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**Raumfahrttechnik –  
Flüssigantriebe für Trägerraketen;  
Englische Fassung EN 16603-35-03:2014**

Space engineering –  
Liquid propulsion for launchers;  
English version EN 16603-35-03:2014

Ingénierie spatiale –  
Propulsion liquide pour lanceurs;  
Version anglaise EN 16603-35-03:2014

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## **Nationales Vorwort**

Dieses Dokument (EN 16603-35-03:2014) wurde vom Technischen Komitee CEN/CLC/TC 5 „Raumfahrt“ erarbeitet, dessen Sekretariat vom DIN (Deutschland) gehalten wird.

Das zuständige deutsche Normungsgremium ist der Arbeitsausschuss NA 131-10-01 AA „Interoperabilität von Informations-, Kommunikations- und Navigationssystemen“ im DIN-Normenausschuss Luft- und Raumfahrt (NL).

Dieses Dokument (EN 16603-35-03:2014) basiert auf ECSS-E-ST-35-03C.

Dieses Dokument enthält unter Berücksichtigung des DIN-Präsidialbeschlusses 1/2004 nur die englische Originalfassung von EN 16603-35-03:2014.

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)

### Begriffe und Abkürzungen

#### 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) |

— Leerseite —

English version

## Space engineering - Liquid propulsion for launchers

Ingénierie spatiale - Propulsion liquide pour lanceurs

Raumfahrttechnik - Flüssigantriebe für Trägerraketen

This European Standard was approved by CEN on 23 February 2014.

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## Foreword

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This document (EN 16603-35-03:2014) has been prepared by Technical Committee CEN/CLC/TC 5 "Space", the secretariat of which is held by DIN.

This standard (EN 16603-35-03:2014) originates from ECSS-E-ST-35-03C.

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 April 2015, and conflicting national standards shall be withdrawn at the latest by April 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 prepared under a mandate 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, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

## Introduction

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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

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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                                    |

## Terms, definitions and abbreviated terms

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### 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 |

## 4

# Overview of a liquid propulsion system

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- 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

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## 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

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### 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.