Dryden Flight Research Center
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Environmental Acceptance Testing: Electronic & Electromechanical Equipment

(With changes 06-02-10)

Electronically approved by
Assistant Director for Management Systems

CONTENTS

1.0 PURPOSE OF DOCUMENT 4
2.0 PROCEDURE SCOPE & APPLICABILITY 4
3.0 PROCEDURE OBJECTIVES, TARGETS, METRICS, & TREND ANALYSIS 5
4.0 WAIVER AUTHORITY 5
5.0 GENERAL INFORMATION 6
6.0 TESTING 6
7.0 TEST CATEGORIES 7
A. Category I 7
B. Category II 7
C. Category III 7
D. Category IV 8
8.0 TEST REQUIREMENTS CATEGORY I 8
8.1 Altitude 8
8.2 Temperature 8
8.3 Vibration 9
9.0 TEST REQUIREMENTS CATEGORY II 10
9.1 Altitude 10
9.2 Temperature 10
9.3 Vibration 11
10.0 TEST REQUIREMENTS CATEGORY III 11
10.1 Altitude 11
10.2 Temperature 11
10.3 Vibration 12
11.0 TEST REQUIREMENTS CATEGORY IV 13
11.1 Altitude 13
11.2 Temperature 13
11.3 Vibration 13
12.0 MANAGEMENT RECORDS & RECORDS RETENTION 20
13.0 RELEVANT DOCUMENTS 20
13.1 Reference Documents 20
13.2 Informational Documents 20
13.3 Forms 20
14.0 ACRONYMS & DEFINITIONS 21
14.1 Acronyms 21
14.2 Definitions 21

FIGURES

Figure 1: Random Vibration Test Curves 14
Figure 2: Random Vibration Test Curve Selection 15
Figure 3: Random Vibration Testing Reduction Factor For Mass Loading 16
Figure 4: Sine Vibration Test Curves 17
Figure 5: Sine Vibration Test Curve Selection 18
Figure 6: Sine Vibration Test Curves, Category IV 19

1.0 PURPOSE OF DOCUMENT

This document provides environmental test specifications for acceptance of electronic, electrical, optical, and electromechanical research and test equipment for use in DFRC aircraft and flight vehicles.

2.0 PROCEDURE SCOPE & APPLICABILITY

Scope: This procedure applies to environmental testing for acceptance of electronic, electrical, optical, and electromechanical research and test equipment for use in DFRC flight vehicles.

Equipment originating in-house as well as equipment from outside sources is subject to this procedure unless specifically waived by Operations Engineering, and Instrumentation or Systems Engineering.

Exceptions to Scope:

1. Pyrotechnic devices are not covered by this procedure.
2. Self-contained devices carried on the person of pilot or crew are not covered by this procedure as long as no interface is established between such equipment and vehicle system.
3. Accelerometers are exempt from the vibration requirements of this procedure since their calibrated range will normally exceed the “G” levels imposed by this procedure. Engineering will specify vibration requirements of such instruments, as required.
4. Environmental flight assurance tests performed on equipment by outside sources (and properly verified) need not be repeated to comply with this procedure, although extraordinary conditions (i.e., suspected rough handling in shipment, etc.) may warrant such repetition. Systems Engineering (RF) or Instrumentation Engineering (RI), Operations Engineering (OE), and Quality Assurance (SQ) personnel will operate jointly in making such determinations.

Applicability: This procedure applies to all DFRC employees involved in the construction, installation, and testing of electronic, electrical, optical, and electromechanical research and test equipment for use on DFRC flight vehicles.

3.0 PROCEDURE OBJECTIVES, TARGETS, METRICS, & TREND ANALYSIS

Objective: Ensure that electrical, electronic, optical, and electromechanical research and test equipment used on DFRC flight vehicles is acceptance-tested or has a documented waiver.

Target: 100% of all electrical, electronic, optical, and electromechanical research and test equipment installed on DFRC flight vehicles is acceptance-tested or has a documented waiver.

Metric: Percentage of electrical, electronic, optical, and electromechanical research and test equipment installed on DFRC flight vehicles that have acceptance tests performed or waivers documented.

Objective: Minimize unanticipated failure modes of electrical, electronic, optical, and electromechanical research and test equipment due to the installation environment on a DFRC flight vehicle.

Target: Zero unanticipated failure modes of electrical, electronic, optical, and electromechanical research and test equipment due to the installation environment on a DFRC flight vehicle.

Metric: Number of unanticipated failures of electrical, electronic, optical, and electromechanical research and test equipment due to the installation environment on DFRC flight vehicles.

Trend analysis: Metrics will be analyzed to determine whether procedural objectives have been met.

4.0 WAIVER AUTHORITY

Any deviation or waiver of any provision within this procedure will be in accordance with DPR-7123.2-001, Waivers and Deviations to Technical Requirements and Standards. Dryden's Chief Engineer, who is the Center's System Technical Warrant holder for Atmospheric Flight Research and Test, has delegated the authority to waive this procedure to the Operations Engineering Branch.

All proposed testing deviations will require the assigned Operations Engineer, Instrumentation Engineer, or Systems Engineer to generate a waiver and record it on form DFRC 117.1f. This waiver will be reviewed and approved by the assigned project Operations Engineer and the Operations Engineering Branch Chief. If the Operations Engineering Branch Chief is not available, the Acting Branch Chief has the review and approval responsibility. If the Acting Branch Chief is unavailable, the responsibility will be elevated to the Deputy Director of Operations, and then the Director of Operations, in that order. In addition, the waiver will be approved by the Director of Operations and the DFRC Chief Engineer.

The original waiver will be filed with the requesting project. (Where or how this waiver is filed with the requesting project may be directed within that project's Configuration Management Plan.) Information copies will be provided to the Operations Engineering Branch, the Instrumentation Fabrication Branch, the Systems or Instrumentation Engineering Branch (if applicable), the Operations Directorate, and the DFRC Chief Engineer.

All environmental testing waivers will be reported at project tech briefs.

5.0 GENERAL INFORMATION

Equipment is herein defined as including all items designed as part of any of the basic flight vehicle systems or as a part of the data system, including critical airborne experiments.

A spreadsheet of electrical, electronic, optical, and electromechanical research and test equipment for use on NASA DFRC flight vehicles will be kept on the I: drive at I:\Code O\Code OE\DCP-O-018 Tracking. This spreadsheet will track the pertinent details of the equipment testing, and include equipment information (such as part name, part number, serial number), a reference to the aircraft that it is intended for use on, the level of testing performed as well as what organization performed it, the planned envelope for use, any applicable waivers, and a log of any installed failures (during ramp operations, taxi, or flight).

6.0 TESTING

This procedure contains acceptance test criteria, not qualification test criteria. Unless otherwise specified by contract, equipment procured under this procedure will be designed with sufficient margin so that all items delivered may be successfully tested per the applicable provisions of this procedure and subsequently placed in unrestricted service with no degradation of performance.

When it is known that the equipment will encounter conditions more severe or less severe than the environmental acceptance test levels stated herein, the tests may be modified by appropriate engineering personnel. If the testing is less severe than described within this procedure, the deviation will be documented within a waiver.

Where feasible, the unit undergoing test will be operating during the complete test cycle, and a concurrent performance evaluation will be made with suitable readout devices. Where not feasible, both pre- and post-testing operational checks will be conducted and a comparison made for any sign of performance degradation. In either case, at the completion of all environmental acceptance testing, a "covers off" inspection will be performed by quality inspection personnel (Quality Assurance Specialists or Designated

Inspectors). Any discrepancies discovered will be documented and may be remedied. If remedied, the appropriate portion of the environmental test will be repeated.

The environmental acceptance test will be directed and documented through either a work order (in accordance with DCP-O-002, Aircraft Work Order Procedure) or a procedure (in accordance with DCP-O-011, Aircraft System Test Procedure Preparation and Release) or both. The environmental acceptance test requirements will be clearly stated within the authorizing documentation and must include information such as whether test temperatures are ambient or component temperatures and when the timing of temperature testing begins and ends.

Other specific acceptance tests such as Radio Frequency Interference (RFI) and power transients, etc., will be determined as required by Systems Engineering, Instrumentation Engineering, and Operations Engineering and are not covered within this procedure.

One-of-a-kind flight articles will be environmentally acceptance-tested in accordance with this procedure in lieu of an environmental qualification test. Qualification-tested items are not to be used in flight vehicles. Where several identical items have been manufactured and one has been qualification tested, the requirements of this procedure may be waived by similarity (in accordance with Section 4.0) for the remainder of those items. However, the qualification test must have been at least as severe as this procedure and documentation must exist that the items intended for use are of the same design and materials. The flight articles also must be manufactured in accordance with the same processes and quality requirements as the qualification-tested item. This last provision does not apply to rakes and other devices that are to be installed inside of engine inlet ducts or in their air inflow path. All such items require at least a vibration acceptance test in accordance with this procedure.

7.0 TEST CATEGORIES

For purposes of this procedure, the following four acceptance test categories are established for all DFRC flight vehicles:

A. Category I
Research vehicles that operate at extreme altitudes, at or near hypersonic speeds, rocket or ramjet powered, with large variations in local temperatures due to cryogenic fluids, high aerodynamic heating, etc.

B. Category II
All turbojet powered aircraft

C. Category III
Propeller and turboprop powered aircraft and all glide vehicles

D. Category IV
Helicopters and other rotating wing aircraft

A unit tested to Category I, II, III, or IV must be retested if it is to be used later in another category of aircraft with the exception that a unit tested to Category I may be used later in a Category II aircraft.

8.0 TEST REQUIREMENTS CATEGORY I

8.1 Altitude

Subject the test unit to an altitude environment from ground level to 75,000 feet if test unit is installed in a pressurized compartment, and to 220,000 feet if installed in an unpressurized compartment.

8.2 Temperature

A. Subject the test unit to a cold soak temperature of zero degrees Fahrenheit and a hot soak of no less than +160 degrees Fahrenheit if installed in a temperature-controlled compartment. The appropriate time/temperature profile and operating cycle will be determined by Flight Systems Engineering or Instrumentation Engineering, and by Operations Engineering.

B. If the test unit is to be installed in a nontemperature-controlled compartment, then Flight Systems Engineering or Instrumentation Engineering, and Operations Engineering will determine the appropriate temperature test after considering the following factors:

1) Proximity to cryogenic fluids.
2) Effects of aerodynamic heating.
3) Protective devices (heaters, insulators, etc.)
4) Proximity of heat-generating devices within the vehicle (exhaust pipes, gas generators, etc.).
5) Temperature extremes encountered in prolonged parking ramp or hangar operations and the extreme cold encountered at high altitudes.

C. In all cases the cold soak temperature test will be –65 degrees Fahrenheit or colder and the hot soak temperature will be +160 degrees Fahrenheit or hotter.

D. If the unit is normally supplied with standby or heater power during actual flight, such power will be supplied to the unit during the hot and cold soak period.

E. Where feasible, the temperature and altitude test will be performed simultaneously. The normal sequence is: (1) to cold temp (2) to altitude (3) to lab altitude (4) to hot temp (5) to altitude (6) to lab altitude and temp.

8.3 Vibration

A. The vibration will be applied in separate tests to each of three mutually perpendicular axes of the test unit. Vibration will be random as described below.

B. Random vibration

1) Test interruptions are permitted, but the clock will be stopped during such interruptions. During the test, any resonant frequencies will be recorded. At the discretion of the test engineer, a resonance dwell test using sine vibration may be conducted at each of the recorded resonance frequencies, the dwell time being a maximum of two minutes at each frequency.

2) The test curve will be selected from Figure 1 and the equipment location described in Figure 2.

3) Operations of the test unit will be monitored throughout the vibration tests and performance will be recorded.

4) If the test unit is to be mounted in the aircraft on vibration isolators, it will be so mounted for the vibration test wherever possible. Where not possible, test in accordance with curve A of Figure 1.

5) In addition to the normal vibration test described above, for equipment designed to be installed in areas where known resonance exists, a special dwell test will be conducted to satisfy the requirements for this structure resonance. Engineering will specify the frequency and amplitude of resonance.

6) The specimen will be tested with random vibration for a minimum of twenty minutes in each of its perpendicular mutual axis.

7) The time required for the system to equalize the table and specimen will not be counted as test time.

8) For equipment being tested that weighs over 80 lbs., the vibration level is reduced as shown in Figure 3.

9) Equipment mounted directly on an engine is tested to curve E of Figure 4 (which is sine vibration).

9.0 TEST REQUIREMENTS CATEGORY II

9.1 Altitude

Subject the test unit to altitude environment from ground level to 75,000 feet if test unit is to be installed in a pressurized compartment; to 100,000 feet if installed in unpressurized compartment.

Note: If concerned aircraft is known to have an altitude zoom limit less than either of the above figures, the lower altitude figure may be used for the altitude test.

9.2 Temperature

A. Subject the test unit to a cold soak temperature of zero degrees Fahrenheit and a hot soak of +160 degrees Fahrenheit if installed in a temperature-controlled compartment. The appropriate time/temperature profile and operating cycle will be determined by Flight Systems Engineering or Instrumentation Engineering, and by Operations Engineering.

B. If the test unit is to be installed in a non-temperature controlled compartment, then Flight Systems Engineering or Instrumentation Engineering, and Operations Engineering will determine the appropriate temperature test after considering the following factors:

   1) Proximity to cryogenic fluids
   2) Effects of aerodynamic hearing
   3) Protective devices (heaters, insulators, etc.)
   4) Proximity to heat generating devices within the vehicle (afterburners, etc.)
   5) Temperature extremes encountered in prolonged ramp or hangar operations and the extreme cold encountered at high altitude

   In all cases, the cold soak temperature test will be -65 degrees Fahrenheit or colder and the hot soak temperature will be +160 degrees Fahrenheit or hotter.

C. If the unit is normally supplied with standby or heater power during actual flight, such power will be supplied to unit during the hot and cold soak period.

D. Where feasible, the temperature and altitude test will be performed simultaneously. The normal test sequence of Section 7.2 E will be followed.

9.3 Vibration

A. Vibration tests will be performed in accordance with Section 7.3 using the appropriate test curve selected from Figures 1 and 2.

B. Equipment mounted on the fuselage of a jet aircraft forward of the engine inlet duct and which is not flush with the mold line will be vibration tested to curve C of Figure 1 and curve C of Figure 4.

C. Equipment mounted on the inlet cowl lip or inside the inlet duct will be vibration tested per curve C of Figure 1 and curve C of Figure 4. The upper frequency at 10g may be increased above 2000 hertz depending on the particular engine and installation.

CAUTION: Any article designed for installation in an inlet must be given a very thorough NDI following vibration tests and prior to installation.

D. Equipment mounted on the engine at the compressor or fan inlet will be vibration tested per curve D of Figure 1 and curve D of Figure 4. The upper frequency at 15g may be increased above 2000 hertz depending on the particular engine and installation.

CAUTION: Any article designed for installation in an inlet must be given a very thorough NDI following vibration tests and prior to installation.

10.0 TEST REQUIREMENTS CATEGORY III

10.1 Altitude

Subject the test unit to altitude environment from ground levels to 40,000.

10.2 Temperature

A. Subject the test unit to a cold soak temperature of zero degrees Fahrenheit and a hot soak of no less than +160 degrees Fahrenheit if

installed in a temperature-controlled compartment. The appropriate time/temperature profile and operating cycle will be determined by Engineering, taking into account both the temperature extreme encountered in prolonged parking ramps or hangar operations and the extreme cold encountered at high altitude.

B. If the unit is to be installed in a non-temperature controlled compartment then test to –65 degrees Fahrenheit and no less than +160 degrees Fahrenheit.

C. If the unit is normally supplied with standby or heater power during the actual flight, such power will be supplied to the unit during the hot and cold soak period.

D. Where feasible, the temperature and altitude test will be performed simultaneously. The normal test sequence of Section 7.2 E will be followed.

10.3 Vibration

A. Vibration tests will be performed using the appropriate test curve selected from Figures 4 and 5 (sine vibration).

B. Vibration loads will be applied in separate tests to each of three mutually perpendicular axes of the test article.

C. Vibration loads applied will be sinusoidal, and the frequency will be cycled at a logarithmic rate between the frequency limits, and at the acceleration levels prescribed by the appropriate test curve. (A linear rate of frequency change may be used if a logarithmic rate is not available).

D. One complete up-and-down sweep between the prescribed frequency limits will be made for each axis. Total elapsed time for the sweep will be approximately 15 minutes, with the time essentially equally divided between the up and down phases. Test interruptions are permitted but the timing will be stopped during any such interruptions. During this frequency sweep any resonant frequencies will be recorded. A resonance dwell test will then be made at each of the recorded resonance frequencies, with the dwell time being a minimum of two (2) minutes at each frequency.

E. Where applicable, the test article will be operating throughout the vibration tests, and operational performance will be monitored and recorded.

F. If the test article is mounted on vibration isolators when installed in a Flight vehicle, it will be similarly mounted for the vibration test where possible. If such mounting is not possible, the test will be conducted in accordance with curve A of Figure 4.

11.0 TEST REQUIREMENTS CATEGORY IV

11.1 Altitude

Subject the test unit to altitude environment from ground level to 45,000 feet.

11.2 Temperature

A. Subject the test unit to a cold soak temperature of –20 degrees Fahrenheit and a hot soak of no less that +160 degrees Fahrenheit if installed in a temperature-controlled or non-controlled compartment. The appropriate time/temperature profile and operating cycle will be determined by Engineering, taking into account both the temperature extreme encountered in prolonged parking ramps or hangar operations and the extreme cold encountered at high altitude.

B. If the unit normally is supplied with standby power or heater power during the actual flight, such power will be supplied to the unit during the hot and cold soak period.

C. Where feasible the temperature and altitude test will be performed simultaneously. The normal test sequence of Section 7.2 E will be followed.

11.3 Vibration

A. Vibration tests will be performed in accordance with Section 9.3, except use the appropriate test curve selected from Figure 6 (sine vibration).

B. Equipment designed for installation without vibration isolators is tested to curve H of Figure 6.

C. Equipment installed on vibration-isolated panels or racks when the panel or rack is not available is tested to curve G of Figure 6.

D. Equipment mounted directly on an engine is tested to curve E of Figure 4.

E. Equipment mounted in an engine compartment is tested to curve D of Figure 4.

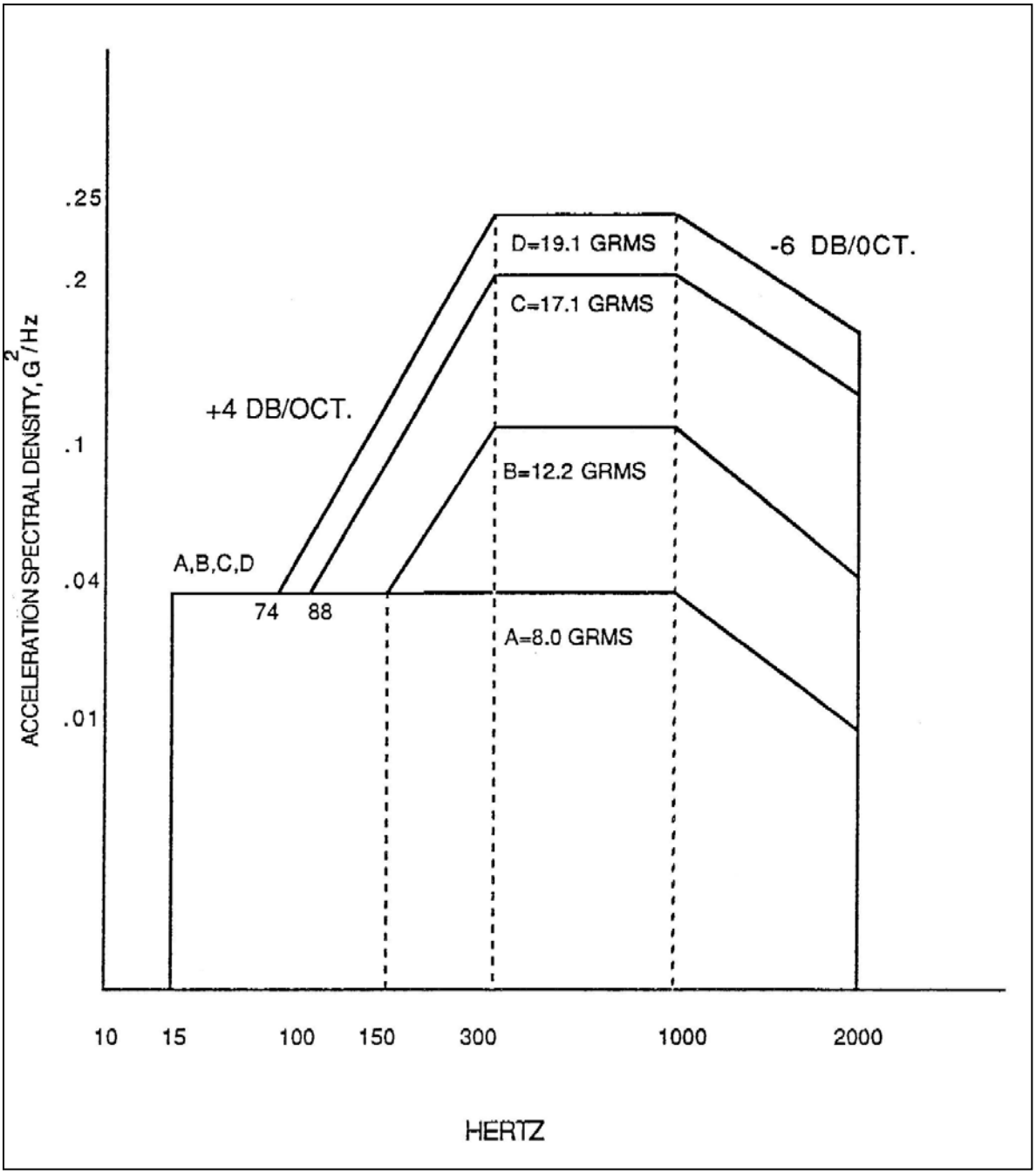

Figure 1: Random Vibration Test Curves
(See Figure 2 for selection)

Curve		Application
A	1)	NORMALLY INSTALLED ON VIBRATION ISOLATOR BUT TESTING WITH RIGID MOUNTING, DUE TO UNAVAILABILITY OF ISOLATOR.
B	1)	EQUIPMENT MOUNTED IN FUSELAGE FORWARD OF C.G. EXCEPT WHEN ENGINE IS MOUNTED IN FORWARD FUSELAGE.
	2)	EQUIPMENT MOUNTED IN FUSELAGE AFT OF C.G. EXCEPT WHEN ENGINE IS MOUNTED IN AFT FUSELAGE.
	3)	EQUIPMENT MOUNTED IN WING INBOARD HALF OF SEMI-SPAN EXCEPT WHEN ENGINE IS WING-MOUNTED.
C	1)	EQUIPMENT MOUNTED IN THAT SECTION OF FUSELAGE FORWARD OF C.G. IN WHICH ENGINE IS MOUNTED (EXCEPT ENGINE IN COMPARTMENT, SEE 'D').
	2)	EQUIPMENT MOUNTED IN WING OUTBOARD HALF OF SEMI-SPAN.
	3)	EQUIPMENT MOUNTED IN WING TIP PODS.
	4)	EQUIPMENT MOUNTED IN ANY WING IN WHICH ENGINE(S) IS/ARE MOUNTED.
D*	1)	EQUIPMENT MOUNTED INSIDE THE ENGINE COMPARTMENT OR ENGINE PYLON.

*Certain boundary conditions will exist where equipment is mounted in one compartment but extends into another, or may be mounted on the engine compartment bulkhead or firewall and subjected to engine vibration but not actually be in the engine compartment. Engineering will evaluate such situations as they arise.

Figure 2: Random Vibration Test Curve Selection

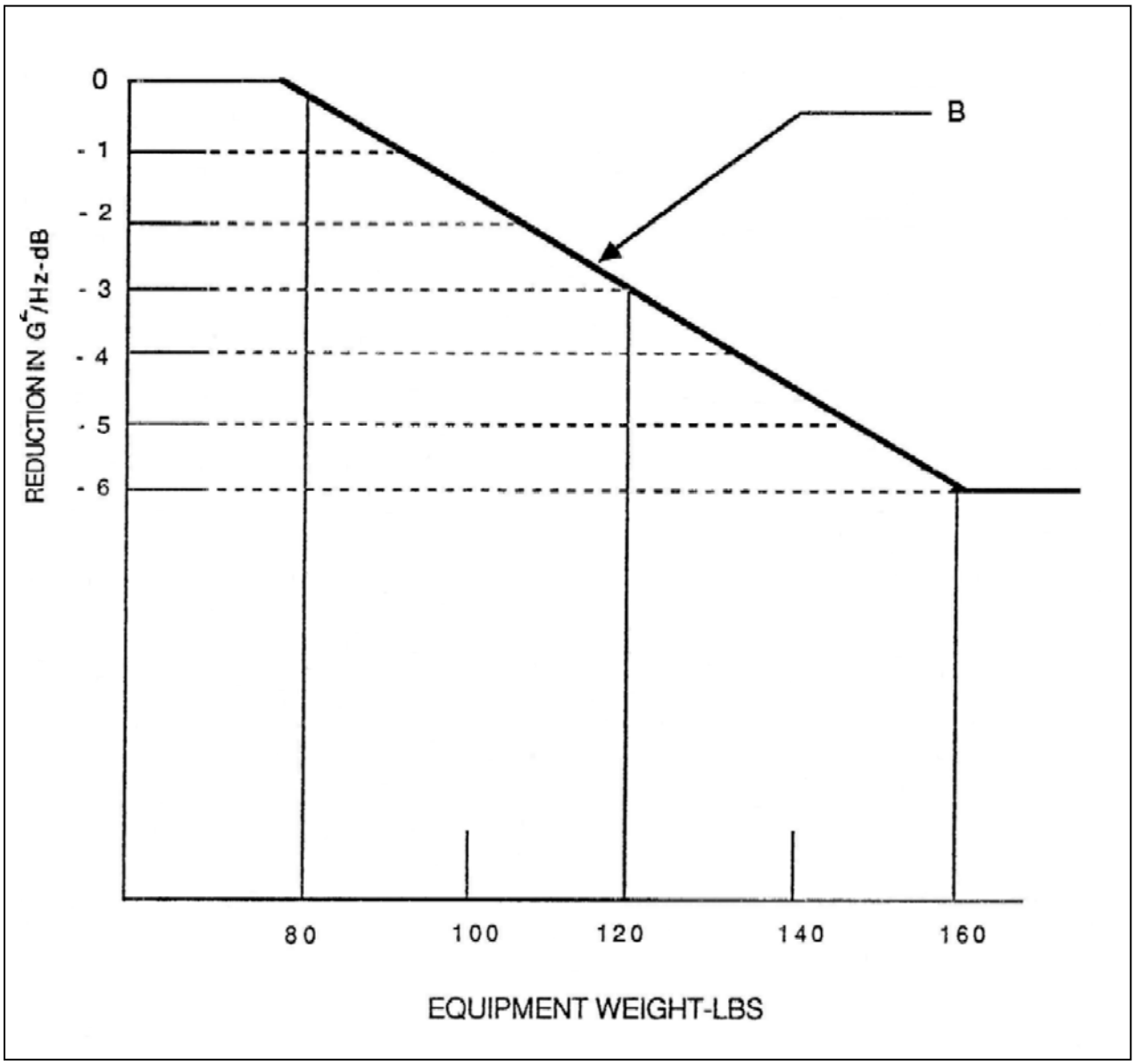

Figure 3: Random Vibration Testing Reduction Factor For Mass Loading

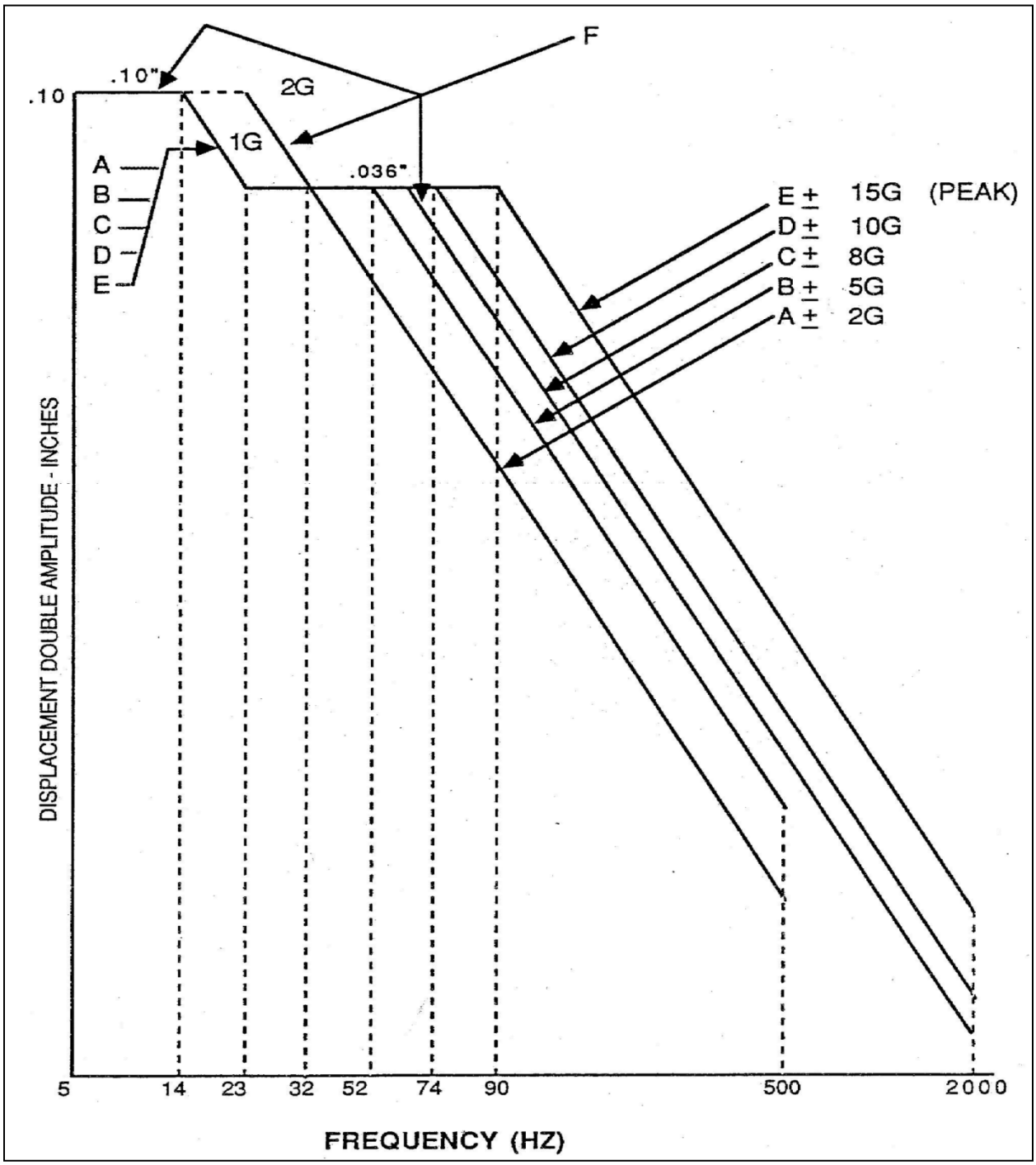

Figure 4: Sine Vibration Test Curves
(See Figure 5 for Vibration Test Curve selection)

Curve		Application
A	1)	EQUIPMENT NORMALLY INSTALLED ON VIBRATION ISOLATOR BUT TESTING WITH RIGID MOUNTING, DUE TO UNAVAILABILITY OF ISOLATOR.
	2)	EQUIPMENT MOUNTED ANYWHERE IN UNPOWERED GLIDE VEHICLES (UNLESS VEHICLE IS CARRIED ATTACHED TO OTHER AIRCRAFT, IN WHICH CASE LOCAL ENVIRONMENT IMPOSED BY THE CARRIER AIRCRAFT MUST BE CONSIDERED).
B	1)	EQUIPMENT MOUNTED IN FUSELAGE FORWARD OF C.G. EXCEPT WHEN ENGINE IS MOUNTED IN FORWARD FUSELAGE.
	2)	EQUIPMENT MOUNTED IN FUSELAGE AFT OF C.G. EXCEPT WHEN ENGINE IS MOUNTED IN AFT FUSELAGE.
	3)	EQUIPMENT MOUNTED IN WING INBOARD HALF OF SEMI-SPAN EXCEPT WHEN ENGINE IS WING-MOUNTED.
C	1)	EQUIPMENT MOUNTED IN THAT SECTION OF FUSELAGE FORWARD OF C.G. IN WHICH ENGINE IS MOUNTED (EXCEPT ENGINE IN COMPARTMENT, SEE 'D').
	2)	EQUIPMENT MOUNTED IN WING OUTBOARD HALF OF SEMI-SPAN.
	3)	EQUIPMENT MOUNTED IN WING TIP PODS.
	4)	EQUIPMENT MOUNTED IN ANY WING IN WHICH ENGINE(S) IS/ARE MOUNTED.
D*	1)	EQUIPMENT MOUNTED INSIDE THE ENGINE COMPARTMENT OR ENGINE PYLON.
E	1)	EQUIPMENT MOUNTED DIRECTLY TO THE ENGINE. (NOTE: ENGINEERING MAY PRESCRIBE A LESS SEVERE TEST BASED ON SPECIFIC DATA ON A GIVEN ENGINE INSTALLATION IF SUCH DATA IS AVAILABLE).
F	1)	THE LOWER FREQUENCY PORTION OF CURVE F (5 CPS TO 32 CPS) IS COMBINED WITH PORTION OF CURVE C ABOVE 32 CPS FOR EQUIPMENT MOUNTED IN POWER-OPERATED RUDDERS, ELEVATORS, OR AILERONS.

*Certain boundary conditions will exist where equipment is mounted in one compartment but extends into another, or may be mounted on the engine compartment bulkhead or firewall and subjected to engine vibration but not actually be in the engine compartment. Engineering will evaluate such situations as they arise.

Figure 5: Sine Vibration Test Curve Selection

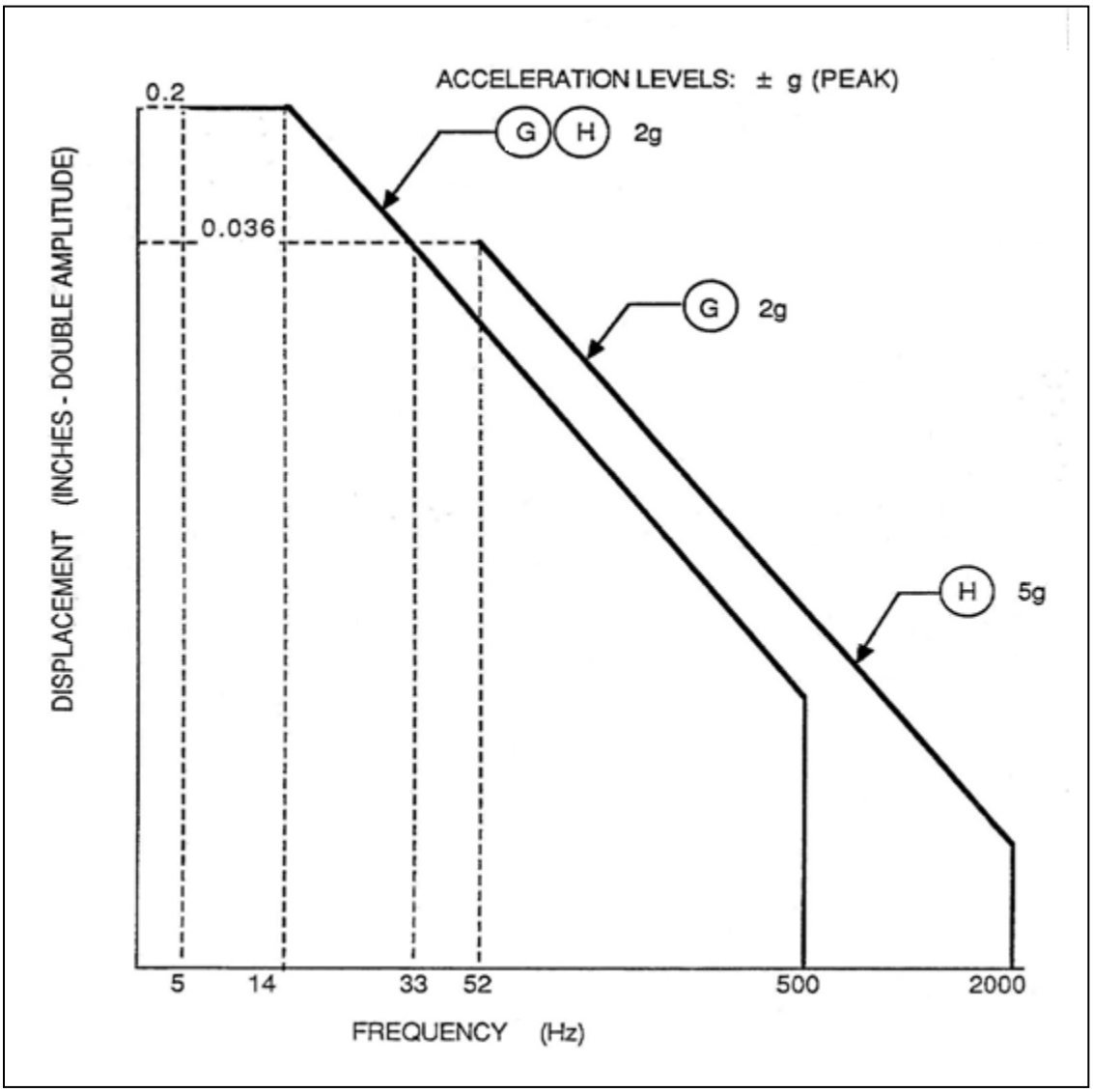

Figure 6: Sine Vibration Test Curves, Category IV

12.0 MANAGEMENT RECORDS & RECORDS RETENTION

Electronic work orders directing and documenting completion of environmental testing are archived within the electronic work order database in accordance with DCP-O-002, Aircraft Work Order Procedure, and are kept at a minimum the lifetime of the project plus 5 to 30 years in accordance with NPR 1441.1. System test procedures directing and documenting (as-run) completion of environmental testing will be retained by the environmental test group. A copy of the as-run procedure will be provided to the engineer that requested the test.

The environmental test group will retain a file of the data recorded during the environmental test it performed for a minimum of 5 to 30 years beyond the life of the project in accordance with NPR 1441.1, NASA Records Retention Schedules. An information copy of the data recorded during the environmental test will be provided to the engineer that requested the test.

A spreadsheet of electrical, electronic, optical, and electromechanical research and test equipment for use on NASA DFRC flight vehicles will be kept on the I: drive at I:\Code O\Code OE\DCP-O-018 Tracking.

Records are preserved, maintained, and disposed of in accordance with NPR 1441.1, NASA Records Retention Schedules, and Dryden records management procedures.

13.0 RELEVANT DOCUMENTS

13.1 Reference Documents

DCP-O-002	Aircraft Work Order Procedure
DCP-O-011	Aircraft System Test Procedure Preparation and Release
DPR-7123.2-001	Waivers and Deviations to Technical Requirements and Standards

13.2 Informational Documents

MIL-STD-810	Department of Defense Test Method Standard for Environmental Engineering Considerations and Laboratory Tests
DO 160	Environmental Conditions and Test Procedures for Airborne Equipment

13.3 Forms

DFRC 117.1f	Request for Deviation or Waiver

14.0 ACRONYMS & DEFINITIONS

14.1 Acronyms

C.G.	Center of Gravity
CPS	Cycles per second
dB	Decibel
G	g-force (acceleration)
GRMS	Root mean square g-acceleration
Hz	Hertz
LBS	Pounds
NDI	Non-Destructive Inspection
OCT	Octave
RFI	Radio Frequency Interference

14.2 Definitions

Acceptance test	A test to verify that specific items conform to acceptable standards for operational use. Acceptance testing is never designed to be destructive.
Qualification test	A relatively severe test to some stress level beyond that normally expected of the test item. May include life tests, overstress tests and in some cases destructive tests. Usually performed on one of a series of identical items to establish validity of design and manufacturing processes for the entire series. Items that have been qualification tested are not to be used for flight or “Mission Essential” support, unless remanufactured per specific engineering instructions and then acceptance tested.

Document History Log
IPRP Review Date: 12-15-09

This page is for informational purposes and does not have to be retained with the document.

Status Change	Document Revision	Effective Date	Page	Description of Change
Baseline		4-21-02		
Admin Change	Baseline	6-25-03	All	Added title of document to header. Improved formatting of informational tables. Replaced Document History Log with current version and moved to end of document. Renumbered Table of Contents to reflect changes. Moved page numbers to header.
Admin Change	Baseline-1	06-11-08		Added notice stating the need for review and revalidation, revision, or cancellation.
Admin Change	Baseline-2	08-11-08	All	• Extended expiration date • Removed notices citing need for review and revision
Revision	A	01-27-10	All	• Formatted to current document template • Completed document sections • Clarified responsibilities and procedure details • Added testing information
Admin Change	A-1	06-02-10	10	Removed “C” from item C to include text with item B. Relettered next two items.