2 pages withheld in their entirety
exemption 4

AFFIDAVIT

I, Stephen G. Bindon, being sworn, depose and say as follows:

1. I am President of Trijicon, Inc. (the "Corporation"). In my capacity as such, I am authorized to execute this Affidavit on behalf of the Corporation and have reviewed the Information set forth in Section 2.

2. I execute this Affidavit pursuant to 10 CFR 2.390 and request that the following be withheld in whole from public disclosure (collectively, the "Drawings"):

> The following data, spreadsheets, drawings, pictures, and photographs (the "Drawings") in their entirety submitted to the U.S. Nuclear Regulatory Commission (the "Commission") in connection with the renewal of Exempt Materials License No. 21-19874-01 and Amendment to our Registry of Radioactive Seal Sources and Devices License No. NR-418-D-101-E.
>
> (a) Attachment 1: MRD3056
> (b) Attachment 2: Estimated Radiation Dose Commitments
> (c) Attachment 3: Miniature Reflex Sight Model Listing
> (d) Attachment 4: Miniature Reflex Sight Prototype Testing Report
> (e) Attachment 6: Reflex Model Listing
> (f) Attachment 8: Reflex Series Test Report
> (g) Attachment 9: Advanced Radiation Monitoring Service Analysis Report
> (h) Attachment 11: ARMS Report 9-30-08
> (i) Attachment 12: TRF3273

3. The Drawings contain trade secrets or privileged or confidential commercial or financial information, and such Information:

(a) has been held in confidence by the Corporation;

(b) is of the type that is customarily and rationally held in confidence by the Corporation due to the sensitive design specifications on Engineering drawings;

(c) was transmitted to and, to my knowledge, received by the Commission in confidence;

(d) is not available in public sources; and

(e) is of the type and nature that, if disclosed publicly, is likely to cause substantial harm to the competitive position of the Corporation by disclosing exact dimensions, tolerances, material specifications, assembly techniques and procedures, which are all

proprietary designs of Trijicon Inc. If such information is revealed as public documents, it may reveal the technology that Trijicon Inc. has researched & developed to become the leader in high quality optics and sighting devices, thus harming our competitive position.

IN WITNESS WHEREOF, I have executed this Affidavit on October 1, 2008.

Stephen G. Bindon
President

STATE OF MICHIGAN)
) ss.
COUNTY OF OAKLAND)

The foregoing instrument was acknowledged before me this 1st day of October, 2008, by STEPHEN G. BINDON

Notary Public, MICHIGAN County, LIVINGSTON
My Commission Expires: OCTOBER 18, 2014

JUDITH E. BASTIAN
NOTARY PUBLIC, STATE OF MI
COUNTY OF LIVINGSTON
MY COMMISSION EXPIRES Oct 18, 2014
ACTING IN COUNTY OF OAKLAND

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Attachment 5

NSF International Strategic Registrations, Ltd.

A Subsidiary of NSF International
789 North Dixboro Road, Ann Arbor, Michigan 48105
(888) NSF-9000

Certificate of Registration

This certifies that the Quality Management System of

Trijicon, Inc.

49385 Shafer Avenue
P.O. Box 930059
Wixom, Michigan, 48393-0059 USA

has been assessed by NSF-ISR and found to be in conformance to the following standard(s):

ISO 9001:2000

Scope of Registration:

Design and manufacture of small arms optical sighting devices.

Industrial Classification:

IAF: 17, 19
SIC: 3829, 3499
NACE: DJ 28.7, DL 33.4

Certificate Number: 61341-5
Certificate Issue Date: 01/10/2007
Company Initial Date: 07/19/1999
Registration Date: 12/05/2006
Expiration Date*: 12/04/2009

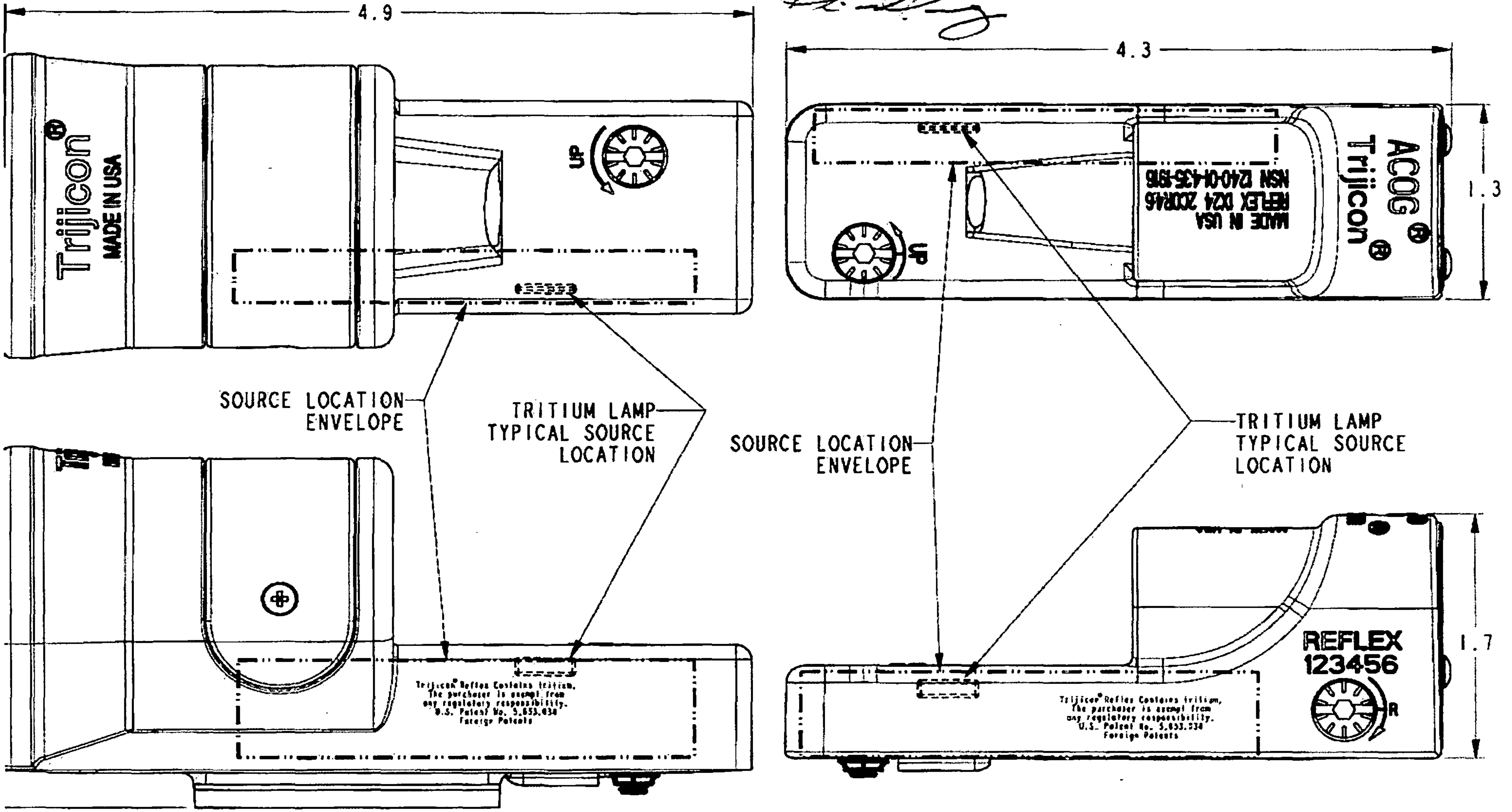
Christian B. Lupo, General Manager
NSF-ISR, Ltd.

Authorized Registration and/or Accreditation Marks

This certificate is the property of NSF-ISR and must be returned upon request. *Company is audited for compliance at regular intervals. To verify registration call (888) NSF-9000 or visit our web site at www.nsf-isr.org.

1 page withheld in its entirety
exemption 4

Attachment 7



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'ARY FROM THE NOMINAL DIMENSIONAL ENVELOPE.
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'ION AS SHOWN IN THE SOURCE LOCATION
.OPE.

DRAFTSMAN: M.LISTER	DATE: 10-01-08	Trijicon, Inc. 49385 SHAFER AVE, WIXOM, MI 48393-0059 PH(248) 960-7700 FAX(248) 960-7725	
CHECKER: A.ADKINS	DATE: 10-01-08	TITLE: REFLEX REFLEX ASSEMBLY	
ENGINEER: M.LISTER	DATE: 10-01-08		
Sr. ENGINEER: D.SCHICK	DATE: 10-01-08	SIZE: A DRAWING NO.: TRF3272	REV. -
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METHOD 514.5

VIBRATION

NOTES:

Tailoring is essential. Select methods, procedures, and parameter levels based on the tailoring process described in Part One, paragraph 4, and Appendix C. Apply the general guidelines for laboratory test methods described in Part One, paragraph 5 of this standard.

Organization. The main body of this method is arranged similarly to the other methods of MIL-STD-810F. A considerable body of supplementary information is included in the Annexes. With the exception of table 514.5-I, all tables and figures for the entire method are in Annex C. Reference citations to external documents are at the end of the main body (paragraph 6). The annexes are as follows:

ANNEX A - TAILORING GUIDANCE FOR VIBRATION EXPOSURE DEFINITION

ANNEX B - ENGINEERING INFORMATION

ANNEX C - TABLES AND FIGURES

1. SCOPE.

1.1 Purpose.

Vibration tests are performed to:

a. Develop materiel to function in and withstand the vibration exposures of a life cycle including synergistic effects of other environmental factors, materiel duty cycle, and maintenance. Combine the guidance of this method with the guidance of Part One and other methods herein to account for environmental synergism.

b. Verify that materiel will function in and withstand the vibration exposures of a life cycle.

1.2 Application.

a. General. Use this method for all types of materiel except as noted in MIL-STD-810F, Part One, paragraph 1.3 and as stated in section 1.3 below. For combined environment tests, conduct the test in accordance with the applicable test documentation. However, use this method for determination of vibration test levels, durations, data reduction, and test procedure details.

b. Purpose of test. The test procedures and guidance herein are adaptable to various test purposes including development, reliability, qualification, etc. See Annex B for definitions and guidance.

c. Vibration life cycle. Table 514.5-I provides an overview of various life cycle situations during which some form of vibration may be encountered, along with the anticipated platform involved. Annex A provides guidance for estimating vibration levels and durations and for selection of test procedures. Annex B provides definitions and engineering guidance useful in interpreting and applying this method. International Test Operations Procedure (ITOP) 1-2-601 (ref d) includes an assortment of specific ground vehicle and helicopter vibration data.

d. Manufacturing. The manufacture and acceptance testing of materiel involves vibration exposures. These exposures are not directly addressed herein. It is assumed that the manufacturing and acceptance process completed on the units that undergo environmental testing are the same as the process used to produce deliverable units. Thus the environmental test unit(s) will have accumulated the same damage prior to test as a delivered unit accumulates prior to delivery. The environmental test then verifies the field life of

delivered units. When a change is made to the manufacturing process that involves increased vibration exposure, evaluate this increased vibration exposure to ensure the field life of subsequent units is not shortened. An example might be a pre-production unit completely assembled in one building, whereas production units are partially assembled at one site and then transported to another site for final assembly. Such exposures could be incorporated as pre-conditioning to the test program.

e. Environmental Stress Screen (ESS). Many materiel items are subjected to ESS, burn-in, or other production acceptance test procedures prior to delivery to the government and sometimes during maintenance. As in basic production processes, it is assumed that both the test units and the field units receive the same vibration exposures so that environmental test results are valid for the field units. Where units do not necessarily receive the same exposures, such as multiple passes through ESS, apply the maximum allowable exposures to the units used for environmental test as pre-conditioning for the environmental tests. (See Annex A, paragraph 2.1.3 and Annex B, paragraph 2.1.8.)

1.3 Limitations.

a. Safety testing. This method may be used to apply specific safety test requirements as coordinated with the responsible safety organization. However, vibration levels or durations for specific safety related issues are not provided or discussed.

b. Platform/materiel interaction. In this method, vibration requirements are generally expressed as inputs to materiel that is considered to be a rigid body with respect to the vibration exciter (platform, shaker, etc.). While this is often not true, it is an acceptable simplification for smaller materiel items. For large materiel items, it is necessary to recognize that the materiel and the exciter vibrate as a single flexible system. There is no simple rule to determine the validity of this assumption (see Annex B, paragraph 2.4). Further, proper treatment of a given materiel item may vary with platform. An example might be a galley designed for an aircraft. For the operational environment, installation on an operating aircraft, consider the galley structure as aircraft secondary structure, and design and test accordingly. Design subassemblies within the galley (e.g., coffee maker) for vibration levels based on guidance of Annex A and tested in accordance with Procedure I. When packaged for shipment, the packaging, galley, and subassemblies are considered a single materiel item, and tested accordingly. Another example is a shelter transported to the field as a pre-assembled office, laboratory, etc. Consider the shelter as large materiel and develop accordingly. A suitable test would be the large assembly transport test of paragraph 4.4.3. Where impedance mismatch between platform/materiel and laboratory vibration exciter/test item are significantly different, force control or acceleration limiting control strategies may be required to avoid unrealistically severe vibration response (see paragraph 4.2). Control limits should be based upon field and laboratory measurements. For sensitive materiel for which over-conservative testing philosophy must not be applied, force or acceleration limiting control is an option. In certain cases in which the field measured response is well defined on a small component, the duration of the vibration is short, then execution of the laboratory test under open loop waveform control based upon the field measured data is an option.

c. Manufacture and maintenance. Vibration associated with processes at the manufacturer's facility, or experienced during maintenance is not addressed herein. Guidance concerning transportation environments may be applicable to transportation elements of manufacture or maintenance processes.

d. Environmental Stress Screen (ESS). No guidance for selection of ESS exposures is contained herein. Some discussion is in Annex A, paragraph 2.1.3.

2. TAILORING GUIDANCE.

2.1 Selecting the Method.

Essentially all materiel will experience vibration, whether during manufacture, transportation, maintenance, or operational use. The procedures of this method address most of the life cycle situations during which vibration is likely to be experienced. Select the procedure or procedures most appropriate for the materiel to be tested and the

environment to be simulated. See table 514.5-I for a general listing of vibration exposures and test procedures as related to environmental life cycle elements. See Annex A for guidance on determining vibration levels and durations.

a. Conservatism in selection of levels. In the past, vibration test criteria often contained added margin to account for variables that cannot be included in criteria derivation. These include (among many others) undefined worst case situations, synergism with other environmental factors (temperature, acceleration, etc.), and three-axis orthogonal versus three dimensional vibration. Due to strong pressure toward minimum cost and weight, this margin is often not included. When margin is not included, be aware that any improvements in weight or cost are purchased with added risk to materiel life and function.

b. Conservatism with measured data. The guidance in this document encourages the use of materiel-specific measured data as the basis for vibration criteria. Due to limitations in numbers of transducers, accessibility of measurement points, linearity of data at extreme conditions, and other causes, measurements do not include all extreme conditions. Further, there are test limitations such as single axis versus multi-axis, and practical fixtures versus platform support. Apply margin to measured data in deriving test criteria to account for these variables. When sufficient measured data are available, use statistical methods as shown in method 516.5.

c. Conservatism with predicted data. Annex A of this method and other sources such as the Mission Environmental Requirements Integration Technology (MERIT) computer program provide information which can be used to generate alternate criteria for those cases where measured data are unavailable. These data are based on envelopes of wide ranges of cases and are conservative for any one case. Additional margin is not recommended.

2.1.1 Effects of environment.

Vibration results in dynamic deflections of and within materiel. These dynamic deflections and associated velocities and accelerations may cause or contribute to structural fatigue and mechanical wear of structures, assemblies, and parts. In addition, dynamic deflections may result in impacting of elements and/or disruption of function. Some typical symptoms of vibration-induced problems follow. This list is not intended to be all-inclusive:

a. Chafed wiring.

b. Loose fasteners/components.

c. Intermittent electrical contacts.

d. Electrical shorts.

e. Deformed seals.

f. Failed components.

g. Optical or mechanical misalignment.

h. Cracked and/or broken structures.

i. Migration of particles and failed components.

j. Particles and failed components lodged in circuitry or mechanisms.

k. Excessive electrical noise.

l. Fretting corrosion in bearings.

2.1.2 Sequence.

Tailor the test sequence as a function of the life cycle environments of the specific Program (See Part One, paragraph 5.5).

a. General. The accumulated effects of vibration-induced stress may affect materiel performance under other environmental conditions such as temperature, altitude, humidity, leakage, or electromagnetic interference (EMI/EMC). When evaluating the cumulative environmental effects of vibration and other environments, expose a single test item to all environmental conditions, with vibration testing generally performed first. If another environment (e.g., temperature cycling) is projected to produce damage that would make the materiel more susceptible to vibration, perform tests for that environment before vibration tests. For example, thermal cycles might initiate a fatigue crack that would grow under vibration or vice versa.

b. Unique to this method. Generally, expose the test item to the sequence of individual vibration tests that follow the sequence of the life cycle. For most tests, this can be varied if necessary to accommodate test facility schedules or for other practical reasons. However, always perform some tests in the life cycle sequence. Complete all manufacture associated preconditioning (including ESS) before any of the vibration tests. Complete any maintenance associated preconditioning (including ESS) prior to tests representing mission environments. Perform tests representing critical end-of-mission environments last.

2.2 Selecting Procedures.

Identify the environments of the materiel life cycle during the tailoring process as described in Part One. Table 514.5-I provides a list of vibration environments by category versus test procedure. Descriptions of each category listed in this table are included in Annex A along with information for tailoring the test procedures of paragraph 4 below, and alternate test criteria for use when measured data are not available. In general, test materiel for each category to which it will be exposed during an environmental life cycle. Tailor test procedures to best accomplish the test purpose (see Annex B, paragraph 2.1), and to be as realistic as possible (Annex A, paragraph 1.2).

2.2.1 Procedure selection considerations.

Depending on relative severity, it may be acceptable to delete vibration tests representing particular life cycle elements for a materiel test program. Base such decisions on consideration of both vibration amplitude and fatigue damage potential across the frequency range of importance. Make analytical estimates of fatigue damage potential on the basis of simple, well-understood models of the materiel.

a. Transportation vibration more severe than application environment. Transportation vibration levels are often more severe than application vibration levels for ground-based and some shipboard materiel. In this case, both transportation and platform vibration tests are usually needed because the transportation test is performed with the test item non-operating and the platform test is performed with the test item operating.

b. Application vibration more severe than transportation vibration. If the application vibration levels are more severe than the transportation levels, it may be feasible to delete transportation testing. It may also be feasible to change the application test spectrum shape or duration to include transportation requirements in a single test. In aircraft applications, a minimum integrity test (see Annex A, paragraph 2.4.1) is sometimes substituted for transportation and maintenance vibration requirements.

c. Transportation configuration versus application configuration. In evaluation of the relative severity of environments, include the differences in transportation configuration (packaging, shoring, folding, etc.) and application configuration (mounted to platform, all parts deployed for service, etc.). In addition, transportation environments are usually defined as inputs to the packaging, whereas application environments are expressed as inputs to the materiel mounting structure or as response of the materiel to the environment.

2.2.2 Difference among procedures.

a. Procedure I - General Vibration. Use Procedure I for those cases where a test item is secured to a vibration exciter and vibration is applied to the test item at the fixture/test item interface. Steady state or transient vibration may be applied as appropriate.

b. Procedure II - Loose Cargo Transportation. Use this procedure for materiel to be carried in/on trucks, trailers, or tracked vehicles and not secured to (tied down in) the carrying vehicle. The test severity is not tailorable and represents loose cargo transport in military vehicles traversing rough terrain.

c. Procedure III - Large Assembly Transportation. This procedure is intended to replicate the vibration and shock environment incurred by large assemblies of materiel installed or transported by wheeled or tracked vehicles. It is applicable to large assemblies or groupings forming a high proportion of vehicle mass, and to materiel forming an integral part of the vehicle. In this procedure, use the specified vehicle type to provide the mechanical excitation to the test materiel. The vehicle is driven over surfaces representative of service conditions, resulting in realistic simulation of both the vibration environment and the dynamic response of the test materiel to the environment. Generally, measured vibration data are not used to define this test. However, measured data are often acquired during this test to verify that vibration and shock criteria for materiel subassemblies are realistic.

d. Procedure IV - Assembled Aircraft Store Captive Carriage and Free Flight. Apply Procedure IV to fixed wing aircraft carriage and free flight portions of the environmental life cycles of all aircraft stores, and to the free flight phases of ground or sea launched missiles. Use Procedure I, II or III for other portions of the store's life cycle as applicable. Steady state or transient vibration may be applied as appropriate. Do not apply Procedure I to fixed wing aircraft carriage or free flight phases.

2.3. Determine Test Levels and Conditions.

Select excitation form (steady state or transient), excitation levels, control strategies, durations and laboratory conditions to simulate the vibration exposures of the environmental life cycle as accurately as possible. Whenever possible, acquire measured data as a basis for these parameters. Annex A includes descriptions of various phases typical of an environmental life cycle along with discussions of important parameters and guidance for developing test parameters. Annex B has further guidance in interpretation of technical detail.

2.3.1 Climatic conditions.

Many laboratory vibration tests are conducted under Standard Ambient Test Conditions as discussed in Part One, paragraph 5. However, when the life cycle events being simulated occur in environmental conditions significantly different than standard conditions, consider applying those environmental factors during vibration testing. Individual climatic test methods of this standard include guidance for determining levels of other environmental loads. Methods 520.2, "Temperature, Humidity, Vibration, Altitude," and 523.2, "Vibro-Acoustic/Temperature," contain specific guidance for combined environments testing.

TABLE 514.5-I. Vibration environment categories.

Life Phase	Platform	Category	Materiel Description	Level & Duration Annex A	Test [1]
Manufacture / Maintenance	Plant Facility / Maintenance Facility	1. Manufacture / Maintenance processes	Materiel / assembly / part	2.1.1	[2]
		2. Shipping, handling	Materiel / assembly / part	2.1.2	[2]
		3. ESS	Materiel / assembly / part	2.1.3	[3]
Transportation	Truck / Trailer / Tracked	4. Restrained Cargo	Materiel as restrained cargo [4]	2.2.1	I
		5. Loose Cargo	Materiel as loose cargo [4]	2.2.2	II
		6. Large Assembly Cargo	Large assemblies, shelters, van and trailer units [4]	2.2.3	III
	Aircraft	7. Jet	Materiel as cargo	2.2.4	I
		8. Propeller	Materiel as cargo	2.2.5	I
		9. Helicopter	Materiel as cargo	2.2.6	I
	Ship	10. Surface Ship	Materiel as cargo	2.2.7	I
	Railroad	11. Train	Materiel as cargo	2.2.8	I
Operational	Aircraft	12. Jet	Installed Materiel	2.3.1	I
		13. Propeller	Installed Materiel	2.3.2	I
		14. Helicopter	Installed Materiel	2.3.3	I
	Aircraft Stores	15. Jet	Assembled stores	2.3.4	IV
		16. Jet	Installed in stores	2.3.5	I
		17. Propeller	Assembled / Installed in stores	2.3.6	IV/I
		18. Helicopter	Assembled / installed in stores	2.3.7	IV/I
	Missiles	19. Tactical Missiles	Assembled / installed in missiles (free flight)	2.3.8	IV/I
	Ground	20. Ground Vehicles	Installed in wheeled / tracked / trailer	2.3.9	I/III
	Watercraft	21. Marine Vehicles	Installed Materiel	2.3.10	I
	Engines	22. Turbine Engines	Materiel Installed on	2.3.11	I
	Personnel	23. Personnel	Materiel carried by/on personnel	2.3.12	[2]
Supplemental	All	24. Minimum Integrity	Installed on Isolators / Life cycle not defined	2.4.1	I
	All Vehicles	25. External Cantilevered	Antennae, airfoils, masts, etc.	2.4.2	[2]

[1] Test procedure – see paragraph 4
[2] See Annex A reference.
[3] Use applicable ESS procedure.
[4] See paragraph 2.3.2.

2.3.2 Test item configuration.

Configure the test item for each test, as it will be in the corresponding life cycle phase. In cases representing transportation, include all packing, shoring, padding, or other configuration modifications of the particular shipment mode. The transportation configuration may be different for different modes of transportation.

a. Loose cargo. The method contained herein is a general representation based on experience as well as measurement, and is not tailorable (see Annex A, paragraph 2.2.2 for details). The most realistic alternative for truck, trailer, or other ground transportation is to utilize Procedure III. Note that Procedure III requires the transportation vehicle and a full cargo load.

b. Restrained cargo. Procedure I assumes no relative motion between the vehicle cargo deck or cargo compartment and the cargo. This applies directly to materiel that is tied down or otherwise restrained such that no relative motion is allowed considering vibration, shock, and acceleration loads. When restraints are not used or are such as to allow limited relative motions, provide allowance in the test set up and in the vibration excitation system to account for this motion. Procedure III is an alternative for ground transportation.

c. Stacked cargo. Stacking or bundling of sets or groups of materiel items may effect the vibration transmitted to individual items. Ensure the test item configuration includes appropriate numbers and groupings of materiel items.

2.4 Test Item Operation.

Whenever practical, ensure test items are active and functioning during vibration tests. Monitor and record achieved performance. Obtain as much data as possible that defines the sensitivity of the materiel to vibration. Where tests are conducted to determine functional capability while exposed to the environment, function the test item. In other cases, function the item where practical. Functioning during transportation will not be possible in almost all cases. Also, there are cases where the functional configuration varies with mission phase, or where operation at high levels of vibration may not be required and may be likely to result in damage.

3. INFORMATION REQUIRED.

The following information is required to conduct and document vibration tests adequately. Tailor the lists to the specific circumstances, adding or deleting items as necessary. Although generally not required in the past, perform fixture and materiel modal surveys when practical. These data are useful in evaluating test results, and in evaluating the suitability of materiel against changing requirements or for new applications. These data can be particularly valuable in future programs where the major emphasis will be to utilize existing materiel in new applications. (When modal survey is ruled out for programmatic reasons, a simple resonance search can sometimes provide useful information.)

3.1 Pretest.

a. General. See Part One, paragraphs, 5.7 and 5.9; and Appendix A, Tasks 405 and 406 of this standard.

b. Specific to this method.

(1) Test fixture requirements.

(2) Test fixture modal survey procedure.

(3) Test item/fixture modal survey procedure.

(4) Vibration exciter control strategy.

(5) Test tolerances.

(6) Requirements for combined environments.

(7) Test schedule(s) and duration of exposure(s).

(8) Axes of exposure.

(9) Measurement instrumentation configuration.

(10) Test shutdown procedures for test equipment or test item problems, failures, etc.

(11) Test interruption recovery procedure.

(12) Test completion criteria.

c. Specific to Procedure.

(1) Procedure II - Loose cargo vibration. Define the orientation of test item(s) in relation to the axis of throw of the test table.

(2) Procedure III - Large assembly transportation. Define the test vehicle(s), loading(s), surface(s), distance(s), and speed(s).

NOTE: Modal surveys of both test fixtures and test items can be extremely valuable. Large test items on large complex fixtures are almost certain to have fixture resonances within the test range. These resonances result in large overtests or undertests at specific frequencies and locations within a test item. Where fixture and test item resonances couple, the result can be catastrophic. Similar problems often occur with small test items, even when the shaker/fixture system is well designed because it is very difficult and often impractical to achieve a lowest fixture resonant frequency above 2000 Hz. In cases where the fixture/item resonance coupling cannot be eliminated, consider special vibration control techniques such as acceleration or force limit control.

3.2 During Test.

Collect the information listed in Part One, paragraph 5.10, and in Appendix A, Tasks 405 and 406 of this standard.

3.3 Post-Test.

a. General. See Part One, paragraph 5.13, and Appendix A, Task 406 of this standard.

b. Specific to this method.

(1) Summary and chronology of test events, test interruptions, and test failures.

(2) Discussion and interpretation of test events.

(3) Functional verification data.

(4) Test item modal analysis data.

(5) Fixture modal analysis data.

(6) All vibration measurement data.

4. TEST PROCESS.

Tailor the following sections as appropriate for the individual contract or program. Note that if these sections are directly referenced in a contract, they will generally not comply with current and future Department of Defense requirements for contractual language.

4.1 Test Facility.

Use a test facility, including all auxiliary equipment, capable of providing the specified vibration environments and the control strategies and tolerances discussed in paragraph 4.2. In addition, use measurement transducers, data recording and data reduction equipment capable of measuring, recording, analyzing and displaying data sufficient to

document the test and to acquire any additional data required. Unless otherwise specified, perform the specified vibration tests and take measurements at standard ambient conditions as specified in Part One, paragraph 5.1.

4.1.1 Procedure I - General vibration.

This procedure utilizes standard laboratory vibration exciters (shakers), slip tables, and fixtures. Choose the specific exciters to be used based on size and mass of test items and fixtures, the frequency range required, and the low frequency stroke length (displacement) required.

4.1.2 Procedure II - Loose cargo transportation.

Simulation of this environment requires use of a package tester (figure 514.5C-5) that imparts a 25.4 mm (1.0 inch) peak-to-peak, circular motion to the table at a frequency of 5 Hz. This motion takes place in a vertical plane. The figure shows the required fixturing. This fixturing does not secure the test item(s) to the bed of the package tester. Ensure the package tester is large enough for the specific test item(s) (dimensions and weight).

a. Test bed. Cover the test bed of the package tester with a cold rolled steel plate (see note), 5 to 10 mm (0.2 to 0.4 in) thick, and secure the plate with bolts, the tops of the heads of which are slightly below the surface. Space the bolts at sufficient intervals around the four edges and through the center area to prevent diaphragming of the steel plate. Do not start a test on an area of steel plate that is severely damaged or worn through.

b. Fencing. The fence opposite the vertical impact wall is not intended as an impact surface, but is used to restrain the test item from leaving the tester. The distance to this restraining fence should be sufficient to prevent constant impact, but still prevent one or more of multiple test items from "walking" away from the others. The height of the test enclosure (sideboards, impact wall, and restraining fence) should be at least 5 cm higher than the height of the test item to prevent unrealistic impacting of the test item on the top of the enclosure.

Note: Comparison of plywood bed and steel bed data show no statistical difference. Also, steel bed requires less maintenance and U. S. Army trucks use steel beds. See reference a.

4.1.3 Procedure III - Large assembly transportation.

The test facility for this method is a test surface(s) and vehicle(s) representative of transportation and/or service phases of the environmental life cycle. The test item is loaded on the vehicle and restrained or mounted to represent the life cycle event. The vehicle is then driven over the test surface in a manner that reproduces the transportation or service conditions. The test surfaces may include designed test tracks (e.g., test surfaces at the U. S. Army Aberdeen Test Center, reference b), typical highways, or specific highways between given points (e.g., a specified route between a manufacturing facility and a military depot). Potentially, such testing can include all environmental factors (vibration, shock, temperature, humidity, pressure, etc.) related to wheeled vehicle transport.

4.1.4 Procedure IV - Assembled aircraft store captive carriage and free flight.

This procedure utilizes standard laboratory vibration exciters (shakers) driving the test item directly or through a local fixture. The test item is supported by a test frame independent of the vibration exciters (see paragraph 4.4.4). Select the specific exciters based on size and mass of test items and fixtures, frequency range, and low frequency stroke length (displacement) required.

4.2 Controls.

The accuracy in providing and measuring vibration environments is highly dependent on fixtures and mountings for the test item, the measurement system and the exciter control strategy. Ensure all instrumentation considerations are in accordance with the best practices available (see reference c). Careful design of the test set up, fixtures, transducer mountings and wiring, along with good quality control will be necessary to meet the tolerances of paragraph 4.2.2 below.

4.2.1 Control strategy.

Select a control strategy that will provide the required vibration at the required location(s) in or on the test item. Base this selection on the characteristics of the vibration to be generated and platform/material interaction (see paragraph 1.3b above and Annex B, paragraph 2.4). Generally, a single strategy is appropriate. There are cases where multiple strategies are used simultaneously.

4.2.1.1 Acceleration input control strategy.

Input control is the traditional approach to vibration testing. Control accelerometers are mounted on the fixture at the test item mounting points. Exciter motion is controlled with feedback from the control accelerometer(s) to provide defined vibration levels at the fixture/test item interface. Where appropriate, the control signal can be the average of the signals from more than one test item/fixture accelerometer. This represents the platform input to the materiel and assumes that the materiel does not influence platform vibration.

4.2.1.2 Force control strategy.

Dynamic force gages are mounted between the exciter/fixture and the test item. Exciter motion is controlled with feedback from the force gages to replicate field measured interface forces. This strategy is used where the field (platform/materiel) dynamic interaction is significantly different from the laboratory (exciter/test item) dynamic interaction. This form of control inputs the correct field-measured forces at the interface of the laboratory vibration exciter and test item. This strategy is used to prevent overtest or undertest of materiel mounts at the lowest structural resonances that may otherwise occur with other forms of control.

4.2.1.3 Acceleration limit strategy.

Input vibration criteria is defined as in paragraph 4.2.1.1. In addition, vibration response limits at specific points on the materiel are defined (typically based on field measurements). Monitoring accelerometers are located at these points. The test item is excited as in paragraph 4.2.1.1 using test item mounting point accelerometer signals to control the exciters. The input criteria are experimentally modified as needed to limit responses at the monitoring accelerometers to the predefined limits. Changes to the specified input criteria are limited in frequency bandwidth and in level to the minimum needed to achieve the required limits.

4.2.1.4 Acceleration response control strategy.

Vibration criteria are specified for specific points on, or within the test item. Control accelerometers are mounted at the vibration exciter/fixture interface. Monitoring accelerometers are mounted at the specified points within the item. An arbitrary low level vibration, controlled with feedback from the control accelerometers, is input to the test item. The input vibration is experimentally adjusted until the specified levels are achieved at the monitoring accelerometers. This strategy is commonly used with assembled aircraft stores where store response to the dynamic environment is measured or estimated. It is also applicable for other materiel when field measured response data are available.

4.2.1.5 Open loop waveform control strategy.

Monitoring accelerometers are mounted at locations on/in the test item for which measured data are available. The exciter is driven by an appropriately compensated time/voltage waveform obtained directly from (1) field measured data, or (2) a specified digitized waveform, and monitor acceleration responses are measured. In general, the compensated voltage waveform will be determined in the same way that a voltage waveform is determined for a shock test, i.e., from a convolution of the desired response waveform with the system impulse response function. This strategy is not generally applicable to the procedures of method 514.5. It is more generally used for control of transient or short duration, time-varying random vibration of method 516.5.

4.2.2 Tolerances.

Use the following tolerances unless otherwise specified. In cases where these tolerances cannot be met, achievable tolerances should be established and agreed to by the cognizant engineering authority and the customer prior to initiation of test. Protect measurement transducer(s) to prevent contact with surfaces other than the mounting surface(s).

4.2.2.1 Acceleration spectral density.

Care must be taken to examine field measured response probability density information for non-Gaussian behavior. In particular, determine the relationship between the measured field response data and the laboratory replicated data relative to three sigma peak height limiting that may be introduced in the laboratory test.

a. Vibration environment. Maintain the acceleration spectral density at a control transducer within +2.0 dB or −1.0 dB over the specified frequency range. This tolerance is usually readily attainable with small, compact test items (such as small and medium sized rectangular electronic packages), well-designed fixtures, and modern control equipment. When test items are large or heavy, when fixture resonances cannot be eliminated, or when steep slopes (> 20 dB/octive) occur in the spectrum, these tolerances may have to be increased. When increases are required, exercise care to ensure the selected tolerances are the minimum attainable, and that attainable tolerances are compatible with test objectives. In any case, tolerances should not exceed ±3 dB over the entire test frequency range and +3, −6 above 500 Hz. These tolerances should be limited to a maximum of 5% of the test frequency range. Otherwise, change the tests, fixtures, or facilities so test objectives can be met. For Procedure IV, Assembled Aircraft Stores, the allowable deviation is ±3 dB.

b. Vibration measurement. Use a vibration measurement system that can provide acceleration spectral density measurements within ±0.5 dB of the vibration level at the transducer mounting surface (or transducer target mounting surface) over the required frequency range. Do not use a measurement bandwidth that exceeds 2.5 Hz at 25 Hz or below or 5 Hz at frequencies above 25 Hz. For control and analysis systems of fast Fourier transform (FFT) type, use a resolution of at least 400 frequency lines. For wider frequency ranges the use of 800 frequency lines is recommended. Ensure the number of statistical degrees of freedom is not be less than 120.

c. Root mean square (RMS) "g." Do not use RMS g for defining or controlling vibration tests because it contains no spectral information. RMS levels are useful in monitoring vibration tests since RMS can be monitored continuously, whereas measured spectra are available on a delayed, periodic basis. Also, RMS values are sometimes useful in detecting errors in test spectra definition. Define the tolerances on RMS g monitoring values based on the test variables and the test equipment. Do not use random vibration RMS g as a comparison with sinusoidal peak g. These values are unrelated.

4.2.2.2 Peak sinusoidal acceleration.

a. Vibration environment. Ensure the peak sinusoidal acceleration at a control transducer does not deviate from that specified by more than ±10% over the specified frequency range.

b. Vibration measurement. Ensure the vibration measurement system provides peak sinusoidal acceleration measurements within ±5% of the vibration level at the transducer mounting surface (or transducer target mounting surface) over the required frequency range.

c. RMS g. The RMS g of a sinusoid equals 0.707 times peak g. It is not related to RMS g of a random (g^2/Hz) spectrum; do not use this to compare sine criteria (g) to random criteria (g^2/Hz).

4.2.2.3 Frequency measurement.

Ensure the vibration measurement system provides frequency measurements within ±1.25% at the transducer mounting surface (or transducer target mounting surface) over the required frequency range.

4.2.2.4 Cross axis accelerations.

Ensure vibration acceleration in two axes mutually orthogonal and orthogonal to the drive axis is less than or equal to 0.45 times the acceleration (0.2 times the spectral density) in the drive axis at any frequency. In a random vibration test the cross axis acceleration spectral density often has high but narrow peaks. Consider these in tailoring cross-axis tolerances.

4.3 Test interruption.

a. General. See Part One, paragraph 5.11, of this standard.

b. Specific to this method.

(1) When interruptions are due to failure of the test item, analyze the failure to determine root cause. With this information, make a decision to restart, to replace, to repair failed components and resume, or to declare the test complete. Tailor this decision to the test and the test objectives. See Annex B, paragraph 2.1 for descriptions of common test types and a general discussion of test objectives.

(2) If a qualification test is interrupted because of a failed component and the component is replaced, continuation of the test from the point of interruption will not verify the adequacy of the replaced component. Each replaced component must experience the full vibration requirement prior to its acceptance. Additional guidance is provided in paragraph 5.2.

4.4 Test Setup.

See Part One, paragraph 5.8.

4.4.1 Procedure I - General vibration.

Configure the test item appropriately for the life cycle phase to be simulated.

a. Transportation. Configure the test item for shipment including protective cases, devices, and/or packing. Mount the test item to the test fixture(s) by means of restraints and/or tie-downs dynamically representative of life cycle transportation events.

b. Operational service. Configure the test item for service use. Secure the test item to the test fixture(s) at the mounting point(s) and use the same type of mounting hardware as used during life cycle operational service. Provide all mechanical, electrical, hydraulic, pneumatic or other connections to the materiel that will be used in operational service. Ensure these connections dynamically simulate the service connections and that they are fully functional unless otherwise specified.

4.4.2 Procedure II - Loose cargo transportation.

Two different setups of fencing are required depending on the type of test item. The two types are those that are more likely to slide on the test surface or "rectangular cross section items" (typically packaged items), and those most likely to roll on the surface or "circular cross section items." (Note that "multiple test items" refers to identical test items and not to a mixture of unrelated items.)

a. Rectangular cross section items. Position the test item on the package tester bed in its most likely shipping orientation. If the most likely shipping orientation cannot be determined, place the test item on the bed with the longest axis of the test item parallel to the long axis of the table (throw axis). Position the wooden impact walls and sideboards so as to allow impacting on only one end wall (no rebounding) and to prevent rotation of the test item through 90 degrees. Do not separate multiple test items by sideboards. The first half of the test is to be conducted with this orientation. The second half is to be conducted with the orientation of the test item rotated 90 degrees.

b. Circular cross section items with 4 or more test items. Place the impact walls so as to form a square test area with the walls parallel and perpendicular to the throw axis. Use the following formulae to determine

the dimensions. Determine the slenderness ratio for individual test items by $R_T = L/D$, where R_T = the item slenderness ratio; L = the item length; D = the item diameter. Calculate an R_R value for defining the test area as follows:

$$R_R = N\,L / [0.767\,L\,N^{1/2} - 2\,S_W - (N-1)\,S_B]$$

where:

S_W = spacing between the test item and the side wall

S_B = spacing between test items

(S_W and S_B are chosen based on test item geometry to provide realistic impacting with impact walls and between test items. 25 mm is a typical value for both.)

N = number of test items where N > 3

If the $R_T > R_R$, the length of each side of the test area is given by "X" where:

$$X = 0.767\,L\,N^{1/2}$$

If $R_T \leq R_R$, the length of each side of the test area is given by "W" where:

$$W = N\,D + 2\,S_W + (N-1)S_B$$

c. Circular cross section items with 3 or fewer test items. Determine the slenderness ratio for individual test items by $R_T = L/D$. Calculate an R_R value for defining the test area as follows:

$$R_R = N\,L / [1.5\,L - 2\,S_W - (N-1)\,S_B]$$

If $R_T > R_R$, the length of each side of the test area is given by "X" where:

$$X = 1.5\,L$$

If $R_T \leq R_R$, the length of each side of the test area is given by "W" where:

$$W = N\,D + 2\,S_W + (N-1)\,S_B$$

Place the test item on the package tester, inside the impact walls, in a random manner. Because part of the damage incurred during these tests is due to items impacting each other, use more than 3 test items if possible.

4.4.3 Procedure III - Large assembly transportation.

Install the test item in/on the vehicle in its intended transportation or service configuration. If the assembly is to be contained within a shelter, or if other units are attached to the materiel assembly in its in-service configuration, also install these items in their design configuration.

a. Test surfaces. When setting up the test, consider the test surfaces available at the particular test location (see reference b). Also, ensure the selection of test surfaces, test distances, and test speeds are appropriate for the specified vehicles and their anticipated use.

b. Test loads. Response of the vehicle to the test terrain is a function of the total load and the distribution of the load on the vehicle. In general, a harsher ride occurs with a lighter load while a heavier load will result in maximum levels at lower frequencies. Multiple test runs with variations in load may be required to include worst case, average, or other relevant cases.

c. Tie-down/mounting arrangements. During the test, it is important to reproduce the more adverse arrangements that could arise in normal use. For example, during transportation, relaxation of tie-down strap tension could allow the cargo to lift off the cargo bed and result in repeated shock conditions. Excessive tightening of webbing straps could prevent movement of test items and thereby reduce or eliminate such shocks.

4.4.4 Procedure IV - Assembled aircraft store captive carriage and free flight.

a. Captive carriage test fixture. Suspend the test item from a structural support frame by means of the operational service store suspension equipment (bomb rack, launcher, pylon, etc.). Ensure that the flexible modes of the support frame are as high as practical, at least twice the first flexible frequency of the store, and that they do not coincide with store modes. Include and load (torque, clamp, latch, etc.) sway braces, lugs, hooks or other locking and load carrying devices that attach the store to the suspension equipment and the suspension equipment to the carrier aircraft, as required for captive carriage in service. Ensure that the layout of the structural support frame and the test area is such that there is adequate access for the vibration exciters and test materiel.

(1) Configure the assembled store for captive carriage and mount it to the structural support frame. Softly suspend the structural support frame within the test chamber. Ensure that rigid body modes of the store, suspension equipment, and structural support frame combination are between 5 and 20 Hz, and lower than one half the lowest flexible mode frequency of the store. Use structural support that is sufficiently heavy and of sufficient pitch and roll inertias to approximately simulate carrier aircraft dynamic reaction mass. If the structural support is too heavy or its inertia too large, the store suspension equipment and store hardback will be over-stressed. This is because unrealistically high dynamic bending moments are needed to match acceleration spectral densities. Conversely, if the structural support is too light or its inertia too low, there will be an undertest of the suspension equipment and store hardback.

(2) Do not use the structural support to introduce vibration into the store. In the past, stores have been hard mounted to large shakers. Do not attempt this because this has proven to be inadequate. Recent test experience with F-15, F-16, and F/A-18 stores indicates that including a structural support/reaction mass greatly improves the match between flight measured data and laboratory vibrations, particularly at lower frequencies.

(3) In cases in which the frequency requirements in (1) and (2) cannot be met, consider force control strategy (see paragraph 4.2.1.2).

b. Free flight test fixture. Configure the assembled test store for free flight and softly suspend it within the test chamber. Ensure rigid body modes of the suspended store are between 5 and 20 Hz and lower than one half the lowest flexible mode frequency of the store.

c. Orientation. With the store suspended for test, the longitudinal axis is the axis parallel to the ground plane and passing through the longest dimension of the store. The vertical axis is mutually perpendicular to the ground plane and the longitudinal axis. The lateral axis is mutually perpendicular to longitudinal and vertical axes.

d. Vibration excitation. Store longitudinal vibration is typically less than vertical and lateral vibration. Vertical and lateral excitation of store modes usually results in sufficient longitudinal vibration. When a store is relatively slender (length greater than 4 times the height or width), drive the store in the vertical and lateral axes. In other cases, drive the store in the vertical, lateral, and longitudinal axes. If a store contains material that is not vibration tested except at assembled store level, or the store contains components that are sensitive to longitudinal vibration, include longitudinal excitation.

(1) Transmit vibration to the store by means of rods (stingers) or other suitable devices running from vibration exciters to the store. Separate drive points at each end of the store in each axis are recommended. Ideally, the store will be driven simultaneously at each end. However, it can be driven at each end separately. A single driving point in each axis aligned with the store aerodynamic center has also been successful. Use drive points on the store surface that are relatively hard and structurally supported by the store internal structure or by test fixture(s) (usually external rings around the local store diameter) that distribute the vibratory loads into the store primary structure.

(2) This test is intended to represent a highly random, highly uncorrelated vibration condition. Thus, when two vibration exciters are used simultaneously, the two drive signals are uncorrelated. Note that two drive signals that start out uncorrelated and that are from two separate controllers may

become correlated unless uncorrelation is forced. In general, the use of two vibration exciters will require some knowledge of current dual drive testing capabilities that include specification of the vibration exciter cross spectral density matrices.

e. Instrumentation. Mount transducers on the store and/or the store excitation devices to monitor compliance of vibration levels with requirements, to provide feedback signals to control the vibration exciter, and to measure materiel function. Additionally, it is usually important to overall program objectives to add transducers to measure local vibration environment throughout the store. Note the vibration exciter control strategy used, e.g., single point response, multipoint response, force limit, waveform, etc. Also note the relationship, if any, between field measurement data and laboratory measurement data.

(1) Mount accelerometers to monitor vibration levels at the forward and aft extremes of the primary load carrying structure of the store. Do not mount these accelerometers on fairings, unsupported areas of skin panels, aerodynamic surfaces, or other relatively soft structures. In some cases (see paragraph 4.4.4c above), transducers are required in the vertical and lateral directions. In other cases, transducers are required in vertical, lateral, and longitudinal directions. Designate these transducers as the test monitor transducers.

(2) An alternate method is to monitor the test with strain gages that are calibrated to provide dynamic bending moment. This has proven successful where integrity of the store primary structure is a major concern. Flight measured dynamic bending moment data is required for this method. Also, use accelerometers positioned as discussed above to verify that general vibration levels are as required.

(3) As feedback control transducers, use either accelerometers on or near the store/vibration transmission device(s)/vibration exciter interface, force transducer(s) in series with the store/vibration transmission device(s)/vibration exciter, or dynamic bending moment strain gages. A clear understanding of the vibration exciter control strategy and its effects on the overall measurements is necessary.

4.5 Test Execution.

The following steps, alone or in combination, provide the basis for collecting necessary information concerning the durability and function of a test item in a vibration environment.

4.5.1 Preparation for test.

4.5.1.1 Preliminary steps.

Before starting test, review pretest information in the test plan to determine test details (procedure(s), test item configuration(s), levels, durations, vibration exciter control strategy, failure criteria, item functional requirements, instrumentation requirements, facility capability, fixture(s), etc.).

a. Select appropriate vibration exciters and fixtures.

b. Select appropriate data acquisition system (e.g., instrumentation, cables, signal conditioning, recording, analysis equipment).

c. Operate vibration equipment without the test item installed to confirm proper operation.

d. Ensure that the data acquisition system functions as required.

4.5.1.2 Pretest standard ambient checkout.

All items require a pretest standard ambient checkout to provide baseline data. Conduct the pretest checkout as follows:

Step 1. Examine the test item for physical defects, etc. and document the results.

Step 2. Prepare the test item for test, in its operating configuration if required, as specified in the test plan.

Step 3. Examine the test item/fixture/exciter combination for compliance with test item and test plan requirements.

Step 4. If applicable, conduct an operational checkout in accordance with the test plan and document the results for comparison with data taken during or after the test.

4.5.2 Procedure I - General vibration.

Step 1. Perform a visual inspection of the test item and an operational check. If a failure is noted, proceed as in paragraph 4.3.

Step 2. Conduct fixture modal survey and verify that fixture meets requirements, if required.

Step 3. Mount the test item to the test fixture in a manner dynamically representative of the life cycle event simulated.

Step 4. Install sufficient transducers on or near the test item/fixture/vibration exciter combination to measure vibration at the test item/fixture interface, to control the vibration exciter as required by the control strategy, and measure any other required parameters. Mount control transducer(s) as close as possible to the test item/fixture interface. Ensure that the total accuracy of the instrumentation system is sufficient to verify that vibration levels are within the tolerances of paragraph 4.2.2 and to meet additionally specified accuracy requirements.

Step 5. Conduct test item modal survey, if required.

Step 6. Perform a visual inspection of the test item and, if applicable, an operational check. If failure is noted, proceed as in paragraph 4.3.

Step 7. Apply low level vibration to the test item/fixture interface. If required, include other environmental stresses.

Step 8. Verify that the vibration exciter, fixture, and instrumentation system functions as required.

Step 9. Apply the required vibration levels to the test item/fixture interface, as well as any other required environmental stresses.

Step 10. Verify that vibration levels at test item/fixture interface are as specified. If the exposure duration is 1/2 hour or less accomplish this step immediately after full levels are first applied, and immediately before scheduled shut down. Otherwise, accomplish this step immediately after full levels are first applied, every half-hour thereafter, and immediately before scheduled shut down.

Step 11. Monitor vibration levels and, if applicable, test item performance continuously through the exposure. If levels shift or a failure occurs, shut down the test in accordance with the test shut down procedure (paragraph 3.1b(10)). Determine the reason for the shift and proceed in accordance with the test interruption recovery procedure (paragraph 3.1b(11)).

Step 12. When the required duration has been achieved, stop the vibration. Depending on the test objectives, the test plan may call for additional exposures at varied levels prior to shut down. If so, repeat steps 6 through 12 as required by the test plan before proceeding.

Step 13. Inspect the test item, fixture, vibration exciter, and instrumentation. If failure, wear, looseness, or other anomalies are found, proceed in accordance with the test interruption recovery procedure (paragraph 3.1b(11)).

Step 14. Verify that the instrumentation functions as required and perform an operational check of the test item. If a failure is noted, proceed as in paragraph 4.3.

Step 15. Repeat steps 1 through 14 for each required excitation axis.

Step 16. Repeat steps 1 through 15 for each required vibration exposure.

Step 17. Remove the test item from the fixture and Inspect the test item, mounting hardware, packaging, etc. Refer to paragraph 4.3 if there are failures.

4.5.3 Procedure II - Loose cargo transportation.

Step 1. Perform a visual inspection of the test item and an operational check.

Step 2. Conduct test item modal survey, if required.

Step 3. Place the test item(s) on the package tester within the restraining fences in accordance with paragraphs 4.1.2 and 4.4.2.

Step 4. Install instrumentation sufficient to measure any required parameters. Ensure that the total accuracy of the instrumentation system is sufficient to meet specified accuracy requirements.

Step 5. Operate the package tester for one-half of the prescribed duration.

Step 6. Perform a visual inspection of the test item and an operational check. If a failure is noted, proceed as in paragraph 4.3.

Step 7. Reorient the test item(s) and/or the fencing/impact walls in accordance with paragraph 4.4.2.

Step 8. Operate the package tester for one-half of the prescribed duration.

Step 9. Perform a visual inspection of the test item and an operational check. If a failure is noted, proceed as in paragraph 4.3.

4.5.4 Procedure III - Large assembly transportation.

Step 1. Perform a visual inspection of the test item and an operational check. If a failure is noted, proceed as in paragraph 4.3.

Step 2. Mount the test item(s) on/in the test vehicle as required in the test plan.

Step 3. Install transducers on or near the test item sufficient to measure vibration at the test item/vehicle interface and to measure any other required parameters. Protect transducers to prevent contact with surfaces other than the mounting surface.

Step 4. Subject the vehicle containing the test item to the specified test conditions.

Step 5. Perform a visual inspection of the test item and an operational check. If a failure is noted, proceed as in paragraph 4.3.

Step 6. Repeat steps 1 through 5 for additional test runs, test loads, or test vehicles as required by the test plan.

4.5.5 Procedure IV - Assembled aircraft store captive carriage and free flight.

Step 1. With the store suspended within the test chamber and the instrumentation functional, verify that the store suspension system functions as required by measuring the suspension frequencies.

Step 2. If required, conduct a test item modal survey.

Step 3. Place the test item in an operational mode and verify that it functions properly.

Step 4. Apply low level vibration to the vibration exciter/store interface(s) to ensure that the vibration exciter and instrumentation system function properly. For acceleration feedback control, use an initial input level 9 dB down from the required forward test monitor transducer spectrum. For force feedback control, use a flat force spectrum where the response at the test monitor accelerometer is at least 9 dB below the required test monitor value at all frequencies. For bending moment feedback

control, use an initial input level that is 9 dB down from the required test monitor transducer spectrum.

Step 5. Adjust the vibration exciter(s) such that the test monitor transducers in the excitation axis meet the test requirements. For acceleration control, identify the test monitor transducer spectrum peaks that exceed the input spectrum by 6 dB or more (frequencies may differ fore and aft). For force feedback control, identify major peaks from the force measurements to check monitor accelerometer transfer functions. For both cases, equalize the input spectra until the identified peaks equal or exceed the required test levels. The resulting input spectra should be as smooth and continuous as possible while achieving the required peak responses. (It is not necessary to fill in valleys in the test monitor transducer spectra; however, it is not acceptable to notch out the input in these valleys.) For bending moment control raise and shape the input spectrum until it matches the required spectrum (peaks and valleys).

Step 6. When the input vibration is adjusted such that the required input response (A1) is achieved, measure the off-axis response(s) (A2, A3). Verify that off-axis response levels are within requirements using the following equations. If the result obtained from the equation is greater than the value established for the equation, reduce the input vibration level until the achieved input and off-axis response levels balance the equation. Apply these equations at each peak separately. Use the first equation for testing that requires vibration application in two separate mutually perpendicular axes, and use the second equation for testing that requires vibration application in three separate mutually perpendicular axes.

$$2 = (R_1/A_1 + R_2/A_2) \text{ or, } 3 = (R_1/A_1 + R_2/A_2 + R_3/A_3)$$

where:
R_i = Test requirement level in g^2/Hz or $(N\text{-}m)^2$/Hz or $(in\text{-}lb)^2$/Hz for i = 1 - 3, and
A_i = Response level in g^2/Hz or $(N\text{-}m)^2$/Hz or $(in\text{-}lb)^2$/Hz for i = 1 - 3

For example:
For testing that requires vibration application in three separate mutually perpendicular axes, and when vibration is being applied in the vertical axis, use the equation below as follows.

$$3 = (R_1/A_1 + R_2/A_2 + R_3/A_3)$$

where;
R_1 = Vertical axis test requirement level
A_1 = Vertical axis response level
R_2 = Horizontal axis test requirement level
A_2 = Horizontal axis response level
R_3 = Longitudinal axis test requirement level
A_3 = Longitudinal axis response level

For vibration being applied in the horizontal axis, use the equation below as follows.

$$3 = (R_1/A_1 + R_2/A_2 + R_3/A_3)$$

where;
R_1 = Horizontal axis test requirement level
A_1 = Horizontal axis response level
R_2 = Vertical axis test requirement level
A_2 = Vertical axis response level
R_3 = Longitudinal axis test requirement level
A_3 = Longitudinal axis response level

For vibration being applied in the longitudinal axis, use the equation below as follows.

$$3 = (R_1/A_1 + R_2/A_2 + R_3/A_3)$$

where;
R_1 = Longitudinal axis test requirement level
A_1 = Longitudinal axis response level
R_2 = Vertical axis test requirement level
A_2 = Vertical axis response level
R_3 = Horizontal axis test requirement level
A_3 = Horizontal axis response level

Step 7. Verify that vibration levels are as specified. If the exposure duration is 1/2 hour or less, accomplish this step immediately after full levels are first applied, and immediately before scheduled shut down. Otherwise, accomplish this step immediately after full levels are first applied, every half-hour thereafter, and immediately before scheduled shut down.

Step 8. Monitor the vibration levels and test item performance continuously through the exposure. If levels shift, performance deviates beyond allowable limits, or failure occurs, shut down the test in accordance with the test shut down procedure (paragraph 3.1b(10)). Determine the reason for the anomaly and proceed in accordance with the test interruption recovery procedure (paragraph 3.1b(11)).

Step 9. When the required duration has been achieved, stop the vibration. Depending on the test objectives, the test plan may call for additional exposures at varied levels prior to shut down. If so, repeat steps 6 through 9 as required by the test plan before proceeding.

Step 10. Inspect the test item, fixture, vibration exciter, and instrumentation. If failure, wear, looseness or other anomalies are found, proceed in accordance with the test interruption recovery procedure (paragraph 3.1b(11)).

Step 11. Verify that the instrumentation functions as required and perform an operational check of the test item for comparison with data collected in paragraph 4.5.1.2. If a failure is noted, proceed as in paragraph 4.3.

Step 12. Repeat steps 1 through 11 for each required excitation axis.

Step 13. Repeat steps 1 through 12 for each required vibration exposure.

Step 14. Remove the test item from the fixture and inspect the test item and mounting hardware. Refer to paragraph 4.3 if there are failures.

5. ANALYSIS OF RESULTS.

In addition to the guidance provided in Part One, paragraph 5.14, the following is provided to assist in the evaluation of the test results.

5.1 Physics of Failure.

Analyses of vibration related failures must relate the failure mechanism to the dynamics of the failed item and to the dynamic environment. It is not enough to determine that something broke due to high cycle fatigue or wear. It is necessary to relate the failure to the dynamic response of the materiel to the dynamic environment. Thus, include in failure analyses a determination of resonant mode shapes, frequencies, damping values and dynamic strain distributions in addition to the usual material properties, crack initiation locations, etc. (See Annex B, paragraph 2.5).

5.2 Qualification Tests.

When a test is intended to show formal compliance with contract requirements the following definitions are recommended.

a. Failure definition. "Materiel is deemed to have failed if it suffers permanent deformation or fracture; if any fixed part or assembly loosens; if any moving or movable part of an assembly becomes free or sluggish in operation; if any movable part or control shifts in setting, position or adjustment, and if test item performance does not meet specification requirements while exposed to functional levels and following endurance tests." Ensure this statement is accompanied by references to appropriate specifications, drawings, and inspection methods.

b. Test completion. "A vibration qualification test is complete when all elements of the test item have successfully passed a complete test. When a failure occurs, stop the test, analyze the failure, and repair the test item. Continue the test until all fixes have been exposed to a complete test. Each individual element is considered qualified when it has successfully passed a complete test. Qualified elements that fail during extended tests are not considered failures and can be repaired to allow test completion."

5.3 Other Tests.

For tests other than qualification tests, prepare success and/or failure criteria and test completion criteria that reflect the purpose of the tests.

6. REFERENCE/RELATED DOCUMENTS.

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c. Handbook for Dynamic Data Acquisition and Analysis, IES-RP-DTE012.1, Institute of Environmental Sciences, 940 East Northwest Highway, Mount Prospect, IL 60056.

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