ECSS-Q-ST-70-02C
15 November 2008

Space product assurance

Thermal vacuum outgassing test for the screening of space materials

ECSS Secretariat
ESA-ESTEC
Requirements & Standards Division
Noordwijk, 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.

This Standard has been prepared by the Working Group, reviewed by the ECSS Executive Secretariat and approved by the ECSS Technical Authority.

Disclaimer

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

Change log

ECSS-Q-70-02A 26 May 2000	First issue Transforming ESA-PSS-01-202 into an ECSS Standard
ECSS-Q-70-02B	Never issued
ECSS-Q-ST-70-02C	Second issue Update and cleaning of ECSS-Q-70-02A according to ECSS drafting rules and new template. In particular: • The Introduction was completed to precise the context of application of this Standard and reinforced by the insertion of a new clause 5.1 • Former notes related to clause 5.2.4.2 were promoted into requirements from 5.2.4.2.d to 5.4.2.4.l. • A DRD for Materials Identification was created in the normative Annex A. • A DRD for Micro-VCM Worksheet was created in the normative Annex B • A DRD for Micro-VCM datasheet was created in the normative Annex C • A DRD for test report was created in the normative Annex D • A DRD for certificate of conformity was created in the normative Annex E

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Introduction

The kinetics of an outgassing process is influenced by vacuum and temperature conditions.

The method described in this Standard gives reliable data for material screening use exclusively. The nominal temperature for the screening test, as described in this standard is 125 °C. Results from the nominal screening test can be used for the screening of materials that have an operational temperature below 50 °C, especially if they are exposed for an extended period of time (in the order of weeks and above).

1
Scope

This Standard describes a thermal vacuum test to determine the outgassing screening properties of materials proposed for use in the fabrication of spacecraft and associated equipment, for vacuum facilities used for flight hardware tests and for certain launcher hardware.

This Standard covers the following:

- critical design parameters of the test system;
- critical test parameters such as temperature, time, pressure;
- material sample preparation;
- conditioning parameters for samples and collector plates;
- presentation of the test data;
- acceptance criteria;
- certification of test systems and their operators by audits and round robin tests.

The test described in this Standard is applicable for all unmanned spacecraft, launchers, payloads, experiments. The test is also valid for external hardware of inhabited space systems and for hardware to be used in terrestrial vacuum test facilities.

The outgassing and condensation acceptance criteria for a material depend upon the application and location of the material and can be more severe than the standard requirements as given in clause 5.5.3.1.

This standard may be tailored for the specific characteristics and constrains 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.

ECSS-S-ST-00-01	ECSS system – Glossary of terms
ECSS-Q-ST-10	Space product assurance – Product assurance management
ECSS-Q-ST-10-09	Space product assurance – Nonconformance control system

3
Terms, definitions and abbreviated terms

3.1 Terms defined in other standards

For the purpose of this Standard, the terms and definitions from ECSS-S-ST-00-01 and ECSS-Q-ST-70 apply.

3.2 Terms specific to the present standard

3.2.1 bakeout

activity of increasing the temperature of hardware to accelerate its outgassing rates with the intent of reducing the content of molecular contaminants within the hardware

NOTE Bakeout is usually performed in a vacuum environment but may be done in a controlled atmosphere.

3.2.2 cleanroom

room in which the concentration of airborne particles is controlled, and which is constructed and used in a manner to minimize the introduction, generation, and retention of particles inside the room, and in which other relevant parameters, e.g. temperature, humidity, and pressure, are controlled as necessary

[ISO 14644-6]

3.2.3 collected volatile condensable material (CVCM)

quantity of outgassed matter from a test specimen that condenses on a collector maintained at a specific temperature for a specific time

NOTE CVCM is expressed as a percentage of the initial specimen mass and is calculated from the condensate mass determined from the difference in mass of the collector plate before and after the test.

3.2.4 outgassing

release of gaseous species from a specimen under high vacuum conditions

3.2.5 quartz crystal microbalance (QCM)

device for measuring small quantities of mass deposited on a quartz crystal using the properties of a crystal oscillator

3.2.6 recovered mass loss (RML)

total mass loss of the specimen itself without the absorbed water

NOTE 1 The following equation holds:
RML = TML - WVR.

NOTE 2 The RML is introduced because water is not always seen as a critical contaminant in spacecraft materials.

3.2.7 sticking coefficient

probability that a molecule, colliding with a surface, stays on that surface before thermal re-evaporation of that molecule occurs

3.2.8 total mass loss (TML)

total mass loss of material outgassed from a specimen that is maintained at a specific constant temperature and operating pressure for a specified time

NOTE TML is calculated from the mass of the specimen as measured before and after the test and is expressed as a percentage of the initial specimen mass.

3.2.9 water vapour regained (WVR)

mass of the water vapour regained by the specimen after the optional reconditioning step

NOTE WVR is calculated from the differences in the specimen mass determined after the test for TML and CVCM and again after exposure to atmospheric conditions and 65 % relative humidity at room temperature (22 ± 3) °C.

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
CVCM	collected volatile condensable material
EOL	end-of-life
IR	infrared
MIC	materials identification card
PTFE	polytetrafluorethylene
QCM	quartz crystal microbalance
RH	relative humidity

RML	recovered mass loss
RT	room temperature
TML	total mass loss
VCM	volatile condensable material
WVR	water vapour regained

4
Test overview

4.1 Test process description

Figure 4-1 and Figure 4-2 are included as a guide to the test procedures. The sequence for the test is given in the flow chart (Figure 4-2).

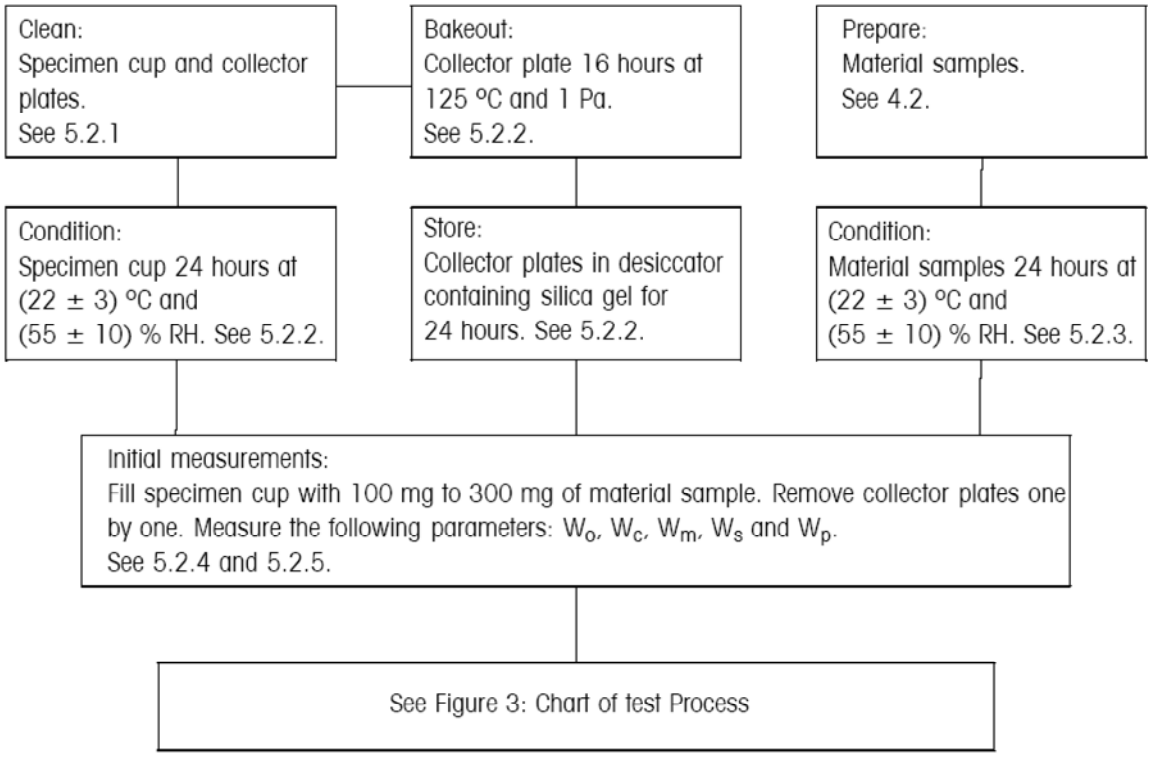

Figure 4-1: Flow chart of preparation and initial measurements

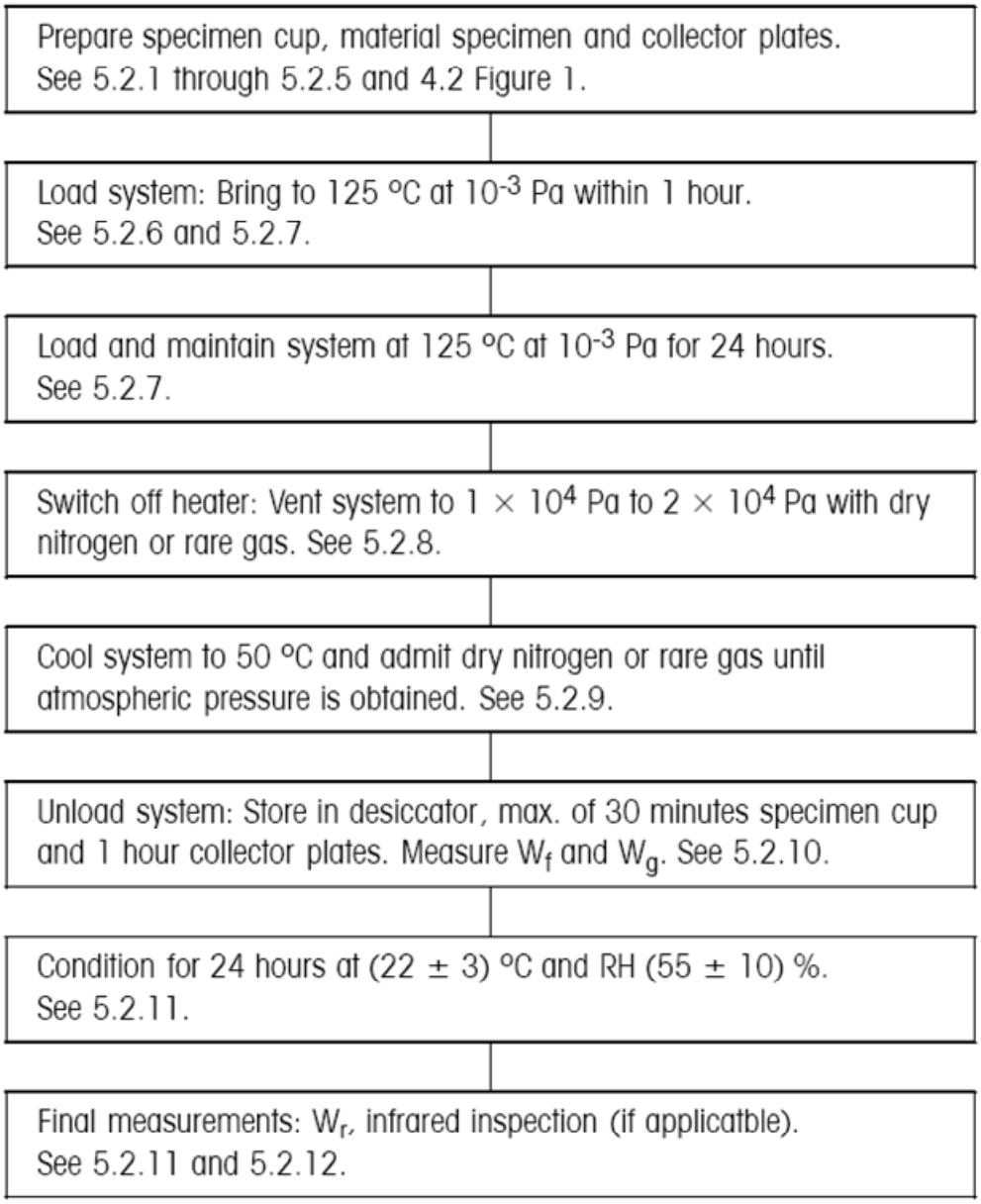

Figure 4-2: Flow chart of test process

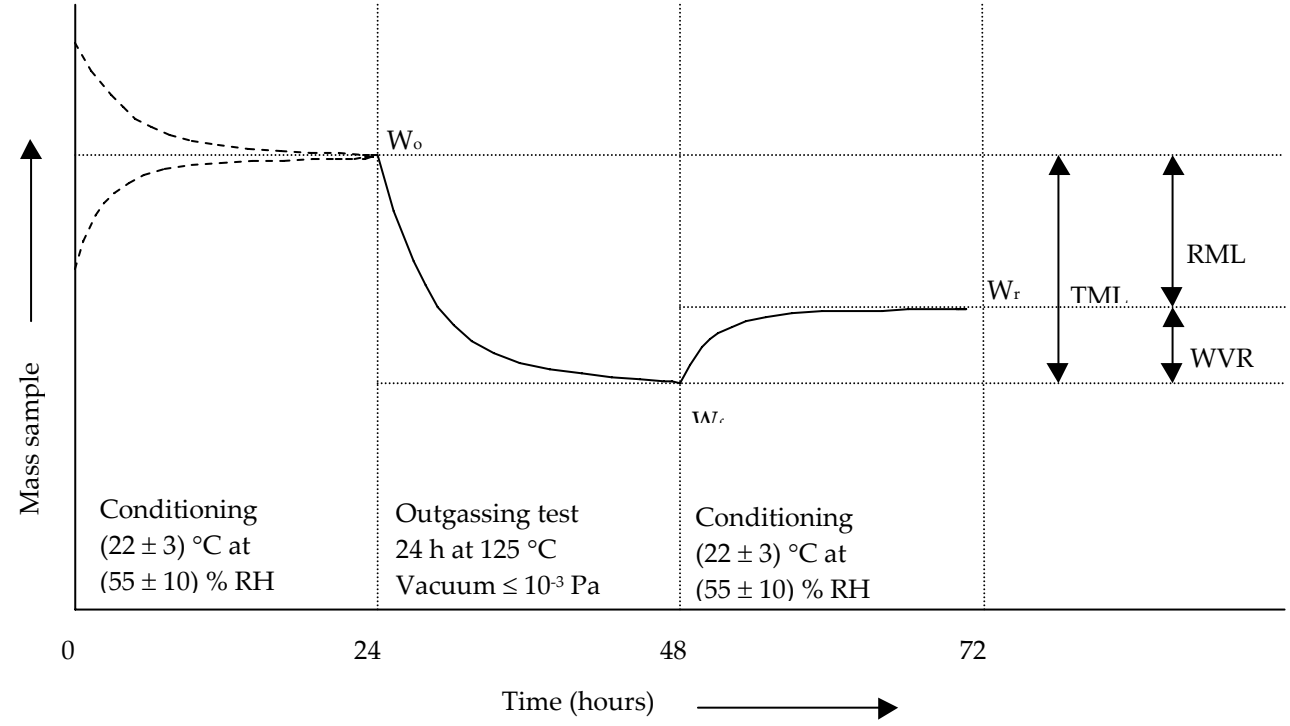

Figure 4-3: Parameters for sample

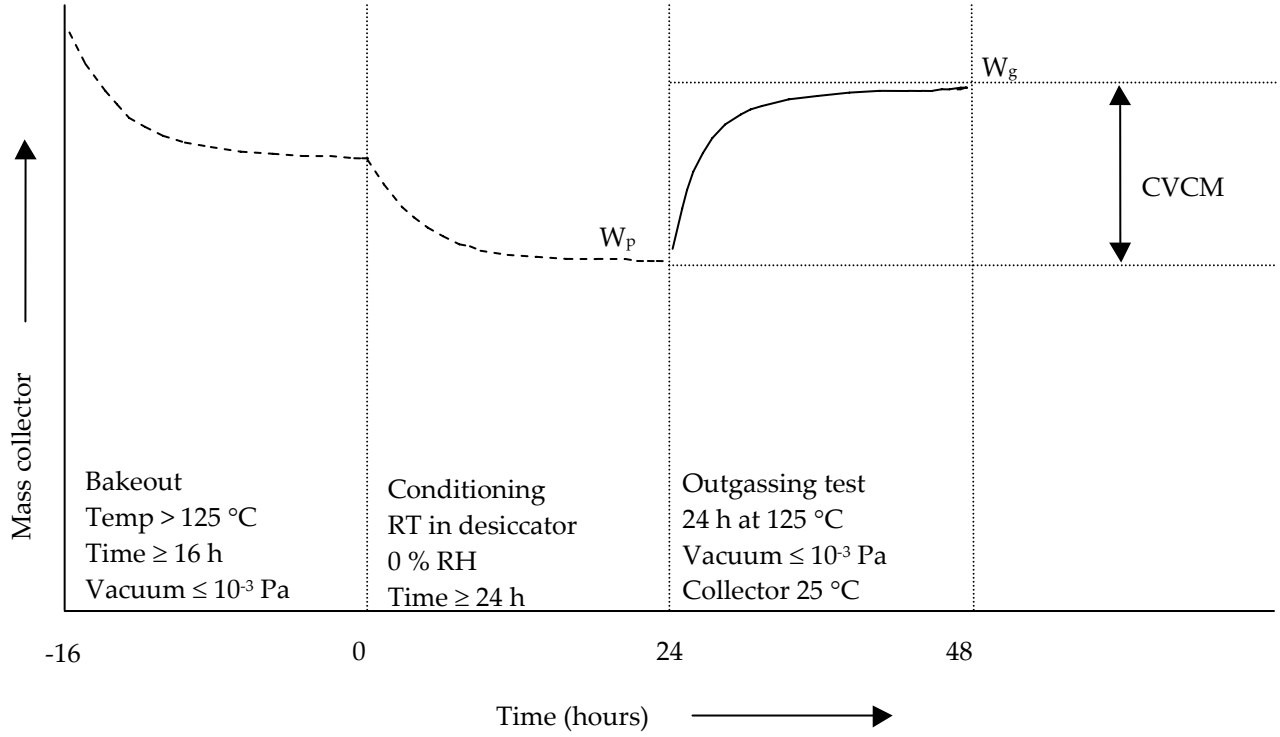

Figure 4-4: Parameters for collector plate

4.2 Acceptance limits

The validity of this screening test as a means for determining the suitability of a material for a specific application depends on the environmental conditions during the lifetime of the material as well as the vicinity of critical or sensitive surfaces.

Especially, in cases were the expected maximum temperature of a material during the lifetime is exceeding 50 °C for an extended period of time, the use of such material are evaluated further through a test programme, mutually agreed between customer and supplier.

Such programme ensures that the characteristics of the material at the EOL are still within the specified requirements.

5
Requirements

5.1 General requirements

a. For those materials that are subjected, during the mission, to temperature above 125 °C for short period of time (in the order of hours) or above 50 °C for an extended period of time (in the order of weeks or above), dedicated tests shall be performed at conditions representative of the real application (i.e. higher temperature tests).

b. Limits for elevated temperature testing shall be specified case by case.

NOTE 1 For example, limits are specified by the requesting project.

NOTE 2 For accelerated tests (i.e. higher temperature testing to take into account long exposures) there can be a limit, above which, the phenomenon is governed by different mechanisms other than those that really interest the material during its on-orbit phase; in such a case, a different kind of test, like a dynamic characterization, can be more pertinent.

c. The measurement of contamination potential shall be only used in a comparative way and is strictly valid only for collectors at 25 °C with similar sticking coefficients.

d. The data obtained from this test shall not be used for contamination predictions.

e. Modelling of the outgassing phenomenon shall be based on dynamic test results only and not on screening results obtained from this Standard.

5.2 Preparatory conditions

5.2.1 Hazards, health and safety precautions

a. The supplier shall take the following health and safety precautions:

1. Control and minimize hazards to personnel, equipment and materials.

2. Locate items and controls in such a way that personnel are not exposed to hazards such as burns, electric shock, cutting edges, sharp points or toxic atmospheres.

3. Provide warning and caution notes in operations, storage, transport, testing, assembly, maintenance and repair instructions and distinctive markings on hazardous items, equipment or facilities for personal protection.

5.2.2 Material samples

5.2.2.1 Configuration

5.2.2.1.1 Preparation

a. If the material is made up of several items, the sample shall be prepared according to the process specification or manufacturer's data.

b. A minimum of 12 g of the material sample shall be prepared.

NOTE The reason of this quantity is to provide representative samples (10 g for the initial test and 2 g for subsequent retest if needed).

c. The material sample shall be made according to the same process parameters as the relevant material to be applied for spacecraft use.

NOTE Typical process parameters are curing and baking.

5.2.2.1.2 Material cuttings

a. Three test specimens of each material shall be prepared as follows:

NOTE The material cuttings are in general made by the test house concerned.

1. For potting materials and bulky adhesives do the following:

(a) Cast them on a PTFE sheet so that a sample of a few millimetres thick (preferably 2 mm) can be separated from the PTFE after curing;

(b) Cut the sample into cubes (1,5 mm to 2 mm per side) before testing.

2. For thin films, coatings, adhesives and adhesive tapes do the following:

(a) Apply them to a degreased, dried metal foil of known thickness;

NOTE The metal foil can be aluminium and an aluminium foil is typically 16 μm (4×10^{-3} g/cm^2) thick.

(b) Cut them into strips 10 mm wide;

(c) Roll up them in such a way that the specimen cup is fit;

3. For non-curing adhesives do the following:

(a) Apply them between thin metal foils.

(b) Prepare them as specified in 5.2.2.1.2a.2.

(c) If the substrate is non-metallic, submit a sample of that substrate for separate testing;

4. When materials are prepared on substrates, submit a substrate sample with the material sample.

5. When primers are applied, test the complete system.

6. Cut materials such as wires, cables or sleeves, the smallest dimension of which is less that 1,5 mm, into pieces 10 mm long.

7. Test materials containing metal parts without the metal parts or, if this is not possible, state the ratio of metal mass to total mass.

NOTE Typical materials with metal parts are electrical wires or connectors.

8. Place liquids and greases in a specimen cup and state the ratio of filler mass to total mass if a filler is used.

NOTE In some cases, it can be more practical to mix the liquid with a neutral filler powder such as silica before placing it in a cup.

5.2.2.2 Cleaning

a. The cleaning and other treatment of the samples shall be the same as that applied to the flight hardware, which the sample is intended to represent, prior to integration into the spacecraft.

b. The supplier shall test the materials as received without any further cleaning or treatment, unless otherwise specified by the customer.

5.2.2.3 Handling and storage

a. Samples shall only be handled with clean nylon or lint-free gloves.

b. Samples shall be stored in a controlled area, with an ambient temperature of (22 ± 3) °C and relative humidity of (55 ± 10) %.

c. Polyethylene or polypropylene bags or sheets shall be used.

NOTE This is to shield coated surfaces from contact.

d. The polyethylene or polypropylene-wrapped workpieces shall be packed in clean, dust- and lint-free material.

NOTE This is to avoid physical damage.

e. 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.

5.2.2.4 Identification of materials

a. The customer shall accompany materials submitted for testing by a completed materials identification card in conformance with Annex A.

5.2.3 Facilities

5.2.3.1 Cleanliness

a. The supplier shall keep the work area clean from dust as achieved with normal house-keeping.

NOTE A cleanroom environment is not necessary.

b. The supplier shall filter the air used for ventilation.

NOTE This is to prevent contamination of the sample.

5.2.3.2 Environmental conditions

a. During the conditioning of the prepared material samples, the supplier shall ensure an ambient temperature of (22 ± 3) °C with a relative humidity of (55 ± 10) %.

5.2.4 Equipment

5.2.4.1 Test equipment

a. The supplier shall use measuring instruments which are capable of monitoring the following items:

1. Temperature from 10 °C to 130 °C with ± 1 °C accuracy.
2. Humidity from 40 % to 80 % RH with ± 1 % RH accuracy.
3. Vacuum at 10^{-4} Pa with ± 10 % accuracy.

b. If requested, the supplier shall use an infrared spectrometer of such a sensitivity that an infrared spectrum of the condensed contaminants in the range 2,5 μm to 16 μm is obtained.

c. The supplier shall use a microbalance from 1×10^{-6} g to 5×10^{-6} g.

d. The supplier shall use a vacuum oven able to guarantee a maximum pressure of 1 Pa and a temperature of at least 150 °C.

5.2.4.2 Special apparatus

a. The apparatus shall consist of an insert located in a common-type vacuum system suitably dimensioned with respect to the insert, able to accommodate the necessary feedthroughs.

b. The insert should consist of a bar (or bars) accommodating a minimum of 6 regularly spaced specimen compartments 16 mm ± 0,1 mm in diameter and 9,6 mm ± 0,8 mm deep.

c. The distance between two adjacent specimen compartments shall be 50 mm ± 0,8 mm.

d. The open ends of the specimen compartments shall face the collector plates on the cooling plate(s).

e. The dimensions of the open ends shall be as follows:

   1. 6,3 mm ± 0,1 mm in diameter,

   2. 12,7 mm ± 0,3 mm long.

f. The cooling plate(s) shall be provided with attachments ensuring a good thermal contact with the collector plates.

g. The distance between the open ends of the specimen compartments and the cooling plate(s) shall be 13,45 mm ± 0,1 mm.

h. Cross contamination between different compartments shall be reduced by a separator plate(s) 0,75 mm ± 0,1 mm thick and perforated with 11,1 mm ± 0,1 mm diameter holes in front of each specimen compartment.

i. The separator plate(s) shall be situated between the heater bar(s) and the cooling plate(s) at a distance of 9,65 mm ± 0,1 mm from the latter.

j. Standard collectors shall be made of chromium-plated aluminium plates 33,0 mm ± 0,1 mm in diameter and 0,65 mm ± 0,1 mm thick.

k. Standards collectors shall be replaceable by sodium-chloride or germanium collector plates.

   NOTE Infrared analysis of the condensed materials can be performed when sodium-chloride or germanium collectors are used instead of the standard ones.

l. Alignment between the hot bar and the cooling plate(s) shall be verified (see Figure 5-1)

m. A pressure of 10^{-4} Pa shall be reached within one hour with an unloaded system.

n. The vacuum system shall be checked to be oil free during each test with the aid of three blank collector plates placed at random.

o. The capability to maintain the heater bars and the cooling plates at temperatures other than those mentioned further in this Standard shall be demonstrated.

   NOTE It is advisable to make provision for a bakeout, at a temperature of 25 °C above the maximum test temperature, of the vacuum system as a means of cleaning it in the event of heavy contamination.

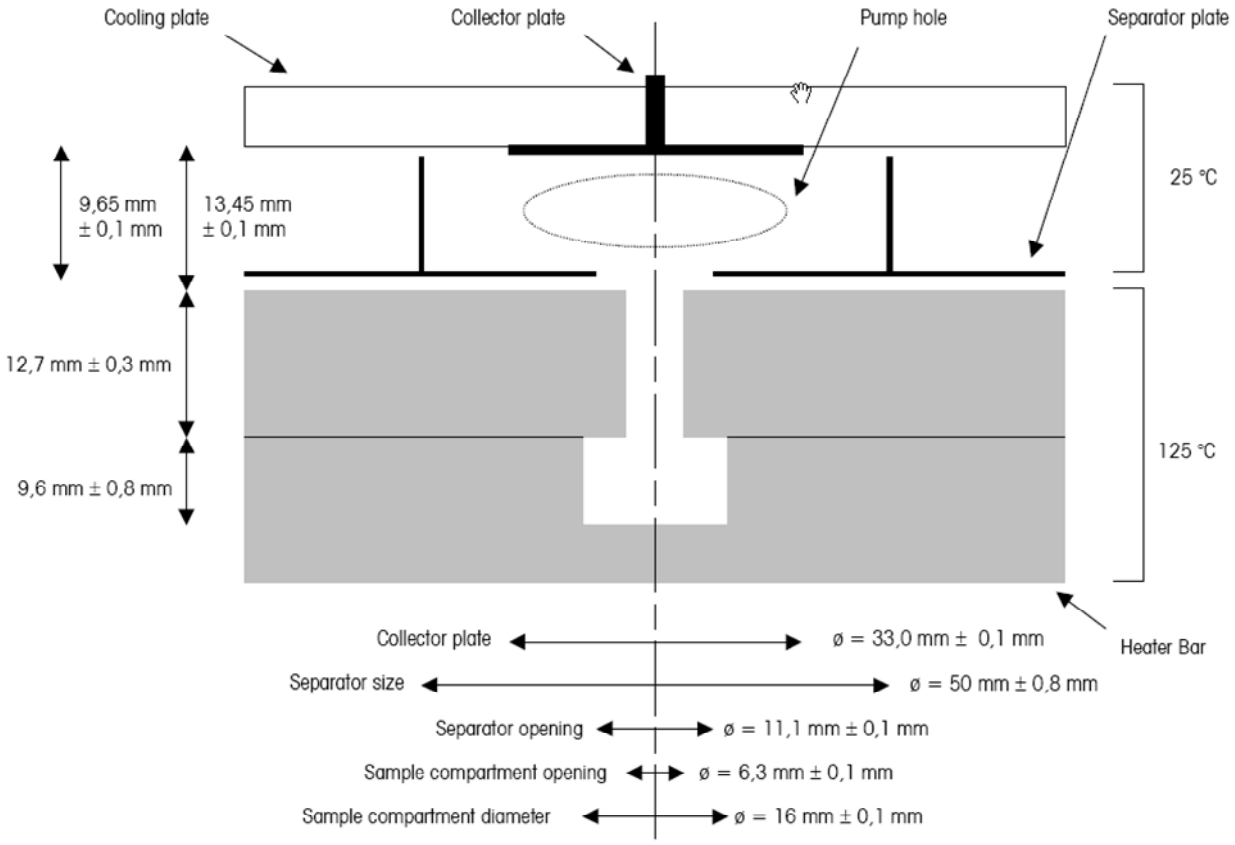

Figure 5-1: Micro-VCM equipment

5.3 Test procedure

5.3.1 General requirements

a. The supplier shall perform the screening test with the minimal and nominal temperature of 125 °C.

NOTE This outgassing temperature can be raised to a mutual agreed level between the customer and the supplier.

5.3.2 Test process for general spacecraft application

5.3.2.1 Cleaning of cups and collector plates

a. The supplier shall clean specimen cups and collector plates with a compatible solvent.

NOTE Solvent compatibilities with different materials are provided in ECSS-Q-ST-70-01.

5.3.2.2 Conditioning of cups and collector plates

a. The supplier shall condition the specimen cups for at least 24 hours in an environment of (22 ±3) °C and (55 ± 10) % RH.

b. The supplier shall perform a bakeout of the collector plates for at least 16 hours in a vacuum oven at a pressure lower than 1 Pa, and at a minimum temperature of 125 °C.

c. After the bakeout the supplier shall condition them for a minimum 24 hours in a desiccator containing silica gel.

d. During the test, the supplier shall expose three specimen cups for each material and three empty specimen cups.

e. During the test, the supplier shall place collector plates in front of each cup.

f. The supplier shall use the three collector plates facing the empty cups as blanks.

NOTE This is to verify the cleanliness of the equipment.

g. The supplier shall incorporate corrections based on the blanks in the actual mass loss calculations.

5.3.2.3 Conditioning of samples

a. The supplier shall prepare material specimens in the manner laid down in clause 5.2.

b. The supplier shall condition them for at least 24 hours at (22 ± 3) °C and (55 ± 10) % RH.

5.3.2.4 Weighing of samples

a. The supplier shall fill the pre-weighed specimen cups with 100 mg to 300 mg of specimen (substrate not included).

NOTE For low density foams a sample mass of 100 mg can be obtained by choosing a sample cup of bigger size, or compressing the foam into the sample cup.

b. The supplier shall perform weighing on a microbalance (see 5.2.4.1c.) located in a room conditioned at (22 ± 3) °C and (55 ± 10) % RH just before the loading of the test system.

5.3.2.5 Weighing of collector plates

a. The supplier shall weigh the collector plates just before the loading of the test system.

NOTE This is done by taking them from the desiccator one by one.

5.3.2.6 Loading of system

a. The supplier shall load the test system with:

1. the specimen cups,
2. the blank cups,
3. the blank collectors,
4. the two chromium-plated collectors, and
5. one infrared-transparent collector or three chromium-plated collectors per material.

5.3.2.7 Pump-down and heating

a. The supplier shall carry out the pump down of the test system in the following procedure:

1. at 10^{-3} Pa bring the heater bar(s) to the specified temperature within one hour;
2. control the cooling plate(s) at 25 °C;
3. maintain these temperatures for a period of 24 hours following the instant at which the heater bar(s) reach(es) the specified temperature.

b. The supplier shall ensure that the specified temperature does not exceed the maximum bakeout temperature.

5.3.2.8 End of test

a. After 24-hour exposure, the supplier shall switch off the heaters

b. The supplier shall vent the system up to 1×10^4 Pa to 2×10^4 Pa with dry nitrogen or rare gas.

c. The supplier shall continue cooling until the end of the test.

5.3.2.9 Gas inlet

a. When the temperature of the heater bar(s) has fallen to 50 °C, the supplier shall admit dry nitrogen or rare gas up to atmospheric pressure.

NOTE The cooling normally takes (90 - 120) minutes.

5.3.2.10 Unloading of system

a. The supplier shall unload the system as soon as possible.

b. The supplier shall keep the specimen cups in a desiccator for not more than 30 minutes.

c. The supplier shall keep the collector plates in a desiccator for one hour.

d. The supplier shall weigh the specimen cups and collector plates.

NOTE This is done by taking them from the desiccator one by one and returned immediately thereafter.

5.3.2.11 Storage of collector plates

a. The supplier shall store the specimen cups with material samples in a room, at an ambient temperature of (22 ± 3) °C and a relative humidity of (55 ± 10) %, for 24 hours.

b. The supplier shall reweigh them afterwards.

5.3.2.12 Infrared analyses

a. The supplier shall examine the infrared-transparent collector plates in the transmission mode, with the aid of an infrared spectrometer of such a sensitivity so that an IR spectrum of the condensed contaminants is obtained.

NOTE 1 See also clause 5.3.2.14.

NOTE 2 In special cases the standard metal collector plates can be analysed by infrared reflection techniques, however, no quantitative information can be expected from this reflection method. The contaminants can also be washed from the metal collector plates and the washing liquid can be used for further analyses.

5.3.2.13 Cleaning of system

a. After each test, the supplier shall clean the heater bar(s), condensor plate(s) and screen(s) of the equipment with a compatible volatile solvent.

b. The supplier shall perform baking at 25 °C above the specified test temperature if the blank collectors indicate a mass increase > 30 µg during the previous test.

NOTE It is a good practice to bake the system once every four months.

5.3.2.14 Improved sensitivity of the CVCM measurements

a. In cases where the CVCM outgassing requirements are more stringent than the standard detection limits, a quartz crystal microbalance should be installed as a fourth collector plate.

NOTE 1 See clause 5.5.2.

NOTE 2 The infrared transmission data (see 5.3.2.12) can also be used for equivalent mass determination as the intensities of the infrared absorption bands are related to the mass of the contaminants by the law of Lambert-Beer.

5.4 Reporting of test data

a. The supplier shall fill in all data obtained during an outgassing test in a micro VCM worksheet form in conformance with Annex B.

b. The supplier shall report the results in a micro VCM datasheet form in conformance with Annex C.

NOTE The outgassing data are given down to 0,01 % for normal tests, and for tests with increased sensitivity these figures can be one order of magnitude lower.

5.5 Acceptance limits

5.5.1 General requirements

a. The validity of this screening test as a means for determining the suitability of a material for a specific application shall depend on the environmental conditions during the lifetime of the material as well as the vicinity of critical or sensitive surfaces.

b. When the expected maximum temperature of a material during the lifetime is exceeding 125 °C for short period of time (in the order of hours) or is exceeding 50 °C for an extended period of time (in the order of week or above), the use of such material shall be evaluated further through a test programme and mutually agreed between the customer and the supplier.

c. The test programme shall ensure that the characteristics of the material at the EOL are still within the specified limits.

5.5.2 Acceptance limits for a retest of the material

a. The supplier shall test a material threefold.

b. The average data of the three values shall be within the limits as given in 5.5.2d.

c. In case these limits are exceeded, the supplier shall perform a retest of the material.

NOTE The variation of the outgassing data can be caused by the material variance or by the variance of the test parameters.

d. The maximum values for one standard deviation (σ) with respect to the mean values derived from the three specimens of each material tested shall be as follows:

1. $\sigma < 1/10$ of the mean values of TML and RML, with a minimum σ value of 0,05 %;
2. $\sigma < 1/5$ of the mean value of CVCM, with a minimum σ value of 0,03 %.

e. The supplier should have a material sample of > 1 g in order to be able to repeat a test.

NOTE For protection of samples, see clause 5.7.4.2.

5.5.3 Acceptance limits for application of a material

5.5.3.1 General

a. As a minimum, the outgassing screening parameters for a material selection shall be as follows:

1. RML < 1,0 %;
2. CVCM < 0,10 %.

NOTE 1 For materials used in the fabrication of optical devices, or in their vicinity, the acceptance limits can be more stringent than those stated below.

NOTE 2 It is nowadays becoming standard practice to bake critical hardware (such as structural parts, harness, electronic boxes and thermal blankets) to the highest permissible temperature for a few days in order to remove residual contaminants, process contaminants and handling contaminants.

NOTE 3 In this respect it is of interest to test materials after such baking as is expected for the hardware. Also, infrared inspection can be invoked if considered necessary (see clause 5.3.2.12).

5.5.3.2 Corrective actions for high outgassing materials

a. In case the material outgassing is higher than the general requirements in 5.5.3.1, corrective actions shall be taken.

NOTE Corrective actions can be relaxed for the following conditions:

- if very small mass is used;
- if the location of the material is far away from the sensitive items;
- if the high outgassing material is shielded;
- if the outgassing species (e.g. water) are not seen as a critical containment.

5.5.3.3 Water absorption of materials

a. The customer should accept materials with TML > 1,0 % and RML < 1,0 % when the following conditions are met:

1. when no equipment at a temperature below -100 °C is involved;
2. when the water desorption is fast (e.g. in the case of polyimide films and polyurethane paints);
3. when no high voltage equipment is involved;
4. when dry gas purging controls the water reabsorption during ground life up to launch.

NOTE 1 In most cases the water absorption of materials is not harmful with respect to contamination.

NOTE 2 Water absorption of materials is included in the measured TML. The TML data for water absorbing materials such as polyamides, polyimides and polyurethanes, is often above 1,0 %. Water absorption is in most cases reversible and can be controlled by purging of critical hardware with dry gases.

NOTE 3 The measuring method as described in this Standard takes water reabsorption into account, as both the TML and the RML are measured.

NOTE 4 The RML is basically the TML value that does not include reabsorbed water or RML = TML - WVR).

5.5.3.4 More stringent outgassing requirements

a. The customer shall make the limits defined in clause 5.5.3.1 more stringent if the materials concerned are used in critical areas.

NOTE The use of materials that are deemed acceptable according to the limits stated above does not ensure that the spacecraft system or component remains uncontaminated.

b. The customer shall use subsequent functional, development and qualification test.

NOTE This is done to ensure that the material's performance continues to be satisfactory.

c. In case water absorption (or desorption) of materials can result in contamination problems, the customer shall evaluate the outgassing requirements for materials on a case by case basis.

NOTE For example, in case of using cryogenic equipment.

d. For cases where the CVCM requirements are lower than 0,1 % the supplier shall calculate that the CVCM detection limit of the standard Micro-VCM test is around 0,02 %.

NOTE 1 This is because of both material variances and measuring errors.

NOTE 2 For example, cases like certain optics.

e. For cases where CVCM < 0,05 % is required, the supplier shall implement other types of CVCM measurements.

NOTE For Improved sensitivity of CVCM measurements, see clause 5.3.2.14.

5.6 Quality assurance

5.6.1 Data

a. The supplier shall provide the test report in conformance with Annex D.

b. The supplier shall provide the certificate of conformity in conformance with Annex E.

c. The supplier shall retain the quality records for at least ten years or in accordance with project business agreement requirements.

NOTE Example of such quality records are logbooks.

d. The quality records shall be composed of the following:

1. The MIC
2. The Micro-VCM worksheet
3. The Micro-VCM datasheet
4. The test report
5. The certificate of conformity.

5.6.2 Calibration

a. The supplier shall calibrate any measuring equipment to traceable reference standards.

b. The supplier shall record any suspected or actual equipment failure as a project nonconformance report in conformance with ECSS-Q-ST-10-09.

NOTE This is to ensure that previous results are examined to ascertain whether or not re-inspection or retesting is necessary.

5.7 Audit of the Micro-VCM test apparatus

5.7.1 General

a. The standard audit shall be performed according to ECSS-Q-ST-10, clause 5.2.3.

NOTE 1 The main purpose of this audit is to ensure the validity of test results by comparison of the test data on identical materials by different test houses.

NOTE 2 The material outgassing data from test houses for the projects of the customer, obtained in the manner laid down in this Standard, are only accepted for the projects of the customer if the test house is certified to perform the Micro-VCM test.

NOTE 3 The auditing exercise can be part of a "Round Robin" test on different apparatus of selected test houses.

5.7.2 Initial audit of the system (acceptance)

5.7.2.1 General requirement

a. The system shall be audited after it has been built.

NOTE The audit is necessary before the system can be accepted for running qualification or quality control tests on materials for use in customer-projects.

5.7.2.2 Inspection of apparatus and associated equipment

a. The customer shall inspect the following parts of the Micro-VCM apparatus:

1. internal dimensions, view factor (sample compartment to collector plates) and cross contamination protection;
2. pumping system and associated monitoring equipment;
3. temperature regulation of sample and collector plates and associated monitoring equipment;
4. thermal contact of the temperature sensors.

b. The customer shall inspect the following associated equipment:

1. precision balance (reading to 1 μg);
2. temperature and relative humidity in the balance room is controlled to obtain the required accuracy and reproducibility;
3. room for sample pre- and post conditioning;
4. vacuum oven for bakeout of collector plates;
5. clean sample preparation room;
6. infrared apparatus (optional).

5.7.2.3 Performing a blank test

a. The supplier shall perform the blank test with identical conditions and procedures as the normal Micro-VCM test as described in clause 5.3.2, but with empty sample cups.

NOTE The purpose of this test is to ensure the apparatus is performing correctly and no self-contamination occurs.

b. The supplier shall calculate the results for TML, RML and CVCM (theoretically all zero) as for a normal VCM-test.

c. The results shall be within the tolerance as specified for a normal Micro-VCM test, i.e. a mass variation of less than 30 µg on the collector plates.

5.7.2.4 Performing an actual test

a. Seven samples for this test shall be selected and supplied.

b. The supplier shall perform the actual test with identical conditions and procedure as the normal Micro-VCM-test as described in clause 5.3.2.

c. The test shall be performed at the same time by all participants in case of "Round Robin".

d. The acceptance limits shall be within the following limits:

   1. for CVCM/TML/RML values > 0,2 % within 20 % of the average value of all participants;

   2. for CVCM/TML/RML values < 0,2 % within ±0,05 % of the average value of all participants.

5.7.2.5 Nonconformance

a. For nonconformances ECSS-Q-ST-10-09 shall apply.

5.7.2.6 Reporting of audit findings

a. The customer shall deliver a written report of the initial audit including the certificate of conformity, in conformance with Annex E within six weeks after the end of the audit provided no nonconformance are detected.

b. The supplier shall renew the certificate of conformity every three years after a successful audit.

5.7.3 Annual regular review (maintenance) of the system

5.7.3.1 Inspection of apparatus and associated equipment

a. Based on the initial test, as described in clause 5.7.2.2, the customer shall perform a review of any modifications made to the test facility or apparatus.

5.7.3.2 Mutual comparability evaluation (testing)

a. The customer shall select and supply the seven samples for the test.

b. The supplier shall perform this test with identical conditions and procedures as the normal Micro-VCM test as described in clause 5.3.2.

c. All suppliers involved in projects of the customer shall run the test.

5.7.3.3 Nonconformance

a. For nonconformances ECSS-Q-ST-10-09 shall apply.

NOTE 1 This can lead to perform a further test in accordance with clause 5.7.2.4.

NOTE 2 For example, a nonconformance with the applicable audit specification of the customer or the acceptable limits of the test results.

5.7.3.4 Reporting of audit findings

a. The customer shall deliver a written report of the result of the regular review to all participants within six weeks after the end of the regular review or evaluation testing.

5.7.4 Special review

5.7.4.1 General

a. The supplier shall report all modifications of the apparatus or associated equipment.

b. The customer shall audit before using the modified system if deemed necessary.

c. For major modifications, the supplier shall retest the apparatus as described in clause 5.7.2.

5.7.4.2 Preservation of samples

a. The supplier shall preserve a quantity of untested material, sufficient for a second Micro-VCM test for a period of not less than one year.

NOTE This is done so that material is available for submittal to the customer in case of request by the customer's project product assurance representative or department.

Annex A(normative) Materials identification card (MIC) - DRD

A.1 DRD identification

A.1.1 Requirement identification and source document

This DRD is called from ECSS-Q-ST-70-02, requirement 5.2.2.4a.

A.1.2 Purpose and objective

The purpose of this document is to uniquely identify and to provide the properties of the material under testing.

A.2 Expected response

A.2.1 Scope and content

<1> Description and history of sample

a. The materials identification card shall contain the following information:
   1. Trade name and number
   2. Manufacturer
   3. Type of product
   4. Chemical nature
   5. Processing details.

<2> Sample batch

a. The materials identification card shall contain the following information:
   1. Batch number
   2. Sample quantity
   3. Preparation date
   4. Prepared by.

<3> Material and substrate

a. The materials identification card shall contain the following information:

1. Material density
2. Substrate density
3. Substrate material.

<4> Outgassing screening data

a. The materials identification card shall contain the following outgassing screening properties:

1. TML
2. RML
3. CVCM.

<5> Test reference number

a. The materials identification card shall contain a test reference number.

A.2.2 Special remarks

An example of a materials identification card is shown in Figure A-1.

<table>
<tr><th colspan="4">Materials identification card</th></tr>
<tr><td rowspan="3">Description and history of sample
a. Trade name + number
b. Manufacturer
c. Type of product
d. Chemical nature
e. Processing details:
e.g. - joining method
- heat treatment
- cure and postcure
- cleaning method
- relevant spec. no</td><td>a. Aeroglaze Z306 + Pyrolac P123</td><td colspan="2">b. Lord Corporation / Akzo</td></tr>
<tr><td>c. Paint, conductive, black,
Primer yellow</td><td colspan="2">d. Polyurethane / Epoxy</td></tr>
<tr><td colspan="3">e. Mix ratio Primer P123: Hardener = 100 : 25
Paint S125 : Z306 : MEK is 50 : 100 : 60
Cure: 24 hours at room temperature + 6 days at 65 °C
Cleaning with IPA</td></tr>
<tr><td>Batch number
Sample quantity
Preparation date
Prepared by</td><td>1108447
A4 sheet
26/03/99
TOS-QMC</td><td>Material density
Substrate density
Substrate material</td><td>Unknown
2,70 kg/m^3 and 0,0432 g/cm^2
Aluminium foil 16 µm</td></tr>
<tr><td>Contractor/Experimenter</td><td rowspan="2">Contractor</td><td>Project/Cost code</td><td>XMM - Project</td></tr>
<tr><td>Sample code (refer to the DML item number of the project)</td><td>ESTEC PA manager or originator name and signature</td><td>PA name</td></tr>
<tr><td>Application</td><td colspan="3">Coating optical equipment</td></tr>
<tr><td>Test specification number</td><td>ECSS-Q-ST-70-02</td><td>Quality control sample or evaluation sample</td><td>Evaluation</td></tr>
<tr><td colspan="2">For materials and processes division use
Date received: 12.10.1996 Test date: 05.11.1996
Responsible section: PXQ Test number: ESTEC 448</td><td colspan="2">Report number:
Results:
TML = 1,55 %
RML = 0,47 %
CVCM = 0,00 %
❑ Accept ❑ Reject</td></tr>
</table>

Figure A-1: Example of filled MIC

Annex B (normative)
Micro-VCM worksheet - DRD

B.1 DRD identification

B.1.1 Requirement identification and source document

This DRD is called from ECSS-Q-ST-70-02, requirement 5.4a.

B.1.2 Purpose and objective

The purpose of this document is to gather all the measurements necessary to be collected or calculated during micro-VCM testing.

B.2 Expected response

B.2.1 Scope and content

<1> Unique sample identification

a. The Micro-VCM worksheet shall contain a unique sample identification.

<2> Material identification

a. The Micro-VCM worksheet shall contain the material identification.

<3> Weights

a. The Micro-VCM worksheet shall contain the following weights data:
   1. Mass of specimen cup: $\mathbf{W_c}$
   2. Total specimen mass just after test: $\mathbf{W_f}$
   3. Final mass of collector plates after test: $\mathbf{W_g}$
   4. Mass of material before test: $\mathbf{W_m}$

      NOTE $W_m = W_o - W_c - W_s$
   5. Total specimen mass before the test: $\mathbf{W_o}$

      NOTE The total specimen mass (W_o) includes the mass of the material, the mass of the cup and the mass pf the substrate.

6. Initial mass of collector plates before test: $\mathbf{W_p}$
7. Total specimen mass after test and after 24 hours and a final conditioning at (22 ± 3) °C and (55 ± 10) % RH environment: $\mathbf{W_r}$
8. Mass of substrate, determined by weighing or by calculation from density and surface area: $\mathbf{W_s}$.

<4> Outgassing screening data

a. The Micro-VCM worksheet shall contain the following outgassing screening properties:
   1. TML
   2. RML
   3. WCR
   4. CVCM.

   NOTE Table B-1 lists the calculations needed to establish these values.

Table B-1: Outgassing screening properties

Term	Calculations	Remarks
TML %	$\frac{W_0 - W_f}{W_m} \times 100$	$W_m = W_0 - W_c - W_s$
CVCM %	$\frac{W_g - W_p}{W_m} \times 100$	
RML %	$\frac{W_0 - W_r}{W_m} \times 100$	W_r is measured on completion of post conditioning
WVR %	$\frac{W_r - W_f}{W_m} \times 100$	

<5> Test reference number

a. The Micro-VCM worksheet shall contain a test reference number.

<6> IR date

a. The Micro-VCM worksheet shall contain the IR date.

B.2.2 Special remarks

An example of a Micro-VCM worksheet is shown in Figure B-1.

Item no.	Commercial identification or standard designation	W_c cup	W_o total before	W_s substr.	W_m material before	W_f total after	W_r total cond.	W_p collect before	W_g collect after	TML %	RML %	WCR %	CVCM %	Test reference no.	IR date	Observations
1	Honeycomb															
									average							
									standard							
2	Aeroglaze Z306 +	174263	507690	89750	243677	503938	506522	367771	367783	1,54	0,48	1,06	0,00	E 448	None	Black paint with yellow primer
	Pyrolac P123	181391	522828	89231	252206	519016	521730	157207	157213	1,51	0,44	1,08	0,00			
		179771	500914	96667	224476	497303	499780	191537	191569	1,61	0,51	1,10	0,01			
									average	1,55	0,47	1,08	0,01			
									standard	0,05	0,04	0,02	0,01			
3	Aeroglaze Z306 + Pyrolac P123															
									average							
									standard							
4	Eccosil 4952															
									average							
									standard							
5	Araldite AV100/HV100															
									average							
									standard							
6	Electrodag 501															
									average							
									standard							
7	Solitane 113															
									average							
									standard							

Figure B-1: Example of filled in Micro-VCM worksheet

Annex C (normative)
Micro-VCM datasheet - DRD

C.1 DRD identification

C.1.1 Requirement identification and source document

This DRD is called form ECSS-Q-ST-70-02 requirement 5.4b.

C.1.2 Purpose and objective

The purpose of this document is to collect the results of the Micro-VCM test with reference to its unique material identification card

C.2 Expected response

C.2.1 Scope and content

<1> Unique sample identification

a. The Micro-VCM datasheet shall contain an unique sample identification.

<2> Material identification

a. The Micro-VCM datasheet shall include the material identification.

b. The Micro-VCM datasheet shall contain a reference to the relevant materials identification card.

NOTE For the MIC, see Annex A.

<3> Chemical nature

a. The Micro-VCM datasheet shall identify the chemical nature of the material.

<4> Product type

a. The Micro-VCM datasheet shall contain the product type.

<5> Manufacturer

a. The Micro-VCM datasheet shall identify the manufacturer's name.

<6> Summary process parameters

a. The Micro-VCM datasheet shall include a summary of the process parameters.

<7> Use and location

a. The Micro-VCM datasheet shall describe the use and location of the materials in the spacecraft.

<8> User code

a. The Micro-VCM datasheet shall contain the user code.

<9> Outgassing screening data

a. The Micro-VCM datasheet shall contain the following outgassing screening properties:

1. TML
2. RML
3. WCR
4. CVCM.

NOTE Table B-1 lists the calculations needed to establish these values.

<10> Test reference number

a. The Micro-VCM datasheet shall contain a test reference number.

<11> IR data results

a. The Micro-VCM datasheet shall contain the IR data results.

C.2.2 Special remarks

An example of a Micro-VCM datasheet is shown in Figure C-1.

Item no.	Commercial identification or standard designation	Chemical nature ISO-1043	Product type	Procurement information manufacturer/ supplier procurement spec.	Summary of process parameters	Use and location	User code contractor project	TML %	RML %	WVR %	CVCM %	Test reference no.	IR-data results	Observations
1	Honeycomb	EP/Al	honeycomb	Casa	Spec Ca-423-95A	structure	Meris-C3							
2	Aeroglaze Z306 + Pyrolac P123	PUR/EP	paint black/ primer yellow	Lord/Akzo	Cure 24 at RT + 6 d at 65 °C	optical equipment	XMM	1,55	0,47	1,08	0,00	E 448	None	
3	Aeroglaze Z306 + Pyrolac P123	PUR/EP	paint black/ primer yellow	Lord/Akzo	Cure 24 at RT + 6 d at 65 °C	battery PF3/a12	Mipas-A5							
4	Eccosil-4952	SI	potting	Emerson & Cuming	Cure 7 d at RT + 24h at 45 °C	connector	EURECA-Columbus							
5	Araldite AV100/ HV100	EP	adhesive	Ciba Geigy	Cure 4 h at 60 °C	insert	ISO-SS-Fok							
6	Electrodag 501	Fluoro Carbon	paint-cond. black	Acheson	as received		SOHO							
7	Solithane 113	PUR	potting	Thiokol	as received		Silex							

Figure C-1: Example of filled in Micro-VCM datasheet

Annex D (normative) Thermal vacuum outgassing test report - DRD

D.1 DRD identification

D.1.1 Requirement identification and source document

This DRD is called from ECSS-Q-ST-70-02, requirement 5.6.1.a.

D.1.2 Purpose and objective

The purpose of this document is to describe the contents of the thermal vacuum outgassing test report to document the thermal vacuum outgassing test for screening of space materials.

D.2 Expected response

D.2.1 Scope and content

<1> Specific mass of the finished product

a. The report shall contain specific mass of the finished product:
   1. per cm^3 for bulk solid;
   2. per cm^2 for coatings and thin layers;
   3. per cm for wires and threads.

<2> Density of substrate

a. The report shall contain density of substrate in g/cm^2 or ratio of material mass to total mass of material plus substrate.

<3> Identification of test specimen

a. The report shall contain identification of size, area and mass of test specimen, together with an indication of whether the sample was of the substrate or sandwich type.

<4> Nature of the collector plates

a. The report shall contain the nature of the collector plates.

<5> Main wavelength peaks

a. The report shall contain the main wavelength peaks with their wavelength value if an infrared spectrum is obtained of the condensed material.

<6> Noticeable incidents

a. The report shall contain any noticeable incident observed during the test.

<7> Outgassing screening data

a. The report shall contain the following outgassing screening properties:

1. TML
2. RML
3. WCR
4. CVCM.

NOTE Table B-1 lists the calculations needed to establish these values.

<8> Failure mode

a. The report shall contain details of failure mode.

<9> Identification of material

a. The report shall contain the identification of the material, in conformance with 5.2.2.4

D.2.2 Special remarks

None.

Annex E (normative) Certificate of conformity for Micro-VCM - DRD

E.1 DRD identification

E.1.1 Requirement identification and source document

This DRD is called from ECSS-Q-ST-70-02B, requirement 5.6.1b.

E.1.2 Purpose and objective

The purpose of this document is to report the audit findings and to provide to provide a declaration of the auditing authority stating that the supplier of micro VCM test data complies with all the ECSS-Q-ST-70-02 requirements and the audit requirements of ECSS-Q-ST-20.

E.2 Expected response

E.2.1 Scope and content

a. The certificate of conformity shall contain the following audit criteria according to the relevant clauses of ECSS-Q-ST-70-02:

   1. Data recording (in conformance with clause 5.6.1)
   2. Nonconformance
   3. Calibration (in conformance with clause 5.6.2)
   4. Traceability
   5. Inspection of apparatus and associated equipment (in conformance with clause 5.7.2.2)
   6. Performing a blank test (in conformance with clause 5.7.2.3)
   7. Performing an actual test (in conformance with clause 5.7.2.4)

E.2.2 Special remarks

An example of a certificate of conformity is shown in Figure E-1.

Certificate of conformity

This certificate of conformity states that the customer declares that the supplier of Micro-VCM data complies with the requirements in ECSS-Q-ST-70-02 and the audit requirements in ECSS-Q-ST-20.		
Customer (incl. Auditor[s])	*	
Supplier (incl. Operator[s])	*	
Audit criteria according relevant clauses of ECSS-Q-ST-70-02		*
1. Data recording		*
2. Nonconformance		*
3. Calibration		*
4. Traceability		*
5. Inspection of apparatus and associated equipment		*
6. Performing a blank test		*
7. Performing an actual test		*
The audit took place on *_____ and the certification is valid from *_____ to *_____		
This certificate is granted by: ** Name: Signature: Function: Date:		

* fill in
** fill in customer and date

Figure E-1: Example of a certificate of conformity for Micro-VCM

Bibliography

ECSS-S-ST-00	ECSS system – Description, implementation and general requirements