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EIA STANDARD

TP-28E

VIBRATION TEST PROCEDURE FOR ELECTRICAL CONNECTORS AND SOCKETS

EIA/ECA-364-28E

(Revision of EIA-364-28D)

AUGUST 2006

Electronic Components, Assemblies & Materials Association

THE ELECTRONIC COMPONENTS SECTOR OF THE ELECTRONIC INDUSTRIES ALLIANCE

Electronic Industries Alliance

EIA/ECA-364-28E

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(From Standards Proposal No. 5125 formulated under the cognizance of the CE-2.0 National Connector Standards Committee.

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TEST PROCEDURE No. 28E

VIBRATION TEST PROCEDURE FOR ELECTRICAL CONNECTORS AND SOCKETS

(From EIA Standards Proposal No. 5125, formulated under the cognizance EIA CE-2.0 Committee on National Connector Standards, and previously published in EIA-364-28D.)

1 Introduction

1.1 Scope

The standard test procedure details a method to assess the ability of electrical connector components to withstand specified severities of vibration.

1.2 Object

The object of this test is to determine the effects of vibration within the predominant or random vibration frequency ranges and magnitudes that may be encountered during the life of the connector.

1.3 Definitions

1.3.1 Axis

The following mounting axis definitions shall be employed during the performance of this test. Figure 1 indicates a pictorial view of the axis definitions. The referencing document shall indicate the fixturing required or the axis definitions if different than as stated in figure 1. Axis definitions for symmetrical, square and “free” connectors shall be defined in the Detail Specification.

1.3.1.1 X-axis

Along the longitudinal length of the test sample

1.3.1.2 Y-axis

The axis perpendicular to the longitudinal length of the sample (transverse direction).

1.3.1.3 Z-axis

The axis perpendicular to the fixture seating plane attached to the test table.

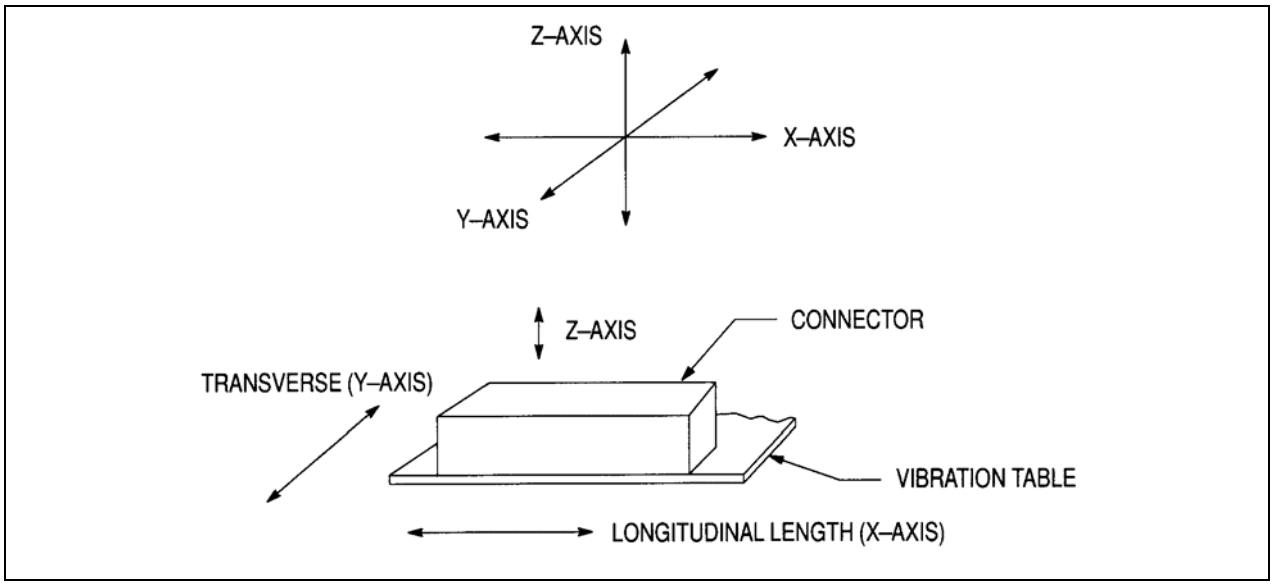


Figure 1 - Mounting axis definitions

1.3.2 The term g_n

This term is the SI unit for the standard acceleration due to the earth's gravity, which itself varies with altitude and geographic latitude.

NOTE — In this standard the value of g_n is 9.81 m/s^2.

2. Test resources

2.1 Equipment

The monitoring transducer shall be calibrated against a standard transducer having an accuracy of ±2%. The vibration system consisting of the vibration machine, together with its auxiliary test equipment, shall be capable of generating either a sinusoidal or random excitation.

Test equipment for random vibration shall produce random excitation that possesses a gaussian (normal) amplitude distribution, except that the acceleration magnitudes of the peak values may be limited to a minimum of three times the rms [three-sigma (3σ) limits].

3 Test specimen

3.1 A vibration test sample shall be a fully wired connector consisting of one of the following, as applicable;

3.1.1 A connector plug and its mating connector receptacle.

3.1.2 A printed circuit connector receptacle and its mating connector board(s).

3.1.3 An integral, functional connector assembly.

3.2 Each test sample shall be prepared with wire and other materials or processes, simulating application assembly of the sample. If normal connector mating is dependent upon forces external to the connector, then such forces and mounting arrangement shall be as closely duplicated as possible (example: printed circuit connectors). If mating is achieved with normal locking means, then only normal locking means shall be used.

3.3 Method of mounting

3.3.1 Test conditions I, II, III and IV (sinusoidal evaluation conditions)

The specimen shall be attached to a fixture capable of transmitting the vibration conditions specified. The test fixture shall be designed so that resonant vibration inherent in the fixture within the frequency range specified for the test shall be minor. The magnitude of the applied vibration shall be monitored on the test fixture near the specimen mounting points. The test specimen shall be mounted rigidly to the test fixture as specified and shall simulate as closely as possible the normal mounting of the specimen. A minimum of 200 mm (approx 8 in) of wire or cable shall be unsupported on both ends of the connector. For specimens with attached brackets, one of the vibration-test directions shall be parallel to the mounting surface of the bracket. Vibration input shall be monitored on the mounting fixture in the proximity of the support points of the specimen.

3.3.2 Test conditions V, VI and VII (random excitation conditions)

The specimen shall be mounted as specified. The orientation of the specimen or direction of application of the applied vibration motion shall be specified in one or more directions. If the order of application of the different directions is critical, it also shall be specified. Any special test fixtures or jigs required to run the test shall be specified in sufficient detail to assure reproducibility of the input motion applied to the specimen. These details shall include the dimensions, the materials, temper, etc., as applicable.

4 Test procedure

Tests and measurements before, during and after vibration shall be as specified in the referencing document.

4.1 Test conditions I, II, III and IV

4.1.1 Electrical load and discontinuity

4.1.1.1 Unless otherwise specified in the referencing document, the electrical load condition shall be 100 milliamperes, maximum for all contacts.

4.1.1.2 Unless otherwise specified in the referencing document, no discontinuities of one microsecond or greater duration are allowed. A detector capable of detecting the specified discontinuity shall be used.

4.1.2 Vibration conditions

Vibration conditions shall be in accordance with table 1, as applicable.

Table 1 - Vibration conditions

Test conditions	Frequency range, Hz	Peak level	
		g_n	m/s^2
I	Low - 10 to 55		
II	High - 10 to 500	10	98.1
III	High - 10 to 2,000	15	147.1
IV	High - 10 to 2,000	20	196.1

4.1.3 Resonance

A critical resonant frequency is that frequency at which any point on the specimen is observed to have a maximum amplitude more than twice that of the support points. When specified, resonant frequencies shall be determined either by monitoring parameters such as contact opening, or by use of resonance-detecting instrumentation.

4.1.4 Test condition I

The specimens shall be subjected to a simple harmonic motion having an amplitude 1.52 mm (0.06 in) double amplitude (maximum total excursion), the frequency being varied uniformly between the approximate limits of 10 Hz and 55 Hz. The entire frequency range, from 10 Hz to 55 Hz and return to 10 Hz, shall be traversed in approximately 1 minute. Unless otherwise specified, this motion shall be applied for 2 hours in each of three mutually perpendicular directions (total of 6 hours). If applicable, this test shall be made under electrical load conditions.

4.1.5 Test condition II [98.1 m/s^2 (10 g_n) peak]

The specimens, while deenergized or operating under the load conditions specified, shall be subjected to the vibration amplitude, frequency range, and duration specified 4.1.5.1, 4.1.5.2 and 4.1.5.3, respectively; see figures 2 and 3.

4.1.5.1 Amplitude

The specimens shall be subjected to a simple harmonic motion having an amplitude of either 1.52 mm (0.06 in) double amplitude (maximum total excursion) or 98.1 m/s^2 (10 g_n) peak, whichever is less. The tolerance on vibration amplitude shall be ±10%.

4.1.5.2 Frequency

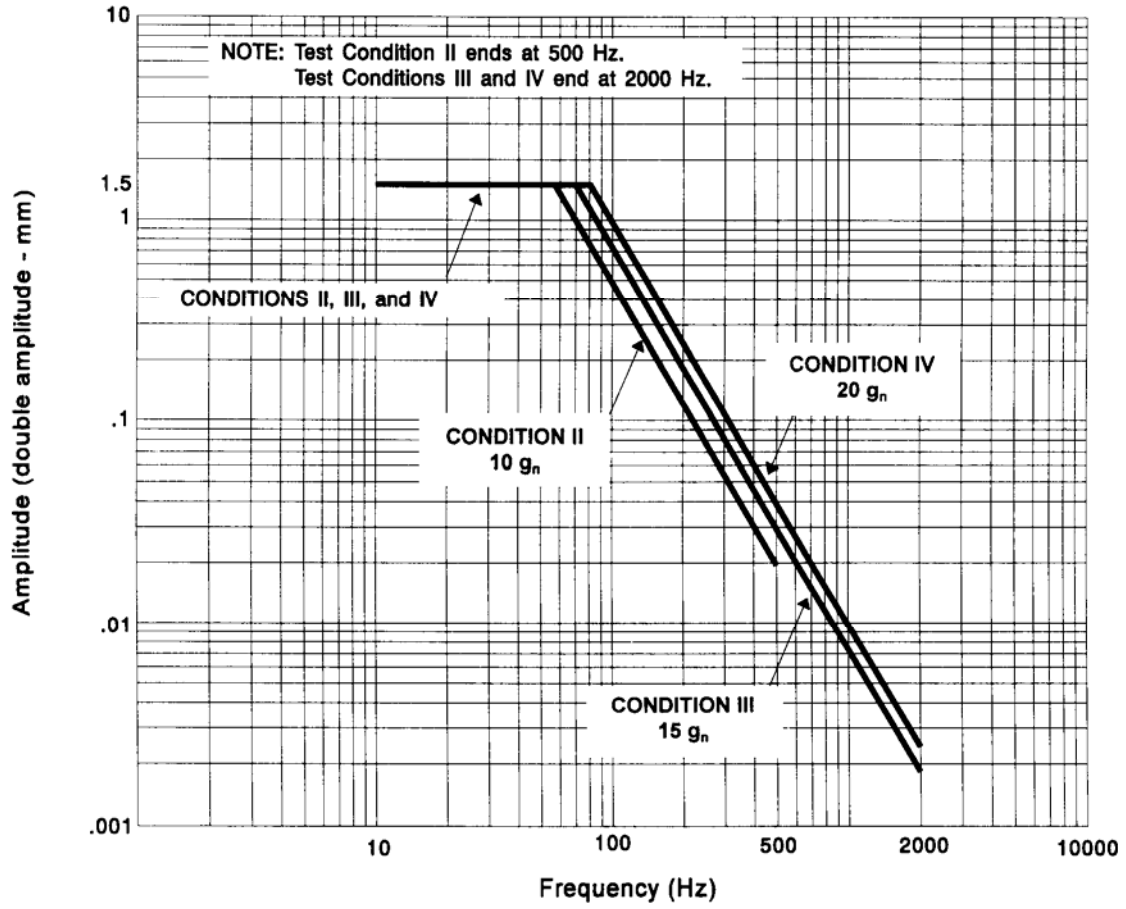
The vibration frequency shall be varied logarithmically between the approximate limits of 10 Hz and 500 Hz (see 4.1.8) except that the procedure (see 4.1.4) of this standard may be applied during the 10 Hz to 55 Hz band of the vibration frequency range.

4.1.5.3 Sweep time and duration

The entire frequency range of 10 Hz to 500 Hz and return to 10 Hz shall be traversed in 15 minutes. This cycle shall be performed 12 times in each of three mutually perpendicular directions (total of 36 times), so that the motion shall be applied for a total period of approximately 9 hours. Interruptions are permitted provided the requirements for rate of change and test duration are met. Completion of cycling within any separate band is permissible before going to the next band. When the procedure (see 4.1.4) is used for the 10 Hz to 55 Hz band, the duration of this portion shall be same as the duration for this band using logarithmic cycling (approximately 1-1/3 hours in each of three mutually perpendicular directions).

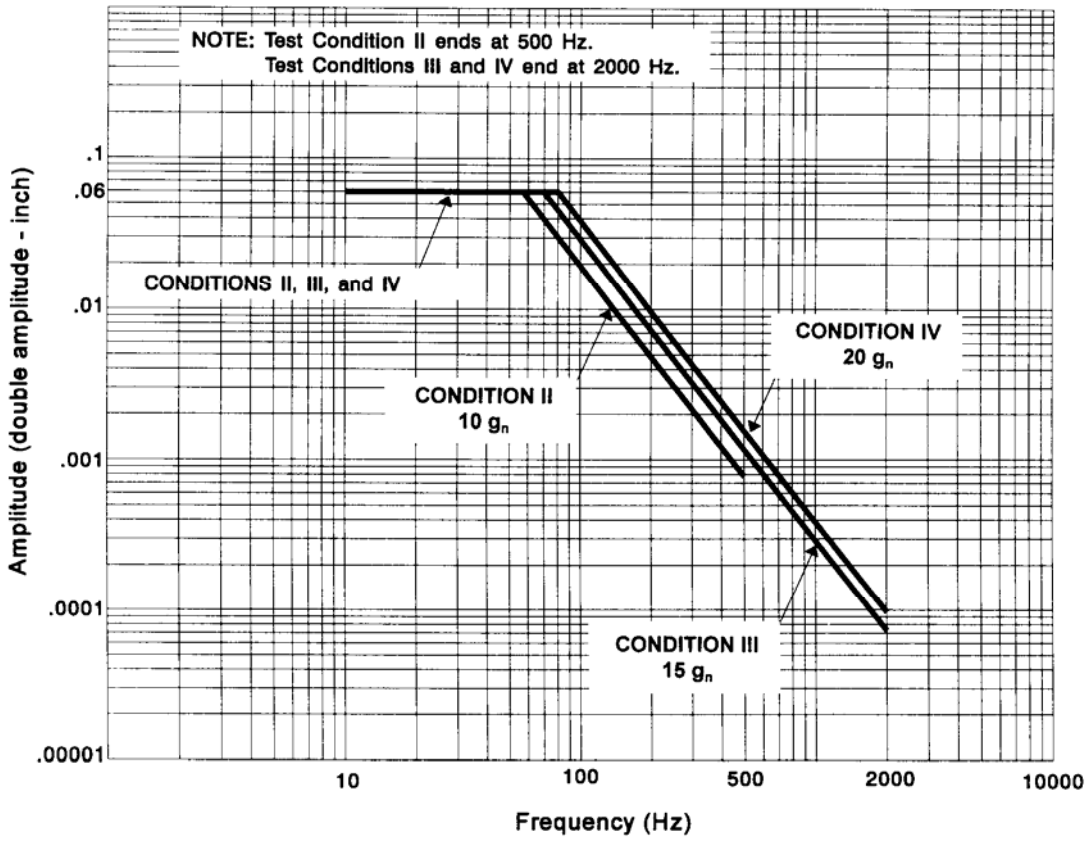
4.1.6 Test condition III 147.1 m/s^2 (15 g_n) peak]

The specimens, while deenergized or operating under the load conditions specified, shall be subjected to the vibration amplitude, frequency range, and duration specified in 4.1.6.1, 4.1.6.2 and 4.1.6.3, respectively; see figures 2 and 3.



NOTE: $g = 0.00201f^2 DA$ (f = frequency in hertz, DA = double amplitude in mm)

Figure 2 - Vibration test curves - high frequency (displacement in mm)



NOTE: $g = 0.0512f^2 DA$ (f = frequency in hertz, DA = double amplitude in inches)

Figure 3 - Vibration test curves - high frequency (displacement in inches)

4.1.6.1 Amplitude

The specimens shall be subjected to a simple harmonic motion having an amplitude of either 1.52 mm (0.06 in) double amplitude (maximum total excursion) or 147.1 m/s^2 (15 g_n) peak, whichever is less. The tolerance on vibration amplitude shall be ±10%.

4.1.6.2 Frequency range

The vibration frequency shall be varied logarithmically between the approximate limits of 10 Hz to 2,000 Hz (see 4.1.8) except that the procedure (see 4.1.4) of this standard may be applied during the 10 Hz to 55 Hz band of the vibration frequency range.

4.1.6.3 Sweep time and duration

The entire frequency range of 10 Hz to 2,000 Hz and return to 10 Hz shall be traversed in 20 minutes. This cycle shall be performed 12 times in each of three mutually perpendicular directions (total of 36 times), so that the motion shall be applied for a total period of approximately 12 hours. Interruptions are permitted provided the requirements for rate of change and test duration are met. Completion of cycling within any separate band is permissible before going to the next band. When the procedure (see 4.1.4) of this standard is used for the 10 Hz to 55 Hz band, the duration of this portion shall be the same as the duration for this band using logarithmic cycling (approximately 1-1/3 hours in each of three mutually perpendicular directions).

4.1.7 Test condition IV [196.1 m/s^2 (20 g_n) peak]

The specimens, while deenergized or operating under the load conditions specified, shall be subjected to the vibration amplitude, frequency range, and duration specified in 4.1.7.1, 4.1.7.2 and 4.1.7.3, respectively; see figures 2 and 3.

4.1.7.1 Amplitude

The specimens shall be subjected to a simple harmonic motion having an amplitude of either 1.52 mm (0.06 in) double amplitude (maximum total excursion) or 196.1 m/s^2 (20 g_n) peak, whichever is less. The tolerance on vibration amplitude shall be ±10%.

4.1.7.2 Frequency range

The vibration frequency shall be varied logarithmically between the approximate limits of 10 Hz to 2,000 Hz (see 4.1.8).

4.1.7.3 Sweep time and duration

The entire frequency range of 10 Hz to 2,000 Hz and return to 10 Hz shall be traversed in 20 minutes. This cycle shall be performed 12 times in each of three mutually perpendicular directions (total of 36 times), so that the motion shall be applied for a total period of approximately 12 hours. Interruptions are permitted provided the requirements for rate of change and test duration are met.

Completion of cycling within any separate band is permissible before going to the next band. When the procedure (see 4.1.4.) of this standard is used for the 10 Hz to 55 Hz band, the duration of this portion shall be the same as the duration for this band using logarithmic cycling (approximately 1-1/3 hours in each of three mutually perpendicular directions).

4.1.8 Alternative procedure for use of linear in place of logarithmic change of frequency

Linear rate of change of frequency is permissible under the following conditions:

4.1.8.1 The frequency range above 55 Hz shall be subdivided into no fewer than three bands. The ratio of the maximum frequency to the minimum frequency in each band shall be not less than two (2).

4.1.8.2 The rate of change of frequency in Hz per minute shall be constant within any one band.

4.1.8.3 The ratios of the rate of change of frequency of each band to the maximum frequency of that band shall be approximately equal.

4.1.8.3.1 Example of alternative procedure

As an example of the computation of rates of change, assume that the frequency spectrum has been divided into three bands, 55 Hz to 125 Hz, 125 Hz to 500 Hz and 500 Hz to 2,000 Hz, in accordance with 4.1.8.1. For each band, let the constant, κ, represent the frequency change (in Hz/minute), divided by the maximum frequency (in Hz). Then the rates of change for the three bands will be 125κ, 500κ and 2,000κ, respectively. The times (in minutes) to traverse the three frequency bands are

$$\frac{125-55}{125\kappa}, \frac{500-125}{500\kappa} \textit{ and } \frac{2{,}000-500}{2{,}000\kappa}$$

Since the minimum total sweep time is 30 minutes,

$$\frac{70}{125\kappa} + \frac{375}{500\kappa} + \frac{1{,}500}{2{,}000\kappa} = 30$$

whence $\kappa = 0.0687$/minute.

The required maximum constant rates of frequency change for the three bands are therefore 8.55 Hz per minute, 34.2 Hz per minute and 137 Hz per minute, respectively. The minimum times of traverse of the bands are 8.2 min, 10.9 min and 10.9 min, respectively.

4.2 Test conditions V, VI and VII

4.2.1 Control and analysis of random vibration

4.2.1.1 Spectral density curves

The output of the vibration machine shall be presented graphically as power-spectral density versus frequency; see 4.2.1.1.1. The spectral-density values shall be within +40% and -30% (±1.5 dB) of the specified values between a lower-specified frequency and 1,000 Hz, and within +100% and -50% (±3 dB) of the specified values between 1,000 and an upper-specified frequency (2,000 Hz). A filter bandwidth will be a maximum of 1/3-octave or a frequency of 25 Hz, whichever is greater.

4.2.1.1.1 Power-spectral density

Power-spectral density is the mean-square value of an oscillation passed by a narrow-band filter per unit-filter bandwidth. For this application it is expressed as g^2 / f, where g^2 / f is the mean-square value of acceleration expressed in gravitational units per number of cycles of filter bandwidth. The spectral density curves are usually plotted either on a logarithmic scale, or in units of decibels (dB). The number of decibels is defined by the equation:

$$dB = 10 \log \frac{g^2 / f}{g_r^{\,2} / f} = 20 \log \frac{g / \sqrt{f}}{g_r / \sqrt{f}}$$

The rms value of acceleration within a frequency band between f_1 and f_2 is:

$$g_{rms} = \left[\int_{f_1}^{f_2} g^2 / f \, df \right]^{1/2}$$

where g_r^2 / f is a given reference value of power-spectral density, usually the maximum specified value.

4.2.1.2 Distribution curves

A probability density-distribution curve may be obtained and compared with a gaussian-distribution curve. The experimentally-obtained curve shall not differ from the gaussian curve by more than ± 10% of the maximum value.

4.2.1.3 Monitoring

Monitoring involves measurements of the vibration excitation and of the test item performance. When required in the referencing document, the specimen may be monitored during the test. The details of the monitoring circuit, including the method and points of connection to the specimen, shall be specified.

4.2.1.4 Vibration input

The vibration magnitude shall be monitored on a vibration machine, on mounting fixtures, at locations that are as near as practicable to the test item mounting points. When the vibration input is measured at more than one point, the minimum input vibration shall normally be made to correspond to the specified test curve; see figures 4 and 5. For massive test items and fixtures, and for large force exciters or multiple vibration exciters, the input control value may be an average of the average magnitudes of three or more inputs. Accelerations in the transverse direction, measured at the test item attachment points, shall be limited to 100% of the applied vibration. The number and location of the test points shall be specified.

4.2.2 Procedure

The specimen, or substitute equivalent mass, shall be mounted in accordance with 3.3.2 and the monitoring equipment attached, if applicable, in accordance with 4.2.1.3. The vibration machine shall then be operated and equalized or compensated to deliver the required frequencies and intensities conforming to the curves specified in test condition V, figure 4, or test condition VI, figure 5, or test condition VII, figure 6 (see 2.1). The specimen shall then be subjected to the vibration specified by the test condition letter (see tables 2, 3 and 4) for the duration as specified:

3 minutes; 15 minutes; 1-1/2 hours; or 8 hours;

in each of three mutually perpendicular directions, and in the order specified (see 3.3.2), as applicable.

The measurements made before, during, and after the test shall be specified and if the specimen is to be monitored during the test, the details shall be in accordance with 4.2.1.3.

4.2.3 Electrical load and discontinuities

4.2.3.1 Unless otherwise specified in the referencing document, the electrical load conditions shall be 100 milliamperes for all contacts.

4.2.3.2 Unless otherwise specified in the referencing document, no discontinuities of one microsecond or greater duration are allowed. A detector capable of detecting the specified discontinuity shall be used.

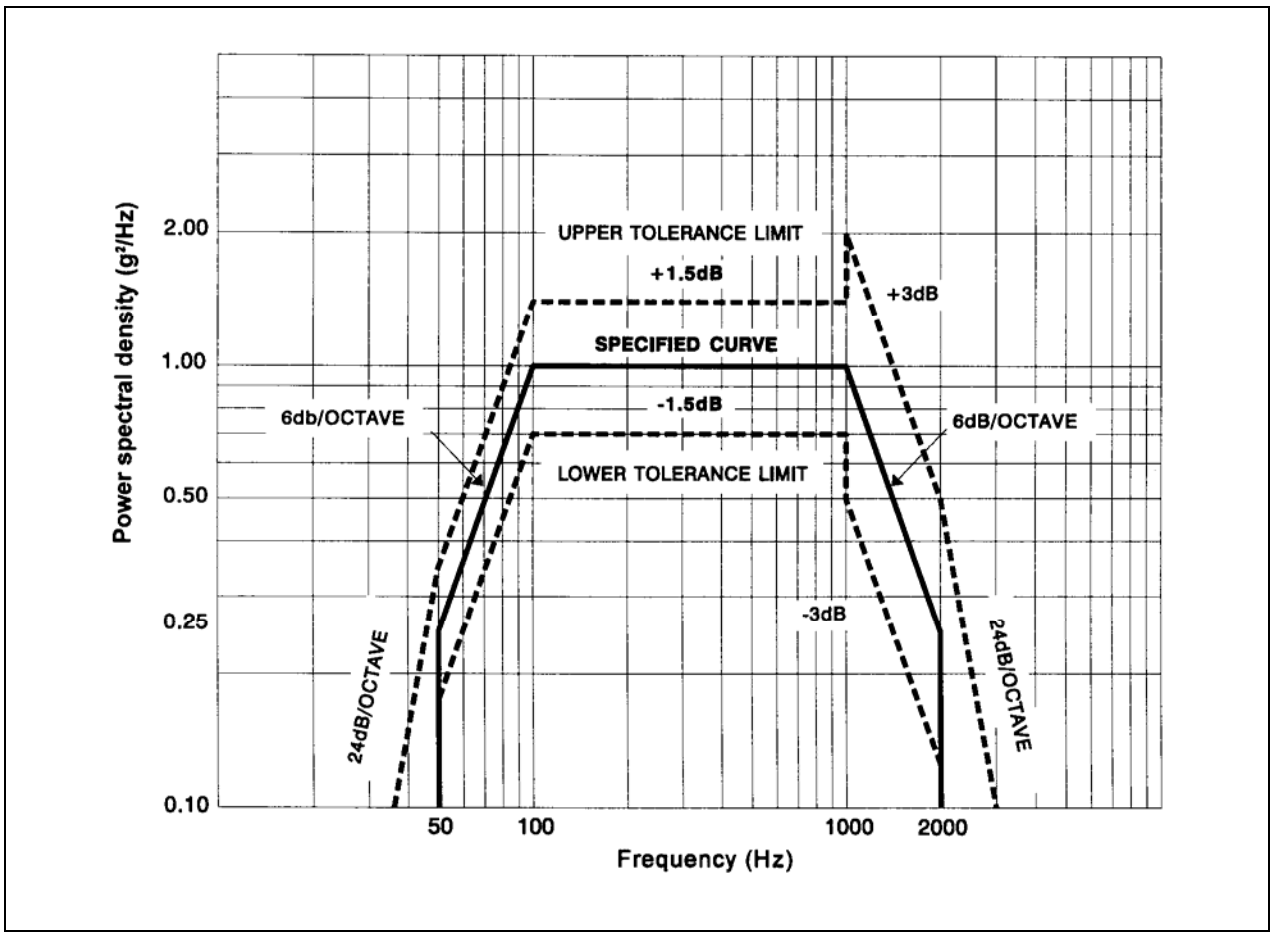


Figure 4 - Test condition V, random vibration test-curve envelope (see table 2).

Table 2 - Values for test condition V [1)]

Test condition letter	Power spectral density, g^2/Hz	Overall rms g
A	0.02	5.35
B	0.04	7.56
C	0.06	9.26
D	0.1	11.95
E	0.2	16.91
F	0.3	20.71
G	0.4	23.91
H	0.6	29.28
I	Superseded by Test condition letter J	
J	1.0	37.80
K	1.5	46.30
1) For duration of test; see 4.2.2.		

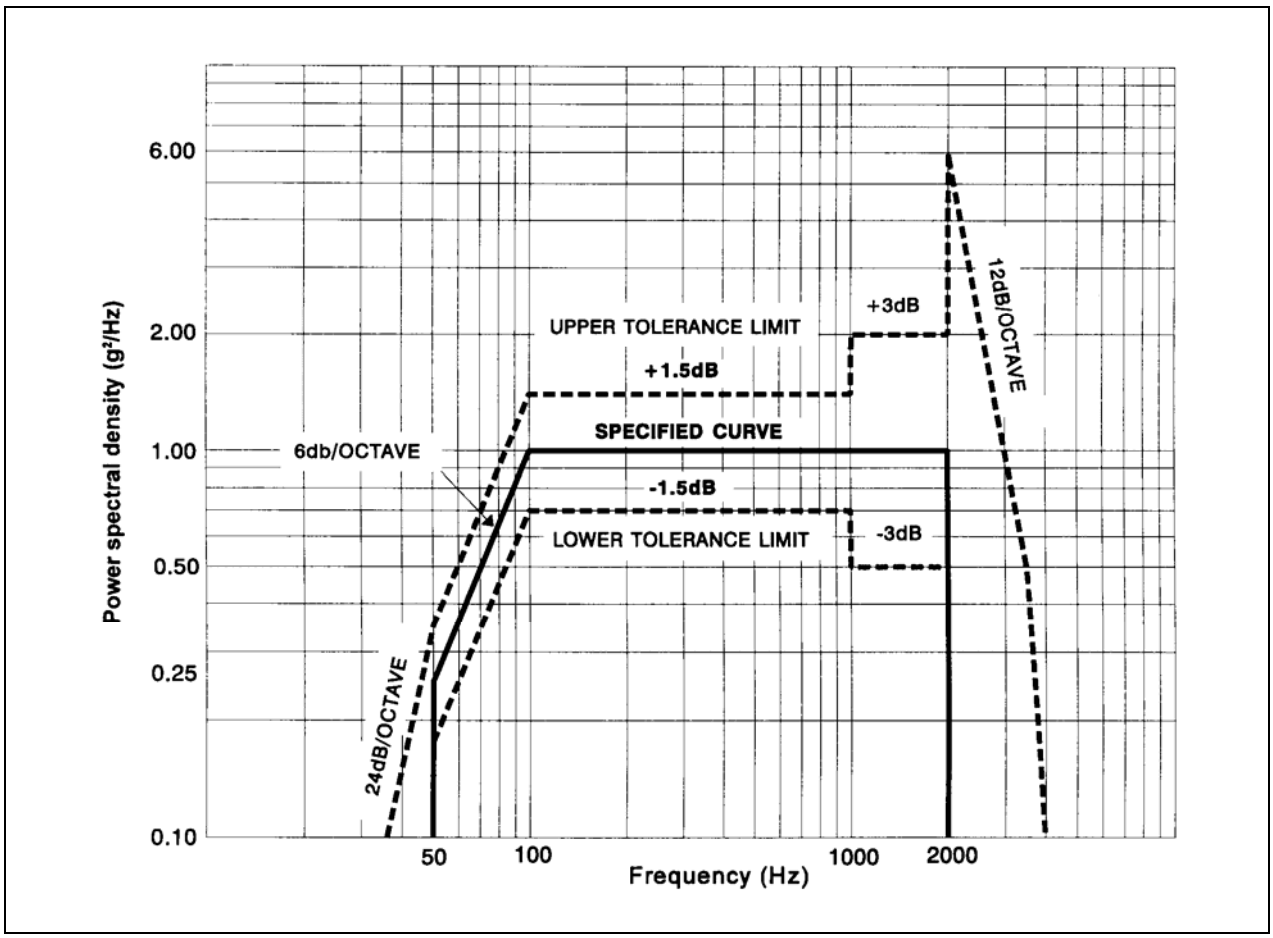


Figure 5 - Test condition VI, random vibration test-curve envelope (see table 3).

Table 3 - Values for test-condition VI [1)]

Test condition letter	Power spectral density, g^2/Hz	Overall rms g
A	0.02	6.21
B	0.04	8.78
C	0.06	10.76
D	0.1	13.89
E	0.2	19.64
F	0.3	24.06
G	0.4	27.78
H	0.6	34.02
I	Superseded by Test condition letter J	
J	1.0	43.92
K	1.5	53.79
1) For duration of test; see 4.2.2.		

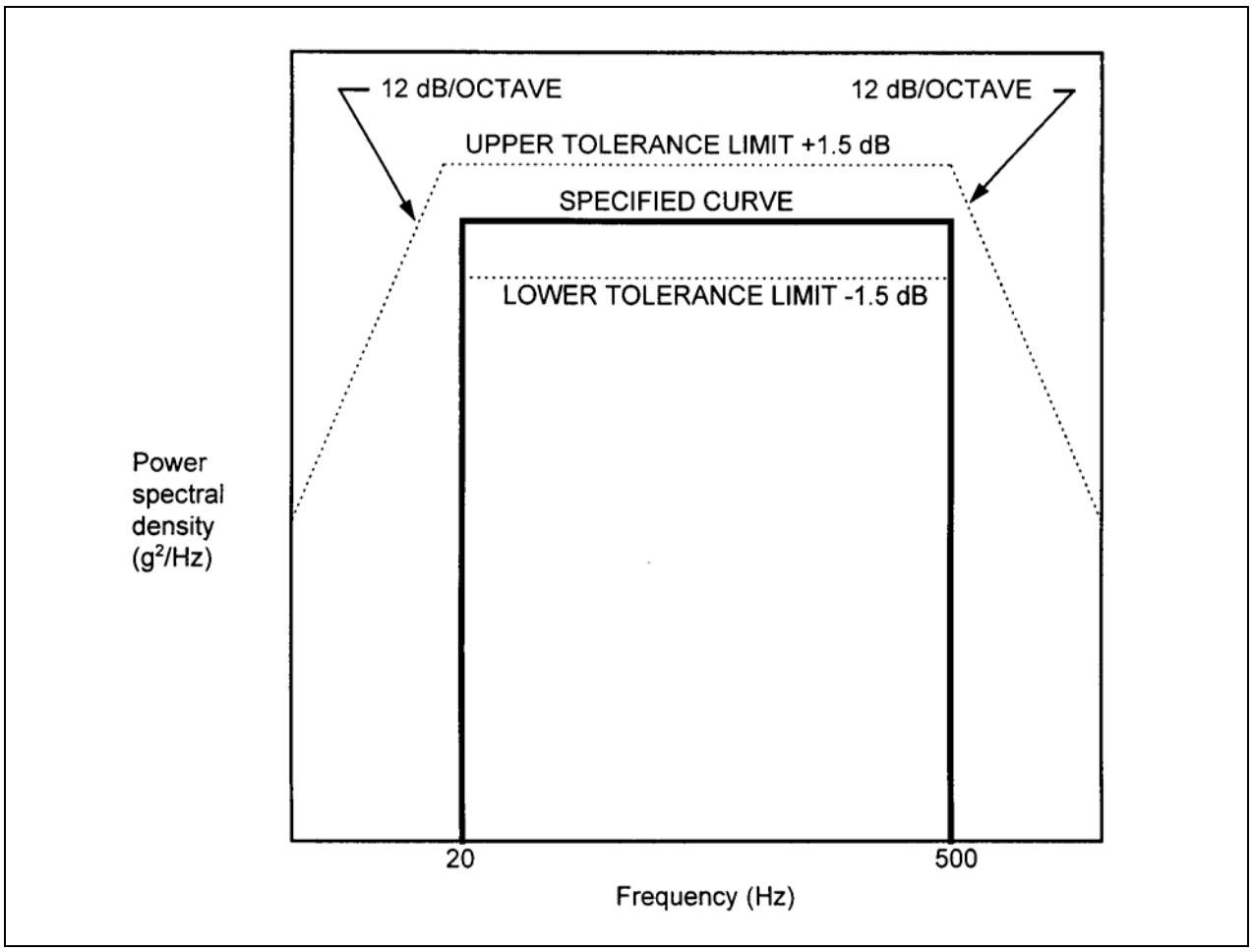


Figure 6 - Test condition VII, random vibration test-curve envelope (see table 4)

Table 4 - Values for test condition VII[1)]

Test condition letter	Power spectral density, g^2/Hz	Overall rms g
A	0.002	0.98
B	0.005	1.55
C	0.01	2.19
D	0.02	3.10
E	0.05	4.90
F	0.1	6.93
G	0.2	9.80
1) For duration of test; see 4.2.2.		

5 Details to be specified

The following details shall be specified in the referencing document:

5.1 Type of sample; see 3.1

5.2 Number of samples to be tested

5.3 Method of mounting; see 3.3

5.4 Test condition number; see tables 1, 2, 3 or 4

5.5 Electrical load conditions, all contacts, if other than 100 milliamperes maximum; see 4.1.1 or 4.2.3

5.6 Discontinuity requirement if other than 1 microsecond

5.7 Measurement of discontinuities during vibration; see 4.1.1 or 4.2.3

5.8 Method of determining resonance, if applicable; see 4.1.3

5.9 Direction of motion and order, if critical; see 3.3

5.10 Tests or measurements before, during and after vibration; see clause 4

5.11 Duration of vibration; see 4.1.4 or 4.2.2

5.12 Monitoring instrumentation, if applicable; see 4.2.1.3

5.13 Number and location of test points, if applicable; see 4.2.1.3

5.14 Mounting axes definitions if other than indicated in figure 1; see 1.3

6 Test documentation

Documentation shall contain the details specified in clause 5, with any exceptions, and the following:

6.1 Title of test

6.2 Sample description - include fixture, if applicable

6.3 Test equipment used, and date of last and next calibration

6.4 Photographs, plots, values and observations necessary for proof of conformance

6.5 Name of operator and date of test

EIA Document Improvement Proposal

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Revision History

Revision letter	Project number	Additions, changes and deletions
E	SP-5125	Changed test condition letter I to J. Superseded test condition letter I by J in table 2 and 3.