

---

---

## Space systems — Determination of test methods to characterize material or component properties required for break-up models used for Earth re-entry

*Systèmes spatiaux — Détermination des méthodes d'essai pour caractériser les matériaux ou les éléments de structure nécessaires pour les modèles de calcul de « désintégration » utilisés pour la rentrée terrestre*

(<https://standards.iteh.ai>)  
Document Preview

ISO 23020:2021

<https://standards.iteh.ai/catalog/standards/iso/cd59f4e8-9742-450d-962c-855f459f270e/iso-23020-2021>



iTeh Standards  
(<https://standards.iteh.ai>)  
Document Preview

ISO 23020:2021

<https://standards.iteh.ai/catalog/standards/iso/cd59f4e8-9742-450d-962c-855f459f270e/iso-23020-2021>



**COPYRIGHT PROTECTED DOCUMENT**

© ISO 2021

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office  
CP 401 • Ch. de Blandonnet 8  
CH-1214 Vernier, Geneva  
Phone: +41 22 749 01 11  
Email: [copyright@iso.org](mailto:copyright@iso.org)  
Website: [www.iso.org](http://www.iso.org)

Published in Switzerland

# Contents

Page

<b>Foreword</b> .....	<b>iv</b>
<b>Introduction</b> .....	<b>v</b>
<b>1 Scope</b> .....	<b>1</b>
<b>2 Normative references</b> .....	<b>1</b>
<b>3 Terms, definitions and abbreviated terms</b> .....	<b>1</b>
3.1 Terms and definitions.....	1
3.2 Abbreviated terms.....	5
<b>4 Methodology of material characterization</b> .....	<b>5</b>
4.1 General.....	5
4.2 Temperature range.....	5
4.3 Type of tests.....	6
4.4 Test conditions.....	6
4.5 Mechanisms of degradation.....	7
<b>5 Definition of the elementary tests</b> .....	<b>7</b>
5.1 General.....	7
5.2 List of the elementary tests.....	8
5.3 Composite materials specifications.....	9
<b>6 Metallic and metallic composite materials</b> .....	<b>10</b>
6.1 Test conditions.....	10
6.2 List of the recommended standards.....	10
<b>7 Organic and organic composite materials</b> .....	<b>11</b>
7.1 Organic materials.....	11
7.1.1 General.....	11
7.1.2 Test conditions.....	11
7.2 Organic composite materials.....	11
7.2.1 General.....	11
7.2.2 Test conditions in virgin state.....	11
7.2.3 Test conditions in charred state.....	12
7.3 List of the recommended standards.....	12
<b>8 Ceramic and associated composite materials</b> .....	<b>12</b>
8.1 Test conditions.....	12
8.2 List of the recommended standards.....	13
8.2.1 Ceramic.....	13
8.2.2 Ceramic composite.....	13
<b>Bibliography</b> .....	<b>14</b>

## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see [www.iso.org/directives](http://www.iso.org/directives)).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

This document was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at [www.iso.org/members.html](http://www.iso.org/members.html).

<https://standards.iteh.ai/catalog/standards/iso/cd59f4e8-9742-450d-962c-855f459f270e/iso-23020-2021>

## Introduction

New regulations require unmanned spacecraft and launch vehicle orbital stages, called space bodies in this document, to be designed and manufactured in such way that fragments generated during Earth re-entry cannot cause casualties, damage to property or environmental pollution on the ground (see ISO 24113).

Space bodies are submitted to high aero-thermodynamic fluxes, pressures and shear stresses that lead to their disintegration into fragments that can potentially reach ground after a re-entry. These fragments are generated by the effect of aero-thermal loads seen by components that constitute a space body. The assessment of the fragmentation and subsequent survivability of the fragments in terms of size and trajectory is based on simulation.

The methodology to determine the size of the debris is based on an idealized two-step process, called fragmentation and survivability.

### — Fragmentation

Based on the knowledge of the orbital (ballistic) trajectory of the space body and the knowledge of its design, the computation of temperature and stresses determine the most probable failure locations that will generate sub components. The breakup fragments prior to re-entry are termed debris.

### — Survivability

The objective is then to determine if debris can survive (no completely burned), and then if the final size and energy when touching down the Earth are in accordance with the international regulation.

The computation of the final size and energy of the debris is based on generic geometry definition, homogenized properties and on the knowledge of their trajectories.

For both fragmentation and survivability, suitable thermal response models require a range of material properties for a full characterization of the material response.

Thermal tests used to determine material properties need to be well defined and shared between spacecraft manufacturers and regulation authorities.

There are a range of relevant spacecraft materials, from metals, organic and ceramics to composite materials.

As a result, the material or component properties used in break-up models is an essential model input.

Objects that separate during the ascent phase and impact the ground are addressed in ISO 14620-2.

Assessment, mitigating and control of potential risks created by the re-enter of objects from the orbit are addressed in ISO 27875.



# Space systems — Determination of test methods to characterize material or component properties required for break-up models used for Earth re-entry

## 1 Scope

This document defines the elementary thermal tests to obtain thermal properties of materials and composite materials used to manufacture space body to support the fragmentation and survivability analysis.

This document does not apply to spacecraft containing nuclear power sources<sup>[1]</sup>.

## 2 Normative references

There are no normative references in this document.

## 3 Terms, definitions and abbreviated terms

### 3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at <https://www.iso.org/obp>

— IEC Electropedia: available at <https://www.electropedia.org/>

#### 3.1.1

##### **ablation**

chemical change and removal of surface *material* (3.1.12) due to the action of external high temperature heating

Note 1 to entry: Ablation can be a chemical process, addressing chemical reaction (gas-solid or gas-liquid).

Note 2 to entry: Ablation can be a physical process addressing vaporization, melting, fusion.

Note 3 to entry: Ablation can be a mechanical process addressing phenomena of erosive process (applied to solid or liquid surface) linked to pressure effect and wall shear stress due to high-speed motion.

[SOURCE: EN 16603-31:2014, 3.2.4.2, modified — Notes 1, 2 and 3 to entry have been added.]

#### 3.1.2

##### **break-up**

event that completely or partially destroys an object and generates *space debris* (3.1.18)

Note 1 to entry: Debris generated during earth *re-entry* (3.1.16) can survive and fall to the ground.

[SOURCE: ISO 24113:2019, 3.2, modified — Note 1 to entry has been added.]

### 3.1.3

#### **break-up altitude**

altitude when the main structural fragmentation occurs leading several *components* (3.1.5)

Note 1 to entry: Altitude *break-up* (3.1.2) can occur on a wide range of values depending on trajectories and attitudes of the *spacecraft* (3.1.19).

### 3.1.4

#### **ceramic**

essentially inorganic and non-metallic *material* (3.1.12)

Note 1 to entry: The concept “ceramic” comprises products based on clay as raw material and also materials which are typically based on oxides, nitrides, carbides, silicides, borides, carbon etc.

[SOURCE: ISO 20507:2014, 2.1.7]

### 3.1.5

#### **component**

##### **part**

set of *materials* (3.1.12), assembled according to defined and controlled processes, which cannot be disassembled without destroying its capability and which performs a simple function that can be evaluated against expected performance requirements

[SOURCE: ISO 10795:2019, 3.48]

### 3.1.6

#### **composite material**

combination of *materials* (3.1.12) different in composition or form on a macro scale

Note 1 to entry: The constituents retain their identities in the composite.

Note 2 to entry: The constituents can normally be physically identified, and there is an interface between them.

[SOURCE: ISO 16454:2007, 3.6]

### 3.1.7

#### **emissivity**

$\varepsilon$

quotient of the radiant exitance of a radiator and the radiant exitance of a Planckian radiator at the same temperature, expressed by

$$\varepsilon = M/M_b$$

where  $M$  is the radiant exitance of a thermal radiator and  $M_b$  is the radiant exitance of a Planckian radiator (called hereafter black body) at the same temperature (ISO 80000-5)

Note 1 to entry: Emissivity of any surface is a function of wavelength, direction, temperature, and surface conditions.

Note 2 to entry: Emittance is a property of a particular object. It is determined by *material* (3.1.12) emissivity, surface roughness, of angle of incidence, oxidation, the sample's thermal and mechanical history, surface finish, and measured wavelength range. Although emissivity is a major component in determining emittance, the emissivity determined under laboratory conditions seldom agrees with actual emittance of a certain sample.

[SOURCE: ISO 80000-7:2019, item 7-30.1, modified — Notes 1 and 2 to entry have been added.]



**3.1.7.1****total directional emissivity**

total radiance,  $L_{\Omega}$ , emitted by the considered surface, divided by total radiance emitted by the black body,  $L^{\circ}_{\Omega}$  at the same temperature

Note 1 to entry: Determined in the domain of near infrared (NIR) and middle infrared (MIR) of the *infrared radiation* (3.1.10).

[SOURCE: ISO 9288:1989, 5.8, modified — Note 1 to entry has been added.]

**3.1.7.2****spectral directional emissivity**

spectral radiance,  $L_{\Omega\lambda}$ , of the considered surface divided by the spectral radiance emitted by the black body,  $L^{\circ}_{\Omega\lambda}$ , at the same temperature

Note 1 to entry: Determined in the domain of near infrared (NIR) and middle infrared (MIR) of the *infrared radiation* (3.1.10).

[SOURCE: ISO 9288:1989, 5.9, modified — Note 1 to entry has been added.]

**3.1.7.3****total hemispherical emissivity**

total hemispherical exitance,  $M$ , of the considered surface divided by the total hemispherical exitance of the black body,  $M^{\circ}$  at the same temperature

Note 1 to entry: Determined in the domain of near infrared (NIR) and middle infrared (MIR) of the *infrared radiation* (3.1.10).

[SOURCE: ISO 9288:1989, 5.10, modified — Note 1 to entry has been added.]

**3.1.8****glass ceramic**

inorganic material (3.1.12) produced by the complete fusion of raw materials at high temperatures into a homogeneous liquid which is then cooled to a rigid condition and temperature treated in such a way as to produce a mostly micro crystalline body

[SOURCE: ISO 7086-2:2000, 2.11]

**3.1.9****glass transition temperature**

$T_g$

characteristic value of the temperature range over which the glass transition takes place

Note 1 to entry: Glass transition temperature characterizes the transition from true solid to very viscous liquid.

Note 2 to entry: The assigned glass transition temperature ( $T_g$ ) may vary, depending on the specific property and on the method and conditions selected to measure it.

[SOURCE: ISO 11357-2:2020, 3.1, modified — Note 1 to entry has been added.]

**3.1.10****infrared radiation**

electromagnetic radiation of wavelength between 780 nm and approximately 1 mm

Note 1 to entry: For infrared radiation, the range between 780 nm and 1 mm is commonly subdivided into:

- near infrared (NIR): 780 nm to 3 000 nm;
- middle infrared (MIR): 3 000 nm to 50 000 nm;
- far infrared (FIR): 50 000 nm to 1 mm.

Note 2 to entry: These limits are also specified in ISO 20473.

Note 3 to entry: For *break-up* (3.1.2) *models* (3.1.14), NIR and MIR are the most representative wavelength domains related to *re-entry* (3.1.16) phenomena.

[SOURCE: ISO 9488:1999, 3.9, modified — Notes 1, 2 and 3 to entry have been added.]

### 3.1.11

#### **launch vehicle orbital stage**

complete element of a launch vehicle that is designed to deliver a defined thrust during a dedicated phase of the launch vehicle's operation and achieve orbit

Note 1 to entry: Non-propulsive elements of a launch vehicle, such as jettisonable tanks, multiple payload structures or dispensers, are considered to be part of a launch vehicle orbital stage while they are attached.

[SOURCE: ISO 24113:2019, 3.13]

### 3.1.12

#### **material**

raw, semi-finished or finished purchased item (gaseous, liquid, solid) of given characteristics from which processing into a functional element of the product is undertaken

Note 1 to entry: Gas is not concerned for *break-up* (3.1.2) *models* (3.1.14).

[SOURCE: ISO 10795:2019, 3.148, modified — Note 1 to entry has been added.]

### 3.1.13

#### **melting point**

temperature at which solid changes state from solid to liquid

Note 1 to entry: At the melting point the solid and liquid phases exist in equilibrium for a single substance. The melting point of a solid depends on pressure and is usually specified at standard pressure.

Note 2 to entry: Solids, which differ from single substances and eutectics, do not have a sharp melting point because fusion occurs in a wide temperature range. Therefore, there is a temperature of beginning of fusion called solidus and an end temperature of fusion called liquidus.

Note 3 to entry: Amorphous solids (including many polymers) do not have a sharp melting point. When these pass from a solid to fluid state, they do so over a wide temperature range, centred roughly about the *glass transition temperature* (3.1.9).

Note 4 to entry: The determination method of the melting point used in the *break-up* (3.1.2) *model* (3.1.14) shall be mentioned if it is liquidus state, solidus state or even as an average of solidus and liquidus.

Note 5 to entry: By conservatism, liquidus is preferred in order to state that no solid debris can fall on ground.

Note 6 to entry: Carbon does not melt at any temperature under standard pressure; instead it sublimates around 4 000 K.

### 3.1.14

#### **model**

physical or abstract representation of relevant aspects of an item or process that is put forward as a basis for calculations, predictions, or further assessment

Note 1 to entry: The term “model” can also be used to identify particular instances of the product, e.g. flight model.

[SOURCE: ISO 10795:2019, 3.155]

### 3.1.15

#### **pyrolysis**

chemical change caused by heat

Note 1 to entry: Sometimes used in a more restricted sense to describe chemical changes resulting from heat treatment in the absence of oxygen.