SLOVENSKI STANDARD
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Vesoljska tehnika - Kontrola razpok

Space engineering - Fracture control

Raumfahrttechnik - Überwachung des Rissfortschritts

Ingénierie spatiale - Maîtrise de la rupture

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Space engineering - Fracture control

Ingénierie spatiale - Maîtrise de la rupture

Raumfahrttechnik - Überwachung des Rissfortschritts

This European Standard was approved by CEN on 5 December 2021.

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European Foreword

This document (EN 16603-32-01:2021) has been prepared by Technical Committee CEN/CLC/TC 5 "Space", the secretariat of which is held by DIN.

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of an identical text or by endorsement, at the latest by June 2022, and conflicting national standards shall be withdrawn at the latest by June 2022.

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 16603-32-01:2014.

The main changes with respect to EN 16603-32-01:2014 are listed below:

- Implementation of change requests
- Replacement of term "non-destructive inspection (NDI)" by "non-destructive testing (NDT)" in the whole document
- Update of Scope
- Removal of information about the NASA Space Shuttle program (STS)
- Update of Normative References and Terms, definitions and abbreviated terms
- Addition of Nomenclature
- Addition of clause 8.2.7 "Pressurized components with non-hazardous LBB failure mode"
- Addition of clause 8.9 "Alloys treated with electric discharge manufacturing (EDM)"
- Addition of clause 11.2.2.5 "Safe life composite, bonded and sandwich structures"
- Addition of clause 11.2.2.6 "Metallic parts classified as PFCI according to 11.2.2.1"
- Addition of clause 11.2.2.7 "Fasteners classified as PFCI according to 11.2.2.1"
- Addition of clause 11.2.2.8 "NDT of fusion welded joints in pressure components, as per 10.3.1p"
- Several clauses and requirements moved to EN 16602-70-15 (equivalent to ECSS-Q-ST-70-15)

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.

1
Scope

This ECSS Engineering Standard specifies the fracture control requirements to be imposed on space segments of space systems and their related GSE.

The fracture control programme is applicable for space systems and related GSE where structural failure can result in a catastrophic hazard in accordance with the definition of ECSS-Q-ST-40 or alternative applicable document specified by the customer like those applicable to the ISS or Exploration systems or payloads.

The requirements contained in this Standard, when implemented, also satisfy the fracture control requirements applicable to the NASA and ISS hardware.

The NASA nomenclature differs in some cases from that used by ECSS. When ISS or Exploration-specific requirements and nomenclature are included, they are identified as such.

This standard may be tailored for the specific characteristic and constrains 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 16603-32	ECSS-E-ST-32	Space engineering – Structural general requirements
EN 16603-32-02	ECSS-E-ST-32-02	Space engineering – Structural design and verification of pressurized hardware
EN 16602-20	ECSS-Q-ST-20	Space product assurance – Quality assurance
EN 16602-40	ECSS-Q-ST-40	Space product assurance – Safety
EN 16602-70	ECSS-Q-ST-70	Space product assurance – Materials, mechanical parts and processes
EN 16602-70-15	ECSS-Q-ST-70-15	Space product assurance - Non-destructive testing
	ECSS-Q-ST-70-36	Space product assurance – Material selection for controlling stress-corrosion cracking
	ECSS-Q-ST-70-45	Space product assurance – Mechanical testing of metallic materials
	DOT/FAA/AR-MMPDS	Metallic Materials Properties Development and Standardization (MMPDS) (former MIL-HDBK-5)
	EN ISO 6520-1	Welding and allied processes – Classification of geometric imperfections in metallic materials – Part 1: Fusion welding
	ISO 17659	Welding – Multilingual terms for welded joints with illustrations

3
Terms, definitions and abbreviated terms

3.1 Terms from other standards

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

1. catastrophic
2. customer

NOTE In this standard, the customer is considered to represent the responsible fracture control or safety authority.

3. hazard

b. For the purpose of this Standard, the following terms and definitions from ECSS-E-ST-32 apply:

1. flaw

NOTE The term defect is used as synonymous.

2. maximum design pressure (MDP)
3. service life
4. proof test
5. limit load
6. structure
7. safe life

c. For the purpose of this Standard, the following terms and definitions from ECSS-E-ST-32-02 apply:

1. burst pressure
2. hazardous fluid container
3. leak before burst, LBB
4. pressure component
5. pressure vessel
6. pressurized structure
7. sealed container
8. special pressurized equipment

9. visual damage threshold, VDT

NOTE 1 For typical implementation of thin-walled composite structure, the VDT is sometimes more specifically defined as the impact energy of an impactor with a hemi-spherical tip of 16 mm diameter resulting in 0,3 mm or more remaining surface deflection, after sufficiently long time to cover potential evolution of the indentation over time (due to e.g. wet ageing, fatigue loading, viscoelasticity of the resin) between impact and non-destructive testing.

NOTE 2 It can be time consuming to determine the VDT based on remaining surface deflection of 0,3 mm (see NOTE 1) after a sufficiently long time. Therefore, tests which cause mechanical damage corresponding to a deflection of at least 1 mm, immediately after impact, are sometimes used to determine the VDT.

10. non-hazardous LBB failure mode

d. For the purpose of this Standard, the following terms and definitions from ECSS-Q-ST-70-15 apply:

1. close visual testing
2. special fracture control NDT
3. standard fracture control NDT

3.2 Terms specific to the present standard

3.2.1 aggressive environment

combination of liquid or gaseous media and temperature that alters static or fatigue crack-growth characteristics from normal behaviour associated with an ambient temperature and laboratory air environment

3.2.2 analytical life

life evaluated analytically by crack-growth analysis or fatigue analysis

3.2.3 containment

damage tolerance design principle that, if a part fails, prevents the propagation of failure effects beyond the container boundaries

NOTE 1 A contained part is not considered PFCI, unless its release can cause a hazard inside the container. The container is a PFCI, and its structural integrity after impact is verified as part of fracture control activities.

NOTE 2 In this standard, the term containment in most cases also covers items which are e.g. restrained

by a tether to prevent the occurrence of hazardous events due to failure of the item.

3.2.4 crack-like defect

defect that has the same mechanical behaviour as a crack

NOTE 1 "Crack" and "crack-like defect" are considered synonymous in this standard.

NOTE 2 Crack-like defects can, for example, be initiated during material production, fabrication or testing or developed during the service life of a component.

NOTE 3 The term "crack-like defect" can include:

- For metallic materials flaws, inclusions, pores and other similar defects.
- For non-metallic materials, debonding, broken fibres, delamination, impact damage and other specific defects depending on the material.

3.2.5 crack aspect ratio, a/c

<part-through surface crack> ratio of crack depth to half crack length

3.2.6 crack aspect ratio, a/c

<part-through corner crack> ratio of crack depth to crack length

3.2.7 crack growth rate

rate of change of crack dimension with respect to the number of load cycles or time

NOTE For example da/dN, dc/dN, da/dt and dc/dt.

3.2.8 crack growth retardation

reduction of crack-growth rate due to overloading of the cracked structural member

3.2.9 critical crack size

the crack size at which the structure fails under the maximum specified load

NOTE The maximum specified load is in many cases the limit load, but sometimes higher than the limit load (e.g. for detected defects, composites and glass items)

3.2.10 critical initial defect, CID

critical (i.e., maximum) initial crack size for which the structure can survive the specified number of lifetimes.

3.2.11 critical stress-intensity factor

value of the stress-intensity factor at the tip of a crack at which unstable propagation of the crack occurs

NOTE 1 This value is also called the fracture toughness. The parameter K_{IC} is the fracture toughness for plane strain and is an inherent property of the material. For stress conditions other than plane strain, the fracture toughness is denoted K_C or K_{Ie} for part through cracks. In fracture mechanics analyses, failure is assumed to be imminent when the applied stress-intensity factor is equal to or exceeds its critical value, i.e. the fracture toughness. See 3.2.22.

NOTE 2 The term fracture toughness is used as a synonymous.

3.2.12 cyclic loading

fluctuating load (or pressure) characterized by relative degrees of loading and unloading of a structure

NOTE For example, loads due to transient responses, vibro-acoustic excitation, flutter, pressure cycling and oscillating or reciprocating mechanical equipment.

3.2.13 damage tolerance threshold strain

<composite structural items> maximum strain level below which damage compatible with the sizes established by non-destructive testing (NDT), close visual testing, the damage threat assessment, or the minimum sizes imposed does not grow in 10^6 cycles (10^8 cycles for rotating hardware) at a load ratio appropriate to the application

NOTE 1 Strain level is the maximum absolute value of strain in a load cycle.

NOTE 2 The damage tolerance threshold strain is a function of the material type and lay-up and is determined from test data in the design environment to the applicable or worst type and orientation of strain and flaw for a particular design and flaw size (e.g. the size determined by the VDT).

NOTE 3 For definition of “close visual testing” see ECSS-Q-ST-70-15.

3.2.14 damage tolerant

characteristic of a structure for which the amount of general degradation or the size and distribution of local defects expected during operation, or both, do not lead to structural degradation below specified performance