



QUALITY ASSURANCE SPECIFICATIONS™

SFI SPECIFICATION 28.1

EFFECTIVE: SEPTEMBER 23, 2011*

PRODUCT: Polymer (Foam-Filled) Fuel Cells

1.0 GENERAL INFORMATION

- 1.1 This SFI Specification establishes uniform test procedures and minimum standards for evaluating and determining performance capabilities for Fuel Cells used by individuals engaged in competitive motorsports.
- 1.2 The procedures, test evaluations and standards contained herein, are intended only as minimum guidelines for construction and evaluation of products. Certification that products meet such minimum standards is made by the product manufacturer and products are not certified, endorsed or approved by SFI under this program.
- 1.3 Use of the "This Manufacturer Certifies That This Product Meets SFI Specification 28.1" logo/designation, the authorized artwork style, or conventional lettering by a manufacturer, on a subject product, is intended only to indicate that the manufacturer of the product has represented that they have submitted the product to the recommended tests, with positive results, in compliance with the standards established herein.
- 1.4 This SFI Specification requires a demonstration that the product of a manufacturer meets or exceeds the requirements when the manufacturer enters the program; and on a periodic basis thereafter. Any manufacturer may participate in the program by providing Fuel Cells that meet or exceed the SFI Specification 28.1 test standards, by complying with the requirements of the SFI Specification 28.1 program, and by signing a licensing agreement with the SFI Foundation, Inc.
- 1.5 Compliance with this specification is entirely voluntary. However, when a manufacturer provides Fuel Cells in compliance with all requirements of the SFI Specification 28.1 and enters into the licensing agreement with the SFI Foundation, Inc., they may certify that compliance with such standards is in accordance with the guidelines established herein.

- 1.6 Manufacturers wishing to participate in the program, in addition to the other requirements of this specification, must label each of their products with the manufacturer's name, trademark or symbol as well as the date of manufacture of the product.
- 1.7 No manufacturer may display the SFI logo/designation on their product unless the manufacturer has signed a licensing agreement with SFI and has successfully complied with all the requirements of this specification and the self-certification program.

2.0 DEFINITIONS

- 2.1 Fuel Cell: An enclosure for fuel that has the capability to deform under impact while resisting rupture.
- 2.2 Reticulated Foam: The porous material used within a fuel cell to prevent explosion and control fuel sloshing.
- 2.3 Filler Assembly: The assembly consisting of the fuel filler port, fuel outlet port and breather vent that mounts to the flange of the fuel cell.
- 2.4 Fitting: A reusable connection for an external fluid line. It may be affixed to the filler assembly or directly to the wall of the fuel cell.
- 2.5 MIL-B-83054: MIL-B-83054B Amendment 2, Military Specification; Baffle and Inerting Material, Aircraft Fuel Tank.

3.0 CONSTRUCTION

A Fuel Cell is typically made of Polymer material. The walls are semi-rigid. Material must be cross-linked resin as supplied by the raw material manufacturer. Exterior containers are not covered by this specification.

A filler assembly is optional. If supplied, it shall have an integral check valve on the fuel filler port and breather vent to prevent leakage due to an unusual attitude of the vehicle. If the filler cap is located directly on the cell, the filler port check valve is optional.

Reticulated foam shall be required for cells using gasoline fuel and optional for alcohol and other fuels. If used, at least 70 percent of the volume of the cell shall be filled. The foam shall be compatible with the fuel being used. The foam shall comply to MIL-B-83054, Type 4 or an equivalent specification. The Fuel Cell manufacturer shall provide documentation that all foam complies to MIL-B-83054.

The use of magnesium in any part of a Fuel Cell is prohibited. All parts in contact with fuel shall have a corrosion resistant coating. Cadmium plated parts shall not be used where they would be normally exposed to fuel.

4.0 MODEL CLASSIFICATION

Fuel Cell models are primarily based on materials and construction method. Models are not based on size or configuration.

5.0 TESTING

The Fuel Cell or Fuel Cell material shall be subjected to the tests specified for its type.

5.1 TENSILE STRENGTH

Material shall be tested in accordance with ASTM D 638 unless otherwise specified.

5.1.1 SAMPLES

The sample material shall have the identical composition, construction and overall assembly as that of the thinnest wall used in the product model that is being evaluated. The sample size and shape shall be appropriate for the apparatus being used. Four samples shall be fabricated. If the material exhibits directional properties, then two samples shall be from a direction perpendicular to the other two.

5.1.2 APPARATUS

A standard tensile test machine shall be used. The machine shall be capable of applying a minimum tensile load of 5,000 pounds {lb} (22,240 newtons {N}) with an excursion travel of two inches per minute {ipm}, and shall have adequate instrumentation to verify the test load. The test machine shall also be in calibration and traceable to the National Bureau of Standards.

5.1.3 PROCEDURE

Measure the actual width of the sample at its narrowest point and the actual thickness of the sample at its thinnest point. Determine its area by multiplying the measured width by the measured thickness. For each sample, increase the tensile load at the rate of two ipm until the test bar breaks. Record the breaking load.

5.1.4 INTERPRET RESULTS

For each sample, calculate the tensile strength by dividing the sample's breaking load by the sample's area. Determine the average of each set, if applicable. The lowest set average shall be considered the tensile strength of the material.

5.2 IMPACT PENETRATION

5.2.1 SAMPLES

Samples shall be fully processed, current style fuel cells which are representative of fuel cells currently produced or to be produced. For a given model, the fuel cell with the greatest volume shall be tested.

5.2.2 CONDITIONING

The samples shall be conditioned at $73 \pm 5^{\circ}\text{F}$ ($23 \pm 3^{\circ}\text{C}$) and $40 \pm 5\%$ relative humidity for 24 hours.

5.2.3 APPARATUS

A. SPECIMEN HOLDER AND PIERCING INSTRUMENT

The apparatus as shown in Figure 3 of MIL-T-6396 shall be used. The piercing instrument shall have a drop weight of 5.0 ± 0.1 lb (22.24 ± 0.44 N).

B. TEST FIXTURE

The test fixture shall enable the piercing instrument to be dropped in guided free fall the required distance.

5.2.4 PROCEDURE

The piercing instrument shall be dropped from a height as specified below onto the approximate center of the sample.

The drop height shall be $4.5 -0/+0.1$ feet {ft}.

5.2.5 INSPECTION

Inspect the material for signs of deterioration.

5.3 HYDROSTATIC LEAKAGE TEST

5.3.1 SAMPLES

All Fuel Cell types shall be subjected to this test. Samples shall be fully processed, current style Fuel Cells which are representative of Fuel Cells currently produced or to be produced. For a given model, the Fuel Cell with the greatest volume shall be tested.

5.3.2 APPARATUS

A. PRESSURIZED WATER

A pressurized water supply that can produce 7 pounds per square inch {psi} shall be used.

B. PRESSURE GAUGE

A gauge to measure water pressure shall be used.

C. LEAK CHECK SOLUTION

A solution that can detect water leakage shall be used.

D. SOLID ACCESS COVER PLATE

A solid plate with gasket and fasteners that can seal the flange opening shall be used, if applicable.

E. FITTING COVERS

Covers to seal the fitting openings shall be used, if applicable.

5.3.3 PROCEDURE

- A. The access cover plate shall be attached to the flange opening and all other openings shall be sealed. Subject the cell to 7 -0/+0.1 psi of water pressure.
- B. Completely cover the exterior of the cell with leak check solution.
- C. Check for any indication of water leakage.

5.4 FITTING PULLOUT TEST

This test shall only be required for all fittings affixed in the wall of the cell, not in a filler plate assembly.

5.4.1 SAMPLES

Samples shall be fully processed, current style Fuel Cells which are representative of Fuel Cells currently produced or to be produced. For a given model, the Fuel Cell with the thinnest wall shall be tested.

5.4.2 APPARATUS

A. FITTING FIXTURE

A fixture that connects to the fitting, in the same manner as a fluid line in actual use, shall be used. The fixture shall allow an axial load to be attached and be able to withstand the test load.

B. TEST MACHINE

A standard tensile test machine shall be used. The machine shall be capable of applying a minimum tensile load of 1,000lbs (4,448 N) with an excursion travel of four to ten ipm (102 - 254 mmpm), and shall have adequate instrumentation to verify the test load. The test machine shall also be in calibration and traceable to the National Bureau of Standards.

5.4.3 PROCEDURE

Connect the fitting fixture to the fitting to be tested. Position the cell in the test machine and secure the corners. The fitting to be tested shall be aligned with the test machine head. Attach the fitting fixture to the test machine head. Increase the tensile load until the applicable load is reached as specified below. Hold the load for five seconds and then reduce to zero. Repeat for each fitting to be tested. The load shall be 500lbs (2,224N).

5.4.4 INSPECTION

Inspect the fitting and surrounding area for signs of delamination or failure.

5.5 FLANGE PULL-OUT STRENGTH

5.5.1 SAMPLES

All Fuel Cell types shall be subjected to this test. Samples shall be fully processed, current style Fuel Cells which are representative of Fuel Cells currently produced or to be produced. For a given model, the Fuel Cell with the thinnest wall shall be tested.

5.5.2 APPARATUS

A. SOLID ACCESS COVER PLATE

A stiff, solid access cover plate with a connection to attach a load shall be used to load the flange. The plate shall be strong enough to transfer the load to the flange without appreciable deflection.

B. TEST MACHINE

A standard tensile test machine shall be used. The machine shall be capable of applying a minimum tensile load of 1,000lbs (4,448 N) with an excursion travel of two ipm (51 mmpm) and shall have adequate instrumentation to verify the test load. The test machine shall also be in calibration and traceable to the National Bureau of Standards.

5.5.3 PROCEDURE

Attach the access cover plate to the flange. All attachment points shall be connected. The fasteners shall fully engage all threads available. Position the cell in the test machine and secure the corners. Connect the cover plate to the head of the test machine. Increase the tensile load until the applicable load is reached as specified below. Hold the load for five seconds and then reduce to zero. The load shall be 1,500lbs (6,672 N).

5.5.4 INSPECTION

Inspect the flange and surrounding area for signs of delamination or failure.

6.0 PROOF OF COMPLIANCE

Fuel Cell manufacturers are required to provide the following information to enroll in this program:

6.1 TEST RESULTS

Test results shall be documented in a test report. Additional abbreviations used in this section: pounds per inch {ppi} and Newtons per meter {Npm}.

6.1.1 TENSILE STRENGTH

The tensile strength shall be 2,400 psi or greater.

6.1.2 IMPACT PENETRATION

For any sample, any evidence of leakage shall constitute failure.

6.1.3 HYDROSTATIC LEAKAGE TEST

Any indication of water leakage shall constitute a failure.

6.1.4 FITTING PULLOUT TEST

For any fitting, any evidence of rupture, delamination or material failure shall constitute failure.

6.1.5 FLANGE TENSILE STRENGTH

Any evidence of rupture, delamination or material failure shall constitute failure.

7.0 TEST REPORTS

A separate test report, or set of test reports if required, shall be submitted for each product model. If more than one test facility is required to complete all necessary tests, then a separate test report shall be submitted from each one. A test report shall be submitted for each component, if tested separately. The test facility shall assign a unique number to each test report. This number along with the report date and page number shall appear on each page. Each test report shall include:

7.1 RELEVANT INFORMATION

7.1.1 Manufacturer's name, contact name, address and telephone number.

7.1.2 Name, address and telephone number of the test facility.

7.1.3 Name and signature of the responsible test supervisor.

7.1.4 Actual date of the test.

7.1.5 Specification number and effective date.

7.1.6 Product name, description and model designation.

7.1.7 Component name and description.

7.2 TESTS

Each test conducted shall be listed showing the test name, apparatus used, procedure used and test results obtained along with any other appropriate information.

7.3 AUTHENTICATION

Test reports shall be authenticated and stamped by a Professional Engineer who is registered in the state in which the testing is conducted. If necessary, SFI may allow an equivalent entity to provide authentication.

8.0 INITIAL DESIGN VALIDATION

To receive initial recognition from SFI as a participant in the SFI Specification 28.1 Program, the manufacturer must submit to SFI all information delineated in the Proof of Compliance section. This information shall be provided for each Fuel Cell model offered by the applicant that is to be included in the program. Any change in design, materials and/or methods of manufacturing not specifically excluded is considered a model change and, therefore, requires initial design validation.

Note: A model certification is based on successful tests of a cell with the thinnest wall and/or the largest volume. A cell variation shall not be considered certified under this model if it is later produced with a thinner wall and/or a larger volume unless it is also successfully tested.

9.0 PERIODIC REVALIDATION

Test reports with successful test results must be submitted to SFI at least once every three (3) year period following the date of the initial design validation test for each model of Fuel Cell manufactured by the participant. If multiple test reports are required to obtain all test results, then the earliest test date shall be used to determine when the periodic revalidation reports are due.

10.0 CERTIFICATION OF COMPLIANCE

Upon demonstration of successful compliance with all the requirements of the specification and the self-certification program and upon entering the licensing agreement with SFI, the manufacturer may advertise, present and offer the Fuel Cells for sale with the representation that their product meets the SFI Specification 28.1. Continuing certification is contingent upon the following additional considerations: (1) the product shall be resubmitted for testing following any change in design, materials and/or methods of manufacturing not specifically excluded, and (2) periodic revalidation test reports are submitted when due to SFI.

11.0 CONFORMANCE LABELS

The conformance label is a sticker. The serialized sticker shall be placed on the exterior surface, near the access flange. The fuel cell type, date of manufacturer and sticker serial number shall be permanently marked on the unit. The permanent markings shall not be affected by fuels used in the cell. The serial number should appear on the customer invoice to aid in identification and tracking.

12.0 DECERTIFICATION

Participating manufacturers are subject to decertification when not in compliance with the requirements of this program or when their products are not in compliance with the requirements of this specification. Decertification will provide SFI the right to effect any and all remedies which are available to SFI in the licensing agreement.

13.0 APPEAL PROCEDURE

In the event of decertification, the manufacturer is entitled to an appeal of the decision of SFI. Requests for appeal must be received by SFI no later than thirty days following receipt of the notice of decertification. Appeals of such decisions will be heard at the next meeting of the Board of Directors of SFI.

14.0 STATEMENT OF LIMITATIONS

Testing procedures and/or standards contained in this specification are intended for use only as a guide in determining compliance with the minimum performance requirements as defined herein. The granting and assignment of the "This Manufacturer Certifies That This Product Meets SFI Specification 28.1" logo/designation is in no way an endorsement or certification of product performance or reliability by SFI. SFI, its officers, directors and/or members assume no responsibility, legal or otherwise, for failure or malfunctions of a product under this program.

15.0 COSTS

All costs involved in this program will be absorbed by the submitting manufacturer.

16.0 COMPLIANCE PERIOD

As this specification is revised to reflect changes in technology and/or field conditions, to remain current, participating manufacturers in the SFI Specification 28.1, Fuel Cell, Program, must demonstrate full compliance with the requirements of this specification within ninety (90) days of the latest effective date.

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