

DIN EN 16603-35-01

ICS 49.140

Einsprüche bis 2014-02-06
Vorgesehen als Ersatz für
DIN EN 14607-5-1:2006-12

Entwurf

**Raumfahrttechnik –
Flüssige und elektrische Antriebe von Raumfahrzeugen;
Englische Fassung FprEN 16603-35-01:2013**

Space engineering –
Liquid and electric propulsion for spacecraft;
English version FprEN 16603-35-01:2013

Ingénierie spatiale –
Propulsion liquide et électrique pour satellites;
Version anglaise FprEN 16603-35-01:2013

Anwendungswarnvermerk

Dieser Norm-Entwurf mit Erscheinungsdatum 2013-12-06 wird der Öffentlichkeit zur Prüfung und Stellungnahme vorgelegt.

Weil die beabsichtigte Norm von der vorliegenden Fassung abweichen kann, ist die Anwendung dieses Entwurfes besonders zu vereinbaren.

Stellungnahmen werden erbeten

- vorzugsweise online im Norm-Entwurfs-Portal des DIN unter www.entwuerfe.din.de bzw. für Norm-Entwürfe der DKE auch im Norm-Entwurfs-Portal der DKE unter www.entwuerfe.normenbibliothek.de, sofern dort wiedergegeben;
- oder als Datei per E-Mail an nl@din.de möglichst in Form einer Tabelle. Die Vorlage dieser Tabelle kann im Internet unter www.din.de/stellungnahme oder für Stellungnahmen zu Norm-Entwürfen der DKE unter www.dke.de/stellungnahme abgerufen werden;
- oder in Papierform an den Normenausschuss Luft- und Raumfahrt (NL) im DIN, 10772 Berlin (Hausanschrift: Burggrafenstr. 6, 10787 Berlin).

Die Empfänger dieses Norm-Entwurfs werden gebeten, mit ihren Kommentaren jegliche relevanten Patentrechte, die sie kennen, mitzuteilen und unterstützende Dokumentationen zur Verfügung zu stellen.

Gesamtumfang 63 Seiten

Normenausschuss Luft- und Raumfahrt (NL) im DIN

Nationales Vorwort

Dieses Dokument (FprEN 16603-35-01:2013) wurde vom Technischen Komitee CEN/CLC/TC 5 „Raumfahrt“ erarbeitet, dessen Sekretariat vom DIN (Deutschland) gehalten wird.

Dieses Dokument (FprEN 16603-35-01:2013) basiert auf ECSS-E-ST-35-01C.

Dieses Dokument wird EN 14607-5-1:2004 ersetzen.

Dieses Dokument ist derzeit zum einstufigen Annahmeverfahren vorgelegt.

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

Änderungen

Gegenüber DIN EN 14607-5-1:2006-12 wurden folgende Änderungen vorgenommen:

- a) Norm-Nummer geändert;
- b) keinerlei Änderungen des Textes.

Nationaler Anhang NA (informativ)

Einleitung, Anwendungsbereich, Begriffe

Einleitung

ECSS-Antriebsnormen sind wie folgt strukturiert.

ECSS-E-ST-35, Allgemeine Anforderungen an Antriebe,

- Normen, die eine bestimmte Antriebsart behandeln:
 - ECSS-E-ST-35-01, Flüssige und elektrische Antriebe von Raumfahrzeugen,
 - ECSS-E-ST-35-02, Feststoffantriebe für Raumfahrzeuge und Trägerraketen,
 - ECSS-E-ST-35-03, Flüssigantriebe für Trägerraketen.
- Normen, die bestimmte Aspekte des Antriebs behandeln:
 - ECSS-E-ST-35-06, Sauberkeitsanforderungen für die Antriebstechnik von Raumfahrzeugen,
 - ECSS-E-ST-35-10, Kompatibilitätstests für Flüssigkeitsantriebe.

1 Anwendungsbereich

Diese Norm legt die regulatorischen Aspekte fest, die für die Bestandteile und Verfahren bei flüssigen (einschließlich Kaltgas) und elektrischen Antrieben von Raumfahrzeugen gelten. Sie spezifiziert die bei der technischen Bearbeitung dieser Antriebssysteme auszuführenden Tätigkeiten und deren Anwendbarkeit, und sie legt die Anforderungen für die technischen Aspekte fest: funktionale, umweltbezogene und betriebliche Anforderungen, Schnittstellen, Konstruktion, qualitative Faktoren und Verifizierung.

Allgemeine Anforderungen, die für sämtliche Arten der technischen Bearbeitung von Antriebssystemen gelten, sind in ECSS-E-ST-35 festgelegt.

Diese Norm darf auf die speziellen Merkmale und Vorgaben eines Raumfahrtprojekts nach ECSS-S-ST-00 ausgelegt sein.

3 Begriffe und Abkürzungen

3.1 Begriffe aus anderen Normen

Für die Anwendung dieses Dokuments gelten die Begriffe nach ECSS-S-ST-00-01 und nach ECSS-E-ST-35.

3.2 Abkürzungen

Für die Anwendung dieses Dokuments gelten die Abkürzungen nach ECSS-S-ST-00-01.

August 2013

ICS 49.140

Will supersede EN 14607-5-1:2004

English version

Space engineering - Liquid and electric propulsion for spacecraft

Ingénierie spatiale - Propulsion liquide et électrique pour satellites

Raumfahrttechnik - Flüssige und elektrische Antriebe von Raumfahrzeugen

This draft European Standard is submitted to CEN members for unique acceptance procedure. It has been drawn up by the Technical Committee CEN/CLC/TC 5.

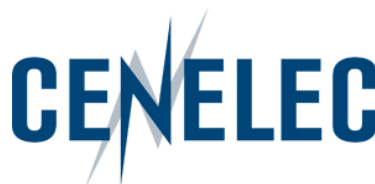
If this draft becomes a European Standard, CEN and CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

This draft European Standard was established by CEN and CENELEC 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.

Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

Warning : This document is not a European Standard. It is distributed for review and comments. It is subject to change without notice and shall not be referred to as a European Standard.



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

Table of contents

Foreword	5
Introduction.....	6
1 Scope.....	7
2 Normative references	8
3 Terms, definitions and abbreviated terms.....	9
3.1 Terms from other standards.....	9
3.2 Abbreviated terms.....	9
4 Liquid propulsion systems for spacecraft	10
4.1 Overview	10
4.2 Functional.....	10
4.2.1 Mission.....	10
4.2.2 Functions	11
4.3 Constraints	11
4.3.1 Accelerations	11
4.3.2 Pressure vessels and pressurized components	12
4.3.3 Induced and environmental temperatures	12
4.3.4 Thermal fluxes	12
4.3.5 Thruster plume effects	12
4.4 Interfaces.....	12
4.5 Design	13
4.5.1 General.....	13
4.5.2 Selection	14
4.5.3 Sizing	15
4.5.4 Design development	16
4.5.5 Contamination.....	17
4.5.6 Draining	17
4.5.7 Risk of explosion	18
4.5.8 Components guidelines.....	18
4.5.9 Filters	20

4.5.10	Pressure vessels.....	20
4.5.11	Propellant tanks	20
4.5.12	Blow-down ratio	22
4.5.13	Flow calibration	22
4.5.14	Thrusters.....	22
4.5.15	Thrust-vector control (TVC).....	23
4.5.16	Pyrotechnic devices	24
4.5.17	Mass imbalance	24
4.5.18	Monitoring and failure detection	24
4.5.19	Ground support equipment (GSE).....	24
4.6	Verification.....	25
4.6.1	General	25
4.6.2	Verification by analysis.....	26
4.6.3	Verification by test.....	28
4.6.4	Data exchange for models	33
4.7	Quality factors.....	33
4.7.1	Reliability	33
4.7.2	Production and manufacturing process	33
4.8	Operation and disposal	33
4.8.1	General	33
4.8.2	Operations on ground	34
4.8.3	Tank operation	34
4.8.4	Disposal	34
4.9	Supporting documents.....	35
5	Electric propulsion systems for spacecraft	36
5.1	Overview	36
5.2	Functional.....	37
5.2.1	Mission.....	37
5.2.2	Function	37
5.2.3	Performance	37
5.3	Constraints	38
5.3.1	General	38
5.3.2	Thermal fluxes	38
5.3.3	Thruster plume effects	39
5.3.4	High frequency current loops	39
5.3.5	Electromagnetic compatibility	39
5.3.6	Spacecraft charging	39

5.4	Interfaces.....	40
5.4.1	Interface with the spacecraft	40
5.4.2	Interface with the power bus	40
5.5	Design	41
5.5.1	General	41
5.5.2	Selection	42
5.5.3	Sizing	43
5.5.4	Design development	44
5.5.5	Contamination	44
5.5.6	Propellant protection	45
5.5.7	Components guidelines.....	45
5.5.8	Propellant management assembly	45
5.5.9	Pressure vessels.....	46
5.5.10	Propellant tanks	47
5.5.11	Blow-down ratio	47
5.5.12	Thrusters.....	47
5.5.13	Thrust-vector control	50
5.5.14	Power supply, control and processing subsystem	50
5.5.15	Electrical design.....	51
5.5.16	Pyrotechnic devices	52
5.5.17	Monitoring and failure detection	52
5.5.18	Ground support equipment (GSE).....	53
5.6	Verification.....	53
5.6.1	General	53
5.6.2	Verification by analysis.....	54
5.6.3	Verification by test.....	55
5.6.4	Data exchange for models	57
5.7	Quality factors.....	57
5.7.1	Reliability	57
5.7.2	Production and manufacturing	57
5.8	Operation and disposal.....	57
5.9	Supporting documents.....	58
	Bibliography.....	59
	Tables	
	Table 4-1: Component failure modes.....	18

Foreword

This document (FprEN 16603-35-01:2013) has been prepared by Technical Committee CEN/CLC/TC 5 "Space", the secretariat of which is held by DIN (Germany).

This document (FprEN 16603-35-01:2013) originates from ECSS-E-ST-35-01C.

This document is currently submitted to the Unique Acceptance Procedure.

This document will supersede EN 14607-5-1:2004.

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

Introduction

The ECSS Propulsion standards structure is as follows.

ECSS-E-ST-35 Propulsion general requirements

- Standards, covering particular type of propulsion
 - ECSS-E-ST-35-01 Liquid and electric propulsion for spacecrafts
 - ECSS-E-ST-35-02 Solid propulsion for spacecrafts and launchers
 - ECSS-E-ST-35-03 Liquid propulsion for launchers
- Standard covering particular propulsion aspects
 - ECSS-E-ST-35-06 Cleanliness requirements for spacecraft propulsion hardware
 - ECSS-E-ST-35-10 Compatibility testing for liquid propulsion systems

1

Scope

This Standard defines the regulatory aspects applicable to elements and processes for liquid, including cold gas, and electrical propulsion for spacecraft. It specifies the activities to be performed in the engineering of such propulsion systems, their applicability, and defines the requirements for the engineering aspects: functional, interfaces, environmental, design, quality factors, operational and verification.

General requirements applying to all type of Propulsion Systems Engineering are defined in ECSS-E-ST-35.

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 16601-01	ECSS-S-ST-00-01	ECSS system – Glossary of terms
EN 16603-10	ECSS-E-ST-10	Space engineering – System engineering general requirements
EN 16603-20	ECSS-E-ST-20	Space engineering – Electrical and electronic
EN 16603-20-06	ECSS-E-ST-20-06	Space engineering – Spacecraft changing
EN 16603-20-07	ECSS-E-ST-20-07	Space engineering – Electromagnetic compatibility
EN 16603-31	ECSS-E-ST-31	Space engineering – Thermal control general requirements
EN 16603-32	ECSS-E-ST-32	Space engineering – Structural general requirements
EN 16603-35	ECSS-E-ST-35	Space engineering – Propulsion general requirements
EN 16602-30	ECSS-Q-ST-30	Space product assurance – Dependability

Terms, definitions and abbreviated terms

3.1 Terms from other standards

For the purpose of this Standard, the terms and definitions from ECSS-S-ST-00-01 and ECSS-E-ST-35 apply.

3.2 Abbreviated terms

For the purpose of this Standard, the abbreviated terms from ECSS-ST-00-01 apply.

4

Liquid propulsion systems for spacecraft

4.1 Overview

Liquid propulsion systems for spacecraft provide the forces and torques for orbit transfer, orbit maintenance and attitude control. For manoeuvrable spacecraft, capsules and transport vehicles, they provide in addition the forces and torques for rendez-vous and docking.

Apart from what is specific for propellant combustion, liquid propulsion criteria are also applicable to cold gas propulsion systems.

The present clause 4 covers also the design and use of propulsion ground support equipment (GSE), defined in ECSS-E-ST-70.

4.2 Functional

4.2.1 Mission

- a. The propulsion system shall conform to the spacecraft mission requirements including:

1. Ground operations

NOTE For example: functional control, testing, propellant, simulant loading and spacecraft transportation.

2. Pre-launch and launch activities

NOTE For example: integration, storage, ageing and transport.

3. In-orbit operations.

NOTE For example: orbit transfer, orbit maintenance and attitude control) and the complete in-orbit life.

4.2.2 Functions

- a. The propulsion system shall provide the total impulse, minimum impulse bit, thrust levels and torques required by the AOCS.
- b. The following aspects shall be defined:
 1. Thruster firing modes
NOTE For example: steady state, off-modulation, pulse mode.
 2. Thrust level and orientation
 3. Thrust-vector control
 4. Thrust centroid time
 5. Minimum impulse bit
 6. Impulse reproducibility
 7. Total impulse
 8. Cycle life
 9. Mission life
 10. Reliability level
 11. Thrust noise
 12. Propellant gauging.
- c. The propulsion system shall fulfil its functions while subjected to the specified external loads during its mission, including:
 1. mechanical loads;
NOTE For example: quasi-static loads, vibrations, transportation.
 2. thermal loads;
 3. electrical loads.

4.3 Constraints

4.3.1 Accelerations

- a. Limits on acceleration levels, induced or experienced by the propulsion system, shall be specified at spacecraft level.
NOTE This is in order to:
 - avoid perturbations, e.g. during possible observations or experiments;
 - protect sensitive equipments;
 - design adequate tank PMD.

4.3.2 Pressure vessels and pressurized components

- a. Support structures of pressure vessels and pressurized components shall allow deformations of the vessels due to pressure or temperature changes and cycles to occur without causing stresses that exceed acceptable limits.

4.3.3 Induced and environmental temperatures

- a. The non-operating and operating temperature limitations of the propulsion system shall be specified.

4.3.4 Thermal fluxes

- a. Thruster surroundings shall conform to the radiative and conductive heat fluxes rejected by the thrusters.

4.3.5 Thruster plume effects

- a. Elements of the spacecraft sensitive to plume effects shall be identified.
- b. The allowed plume effects on elements identified in clause 4.3.5a shall be specified at spacecraft level.
- c. The generation of perturbing torques, forces, thermal gradients, contamination and erosion of surfaces, due to plume effects, shall be defined and documented accordingly.
- d. The plume analysis specified in 4.3.5c shall be reported in conformance with the Plume analysis report DRD in ECSS-E-ST-35.

4.4 Interfaces

- a. The liquid propulsion system shall conform to its specified spacecraft interfaces, including:
 - 1. Structure
 - NOTE For example: inserts, tank support structure and vibration levels.
 - 2. Thermal
 - NOTE For example: conduction, radiation levels, tank, thruster and line thermal control.
 - 3. Power
 - NOTE For example: valve drivers, pressure transducers, thermistors, heaters and thermocouples.
 - 4. Electromagnetic compatibility
 - 5. Pyrotechnics
 - NOTE For example: pyrotechnic valves.

6. Mechanisms

NOTE For example: valves, regulators, actuators and actuation system.

7. AOCS, OBDH and TM/TC.

NOTE For example: commanding, handling of data for status and health monitoring and failure detection.

b. Interfaces shall be defined:

1. For ground tests and loading activities, with the propulsion GSE.
2. For safety and prelaunch operation with the launcher authorities.

4.5 Design

4.5.1 General

4.5.1.1 Architecture

- a. The propulsion system architecture shall apply the requirements in ECSS-Q-ST-30.
- b. The propulsion system architecture shall provide evidence that fail safe, redundancy, reliability and safety requirements are met.

4.5.1.2 Replacement of parts

- a. For replacement of parts during development, testing and mission life pre-launch activities ECSS-E-ST-35, requirements 4.5.1c, d and e. shall be applied.

4.5.1.3 Water-hammer effect

- a. A water-hammer effects analysis shall be performed to support the propulsion system design and ensure proper functioning.
- b. The analysis specified in 4.5.1.3a shall be reported in conformance with the Propulsion transient analysis report DRD in ECSS-E-ST-35.

4.5.1.4 Piping

- a. A pipework design analysis shall be performed including non-consumables, cross-coupling, leakage, pressure, eigenfrequencies, water-hammer.
- b. The consequences in terms of operational restrictions shall be identified.

4.5.1.5 Closed volumes

- a. The design of the propulsion system shall prevent hazardous pressure increase in closed volumes.
- b. The need for any pressure relief capability shall be identified and analysed.

4.5.1.6 Pressure vessels and pressurized components

- a. The design of pressure vessels and pressurized components shall:
 - 1. Apply margins and factors of safety (FOS) for proof, burst and component life cycle.

NOTE See ECSS-E-ST-32-02.
 - 2. Conform to the environmental aspects, including but not limited to:
 - (a) Temperature
 - (b) Vibration
 - (c) Humidity
 - (d) Corrosive environment
 - (e) Vacuum
 - (f) Outgassing
 - (g) Radiation.

4.5.1.7 Multi-tanks

- a. If a multi-tank layout is used, inadvertent propellant transfer between tanks shall be prevented by design.
- b. If PMD tanks are being used, the consequences of selecting parallel or series connections shall be analysed.

4.5.1.8 Cycles

- a. The system and its components shall be designed for the expected number of cycles during the whole mission life, for both on-ground and in-service operation.

4.5.2 Selection

4.5.2.1 Reporting

- a. The reporting shall be done in the DJF in conformance with ECSS-E-ST-10.

4.5.2.2 General

- a. The selection shall be based on trade-off analyses of:
 - 1. The propulsion system.

NOTE For example: monopropellant, bipropellant, or cold gas.
 - 2. The operating mode.

NOTE For example: pressure regulated and blow-down.

- b. Selected materials, propellants and test fluids shall be compatible for all components.

NOTE Compatibility includes:

- dissolution;
- chemical reaction;
- erosion;
- corrosion.

4.5.2.3 Propellant selection

4.5.2.3.1 General

- a. The criteria to be used for propellant selection shall include:
1. Mission requirements
 2. Resulting layout of the propulsion system
 3. Availability of off-the-shelf components
 4. Experience
 5. Compatibility and contamination
 6. Performance.
- b. The propellant shall be defined and specified including:
1. Chemical composition
 2. Purity
 3. Cleanliness.

4.5.2.3.2 Propellant for Thruster qualification

- a. Thruster qualification firing tests shall use the same propellant grade as the one selected for flight.

4.5.3 Sizing

- a. The sizing process shall begin with a definition of the life phases of each subsystem or component, including at least:
1. Pressure cycles combined with temperature cycles
 2. Propellant, pressurant and leakage budgets
 3. Establishment of the operational envelope
 4. Minimum and maximum electrical supply voltages
 5. Interfaces with GSE functions
 6. Evolution of the operational conditions.
- b. The sizing process shall demonstrate margins based on:
1. Safety
 2. Reliability requirements established by the customer