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Ersatz für
DIN EN 14607-6:2006-12**Raumfahrttechnik –
Explosive Subsysteme und Geräte;
Englische Fassung EN 16603-33-11:2019**Space engineering –
Explosive subsystems and devices;
English version EN 16603-33-11:2019Ingénierie spatiale –
Sous-systèmes et dispositifs explosifs;
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DIN-Normenausschuss Luft- und Raumfahrt (NL)

Nationales Vorwort

Dieses Dokument (EN 16603-33-11:2019) wurde vom Technischen Komitee CEN/CLC/TC 5 „Raumfahrt“ erarbeitet, dessen Sekretariat von DIN (Deutschland) gehalten wird.

Das zuständige deutsche Normungsgremium ist der Arbeitsausschuss NA 131-06-02 AA „Interoperabilität von Informations-, Kommunikations- und Navigationssystemen“ im DIN-Normenausschuss Luft- und Raumfahrt (NL).

Dieses Dokument (EN 16603-33-11:2019) basiert auf ECSS-E-ST-33-11C Rev.1.

Dieses Dokument ersetzt DIN EN 14607-6:2006-12.

Dieses Dokument enthält unter Berücksichtigung des DIN-Präsidialbeschlusses 1/2004 nur die Englische Fassung von EN 16603-33-11:2019.

Dieses Dokument wurde speziell zur Behandlung von Raumfahrtssystemen erarbeitet und hat daher Vorrang vor jeglicher Europäischen Norm, die denselben Anwendungsbereich hat, jedoch über einen größeren Geltungsbereich (z. B. Luft- und Raumfahrt) verfügt.

Änderungen

Gegenüber DIN EN 14607-6:2006-12 wurden folgende Änderungen vorgenommen:

- a) vollständige Überarbeitung zur Einhaltung der ECSS-Entwurfsregeln für „ECSS Issue C Standards“;
- b) Umsetzung der ECSS-Änderungsanfragen und Harmonisierung der Norm mit ISO in ECSS Revision 1 (2017);
- c) Änderung des Titels von „Raumfahrttechnik — Mechanik — Teil 6: Pyrotechnik“ in „Raumfahrttechnik — Explosive Subsysteme und Geräte“;
- d) Verwendung des genaueren Begriffs „explosiv“ statt „pyrotechnisch“ in Bezug auf das Thema Komponenten und Systeme;
- e) Betonung der Zuverlässigkeit verbunden mit dem Vertrauensniveau bei Leistungsmerkmalen;
- f) Aufnahme detaillierter Anforderungen für die verschiedenen Arten von explosiven Geräten;
- g) Hervorhebung der Anforderung, die Eigenschaften von Komponenten vor der Beschaffungsverpflichtung mit dem Endverbraucher zu vereinbaren.

Frühere Ausgaben

DIN EN 14607-6: 2006-12

Nationaler Anhang NA (informativ)

Begriffe und Abkürzungen

Die Benummerung der folgenden Begriffe und Abkürzungen ist identisch mit der Benummerung in der englischen Fassung.

3.1 Begriffe aus anderen Normen

- a) Für die Anwendung dieser Norm gelten die Begriffe nach ECSS-S-ST-00-01, insbesondere der folgende Begriff:

- 1) Lebensdauer

3.2 Für diese Norm spezifische Begriffe

3.2.1

Ansprechen

Impuls mit einer Funktionswahrscheinlichkeit von gleich oder besser als 0,999 bei einem 95 %-Vertrauensniveau

3.2.2

Zweigsteckdose

Steckverbinder, der an der Außenhaut eines Raumfahrzeugs befestigt ist und mit einem Sicherheits-, Prüf- oder Zweigstecker verbunden werden kann

3.2.3

gerüstet

Zustand eines explosiven Subsystems, wenn alle Sicherheitseinrichtungen deaktiviert wurden und das System ausgelöst werden kann

[QUELLE: Dictionary of explosive related terms, mit Änderungen übernommen]

3.2.4

Kartusche

explosives Gerät, das dafür ausgelegt ist, einen Druck aufzubauen, um eine mechanische Funktion ausführen

Anmerkung 1 zum Begriff: Eine Kartusche wird als Initialzündler bezeichnet, wenn sie das erste oder das einzige explosive Element in einer **Zündkette** ist (siehe Begriff 3.2.14).

3.2.5

Ladung

explosiver Stoff, der in eine Kartusche, in einen Detonator oder in einen separaten Behälter gefüllt wird und zur Verwendung in einem explosiven Gerät vorgesehen ist

3.2.6

Komponente

kleinste funktionale Einheit in einem explosiven Subsystem

3.2.7

Deflagration

selbsterhaltende, exotherme Zerfallreaktion einer explosiven Substanz, deren scheinbare Geschwindigkeit geringer ist als die Schallgeschwindigkeit in der Substanz und größer ist als die Schallgeschwindigkeit in Luft

Anmerkung 1 zum Begriff: Es ist allgemein anerkannt, dass die Energieübertragung über eine mechanische Druckwelle stattfindet. Diese Art von Reaktion findet zwischen der Verbrennung und der Detonation statt. Sie unterscheidet sich von der Verbrennung durch eine in der Umgebung auftretende signifikante Druckwelle.

[QUELLE: Dictionary of explosive related terms]

3.2.8

Detonation

exotherme Zerfallreaktion einer explosiven Substanz, selbsterhaltend durch eine Druckwelle, deren Ausbreitungsgeschwindigkeit größer ist als die Schallgeschwindigkeit in der Substanz

Anmerkung 1 zum Begriff: Die Ausbreitungsgeschwindigkeit beträgt mehrere Tausend m/s.

[QUELLE: Dictionary of explosive related terms]

3.2.9

Detonator

Initialzündler, dessen Funktion es ist, externe Energie direkt in eine Druckwelle umzuwandeln, die stark genug ist, um einen sekundären brisanten Sprengstoff zu zünden

Anmerkung 1 zum Begriff: Externe Energie kann z. B. mechanische, elektrische und thermische Energie sein.

[QUELLE: Dictionary of explosive related terms]

3.2.10

elektrisch-explosives Gerät

Gerät, das ein Reaktionsgemisch enthält, das elektrisch gezündet wird

Anmerkung 1 zum Begriff: Das Ergebnis der Zündung ist Wärme, Druck oder eine mechanische Einwirkung.

Anmerkung 2 zum Begriff: Das Reaktionsgemisch kann explosiv oder pyrotechnisch sein.

[QUELLE: Dictionary of explosive related terms]

3.2.11

Endanwender

Person oder Organisation, die ein Produkt unmittelbar anwendet

Anmerkung 1 zum Begriff: Der Endanwender braucht nicht der Eigentümer oder der Käufer zu sein.

Anmerkung 2 zum Begriff: Im Kontext dieser Norm ist der Endanwender in der Regel der Kunde der obersten Ebene.

3.2.12

energetisches Material

Material, bestehend aus oder mit dem Inhalt von einem Explosivstoff, Oxidationsmittel, Brennstoff, oder einer Kombination daraus, das einen schnellen exothermen Zerfall, eine Verbrennung, Deflagration oder Detonation durchlaufen kann, dazu beitragen kann oder diese verursachen kann

3.2.13**explosiv betätigtes Gerät**

Gerät, das die Explosionsprodukte in nutzbare mechanische Arbeit umwandelt

Anmerkung 1 zum Begriff: Die Explosion kann eine Verbrennung, Deflagration oder Detonation sein.

Anmerkung 2 zum Begriff: Pyromechanismen und linear detonierende Trennvorrichtungen sind explosiv betätigte Geräte.

3.2.14**Zündkette**

Reihe explosiver Komponenten, einschließlich des Initialzünders, der explosiven Transferbaugruppe und des explosiv betätigten Geräts

3.2.15**explosive Komponente**

einzelnes Bauteil, das eine explosive Substanz enthält

3.2.16**Explosionsfunktion**

Funktion, die für ihre Ausführung die Energie nutzt, die von den explosiven Substanzen freigesetzt wird

3.2.17**explosives Subsystem**

Zusammenfassung aller Zündketten am Raumfahrzeug oder Trägersystem sowie der Schnittstellenaspekte sämtlicher Bordrechner, Trägersausrüstungen, Bodendienst- und Prüfgeräte und der gesamten Software in Zusammenhang mit Explosionsfunktionen

3.2.18**betriebssicher**

nach einem Ausfall noch durchführbare Raumfahrtmission

Anmerkung 1 zum Begriff: Die Aufrechterhaltung der Betriebsbedingungen nach einem Ausfall und die Aufrechterhaltung der Sicherheitsbedingungen nach einem zweiten unabhängigen Ausfall wird als „betriebssicher – ausfallsicher“ bezeichnet.

3.2.19**ausfallsicher**

Konstruktionseigenschaft eines Subsystems oder eines Bereichs davon, die nach einem Ausfall sicher erhalten bleibt

Anmerkung 1 zum Begriff: Die Aufrechterhaltung der Sicherheit nach zwei unabhängigen Ausfällen wird als „ausfallsicher – ausfallsicher“ bezeichnet.

3.2.20**Gasgeneratoren**

explosive Geräte, die ein gewisses Volumen an Gas oder ein exothermes Produkt oder beides erzeugen

Anmerkung 1 zum Begriff: Z. B. pyrotechnische Zündvorrichtungen für Feststoffantriebe, Gasgenerator für aufblasbare Strukturen.

3.2.21

Initialzünder

einer Zündkette vorgelagerte Hauptkomponente, von der eine Umwandlung von mechanischer, elektrischer oder optischer Energie ausgeht, und der dabei entstandene Effekt eine Verbrennung, Deflagration oder Detonation ist

Anmerkung 1 zum Begriff: Er enthält eine kleine Menge an energetischem Material.

Anmerkung 2 zum Begriff: Beispiele: heißer Glühbrückenzünder, explosionsfähiger Glühbrückenzünder.

3.2.22

Grenzprüfung

Prüfung zur Feststellung der Grenze einer Kenngröße von einer Komponente

3.2.23

Los

Gruppe von Komponenten, die in gleichartigen Gruppen und unter einheitlichen Bedingungen hergestellt wurden

Anmerkung 1 zum Begriff: Eine Charge ist das gleiche wie ein Los.

3.2.24

Losannahme

Nachweis durch Messung oder Prüfung, dass ein Teilelos den Anforderungen entspricht

3.2.25

kein Ansprechen

Impuls mit einer Funktionswahrscheinlichkeit von gleich oder weniger als 0,001 bei einem 95 %-Vertrauensniveau

3.2.26

gekapselte Ladung

explosives Material in einem verschlossenen Behälter

3.2.27

pyrotechnische Einrichtung

pyrotechnische Grundvorrichtung, die explosive Substanzen enthält und dafür vorgesehen ist, eine Initialisierung herbeizuführen (Zündung, Initialzündung), pyrotechnische Effekte zu übertragen, Verstärkungs- oder Erzeugungsfunktionen durchzuführen

[QUELLE: Dictionary of explosive related terms]

3.2.28

Pyromechanismus

Gerät, das dafür vorgesehen ist, eine oder mehrere mechanische Funktionen mithilfe der durch die Reaktion eines energetischen Materials erzeugten Energie durchzuführen

[QUELLE: Dictionary of explosive related terms]

3.2.29

sicher

Zustand, in dem die Wahrscheinlichkeit, dass ein unerwünschtes Ereignis eintritt, unterhalb einer vereinbarten Grenze liegt

3.2.30**Sekundärmerkmal**

jedes andere Merkmal als die Funktion

3.2.31**sequentielle Zündung**

zeitlich aufeinanderfolgendes Aufbringen der Zündimpulse an den Initialzündern

3.2.32**Erfolg**

gleichzeitiges Erreichen der erforderlichen Leistung durch alle Merkmale

3.2.33**Folgezündung**

Zündung weiterer explosiver Geräte aufgrund der Produkte eines beliebigen anderen Geräts

3.2.34**Transferleitung**

lineare explosive Baugruppe zur Ausbreitung der Deflagration oder Detonation

3.2.35**durch eine Trennwand hindurchgeführter Zünder****TBI**

(en: through-bulkhead initiator)

Relais, das einen Übergang zwischen der Detonation einer Übertragungsleitung und der Verbrennung einer Zündladung durch eine abgedichtete Trennwand bietet

[QUELLE: Dictionary of explosive related terms]

Anmerkung 1 zum Begriff: Die Trennwand bleibt nach dem Einsatz in der festgelegten Umgebung, z. B. Druck und Temperatur, dicht.

3.3 Abkürzungen

Für die Anwendung dieser Norm gelten die Abkürzungen nach ECSS-S-ST-00-01 und die folgenden Abkürzungen:

Abkürzung	Bedeutung	
DC	Gleichstrom	(en: direct current)
DMPL	Liste der deklarierten Werkstoffe und Prozesse	(en: declared materials and processes list)
DSC	dynamische Differenzkalorimetrie	(en: differential scanning calorimetry)
DR	Konstruktionsregeln	(en: design rules)
DTA	Differenzthermoanalyse	(en: differential thermal analysis)
EED	elektrisch-explosives Gerät	(en: electro-explosive device)
EMC	elektromagnetische Verträglichkeit	(en: electromagnetic compatibility)
EMI	elektromagnetische Störung	(en: electromagnetic interference)
ESD	elektrostatische Entladung	(en: electrostatic discharge)
FOSU	Sicherheitsfaktor für Bemessungsbruchlast	(en: ultimate design factor of safety)
FOSY	Sicherheitsfaktor für Bemessungsfließlast	(en: yield design factor of safety)

Abkürzung	Bedeutung	
GDIR	allgemeine Konstruktions- und Schnittstellenanforderung	(en: general design and interface requirement)
GSE	Bodendienstgeräte	(en: ground support equipment)
GTPS	Groupe de Travail de Pyrotechnie	
ICD	Schnittstellenüberwachungsdokument	(en: interface control document)
MEOP	größter erwarteter Betriebsdruck	(en: maximum expected operating pressure)
N/A	nicht zutreffend	(en: not applicable)
NC	gewöhnlich geschlossen	(en: normally closed)
NO	gewöhnlich geöffnet	(en: normally open)
RF	Hochfrequenz	(en: radio frequency)
SDS	Sicherheitsdatenblatt	(en: Safety Data Sheet)
SG	allgemeine Spezifikation	(en: general specification)
SRS	Stoßreaktionsspektrum	(en: shock response spectrum)
TBI	durch eine Trennwand hindurchgeführter Zünder	(en: through-bulkhead initiator)
TBPM	vom Hersteller bereitzustellen	(en: to be provided by manufacturer)
TBPC	vom Kunden bereitzustellen	(en: to be provided by customer)
TBPU	vom Anwender bereitzustellen	(en: to be provided by user)
TGA	Thermogravimetrie	(en: thermo gravimetric analysis)
UNECE	Wirtschaftskommission für Europa der Vereinten Nationen	(en: United Nations Economic Commission for Europe)
VTs	thermische Stabilität im Vakuum	(en: vacuum thermal stability)

3.4 Symbole

@	At-Zeichen
g	Norm-Oberflächengravitation
h	Fallhöhe (m)
M	Masse des Fallgewichts (kg)
σ	Standardabweichung
A	Ampere
V	Volt

EUROPEAN STANDARD

EN 16603-33-11

NORME EUROPÉENNE

EUROPÄISCHE NORM

April 2019

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English version

Space engineering - Explosive subsystems and devices

Ingénierie spatiale - Sous-systèmes et dispositifs
explosifs

Raumfahrttechnik - Explosive Subsysteme und Geräte

This European Standard was approved by CEN on 28 September 2018.

CEN and CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN and CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN and CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CEN and CENELEC members are the national standards bodies and national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.



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European Foreword

This document (EN 16603-33-11:2019) has been prepared by Technical Committee CEN-CENELEC/TC 5 "Space", the secretariat of which is held by DIN.

This standard (EN 16603-33-11:2019) originates from ECSS-E-ST-33-11C Rev.1.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2019, and conflicting national standards shall be withdrawn at the latest by October 2019.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 14607-6:2004.

Changes to EN 14607-6:2004 that was based on ECSS-E-30 Part 6A (25 April 2000) are:

- Complete edit to conform to the ECSS Drafting Rules for "ECSS Issue C standards"
- Implementation of ECSS Change Requests and harmonization the standard with ISO in ECSS Revision 1 (2017)
- Change of the title from ~~Space engineering - Mechanical - Part 6: Pyrotechnics~~ to ~~Space engineering - Explosive subsystems and devices~~
- Use of the more accurate term ~~explosives~~ rather than ~~pyrotechnics~~ in relation to the subject components and systems
- Emphasis on reliability coupled with confidence level for performance properties
- Inclusion of detailed requirements for the different types of explosive device
- Emphasis on the requirement for properties of components to be agreed with the end user before commitment to purchase.

This document has been prepared under a standardization request given to CEN by the European Commission and the European Free Trade Association.

This document has been developed to cover specifically space systems and has therefore precedence over any EN covering the same scope but with a wider domain of applicability (e.g. : aerospace).

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

As any explosive item used for flight can function only once, it can never be fully tested before its crucial mission operation. The required confidence can only be established indirectly by the testing of identical items. Test results and theoretical justification are essential for demonstration of fulfilment of the requirements. The requirement for repeatability shows that product assurance plays a crucial role in support of technical aspects.

The need for statistics requires that the explosive components used in the explosive subsystem be tested and characterized extensively. The variability in components requires that manufacturers prove to customers that delivered items are identical to those qualified.

The failure or unintentional operation of an explosive item can be catastrophic for the whole mission and life threatening. Specific requirements can exist for the items associated with it. As all explosives where ever used are treated similarly, the same requirements, regulations, practices and standards need to be applied to help avoiding human error.

1

Scope

This Standard defines the requirements for the use of explosives on all spacecraft and other space products including launch vehicles. It addresses the aspects of design, analysis, verification, manufacturing, operations and safety.

This standard may be tailored for the specific characteristics and constraints of a space project in conformance with ECSS-S-ST-00.

2

Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this ECSS Standard. For dated references, subsequent amendments to, or revision of any of these publications, do not apply. However, parties to agreements based on this ECSS Standard are encouraged to investigate the possibility of applying the more recent editions of the normative documents indicated below. For undated references, the latest edition of the publication referred to applies.

EN reference	Reference in text	Title
EN 16601-00-01	ECSS-S-ST-00-01	ECSS system - Glossary of terms
EN 16603-10-02	ECSS-E-ST-10-02	Space engineering - Verification
EN 16603-10-03	ECSS-E-ST-10-03	Space engineering - Testing
EN 16603-20	ECSS-E-ST-20	Space engineering - Electrical and electronic
EN 16603-20-07	ECSS-E-ST-20-07	Space engineering – Electromagnetic compatibility
EN 16603-32-10	ECSS-E-ST-32-10	Space engineering - Reliability based mechanical factors of safety
EN 16603-33-01	ECSS-E-ST-33-01	Space engineering - Mechanisms
EN 16602-20	ECSS-Q-ST-20	Space product assurance - Quality assurance
EN 16602-30	ECSS-Q-ST-30	Space product assurance - Dependability
EN 16602-40	ECSS-Q-ST-40	Space product assurance - Safety
EN 16602-70-01	ECSS-Q-ST-70-01	Space product assurance - Contamination and cleanliness control
EN 16601-40	ECSS-M-ST-40	Space management - Configuration and information management
	ST/SG/AC.10/1 latest version (UNECE publication)	Recommendations on the Transport of Dangerous Goods – Model Regulations
	Commission Directive 2012/4/EU (22 February 2012)	Commission Directive 2012/4/EU of 22 February 2012 amending Directive 2008/43/EC setting up, pursuant to Council Directive 93/15/EEC, a system for the identification and traceability of explosives for civil uses

	Commission Directive 2008/43/EC (4 April 2008)	Commission Directive 2008/43/EC of 4 April 2008 setting up, pursuant to Council Directive 93/15/EEC, a system for the identification and traceability of explosives for civil uses
	Council Directive 93/15/EEC (5 April 1993)	Council Directive 93/15/EEC of 5 April 1993 on the harmonization of the provisions relating to the placing on the market and supervision of explosives for civil uses
	Dictionary of explosive related terms, 7th Edition, 2016	Groupe de Travail de Pyrotechnie, Dictionnaire de pyrotechnie

NOTE For launcher subsystems and Transfer Vehicle programmes, the specific General Specification (SG) or Design Rules (DR) documents are applicable for designing, dimensioning and testing.

Terms, definitions and abbreviated terms

3.1 Terms defined in other standards

- a. For the purpose of this Standard, the terms and definitions from ECSS-S-ST-00-01 apply, in particular for the following terms:

1. lifetime

3.2 Terms specific to the present standard

3.2.1 all fire

stimulus with a probability of functioning equal to or better than 0,999 at 95 % confidence level

3.2.2 arm plug receptacle

connector mounted on the skin of a spacecraft that can be connected to a Safe or Test or Arm plug

3.2.3 armed

status of an explosive subsystem when all the safety devices have been disabled and which can be triggered

[Adapted from Dictionary of explosive related terms]

3.2.4 cartridge

explosive device designed to produce pressure for performing a mechanical function

NOTE A cartridge is called an initiator if it is the first or only explosive element in an **explosive train** (see definition 3.2.14).

3.2.5 charge

explosive loaded in a cartridge, detonator, or separate container for use in an explosive device

3.2.6 component

smallest functional item in an explosive subsystem

3.2.7 deflagration

self-sustaining, exothermic decomposition reaction of an explosive substance, whose apparent velocity is less than the velocity of sound in the substance and greater than the speed of sound in air

NOTE It is generally accepted that the energy transmission takes place via a mechanical compression wave. This type of reaction is intermediary between combustion and detonation. It differs from combustion through the presence of a significant compression wave in the surrounding environment.

[Dictionary of explosive related terms]

3.2.8 detonation

exothermic decomposition reaction of an explosive substance self-sustained by a shock wave, whose velocity of propagation is greater than the velocity of sound in the substance

NOTE The velocity of propagation is of the order of several thousands of m/s.

[Dictionary of explosive related terms]

3.2.9 detonator

initiator whose function is to transform external energy directly into a shock wave strong enough to detonate a secondary high explosive

NOTE External energy can be, for example, mechanical, electrical and thermal.

[Dictionary of explosive related terms]

3.2.10 electro-explosive device

device containing some reaction mixture that is electrically initiated

NOTE 1 The output of the initiation is heat, shock or mechanical action.

NOTE 2 The reaction mixture can be explosive or pyrotechnic.

[Dictionary of explosive related terms]

3.2.11 end-user

person who or organization that actually uses a product

NOTE 1 The end-user need not to be the owner or buyer.

NOTE 2 In the context of this standard the end user is generally the first level customer.

3.2.12 energetic material

material consisting of, or containing, an explosive, oxidizer, fuel, or combination of them, that can undergo, contribute to, or cause rapid exothermic decomposition, combustion, deflagration, or detonation

3.2.13 explosively actuated device

device that converts the products of explosion into useful mechanical work

NOTE 1 The explosion can be combustion, deflagration or detonation.

NOTE 2 Pyromechanisms and linear detonating separation devices are explosively actuated devices.

3.2.14 explosive train

series of explosive components including the initiator, explosive transfer assembly and explosively actuated device

3.2.15 explosive component

discrete item containing an explosive substance

3.2.16 explosive function

function that uses energy released from explosive substances for its operation

3.2.17 explosive subsystem

collection of all the explosive trains on the spacecraft or launcher system, and the interface aspects of any on-board computers, launch operation equipment, ground support and test equipment and all software associated with explosive functions

3.2.18 fail operational

mission capable after one failure

NOTE Maintaining operational conditions after one failure and safety conditions after a second independent failure is referred to as ~~s~~Fail operational – Fail safes

3.2.19 fail safe

design property of a subsystem, or part of it, which remains safe after one failure

NOTE Maintaining safety following two independent failures is referred to as ~~s~~Fail safe – Fail safes

3.2.20 gas generators

explosive devices that produce a volume of gas or exothermic output or both

NOTE E.g. pyrotechnic igniters for solid propulsion applications, gas generator for inflatable structures.

3.2.21 initiator

basic component located upstream of an explosive train, from which originates a transformation of mechanical, electrical or optical energy, the effect produced being a combustion, deflagration or detonation.

NOTE 1 It contains a small quantity of an energetic material.

NOTE 2 Examples: hot bridge wire initiator, exploding bridge wire initiator

3.2.22 limit testing

testing to establish the limit of a performance characteristic of a component

3.2.23 lot

group of components produced in homogeneous groups and under uniform conditions

NOTE A batch is the same as a lot.

3.2.24 lot acceptance

demonstration by measurement or test that a lot of items meets requirements

3.2.25 no fire

stimulus with a probability of functioning equal to or less than 0,001 at 95 % confidence level

3.2.26 packaged charge

explosive material in a closed container

3.2.27 pyrotechnic device

a basic pyrotechnic object containing explosive substances and intended to perform an initiation (ignition, priming), pyrotechnic effect transmission, amplification or generation function

[Dictionary of explosive related terms]

3.2.28 pyromechanism

device intended to perform one or more mechanical actions, using the energy produced by the reaction of an energetic material

[Dictionary of explosive related terms]

3.2.29 safe

condition that renders the probability of an unwanted event below an agreed limit

3.2.30 secondary characteristic

any characteristic other than the function

3.2.31 sequential firing

application of the firing pulses to initiators separated in time

3.2.32 success

simultaneous achievement by all characteristics of required performance

3.2.33 sympathetic firing

firing of other explosive devices due to the output of any other

3.2.34 transfer line

linear explosive assembly for propagation of deflagration or detonation

3.2.35 through-bulkhead initiator (TBI)

relay which provides transition between the detonation of a transmission line and the combustion of an ignition charge, through a sealed bulkhead

[Dictionary of explosive related terms]

NOTE The bulkhead remains tight after functioning under the specified environment, e.g. pressure and temperature.

3.3 Abbreviated terms

For the purpose of this Standard, the abbreviated terms from ECSS-S-ST-00-01 and the following apply:

Abbreviation	Meaning
DC	direct current
DMPL	declared materials and processes list
DSC	differential scanning calorimetry
DR	design rules
DTA	differential thermal analysis
EED	electro-explosive device
EMC	electromagnetic compatibility
EMI	electromagnetic interference
ESD	electrostatic discharge
FOSU	ultimate design factor of safety
FOSY	yield design factor of safety
GDIR	general design and interface requirement
GSE	ground support equipment
GTPS	Groupe de Travail de Pyrotechnie
ICD	interface control document
MEOP	maximum expected operating pressure
N/A	not applicable
NC	normally closed
NO	normally open
RF	radio frequency
SDS	Safety Data Sheet
SG	general specification
SRS	shock response spectrum
TBI	through-bulkhead initiator
TBPM	to be provided by manufacturer
TBPC	to be provided by customer
TBPU	to be provided by user

Abbreviation	Meaning
TGA	thermo gravimetric analysis
UNECE	United Nations Economic Commission for Europe
VTs	vacuum thermal stability

3.4 Symbols

@	at
g	standard surface gravity (9,80665 m/s ²)
h	drop height (m)
M	mass of drop weight (kg)
σ	standard deviation
A	Ampere
V	Volt

3.5 Nomenclature

The following nomenclature apply throughout this document:

- a. The word “shall” is used in this standard to express requirements. All the requirements are expressed with the word “shall”.
- b. The word “should” is used in this standard to express recommendations. All the recommendations are expressed with the word “should”.

NOTE It is expected that, during tailoring, all the recommendations in this document are either converted into requirements or tailored out.

- c. The words “may” and “need not” are used in this standard to express positive and negative permissions respectively. All the positive permissions are expressed with the word “may”. All the negative permissions are expressed with the words “need not”.
- d. The word “can” is used in this standard to express capabilities or possibilities, and therefore, if not accompanied by one of the previous words, it implies descriptive text.

NOTE In ECSS “may” and “can” have a complete different meaning: “may” is normative (permission) and “can” is descriptive.

- e. The present and past tense are used in this standard to express statement of fact, and therefore they imply descriptive text.

4

Requirements

4.1 General

4.1.1 Overview

Being generally applicable, the requirements stated in this clause apply throughout and are not repeated in the clauses relating to specific topics.

Explosive subsystem and devices use energetic materials (explosives, propellants, powder) initiated by mechanical, electrical, thermal, or optical stimuli, for unique (single shot) functions e.g. solid booster initiation, structure cutting, stage distancing, pressurized venting, stage neutralisation, valve opening or closing, release of solar arrays, antennas, booms, covers and instruments.

The properties of the initiator govern the major part of the behaviour of the subsystem.

The requirements for initiators and their derivatives, such as cartridges and detonators, are defined in specific requirements related to the specific types.

Properties of explosive components and subsystem, which cannot be covered by requirements for the initiators alone, are defined in specific requirements relating to the types of explosively actuated device or pyromechanisms.

Other components of the explosive subsystem, which can be tested and do not need specific requirements, are subject to the general technical and product assurance requirements. Detailed aspects of these components are included where they have a significant influence on the success of the system.

Single-shot items can never be tested in advance. Particular care is needed in their development, qualification, procurement and use. Explosive components are not governed by the institutional component control organisations.

The content and phasing of deliverable documents are identified in each of the top level discipline standards of each ECSS branch. A list of deliverable documents specific to this standard is provided in informative Annex B.

4.1.2 Properties

- a. The two states of the properties of the explosive subsystem before firing and after firing shall be identified and listed.
- b. For every explosive component the function, primary stimulus, unwanted stimuli and secondary characteristics shall be identified and quantified.

- c. Only qualified and lot accepted items shall be used in flight systems.
- d. The properties of an explosive subsystem shall remain stable over time before firing and after firing when subject to external loads or environmental conditions, within the qualification values.

4.2 Design

4.2.1 General

- a. In case of redundancy, no component shall adversely affect its substitute.
- b. The system lay-out should facilitate the replacement of subsystems or components.
- c. Parts of the explosive subsystem and devices identified as critical on the basis of a RAMS analysis shall be replaceable.
- d. Replaceable parts shall be listed in the User's Manual of the explosive subsystem and devices.

4.2.2 Reliability and confidence

- a. The explosive subsystem shall achieve the specified properties within the required reliability and confidence level defined at system level.
- b. The reliability demonstration shall be:
 - 1. used to justify design margins including the influence of ageing, temperature and explosive batch,
 - 2. justified according to clause 6.4.2 of ECSS-Q-ST-30 or dedicated system specification, and
 - 3. stated in a reliability prediction document as per Annex E of ECSS-Q-ST-30.

NOTE Dedicated system specifications are, for example, GDIR and SG.

- c. The allocation of the probability and the confidence level of unwanted actuating of an explosive device shall be determined and justified according to clause 7.5 of ECSS-Q-ST-40 or dedicated system specification.

NOTE Dedicated system specifications are, for example, GDIR and SG.

- d. <<deleted>>
- e. <<deleted>>
- f. For the reliability demonstration, the customer shall agree which performance characteristics are declared as mean values with associated standard deviation.

NOTE The reliability demonstration is used to justify design margins including the influence of ageing, temperature and explosive batch.

- g. The selection of the statistical methods and functional parameters shall be justified and approved by the customer.