



**International
Standard**

ISO 15104

**Space systems — Environmental
testing for spacecraft thermal
control materials**

*Systèmes spatiaux — Essais environnementaux pour les
matériaux de contrôle thermique des engins spatiaux*

**First edition
2025-01**

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

[ISO 15104:2025](https://standards.iteh.ai/catalog/standards/iso/efab738f-713d-4e-3-b989-e7846ab216a1/iso-15104-2025)

<https://standards.iteh.ai/catalog/standards/iso/efab738f-713d-4e-3-b989-e7846ab216a1/iso-15104-2025>

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

[ISO 15104:2025](https://standards.iteh.ai/catalog/standards/iso/efab738f-713d-4e43-b989-e7846ab216a1/iso-15104-2025)

<https://standards.iteh.ai/catalog/standards/iso/efab738f-713d-4e43-b989-e7846ab216a1/iso-15104-2025>



COPYRIGHT PROTECTED DOCUMENT

© ISO 2025

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
Website: www.iso.org

Published in Switzerland

Contents

	Page
Foreword	iv
Introduction	v
1 Scope	1
2 Normative references	1
3 Terms, definitions and abbreviated terms	1
3.1 Terms and definitions.....	1
3.2 Abbreviated terms.....	2
4 Test principle	3
5 Test request determination	3
5.1 General.....	3
5.2 Test objectives.....	4
5.3 Normative documents.....	4
5.4 TCM(s) information and properties for evaluation.....	4
5.5 Space environment.....	4
5.6 Quality assurance.....	4
5.7 Deliverables.....	4
6 Test specification	4
6.1 General.....	4
6.2 Test objectives.....	4
6.3 Test samples.....	5
6.4 Test conditions.....	5
6.4.1 General.....	5
6.4.2 Ground simulation parameter.....	5
6.4.3 Properties to be measured.....	6
6.4.4 Detailed requirements.....	6
6.5 Test facilities.....	8
6.5.1 Charged particle radiation(s) test.....	8
6.5.2 UV radiation test.....	9
6.5.3 AO test.....	9
6.5.4 Thermal cycling test.....	10
6.6 Success criteria.....	10
7 Test preparation and execution	11
7.1 Test preparation.....	11
7.1.1 Preparation of test samples.....	11
7.1.2 Preparation of test facility and instruments.....	11
7.1.3 Preparation of test procedure.....	11
7.2 Test execution.....	12
7.2.1 Charged particle irradiation and UV irradiation test.....	12
7.2.2 AO test.....	12
7.2.3 Thermal cycling test.....	12
7.3 Non-conformity handling.....	13
8 Test report	13
8.1 Purpose.....	13
8.2 Content.....	13
Annex A (informative) Degradation of TCM(s) under UV irradiation	14
Annex B (informative) The effects of neutron on TCM(s)	17
Annex C (informative) Test facilities specifications information	18
Bibliography	22

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 document 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).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

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.

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.

ISO 15104:2025

<https://standards.iteh.ai/catalog/standards/iso/efab738f-713d-4e43-b989-e7846ab216a1/iso-15104-2025>

Introduction

Spacecraft thermal control materials (TCMs) are functional materials applied to control spacecraft temperature within design operation limits, by regulating the thermo-optical properties of spacecraft surfaces exposed to the space environment. TCMs' thermo-optical properties can degrade while exposed to the space environment. To ensure that the performance of TCM(s) is within design limits, environmental testing on TCM(s) is necessary. For application to spacecraft, TCMs' performance is evaluated in relevant simulated environments including charged particle radiation(s), solar ultraviolet (UV) radiation, atomic oxygen (AO), and thermal cycling, with parameters depending on spacecraft orbit and life time. The purpose of this document is to specify the environmental testing methods applied for experiments simulating effects of the space environment.

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

[ISO 15104:2025](https://standards.iteh.ai/catalog/standards/iso/efab738f-713d-4e43-b989-e7846ab216a1/iso-15104-2025)

<https://standards.iteh.ai/catalog/standards/iso/efab738f-713d-4e43-b989-e7846ab216a1/iso-15104-2025>

Space systems — Environmental testing for spacecraft thermal control materials

1 Scope

This document establishes requirements and guidance for the ground-based environmental testing of thermal control materials (TCMs) applied on spacecraft surface.

This document describes the test methods for the following environmental conditions: charged particle radiation(s), solar ultraviolet (UV) radiation, atomic oxygen (AO) and thermal cycling.

This document does not cover other environmental effects such as contamination effect of the Xenon ion engines plume (so called artificial effect) or the effects of neutron (see detailed information in [Annex B](#)).

This document is applicable to typical TCM(s), including but not limited to, paint, silicate, film, anodic oxide, and glass (optical solar reflector, OSR). This document can be referenced for other materials, to which similar requirements apply. This document is devoted to material estimation or evaluation tests and can be tailored according to specific applications.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 23461, *Space systems — Programme management — Non-conformance control system*

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

acceleration factor

ratio of dose rate between simulation and expectation in space application for the same type of radiation

[SOURCE: ISO 15856:2010, 3.1.2]

3.1.2

depth dose profile

distribution of the absorbed dose through the depth of the material.

[SOURCE: ISO 15856:2010, 3.1.5]

3.1.3

ex-situ measurement

measurement performed after exposure to atmosphere

3.1.4

in-situ measurement

measurement performed in vacuum or pressurized (without exposure to atmosphere)

Note 1 to entry: In-situ measurement is employed to avoid the influence of *recovery effect* (3.1.7) to test results. See [Clause A.2](#).

3.1.5

MUV radiation

medium ultraviolet radiation

solar electromagnetic radiation with a wavelength in the range of 200 nm to 300 nm

Note 1 to entry: See ISO 21348.

3.1.6

NUV radiation

near ultraviolet radiation

solar electromagnetic radiation with a wavelength in the range of 300 nm to 400 nm

Note 1 to entry: See ISO 21348.

3.1.7

recovery effect

bleaching effect

phenomenon observed when a TCM is moved into atmosphere from vacuum after an environmental test, where the degradation after exposure to atmosphere is less than that in vacuum

Note 1 to entry: Detailed information is shown in [Annex A](#).

3.1.8

solar absorptance

α_s
ratio of the solar radiant flux absorbed by a material (or body) to the radiant flux of the incident radiation

[SOURCE: ISO 16691:2014, 3.1.13]

3.1.9

VUV radiation

vacuum ultraviolet radiation

solar electromagnetic radiation with a wavelength in the range of 10 nm to 200 nm

[SOURCE: ISO 15856:2010, 3.1.21]

3.2 Abbreviated terms

AO	atomic oxygen
AM0	air mass 0
eV	electron volts
GCR	galactic cosmic ray
OSR	optical solar reflector
QCM	quartz crystal microbalance
SEP	solar event proton
UV	ultraviolet

4 Test principle

The test principle is to simulate space environmental effects on spacecraft TCM(s) by ground-based tests. This includes exposure to the following environmental factors:

- a) charged particle radiation;
- b) UV radiation;
- c) AO;
- d) thermal cycling.

Unless otherwise specified, the space environmental test is performed with single-factor effect test instead of synergistic effect test.

Environmental tests relating to the outgassing of TCM(s) are specified in ISO 17851 and ASTM E595.

Environmental tests relating to the ejecta released by micrometeoroid or space debris impacts on TCM(s) are specified in ISO 11227.

NOTE 1 This document can be referenced for tests of other environmental effects (such as Xe erosion or contamination).

This document specifies requirements for test customers and test suppliers regarding the following aspects to perform environmental tests for TCM(s) evaluation:

- test request;
- test specification;
- test preparation and execution;
- test report.

NOTE 2 The test customer is the test proposer or demander. The test supplier is the test executor.

NOTE 3 The forecast of material durability in relation to the impact of the space environment is based on results of ground tests, mathematical modelling of processes of space environment effects on materials and on-board experiments (refer to ISO 17851).

Aspects related to the test request, test specification approval by the customer and non-conformities treatment, if any, shall be resolved through communication or negotiation between the customer and the supplier.

5 Test request determination

5.1 General

The test customer and the test supplier shall reach an agreement on the test request, which contains the following information:

- a) test objectives;
- b) normative documents;
- c) TCM(s) information and properties for evaluation;
- d) spacecraft orbit, lifetime and environment parameters;
- e) quality assurance;
- f) deliverables.

Unless otherwise specified, the test request is a general document that applies to all tests in this document.

5.2 Test objectives

The test customer shall describe the objectives of the tests.

5.3 Normative documents

The test customer shall specify standards and technical documents as normative documents to be applied or used as references for the test supplier.

5.4 TCM(s) information and properties for evaluation

The test customer shall specify the shape or form of the TCM(s) sample and its main constituent materials or material family. For the purpose of this document, measurements include, but are not limited to, thermo-optical properties, electric properties (surface resistivity or volume resistivity), and mechanical properties (refer to ISO 16378, ECSS-Q-ST-70-09C, and ISO 16691).

The test samples should be visually checked after the test to determine whether there is flaking or shedding. If such a possibility exists, the mass of samples should be measured.

5.5 Space environment

The test customer shall specify requirements for test environment parameters, in particular, spacecraft orbit parameters and life time, the absorbed dose, the TCMs' locations on the external and internal surfaces of spacecraft, the main constituent materials or material family of TCM(s) and environmental models.

5.6 Quality assurance

The test customer shall specify quality assurance requirements, including handling of failed tests and non-conformities.

5.7 Deliverables

The test customer shall specify the deliverables and due dates.

6 Test specification

6.1 General

The test specification serves as a basis to prepare for and perform the test and shall be approved by the test customer. The test supplier shall establish a test specification according to consideration of the test request. The test specification should contain the following items:

- a) test objectives;
- b) test samples;
- c) test conditions;
- d) test facilities;
- e) success criteria.

6.2 Test objectives

The test specification shall contain objectives for each test to be performed, as agreed by the test customer and the test supplier.

6.3 Test samples

Unless otherwise specified, the following general requirements and recommendations apply for test samples in this document.

- a) The sample shape, size, and quantity shall meet the requirements of the corresponding measurement.
- b) Each sample shall be traceable (e.g. marked with identification sign or serial number).
- c) Samples shall be packed or wrapped with an appropriate material to avoid mechanical damage or contamination.
- d) For the charged particle radiation(s) test, all the electrically conductive coating on TCM(s) should be electrically grounded to decrease surface charging induced by the charged particle radiation(s).
- e) For the AO test, besides test samples, witness samples should be applied to measure the effective atomic oxygen flux or fluence. The erosion yield of witness samples should be well known (polyimide films are recommended^[1]).

6.4 Test conditions

6.4.1 General

Test conditions are defined as test parameters performed during the test.

6.4.2 Ground simulation parameter

Ground simulation parameters should be provided by the test customer. If not, the test supplier shall specify the environment parameters during testing based on the information provided and approved by the test customer in the test request. The ground simulation environment test and corresponded parameters are shown in [Table 1](#).

[ISO 15104:2025](#)

<https://standards.iteh.ai/catalog/standards/iso/efab738f-713d-4e43-b989-e7846ab216a1/iso-15104-2025>