Designation: F2866 – 11

Standard Test Method for Flammability of a Membrane Switch in Defined Assembly[1]

This standard is issued under the fixed designation F2866; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the determination of the flammability characteristics of a membrane switch.

1.2 This test method defines the MSB rating of a membrane switch. Each character of the MSB rating represents a discrete characteristic of a membrane switch performance under destructive thermal loading.

1.3 This test procedure will be destructive, but should provide an insight into the relative performance flame-resistance characteristics of differing designs or assemblies, or both.

1.4 This test method will focus on the use of convective contact (burner flame) method for ignition, though other methods of ignition are available.

1.5 This test method is designed to determine if the membrane switch assembly will add (or detract) from the flame propagation from an exterior flame/fire source.

1.6 If this test is intended to be used for an internal flammability source then set up the unit under test (UUT) appropriately and note it in the test scope and results.

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E906 Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using a Thermopile Method

3. Terminology

3.1 *Definitions:*

3.1.1 *burn damage*—percentage of the UUT that is damaged due to burn test. This is a visiual observation.

3.1.2 *flame propagation*—refers to patterns in the flame front that are examined (for example, uniform rate of advance, spotty ignition or charring, etc.). These observations are qualitative and should be noted in the data field.

3.1.3 *flame spread rate (FSR)*—the rate at which a flame front travels along the surfaces of tested materials/assemblies, typically measured in mm/s or in./min.

3.1.4 *flame target area*—refers to the normalized target area of a UUT that will be used for ignition location. Any variations should be noted.

3.1.5 *flame time (F_{time}) or flame endurance*—amount of time, usually in seconds, that a self-sustaining flame will endure after removal of initial ignition source before flame on UUT is extinguished.

3.1.6 *flame time of drippings ($F_{time,drip}$)*—amount of time that burning drippings, if any, remain burning. Typically measured in seconds.

3.1.7 *gauze ignition*—this is a verification that UUT ignites the gauze.

3.1.8 *ignition source*—the source that provides the heat-flux to begin the flammability test. This test method will recommend a convective flame for the ignition source, however, care should be taken that any comparative tests should use the same method of ignition.

3.1.9 *mass-loss (m_{loss})*—the mass from a test specimen it lost to smoke, vaporization and char debris carried away or fallen away, or both, during the flammability test cycle. Typically measured in grams (average).

3.1.10 *membrane switch assembly*—the membrane switch should not be tested in its unmounted state. The switch sample should be mounted onto the final end-use enclosure, panel, bezel, or agreed upon material.

3.1.10.1 *Discussion—Assembly Specimen*: This test method is trying to provide a practical world analog for the results herein obtained. As a result, the unit under test (UUT) must in the final mounted condition. The test is able to show flame-resistance in the final assembly as it interacts with the membrane switch's construction.

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[1] This test method is under the jurisdiction of ASTM Committee F01 on Electronics and is the direct responsibility of Subcommittee F01.18 on Membrane Switches.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.1.11 *MSB*—rating to quantify the burn characteristics of a membrane switch. Each character of the MSB rating represents a discrete characteristic of a membrane switch performance under destructive thermal loading. (see Table 1.)

3.1.12 *time-to-ignition (t_{ign})* —the time to ignite UUT under thermal loading (by any ignition source selected) with a self-standing flame front on the UUT (flame on the test specimen moving away from the thermal load source). The method for ignition (source) can be conductive contact (heated filament), radiant energy (electrical or gas) or convective (free flame). Typically measured in seconds.

3.1.12.1 *Discussion*—A "perfect" incombustible material will have infinite time to ignition; similarly a UUT with no sustained flame within the length of the ignition exposure would be reported as "no ignition time observed".

3.1.12.2 *Discussion*—Using a convective (free flame) ignition source the time to ignition may be difficult to determine (due to the fact that there is interference between the ignition source and the ignition of the UUT).

4. Significance and Use

4.1 There are numerous flammability ratings and tests. Almost without fail, these standards and tests are focused on very specific industries or results, many of which are not applicable to the membrane switch/human machine interface assembly. This test is designed to provide relative results between membrane switches that have been assembled to the unit's final enclosure, housing, etc.

4.2 In addition to the test's measurement of the rate of burn, a laboratory can also observe the effects of burning material falling from the test specimen onto other materials (typically a gauze test area) not directly part of the test specimen. The indirect burning is an issue of interest to see if the test specimen will be able to act as an initiator for a far greater and more damaging flame event (fire). Observations should be noted, as qualitative descriptions, as appropriate.

4.3 This test can measure the flammability via the use of high-speed photographic or video equipment.

4.4 Temperature of the ignition source can be measured via a calibrated thermocouple pyrometer, calorimeter or IR thermometer with an appropriate range.

4.5 This test is not designed to provide a PASS or NO PASS status for a switch, rather, it is designed to provide a "grade" for the level of flammability of a membrane switch assembly (as defined in 3.1.10). The end user should make the final determination if the level of flammability is acceptable for the particular application.

5. Interferences

5.1 *Method of Ignition*—Results compared between different methods of ignition (radiant versus convective) may provide different results for t_{ign}. Therefore any comparative samples should use the same calibrated method of ignition.

5.2 *Mounted in Final Assembly*—Mounting the membrane switch to the end use substrate or enclosure will account for the thermal heat sink effect provided by the mounting substrate or enclosure.

5.3 *Rigid Fixture Support*—The membrane switch assembly should have rigid fixture support in order to allow remote testing during the burn cycle. UUT should be mounted to insure that the parts to do not fall while under test.

5.4 *Venting of the FPA Test Booth*—The type and placement of venting and exhausting for airflow in test booth should be noted or documented by photos or drawings, or both. Duplication of test results may be achieved only with the same amount of air-flow and air-to-fuel mixture in the test booth.

5.5 *Oxygen Concentration*—The concentration of the oxygen in the FPA chamber atmosphere (normal air, concentrated O_2, pressurized, etc.) during the test or oxidizers, or both, found in the test material(s) will affect the results.

5.6 *Duration of Ignition*—The longer the ignition burn test the greater the chance the part will ignite and begin to exhibit flame propagation.

5.7 *Relative Humidity in FPA*—It is thought this will have some effect on the results, however the extent of which is to be determined.

6. Apparatus

6.1 *Fire Propagation Apparatus (FPA)*—Draft-free booth made of non-flammable material (high-temp Pyrex, ceramic or steel) rectangular or cylindrical space with proper: *(1)* ventilation for exhaust fumes, smoke, etc., *(2)* free empty area for mounting rigs and UUT and *(3)* appropriate fixings and mounts, as needed for ignition source and *(4)* vent holes or ventilation, or both, for inflow of fresh air.

6.1.1 *FPA*—may also provide oxygen in standard sea-level normal air concentration, 40 % oxygen, air with pure nitrogen

TABLE 1 MSB Rating

Model	$t_{(ign)}$ Time to ignition	*FSR* Flame Spread Rate	$F_{(time)}$ Continuation of burn	$m_{(loss)}$ Mass loss	Burn Damage %	Gauze Ignition
The following >>	0 = no ignition	0 = no burn	0 = self extinguishing	0 = no loss	0 = 0 % damage	0 = no
should be	1 = 10 s>	1 = 1 mm/s	1 = 1 s	1 = 10 % loss	1 = 10 % damage	
considered	2 = 9 s	2 = 2 mm/s	2 = 2 s	2 = 20 % loss	2 = 20 % damage	
when deciding	3 = 8 s	3 = 3 mm/s	3 = 3 s	3 = 30 % loss	3 = 30 % damage	
on a switch	4 = 7 s	4 = 4 mm/s	4 = 4 s	4 = 40 % loss	4 = 40 % damage	
MSB rating	5 = 6 s	5 = 5 mm/s	5 = 5 s	5 = 50 % loss	5 = 50 % damage	
	6 = 5 s	6 = 6 mm/s	6 = 6 s	6 = 60 % loss	6 = 60 % damage	
	7 = 4 s	7 = 7 mm/s	7 = 7 s	7 = 70 % loss	7 = 70 % damage	
	8 = 3 s	8 = 8 mm/s	8 = 8 s	8 = 80 % loss	8 = 80 % damage	
	9 = 2 s or less	9 = very very fast burn	9 = 9 s>	9 = 90 %>	9 = 90 % or more	9 = yes

or mixtures of gaseous suppression agents. These are all optional and should be recorded.

6.1.1.1 *Example FPA Test Booth*—Ohio State University (OSU) rate of release apparatus may be used for radiant flux ignition tests, as described below. This is a modified version of the rate of heat release apparatus standardized by Test Method E906. See Fig. 1.

6.2 *Mounting Device*—Steel mount stand to hold measuring probe securely and provide orthogonal (for horizontal and vertical) and angled (45° or defined angle from vertical) mounting of UUT with respect to ignition source. See 5.3 if needed.

6.3 *Ignition Source*—To provide the heat flux needed to initiate flame propagation. The source may be conductive, convective or radiant and should be mounted on a swing-out stand so that the ignition source (such as a burner) may be swung out of position for warm up prior to the test under the UUT.

6.3.1 *Conductive Ignition Source*—Example: Tungsten wire filament, AWG #20 or greater, with proper electrical input to achieve a 3000°K (4940.3°F) surface temperature.

6.3.2 *Convective Ignition Source*—Example: Bunsen burner with a nominal 0.375 in. (9.5 mm) inside diameter tube adjusted to give a free-standing flame 1.5 in. (38.1 mm) high. The minimum flame temperature measured by a calibrated thermocouple pyrometer in the center of the flame must be 1120°K (1556°F).

6.3.3 *Radiant Ignition Source*—Example: A radiant heat source incorporating four (4) Type LL silicon carbide elements, 20 in. (508 mm) long by 0.63 in. (16 mm) outside diameter. The heat source should have a nominal resistance of 1.4 Ω and be capable of generating a radiant flux of ≥100 kW/m^2, or a tungsten-quartz external isolated heat element that can provide a radiant flux of ≥65 kW/m^2.

6.4 *Photographic / Video Monitoring*— Equipment capable of making visual recording of the burn test. A calibration strip or grid should be mounted in the visual focal plane so that the rate of flame advance or flame spread-rate, (flammability) can be measured in mm/s or in./min.

6.5 *Timing Device*—Stop watch or other timing device in seconds or minutes of elapsed test time for UUT. It must be used to measure the time of application of burner flame to UUT and self-extinguishing time or test duration, or both.

6.6 *Temperature Measuring Device,* radiant flux meter, calorimeter, thermocouple pyrometer or IR pyrometer of suitable ranges, as required depending on ignition source set up used.

6.6.1 *Thermocouple Pyrometers*—Thermocouples suitable for testing the thermal output of the ignition flame. These should be 0.0625 in. (1.6 mm) to 0.125 in. (3.18 mm) metal sheathed, ceramic packed, type K, grounded thermocouples with a nominal 22 to 30 AWG conductors.

6.6.2 *Calorimeter*—Calorimeter must be a 0-17.0 W/cm ^{2}(0-15.0 BTU/ft^2-s) calorimeter, accurate to within ±3 %.

6.7 *Data Recording*—Suitable calibrated instrument with an appropriate range to measure and record the outputs of the calorimeter and thermocouples.

6.8 *Weight Scale*—Weighing device, capable of measuring the mass (weight) of the UUT. The part may be weighed before and after flammability test or a continual weighing system may be used to provide real-time mass changes during test. The scale should be accurate to ±1 g.

6.9 *Gauze*—Cotton, a supply of (absorbent) 100 % untreated cotton. First Aid Steri Pad (4 by 4 in. 12 ply sterile 100 % cotton pad constructed of fine mesh USP Type VII gauze).

7. Procedure

7.1 *Pre-Test Setup:*

7.1.1 Precondition membrane switch assembly until approximation of steady-state condition is achieved. UTT must be conditioned at 77 ± 20°F (25 ± 10°C) @ 55 % ± 10 relative humidity for a minimum of 24 h before testing. UUT

FIG. 1 Typical FPA Test Booth

shall remain in this conditioned state up to being placed in FPA for flammability testing.

7.1.2 Weigh UUT just prior to test.

7.1.3 Calibrate ignition source with NIST traceable measuring devices, as appropriate: radiant flux meter, calorimeter, thermocouple pyrometer or IR pyrometer.

7.1.4 Ensure that the test specimen (unit under test, UUT) is mounted securely onto the rigid substrate or enclosure using the same manner and material(s) of attachment representative of the final product. The entire assembly should then be securely fixed into position by means of nonflammable clamps or spring grips.

7.1.4.1 *Vertical Test*—UUT should be mounted vertically above ignition source; see Fig. 2.

7.1.4.2 *Horizontal Test*—UUT should be mounted horizontally (90° orthogonal plane) directly above ignition source; see Fig. 3.

7.1.4.3 *Angle Test*—UUT should be mounted at the defined angle from the direction of the ignition source; see Fig. 4. All angles are approximate.

7.1.5 Clamp UUT in test fixture and position desired.

7.1.6 Position test Bunsen burner under center of the designated flame target area of UUT switch assembly (*X-Y* location). Burner is in "off" (cold) state.

7.1.7 Position Bunsen burner at the appropriate height (Z-direction) under flame target area of the UUT. Burner is in "off" (cold) state.

7.1.8 Swing the Bunsen burner out of position from under UUT and ignite. Burn for approximately 2 min to allow it to come up to steady state.

NOTE 1—Calorimeter should read 11.9 ± 0.6 W/cm^2 (10.5 ± 0.5 BTU/ft^2-s). Thermocouple should read 1556 ± 36°F.

7.1.9 Position clean white gauze below UUT for target on burn drippings, as applicable.

7.2 *In-Process Test:*

7.2.1 *Vertical, Horizontal or Angle Test:*

7.2.1.1 A minimum of three (3) specimens should be tested and the results averaged.

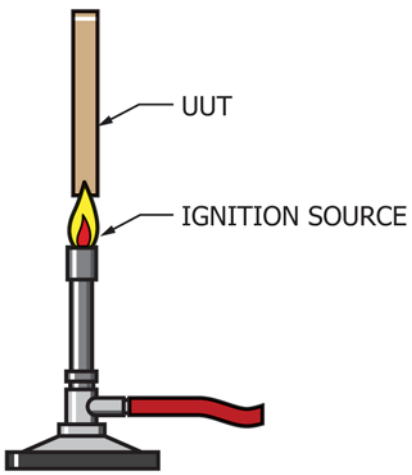

FIG. 2 Vertical Test

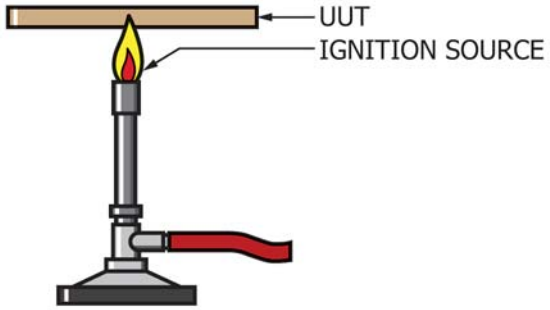

FIG. 3 Horizontal Test

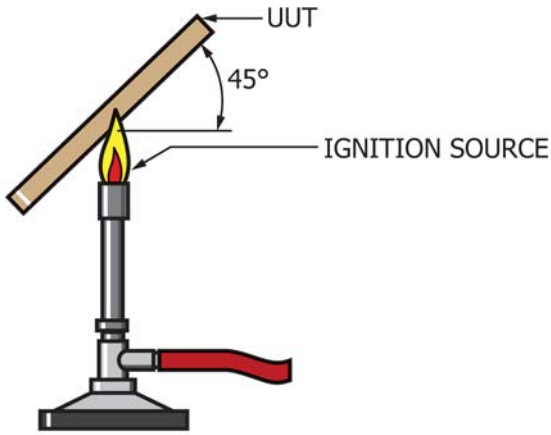

FIG. 4 45° Test

7.2.1.2 Begin by swinging the lit steady-state burner into position under the vertically mounted UUT.

7.2.1.3 Simultaneously start timing and video/photographic recording. Timing device should be within the field of view of the video recording equipment.

7.2.1.4 Expose UUT to flame source; flame target area to be exposed to flame 0.5 in. inside the flame cone (see Fig. 2)

7.2.1.5 UUT to be exposed to ignition source (0.5 in. [12.7 mm] within the flame cone; see Fig. 5) for 15 s and then removed.

7.2.1.6 Record the *FSR*, $F_{(time)}$, $t_{(ign)}$, $m_{(loss)}$ and $F_{(time,drip)}$.

7.2.1.7 Repeat 7.2.1.1 through 7.2.1.6 on each specimen.

8. Calculation

8.1 Determine the average of the readings.

8.2 Calculate the mass-loss, $m_{(loss)}$, if FPA does not have continual weighing system.

$$\therefore m_{(loss)} = (mass_1 - mass_2)$$

where:

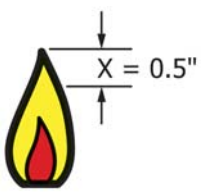

FIG. 5 Flame Cone

$mass_1$ = initial mass of UUT prior to test, and
$mass_2$ = final mass of UUT after burn test and extinguishing of flame.

8.3 Calculate the temperature (T) of ignition source, if direct measurement is not used, of radiant ignition source or conductive filament using the color (spectral distribution) of the glow from the radiant or filament element. In the idealized case, this is known as "black body" or "cavity" radiation, and is described by Planck's Radiation Law.

9. Report

9.1 Report the following information in SI units:
9.1.1 Temperature, ambient laboratory,
9.1.2 Humidity,
9.1.3 Atmospheric mixture used, (air, concentrated O_2, etc.),
9.1.4 Ignition source type and specifications,
9.1.5 Description of test FPA apparatus may include pictures or drawings, optional,
9.1.6 Temperature, ignition source, as needed °K or °C (°F),
9.1.7 Heat output, W/cm^2(BTU/ft^2-s),
9.1.8 *FSR*,
9.1.9 $F_{(time)}$,
9.1.10 $t_{(ign)}$,
9.1.11 $m_{(loss)}$,
9.1.12 $F_{(time,drip)}$,
9.1.13 Angle of test UUT (vertical, horizontal or other),
9.1.14 Part number or description of switch, or both,
9.1.15 Part number or description of mounting substrate or enclosure,
9.1.16 Date of test,
9.1.17 Description of flame propagation visual observations (such as, self-extinguished, charred, etc.),
9.1.18 Other functional or relevant observations as needed.
9.1.19 Based on the UUT results the following MSB rating is assigned. Example MSB 427350,

10. Precision and Bias

10.1 *Precision*—It is not possible to specify the precision of the procedure in Test Method F2866 for measuring flammability because the test has numerous variables that are intrinsically impossible to control. However, within a single laboratory where uniformity allows some level of control to occur, this method is useful for comparative analysis.

10.2 *Bias*—Bias of this Test Method F2866 for measuring flammability is under investigation and to be determined.

11. Keywords

11.1 fire propagation apparatus; flame endurance; flame propagation; flame spread rate; flame target area; flame time; flame time of drippings; flammability; mass loss rate; membrane switch; time to ignition