



STANDARD 262-02

**ELECTRONIC TRAJECTORY
MEASUREMENTS GROUP**

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

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

**ATLANTIC FLEET WEAPONS TRAINING FACILITY
NAVAL AIR WARFARE CENTER WEAPONS DIVISION
NAVAL AIR WARFARE CENTER AIRCRAFT DIVISION
NAVAL UNDERSEA WARFARE CENTER DIVISION, NEWPORT
PACIFIC MISSILE RANGE FACILITY
NAVAL UNDERSEA WARFARE CENTER DIVISION, KEYPORT
NAVAL STRIKE AND AIR WARFARE CENTER**

**30TH SPACE WING
45TH SPACE WING
AIR FORCE FLIGHT TEST CENTER
AIR ARMAMENT CENTER
AIR WARFARE CENTER
ARNOLD ENGINEERING DEVELOPMENT CENTER
BARRY M. GOLDWATER RANGE
UTAH TEST AND TRAINING RANGE**

NEVADA TEST SITE

**DISTRIBUTION A: APPROVED FOR PUBLIC RELEASE;
DISTRIBUTION IS UNLIMITED**

Report Documentation Page

Report Date 00 Apr 2002	Report Type N/A	Dates Covered (from... to) -
Title and Subtitle C (G)-Band & X (I) - Band Noncoherent Radar Transponder Performance Specifications Standard		Contract Number
		Grant Number
		Program Element Number
Author(s)	Project Number	
	Task Number	
	Work Unit Number	
Performing Organization Name(s) and Address(es) Range Commanders Council White Sands Missile Range New Mexico 88002-5110		Performing Organization Report Number
Sponsoring/Monitoring Agency Name(s) and Address(es)		Sponsor/Monitor's Acronym(s)
		Sponsor/Monitor's Report Number(s)
Distribution/Availability Statement Approved for public release, distribution unlimited		
Supplementary Notes The original document contains color images.		
Abstract		
Subject Terms		
Report Classification unclassified	Classification of this page unclassified	
Classification of Abstract unclassified	Limitation of Abstract UU	
Number of Pages 157		

STANDARD 262-02

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

APRIL 2002

Prepared by

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

Published by

**Secretariat
Range Commanders Council
White Sands Missile Range
New Mexico 88002-5110**

**THIS DOCUMENT IS AVAILABLE ON THE
RANGE COMMANDERS COUNCIL WEBSITE AT**

<http://jcs.mil/RCC>

TABLE OF CONTENTS

PREFACE	vii
ACRONYMS AND INITIALISMS.....	x
CHAPTER 1: INTRODUCTION	1-1
1.1 General.....	1-1
1.2 Scope.....	1-1
1.3 Purpose.....	1-1
1.4 Order of Precedence	1-1
1.5 Reference Documents.....	1-2
1.6 Requirements/Specified Frequency.....	1-2
1.7 Background.....	1-3
1.8 Description of Test Types	1-3
CHAPTER 2: NONCOHERENT TRANSPONDER SPECIFICATIONS.....	2-1
2.1 20/50/400 Watt Performance Specifications	2-1
2.1.1 Electrical Characteristics.....	2-1
2.1.2 Identification	2-2
2.1.3 Technical Data	2-2
2.1.4 Mechanical Construction.....	2-2
2.1.5 Receiver Section.....	2-5
2.1.6 Transmitter Section.....	2-7
2.1.7 Environment Requirements	2-10
2.1.8 Quality Assurance Provisions	2-10
2.1.9 Type I Tests: Qualification Testing	2-11
2.1.10 Type II Tests: Acceptance Testing	2-12
2.1.11 Preparation For Delivery.....	2-12
CHAPTER 3: GENERAL TEST PROCEDURES – TYPE I TESTS.....	3-1
3.1 Section I: Reliability Testing.....	3-1
3.1.1 Reliability Test Procedures	3-1
3.2 Section II: Transmitter and Receiver Electrical Parameters	3-4
3.2.1 Scope.....	3-4
3.2.2 Test Schedule	3-4
3.2.3 Standard Test Set-up.....	3-6
3.2.4 TEST: Receiver sensitivity and random triggering vs. receiver frequency.....	3-7
3.2.5 TEST: Receiver sensitivity vs. input pulse width.....	3-7
3.2.6 TEST: Receiver sensitivity and random triggering vs. line voltage	3-8
3.2.7 TEST: Receiver code accept/reject limits.....	3-8
3.2.8 TEST: Receiver code reject test, random triggering.....	3-9
3.2.9 TEST: Rejection of improper signals.....	3-10
3.2.10 TEST: Receiver bandwidth at 3 dB.....	3-10
3.2.11 TEST: Peak power output vs. PRF in 500 p/s steps 100-2600 p/s	3-11
3.2.12 TEST: Peak power output vs. transmitter frequency.....	3-12

3.2.13	TEST: Transponder recovery time and recovery characteristics.....	3-12
3.2.14	TEST: Transmitter frequency vs. pulse repetition frequency	3-13
3.2.15	TEST: Delay, delay variation, and delay jitter vs. signal level.....	3-13
3.2.16	TEST: Delay and delay jitter vs. line voltage	3-14
3.2.17	TEST: Recovery time vs. difference in signal level of two signals	3-15
3.2.18	TEST: Transmitter pulse width, pulse width jitter, rise time and fall time vs. transmitter frequency	3-16
3.2.19	TEST: Transmitter RF spectrum	3-16
3.2.20	TEST: Over-interrogation.....	3-17
3.2.21	TEST: Power consumption vs. line voltage.....	3-18
3.2.22	TEST: Pressurization.....	3-18
3.3	Section III: Electromagnetic Interference (EMI) Requirements	3-19
3.3.1	Test Procedure.....	3-19
3.3.2	Test Data Recording.....	3-19
3.3.3	Standard Conditions	3-19
3.3.4	Test Conditions.....	3-19
3.3.5	Tests and Test Sequence	3-20
3.3.6	Test Equipment.....	3-20
3.3.7	TEST: Requirement CE102: Conducted emissions, power leads	3-22
3.3.8	TEST: Requirement CE106: Conducted emissions, antenna terminal.....	3-22
3.3.9	TEST: Requirement CS101: Conducted susceptibility, power leads.....	3-22
3.3.10	TEST: Requirement CS103: Conducted susceptibility, antenna port.....	3-23
3.3.11	TEST: Requirement CS104: Conducted susceptibility, antenna port	3-23
3.3.12	TEST: Requirement CS114: Conducted susceptibility	3-23
3.3.13	TEST: Requirement CS115: Conducted susceptibility, bulk cable injection	3-24
3.3.14	TEST: Requirement CS116: Conducted susceptibility, damped sinusoidal transients, cables and power leads.....	3-24
3.3.15	TEST: Requirement RE102: Radiated emissions, electric field.....	3-24
3.3.16	TEST: Requirement RE103: Radiated emissions, antenna outputs	3-25
3.3.17	TEST: Requirement RS101: Radiated susceptibility, magnetic field	3-25
3.3.18	TEST: Requirement RS103: Radiated susceptibility, electric field.....	3-26
3.4	Section IV: Environmental Testing Procedures	3-27
3.4.1	Introduction.....	3-27
3.4.2	Applicable Documents	3-27
3.4.2.1	Documents of Issue.....	3-27
3.4.3	General Requirements	3-28
3.4.3.1	Test Conditions.....	3-28
3.4.3.2	Performance of Test.....	3-30
3.4.3.3	Test Facilities and Apparatus.....	3-31
3.4.3.4	Test Data.....	3-32
3.4.3.5	Specified Electrical Functional Tests.....	3-32
3.4.4	Test Sequence.....	3-34
3.4.5	Environmental Test Methods	3-36
3.4.5.1	TEST: Temperature Shock	3-36
3.4.5.2	TEST: Temperature-Altitude	3-38
3.4.5.3	TEST: Humidity	3-51
3.4.5.4	TEST: Salt Fog.....	3-55
3.4.5.5	TEST: Acceleration.....	3-61
3.4.5.6	TEST: Vibration.....	3-66
3.4.5.7	TEST: Acoustical Noise.....	3-93
3.4.5.8	TEST: Shock.....	3-98

CHAPTER 4: GENERAL TEST PROCEDURES – TYPE II TESTS	4-1
4.1 Section I: Transmitter and Receiver Electrical Parameters	4-1
4.1.1 Test Schedule	4-1
4.1.2 Test Failures.....	4-1
4.1.3 Retrofit	4-1
4.2 Tests	4-1
4.2.1 TEST: Receiver Sensitivity and Random Triggering at 5800MHz.....	4-2
4.2.2 TEST: Receiver Bandwidth at 3 dB, 5800 MHz.....	4-4
4.2.3 TEST: Receiver Code Accept/Reject Test at 3.5, 9.5 and 15.5 μ s Code	4-4
4.2.4 TEST: Peak Power Output vs. PRF in 500 p/s steps 100-2600 p/s	4-5
4.2.5 TEST: Peak Power Output vs. Transmitter Frequency.....	4-6
4.2.6 TEST: Recovery Time for Two Interrogating Signals.....	4-6
4.2.7 TEST: Delay, Delay Variation and Delay Jitter vs. Input Signal Level.....	4-7
4.2.8 TEST: Pressure Test.....	4-8
4.3 Section II: Environmental Test Procedures	4-8
4.3.1 Test Schedule:.....	4-8
4.3.2 TEST: Sinusoidal Vibration Test	4-9
4.3.3 TEST: Temperature and Altitude Test.....	4-9
REFERENCES.....	5-1
APPENDIX A: GLOSSARY.....	A-1
APPENDIX B: FORM 1423.....	B-1

LIST OF FIGURES

Figure 2-1.	Case dimensions for 20-watt transponders.	2-2
Figure 2-2.	Case dimensions for 50-watt transponders.	2-3
Figure 2-3.	Case dimensions for 400-watt transponders.....	2-4
Figure 2-4.	Pulse waveform definition.	2-8
Figure 3-1.	Reliability test.....	3-2
Figure 3-2.	Operating characteristic curve for reliability test.....	3-3
Figure 3-3.	Basic test bench set-up.	3-6
Figure 3-4.	Temperature vs. altitude requirements for category (6) equipment.	3-50
Figure 3-5.	Humidity cycle – Procedure I.....	3-52
Figure 3-6.	Humidity cycle – Procedure II.	3-54
Figure 3-7.	Variations of specific gravity of salt (NaCl) solution with temperature.	3-57
Figure 3-8.	Salt solution filter.....	3-58
Figure 3-9.	Location of salt solution filter.	3-58
Figure 3-10.	Direction of vehicle acceleration.	3-65
Figure 3-11.	Vibration test curves for equipment installed in airplanes, excluding helicopters, equipment category (b.1).	3-75
Figure 3-12.	Random vibration test curve and mass loading reduction factor for jet aircraft equipment category (b.2).	3-76
Figure 3-13.	Vibration test curves for equipment installed in helicopters, category (c).	3-77
Figure 3-14.	Vibration test levels for equipment installed in external stores carried on airplanes, equipment category (d.1).	3-78
Figure 3-15.	Vibration test curves for equipment installed in ground launched missiles, equipment category (e).	3-79
Figure 3-16A.	Vibration test curves for equipment installed in ground vehicles, equipment category (f).	3-80
Figure 3-16B.	Logarithmic sweep.....	3-81
Figure 3-17.	Octave band spectrum for the acoustical noise test.	3-97
Figure 3-18.	Terminal-peak sawtooth shock pulse configuration and its tolerance limits.....	3-101
Figure 3-19.	Half sine shock pulse configuration and its tolerance limits.....	3-102
Figure 3-20.	Shock measuring system frequency response.	3-103
Figure 4.1.	Basic test bench set-up.	4-3

LIST OF TABLES

Table 3-1.	Type I (Qualification) Tests.....	3-5
Table 3-2.	Electromagnetic Interference (EMI) Tests	3-20
Table 3-3.	Typical Test Equipment For EMI Testing.....	3-21
Table 3-4A.	Recommended Test Sequence: Group I	3-34
Table 3-4B.	Recommended Test Sequence: Group II	3-35
Table 3-5.	Test Chamber Temperatures.....	3-37
Table 3-6.	Equipment Categories for Temperature-Altitude Tests	3-44
Table 3-7.	Test Conditions for Temperature-Altitude Tests.....	3-49
Table 3-8.	Instructions for Selection of Test Levels	3-62
Table 3-9.	G Levels for Operational Test.....	3-63
Table 3-10.	Test Procedures by Equipment Category	3-66
Table 3-11A.	Test Procedures and Time Schedule Chart for Equipment Installed in Propeller Airplanes – Equipment Category (b.1).....	3-82
Table 3-11B.	Test Procedures and Time Schedule Chart for Equipment Installed in Propeller Airplanes – Equipment Category (b.1).....	3-86
Table 3-12.	Random Vibration Test Criteria for Jet Aircraft –Equipment Category (b.2)	3-87
Table 3-13A.	Test Procedure and Time Schedule Chart for Equipment in Helicopters –	
	Equipment Category (c)	3-88
Table 3-13B.	Curve Selection Chart for Equipment Category (c).....	3-88
Table 3-14A.	Vibration Criteria for External Stores Carried on Airplanes – Equipment Category (d.1).....	3-89
Table 3-14B.	Vibration Criteria for External Stores Carried on Airplanes – Equipment Category (d.1).....	3-90
Table 3-15A.	Test Procedure and Time Schedule Chart for Equipment Installed in Ground- Launched Missiles – Equipment Category (e).....	3-91
Table 3-15B.	Curve Selection Chart for Equipment Category (e).....	3-91
Table 3-16.	Test Procedure and Time Schedule Chart for Equipment Installed in Ground	
	Vehicles – Equipment Category (f)	3-92
Table 3-17.	Acoustic Noise Test Categories	3-95
Table 4-1.	Type II Tests	4-2

PREFACE

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, however, 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 "cut-backs," this process became an increasingly more difficult task.

In addition, provider companies merged, market competition decreased, spare parts became non-existent, 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 Electronic Trajectory Measurements Group (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.

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. Typically, transponders are not off-the-shelf items. Most are manufactured under a specific end-user construction/design specification. All of these factors have contributed to an increasing problem in meeting range requirements.

Thus, through the 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 MIL-STD interpolations into the ETMG or Range Safety Group (RSG) 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 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.

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

Secretariat, Range Commanders Council,
CSTE-DTC-WS-RCC
100 Headquarters Avenue
White Sands Missile Range, New Mexico 88002-5110

Attn: ETMG Transponder Committee

TELEPHONE: (505) 678-1107
DSN 258-1107
EMAIL: rcc@wsmr.army.mil

ACKNOWLEDGMENTS

The intent of the Electronic Trajectory Measurement Group's (ETMG) document, *C (G)-Band and X (I)-Band Non-Coherent Radar Transponder Performance Specification Standard, RCC 262-02*, is to provide a complete and over-all 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: Donald H. Sammon, Radar Branch, White Sands Missile Range, NM and Paul Olson, Radar Branch, Naval Air Warfare Center Weapons Division, China Lake, CA for their unique contributions as radar experts.

Special thanks go to Jim Bogan, NASA/Goddard Space Flight Center, Wallops Island, VA; Robert Hunt, Naval Undersea Warfare Center, AUTEC Range Service, West Palm Beach, FL; Linda Abbing, Computer Sciences Corporation Beacon Lab, Edwards AFB, CA; Ben Lary, Naval Air Warfare Center Weapons Division, Pt. Mugu, CA; Martin Diaz, ITT Federal Services Corp., Vandenberg AFB, CA; and Steve Weimers, Eglin AFB, FL. A very special acknowledgment goes to Robert Robinson, Air Force Flight Test Center, Nellis AFB, NV for his committed and tireless support of this project.

ACRONYMS AND INITIALISMS

2D	two-dimensional
3D	three-dimensional
AC/ac	alternating current
AMP	ampere
ANSI	American National Standards Institute
ANT	antenna
ASSIST	Acquisition Streamlining and Standardization Information System
ASTM	American Society for Testing and Materials
AWG	American wire gauge
C	Celsius
CE	conducted emissions
C.G.	center of gravity
CONUS	continental United States
COTS	commercial off the shelf
C.P.	chemically pure
CS	conducted susceptibility
CW	continuous wave
dB	decibel
dBic	decibels referenced to isotropic
dBm	decibels (referenced to milliwatts)
DC/dc	direct current
DoD	Department of Defense
EMI	electromagnetic interference
ETP	environmental test procedures
EUT	equipment under test
FAT	first article test
F	Fahrenheit
G	gravity
g	acceleration due to gravity
GHz	gigahertz
Hg	mercury
Hz	hertz
IAW	in accordance with
IEEE	Institute of Electrical and Electronic Engineers
IF	intermediate frequency
IO	internal oscillator
IRIG	Inter-Range Instrumentation Group

ISLS	interrogation side lobe suppression
ISO	International Organization for Standardization
kHz	kilohertz
M	meter
mA	milli-ampere
MER	multiple ejection rack
MHz	megahertz
MIL-STD	military standard
μs	microsecond
ms	millisecond
MTBF	mean-time-between-failures
MTL	minimum triggering level
mW	milliwatt
NATO	North Atlantic Treaty Organization
N/A	not applicable
NCSL	National Conference of Standards Laboratories
NIST	National Institute of Standards and Technology
ns/nsec	nanosecond
P/N	part number
p/s	pulses per second
PRF	pulse repetition frequency
psi	pounds per square inch
PSS	performance specification standard
PW	pulse width
RAE	range, azimuth, elevation
RCVR	receiver
RE	radiated emissions
RF	radio frequency
RFI	radio frequency interference
RH	relative humidity
rms	root mean square
RPP	reliability program plan
RQT	reliability qualification testing
RS	radiated susceptibility
SCR	silicon controlled rectifier
sd	standard deviation
SPL	sound pressure level
STANAG	standard agreements (NATO)
TER	tri-ejection rack

UUT	unit under test
V	volt
Vdc	volts direct current
VSWR	voltage standing wave ratio

CHAPTER 1

INTRODUCTION

1.1 General

The following radar transponder specifications and system test verification procedures have been provided by technical members of the Electronic Trajectory Measurements Group (ETMG), Transponder Ad-Hoc Committee, represented and staffed by members from all major ranges throughout the CONUS and U.S. possessions. 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.

1.2 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 transponder set consists of a receiver and a transmitter with integral power supply. The function of this transponder set is to extend tracking range, increase precision, improve target tracking identification, and to extend the low-level tracking capability of precision tracking C (G)-band instrumentation radar sets such as the AN/FPS-16, AN/MPS-36, and X (I)-band radar sets such as the NIKE Hercules, and others.

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, 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, supercedes applicable laws and regulations unless a specific exemption has been obtained.

1.5 **Reference Documents**¹

The following documents form a part of this performance specification to the extent specified herein:

DD FORM 1423	Contract Data Requirements List (Feb, 2000) (See Appendix B).
ISO-9000-1 ²	Quality Management and Quality Assurance Standards; Part 1, Guidelines for Selection and Use
ISO-9000-2	Quality Management and Quality Assurance Standards; Part 2, Generic Guidelines for Application of ISO-9001, ISO-9002, and ISO-9003
ISO-9000-4	Quality Management and Quality Assurance Standards; Part 4, Guide to Dependability Programme Management
MIL-HDBK-454A	General Guidelines for Electronic Equipment
MIL-STD-461E	Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
MIL-STD-704E	Aircraft Electric Power Requirements
MIL-STD-889B	Dissimilar Metals
MIL-C-5541E	Chemical Conversion Coatings on Aluminum and Aluminum Alloys

Copies of the above documents may be obtained from Standardization Document Order Desk, Bldg. 4, Sec. D, 700 Robbins Ave., Philadelphia, PA 19120 as long as they are still applicable. Documents no longer available may have to be provided by the purchasing agent.^{3 4}

1.6 **Requirements/Specified Frequency**

The transponder set is to consist of a receiver and a transmitter with an integral power supply. The transponder set receives pulse type interrogating signals and transmits a pulse type signal in the same frequency band. The transponder is required to 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 have been determined as the normal range frequency bands for C-band of 5400-5900 MHz and X-Band 9000 MHz to 9600 MHz. Individual purchasing agents may determine a variant of the specified

¹ See also additional references beginning on page 5-1.

² International Standards Organization, 3 Rue de Varembe, 1211 Geneve 20, Geneve, Switzerland (Telephone 41-22-734-0150).

³ Military specifications and standards may also be available through Global Engineering Documents, California (800) 854-7179 or Document Center, Belmont, CA. (415) 591-7600.

⁴ Documents may also be available through ASSIST (<http://assist/daps/mil>).

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.

For the purposes of this standard, X(I)-band requirements are annotated in text boxes at each point throughout this specification where frequency adjustments are required.

1.7 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 radar sets such as the AN/FPS-16, AN/MPS-36 and Nike Hercules, and others. 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, i.e., 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 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 (RAE) 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 rms and range errors of less than 5.0 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 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.

1.8 Description of Test Types:

- a. *Type I tests:* also called *qualification* tests; includes all tests conducted by the vendor that are for the purpose of proving the design.

- b. *Reliability tests*: for the purposes of this Standard, reliability testing is included under Type I testing procedures and represents all tests conducted by the vendor that are for the purpose of demonstrating the reliability of the transponder.
- c. *Type II tests*: also referred to as *acceptance* tests and includes all tests conducted by the purchasing agent that are for the purpose of establishing and maintaining quality control during production under contract.
- d. *Functional tests*: electrical tests required to determine the functional characteristics of the transponder before and after testing in each of the environments during environmental testing.

CHAPTER 2

NONCOHERENT TRANSPONDER SPECIFICATIONS

2.1 20/50/400 Watt Performance Specifications

2.1.1 Electrical Characteristics

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

2.1.1.2 Input Voltage. The transponder shall operate to the requirements of this specification with input voltages from 22 volts dc (Vdc) to 32 Vdc.

2.1.1.3 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.

2.1.1.4 Input Current:

2.1.1.4.1 20 watt: No greater than 300 milliamperes (mA) at 1000 pulses per second (p/s) and 28 Vdc and no greater than 350 mA maximum at maximum pulse repetition frequency (PRF) and 32 Vdc. Quiescent current shall not exceed 250 mA.

2.1.1.4.2 50 watt: No greater than 400 mA at 1000 p/s and 28 Vdc and no greater than 450 mA maximum at maximum PRF and 32 Vdc. Quiescent current shall not exceed 300 mA.

2.1.1.4.3 400 watt: No greater than 750 mA at 1000 p/s and 28 Vdc and no greater than 1.0 A maximum at maximum PRF and 32 Vdc. Quiescent current shall not exceed 500 mA.

2.1.1.5 Fuses and Circuit Breakers. Shall not be used.

2.1.1.6 Transient Protection. The transponder input 28 Vdc power leads shall be subjected to the requirements of MIL-STD-704E, paragraph 5.3.3 and Table II requirement for 28.0-volt (nominal) systems, modified for the upper setting voltage of 32.0 volts. The voltage transients shall be per the amplitudes and time duration of MIL-STD-704E, Figure 9.

2.1.1.7 Under-Voltage/Over-Voltage Protection. Parameters shall be consistent with paragraph 5.3.3 of MIL-STD-704E.

2.1.1.8 In-rush Current Limits. The transponder shall not generate "in-rush spikes" greater than 2 amps in amplitude and 50 μ s (microseconds) in duration.

2.1.2 Identification

The following information shall be marked visibly and externally on the transponder: manufacturer's name, model number, serial number, and contract number. The unit's serial number shall also be provided on the face of the connector side of the transponder.

2.1.3 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 the Data Item Descriptions attached thereto.

2.1.4 Mechanical Construction

2.1.4.1 Maximum Weight.

2.1.4.1.1 20 watt: The weight of the transponder shall not exceed 15 oz, exclusive of mating power and antenna connectors.

2.1.4.1.2 50 watt: The weight of the transponder shall not exceed 26 oz, exclusive of mating power and antenna connectors.

2.1.4.1.3 400 watt: The weight of the transponder shall not exceed 43 oz, exclusive of mating power and antenna connectors.

2.1.4.2 Physical Size. The transponder case shall be constructed as shown in the footprint in Figures 2-1 (20 watt), 2-2 (50 watt) and 2-3 (400 watt). (Also see reference note below.)

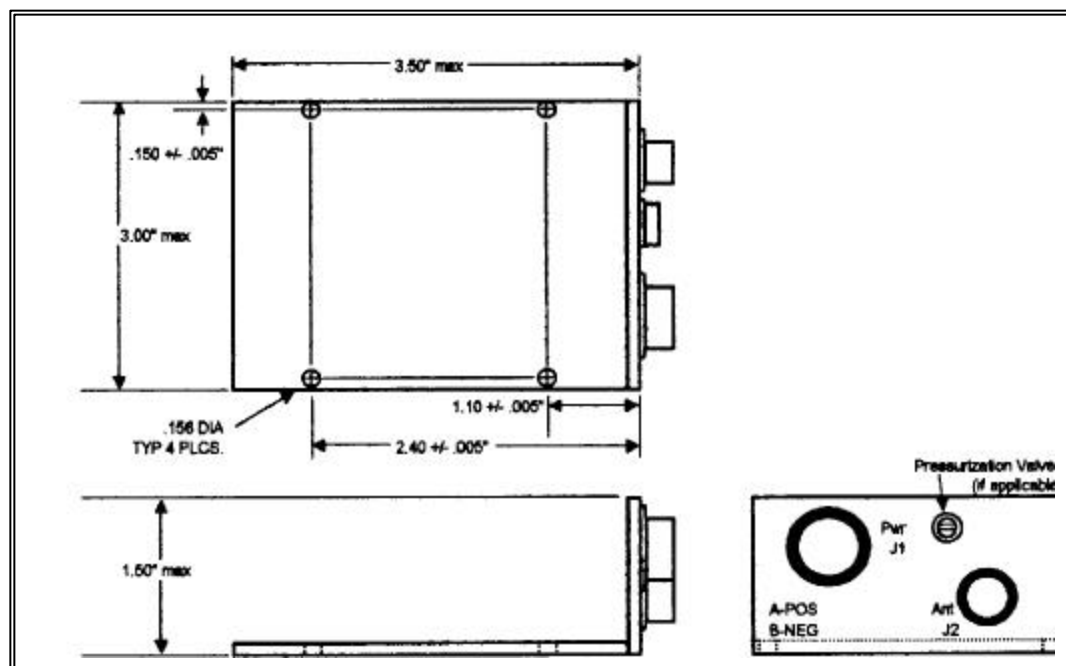


Figure 2-1. Case dimensions for 20-watt transponders. (Not drawn to scale.)

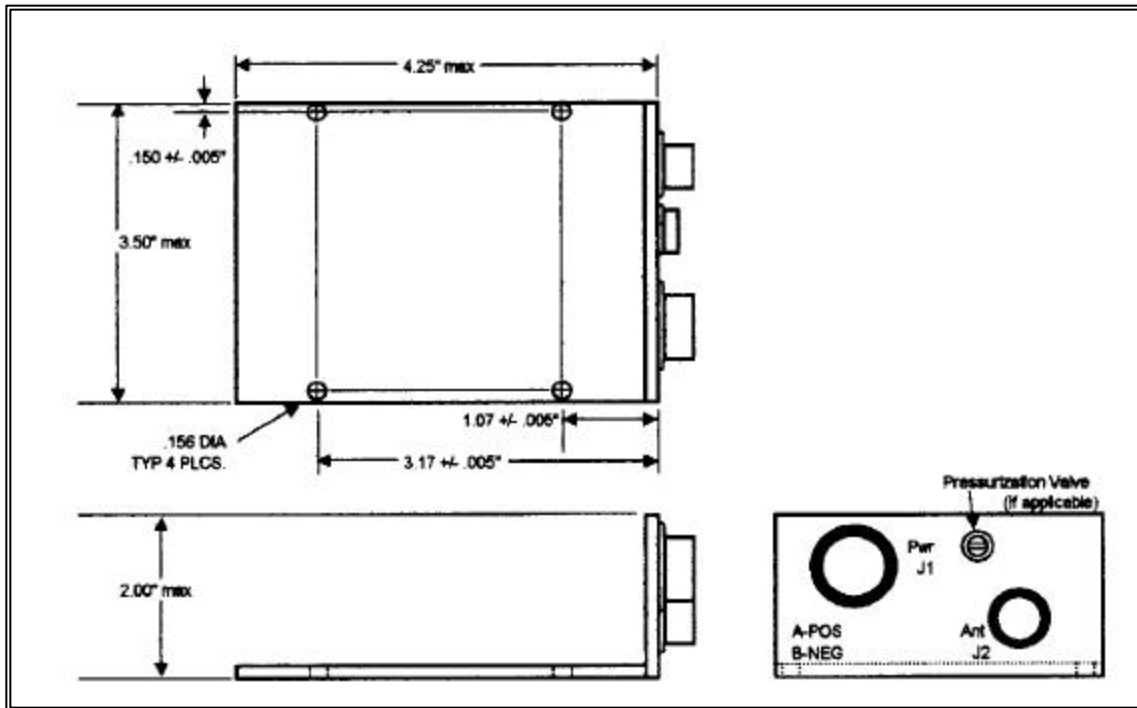


Figure 2-2. Case dimensions for 50-watt transponders. (Not drawn to scale.)

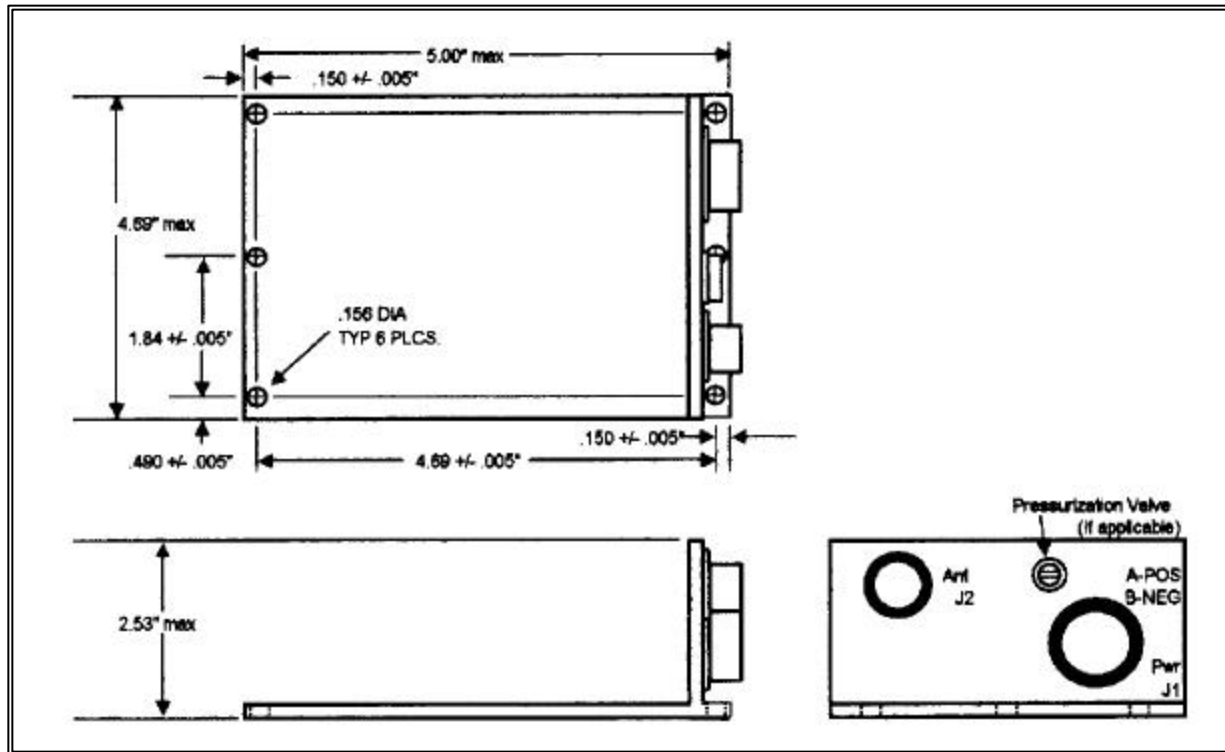


Figure 2-3. Case dimensions for 400-watt transponders. (Not drawn to scale.)

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.

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

2.1.4.4 Finish. All production units shall be protected against corrosion by a coating, which shall be electrically conductive in accordance with the guidance outlined in MIL-C-5541E.

2.1.4.5 Power Connectors:

2.1.4.5.1 20 watt: 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.

2.1.4.5.2 50 watt: 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.

2.1.4.5.3 400 watt: 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.

2.1.4.6 RF Connectors. The 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-watt units and of the TNC female type for the 400-watt units. A mating connector shall also be supplied with each unit.

2.1.4.7 TM Connectors. No defined requirements (optional feature).

2.1.4.8 Pressurization. If applicable to the design, the transponder shall maintain an interior pressure of 15 psi $\pm$ 1 psi (20 and 50 watt units) and 20-psi $\pm$ 1 psi (400 watt units) above the exterior pressure for at least eight hours, or as required during Type 1 testing. Pressurization shall be checked through a tuning access port. After test, the port seal screw will be installed to cover port.

2.1.4.9 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 not relieve the manufacturer of its warranty.

2.1.4.10 Shock Mounts. External vibration isolators or shock mounts shall not be used.

2.1.4.11 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 [paragraph 2.1.7](#). “Survivability” shall be determined by meeting the environmental test criteria outlined in Section IV of [Chapter 3](#).

2.1.4.12 Orientation. The transponder shall operate to the requirements of this performance specification standard (PSS) independent of orientation.

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

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

2.1.5 Receiver Section

2.1.5.1 Frequency Range. The tunable range shall be at least 5400 MHz to 5900 MHz, inclusive. The frequency may be either continuously adjustable or programmable in increments no greater than 1 MHz.

X-Band range is 9000 MHz to 9600 MHz inclusive.

2.1.5.2 Bandwidth. The receiver 3dB RF bandwidth shall be dependent on the number of pre-selector cavities as follows:

Two-cavity pre-selector: not less than 12 MHz and not more than 17 MHz.

Three-cavity pre-selector: not less than 6 MHz and not more than 16 MHz.

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

2.1.5.4 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 2.1.5.9](#).

2.1.5.5 Sensitivity. The transponder shall reply to 99 percent of the interrogation signals at input signal levels as specified in [paragraph 2.1.5.9](#). 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.

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

2.1.5.6.1 Pulse Width. The transponder shall accept interrogation signals of 250 ns (nanoseconds) to 1.0 μ s measured at the 50 percent amplitude points of the detected RF pulses for two-pulse code operations and 250 ns to 5.0 μ s for single-pulse operations.

2.1.5.6.2 Two-Pulse Code Spacing. Shall be adjustable either continuously or in 0.5 μ s increments, from 3.0 μ s to 15.5 μ s by external adjustment. Spacing is measured at 50 percent amplitude points on leading edges of adjacent detected RF pulses.

2.1.5.6.3 Two-Pulse Code Accept Limits. Two-pulse code spacing ± 150 ns at input signal levels as specified in [paragraph 2.1.5.9](#). The transponder shall perform to full specification to interrogations within these limits.

2.1.5.6.4 Two-Pulse Code Reject. Two-pulse code spacing ± 200 ns, positive rejection.

2.1.5.6.5 Interrogation Rejection. The transponder shall reject all signals not having the characteristics as specified in [paragraph 2.1.5.6](#) and shall not be triggered by single-pulse interrogations with durations as great as 50.0 μ s when set for a two-pulse code operation at input signal levels as specified in [paragraph 2.1.5.9](#), either on or off frequency.

2.1.5.7 Random Triggering. Not to exceed 10 pulses per second (p/s) under all specified operating conditions.

2.1.5.8 Input Impedance. The input impedance shall be 50 ohms, voltage standing wave ration (VSWR) not to exceed 2:1.

2.1.5.9 Maximum Input Signal Level.

2.1.5.9.1 20 watt: The transponder shall operate continuously within specified performance while being subjected to +20 dBm to –65 dBm, establishing a dynamic range.

2.1.5.9.2 50 watt: The transponder shall operate continuously within specified performance while being subjected to +20 dBm to –68 dBm, establishing a dynamic range.

2.1.5.9.3 400 watt: The transponder shall operate continuously within specified performance while being subjected to +20 dBm to –70 dBm, establishing a dynamic range.

2.1.6 Transmitter Section

2.1.6.1 Frequency Range. The frequency is tunable over a range of at least 5400 MHz to 5900 MHz, inclusive. The frequency may be either continuously adjustable or programmable in increments not greater than 1 MHz.

X-Band range is 9000
MHz to 9600 MHz
inclusive.

2.1.6.2 Frequency Stability:

2.1.6.2.1 20 watt: Under all operating conditions the transmitter frequency shall not drift or vary more than ± 3 MHz from the preset and initial measurement, after a three minute warm-up, and for at least 12 hours, and with temperature variations of -27°C to $+50^{\circ}\text{C}$; nor vary ± 5 MHz with temperature variations of -51°C to $+85^{\circ}\text{C}$.

2.1.6.2.2 50 watt: Under all operating conditions the transmitter frequency shall not drift or vary more than ± 3 MHz from the preset and initial measurement, after a three minute warm-up, and for at least 12 hours, and with temperature variations of -27°C to $+50^{\circ}\text{C}$; nor vary ± 5 MHz with temperature variations of -54°C to $+85^{\circ}\text{C}$.

2.1.6.2.3 400 watt: Under all operating conditions the transmitter frequency shall not drift or vary more than ± 3 MHz from the preset and initial measurement, after a three minute warm-up, and for at least 12 hours, and with temperature variations of -27°C to $+50^{\circ}\text{C}$; nor vary ± 5 MHz with temperature variations of -40°C to $+85^{\circ}\text{C}$.

2.1.6.3 Peak Power Output. The transponder shall have 20 watts, 50 watts or 400 watts minimum, peak power output, depending upon the unit under test (UUT).

2.1.6.4 Pulse Repetition Frequency (PRF). The transponder shall operate at PRF rates of 10 p/s to 2600 p/s minimum at maximum pulse width as defined by [paragraph 2.1.6.5](#).

2.1.6.4.1 PRF Over-Interrogation. A PRF limit adjustment of at least 2000 to maximum duty cycle shall be provided and accessible by access to adjustment after cover removal. Over-interrogation protection shall be provided from excessive interrogation above the set limit set by the PRF limit circuit. Recovery to specified performance from over-interrogation shall not exceed 500 μ s.

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

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

2.1.6.5.2 Rise Time. The transmitter reply pulse rise time shall not exceed 50 ns (20 and 50 watt units) or 100 ns (400 watt units) measured at 10 percent to 90 percent points.

2.1.6.5.3 Fall Time. The transmitter reply pulse fall time shall not exceed 100 ns (20 and 50 watt units) and 150 ns (400 watt units) measured at 90 percent to 10 percent points.

2.1.6.5.4 Pulse Droop. The transmitted reply pulse shall not “droop” more than 5 percent measured from the established peak amplitude to the established fall peak amplitude (reference pulse waveform definition chart, [Figure 2-4](#)).

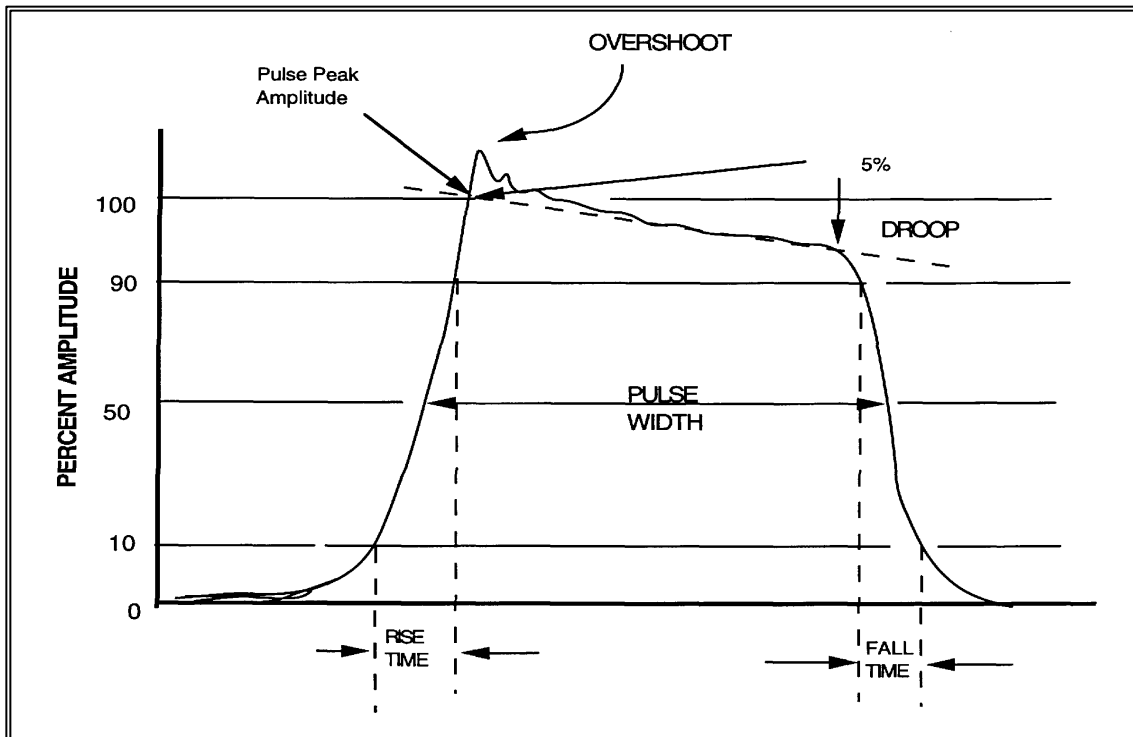


Figure 2-4. Pulse waveform definition. (Not drawn to scale.)

2.1.6.6 Transmitter Spectrum. The RF pulse spectrum measured at the 6 dB points, shall not exceed 1.7 divided by the pulse width (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 pulse width (in MHz) apart and shall be a minimum of 12 dB below the peak of the main lobe.

2.1.6.7 Load VSWR. 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 [paragraph 2.1.6.2](#).

2.1.6.8 Transponder Delay. The transponder shall have a delay from 1.5 μ s to 9.0 μ s inclusive. The delay may be continuously adjustable or programmable in increments not greater than 0.5 μ s. 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 percent point on the leading edge of the interrogating single pulse to the 50 percent 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.

2.1.6.8.1 Reply Delay Variations:

- a. Signal Strength Variation: The transponder delay shall not vary more than ± 15 ns, with input signal strengths from -10 dBm to -50 dBm, from the “set” delay, measured at -30 dBm input signal level and at a rate of 1000 p/s. For input signal levels from $+10$ dBm to -10 dBm, and -50 dBm to -65 dBm (-63 dBm for 50 watt units or -70 dBm for 400 watt units), the delay shall not vary more than ± 30 ns.
- b. 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, 2400 p/s from the “set” delay, measured at -30 dBm input signal level and at a rate of 1000 p/s.
- c. Interrogation Frequency Variation: The transponder delay shall not vary more than ± 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 p/s.
- d. Two Pulse Code Variation: The transponder delay shall not vary more than ± 15 nanoseconds, 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 p/s.
- e. 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 p/s.

- f. Temperature Variation: The transponder delay ([paragraph 2.1.6.8](#)) shall not vary more than ± 15 ns from the “set” delay over the required temperature range.
- g. Jitter: The transponder delay jitter shall not exceed 30 ns standard deviation (sd) maximum for input signal levels as specified in [paragraph 2.1.5.9](#).

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

2.1.7 Environment Requirements

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

2.1.7.1 Electromagnetic Interference (EMI). General test procedures for EMI testing are outlined in [Section III](#) of Chapter 3. The transponder shall meet the emission and susceptibility requirements of MIL-STD-461E, Methods CE102, CE106, CS101, CS103, CS104, CS114, CS115, CS116, RE102, RE103, RS101 and RS103. The test shall be performed in accordance with MIL-STD-461E and shall be accomplished in both key-up and key-down modes.

2.1.7.2 Environmental Test Procedures (ETP). Environmental test procedures are outlined in [Section IV](#) of Chapter 3. The schedule for performing these procedures is specified in [Tables 3-4A/B](#). Transponders selected for environmental testing shall meet the requirements specified in Chapter 3.

2.1.8 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.

2.1.8.1 Workmanship. Workmanship shall be in accordance with the guidance outlined in MIL-HDBK-454A, Guideline 9, 10, and 15 (to include, MIL-STD-889B ‘Dissimilar Metals’). If applicable to the design, conformal coating shall be applied to circuit boards.

2.1.8.2 Quality Assurance. The quality assurance requirement of this specification shall be met by compliance with the provisions of ISO-9000-1, ISO-9000-2, and ISO-9000-4.

2.1.8.3 Test Requirements. In addition to any inspections or tests required by the provisions specified in paragraphs 2.1 through 2.1.8.5, inclusive, vendors shall conduct performance verification tests as described in [paragraph 2.1.9](#). All test results shall be furnished to the purchasing agent in accordance with the Technical Data Requirements of the Contract, [paragraph 2.1.3](#).

2.1.8.4 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 his 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.

2.1.8.5 Failures. If a failure occurs in any of the individual Type I 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.

2.1.9 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, and 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 ETP as specified in [Chapter 3](#). No transponder shall be operated in excess of 150 hours prior to delivery without being reconditioned.

2.1.10 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.

2.1.10.1 Failures. Repair of failed equipment returned to the vendor will be accomplished according to procedures specified by 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.

2.1.10.2 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 and at no further expense to purchasing agent.

2.1.10.3 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 (IF) circuit card assembly, video amplifier and digital control assembly, power supply and modulator card assembly, RF module assembly, circulator, and internal oscillator (IO) mixer assembly.

2.1.11 Preparation For Delivery

Packaging, packing, and marking for shipment shall be as set forth in other contract documents.

CHAPTER 3

GENERAL TEST PROCEDURES FOR RADAR TRANSPONDERS

Type I Tests: Qualification Testing (Vendor's Responsibility)

Section I:	Reliability Testing
Section II:	Transmitter and Receiver Electrical Parameters
Section III:	Electromagnetic Interference Requirements
Section IV:	Environmental Test Procedures

3.1 Section I: Reliability Testing

3.1.1 Reliability Test 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 percent level of confidence, that the transponder MTBF (mean time between failures) 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 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 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 percent 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 percent chance that the reliability test will be passed.

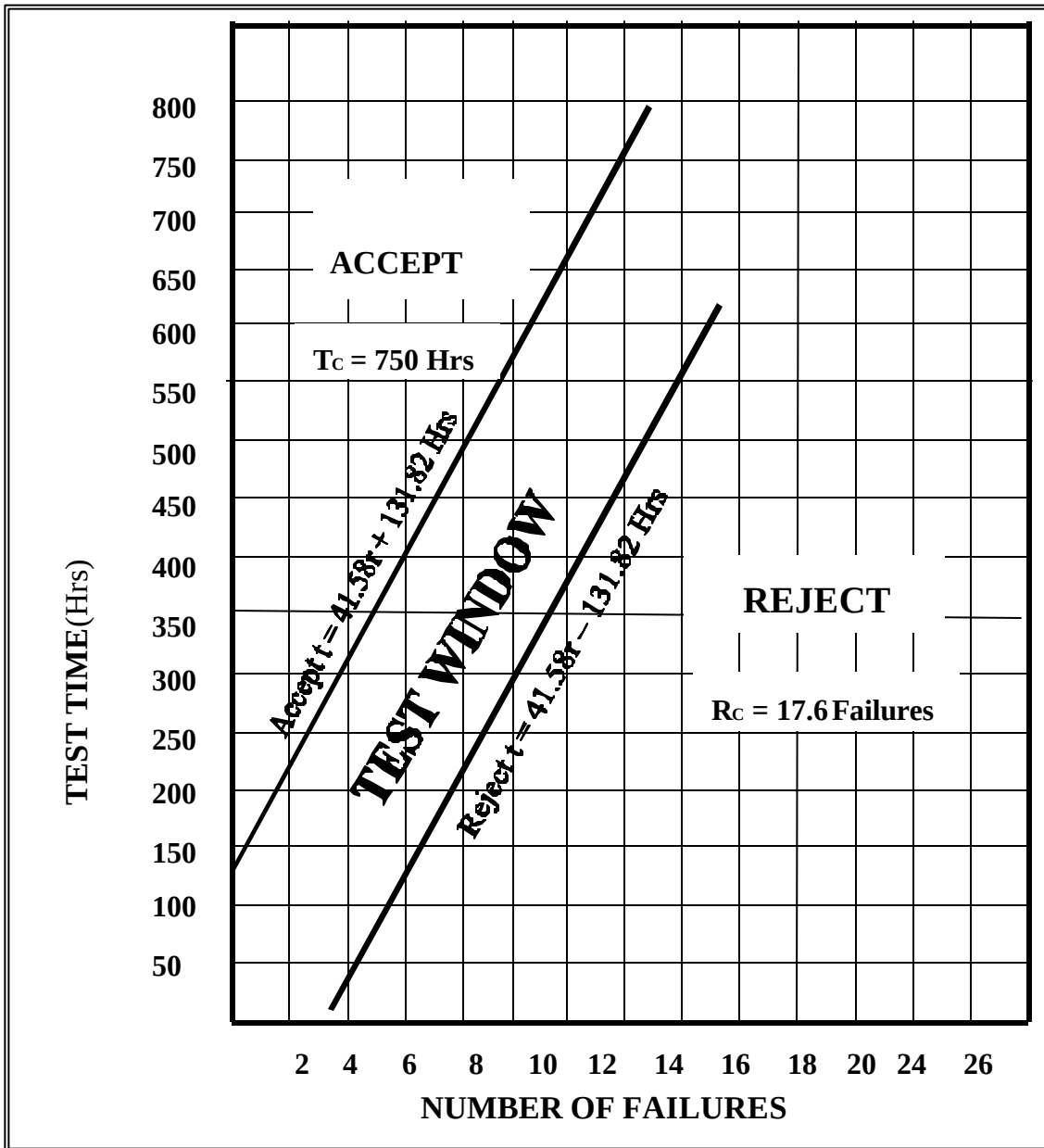


Figure 3-1. Reliability test.

With reference to Figure 3-1:

- t_a = Minimum acceptance time = 131.82 hrs
- t_r = Minimum rejection time = 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]

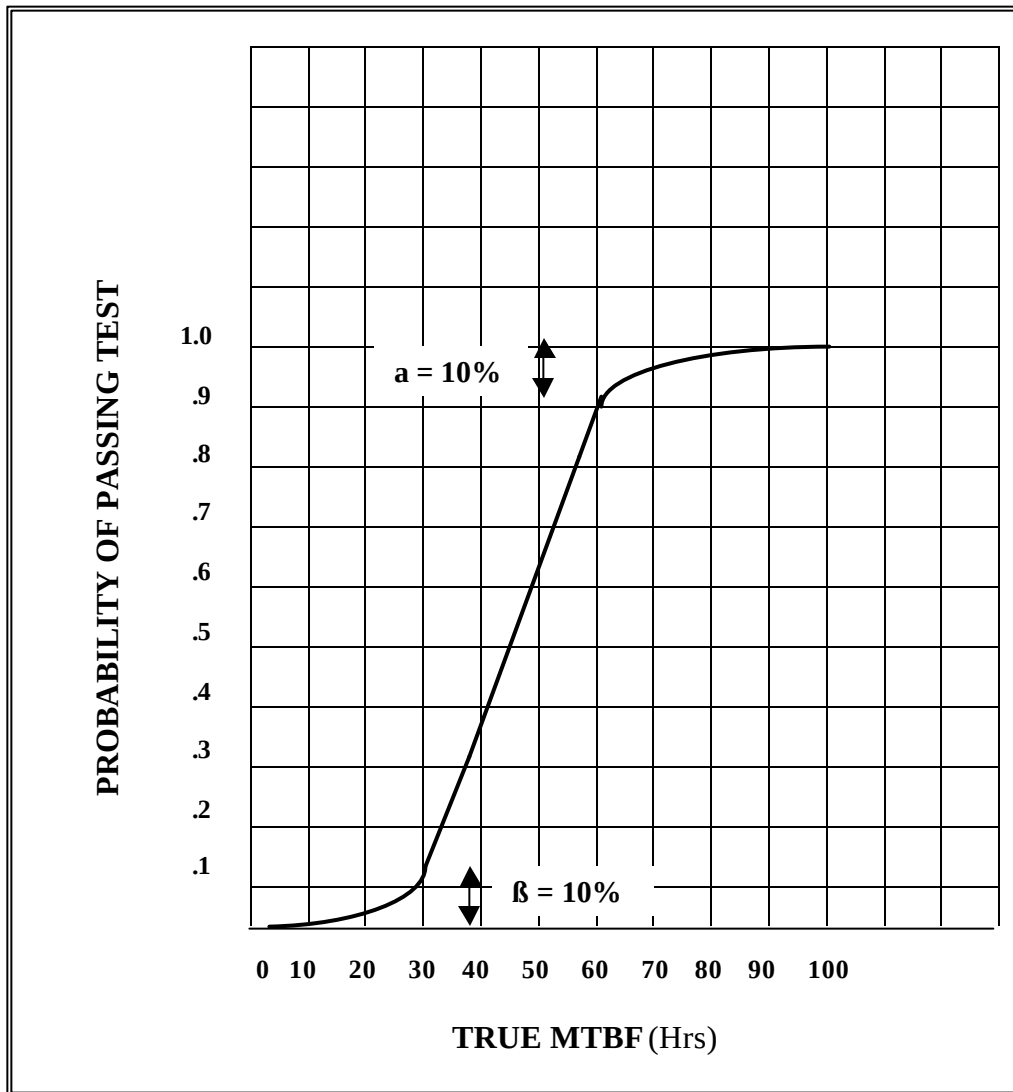


Figure 3-2. Operating characteristic curve for reliability test.

With reference to Figure 3-2:

- a = the probability (10%) that acceptable items will fail to pass the reliability test; also called “vendor’s/contractor’s risk.”
- b = the probability (10%) that unacceptable items will pass the reliability test; also called “consumer’s/government’s risk.”

3.2 Section II: Transmitter and Receiver Electrical Parameters

3.2.1 Scope

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

3.2.1.1 Applicable Documents

MIL-STD-461E, to the extent specified herein.

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 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, and 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 ETP specified in [Section IV](#) of this document. No transponder shall be operated in excess of 150 hours prior to delivery without being reconditioned.

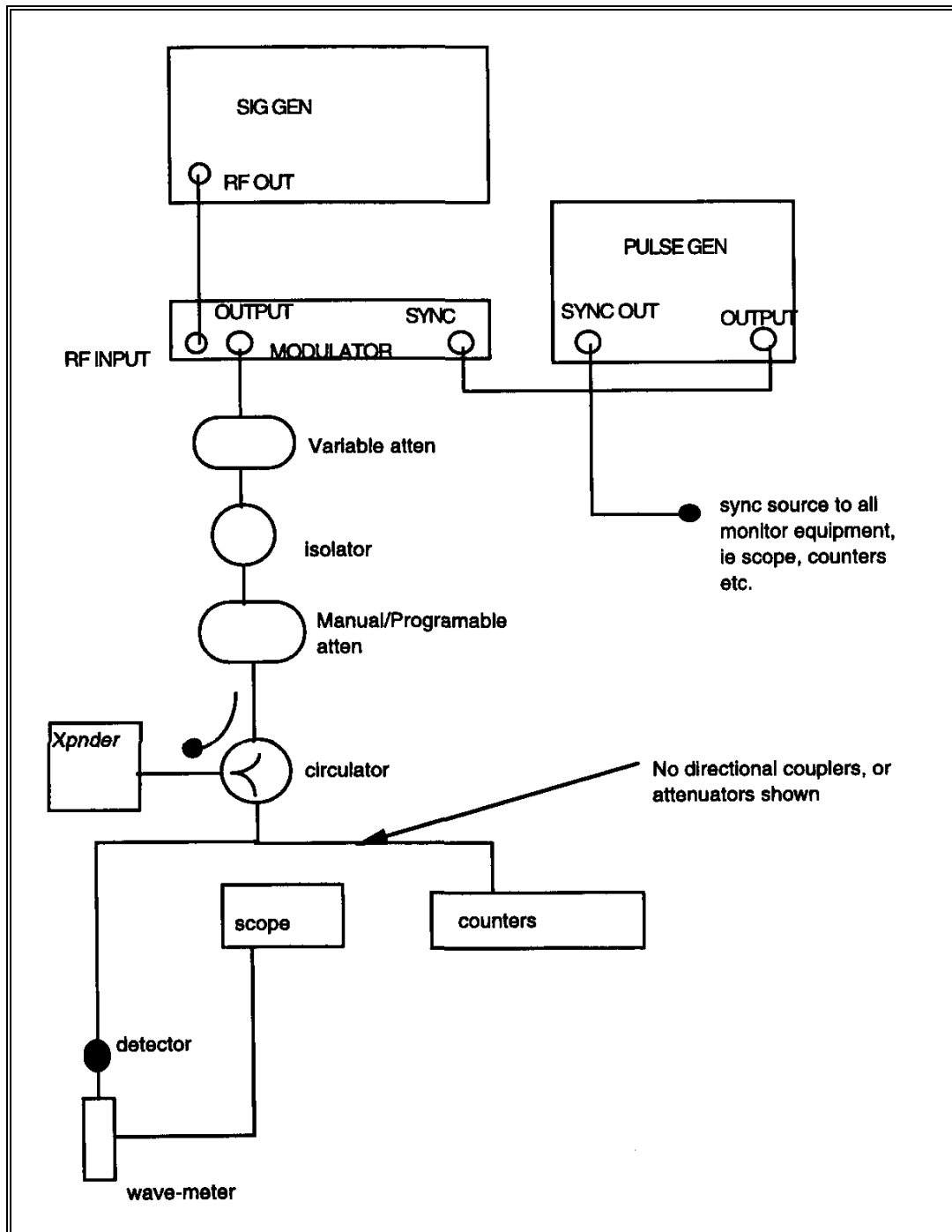


Each piece of test equipment utilized in the commission of these test procedures shall be within current calibration, and the test bench setup shall also be within current calibration. Equipment with expired calibrations must be re-calibrated prior to performing these tests. Test conditions may be modified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

TABLE 3-1. TYPE I (Qualification) TESTS (Vendor's Responsibility)	
Paragraph No.	Test Description
3.2.4	Receiver sensitivity and random triggering vs. receiver frequency
3.2.5	Receiver sensitivity vs. input pulse widths, 0.25 μ s, 0.50 μ s and 1.0 μ s
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, 3.0 μ s to 15.5 μ s codes
3.2.8	Receiver code reject test, 3.0 μ s to 15.5 μ s codes
3.2.9	Rejection of improper signals
3.2.10	Receiver bandwidth at 3 dB
3.2.11	Peak power output vs. pulse repetition frequency in 500 p/s steps through 2600 p/s
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 pulse width, pulse width 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

3.2.3 **Standard Test Set-up:** The standard test set-up is shown in Figure 3-3:



Under certain applications, a portable radar simulator may be substituted for this basic bench set-up.

3.2.4 **TEST: Receiver sensitivity and random triggering vs. receiver frequency**

a. Test Set-up: Test set-up as shown in [Figure 3-3](#).

b. Test Conditions:

- 1) Uplink frequency 5400 MHz
- 2) Interrogate with 2 pulses, 5.0 μ s leading edge to leading edge
- 3) Downlink frequency 5700 MHz
- 4) Repetition rate 1000 p/s

X-Band:
uplink: 9300 MHz;
downlink: 9100 MHz

c. Test Method:

- 1) With the transponder tuned to 5400 MHz measure the receiver sensitivity to the requirements of paragraph [2.1.5.5](#). Monitor the 99 percent response over a 10-second period.
- 2) With interrogation off, monitor for random replies, to the requirements of paragraph [2.1.5.7](#). Monitor for a 10-second period.
- 3) Repeat the steps (1) and (2) with transponder receiver frequencies of 5600 and 5900 MHz.

9300 MHz

9100 and
9500 MHz

d. Criteria: Must satisfy requirements of paragraphs [2.1.5.5](#) and [2.1.5.7](#).

3.2.5 **TEST: Receiver sensitivity vs. input pulse width**

a. Test Set-up: As shown in [Figure 3-3](#).

b. Test Conditions:

- 1) Uplink frequency 5800 MHz
- 2) Interrogate with 2 pulses, 5.0 μ s leading edge to leading edge
- 3) Downlink frequency 5700 MHz
- 4) Repetition rate 1000 p/s

X-Band:
uplink: 9300 MHz;
downlink: 9100 MHz

c. Test Method:

1. Interrogate the transponder with the above conditions with interrogate pulse widths of 0.25, 0.50, and 1.0 μ s.
 2. Record the sensitivity for each pulse width.
- d. Criteria: Must satisfy requirements of paragraphs 2.1.5.5 and 2.1.5.6.1.

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

a. Test Set-up: As shown in Figure 3-3.

b. Test Conditions:

- 1) Uplink frequency 5800 MHz
- 2) Interrogate with 2 pulses, 5.0 μ s leading edge to leading edge
- 3) Downlink frequency 5700 MHz
- 4) Repetition rate 1000 p/s

X-Band:
uplink: 9300 MHz;
downlink: 9100 MHz

c. Test Methods:

- 1) Adjust the primary dc input voltage to the transponder to 28.0 +1.0Vdc and interrogate with the above conditions.
- 2) With the transponder tuned to 5800 MHz measure the receiver sensitivity to the requirements of paragraph 2.1.5.5. Monitor the 99 percent response over a 10 second period.
- 3) With interrogation off, monitor for random replies to the requirements of paragraph 2.1.5.7. Monitor for a 10 second period.
- 4) Repeat this test for input line voltages of 22.0 (+0.5/-0) Vdc and 32.0 (+0/-0.5) Vdc without making any adjustments to the transponder.

9300 MHz

d. Criteria: Must satisfy requirements of paragraphs 2.1.1.2, 2.1.5.5 and 2.1.5.7.

3.2.7 **TEST: Receiver code accept/reject limits**

a. Test Set-up: As shown in Figure 3-3.

b. Test Conditions:

- 1) Uplink frequency 5800 MHz
- 2) Interrogate with 2 pulses, 5.0 μ s leading edge to leading edge (test method will vary interrogation code)
- 3) Downlink frequency 5700 MHz

X-Band:
uplink: 9300 MHz;
downlink: 9100 MHz

- 4) Repetition rate 1000 p/s

c. Test Methods:

- 1) Adjust the input signal to 0 dBm and the code to $3.0 \pm 0.05 \mu\text{s}$.
- 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 percent 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 $3.0 \mu\text{s}$ and $15.0 \mu\text{s}$; record results on data sheet.

- d. Criteria: Must satisfy paragraphs 2.1.5.6 thru 2.1.5.6.4.

3.2.8 **TEST: Receiver code reject test, random triggering:**

- a. Test Set-up: As shown in [Figure 3-3](#).

b. Test Conditions:

- 1) Uplink frequency 5800 MHz
- 2) Interrogate with 2 pulses, $3.0 \mu\text{s}$ leading edge to leading edge (test method will vary interrogation code spacing and pulse width)
- 3) Downlink frequency 5700 MHz
- 4) Repetition rate 1000 p/s

X-Band: uplink: 9300 MHz; downlink: 9100 MHz
--

c. Test Methods:

- 1) Apply a double pulse code spacing of $3.0 \mu\text{s}$, signal level of 0 dBm. Repeat for the following codes: 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0, 11.0, 12.0, 13.0, 14.0, 15.0, and $15.5 \mu\text{s}$.
- 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 pulse width from 3.0 to 50.0 μ s while monitoring random replies.
 - 4) Record any random replies.
- d. Criteria: Must satisfy paragraph 2.1.5.7.

3.2.9 **TEST: Rejection of improper signals**

a. Test Set-up: As shown in Figure 3-3.

b. Test Conditions:

- 1) Uplink frequency 5800 MHz.
- 2) Interrogate with 2 pulses, 5.0 μ s leading edge to leading edge.
- 3) Downlink frequency 5700 MHz.
- 4) Repetition rate 1000 p/s.

X-Band:
uplink: 9300 MHz;
downlink: 9100 MHz

c. Test Methods:

- 1) Adjust the receiver for proper coded operation.
- 2) Set the RF generator modulation to provide a continuous wave (CW) 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 p/s and RF frequency at which the increase occurs.

$9000 - 9600$ MHz

d. Criteria: Must satisfy paragraph 2.1.5.7.

3.2.10 **TEST: Receiver bandwidth at 3 dB**

(i.e., selectivity curves at 5400 , 5600 and 5900 MHz)

a. Test Set-up: As shown in Figure 3-3.

b. Test Conditions:

9000 , 9300
and 9600 MHz

- 1) Uplink frequency 5400 MHz; test method will vary receiver frequency
- 2) Interrogate with 2 pulses, 5.0 μ s leading edge to leading edge
- 3) Downlink frequency 5700 MHz
- 4) Repetition rate 1000 p/s

X-Band:
uplink: 9300 MHz;
downlink: 9100 MHz

c. Test Methods:

- 1) Adjust the signal generator to the receiver center frequency; adjust the level until the PRF counter reads 990 p/s 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 p/s. 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 p/s. Measure the signal generator frequency and record this as the *lower 3dB 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 [2.1.5.2](#).

3.2.11 **TEST: Peak power output vs. PRF in 500 p/s steps 100-2600 p/s**

a. Test Set-up: As shown in [Figure 3-3](#).

b. Test Conditions:

- 1) Uplink frequency 5800 MHz
- 2) Interrogate with 2 pulses, 5.0 μ s leading edge to leading edge
- 3) Downlink frequency 5700 MHz
- 4) Repetition rate 1000 p/s (test method will vary PRF rate)

X-Band:
uplink: 9300 MHz;
downlink: 9100 MHz

c. Test Method:

- 1) Adjust input PRF in steps from 100 to 2600 p/s. With input PRF set to 100 p/s, measure pulse width (PW) and average power.
 - 2) Calculate peak power using formula: $\text{peak power} = \frac{\text{P average (attenuation in dB)}}{\text{PRF} \cdot \text{PW}}$
 - 3) Record results for each PRF specified.
- d. Criteria: Must satisfy paragraph 2.1.6.3.

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

9000 to 9600 MHz

a. Test Set-up: As shown in Figure 3-3.

b. Test Conditions:

- 1) Input voltage 28.0 ± 1.0 volts
- 2) Uplink frequency 5800 MHz
- 3) Downlink frequency 5400 MHz
- 4) Repetition rate 1000 p/s

X-Band:
uplink: 9300 MHz;
downlink: 9100 MHz

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 2.1.6.3.

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

a. Test Set-up: As shown in Figure 3-3.

b. Test Conditions:

- 1) Uplink frequency 5800 MHz
- 2) Interrogate with 2 pulses, 5.0 μ s leading edge to leading edge

X-Band:
uplink: 9300 MHz;
downlink: 9100 MHz

- 3) Downlink frequency 5700 MHz
- 4) Repetition rate 1000 p/s
- c. Test Methods:
 - 1) Interrogate transponder with above conditions, monitor reply.
 - 2) Apply a second interrogation pulse group at approximately 100 μ s 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 [2.1.6.9](#).

3.2.14 **TEST: Transmitter frequency vs. pulse repetition frequency (PRF)**

- a. Test Set-up: As shown in [Figure 3-3](#).
- b. Test Conditions:
 - 1) Uplink frequency 5800 MHz
 - 2) Interrogate with 2 pulses, 5.0 μ s leading edge to leading edge
 - 3) Downlink frequency 5700 MHz
 - 4) Repetition rate 1000 p/s

X-Band:
uplink: 9300 MHz;
downlink: 9100 MHz

- c. Test Methods:
 - 1) Measure the transmitter frequency at 1000 p/s.
 - 2) Record frequency and distinguish measurement.
 - 3) Change PRF to 160 p/s and measure transmitter frequency and record.
 - 4) Repeat step (3) for PRFs of 320, 640 and 1280 and 2600 p/s.
- d. Criteria: Must satisfy paragraphs [2.1.6.2](#), [2.1.6.4](#) and [2.1.6.4.1](#).

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

- a. Test Set-up: As shown in [Figure 3-3](#).
- b. Test Conditions:

- 1) Uplink frequency 5800 MHz
- 2) Interrogate with 2 pulses, 5.0 μ s leading edge to leading edge
- 3) Downlink frequency 5700 MHz
- 4) Repetition rate 1000 p/s

X-Band:
uplink: 9300 MHz;
downlink: 9100 MHz

Double pulse code, time measurements taken at the 50 percent amplitude point of the second interrogate pulse leading edge and the detected reply pulse.

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 paragraphs 2.1.6.8 through 2.1.6.8.1.

3.2.16 **TEST: Delay and delay jitter vs. line voltage**

a. Test Set-up: As shown in [Figure 3-3](#).

b. Test Conditions:

- 1) Uplink frequency 5800 MHz
- 2) Interrogate with 2 pulses, 5.0 μ s leading edge to leading edge
- 3) Downlink frequency 5700 MHz
- 4) Repetition rate 1000 p/s

X-Band:
uplink: 9300 MHz;
downlink: 9100 MHz

c. Test Methods:

- 1) With the transponder input voltage at 22.0 ± 0.5 volts.
- 2) Establish the transmitted reply delay at 0 dBm and with the above conditions.
- 3) Record this spacing as the *fixed delay time at 22.0 volts*.
- 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 ± 0.5 volts.
- 7) Repeat steps (2) and (3). Record the *fixed delay time at 32.0 volts*.
- 8) Repeat steps (4) and (5). Record the *delay jitter at 32.0 volts*.

d. Criteria: Must satisfy paragraphs [2.1.1.2](#), and [2.1.6.8](#) through 2.1.6.8.1.

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

a. Test Set-up: As shown in [Figure 3-3](#).

b. Test Conditions:

- 1) Uplink frequency 5800 MHz
- 2) Interrogate with 2 pulses, $5.0 \mu\text{s}$ leading edge to leading edge
- 3) Downlink frequency 5700 MHz
- 4) Repetition rate 1000 p/s

X-Band: uplink: 9300 MHz; downlink: 9100 MHz
--

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 No. 1.
- 3) Adjust pulse source No. 2 to provide a second $5.0 \mu\text{s}$ pulse group $5.0 \mu\text{s}$ apart.
- 4) Adjust the RF signal generator No.1 for a 0 dBm level at the transponder RF input.
- 5) Adjust RF signal source No. 2 for a -65 dBm (20 W), -68 dBm (50W) or

–70 dBm level (400W) 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 [2.1.6.9](#).

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

a. Test Set-up: As shown in [Figure 3-3](#).

b. Test Conditions:

- 1) Uplink frequency 5800 MHz
- 2) Interrogate with 2 pulses, 5.0 μ s leading edge to leading edge
- 3) Downlink frequency 5700 MHz
- 4) Repetition rate 1000 p/s

X-Band:
uplink: 9300 MHz;
downlink: 9100 MHz

c. Test Methods:

- 1) Measure and record detected *reply pulse width* at the above conditions.
- 2) Measure and record the *transmitted pulse width 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.

9000, 9300 and 9600 MHz

d. Criteria: Must satisfy the requirements of paragraphs [2.1.6.5](#) through [2.1.6.5.4](#), as they apply.

3.2.19 TEST: Transmitter RF spectrum

a. Test Set-up: As shown in [Figure 3-3](#).

b. Test Conditions:

- 1) Uplink frequency 5800 MHz

X-Band:
uplink: 9300 MHz;
downlink: 9100 MHz

- 2) Interrogate with 2 pulses, 5.0 μ s leading edge to leading edge
 - 3) Downlink frequency 5700 MHz
 - 4) Repetition rate 1000 p/s
- 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 [2.1.6.6](#).

3.2.20 **TEST: Over-interrogation**

- a. Test Set-up: As shown in [Figure 3-3](#).
- b. Test Conditions:
- 1) Uplink frequency 5800 MHz
 - 2) Interrogate with 2 pulses, 5.0 μ s leading edge to leading edge
 - 3) Downlink frequency 5700 MHz
 - 4) Repetition rate 1000 p/s
- X-Band:
uplink: 9300 MHz;
downlink: 9100 MHz
- c. Test Methods:
- 1) Apply double pulse code at 5000 p/s.
 - 2) Adjust the pulse source for an output PRF of 5000 p/s. Observe the reply PRF on the counter, it should read 2750 ± 50 p/s. This is to allow the transponder to operate up to 2600 p/s under all conditions.
 - 3) Record *reply PRF* on data sheet.
- d. Criteria: Must satisfy the requirements of the paragraphs [2.1.6.4](#) and [2.1.6.4.1](#).

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

a. Test Set-up: As shown in [Figure 3-3](#).

b. Test Conditions:

- 1) Uplink frequency 5800 MHz
- 2) Interrogate with 2 pulses, 5.0 μ s leading edge to leading edge.
- 3) Downlink frequency 5700 MHz
- 4) Repetition rate 1000 p/s

X-Band: uplink: 9300 MHz; downlink: 9100 MHz
--

c. Test Methods:

- 1) Apply an interrogation signal at a PRF of 2600 p/s. Adjust input line voltage to 32.0 volts. Monitor input current on current meter.
- 2) Apply an interrogation signal at 1000 p/s. Adjust the input line voltage to 28.0 volts. Monitor the current on current meter.
- 3) Measure and record transponder *power consumption*.

d. Criteria: Must satisfy the requirements of paragraph [2.1.1.4](#).

3.2.22 **TEST: Pressurization**

a. Test Set-up:

- 1) Have a supply of 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 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 the paragraph [2.1.4.8](#).

3.3 Section III: Electromagnetic Interference (EMI) Requirements

3.3.1 Test Procedure

All calibration requirements identified in MIL-STD-461E 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 set-up is described in Chapter 3, [Figure 3-3](#).

3.3.4 Test Conditions

3.3.4.1 Electrical:

- a. Transmitter frequency: 5700 $\pm$ 3 MHz
- b. Receiver frequency: 5800 $\pm$ 2 MHz
- c. Code spacing: 5.0 $\pm$ 0.2 μ s
- d. Fixed delay: 2.5 $\pm$ 0.1 μ s
- e. DC input voltage: 28.0 $\pm$ 1.0 Vdc
- f. Receiver sensitivity setting: Set to upper limit as specified in paragraph [2.1.5.5](#) (sensitivity)
- 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 $\pm$ 0.5 inches from the edge of the ground plane.
- j. Equipment warm-up time: 15 minutes minimum

9100 $\pm$ 3 MHz 9300 $\pm$ 2 MHz

3.3.4.2 Environmental:

- a. Ambient temperature: 67°F $\pm$ 15°F
- b. Humidity: less than 100 percent

- 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 following tests 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 (EMI) TESTS		
Paragraph No.	Requirement No. (per MIL-STD-461E)	Test Description
3.3.7	Requirement CE102	Conducted emissions (CE), power leads
3.3.8	Requirement CE106	Conducted emissions, antenna terminal
3.3.9	Requirement CS101	Conducted susceptibility (CS), 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 (RE), electric field
3.3.16	Requirement RE103	Radiated emissions, antenna spurious and harmonic outputs
3.3.17	Requirement RS101	Radiated susceptibility (RS), magnetic field
3.3.18	Requirement RS103	Radiated susceptibility, electric field

3.3.6 Test Equipment

The following list of typical test equipment is 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 shall be within current calibration and the test bench setup shall also 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 kHz to 10 MHz)

- a. Test Set-up: As shown in [Figure 3-3](#) of this document, and paragraph 5.5, and Figure CE102-2 and CE102-3 of MIL-STD-461E, as applicable, or equivalent test set-up.
- b. Test Conditions: Per [paragraph 3.3.4](#) of this section, and paragraphs 5.5, 50.5 (Appendix) of requirement CE102 of MIL-STD-461E. The positive and negative input dc power leads of the unit under test (UUT) will be tested in the interrogate and uninterrogate mode for worst-case conducted emissions interference. The input power line determined to be the worst case will be tested from 10kHz to 10 MHz.
- c. Test Method: As per MIL-STD 461E, CE 102.
- d. Criteria: Determine that the level of noted conducted emissions does not exceed the maximum limits as stated in paragraph 5.5.2 and Figure CE102-1 of MIL-STD-461E.

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

- a. Test Set-up: As shown in [Figure 3-3](#) of this document, and paragraph 5.6, Figures CE106-1, CE106-2, and CE106-3 of MIL-STD-461E or equivalent test set-up.
- b. Test Conditions: Per [paragraph 3.3.4](#) of this section, and paragraphs 5.6, 50.6 (Appendix) of requirement CE106 of MIL-STD-461E. The UUT will be tested in the interrogate and uninterrogate mode from 10 kHz to 40 GHz and verified within limits of CE106.
- c. Test Method: As per MIL-STD 461E, CE106.
- d. Criteria: Harmonic and all other spurious emissions shall meet provisions as stated in paragraph 5.6.3.5 and paragraph 50.6 (Appendix) of MIL-STD-461E. This limit does not apply to the transmitter's specified emission bandwidth.

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

- a. Test Set-up: Per [Figure 3-3](#) of this document, and paragraph 5.7 and Figures CS101-4, CS101-5 and CS101-6 of MIL-STD-461E, or equivalent test set-up.
- b. Test Conditions: Per [paragraph 3.3.4](#) of this section, and paragraphs 5.7, 50.7 (Appendix) of requirement CS101 of MIL-STD-461E.

- c. Test Method: Per paragraph 5.7.3.4(c) of requirement CS101 of MIL-STD-461E.
- d. Criteria: If susceptibility is noted, determine the threshold level in accordance with paragraph 4.3.10.4.3 of MIL-STD-461E 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 Set-up: Per [Figure 3-3](#) of this document, and paragraph 50.8, Figure A-6, (Appendix) of MIL-STD-461E, or equivalent test set-up.
- b. Test Conditions: Per [paragraph 3.3.4](#) of this section, and paragraphs 5.8 and 50.8 (Appendix) of requirement CS103 of MIL-STD-461E. The test will be performed in the uninterrogate mode only. The transmitter may be disabled and the SCR Gate monitored during this test, if necessary.
- c. Test Method: As per MIL-STD 461E, Requirement CS103.
- d. Criteria: Any random triggering of the transponder exceeding 10 p/s is criteria for rejection.

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

- a. Test Set-up: Per [Figure 3-3](#) of this document, and paragraph 50.9, Figure A-7 (Appendix) of MIL-STD-461E, or equivalent test set-up.
- b. Test Conditions: Per [paragraph 3.3.4](#) of this section, and requirement CS104 of MIL-STD-461E. The UUT will be tested in the interrogate and uninterrogate mode.
- c. Test Method: As per MIL-STD 461E, CS104.
- d. Criteria: All random triggering of the transponder exceeding 10 p/s is criteria for rejection.

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

- a. Test Set-up: Per [Figure 3-3](#) of this document, and paragraph 5.12 and Figure CS114-4 of MIL-STD-461E, or equivalent test set-up.
- b. Test Conditions: Per [paragraph 3.3.4](#) of this section, and paragraphs 5.12, 50.12 (Appendix) of requirement CS114 of MIL-STD-461E.

- c. Test Method: Per paragraph 5.12.3.4(c) of requirement CS114 of MIL-STD-461E.
- d. Criteria: If susceptibility is noted, determine the threshold level in accordance with paragraph 4.3.10.4.3 of MIL-STD-461E and verify that it is above the limit.

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

- a. Test Set-up: Per [Figure 3-3](#) of this document, and paragraph 5.13 and Figure CS115-3 of MIL-STD-461E, as applicable.
- b. Test Conditions: Per [paragraph 3.3.4](#) of this section, and paragraphs 5.13, 50.13 (Appendix) of requirement CS115 of MIL-STD-461E.
- c. Test Method: Per paragraph 5.13.3.4 of requirement CS115 of MIL-STD-461E.
- d. Criteria: Per paragraph 5.13.3.5 of requirement CS115 of MIL-STD-461E.

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

- a. Test Set-up: Per [Figure 3-3](#) of this document, and paragraph 5.14 and Figure CS116-4 of MIL-STD-461E, or equivalent test set-up.
- b. Test Conditions: Per [paragraph 3.3.4](#) of this section, and paragraphs 5.14 and 50.14 (Appendix) of requirement CS116 of MIL-STD-461E.
- c. Test Method: Per paragraph 5.14.3.4(c) of requirement CS116 of MIL-STD-461E
- d. Criteria: If susceptibility is noted, determine the threshold level in accordance with 4.3.10.4.3 of MIL-STD-461E 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 Set-up: Per [Figure 3-3](#) of this document, and paragraph 5.16 and Figure RE102-5 of MIL-STD-461E, or equivalent test setup.
- b. Test Conditions: Per [paragraph 3.3.4](#) of this section, and paragraphs 5.16, 50.16 (Appendix) of requirement RE102 of MIL-STD-461E. 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 paragraph 5.16.3.4 of requirement RE102 of MIL-STD-461E. The acceptance/rejection criteria are located in Figures RE102-1 through RE102-4.

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

- a. Test Set-up: Per [Figure 3-3](#) of this document, and paragraph 5.17, Figures RE103-1, RE103-2 of MIL-STD-461E.
- b. Test Conditions: Per [paragraph 3.3.4](#) of this section, and paragraphs 5.17, 50.17 (Appendix) of requirement RE103 of MIL-STD-461E. This test will be performed in the interrogate mode. All random triggering or misfiring of the UUT exceeding 10 p/s is criteria for rejection.
- c. Test Method: Per paragraph 5.17.3.4 of requirement RE103 of MIL-STD-461E.
- d. Criteria: As per requirement RE103 of MIL-STD-461E.

3.3.17 **TEST: Requirement RS101: Radiated susceptibility, magnetic field** (30 Hz to 100 kHz)

- a. Test Set-up: Per [Figure 3-3](#) of this document, and paragraph 5.18, Figures RS101-1, RS101-2 of MIL-STD-461E.
- b. Test Conditions: Per [paragraph 3.3.4](#) of this section, and paragraphs 5.18, 50.18 (Appendix) of requirement RS101 of MIL-STD-461E. This test will be performed in the interrogate mode.
- c. Test Method: Per paragraph 5.18.3.4 of requirement RS101 of MIL-STD-461E.
- d. Criteria: The transponder's reply pulse will be monitored. All random triggering or misfiring of the transponder exceeding ten pulses per minute is criteria for rejection.

3.3.18 **TEST: Requirement RS103: Radiated susceptibility, electric field** (2 MHz to 40 GHz)

- a. Test Set-up: Per [Figure 3-3](#) of this document, and paragraph 5.19, Figures RS103-1, RS103-2, RS103-3 and RS103-4 of MIL-STD-461E.
- b. Test Conditions: Per [paragraph 3.3.4](#) of this section, and paragraphs 5.19, 50.19 (Appendix) of requirement RS103 of MIL-STD-461E. The UUT will be tested in the interrogate and uninterrogate modes.
- c. Test Method: Per paragraph 5.19.3.4 of requirement RS103 of MIL-STD-461E
- d. Criteria: The transponder's reply pulse will be monitored. All random triggering or misfiring of the transponder exceeding ten pulses per minute is criteria for rejection.

3.4 Section IV: Environmental Testing Procedures

3.4.1 Introduction

3.4.1.1 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.

3.4.1.2 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.**

3.4.2 Applicable Documents^{5 6 7}

3.4.2.1 Documents of Issue

The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this standard to the extent specified herein:

3.4.2.1.1 Standards and Specifications:

MIL-S-901D: Requirements for Shock Tests, HI. (High Impact), Shipboard Machinery, Equipment and Systems

FED-STD-101C (3): Test Procedures for Packaging Materials

MIL-STD-167/1: Mechanical Vibrations of Shipboard Equipment

MIL-HDBK-310: Global Climatic Data for Developing Military Products

MIL-A-8591H: General Design Criteria for Airborne Stores, Suspension Equipment and Aircraft-Store Interface (Carriage Phase)

ISO 10012-1: Quality Assurance Requirements for Measuring Equipment (Part 1, "Meteorological Confirmation System for Measuring Equipment")⁸

⁵ Copies of specifications, standards, drawings and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.

⁶ Military Specifications and Standards may be available through Global Engineering Documents, California (800) 854-7179 or Document Center, Belmont, CA. Tel No. (415) 591-7600.

⁷ Documents may also be available through ASSIST (<http://assist/daps/mil>).

⁸ See Note 2, p.1-2.

3.4.2.1.2 Other Publications:

American Society for Testing and Materials (ASTM):⁹

ASTM-E-491-73 (1999): Standard Practice for Solar Simulation for Thermal Balance Testing of Spacecraft

National Conference of Standards Laboratories (NCSL):¹⁰

ANSI-NCSL-Z540.1 (1994): Calibration Laboratories and Measuring and Test Equipment, General Requirements

American National Standards Institute (ANSI):¹¹

ANSI-S1.1: (1994) Acoustical Terminology (including mechanical shock and vibration)



The following test methods, figures and tables are derived from MIL-STD 810C/E (canceled).

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:

Temperature:	23° ±10°C (73° ±18°F)
Relative humidity:	50 percent ±30 percent
Atmospheric pressure:	725 +50/−75 mm Hg (28.5 +2.0/−3.0 in. Hg)

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

Temperature:	23° ±1.4° C (73° ±2.5° F)
Relative humidity:	50 percent ±5 percent
Atmospheric pressure:	725 +50/−75 mm Hg (28.5 +2.0/−3.0 in. Hg)

⁹ Application for copies should be addressed to the American Society for Testing and Materials (ASTM), 1916 Race Street, Philadelphia, Pennsylvania 19103-1187 (215-299-5585) or www.astm.org.

¹⁰ National Conference of Standards Laboratories (NCSL) or www.ncsli.org.

¹¹ American National Standards Institute (ANSI), 25 W. 42nd St., NY, NY 10036 or www.ansi.org.

3.4.3.1.1 Measurement of Test Conditions. All measurements of test conditions shall be made with instruments of the accuracy specified in [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 $\pm 1.4^{\circ}\text{C}$ ($\pm 2.5^{\circ}\text{F}$). 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 percent or ± 1.5 mm (0.059 inch) of mercury, whichever provides the greatest accuracy. When measured by devices such as ion gages, ± 10 percent to 10^{-5} torr.
- c. Relative humidity at the control sensor: ± 5 percent
- d. Vibration amplitude: sinusoidal: ± 10 percent
random: See test [paragraph 3.4.5.6](#).
- e. Vibration frequency: ± 2 percent, or $\pm 1/2$ Hz below 25 Hz
- f. Acceleration: ± 10 percent



(T) is the time required for the sensing system to respond to 62.3 percent 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 10012-1 and ANSI-NCSL-Z540-1 to the satisfaction of the procuring activity. All instruments and test equipment used in conducting the tests specified herein shall:

- a. Conform to laboratory standards whose calibration is traceable to the prime standards at the U.S. National Institute of Standards and Technology (NIST).
- 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 2.0°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 2.0°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 paragraph 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 specified 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 in accordance with the equipment specification and the results shall be compared with the pretest data obtained in accordance with paragraph 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 [paragraph 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 [paragraph 3.4.3.2.1](#) (record to be made after test)



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

- f. Any additional deviations from acceptable criteria established before the test and recorded according to [paragraph 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 Test Facilities and Apparatus

Test facilities, chambers, and apparatus used in conducting the tests contained in this standard shall be capable of meeting the conditions required.

3.4.3.3.1 Test Chamber.

- 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

Where specified that a functional test is to be performed prior to or after an operating cycle in any of the following methods or procedures, refer to the following test conditions and list of parameters to be tested.

3.4.3.5.1 Test Conditions:

- a. Receiver frequency: 5800 ± 2 MHz
- b. Transmitter frequency: 5700 ± 3 MHz
- c. Code spacing: 5.0 ± 0.15 μ s
- d. PRF: 1000 ± 10 p/s

Receiver: 9150 ± 2 MHz Transmitter: 9300 ± 3 MHz

3.4.3.5.2 Pre/Post Functional Test Parameters:

- a. Receiver sensitivity: (see [paragraph 2.1.5.5](#))
- b. Receiver 3dB bandwidth: (see [paragraph 2.1.5.2](#))
- c. Receiver center frequency: 5800 ± 2 MHz
- d. Receiver code accept/reject limits: (see [paragraph 2.1.5.6](#))

R = 9150 ± 2 MHz

- e. Random triggering: (see [paragraph 2.1.5.7](#))
- f. Transmitter frequency: 5700 ± 3 MHz
- g. Transmitter pulse width: (see [paragraph 2.1.6.5](#))
- h. Transmitter peak power: (see [paragraph 2.1.6.3](#))
- i. Transponder fixed delay: (see [paragraph 2.1.6.8](#))

$T = 9300 \pm 3 \text{ MHz}$

3.4.4 Test Sequence

See Tables 3-4A and 3-4B for the recommended test sequence.

TABLE 3-4A. RECOMMENDED TEST SEQUENCE: Group I (Read down)					
Test Method	Group I (See Notes 1 and 2)				
	A	B	C	D	E
3.4.5.1 Temperature- Shock	1 ¹	1 ¹	1 ¹	1 ¹	1 ¹
3.4.5.2 Temperature-Altitude	--	--	--	--	--
3.4.5.3 Humidity	2	2	2	4	4
3.4.5.4 Salt Fog	3 ¹	3	3	5 ¹	5
3.4.5.5 Acceleration	--	--	--	--	--
3.4.5.6 Vibration	5	5	5	3	3
3.4.5.7 Acoustic Noise	--	--	--	--	--
3.4.5.8 Shock	4	4	4	2	2

Note 1: 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)

Note 2: Test sequence is given in 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

TABLE 3-4B. RECOMMENDED TEST SEQUENCE: Group II (Read down)										
Test Method	Group II (See Notes 1 and 2)									
	a	b	c	d	e	f	g	h	i	j
3.4.5.1 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}
3.4.5.2 Temperature-Altitude	2 ⁵	1 ⁵	1 ⁵	1 ⁵	2 ^{1,2,5}	1 ⁵	2 ⁵	2 ⁵	1 ⁵	1 ⁵
3.4.5.3 Humidity	3	3 ¹	3	3	3	3	3	3	3 ¹	6
3.4.5.4 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}
3.4.5.5 Acceleration	5	5	5	5	5	5	5	5	5	3
3.4.5.6 Vibration	7	7	7	7	7	7	6	7	7	5
3.4.5.7 Acoustic Noise	8 ^{1,4}	8 ^{1,4}	8 ^{1,4}	8	8	8	8 ¹	8	8	8
3.4.5.8 Shock	6	6	6	6	6	6	7	6	6	4

Note 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

Note 2: Test sequence is given in 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

3.4.4.9 Notes on International Applications

3.4.4.9.1 Worldwide Climatic Environmental Conditions. These are enumerated in MIL-HDBK-310, Global Climatic Data for Developing Military Products. Document ASTM E491-73,¹² Standard Recommended Practice for Solar Simulation for Thermal Balance Testing of Spacecraft, lists specific solar simulation techniques.

3.4.4.9.2 International Standardization Agreement. Certain provisions of this standard are subject to international standardization agreement STANAG 3518 AE, Environmental Test Methods (1990).¹³ When amendment, revision, or cancellation of this standard is proposed which affects or violates the international agreement concerned, the preparing activity will take appropriate reconciliation action through international standardization channels including departmental standardization offices, if required.

3.4.5 Environmental Test Methods

3.4.5.1 TEST: Temperature Shock

3.4.5.1.1 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 watt, 50 watt, and 400 watt transponders as specified in [Table 3-5](#).

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

3.4.5.1.3 Apparatus. Two temperature chambers (hot and cold) with associated controls and monitors.

3.4.5.1.4 Procedure:



Where functional testing is specified prior to or following a procedure, refer to General Requirements, paragraph [3.4.3.5](#).

¹²See note 9, p.3-21.

¹³ STANAGS are available from the Department of Defense Single Source Stock Point, 700 Robbins Ave., Bldg. 4D, Philadelphia, PA 19111-5094 (telephone 215-697-2179).

3.4.5.1.4.1 Method: Prepare the test item in accordance with [General Requirements 3.4.3.2](#). Perform pre-functional test and verify operation is satisfactory. Measure and record. 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 unit under test. 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 unit under test. 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, within 5 minutes be returned to the “HOT” chamber with an internal chamber temperature as specified for the unit under test. 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 $+22^{\circ}\text{C} \pm 3^{\circ}\text{C}$ and stabilize.

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

TABLE 3-5. TEST CHAMBER TEMPERATURES			
Temperature Chamber	Equipment in Non-Operating Mode		
	20 watt	50 watt	400 watt
Hot	$+85^{\circ}\text{C} \pm 2^{\circ}\text{C}$	$+85^{\circ}\text{C} \pm 2^{\circ}\text{C}$	$+85^{\circ}\text{C} \pm 2^{\circ}\text{C}$
Cold	$-51^{\circ}\text{C} \pm 2^{\circ}\text{C}$	$-54^{\circ}\text{C} \pm 2^{\circ}\text{C}$	$-40^{\circ}\text{C} \pm 2^{\circ}\text{C}$

3.4.5.1.4.2 Summary: The following details shall be specified in the equipment specification:

- Pretest data required
- Failure criteria

3.4.5.2 **TEST: Temperature-Altitude**

3.4.5.2.1 **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 3-6](#).

3.4.5.2.2 **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 which 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.

3.4.5.2.2 **Apparatus**: Temperature-altitude chamber and auxiliary thermal sensors with associated recording devices (see 3.4.5.2.4.2 [note a](#)).

3.4.5.2.4 **Procedure**:



When functional testing is specified prior to or following a procedure, refer to General Requirements, [3.4.3.5](#).

3.4.5.2.4.1 **Procedure I**: The test item shall be prepared in accordance with [General Requirements, 3.4.3.2](#). In general, the testing schedule outlined in [Table 3-7](#) for category 6 equipment (reference [Table 3-6](#)) shall be followed. However, each step in Table 3-7 represents a condition which 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 3-6, 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 3-7 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 (1.8° F) per second for airborne equipment or 10° C (18° F) per minute for test equipment and 0.5 inch of mercury per second. Tables indicating pressure levels for varying altitudes are contained in *U. S. Standard Atmosphere supplement, 1966*.¹⁴

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 3-7](#). After the test item temperature has stabilized, the chamber pressure shall be adjusted to simulate the altitude specified in step (1a) of Table 3-7. Maintain these test conditions for at least the length of time specified in step (1a) of Table 3-7. At the conclusion of this time

¹⁴ U.S. Committee on Extension to the Standard Atmosphere. Available from the Superintendent of Documents, Government Printing Office, Washington, DC 20402.

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 3-7](#). After the test item temperature has stabilized, maintain these test conditions for at least the length of time specified in step (1b) of [Table 3-7](#). 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 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 3-7](#). 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 (see paragraph 3.4.5.2.4.2 [note b](#)). The test item shall operate satisfactorily immediately following the specified warm-up time (see [note c](#)). The test item shall be de-energized and restabilized at the temperature specified in step (2) of [Table 3-7](#). The above operational sequence shall be repeated two additional times. **If 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 3-7](#). The test item temperature shall be stabilized. The test item shall be energized at the highest specified input voltage (see paragraph 3.4.5.2.4.2 [note d](#)) and the chamber pressure adjusted to simulate the altitude specified in step (3) of [Table 3-7](#). 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 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 3-7](#). After the test item temperature has stabilized, the chamber door shall be opened and frost permitted to form on the test item (see paragraph 3.4.5.2.4.2 [note e](#)). 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 (see [note d](#)) 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 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 General Requirements, 3.4.3.2.1, and evaluated using the failure criteria of General Requirements, 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 3-7. The test item temperature shall be stabilized and then maintained for at least the length of time specified in step (6) of Table 3-7. 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 General Requirements, 3.4.3.2.1, and evaluated using the failure criteria of General Requirements, 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 3-7. After the test item temperature has stabilized and while maintaining the chamber temperature, operate the test item continuously at the highest specified input voltage (see paragraph 3.4.5.2.4.2 note d) for the length of time specified in step (7) of Table 3-7. 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 3-7, 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 3-7 and maintain until completion of the second operating time period. After the test item temperature has stabilized, the test item shall be operated at the highest specified input voltage (see paragraph 3.4.5.2.4.2 note d) for two time periods each of the duration specified in step (8) of Table 3-7. The first time period of operation shall be followed by a fifteen-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 3-7 and maintain until completion of the fourth operating time period. After the test item temperature has stabilized, the test item shall be operated at the highest specified input voltage (see paragraph 3.4.5.2.4.2 note d) for four time periods each of the duration specified in step (9) of Table 3-7. 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 3-7](#). The test item temperature shall be stabilized. The test item shall be operated at the highest specified input voltage (see paragraph 3.4.5.2.4.2 [note d](#)) and the chamber pressure adjusted to simulate the altitude specified in step (10) of [Table 3-7](#). Maintain these test conditions for the length of time specified in step (10) of [Table 3-7](#). 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 3-7](#), 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 3-7](#) (see paragraph 3.4.5.2.4.2 [note f](#)), and maintain until completion of the fourth operating time period. The test item temperature shall be stabilized. The test item shall de-energize at the highest specified input voltage (see [note d](#)) and the chamber pressure adjusted to simulate the altitude specified in step (11) of [Table 3-7](#). The test item shall be operated for four time periods each of the duration specified in step 11 of [Table 3-7](#). 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 3-7](#) (see paragraph 3.4.5.2.4.2 [note f](#)). The test item temperature shall be stabilized. The test item shall then be energized at the highest specified input voltage (see [note d](#)) and the chamber pressure adjusted to simulate the altitude specified in step (12) of [Table 3-7](#). Maintain these test conditions for the length of time specified in step (12) of [Table 3-7](#). 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 3-7](#), 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 3-7](#) (see paragraph 3.4.5.2.4.2 [note f](#)), and maintain until completion of the fourth operating time period. 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 (13) of [Table 3-7](#). The test item shall be operated for four time periods as specified in step (13) of [Table 3-7](#). 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 3-7](#) (see [note f](#)), and maintain until completion of the fourth operating time period. 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 3-7. The test item shall be operated four time periods each of the duration specified in step (14) of Table 3-7, 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 General Requirements, [3.4.3.2.1](#), and evaluated using the failure criteria of General Requirements [3.4.3.2.6](#).

3.4.5.2.4.2 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. For equipment other than electronic equipment, the input conditions shall be such as to produce the minimum internal physical stress.
- c. 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 fifteen minutes beyond the warm-up time, the test item shall again be stabilized at the temperature specified for step (2) in [Table 3-7](#) and the operational check continued.
- d. For equipment other than electronic equipment, the input conditions shall be such as to produce the maximum internal physical stress.
- e. 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 should be used to provide the relative humidity necessary to have frost form.
- f. 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.

3.4.5.2.4.3 Summary. The following details shall be as specified in the equipment specifications:

- a. Pretest data required
- b. Pertinent equipment operation parameters limits (input voltage, etc.)
- c. Failure criteria.

**TABLE 3-6.
EQUIPMENT CATEGORIES FOR TEMPERATURE-ALTITUDE TESTS**

Equipment Category	Altitude Range (ft)	Temperature (°C)	Equipment Mode
			Operating Non- Operating
			Continuous Intermittent ¹ Short-Time ²
	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 which could damage the aircraft, the equipment shall also be tested to withstand an altitude of 40 000 ft, non-operating.

TABLE 3-7. TEST CONDITIONS FOR TEMPERATURE-ALTITUDE TESTS

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

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

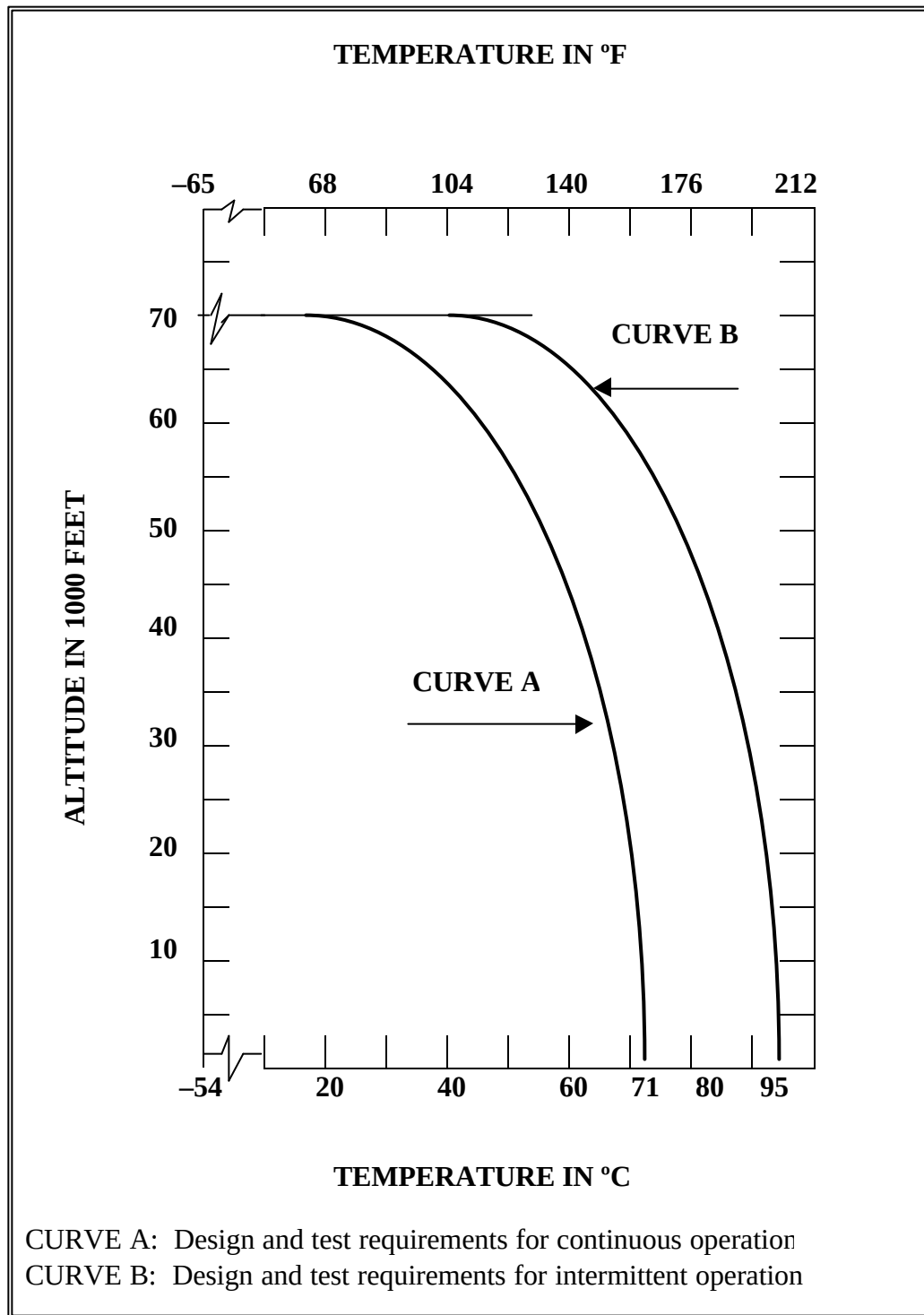


Figure 3-4. Temperature vs. altitude requirements for category (6) equipment.

3.4.5.3 **TEST: Humidity**

3.4.5.3.1 **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.

3.4.5.3.2 **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.

3.4.5.3.3 **Apparatus.** Humidity-temperature chamber and associated equipment.

3.4.5.3.3.1 **Chamber.** 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 6.0 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.

3.4.5.3.4 **Procedure.** Continuous measurements, if analog; every 15 minutes, if digital.



Where functional testing is specified prior to or following a procedure, refer to General Requirements, [3.4.3.5](#).

3.4.5.3.4.1 Procedure I: Airborne electronic equipment.

- Step 1:** Perform a functional test prior to exposure to humidity.
- Step 2:** Prepare the test item in accordance with General Requirements, [3.4.3.2](#) and [3.4.3.5.2](#). Prior to starting the test, the internal chamber temperature shall be at standard ambient with uncontrolled humidity. Install test item in chamber.
- Step 3:** Gradually raise internal chamber temperature to 65°C (149°F) and the relative humidity to 95 (+5/–3) percent over a period of 2 hours.
- Step 4:** Maintain conditions of step (2) for not less than 6 hours.
- Step 5:** Maintain 85 percent 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.
- Step 7:** At the end of the fifth cycle, while still at 30°C (86°F) and 85 percent relative humidity, operate the test item and obtain results in accordance with General Requirements, [3.4.3.2](#).
- Step 8:** Remove and inspect the test item and obtain results in accordance with General Requirements, [3.4.3.2](#).
- Step 9** Perform a functional test after exposure to humidity.

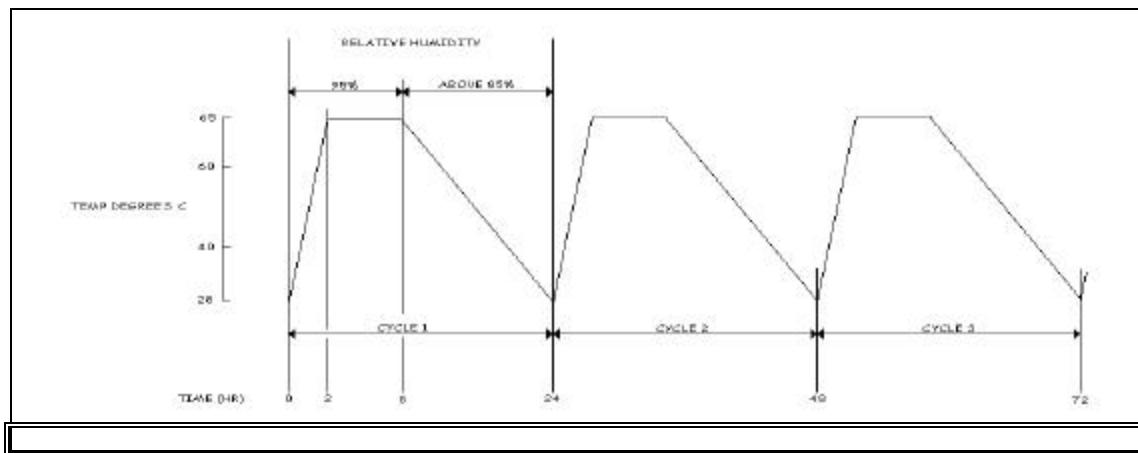


Figure 3-5. Humidity cycle – Procedure I.

Note: Continue for a total of 5 cycles (120 hr).

3.4.5.3.4.2 Procedure II: Ground fire control and shipboard equipment.

- Step 1** Prepare the test item in accordance with General Requirements, [3.4.3.2](#).
- Step 2** Dry the test item at a temperature of not less than 40°C (104°F) nor more than 50° C (122°F) for not less than 2 hours.
- Step 3** Condition the test item at 25° ±5°C (77° ±9°F) and 50 percent relative humidity for 24 hours.
- Step 4** Take initial measurements as specified in the equipment specification in accordance with General Requirements, [3.4.3.2](#).



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 in accordance with [Figure 3-6](#). A 24-hour cycle consists of 16 hours at 60° ±5°C (140° ±9° F) and approximately 8 hours at 30° ±5°C (86° ±9°F) (includes transition times). The relative humidity shall be maintained at 95 percent, or greater, at both temperatures. Each transition time between 30° ±5° C (86° ±9°F) and 60° ±5°C (140° ±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.

Measurements as specified in the equipment specification shall be made during the second cycle at 60° ± 5°C (140° ±9°F) immediately prior to decreasing to 30° ±5°C (86° ±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.

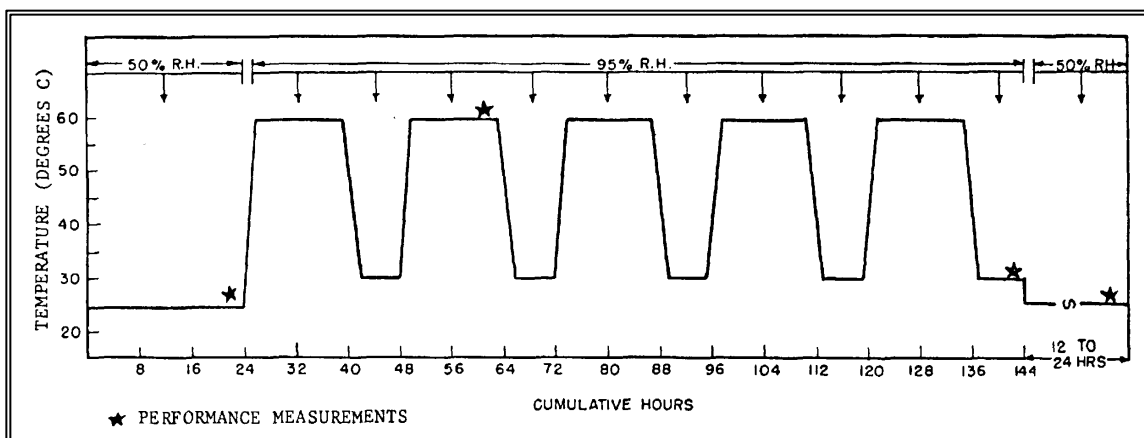


Figure 3-6. Humidity cycle – Procedure II.

- Step 6** After completion of the fifth cycle with the test item in the chamber and the chamber at $30^{\circ} \pm 5^{\circ}\text{C}$ ($86^{\circ} \pm 9^{\circ}\text{F}$) and a relative humidity of not less than 95 percent, take measurements specified in the equipment specification (no repair, realignment, readjustment, or replacement of parts shall be made, except as specified herein). Obtain results in accordance with General Requirements, [3.4.3.2](#).
- Step 7** Condition the test item at $25^{\circ} \pm 5^{\circ}\text{C}$ ($77^{\circ} \pm 9^{\circ}\text{F}$) and 50 ± 5 percent relative humidity for not less than 12 hours nor more than 24 hours.
- Step 8** While at $25^{\circ} \pm 5^{\circ}\text{C}$ ($77^{\circ} \pm 9^{\circ}\text{F}$) and 50 percent relative humidity, take measurements as specified in the equipment specification.
- Step 9** Inspect test item to detect evidence of physical degradation (such as corrosion of metal parts, distortion of plastic parts, and insufficient lubrication of moving parts) in accordance with General Requirements, [3.4.3.2](#).

3.4.5.3.5 Summary. The following details shall be specified in the equipment specification:

- Procedure number
- Pretest data required
- Failure criteria
- Periods at which measurements are to be taken
- 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.)
- If test item must be exposed to extreme temperature prior to test (Procedure I).

3.4.5.4 **TEST: Salt Fog**

3.4.5.4.1 Purpose. 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.

3.4.5.4.2 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.

3.4.5.4.3 General Effects:

3.4.5.4.3.1 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.)

3.4.5.4.3.2 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.



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.

- b. 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.

3.4.5.4.4 Apparatus. The apparatus used in the salt fog test shall include the following:

- a. Exposure chamber with racks for supporting test items
- b. Salt solution reservoir with means for maintaining an adequate level of solution
- c. Means for atomizing salt solution, including suitable nozzles and compressed air supply
- d. Chamber heating means and control
- e. Means for humidifying the air at a temperature above the chamber temperature.

3.4.5.4.4.1 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 which 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.

3.4.5.4.4.2 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.

3.4.5.4.4.3 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 should have a relative humidity of at least 85 percent 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 should be automatically maintained at a constant level. The temperature of the water should 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 should 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.

3.4.5.4.4.4 Preparation of Salt Solution. The salt used shall be sodium chloride containing on the dry basis not more than 0.1 percent sodium iodide and not more than 0.5 percent of total impurities. Unless otherwise specified, a 5 ± 1 percent 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 g (1/4 level teaspoon) sodium tetraborate to 20 gallons of salt solution as a pH stabilization agent.

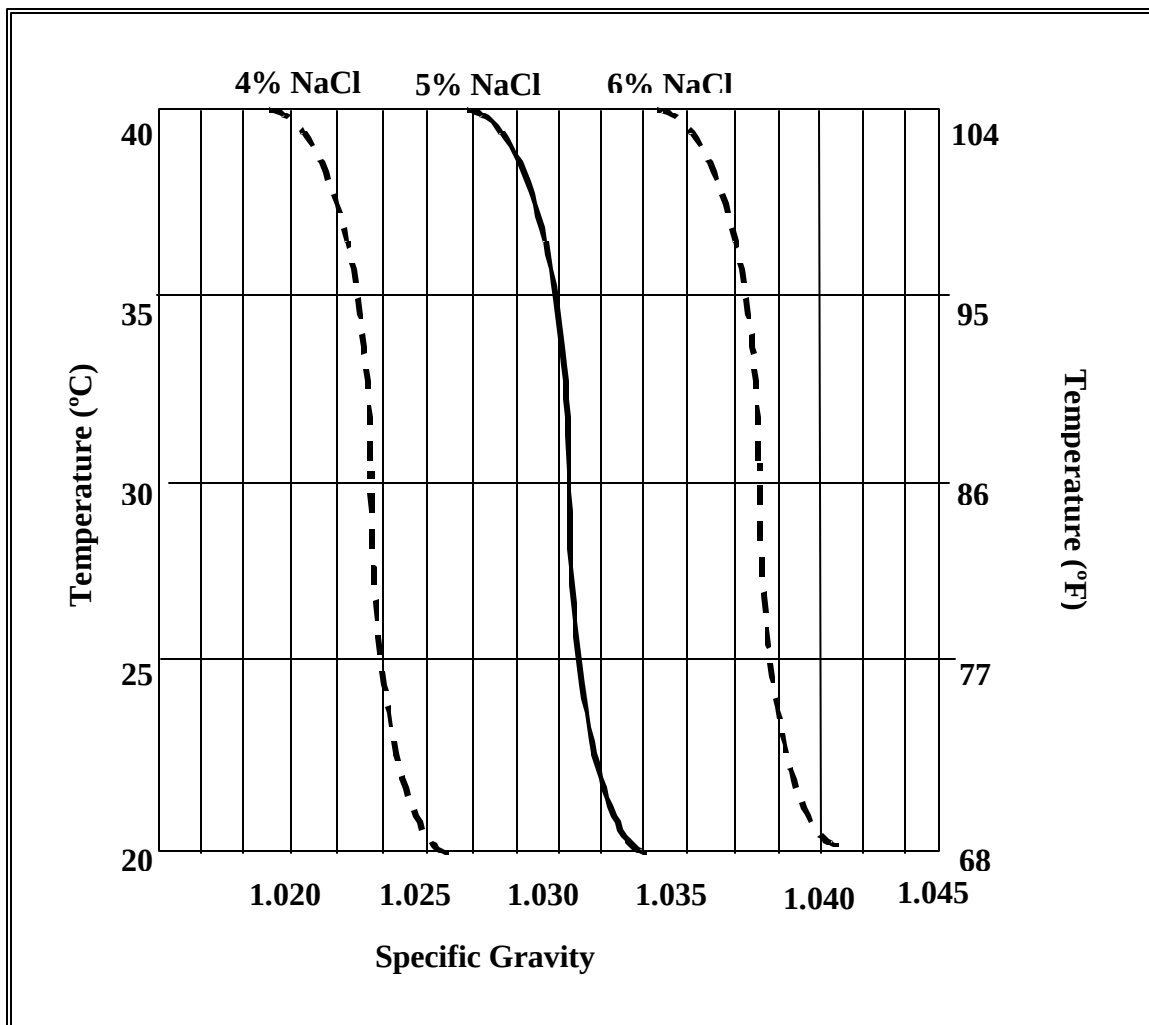


Figure 3-7. Variations of specific gravity of salt (NaCl) solution with temperature.

3.4.5.4.4.4.1 Adjustment of pH. 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 3.4.5.4.5.3](#) 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 in [paragraph 3.4.5.4.4.4](#) 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 in [paragraph 3.4.5.4.5.4](#).

3.4.5.4.4.5 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](#).

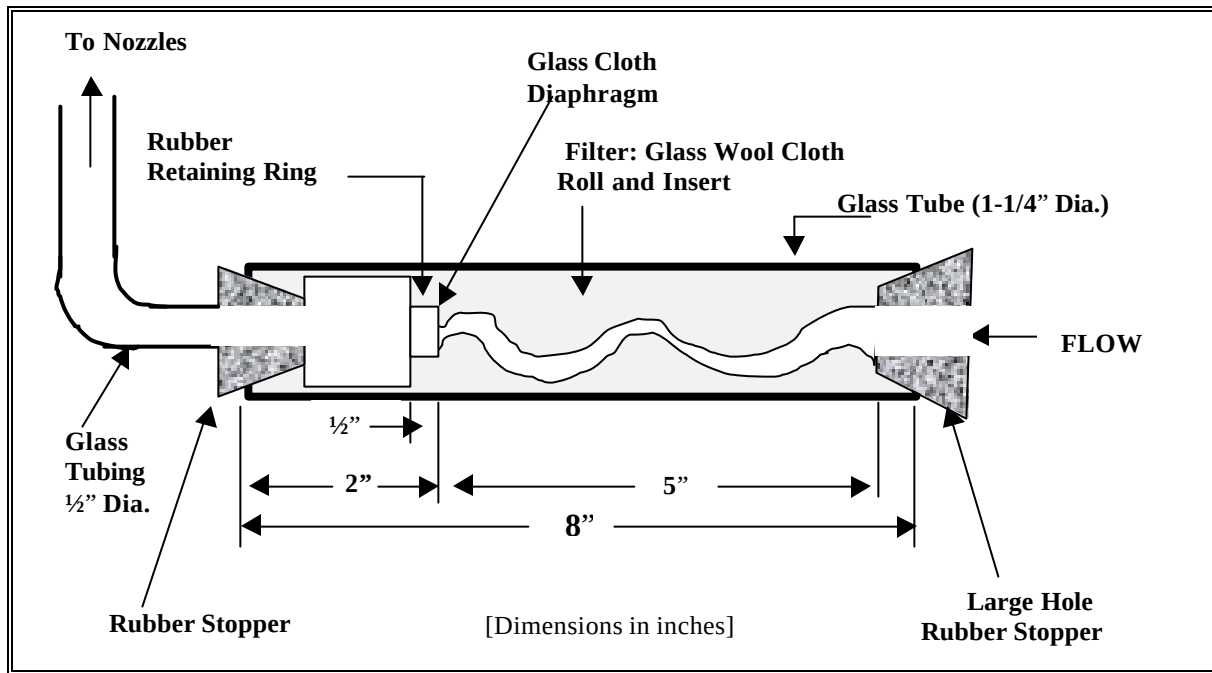


Figure 3-8. Salt solution filter.

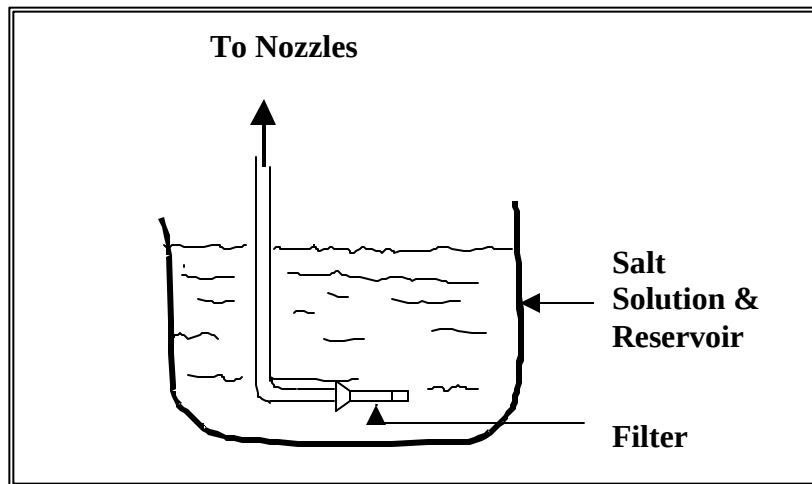


Figure 3-9. Location of salt solution filter.

3.4.5.4.5 Procedure:



Where functional testing is specified prior to or following a procedure, refer to General Requirements, [3.4.3.5](#).

3.4.5.4.5.1 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 by 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.

3.4.5.4.5.2 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.

3.4.5.4.5.3 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 of horizontal collecting area (10 centimeters 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.

3.4.5.4.5.4 Measurement of Salt Solution. The solution, collected in a manner specified in paragraph 3.4.5.4.5.3, shall have the sodium chloride content and pH specified in [paragraph 3.4.5.4.4.4](#) 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 “adjustment of pH,” [paragraph 3.4.5.4.4.1](#)
- 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.

3.4.5.4.5.5 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 nor solvents which deposit either corrosive or protective films, nor the use of 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.

3.4.5.4.5.6 Performance of Test. The test item shall be placed in the test chamber in accordance with General Requirements, 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 in accordance with General Requirements, 3.4.3.2.1. The test item shall be inspected for corrosion in accordance with General Requirements 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 forty-eight hours, or as specified in the equipment specification, for drying. At the end of the drying period, when specified, the test item shall be again operated and the results compared with the data obtained in accordance with General Requirements 3.4.3.2.1. The test item shall then be inspected in accordance with General Requirements, 3.4.3.2.4

3.4.5.4.6 Summary. The following details shall be specified in the equipment specification:

- a. Pretest data required
- b. Failure criteria
- c. Applicable salt solution, if other than 5 percent
- d. Salt fog exposure period if other than 48 hours (see paragraph 3.4.5.4.5.6)
- e. Drying period if other than 48 hours (see paragraph 3.4.5.4.5.6)
- f. Inspection and operation after 24 hours of salt fog exposure where buildups of salt deposits are critical to the proper operation of the test item
- g. Specify if operation of electrical system is required (see paragraph 3.4.5.4.5.6).

3.4.5.5 **TEST: Acceleration**

3.4.5.5.1 **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.

3.4.5.5.2 **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.

3.4.5.5.3 **Procedure:**



Where functional testing is specified prior to or following a procedure, refer to General Requirements, [3.4.3.5](#)

3.4.5.5.3.1 **Mounting of Test Item.** Direction of forward acceleration is always considered to be the direction of the vehicle acceleration, and equipment shall be oriented accordingly, using its normal mounting means. For centrifuges, the location of the test item (with reference to the G level 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 percent of the specified G level, 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 percent of the specified G level is obtained.



If the furthest end of the test item experiences more than 110 percent of the desired G level at the geometric center (while the nearest end experiences 90 percent 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.

3.4.5.5.3.1.1 **Test Item Orientation (Centrifuge).** When a centrifuge is used to attain the required acceleration levels, the test item shall be oriented as follows:

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.

3.4.5.5.3.2 Test Level Determination. The G level to be applied to the test item is contingent on two factors: the direction of forward acceleration level “A” of the vehicle, and the orientation of the test item within the vehicle.

Where: A = The highest possible known or unknown forward acceleration of a vehicle in which equipment is to be mounted. “A” shall never be less than one g, where g is acceleration due to gravity.

Use the instructions in Table 3-8 to select test levels as listed in [Table 3-9](#).

TABLE 3-8. 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 3-9. G LEVELS 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	2.0	1.0•A	3.0•A	4.5•A	1.5•A	2.0•A
Helicopter	2.0	1.0•A	1.0•A	3.5•A	1.5•A	2.0•A
Manned Aerospace Vehicles	6.0 to 12.0 ²	1.0•A	0.33•A	1.5•A	0.5•A	0.66•A
Air Carried Stores	In accordance with Mil-A-8591					
Ground Launched Missiles	6.0 to 30.0 ²	1.0•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 4g.
4. Add pitch and roll accelerations, as applicable.

3.4.5.5.3.2.1. G Levels for Fighter Aircraft. The test levels for Table 3-9 are based on accelerations at the C.G. (center of gravity) of the vehicle. For fighter aircraft, these G levels 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:

$$\Delta Gr = \frac{d(\alpha_r)}{g} \quad (\text{Eq. 3-1})$$

where:

ΔGr = additional acceleration due to roll

d = lateral distance from C.G. in feet

α_r = maximum roll acceleration, rad/s^2 (use $\alpha_r = 15$ unless otherwise known)

g = 32.17 ft/s^2

Add the ΔG_r value obtained above to the [Table 3-9](#) acceleration value for the operational test acceleration level.

- b. For lateral directions, the G level shall be determined as follows for wing locations:

$$G_{cr} = \frac{d(\omega)^2}{g} \quad (\text{Eq. 3-2})$$

where: G_{cr} = centrifugal acceleration due to roll
 ω = maximum roll velocity, rad/s (use $\omega = 5$ unless otherwise known)
 d = lateral distance from C.G. in feet
 g = 32.17 ft/s²

Use the G_{cr} level obtained above for the operational test acceleration level when the computed value is larger than that in [Table 3-9](#).

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

$$\Delta G_p = \frac{d(\alpha_p)}{g} \quad (\text{Eq. 3-3})$$

where ΔG_p = additional acceleration due to pitch
 d = fore and aft distance from C.G.
 α_p = maximum pitch acceleration in rad/s² (use $\alpha_p = 5$ unless otherwise known)
 g = 32.17 ft/s²

Add the ΔG_p value obtained above to the [Table 3-9](#) acceleration value for the operational test acceleration level.

- d. For the fore and aft directions, the G level shall be determined as follows for fuselage locations:

$$G_{cp} = \frac{d(\omega)^2}{g} \quad (\text{Eq. 3-4})$$

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/s²

Use the G_{cp} level computed above for the operational test acceleration level when the computed value is larger than that in [Table 3-9](#).

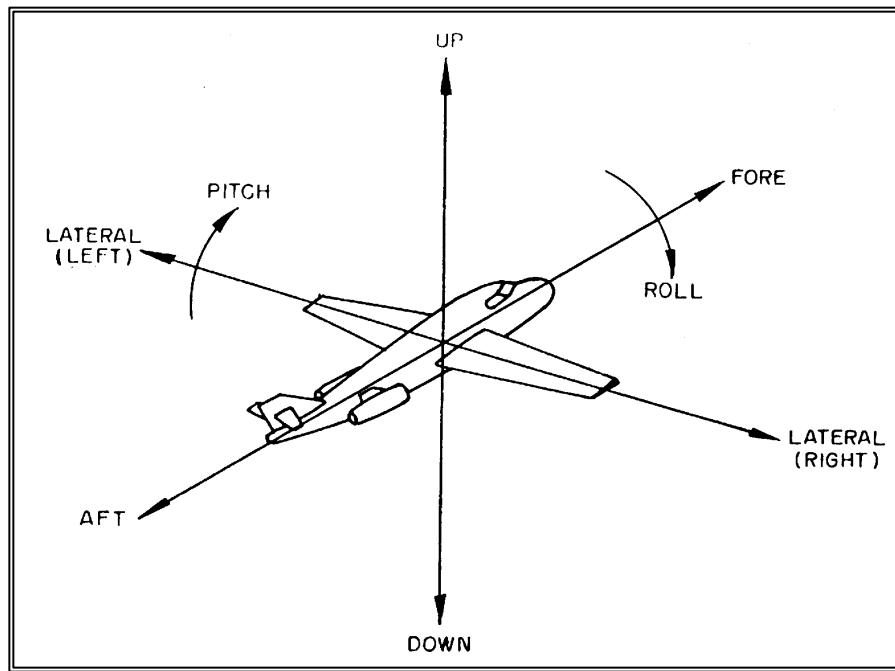


Figure 3-10. Direction of vehicle acceleration.

3.4.5.5.3.3 Operational Test. The test item shall be installed on the accelerated apparatus in accordance with General Requirements, 3.4.3.2.2, by its normal mounting means. The G level shall be determined in accordance with paragraph 3.4.5.5.3.2, and shall be applied while the test item is operating. The test item shall then be inspected as specified in General Requirements, 3.4.3.2.

3.4.5.5.3.3.1 Performance of test. The G level 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 in accordance with General Requirements, 3.4.3.2.

3.4.5.5.3.4 Summary. The following details shall be as specified in the equipment specification or test plan:

- a. Pretest data required
- b. Failure criteria
- c. Test level and test time (see paragraph 3.4.5.5.3.3)
- d. Length of time required for operation and required measurements.

3.4.5.6 **TEST: Vibration**

3.4.5.6.1 **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.

3.4.5.6.2 **Apparatus.** Vibration equipment with required instrumentation.

3.4.5.6.3 **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. Guidance for selecting a test is as follows:

- a. Determine equipment category (or categories) in accordance with [Table 3-10](#).
- b. Proceed to the designated table(s) and figure(s) corresponding to the applicable equipment category. Select a test based on the table instructions, procedure, and figure designated.

3.4.5.6.3.1 **Equipment Category.** For purposes of this test standard, equipment is categorized according to the vehicle in which it will be installed or transported as follows:

TABLE 3-10. TEST PROCEDURES BY EQUIPMENT CATEGORY				
Category¹⁵	Description	Procedure	Table	Figure
b.1	Equipment installed in propeller airplanes and equipment mounted directly to engines including jet engines	I	3-11A/B	3-11
b.2	Equipment installed in jet airplanes except for jet engine mounted equipment	IA	3-12	3-12
c	Equipment installed in helicopters	I	3-13 A/B	3-13
d.1	Equipment installed in external stores carried on airplanes	IIA	3-14A/B	3-14
e	Equipment installed in ground launched missiles	III or IV	3-15A/B	3-15
f	Equipment installed in ground vehicles	V	3-16	3-16A
i	Shipboard and amphibious equipment or when a ship is the common carrier	VI	--	--

¹⁵ Equipment categories used here are derived from MIL-STD 810C (canceled).

3.4.5.6.3.2 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 3-15A](#) 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.

3.4.5.6.3.3 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.

3.4.5.6.3.4 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 3-11A/B](#), 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 [Table 3-11A](#). Next, with vibration isolators removed in accordance with 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 [Table 3-11A](#).

3.4.5.6.4 Procedures. The basis for selecting a test procedure for a particular equipment category shall be according to paragraph 3.4.5.6.3. The vibration environment, specified by the curve selected from applicable tables in accordance with paragraph 3.4.5.6.3, 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 percent of the input motion except that reaction machines shall be balanced to reduce transverse motion 100 percent.



Where functional testing is specified prior to or following a procedure, refer to General Requirements, [3.4.3.5](#).

3.4.5.6.4.1 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 [3.4.5.6.4.5.2](#)) and IIA (paragraph [3.4.5.6.4.5.3](#)) 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 General Requirements [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 in accordance with General Requirements [3.4.3.2](#).

3.4.5.6.4.2 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.

3.4.5.6.4.3 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.

3.4.5.6.4.4. Common Test Techniques.

3.4.5.6.4.4.1 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 specified, for sinusoidal resonance search, resonance dwell, and cycling tests of items weighing more than 80 pounds mounted in airplanes, and missiles, the vibratory accelerations shall be reduced 1g for each 20-pound increment over 80 pounds. Acceleration derating shall apply only to the highest test level of the selected curve,

but in no case shall the derated test level be less than 50 percent of the selected curve (see note 1 of applicable table). 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 or more 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 number 3.
- b. **Resonance Dwell.** The test item shall be vibrated along each axis at the most severe resonant frequencies determined above in number 1. Test levels, frequency ranges, and test times shall be in accordance with 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 in accordance with 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 in accordance with [Figure 3-16B](#). The specified sweep time is that of an ascending plus a descending sweep and is twice the ascending sweep time shown on Figure 3-16B for the specified range.

3.4.5.6.4.4.2 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 percent (+3/-1.5 dB) below 500 Hz and +100, -50 percent (± 3 dB) between 500 Hz and 2000 Hz except that deviations as large as +300, -75 percent (± 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:

$$\text{dB} = 10 \log_{10} \frac{W_1}{W_0} \quad (\text{Eq. 3-5})$$

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 having a bandwidth as follows:

B = 25 Hz, maximum between 20 and 200 Hz
 B = 50 Hz, maximum between 200 and 1000 Hz
 B = 100 Hz, maximum between 1000 and 2000 Hz

b. Swept frequency analysis systems characterized as follows:

1) Constant bandwidth analyzer

a) Filter bandwidth as follows:

B = 25 Hz, maximum between 20 to 200 Hz
 B = 50 Hz, maximum between 200 to 1000 Hz
 B = 100 Hz, maximum between 1000 to 2000 Hz

b) Analyzer averaging time = $T = 2 RC = 1$ second, minimum,
 where T = true averaging time and RC = analyzer time constant

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

2) Constant percentage bandwidth analyzer

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

b) Analyzer averaging time = $T = \frac{50}{pf_c}$, minimum

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

c. Digital power spectral density analysis system employing quantization techniques providing accuracies corresponding to the above approach.

Accelerometer(s) employed for test level control shall be mounted in accordance with paragraph 3.4.5.6.4.2. 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.

3.4.5.6.4.5 Procedures:



Where functional testing is specified prior to or following a procedure, refer to General Requirements, [3.4.3.5](#).

3.4.5.6.4.5.1 Procedure I. Equipment installed in airplanes or helicopters, category (b.1) or (c).

- a. **Part 1.** For category (b.1) equipment, proceed the same as in paragraph [3.4.5.6.4.4.1](#), No's. a, b and c. The test levels and time durations shall be as specified in [Table 3-11A](#) and [Figure 3-11](#). For category (c) equipment, proceed the same as in paragraph [3.4.5.6.4.4.1](#), [No. c](#) only. The test levels and time schedules shall be as specified in [Table 3-13A /B](#) and [Figure 3-13](#).

Part 2. For category (b.1) equipment, test items normally provided with vibration isolators shall be vibrated in accordance with paragraph [3.4.5.6.4.4.1](#), No's. a,b and c with the vibration isolators removed but including any other required holding devices. The test levels and time durations shall be as specified in [Table 3-11A](#) and [Figure 3-11](#). For category (c) equipment, proceed the same as in paragraph [3.4.5.6.4.4.1](#), [No. c](#) only with the vibration isolators removed but including any other holding devices. The test levels and time schedules shall be as specified in [Table 3-13A](#) and [Figure 3-13](#).

3.4.5.6.4.5.2 Procedure IA. Random vibration test for equipment installed in jet airplanes (category b.2). (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 3-11A & B](#), [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 3-12](#) and [Figure 3-12](#). 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.

- 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 3.4.5.6.4.4.2. The test item shall be attached to the vibration exciter according to paragraph 3.4.5.6.4.2. 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 in accordance with General Requirements, 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 3-12 and Figure 3-12. 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 3-12.
- 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, Table 3-11A, and curve AR of Figure 3-11. At the conclusion of this test the equipment shall provide specified performance, in accordance with General Requirements, 3.4.3.2.

3.4.5.6.4.5.3 Procedure IIA. Equipment installed in external stores carried on airplanes (category d.1).

- 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 3.4.5.6.4.4.2. The test item shall be attached to the vibration exciter according to paragraph 3.4.5.6.4.2. 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 in accordance with General Requirements, 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 3-14A & B and Figure 3-14 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 3-14A/B. If the computed functional and endurance ($T=1$) test levels (W_2) are less than $0.04 \text{ G}^2/\text{Hz}$, use $W_2 = 0.04 \text{ G}^2/\text{Hz}$ and $T=1$ for the endurance test.

- 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 2. The equipment shall perform according to the equipment specification operating requirements in accordance with General Requirements, 3.4.3.2 during the functional testing. Paragraph numbers 1 and 2 above, Table 3-14A & B, and Figure 3-14 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.

3.4.5.6.4.5.4 Procedure III. Equipment installed in ground launched missiles (without vibration isolators), equipment category (e).

Part 1. Proceed the same as in paragraph 3.4.5.6.4.4.1, No. c. The test level shall be according to one specified curve P through U from Table 3-15A and Figure 3-15. Test time schedules shall be as listed for part 1 of procedure III as specified in Table 3-15A.

Part 2. Proceed the same as in paragraph 3.4.5.6.4.5.2. The test level shall be according to one specified in curve AE through AP from Table 3-15B and Figure 3-15. Test time schedules shall be as listed for Part 2 of Procedure III as specified in Table 3-15A.

3.4.5.6.4.5.5 Procedure IV. Equipment installed in ground launched missiles (isolated equipment, tested without isolators), equipment category (e).

Part 1. Proceed the same as in paragraph 3.4.5.6.4.4.1, No. c. Test levels shall be according to curve N from Figure 3-15. Test time schedules shall be as listed for Part 1 of Procedure IV as specified in Table 3-15A.

Part 2. Proceed the same as in paragraph 3.4.5.6.4.2. Test levels shall be according to curve AE from Figure 3-15. Test time schedules shall be as specified for Part 2 of Procedure IV as specified in Table 3-15A.

3.4.5.6.4.5.6 Procedure V. Equipment installed in ground vehicles, equipment category (f). Proceed the same as in paragraph 3.4.5.6.4.4.1, No. c. Test levels shall be according to one specified curve V, W, or Y from Figure 3-16A. Test time schedules shall be as specified in Procedure V as specified in Table 3-16. When test item resonances below 5 Hz are measured or

expected, the test curves shall be extended to 2 Hz and the sweep time shall be 18 minutes (2-500-2 Hz); 15 minutes (2-200-2 Hz).

3.4.5.6.4.5.7 Procedure VI. For shipboard and amphibious equipment (category i) or when a ship is the common carrier, the vibration test shall be in accordance with Type I of MIL-STD-167.

3.4.5.6.5 Summary. The following details shall be as specified in the equipment specification or test plan:

- a. Equipment category, applicable table, procedure, figure, and test curve (see [3.4.5.6.3.](#))
- b. Pretest data required (General Requirements, [3.4.3.2](#))
- c. Failure criteria
- d. Weight of test item when acceleration derating of selected curve is required (see [3.4.5.6.4.4.1](#) and [Table 3-12, note 6](#))
- e. Temperature extremes and temperature test time durations (see [3.4.5.6.4.3](#))
- f. Total vehicle mileage for category f equipment (see [Table 3-16](#))
- g. Necessary parameters for calculating test levels for equipment categories b.2, d.1.

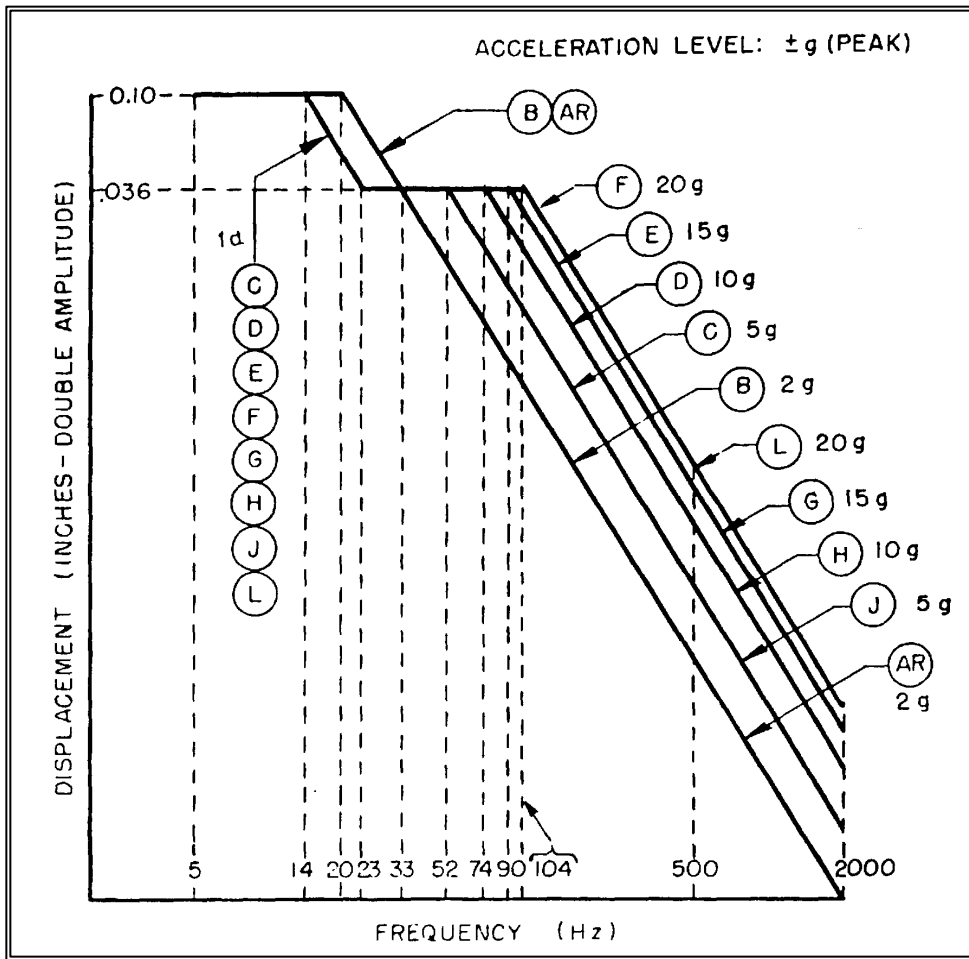


Figure 3-11. Vibration test curves for equipment installed in airplanes, excluding helicopters, equipment category (b.1).

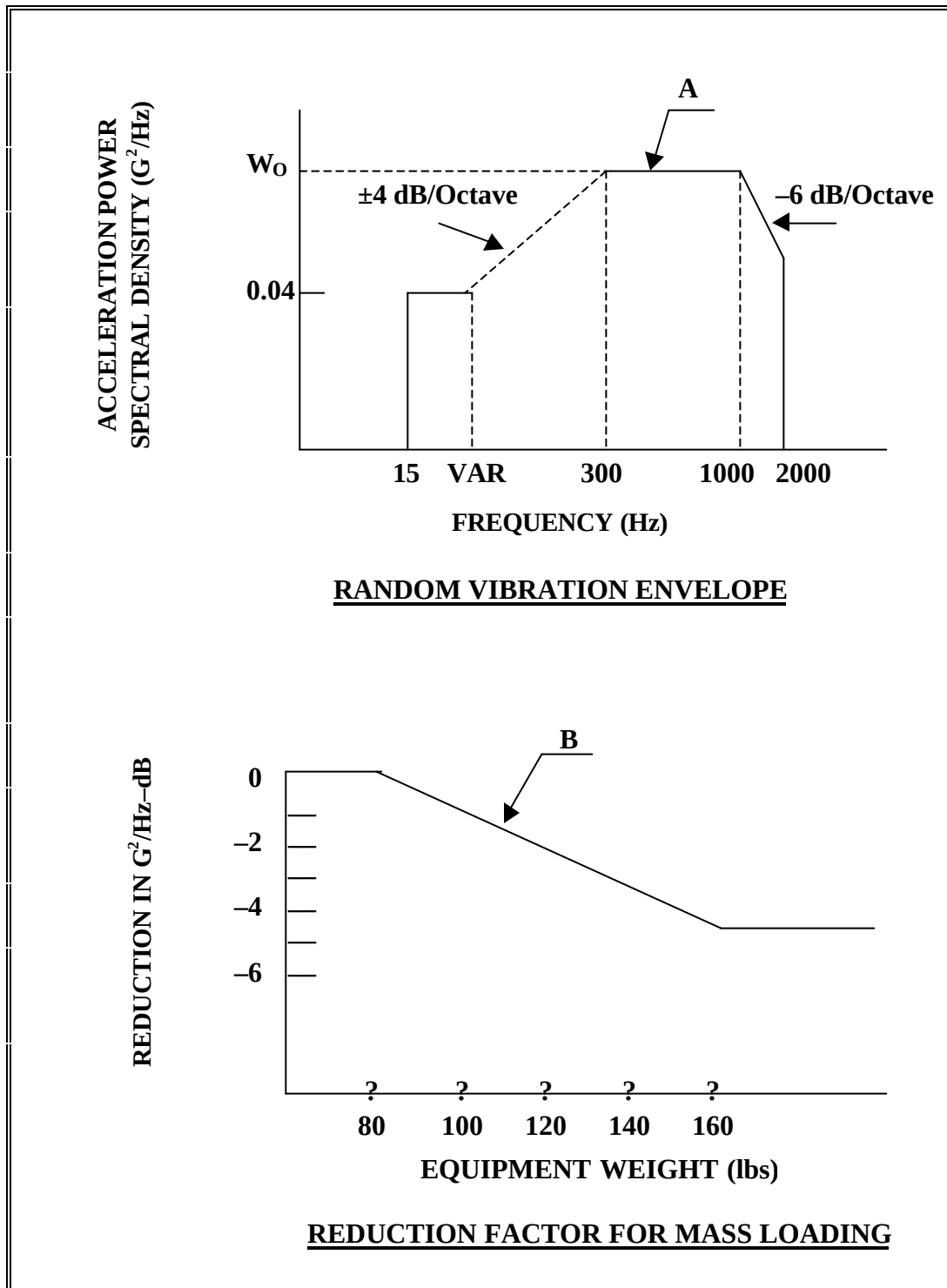


Figure 3-12. Random vibration test curve and mass loading reduction factor for jet aircraft equipment (category b.2).

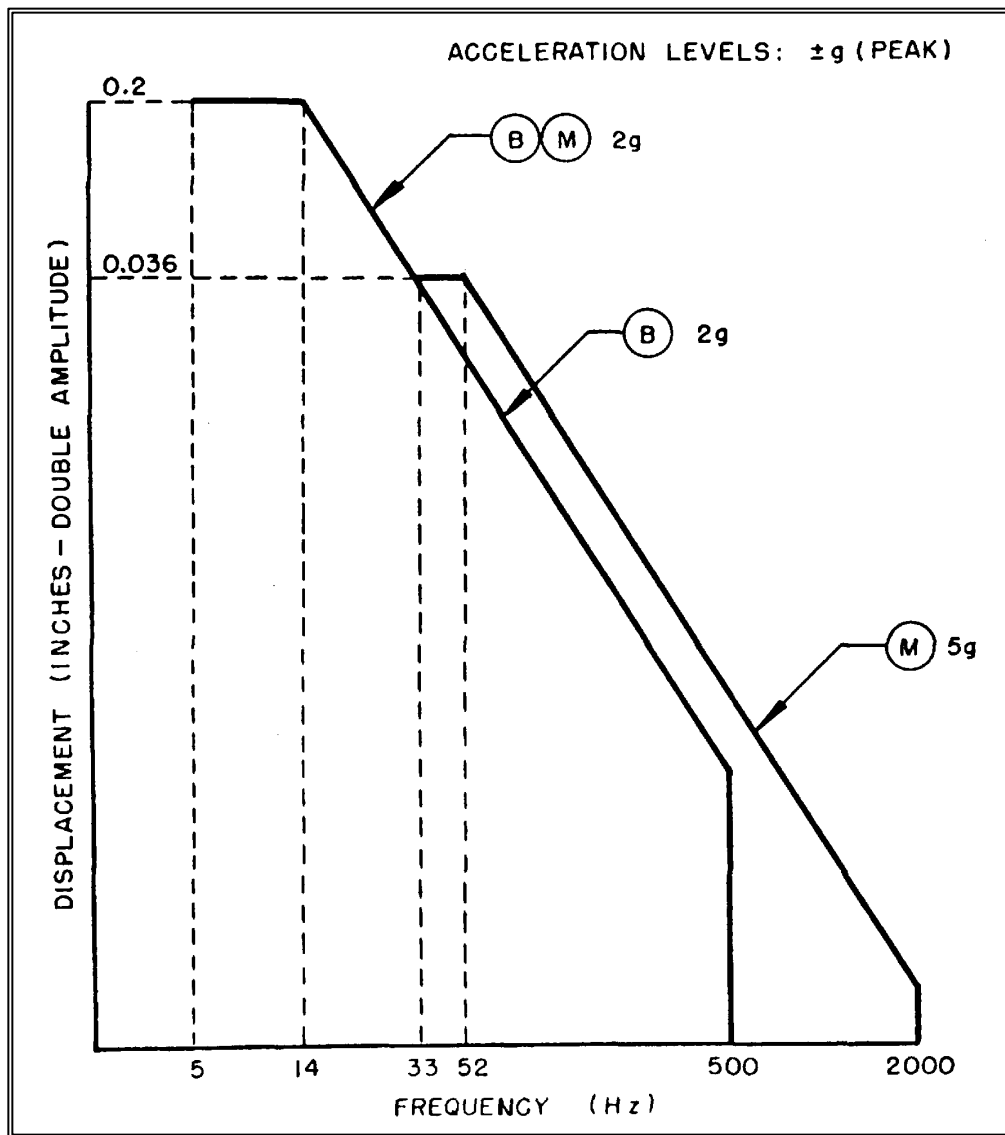


Figure 3-13. Vibration test curves for equipment installed in helicopters, equipment category (c).

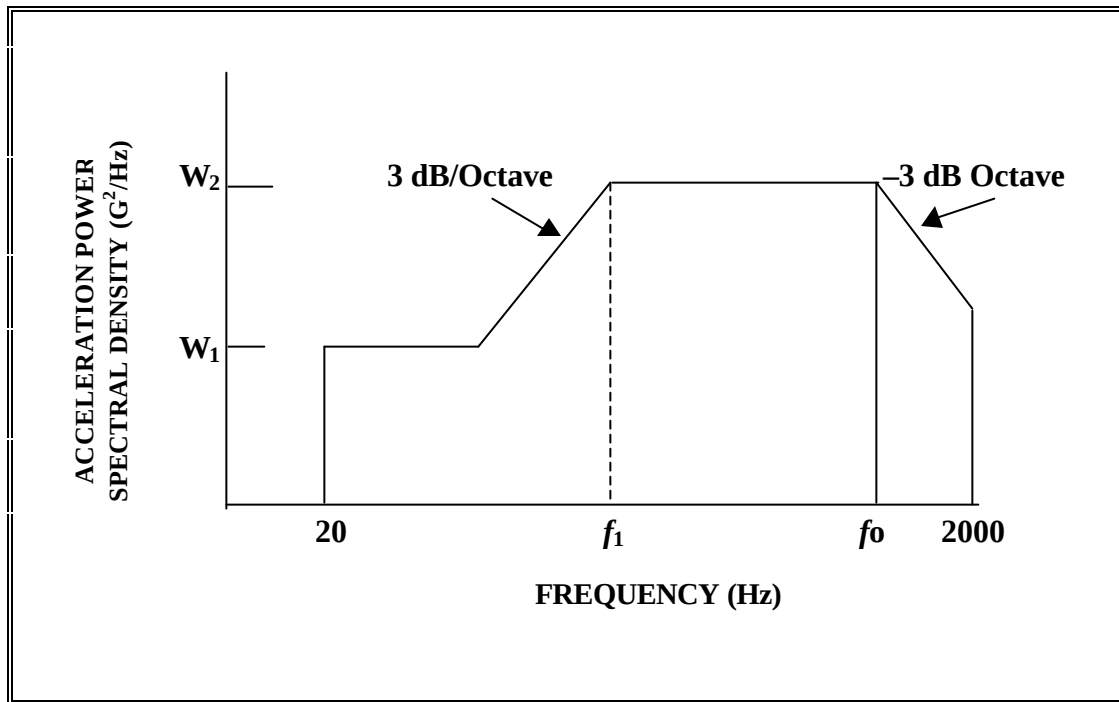


Figure 3-14. Vibration test levels for equipment installed in external stores carried on airplanes, equipment category (d.1).

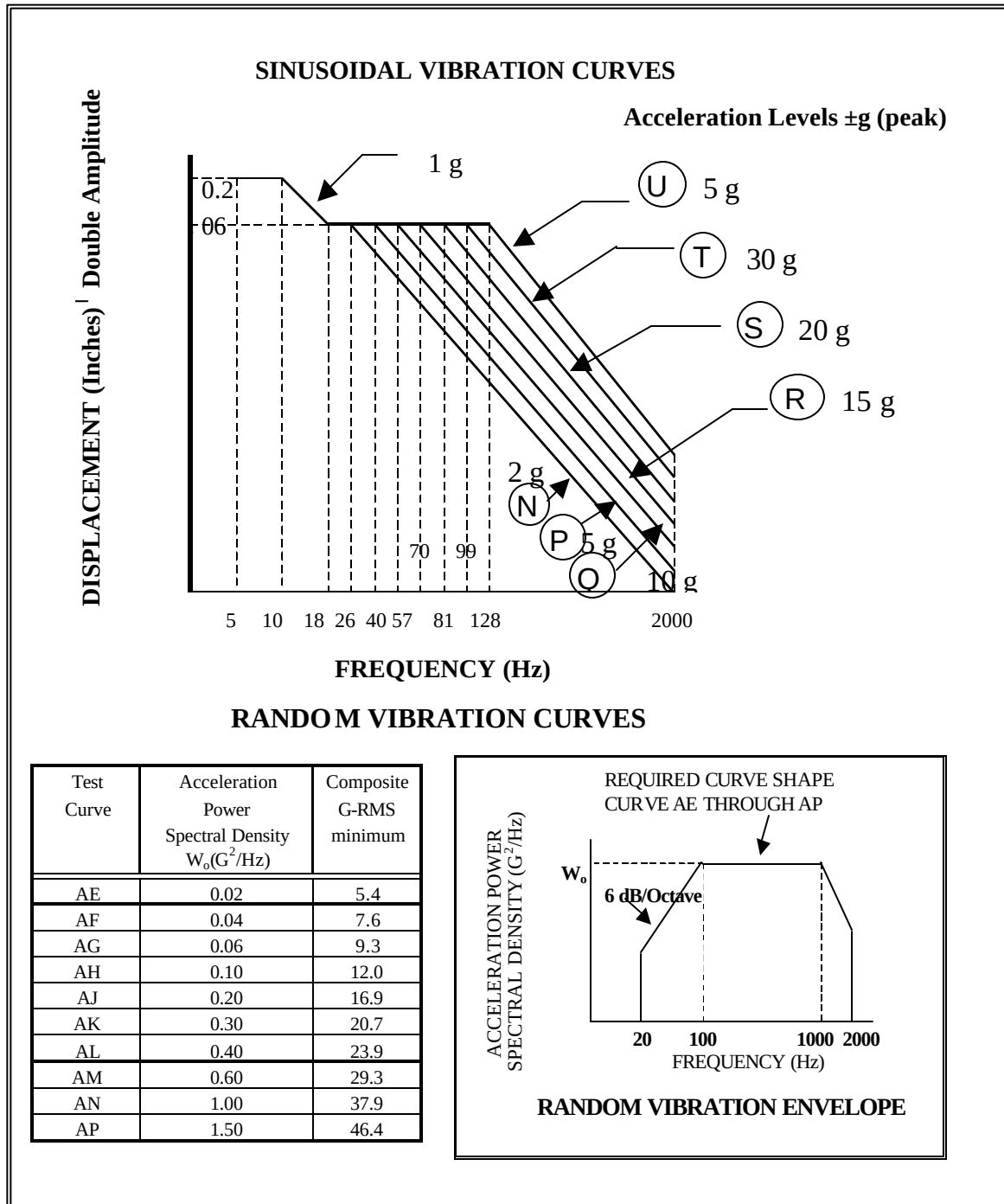


Figure 3-15. Vibration test curves for equipment installed in ground launched missiles, equipment category (e).

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

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

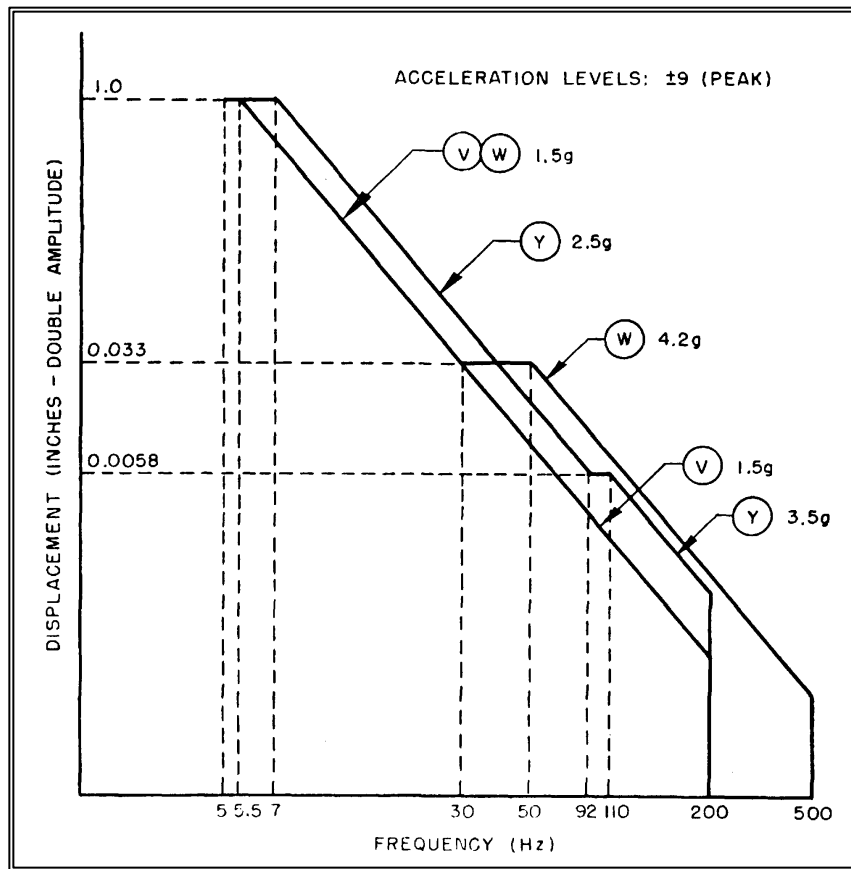


Figure 3-16A. Vibration test curves for equipment installed in ground vehicles, equipment category (f).

in

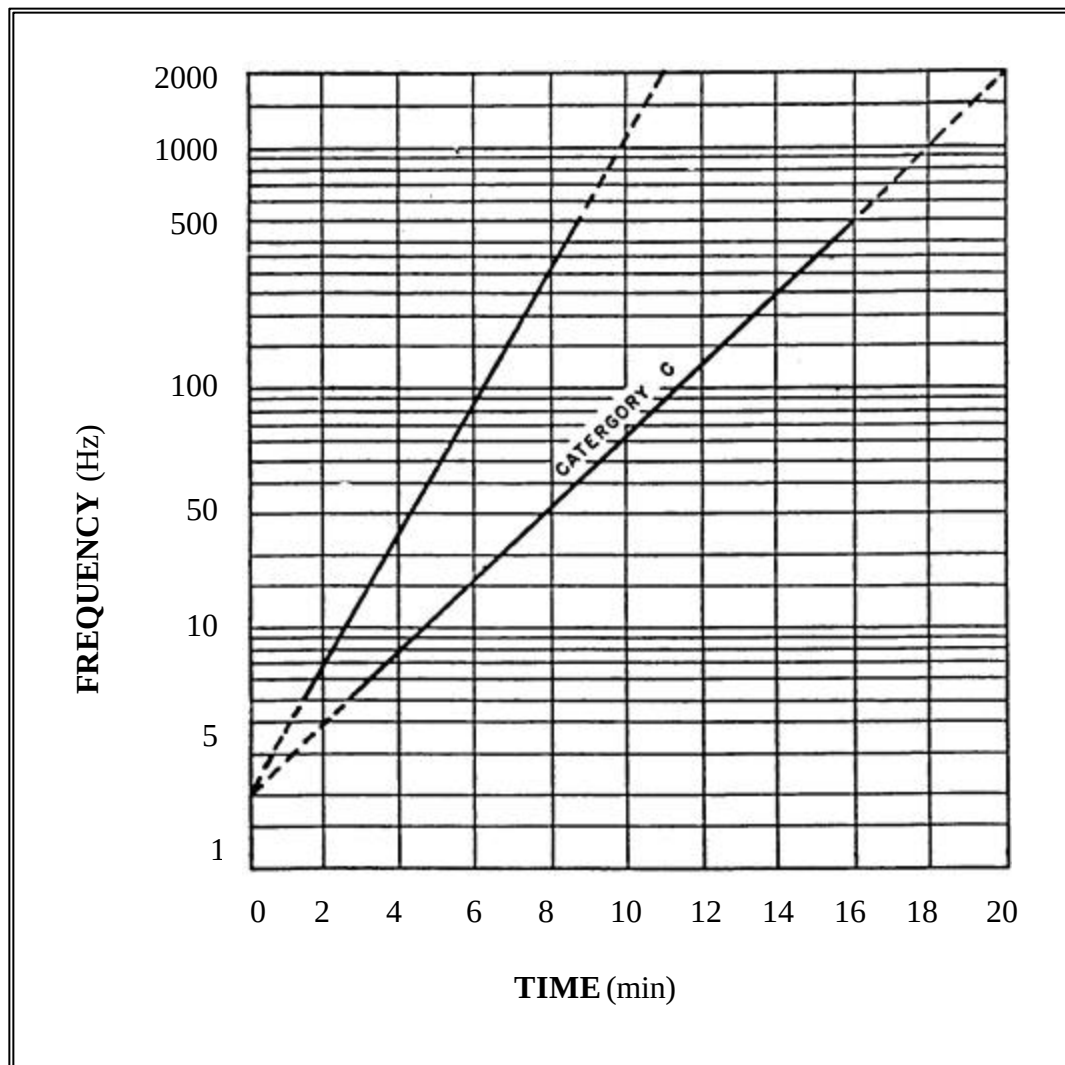


Figure 3-16B. Logarithmic sweep.

TABLE 3-11A.
TEST PROCEDURES and TIME SCHEDULE CHART for EQUIPMENT INSTALLED in
PROPELLER AIRPLANES – EQUIPMENT CATEGORY (b-1)

A: Procedure Selection and Time Schedule Chart

Equipment
Mounting
Config.
Procedure #
Procedure Part #
Applicable Tests
(note 3)
Test Time Schedule (per axis)
Fig. 3-11
Curve
(note 1)

Dwell Time
at each
Resonance
(note 5)
Sinusoidal
Cycling
Time

Sweep Time

Resonance
Search
(note 4)
Resonance
Dwell
(note 5)
Sinusoidal
Cycling
(note 6)

5-500-5
Hz

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
(note 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 1g 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 percent 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 paragraph 3.4.5.6.4 for procedures.
4. See paragraph 3.4.5.6.4.4.1.1 (No.a).
5. See paragraph 3.4.5.6.4.4.1.1 (No.b).
6. See paragraph 3.4.5.6.4.4.1.1 (No.c).

**TABLE 3-11B.
TEST PROCEDURES and TIME SCHEDULE CHART for EQUIPMENT
INSTALLED in PROPELLER AIRPLANES – EQUIPMENT CATEGORY (b.1)**

B. Curve Selection Chart for Equipment Category (b.1)

Selection Criteria

**Fig. 3-11
Curve
(for freq.
to 500 Hz)**

**Fig. 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

TABLE 3-12.
RANDOM VIBRATION TEST CRITERIA for JET AIRCRAFT –
EQUIPMENT CATEGORY (b.2)

Criteria	
Aerodynamic induced vibration (curve A, Figure 3-12)	
Functional test level (notes 1,6)	$W_o = K(q)^2$
Endurance test level (notes 2,3,6)	$W_o = K(q)^2 (N/3T)^{1/4}$
Jet engine noise induced vibration (curve A, Figure 3-12)	
Functional test level (notes 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 (notes 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 = 2.7×10^{-8} for cockpit equipment and equipment attached to structure in compartments adjacent to external surfaces that are smooth, free from discontinuities.
- K = 4×10^{-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/ft² or maximum aircraft q, whichever is less.
- N = maximum number of anticipated service missions for equipment or carrying aircraft (N=3)
- T = test time per axis, hours (T = 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 center of gravity 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:

- Functional test time shall be 1 hour per axis.
- Use $W_o = 0.04 \text{ g}^2/\text{Hz}$ if calculated endurance test level values are less than $0.04 \text{ g}^2/\text{Hz}$, T = 1.
- If one hour (T = 1) endurance test level is = functional test level, no endurance test is required except according to note 2.
- If aircraft has more than one engine, W_o shall be the sum of the individually computed values for each engine.
- For equipment weighing more than 80 pounds, the vibration W_o level may be reduced according to Curve B, Figure 3-12.
- For $70^\circ < \theta = 180^\circ$, use $\theta = 70^\circ$ to compute W_o .
- 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.

TABLE 3-13A. TEST PROCEDURE and TIME SCHEDULE CHART for EQUIPMENT in HELICOPTERS – EQUIPMENT CATEGORY (c)					
Equipment Mounting Configuration	Procedure Number	Procedure Part Number	Test Time Schedule (per axis)		Fig. 3-13 Curve (note 1)
			Sinusoidal Cycling (note 4)	Sweep Time (note 3)	
Without vibration isolators	I	1	3 hrs	36 min	M
With vibration isolators (note 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 percent 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 3.4.5.6.4.4.1 ([No.c](#)).

TABLE 3-13B. 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

TABLE 3-14A. VIBRATION CRITERIA for EXTERNAL STORES CARRIED on AIRPLANES – EQUIPMENT CATEGORY (d.1)		
Parametric Equations for Figure 3-14A		
Eq. 1 (notes 1,2):	$W_1 = (5)(10^{-3})(N/3T)^{1/4} (A_1)(B_1)(C_1)(D_1)(E_1)g^2/\text{Hz}$	
Eq. 2 (notes 1,2,5):	$W_2 = (5)(10^{-5})(q/p)^2(N/3T)^{1/4} (A_2)(B_2)(C_2)(D_2)(E_2)g^2/\text{Hz}$	
Eq. 3 (notes 3,4,5):	$f_1 = 10^5 (t/R^2) \text{ Hz}$	
Eq. 4 (notes 3,4):	$f_2 = f_1 + 1000 \text{ Hz}$	
Location, Configuration, Special Adjustments	Factor	
	A ₁	A ₂
TER (tri-ejection rack, cluster mount)	1	2
MER (multiple ejection rack, 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 nonintegral, 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)	1/2	1/4
All other conditions	1	1
Note: For representative parameter values to be used for captive flight when specific parameters are not available, see Table 3-14B.		

Definitions:

- q = maximum flight dynamic pressure in lbs/ft² (see note 1).
p = average store weight density in lbs/ft³ (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 f₁ 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 f₁ = 300 Hz).
N = maximum number of anticipated service missions (functional test, N = 3; endurance test, N = 3).
T = test time per axis in hours (functional test, T = 1; endurance test, T > 1).

Notes:

1. For endurance test, $q = 1200 \text{ lbs/ft}^2$ or maximum q , whichever is less. For functional test $q = 1800 \text{ lbs/ft}^2$ 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 paragraph 3.4.5.6.4.5.3. (No.b).
3. Free fall stores with tail fins, used $f_1 = 125\text{Hz}$; $f_2 = 10^5 (t/R^2) + 1000 \text{ Hz}$
4. For general use fuses which can be used in several stores; use $W_1 = .04 \text{ g}^2/\text{Hz}$; $W_2 = 0.15 \text{ g}^2/\text{Hz}$; $f_1 = 100 \text{ Hz}$; $f_2 = 1000 \text{ Hz}$; $T = 30 \text{ min/axis}$.
5. Acceptance range for parameter values: $40 \leq p \leq 150$ $.001 t/R^2 \leq .02$
If calculated values fall outside these limits, use these limit values.

TABLE 3-14B.
VIBRATION CRITERIA for EXTERNAL STORES CARRIED on AIRPLANES
EQUIPMENT CATEGORY (d.1)

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

TABLE 3-15A
TEST PROCEDURE and TIME SCHEDULE CHART for EQUIPMENT INSTALLED
in GROUND-LAUNCHED MISSILES – EQUIPMENT CATEGORY (e)

A. Procedure Selection and Time Schedule Chart								
Equipment Mounting Configuration	Procedure Number	Procedure Part Number	Applicable Tests		Test Time Schedule (per axis)			Curve Figure 3-15 (note 1)
			Sinusoidal Cycling (note 3)	Random (note 4)	Sinusoidal cycling time (note 3)	Sweep time 5-2000-5 Hz	Random time (note 2)	
Without vibration isolators	III	1	X		30 min	20 min		One of P thru U
		2		X			30 min	One of AE thru 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 1g 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 percent of the specified curve level.
2. When flight distances are less than 100 miles, the test time is reduced to 5 minutes.
3. See paragraph [3.4.5.6.4.4.1 \(No.c\)](#).
4. See paragraph [3.4.5.6.4.4.2](#).

TABLE 3-15B.
CURVE SELECTION CHART FOR EQUIPMENT CATEGORY (e)

Equipment Location by Vehicle Section	Approximate Thrust (power)	Vibration Test Curves (Figure 3-15)	
		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

TABLE 3-16. TEST PROCEDURE AND TIME SCHEDULE CHART FOR EQUIPMENT INSTALLED IN GROUND VEHICLES – EQUIPMENT CATEGORY (f)								
Equipment Conditions	Procedure Number	Procedure Part Number	Applicable Tests		Test Time Schedule (per axis)			Curve
			Sinusoidal Cycling (note 4)	Bounce Vehicular	Sinusoidal Cycling Time (note 4)	Maximum Cycling Time	Sweep Time	
Tracked vehicles	V	--	X	--	Schedule A			W
					30 min/1000 miles (note 2)	3 hours	15 min 5-500-5Hz (note 1)	
Wheeled vehicles	V	--	X	--	Schedule B			V or Y (note 3)
					30 min/1000 miles (note 2)	5 1/2 hours	12 min 5-200-5Hz (note 1)	
Vehicle & mileage unknown	V	--	X	--		3 hours	15 min 5-500-5Hz (note 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 3-16](#).
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 paragraph 3.4.5.6.4.4.1 ([No.c](#)).

3.4.5.7 **TEST: Acoustical Noise**

3.4.5.7.1 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.

3.4.5.7.2 Apparatus. A suitable type 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.

3.4.5.7.3. Definitions and Terms. A comprehensive list of standard terminology is titled Acoustical Terminology (including Mechanical Shock and Vibration) contained in ANSI-S1.1-1994.

3.4.5.7.4 Procedure. The basis for selecting a test procedure for a particular category shall be according to the test selection paragraph below.



Where functional testing is specified prior to or following a procedure, refer to General Requirements, [3.4.3.5](#).

3.4.5.7.4.1 Test selection. For the purpose of this test standard, equipment is categorized as mounted either external or internal to the vehicle structure (see paragraphs [3.4.5.7.5](#), [3.4.5.7.6](#), and [3.4.5.7.7](#)). 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 Method 106.

3.4.5.7.5 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 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.

3.4.5.7.5.1 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.

3.4.5.7.5.2 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.

3.4.5.7.6 Selection of Test Intensity. The noise levels are divided into four intensity categories as listed in [Table 3-17](#). 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 3-17. ACOUSTIC NOISE TEST CATEGORIES				
Category	Test Overall Sound Pressure Level (dB) (note 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

Note:

1. Reference 2×10^{-4} dynes/cm² (2×10^{-5} N/m²)

3.4.5.7.7 Procedure I:

3.4.5.7.7.1 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 percent 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.

3.4.5.7.7.2 Performance of Test

Step 1: The overall sound pressure level for the specified test category of [Table 3-17](#) shall be introduced into the test chamber to conform to the octave band spectrum specified on [Figure 3-17](#). The average sound pressure distribution (overall level) shall be uniform within -2 to +4 dB of the desired value. The sound pressure field shall be measured

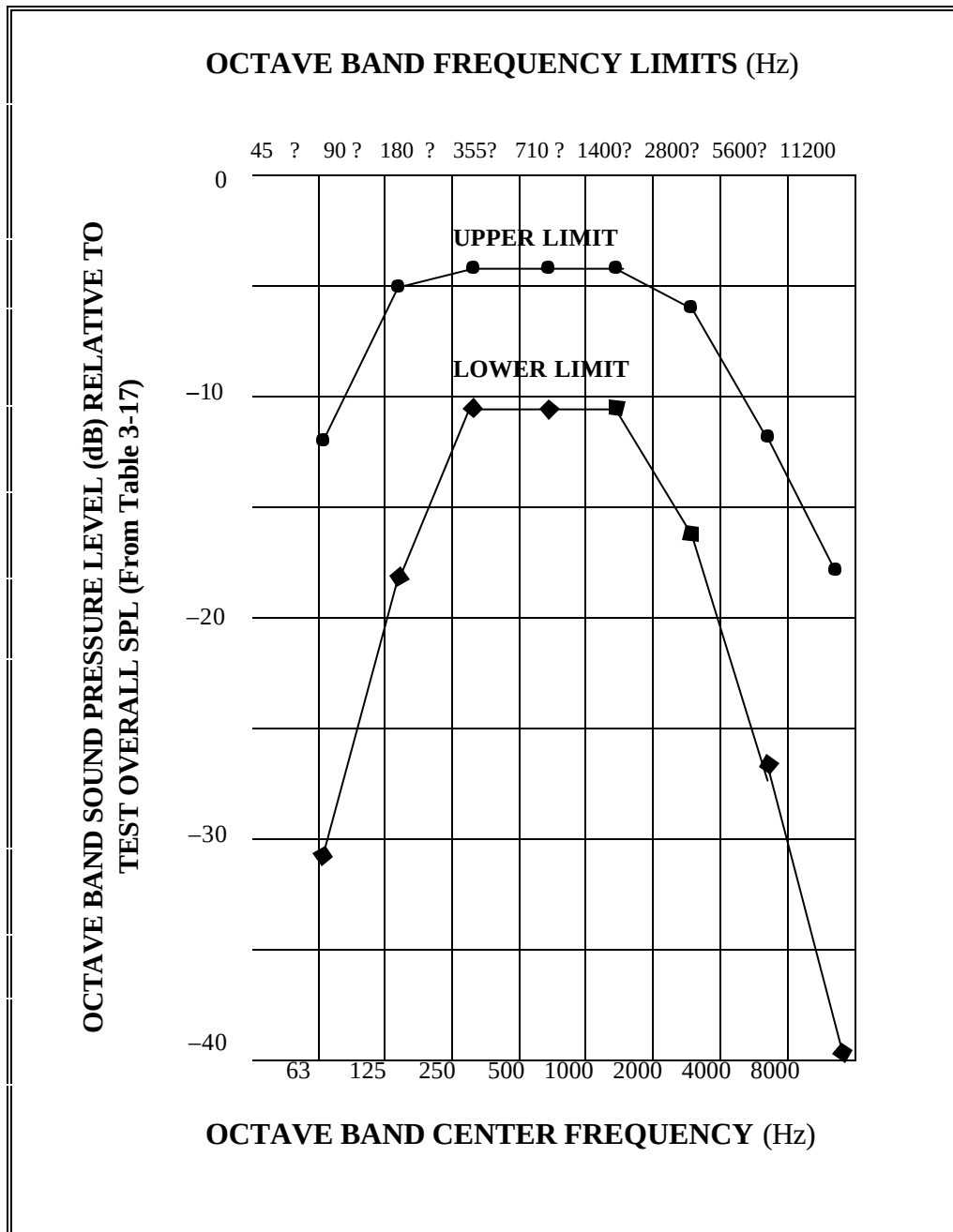
without the test item mounted in the test chamber. Measurements shall be made by using a microphone (more than one if desired) to define the sound field within the test volume (central 10 percent of the chamber volume).

Step 2: The test item shall be placed in the chamber as specified in paragraph 3.4.5.7.7.1. 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 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 3-17. 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 in accordance with General Requirements, 3.4.3.2. At the conclusion of the test, the test item shall be inspected in accordance with General Requirements, 3.4.3.2

3.4.5.7.8 Summary. The following details shall be specified in the equipment specification or test plan:

- a. Procedure number
- b. Pretest data required (see General Requirements, 3.4.3.2)
- c. Failure criteria
- d. Test category (see paragraph 3.4.5.7.6)
- e. Whether operation during the test is required, and if and how the operation is to be monitored.

Figure 3-17. Octave band spectrum for the acoustical noise test.



3.4.5.8 **TEST: Shock**

3.4.5.8.1 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.

3.4.5.8.2 Apparatus.

3.4.5.8.2.1 Shock machine. The shock machine utilized for this procedure shall be capable of producing the specified input shock pulse shown in [Figure 3-18](#) or [3-19](#). 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.

3.4.5.8.2.1.1 Shock machine calibration. 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 center of gravity 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 on Figures 3-18 and 3-19. 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.

3.4.5.8.2.2 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.

3.4.5.8.2.2.1 Frequency response. The frequency response of the complete measuring system, from the accelerometer through the readout instrument, shall be as shown on [Figure 3-20](#). 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.

3.4.5.8.2.2.2 Accelerometer, piezoelectric. When a piezoelectric accelerometer is employed as the shock sensor, the fundamental resonant frequency of the accelerometer shall be greater than 14 000 Hz (resonant frequencies of 30 000 Hz 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)

3.4.5.8.2.2.3 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 0.64 to 0.70 of critical.

3.4.5.8.2.2.4 Accelerometer calibration. The accelerometer shall be dynamically calibrated to the specified accuracy.

3.4.5.8.2.2.5 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.

3.4.5.8.3 Procedure:



Where functional testing is specified prior to or following a procedure, refer to General Requirements, [3.4.3.5](#).

3.4.5.8.3.1 Shock Pulse. The shock pulses for this procedure shall be as shown in [Figures 3-18](#) or [3-19](#) (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 saw tooth shock pulse be used since its broad frequency spectrum tends to excite all resonant frequencies.

3.4.5.8.3.2 Mounting of Test Item. The test item shall be rigidly attached to the shock machine table for Procedure I, in accordance with General Requirements, [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.

3.4.5.8.3.3 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 in accordance with either [Figures 3-18](#) or [3-19](#), 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 in accordance with General Requirements, [3.4.3.2](#).

3.4.5.8.3.4 Related Shock Tests.

- a. High impact: Unless otherwise specified, ballistic shock tests and high impact tests shall be performed in accordance with MIL-S-901.
- b. Shipboard equipment: Shock tests for shipboard equipment shall be performed in accordance with MIL-S-901.
- c. Rough handling for packaged items: Tests for shipping and handling shall be performed in accordance with FED-STD-101C(3).

3.4.5.8.3.5 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.

3.4.5.8.4 Summary. The following details shall be as specified in the equipment specification or test plan:

- a. Retest data required (see General Requirements, [3.4.3.2.](#))
- b. Shock pulse selection, specify shape, peak value, and duration (see paragraph [3.4.5.8.3.1](#))
- 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.

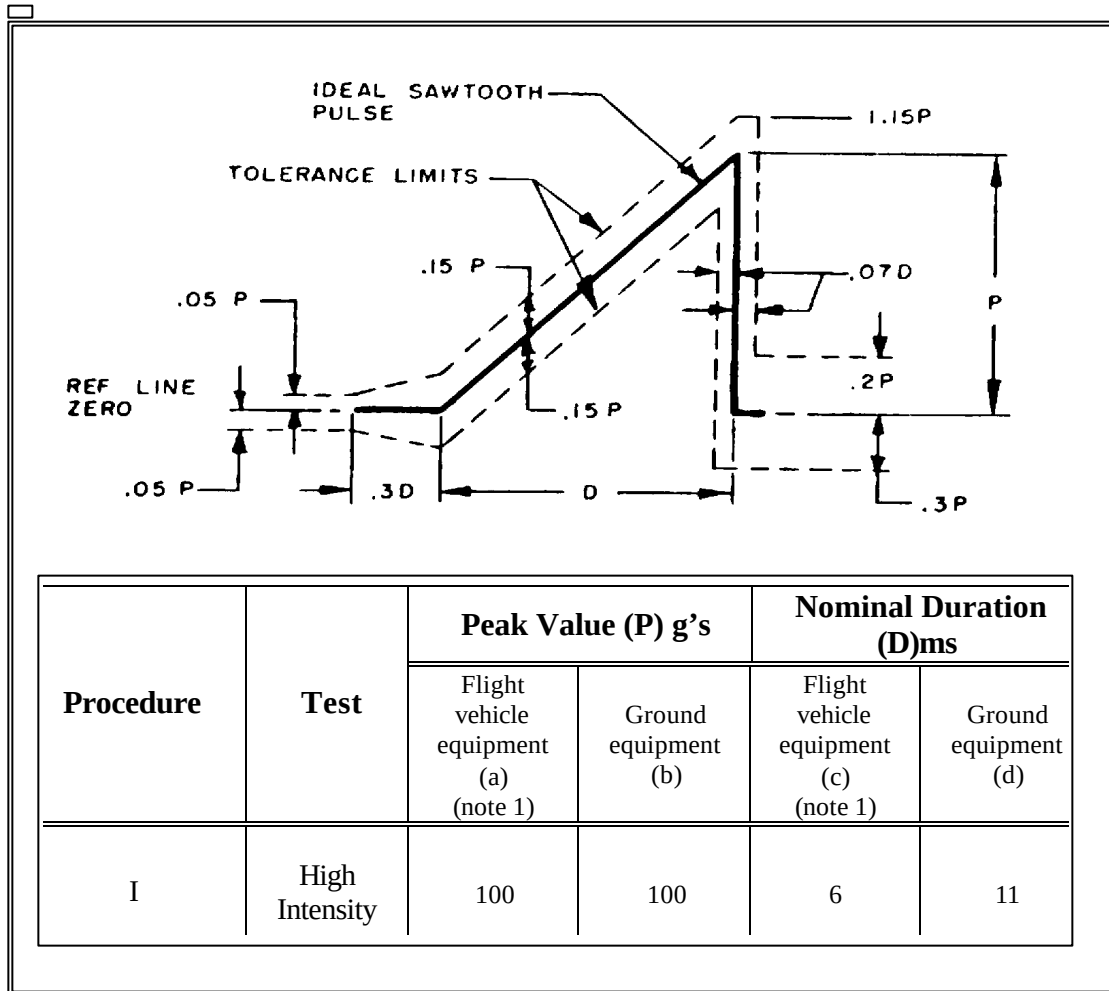


Figure 3-18. Terminal-peak sawtooth shock pulse configuration and its tolerance limits.

Notes:

1. Shock parameters (a) and (c): recommended for equipment that is not shock mounted and weighing less than 300 pounds.
2. 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.

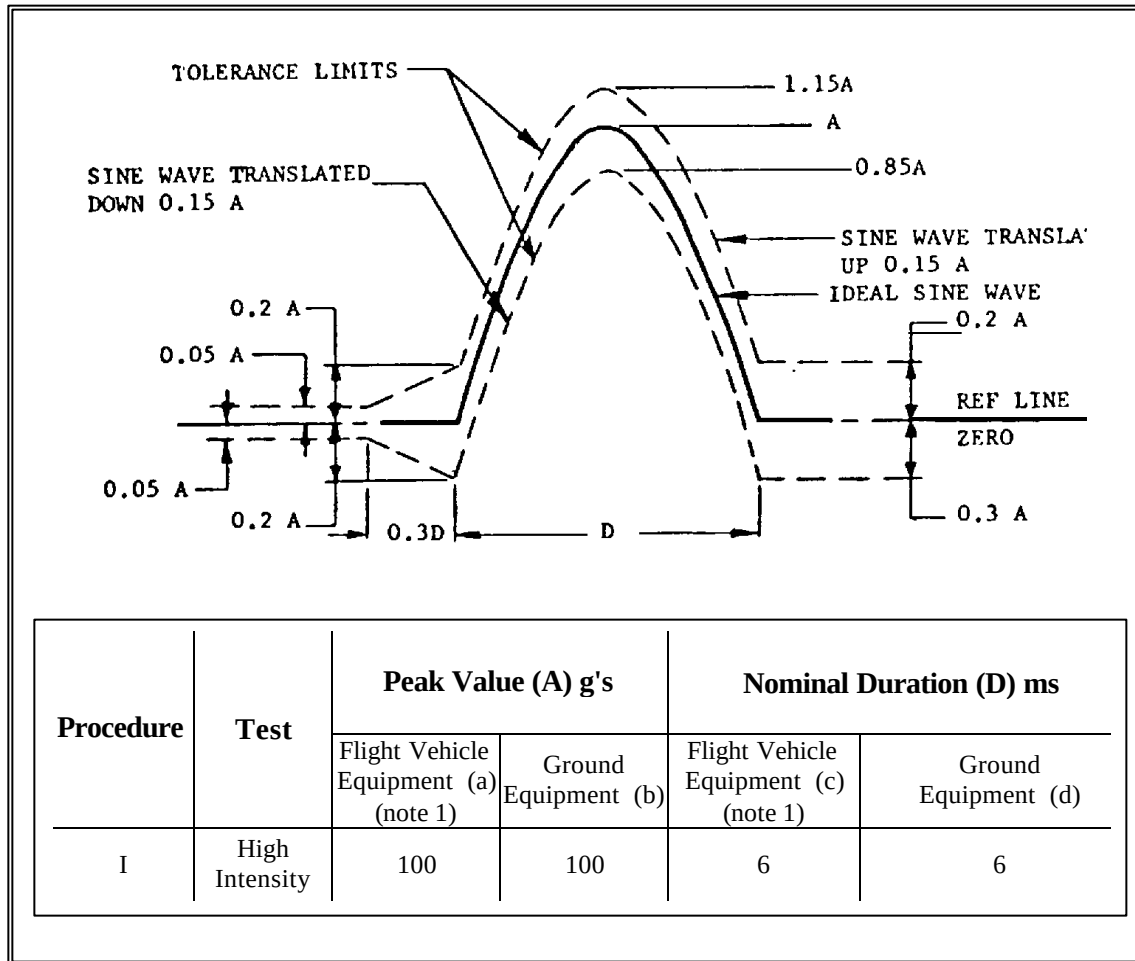


Figure 3-19. Half sine shock pulse configuration and its tolerance limits.

Notes:

1. Shock parameters (a) and (c): recommended for equipment that is shock-mounted or weighing 300 pounds or more.
2. 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 $2AD/\pi$. The integration to determine velocity change shall extend from 0.4D before the pulse to 0.1D after the pulse.

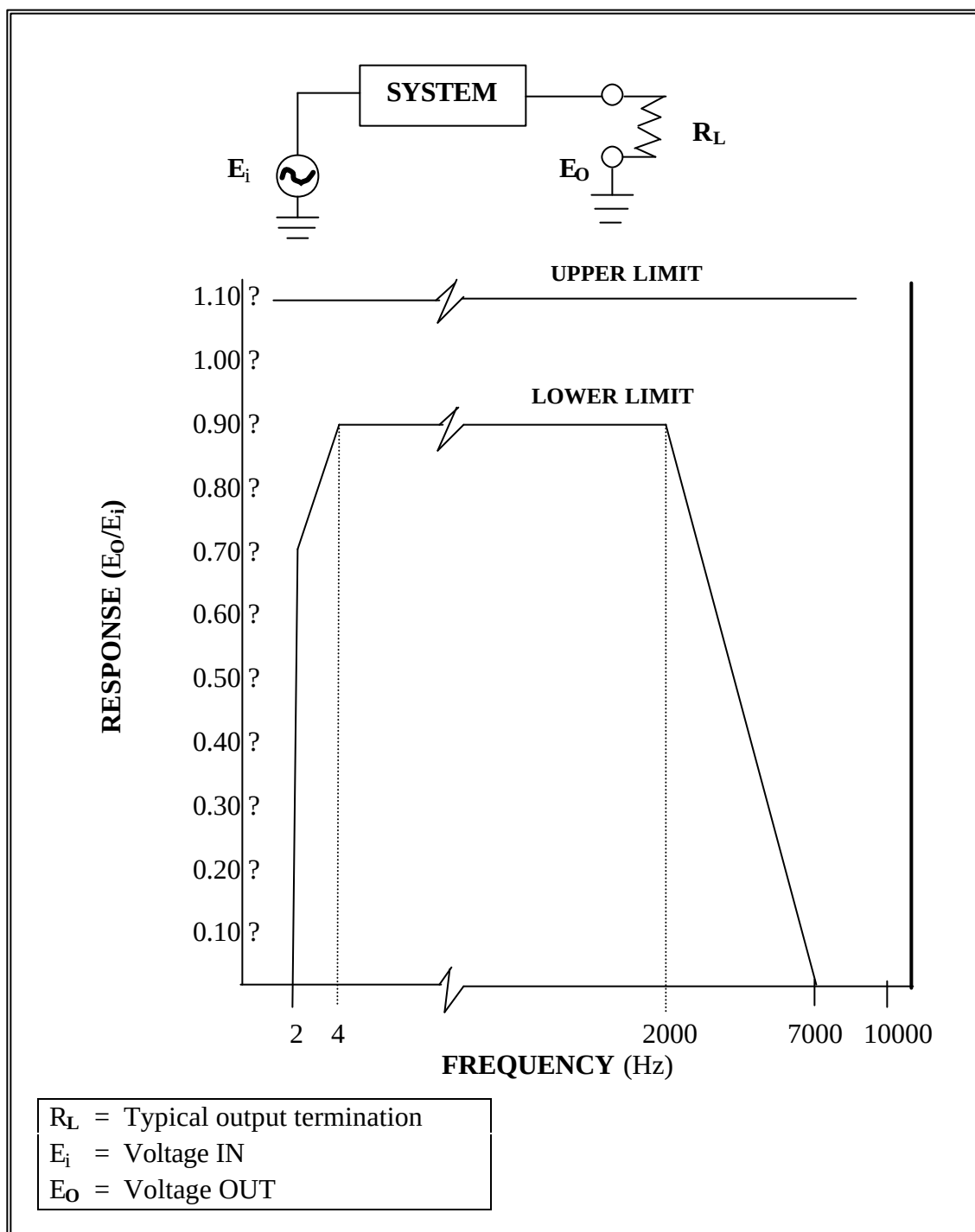


Figure 3-20. Shock measuring system frequency response.

CHAPTER 4

GENERAL TEST PROCEDURES FOR RADAR TRANSPONDERS

Type II Tests: Acceptance Testing (Purchasing Agent's Responsibility)

Section I: Transmitter and Receiver Electrical Parameters
Section II: Environmental Test Procedures

4.1 Section I: 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 thirty 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 turn-around time of equipment with completed report shall be sixty 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 utilized in the commission of these test procedures shall be within current calibration and the test bench setup shall also 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 No.
4.2.1	Receiver sensitivity and random triggering	2.1.5.5 and 2.1.5.7
4.2.2	Receiver bandwidth (3 dB)	2.1.5.2
4.2.3	Receiver code accept and reject at 3.5, 9.5 and 15.5 μ s spacing	2.1.5.6.3 and 2.1.5.6.4
4.2.4	Peak power output vs. PRF in 500 p/s steps, 100-2600 p/s	2.1.6.3, 2.1.6.4, 2.1.6.4.1
4.2.5	Peak power output versus set transmitter frequency	2.1.6.2 and 2.1.6.3
4.2.6	Recovery time for two interrogating signals	2.1.6.9
4.2.7	Delay, delay variation, and delay jitter vs. input signal level	2.1.6.8, 2.1.6.8.1
4.2.8	Pressurization test	2.1.4.8

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

9300 MHz

a. Test Set-up: As shown in [Figure 4-1](#).

b. Test Conditions:

- 1) Uplink frequency 5800 MHz.
- 2) Interrogate with 2 pulses, 5.0 μ s leading
i. edge to leading edge.
- 3) Downlink frequency 5700 MHz.
- 4) Repetition rate 1000 p/s.

X-Band:
uplink: 9300 MHz;
downlink: 9100 MHz

c. Test Method:

- 1) With the transponder tuned to 5800 MHz measure the receiver sensitivity to the requirements of paragraph [2.1.5.5](#). Monitor the 99 percent response over a 10 second period.
- 2) Turn off interrogation to the transponder and monitor for random replies to the requirements of paragraph [2.1.5.7](#). Monitor for a 10 second period.
- 3) Repeat steps (1) and (2) with transponder receiver frequencies of 5600 and 5900 MHz.

9300 MHz

9100 and 9500 MHz

d. Criteria: Must satisfy requirements of the appropriate PSS test paragraphs listed in [Table 4-1](#).

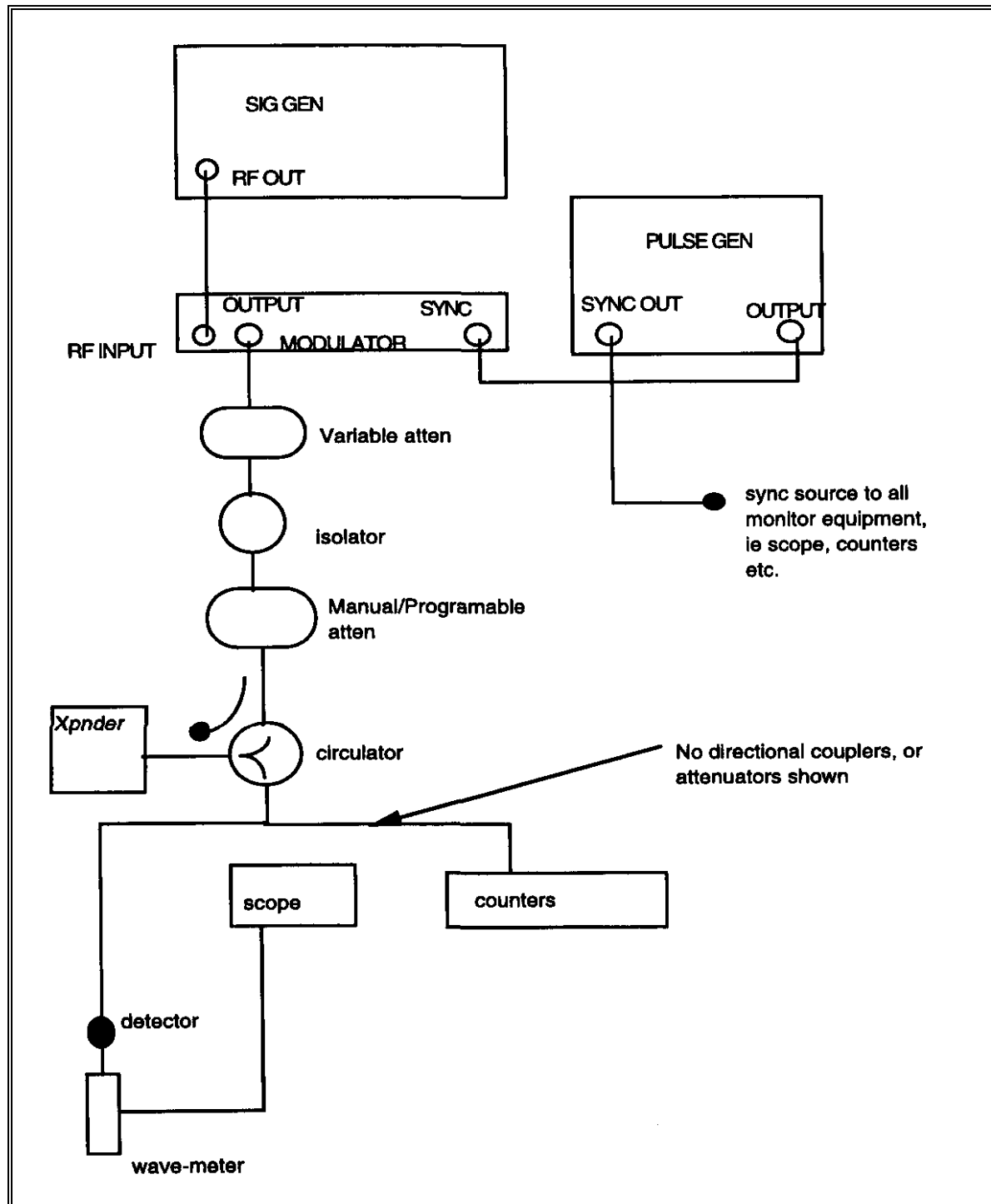


Figure 4.1 Basic test bench set-up.



Under certain applications, a portable radar simulator may be substituted for this basic test bench set-up.

4.2.2 **TEST: Receiver bandwidth at 3 dB, 5800 MHz**

9300 MHz

a. Test Set-up: As shown in [Figure 4-1](#).

b. Test Conditions:

- 1) Uplink frequency 5800 MHz
- 2) Interrogate with 2 pulses, 5.0 μ s leading edge to leading edge
- 3) Downlink frequency 5700 MHz
- 4) Repetition rate 1000 p/s

X-Band:
uplink: 9300 MHz;
downlink: 9100 MHz

c. Test Method:

- 1) Adjust the signal generator to the receiver center frequency; adjust the level until the PRF counter reads 990 p/s nominal averaged over a 10 second period. Record the *receiver sensitivity*.
- 2) Increase the input signal level 3dB above the level recorded in step (1). Increase the signal generator frequency until the PRF counter reads 990 p/s. 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 p/s. 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 μ s code spacing**

a. Test Set-up: As shown in [Figure 4-1](#).

b. Test Conditions:

- 1) Uplink frequency 5800 MHz
- 2) Interrogate with 2 pulses, 3.5 μ s leading edge to leading edge (test method will vary interrogation code spacing)
- 3) Downlink frequency 5700 MHz
- 4) Repetition rate 1000 p/s

X-Band:
uplink: 9300 MHz;
downlink: 9100 MHz

c. Test Method:

- 1) Apply a double pulse code spacing of 3.5 μ s, signal level of 0 dBm. Repeat for the following codes: 9.5 μ s, and 15.5 μ s.
- 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 pulse width from 3.0 to 50.0 μ s 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 p/s steps 100-2600 p/s

a. Test Set-up: As shown in [Figure 4-1](#).

b. Test Conditions:

- 1) Uplink frequency 5800 MHz
- 2) Interrogate with 2 pulses, 5.0 μ s leading edge to leading edge
- 3) Downlink frequency 5700 MHz
- 4) Repetition rate 1000 p/s (test method will vary PRF rate)

X-Band:
uplink: 9300 MHz;
downlink: 9100 MHz

c. Test Method:

- 1) Adjust input PRF in steps from 100 to 2600 p/s. With input PRF set to 100 p/s, measure pulse width and average power.

- 2) Calculate peak power using formula: $\text{Peak Power} = \frac{\text{P Average (attenuation in dB)}}{\text{PRF} \cdot \text{PW}}$
- 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 Set-up: As shown in [Figure 4-1](#).
- b. Test Conditions:

X-Band:
 uplink: 9300 MHz;
 downlink: 9100 MHz

 - 1) Input voltage 28.0 ± 1.0 volts
 - 2) Uplink frequency 5800 MHz
 - 3) Downlink frequency 5400 MHz
 - 4) Interrogate with 2 pulses, 5.0 μs leading edge to leading edge
 - 5) Repetition rate 1000 p/s
- 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 Set-up: As shown in [Figure 4-1](#).
- b. Test Conditions:

X-Band:
 uplink: 9300 MHz;
 downlink: 9100 MHz

 - 1) Uplink frequency 5800 MHz
 - 2) Interrogate with 2 pulses, 5.0 μs leading edge to leading edge

- 3) Downlink frequency 5700 MHz
 - 4) Repetition rate 1000 p/s
- c. Test Method:
- 1) This test will require two pulse generators and two RF signal generators.
 - 2) Commonly sync both pulse generator and oscilloscope from generator No. 1.
 - 3) Adjust pulse generator No. 2 to provide a second 5.0 μ s pulse group 5.0 μ s after the first pulse group measuring from the leading edge of the first pulse of each group.
 - 4) Adjust the RF signal generator No. 1 for a 0 dBm level at the transponder.
 - 5) Adjust RF signal generator No. 2 for a -65 (20 W), -68 (50 W) or -70 (400 W) dBm level at the transponder.
 - 6) 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 Set-up: As shown in [Figure 4-1](#).
- b. Test Conditions:
- 1) Uplink frequency 5800 MHz
 - 2) Interrogate with 2 pulses, 5.0 μ s leading edge to leading edge
 - 3) Downlink frequency 5700 MHz
 - 4) Repetition rate 1000 p/s

X-Band:
uplink: 9300 MHz;
downlink: 9100 MHz

Double pulse code, time measurements taken at the 50 percent amplitude point of the second interrogate pulse leading edge and the detected reply pulse.

- 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 Set-up:
 - 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 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 **Section II: Environmental Test Procedures**

4.3.1 Test Schedule:

Sinusoidal vibration
Temperature and altitude

4.3.2 TEST: Sinusoidal vibration

Use test method for sinusoidal vibration, as specified in Chapter 3 paragraph [3.4.5.6.4.4.1](#), with the exception that vibration may be limited to one axis, the axis determined to be the most critical during Type I testing.

4.3.3 TEST: Temperature and altitude

Use test method for temperature and altitude, as specified in Chapter 3 paragraph [3.4.5.2](#). Testing shall be conducted at -37.2°C and $+75^{\circ}\text{C}$ with a 15 minute soak time during temperature. Altitude test shall be conducted at 100 000 feet at site temperature.

REFERENCES

Bulletins and Proceedings:

- Burkhard, A.H. (1974). Acoustic testing to simulate the flight vibration environment of aircraft stores. AFFDL-TR-73-110.
- Burkhard, A. "Captive flight acoustic test criteria for aircraft stores," Shock and Vibration Bulletin, No. 43 (part 3). Washington, DC, National Research Laboratory, 1973. (pp.113-126).
- Dreher, J.F. Effects of vibration and acoustical noise on aircraft/stores compatibility, Proceedings of the Aircraft Compatibility Symposium, Eglin AFB, FL, November 1969 (Vol. 6, pp. 245-272).
- Dreher, J.F. "Aircraft equipment random vibration test criteria based on vibrations induced by turbulent airflow across aircraft external surfaces," Shock and Vibration Bulletin No. 43 (part 3), Washington, DC, National Research Laboratory, 1973 (pp. 127-139).
- Dreher, J.F., Lakin, E.D., Tolle, E.A. "Vibracoustic environment and test criteria for aircraft stores during captive flight," Shock and Vibration Bulletin No. 39, Supplement). Washington, DC, National Research Laboratory, 1969. (pp. 15-40).
- Piersol, A.G. "Vibration and Acoustical Noise on Aircraft Stores Compatibility," Proceedings of Aircraft Store Compatibility Symposium, Eglin AFB, FL, November 1969 (Vol. 6 pp. 245-272).
- Wafford, J.H., and Dreher, J.F. "Aircraft equipment random vibration test criteria based on vibration induced by jet and fan engine exhaust noise," Shock and Vibration Bulletin No. 43 (part 3). Washington, DC, National Research Laboratory, 1973 (pp. 141-151).

Documents and Standards

- ANSI-NCSL-Z540.1 (1994): Calibration Laboratories and Measuring and Test Equipment, General Requirements.
- ANSI-S1.1 (1994): Acoustical Terminology (including mechanical shock and vibration).
- ASTM - E-491-73 (1999): Standard Practice for Solar Simulation for Thermal Balance Testing of Spacecraft.
- DD FORM 1423: Contract Data Requirement List (Feb, 2000).
- FED-STD-101C (3): Test Procedures for Packaging Materials.

ISO-9000-1: Quality Management and Quality Assurance Standards; Part 1, Guidelines for Selection and Use.

ISO-9000-2: Quality Management and Quality Assurance Standards; Part 2, Generic Guidelines for Application of ISO-9001, ISO-9002, and ISO-9003.

ISO-9000-4: Quality Management and Quality Assurance Standards; Part 4, Guide to Dependability Programme Management.

ISO 10012-1: Quality Assurance Requirements for Measuring Equipment (Part 1, “Meteorological Confirmation System for Measuring Equipment”).

MIL-A-8591H: General Design Criteria for Airborne Stores, Suspension Equipment and Aircraft-Store Interface (Carriage Phase).

MIL-C-5541E: Chemical Conversion Coatings on Aluminum and Aluminum Alloys.

MIL-HDBK-310: Global Climatic Data for Developing Military Products.

MIL-HDBK-454A: General Guidelines for Electronic Equipment.

MIL-S-901D: Requirements for Shock Tests, HI. (High Impact), Shipboard Machinery, Equipment and Systems.

MIL-STD-167/1: Mechanical Vibrations of Shipboard Equipment.

MIL-STD-461E: Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment.

MIL-STD-704E: Aircraft Electric Power Requirements.

MIL-STD 810C: Environmental Test Methods (canceled).

MIL-STD-889B: Dissimilar Metals.

STANAG-3518: Environmental Test Methods, Ed.4 (1990).

U.S. Standard Atmosphere Supplement, 1966. U.S. Committee on Extension to the Standard Atmosphere. Superintendent of Documents, GPO, Washington, DC 20402.

APPENDIX A

GLOSSARY

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.

colorimeter: a device for measuring concentration of a known constituent in solution by comparison with colors of a few solutions of known concentration of that constituent.

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 which 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.

dynamic range: the range of input signal level to which the transponder will reply to 99 percent of interrogation pulses without receiver saturation. The ratio of the highest signal level a circuit can handle to the smallest level it can handle (usually equal to the noise level, normally expressed in dB).

electromagnetic interference (EMI): 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 decibels 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 (MTBF): 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 percent 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 (PCM): 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-percent 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.

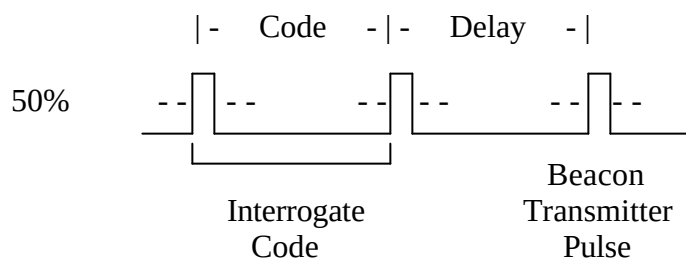
pulse fall time: the time required for the trailing edge of a voltage pulse to decrease from 90 to 10 percent of the amplitude of the pulse.

pulse repetition frequency (PRF): 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 percent of the amplitude of the pulse.

pulse-time modulation (PTM): modulation in which the time of occurrence of some characteristic of a pulse carrier is varied from the unmodulated value; examples include pulse-duration, pulse-interval, and pulse-position modulation.

pulse width: the time interval (pulse duration) at the 50 percent 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 thyristor.

sensitivity: the minimum signal level, measured at the transponder antenna terminal, which causes the transponder to reply to at least 99.9 percent 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 1.0 μs to 9.0 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 which 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-percent amplitude point that triggers a transmitter, to the 50-percent 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 which constrains or guides the propagation of electromagnetic waves along a path defined by the physical construction of the waveguides.

APPENDIX B

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, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including 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 22202-4302. 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 completed 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			
8. APP CODE				11. AS OF DATE		13. DATE OF SUBSEQUENT SUBMISSION			
16. REMARKS				14. DISTRIBUTION					
				a. ADDRESSEE		b. COPIES			
						Draft		Final	
								Reg	
								Repro	
								15. TOTAL	
G. PREPARED BY			H. DATE		I. APPROVED BY				
					J. DATE				

INSTRUCTIONS FOR COMPLETING DD FORM 1423

(See DoD 5010.12-M for detailed instructions.)

FOR GOVERNMENT PERSONNEL	FOR THE CONTRACTOR
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 I. 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.	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 III. 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 III 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