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**Raumfahrttechnik –
Kompatibilitätstests für Flüssigkeitsantriebe;
Englische Fassung EN 16603-35-10:2014**

Space engineering –
Compatibility testing for liquid propulsion components, subsystems and systems;
English version EN 16603-35-10:2014

Ingénierie spatiale –
Essais de compatibilité des composants, sous-systèmes et systèmes de propulsion
liquide;
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Nationales Vorwort

Dieses Dokument (EN 16603-35-10:2014) 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 16603-35-10:2014) basiert auf ECSS-E-ST-35-10C.

Dieses Dokument enthält unter Berücksichtigung des DIN-Präsidialbeschlusses 1/2004 nur die englische Originalfassung von EN 16603-35-10:2014.

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 ECSS-E-ST-35.

Für die Anwendung dieses Dokuments gilt der folgende Begriff nach ECSS-E-ST-32:

größter erwarteter Betriebsdruck (MEOP)

Für die Anwendung dieses Dokuments gilt der folgende Begriff nach ECSS-Q-ST-70-36:

Spannungskorrosion

3.2 Für diese Norm spezifische Begriffe

3.2.1

Alterung

Gesamtheit aller Änderungen der chemischen und physikalischen Eigenschaften, die im Laufe der Zeit in einem Werkstoff auftreten

3.2.2

Selbstentzündungstemperatur

niedrigste Temperatur, bei der eine Substanz ohne Hilfe einer äußeren Energiequelle bei Umgebungstemperatur und –druck eine heißflammige Entzündung erzeugt

3.2.3

Kompatibilität

Fehlen von inakzeptabler Leistungsfähigkeit oder inakzeptabler Zuverlässigkeitseinbuße aufgrund chemischer Reaktionen und physikalischer Änderungen in den Werkstoffen oder Substanzen während der Kompatibilitätsdauer

ANMERKUNG 1 Kompatibilität betrifft immer zwei oder mehr Werkstoffe, die einander berühren.

ANMERKUNG 2 Kompatibilität hängt immer mit der Anwendung und den Anforderungen zusammen.

3.2.4

Kompatibilitätsdauer

Lebenszyklus ab dem Moment, in dem zwei oder mehr Werkstoffe einander ausgesetzt sind, bis zur Entsorgung

3.2.5

Schadgas

Verunreinigungsgas

unerwünschtes Gas, das im Antriebssystem zu jeder Zeit seiner Lebensdauer vorhanden ist

3.2.6

Korrosion

Reaktion des Entwicklungswerkstoffes mit der Umgebung mit einer daraus resultierenden Verschlechterung der Werkstoffeigenschaften

3.2.7**ungleiche Metalle**

Metalle mit unterschiedlichen elektrochemischen Potenzialen

3.2.8**Kontaktkorrosion**

Korrosion als Ergebnis eines elektrochemischen Potenzialunterschieds zwischen elektrischen Leitern in einem Elektrolyt

3.2.9**Wasserstoffversprödung**

Zustand niedriger Duktilität oder reduzierter mechanischer Eigenschaften aufgrund der Absorption von Wasserstoff

ANMERKUNG Spannungsfaktors K

Faktor, der den Spannungszustand in der Nähe der Spitze eines Risses beschreibt, der durch eine abgesetzte Last, durch Eigenspannung oder durch beide verursacht wurde.

ANMERKUNG Die Größe von K hängt von der Probengeometrie, der Größe und Lage des Risses und der Größe und modalen Verteilung der Lasten auf dem Werkstoff ab.

$$K = \sigma Y \cdot \sqrt{\pi \cdot \alpha}$$

Dabei ist

- α die halbe Risslänge;
- K der Spannungsfaktor;
- Y eine dimensionslose geometrische Funktion;
- σ die aufgebrachte Spannung.

3.3 Abkürzungen

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

Abkürzung	Bedeutung	
CAAR	Bericht zur Kompatibilitätsbewertung und Anwendbarkeit	(en: compatibility assessment and applicability report)
COTS	Kommerzielles Standardprodukt	(en: commercial off-the-shelf)
CPE	Chloriertes Polyethylen	(en: chlorinated poly ethylene)
CTLP	Kompatibilitätstest für Flüssigkeitsantrieb	(en: compatibility testing for liquid propulsion)
DSC	Dynamische Differenzkalorimetrie (DDK)	(en: differential scanning calorimeter)
EPDM	Ethylen-Propylen-Dien-Kautschuk	(en: ethylene propylene diene monomer)
EPR	Ethylen-Propylen-Kautschuk	(en: ethylene propylene rubber)
GOx	Gasförmiger Sauerstoff	(en: gaseous oxygen)
LOx	Flüssiger Sauerstoff	(en: liquid oxygen)
MMH	Monomethylhydrazin	(en: mono methyl hydrazine)
MON	Stickstoffmischoxide (MON-X besteht aus X % NO und (100 – X) % N ₂ O ₄)	(en: mixed oxides of nitrogen) (MON-X is X % NO und (100 – X) % of N ₂ O ₄)
NVR	nichtflüchtiger Rückstand	(en: non-volatile residue)
PVC	Polyvinylchlorid	(en: poly vinyl chloride)
SEM	Rasterelektronenmikroskop	(en: scanning electron microscope)
SS	Nichtrostender Stahl	(en: stainless steel)
TGA	Thermogravimetrische Analyse	(en: thermal gravimetric analysis)

English version

Space engineering - Compatibility testing for liquid propulsion components, subsystems and systems

Ingénierie spatiale - Essais de compatibilité des composants, sous-systèmes et systèmes de propulsion liquide

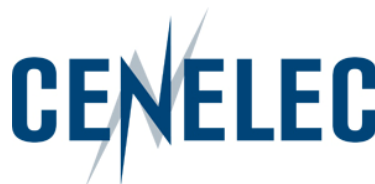
Raumfahrttechnik - Kompatibilitätstests für Flüssigkeitsantriebe

This European Standard was approved by CEN on 1 March 2014.

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

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Foreword

This document (EN 16603-35-10:2014) has been prepared by Technical Committee CEN/CLC/TC 5 "Space", the secretariat of which is held by DIN.

This standard (EN 16603-35-10:2014) originates from ECSS-E-ST-35-10C.

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.

1

Scope

ECSS-E-ST-35-10 belongs to the propulsion field of the mechanical discipline, as defined in ECSS-S-ST-00, and concerns itself with compatibility testing of propulsion components, sub-systems and systems.

Compatibility encompasses the interaction of two or more materials, solids (e.g. structural materials), liquids (e.g. propellants, simulation and cleaning liquids) or gases (e.g. air, pressurants). In case the interaction has the effect that the properties of the materials change, there is the possibility of a compatibility issue.

The standard:

- identifies materials used in propulsion for which incompatibility can create problems,
- identifies the time scale at which problems can occur. It makes a difference whether a system is only stored or operational for a short period and is to function only during launch (time scale measured in months) and systems that have a long life in orbit (time scale measured in years),
- identifies the liquid propulsion components, subsystems and systems to be subject to compatibility testing,
- identifies, specifies and defines the tests, test conditions and compatibility test procedures to ensure that representative compatibility testing can take place, and
- establishes the test requirements.

The standard is applicable to the design and the qualification of liquid propulsion components, sub-systems and systems and can be applied to their development; it also applies to COTS items procured for the propulsion system.

From the tests described in this standard the effects of interactions of space propulsion materials and fluids on the components, subsystems and systems can be established. In this way it can be assured that the component, subsystem or system satisfies the requirements.

This standard is limited to tests on component-, subsystem- and system-level. Only for those cases where new materials, substances or conditions are involved for which there is no experience or data available, the performance of screening tests is specified.

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 16603-32	ECSS-E-ST-32	Space engineering – Structural general requirements
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 16603-35-06	ECSS-E-ST-35-06	Space engineering – Cleanliness requirements for spacecraft propulsion hardware
EN 16602-70-36	ECSS-Q-ST-70-36	Space product assurance – Material selection for controlling stress-corrosion cracking
EN 16602-70-37	ECSS-Q-ST-70-37	Space product assurance – Determination of the susceptibility of metals to stress-corrosion cracking
EN 16602-70-45	ECSS-Q-ST-70-45	Space product assurance – Mechanical testing of metallic materials
	ASTM C 1291-00a	Standard Test Method for Elevated Temperature Tensile Creep Strain, Creep Strain Rate, and Creep Time-to-Failure for Advanced Monolithic Ceramics
	ASTM C 1337-96	Standard Test Method for Creep and Creep Rupture of Continuous Fiber-Reinforced Ceramic Composites under Tensile Loading at Elevated Temperatures
	ASTM C 1368-06	Standard Test Method for Determination of Slow Crack Growth Parameters of Advanced Ceramics by Constant Stress-Rate Flexural Testing at Ambient Temperature
	ASTM C 1465-08	Standard Test Method for Determination of Slow Crack Growth Parameters of Advanced Ceramics by Constant Stress-Rate Flexural Testing at Elevated

		Temperatures
	ASTM C 1576-05	Standard Test Method for Determination of Slow Crack Growth Parameters of Advanced Ceramics by Constant Stress Flexural Testing (Stress Rupture) at Ambient Temperature
	ASTM D 395	Test Methods for Rubber Property —Compression Set
	ASTM D 570-98	Standard Test Method for Water Absorption of Plastics
	ASTM D 624-00	Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
	ASTM D 638-03	Standard Test Method for Tensile Properties of Plastics
	ASTM D 1434-82 (Reapproved 2003)	Standard Test Method for Determining Gas Permeability Characteristics of Plastic Film and Sheeting
	ASTM D 2240-04	Standard Test Method for Rubber Property – Durometer Hardness
	ASTM G 4-95	Standard Guide for Conducting Corrosion Coupon Tests in Field Applications
	ASTM G 31-72 (Reapproved 1999)	Standard Practice for Laboratory Immersion Corrosion Testing of Materials
	ASTM G 71-81 (reapproved 1998)	Standard Guide for Conducting and Evaluating Galvanic Corrosion Tests in Electrolytes.
	ASTM G 72-01	Standard Test Method for Autogenous Ignition Temperature of Liquids and Solids in a High-Pressure Oxygen-Enriched Environment
	ASTM G 86-98a	Standard test method for Determining Ignition Sensitivity of Materials to Mechanical Impact in Ambient Liquid Oxygen and Pressurized Liquid and Gaseous Oxygen Environments
	ASTM G 111-97	Standard Guide for Corrosion Tests in High Temperature or High Pressure Environment, or Both
	ASTM G 142-98	Standard Test Method for Determination of Susceptibility of Metals to Embrittlement in Hydrogen Containing Environments at High Pressure, High Temperature, or Both
	ISO 175	Plastics; Methods of Tests for the Determination of the Effects of Immersion in Liquid Chemicals
	ISO 1817, 3rd edition 1999-03-01	Rubber, vulcanized – Determination of the effect of liquids
	ISO 10297	Transportable gas cylinders – Cylinder valves – Specification and type testing
	ISO 15859-1	Space systems – Fluid characteristics sampling and test methods - Oxygen

	ISO 15859-7	Space systems – Fluid characteristics sampling and test methods – Hydrazine
	ISO 21010	Cryogenic vessels — Gas/materials compatibility
	NACE TM0499-99 Item No. 21239	Standard Test Method Immersion Corrosion Testing of Ceramic Materials

Terms, definitions and abbreviated terms

3.1 Terms from other standards

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

For the purpose of this Standard, the following term from ECSS-E-ST-32 applies:

maximum expected operating pressure (MEOP)

For the purpose of this Standard, the following term from ECSS-Q-ST-70-36 applies:

stress corrosion

3.2 Terms specific to the present standard

3.2.1 ageing

entirety of all changes in chemical and physical characteristics occurring in a material in the course of time

3.2.2 auto ignition temperature

lowest temperature at which a substance produces hot-flame ignition in the environment and at the pressure without the aid of an external energy source

3.2.3 compatibility

absence of unacceptable performance or reliability loss due to chemical reactions and physical changes in materials or substances during the compatibility life

NOTE 1 Compatibility always involves two or more materials in contact with each other.

NOTE 2 Compatibility is always related to the application and the requirements.

3.2.4 compatibility life

life cycle from the first exposure of two or more materials to each other until disposal

3.2.5 contaminant gas

undesired gas present in the propulsion system at any time in its life

3.2.6 corrosion

reaction of the engineering material with its environment with a consequent deterioration in properties of the material

3.2.7 dissimilar metals

metals with different electrochemical potentials

3.2.8 galvanic corrosion

corrosion as a result of an electrochemical potential difference between electrical conductors in an electrolyte

3.2.9 hydrogen embrittlement

condition of low ductility or reduced mechanical properties resulting from the absorption of hydrogen

NOTE stress intensity factor, K

factor describing the stress state near the tip of a crack caused by a remote load, residual stress or both.

NOTE The magnitude of K depends on sample geometry, the size and location of the crack, and the magnitude and the modal distribution of loads on the material. $K = \sigma \cdot Y \cdot \sqrt{\pi \cdot a}$

where:

a half the crack length
 K stress intensity factor
 Y dimensionless geometrical function
 σ applied stress

3.3 Abbreviated terms

For the purpose of this Standard, the abbreviated terms from ECSS-S-ST-00-01 and the following apply:

Abbreviation	Meaning
CAAR	compatibility assessment and applicability report
COTS	commercial off-the-shelf
CPE	chlorinated poly ethylene
CTLP	compatibility testing for liquid propulsion
DSC	differential scanning calorimeter
EPDM	ethylene propylene diene monomer
EPR	ethylene propylene rubber

GO_x	gaseous oxygen
LO_x	liquid oxygen
MMH	mono methyl hydrazine
MON	mixed oxides of nitrogen (MON-X is X% NO and (100-X) % of N ₂ O ₄)
NVR	non-volatile residue
PVC	poly vinyl chloride
SEM	scanning electron microscope
SS	stainless steel
TGA	thermal gravimetric analysis

4

General requirements for compatibility tests

4.1 General

4.1.1 Compatibility test assessment

- a. The supplier shall analyse and define the conditions for the compatibility tests with respect to the application and the requirements for the component, sub-system or system and define them in conformance with the DRD in Annex A.

4.1.2 Test conditions

- a. Compatibility testing shall take place under conditions reproducing the actual use of the items.

NOTE For example: The test items treatments, processes and handling, to be the same as those for the actual flight hardware items.

- b. The extent of compatibility testing shall comply with the reliability requirements for the component, subsystem or system.

4.1.3 Test duration

- a. The duration of the compatibility test shall be established using the compatibility life and mission reliability requirements

NOTE 1 The type of information to be obtained for the component, subsystem or system is e.g. a quick first impression or an impression based on an exposure under well controlled conditions with detailed and precise measurements.

NOTE 2 For short compatibility lives (e.g. as for launchers), the duration of compatibility tests can be the same as the compatibility life or somewhat larger. For large compatibility lives (e.g. satellites in orbit) accelerated compatibility tests can be used.

4.1.4 Criticality

- a. In Phase A and in Phase B the following shall be performed:
 - 1. establish which compatibility problems are expected, or where there is a lack of information;
 - 2. ranking of the severity of the compatibility problems;
 - 3. assess and report the criticality and the effect on material selection and planning in conformance with Annex A.

NOTE The severity of the compatibility issue can lead to intensive investigations (new materials, development risks), which can endanger the development schedule.

4.1.5 Phasing of tests

- a. The compatibility tests of clauses 4.2 and 5.1.2 shall be performed early during project Phase B.

NOTE This requirement is included in order that a proper material selection can be made, and that a proper data base can be established for the PDR. The priority and the planning of the tests is based on their duration or on those combinations of materials where the compatibility problems have been ranked severe.

4.2 Compatibility tests

4.2.1 Requirement for compatibility testing

- a. Compatibility testing of material combinations in propulsion systems shall be done in case there is no experimental or historical evidence that the combination meets the compatibility requirements.

NOTE This includes simulation and cleaning fluids, purging gases and cleaning and drying processes.

- b. The need for compatibility testing shall be assessed and included in Annex A.

4.2.2 Compatibility testing of surface treated samples

- a. Samples of surface treated materials for propulsion systems, where there is no evidence that they meet the compatibility life, shall undergo compatibility testing.

- b. 'Untreated' parts of the samples shall be insulated or protected in such a way that they do not disturb the measurements or cause false information.

NOTE Surface treatment of materials is done for various reasons, amongst which improving the material compatibility characteristics. Typical surface treatments encompass passivation / chemical etching, anodising, polishing, coating such as: painting, plating, vacuum spraying / vacuum deposition, electro-deposition, organic coating, or changing surface properties by chemical adsorption (e.g. nitration, carbonization).

4.2.3 Provision COTS components

4.2.3.1 General

- a. It shall be demonstrated that COTS components meet the compatibility life requirement.

NOTE For cost or time reasons COTS components can be selected for propulsion systems. If there is no certainty that all components of the COTS components meet the compatibility requirements, solutions are sought (e.g. redesign, surface treatment, replacement, requalification).

4.2.3.2 Surface treatment of COTS components

- a. If a component has undergone a surface treatment to meet the compatibility requirements, this component shall undergo compatibility testing in conformance with clauses 4.1.2 and 4.1.3.
- b. Modified COTS components shall undergo re-qualification and full functional testing to ensure its functionality according to clause 6.10.

4.2.4 Compatibility testing logic

- a. For completely unknown material combinations that involve energetic materials or materials for which the possibility exists of generating toxic or poisonous materials, safety tests shall be performed before starting compatibility testing, see clause 6.1.2.
- b. Compatibility testing should take place following the logic of Figure 4-1

NOTE 1 This guarantees that they are performed with increasing complexity, generation of details, and for the specific applications.

NOTE 2 The requirements list needs to be tailored. It depends on the specific application which tests are going to be performed and which by-

passed: e.g. if no hydrogen is involved, no hydrogen embrittlement tests are performed.

NOTE 3 An example of tailoring the requirements list is given in Annex C and Annex E.

4.2.5 Compatibility test plan and compatibility test procedure

- a. For every propulsion compatibility test the following shall be performed:
 - 1. establishing a compatibility test plan in conformance with the elements identified in Annex B,
 - 2. establishing a compatibility test procedure in conformance with the elements identified in Annex B,
 - 3. assessing the results.
- b. In case no specific procedures have been identified in this standard, the compatibility test plan and compatibility test procedure shall be agreed with the customer.

4.2.6 Accept and reject criteria

- a. For every propulsion compatibility test, accept and reject criteria shall be established.

NOTE 1 Accept and reject criteria judge the quality of the test itself as well as whether the material combinations meet the compatibility requirements.

NOTE 2 A 'grey zone' in the accept / reject criteria requires consultation with the customer.

4.2.7 Deviations from standards or standard guides

- a. All deviations shall be identified, agreed with the customer and described in the compatibility test procedure 4.2.5a.2.

4.2.8 Execution of tests

4.2.8.1 Laboratories

- a. The laboratories performing the compatibility tests shall provide documented evidence that
 - 1. they are certified to perform these tests, or
 - 2. they are well experienced in the foreseen tests.

4.2.8.2 Personnel

- a. For the personnel executing the tests documented evidence shall be provided showing that
 - 1. the personnel is certified to perform these tests or
 - 2. the personnel is well experienced to perform these tests.