

AIA COMMENTS ON APPENDIX F OF NPRM 84-21: SPECIAL REVIEW; TRANSPORT CATEGORY AIRPLANE AIRWORTHINESS STANDARDS

Many sections of the current version of Appendix F, and the proposed version in this NPRM, need to be updated and clarified. The current version of Appendix F is ambiguous about several aspects of Test Procedures, and these ambiguities also appear in the Appendix F of this NPRM. A variety of interpretations has been developed and is currently practiced, with the result that it is uncommon for any two test facilities to perform a given test or to interpret test results in the same way. It is not in fact unusual for one test facility and/or operator to fail a material that another test facility and/or operator passes. This situation is very frustrating.

The AIA has conducted a review of the test practices used over the years by the Federal Aviation Administration Technical Center (FAATC), and by airplane manufacturers to generate certification data. From the results of this survey, the AIA has developed several recommendations for removing the ambiguities and establishing uniform test practices: AIA members will implement these recommendations immediately.

Other comments propose substantial changes in wording to update and clarify what the AIA believes is intended in the regulation. Most comments however involve changes to the proposed wording to correct omissions, remove redundancies, and clarify minor points. These modifications have been incorporated into and are presented in a recommended rewrite of the NPRM Appendix F.

The more extensive changes recommended by the AIA are as follows:

1) APPARATUS

This section needs updating to modify the callout for test cabinets, and to clarify the callout for burner fuel.

a) Test Cabinets

In subparagraph (b)(3) of the NPRM, it is stated that the "test must be conducted in a draft-free cabinet in accordance with Federal Test Method Standard 191, Method 5903 for the vertical test, or Method 5906 for the horizontal test." No callout is given for either the forty-five degree angle test or the sixty degree angle test.

The FAA requested that the ASTM F07.06 subcommittee on Aerospace Industry Test Methods--Flammability be established, with representation from the FAA and the AIA, to create test methods that could be used in FAA regulations. The F07.06 committee has released several standards that can be used. The AIA recommends that the sub paragraph (b)(3) be revised to replace the reference to Federal Test Method Standard 191, Methods 5903 and 5906 for test cabinet construction with ASTM F501 for the vertical test, ASTM F776 for the horizontal and forty-five degree angle test, and ASTM F777 for the sixty degree angle test.

b) Burner Fuel

Method 5903 requires that a rather expensive gas mixture (commonly called B-gas, which is supplied by suppliers in cylinders) be used for the burner fuel; Method 5906 does not require a specific gas. For reasons that are not understood, B-gas produces inconsistent flame charac-

teristics from cylinder to cylinder. This inconsistency is reflected in test results. The FAATC and several test facilities in the AIA have switched to minimum 99% purity methane instead of B-gas. The AIA recommends that subparagraph (b)(3) be revised to specify methane at minimum 99% purity for the burner fuel.

2) FLAME PLACEMENT

Currently, flame placement for the vertical tests in FAR 25.853(a) and 25.853(b) is required to be "at the centerline of the lower edge". The NPRM does not contain a requirement for flame placement; presumably this was an inadvertent oversight.

The "centerline of the lower edge" is reasonably a line that bisects the bottom surface of the specimen from back to front. This callout for flame placement is ambiguous since it does not specify a point, but a line. Where the flame is placed along this line greatly affects test results for many materials. Some facilities/operators place the centerline of the burner at the geometrical center of the bottom surface of the specimen; some place the centerline of the burner in line with the face of the specimen; others place it somewhere in between.

The AIA feels it is essential to resolve the flame placement question to ensure uniformity of test results, and recommends that sub paragraph (b)(4) be revised to incorporate the following, which generally reflects flame placement practices at airplane manufacturers and the FAA Technical Center: For specimens up to 3/4 inch thick, the burner centerline must be positioned under the center of the bottom surface of the specimen; for thicker specimens, the burner centerline must be centered under the bottom surface of the specimen 3/8 inch in from the surface exposed in the airplane.

3) FLAME TEMPERATURE

The current and proposed Appendix F versions require that flame temperature of the burner be monitored, and that it be at least 1550F for the vertical, horizontal, and 45-degree tests, and at least 1750F for the 60-degree test.

Neither the current or proposed Appendix F specifies a measurement method beyond a "calibrated thermocouple pyrometer". The temperature indicated by a thermocouple placed in a flame is that temperature which the thermocouple reaches, which is always lower than the actual flame temperature because the thermocouple loses heat (energy) both by radiation and conduction. The rate of energy loss by the thermocouple therefore affects the apparent flame temperature, and depends on several factors (i.e., wire size or gage, flame size, and whether it is placed in the flame horizontally or vertically).

All the burner fuels (e.g., methane, natural gas, propane, B-gas) that have been used for these tests in the past produce flames whose actual temperatures are known to be substantially higher (up to several hundred degrees) than the minimum temperatures required. It is not possible in principle to satisfy the burner size and flame height requirements, and simultaneously achieve a flame whose temperatures are near the allowed 1550F and 1750F minimums.

The AIA recommends that the flame temperature requirement be removed since it adds unnecessary confusion and expense to the test requirements.

4) BURN LENGTH

The definition of burn length in subparagraph (b)(8) of the NPRM is the same as that in the current version of Appendix F: "Burn length is the distance from the original edge to the farthest evidence of damage to the test specimen due to flame impingement, including areas of partial or complete consumption, charring, or embrittlement, but not including areas sooted, stained, warped, or discolored, nor areas where material has shrunk or melted away from the heat source." This is verbatim the definition the AIA recommended to the FAA for use in rulemaking in July, 1968 from the results of its Crashworthiness Development Program.

This definition has caused much confusion, because it is difficult to determine where "damage ... due to flame impingement" stops and "areas where material has shrunk or melted away from the heat source" start. Subjective judgment is required, and widely varying results are obtained by different test operators. Frequently materials that are said to pass by some are said to fail by others. In reference to a specific case involving questions about the certification of a particular material, after widely different estimates of burn length were offered by airplane manufacturers and FAA regions, the Chief, Airframe Branch, AFS-120 was requested by the Chief, Systems and Equipment Branch, AWE-130 (ref. AWE-130:8109 dated July 1977) "to review this subject, since there exists a difference of interpretation between manufacturers and (FAA) regions, and inform us as to the intent of the rule and the correct interpretation of test results. It is imperative that all persons apply the rules uniformly; therefore, we suggest that you inform all regions of the correct interpretation of burn length and consider rewording for paragraph (h) (burn length) of Appendix F." The subject is still under review by AFS-120.

To assist the resolution of this problem, the AIA recommends the following modified wording, which provides a more objective criterion for measurement and reflects the intent of the original AIA recommendation: "Burn length is the distance from the original specimen edge or test mark to the farthest point showing evidence of damage due to that area's combustion, including areas of partial consumption, charring, or embrittlement, but not including areas sooted, stained, warped, or discolored, nor areas where material has shrunk or melted away from the heat."

Minor changes to the NPRM Appendix F that are recommended by the AIA are as follows:

Subparagraphs (a)(1)(i), (a)(1)(ii), (a)(1)(iv), and (a)(1)(v): Revise statements "when tested....in accordance with applicable portions of this Appendix" to read "when tested....in accordance with applicable portions of paragraph (b) of this Appendix" to identify paragraph (b) as the section involved.

Subparagraph (b)(1) Conditioning: Revise the second sentence "Each specimen must remain in the conditioning environment until it is subjected to the flame" to read "Each specimen must remain in the conditioning environment until immediately before being tested" to allow a reasonable amount of time for specimen installation into the test fixture before its being subjected to the flame.

Subparagraph (b)(2) Specimen Configuration: Revise the sentence "In the case of fabrics, both the warp and fill direction of the weave must be tested to

determine the most critical flammability condition" to read "In the case of coated and uncoated fabrics, both the warp and fill direction of the weave must be tested" for clarification, and to delete a redundant phrase. Relocate the requirements for specimen mounting during a test to subparagraphs (b)(4), (b)(5), and (b)(6) as appropriate. Delete the requirement that the edges away from the fire for horizontal and vertical test specimens be held securely during a test since doing so does not affect the test or its results, but does necessitate that the specimens be longer than 12 inches, adding unnecessary expense to the fabrication of test specimens because of the non-standard size. Restructuring this paragraph as presented in the proposed rewrite of the NPRM Appendix F is recommended to improve clarity: no changes in content are involved.

Subparagraph (b)(3) Apparatus: Include the callout for a Bunsen or Tirrill burner and the burner fuel in this paragraph, since the same burner is used for all tests specified. Use of the rewrite of this paragraph presented in the proposed rewrite of the NPRM Appendix F is recommended.

Subparagraph (b)(4) Vertical Test: Delete the sentence "For fabrics, the direction of weave corresponding to the most critical flammability conditions must be parallel to the longest dimension" since this requirement is already covered in subparagraph (b)(2). Revise the sentence "Flame time...may be recorded" to "Flame time...must be recorded" since it is required that data be recorded. Revise the sentence "The burn length determined in accordance with subparagraph (7) of this paragraph..." to read "The burn length determined in accordance with subparagraph (b)(8) of this Appendix..." to correct a typographical error and provide clarity. Restructuring this paragraph as presented in the proposed rewrite of the NPRM Appendix F is recommended to improve clarity: no changes in content are involved.

Subparagraph (b)(5) Horizontal Test: Revise the sentence "The specimen must be positioned to that edge being tested is centered 3/4 inch above top of the burner" (sic) to read "The specimen must be positioned so that the edge being tested is 3/4 inch above the top of, and on the centerline of, the burner", which is the wording in the current Appendix F, to provide clarification. Revise the sentence "A minimum of 10 inches of specimen must be used for timing purposes, approximately 1 1/2 inches must burn before the burning front reaches the timing zone, and the average burn rate must be recorded" to read "The time required for the burning front to move the 10 inches between a point 1 1/2 inches and a point 11 1/2 inches from the ignited end of the specimen, and the resulting calculated burn rate, must be recorded for each specimen and the results averaged" for clarification. Restructuring this paragraph as presented in the proposed rewrite of the NPRM Appendix F is recommended to improve clarity: no changes in content are involved.

Subparagraph (b)(6) Forty-five degree Test: Delete the sentence "Suitable precautions must be taken to avoid drafts" because it is superfluous since the test is required to be performed in a draft-free cabinet per Subparagraph (b)(2). Revise the sentence "One-third of the flame must be applied for 30 seconds and then removed" to read "The burner must be positioned vertically with its center 3/4 inch below the center of the specimen. The flame must be applied for 30 seconds and then removed" to remove ambiguity and to conform with current test practices. Add a sentence "Flame penetration through any specimen tested is considered a failure" to conform to current practices in interpretation of test results. Use of the rewrite of this paragraph presented in the proposed rewrite of the NPRM Appendix F is recommended for clarity.

Subparagraph (b)(7) Sixty degree Test: Restructuring this paragraph as presented in the proposed rewrite of the NPRM Appendix F is recommended to improve clarity. No changes in content are involved.

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The AIA proposes that the following rewrite of Appendix F be adopted:

Appendix F--Test Criteria and Procedures for Showing Compliance with §25.853

(a) Material test criteria

(1) Interior compartments occupied by crew or passengers:

- (i) Interior ceiling panels, interior wall panels, partitions, galley structure, large cabinet walls, structural flooring, and materials used in the construction of stowage compartments (other than under-seat stowage compartments and compartments for stowing small items such as magazines and maps) must be self-extinguishing when tested vertically in accordance with the applicable portions of paragraph (b) of this Appendix. The average burn length may not exceed 6 inches, the average flame time after removal of the flame source may not exceed 15 seconds, and drippings from the test specimens may not continue to flame for more than an average of 3 seconds after falling.
- (ii) Floor coverings, textiles (including draperies and upholstery), seat cushions, padding, decorative and nondecorative coated fabrics, leather, trays and galley furnishings, electrical conduit, thermal and acoustical insulation and insulation covering, air ducting, joint and edge covering, cargo compartment liners, insulation blankets, cargo covers and transparencies, molded and thermoformed parts, air ducting joints, and trim strips (decorative and chafing), that are constructed of materials not covered in subparagraph (a)(1)(iv) below, must be self-extinguishing when tested vertically in accordance with the applicable portions of paragraph (b) of this Appendix. The average burn length may not exceed 8 inches, the average flame time after removal of the flame source may not exceed 15 seconds, and drippings from the test specimens may not continue to flame for more than an average of 5 seconds after falling.
- (iii) Motion picture film must be safety film meeting the Standard Specifications for Safety Photographic Film PH 1.25 (available from the American National Standards Institute, 1430 Broadway, New York, N.Y., 10018). If the film travels through ducts, the ducts must meet the requirements of subparagraph (a)(1)(ii) of this Appendix.
- (iv) Clear plastic windows and signs, parts constructed in whole or in part of elastomeric materials, edge-lighted instrument assemblies consisting of two or more instruments in a common housing, seat belts, shoulder harnesses, and cargo and baggage tiedown equipment, including containers, bins, pallets, etc., used in passenger or crew compartments, may not have an average burn rate greater than 2.5 inches per minute when tested horizontally in accordance with the applicable portions of paragraph (b) of this Appendix.

(v) Except for small parts (such as knobs, handles, rollers, fasteners, clips, grommets, rub strips, pulleys, and small electrical parts) that would not contribute significantly to the propagation of a fire and for electrical wire and cable insulation, materials in items not specified in subparagraphs (a)(1)(i), (a)(1)(ii), (a)(1)(iii), or (a)(1)(iv) may not have an average burn rate greater than 4.0 inches per minute when tested horizontally in accordance with the applicable portions of paragraph (b) of this Appendix, or by other approved methods.

(2) Cargo and baggage compartments not occupied by crew or passengers:

- (i) Thermal and acoustic insulation (including coverings) used in each cargo and baggage compartment must be constructed of materials that meet the requirements set forth in subparagraph (a)(1)(ii) of this Appendix.
- (ii) Cargo or baggage compartments defined in §25.857 as Class B through E must have a liner constructed of materials that meet the requirements of subparagraph (a)(1)(ii) of this Appendix, and be separated from the airplane structure (except for attachments). Such liners must also be tested at a 45-degree angle in accordance with the applicable portions of paragraph (b) of this Appendix. The flame may not penetrate (pass through) the material during application of the flame or subsequent to its removal, the average flame time after removal of the flame source may not exceed 15 seconds, and the average glow time may not exceed 10 seconds.
- (iii) Insulation blankets and covers used to protect cargo must be constructed of materials that meet the requirements of subparagraph (a)(1)(ii) of this Appendix. Tiedown equipment (including containers, bins, and pallets) used in each cargo and baggage compartment must be constructed of materials that meet the requirements of subparagraph (a)(1)(v) of this Appendix.

(3) Electrical system components

Insulation on electrical wire or cable installed in any area of the fuselage must be self-extinguishing when tested at a 60-degree angle according to the applicable portions of paragraph (b) of this Appendix. The average burn length may not exceed 3 inches, the average flame time after removal of the flame source may not exceed 30 seconds, and drippings from the test specimens may not continue to flame for more than an average of 3 seconds after falling.

(b) Test Procedures

- (1) Conditioning: Specimens must be conditioned to 70 +/- 5 F, and at 50 percent +/- 5 percent relative humidity until moisture equilibrium is reached, or for 24 hours. Each specimen must remain in the conditioning environment until immediately before being tested.
- (2) Specimen configuration: Except for small parts and electrical wire and cable insulation, materials must be tested either as a section cut from a fabricated part as installed in the airplane or as a specimen simulating a cut section, such as a specimen cut from a flat sheet of the

material or a model of the fabricated part. The specimen may be cut from any location in a fabricated part, except that (1) specimens cut from materials covered by subparagraphs (a)(1)(i) and (a)(1)(ii) of this Appendix must not include a finished or protected edge, but edges representative of the actual cross-section of the material or part installed in the airplane, and (2) fabricated units, such as sandwich panels, must not be separated for test. The specimen thickness must be no thicker than the minimum thickness to be qualified for use in the airplane, except that (1) for thick foam parts, such as seat cushions, test specimens must be 1/2 inch in thickness; (2) for parts covered by subparagraph (a)(1)(v) of this Appendix, test specimens must be no more than 1/8 inch in thickness; and (3) for electrical wire and cable covered by subparagraph (a)(3) of this Appendix, test specimens must be the same size as used in the airplane. In the case of coated and uncoated fabrics, both the warp and fill direction of the weave must be tested.

- (3) Apparatus: Tests must be conducted in draft-free cabinets constructed in accordance with ASTM F501 for the vertical test, ASTM F776 for the horizontal and 45-degree angle test, and ASTM F777 for the 60-degree angle test, or equivalent. Specimens that are too large for these cabinets must be tested under similar draft free conditions. The flame source must be provided by a Bunsen or Tirrill burner that has a nominal 3/8 inch internal diameter, and that is fueled with methane gas of 99% minimum purity.
- (4) Vertical test: A minimum of three specimens must be tested. Unless the actual size of the part used in the airplane is smaller, the specimens must have an exposed area at least 2 inches wide and 12 inches long, and during the test be mounted vertically in a metal frame so that the two long edges are held securely. For smaller specimens, the specimens must be no smaller than the part used in the airplane and be mounted vertically in a metal frame during the test. The specimen must be exposed to the flame source described in subparagraph (b)(3) of this Appendix, with the air supply to the burner shut off and flame height adjusted to 1 1/2 inches. The lower edge of the specimen must be 3/4 inch above the top edge of the burner. For specimens up to 3/4 inch thick, the burner centerline must be positioned under the center of the bottom surface of the specimen; for thicker specimens, the burner centerline must be centered under the bottom surface of the specimen 3/8 inch in from the surface exposed when installed in the airplane. For materials covered by subparagraph (a)(1)(i) of this Appendix, the flame must be applied for 60 seconds and then removed; for materials covered by subparagraph (a)(1)(ii) of this Appendix, the flame must be applied for 12 seconds and then removed. The burn length must be determined to the nearest tenth of an inch in accordance with subparagraph (b)(8) of this Appendix. Flame time, burn length, and flaming time of any drippings must be recorded for each specimen and the results averaged.
- (5) Horizontal test: A minimum of three specimens must be tested. Unless the actual size of the part used in the airplane is smaller, the specimens must have an exposed area at least 2 inches wide and 12 inches long, and during the test be mounted horizontally in a metal frame so that the two long edges are held securely. For smaller specimens, the specimen must be no smaller than the part used in the airplane and be

mounted horizontally in a metal frame during the test. The surface exposed when installed in the airplane must be face down for the test. The specimen must be exposed to the flame source described in subparagraph (b)(3) of this Appendix, with the air supply to the burner shut off and the flame height adjusted to 1 1/2 inches. The specimen must be positioned so that the edge being tested is 3/4 inch above the top of, and on the centerline of, the burner. The flame must be applied for 15 seconds and then removed. The time required for the burning front to move the 10 inches between a point 1 1/2 inches and a point 11 1/2 inches from the ignited end of the specimen, and the resulting calculated burn rate, must be recorded for each specimen and the results averaged.

- (6) Forty-five degree test: A minimum of three specimens must be tested. During the test, the specimens must be mounted at a 45-degree angle to the horizontal in a metal frame so that all four edges are held securely and the exposed area of the specimens is at least 8 inches by 8 inches. The surface exposed when installed in the airplane must be face down for the test. The specimen must be exposed to the flame source described in subparagraph (b)(3) of this Appendix, with the air supply to the burner shut off and the flame height adjusted to 1 1/2 inches. The burner must be positioned vertically with its center one inch below the center of the specimen. The flame must be applied for 30 seconds and then removed. Flame time, glow time, and whether the flame penetrates (passes through) the specimen either during application of the flame or subsequent to its removal must be recorded for each specimen and the results averaged for flame time and glow time. Flame penetration through any specimen tested is considered a failure.
- (7) Sixty degree test: A minimum of three specimens of each wire specification (make and size) must be tested. The specimen, including insulation, must be placed parallel to and approximately 6 inches from the front of the test chamber, and at an angle of 60 degrees to the horizontal. The lower end of the specimen must be held rigidly clamped. The upper end of the specimen must pass over a pulley or rod and must have an appropriate weight attached to it so that the specimen is held taut throughout the test. The distance between the lower clamp and the upper pulley or rod must be 24 inches, and the test specimen must be marked 8 inches from the lower end to indicate the point for flame application. The specimen must be exposed to the burner described in subparagraph (b)(3) of this Appendix, with the flame height adjusted to 3 inches with an inner cone one inch long. The burner must be positioned underneath the specimen so that it is perpendicular to the specimen, makes an angle of 30 degrees to the vertical plane of the specimen, and the tip of the inner cone of the flame contacts the test mark. The flame must be applied for 30 seconds and then removed. The burn length must be determined to the nearest tenth of an inch in accordance with subparagraph (b)(8) of this Appendix. The flame time, burn length, and flaming time of any drippings must be recorded for each specimen and the results averaged. Breaking of the wire specimen is not considered a failure.
- (8) Burn Length: Burn length is the distance from the original specimen edge or test mark to the farthest point showing evidence of damage due to that area's combustion, including areas of partial consumption, charring, or embrittlement, but not including areas sooted, stained,

warped, or discolored, nor areas where material has shrunk or melted away from the heat.