Standard 262-14

Range Commanders Council
Electronic Trajectory Measurements Group

C (G) - BAND & X (I) - BAND NONCOHERENT RADAR TRANSPONDER PERFORMANCE SPECIFICATION STANDARD

ABERDEEN TEST CENTER
DUGWAY PROVING GROUND
REAGAN TEST SITE
WHITE SANDS MISSILE RANGE
YUMA PROVING GROUND

NAVAL AIR WARFARE CENTER AIRCRAFT DIVISION
NAVAL AIR WARFARE CENTER WEAPONS DIVISION
NAVAL UNDERSEA WARFARE CENTER DIVISION, KEYPORT
NAVAL UNDERSEA WARFARE CENTER DIVISION, NEWPORT
PACIFIC MISSILE RANGE FACILITY

30TH SPACE WING
45TH SPACE WING
96TH TEST WING
412TH TEST WING
ARNOLD ENGINEERING DEVELOPMENT COMPLEX

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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STANDARD 262-14

C (G) - BAND & X (I) - BAND NONCOHERENT RADAR TRANSPONDER PERFORMANCE SPECIFICATION STANDARD

June 2014

Prepared by

Electronic Trajectory Measurements Group
Transponder Ad-Hoc Committee
Range Commanders Council

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New Mexico 88002-5110

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Preface

Through the Electronic Trajectory Measurements Group (ETMG) Transponder Ad-Hoc Committee, an effort to write a common specification for C-band and X-band transponders was launched that would meet the needs of most ranges. This effort incorporates the Military Standard (MIL-STD) interpolations into the ETMG or Range Safety Group documents for future referencing. The intent of this document is not to delete any range's current transponder capabilities, as each range has its own unique requirements that necessitate the utmost flexibility in order to provide support. For example, flight certification testing and preflight requirements at each range differ from one another. Participating ranges will continue to use their current stock and can participate in an exchange program that will gather working and non-working units for issuance as aircraft transponders or for manned aircraft use. Individual ranges may also participate in a replacement program where older units can be exchanged for newer design models (as of this date, however, such an exchange program does not exist).

The ETMG welcomes any comments, questions, corrections, additions, or deletions to this document. Any inquiries should be addressed to:

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Acknowledgments

The intent of the ETMG's document, *C (G)-Band and X (I)-Band Non-Coherent Radar Transponder Performance Specification Standard,* RCC 262-14, is to provide a complete and overall standard for radar tracking transponder use on multiple ranges. Accomplishment of this goal required a total team effort by multiple ranges and their personnel, who dedicated many hours and much expertise to this project.

The chair of the ETMG's Transponder Ad Hoc Committee would like to give special recognition to the following contributors for their unique contributions as radar experts.

- Donald H. Sammon, Radar Branch, White Sands Missile Range, NM
- Paul Olson, Radar Branch, Naval Air Warfare Center Weapons Division, China Lake, CA

Special thanks go to the following people.

- Jim Bogan, NASA/Goddard Space Flight Center, Wallops Island, VA
- Robert Hunt, Naval Undersea Warfare Center, AUTEC Range Service, West Palm Beach, FL
- Linda Abling, Computer Sciences Corporation Beacon Lab, Edwards Air Force Base (AFB), CA
- Ben Lary, Naval Air Warfare Center Weapons Division, Pt. Mugu, CA
- Martin Diaz, ITT Federal Services Corp., Vandenberg AFB, CA
- Steve Weimers, Eglin AFB, FL.

A very special acknowledgment goes to Robert Robinson, 412th Test Wing, Edwards AFB, CA for his committed and tireless support of this project.

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Acronyms

µs	microsecond
A	amp
AFB	Air Force Base
°C	degrees Celsius
C.G.	center of gravity
cm	centimeter
C.P.	chemically pure
dB	decibel
dBm	decibels referenced to milliwatts
DC	direct current
EMI	electromagnetic interference
ETMG	Electronic Trajectory Measurements Group
°F	Fahrenheit
g	acceleration due to gravity
GHz	gigahertz
Hz	hertz
IAW	in accordance with
inHg	inches mercury
kHz	kilohertz
mA	milliamps
MER	multiple ejection rack
MHz	megahertz
MIL-HDBK	Military Handbook
MIL-S	Military Specification
MIL-STD	Military Standard
mmHg	millimeters mercury
ms	millisecond
MTBF	mean time between failures
ns	nanosecond
oz	ounces
ppm	pulses per minute
pps	pulses per second
PRF	pulse repetition frequency
psi	pounds per square inch
PSS	performance specification standard
PW	pulse width
RF	radio frequency
rms	root mean square
t_a	minimum acceptance time
TER	tri-ejection rack
t_r	minimum rejection time
UUT	unit under test
V	volt
VDC	volts direct current
VSWR	voltage standing wave ratio

W	watt

CHAPTER 1

Introduction

1.1 General

Historically, each testing range in this country has been able to purchase or obtain transponder equipment via the normal procurement channels or through other ranges. This procedure required the procuring range or the supplying range to write their own specifications and to conduct their own testing and monitoring. The end result was that hardware often was not compatible with another range's requirements. This method required long lead times, frequent specification updating, the ongoing need to establish, qualify, and approve new sources, and continuous testing. With government cutbacks, this process became an increasingly more difficult task.

In addition, provider companies merged, market competition decreased, spare parts became nonexistent, and prices skyrocketed. Many ranges experienced problems with contract off-loading - that is, the procuring range had to be mission-tied to the supplying range for any transaction to not be considered contract off-loading.

A study conducted by the ETMG Transponder Ad-Hoc Committee estimated that at least 55 types/models of transponders are in use among all the ranges. This count did not include special transponders, such as drone control transponders with their encoder/decoders, or coherent transponders currently being used by some ranges and in satellites.

Typically, transponders are not off-the-shelf items. Most are manufactured under a specific end-user construction/design specification. Historically, there have been no more than two or three manufacturers of C-band and X-band transponders at any given time, with only one being qualified to provide transponders to most ranges. There are several other potential manufacturers that still need evaluation. These new vendors normally require a two-year lead time, and initial procurement costs from these sources are generally much higher than producing manufacturers. All of these factors have contributed to an increasing problem in meeting range requirements.

The goal of this specification standard is to allow ranges to reference RCC documents in their purchase specifications, thus removing the need to create a large document that may lead to improper interpretations, incorrect levels, improper test methods, and poor quality control. Vendors benefit by having exact, standard guidelines, thus ensuring proper product design and performance.

1.2 Scope

This document sets forth the minimum transponder parameter requirements for both C (G)-band and X (I)-band, noncoherent, pulse-type transponder sets that any instrumentation tracking radar on any test range may use. The following radar transponder specifications and system test verification procedures have been provided by technical members of the ETMG, Transponder Ad Hoc Committee, represented and staffed by members from all RCC-affiliated ranges. These specifications and test procedures have been extensively reviewed, rewritten, and verified by members of the major ranges and qualified industry manufacturers. All departments and agencies of the Department of Defense approve the performance specifications contained within this document.

1.3 Purpose

The specifications and procedures outlined in this document can be utilized as a standard for procurement of future radar transponders, as a performance standard for transponder manufacture, or for quality assurance and acceptance testing. These guidelines are approved for use on all major military ranges to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or requests for proposal shall apply.

These specifications are not intended for special applications such as space-level qualification or drone-control requirements; however, the electrical operation is the same. Even though this document does not specifically address specialty transponders, it can be used with noted exceptions that address specific requirements. The equipment user may modify environmental test levels, as needed.

1.4 Order of Precedence

In the event of conflict between the text of this standard and the references cited herein, the text of this standard should take precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

1.5 Requirements and Specified Frequency

The transponder set is to consist of a receiver and a transmitter with an integral power supply. The transponder must accept interrogation signals from single or multiple radar sets and provide a tracking pulse for specified band instrumentation radar sets. Frequencies specified in this performance specification standard (PSS) have been determined as the normal range frequency bands for C-band of 5400-5900 megahertz (MHz) and X-band of 9000-9600 MHz. Individual purchasing agents may determine a variant of the specified frequency band (i.e., 8400-9000 MHz), and, in this event, shall be responsible for annotation of the variant frequencies in each of the tests and procedures requiring a frequency test.

1.6 Background

The radar transponder is a radar tracking aid. The function of this pulse-type transponder is to extend the tracking range and accuracy of precision tracking instrumentation radars. To accomplish this function, the transponder receives a coded pulse interrogation from the ground radar and transmits a single pulse reply in the same frequency band.

The transponder tracking system has several advantages over the conventional skin-tracking method.

- The transponder provides a point source track that allows for identification and tracking of specific sections of the airborne vehicle that have individual transponders installed, such as payload, first stage, etc.
- Different missile sections can be identified by using more than one transponder with different codes and frequencies.

- The radar tracking range is extended by the transponder transmitting a high-power reply, instead of the reflected signal obtained from a skin track.
- Point source not only enhances the tracking accuracy, but also satisfies stringent range safety requirements.
- The use of transponders for identification of multiple targets also adds to the importance and significance of the transponder to the radar system for range operations. In multiple-target operations, each target can be identified if provided with a radar transponder. It is not possible to do this in the skin-tracking mode because, when targets are in close proximity, the tracks may jump from one target to another.

Position data from the transponder radar includes range, azimuth, and elevation and is obtained by using either a single tracking station or several tracking stations along the flight path of the target vehicle. The accuracy gained by use of transponders is significant. For example, the accuracy achieved by use of the AN/FPS-16 radar is such that the position data obtained from point-source targets has azimuth and elevation angular errors of less than 0.1 mil root mean square (rms) and range errors of less than 5 yards rms. The data is also presented in digital form.

It should be realized that the transponder, as installed in the airborne vehicle, is a system consisting of the transponder, antenna, and primary direct current (DC) power supply. Since the quality and accuracy of the radar data depends on the quality of the transponder system, it is imperative that each component of the system be of the highest quality and be compatible with the overall radar instrumentation tracking system.

1.7 Description of Test Types

This PSS describes the following types of tests for transponders.

a. Qualification tests: tests conducted by the vendor that are for the purpose of proving the design.

b. Reliability tests: tests conducted by the vendor that are for the purpose of demonstrating the reliability of the transponder.

c. Acceptance tests: tests conducted by the purchasing agent for the purpose of establishing and maintaining quality control during production under contract.

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CHAPTER 2

Noncoherent Transponder Specifications

This chapter describes performance specifications for 20-, 50-, and 400-watt noncoherent transponders.

2.1 Electrical Characteristics

2.1.1 Power Supply

The transponder shall be furnished with an integral power supply. Mechanical vibrator-type power supplies are not acceptable.

2.1.2 Input Voltage

The transponder shall conform to the requirements of this specification with input voltages from 22 volts (V) DC (VDC) to 32 VDC.

2.1.3 Isolation

The power lines shall not be grounded within the transponder. Reverse polarity and over-voltage protection shall be provided. The primary power return shall be isolated from the case by 1 megohm resistance or greater.

2.1.4 Input Current

This standard provides the following specifications for electric current powering transponders.

a. 20-watt transponders require current that is ≤300 milliamps (mA) at 1000 pulses per second (pps) 28 VDC and ≤350 mA at maximum pulse repetition frequency (PRF) 32 VDC. Quiescent current shall not exceed 250 mA.

b. 50-watt transponders require current that is ≤400 mA at 1000 pps 28 VDC and ≤450 mA at maximum PRF 32 VDC. Quiescent current shall not exceed 300 mA.

c. 400-watt transponders require current that is ≤750 mA at 1000 pps 28 VDC and ≤1 amp (A) at maximum PRF 32 VDC. Quiescent current shall not exceed 500 mA.

2.1.5 Fuses and Circuit Breakers

Noncoherent radar transponders shall not include fuses and circuit breakers.

2.1.6 Transient Protection

The transponder input 28 VDC power leads shall be subjected to the requirements of MIL-STD-704F[1], modified for the upper setting voltage of 32 V. The voltage transients shall be per the amplitudes and time duration of MIL-STD-704F.

2.1.7 Under-Voltage/Over-Voltage Protection

Parameters shall be consistent with MIL-STD-704F.

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[1] Department of Defense. Aircraft Electric Power Characteristics. MIL-STD-704F. 12 March 2004. May be superseded by update. Available at http://quicksearch.dla.mil.

2.1.8 In-rush Current Limits

The transponder shall not generate in-rush spikes greater than 2 A in amplitude and 50 microseconds (μs) in duration.

2.2 Identification

The following information shall be marked on the transponder and visible when installed.

- Manufacturer's name
- Model number
- Serial number
- Contract number

The unit's serial number shall also be provided on the face of the connector side of the transponder.

2.3 Technical Data

Technical data shall be furnished as set forth in the Contract Data Requirements List, DD Form 1423 (Appendix B), and in accordance with (IAW) the data item descriptions attached thereto.

2.4 Mechanical Construction

2.4.1 Maximum Weight

The following are the maximum weight limits for the three sizes of transponder.

- 20-Watt: The weight of the transponder shall not exceed 15 ounces (oz), exclusive of mating power and antenna connectors.
- 50-Watt: The weight of the transponder shall not exceed 26 oz, exclusive of mating power and antenna connectors.
- 400-Watt: The weight of the transponder shall not exceed 43 oz, exclusive of mating power and antenna connectors.

2.4.2 Physical Size

The transponder case shall be constructed as shown in the footprint in Figure 2-1 (20-watt [W]), Figure 2-2 (50-W), and Figure 2-3 (400-W). Also see reference note below Figure 2-3.

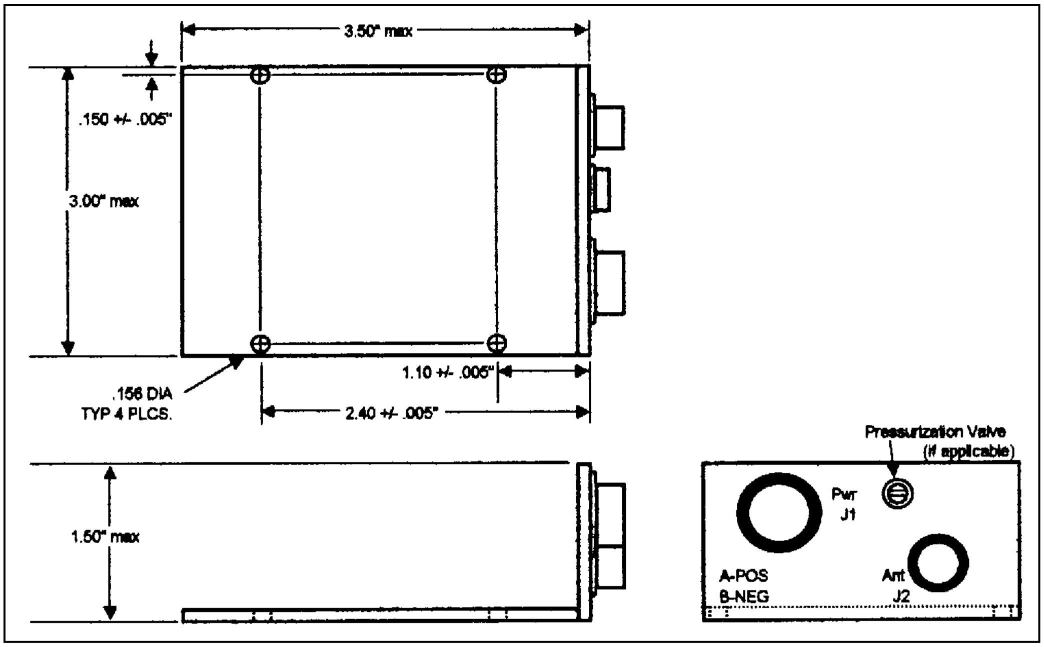

Figure 2-1. Case Dimensions for 20-Watt Transponders (Not Drawn to Scale)

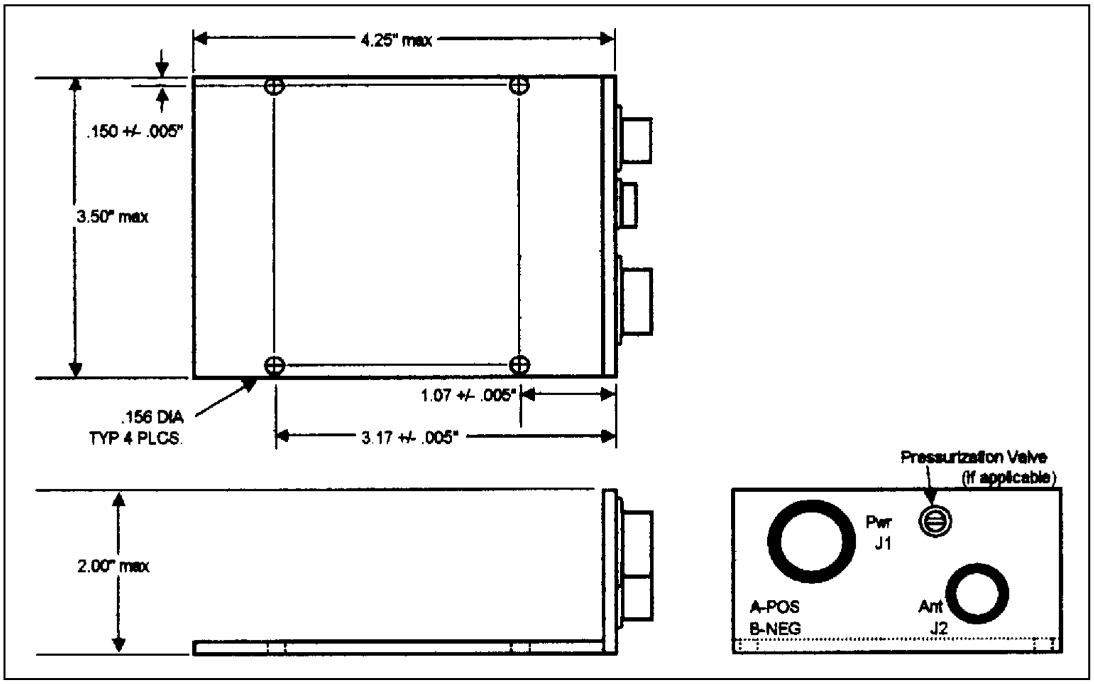

Figure 2-2. Case Dimensions for 50-Watt Transponders (Not Drawn to Scale)

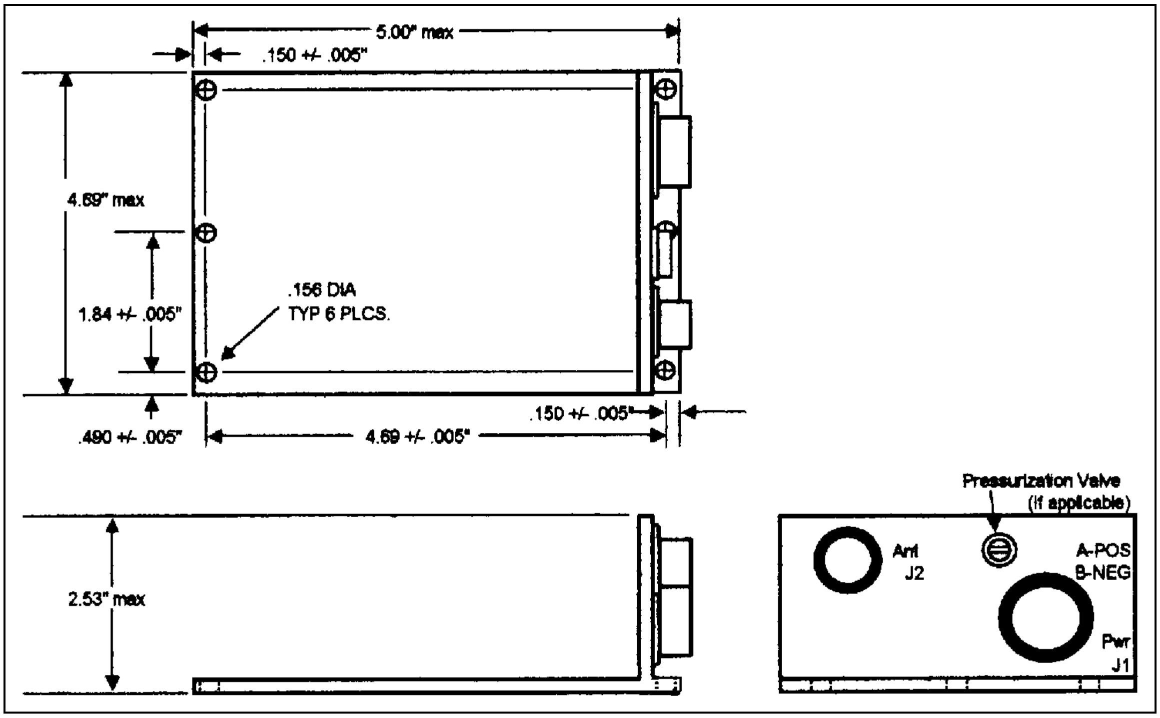

Figure 2-3. Case Dimensions for 400-Watt Transponders (Not Drawn to Scale)

NOTE	If the transponder physical size is reduced and separate adapter plates are fabricated in order to maintain the footprint per the case dimension drawings, those plates or adapters shall be considered an integral part of the transponder and shall be subjected to the requirements of environmental testing.

2.4.3 Connector Location

The appropriate antenna and power connectors shall be located on the front panels as shown in Figure 2-1, Figure 2-2, and Figure 2-3 for each wattage.

2.4.4 Finish

All production units shall be protected against corrosion by a coating that shall be electrically conductive IAW the guidance outlined in Military Detail Specification MIL-DTL-5541F[2].

2.4.5 Power Connectors

Necessary power connectors for the three sizes of transponder are listed as follows.

- 20-Watt: The power connector shall be an integral part of the unit and of Bendix type 27476-Y08D-35P. A mating connector shall also be supplied with each unit, type MS-27484E8-B35S.
- 50-Watt: The power connector shall be an integral part of the unit and of Bendix type 27476-Y08D-35P. A mating connector shall also be supplied with each unit, type MS-27484E8-B35S.

[2] Department of Defense. Chemical Conversion Coatings on Aluminum and Aluminum Alloys. MIL-DTL-5541F. 11 July 2006. May be superseded by update. Available at http://quicksearch.dla.mil.

- 400-Watt: The power connector shall be an integral part of the unit and of Bendix type 6727-MS3114-H8-4P. A mating connector shall also be supplied with each unit, type PT06E-8-4S.

2.4.6 Radio Frequency Connectors

The radio frequency (RF) output shall be an integral part of the unit and of the SMA female type (common to receiver and transmitter) for the 20/50-W units and of the TNC female type for the 400-W units. A mating connector shall also be supplied with each unit.

2.4.7 Pressurization

If applicable to the design, the transponder shall maintain an interior pressure of 15 pounds per square inch (psi) ± 1 psi (20- and 50-W units) and 20 psi ± 1 psi (400-W units) above the absolute pressure for at least 8 hours, or as required during qualification testing (Paragraph 2.9). Pressurization shall be checked through a tuning access port. After the test, the port seal screw will be installed to cover the port.

2.4.8 Case Design

The transponder case shall be constructed so that the transponder does not become inoperable when the cover is removed from its case (housing). Removal of the transponder cover for inspection or adjustment shall void the manufacturer's warranty.

2.4.9 Shock Mounts

External vibration isolators or shock mounts shall not be used.

2.4.10 Component Mounting

All components shall be secured in a method that will not degrade the unit's performance under all operating conditions. Components shall be hard-mounted and soldered to the circuit board in a manner that adheres to acceptable engineering practices to ensure survivability when subjected to environments as specified in Section 2.7. Survivability shall be determined by meeting the environmental test criteria outlined in Section 3.4.

2.4.11 Orientation

The transponder shall operate to the requirements of this PSS independent of orientation.

2.4.12 Test Points

Marked internal test points shall be provided for service and repair of the transponder.

2.4.13 Special Tools

If any special tools are required for servicing and adjusting, the manufacturer shall provide a list of equipment software, recommended tools, and a source for such tools.

2.5 Receiver Section

2.5.1 Frequency Range

The tunable range shall be at least 5400 MHz to 5900 MHz (inclusive) for C-band transponders and 9000 MHz to 9600 MHz (inclusive) for X-band transponders. The frequency may be either continuously adjustable or programmable in increments no greater than1 MHz.

2.5.2 Bandwidth

The receiver 3 decibels (dB) RF bandwidth shall be dependent on the number of pre-selector cavities as follows.

- Two-cavity pre-selector: $\geq$12 MHz and $\leq$17 MHz
- Three-cavity pre-selector: $\geq$6 MHz and $\leq$16 MHz or (11 MHz ± 5 MHz)

2.5.3 Image Rejection

If applicable to the design, the receiver shall have an image rejection of at least 60 dB.

2.5.4 Frequency Stability

The transponder shall meet all performance requirements to any valid interrogation that is within ± 2 MHz minimum from the assigned center frequency, over all conditions, referenced to signal levels in Paragraph 2.5.9.

2.5.5 Sensitivity

All transponders shall have a sensitivity of less than or equal to –68 dB referenced to milliwatts (dBm) The transponder shall reply to 99% of the interrogation signals at input signal levels as specified in Paragraph 2.5.9. The input signal shall be measured at the transponder antenna terminal. If a sensitivity adjustment is provided by design, it shall be accessible by external (through-case) control.

2.5.6 Interrogations

The transponder shall operate from either single- or double-pulse interrogations with pulse characteristics as follows.

2.5.6.1 Pulse Width

The transponder shall accept interrogation signals of 250 nanoseconds (ns) to 1 µs measured at the 50% amplitude points of the detected RF pulses for two-pulse code operations and 250 ns to 5 µs for single-pulse operations.

2.5.6.2 Two-Pulse Code Spacing

Code spacing shall be adjustable either continuously or in 0.5-µs increments, from 3 µs to 15.5 µs by external adjustment. Spacing is measured at 50% amplitude points on leading edges of adjacent detected RF pulses.

2.5.6.3 Two-Pulse Code Accept Limits

The transponder shall perform to full specification to interrogations within the two-pulse code spacing limit of ± 150 ns at input signal levels as specified in Paragraph 2.5.9.

2.5.6.4 Two-Pulse Code Reject

The two-pulse code spacing reject limit is ± 200 ns, positive rejection."

2.5.6.5 Interrogation Rejection

The transponder shall reject all signals not having the characteristics as specified in this section and shall not be triggered by single-pulse interrogations with durations as great as 50 µs when set for a two-pulse code operation at input signal levels as specified in Paragraph 2.5.9, either on or off frequency.

2.5.7 Random Triggering

The random triggering limit of transponders shall be less than or equal to10 pps under all specified operating conditions.

2.5.8 Input Impedance

The input impedance shall be 50 ohms ± 1%, voltage standing wave ratio (VSWR) not to exceed 2:1.

2.5.9 Maximum Input Signal Level

The maximum input signal level of radar transponders should range from –68 dBm to 20 dBm.

2.6 Transmitter Section

2.6.1 Frequency Range

The frequency is tunable over a range of at least 5400 MHz to 5900 MHz (inclusive) for C-band transponders and 9000 MHz to 9600 MHz (inclusive) for X-band transponders. The frequency may be either continuously adjustable or programmable in increments not greater than 1 MHz.

2.6.2 Frequency Stability

After a three-minute warm-up, and for at least 12 hours, the transmitter frequency shall not drift or vary more than ± 3 MHz from the preset and initial measurement, from –27 degrees Celsius (°C) to 50°C; or vary ± 5 MHz from –54°C to –27°C and 50°C to 85°C.

2.6.3 Peak Power Output

The unit under test (UUT) shall determine whether a 20-W, 50-W, or 400-W transponder is used.

2.6.4 Pulse Repetition Frequency

The transponder shall operate at PRF rates of 10 pps to 2600 pps minimum at maximum pulse width (PW) as defined by Subsection 2.6.5. Regarding PRF over-interrogation, a PRF limit adjustment of at least 2000 pulse repetition integration to maximum duty cycle shall be provided and accessible to adjustment after cover removal. The PRF limit circuit shall provide over-interrogation protection. Recovery to specified performance from over-interrogation shall not exceed 500 µs.

2.6.5 Pulse Width

The transponder reply signal shall have a PW that is adjustable over the range of 230 ns through 600 ns. The width shall be measured at the 50% (–3 dB) point on the detected peak RF value. The PW adjustment shall be accessible after cover removal.

2.6.5.1 Jitter

The transmitter reply pulse jitter shall not exceed 10 ns standard deviation of the set PW, measured at the 50% (–3 dB) point on the detected peak RF value.

2.6.5.2 Rise Time

The transmitter reply pulse rise time shall not exceed 50 ns (20- and 50-W units) or 100 ns (400-W units) measured at 10% to 90% points.

2.6.5.3 Fall Time

The transmitter reply pulse fall time shall not exceed 100 ns (20- and 50-W units) and 150 ns (400-W units) measured at 90% to 10% points.

2.6.5.4 Pulse Droop

The transmitted reply pulse shall not droop more than 5% measured from the established peak amplitude to the established fall peak amplitude (reference pulse waveform definition chart, Figure 2-4).

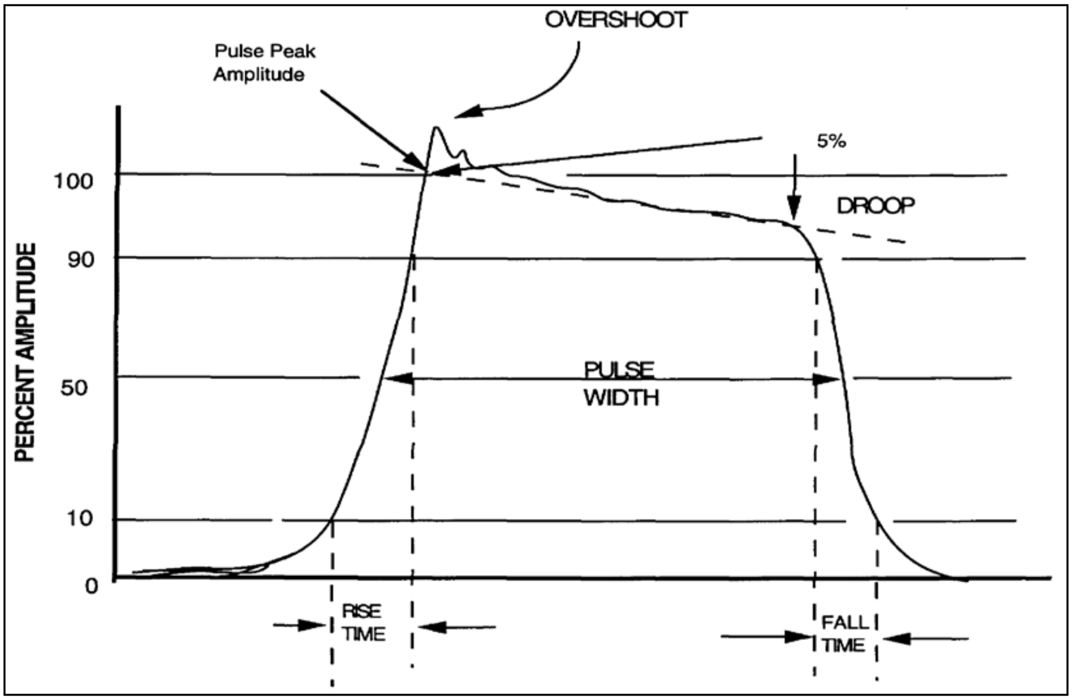

Figure 2-4. Pulse Waveform Definition (Not Drawn to Scale)

2.6.6 Transmitter Spectrum

The RF pulse spectrum measured at the 6-dB points shall not exceed 1.7 divided by the PW (in MHz). The first side lobes shall be a minimum of 9 dB below the main, measured from peak to peak. The first nulls bordering the main lobe shall be spaced a nominal 2 divided by the PW (in MHz) apart and shall be a minimum of 12 dB below the peak of the main lobe.

2.6.7 Load Voltage Standing Wave Ratio

The transponder shall meet all requirements of this specification when operating into a mismatch, referenced to a 50-ohm system such as to cause a VSWR up to 2:1, at any phase angle, or after application and removal of a short or an open circuit at the antenna terminal. Transmitter frequency changes due to VSWR will not be measured as part of the transmitter frequency stability requirement as defined by Section 2.6.2

2.6.8 Transponder Delay

The transponder shall have a delay from 1.5 μs to 9 μs inclusive. The delay may be continuously adjustable or programmable in increments not greater than 0.5 μs. The transponder shall also have the capability of maintaining a set delay ± 15 ns measured at a –30-dBm received signal interrogation level measured from leading edge of the second interrogation pulse to the leading edge of the transmitter reply pulse. For single-pulse operations, the delay shall be measured from the 50% point on the leading edge of the interrogating single pulse to the 50% point on the leading edge of the transmitter reply pulse. The delay adjustment shall be accessible either by external (through-cover) control or by access to adjustment after cover removal.

Reply delay variations (signal strength) shall adhere to the following tolerances. With reference input signal set at –30 dBm and 1000 pps, the transponder delay shall not vary more than ± 15 ns from –50 dBm to –10 dBm and no more than ± 30 ns from –10 dBm to 10 dBm and –68 dBm to –50 dBm.

a. Interrogation Rate Variation: The transponder delay shall not vary more than ± 15 ns at interrogation rates of 160, 320, 640, 800, 960, 1120, 1280, 1440, and 2400 pps from the set delay measured at –30 dBm input signal level and at a rate of 1000 pps.

b. Interrogation Frequency Variation: The transponder delay shall not vary more that ± 15 ns for interrogation frequency deviations of ± 3 MHz at 1 MHz increments from the set delay measured at –30 dBm input signal level and at a rate of 1000 pps.

c. Two-Pulse Code Variation: The transponder delay shall not vary more than ± 15 ns with typical two-pulse code space variations of ± 150 ns from the set delay measured at –30 dBm input signal level and at a rate of 1000 pps.

d. Input Voltage Potential Variation: The transponder delay shall not vary more than ± 15 ns with input voltage potential variations from 22 VDC to 32 VDC referenced to the set delay measured at –30 dBm input signal level and at a rate of 1000 pps.

e. Temperature Variation: The transponder delay (Paragraph 2.6.8) shall not vary more than ± 15 ns from the set delay over the required temperature range.

f. Jitter: The transponder delay jitter shall not exceed 30 ns standard deviation maximum for input signal levels as specified in Section 2.5.9.

2.6.9 Recovery Time

The transponder shall reply to successive interrogations (from single or multiple radar sets) with a recovery time not to exceed 50 µs. Each successive transponder reply shall satisfy the characteristics specified herein. Lockout protection shall provide for no response during recovery.

2.7 Environment Requirements

The transponder shall operate to the requirements of this specification during and after subjection to environments specified as follows.

2.7.1 Electromagnetic Interference

General test procedures for electromagnetic interference (EMI) testing are outlined in Section 3.3. The transponder shall meet the emission and susceptibility requirements of MIL-STD-461F[3], Methods CE102, CE106, CS101, CS103, CS104, CS114, CS115, CS116, RE102, RE103, RS101, and RS103. The test shall be performed IAW MIL-STD-461F and shall be accomplished in both key-up and key-down modes.

[3] Department of Defense. Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment. MIL-STD-461F. 10 December 2007. May be superseded by update. Available at http://quicksearch.dla.mil.

2.7.2 Environmental Test Procedures

Environmental test procedures are outlined in Section 3.4. The schedule for performing these procedures is specified in Table 3-4 and Table 3-5. Transponders selected for environmental testing shall meet the requirements specified in Chapter 3.

2.8 Quality Assurance Provisions

Unless otherwise specified, vendors shall provide and maintain a quality control system, and will utilize their own facilities or any commercial laboratory acceptable to the purchasing agent for performance testing.

2.8.1 Workmanship

Workmanship shall be IAW the guidance outlined in Military Handbook (MIL-HDBK) 454B,[4] Guideline 9, 10, and 15 (to include MIL-STD-889B[5]). If applicable to the design, conformal coating shall be applied to circuit boards.

2.8.2 Quality Assurance

The quality assurance requirement of this specification shall be met by compliance with the provisions of ISO-9000-1,[6] ISO-9000-2,[7] and ISO-9000-4.[8]

2.8.3 Test Requirements

In addition to any inspections or tests required by the provisions specified in Section 2.1 through Section 2.8 (inclusive), vendors shall conduct performance verification tests as described in Paragraph 2.9. All test results shall be furnished to the purchasing agent IAW the technical data requirements of the contract, Paragraph 2.3.

2.8.4 Inspection

The vendor shall provide and maintain an inspection system that assures that all supplies and services submitted to the purchasing agent for acceptance shall conform to the contract requirements whether manufactured or processed by the vendor or procured from sub-vendors or other vendors. The vendor's inspection system shall be documented and available for review by the purchasing agent prior to initiation of production and throughout the life of the contract. The vendor shall notify the purchasing agent of any change to the inspection system. The vendor is responsible for the performance of all inspection requirements and testing as specified herein. The purchasing agent reserves the right to perform any of the inspections set forth in this specification where such testing may be deemed necessary to assure that the product meets the requirements of this specification.

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[4] Department of Defense. General Guidelines for Electronic Equipment. MIL-HDBK-454B. 15 April 2007. May be superseded by update. Available at http://quicksearch.dla.mil.

[5] Department of Defense. Dissimilar Metals. MIL-STD-889B. 7 July 1976. May be superseded by update. Available at http://quicksearch.dla.mil.

[6] International Organization for Standardization. *Quality management and quality assurance standards -- Part 1: Guidelines for selection and use*. ISO 9000-1:1994. Withdrawn with no replacement. Geneva: International Organization for Standardization, 1994.

[7] International Organization for Standardization. *Quality management and quality assurance standards -- Part 2: Generic guidelines for the application of ISO 9001, ISO 9002 and ISO 9003*. ISO 9000-2:1997. Withdrawn with no replacement. Geneva: International Organization for Standardization, 1997.

[8] International Organization for Standardization. *Quality management and quality assurance standards -- Part 4: Guide to dependability programme management*. ISO 9000-4:1993. Withdrawn with no replacement. Geneva: International Organization for Standardization, 1993.

2.8.5 Failures

If a failure occurs in any of the individual qualification tests of the transponder, the cause of the failure shall be ascertained and corrected by the repair of the failed subassembly or by replacement of the failed piece or part. The specific test during which the failure occurred shall be repeated. If the replacement or the repair alters the performance characteristics of the failed subassembly, piece, part, or related assembly, then all required tests should be repeated. The transponder failure shall be considered corrected after successfully passing that particular test requirement at which the failure occurred during repeat testing with an engineering analysis of the specific failure to indicate one of the following causes:

a. Defective workmanship or improper handling;
b. Environment or electrical interface during the test exceeding specific limits;
c. Any previous design deficiency that has been corrected and incorporated into the re-tested transponder.

If the transponder fails the retest because of the recurrence of the identical failure or related failure attributable to the replacement or repair of the failed subassembly or piece part, the test in progress shall be discontinued and the deficiency analyzed and corrected to the satisfaction of the purchasing agent. The determination of which individual tests, or applicable portions thereof, that were completed prior to the failure and which are to be repeated shall depend on the type of failure and the nature of the design change required as a result of the engineering analysis performed.

2.9 Type I Tests: Qualification Testing

General test procedures for Type I tests are outlined in Chapter 3. The vendor shall have the responsibility of accomplishing these tests. The vendor shall notify the purchasing agent 15 days prior to start of tests, so that the purchasing agent can be present. As set forth in the contract schedule, a pre-determined quantity of transponders (hereafter referred to as test batch) shall be randomly selected by the purchasing agent to undergo the Type I test schedule. These tests shall demonstrate specified performance of the outlined procedures, shall be satisfactorily completed prior to first delivery, and shall be part of that delivery. A select quantity of the test batch transponders shall undergo reliability testing. After completion of this test, another select quantity of these test batch transponders shall undergo room-ambient electrical tests as specified. Another quantity shall be selected for EMI testing. The remaining transponders of the test batch not selected for reliability or EMI testing shall be subjected to the environmental test procedures as specified in Chapter 3. No transponder shall be operated in excess of 150 hours prior to delivery without being reconditioned.

2.10 Type II Tests: Acceptance Testing

General test procedures for Type II tests are outlined in Chapter 4. The purchasing agent shall have the responsibility of accomplishing these tests. Type II tests will be performed through the purchasing agent on all transponders provided under the contract. These tests will be accomplished within 30 days after delivery.

2.10.1 Failures

Repair of failed equipment returned to the vendor will be accomplished according to procedures specified by the purchasing agent. The turn-around time of equipment with completed report shall be 60 days maximum. The vendor shall supply the following information on each unit.

a. Type of failure

b. Cause of failure

c. Description of corrective action taken

d. Operating time

2.10.2 Retrofits

If a failure is found by the purchasing agent or the vendor to be a design problem, the vendor shall retrofit all delivered units to correct the problem at no further expense to purchasing agent.

2.10.3 Spare Parts

The purchasing agent shall identify requirements for spare parts. Unassembled transponder units shall be provided as spare parts to a level of major assemblies and sub-assemblies consisting of a transmitter, intermediate frequency circuit card assembly, video amplifier and digital control assembly, power supply and modulator card assembly, RF module assembly, circulator, and internal oscillator mixer assembly.

2.10.4 Preparation for Delivery

Packing and marking for shipment shall be as set forth in other contract documents.

CHAPTER 3

Qualification Testing of Radar Transponders

Qualification tests, also known as Type I tests, are designed by the customer and performed by the vendor.

3.1 Reliability Testing Procedures

The sequential reliability test shall be the first test conducted under the Type I test schedule. This required test is designed to verify, at the 90% level of confidence, that the transponder mean time between failures (MTBF) is at least 30 hours or greater. The reliability test shall be conducted on one transponder. As shown in Figure 3-1, if no failures occur during the first 131 hours and 50 minutes or if the minimum acceptance time (t_a) line is crossed, the transponder will pass the test and the required reliability is demonstrated. On the other hand, if 4 failures occur prior to 34 hours and 30 minutes of testing, or the minimum rejection time (t_r) line is crossed, the transponder will fail the reliability test and the required reliability is not demonstrated. In addition, the test is forced to completion after 750 hours of test time or after 18 failures. The operating characteristic curve, Figure 3-2, shows that if the true transponder MTBF is equal to 30 hours, there is a 10% chance that the reliability test will be passed. On the other hand, if the true transponder MTBF is equal to 60 hours, there is a 90% chance that the reliability test will be passed.

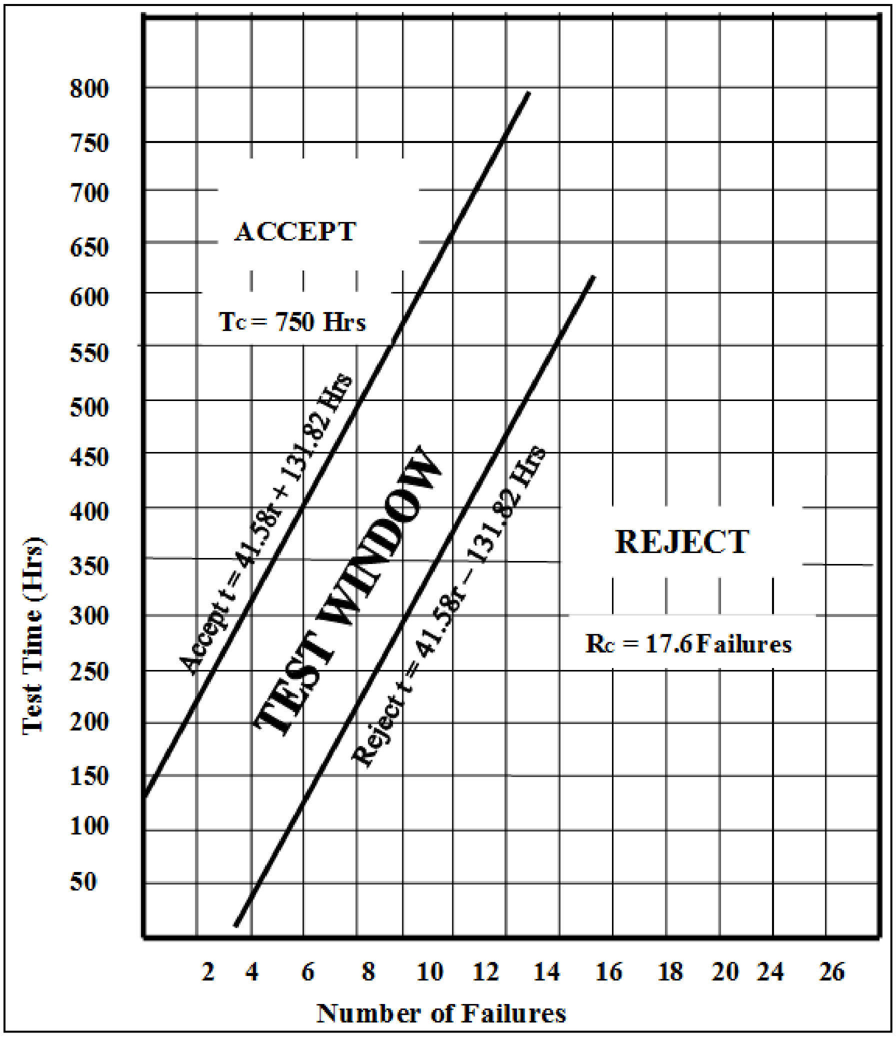

Figure 3-1. Reliability Test

With reference to Figure 3-1:

t_a = 131.82 hrs

t_r = 4 failures before t = 34.5 hrs

R_c = Maximum number of failures for completion of test

T_c = Maximum time duration for completion of test

41.58 = Reliability constant based on the value of ($t_a + t_r$) / 4 (where 4 = minimum t_r failures)

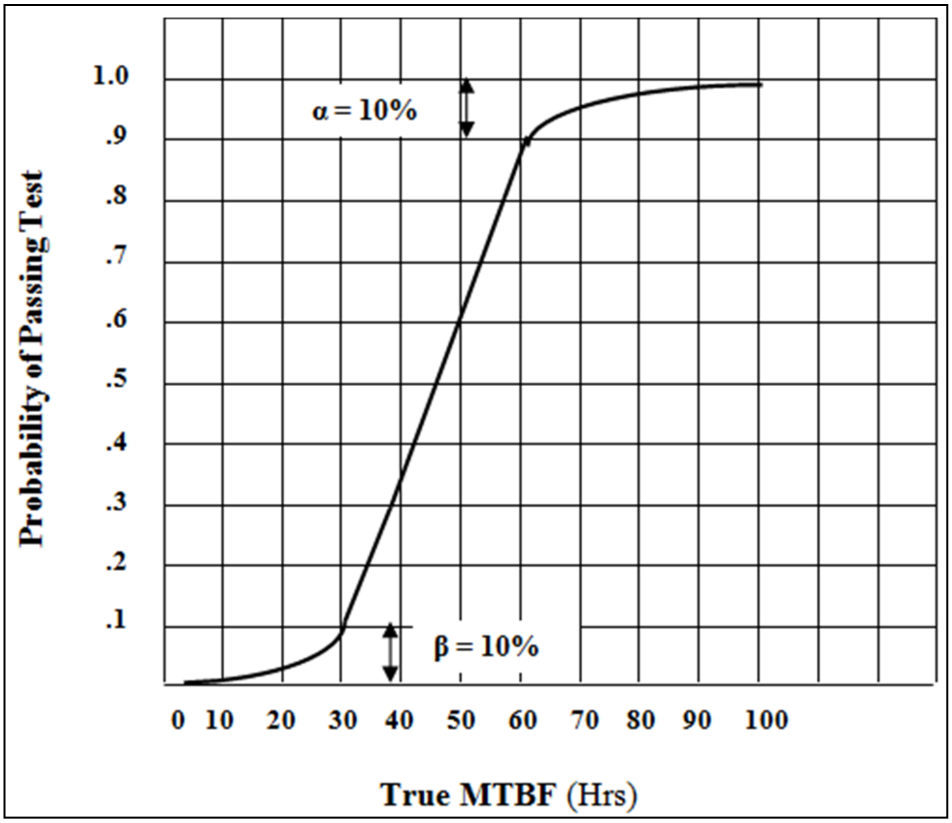

Figure 3-2. Operating Characteristic Curve for Reliability Test

With reference to Figure 3-2:

α = the probability (10%) that acceptable items will fail to pass the reliability test; also called "vendor's/contractor's risk."

β = the probability (10%) that unacceptable items will pass the reliability test; also called "consumer's/government's risk."

3.2 Transmitter and Receiver Electrical Parameters

3.2.1 Scope

These general test procedures are provided to clarify the test requirements described in the PSS. The schedules included herein consist of electrical, electromagnetic, and environmental test procedures. Type I tests are listed in Table 3-1.

Table 3-1. Type I (Qualification) Tests (Vendor's Responsibility)

Paragraph Number	Test Description
3.2.4	Receiver sensitivity and random triggering vs. receiver frequency
3.2.5	Receiver sensitivity vs. input PW, 0.25 µs, 0.50 µs, and 1 µs
3.2.6	Receiver sensitivity and random triggering vs. line voltage, 22 VDC to 32 VDC
3.2.7	Receiver code accept/reject limit test, 3-µs to 15.5-µs codes
3.2.8	Receiver code reject test, 3-µs to 15.5-µs codes
3.2.9	Rejection of improper signals

3.2.10	Receiver bandwidth at 3 dB
3.2.11	Peak power output vs. PRF in 500 pps steps through 2600 pps
3.2.12	Peak power output vs. transmitter frequency
3.2.13	Transponder recovery time and recovery characteristics
3.2.14	Transmitter frequency vs. pulse repetition frequency
3.2.15	Delay, delay variation, and delay jitter vs. signal level
3.2.16	Delay and delay jitter vs. line voltage
3.2.17	Recovery time vs. difference in signal level of two interrogation signals
3.2.18	Transmitter PW, PW jitter, rise time, and fall time vs. transmitter frequency
3.2.19	Transmitter RF spectrum
3.2.20	Over-interrogation
3.2.21	Power consumption vs. line voltage
3.2.22	Pressurization

3.2.2 Test Schedule

The vendor shall notify the purchasing agent 15 days prior to start of tests so that the purchasing agent can be present. As set forth in the contract schedule, a test batch shall be randomly selected by the purchasing agent to undergo the Type I test schedule. These tests shall demonstrate specified performance of the outlined procedures, shall be satisfactorily completed prior to first delivery, and shall be part of that delivery.

A select quantity of the test batch transponders shall undergo room-ambient electrical tests as specified. After completion of these tests, another select quantity of these test batch transponders will undergo EMI testing and a quantity will be selected for reliability testing. The remaining transponders of the test batch not selected for EMI or reliability testing shall be subjected to the environmental test procedures specified in Section 3.4. No transponder shall be operated in excess of 150 hours prior to delivery without being reconditioned.

NOTE	Each piece of test equipment utilized in the commission of these test procedures and the test bench setup shall be within current calibration. Equipment with expired calibrations must be re-calibrated prior to performing these tests. Test conditions may be modified to meet variables of testing. Results must satisfy the criteria.

Following the reliability test, the tests listed below shall be performed on selected transponders from the test batch of transponders provided in the contract.

3.2.3 Standard Test Setup

The standard test setup is shown in Figure 3-3.

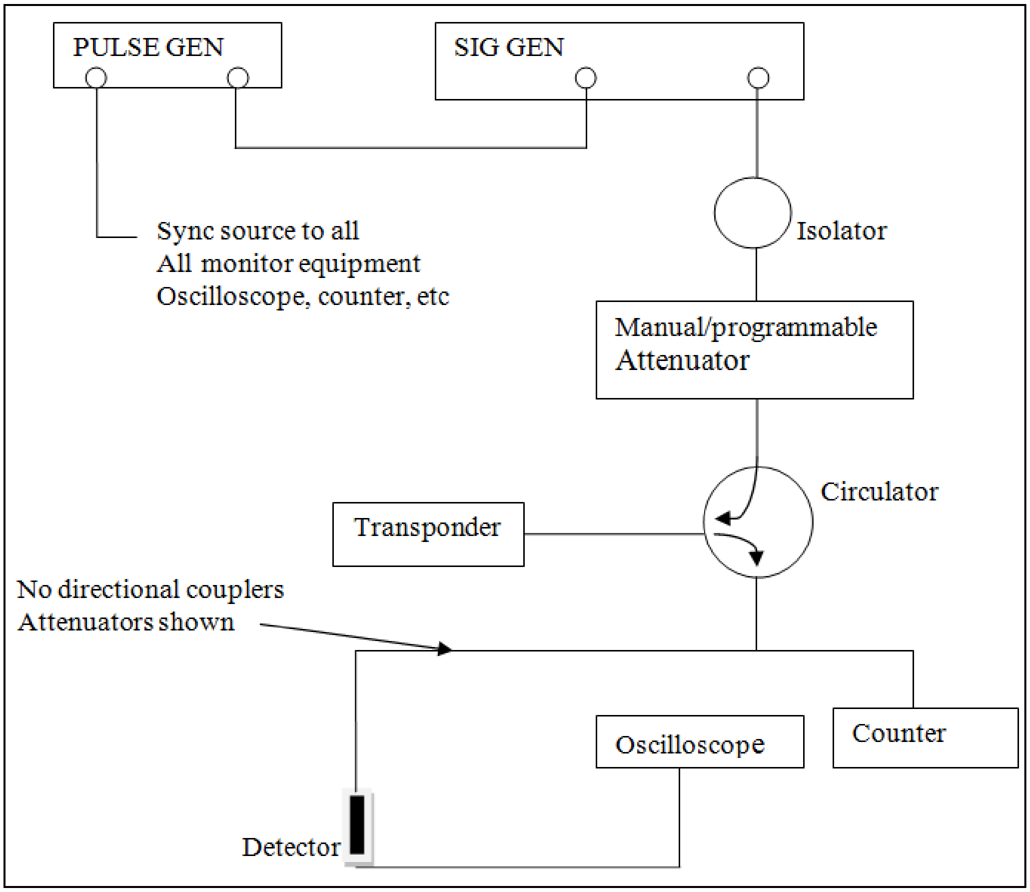

Figure 3-3. Basic Test Bench Setup

3.2.4 <u>**TEST: Receiver sensitivity and random triggering vs. receiver frequency**</u>

a. <u>Test Setup</u>: Test setup as shown in Figure 3-3

b. <u>Test Conditions</u>

(1) Uplink frequency 5400 MHz

(2) Interrogate with 2 pulses, 5 μs leading edge to leading edge

(3) Downlink frequency 5700 MHz

(4) Repetition rate 1000 pps

c. <u>Test Method</u>

(1) With the transponder tuned to 5400 MHz, measure the receiver sensitivity to the requirements of Paragraph 2.5.5. Monitor the 99% response over a 10-second period.

(2) With interrogation off, monitor for random replies to the requirements of Paragraph 2.5.7. Monitor for a 10-second period.

(3) Repeat steps 1 and 2 with transponder receiver frequencies of 5600 and 5900 MHz.

d. <u>Criteria</u>: Must satisfy requirements of Paragraph 2.5.5 and Paragraph 2.5.7.

3.2.5 TEST: Receiver sensitivity vs. input pulse width

a. Test Setup: As shown in Figure 3-3

b. Test Conditions

(1) Uplink frequency 5800 MHz

(2) Interrogate with 2 pulses, 5 μs leading edge to leading edge

(3) Downlink frequency 5700 MHz

(4) Repetition rate 1000 pps

c. Test Method

(1) Interrogate the transponder with the above conditions with interrogate PW of 0.25, 0.50, and 1 μs.

(2) Record the sensitivity for each PW.

d. Criteria: Must satisfy requirements of Paragraph 2.5.5 and Paragraph 2.5.6.1.

3.2.6 TEST: Receiver sensitivity and random triggering vs. line voltage

a. Test Setup: As shown in Figure 3-3

b. Test Conditions

(1) Uplink frequency 5800 MHz

(2) Interrogate with 2 pulses, 5 μs leading edge to leading edge

(3) Downlink frequency 5700 MHz

(4) Repetition rate 1000 pps

c. Test Methods

(1) Adjust the primary DC input voltage to the transponder to 28 V ± 2% and interrogate with the above conditions.

(2) With the transponder tuned to 5800 MHz, measure the receiver sensitivity to the requirements of Paragraph 2.5.5.

(3) Monitor the 99% response over a 10-second period.

(4) With interrogation off, monitor for random replies to the requirements of Paragraph 2.5.7. Monitor for a 10-second period.

(5) Repeat this test for input line voltages of 22 (+0.5/–0) VDC and 32 (+0/–0.5) VDC without making any adjustments to the transponder.

d. Criteria: Must satisfy requirements of Paragraph 2.1.2, Paragraph 2.5.5, and Paragraph 2.5.7.

3.2.7 TEST: Receiver code accept/reject limits

a. Test Setup: As shown in Figure 3-3

b. Test Conditions

(1) Uplink frequency 5800 MHz

(2) Interrogate with 2 pulses, 5 µs leading edge to leading edge (test method will vary interrogation code)

(3) Downlink frequency 5700 MHz

(4) Repetition rate 1000 pps

c. Test Methods

(1) Adjust the input signal to 0 dBm and the code to 3 ± 0.05 µs.

(2) Adjust the pulse generator for proper pulse code at 1000 PRF. Monitor the pulse spacing and the reply PRF.

(3) Decrease the spacing of the pulse code (at the 50% points leading edge to leading edge) for a countdown of 990 PRF; this is the *low-end accept spacing* (record this spacing).

(4) Increase the spacing as above for a countdown to 990 PRF; this is the *high-end accept spacing* (record this spacing).

(5) Decrease the spacing of the pulse code as above for a count of 10 PRF; this spacing is the *low reject reading* (record this spacing).

(6) Increase the spacing of the pulse code as above for a count of 10 PRF; this spacing is the *high reject reading* (record this spacing).

(7) Repeat steps 1 through 6 for spacing of 3 µs and 15 µs; record results on data sheet.

d. Criteria: Must satisfy Section 2.5.6.

3.2.8 TEST: Receiver code reject test, random triggering

a. Test Setup: As shown in Figure 3-3

b. Test Conditions

(1) Uplink frequency 5800 MHz

(2) Interrogate with 2 pulses, 3 µs leading edge to leading edge (test method will vary interrogation code spacing and PW)

(3) Downlink frequency 5700 MHz

(4) Repetition rate 1000 pps

c. Test Methods

(1) Apply a double-pulse code spacing of 3 µs, signal level of 0 dBm. Repeat for the following codes: 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, and 15.5 µs.

(2) Monitor all code spacing for random replies and record results.

(3) Apply a single pulse to the receiver with a signal level of –10 dBm to 20 dBm; vary PW from 3 to 50 µs while monitoring random replies.

(4) Record any random replies.

d. Criteria: Testing must satisfy Paragraph 2.5.7.

3.2.9 TEST: Rejection of improper signals

a. Test Setup: As shown in Figure 3-3

b. Test Conditions

(1) Uplink frequency 5800 MHz.

(2) Interrogate with 2 pulses, 5 μs leading edge to leading edge.

(3) Downlink frequency 5700 MHz.

(4) Repetition rate 1000 pps.

c. Test Methods

(1) Adjust the receiver for proper coded operation.

(2) Set the RF generator modulation to provide a continuous wave signal.

(3) Adjust the RF signal input to the transponder to 0 dBm.

(4) Vary the frequency of the RF signal generator from 5400 to 5900 MHz.

(5) Record any increase in random triggering above 10 pps and RF frequency at which the increase occurs.

d. Criteria: Must satisfy Paragraph 2.5.7.

3.2.10 TEST: Receiver bandwidth at 3 dB (i.e., selectivity curves at 5400, 5600, and 5900 MHz)

a. Test Setup: As shown in Figure 3-3

b. Test Conditions

(1) Uplink frequency 5400 MHz; test method will vary receiver frequency

(2) Interrogate with 2 pulses, 5 μs leading edge to leading edge

(3) Downlink frequency 5700 MHz

(4) Repetition rate 1000 pps

c. Test Methods

(1) Adjust the signal generator to the receiver center frequency until the PRF counter reads 990 pps nominal averaged over a 10-second period. Record the *receiver sensitivity*.

(2) Increase the input signal level 3 dB above the level recorded in step 1. Increase the signal generator frequency until the PRF counter reads 990 pps. Measure and record the signal generator frequency measured on the electronic counter. This is the *upper 3 dB frequency*, F_1.

(3) Decrease the input signal frequency until the PRF counter reads 990 pps. Measure the signal generator frequency and record this as the *lower 3 dB frequency*, F_2.

(4) Calculate and record the *3 dB bandwidth* (F_1–F_2).

(5) Repeat for remaining specified frequencies.

d. Criteria: Must satisfy Paragraph 2.5.2.

3.2.11 TEST: Peak power output vs. PRF in 500 pps steps 100-2600 pps

a. Test Setup: As shown in Figure 3-3

b. Test Conditions

(1) Uplink frequency 5800 MHz

(2) Interrogate with 2 pulses, 5 µs leading edge to leading edge

(3) Downlink frequency 5700 MHz

(4) Repetition rate 1000 pps (test method will vary PRF rate)

c. Test Method

(1) Adjust input PRF in steps from 100 to 2600 pps. With input PRF set to 100 pps, measure PW and average power.

(2) Calculate peak power using Equation 3-1.

$$\boxed{peak\,power = \frac{P\,average\,(attenuation\,in\,dB)}{PRF \bullet PW}} \qquad \text{Equation 3-1}$$

(3) Record results for each PRF specified.

d. Criteria: Must satisfy Paragraph 2.6.3.

3.2.12 TEST: Peak power output vs. transmitter frequency (5400 to 5900 MHz)

a. Test Setup: As shown in Figure 3-3

b. Test Conditions

(1) Input voltage 28 ± 1 V

(2) Uplink frequency 5800 MHz

(3) Downlink frequency 5400 MHz

(4) Repetition rate 1000 pps

c. Test Methods

(1) Interrogate transponder with above conditions.

(2) Measure peak power out of the transponder.

(3) Record results for each step in frequency specified.

(4) Repeat steps 1 and 2 while varying the downlink frequency in steps of 100 MHz.

d. Criteria: Must satisfy Paragraph 2.6.3.

3.2.13 **TEST: Transponder recovery time and recovery characteristics**

a. Test Setup: As shown in Figure 3-3

b. Test Conditions

(1) Uplink frequency 5800 MHz

(2) Interrogate with 2 pulses, 5 µs leading edge to leading edge

(3) Downlink frequency 5700 MHz

(4) Repetition rate 1000 pps

c. Test Methods

(1) Interrogate transponder with above conditions; monitor reply.

(2) Apply a second interrogation pulse group at approximately 100 µs spacing from first group and slowly decrease spacing while viewing two detected output pulses. Record the spacing at the time the second pulse just begins to miss interrogations (countdown) as the *recovery time*.

(3) Ensure lock-out protection in effect during recovery and record results.

d. Criteria: Must satisfy Paragraph 2.6.9.

3.2.14 **TEST: Transmitter frequency vs. pulse repetition frequency**

a. Test Setup: As shown in Figure 3-3

b. Test Conditions

(1) Uplink frequency 5800 MHz

(2) Interrogate with 2 pulses, 5 µs leading edge to leading edge

(3) Downlink frequency 5700 MHz

(4) Repetition rate 1000 pps

c. Test Methods

(1) Measure the transmitter frequency at 1000 pps.

(2) Record frequency and distinguish measurement.

(3) Change PRF to 160 pps, measure transmitter frequency, and record.

(4) Repeat step 3 for PRFs of 320, 640, 1280, and 2600 pps.

d. Criteria: Must satisfy Paragraph 2.6.2 and Subsection 2.6.4.

3.2.15 **TEST: Delay, delay variation, and delay jitter vs. signal level**

a. Test Setup: As shown in Figure 3-3. Double pulse code, time measurements taken at the 50% amplitude point of the second interrogate pulse leading edge and the detected reply pulse.

b. Test Conditions

(1) Uplink frequency 5800 MHz

(2) Interrogate with 2 pulses, 5 µs leading edge to leading edge

(3) Downlink frequency 5700 MHz

(4) Repetition rate 1000 pps

c. Test Methods

(1) Establish the transmitted reply delay at 0 dBm and with the above condition.

(2) Record this spacing as the *fixed delay time*.

(3) View the leading edge of the detected reply pulse and vary the level of the input signal from 0 to –65 dBm. Measure the time difference or change as the level is varied. Record this time as *delay variation*.

(4) Apply a signal level to the antenna connector of the transponder of –55 dBm. Observe the peak-to-peak time jitter of the detected reply pulse leading edge. Record this time as *–55 dBm jitter*.

(5) Apply a signal to the transponder antenna of –65 dBm. Observe the peak-to-peak time jitter of the detected reply pulse leading edge. Record this time as *–65 dBm jitter.*

d. Criteria: Must satisfy Subsection 2.6.8.

3.2.16 TEST: Delay and delay jitter vs. line voltage

a. Test Setup: As shown in Figure 3-3

b. Test Conditions

(1) Uplink frequency 5800 MHz

(2) Interrogate with 2 pulses, 5 µs leading edge to leading edge

(3) Downlink frequency 5700 MHz

(4) Repetition rate 1000 pps

c. Test Methods

(1) With the transponder input voltage at 22 ± 0.5 V.

(2) Establish the transmitted reply delay at 0 dBm and with the above conditions.

(3) Record this spacing as the *fixed delay time at 22 V*.

(4) Apply a signal level to the antenna connector of the transponder of –55 dBm. Observe the peak-to-peak time jitter of the detected reply pulse leading edge. Record this time as *–55 dBm jitter*.

(5) Apply a signal to the transponder antenna of –65 dBm. Observe the peak-to-peak time jitter of the detected reply pulse leading edge. Record this time as *–65 dBm jitter*.

(6) Adjust input voltage to 32 ± 0.5 V.

(7) Repeat steps 2 and 3. Record the *fixed delay time at 32 V*.

(8) Repeat steps 4 and 5. Record the *delay jitter at 32 V*.

d. Criteria: Must satisfy Paragraph 2.1.2 and Subsection 2.6.8.

3.2.17 TEST: Recovery time vs. difference in signal level of two interrogating signals

a. Test Setup: As shown in Figure 3-3

b. Test Conditions

(1) Uplink frequency 5800 MHz

(2) Interrogate with 2 pulses, 5 μs leading edge to leading edge

(3) Downlink frequency 5700 MHz

(4) Repetition rate 1000 pps

c. Test Methods

(1) This test requires two pulse sources and two RF signal sources.

(2) Commonly sync both pulse sources and the oscilloscope from pulse source #1.

(3) Adjust pulse source #2 to provide a second 5-μs pulse group 5 μs leading edge to leading edge.

(4) Adjust the RF signal generator #1 for a 0-dBm level at the transponder RF input.

(5) Adjust RF signal source #2 for a –65 dBm (20-W), –68 dBm (50-W), or –70 dBm level (400-W) at the transponder.

(6) Interrogate the transponder with the above combined signals and measure the *recovery time*.

(7) Ensure and record lock-out protection in effect.

d. Criteria: Must satisfy Paragraph 2.6.9.

3.2.18 TEST: Transmitter pulse width, pulse width jitter, rise time, and fall time vs. transmitter frequency

a. Test Setup: As shown in Figure 3-3

b. Test Conditions

(1) Uplink frequency 5800 MHz

(2) Interrogate with 2 pulses, 5 μs leading edge to leading edge

(3) Downlink frequency 5700 MHz

(4) Repetition rate 1000 pps

c. Test Methods

(1) Measure and record detected *reply PW* at the above conditions.

(2) Measure and record the *transmitted PW jitter*.

(3) Measure *pulse rise time* and record.

(4) Measure *pulse fall time* and record.

(5) Measure and record all parameters listed above for 5400, 5600, and 5900 MHz.

d. Criteria: Must satisfy the requirements of Subsection 2.6.5.

3.2.19 TEST: Transmitter radio frequency spectrum

a. Test Setup: As shown in Figure 3-3

b. Test Conditions

(1) Uplink frequency 5800 MHz

(2) Interrogate with 2 pulses, 5 μs leading edge to leading edge

(3) Downlink frequency 5700 MHz

(4) Repetition rate 1000 pps

c. Test Methods

(1) Observe the transmitter RF spectrum on the analyzer. Measure and record the *spectrum width at the 6 dB point*.

(2) Measure and record the *difference* in amplitude of the peak of the first side lobe to the peak of the fundamental.

(3) Measure and record the *depth* of the first null measuring from the peak of the fundamental to the minimum point of the null.

d. Criteria: Must satisfy the requirements of the Paragraph 2.6.6.

3.2.20 TEST: Over-interrogation

a. Test Setup: As shown in Figure 3-3

b. Test Conditions

(1) Uplink frequency 5800 MHz

(2) Interrogate with 2 pulses, 5 μs leading edge to leading edge

(3) Downlink frequency 5700 MHz

(4) Repetition rate 1000 pps

c. Test Methods

(1) Apply double pulse code at 5000 pps.

(2) Adjust the pulse source for an output PRF of 5000 pps. Observe the reply PRF on the counter; it should read 2750 ± 50 pps. This is to allow the transponder to operate up to 2600 pps under all conditions.

(3) Record *reply PRF* on the data sheet.

d. Criteria: Must satisfy the requirements of Subsection 2.6.4.

3.2.21 **TEST: Power consumption vs. line voltage**

a. Test Setup: As shown in Figure 3-3

b. Test Conditions

(1) Uplink frequency 5800 MHz

(2) Interrogate with 2 pulses, 5 µs leading edge to leading edge.

(3) Downlink frequency 5700 MHz

(4) Repetition rate 1000 pps

c. Test Methods

(1) Apply an interrogation signal at a PRF of 2600 pps. Adjust the input line voltage to 32 V. Monitor the input current on a current meter.

(2) Apply an interrogation signal at 1000 pps. Adjust the input line voltage to 28 V. Monitor the current on a current meter.

(3) Measure and record transponder *power consumption*.

d. Criteria: Must satisfy the requirements of Paragraph 2.1.4.

3.2.22 **TEST: Pressurization**

a. Test Setup

(1) Have a supply of clean, dry air to pressurize the unit.

(2) Have a container filled with water deep enough to entirely submerge the unit.

b. Test Conditions: Not applicable

c. Test Methods

(1) Pressurize transponder.

(2) Submerge the unit in the water for a period of 20 minutes to determine if there will be leakage.

(3) There should be no evidence of bubbles coming from the case or connector.

(4) Remove the unit from the water and allow it to sit for a period of 8 hours.

d. Criteria: Must satisfy the requirements of Paragraph 2.4.7

3.3 Electromagnetic Interference Requirements

3.3.1 Test Procedure

All calibration requirements identified in MIL-STD-461F for EMI testing shall be complied with prior to the start of actual testing.

3.3.2 Test Data Recording

All data will be recorded on data records initiated by the test facility to document objective evidence of the test performance results. A formal EMI test report will be submitted to the purchasing agent.

3.3.3 Standard Conditions

The electrical inputs to the transponder will remain constant during these EMI tests. Testing will be limited to the third harmonic. Any deviations to these conditions will be discussed in the applicable testing method. The test setup is described in Figure 3-3.

3.3.4 Test Conditions

3.3.4.1 Electrical

a. Transmitter frequency: 5700 ± 3 MHz.

b. Receiver frequency: 5800 ± 2 MHz.

c. Code spacing: 5 ± 0.2 µs.

d. Fixed delay: 2.5 ± 0.1 µs.

e. DC input voltage: 28 ± 1 VDC.

f. Receiver sensitivity setting: Set to the upper limit as specified in Paragraph 2.5.5.

g. Ambient interference level: At least 6 dBm below allowable level.

h. Ground plane: A copper or brass ground plane, 0.01 inch thick for copper, 0.025 inch thick for brass, 12 square feet or more in area (30-inch minimum width) shall be used.

i. Arrangement of equipment: The front surface of each unit shall be 4 ± 0.5 inches from the edge of the ground plane.

j. Equipment warm-up time: 15 minutes minimum.

3.3.4.2 Environmental

a. Ambient temperature: 67 degrees Fahrenheit (°F) ± 15°F.

b. Humidity: less than 100%.

c. Shield room description: A solid-wall, shielded enclosure having its own light, exhaust fans, and ventilation capability. All power mains shall be filtered to preclude external interference and radiation.

3.3.5 Tests and Test Sequence

The tests listed in Table 3-2 shall be performed on selected transponders from the test batch of transponders provided in the contract. These tests may be performed in any order deemed necessary by the test facility.

Table 3-2. Electromagnetic Interference Tests

Paragraph Number	Requirement Number (per MIL-STD-461F)	Test Description
3.3.7	Requirement CE102	Conducted emissions, power leads

3.3.8	Requirement CE106	Conducted emissions, antenna terminal
3.3.9	Requirement CS101	Conducted susceptibility, power leads
3.3.10	Requirement CS103	Conducted susceptibility, antenna port, inter-modulation
3.3.11	Requirement CS104	Conducted susceptibility, antenna port, rejection of undesired signals
3.3.12	Requirement CS114	Conducted susceptibility, bulk cable injection
3.3.13	Requirement CS115	Conducted susceptibility, bulk cable injection, and impulse excitation
3.3.14	Requirement CS116	Conducted susceptibility, damped sinusoidal transients, cables, and power leads
3.3.15	Requirement RE102	Radiated emissions, electric field
3.3.16	Requirement RE103	Radiated emissions, antenna spurious and harmonic outputs
3.3.17	Requirement RS101	Radiated susceptibility, magnetic field
3.3.18	Requirement RS103	Radiated susceptibility, electric field

3.3.6 Test Equipment

Table 3-3 lists typical test equipment peculiar to the range of EMI tests performed on the transponder. This equipment, or their equivalents, may be used to fulfill the intent of this test. Each piece of test equipment utilized in the commission of these test procedures and the test bench setup shall be within current calibration. Equipment with expired calibrations must be re-calibrated prior to performing these tests.

Table 3-3. Typical Test Equipment for EMI Testing

Name	Manufacturer	Model
EMI Meter	Eaton	NM67A
EMI Meter	Eaton	NM37/57A
EMI Meter	Eaton	NM17/27A
EMI Meter	Eaton	NM7A
Control Input Unit A	Eaton	CIU-7
Control Counter Interface	Eaton	CCI-7
Control Input Unit B	Eaton	CIU-7
Computer	Hewlett Packard	9836
Printer	Hewlett Packard	2671G
Log Periodic Antenna	EMCO	3146
Log Periodic Antenna	EMCO	3146A
Bi Conical Antenna	EMCO	3104
Bi Conical Antenna	EMCO	3109
41” Active Rod	EMCO	3301B
Parallel Element Electric	Metric	PEA-25
Horn Antenna	EMCO	3115
Horn Antenna	EMCO	3115
10 Micro Farad	EMCO	6512-106R2754
10 Micro Farad	EMCO	6512-106R2755

10 Micro Farad	EMCO	6512-106R2756
Signal Generator	Marconi Instruments	2019A
Signal Generator	Hewlett Packard	8350B
Plug In	Hewlett Packard	83592A
Power Amp	ENI	603L
Power Amp	ENI	550L
Power Amp	ENI	1040L
TWT Amp	Hughes	8020H09F000
TWT Amp	Hughes	8020H02F000
TWT Amp	Hughes	8020H03F000
TWT Amp	Varian	VZS6951K11126
RF Coupler	Solar	7415-3
Isolation Transformer	Solar	6220-1A
RFI Transient Generator	Solar	8282-1
Current Probe	Solar	6741-1
Frequency Generator	Gigatronics	600
Timer/Counter	Phillips	PM6665
Directional Coupler	Narda	30004-20
Variable Attenuator	Arra	5-6684-4
Power Meter	Hewlett Packard	427B
Oscilloscope	Tektronics	2445A
Crystal Detector	Hewlett Packard	423B

3.3.7 **TEST: Requirement CE102: Conducted emissions, power leads** (10 kilohertz [kHz] to 10 MHz)

a. Test Setup: As shown in Figure 3-3 and MIL-STD-461F, as applicable, or equivalent test setup.

b. Test Conditions: Per Subsection 3.3.4 and Requirement CE102 of MIL-STD-461F. The positive and negative input DC power leads of the UUT will be tested in the interrogate and uninterrogate modes for worst-case conducted emissions interference. The input power line determined to be the worst case will be tested from 10 kHz to 10 MHz.

c. Test Method: As per MIL-STD-461F, CE102.

d. Criteria: Determine that the level of noted conducted emissions does not exceed the maximum limits as stated in MIL-STD-461F.

3.3.8 **TEST: Requirement CE106: Conducted emissions, antenna terminal** (10 kHz to 40 gigahertz [GHz])

a. Test Setup: As shown in Figure 3-3 and MIL-STD-461F or equivalent test setup.

b. Test Conditions: Per Subsection 3.3.4 and Requirement CE106 of MIL-STD-461F. The UUT will be tested in the interrogate and uninterrogate modes from 10 kHz to 40 GHz and verified within limits of CE106.

c. Test Method: As per MIL-STD-461F, CE106.

d. Criteria: Harmonic and all other spurious emissions shall meet provisions as stated in MIL-STD-461F. This limit does not apply to the transmitter's specified emission bandwidth.

3.3.9 **TEST: Requirement CS101: Conducted susceptibility, power leads** (30 hertz [Hz] to 150 kHz)

a. Test Setup: Per Figure 3-3 and MIL-STD-461F, or equivalent test setup.

b. Test Conditions: Per Subsection 3.3.4 and Requirement CS101 of MIL-STD-461F.

c. Test Method: Per Requirement CS101 of MIL-STD-461F.

d. Criteria: If susceptibility is noted, determine the threshold level IAW MIL-STD-461F and verify that it is above the limit.

3.3.10 **TEST: Requirement CS103: Conducted susceptibility, antenna port, inter-modulation** (15 kHz to 10 GHz)

a. Test Setup: Per Figure 3-3 and MIL-STD-461F, or equivalent test setup.

b. Test Conditions: Per Subsection 3.3.4 and Requirement CS103 of MIL-STD-461F. The test will be performed in the uninterrogate mode only. The transmitter may be disabled and the silicon-controlled rectifier gate monitored during this test, if necessary.

c. Test Method: As per MIL-STD-461F, Requirement CS103.

d. Criteria: Any random triggering of the transponder exceeding 10 pps is criterion for rejection.

3.3.11 **TEST: Requirement CS104: Conducted susceptibility, antenna port, rejection of undesired signals** (30 Hz to 20 GHz)

a. Test Setup: Per Figure 3-3 and MIL-STD-461F, or equivalent test setup.

b. Test Conditions: Per Subsection 3.3.4 and Requirement CS104 of MIL-STD-461F. The UUT will be tested in the interrogate and uninterrogate modes.

c. Test Method: As per MIL-STD-461F, CS104.

d. Criteria: Any random triggering of the transponder exceeding 10 pps is criterion for rejection.

3.3.12 **TEST: Requirement CS114: Conducted susceptibility, bulk cable injection** (10 kHz to 200 MHz)

a. Test Setup: Per Figure 3-3 and MIL-STD-461F, or equivalent test setup.

b. Test Conditions: Per Subsection 3.3.4 and Requirement CS114 of MIL-STD-461F.

c. Test Method: Per Requirement CS114 of MIL-STD-461F.

d. Criteria: If susceptibility is noted, determine the threshold level IAW MIL-STD-461F and verify that it is above the limit.

3.3.13 **TEST: Requirement CS115: Conducted susceptibility, bulk cable injection, and impulse excitation**

a. Test Setup: Per Figure 3-3 and MIL-STD-461F, as applicable.

b. Test Conditions: Per Subsection 3.3.4 and Requirement CS115 of MIL-STD-461F.

c. Test Method: Per Requirement CS115 of MIL-STD-461F.

d. Criteria: Per Requirement CS115 of MIL-STD-461F.

3.3.14 **TEST: Requirement CS116: Conducted susceptibility, damped sinusoidal transients, cables, and power leads** (10 kHz to 100 MHz)

a. Test Setup: Per Figure 3-3 and MIL-STD-461F, or equivalent test setup.

b. Test Conditions: Per Subsection 3.3.4 and Requirement CS116 of MIL-STD-461F.

c. Test Method: Per Requirement CS116 of MIL-STD-461F.

d. Criteria: If susceptibility is noted, determine the threshold level IAW MIL-STD-461F and verify that it is above the limit.

3.3.15 **TEST: Requirement RE102: Radiated emissions, electric field** (10 kHz to 18 GHz)

a. Test Setup: Per Figure 3-3 and MIL-STD-461F, or equivalent test setup.

b. Test Conditions: Per Subsection 3.3.4 and Requirement RE102 of MIL-STD-461F. Determine the worst-case mode (interrogate or uninterrogate) and perform the test at that mode.

c. Test Method

(1) Probe the test sample to locate the points of maximum radiation.

(2) In the frequency range of 25 to 200 MHz, position the test antenna so as to make both vertical and horizontal measurements.

(3) For each test antenna, scan the applicable frequency range of this test with the EMI meter and take measurements as required.

d. Criteria: Per Requirement RE102 of MIL-STD-461F. The acceptance/rejection criteria are located in Figure RE102-1 through Figure RE102-4.

3.3.16 **TEST: Requirement RE103: Radiated emissions, antenna spurious and harmonic output** (10 kHz to 40 GHz).

a. Test Setup: Per Figure 3-3 and MIL-STD-461F.

b. Test Conditions: Per Subsection 3.3.4 and Requirement RE103 of MIL-STD-461F. This test will be performed in the interrogate mode. Any random triggering or misfiring of the UUT exceeding 10 pps is criterion for rejection.

c. Test Method: Per Requirement RE103 of MIL-STD-461F.

d. Criteria: Per Requirement RE103 of MIL-STD-461F.

3.3.17 **TEST: Requirement RS101: Radiated susceptibility, magnetic field** (30 Hz to100 kHz)

a. Test Setup: Per Figure 3-3 and MIL-STD-461F.

b. Test Conditions: Per Subsection 3.3.4 and Requirement RS101 of MIL-STD-461F. This test will be performed in the interrogate mode.

c. Test Method: Per Requirement RS101 of MIL-STD-461F.

d. Criteria: The transponder's reply pulse will be monitored. Any random triggering or misfiring of the transponder exceeding 10 pulses per minute (ppm) is criterion for rejection.

3.3.18 **TEST: Requirement RS103: Radiated susceptibility, electric field** (2 MHz to40 GHz)

a. Test Setup: Per Figure 3-3 and MIL-STD-461F**.**

b. Test Conditions: Per Subsection 3.3.4 and Requirement RS103 of MIL-STD-461F. The UUT will be tested in the interrogate and uninterrogate modes.

c. Test Method: Per Requirement RS103 of MIL-STD-461F.

d. Criteria: The transponder's reply pulse will be monitored. Any random triggering or misfiring of the transponder exceeding 10 ppm is criterion for rejection.

3.4 Environmental Testing Procedures

The information in this section is taken from MIL-STD-810C[9]. While Revision C was superseded in 1983 by Revision D, it remains the most appropriate version of MIL-STD-810 for the purposes of this PSS. The test methods within MIL-STD-810 are intended for testing non-specific Department of Defense materiel. Some of the test procedures and parameter values have been adjusted to fit the narrower scope of this document. Where possible, document citations within this section are for the same versions of documents cited in MIL-STD-810C. In other cases, citations are for the most up-to-date versions of the documents.

3.4.1 Scope

This standard establishes uniform environmental test procedures for determining the resistance of equipment to the effects of natural and induced environments peculiar to military operations. The test procedures have been designed to provide reproducible test results that can be incorporated into contractual documents.

3.4.2 Application of Test Methods

Test methods contained in this standard apply to all items of equipment. **When it is known that the equipment will encounter conditions more severe or less severe than the environmental levels stated herein, the test may be modified by the equipment specification.**

3.4.3 General Requirements

3.4.3.1 Test Conditions

Unless otherwise specified herein or in the equipment specification, measurements and tests shall be made at standard ambient conditions as listed below:

a. Temperature: 23°C ± 10°C (73°F ± 18°F)

b. Relative humidity: 50% ± 30%

c. Atmospheric pressure: 725 +50/–75 millimeters mercury (mmHg) (28.5 +2/–3 inches mercury [inHg])

[9] Department of Defense. Environmental Test Methods. MIL-STD-810C. 10 March 1975. Superseded 19 July 1983. Available at http://www.atec.army.mil/publications/Mil-Std-810C/810C.pdf.

When these conditions must be closely controlled, the following shall be maintained:

a. Temperature: 23°C ± 1.4°C (73°F ± 2.5°F)

b. Relative humidity: 50% ± 5%

c. Atmospheric pressure: 725 +50/–75 mmHg (28.5 +2/–3 inHg)

3.4.3.1.1 Measurement of Test Conditions

All measurements of test conditions shall be made with instruments of the accuracy specified in Paragraph 3.4.3.1.3.

3.4.3.1.2 Tolerance of Test Conditions

Unless otherwise specified, tolerance of test conditions shall be as follows.

a. Temperature: Air temperature at the control sensor ± l.4°C (± 2.5°F). The equipment sensor response time (*T*) shall be 20 seconds or less. Temperature gradient across the cross-sectional area occupied by the test item shall not exceed 0.3°C (0.5°F) per foot in any direction, but never more than 2.2°C (4°F) total (equipment non-operating).

b. Pressure: When measured by devices such as manometers, ± 5% or ± 1.5 mmHg (0.059 inHg), whichever provides the greatest accuracy. When measured by devices such as ion gages, ± 10% to 10^{-5} torr.

c. Relative humidity at the control sensor: ± 5%

d. Vibration amplitude:

   (1) Sinusoidal: ± 10%

   (2) Random: See Subsection 3.4.10

e. Vibration frequency: ± 2%, or ± 1/2 Hz below 25 Hz

f. Acceleration: ± 10%

NOTE	*(T)* is the time required for the sensing system to respond to 62.3% of a step change in temperature in the measured environment.

3.4.3.1.3 Accuracy of Test Apparatus

The accuracy of instruments and test equipment used to control or monitor the test parameters shall be verified and shall satisfy the requirements of ISO 10012:2003[10] and ANSI-NCSL-Z540-1[11] to the satisfaction of the procuring activity. All instruments and test equipment used in conducting the tests specified herein shall:

[10] International Organization for Standardization. *Measurement Management Systems - Requirements for Measuring Processes and Measurement Equipment*. ISO 10012:2003. Geneva: International Organization for Standardization, 2003.

[11] American National Standards Institute. *American National Standard for Calibration: Calibration Laboratories and Measuring and Test Equipment: General Requirements.* ANSI/NCSL Z540-1-1994. Boulder: American National Standards Institute.

a. Conform to laboratory standards whose calibration is traceable to the prime standards at the U.S. National Institute of Standards and Technology;

b. Have an accuracy of at least one-third the tolerance for the variable to be measured. In the event of conflict between this accuracy and a requirement for accuracy in any one of the test methods of this standard, the latter shall govern.

3.4.3.1.4 Stabilization of Test Temperature

a. Operating: Unless otherwise specified, temperature stabilization will have been attained when the temperature of the part of the test item considered to have the longest thermal lag is changing no more than 2°C (3.6°F) per hour. Exceptions may occur on large test items.

b. Non-operating: Unless otherwise specified, temperature stabilization will have been attained when the temperature of the part of the test item considered to have the longest thermal lag reaches a temperature within 2°C (3.6°F) of the prescribed temperature, except that any critical component (e.g., battery electrolyte for engine starting test) will be within 1°C (1.8°F). Exceptions may occur on large test items. When changing temperatures, the temperature of the chamber air may be adjusted up to 5°C (9°F) beyond the desired end point for a period of time of up to one hour to reduce stabilization time, provided that the stabilization requirements of this paragraph are ultimately attained relative to the specified end point temperature, and provided that the extended chamber temperatures will not cause damage to the test item.

3.4.3.2 Performance of Test

3.4.3.2.1 Pretest Performance Record

Prior to proceeding with any of the environmental tests, the test item shall be operated under standard ambient conditions (see Subsection 3.4.3.1) to obtain data for determining satisfactory operation of the item as specified in the equipment specification before, during, and after the environmental tests, as applicable. A record of specific pretest data shall be made to determine that the test item performs within prime item specification requirements.

The pretest record shall also include, where applicable, the functional parameters to be monitored during and after the test if not included in the equipment specification. This shall include acceptable functional limits (with permissible degradation) when operation of the test item is required.

3.4.3.2.2 Installation of Test Item in Test Facility

Unless otherwise specified, the test item shall be installed in the test facility in a manner that will simulate service usage, including installation of the test item's representative mounting plate, connections, and attached instrumentation, as necessary. Plugs, covers, and inspection plates not used in operation, but used in servicing, shall remain in place. When mechanical or electrical connections are not used, the connections normally protected in service shall be adequately covered. For tests where temperature values are controlled, the test chamber shall be at standard ambient conditions when the test item is installed. The test item shall then be operated to determine that no malfunction or damage was caused due to faulty installation or handling. The requirement for operation following installation of the test item in the test facility is applicable only when operation is required during exposure to the specified test.

3.4.3.2.3 Performance Check During Test

When operation of the test item is required during the test exposure, suitable tests shall be performed to determine whether the test exposure is producing changes in performance when compared with pretest data.

3.4.3.2.4 Post-Test Data

At the completion of each environmental test, the test item shall be inspected IAW the equipment specification and the results shall be compared with the pretest data obtained IAW Subsection 3.4.3.2.1.

3.4.3.2.5 Test Data

Test data shall include complete identification of all test equipment and accessories. The data shall include the actual test sequence used and ambient test conditions recorded periodically during the test period. The test record shall contain a signature and data block for certification of the test data by the test engineer.

3.4.3.2.6 Failure Criteria

The item shall have failed the test when any of the following occur.

a. Monitored functional parameters deviate beyond acceptable limits established in Subsection 3.4.3.2.1.

b. Catastrophic or structural failure.

c. Mechanical binding or loose parts, including screws, clamps, bolts, and nuts, that clearly result in component failure or a hazard to personnel safety.

d. Malfunction.

e. Degradation of performance beyond pretest record or equipment specification requirements established in Subsection 3.4.3.2.1 (record to be made after test).

NOTE	Certain types of equipment (e.g., propellants and electrically driven devices) are often expected to demonstrate lesser performance at an environmental extreme, particularly at low temperature. A failure would occur only if degradation is more than expected.

f. Any additional deviations from acceptable criteria established before the test and recorded according to Subsection 3.4.3.2.1.

g. Deterioration, corrosion, or change in tolerance limits of any internal or external parts that could in any manner prevent the test item from meeting operational service or maintenance requirements.

h. Any additional or different failure criteria that are specified in the equipment specification.

3.4.3.3 <u>Test Facilities and Apparatus</u>

Test facilities, chambers, and apparatus used in conducting the tests contained in this standard shall be capable of meeting the conditions required. Characteristics of the test chamber are described as follows.

a. Volume of test chamber: The volume of the test chamber shall be such that the bulk of the item under test will not interfere with the generation and maintenance of the test conditions. When testing multiple sample items simultaneously, the test chamber shall be of sufficient size so that each test unit is provided uniform environmental conditions and is not subjected to non-test environments.

b. Heat source: The heat source of the test facility shall be so located that radiant heat from the source will not fall directly on the test item, except where application of radiant heat is one of the test conditions.

c. Location of temperature sensors: Unless otherwise specified, thermocouples or equivalent temperature sensors utilized to determine or control the specified chamber temperature shall be located centrally within the chamber, in the supply air stream, or in the return air stream, whichever provides the specified test conditions at the bulk under test and shall be baffled or otherwise protected against radiation effects.

d. Internal air circulation: The conditioned airflow shall be suitably baffled to provide uniform airflow around the test item. If multiple test items are tested, they shall be so spaced as to provide free circulation between the test items and the chamber walls.

3.4.3.4 Test Data

Test data shall include complete identification of all test equipment and accessories. The data shall include the actual test sequence used and ambient test conditions shall be recorded periodically during the test period. The test record shall contain a signature and date block for certification of the test data by the test engineer.

3.4.3.5 Specified Electrical Functional Tests

Refer to the following test conditions and list of parameters to be tested when any of the following methods or procedures specify that a functional test is to be performed prior to or after an operating cycle.

3.4.3.5.1 Test Conditions

a. Receiver frequency: 5800 ± 2 MHz

b. Transmitter frequency: 5700 ± 3 MHz

c. Code spacing: 5 ± 0.15 μs

d. Pulse repetition frequency: 1000 ± 10 pps

3.4.3.5.2 Pre/Post Functional Test Parameters

a. Receiver sensitivity: see Paragraph 2.5.5.

b. Receiver 3-dB bandwidth: see Paragraph 2.5.2.

c. Receiver center frequency: 5800 ± 2 MHz.

d. Receiver code accept/reject limits: see Subsection 2.5.6.

e. Random triggering: see Paragraph 2.5.7.

f. Transmitter frequency: 5700 ± 3 MHz

g. Transmitter PW: see Subsection 2.6.5.

h. Transmitter peak power: see Paragraph 2.6.3.

i. Transponder fixed delay: see Subsection 2.6.8.

3.4.4 Test Sequence

See Table 3-4 and Table 3-5 for the recommended test sequence.

Table 3-4. Recommended Test Sequence: Group I (Read Down)

Test Method	**Group I[1,2]**				
	A	**B**	**C**	**D**	**E**
3.4.5 Temperature- Shock	1[1]	1[1]	1[1]	1[1]	1[1]
3.4.6 Temperature-Altitude	--	--	--	--	--
3.4.7 Humidity	2	2	2	4	4
3.4.8 Salt Fog	3[1]	3	3	5[1]	5
3.4.9 Acceleration	--	--	--	--	--
3.4.10 Vibration	5	5	5	3	3
3.4.11 Acoustic Noise	--	--	--	--	--
3.4.12 Shock	4	4	4	2	2

[1]Test with limited application

Group I: Types and placements of equipment being tested:

A. General base (sheltered): All ground equipment not included in electronics and communications, or aircraft and missile support classes
B. General base (unsheltered)
C. Aircraft and missile support: Equipment used outdoors on airfields and missile launching pads for servicing, maintenance support, checkout, etc., excluding electronic equipment
D. Communications and electronics (sheltered): Communications and electronic equipment of all types, equipment with electric circuits
E. Communications and electronics (unsheltered)

Table 3-5. Recommended Test Sequence: Group II (Read Down)

Test Method	**Group II[1,2]**									
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
3.4.5 Temperature-Shock	1[1,2]	2[1,2]	2[1,2]	2[1,2]	1[1,2]	2[1,2]	1	1	2[1,3]	2[1,2]
3.4.6 Temperature-Altitude	2[5]	1[5]	1[5]	1[5]	2[1,2,5]	1[5]	2[5]	2[5]	1[5]	1[5]
3.4.7 Humidity	3	3[1]	3	3	3	3	3	3	3[1]	6
3.4.8 Salt Fog	4[1]	4[1]	4[1]	4[1]	4[1,3]	4[1]	4[1,3]	4[3]	4[1,3]	7[1,3]
3.4.9 Acceleration	5	5	5	5	5	5	5	5	5	3
3.4.10 Vibration	7	7	7	7	7	7	6	7	7	5
3.4.11 Acoustic Noise	8[1,4]	8[1,4]	8[1,4]	8	8	8	8[1]	8	8	8
3.4.12 Shock	6	6	6	6	6	6	7	6	6	4

[1]Group II: Equipment installed in airplanes, helicopters, air-launched, and ground-launched vehicles.

A. Auxiliary power plants and power plant accessories (primary power plants excluded)
B. Liquid systems: liquid carrying or hydraulic-actuated equipment
C. Gas systems: gas carrying or gas-actuated equipment
D. Electrical equipment: all electrical equipment excluding electronic
E. Mechanical equipment: equipment having only mechanical operating parts
F. Autopilots, gyros, and guidance equipment, including accessories, but excluding electronics
G. Instruments including indicators, electric motors, signal devices, etc., but not electronics
H. Armament: guns, bombing, and rocket equipment, excluding electronics
I. Photographic equipment and optical devices
J. Electronic and communications equipment

[2]The test sequence is given in the vertical column. A superscript adjacent to the sequence number is explained as follows:

1. Test with limited application
2. Test recommended for missile in addition to those tests not marked with a superscript
3. Test not generally applicable to airborne or ground launched vehicles
4. Test not generally applicable to aircraft or helicopters
5. Test not generally applicable to ground launched vehicles

3.4.5 **TEST: Temperature Shock**

3.4.5.1 Purpose

The temperature shock test is conducted to determine the effects on equipment of sudden changes in temperature of the surrounding atmosphere. This procedure will ensure the test item will operate within specifications and suffer no deleterious effects when subjected to the test requirements. This procedure will be accomplished for 20-W, 50-W, and 400-W transponders as specified in Table 3-6.

Table 3-6. Test Chamber Temperatures

Temperature Chamber	Equipment in Non-Operating Mode		
	20-Watt	**50-Watt**	**400-Watt**
Hot	85°C ± 2°C	85°C ± 2°C	85°C ± 2°C
Cold	–51°C ± 2°C	–54°C ± 2°C	–40°C ± 2°C

3.4.5.2 General Effects

Adverse effects could occur in service due to rapid altitude changes during shipments.

3.4.5.3 Apparatus

This test requires two temperature chambers (hot and cold) with associated controls and monitors.

3.4.5.4 Required Parameters

The following details shall be as identified in the equipment specification:

a. Pretest data required;

b. Failure criteria.

3.4.5.5 Procedure

NOTE	Where functional testing is specified prior to or following a procedure, refer to Subsection 3.4.3.5.

Prepare the test item IAW Subsection 3.4.3.2. Perform a pre-functional test to verify that operation is satisfactory and then record the results. Equipment shall be non-operating while in the temperature chamber. Attach a thermocouple to the base plate of the test item. Monitor test item temperature on a temperature display.

Step 1: Install the test item in the hot chamber with an internal chamber temperature as specified for the UUT. Maintain for a period of not less than 4 hours or until the test item temperature stabilizes.

Step 2: At the conclusion of the required time period, the test item shall be transferred, within 5 minutes, to the cold chamber with an internal chamber temperature as specified for the UUT. Maintain for a period of not less than 4 hours or until the test item temperature stabilizes.

Step 3: At the conclusion of this time period, the test item shall be returned within 5 minutes to the hot chamber with an internal chamber temperature as specified for the UUT. Maintain for a period of not less than 4 hours or until the test item temperature stabilizes.

Step 4: Repeat steps 1 through 3 for three complete cycles.

Step 5: Remove the test item from the hot chamber and return the test item to standard ambient conditions of 22°C ± 3°C and stabilize.

Step 6: Perform a post-functional test and verify operation is satisfactory. Measure and record.

3.4.6 TEST: Temperature-Altitude

3.4.6.1 Purpose

The temperature-altitude test is conducted to determine the ability of equipment to operate satisfactorily under simultaneously applied varying conditions of low pressure and high/low temperature. The equipment category, as used in this method, is determined by the required altitude operating range and the required sea-level continuous operating temperature delineated in Table 3-7.

Table 3-7. Equipment Categories for Temperature-Altitude Tests

Equipment Category	Altitude Range (ft)	Temperature (°C)	Equipment Mode: Operating: Continuous	Equipment Mode: Operating: Intermittent[1]	Equipment Mode: Operating: Short-Time[2]	Equipment Mode: Non-Operating
1	Sea level to 10,000	0 to 55	x	-	-	-
		–62 to 85	-	-	-	x[3]
2	Sea level to 10,000	–40 to 55	x	-	-	-
		55 to 71	-	x	-	-
		–62 to 85	-	-	-	x[3]
3	Sea level to 15,000	–40 to 55	x	-	-	-
		55 to 71	-	x	-	-
		–62 to 85	-	-	-	x
4	Sea level to 30,000	–54 to 55	x	-	-	-
		55 to 71	-	x	-	-
		–62 to 85	-	-	-	x
5	Sea level to 50,000	–54 to 55	x	-	-	-
		55 to 71	-	x	-	-
		–62 to 85	-	-	-	x
6	Sea level to 70,000	–54 to 71	x	-	-	-
		71 to 85	-	x	-	-
		–62 to 85	-	-	-	x
7	Sea level to 100,000 (95°C continuous sea level operation)	–54 to 95	x	-	-	-
		95 to 125	-	x	-	-
		125 to 150	-	-	x	-
		–62 to 125	-	-	-	x
8	Sea level to 100,000 (125°C continuous sea level operation)	–54 to 125	x	-	-	-
		125 to 150	-	x	-	-
		150 to 260	-	-	x	-
		–62 to 150	-	-	-	x

x = **applicable equipment mode at specified temperature and altitude.**

Notes
[1]Thirty minutes of operation followed by a 15-minute de-energized period
[2]Ten minutes of operation followed by a 15-minute de-energized period
[3]Air transportation to 15,000 ft except where a sudden loss of pressure in the cargo compartment could cause failure of the test item that could damage the aircraft. The equipment shall also be tested to withstand an altitude of 40,000 ft, non-operating.

3.4.6.2 General Effects

Deleterious effects to be anticipated include leakage of gases or fluids from sealed enclosures, rupture of pressurized containers, congealing of lubricants, cracking or rupture of materials due to contraction or expansion, short circuiting of electrical wiring, and other damaging effects that might be expected from exposure to any of the above environments singly. In addition, equipment dependent on a convection-type cooling system may be affected due to the reduction of efficiency of heat dissipation in less dense air.

3.4.6.3 Apparatus

This test requires a temperature-altitude chamber and auxiliary thermal sensors with associated recording devices (see Subsection 3.4.6.6 note a).

3.4.6.4 Required Parameters

The following details shall be as identified in the equipment specifications:

a. Pretest data required;

b. Pertinent equipment operation parameter limits (input voltage, etc.);

c. Failure criteria.

3.4.6.5 Procedure

NOTE	Where functional testing is specified prior to or following a procedure, refer to Subsection 3.4.3.5.

The test item shall be prepared IAW Subsection 3.4.3.2. In general, the testing schedule outlined in Table 3-8 for category 6 equipment (reference Table 3-7) shall be followed; however, each step in Table 3-8 represents a condition that the test item may encounter in service; therefore, each step may be applied independently of the others. For operating conditions other than those specified in Table 3-7, the alternate temperature-altitude conditions in Figure 3-4 shall be used. When changing chamber conditions from those required for one step to those required for any other step, in the sequence given in Table 3-8 or in any sequence, the rates of temperature and pressure changes may be the maximum attainable by the chamber, but these rates shall not exceed 1°C (l.8°F) per second for airborne equipment or 10°C (18°F) per minute for test equipment and 0.5 inHg per second. Tables indicating pressure levels for varying altitudes are contained in *U. S. Standard Atmosphere supplements, 1966.*[12]

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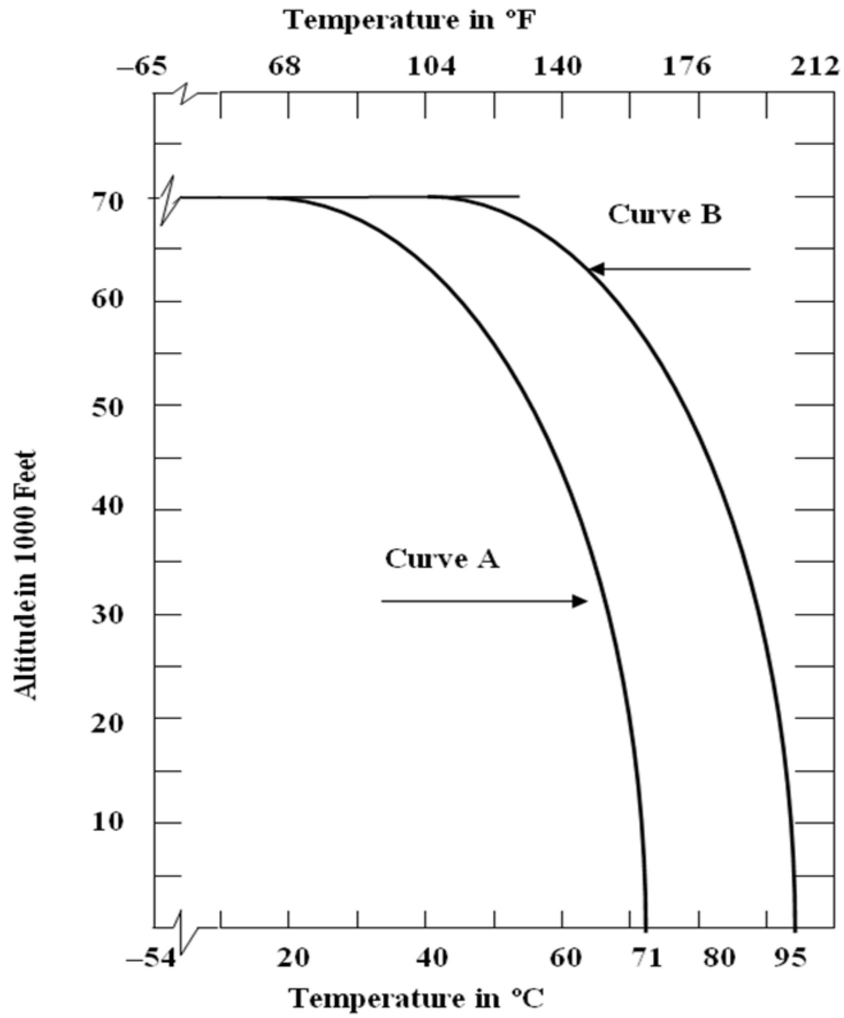
[12]United States Committee on Extension to the Standard Atmosphere. *U.S. Standard Atmosphere Supplements, 1966.* Washington: U.S. Government Printing Office, 1967.

Table 3-8. Test Conditions for Temperature-Altitude Tests

Cat.	Step	1a	1b	2	3	4	5	6	7	8	9	10	11	12	13	14
	Temp (°C)	25	–51	0	0			85	55			52				
1	ALT (ft)	40,000	Site	Site	10,000	Omit		Site	Site	Omit	Omit	10,000	Omit	Omit	Omit	Omit
	Time	1 hr	2 hrs	--	--			12 hrs	4 hrs			4 hr				
	Temp (°C)	25	–51	–51	–51	–10		85	55	71		52	68			
2	ALT (ft)	40,000	Site	Site	10,000	Site		Site	Site	Site	Omit	10,000	10,000	Omit	Omit	Omit
	Time	1 hr	2 hrs	--	--	--		12 hrs	4 hrs	20 min		4 hr	20 min			
	Temp (°C)		–51	–51	–51	–10		85	55	71		49	65			
3	ALT (ft)	Omit	Site	Site	15,000	Site		Site	Site	Site	Omit	15,000	15,000	Omit	Omit	Omit
	Time		2 hrs	--	--	--		12 hrs	4 hrs	30 min		4 hr	20 min			
	Temp (°C)		–51	–54	–54	–10		85	55	71		48	64	40	57	
4	ALT (ft)	Omit	Site	Site	30,000	Site		Site	Site	Site	Omit	20,000	20,000	30,000	30,000	Omit
	Time		2 hrs	--	--	--		12 hrs	4 hrs	30 min		4 hr	30 min	4 hr	30 min	
	Temp (°C)		–51	–54	–54	–10		85	55	71		30	47	20	35	
5	ALT (ft)	Omit	Site	Site	50,000	Site		Site	Site	Site	Omit	40,000	40,000	50,000	50,000	Omit
	Time		2 hrs	--	--	--		12 hrs	4 hrs	30 min		4 hr	30 min	4 hr	30 min	
	Temp (°C)		–54	–54	–54	–10		85	71	85		36	60	10	35	
6	ALT (ft)	Omit	Site	Site	70,000	Site		Site	Site	Site	Omit	50,000	50,000	70,000	70,000	Omit
	Time		2 hrs	--	--	--		12 hrs	4 hrs	30 min		2 hr	30 min	2 hr	30 min	
	Temp (°C)		–51	–54	–54	–10		125	95	125	150	60	90	-10	20	45
7	ALT (ft)	Omit	Site	Site	80,000	Site		Site	Site	Site	Site	50,000	50,000	100,000	100,000	100,000
	Time		2 hrs	--	--	--		12 hrs	4 hrs	30 min	10 min	4 hr	30 min	4 hr	30 min	10 min
	Temp (°C)		–51	–54	–54	–15		150	125	150	260	90	115	25	50	155
8	ALT (ft)	Omit	Site	Site	80,000	Site		Site	Site	Site	Site	50,000	50,000	100,000	100,000	100,000
	Time		2 hrs	--	--	--		12 hrs	4 hrs	30 min	10 min	4 hr	30 min	4 hr	30 min	10 min

Site: Altitude of test facility. Steps 5 and 15 do not have values in this table. These tests are conducted at standard ambient temperatures.



Curve A: Design and test requirements for continuous operation
Curve B: Design and test requirements for intermittent operation

Figure 3-4. Temperature vs. Altitude Requirements for Category 6 Equipment

Step 1a: (Equipment categories 1 and 2 only) With the test item de-energized, adjust the chamber temperature to that specified in step 1a of Table 3-8. After the test item temperature has stabilized, the chamber pressure shall be adjusted to simulate the altitude specified in step 1a of Table 3-8. Maintain these test conditions for at least the length of time specified in step 1a of Table 3-8. At the conclusion of this time period the test item shall, to the extent practical, be visually inspected for the presence of deterioration that would impair future operation.

Step 1b: (All equipment categories) With the test item de-energized, adjust the chamber test conditions to those specified in step 1b of Table 3-8. After the test item temperature has stabilized, maintain these test conditions for at least the length of time specified in step lb of Table 3-8. Where it is possible, without changing the test conditions, the test item shall be visually inspected for the presence of deterioration that would impair future operation. **If the test item is equipped with a heating circuit, apply**

heater simultaneously with the primary power to the transponder and perform a functional test after 15 minutes of heating time and record.

Step 2: With the test item de-energized, adjust the chamber test conditions to those specified in step 2 of Table 3-8. These chamber test conditions shall be maintained throughout this step. After the test item temperature has stabilized, the test item shall be operated at the lowest specified input voltage. The test item shall operate satisfactorily immediately following the specified warm-up time (see note b). The test item shall be de-energized and re-stabilized at the temperature specified in step 2 of Table 3-8. The above operational sequence shall be repeated two additional times. **If the test item is equipped with a heating circuit, apply heater simultaneously with the primary power to the transponder and perform a functional test after 15 minutes of heating time and record.**

Step 3: With the test item de-energized, adjust the chamber temperature to that specified in step 3 of Table 3-8. The test item temperature shall be stabilized. The test item shall be energized at the highest specified input voltage and the chamber pressure adjusted to simulate the altitude specified in step 3 of Table 3-8. Upon reaching the specified chamber pressure and while maintaining the chamber temperature, the test item shall be checked for satisfactory operation and the results recorded. **If the test item is equipped with a heating circuit, apply heater simultaneously with the primary power to the transponder and perform a functional test after 15 minutes of heating time and record.**

Step 4: With the test item de-energized, adjust the chamber test conditions to those specified in step 4 of Table 3-8. After the test item temperature has stabilized, the chamber door shall be opened and frost permitted to form on the test item (see note c). The door shall remain open long enough for the frost to melt, but not long enough for the moisture to evaporate. The chamber door shall be closed and the test item operated at the highest specified input voltage to ascertain satisfactory operation immediately following the specified warm-up time. The test item shall be energized and de-energized at least three times. **If the test item is equipped with a heating circuit, apply heater simultaneously with the primary power to the transponder and perform a functional test after 15 minutes of heating time and record.**

Step 5: Adjust the chamber test conditions to standard ambient conditions. After the test item temperature has stabilized, an operational and performance check of the test item shall be made and the results compared with the data obtained in Subsection 3.4.3.2.1 and evaluated using the failure criteria of Subsection 3.4.3.2.6.

Step 6: With the test item de-energized, adjust the chamber test conditions to those specified in step 6 of Table 3-8. The test item temperature shall be stabilized and then maintained for at least the length of time specified in step 6 of Table 3-8. At the conclusion of this time period, where practicable, the test item shall be visually inspected for any deterioration. An operational and performance check of the test item shall be made and the results compared with the data obtained in Subsection 3.4.3.2.1 and evaluated using the failure criteria of Subsection 3.4.3.2.6.

Step 7: With the test item de-energized, adjust the chamber test conditions to those specified in step 7 of Table 3-8. After the test item temperature has stabilized and while maintaining the chamber temperature, operate the test item continuously at the highest specified input voltage for the length of time specified in step 7 of Table 3-8. Thermal sensor readings of the test item temperature shall be recorded every 30 minutes. At the end of the time period specified in step 7 of Table 3-8 and while maintaining the test conditions, the test item shall be checked for satisfactory operation and the results recorded.

Step 8: With the test item de-energized, adjust the chamber test conditions to those specified in step 8 of Table 3-8 and maintain throughout this step. After the test item temperature has stabilized, the test item shall be operated at the highest specified input voltage for two time periods each of the duration specified in step 8 of Table 3-8. The first time period of operation shall be followed by a 15-minute period with the test item de-energized. The test item shall be checked for satisfactory operation during each operating time period and the results recorded. A functional test of the item will be performed after each operating period. Thermal sensor readings of the test item temperature shall be recorded every 10 minutes of test item operation.

Step 9: With the test item de-energized, adjust the chamber test conditions to those specified in step 9 of Table 3-8 and maintain throughout this step. After the test item temperature has stabilized, the test item shall be operated at the highest specified input voltage for four time periods each of the duration specified in step 9 of Table 3-8. The first three periods of operation shall be followed by a 15-minute period with the test item de-energized. The test item shall be checked for satisfactory operation during each operating time period and the results recorded. Thermal sensor readings of the test item temperature shall be recorded at the beginning and end of each operating time period.

Step 10: With the test item de-energized, adjust the chamber temperature to that specified in step 10 of Table 3-8. The test item temperature shall be stabilized. The test item shall be operated at the highest specified input voltage and the chamber pressure adjusted to simulate the altitude specified in step 10 of Table 3-8. Maintain these test conditions for the length of time specified in step 10 of Table 3-8. Thermal sensor readings of the test item temperature shall be recorded every 30 minutes. At the end of the time period specified in step 10 of Table 3-8 and while maintaining the test conditions, the test item shall be checked for satisfactory operation and the results recorded.

Step 11: With the test item de-energized, adjust the chamber temperature to that specified in step 11 of Table 3-8 (see note d) and maintain throughout this step. The test item temperature shall be stabilized. The test item shall de-energize at the highest specified input voltage and the chamber pressure adjusted to simulate the altitude specified in step 11 of Table 3-8. The test item shall be operated for four time periods each of the duration specified in step 11 of Table 3-8. The first three time periods of operation shall be followed by a 15-minute period with the test item de-energized. The test item shall be checked for satisfactory operation during each operating time period and the results recorded. Thermal sensor readings of the test item temperature shall be recorded every 10 minutes of test item operation.

Step 12: With the test item de-energized, adjust the chamber temperature to that specified in step 12 of Table 3-8 (see note d). The test item temperature shall be stabilized. The test item shall then be energized at the highest specified input voltage and the chamber pressure adjusted to simulate the altitude specified in step 12 of Table 3-8. Maintain these test conditions for the length of time specified in step 12 of Table 3-8. Thermal sensor readings of the test item temperature shall be recorded every 30 minutes. At the end of the time period specified in step 12 of Table 3-8 and while maintaining the test conditions, the test item shall be checked for satisfactory operation and the results recorded.

Step 13: With the test item de-energized, adjust the chamber temperature to that specified in step 13 of Table 3-8 (see note d) and maintain throughout this step. The test item temperature shall be stabilized. The test item shall be energized at the highest specified input voltage and the chamber pressure adjusted to simulate the altitude specified in step 13 of Table 3-8. The test item shall be operated for four time periods as specified in step 13 of Table 3-8. The first three time periods of operation shall be followed by a 15-minute period with the test item de-energized. The test item shall be checked for satisfactory operation during each operating time period and the results recorded. Thermal sensor readings shall be recorded every 10 minutes of test item operation.

Step 14: With the test item de-energized, adjust the chamber temperature to that specified in step 14 of Table 3-8 (see note d) and maintain throughout this step. The test item temperature shall be stabilized. The test item shall be energized at the highest specified input voltage (see note d) and the chamber pressure adjusted to simulate the altitude specified in step 14 of Table 3-8. The test item shall be operated four time periods each of the duration specified in step 14 of Table 3-8 and shall be followed by a 15-minute period with the test item de-energized. The test item shall be checked for satisfactory operation during each operating time period and the results recorded. Thermal sensor readings of the test item temperature shall be recorded at the beginning and end of each operating time period.

Step 15: Adjust the chamber test conditions to standard ambient conditions. After the test item temperature has stabilized, an operational and performance check of the test item shall be made and the results compared with the data obtained in Subsection 3.4.3.2.1 and evaluated using the failure criteria of Subsection 3.4.3.2.6.

3.4.6.6 Notes

a. The following guidelines are provided for consideration when determining location of thermal sensors used to monitor the test items.

   (1) One or more sensors in the ambient air within each major unit

   (2) Contact temperature on the largest mass in each major unit

   (3) Contact temperature on the part(s) where the highest surface temperature is expected

(4) Contact temperature on the part(s) whose temperature is likely to limit equipment performance

b. All characteristics that are likely to be affected by low temperatures shall be checked first. Should the time required to check the test item exceed 15 minutes beyond the warm-up time, the test item shall again be stabilized at the temperature specified for step 2 in Table 3-8 and the operational check continued.

c. When the chamber door is opened, it is intended that frost will form; however, should the relative humidity of the air be such that frost will not form, an artificial means shall be used to provide the relative humidity necessary to have frost form.

d. Following those steps where a change in temperature at low pressure is required, the pressure may be increased to ambient before changing the temperature and then returned to the required pressure following temperature stabilization.

3.4.7 **TEST: Humidity**

3.4.7.1 Purpose

The humidity test is conducted to determine the resistance of equipment to the effects of exposure to warm, highly humid atmosphere such as that encountered in tropical areas. This is an exaggerated environmental test, accomplished by the continuous exposure of the equipment to high relative humidity at cycling-elevated temperatures. These conditions impose a vapor pressure on the equipment under test, which constitutes the major force behind the moisture migration and penetration.

3.4.7.2 General Effects

Corrosion is one of the principal effects of humidity. Hygroscopic materials are sensitive to moisture and may deteriorate rapidly under humid conditions. Absorption of moisture by many materials results in swelling, which destroys their functional utility and causes loss of physical strength and changes in other important mechanical properties. Insulating materials that absorb moisture may suffer degradation of their electrical and thermal properties. Cycling temperature and humidity may cause condensation of moisture inside of the equipment that could cause the equipment to malfunction due to electrical shorts or cause binding due to corrosion or fouling of lubricants between moving parts.

3.4.7.3 Apparatus

The test apparatus includes a humidity-temperature chamber and associated equipment. The chamber and accessories shall be constructed and arranged in such a manner as to avoid condensate dripping on the test item. The chamber shall be trap-vented to the atmosphere to prevent the buildup of total pressure. Relative humidity shall be determined from the dry-bulb/ wet-bulb thermometer comparison method or an equivalent method approved by the procuring activity. When readout charts are used, they shall be capable of being read with a resolution within 0.6°C (1°F). When the wet-bulb control method is used, the wet-bulb thermometer and tank shall be cleaned and a new wick installed at least every 30 days. The air velocity flowing across the wet bulb shall be not less than 900 feet per minute. Provisions shall be made for controlling the flow of air throughout the internal chamber test space where the velocity of air shall not exceed 150 feet per minute. Steam or distilled, demineralized, or deionized water having a pH value between 6 and 7.2 at 23°C (73°F) shall be used to obtain the specified humidity. No rust or corrosive contaminants shall be imposed on the test item by the test facility.

3.4.7.4 Required Parameters

The following details shall be as identified in the equipment specification.

a. Procedure number.

b. Pretest data required.

c. Failure criteria.

d. Periods at which measurements are to be taken.

e. Method for determining purity of water if a more precise method is desired. An alternate to pH criteria is to perform a conductivity measurement. The maximum acceptable value would be that resistance which is equivalent to 3.5 parts per million total ionized solids.

f. If the test item must be exposed to extreme temperature prior to test (Procedure I).

3.4.7.5 Procedure

This test requires continuous measurements for analog equipment and every 15 minutes for digital equipment.

NOTE	Where functional testing is specified prior to or following a procedure, refer to Subsection 3.4.3.5.

3.4.7.5.1 Procedure I: Airborne electronic equipment.

Step 1: Perform a functional test prior to exposure to humidity.

Step 2: Prepare the test item IAW Subsection 3.4.3.2 and Subsection 3.4.3.5.2. Prior to starting the test, the internal chamber temperature shall be at standard ambient with uncontrolled humidity. Install the test item in the chamber.

Step 3: Gradually raise internal chamber temperature to 65°C (149°F) and the relative humidity to 95% (+5/–3%) over a period of 2 hours.

Step 4: Maintain the conditions of step 2 for not less than 6 hours.

Step 5: Maintain 85% or greater relative humidity and reduce internal chamber temperature in 16 hours to 30°C (86°F).

Step 6: Repeat steps 3, 4, and 5 for a total of 5 cycles, 24 hours each (not less than 120 hours). Figure 3-5 is an outline of the humidity cycle for this procedure.

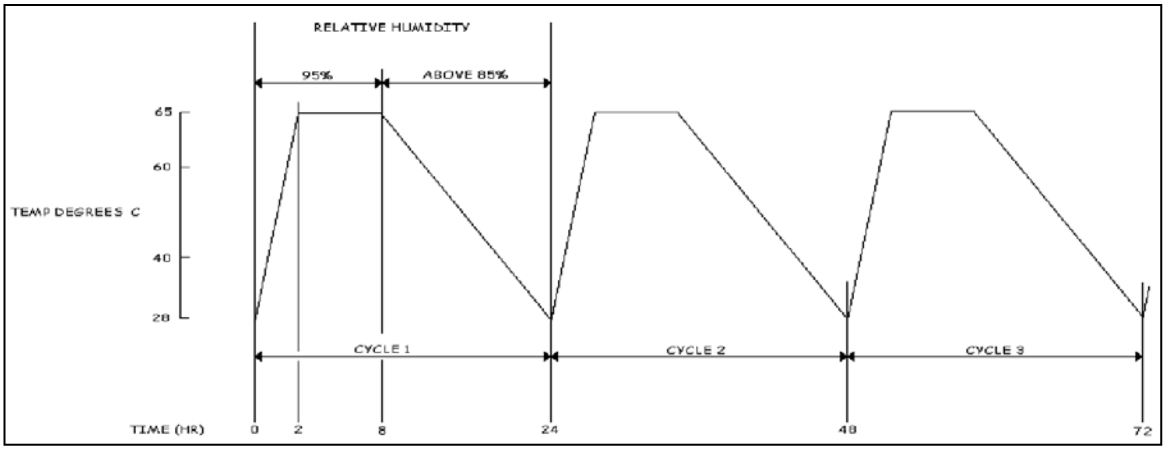


Figure 3-5. Humidity Cycle - Procedure I

Step 7: At the end of the fifth cycle, while still at 30°C (86°F) and 85% relative humidity, operate the test item and obtain results IAW Subsection 3.4.3.2.

Step 8: Remove and inspect the test item and obtain results IAW Subsection 3.4.3.2.

Step 9: Perform a functional test after exposure to humidity.

3.4.7.5.2 Procedure II: Ground fire control and shipboard equipment.

Step 1: Prepare the test item IAW Subsection 3.4.3.2.

Step 2: Dry the test item at a temperature of not less than 40°C (104°F) or more than 50°C (122°F) for not less than 2 hours.

Step 3: Condition the test item at 25°C ± 5°C (77°F ± 9°F) and 50% relative humidity for 24 hours.

Step 4: Take initial measurements as specified in the equipment specification IAW Subsection 3.4.3.2.

NOTE	The test item may be readjusted or realigned as necessary to conform to the equipment specification requirements. No further realignment or readjustment shall be permitted throughout the test period other than with accessible controls, external to the test item, employed for operation of the test item. If repairs, replacement of parts, or adjustments other than by the accessible external controls are made at any time prior to completion of the measurements required at the end of the fifth cycle, all 5 of the 24-hour cycles shall be repeated. Repairs include any change to the test item that is not made by use of the accessible controls external to the test item. The test item shall only be operated when specified test measurements are being performed.

Step 5: Subject the test item to five 24-hour cycles IAW Figure 3-6. A 24-hour cycle consists of 16 hours at 60°C ± 5°C (140°F ± 9°F) and approximately 8 hours at 30°C ± 5°C (86°F ± 9°F) (includes transition times). The relative humidity shall be maintained at 95% or greater at both temperatures. Each transition time between 30°C ± 5°C (86°F ± 9°F) and 60°C ± 5°C (140°F ± 9°F) shall be not greater than 1½ hours. The relative

humidity during each transition need not be controlled. Approximately 2 hours after stabilization during the high-temperature and low-temperature portions of the first or second cycle, a sampling of the atmosphere in the chamber shall be made to determine that the conditions of temperature and relative humidity are uniform throughout the chamber.

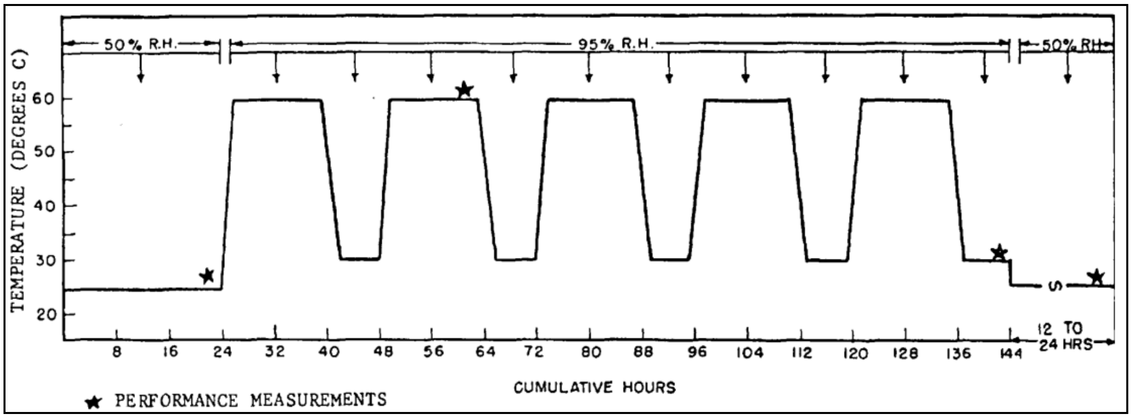


Figure 3-6. Humidity Cycle - Procedure II

Measurements as specified in the equipment specification shall be made during the second cycle at 60°C ± 5°C (140°F ± 9°F) immediately prior to decreasing to 30°C ± 5°C (86°F ± 9°F). The test item shall be energized only a sufficient time to allow the required warm-up and measurements specified in the equipment specification.

Step 6: After completion of the fifth cycle with the test item in the chamber and the chamber at 30°C ± 5°C (86°F ± 9°F) and a relative humidity of not less than 95%, take measurements specified in the equipment specification (no repair, realignment, readjustment, or replacement of parts shall be made, except as specified herein). Obtain results IAW Subsection 3.4.3.2.

Step 7: Condition the test item at 25°C ± 5°C (77°F ± 9°F) and 50 ± 5% relative humidity for not less than 12 hours or more than 24 hours.

Step 8: While at 25°C ± 5°C (77°F ± 9°F) and 50% relative humidity, take measurements as specified in the equipment specification.

Step 9: Inspect the test item to detect evidence of physical degradation (such as corrosion of metal parts, distortion of plastic parts, and insufficient lubrication of moving parts) IAW Subsection 3.4.3.2.

3.4.8 **<u>TEST: Salt Fog</u>**

3.4.8.1 <u>Purpose</u>

The salt fog test is conducted to determine the resistance of equipment to the effects of a salt atmosphere. The specified concentration of moisture and salt is greater than that found in service. The test is applicable to any equipment exposed to salt fog conditions in service.

3.4.8.2 Application

This test is valuable for determining the durability of coatings and finishes exposed to a corrosive salt atmosphere. For other applications, this test should be applied only after full recognition of its deficiencies and limitations, which are listed below.

3.4.8.3 Deficiencies

a. The successful withstanding of this test does not guarantee that the test item will prove satisfactory under all corrosive conditions.

b. The salt fog used in this test does not truly duplicate the effects of a marine atmosphere.

c. It has not been demonstrated that a direct relationship exists between salt-fog corrosion and corrosion due to other media.

d. This test is generally unreliable for comparing the corrosion resistance of different materials or coating conditions or for predicting their comparative service life. Some idea of the service life of different samples of the same, or closely related metals, or of protective-coating/base-metal combinations exposed to marine or seacoast locations, can be gained by this test provided the correlation of field service test data with laboratory tests can be established. In the case of aluminum alloys, such correlation tests are also necessary to show the degree of acceleration, if any, produced by the laboratory test.

3.4.8.4 Limitations

a. The salt-fog test is acceptable for evaluating the uniformity (i.e., thickness and degree of porosity) of protective coatings, metallic and nonmetallic, of different lots of the same product, once some standard level of performance has been established.

b. When used to check the porosity of metallic coatings, the test is more dependable when applied to coatings that are cathodic rather than anodic toward the basic metal.

c. This test can also be used to detect the presence of free iron contaminating the surface of another metal by inspection of the corrosion products.

3.4.8.5 Apparatus

The following subsections describe the apparatus necessary to perform this test.

3.4.8.5.1 Chamber

The chamber and all accessories shall be made of material that will not affect the corrosiveness of the fog, e.g., glass, hard rubber, plastic, or kiln-dried wood other than plywood. In addition, all parts that come in contact with test items shall be of materials that will not cause electrolytic corrosion. The chamber and accessories shall be constructed and arranged so that there is no direct impingement of the fog or dripping of the condensate on the test items, that the fog circulates freely about all test items to the same degree, and that no liquid that has come in contact with the test items returns to the salt-solution reservoir. The chamber shall be properly vented to prevent pressure buildup and to allow uniform distribution of salt fog. The discharge end of the vent shall be protected from strong drafts that can create air currents in the test chamber.

3.4.8.5.2 Atomizers

The atomizers used shall be of such design and construction as to produce a finely divided, wet, dense fog. Atomizing nozzles shall be made of material that is non-reactive to the salt solution.

3.4.8.5.3 Air Supply

The compressed air entering the atomizer shall be essentially free from all impurities, such as oil and dirt. Means shall be provided to humidify and warm the compressed air as required to meet the operating conditions. The air pressure shall be suitable to produce a finely divided dense fog with the atomizer or atomizers used. To ensure against clogging the atomizers by salt deposition, the air shall have a relative humidity of at least 85% at the point of release from the nozzle. A satisfactory method is to pass the air in very fine bubbles through a tower containing heated water that shall be automatically maintained at a constant level. The temperature of the water shall be at least 35°C (95°F). The permissible water temperature increases with increasing volume of air and with decreasing insulation of the chamber and the chamber's surroundings; however, the temperature shall not exceed a value above which an excess of moisture is introduced into the chamber (for example 43°C [109°F] at an air pressure of 12 psi) or a value that makes it impossible to meet the requirements for operating temperature.

3.4.8.5.4 Preparation of Salt Solution

The salt used shall be sodium chloride containing on the dry basis not more than 0.1% sodium iodide and not more than 0.5% of total impurities. Unless otherwise specified, a 5% ± 1% solution shall be prepared by dissolving five parts by weight of salt in 95 parts by weight of distilled or demineralized water. The solution shall be adjusted to and maintained at a specific gravity between the limits shown on Figure 3-7 by utilizing the measured temperature and density of the salt solution. Sodium tetraborate (common borax) may be added to the salt solution in a ratio not to exceed 0.7 grams (1/4 level teaspoon) sodium tetraborate to 20 gallons of salt solution as a pH stabilization agent.

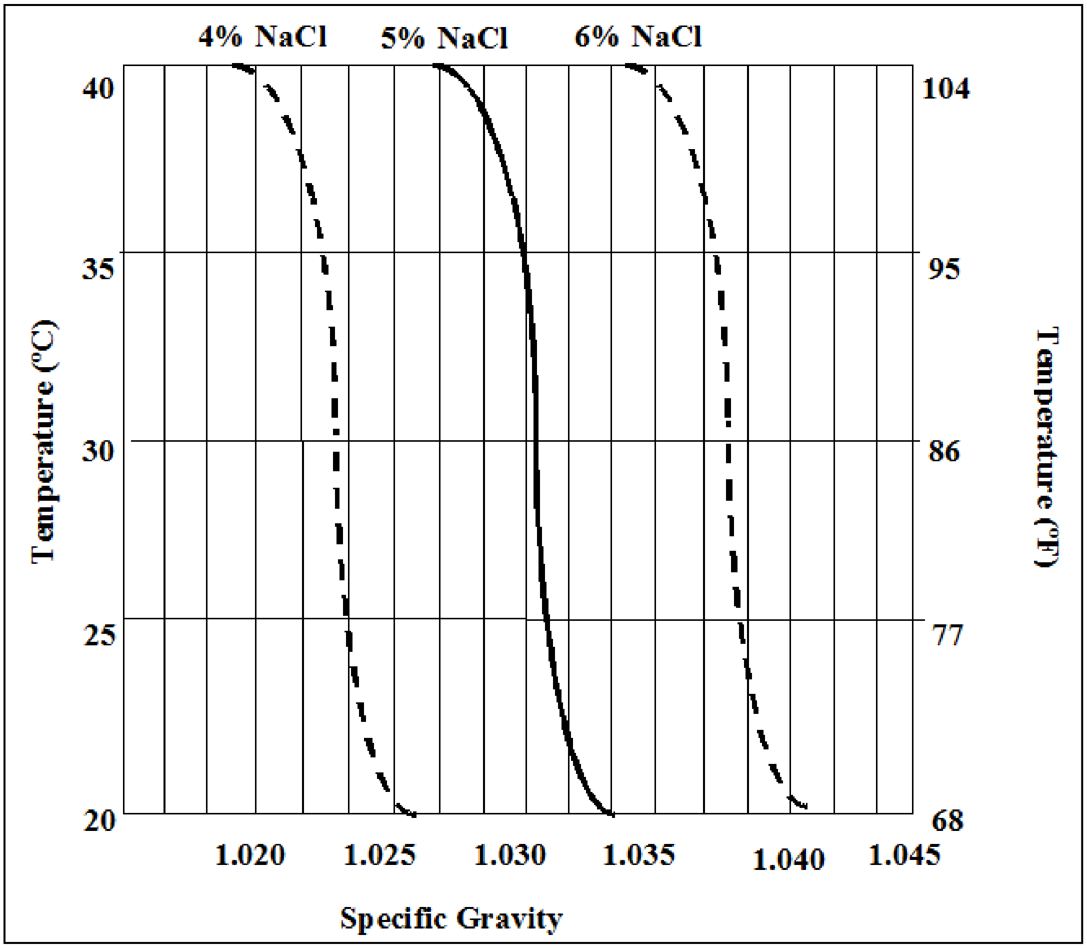


Figure 3-7. Variations of Specific Gravity of Salt (NaCl) Solution with Temperature

The pH level of the salt solution shall be so maintained that the solution atomized at 35°C (95°F) and collected by the method specified in Paragraph 3.4.8.7.3 will be in the pH range of 6.5 to 7.2. Only diluted, chemically pure (C.P.) hydrochloric acid or C.P. sodium hydroxide shall be used to adjust the pH. The addition of sodium tetraborate as recommended above will aid in maintaining a stable pH value. The measurement shall be made electrometrically, using a glass electrode with a saturated potassium chloride bridge, or by a colorimetric method, such as bromothymol blue, provided the results are equivalent to those obtained with the electrometric method. The pH shall be measured when preparing each new batch of solution and as specified above.

3.4.8.5.5 *Filter*

A filter fabricated of noncorrosive materials similar to that shown in Figure 3-8 shall be provided in the supply line and immersed in the salt solution reservoir in a manner such as that illustrated in Figure 3-9.

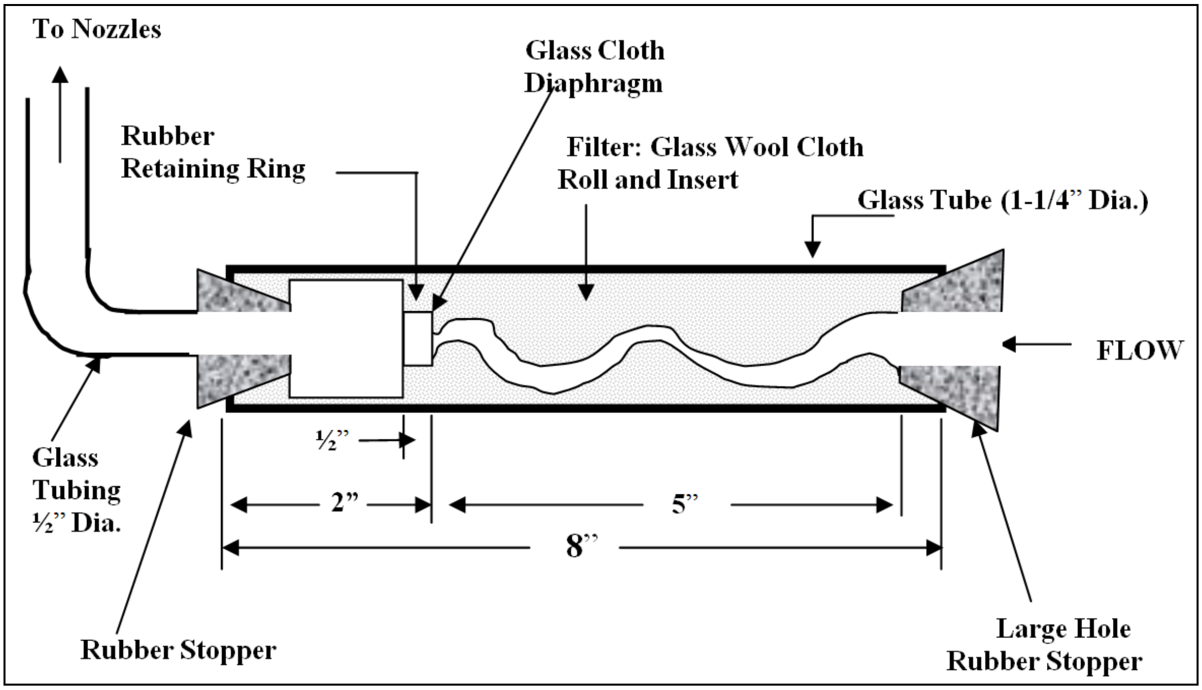


Figure 3-8. Salt Solution Filter

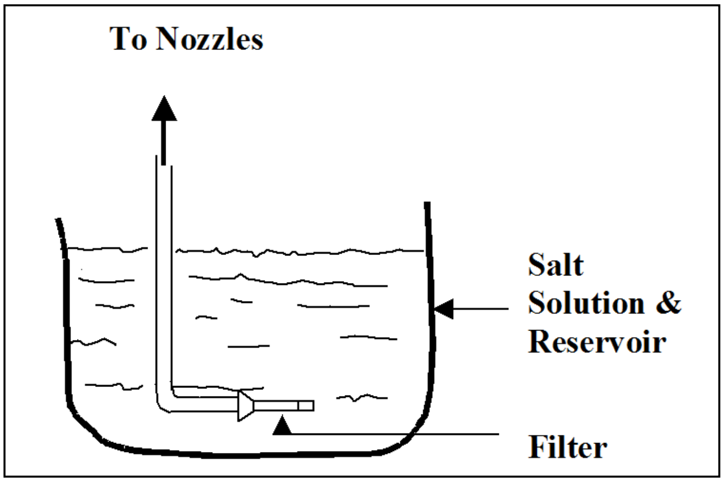


Figure 3-9. Location of Salt Solution Filter

3.4.8.6 Required Parameters

The following details shall be as identified in the equipment specification:

a. Pretest data required;

b. Failure criteria;

c. Applicable salt solution, if other than 5%;

d. Salt fog exposure period if other than 48 hours;

e. Drying period if other than 48 hours;

f. Inspection and operation after 24 hours of salt fog exposure where buildups of salt deposits are detrimental to the proper operation of the test item;

g. Specify if operation of electrical system is required.

3.4.8.7 Procedure

NOTE	Where functional testing is specified prior to or following a procedure, refer to Subsection 3.4.3.5.

3.4.8.7.1 Temperature

The test shall be conducted with a temperature in the exposure zone maintained at 35°C (95°F). Satisfactory methods for controlling the temperature accurately are by housing the apparatus in a properly controlled, constant-temperature room, by thoroughly insulating the apparatus and preheating the air to the proper temperature prior to atomization, or by jacketing the apparatus and controlling the temperature of the water or of the air used in the jacket. The use of immersion heaters within the chamber for the purpose of maintaining the temperature within the exposure zone is prohibited.

3.4.8.7.2 Atomization

Suitable atomization has been obtained in chambers having a volume of less than 12 cubic feet under the following conditions:

a. Nozzle pressure as low as practicable to produce fog at the required rate;

b. Orifices between 0.02 and 0.03 inch in diameter;

c. Atomization of approximately 3 quarts of salt solution per 10 cubic feet of chamber volume per 24 hours.

When using large chambers having a volume considerably in excess of 12 cubic feet, the conditions specified above may require modification to meet the requirements for operating conditions.

3.4.8.7.3 Placement of Salt Fog Collection Receptacles

The salt-fog conditions maintained in all parts of the exposure zone shall be such that a clean fog-collecting receptacle placed at any point in the exposure zone will collect from 0.5 to 3 milliliters of solution per hour for each 80 square centimeters (cm) of horizontal collecting area (10-cm diameter) based on an average test of at least 16 hours. A minimum of two receptacles shall be used, one placed nearest to any nozzle and one farthest from all nozzles. Receptacles shall be placed so that test items do not shield them and so no drops of solution from test items or other sources will be collected.

3.4.8.7.4 Measurement of Salt Solution

The solution, collected in a manner specified in Paragraph 3.4.8.7.3, shall have the sodium chloride content and pH specified in Subsection 3.4.8.5.4 when measured at a temperature of 35°C (95°F). The salt solution from all collection receptacles used can be combined to provide that quantity required for the measurements specified.

a. Measurement of sodium chloride content. The solution maintained at the specified temperature can be measured in a graduate of approximately 2.5-cm inside diameter. A small laboratory-type hydrometer will be required for measurement within this volume.

b. Measurement of pH. The pH shall be measured as specified in Subsection 3.4.8.5.4.

c. Time of measurements. The measurement of both sodium chloride content and pH shall be made at the following specified times.

   (1) For salt fog chambers in continuous use, the measurements shall be made following each test.

   (2) For salt fog chambers that are used infrequently, a 24-hour test run shall be accomplished, followed by the measurements. The test item shall not be exposed to this test run.

3.4.8.7.5 Preparation of Test Item

The test item shall be given a minimum of handling, particularly on the significant surfaces, and shall be prepared for test immediately before exposure. Unless otherwise specified, uncoated metallic or metallic-coated devices shall be thoroughly cleaned of oil, dirt, and grease as necessary until the surface is free from water break. The cleaning methods shall not include the use of corrosive solvents, solvents that deposit either corrosive or protective films, or abrasives other than a paste of pure magnesium oxide. Test items having an organic coating shall not be cleaned with solvents. Those portions of test items that come in contact with the support and, unless otherwise specified in the case of coated devices or samples, cut edges and surfaces not required to be coated shall be protected with a suitable coating of wax or similar substance impervious to moisture.

3.4.8.7.6 Performance of Test

The test item shall be placed in the test chamber IAW Paragraph 3.4.3.2.2 and exposed to the salt fog for a period of 48 hours or as specified in the equipment specification. At the end of the exposure period, unless otherwise specified, the test item shall be operated and the results compared with the data obtained IAW Subsection 3.4.3.2.1. The test item shall be inspected for corrosion IAW Paragraph 3.4.3.2.4. If necessary to aid in examination, a gentle wash in running water not warmer than 38°C (100°F) may be used. The test item shall then be stored in an ambient atmosphere for 48 hours, or as specified in the equipment specification, for drying. At the end of the specified drying period, the test item shall be again operated and the results compared with the data obtained IAW Subsection 3.4.3.2.1. The test item shall then be inspected IAW Paragraph 3.4.3.2.4.

3.4.9 **TEST: Acceleration**

3.4.9.1 Purpose

The acceleration test is performed to determine if equipment is constructed to withstand expected steady-state stresses and to ensure that performance degradations or malfunctions will not be produced by the simulated service acceleration environment.

3.4.9.2 Apparatus

Either of two facilities may be utilized for acceleration tests: a centrifuge or a track and rocket sled facility. A centrifuge of adequate size is recommended for all operational tests because of the convenience and ease of control; however, the performance of space-oriented equipment, such as gyros, space control platforms, etc., is difficult to test on a centrifuge, even when a counter-rotating fixture is employed. A rocket sled run is advantageous where strictly linear acceleration is required.

3.4.9.3 Required Parameters

The following details shall be as identified in the equipment specification or test plan:

a. Pretest data required;

b. Failure criteria;

c. Test level and test time (see Paragraph 3.4.9.4.3);

d. Length of time required for operation and required measurements.

3.4.9.4 Procedure

NOTE	Where functional testing is specified prior to or following a procedure, refer to Subsection 3.4.3.5.

3.4.9.4.1 Mounting of Test Item

Direction of forward acceleration is always considered to be the direction of the vehicle acceleration. Equipment shall be oriented accordingly, using its normal mounting means. For centrifuges, the location of the test item (with reference to the acceleration due to gravity [g's] established for the test) shall normally be determined by a measurement from the rotational center of the centrifuge to the geometric center of the test item. Should any point of the test item nearest the center of the centrifuge experience less than 90% of the specified g's, the test item shall be moved outward on a radius of the centrifuge or the speed of rotation shall be increased until not less than 90% of the specified g's is obtained.

NOTE	If the furthest end of the test item experiences more than 110% of the desired g's at the geometric center (while the nearest end experiences 90% or under), the test item may be tested using a lower speed and a larger-radius centrifuge arm. For large test specimens, exceptions should be made to allow for maximum gradient based on the existing availability of large centrifuges in commercial or government test facilities.

When a centrifuge is used to attain the required acceleration levels, five different tests shall subject the item to the following orientations.

Fore: Front or forward end of test item shall face toward center of centrifuge.
Aft: Reverse item 180 degrees from the fore position.
Up: Top of specimen shall face toward center of centrifuge.

Down: Reverse item 180 degrees from the up position.
Lateral: Each side (right, left), in turn, shall face toward center of centrifuge.

3.4.9.4.2 Test Level Determination

The g's to be applied to the test item are contingent on two factors: the direction of forward acceleration (level A) of the vehicle, and the orientation of the test item within the vehicle. The value of A is the highest possible known or unknown forward acceleration of a vehicle in which equipment is to be mounted. Forward acceleration shall never be less than one g.

Use the instructions in Table 3-9 to select test levels as listed in Table 3-10.

Table 3-9. Instructions for Selection of Test Levels

Forward Acceleration of Vehicle	Orientation of Test Item in Vehicle	Test Level
Known	Known	Substitute known acceleration A in forward acceleration column of appropriate vehicle category, and use given multiplying factors to attain test level for indicated directions.
Known	Unknown	Substitute known acceleration A in forward acceleration column of appropriate category, and use largest given multiplying factor to attain test level for all directions.
Unknown	Known	Select most probable level from those given in forward acceleration column of appropriate category, and use given multiplying factors to test level for required direction.
Unknown	Unknown	Select most probable level from those given in forward acceleration column of appropriate category, and use largest given multiplying factor to attain test level for all directions.

Table 3-10. Levels of Acceleration due to Gravity for Operational Test

Vehicle Category	Forward Acceleration A(g)[1]	Test Level[4]				
		Direction of Vehicle Acceleration (see Figure 3-10)				
		Fore	Aft	Up	Down	Lateral (two directions)
Aircraft[3]	2	1•A	3•A	4.5•A	1.5•A	2•A
Helicopter	2	1•A	1•A	3.5•A	1.5•A	2•A
Manned Aerospace Vehicles	6 to12[2]	1•A	0.33•A	1.5•A	0.5•A	0.66•A
Air-Carried Stores	IAW MIL-STD-8591[13]					

[13] Department of Defense. Airborne Stores, Suspension Equipment and Aircraft-Store Interface (Carriage Phase). MIL-STD-8591. 16 November 2012. May be superseded by update. Available at http://quicksearch.dla.mil/Transient/7476196E5495440AB7CE54B354BF3B97.pdf.

Ground-Launched Missiles	6 to 30[2]	1•A	0.33•A	0.66•A	0.66•A	0.66•A

Notes
[1]Levels in this column shall be used when forward acceleration is unknown. When the forward acceleration of the vehicle is known, that level shall be used for A.
[2]When forward acceleration is not known, the high limits shown shall be specified.
[3]Forward acceleration for carrier-based aircraft shall be 4 g's.
[4]Add pitch and roll accelerations, as applicable.

The test levels for Table 3-10 are based on accelerations at the center of gravity (C.G.) of the vehicle. For fighter aircraft, these g's must be increased for equipment locations away from the C.G. to account for maneuver loads, including the effects of roll and pitch motions.

a. For the up and down directions, the increase shall be as follows for wing locations:

$$\boxed{\Delta Gr = \frac{d(\alpha_r)}{g}} \qquad \text{Equation 3-2}$$

where: ΔGr = additional acceleration due to roll
d = lateral distance from C.G. in feet
α_r = maximum roll acceleration, rad/s^2 (use α_r = 15 unless otherwise known)
g = 32.17 ft/s^2

Add the ΔGr value obtained above to the Table 3-10 acceleration value for the operational test acceleration level.

b. For lateral directions, the g's shall be determined as follows for wing locations:

$$\boxed{G_{cr} = \frac{d(\omega)^2}{g}} \qquad \text{Equation 3-3}$$

where: G_{cr} = centrifugal acceleration due to roll
ω = maximum roll velocity, rad/s (use ω = 5 unless otherwise known)
d = lateral distance from C.G. in feet
g = 32.17 ft/s^2

Use the G_{cr} level obtained above for the operational test acceleration level when the computed value is larger than that in Table 3-10.

c. For the up and down directions, the increase shall be as follows for fuselage locations:

$$\boxed{\Delta G_p = \frac{d(\alpha_p)}{g}} \qquad \text{Equation 3-4}$$

where: ΔG_p = additional acceleration due to pitch

d = fore and aft distance from C.G.
α_p = maximum pitch acceleration in rad/s^2 (use $\alpha_p = 5$ unless otherwise known)
g = 32.17 ft/s^2

Add the ΔG_p value obtained above to the Table 3-10 acceleration value for the operational test acceleration level.

d. For the fore and aft directions, the g's shall be determined as follows for fuselage locations:

$$\boxed{G_{cp} = \frac{d(\omega)^2}{g}} \qquad \text{Equation 3-5}$$

where: G_{cp} = centrifugal acceleration due to pitch
ω = maximum pitch velocity, radians/sec (use $\omega = 2.5$ unless otherwise known)
d = fore or aft distance from C.G.
g = 32.17 ft/s^2

Use the G_{cp} level computed above for the operational test acceleration level when the computed value is larger than that in Table 3-10.

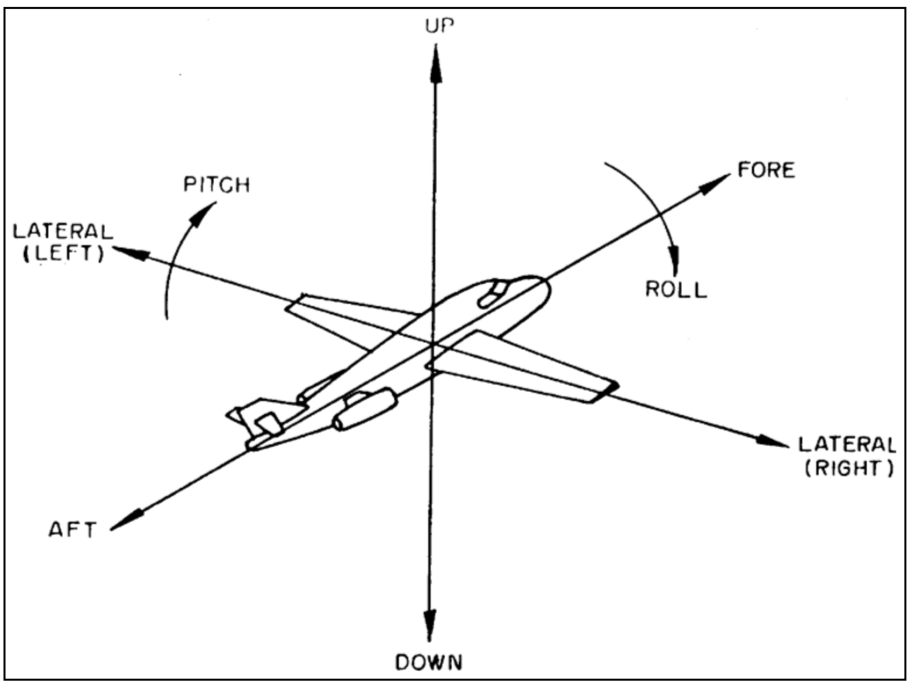


Figure 3-10. Direction of Vehicle Acceleration

3.4.9.4.3 Operational Test

The test item shall be installed on the accelerated apparatus IAW Subsection 3.4.3.2.2 by its normal mounting means. The g's shall be determined IAW Subsection 3.4.9.4.2 and shall be applied while the test item is operating. The test item shall then be inspected as specified in Subsection 3.4.3.2.

The level of g's determined for the test shall be applied along at least three mutually perpendicular axes in two opposite directions along each axis. The test time duration in each direction shall be at least one minute following centrifuge stabilization. A test time of one minute is usually sufficient to determine proper operation; however, the test time may be increased. The test item shall be operated before, during, and at the conclusion of each test, and results obtained IAW Subsection 3.4.3.2

3.4.10 **TEST: Vibration**

3.4.10.1 Purpose

The vibration test is performed to determine if equipment is constructed to withstand expected dynamic vibrational stresses and to ensure that the service vibration environment will not produce performance degradations or malfunctions. Tests specified herein are established for equipment that may be used in a variety of military applications.

3.4.10.2 Apparatus

This test utilizes vibration equipment with required instrumentation.

3.4.10.3 Required Parameters

The following details shall be as identified in the equipment specification or test plan:

a. Equipment category, applicable table, procedure, figure, and test curve (see Paragraph 3.4.10.4);

b. Pretest data required (Subsection 3.4.3.2);

c. Failure criteria;

d. Weight of test item when acceleration derating of selected curve is required (see Subsection 3.4.10.5.4.1 and Table 3-15, note 6);

e. Temperature extremes and temperature test time durations;

f. Total vehicle mileage for category F equipment (see Table 3-19);

g. Necessary parameters for calculating test levels for equipment categories B.2 and D.1.

3.4.10.4 General

The vibration test tables and figures provide a convenient means of summarizing test procedures to be specified in the equipment specification or test plan according to various military applications. Each table title refers to the applicable category of the equipment to be tested. Select a test based on the equipment categories as listed in Table 3-11, then proceed to the appropriate table and figure for that equipment category.

Table 3-11. Test Procedures by Equipment Category

Category	Description	Procedure	Table	Figure
B.1	Equipment installed in propeller airplanes and equipment mounted directly to engines, including jet engines	I	Table 3-12	Figure 3-11
B.2	Equipment installed in jet airplanes except for jet-engine-mounted equipment	IA	Table 3-15	Figure 3-14
C	Equipment installed in helicopters	I	Table 3-13	Figure 3-13
D.1	Equipment installed in external stores carried on airplanes	IIA	Table 3-16	Figure 3-15
E	Equipment installed in ground-launched missiles	III or IV	Table 3-17	Figure 3-16
F	Equipment installed in ground vehicles	V	Table 3-19	Figure 3-17
I	Shipboard and amphibious equipment or when a ship is the common carrier	VI	--	--

3.4.10.4.1 Applicable Tests

For any given equipment category, all tests listed beside the selected procedure for the applicable equipment-mounting configuration in the tables shall be performed unless otherwise specified. For example, referring to Table 3-17 for testing equipment category E when procedure III is selected, there are two parts with different test levels indicated by the test curves. Tests indicated (X) in both parts shall be performed to evaluate equipment without isolators.

3.4.10.4.2 Selection of Test Curves

A curve shall be selected from the tables and figures or by making a detailed analysis of the expected vibration environment within the particular vehicle involved. A primary consideration is the equipment location with respect to predominant vibration sources, such as high-intensity noise of jet and rocket exhausts, aerodynamic excitation including atmospheric wind and turbulence, and unbalance of rotating parts. Additional factors to be considered shall include attenuation or amplification and filtering by structural members. Guidance for selecting vibration curves with respect to equipment location or application is given in the tables. Applicable test curves for each equipment category are shown in the figures.

3.4.10.4.3 Procedure Selection

The equipment specification or test plan shall identify which tests are to be imposed on the equipment by specifying the applicable procedure, table, figure, and test curve. The following is an example.

Select the test conditions for equipment to be used in the following application:

Category: equipment installed in a propeller airplane
Equipment location: forward half of fuselage
Equipment mounting: on vibration-isolated panel

Referring to Table 3-12, the above identification specifies the following test conditions:

Procedure I
Part 1 (curve C)
Part 2 (curve B)

Part 1 specifies a resonance search, resonance dwell, and sinusoidal vibration cycling to the level of curve C from Figure 3-11 within the time schedule specified for Part 1 on Section A of Table 3-12. Next, with vibration isolators removed IAW note 2, Part 2 is performed the same as Part 1 but to the test level of curve B from Figure 3-11 within the time schedule specified for Part 2 from Section A of Table 3-12.

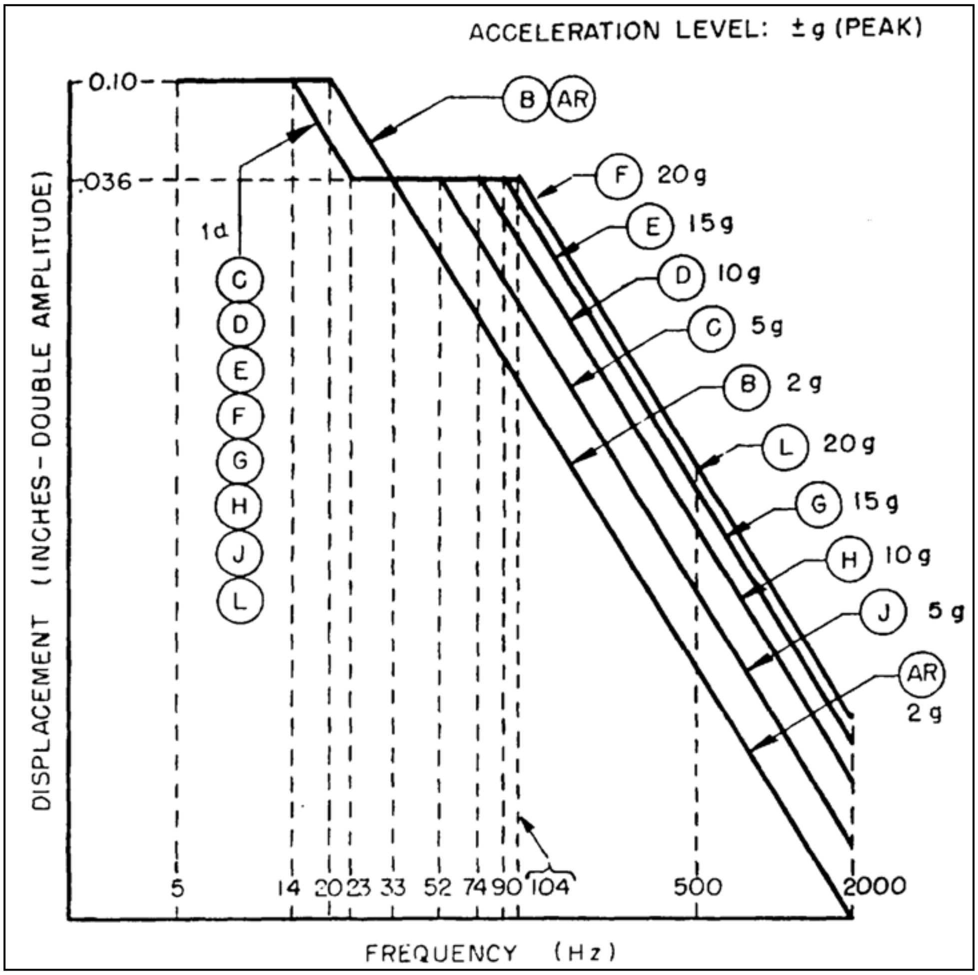


Figure 3-11. Vibration Test Curves for Equipment Category B.1

Table 3-12. Test Procedures and Time Schedule Chart for Equipment Category B.1

A: Procedure Selection and Time Schedule Chart

Equipment Mounting Configuration	Procedure #	Procedure Part #	Applicable Tests[3]			Test Time Schedule (per axis)				Figure 3-11 Curve[1]
			Resonance Search[4]	Resonance Dwell[5]	Sinusoidal Cycling[6]	Dwell Time at Each Resonance[5]	Sinusoidal Cycling Time	Sweep Time: 5-500-5 Hz	Sweep Time: 5-2000-5 Hz	
Without vibration isolators	I	1	X	X	X	30 min	3 hrs less dwell time	15 min	20 min	C, D, E, F, G, H, J, or L
With vibration isolators[2]	I	1	X	X	X	30 min	3 hrs less dwell time	15 min	20 min	C, D, E, F, G, H, J, or L
		2	X	X	X	10 min	30 min	15 min	20 min	B, AR
Normally with vibration isolators but tested without isolators	I	2	X	X	X	30 min	3 hrs less dwell time	15 min	20 min	B, AR

Notes

[1]For sinusoidal vibration resonance tests and cycling tests of item mounted in airplanes and weighing more than 80 pounds, the vibratory accelerations shall be reduced by 1 g for each 20-pound increment of weight over 80 pounds. Acceleration derating shall apply only to the highest test level of the selected test curve; however, the vibratory acceleration shall in no case be less than 50% of the specified curve level.

[2]Test items of equipment normally provided with vibration isolators first shall be tested with the isolators in place (part 1). The isolators then shall be removed, and the test item rigidly mounted and subjected to the test level indicated (part 2).

[3]See Subsection 3.4.10.5 for procedures.

[4]See Subsection 3.4.10.5.4.1, letter a.

[5]See Subsection 3.4.10.5.4.1, letter b.

[6]See Subsection 3.4.10.5.4.1, letter c.

B. Curve Selection Chart for Equipment Category B.1		
Selection Criteria	**Figure 3-11 Curve (for freq. to 500 Hz)**	**Figure 3-11 Curve (for freq. to 2000 Hz for jet engines)**
Equipment installed on vibration-isolated panels or racks when the panel or rack is not available for test or when the equipment is tested with isolators removed as specified by the applicable procedure	B	AR
Equipment in forward half of fuselage or equipment in wing areas of airplanes with engines at rear of fuselage	C	J
Equipment in rear half of fuselage or equipment in wing areas of airplanes with wing- or front-mounted engines or other equipment of engine locations not specifically mentioned for other curves	D	H
Equipment located in the engine compartments, or engine pylons of airplanes	E	G
Equipment mounted directly on airplane engines	F	L

3.4.10.5 Procedures

The basis for selecting a test procedure for a particular equipment category shall be according to Subsection 3.4.10.4. The vibration environment, specified by the curve selected from applicable tables IAW Subsection 3.4.10.4, shall be applied to each of the three mutually perpendicular axes of the test item. The entire sequence of tests may be accomplished for any one axis before changing to the next axis. The transverse motion at the input monitoring point(s) shall be minimized, and should be limited to 100% of the input motion except that reaction machines shall be balanced to reduce transverse motion 100%.

NOTE	Where functional testing is specified prior to or following a procedure, refer to Subsection 3.4.3.5.

3.4.10.5.1 Test Item Operation

Unless otherwise specified, the test item shall be operated during application of vibration (resonance search, resonance dwell, cycling, and random vibration) so that functional effects caused by these tests may be evaluated. Procedures IA (Paragraph 3.4.10.5.6) and IIA (Paragraph 3.4.10.5.7) provide for a functional vibration test and an endurance vibration test. The test item shall meet performance requirements as specified in the detail equipment specification and Subsection 3.4.3.2. While the functional vibration and the time required for the performance test is greater than the duration of the vibration test, the performance test may be abbreviated accordingly. The test item shall be operated and inspected and the results shall be obtained IAW Subsection 3.4.3.2.

3.4.10.5.2 Mounting Techniques

The test item shall be attached by its normal mounting means, either directly to the vibration exciter or transition table, or by means of a rigid fixture capable of transmitting the vibration conditions specified herein. Precautions shall be taken in the establishment of mechanical interfaces to minimize the introduction of extraneous responses in the test setup. The test load shall be distributed as uniformly as possible on the vibration exciter table in order to minimize effects of unbalanced loads. The input control sensing device(s) shall be rigidly attached to the vibration table, or fixture if used, as near as possible to the attachment point(s) of the test item. Additional vibration sensors shall be located in or on the test item to determine resonant frequencies and amplification factors. Locations to be selected should include main structure, printed circuit boards, large components, and modules, where practicable. The sensor sizes and weights shall be limited so that their effect on the dynamic responses being measured is minimal. For sinusoidal vibration, when necessary for obtaining uniform results, a tracking filter should be used in the vibration exciter control feedback loop prior to the servo input.

3.4.10.5.3 Combined Temperature-Vibration Test

Tests shall be performed under room-ambient conditions unless a high- or low-temperature vibration test is specified, in which case the temperature extremes and time duration also shall be as specified in the equipment specification.

3.4.10.5.4 Common Test Techniques

3.4.10.5.4.1 Sinusoidal Vibration Tests

The vibration shall be applied along each of three mutually perpendicular axes of the test item. The vibratory acceleration levels or double amplitudes of the specified test curve shall be maintained at the test item mounting points. When necessary for obtaining uniform results, a tracking filter should be used in the exciter control feedback loop prior to the servo input. When the input vibration is measured at more than one control point, the control signal shall be the average of all the accelerometers unless otherwise specified. For massive test items, fixtures, and large force exciters, it is recommended that the input control level be an average of at least three inputs.

a. Resonance Search. Resonant frequencies of the equipment shall be determined by varying the frequency of applied vibration slowly through the specified range at reduced test levels but with sufficient amplitude to excite the item. Sinusoidal resonance search may be performed using the test level and cycling time specified for sinusoidal cycling test, provided the resonance search time is included in the required cycling test time listed below in letter c.

b. Resonance Dwell. The test item shall be vibrated along each axis at the most severe resonant frequencies determined above in letter a. Test levels, frequency ranges, and test times shall be IAW the applicable conditions from the tables and figures for each equipment category. If more than four significant resonant frequencies are found for any one axis, the four most severe resonant frequencies shall be chosen for the dwell test. If a change in the resonant frequency occurs during the test, its time of occurrence shall be recorded and immediately the frequency shall be adjusted to maintain the peak resonance condition. The final resonant frequency shall be recorded.

c. Cycling. The test item shall be vibrated along each axis IAW the applicable test levels, frequency range, and times from the applicable tables and figures. The frequency of applied vibration shall be swept over the specified range logarithmically IAW Figure 3-12 The specified sweep time is that of an ascending plus a descending sweep and is twice the ascending sweep time shown on Figure 3-12 for the specified range.

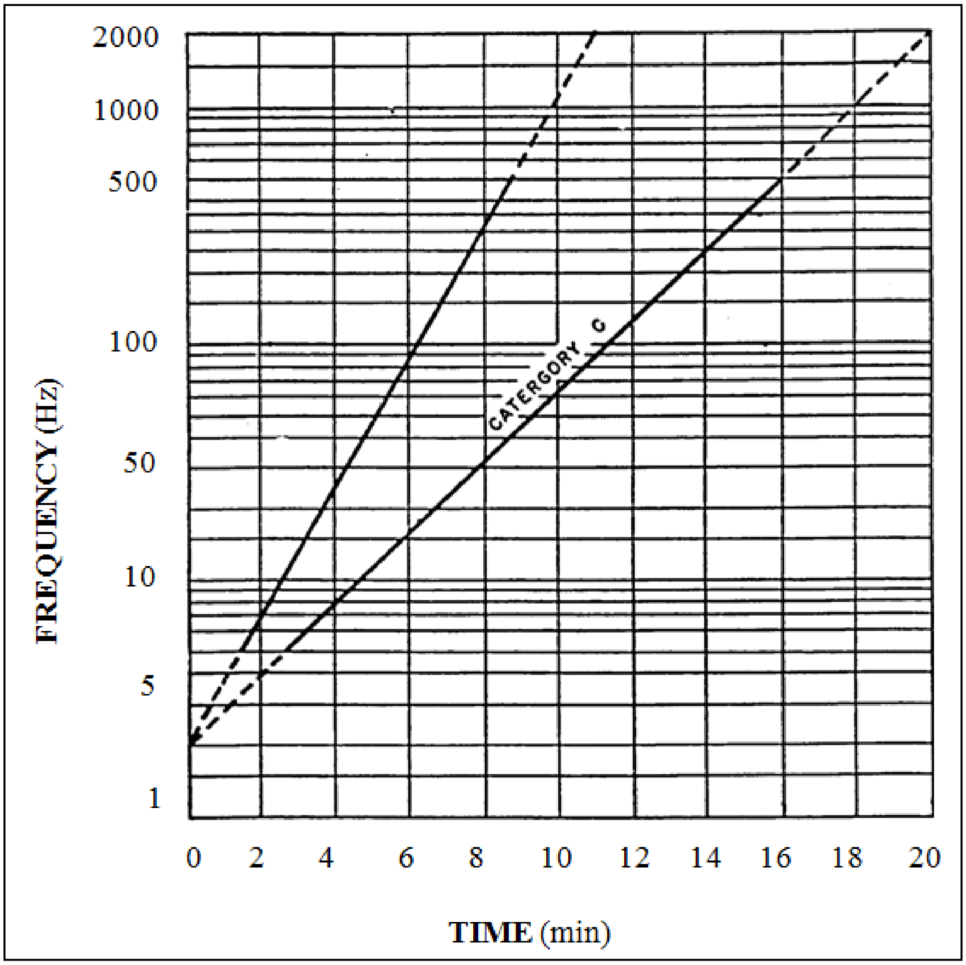


Figure 3-12. Logarithmic Sweep

3.4.10.5.4.2 Random Vibration Test

The test item shall be subjected to random vibration along each of three mutually perpendicular axes according to the specified curve. Test times shall be according to the applicable schedule from the tables. The instantaneous random vibration acceleration peaks may be limited to three times the rms acceleration level. The power spectral density of the test control signal shall not deviate from the specified requirements by more than +100/–30% (+3 dB /–1.5 dB) below 500 Hz and +100/–50% (± 3 dB) between 500 Hz and 2000 Hz except that deviations as large as +300/–75% (± 6 dB) shall be allowed over a cumulative bandwidth of 100 Hz maximum between 500 and 2000 Hz.

Tolerance levels in terms of dB are defined as:

$$\boxed{\mathrm{dB} = 10\log_{0}\frac{W_1}{W_0}} \qquad \text{Equation 3-6}$$

where: W_1 = measured acceleration power spectral density in G^2/Hz
W_0 = the specified level in G^2/Hz units.

Confirmation of these tolerances shall be made by use of an analysis system providing statistical accuracy corresponding to a bandwidth-time constant product, BT = 50, minimum. Specific analyzer characteristics shall be as specified below or equivalent, subject to the BT = 50, minimum limitation.

a. On-line, contiguous filter, equalization/analysis system has a bandwidth as follows:

   (1) B = 25 Hz, maximum between 20 and 200 Hz

   (2) B = 50 Hz, maximum between 200 and 1000 Hz

   (3) B = 100 Hz, maximum between 1000 and 2000 Hz

b. Swept frequency analysis systems are characterized as follows:

   (1) Constant bandwidth analyzer

      i. Filter bandwidth as follows:

         1. B = 25 Hz, maximum between 20 to 200 Hz

         2. B = 50 Hz, maximum between 200 to 1000 Hz

         3. B = 100 Hz, maximum between 1000 to 2000 Hz

      ii. Analyzer averaging time: T = 2 RC = 1 second, minimum, where T = true averaging time and RC = analyzer time constant

      iii. Analysis sweep rate (linear): $R = \frac{B}{4RC}$ or $\frac{B^2}{8}$ (Hz/s) maximum, whichever is smaller.

   (2) Constant percentage bandwidth analyzer

      i. Filter bandwidth pf_c = one-tenth of center frequency maximum, $(0.1f_c)$ where p = percentage and f_c = analyzer center frequency

      ii. Analyzer averaging time: $T = \frac{50}{pf_c}$, minimum

      iii. Analysis sweep rate (logarithmic): $R = \frac{pf_c}{4RC}$ or $\frac{(pf_c)^2}{8}$ (Hz/s), maximum, whichever is smaller.

c. Accuracies corresponding to the above approach shall be provided by quantization techniques included in digital power spectral density analysis. Accelerometer(s) employed for test-level control shall be mounted IAW Paragraph 3.4.10.5.2. Where more than one accelerometer is employed for test-level control, the power average of the several accelerometer signals shall be used as the test-level signal control.

NOTE	Where functional testing is specified prior to or following a procedure, refer to Subsection 3.4.3.5.

3.4.10.5.5 Procedure I - Category B.1 or category C equipment

For category B.1 equipment, proceed the same as in Subsection 3.4.10.5.4.1, letters a, b, and c. The test levels and time durations shall be as specified in Section A of Table 3-12 and Figure 3-11. For category C equipment, proceed the same as in Subsection 3.4.10.5.4.1, letter c only. The test levels and time schedules shall be as specified in Table 3-13, Table 3-14, and Figure 3-13. For items normally provided with vibration isolators, remove the isolators (but retain other required holding devices) prior to performing the tests.

Table 3-13. Test Procedure and Time Schedule for Equipment Category C

Equipment Mounting Configuration	**Procedure Number**	**Procedure Part Number**	**Test Time Schedule (per axis)**		**Figure 3-13 Curve[1]**
			Sinusoidal Cycling[4]	**Sweep Time[3]**	
Without vibration isolators	I	1	3 hrs	36 min	M
With vibration isolators[2]	I	1	3 hrs	36 min	M
		2	30 min	30 min	B
Normally with vibration isolators but tested without isolators	I	2	30 min	30 min	B

Notes
[1]For sinusoidal vibration cycling tests of items mounted in helicopters and weighing more than 80 pounds, the vibratory accelerations shall be reduced by 1 g for each 20-pound increment of weight over 80 pounds. Acceleration derating shall apply only to the highest test level of the selected test curve; however, the vibratory acceleration shall in no case be less than 50% of the specified curve level.
[2]Test items of equipment normally provided with vibration isolators first shall be tested with the isolators in place.
[3]Sweep for curve M is 5-2000-5 Hz; curve B is 5-500-5 Hz.
[4]See paragraph 3.4.10.5.4.1 letter c.

Table 3-14. Curve Selection Chart for Equipment Category C

Selection Criteria	**Curve**
Equipment designated for installation without vibration isolators	M
Equipment installed on vibration-isolated panels or racks when the panel or rack is not available for test or when the equipment is tested with the isolators removed as specified by the applicable procedure	B

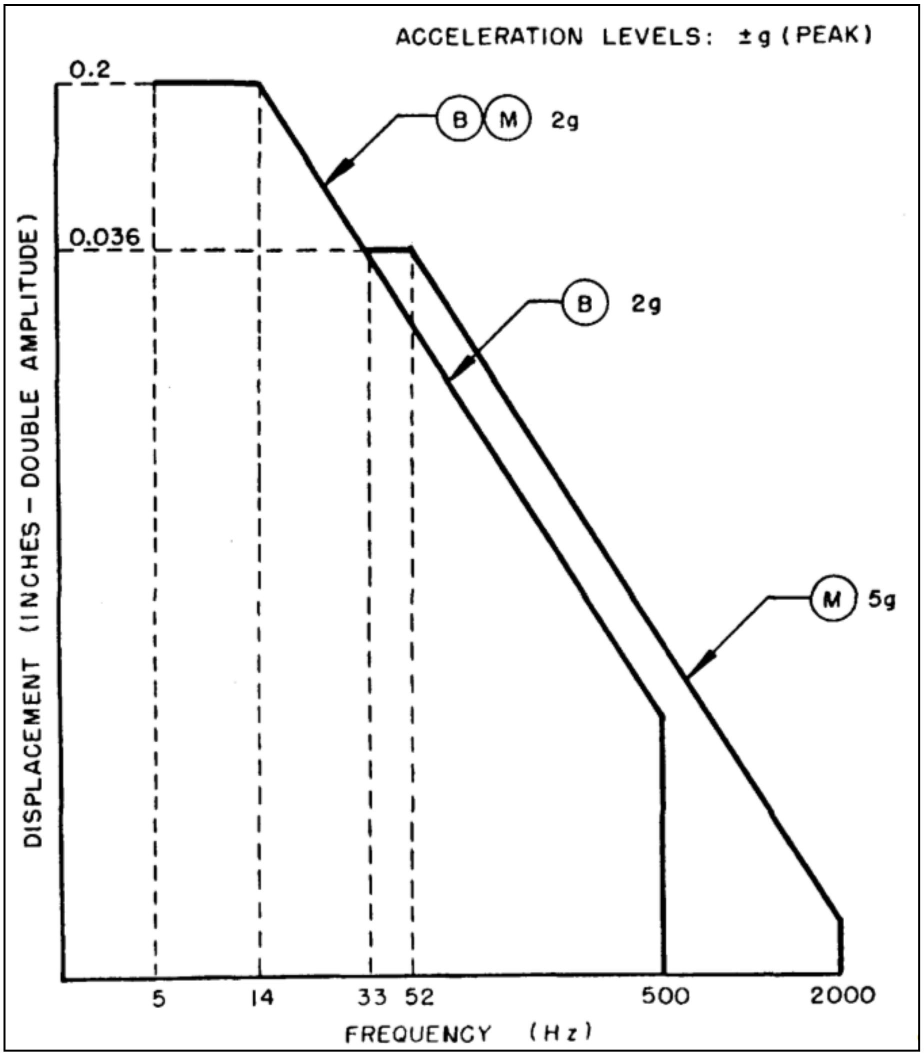


Figure 3-13. Vibration Test curves for Equipment Category C

3.4.10.5.6 Procedure IA - Random vibration test for category B.2 equipment

This test does not apply to turboprop aircraft or jet-powered helicopters. The random vibration environment, which occurs at equipment locations in jet aircraft, stems from four principal sources:

a. Turbulent aerodynamic airflow along external surfaces of the aircraft structure;

b. Jet engine noise impinging on aircraft structure;

c. Gun blast pressure impinging on aircraft structure from high-speed repetitive firing of installed guns;

d. General aircraft motions caused by such factors as runway roughness, landing, and gusts of wind.

The tests outlined in this procedure consider all of these environments and require design to the most severe of these. These tests are preferred for use with equipment in jet aircraft in lieu of the sinusoidal tests of Procedure I, Table 3-12, Figure 3-11, except for jet-engine-mounted equipment. For equipment mounted directly to aircraft jet engines, use Procedure I. To determine an equipment-specific random vibration test, compute functional and endurance test levels for aerodynamic-induced and for jet-engine-induced vibration from Table 3-15 and Figure 3-14. Use the more severe of the two functional levels as the equipment's functional test and the more severe of the two endurance levels (on an equal time [T] basis) for the equipment's endurance test.

Table 3-15. Random Vibration Test Criteria for Equipment Category B.2

Aerodynamic-induced vibration (curve A, Figure 3-14)	
Functional test level[1,6]	$W_O = K(q)^2$
Endurance test level[2,3,6]	$W_O = K(q)^2 \ (N/3T)^{1/4}$
Jet-engine-noise-induced vibration (curve A, Figure 3-14)	
Functional test level[1,4,6,7]	$W_O = (0.48 \cos^2 \theta/R) [D_C (V_C/1850)^3 + D_f (V_f/1850)^3]$
Endurance test level[2,3,4,6,7]	$W_O = (0.48 \cos^2 \theta/R) [D_C (V_C/1850)^3 + D_f (V_f/1850)^3] (N/10T)^{1/4}$

Definitions

K	$2.7\text{x}10^{-8}$ for cockpit equipment and equipment attached to structure in compartments adjacent to external surfaces that are smooth, free from discontinuities.
K	$4\text{x}10^{-8}$ for equipment attached to structure in compartments adjacent to or immediately aft of external surfaces have discontinuities (cavities, chins, blade antennas, speed brakes, etc.) and equipment in wings, pylons, stabilizers, and fuselage aft of trailing edge wing root.
q	1200 lbs/ft^2 or maximum aircraft q, whichever is less.
N	maximum number of anticipated service missions for equipment or carrying aircraft ($N \geq 3$)
T	test time per axis, hours ($T \geq 1$).
D_C	engine core exhaust diameter, feet (for engines without fans, use maximum exhaust diameter).
D_f	engine fan exhaust diameter, feet.
R	minimum distance between center of engine aft exhaust plane and the C.G. of installed equipment, feet.
V_C	engine core exhaust velocity, ft/s (for engines without fans, use maximum exhaust velocity without afterburner).
V_f	engine fan exhaust velocity, ft/s.
θ	angle between R line and engine exhaust axis, degrees, aft vectored.

Notes

[1]Functional test time shall be 1 hour per axis.
[2]Use $W_O = 0.04\ g^2/Hz$ if calculated endurance test level values are less than $0.04\ g^2/Hz$, T = 1.
[3]If one hour (T = 1) endurance test level is ≤ functional test level, no endurance test is required except according to note 2.
[4]If aircraft has more than one engine, W_O shall be the sum of the individually computed values for each engine.
[5]For equipment weighing more than 80 pounds, the vibration W_O level may be reduced according to Curve B, Figure 3-14.
[6]For $70° < \theta \leq 180°$, use $\theta = 70°$ to compute W_O.
[7]For engines with afterburners use W_O that is 4 times larger than W_O computed using max V_C and V_f without afterburner.

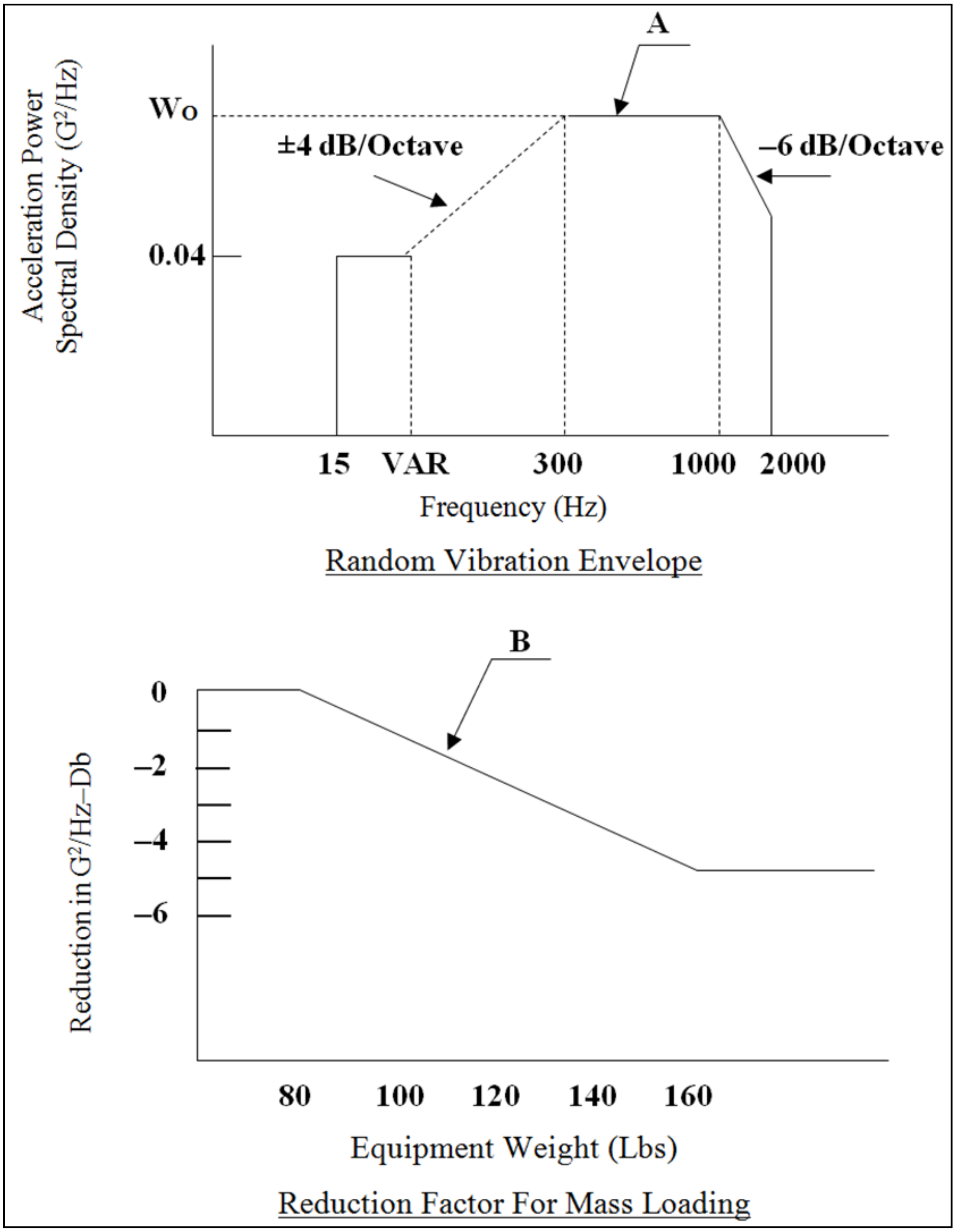


Figure 3-14. Random Vibration Test Curve and Mass Loading Reduction Factor for Equipment Category B.2

a. Performance of test. The individual equipment test item shall be subjected to broadband random vibration excitation. The power spectral density tolerances of applied vibration shall be according to Paragraph 3.4.10.5.4.2. The test item shall be attached to the vibration exciter according to Paragraph 3.4.10.5.2. Equipment that is hard-mounted in service shall be hard-mounted to the test fixture. Equipment isolated in service shall use service isolators when mounted on the test fixture. If service isolators cannot be made available during the qualification test, isolators shall be provided with characteristics such that the isolator/equipment resonant frequencies shall be between 20 Hz and 45 Hz with resonant amplification ratio between 3 and 5. Vibration shall be applied sequentially along each of the three orthogonal axes of the test item. Two test levels are required: a functional level and an endurance level. For each axis, one half of the functional test shall be conducted first, and then the endurance test followed by the second half of the functional test. The equipment shall perform according to the equipment specification operating requirements IAW Subsection 3.4.3.2 during the functional testing. The acceleration power spectral density (G^2/Hz) of applied vibration, as measured on the test fixture at mounting points of the test item, shall be according to Table 3-15 and Figure 3-14. The functional and endurance test time durations and other test conditions shall be determined from the test level equations and other parameter values from Table 3-15.

b. Equipment with isolators. Equipment designed for operational installation on vibration isolators shall also be subjected to a minimum rigidity endurance test with the isolators removed. This test shall be conducted according to Part 2, Procedure I, Section A of Table 3-12 and curve AR of Figure 3-11. At the conclusion of this test the equipment shall provide specified performance, IAW Subsection 3.4.3.2.

3.4.10.5.7 Procedure IIA - Category D.1 equipment.

a. Test conditions. The individual equipment test item (designed for installation in an external store) shall be subjected to broadband random vibration excitation. The power spectral density tolerances of applied vibration shall be according to Paragraph 3.4.10.5.4.2. The test item shall be attached to the vibration exciter according to Paragraph 3.4.10.5.2. Vibration shall be applied sequentially along each of the three orthogonal axes of the test item.

b. Captive flight. Two test levels are required: a functional level and an endurance level. For each axis, one half of the functional test shall be conducted first, then the endurance test, followed by the second half of the functional test. The equipment shall perform according to the equipment specification operating requirements IAW Subsection 3.4.3.2 during the functional testing. The acceleration power spectral density (G^2/Hz) of applied vibration, as measured on the test fixture at mounting points of the test item, shall be according to Table 3-16 and Figure 3-15 except as noted below. The functional and endurance test time durations and other test conditions shall be determined from the test level requirements and other parameter values from Table 3-16. If the computed functional and endurance (T=1) test levels (W_2) are less than 0.04 G^2/Hz, use $W_2 = 0.04$ G^2/Hz and T=1 for the endurance test.

Table 3-16. Vibration Criteria for Equipment Category D.1

Parametric Equations for Figure 3-16	
Eq. 1[1,2]	$W_1 = (5)(10^{-3})(N/3T)^{1/4}\ (A_1)(B_1)(C_1)(D_1)(E_1)g^2/Hz$
Eq. 2[1,2,5]	$W_2 = (5)(10^{-5})(q/p)^2(N/3T)^{1/4}\ (A_2)(B_2)(C_2)(D_2)(E_2)g^2/Hz$
Eq. 3[3,4,5]	$f_1 = 10^5\ (t/R^2)$ Hz
Eq. 4[3,4]	$f_2 = f_1 + 1000$ Hz

Location, Configuration, Special Adjustments	**Factor**	
	A_1	**A_2**
Tri-ejection rack (TER) ,cluster mount	1	2
Multiple ejection rack (MER), cluster mount)	2	4
Single station	1	1
	B_1	**B_2**
Aft half of air-fired missiles	1	4
Aft half of all other stores	1	2
Forward half of all stores	1	1
	C_1	**C_2**
Blunt-nosed stores, single station and TER	2	4
Blunt-nosed stores, MER	1	2
All other stores	1	1
	D_1	**D_2**
Free-fall munitions with non-integral, finned sheet-metal tail cones	8	16
Air-fired missiles	1	1
All other stores	4	4
	E_1	**E_2**
Fire bombs (jelly filled)	½	1/4
All other conditions	1	1
Note: The end of this table lists representative parameter values to be used for captive flight when specific parameters are not available.		

Definitions

q maximum flight dynamic pressure in lbs/ft^2 (see note 1).

p average store weight density in lbs/ft^3 (total weight / total volume).

t local store average skin thickness where R is measured (inches).

R one-half the average of the major and minor diameters (inches) for a store with an elliptical cross-section (for cylindrical sections use local geometry; for conical sections use smallest f_1 calculated using geometry within one foot of equipment mounting point; for cast irregular shaped cross-section, R shall be one-half the longest inscribed cord; for monocoque irregular cross-section f_1 = 300 Hz).

N maximum number of anticipated service missions (functional test, N = 3; endurance test, $N \geq 3$).

T test time per axis in hours (functional test, T = 1; endurance test, T > 1).

Notes

[1]For endurance test, q = 1200 lbs/ft^2 or maximum q, whichever is less. For functional test, q = 1800 lbs/ft^2 or maximum q, whichever is less.

[2]If functional test level is equal to or larger than the endurance test level when T = 1, no endurance test is required, except as noted in Subsection 3.4.10.5.7 letter b.

[3]Free-fall stores with tail fins, use f_1 = 125Hz; $f_2 = 10^5\,(t/R^2) + 1000$ Hz

[4]For general-use fuses that can be used in several stores, use $W_1 = 0.04\ g^2/Hz$; $W_2 = 0.15\ g^2/Hz$; f_1 = 100 Hz; f_2 = 1000 Hz; T = 30 min/axis.

[5]Acceptance range for parameter values: $40 < p < 150$ and $(0.001\ t)/R^2 < 0.02$. If calculated values fall outside these limits, use these limit values.

Representative Parametric Values for Captive Flight						
Store type	**Max q**	**p**	**N Endurance**	**T Endurance**	**f_1 (Hz)**	**f_2 (Hz)**
Missile, air to ground	1600	100	3	None	500	1500
Missile, air to air	1600	100	100	1	500	1500
Instrument pod	1800	50	500	1	500	1500
Dispenser (reusable)	1200	50	50	1	200	1200
Demolition bomb	1200	120	3	None	125	2000
Fire bomb	1200	40	3	None	100	1100

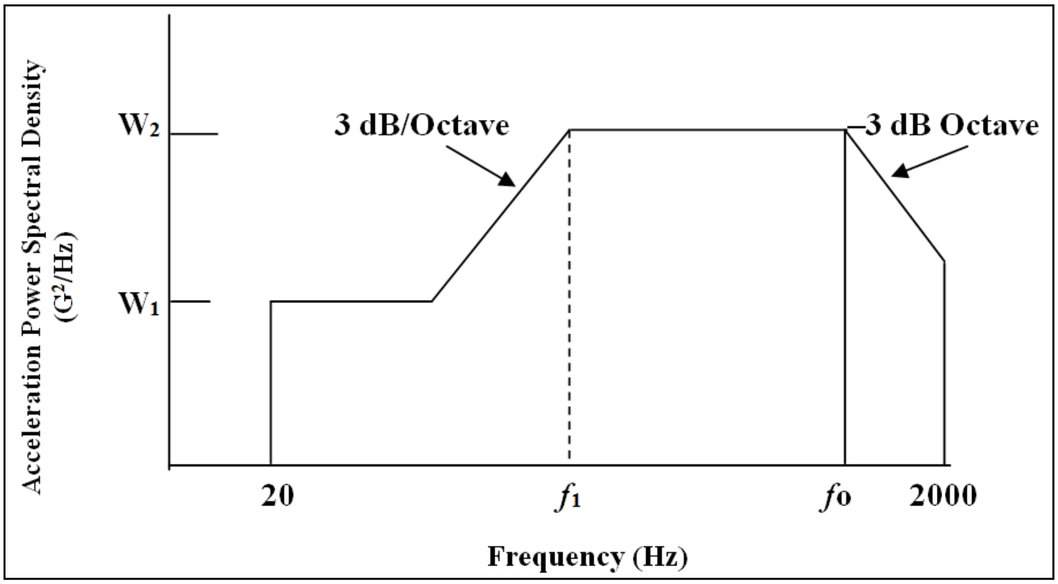


Figure 3-15. Vibration Test Levels for Equipment Category D.1

c. Free-flight functional test. For stores that are deployed by separation from the aircraft (free flight) such as bombs and missiles, a free-flight functional test shall be conducted in addition to the captive flight tests of Paragraph b. The equipment shall perform according to the equipment specification operating requirements IAW Subsection 3.4.3.2 during the functional testing. Paragraphs a and b above, Table 3-16, and Figure 3-15 shall be used to determine the test procedures, levels, and frequency spectra for the free-flight test except as noted below. In this case, factors A_1, A_2, and (N/3T) shall be set equal to one. The value of q shall be the maximum value attainable during free flight. The duration of this functional test, per axis, shall equal the maximum free-flight time expected at maximum q, but not less than 30 seconds. In the event that all free-flight functional checks are made during the captive functional test and the captive functional test levels are larger than or equal to those derived here, no free-flight functional test is required.

3.4.10.5.8 Procedure III - Category E equipment

Part 1. Proceed the same as in Subsection 3.4.10.5.4.1, letter c. The test level shall be according to one specified curve P through U from Table 3-17 and Figure 3-16. Test time schedules shall be as listed in Table 3-17.

Table 3-17. Test Procedure and Time Schedule Chart for Equipment Category E

Procedure Selection and Time Schedule Chart								
Equipment Mounting Configuration	Procedure Number	Procedure Part Number	Applicable Tests		Test Time Schedule (per axis)			Curve Figure 3-16[1]
			Sinusoidal Cycling[3]	Random[4]	Sinusoidal cycling time[3]	Sweep time 5-2000-5 Hz	Random time[2]	
Without vibration isolators	III	1	X		30 min	20 min		One of P through U
		2		X			30 min	One of AE through AP
With vibration isolators	IV	1	X		30 min	20 min		Curve N
		2		X			30 min	Curve AE

Notes

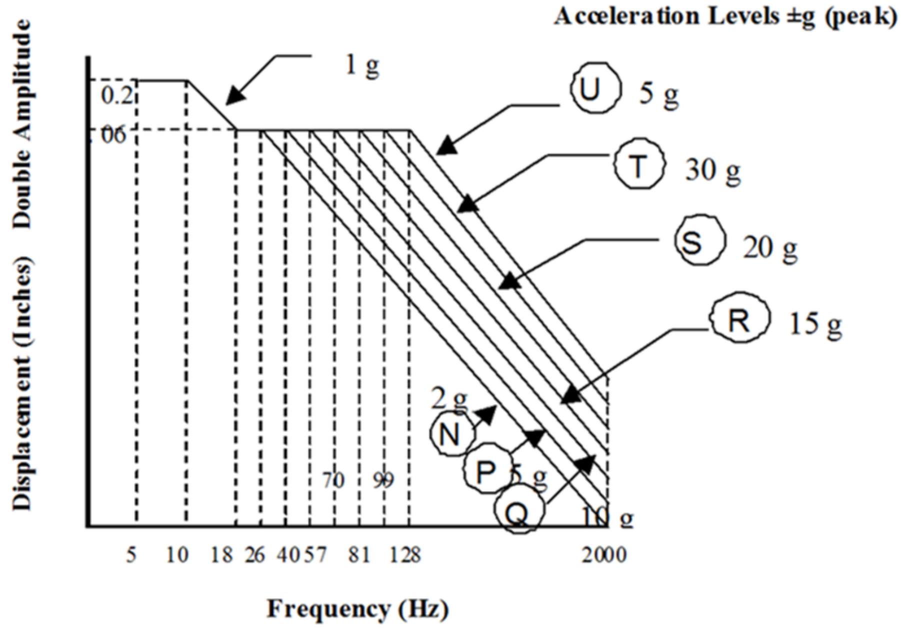
[1]For sinusoidal vibration resonance tests and cycling tests of items mounted in missiles and weighing more than 80 pounds, the vibratory accelerations shall be reduced by 1 g for each 20-pound increment of weight over 80 pounds. Acceleration derating shall apply only to the highest test level of the selected curve; however, the vibratory acceleration shall in no case be less than 50% of the specified curve level.

[2]When flight distances are less than 100 miles, the test time is reduced to 5 minutes.

[3]See Subsection 3.4.10.5.4.1, letter c.

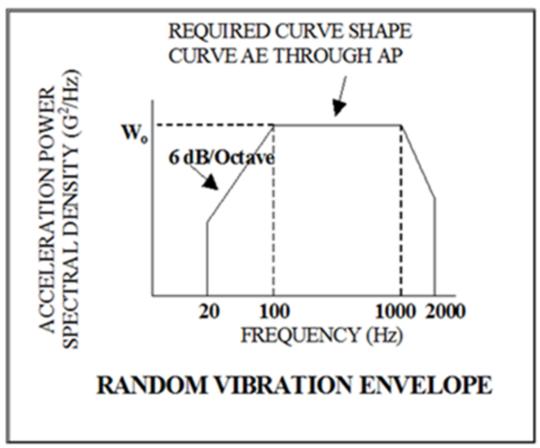
[4]See Subsection 3.4.10.5.4.2.

Sinusoidal Vibration Curves



Random Vibration Curves

Test Curve	Acceleration Power Spectral Density $W_o(G^2/Hz)$	Composite G-RMS[1] minimum
AE	0.02	5.4
AF	0.04	7.6
AG	0.06	9.3
AH	0.10	12.0
AJ	0.20	16.9
AK	0.30	20.7
AL	0.40	23.9
AM	0.60	29.3
AN	1.00	37.9
AP	1.50	46.4



$$^{1}\text{Composite G-rms} = \left[\int_{f_1}^{f_2} W(f)\,df\right]^{1/2}$$

Where: f_1 and f_2 are the lower and upper test frequency limits, respectively; $W(f)$ is the acceleration power spectral density in G^2/Hz units.

Figure 3-16. Vibration Test Curves for Equipment Category E

Part 2. Proceed the same as in Subsection 3.4.10.5.6. The test level shall be according to one specified in curve AE through AP from Table 3-18 and Figure 3-16. Test time schedules shall be as listed in Table 3-17.

Table 3-18. Curve Selection Chart for Equipment Category E			
Equipment Location by Vehicle Section	**Approximate Thrust (power)**	Vibration Test Curves (**Figure 3-16**)	
		Sinusoidal	**Random**
All except booster	All	P or Q	AE, AF, or AG
By individual booster stage	250,000 lbs or less	Q or R	AH, AJ, or AK
	250,000 lbs to 500,000 lbs	R or S	AK, AL, or AM
	Over 500,000 lbs	T or U	AM, AN, or AP

3.4.10.5.9 Procedure IV - Category E equipment

Part 1. Proceed the same as in Subsection 3.4.10.5.4.1, letter c. Test levels shall be according to curve N from Figure 3-16. Test time schedules shall be as listed in Table 3-17.

Part 2. Proceed the same as in Paragraph 3.4.10.5.2. Test levels shall be according to curve AE from Figure 3-16. Test time schedules shall be as specified in Table 3-17.

3.4.10.5.10 Procedure V - Category F equipment

Proceed the same as in Subsection 3.4.10.5.4.1, letter c. Test time schedules shall as specified in Table 3-19. Test levels shall be according to one specified curve V, W, or Y from Figure 3-17.

Table 3-19. Test Procedure and Time Schedule Chart for Equipment Category F								
Equipment Conditions	**Procedure Number**	**Procedure Part Number**	**Applicable Tests**		**Test Time Schedule (per axis)**			**Curve**
			Sinusoidal Cycling[4]	**Bounce Vehicular**	**Sinusoidal Cycling Time**[4]	**Maximum Cycling Time**	**Sweep Time**	
					Schedule A			
Tracked vehicles	V	--	X	--	30 min/ 1000 miles[2]	3 hours	15 min 5-500-5 Hz[1]	W
					Schedule B			
Wheeled vehicles	V	--	X	--	30 min/ 1000 miles[2]	5½ hours	12 min 5-200-5 Hz[1]	V or Y[3]
Vehicle & mileage unknown	V	--	X	--		3 hours	15 min 5-500-5 Hz[1]	W

Notes
[1]Sweep time shall be increased by 3 minutes if test frequencies go to 2 Hz. [2]Cycling time shall be 30 min/1000 miles or as specified in the equipment specification except that it shall not exceed the maximum specified in Table 3-19. [3]Curve V is for equipment installed in wheeled vehicles except for two-wheeled trailers. Curve Y is for equipment installed in two-wheeled trailers. [4]See Subsection 3.4.10.5.4.1, letter c.

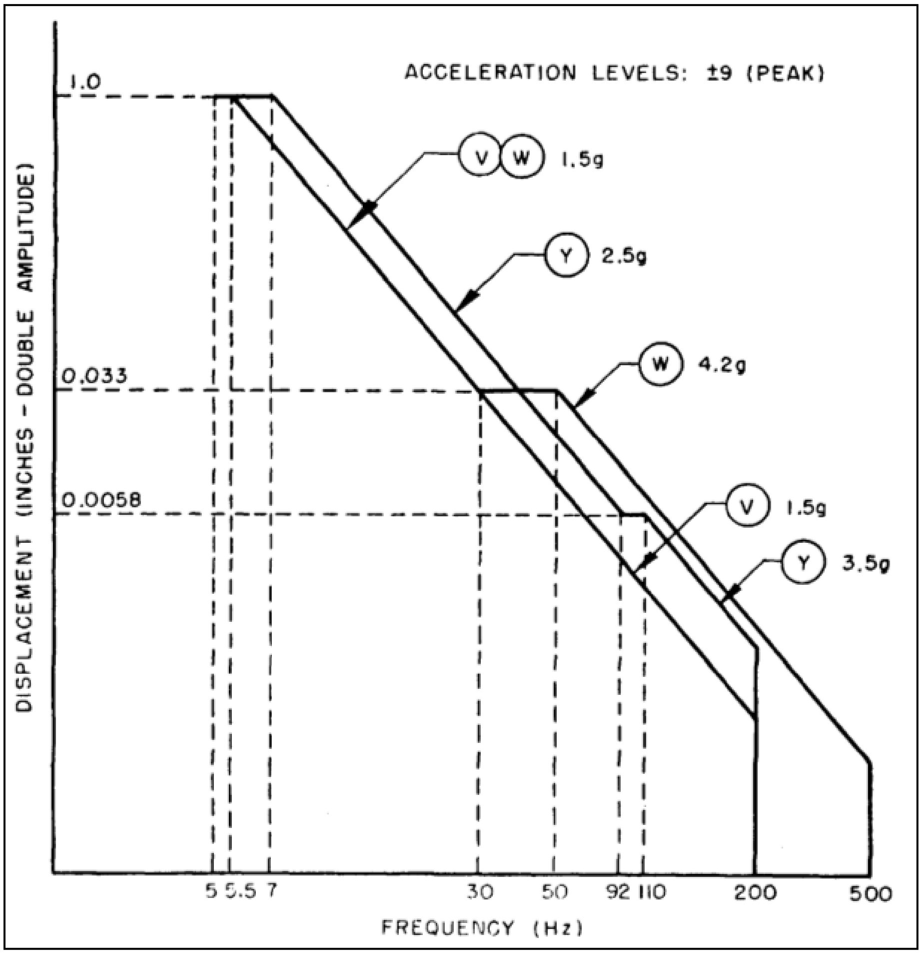


Figure 3-17. Vibration Test Curves for Equipment Category F

3.4.10.5.11 Procedure VI - Category I equipment

For shipboard and amphibious equipment (category I) or when a ship is the common carrier, the vibration test shall be IAW Type I of MIL-STD-167.[14]

[14] Department of Defense. Mechanical Vibrations of Shipboard Equipment (Type I - Environmental and Type II - Internally Excited). MIL-STD-167-1A. 2 November 2005. May be superseded by update. Available at http://quicksearch.dla.mil/Transient/9E22A958580B4127B17A3AAE8657446B.pdf.

3.4.11 **TEST: Acoustical Noise**

3.4.11.1 Purpose

The acoustical noise test is performed to determine the effects on equipment of fluctuating pressure fields associated with turbulent aerodynamic flow and acoustic noise that are characteristic of aircraft, missiles, and other high-performance vehicles. The acoustical noise test complements conventional sinusoidal and random vibration tests, which are for structure-borne vibrations.

3.4.11.2 Apparatus

A suitable test chamber shall be used to apply the conditions as specified in the following procedures. Measuring equipment shall be suitable to accomplish the required analysis.

3.4.11.3 Required Parameters

The following details shall be as identified in the equipment specification or test plan:

a. Procedure number;

b. Pretest data required (see Subsection 3.4.3.2);

c. Failure criteria;

d. Test category (see Paragraph 3.4.11.7);

e. Whether operation during the test is required, and if and how the operation is to be monitored.

3.4.11.4 Definitions and Terms

A comprehensive list of standard terminology is contained in ANSI-S1.1-1994.[15]

3.4.11.5 Procedure

	Where functional testing is specified prior to or following a procedure, refer to Subsection 3.4.3.5.

For the purpose of this test standard, equipment is categorized as mounted either external or internal to the vehicle structure (see Subsection 3.4.11.6, Paragraph 3.4.11.7, and Subsection 3.4.11.8). In general, equipment located in areas where noise levels are 130 dB overall or less will not require testing to noise environments. This test is not a substitute for the conventional sinusoidal or random vibration tests of Subsection 3.4.10.

3.4.11.6 Criteria for Application

Some equipment is insensitive to acoustic stimulation even at very high levels. Other equipment may respond in a manner that will modify or disrupt the equipment function, and in extreme cases mechanical failure may result. Equipment that is sensitive to vibration is usually

[15] American National Standards Institute. *American National Standard: Acoustical Terminology*. New York : Standards Secretariat, Acoustical Society of America, 1994

sensitive to sound field exposure. For this reason, a suitable vibration test is often a good indicator of acoustic sensitivity; however, it is possible that high-frequency resonances of some responding equipment elements may be overlooked during the vibration test due to the high-frequency limitations of the shaker and vibration attenuation of the fixture and the equipment under test. Of importance is the fact that some equipment may possess both sensitive and insensitive characteristics, and it may be difficult to ascertain, before a test is performed, whether the equipment is sensitive to acoustic stimulation.

The following criteria are presented as a guide to initially determine whether equipment is sensitive to acoustic stimulation. Such criteria cannot be considered as the only determining factors. The final decision whether to perform an acoustical noise test must be supplemented by such additional factors as a description of the characteristics and duration of the end-use acoustic environment, the location of the equipment within the vehicle structure, and a consideration of special mounting means or protective enclosures employed for the equipment.

3.4.11.6.1 Equipment Insensitive to Acoustic Stimulation

This equipment is likely to have small surface areas, high mass-to-area ratios, and high internal damping. Examples are as follows:

a. High-density modules, particularly the solid or encapsulated type;
b. Modules or packages with solid-state elements mounted on small constrained or damped printed circuit boards or matrices;
c. Valves, hydraulic servo controls, or auxiliary power unit pumps;
d. Equipment surrounded by heavy metallic castings, particularly those that are potted or are encased within the casting by attenuating media.

3.4.11.6.2 Equipment Sensitive to Acoustic Stimulation

This equipment is normally classified as microphonic or usually having large compliant areas of exposure, low mass-to-area ratios, or low internal damping. Examples are as follows:

a. Equipment containing microphonic elements with high-frequency resonances such as electron tubes, waveguides, klystrons, magnetrons, piezoelectric components, or relays attached to thin plate surfaces;
b. Equipment containing or consisting of exposed diaphragmatic elements such as pressure sensitive transducers, valves, switches, relays, or flat spiral antenna units.

3.4.11.7 Selection of Test Intensity

The noise levels are divided into four intensity categories as listed in Table 3-20. The categories are in order of increasing severity (overall sound pressure level) from A through D. The category should be selected as appropriate for the expected noise level of the end-use environment.

Table 3-20. Acoustic Noise Test Categories

Category	Test Overall Sound Pressure Level (dB)[1]	Typical Applications		Exposure Time (min)
		Vehicle	Equipment Location	
A	140	Aircraft	Majority of Locations	30
B	150	Aircraft	Near the noise source or in the noise cone, if separated by thin partitions	30
C	160	Aircraft	External stores or open exterior compartments near the noise source or subject to the noise cone environment of any aircraft	30
		Rocket	Majority of locations exclusive of booster or engine compartments	8
D	165	Rocket	Booster or engine compartment, on-site launch equipment, or externally mounted pods near the noise source	8

[1]Reference $2\text{x}10^{-4}$ dynes/cm^2 ($2\text{x}10^{-5}$ Newtons per meter^2)

3.4.11.8 Procedure

3.4.11.8.1 Test Setup

The test item shall be softly suspended in the test chamber by means of springs or elastic cord. If a mounting structure is required between the soft suspension and the test item or to hold the soft suspension, care must be exercised to assure that no spurious acoustic or vibratory inputs are introduced. The natural frequency of suspension shall be less than 25 Hz. The test item shall be exposed on every surface to the sound field by centrally locating it in the test chamber. The test item volume shall be no more than 10% of the test chamber volume. When the test chamber is rectangular, no major surface of the test item shall be installed parallel to the chamber wall. A reverberation-type test chamber shall be used and shall be suitably formed and proportioned to produce a diffuse sound field and a uniform sound energy density throughout the enclosure.

3.4.11.8.2 Performance of Test

Step 1: The overall sound pressure level for the specified test category of Table 3-20 shall be introduced into the test chamber to conform to the octave band spectrum specified on Figure 3-18. The average sound pressure distribution (overall level) shall be uniform within –2 dB to 4 dB of the desired value. The sound pressure field shall be measured without the test item mounted in the test chamber. Measurements shall be made by using a microphone (more than one if desired) to define the sound field within the test volume (central 10% of the chamber volume).

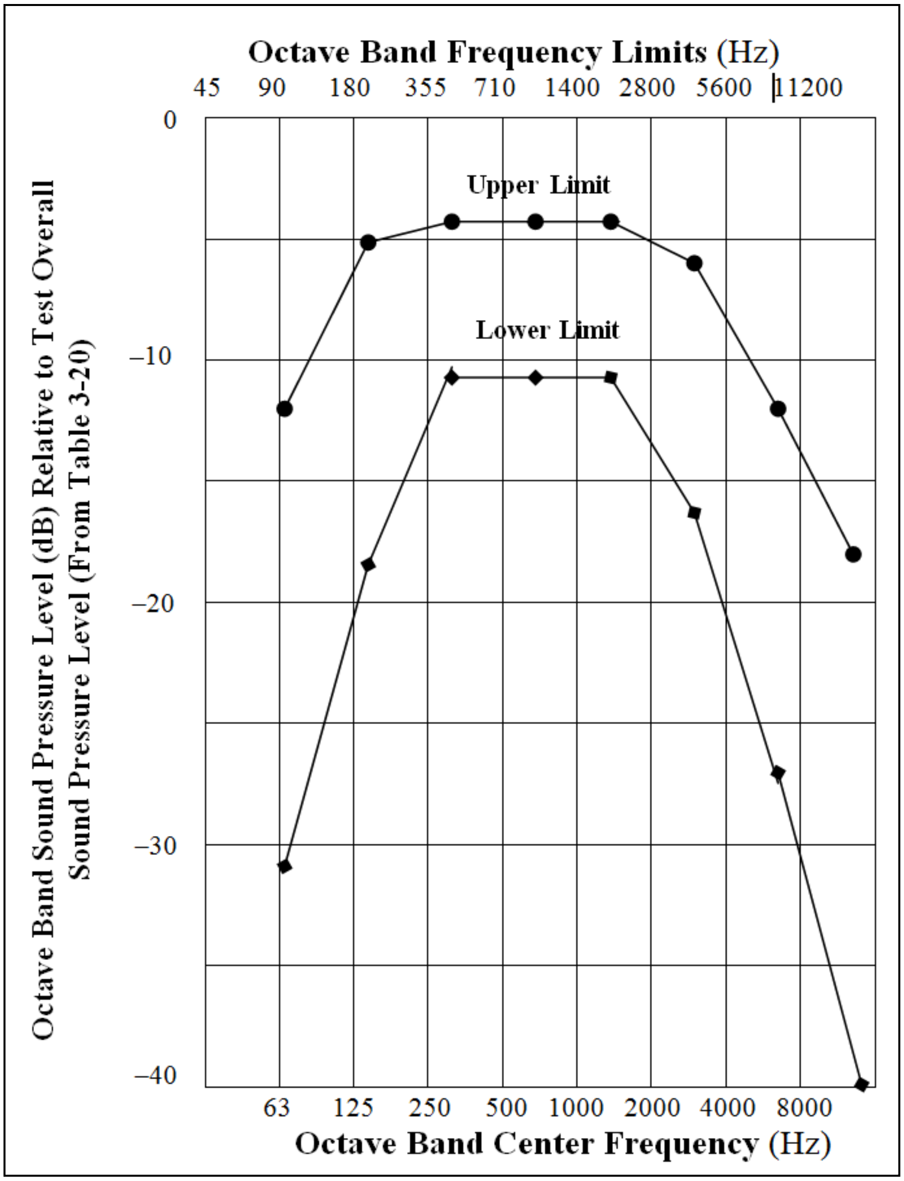


Figure 3-18. Octave Band Spectrum for the Acoustical Noise Test

Step 2: The test item shall be placed in the chamber as specified in Paragraph 3.4.11.8.1. At least three microphones shall be monitored. They shall be located in proximity to each major dissimilar test item surface, at least 18 inches from the test item surface or one-half the distance to the nearest chamber wall, whichever is less. The average overall sound pressure distribution around the test item shall be measured and be uniform within –2 dB to 4 dB of the desired value; however, for large or irregularly shaped items where this tolerance cannot be achieved, the tolerance shall be ± 6 dB. Test times shall be as specified in Table 3-20. The operation of the test item during the test shall be monitored when and as specified. When measurements are made during or following the test, they shall be compared with the data obtained IAW Subsection 3.4.3.2. At the conclusion of the test, the test item shall be inspected IAW Subsection 3.4.3.2

3.4.12 **TEST: Shock**

3.4.12.1 Purpose

The shock test is performed to determine if equipment is constructed to withstand expected dynamic shock stresses and that performance degradations or malfunctions will not be produced by the service shock environment expected in handling, transportation, and service use.

3.4.12.2 Apparatus

3.4.12.2.1 Shock machine

The shock machine utilized for this procedure shall be capable of producing the specified input shock pulse shown in Figure 3-19 or Figure 3-20. The shock machine may be of the free-fall, resilient rebound, non-resilient, hydraulic, compressed gas, or other activating types. Apparatus for other procedures are included in the individual procedure.

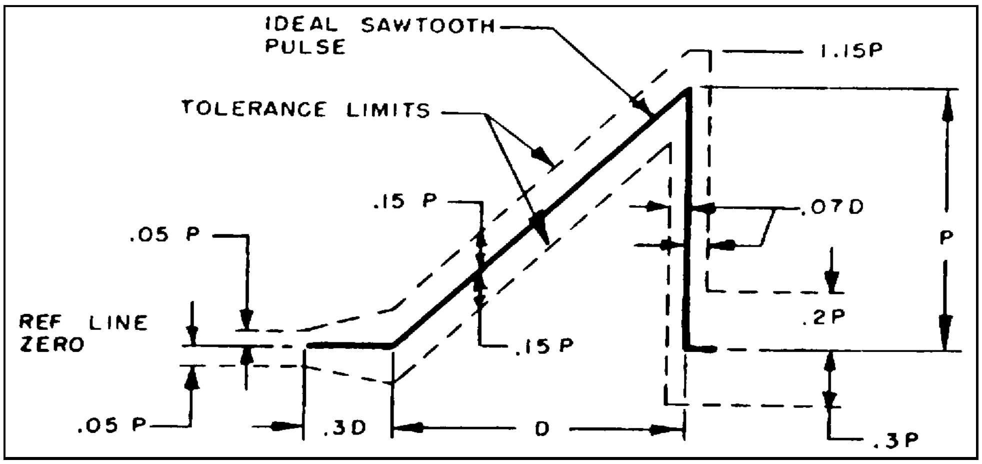


Figure 3-19. Terminal-Peak Sawtooth Shock Pulse Configuration

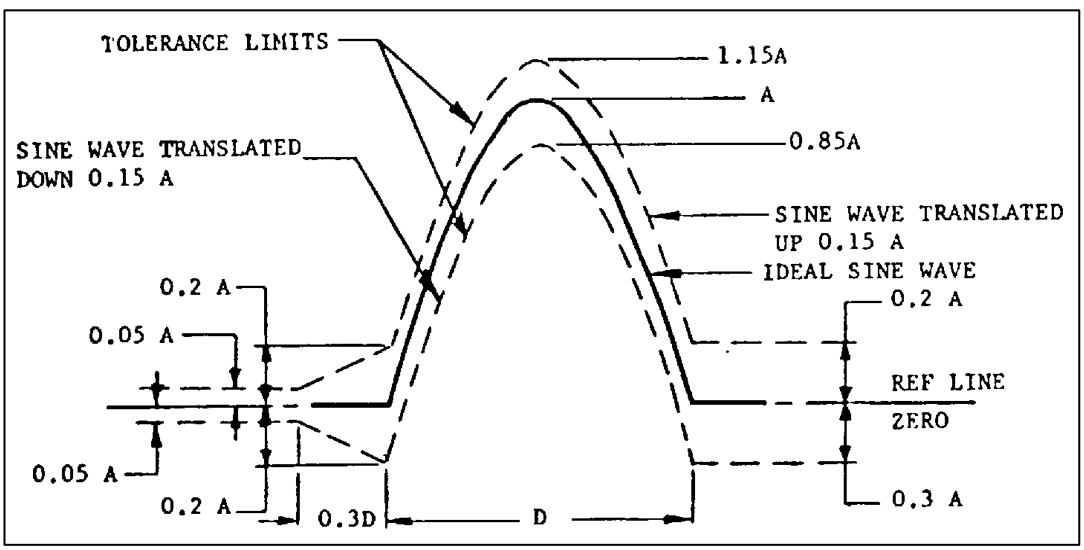


Figure 3-20. Half Sine Shock Pulse Configuration

The actual test item, a rejected item, or a rigid dummy mass shall be used to calibrate the shock machine for conformance with the specified wave shape. When a rigid dummy mass is used, it shall have the same C.G. and the same mass as that intended for the test item and shall be installed in a manner similar to that of the test item. When a rigid dummy mass or rejected item is used for calibration, the waveform during the actual test may be somewhat different from that observed during calibration. The shock machine shall then be calibrated for conformance with the specified waveform. Two consecutive shock applications to the calibration load shall produce waveforms that are all within the tolerance envelope given in Figure 3-19 and Figure 3-20. The calibrating load shall then be removed and the shock test performed on the actual test item. Provided all conditions remain the same other than the substitution of the test item for the calibrating load, the waveform shall be considered to meet the specified test requirement. The actual test waveform shall be recorded for later use should a failure analysis be required.

3.4.12.2.2 Instrumentation

The instrumentation used to measure the input shock pulse, in order to meet the tolerance requirements of the test procedure, shall have the characteristics specified in the following paragraphs.

3.4.12.2.2.1 Frequency response

The frequency response of the complete measuring system, from the accelerometer through the readout instrument, shall be as shown in Figure 3-21. Particular care shall be exercised in the selection of each individual instrument of the shock-measuring instrumentation system in order to assure compatibility with the prescribed frequency response tolerance.

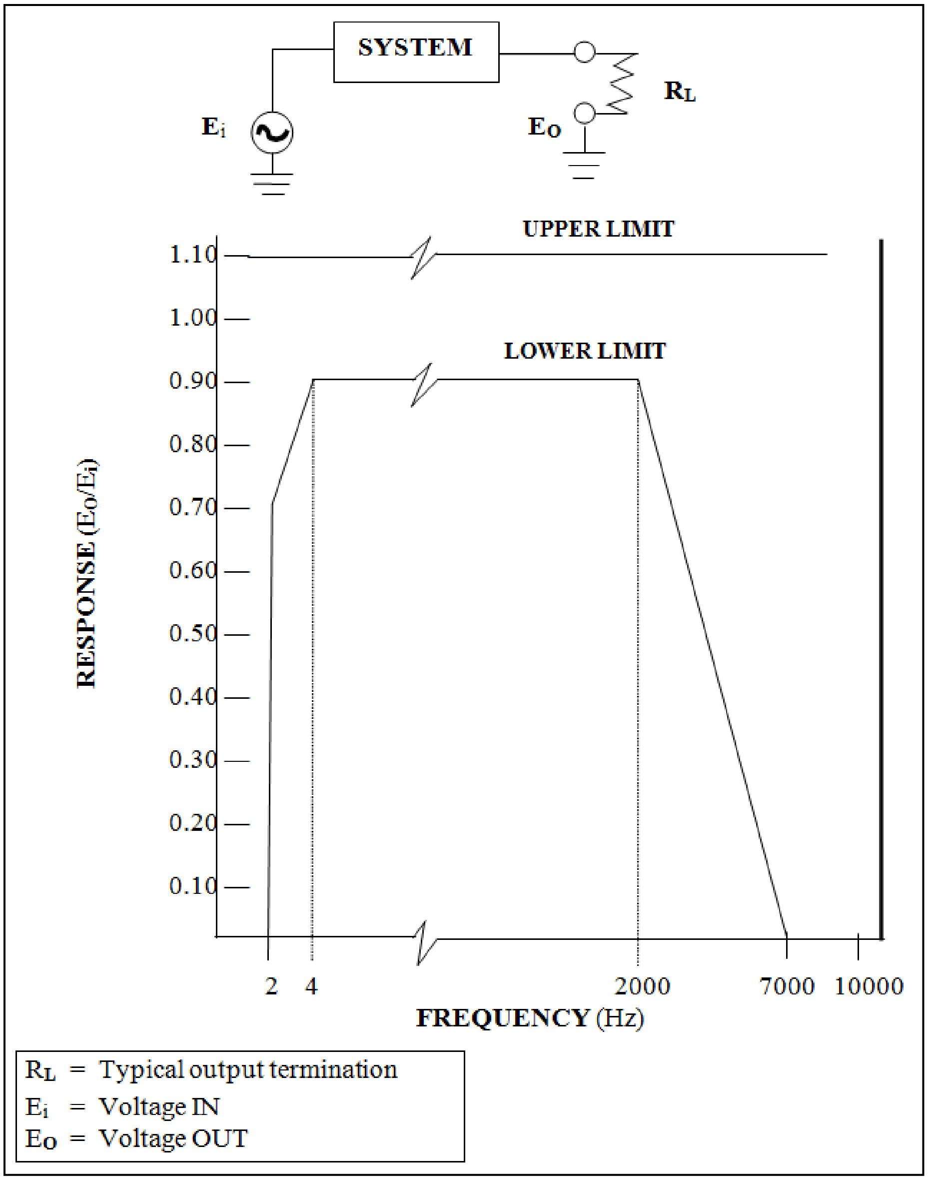


Figure 3-21. Shock-Measuring System Frequency Response

3.4.12.2.2.2 Accelerometer, Piezoelectric

When a piezoelectric accelerometer is employed as the shock sensor, the fundamental resonant frequency of the accelerometer shall be greater than 14 kHz (resonant frequencies of 30 kHz or higher are recommended). For suitable low-frequency response, the accelerometer and load (cathode follower, amplifier, or other load) shall have the following characteristics:

$$RC > 0.2$$

where: R = load resistance (ohms)
C = accelerometer capacitance plus shunt capacitance of cable and load (farads)

3.4.12.2.2.3 Accelerometer, strain gage

A strain gage or an accelerometer may be used, provided the undamped natural frequency is equal to or greater than 1500 Hz with damping approximately 64% to 70% of critical.

3.4.12.2.2.4 Accelerometer calibration

The accelerometer shall be dynamically calibrated to the specified accuracy.

3.4.12.2.2.5 Accelerometer mounting

The monitoring accelerometer shall be rigidly attached to the test item support fixture at or near the attachment point(s) of the test item.

3.4.12.3 Required Parameters

The following details shall be as identified in the equipment specification or test plan:

a. Retest data required (see Subsection 3.4.3.2);

b. Shock pulse selection, specify shape, peak value, and duration (see Paragraph 3.4.12.4.1);

c. Filter(s) used shall be identified;

d. Whether operation during the test is required, mode of such operation, and if and how the operation is to be monitored;

e. Failure criteria.

3.4.12.4 Procedure

NOTE	Where functional testing is specified prior to or following a procedure, refer to Subsection 3.4.3.5.

3.4.12.4.1 Shock Pulse

The shock pulses for this procedure shall be as shown in Figure 3-19 and Table 3-21 or Figure 3-20 and Table 3-22 (whichever is specified). All points of the acceleration waveform obtained shall lie within the area enclosed by the tolerance limit lines. It is recommended that the sawtooth shock pulse be used since its broad-frequency spectrum tends to excite all resonant frequencies.

Table 3-21. Terminal-Peak Sawtooth Shock Pulse Tolerance Limits

Procedure	**Test**	**Peak Value (P) g's**		**Nominal Duration (D) (milliseconds [ms])**	
		Flight vehicle equipment a[1]	Ground equipment b	Flight vehicle equipment c[1]	Ground equipment d
I	High Intensity	100	100	6	11

Notes
[1]Shock parameters a and c: recommended for equipment that is not shock mounted and weighing less than 300 pounds.

The oscillogram shall include a time about 3D long with a pulse located approximately in the center. The peak acceleration magnitude of the sawtooth pulse is P and its duration is D. The measured acceleration pulse shall be contained between the broken-line boundaries and the measured velocity change (which may be obtained by integration of the acceleration pulse) shall be within the limits of $V_i \pm 0.1\ V_i$, where V_i is the velocity change associated with the ideal pulse that equals 0.5 DP. The integration to determine velocity change shall extend from 0.4D before the pulse to 0.1D after the pulse.

Table 3-22. Half Sine Shock Pulse Tolerance Limits

Procedure	Test	Peak Value (A) g's		Nominal Duration (D) ms	
		Flight Vehicle Equipment a[1]	Ground Equipment b	Flight Vehicle Equipment c[1]	Ground Equipment d
I	High Intensity	100	100	6	6

Notes
[1]Shock parameters a and c: recommended for equipment that is shock-mounted or weighing 300 pounds or more.

The oscillogram shall include a time about 3D long with a pulse located approximately in the center. The acceleration amplitude of the ideal half sine pulse is A, and its duration is D. The measured acceleration pulse shall be contained between the broken-line boundaries and the measured velocity change (which may be obtained by integration of the acceleration pulse) shall be within the limits $V_i \pm 0.1V_i$, where V_i is the velocity change associated with the ideal pulse that equals $2\ AD/\pi$. The integration to determine velocity change shall extend from 0.4D before the pulse to 0.1D after the pulse.

3.4.12.4.2 Mounting of Test Item

The test item shall be rigidly attached to the shock machine table for Procedure I IAW Subsection 3.4.3.2. Wherever possible, the test load shall be distributed uniformly on the test platform in order to minimize the effects of unbalanced loads.

3.4.12.4.3 High-Intensity Test Procedure I

This procedure shall be used where high-acceleration, short-time-duration shock excitation results from handling, stage ignition, separation, re-entry, and high-velocity aerodynamic buffeting experienced by missiles and high-performance weapon systems. Two shocks shall be applied to the test item in each direction along each of three mutually perpendicular axes (total of 12 shocks). The shock pulse shape shall be IAW either Figure 3-19 or Figure 3-20, of amplitude a or b and time duration c or d, as specified. The test item shall be operating during the test if required by the equipment specification. At the conclusion of the test, the test item shall be operated and inspected and results obtained IAW Subsection 3.4.3.2.

3.4.12.4.4 Related Shock Tests

a. High impact: Unless otherwise specified, ballistic shock tests and high-impact tests shall be performed IAW Military Specification (MIL-S) 901D.[16]

b. Shipboard equipment: Shock tests for shipboard equipment shall be performed IAW MIL-S-901D.

c. Rough handling for packaged items: Tests for shipping and handling shall be performed IAW MIL-STD-3010C.[17]

3.4.12.4.5 Combined Temperature and Shock Tests

Tests shall be performed at room ambient conditions unless a high- or low-temperature shock test is required, in which case the temperature extremes shall be as specified.

[16] United States Navy. Shock Tests. H.I. (High-Impact) Shipboard Machinery, Equipment, and Systems, Requirements for. MIL-S-901D. 17 March 1989. May be superseded by update. Available at http://quicksearch.dla.mil.

[17] Department of Defense. Test Procedures for Packaging Materials and Containers. MIL-STD-3010C. 1 August 2013. May be superseded by update. Available at http://quicksearch.dla.mil.

CHAPTER 4

Acceptance Testing of Radar Transponders

Acceptance tests, also known as Type II tests, are performed by the purchasing agent.

4.1 Transmitter and Receiver Electrical Parameters

4.1.1 Test Schedule

Type II tests will be performed through the purchasing agent on all transponders. These tests will be accomplished within 30 days after delivery and shall demonstrate performance levels specified in the applicable performance specifications.

4.1.2 Test Failures

Equipment returned to the vendor for repair of failures will be accomplished by purchasing agent procedures. The turnaround time of equipment with completed report shall be 60 days maximum. The vendor shall supply the following information on each unit:

a. Type of failure;

b. Cause of failure;

c. Description of corrective action taken;

d. Operating time.

4.1.3 Retrofit

If a failure is found by the purchasing agent or the vendor to be a design problem, the vendor shall retrofit all delivered units to correct the problem and at no further expense to the purchasing agent.

4.2 Tests

Table 4-1 outlines the Type II tests.

	Each piece of test equipment and the test bench setup utilized in the commission of these test procedures shall be within current calibration. Equipment with expired calibrations must be re-calibrated prior to performing these tests.

Table 4-1. Type II Tests

Paragraph Number	Test Description	PSS Test Paragraph Number
4.2.1	Receiver sensitivity and random triggering	2.5.5 and 2.5.7
4.2.2	Receiver bandwidth (3 dB)	2.5.2
4.2.3	Receiver code accept and reject at 3-.5, 9.5-, and 15.5-µs spacing	2.5.6.3 and 2.5.6.4
0	Peak power output vs. PRF in 500 pps steps, 100-2600 pps	2.6.3 and 2.6.4

4.2.5	Peak power output vs. set transmitter frequency	2.6.2 and 2.6.3
4.2.6	Recovery time for two interrogating signals	2.6.9
4.2.7	Delay, delay variation, and delay jitter vs. input signal level	2.6.8
4.2.8	Pressurization test	2.4.7

4.2.1 **TEST: Receiver sensitivity and random triggering at 5800 MHz**

a. Test Setup: As shown in Figure 4-1

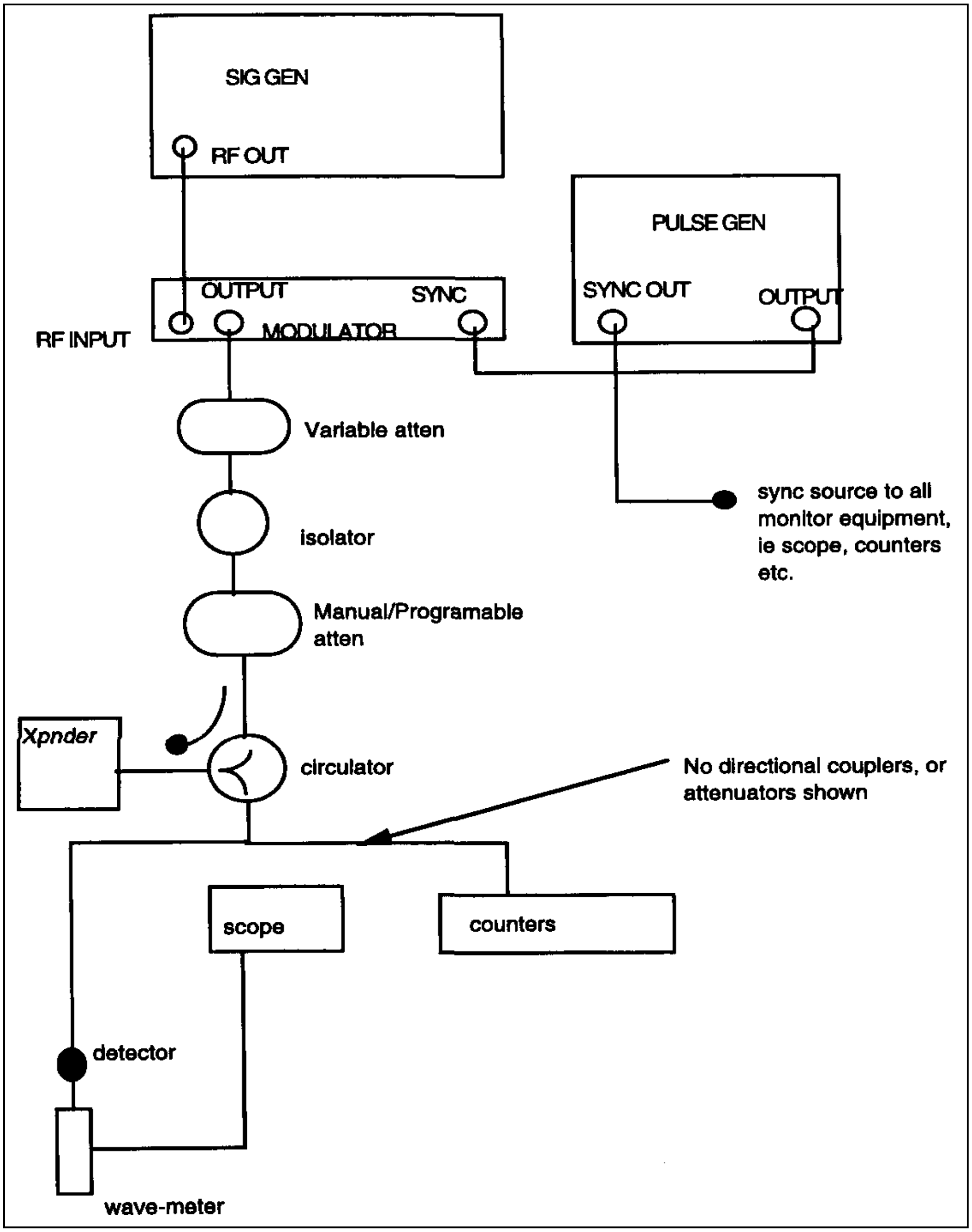


Figure 4-1. Basic Test Bench Setup

b. <u>Test Conditions</u>

(1) Uplink frequency 5800 MHz.

(2) Interrogate with 2 pulses, 5 µs leading edge to leading edge.

(3) Downlink frequency 5700 MHz.

(4) Repetition rate 1000 pps.

c. <u>Test Method</u>

(1) With the transponder tuned to 5800 MHz, measure the receiver sensitivity to the requirements of Paragraph 2.5.5. Monitor the 99% response over a 10-second period.

(2) Turn off interrogation to the transponder and monitor for random replies to the requirements of Paragraph 2.5.7. Monitor for a 10-second period.

(3) Repeat steps 1 and 2 with transponder receiver frequencies of 5600 and 5900 MHz.

d. Criteria: Must satisfy requirements of the appropriate PSS test paragraphs listed in Table 4-1.

NOTE	Under certain applications, a portable radar simulator may be substituted for this basic test bench setup.

4.2.2 **<u>TEST: Receiver bandwidth at 3 dB, 5800 MHz</u>**

a. <u>Test Setup</u>: As shown in Figure 4-1

b. <u>Test Conditions</u>

(1) Uplink frequency 5800 MHz

(2) Interrogate with 2 pulses, 5 µs leading edge to leading edge

(3) Downlink frequency 5700 MHz

(4) Repetition rate 1000 pps

c. <u>Test Method</u>

(1) Adjust the signal generator to the receiver center frequency until the PRF counter reads 990 pps nominal averaged over a 10-second period. Record the *receiver sensitivity*.

(2) Increase the input signal level 3 dB above the level recorded in step 1. Increase the signal generator frequency until the PRF counter reads 990 pps. Measure and record the signal generator frequency measured on the electronic counter. This is the *upper 3 dB frequency*, F_1.

(3) Decrease the input signal frequency until the PRF counter reads 990 pps. Measure the signal generator frequency and record this as the *lower 3 dB frequency*, F_2.

(4) Calculate and record the *3 dB bandwidth* $(F_1 - F_2)$.

d. Criteria: Must satisfy the requirements of the appropriate PSS test paragraph as listed in Table 4-1.

4.2.3 TEST: Receiver code accept/reject test at 3.5-, 9.5-, and 15.5-µs code spacing

a. Test Setup: As shown in Figure 4-1

b. Test Conditions

(1) Uplink frequency 5800 MHz

(2) Interrogate with 2 pulses, 3.5 µs leading edge to leading edge (test method will vary interrogation code spacing)

(3) Downlink frequency 5700 MHz

(4) Repetition rate 1000 pps

c. Test Method

(1) Apply a double pulse code spacing of 3.5 µs, signal level of 0 dBm. Repeat for the following codes: 9.5 µs and 15.5 µs.

(2) Monitor all code spacing for random replies and record results.

(3) Apply a single pulse to the receiver with a signal level of –10 dBm to 20 dBm. Vary PW from 3 to 50 µs while monitoring random replies.

(4) Record any random replies.

d. Criteria: Must satisfy requirements of appropriate PSS test paragraphs as listed in Table 4-1.

4.2.4 TEST: Peak power output vs. PRF in 500 pps steps 100-2600 pps

a. Test Setup: As shown in Figure 4-1

b. Test Conditions

(1) Uplink frequency 5800 MHz

(2) Interrogate with 2 pulses, 5 µs leading edge to leading edge

(3) Downlink frequency 5700 MHz

(4) Repetition rate 1000 pps (test method will vary PRF rate)

c. Test Method

(1) Adjust input PRF in steps from 100 to 2600 pps. With input PRF set to 100 pps, measure PW and average power.

(2) Calculate peak power using Equation 3-1.

(3) Record results for each PRF specified.

d. Criteria: Must satisfy requirements of appropriate PSD test paragraphs as listed in Table 4-1.

4.2.5 TEST: Peak power output vs. transmitter frequency

a. Test Setup: As shown in Figure 4-1

b. Test Conditions

(1) Input voltage 28 ± 1 V

(2) Uplink frequency 5800 MHz

(3) Downlink frequency 5400 MHz

(4) Interrogate with 2 pulses, 5 µs leading edge to leading edge

(5) Repetition rate 1000 pps

c. Test Method

(1) Record results for each step in frequency specified.

(2) Do not adjust transmitter frequency any closer than ± 50 MHz to the receiver operating frequency (**use extreme caution).**

(3) Repeat steps 1 and 2 while increasing the downlink frequency in steps of 100 MHz.

d. Criteria: Must satisfy requirements of appropriate PSS test paragraphs as listed in Table 4-1.

4.2.6 TEST: Recovery time for two interrogating signals

a. Test Setup: As shown in Figure 4-1. This test will require two pulse generators and two RF signal generators.

b. Test Conditions

(1) Uplink frequency 5800 MHz

(2) Interrogate with 2 pulses, 5 µs leading edge to leading edge

(3) Downlink frequency 5700 MHz

(4) Repetition rate 1000 pps

c. Test Method

(1) Commonly sync both pulse generator and oscilloscope from generator #1.

(2) Adjust pulse generator #2 to provide a second 5-µs pulse group 5 µs leading edge to leading edge.

(3) Adjust RF signal generator #1 for a 0-dBm level at the transponder.

(4) Adjust RF signal generator #2 for a –65 (20 W), –68 (50 W), or –70 (400 W) dBm level at the transponder.

(5) Interrogate the transponder with the above combined signals and measure the recovery time.

d. Criteria: Must satisfy the requirements of the appropriate PSS test paragraph as listed in Table 4-1.

4.2.7 **TEST: Delay, delay variation, and delay jitter vs. input signal level**

a. Test Setup: As shown in Figure 4-1. Double pulse code, time measurements taken at the 50% amplitude point of the second interrogate pulse leading edge, and the detected reply pulse.

b. Test Conditions

(1) Uplink frequency 5800 MHz

(2) Interrogate with 2 pulses, 5 μs leading edge to leading edge

(3) Downlink frequency 5700 MHz

(4) Repetition rate 1000 pps

c. Test Method

(1) Use the second pulse of the interrogation. Determine a time reference from the leading edge of this pulse on the oscilloscope at an input signal level of 0 dBm.

(2) Apply the interrogate pulse to the transponder and measure the time from the interrogate pulse reference to the detected reply pulse.

(3) Record this spacing as the *fixed delay time*.

(4) View the leading edge of the detected reply pulse and vary the level of the input signal from 0 to –65 dBm. Measure the time difference or change as the level is varied. Record this time as *delay variation*.

(5) Apply a signal level to the antenna connector of the transponder of –55 dBm. Observe the peak-to-peak time jitter of the detected reply pulse leading edge. Record this time as *–55 dBm jitter*.

(6) Apply a signal to the transponder antenna of –65 dBm. Observe the peak to peak time jitter of the detected reply pulse leading edge. Record this time as *–65 dBm jitter*.

d. Criteria: Must satisfy the requirements of the appropriate PSS test paragraphs as listed in Table 4-1.

4.2.8 **TEST: Pressure test**

a. Test Setup

(1) Have clean, dry air to pressurize unit.

(2) Have a container filled with water deep enough to entirely submerge unit.

b. Test Conditions: Not applicable

c. Test Method

(1) Pressurize the unit through the air valve.

(2) Submerge the unit in the water for a period of 20 minutes to determine if there will be leakage.

(3) There should be no evidence of bubbles coming from the case or connector.

(4) Remove the unit from the water and allow it to sit for a period of 8 hours.

d. Criteria: Must satisfy the requirements of the appropriate PSS test paragraph as listed in Table 4-1.

4.3 Environmental Test Procedures

The following subsections describe the environmental acceptance test procedures.

4.3.1 TEST: Sinusoidal vibration

Use this test method for sinusoidal vibration, as specified in Subsection 3.4.10.5.4.1, with the exception that vibration may be limited to one axis, the axis determined to be the most critical during Type I testing.

4.3.2 TEST: Temperature and altitude

Use this test method for temperature and altitude, as specified in Subsection 3.4.6. Testing shall be conducted at –37.2°C and 75°C with a 15-minute soak time during temperature. The altitude test shall be conducted at 100,000 feet at site temperature.

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APPENDIX A

References

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APPENDIX B

Glossary

α: alpha symbol used to represent the "producer's risk" or the probability of rejecting equipment that is reliable; the probability that acceptable items will fail to pass the reliability test.

β: beta symbol used to represent "consumer's risk" or the probability of accepting equipment that is unreliable; the probability of unacceptable items passing the reliability test.

bulk cable injection: an EMI test procedure involving cable routings that are in bulk as typically found on aircraft and naval ships.

captive flight: a condition where equipment is attached to aircraft, but not deployed.

centroid: that time within the signal that divides the total signal energy in two equal portions.

coherent transponder: a transponder in which a fixed relation is maintained between frequency and phase of input and output signals.

colorimetry: a technique by which an unknown color is evaluated in terms of standard colors; the technique may be visual, photoelectric, or indirect by means of spectrophotometry.

conducted susceptibility: the amount of EMI generated by wiring or cables that may affect a component. Also, the testing of a device to verify that it is not susceptible to conducted emissions between pre-defined limits as set by various national and international standards.

constant bandwidth analyzer: a tunable sound analyzer that has a fixed pass band that is swept through the frequency range of interest. Also known as a constant bandwidth filter.

contiguous filter: an open-air filter where no physical connection may be required.

critical: a level of failure of a function that would prevent the continued safe flight and landing of an aircraft or operation of a component.

downlink: transponder transmitter frequency.

dummy mass: extraneous elements added to a missile for weight and balance purposes.

electromagnetic interference: interference, generally at radio frequencies, that is generated inside systems, as contrasted with radio-frequency interference coming from sources outside a system.

electron tube: an electron device in which conduction of electricity is provided by electrons moving through a vacuum or gaseous medium within a gas-tight envelope.

environmental tests: tests that require some type of conditioning. Environmental conditioning may involve dynamic testing with vibration or temperature parameters, or both.

free flight: airborne equipment that is not being guided independently.

frequency stability: the ability of an oscillator to maintain a desired frequency; usually expressed as percent deviation from the assigned frequency value.

harmonic emissions: emissions that radiate at integral multiples of the fundamental frequency.

image rejection: a measure of suppression of unwanted square-law response of a single ended mixer. Image rejection is measured in dB of attenuation relative to the magnitude of the desired response.

in-rush current limits: electrical current limits that flow into a component upon initial application of power, usually of higher amplitude than desired.

interrogations: the transmission of a radio frequency pulse, or combination of pulses, intended to trigger a transponder or group of transponders, a racon system, or an IFF system to elicit an electromagnetic reply. Also known as challenging signals.

klystron: an evacuated electron-beam tube in which an initial velocity modulation imparted to electrons in a beam results subsequently in density modulation of the beam; used as an amplifier in the microwave region or as an oscillator.

jitter: small, rapid variations in a waveform due to mechanical vibrations, fluctuations in supply voltages, control-system instability, and other causes.

magnetron: one of a family of cross-field microwave tubes, wherein electrons generated from a heated cathode move under the combined force of a radial electric field and an axial magnetic field to produce pulsed microwave radiation in the frequency range 1-40 GHz. These pulses are used as a radiation source for radar.

manometer: a double-leg, liquid-column gage used to measure the difference between two fluid pressures.

mean time between failures: a basic measure of the system reliability parameter related to availability and readiness. The total number of system life units divided by the total number of events in which the system becomes unavailable to initiate its mission(s) during a stated period of time.

minimum triggering level: that signal level at which the transponder will reply to 99% of the interrogation pulses.

noncoherent transponder: a transponder whose transmitted power (a function of frequency) is not related to input power.

on-line: within the path of the circuit or system.

pulse code modulation: modulation in which the peak-to-peak amplitude range of the signal to be transmitted is divided into a number of standard values, each having its own three-place code. Each sample of the signal is then transmitted as the code for the nearest standard amplitude.

pulse delay (spacing): the time interval between 50% amplitude points on the leading edge of the voltage pulses being measured. The measurement method shall be as indicated in definition of “pulse width.”

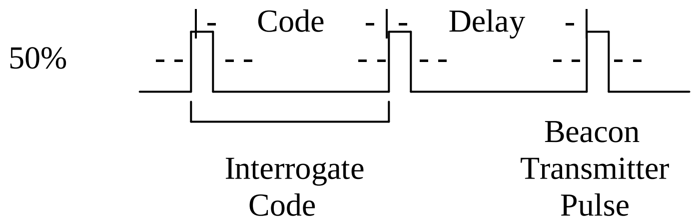
pulse droop: the distortion of an otherwise essentially flat-topped rectangular pulse, characterized by a decline of the pulse top.

pulse fall time: the time required for the trailing edge of a voltage pulse to decrease from 90 to 10% of the amplitude of the pulse.

pulse repetition frequency: the rate (usually given in cycles or pulses per second) at which pulses or pulse groups are transmitted from a radar set.

pulse rise time: the time required for the leading edge of a voltage pulse to increase from 10 to 90% of the amplitude of the pulse.

pulse width: the time interval (pulse duration) at the 50% point(–3 dB) of the detected peak value of the pulse.



radiated susceptibility: the degree to which a device is susceptible to EMI below certain pre-defined limits as set by various national and international standards.

random triggering: transponder firing or replying by a means other than what it is intended to respond to.

receiver bandwidth: the difference between the frequency limits of a band containing the useful frequency components of a signal.

recondition: to renovate, repair, overhaul, rebuild or any combination of these actions taken to return the transponder to its specified state of serviceability.

resonance dwell: the time required for the completion of a measurement on a channel.

resonance search: a method used to seek out the resonance of the system under test.

salt fog test: an accelerated corrosion test in which a piece of metal is subjected to a fine spray of sodium chloride solution.

silicon-controlled rectifier: a semiconductor rectifier that can be controlled; a pnpn four-layer semi-conductor device that normally acts as an open circuit, but switches rapidly to a conducting state when an appropriate gate signal is applied to the gate terminal. Also known as a reverse-blocking triode tryristor.

sensitivity: the minimum signal level, measured at the transponder antenna terminal, which causes the transponder to reply to at least 99.9% of the interrogations.

set delay: that time interval of the reply pulse measured from the leading edge of the interrogation pulse(s) to the leading edge of the transmitted reply pulse that has been set anywhere from 1 µs to 9 µs (typically set at 2.5 µs).

sinusoidal vibration amplitude: a signal wave having a smooth curve where the ordinate is proportional to the sine of the abscissa.

spurious emission: any emission from a radio transmitter at frequencies outside its frequency band. Also known as spurious radiation.

swept frequency analysis: analysis based on a continuous change of a parameter in an electronic system that characterizes the response of a device as a function of frequency. The analysis is normally either linear or logarithmic.

transponder delay: the time delay from the leading edge of the last pulse of the interrogation signal, measured at the 50% amplitude point that triggers a transmitter, to the 50% amplitude point of the transmitter response pulse or from the centroid of the last interrogation signal to the centroid of the transmitter response signal.

uplink: transponder receiver frequency.

waveguide: broadly defined, a device that constrains or guides the propagation of electromagnetic waves along a path defined by the physical construction of the waveguides.

APPENDIX C

Form 1423: Contract Data Requirements List

CONTRACT DATA REQUIREMENTS LIST (1 *Data Item)*					*Form Approved OMB No. 0704-0188*
The public reporting burden for this collection of information is estimated to average 110 hours per response, including the time for reviewing instructions, searching existing data sources, lathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect a this collection of information, includinp2 suggestions for reducing the burden, to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0701-0188), 15 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-43 2. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply, with a collection of information if it does not display a currently valid OMB control number. Please DO NOT RETURN your form to the above address. Send competed form to the Government Issuing Contracting Officer for the Contract/PR No. listed in Block E.					
A. CONTRACT LINE ITEM NO.	B. EXHIBIT	C. CATEGORY: TDP______ TM _________OTHER__________________________________			
D. SYSTEM/ITEM		E. CONTRACT/PR NO.		F. CONTRACTOR	
1. DATA ITEM NO.	2. TITLE OF DATA ITEM			3. SUBTITLE	
4. AUTHORITY (*Data Acquisition Document No.)*		5. CONTRACT REFERENCE		6. REQUIRING OFFICE	
7. DD 250 REQ	9. DIST STATEMENT REQUIRED	10.FREQUENCY	12. DATE OF FIRST SUBMISSION	14. DISTRIBUTION	
8. APP CODE		11. AS OF DATE	13. DATE OF SUBSEQUENT SUBMISSION		
16. REMARKS					
G. PREPARED BY	H. DATE	I. APPROVED BY	J. DATE		

14. DISTRIBUTION			
a. ADDRESSEE	b. COPIES		
	Draft	Final	
		Reg	Repro
15. TOTAL			

INSTRUCTIONS FOR COMPLETING DD FORM 1423

(See DoD 5010.12-M for detailed instructions.)

FOR GOVERNMENT PERSONNEL

Item A. Self-explanatory.

Item B. Self-explanatory.
Item C. Mark (X) appropriate category: TDP - Technical Data Package;
TM - Technical Manual; Other - other category of data, such as "Provisioning, ""Configuration Management," etc.

Item D. Enter name of system/item being acquired that data will support.

Item E. Self-explanatory (to be filled in after contract award).
Item F. Self-explanatory (to be filled in after contract award).
Item G. Signature of preparer of CDRL.

Item H. Date CDRL was prepared.

Item 1. Signature of CDRL approval authority.
Item J. Date CDRL was approved.

Item 1. See DoD FAR Supplement Subpart 4.71 for proper numbering.
Item 2. Enter title as it appears on data acquisition document cited in Item 4.
Item 3. Enter subtitle of data item for further definition of data item (optional entry).

Item 4. Enter Data Item Description (DID) number, military specification number, or military standard number listed in DoD 5010.12-L (AMSDQ, or one-time DID number, that defines data content and format requirements.
Item 5. Enter reference to tasking in contract that generates requirement for the data item (e.g., Statement of Work paragraph number).

Item 6. Enter technical office responsible for ensuring adequacy of the data item.

Item 7. Specify requirement for inspection/acceptance of the data item by the Government.

Item 8. Specify requirement for approval of a draft before preparation of the final data item.
Item 9. For technical data, specify requirement for contractor to mark the appropriate distribution statement on the data (ref. DoDD 5230.24).

Item 10. Specify number of times data items are to be delivered.

Item 11. Specify as-of date of data item, when applicable.
Item 12. Specify when first submittal is required.
Item 13. Specify when subsequent submittals are required, when applicable.
Item 14. Enter addressees and number of draft/final copies to be delivered to each addressee. Explain reproducible copies in Item 16.

Item 15. Enter total number of draft/final copies to be delivered.

Item 16. Use for additional/clarifying information for Items 1 through 15. Examples are: Tailoring of documents cited in Item 4; Clarification of submittal dates in Items 12 and 13; Explanation of reproducible copies in Item 14.; Desired medium for delivery of the data item.

FOR THE CONTRACTOR

Item 17. Specify appropriate price group from one of the following groups of effort in developing estimated prices for each data item listed on the DD Form 1423.

a. Group 1. Definition - Data which is not otherwise essential to the contractor's performance of the primary contracted effort (production, development, testing, and administration) but which is required by DID Form 1423.

Estimated Price - Costs to be included under Group I are those applicable to preparing and assembling the data item in conformance with Government requirements, and the administration and other expenses related to reproducing and delivering such data items to the Government.

b. Group 11. Definition - Data which is essential to the performance of the primary contracted effort but the contractor is required to perform additional work to conform to Government requirements with regard to depth of content, format, frequency of submittal, preparation, control, or quality of the data item.

Estimated Price - Costs to be included under Group 11 are those incurred over and above the cost of the essential data item without conforming to Government requirements, and the administrative and other expenses related to reproducing and delivering such data item to the Government.

c. Group Ill. Definition - Data which the contractor must develop for his internal use in performance of the primary contracted effort and does not require any substantial change to conform to Government requirements with regard to depth of content, format, frequency of submittal, preparation, control, and quality of the data item.

Estimated Price - Costs to be included under Group Ill are the administrative and other expenses related to reproducing and delivering such data item to the Government.

d. Group IV. Definition - Data which is developed by the contractor as part of his normal operating procedures and his effort in supplying these data to the Government is minimal.

Estimated Price - Group IV items should normally be shown on the DID Form 1423 at no cost.

Item 18. For each data item, enter an amount equal to that portion of the total price which is estimated to be attributable to the production or development for the Government of that item of data. These estimated data prices shall be developed only from those costs which will be incurred as a direct result of the requirement to supply the data, over and above those costs which would otherwise be incurred in performance of the contract if no data were required. The estimated data prices shall not include any amount for rights in data. The Government's right to use the data shall be governed by the pertinent provisions of the contract.

DD FORM 1423-1 (BACK), FEB 2001

****** End of Document ******