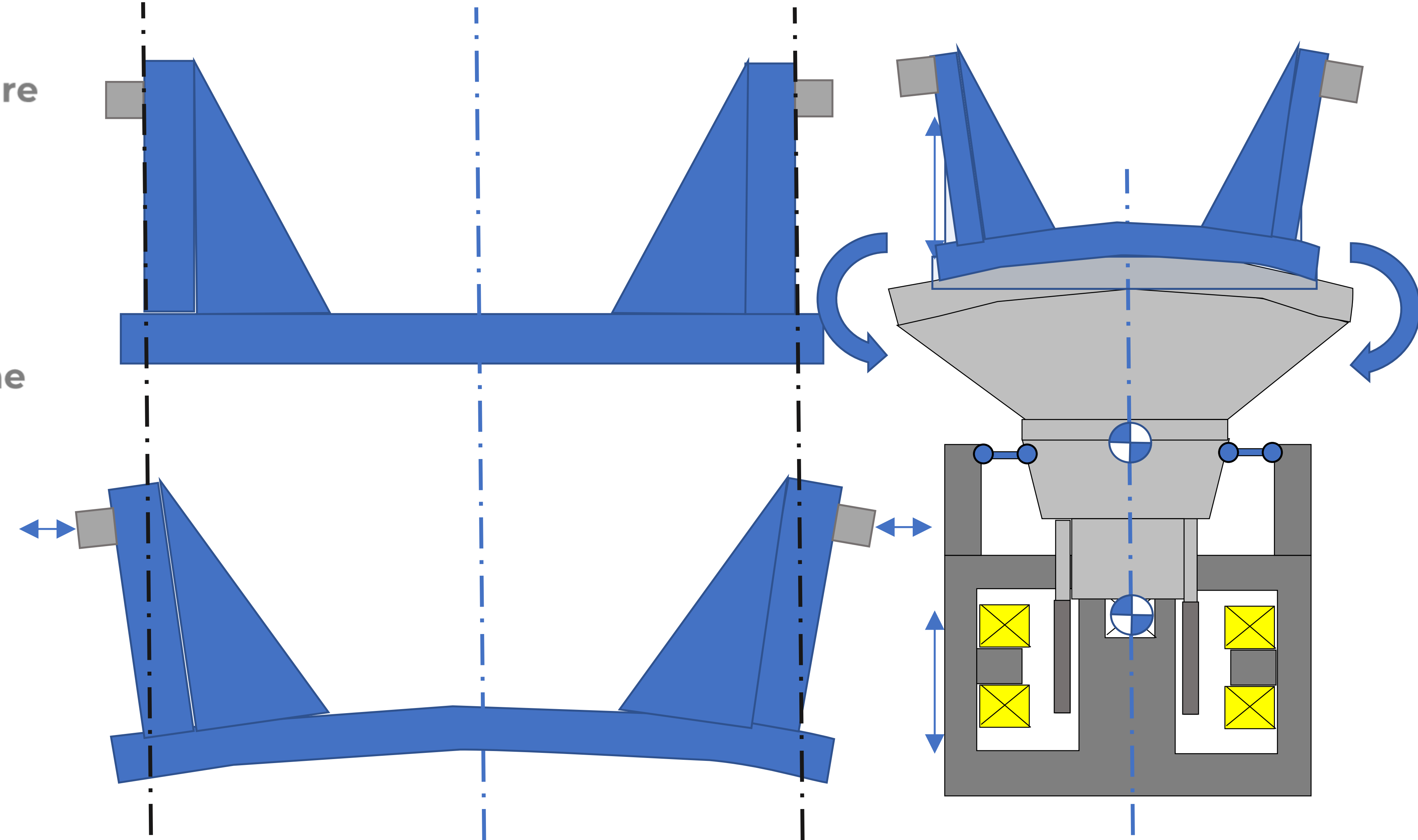

CROSS AXIS ACCELERATIONS

What Should I Do?
How Can
VibrationView Help?

Action	Summary of Requirement	VibrationView Features
Preventative Maintenance	Bare Armature / Slip Table Characterisation And Regular Comparisons	Set up a regular maintenance test Saved graph layout with baseline traces for comparison. Cut and Paste Measurements into graph layouts
Add More Measurement Channels	Measure Armature Surface to Characterise Motion Measure Cross Axis During Test	Add additional Channels (+16 Channels?) +5 Triaxials? Automated Test Reports - Add triaxial measurement of fixture attachments to test reports Add Math Trace to show limits
Pre- Cursor Tests	Fixture Resonance Search Low Level Test with Test Item Installed	Analyser Functions to review transfer Functions, Coherence and Phase Relationships / Cross Specrum
Control/ Measurement Accelerometers	Position Close to Test Item / Fixture Interface	Multiple channel control – average / maximum control Measure Cross Axis During Test
Channel Aborts		Set Channel Limits / Aborts for measurement Channels
Spectrum Notching / Limiting	After identifying cause of cross axis motion – create a limit or notch profile	VibrationView comes with limiting and notching capability as standard

VIBRATIONVIEW

Open VibrationView

- **Features Within VibrationView**
  - Use Your System Check
  - Paste ghost graphs and save with your graph layouts to check for changes is responses (part of preventative maintenance
  - Add cross axis channels to your set up
  - Set Channel Limits / Aborts
  - Set Up Notch Profiles
  - Add Maths Traces to show limits

RANDOM TEST CONTROL PARAMETERS

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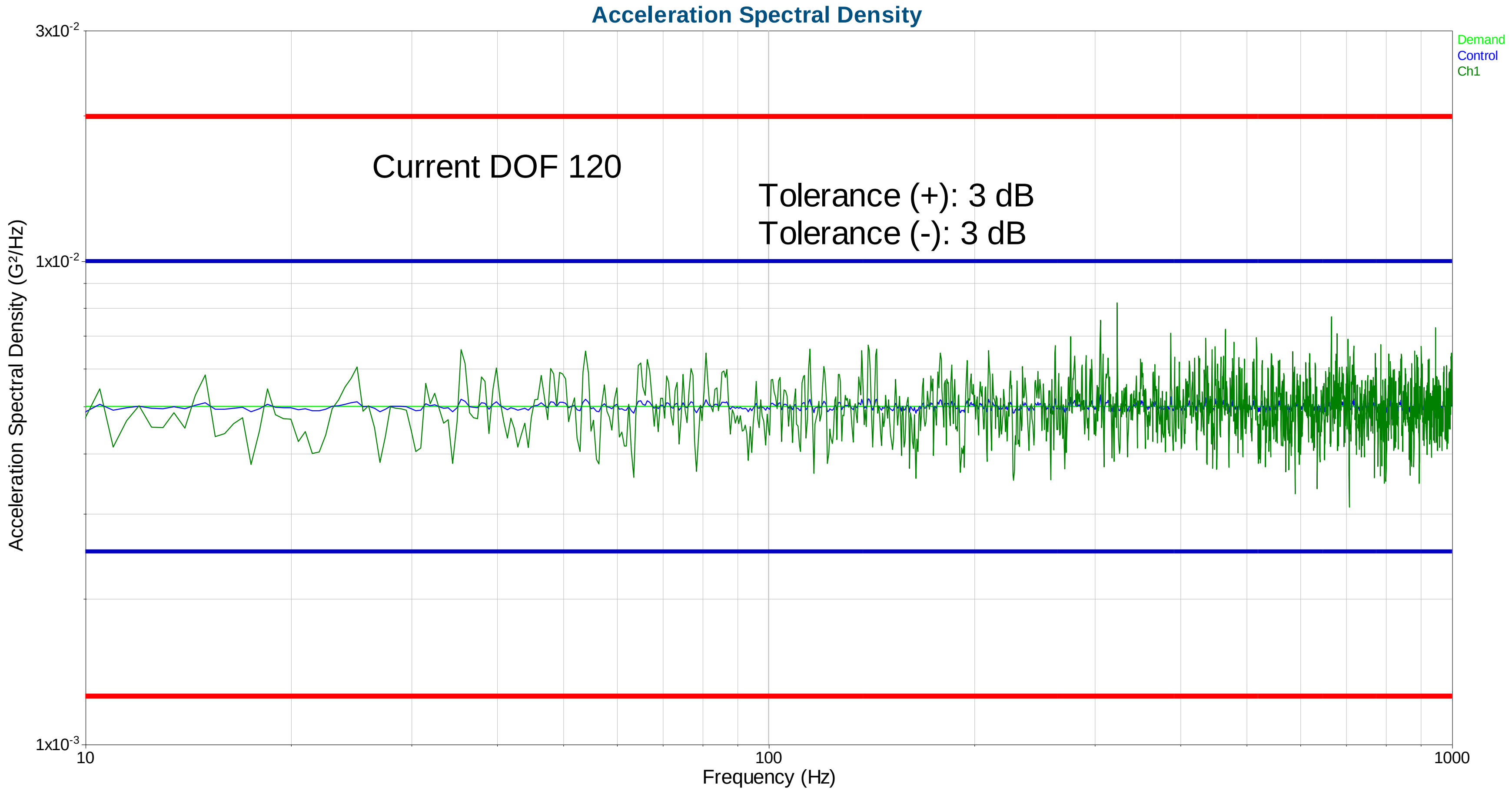
RANDOM CONTROL PARAMETERS

- POWER SPECTRAL DENSITY
- STATISTICAL RANDOM SAMPLING ERROR (DEGREES OF FREEDOM)
- ANALYSER FREQUENCY BANDWIDTH (SPECTRAL LINES / RESOLUTION)
- OUT OF TEST FREQUENCY RANGE RESPONSE
- ROOT MEAN SQUARE (R.M.S.) (IN BAND AND OUT OF BAND)
- AMPLITUDE DISTRIBUTION / KURTOSIS

POWER SPECTRAL DENSITY AMPLITUDE

Maximum local amplitude deviation of the control ASD in relation to the specified ASD

± g2/Hz Tolerance (usually in decibels)



POWER SPECTRAL DENSITY AMPLITUDE

RANDOM TEST PARAMETERS (RTCA DO160)

Maximum local amplitude deviation of the control ASD in relation to the specified ASD

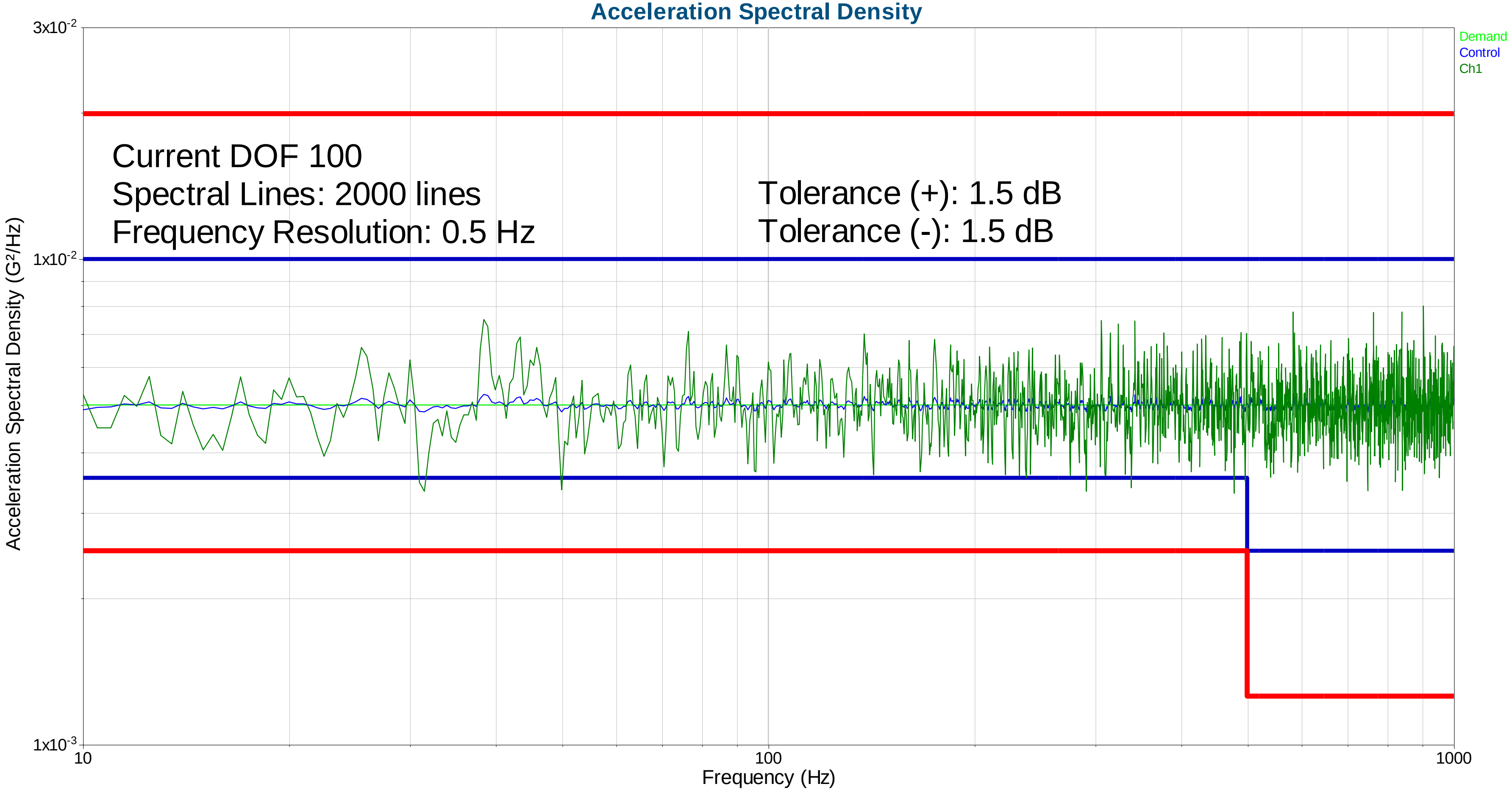
± g2/Hz Tolerance (usually in decibels)

SPECTRAL DENSITY STATISTICAL ACCURACY - DEGREES OF FREEDOM (DOF)

RANDOM TEST PARAMETERS

Maximum local amplitude deviation of the control ASD in relation to the specified ASD

± g2/Hz Tolerance (usually in decibels)



SPECTRAL DENSITY STATISTICAL ACCURACY - DEGREES OF FREEDOM (DOF)

RANDOM TEST PARAMETERS

Degrees of Freedom = 2 x Frequency Resolution x Averaging Time

(Guide each FFT Loop provides 2 DoF) – No Overlapping

Mil Std 810 ≥ 120 DOF

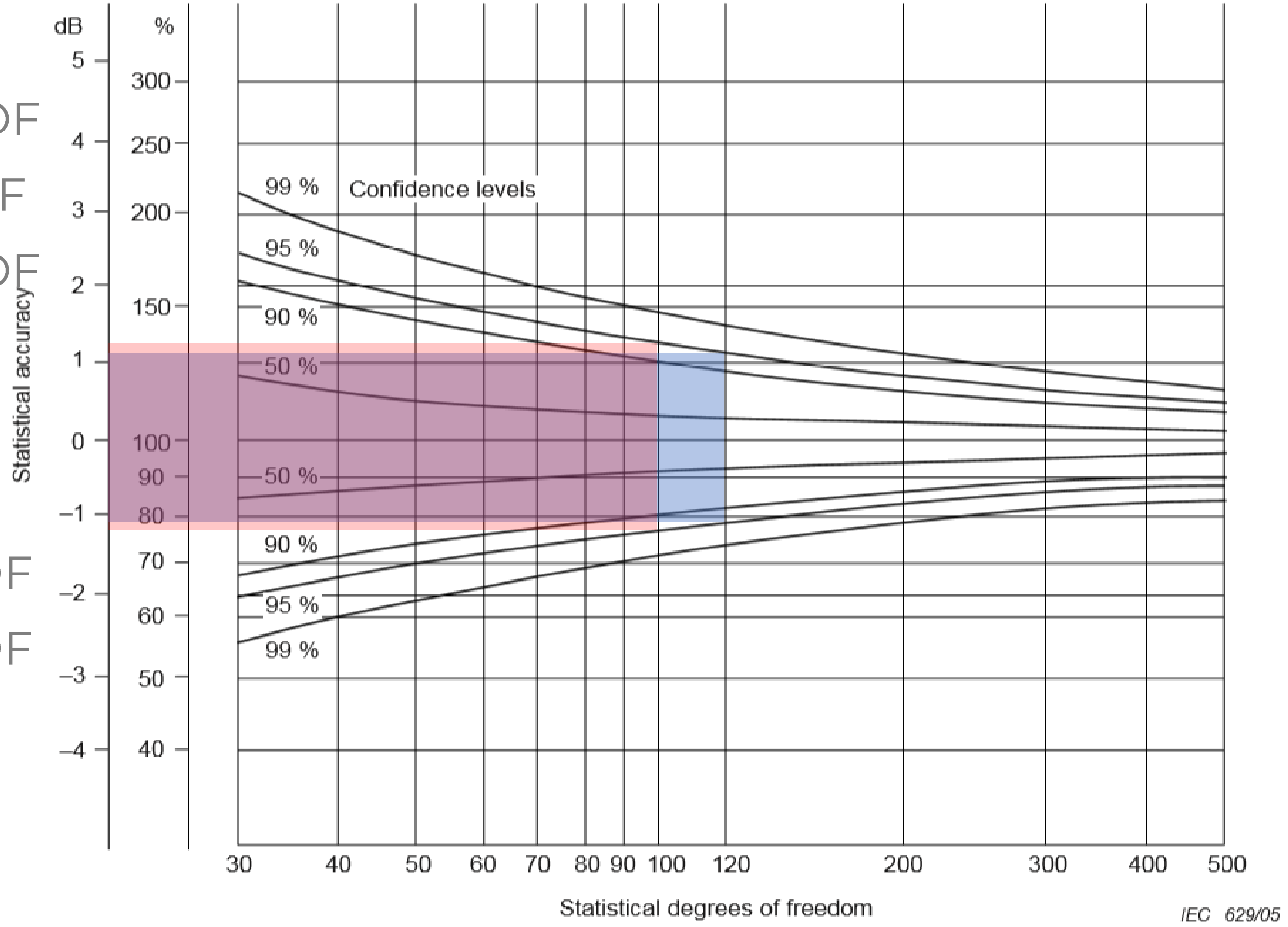
Def Stan 00-35 ≥ 120 DOF

60068-2-64 ≥ 120 DOF

95% Confidence

AECTP 400 ≥100 DOF

RTCA 160G ≥100 DOF



POWER SPECTRAL DENSITY AMPLITUDE AND STATISTICAL DEGREES OF FREEDOM

RANDOM TEST PARAMETERS

Standard	Degrees of Freedom	PSD Tolerances (Control)
Mil Std 810	≥ 120 DOF	± 3 dB
Def STAN 00-35	≥ 120 DOF	± 3 dB
RTCA DO160	≥100 DOF	+3 / -1.5 dB below 500 Hz ± 3 dB above 500 Hz
AETCP 400	≥100 DOF	± 3 dB below 500 Hz ± 6 dB above 500 Hz
ISO 60068-2-64	≥ 120 DOF	± 3 dB

POWER SPECTRAL DENSITY AMPLITUDE AND STATISTICAL DEGREES OF FREEDOM

RANDOM TEST PARAMETERS

Standard	PSD Tolerances (Control)	Additional Notes / Alleviations	
Mil Std 810H	± 3 dB below 500 Hz ± 6 dB above 500 Hz ± 10% overall g_{rms}	Average Control ± 6 dB below 500 Hz ± 9 dB above 500 Hz ± 25% overall g_{rms}	Extremal Control - 6 dB / + 3 dB below 500 Hz - 9 dB / + 6 dB above 500 Hz ± 25% overall g_{rms}
Def STAN 00-35 Issue 5	± 3 dB	Above 500Hz may allow ±6dB (but no more than 5% of frequencies) Multi-point control: +5dB -10dB at each control ppoint	
RTCA DO160G	+3 / -1.5 dB below 500 Hz ± 3 dB above 500 Hz		
AETCP 400	± 3 dB below 500 Hz ± 6 dB above 500 Hz	maximum of 5 % of the total test control bandwidth	
ISO 60068-2-64	± 3 dB	Acknowledges it may be difficult with large / high mass items, wider tolerances may be specified.	

FREQUENCY RESOLUTION

RANDOM TEST PARAMETERS

Standard	Measurement Frequency Resolution (Hz)
Mil Std 810	**2.5 Hz at 25 Hz or below** **5 Hz above 25 Hz** (but use frequency resolution appropriate to the test – wheeled vehicle 1Hz is sufficient
Def STAN 00-35	**Not greater than 5Hz** (Shall be **at least 5 Spectral lines at ½ power point** on any resonances)
RTCA DO160	**Less than 5Hz**
AETCP 400	**Not Specified -**
ISO 60068-2-64	shall be chosen such that, as a minimum, a frequency line coincides with the frequency f1 in Figure 1 and the first frequency line is at 0,5 of f1; also that two frequency lines define the initial slope. If this gives two different values then the smallest be shall be chosen.

RANDOM TEST PARAMETERS (Half Power Point)

FREQUENCY RESOLUTION

$$\text{½ Power Point (-3dB) Bandwidth } (Hz) = \frac{Resonance\ Frequency\ (Hz)}{Q\ Factor}$$

$$\text{Q Factor} = \frac{1}{2 * Damping\ Ratio(\xi)}$$

$$\text{Test Minimum Resolution } (\Delta\text{Hz}) = \frac{\text{½ Power Point } (-3\text{dB Bandwidth}) \ (Hz)}{5}$$

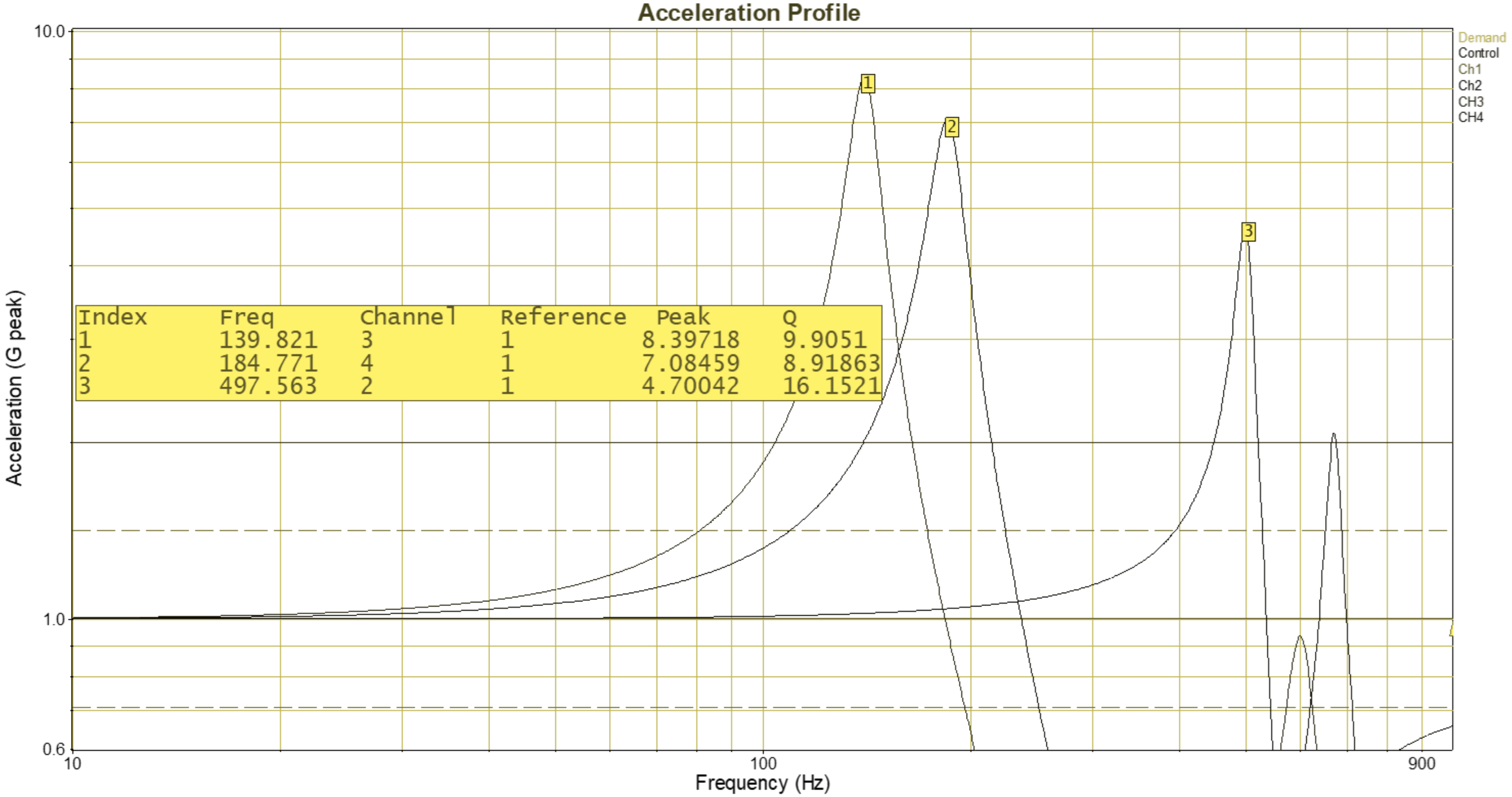
Example: Resonant Frequency 130 Hz with a Q Factor of 10

$$\text{½ Power Point (-3dB Bandwidth) } (Hz) = \frac{130Hz}{10} = 13Hz$$

$$\text{Test Minimum Resolution } (\Delta\text{Hz}) = \frac{13Hz}{5} = \mathbf{2.6Hz}$$

RANDOM TEST PARAMETERS

FREQUENCY RESOLUTION



Index	Freq	Channel	Reference	Peak	Q
1	139.821	3	1	8.39718	9.9051
2	184.771	4	1	7.08459	8.91863
3	497.563	2	1	4.70042	16.1521

Example: Resonant Frequency 139 Hz with a Q Factor of 9.9, ΔHz = 14Hz

$$\text{Test Minimum Resolution } (\Delta\text{Hz}) = \left(\frac{\text{½ Power Point } (-3\text{dB Bandwidth}) \ (Hz)}{5}\right) = \frac{14Hz}{5} = 2.8\text{Hz}$$

FREQUENCY RESOLUTION (LOW FREQUENCY)

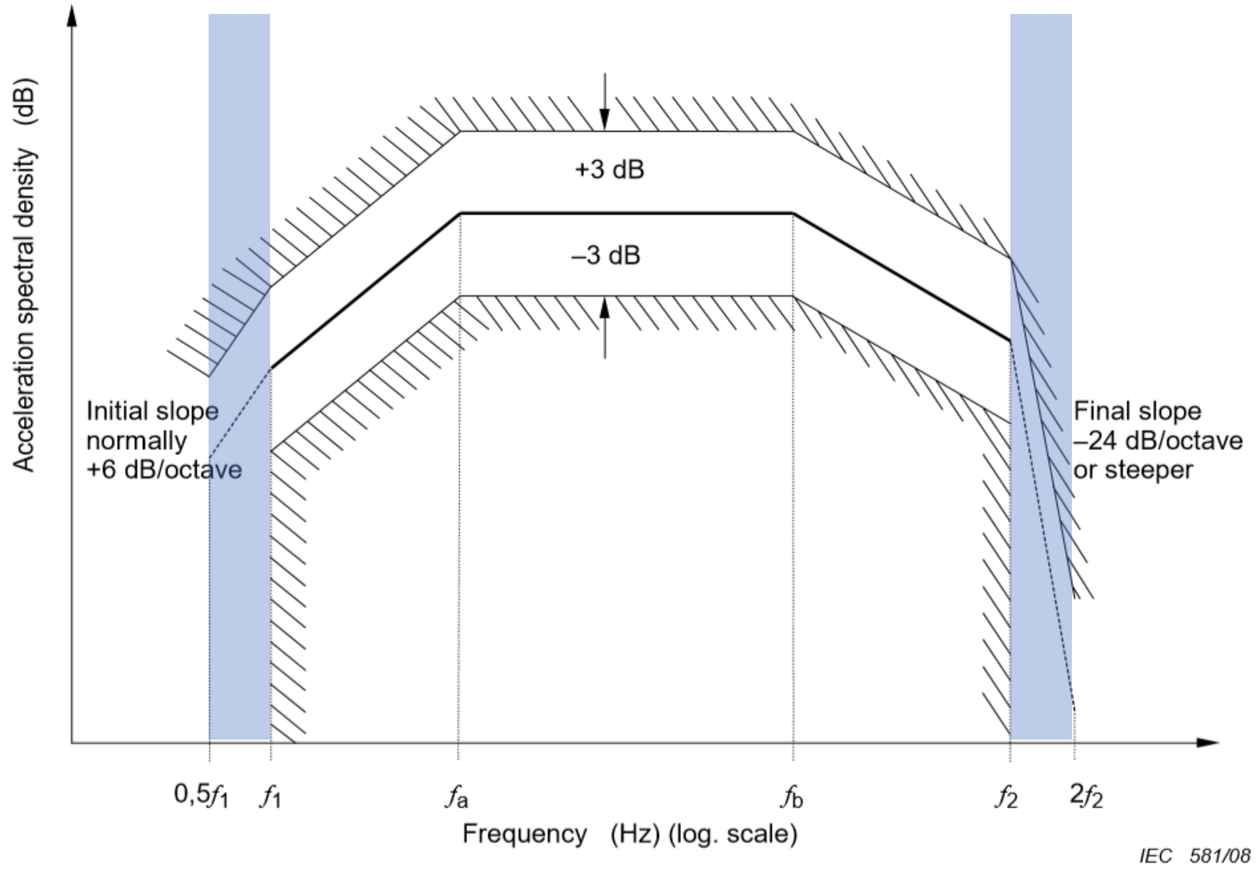
RANDOM TEST PARAMETERS

Example:

If f1 = 5Hz

Two Spectral Lines should define slope between 0.5f1 and f1, so resolution would be 2.5Hz

If f1 = 1Hz
Two Spectral Lines should define slope between 0.5f1 and f1, so resolution would be 0.5Hz

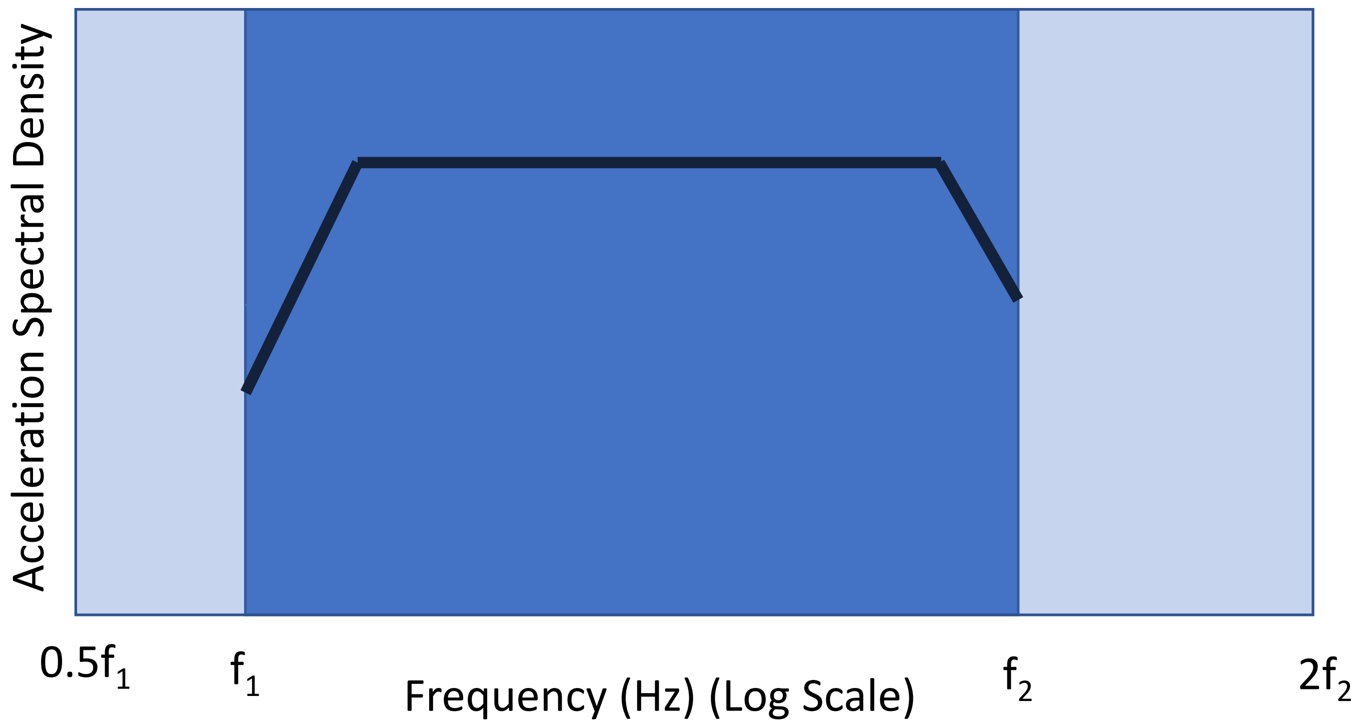


RANDOM TEST PARAMETERS

OUT OF TEST FREQUENCY RANGE

Specifications require that the vibration response outside the test frequency shall be minimized.

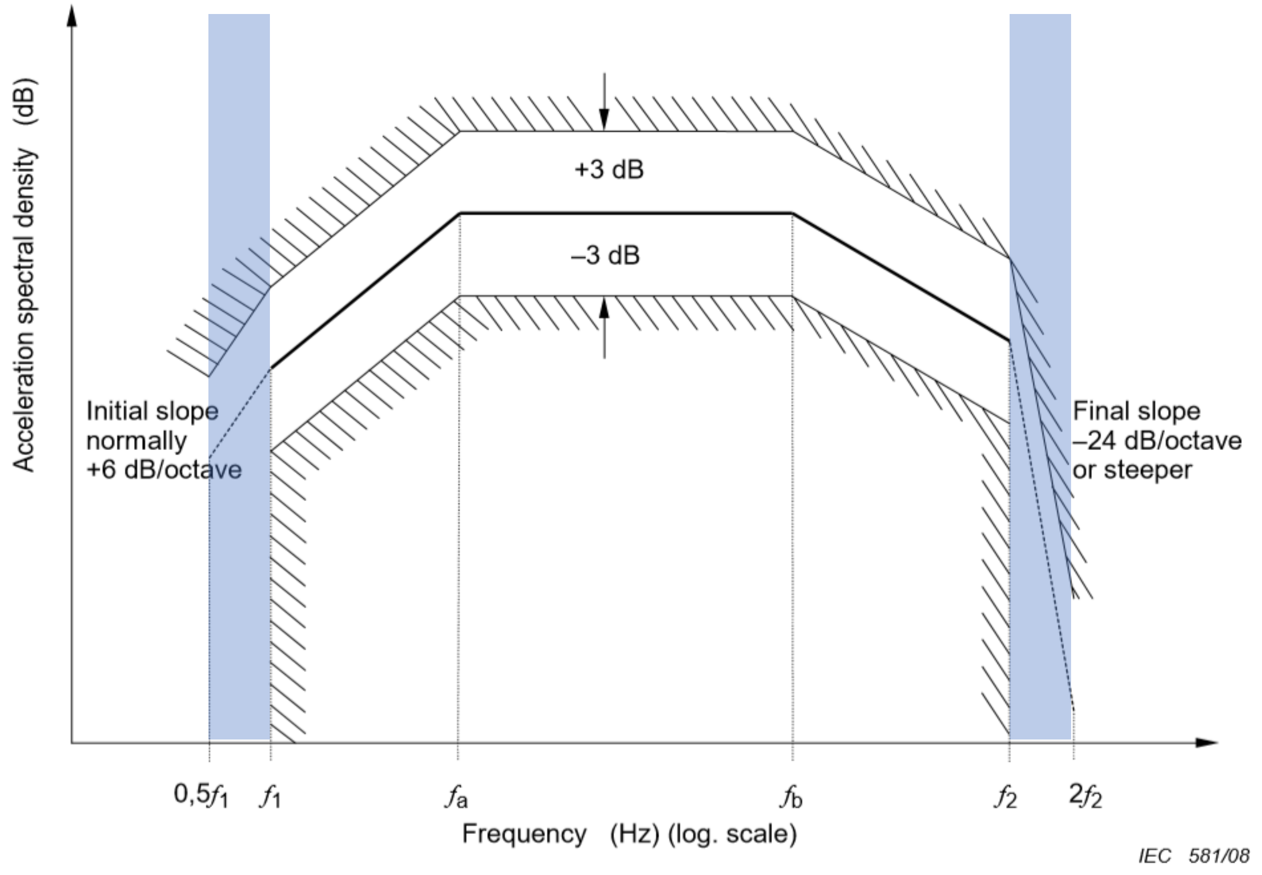
And the frequency range of the overall measurement system shall extend below and above the test frequency range



OUT OF TEST FREQUENCY RANGE

RANDOM TEST PARAMETERS

- PARAMETERS ASSOCIATED WITH FREQUENCY RANGE
- MEASUREMENT FREQUENCY RANGE (OVER SAMPLING)
- INITIAL AND FINAL SLOPES
- IN BAND AND OUT OF BAND RMS



VIBRATION RESEARCH

POWER SPECTRAL DENSITY AMPLITUDE AND STATISTICAL DEGREES OF FREEDOM

RANDOM TEST PARAMETERS

Standard	G_{rms} Tolerance (Control)	Additional Notes / Alleviations	
Mil Std 810H	± 10% overall g_{rms}	Average Control Individual Channels ± 25% overall g_{rms}	Extremal Control Individual Channels ± 25% overall g_{rms}
Def STAN 00-35 Issue 5	±10% at reference point	± 2 dB at reference point	
RTCA DO160G	+20% -5%		
AETCP 400	±10% of the preset RMS value at Control point	Individual Fixing Points ±25% of the preset RMS value	
ISO 60068-2-64	±10% at reference point		

OUT OF TEST FREQUENCY RANGE RESPONSES

RANDOM TEST PARAMETERS

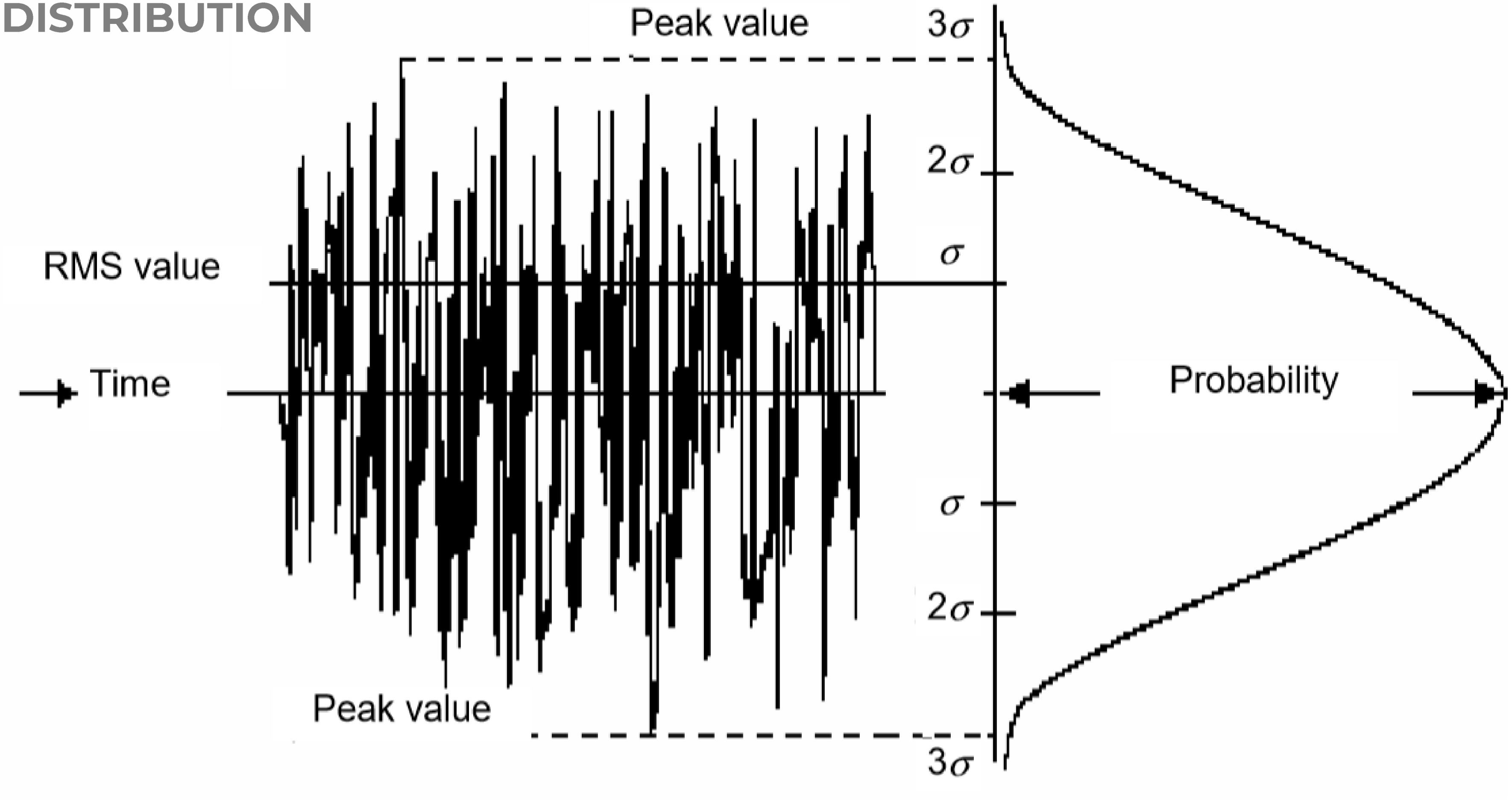
Standard	Out of Band Noise / Response	Frequency Range
DEF STAN 00-35 Issue 5	Out of Band RMS % shall be less than 20%	Out of Test Frequency shall be measured upto 5000Hz or 5 times the driving frequency whichever is lesser
IEC 60068-2-64	Not Specified	The frequency range of the measuring system shall extend from at least 0,5 times the lowest frequency (f1) to 2,0 times the highest frequency (f2) of the test frequency range
Mil Std 810H	Not Specified	Not Specified
RTCA DO160G	Not Specified	Not Specified
AECTP	Not Specified	Not Specified

$$Out\ of\ Test\ Frequency\ Range\ Response = \left(\frac{Full\ Bandwidth\ Grms}{In\ Band\ Grms} - 1\right) * 100\%$$

AMPLITUDE DISTRIBUTION – CLIPPING AND KURTOSIS

RANDOM TEST PARAMETERS

AMPLITUDE DISTRIBUTION

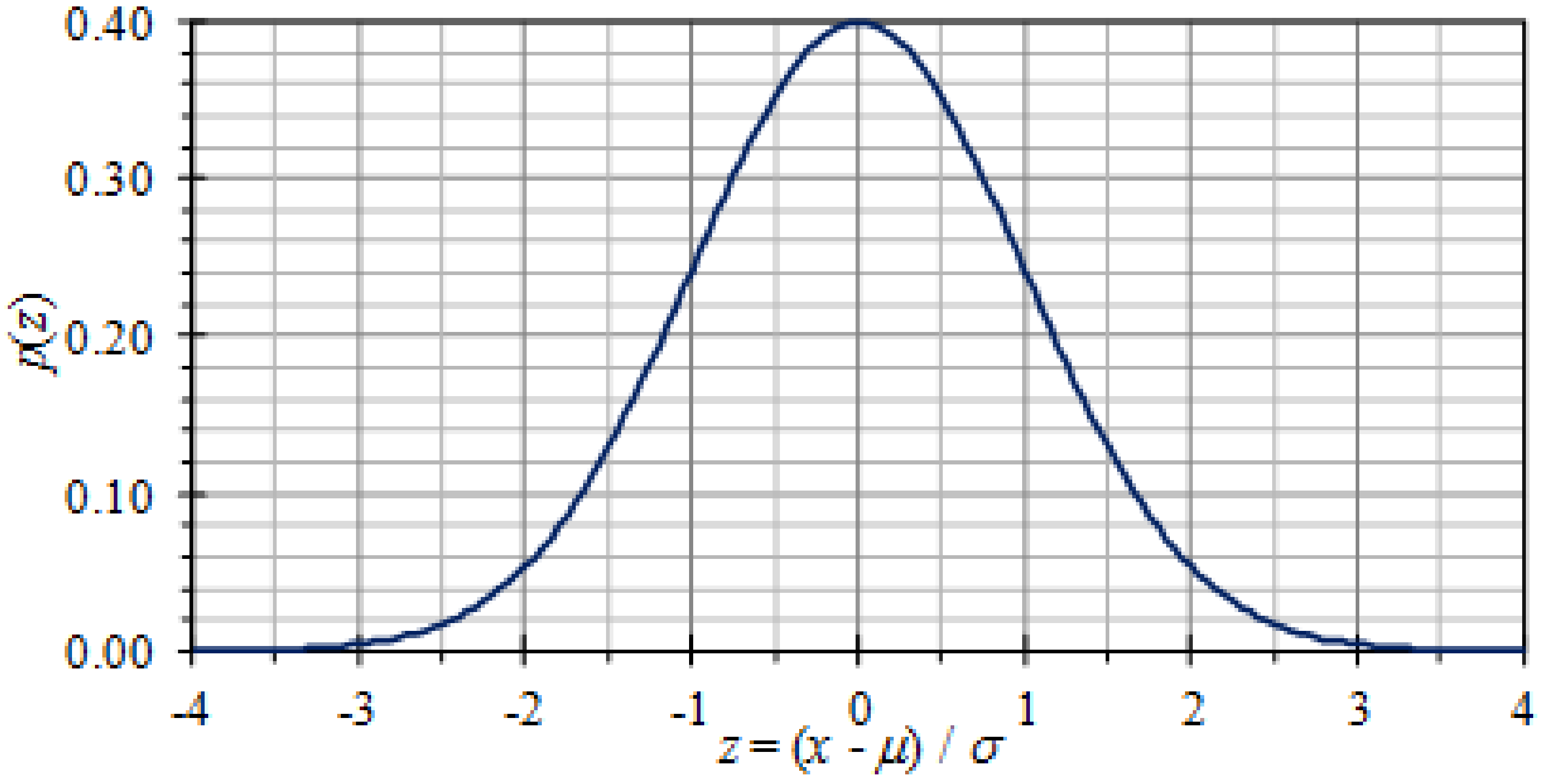


AMPLITUDE DISTRIBUTION – CLIPPING AND KURTOSIS

RANDOM TEST PARAMETERS

GAUSSIAN DISTRIBUTION

$$p(\chi) = \frac{1}{\sigma\sqrt{2\pi}} e^{-1/2(\chi/\sigma)^2}$$



AMPLITUDE DISTRIBUTION – CLIPPING AND KURTOSIS

RANDOM TEST PARAMETERS

SIGMA LIMITING / CLIPPING

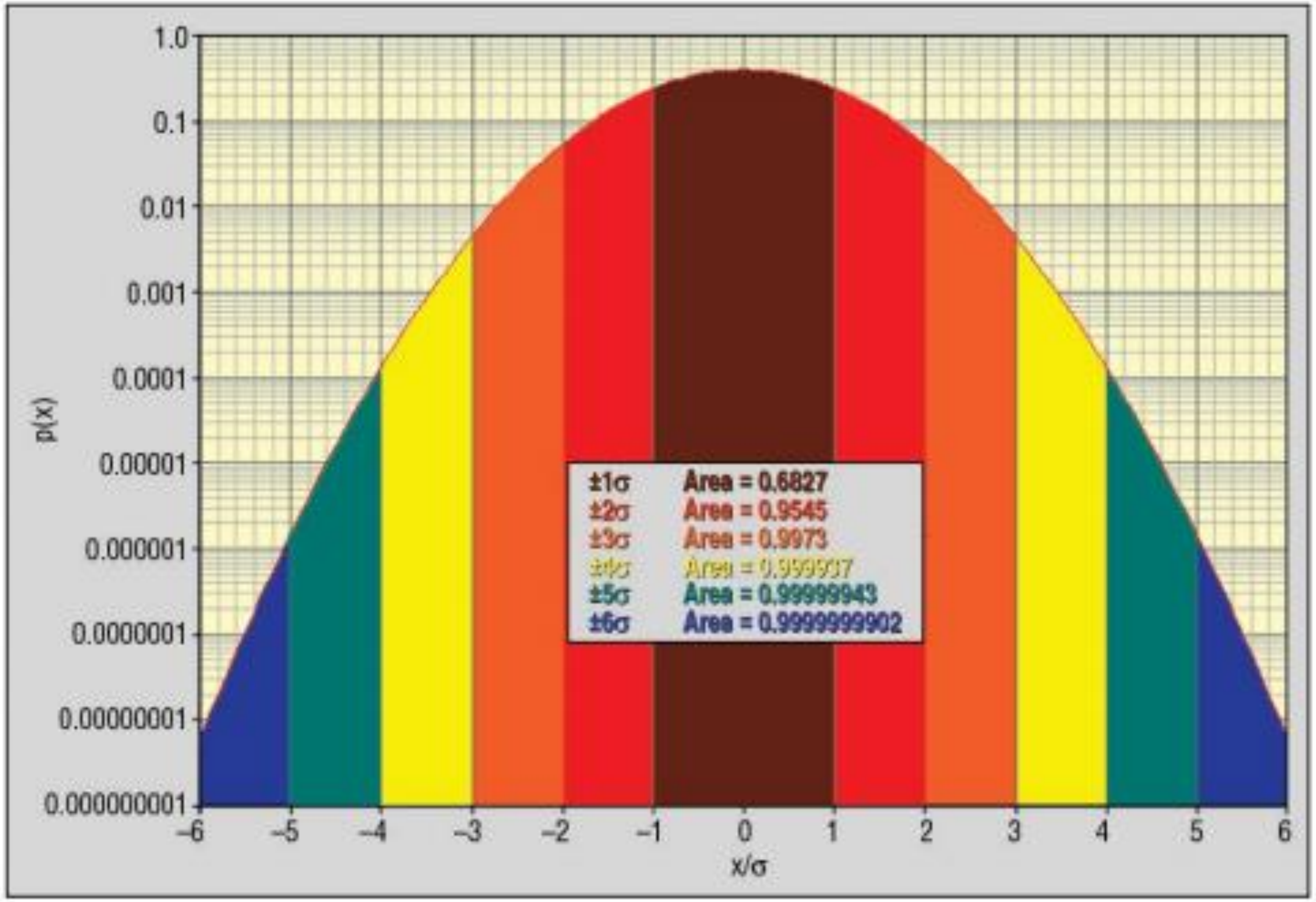


Figure 22. Gaussian signal PDF repeated using log vertical axis and color marking ±nσ bands.

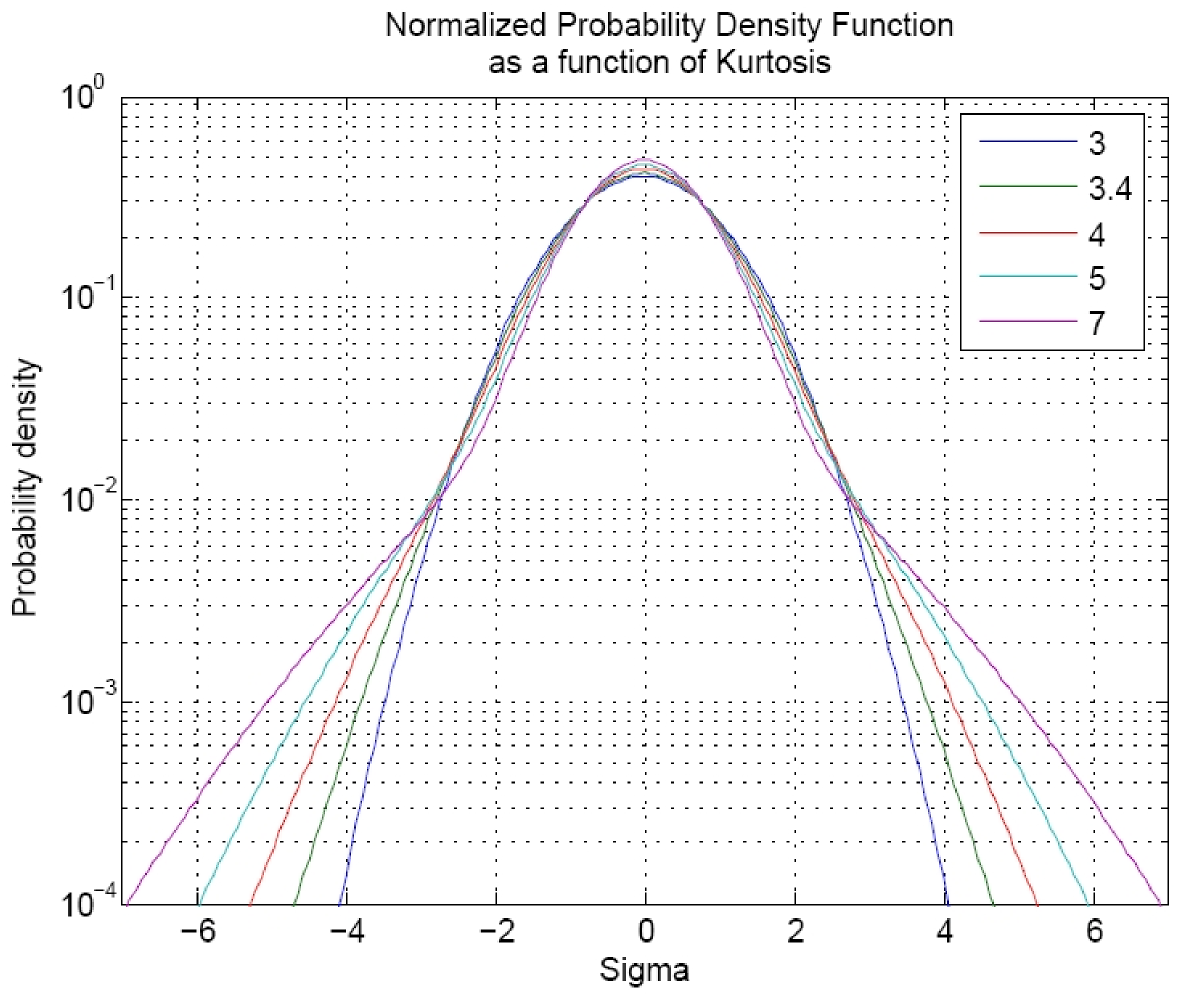
AMPLITUDE DISTRIBUTION – CLIPPING AND KURTOSIS

RANDOM TEST PARAMETERS

KURTOSIS

GAUSSIAN (NORMAL) DISTRIBUTION HAS A KURTOSIS OF 3

KURTOSIS TOLERANCES ARE SOMETIMES DEFINED AT ±10%



AMPLITUDE DISTRIBUTION – CLIPPING AND KURTOSIS

RANDOM TEST PARAMETERS

Standard	Amplitude Distribution	Additional Notes
DEF STAN 00-35 Issue 5	Nominally Gaussian	Shall contain all occurrences upto 2.7 SD, while occurrences greater than 3SD shall be kept to a minimum.
IEC 60068-2-64	Instantaneous values at reference point shall be approximately normal (Gaussian)	The drive signal clipping – the Crest Factor at the reference point shall be examined to ensure it contains **at least 3 times** the rms value. (Crest Factor applies to each checkpoint) **Probability Density** shall be computed for the reference point **during testing**
Mil Std 810H	Gaussian at Drive Signal	Drive limiting should not be invoked and shall never be below 3
RTCA DO160G	Random Signal shall have a Gaussian distribution	The control signal (Drive?) **may** be limited to 3 times the g_{rms}
AECTP	Nominally Gaussian	Shall contain all occurrences upto 2.7 SD, while occurrences greater than 3 SD shall be kept to a minimum.

VIBRATION RESEARCH

VIBRATIONVIEW

Open VibrationView

- **Features Within RandomView**
    - Breakpoint Table Tolerances / Aborts
    - % Lines outside Tolerance
    - Individual Channel Tolerances (PSD and RMS)
    - Control and Channel Aborts (RMS)
    - Spectral Limiting / Notching
    - Oversampling
    - In Band and Full Band RMS
    - Degrees of Freedom and iDoF
    - Frequency Resolution and affect on DoF achievement
    - Clipping Types (IF YOU MUST)
    - Probablity Density and Kurtosis Display

VIBRATION RESEARCH

SINE TEST PARAMETERS

THE INNOVATOR IN
SOUND & VIBRATION
TECHNOLOGY

SINE TESTS

SINE CONTROL PARAMETERS

- **AMPLITUDE (G PEAK)**
    - SINGLEPOINT CONTROL
    - MULTIPOINT CONTROL (AVERAGE / MAX)
- **FREQUENCY**
- **SIGNAL TOLERANCE / DISTORTION**
- **TRACKING FILTERS**

SINE TEST PARAMETERS

SINE TEST AMPLITUDE

Standard	Amplitude	Additional Amplitude Tolerance
DEF STAN 00-35 Issue 5	Test Level Control **±10%**	General Multi-Point Control: ± 5 dB at each Control Point Additional Control Alleviation (Annex D) : ±10% below 500Hz, ±20% above 500Hz **Amplitudes outside the range ±10%** of the specified value should **not total more than 5% of control frequency range**
IEC 60068-2-64	Test Level Control **±15%**	Checkpoints ±25% below 500Hz Checkpoints ±50% above 500Hz (Note: Tolerance includes ±5% Instrumentation error.)
Mil Std 810H	Test Level Control **±10%**	Multi-Point Control Average Control: ± 25% below 500 Hz ± 50% above 500 Hz Maxi Control: +10% / -25% below 500 Hz; +10% / -50% above 500Hz
RTCA DO160G	Test Level Control **±10%**	No additional tolerances specified
AECTP	Test Level Control **±15%**	± 25% at the fixing points up to 500 Hz ± 50% at the fixing points above 500 Hz

SINE TEST PARAMETERS

SINE TEST AMPLITUDE

Standard	Frequency Tolerance
DEF STAN 00-35	±2% or ±1.0 Hz of the specified value, whichever is the greater.
IEC 60068-2-64	Endurance Tests Fixed frequencies: ±2 % Swept frequencies: ±0,05 Hz up to 0,25 Hz; ±20 % from 0,25 Hz to 5 Hz; ±1 Hz from 5 Hz to 50 Hz; ±2 % above 50 Hz. Measurement of Critical Frequencies ±0,05 Hz up to 0,5 Hz; ±10 % from 0,5 Hz to 5 Hz; ±0,5 Hz from 5 Hz to 100 Hz; ±0,5 % above 100 Hz
Mil Std 810H	Frequency ± 0.1 %
RTCA DO160G	±2% (Accuracy of Instrumentation)
AECTP 400	Test Profile Frequencies ±0,05 Hz up to 0,25 Hz; ±20 % from 0,25 Hz to 5 Hz; ±1 Hz from 5 Hz to 50 Hz; ±2 % above 50 Hz. Measurement of Critical Frequencies ±0,05 Hz up to 0,5 Hz; ±10 % from 0,5 Hz to 5 Hz; ±0,5 Hz from 5 Hz to 100 Hz; ±0,5 % above 100 Hz

SINE TEST PARAMETERS

SINE TEST
Distortion /
Signal Tolerance

Standard	Distortion / Signal Tolernace	Notes
DEF STAN 00-35 Issue 5	**Signal Tolerance 5% or less**	**Unfiltered to be measured upto 5,000Hz or 5 times the drive frequency which ever is the lesser**
IEC 60068-2-64	**Signal Tolerance shall not exceed 5%**	Reference Point shall be measured upto 5,000Hz or beyond or five times the drive frequency (a tracking filter shall be used if Signal Tol. above 5%)
Mil Std 810H	**±5% on grms values**	See distortion equation below
RTCA DO160G	**Not Specified**	
AECTP	**±5% on grms values**	See distortion equation below

$$\text{Distortion}(\%) = \frac{\sqrt{a^2_{unfiltered} - a^2_{filtered}}}{a_{filtered}} \text{ x } 100$$

$$\text{Signal Tolerance} = \left(\frac{a_{unfiltered}}{a_{filtered}} - 1\right) \text{x } 100$$

$$\frac{D}{100} = \sqrt{\left(\frac{T}{100}\right)^2 + \frac{2 * T}{100}}$$

Signal Tolerance of 5% corresponds to a distortion of 32%

SINE TEST PARAMETERS

SINE TEST
Tracking Filters

Standard	Notes
DEF STAN 00-35 Issue 5	Advice - Tracking Filter response should be at lest 5 times the controller compression speed. The filter band width should be less than the drive frequency!
IEC 60068-2-64	
Mil Std 810H	Not mentioned
RTCA DO160G	Constant Bandwidth: 10Hz max (from 10-200Hz); 50Hz max from 200to 2kHz Constant Percentage Bandwidth: less than 23%
AECTP	Not mentioned

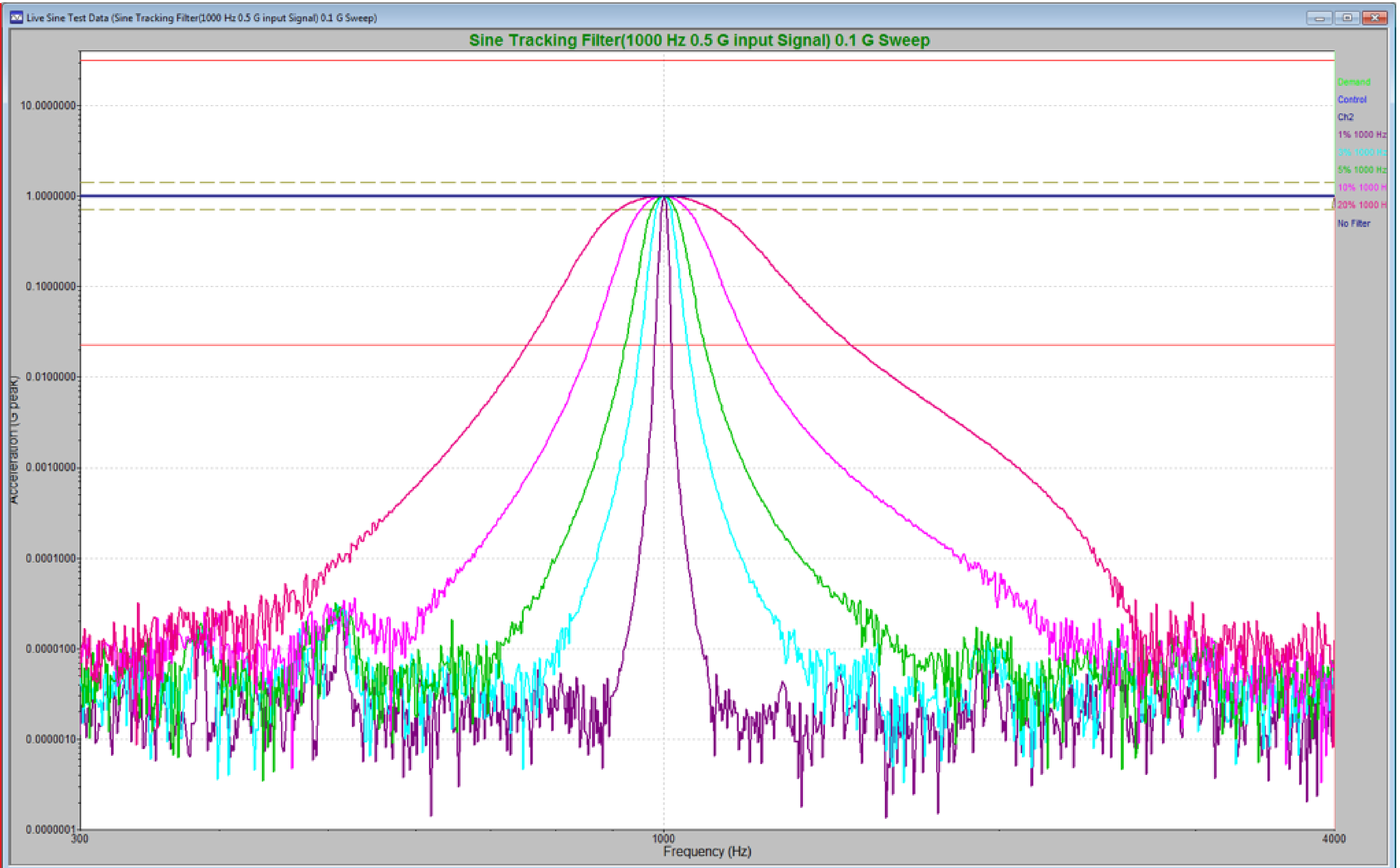
$$\text{Response Time } (T_r) = \frac{1}{Filter\ Bandwidth(Hz)}$$

10Hz Constant Bandwidth = 100ms Response Time

10% Constant Percentage Bandwidth = 10 periods at the drive frequency

TRACKING FILTERS

SINE TEST PARAMETERS



VIBRATION RESEARCH

SINE TESTS

SINE CONTROL PARAMETERS

- **AMPLITUDE (G PEAK)**
  - SINGLEPOINT CONTROL
  - MULTIPOINT CONTROL (AVERAGE / MAX)
- **FREQUENCY**
- **SWEPT TOTAL HARMONIC DISTORTION**
- **TRACKING FILTERS**

VIBRATION RESEARCH

SHOCK (CLASSICAL)

SHOCK CONTROL PARAMETERS

- **CLASSICAL SHOCK TOLERANCES**
    - PULSE SHAPES
    - ACCELERATION TIME HISTORY
    - VELOCITY CHANGE
    - FREQUENCY RESPONSE FILTERS
- **COMPENSATION PULSE AFEFCTS ON FREQUENCY CONTENT**

CLASSICAL SHOCK PARAMETERS

Shock Test
Parameters
Pulse Shapes

Standard	Pulse Shapes					
	Half Sine	Terminal-Peak Sawtooth	Trapezoidal	Damped Sinusoidal	Synthesised Shock Response Spectrum	Time Waveform Replication
Mil Std 810 H Method 516	✓	✓	✓		✓	✓
Def STAN 00-35 Issue 5 M3	✓	✓	✓	✓	✓	✓
RTCA DO160G Section 7		✓				
AETCP 400 (Method 403) 415 417	✓	✓	✓		✓	✓
ISO 60068-2-29 and -81	✓	✓	✓		✓	✓

CLASSICAL SHOCK PARAMETERS

Shock Parameters

TD: duration of nominal pulse (tolerance on TD is ± 10%).

A: peak acceleration of nominal pulse

T1: minimum time duration which the pulse shall be monitored for shocks produced using a conventional mechanical shock machine.

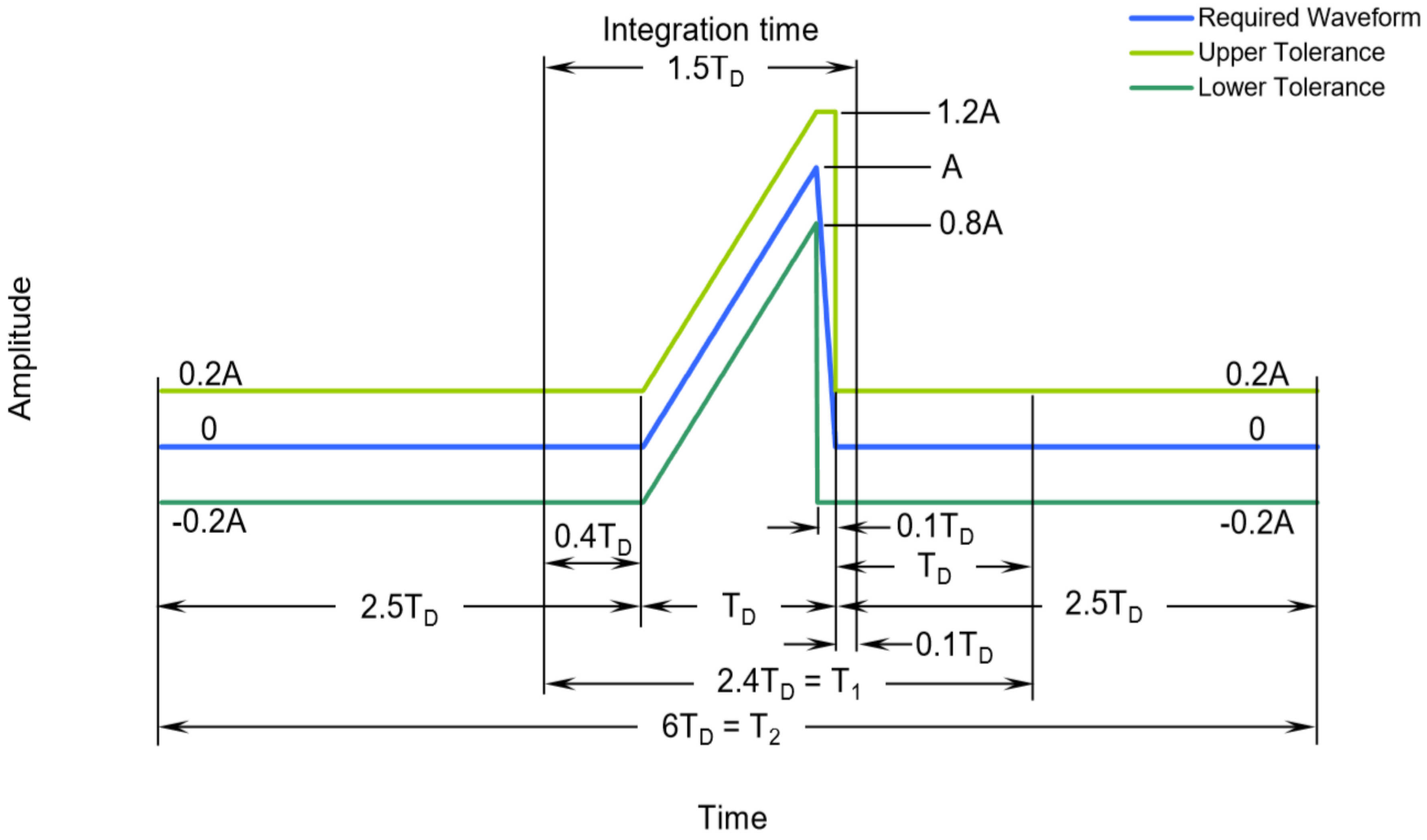
T2: minimum time during which the pulse shall be monitored for shocks produced using a vibration exciter.

The duration associated with the post-pulse slope of a terminal peak sawtooth and durations associated with the pre and post slopes of a trapezoidal pulse should be less than 10% TD.

The tolerance on velocity, due to combined effects of any amplitude and/or duration deviations from the nominal pulse, is limited to ± 20% of the pulse's nominal velocity.

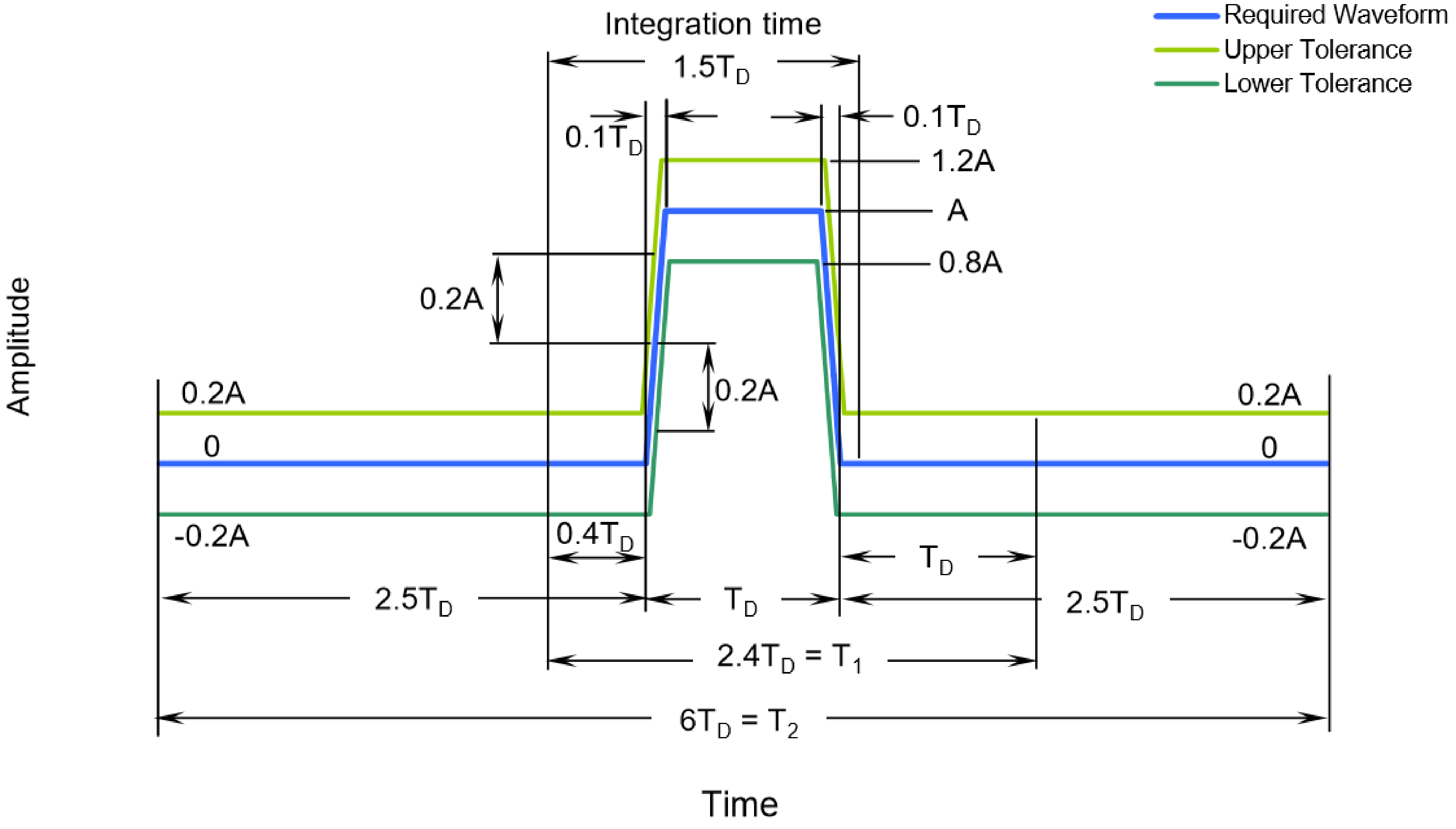
CLASSICAL SHOCK PARAMETERS

Shock Parameters Time History (Mil Std 810H, Def Stan 00-35 AETCP 403)



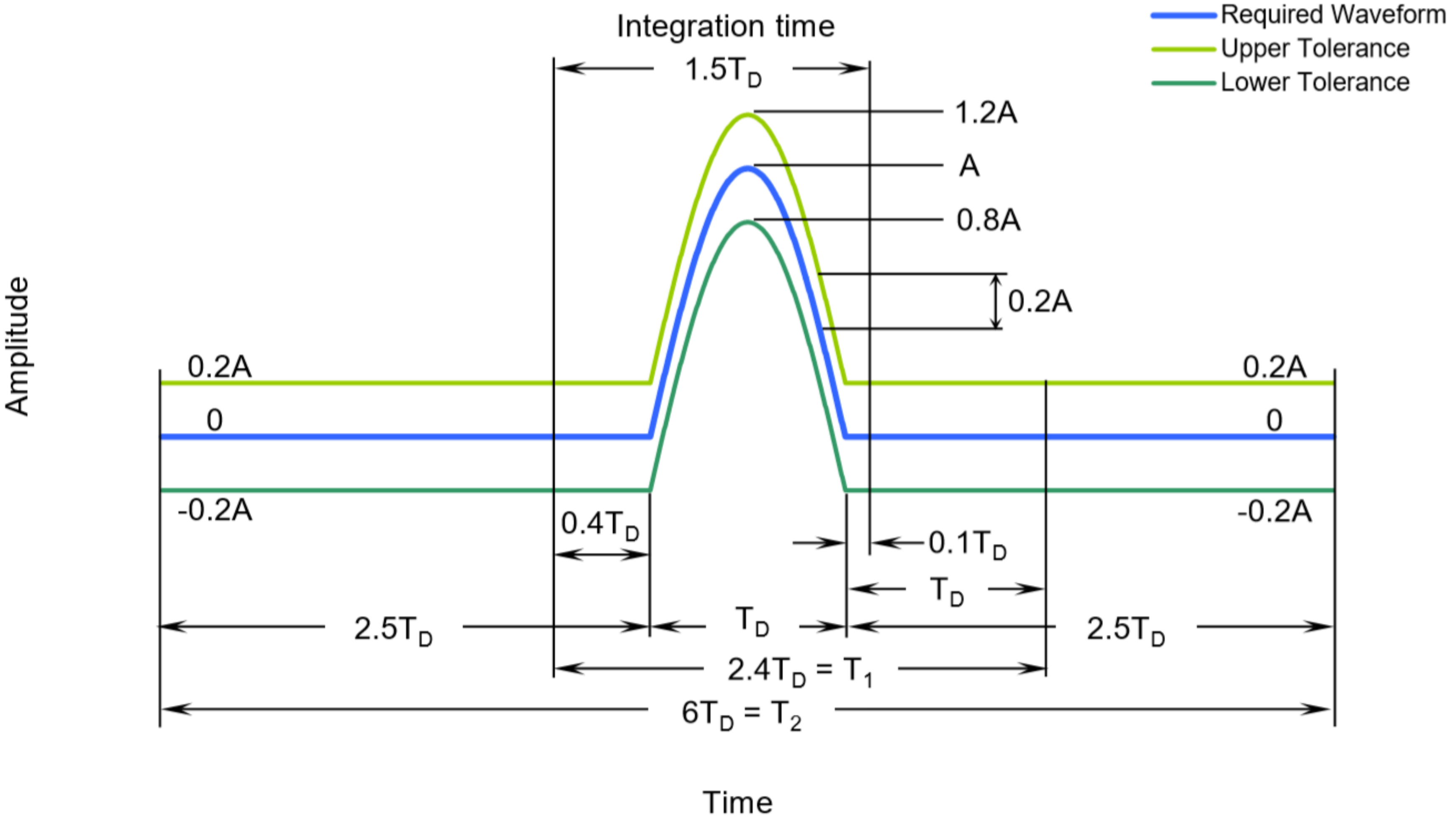
CLASSICAL SHOCK PARAMETERS

Shock Parameters Time History (Mil Std 810H, Def Stan 00-35 AETCP 403)



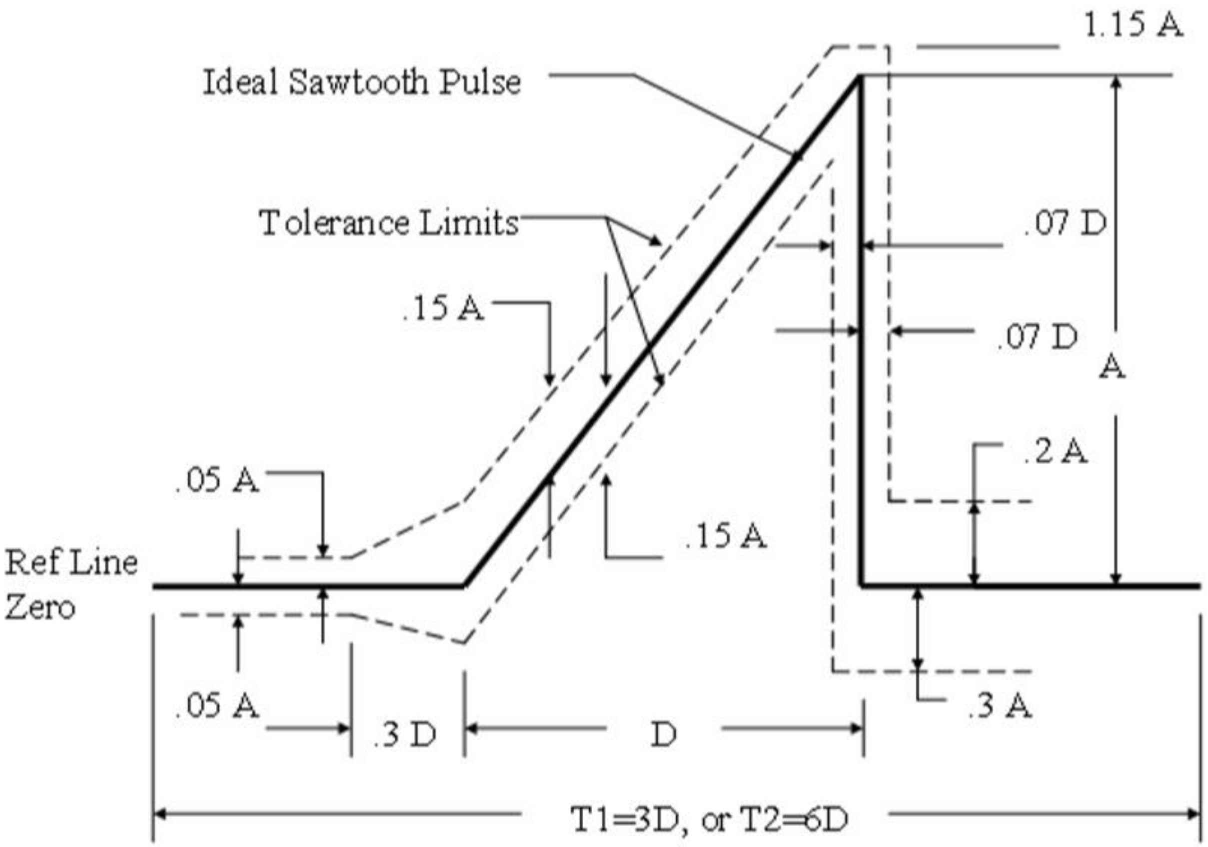
CLASSICAL SHOCK PARAMETERS

Shock Parameters Time History (Mil Std 810H, Def Stan 00-35 AETCP 403)



CLASSICAL SHOCK PARAMETERS

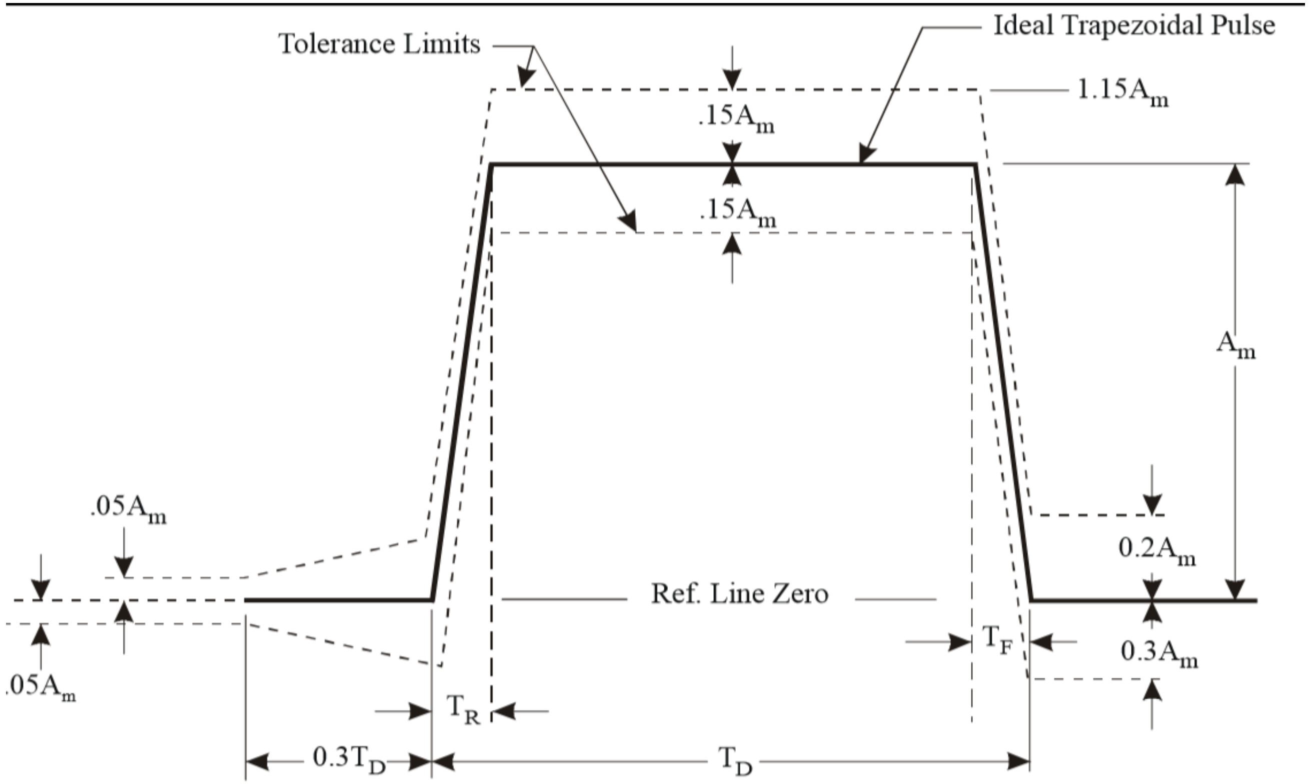
Shock Parameters
Mil Std 810G
and RTCA 160G



The Tolerance on Velocity Change = ±10% from Nominal Pulse
(with integration time $0.4T_D$ before the pulse and $0.1T_D$ after the pulse)

CLASSICAL SHOCK PARAMETERS

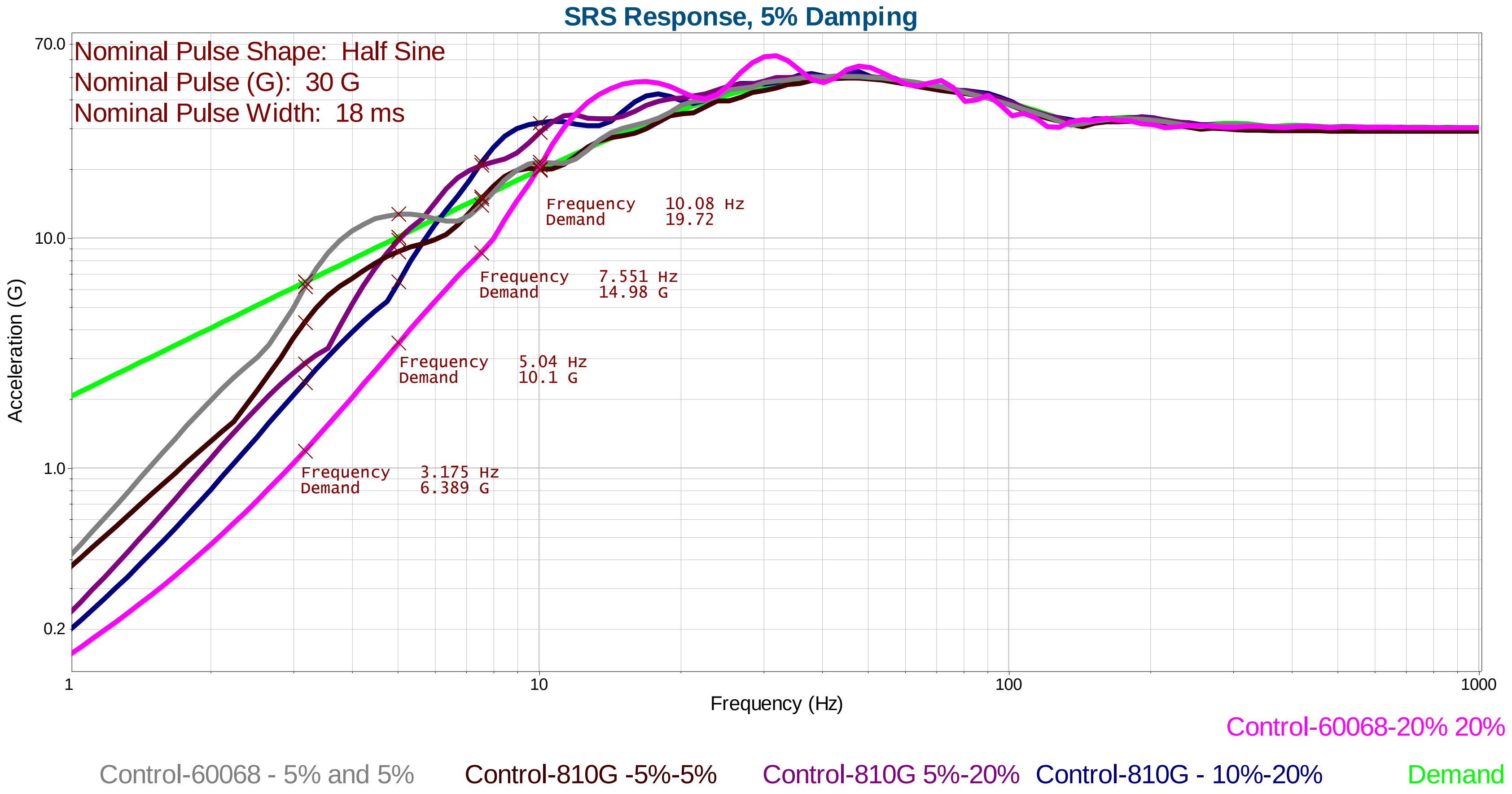
Shock Parameters
Mil Std 810G



Monitor Time History 3 times Pulse Duration (with Shock Centred).
The Tolerance on velocity = 10% with integration time $0.4T_D$ before the pulse and $0.1T_D$ after the pulse.
T_R and T_F = less than or equal to $0.1T_D$

CLASSICAL SHOCK PARAMETERS (COMPENSATION PULSE AFFECTS)

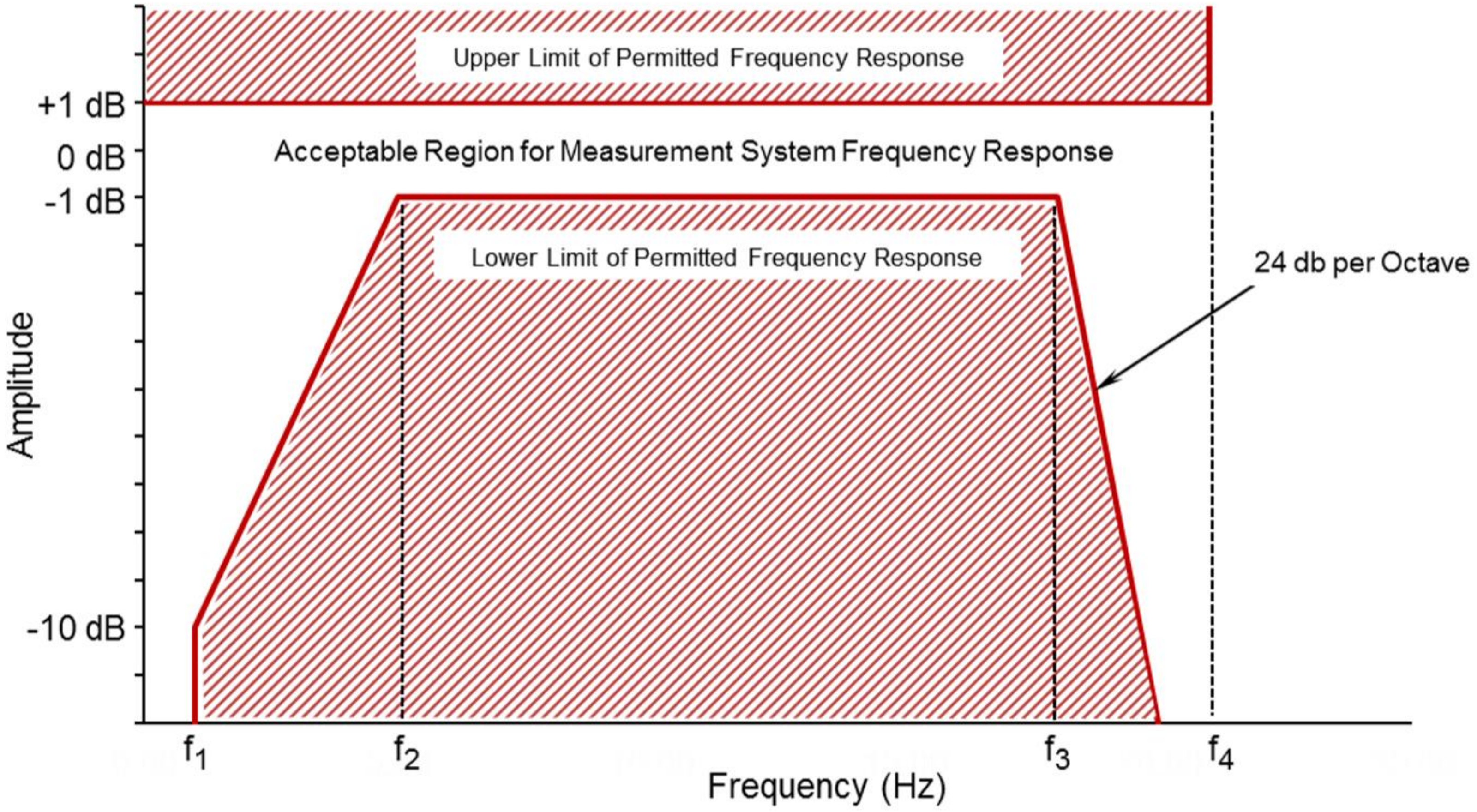
Compensation Pulse Affect on Frequency Content Mil Std 810G



The drop-off at f1 is considered to be acceptable if and only if the lowest resonant frequency of the item being tested (fN), is greater than f1 by a factor of two or more ($f_N \geq 2 * f_1$)

CLASSICAL SHOCK PARAMETERS

Measurement Instruments Frequency Response Def Stan 00-35



CLASSICAL SHOCK PARAMETERS

Measurement Instruments Frequency Response Def Stan 00-35

Duration of Pulse (ms)	Low Frequency Cut Off (Hz)		High Frequency Cut Off (kHz)	Frequency at Which Response May Rise Above +1 dB (kHz)
	f_1	f_2	f_3	f_4
16, 18, 25 and 30	0.2	1	1	2
11	0.5	2	1	2
5 and 6	1	4	2	4
2 and 3	2	10	5	10
1	4	20	10	20
0.5	10	50	15	30
0.2 and 0.3	20	120	20	40

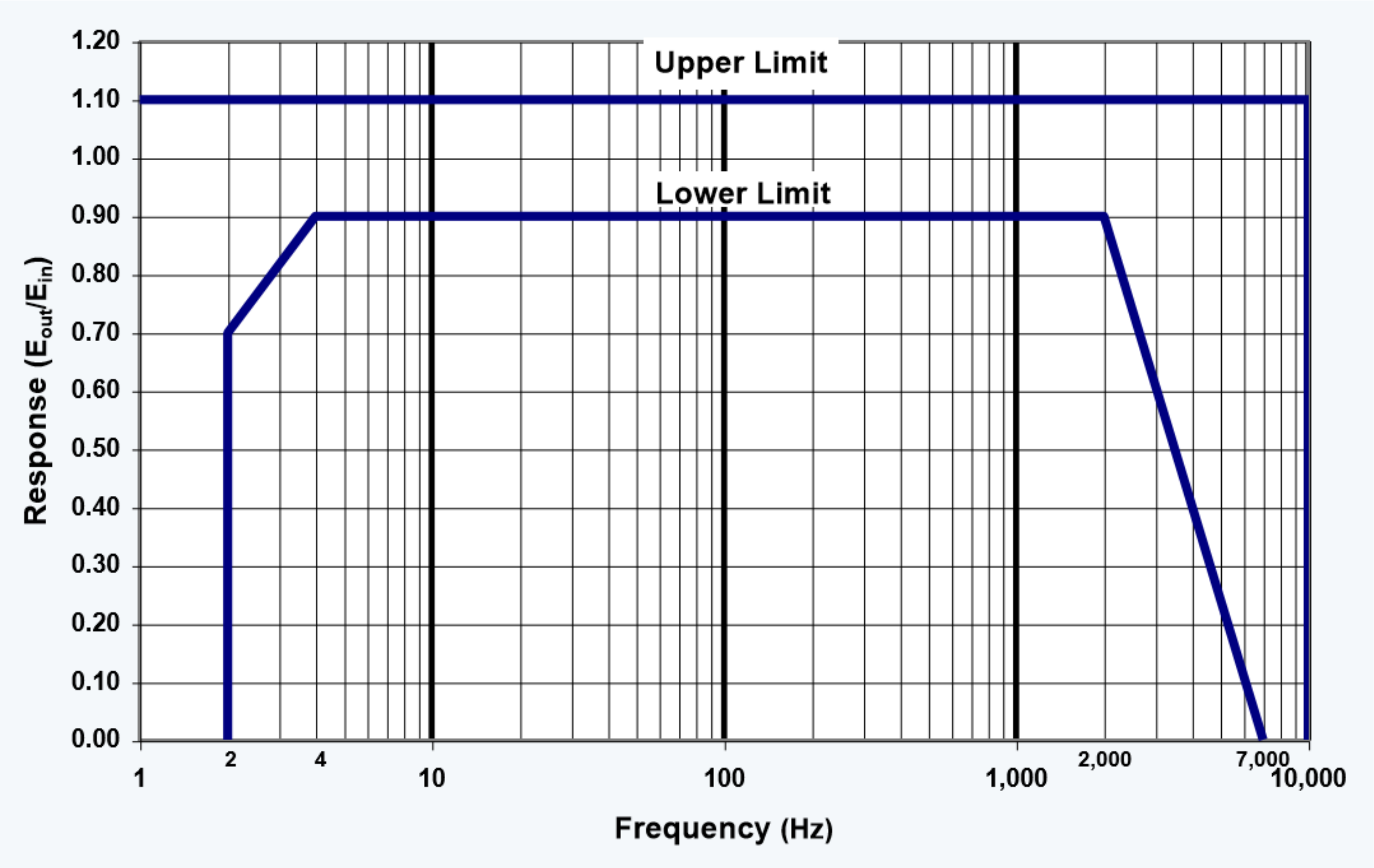
Note: Ideally there should be no significant phase shift over the frequency range of the measurement. However, a constant phase shift for all measurement channels may be acceptable with the agreement of the Test Specifier.

The requirements apply to the acceleration frequency response of the measuring system without the use of a low-pass filter on the control signal. When a low-pass filter is used, the characteristics of the filter should be such that its cut-off frequency (–3 dB point) is not lower than:

$$Cut\ off\ frequency\ of\ low\ pass\ filter\ in\ kHz = \frac{1.5}{pulse\ duration\ in\ ms}$$

CLASSICAL SHOCK PARAMETERS

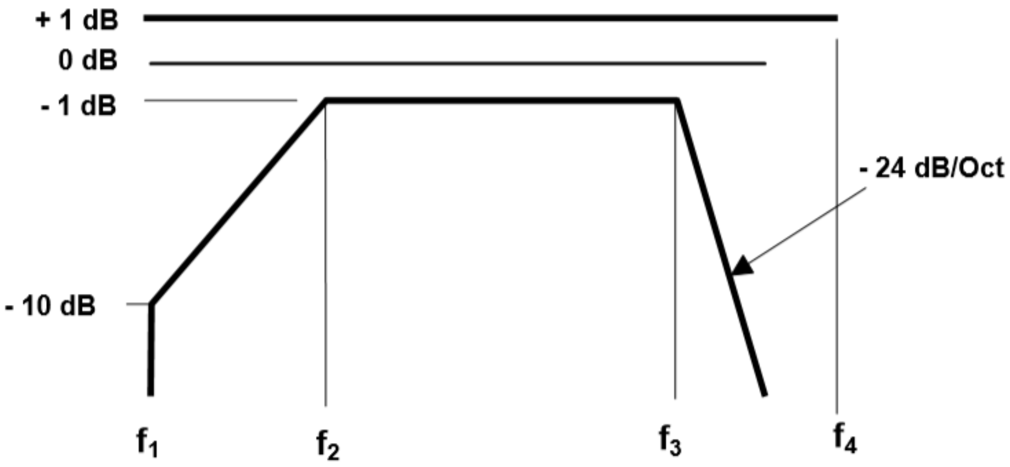
Measurement Instruments Frequency Response RTCA 160G



RTCA Operational and Crash Safety Shock Durations are either 11ms or 20ms

CLASSICAL SHOCK PARAMETERS

Measurement Instruments Frequency Response AECTP 403



For shocks of duration less than 3 milliseconds, the high frequency cut-off and +1dB response frequencies indicated may be inadequate if accurate measurement of the pulse shape is required

Duration of Pulse (ms)	Low frequency Cut off (Hz)		High frequency Cut Off (kHz)	Frequency at which response may rise above +1 dB (kHz)
	f_1	f_2	f_3	f_4
25	0.2	1	1	2
11	0.5	1	1	2
6	1	4	2	4
3	4	16	5	25
<3	4	16	15	25

CLASSICAL SHOCK PARAMETERS

Typical Instrumentation Control Parameters

Standard	Notes
DEF STAN 00-35 Issue 5	Advice - Tracking Filter response should be at lest 5 times the controller compression speed. The filter band width should be less than the drive frequency!
IEC 60068-2-64	
Mil Std 810H	Check accelerometer linearities within 10% at intervals of 20-30% of rated amplitudes (shock calibration Pulse $T_D = 1/2f_{max}$ Flat Frequency Response ±5% (via vibration calibration)
RTCA DO160G	Constant Bandwidth: 10Hz max (from 10-200Hz); 50Hz max from 200to 2kHz Constant Percentage Bandwidth: less than 23%
AECTP	Not mentioned

RTCA Operational and Crash Safety Shock Durations are either 11ms or 20ms

VIBRATION RESEARCH

VIBRATIONVIEW

Open VibrationView

- **Features Within Shock View**
    - Automatic Velocity Change
    - Shock Pulse History Table
    - Shock Response Spectrum To Show Effect of Compensation Pulses
    - Auto Count Pulses In Tolerance
    - Filter Settings (Differential and Integration)
    - Pulse Storage Intervals

VIBRATION RESEARCH

ANY QUESTIONS?

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YouTube

in

About Vibration Research

Established 1995

John Van Baren
President/CEO

Phil Van Baren
Senior VP Product Development

CORE VALUES

COLLABORATION

CAPABLE & COMPETENT

ACCOUNTABLE & RESPONSIBLE

STRONG & DRIVEN WORK ETHIC

DO THE RIGHT THING

INNOVATION

WORLDWIDE LOCATIONS

VIBRATIONRESEARCH.COM/CONTACT

SALES & SUPPORT OFFICES

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Shanghai

Czech Republic
Hermanuv Mestec

Germany
Neuhaus-Schierschnitz

India
Mallapur, Hyderabad

Russia
Moscow

United Kingdom
Fordingbridge, England

USA (Headquarters)
Jenison, Michigan

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Malaysia
Mexico
New Zealand
Norway
Philippines
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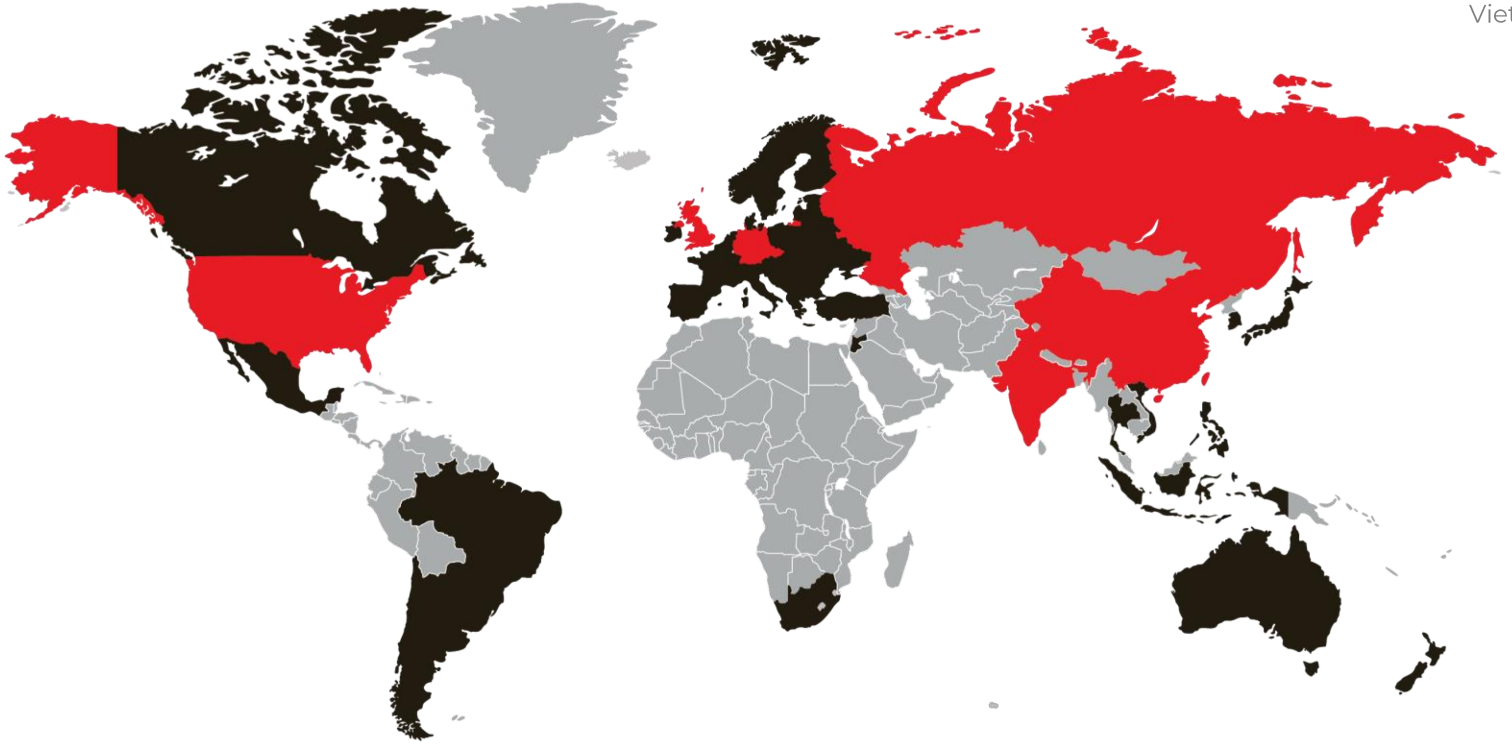
Sweden
Switzerland
Thailand
Turkey
Ukraine
Vietnam



INNOVATIONS

We Develop. You Advance.

1995 — FDR

Field Data Replication enables test engineers to reproduce data in their lab from actual acceleration waveforms measured in the field.

2005 — Kurtosion®

Kurtosis Control Method effectively brings real world peak acceleration back into random vibration tests, making the tests more representative than traditional gaussian methods of the real world.

2010 — FDS

Fatigue Damage Spectrum gives engineers a reliable way to use real world data to create an accelerated life test that represents a lifetime of fatigue damage on a product.

2015 — iDOF®

Instant Degrees of Freedom provides the smoothest control lines in the industry. This helps with quick ramp up periods, tight tolerances, and easy detection of resonances.

VIBRATION RESEARCH

VR CUSTOMERS

Whirlpool | GENTEX CORPORATION | EXCELITAS TECHNOLOGIES | LOCKHEED MARTIN | Continental The Future in Motion | Johnson Controls | Honeywell | IBM

B/E AEROSPACE | BMW | Cochlear | JOHN DEERE | MOTOR HARLEY-DAVIDSON CYCLES | MOTOROLA | PHILIPS Healthcare | NASA

Advanced Packaging Technology Laboratories, Inc. | Abbott | Agilent Technologies | BOEING | element | GE Aviation | POLARIS | MAGNA

TORO | U.S. NAVAL RESEARCH LABORATORY | UNIVERSITY OF MICHIGAN | Ford | Intertek | GM | Elite | UNIVERSITY OF DELAWARE

VIBRATION RESEARCH

VIBRATION RESEARCH PRODUCTS

ObserVR1000®
Dynamic Signal Analyzer

VR9500
Vibration Controller

Electrodynamic Shakers
Small Force < 600 F-lb

VR9500

VIBRATION CONTROLLER

HARDWARE SPECIFICATIONS

- Gigabit ethernet interface
- 24-bit inputs & outputs
- Integrated IEPE/ICP® supply
- Up to 200kHz sample rate
- Scalable to 128 channels
- Read & write TEDS
- 26,000 lines of resolution
- Simultaneously record & control
- Up to 50kHz control
- Self-resetting fused inputs

VibrationVIEW SOFTWARE

System Check	Sine	Random	Shock	Sine on Random	Sine on Sine
Random on Random	Sine and Random on Random	Shock Response Spectrum	User Defined Transient	Transient Capture	Field Data Replication

ObserVR1000®

Dynamic Signal Analyzer

HARDWARE SPECIFICATIONS

- Stand-alone device
  - ➢ Control buttons + feedback indication
- WiFi connected to a web app
- 16 Input channels
  - ➢ IEPE + TEDS
- Dual tachometer
- SD card storage
- Gigabit ethernet connection
- 10Volt output/drive (Open Loop)
- 6^{+} Hour battery life
- 128kHz sample rate

VIBRATION RESEARCH

OBSERVR1000
VIBRATIONVIEW SOFTWARE OPTIONS

SOFTWARE (Standard)

- RecorderVIEW
- EditVIEW
- Transient Capture
- Live/Offline FFT
- Live/Offline PSD

SOFTWARE (Optional)

- Analyzer Mode
- Shock Response Spectra
- Fatigue Damage Spectrum
  Includes FDS Stand-alone

System Check

Analyzer Mode

Transient Capture

RecorderVIEW and EditVIEW

SRS

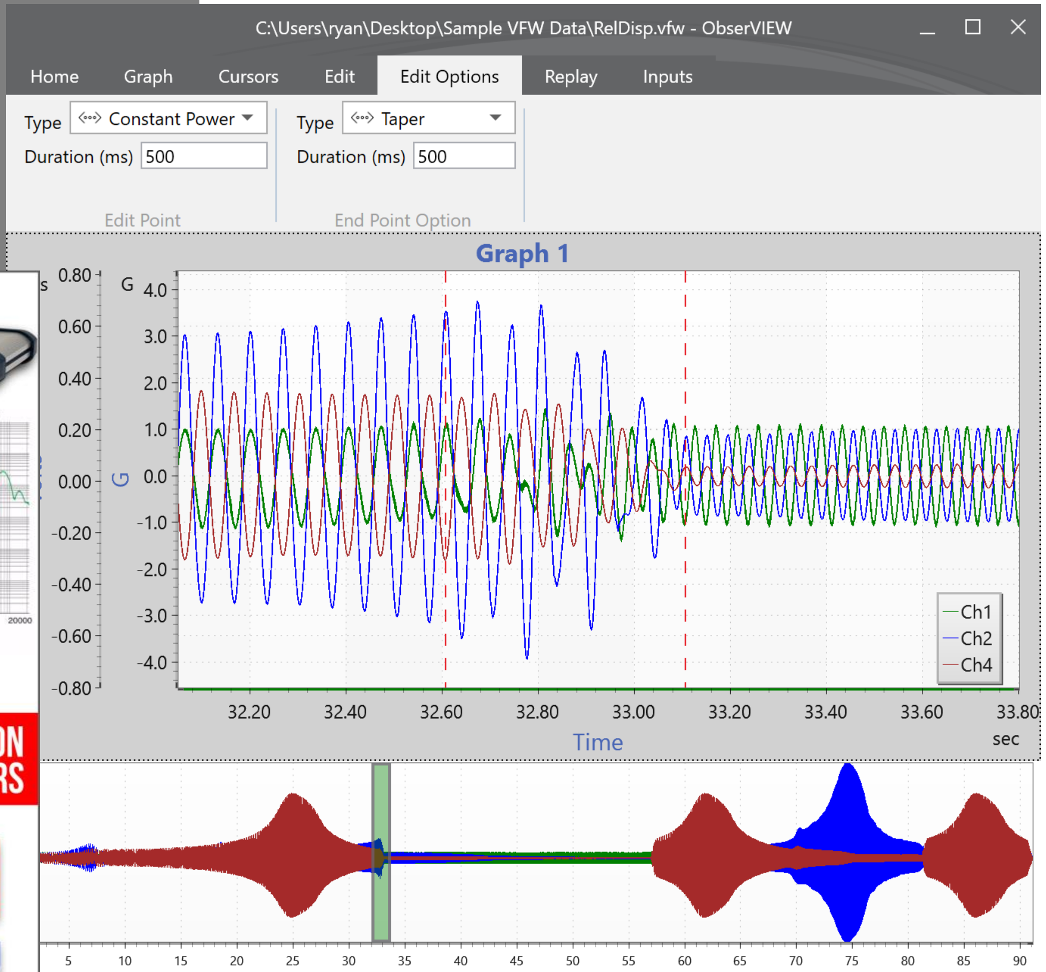
Shock Response Spectrum

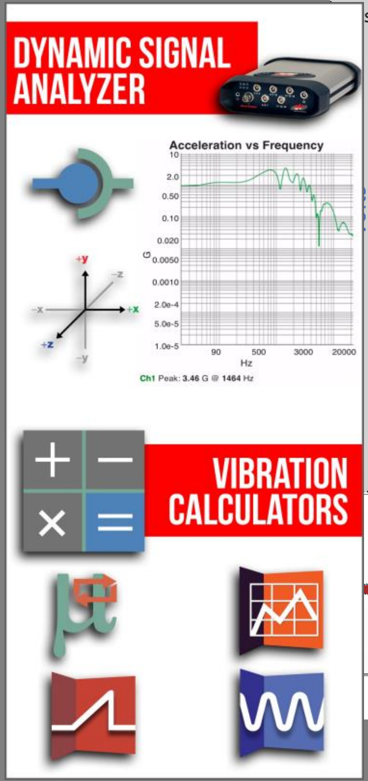
Fatigue Damage Spectrum

OBSERVIEW®
DYNAMIC SIGNAL ANALYSIS

FEATURES INCLUDE

- Short start-up time
- Open a recording
- Open an edited recording session
- View and configure channels
- Navigate large recordings
- Drag cursors
- EditVIEW: edit VFW recordings
- See changes live without saving





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VIBRATION RESEARCH

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