



Space product assurance

**Measurement of the peel and pull-off
strength of coatings and finishes using
pressure-sensitive tapes**

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Foreword

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

Requirements in this Standard are defined in terms of what shall be accomplished, rather than in terms of how to organize and perform the necessary work. This allows existing organizational structures and methods to be applied where they are effective, and for the structures and methods to evolve as necessary without 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 the ESA PSS-01-713, reviewed by the ECSS Technical Panel and approved by the ECSS Steering Board.

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Introduction

Surface coatings, such as thermal control paints and corrosion protection coatings, are affected, both on the ground and after launch, by exposure to the environment.

It is therefore important that the adhesion of the coating to the relevant substrate remains at an acceptable level after exposure to the relevant environmental condition.

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Scope

This Standard details a test in which pressure-sensitive tapes are used to assess the suitability of, for example, coatings, paints, films and other thin materials, proposed for use on spacecraft and associated equipment.

The following materials and assemblies are covered by this test method:

- organic coating, e.g. varnishes, paints and plastic films;
- metallic finishes on, for example, printed-circuit boards, second-surface mirrors, thermal radiators, plastic films;
- adhesive layers;
- composite thin films;
- small assemblies, e.g. solar cells having attached glass covers.

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Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this ECSS Standard. For dated references, subsequent amendments to, or revisions of any of these publications do not apply. However, parties to agreements based on this ECSS Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the 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

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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.

Abbreviation	Meaning
RH	relative humidity

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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 sample for testing shall have clean flat surfaces which do not overlap the sample holder described in subclause 4.4. The width of the test sample surface shall be at least equal to the width of the tape used in the test procedure. The nominal tape width shall be 20 mm.
- d. The number of samples to be taken from a qualification batch, test programme, or production batch shall be specified at the start of the test in a material specification. Normally at least ten (10) test samples shall be tested.
- e. If it is not practicable to obtain suitable test samples from the finished article, the supplier shall furnish bonded test samples (samples under strict source to test control, that shall not be used other than for the designated test) suitable for the tests specified. The supplier shall furnish a certificate of conformance for the purpose of traceability. All test samples shall be marked with appropriate identification to maintain traceability but in such a way as not to degrade the quality of the sample during testing.

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 $(22 \pm 3) ^\circ\text{C}$ and relative humidity of $(55 \pm 10) \%$. 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 Sample conditioning

The sample shall be environmentally conditioned for a nominal 24 hour period. Temperature shall be $(22 \pm 3) ^\circ\text{C}$ with a relative humidity of $(55 \pm 10) \%$. The humidity requirement can be achieved either in a conditioning room, or by dessicators filled with silica gel or a saturated salt solution.

NOTE A saturated salt solution of calcium nitrate gives approximately 51 % relative humidity at the testing temperature.

4.4 Equipment

4.4.1 Special equipment

The following special equipment shall be used.

a. Testing machine

A power-driven machine capable of maintaining a specified constant rate of loading and able to be used for both tensile and compressive testing shall be employed. The machine shall have a fixed or essentially stationary member supporting a load cell and the tape holder. A movable member shall carry the sample holder. The applied compressive and tensile loads, as measured and recorded, shall be accurate within 1 percent of the load. The rate of travel of the sample holder shall be at a nominal rate of 0,2 cm/min.

b. Fixtures

The tape holder shall be of a design similar to that depicted in Figure 1. The part shall screw into the fixed member of the testing machine or be located firmly on it. A length of tape shall be clamped at both ends, the tape passing

over and being in continuous contact with the flat surface of a rubber block having a loading face of $4 \text{ cm}^2 \pm 5 \%$.

4.4.2 Sample holder

The sample holder shall be firmly located beneath the tape holder on the movable member of the testing machine. A suitable design is seen in Figure 1. This preferred system utilizes “top hat” supports onto which individual samples may be mechanically clamped or bonded in such a way that there is no relative movement between the support and the test sample at any time during the test cycle. This type of “top hat” sample support shall slide into a horizontal fixture slot in such a way that its top surface is parallel to and directly beneath the rubber face of the tape holder.

4.4.3 Peel adhesion tape

A range of pressure-sensitive tapes shall be employed for the tests with peel adhesion strengths of 220, 330, 440 and 670 g/cm, all with a tolerance of $\pm 10 \%$.

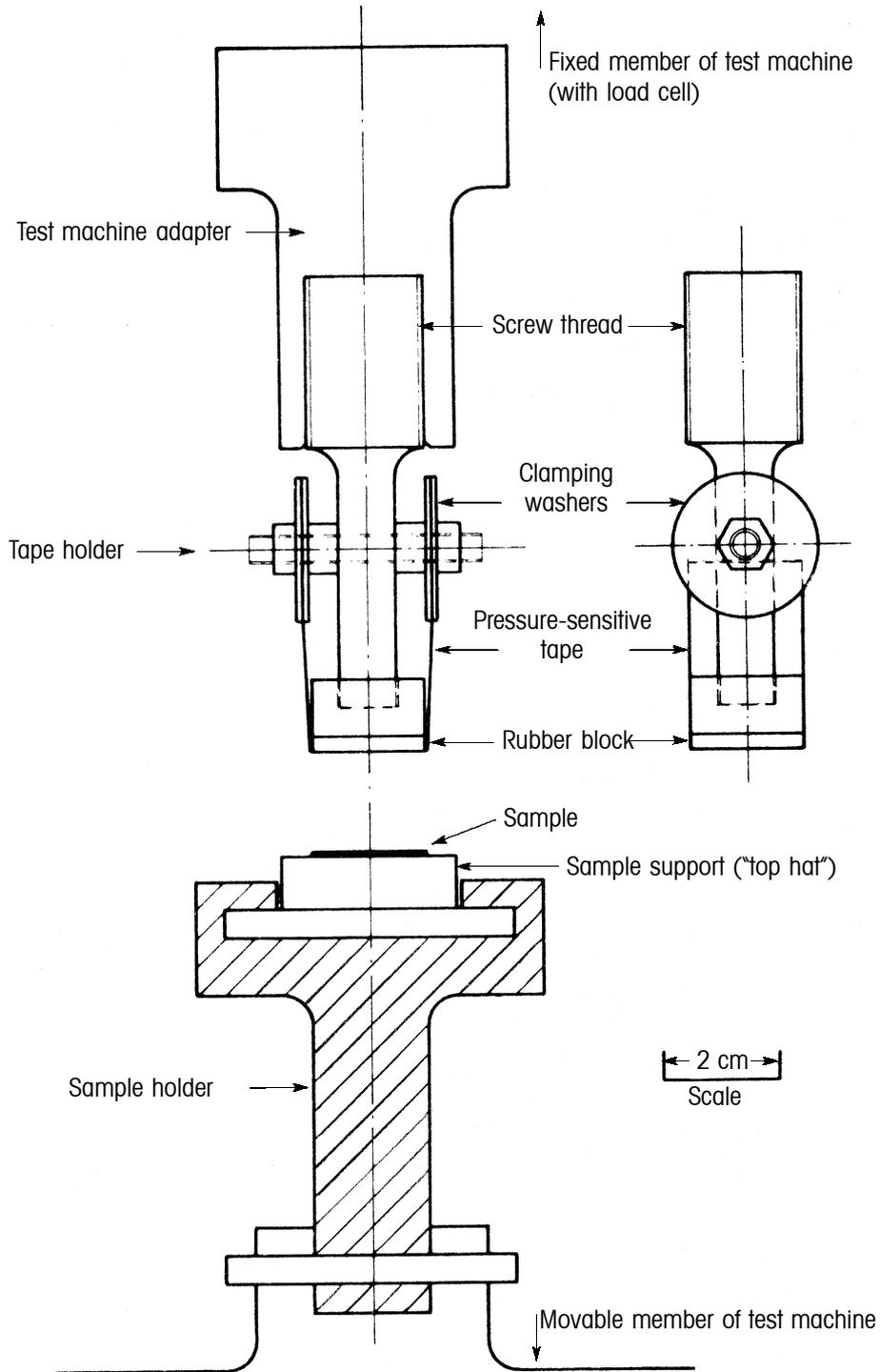


Figure 1: Side view of the test fixtures

Test procedure

5.1 General

The test procedure flow is shown in Figure 2.

5.2 Preparation

5.2.1 Mounting

The test sample shall be located on the sample holder as outlined in subclause 4.4.1 b. If an adhesive bond is used between the sample and the sample support, this shall in no way interfere with the area under test. Care shall be taken to ensure that there is no physical or chemical interaction between any adhesive employed during sample preparation and the sample materials.

5.2.2 Conditioning

The loaded sample support shall be conditioned for a nominal 24 hours in accordance with the requirements stated in subclause 4.3.2 before the test starts.

5.3 Peel and pull-off test

- a. The test shall be conducted as soon as possible after the loaded sample support has been removed from the conditioning atmosphere. The test should be conducted under the same environment conditions.
- b. The tape holder shall be prepared by hand. A length of the lowest peel-strength tape is fixed in such a way that it follows the contour of the rubber block without creases, folds, visible surface flaws or slack spots. The two free ends of the tape are then secured, the tape being stretched so as to leave no slack.
- c. The tape holder and sample support holder shall then be located on the fixed member and the movable member of the machine respectively.
- d. The sample under test, being bonded onto the sample support, shall be positioned in the support holder in such a way as to be directly beneath the rubber block of the tape holder.
- e. The lower adjustable member of the machine is then raised so that the surface of the test sample comes into contact with the pressure-sensitive tape.

- f. A compressive load of a nominal 5 kg shall be carefully applied for a nominal 60 s, so as to ensure that the pressure-sensitive tape is in positive contact with the sample surface.
- g. The movable member of the machine shall then be moved away from the test sample at a constant rate of a nominal 0,2 cm/min until such time as there is complete detachment between the tape and the sample.
- h. The parted surfaces shall be visually examined at a magnification of between $\times 3$ and $\times 7$. Examination shall determine whether separation has occurred cleanly between the tape and the sample surface or whether the surface finish has delaminated from the substrate of the sample.
- i. In the case where separation has occurred cleanly between the tape and the sample surface, the tape fixture shall be removed from the machine and the used tape replaced by a new length of tape having a greater peel strength.
- j. The procedure shall recommence from subclause 5.3 b. and continue until either delamination of the surface finish occurs, or the tape having the maximum peel strength given at subclause 4.4.3 has been employed.

5.4 Handling and packaging of tested samples

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

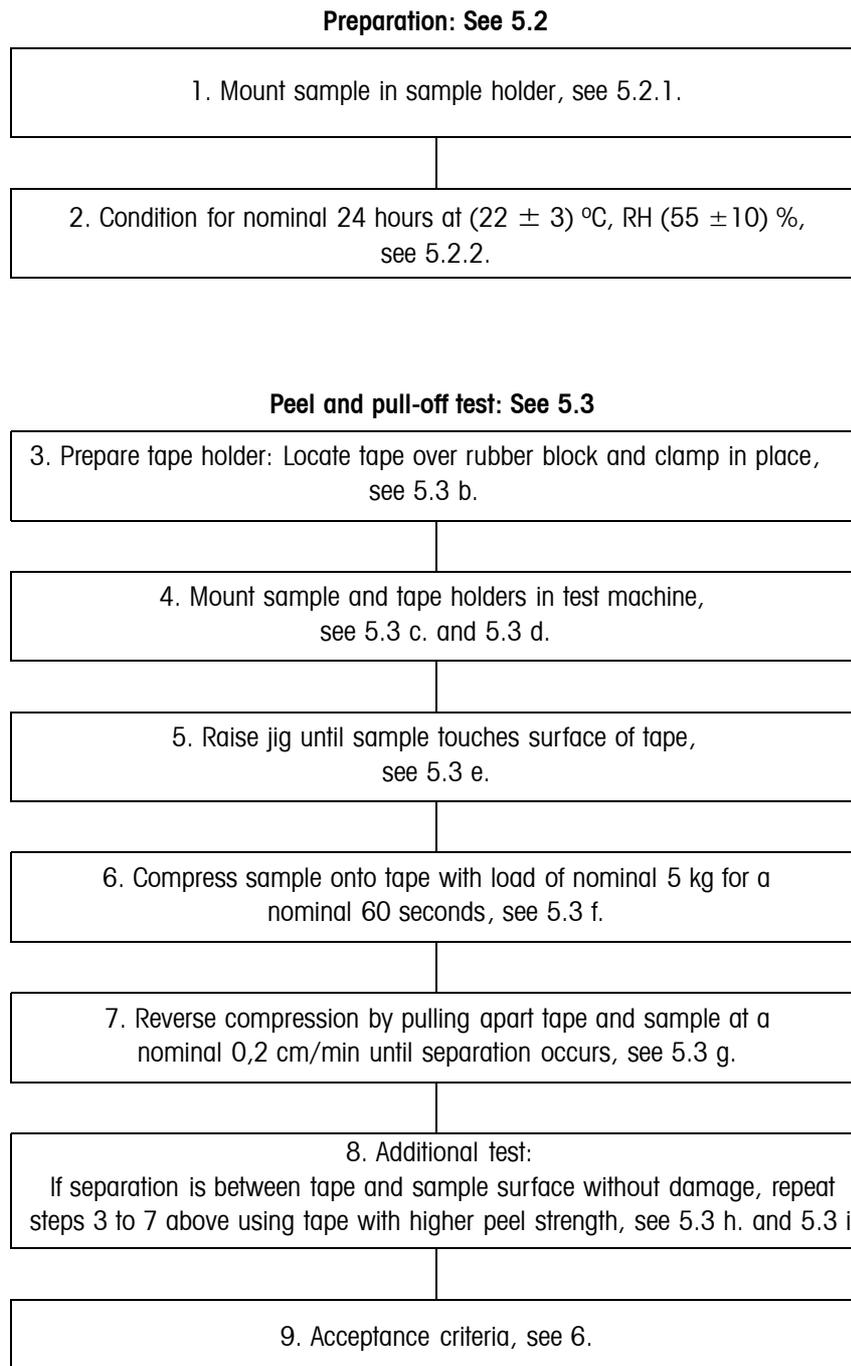


Figure 2: Test procedure flow diagram

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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. Samples which have been disturbed during the test sequence shall be examined in detail. A visual examination for sample defects shall be carried out at $\times 7$ magnification. Higher magnifications should be used during further analysis for locating microscopic defects on any fracture surfaces. Defects (e.g. air bubbles or material inclusions) and the appearance of the fracture (e.g. rough, ductile, smooth or brittle) shall be reported. The particular material or interface along which the fracture path has propagated through the test sample shall be stated. This can be wholly or partly an adhesion fracture, a cohesive separation or an adherent fracture as schematically drawn in Figure 3.
- c. A photographic record of the tested samples should be taken upon request by the customer who shall advise prior to the test. Topographical features should normally be recorded at $\times 2$, $\times 20$, $\times 50$, $\times 100$, $\times 250$, $\times 500$ or $\times 1000$ magnifications as determined by the test engineer.
- d. A full failure analysis, which may include, for example, metallographic studies, chemical analysis or scanning electronic microscopy, shall be performed upon request by the customer who shall advise prior to the test.

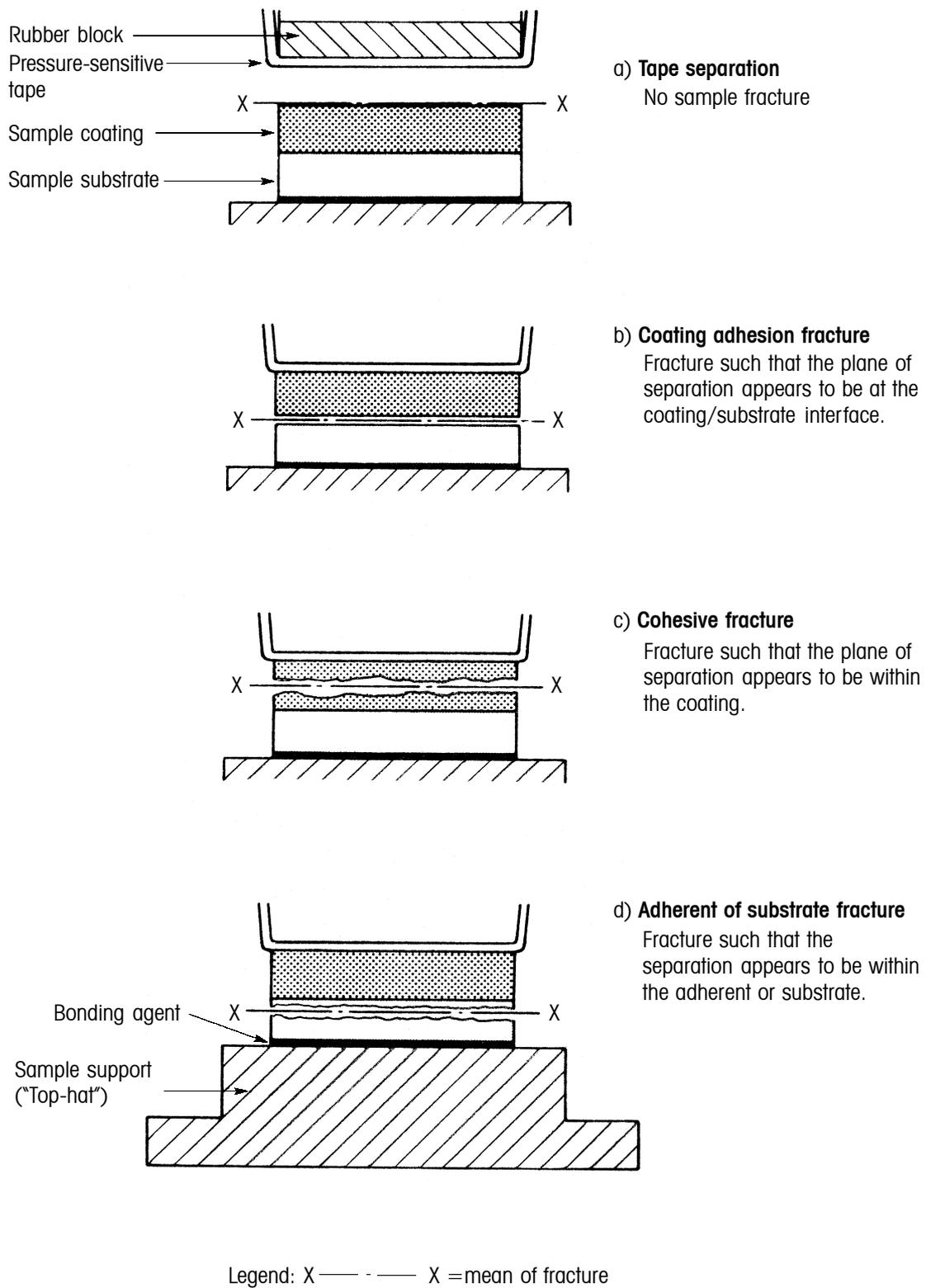


Figure 3: Schematic cross-section of a coated substrate showing various fracture lines dependent on the weakest layer

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 (see also annex A):

- a. trade names and batch numbers of the materials under test;
- b. name of 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;
- e. details of the test parameters outlined in subclause 5.3. This shall also include any variation in testing environment conditions;
- 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. number of sample tests;
- h. results of the values obtained for peel or pull-off strength;
- i. the peel strength indicated by the manufacturer of the pressure-sensitive tape used;
- j. results of any failure analysis carried out according to clause 6;
- k. mode of fracture, as indicated in Figure 3, and any photographic records;
- l. 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 test equipment and personnel employed in performing the task.

Annex A (informative)

Example of a test result sheet

Materials Section, Product Assurance Division, ESTEC				
Sample details				
1. Description and history of sample:				
2. Trade name:				
2. Batch number:				
4. Coating or finish material manufacturer:				
5. Supplier through whom material is purchased:				
6. Coating or finish prepared by:				
7. Summary of preparation schedule:				
8. Number of samples submitted:				
9. Criteria for test, e.g. lowest acceptable peel or pull-off strength:				
10. Project and cost code number:				
Date:	Originator:	Telephone:		
Test results				
11. Test equipment:				
12. Test temperature: °C			13. Relative humidity: %	
14. Speed of testing: cm/min				
15. Sample number	16. Peel strength of tape employed *	17. Peel or pull-off strength of sample **	18. Mode of fracture, see Figure 3	19. Further examinations
Conclusions				
Date:	Test engineer:	Approval:		

* as indicated by manufacturer, the peel strength of tape when sample separation commenced is underlined.
 ** from chart record

ECSS Document Improvement Proposal

1. Document I.D. ECSS-Q-70-13A	2. Document date 4 October 1999	3. Document title Measurement of the peel and pull-off strength of coatings and finishes using pressure-sensitive tapes
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:	7. Date of submission:
Address:	Phone: Fax: E-Mail:	
8. Send to ECSS Secretariat		
Name: W. Kriedte ESA-TOS/QR	Address: ESTEC, P.O. Box 299 2200 AG Noordwijk The Netherlands	Phone: +31-71-565-3952 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.

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<http://www.estec.esa.nl/ecss/improve/>

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