

INCH-POUND

MIL-DTL-5578D

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SUPERSEDING

MIL-T-5578C

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DETAIL SPECIFICATION

TANKS, FUEL, AIRCRAFT, SELF-SEALING

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

1. SCOPE

1.1 Scope. This specification covers self-sealing and partially self-sealing fuel tanks for use on aircraft. A tank consists of a cell or group of cells interconnected and the components attached directly thereto, to form a complete tank or reservoir.

1.2 Classification. The tanks are of the following general types, classes, styles and protection levels to be furnished as specified by the procuring activity (see 6.2):

Type I - For use with engine fuel conforming to ASTM-D910 (intended for use with reciprocating engines).

Type II - For use with engine fuel conforming to ASTM-D910, MIL-DTL-5624 or MIL-DTL-83133 (intended for use with jet engines).

Class A - Flexible cell construction.

Class B - Semi-rigid or self-supporting cell construction.

Style 1 - Non-pressurized fuel system.

Style 2 - Pressurized fuel system.

Comments, suggestions, or questions on this document should be addressed to: Commander, Naval Air Warfare Center Aircraft Division, Code 4L8000B120-3, Highway 547, Lakehurst, NJ 08733-5100 or emailed to michael.sikora@navy.mil . Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at http://assist.daps.dla.mil/ .

MIL-DTL-5578D

Protection level (A) - Cell is completely self-sealing against .50 caliber (cal) and 20 millimeter (mm) ordnance.

Protection level (B) - Cell is completely self-sealing against 14.5 mm armor piercing (AP) and 23 mm AP.

Protection level (C) - Part of cell is bladder construction and part is self-sealing against .50 cal and 20 mm ordnance.

Protection level (D) - Part of cell is bladder construction and part is self-sealing against 14.5 mm AP and 23 mm AP.

For cells of protection levels (C) and (D), the portions of the cells to be self-sealing and non-self-sealing are as specified by the procuring activity.

2. APPLICABLE DOCUMENTS

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

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications and standards 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.

FEDERAL STANDARDS

FED-STD-191	- Textile Test Methods
FED-STD-601	- Rubber, Sampling and Testing
FED-STD-791	- Lubricants, Liquid Fuels, and Related Products, Methods of Testing

MIL-DTL-5578D

DEPARTMENT OF DEFENSE SPECIFICATIONS

- | | |
|---------------|--|
| MIL-F-5577 | - Fitting, Tank, Powerplant Fluid, Removable, General Specification for. (Inactive for New Design) |
| MIL-DTL-5624 | - Turbine Fuel, Aviation, Grades JP-4 and JP-5 |
| MIL-DTL-6396 | - Tanks, Aircraft Propulsion Fluid System, Internal, Removable, Non-Self-Sealing |
| MIL-DTL-83133 | - Turbine Fuels, Aviation, Kerosene Types, NATO F-34 (JP-8), NATO F-35 and JP-8 + 100 |
| MIL-DTL-85470 | - Inhibitor, Icing, Fuel System, High Flash NATO Code S-1745 |

DEPARTMENT OF DEFENSE STANDARDS

- | | |
|-------------|---|
| MIL-STD-129 | - Military Marking for Shipment and Storage |
| MIL-STD-801 | - Inspection and Acceptance Standards for Fuel Cells and Fittings |

(Copies of these documents are available online at <http://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.

AEROSPACE INDUSTRIES ASSOCIATION

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|-----------|--|
| NASM20470 | - Rivet, Solid, Universal Head, Aluminum Alloy and Titanium Columbium Alloy. (DoD adopted) |
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(Application for copies should be addressed to the Aerospace Industries Association, 1000 Wilson Boulevard, Suite 1700, Arlington, VA 22209-3901 or <http://aia-aerospace.org/pubs.>)

MIL-DTL-5578D

ASTM INTERNATIONAL

ASTM-D381	- Fuels by Jet Evaporation, Gum Content In. (DoD adopted)
ASTM-D412	- Rubber, Vulcanized and Thermoplastic Elastomers - Tension. (DoD adopted)
ASTM-D413	- Rubber Property - Adhesion to Flexible Substrate. (DoD adopted)
ASTM-D471	- Rubber Property - Effect of Liquids. (DoD adopted)
ASTM-D910	- Gasolines, Aviation. (DoD adopted)

(Application for copies should be addressed to ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19248-2959 or <http://www.astm.org>.)

SAE INTERNATIONAL

SAE-AS8879	- Screw Threads - UNJ Profile, Inch Controlled Radius Root with Increased Minor Diameter. (DoD adopted)
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(Application for copies should be addressed to SAE International, 400 Commonwealth Drive, Warrendale, PA 15096 or <http://www.sae.org>.)

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

3. REQUIREMENTS

3.1 Non-self-sealing tanks. All fuel tanks qualified to this specification shall meet the requirements of MIL-DTL-6396, Type II or Type III.

3.2 First article. When specified (see 6.2), a sample shall be subjected to first article inspection in accordance with 4.2.

MIL-DTL-5578D

3.3 Materials. The materials used in the manufacture of self-sealing fuel cells shall conform to applicable Government specifications. The use of magnesium is prohibited.

3.4 Design. The self-sealing fuel cells shall be designed for use with fuels conforming to ASTM-D910, MIL-DTL-5624, MIL-DTL-83133, or all three and shall be designed in conjunction with the containing structure to avoid concentration of loads on splices, seams, fittings, or locations of concentrated flexure. The assembly consisting of the cell(s) and aircraft structure on which it is mounted shall be strong enough to handle the stresses caused by the following:

- a. Flexing resulting from vibration
- b. Impact loads incident to takeoff, taxiing, and landing (including catapulting and arresting)
- c. Hydraulic surge of fuel incident to all dynamic conditions of flight
- d. Hydraulic surge of fuel incident to gunfire
- e. Pressure from hydrostatic head of fuel during level flight or maneuvers
- f. Pressure from neutral gases, if any, used to pressurize fuel cells

3.4.1 Dimensions. The dimensions and dimensional tolerances shall be developed by the contractor or Government procuring activity. The dimensional tolerance specified shall be such that the capacity of the production tanks is within 1.5 percent of the designed total capacity.

3.4.2 Capacity. The head-versus-volume curve on production tanks shall conform within 1.5 percent to the average head-versus-volume curve prepared in accordance with 4.3.2.1.

3.5 Construction. The following requirements apply to fuel cell construction intended for protection levels (A) and (B) and for the self-sealing portions of fuel cell construction intended for protection levels (C) and (D) (see 4.2.1.1). The non-self-sealing portions of construction shall conform to MIL-DTL-6396, Type II, Class B.

3.5.1 Inner-layer ply. The construction shall be such that it will be impossible to transmit fuel to the sealant. If necessary to meet this requirement, a special barrier shall be utilized. The inner-layer ply shall be free of foreign matter, and the thickness shall agree with the approved construction within the established manufacturing tolerances as described in the manufacturer's specifications.

MIL-DTL-5578D

3.5.2 Fabric ply. Fuel cells shall be so fabricated that the seam on any fabric ply shall not be superimposed with parallel seams of any adjacent fabric ply.

3.5.3 Sealant. The fuel cells shall use an approved sealant processed to meet the requirements of this specification. The sealant shall be free of foreign matter, and the thickness shall agree with the approved construction within the established manufacturing tolerance as described in the manufacturer's specifications.

3.5.4 Fittings. All fittings used in self-sealing fuel cells shall conform to MIL-F-5577. All flanges of the fitting shall be bonded to the cell. Every effort shall be made to utilize fittings in a single plane. Where the aircraft design necessitates the use of double plane fittings, particular care shall be taken to provide adequate exterior flange area to ensure satisfactory adhesive strength under all conditions of operation. The use of through bolts is prohibited.

3.5.4.1 Screw threads. Screw threads shall be in accordance with SAE-AS8879. The use of pipe threads is prohibited.

3.6 Performance. The cells and tanks or specified parts thereof shall meet the requirements specified herein when subjected to the following tests, as specified in Section 4:

- a. Inspection (4.5.1)
- b. Stand (4.5.2)
- c. Dissection (4.5.3)
- d. Inner-layer Ply (4.5.4)
- e. Test cubes (cells) (4.5.5)
- f. Installation (4.5.6)
- g. Capacity (4.5.7)
- h. Pressure (4.5.8)
- i. Slosh or Slosh and Vibration Resistance (4.5.9)
- j. Dissection after slosh (4.5.13)
- k. Accelerated Load Resistance (4.5.14)
- l. Gunfire resistance on tank installation (4.5.15)

3.6.1 Operating temperature. The self-sealing fuel cell shall operate throughout the temperature range of -40 to 160 °F (-40 to 71 °C) insofar as self-sealing performance is concerned. For all other operating conditions, the cell shall operate throughout the temperature range of -65 to 160 °F (-54 to 71 °C) or as directed by the procuring activity.

3.7 Weight. The weight of production cells shall be within 5 percent of the average weight of the first 10 production cells.

3.8 Finish. Finishes shall meet the requirements of MIL-DTL-6396, Type II or Type III.

MIL-DTL-5578D

3.9 Age. Cells shall be not greater than 2 years old from date of initial cure to delivery to the procuring activity.

3.10 Marking. Each assembly part shall be marked with a part number that is the same as the drawing number of that part or assembly. (An assembly consists of parts that are permanently fastened together.) Exceptions to this marking requirement are those parts that do not have enough surface area for a part number.

3.11 Identification of product. Equipment assemblies and parts shall be marked as follows:

- a. Reorder by part number (insert current aircraft contractor part number)
- b. Federal stock number
- c. Aircraft model(s) and cell location
- d. Cure date (month and year)
- e. Construction numbers
- f. Cell manufacturer and CAGE code
- g. Cell manufacturer part number
- h. Weight, empty (actual)
- i. MIL-DTL-5578D, Type, Class, Style, Protection Level (if applicable)
- j. Contract or order number

The nameplate shall be located on the cell in such a position that when the tank is installed in the aircraft, the nameplate shall be readily accessible and visible after removal of aircraft access panels, deck doors, etc.

3.12 Marking of shipments. Each shipping container shall be marked to indicate presence of preservation and method of packing. The container shall be marked in accordance with MIL-STD-129. The following additional information shall be applied to the container:

TANK, FUEL, AIRCRAFT, SELF-SEALING
 TYPE -, CLASS-, STYLE -
 PROTECTION LEVEL -,
 Model of aircraft for which cell is intended and location in the aircraft.
 Construction number of the cell.

4. VERIFICATION

4.1 Classification of inspections. The inspection and testing of fuel tanks shall be classified as follows:

- a. First article inspection (see 4.2).
- b. Conformance inspection (see 4.3).

MIL-DTL-5578D

4.2 First article. First article inspection shall consist of phase I and phase II tests. (See 4.2.1.2 and 4.2.2.2.) For previously approved fuel cells, conformance inspections of 4.3.1 shall apply.

4.2.1 Phase I testing. Phase I tests shall consist of the tests (see 4.2.1.2) performed on materials and construction samples (see 4.2.1.1) used in the manufacture of self-sealing or dual construction fuel cells.

4.2.1.1 Phase I test samples. All phase I test samples shall meet the requirements for phase I testing as specified in MIL-DTL-6396 and the following:

a. Class A (flexible construction)

1. Protection levels (A) and (B)

- (a) A sufficient number of test cubes to fit the metal structure shown in figure 1 with panels representative of the host cavity as specified by the procuring activity. The test cube configuration and fitting(s) shall be as specified by the procuring activity.
- (b) Eight side panels as specified by the procuring activity
- (c) Eight sheets of backing material 27 by 30 inches and two sheets of backing material 30 by 30 inches.
- (d) Two 12 by 12-inch samples of composite cell construction.
- (e) One sample 6 by 6 by 0.075 to 0.125-inch inner-layer ply without barrier.

b. Class B (semi-rigid or self-supporting construction)

1. Protection levels (A) and (B)

- (a) A sufficient number of test cubes to fit the metal container shown in figure 1 or as defined by the procuring activity. The test cube configuration and fitting(s) shall be as specified by the procuring activity.
- (b) Two 12 by 12-inch samples of composite cell construction.

c. Class A or B

1. Protection levels (C) or (D)

MIL-DTL-5578D

- (a) A sufficient number of test cubes to fit the metal structure shown on figure 1 with panels representative of the host cavity as specified by the procuring activity. The test cubes configuration and fitting(s) shall be as specified by the procuring activity.
- (b) Eight side panels as specified by the procuring activity.
- (c) Eight sheets of backing material 27 by 30 inches and two sheets of backing material 30 by 30 inches.
- (d) Two 12 by 12-inch samples of composite cell construction.
- (e) One sample of inner-layer ply, without barrier, approximately 900 square inches in area with seam (self-sealing portion only).
- (f) One sample of inner-layer ply, with barrier, approximately 900 square inches in area without seam (self-sealing portion only).
- (g) One sample 6 by 6 by 0.075 to 0.125 inch inner-layer ply without barrier.

None of these samples shall be pre-plasticised with fluid prior to submission. Any variations in the basic construction shall be approved by the procuring activity and shall be identified by a suitable dash numbering system.

4.2.1.2 Phase I tests. Phase I first article tests shall consist of the following described under 4.5:

- a. Inspection ----- 4.5.1
- b. Inner-layer ply ----- 4.5.4
- c. Test cubes ----- 4.5.5

4.2.2 Phase II first article testing. Phase II testing shall consist of those tests performed on complete full-scale fuel tanks submitted for approval as satisfactory tanks for a particular aircraft installation.

4.2.2.1 Phase II test samples. Phase II test samples shall consist of one or more complete full-scale fuel tanks and the supporting structure or jig, or both, equipped with all applicable fuel cell components. The tank or tanks shall be of the same materials and construction as used in the cell submitted for phase I tests, and shall be designed to fit in a particular location of a specific aircraft. Exceptions to the above shall comprise those cells which, because of the particular aircraft design, require the use of graduated wall thickness and weight, and any other exceptions specifically authorized by the procuring activity.

MIL-DTL-5578D

4.2.2.2 Phase II tests. Phase II first article tests shall consist of the following tests described under 4.5 and shall be conducted in the order listed:

- a. Inspection -----4.5.1
- b. Installation -----4.5.6
- c. Capacity -----4.5.7
- d. Pressure -----4.5.8
- e. Slosh or slosh and vibration resistance -4.5.9
- f. Dissection -----4.5.13
- g. Accelerated load resistance -----4.5.14
- h. Gunfire resistance on tank installation --4.5.15

4.3 Conformance inspections. Conformance inspections shall consist of:

- a. Individual tests -----4.3.1
- b. Sampling plans and tests --4.3.2

4.3.1 Individual tests. Each fuel cell shall be subjected to the following tests as described under 4.5.1:

- a. Examination -----4.5.1.1
- b. Workmanship -----4.5.1.2
- c. Dimensions -----4.5.1.3
- d. Weight -----4.5.1.4

4.3.2 Sampling plans and tests.

4.3.2.1 Capacity check samples. Each of the first 10 production cells shall be checked for capacity in accordance with 4.5.7. An average head-versus-volume curve shall be constructed from these tests.

4.3.2.2 Stand test samples. Cells selected at random from part numbers specified by the contractor and the procuring activity, in accordance with the following schedule, or as specified by the procuring activity, shall be subjected to the stand test described in 4.5.2. In the event that more than one part number is selected for sampling, the tests shall be conducted on an alternating basis.

<u>Number of samples</u>	<u>Number of units produced</u>
1	1-50
1	1 every 90 days or 1 out of each additional 500 cells, whichever occurs first

MIL-DTL-5578D

The samples specified above shall be selected from all cells produced at a particular plant for a specific aircraft and approved under the same first article test and identified with the manufacturer's same construction number. The random samples selected shall be representative of cells submitted by the manufacturer for acceptance with respect to quality of workmanship and the number and type of repairs.

4.3.2.3 Dissection test samples. The procuring activity shall specify whether the dissection test is to be a periodic sampling test or a contingency option.

4.3.2.3.1 Dissection test (sampling plan). The dissection test shall be designated by the procuring activity as a mandatory sampling test for cells incorporating newly developed materials or manufacturing processes. For this test, cells selected at random and at a frequency specified by the procuring activity shall be dissected in accordance with figure 1 and subjected to the dissection test of 4.5.3.

4.3.2.3.2 Dissection test (contingency option). During cell acquisitions in which the dissection test is not required as part of a periodic sampling plan, the procuring activity may invoke a dissection test as a contingency option. In the event that other acceptance tests, service use, disclosure of chronic deficiencies in materials or manufacturing processes (see 4.3.2.4), or when questions regarding the acceptability of cells cannot be resolved by non-destructive tests, a contingency option may be invoked. Cells selected by the procuring activity shall be dissected as shown on figure 1 and tested as required in 4.5.3.

4.3.2.4 Inspection standards. When one item selected from production fails to meet this specification, action shall be taken in accordance with MIL-STD-801.

4.4 Test conditions. In addition to the test conditions set forth in specific tests, the conditions specified herein shall apply.

4.4.1 Test fluids. Fluids used in the design verification process shall include, but not be limited to test fluids described in ASTM-D471 (Ref Fuel A and B), JP-5 and JP-8 aviation fuel, or other test fluid as specified by the procuring activity.

4.4.2 Temperature tolerances. Unless otherwise specified, the following temperature tolerances shall be maintained:

Above 100 °F (38 °C)----- ±10 °F (±6 °C)
Below 100 °F (38 °C)----- ±5 °F (±3 °C)

4.4.3 Tank mounting structure. The mounting structure shall be either the applicable portion of the actual aircraft structure or a simulated structure. If a simulated structure is used, it shall duplicate the shape and dimensions of the tank supporting structure in the aircraft. The preferred

MIL-DTL-5578D

test method is an aircraft structure, however, the procuring activity can allow the use of a simulated structure.

4.4.4 Tank support jig. The jig shall support the tank mounting structure as specified in 4.4.3 to simulate actual aircraft installation. The support jig shall be strong enough to mount the sample tank and designed for bolting to the vibrator and rocker assembly. The jig framework shall be rigid to prevent additional stresses on the mounted tank due to flexure of the jig framework.

4.5 Test methods.

4.5.1 Inspection.

4.5.1.1 Examination. Each fuel cell shall be examined to determine conformance with all the requirements of this specification for which no specific tests are described and to determine conformance with the manufacturer's material and fabrication specifications.

4.5.1.2 Workmanship. The fuel cells shall be inspected to determine conformance to the requirements listed in MIL-STD-801 and as specified by the procuring activity.

4.5.1.3 Dimensions. A check shall be made on each cell to ensure that all dimensions critical to the installation are within the dimensional tolerances established by the contractor or procuring activity. The tolerances specified for this test shall not conflict with the capacity requirements specified in 3.4.2.

4.5.1.4 Weight. Each cell shall be weighed to determine compliance with the tolerance on weight (see 3.7).

4.5.2 Stand. Class A cells only shall be collapsed and held strapped for 30 minutes in a position comparable to that encountered prior to installation in its respective aircraft cavity, then released, and adequately supported. Both class A and class B cells shall be filled with fluid as specified by the procuring activity. During the filling process, the capacity test (see 4.5.7) shall be conducted to determine conformance with 3.4.2. Test temperature shall be above 65 °F (18 °C). Cells shall then be tested in accordance with the following time cycle:

- a. First cell selected ----- 10 days
- b. Second cell----- 10 days
- c. Third cell----- 10 days

This time cycle shall be repeated for additional cells chosen in accordance with 4.3.2.2 for the duration of the contract. Upon completion of the test and at the intermediate inspections, the cells shall be carefully examined for any evidence of failure. After the examination, if any

MIL-DTL-5578D

evidence of failure is indicated, the cell shall be dissected by removal of the failed area and inspected for cause of failure. The cell shall be dispositioned as directed by the procuring activity. In the event of failure of this test, the procuring activity and the contractor shall be notified. MIL-STD-801 shall apply.

4.5.3 Dissection. The sectioned portion of each cell selected in 4.3.2.3 shall be examined for conditions specified in MIL-STD-801. In the event of failure, the procuring activity and contractor shall be notified immediately.

4.5.4 Inner-layer ply. Samples of the inner-layer ply of constructions intended for protection levels (A) and (B) and of the self-sealing portions of constructions intended for protection levels (C) and (D) shall be subjected to the following tests:

4.5.4.1 Fuel contamination.

4.5.4.1.1 Non-volatile gum residue. A 5-gram sample of the inner layers, up to the barrier, shall be cut up into approximately 0.062 inch squares and placed in a flask containing 250 milliliter (ml) of test fluid conforming to ASTM-D471 Ref Fuel B, and allowed to stand for 48 hours at 77 ± 5 °F (25 ± 3 °C). The contaminated test fluid shall be decanted off and the non-volatile gum residue determined by FED-STD-791, Method 3302, and ASTM-D381 except that the total evaporation time shall be 45 minutes. The non-volatile material shall be not greater than 60 milligrams (mg) per 100 ml of the contaminated fluid.

4.5.4.1.2 Stoved gum residue. The beakers containing the non-volatile material shall be placed in an appropriate bath maintained constantly at a temperature of 572 ± 9 °F (300 ± 5 °C) for 30 minutes. After cooling in a closed container, the beakers shall be weighed. The stoved gum residue shall be not greater than 20 mg per 100 ml of the contaminated fluid, after necessary corrections have been made for preformed gums originally present in the test fluid.

4.5.4.2 Inner liner strength.

4.5.4.2.1 Gum inner liner strength. The tensile strength of the gum inner layer ply, without barrier, shall be determined in accordance with ASTM-D412, before and after immersion in ASTM-D471 Ref Fuel B test fluid for 72 hours at a temperature of 135 ± 3 °F (57 ± 2 °C). The tensile strength shall also be determined before and after immersion in a solution of 25 percent MIL-DTL-85470 inhibitor and 75 percent water, by volume, for 72 hours at a temperature of 135 ± 2 °F (57 ± 2 °C). The tensile strength reduction shall be reported to the procuring activity. The strength shall be reduced no greater than 50 percent for fuel immersion and 20 percent for water immersion calculated on the basis of the original cross-sectional area.

4.5.4.2.2 Fabric inner liner strength. The tensile strength of the fabric inner layer ply, without barrier, shall be determined in accordance with FED-STD-191, Method 5100 before and

MIL-DTL-5578D

after immersion in ASTM-D471 Ref Fuel B test fluid for 72 hours at a temperature of 135 ± 3 °F (57 ± 2 °C). Also, the tensile strength shall be determined before and after immersion in a solution of 25 percent MIL-DTL-85470 inhibitor and 75 percent water, by volume, for 72 hours at a temperature of 135 ± 3 °F (57 ± 2 °C). The tensile strength reduction shall be reported to the procuring activity. The tensile strength shall be not less than 20 percent for fuel immersion and 50 percent for water immersion calculated on the basis of the original cross-sectional area.

4.5.4.3 Permeability.

4.5.4.3.1 Test apparatus. The test apparatus shall consist of:

- a. A permeability cup and ring constructed as shown on figure 2.
- b. A nylon solution to be used for sealing the test disk to the permeability cup.

4.5.4.3.2 Preparation of test specimen. The test samples shall be prepared utilizing a manufacturing method similar to production and shall be given a cure equivalent to that used in production. Two test samples consisting of the inner liner and fuel barrier (if required) or the total construction shall be used. The samples shall be conditioned 24 hours at 77 ± 5 °F (25 ± 3 °C) and a relative humidity of 50-65 percent prior to test. A nylon solution or other suitable sealing liquid may be applied to the face of the cup flange and sample edge. The inside or inner liner surface shall be exposed to the fuel.

4.5.4.3.3 Method of conducting test. Permeability cups prepared as specified in 4.5.4.3.2 shall be placed in a rack at a constant temperature of 77 ± 5 °F (25 ± 3 °C) and relative humidity of 50-65 percent. After allowing 1 hour for equilibrium, the cup shall be weighed to the nearest 0.005 gram and placed in the rack with the face of the cup facing upward. The cup shall be kept at the above constant temperature for 24 hours, then weighed to check for seal integrity. If necessary, the bolts shall be retorqued at this weighing and at subsequent weighings. The cup shall be inverted (test disk down) in a rack that permits free access of air to test disk. Cups shall be weighed at the end of the third, fifth, and eighth day after inverting. Defective films or leaks caused by faulty assembly will usually be found when making the weighing on the third day. The diffusion rate calculation shall be made on the fifth- to the eighth-day period and expressed as fluid ounces per square foot per 24 hours. The permeability shall be less than 0.025 fluid ounce per square foot per 24 hours for each sample tested.

NOTE: Diffusion expressed in fluid ounces per square foot per 24 hours equals the gram loss of the test specimen per 24 hours multiplied by a factor K which is defined as:

MIL-DTL-5578D

$$K = \frac{144}{(\text{sp.gr.})(29.573)(3.142)R^2}$$

Where sp.gr. = Specific gravity of test fluid at 77 °F (25 °C).

R = Inside radius of test cup expressed in inches.

Alternate test methods may be used if approved by the procuring activity. A test apparatus utilizing a grooved mounting flange with mating head in the retainer ring has been found to yield more consistent results for some materials.

4.5.4.4 Seam adhesion (immersion). The seam adhesion of the inner layer ply to itself before and after immersion in ASTM-D471 Ref Fuel B test fluid for 72 hours at a temperature of 135 ± 3 °F (57 ± 2 °C) shall be tested within 4 hours along the length of the seam by the strip-back method, using a jaw separation rate of 2 inches per minute in accordance with ASTM-D413. Where the adhesion of the seam is less than the strength of the material, the adhesion shall be a minimum of 6 pounds per inch.

4.5.4.4.1 Seam adhesion. Seam adhesion of the inner layer ply to itself shall be tested by cutting a strip of inner layer material 1-inch wide. This seam shall be perpendicular to and midway in the length of the strip. When a tensile load has been applied parallel to the length of the strip to break the strip, there shall be no failure of the seam.

4.5.4.5 Slit resistance. A section of the composite cell construction sample shall be selected. A slit of the inner-layer ply, 1 inch long to the depth of the sealant, shall be cut parallel to the calender grain, if present, or to the direction of minimum tear resistance. The test section shall be 5 inches long with width sufficient to clamp in a vise, with the jaws of vise 1 inch from the slit when the test section is bent 180 degrees. The slit shall be parallel to vise jaws and on the outside of the bend. The sample shall be held in this folded condition for 1 hour and the increase in length of the slit noted. The slit shall not increase more than 0.25 inch.

4.5.4.6 Inner-liner adhesion. The adhesion of the inner-layer ply to the sealant shall be tested by the strip back method, using a jaw separation rate of 2 inches per minute in accordance with FED-STD-601, Method 8011. The adhesion shall be a minimum of 6 pounds per inch.

4.5.5 Test cubes. The sample phase I test cubes shall be subjected to the tests described in the following paragraphs.

4.5.5.1 Fuel resistance of exterior surfaces. The test cubes shall be placed in a container large enough to permit immersion of the self-sealing portion of the test cube in JP-5 or JP-8 or other test fluid as specified by the procuring activity. The cells shall be immersed for 60 days or as directed by the procuring activity. Test temperature shall be above 65 °F (18 °C). The test cubes shall then be removed and examined for swelling, separation, blisters, pinhole material

MIL-DTL-5578D

loss, or other evidence of deterioration. The exterior surface of the cell construction shall show no unsatisfactory swelling, separation, blistering, material loss, or other deterioration.

4.5.5.2 Slosh resistance. The phase I test cube shall be tested for slosh resistance by mounting on a rocker assembly and rocking the test cube through an angle of 15 degrees on each side of the level position (total 30 degrees) at a rate of 18 ± 2 cycles per minute for a period of 25 hours with the test cube two-thirds full of JP-5 or JP-8 or other test fluid as specified by the procuring activity. Test cubes that are non-self-supporting shall be installed in a test structure as shown on figure 3. The fluid shall be maintained at a temperature of 110 °F (43 °C) throughout the test. The time for the temperature rise to 110 °F (43 °C) from the ambient temperature shall be not greater than 2 hours. There shall be no evidence of leakage or failure of any kind during or as a result of this test.

4.5.5.3 Gunfire resistance on phase I test cubes.

4.5.5.3.1 Test setup. Class A test cubes shall be installed in the support structure as directed by the procuring activity. Class B test cubes shall be tested without auxiliary support. The temperature shall be measured by a thermometer or thermocouple immersed in the fluid. The test cubes shall be mounted not greater than 75 feet from the gun. All rounds shall be fired at service velocity. All entrance rounds shall be fired into the cube space occupied by the fluid. A non-metallic yaw plate may be used for tumbled entrances.

4.5.5.3.2 Firing schedule. The firing schedule as shown on table I shall be conducted at ambient temperature on test cube No. 1.

4.5.5.3.2.1 Normal temperature gunfire. The test cube shall be filled three-quarters full of JP-5 or JP-8 or other test fluid as specified by the procuring activity. The temperature of the fluid at the time of the test shall be 50 to 120 °F (10 to 49 °C).

4.5.5.3.3 Evaluation. Following gunfire tests, fuel cells shall be examined to ensure the wound dry or damp seals within 2 minutes at ambient temperature.

MIL-DTL-5578D

TABLE I. Phase II firing schedule.

Round Number	Protection Level			
	A	B	C <u>1/</u>	D <u>1/</u>
1	One .50 caliber 90° to cell straight in	One 14.5mm 90° to cell straight in	One .50 caliber 90° to cell straight in	One 14.5mm 90° to cell straight in
2	One .50 caliber 90° to cell ¾ to full tumble	One 14.5mm 90° to cell ¾ to full tumble	One .50 caliber 90° to cell ¾ to full tumble	One 14.5mm 90° to cell ¾ to full tumble
3	One .50 caliber 90° to cell ¾ to full tumble	One 14.5mm 90° to cell ¾ to full tumble	One .50 caliber 90° to cell ¾ to full tumble	One 14.5mm 90° to cell ¾ to full tumble
4	One .50 caliber 45° to cell straight in	One 14.5mm 45° to cell straight in	One .50 caliber 45° to cell straight in	One 14.5mm 45° to cell straight in
5	One 20mm 90° to cell straight in	One 23mm 90° to cell straight in	One 20mm 90° to cell straight in	One 23mm 90° to cell straight in
6	N/A	N/A	One 20mm 90° to cell straight in within 3 inches of transition seam in non-self-seal portion	One 23mm 90° to cell straight in within 3 inches of transition seam in non-self-seal portion

1/ All rounds except round 6 shall be fired into the self-seal portion of the fuel cell. Non-self-seal gunfire shall be as specified in MIL-DTL-6396.

4.5.5.3.3.1 Non-evaluation. Shots striking as noted below shall not be considered in evaluating the tank.

- a. Slicing shots wherein a projectile slices parallel to the cell wall instead of piercing
- b. Striking of cell fittings by the projectile
- c. Shots where the wounds overlap or run together
- d. Shots that strike within 3 inches of corners
- e. Shots where the projectile remains embedded in the construction

MIL-DTL-5578D

- f. Shots where metallic fingers or composite fragments project into wounds, and in a mechanical manner, prevent the sealant from functioning
- g. Shots where coring is present.

4.5.5.4 Fuel aging following gunfire resistance. After the gunfire resistance test of 4.5.5.3, the test cube shall be emptied and inspected, and any wounds which failed to seal (but did not disqualify the test cube) shall be plugged. The test cube shall be refilled with JP-5 or JP-8 or other test fluid as specified by the procuring activity. After 24 hours test cube 1 shall be emptied, and the wounds shall be carefully examined. There shall be no evidence of deterioration of the inner-layer ply or sealant.

4.5.5.5 Stand. For this test, a tank mounting structure in accordance with 4.4.3 shall be used. The stand test (see 4.5.2) shall be conducted on the third test cube which shall be the same cell subjected to the slosh resistance test (see 4.5.5.2). The test cube shall be adequately supported, completely filled with JP-5 or JP-8 or other test fluid as specified by the procuring activity and allowed to stand. The cell shall be carefully examined every 30 days for any evidence of failure. If no evidence of failure is found after 90 days, the test cube shall have passed this test.

4.5.6 Installation. For this test the aircraft or a section thereof shall be used. The installation test shall be conducted prior to the pressure test described in 4.5.8. The installation test shall consist of removing and installing the tank in the test structure three times. Applicable service procedure shall be followed in tank installation and removal. All tank fittings shall be fastened to corresponding structure fittings and interconnect fittings at each installation. The tank shall pass in accordance with MIL-STD-801 at the completion of this test.

4.5.7 Capacity. The cell, installed in a structure approved by the procuring activity, shall be slowly filled to capacity with fluid. The volume in gallons and the head in inches shall be recorded at a sufficient number of points during the filling to construct a head-versus-volume curve.

4.5.8 Pressure. For this test, the tank shall be mounted in the slosh test structure. All openings in the tank shall be sealed during the pressure test. All parts necessary to effect a satisfactory seal at the openings shall be furnished by the aircraft contractor. Tanks shall be subjected to a pressure equivalent to the normal head measured at the bottom of the tank multiplied by a factor of 1.5. Pressures shall be measured by means of a manometer using JP-5 or JP-8 or other test fluid as specified by the procuring activity. Once temperature and pressure are stable, conduct the tests specified in 4.5.8.1 and 4.5.8.2. No loss in pressure shall occur during the 15 minute duration of this test.

4.5.8.1 Proof pressure. After all air has been bled from the tank and the necessary ports plugged, hydrostatic pressure equal to 1.33 times the maximum operating pressure shall be

MIL-DTL-5578D

applied to the sample tank and held for a minimum of 2 minutes. Any evidence of permanent set, distortion, or failure of any kind is cause for rejection. Water may be used for this test.

4.5.8.2 Burst pressure. All air shall be bled from the tank and the necessary ports plugged. Hydrostatic pressure shall then be applied to the tank. This pressure shall be at least 2.0 times the maximum operating pressure. Evidence of permanent set or distortion is permitted, but any evidence of rupture is cause for rejection. Water may be used for this test.

4.5.9 Slosh or slosh and vibration resistance. Slosh and vibration tests shall be conducted as follows:

4.5.9.1 Vibrator and rocker assembly. These tests shall be conducted on a simultaneous vibrator and rocker assembly acceptable to the procuring activity.

4.5.9.2 Vibration speed. Unless otherwise specified by the procuring activity, for testing a tank intended for installation in an aircraft propelled entirely or partially by a reciprocating engine(s), the rotational speed of the eccentric weights shall be 87 to 90 percent of the normal rated crankshaft speed of the engine used. Unless otherwise specified by the procuring activity, for testing all other aircraft tanks, the rotational speed of the eccentric weights shall be 1,940 to 2,000 revolutions per minute.

4.5.9.3 Vibration displacement. Unless otherwise specified by the procuring activity, the throw of the eccentric weights on the vibration machine shall be adjusted to produce a total displacement of 0.032 to 0.042 inch, measured at points of inherent rigidity on the tank (such as points along the seams or near mounting points). Where the above frequencies and displacements are not applicable, the tank shall be vibrated at a frequency and displacement specified by the procuring activity.

4.5.9.4 Mounting axis. Unless otherwise specified by the procuring activity, the tank shall be mounted in such a manner as to simulate pitching in the actual aircraft. Special fixtures, such as baffles, may also be tested, if applicable, by mounting in another position for a portion of the test time.

4.5.9.5 Slosh rocking angle. Unless otherwise specified by the procuring activity, the slosh rocking angle shall be 30 degrees total, approximately 15 degrees on either side of the horizontal position.

4.5.9.6 Type I tanks (reciprocating engines). The test tank, complete with all caps, vents, gages, fittings and other parts or accessories that will be mounted on or in an aircraft, shall be mounted in the support jig and installed on the vibrator and rocker assembly. In addition, all lines attached to the tank in the actual aircraft installation shall be included. The minimum length of these lines shall be that length in the actual aircraft installation from the tank to the first

MIL-DTL-5578D

support. (For testing of tanks which incorporate reticulated foam or similar materials, see 4.5.9.8.) The test specimen shall be filled two-thirds full with water and simultaneously slosh and vibration tested in accordance with applicable conditions specified in 4.5.9.1 through 4.5.9.5 and 4.5.9.8. The temperature of the test fluid shall be as specified in table II. This test shall be conducted with the test specimen subjected to a pressure equivalent to the maximum operating pressure encountered in any prescribed flight conditions. At the conclusion of this test, the test specimen shall be filled with the applicable test fluid and thoroughly inspected for leakage or other evidence of failure such as sagged panels or buckled plates which is cause for rejection.

TABLE II. Test fluid temperature.

Test fluid	Temperature
Fuel	135 \pm 10 °F (57 \pm 6 °C)
Oil	275 \pm 5 °F or 325 \pm 5 °F (135 \pm 3 °C or 163 \pm 3 °C)
Water	Ambient
Water-alcohol	135 \pm 10 °F (57 \pm 6 °C)

4.5.9.7 Type II tanks (jet engines). The test tank, complete with all caps, vents, gages, fittings, and other parts or accessories that will be mounted on or in an aircraft shall be mounted in the support jig and installed on the vibrator and rocker assembly. In addition, all lines attached to the tank in the actual aircraft installation shall be included. The minimum length of these lines shall be that length in the actual aircraft installation from the tank to the first support. The interior of each compartment shall be completely lined with brown paper and held in place with a suitable adhesive. (For testing the tanks which incorporate reticulated foam or similar materials, see 4.5.9.8.) The test specimen shall be filled two-thirds full with the applicable test fluid containing a suitable dye. The tank shall be simultaneously slosh and vibration tested in accordance with the applicable conditions specified in 4.5.9.1 through 4.5.9.5 and 4.5.9.8. The temperature of the test fluid shall be 135 \pm 10 °F (57 \pm 6 °C). This test shall be conducted with the test specimen subjected to a pressure equivalent to the maximum operating pressure encountered in any prescribed flight conditions. At the conclusion of this test, the test specimen shall be filled with the applicable test fluid as specified in ASTM-D471 Ref Fuel A or B and thoroughly inspected for leakage or other evidence of failure.

4.5.9.8 Special baffling materials. Tanks incorporating reticulated foam or similar materials for fire and explosion protection shall have the material removed during the slosh, vibration or slosh and vibration tests described herein. If deemed necessary by the procuring activity, a second slosh test with the foam installed shall be conducted.

4.5.10 Test duration. Unless otherwise specified by the procuring activity, test duration and procedure shall be:

MIL-DTL-5578D

- a. Vibrate for 25 hours at 16 to 20 slosh cycles per minute (cpm); or
- b. Vibrate for 25 hours at 10 to 16 slosh cpm with 15 hours of additional slosh at 10 to 16 slosh cpm.

4.5.11 Vibration (Type I tanks only). A tank shall be tested in accordance with the procedure specified in 4.5.9.6 or 4.5.9.7, as applicable, except:

- a. The tank shall not be sloshed.
- b. The tank shall be completely filled with test fluid.

4.5.12 Slosh.

4.5.12.1 Phase I slosh. A test cube (tank) shall be tested in accordance with the procedure specified in 4.5.9.7 except that this cube shall not be subjected to vibration. The cube shall be sloshed for at least 25 hours at 16 to 20 cpm. Type II cubes shall be installed in the gun fire test structure with the test structure rigidly mounted to the slosh table. The backing board on the four sides shall be removed so that the sides of the cube are supported by the hat sections of the structure.

4.5.12.2 Phase II slosh (Type II tanks only). A tank shall be tested in accordance with the procedure specified in 4.5.9.7 except that the tank shall not be subjected to vibration. The tank shall be sloshed for at least 25 hours at 16 to 20 slosh cpm, or at least 40 hours at 10 to 16 slosh cpm or as specified by the procuring activity.

4.5.13 Dissection after slosh. After completion of the above test, the cell shall be dissected as shown on figure 1. The sectioned portion of each cell shall be examined for conditions specified in MIL-STD-801.

4.5.14 Accelerated loads. The tank assembly, consisting of the tank and tank structure shall be mounted in a support jig that provides support equivalent to the aircraft structure for which it is designed and subjected to the applicable dynamic load tests specified herein to simulate the aircraft design accelerations including the appropriate magnification factors. The tank shall be tested at a fill level of 75 percent of the rated capacity. Tanks of pressurized systems shall be subjected to the normal operating pressures for the conditions being tested, except where unpressurized conditions are considered more critical. Deflections on various parts of the tank structure including the areas surrounding components within the cell shall be measured during the test.

4.5.14.1 Accelerated loads to design limit load. The tank assembly shall be subjected to 100 percent design limit accelerations at the 75 percent fill level and applicable pressure to determine

MIL-DTL-5578D

the most critical condition. There shall be no evidence of failure, leakage or chaffing of the cell or components. Further, the deflection of the cell shall be such that there will be no contact with the tank or aircraft component.

4.5.14.1.1 Accelerated loads to design limit load of carrier based aircraft. Following the test of 4.5.14.1 and prior to the test of 4.5.14.2, the tank assembly shall be subjected to 100 percent design limit accelerations simulating catapult launched and arrested landings at the specified fill levels and pressurized conditions to determine the most critical catapult launch and arrested landing condition. The tank shall be subjected to load application(s) at the critical catapult launch condition and load application(s) at the critical arrested landing condition as directed by the procuring activity. There shall be no evidence of failure, leakage or chaffing of the cell or components. Further, the deflection of the cell shall be such that there will be no contact with the tank or aircraft components.

4.5.14.2 Accelerated loads to design ultimate load. The tank assembly shall be subjected to one application of load at 150 percent of the design limit load at the most critical condition. There shall be no evidence of failure, leakage, or deflection that contacts the tank or aircraft components.

4.5.14.2.1 Accelerated loads to design ultimate load of carrier based aircraft. The tank assembly shall be subjected to one application of load at 150 percent of the design limit load at both the most critical catapult launch and the most critical arrested landing condition. There shall be no evidence of failure, leakage or deflection that contacts the tank or aircraft components.

4.5.15 Gunfire resistance on tank installation. For this test, the tank shall be mounted in an actual section of the aircraft structure containing the backing board or backing board and foam that will be used in the specific application. The tank for this test need not include accessories. Purging capabilities shall be provided to help prevent fires during gunfire test. The tank shall be filled two-thirds full with JP-5 or JP-8 or other test fluid as specified by the procuring activity. All gunfire testing shall be conducted with the tank subjected to an internal pressure equivalent to the maximum stabilized vapor pressure encountered during any prescribed stabilized level flight conditions. The tank shall be subjected to the gunfire test in accordance with direction from the procuring activity. For cells intended for protection levels (C) and (D), at least two rounds of .50 caliber or 14.5 mm armor piercing (AP), as applicable, shall be fired into the non-self-sealing portion of the cell. For protection levels (A) and (C), in addition to the .50 caliber gunfire, one round of 20-mm AP ammunition shall be fired. For protection level (C), this round of 20-mm AP ammunition shall be placed in the self-sealing portion of the cell. For protection level (D), this round of 23-mm AP ammunition shall be placed in the self-sealing portion of the cell. All shots shall be placed so as to be compatible with the aircraft installation and the combat utility of the aircraft. Tumbled .50 caliber AP rounds shall be utilized to simulate shrapnel. No

MIL-DTL-5578D

bursts shall be fired, and the test shall be conducted at ambient temperature. The same conditions that are cause for rejection of the phase I test cell shall apply to this test.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When packaging of materiel is 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 systems commands. Packaging data retrieval is available from the managing military service'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. Self-sealing fuel tanks manufactured under this specification are intended for use in aircraft as a means of carrying aircraft fuel including aromatic constituents under all prescribed operating conditions and as a means of preventing, under gunfire conditions specified herein, an excessive loss of fuel.

6.2 Acquisition requirements. Acquisition documents should specify the following:

- a. Title, number, and date of the specification.
- b. Model designation of the aircraft.
- c. Name of the cell manufacturer.
- d. Part number, type, class, style, and protection level of cell desired (see 1.2).
- e. When first article is required (see 3.2).
- f. Fuel suitability (see 3.4).
- g. Packaging requirements (see 5.1).

MIL-DTL-5578D

6.3 Definitions.

6.3.1 Manufacturer. For purposes of this specification, the term manufacturer refers to the manufacturer of the tank.

6.3.2 Contractor. The term contractor refers to the prime contractor or airframe manufacturer.

6.3.3 Supplier. The term supplier as used herein refers to both the manufacturer and the contractor.

6.3.4 Damp seal. A wound that shows no evidence of continuous leakage but may show wetting around the wound.

6.3.5 Coring. A wound that shows evidence of sealing material and fibers being removed.

6.4 First article inspection. With respect to products requiring first article inspection, awards will be made only for products which are, at the time of award of contract, qualified under first article inspection. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. Information pertaining to first article inspection may be obtained from Commander, Naval Air Systems Command, Code 4.3.5.3, 48110 Shaw Road, Bldg 2187, Patuxent River, MD 20670-5304.

6.5 Service life. Based on past experience, the normal service life of fuel cells covered by this specification is equivalent to that of the aircraft in which they are installed.

6.6 Gunfire. The procuring activity may have one round of 40-mm high explosive statically detonated 24 inches from the outside of the tank. The results of this round will not be utilized in appraising and formulating tank approval decision, but will aid in the development of a possible cell construction that the Armed Services are desirous of obtaining.

6.7 Special environment. When the test methods specified herein do not represent the tank environment, for example, temperatures resulting from aerodynamic heating in excess of 160 °F (71 °C), the test method should be modified as agreed upon by the contractor and the procuring activity to simulate operational conditions.

6.8 Subject term (key word) listing.

Cell
Inner liner
Slosh

MIL-DTL-5578D

6.9 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.

MIL-DTL-5578D

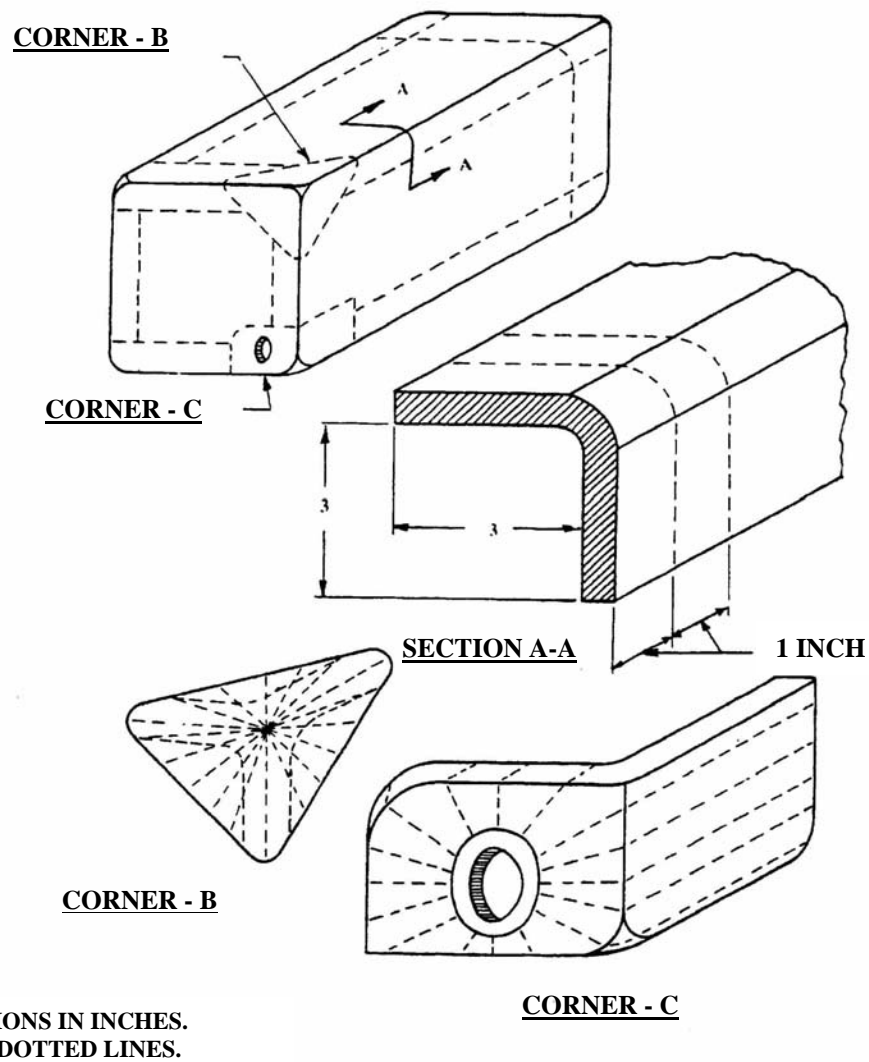
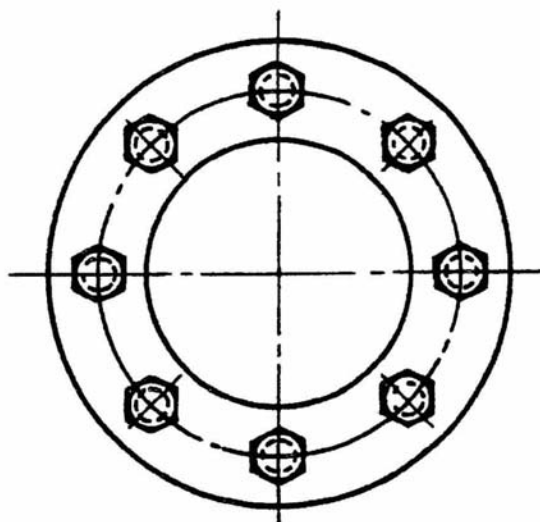
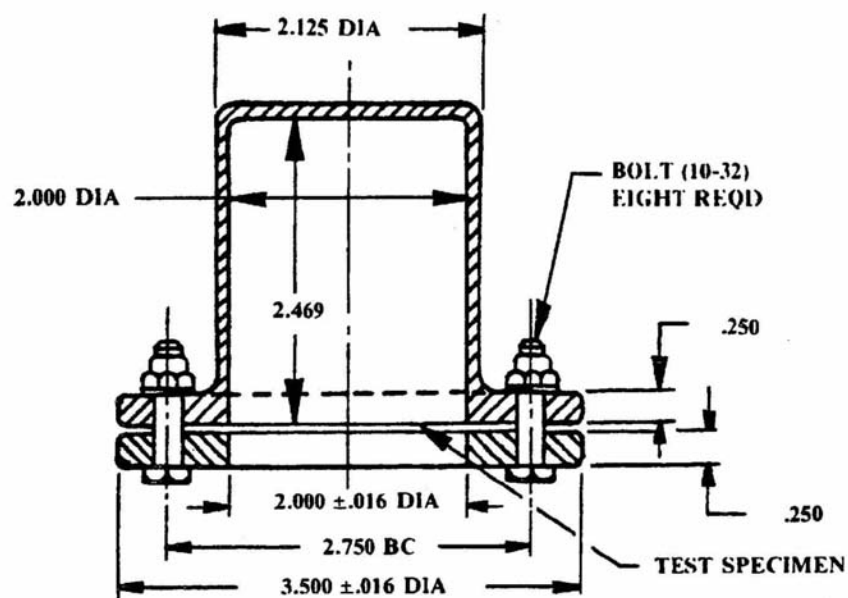


FIGURE 1. Location of cuts for dissection sample.

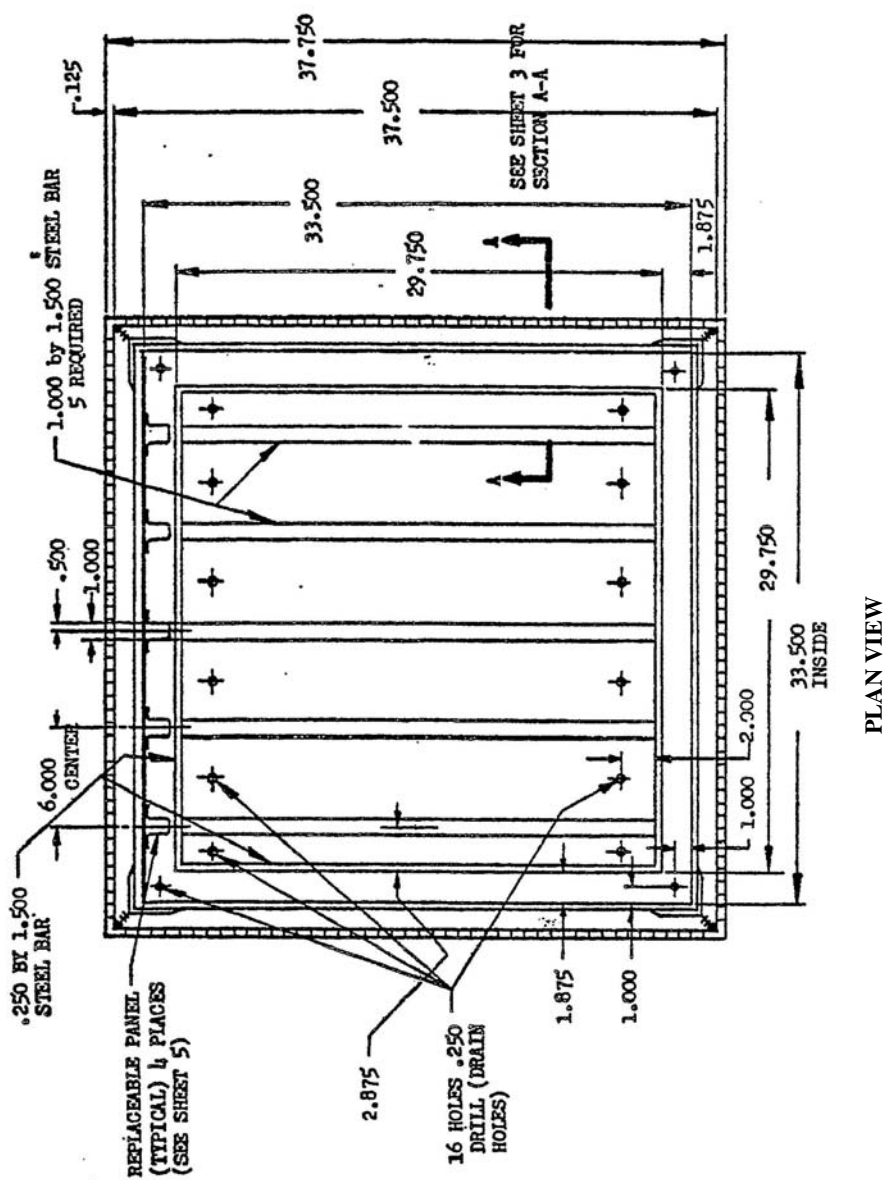
MIL-DTL-5578D



DIMENSIONS IN INCHES.

FIGURE 2. Permeability cup assembly.

MIL-DTL-5578D



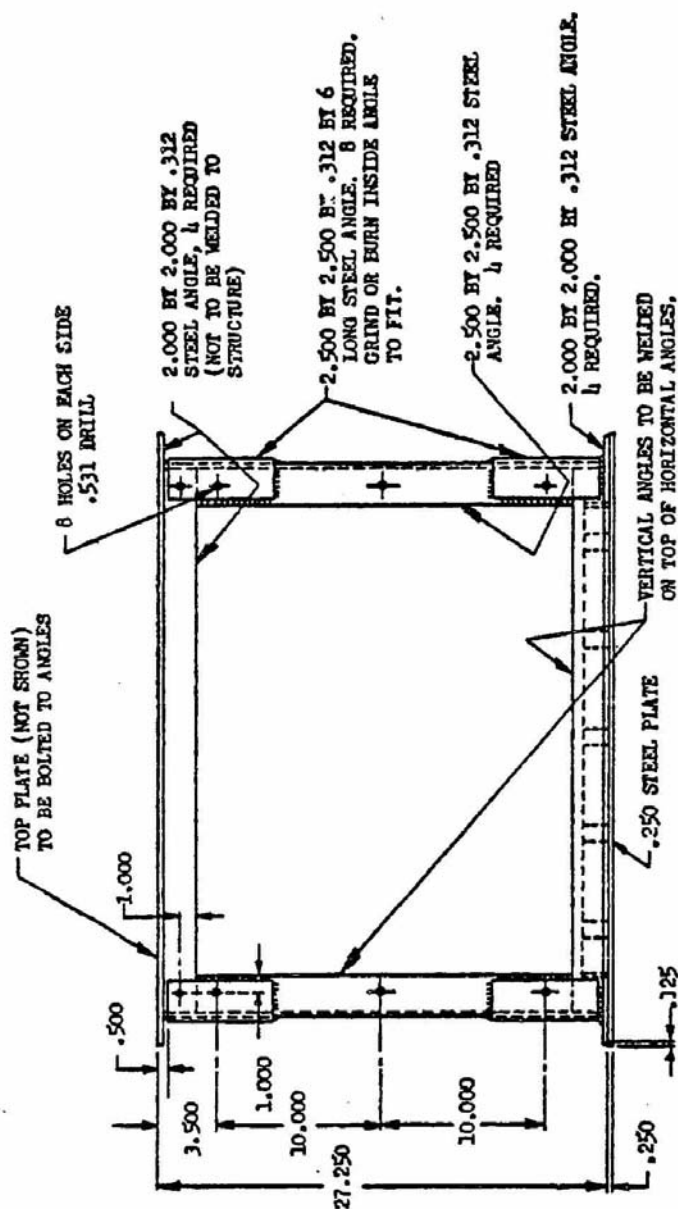
PLAN VIEW

(TOP PLATE AND ANGLES NOT SHOWN)
(SEE SHEET 4 FOR DETAIL OF TOP)

DIMENSIONS IN INCHES. TOLERANCES, DECIMALS $\pm .016$.

FIGURE 3. Gunfire test structure (1 of 5).

MIL-DTL-5578D



DIMENSIONS IN INCHES. TOLERANCES: DECIMALS $\pm .016$.

FIGURE 3. Gunfire test structure (2 of 5) - Continued.

MIL-DTL-5578D

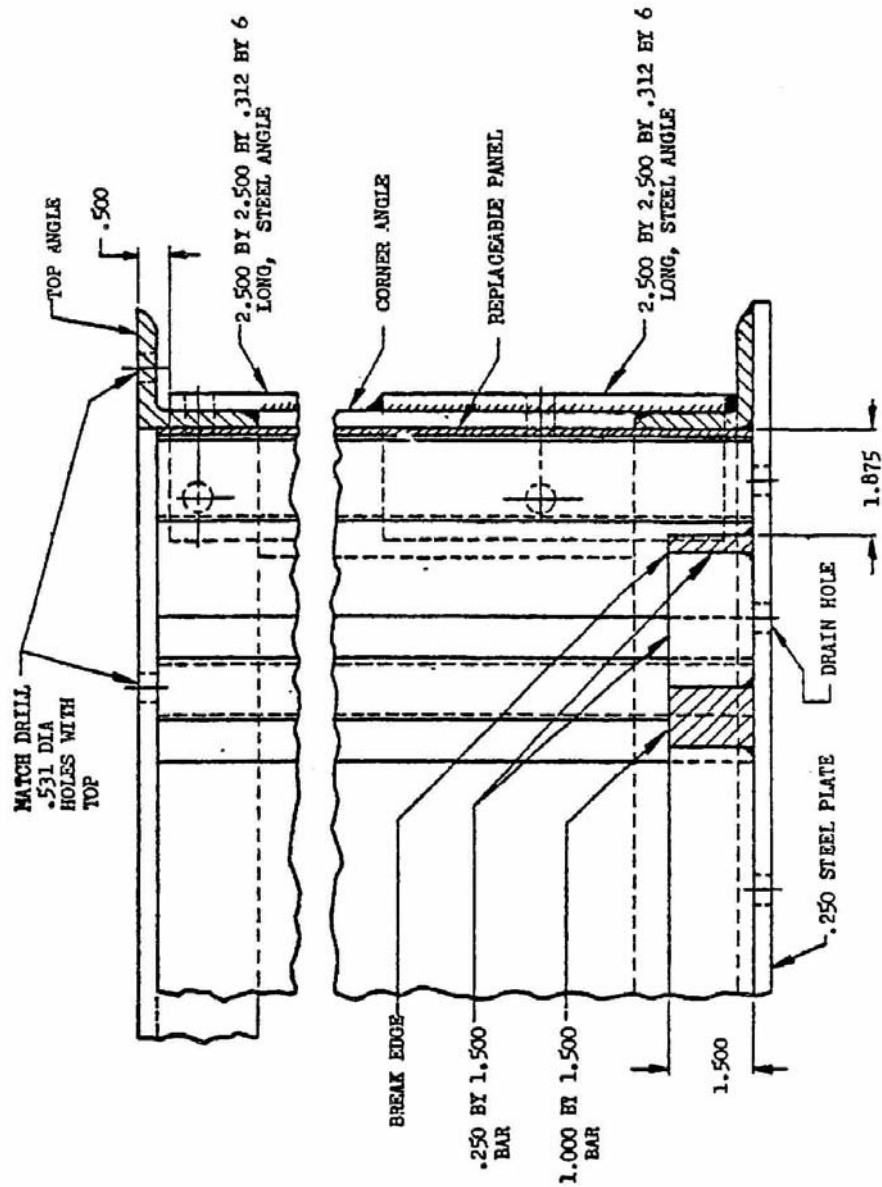
DIMENSIONS IN INCHES. TOLERANCES: DECIMALS $\pm .016$.

FIGURE 3. Gunfire test structure (3 of 5) - Continued.

MIL-DTL-5578D

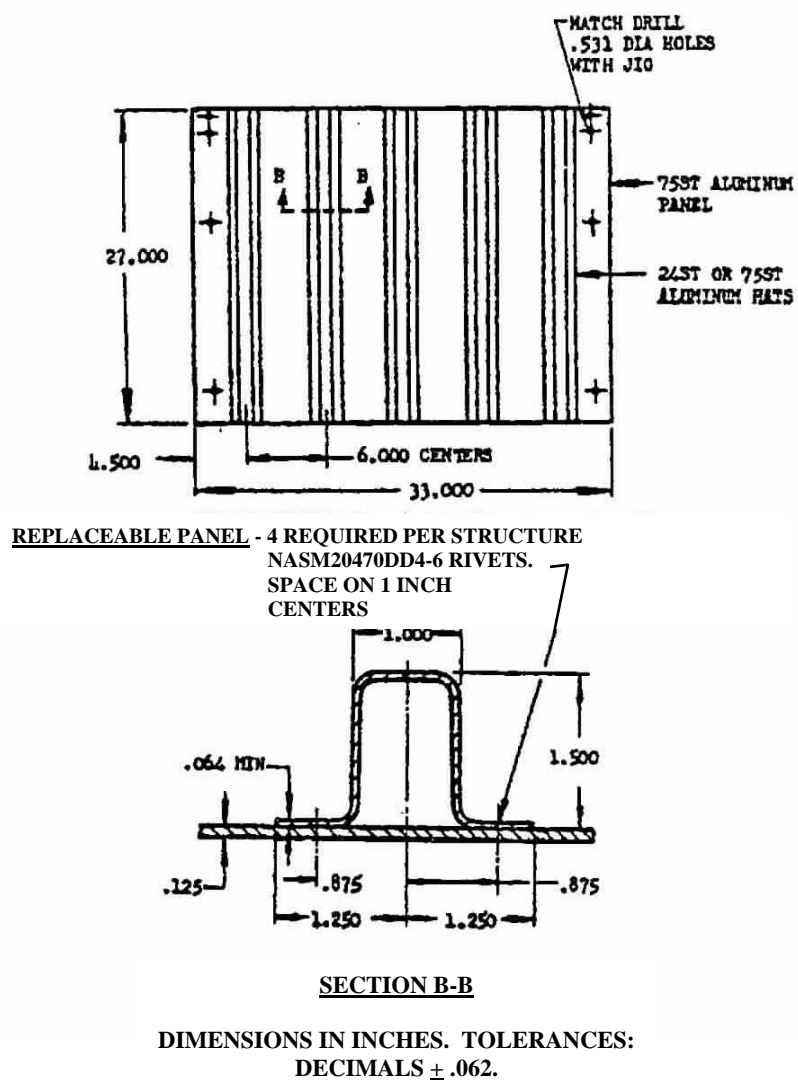


FIGURE 3. Gunfire test structure (5 of 5) - Continued.

MIL-DTL-5578D

CONCLUDING MATERIAL

Custodians:

Army - AV

Navy - AS

Air Force - 99

Preparing activity:

Navy - AS

(Project 1560-0029-000)

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 <http://assist.daps.dla.mil/>.