

Space product assurance

The application of the thermal control
coating PSG120FD

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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 documents.

This Standard has been prepared by editing the ESA PSS-01-733, reviewed by the ECSS Technical Panel and approved by the ECSS Steering Board.

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Introduction

The most critical use of paints in satellites is in the thermal-control subsystem. PSG120FD has a purified binder which renders it low in outgassing and condensable contaminants and can be cured at room temperature. A good adherence is obtained on ferrous metals, steels, light alloys and glass-reinforced-resin structures after treatment of the substrate with P128 primer, and on electrolytic gold surfaces with P123 primer followed by P128 primer.

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Scope

This Standard defines the process by which PSG120FD white, zinc-oxide-pigmented, silicone-based coating (paint) is used to produce a low outgassing, thermal control coating on spacecraft items.

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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-70	Space product assurance - Materials, mechanical parts and processes
ECSS-Q-70-02	Space product assurance - Thermal vacuum outgassing test for the screening of space materials (to be published)
ECSS-Q-70-09	Space product assurance - Measurement of thermo-optical properties of thermal control materials (to be published)
ECSS-Q-70-13	Space product assurance - Measurement of the peel and pull-off strength of coatings and finishes with pressure sensitive tapes
ASTM D1005-95	Standard Test Method for Measurement of Dry-Film Thickness of Organic Coatings Using Micrometers
ASTM D1400-94	Standard Test Method for Nondestructive Measurement of Dry Film Thickness of Nonconductive Coatings Applied to a Nonferrous Metal Base

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Terms, definitions and abbreviated terms

3.1 Terms and definitions

The following terms and definitions are specific to this Standard in the sense that they are complementary or additional with respect to those contained in ECSS-P-001.

3.1.1 Flammability

A measure of the ease with which a material is set on fire.

3.1.2 Flashpoint

The flashpoint is the lowest temperature at which a material gives off flammable vapour which, when mixed with the test atmosphere and exposed to an ignition source, will provide a non-self sustaining flash.

3.1.3 Hemispherical emittance (ϵ_h)

Is the total energy emitted over the hemisphere above the emitting element for all wavelengths.

3.1.4 Solar absorptance (α_s)

The relationship between the absorptance of a test item irradiated with a solar simulator to the absorptance the test item would experience from the sun.

3.1.5 Toxic

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

3.1.6 Viscosity

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

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

The details of hazards for each material used in the process are tabulated in Table 1. In addition, hazards to personnel, equipment and materials shall be controlled and reduced to a minimum.

4.2 Preparation of materials and workpieces

4.2.1 Handling and storage

The conditions for handling and storage of materials used in this process are given in Table 1.

The workpiece or sample shall only be handled with clean nylon or lint-free gloves and shall be stored in a cleanliness 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. Mechanical damage shall be avoided in the standard way by packing the polyethylene- or polypropylene- wrapped workpieces in clean, dust- and lint-free material.

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.

4.2.2 Identification

- a. **Materials.** Materials used in this process shall be labelled as stated in sub-clause 4.2.1 (if applicable) and be fully identified by:
 1. Trade name and lot number.
 2. Name of manufacturer or agent through whom the purchase was made.
- b. **Workpiece.** The 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 item was obtained.
 3. Configuration-control status of the item.

4.2.3 Test samples

For spraying operation samples shall be produced at the same time as the painting operation in order to control the quality of the coating. The test pieces shall be of the same material and be surface treated in the same manner as the workpiece.

For the adhesion test a minimum of 5 samples of dimension 20 mm × 20 mm × 1 mm shall be prepared and tested according to annex A.

For the thermo-optical properties measurement at least 4 samples of dimension 20 mm × 20 mm × 1 mm shall be prepared and tested according to ECSS-Q-70-09.

The samples prepared above may be used for paint thickness measurement.

4.3 Procurement

The procurement details for each material used in the process are listed in Table 1.

4.4 Facilities

4.4.1 Cleanliness

The work area shall be clean and free of dust. Air used for ventilation shall be filtered to prevent contamination of the workpieces.

4.4.2 Environmental conditions

The ambient conditions for the process and work areas shall be $(22 \pm 3) ^\circ\text{C}$ with a relative humidity of $(55 \pm 10) \%$ unless otherwise stated. During painting operations the temperature of the workpiece shall not fall below the dew point of the ambient air. If condensation is observed on the workpiece, the painting operation shall be suspended immediately.

4.4.3 Special utilities

- a. **Ultrasonic bath.** A combined system should be used, in which ultrasonic cleaning can be followed by vapour cleaning.
- b. **Fume cupboard.** For use when handling paints or solvents.
- c. **Spray booth.** The air flow velocity at the spray table shall be sufficient to prevent dry overspray from settling on surfaces which have been painted and which are still tacky. Vapour from solvents shall be controlled by means of a positive exhaust at the rear of the spray booth.

4.5 Equipment

The following special items of equipment shall be used:

- a. **Spray-gun.** 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. For small areas or places difficult to reach, an airbrush may be used. A spray-gun specifically for PSG120FD should be reserved.

The spray-gun used for PSG120FD shall be cleaned with S105 thinners before and after spraying. Clean the spray-gun used for P123 primer with S125 thinner.

- b. **Brushes.** For repairing small damaged areas, brushes may be used. They should be new and cleaned after use with the relevant diluent. Never use brushes that have been used for other types of paint.
- c. **Containers.** All containers to be used for preparing paints shall be cleaned and dried carefully so that the paint is not contaminated.

d. Test equipment

1. For acceptance tests the appropriate test equipment as specified in the following documents, shall be used:

ECSS-Q-70-09	Thermo-optical properties
Annex A	Adhesion test method
ASTM D1005-95	Standard Test Method for Measurement of Dry Film Thickness of Organic Coatings Using Micrometers
ASTM D1400-94	Standard Test Method for Nondestructive Measurement of Dry Film Thickness of Nonconductive Coatings Applied to a Nonferrous Metal Base

2. Suitable measuring equipment to fulfil the monitoring requirements of the process i.e.:

Temperature	10 °C to 30 °C accurate to ± 1 °C
Humidity	RH 40 % to 70 % accurate to ± 1 % RH
Weight	Suitable range to weigh paint and thinners
Viscosity	Viscosity cup (Ford or DIN)
Volume	Graduated containers

Table 1: Materials: procurement, storage and hazards

Item no.	Description	Supplier	Storage	Safety precautions
1	PSG120FD paint including Hardener CT122, Thinners S105	AKZO-Dexter Aerospace B.P. 141 F-60761 Montataire Cedex France	Shall be stored at a temperature of $(22 \pm 3) ^\circ\text{C}$ in hermetically sealed containers. Shelf-life is 6 months from date of manufacture.	Use paint in well ventilated areas. Contact with skin and eyes shall be avoided. Not all health effects have been investigated and it shall be handled with utmost care. Flammable. Toxic.
2	P123 primer including Hardener CX124, Thinners S125	AKZO-Dexter Aerospace B.P. 141 F-60761 Montataire Cedex France	Shall be stored at a temperature of $(22 \pm 3) ^\circ\text{C}$ in tinned metal or polypropylene containers. Shelf-life is 12 months from date of manufacture.	Use paint in well ventilated areas. Contact with skin and eyes shall be avoided.
3	P128 primer	AKZO-Dexter Aerospace B.P. 141 F-60761 Montataire Cedex France	Shall be stored at a temperature of $(22 \pm 3) ^\circ\text{C}$ in hermetically sealed containers. Shelf-life is 6 months from date of manufacture.	Use paint in well ventilated areas. Contact with skin and eyes shall be avoided.
4	Ethane, 1,1,2-trichloro-1,2,2-trifluoro-, Ethane, 1,1-dichloro-1-fluoro-, or equivalent ①	Any suitable supplier	Shall be stored at a temperature of $(22 \pm 3) ^\circ\text{C}$ in their original containers. Preferably sealed to avoid contamination by improper use.	Shall be used in a well ventilated area in accordance with suppliers data sheet.
5	Isopropanol Analytical grade	Any supplier that meets this specification	Shall be stored at a temperature of $(22 \pm 3) ^\circ\text{C}$ in a hermetically sealed container.	Flashpoint $11 ^\circ\text{C}$. Maximum allowable concentration is 400 ppm or 980 mg/m ³ . Flammable.

Table 1: Materials: procurement, storage and hazards (continued)

Item no.	Description	Supplier	Storage	Safety precautions
6	Ethanol Analytical grade	As per item 5	As per item 5	Flashpoint 13 °C. Maximum allowable concentration is 1 000 ppm or 1 900 mg/m ³ . Flammable.
7	Methanol Analytical grade	As per item 5	As per item 5	Flashpoint 10 °C. Maximum allowable concentration shall be 200 ppm or 260 mg/m ³ . Use only in well ventilated areas. Contact with skin and eyes shall be avoided. Flammable.
8	Polyethylene or polypropylene gloves, bags, sheets without any plasticizer or other contaminants	Any supplier that meets this specification.	Shall be stored in a cleanliness-controlled area to avoid contamination.	-
9	White cotton or nylon gloves ②	As per item 8	As per item 8	-
10	Kimwipes	Kimberley Clark Ltd., UK	As per item 8	-
11	Masking tape: Sellotape D1610 or any tape which does not contaminate the surface of the workpiece	Sellotape Products Ltd., England	Shall be stored at a temperature of (22 ± 3) °C in a cleanliness controlled area. Shelf-life is 12 months.	-
12	Nitrogen, extra dry quality. Dew point less than -70 °C	Any supplier that meets this specification.	-	-
13	Paint filters	-	As per item 8	-

Table 1: Materials: procurement, storage and hazards (continued)

Item no.	Description	Supplier	Storage	Safety precautions
14	Scotch-brite Medium grade	3M	As per item 8	-
15	RTV 566 silicone Rubber	General Electric	Shall be freezer stored at a temperature of minus 18 °C in hermetically sealed container. Shelf-life is 4 months from date of shipment.	-
16	SS 4155 Primer	As per Item 15	Shall be stored in cool place below 30 °C in hermetically sealed container. Shelf-life is 6 months from date of shipment.	<p>Harmful if swallowed or inhaled. Keep away from heat, sparks and open flame. Keep container closed when not in use. Use only with adequate ventilation.</p> <p>If exposed to high or prolonged vapour concentration remove personnel to fresh air. Avoid contact with skin or eyes. For eye contact, flush with water for 15 minutes and get medical attention. Wash skin thoroughly after handling. If swallowed, do not induce vomiting. Call physician immediately. Flammable.</p>
<p>① The cleaning agents, mentioned under item 4, have ozone depletion coefficients that are considered by some countries to be too high and their use within these countries has been banned. Where the use of either cleaning agent is forbidden, an equivalent product(s) shall be used, provided it exhibits similar cleaning properties and conforms to all other requirements defined in this standard.</p> <p>② Gloves shall not leave any stain on a polished metal surface when they are used.</p>				

Procedures

5.1 Pre-treatment

5.1.1 Cleaning

Surfaces shall be free of dust and grease. This can be achieved by standard cleaning procedures. Before final cleaning all workpieces shall be dry. The final cleaning shall be ultrasonic, followed by vapour cleaning. This should be done in a combined installation with one of the fluorocarbon solvents mentioned in the materials list. Workpieces, especially with complex shapes, shall be ultrasonically cleaned for 1 minute and then transferred to the vapour cleaning compartment. Here they shall be held in the vapour for about 10 seconds and then slowly removed. For large pieces, which cannot be ultrasonically cleaned, surfaces shall be carefully cleaned by hand with cleaning solvents and tissues (e.g. Kimwipes). If a vapour cleaning unit of the desired size is available, the workpieces shall be held for at least one minute in the vapour and then withdrawn slowly to prevent drying marks.

Carbon fibre or fibreglass reinforced materials shall be abraded with medium grade Scotch-brite to remove any traces of release agent used in the lay-up procedure. After abrasion, the surface shall be washed with distilled water and dried. The surface shall then be scrubbed with isopropanol or ethanol. Rinse with either of the above alcohols, dry and then test for further contamination with the water break-free test. The surface shall remain wet when sprayed with distilled water. There shall not be any running away of the water to reveal grease like patches. Wipe with tissue and leave the surface to dry at least 1 hour before application of primer.

5.1.2 Handling and protection of surfaces

Unless specified otherwise, all operations following cleaning shall be performed by personnel wearing clean cotton or nylon gloves. The handling of parts shall be kept to a minimum. Gloves shall be changed with sufficient frequency to ensure cleanliness.

Throughout all operations, adequate care shall be taken to avoid contamination of surfaces by e.g. fingerprints, hair or dust. The hardware shall be protected from random temperature extremes, high humidity and physical damage. The paint shall not be applied before any mechanical operations such as machining, drilling, forming or welding. Adhesive bonding on surfaces to be painted shall be completed before paint application.

5.1.3 Masking

Surfaces that shall be free of paint shall be masked with the pressure-sensitive tape named in Table 1 and clean non-absorbent paper. Parts that are subject to damage by tape removal, such as thin-gauge materials or thin plating, parts that are subject to possible contamination by tape adhesive, i.e. optical components, or other temperature control surfaces, shall be noted and suitable protective measures taken. If the wearing of cotton or nylon gloves during masking is not feasible, contact with thermal control surfaces shall be kept to an absolute minimum and the hands of the operators shall be clean. Any areas which have been touched by hand shall be degreased with one of the solvents mentioned in Table 1.

Parts shall be painted as soon as possible after cleaning. If the time before application is likely to exceed eight hours, the parts shall be stored in polyethylene or polypropylene bags as specified in Table 1.

5.2 P123 and P128 Primer

5.2.1 Constraints

Electrolytic gold surfaces shall have a thin coat of P123 primer applied as described in subclause 5.2.2 followed by P128 primer after a minimum of 8 hours drying at $(22 \pm 3)^\circ\text{C}$. For ferrous metals, steels, light alloys, carbon and glassfibre-reinforced-resins, a thin coat of P128 primer applied as described in subclause 5.2.4 is sufficient to provide good adhesion.

5.2.2 P123 primer

The base constituent P123 shall be stirred thoroughly to disperse the pigment and ensure an homogeneous mixture. The three components of the paint shall be mixed in the following proportions by volume:

P123 base	4 parts by volume
CX124 hardener	1 part by volume
S125 thinner	2 parts by volume

Additional thinner may be added to obtain the desired viscosity. After obtaining a homogeneous mixture, filter through a $50\ \mu\text{m}$ mesh nylon filter.

The primer thus prepared shall be used within 6 hours. Using dry nitrogen as spray gas, apply a crossed layer $10\ \mu\text{m}$ to $15\ \mu\text{m}$ thick.

5.2.3 Curing

Cure in a clean and dust-free area. Complete polymerization takes 8 days at a temperature of $(22 \pm 3)^\circ\text{C}$, RH $(55 \pm 10)\%$, but the finishing coat may be applied after a minimum drying time of 8 hours. The primer is tack-free after 30 minutes and may be handled with caution after 4 hours.

5.2.4 P128 primer

A thin coat of $5\ \mu\text{m}$ thickness or less shall be applied by brush, tissue or spray gun.

5.2.5 Curing

The primer shall be dried in a clean and dust-free area.

Complete polymerization takes 3 hours at $(22 \pm 3)^\circ\text{C}$ but the finish coat (PSG120FD) may be applied after 30 minutes drying time. The primer is tack-free after 15 minutes and may be handled carefully after 30 minutes.

5.3 PSG120FD coating

5.3.1 Preparation and application

The base constituent PSG120FD shall be stirred thoroughly to disperse the pigment. The three components of the paint shall be mixed by weight in the following proportions:

PSG120FD base	100 parts by weight
CT122 hardener	20 parts by weight
S105 thinner	30 parts by weight

An additional 20 parts by weight of S105 thinner may be added to acquire the desired viscosity. When a homogeneous mixture is obtained, it shall be filtered through a 50 μm mesh nylon filter. The paint thus prepared shall be used within 12 hours. 5 to 8 coats shall be applied until a thickness of 90 μm -110 μm is attained. For substrates with high absorptance, a coating thickness of 200 μm is necessary if low absorptance is required (the coating is slightly transparent). A drying time of 3 min to 4 min should be allowed between layers or until the gloss has disappeared.

Weight per m^2 for 100 μm coating = 260 g to 300 g.

5.3.2 Curing

Cure for 5 days at a temperature of $(22 \pm 3) ^\circ\text{C}$ in a clean dust-free room with relative humidity of $(55 \pm 10) \%$. The workpiece may be handled carefully after 24 hours curing.

5.3.3 Unmasking

Unmasking shall be performed carefully to avoid the starting of pulling stresses in the paint coating.

After final cure, the residual adhesive of the masking tape shall be removed.

5.4 Handling and packaging of finished parts

Conditions of subclause 4.2.1 shall apply.

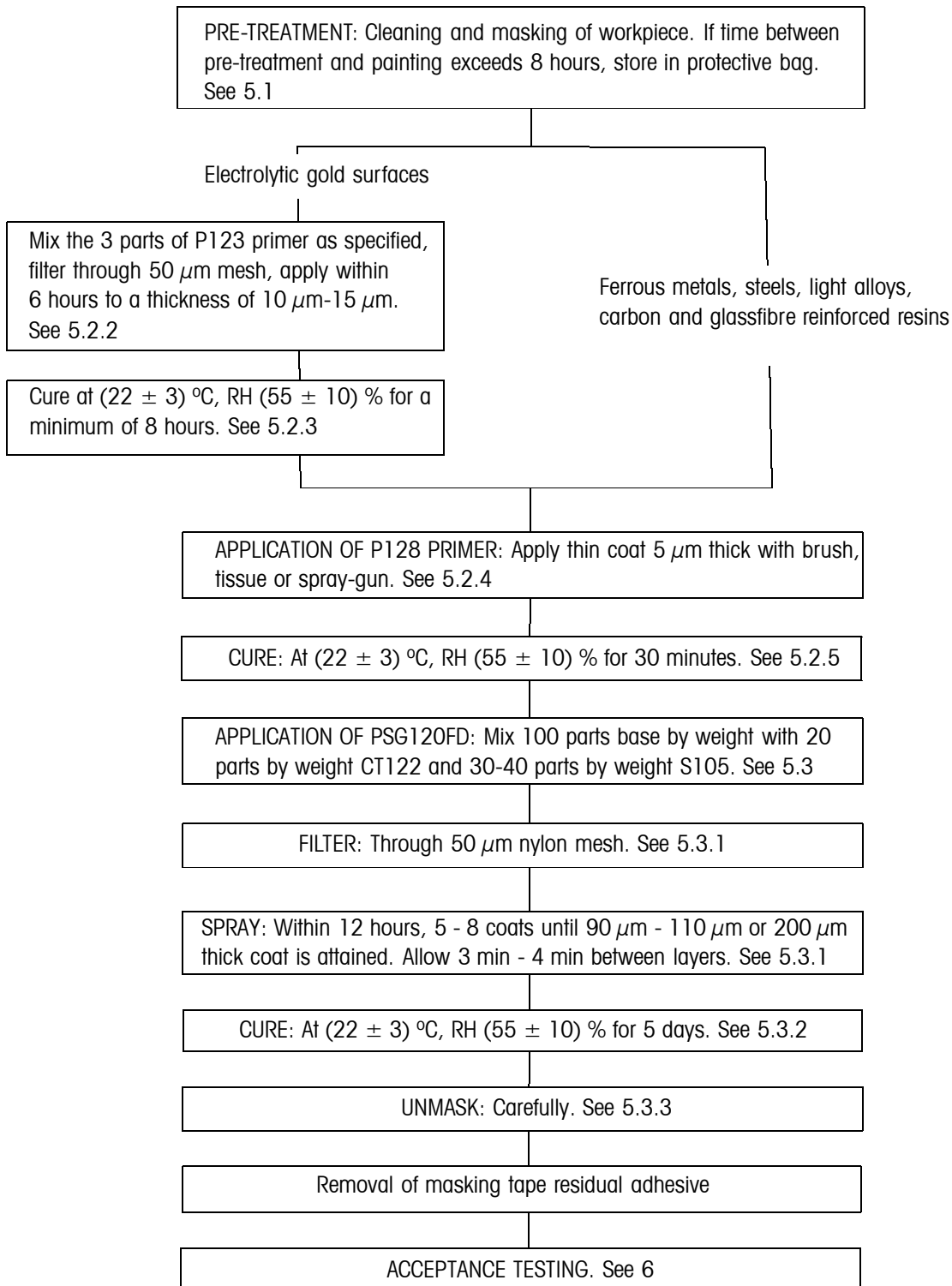


Figure 1: Procedure flow diagram

Acceptance criteria

The test pieces that were prepared at the same time as the workpieces shall be tested for the following properties.

- a. **Thermo-optical properties** shall be measured according to ECSS-Q-70-09. Solar absorptance (α_s) or solar absorptance with portable equipment (α_p). Hemispherical emittance (ϵ_h) or normal emittance with portable equipment (ϵ_n).
- b. **Adhesion properties** shall be measured according to annex A. There shall be no sign of paint lifting from the substrate.

NOTE Because the coating contains silicone, the test method defined in ECSS-Q-70-13 is not suitable.

- c. **Thickness** shall be measured in accordance with ASTM D1005-95 or ASTM D1400-94. The thickness shall not be less than 90 μm to 110 μm for the PSG120FD. For substrates with high absorptance the thickness shall be 200 μm .
- d. **Outgassing properties** shall be measured according to ECSS-Q-70-02 acceptance criteria:
 - RML 1 %
 - CVCM 0,1 %

NOTE Since the paint is somewhat hygroscopic, the TML (Total Mass Loss) value can be above 1 %. It is therefore proposed to use the RML (Recovered Mass Loss) value.

Tests detailed in ECSS Standards shall be used whenever possible in preference to other documents.

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Quality assurance

7.1 General

The quality assurance requirements are defined in ECSS-Q-20. Particular attention shall be given to the following points.

7.2 Data

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

- a. copy of the final inspection documentation;
- b. index of limited-life materials articles and their use times;
- c. nonconformance reports and their corrective actions;
- d. copy of the inspection and test results with reference to relevant procedure;
- e. an event log which is a chronological history of process operations, inspections and tests;
- f. details of failure mode (if applicable).

7.3 Nonconformance

Any nonconformance which is observed in respect of the process shall be dispositioned in accordance with the quality assurance requirements, see ECSS-Q-20-09. However, if reworking or cleaning is recommended the following procedures shall be used:

- a. **Rework and touching up of damaged areas.**
It is not easy to remove this paint with strippers or solvents. Scratched or damaged areas shall have loose or flaking paint removed and be cleaned with any of the solvents mentioned in Table 1. The surface shall be primed as before with P123 or P128 and be repainted with PSG120FD in the manner described in subclauses 5.2 and 5.3. Small areas may be painted by brush.
- b. **Cleaning of painted surfaces.**
Cleaning with ethanol, methanol or isopropanol, with a lint-free cloth (e.g. Kimwipe) does no harm to the properties of the paint.
- c. **Cleaning of unpainted areas.**
If tape adhesive remains on the unpainted surface, it shall be cleaned off

carefully with any of the solvents mentioned in subclause 7.3 NO TAGb. and allowed to dry.

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 or 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 (normative)

Adhesion test method

A.1 Test process

The test sample should be in the form of a 20 mm × 20 mm × 1 mm substrate of the same alloy and surface treatment as the workpiece. It shall be painted on one side at the same time as the workpiece. The uncoated side shall be bonded to a top-hat specimen support (see Figure A-1) using epoxy adhesive.

The painted side shall be bonded to the other top-hat specimen support by means of a suitable silicone adhesive. (General Electric RTV566 silicone rubber used with SS4155 silicone primer are recommended). The adhesive shall be cured for at least 24 hours before test.

The completed assembly (see Figure A-1) shall be transferred to a tensile testing machine and fitted as indicated in Figure A-2.

A speed of testing of 2 mm/min shall be applied to the test assembly and the test results recorded as defined in ECSS-Q-70-13.

A.2 Acceptance criteria

Acceptance criteria shall be stated prior to commencement of the test.

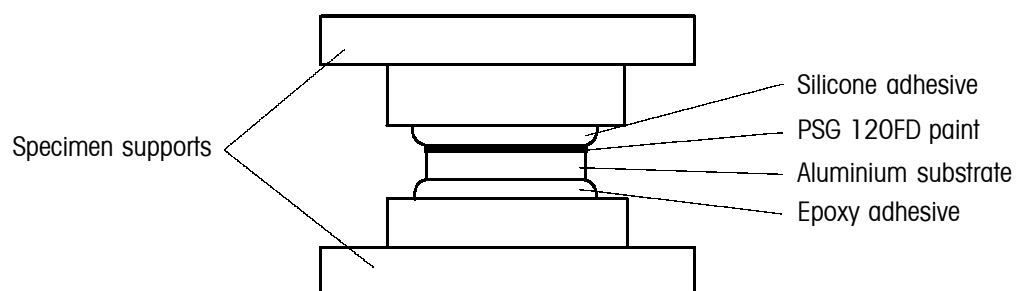


Figure A-1: Test assembly

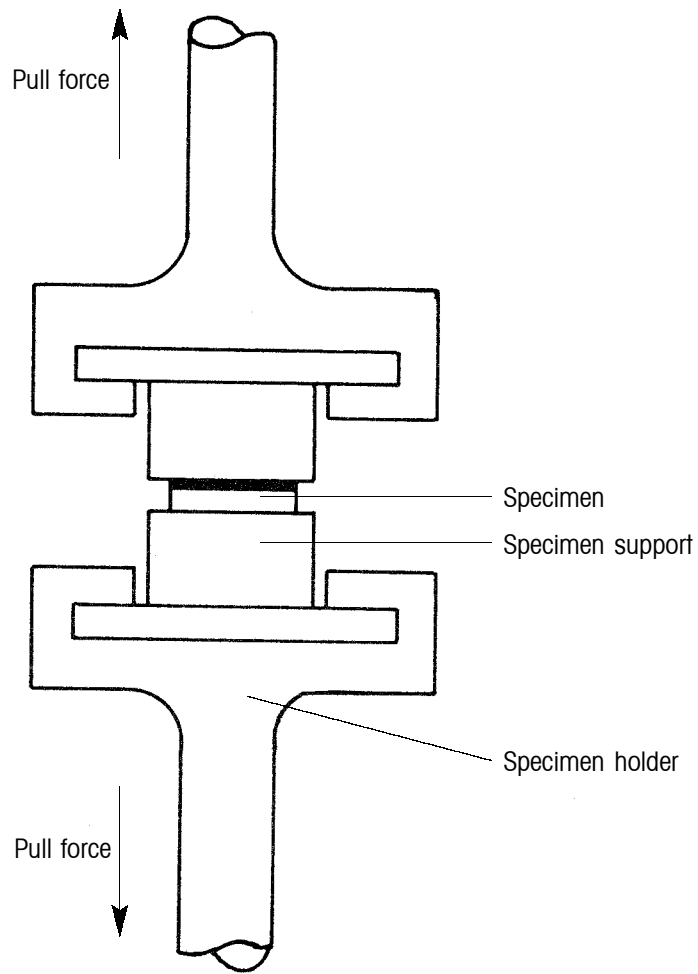


Figure A-2: Loading of tensile test machine

Bibliography

Informative references are listed hereafter.

- | | |
|--------------|--|
| ECSS-Q-70-22 | Space product assurance - The control of limited-life materials (to be published) |
| ECSS-Q-70-71 | Space product assurance - Data for the selection of space materials (to be published)
(or MSFC-SPEC-250 Protective finishes for space vehicle structures) |

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5. Reason for recommendation		
6. Originator of recommendation		
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Address:	Phone: Fax: E-Mail:	7. Date of submission:
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