Designation: D3580 – 22

Standard Test Methods for Vibration (Vertical Linear Motion) Test of Products[1]

This standard is issued under the fixed designation D3580; 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 These test methods cover the determination of resonances of unpackaged products and components of unpackaged products by means of vertical linear motion at the surface on which the product is mounted for test. Two alternate test methods are presented:

Test Method A—Resonance Search Using Sinusoidal Vibration, and
Test Method B—Resonance Search Using Random Vibration.

NOTE 1—The two test methods are not necessarily equivalent and may not produce the same results. It is possible that tests using random vibration may be more representative of the transport environment and may be conducted more quickly than sine tests.

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 these critical frequencies, when these products resonances are within the expected transportation environment frequency range. Since vibration damage is most likely to occur at product resonant frequencies, these resonances may be thought of as potential product fragility points.

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

1.4 These test methods do not necessarily simulate the vibration effects that the product will encounter in its operational or in-use environment. Other, more suitable test procedures should be used for this purpose.

1.5 Test levels given in these test methods represent the correlation of the best information currently available from research investigation and from experience in the use of these test methods. If more applicable or accurate data are available, they should be substituted.

1.6 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.7 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* See Section 6 for specific precautionary statements.

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D996 Terminology of Packaging and Distribution Environments

D4332 Practice for Conditioning Containers, Packages, or Packaging Components for Testing

D4728 Test Method for Random Vibration Testing of Shipping Containers

E122 Practice for Calculating Sample Size to Estimate, With Specified Precision, the Average for a Characteristic of a Lot or Process

2.2 *Military Standard:*

MIL-STD 810, Method 514 Vibration[3]

3. Terminology

3.1 *Definitions*—For definitions of terms used in these test methods, see Terminology D996.

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).

[1] These test methods are under the jurisdiction of ASTM Committee D10 on Packaging and are the direct responsibility of Subcommittee D10.13 on Interior Packaging.

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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 Defense Printing Service Detachment Office, Bldg. 4D, NPM-DODSSP, 700 Robbins Ave., Philadelphia, PA 19111–5094.

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, $dB = 10 \log_{10} \{P1/P2\}$.

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

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

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

3.2.6 *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.

3.2.7 *random vibration*—oscillatory motion which contains no periodic or quasiperiodic constituent.

3.2.8 *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.

3.2.9 *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.

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

3.2.11 *sinusoidal vibration*—periodic motion whose acceleration versus time waveform has the general shape of a sine curve, that is, $y = \text{sine } x$.

3.2.12 *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.

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

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

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 may aid the packaging designer in determining the proper packaging system to provide adequate protection for 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*—The machine shall consist 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 vertical linear motion throughout the desired range of amplitudes and frequencies.

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

5.1.2 *Random Control*—The frequency and amplitudes 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*—Devices of sufficient strength and rigidity are required to attach the product securely to the test surface. The mounting devices shall not have significant resonances in the test frequency range. They shall rigidly mount 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 specimen mounting interface shall not be permitted.

5.3 *Instrumentation:*

5.3.1 Sensors, signal conditioners, filters, and a 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.

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. Hazards

6.1 *Precaution*—These test methods 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 shall remain alert to potential hazards and take necessary precautions for their safety. Stop the test method immediately if a dangerous condition should develop.

7. Sampling

7.1 Test specimens and 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 E122).

8. Test Specimens

8.1 The product as intended for packaging shall constitute the test specimen. Sensor(s) may be applied as appropriate to