MEASUREMENT SYSTEM INCH - POUND

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EM40

MSFC TECHNICAL STANDARD

POLYURETHANE FOAM, SPRAY APPLICATION PROCEDURE FOR

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DOCUMENT HISTORY LOG

Status	Document Revision	Effective Date	Description
Baseline	-	5/28/2013	Baseline Release; document authorized through Multiprogram Document Management System (MPDMS).
Revision	A	6/08/2015	Revision A Release; document authorized through Multiprogram Document Management System (MPDMS). General, Overall: A. Removed Sensitive But Unclassified (SBU) designation and International Traffic in Arms Regulation (ITAR) notice B. The term “drawing” was replaced with “released engineering documentation” C. The term “NASA MSFC M&P TPS Development team” was replaced by “user’s M&P” in many locations for ease of use The following is a summary list of major updates/modifications. Minor changes (e.g. formatting and typographical corrections) are not listed here. 1.1, Reworded “…foam material. This specification establishes the processing requirements for foam application using either computer controlled automated equipment or hand spray techniques. Foam applications conducted under this standard necessitate the application of a cryogenically compatible primer, listed herein, prior to foam application.” 1.2 Updated “…procedures, will contain sufficient…,” “Any contractor proposed variations to materials or processes specified in this document will be submitted to NASA MSFC M&P for evaluation. Approval by NASA MSFC M&P is required before implementation.,” and “…contractor will supply necessary…” 1.3, New section 1.4, Updated “…documentation will specify…” Changed to numbered list and updated line items as needed. Reworded second paragraph in section. 2, Updated “…specification takes precedence.” 2.1.3, Removed MSFC-SPEC-3615, MSFC-SPEC-3616, and EM40-OWI-040 2.2.2, Added to/updated document list 3.1, Added “…authority NASA MSFC M&P or the User’s M&P (6.4) organization prior to implementation. Contractor and/or subcontractors shall…” 3.2.3, Removed 3.2.5, Added “Alternative equivalent materials shall be approved by the user’s M&P (6.4) organization” 3.2.5.9, Removed “…(Primer 3.2.2 applications only)” 3.2.5.11, Added “…or #316” 3.2.5.12, Removed “…(Primer 3.2.2 applications only)” 3.2.5.13, Added “Abrasive Paper, Aluminum Oxide, 120-400 grit” 3.3.1.3, Added “…in accordance with the manufacturers specifications or otherwise indicated as a limited use item.” 3.3.2.1, Updated “…mix ratio of (0.97 to 1.05) to 1…” 3.3.2.3, Updated pressurization requirement 3.4.1.1, Reworded section for clarity 3.4.1.1.1, New section 3.4.1.3, Removed 3.4.2, Updated section

			3.4.3, Removed 3.4.4, New section 3.5.1.2, Updated section 3.5.1.3, Updated "Within 2 hours…" and added "…40 to 110 °F. Materials should not be stored at temperatures greater than 95 °F for extended periods (i.e. 7 days) of time." 3.5.1.4, Updated section 3.5.1.5, Updated first paragraph and added second paragraph 3.5.1.6, Updated ratio ranges 3.5.1.7, Updated section 3.5.1.8, Added pointer to external set of documents for spray specific set-up information 3.5.1.9, New section Table I, Updated table with latest information Figure 1, Updated figure for clarity Table II, Updated table with latest information 3.5.3.1, Added "…tape (3.2.5.2, 3.2.5.4, or 3.2.5.5) or an approved…" 3.5.3.2, Added "…Wet bulb-dry bulb type psychrometers shall be calibrated to ±1°F per thermometer and matched to ±0.5°F differential. Electronic type psychrometers shall be calibrated to an accuracy…" 3.5.3.6 b, Updated paragraph wording with respect to parts and witness panel relocation 3.5.3.7, Updated section 3.5.5, Updated section 3.5.6.1, Added knit line count to density specimens 3.5.6.2.1, Added second paragraph 3.5.6.2.2, Added test acceptable values 3.5.6.3, Reworded for clarity Table III, New Table 3.5.7, New section 3.6, Updated section 3.7, Updated section 3.8, Added "…If required, adjacent work…" 4.1, New section 4.2, Updated section 4.3.2, Added "…Regardless of time to failure, the test…" 4.3.4, Added "…be -310 ± 10°F or -423 to -400 °F. Test temperature…" for clarity 5.1, Updated section 6.1, Removed "Ambient shall be…" 6.2, Removed "Laboratory conditions shall be…" 6.4, Added section App. A, Added section

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1.0 SCOPE

1.1 Purpose

This specification establishes the requirements for the spray application of a polyurethane foam material. This specification establishes the processing requirements for foam application using either computer controlled automated equipment or hand spray techniques. Foam applications conducted under this standard necessitate the application of a cryogenically compatible primer, listed herein, prior to foam application.

Contractors and subcontractors (hereinafter, “contractors”) may use other specifications if they have prior approval of National Aeronautics and Space Administration (NASA) Marshall Space Flight Center (MSFC) Materials and Processes (M&P) and meet the Product Requirements along with the intent of this specification.

1.2 Implementing Documentation

Implementing documentation, such as manufacturing process instructions and process plans and procedures, will contain sufficient detailed instructions and guidelines on operating parameters to ensure reliable and consistent quality processing of hardware. Any contractor proposed variations to materials or processes specified in this document will be submitted to NASA MSFC M&P for evaluation. Approval by NASA MSFC M&P is required before implementation. The contractor will supply necessary technical and safety data sheets and supporting test data before approval.

1.3 Requirements With Limited Applicability to Programs/Projects, Hardware Items, or Contractors

This specification includes requirements that have applicability to specific program/projects, hardware items, or contractors. When a requirement has limited applicability, the program/project or hardware item applicability is identified preceding the requirement (i.e. paragraph heading or preceding sentence) or is identified in parentheses immediately following the requirement. When requirements include references to contractor documents, those requirements are only applicable to the contractor that originated the applicable document. Access to contractor documentation is only available from the issuing contractor.

1.4 Engineering Information

Released engineering documentation will specify, as applicable, this specification including:

a. Any particular requirements for the substrate finish including presence of rind on previously applied foam if required
b. Primer type
c. Primer finish
d. Foam thickness
e. Any special foam surface acceptance criteria including, but not limited to, surface waviness or appearance

f. Location and configuration of planned applications.
g. Location and orientation for in-process witness panels (3.5.5)

Released engineering documentation will specify tensile testing on the production part or witness panels. If cryoflex witness panels are required by the Released engineering documentation it will designate the unique identification marking(s) for each panel.

2.0 APPLICABLE DOCUMENTS

The latest issues of the following documents form a part of this specification to the extent specified herein. In the event of a conflict between the documents referenced herein and the contents of this specification, the content of this specification takes precedence. The contractor may pursue substituting specifications and documents equivalent to those identified herein if the substitution does not compromise the intent of the specifications and documents identified herein and is approved by the NASA MSFC M&P organization before implementation.

2.1 Government Documents

2.1.1 Federal

TT-I-735	Federal Specification, Isopropyl Alcohol

2.1.2 Military

MIL-DTL-17667	Paper, Wrapping, Chemically Neutral (Non-Corrosive)
MIL-PRF-27401	Performance Specification: Propellant Pressurizing Agent, Nitrogen

2.1.3 NASA

MSFC-SPEC-3686	Material Specification for Polyurethane Foam – Sprayable
EM40-OWI-043	EM40 – Nonmetals Engineering Branch EM40 Nonmetallic Material Specimen Bonding
EM40-OWI-058	Gradient Cryoflex Testing
MSFOC 06-0187WI	Gradient Cryoflex Testing of TPS (Thermal Protection System) Foam Materials

2.1.4 Federal Specifications and Standards

Code of Federal Occupational Safety and Health Administration Regulations (CFR) (OSHA) Title 29 Part 1910 Standards

2.2 Non-Government Documents

ASTM-D329	Standard Specification for Acetone
ASTM-D740	Standard Specification for Methyl Ethyl Ketone
ASTM-D1622	Standard Test Method for Apparent Density of Rigid Cellular Plastics
ASTM-D1623	Standard Test Method for Tensile and Tensile Adhesion Properties of Rigid Cellular Plastics
SAE AMS 3819	Cloths, Cleaning, For Aircraft Primary and Secondary Structural Surfaces

2.2.1 National Conference of Standards Laboratories

ANSI/NCSL Z540.3	Requirements for the Calibration of Measuring and Test Equipment

NOTE: Copies may be obtained via the NASA Technical Standards Program.

2.2.2 Boeing Specifications

NOTE: Copies of Boeing specifications may not be obtained through NASA.

STM0878	Foam, Polyurethane, Pour-in-Place
STM0882	Adhesive/Tiecoat, Polyurethane, Cryogenic
STM0907	Primer, Epoxy, Cryogenic, No-Degloss
STP0292	Finishes: Organic, Application and Controls of
STP0598	Insulation Closeouts, Cryogenic, Forming

3.0 REQUIREMENTS

3.1 Engineering Controls

Implementing documentation, such as manufacturing process instructions, process plans and procedures shall contain sufficient detailed instructions and guidelines on operating parameters to ensure reliable and consistent quality processing of hardware and for maintaining cleanliness between cleaning and application of subsequent finishes. Any variations to materials or processes specified in this document shall be approved by the procuring authority NASA MSFC M&P or the User's M&P (6.4) organization prior to implementation. Contractors shall supply necessary technical and material data sheets and supporting test data before approval of changes.

3.2 Materials

3.2.1 Foam, Polyurethane (Component A and Component B)
Spec: MSFC-SPEC-3686, Material Specification for Polyurethane Foam - Sprayable (Hazardous Material)

3.2.2 Primer, (Cryogenic Compatible)
Spec: STM0907, "Primer, Epoxy, Cryogenic, No-Degloss" (Hazardous Material)

3.2.3 *Removed

3.2.4 Tiecoat Adhesive (Cryogenic Compatible)
Spec: STM0882, "Adhesive/Tiecoat, Polyurethane, Cryogenic" (Hazardous Material)

3.2.5 Shop Aids and Expendable Materials
The following materials shall be used to support the primer surface preparation and foam application process. Alternative equivalent materials shall be approved by the user's M&P (6.4) organization.

3.2.5.1 Abrasive Pads, Aluminum Oxide
3M (CAGE code 76381) Scotch Brite MMM7447 Maroon

3.2.5.2 Tape, Teflon
3M (CAGE code 76381) Tape Part Number: 5490

3.2.5.3 Purified Wiping Cloth, AMS 3819 Class 1, Grade A, Form 1
American Fiber and Finishing #301 Rymplecloth® silicone-free cotton

3.2.5.4 Tape, Polyethylene, black, pressure sensitive
3M (CAGE code 76381) Preservation 481

3.2.5.5 Tape: Polyester, tan, pressure sensitive
Intertape Polymer Group (CAGE code 1VJW7) #51596

3.2.5.6 Paper, wrapping, chemically neutral
MIL-DTL-17667, Type 1

3.2.5.7 Solvent, Methyl Ethyl Ketone (MEK) (Hazardous Material)
ASTM-D740, Type I or Type II

3.2.5.8 Solvent, Isopropyl Alcohol (IPA) (Hazardous Material)
TT-I-735, Grade A

3.2.5.9 Solvent, Acetone (hazardous material)
ASTM-D329

3.2.5.10 Nitrogen, Drying or Purging Gas
MIL-P-27401

3.2.5.11 Staedtler Lumocolor® marker #315 or #316

3.2.5.12 Solvent, Ardrox 5529 (Hazardous Material)

3.2.5.13 Abrasive Paper, Aluminum Oxide, 120-400 grit

3.3 Equipment and Facilities

3.3.1 General

3.3.1.1 Equipment used in this process shall ensure conformance to the requirements of this specification. All direct-contact materials/equipment used to implement the requirements of this specification shall be compatible with the materials being processed.

3.3.1.2 Control of the processing area environment, including cleanliness, temperature and humidity, is required.

3.3.1.3 Measuring instruments, test equipment and controlling or recording instruments used for control of production and inspection operations shall be calibrated in accordance with the manufacturers specifications or otherwise indicated as a limited use item.

3.3.2 Foam Dispensing Equipment

3.3.2.1 The pumping systems shall have the capability of dispensing the components in an average mix ratio of (0.97 to 1.05) to 1 by volume.

3.3.2.2 The pumping systems shall include component supply filters, air and nitrogen pressure regulators, and foam dispensing equipment.

3.3.2.3 The component supply system shall be sealed and pressurized with dry nitrogen (3.2.5.10) during material usage. The nitrogen system may be disconnected when the supply system is not activated provided a nitrogen blanket is sealed over the material at 30 to 90 psig.

3.4 Product

3.4.1 Primer Type and Thickness

3.4.1.1 The primer used on surfaces that will receive spray on foam insulation shall be compatible with the sprayable foam TPS outlined in this specification and the substrate material.

3.4.1.1.1 All metallic surfaces (except fastener assemblies and lockwire) to be foamed shall be primed in accordance with 3.4.1.2 or 3.4.1.3, unless otherwise specified by the released engineering documentation. The priming of fastener assemblies and lockwire shall be optional when not otherwise specified. Foam may be applied to primed surfaces after thickness and adhesion requirements of the primer application procedure have been met.

Primer applied 60 days before application of foam, or primer that exhibits visible signs of contamination shall be cleaned by the two-hand wipe technique described in 3.4.2. Primer shall not be removed during cleaning. Primer surfaces shall be touched up as required per the requirements of the primer application procedure and part protected from contamination until further processing is required.

3.4.1.2 Primer application and cure shall be in accordance with STP0292, “Finishes: Organic, Application and Controls of ” when using primer (3.2.2).

3.4.2 Primed Metallic Substrate Preparation for Foam Spray Application When Using Primer (3.2.2)

To clean/prepare the substrate for foam application use Rymple cloth (3.2.5.3) with Ardrox 5529 solvent (3.2.5.12) to wipe the primed substrate. This cleaning process shall be performed within the 72-hour period just before the foam application begins. This cleaning shall be performed wearing polyethylene laminate, chemical resistant gloves and shall be performed using the “two-handed” wiping method described herein.

The 72-hour clock begins upon first contact of the wetted rymple cloth.

3.4.2.1 Using rymple cloth (3.2.5.3) wetted with the Ardrox 5529 solvent (3.2.5.12), wipe the surface to remove contaminants.

3.4.2.2 Before the solvent (3.2.5.12) evaporates off the surface, immediately wipe the surface dry with a clean rymple cloth (3.2.5.3).

Note: This is performed by using two hands, one hand applying the solvent followed immediately with the other hand wiping with a clean, dry rymple cloth.

3.4.2.3 If the rymple cloth shows contamination, repeat wiping process with a clean cloth surface (steps 3.4.2.1 and 3.4.2.2) until the rymple cloth (3.2.5.3) is clean.

3.4.2.4 Allow the substrate to stand for 15 minutes minimum

3.4.3 *Removed

3.4.4 Surface Preparation of Application Areas

a. Foam shall be cut or trimmed as specified on the appropriate released engineering documentation. The substrate surface of production parts and major test articles shall not be marred by foam trimming operations.

b. The trimmed foam edge shall be protected from contamination during the surface preparation of the perimeter area.

c. Unless otherwise specified by the released engineering documentation, the surface preparation for cured foam substrates where new foam is to be applied, shall include the removal of any topcoat or rind surface followed by surface preparation by abrasion (3.4.4 d) and adhesive application in accordance with STP0292 (usage of STP0292 for SLS Core Stage manufacturing only).

d. Abrasion of foam surfaces shall be performed using aluminum oxide pads (3.2.5.1) or paper (3.2.5.13) only. Areas shall be sanded to remove topcoat or rind layer. Repetitive processing is acceptable provided material removal does not exceed part dimensional tolerances. Abrasive residue shall be thoroughly removed with a clean, dry cloth wipe (3.2.5.3), by blowing off with nitrogen (3.2.5.10) or clean dry air, or by vacuum. The use of a vacuum to clear away residue is preferable.

3.5 Fabrication Control

3.5.1 Preparation of Material (3.2) and Equipment for Spraying Foam

3.5.1.1 The foam components (3.2.1) shall be within the manufacturers recommended shelf life.

3.5.1.2 Prior to removal from controlled storage verify the B-Component is pressurized in accordance with 3.3.2.3.

3.5.1.3 Within 2 hours from the time the materials are withdrawn from controlled storage of 40 to 60 °F the materials shall be relocated to the preparation or using area where the temperature shall be 40 to 110 °F. Materials should not be stored at temperatures greater than 95 °F for extended periods (i.e. 7 days) of time.

3.5.1.4 When transferring A-Component from the original 55 gallon shipping container to a pressure pot, the room temperature shall be between 40°F and 85°F. A-Component container transfer shall be conducted in such a fashion as to minimize the amount of time either container is open to the ambient environment. A nitrogen blanket, as defined in 3.3.2.3, shall be applied over the A-Component before (a) relocation of the pressure pot from one location to another or (b) the temperature in the room where the pressure pot is located reaches temperatures above 85°F. At no time during relocation shall the materials be stored in direct exposure of sunlight.

B-Component shall be stored, relocated, and used in its original shipping container with constant nitrogen pressure applied as defined in 3.3.2.3. At no time during relocation shall the materials be stored in direct exposure of sunlight.

If the nitrogen blanket pressure or storage area temperature falls outside the specified range, the material shall be subject to retest and re-evaluation for conformance to the material acceptance requirements listed in MSFC-SPEC-3686 Table I and II.

3.5.1.5 In automatic applications, the average ratio of Component A (3.2.1) (Isocyanate) to Component B (3.2.1) (Polyol), during spray operations shall be (0.97 to 1.05) to 1 by volume. Using equipment calibrated to an accuracy of ±2.5 percent or better, the indicated average ratio shall be monitored during application of foam to the hardware to ensure conformance to this requirement.

In manual applications, the average ratio of Component A (Isocyanate) (3.2.1) to Component B (Polyol) (3.2.1) shall be (0.97 to 1.05) to 1 by volume. Ratio shall be verified prior to (lead-in) and upon completion (lead-out) of the spray process. Lead-in verification shall be made during a constant output purge after flows have stabilized. Lead-out verification shall be made during a constant output purge immediately after the completion of the spray process and flows have stabilized. Equipment used to monitor ratio shall be calibrated to an accuracy of ±2.5 percent or better.
3.5.1.6 Indicated average-ratio transients associated with spray-gun activation shall be within (0.94 to 1.12) to 1 by volume and shall not exceed (0.97 to 1.05) to 1 by volume for more than 5 seconds.

3.5.1.7 The temperature of the foam material components shall be 120 ± 5°F at application time when measured with equipment accurate within ± 4°F.

3.5.1.8 Spray gun parts shall be installed to provide the desired foam output. Reference the appropriate spray procedure for spray gun set up.

3.5.1.9 The Component A (Isocyanate) (3.2.1) and Component B (Polyol) (3.2.1) shall be used as a kit as provided by the manufacturer.

Mixing of B-Component with other B-component containers with different lot numbers is not allowed.

Mixing of A-Component with other A-Component containers with different lot numbers is not allowed.

3.5.2 Spray Foam Application Methods

Two different spray foam application methods may be utilized for this process specification.

3.5.2.1 Manually sprayed foam

3.5.2.1.1 The following gun spray parameters shall be utilized as shown in Table I and Figure 1.

Table I. Manual Spray Process Parameters

Parameter		Spray Settings or Values (Min-Max)
Overlap Time (seconds)(2)		60 maximum
Mix Ratio	by mass	(1.03 – 1.11) to 1
	by volume	(0.97 – 1.05) to 1
Component A & B Temperature (°F) (3)		115 – 125
Application Area Temperature (°F)		See Figure 1
Application Area Relative Humidity		
Substrate Temperature (°F)		68 – 100
(1) Gun set up details will be located in the part-specific spray schedules (2) Do not spray onto rising foam (3) As measured per 3.5.1.7		

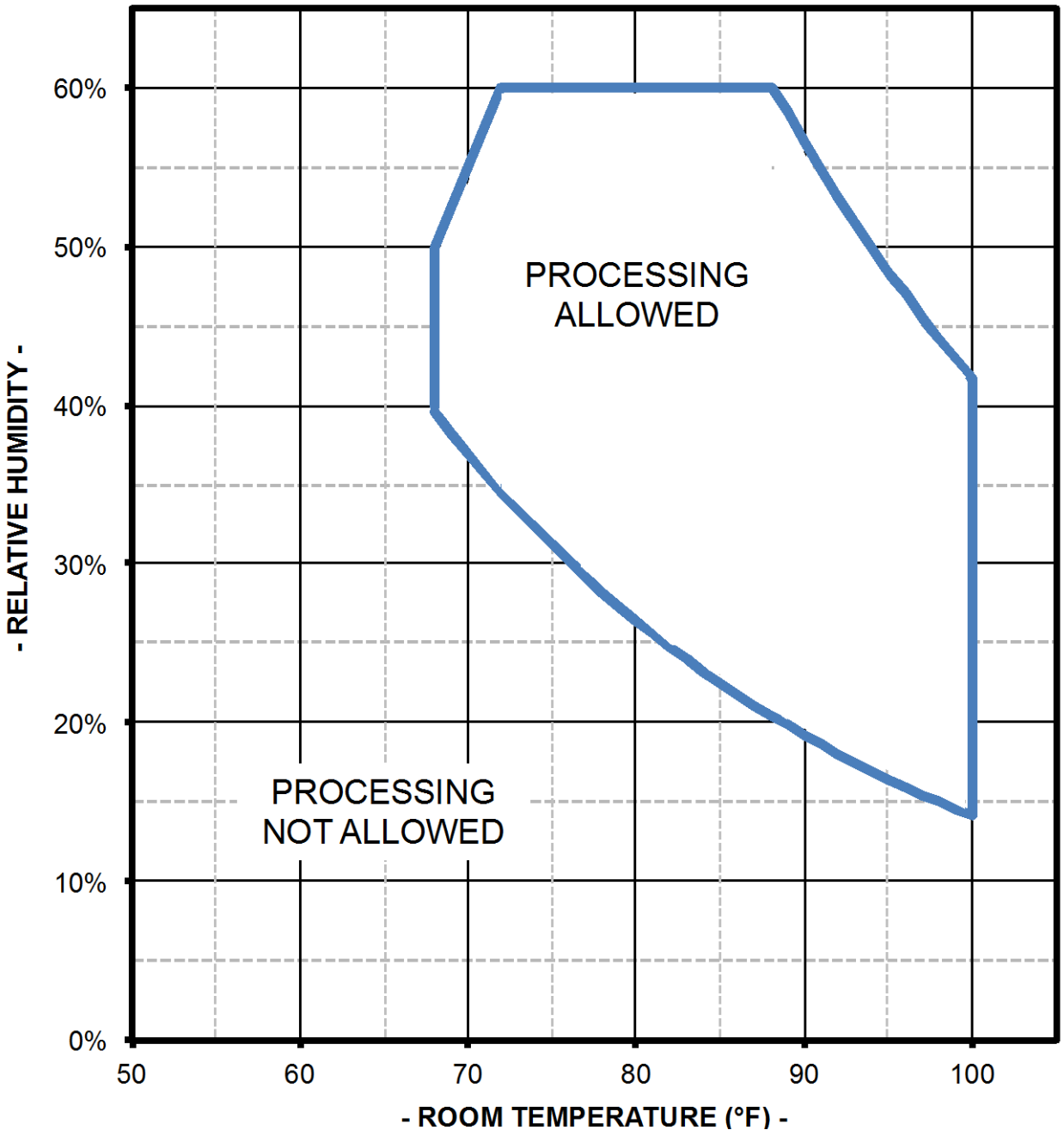

Figure 1. S-180 Environmental Allowable Processing Window

3.5.2.2 Automatically sprayed

3.5.2.2.1 The following gun spray parameters shall be utilized as shown in Table II and Figure 1.

Table II. Automated Spray Process Parameters

Parameter		Spray Settings or Values (Min-Max)
Overlap Time (seconds)		10 – 60
Mix Ratio	by mass	(1.03 – 1.11) to 1
	by volume	(0.97 – 1.05) to 1
Gun stand-off distance (inches)		16 – 28
Component A & B Temperature (°F)(2)		115 – 125
Booth Temperature (°F)		See Figure 1
Booth Relative Humidity		
Substrate Temperature (°F)		68 – 100
(1) Gun set up details will be located in the part-specific spray schedules (2) As measured per 3.5.1.7		

3.5.3 Spray Foam Application Requirements

3.5.3.1 Area surfaces and tooling not to be covered with foam shall be protected from foam overspray. When necessary to use pressure sensitive tape on production substrates to achieve masking, tape (3.2.5.2, 3.2.5.4, or 3.2.5.5) or an approved substitute shall be used.

3.5.3.2 The temperature and relative humidity in the spray areas shall conform to requirements stated in the spray process parameter tables for the respective spray configuration. Wet bulb-dry bulb type psychrometers shall be calibrated to ±1°F per thermometer and matched to ±0.5°F differential. Electronic type psychrometers shall be calibrated to an accuracy of ±2 percent for relative humidity and ±2°F for temperature.

3.5.3.3 Substrate surface temperature measuring instruments shall be accurate within ± 4°F.

3.5.3.4 Preheated foam material shall be purged from the dispense unit within 30 seconds prior to spraying the part.

3.5.3.5 The overlap time between consecutive spray passes on all applications shall be in accordance with the corresponding spray process parameter tables shown in 3.5.2.

3.5.3.6 Allow foam to cure for a minimum of 24 hours at ambient (6.1) before finish trimming or application of stress and a minimum of 48 hours at ambient (6.1) before any testing is performed. The following operations may be performed as necessary prior to 24 hours:

a. Handling: Foam surfaces may be handled with clean, approved gloves after a minimum ambient (6.1) cure of 4 hours.

b. Relocation of Foamed Parts: Small components, and their respective witness panels, may be relocated as required after foam hardens provided contact with foam surface is avoided. Tanks, domes, major components, and their respective witness panels may be relocated after a minimum ambient (6.1) cure of 8 hours provided the relocation process does not induce part stress in the foamed area.

c. Rough Trimming: Excess foam may be trimmed no closer than 2 inches of finished dimensions after a minimum ambient (6.1) cure of 4 hours provided the cutting process does not induce stress on the foamed part.

3.5.3.7 The following pens shall be used to mark on foam surfaces
a. Staedtler Lumocolor® non-permanent marker, medium point, #315 (3.2.5.11)
b. Staedtler Lumocolor® non-permanent marker, fine point, #316 (3.2.5.11)

3.5.4 Foam Applications

3.5.4.1 Sprayed Foam Cured Properties

3.5.4.1.1 All sprayed foam shall be allowed to cure per 3.5.3.6 before testing and before being subjected to the use environment..

3.5.4.1.2 Cured sprayed foam shall have a density of 2.3 – 2.5 pounds per cubic foot (pcf) as tested per 3.5.6.1. Tensile strength of cured foam (parallel to rise) shall conform 3.5.6.2 or 3.5.6.3 as applicable.

3.5.4.2 Foam Application

Foam shall be applied in accordance with the appropriate released engineering documentation.

3.5.5 Test Panels

3.5.5.1 Tensile Panels: When specified by the released engineering documentation, a minimum of one lead-in and one lead-out witness panel of the production foam shall be prepared with the part, or series of parts, being foamed. The test panel substrate shall have nominal dimensions of 6 x 12 x 0.125 inches, simulate the production part with respect to the predominant base material, including primer and any additional surface pre-treatments (if required), and shall be prepared and foamed concurrently with and in the same manner as the part it represents. Tensile tests shall be performed per 4.3.2.

3.5.5.2 Density Panels: Density specimens shall be taken from lead-in and lead-out foam, irrespective of substrate. Density specimens shall be prepared per 3.5.6.1 and tested per 4.3.1.

3.5.5.3 Cryoflex Panels: When specified by the released engineering documentation, cryoflex test panels with substrates representative of the production part shall be provided. The panels shall be cleaned, primed, and pre-treated (if required) in accordance with standard procedures used on like production substrates, and foamed concurrently with and by the same application techniques as those used on the production part. When cryoflex panels are required, they may provide test material for tensile and density tests. Cryoflex tests shall be performed per 4.3.4.

3.5.6 Test Specimen Preparation

Allow production foam or representative foam to cure per 3.5.3.6 at ambient (6.1) temperature prior to testing. Prepare specimens as required by this specification and/or the released engineering documentation.

3.5.6.1 Density: Three specimens, machined on all surfaces, shall be fabricated to a nominal 2-inch by 2-inch by 0.75-inch dimension with the larger surface area sides parallel to the substrate from which it was removed. The density of these specimens shall be determined in accordance with 4.3.1. Density of cured spray foam, with 0 to 3 knit lines, shall conform to 3.5.4.1.2.

3.5.6.2 Tensile Strength of Foam Applied to Components

3.5.6.2.1 When the released engineering documentation calls out tensile testing on the production part, tensile strength shall be determined by using approved portable tensile testing equipment. A minimum of one test each shall be performed on start and finish foam areas and the test results shall be a minimum of 35 psi. When the minimum tensile requirement is not met, the nonconformance shall be documented per standard nonconformance procedures and, when approved by NASA MSFC M&P or the user's M&P (6.4) one (1) additional tensile test shall be performed adjacent to the original failure. The user's M&P (6.4) shall determine the retest location. If the result of the additional test meets the minimum tensile requirement, the part shall be considered conforming. Additional tests may be performed as required by the user's M&P (6.4) and Product Assurance.

Test areas of foam only shall be restored per this specification or STP0598 with STM0878, unless otherwise specified by the released engineering documentation.

3.5.6.2.2 When the released engineering documentation calls out witness panels for the purpose of tensile testing, the test shall be performed per 3.5.6.2.1 or the test shall be performed per ASTM-D1623 with the following exceptions: The test specimens shall be conditioned at laboratory conditions (6.2) for 45 minutes, minimum, prior to testing at laboratory conditions (6.2). Test specimens shall be prepared as follows:

a. A minimum of three specimens shall be fabricated in accordance with EM40-OWI-043, or user's M&P (6.4) approved equivalent, from each witness panel.
b. Each specimen shall be identified with the appropriate information to maintain necessary traceability.

The test results shall be a minimum of 35 psi.

3.5.6.3 Cryoflex Specimens: The configuration, number and thickness of specimens shall be per released engineering documentation. Each specimen shall withstand the minimum substrate stress level as defined in Table III. Test temperatures shall be chosen based on the in-service substrate temperature of the part being foamed.

Table III. Gradient Cryoflex Test Requirements

Test Temperature (°F)	Minimum Acceptable Stress (ksi)(1)	Test Anvil Radius
-310 ±10	59	Infinite
-423 to -400	61	Infinite
(1) For specimens on 2219-T87 Aluminum		

3.5.7 In-Process Material Storage

A and B components in pressurized cylinders shall be stored at 40 – 110°F when pressurized to 30 – 90 psi with dry nitrogen gas (3.2.5.10).

Opened drums of A-component shall be stored at 40 – 60 °F and shall be sealed with a 3.5 psi, maximum, dry nitrogen gas (3.2.5.10) blanket.

3.6 Special Skills

Special skills are required to perform these processes.

Any group using this specification to apply polyurethane foam (MSFC-SPEC-3686) shall have a foam spray operator training, certification and proficiency program, as determined by the user, to meet Program requirements. Applications may exist that mandate enhanced operator preparation that requires specialized training, qualification, and certification beyond standard training. For example, this enhanced preparation may include:

- High-fidelity mock up sprays
- Sprayed foam dissection and inspection for flaws
- A proficiency spray-and-test regime

This program shall be reviewed and approved by the user's M&P (6.4) before implementation. Changes to the approach must be approved by the user's M&P (6.4) before implementation.

3.7 Safety

Implementing documentation released by NASA MSFC M&P, such as manufacturing process plans, process instructions, and test procedures shall adhere to the requirements levied within the applicable usage site safety, health, and environmental regulations. Documents approved by NASA MSFC M&P or the user's M&P (6.4) for supplier or contractor use shall contain appropriate safety criteria and requirements applicable to the operations described within the procedure.

3.8 Contamination Control

Processes shall be controlled to prevent contamination of the process materials and of the surrounding surfaces. If required, adjacent work surfaces in the area of foam applications shall be protected and/or masked using approved materials.

4.0 PRODUCT ASSURANCE PROVISIONS

4.1 General

Product Assurance shall ensure conformance to this specification.

4.2 Records

Suitable records covering the entire process shall be maintained for traceability. The following data shall be recorded, at a minimum, for traceability:

a. Identification of foam components

b. Temperature of work area, substrate and foam components (as measured per 3.5.1.7)

c. Relative humidity in work area

d. A to B foam component ratio

e. Strength data, sprayed density

f. Delivery system identification number

g. Time and date for start of spray and end of spray

4.3 Special Test Methods

4.3.1 Density

Apparent density shall be determined in general accordance with ASTM-D1622 with the following exception: test specimens shall be conditioned at laboratory conditions (6.2) for 45 minutes minimum, prior to testing at laboratory conditions (6.2). Custom, standardized, procedures approved by Product Assurance and the user's M&P (6.4) may also be used for determination of density.

4.3.2 Tensile Strength

In accordance with the instructions of 3.5.6.2.1 and 3.5.6.2.2, tensile strength shall be determined using approved portable tensile testing equipment. Tensile strength may also be determined per ASTM-D1623, Type C with the following exception: test specimens shall be conditioned at laboratory conditions (6.2) for 45 minutes minimum, prior to testing at laboratory conditions (6.2). Regardless of time to failure, the test machine head travel speed shall be 0.05 inch per minute for specimens 0.6 to 1 inch thick and 0.02 inch per minute for specimens under 0.6 inch thick.

4.3.3 Rounding Off Values

Reported values shall be rounded off per standard procedure to the same number of significant places as are shown in the requirement. When the next significant number is 5, only odd numbers shall be increased.

4.3.4 Cryoflex Properties

Cryoflex testing shall be in accordance MSFOC 06-0187WI, (for testing at the Michoud Assembly Facility (MAF)) or EM40-OWI-058 (for testing at MSFC). Test temperature shall be -310 ± 10°F or -423 to -400 °F. Test temperature, stress load and success criteria shall be per the released engineering documentation.

5.0 NOTES

5.1 Changes From the Previous Issue

Changes from the previous issuance of this standard are noted in the Document History Log located at the beginning of this document. This was done as a convenience only and NASA MSFC M&P assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this specification based on the entire content irrespective of the marginal notations and relationship to the previous issue.

6.0 DEFINITIONS

6.1 Ambient

65 to 100°F

6.2 Laboratory Conditions

65 to 85°F with a relative humidity of 70% or less.

6.3 Shelf Life

The period of time during which an item can remain in storage without having its operability affected.

6.4 User's M&P

Applicable contractor or sub-contractor responsible materials and processes engineering function

APPENDIX A: SUMMARY INFORMATION

Table IV. Storage and Transit Condition Summary

Location	Conditions (°F)	Ref. Paragraph
Controlled Storage	40 to 60	3.5.1.3
Transit	No Requirement	3.5.1.3
Preparation or Usage Location	40 to 110	3.5.1.3
Container Transfer (A-Component only)	40 to 85	3.5.1.4