

**Space engineering - Structural factors of safety for
spaceflight hardware**

EESTI STANDARDI EESSÕNA

NATIONAL FOREWORD

| | |
|---|--|
| See Eesti standard EVS-EN 16603-32-10:2014 sisaldab Euroopa standardi EN 16603-32-10:2014 inglisekeelset teksti. | This Estonian standard EVS-EN 16603-32-10:2014 consists of the English text of the European standard EN 16603-32-10:2014. |
| Standard on jõustunud sellekohase teate avaldamisega EVS Teatajas. | This standard has been endorsed with a notification published in the official bulletin of the Estonian Centre for Standardisation. |
| Euroopa standardimisorganisatsioonid on teinud Euroopa standardi rahvuslikele liikmetele kättesaadavaks 13.08.2014. | Date of Availability of the European standard is 13.08.2014. |
| Standard on kättesaadav Eesti Standardikeskusest. | The standard is available from the Estonian Centre for Standardisation. |

Tagasisidet standardi sisu kohta on võimalik edastada, kasutades EVS-i veebilehel asuvat tagasiside vormi või saates e-kirja meiliaadressile standardiosakond@evs.ee.

ICS 49.140

Standardite reprodutseerimise ja levitamise õigus kuulub Eesti Standardikeskusele

Andmete paljundamine, taastekitamine, kopeerimine, salvestamine elektroonsesse süsteemi või edastamine ükskõik millises vormis või millisel teel ilma Eesti Standardikeskuse kirjaliku loata on keelatud.

Kui Teil on küsimusi standardite autorikaitse kohta, võtke palun ühendust Eesti Standardikeskusega:
Aru 10, 10317 Tallinn, Eesti; www.evs.ee; telefon 605 5050; e-post info@evs.ee

The right to reproduce and distribute standards belongs to the Estonian Centre for Standardisation

No part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying, without a written permission from the Estonian Centre for Standardisation.

If you have any questions about copyright, please contact Estonian Centre for Standardisation:
Aru 10, 10317 Tallinn, Estonia; www.evs.ee; phone 605 5050; e-mail info@evs.ee

English version

Space engineering - Structural factors of safety for spaceflight
hardware

Ingénierie spatiale - Facteurs de sécurité pour les structure
spatiales

Raumfahrttechnik - Strukturelle Sicherheitsfaktoren für
Raumflughardware

This European Standard was approved by CEN on 10 February 2014.

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, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.



CEN-CENELEC Management Centre:
Avenue Marnix 17, B-1000 Brussels

Table of contents

| | |
|--|-----------|
| Foreword | 4 |
| 1 Scope | 5 |
| 2 Normative references | 7 |
| 3 Terms, definitions and abbreviated terms | 8 |
| 3.1 Terms and definitions | 8 |
| 3.2 Terms specific to the present standard | 8 |
| 3.3 Abbreviated terms..... | 9 |
| 4 Requirements | 10 |
| 4.1 Applicability of structural factors of safety | 10 |
| 4.1.1 Overview | 10 |
| 4.1.2 Applicability | 10 |
| 4.1.3 General | 10 |
| 4.1.4 Design factor for loads | 10 |
| 4.1.5 Additional factors for design | 12 |
| 4.2 Loads and factors relationship | 13 |
| 4.2.1 General | 13 |
| 4.2.2 Specific requirements for launch vehicles | 15 |
| 4.3 Factors values | 16 |
| 4.3.1 Test factors | 16 |
| 4.3.2 Factors of safety | 17 |
| Annex A (informative) Qualification test factor for launch vehicles | 21 |
| Bibliography | 23 |
| Figures | |
| Figure 4-1: Logic for Factors of Safety application..... | 14 |
| Figure 4-2: Analysis tree..... | 15 |

Tables

| | |
|---|----|
| Table 4-1: Relationship among (structural) factors of safety, design factors and additional factors | 14 |
| Table 4-2: Test factor values | 16 |
| Table 4-3: Factors of safety for metallic, FRP, sandwich, glass and ceramic structural parts..... | 18 |
| Table 4-4: Factors of safety for joints, inserts and connections..... | 19 |
| Table 4-5: Factors of safety for buckling..... | 20 |
| Table 4-6: Factors of safety for pressurized hardware | 20 |

Foreword

This document (EN 16603-32-10:2014) has been prepared by Technical Committee CEN/CLC/TC 5 "Space", the secretariat of which is held by DIN.

This standard (EN 16603-32-10:2014) originates from ECSS-E-ST-32-10C 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 February 2015, and conflicting national standards shall be withdrawn at the latest by February 2015.

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 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, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1

Scope

The purpose of this Standard is to define the Factors Of Safety (FOS), Design Factor and additional factors to be used for the dimensioning and design verification of spaceflight hardware including qualification and acceptance tests.

This standard is not self standing and is used in conjunction with the ECSS-E-ST-32, ECSS-E-ST-32-02 and ECSS-E-ST-33-01 documents.

Following assumptions are made in the document:

- that recognized methodologies are used for the determination of the limit loads, including their scatter, that are applied to the hardware and for the stress analyses;
- that the structural and mechanical system design is amenable to engineering analyses by current state-of-the-art methods and is conforming to standard aerospace industry practices.

Factors of safety are defined to cover chosen load level probability, assumed uncertainty in mechanical properties and manufacturing but not a lack of engineering effort.

The choice of a factor of safety for a program is directly linked to the rationale retained for designing, dimensioning and testing within the program. Therefore, as the development logic and the associated reliability objectives are different for:

- unmanned scientific or commercial satellite,
- expendable launch vehicles,
- man-rated spacecraft, and
- any other unmanned space vehicle (e.g. transfer vehicle, planetary probe)

specific values are presented for each of them.

Factors of safety for re-usable launch vehicles and man-rated commercial spacecraft are not addressed in this document.

For all of these space products, factors of safety are defined hereafter in the document whatever the adopted qualification logic: proto-flight or prototype model.

For pressurized hardware, factors of safety for all loads except internal pressure loads are defined in this standard. Concerning the internal pressure, the factors

of safety for pressurised hardware can be found in ECSS-E-ST-32-02. For loads combination refer to ECSS-E-ST-32-02.

For mechanisms, specific factors of safety associated with yield and ultimate of metallic materials, cable rupture factors of safety, stops/shaft shoulders/recess yield factors of safety and limits for peak Hertzian contact stress are specified in ECSS-E-ST-33-01.

Alternate approach

The factors of safety specified hereafter are applied using a deterministic approach i.e. as generally applied in the Space Industry to achieve the structures standard reliability objectives. Structural safety based on a probabilistic analysis could be an alternate approach but it has to be demonstrated this process achieves the reliability objective specified to the structure. The procedure is approved by the customer.

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 16603-32 | 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 |