



# Space engineering

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## Mechanical — Part 7: Mechanical parts

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## Foreword

This Standard is one of the series of ECSS Standards intended to be applied together for the management, engineering and product assurance in space projects and applications. ECSS is a cooperative effort of the European Space Agency, national space agencies and European industry associations for the purpose of developing and maintaining common standards.

Requirements in this Standard are defined in terms of what shall be accomplished, rather than in terms of how to organize and perform the necessary work. This allows existing organizational structures and methods to be applied where they are effective, and for the structures and methods to evolve as necessary without re-writing the standards.

This Standard has been prepared by the ECSS Mechanical Engineering Standard Working Group, reviewed by the ECSS Technical Panel and approved by the ECSS Steering Board.

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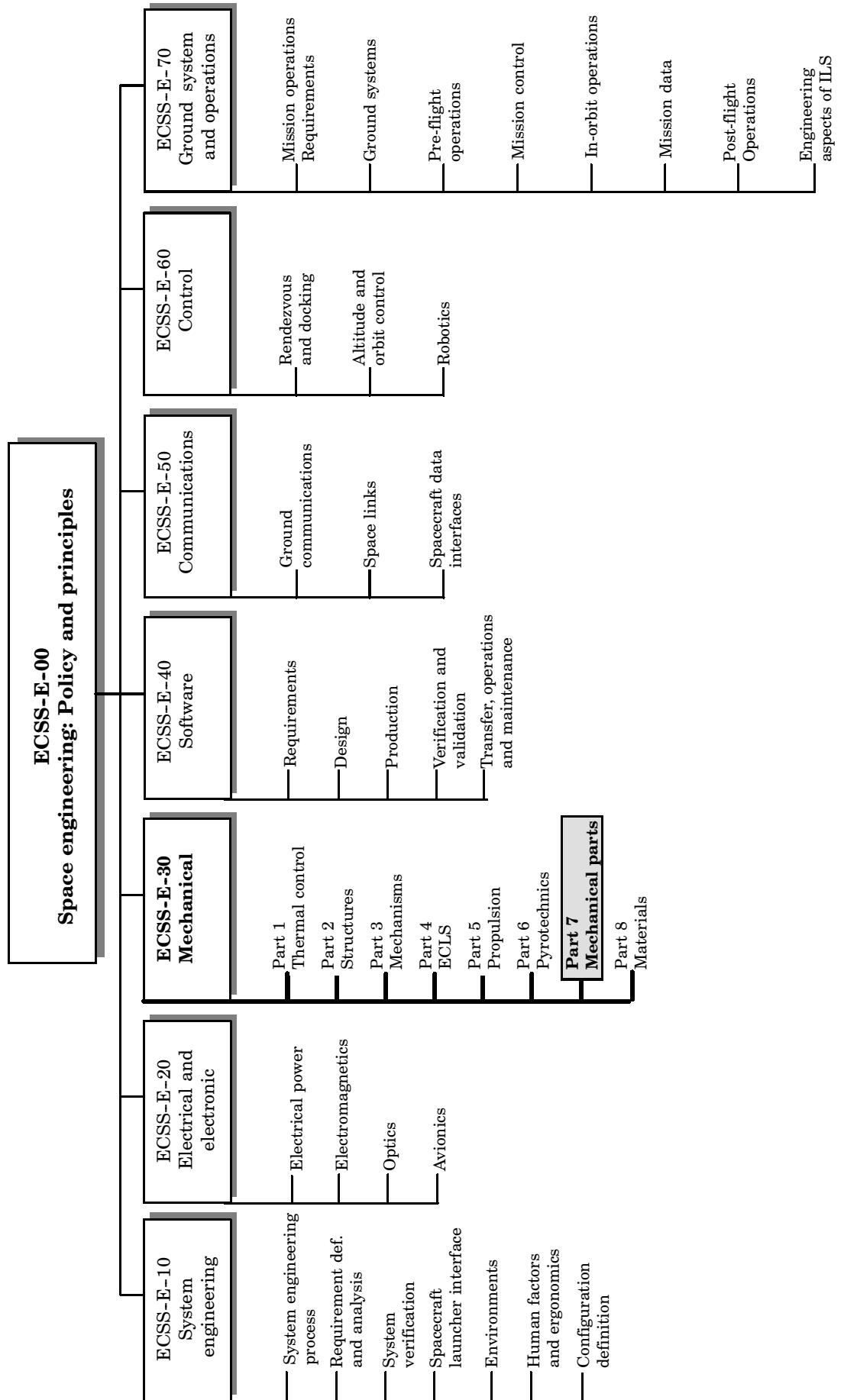
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*Structure of the ECSS-Engineering standards system*



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## Scope

Part 7 of ECSS-E-30 in the engineering branch of ECSS Standards defines mechanical engineering requirements for mechanical parts.

This Standard defines the requirements and statements applicable to the selection, design, verification and application of mechanical parts to promote the use of high-quality non-critical mechanical parts that achieve robust functionality and satisfy the mission performance requirements.

This Standard defines a pragmatic approach to the selection of parts by the mechanical and design engineer on the basis of their effect on the integrity of the equipment and to streamline the selection of space-proven rather than non space-proven parts during the design of a new equipment in order to select the least number of different parts to satisfy the mission requirements.

It defines the content and extent of the mechanical parts and the requirements for its performance, design and test, product assurance and support activities.

When viewed from the perspective of a specific project context, the requirements defined in this Standard should be tailored to match the genuine requirements of a particular profile and circumstances of a project.

**NOTE** Tailoring is a process by which individual requirements of specifications, standards and related documents are evaluated, and made applicable to a specific project by selection, and in some exceptional cases, modification of existing or addition of new requirements.

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## 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 revisions 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 most recent editions of the normative documents indicated below. For undated references the latest edition of the publication referred to applies.

ECSS-P-001	Glossary of terms
ECSS-E-30 Part 2	Space engineering — Mechanical — Part 2: Structural
ECSS-E-30 Part 8	Space engineering — Mechanical — Part 8: Materials
ECSS-Q-00	Space product assurance — Policy and principles
ECSS-Q-20	Space product assurance — Quality assurance
ECSS-Q-70	Space product assurance — Materials, mechanical parts and processes

References to sources of approved lists, procedures and processes can be found in the bibliography.

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## Terms, definitions and abbreviated terms

### 3.1 Terms and definitions

The following terms and definitions are specific to this Standard in the sense that they are complementary or additional with respect to those contained in ECSS-P-001

#### 3.1.1

##### **spacing part**

component whose function it is to provide a separation between adjacent parts

EXAMPLE Washers, spacers and shims.

#### 3.1.2

##### **connecting part**

structural elements to provide a mechanical joint

EXAMPLE Bolts, nuts, rivets, inserts and clips.

#### 3.1.3

##### **bearing part**

component whose function is to permit rotation or sliding between load-bearing parts

EXAMPLE Ball-bearing and ball-joint.

#### 3.1.4

##### **separating part**

component with the function of releasing or separating adjoining components

EXAMPLE Pyrotechnic actuators, springs and cutters.

#### 3.1.5

##### **control part**

component which regulates systems for variable environmental conditions

EXAMPLE Gears.

#### 3.1.6

##### **fluid handling part**

component that is used for moving fluids

EXAMPLE Containers, ducts, valves, fittings, couplings, O-rings and diffusers.

### 3.1.7

#### **heater**

device for the conversion of energy or work into heat

### 3.1.8

#### **measuring part**

component used to measure a physical quantity, with a selected unit, within a given tolerance, and inside a certain range of variation of the physical quantity

EXAMPLE Gauges and thermocouples.

### 3.1.9

#### **optical passive equipment**

fixed optical elements requiring no external energy supply

EXAMPLE Gratings, beam-splitters, lenses (reflecting, refractive) and mirrors.

### 3.1.10

#### **magnetic part**

device which functions either by the generation of or by the response to magnetic fields

### 3.1.11

#### **certificate of conformity**

document attached to the part with relevant data certifying that the part fulfils the requirements

### 3.1.12

#### **critical mechanical part**

mechanical part featuring risk which can be unacceptable to the project and requires specific attention or control or with which the contractor has had no previous applications experience

EXAMPLE Critical mechanical parts include: single point failure part, limited life part, hazardous part, part without possibility of check out after integration, part with critical technology, part with a known history of failures.

### 3.1.13

#### **development testing**

set of tests performed to prove the validity of the design and the technologies involved and to supplement analytical techniques in the pre-selected part or subassemblies

### 3.1.14

#### **evaluation**

combination of tests, analyses and audit, if required, permitting to pronounce approval, validation or qualification

### 3.1.15

#### **mechanical part**

off-the-shelf commercial and military (CAM) equipment or item designed and produced to feature primarily a distinct mechanical function

NOTE 1 CAM equipment has been developed and lot produced to military or commercial national standards, in-house specifications or manufacturer data sheets and is readily available from several procurement sources.

NOTE 2 CAM equipment may be acquired without change to satisfy special requirements. For the purpose of this standard, if changes are performed on a space-proven part, the transformed part is considered as equivalent to a “Space-proven part but with deviation in materials, design or use environment”.

### 3.1.16

#### **space-proven part**

mechanical item whose properties are known and that is produced by means of stable processes and has been approved for use in previous space applications which are still valid for its intended use

## 3.2 Abbreviated terms

The following abbreviated terms are defined and used within this Standard.

<b>Abbreviation</b>	<b>Meaning</b>
<b>CAM</b>	commercial and military (part)
<b>DML</b>	declared materials list
<b>DPL</b>	declared processes list
<b>DMPL</b>	declared mechanical parts list
<b>EMC</b>	electromagnetic compatibility
<b>ESC</b>	electrostatic compatibility
<b>UV</b>	ultraviolet

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## Requirements

### 4.1 General

#### 4.1.1 Requirements overview

Clause 4 contains the technical requirements for a project or programme requiring high reliable mechanical parts.

- a. This Standard shall be used in the establishment of mechanical and physical properties of materials, including the effects of environmental conditions.
- b. This Standard shall be applicable to destructive and non-destructive test methods required for material selection, procurement, production and verification.

NOTE The use of space-proven parts avoids additional testing and assures that such parts perform satisfactorily in nominal environment.

#### 4.1.2 Part classification

The mechanical parts requirements are defined according to the following part classifications:

- space-proven mechanical part;
- non-space-proven mechanical part;
- space-proven part, with deviation in materials, design or use environment.

#### 4.1.3 Part types

The mechanical parts classifications are defined according to following part types:

- non-critical mechanical part;
- critical mechanical part.

#### 4.1.4 Application

- a. This Standard applies to mechanical parts used in all space products as defined in ECSS-E-10. It is intended for end-users, design authorities, safety officials, project offices and manufacturers.

- b. The requirements shall be applied to mechanical parts for the selection and for the fabrication or the acquisition of the parts to be used and integrated in a structure, assembly or subsystem of
  - 1. manned space vehicles,
  - 2. unmanned space vehicles,
  - 3. expendable or reusable launch vehicles, and
  - 4. ground equipment.

NOTE Practical application can be impaired by the (provisional) absence of a particular standard or by the need to modify a space product targeted standard or by the existence of several standards addressing the same topic.
- c. An early programme of parts identification and control shall be implemented by a materials, parts and processes board in accordance with the requirements of this Standard and as required by ECSS-Q-20 and by ECSS-Q-70.
- d. The contractor shall be responsible for the establishment and the implementation of the parts identification and control programme (including the DMPL) required by the ECSS-Q-70.
- e. The contractor shall, where practicable, select space-proven parts.
- f. Critical mechanical parts requiring development tests shall be identified early in the design and development plan. The list of tests and items identified shall be documented.
- g. All programme contractors and subcontractors shall support the materials, parts and process board. Unless otherwise specified, the responsibility of the correct application of these requirements to a project shall be delegated to the procurement agency project manager.

## 4.2 Mission

The engineering of the part shall consider every mission phase identified for the specific space programme and conform to mission requirements.

## 4.3 Functionality

The mechanical part shall conform to the functional requirements.

## 4.4 Constraints

- a. Space-proven mechanical part:

The contractor shall demonstrate the conformance of the part specification with the requirements for which the part has been qualified.
- b. Non-space-proven mechanical part or space-proven part with deviation in materials, design or use environment:

The pre-selected part shall be covered by procurement specifications detailing the following points:

  - 1. measurable criteria with respect to the usage;
  - 2. detailed control requirements and procedures;
  - 3. protection, packing and storage conditions according to the standards normally used for space programmes.

## 4.5 Interface

The method of interfacing part and part interface compatibility, in particular material coupling and joining shall be adapted according to the approved standard documents.

## 4.6 Design

The mechanical parts shall conform to the design requirements.

## 4.7 Verification

### 4.7.1 Product assurance evaluation

- a. Prior to the engineering part requirements implementation, product assurance part material approval, process validation and part qualification shall be performed as required by ECSS-Q-70. In particular, the following evaluation schemes shall be implemented:
  1. a material shall be evaluated for approval in a given application;
  2. a process shall be evaluated to achieve validation for a given application in a specified facility;
  3. a product, piece or part shall be qualified for a given application.
- b. The materials and processes used for mechanical parts shall conform to the material requirements defined in ECSS-E-30 part 8.

### 4.7.2 Part design verification and sizing requirements

- a. The structural dimensioning of mechanical parts shall conform to the structural engineering requirements defined in ECSS-E-30 part 2.
- b. Development testing of part or sub-assemblies shall be performed where practicable.

### 4.7.3 Part qualification

- a. Parts shall undergo a qualification test programme to prove the product specified performance under a predicted environment, including any life testing.
- b. The test sequence of qualification tests, environmental conditions and the most severe combined loading conditions similar to that of the actual mission shall be considered.
- c. Life tests shall prove that there is no basic life limiting effect present in the design. The testing, real-time or accelerated, shall be performed according to the acceptance criteria of this Standard.

### 4.7.4 Part acceptance

The following test programme shall be carried out:

- a. Acceptance tests to prove the quality and integrity of an individual part, manufactured from production specifications and procedures. The tests shall be performed under operational loads and environment, in accordance with the acceptance criteria described in this Standard.
- b. Refurbishment or repair tests to demonstrate the flight worthiness of an item after repair, minor changes to performance specifications or mechanical interfaces, replacement of pieces or storage (e.g. case of the part submitted to qualification and life testing).

### 4.7.5 Summary of the requirement levels

The requirement levels are summarized in Table 1.

- a. Mandatory requirement. Any deviation from the contractually imposed mandatory requirements shall be approved by the procurement agency using a waiver procedure.
- b. Recommended requirement. Alternative designs, items or practices may be used and substantiated by documented technical trade-off studies. Devi-

ations from these recommended requirements need not be approved by the procurement agency. However, these studies shall be made available for review when requested.

- c. Preferred, where practicable. Deviations from these preferred requirements need not be approved by the contractor and do not need documented by technical substantiation. These deviations shall be recorded in the relevant contractor's mechanical part document.

**Table 1: Summary of requirements covering mechanical part usage**

<i>Part category</i>	<b>from non-space-proven to space-proven part status</b>	<b>from a selected space-proven part</b>		<b>from a selected space-proven part but with deviation in materials, design or use environment</b>	
<i>Part type</i>	Non-critical mechanical part <b>and</b> critical mechanical part	Non-critical mechanical part	Critical mechanical part	Non-critical mechanical part	Critical mechanical part
<i>Test category</i>					
Design verification and sizing requirements					
	Analysis	M	n.a.	R	n.a.
Development testing	R	n.a.	n.a.	n.a.	R
Qualification					
	Qualification testing	M	n.a.	n.a.	P
Life tests	M	n.a.	n.a.	n.a.	n.a.
Acceptance					
	Acceptance tests	M	M	M	M
Refurbishment tests	R	n.a.	n.a.	P	R
PA part qualification programme	M	n.a.	R	M	M
Product assurance evaluation	According to relevant product assurance standards				
n.a. not applicable M Mandatory requirement. R Recommended requirement. P Preferred, where practicable.					

#### 4.7.6 Testing

- a. The testing programme shall be performed by experienced test houses and in accordance with recognized and approved procedures.

NOTE Annex A features the typical testing to be carried out according to the part type requirements.

- b. Prior to performing tests, the test facility shall be evaluated to achieve certification to perform the specified tests.

- c. The testing shall include as a minimum:

1. Functional and performance tests

Functional and performance tests include the measurements of dimensions, mass, physical and electrical properties. The results shall meet the requirements and specifications. They shall be a reference for comparison of functionality of the part before and after the testing described hereafter.

2. Mechanical tests

Mechanical tests shall demonstrate the behaviour of the part under quasi-static, dynamic, cyclic, shock and vibration loadings in basic conditions or within its nominal environments.

3. Environmental tests

Environmental test shall check the response of the part under natural or induced environmental constraints such as

- chemical (corrosion, contamination, atomic and oxygen),
- vacuum,
- temperature,
- radiation (UV and particles),
- flammability,
- toxicity (for manned spacecraft), and
- impacts (debris, micrometeorites).

The environmental tests shall be performed with the nominal environment alone or in the combined action of environment and stresses (thermo-elastic behaviour, stress corrosion).

4. Storage tests

Storage tests shall be a short term test to simulate the launch and first activation of the spacecraft part and long term to reproduce the activation after long dormant mode period.

5. EMC and ESC

EMC (electromagnetic compatibility) and ESC (electrostatic compatibility) tests shall be performed when applicable.

- d. Testing matrix

A testing matrix (see annex A) shall be created for each part featuring the required type of tests as described above. The sequence of the tests and their acceptance or rejection criteria shall be described in accordance with the requirements of this Standard. A typical testing list and sequence is given in Table 2.

**Table 2: Typical testing list**

Tests and sequence	Comments
PA qualification check	
Functional	Before and after environment tests
Performance	Before and after environment tests
Any other PA qualification tests	
EMC/ESC	Mainly for electronic commands associated with part
Mechanical:	
Static loading or acceleration.	
Acoustic	
Sinusoidal vibration	
Random vibration	
Shock	
Environment:	
Special medium	
Pressure	On sealed pressurized equipment
Leak	
Microgravity	In-orbit active equipment
Performance (2nd)	
Thermal:	
Thermal cycling	
Thermal vacuum performance (3rd)	Tribology issues
Other types of tests:	
Audible noise	Manned spacecraft part
Storage	
NOTE: This table is not exhaustive and is given only as an example.	

## 4.8 Production and manufacturing

The mechanical part shall conform to the production and manufacturing requirements.

## 4.9 In-service

The mechanical part shall conform to the functional performance, reliability and strength requirements during its life cycle, including all environmental degradation effects.

## 4.10 Product assurance

- a. Quality assurance is very important and for a new design, quality starts with each individual part. The contractor's quality assurance programme shall conform with the general quality assurance requirements as defined in the ECSS quality assurance standards.
- b. The general methodology regarding technical and contractual aspects of quality assurance shall conform with ECSS-Q-00.
- c. A full lot traceability shall be performed for critical mechanical parts. For non-critical mechanical parts, traceability shall be maintained according to risk and cost.
- d. Tests shall be carefully planned and performed and the test results documented.
- e. Part test programmes shall be carried out according to a test plan submitted to the customer for approval prior to the tests.
- f. A test report shall be established and provided to the customer after the testing.
- g. All mechanical parts shall be inspected before and after exposure to environmental tests. The inspection process shall include, but shall not be limited to
  - visual inspection for general aspect,
  - scratches,
  - handling damage or damaged surfaces
  - rust or corrosion,
  - fastener torque,
  - cleanliness,
  - clearances, and
  - other features described in the inspection plan.

## 4.11 Deliverables

- a. The documents required for the control of mechanical parts shall include as a minimum the documents listed in Table 3. Where applicable reference is provided to the document requirements definition (DRD) title and the DRD controlling standard.
- b. Requirements for acceptance and delivery shall be in accordance with ECSS-Q-20.
- c. Certificate of conformity for the part shall be provided according to the material parts and process board requirements.
- d. Document requirement definitions (DRD) shall be provided.

**Table 3: Document requirements for mechanical parts**

<b>Term used in this Standard</b>	<b>Document title</b>	<b>Controlling DRD reference</b>
Part identification and control plan	Procurement plan	ECSS-M-30
Critical mechanical parts list	Critical items list	ECSS-Q-20-04
Verification documents	Test plan	ECSS-E-10-02
	Test procedure	ECSS-E-10-02
	Test report	ECSS-E-10-02
	Test specification	ECSS-E-10-02
	Verification control document	ECSS-E-10-02
	Verification plan	ECSS-E-10-02
Mechanical part product assurance plan	Product assurance plan	ECSS-Q-00
Certificate of conformity	Certificate of conformance	ECSS-Q-20



## Annex A (informative)

### Example of a testing matrix

Non-space-proven part [DMPL number .....]						
Part testing	Design verification or development		Qualification		Acceptance	
	Analysis	Development testing	Qualification testing	Life tests	Acceptance testing	Repair or refurbishment testing
Functional	X	X	X		X	X
Performance	X	X	X		X	X
Other <sup>a</sup>						
EMC/ESC			X			
<b>Mechanical:</b>						
Static loading or acceleration		X	X		X	
Acoustic						
Sinusoidal vibration			X		X	X
Random vibration		X	X		X	X
Shock		X	X			
<b>Environment:</b>						
Special medium		X	X			
Pressure or leak						
Performance (2nd)			X			
<b>Thermal:</b>				X		
Thermal cycling	X	X	X	X		
Thermal vacuum performance (3rd)		X	X			
Other <sup>a</sup>						

<sup>a</sup> List to be completed.

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## Bibliography

Informative references listed below were used in the preparation of this standard and contain background information relating to the subject addressed.

MIL-HDBK-5F	Metallic Materials and Elements for Aerospace Vehicle Structures
MIL-HDBK-17B	Polymer Matrix Composites, volume 1: Guidelines
MIL-HDBK-23A	Structural Sandwich Composites
MIL-STD-410E	Non-destructive testing personnel qualification and certification
MIL-B-7883B	Brazing of Steels, Copper, Copper Alloys, Nickel Alloys, Aluminium and Aluminium Alloys
MSFC-STD-506C	Material and Process Control Standard
MSFC-SPEC-522A	Design Criteria for Controlling Stress Corrosion
MIL-STD-1546	Parts, materials and processes control program for space and launch vehicles

The requirements defined in this ECSS Standard, provide references to lower level ECSS documents. These detailed standards and guidelines are identified below:

ECSS-E-30-04 <sup>1)</sup>	Space engineering - Structural materials handbook
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