SLOVENSKI STANDARD
SIST EN 14165:2004

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Standardi v vesoljski tehniki – Kontrola razpok

Space engineering standards - Fracture control

Raumfahrttechnik - Überwachung des Rissfortschritts

Ingénierie Spatiale - Maîtrise de la rupture

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Space engineering standards - Fracture control

Ingénierie Spatiale - Maîtrise de la rupture

Raumfahrttechnik - Überwachung des Rissfortschritts

This European Standard was approved by CEN on 27 February 2004.

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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 member into its own language and notified to the Central Secretariat has the same status as the official versions.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Foreword

This document (EN 14165:2004) has been prepared by CEN/CS.

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of an identical text or by endorsement, at the latest by October 2004, and conflicting national standards shall be withdrawn at the latest by October 2004.

It is based on a previous version[1)] originally prepared by the ECSS Engineering Working Group, reviewed by the ECSS Technical Panel and approved by the ECSS Steering Board. The European Cooperation for Space Standardization (ECSS) is a cooperative effort of the European Space Agency, National Space Agencies and European industry associations for the purpose of developing and maintaining common standards.

This standard is one of the series of space standards intended to be applied together for the management, engineering and product assurance in space projects and applications.

Requirements in this standard are defined in terms of what shall be accomplished, rather than in terms of how to organize and perform the necessary work. This allows existing organizational structures and methods to be applied where they are effective, and for the structures and methods to evolve as necessary without rewriting the standards.

This European Standard specifies the fracture control requirements to be imposed in space programmes.

The formulation of this standard takes into account the existing ISO 9000 family of documents.

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

[1)] ECSS-E-30-01A.

1 Scope

This standard specifies the fracture control requirements to be imposed on space systems.

The requirements contained in this standard, when implemented, also satisfy the requirements applicable to the NASA STS and ISS as defined in the NASA document NSTS 1700.7 (incl. the ISS Addendum). Since this standard and the NASA document NSTS 1700.7 (incl. the ISS Addendum) are subject to different independent approval authorities, and recognizing that possible changes to documents may occur in the future, the user of this standard is advised to confirm the current status.

NOTE The definitions used in this standard are based on ECSS nomenclature and are given in clause 3. The NASA nomenclature differs in some cases from that used by ECSS. When STS-specific requirements and nomenclature are included, they are identified as such.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 13291-2:2003, *Space product assurance — General requirements — Part 2: Quality assurance.*

EN 13291-3:2003, *Space product assurance — General requirements — Part 3: Materials, mechanical parts and processes.*

EN 13701:2001, *Space systems — Glossary of terms.*

EN 14097, *Space product assurance — Nonconformance control system.*

EN 14101:2001, *Space product assurance — Material selection for controlling stress-corrosion cracking.*

EN ISO 14620-1, *Space systems - Safety requirements - Part 1: System safety (ISO 14620-1:2002).*

NAS410, *Certification and qualification of non-destructive test personnel.*

MIL-STD-1522A, *Standard general requirements for safe design and operation of pressurized missile and space systems.*

MIL-I-6870, *Inspection program requirements, nondestructive, for aircraft and missile materials and parts.*

MSFC-STD-1249, *Standard NDE guidelines and requirements for fracture control programs.*

NSTS/ISS 13830, *Implementation Procedure for NSTS Payload System Safety Requirements.*

NSTS 1700.7, *Safety Policy and Requirements For Payloads Using the Space Transportation System (STS).*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this European Standard, the terms and definitions given in EN 13701:2001, EN 13291-3:2003 and the following apply.

3.1.1
aggressive environment
any 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

3.1.2
allowable load
load that induces the allowable stress in a material

3.1.3
allowable stress
maximum stress tolerated in a material for a given operating environment to prevent rupture, collapse, detrimental deformation or unacceptable crack growth

3.1.4
analytical life
life evaluated analytically, i.e. by crack-growth analysis or fatigue analysis

3.1.5
burst pressure
pressure at which a pressurized system ruptures or collapses

3.1.6
catastrophic hazard
potential risk situation that can result in loss of life, in life threatening or permanently disabling injury, in occupational illness, loss of an element of an interfacing manned flight system, loss of launch site facilities or long term detrimental environmental effects

NOTE For payloads of the NASA STS or ISS, the applicable definition is: "A potential risk situation that can result in personnel injury, loss of the NASA orbiter, ground facilities, or STS equipment (see NSTS 1700.7, paragraph 302)".

3.1.7
containment
technique that, if a part fails, prevents the propagation of failure effects beyond the container boundaries

3.1.8
crack or crack-like defect
defect that behaves like a crack that is initiated, for example, during material production, fabrication or testing or developped during the service life of a component

NOTE The term "crack" in this definition includes flaws, inclusions, pores and other similar defects.

3.1.9
crack aspect ratio
for a part-through crack, the ratio of crack depth (a) to half crack length (c), i.e. a/c

3.1.10
crack growth rate (*da/dN, dc/dN, da/dt or dc/dt*)
rate of change of depth a or length c with respect to the number of load cycles N or time t

3.1.11
crack growth retardation
reduction of crack-growth rate due to intermittent overloading of the cracked structural member

3.1.12
critical hazard
potential risk situation that can result in:

- temporarily disabling but not life-threatening injury, or temporary occupational illness;
- loss of, or major damage to, flight systems, major flight system elements or ground facilities;
- loss of, or major damage to, public or private property; or short-term detrimental environmental effects

3.1.13
critical stress-intensity factor (fracture toughness)
value of the stress-intensity factor at the tip of a crack at which unstable propagation of the crack occurs

NOTE 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. 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 3.1.41.

3.1.14
cyclic loading
fluctuating load (or pressure) characterized by relative degrees of loading and unloading of a structure

NOTE Examples are loads due to transient responses, vibro-acoustic excitation, flutter and oscillating or reciprocating mechanical equipment.

3.1.15
damage-tolerant
attribute of a structure if the amount of general degradation or the size and distribution of local defects expected during operation do not lead to structural degradation below limit-specified performance

3.1.16
fail safe (structure)
damage-tolerance acceptability category in which the structure is designed with sufficient redundancy to ensure that the failure of one structural element does not cause general failure of the entire structure

3.1.17
failure (structural)
rupture, collapse, seizure, excessive wear or any other phenomenon resulting in an inability to sustain limit loads, pressures and environments

3.1.18
fastener
any item that joins other structural items and transfers loads from one to the other across a joint (see 3.1.23)

3.1.19
fatigue
cumulative irreversible damage in materials and structures incurred by cyclic application of loads in given environments

NOTE Fatigue can initiate and extend cracks, which degrade the strength of materials and structures.

3.1.20
fracture limited life item
any item that requires periodic reinspection to conform to safe life (see 3.1.37) or fail safe (see 3.1.16) requirements

3.1.21
fracture toughness
see 3.1.13

3.1.22
initial crack size
maximum crack size, as defined by non-destructive inspection, that is assumed to exist for the purpose of performing a fracture mechanics evaluation

3.1.23
joint
any element that connects other structural elements and transfers loads from one to the other across a connection

3.1.24
K_{IC}
plane strain fracture toughness (see critical stress intensity factor)

3.1.25
K_{ISCC}
threshold stress-intensity factor for stress corrosion cracking; the maximum value of the stress-intensity factor for a given material at which no environmentally induced crack growth occurs at sustained load for the specified environment

3.1.26
K_{th}
threshold stress-intensity factor for dynamic loading; the stress-intensity range below which crack growth will not occur under cyclic loading

3.1.27
leak before burst
fracture mechanics design concept in which it is shown that any initial defect grows through the wall of a pressurized system and cause leakage prior to burst (catastrophic failure) at maximum design pressure (see 3.1.31)

3.1.28
limit load or stress
maximum load or stress assumed to act on a structure in the expected operating environments

3.1.29
loading event
condition, phenomenon, environment or mission phase to which the payload is exposed and which induces loads in the payload structure

3.1.30
load spectrum (history)
representation of the cumulative static and dynamic loadings anticipated for a structural element during its service life

3.1.31
maximum design pressure (MDP)
highest possible pressure for a pressurized system occurring from maximum relief pressure, maximum regulator pressure, maximum temperature or transient pressure excursions

NOTE Factors of safety apply to MDP.

3.1.32
payload
any equipment or material carried by the launcher that is not considered part of the basic launcher itself

NOTE Payload includes items such as free-flying automated spacecraft, individual experiments and instruments.

3.1.33
proof test
test of a flight structure at a proof load or pressure that gives evidence of satisfactory workmanship and material quality or establishes the initial crack sizes in the structure

3.1.34
R
ratio of the minimum stress to maximum stress

3.1.35
residual stress
stress that remains in the structure, owing to processing, fabrication or prior loading

3.1.36
rotating machinery
any rotating mechanical assembly that has a kinetic energy of 19 300 J or more

NOTE The amount being based on 0,5 $I\omega^2$ where I is the moment of inertia (kg/m^2) and ω is the angular velocity (rad/s).

3.1.37
safe life
a fracture-control acceptability category which requires that the largest undetected crack that can exist in the part does not grow to failure when subjected to the cyclic and sustained loads and environments encountered in the service life

3.1.38
service life
interval beginning with an item's inspection after manufacture and ending with completion of its specified life

3.1.39
static load (stress)
load (stress) of constant magnitude and direction with respect to the structure

3.1.40
stress corrosion cracking (SCC)
initiation or propagation of cracks, owing to the combined action of applied sustained stresses, material properties and aggressive environmental effects

3.1.41
stress intensity factor (K)
calculated quantity that is used in fracture mechanics analyses as a measure of the stress-field intensity near the tip of an idealized crack, calculated for a specific crack size, applied stress level and part geometry (see 3.1.13)

3.1.42
thermal load (stress)
structural load (or stress) arising from temperature gradients and differential thermal expansion between structural elements, assemblies, subassemblies or items

3.1.43
ultimate strength
strength corresponding to the maximum load or stress that an unflawed structure or material can withstand without incurring rupture or collapse

3.1.44
variable amplitude spectrum
load spectrum or history whose amplitude varies with time

3.1.45
yield strength
strength corresponding to the maximum load or stress that an unflawed structure or material can withstand without incurring permanent deformation

3.2 Abbreviated terms

The following abbreviated terms are defined and used within this European Standard.

Abbreviation	Meaning
AR	acceptance review
ASME	American Society of Mechanical Engineers
CDR	critical design review
DOT	United States Department of Transportation
DRD	document requirements definition
EFCB	ESA fracture control board
ESA	European Space Agency
FCI	fracture critical item
FCIL	fracture critical item list
FLLI	fracture limited life item
FLLIL	fracture limited life items list
GSE	ground support equipment
ISS	international space station
LBB	leak before burst
MDP	maximum design pressure
MEOP	maximum expected operating pressure
NASA	National Aeronautics and Space Administration
NDI	non-destructive inspection
NDE	non-destructive evaluation
NSTS	National Space Transportation System (NASA Space Shuttle)
PDR	preliminary design review