ENVIRONMENTAL TEST METHODS DYNAMICS

VIBRATION • SHOCK • HANDLING • TRANSPORTATION

Tektronix®
COMMITTED TO EXCELLENCE

TEKTRONIX STANDARD

062-2858-00 REVISION B

PRODUCT DESIGN STANDARDS

ENVIRONMENTAL TEST METHODS

DYNAMICS - VIBRATION,SHOCK,HANDLING,TRANSPORTATION

FOREWARD

This document was prepared by a committee consisting of representatives from the Tektronix Environmental Laboratories and Tektronix CGG Package Design Engineering.

The objective of the committee was to review and update the Tektronix Standard 062-2858-00 Revision A, "Product Design Standard, Environmental Test, Dynamics".

A draft version of the updated standard, designated as "Revision B" of the Tektronix Standard 062-2858-00, was distributed to selected individuals in the impacted divisions of Tektronix for review and approval.

The returned comments were addressed by the committee and were incorporated into the final version, where it was feasible and appropriate.

NOTE: This document supersedes the Tektronix Standard 062-2858-00 Revision A (last change date; June 17, 1981).

PRODUCT DESIGN STANDARDS
ENVIRONMENTAL TEST METHHODS
DYNAMICS - VIBRATION, SHOCK, HANDLING, TRANSPORTATION

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1. PURPOSE OF THIS STANDARD.
The primary purpose of this standard is to define the dynamics classifications, test conditions and applicable test procedures for Tektronix products.

2. SCOPE.
This standard is intended to assist with the design and testing of unpackaged and packaged electronic and related equipment for the dynamic environment.

3. CONTROLLING DOCUMENT.
In circumstances where there is a conflict between the product Engineering Instrument Specification (EIS) and this environmental test standard, the EIS is the controlling document.

4. AUTHORITY FOR CHANGES.
All revisions of this standard must be approved by a consensus of the original document approval areas. All revisions will be implemented by the Tektronix Technical Standards Group.

Any suggestions for changes and improvements, notice of deficiencies and errors and any questions in using this standard can be directed to the Tektronix Environmental Labs.

5. REFERENCE DOCUMENTS.

(a) MIL-T-28800D (Military Specification), General Specification for Use with Electrical and Electronic Equipment.
(b) MIL-STD-810C and E (Military Standard), Environmental Test Methods and Engineering Guidelines.
(c) ASTM D4728-87 (Commercial Standard), Random Vibration Testing of Shipping Containers.
(d) ASTM D4169-86 (Commercial Standard), Performance Testing of Shipping Containers and Systems.
(e) ASTM 3332-88, D642-76, D775-80, D999-86, D1083-85, D3580-80 (Commercial Standards).
(f) National Safe Transit Association (NSTA), Pre-shipment Test Procedures, January 1984 (Commercial Standard).
(g) Tektronix Standard 062-3616-00: Basic Environmental Test Limits For Materials And Components.
(h) Tektronix Standard 062-2849-00, Environmental Design Standard (GWD).

6. PURPOSE OF DYNAMICS TESTING.
Dynamics testing is conducted to evaluate, determine and demonstrate that a product has the ability to satisfactorily survive/endure and function, if needed, in the transport and application environments it may encounter.

Dynamics testing provides a laboratory means of determining the performance characteristics of products in the dynamic environment conditions representative of those that may be encountered in real life.

These tests will help to ensure quality and reliable products.

7. PRELIMINARY TESTING CONSIDERATIONS.

7.1 RESPONSIBILITY FOR THE DYNAMICS CLASS, DYNAMICS TEST METHODS AND DYNAMICS TESTING SEQUENCE SELECTION DECISION.

The selection of the appropriate dynamics class, dynamics tests and testing sequence for a particular product is the responsibility of the individual product group. The considerations influencing these decisions include the market targeted, customer requirements, competing product capabilities and possible military contracts.

This standard contains recommendations and guidelines to assist in these decisions. Customized dynamic environments may be more appropriate for some products. The Tektronix Environmental Labs can be contacted to further assist in these decisions.

7.2 TEST METHOD AND TEST SEQUENCE SELECTION.

7.2.1 REFFERENCE DOCUMENTS.

(a) Mil-T-28800D (Military Specification), Paragraph 4, Table XIII for Group C environmental tests.

7.2.2 RECOMMENDED LIST OF DYNAMICS TESTS AND DYNAMICS TESTING SEQUENCE.

A listing of the recommended dynamic tests to conduct and recommended testing sequence is as follows:

(1) Dynamics Engineering Evaluation testing of the unpackaged product..
(2) Qualification Non-Operating Random Vibration Test of the unpackaged product (See Note 2 and Note 3).
(3) Qualification Operating Random Vibration Test of the unpackaged product (See Note 2 and Note 3).
(4) Mechanical Shock Test of the unpackaged product.
(5) Bench Handling Test of the unpackaged product.
(6) Topple Test of the unpackaged product.
(7) Accessory Cable Pullout Drop Test of the unpackaged product.
(8) Transportation package testing of the packaged product.

NOTE 1: The recommended dynamics testing sequence of parts (2) thru (5) follows the listing of Military Specification Mil-T-28800D, Paragraph 4, Table XIII for the Group C environmental test, for the test methods detailed in this standard.

NOTE 2: Sine vibration qualification can be conducted in addition to or in place of the random vibration qualification testing, for products where this is desired or required (e.g. for products where military contracts are anticipated).

NOTE 3: For products conducting both sine and random vibration testing, the Military Specification Mil-T-28800D environmental test listing, previously referenced in Note 1, lists the sine vibration testing prior to the random vibration testing.

NOTE 4: Some products may require additional dynamics tests than those detailed in this standard (e.g. UL mechanical tests, military transit test, military mechanical stability test, flex testing, cycle testing, and sound level measurement testing).

NOTE 5: The Environmental Labs can be contacted for further information.

7.2.3 DYNAMICS TESTING WITHIN THE GENERAL ENVIRONMENTAL TESTING SEQUENCE.

The recommended placement of the dynamics testing in the sequence of other environmental tests follows that of the general environmental test sequence listing of military specification Mil-T-28800D, Paragraph 4, Table XIII for the Group C environmental tests.

The dynamics testing should follow the climatics testing (temperature, humidity, and altitude).

7.3 QUALIFICATION PRODUCT SAMPLE SET VERSUS THE GROUP OF QUALIFICATION ENVIRONMENTAL TESTS.

A preliminary testing consideration is deciding which product sample unit(s) will be subjected to which of the environmental tests, or will each of the samples be subjected to every one of the environmental tests.

For products where future military contracts are anticipated, it is strongly recommended that the product groups consider following the requirements of military specification Mil-T-28800D on this subject, as contracts usually reference this requirement.

Military specification Mil-T-28800D, paragraph 4.3.1.3 and Table XIII Group C tests requires that the samples to be subjected to Dynamics testing also be subjected to the other environmental tests included in Group C.

A general listing of the Mil-T-28800D Group C tests includes: temperature, humidity, altitude, dynamics tests, water resistance and electrical power tests.

Recent Tektronix military contracts have also specified a specific sequence for performing environmental tests. Refer to the Recommended Dynamics Test Sequence section of this standard for further test sequence information.

It should be noted that the application of a particular environment test condition on a test sample may impact its performance in other succeeding environmental tests.

The decision of "which test sample is to be subjected to which environmental tests" is the responsibility of the individual product group. The availability of product samples and time schedule will impact this decision.

The Environmental Labs can be contacted for further details.

7.4 SAMPLE SIZE DETERMINATION.

7.4.1 REFERENCE DOCUMENTS.

(a) Journal of Quality Technology, Vol. 10, No. 1, January 1978, Pages 36-37, Technical Aids - Nomograph for Samples Having Zero Defectives, By Lloyd S. Nelson.
(b) Quality Magazine, July 1986, Page 271, Nomograph for Sample With Zero Defectives.
(c) Quality Control and Industrial Statistics, by Acheson J. Duncan, Irwin Inc., 5th Edition 1986, Pages 94-104.
(d) Statistics for Modern Business Decisions, by Lawrence L. Lapin, Harcourt Brace Jovanovich, Inc., 1973, Pages 366-381.

7.4.2 SAMPLE SIZE CONSIDERATIONS.

When a small sample size of a product is judged to have successfully completed qualification environment testing, care must be taken when making inferences about all of that product that is produced in the future.

There is a danger in making the inference that the entire future production of a particular product will be successful in meeting the qualification environment requirements because a small sample of the initial production of the product is successful.

However, a statistical inference based on the sample size can be made about the same production product. This inference would be our confidence that no more than a certain fraction of the like population would fail the test requirements that the sample(s) successfully met.

7.4.3 SAMPLE SIZE DETERMINATION AIDS.

To assist in the determination of the sample size and confidence levels, some useful formulas and a nomograph of the formulas are provided as aids. These formulas and the nomograph relate the sample size, confidence level and the "no worse than" fraction of the population that would be unsuccessful.

The formulas and nomograph are based on a Binomial and Poisson approximation of the Hypergeometric distribution. The Hypergeometric distribution for approximating probabilities can be applied to the environmental testing situation. The general requirements in applying these approximations are that we are working with a discrete (yes/no) situation and that the sampling is done without replacement (without placing the sample back in the population so that it could be re-sampled and redundantly re-tested). These requirements are usually met in environmental testing.

The requirements in applying the formulas and the nomograph are as follows:
(a) The samples have all been judged as successfully completing the environmental testing (i.e. there were not any non-successes encountered).
(b) The samples are all alike. They have the same design, same components and are produced with the same production process.
(c) The population of products that we are making inferences to are all like the samples tested. They have the same design, same components and are produced with the same production process.
(d) The total sample size is less than 20% of the total population of the product being sampled.
(e) The samples are subjected to the same environmental test conditions and in the same environmental testing sequence.

The sample size value applied to the formulas and the nomograph may be the cumulative number of the samples of that product that have been environmentally tested previously in addition to the number of samples taken for the present testing. This can be done as long as the requirements listed previously in (a) through (e) are met.

7.4.3.1 FORMULAS FOR SAMPLE SIZE DETERMINATION.
A formula for determining the confidence level is:

$C = (1-e^{-(n*f)})$ (Formula #1)

where,
C = Confidence level in decimal fraction form (0 to 1.0)
e = the base of the system of natural logarithms (approximate value of 2.71828)
n = number of samples evaluated (could be the cumulative number)
f = the "no worse than" fraction of the population that would fail to meet the environmental test requirements that the samples successfully met.

The formula for determining the "no-worse than" fraction unsuccessful in the population is derived by transposing formula #1. This gives:

$f = -[(Ln (1-C)) / (n)]$ (Formula #2)

where,
f = the "no worse than" fraction of the population that would fail to meet the environmental test requirements that the samples successfully met.
Ln = the natural logarithm.
C = Confidence level in decimal fraction form (0 to 1.0).
n = number of samples evaluated (could be the cumulative number).

An example showing use of the formula #2 is:

Example #1
n = 5, (sample size chosen, could be cumulative, is 5 units)
C = 0.90 (confidence level chosen, in percentage form, is 90%)

Solving for the value of "f", the "no worse than" fraction of the population that would be unsuccessful, using formula #2 yields:

f = -[(Ln (1-C)) / (n)]
f = -[(Ln (1-0.90)) / (5)]
f = 0.46 (in percentage form, f% = 46%)

Translating this means that: if the sample of 5 products successfully meets the environmental test requirements, then we can be 90% confident that the percentage of the population of like products that would fail to meet the environmental test requirements would be no worse than 46%.

7.4.3.2 NOMOGRAPGH FOR SAMPLE SIZE DETERMINATION.
An easy to use nomograph of the formulas is displayed on the following page. It can be used to more quickly determine the sample sizes, confidence levels and "no worse than" fraction to fail values. The nomograph is a graphical approximation of the formulas, but provides results close enough to the formula results to be considered useable for this application.

Instructions for using the nomograph are included with the nomograph. As an additional instruction, the following Example #2 applies the nomograph to the information from Example #1:

Example #2:

Again using:
n = 5, (sample size chosen is 5 units, could be cumulative)
C = 0.90 (confidence level chosen in percentage form is 90%)

On the nomograph, the vertical line labeled 5 (5 samples) intersects the diagonal 90% confidence level line at the horizontal value of "f" of 0.4 or 40%, which is the "no worse than" fraction of the population to fail. This compares with the formula derived value of f% of 46% in Example #1.

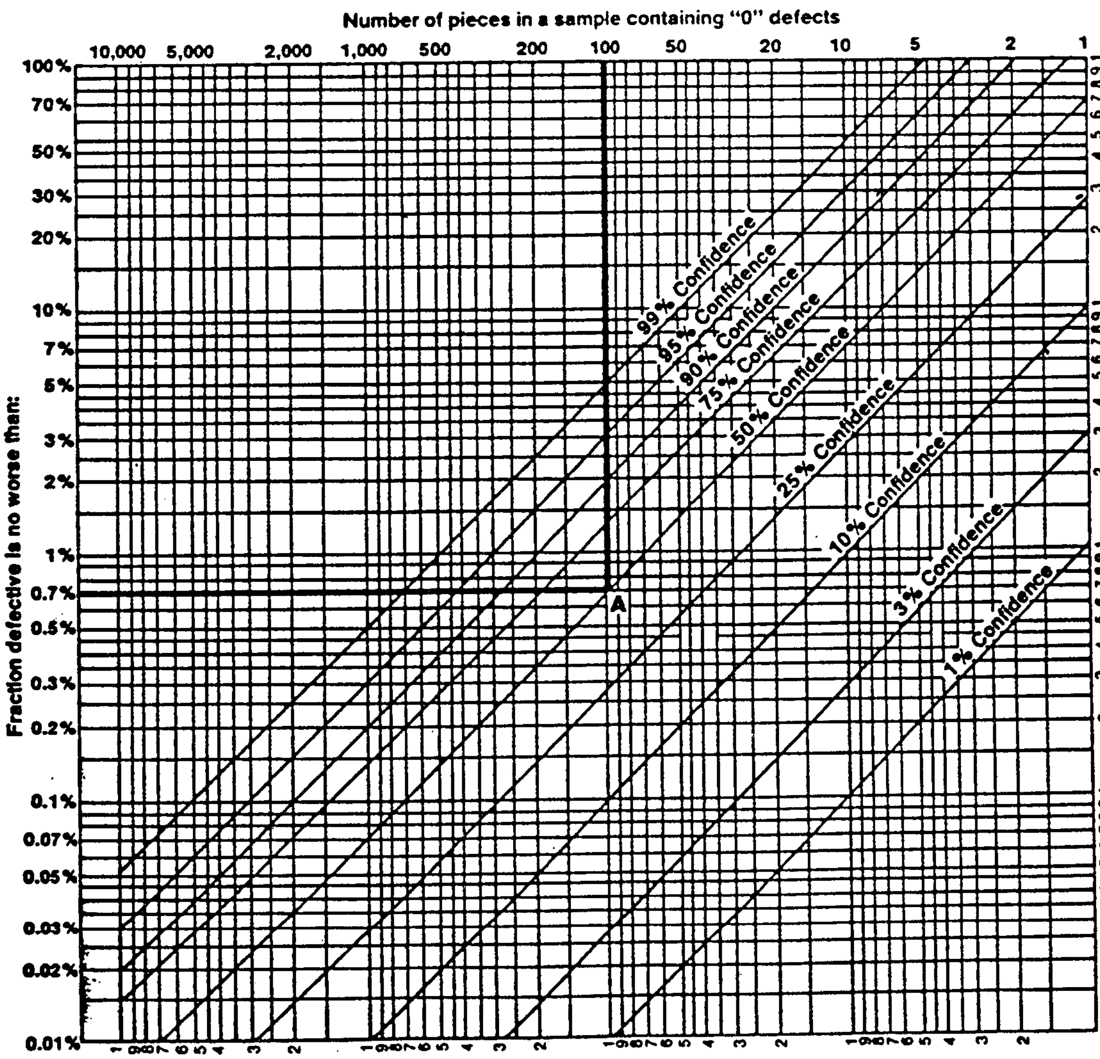
Nomograph for sample with zero defects

A nomograph of the Poisson frequency distribution provides a simple and easy method to determine the fraction defective and associated confidence level of a population on the basis of a defect-free sample.

Example:

A sample of 100 pieces has been evaluated and there were no defects found. With the aid of the nomograph a variety of statements can be made about the fraction defective lot.

At the top of the nomograph find the vertical line headed 100. To find the percent of defects in the worst case with a 50 percent confidence, follow the vertical line downward to the point of intersection with the 50 percent confidence line (point A). From point A follow the horizontal line to the left until you find its point of intersection with the vertical scale. The intersection is at 0.7 percent. With 50 percent confidence you can expect a fraction defective that is no worse than 0.7 percent.



Nomograph of fraction defective and confidence levels when sample has "0" defects.

7.4.4 RECOMMENDATIONS FOR SAMPLE SIZE SELECTION.

As can be seen from the nomograph, the larger the number of samples tested (could be the cumulative number), the higher the confidence level will be for a selected "no worse than fraction unsuccessful" value. Stating this another way, the larger the number of samples tested, the lower the "no worse than fraction unsuccessful" value will be for a certain confidence level.

The final selection of the sample size of products for environmental testing is the responsibility of the individual product group. The availability of sample products, time schedules and confidence level desired will impact this decision.

The Tektronix Environmental Labs can be contacted for further assistance in this selection.

NOTE: Military specification Mil-T-28800D at Paragraph 4.3.1.3 calls out for a sample size of three units to be subjected to the Group C set of environmental tests (which includes the dynamics tests) for environmental testing qualification. Recent Tektronix military contracts have included this as a requirement.

7.5 ENVIRONMENTAL AUDITS.

It is strongly recommended that a product be periodically environmentally audited on a sampling basis. This is to check that the current production of a product continues to meet its environmental requirements. Changes to a product's production process can affect the product's ability to meet its environmental requirements. The performance of a periodic environmental audit can assist in detecting any changed abilities.

Changes in component vendors and other modifications can also affect a product's environmental performance. An environmental audit is recommended whenever product modifications are implemented.

7.6 AMBIENT CONDITIONS FOR CONDUCTING DYNAMICS TESTING.

7.6.1 REFERENCE DOCUMENTS.

(a) Mil-T-28800D (Military Specification), Paragraph 4.5.2.1

7.6.2 COMPLIANCE TO APPLICABLE MILITARY STANDARDS REQUIREMENTS.

The following listed ambient test conditions meet the requirements of:
(a) Mil-T-28800D (Military Specification), Paragraph 4.5.2.1

7.6.3 AMBIENT TEST CONDITIONS.

The recommended ambient conditions for conducting dynamics testing, as listed in Military Specification Mil-T-28800D, are as follows:

Temperature: between 59 degrees F and +95 degrees F (between 15 degrees C and 35 degrees C)

Humidity: 0 to 70% RH

Altitude: 0 to 10,000 feet (0 to 3050 meters)

7.7 TOLERANCE OF DYNAMIC TEST CONDITIONS.

7.7.1 REFERENCE DOCUMENTS.

(a) Mil-T-28800D (Military Specification), Paragraph 4.5.2.1.2
(b) Mil-Std-810E (Military Standard), Method 514, Section II, Paragraph II-1.1.1
(c) Mil-Std-810C (Military Standard), Method 516.2.

7.7.2 COMPLIANCE TO APPLICABLE MILITARY STANDARDS REQUIREMENTS.

The following listed ambient conditions and test tolerances meet the requirements of:
(a) Mil-T-28800D (Military Specification), Paragraph 4.5.2.1
(b) Mil-Std-810E (Military Standard), Method 514, Section II, Paragraph II-1.1.1; method 516.4, figure 516.4-4 (ground equipment).
(c) Mil-Std-810C (Military Standard), method 516.2, figure 516.2-1, figure 516.2-2 (ground equipment).

7.7.3 DYNAMIC TEST CONDITION TOLERANCES.

(a) Acceleration: Measured within an accuracy of +10% and -10%.
(b) Time: elapsed time measurement within an accuracy of +1% and -1%.
(c) Vibration Frequency: measured within an accuracy of +2% and -2%, or +0.5% and -0.5% below 25 Hz.
(d) Sine Vibration Amplitude: controlled within an accuracy of +10% and -10%.
(e) Random Vibration Amplitude: The Acceleration Power Spectral Density (APSD) of the test control signal shall not deviate from the specified requirements by more than +3 dB and -3 dB over the entire test frequency range. However, deviations of -6 dB in the test control signal may be granted for frequencies above 500 Hz due to fixture resonance, test item resonances or facility limitations. The cumulative bandwidth over which this reduction shall be allowed cannot be greater than 5% of the test frequency range. In no case shall the APSD be more than -6 dB below the specified requirements. No deviation shall be granted for frequencies below 500 HZ. When the test can not be controlled within +3 dB and -3 dB from the specified requirement, at the risk of the tester, the test may continue. The risk is to assume no over testing is occurring and the test results are valid.
(f) Shock (terminal peak saw tooth pulse) amplitude - Refer to the Appendix section for the terminal peak saw tooth shock pulse configuration and tolerance limits per military standard Mil-Std-810C and E.
(g) Shock (half sine pulse) amplitude - Refer to the Appendix section for the half sine shock pulse configuration and tolerance limits per Mil-Std-810C.

NOTE: The tolerance of the test conditions listed in (a) through (d) are as specified in the military specification Mil-T-28800D. Those listed in (e) and (f) are as specified in military standard Mil-Std-810E . Listing (g) is as specified in military standard Mil-Std-810C.

8. DYNAMIC ENVIRONMENT CLASSIFICATIONS.

Dynamic environment classifications (classes) are used to identify the dynamic environment that products may experience. The classes are categorized by intended location of use, expected dynamic conditions of such locations and the expected amount and severity of handling.

The dynamics classes range from the rugged dynamic environments that small accessories and hand held products can experience, to the more gentle laboratory room environments. The more general purpose environments, such as portable, semi-portable, and bench top/rack mount are included in the middle range of classes. Classes for special operations requirements and office equipment are also included.

8.1 REFERENCE DOCUMENTS.

(a) Mil-T-28800D, Paragraph 1.2.2 (Military Specification, General Specification for Test Equipment).

8.2 COMPLIANCE TO APPLICABLE MILITARY AND COMMERCIAL STANDARDS REQUIREMENTS.

Each of the dynamic environment descriptions listed for Tektronix dynamic classes 3, 5, 6 and 7 respectively meets the military class 3, 5, 6 and 7 dynamics environment descriptions of Military Specification Mil-T-28800D, Paragraph 1.2.2. The dynamic environment descriptions for Tektronix dynamic classes T1, T2, T4 and T8 are unique to Tektronix.

A table detailing each of the Tektronix dynamic classes and their dynamic environment descriptions is displayed in the following paragraph. The table also includes an explanation of the type of products that are recommended as appropriate to include in each Tektronix dynamic environment class.

8.3 TEKTRONIX DYNAMIC ENVIRONMENT CLASSIFICATIONS TABLE

Dynamics Class	Dynamic Environment Description	Applicable Product Types
T1	Severe environment, extremely rough handling in use. Moved about very frequently in use.	Small accessories type products (e.g. probes).
T2	Rugged environment, very rough handling in use. Moved about very frequently in use.	Hand held and other heavy field use type products (e.g. battery powered products).
3	Portable or bench-top use in multiple locations. Could be moved about frequently in use.	Portable type products and most plug-in units.
T4	Moderately portable use in a light industrial or commercial environment. Multiple location use. Moved about with care.	Semi-portable products.
5	Fixed location bench-top or rack mounted use.	Bench-top and rack mount products.
6	Fully protected and environmentally controlled location use such as laboratories.	Certain high performance displays and delicate test and measurement products.
7	Where special operational requirements are not compatible with the environmental requirements of the other dynamics classes.	Special state of the art designed and constructed products.
T8	Office environment with a relatively fixed location.	Office and desk top products (e.g. printers, displays and medium-size systems on casters).

9. QUALIFICATION VIBRATION TESTS FOR UNPACKAGED PRODUCTS.

9.1 PURPOSE OF QUALIFICATION VIBRATION TESTING.

Qualification vibration testing is conducted as part of the process of qualifying a product design by demonstrating compliance to the requirements of specified vibration environments.

9.2 SCOPE.

The scope of this test if for all Tektronix products in their unpackaged state.

9.3 ACCEPTANCE CRITERIA.

The acceptance criteria for vibration environment qualification is by the demonstrated ability of the product to endure a specified vibration environment without suffering damage. At the completion of the test procedure the product should function mechanically and electrically, as specified in the product's Engineering Instrument Specification (EIS).

When required, the product must remain operating and functioning properly during the application of the vibration.

9.4 RANDOM VIBRATION (NON-OPERATING) TEST.

9.4.1 PURPOSE.

The purpose of this test is to ensure that the unpackaged product will survive the vibration levels anticipated during transportation without the original transport package and between uses.

9.4.2 REFERENCE DOCUMENTS.

(a) MIL-T-28800D (Military Specification), Section 4.5.5.3.2
(b) MIL-STD-810E (Military Standard), Method 514.4, Figures 514.4-1, 514.4-2 and 514.4-3. (Basic transport, common carrier, for the vertical, transverse and longitudinal axes.)
(c) ASTM D4728-87 (Commercial Standard), Appendix X1, Figure X1.1, Commercial Transport Random Vibration Spectra Summary.

9.4.3 COMPLIANCE TO APPLICABLE MILITARY AND COMMERCIAL STANDARDS REQUIREMENTS.

The vibration amplitudes for Tektronix dynamic classes T2, 3, T4, 5, 6, and T8 meet or exceed the vibration amplitude requirements for the following military and commercial standards.

(a) MIL-STD-810E (Military Standard), Method 514.4, Figures 514.4-1, 514.4-2 and 514.4-3. (Basic transport, common carrier, for the vertical, transverse and longitudinal axes.)
(b) ASTM D4728-87 (Commercial Standard), Appendix X1, Figure X1.1, Commercial Transport Random Vibration Spectra Summary.

9.4.4 RANDOM VIBRATION (NON-OPERATING) TEST CONDITIONS.

Dynamic Class	5-100 Hz g^2/Hz APSD	100-200 Hz Slope dB/ Octave	200-350 Hz g^2/Hz APSD	350-500 Hz Slope dB/ Octave	500 Hz g^2/Hz APSD	GRMS Overall	Time Min/ Axis
T1	(See Note)						
T2	0.040	-3	0.020	-3	0.014	3.48	10
3	0.020	-3	0.010	-3	0.007	2.46	10
T4	0.01875	-3	0.009375	-3	0.00657	2.38	10
5	0.0175	-3	0.00875	-3	0.006132	2.28	10
6	0.01625	-3	0.008125	-3	0.005694	2.22	10
7	(To be determined in the detailed specification for the product)						
T8	0.015	-3	0.0075	-3	0.005256	2.13	10

NOTE: The Non-Operating Random Vibration Test is not required for Tektronix dynamic class T1 due to the high level of the Operating Random Vibration Test for class T1.

9.4.5 TEST PROCEDURE.

(a) A physical and performance evaluation of the product should be conducted prior to testing. This will determine the pre-test state of the product.

(b) The product should be rigidly secured directly to the vibration table or to an intermediate structure. The intermediate structure should be capable of transmitting the specified magnitudes of vibration evenly to the points of the test product attachment throughout the required test frequency range. Additional bracing may be necessary because of the variations in the stiffness of product structures, especially when vibrating with the product cabinet or case removed. While this may not be an exact simulation of the real world, the intent is to enable a repeatable and even input of vibration into the structure by preserving the basic structure shape of the product.

(c) The product will usually be in the non-operating state with power not applied. If the product has power applied and is in the operating condition during the vibration testing, it is not required to meet performance requirements during the application of vibration. (The Operating Random Vibration Test Method is listed in another section of this standard).

(d) Subject the product to the specified Non-Operating Random Vibration test conditions.

(e) At the completion of each axis of testing, a physical and performance evaluation of the product should be conducted.

(f) Repeat steps (b) through (e) for each of the three mutually perpendicular axes of the product.

9.5 RANDOM VIBRATION (OPERATING) TEST.

9.5.1 PURPOSE.
The purpose of this test is to ensure that the unpackaged product will properly function while operating at anticipated use environment vibration levels.

9.5.2 SCOPE.
The scope of this test being for products that may encounter vibration while in their functional use state. Products in the T1,T2, 3 and T4 Tektronix dynamics classes should especially be considered for this test. Usually products being subjected to this test will also be subjected to the Random Vibration Non-Operating Test contained in this standard. (The exception being products in the Tektronix dynamics class T1 for which the level of the random vibration operating test is already sufficiently high).

9.5.3 REFERENCE DOCUMENTS.
(a) MIL-T-28800D (Military Specification), Section 4.5.5.3.2.
(b) MIL-STD-810E (Military Standard), Method 514.4, Figures 514.4-1, 514.4-2 and 514.4-3.
(c) ASTM D4728-87 (Commercial Standard), Appendix X1, Figure X1.1.

9.5.4 COMPLIANCE TO APPLICABLE MILITARY AND COMMERCIAL STANDARDS REQUIREMENTS.
The vibration amplitudes for Tektronix dynamics classes T1 and T2 meet or exceed the amplitude requirements for the following military and commercial standards listed in the following at (a) and (b).

(a) Mil-Std-810E (Military Standard), Method 514.4, Figures 514.4-1, 514.4-2 and 514.4-3 (Basic transport, common carrier, for the vertical, transverse and longitudinal axes).
(b) ASTM D4728-87 (Commercial Standard), Appendix X1, Figure X1.1, Commercial Transport Random Vibration Spectra Summary.

9.5.5 RANDOM VIBRATION (OPERATING) TEST CONDITIONS.

Dynamic Class	5-350 Hz g^2/Hz APSD	350-500 Hz Slope dB/ Octave	500 Hz g^2/Hz APSD	GRMS Overall	Time Min/ Axis
T1	0.040	-3	0.028	4.31	20
T2	0.015	-3	0.0105	2.66	10
3	0.0002	-3	0.00014	0.31	10
T4	0.000175	-3	0.000123	0.29	10
5	0.00015	-3	0.000105	0.27	10
6	0.000125	-3	0.0000876	0.24	10
7	(To be determined in the detailed specification for the product)				
T8	0.00010	-3	0.00007	0.22	10

9.5.6 TEST PROCEDURE.

(a) A physical and performance evaluation of the product should be conducted prior to testing. This will determine the pre-test state of the product.

(b) The product should be rigidly secured directly to the vibration table or to an intermediate structure. The intermediate structure should be capable of transmitting the specified magnitudes of vibration evenly to the points of the test product attachment throughout the required test frequency range. Additional bracing may be necessary because of the variations in the stiffness of product structures, especially when vibrating with the product cabinet or case removed. While this may not be an exact simulation of the real world, the intent is to enable a repeatable and even input of vibration into the structure by preserving the basic structure shape of the product.

(c) The product will have power applied and will be in the operating condition that allows checking for satisfactory operation during the application of the vibration. (the Non-Operating Random Vibration Test Method is listed in another section of this document).

(d) Subject the product to the specified Operating Random Vibration test conditions.

(e) At the completion of each axis of testing, a physical and performance evaluation of the product should be conducted.

(f) Repeat steps (b) through (e) for each of the product's three mutually perpendicular axes.

9.6 SINE VIBRATION TESTS - OPTIONAL.

9.6.1 PURPOSE.
The purpose of these tests is to determine that products comply with applicable equipment performance requirements when subjected to a sine vibration environment.

9.6.2 SCOPE.
The scope of these tests is for products where a sine vibration qualification environment is required.

9.6.3. OPTION "A" - CONSTANT DISPLACEMENT SINE VIBRATION TEST.

9.6.3.1 SCOPE.
The Option "A" Sine Vibration Qualification Test Method has historically been applied to products now considered to be in Tektronix dynamics classes T1, T2, 3, T4, 5 and 6. This includes products for which military contracts are anticipated.

9.6.3.2 REFERENCE DOCUMENTS.
MIL-T-28800D (Military Specification), Paragraph 3.7.4.1, Table VII, Paragraph 4.5.5.3.1, Table XVIII.

9.6.3.3 COMPLIANCE TO APPLICABLE MILITARY STANDARDS REQUIREMENTS.
The Sine Qualification Test conditions for Tektronix dynamics classes T1, T2 and 3 meet the sine vibration test conditions requirements for military environmental class 3 of the military specification Mil-T-28800D. (Refer to the Reference Documents paragraph.)

The Sine Qualification Test conditions for Tektronix dynamics classes T4, 5 and 6 meet the sine vibration test conditions requirements for military environmental classes 5 and 6 of the military specification Mil-T-28800D. (Refer to the Reference Documents paragraph.)

9.6.3.4 TEST CONDITIONS.
Option "A" Sine Vibration Test Conditions Table

Dynamic Class	Frequency Sweep Cycle (Hz)	Displacement inches p-p (mm p-p)	Min-Max Acceleration (g)	Resonance Search Sweep Cycles per Axis	Resonance Search Sweep Time per Axis (minutes)	Resonance Dwell Time per Axis (minutes)
T1, T2,3	5-15-5	0.060 (1.524)	0.08 - 0.69	1	5	10
	15-25-15	0.040 (1.016)	0.46 - 1.28	1	5	(See
	25-55-25	0.020 (0.508)	0.64 - 3.09	1	5	Note 2)
T4, 5, 6	5-55-5	0.013 (0.330)	0.02 - 2.01	1	15	10 (See note 2)
7	(To be determined in the detailed specification for the product)					

NOTE 1: Refer to the Option "B" Constant Acceleration Sine Vibration test for products in the Tektronix dynamics class T8.

NOTE 2: The Resonance Dwell vibration shall be performed at the conclusion of the Resonance Search Sweep Cycling vibration of an axis. The vibration frequency of the dwell shall be at the most severe resonance frequency determined for that axis during the Resonance Search Sweep Cycling vibration. If no significant resonance response is detected in an axis of a test, the resonance dwell shall be performed at 33 Hz. (Refer to the Test Procedure).

NOTE 3: Military specification Mil-T-28800D states that the resonance search sweep cycling vibration time and the resonance dwell vibration time should be continuous for the time specified.

9.6.3.5 TEST PROCEDURE.

(a) A physical and performance evaluation of the product should be conducted prior to testing. This will determine the pre-test state of the product.

(b) The product should be rigidly secured directly to the vibration table or to an intermediate structure which is designed to be capable of transmitting the specified magnitudes of vibration evenly to the points of the test product attachment throughout the required test frequency range. Additional bracing may be necessary because of the variations in the stiffness of product structures, especially when vibrating with the product cabinet or case removed. While this may not be an exact simulation of the real world, the intent is to enable a repeatable and even input of vibration into the product structure by preserving the basic structure shape.

(c) The product should have power applied and be in the operating state and functioning in a satisfactory operation check mode.

(d) Subject the product to the specified Option "A" Sine Vibration Resonance Search Sweep Cycling and Resonance Dwell test levels and test times as specified in the Test Conditions paragraph and as detailed in the following:

<u>Resonance Search Sweep Cycling:</u> The specified sweep cycling time is that of an ascending plus a descending sweep and is twice the ascending time. Perform a resonance search during the vibration sweep cycling period. A difference of 6 dB or more between the excitation source and the test product, or a part thereof, shall indicate the presence of a resonance. Optical displacement sensors, strobe lights and transducers can be utilized to assist in resonance detection and measurement.

<u>Resonance Dwell:</u> The resonance dwell vibration shall be performed at the conclusion of the Resonance Search Sweep Cycling vibration for an axis. The vibration frequency of the dwell shall be at the most severe resonant frequency determined for that axis during the Resonance Sweep Cycling. If a change in resonant frequency occurs during the test, its time of occurrence shall be recorded and immediately the frequency shall be adjusted to maintain the peak resonance condition. The final resonant frequency shall be recorded. If no significant resonance response is found

in an axis of test, the resonance dwell shall be performed for 10 minutes at 33 Hz.

(e) At the completion of each axis of testing, a physical and performance evaluation of the product should be conducted.

(f) Repeat steps (b) through (e) for each of the three mutually perpendicular axes of the product.

9.6.4 OPTION "B" - CONSTANT ACCELERATION SINE VIBRATION TEST.

9.6.4.1 SCOPE.

The Option "B" Sine Vibration Qualification Test method has historically been applied to products now considered to be in the Tektronix dynamics class T8.

9.6.4.2. REFERENCE DOCUMENTS.

Tektronix Standard 062-2849-00 (GWD/Wilsonville), Section 9.0.

9.6.4.3 COMPLIANCE TO APPLICABLE COMMERCIAL STANDARDS REQUIREMENTS.

The vibration test amplitude meets the the test amplitude requirements of ASTM (commercial standard) D999-86, Standard Methods for Vibration Testing of Shipping Containers, Method B, Single Container Resonance Test.

9.6.4.4 ACCEPTANCE CRITERIA.

The product group is responsible for establishing the acceptance criteria for a product. Historically the acceptance criteria has been the following:

(a) No major product resonances below 25 Hz (transportation package/product resonance frequencies are typically 25 Hz or less).

(b) Products are to operate and function per the product's EIS after each axis of vibration completed.

(c) Failures are not permissible.

9.6.4.5 TEST CONDITIONS

Option "B" Sine Vibration Test Conditions Table

Dynamics Class	Frequency Sweep Cycle, Hz	Acceleration, g peak	Sweep Cycles per Axis	Test Time Per Axis, minutes
7	(To be determined in the detailed specification for the product)			
T8	5-200-5	0.50	1	25

NOTE: Refer to the Option "A" Constant Displacement Sine Vibration Test for products in the Tektronix dynamics classes T1, T2, 3, T4, 5 and 6.

9.6.4.6 TEST PROCEDURE.

(a) A physical and performance evaluation of the product should be conducted prior to testing. This will determine the pre-test state of the product.

(b) The product should be rigidly secured directly to the vibration table or to an intermediate structure which is designed to be capable of transmitting the specified magnitudes of vibration evenly to the points of the test product attachment throughout the required test frequency range. Additional bracing may be necessary because of the variations in the stiffness of product structures, especially when vibrating with the product cabinet or case removed. While this may not be an exact simulation of the real world, the intent is to enable a repeatable and even input of vibration into the product structure by preserving the basic structure shape.

(c) The product will usually be in the non-operating state with power not applied. If the product has power applied and is in the operating state, it is not required to meet electrical performance requirements during the application of the vibration.

(d) Subject the product to the specified Option "B" sine vibration test conditions as specified in the Test Conditions paragraph and as detailed in the following discussion:

Frequency Sweep Cycling: The specified vibration frequency sweep cycling time is that of an ascending frequency sweep plus a descending frequency sweep and is twice the ascending time. Perform a resonance search during the vibration frequency sweep cycling period. Optical displacement sensors, strobe lights and transducers can be utilized to assist in resonance detection and measurement. Note the frequencies and severities of the resonances for acceptance determination.

(e) At the completion of each axis of testing, a physical and performance evaluation of the product should be conducted.

(f) Repeat steps (b) through (e) for each of the three mutually perpendicular axes of the product.

10. ENGINEERING EVALUATION VIBRATION TESTS FOR UNPACKAGED PRODUCTS.

10.1 PURPOSE OF ENGINEERING EVALUATION VIBRATION TESTING.

Engineering evaluation vibration tests are used, especially early in the design stages, for providing information that can be utilized in decision making and product improvement.

10.2 SINE SWEEP VIBRATION RESONANCE SEARCH METHODS.

10.2.1 PURPOSE.

Sine vibration is a useful engineering tool for product development evaluation. It is used for determining the severity of responses (resonances) to a vibration input and their damage potential.

10.2.2 REFERENCE DOCUMENTS.

MIL-T-28800D (Military Specification), Section 3.7.4.1.

10.2.3 TEST PROCEDURES AND TEST CONDITIONS.

(a) A physical and performance evaluation of the test items may be conducted prior to testing. This will help determine the pre-test state of the test item.

(b) The test item should be rigidly secured directly to the vibration table or to an intermediate structure. The intermediate structure should be capable of transmitting the specified magnitudes of vibration evenly to the points of the test product attachment throughout the required test frequency range. Additional bracing may be necessary because of the variations in the stiffness of test item structures, especially when vibrating with the product's cabinet or case removed. While this may not be in an exact simulation of the real world, the intent is to enable a repeatable and even input of the vibration into the product structure by preserving the basic structure shape of the test item. (All the major axes should be considered for analysis.)

(c)The test item may be in the power applied/operating state or in the power not applied/non-operating state, depending on the needs of the test.

(d) Subject the test item to an appropriate sine vibration input.

NOTE: The sine vibration input frequency range and amplitude should be sufficient to excite the test item's natural resonances to a level that will enable analysis. Over-excitation may result in damage. The sine vibration input frequency and amplitude may be adjusted as needed.

The following engineering vibration test conditions options are suggested:

(1) Option "A"

The historical approach to vibration resonance search is still considered valid. Therefore the Option "A" test conditions, listed in the Optional Sine Qualification Test Methods section of this standard, may be used.

NOTE: If it is known that the test item has no major resonances below 25 Hz, a constant displacement vibration of 0.020 inches (0.508 mm) peak-to-peak over the entire 10-55 Hz frequency range may be sufficient.

(2) Option "B"

The historical approach to vibration resonance search is still considered valid. Therefore the Option "B" test conditions, listed in the Optional Sine Qualification Test Methods section of this standard, may be used.

(3) Option "C"

Constant acceleration sine sweep vibration of 1 g peak from 5-100 Hz (up to 500 Hz or higher, if needed).

(4) Option "D"

A stepped constant displacement vibration approximation of the constant acceleration vibration of Option "C" can also be achieved on a mechanical vibration table. The suggested vibration test conditions are:

0.060 inches (1.520 mm) peak to peak constant displacement from 8-20 Hz,
0.015 inches (0.380 mm) peak to peak constant displacement from 20-45 Hz,
0.003 inches (0.076 mm) peak to peak constant displacement from 45-100 Hz.

NOTE: Due to limitations in the mechanical vibration table capabilities, a test frequency below 8 Hz or above 100 Hz may not be possible.

(e) In some cases, such as when military contracts are certain, the product group should consider vibration resonance search frequencies up to 500 Hz, or in some cases up to 2000 Hz.
(f) The vibration sweep rate should be sufficiently slow to enable the detection of resonances. A rate less than 1 octave per minute is suggested.
(g) Accelerometer sensors, optical displacement indicators and strobe light can be used to monitor the response of the test item to the vibration input.
(h) Vibration dwells may be performed at specific frequencies of interest to enable analysis of the test item resonance responses.
(i) The product group will determine the acceptance criteria. Test item resonances resulting in responses exceeding 5 times the vibration input could be potentially damaging. These resonances may need to be evaluated further and action taken to reduce the severity of the resonance.

10.3 MODULE AND ASSEMBLY UNIT VIBRATION TEST METHODS.

10.3.1 PURPOSE.

The purpose of these tests is to evaluate and demonstrate that modules and assemblies have the integrity to satisfactorily endure the vibration environment they may be subjected to when installed in the end product.

NOTE: A final evaluation should be conducted with the module or assembly installed in the end product.

10.3.2 SCOPE.

These test methods apply to both internally produced and OEM supplied modules and assemblies. (Examples include power supply modules, monitor modules, fan assemblies and CRT'S.)

10.3.3 ACCEPTANCE CRITERIA.

The product group will determine acceptability. However, any test item responses exceeding 5 times the vibration input could be potentially damaging. These may need to be evaluated further and action taken to reduce the severity of the resonance.

10.3.4 VIBRATION TEST METHODS.

It may be appropriate to use greater vibration levels, for some modules/assemblies, than those specified for the end product that the unit will be installed in. This is because of the vibration amplifications that can occur through a product's mechanical structure. This technique can be extended to the random vibration application by selecting a more stressful Tektronix dynamic environment class than that specified for the end product that the module/assembly is to be installed in.

NOTE: Historically, where sine vibration was specified for the end product, the modules/assemblies were subjected to a sine vibration level twice(2X) that specified for the end product.

10.3.4.1 RANDOM VIBRATION TEST METHODS.

Module/assembly vibration testing can utilize the Random Vibration Non-Operating Test Method and the Random Vibration Operating Test Method contained in this standard.

10.3.4.2 SINE VIBRATION TEST METHODS.

Where the sine vibration environment is desired for module/assembly testing, the following test methods contained elsewhere in this standard can be utilized:

(a) Sine Vibration Qualification Test Methods.
(b) Sine Sweep Resonance Search Vibration.
(c) Component Vibration Test Methods.

10.4 COMPONENT VIBRATION TEST METHODS.

10.4.1 PURPOSE.

The purpose of these test methods is to provide the basic test procedures and test conditions for determining the mechanical integrity of components in the vibration environment.

10.4.2 SCOPE.

These methods can be applied to new or alternate parts being considered for use in products.

10.4.3 ACCEPTANCE CRITERIA.

Any resulting physical or functional degradation, damage or major resonances should be considered for further evaluation.

10.4.4 UTILIZING EXISTING MILITARY STANDARDS FOR COMPONENT TESTING.

Existing military test methods for components can be utilized. Some of the applicable standards and test methods are:

(a) Mil Std 202F (Military Standard), Test Methods for Electrical and Electronic Component Parts; Method 214A - Random Vibration; Method 204D - High Frequency Sine Vibration.

(b) Mil Std 883C (Military Standard), Test Methods and Procedures for Microelectronics, Method 2026 - Random Vibration; Method 2007.1 - Vibration, Variable Frequency.

(c) Mil Std 1344A (Military Standard), Test methods for Electrical Connectors. Method 2005.1 Vibration.

10.4.5 OTHER AVAILABLE COMPONENT TEST STANDARDS AND TEST METHODS.

10.4.5.1 TEKTRONIX STANDARD 062-3616-00.

The test methods from the Tektronix Product Design Standard on Basic Environmental Test Limits For Materials And Components (062-3616-00) can be utilized.

10.4.5.1.1 TEST CONDITIONS.

75 minutes total sine vibration; consisting of 15 minutes cycling from 10-55-10 Hz and 10 minutes dwell at frequency of maximum response (if present) or at 55 Hz, along each of the three major axes. The vibration amplitudes are:

Dynamics Class	Displacement, inches (mm) peak-to-peak
T1, T2, 3	0.050 (1.270)
T4, 5	0.030 (0.762)
6,	0.020 (0.508)
7, T8	(Contact the Tektronix environmental lab for details)

NOTE: The dynamics class is the Tektronix dynamics class of the end product that the component will be used in.

11. SPECIAL VIBRATION APPLICATIONS FOR UNPACKAGED PRODUCTS.

11.1 LOW AMPLITUDE SWEPT SINE OPERATING/FUNCTIONAL VIBRATION TEST.

11.1.1 PURPOSE.

The purpose of this test is to provide a method to enable the determination of a product's degree of susceptibility to performance degradation from typical low amplitude sine vibration use/application environments that may be encountered.

Sources of sine vibration include rotating and reciprocating devices, such as cooling fans, motors, generators, and pumps. The environment in the vicinity of these sources may contain low amplitudes of sine vibration.

11.1.2 SCOPE.

The scope of this test is for products whose ability to meet functional performance specifications may be impacted by a low amplitude sine vibration use/application environment.

Products containing crystal oscillators , sensitive electrical circuits, and sensitive electro-mechanical mechanisms may be particularly susceptible to performance degradation. This susceptibility may be more apparent in the frequency domain and with sine vibration.

Example products that may be especially sensitive include: frequency domain analyzers, signal generators, printers, plotters, and products with disk drives.

11.1.3 ACCEPTANCE CRITERIA.

The product group will be responsible for determining the appropriate failure criteria for their product. However, any degradation of performance beyond specifications experienced in this test indicates that there is a possibility that some products may be affected by the sine vibration experienced in the customer's end-use environment.

Examples of performance degradations include:

(a) Unwanted movement of critical components and mechanisms such as in disk drives, printers and plotters.
(b) Generation of crystal oscillator side bands.
(c) Microphonics.
(d) Triboelectric noise generation in coax cabling.
(e) Fluctuating component values, such as trace capacitance.
(f) Variations in video displays.

11.1.4 TEST CONDITIONS.

The product group will be responsible for determining the appropriate test conditions for their product. The following table of typical values of sine vibration experienced in some end-use environments is provided as an aid.

END -USE ENVIRONMENT	TYPICAL AMPLITUDES OF OF SINE VIBRATION	
(a) Instrument Racks	typical:	0.1 g peak.
(b) Computer, Office Room Floors	typical:	0.1 g peak.
(c) Industrial Areas	typical:	0.18 g peak.

11.1.5 TEST PROCEDURE.

(a) A physical and performance evaluation of the test items should be conducted prior to testing. This will help determine the pre-test state of the test item.

(b) Identify the product's important performance specifications that may be susceptible to degradation from a sine vibration environment.

(c) Determine the applicable sine vibration test conditions.

(d) Place the product on the vibration table surface, mounted and supported as in normal use. Securing the product to the vibration table surface may not be required for vibration amplitudes less than about 1 g. The product should have power applied and be in the operating / functioning state.

(e) Subject the product to the following sine sweep vibration :

1. Frequency range: 5 - 500 Hz. (up to 2000 Hz for jet aircraft environments.)
2. Amplitude: which may be selected from the expected typical application environment. (Refer to the Test Conditions paragraph).
3. Sweep rate: slow sweep (0.5 octave per minute or slower suggested).

(f) Monitor the product for unacceptable performance degradation conditions at the suspected sensitive instrument parameters.

(g) Conduct vibration dwells at critical frequencies, if needed.

(h) Repeat steps (d) through (g) for the other major axes of the product.

11.2 ENVIRONMENTAL STRESS SCREENING USING RANDOM VIBRATION.

11.2.1 PURPOSE.

The purpose of Random Vibration Environmental Stress Screening is to STIMULATE production products with a random vibration input, to reveal latent failures so the defects can be removed before product is shipped to the user.

11.2.2 SCOPE.

Environmental stress screening using random vibration is a process normally used in production and applied to production products.

11.2.3 TEST METHOD.

Product groups considering environmental stress screening using random vibration should contact the Tektronix Environmental Labs for further information. Random vibration stress screening profiles need to be individually tailored for each product.

12. MECHANICAL SHOCK TESTS FOR UNPACKAGED PRODUCT.

12.1 PURPOSE.

Shock testing is conducted to demonstrate that the equipment has the integrity to survive the bumps and jolts of transportation and application environments. It may reveal weaknesses that can be corrected to avoid problems for the user in the field. For many products shock testing is the most valuable physical test performed because it approximates the worst real world use condition - dropping the instrument.

12.2 SCOPE.

The scope of this test is for all dynamics classes of Tektronix products in their unpackaged state.

12.3 REFERENCE DOCUMENTS.

Military Standards and Specifications:

(a) MiL-T-28800C or earlier, Section 4.5.5.4 (half sine shocks).
(b) MiL-T-28800D or later refers to Mil-Std-810 Method 516, Procedure I:
    Mil - Std-810C or earlier - half sine <u>or</u> sawtooth shocks;
    Mil - Std-810D or later - sawtooth shocks.

12.4 COMPLIANCE TO APPLICABLE MILITARY AND INDUSTRY STANDARDS.

The shock amplitudes and duration specified for Tektronix dynamics classes 3, T4, 5 and T8 meet or exceed that specified in military specification Mil-T-28800 (versions A through C). Dynamics classes T1 and T2 include items so diverse in application that shock testing should be tailored to specific actual use shock simulation. The shock test conditions for products in Tektronix dynamics class 7 should be per the detailed specification for that product.

12.5 ENGINEERING VERSUS QUALIFICATION TEST.

It is recommended that half sine shocks be used for most engineering evaluations as they are representative of many real world situations and are a very cost effective tool. Sawtooth and trapezoidal shocks, although typically more costly to do, excite a wider range of resonant frequencies, so they may be preferred in some cases. Sawtooth shocks should be considered whenever military contracts are likely because the newer versions of military specification Mil-T-28800 (D and E) and military standard Mil-Std 810 (D and E) no longer specify half sine shocks. Of more practical importance, and usually more difficult, is choosing shock amplitudes and durations that are representative of the likely worst case real world environment.

12.6 TEST PROCEDURE.

(a) A physical and performance evaluation of the test items should be conducted prior to testing. This will help determine the pre-test state of the test item.

(b) The product should be firmly secured directly to the shock test table or to an intermediate structure. The intermediate structure should be capable of transmitting the specified shock pulse evenly to the attachment points of the test product.

(c) Products will usually be non-operating during shocks (transportation to the customer), so for many items, non-operating test shocks are appropriate. However, when use dictates or when required for the military, shock testing while operating should be done. (Refer to Note 3 of the Test Conditions.)

(d) Subject the product to the appropriate test conditions as specified in the following test conditions table.

(e) At the completion of each face or direction of testing, a physical and performance evaluation of the product should be conducted.

12.7 TEST CONDITIONS.

Recommended Half Sine Shock Levels:

PRODUCT CLASS	PEAK LEVEL (g) INSTRUMENT	SUB ASSY.	PULSE DURATION (ms)	# SHOCKS PER DIRECTION
T1, T2	Real world shock simulation (see Note 1 below)			-
3	50	100	11	3
T4	40	80	11	3
5	30	60	11	3
6	20	40	11	3
7	(to be determined in the detailed specification for the product)			
T8	30	(to be determined)	11	3

Recommended Sawtooth Shock Levels, Per Mil-Std 810 :

PRODUCT CLASS	PEAK LEVEL (g), PULSE DURATION (ms) OPERATIONAL	CRASH SAFETY (see Note 4)	# SHOCKS PER DIRECTION
T1, T2	Real world shock simulation (see Note 1 below)		-
3	40, 11	75, 6	3
T4	40, 11	75, 6	3
5	40, 11	75, 6	3
6	40, 11	75, 6	3
7	(to be determined in the detailed specification for the product)		
T8	Not Applicable		

NOTE 1: During real-world drops of small hand held items the shock levels experienced will be a function of drop height and, more importantly, the degree of padding inherent in the item and in the floor (carpeting, etc.). Because of the wide variation in amplitude, free-fall drops from some realistic height are recommended. The item should be dropped on each possible surface enough times to verify that there is no problem.

NOTE 2: Refer to the Appendix Section for further information on the terminal peak saw tooth and halfsine shock pulse configuration and tolerance limits per Mil-Std-810C and E.

NOTE 3: For fragile instruments that can tolerate very little shock while operating, such as disk drive systems that should be turned off and parked before moving is even attempted, it may make more sense to test only in the non-operating state to simulate the perceived worst case shipping environment and movement by the customer. Again, shock testing should be tailored to the specific use requirements.

NOTE 4: The crash safety test is a test for equipment mounted in an air or ground vehicle that could break loose from its mounts and present a hazard to vehicle occupants. It is intended to verify the structural integrity of the equipment mounts, and is not intended for equipment transported as loose cargo.

NOTE 5: Products with attached external interconnect cable(s) should be considered for testing of the cable attachment. Refer to the Accessory Cable Pullout Drop Test section of this specification for further information.

13. BENCH HANDLING TESTS FOR UNPACKAGED PRODUCTS.

13.1 PURPOSE.

The purpose of bench handling testing is to simulate the conditions that may be encountered when a product is bench handled by operating or service personnel.

13.2 SCOPE.

The scope of this test is for all dynamics classes of Tektronix products in their unpackaged state.

13.3 REFERENCE DOCUMENTS.

(a) Mil-T-28800D (Military Specification), Paragraph 4.5.5.4.3
(b) Mil-Std-810E (Military Standard), Method 516.4, Paragraph I - 3.8, Procedure VI; Paragraph II - 3.6, Procedure VI.

13.4 COMPLIANCE TO APPLICABLE MILITARY STANDARDS REQUIREMENTS.

The following test procedures and test conditions meet the requirements of the following applicable military standards.
(a) Mil-T-28800D (Military Specification), Paragraph 4.5.5.4.3
(b) MIL-STD-810E (Military Standard), Method 516.4, Paragraph I - 3.8, Procedure VI; Paragraph II- 3.6 Procedure VI.

13.5 ACCEPTANCE CRITERIA.

The product group shall be responsible for determining the acceptance criteria for their product. However, any resulting damage, improper mechanical or electrical operation would usually constitute a failure or merit further evaluation.

13.6 QUALIFICATION TEST PROCEDURES AND TEST CONDITIONS.

(a) A physical and performance evaluation of the product should be conducted prior to testing. This will help establish the pre-test state of the product.
(b) The product should have power applied and be in the operating state in a satisfactory operation check mode with the product cabinet or case installed.
(c) The product is placed on a solid wooden bench top that is at least:
  (1) 1.62 inches (4.1 cm) thick as required by Mil-T-28800D,
  or
  (2) 1.675 inches (4.25 cm) thick as required by Mil-Std-810E.
(d) The product is placed on a face which it could be reasonably placed during operation or servicing.

(e) Raise one edge of the product to one of the following conditions, whichever occurs first:

(1) Until the lifted edge is a distance of 4 inches (10.16 cm) above the horizontal bench top;

or

(2) Until the product chassis forms an angle of 45 degrees with the horizontal bench top;

or

(3) Until the lifted edge of the product is just below the point of perfect balance.

NOTE 1: An optional test condition for Tektronix dynamics class T8 products of greater than 35 lbs. (15.87 kg) in weight is as follows:

Reduce the maximum lifted edge distance from 4 inches (10.16 cm) to 2 inches (5.08 cm) and reduce the maximum angle from 45 degrees to 15 degrees. However, these reduced test conditions do not meet requirements of the referenced military standards.

NOTE 2: For Tektronix dynamics class 7 products, the test conditions will be determined by the detailed specification for the product.

(f) Let the product drop back freely onto the horizontal bench top.

(g) Visually inspect the product for damage and check for proper mechanical and electrical operation.

(h) Repeat steps (e) through (g) using the other reasonable edges of the same horizontal face of the product as pivot points, for a total of up to four drops.

(i) Repeat steps (d) through (g) with the product resting on other faces until it has been dropped a total of up to four times onto each face which the product could be reasonably placed during operation and servicing.

(j) Repeat steps (c) through (i) with the product in the non-operating state with power not applied and with the product cabinet or case removed, except for products where the cabinet or case serves as the only chassis support structure.

NOTE 3: Consideration should be given for also conducting the Topple Test contained in this standard. The Topple Test addresses topples of the product that may occur in customer use onto a hard floor surface with different product configurations (e.g. handles rotated, tilt bails and tilt feet extended, etc.).

13.7 ENGINEERING EVALUATION TEST PROCEDURES AND TEST CONDITIONS.

Engineering evaluation bench handling testing can be conducted using the same test procedures and test conditions as those of the Qualification Bench Handling Test.

14. TOPPLE TEST FOR UNPACKAGED PRODUCTS

14.1 PURPOSE.

The purpose of topple testing is to simulate the conditions encountered when the unpackaged product is toppled over in use.

14.2 SCOPE.

The scope of this test is for all dynamics classes of Tektronix products in their unpackaged state.

14.3 REFERENCE DOCUMENTS.

There are not any military or commercial standards referenced.

14.4 COMPLIANCE TO APPLICABLE STANDARDS.

This test method is unique to Tektronix.

14.5 ACCEPTANCE CRITERIA.

The product group shall be responsible for determining the acceptance criteria for their product. However, any resulting damage, improper mechanical or electrical operation would usually constitute a failure or merit further evaluation.

14.6 QUALIFICATION TEST PROCEDURES AND TEST CONDITIONS.

(a) A physical and performance evaluation of the product should be conducted prior to testing. This will help establish the pre-test state of the product.
(b) The product should have power applied and be in the operating state in a satisfactory operation check mode.
(c) The product should be in the normal customer use configuration with cabinet or case installed and any applicable accessories and accessories pouches attached.
(d) Adjustable handles, bails and other tilting mechanisms should be in their retracted or normal transport positions.
(e) Place the product on the surface of a hard tiled concrete floor or other similar non-resilient hard floor surface.
(f) The product should be placed in a position that it could reasonably be placed in and be toppled from (e.g. on rear feet, on side feet, etc.).
(g) Tip the product over to just past the point of balance, in a direction that it could reasonably be toppled, and allow the product to fall freely onto the floor surface.
(h) Visually inspect the product for damage and check for proper mechanical and electrical operation.
(i) Return the product to the original position prior to the topple and repeat steps (e) through (h) for another direction that the product could reasonably be toppled in for that starting position.
(j) Repeat steps (e) though (i) for any other starting position that the product could reasonably be set in and toppled from.

(k) Repeat steps (e) through (i) for topples onto the faces of the product where there could be changes in the configuration of the product.

For example:
(1) Handle rotated for tilt use.
(2) Bail extended for tilt use.
(3) Tilt feet or other tilt mechanisms extended for tilt use.
(4) Accessories pouch removed.

14.7 ENGINEERING EVALUATION TEST PROCEDURES AND TEST CONDITIONS.

Engineering evaluation topple testing can be conducted using the same test procedures and test conditions as those of the Qualification Topple Test.

15. ACCESSORY CABLE PULLOUT DROP TEST FOR UNPACKAGED PRODUCTS.

15.1 PURPOSE.

The purpose of this test is to insure that the external interconnect cable attachment method for the product under test is not damaged by the product being dropped from the height of a table top.

15.2 SCOPE.

The scope of this test is for all dynamics classes of Tektronix products, in their unpackaged state, that have external modules that are attached to the main product body by external cable attachment. Examples include products with probes, keyboards, etc..

15.3 REFERENCE DOCUMENTS.

Tektronix Environmental Design Standard 062-2849-00 for Graphics Workstations Division (GWD/Wilsonville) .

15.4 COMPLIANCE TO APPLICABLE MILITARY AND COMMERCIAL STANDARDS REQUIREMENTS.

This test method is unique to Tektronix.

15.5 ACCEPTANCE CRITERIA.

Acceptance criteria must be established prior to test. The product shall properly operate and function per the EIS after completion of the test.

(a) A fixed cable mounting method must not sustain physical or electrical damage. Also soft electrical failures caused by the disconnection (product operates after resetting) should not occur.

(b) A removable cable mounting method must not sustain physical or electrical damage, but disconnection and soft electrical failures caused by the disconnection are allowed.

15.6 TEST PROCEDURE.

(a) Restrain the cable in a manner which allows the product under test to fall a distance of 30 inches (76 cm), or to the maximum cable length distance when the cable is less than 30 inches (76 cm) in length, without interference and without contacting the floor.
(b) Drop the product three (3) times from this height.

NOTE: If full disconnection of the interconnect cable is possible, precautions should be taken to prevent the disconnected product from being subjected to a hard landing during testing.

16. FRAGILITY TEST FOR UNPACKAGED PRODUCTS

16.1 PURPOSE.

The purpose of this test is to determine the fragility level of the mechanical package. This is accomplished by determining the critical velocity change (Vc) and critical shock amplitude (Ac) required to cause product failure. The critical velocity change is determined through the use of a 2 ms half sine shock pulse. The critical shock amplitude is determined through the use of a trapezoidal shock pulse. This data is then used to plot a "Damage Boundary Curve" which defines the product's fragility.

The fragility test can be used to redesign a product to decrease its sensitivity to shock. It is often possible through minor product modifications to significantly increase the critical velocity change or critical shock amplitude resulting in a more rugged design. For example, if the critical velocity change can be increased so that it is greater than that which will be experienced during distribution, no protective cushioning will be required.

The fragility test also provides information needed to design the most cost effective shipping container. The critical shock amplitude used in conjunction with available cushion curves will enable the designer to choose the optimum protective cushioning required for the product under test.

16.2 SCOPE.

The scope of this test is for all dynamics classes of Tektronix products in their unpackaged state.

16.3 REFERENCE DOCUMENTS.

ASTM Standard 3332-88 (Commercial Standard) - Mechanical-Shock Fragility of Products, Using Shock Machines.

16.4 ACCEPTANCE CRITERIA.

Acceptance criteria must be established prior to test. The product shall operate and function per the EIS after completion of the test. Mechanical part or component failures are not permissible. Cosmetic blemishes which make the product non-saleable are not permissible.

16.5 PROCEDURE - Critical Velocity Change (Vc) Shock Test.

(a) Mount the product to be tested on the carriage of the shock test machine. The product should be supported by a fixture similar in shape and configuration to the cushion which will support the product in its shipping container. The fixture should be as rigid as possible so as not to distort the shock pulse imparted to the product. Securely fasten the fixture and product to the carriage so that it will not leave the surface of the carriage during the shock test.

NOTE 1 - The points at which the fixture supports the product are very important because the dynamic response of the product is strongly influenced by the location of these support points.

NOTE 2 - If the orientation of the product can change during handling impacts then a test may be required for each of the directions in which the input shock can occur. Multidirectional tests are recommended since most products have different fragilities in different orientations.

(b) Mount the plastic programmers with felt pads on the shock test machine so that a 2 ms half sine shock pulse is produced and set the table drop height to two (2) inches (5.08 cm).
(c) Drop the test specimen from this height and examine or functionally test the product to determine if damage due to shock has occurred.
(d) If no damage has occurred, increase the drop height by one (1) inch (2.54 cm) and repeat step (c). Continue this process until product damage occurs.
(e) The last successful drop height before failure is used to determine the critical velocity change (Vc). Use table A (DROP HEIGHT vs VELOCITY CHANGE FOR HALF SINE SHOCK PULSE) to determine what the critical velocity change value is for the last successful drop height.

TABLE A - DROP HEIGHT vs VELOCITY CHANGE FOR HALF SINE SHOCK PULSE.

Drop Height inches (cm)	Velocity Change in. / sec. (cm/sec)	Drop Height inches (cm)	Velocity Change in. / sec. (cm/sec)
2 (5.1)	81 (205.7)	11 (27.9)	162 (411.5)
3 (7.6)	93 (236.2)	12 (30.5)	169 (429.3)
4 (10.2)	103 (261.6)	13 (33.0)	176 (447.0)
5 (12.7)	118 (299.7)	14 (35.6)	185 (469.9)
6 (15.2)	124 (315.0)	15 (38.1)	190 (482.6)
7 (17.7)	134 (340.4)	16 (40.6)	196 (497.8)
8 (20.3)	143 (363.2)	17 (43.2)	202 (513.1)
9 (22.9)	148 (375.9)	18 (45.7)	208 (528.3)
10 (25.4)	157 (398.8)	19 (48.3)	216 (548.6)

NOTE : The values for this table were recorded on the Lansmont Model 122 Shock Test Machine located in the Tektronix Wilsonville Dynamics Laboratory. The velocity change values were recorded on a Tektronix 7854 Oscilloscope. For actual values and a more detailed explanation of the calculations, refer to Appendix A of this standard.

16.6 PROCEDURE - Critical Acceleration Amplitude (Ac) Shock Test.
(a) Multiply the critical velocity (Vc) by 2.0 and look at table B (DROP HEIGHT vs VELOCITY CHANGE FOR TRAPEZOIDAL SHOCK PULSE) to determine which table height will produce shocks of this minimum velocity change. If the value calculated falls between those listed on the chart, use the higher table height of the two in question.
(b) Set the shock table to this height and mount the pneumatic cylinders to produce a trapezoidal shock pulse.
(c) Set the gas cylinder pressure to 100 psi and place an accelerometer on the table top to monitor the shock pulse produced.

NOTE - Table C shows some approximate shock amplitudes produced for various gas pressures. These shock amplitudes are independent of table height. The table height effects the velocity change, not the shock amplitude.

(d) Using the same fixture to support the unpackaged product, perform one drop and examine the recorded shock pulse to be certain the desired velocity change was obtained. Some adjustment in table height may have to be made.
(e) Take a picture of this shock pulse for future reference.
(f) Examine or functionally test the product to determine if damage due to shock has occurred.
(g) If no damage has occurred, increase the gas pressure 50 psi, use the same drop height and repeat steps (d) through (f). Continue this process until product damage occurs.
(h) The last successful drop at which damage did not occur is used to determine the critical acceleration (Ac) amplitude. This value is obtained from the shock trace recorded on the shock machine oscilloscope.

TABLE B - DROP HEIGHT vs VELOCITY CHANGE FOR TRAPEZOIDAL SHOCK PULSE.

Drop Height inches (cm)	Velocity Change in. / sec. (cm/sec.)	Drop Height inches (cm)	Velocity Change in. / sec. (cm/sec.)
3 (7.6)	71 (180.3)	21 (53.3)	165 (419.1)
6 (15.2)	97 (246.4)	24 (61.0)	174 (442.0)
9 (22.9)	116 (294.6)	27 (68.5)	182 (462.3)
12 (30.5)	131 (332.7)	30 (76.2)	189 (480.1)
15 (38.1)	143 (363.2)	33 (83.3)	196 (497.8)
18 (45.7)	156 (396.3)	36 (91.4)	202 (513.1)

TABLE C - GAS PRESSURE vs ACCELERATION AMPLITUDE FOR TRAPEZOIDAL SHOCK PULSE AND 18" DROP HEIGHT.

Gas Pressure (psi)	Acceleration Amplitude (g)
50	8
100	15
150	20
200	30
250	40
300	50
350	60
400	70

NOTE: The values for these tables were recorded on the Lansmont Model 122 Shock Test Machine located in the Tektronix Wilsonville Dynamics Laboratory. The velocity change values were recorded on a Tektronix 7854 Oscilloscope. For actual values and a more detailed explanation of the calculations, refer to Appendix A of this standard.

16.7 DAMAGE BOUNDARY DETERMINATION.

Sensitivity to shock of a product is dependent on three parameters of the shock pulse: shock pulse shape (trapezoidal or half sine), shock-pulse velocity change (Vc), and shock-pulse maximum-faired acceleration (Ac). For a given product, the interrelation of these three parameters is shown by a damage boundary curve as plotted in figure A. For shock pulses having peak acceleration and velocity-change values falling in the shaded area, product damage will occur. Shock pulses having values outside the shaded area will not damage the product. For most products the damage boundary will be different for each direction in which the shock occurs.

The example plotted in figure A is based on tests conducted in accordance with the critical velocity shock test and critical acceleration shock test. Drops numbered 1 to 5 were performed using the 2 ms half sine shock pulse and those numbered 6 to 10 used a trapezoidal shock pulse. Failure occurred in the fifth and tenth drops establishing the critical velocity and critical amplitude values that were plotted.

As shown in figure A, the corner where the critical velocity and critical acceleration lines intersect is rounded. To avoid inconclusive test results, the critical acceleration test is conducted at least two times the product's critical velocity. In this way the rounded region of the damage boundary is avoided. (Refer to ASTM 3332-88 for a detailed calculation and plot of this curved portion).

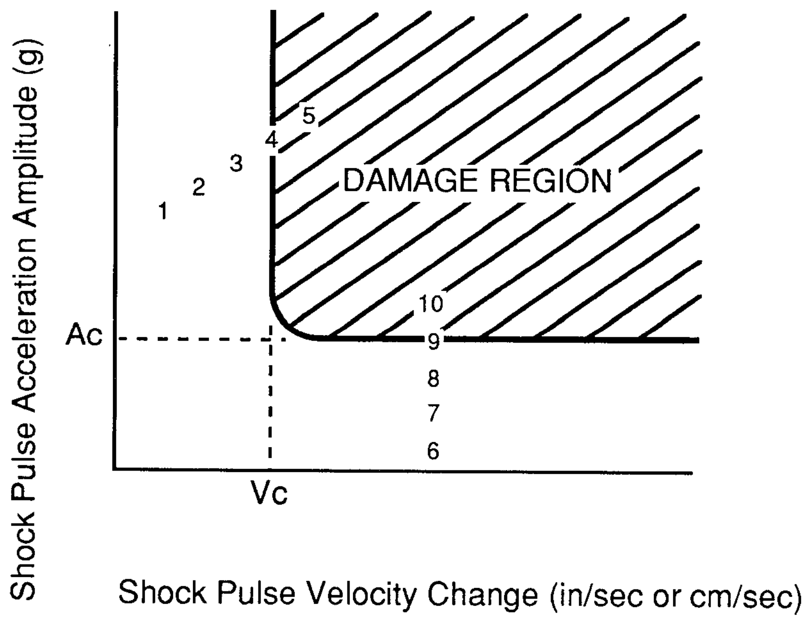
When the damage boundary curve has been plotted, three things can be learned from it:

(1) If the velocity change that the product will undergo in shipment is below the critical velocity (Vc), no cushioning is required.

(2) If the critical velocity (Vc) is below the velocity change which the product will be subjected to during unpackaged product handling, then the product should be modified to increase its critical velocity. Examples of unpackaged product handling are movement of the finished product on a production line or customer handling and installation upon receipt. In these cases, the test will have shown that the unmodified product is too fragile to be handled in its normal production or in-use environment.

(3) If the velocity change that the product will undergo in shipment is above the critical velocity (Vc), package cushioning should be designed so that it transmits no more than the critical acceleration (Ac) as determined through testing.

FIGURE A - DAMAGE BOUNDARY PLOT.



16.8 EFFECT OF MULTIPLE SHOCKS.

The critical velocity and critical acceleration shock tests require that the product be subjected to a series of shocks of incrementally increasing severity. Most products are not affected by this multiplicity of tests. However, some products will fail prematurely due to cumulative effects. For a product of this type, it is important to determine the probable number of shocks which it will be subjected to in shipment. If significantly fewer shocks than those used in the test are anticipated, then the test data will have to be corrected. Usually multiple samples of such a product are tested. Two examples of such tests are shown in Appendix B of this standard.

17. TRANSPORTATION PERFORMANCE SPECIFICATION

17.1 TABLE OF CONTENTS.

17.2 PURPOSE.

The purpose of this test is to insure that the packaged product under test will survive anticipated transportation shock and vibration conditions and arrive at its destination in working order. This is accomplished by subjecting the packaged product to a sequence of tests which simulate a typical distribution cycle.

17.3 SCOPE.

The scope of this test is for all dynamics classes of Tektronix products in their packaged state.

17.4 REFERENCE DOCUMENTS.

(a) ASTM Standard D4169-86 (Commercial Standard) - Performance Testing of Shipping Containers and Systems is the primary source document for this standard.
(b) ASTM Standard D642-76 (Commercial Standard) - Method of Compression Test for Shipping Containers.
(c) ASTM Standard D775-80 (Commercial Standard) - Test Method for Drop Test for Loaded Boxes.
(d) ASTM Standard D999-86 (Commercial Standard) - Methods for Vibration Testing of Shipping Containers.
(e) ASTM Standard D1083-85 (Commercial Standard) - Mechanical Handling of Unitized Loads and Large Shipping Cases and Crates.
(f) ASTM Standard D3580-80 (Commercial Standard) - Vibration (Vertical Sinusoidal Motion) Test of Products.
(g) ASTM Standard D4728-87 (Commercial Standard) - Random Vibration Testing of Shipping Containers.
(h) NSTA National Safe Transit Association (Commercial Standard) - Pre-shipment Test Procedures (Revision January 1984).
(i) Military Standard Mil-Std-810E - Environmental Test Methods and Engineering Guidelines.

17.5 ACCEPTANCE CRITERIA.

Acceptance criteria must be established prior to test. The product shall operate (power applied) per EIS after completion of the test. Mechanical part or component failures are not permissible. Cosmetic blemishes which make the product non-saleable are not permissible. The packaging shall continue to protect the product.

Initial inspection for qualification and engineering testing: An inspection of the product and shipping package, including cosmetic, mechanical, electrical performance and package cushioning materials, should be conducted prior to testing. This will determine the pre-test state of the product and its shipping package.

Final inspection for qualification testing: For Distribution Cycles 1, 2, 3 or 4, final inspection will usually be at the completion of the test sequence. The intent is to see the combined effects of shipping hazards on the packaged product. An inspection midstream could alter this information. For Distribution Cycle 5, the final check point may be at the completion of each test conducted.

Final inspection for engineering testing: Monitoring during and inspecting after each test within the test sequence is recommended.

17.6 DISTRIBUTION CYCLES (Summary).
Choose the distribution cycle which best describes the type of distribution that your product will experience during normal transportation. Perform each test within the sequence in the order listed using the same package. DO NOT use a new package for each test, the intent is to test the package's integrity throughout the entire distribution cycle. The five distribution cycles to choose from are listed in the following paragraphs.

17.6.1 ASSURANCE LEVEL.
Choose one assurance level for each test. The level of test intensity is based on its probability of occurring in a typical distribution system. Assurance Level I is a more severe test with a lower probability of occurring. Assurance level II is suggested unless conditions dictate otherwise.

NOTE: Assurance level III from ASTM Standard D4169-86 is not listed in this specification. Its test conditions are considered too mild for the typical Tektronix distribution system. Contact the Tektronix Environmental Labs if further information is needed.

17.6.2 DISTRIBUTION CYCLE 1 (Summary).
Single package environment with a packaged product weight up to 150 pounds (68.1 kg).

This category includes packaged products shipped directly to the end user through the normal Tektronix distribution system, including UPS shipments. Typical products would include scopes, printers, terminals, and other smaller products and accessories.

Tests performed:

- 1st Manual Handling (Shock)
- Warehouse and Vehicle Stacking (Compression)
- Loose-load Vibration (Repetitive Shock)
- Vehicle Vibration (Random Vibration)
- 2nd Manual Handling (Shock).

17.6.3 DISTRIBUTION CYCLE 2 (Summary).
Single package environment with a packaged product weight over 150 pounds (68.1 kg).

This category includes packaged products shipped through the normal Tektronix distribution system. This category includes products that are unitized on a pallet for shipment in bulk to the end user. Typical products would include larger computers and printers.

Tests performed:

- 1st Handling (Shock)
- Warehouse and Vehicle Stacking (Compression)
- Loose-load Vibration (Repetitive Shock)
- Vehicle Vibration (Random Vibration)
- 2nd Handling (Shock).

17.6.4 DISTRIBUTION CYCLE 3 (Summary).
OEM products with a packaged weight up to 150 pounds (68.1 kg).

This category includes packaged products that come to Tektronix for redistribution to our customers or Tektronix products sold to outside companies for redistribution to their customers. An example would be a printer or display that comes to Tektronix in the original vendor package for additional manufacturing, but will be redistributed to the end user in the same package.

Tests performed:

- 1st Manual Handling (Shock)
- 1st Warehouse and Vehicle Stacking (Compression)
- 2nd Manual Handling (Shock)
- 2nd Warehouse and Vehicle Stacking (Compression)
- Loose-load Vibration (Repetitive Shock)
- Vehicle Vibration (Random Vibration)
- 3rd Manual Handling (Shock).

17.6.5 DISTRIBUTION CYCLE 4 (Summary).
OEM products with a packaged weight over 150 pounds (68.1 kg).

Similar to the types of products described in Distribution Cycle 3, but with a packaged weight over 150 pounds (68.1 kg).

Tests performed:

- 1st Handling (Shock)
- 1st Warehouse and Vehicle Stacking (Compression)
- 2nd Handling (Shock)
- 2nd Warehouse and Vehicle Stacking (Compression)
- Loose-load Vibration (Repetitive Shock)
- Vehicle Vibration (Random Vibration)
- 3rd Handling (Shock).

17.6.6 DISTRIBUTION CYCLE 5 (Summary).
Optional test set for all packaged product weights.

This is an optional test set selection and sequence, for all packaged product weights, of packaged product transportation test methods. This option is provided for products whose distribution cycle does not fit one of the previously listed distribution cycles 1,2,3 or 4.

Tests included:

- Vibration Test (random, repetitive shock/vibration and sinusoidal sweep and resonance dwell).
- Shock Test (Freefall Drop and Tilt Drop).

One or a combination of individual tests can be selected from those listed in the other packaged product distribution cycles and from the tests listed above.

17.7 PROCEDURE - DISTRIBUTION CYCLE 1.
Single package environment with a packaged product weight under 150 lbs (68.1 kg).

This category includes packaged products shipped directly to the end user through the normal Tektronix distribution system, including UPS shipments. Typical products would include scopes, printers, terminals, and other smaller products and accessories.

Tests performed:

- 1st Manual Handling (Shock)
- Warehouse and Vehicle Stacking (Compression)
- Loose-load Vibration (Repetitive Shock)
- Vehicle Vibration (Random Vibration)
- 2nd Manual Handling (Shock).

17.7.1 - COMPLIANCE TO APPLICABLE COMMERCIAL STANDARDS.

(a) This test sequence meets or exceeds the requirements of ASTM Standard D4169-86, Distribution Cycle 3, Assurance Level I or II.

(b) The vibration amplitudes for the vehicle vibration test (random vibration) meet or exceed the requirements of Military Standard Mil-Std-810E, Method 514.4, Figures 514.4-1, 514.4-2 and 514.4-3 (Basic Transportation, Common Carrier) and commercial standard ASTM D4728-87, Figure X1.1 (Commercial Transport Random Vibration Spectra Summary).

17.7.2 TEST 1 - 1st MANUAL HANDLING (SHOCK).

(a) Attach the packaged product to the shock test table or place onto the swing arm of the free-fall drop tester.

(b) Choose the appropriate drop height from the following table based on assurance level and packaged product weight.

(c) Drop the packaged product once on the bottom.

(d) Drop the packaged product once on two adjacent bottom edges.

(e) Drop the packaged product once on two diagonally opposite bottom corners.

(f) Drop the packaged product once on the top.

PACKAGED PRODUCT WEIGHT pounds (kg)		FREE-FALL DROP HEIGHT inches (cm) Assurance Level I	II
0 - 20	(0 - 9.1)	24 (61)	15 (38.1)
> 20 - 40	(> 9.1 - 18.2)	21 (53.3)	13 (33.0)
> 40 - 60	(>18.2 - 27.3)	18 (45.7)	12 (30.5)
> 60 - 80	(>27.3 - 36.4)	15 (38.1)	10 (25.4)
> 80 - 100	(>36.4 - 45.5)	12 (30.5)	9 (22.9)
>100 - 150	(>45.5 - 68.2)	10 (25.4)	7 (17.8)

NOTE 1: The notation "(>weight A - weight B)" indicates a packaged weight that is in the range of greater than weight A and up to and including weight B.

NOTE 2: When using a free-fall drop tester the packaged product should be dropped onto a flat, firm, non-yielding surface such as steel or concrete.

NOTE 3: When using a programmable shock test table the input pulse shall be approximately half sine in shape and 2 ms in duration. Allowances must be made for the rebound of the platform. The intent being to achieve the same velocity change as in a free-fall drop. This may result in the test table and packaged product being dropped a shorter distance than the free-fall drop height called for in this specification. (This shorter distance is called the free-fall equivalent drop height.)

17.7.3 TEST 2 - WAREHOUSE AND VEHICLE STACKING (COMPRESSION).

This test is intended to determine the ability of the packaged product to withstand top to bottom compressive loads.

(a) Place the packaged product on the compression testing machine in its normal stacking orientation.
(b) Choose an F Factor from the following table based on the assurance level and construction of the shipping package:

SHIPPING UNIT CONSTRUCTION TYPE	F FACTOR	
	Assurance Level	
	I	II
1. Corrugated, fiberboard, or plastic container that may not have stress-bearing interior packaging using these materials, and where the product does not support any of the load.	8.0	4.5
2. Corrugated, fiberboard, or plastic container that has stress-bearing interior packaging with rigid inserts such as wood.	4.5	3.0
3. Containers constructed of materials other than corrugated, fiberboard, or plastic that are not temperature sensitive or where the product supports the load directly, for example compression of the package.	3.0	2.0

4. If the product supports a known portion of the load, the F factor is calculated in the following manner: F=P(Fp) + C(Fc)
where:
Fp = F factor given above for construction type 3,
P = percentage of load supported by product,
Fc = factor given above for appropriate container construction, and
C = percentage of load supported by container.

NOTE: If a full pallet load is tested, F factors may be reduced by 30%.

(c) Calculate the load to be applied based on the following equation:

L = [W ((H-h) / h)] [F]

where:
L = minimum required load, pound-force (lbf) or Newtons (N).
H = maximum height of stack in storage or transit vehicle, inches (in) or meters (m).
W = weight of one shipping unit or individual container, pound-force (lbf) or Newtons (N).
h = height of shipping unit or individual container, inches (in). or meters (m).
F = a factor to account for the combined effect of the individual factors described in step (b).

(d) Once the load (L) has been calculated, load the packaged product to this value. Remove the load immediately after reaching the specified value.

17.7.4 TEST 3 - LOOSE LOAD VIBRATION (REPETITIVE SHOCK).
Assurance Levels I and II will use the same test.

(a) Place the packaged product on the vibration table in its vertical top to bottom orientation without restricting its movement. A fence or similar device should be attached to the vibration table to prevent the test specimen from falling off during the test.
(b) Adjust the vibration frequency until the package leaves the platform about 1/8 inches (0.32 cm). To ensure that the packaged product is receiving repetitive shocks from this height, a shim 1/8 inches thick (0.32 cm) and 2 inches wide (5.08 cm) is inserted a minimum of 4 inches (10.2 cm) under the bottom edge of the longest dimension of the packaged . When vibrating from the proper height, the shim should move intermittently along the entire edge.
(c) Perform test for 30 minutes.
(d) Place the packaged product onto its side and repeat steps (b) and (c). The side to be tested will be the surface on which the package rests in its most stable configuration other than the top or bottom. If this is impractical, the packaged product can be rotated 180 degrees and tested in this orientation.

NOTE: Palletized products will normally be vibrated for the total 60 minutes with the pallet surface down.

17.7.5 TEST 4 - VEHICLE VIBRATION (RANDOM VIBRATION).
Assurance Levels I and II will use the same test.

(a) Attach the packaged product to the vibration table surface in its vertical top to bottom orientation. Additional load spreading fixturing and bracing may be required.

(b) Subject the packaged product to the following test conditions:

Break point Frequency	Acceleration Power Spectral Density (APSD) (g2/Hz)
5 Hz	0.015
40 Hz	0.015
50 Hz	0.010
100 Hz	0.010
125 Hz	0.003
200 Hz	0.003
500 Hz	0.00015

Overall Vibration Level: 1.33 GRMS
Test time per axis: 1 hour

(c) Repeat steps (a) and (b) for the other two major axes (longitudinal front to rear and transverse side to side).

17.7.6 TEST 5 - 2nd MANUAL HANDLING (SHOCK).

(a) Attach the packaged product to the shock test table or place onto the swing arm of the free-fall drop tester.
(b) Choose a drop height from the table below based on assurance level and packaged product weight.
(c) Drop the packaged product once on the four faces not previously tested.
(d) Drop the packaged product once on the bottom from twice the specified height. For example a product weighing 19 lbs. with an assurance level II classification should be dropped 30 inches on the bottom.

PACKAGED PRODUCT WEIGHT pounds (kg)		FREE-FALL DROP HEIGHT inches (cm) Assurance Level I	II
0 - 20	(0 - 9.1)	24 (61)	15 (38.1)
> 20 - 40	(>9.1 - 18.2)	21 (53.3)	13 (33.0)
> 40 - 60	(>18.2 - 27.3)	18 (45.7)	12 (30.5)
> 60 - 80	(>27.3 - 36.4)	15 (38.1)	10 (25.4)
> 80 - 100	(>36.4 - 45.5)	12 (30.5)	9 (22.9)
>100 - 150	(>45.5 - 68.2)	10 (25.4)	7 (17.8)

17.8 PROCEDURE - DISTRIBUTION CYCLE 2.

Single package environment with a packaged product weight over 150 lbs (68.1 kg).

This category includes packaged products shipped through the normal Tektronix distribution system. This category includes products that are unitized on a pallet for shipment in bulk to the end user. Typical products would include larger computers and printers.

Tests performed:

- 1st Handling (Shock)
- Warehouse and Vehicle Stacking (Compression)
- Loose-load Vibration (Repetitive Shock)
- Vehicle Vibration (Random Vibration)
- 2nd Handling (Shock).

17.8.1 - COMPLIANCE TO APPLICABLE COMMERCIAL STANDARDS.

(a) This test sequence meets or exceeds ASTM Standard D4169-86 (Commercial Standard), Distribution Cycle 4, Assurance Level I or II.

(b) The vibration amplitudes for the vehicle vibration test (random vibration) meet or exceed the requirements of Military Standard Mil-Std-810E, Method 514.4, Figures 514.4-1, 514.4-2 and 514.4-3 (Basic Transportation, Common Carrier) and ASTM Standard D4728-87, Figure X1.1 (Commercial Transport Random Vibration Spectra Summary).

17.8.2 TEST 1 - 1st HANDLING (SHOCK).

Perform all three of the following drop tests (Rotational Edge, Corner and Unsupported Free Fall) using the following table to determine drop heights.

PACKAGED PRODUCT WEIGHT pounds (kg)	FREE-FALL DROP HEIGHT inches (cm) Assurance Level I	II
150 - 500 (68.2 - 227.3)	12 (30.5)	9 (22.9)
500+ (227.3+)	9 (22.9)	6 (15.2)

NOTE 1: The notation "weight A+" indicates a packaged weight that is greater than weight A.

NOTE 2: When using a free-fall drop tester the packaged product should be dropped onto a flat, firm, non-yielding surface such as steel or concrete.

NOTE 3: When using a programmable shock test table the input pulse shall be approximately half sine in shape and 2 ms in duration. Allowances must be made for the rebound of the platform. The intent being to achieve the same velocity change as in a free-fall drop. This may result in the test table and packaged product being dropped a shorter distance than the free-fall drop height called for in this specification. (This shorter distance is called the free-fall equivalent drop height.)

17.8.2.1 ROTATIONAL EDGE DROP TEST.

(a) Choose a drop height from the previous table based on assurance level and packaged product weight.
(b) One bottom edge of the packaged product is raised to the appropriate drop height and supported along that edge.
(c) The opposite edge is then raised to the appropriate drop height and released onto a hard solid surface.
(d) Repeat steps (b) and (c) for the three remaining bottom edges.

17.8.2.2 CORNER DROP TEST.

(a) Choose a drop height from the previous table based on assurance level and packaged product weight.
(b) One bottom corner of the packaged product is raised to the appropriate drop height and supported.
(c) The opposite corner is then raised to the appropriate drop height and released onto a hard solid surface.
(d) Repeat steps (b) and (c) for the three remaining bottom corners.

17.8.2.3 UNSUPPORTED FREE-FALL DROP TEST.

(a) Choose a drop height from the previous table based on assurance level and packaged product weight.
(b) Attach the packaged product to the shock test table or place onto the platform of the free-fall drop tester in its normal shipping orientation.
(c) Drop the packaged product from the appropriate height.

17.8.3 TEST 2 - WAREHOUSE AND VEHICLE STACKING (COMPRESSION).

This test is intended to determine the ability of the packaged product to withstand top to bottom compressive loads.

(a) Place the packaged product on the compression testing machine in its normal stacking orientation.
(b) Choose an F Factor from the following table based on the assurance level and construction of the shipping package:

SHIPPING UNIT CONSTRUCTION TYPE	F FACTOR Assurance Level I	II
1. Corrugated, fiberboard, or plastic container that may not have stress-bearing interior packaging using these materials, and where the product does not support any of the load.	8.0	4.5

2. Corrugated, fiberboard, or plastic container that has stress-bearing interior packaging with rigid inserts such as wood.	4.5	3.0
3. Containers constructed of materials other than corrugated, fiberboard, or plastic that are not temperature sensitive or where the product supports the load directly, for example compression of the package.	3.0	2.0

4. If the product supports a known portion of the load, the F factor is calculated in the following manner: F=P(Fp) + C(Fc)

where:
Fp = F factor given above for construction type 3,
P = percentage of load supported by product,
Fc = factor given above for appropriate container construction, and
C = percentage of load supported by container.

NOTE: If a full pallet load is tested, F factors may be reduced by 30%.

(c) Calculate the load to be applied based based on the following equation:

$$L = [W ((H-h) / h)] [F]$$

where:
L = minimum required load, pound-force (lbf) or Newtons (N).
H = maximum height of stack in storage or transit vehicle, inches (in) or meters (m).
W = weight of one shipping unit or individual container, pound-force (lbf) or Newtons (N).
h = height of shipping unit or individual container, inches (in) or meters (m).
F = a factor to account for the combined effect of the individual factors described in step (b).

(d) Once the load (L) has been calculated, load the packaged product to this value. Remove the load immediately after reaching the specified value.

17.8.4 TEST 3 - LOOSE LOAD VIBRATION (REPETITIVE SHOCK). Assurance Levels I and II will use the same test.

(a) Place the packaged product on the vibration table in its vertical top to bottom orientation without restricting its movement. A fence or similar device should be attached to the vibration table to prevent the test specimen from falling off during the test.
(b) Adjust the vibration frequency until the package leaves the platform about 1/8 inches (0.32 cm). To ensure that the packaged product is receiving repetitive shocks from this height, a shim 1/8 inches thick (0.32 cm) and 2 inches wide (5.08 cm) is inserted a minimum of 4 inches (10.2 cm) under the bottom edge of the longest dimension of the packaged . When vibrating from the proper height, the shim should move intermittently along the entire edge.
(c) Perform test for 30 minutes.
(d) Place the packaged product onto its side and repeat steps (b) and (c). The side to be tested will be the surface on which the package rests in its most stable configuration other than the top or bottom. If this is impractical, the packaged product can be rotated 180 degrees and tested in this orientation. Palletized products will normally be vibrated for the total 60 minutes with the pallet surface down.

17.8.5 TEST 4 - VEHICLE VIBRATION (RANDOM VIBRATION). Assurance Levels I and II will use the same test.

(a) Attach the packaged product to the random vibration table surface in its vertical top to bottom orientation. Additional load spreading fixturing and bracing may be required.
(b) Subject the packaged product to the following test conditions:

Break point Frequency	Acceleration Power Spectral Density (APSD) (g2/Hz)
5 Hz	0.015
40 Hz	0.015
50 Hz	0.010
100 Hz	0.010
125 Hz	0.003
200 Hz	0.003
500 Hz	0.00015

Overall Vibration Level: 1.33 GRMS
Test time per axis: 1 hour

(c) Repeat steps (a) and (b) for the other two major axes (longitudinal front to rear and transverse side to side).

17.8.6 TEST 5 - 2nd HANDLING (SHOCK).
Perform all three of the following drop tests (Rotational Edge, Corner and Unsupported Free Fall) using the following table to determine drop heights.

PACKAGED PRODUCT WEIGHT pounds (kg)	FREE-FALL DROP HEIGHT inches (cm) Assurance Level I	II
150 - 500 (68.2 - 227.3)	12 (30.5)	9 (22.9)
500+ (227.3+)	9 (22.9)	6 (15.2)

17.8.6.1 ROTATIONAL EDGE DROP TEST.
(a) Choose a drop height from the previous table based on assurance level and packaged product weight.
(b) One bottom edge of the packaged product is raised to the appropriate drop height and supported along that edge.
(c) The opposite edge is then raised to the appropriate drop height and released onto a hard solid surface.
(d) Repeat steps (b) and (c) for the three remaining bottom edges.

17.8.6.2 CORNER DROP TEST.
(a) Choose a drop height from the previous table based on assurance level and packaged product weight.
(b) One bottom corner of the packaged product is raised to the appropriate drop height and supported.
(c) The opposite corner is then raised to the appropriate drop height and released onto a hard solid surface.
(d) Repeat steps (b) and (c) for the three remaining bottom corners.

17.8.6.3 UNSUPPORTED FREE-FALL DROP TEST.
(a) Choose a drop height from the previous table based on assurance level and packaged product weight.
(b) Attach the packaged product to the shock test table or place onto the platform of the free-fall drop test machine in its normal shipping orientation.
(c) Drop the packaged product from the appropriate height.

17.9. PROCEDURE - DISTRIBUTION CYCLE 3.

OEM products with a packaged product weight under 150 lbs (68.1 kg).

This category includes packaged products that come to Tektronix for redistribution to our customers or Tektronix products sold to outside companies for redistribution to their customers. An example would be a printer or display that comes to Tektronix in the original vendor package for additional manufacturing, but will be redistributed to the end user in the same package.

Tests performed:

- 1st Manual Handling (Shock)
- 1st Warehouse and Vehicle Stacking (Compression)
- 2nd Manual Handling (Shock)
- 2nd Warehouse and Vehicle Stacking (Compression)
- Loose-load Vibration (Repetitive Shock)
- Vehicle Vibration (Random Vibration)
- 3rd Manual Handling (Shock).

17.9.1 - COMPLIANCE TO APPLICABLE COMMERCIAL STANDARDS.

(a) This test sequence meets or exceeds ASTM Standard D4169-86 (Commercial Standard), Distribution Cycle 3 and Distribution Cycle 17, Assurance Level I or II.

(b) The vibration amplitudes for the vehicle vibration test (random vibration) meet or exceed the requirements of Military Standard Mil-Std-810E, Method 514.4, Figures 514.4-1, 514.4-2 and 514.4-3 (Basic Transportation, Common Carrier) and commercial standard ASTM D4728-87, Figure X1.1 (Commercial Transport Random Vibration Spectra Summary).

17.9.2 TEST 1 - 1st MANUAL HANDLING (SHOCK).

(a) Attach the packaged product to the shock test table or place onto the swing arm of the free-fall drop tester.

(b) Choose the appropriate drop height from the following table based on assurance level and packaged product weight.

(c) Drop the packaged product once on the bottom.

(d) Drop the packaged product once on two adjacent bottom edges.

(e) Drop the packaged product once on two diagonally opposite bottom corners.

(f) Drop the packaged product once on the top.

PACKAGED PRODUCT WEIGHT pounds	(kg)	FREE-FALL DROP HEIGHT inches (cm) Assurance Level I	II
0 - 20	(0 - 9.1)	24 (61)	15 (38.1)
> 20 - 40	(>9.1 - 18.2)	21 (53.3)	13 (33.0)
> 40 - 60	(>18.2 - 27.3)	18 (45.7)	12 (30.5)
> 60 - 80	(>27.3 - 36.4)	15 (38.1)	10 (25.4)
> 80 - 100	(>36.4 - 45.5)	12 (30.5)	9 (22.9)
>100 - 150	(>45.5 - 68.2)	10 (25.4)	7 (17.8)

NOTE 1: The notation "(>weight A - weight B)" indicates a packaged weight that is in the range of greater than weight A and up to and including weight B.

NOTE 2: When using a free-fall drop tester the packaged product should be dropped onto a flat, firm, non-yielding surface such as steel or concrete.

NOTE 3: When using a programmable shock test table the input pulse shall be approximately half sine in shape and 2 ms in duration. Allowances must be made for the rebound of the platform. The intent being to achieve the same velocity change as in a free-fall drop. This may result in the test table and packaged product being dropped a shorter distance than the free-fall drop height called for in this specification. (This shorter distance is called the free-fall equivalent drop height.)

17.9.3 TEST 2 - 1st WAREHOUSE AND VEHICLE STACKING (COMPRESSION).

This test is intended to determine the ability of the packaged product to withstand top to bottom compressive loads.

(a) Place the packaged product on the compression testing machine in its normal stacking orientation.
(b) Choose an F Factor from the following table based on the assurance level and construction of the shipping package:

SHIPPING UNIT CONSTRUCTION TYPE	F FACTOR Assurance Level I	II
1. Corrugated, fiberboard, or plastic container that may not have stress-bearing interior packaging using these materials, and where the product does not support any of the load.	8.0	4.5
2. Corrugated, fiberboard, or plastic container that has stress-bearing interior packaging with rigid inserts such as wood.	4.5	3.0
3. Containers constructed of materials other than corrugated, fiberboard, or plastic that are not temperature sensitive or where the product supports the load directly, for example compression of the package.	3.0	2.0

4. If the product supports a known portion of the load, the F factor is calculated in the following manner: F=P(Fp) + C(Fc)

where:
Fp = F factor given above for construction type 3,
P = percentage of load supported by product,
Fc = factor given above for appropriate container construction, and
C = percentage of load supported by container.

NOTE: If a full pallet load is tested, F factors may be reduced by 30%.

(c) Calculate the load to be applied based based on the following equation:

L = [W ((H-h) / h)] [F]

where:
L = minimum required load, pound-force (lbf) or Newtons (N).
H = maximum height of stack in storage or transit vehicle, inches (in) or meters (m).
W = weight of one shipping unit or individual container, pound-force (lbf) or Newtons (N).
h = height of shipping unit or individual container, inches (in). or meters (m).
F = a factor to account for the combined effect of the individual factors described in step (b).

(d) Once the load (L) has been calculated, load the packaged product to this value. Remove the load immediately after reaching the specified value.

17.9.4 TEST 3 - 2nd MANUAL HANDLING (SHOCK).

(a) Attach the packaged product to the shock test table or place onto the swing arm of the free-fall drop tester.
(b) Choose the appropriate drop height from the following table based on assurance level and packaged product weight.
(c) Drop the packaged product once on the bottom.
(d) Drop the packaged product once on the two adjacent bottom edges not previously tested.
(e) Drop the packaged product once on the two diagonally opposite bottom corners not previously tested.

(f) Drop the packaged product once on the top.

PACKAGED PRODUCT WEIGHT pounds (kg)		FREE-FALL DROP HEIGHT inches (cm) Assurance Level I	II
0 - 20	(0 - 9.1)	24 (61)	15 (38.1)
> 20 - 40	(>9.1 - 18.2)	21 (53.3)	13 (33.0)
> 40 - 60	(>18.2 - 27.3)	18 (45.7)	12 (30.5)
> 60 - 80	(>27.3 - 36.4)	15 (38.1)	10 (25.4)
> 80 - 100	(>36.4 - 45.5)	12 (30.5)	9 (22.9)
>100 - 150	(>45.5 - 68.2)	10 (25.4)	7 (17.8)

17.9.5 TEST 4 - 2nd WAREHOUSE AND VEHICLE STACKING (COMPRESSION).

(a) Place the packaged product on the compression testing machine in its normal stacking orientation.
(b) Choose an F Factor from the following table based on the assurance level and construction of the shipping package:

SHIPPING UNIT CONSTRUCTION TYPE	F FACTOR Assurance Level I	II
1. Corrugated, fiberboard, or plastic container that may not have stress-bearing interior packaging using these materials, and where the product does not support any of the load.	8.0	4.5
2. Corrugated, fiberboard, or plastic container that has stress-bearing interior packaging with rigid inserts such as wood.	4.5	3.0
3. Containers constructed of materials other than corrugated, fiberboard, or plastic that are not temperature sensitive or where the product supports the load directly, for example compression of the package.	3.0	2.0

4. If the product supports a known portion of the load, the F factor is calculated in the following manner: F=P(Fp) + C(Fc)

where:
Fp = F factor given above for construction type 3,
P = percentage of load supported by product,
Fc = factor given above for appropriate container construction, and
C = percentage of load supported by container.

NOTE: If a full pallet load is tested, F factors may be reduced by 30%.

(c) Calculate the load to be applied based based on the following equation:

L = [W ((H-h) / h)] [F]

where:
L = minimum required load, pound-force (lbf) or Newtons (N).
H = maximum height of stack in storage or transit vehicle, inches (in) or meters (m).
W = weight of one shipping unit or individual container, pound-force (lbf) or Newtons (N).
h = height of shipping unit or individual container, inches (in). or meters (m).
F = a factor to account for the combined effect of the individual factors described in step (b).

(d) Once the load (L) has been calculated, load the packaged product to this value. Remove the load immediately after reaching the specified value.

17.9.6 TEST 5 - LOOSE LOAD VIBRATION (REPETITIVE SHOCK).
Assurance Levels I and II will use the same test.

(a) Place the packaged product on the vibration table in its vertical top to bottom orientation without restricting its movement. A fence or similar device should be attached to the vibration table to prevent the test specimen from falling off during the test.
(b) Adjust the vibration frequency until the package leaves the platform about 1/8 inches (0.32 cm). To ensure that the packaged product is receiving repetitive shocks from this height, a shim 1/8 inches thick (0.32 cm) and 2 inches wide (5.08 cm) is inserted a minimum of 4 inches (10.2 cm) under the bottom edge of the longest dimension of the packaged . When vibrating from the proper height, the shim should move intermittently along the entire edge.
(c) Perform test for 30 minutes.
(d) Place the packaged product onto its side and repeat steps (b) and (c). The side to be tested will be the surface on which the package rests in its most stable configuration other than the top or bottom. If this is impractical, the packaged product can be rotated 180 degrees and tested in this orientation. Palletized products will normally be vibrated for the total 60 minutes with the pallet surface down.

17.9.7 TEST 6 - VEHICLE VIBRATION (RANDOM VIBRATION).
Assurance Levels I and II will use the same test.

(a) Attach the packaged product to the vibration table surface in its vertical top to bottom orientation. Additional load spreading fixturing and bracing may be required.
(b) Subject the packaged product to the following test conditions:

Break point Frequency	Acceleration Power Spectral Density (APSD) (g2/Hz)
5 Hz	0.015
40 Hz	0.015
50 Hz	0.010
100 Hz	0.010
125 Hz	0.003
200 Hz	0.003
500 Hz	0.00015

Overall Vibration Level: 1.33 GRMS
Test time per axis: 1 hour

(c) Repeat steps (a) and (b) for the other two major axes (longitudinal front to rear and transverse side to side).

17.9.8 TEST 7 - 3rd MANUAL HANDLING (SHOCK).
(a) Attach the packaged product to the shock test table or place onto the swing arm of the free-fall drop tester.
(b) Choose the appropriate drop height from the table below based on assurance level and packaged product weight.
(c) Drop the packaged product once on the four faces not previously tested.
(d) Drop the packaged product once on the bottom from twice the specified height. For example a product weighing 19 lbs. with an assurance level II classification should be dropped 30 inches.

PACKAGED PRODUCT WEIGHT pounds (kg)		FREE-FALL DROP HEIGHT inches (cm) Assurance Level I	II
0 - 20	(0 - 9.1)	24 (61)	15 (38.1)
> 20 - 40	(>9.1 - 18.2)	21 (53.3)	13 (33.0)
> 40 - 60	(>18.2 - 27.3)	18 (45.7)	12 (30.5)
> 60 - 80	(>27.3 - 36.4)	15 (38.1)	10 (25.4)
> 80 - 100	(>36.4 - 45.5)	12 (30.5)	9 (22.9)
>100 - 150	(>45.5 - 68.2)	10 (25.4)	7 (17.8)

17.10 PROCEDURE - DISTRIBUTION CYCLE 4.

OEM products with a packaged product weight over 150 lbs (68.1 kg).

This category includes packaged products that come to Tektronix for redistribution to our customers or Tektronix products sold to outside companies for redistribution to their customers. An example would be a printer or display that comes to Tektronix in the original vendor package for additional manufacturing, but will be redistributed to the end user in the same package.

Tests performed:

- 1st Handling (Shock)
- 1st Warehouse and Vehicle Stacking (Compression)
- 2nd Handling (Shock)
- 2nd Warehouse and Vehicle Stacking (Compression)
- Loose-load Vibration (Repetitive Shock)
- Vehicle Vibration (Random Vibration)
- 3rd Handling (Shock).

17.10.1 - COMPLIANCE TO APPLICABLE COMMERCIAL STANDARDS.

(a) This test sequence meets or exceeds ASTM Standard D4169-86 (Commercial Standard), Distribution Cycle 4 and Distribution Cycle 16, Assurance Level I or II.

(b) The vibration amplitudes for the vehicle vibration test (random vibration) meet or exceed the requirements of Military Standard Mil-Std-810E, Method 514.4, Figures 514.4-1, 514.4-2 and 514.4-3 (Basic Transportation, Common Carrier) and commercial standard ASTM D4728-87, Figure X1.1 (Commercial Transport Random Vibration Spectra Summary).

17.10.2 TEST 1 - 1st HANDLING (SHOCK).

Perform all three of the following drop tests (Rotational Edge, Corner and Unsupported Free Fall) using the following table to determine drop heights.

PACKAGED PRODUCT WEIGHT pounds (kg)	FREE-FALL DROP HEIGHT inches (cm)	
	Assurance Level	
	I	II
150 - 500 (68.2 - 227.3)	12 (30.5)	9 (22.9)
500+ (227.3+)	9 (22.9)	6 (15.2)

NOTE 1: The notation "weight A+" indicates a packaged weight that is greater than weight A.

NOTE 2: When using a free-fall drop tester the packaged product should be dropped onto a flat, firm, non-yielding surface such as steel or concrete.

NOTE 3: When using a programmable shock test table the input pulse shall be approximately half sine in shape and 2 ms in duration. Allowances must be made for the rebound of the platform. The intent being to achieve the same velocity change as in a free-fall drop. This may result in the test table and packaged product being dropped a shorter distance than the free-fall drop height called for in this specification. (This shorter distance is called the free-fall equivalent drop height.)

17.10.2.1 ROTATIONAL EDGE DROP TEST.

(a) Choose a drop height from the previous table based on assurance level and packaged product weight.
(b) One bottom edge of the packaged product is raised to the appropriate drop height and supported along that edge.
(c) The opposite edge is then raised to the appropriate drop height and released onto a hard solid surface.
(d) Repeat steps (b) and (c) for the three remaining bottom edges.

17.10.2.2 CORNER DROP TEST.

(a) Choose a drop height from the previous table based on assurance level and packaged product weight.
(b) One bottom corner of the packaged product is raised to the appropriate drop height and supported.
(c) The opposite corner is then raised to the appropriate drop height and released onto a hard solid surface.
(d) Repeat steps (b) and (c) for the three remaining bottom corners.

17.10.2.3 UNSUPPORTED FREE-FALL DROP TEST.

(a) Choose a drop height from the previous table based on assurance level and packaged product weight.
(b) Attach the packaged product to the shock test table or place onto the platform of the free-fall drop test machine in its normal shipping orientation.
(c) Drop the packaged product from the appropriate height.

17.10.3 TEST 2 - 1st WAREHOUSE AND VEHICLE STACKING (COMPRESSION).

This test is intended to determine the ability of the packaged product to withstand top to bottom compressive loads.

(a) Place the packaged product on the compression testing machine in its normal stacking orientation.
(b) Choose an F Factor from the following table based on the assurance level and construction of the shipping package:

SHIPPING UNIT CONSTRUCTION TYPE	F FACTOR Assurance Level I	F FACTOR Assurance Level II
1. Corrugated, fiberboard, or plastic container that may not have stress-bearing interior packaging using these materials, and where the product does not support any of the load.	8.0	4.5
2. Corrugated, fiberboard, or plastic container that has stress-bearing interior packaging with rigid inserts such as wood.	4.5	3.0
3. Containers constructed of materials other than corrugated, fiberboard, or plastic that are not temperature sensitive or where the product supports the load directly, for example compression of the package.	3.0	2.0
4. If the product supports a known portion of the load, the F factor is calculated in the following manner:	$F=P(Fp) + C(Fc)$	

where:
Fp = F factor given above for construction type 3,
P = percentage of load supported by product,
Fc = factor given above for appropriate container construction, and
C = percentage of load supported by container.

NOTE: If a full pallet load is tested, F factors may be reduced by 30%.

(c) Calculate the load to be applied based based on the following equation:

$$L = [W ((H-h) / h)] [F]$$

where:
L = minimum required load, pound-force (lbf) or Newtons (N).
H = maximum height of stack in storage or transit vehicle, inches (in) or meters (m).
W = weight of one shipping unit or individual container, pound-force (lbf) or Newtons (N).
h = height of shipping unit or individual container, inches (in). or meters (m).
F = a factor to account for the combined effect of the individual factors described in step (b).

(d) Once the load (L) has been calculated, load the packaged product to this value. Remove the load immediately after reaching the specified value.

17.10.4 TEST 3 - 2nd HANDLING (SHOCK).
Perform all three of the following drop tests (Rotational Edge, Corner and Unsupported Free Fall) using the following table to determine drop heights.

PACKAGED PRODUCT WEIGHT pounds (kg)	FREE-FALL DROP HEIGHT inches (cm) Assurance Level I	II
150 - 500 (68.2 - 227.3)	12 (30.5)	9 (22.9)
500+ (227.3+)	9 (22.9)	6 (15.2)

17.10.4.1 ROTATIONAL EDGE DROP TEST.
(a) Choose a drop height from the previous table based on assurance level and packaged product weight.
(b) One bottom edge of the packaged product is raised to the appropriate drop height and supported along that edge.
(c) The opposite edge is then raised to the appropriate drop height and released onto a hard solid surface.
(d) Repeat steps (b) and (c) for the three remaining bottom edges.

17.10.4.2 CORNER DROP TEST.
(a) Choose a drop height from the previous table based on assurance level and packaged product weight.
(b) One bottom corner of the packaged product is raised to the appropriate drop height and supported.
(c) The opposite corner is then raised to the appropriate drop height and released onto a hard solid surface.
(d) Repeat steps (b) and (c) for the three remaining bottom corners.

17.10.4.3 UNSUPPORTED FREE-FALL DROP TEST.

(a) Choose a drop height from the previous table based on assurance level and packaged product weight.
(b) Attach the packaged product to the shock test table or place onto the platform of the free-fall drop test machine in its normal shipping orientation.
(c) Drop the packaged product from the appropriate height.

17.10.5 TEST 4 - 2nd WAREHOUSE AND VEHICLE STACKING (COMPRESSION).

(a) Place the packaged product on the compression testing machine in its normal stacking orientation.
(b) Choose an F Factor from the following table based on the assurance level and construction of the shipping package:

SHIPPING UNIT CONSTRUCTION TYPE	F FACTOR Assurance Level I	F FACTOR Assurance Level II
1. Corrugated, fiberboard, or plastic container that may not have stress-bearing interior packaging using these materials, and where the product does not support any of the load.	8.0	4.5
2. Corrugated, fiberboard, or plastic container that has stress-bearing interior packaging with rigid inserts such as wood.	4.5	3.0
3. Containers constructed of materials other than corrugated, fiberboard, or plastic that are not temperature sensitive or where the product supports the load directly, for example compression of the package.	3.0	2.0
4. If the product supports a known portion of the load, the F factor is calculated in the following manner:	F=P(Fp) + C(Fc)	

where:
Fp = F factor given above for construction type 3,
P = percentage of load supported by product,
Fc = factor given above for appropriate container construction, and
C = percentage of load supported by container.

NOTE: If a full pallet load is tested, F factors may be reduced by 30%.

(c) Calculate the load to be applied based based on the following equation:

$$L = [W((H-h)/h)][F]$$

where:
L = minimum required load, pound-force (lbf) or Newtons (N).
H = maximum height of stack in storage or transit vehicle, inches (in) or meters (m).
W = weight of one shipping unit or individual container, pound-force (lbf) or Newtons (N).
h = height of shipping unit or individual container, inches (in). or meters (m).
F = a factor to account for the combined effect of the individual factors described in step (b).

(d) Once the load (L) has been calculated, load the packaged product to this value. Remove the load immediately after reaching the specified value.

17.10.6 TEST 5 - LOOSE LOAD VIBRATION (REPETITIVE SHOCK). Assurance Levels I and II will use the same test.

(a) Place the packaged product on the vibration table in its vertical top to bottom orientation without restricting its movement. A fence or similar device should be attached to the vibration table to prevent the test specimen from falling off during the test.
(b) Adjust the vibration frequency until the package leaves the platform about 1/8 inches (0.32 cm). To ensure that the packaged product is receiving repetitive shocks from this height, a shim 1/8 inches thick (0.32 cm) and 2 inches wide (5.08 cm) is inserted a minimum of 4 inches (10.2 cm) under the bottom edge of the longest dimension of the packaged . When vibrating from the proper height, the shim should move intermittently along the entire edge.
(c) Perform test for 30 minutes.
(d) Place the packaged product onto its side and repeat steps (b) and (c). The side to be tested will be the surface on which the package rests in its most stable configuration other than the top or bottom. If this is impractical, the packaged product can be rotated 180 degrees and tested in this orientation. Palletized products will normally be vibrated for the total 60 minutes with the pallet surface down.

17.10.7 TEST 6 - VEHICLE VIBRATION (RANDOM VIBRATION).
Assurance Levels I and II will use the same test.

(a) Attach the packaged product to the vibration table surface in its vertical top to bottom orientation. Additional load spreading fixturing and bracing may be required.
(b) Subject the packaged product to the following test conditions:

Break point Frequency	Acceleration Power Spectral Density (APSD) (g2/Hz)
5 Hz	0.015
40 Hz	0.015
50 Hz	0.010
100 Hz	0.010
125 Hz	0.003
200 Hz	0.003
500 Hz	0.00015

Overall Vibration Level: 1.33 GRMS
Test time per axis: 1 hour

(c) Repeat steps (a) and (b) for the other two major axes (longitudinal front to rear and transverse side to side).

17.10.8 TEST 7 - 3rd HANDLING (SHOCK).
Perform all three of the following drop tests (Rotational Edge, Corner and Unsupported Free Fall) using the following table to determine drop heights.

PACKAGED PRODUCT WEIGHT pounds (kg)	FREE-FALL DROP HEIGHT inches (cm) Assurance Level I	II
150 - 500 (68.2 - 227.3)	12 (30.5)	9 (22.9)
500+ (227.3+)	9 (22.9)	6 (15.2)

17.10.8.1 ROTATIONAL EDGE DROP TEST.
(a) Choose a drop height from the previous table based on assurance level and packaged product weight.
(b) One bottom edge of the packaged product is raised to the appropriate drop height and supported along that edge.
(c) The opposite edge is then raised to the appropriate drop height and released onto a hard solid surface.
(d) Repeat steps (b) and (c) for the three remaining bottom edges.

17.10.8.2 CORNER DROP TEST.

(a) Choose a drop height from the previous table based on assurance level and packaged product weight.
(b) One bottom corner of the packaged product is raised to the appropriate drop height and supported.
(c) The opposite corner is then raised to the appropriate drop height and released onto a hard solid surface.
(d) Repeat steps (b) and (c) for the three remaining bottom corners.

17.10.8.3 UNSUPPORTED FREE-FALL DROP TEST.

(a) Choose a drop height from the previous table based on assurance level and packaged product weight.
(b) Attach the packaged product to the shock test table or place onto the platform of the free-fall drop test machine in its normal shipping orientation.
(c) Drop the packaged product from the appropriate height.

17.11 PROCEDURE - DISTRIBUTION CYCLE 5.

Optional test set for all packaged product weights.

17.11.1 SCOPE.

This is an optional test set selection and sequence, for all packaged product weights, of packaged product transportation test methods. This option is provided for products whose distribution cycle does not fit one of the previously listed distribution cycles 1,2,3 or 4.

Tests included:

- Vibration Test (random, repetitive shock/vibration and sinusoidal sweep and resonance dwell).
- Shock Test (Freefall Drop and Tilt Drop).

17.11.2 REFERENCE DOCUMENTS.

(a) Military Standard Mil-Std-810E, Method 514.4, Figures 514.4-1, 514.4-2 and 514.4-3 (Basic Transportation, Common Carrier).
(b) American Society For Testing And Materials (ASTM) Standard D4728-87, Figure X1.1 (Commercial Transport Random Vibration Spectra Summary).
(c) National Safe Transit Association (NSTA) Standard (Commercial Standard), Pre-shipment Test Procedures, Project 1 and 1A, Revision January, 1984.
(d) National Safe Transit Association (NSTA) Standard D999-86 (Commercial Standard), Standard Methods for Vibration Testing of Shipping Containers.
(e) American Society For Testing And Materials (ASTM) Standard D775-80 (Commercial Standard), Standard Test Method for Drop Tests for Loaded Boxes.

17.11.3 GENERAL PROCEDURE.

One or a combination of individual tests can be selected from those listed in the other packaged product distribution cycles and from the following optional set of vibration and shock tests for packaged products. Usually, one shock test and at least one vibration test method will be selected.

17.11.4 PACKAGED PRODUCT VIBRATION TEST METHOD A (RANDOM).

17.11.4.1 COMPLIANCE TO APPLICABLE MILITARY AND COMMERCIAL STANDARDS.

The test conditions meet or exceed the requirements of the following standards:
(a) Military Standard Mil-Std-810E, Method 514.4, Figures 514.4-1, 514.4-2 and 514.4-3 (Basic Transportation, Common Carrier).
(b) Commercial Standard ASTM D4728-87 , Figure X1.1 (Commercial Transport Random Vibration Spectra Summary).

17.11.4.2 PROCEDURE.

(a) An inspection of the product and shipping package, including cosmetic, mechanical, electrical performance and package cushioning materials, should be conducted prior to testing. This will determine the pre-test state of the product and its shipping package.

(b) Place the packaged product on the vibration table surface so that the package is oriented for the top/bottom (vertical) axis of vibration. Packages with a definite skid bottom on which the unit is intended to be shipped will usually be oriented with the skid in the normal skid side down position.

(c) Attach the packaged product to the vibration table surface. Additional load spreading fixturing and bracing may be required.

(d) Subject the packaged product to the following test conditions:

Break point Frequency	Acceleration Power Spectral Density (APSD) (g2/Hz)
5 Hz	0.015
40 Hz	0.015
50 Hz	0.010
100 Hz	0.010
125 Hz	0.003
200 Hz	0.003
500 Hz	0.00015

Overall Vibration Level: 1.33 GRMS
Test time per axis: 1 hour

(e) At the completion of each axis of testing, perform an inspection of the product and shipping package, including cosmetic, mechanical, electrical performance and package cushioning materials. The packaging should continue to protect the product. This inspection may be postponed until completion of all axes of testing if so desired. However, if damage is experienced, inspection at the completion of each axis could provide more detailed information.

(f) Repeat steps (c) through (e) for the other two major axes (longitudinal front to rear and transverse side to side).

17.11.5 PACKAGED PRODUCT VIBRATION TEST METHOD B (REPETITIVE SHOCK/VIBRATION).

17.11.5.1 COMPLIANCE TO APPLICABLE COMMERCIAL STANDARDS.

The test conditions and procedures meet or exceed the requirements of the following commercial standards:

(a) National Safe Transit Association (NSTA) Standard, Pre-shipment Test Procedures, Revision January, 1984.

(b) ASTM Standard D999-86, Standard Methods for Vibration Testing of Shipping Containers.

17.11.5.2 PROCEDURE.

(a) An inspection of the product and shipping package, including cosmetic, mechanical, electrical performance and package cushioning materials, should be conducted prior to testing. This will determine the pre-test state of the product and its shipping package.

(b) Place the packaged product on the platform of the vibration test machine (traffic simulator) in its normal shipping orientation. Packages with a definite skid bottom on which the unit is intended to be shipped will usually be oriented with the skid in the normal skid side down position.

(c) Attach restraining devices or fences to prevent the package from moving horizontally off the platform and to prevent excessive rocking without restricting the vertical movement.

(d) Adjust the restraining devices or fences to permit free movement of the packaged product of approximately 0.4 inches (10.16 mm) in any horizontal direction from the center position.

(e) Start the vibration of the platform with a 1 inch (2.54 cm) peak-to-peak constant displacement amplitude. With a starting frequency of about 2 Hz, steadily increase the frequency until some portion of the packaged product repeatedly leaves the platform surface.

NOTE: The packaged product repeatedly leaving the platform surface will usually occur when the vibration acceleration level reaches about 1 g peak. With a constant 1 inch (2.54 cm) peak-to-peak displacement of the platform the following vibration parameters are provided:

Frequency Hz	Cycles per minute minute, CPM-RPM	Impacts in 60 minutes	Acceleration g's peak	Displacement inches (cm)
4.42	265	15,900	1.0	1 (2.54)
4.64	278	16,680	1.1	1 (2.54)

(f) To ensure that the packaged product receives a continuing series of repetitive shocks, a shim with a 1/16 inch (1.59 mm) thickness and a width of 2 inches (5.08 cm) shall be used. The shim will be used to determine when the package is adequately leaving the test platform by being able to insert the shim under the package, a minimum of 4 inches (10.16 cm), and moving it intermittently along one entire edge of the longest dimension of the package.

(g) Vibrate for 30 minutes.

(h) Rotate the package 90 degrees onto a side and vibrate for an additional 30 minutes in this orientation.

NOTE 1: If the packaged product is not stable while standing on its side, the additional 30 minutes of vibration can be performed with the package rotated 180 degrees from its normal shipping orientation.

NOTE 2: Palletized products will normally be vibrated for the total 60 minutes with the pallet surface down to the platform of the vertical motion testing machine.

NOTE 3: NSTA Pre-Shipment Test Procedures Standard specifies the following:

Project 1 (Packaged products 100 pounds (45.4 kg) and over) - Vibrate the packaged product for a total of 11,800 vibratory impacts. Use the NSTA procedure details listed below.

Project 1A (Packaged products under 100 pounds(45.4 kg)) - Vibrate the packaged product for a total of 14,200 vibratory impacts. Use the NSTA procedure details listed below.

NSTA Procedure Details:
The total duration of the test time in minutes to meet the specified number of vibratory impacts requirement is determined by dividing the number of impacts by the cycles per minute frequency used. A single 90 degree horizontal rotation should be elected after one-half of the vibration has been accomplished. If a single 90 degree horizontal rotation is impractical because of the size of the packaged product, a 180 degree horizontal rotation will be permissible.

(i) At the completion of testing, perform an inspection of the product and shipping package, including cosmetic, mechanical, electrical performance and package cushioning materials. The packaging should continue to protect the product.

17.11.6 PACKAGED PRODUCT VIBRATION TEST METHOD C (SINUSOIDAL SWEEP AND RESONANCE DWELL).

17.11.6.1 COMPLIANCE TO APPLICABLE COMMERCIAL STANDARDS.

The test conditions and procedures meet or exceed the requirements of the following commercial standards:

(a) NSTA (National Safe Transit Association) Standard, Pre-shipment Test Procedures, Revision January, 1984.

(b) ASTM Standard D999-86, Standard Methods for Vibration Testing of Shipping Containers, Method B, Single Container Resonance Test.

17.11.6.2 PROCEDURE.

(a) An inspection of the product and shipping package, including cosmetic, mechanical, electrical performance and package cushioning materials, should be conducted prior to testing. This will determine the pre-test state of the product and its shipping package.

(b) Place the packaged product on the vibration table so that the package is oriented for vibration in the top/bottom (vertical) axis. Packages with a definite skid bottom on which the unit is intended to be shipped will usually be oriented with the skid in the normal skid side down position.

(c) Feed an accelerometer sensor into the package and attach it to the product so that resonance of the product in the package can be monitored.

(d) Attach the packaged product securely to the vibration table surface. Additional load spreading fixturing and bracing may be required.
(e) Subject the packaged product to the specified sine vibration test conditions while monitoring and noting the resonant responses of the product in the package.

Sine vibration test conditions:

(1) Frequency cycle:	5-100-5 Hz
(2) Number of cycles:	2
(3) Vibration amplitude:	0.5 g constant acceleration
(4) Sweep type:	logarithmic
(5) Sweep rate:	0.5 to 1 octave per minute
(6) Total sweep time:	17.29 minutes to 34.58 minutes, depending on the sweep rate.

(f) Subject the packaged product to a vibration frequency dwell of 15 minutes at each resonant frequency noted during the sweep, limited to a maximum of the four most severe resonances.
(g) Repeat steps (c) through (f) for the other two major axes of the package (side/side transverse and front/back longitudinal).
(h) At the completion of testing, perform an inspection of the product and package, including cosmetic, mechanical, electrical performance and package cushioning materials.

17.11.7 PACKAGED PRODUCT WEIGHT UP TO 150 LBS (68.1 kg), FREE-FALL DROP SHOCK TEST

17.11.7.1 COMPLIANCE TO APPLICABLE COMMERCIAL STANDARDS.

(a) The drop heights for packaged products up to 100 lbs (45.4 kg) weight meet or exceed the requirements of: National Safe Transit Association (NSTA), Pre-Ship Test Procedures, Revision January, 1984, Project 1A.
(b) The drop heights for packaged products with weights above 100 lbs (45.4 kg) up to 150 lbs (68.1 kg) were selected based on the purpose of the test as is stated in the commercial standard American Society for Testing and Materials (ASTM) Standard D775-80, Drop Test for Loaded Boxes.

17.11.7.2 PROCEDURE.

(a) An inspection of the product and shipping package, including cosmetic, mechanical, electrical performance and package cushioning materials, should be conducted prior to testing. This will determine the pre-test state of the product and its shipping package.

(b) Select the appropriate free-fall drop height, determined by the weight of the packaged product to be tested, from the following table. Adjust the test machine to the specified drop height.

PACKAGED PRODUCT WEIGHT pounds	(kg)	FREE-FALL DROP HEIGHT inches (cm)	Reference
0 - 20	(0-9.1)	36 (91.4)	(NSTA Project 1A)
>20 - 40	(9.18.1)	30 (76.2)	(NSTA Project 1A)
>40 - 60	(18.1 - 27.2)	24 (61.0)	(NSTA Project 1A)
>60 - 100	(27.2 - 45.4)	18 (45.7)	(NSTA Project 1A)
>100 - 150	(45.4 - 68.0)	12 (30.5)	(ASTM D775-80)

NOTE 1: The notation "(>weight A - weight B)" indicates a packaged weight that is in the range of greater than weight A and up to and including weight B.

NOTE 2: When using a free-fall drop tester the packaged product should be dropped onto a flat, firm, non-yielding surface such as steel or concrete.

NOTE 3: When using a programmable shock test table the input pulse shall be approximately half sine in shape and 2 ms in duration. Allowances must be made for the rebound of the platform. The intent being to achieve the same velocity change as in a free-fall drop. This may result in the test table and packaged product being dropped a shorter distance than the free-fall drop height called for in this specification. (This shorter distance is called the free-fall equivalent drop height.)

(c) Place a face of the packaged product on the platform of a swing arm drop test machine. (When using a shock test table, attach the packaged product securely to the table surface).

(d) Drop the packaged product in the following orientations:
- Once on each face.
- Once onto a critical corner. The choice of a critical corner is the one that most likely would result in damage.
- Once onto each of the three edges radiating out from the critical corner.

(e) At the completion of testing, perform an inspection of the product and package, including cosmetic, mechanical, electrical performance and package cushioning materials. The packaging shall continue to protect the product.

17.11.8 PACKAGED PRODUCT WEIGHT OVER 150 LBS (68.1 kg), FREE-FALL DROP SHOCK TEST (METHOD A)

17.11.8.1 COMPLIANCE TO APPLICABLE COMMERCIAL STANDARDS.

The free-fall drop test is offered as a substitute for the commercial standard NSTA Inclined Impact Test. The impact velocity achieved in the free-fall drop exceeds the minimum impact velocity requirements of:

- National Safe Transit Association (NSTA), Pre-ship test Procedures, Revision January 1984, Project 1 for packaged products 100 lbs (45.4 kg) or over, Inclined Impact Test. (Refer to the procedure for further details).

17.11.8.2 PROCEDURE.

(a) An inspection of the product and shipping package, including cosmetic, mechanical, electrical performance and package cushioning materials, should be conducted prior to testing. This will determine the pre-test state of the product and its shipping package.

(b) Adjust the test machine for a drop height as specified in the following table. Free-fall drops should be onto a flat, firm, non-yielding surface such as steel or concrete. (When using a shock test table, use an equivalent free-fall drop height).

PACKAGED PRODUCT WEIGHT pounds (kg)	FREE-FALL DROP HEIGHT inches (cm)	Reference
>150 (>68.0)	6.25 (15.9)	NSTA Project 1 Inclined Impact Test

NOTE 1: The notation ">weight A" indicates a packaged product weight of greater than weight A.

NOTE 2: The impact velocity achieved with a free-fall drop from 6.25 inches (15.9 cm) is 5.79 feet per second (1.76 meters per second). This exceeds the minimum impact velocity requirements of the NSTA Inclined Impact Test, 5.75 feet per second (1.75 meters per second). The free-fall drop test is offered as a substitute for the Inclined Impact Test. (Impact velocity of a free-fall drop is calculated using $V=(2gh)^{1/2}$, with g=32.17 feet per second per second (9.805 meters per second per second) and h= height of the drop in feet (meters)).

(c) Place a face of the packaged product on the platform of a swing arm drop test machine. (When using a shock test table, attach the packaged product securely to the table surface).

(d) Drop the packaged product in the following orientations:
- One drop onto each face (6 total drops).

NOTE: Per the NSTA standard, the top side impact may be eliminated for packaged products having a definite skid bottom on which the unit is intended to be shipped, or where the gross weight exceeds 500 pounds (225.2 kg). However, in all instances the four vertical faces of the packaged product must be subjected to impacts. If the top side is not impacted, the bottom surface must receive two flat drops from a height of 8 inches (30.3 cm) or two tilt (edge rotation) drops from a height of 8 inches (20.3 cm). Each bottom tilt drop may be performed by raising one end (line perpendicular to the skid bottom's longest dimension) to the required height, while releasing the lifted end so that it falls freely on a flat, firm, non-yielding surface such as steel or concrete.

(e) At the completion of testing, perform an inspection of the product and package, including cosmetic, mechanical, electrical performance and package cushioning materials. The packaging shall continue to protect the product.

17.11.9 PACKAGED PRODUCT WEIGHT OVER 150 LBS (68.1 kg), TILT (EDGE ROTATION) DROP SHOCK TEST (METHOD B)

17.11.9.1 COMPLIANCE TO APPLICABLE COMMERCIAL STANDARDS.

This test method does not fully comply with the requirements of the: National Safe Transit Association (NSTA), Pre-ship test Procedures, Revision January 1984, Project 1 for packaged products 100 lbs (45.4 kg) or over, Inclined Impact Test.

For packaged products greater than 100 lbs weight (45.4 kg), the NSTA standard allows Tilt (Edge Rotation) Drop Shock testing onto only the bottom surface of the package if the package has a definite skid bottom on which the package is intended to be shipped or if the packaged product's gross weight exceeds 500 lbs. (226.8 kg). The NSTA standard specifies the Inclined Impact Test for the other surfaces. (Refer to the procedure section for further details).

Although not fully complying with the NSTA standard, this Tilt (Edge Rotation) Test for all surfaces of packaged products of greater than 150 lbs (68.1 kg) is offered as an optional test method.

17.11.9.2 PROCEDURE.

(a) An inspection of the product and shipping package, including cosmetic, mechanical, electrical performance and package cushioning materials, should be conducted prior to testing. This will determine the pre-test state of the product and its shipping package.

(b) Place a face of the packaged product down onto a flat, firm, non-yielding test surface such as steel or concrete.

(c) Raise one edge of the face of the packaged product that is contacting the non-yielding test surface to a height of 8 inches (29.3 cm).

(d) Release the lifted edge so that the packaged product falls freely back down onto the test surface.

(e) Repeat step (d) for all four of the edges of the face of the packaged product that is in contact with the test surface.

NOTE: The NSTA standard only allows tilt (rotational edge) drops on the bottom face of the packaged product as an alternative test. The NSTA standard specifies an Inclined Impact Test method for the other faces of the package. This test method does not fully comply with the NSTA standard, but is offered as an optional test method.

(f) Repeat steps (b) through (e) for the remaining faces of the packaged product.

(g) At the completion of testing, perform an inspection of the product and package, including cosmetic, mechanical, electrical performance and package cushioning materials. The packaging shall continue to protect the product.

LIST OF CHANGES.

REFERENCE	DESCRIPTION OF CHANGE	CHK'D BY	DATE
Tom Basta Bob Carroll Ed Fegles Mark James Mary Locke Tom Louie Rick Toda	This document replaces 062-2858-00 Revision A (last change date: June 17, 1981)	Tektronix Environmental Labs and CGG Package Design	

APPENDIX A - CALCULATIONS for TABLES A, B and C of the FRAGILITY TEST FOR UNPACKAGED PRODUCTS

The following values were recorded using a Tektronix 7854 Oscilloscope and the Lansmont Model 122 Shock Test Machine located in the Tektronix Wilsonville Dynamics Laboratory on 10-25-89. The accelerometer was bolted to the shock table surface using an aluminum block that was specifically designed for this purpose.

The values for tables A and B were an average of five (5) drops from each height. For table C the shock table was raised to 18 inches and dropped onto the gas programmers set to the appropriate pressure producing a trapezoidal shock pulse.

Table A - Half Sine Shock Pulse

	Velocity Change (in / sec)					
Drop Ht. (in)	Drop 1	Drop 2	Drop 3	Drop 4	Drop 5	Average
2	76	81	81	86	83	81
3	95	90	93	92	95	93
4	99	106	105	100	104	103
5	115	120	120	120	115	118
6	125	124	126	122	123	124
7	133	133	137	132	134	134
8	143	143	141	145	143	143
9	151	149	148	149	149	148
10	158	157	158	155	158	157
11	163	160	162	162	165	162
12	168	170	169	167	170	169
13	174	178	177	175	174	176
14	185	185	185	186	187	185
15	192	189	191	191	189	190
16	199	197	194	197	196	196
17	201	204	202	202	201	202
18	208	208	208	207	208	208
19	215	214	213	218	218	216
20	Reached the 600 g limit of the table					

APPENDIX A - continued

Table B - Trapezoidal Shock Pulse

	Velocity Change (in / sec)						
Drop Ht. (in)	Drop 1	Drop 2	Drop 3	Drop 4	Drop 5	Average	Gas Pressure (psi)
3	74	73					100
	71	72	72	71	71	71	200
	70	71	71	71	71	71	250
6	96	97	97	97	96	97	250
9	116	116	116	116	115	116	250
12	120	120				120	100
	125	125				125	150
	129	129				129	200
	131	131	131	131	131	131	250
	131	131				131	300
15	143	143	144	143	144	143	250
18	137	136				137	100
	156	156	156	156	156	156	250
	157	157				157	300
21	166	165	165	165	165	165	250
24	149	149				149	100
	173	173	174	174	174	174	250
	177	178				177	300
27	182	182	182	181	181	182	250
30	189	189	190	190	198	189	250
33	189					189	200
	196					196	250
36	202					202	250

Table C - Trapezoidal Shock Pulse w/ 18" drop Height

Gas Pressure (psi)	Acceleration (g)	Duration (ms)	Vel. Change (in / sec.)
50	8	46	121
100	15	24	136
150	20	17	145
200	30	12.7	152
250	40	15	83
300	50		
350	60	9	83
400	70	7.6	83

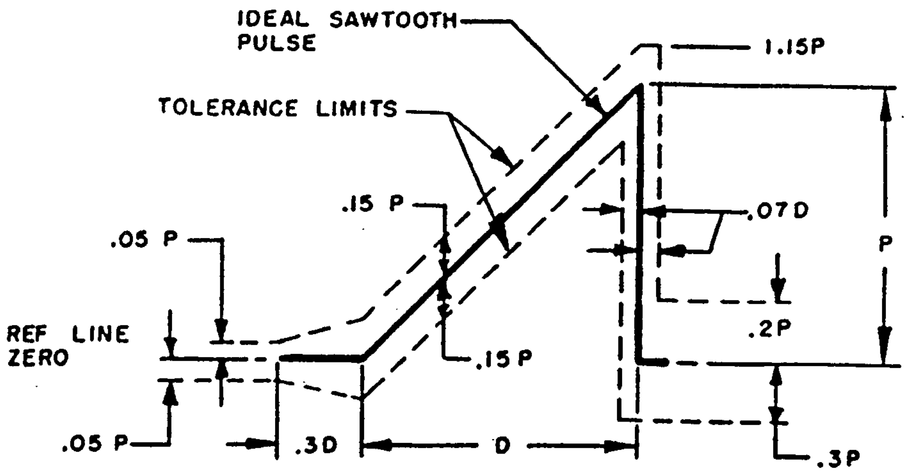
APPENDIX B - EFFECTS OF MULTIPLE SHOCKS DURING FRAGILITY TESTING

The effect of multiple shocks should be considered even if only a single sample of the product is available for testing. If the product is complex, usually some sub-element of the product will fail first. Frequently, even though the product may be a prototype, additional sub-elements are available to replace the one which was damaged. If all parts of the product are one-of-a-kind and no more are available, then a correction factor allowing for the effects of multiple tests may have to be used as outlined in the examples below.

Method A - If only a few samples of the product are available, a simplified calculation technique may be used to determine the effect of multiple shocks. After the tests of the first samples, successive samples are tested at shock levels beginning near the failure level of the first sample. Three to five new or repaired test items are often used for each test orientation and for each part of the damage boundary (Vc and Ac). The failure level is then defined as the average (arithmetic mean) of the midpoints between the last tests and the test which produced failure (excluding the first sample, which failed prematurely due to cumulative effects). This procedure is less accurate than the procedure described in method B.

Method B - A test procedure known as the "up-and-down" or "staircase" method is well suited for use in product fragility testing. Several specimens are tested sequentially with the test specimen being discarded or repaired after each individual shock test. The first specimen is tested at the estimated failure point. If it fails at that shock level, the next specimen is tested at a level which is a fixed increment lower. If it passes, the specimen is tested at a shock level which is incrementally higher. The shock input for each test is thus determined by the previous test result. At the completion of a fixed number of tests, often ten or more, an average or median value and the standard deviation are calculated. This procedure is repeated for each orientation and each part of the damage boundary (Vc and Ac) which is of interest. When possible, analyze the data for normality (reasonable conformance with Gaussian probability distribution). For additional information, ASTM Test Methods D2463 and E680 also describe this procedure.

APPENDIX C1 - TERMINAL PEAK SAWTOOTH MECHANICAL SHOCK PULSE CONFIGURATION AND TOLERANCE LIMITS PER MIL-STD-810C AND E



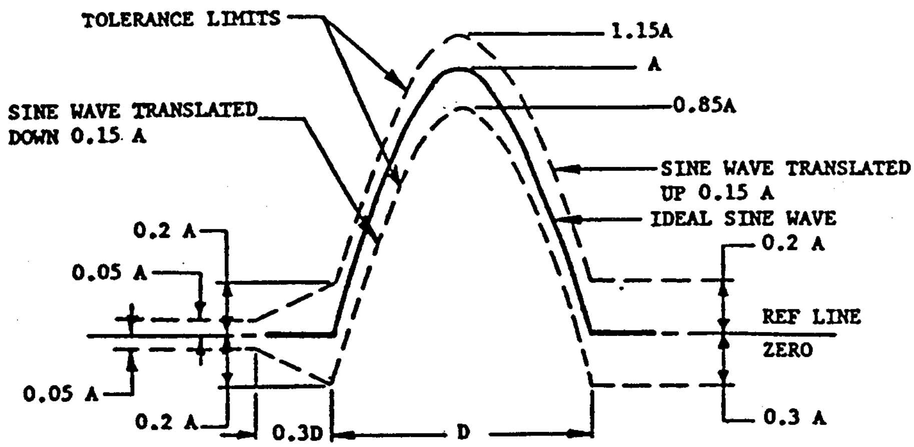
PROCEDURE	TEST	PEAK VALUE (P) g's		NOMINAL DURATION (D) ms	
		FLIGHT VEHICLE EQUIPMENT a 1/	GROUND EQUIPMENT b	FLIGHT VEHICLE EQUIPMENT c 1/	GROUND EQUIPMENT d
I	BASIC DESIGN	20	40 2/	11	11
III	CRASH SAFETY	40	75	11	6
IV	HIGH INTENSITY	100	100	6	11

1/ SHOCK PARAMETERS a AND c: RECOMMENDED FOR EQUIPMENT NOT SHOCK MOUNTED AND WEIGHING LESS THAN 300 POUNDS.

2/ EQUIPMENT MOUNTED ONLY IN TRUCKS AND SEMITRAILERS MAY USE A 20g PEAK VALUE.

NOTE: THE OSCILLOGRAM SHALL INCLUDE A TIME ABOUT 3D LONG WITH A PULSE LOCATED APPROXIMATELY IN THE CENTER. THE PEAK ACCELERATION MAGNITUDE OF THE SAWTOOTH PULSE IS P AND ITS DURATION IS D. THE MEASURED ACCELERATION PULSE SHALL BE CONTAINED BETWEEN THE BROKEN LINE BOUNDARIES AND THE MEASURED VELOCITY CHANGE (WHICH MAY BE OBTAINED BY INTEGRATION OF THE ACCELERATION PULSE) SHALL BE WITHIN THE LIMITS OF $V_i \pm 0.1\ V_i$, WHERE V_i IS THE VELOCITY-CHANGE ASSOCIATED WITH THE IDEAL PULSE WHICH EQUALS 0.5 DP. THE INTEGRATION TO DETERMINE VELOCITY CHANGE SHALL EXTEND FROM 0.4D BEFORE THE PULSE TO 0.1D AFTER THE PULSE.

APPENDIX C2 - HALF SINE MECHANICAL SHOCK PULSE CONFIGURATION AND TOLERANCE LIMITS PER MIL-STD-810C



PROCEDURE	TEST	PEAK VALUE (A) g's		NOMINAL DURATION (D) ms	
		FLIGHT VEHICLE EQUIPMENT a	GROUND EQUIPMENT b	FLIGHT VEHICLE EQUIPMENT c	GROUND EQUIPMENT d
I	BASIC DESIGN	15	30 2/	11	11
III	CRASH SAFETY	30	60	11	6
IV	HIGH INTENSITY	100	100	6	6

1/ SHOCK PARAMETERS a AND c: RECOMMENDED FOR EQUIPMENT SHOCK MOUNTED OR WEIGHING 300 POUNDS OR MORE.

2/ EQUIPMENT MOUNTED ONLY IN TRUCKS AND SEMITRAILERS MAY USE A 20g PEAK VALUE.

NOTE: THE OSCILLOGRAM SHALL INCLUDE A TIME ABOUT 3D LONG WITH A PULSE LOCATED APPROXIMATELY IN THE CENTER. THE ACCELERATION AMPLITUDE OF THE IDEAL HALF SINE PULSE IS A AND ITS DURATION IS D. THE MEASURED ACCELERATION PULSE SHALL BE CONTAINED BETWEEN THE BROKEN LINE BOUNDARIES AND THE MEASURED VELOCITY CHANGE (WHICH MAY BE OBTAINED BY INTEGRATION OF THE ACCELERATION PULSE) SHALL BE WITHIN THE LIMITS $V_i \pm 0.1 V_i$ WHERE V_i IS THE VELOCITY-CHANGE ASSOCIATED WITH THE IDEAL PULSE WHICH EQUALS $2 AD/\pi$. THE INTEGRATION TO DETERMINE VELOCITY CHANGE SHALL EXTEND FROM 0.4D BEFORE THE PULSE TO 0.1D AFTER THE PULSE.

APPENDIX D - GLOSSARY

Acceleration: acceleration is the rate of change of velocity with time, usually along a specified axis and usually expressed in "g" or gravitational units.

Accelerometer: a device (sensor or transducer) for converting sensed acceleration to an electrical signal.

Acceptance Test: A test used to demonstrate compliance of a product to specified criteria as a condition of acceptability for "next" usage.

Ambient Environment: Room conditions with no special controls imposed except for worker comfort.

Amplitude: the magnitude of a quantity. It is usually modified with an adjective such as Peak To Peak, Peak, RMS, or Average.

APSD: Acceleration Power Spectral Density - Also referred to as Power Spectral Density (PSD).

Axis: The principal direction of an item along which a mechanical stress is applied.

Broad-Band Random Vibration: random vibration that covers a wide and continuous range of frequencies.

Circuit Board: An assembly containing a group of interconnected parts which are mounted on a single board.

Commercial: Military specifications are not imposed.

Complex Vibration: vibration whose components are sinusoids not harmonically related to one another.

Component: A non-repairable throwaway item (e.g., integrated circuit, resistor, capacitor, diode, transistor, transformer, hybrid, etc.)

Component Defect: A defect caused by the failure of a component to meet its design specification.

Corrective Action: A process of correcting the root cause of a defect.

CPM: Cycles Per Minute - sometimes referred to as Revolutions Per Minute (RPM). See RPM for definition.

Critical Frequency: a particular resonant frequency at which product degradation in performance or damage is likely.

Cycle: the complete sequence of instantaneous values of a periodic event, during one period.

Damaging Overstress: An induced or natural overstress which exceeds the design capability of the article being screened or under test and which causes partial or catastrophic failure of the item.

Decibel (dB): the amplitude or change in amplitude of a quantity expressed in terms of the logarithm (base 10) of the ratio of the quantity to some reference value.

Defect (Latent Defect): A flaw in an item that might eventually prevent it from meeting its functional requirements when operating within its specified environment and within its expected lifetime.

Degradation Failure: A deterioration of one or more parameters beyond specification limits.

Design Defect: A defect caused by faulty product design or process design.

Design Margin: The self imposed requirement on the design more severe than either specified or operational use requirements.

Designed Test: A controlled test to evaluate a parameter or group of parameters.

Deterministic Vibration: A vibration whose instantaneous value at any future time can be predicted by an exact mathematical expression. Sinusoidal (sine) vibration is an example.

Discrete frequency, sinusoidal: a periodic function having a sinusoidal waveform of only one frequency.

Displacement: specifies change in position, usually measured from a mean position or position of rest.

Duration: the time span of how long something lasts.

Environmental Sensitivity: The change in a specified parameter of a part, assembly, unit, or system that results from exposure to the environment.

Environmental Stress Screening (ESS): The process or method where 100% of a lot or group of identical items is subjected to the application of physical or climatic stresses or forces (or combinations thereof) to identify and eliminate defective, abnormal or marginal parts and manufacturing defects.

Field: The place where a product is ultimately used.

Fixed Sinusoidal Vibration: Vibration excitation with a constant level and frequency with a waveform of a sinusoid.

Forced Vibration: the vibratory motion of a system caused by some mechanical excitation.

Free Vibration: vibration that occurs without forcing, as after a guitar string is plucked.

Frequency: the reciprocal of the period in seconds (of a periodic function). Usually given in units of Hertz (Hz) meaning cycles per second (CPS).

Functional Test: A test which measures a limited number of critical parameters to assure that the test article is operating properly.

Fundamental Frequency: the number of Hertz or cycles per second of the lowest frequency component of a complex, cyclic motion.

g: the acceleration produced by the Earth's gravity.

g units (gravitational units): the way to express acceleration in terms of the Earth's gravitational acceleration. One (1) g is equal to the acceleration of 386 inches / second / second or 32.17 feet/second/second (980 cm/sec^2 or 9.80 m/sec^2).

Harmonic: a sinusoidal quantity having a frequency that is an integral multiple (x2, x3, etc.) of a fundamental (x1) frequency.

Input: the mechanical motion, force or energy applied to a mechanical system.

Level: The magnitude of the test environment.

Lot: A group of products manufactured or processed under substantially the same conditions.

Manufacturing Defect: A flaw caused by in-process errors or uncontrolled conditions during assembly, inspection, or handling.

Module: An assembly of parts designed to function in conjunction with similar or different modules when assembled as a unit. (e.g., Printed circuit assembly, power supply module, monitor/high voltage assembly, etc.)

Narrow-band Random Vibration: random vibration having frequency components only within a narrow band, It has the appearance of a sine wave whose amplitude varies in an unpredictable manner. A narrow-band is usually within +/- 10% or +/- 3 Hz, whichever is greater, of the center frequency of interest.

Natural Frequency (F_n): the frequency of free vibration of a system.

Octave: the interval between two frequencies which differ by a ratio of 2:1.

Orthogonal Axis Vibration: Excitation applied to axes at right angles to each other.

Packaged Product: the shipping container loaded with the interior packing material, the product and the documentation and accessories, where applicable.

Peak Value: extreme value of a varying quantity, measured from the zero or mean value.

Peak-To-Peak Value: the algebraic difference between the peak values on each side of the zero or mean value.

Period: the smallest interval of time in which a cyclic vibration repeats itself.

Periodic Conformance Test: A test performed a regular intervals to verify continued compliance with specified requirements.

Periodic Vibration: (see also Deterministic Vibration) An oscillation whose wave form repeats itself at equal increments of time.

Power Spectral Density (PSD): describes the level of random vibration intensity, in mean-square acceleration per frequency units. It is the limiting mean-square acceleration per unit bandwidth. Units are in g^2/Hz. PSD is the industry accepted measurement to describe random vibration amplitude with respect to frequency. Also refer to APSD.

Probablistic Vibration: (as compared to Deterministic Vibration) Vibration whose magnitude at any future time can only be predicted on a statistical basis.

Production Sampling: Sample testing to determine compliance to specifications.

Proof Of Design Test: A test performed during the design cycle to demonstrate compliance with specified design criteria.

PSD: refer to Power Spectral Density.

Qualification test: A test to verify that a product's design meets specified requirements.

Random Vibration: (see Probablistic Vibration) Vibration whose instantaneous magnitude cannot be specified for any given instant in time. The instantaneous magnitude of a random vibration is specified only by probability distribution functions, giving the probable fraction of the total time that the magnitude lies within a specified range (usually random vibration testing utilizes a Gaussian distribution). It contains no periodic components. Random vibration can be narrow-band or, as it usually is, wide-band.

Repetitive Shock: impacts of a package on a test platform which occur cyclically from input vibration.

Resonance: a resonance condition of a system in forced vibration exists when any change of excitation frequency causes a decrease in the system response.

Resonant Dwell: Vibration excitation of a test article at one of its resonant frequencies for a sustained period of time.

Response: The motion that results from some mechanical input.

RMS (Root-Mean-Square): the square root of the time-averaged squares of a series of measurement.

RPM: Revolutions Per Minute - also refer to CPM.

Sample Test: A test performed on a limited number of items during the production process.

Screening: A process or combination of processes applied to 100% of a lot or group of like items to identify and eliminate defects.

Shock (mechanical): a transient condition where the equilibrium of a system is disrupted by a sudden force or increment of force, or by a sudden change in the direction of magnitude of a velocity vector.

Shock Machine: a device for subjecting a system to controlled and reproducible mechanical shock pulses.

Shock Test: Subjection of a test article to one or more individually applied acceleration pulses.

Sine Vibration: The vibratory excitation is sinusoidal.

Standard: a rule or principle that is used as a basis for judgement.

Standard Deviation: a statistical term. The square root of the variance or the square root of the mean of the squares of the deviations from the mean value.

Steady State Vibration: periodic vibration for which the statistical measurement properties (such as peak, average, RMS and mean values) are constant.

Step stress: an experimental process of increasing stress levels incrementally so that the effects of each step may be evaluated.

Stress Screening: a modern production process tool for precipitating latent defects so that they are detectable using exaggerated environmental conditions. Usually one or more of the following environments are used: random vibration, temperature cycling, temperature shock.

Swept Sinusoidal Vibration: Vibration excitation with frequency progressively varying over a specified frequency range.

Tailoring: the process of selecting an initial stress screening program and the subsequent changes to the methods and severities of the screens to achieve maximum effectiveness.

Test: A process of subjecting an item to conditions designed to determine whether or not the item meets specified performance requirements. (e.g., Qualification test, Reliability demonstration test, Acceptance test, etc).
Note: The conditions of a test may duplicate those of a screen. However, the intent of a test is to demonstrate how well the item meets its specific requirements. The goal of a test is usually zero failures. The goal of a screen is to force defects to surface during the screen rather than during subsequent testing or operation.

Test Specification: A document defining tests to be performed and the specified parameter limits.

Transducer: a device or sensor that converts some mechanical quantity into an electrical signal.

Unit: A self-contained collection of parts/or assemblies within one package performing a specific function or group of functions, and removeable as a single package from an operating system.

Velocity: the rate of change of displacement with time, usually along a specified axis.

Vibration: a mechanical oscillation or motion about a reference point of equilibrium.

Vibration Table (Machine, Generator, Shaker): a device which produces controlled and reproducible mechanical vibration for the vibration testing of mechanical systems, components and structures.

Weight: the gravitational force on an object.

Workmanship Defects: Defects caused by human error during fabrication and assembly.

Tektronix Dynamic Test Standard Quick Reference Sheet 1

Qualification — Random Vibration (Non-Operating) Test

Test Conditions

Dynamic Class	5-100 Hz g²/Hz APSD	100-200 Hz Slope dB/Octave	200-350 Hz g²/Hz ASPD	350-500 Hz Slope dB/Octave	500 Hz g²/Hz ASPD	GRMS Overall	Time Min/ Axis
T1	(See Note)						
T2	0.040	-3	0.020	-3	0.014	3.48	10
3	0.020	-3	0.010	-3	0.007	2.46	10
T4	0.01875	-3	0.009375	-3	0.00657	2.38	10
5	0.0175	-3	0.00875	-3	0.006132	2.28	10
6	0.01625	-3	0.008125	-3	0.005694	2.22	10
7	(To be determined in the detailed specfication for the product)						
T8	0.015	-3	0.0075	-3	0.005256	2.13	10

NOTE: The Non-Operating Random Vibration Test is not required for Tektronix dynamics class T1 due to the high level of the Operating Random Vibration Test for class T1.

Qualification — Random Vibration (Operating) Test

Test Conditions

Dynamic Class	5-350 Hz g²/Hz APSD	350-500 Hz Slope dB/Octave	500 Hz g²/Hz ASPD	GRMS Overall	Time Min/ Axis
T1	0.040	-3	0.028	4.31	20
T2	0.015	-3	0.0105	2.66	10
3	0.0002	-3	0.00014	0.31	10
T4	0.000175	-3	0.000123	0.29	10
5	0.00015	-3	0.000105	0.27	10
6	0.000125	-3	0.0000876	0.24	10
7	(To be determined in the detailed specification for the product)				
T8	0.00010	-3	0.00007	0.22	10

Qualification (Optional) — Sine Vibration Tests for Unpackaged Products (Operating)

Option "A" Sine Vibration Test Conditions

Dynamic Class	Frequency Sweep Cycle (Hz)	Displacement inches p-p (mm p-p)	Min-Max Acceleration (g)	Resonance Search Sweep Cycles per Axis	Resonance Search Sweep Time per Axis (minutes)	Resonance Dwell Time per Axis (minutes)
T1,T2,3	5-15-5 15-25-15 25-55-25	0.060 (1.524) 0.040 (1.016) 0.020 (0.508)	0.08-0.69 0.46-1.28 0.64-3.09	1 1 1	5 5 5	10 (See Note)
T4,5,6	5-55-5	0.013(0.330)	0.02-2.01	1	15	10 (See Note)
7	(To be determined in the detailed specification for the product)					

NOTE: The Resonance Dwell vibration shall be performed at the conclusion of the Resonance Search Sweep Cycling vibration of an axis. The vibration frequency of the dwell shall be at the most severe resonance frequency determined for that axis during the Resonance Search Sweep Cycling vibration. If no significant resonance response is detected in an axis of a test, the resonance dwell shall be performed at 33 Hz.

Option "B" Sine Vibration Test Conditions (Non-Operating)

Dynamics Class	Frequency Sweep Cycle (Hz)	Acceleration peak (g)	Sweep Cycles per Axis	Test Time per Axis (minutes)
T8	5-200-5	0.50	1	25

(062-2858-00 Rev. B)

Dynamic Environment Classifications Table

Dynamic Class	Dynamic Environment Description	Applicable Products Types
T1	Severe environment, extremely rough handling in use. Moved about very frequently in use.	Small accessories type products (e.g. probes).
T2	Rugged environment, very rough handling in use. Moved about very frequently in use.	Hand held and other heavy field use type products (e.g. battery powered products).
3	Portable or bench-top use in multiple locations. Could be moved about frequently in use.	Portable type products and most plug-in units.
T4	Moderately portable use in a light industrial or commercial environment. Multiple location use. Moved about with care.	Semi-portable products.
5	Fixed location bench-top or rack mounted use.	Bench-top and rack mount products.
6	Fully protected and environmentally controlled location use such as laboratories.	Certain high performance displays and delicate test and measurement products.
7	Where special operational requirements are not compatible with the enviromental requirements of the other dynamics classes.	Special state of the art designed and constructed products.
T8	Office environment with a relatively fixed location.	Office and desk top products (e.g. printers, displays and medium-size systems on casters).

Qualification — Mechanical Shock Test for Unpackaged Products

Product Class	Half Sine, Peak Level (g) Instrument	Sub-Assembly	Pulse Duration (ms)	No. of Shocks Per Direction
T1, T2	Real world shock simulation (see Note 1 below)			
3	50	100	11	3
T4	40	80	11	3
5	30	60	11	3
6	20	40	11	3
7	(To be determined in the detailed specification for the product)			
T8	30	(To be determined)	11	3

Product Class	Sawtooth Peak Level (g), Pulse Duration (m Sec) Operational	Crash Safety (see note 3)	No. of Shocks Per Direction
T1, T2	Real world shock simulation (see Note 1 below)		—
3	40, 11	75, 6	3
T4	40, 11	75, 6	3
5	40, 11	75, 6	3
6	40, 11	75, 6	3
7	(To be determined in the detailed specification for the product)		
T8	Not Applicable		

NOTE 1: During real-world drops of small hand held items the shock levels experienced will be a function of drop height and, more importantly, the degree of padding inherent in the item and in the floor (carpeting, etc.) Because of the wide variation in amplitude, free-fall drops from some realistic height are recommended. The item should be dropped on each possible surface enough times to verify there is no problem.

NOTE 2: For fragile instruments that can tolerate very little shock while operating, such as disk drive systems that should be turned off and parked before moving is even attempted, it may make more sense to test only in the non-operating state to simulate the perceived worst case shipping environment and movement by the customer. Again, shock testing should be tailored to the specific use requirements.

NOTE 3: The crash safety test is a test for equipment mounted in an air or ground vehicle that could break loose from its mounts and present a hazard to vehicle occupants. It is intended for equipment mounts, and is not intended for equipment transported as loose cargo.

Engineering — Sine Sweep Vibration Resonance Search Methods

- The recommended test conditions are:
- The Option "A" Sine Vibration Qualification test conditions
- The Option "B" Sine Vibration Qualification test conditions
- The Option "C" Resonance Search test conditions, which are: 1 g constant acceleration, 5-100 Hz
- The Option "D" Resonance Search test conditions, which are: a stepped constant displacement approximation of Option "C", and are: 0.060 in., p-p constant displacement from 8-20 Hz, and 0.015 in., p-p constant displacement from 20-45 Hz, and 0.003 in., p-p constant displacement from 45-100 Hz.
- Resonance searches up to 500 Hz or even 2000 Hz may need to be considered, depending on the application.
- The sweep rate should be sufficiently slow to enable the detection and analysis of test item resonance responses. A rate of 0.5 octave per minute is recommended.
- Vibration dwells may be performed at specific frequencies of interest, to enable further analysis of test item resonance responses.

Analysis Criteria:

- Resonances resulting in test item responses exceeding 5 times the vibration input level could be potentially damaging. These resonances may need to be further evaluated and action taken to reduce the severity of the resonance.

Engineering — Component / Module Vibration Tests and Low Level Swept Sine Functional Vibration Test

Refer to the Tektronix Dynamics Enviroment Test Standard 062-2858-00 Revision B, for further details.

Engineering — Bench Handling Test

Dynamic Class	Height, Angle or Balance Point (Lesser of)
T1, T2, 3, T4, 5, 6	4 inches or 45 degrees or Balance Point
7	Refer to the detailed specification for the product
T8 (up to 35 lbs) (over 35 lbs)	4 inches or 45 degrees or Balance Point 2 inches or 15 degrees or Balance Point

NOTE: Test with cabinet installed/operating and again with cabinet removed/nonoperating, except where cabinet serves as only chassis support.

Engineering — Topple Test

Product in a normal use configuration and operating in satisfactory operation check mode.

Product placed on a non-resilient hard floor surface in a position that it could be reasonably be toppled from.

Tip the product over just past point of balance in a direction that it could be reasonably be toppled and allow the product to fall freely to the floor.

Repeat for other reasonable topple directions and for other reasonable topple starting positions.

Repeat for other use configurations of the product.

Engineering — Accessory Cable Pull-out Test

Restain the cable in a manner that allows the product under test to fall a distance of 30 inches (or to maximum cable length if less than 30 inches in length) without interference and without contacting the floor.

Drop the product (3) times from this height.

Production Process — Environmental Stress Screening

Contact the Tektronix Environmental Labs for further details.

Tektronix Dynamic Test Standard Quick Reference Sheet 2

Transportation Package Performance Test

Qualification Sequence	1	2	3	4	5	6	7
Distribution Cycle 1	Single Package with a Packaged Weight under 150 lbs. (68.1 Kg)			Packaged products shipped directly to the end user through the normal Tektronix distribution system including UPS shipments.			
Test Type	Handling	Warehouse and Vehicle Stacking	Loose Load Vibration	Vehicle Vibration	Handling		
Element	**A1**	**C**	**D**	**E**	**A2**		
Distribution Cycle 2	Single Package with a Packaged Weight over 150 lbs. (68.1 Kg)			Larger packaged products that may or may not be individually palletized or products that are unitized on a pallet for shipment in bulk to the end user through normal Tektronix distribution.			
Test Type	Handling	Warehouse and Vehicle Stacking	Loose Load Vibration	Vehicle Vibration	Handling		
Element	**B**	**C**	**D**	**E**	**B**		
Distribution Cycle 3	OEM Package with a Packaged Weight under 150 lbs. (68.1 Kg)			Packaged products that come to Tektronix for redistribution to our customers or packaged products sold to outside companies for redistribution to their customers..			
Test Type	Handling	Warehouse and Vehicle Stacking	Handling	Warehouse and Vehicle Stacking	Loose Load Vibration	Vehicle Vibration	Handling
Element	**A1**	**C**	**A1**	**C**	**D**	**E**	**A2**
Distribution Cycle 4	OEM Package with a Packaged Weight over 150 lbs. (68.1 Kg)			Larger packaged products that may or may not be individually palletized that come to Tektronix for redistribution to our customers or packaged products sold to outside companies for redistribution to their customers.			
Test Type	Handling	Warehouse and Vehicle Stacking	Handling	Warehouse and Vehicle Stacking	Loose Load Vibration	Vehicle Vibration	Handling
Element	**B**	**C**	**B**	**C**	**D**	**E**	**B**

Element A1

Handling up to 150 pounds (68.1 kg)
(Shock Test)

• Drop heights for element A1:

PACKAGED PRODUCT WEIGHT pounds (kg)		FREE-FALL DROP HEIGHT inches (cm) Assurance Level I	II
0 - 20	(0 - 9.1)	24 (61)	15 (38.1)
> 20 - 40	(> 9.1 - 18.2)	21 (53.3)	13 (33.0)
> 40 - 60	(>18.2 - 27.3)	18 (45.7)	12 (30.5)
> 60 - 80	(>27.3 - 36.4)	15 (38.1)	10 (25.4)
> 80 - 100	(>36.4 - 45.5)	12 (30.5)	9 (22.9)
>100 - 150	(>45.5 - 68.2)	10 (25.4)	7 (17.8)

• Drop sequence for element A1:
Bottom, top, two bottom corners, two bottom edges.

NOTE: When a second A1 handling operation is present in the distribution cycle, drop the packaged product on corners and edges not previously tested.

Element A2

Handling up to 150 pounds (68.1 kg)
(Shock Test)

• Drop heights for element A2:

PACKAGED PRODUCT WEIGHT pounds (kg)		FREE-FALL DROP HEIGHT inches (cm) Assurance Level I	II
0 - 20	(0 - 9.1)	24 (61)	15 (38.1)
> 20 - 40	(> 9.1 - 18.2)	21 (53.3)	13 (33.0)
> 40 - 60	(>18.2 - 27.3)	18 (45.7)	12 (30.5)
> 60 - 80	(>27.3 - 36.4)	15 (38.1)	10 (25.4)
> 80 - 100	(>36.4 - 45.5)	12 (30.5)	9 (22.9)
>100 - 150	(>45.5 - 68.2)	10 (25.4)	7 (17.8)

• Drop sequence for element A2:
Front, rear, left hand side, right hand side, bottom.

NOTE: Bottom drop will be made at twice the specified height.

Element B

Handling over 150 pounds (68.1 kg)
(Shock Test)

• Drop heights for element B:

PACKAGED PRODUCT WEIGHT pounds (kg)		FREE-FALL DROP HEIGHT inches (cm) Assurance Level I	II
150 - 500	(68.2 - 227.3)	12 (30.5)	9 (22.9)
500+	(227.3+)	9 (22.9)	6 (15.2)

• Element B drop sequence:
Rotational Edge Drop, Corner Drop, Unsupported Free Fall Drop

Element C

Warehouse and Vehicle Stacking (Compression Test)
L = [W(H - h)/h][F] where:
L = min.required load, lbf or N
W = weight of one shipping unit or individual container, lbf or N
H= maximum height of stack in storage or transit vehicle, in. or m.
h = height of shipping unit or individual container, in. or m
F = a factor to account for the combined effect of the individual factors described below

Shipping Unit Construction	F Factor Assurance Level I	II
1. Corr. w/o internal support	8.0	4.5
2. Corr. with internal support	4.5	3.0
3. Other mtl. w/o internal support	3.0	2.0
4. Product supports part of load formula	$F = P(F_p) + C(F_c)$	

Where:

Fp = factor given above for compression package (construction type 3)
P = % of load supported by product
Fc = factor given for appropriate container construction
C = % of load supported by container
NOTE: If a full pallet load is tested, F factors may be reduced by 30%
Procedure: Once load (L) has been calculated, load the shipping unit to this value. Remove the load immediately after reaching the specified value.

Element D

Loose Load Vibration
(Repetitive Shock Test)

• Place the packaged product on the vibration table in its vertical top to bottom orientation without restricting its movement.
• Adjust the vibration frequency until the package leaves the platform approximately 0.125 inches (0.32 cm).
• Perform test for 30 minutes on package bottom and 30 minutes on a side. The side to be tested will be the surface on which the package rests in its most stable configuration other than the top or bottom. If this is impractical, the packaged product can be rotated 180 degrees and tested in this orientation.
• Palletized products will normally be vibrated for the total 60 minutes with the pallet surface down.

Element E

Vehicle Vibration
(Random Vibration)

• Perform test in 3 major axis
• Overall GRMS: 1.33
• Test time: 1 hour per axis
• Test conditions:

Breakpoint Frequency (Hz)	Acceleration Power Spectral Density (APSD) (g2/Hz)
5	0.015
40	0.015
50	0.010
100	0.010
125	0.003
200	0.003
500	0.00015

Qualification — Transportation Package Performance Test

Distribution Cycle 5 This distribution cycle allows optional individual transportation test selection and sequencing for packaged products for which the formal test sequences of the other distribution cycles is not applicable

Test Type User Defined

Element One or a combination of individual tests can be selected from the other distribution cycles and from the optional set of vibration and shock test methods for packaged products.

Optional Packaged Product Vibration Test Methods

Method A (Random Vibration)

Breakpoint Frequency Hz	Acceleration Power Spectral Density (APSD) g^2/Hz
5	0.0150
40	0.0150
50	0.0100
100	0.0100
125	0.0030
200	0.0030
500	0.00015

Overall Vibration Level: 1.33
Test Time Per Axis: 1 Hour
Major Axes tested: 3

Method B (Repetitive Shock/Vibration)

- Adjust vibration frequency until package leaves platform about 1/16" (usually at about 1.1g at 4.64 Hz or 278 rpm)
- Test 30 minutes in normal shipping orientation (e.g. on package bottom) and an additional 30 minutes on a side (Use top if side is unstable)
- Palletized products tested 60 minutes on bottom side only

Method C (Sine Sweep & Resonance Dwell)

- Frequency Cycle: 5-100-5 Hz
- Number of Cycles: 2
- Vibration amplitude: 0.5g
- Sweep Rate: 0.5 to 1.0 octave/minute
- Vibration dwell for 15 minutes at each resonant frequency, limited to a maximum of 4 most severe resonances per axis
- Repeat Test for each of the 3 major axes

Optional Packaged Product Shock Test Methods

Packaged Product Weight Up To 150 LB Free-Fall Drop Shock

Drop Sequence
- Top
- Bottom
- Four sides
- One critical corner
- Three edges radiating from the critical corner

Packaged Weight (LBS)	Drop Height (inches)
0-20	36
>20-40	30
>40-60	24
>60-100	18
>100-150	12

Packaged Product Weight Over 150 LB Free-Fall Drop Shock (Method A)

- Drop onto each of 6 faces from 6.25 inches
- Top face drop may be eliminated for definite skid bottom packages and packages over 500 LBS. If so conduct 2 bottom face free-fall drops or 2 bottom tilt drops form 8 inches.

Packaged Product Weight Over 150 LBS Tilt/Edge Rotation Drop Shock (Method B)

- Place packaged product on a hard floor surface
- Raise 1 edge 8" and allow to drop freely
- Repeat for each of the 4 edges of each face

Engineering — Fragility Test of Mechanical Package

Procedure: Perform the critical velocity change test first to determine the critical velocity of the test specimen. Use this value to perform the critical acceleration amplitude test. This information can be used for product redesign to increase fragility of the test specimen as well as to gain information for shipping package design.

Critical Velocity Change Test:
1) 1/2 sine shock pulse.
2) Begin dropping at 2" and increase each drop 1" until damage.

Critical Acceleration Amplitude Shock Test:
1) Trapezoidal shock pulse.
2) Multiply critical velocity by 2.0 and choose a shock table drop height from table B that will produce at least this velocity change.
3) Begin dropping at 100 psi gas pressure and increase each drop by 50 psi until damage.

Critical Velocity Table A

Drop Height (in)		Velocity Change (in/sec)	
2	9	81	148
3	10	93	157
4	11	103	162
5	12	118	169
6	13	124	176
7	14	134	185
8	15	143	190

Critical Acceleration Table B

Drop Height (in)		Velocity Change (in/sec)	
3	24	71	174
6	27	97	182
9	30	116	189
12	33	131	196
15	36	143	202
18		156	
21		165	