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Entwurf**Raumfahrttechnik –
Flüssigantriebe für Trägerraketen;
Englische Fassung FprEN 16603-35-03:2013**

Space engineering –
Liquid propulsion for launchers;
English version FprEN 16603-35-03:2013

Ingénierie spatiale –
Propulsion liquide pour lanceurs;
Version anglaise FprEN 16603-35-03:2013

Anwendungswarnvermerk

Dieser Norm-Entwurf mit Erscheinungsdatum 2013-12-20 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

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- 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 57 Seiten

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Nationales Vorwort

Dieses Dokument (FprEN 16603-35-03:2013) wurde vom Technischen Komitee CEN/CLC/TC 5 „Raumfahrt“ erarbeitet, dessen Sekretariat vom DIN (Deutschland) gehalten wird.

Dieses Dokument (FprEN 16603-35-03:2013) basiert auf ECSS-E-ST-35-03C.

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.

Nationaler Anhang NA (informativ)

Einleitung, Anwendungsbereich, Begriffe

Einleitung

Die Anforderungen in dieser Norm (sowie in den anderen drei Normen zu Antrieben von Raumfahrzeugen ECSS-E-ST-35, ECSS-E-ST-35-01 und ECSS-E-ST-35-03) sind mithilfe einer typischen Struktur wie folgt aufgebaut:

- funktionale Struktur,
- Vorgaben,
- Entwicklung,
- Schnittstellen,
- Konstruktion,
- GSE,
- Materialien,
- Verifizierung,
- Herstellung oder Bereitstellung,
- in Betrieb (Betrieb und Entsorgung),
- Ergebnisse.

Diese Norm ist Bestandteil der Normenreihe ECSS-E-ST-35, die wie folgt aufgebaut ist:

- ECSS-E-ST-35, *Antrieb, allgemeine Anforderungen und Grundsätze*,
- 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*,
- ECSS-E-ST-35-06, *Sauberkeitsanforderungen für die Antriebstechnik von Raumfahrzeugen*,
- ECSS-E-ST-35-10, *Kompatibilitätstests für Flüssigkeitsantriebe*.

ECSS-E-ST-35 enthält sämtliche normativen Verweisungen, Benennungen, Definitionen, Abkürzungen, Symbole und DRDs, die für ECSS-E-ST-35, ECSS-E-ST-35-01, ECSS-E-ST-35-02 und ECSS-E-ST-35-03 gelten.

Bei der Anwendung dieser Norm ist die Benennung „Antriebssystem“ ausschließlich und insbesondere als „Flüssigantriebssystem“ zu lesen und zu interpretieren.

1 Anwendungsbereich

Die allgemeinen Anforderungen gelten für sämtliche Arten von Antriebssystemtechnik, die in ECSS-E-ST-35 festgelegt sind. Für den Betrieb von Flüssigantrieben bei Trägerraketen im Rahmen eines Raumfahrtprojektes werden die Normen ECSS-E-ST-35 und ECSS-E-ST-35-03 gemeinsam angewendet.

Diese Norm legt die regulatorischen Aspekte, die für Elemente und Verfahren bei Flüssigantrieben für Trägerraketen gelten, fest. Sie spezifiziert die bei der technischen Bearbeitung dieser Antriebssysteme auszuführenden Tätigkeiten und deren Anwendbarkeit. Sie legt die Anforderungen für die technischen Aspekte fest: funktionale, physikalische, umweltbezogene und betriebliche Anforderungen, qualitative Faktoren und Verifizierung.

Andere Antriebsformen (z. B. atomare, atomar-elektrische, solar-thermische und hybride Antriebe) sind gegenwärtig nicht Gegenstand dieser Ausgabe der Norm.

Diese Norm kann 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, ECSS-E-ST-35 und die Folgenden.

Abkürzung	Bedeutung
LPS	Flüssigantriebssystem (en: liquid propulsion system)

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English version

Space engineering - Liquid propulsion for launchers

Ingénierie spatiale - Propulsion liquide pour lanceurs

Raumfahrttechnik - Flüssigantriebe für Trägerraketen

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.

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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.

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Foreword

This document (FprEN 16603-35-03:2013) has been prepared by Technical Committee CEN/CLC/TC 5 "Space", the secretariat of which is held by DIN (Germany).

This document (FprEN 16603-35-03:2013) originates from ECSS-E-ST-35-03C.

This document is currently submitted to the Unique Acceptance Procedure.

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 requirements in this Standard ECSS-E-ST-35-03 (and in the 3 other space propulsion standards ECSS-E-ST-35, ECSS-E-ST-35-01 and ECSS-E-ST-35-02) are organized with a typical structure as follows:

- functional;
- constraints;
- development;
- interfaces;
- design;
- GSE;
- materials;
- verification;
- production and manufacturing;
- in-service (operation and disposal);
- deliverables.

This standard forms parts of ECSS-E-ST-35 series which has the following structure;

- ECSS-E-ST-35 Propulsion general requirements
- 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
- ECSS-E-ST-35-06 Cleanliness requirements for spacecraft propulsion components, subsystems, and systems
- ECSS-E-ST-35-10 Compatibility testing for liquid propulsion components, subsystems, and systems

ECSS-E-ST-35 contains all the normative references, terms, definitions, abbreviated terms, symbols and DRD that are applicable for ECSS-E-ST-35, ECSS-E-ST-35-01, ECSS-E-ST-35-02 and ECSS-E-ST-35-03.

In the use of this standard, the term 'propulsion system' is intended to be read and interpreted only and specifically for 'liquid propulsion system'.

1

Scope

General requirements applying to all type of Propulsion Systems Engineering are defined in ECSS-E-ST-35. For Liquid propulsion for launchers activities within a space project the standards ECSS-E-ST-35 and ECSS-E-ST-35-03 are applied together.

This Standard defines the specific regulatory aspects that apply to the elements and processes of liquid propulsion for launch vehicles. It specifies the activities to be performed in the engineering of these propulsion systems and their applicability. It defines the requirements for the engineering aspects such as functional, physical, environmental, quality factors, operational and verification.

Other forms of propulsion (e.g. nuclear, nuclear-electric, solar-thermal and hybrid propulsion) are not presently covered in this issue of the Standard.

This standard may be tailored for the specific characteristic 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	ECSS-E-ST-10	Space engineering - System engineering general requirements
EN 16603-10-02	ECSS-E-ST-10-02	Space engineering - Verification
EN 16603-10-06	ECSS-E-ST-10-06	Space engineering - Technical requirements specification
EN 16603-32	ECSS-E-ST-32	Space engineering - Structural general requirements
EN 16603-32-02	ECSS-E-ST-32-01	Space engineering - Fracture control
EN 16603-32-02	ECSS-E-ST-32-02	Space engineering - Structural design and verification of pressurized hardware
EN 16603-32-10	ECSS-E-ST-32-10	Space engineering - Structural factors of safety for spaceflight hardware
EN 16603-35	ECSS-E-ST-35	Space engineering - Propulsion general requirements
EN 16602-70	ECSS-Q-ST-70	Space product assurance - Materials, mechanical parts and processes
	ISO 15389:2001	Space systems - Flight-to-ground umbilicals

3

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-S-ST-00-01, ECSS-E-ST-35 and the following apply:

Abbreviation	Meaning
LPS	liquid propulsion system

Overview of a liquid propulsion system

- Main functions of a liquid propulsion system are:
 - To provide thrust
 - To provide thrust vector control
 - To provide multiple burn capability if necessary
 - To supply pressurized gas for auxiliary functions (e.g. roll control, stage orientation)
 - To supply fluid for pneumatic control (e.g. Helium)
 - To provide thrust for propellant settling
 - To provide information concerning its status (e.g. measurement)
- The liquid propulsion system generally consists in:
 - the engine
 - the tank
 - the feed system
 - the pressurisation system
 - the command system
 - the TVC
 - auxiliary systems such as the anti-POGO device, roll control system
- The typical life of a liquid propulsion system is the following:
 - Manufacturing and assembly
 - Acceptance test (if any)
 - Storage and transport
 - Launcher integration
 - Pre-launch activities (e.g. flushing, leak tightness checks)
 - Tanks filling
 - Main stage Chill down (for cryogenic liquid propulsion system)
 - Launch chronology (including launch-abort activities)

- Lift-off
- Chill-down (for cryogenic liquid propulsion upper stages)
- Boost phases
- Stage separation
- Ballistic phase
- Passivation
- De-orbiting, reaching a graveyard orbit, or both

NOTE The way how to write the technical specification is given in ECSS-E-ST-10-06.

5

Functional

5.1 Overview

The general functional specification coming from mission optimisation at system level provides values for:

- Thrust
- Isp
- Burning time

The additional functional requirements are:

- thrust level versus time (throttling)
- propellant budget management (e.g. mixture ratio variation)
- TVC (e.g. maximum angle, acceleration, response time)
- start-up and shutdown transient requirements (e.g. duration, impulse scatter)
- auxiliary power to be delivered to the launcher (e.g. electrical and fluids)
- re-startability
- propellant depletion

5.2 Mission

- a. ECSS-E-ST-35 clause 4.2 shall apply.

5.3 Functions

- a. The technical specification shall provide the values of thrust, Isp and burning time with their deviations.

6 Constraints

6.1 Acceleration

- a. Accelerations in the axial and lateral directions, assessed at launch vehicle level, shall be specified as an input for the propulsion system.

NOTE The acceleration has an impact on the:

- functioning of the vortex suppression devices in the tank outlets;
- pressure at the pump inlets;
- flow pattern in the tank;
- mechanical loads.

6.2 Geometrical constraints

- a. The dimensioning of the liquid propulsion system and its components shall conform to the overall launch vehicle dimensions, interfaces between stages, ground infrastructure and requirements for transportation.

6.3 Electrical constraints

- a. The design of the prop system shall be such that the electrical continuity is ensured.

6.4 Safety

- a. The design of the liquid propulsion system shall conform to the safety requirements of the launch system.

NOTE For Example, ground safety requirements, flight safety requirements.

7

Development

7.1 Overview

The phases of development for a liquid propulsion system are as follows:

- definition of system and subsystem requirements conforming to mission requirements
- establishment of the general concepts
- trade-off of various concepts
- preliminary design
- risk analysis of the preliminary design and trade-off of various options
- detailed design and definition
- manufacturing and assembly of
 - components,
 - subsystems.
- integration of subsystem and system
- testing of:
 - components,
 - subsystems,
 - engines, and
 - system (functional stage).
- selection of the design to be qualified
- qualification process
- review of first article

7.2 Development logic

- a. The development logic shall include a requirement verification plan in conformance with ECSS-E-ST-10-02 'verification plan'.

NOTE Example of verification methods are analyses, tests.

- b. The development logic shall be structured into phases with a goal assigned to each phase.
- c. Mathematical models shall be implemented during the preliminary design phase and used for system trade-off analysis.

NOTE 1 See clause 9.3.

NOTE 2 Preliminary design phase is Phase B of ECSS-M-ST-10.

- d. Mathematical models shall be updated using component and subsystem results at milestones agreed by the customer.
- e. Mathematical models shall be validated using test results.
- f. Mathematical models shall be used to determine the design margins.
- g. The development logic shall list the activities that are submitted to cross-check.

NOTE See ECSS-E-ST-35 clause 4.8.1.

- h. The sequence of development activities shall include components and subsystem tests prior to system tests.
- i. The development logic shall mention the difficulties and critical activities of the development.

NOTE In particular major development critical path.

- j. The development logic shall include risk management activities for project and technical risks.
- k. The development activities shall include verification that manufacturing and control processes lead to products that satisfy specified product-to-product variation limit.
- l. Lessons learned from previous programs shall be introduced in the design development plan.
- m. The critical technologies, manufacturing and control processes shall be listed and their qualification process described.

NOTE See ECSS-Q-ST-20.

- n. Liquid propulsion system verification shall be obtained by testing the liquid propulsion system in conditions representative of flight.

NOTE Following the typical approach "Test as you fly".

- o. Through the measurement plan of the qualification flight the LPS qualification shall be checked by post flight analysis.
- p. The development test plan shall include limit testing and failure cases.
- q. At the end of the development, the testing of the integrated system in its final configuration, including the electrical system, shall include tests with representative interfaces.

NOTE For example, typical interfaces are control computer, electrical interface, flight instrumentation.

- r. Phase by phase analyses of the life cycle of the liquid propulsion system shall be performed in relationship with the launch vehicle system in support of the failure mode analysis and the mechanical and thermal load case selection.
- s. A matrix of configuration of engine hardware versus subsystem hardware shall be produced.
- t. An integrated schedule for subsystem hardware deliveries, engine integration, engine testing for all development and qualification hardware shall be produced.
- u. The output of all the requirement of clause 7.2 shall be detailed in the SEP (System Engineering Plan) as defined in the ECSS-E-ST-10 Annex D DRD.