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MILITARY SPECIFICATION

CORE MATERIAL, ALUMINUM, FOR SANDWICH CONSTRUCTION

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

1. SCOPE

* 1.1 Scope. This specification covers treated aluminum core material for structural sandwich construction.

* 1.2 Classification. Aluminum core material for sandwich construction shall be furnished in the following grades, as specified (see 6.2.1 and 6.4):

Grade	Description
B	For exposure up to 350°F (see 3.2.1.1).
C	For exposure up to 430°F (see 3.2.1.2).

2. APPLICABLE DOCUMENTS

2.1 Government documents.

* 2.1.1 Specifications and standards. Unless otherwise specified, the following specifications and standards of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DoDISS) specified in the solicitation form a part of this specification to the extent specified herein.

SPECIFICATIONS

FEDERAL

QQ-A-250/4	-	Aluminum Alloy 2024, Plate and Sheet.
QQ-A-250/5	-	Aluminum Alloy Alclad 2024, Plate and Sheet.
UU-P-268	-	Paper, Kraft, Wrapping.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Systems Engineering and Standardization Department (Code 93), Naval Air Engineering Center, Lakehurst, NJ 08733-5100, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

FSC 5680

SPECIFICATIONS

FEDERAL (continued)

PPP-B-576	-	Box, Wood, Cleated, Veneer, Paper Overlaid.
PPP-B-585	-	Boxes, Wood, Wirebound.
PPP-B-591	-	Boxes, Shipping, Fiberboard, Wood-Cleated.
PPP-B-636	-	Boxes, Shipping, Fiberboard.
PPP-B-640	-	Box, Fiberboard, Corrugated, Triple-Wall.

MILITARY

MIL-P-116	-	Preservation, Methods of.
MIL-C-5541	-	Chemical Conversion Coatings on Aluminum Alloys
MIL-H-6088	-	Heat Treatment of Aluminum Alloys.
MIL-A-81596	-	Aluminum Foil for Sandwich Construction.

STANDARDS

FEDERAL

FED-STD-595	-	Colors.

MILITARY

MIL-STD-105	-	Sampling Procedures and Tables for Inspection by Attributes.
MIL-STD-129	-	Marking for Shipment and Storage.
MIL-STD-401	-	Sandwich Construction and Core Materials, General Test Methods.

(Copies of specifications, standards, handbooks, drawings, and publications required by contractors in connection with specific acquisition functions should be obtained from the acquisition activity or as directed by the contracting officer.)

* 2.2 Other publications. The following documents form a part of this specification to the extent specified herein. The issues of the documents which are indicated as DoD adopted shall be the issue listed in the current DoDISS and supplement thereto, if applicable.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM B 117	-	Salt Spray (Fog) Testing.
ASTM C 366	-	Measurement of Thickness of Sandwich Cores
ASTM D 3951	-	Commercial Packaging, Practice for.

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

(Industry association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

2.3 Order or precedence. In the event of a conflict between the text of this specification and the references cited herein, the text of this specification shall take precedence.

3. REQUIREMENTS

* 3.1 First article. When specified, samples shall be subjected to first article inspection (see 4.5 and 6.3).

3.2 Materials. The materials comprising the core shall conform to the applicable specifications and as specified herein.

3.2.1 Metal. The core shall be fabricated from aluminum alloy foil conforming to MIL-A-81596.

3.2.1.1 Grade B. Grade B core shall be of Alloy 5052 or Alloy 5056 foil, as specified (see 3.2.4 and 6.2.1).

* 3.2.1.2 Grade C. Grade C core shall be of Alloy 2024-T3 or Alloy 2024-T81 foil (see 3.2.4 and 6.2.1). Alloy 2024-T3 shall be subsequently precipitation hardened to the -T81 condition according to the recommended time-temperature cycle specified in MIL-H-6088, either prior to bonding into a sandwich assembly or during the bonding cycle of a sandwich assembly. When specified in the -T3 temper, the samples selected for testing shall be converted to the -T81 condition, except for the material for delamination strength testing.

* 3.2.2 Metal Finish. The core shall be formed from chemically treated or coated foil for protection against corrosion. The foil shall be given a chemical conversion coating in accordance with MIL-C-5541, Class 1A or equivalent.

3.2.3 Bonding material. The adhesive used to bond the aluminum foil to form the cells of the core shall be of such quality that the resultant core will meet the requirements specified herein.

* 3.2.4 Trade name and code number. The manufacturer shall designate each core material combination by a trade name and code number which shall be used to identify the core (see 6.2.1). The code number shall consist of the following:

a. Designated density.

b. Cell size in fractions of an inch.

c. Nominal foil thickness in ten-thousandths of an inch.

d. "P" for perforation, if so specified (see 3.3.2). For non-perforation, no coding required.

e. Alloy (standard designation). If applicable, temper required (see 3.2.1.2).

f. For hexagonal core cell walls, "C" for corrugated if so specified. For expanded, no coding required.

g. "S" for special core cell configurations, if other than hexagonal.

Example: Grade B material with a density of 4.5 pounds per cubic foot, fabricated with a 1/8-inch cell size, and 0.0010 inch nominal thickness, nonperforated and using corrugated untreated Alloy 5052 shall be coded as follows:

Trade name - 4.5-1/8-10(5052)C

Example: Grade C material with a density of 5.0 pounds per cubic foot, fabricated with a 1/8-inch cell size, and 0.0015 inch nominal thickness, nonperforated and capable of being expanded, using treated Alloy 2024-T3 shall be coded as follows:

Trade name - 5.0-1/8-15(2024-T3)

If the core cell configuration is other than hexagonal, such as reinforced hexagonal, double corrugated, or staggered hexagonal, then the core shall be coded as follows:

Trade name - 4.5-1/8-10(5056)S

3.3 Fabrication.

3.3.1 Configuration. The core material shall consist of thin aluminum sheets bonded together to form cells approximately of uniform shapes, usually hexagonal in shape. The cores shall be made either by assembling corrugated ribbons or by strip-bonding flat ribbons and then expanding the core cells to proper shape. If the core material is purchased in the unexpanded condition, it shall be capable of meeting the requirements of this specification after proper expansion to the full cell configuration and proper density.

3.3.2 Perforation. Unless otherwise specified (see 6.2.1), the aluminum foil shall be non-perforated. When perforation is specified, the perforations shall be of such size and location that all cells are vented at least every 1/4 inch in thickness dimension.

3.3.3 Form. The core shall be furnished as pieces, unexpanded blocks or slices, or expanded panels as specified by the acquiring activity. The dimensions and tolerances for the pieces, blocks, slices or panels shall be as specified by the acquiring activity.

3.4 Physical properties. Physical properties and tolerances shall be in accordance with Table I.

* 3.4.1 Foil thickness. The core foil thickness shall be within the limits of designated value specified in Table II.

3.5 Compressive and shear strength properties of hexagonal configuration core. Core flatwise compressive strength and shear strength (associated with shear distortion in the LT and WT planes, see Figure 2) for the nominal density of the core shall conform to the requirements listed in Table III as applicable for the basis metal and test conditions. Compressive strength and shear strength of any specimen shall be not less than the value specified in the applicable tables (see Tables IV - X) when tested in accordance with the applicable test procedure (see 4.7.5 - 4.7.8). When shear strength is

determined by using the beam flexural shear test, the facings of the core sandwich shall be Alloy 2024-T3 or 2024-T81 bare, conforming to QQ-A-250/4, or clad, conforming to QQ-A-250/5.

3.6 Delamination strength. The core shall have a delamination strength or node bond strength capable of withstanding not less than the ultimate tensile load specified in Table XI or Table XII, as applicable, for the Grades and test conditions. In case of partial delamination at not less than the specified ultimate tensile strength load for a specified test condition, the delamination areas shall be less than 10 percent of the total bond area in the stress section of the core (see 4.7.9).

* 3.7 Corrosion resistance properties. The material shall be treated so as to be capable of protecting the base metal when subjected to the salt spray test specified in 4.7.10. At the end of 30 days exposure, the core shall not show a loss of weight greater than 125 milligrams per square foot of exposed foil area.

3.8 Mechanical properties of special core configuration. The mechanical properties of special core configuration or hexagonal configuration material, not specified herein, shall be specified in the contract or purchase order, or covered by applicable drawings (see 6.2.1).

3.9 Color code identification.

3.9.1 Grade B. Each block or slice of Grade B core shall be identified on the edges by red stripes, about 2 inches wide, which shall match Color No. 11105 or 21105 of FED-STD-595 and 1/2 inch wide stripes applied at intervals of not less than 2 feet. The color of the stripes for the core alloy material and designated density range shall be in accordance with Table XIII. The color shall be produced by adding a dye to an adhesive which is compatible with the core. Stripes shall be painted or sprayed on the edges of core blocks or slices. The permanent dye shall retain its color through the curing cycle and shall be non-corrosive. The dye shall not adversely affect the curing nor the strength of the adhesive used for construction of the core nor the adhesive used with the core in the fabrication of sandwich components.

3.9.2 Grade C. Each block or slice of Grade C core shall be identified on the edges by two stripes, about 2 inches wide with a narrow stripe about 1/2 inch wide between the wide stripes. The stripes shall be applied at intervals of not less than two feet. The wide stripes shall be yellow and shall match Color No. 13655 or 23655 of FED-STD-595. The color of the stripes for the designated nominal density shall be in accordance with Table XIV. Other requirements for color shall be as detailed in 3.9.1.

3.10 Workmanship. The core material shall be free from defects that would affect adversely the properties of the end item. The material shall be clean and free from grease, oil, trim scraps, and impurities. The foil edges of the core material shall be free from notches, crush lines and rolled metal. Expanded core slices having double foils (two ribbons bonded together causing uneven expansion in the "L" direction) shall be acceptable if the double foils are not more frequent than one in eight inches in the transverse (W) direction (see 4.6.2.1).

3.10.1 Visual imperfections. Visual imperfections shall not exceed the values specified in Table XV for the specified cell size (see 4.6.2.1.1).

3.10.2 Mismatched nodes. The c/d ratio of mismatched nodes for corrugated core shall not exceed 0.25 (see 4.6.2.1.1).

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements.

4.2 Sampling. Unless otherwise specified, sampling plans and procedures in the determination of the acceptability of products shall be in accordance with the provisions set forth in MIL-STD-105.

4.3 Lot. Unless otherwise specified in the contract or order (see 6.2.1), a lot shall consist of not more than 100 cubic feet of material of the same designated cell size dimension, nominal foil thickness, density, perforation, alloy composition and core configuration design, manufactured under essentially the same conditions.

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

a. First article inspection (see 4.5).

b. Quality conformance inspection (see 4.6).

4.5 First article inspection. First article inspection shall consist of all inspection procedures of this specification (see 4.6 and 4.7). The responsibility for the performance of the first article inspection shall be as specified by the acquiring activity (see 6.2.1 and 6.3).

4.5.1 Test samples. The first article test samples shall consist of randomly selected material cut to a thickness of 0.625 ± 0.010 inch for Grade B or of 0.500 ± 0.010 inch for Grade C. In addition, sufficient material for the plate shear tests or sandwich specimens for flexural tests shall be provided for a minimum of 5 specimens for each applicable direction and temperature determination. First article samples (of designated density, cell size dimension, nominal foil thickness, alloy composition, finish, core cell configuration) which are selected shall have been manufactured using the same production processes, procedures and equipment which will be used in filling the contract.

4.5.2 Certified statement. Whether or not a first article sample is required (see 4.5.3), the contractor shall supply a certified statement of composition and prior tests which shows the material furnished complies with

the requirements of this specification. The statement shall also include the manufacturer's trade name and code number for the material and the proprietary name of the bonding material used (see 6.3).

4.5.3 Prior approval. If a contractor has previously delivered material in accordance with the requirements of this specification and his product has been found to be satisfactory, the requirements for first article inspection for that product, in connection with any subsequent contract or order for that product, may be waived at the discretion of the acquiring activity (see 6.2.1 and 6.3). The approval of First Article samples or the waiving of the First Article inspection shall not relieve the contractor of his obligation to fulfill all other requirements of the specifications and contract.

4.5.4 Further production. Any production of core material by the contractor prior to approval of the acquiring activity shall be at the contractor's risk.

4.6 Quality conformance inspection.

4.6.1 Sampling. Samples shall be taken at random from each inspection lot. Failure of any specimen to meet the requirements of this specification shall constitute cause for rejection of the lot represented (see 4.8). The contractor shall furnish all samples and shall be responsible for accomplishing the required tests.

4.6.1.1 Visual and dimensional examination. Samples shall be selected in accordance with MIL-STD-105, Inspection Level II, Acceptable Quality Level 2.5 percent defective for visual and dimensional examination (see 4.6.2.1).

4.6.1.2 Physical and mechanical properties. Sufficient material shall be selected to conduct the tests detailed in Table XVI applicable for the Grade of core.

4.6.1.3 Corrosion resistance properties. Five (5) test specimens shall be selected to conduct the test detailed in 4.7.10 (see Table XVI). In lieu of sampling each inspection lot, the contractor shall be permitted once each week to select a minimum of 5 random specimens from his production line for determination of corrosion resistance properties.

4.6.2 Tests. The quality conformance tests shall consist of examination as specified in 4.6.2.1 and in Table XVI. The tests shall be in conformance with the applicable requirements of Section 3, except as noted. In addition, the material shall be subjected to any other tests specified herein which the acquiring activity considers necessary to determine conformance with this specification.

4.6.2.1 Examination. The material, selected in accordance with 4.6.1.1, shall be examined to determine compliance with the requirements of this specification for configuration, perforation, size identification, workmanship and double foils, visual imperfections and mismatched nodes. Except for the maximum number of imperfections allowed as indicated in Table XV (see 4.6.2.1.1), a unit of sample containing one or more defects shall be rejected. Figure 1 illustrates double foils and mismatched nodes.

4.6.2.1.1 Visual imperfections. A square foot of each selected sample item shall be examined for the number of mismatched nodes, loose metal, flakes, unbonded nodes, split cell walls and buckled cell walls. The c/d ratio of mismatched nodes shall also be determined. If the number of nonconforming imperfections exceeds the acceptance number for that defect as stated in Table XV as well as the c/d ratio of mismatched nodes is greater than the specified value, the lot represented by the sample shall be rejected.

4.6.2.2 Physical, mechanical and corrosion resistance properties. The material selected shall be tested in accordance with Table XVI.

4.7 Test methods.

4.7.1 Core density. The test specimens may be any convenient size or shape that can be accurately measured from blocks or slices. Specimen size shall be approximately 4 square feet or larger of the core material. Specimens shall be weighed to an accuracy of at least 1 percent. Length and width dimensions shall be measured to the nearest 0.01 inch. Thickness of slices shall be measured to the nearest 0.001 inch by the use of a dial gage which applies 10 pounds pressure on a 1.5 inch diameter area. The core density shall be calculated by dividing the weight of the piece in pounds by the volume in cubic feet as follows:

$$\text{Density } (\text{lbs/ft}^3) = \frac{\text{wt.(lb)}}{\text{vol(ft.}^3)} \text{ or } \frac{1728 \text{ wt.(lb)}}{\text{vol } (\text{in}^3)} \text{ or } \frac{3.81 \text{ wt.(gm)}}{\text{vol } (\text{in}^3)} \text{ or } \frac{6.24 \text{ wt.(gm)}}{\text{vol } (\text{cm}^3)}$$

4.7.2 Cell size. The test specimens may be any convenient size or shape that can be accurately measured from blocks or slices. The distance between flats for ten cells in a row in the transverse direction (W) in six random selected locations shall be measured to the nearest 0.01 inch. The nominal cell size shall be taken as a tenth of a measured distance as illustrated in Figure 2 and the results averaged.

4.7.3 Cell pitch. The test specimens may be any convenient size or shape that can be accurately measured from blocks or slices. The distance between nodes for ten cells in a row in the longitudinal direction (L) in six random selected locations shall be measured to the nearest 0.01 inch. The nominal cell pitch shall be taken as a tenth of the measured distance as illustrated in Figure 2 and the results averaged.

4.7.4 Foil thickness. The test specimens may be any convenient size or shape that can be accurately measured. The thickness of the foil shall be measured to the nearest 0.0001 inch by any suitable method as long as no adhesive thickness is included. The thickness shall be computed as the average of ten measurements (see Table II).

4.7.5 Core flatwise compressive strength at room temperature.

4.7.5.1 Specimens and preparation. Specimens for flatwise compressive strength shall be 3 inches square and 0.625 $\pm$ 0.010 inch for Grade B or 0.500 $\pm$ 0.010 inch for Grade C in thickness. The cross sectional dimensions shall be measured to the nearest 0.05 inch. The testing machine loading faces shall be approximately 4 inches square.

Care should be taken to prepare the specimen so that the loaded ends shall be parallel to each other within 0.001 inch and perpendicular within 5 degrees to the cell axis of the specimen. The surface of the specimen shall be free of burrs or tears. The core may be stabilized as detailed in MIL-STD-401 to avoid local crushing of the ends.

4.7.5.2 Procedure. The test procedure shall be in accordance with MIL-STD-401. The load shall be applied with a continuous and constant rate of movement of the head of the testing machine at 0.020 ± 0.005 inch per minute.

4.7.5.3 Calculation. The flatwise compressive strength shall be computed by dividing the maximum load by the cross section area.

4.7.6 Core flatwise compressive strength at elevated temperatures.

4.7.6.1 Specimens and preparation. Specimen size and preparation shall be as detailed in 4.7.5.1. At the option of the supplier, a heat resistant adhesive bonded sandwich flatwise compression sample of the core may be used in lieu of stabilization in accordance with MIL-STD-401. Facings shall be 0.020 inch Alloy 2024-T3 or 2024-T81 conforming to QQ-A-250/4 or clad 2024-T3 or clad 2024-T81 conforming to QQ-A-250/5.

4.7.6.2 Procedure. Grade B core specimens shall be heated and held at 350 ± 10°F for 10 minutes. One set of Grade C core shall be conditioned at 350 ± 10°F for 10 minutes and another set at 430 ± 10°F for 10 minutes. Specimens shall be subjected to the load as detailed in 4.7.5.2 at the temperature conditioned. If the temperature has been allowed to vary beyond the plus range of 10°F from the test temperature, the test shall not be considered valid.

4.7.6.3 Calculation. The flatwise compressive strength at elevated temperature shall be computed as detailed in 4.7.5.3.

4.7.7 Shear strength at room temperature. For core with a nominal density not exceeding 10.0 pounds per cubic foot, shear strength shall be determined in two directions (longitudinal and transverse) by the plate shear procedure (see 4.7.7.1) as detailed in MIL-STD-401. For core with a nominal density of 10.5 pounds per cubic foot or greater, shear strength shall be determined by the beam flexural shear procedure (see 4.7.7.2) as shown in Figure 3.

4.7.7.1 Plate shear. Specimens shall be 7.5 by 2 inches minimum with a thickness of 0.625 ± 0.010 inch for Grade B or 6 by 2 inches minimum with a thickness of 0.500 ± 0.010 inch for Grade C. Specimens shall be bonded to the loading plates of the apparatus as detailed in MIL-STD-401. For testing, the load shall be applied at the rate of 0.04 inch per minute. Core shear strength in pounds per square inch (psi) shall be calculated as follows:

$$V = \frac{P_m}{LB}$$

Where:

V = Shear strength

P_m = Maximum load (lb.)

L = Length (in.)

B = Width (in.)

4.7.7.2 Flexural shear. Specimens shall be fabricated to comprise an 8 by 3 inches sandwich with a 0.625 ± 0.010 inch core. Facing shall be 0.125 inch thick base 2024-T3 or 2024-T81 conforming to QQ-A-250/4 or clad 2024-T3 or 2024-T81 conforming to QQ-A-250/5. Length and width of the sandwich shall be measured to the nearest 0.01 inch. Specimens shall be positioned and loaded as detailed in Figure 3. The load rate shall be 0.015 to 0.020 inch per minute. Sandwich core shear strength (pounds per square inch) shall be calculated as follows:

$$V = \frac{P_m}{B(T+T_c)}$$

Where:

V = Sandwich shear strength

P_m = Maximum load (lb.)

B = Sandwich width (in.)

T = Sandwich thickness (in.)

T_c = Core thickness (in.)

4.7.8 Shear strength at elevated temperatures. For core with a nominal density not exceeding 10.0 pounds per cubic foot, shear strength shall be determined in two directions by the plate shear procedure as detailed in MIL-STD-401. For core with a nominal density of 10.5 pounds or more, shear strength shall be determined by the sandwich flexural shear procedure as shown in Figure 3.

4.7.8.1 Specimens and procedures. Specimens of core shall be as detailed in 4.7.7.1 or 4.7.7.2 as applicable for the procedure to be used. Specimens shall be placed in the testing machine, conditioned by heating as detailed in 4.7.6.2 and then subjected to the load as stated in 4.7.7.1 or 4.7.7.2 at the conditioning temperature. If the temperature has been allowed to vary beyond the plus range of 10°F from the test temperature, the test shall not be considered valid.

4.7.8.2 Calculation. The shear strength at elevated temperature shall be calculated as specified in 4.7.7.1 or 4.7.7.2 in accordance with the procedure used.

4.7.9 Delamination strength.

4.7.9.1 At room temperature. The core specimen shall be 5 ± 1/16 inches wide, 10 ± 1/2 inches long and 0.625 ± 0.010 inch thick for Grade B or 0.500 ± 0.010 inch thick for Grade C. Width shall be parallel to the node-to-node bond area. Specimens shall be tested in accordance with MIL-STD-401. The testing machine shall be capable of maintaining a steady load rate of 1.0 inch per minute of head travel to produce a constant rate of grip separation. Failure in grips shall be considered a satisfactory test provided the values obtained are equivalent or exceed the values contained in this specification. Delamination strength shall be the ultimate tensile force in pounds.

4.7.9.2 After boiling water immersion. The core specimens shall be of the size detailed in 4.7.9.1. The core shall be totally immersed in boiling distilled water for 120 ± 5 minutes, removed and cooled. Within 4 hours after removal from the boiling water, specimens shall be tested for delamination in a fixture and the delamination strength recorded as detailed in 4.7.9.1.

4.7.9.3 At elevated temperatures. The core specimens shall be of the size detailed in 4.7.9.1. Specimens shall be placed in the test fixture, then heated and held at 350 ± 10°F for 10 minutes. Specimens shall be subjected to the load at 350 ± 10°F and the delamination strength recorded as detailed in 4.7.9.1. If the temperature has been allowed to vary beyond the plus range of 10°F from 350°F, the test shall not be considered valid.

4.7.10 Corrosion resistance.

4.7.10.1 Test specimens and preparation. Specimens for corrosion resistance shall be 5 ± 1/16 inches long (longitudinal direction), 6 ± 1/16 inches wide (transverse direction) (see Figure 2) and 0.625 ± 0.010 inch thick for Grade B or 0.500 ± 0.010 inch thick for Grade C. Grade B core shall be heated in an electric drying oven for 16 hours ± 15 minutes at 350 ± 10°F, whereas Grade C shall be heated for 6 hours ± 10 minutes at 430 ± 10°F. Specimens shall be removed from the oven, allowed to cool to room temperature in a desiccator before weighing to the nearest milligram, using an analytical balance.

4.7.10.2 Procedure. The test specimens shall be subjected to a 5 percent salt spray test in accordance with ASTM B 117, except that the cell axis (W-L axes) shall be supported or suspended horizontal approximately 90 degrees from the vertical. At the end of 30 days exposure, the specimens shall be removed and rinsed thoroughly in clear running water. Immediately following rinsing, the specimens shall be stripped by immersion in a phosphoric-chromic acid solution for 5 minutes at 212°F. The solution shall consist of the following:

Phosphoric acid, 85 percent	103 milliliters
Chromic acid (CrO_3)	76 grams
Water, to make	3.75 liters

The specimens shall be removed from the solution, washed in distilled or deionized water, dried at 225 ± 5°F for 30 minutes, cooled to room temperature and reweighed. The stripping solution should be discarded after 3.75 liters of the solution has dissolved 20 grams of oxides or coating.

4.7.10.3 Calculation. The loss of weight as milligrams per square foot of exposed foil area is calculated as follows:

$$M = \frac{36C(O-A)}{TLW}$$

Where:

M = Weight loss per square foot of exposed foil area in milligrams

C = Nominal cell size, inch (1/8, 5/32, 3/16, 1/4, 3/8)

T = Thickness measurement in direction of cell axis, inch

L = Ribbon length direction, inches

W = Transverse direction, inches

O = Original weight of specimen in milligrams before exposure

A = Final weight of specimen in milligrams after stripping

4.8 Rejection and retest. If the results of the quality conformance tests show failure to conform to 3.5 and Table III, tests shall be conducted on the remaining material samples held for retest (see Table XVI). Failure of the retest specimens to conform to the respective requirements shall then be cause for rejection of the lot represented by the material.

* 5. PACKAGING

5.1 Preservation. Preservation shall be Level A or C, as specified (see 6.2.1).

5.1.1 Level A. Material shall be preserved in accordance with MIL-P-116, Method III, and packaged in containers conforming to PPP-B-636. For slices or for more than 1 block per container, the layers of core material shall be interleaved with kraft paper conforming to UU-P-268. Unit quantities shall be as specified by the procuring activity.

5.1.2 Level C. Material shall be preserved in accordance with ASTM D 3951.

5.2 Packing. Packing shall be Level B or C as specified (see 6.2).

5.2.1 Level B. Material preserved as specified in 5.1.1, shall be packed in containers conforming to PPP-B-576, PPP-B-585, PPP-B-591, PPP-B-636 Domestic Class, or PPP-B-640 Domestic Class. Containers shall be closed and strapped in accordance with the applicable container specification or appendix thereto.

5.2.2 Level C. Material shall be packed in accordance wtih ASTM D 3951.

5.3 Marking. *In addition to any special marking required by the contract* or order (see 6.2.1), interior and exterior containers shall be marked in accordance with requirements of MIL-STD-129. Also, the interior and exterior containers shall be marked with the code number (see 3.2.4).

6. NOTES

* 6.1 Intended use. The core material covered by this specification is intended for use in fabricating sandwich construction for air frame structural use and in weapons systems. The fabrication and quality conformance inspection requirements for the core material detailed in this specification shall not be used for the design allowables required for sandwich construction.

6.2 Ordering data.

* 6.2.1 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number and date of this specification.

b. Grade of material (see 1.2).

c. Core code number, to include density, cell size, foil thickness, alloy, etc, (see 3.2.4).

d. Perforation, if required (see 3.3.2).

e. Blocks or slices, dimensions of core material and tolerances (see 3.3.3).

f. Mechanical properties of special core configuration, if applicable (see 3.8).

g. Quantity (cubic feet) of core material (see 4.3).

h. Responsibility for performance of first article inspection (see 4.5).

i. Applicable levels of preservation and packing (see 5.1 and 5.2).

j. Special markings (see 5.3).

k. Cell size, cell pitch and foil thickness determinations, if required (see Tables I, II and XVI).

l. Mechanical and physical testing, if required (see Table XVI).

m. Where the First Article inspection is to be conducted, if *required.*

* 6.3 First article test report. When First Article samples are submitted (see 6.2.1), they should be accompanied by a complete inspection report showing the results of the contractor's inspections. The inspection report shall include the following:

a. Report of inspections numerically presented when possible, together with a detailed statement indicating compliance or extent of noncompliance with all requirements of this specification, referring specifically to paragraph numbers. Wherever a requirement is considered to be not applicable, the report shall so state.

b. Diagrams of inspection set-ups. A complete description of inspection equipment and inspection procedures.

c. Where inspections specified in this specification are not considered applicable, the reason, and the substituted inspection should be clearly described.

d. Copies of inspection log sheets.

* 6.4 Superseding data. Where Grade A core materials (Alloy 3003, 5052 and 5056) are specified to be used as listed on applicable drawings, Grade B material should be acquired as a substitution. Treated material may be used where untreated material was used in previous construction. Revision G was prepared to cover treated (previously Class 2) material only.

6.5 Measurement of thickness of sandwich cores. To provide information regarding the variation in thickness of flat aluminum core material and provide a basis for obtaining average thickness dimensions, the methods covered in ASTM C 366, Measurements of Thickness of Sandwich Cores, may be used. The methods are designated for measuring thickness of core as produced (see 3.3.3) and are not intended for use in determining dimensions of core specimens for tests in this specification.

* 6.6 Changes from previous issues. The margin of this specification are marked with asterisks to indicate where changes (additions, modifications, corrections, deletions) from the previous issue were made. This was done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations and relationships to the last previous issue.

Custodians:
Army - ME
Navy - AS
Air Force - 20

Review activities:
Army - MI, MR
Air Force - 99

User activities:
Army - AV
Navy - OS

Preparing activity:
Navy - AS

(Project 5680-0120)

* TABLE I. Physical property requirements.

Characteristic	Requirement tolerances	Test paragraph
Density	Within ± 10 percent of the designated or specified nominal value (see Tables IV, V or VIII, as applicable, for the alloy) based upon cell size and designated foil thickness	4.7.1
Cell size 1/	Within ± 10% of designated value	4.7.2
Cell pitch 1/	Within +20 percent, -10 percent of designated cell size multiplied by factor of 1.733	4.7.3

1/ Shall be determined when specified.

TABLE II. Aluminum core foil thickness, inch. 1/

Designated	Maximum	Designated	Maximum
0.0007	0.0011	0.0030	0.0042
0.0010	0.0015	0.0040	0.0053
0.0015	0.0022	0.0050	0.0065
0.0020	0.0029	0.0060	0.0078
0.0025	0.0034		

1/ Shall be determined when specified.

TABLE III. Tables of compressive and shear strength requirements.

Grade	Alloy	Room temperature (70 - 85°F)		Elevated temperatures 350 ± 10°F		430 ± 10°F	
		Table	Test reference	Table	Test reference	Table	Test reference
B	5052	IV	4.7.5 & 4.7.7	IV	4.7.6 & 4.7.8	-	-
	5056	V	4.7.5 & 4.7.7	VII	4.7.6 & 4.7.8	-	-
C	2024	VIII	4.7.5 & 4.7.7	IX	4.7.6 & 4.7.8	X	4.7.6 & 4.7.8

TABLE IV. Mechanical properties of 5052 aluminum honeycomb core at room temperature. 1/

Nominal core density, PCF	Cell size, inch	Foil thickness, inch	Stabilized flatwise compressive strength, psi	Plate shear	
				Longitudinal (L) shear strength, psi	Transverse (W) shear strength, psi
1.0	3/8	0.0007	20	32	20
1.6	1/4	0.0007	70	60	32
1.6	3/8	0.0010	70	60	32
2.0	3/16	0.0007	100	80	46
2.3	1/4	0.0010	130	100	57
2.3	3/8	0.0015	130	100	57
2.6	5/32	0.0007	160	120	70
3.0	3/8	0.0020	200	145	85
3.1	1/8	0.0007	215	155	90
3.1	3/16	0.0010	215	155	90
3.4	1/4	0.0015	250	180	105
3.7	3/8	0.0025	290	205	120
3.8	5/32	0.0010	300	215	125
4.2	3/8	0.0030	360	255	150
4.3	1/4	0.0020	370	265	155
4.4	3/16	0.0015	385	280	160
4.5	1/8	0.0010	405	285	168
5.2	1/4	0.0025	510	360	200
5.3	5/32	0.0015	535	370	215
5.4	3/8	0.0040	540	380	228
5.7	3/16	0.0020	600	410	244
6.0	1/4	0.0030	660	445	265
6:1	1/8	0.0015	680	455	272
6.5	3/8	0.0050	760	500	300
6.9	5/32	0.0020	800	540	328
6.9	3/16	0.0025	800	540	328
7.6	3/8	0.0060	1000	615	370
7.9	1/4	0.0040	1050	650	390
8.1	1/8	0.0020	1100	670	400
8.1	3/16	0.0030	1100	670	400
8.4	5/32	0.0025	1180	690	420
9.2	1/4	0.0050	1330	780	455
10.0	1/8	0.0025	1500	860	490
10.0	5/32	0.0030	1500	860	490
10.5	1/4	0.0060	1600	1120 2/	640 2/
10.6	3/16	0.0040	1620	1130 2/	650 2/
12.0	1/8	0.0030	1910	1250 2/	750 2/

1/ Values are for test purposes only. Data shall not be used for design allowances.

2/ Shear strength values determined by Beam Flexure Shear.

TABLE V. Mechanical properties of 5056 aluminum honeycomb core at room temperature. 1/

Nominal core density, PCF	Cell size, inch	Foil thickness, inch	Stabilized flatwise compressive strength, psi	Plate shear	
				Longitudinal (L) shear strength, psi	Transverse (W) shear strength, psi
1.0	3/8	0.0007	35	45	25
1.6	1/4	0.0007	80	78	38
1.6	3/8	0.0010	80	78	38
2.0	3/16	0.0007	120	105	50
2.3	1/4	0.0010	155	130	62
2.3	3/8	0.0015	155	130	62
2.6	5/32	0.0007	185	152	80
3.0	3/8	0.0020	250	190	100
3.1	1/8	0.0007	260	200	110
3.1	3/16	0.0010	260	200	110
3.4	1/4	0.0015	315	230	130
3.7	3/8	0.0025	362	260	150
3.8	5/32	0.0010	375	272	155
4.2	3/8	0.0030	443	315	180
4.3	1/4	0.0020	465	325	190
4.4	3/16	0.0015	490	340	198
4.5	1/8	0.0010	500	350	205
5.2	1/4	0.0025	645	425	245
5.3	5/32	0.0015	650	435	250
5.4	3/8	0.0040	680	450	260
5.7	3/16	0.0020	735	480	280
6.0	1/4	0.0030	805	512	300
6.1	1/8	0.0015	825	525	305
6.5	3/8	0.0050	908	568	335
6.9	5/32	0.0020	1000	610	360
6.9	3/16	0.0025	1000	610	360
7.6	3/8	0.0060	1155	687	410
7.9	1/4	0.0040	1265	720	430
8.1	1/8	0.0020	1300	740	440
8.1	3/16	0.0030	1300	740	440
8.4	5/32	0.0025	1375	775	455
9.2	1/4	0.0050	1570	865	500
10.0	1/8	0.0025	1760	950	538
10.0	5/32	0.0030	1760	950	538
10.5	1/4	0.0060	1900	1175 2/	700 2/
10.6	3/16	0.0040	1920	1180 2/	710 2/
12.0	1/8	0.0030	2270	1375 2/	820 2/

1/ Values are for test purposes only. Data shall not be used for design allowances.

2/ Shear strength values determined by Beam Flexure Shear.

TABLE VI. Mechanical properties of 5052 aluminum honeycomb core at 350 ± 10°F. 1/

Nominal core density, PCF	Cell size, inch	Foil thickness, inch	Stabilized flatwise compressive strength, psi	Plate shear	
				Longitudinal (L) shear strength, psi	Transverse (W) shear strength, psi
1.0	3/8	0.0007	13	22	13
1.6	1/4	0.0007	43	42	21
1.6	3/8	0.0010	43	42	21
2.0	3/16	0.0007	62	56	30
2.3	1/4	0.0010	82	70	37
2.3	3/8	0.0015	82	70	37
2.6	5/32	0.0007	105	84	46
3.0	3/8	0.0020	131	102	55
3.1	1/8	0.0007	141	109	59
3.1	3/16	0.0010	141	109	59
3.4	1/4	0.0015	164	126	68
3.7	3/8	0.0025	190	144	78
3.8	5/32	0.0010	197	151	81
4.2	3/8	0.0030	236	179	98
4.3	1/4	0.0020	243	186	101
4.4	3/16	0.0015	253	196	104
4.5	1/8	0.0010	262	200	109
5.2	1/4	0.0025	335	252	130
5.3	5/32	0.0015	341	259	140
5.4	3/8	0.0040	367	266	148
5.7	3/16	0.0020	394	287	159
6.0	1/4	0.0030	433	312	172
6.1	1/8	0.0015	446	319	177
6.5	3/8	0.0050	499	350	195
6.9	5/32	0.0020	525	378	213
6.9	3/16	0.0025	525	378	213
7.6	3/8	0.0060	656	431	241
7.9	1/4	0.0040	689	455	254
8.1	1/8	0.0020	722	469	260
8.1	3/16	0.0030	722	469	260
8.4	5/32	0.0025	774	483	273

TABLE VI. Mechanical properties of 5052 aluminum honeycomb core at 350 ± 10°F. 1/ - Continued

Nominal core density, PCF	Cell size, inch	Foil thickness, inch	Stabilized flatwise compressive strength, psi	Plate shear	
				Longitudinal (L) shear strength, psi	Transverse (W) shear strength, psi
9.2	1/4	0.0050	872	546	296
10.0	1/8	0.0025	981	602	319
10.0	5/32	0.0030	981	602	319
10.5	1/4	0.0060	1060	785 2/	325 2/
10.6	3/16	0.0040	1063	790 2/	325 2/
12.0	1/8	0.0030	1263	875 2/	325 2/

1/ Values are for test purposes only. Data shall not be used for design allowances.

2/ Shear strength values determined by Beam Flexure Shear.

TABLE VII. Mechanical properties of 5056 aluminum honeycomb core at 350 ± 5°F. 1/

Nominal core density, PCF	Cell size, inch	Foil thickness, inch	Stabilized flatwise compressive strength, psi	Plate shear	
				Longitudinal (L) shear strength, psi	Transverse (W) shear strength, psi
1.0	3/8	0.0007	23	29	16
1.6	1/4	0.0007	49	51	25
1.6	3/8	0.0010	53	51	25
2.0	3/16	0.0007	72	68	33
2.3	1/4	0.0010	102	85	40
2.3	3/8	0.0015	102	89	40
2.6	5/32	0.0007	117	99	52
3.0	3/8	0.0020	168	124	65
3.1	1/8	0.0007	162	130	72
3.1	3/16	0.0010	175	130	72
3.4	1/4	0.0015	210	150	85
3.7	3/8	0.0025	235	169	98
3.8	5/32	0.0010	252	177	101
4.2	3/8	0.0030	287	205	117
4.3	1/4	0.0020	308	211	124
4.4	3/16	0.0015	322	221	129
4.5	1/8	0.0010	333	228	133
5.2	1/4	0.0025	420	276	159

TABLE VII. Mechanical properties of 5056 aluminum honeycomb core at 350 ± 5°F. 1/ - Continued

Nominal core density, PCF	Cell size, inch	Foil thickness, inch	Stabilized flatwise compressive strength, psi	Plate shear	
				Longitudinal (L) shear strength, psi	Transverse (W) shear strength, psi
5.3	5/32	0.0015	431	283	163
5.4	3/8	0.0040	441	293	169
5.7	3/16	0.0020	480	312	182
6.0	1/4	0.0030	518	333	195
6.1	1/8	0.0015	532	341	198
6.5	3/8	0.0050	636	369	218
6.9	5/32	0.0020	700	397	234
6.9	3/16	0.0025	700	397	234
7.6	3/8	0.0060	809	447	267
7.9	1/4	0.0040	886	468	280
8.1	1/8	0.0020	910	481	286
8.1	3.16	0.0030	910	481	286
8.4	5/32	0.0025	963	504	296
9.2	1/4	0.0050	1099	562	325
10.0	1/8	0.0025	1232	618	350
10.0	5/32	0.0030	1232	618	350
10.5	1/4	0.0060	1330	820 2/	350 2/
10.6	3/16	0.0040	1344	825 2/	350 2/
12.0	1/8	0.0030	1589	965 2/	350 2/

1/ Values are for test purposes only. Data shall not be used for design allowances.

2/ Shear strength values determined by Beam Flexure Shear.

TABLE VIII. Mechanical properties of 2024-T81 aluminum honeycomb core at room temperature. 1/

Nominal core density, PCF	Cell size, inch	Foil thickness, inch	Stabilized flatwise compressive strength, psi	Plate shear	
				Longitudinal (L) shear strength, psi	Transverse (W) shear strength, psi
2.8	1/4	0.0015	175	140	88
3.5	3/16	0.0015	290	230	143
5.0	1/8	0.0015	620	400	250
6.7	1/8	0.0020	980	600	375
8.0	1/8	0.0025	1320	770	470
9.5	1/8	0.0030	1725	950	585

1/ Values are for test purposes only. Data shall not be used for design allowances.

TABLE IX. Mechanical properties of 2024-T81 aluminum honeycomb core at 350 ± 10°F. 1/

Nominal core density, PCF	Cell size, inch	Foil thickness, inch	Stabilized flatwise compressive strength, psi	Plate shear	
				Longitudinal (L) shear strength, psi	Transverse (W) shear strength, psi
2.8	1/4	0.0015	140	105	60
3.5	3/16	0.0015	230	170	100
5.0	1/8	0.0015	495	300	175
6.7	1/8	0.0020	785	450	260
8.0	1/8	0.0025	1055	580	330
9.5	1/8	0.0030	1380	715	410

1/ Values are for test purposes only. Data shall not be used for design allowances.

TABLE X. Mechanical properties of 2024-T81 aluminum honeycomb at 430 ± 10°F. 1/

Nominal core density, PCF	Cell size, inch	Foil thickness, inch	Stabilized flatwise compressive strength, psi	Plate shear	
				Longitudinal (L) shear strength, psi	Transverse (W) shear strength, psi
2.8	1/4	0.0015	120	90	52
3.5	3/16	0.0015	200	150	85
5.0	1/8	0.0015	435	260	150
6.7	1/8	0.0020	685	390	225
8.0	1/8	0.0025	925	500	280
9.5	1/8	0.0030	1210	620	350

1/ Values are for test purposes only. Data shall not be used for design allowances.

TABLE XI. Delamination strength of 5052 and 5056 aluminum core material (Grade B) in pounds load (force).

Nominal core density, PCF	Test conditions		
	Room temperature (70 to 85°F)	After boiling water immersion	350 ± 10°F
	Strength, minimum	Strength, minimum	Strength, minimum
1.0 to 3.1,	30	10	10
3.4 to 7.9,	40	10	20
8.1 to 12.0	50	10	25

TABLE XII. Delamination strength of 2024 aluminum core material (Grade C) in pounds load (force).

Nominal core density, PCF	Cell size, inch	Foil thickness, inch	Test conditions		
			Room temperature (70 to 85°F)	After boiling water immersion	350 ± 10°F
			Strength, minimum	Strength, minimum	Strength, minimum
2.8	1/4	0.0015	30	25	10
3.5	3/16	0.0015	40	25	10
5.0	1/8	0.0015	55	30	15
6.7	1/8	0.0020	70	30	15
8.0	1/8	0.0025	75	30	15
9.5	1/8	0.0030	90	40	15

TABLE XIII. Color code identification for Grade B.

Color	FED-STD-595 Color No.	Aluminum Alloy	
		5052	5056
		Black 1/ 2/	Two black 1/ 3/
		Density range - PCF	
Brown	10076	Up to 1.9, inclusive	
Orange	12246 or 22246	2.0 to 2.9, inclusive	
Blue	15102 or 25102	3.0 to 3.9, inclusive	
Red	11105 or 21105	4.0 to 4.9, inclusive	
Yellow	13655 or 23655	5.0 to 5.9, inclusive	
Purple	17142 or 27142	6.0 to 6.9, inclusive	
Green	14187	7.0 to 8.9, inclusive	
Brown and green	10076 and 14187	9.0 to 10.9, ilnclusive	
Brown and purple	10076 and 17142 or 27142	Over 11.0	

1/ Black should match Color No. 17308 or 27308 of FED-STD-595.

2/ One black stripe along side of required density color code.

3/ Two black stripes, one on either side of required density color code.

TABLE XIV. Color code identification for Grade C.

Color	FED-STD-595 Color No.	Nominal density - PCF
Yellow	13655 or 23655	2.8
Red	11105 or 21105	3.5
Purple	17142 or 27142	5.2
Green	14187	6.7
Blue	15102 or 25102	8.1
Black	17308 or 27308	9.5

TABLE XV. Visual imperfections (maximum number in a square foot of material).

Imperfection types	Acceptance number of visual imperfections for cell size in inch				
	1/8	5/32	3/16	1/4	3/8
Mismatched nodes	90	70	50	30	13
Loose metal or flakes 1/	45	35	25	15	6
Unbonded nodes	2	2	2	2	2
Split cell walls	0	0	0	0	0
Buckled cell walls	0	0	0	0	0

1/ Flakes are excess metal attached to foil edges which do not interfere with core thickness measurement.

* TABLE XVI. Quality conformance testing.

Tests	Material grades	Number of specimens required	Reference paragraph	Conforming to paragraph
Core density	B and C	1 1/	4.7.1	3.4 and Table I
Cell size 3/	B and C	1	4.7.2	3.4 and Table I
Cell pitch 3/	B and C	1	4.7.3	3.4 and Table I
Foil thickness 3/	B and C	1	4.7.4	3.4.1 and Table II

* TABLE XVI. Quality conformance testing. - Continued

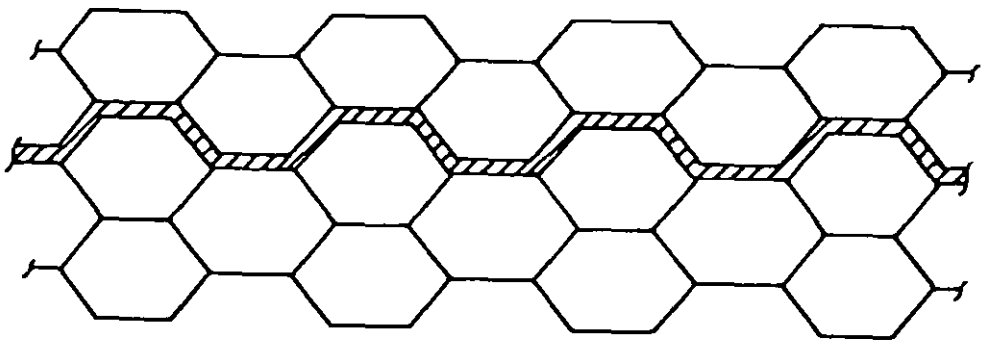
Tests	Material grades	Number of specimens required	Reference paragraph	Conforming to paragraph
Core flatwise compressive strength at room temperature	B and C	6 3/	4.7.5	3.5, Tables III, IV, V and VIII
Core flatwise compressive strength at elevated temperature, 350 ± 10°F	B	6 2/	4.7.6	3.5, Tables III, VI and VII
Core flatwise compressive strength at elevated temperature, 430 ± 10°F	C	6 2/	4.7.6	3.5, Tables III and X
Transverse (W) shear strength at elevated temperature, 350 ± 10°F	B	6 2/	4.7.8	3.5, Tables III VI and VII
Transverse (W) shear strength at elevated temperature, 430 ± 10°F	C	6 2/	4.7.8	3.5, Tables III and X
Delamination strength at room temperature	B and C	3	4.7.9.1	3.6 and Tables XI and XII
Delamination strength after boiling water immersion	B and C	3	4.7.9.2	3.6 and Tables XI and XII
Delamination strength at elevated temperature	B and C	3	4.7.9.3	3.6 and Tables XI and XII
Corrosion resistance 4/	B and C	5	4.7.10	3.7

1/ The same sample used for the core density may be used for specimens of the strength tests, cell size, cell pitch and foil thickness.

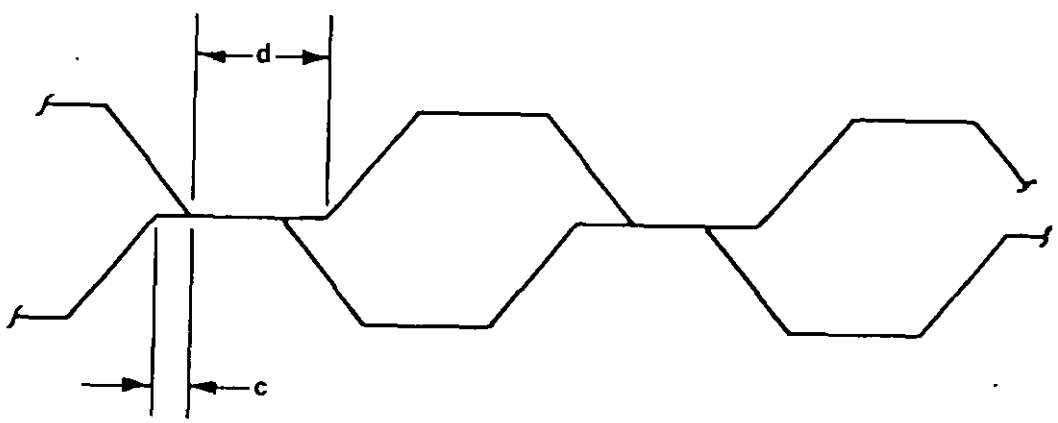
2/ The specimens selected for compressive and shear strength shall be divided into two equal parts; one part shall be available for the required quality conformance tests and the other part shall be retained for retests (see 4.8) if necessary.

3/ Shall be determined when specified.

4/ Selection in accordance with 4.6.1.3



DOUBLE FOILS



MISMATCHED NODES

Figure 1.

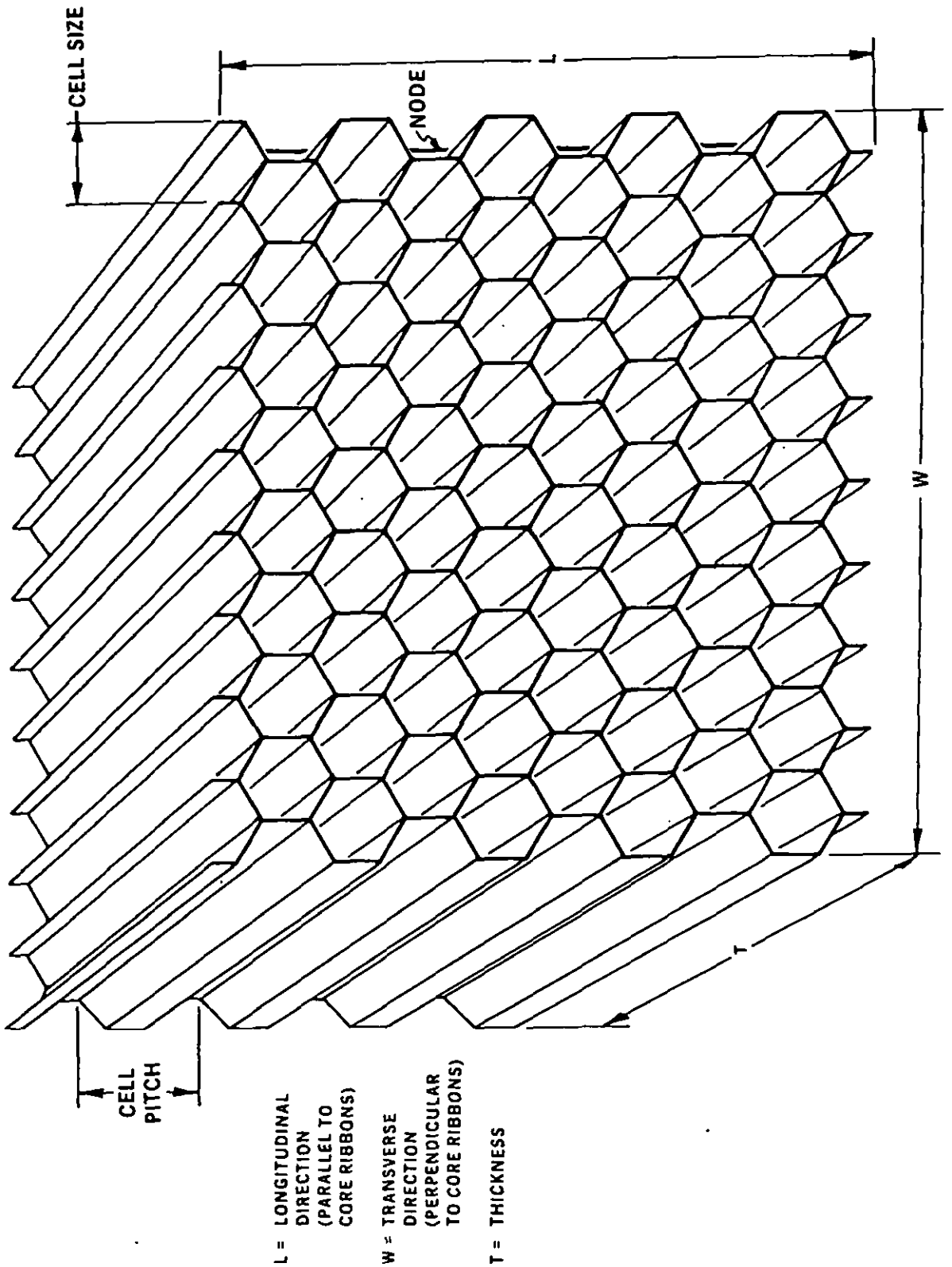
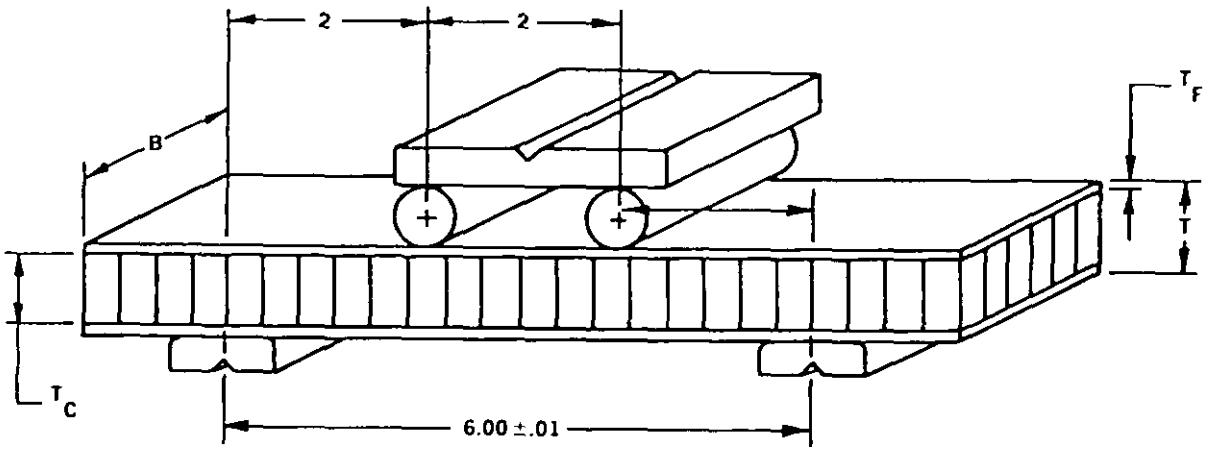


Figure 2.



B — SPECIMEN WIDTH (3 INCHES)
T — SPECIMEN THICKNESS
T_C — CORE THICKNESS
T_F — FACING THICKNESS

END SUPPORT PLATES ARE 1 BY 3 BY 1/4 INCHES WIDTH GROOVES FOR ALIGNMENT.
LOADED EDGES ARE ROUNDED TO 0.06 INCH RADIUS.
LOAD BARS ARE 1/2 INCH ROUND.
DIMENSIONS IN INCHES.
TOLERANCES: AS INDICATED.

Figure 3.

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STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER	2. DOCUMENT TITLE
MIL-C-7438G	Core Material, Aluminum, For Sandwich Construction

3a. NAME OF SUBMITTING ORGANIZATION	4. TYPE OF ORGANIZATION *(Mark one)*
	☐ VENDOR
b. ADDRESS *(Street, City, State, ZIP Code)*	☐ USER
	☐ MANUFACTURER
	☐ OTHER *(Specify)*:

5. PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

6. REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional	b. WORK TELEPHONE NUMBER *(Include Area Code)* – Optional
c. MAILING ADDRESS *(Street, City, State, ZIP Code)* – Optional	8. DATE OF SUBMISSION *(YYMMDD)*

DD FORM 82 MAR 1426

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