MEASUREMENT SYSTEM INCH POUND

National Aeronautics and Space Administration

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MSFC TECHNICAL STANDARD

POLYURETHANE COATING, APPLICATION OF

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DOCUMENT HISTORY LOG

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1.0 SCOPE

1.1 General.

This specification covers the detail requirements for the application of one-part urethane paints for thermal control purposes on space flight hardware.

1.2 Classification

The process covered by this specification consists of the following classes. If a class is not specified, the method of thickness verification is optional and either Class I or Class II is acceptable.

a. Class I – This class is designated for spacecraft hardware with simple configuration where strict control of the coating thickness is not difficult.
b. Class II – This class is designated for spacecraft hardware with complex configuration where strict control of the coating thickness is not practicable.
c. Class III – This class is designated for spacecraft hardware being coated for the purpose of meeting esthetic requirements. Control samples for thermal emittance and solar absorptance are not required.

2.0 APPLICABLE DOCUMENTS

2.1 General

The following documents of the latest issue form part of this specification to the extent specified herein.

2.1.1 Specifications

2.1.1.1 Federal

BB-N-411	Nitrogen, Technical
O-A-51	Acetone, Technical
TT-M-261	Methyl-Ethyl-Ketone, for use in Organic Coatings
TT-M-268	Methyl-IsoButyl-Ketone
TT-T-548	Toluene, Technical

2.1.1.2 Military

MIL-A-8625	Anodic Coatings for Aluminum and Aluminum Alloys
MIL-C-5541	Chemical Conversions Coatings on Aluminum and Aluminum Alloys
MIL-P-17667	Paper, Wrapping, Chemically Neutral (Non-Corrosive)

2.1.1.3 NASA

JSC SN-C-005	Contamination Control Requirements

2.1.1.4 Other

ASTM-A967	Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts
ASTM-D3359	Standard Test Methods for Measuring Adhesion by Tape Test
ASTM-D4376	Standard Specification for Vapor-Degreasing Grade Perchloroethylene
ASTM-E408	Total Normal Emittance of Surfaces Using Inspection-Meter Techniques
ASTM F-22	Standard Test Method for Hydrophobic Surface Films by the Water-Break Test

NOTE: Alternate test methods or deviations from the subject specifications shall be submitted to NASA for evaluation and approval.

3.0 REQUIREMENTS

3.1 Application and Property Requirements

3.1.1 Thermal Control Paint Application Requirements

Paint for thermal control of a spacecraft shall be applied to flight hardware as specified in Table I.

Table I. Paint Application Requirements

Type	Designation	Total Thickness (in.)	Pot Life (hr.)	Thinner
Gloss White	Aeroglaze A-276	0.003 ± 0.001	8	90% Aeroglaze 9951 10% Aeroglaze 9956
Gloss Black	Aeroglaze Z-302	0.003 ± 0.001	8	Aeroglaze 9956
Flat Black	Aeroglaze Z-306	0.003 ± 0.001	8	Aeroglaze 9956 or Toluene

3.1.2 Optical Property Requirements

Unless otherwise specified, the coatings shall meet the optical property criteria in Table II. The solar absorptance (α_s) shall be calculated and verified from total-hemispherical reflectance measurements using an AZ Technology Laboratory Portable Spectroreflectometer (or approved equal) in the wavelength range of 0.25 to 2.5 microns, at normal ambient pressure and temperature. Measurements in the wavelength range of 0.25 to 2.8 microns are also acceptable. The infrared emittance shall be determined according to ASTM-E408.

Table II. Optical Property Requirements

Coating	Solar Absorptance (α_s)	Infrared Emittance (ε_{IR})
Aeroglaze A-276	0.23 ± 0.03	0.90 ± 0.02
Aeroglaze Z-302	≥ 0.95	0.90 ± 0.02
Aeroglaze Z-306	≥ 0.95	0.90 ± 0.02

3.1.3 Adhesion Requirements

The coating adhesion, after curing for a minimum of 48 hours, shall be tested by the following method. Two parallel lines shall be scribed one inch apart with a new Exacto or scalpel blade, no closer to the edge of the sample than one inch. This scribing shall be through the coating to the substrate. If the cut does not reveal the substrate, then two new cuts shall be made in a different area; do not attempt to deepen a previous cut. A strip of 3M 250 tape a minimum of 3.5 inches in length shall be placed parallel to the scribed lines. Allow enough tape for one inch overhang of each scribe line plus enough to grip. Tape equivalent to 3M 250 may be substituted. Use a weighted roller, eraser, or finger to ensure a good bond between tape and coating. Remove the tape quickly in a single smooth motion, and inspect the sample. Any apparent peeling or debond more than 1/16-inch wide shall be considered a failure.

Adhesion may also be tested according to ASTM-D3359, test method A. A rating of 3A or lower (section 7.7) shall be considered a failure.

3.2 Process Control Requirements

3.2.1 Process Control Documentation

A suitable document shall be used to provide instructions to the operator, to record compliance to the requirements specified herein, and to achieve traceability. The form or document shall be completely filled in, including hardware serial numbers and spacecraft models. Special handling, control, or precautions shall be noted on the document.

3.2.2 Paint Identification and Control

The lot number of the paint used shall be record to maintain traceability. Witness samples shall be prepared, during the processing of parts, in accordance with 3.2.2.1 and identified with the processed parts.

3.2.2.1 Witness Samples

Witness samples for paint adhesion, solar absorptance, and infrared emittance tests for each application of the same lot of paint shall be prepared from the same type material as the hardware. Witness samples shall consist of four samples measuring a minimum of 4 x 6 inches and a minimum thickness of 0.050 inch. Surface preparation, priming, coating, and curing of the witness samples shall be done in the same manner and at the same time as the hardware.

3.2.3 Thickness Measurements

Thickness measurements for Class I and Class II process shall be as follows:

a. Class I. Class I thickness measurements shall be made directly on the workpart, after the paint has been applied and cured, using an approved thickness gage and the measuring procedure specified in 4.2.3.
b. Class II. Class II thickness measurements for control of the paint spraying process, independent of the configuration of parts, shall be made on the 4 by 6 inch witness samples.

3.2.4 Storage and Shelf Life

The shelf life of the thermal control paint shall not be exceeded. The shelf life shall be considered to begin with the date of manufacture. Control should be exercised to assure receipt of paint for storage within 30 days of the date of manufacture.

3.2.5 Hardware Release

Once a part has been submitted for processing, it shall not be released until it has completed the curing process specified in 3.4.5.

3.3 Cleanliness Requirements

The thermal control paint shall be applied in a paint-room facility, specifically designated to serve as a thermal control paint application facility, to assure that the applied coating meets the requirements specified herein. Surface preparation, precleaning, inspection, storage, and operations subordinate to paint application shall be performed in an environment adequately contamination controlled to assure compliance with the requirements specified herein. The thermal control paint shall not be applied prior to any mechanical operations such as machining, drilling, forming, or welding. Adhesive bonding on surfaces to be painted shall have been completed prior to paint application.

3.3.1 Protection of Parts

During and after an operation specified herein, parts shall be handled in a manner that will minimize biogenic substance, dust, or other foreign matter from contaminating the surface being processed. For the purpose of this specification, fingerprints, perspiration, dandruff, hair follica, and saliva shall be considered biogenic contamination. Protection may include clean drape material, hardcovers, shipping containers, etc. In all cases, flight hardware shall be protected from temperature extremes, high humidity, contamination, and physical damage. Temperature and humidity parameters are defined in 3.3.2.1 and 3.3.2.2. Parts shall meet visibly clean standard per JSC SN-C-0005 unless otherwise specified in the associated design specification/ drawing.

3.3.2 Paint Facility Cleanliness and Environmental Requirements

3.3.2.1 Temperature

Temperature shall be maintained at 80 ± 15 °F (27 ± 8 ^{o}C) during the processing of parts.

3.3.2.2 Humidity -Temperature

Temperature of the parts to be coated shall not be allowed to fall below the dew point of the ambient air. If condensation on parts in process is observed, paint operations shall be suspended immediately. In the event that the relative humidity of the paint facility exceeds 50 percent, parts that have been prepared for painting by the mechanical surface treatments of 3.4.2.1 shall be processed as rapidly as possible. In no event shall cleaned and prepped surfaces be exposed to high humidity conditions prior to painting for a period of time greater than 24 hours.

3.3.2.3 Intake Air Filters

All intake air to the paint facility shall be drawn through filters having a minimum efficiency for 30 percent on the NBS atmospheric dust test. Filter elements shall be changed with sufficient frequency to assure efficient dust removal.

3.3.2.4.1 Air Flow

The velocity of the air flow at the spray table in the paint facility shall be 100 to 150 feet per minute.

3.3.2.5 Vapor Control

The vapor from solvents shall be controlled by a positive exhaust of the spray booth. Vapor handling and protection of the operator from solvent fumes shall be in accordance with applicable industrial hygiene safety regulations.

3.3.2.6 Personnel Protection

All precautions for personnel protection shall be observed to prevent the inhalation of fumes or dust generated by vapor degreasing, surface treatment, and spray painting. This may include respirators, gloves, and protective clothing such as “bunny suits”.

3.4 Process Requirements

The standard process for the application of thermal control paint shall consist of masking of areas to be free of paint, surface preparation by chemical or mechanical methods, cleaning, primer and paint application, paint cure, and special handling of parts.

3.4.1 Masking

Surfaces that are to be free of paint shall be masked with pressure sensitive tape or, in the case of a large area to be masked, a combination of approved plastic film and pressure sensitive tape. Parts that are subject to damage by tape removal such as thin gage materials, thin plating, or surfaces subject to possible contamination by tape adhesive, e.g. dry film lubricants or optical components, shall be so noted. Contact with thermal control surfaces shall be kept to an absolute minimum and the operator’s hands shall be clean, since handling of the parts with gloves may not be feasible during masking operations. Parts and assemblies containing holes or fasteners shall be suitably masked during surface preparation and painting.

3.4.1.1 Masking Materials

Paper backed pressure sensitive adhesive tape shall be used. Tapes that have met strict contamination control requirements include 3M Scotch Tapes #1170 and #232 and Orcotape OT-7. In general, tapes with acrylic adhesive are acceptable, tape with silicone adhesive shall not be used. A cellophane or mylar pressure sensitive adhesive tape of 0.5 mil nominal thickness may be used in special areas where a heavy buildup along the tape edge is undesirable. Drilled holes may be plugged with cork or other approved material to maintain hole tolerance.

3.4.1.2 Masking Procedure

Masking tape shall be applied in a manner that will seal all surfaces to be left unpainted or protected from paint overspray. Pulling or stretching of the tape around contours shall be avoided. Pressure shall be applied to seal progressively away from one end of the tape strip.

3.4.2 Surface Preparation

Surfaces to be painted shall be cleaned and prepared in accordance with the procedures specified in the following paragraphs and per applicable drawings. Metal surfaces shall be prepared for coating by either mechanical or chemical means and, generally, by application of a primer coating.

3.4.2.1 Mechanical Surface Preparation

Polished or machined aluminum or stainless steel may, if allowed, be abraded with 180-240 grit aluminum oxide paper or cloth, or Scotchbrite type abrasive pads to a water-break-free condition. Following abrasion, the surface shall be solvent cleaned according to 3.4.2.3.

3.4.2.2 Chemical Surface Preparation

Metal surfaces which have chemical conversion or anodic coatings or which have been passivated shall not be abraded but shall be solvent cleaned according to 3.4.2.3. Aluminum alloys may be prepared by either chemical conversion coating per MIL-C-5541, Class 1A or anodized per MIL-A-8625, Type 1, Class 1, unsealed. Corrosion-resistant steel alloys shall be passivated in accordance with ASTM-A967.

3.4.2.2.1 Special Handling of Chemical Conversion Coatings

Aluminum alloys prepared for painting by means of chemical conversion coating shall be considered life-limited material until painted. No more than ten days shall pass between the time the hardware is alodined and the application of primer. If more than ten but less than thirty days have elapsed between alodining and priming, a light application of the alodine may be used to re-activate the surface for painting. Overconversion of the aluminum, as indicated by dark brown powdery residue, shall be avoided. If more than thirty days have elapsed since the chemical conversion coating was applied, the alodine shall be stripped off by either bead blast or chemical etch, then re-alodined per MIL-C-5541, Class 1A.

Anyone handling conversion coated hardware must wear clean, non-contaminating gloves. Hardware shall also be protected from falling particles or debris, footprints, dirty tools, grease, etc. Drape or cover hardware when not in process. Witness samples should be included in all processing, including storage and draping.

3.4.2.3 Solvent Cleaning

The surface to be painted shall be solvent cleaned with toluene or MIBK followed by MEK or acetone using clean lint-free cloth and liberal amounts of solvent. Cleaning cloths and gloves used during this procedure shall be compatible with the applied solvents. The lint-free material shall be changed frequently to remove contamination and avoid smearing of contaminant residue. Solvents required by this instruction are toxic and must be used in well ventilated areas. Personnel performing the cleaning shall wear non-contaminating protective gloves and other protective gear as required. The painting operation shall immediately follow final solvent cleaning and natural drying of the solvent.

3.4.2.4 Primer Application

After surface preparation and cleaning, metal surfaces shall be primed as specified in Table III as applicable.

Table III. Nominal Primer Requirements

Primer	Catalyst	Ratio (by volume)	Thinner	Coating Thickness (mil)
Super Koropon 515-700	DeSoto 910-704	1:1	None	0.7 – 1.3
Aeroglaze 9924	2 Component Mixture	1:1	Aeroglaze 9958 up to 20%	0.25 – 0.75
Aeroglaze 9929	2 Component Mixture	3.5A:1B	Aeroglaze 9953 up tp 15%	1.0 – 3.0

Systems using Aeroglaze 9924 wash primer must be vacuum baked a minimum of 9 hours at 212 ± 10 °F and less than 10^{-6} Torr to meet outgassing requirements. Hardware shall be primed, then vacuum baked, then painted.

The primer shall set for 15 minutes after the catalyst addition before application begins. The primer shall be applied using standard spray equipment in a single wet coat to the thickness specified in Table III. The pot life of the primer is 8 hours, and any material not used within this time period shall be discarded. The primer shall be air dried 2-16 hours before application of the thermal control paint.

3.4.2.5 Special Considerations

Components that might be adversely affected by common solvents should be noted and shall not be exposed to these solvents. Where safety regulations prohibit the use of specified flammable solvents, non-flammable solvents may be used.

3.4.2.6 Post Cleaning Requirements

All operations subsequent to cleaning shall be performed by personnel wearing clean dry cotton, dacron, nylon, or latex gloves, except as noted. Handling of parts and assemblies shall be kept to a minimum. Gloves shall be changed with sufficient frequency to assure cleanliness. Cleaned

parts may be covered in a protective wrapping of clean, neutral film materials such as Capran 980, Tedlar, or plain polyethylene. Parts shall be painted as soon as possible after final cleaning and drying or after being removed from the clean-protective wrapping.

3.4.3 Paint Application

3.4.3.1 Equipment

The following equipment shall be used for the application of thermal control paint.

a. Reciprocating paint shaker
b. Spray booth, dry baffle, or paint arrestor
c. Spray gun equipped with suction feed cup or pressure pot, or an airbrush
d. Paint strainer
e. Vapor degreaser using perchloroethylene
f. Viscosimeter, No. 2 Zahn cup
g. Forced air oven
h. Electronic thickness tester
i. Nylon or cotton gloves
j. Five micron air filter

3.4.3.2 Mixing and Preparation

The paint shall be mixed by shaking the container on a paint shaker for 15 minutes prior to removing the paint from the container. The mixed paint shall be thinned to spraying consistency with solvent, according to 3.1. The paint shall then be double strained with paint strainers. Check and record the viscosity and temperature of the paint with the No. 2 Zahn cup at ambient temperature (between 70 and 80 °F). The viscosity of the paint as thinned for spraying shall be within the 20-24 second range of the No. 2 Zahn cup.

3.4.3.3 Pressure and Gas

The following pressurized gases are suitable for paint spraying:

1. Nitrogen meeting BB-N-411, Type I, Class I, Grade A
2. Nitrogen obtained from the boil-off of liquid nitrogen
3. High purity air or nitrogen.

The pressure at the nozzle of the spray gun shall be sufficient to apply a smooth coating (approximately 35 to 45 pounds per square inch (psi)). A 5 micron filter shall be inserted into the pressurizing gas line to remove particulate matter.

3.4.3.4 Spray Painting Procedure

Thermal control paint shall be applied over clean, dry substrate. The paint shall be applied in the required viscosity range with the appropriate spray gun or air brush. The line pressure and spray gun controls shall be adjusted to provide a smooth coating. Pressure required to obtain a uniform coating shall be determined by the operator. The coating shall be sprayed, preferably in a vertical plane, in a uniform thickness for each coat. The paint shall be applied as an initial, thin tack coat followed by wet, heavy cross coats, allowing for solvent flash-off between coats. The paint shall be applied to provide the total nominal thickness specified in Table I.

3.4.4 Thickness Verification and Demasking

After the application of paint and prior to demasking, the paint thickness shall be measured to verify that the thickness requirement of Table I has been met. Demasking shall be performed carefully to avoid pulling or stressing of the paint. In the event masking tape adhesive remains on the untreated surface, the surface shall be carefully cleaned, avoiding contact or contamination of the painted surface with solvents. To remove adhesive residue from the tape on a bare, unpainted surface, wipe the surface carefully with a cotton swab saturated with toluene or other approved solvent and allow to dry. To remove adhesive residue from the tape on painted surfaces, wipe the surface carefully with a cotton swab saturated with alcohol or other cleaner specified in the associated design specification/drawing.

3.4.5 Curing

Paint shall be cured by air drying at room temperature for 16 hours minimum before handling, 24 hours minimum before optical property measurements, 48 hours minimum before adhesion testing, and a total of 21 days minimum at room temperature before flight usage. Upon completion of the curing cycle, parts shall be handled only by operators wearing latex, nylon, or dacron gloves and protective clothing to prevent contamination and fingerprints.

3.4.6 Reapplication

Soiled, damaged, or thin-coated surfaces may be recoated. Soiled surfaces shall be cleaned thoroughly with an approved solvent. The damaged area to be recoated shall be lightly abraded with 180-240 grit aluminum oxide paper or cloth, cleaned with methyl-ethyl-ketone, and allowed to dry. These areas shall be coated by means of an air brush or camels hair brush. Previously painted surfaces shall be protected to avoid overspray from settling on the surfaces when an air brush is used.

4.0 QUALITY ASSURANCE REQUIREMENTS

4.1 Responsibility for Inspection

Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may use his own facilities or any commercial laboratory acceptable to the procurer. The procurer reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to the prescribed requirements.

4.2 Inspection

Spacecraft flight hardware and parts processed in accordance to this specification shall be inspected before and after painting to ensure requirements are enforced.

4.2.1 Prepainting Inspection

Surfaces to be coated shall be inspected by water break test per ASTM F-22 prior to painting for conformance to surface preparation requirements of 3.4.2 and for contamination by oil, grease, dirt, biogenic and other contaminants.

4.2.2 Coating Inspection

Coated surfaces shall be visually inspected for uniformity and freedom from discoloration and other gross contamination, cracks, peeling, and blisters. Aeroglaze A-276 paint may produce gas bubble during cure which appear to be blisters and sometimes leave craters in the coating. This is an undesirable effect but is not detrimental to the physical properties. The paint shall be adherent, uniform in color, and generally smooth. Minor roughness associated with coating repairs, unavoidable paint runs, or small inclusions in the paint shall not be cause for rejection of the coating. No primer material should be visible except at masked or sharp edges where the topcoat has experienced pullback.

4.2.3 Coating Thickness Inspection

The paint thickness shall be measured on the part or on the reference sample, as appropriate per 3.2.3, and recorded on the control request form. Excessive coating thickness at coating repairs shall be acceptable. Paint thickness at runs and sags which do not exceed three times the nominal paint thickness shall be acceptable. If paint thickness is measured by other than direct Dermitron reading on the part, the inspection record shall clearly indicate the method used. Paint thickness requirements are given in Table 1.

4.2.4 Witness Samples

The witness samples prepared in accordance with 3.2.2.1 will be tested for paint adhesion, solar absorptance, and infrared emittance. Adhesion requirements are given in 3.1.3. Solar absorptance and infrared emittance requirements are given in 3.1.2. In rare circumstances, solar absorptance and infrared emittance may be measured directly on the hardware. Paint adhesion testing with scribing shall not be performed on hardware.

5.0 PACKAGING

Parts that have completed processing (see 3.4.5 for curing) shall be wrapped in appropriate film, then wrapped in paper and sealed with tape. Film packaging material and protective wrapping shall consist of clean, neutral, unplasticized film. Film materials suitable for wrapping or covering painted surfaces are: Capran 980, Tedlar, Teflon FEP, Mylar, or plain clear (not pink) polyethylene. Capran 980 should not be used where electrostatic discharge is a concern. Neutral paper conforming to MIL-P-17667B or Capran 512H film shall be used for external wrapping. Appropriate packaging or masking tape shall be used for closure.

6.0 NOTES

6.1 Definitions/Acronyms

α	Solar absorptance
ε	Infrared emittance
C	Celsius
cm	centimeter
F	Fahrenheit
FEP	Fluorinated ethylene propylene
in.	Inch
lb.	Pound
MEK	Methyl-ethyl-ketone
MIBK	Methyl-isobutyl-ketone
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
psi	pounds per square inch

6.2 Vendors

The coatings and primers described herein may be purchased from the following vendors:

PRC – Desoto International
DeSoto Aerospace Coatings
5454 San Fernando Rd.
P.O. Box 1800
Glendale, CA 91209
Tel: 818-240-2060
Fax: 818-549-7771

Lord Corporation
2000 West Grandview Boulevard
P. O. Box 10038
Erie, PA 16514-0038
Tel: 814/868-5424
Fax: 814/864-3109