INCH-POUND

MIL-DTL-64154B
w/AMENDMENT 1
19 January 2012
SUPERSEDING
MIL-DTL-64154B
17 December 2008

DETAIL SPECIFICATION

LAMINATE: FIBERGLASS-FABRIC-REINFORCED, PHENOLIC

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

1. SCOPE

1.1 Scope. This specification covers a fiberglass-fabric-reinforced Phenolic laminate for use in composite armor systems (see 6.1).

1.2 Classification. The laminates should be of the class and code specified (see 6.2).

1.2.1 Class of fibers. See 6.1 and A.1.2 for legacy systems and applicability requirements.

1.2.1.1 Class A. A family of glasses composed primarily of the oxides of magnesium, aluminum, and silicon.

1.2.1.2 Class B. A family of glasses composed primarily of the oxides of silicon, aluminum, magnesium, and calcium

1.2.1.3 Class C. A family of glasses composed primarily of the oxides of magnesium, aluminum, silicon, and lithium.

Comments, suggestions, or questions on this document should be addressed to: Director, U.S. Army Research Laboratory, Weapons and Materials Research Directorate, Materials and Manufacturing Technology Branch, Specifications and Standards Office, Attn: RDRL-WMM-D, Aberdeen Proving Ground, MD 21005-5069 or emailed to richard.j.squillacioti.civ@mail.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at https://assist.daps.dla.mil/.

AMSC N/A FSC CMPS

1.2.2 Code of reinforcements.

1.2.2.1 Code 1. G-filament (0.00035 – 0.000399 inch) [8.89 – 10.15 micron (µ)].

1.2.2.2 Code 2. J-filament (0.00045 – 0.000499 inch) [11.43– 12.69 micron (µ)].

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3, 4, or 5 of this specification. This section does not include documents cited 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 of documents cited in sections 3, 4, or 5 of this specification, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-662	-	V_{50} Ballistic Test for Armor
MIL-STD-810	-	Environmental Test Methods and Engineering Guidelines

(Copies of these documents are available online at https://assist.daps.dla.mil/quicksearch/ or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

ASTM INTERNATIONAL

ASTM D123	-	Standard Terminology Relating to Textiles
ASTM D2563	-	Standard Practice for Classifying Visual Defects in Glass-Reinforced Plastic Laminate Parts
ASTM D3776	-	Fabric, Mass per Unit Area (Weight) of

(Copies of these documents are available from www.astm.org or ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959.)

2.4 Order of precedence. Unless otherwise noted herein or in the contract, 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 and 6.2). The purchase document will identify the geometry of the parts required. Production parts may be of thickness or areal density (weight/unit surface area) different from those of the ballistic control panels. If that is the case, first article will include both panels made to the drawings (geometry specified) and 3 panels 24" x 24" of 25 plies or 5.0 +/- 0.3 pounds/ft ^{2} (psf) areal density for first article ballistic acceptance testing. The intent is to use identical manufacturing process on the 5.0 psf panels as used for the production articles. Adjustment to dwell time for panels of thickness or ply count higher than the ballistic test articles is anticipated and will likely be greater, but the cycle should include similar ramp rates for temperature and pressure, identical hold pressures and identical pressure release points. All subsequent laminates delivered to the procuring activity shall conform to these samples in all of their pertinent physical and performance attributes.

3.2 Materials. The fiber reinforcement is glass and the resin is Phenolic. The materials shall be as specified herein or as otherwise indicated in the documentation as specified in the contract or purchase order (see 6.2). Materials shall be free of any and all defects that adversely affect the performance or serviceability of the finished product as required by this specification. Changes in the fabric weave, the reinforcement material, the laminating resin, the laminate construction (including resin content and through thickness reinforcement), or the manufacturing process including changes in the place or location of manufacture shall require a resubmission of all first article testing unless otherwise specified in the contract or purchase order (see 6.2).

3.2.1 Reinforcement. The reinforcement (see 1.2.1) shall be a high tensile strength fiberglass meeting the requirements specified in Appendix A and consisting of either a G filament (Code 1) or a J filament (Code 2) and a sizing system compatible with epoxy resin. The two codes of reinforcement shall differentiate the materials into two separate products. The three fiber products are different in chemistry and process, hence different in mechanical, physical and ballistic properties. The surface finish, fabric architecture, resin chemistry and resin distribution are intended to be identical, regardless of which reinforcement is used. The finished laminates will be differentiated by class identification and need to be specifically identified in the purchase document as to which is desired (see 6.1).

3.2.2 Fabric. The fabric shall be fiberglass single tow plain weave or a multi tow basket weave equivalent to a plain weave with the construction of 5 +/- 0.5 ends per inch in the warp (For Class B/Code 2 and Class C materials use 5.6 +/-.3 ends per inch in the warp) and 5.2 +/- 0.9 ends per inch in the fill with a nominal weight of 24 ounces/square yard +/- 5% (814 g/m^2 +/- 5%). A single colored tracer yarn of K-18 1/0 E-glass or equivalent is to be woven in the warp direction in the

center width of the fabric. Colored tracer yarns are also acceptable on the edges of the fabric for Class C material.

Class A - Red Tracer
Class B - Blue Tracer
Class C - Grey Tracer

3.2.3 Phenolic Resin. The Phenolic resin shall be in accordance with the requirements specified in Appendix B. Note: these tests involve laminated plates cut into coupons for testing. The reinforcement fiber, reinforcement architecture and resin content are not similar to those properties of the laminated product developed by this specification. The evaluation of the appropriate resin chemistry and curing cycle shall be performed independently on these different laminates. Once confirmed, then the resin shall be combined with the fabric as specified in 3.2.2.

3.2.4 Resin Content. Resin content of glass fiber reinforced laminate after coating shall be 18 to 22 weight percent solids (volatile free) based on the weight of glass fabric as determined by ASTM D3776 (option C) with moisture content reduced to less than 2 percent. NOTE: A sample of resin coated fabric that has been placed in a forced air circulating oven at 330 $\pm$10 degrees Fahrenheit (°F) [166 $\pm$ 6 degrees Celsius (°C)] for 10 minutes is considered to be volatile free.

3.3 Construction (fabrication).

3.3.1 Dimensions and structure. The laminates shall conform to the dimensions and shape (flat or curved) (see 6.5) as stated in the contract or purchase order (see 6.2). The laminates shall consist of the specified number of plies of prepreg or areal density of the finished panel made with the above fabric and resin. The laminates shall be symmetric about the center line. Laminates of 25 plies or more shall have no more than 4% of plies containing a splice. Laminates of less than 25 plies shall have no splices.

3.3.2 Thickness. The average thickness of the finished laminates shall fall within the ranges established by Table I and Table Ia (see 4.2.3).

3.3.3 Unit weight. The unit weight or areal density of the finished laminates shall fall within the ranges established by Table II and Table IIa (see 4.2.4).

3.3.4 Finished laminate. The finished laminate shall consist of the specified number of plies or areal density with exterior peel-plies incorporated in the lamination process. All cutting and machining of laminate panels shall be done with the peel-plies intact. Wet cutting and machining procedures shall be followed by a drying process. Any resulting moisture film remaining on cut surface shall be removed by local heat application (heater/blower) or by using clean, dry toweling. The finished laminate shall have an epoxy resin sealed surface on all cut, trimmed or drilled hole edges which is applied after any required drying process. The epoxy resin used shall have a service temperature of not less than 250°F (121°C) and meet the requirement of 3.2.4.

Application of the resin shall not interfere with the peel-ply removal. The use of CARC paint coating, if covering the cut surfaces, would preclude the need for additional epoxy sealing.

3.4 Performance.

3.4.1 Peel-ply removal. The peel-plies are intended to keep panel surfaces clean and shall be easily removable by hand, without requiring heat or solvents. Laborious or difficult removal shall be unacceptable (see 4.2.5).

3.4.2 Thermal shock resistance. The composite armor laminate shall not show evidence of delamination greater than 2 percent of original measured thickness following a two-cycle exposure to a temperature range of -65°F to 250°F (-54°C to 121°C) (see 4.2.6).

TABLE I. Finished laminate thickness range (inches). 1/

PLIES	THICKNESS RANGE (Inches)	PLIES	THICKNESS RANGE (Inches)	PLIES	THICKNESS RANGE (Inches)	PLIES	THICKNESS RANGE (Inches)
1	0.019 - 0.021	11	0.207 - 0.233	21	0.395 - 0.445	31	0.583 - 0.657
2	0.038 - 0.042	12	0.226 - 0.254	22	0.414 - 0.466	32	0.602 - 0.678
3	0.056 - 0.064	13	0.244 - 0.276	23	0.432 - 0.488	33	0.620 - 0.700
4	0.075 - 0.085	14	0.263 - 0.297	24	0.451 - 0.509	34	0.639 - 0.721
5	0.094 - 0.106	15	0.282 - 0.318	25	0.470 - 0.530	35	0.658 - 0.742
6	0.113 - 0.127	16	0.301 - 0.339	26	0.489 - 0.551	36	0.677 - 0.763
7	0.132 - 0.148	17	0.320 - 0.360	27	0.508 - 0.572	37	0.696 - 0.784
8	0.150 - 0.170	18	0.338 - 0.382	28	0.526 - 0.594	38	0.714 - 0.806
9	0.169 - 0.191	19	0.357 - 0.403	29	0.545 - 0.615	39	0.733 - 0.827
10	0.188 - 0.212	20	0.376 - 0.424	30	0.564 - 0.636	40	0.752 - 0.848

1/ Laminates greater than 40 plies shall use the thickness range 0.0188n - 0.0212n (inches), where n is the number of plies.

TABLE Ia. Finished laminate thickness range (millimeters). 1/

PLIES	THICKNESS RANGE (millimeters)	PLIES	THICKNESS RANGE (millimeters)	PLIES	THICKNESS RANGE (millimeters)	PLIES	THICKNESS RANGE (millimeters)
1	0.478 - 0.538	11	5.25 - 5.92	21	10.0 - 11.3	31	14.8 - 16.7
2	0.955 - 1.08	12	5.73 - 6.46	22	10.5 - 11.8	32	15.3 - 17.2
3	1.43 - 1.62	13	6.21 - 7.00	23	11.0 - 12.4	33	15.8 - 17.8
4	1.91 - 2.15	14	6.69 - 7.54	24	11.5 - 12.9	34	16.2 - 18.3
5	2.39 - 2.69	15	7.16 - 8.08	25	11.9 - 13.5	35	16.7 - 18.8
6	2.87 - 3.23	16	7.64 - 8.62	26	12.4 - 14.0	36	17.2 - 19.4
7	3.34 - 3.77	17	8.12 - 9.15	27	12.9 - 14.5	37	17.7 - 19.9
8	3.82 - 4.31	18	8.60 - 9.69	28	13.4 - 15.1	38	18.1 - 20.5
9	4.30 - 4.85	19	9.07 - 10.2	29	13.8 - 15.6	39	18.6 - 21.0
10	4.78 - 5.38	20	9.55 - 10.8	30	14.3 - 16.2	40	19.1 - 21.5

1/ Laminates greater than 40 plies shall use the thickness range 0.4775n - 0.5385n (millimeters), where n is the number of plies.

TABLE II. Finished laminate unit weight - pounds/square foot (lb/ft^2). 1/

PLIES	WEIGHT RANGE (lbs/sq.ft.)	PLIES	WEIGHT RANGE (lbs/sq.ft.)	PLIES	WEIGHT RANGE (lbs/sq.ft.)	PLIES	WEIGHT RANGE (lbs/sq.ft.)
1	0.184 - 0.216	11	2.02 - 2.38	21	3.86 - 4.54	31	5.70 - 6.70
2	0.368 - 0.432	12	2.21 - 2.59	22	4.05 - 4.75	32	5.89 - 6.91
3	0.552 - 0.648	13	2.39 - 2.81	23	4.23 - 4.97	33	6.07 - 7.13
4	0.736 - 0.864	14	2.58 - 3.02	24	4.42 - 5.18	34	6.26 - 7.34
5	0.920 - 1.08	15	2.76 - 3.24	25	4.60 - 5.40	35	6.44 - 7.56
6	1.10 - 1.30	16	2.94 - 3.46	26	4.78 - 5.62	36	6.62 - 7.78
7	1.29 - 1.51	17	3.13 - 3.67	27	4.97 - 5.83	37	6.81 - 7.99
8	1.47 - 1.73	18	3.31 - 3.89	28	5.15 - 6.05	38	6.99 - 8.21
9	1.66 - 1.94	19	3.50 - 4.10	29	5.34 - 6.26	39	7.18 - 8.42
10	1.84 - 2.16	20	3.68 - 4.32	30	5.52 - 6.48	40	7.36 - 8.64

1/ Laminates greater than 40 plies shall use the unit weight range 0.184n - 0.216n (pounds/square foot), where n is the number of plies.

TABLE IIa. Finished laminate unit weight - kilograms/square meter (kg/m^2). 1/

PLIES	WEIGHT RANGE (kg/sq meter)	PLIES	WEIGHT RANGE (kg/sq meter)	PLIES	WEIGHT RANGE (kg/sq meter)	PLIES	WEIGHT RANGE (kg/sq meter)
1	0.900 - 1.06	11	9.90 - 11.6	21	18.9 - 22.2	31	27.9 - 32.8
2	1.80 - 2.11	12	10.8 - 12.7	22	19.8 - 23.3	32	28.8 - 33.8
3	2.70 - 3.17	13	11.7 - 13.7	23	20.7 - 24.3	33	29.7 - 34.9
4	3.60 - 4.23	14	12.6 - 14.8	24	21.6 - 25.4	34	30.6 - 35.9
5	4.50 - 5.28	15	13.5 - 15.9	25	22.5 - 26.4	35	31.5 - 37.0
6	5.40 - 6.34	16	14.4 - 16.9	26	23.4 - 27.5	36	32.4 - 38.0
7	6.30 - 7.40	17	15.3 - 18.0	27	24.3 - 28.5	37	33.3 - 39.1
8	7.20 - 8.46	18	16.2 - 19.0	28	25.2 - 29.6	38	34.2 - 40.2
9	8.10 - 9.51	19	17.1 - 20.1	29	26.1 - 30.6	39	35.1 - 41.2
10	9.00 - 10.6	20	18.0 - 21.1	30	27.0 - 31.7	40	36.0 - 42.3

1/ Laminates greater than 40 plies shall use the unit weight range 0.900n - 1.058n (kilograms/square meter), where n is the number of plies.

3.4.3 Ballistic resistance. The V_{50} protection ballistic limit, as defined by MIL-STD-662, the velocity at which the probability of penetration of an armor material is 50 percent, shall not average less than 2455 ft/s (748 m/s) for Class A, Code 1, 2152 ft/s (656 m/s) for Class B, Code 1 or Class B, Code 2, and 2461ft/s (750 m/s) for Class C, Code 1 for a laminate of nominal five pounds per square foot (4.7 to 5.3 lbs/ft^2) areal density. This areal density is achieved with nominal 25 plies of the coated fabric.

3.5 Workmanship. The laminates shall satisfy visual acceptance Level 1 of ASTM D2563 for the following defects: (1) blister, (2) burned, (3) crack, (4) crack surface, (5) crazing, (6) edge delamination, (7) internal delamination, (8) dry spot, (9) lack of fill-out, and (10) wrinkles. Fabric reinforcement layers shall not have pleats, wrinkles, or creases. Fabric layers shall be free of tears, reasonably straight, and perpendicular warp-to-fill (see 4.2.2.4).

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 or purchase order (see 6.2), if required.

4.1.1 Material conformance. Materials used to construct the laminate (3.2.1 to 3.2.4) shall be inspected for compliance and their certification records shall be maintained by the contractor for a minimum of six years. Records shall be subject to review by the Government and shall include date, part, inspection results, and disposition of lot (accepted or rejected). Corrective action taken on noted defects shall be subject to approval by the Government.

4.1.1.1 Resin testing. The resin shall be tested in accordance with Appendix B. The methods of testing specified/listed in Appendix B shall be followed.

4.1.2 Parts and components. Components and assemblies shall be inspected for conformance to specified requirements of drawings and in accordance with pertinent specifications and standards.

4.2 Classification of inspection. The inspection requirements specified herein are classified as follows:

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

4.2.1 First article inspection. When required (see 3.1), the first article sample shall be examined for compliance with the requirements and verifications in section 3 and section 4. All samples shall be produced with materials and processes proposed for use on production laminates. Inspection shall be carried out by the contractor under Government surveillance, unless otherwise specified in the contract or purchase order (see 6.2). First article inspection shall consist of all quality conformance examinations and control tests.

4.2.1.1 Sampling for first article inspection. The contractor shall supply five (5) samples for first article inspection. Two (2) samples shall measure 24 inches by 24 inches (610 mm by 610 mm) by the number of plies or by the designated areal density specified in the contract or purchase order (see 6.2), within the tolerance limits specified by the contract or purchase order (see 6.2). The other three (3) samples shall measure 24 inches by 24 inches of 25 plies or 5.0 +/- 0.3 pounds/ft^2 areal density for ballistic test.

4.2.1.1.1 Ballistic tests. The three (3) ballistic samples shall be forwarded to the test site identified (see 4.2.1.1.1.1). The test samples shall be adequately identified as to contractor, contract number, manufacturer, and date.

4.2.1.1.1.1 Ballistic testing facility. Unless otherwise specified in the contract or purchase order (see 6.2), the ballistic samples shall be forwarded to the Commander, USA ATC, ATTN:

DTC-AT-SL-V, Building 358, 400 Colleran Road, APG, MD 21005-5059 for ballistic testing for first article or conformance acceptance.

4.2.1.2 First article inspection failure. Failure of any first article sample to pass specified examinations or tests shall be cause for refusal to grant first article approval and reject product until corrective action by the contractor has been approved by the procuring agency.

4.2.2 Conformance inspection.

4.2.2.1 Lot formation. An inspection lot shall consist of all the laminated assemblies of one class, and one code, from an identifiable production period, from one manufacturer, submitted at one time for acceptance. Unless otherwise specified in the contract or purchase order (see 6.2), the default definition of a lot shall be 30 days of production of the product or 1/12 of the average yearly production of the product, whichever is larger, utilizing the same components . Any changes in materials, in composition, in fabric weave, in the reinforcement material, in the laminating resin, in the laminate construction (see 3.2) or in the manufacturing process including changes in the place or location of manufacture shall constitute another lot and therefore require a separate set of testing requirements.

4.2.2.2 Sampling for conformance inspection. Each sample selected from an inspection lot shall be examined as specified herein for the visual defects listed in 3.5. Conformance to a lot shall be accepted when zero (0) defects are found and rejected when one (1) or more defects are found. First article test samples shall not be shipped.

4.2.2.3 In-process examination. The contractor shall initiate, perform, and document on a recurring basis an in-process procedure consisting of process controls and examination criteria satisfactory to the Government, and include the requirements and verifications in section 3 and section 4.

4.2.2.4 Control test. The contractor shall supply two (2) test samples 24 in. by 24 in. (610 mm by 610 mm), for each lot of laminate fabrication, for control testing. The samples shall have the contract designated number of plies or areal density and shall be produced with materials and processes used for production laminates. Testing shall be carried out by the contractor under Government surveillance and shall consist of tests to show conformance to the requirements in 3.3.2, 3.3.3, 3.4.1, 3.4.2, and 3.5. The contract or purchase order (see 6.2) shall identify an inspection delegation to the QAR that services the contractor's facility.

4.2.3 Determination of laminate thickness. The thickness of a finished laminate is determined as follows: Choose a square laminate of nominal size at least 24 in. by 24 in. (610 mm by 610 mm), and remove peel-plies. Measure thickness to nearest 0.001 in. (0.0254 mm) at least 1.0 in. (25.4 mm) in from each of four (4) corners. Average the four (4) readings (see Table I and Ia).

4.2.4 Determination of unit weight. The unit weight or areal density of a finished laminate is determined as follows: Choose a square laminate of nominal size at least 24 in. by 24 in. (610 mm by 610 mm), and remove peel-plies. Dry the panel in a forced draft or convection type oven in a stream of ambient air heated to 200 ± 10°F (93 ± 6°C). Dry the panel until no further change of

mass occurs when it is weighed with an error of less than 0.1% after cooling to room temperature in the standard atmosphere for testing textiles as defined in ASTM D123. Calculate the unit weight to three significant figures as follows:

$$\text{Unit weight} = \frac{144M}{LW} \quad \text{lb/ft}^2$$

Where M is the dry panel weight in pounds measured with an error of less than 0.1%, L is the length of the panel in inches measured to the nearest 0.063 in. and W is the width of the panel in inches measured to the nearest 0.063 inch (see Table II).

$$\text{Unit weight} = \frac{1 \times 10^6 M}{LW} \quad \text{kg/m}^2$$

Where M is the dry panel weight in kilograms measured with an error of less than 0.1%, L is the length of the panel in millimeters measured to the nearest 1.5 mm, and W is the width of the panel in millimeters measured to the nearest 1.5 mm (see Table IIa).

4.2.5 Peel-ply test. The peel-ply test shall consist of removing the peel-plies by hand.

4.2.6 Thermal shock resistance test. The thermal shock resistance test shall be performed in accordance with APPENDIX C.

4.2.7 Ballistic control test. The contractor shall supply three (3) test samples 24 in. by 24 in. (610 mm by 610 mm) by 25 plies or 5.0 +/- 0.3 pounds/ft^2 areal density for each lot of laminate fabrication for ballistic control testing at a Government approved facility (see 4.2.1.1.1.1) to show conformance to 3.4.3. The test panels shall be adequately identified as to contractor, contract number, manufacturer, and date. The testing facility shall report raw data, velocities, penetration observation, thickness, and the laminate classification (see 1.2) for each test sample.

4.2.7.1 Ballistic test. The ballistic resistance test shall be conducted in accordance with MIL-STD-662. The test projectile shall be a 0.30 caliber (7.62 mm) (44 grain) fragment-simulating projectile at 0° obliquity. The V_{50} ballistic limit protection reported shall be the average of three (3) determinations made on separate nominal 25 plies laminate panels. Each determination shall be a six round (three pair) V_{50} ballistic limit with a maximum velocity spread of 125 ft/s (38 m/s). If a panel has at least five partial penetrations at impact velocities above the required minimum V50, and no complete penetrations at impact velocities below the required minimum V50, then that panel test result shall be considered compliant with the ballistic test requirement, even if the range of results is greater 125 ft/s and the V50 cannot be determined. In such a case where a panel is determined to meet the ballistic test requirement but its V50 cannot be determined, the highest partial penetration velocity or the lowest complete penetration velocity, whichever is lower, shall be used to represent the panel V50 when averaging the result with the other panel to determine compliance of the first articles or production lot.

4.2.8 Failure. Failure of the samples to meet any of the test requirements shall be cause for the procuring activity to stop acceptance of quality conformance samples and reject the specific lot of material until the cause of the failure(s) is identified, corrective action is taken by the contractor, and approval is granted by the procuring activity.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging and marking requirements shall be as specified in the contract or order (see 6.2). When packaging of materiel components are to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activities within the Military Service or Defense Agency, or within the military service's system commands. 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 that may be helpful, but is not mandatory.)

6.1 Intended use. The laminates furnished under this specification are military unique because they are intended for use as a component of composite armor and must meet ballistic limit protection requirements. Systems requiring prior version of this specification, namely, MIL-L-64154 or MIL-PRF-64154, should use material designated as Class A of this specification to ensure compatibility.

6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number, and date of the specification.
b. Specify class of fiber (see 1.2.1), and code of reinforcement (see 1.2.2).
c. If first article is required (see 3.1).
d. Specify the documents (specifications, standards, or drawings) that indicate the material that are to be specified (see 3.2).
e. If a resubmission of all first article testing is not required (see 3.2).
f. Specify the dimensions and shape (flat or curved) of the laminate (see 3.3.1)
g. If alternative verification approaches are identified (see 4.1)
h. Whether First Article inspection is carried out by the contractor under Government surveillance or by someone else (see 4.2.1).
i. Specify number of plies or areal density for the first article samples (see 4.2.1.1).
j. Specify the tolerance limits for the number of plies or areal density for the first article samples (see 4.2.1.1).
k. If the ballistic testing facility is different than that listed (see 4.2.1.1.1.1).
l. If the default definition of a lot is different (see 4.2.2.1).
m. Specify the responsible Government Agency that will witness the contractor's testing (see 4.2.2.4).
n. Specify packaging and marking requirements (see 5.1).

6.3 Definitions.

6.3.1 Fair impact. An impact is considered fair when an un-yawed fragment simulator strikes an unsupported area of the target material at a specified obliquity at a distance of at least two inches from any previous impact or disturbed area resulting from an impact, or from any crack, or from any edge of the specimen.

6.4 First time suppliers. First time suppliers, who have not previously supplied composite armor laminate to MIL-DTL-64154 and wish to have their material tested, may do so at their own expense. It is recommended that inquires for testing be directed to Commander, U.S. ATC, ATTN: TEDT-AT-SLV, Bldg 358, 400 Colleran Road, Aberdeen Proving Ground, MD 21005-5059. Technical questions regarding testing may be directed to U.S. Army Aberdeen Test Center, Vulnerability/Lethality Division, ATTN: TEDT-AT-SLV, Aberdeen Proving Ground, MD 21005.

6.5 Shape of laminates. Both flat and curved laminates are produced by this specification. A suggested molding cycle could consist of the following sequence:

1. Preheat press platens to 275 F.
2. Charge press with required prepreg, and insert hard press stops at finished panel thickness.
3. Close to contact pressure of 25 psi
4. Monitor temperature in center of laminate, about 1 inch from edge, until laminate center reaches 265° F.
5. Increase laminating pressure to 125 psi, and increase platen temperature to 345° F at a rate of 4° to 7° F per minute. Platens should close to hard stops.
6. Hold pressure and temperature until laminate centerline reaches 340° F.
7. Hold pressure and temperature for 30 minutes once a laminate center temperature of 340° F is reached.
8. Once 30 minutes has elapsed, cool laminate under pressure until laminate center is 180° F or below.
9. Open press and trim panels to desired dimensions

6.6 Peel-ply. It is recommended that the peel-ply be porous and polytetra-fluoroethylene (PTFE) coated with a thickness of 0.003 in. (0.076 mm).

6.7 Subject term (key word) listing.

Ballistic resistance
Composite armor
Resin
Peel-ply

6.8 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extent of the changes.

APPENDIX A

HIGH TENSILE STRENGTH FIBERGLASS REINFORCEMENT

A.1 SCOPE

A.1.1 Scope. This appendix provides the requirements for the three (3) classes of reinforcement materials that will be used in the construction of the laminates. This appendix is a mandatory part of this specification. The information contained herein is intended for compliance.

A.1.2 Applicability. The requirements specified in this appendix are required. The content of this appendix was taken from specification, MIL-R-60346C. The requirements of MIL-R-60346C, type IV, Class 1 material is a general purpose high tensile strength glass, G filament (Code 1) with a sizing system compatible with epoxy resin and is classified as Class A or Class C (see 1.2.1 of the main document). Class B material is a general purpose high-strength glass, J filament (Code 2) with a sizing system compatible with epoxy resin. Specific property requirements for all classes are listed in Table A-III (see 6.1).

A.2 APPLICABLE DOCUMENTS (This section is applicable to this appendix only)

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-129	-	Military Marking for Shipment and Storage

(Copies of these documents are available online at http://assist.daps.dla.mil/quicksearch/ or http://assist.daps.dla.mil or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

ASTM INTERNATIONAL

ASTM D618	-	Plastics Conditioning for Testing
ASTM D2343	-	Glass Fiber Strands, Yarns, and Rovings used in Reinforced Plastics, Tensile Properties of
ASTM D2344/D2344M	-	Standard Test Method for Short-Beam Strength of Polymer Matrix Composite Materials and their Laminates

(Copies of these documents are available from www.astm.org or ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959.)

A.3 REQUIREMENTS

A.3.1 Roving.

A.3.1.1 Construction. The roving shall consist of a number of continuous glass filaments coated with suitable sizing system (see A.3.1.5) and laid essentially parallel with little

or no twist. The filaments may or may not be grouped into strands, intermediate in size, between a single filament and the roving itself (see A.6.3). The roving shall be supplied in the form of roving balls (see A.3.3). The construction shall be in accordance with A.3.3, and the acceptable quality levels (AQL), specified in Table A-I (see A.4.2.1) or as otherwise specified in the contract or purchase order (see A.6.2).

TABLE A-I. Examination of Roving Ball for Visual Defects.

EXAMINE	AQL PERCENT DEFECTIVE	DEFECT 1/	METHOD INSPECTION
Workmanship: Outer layer 2/ Of roving ball (see A.3.4, A.3.4.1 & A.6.2)	1.0	Dirt, grease, oil or foreign matter in quantity sufficient to be detrimental to end use.	Visual
	1.0	Any knot or fuzz accumulation.	Visual
	1.0	Any splice or group of two or more splices not in accordance with A.3.4.1.	Visual
	3/	Difference in color, transparency or other appearance of the filaments.	Visual
Package (ball) build: Roving ball (see A.3.3, A.6.2, and A.6.4)	2.5	Not cylindrical within 5/16 inch	Carpenter's square & scale
	2.5	Not centered on tube, where applicable, within 1/8 inch.	Carpenter's square & scale
	2.5	Diameter or length improper.	Scale
	2.5	Direction and angle of winding improper.	Scale and visual
	2.5	Number of turns per transverse improper.	Visual
Tube (see A.3.3 and A.6.2)	2.5	Inside diameter or length improper.	Visual
	2.5	Not suitable, color code improper.	Visual

1/ The lot shall be evaluated separately in respect to each category or defect.

2/ Unless the external appearance of a ball or supplier's previous history shows interior of the ball may contain defects, a ball shall not be unwound merely for examination for visual defects.

3/ The lot shall be rejected if there is a visual difference in color, transparency, or other appearance of the filaments indicating a possible mixing of different types of glass fibers.

A.3.1.2 Glass.

A.3.1.2.1 Chemical composition. The chemical composition of high tensile strength glass and general purpose high tensile strength glass shall be certified (see A.4.2.1) as being within the limits listed in Table A-II. Any deviation from the composition ranges listed in Table A-II shall require the approval of the procuring activity (see A.6.5).

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TABLE A-II. Chemical composition range (weight percent).

Oxides	Class A	Class B	Class C
SiO_2	64.0 – 66.0	61.0 – 63.0	67.0 - 71.0
Al_2O_3	24.0 – 26.0	18.0 – 20.0	19.0 - 21.0
MgO	9.0 – 11.0	9.0 – 11.0	9.0 - 11.0
CaO	< 0.2	7.0 – 9.0	< 0.3
$Li_2O + Na_2O$	N/A	0-3.0	0.25 – 3.0

A.3.1.2.2 Properties. The properties listed in Table A-III shall be required for the classes of glass (see A.6.3). Any new or modified glass shall not be acceptable unless approved by the procuring activity (see A.6.5).

A.3.1.3 Filament diameter and code letter of current commercial filaments. The nominal filament diameter range and code letters shall be as listed in Table A-IV.

A.3.1.4 Roving yield. Each roving package fabricated by either conventional or non conventional roving winding processes shall contain a sufficient number of filaments of the specified diameter code (see A.3.1.3) to produce the nominal roving yield specified in the Table A-III, unless otherwise specified in the contract or purchase order (see A.6.2) to within a tolerance of ± 5.0 percent (see A.4.3.4, A.6.3, and A.6.4).

A.3.1.5 Sizing system The roving shall have a sizing system selected and applied so as to provide compatibility between the glass and epoxy resin (see A.6.3).

A.3.2 Property requirements. The roving shall conform to the property values specified in Table A-III, when tested as specified in the applicable testing procedure as specified in section A.4.3 (see A.4.2.2).

A.3.3 Package build. (see Table A-I) The roving shall be wound with uniform tension on a tubeless package or a heavy duty winding tube of the dimensions and color code as specified in the contract or purchase order (see A.6.2) to make essentially cylindrical roving package. The dimensions, direction and angle of winding, the number of turns per transverse, and the spacing of the roving, shall be as specified in the contract or purchase order (see A.6.2) When not specified, the manufacturer's standard dimensions, winding pattern, and color code shall be considered acceptable. The roving shall unwind from the package on commercial filament winding equipment without excessive process interruptions or excessive tension variation.

A.3.4 Workmanship. The material shall be free from visible dirt, grease, oil, or foreign matter. Any group of knots, strands or fuzz accumulation occurring at any point in the package which is sufficient to cause an appreciable change in the smoothness of the roving shall be cause for rejection unless the defect can be removed without rendering the

remainder of the package rejectable (see Table A-I). There shall be no visible differences in color, transparency, or other appearance of the filaments which may indicate mixing of different types of glass fibers for conventional roving products.

TABLE A-III. Property Requirements.

PROPERTY	CLASS A / Code 1 (G filament)	CLASS B / Code 1 (G filament)	CLASS B / Code 2 (J filament)	CLASS C / Code 1 (G filament)
1/ Package (ball density) (pounds/cubic inch)				
minimum	0.035	0.035	N/A	N/A
maximum	0.065	0.065	N/A	N/A
1/ Shore "O" package (ball hardness)				
minimum	50	50	70	70
maximum	90	90	95	95
2/ Catenary, inches/50 feet, maximum	1.0	1.0	N/A	N/A
Total Roving yield (yds/lb) (single end & multi-tow)	244 +/- 5% 5/	244 +/- 5% 5/	820 +/- 8% 6/	1370 +/- 8% 6/
Tensile strength, psi, minimum	450,000	400,000	400,000	450,000
Horizontal shear strength (after 6-hour boil) psi, minimum	3/	3/	3/	3/
Resistance to Fusion Test	4/	4/	4/	4/

1/ The supplier has the option to perform either the Package (Ball) Density or the Shore "O" Package Hardness test for multiple end roving. Only one of the two tests is required for multiple end roving. Shore “O” Package Hardness data is given only for reference for a single end package.

2/ Unless otherwise specified, the catenary requirement applies only to rovings having a yield of 700 or more Yards per pound.

3/ Applicable only when specified by the procuring activity (see A.4.3.6 and A.6.2). Actual values are dependent upon a given resin. Therefore, values shall be agreed upon between the supplier and the procuring activity for the matrix resin which is to be used. Using NOL Ring method in ASTM D2344/D2344M, normal values are 8,500 psi for epoxy and 7,000 psi for polyester resin matrices.

4/ The specimens of A.4.3.8 shall not fuse.

5/ Multi-tow roving.

6/ Single end roving.

TABLE A-IV. Filament diameter and code.

Filament	Diameter Range, inches	Diameter Range, microns
G	0.00035 – 0.000399	8.89 – 10.15
J	0.00045 – 0.000499	11.43 – 12.69

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A.3.4.1 Splices. When insertion of a broken strand by skip knotting or mechanical insertion method is not acceptable, it shall be spliced with cellulose acetate cement, or any mutually acceptable substitute, with a one inch minimum overlap. When two or more ends are spliced simultaneously, splices shall be spaced so as to prevent any overlapping of the spliced areas, with the exception of gang splices. The maximum number of splices shall not exceed an average of one splice per pound of roving.

A.4 VERIFICATION

A.4.1 Testing responsibility and facilities. Unless otherwise specified in the contract or purchase order (see A.6.2), the contractor is responsible for the performance of all the requirements as specified herein. Unless otherwise specified in the contract or purchase order (see A.6.2), the contractor may use his own or any other facilities suitable for the performance of the requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform or check any of the inspections set forth in this specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements and to determine the validity of the certifications.

A.4.2 Lot. Unless otherwise specified in the contract or purchase order (see A.6.2), a lot shall consist of all material of the same filament code, and class and manufactured at the same place and location utilizing the same equipment and submitted for delivery at one time.

A.4.2.1 Supplier's certification. The supplier shall certify that (a) all roving packages were produced under the same manufacturing process; (b) the glass is Class A, Class B, or Class C or general purpose high tensile strength Class A, Class B, or Class C as specified (see A.3.1.2); (c) the nominal filament diameter corresponds with code letter designation applicable to the strand specified (see A.3.1.3); (d) the sizing on the glass is compatible with the epoxy resin specified; (e) that all splices, if used, were made in accordance with A.3.4.1.

A.4.2.2 Testing. The material shall be tested for characteristics listed in Table A-III, in accordance with the test methods specified herein. The lot size for the purpose of determining sample size for testing shall be expressed in units of one roving ball. The sample unit shall consist of sufficient material to prepare all required specimens. Testing for hardness, package (ball) density, catenary and roving yield shall be as specified in the contract or purchase order (see A.6.2).

A.4.3 Testing Methods.

A.4.3.1 Specimen conditioning and testing. Unless otherwise specified in the contract or purchase order (see A.6.2), specimens for tensile and shear testing shall be conditioned in accordance with procedure A of ASTM D618. Specimens for other testing shall be conditioned for a minimum of 2 hours in accordance with ASTM D618. Testing shall be at 73.4 ± 3.6 F (23 ± 2 C) and 50 ± 5 percent relative humidity.

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A.4.3.2 Hardness. A shore "O" durometer or equivalent shall be used to test as follows: Set the roving ball on its end on a horizontal flat surface. Support the ball with one hand, hold the durometer in the other, and bring the instrument plunger and foot into contact with outermost layer of roving. Apply such pressure as is required to bring about constancy in the reading attained on the dial indicator. Three readings shall be made randomly spaced around the circumference and along the length of the ball.

A.4.3.3 Catenary. Unless otherwise specified in the contract or purchase order (see A.6.2), this test is applicable only to roving having a yield more than 700 yards per pound. One specimen per roving ball shall be tested and each obtained by pulling roving from the ball until the slack is taken off, then tying a knot in the roving approximately 12 inches from the package. The roving shall be pulled over a spindle and clamped to a strand which is located approximately 50 feet from the spindle. After returning to the roving ball and holding a 50 foot portion of the strand tight, a hard knot shall be tied. A clamp and sufficient weights to give a total of 2 ± 0.1 pounds shall be placed on the hanging end of the roving. The roving shall be grasped lightly at the center of the span (25 feet) and pulled down 1 foot. The roving shall be released. The pull down and release shall be repeated three additional times. The distance between the furthermost separated strands perpendicular to the lengthwise direction shall be measured.

A.4.3.4 Roving yield. One specimen shall be tested per roving ball sample. The roving yield shall be computed by dividing the weight into measured length resulting in units such as yards/pound (see A.6.3).

A.4.3.5 Tensile strength. A minimum of five specimens per roving ball shall be tested in accordance with ASTM D 2343. The roving shall be tested on specimens made with resin specified in the contract or purchase order (see A.6.2).

A.4.3.6 Horizontal shear strength test. When specified in the contract or purchase order (see A.6.2), a horizontal shear strength test shall be performed. Unless otherwise specified in the contract or purchase order (see A.6.2), a minimum of five (5) specimens per roving shall be tested in accordance with ASTM D2344/D2344M when this test is required.

A.4.3.7 Package density. One density determination is made for each ball (package) in the sample from the lot being tested. Density (reported to the nearest 0.001 pounds/cubic inch) is determined by measuring inside diameter to the nearest 1/16 inch with a steel rule, outside diameter to the nearest 1/16 inch with a circumference tape (or steel rule), length to the nearest 1/16 inch with a steel rule and ball (package) weight to the nearest 0.1 pound and calculating the following:

$$D = \frac{1.27 \times \text{weight}}{\text{length}\ (d_o^2 - d_i^2)}$$

where D = package (ball density, lbs/cubic inch)
d_o = outside diameter, inches d_i = inside diameter, inches

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A.4.3.8 Resistance to fusion. One specimen per roving ball shall be tested for resistance to fusion. Class A or Class C material shall not fuse when ignited at a temperature of 1500 ^{o} +/-45^{o} F (816 ^{o} +/-25^{o} C). Class B material shall not fuse when ignited at a temperature of 1400 ^{o} +/-45^{o} F (760 ^{o} +/-25^{o} C), but they will fuse when ignited at 1500 ^{o} +/-45 ^{o} F. Standard E-glass will fuse when ignited at a temperature of 1400 ^{o} +/-45 ^{o} F (760 ^{o} +/-25 ^{o} C) or higher.

A.4.3.9 Marking. In addition to any special marking specified in the contract or purchase order (see A.6.2), containers shall be marked in accordance with MIL-STD-129. If special storage conditions are required, containers shall be so marked to specify the complete conditions for storage.

A.5 PACKAGING

A.5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see A.6.2). When packaging of materiel components are to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain packaging requirements.

A.6 NOTES

A.6.1 Intended use. The high tensile strength fiberglass covered by this appendix is intended to be used as reinforcement for the laminates specified in the specification this appendix is a part.

A.6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Specify the acceptable quality levels (AQL), if different (see A.3.1.1 and Table A-I).
b. Specify nominal roving yield, if different (see A.3.1.4).
c. Specify the dimensions and color code of a heavy duty winding tube, if required (see A.3.3).
d. Specify dimensions, direction and angle of winding, the number of turns per transverse, and the spacing of the roving (see A.3.3).
e. If someone besides the contractor is responsible for the performance of all the requirements (see A.4.1).
f. If the contractor cannot use his own or any other facility for testing (see A.4.1).
g. If the definition of a lot is different (see A.4.2).
h. Specify the testing for hardness, package (ball) density, catenary and roving yield (see A.4.2.2).
i. If specimens for tensile and shear testing are to be conditioned differently (see A.4.3.1).
j. If a catenary test is applicable to roving having a yield less than 700 yards per pound (see A.4.3.3).

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k. Specify the resin the roving specimens will be made from (see A.4.3.5).
l. Specify if a horizontal shear strength test is required (see A.4.3.6 and Table A-III).
m. If the number of specimens and the test method are different (see A.4.3.6).
n. Specify any special markings (see A.4.3.9).
o. Specify packaging requirements (see A.5.1).

A.6.3 Definitions. For the purpose of this appendix, the following definitions have been used.

A.6.3.1 Filament. Filament - a single glass fiber, as drawn.

A.6.3.2 Strand. Strand - a plurality of filaments gathered together with little or no twist and bonded with sizing.

A.6.3.3 Roving. Roving - a plurality of strands of filaments gathered together with little or no twist.

A.6.3.4 Roving yield. Roving yield - the roving yield in yards per pound is obtained as follows:

$$\text{Roving yield, yards per pound} = \frac{453.6 \times \text{length of specimen (yards)}}{\text{weight of specimen (grams)}}$$

Upon request, the supplier should provide a value for a yield in grams per kilometer (roving weight in TEX).

A.6.3.5 Roving designation. Roving designation - a roving ordinarily is designated by a roving yield (yards per pound) and a filament diameter code; i.e., “700G” plus the class.

A6.3.6 Sizing system. Sizing system - a surface treatment or coating applied to the glass during the fiber forming operation to improve its ability to bond to a laminating resin. Different sizing systems may be necessary for use with different resins. The Class A or Class B or Class C, and general purpose high tensile strength Class A or Class B or Class C glass is a magnesia-alumina-silicate glass of higher tensile strength and melting point than “E” glass.

A.6.4 Construction. In the past, it was common practice to attenuate glass through bushings having 204 or 408 holes to produce strands containing those numbers of filaments and then to supply 1, 12, 15, 20, 30 and 60–end rovings made from those strands as described in A.6.3. Although many suppliers still are using this practice, others are attenuating fiber glass through bushings containing up to several thousand holes so that they can make a heavy roving containing only a single strand. Since the strands are not twisted, rovings made with the larger single strands are equivalent, for most purposes, to those made with the smaller multiple strands. Since existing drawings may specify rovings in accordance with the old

multiple strand designation, a purchasing activity receiving a requisition for roving having a specific strand yield and end count should check with the purchaser to determine whether or not there may be considered for substitution.

A.6.5 Glass composition and properties. To insure that the final laminate does not vary from what was tested, any new glass material should not be acceptable unless approved by the procuring activity. Approval requires that each class of new or modified glass must be tested by an independent facility and pass all the required tests specified by the Procuring Activity. These tests should include but not be limited to the following; environmental, mechanical, and ballistic requirements. Subsequently, when the new or modified glass is approved by a Procuring Activity (Buyer), a new or modified classification will be added to Appendix A of this specification with corresponding requirements, such as, chemical composition and the property requirements listed in Table A-III. Finally when enough ballistic data has been collected and analyzed, a V_{50} requirement will be determined. Alternative glass chemistries that demonstrate acceptable performance for all the required properties should be encouraged, such as, the new Class B and Class C material of this specification. Prior to this revision and amendment, the procuring activity realized that new glass fibers were available. Therefore, laminates were made utilizing these new fibers and a trial and error type program was initiated to develop its' properties. Testing continued and subsequently the company did demonstrate that the new or modified glasses did not cause any problems. The procuring activity notified Army-MR Standardization Office (see contact information on first page of this specification) of the variations and once received, changes to this specification were made by adding the additional classes of fiber, namely, Class B during Revision B and Class C during Amendment 1.

APPENDIX B

RESIN, PHENOLIC, LAMINATING (GRADE B – IMPROVED PROPERTIES)

B.1 SCOPE

B.1.1 Scope. This appendix provides the requirements for an improved grade of resin that will be used in the construction of the laminates. This appendix is a mandatory part of this specification. The information contained herein is intended for compliance.

B.1.2 Applicability. The requirements specified in this appendix are required. The content of this appendix was taken from specification, MIL-R-9299C. The requirements of MIL-R-9299C, Grade B material is an improved properties Phenolic, laminating resin.

B.2 APPLICABLE DOCUMENTS (This section is applicable to this appendix only)

COMMERCIAL ITEM DESCRIPTIONS

A-A-52624	-	Antifreeze, Multi-Engine Type

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-129	-	Military Marking for Shipment and Storage
MIL-PRF-5606	-	Hydraulic Fluid, Petroleum Base; Aircraft, Missile, and Ordnance
MIL-PRF-83282	-	Hydraulic Fluid, Fire Resistant, Synthetic Hydrocarbon Base, Metric, NATO CODE NUMBER H-537
MIL-PRF-87257	-	Hydraulic Fluid, Fire Resistant; Low Temperature, Synthetic Hydrocarbon Base, Aircraft and Missile
TT-I-735	-	Isopropyl Alcohol

(Copies of these documents are available online at http://assist.daps.dla.mil/quicksearch/ or http://assist.daps.dla.mil or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

ASTM INTERNATIONAL

ASTM C393/C393M	-	Standard Test Method for Core Shear Properties of Sandwich Constructions by Beam Flexure
ASTM D471	-	Rubber Property-Effect of Liquids
ASTM D570	-	Standard Test Method for Water Absorption of Plastics
ASTM D618	-	Standard Practice for Conditioning Plastics for Testing

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ASTM D695	-	Standard Test Method for Compressive Properties of Rigid Plastics
ASTM D790	-	Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
ASTM D792	-	Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
ASTM D870	-	Standard Practice for Testing Water Resistance of Coatings Using Water Immersion
ASTM D1505	-	Standard Test Method for Density of Plastics by the Density-Gradient Technique
ASTM D2583	-	Standard Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor
ASTM D2584	-	Standard Test Method for Ignition Loss of Cured Reinforced Resins
ASTM D3039/D3039M	-	Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials
ASTM D3410/D3410M	-	Standard Test Method for Compressive Properties of Polymer Matrix Composite Materials with Unsupported Gage Section by Shear Loading
ASTM E84	-	Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM E162	-	Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source

(Copies of these documents are available from www.astm.org or ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959.)

SAE INTERNATIONAL

SAE-AMS-C-9084	-	Cloth, Glass, Finished, For Resin Laminates

(Copies of these documents are available from http://www.sae.org or SAE World Headquarters, 400 Commonwealth Drive, Warrendale, PA 15096-0001)

B.3 REQUIREMENTS

B.3.1 Materials. The materials used in the manufacture of the resin shall be as specified herein. The resin shall be of the Phenolic or modified Phenolic thermosetting laminating type. The component materials of the resin shall be such that the cured resin shall not be corrosive to metals.

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B.3.2 Form. The resin shall be in a form suitable for impregnating, or may be already impregnated on glass fabric (dry lay-up). Unless otherwise specified in the contract or purchase order (see B.6.2), the prepreg shall be made using glass fabric, style 7781, E-glass.

B.3.2.1 Code number. The manufacturer shall designate each resin composition by a code number which shall be used to identify the resin. The code number may include the trade name, if desired. The manufacturer's code number shall appear on the instruction sheet (see B.3.5.1.(a)) and on the label of the resin container and on the dry lay-up material. Any changes in the components or manufacturing procedures shall necessitate the assignment of a new code number. For dry lay-up materials; the materials using the same resin but having different properties under B.3.4 as a result of different impregnating conditions, shall have different designations and shall be submitted independently for acceptance as different materials. The designation shall consist of the resin code number with a suffix indicating impregnating conditions.

B.3.3 Limiting values of components. The manufacturer shall submit limiting values within which the specific gravity and viscosity of the liquid resin can be controlled (see B.3.5.1(b)). For dry lay-up materials, the manufacturer shall submit values within which the volatile content, solids content, and flow can be controlled (see B.3.5.2 (b), (c), and (d)). These values shall be considered requirements of this appendix which are applicable to the manufacturer's material code number it represents.

B.3.4 Mechanical and physical properties. For each specific resin utilized, the mechanical and physical properties of the laminate (laminated plates cut into coupons for testing purposes), fabricated as specified in B.4.4.1.1, shall conform to the properties listed in Table B-I. In addition, the mechanical properties at elevated temperatures shall also conform to the requirements of Table B-II. If material other than glass fabric No. 7781 is specified for test, mechanical and physical properties shall be as specified in the contract or purchase order (see B.6.2).

B.3.5 Instruction sheet.

B.3.5.1 Liquid resin. For each unit package of resin the manufacturer shall provide an approved instruction sheet containing the following information.

(a) Resin code number (see B.3.2.1).
(b) Limiting values for specific gravity and viscosity (see B.3.3).
(c) Maximum usable storage life of the resin and recommended storage conditions.
(d) Recommended mixing and impregnating procedures.
(e) Recommended finishes to be used on the glass fabric
(f) Maximum allowable shelf life at various temperatures of impregnated fabric before curing.
(g) Range of time, temperature and pressure cycles recommended to affect the cure for the laminates.
(h) Any other pertinent information, at the manufacturer's option, on storage and handling.

APPENDIX B

TABLE B-I. Lengthwise mechanical and physical properties of glass fabric base laminate. [1/]

Property	Requirements and Values [2/]
Under standard conditions (73.4 ± 2°F at 50% ± 4% relative humidity)	
Flexural, flatwise: Ultimate strength Initial modulus of elasticity	 73 Ksi (503 MPa) 3.5 msi (24,132 MPa)
Ultimate tensile strength	46 Ksi (317 MPa)
Ultimate compressive strength edgewise	58 Ksi (400 MPa)
Flammability, inches per minute	1.0 (max.)
Water absorption, 24 hours immersion, percent change in weight	+ 1.25 (max.)
Barcol hardness	55
Specific gravity [3/]	No Requirement
Resin content, percent [3/]	No Requirement
Wet conditions (2 hours in boiling distilled water then remove, cool in water to 73.4 ± 2°F and immediately test samples wet)	
Flexural, flatwise: Ultimate strength Initial modulus of elasticity	70 Ksi (483 MPa) 3.0 msi (20,684 MPa)
Ultimate tensile strength	44 Ksi (303 MPa)
Ultimate compressive strength, edgewise	53 Ksi (365 MPa)
Tested at 160°F (exposure to 160°F for 1/2 hour then tested immediately at same temperature) (± 2°F)	
Flexural, flatwise: Ultimate strength Initial modulus of elasticity	69 Ksi (476 MPa) 3.3 msi (22,753 MPa)
After immersion in chemical fluids (see B.6.3) (specimen size 1″ x 4″) (specimens shall be immersed in fluid for 24 hours at 73.4 ± 2°F) [4/]	
Hydraulic Fluid (see B.6.3.1): Percent change in weight (increase or decrease) Percent change in thickness (increase or decrease) Ultimate flexural strength	 0.2 (max.) 0.2 (max.) 70 Ksi (483 MPa) (min.)
Isopropyl Alcohol (see B.6.3.2): Percent change in weight (increase or decrease) Percent change in thickness (increase or decrease) Ultimate flexural strength	 0.2 (max.) 0.1 (max.) 70 Ksi (483 MPa) (min.)
Antifreeze (see B.6.3.3): Percent change in weight (increase or decrease) Percent change in thickness (increase or decrease) Ultimate flexural strength	 0.2 (max.) 0.1 (max.) 70 Ksi (483 MPa) (min.)
Hydrocarbon, (Reference Fuel B) (see B.6.3.4): Percent change in weight (increase or decrease) Percent change in thickness (increase or decrease) Ultimate flexural strength	 0.2 (max.) 0.2 (max.) 70 Ksi (483 MPa) (min.)

[1/] Lengthwise direction of test specimens is parallel to warp direction of glass fabric.
[2/] Unless otherwise specified, all values are minimum for the average of five specimens.
[3/] The specific gravity and resin content by weight shall be noted for the panels tested.
[4/] The samples shall show no cracking, crazing, delamination, or any other visible deterioration after exposure or immersion cycle.

APPENDIX B

TABLE B.II. Lengthwise mechanical properties of glass fabric base laminate at elevated temperature. 1/

Property	Requirements and Values 2/
Tested at 500°F after 1/2 hour exposure to 500°F (± 3°F)	
Flexural, flatwise: Ultimate strength Initial modulus of elasticity	 52 Ksi (359 MPa) 3.1 msi (21,374 MPa)
Ultimate compressive strength, edgewise	32 Ksi (221 MPa)
Ultimate tensile strength	39 Ksi (269 MPa)
Tested at 500°F after 100 hours exposure to 500°F (± 3°F)	
Flexural, flatwise: Ultimate strength Initial modulus of elasticity	 45 Ksi (310 MPa) 2.9 msi (19,995 MPa)

1/ Lengthwise direction of test specimens is parallel to warp direction of glass fabric.
2/ Unless otherwise specified, all values are minimum for the average of five specimens.

B.3.5.2 Dry lay-up. For dry lay-up, the manufacturer shall provide an approved instruction sheet containing the following information, together with a description of method for determining the properties.

(a) Material designation (see B.3.2.1).
(b) Volatile content (average and tolerance).
(c) Solids content (average and tolerance).
(d) Flow (average and tolerance).
(e) Maximum allowable shelf life at various temperatures of impregnated fabric before curing.
(f) Range of time, temperature and pressure cycles recommended to affect the cure for the laminates.
(g) Any other pertinent information, at the manufacturer's option, on storage and handling.

B.4 VERIFICATION

B.4.1 Testing responsibility and facilities. Unless otherwise specified in the contract or purchase order (see B.6.2), the contractor is responsible for the performance of all the requirements as specified herein. Unless otherwise specified in the contract or purchase order (see B.6.2), the contractor may use his own or any other facilities suitable for the performance of the requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform or check any of the inspections set forth in this specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements and to determine the validity of the certifications.

APPENDIX B

B.4.2 Classification of inspection. The inspection requirements of the resin specified herein are classified as follows.

a. Preproduction inspection (see B.4.5)
b. Conformance inspection (see B.4.6)

B.4.3 Lot. Unless otherwise specified in the contract or purchase order (see B.6.2), a lot shall consist of all the same type of resin (class, grade and batch number), manufactured at the same place and location utilizing the same equipment and submitted for delivery at one time.

B.4.4 Test conditions for the specimens used to determine the mechanical and physical properties from Tables B-I and B-II.

B.4.4.1 Standard conditions. Standard conditions shall be $73.4^{o} \pm 2^{o}$ F and 50 ± 4 percent relative humidity. Specimens shall be tested after being exposed for 4 days to this temperature and humidity.

B.4.4.2 Wet conditions. Wet conditions shall be define as immersing a specimen into boiling, distilled water for 2 hours, removing the specimen and cooling it in distilled water to $73.4^{o} \pm 2^{o}$ F. The specimen shall be tested immediately (within 5 minutes) after removal from the distilled water while it is still wet.

B.4.4.3 Exposure at elevated temperatures.

B.4.4.3.1 Exposure at 160^{o} F. Specimens shall be exposed to a temperature of $160^{o} \pm 2^{o}$ F for 30 minutes in a test chamber that has been preheated to $160^{o} \pm 2^{o}$ F. The specimen shall be tested immediately (within 5 minutes) after removal from the test chamber.

B.4.4.3.2 Exposure at 500^{o} F. Specimens shall be exposed to a temperature of $500^{o} \pm 3^{o}$ F for 30 minutes or 100 hours as specified in Table B.II in a test chamber that has been preheated to $500^{o} \pm 3^{o}$ F. The specimen shall be tested immediately after removal from the test chamber.

B.4.4.4 Immersion in chemical fluids. Specimens shall be immersed in the chemical fluid (see B.6.3) specified in Table B-I for a period of 24 hours and at a temperature of $73.4^{o} \pm 2^{o}$ F. The specimen size shall be 4 inches by 1 inch by thickness.

B.4.5 Preproduction inspection.

B.4.5.1 Sample. For each code number of resin or dry lay-up, the sample shall consist of 1 gallon of resin (not required for dry lay-up) or sufficient impregnated fabric to fabricate a 2 by 2 foot by 1/8 inch thick laminate. Two (2) copies of the instruction sheet specified in B.3.5 shall be furnished with the sample.

APPENDIX B

B.4.5.1.1 Fabrication of laminate for test purposes. A glass fabric base plastic laminate panel shall be fabricated in the form of a flat sheet employing a parallel lay-up, using the resin to be tested and 12 plies of 7781 glass fabric finished in accordance with SAE-AMS-C-9084. The laminate shall be fully cured in accordance with the manufacturer's instruction sheet. The laminate shall be essentially void-free and representative of the best workmanship and shall have a resin content by weight which shall produce laminates with optimum mechanical properties. Specimens from this panel shall be tested to determine conformance with B.3.4. Five (5) specimens shall be used for each test.

B.4.5.2 Identification. Preproduction test specimens shall be forwarded to the activity responsible for testing, as specified in the contract or purchase order (see B.6.2). The preproduction test specimens shall be plainly identified by securely attaching durable tags marked with the following information.

Sample for preproduction inspection
Resin, or dry lay-up, Grade _____
Manufacturer's name
Manufacturer's designation and code number
Submitted by (name) (date) for testing in accordance with this
Appendix under authorization (reference letter of authorization)

B.4.5.3 Inspections. The preproduction inspection of resin (or dry lay-up) shall consist of the examinations specified in B.4.7 and the tests specified in B.4.8.

B.4.6 Conformance inspection.

B.4.6.1 Lot size. All materials offered for delivery at one time shall be considered a lot for the purpose of conformance inspection.

B.4.6.2 Sampling for material conformance. Two (2) quarts of resin or sufficient dry lay-up material to fabricate a 1by 2 foot by 1/8 inch thick laminate shall be selected at random from each lot and shall be subjected to the tests specified in B.4.8.2 and B.4.8.3 for the resin and the tests specified in B.4.8.4, B.4.8.5, and B.4.8.6 for the dry lay-up.

B.4.6.3 Sampling for filled container conformance. A random sample of filled resin containers shall be selected from each lot in accordance with the sampling plan specified in the contract or purchase order (see B.6.2) and subjected to the examination specified in B.4.7.1. Any container in the sample having one (1) or more defects, or which is under the required fill, shall be cause for rejection of that container. If the number of defective containers in any sample exceeds the acceptance number specified in the contract or purchase order (see B.6.2), the lot represented by that sample shall be rejected.

B.4.7 Examinations.

APPENDIX B

B.4.7.1 Examination of filled containers. Each sample selected as specified in B.4.6.3 shall be visually examined for the defects listed in Table B-III.

TABLE B-III. Classification of defects.

CATEGORIES	DEFECTS
Critical:	
1	None defined
Major:	
101	Type not as specified, (oblong, square or round)
102	Gauge of steel not within requirements
103	Size (capacity) not as specified
104	Container not coated or coating nonconforming, (internal and external, as applicable)
105	Means of closure not as required; closure (cover) leaks, (container inverted); gasket, when applicable, missing, damaged or conforming
106	Seam improperly formed, soldered or welded
107	Seam leaks
108	Not the required volume (fill)
109	Marking (as to content) not as specified, missing or illegible
Minor:	
201	Not free from dents, scratches, burrs or sharp exposed edges
202	Evidence of rust or corrosion
203	bails improperly attached or missing (when applicable)
204	Diameter of bail wire less than allowable minimum (when applicable)
205	Bail wire hand grip missing, nonconforming, not wood or metal as required (when applicable)

B.4.8 Tests.

B.4.8.1 Mechanical and physical properties. The mechanical and physical properties of the laminate shall be tested in accordance with the test methods specified in Table B-IV, and as follows.

B.4.8.1.1 Change in weight, thickness, and flexural strength after immersion in chemical fluids. At least five (5) samples of the laminates, approximately 1 inch by 4 inch, shall be weighed to the nearest ounce and measured for thickness at the center to the nearest 0.0001 inch. The samples shall then be immersed in the fluid as specified in Table B-I for 24 hours at a temperature of $73.4^{o} \pm 2^{o}$ F. After removal from the fluid, the samples shall be wiped free of surface fluid and immediately weighed and the thickness measured as above. A separate set of specimens shall be used for chemical resistance tests in each of the four (4) specified fluids and immediately after the measurements are completed, the flexural strength shall be determined. The flexural strength shall be based on the dimensions of the specimen

before immersion. The percent increase or decrease in weight and thickness and the flexural strength shall be reported, as well as any perceptible softening, delamination, or other deterioration.

B.4.8.1.2 Barcol hardness. The Barcol hardness of the laminate shall be obtained on each specimen by direct reading on a Barcol Impressor.

B.4.8.2 Specific gravity. Specific gravity of the liquid resin shall be determined by weighing a specific volume of the resin to the nearest 0.001gram and dividing by the volume in cubic centimeters.

B.4.8.3 Viscosity. Viscosity of the liquid resin shall be determined by a calibrated McMichael viscometer, or equivalent. The test procedure shall be specified by the manufacturer.

B.4.8.4 Volatile content (dry lay-up). The test method shall be specified by the manufacturer (see B.3.5.2).

B.4.8.5 Solid content (dry lay-up). The test method shall be specified by the manufacturer (see B.3.5.2).

TABLE B-IV. Test methods.

Property	Test Method
Ultimate flexural strength	ASTM C393, ASTM D790
Initial modulus of elasticity	ASTM C393, ASTM D790
Ultimate tensile strength	ASTM D3039/D3039M
Ultimate compressive strength	Modified ASTM D695, ASTM D3410/D3410M
Flammability	ASTM E84, ASTM E162
Water absorption	ASTM D570, ASTM D618
Barcol hardness	ASTM D2583
Specific gravity	ASTM D792, ASTM D1505
Resin content	ASTM D2584
Immersion	Modified ASTM D870

B.4.8.6 Flow of pre-impregnated material (dry lay-up). The flow of pre-impregnated material shall be determined in the following manner: Four (4) 4-inch squares shall be cut from the impregnated fabric material. These specimens shall be weighed. Specimens of 4-plies shall be wrapped in cellophane and placed between platens of the flow meters before being pressed into a laminate under conditions specified by the manufacturer. After removing the specimen from the flow meter the cellophane, as well as all the flash

resin that has flowed from the laminate, shall be removed from the 4 edges. The specimen shall then be re-weighed. This weight shall be subtracted from the original weight, divided by the original weight, and multiplied by 100 to obtain the flow (see B.3.5.2).

B.4.9 Rejection. Failure of any lot sample to fully meet the requirements specified in this Appendix shall reject the lot it represents. Disposition of inspection lots found unacceptable under initial conformance inspection shall be as specified in the contract or purchase order (see B.6.2).

B.4.10 Marking. In addition to any special marking (hazardous chemicals, adequate ventilation required, etc.) specified in the contract or purchase order (see A.6.2), containers shall be marked in accordance with MIL-STD-129. The nomenclature shall include:

RESIN, PHENOLIC, LAMINATING
Resin, Grade B
Batch number _____

B.5 PACKAGING

B.5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see B.6.2). When packaging of materiel components are to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain packaging requirements.

B.6 NOTES

B.6.1 Intended use. The modified Phenolic laminating resin covered by this appendix is intended to be used in fabricating the laminates specified by the specification this appendix is a part.

B.6.2 Acquisition requirements. Acquisition documents should specify the following:

a. If the prepreg to be used is made of a different glass fabric (see B.3.2 and B.3.4).
b. Specify mechanical and physical properties if material other than glass fabric, style 7781, E-glass is specified (see B.3.2 and B.3.4).
c. If someone besides the contractor is responsible for the performance of all the requirements (see B.4.1).
d. If the contractor cannot use his own or any other facility for testing (see B.4.1).
e. If the definition of a lot is different (see B.4.3).
f. Specify activity responsible for preproduction testing (see B.4.5.2).
g. Specify sampling plan (see B.4.6.3).
h. Specify the acceptance number for defective containers (see B.4.6.3).

i. Specify the disposition of lots found to be unacceptable under conformance inspection (see B.4.9).
j. Specify any special markings (see B.4.10).
k. Specify packaging requirements (see B.5.1).

B.6.3 Chemical fluids. The chemical fluids specified in Table B-I are as follows:

B.6.3.1 Hydraulic fluids.

B.6.3.1.1 Prior designs. Use MIL-PRF-5606H w/Amendment 3. Hydraulic fluids that are intended for use in automatic pilots, shock absorbers, brakes, flap-control mechanisms, missile hydraulic servo-controlled systems, and other hydraulic systems which use synthetic sealing material. This fluid is identified by military symbol OHA and NATO Code No. H-515.

B.6.3.1.2 New designs.

B.6.3.1.2.1 Use MIL-PRF-87257B. The hydraulic fluid covered by this specification is a synthetic hydrocarbon base hydraulic fluid intended for use from -54°C to +200°C in automatic pilots, shock absorbers, brakes, flap-control mechanisms, missile hydraulic servo- controlled systems, and other hydraulic systems using synthetic sealing material.

B.6.3.1.2.2 Use MIL-PRF-83282D. The hydraulic fluid covered by this specification is a synthetic hydrocarbon base hydraulic fluid intended for use from -40°to +205°C in automatic pilots, shock absorbers, air compressor gear boxes, brakes, flap-control mechanisms, missile hydraulic servo-controlled systems and other hydraulic systems using synthetic sealing material. This hydraulic fluid is identified by NATO Code Number H-537.

B.6.3.2 Isopropyl alcohol.

B.6.3.2.1 Use TT-I-735. The two (2) grades of isopropyl alcohol covered by this specification are intended for use as an intermediate in the manufacture of chemicals (Grade A) and intended for use in organic coatings, anti-icing fluid and ordnance material (Grade B).

B.6.3.3 Antifreeze.

B.6.3.3.1 Use A-A-52624. The two (2) types of antifreeze covered by this commercial item description (CID) are for the requirements for ethylene glycol-based (Type I) and propylene glycol-based (Type II) automotive engine antifreeze. The antifreeze is to be suitable for use in all administrative vehicles, construction and materiel handling vehicles and equipment, and military ground combat and tactical vehicles and equipment.

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B.6.3.4 Hydrocarbons. In prior documentations the fluid required to be tested conformed to TT-S-735, Type III, namely, 2,2,4 -Trimethylpentane and toluene with a mixture of 70:30.

B.6.3.4.1 Use ASTM D471. The corresponding equivalent hydrocarbon fluid is listed as Reference Fuel B (Isooctane, 70: Toluene, 30).

APPENDIX C

THERMAL SHOCK TEST PROCEDURE

C.1 SCOPE

C 1.1 Scope. This appendix covers a procedure used to measure the dimensional changes of materials which are exposed to extreme rapid temperature changes. This appendix is a mandatory part of this specification. The information contained herein is intended for compliance.

C 1.2 Applicability. The requirements specified in this appendix are required. The content of this appendix was taken for the most part from MIL-STD 810G, Method 503.5 Temperature Shock.

C.2 APPLICABLE DOCUMENTS (Not Applicable)

C.3 REQUIREMENTS

C.3.1 Equipment. The equipment listed below or its equivalent shall be required to perform the thermal shock test.

1. Hot Chamber @ 275°F, Ex: Russells Technical Products, Model GD-64-5-5-AC
2. Cold Chamber @ -90°F, Ex: Russells Technical Products, Model GD-64-5-5-AC
3. Temperature Recorder w/ multiple channels, Ex: Yokogawa Mobilecorder, Model MV200
4. Thermocouple wire, Ex: Type J, 100ft
5. Micrometer, Ex: Mitutoyo, IP65, No. 389-351, Res = 0.00005
6. Transfer board, Ex: ½" Teflon sheet or ¾" plywood board, 24" x 24"
7. PPE: Safety glasses, Face shield, and insulated gloves
8. Misc: Steel Ruler 24", Marker (Sharpie), High Temp adhesive tape, Timer, binder clips

C 3.2 Test panel. The test panel shall be manufactured as specified herein and shall be of the following size and weight 24" x 24", @ 3.0 psf.

C 3.3 Procedure.

C 3.3.1 Chamber preparation. Both chambers (Hot and Cold) shall be turned on and set at the following set points.

a. Hot chamber set point = 275°F/135°C
b. Cold chamber set point = -90°F/-68°C

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The installation of shelving racks shall be used as needed. Note: Use of shelf racks are optional and may increase or decrease cycle times. Allow up to 1 hour for preheat/precool.

C 3.3.2 Test panel preparation and pretest measurement. Identify and place a mark on the test panel at the eight measurement locations. Each location is to be 1 ¼" from the edge and 6" from the side as shown in FIGURE C-1. Measure thickness at each location using a micrometer. Ensure the micrometer is flat and level relative to the panel and that the panel is clean and free of debris. Record to the nearest 0.001". Measure and record the weight of the test panel. Place and center the test panel on the transfer board. Construct a five wire thermocouple harness and connect to a recorder. Use enough wire length to reach both hot and cold chambers. Attach each of five thermocouple wires to the thermocouple locations shown in FIGURE C-2. Use high temperature tape to secure the thermocouple to the panel. Additional binder clips can be used to hold the lead wires to the transfer board.

*** Safety: Always use appropriate Personal Protective Equipment while working at elevated or sub-ambient conditions. Several steps in the following sections of the procedure shall be designated in **bold red font**, which require the use of safety glasses, face shield, and insulated gloves.

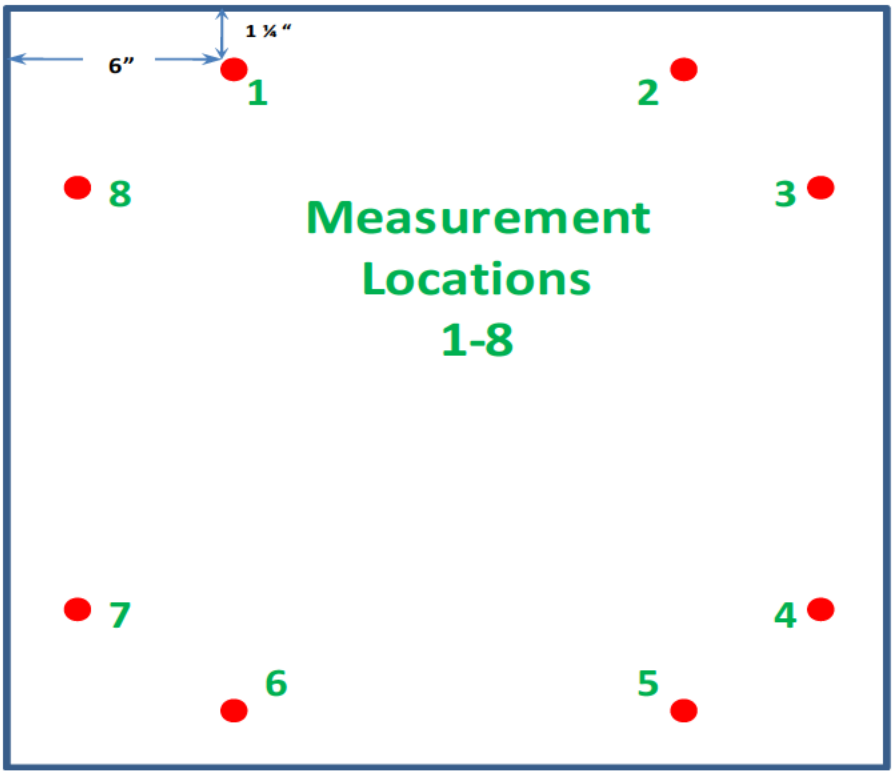

FIGURE C-1. Measurement Locations

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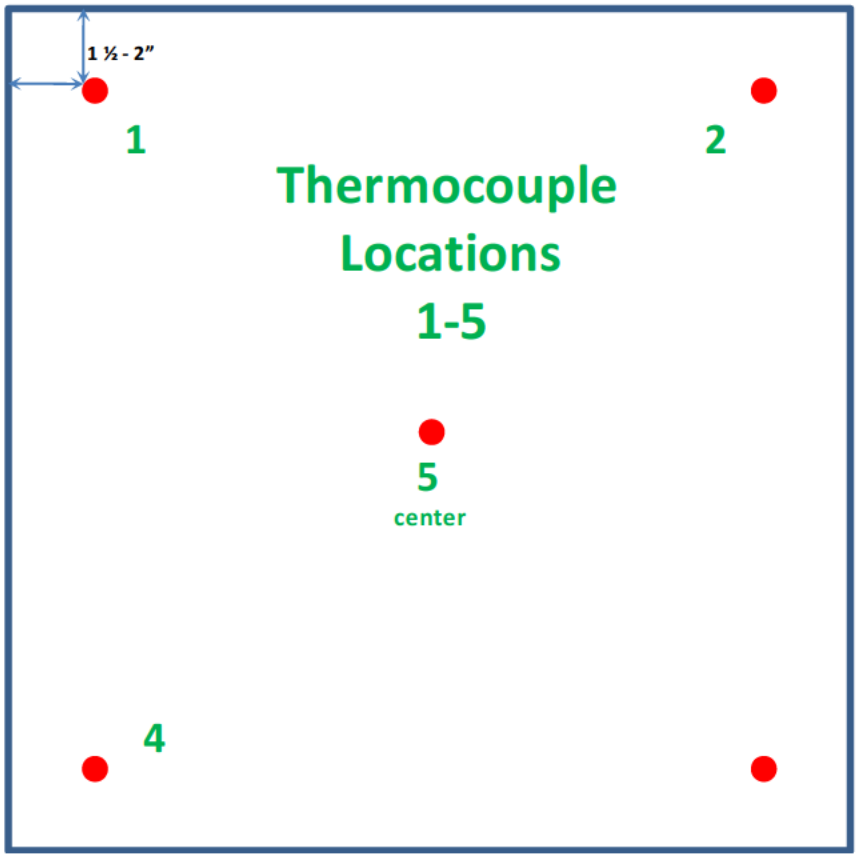

FIGURE C-2. Thermocouple Locations

C 3.3.3 Thermal cycling. Record initial temperatures of each thermocouple and inspect recorder for proper functioning. **Place test panel/transfer board into center of cold chamber and begin timer.** Record time and temperature of each thermocouple location at intervals of: 1 min, 2 min, 5 min, 10 min, etc. Recording interval may be adjusted based on relative ramp rate of test panel. Continue recording the temperature of each thermocouple location until one of the thermocouples reach set point = -65°F. See note 1. **Transfer the test panel/transfer board to the hot chamber and record time. Transfer should be completed in 5 minutes or less. Inspect the thermocouple wires to confirm secure attachment and proper location.** Record time and temperature of each thermocouple location at intervals of: 1 min, 2 min, 5 min, 10 min, etc. Recording interval may be adjusted based on relative ramp rate of test panel. Continue recording the temperature of each thermocouple location until one of the thermocouples reach set point = 250°F. **Transfer the test panel/transfer board to the cold chamber and record time. Transfer should be completed in 5 minutes or less. Inspect the thermocouple wires to confirm secure attachment and proper location.** Record time and temperature of each thermocouple location at intervals of: 1 min, 2 min, 5 min, 10 min, etc. Recording interval may be adjusted

based on relative ramp rate of test panel. Continue recording the temperature of each thermocouple location until one of the thermocouples reach set point = -65°F. **Transfer the test panel/transfer board to the hot chamber and record time. Transfer should be completed in 5 minutes or less. Inspect the thermocouple wires to confirm secure attachment and proper location.** Record time and temperature of each thermocouple location at intervals: 1 min, 2 min, 5 min, 10 min, etc. Recording interval may be adjusted based on relative ramp rate of test panel. Continue recording the temperature of each thermocouple location until one of the thermocouples reach set point = 250°F. **Remove the test panel/transfer board from the hot chamber to a flat countertop and allow it to cool and equilibrate for a minimum of 8 hours in normal ambient conditions (70°F +/- 5°F, 50% +/- 20% RH).**

Note 1: Thermal chambers can have uneven and irregular air flow patterns. It is the intent of the test to expose the panel to a maximum temperature of 250°F and a minimum of -65°F. Hence, when the first of the five measurements reaches the designated 250°F or -65°F, the panel should be transferred to the other environment to achieve the temperature shock and to avoid thermal soak.

C 3.3.4 Post-test measurement. Carefully remove the thermocouple wires and harness so as not to distort or damage the surface at or near the measurement locations. Measure thickness at each location using micrometer. Ensure the micrometer is flat and level relative to the panel and that the panel is clean and free of debris. Record to 0.001”. Measure and record the weight of the test panel. Calculate the thickness change for each location and the average thickness change of the panel. The thickness change is equal to the (final thickness minus the original thickness) divided by the original thickness times 100.

CONCLUDING MATERIAL

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

Preparing activity:
Army - MR

Project No. CMPS-2011-001

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

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at https://assist.daps.dla.mil/