

HISTORY OF EVENTS: FAR VERTICAL FLAMMABILITY TESTS

DATE	EVENT	SIGNIFICANCE; TEST CRITERIA
9/11/45	CAM 4b Regulation	No vertical tests required; horizontal only
5/15/51	Federal Specification CCC-T-191b Method 5902	<p>CCC-T-191b, "Textile Test Methods", was issued for government procurement purposes. There was a horizontal flammability test for cloth, Method 5906, and a vertical flammability test, Method 5902, whose general apparatus and procedures were eventually used in FAA regulations. This test method could not be applied to materials other than cloth without appropriate modifications.</p> <p>VERTICAL TEST: CCC-T-191b, METHOD 5902 Burner: Bunsen or Tirrill with 3/8 inch nominal I.D. Air supply completely shut off. Burner fuel: not specified: propane and natural gas were commonly used Flame height: 1 1/2 inches Flame temperature: not specified Ignition time: 12 seconds Flame placement: The burner shall be placed 3/4 inch below the lower end of the specimen "with the flame applied vertically near the middle of the width of the lower end of the specimen."</p> <p>MONITORED CRITERIA: Flaming time: the time the specimen continues to flame after the burner flame is removed from the specimen (= extinguishing time) Glow time: the time the specimen continues to glow after it has ceased to flame Char length: "the distance from the end of the (fabric) specimen, which was exposed to the flame, to the end of a tear made lengthwise of the specimen through the center of the charred area as follows:" (a detailed procedure was given; it is not repeated here)</p>
1/15/59	Federal Specification CCC-T-191b Method 5903	This new standard, "Flame Resistance of Cloth, Modified Vertical", was similar to CCC-T-191b, Method 5902, "Flame Resistance of Cloth, Vertical" except that it specified B-gas for the burner fuel. No gas was specified in Method 5902: propane and natural gas were commonly used.
2/1/65	FAR 25	FAR 25 superseded CAM 4b. No changes were made in flammability requirements. No vertical tests were required, horizontal only.
/ /65	727 Crash in Salt Lake City	Airplane suffered hard landing. A fuel line was ruptured by a landing gear being forced upward by the impact, resulting in a fuel-fed fire entering the fuselage. Many fatalities and injuries resulted.
7/29/66 9/7/66	NPRM 66-26 NPRM 66-26A "Crashworthiness and Passenger	FAA stated "The current requirements for flame resistant material in passenger and crew compartments were designed primarily to prevent serious fires from passenger carelessness

such as cigarette burns. However, recent events have shown that these fire protection requirements must be amplified in order to provide protection from an occurrence such as a fuel fire...It is considered possible, and practical to require that materials used in passenger and crew meet a specified horizontal and vertical burn rate..." The proposal affected all cabin materials.

PROPOSED VERTICAL TEST: CCC-T-191b, Method 5902

PROPOSED ACCEPTANCE CRITERIA:

flaming (extinguishing) time not to exceed 2 seconds; no flaming drips; "must not burn for a total length in excess of 6 inches"

NOTE: No definition of "burn length" was offered by NPRM 66-26. CCC-T-191b, Method 5902 defined a "char length" for fabrics but not for anything else.

10/ /67	AIA response to NPRM 66-26	In Appendix C, Comments on NPRM 66-26, AIA responded that the proposed "rule was too severe--the materials available to meet the properties necessary to build functional airplanes would not pass these burn requirements. In addition to burn tests, the materials must meet other requirements such as being color-fast, abrasion resistant, fluid resistant, moisture permeant, impact resistant, and dimensionally stable and must have high tensile and tear strengths." AIA proposed a comprehensive Crashworthiness Development Program requiring substantial resources and involving considerable large scale testing to study the issues addressed by NPRM 66-26.
2/7/67	FAA letter to AIA	FAA wrote to the AIA encouraging the proposed Crashworthiness Development Program.
3/22/67	AIA Crashworthiness Organizational Meeting	Milestones and assignments were made at an organizational meeting of the AIA Crashworthiness Development Program.
10/24/67	FAR 25, Amendment 15	FAA issued a rule which, in consideration of industry comments, adopted less stringent requirements than those proposed in NPRM 66-26, and could be met by available materials. Only certain components were subject to a vertical test instead of all cabin materials, as proposed in NPRM 66-26. Whereas NPRM 66-26 had proposed CCC-T-191b, Methods 5902 and 5906 for vertical and horizontal tests, respectively, Amendment 15 did not adopt CCC-T-191b methods but instead found it more convenient to spell everything out. The required vertical test differed importantly from CCC-T-191b, Method 5902 in that the flame placement callout was very much more specific, and it defined a char length for materials other than fabrics. REQUIRED VERTICAL TEST: Burner: Bunsen or Tirrill with 3/8 inch nominal I.D. Air completely shut off. Burner fuel: not specified Flame temperature: not specified Flame height: 1 1/2 inches Flame placement: "The center of the burner must be 3/4 inch below and in line with a surface of the material being tested or, in

same concept as char length; the Materials Technical Group that the burn length requirement is more stringent than the char-length (requirement) because the burn length includes more of the effects of flame impingement and will always be equal to or greater than the char length."

In addition, other test types were considered such as the ASTM E162 radiant panel test to determine a flame spread index; the ASTM E84 Steiner tunnel test to determine a different flame spread index; the ASTM D1929 Setchkin test to determine auto-ignition temperature; differential thermal analysis; thermal gravimetric analysis; FTMS 406, Method 2023 resistance coil and spark ignition test; and several variants of horizontal tests using a propane-fired Bunsen burner. Also considered were tests to evaluate the evolution of smoke and noxious gases.

7/ /68 AIA Crashworthiness Development Program Recommendations

The AIA CDP-1 report on the materials studies had concluded that the only viable upgrading of the FAR which was practical, and for which an adequate number of materials was available, was a more stringent vertical Bunsen burner test for certain materials and/or applications. This regulatory change was recommended in AIA CDP-RC, "Recommended Regulation Changes".
RECOMMENDED VERTICAL TEST: new Appendix F (apparatus essentially per CCC-T-191b, Method 5902)

Burner: Bunsen or Tirrill with a nominal 3/8 I.D. Air supply not specified.
Burner fuel: not specified.
Flame height: 1 1/2 inches
Flame temperature: 1550F minimum in the center of the flame.

NOTE: A 1575F temperature in the center of a propane flame with no added air, measured with a 22 gage thermocouple, was reported the AIA Materials Technical Group report (AIA CDP-1). Specifying that no air would be added to the gas by opening up the air holes at the bottom of the burner was not done, in the event that it might be necessary to do so to achieve 1550F or to satisfy a tolerance (e.g., 1155F + 100F, - 0F). However, adding air was at variance to CCC-T-191b, Method 5902, so the AIA spelled out the burner in its recommendation and did not defer to the Method 5902 burner. The AIA did not specify either thermocouple size or whether it was to be inserted into the flame horizontally or vertically, which was an unfortunate oversight: the effect of such variables had not been pursued in the AIA study, so their importance was not recognized.

Burner placement: The flame must be applied 3/4 inch below "the most critical exposed portion of the specimen."

NOTE: With rare exceptions, as a general rule the "most critical exposed portion of the specimen" for flame placement is per Amendment 15 for burn length, and is the geometrical center of the bottom surface of the specimen for extinguishing time. Since the Materials Technical Group surmised that a regulatory upgrade would have to be at least as stringent as Amendment 15, it selected this burner placement to assure that a "satisfactory" material would pass regardless of where the burner flame was placed. Also, specifying "most critical exposed portion of the specimen" for the flame placement would assure that candidate materials would meet both FAR 25, Amendment 15 requirements and the anticipated new requirements for 12-second vertical ignition, and could be used in airplanes certified to either set of regulations. However, in general the Amendment 15 placement is more stringent since more materials are historically marginal with respect to burn length (e.g., Tedlar-covered sandwich panels with Nomex core) than to extinguishing time (e.g., sandwich panels with balsa wood or polyurethane foam core).

ACCEPTANCE CRITERIA: Burn length less than 6 inches for 60-second ignition, less than 8 inches for 12-second ignition. Self-extinguishing time less than 15 seconds for both 60-second and 12-second ignition. Flaming drips self-extinguishing time less than 3 seconds for 60-second ignition, and less than 5 seconds for 12-second ignition.

12/31/68 Federal Test Method Standard (FTMS) 191, Method 5903

CCC-T-191b was superseded by Federal Test Method Standard 191. "Methods" nomenclature remained the same. Method 5902 was dropped at the time of the change. Whereas Method 5902 had not specified a burner fuel, Method 5903 called out B-gas.

8/12/69 NPRM 69-33

The FAA, following its promise when it issued Amendment 25-15 that it "would consider additional revisions to the regulations as advances in the state-of-the-art allowed in order to further increase the probability of occupant survival in an airplane accident", issued NPRM 69-33, "Transport Category Airplanes, Crash-worthiness and Passenger Evacuation."

PROPOSED VERTICAL TESTS:

Apparatus per FTMS-191, Method 5903, or approved equivalent

Burner: Bunsen or Tirrill with 3/8 inch nominal I.D. Air supply completely shut off.

Burner fuel: B-gas

Flame height: 1 1/2 inches

Flame temperature: 1550F minimum in the center of the flame.

NOTE: The AIA had not recommended a burner fuel for vertical tests, since no specific fuel callout existed in CCC-T-191b, Method 5902. However, between the time AIA issued its Recommended Regulation Changes (7/68) and the time NPRM 69-33 was issued (8/69), CCC-T-191b had been superseded by (essentially renamed as) FTMS 191, and Method 5902 had been replaced at the time of this change by Method 5903, which was different in that it specified B-gas, whereas Method 5902 had not specified any gas type. The AIA Materials Technical Group had not considered Method 5903 and/or B-gas. When the FAA adopted the AIA-recommended minimum flame temperature, they overlooked the fact that flame temperature is not an independent, adjustable variable (i.e., the burner flame is completely defined) when the burner type, burner fuel (B-gas or propane, without air), and flame height (1 1/2 inches) are all completely specified. The flame temperature can be adjusted only if something else can be adjusted as well--say, the air supply is not shut off and air may be added to the gas. The temperature of a B-gas flame, as specified in the NPRM and as it was later adopted into the regulations, is greater than 1550F by several hundred degrees so that the "minimum requirement" is automatically met.

Burner placement: The lower edge of the specimen must be 3/4 inch above the top edge of the burner. "The flame must be applied to the centerline of the lower edge of the specimen."

NOTE: The AIA had recommended that the flame be applied 3/4 inch below "the most critical exposed portion of the specimen." The NPRM callout "the flame must be applied to the centerline of the lower edge of the specimen" is ambiguous, and because it was eventually adopted into the regulations, has caused great confusion. "The centerline of the lower edge of the specimen", if the "edge" is taken to be the cut bottom surface, would sensibly be a line that bisects that surface from front to back. Since specimens usually have some thickness, exactly where along that line the flame is to be placed is not defined. A common interpretation has been that "the centerline of the lower

the specimen. For some materials, this is "the most critical exposed portion of the specimen", but for most materials "the most critical exposed portion of the specimen" is the point specified for burner placement in Amendment 15, i.e., in line with the specimen face that faces the air in the airplane.

5/1/72 FAR 25 Amendment 32 FAR 25 Amendment 32 was released. The 747 had already been certified to its proposed requirements.

7/ /78 ASTM Meeting of F7.06 Committee: Interpretation of "Burn Length" The ASTM F7.06 committee had been requested by the FAA to establish test procedures that the FAA could eventually call out in regulations. The meeting was attended by representatives of McDonnell-Douglas, Boeing, Lockheed, FAA Southwest Region, and NAFEC (FAA Technical Center). The FAA Southwest Region requested that each committee member estimate the "burn length" of a flammability test specimen. The results were 4.5 inches (Boeing and one FAA representative), 5.4 inches (McDonnell-Douglas), and 8.2 inches (Lockheed and another FAA representative). The pass/fail limit is 6 inches. The FAA Southwest Region wrote a letter to FAA Headquarters requesting a ruling on the "correct" interpretation. The letter was never answered.

NOTE: The problem here is where "damage due to flame impingement" stops and "shrinking away from the heat source" begins. Such estimates involve subjective judgments which vary not only from company to company but also from individual to individual, and may as in this example result in ambiguous pass/fail judgments for a particular material. The "burn length" measurement made by the Boeing representative and one FAA representative was based on their estimate of the extent of the flame front, which is where the flame became "unstuck" from the specimen surface, and did not include any material that had "shrunk away from the heat source." These representatives emphasized that it is imperative to witness the test when it is performed, and that post-test examination of burned specimens is inadequate for burn length measurement. The McDonnell-Douglas representative estimated the "burn length" on the same basis as the Boeing representative and the one FAA representative, but disagreed on the result. The Lockheed representative and the other FAA representative estimated the "burn length" to extend to the end of all damage to the specimen, which included material that had probably "shrunk away from the heat source"; they pointed out that the "all damage" criterion was more objective than the FAR definition, and since it is more conservative it can be used.

11/ /84 Industry-wide Test Practices Identified A survey was made of FAR 25 practices at other members' facilities and the FAATC as applied to Tedlar-covered panels. The results of the survey are shown in the following table:

FAR 25-32 VERTICAL FLAMMABILITY TEST PRACTICES
TEDLAR-COVERED LAMINATES

Test Facility	Gas Type	Air Supply	Flame Placement	Burn Length
FAR 25-Appendix F Requirements	Ambiguous, but could be interpreted to be B-gas	-- No	"Centerline of lower edge..." (ambiguous)	"Furthest evidence of damage due to flame impingement..." (ambiguous and very subjective)
FAA NWM Region (Seattle Field Office)	--	--	Face	End of Tedlar Split

