ECSS-Q-70-04A
4 October 1999

Space product assurance

Thermal cycling test for the screening of space materials and processes

ECSS Secretariat
ESA-ESTEC
Requirements & Standards Division
Noordwijk, The Netherlands

Published by: ESA Publications Division
ESTEC, P.O. Box 299,
2200 AG Noordwijk,
The Netherlands

ISSN: 1028-396X

Price: EUR 10

Printed in The Netherlands

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 rewriting the standards.

The formulation of this Standard takes into account the existing ISO 9000 family of standards.

This Standard has been prepared by editing ESA PSS-01-704, reviewed by the ECSS Technical Panel and approved by the ECSS Steering Board.

(This page is intentionally left blank)

Contents list

Figures

Introduction

The deleterious effects to be anticipated during the thermal cycling test under vacuum include: outgassing (testing for this is detailed in ECSS-Q-70-02), cracking or fracture of materials or assemblies due to sudden dimensional changes by expansion, contraction or pressure, short circuiting of electrical wiring and overheating of materials or assemblies due to change in convection and conductive heat transfer characteristics.

(This page is intentionally left blank)

1

Scope

This Standard details a thermal cycling test under vacuum for the screening of materials and processes intended for use in the fabrication of spacecraft and associated equipment. The test determines the ability of these or other articles to withstand changes of ambient temperature under vacuum.

Typical materials or assemblies that can be evaluated by means of this test method are listed below. This is not an exhaustive list and other products or items can be tested:

- adhesives;
- adhesive bonded joints;
- coatings (paint, thermal and protective);
- insulating materials;
- metallic bonded joints;
- metallic samples, finished by plating or chemical conversion;
- metallized plastic films;
- organic or non-organic bonding;
- plated surfaces;
- potting compounds;
- pressure-sensitive tapes;
- printed circuit boards;
- reinforced structural laminates;
- sealants;
- soldered or welded joints.

(This page is intentionally left blank)

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 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 normative document referred to applies.

ECSS-P-001	Glossary of terms
ECSS-Q-20	Space product assurance - Quality assurance
ECSS-Q-20-09	Space product assurance - Nonconformance control system
ECSS-Q-40	Space product assurance - Safety
ECSS-Q-70-02	Space product assurance - Thermal vacuum outgassing test for the screening of space materials (to be published)
ECSS-Q-70-09	Space product assurance - Measurement of thermo-optical properties of thermal control materials (to be published)

(This page is intentionally left blank)

3

Terms, definitions and abbreviated terms

3.1 Terms and definitions

The following term is specific to this Standard in the sense that it is complementary or additional with respect to those contained in ECSS-P-001 and ECSS-Q-70.

Batch
A quantity produced at one operation.

NOTE One batch can be subdivided into several lots.

3.2 Abbreviated terms

The following abbreviated term is defined and used within this Standard.

RH relative humidity

(This page is intentionally left blank)

4

Preparatory conditions

4.1 Hazards, health and safety precautions

Materials and parts with hazardous characteristics shall be identified, managed and processed according to ECSS-Q-40. Particular attention shall be given to health and safety precautions. In particular, hazards to personnel, equipment and materials shall be controlled and minimized.

4.2 Preparation of samples

4.2.1 Configuration

a. The material samples shall be prepared according to the relevant process specifications or manufacturer's data and shall be representative of batch variance.

b. If it is not practicable to test completed assemblies, the manufacturer shall submit samples made from the same materials and by the same processes as those used in the manufacture of the assemblies.

c. The test sample shall be prepared from the material or assembly samples as follows:

- The sample for testing shall have one flat surface which do not overlap the dimensions of the sample holder to be used in the test.
- The flat surface shall be in continuous contact with the sample holder, attached by any form of clamping arrangement which does not cover more than 10 % of the sample's remaining surfaces.
- The maximum thickness of the sample shall be such that, under vacuum of 10^{-5} Pa, any point of extremity will not differ by more than 5 ^{o}C from the temperature of the sample holder. This parameter will depend on the thermal conductivity properties of the sample.

4.2.2 Cleaning

The cleaning and other treatments of the sample shall be the same as that applied to the finished article, which the sample is intended to represent, prior to integration into the spacecraft. Further cleaning or other treatments are not permitted.

4.2.3 Handling and storage

Samples shall only be handled with clean nylon or lint-free gloves and shall be stored in a controlled area, with an ambient temperature of (22 ± 3) °C and relative humidity of (55 ± 10) %. Coated surfaces shall be shielded from contact by using polyethylene or polypropylene bags or sheets. Physical damage shall be avoided by packing the polyethylene or polypropylene-wrapped workpieces in clean, dust- and lint-free material. Limited-life materials shall be labelled with their shelf lives and dates of manufacture, or date of delivery if date of manufacture is not known.

4.2.4 Identification

4.2.4.1 Materials

Materials submitted for testing shall be clearly identified with appropriate details to maintain traceability.

4.2.4.2 Assemblies

Assemblies submitted for testing shall be identified, as a minimum, by:

a. trade name and batch number;

b. name of manufacturer or supplier through whom the purchase was made;

c. configuration control status of the assembly.

4.3 Facilities

4.3.1 Cleanliness

The work area shall be nominally clean with minimum dust, but not necessarily a cleanroom environment. Air used for ventilation shall be nominally filtered to prevent contamination of the sample.

4.3.2 Environment conditions

The ambient conditions for the process and work areas shall be (22 ± 3) °C with a relative humidity of (55 ± 10) % unless otherwise stated.

4.4 Equipment

4.4.1 Test equipment

The following test equipment shall be used. Additional test equipment may be used if further tests are invoked by the project.

a. **Microscope**

   At least ×20 magnification with attachment to enable photomicrographs to be taken.

b. **Electrical instruments** (if applicable).

   To monitor any electrical degradation of the sample, i.e. insulation, current and other parameters as appropriate.

c. **Monitoring instruments**

   To fulfil the monitoring requirements of the test process:

Temperature:	-150 °C to +150 °C accurate to ± 1 °C;
Relative Humidity (RH):	40 % to 70 % accurate to ± 1 %;
Vacuum:	1×10^{-5} Pa accurate to ± 5 %.

4.4.2 Special apparatus

The test shall be conducted in a thermal-vacuum chamber containing a suitable sample holder and meeting the following requirements:

a. The vacuum capacity of the chamber shall be capable of maintaining the test vacuum of 1×10^{-5} Pa. The vacuum shall be monitored by a vacuum gauge mounted in close proximity to the sample under test.

b. The sample holder and associated heating and cooling systems shall be capable of cycling, at a nominal rate of (10 ± 2) °C/min, the sample between -150 °C and +150 °C. The thermal-cycling sequence shall be controlled by the temperature of the sample and shall be continuously monitored and recorded by a minimum of two thermocouples, having an accuracy of $\pm$ 2 °C, in direct contact with the sample holder in close proximity to the sample under test.

(This page is intentionally left blank)

5

Test procedure

5.1 General

The test procedure flow is shown in Figure 1.

5.2 Pre and post test

a. The extent of physical and mechanical properties to be examined before and after testing shall depend on the intended application of the sample material and assembly. The inspection and test methods shall be specified by the customer before each sample undergoes thermal cycling in vacuum.

b. Visual examination for defects in the sample shall be initially carried out at $\times 20$ magnification. Higher magnification should be used post test for locating microscopic defects such as surface crazing, embrittlement and blistering. Photomicrographs shall be taken before and after the thermal cycling sequence at the same magnification. Thermo-optical properties and surface properties should be recorded for comparison post test if detailed by the customer.

c. For mechanical testing and other forms of destructive testing identical samples shall be supplied for the comparison of results before and after the thermal cycling sequence. These tests can include the recording of tensile, compression, elongation, hardness and adhesion properties (see ECSS-Q-70-09).

d. Surface roughness shall be recorded upon request by the customer.

e. Electrical measurements may be performed before, during or after the thermal cycling on the sample. These shall be specified before testing by the customer.

5.3 Thermal cycling test

a. The initial characteristics shall be investigated at $(22 \pm 3)\,^{o}C$ and RH (55 ± 10) % within six hours prior to the commencement of the thermal cycling.

b. The sample shall then be mounted on the sample holder as described in subclause 4.2.1.

c. After insertion of the sample holder, the chamber shall be evacuated.

d. Thermal cycling shall commence after a working vacuum of 1×10^{-5} Pa has been reached.

e. The chamber shall be thermally cycled between temperatures of +(100 ± 5) °C to -(100 ± 5) °C, unless otherwise specified, at a nominal heating or cooling rate of (10 ± 2) °C per minute between the two temperature extremes with the temperature recorded at the sample as detailed in subclause 4.4.2. The sample dwell time shall be not less than five minutes, the maximum dwell time determined by the customer, at each of the temperature extremes. Certain special samples, e.g. electrical circuits, may require a modified cycling sequence with different temperature parameters.

f. The minimum number of thermal cycles performed on each sample shall be 100. Certain samples can require further cycling, e.g. when thermal fatigue conditions exist, but in these cases the number of cycles shall be specified before tests start.

g. Final inspection and testing of the sample shall be conducted at (22 ± 3) °C and RH (55 ± 10) % within six hours after the completion of thermal cycling in vacuum.

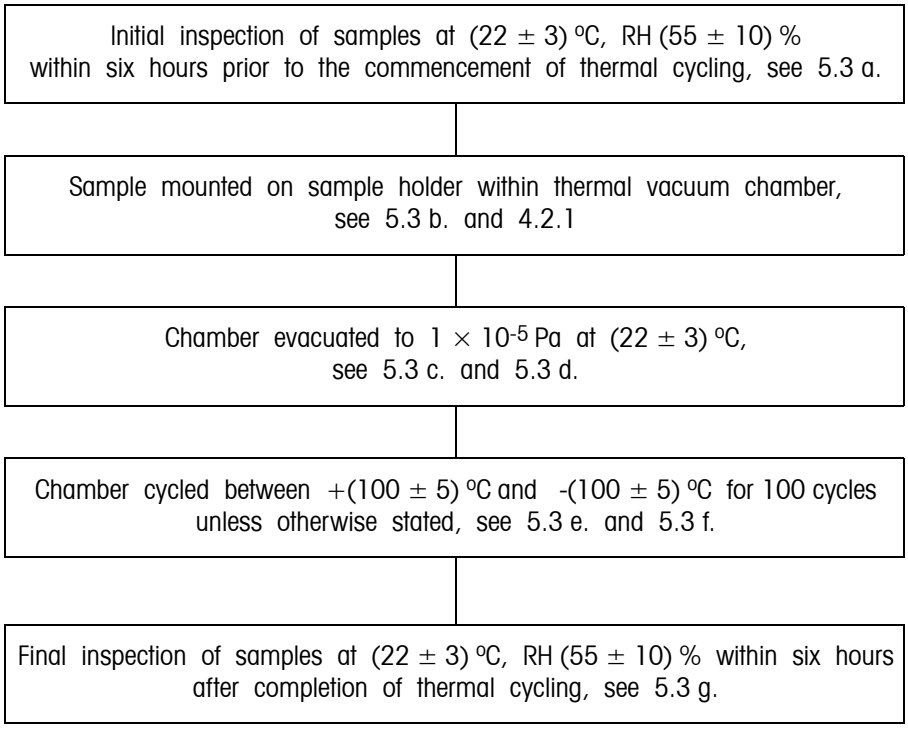

Figure 1: Test procedure flow diagram

5.4 Handling and packing of tested samples

Conditions specified in subclause 4.2.3 shall apply, unless other post test disposal instructions are given.

6

Acceptance criteria

a. Samples which have been tested and are not seen to be disturbed in any way by the processing described in subclause 5.3 shall be considered as having passed this test.

b. As a minimum, there shall be no signs of cracking, fracture, overheating, or significant electrical degradation (if relevant) of the sample during and upon completion of the test sequence.

c. Photomicrographs shall be taken of the sample to the requirements of the customer.

d. Evaluation of other properties may be invoked by the customer, such as those indicated in subclause 5.2.

(This page is intentionally left blank)

7

Quality assurance

7.1 General

The quality assurance requirements are defined in ECSS-Q-20.

7.2 Data

The quality records (e.g. logbooks) shall be retained for at least ten years or in accordance with project contract requirements, and contain as a minimum the following:

a. trade names and batch numbers of the materials under test;

b. name of the manufacturer or supplier through whom the purchase was made;

c. summary of the preparation and conditioning schedule (e.g. mixing proportions, coating thickness, cure time and temperature, post-cure, cleaning procedure);

d. details of the testing room environment conditions and test equipment used for the thermal cycling in vacuum;

e. details of the test parameters outlined in subclause 5.3. This shall also include any variation in working vacuum pressure during the test;

f. details of equipment used for visual, mechanical, chemical and physical property measurement or inspection, as outlined in subclause 5.3 and test specifications where they exist;

g. comments concerning any unusual occurrence during the temperature cycling;

h. all samples subjected to thermal cycling under vacuum tests shall be recorded and the results, subsequent to visual examination and testing, shall be reported to the customer;

i. number of sample tests;

j. results of any failure analysis carried out according to clause 6;

k. details of failure mode (if applicable):

   1. deficient design;
   2. poor workmanship;
   3. wrong fabrication or application procedure;
   4. wrong choice of materials;
   5. others.

7.3 Nonconformance

Any nonconformance which is observed in respect of the test process shall be dispositioned in accordance with the quality assurance requirements, see ECSS-Q-20-09.

7.4 Calibration

Each reference standard and piece of measuring equipment shall be calibrated. Any suspected or actual equipment failure shall be recorded as a project nonconformance report so that previous results may be examined to ascertain whether or not re-inspection and retesting is required. The customer shall be notified of the nonconformance details.

7.5 Traceability

Traceability shall be maintained throughout the process from incoming inspection to final test, including details of the test equipment and personnel employed in performing the task.

ECSS Document Improvement Proposal

1. Document I.D.	2. Document date	3. Document title
ECSS-Q-70-04A	4 October 1999	Thermal cycling test for the screening of space materials and processes

4. Recommended improvement (identify clauses, subclauses and include modified text or graphic, attach pages as necessary)

5. Reason for recommendation

6. Originator of recommendation

Name:	Organization:	
Address:	Phone: Fax: E-Mail:	**7. Date of submission:**

8. Send to ECSS Secretariat

Name:	Address:	Phone: +31-71-565-3952
W. Kriedte ESA-TOS/QR	ESTEC, P.O. Box 299 2200 AG Noordwijk The Netherlands	Fax: +31-71-565-6839 E-Mail: wkriedte@estec.esa.nl

Note: The originator of the submission should complete items 4, 5, 6 and 7.

This form is available as a Word and Wordperfect-Template on internet under
http://www.estec.esa.nl/ecss/improve/

(This page is intentionally left blank)