

Standard

Criteria for Explosive Systems and Devices on Space and Launch Vehicles

AIAA standards are copyrighted by the American Institute of Aeronautics and Astronautics (AIAA), 12700 Sunrise Valley Drive, Reston, VA 20191-5807 USA. All rights reserved.

AIAA grants you a license as follows: The right to download an electronic file of this AIAA standard for storage on one computer for purposes of viewing, and/or printing one copy of the AIAA standard for individual use. Neither the electronic file nor the hard copy print may be reproduced in any way. In addition, the electronic file may not be distributed elsewhere over computer networks or otherwise. The hard copy print may only be distributed to other employees for their internal use within your organization.

Published by

American Institute of Aeronautics and Astronautics

12700 Sunrise Valley Drive, Reston, VA 20191

Copyright © 2024 American Institute of Aeronautics and Astronautics.

All rights reserved.

No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without prior written permission of the publisher.

Printed in the United States of America.

Standard

Criteria for Explosive Systems and Devices on Space and Launch Vehicles

Sponsored by

American Institute of Aeronautics and Astronautics

Approved

20 December 2023

Abstract

This standard establishes criteria for design, manufacture, and performance certification of explosive systems and explosive devices commonly used on unmanned launch and space vehicle systems. The requirements contained in this specification are intended to serve as a universal set of tools for use by explosive device manufacturers and users during all phases of development and certification. This information may also be used for guidance during preparation of acquisition contracts and program-specific documents, and may be used for explosive system applications unrelated to space vehicles such as manned launch vehicles or military missile applications in which high reliability explosive devices and systems are required.

Contents

Contents	ii
Foreword	iv
Introduction.....	v
1 Scope	6
2 Tailoring.....	6
3 Reference Documents	6
4 Vocabulary.....	7
4.1 Acronyms and Abbreviated Terms	7
4.2 Terms and Definitions.....	9
5 Design Requirements	17
5.1 General Requirements.....	17
5.2 System Design Requirements.....	24
5.3 Component Design Requirements	32
5.4 Margin Requirements.....	46
5.5 Operations and Maintenance.....	52
6 Verification Requirements.....	53
6.1 General	53
6.2 Margin Verification.....	63
6.3 Functional Test Requirements.....	72
A.1 Nondestructive Inspection and Test Methods	97
A.2 Destructive and Environmental Tests.....	126
A.3 All-Fire/No-Fire Test and Analysis Methods.....	157
A.4 Seal Effectiveness	165
Figures	
Figure 1 — Explosive System Flow Diagram	25
Figure 2 — Acceptable Explosive Transfer Modes.....	31
Figure B.1 — Representative Thermal Time Constant Test Data (ref. AIAA-2003-5139 Figure 10, Copyright, AIAA).....	104
Figure C.1 — Comparison of the Variation in Estimates of the Standard Deviation	160
Figure C.2 — 5% and 95% Estimates of the Relative Standard Deviation	161
Figure C.3 — Comparison of Confidence Likelihood Ratio vs ASENT	164
Tables	
Table 1 — Test Tolerances.....	62
Table A.1 — EED, EFI, SCB, EBW, & LID Nondestructive Acceptance Tests.....	79
Table A.2 — S&A, ESA, and LFU Nondestructive Acceptance Tests	80
Table A.3 — FOCA Nondestructive Acceptance Tests	82
Table A.4 — Other Devices Nondestructive Acceptance Tests	83
Table A.5 — Thermal Battery Nondestructive Acceptance Tests.....	84
Table A.6 — EED, EFI, SCB, EBW, & LID Qualification Tests.....	85
Table A.7 — S&A Qualification Tests	86
Table A.8 — ESA and LFU Qualification Tests.....	87
Table A.9 — FOCA Qualification Tests	88
Table A.10 — Other Devices Qualification Tests	89
Table A.11 — Thermal Battery Qualification Tests.....	90
Table A.12 — EED, EFI, SCB, EBW, LID Destructive Acceptance Tests.....	91

Table A.13 — FOCA Destructive Acceptance Tests..... 92

Table A.14 — Other Devices Destructive Acceptance Tests..... 93

Table A.15 — Thermal Battery Destructive Acceptance Tests 94

Table A.16 — EED, EFI, SCB, EBW, LID Service Life Extension Tests 95

Table A.17 — Other Devices Service Life Extension Tests 96

Table B.1 — Leak Rate Requirements for Various Leak Test Parameters 101

Table B.2 — Minimum Random Frequency versus Power Spectral Density 115

Table C.1 — Frequency versus Minimum Power Spectral Density 133

Table C.2 — Default Test Frequencies and Modulations..... 141

Foreword

The purpose of this standard, developed by the AIAA Ordnance Committee on Standards, is to clearly define technical requirements, practices, and expectations associated with ordnance systems and components to be used on launch and space vehicles. It is to be applied as part of the technical baseline for acquisition, contracting, and program management. To the greatest extent possible, requirements from past and existing government and military specifications and standards have been incorporated herein. In addition, the requirements herein include those generated as a result of explosive systems and devices lessons learned from launch and space vehicle programs as well as from other military and aerospace programs.

This standard will be updated and revised as appropriate to incorporate technological advances and innovations as well as new lessons learned.

This standard may be tailored by the procuring authority, or may be replaced in part by another document from the government, industry, technical society, international community, or contractor provided the new document is comparable in rigor and effectiveness. Tailoring must be relevant and approved by procuring authority.

The individuals who participated in the second revision of the document include the following:

Donald Jackson (Chair)	Retired
Dr. Selma Goldstein (Co-chair)	The Aerospace Corporation
Frank Aldrich	Lockheed Martin
James Baglini Jr.	Northrop Grumman
Tom Blachowski	Retired
Hunter Golden	Karman Space & Defense
John Gormley	Lockheed Martin
Dr. Hobin Lee	Chemring Energetic Devices
John Niehues	US Government
Stephanie Sawhill	Karman Space & Defense
John Scott	Lockheed Martin
Dr. Mikhaylo Trunov	Northrop Grumman
Ian Whalley	Consultant
Dr. Lien Yang	Consultant

In memory of Dr. Selma Goldstein, a principled leader in aerospace ordnance and a friend to many.

The AIAA Standards Procedures dictate that all approved Standards, Recommended Practices, and Guides are advisory only. Their use by anyone engaged in industry or trade is entirely voluntary. There is no agreement between industry or trade, in general or specific, and AIAA to adhere to any AIAA standards publication and no commitment to conform to or be guided by standards reports. However, should a procuring authority choose to use this standard and contractually impose it upon a contractor and/or subcontractor, the use of this standard will be as defined by that particular contract.

In formulating, revising, and approving standards publications, the committees on standards will not consider patents or copyrights that may apply to the subject matter. Prospective users of the publications are responsible for protecting themselves against liability for infringement of patents or copyright or both.

Introduction

Explosive systems include initiation devices/mechanisms, explosive trains, and end effector explosive devices that use explosive energy to do work. These systems may consist of a number of different explosive devices, which are electrical or mechanical components or assemblies containing or operated by explosive materials. Except for electronic safe arms (ESA) and laser firing units (LFU) without integral ordnance, these are, by design, “one-shot” components. Performance confidence of “one-shot” components can only be obtained by destructive tests of like samples from common production lots and nondestructive inspection of flight units. ESAs and LFUs with separable ordnance can each be fully tested including firing into a representative load, or an optical power meter. This document describes criteria to certify safe and reliable performance of explosive systems and their components.

The criteria outlined in this standard are a composite of those that have been verified by previous use in space and launch vehicle applications. Described are essential design characteristics, manufacturing controls, and methods for certifying performance, acceptance, qualification, and useful life.

This document is intended for unmanned launch applications but may also be used for more specific applications such as manned launch vehicles or military missiles.

For a specific program or project, the requirements defined in this standard may be tailored to match the actual requirements of the particular program or project. Tailoring of requirements shall be undertaken in agreement with the procuring authority where applicable.

1 Scope

This standard establishes criteria for design, manufacture, and performance certification of explosive systems and explosive devices commonly used on launch and space vehicle systems. The requirements contained in this standard are intended to serve as a universal set of tools for use by explosive system manufacturers and users during all phases of development and certification to assure safe application and high quality products. This information may also be used for guidance during preparation of acquisition contracts and program-specific documents, and may be used for explosive system applications unrelated to space vehicles.

Any use of commercial trade names herein does not imply endorsement of the product; they are used to help identify the generic type of design.

2 Tailoring

For a specific program or project, the requirements defined in this standard may be tailored to match the actual requirements of the particular program or project. Tailoring of requirements shall be undertaken in agreement with the procuring authority where applicable.

Tailoring is a process by which individual requirements or specifications, standards, and related documents are evaluated and made applicable to a specific program or project by selection, and, in some cases, modification and addition (e.g., for manned spaceflight) of requirements in the standards.

The criteria offered here are generic in nature; therefore, users are encouraged to consider tailoring these criteria to best fit individual applications. However, the tailored requirements shall achieve a level of verification equivalent to the baseline described herein. Rationale for each tailored requirement shall be established. If the requirements in this specification are not tailored by a contract, they stand as written.

3 Reference Documents

The following references provide additional information that may be useful to programs. They are not considered in this document to be contractually applicable.

In the event of conflict between the text of this document and the references cited herein, the text of this document takes precedence.

Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

Requirements in this document do not take precedence over Flight Termination System Requirements defined in Range Safety documents such as RCC 319 and AFSPCMAN 91-710.

AFSPCMAN 91-710	<i>Air Force Space Command Range Safety User Requirements</i>
AIAA 2000-3735	<i>Aerospace Leak Test Requirements</i>
AIAA 2005-4039	<i>Advanced Applications of Statistical Methods in Testing of Energetic Components and Systems</i>
AIAA 2007-5135	<i>Practical Problems and Solutions in Age Trend-Line Analyses for Energetic Components</i>
AIAA 2007-5138	<i>Correlation Between the Accelerated Aging Test (AAT) and Real-World Storage Temperature</i>
AIAA 2016-4931	<i>A Review on Relationship between Reliability and Lot Acceptance Sample Size for ECS</i>