Designation: D 5112 – 98 (Reapproved 2003)

Standard Test Method for Vibration (Horizontal Linear Motion) Test of Products[1]

This standard is issued under the fixed designation D 5112; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the determination of resonances of unpackaged products and components by means of horizontal linear motion applied at the surface on which the product is mounted. For vertical vibration testing of products see Test Method D 3580. Two alternate test methods are presented:

1.1.1 *Test Method A*—Resonance Search Using Sinusoidal Vibration, and

1.1.2 *Test Method B*—Resonance Search Using Random Vibration.

NOTE 1—These two test methods are not necessarily equivalent and may not produce the same results.

1.2 This information may be used to examine the response of products to vibration for product design purposes, or for the design of a container or interior package that will minimize transportation vibration inputs at the critical frequencies, when these product resonances are within the expected transportation environment frequency range. Since vibration damage is most likely to occur at product resonant frequencies, these may be thought of as potential product fragility points.

1.3 Information obtained from the optional sinusoidal dwell and random test methods may be used to assess the fatigue characteristics of the resonating components and for product modification. This may become necessary if a product's response would require design of an impractical or excessively costly shipping container.

1.4 This test method does not necessarily simulate vibration effects the product will encounter in operating or end-use environments. Other, more suitable test procedures should be used for this purpose.

1.5 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements, see Section 6.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 996 Terminology of Packaging and Distribution Environments

D 3580 Test Methods for Vibration (Vertical Linear Motion) Test of Products

D 4332 Practice for Conditioning Containers, Packages, or Packaging Components for Testing

E 122 Practice for Calculating Sample Size to Estimate, With a Specified Tolerable Error, the Average for a Characteristic of a Lot or Process

2.2 *Military Standard:*

MIL STD 810E, Method 514, Vibration[3]

3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method, see Terminology D 996.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *decade*—the interval of two frequencies having a basic frequency ratio of 10 (1 decade = 3.322 octaves).

3.2.2 *decibel (dB)*—a logarithmic expression of the relative values of two quantities. For relative power measurements, the dB value equals 10 times the base-10 logarithm of the ratio of the two quantities, that is, $dB = 10 \log_{10} [P_1/P_2]$.

3.2.3 *horizontal linear motion*—motion occurring essentially along a straight horizontal line, with no significant vertical or off-axis components.

[1] This test method is under the jurisdiction of ASTM Committee D10 on Packaging and is the direct responsibility of Subcommittee D10.15 on Fragility Assessment.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

3.2.4 *mean-square*—the time average of the square of the function.

3.2.5 *octave*—the interval of two frequencies having a basic frequency ratio of 2 (1 octave = 0.301 decade).

3.2.6 *overall g rms*—the square root of the integral of power spectral density over the total frequency range.

3.2.7 *power spectral density (PSD)*—a term used to quantify the intensity of random vibration in terms of mean-square acceleration per unit of frequency. The units are g^2/Hz (g^2/cycles/s). Power spectral density is the limiting mean square value in a given rectangular bandwidth divided by the bandwidth, as the bandwidth approaches zero.

3.2.8 *random vibration*—oscillatory motion which contains no periodic or quasi-periodic constituent.

3.2.9 *random vibration magnitude*—the root-mean square of the power spectral density value. The instantaneous magnitudes of random vibration are not prescribed for any given instant in time, but instead are prescribed by a probability distribution function, the integral of which over a given magnitude range will give the probable percentage of time that the magnitude will fall within that range.

3.2.10 *resonance*—for a system undergoing forced vibration, the frequency at which any change of the exciting frequency in the vicinity of the exciting frequency, causes a decrease in the response of the system.

3.2.11 *root-mean square (rms)*—the square root of the mean-square value. In the exclusive case of sine wave, the rms value is 0.707 times the peak.

3.2.12 *sinusoidal vibration*—periodic motion whose acceleration versus time waveform has the general shape of a sine curve, that is, y = sine x.

3.2.13 *sinusoidal vibration amplitude*—the maximum value of a sinusoidal quantity. By convention, acceleration is typically specified in terms of zero-to-peak amplitude, while displacement is specified in terms of peak-to-peak amplitude.

3.2.14 *transmissibility*—the ratio of measured acceleration amplitude at a point of interest in the product to the measured input acceleration amplitude of the test surface of the apparatus.

4. Significance and Use

4.1 Products are exposed to complex dynamic stresses in the transportation environment. The determination of the resonant frequencies of the product, either horizontal, vertical or both, aids the package designer in determining the proper packaging system to provide adequate protection of the product, as well as providing an understanding of the complex interactions between the components of the product as they relate to expected transportation vibration inputs.

5. Apparatus

5.1 *Vibration Test Machine*, consisting of a flat horizontal test surface of sufficient strength and rigidity such that the applied vibrations are essentially uniform over the entire test surface when loaded with the test specimen. The test surface shall be driven to move only in horizontal linear motion throughout the desired range of amplitudes and frequencies.

5.1.1 *Sinusoidal Control*—The frequency and amplitude of motion shall be variable, under control, to cover the range specified in 10.4.

5.1.2 *Random Control*—The frequency and amplitude of motion shall be continuously variable, under control to achieve the bandwidths, amplitudes and overall *g* rms values specified in 10.5.

5.2 *Specimen-Mounting Devices*, of sufficient strength and rigidity to attach the product securely to the test surface. The resonant frequency of the mounting devices shall be, at a minimum, twice that of the high end of the intended test range for the product. The device(s) shall support the product in a manner similar to the way in which it will be supported in its shipping container. Relative motion between the test surface and the test mounting interface shall not be permitted.

5.3 *Instrumentation*:

5.3.1 Sensors, signal conditioners, filters, and data acquisition apparatus are required to monitor or record, or both, the accelerations and frequencies at the test surface of the apparatus and at points of interest in the product. The instrumentation system shall have a response accurate to within ±5 % over the test range.

NOTE 2—Strain gage type accelerometers may be required to monitor the product, control the test system, or both.

5.3.1.1 For Test Method A, the frequencies and acceleration amplitudes or transmissibilities may be taken either manually or by means of a recording instrument. A stroboscope or video system may be beneficial for visual examination of the specimen under test.

5.3.1.2 For Test Method B, the data acquisition apparatus shall be capable of recording or indicating the transmissibilities between points of interest in the product to the test surface, over the frequency bandwidth specified in 10.5.

6. Safety Precautions

6.1 *Precaution:* This test method may produce severe mechanical response in the product being tested. Therefore, the means used to fasten the product to the test surface must be of sufficient strength to keep it adequately secured. Operating personnel must remain alert to potential hazards and take necessary precautions for their safety. Stop the test immediately if a dangerous condition should develop.

7. Sampling

7.1 Test specimens and the number of samples shall be chosen to permit an adequate determination of representative performance. Whenever sufficient products are available, five or more replicate samples should be tested to improve the statistical reliability of the data obtained (see Practice E 122).

8. Test Specimen

8.1 The product as intended for packaging shall constitute the test specimen. Sensor(s) may be applied as appropriate to measure data at points of interest with the minimum possible alteration of the test specimen. In particular, sensors shall be lightweight and have flexible cables to prevent changing either the effective weight or stiffness of the components to which they are mounted, thereby changing the resonant frequencies of