



Space product assurance

Application of paints on space hardware

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 ECSS-Q-70-31 Working Group, reviewed by the ECSS Executive Secretariat and approved by the ECSS Technical Authority.

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Introduction

This Standard describes in a generic way the methods and techniques that can be used for application of paints on space hardware. This document is prepared to replace all existing ECSS-Q-70 paint standards, i.e. ECSS-Q-70-25A, ECSS-Q-70-33A, ECSS-Q-70-34A and ECSS-Q-70-35A. It also covers the acceptance criteria for paints.

The parameters to be defined are:

- For substrate:
 - Cleanliness
 - Roughness or other preparation
- For primer:
 - Quality
 - Thickness
 - Adhesion
 - Time between application of primer and application of paint
- For paint:
 - Aspect
 - Thickness
 - Adhesion
 - Thermo-optical properties
 - Electrical properties

NOTE This list is not exhaustive.

1 Scope

This Standard defines the approach for producing a defined surface finish to spacecraft or associated equipment, by means of the controlled application of a paint. This also includes measurements and verifications to be performed.

This standard may be tailored for the specific characteristic and constraints of a space project in conformance with ECSS-S-ST-00.

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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 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-10-09	Space product assurance - Nonconformance control system
ECSS-Q-ST-20	Space product assurance - Quality assurance
ECSS-Q-ST-70	Space product assurance - Materials, mechanical parts and processes
ECSS-Q-ST-70-02	Space product assurance - Thermal vacuum outgassing test for the screening of space materials
ECSS-Q-ST-70-09	Space product assurance - Measurement of thermo-optical properties of thermal control materials
ECSS-Q-ST-70-13	Space product assurance - Measurement of the peel and pull-off strength of coatings and finishes using pressure-sensitive tapes
ECSS-Q-ST-70-22	Space product assurance - Control of limited shelf-life materials
ASTM D1005-95	Standard Test Method for Measurement of Dry-Film Thickness of Organic Coatings Using Micrometers
ASTM D1400-94	Standard Test Method for Non-destructive Measurement of Dry Film Thickness of Nonconductive Coatings Applied to a Nonferrous Metal Base
ISO 2409:2007	Paints and Varnishes – Cross-cut test
ISO 2360:2003	Non-conductive coatings on non-magnetic electrically conductive basis materials – Measurement of coating thickness – Amplitude-sensitive eddy current method
EC 1907/2006	European regulation for the registration, evaluation, authorisation and restriction of chemicals

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Terms, definitions and abbreviated terms

3.1 Terms from other standards

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

3.2 Terms specific to the present standard**3.2.1 hemispherical emittance (ϵ_h)**

ratio of the radiant intensity of the specimen to that emitted by a black body radiator at the same temperature and under the same geometric and wavelength conditions

NOTE Examples are:

- Hemispherical emittance (ϵ_h) -- conditions for incident or viewing of flux over a hemispherical region.
- Normal emittance (ϵ_n) -- conditions for incidence or viewing through a solid angle normal to the specimen.

3.2.2 solar absorptance (α_s)

ratio of the solar radiant flux absorbed by a material (or body) to that incident upon it

NOTE Differentiation is made between two methods:

- Spectroscopic method using a photospectrometer covering the range from 0,25 μm to 2,5 μm for the determination of α_s .
- Portable equipment using a xenon flash for relative measurements (α_p).

3.2.3 toxic

substance causing serious, acute or chronic effects, even death, when inhaled, swallowed or absorbed through the skin

3.2.4 viscosity

measure of the fluidity of a liquid, in comparison with that of standard oil based on the time of outflow through a certain orifice under specified conditions

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
RML	recovered mass loss
REACH	registration, evaluation, authorisation of chemicals

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Requirements

4.1 General

4.1.1 Establishment of verification programme

- a. The adequacy of a paint process shall be demonstrated through a verification programme.
- b. Depending on the specific project requirements, the paint applied shall fulfil part or all the acceptance criteria given in 4.4 of this Standard.
- c. ECSS-Q-ST-70 shall apply.
- d. The supplier shall use for paint applications only materials that are registered in the REACH database and follow the REACH instructions.

4.1.2 Surface to be coated

- a. All couples paint - substrate shall be qualified for the given application, taking into account the use conditions.

NOTE 1 Examples of use conditions are temperature, thermal cycling, optical, mechanical and electrical properties.

NOTE 2 There exist no universal paint systems that can be applied to all substrates.

- b. The suitability of the substrate with respect to the paint process shall be demonstrated on representative test pieces having the same specific characteristics as the workpiece.

NOTE Representative sample does not only concern the composition, but also the state of the surface and the geometry of the work piece.

4.1.3 Potential limitations on parts geometry and structure

- a. The paint application process shall be adapted to the geometry of the surface to be coated.

NOTE The geometry of the surface to be coated has an impact on the characteristics of the paints

4.1.4 Aspect and dimensions of parts prior to painting

- a. In case of scratching, shock or any other event disturbing the surface aspect, the customer shall be informed and a non conformance report issued.

NOTE While handling the parts to be coated, it is important to note that the paint layer mimics the underlying substrate.

4.2 Preparatory conditions

4.2.1 Hazards, health and safety precautions

- a. The details of hazards for each material used in the process shall be available to all personnel involved into the application.
- b. All Material Safety Data Sheets shall be available and known to the operators and supervising staff.
- c. In addition, hazards to personnel, equipment, environment and materials shall be controlled and reduced to an acceptable risk.

NOTE Hazard can be reduced by using protective clothing.

4.2.2 Preparation of materials and workpieces

4.2.2.1 Handling and storage

- a. The conditions for handling and storage of materials used in this process shall be clearly indicated to all operators and supervising staff.
- b. The workpiece or sample shall only be handled with clean, powder-free and lint-free gloves and shall be stored in a clean area.
- c. Gloves shall be compatible with all compounds used.

NOTE For example: compatibility between paint, solvents, and cleaning agents.

- d. Coated surfaces shall be shielded from contact by using appropriate bags or sheets.

NOTE The suitable bags are for example plastic bags with desiccators, sheet of tissue-paper, sheet of polyethylene foam.

- e. Mechanical damage shall be avoided in the standard way by wrapping the packed pieces in clean, dust- and lint-free material.
- f. Limited-life materials shall be labelled with their relative shelf-lives and dates of manufacture or date of delivery if date of manufacture is not known.

NOTE See ECSS-Q-ST-70-22, clause 4.1.3.

4.2.2.2 Identification

- a. Materials used in this process shall be labelled and identified by:
 1. Trade name and lot number.
 2. Name of manufacturer or agent through whom the purchase was made.
- b. Workpiece submitted for treatment shall as a minimum be identified by:
 1. Name and lot number of item.
 2. Name of manufacturer or supplier through whom the item was obtained.
 3. Configuration-control status of the item.

4.2.2.3 Quality control samples

- a. For spraying operation, samples shall be produced at the same time as the paint operation in order to control the quality of the paint.
- b. These samples shall be of the same material and be surface treated in the same manner as the workpiece.
- c. Adhesion test sample shall be prepared and tested according to ECSS-Q-ST-70-13, clause 5.1.2, ISO-2409:2007, or equivalent national standards.

NOTE For silicone's paint, a tape based on silicon adhesive is used. However the added power of such tape can be out of the ISO specified strength

- d. For the thermo-optical properties measurement at least 4 control samples of minimal dimension 20 mm × 20 mm shall be prepared and tested according to ECSS-Q-ST-70-09 clause 4.2.
- e. The samples prepared as specified in 4.2.2.3a. to d. may be used for paint thickness measurement.

4.2.3 Procurement

- a. The procurement details for each material used in the process shall be stated in the relevant procurement specifications and supporting documentation.

NOTE For example, in a traceability folder.

4.2.4 Facilities

4.2.4.1 Cleanliness

- a. The work area shall be a clean area.
- b. Air used for ventilation shall be filtered to prevent contamination of the workpieces.

4.2.4.2 Environmental conditions

- a. The ambient conditions for the process and work areas shall be (22 ± 3) °C with a relative humidity of (55 ± 10) % unless otherwise stated.
- b. The ambient conditions specified in 4.2.4.2a may be different, providing that are qualified for the specific process.
- c. During paint operations the temperature of the workpiece shall not fall below the dew point of the ambient air.
- d. If condensation is observed on the workpiece, the paint operation shall be suspended immediately.

4.2.4.3 Special utilities

- a. Dependant on the specific requirements, the following utilities shall be available:
 1. An oven capable of maintaining the workpiece in a clean environment and within ± 5 °C of the required control temperature.
 2. An ultrasonic bath.

NOTE A combined system can be used, in which ultrasonic cleaning can be followed by vapour cleaning.
 3. A fume cupboard used for handling toxic or irritating primers, paints, solvents or cleaning agents.
 4. A spray booth.
- b. The air flow velocity at the spray table shall be sufficient to prevent dry overspray from settling on surfaces which have been coated and which are still tacky.
- c. Vapour from solvents shall be controlled by means of a positive exhaust at the rear of the spray booth.

4.2.5 Equipment

- a. Dependant on the specific application, the following special items of equipment shall be used:
 1. Spray-gun

NOTE Size and type of spray-gun depend on the size and shape of the workpiece. For most of the work, a standard spray-gun of a good make, preferably with a gravity cup, is adequate.
 2. Brushes

NOTE For repairing small damaged areas, brushes can be used.
 3. Containers
 4. Test equipment.

- b. For small areas or places difficult to reach, an airbrush may be used.
- c. For each type of paint or primer, a spray-gun specifically for that paint/primer shall be reserved.
- d. A spray gun shall be cleaned with an adequate solvent before and after spraying.
- e. For repairing small damaged areas, brushes may be used.
- f. Brushes shall be new or cleaned after use with a proper solvent.
- g. All containers to be used for preparing paints shall be cleaned and dried so that the paint is not contaminated.
- h. For acceptance tests, the test equipment as specified in the following documents, shall be used:
 - 1. ECSS-Q-ST-70-13 or ISO 2409:2007 or equivalent national standards for the adhesion properties.
 - 2. ECSS-Q-ST-70-09 or equivalent national standards for the thermo-optical properties.
 - 3. ASTM D1005-95 or ISO 2360:2003 or equivalent national standards for the thickness measurements.
 - 4. ECSS-Q-ST-70-02 or equivalent national standards for the outgassing properties.
 - 5. Suitable measuring equipment to fulfil the monitoring requirements of the process i.e.:
 - (a) Calibrated equipment for measuring the required temperature and humidity environment;
 - (b) Weighing equipment for thinner and paint;
 - (c) Viscosity cup (Ford, DIN, ISO or AFNOR);
 - (d) Volume Graduated containers to measure primer;
 - (e) Equipment for determining electrical surface / bulk resistance in the case of electrical conductive paints.

4.3 Procedures

4.3.1 Pre-treatment

4.3.1.1 Abrasion of surface

- a. Surfaces shall be abraded in order to increase the adherence according to coating material manufacturer requirement and agreed with customer.

NOTE 1 Emery paper, sand paper, grit blasting can be used as abrasion medium.

NOTE 2 In certain cases, abrasion is not feasible or can damage the item.

- b. The maximum duration between abrasion and application of primer or paint shall be in line with the manufacturers' suggestions.

NOTE Typically for metals re-growth of the oxide layer means there is a limit of 2-4 hours.

4.3.1.2 Cleaning

- a. Surfaces shall be cleaned according to an agreed procedure between the supplier and the customer.
- b. Surfaces shall be free of dust and grease.

NOTE This can be achieved by standard cleaning procedures or by the manufacturer cleaning method.

- c. Workpieces with complex shapes shall be ultrasonically cleaned.
- d. For large pieces, or pieces that for other reasons cannot be ultrasonically cleaned, surfaces shall be carefully cleaned by hand with cleaning solvents and clean tissues.

NOTE The cleaning solvents are for example ketons, alcohols or ionic liquids.

- e. When cleaning with tissues, the single wipe approach shall be used.

4.3.1.3 Handling and protection of surfaces

- a. Unless specified otherwise, all operations following cleaning shall be performed by personnel wearing appropriate clean gloves.
- b. The handling of parts shall be kept to a minimum.
- c. Throughout all operations, contamination of surfaces shall be avoided.

NOTE Example of such contamination are fingerprints, hair or dust.

- d. The hardware shall be protected from random temperature extremes, high humidity and physical damage.
- e. The paint shall not be applied before any mechanical operations.

NOTE Examples of mechanical operations are machining, drilling, forming or welding.

- f. Adhesive bonding on surfaces to be coated shall be completed before paint application.

4.3.2 Masking

- a. Surfaces to be masked shall be free of dust and grease.
- b. Paint shall be masked with pressure-sensitive tape, leaving no residue after removal or with clean non-absorbent paper.
- c. Parts that are subject to damage by tape removal shall be identified and protective measures shall be taken.

NOTE Examples of these parts are thin-gauge materials or thin plating.

- d. Parts that are subject to possible contamination by tape adhesive shall be identified and protective measures shall be taken.

NOTE Examples of these parts are optical components, or other temperature control surfaces.

- e. Parts shall be coated as soon as possible after cleaning.

NOTE When using solvents, it is important to take care of the dewpoint.

- f. If the time before application is likely to exceed eight hours, the parts shall be protected through bagging.

4.3.3 Primer

4.3.3.1 Preparation and application

- a. The primer shall be prepared as defined in the manufacturer's or other primer specific preparation procedure, taking into account all needed precautions regarding mixing.
- b. The primer shall be applied within the specified pot-life and to the thickness as defined in the manufacturer's or other primer specific application procedure and using dry nitrogen or clean compressed air as spray gas.

NOTE 1 Generally the thickness of the primer is measured after the drying, and before application of the next layer.

NOTE 2 This is however not possible in case of silane primer.

4.3.3.2 Curing

- a. Before application of the paint, the primer shall be cured in a clean and dust-free area for duration as defined in the manufacturer's or other paint specific application procedure.
- b. Following priming and primer cure the workpieces may be stored before commencing painting in accordance with the manufacturers' instructions.

4.3.4 Paint

4.3.4.1 Preparation and application

- a. The paint shall be thoroughly homogenised in its original container by stirring or shaking, as defined in the manufacturer's or other paint specific application procedure.

- b. After the desired amount has been poured into a dry, clean container, thinner or solvent shall be added to obtain the specified viscosity and the mixture homogenised.
- c. The amount of thinner/solvent shall be established by making test pieces which bear a strongly adhering, homogeneous layer.

NOTE The amount of thinner/solvent needed depends on the type of spray gun that is used.

- d. Once the amount of thinner/solvent is defined for a certain set-up, the viscosity shall be measured, and instructions for the workshop set down to obtain duplication of the process.
- e. The paint shall be filtered according to supplier requirements.
- f. Dry nitrogen or clean compressed air shall be used as spray gas.
- g. For brush application, the amount of thinner/solvent shall be established.
- h. Depending on the desired thickness, an adequate number of crossed layers shall be sprayed with a drying time between each layer as defined in manufacture's or other paint specific application procedure.
- i. The crossed layers shall be smooth and even with no localised concentrations of paint or agglomerations.

NOTE In order to avoid pooling of the liquid paint through dwelling the spray too long in one area.

- j. After the last layer has been applied, the workpieces shall be dried for a time needed to obtain a touch-dry surface before they are transported to the curing area.

4.3.4.2 Unmasking

- a. Unmasking shall be performed after the paint is sufficiently dried or cured to avoid damage.
- b. Preliminary test pieces shall be made to evaluate this drying time.
- c. Unmasking shall be performed carefully to avoid the starting of pulling stresses in the paint.
- d. If masking tape adhesive remains on the surface, no attempt shall be made to clean it off until after the final cure.

4.3.4.3 Curing

- a. The workpiece shall be placed in a clean, controlled environment for final cure.
- b. The temperature, humidity and pressure conditions used for the final curing shall be as defined in manufacture or other paint specific application procedure.

NOTE For temperature sensitive equipment, it is possible to reduce the temperature, provided that the cure time is increased.

4.3.5 Handling and packaging of finished parts

- a. For handling and packaging of finished parts 4.2.2.1a and 4.2.2.1b shall apply.

4.3.6 Paint repairing process

4.3.6.1 General

- a. In agreement with the customer, surfaces shall be repaired according to the manufacturer's specifications.
- b. For small areas (less than 2 cm x 2 cm), the repairing shall be done with a paint brush in a clean room.
- c. For areas between 2 cm x 2 cm and 10 cm x 10 cm, a low pressure spray shall be used.
- d. For areas between 2 cm x 2 cm and 10 cm x 10 cm, the repairing shall be done in a painting room.
- e. If the area to repair is larger than 10 % of the total surface, the paint shall be removed from the total surface by using paint stripper or mechanical stripping.
- f. After stripping, the surface shall be cleaned according to 4.3.1.2a.
- g. Paint stripper shall be washable with normal cleaning solvent.

4.3.6.2 Paint brush repairing process

- a. For paint brush repairing, cleaning shall consist in:
 - 1. removing any non adhesive part on the area to repair with a small wooden stick;
 - 2. cutting the edges with a scalpel, to obtain bevelled sides;
 - 3. cleaning the area to repair with a thinner soaked cotton stick;
 - 4. moistening the adjacent paint with the same thinner.
- b. For paint brush repairing, painting shall consist in:
 - 1. applying thin coats of paint when the thinner is evaporated, and letting dry a few minutes between each coat;
 - 2. applying the two first coats and the last one with a diluted paint.
- c. If the primer needs to be repaired, the same process as the paint shall apply (see technical data sheet).

4.3.6.3 Spray gun process

- a. For spray gun, cleaning shall consist in:
 - 1. removing any non adhesive part on the area to repair with a small wooden stick;
 - 2. cutting the edges with a scalpel, to obtain bevelled sides;

3. cleaning the area to repair with a thinner soaked cotton stick;
 4. masking the areas already painted to avoid a fog of paint on them;
NOTE This ensures that the masking is not damaging the paint.
 5. moistening the adjacent paints with the same thinner.
- b. For spray gun, painting shall consist in:
1. applying the paint using the spray gun as soon as the thinner has evaporated;
 2. applying the primer as described in technical data sheet, if the primer needs to be repaired;
 3. applying the paint after complete drying.

4.4 Acceptance criteria

- a. The following properties of the control samples that were prepared at the same time as the workpieces shall be tested:
 1. Thickness
 2. Thermo-optical properties
 3. Adhesion properties
 4. Outgassing properties
- b. Thickness shall be measured in accordance with ASTM D1005-95 or ASTM D1400-94 or equivalent national standards
- c. Thermo-optical properties shall be measured according to ECSS-Q-ST-70-09.
NOTE 1 Solar absorptance (α_s) or solar absorptance with portable equipment (α_p).
NOTE 2 Hemispherical emittance (ϵ_h) or normal emittance with portable equipment (ϵ_n).
- d. Adhesion properties shall be measured according to ECSS-Q-ST-70-13, ISO 2409:2007 or equivalent national standards.
- e. When measuring the adhesion properties, there shall be no sign of paint lifting from the surface.
- f. Outgassing properties shall be measured according to ECSS-Q-ST-70-02.
- g. Unqualified couple paint substrate with respect to outgassing requirement (as defined in ECSS-Q-ST-70-02), shall undergo a four weeks curing under atmospheric condition prior performing the outgassing qualification.

4.5 Quality assurance

4.5.1 General

- a. The quality assurance requirements defined in ECSS-Q-ST-20 shall apply

4.5.2 Data

- a. The quality records shall be retained for at least ten years or in accordance with project business agreement requirements, and contain as a minimum the following:
 - 1. copy of the final inspection documentation;
 - 2. index of limited-life materials and their use times;
 - 3. nonconformance reports and their corrective actions;
 - 4. test pieces for ongoing verification;
 - 5. copy of the inspection and test results with reference to relevant procedure;
 - 6. event log which is a chronological history of process operations, inspections;
 - 7. tests reports ;
 - 8. details of failure mode (if applicable);
 - 9. REACH identification number (if applicable).

NOTE Example of quality records are logbooks.

4.5.3 Nonconformance

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

4.5.4 Calibration

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

4.5.5 Traceability

- a. 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.

Bibliography

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