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MEASUREMENT SYSTEM IDENTIFICATION INCH-POUND

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George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

EM40

MSFC TECHNICAL STANDARD

POLYURETHANE FOAM, SPRAY APPLICATION PROCEDURE FOR

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DOCUMENT HISTORY LOG

Status (Baseline/ Revision/ Canceled)	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

Status (Baseline/ Revision/ Canceled)	Document Revision	Effective Date	Description
			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 section3.5.5, 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
Revision	B	6/23/2017	Throughout the document the section numbering and formatting was updated for Revision B. Added sections 3.2.5.14, 3.2.5.15, 3.2.5.16, 3.2.5.17, 3.4.1, 3.9, 6.5, 6.6. Extensive updates were performed to sections 3.3.2, 3.4.2, 3.4.4, 3.4.5, 3.5, Table 1 & Table 2, 4.2, 4.3.3. Deleted Table 3 and sections 3.5.5.3, 3.5.6.2, 4.3.1, 4.3.2, 4.3.4. Most of the deleted information was moved to MSFC-SPEC-3686 and updated in that document. 1.2 Deleted text and referred reader to applicable requirements section.

Status (Baseline/ Revision/ Canceled)	Document Revision	Effective Date	Description
			1.4 Added "Tie coat type", clarified density and tensile testing requirements for released engineering documentation. 2.1 Added MPR 8730.5, SLS-SPIE-PROC-005, SLS-SPIE-PROC-008, SLS-SPIE-SPEC-010, SLS-SPIE-SPEC-012. 2.1.1 Deleted numbering, moved section heading and text to 2.1. 2.1.2 Deleted numbering and section heading, moved text to 2.1. 2.1.3 Deleted numbering, moved section heading and text to 2.1, except for the following: deleted MSFOC 06-0187WI, EM40-OWI-043, EM40-OWI-058. 2.1.4 Deleted numbering and section heading, moved text to 2.1. 2.2 Added ASTM-D5486, SAE AMS 4613, SAE AMS 5596, STM0877, STP0597 2.2.1 Deleted section. 2.2.2 Deleted numbering, moved section heading and text to 2.2. 3.2.2 Added SLS-SPIE-SPEC-010. 3.2.4 Added SLS-SPIE-SPEC-012. 3.2.5.1 Added "on nylon web". 3.2.5.10 Updated designation, added PIN number and description. 3.3.1.3 Changed to 3.3.1.4 and added callout for MPR 8730.5 3.8.1 Added a callout for Dura-Skrim and other approved materials. 4.3.3 Changed to 4.3.1, deleted "per standard procedure", and "When the next significant number is 5, only odd numbers shall be increased." Appendix A: Table 4 label was changed to Table 3, and extensive updates were made to the table.
Revision	C	07/20/2020	Section 2.2 Deleted ASTM-D1622 and ASTM D1623. Extended the overlap time in Table 1 and Table 2 Expanded the S-180 Environmental allowable processing window and updated Figure 1. Added requirements for portable tensile testing on hardware and witness panels for hardware acceptance in Section 3.5.4.2. Deleted Section 3.5.3.5 and moved text to Section 3.5.4.1. Deleted Section 3.5.3.6 and moved text to 3.5.4.1.3. Rewrote Section 3.5.4, including deletion of duplicate requirements/information and addition of text in Section 3.5.4.2.2. Changed content of Section 6.6 to Section 6.8, added new content for Sections 6.6 and 6.7.
Revision	D	04/12/2022	Updated Section 3.2.4.13 to include a coarser grit sandpaper in the allowable grit range.

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1. 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. This document is applicable to all MSFC programs and projects.

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.

This standard applies the following: All mandatory actions (i.e., requirements) are denoted by statements containing the term, "shall." The terms: "may" or "can" denote discretionary privilege or permission; "should" denotes a good practice and is recommended, but not required; "will" denotes an expected outcome; and "are/is" denotes descriptive material.

1.2 Implementing Documentation

See Section 3.1, Engineering Controls, for requirements related to implementing documentation.

1.3 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. Tie coat type
f. Any special foam surface acceptance criteria including, but not limited to, surface waviness or appearance
g. Location and configuration of planned applications.
h. Location and orientation for in-process witness panels (3.5.5)

Released engineering documentation will specify any required density and tensile testing on the production part. If witness panels are required, the released engineering documentation will specify the type of tensile testing and any other testing to be performed on witness panels and the unique identification marking(s) for each panel.

2. 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

Federal Specifications and Standard

29 CFR 1910	Occupational Safety and Health Standards
MIL-DTL-17667	Paper, Wrapping, Chemically Neutral (Non-Corrosive)
MIL-PRF-27401	Performance Specification: Propellant Pressurizing Agent, Nitrogen
TT-I-735	Federal Specification, Isopropyl Alcohol

NASA

MPR 8730.5	Metrology and Calibration
MSFC-SPEC-3686	Material Specification for Polyurethane Foam – Sprayable
NRRS 1441.1	NASA Records Retention Schedules
SLS-SPIE-PROC-005	Surface Preparation and Application Instructions for Hexavalent Chromium Epoxy Primer
SLS-SPIE-PROC-008	Surface Preparation and Application Instructions for Cryogenic Polyurethane Tiecoat
SLS-SPIE-SPEC-010	Hexavalent Chromium Epoxy Primer, Material Specification for
SLS-SPIE-SPEC-012	Cryogenic Polyurethane Adhesive/Tiecoat, Material Specification for

2.2 Non-Government Documents

ASTM-D329	Standard Specification for Acetone
ASTM-D740	Standard Specification for Methyl Ethyl Ketone
ASTM-D5486	Standard Specification for Pressure-Sensitive Tape for Packaging, Box Closure, and Sealing

SAE AMS 3819	Cloths, Cleaning, For Aircraft Primary and Secondary Structural Surfaces
SAE AMS 4613	Aluminum Alloy, Sheet and Plate, 6.3Cu - 0.30Mn - 0.06Ti - 0.10V - 0.18Zr, Solution Heat Treated, Cold Worked (8%) and Precipitation Heat Treated (2219 -T87)
SAE AMS 5596	Nickel Alloy, Corrosion and Heat-Resistant, Sheet, Strip, Foil and Plate 52.5Ni - 19Cr - 3.0Mo - 5.1Cb (Nb) - 0.90Ti - 0.50Al - 18Fe Consumable Electrode Remelted or Vacuum Induction Melted 1775 °F (968 °C) Solution Heat Treated

Boeing Specifications

STM0877	Foam, Spray-On, Polyisocyanurate
STM0878	Foam, Polyurethane, Pour-in-Place
STM0882	Adhesive/Tiecoat, Polyurethane, Cryogenic
STM0907	Primer, Epoxy, Cryogenic, No-Degloss
STP0292	Finishes: Organic, Application and Controls of
STP0597	Foam, Polyisocyanurate, Spray Application of
STP0598	Insulation Closeouts, Cryogenic, Forming

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

3. REQUIREMENTS

3.1 Engineering Controls

3.1.1 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.

3.1.2 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.

3.1.3 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) or SLS-SPIE-SPEC-010, "Hexavalent Chromium Epoxy Primer, Material Specification for"

3.2.3 Tie Coat (cryogenic compatible)
Spec: STM0882, "Adhesive/Tiecoat, Polyurethane, Cryogenic" (Hazardous Material) or SLS-SPIE-SPEC-012, "Cryogenic Polyurethane Adhesive/Tiecoat, Material Specification for"

3.2.4 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.

3.2.4.1 Abrasive pads, Aluminum Oxide on nylon web, 3M (CAGE code 76381) Scotch Brite MMM7447 Maroon

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

3.2.4.3 Purified wiping cloth, SAE AMS 3819 Class 1, Grade A, Form 1, American Fiber and Finishing #301 Rymplecloth® silicone-free cotton

3.2.4.4 Tape, polyethylene, black, pressure sensitive, 3M (CAGE code 76381) Preservation 481

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

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

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

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

3.2.4.9 Solvent, Acetone (hazardous material), ASTM-D329

3.2.4.10 Nitrogen, drying or purging gas. Per MIL-PRF-27401, PIN M-27401-1A (Type 1, Grade A minimum)

3.2.4.11 Staedtler Lumocolor® marker #315 or #316

3.2.4.12 Solvent, Ardrox 5529 (Hazardous Material)

3.2.4.13 Abrasive paper, Aluminum Oxide, 40-400 grit

3.2.4.14 Polyethylene laminate, chemical resistant gloves

3.2.4.15 Tape, polyethylene, olive, pressure sensitive, ASTM D 5486, Type IV Class 1

3.2.4.16 Laminate, polyethylene extrusion, four-layer reinforced, fire-retardant, high puncture and tear strength. Raven Industries DURA-SKRIM 2FR or 10FR.

3.2.4.17 Tape, fire-retardant, black, rubber adhesive. Meets ASTM D 568, 20-200F performance temperature, Polyken 268 or 268FR.

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.

3.3.1.2 All direct-contact materials/equipment used to implement the requirements of this specification shall be compatible with the materials being processed.

3.3.1.3 Control of the processing area environment, including cleanliness, temperature and humidity, is required. Reference Table I and Figure I, Section 3.5.2.1.1, and Table II, Section 3.5.2.2.1.

3.3.1.4 Measuring instruments, test equipment and controlling or recording instruments used for control of production and inspection operations shall be calibrated in accordance with MPR 8730.5 or otherwise indicated as a limited use item.

3.3.2 Foam dispensing equipment

3.3.2.1 The dispensing systems shall have the capability of delivering the components in an average mix ratio, either by volume or by mass, as listed in Table I & Table II, Mix Ratio (A to B Components).

3.3.2.2 The dispensing systems shall include component material supply filters, pressure regulators, and material flow, temperature, and pressure instrumentation.

3.3.2.3 The component supply system shall be pressurized by connection to a nitrogen supply system with dry nitrogen (3.2.4.10) at 30 – 90 psig during material usage.

3.3.2.3.1 For the A component, the nitrogen system may be disconnected when the supply system is not being used provided a nitrogen blanket is maintained over the material.

3.3.2.3.2 For the B component, the nitrogen supply system may be disconnected when the component supply system is not being used provided a nitrogen blanket is maintained over the material at 30 to 90 psig.

3.4 Product

3.4.1 Approved substrates

MSFC-SPEC-3686 foam (3.2.1) is only approved for use on the following substrates, unless otherwise specified by the released engineering documentation. Other substrates may be acceptable with approval from the User's M&P (6.4). Metallic substrates shall be primed per 3.4.2 and 3.4.3, and foam substrate shall receive tie coat per 3.4.4 prior to MSFC-SPEC-3686 foam (3.2.1) deposition onto the substrate.

a. 2219 – T87 Aluminum (SAE AMS 4613)
b. Inconel ® alloy 718, solution treated and heat aged (SAE AMS 5596)
c. MSFC-SPEC-3686 foam with tie coat (3.2.3) applied per 3.4.4.
d. NCFI 16-009 foam that complies with STM0877 applied per STP0597 with tie coat (3.2.3) applied per 3.4.4
e. Utah 503-2.5-45p-R.1 foam that complies with STM0878 applied per STP0598 with tie coat (3.2.3) applied per 3.4.4

NOTE: Material properties of MSFC-SPEC-3686 foam (3.2.1) are influenced by a number of factors. Some factors that influence material properties include substrate, primer, and tie coat materials chosen, processing conditions, and end-item use environment (temperature, humidity, etc.).

3.4.2 Primer type, thickness, and processing

3.4.2.1 The primer used on surfaces that will receive spray on foam insulation shall be compatible with the sprayable foam detailed in MSFC-SPEC-3686 and with the substrate material.

3.4.2.1.1 All metallic surfaces (except fastener assemblies and lockwire) to be foamed shall be primed in accordance with 3.4.2.2, unless otherwise specified by the released engineering documentation.

3.4.2.1.2 The priming of fastener assemblies and lockwire shall be optional when not otherwise specified. Foam may be applied to primed surfaces after thickness, visual, and adhesion requirements of the primer application procedure have been met.

3.4.2.2 Primer application, touch-up, and cure shall be in accordance with STP0292 or SLS-SPIE-PROC-005 when using primer (3.2.2).

3.4.3 Primed metallic substrate preparation for foam spray application when using primer (3.2.2).

To clean/prepare the substrate for foam application use Rymplecloth® (3.2.4.3) wetted with Ardrox 5529 solvent (3.2.4.12) to wipe the primed substrate. This cleaning process shall be performed within the 72-hour period just before the foam application begins. The 72-hour clock begins upon first contact of the wetted Rymplecloth® and stops when foaming starts. This cleaning will be performed wearing polyethylene laminate, chemical resistant gloves (3.2.4.14) and will be performed using the "two-handed" wiping method described herein.

3.4.3.1 Two-handed wiping method

a. Rymplecloth® (3.2.4.3) wetted with the Ardrox 5529 solvent (3.2.4.12) shall be used to wipe the surface to remove contaminants.

b. Before the solvent (3.2.4.12) evaporates off the surface, the surface shall immediately be wiped dry with a clean Rymplecloth® (3.2.4.3).

NOTE: This is performed by using two hands, one hand applying the solvent followed immediately with the other hand wiping with a clean, dry Rymplecloth®.

c. If the Rymplecloth® shows contamination, inspect the part for surface contamination. If there is contamination on the Rymplecloth® and/or the part, the wiping process shall be repeated with a clean cloth surface (3.4.3.1 (a-c)) until the part and the Rymplecloth® (3.2.4.3) show no indications of contamination. Primer residue on the Rymplecloth® is not considered contamination.

3.4.3.2 Visual verification shall occur to ensure that primer coverage remains during cleaning.

3.4.3.3 The part shall be protected from contamination after it is cleaned until further processing is required.

3.4.3.4 Allow the substrate to stand for 15 minutes minimum after completion of cleaning.

3.4.4 Surface preparation of foam covered application areas

CAUTION: Procedural controls, coupled with engineering controls, should be exercised to reduce the explosion potential to acceptable levels when dealing with foam dust.

NOTE: Shop vacuums utilized to collect dust residue during hand sanding or grinding operations should be rated as Class II Division I (per OSHA Title 29 CFR 1910.399) or approved equivalent. They should be properly grounded and bonded to reduce the potential for providing adequate energy to initiate a dust explosion.

a. Foam shall be cut or trimmed as specified on the appropriate released engineering documentation.
b. Unless otherwise specified by the released engineering documentation, the surface preparation for cured foam substrates where new foam is to be applied shall include:
    i. The removal of any topcoat or rind surface by abrasion (3.4.4). Repetitive processing is acceptable provided material removal does not exceed part dimensional tolerances.
    ii. Application of tie-coat adhesive (3.2.3) in accordance with STP0292 or SLS-SPIE-PROC-008 or a procuring authority M&P approved alternate.
c. If the time at which foam application starts is greater than 72 hours from the start of the tie coat application, the tie coat shall be wiped down with IPA using Rymplecloth® (3.2.4.3) before foam is applied onto the tie coat and allowed to dry for a minimum of 15 minutes and a maximum of 24 hours.
d. The substrate surface shall not be marred by foam trimming operations.
e. The trimmed foam edge shall be protected from contamination during the surface preparation of the perimeter area.
f. Abrasion of foam surfaces shall be performed using aluminum oxide on nylon web pads (3.2.4.1) or paper (3.2.4.13) only.
g. Abrasive residue shall be thoroughly removed with a clean, dry cloth wipe (3.2.4.3), by blowing off with nitrogen (3.2.4.10) or clean, dry air, or by vacuum. The use of a vacuum to clear away residue is preferable. See 3.4.4 NOTE.

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 shelf life per MSFC-SPEC-3686.

3.5.1.2 Prior to removal from controlled storage (6.5), verify the B-Component is pressurized in accordance with MSFC-SPEC-3686, Section 3.1.8.

3.5.1.3 B-Component shall be stored, relocated, and used in its original shipping container with constant nitrogen pressure maintained per 3.5.7.

3.5.1.4 Within 2 hours from the time the materials are withdrawn from controlled storage (6.5) the materials shall be relocated to the preparation area or Booth/Application Area and stored per 3.5.7, In-process material storage.

3.5.1.5 At no time during relocation shall the materials be stored in direct sunlight.

3.5.1.6 When performing an open air transfer of A-Component from the original 55 gallon shipping container to a pressure pot, the room temperature shall be 40°F to 100°F.

3.5.1.6.1 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 in order to reduce moisture exposure.

3.5.1.6.2 After A-Component has been transferred from the drum to the pressure pot, perform the following:

a. Purge the drum of A-Component per 3.5.7 and seal it.
b. Pressurize the pressure pot of A-component per 3.5.7.
c. Store the purged and sealed drum of A-Component and the pressurized pressure pot of A-component per 3.5.7.

3.5.1.7 Spray gun parts shall be assembled or installed to provide the desired foam output while conforming to Table I or Table II.

3.5.1.8 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.

3.5.1.9 Equipment used to monitor average mix ratio shall be calibrated to an accuracy of ±2.5 percent or better.

3.5.2 Spray foam application methods

Two different spray foam application methods may be utilized for this process specification, manually sprayed foam and automatically sprayed foam.

3.5.2.1 Manually sprayed foam

Manually sprayed foam knit line targets shall be set in the released engineering work instructions.

3.5.2.1.1 The parameters shown in Table I and Figure 1 shall be utilized for manually sprayed foam

TABLE I. Manual spray process parameters

Parameter		Spray Settings or Values (Min-Max)
Overlap Time (seconds)(1)		10 to 120
Mix Ratio (A to B components)	by mass	(1.03 to 1.11) to 1
	by volume	(0.97 to 1.05) to 1
Component A & B Temperature (°F) (2)		115 to 125
Application Area Temperature (°F)		See Figure 1
Application Area Relative Humidity		
Substrate Temperature (°F)		(+/-) 5 degrees of the application area temperature not exceeding Figure 1
Gun Set up Details		Located in the released engineering work instructions
(1) Do not spray onto rising foam. (2) As measured within accuracy per 3.5.2.3.1.		

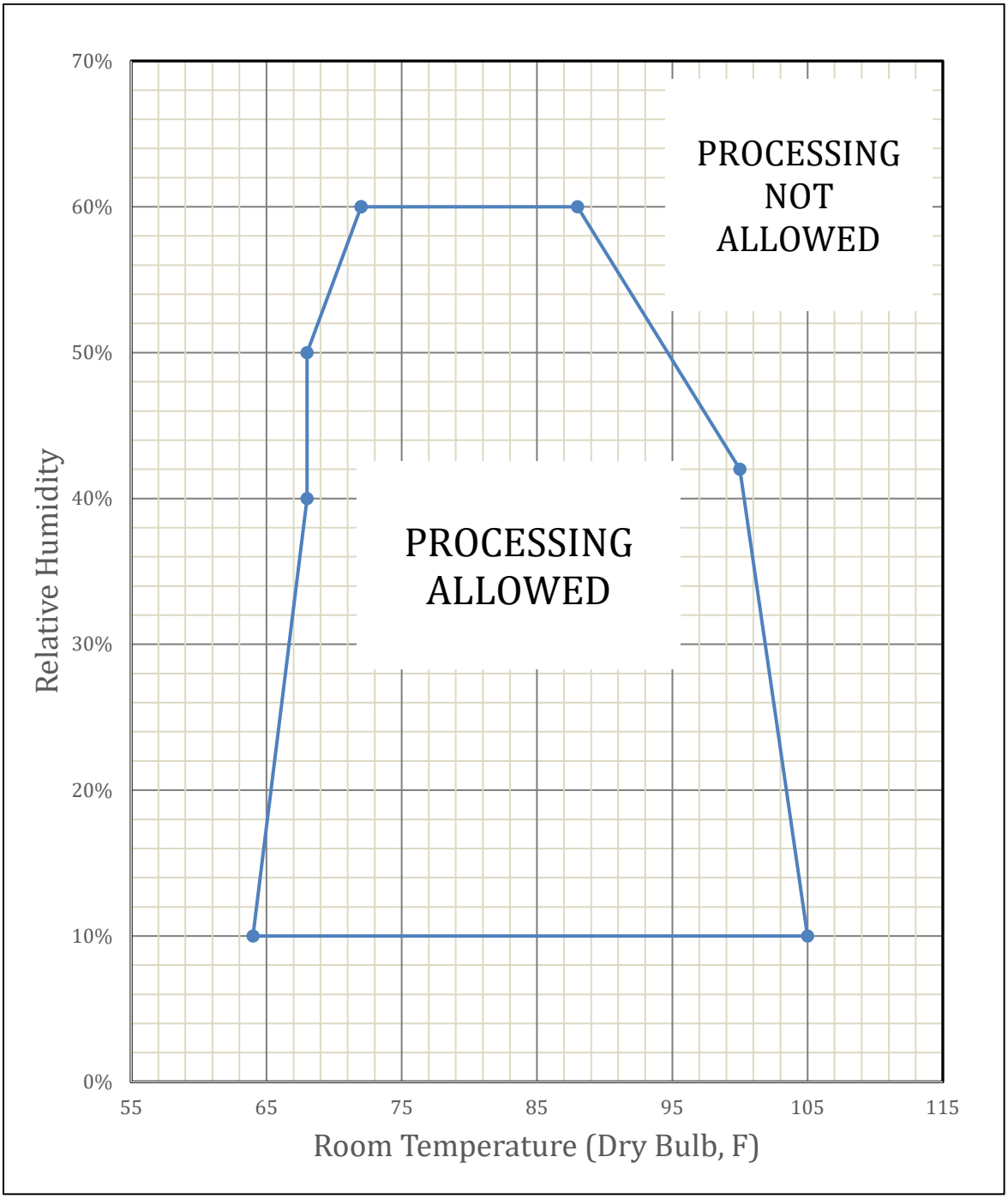

FIGURE 1. S-180 (MSFC-SPEC-3686) Environmental allowable processing window

3.5.2.2 Automatically sprayed foam

3.5.2.2.1 The parameters shown in Table II and Figure 1 shall be utilized for automatically sprayed foam.

TABLE II. Automated spray process parameters

Parameter		Spray Settings or Values (Min-Max)
Overlap Time (seconds)		10 to 120
Mix Ratio (A to B Components)	by mass	(1.03 to 1.11) to 1
	by volume	(0.97 to 1.05) to 1
Component A & B Temperature (°F)(1)		115 to 125
Booth Temperature (°F)		See Figure 1
Booth Relative Humidity		
Substrate Temperature (°F)		(+/-) 5 of the booth temperature not exceeding Figure 1
Gun Set up Details		Located in the released engineering work instructions
(1) As measured within accuracy per 3.5.2.3.1		

3.5.2.3 Spray foam application process monitoring

3.5.2.3.1 The temperature of the foam material components shall be found in accordance with Table I or Table II, as applicable, during application time when measured with equipment accurate within (±) 4°F.

3.5.2.3.2 Indicated average mix-ratio transients associated with spray-gun activation shall not exceed the average mix ratio requirements in Table I or Table II and flow rate (if applicable) for more than 5 seconds. Flow rate requirements may be levied by spray schedules. When exceeding the requirements in Table I or Table II, transients shall be within (0.94 to 1.12) to 1 by volume. Single point outliers associated with gun activation and deactivation that fall outside of (0.94 to 1.12) to 1 by volume are acceptable.

3.5.2.3.3 The average mix ratio of Component A (3.2.1) (Isocyanate) to Component B (3.2.1) (Polyol), during spray operations shall be in accordance with Table I for manual spray processes or Table II for automated spray processes, and shall be monitored during application of foam to the hardware to ensure compliance to the ranges given in Table I or Table II.

3.5.2.3.4 Operating technicians and engineers shall verify that all parameters listed in Tables I or II, as applicable, fall within the ranges stated in Tables I or II during spraying of hardware. If more restrictive range values are given in released engineering work instructions, the ranges in the work instructions shall supersede ranges given in Tables I or II.

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. Dura-skrim (3.2.4.16) may be used as masking for area surfaces and production parts. When it is necessary to use pressure sensitive tape on production substrates to achieve masking, tape (3.2.4.2, 3.2.4.4, 3.2.4.5, or 3.2.4.15) or an approved substitute that meets ASTM D 5486 shall be used.

3.5.3.2 The temperature and relative humidity in the Booth or Application Area shall fall within the ranges stated in Table I or Table II and shall comply with released engineering work instructions.

3.5.3.2.1 Wet bulb-dry bulb type psychrometers shall be calibrated to (±) 1°F per thermometer and matched to (±) 0.5°F differential.

3.5.3.2.2 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 Foam material shall be purged from the dispense unit within 30 seconds prior to spraying the part.

3.5.4 Foam applications

Foam shall be applied per this specification with exceptions and additional instructions as noted in the released engineering documentation.

3.5.4.1 Post-spray foam curing

3.5.4.1.1 Curing required prior to application of stress
Sprayed foam shall be allowed to cure for a minimum of 24 hours before finish trimming/machining or application of stress, with exceptions given in 3.5.4.1.1 a, b, and c. For the first hour of the 24 hr cure, environmental conditions shall conform to Figure 1. After the first hour of the 24 hr cure, environmental conditions shall be ambient (6.1). 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, along with 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, rotated, or reoriented after a

minimum ambient (6.1) cure of 8 hours provided the movement 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.

3.5.4.1.2 Curing required prior to testing

Allow foam to cure for a minimum of 24 hours per 3.5.4.1.1 and then for an additional 24 hours minimum at ambient (6.1) before any testing is performed.

3.5.4.1.3 Marking on cured foam surfaces

The following pens shall be used to mark on foam surfaces

a. Staedtler Lumocolor® non-permanent marker, medium point, #315 (3.2.4.11)
b. Staedtler Lumocolor® non-permanent marker, fine point, #316 (3.2.4.11)

3.5.4.2 Sprayed foam cured properties

All sprayed foam shall be allowed to cure per 3.5.4.1 before testing and before being subjected to the use environment. All test specimens (except for Hardware/Product Acceptance testing – see Section 3.5.4.2.2) shall be prepared and tested in accordance with MSFC-SPEC-3686 and/or the released engineering work instructions. Material properties of cured foam sprayed per this specification with samples prepared and tested per MSFC-SPEC-3686 shall conform to MSFC-SPEC-3686 Table III.

3.5.4.2.1 Witness panel requirements

When witness panels (aka test panels) are required by the released engineering documentation

a. 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.
b. A minimum of 5 density and 5 portable tensile tests (tested per 3.5.4.2.2) shall be performed on each lead-in and each lead-out witness panel. Bond tension testing may also be performed on the witness panels if desired by the TPS Lead Engineer (6.6) or the user's M&P (6.4) or directed by the released engineering documentation.
c. The witness panel substrate shall 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.

3.5.4.2.2 Hardware / product acceptance testing

When the released engineering documentation directs hardware / product acceptance testing using portable tensile testing on production hardware and/or witness panels, portable tensile testing shall be performed per MSFC-SPEC-3686 Section 3.5.3.8 with the following exceptions:

a. For production hardware, a minimum of one test each shall be performed on start and finish foam areas and shall have results no lower than 30 psi.

b. For witness panels, a minimum of 5 portable tensile tests shall be performed on each witness panel to yield results no lower than 30 psi.
c. 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 (6.7) or the user's M&P (6.4) one (1) additional tensile test shall be performed adjacent to the original failure.
d. The user's M&P (6.4) shall determine the retest location.
e. If the result of the additional test meets the minimum tensile requirement, the production hardware or the witness panel shall be considered conforming. Additional tests may be performed as required by the disposition of the nonconformance.

For production hardware, test areas of foam only shall be restored per MSFC-PROC-3687 or by using pour foam per STP0598 with STM0878, unless otherwise specified by the released engineering documentation.

3.5.7 In-process material storage

3.5.7.1 B components in pressurized cylinders shall be stored at 40 to 100°F and pressurized at 30 to 90 psig with dry nitrogen gas (3.2.4.10).

3.5.7.2 B components shall not be stored in the unpressurized state.

3.5.7.3 Once A-component containers are opened, they shall be purged with dry nitrogen gas (3.2.4.10) prior to sealing the material container.

3.5.7.4 A components shall be stored in sealed containers at 40 to 100°F.

NOTE: If either (a) cylinder/container pressure OR (b) temperature of the location where the materials are stored falls outside of the ranges listed in 3.5.7, a non-conformance or event record will be required. Disposition of the non-conformance or event record will determine if the materials need to be re-tested and re-evaluated for conformance to the material acceptance requirements listed in MSFC-SPEC-3686 Table I and II.

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:

a. High-fidelity mock up sprays
b. Sprayed foam dissection and inspection for flaws

c. 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.

3.7.1 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.

3.8.1 If required, adjacent work surfaces in the area of foam applications shall be protected and/or masked using Dura-Skrim (3.2.4.16) and other approved materials (3.2.4).

3.9 Recording Requirements

Released engineering documentation shall require recording of the following data, at a minimum:

a. Identification of foam components including Specification Number and revision, Material Name, Manufacturer, Lot Identification, Date of Manufacture and Expiration Date
b. A to B foam component ratio – monitor and record during the entire spray event.
c. Strength data, sprayed density
d. Temperature of work area, substrate, and foam components
    i. The temperature of the substrate shall be recorded at the commencement of the spray activity.
    ii. The temperature of the work area and foam components shall be monitored throughout the activity.
e. Relative humidity in work area –
    i. Control and monitor during the entire spray when working in the Booth.
    ii. Monitor during the entire spray when working in an Application Area other than the Booth.
    iii. Record during the entire spray for automated sprays, and at key processing points (e.g. before spraying, etc.) for manual sprays.
    iv. Monitor during the first hour of post-spray cure.

v. Record for the entire first hour of post-spray curing for automated sprays, and at key processing points during the first hour of post-spray curing for manual sprays.

f. Delivery system identification number
g. Time and date for start of spray and end of spray
h. Gun type and setup details

4.0 QUALITY ASSURANCE PROVISIONS

4.1 General

Quality Assurance shall ensure conformance to this specification.

4.2 Records

Suitable records covering the entire process will be maintained for traceability (reference NRRS 1441.1 for length of retention). See 3.9 for minimum recording requirements.

4.3 Special Test Methods

4.3.1 Rounding off values

Reported values shall be rounded off to the same number of significant places as are shown in the requirement.

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.

6.0 DEFINITIONS AND ACRONYMS

6.1 Ambient Temperature

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 for the materials and processes engineering function.

6.5 Controlled Storage

Controlled storage is refrigerated storage with a temperature range of 40°F to 60°F.

6.6 TPS Lead Engineer

The subject matter expert directing the TPS task.

6.7 MSFC Materials and Processes Laboratory, M&P, or MSFC

These terms refer to the Materials and Processes Laboratory of the MSFC Engineering Directorate.

6.8 Acronyms

AMS	Aerospace Material Specification
ANSI	American National Standards Institute
ASTM	ASTM International
CAGE	Commercial and Government Entity
CFR	Code of Federal Occupational Safety and Health Administration Regulations
EM40	Nonmetallic Materials & Advanced Manufacturing Division
IPA	Isopropyl Alcohol
ITAR	International Traffic in Arms Regulations
M&P	Materials and Processes
MEK	Methyl Ethyl Ketone
MPDMS	Multiprogram Document Management System
MPR	Marshall Procedural Requirements
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
NCSL	National Conference of Standards Laboratories, now NCSL International

OSHA	Occupational Safety and Health Administration
OWI	Organizational Work Instruction
SAE AMS	Society of Automotive Engineers / Aerospace Material Specification
SBU	Sensitive But Unclassified
TPS	Thermal Protection System

APPENDIX A. SUMMARY INFORMATION

TABLE III. Storage and transit condition summary

Location	Conditions (°F)	Ref. Paragraph
Controlled Storage	40 to 60	3.5.1.2 and 6.5
Transit of Material Between Controlled Storage and Preparation or Booth/Application Area	No Temperature Requirement(1)	3.5.1 and 3.5.7
Preparation Area or Booth/Application Area	40 to 100	3.5.1 and 3.5.7
Material Transfer Between Containers (A-Component only)	40 to 100	3.5.1.6 and 3.5.7
(1) Per section 3.5.1.5, at no time during relocation shall the materials be stored in direct sunlight.		