ETSO-C80
Date : 24.10.03

European Aviation Safety Agency

European Technical Standard Order

Subject: FLEXIBLE FUEL AND OIL CELL MATERIAL

1 - Applicability

This ETSO gives the requirements that flexible fuel and oil cell material which are manufactured on or after the date of this ETSO must meet in order to be identified with the applicable ETSO marking.

2 - Procedures

2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

2.2 - Specific

None.

3 - Technical Conditions

3.1 - General

3.1.1 - Minimum Performance Standard

Standards set forth in Federal Aviation Agency Standard, "Flexible Fuel and Oil Cell Material", dated August 1, 1963 (see Appendix 1).

3.1.2 - Environmental Standard

See CS-ETSO Subpart A paragraph 2.1

3.1.3 – Computer Software

None

4 - Marking

4.1 - General

Marking is detailed in CS-ETSO Subpart A paragraph 1.2; in addition, each flexible fuel and oil cell material shall be legibly and permanently marked with the following information:

(i) Type of fluid for which approved, i.e. fuel, or MIL-L-6082 oil, or MIL-L-7808 oil,

(ii) For oil cell material, the minimum and maximum temperature limit,

(iii) For oil cell material, the oil-dilution suitability.

4.2 - Specific

None.

5 - Availability of referenced documents

See CS-ETSO Subpart A paragraph 3.

APPENDIX 1
FEDERAL AVIATION AGENCY STANDARD
FOR
FLEXIBLE FUEL AND OIL CELL MATERIAL

1.0 ***Purpose***. To specify minimum requirements for flexible fuel and oil cell material intended for use in fuel and oil tanks of aircraft.

2.0 ***Scope***. This standard covers the requirements of fuel and oil cell material in which hydrostatic loads are resisted by the structure of the cavity or tank and not by the cell material itself.

3.0 ***General Requirements.***

3.1 ***Materials***. Samples of flexible fuel and oil cell materials and construction techniques shall be subjected to and satisfy the following tests prescribed under paragraph 4.0

4.0 ***Tests.*** The applicable tests for substantiating flexible fuel and oil cell material and construction techniques are indexed below in Table I.

TABLE I

Tests	*Par. No.*	*Oil*	*Fuel*
Leakage[1]	5.0	X	X
Aging	6.0	X	-
Slosh	7.0	X	X
Stand	8.0	X	X
Humidity	9.0	X	X
Fluid Resistance of Exterior Surfaces	10.0	X	X
Permeability	11.0	-	X
Fuel Contamination[2]	12.0	-	X
Oil Dilution Resistance	13.0	X	-
Inner Liner Strength	14.0	X	X
Seam Adhesion	15.0	X	X
Puncture Resistance	16.0	X	X
Low Temperature Leakage	17.0	X	X

4.1 ***Test Samples.*** Test samples shall consist of the following :

a. Two cells with outside dimensions of 24x30x30 inches containing fittings representative of those used in tank construction for airframe installation. One cell to be used for stand test (par. 8.0), the other for all other cell tests.

b. Two 12x12 inch samples of composite cell construction. One for humidity test (par. 9.0), the other for puncture test (par. 16.0).

c. One sample of inner layer ply, without barrier, approximately 900 square inches in area including seam for inner liner strength test (par. 14.0) and seam adhesion test (par. 15.1).

d. One sample 6x6 inch inner layer ply, without barrier for all other inner layer tests.

e. Two permeability samples as specified in paragraph 11.0. None of these samples shall be preplasticized with fluid prior to testing.

4.2 ***Test Fluids***. Unless otherwise specified, the following test fluids shall be used in testing the different tanks.

a. Fuel Tank: Test fluid conforming to MIL. Spec. MIL-S-3136, Type III.

b. Oil Tank: Oil conforming to MIL. Spec. MIL-L-6082, Grade 1100.

c. Oil Tank: Oil conforming to MIL. Spec. MIL-L-7808.

5.0 ***Leakage***. Each cell, with all openings sealed and with the minimum of external support necessary to maintain the cell shape, shall be subjected to an internal air pressure of 2.0 p.s.i. The cell shall then be completely submerged in water or completely covered with soapy water. Leakage indicated by air bubbles in the water or soapy water solution shall be cause for rejection. Alternate methods of checking leakage may be used if approved by the Authority.

6.0 ***Aging.***

6.1 ***Test Conditions***. The maximum temperature capability of oil cell material shall be selected by the manufacturer and stated as a limitation under § 514.86(c) (2). During the tests, the test fluid temperature shall be uniformly maintained throughout the cell.

6.1.1 ***Test Duration.*** This test shall be conducted for period of 200 hours.

6.1.2 ***Test Procedure.*** The cell shall be filled with 80 gallons of either test fluid 4.2b. or c. as applicable. At the end of the test period, the cell shall show no sins of deterioration or other unsatisfactory conditions.

7.0 ***Slosh.***

7.1 ***Test Conditions.*** The following test conditions shall prevail during slosh test.

7.1.1 ***Rocking Angle***. The slosh rocking angle shall be 30 degrees total, approximately 15 degrees on either side of' the horizontal position.

7.1.2 ***Mounting Axis***. The cell shall be mounted in such a manner that the 24 inch dimension is vertical. This position shall be known as the horizontal position.

7.1.3 ***Fluid Temperatures***. The temperature of the fluid during the slosh test shall be as shown in the table below:

Test Fluid Temperatures

Test Fluid	*Temperatures*
Fuel	135°±10° F.
Oil	Maximum temperature (±10° F.) selected by manufacturer and stated as a limitation

7.14 ***Test Duration.*** This test shall be run as follows:

a. Slosh for 25 hours at 16 to 20 c.p.m., or

b. Slosh for 40 hours at 10 to 16 c.p.m.

7.15 ***Test Procedure***. The test cell complete with filler cap, vents, and typical outlet fittings shall be installed in a suitable mounting structure, then mounted on the support jig and rocker assembly. Sections of flexible hose shall be connected to the vent and outlet fittings. The other end of each of these sections shall be rigidly attached to the support jig. The hoses shall be installed and supported in a manner representative of an actual installation in an aircraft.

The tank mounting structure is to be representative of an actual aircraft fuel cell compartment. Recommendations of' the cell manufacturer for supporting or mounting the fuel cell in the aircraft fuel cell compartment are to be incorporated. The interior of the support jig shall be completely lined with brown paper held in place by a suitable adhesive.

The test specimen shall be filled two-thirds full with the applicable test fluid containing a suitable dye. For fuel cells, one-half' gallon of' water shall also be added. For oil cells intended for use in aircraft using an oil dilution system, 30 percent by volume of' fluid 4.2a. shall be added to the test fluid. At the conclusion of this test, the test specimen shall be completely filled with the applicable test fluid and thoroughly inspected for leakage or other evidence of' failure.

8.0 ***Stand Test***. This test shall be conducted on the second test cell as provided for in paragraph 4.1a. The test cell may be installed in the support structure used for the slosh test or a similar structure which is lined with brown paper. The cell shall be filled with the appropriate test fluid containing a satisfactory staining agent. There should be no leakage or evidence of other failure at the end of 90 days under these conditions.

9.0 ***Humidity***. A 12x12 inch sample of the composite cell construction shall be subjected for a total period of 15 days to the following 24-hour test cycle.

a. 8 hours at 130°±3° F. and 100 percent relative humidity

b. 4 hours cooling to approximately 70°±3° F.

c. 8 hours at 70°±3° F. and 100 percent relative humidity.

d. 4 hours heating to 130°±3° F. There shall be no corrosion, peeling, cracking, warping, blistering, delamination or discoloration of the cell after this period.

10.0 ***Fluid Resistance of Exterior Surfaces***. The cell shall be placed in a container sufficiently large to permit immersion to one-half the depth of the cell in the applicable test fluid. The cell shall be immersed for 24 hours at ambient temperature, after which it will be removed and examined. The exterior surface of the cell construction shall show no unsatisfactory swelling, blistering, dissolution, or other deterioration.

11.0 ***Permeability.***

11.1 ***Test Apparatus***. The test apparatus shall consist of' the following:

a. Two permeability cups and rings constructed in accordance with Figure 1.

b. A nylon solution shall be used for sealing the test disk to the permeability cup.

11.1.1 ***Preparation of Test Specimens***. The uncured inner liner shall be applied to a 10x10 inch piece of corrugated fiberboard coated on one side with a suitable water soluble breakaway agent. The exposed surface of the inner liner shall be coated with prime cement and barrier resin (if required) in accordance with applicable manufacturing specifications. The assembly shall be wrapped with cellophane and covered with a suitable waterproof bag.

The assembly shall be vulcanized as in normal production. After vulcanizing, the waterproof bag and cellophane shall be removed and the inner liner shall be removed from the fiberboard using water as necessary. Free moisture shall be wiped from the assembly and it shall be conditioned 24 hours at a constant temperature of 77°±5° F. and a relative humidity of 40±5 percent. Two 2.5 inch diameter disks shall be cut from the vulcanized panel. One hundred ml. of test fluid specified in paragraph 4.2a. shall be placed in each of the permeability cups. Nylon solution shall be applied to the face of the cup flanges covering the area inside the bolt circle. The nylon solution shall be allowed to come almost to dryness, then the test disks shall be applied to the cups with the barrier, if any, facing outward. The assemblies shall be completed by attaching the bolting rings and tightening the bolts in accordance with the following schedule:

Inner Liner Type	*Bolt Torque*
Gum stock	5 to 10 in.-lb.
Coated fabrics	15 to 20 in.-lb.
Unsupported plastic films	20 to 25 in.-lb.

11.1.2 ***Test Procedure***. Permeability cups prepared as specified above shall be placed in a suitable rack in a constant temperature of 77°±5° F. and a relative humidity of 40±5 percent.

After allowing 1 hour for equilibrium, the cups shall be weighed to the nearest 0.005 gram and placed in the rack with the faces of the cups facing upward (test disks up). The cups shall be kept at the above constant temperature for 24 hours, then weighed to check for seal integrity. The bolts shall be retorqued if necessary. The cups shall then be inverted (test disks down) in a rack that permits free access of air to the test disks.

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 day to eighth day period and expressed as fluid ounces per square foot per 24 hours. The permeability shall be less than 0.025 fluid ounces 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 follows:

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

Where

sp.gr. = Specific gravity of test fluid at 77° F.

R = Inside radius of test cup expressed in inches.

12.0 ***Fuel Contamination.***

12.1 ***Nonvolatile Gum Residue***. A five gram sample of the inner layers up to the barrier, shall be diced up into approximately 0.062 inch squares and placed in a flash containing 250 ml. of test fluid as specified in paragraph 4.2a. and allowed to stand for 48 hours at 77°±5° F.

The contaminated test fluid shall be decanted off, and the nonvolatile gum residue determined by Method 3302 of Federal Test Method Standard No. 791,[4] ASTM D381-54T, except that the total evaporation time shall be 45 minutes. The nonvolatile material shall not exceed 60 milligrams per 100 ml. of the contaminated fluid.

12.1.1 ***Stoved Gum Residue***. The beakers containing the nonvolatile material shall be placed in an appropriate bath maintained constantly at a temperature of 572°±9° F. for 30 minutes. After cooling in a closed container, the beakers shall be weighed. The staved gum residue shall not exceed 20 milligrams per 100 ml. of the contaminated fluid, after necessary corrections have been made for preformed gums originally present in the test fluid.

13.0 ***Oil Dilution Resistance***. Tensile and elongation tests shall be made on the inner layer ply according to the methods described in Federal Test Method Standard No. 601,[5] Methods 4111 and 4121, respectively. Before and after the tests the test specimens shall be immersed for 48 hours at room temperature in the appropriate oil diluted 30 percent by volume with test fluid specified in paragraph 4.2a. The tensile properties shall not be reduced more than 40 percent from the original values, and the Shore A durometer hardness shall not vary more than 15 points from the original value.

14.0 ***Inner Liner Strength*****.**

14.1 ***Gum Inner Liner Strength***. The strength of the gum inner layer ply, without barrier, shall be determined in accordance with Federal Test Method Standard No. 601,[5] Method 4111 before and after immersion in the test fluid specified in paragraph 4.2a. for 72 hours at a temperature of 135°±3° F. The tensile strength shall also be determined before and after immersion in water for 72 hours at a temperature of 135°±3° F. The tensile strength shall not be reduced more than 50 percent for fuel immersion and 20 percent for water immersion calculated on the basis of the original cross-sectional area.

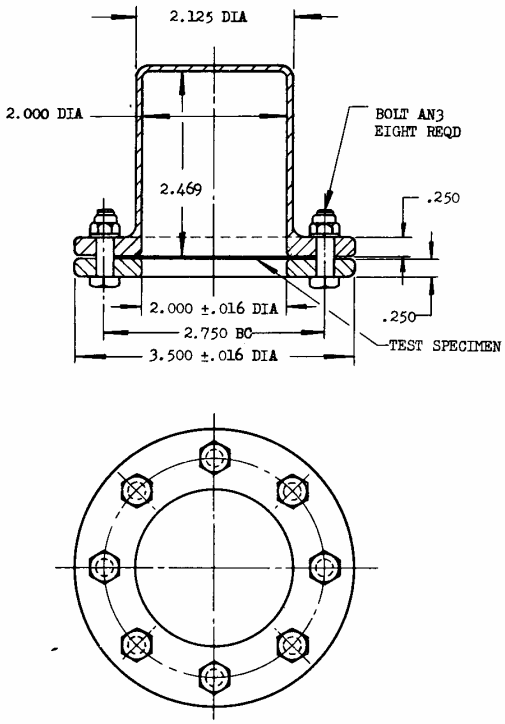
14.2 ***Fabric Inner Liner Strength***. The tensile strength of the fabric inner layer ply, without barrier, shall be determined in accordance with Specification CCC-T-191,[5] Method 5100 before and after immersion in test fluid specified in paragraph 4.2a. for 72 hours at a temperature of 135°±3° F. The tensile strength shall also be determined before and after immersion in water for 72 hours at a temperature of 135°±3° F. The tensile strength shall not be reduced more than 20 percent for fuel immersion and 50 percent for water immersion calculated on the basis of the original cross-sectional area.

15.0 ***Seam Adhesion***. The seam adhesion of the inner layer ply to itself before and after immersion in the test fluid specified in paragraph 4.2a for 72 hours at a temperature of 135°±3° F. 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 Federal Test Method Standard No. 601,[5] Method 8011. 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.

15.1 ***Seam Adhesion (Alternate Procedure).*** As an alternate procedure to the above, the seam adhesions of the inner-layer ply to itself may be tested by cutting a strip of inner-layer material one inch wide having a seam made in the same manner as is used in the tanks submitted under paragraph 4.1a. This seam shall be perpendicular to and midway in the length of the strip. When a tensile load has been applied of sufficient magnitude to break the strip, there shall be no failure of the seam.

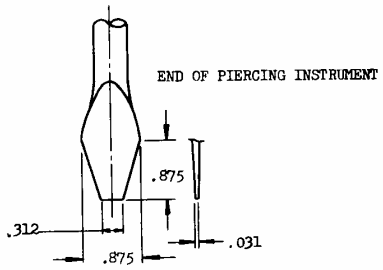
16.0 ***Puncture Resistance***. A cell wall shall be fastened in a specimen holder in accordance with Figure 2. A piercing instrument with its end conforming to Figure 2 shall be forced against the cell wall at approximately the centre of the area enclosed by the specimen holder. The force required to puncture the cell shall not be less than 15 pounds.

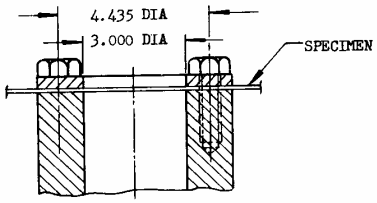
17.0 ***Low Temperature Leakage.*** The cell supporting structure cavity shall be lined with brown paper and the cell installed in the structure. The cell shall be completely filled with the appropriate test fluid containing a staining agent and allowed to stand for seven days at 135°±10° F. The cell shall then be emptied and subjected to an air dry out at 155°±5° F for seven days. The cell shall then be completely refilled with the appropriate test fluid containing a straining agent, cooled to -65°±5° F. and allowed to stand a this temperature a minimum of three days. The test fluid in contact with the cell inner liner shall have reached -65° F. prior to the start of the three-day period. The cell shall be instrumented by placing thermo-couples against the inside surface of the cell liner, one with six inches of the top surface on one side panel and the other within six inches of the bottom surface on the opposite side panel. At the end of the three-day period, the cell shall be brought back to room temperature, drained and examined internally and externally for fluid leakage or other evidence of failure. Any indication of failure shall be cause for rejection.



DIMENSIONS IN INCHES

FIGURE 1. Permeability cup assembly





SPECIMEN HOLDER

DIMENSIONS IN INCHES.

FIGURE 2. Piercing instrument and specimen holder