SFI SPECIFICATION 28.2 EFFECTIVE: July 14, 2000*

PRODUCT: Crash Resistant Fuel Cells (Does Not Apply to Indy-Type Car Crashworthy 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 Crash Resistant Fuel Cells used by individuals engaged in competitive motorsports at least in the following USAC divisions: Sprint Car, Midget and T.Q. Midget.

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 28.2" 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 Crash Resistant Fuel Cells that meet or exceed the SFI Specification 28.2 test standards, by complying with the requirements of the SFI Specification 28.2 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 Crash Resistant Fuel Cells in compliance with all requirements of the SFI Specification 28.2 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 so they can be visually inspected after installation with the manufacturer's name, trademark or symbol, model, serial number, 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 Crash Resistant Fuel Cell: An enclosure for fuel that is generally encased within a metal container or other appropriate structural material but which has the capability to undergo moderate crash loads while retaining integrity and resisting rupture.

2.2 Flange: Flanges are collar-like structural materials, generally either of rubber or of the same material as the bladder wall, which tends to neutralize the effects of bolt holes in the bladder wall and prevents fuel seepage at the nut ring.

2.3 Nut Rings: A metal ring conforming to the flange shape that contains nuts for securing access covers, etc. to the bladder flange.

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.

3.0 CONSTRUCTION

3.1 A fuel cell is typically made of Polymer type material with or without reinforcement provided by a molded-in fabric. The walls are generally flexible to allow compliance with the external container. Exterior containers are not covered by this specification.

3.2 The fuel cell shall be constructed such that it meets all minimum requirements of this specification and that it conforms to all operational and environmental requisites established by sanctioning bodies and generally accepted motorsports circumstances.

3.3 All fuel cells must conform to the following specifications:

3.3.1 They must be capable of readily rearranging their shapes safely and must have a fuel resistant inner surface.

3.3.2 They must be fit for the purposes intended and shall be constructed in accordance with standard industry practices.

3.3.3 They must continue to meet or exceed the values achieved during the test program (Section 5.0) throughout their useful life.

3.3.4 All fuel cell openings shall be through metal fittings attached to the tank. Rubber or fabric reinforced nipple fittings are prohibited.

3.3.5 All access covers shall be of materials that have an elongation and ultimate load-carrying capability equal to or greater than 2024-T4 aluminum in the .1875 thickness.

4.0 MODEL CLASSIFICATION

Model designation is based on type of material, wall thickness and construction method and configuration, but not generally shape or size. Therefore, changes in shape and/or size do not constitute a model change unless those changes produce a required modification to wall thickness or construction method. Any other changes will be considered a model modification and will require revalidation testing.

5.0 TESTING

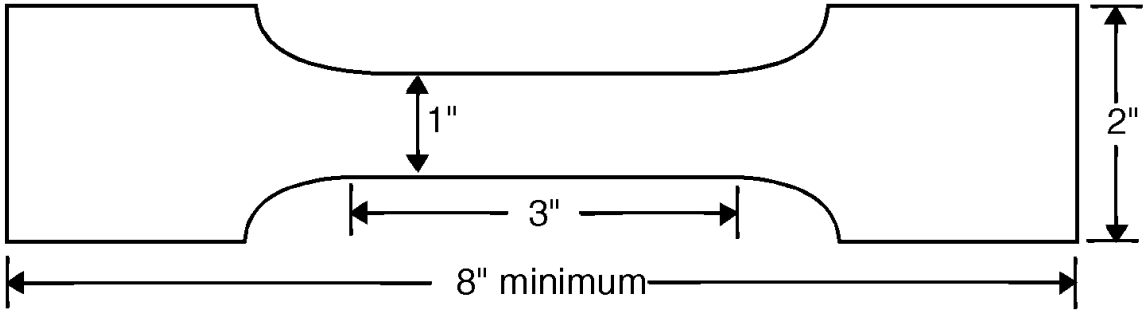
The fuel cell bladder (insert) product and material shall be subjected to the following tests:

5.1 TENSILE STRENGTH

5.1.1 SAMPLES

Eight (8) samples cut from a production fuel cell bladder per Figure 1 of this specification shall be conditioned at 73° ± 5°F and 50% ± 5% relative humidity for 24 hours prior to testing. If the bladder is not a constant thickness, the samples shall be obtained from the area of minimum wall thickness. If the bladder contains fabric ply or plies, four (4) samples shall be

cut parallel and four (4) samples shall be cut perpendicular to the strongest fabric warp threads direction.



Note: if insert material contains a fabric, cut 4 specimens parallel to the warp and 4 specimens perpendicular to the warp.

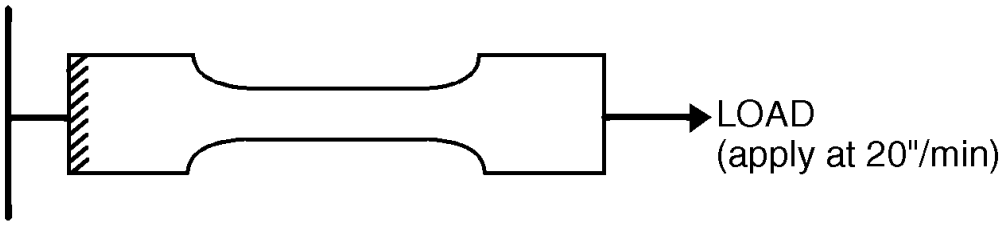


Figure 1
Tensile Test Material Specimen Size and Shape

5.1.2 APPARATUS

The testing machine, grip arrangement and associated measuring devices shall conform to paragraph 5.0 of ASTM D638 unless otherwise specified.

5.1.3 PROCEDURE

After conditioning, each sample shall be subjected to a tensile load at a rate of 20 inches per minute until separation occurs. All the load values at failure shall be recorded and the minimum value shall be specified as the fuel cell bladder wall tensile strength.

5.2 CONSTANT RATE TEAR

5.2.1 SAMPLES

Twenty (20) samples cut from a production fuel cell bladder conforming to Figure 2 dimensions and including any locally thinned bladder material, if any, shall be conditioned at 73° ± 5°F and 50% ± 5% relative humidity for 24 hours prior to testing. If the fuel cell bladder includes fabric ply or plies, ten (10) samples shall be cut parallel and ten (10) samples shall be cut perpendicular to the strongest fabric warp threads direction.

5.2.2 APPARATUS

The testing machine and associated measuring devices shall conform to paragraph 5.0 of ASTM D638 unless otherwise specified. The metal test clips shall conform to Figures 2A and 2B of these SFI Specification requirements.

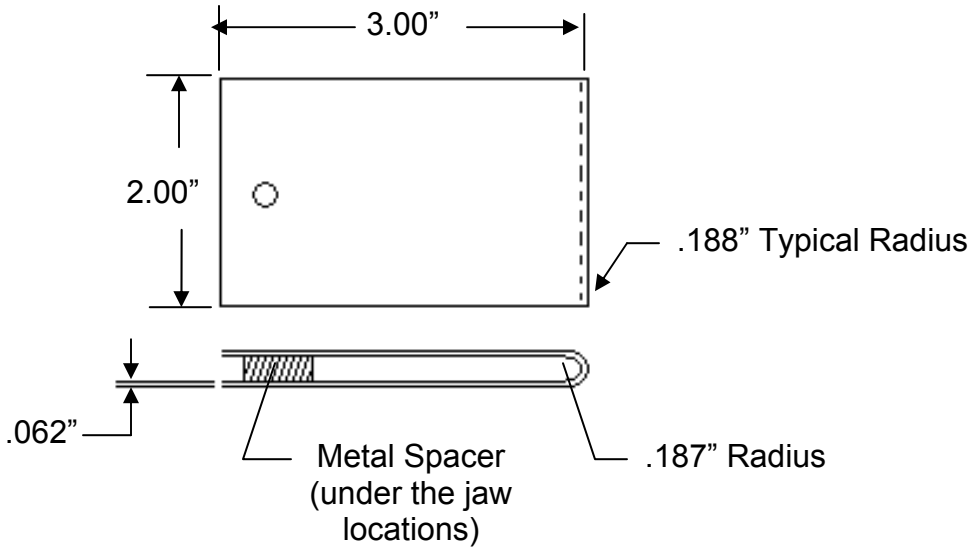


Figure 2A

Metal Test Clip
(2 required)

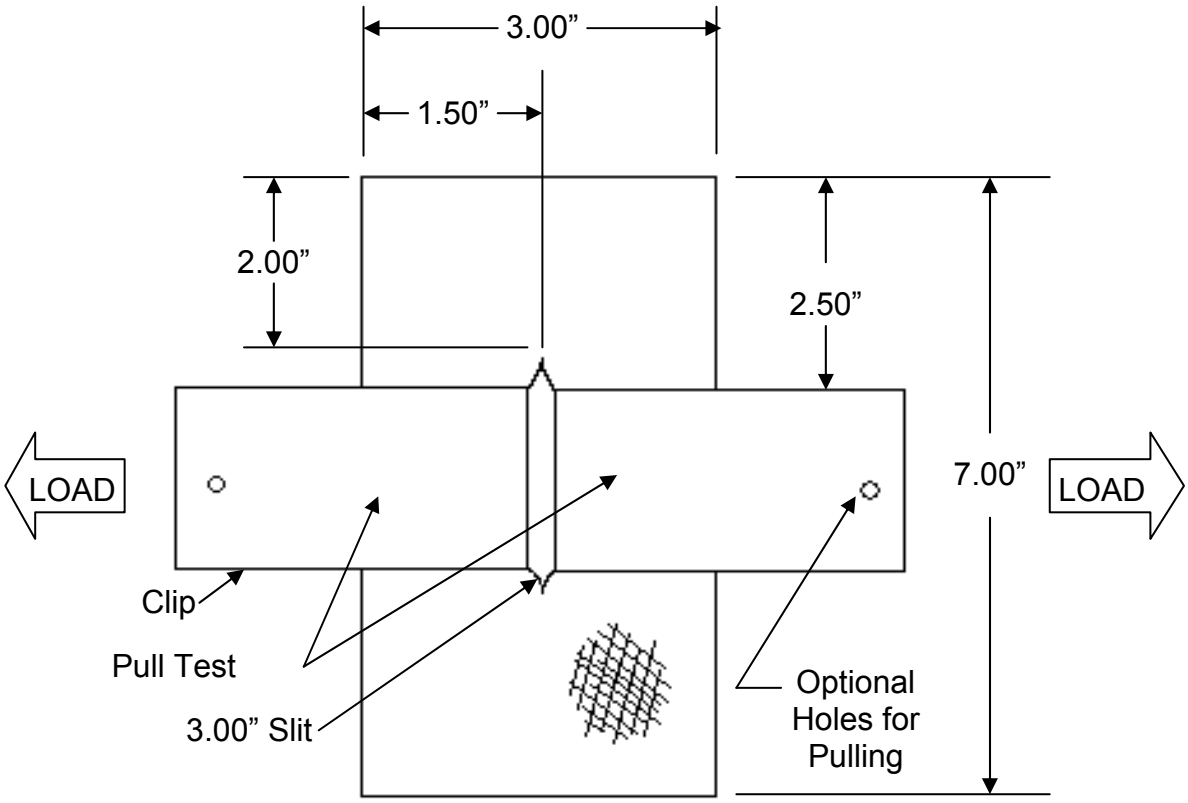


Figure 2B

Constant Tear Rate Test Specimen

Unless otherwise specified, tolerances: .xx” ± .06”
Dimensions: .xxx” ± .030”

5.2.3 PROCEDURE

After conditioning, each sample shall be subjected to jaw separation at a rate of 20 ± 5 inches per minute until complete separation takes place. A graph of applied force versus jaw separation shall be generated for each sample. Determine the total energy required for separation of each sample by calculating the area under the curve in foot pounds and recording all the values.

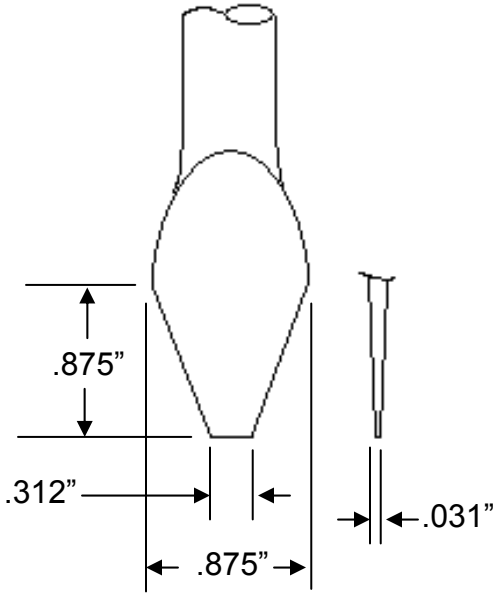
5.3 PUNCTURE RESISTANCE

5.3.1 SAMPLES

Five (5) samples approximately 6.0 inches in diameter cut from a production fuel cell bladder shall be conditioned at 73° ± 5°F and 50% ± 5% relative humidity for 24 hours prior to testing. If the bladder is not a constant thickness, the samples shall be cut from the area of minimum wall thickness.

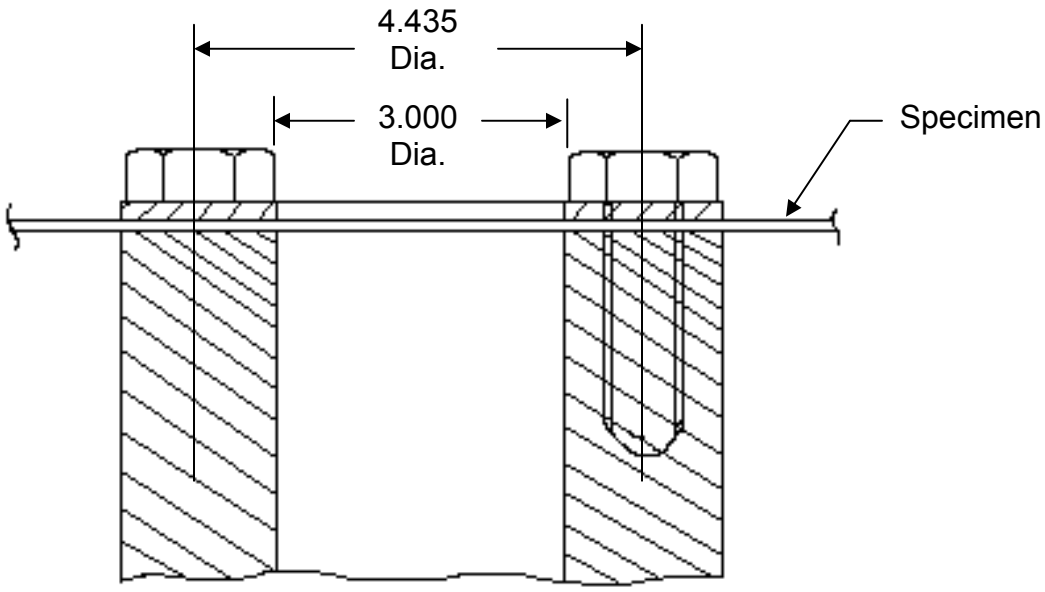
5.3.2 APPARATUS

The testing machine shall conform to paragraph 5.0 of ASTM D638 unless otherwise specified. The piercing instrument and sample holder shall conform to Figure 3 of this Specification (Figure 3 of MIL-T-6396).



End of Piercing Instrument

Figure 3



Specimen Holder

5.3.3 PROCEDURE

The piercing instrument shall be forced into the sample at its approximate center at a rate of 20 ± 5 inches per minute until puncture is achieved. Puncture is defined as visible evidence that the instrument can be seen from the side of the sample opposite to the instrument. The force required shall be recorded.

5.4 FITTING PULLOUT STRENGTH

5.4.1 SAMPLES

Eight (8) samples cut from a production fuel cell bladder with fitting and access cover attached per Figures 4 and 5 of this Specification shall be conditioned at 73° ± 5°F and 50% ± 5% relative humidity for 24 hours prior to testing.

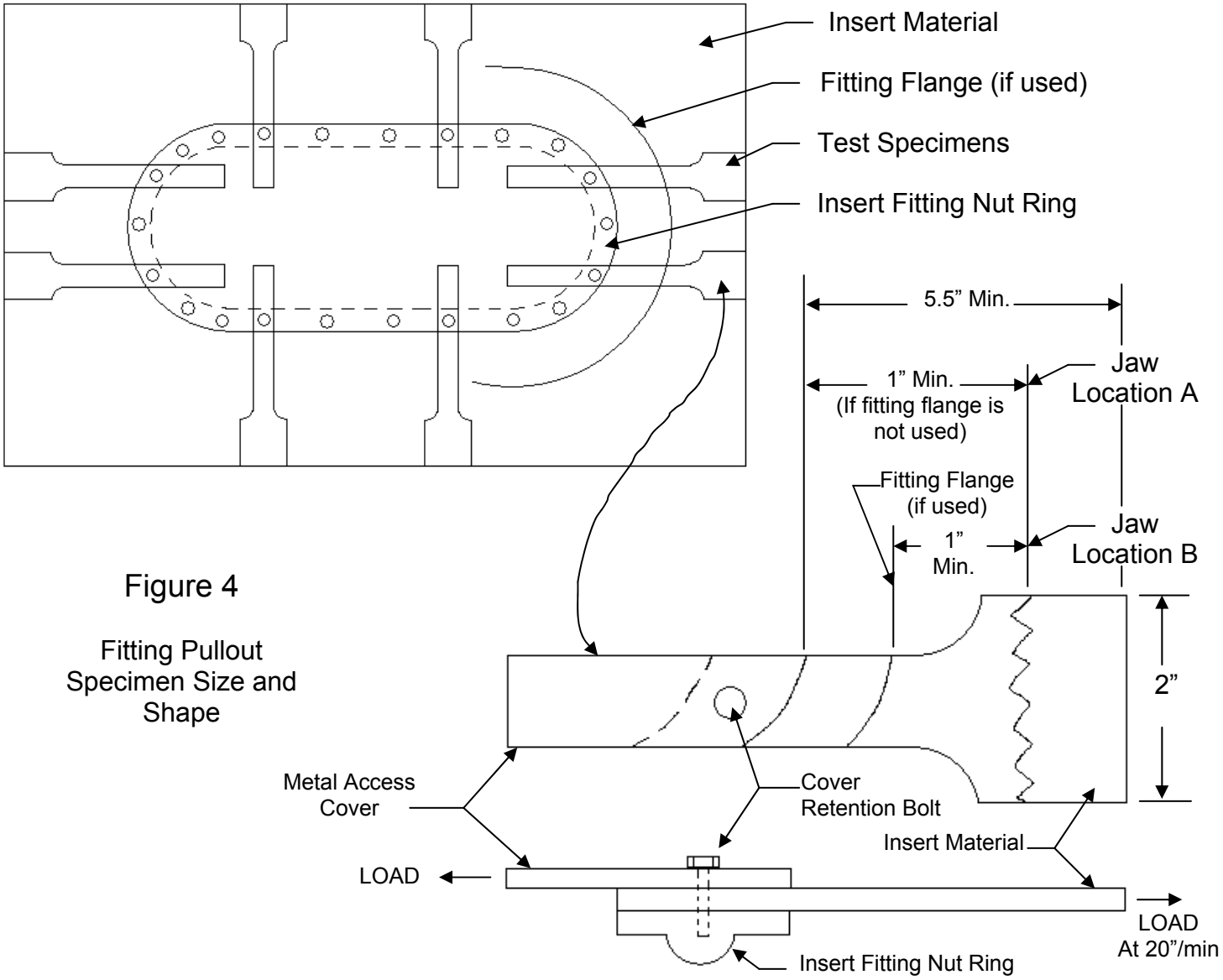


Figure 4

Fitting Pullout Specimen Size and Shape

5.4.2 APPARATUS

The testing machine and grip arrangement and associated measuring devices shall be the same as in paragraph 5.1.2 above. Jaw location with a fitting flange not used shall be at location (A) on Figure 5. Jaw location with a fitting flange bonded to the bladder wall shall be at location (B) on Figure 5. Bolt design and torque shall be as prescribed by the manufacturer.

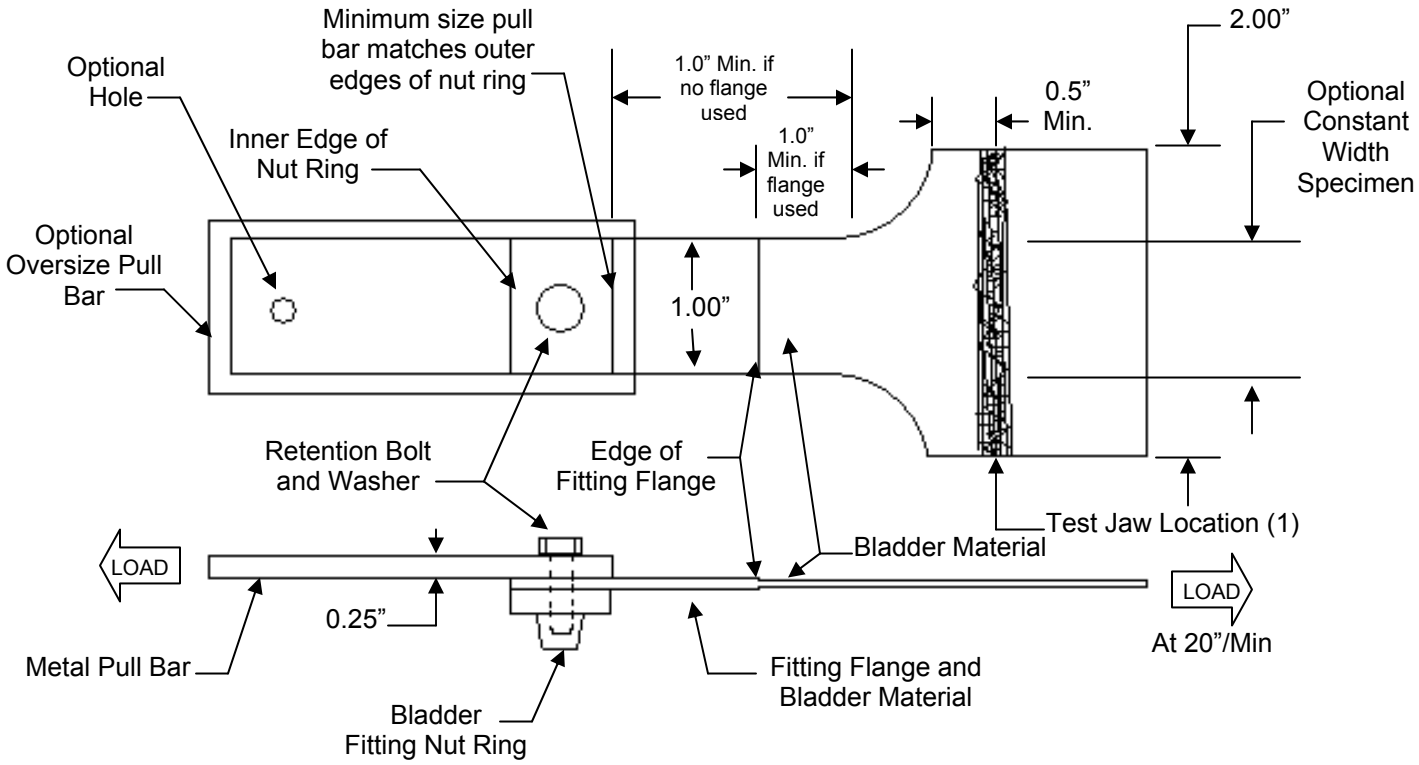


Figure 5
Fitting Pullout Specimen &
Test Hardware

5.4.3 PROCEDURE

After conditioning, each sample shall be subjected to a tensile load at a rate of 20 inches per minute until separation occurs (see Figure 5 for loading method). All the load values at failure shall be recorded and the minimum value shall be specified as the fitting pullout strength.

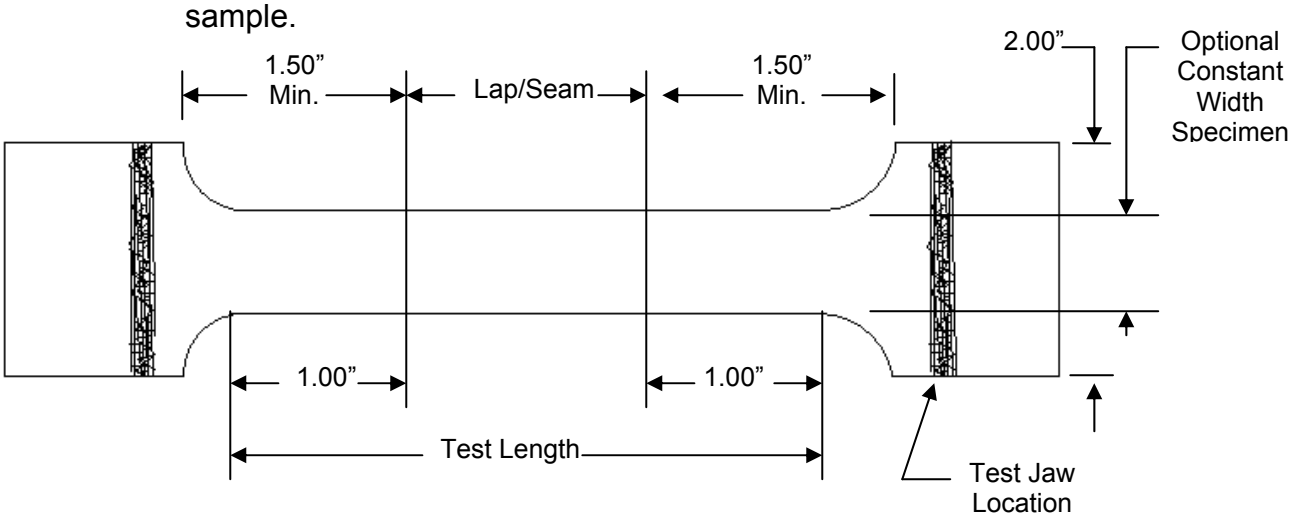
5.5 SEAM STRENGTH

5.5.1 SAMPLES

Eight (8) samples cut from a production fuel cell bladder containing a minimum overlap seam per Figure 6 of this specification, four (4) samples aligned parallel and four (4) samples aligned perpendicular to the strongest fabric warp plies (if used), shall be conditioned at 73° ± 5°F and 50% ± 5% relative humidity for 24 hours prior to testing.

5.5.2 APPARATUS

Same as in paragraph 5.1.2 above. Jaw location shall be a minimum of 1.50 inches from edges of seam as shown in Figure 6 and in the 2.00 inch width of sample.



Test Length Shall Be Long Enough to Hold a Complete Seam or Lap and Have One (1) Inch of Unseamed Bladder Material at Each End as Shown Below

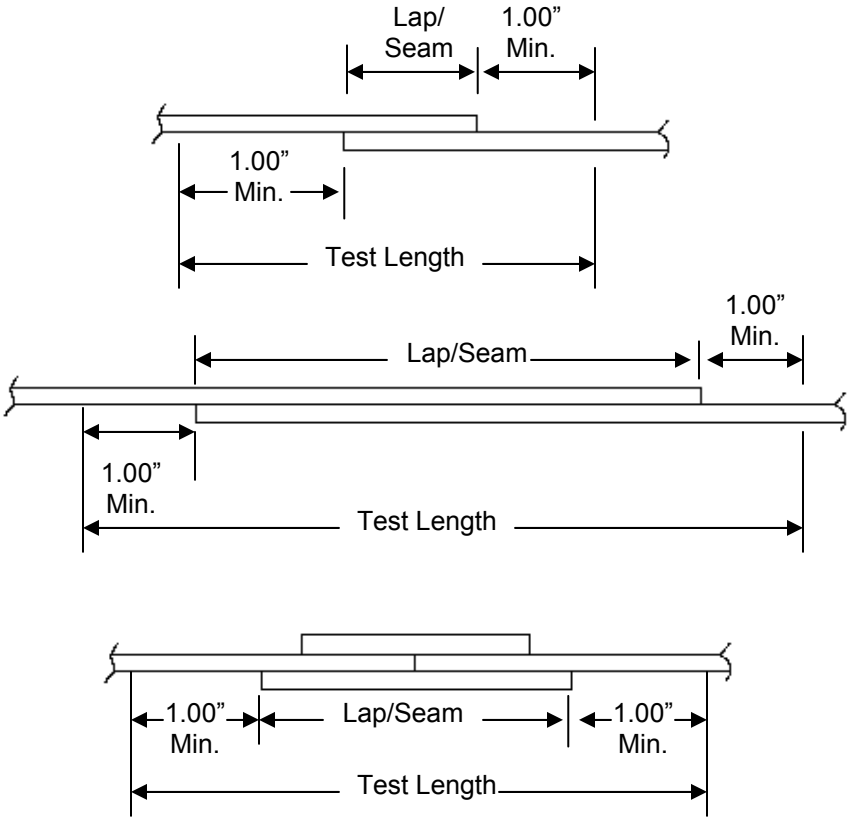


Figure 6

Seam Specimens, Size and Shape

5.5.3. PROCEDURE

After conditioning, each sample shall be subjected to a tensile load at a rate of 20 inches per minute until separation occurs. All the load values at failure shall be recorded and the minimum value shall be specified as the seam strength.

6.0 PROOF OF COMPLIANCE

Crash Resistant 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.

6.1.1 TENSILE STRENGTH

Tensile strength values in pounds per inch of width shall be reported for all samples tested but the minimum value shall be established as the "Tensile Strength."

6.1.2 CONSTANT RATE TEAR RESISTANCE

All values of separation energy in foot-pounds calculated per paragraph 5.2.3 shall be reported but no value under 100 foot-pounds shall be acceptable. The minimum value (above 100 foot-pounds) shall be established as "Constant Rate Tear Resistance."

6.1.3 PUNCTURE RESISTANCE

All values of puncture load as measured per paragraph 5.3.3 shall be reported but no value under 300 lbs. shall be acceptable. The minimum value above 300 lbs. shall be established as "Puncture Resistance."

6.1.4 FITTING PULLOUT STRENGTH

All values of the fitting pullout strength shall be reported in pounds-per-inch of width but the minimum acceptable value shall not be less than 80% of the tensile strength as determined per paragraph 6.1.1 above.

6.1.5 SEAM STRENGTH

All values of the seam strength shall be reported in pounds-per-inch of width but the minimum acceptable value shall not be less than 80% of the tensile strength as determined per paragraph 6.1.1 above.

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 28.2 Program, the manufacturer must submit to SFI all information delineated in the Proof of Compliance section. This information shall be provided for each Crash Resistant 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.

9.0 PERIODIC REVALIDATION

Test reports with successful test results must be submitted to SFI at least once every 36 month period following the date of the initial design validation test for each model of Crash Resistant 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 Crash Resistant Fuel Cells for sale with the representation that their product meets the SFI Specification 28.2. 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.

The manufacturer is required to keep all top drawings, copies of test reports, and all other engineering records which define the specific product under safe keeping and in its possession, available for inspection by SFI, for not less than fifteen (15) years after approval is granted, or for three (3) years after the last tank still being used in racing is retired, whichever is longer.

11.0 CONFORMANCE LABELS

The conformance label is a sticker. The serialized sticker shall be placed on the exterior surface, near the access flange ***in a location easily readable by technical inspectors***. The Crash Resistant 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 28.2" 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 28.2, Crash Resistant Fuel Cells, Program, must demonstrate full compliance with the requirements of this specification within ninety (90) days of the latest effective date.

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