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MIL-PRF-46194A
8 August 1997
SUPERSEDING
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PERFORMANCE SPECIFICATION

FOAM, RIGID, STRUCTURAL, CLOSED CELL

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers rigid, structural, closed cell foam (see 6.1).

1.2 Classification. The foam to be of the following types and classes:

Type I — For processing up to temperatures of 250°F (121°C)

Class 1	2.0 lb_m /ft^3 (32.0 kg/m^3) density, nominal
Class 2	3.2 lb_m /ft^3 (51.3 kg/m^3) density, nominal
Class 3	4.7 lb_m /ft^3 (75.3 kg/m^3) density, nominal

Type II — For processing up to temperatures of 350°F (177°C) after post-curing (see 6.4)

Class 2	3.2 lb_m /ft^3 (51.3 kg/m^3) density, nominal
Class 3	4.7 lb_m /ft^3 (75.3 kg/m^3) density, nominal
Class 4	6.9 lb_m /ft^3 (110.5 kg/m^3) density, nominal
Class 5	12.8 lb_m /ft^3 (205.0 kg/m^3) density, nominal
Class 6	18.7 lb_m /ft^3 (299.5 kg/m^3) density, nominal

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 of this specification. This section does not include documents in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements documents cited in sections 3 and 4 of this specification, whether or not they are listed.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Director, U.S. Army Research Laboratory, Weapons and Materials Research Directorate, ATTN: AMSRL-WM-M, APG, MD 21005-5069 by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the issue of the DoDISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DoDISS are the issues of the documents cited in the solicitation (see 6.2).

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C273 - Standard Test Method for Shear Properties of Sandwich Core Materials

ASTM D638/ D638M - Standard Test Method for Tensile Properties of Plastics

ASTM D910 - Standard Specification for Aviation Gasolines

ASTM D1621 - Standard Test Method for Compressive Properties of Rigid Cellular Plastics

ASTM D1622 - Standard Test Method for Apparent Density of Rigid Cellular Plastics

(Application for copies should be addressed to the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428).

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

AS 1241 - Fire Resistant Phosphate Ester Hydraulic Fluid for Aircraft

(Application for copies should be addressed to Aerospace Material Specifications, 400 Commonwealth Drive, Warrendale, PA 15096).

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 First article. When specified in the contract or purchase order, a sample shall be subjected to first article inspection (see 4.2.1).

3.2 Recycled, recovered, or environmentally preferable materials. Recycled, recovered, or environmentally preferable materials should be used to the maximum extent possible provided the material meets or exceeds all specified requirements and promotes economically advantageous life cycle costs.

3.3 Material. The material shall be a dimensionally stable, closed cell, rigid foam. The foam material shall be homogeneous throughout. The cells shall be of approximately the same size, without large accumulations of unexpanded resin, or other inclusions. The foam shall be free of cracks, surface irregularities, handling damage, and contaminants. The foam shall conform to the dimensional requirements of the purchase order.

3.4 Thermal stability. Type I expanded foam shall maintain dimensional stability at temperatures up to 250°F (121°C). Type II foam shall maintain dimensional stability at temperatures up to 350°F (177°C).

3.5 Marking. Each individual sheet shall be permanently marked in one corner with the following information:

a) Material specification number, revision letter
b) Type and class
c) Lot number and batch number
d) Date of manufacture
e) Manufacturer's product designation

3.6 Properties. Unless otherwise specified, the physical, chemical, and mechanical properties of the foam shall be as specified herein when tested in accordance with the test methods listed in Table V.

3.7 Physical properties. The density range and maximal water absorption of the foam shall be as specified in Table I.

3.8 Fluid resistance. The foam shall be resistant to the fluids listed in Table II. The compressive strength of the foam at 73.4 ± 3.6°F (23.0 ± 2.0°C) shall remain above the minimal values specified in 3.3.3 when immersed in the fluids for the exposure times and temperatures as specified in Table II.

3.9 Mechanical properties.

3.9.1 Type I foam. The minimal mechanical properties of type I foam shall be as specified in Table III.

3.9.2 Type II foam. The minimal mechanical properties of type II foam shall be as specified in Table IV.

4. VERIFICATION

4.1 Verification alternatives. Alternative test methods, techniques, or equipment, including the application of statistical process control, tool control, or cost effective sampling procedures may be proposed by the contractor. Acceptable alternative verification approaches shall be identified in the contract.

4.2 Classification of inspection. The examination and testing of the foam material shall be classified as follows:

a) First article inspection (see 4.2.1)
b) Conformance inspection (see 4.2.2)

4.2.1 First article inspection. First article inspection shall be performed on the first production-representative samples of an order when a first article sample is required (see 3.1). The first article sample(s) shall be examined for all the provisions specified by the procuring activity, the contract or the purchase order (see 6.2). This inspection shall consist of the tests specified in table V.

4.2.2 Conformance inspection. Conformance inspection for acceptance of rigid, structural, closed cell foam shall meet all the provisions specified by the procuring activity, the contract or the purchase order (see 6.2).

4.3 Lot size. Lot size shall consist of all foam material of the same density produced from one batch during a single production run.

4.4 Sampling. Unless otherwise specified, at least one sample sheet which is representative of each lot (4.3) shall be selected at random for conformance testing. When material is supplied in thicknesses of less than 1 inch (2.5 cm), the supplier shall also furnish material from the same lot, not less than 1 inch (2.5 cm) thick for conformance inspection.

4.5 Water absorption test. Water absorption shall be determined on five specimens selected at random from each density submitted for testing. Each specimen shall be 2 inches by 2 inches by 1 inch thick (5 x 5 x 2.5 cm). The specimens shall not be sealed or protected with any coating which would inhibit moisture absorption. After drying as specified in 6.3, the specimens shall be allowed to cool to room temperature (73.4 $\pm$ 3.6°F) (23.0 $\pm$ 2.0°C) in an environmentally controlled (50 $\pm$ 5% RH) room for 2 hours, and then shall be weighed. The specimens shall then be placed into an environmental chamber at a relative humidity of 85 $\pm$ 2 percent and a temperature of 160 $\pm$ 5°F (71 $\pm$ 3°C).

Specimens shall be removed from the chamber periodically (but at least once a week), allowed to cool to room temperature, then reweighed to determine weight after exposure. The above procedure shall be repeated until the equilibrium moisture level (saturation) is attained. Equilibrium shall be defined as two consecutive weekly measurements indicating a moisture gain of less than 0.05 percent. Except for reweighing, wet conditioning shall not be interrupted. Calculate moisture absorption for each specimen as: weight (percent) absorbed = [(weight wet specimen - weight dry specimen)/(weight dry specimen)] x 100. Calculate the average moisture absorbed.

4.6 Noncompliance.

4.6.1 Rejection. Unless otherwise specified where one or more test specimens fail to meet the requirements of the specification, the lot represented by the specimen or specimens shall be subject to rejection.

4.6.2 Retest. When a sampling plan is not provided or approved by the procuring agency, where there is evidence that indicates that the specimen was not representative of the lot of material, and when the contract does not otherwise specify, at least two specimens shall be selected to replace each test specimen which failed. All specimens so selected for retest shall meet the requirements of the specification or the lot shall be subject to rejection.

4.7 Test results. Test results shall be kept in the contractor’s file for the duration of the contract.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When actual packaging of

materiel is to be performed by DoD personnel, these personnel need to contact the responsible packaging activity to ascertain requisite packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activity within the Military Department or Defense Agency, or within the Military Department's System Command. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

6. NOTES

(This section contains information of a general or explanatory nature which may be helpful, but is not mandatory).

6.1 Intended use. The foams which are specified in this document are rigid, closed cell materials comparable in density to some types of honeycomb core. This material may be a viable candidate for structural aerospace applications whenever a core or filler is needed and in nonstructural applications including formed configurations. Polymethacrylimide (PMI) foam has been used to comply with the requirements of this specification.

6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number and date of the specification
b. Type and class of material (see 1.2)
c. Issue of DoDISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.2).
d. When first article is required (see 3.1).
e. Dimensions in SI and English units.
f. Sampling plan, if other than specified in 4.4
g. Packaging requirements (see 5.1).

6.3 Procedure for drying type I and type II foams. Dry foam sections and panels in an air circulating oven at 250± 10°F (121 ± 5°C) for a minimum of 2 hours. Do not allow panels to come in contact with other panels in the oven (do not stack panels). Separate each panel from the closest panel by not less than one inch (2.5 cm). Arrange panels parallel to the direction of air flow. Do not place panels directly on the bottom of the oven, or on any other piece of nonperforated metal (which could restrict air flow). Place a piece of perforated metal or heavy metal screen atop the panel to prevent warpage during the drying cycle.

6.4 Procedure for heat treating type II foams. Prior to heat treating, dry the material in accordance with 6.3. Heat treat the material immediately after the drying cycle for the following times and temperatures: 48 hours @ 350 ± 10°F (177 ± 5°C) for class 2 and 3, 20 hours @ 320 ± 10°F (160 ± 5°C) followed by 28 hours @ 350 ± 10°F (177 ± 5°C) for class 4 and 5, and 24 hours @ 350 ± 10°F (177 ± 5°C) for class 6. Do not allow panels to come in contact with other panels in the oven (do not stack panels), and separate each panel from the closest panel by not less than one inch (2.5 cm). Arrange panels parallel to the direction of air flow. Do not place panels directly on the bottom of the oven, or on any other piece of nonperforated metal (which could restrict air flow). Place a piece of perforated metal or heavy metal screen on both

sides of each panel to prevent warpage during the heat treating cycle. Heat treating is a processing step involving extended exposure of foam to elevated temperatures; heat treat under highly controlled conditions to ensure dimensional stability of the foam.

6.5 Subject term (key word) listing.

Honeycomb core
Polymethacrylimide

Custodians:
Army - MR
Navy - AS
Air Force - 11

Review activities:
Army - AT, AV, IE
Navy - SH
Air Force - 13
DLA - DH

Preparing activity:
Army - MR

Project No. CMPS-0136

TABLE I. Physical properties of rigid foam.

Class	Density		Water Absorption (%), Max 1/	
	lb_m/ft^3	(kg/m^3)	Type I	Type II
1	1.56 to 2.44	(25.0 - 39.1)	13	--
2	2.45 to 3.85	(39.2 - 61.7)	13	10
3	3.86 to 5.59	(61.8 - 89.5)	13	10
4	5.60 to 8.20	(89.7 - 131.3)	--	10
5	10.60 to 15.00	(169.8 - 240.3)	--	10
6	15.60 to 21.80	(249.9 - 349.2)	--	10

1/ The procedure in paragraph 4.5 shall be used to determine water absorption.

TABLE II. Fluid resistance times and temperatures of immersion. 1/

Fluid	Immersion Time	Temperature
Gasoline (ASTM D910, octane 100)	1500 hours	73.4 ± 3.6°F (23 ± 2.0°C)
Hydraulic oil, petroleum base	1500 hours	73.4 ± 3.6°F (23 ± 2.0°C)
Hydraulic oil, synthetic hydrocarbon base	1500 hours	73.4 ± 3.6°F (23 ± 2.0°C)
JP-4 turbine fuel, aviation	1500 hours	73.4 ± 3.6°F (23 ± 2.0°C)
Lubricating oil, aircraft turbine engine, synthetic base with a kinematic viscosity of 4.0 ± 1.0 centistokes [4.3 ± 1.1(10)$^{-5}$ ft^2/sec] at 212°F (100°C)	1500 hours	73.4 ± 3.6°F (23 ± 2.0°C)
Deicing fluid (propylene glycol base with a specific gravity of 1.103 ± 0.003 or ethylene glycol base with a specific gravity of 1.105 ± 0.005)	1500 hours	73.4 ± 3.6°F (23 ± 2.0°C)
Cleaning compound, water dilutable for exterior surfaces of aircraft	1500 hours	73.4 ± 3.6°F (23 ± 2.0°C)
Acetone (If the end item will be exposed to methyl ethyl ketone, MEK shall replace acetone)	1500 hours	73.4 ± 3.6°F (23 ± 2.0°C)
Fire resistant phosphate ester hydraulic fluid (SAE AS 1241, type IV, class I)	1500 hours	158.0 ± 3.6°F (70 ± 2.0°C)

1/ Specimens shall be dried prior to immersion and prior to testing in accordance with paragraph 6.3.

TABLE III. Minimal mechanical properties of type I foam.

Class	Compressive Strength psi (kPa)	Tensile Strength psi (kPa)	Tensile Modulus ksi (MPa)	Shear Strength psi (kPa)	Shear Modulus ksi (MPa)
1	29 (200)	80 (552)	3.2 (22.1)	42.6 (293.7)	1.1 (7.6)
2	61 (421)	152 (1048)	6.2 (42.7)	72.5 (499.9)	2.0 (13.8)
3	137 (945)	246 (1696)	10.6 (73.1)	127.0 (875.7)	3.0 (20.7)

TABLE IV. Minimal mechanical properties of type II foam. 1/

Class	Compressive Strength psi (kPa)	Tensile Strength psi (kPa)	Tensile Modulus psi (kPa)	Shear Strength psi (kPa)	Shear Modulus ksi (MPa)
2	58 (400)	128 (883)	6.5 (44.8)	72 (496)	2.0 (13.8)
3	152 (1048)	227 (1565)	10.8 (74.5)	145 (1000)	3.5 (24.1)
4	319 (2200)	369 (2544)	19.5 (134.4)	253 (1744)	5.8 (40.0)
5	928 (6399)	780 (5378)	39.1 (269.6)	426 (2937)	14.5 (100.0)
6	1150 (7929)	1180 (8136)	43.5 (299.9)	760 (5240)	29.0 (200.0)

1/ Aerospace users may specify higher values for structural applications in consultation with the manufacturer/supplier.

TABLE V. Test methods.

Property	Test Method
Compressive strength	ASTM D1621 1/ 2/
Apparent density	ASTM D1622 3/
Shear strength	ASTM C273 4/
Shear modulus	ASTM C273 4/
Tensile strength	ASTM D638 5/
Tensile modulus	ASTM D638 6/

1/ Procedure A in ASTM D1621.
2/ Specimen size: 2 in. x 2 in. x 1 in. (5 x 5 x 2.5 cm), speed 0.2 in./min (0.5 cm/min).
3/ Specimen size: 4 in. x 4 in. x 1 in. (10 x 10 x 2.5 cm).
4/ Compression method, speed: 0.08 in./min (0.20 cm/min), thickness: 0.78 in. (1.98 cm).
5/ Specimen type I, 0.4 in. x 0.4 in. (1 x 1 cm), speed: 0.2 in/min (0.5 cm/min).
6/ Specimen type I, 0.4 in. x 0.4 in. (1 x 1 cm), speed: 0.04 in/min (1 mm/min).

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
2. The submitter of this form must complete blocks 4, 5, 6, and 7.
3. The preparing activity must provide a reply within 30 days from receipt of the form.

NOTE: This form may not be used to request copies of documents, nor to request waivers, or clarification of requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

I RECOMMEND A CHANGE:	**1. DOCUMENT NUMBER** MIL-PRF-46194A	**2. DOCUMENT DATE (YYMMDD)** 970808

3. DOCUMENT TITLE FOAM, RIGID, STRUCTRUAL, CLOSED CELL

4. NATURE OF CHANGE *(Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)*

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME *(Last, First, Middle Initial)*	**b. ORGANIZATION**	
c. ADDRESS *(Include Zip Code)*	**d. TELEPHONE** (Include Area Code) **(1) Commercial** **(2) AUTOVON** *(if applicable)*	**7.DATE SUBMITTED** (YYMMDD)

8. PREPARING ACTIVITY

a. NAME US Army Research Laboratory	b. TELEPHONE *Include Area Code)* (1) Commercial 410-306-0725 (2) AUTOVON 458-0725
c. ADDRESS *(Include Zip Code)* Weapons & Materials Research Directorate ATTN: AMSRL-WM-M Aberdeen Proving Ground, MD 21005-5069	**IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT:** DEFENSE QUALITY AND STANDARDIZATION OFFICE 5203 Leesburg Pike, Suite 1403, Falls Church, VA 22401-3466 Telephone (703) 756-2340 AUTOVON 289-2340