

## Chapter B3

### Vertical Flame Propagation Test Method for Materials in Inaccessible Areas of Passenger Cabin

#### B3.1 Scope

The Vertical Flame Propagation test method can be used to evaluate the flame-propagation potential of extensively used materials located in inaccessible areas of a passenger airplane.

#### B3.2 Definitions

##### B3.2.1 Burn Length

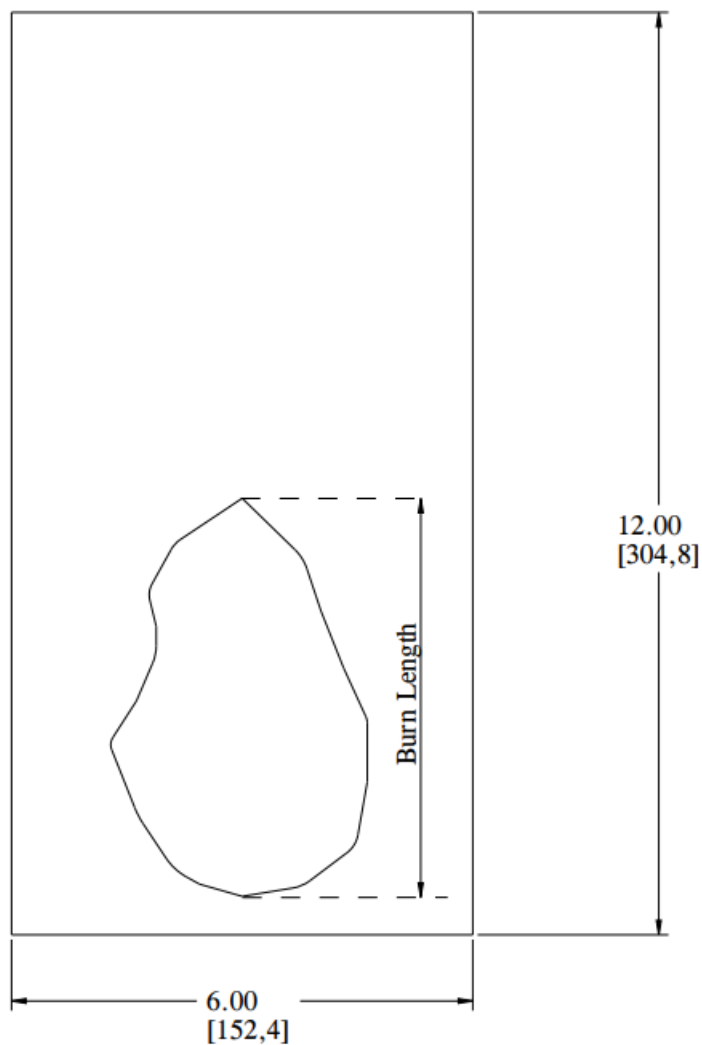
The burn length is the measurement of the length of the burned surface of the test sample, parallel to the long edge (12-inch dimension). For the purposes of this test method, the burn length is the distance of the farthest observed evidence of damage to the test sample due to that area's combustion burning both downward and upward from the point of the ribbon burner application. This includes 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. An example of a burn length measurement is displayed in Figure B3-1. The test must be witnessed to obtain a proper burn length measurement.

##### B3.2.2 After-Flame Time

The after-flame time is defined as the time, in seconds, that visible flaming is observed on the test-sample surface after the removal of the ribbon burner flame. Surface burning that results in a glow but not in a flame is not included.

##### B3.2.3 Self- Extinguishing

A test article that has been burning ceases to burn without external input from the test operator, and without burning of the full vertical length, either during the period of time where the pilot flame is applied or after the pilot flame is removed.

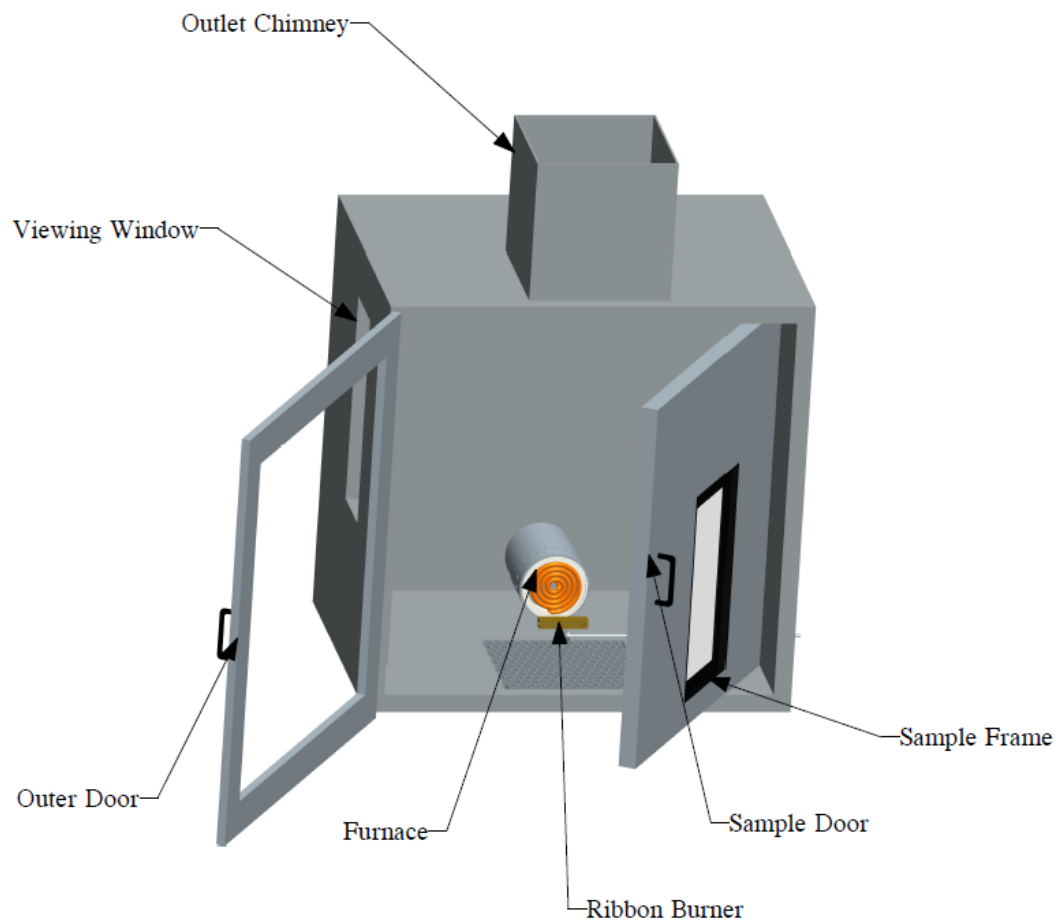


**Figure B3-1. Schematic of the witnessed burned area, showing the burn length measurement**

### **B3.3 Apparatus**

#### **B3.3.1 Test Apparatus**

The test apparatus is the vertical flame propagation (VFP) test device, as described in Appendix N and displayed in Figure B3-2. The sample type (i.e., composite skin, duct, or wire) will dictate the exact configuration and operation of the device. [See Appendix N for further information on the details of the construction of the apparatus.](#)



**Figure B3-2. Schematic of the VFP test apparatus**

### B3.3.2 Instrumentation

#### B3.3.2.1 Data-Acquisition System

The data to be acquired electronically prior to testing are the thermocouple temperature on the side of the machine to monitor ambient air temperatures entering the machine, as defined in B3.3.2.6 (Figure B3-3), and the power provided to the radiant heater (watts) or alternatively for the radiant heater set point, the heater temperature. Current (amps) and voltage (volts) shall also be monitored to track the health of the furnace coil.

#### B3.3.2.2 Timing Device

A stopwatch or other device, calibrated to the nearest 0.1 second, must be used to measure the time of application of the ribbon burner flame and any after-flame time. It is allowable to have the pilot flame time measurement built into the unit's software and automatically

remove the pilot flame from the sample at the appropriate time in place of the physical stopwatch.

#### B3.3.2.3 Anemometer and Flow Hood

A handheld, 4-inch (101.6 mm) outer diameter vane-type anemometer should be used to measure the flow of air through the chamber exhaust chimney of the test apparatus. The anemometer is mounted to an exhaust cone. The following air cone or similar construction is acceptable to be used to measure the air flow through the hood of the chimney. TSI Incorporated *Aircone Flow Hoods*, Model Number AFL72852201. An adaptor construction can be constructed flat on the outside of the VFP exhaust chimney to mount the cone so that the only air flow through the cone is from the machine exhaust. It must not be constructed inside the 8 inch by 8 inch (203.2 by 203.2 mm) exhaust cross-section to prevent obstruction and not affect airflow readings.

#### B3.3.2.4 Test Room

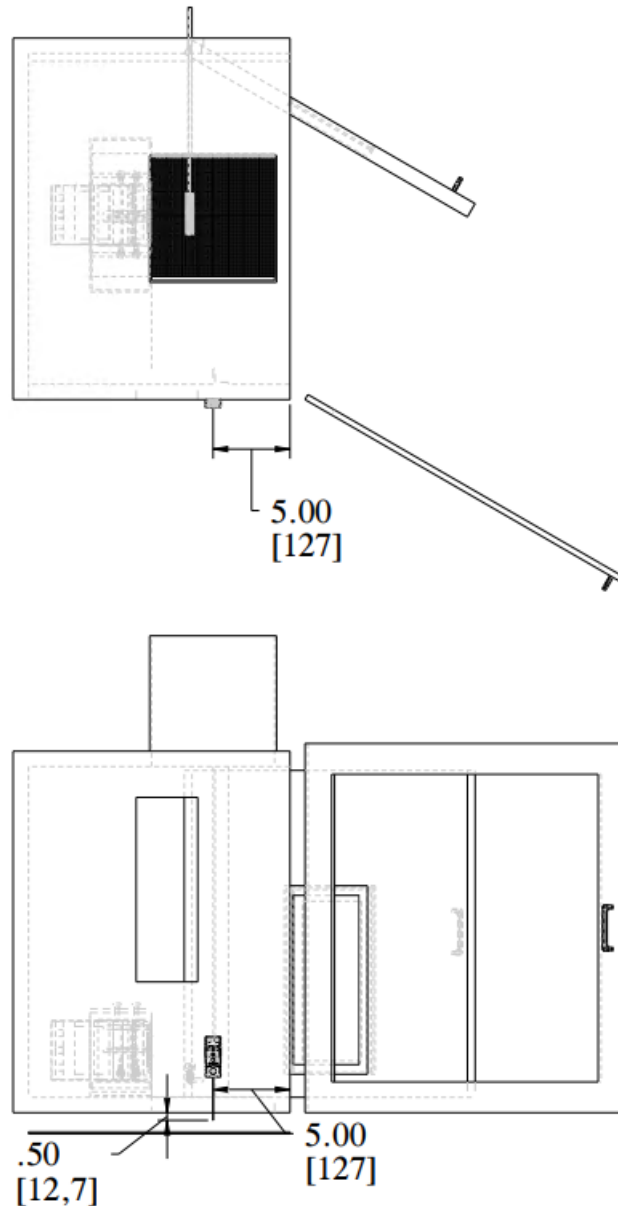
The test apparatus shall be located in a suitable room to reduce or eliminate the possibility of test fluctuation due to air movement. The test room should have a minimum floor area of 10 by 10 feet (3.048 by 3.048 meters).

#### B3.3.2.5 Room Ventilation

The room in which the VFP apparatus is situated must have an exhaust system capable of removing the products of combustion expelled during the test, but not strong enough to affect the ribbon burner flame. The VFP chamber exhaust must be decoupled from the lab's exhaust hood to prevent external influences on the chamber's air flow.

#### B3.3.2.6 Thermocouple

A Type K 1/16 inch (1.6mm) diameter stainless steel thermocouple is placed on the outer left or right hand side of the chamber to monitor ambient air temperatures entering the machine. The thermocouple is to be placed so that the measurement point is  $0.5 \pm 0.0625$  inches ( $12.7 \pm 1.59$  mm) below the base of the unit and is  $5 \pm 0.125$  inches ( $127 \pm 3.17$  mm) behind the front edge of the chamber body frame. This is shown in figure B3-3. This thermocouple must read  $74 \pm 4$  °F ( $23 \pm 2$  °C).



**Figure B3-3. Location of Ambient Temperature Thermocouple**

#### B3.3.2.7 Mass Flow Controllers

The air and fuel flow to the ribbon burner must be precisely measured and controlled using two mass flow controllers for air and methane. The air and fuel flow are measured in liters per minute. They must be calibrated to output flow rates of 0.66 LPM methane and 3.6 LPM air at temperature and pressure conditions of 77 °F (25 °C) and 14.7 PSIA (101.325 KPa). **Condensation must be prevented through the lines leading to the mass flow controllers to preserve function and calibrations.**

#### B3.3.2.8 Heat Flux Gauge

A Gardon type heat flux gauge shall be used to calibrate the radiant heat source. The heat flux gauge is defined in section N3.16 of the Fire Test Handbook.

### B3.4 Test Samples

#### B3.4.1 Sample Preparation

Test samples representing the material/part to be evaluated shall be constructed of the representative layup as the material/part used in service.

#### B3.4.2 Sample Number

Each separate set of samples prepared for testing will consist of at least three samples.

##### B3.4.2.1 Electrical Wire and Cable Insulation Material

A minimum of three sample sets for each component or design configuration must be prepared for testing. Each sample set consists of three wires, except for large diameter wires which may be tested as a single wire.

#### B3.4.3 Sample Size

##### B3.4.3.1 Composite Material

The samples to be tested will measure 6 +0/-0.125 inches (152.4 +0/-3 mm) wide by 12 +0/-0.125 inches (304.8 +0/-3 mm) long, with the thickness representing the component or design configuration to be tested.

##### B3.4.3.2 Duct Material

The samples to be tested will measure 12 +0/-0.125 inches (304.8 +0/-3 mm) long, with the thickness representing the component or design configuration to be tested. If the duct in use is comprised of different layers of material, then the duct will be tested with all the layers together as it is in use. If the duct cannot be made in a flat sheet configuration, then alternative sample sizes will be used.

##### B3.4.3.3 Electrical Wire and Cable Insulation Material

The wire samples to be tested will be strung taut through the sample holder. The sample holder for wire insulation material will be placed into the VFP's sample holder and will display a minimum of 11 inches (279.4 mm) full length of wire when held into the sample holder. Three wires of the length of the sample holder will be tested. The wire sample holder construction is described in section N3.10.3.

#### B3.4.3.4 Electrical Wire and Cable Sleeving Material

One wire sleeve material is to be tested, a minimum of 12 inches (304.8 mm) in length so that when fastened in the sample holder it remains held vertically. This is described in section N3.10.4 and displayed in Figure N-9. Sleeving may be tested either by itself or shrunk or wrapped around any VFP compliant wire or cable type.

#### B3.4.4 Sample Orientation

The samples are mounted so the 12-inch dimension is the vertical dimension.

#### B3.4.5 Sample Conditioning

The samples must be conditioned at  $70^{\circ} \pm 5^{\circ}\text{F}$  ( $21^{\circ} \pm 3^{\circ}\text{C}$ ) and  $55\% \pm 10\%$  relative humidity for a minimum of 24 hours prior to testing.

### B3.5 Preparation of Apparatus

#### B3.5.1 Furnace Alignment

##### B3.5.1.1 Furnace to Sample Distance

Measure the horizontal distance from the surface of the coil heating element/radiating surface of the heater to the inner surface of the sample holder where the test-sample surface would be located. The distance must be  $3 \pm 0.1$  inches ( $76.2 \pm 2.5$  mm). See figure N-11.

##### B3.5.1.2 Furnace Height

Measure the vertical height from the center of the coil heating element to the bottom inner surface of the sample frame where the bottom edge of the test sample would be located. The distance must be  $1.5 \pm 0.1$  inches ( $38.1 \pm 2.5$  mm). See figure N-11.

##### B3.5.1.3 Confirmation of Radiant Heater Function

The heater function will be confirmed by performing the Radiant Heater Calibration for Confirmation of Heater Set Up described in B3.6. Reference N3.16.2 for the frequency to perform the confirmation of heater set up.

#### B3.5.2 Ribbon Burner Alignment

B3.5.2.1 Push the ribbon burner into the test position.

B3.5.2.2 The vertical height of the ribbon burner central axis must be  $1.125 \pm 0.03$  inches ( $28.6 \pm 1$  mm) from the bottom inner surface of the sample frame. See figure N-11.

B3.5.2.3 The lateral positioning of the ribbon burner will be such that the vertical centerline is aligned with the vertical centerline of the furnace coil heating element. The distance from the face of the ribbon burner to the inner surface of the sample frame must be  $0.5 \pm 0.063$  inch ( $12.7 \pm 2$  mm). See figure N-11.

### B3.5.3 Ribbon Burner Flame Adjustment

#### B3.5.3.1 Methane/Air

Methane and air pressure should be set to the pre-pressure allowed for the mass flow controllers by the equipment manufacturer. Adjust the methane and air flow rates to 0.66 LPM/3.6 LPM respectively. These rates are set for a mass flow controller that is calibrated to the standard temperature and pressure conditions of 77 °F (25°C) and 14.7 PSIA (101.325 KPa). Consideration should be made upon whether the device is analog or digital before calibrating the mass flow controllers.

### B3.6 Radiant Heater Furnace Calibration for Confirmation of Heater Set Up

B3.6.1 Switch on heating element, preferably using the power levels from the last successful heat flux calibration. The ribbon burner is withdrawn away from the test position and a blank ceramic fiberboard is secured in the sample holder and both test doors are closed.

B3.6.2 Begin monitoring the ambient room temperature to verify temperatures are within  $74 \pm 4$  °F ( $23 \pm 2$  °C).

B3.6.3 Ensure that the exhaust fan that will run during testing is switched on.

B3.6.4 Allow chamber to heat up until stabilized.

B3.6.5 Once the chamber has stabilized, confirm and record the ambient air temperature is at  $74 \pm 4$  °F ( $23 \pm 2$  °C). Turn on cooling water to the heat flux gauge. Then, open the outer door, remove the blank fiberboard panel in the sample holder, and insert the board holding the heat flux gauge location depicted in Figure N-12 and location 1 in Figure N-13 (left picture), so that it is holding the heat flux gauge face flush with the board face. The test sample door should be shut during this pre-heat and the outer door should be closed as much as the heat flux gauge leads allow.

B3.6.6 Leave the ceramic fiberboard holding the heat flux gauge in the sample holder in front of the heater for 5 minutes and check whether  $1.59 \pm 0.04$  Btu/ft<sup>2</sup>sec ( $1.8 \pm 0.05$  Watts/cm<sup>2</sup>) has been achieved during this time. If necessary, adjust the radiant heater in order to achieve  $1.59 \pm 0.04$  Btu/ft<sup>2</sup>sec ( $1.8 \pm 0.05$  Watts/cm<sup>2</sup>). After each adjustment, allow for an additional 5 minutes of stabilization and check the heat flux again.

B3.6.7 Once the heat flux is achieved, record heat flux for a duration of 5 additional minutes. The heat flux must be within  $1.59 \pm 0.04$  Btu/ft<sup>2</sup>sec ( $1.8 \pm 0.05$  Watts/cm<sup>2</sup>) over the full 5-minute period

B3.6.8 Record heater setpoint at this time. The heater must remain at this setpoint for the remainder of the measurements.

B3.6.9 Replace the heat flux gauge holder board with a board that can measure the heat flux at location 2 depicted in Figure N-13 with the heat flux gauge already installed.

B3.6.10 Leave the ceramic fiberboard holding the heat flux gauge in the sample holder in front of the heater for 5 minutes.

B3.6.11 Once the 5 minutes is complete, record the average heat flux for a duration of 5 additional minutes confirming the heat flux is at the depicted heat flux for its corresponding location shown in Figure N-15.

B3.6.12 Repeat for the remainder of the heat flux locations 3-6 depicted in Figures N-13, N-14, and N-15 ensuring all heat flux locations are in range as shown.

B3.6.13 The periodic calibration is now complete, and the heater is confirmed in its proper set up and function.

### **B3.7 Apparatus Pre-Heat and Radiant Heater Furnace Calibration Before Testing Procedure**

B3.7.1 Switch on heating element. The ribbon burner is withdrawn away from the test position and the sample door and outer door are closed with a ceramic fiberboard secured in the sample holder.

B3.7.2 Ensure that the exhaust fan that will run during testing is switched on.

B3.7.3 Allow chamber to heat up until stabilized.

B3.7.4 Once the chamber has stabilized, confirm and record the ambient air temperature is at  $74 \pm 4$  °F ( $23 \pm 2$  °C). Turn on cooling water to heat flux gauge. Then, open the outer door, remove the blank panel in the sample holder, and insert ceramic fiberboard that is holding the heat flux gauge (Figure N-12).

B3.7.5 Leave the ceramic fiberboard holding the heat flux gauge in the sample holder in front of the heater for 5 minutes and adjust the radiant heater in order to achieve  $1.59 \pm 0.04$  Btu/ft<sup>2</sup>sec ( $1.8 \pm 0.05$  Watts/cm<sup>2</sup>) during this time. The outer door should be closed as much as the heat flux gauge leads allow.

B3.7.6 Once the heat flux is achieved, record heat flux for a duration of 5 additional minutes holding the heat flux at the steady value of  $1.59 \pm 0.04$  Btu/ft<sup>2</sup>sec ( $1.8 \pm 0.05$  Watts/cm<sup>2</sup>).

B3.7.7 Once the required heat flux is achieved and stabilized for the test, remove the heat flux gauge and replace with a ceramic fiberboard.

B3.7.8 Ignite the ribbon burner and place the burner in test position.

B3.7.9 Place the exhaust cone holding the 4-inch vane anemometer on the VFP chimney. Measure and record the average flow velocity through the anemometer in feet per minute (or meters per second).

B3.7.10 Turn off the lab's exhaust fan and measure and record the average flow velocity through the anemometer. Record the difference between the average flow velocity through the anemometer with the lab's exhaust fan off and on.

B3.7.11 Remove the anemometer and the exhaust cone. Place ribbon burner in standby position.

### **B3.8 Test Procedure**

B3.8.1 Confirm and record the ambient air temperature is at  $74 \pm 4$  °F ( $23 \pm 2$  °C).

B3.8.2 Initiate flow of premixed methane and air mixture to ribbon burner with the flow set to the parameters of B3.5.3.1 and ignite.

B3.8.3 Open outer door.

B3.8.4 Open sample door.

B3.8.5 Remove fiberboard and place test sample in sample holder with the face to be tested toward the radiant heater.

B3.8.6 Secure test sample by ensuring it is firmly placed in the holder and the sample retaining frame (when used, see Section N.3.10 for details) is placed behind the sample. The sample door is still open and should not be closed yet. If the test sample holder allows for the sample to be secure in the frame prior to loading into the door, the entire assembly may be placed in the test sample door at one time.

B3.8.7 Push/translate ribbon burner into position.

B3.8.8 Reset stopwatch to 0 and prepare to start timing upon sample door closing. If the test apparatus has a built-in timing system, this may be used in place of the physical stopwatch.

B3.8.9 Close sample door, begin stopwatch count.

B3.8.10 Close outer door gently to protect user.

B3.8.11 After 30 seconds, pull the ribbon burner back into the standby. Do not stop the timer yet.

B3.8.12 Monitor sample burning via viewing windows.

B3.8.13 Stop timer when all flaming on sample surface ceases, visually remembering where the furthest point of the sample surface appears to be burned/damaged. Video recording may be useful in determining this point in post-test review for clarity.

B3.8.14 Record after flame time as the time at extinguishment minus the flame impingement time.

B3.8.15 Open door, remove sample or entire test sample holder assembly, and place under lab's fume hood until off-gassing ceases and sample is ready to handle and measure.

B3.8.15.1 If continuing to test, clean any material residue from this test out of the test chamber, ensuring the perforated steel sheet and the honeycomb sheet are free of any residues, and place next sample in sample holder and repeat.

B3.8.15.2 If testing is complete, place ceramic fiberboard back into the sample holder, and close sample and outer doors.

### **B3.9 Burn Length Measurement Procedure**

B3.9.1 Wait until sample has cooled to the touch and is no longer off-gassing.

B3.9.2 Use a cloth or brush to wipe away sooted areas of the sample face to help with determining the burn length. A mild detergent cleaner or water may be used to remove soot or to clean the surface of the sample.

B3.9.3 Burn length measurement. Reference B3.2.1 and see figure B3-1 for more details.

### **B3.10 Report**

B3.10.1 Report a complete description of the material(s) being tested, including manufacturer, composition, trade name(s), **or the test article ID number from the test plan, as applicable. Also include sample configuration (flat, round, diameter if round, thickness, stacking sequence etc.).**

B3.10.2 For each of the samples tested, report the after-flame time and burn length.

B3.10.3 Record any observations regarding the behavior of the test sample during the test, such as popping, smoke, backside flaming, and the time of the event.

**B3.10.4 Report the test apparatus thermocouple stability measurement, the ambient air temperature, and the difference between the average flow velocity through the anemometer with the lab's exhaust fan off and on, as defined in B3.7.10.**

### **B3.11 Requirements**

**B3.11.1 Pass/fail criteria to be declared.**

B3.11.2 If one or more of the samples fail to meet the above requirements, it is possible to run additional recovery tests if 80 percent or more of the total number of samples meet the requirements. For example, if one of the three original samples fails the test requirement, two additional passing tests can be conducted for a total of four passing tests in five opportunities (4/5=80%).