

Chapter A5

Test Method to Determine the Burnthrough Resistance of Thermal/Acoustic Insulation Materials

A5.1 Scope

A5.1.1 Applicability

This test method evaluates the burnthrough resistance characteristics of aircraft thermal/acoustic insulation materials when exposed to a high-intensity open flame.

A5.2 Definitions

A5.2.1 Burnthrough Time

Burnthrough time means the time, in seconds, for the burner flame to penetrate the test sample or the time required for the heat flux to reach 2.0 Btu/ft²sec (2.27 W/cm²) on the inboard side, at a distance of 12 inches (30.5 cm) from the front surface of the insulation blanket test frame, whichever is sooner. The burnthrough time is measured at the inboard side of each of the insulation blanket samples.

A5.2.2 Insulation Blanket Sample

Insulation blanket sample means one of two samples positioned in either side of the test rig at an angle of 30 degrees with respect to horizontal.

A5.2.3 Sample Set

Sample set means two insulation blanket samples. Both samples must represent the same production insulation blanket construction and materials, proportioned to correspond to the sample size.

A5.3 Apparatus

A5.3.1 Test Apparatus

The arrangement of the test apparatus is shown in figures A5-1 and A5-2 and must include the capability of moving the test samples into and away from the sonic burner. Construct the mounting frame for the test samples of 0.125-inch-thick (3.2 mm) steel, as shown in figure A5-1, except for the center vertical former, which should be 0.25-inch thick (6.4 mm) to minimize warpage. The sample mounting frame stringers (horizontal) should be bolted to the test frame formers (vertical) so the expansion of the stringers will not cause the entire structure to warp. Use the mounting frame for mounting the two insulation blanket test samples, as shown in figure A5-2.

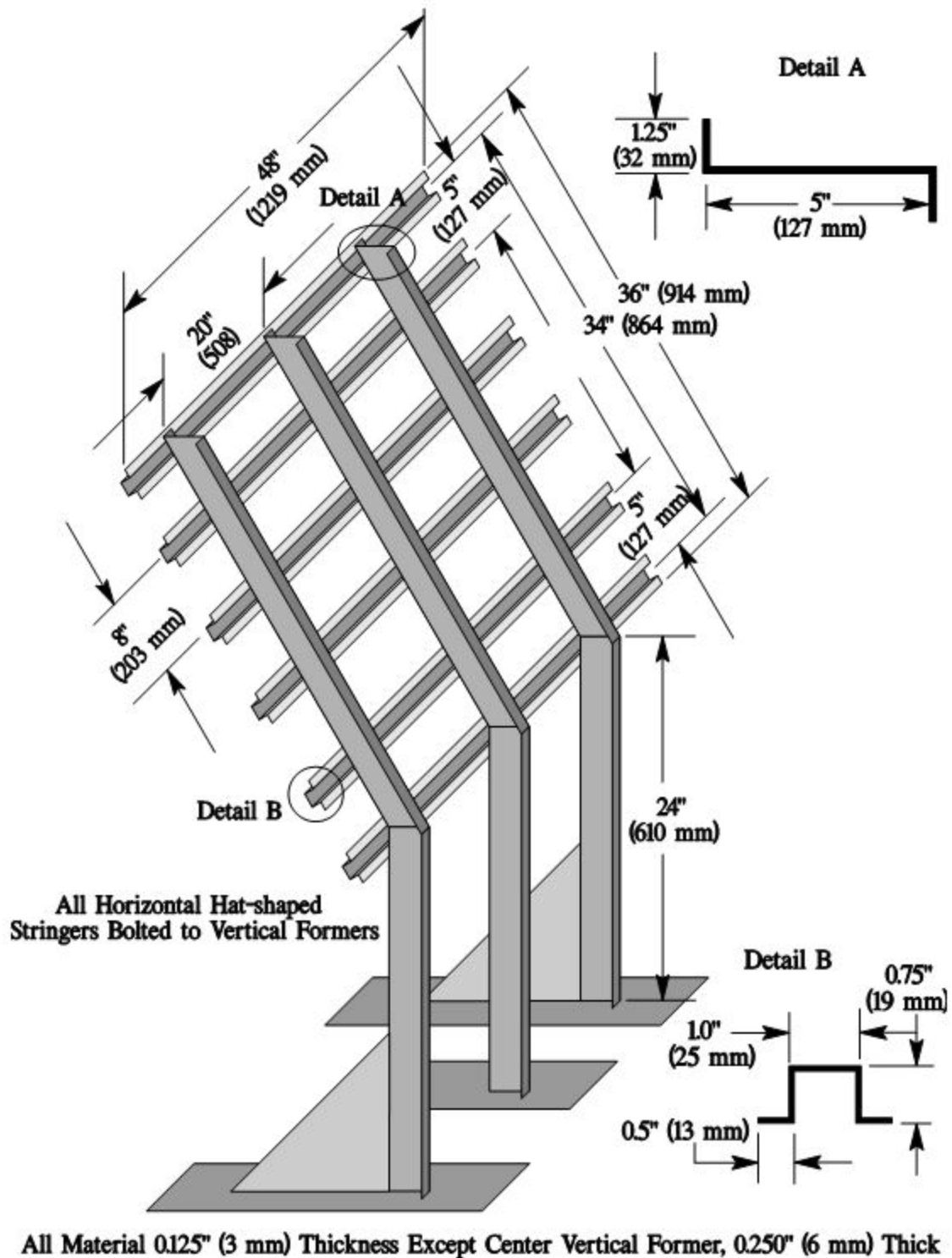


Figure A5-1. Test apparatus sample holder

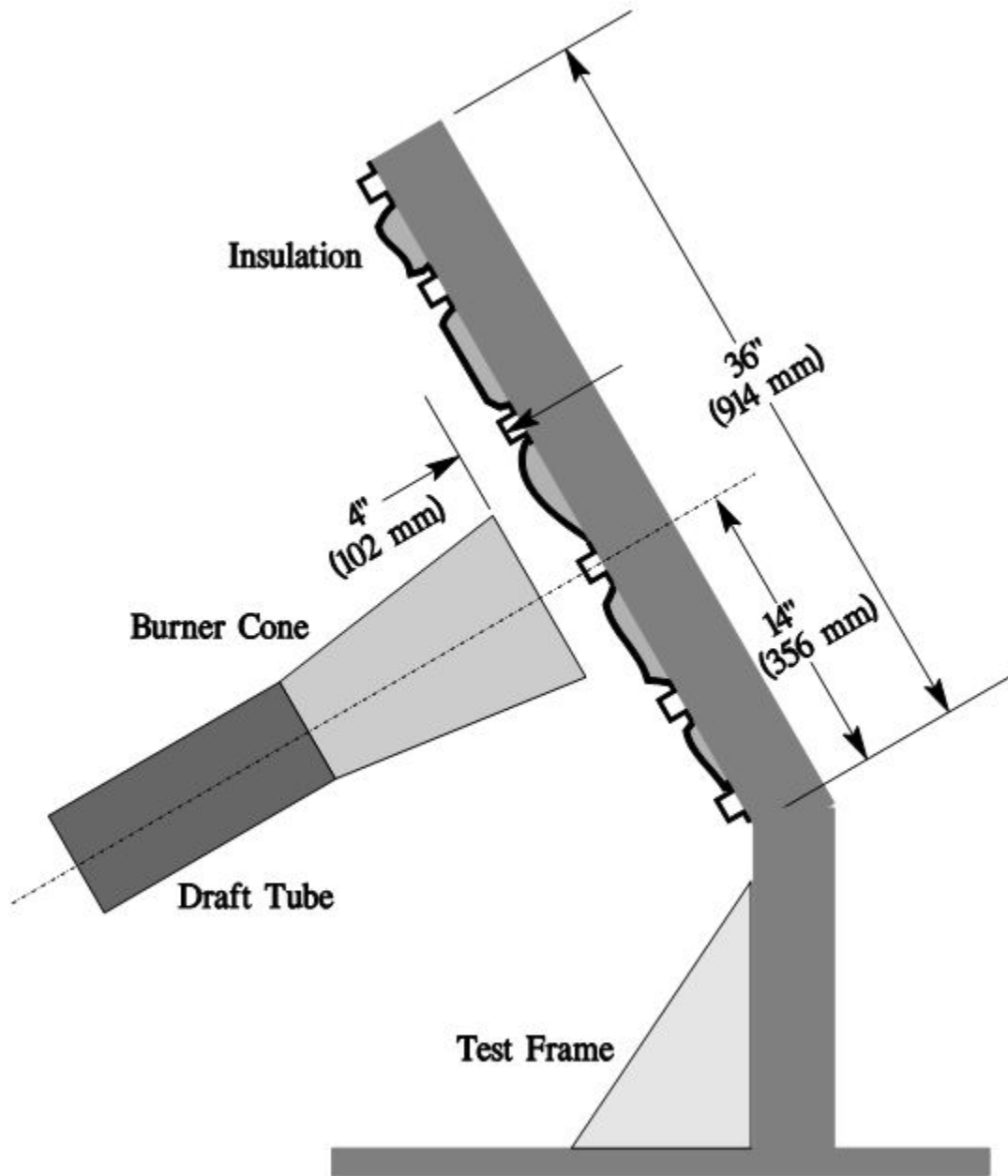


Figure A5-2. Burnthrough test apparatus sample holder

A5.3.2 Burner

The test burner is the Sonic fire test burner, described in detail in appendix K. The burner configuration for this test method is displayed in table A5-1.

Table A5-1. Burner configuration for the insulation burnthrough test

Fuel	Nozzle	6.0 gal/hr 80° General Purpose or Semi-Solid Spray
	Volumetric Flow Rate (gal/hr)	6.0 ± 0.2
	Pressure	110 ± 10
Air	Diffusion Method	Stator and Turbulator
	Pressure (psig)	60 ± 2
	Mass Flow Rate (SCFM)	65.8
	Burner Orientation	30° From Horizontal

A5.3.2.1 Inlet Condition Measuring

To obtain an accurate measurement of the conditions entering the burner, fuel pressure and temperature, and air pressure and temperature measurements must be made nearest to the burner inlet (see figure A5-3). To minimize air-stream disruptions, the intake air temperature must be measured prior to the sonic nozzle.

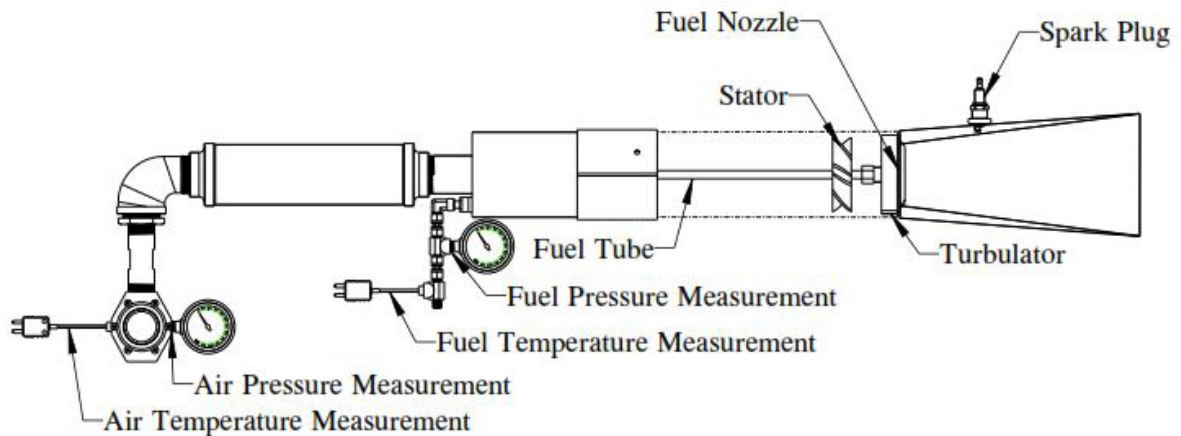


Figure A5-3. Inlet condition measurement location (side view)

A5.3.2.2 Fuel Nozzle

A screw-in fuel nozzle is required to maintain a fuel pressure that will yield a 6.0 ± 0.2 gal/hr ($22.68 \text{ L/hr} \pm 0.756 \text{ L/hr}$) fuel flow. A Delavan type-W nozzle with an 80° general purposespray angle nominally rated at 6.0 gal/hr (22.68 L/hr) at 100 lb/in^2 (0.69 MPa) has been found to deliver the appropriate flow rate and produce the proper flame pattern and is the recommended nozzle. Actual flow-rate measurements may deviate from the advertised flow rate. The actual flow rate must be measured manually using a flexible tube, graduated cylinder, and timing device, as described in section A5.5.4.6. The fuel pressure must then be adjusted accordingly to produce the required fuel flow of 6 ± 0.2 gal/hr ($22.68 \text{ L/hr} \pm 0.756 \text{ L/hr}$). For more details, refer to appendix K, section K.3.4.4, Fuel Nozzle.

A5.3.2.3 Fuel Pressure Regulation

The fuel must be properly pressurized to deliver the proper fuel flow. Ideally, this pressure must be in the range of $100\text{--}120 \text{ lb/in}^2$ (0.69 to 0.83 MPa). For details on fuel pressurization and regulation, refer to appendix K, section K.3.4, Fuel System.

A5.3.2.4 Fuel Type

A kerosene-type fuel is used in the burner equipment. Jet A and JP-8 (military equivalent to Jet A) fuel is recommended; however, other fuels are permissible if the flame temperature can be maintained, according to section A5.6.1.3. For more details, refer to appendix K, section K.3.4.6, Fuel.

A5.3.2.5 Burner Cone

A 12 ± 0.125 -inch (305 ± 3 -mm) burner extension cone is fitted to the end of the burner draft tube. The opening must be 6 ± 0.125 inches ($152 \pm 3 \text{ mm}$) high and 11 ± 0.125 inches ($280 \pm 3 \text{ mm}$) wide. For more details, refer to appendix K, section K.3.7, Burner Cone.

A5.3.2.6 Spark Plug

An automotive-style spark plug is fitted into a threaded boss, which is welded to the burner extension cone. The threaded boss is centered on the upper surface of the burner cone at a distance of 6 ± 0.125 inches ($152 \pm 3 \text{ mm}$) from the intake end of the burner cone. For more details, refer to appendix K, section K.3.5, Ignition.

A5.3.3 Burner Flame Consistency Validation Thermocouples

Seven thermocouples must be used to check the flame temperature of the burner. The thermocouples must be 0.125 -inch (3.2 -mm) diameter, insulation-packed, 310 stainless-steel sheathed, type K (Chromel-Alumel), grounded junction with a nominal 24 American Wire Gauge (AWG) size conductor. Thermocouples purchased with a certificate of calibration may provide more accurate readings but are not required. The seven thermocouples must be attached to a steel mounting plate to form a thermocouple rake for placement in the test stand during the burner flame consistency validation procedure (see figure A5-4). It is recommended

the thermocouple mounting plate be a minimum of 4 inches (102 mm) away from the tips of the thermocouples.

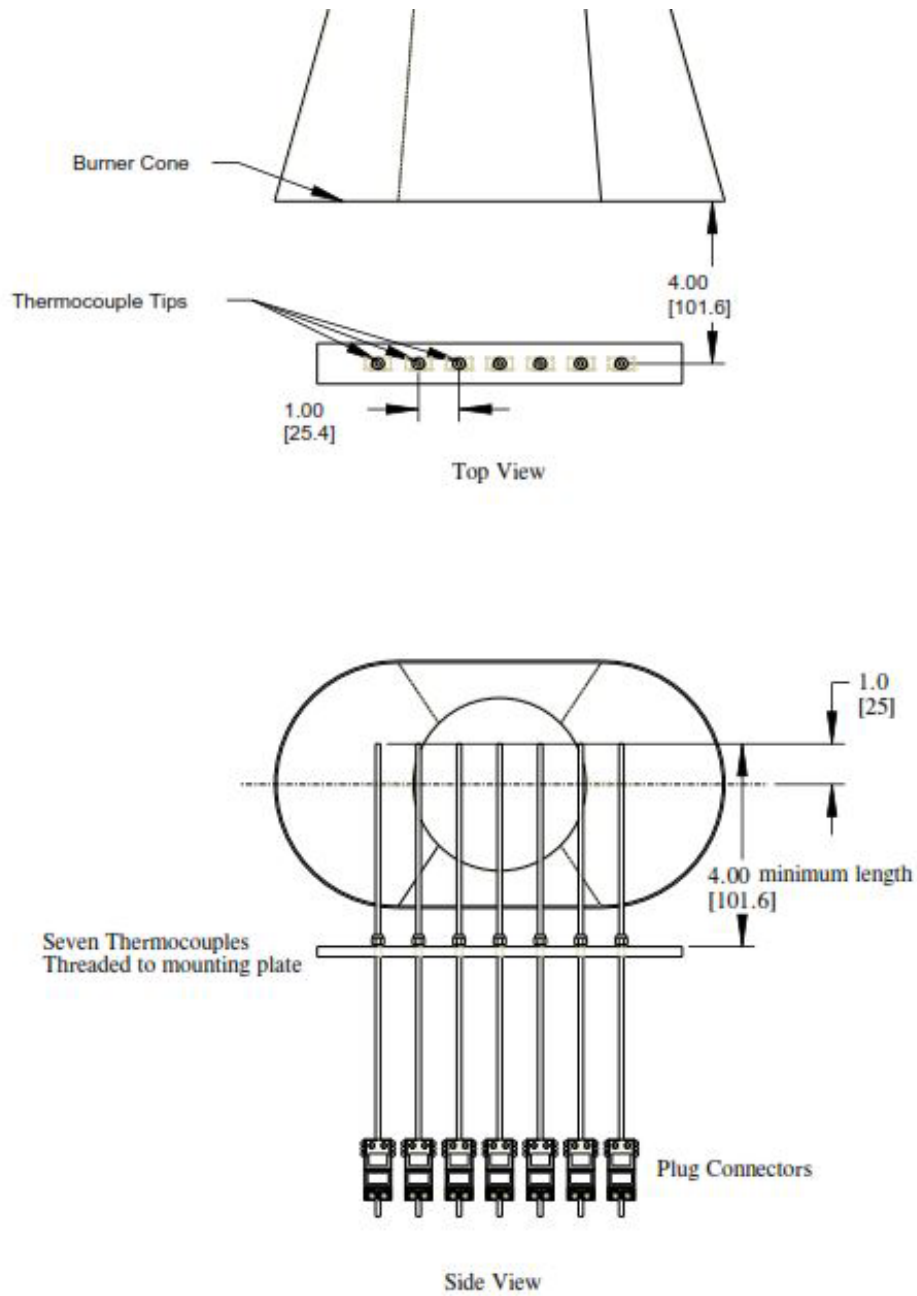


Figure A5-4. Top and side view of thermocouple rake bracket

A5.3.4 Backface Heat Flux Gauges

Mount two total heat-flux, Gardon-type gauges behind the insulation test samples on the back side (cold) area of the test-sample mounting frame, as shown in figure A5-5. Position the

backface heat flux gauges (HFGs) along the same plane as the burner cone centerline, at a distance of 4 inches (102 mm) from the vertical centerline of the test frame.

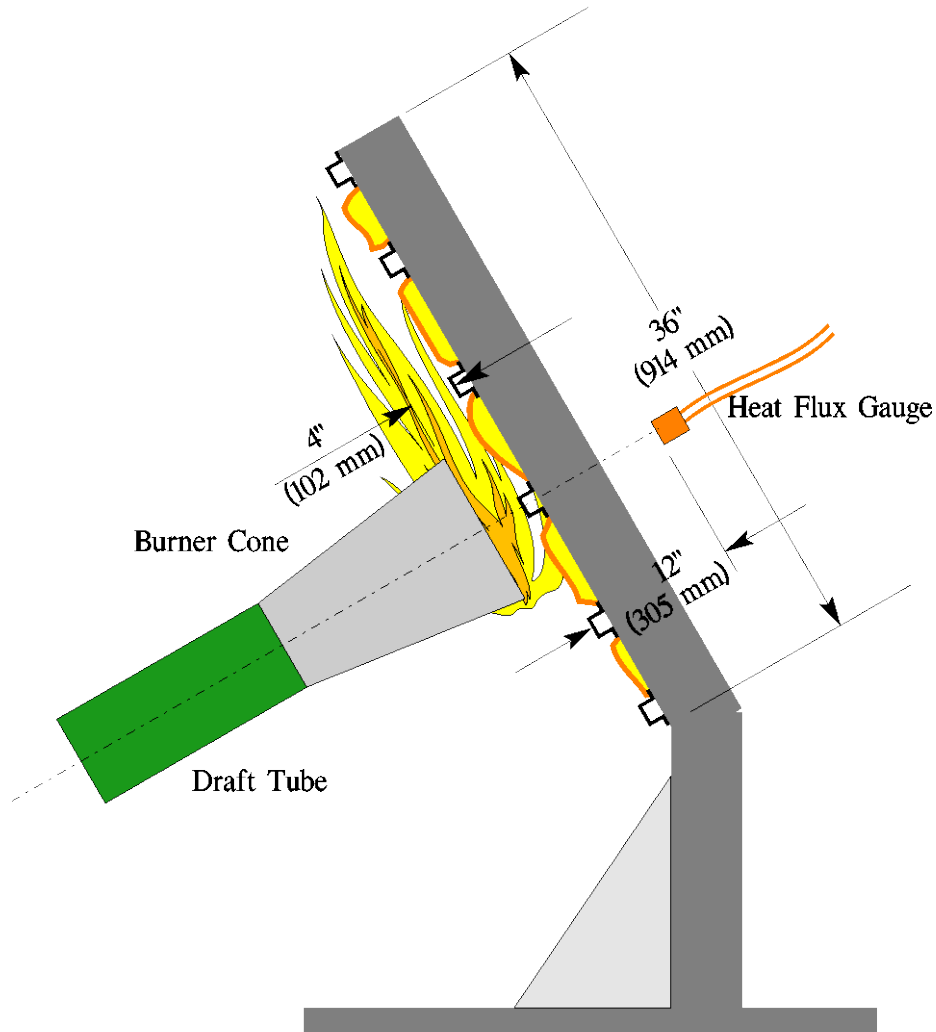


Figure A5-5. Position of backface HFGs relative to test-sample frame

A5.3.4.1 Backface HFG Requirements

The HFGs must be a total heat flux, foil-type Gardon gauge of an appropriate range, such as 0-5 Btu/ft²-sec (0-5.7 W/cm²), accurate to $\pm 3\%$ of the indicated reading. The heat-flux calibration method must comply with the requirements of appendix H.

A5.3.5 Instrumentation and Supporting Equipment

A5.3.5.1 Data Acquisition

A calibrated recording device or a computerized data-acquisition system with an appropriate range must be used to measure and record the outputs of the thermocouples and HFGs.

A5.3.5.2 Timing Device

A stopwatch or other device, accurate to within ± 1 second per 8 hours (± 3 sec/day), must be used to measure the time of application of the burner flame, the test-sample ignition, and the extinguishment times.

A5.3.5.3 Test Chamber Anemometer

A handheld vane-type or hotwire-type air velocity sensing unit capable of measuring accurately in the 0–100 ft/min range must be used to monitor the flow of air inside the test chamber when the ventilation hood is operating. Airflow measurements should be taken at the beginning of the day prior to operating the test burner. A suitable hotwire anemometer, which may be mounted to the sample test frame, is manufactured by Dwyer® Instruments, model number 641-6-LED. A suitable handheld hotwire anemometer is manufactured by TSI, model number 9515. Vane-type anemometers typically do not function properly with airflow rates less than 50 ft/min.

A5.3.5.4 Test Chamber

A suitable test chamber must be used to reduce or eliminate the possibility of test fluctuation due to air movement. Although not required, the recommended minimum of the test-chamber floor area is 15 feet by 15 feet (4.57 m by 4.57 m) or larger.

NOTE: Smaller test cells may experience significant increases in ambient air temperature while testing. This may increase the severity of the test.

A5.3.5.5 Ventilation Hood

The test chamber must have an exhaust system capable of removing the products of combustion expelled during the tests.

A5.4 Test Samples

A5.4.1 Sample Preparation

Prepare a minimum of three sample sets of the same construction and configuration for testing.

A5.4.2 Insulation Blanket Test Sample

A5.4.2.1 For batt-type materials, such as fiberglass, the constructed, finished blanket sample assemblies must be 32 inches wide by 36 inches long (81.3 by 91.4 cm), exclusive of heat-sealed film edges.

A5.4.2.2 For rigid and other nonconforming types of insulation materials, the finished test samples must fit into the test rig in such a manner as to replicate the actual in-service installation.

A5.4.3 Construction

Make each of the samples tested using the principal components (i.e., insulation, fire barrier material if used, and moisture barrier film) and assembly processes (representative seams and closures).

A5.4.3.1 Fire Barrier Material

If the insulation blanket is constructed with a fire barrier material, place the fire barrier material in a manner reflective of the installed arrangement. For example, if the material will be placed on the outboard side of the insulation material inside the moisture film, place it the same way in the test sample.

A5.4.3.2 Insulation Material

Blankets that use more than one variety of insulation (e.g., composition, density) must have sample sets constructed that reflect the insulation combination used. If, however, several blanket types use similar insulation combinations, it is not necessary to test each combination if it is possible to bracket the various combinations.

A5.4.3.3 Moisture Barrier Film

If a production blanket construction uses more than one type of moisture barrier film, perform separate tests on each combination. For example, if a polyimide film is used in conjunction with insulation to enhance the burnthrough capabilities, also test the same insulation when used with a polyvinyl fluoride film.

A5.4.4 Installation on Test Frame

Attach the blanket test samples to the test frame using 12 steel spring-type clamps, as shown in figure A5-6. Use the clamps to hold the blankets in place in both of the outer vertical formers and the center vertical former (four clamps per former). The clamp surfaces should measure 1 inch by 2 inches (25 by 51 mm). Place the top and bottom clamps 6 inches (15.2 cm) from the top and bottom of the test frame, respectively. Place the middle clamps 8 inches (20.3 cm) from the top and bottom clamps.

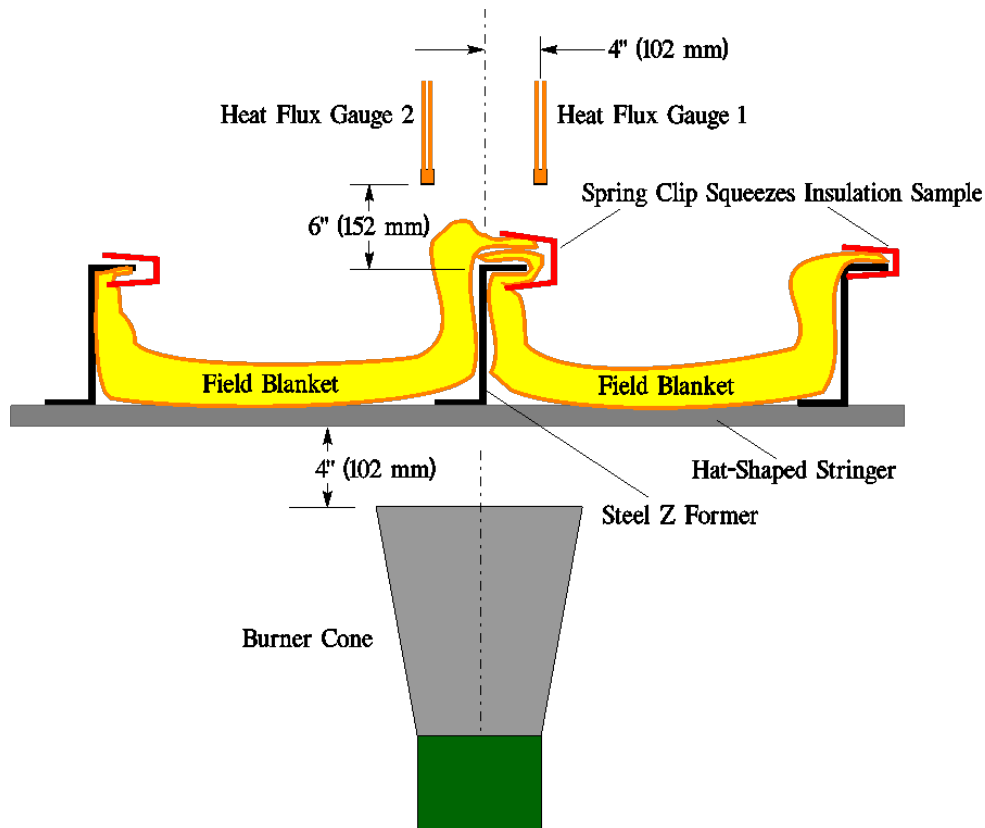


Figure A5-6. Test-sample installation on test frame

NOTE: For blanket materials that cannot be installed in accordance with figure A5-6, the blankets must be installed in a manner approved by the FAA.

A5.4.5 Conditioning

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. Remove only one sample at a time from the conditioning environment immediately before testing.

A5.5 Preparation of Apparatus

A5.5.1 Alignment

Mount a test sample on the test-sample frame. Level and center the sample holder frame assembly to ensure alignment with the burner cone. Move the test-sample mounting frame into position in front of the burner, and check for proper alignment (i.e., distance from exit of burner cone to face of test sample, and proper sample height with respect to cone centerline). The movable assembly should incorporate mechanical stops or detents to ensure that the samples can be moved into position quickly without measurement during testing.

A5.5.2 Chamber Ventilation

Turn on the ventilation hood for the test chamber. Do not turn on the pressurized burner air. With the test sample still in place on the test frame, measure the airflow in the test chamber using a hotwire anemometer or equivalent measuring device. The vertical air velocity within a 12-inch (30.5 cm) radius from any point on the test sample must be less than 100 ft/min (50.8 cm/sec). The horizontal air velocity within a 12-inch (30.5 cm) radius from any point on the sample must be less than 50 ft/min (25.4 cm/sec).

NOTE 1: Airflow measurements do not have to be taken for each sample tested. It is recommended the airflow measurements be taken at the beginning of the day before testing and at the end of the day when testing is completed.

NOTE 2: Personnel present within the test cell may influence air velocity readings. This may be avoided by mounting the anemometer instrumentation to the sample holder during test cell air velocity measurements.

A5.5.3 Test Chamber Air Temperature

The temperature of the test chamber should be between 50°F and 100°F (10°C and 38°C) before the start of each test. The chamber air temperature should be measured at the same height as the center of the test sample, within 12 inches (30.5 cm) laterally. Remove the sample from the test frame. Do not use this sample for testing. The sample may be kept for future test chamber airflow and temperature measurements.

A5.5.4 Sonic Burner Configuration

A5.5.4.1 Fuel Nozzle Location

The tip of the fuel nozzle, or fuel exit plane, must be located 0.1875 ± 0.020 inches (4.763 ± 0.5 mm) from the exit plane of the turbulator (see figure A5-7).

A5.5.4.2 Stator Adjustment

The stator is positioned by adjusting its translational position and its axial position on the fuel rod.

A5.5.4.2.1 Stator Translational Position

The front face of the stator must be located 2.6875 ± 0.020 inches (68.263 ± 0.5 mm) from the exit plane of the turbulator (see figure A5-7). This stator translational position is also 2.5 inches (63.5 mm) from the tip of the fuel nozzle.

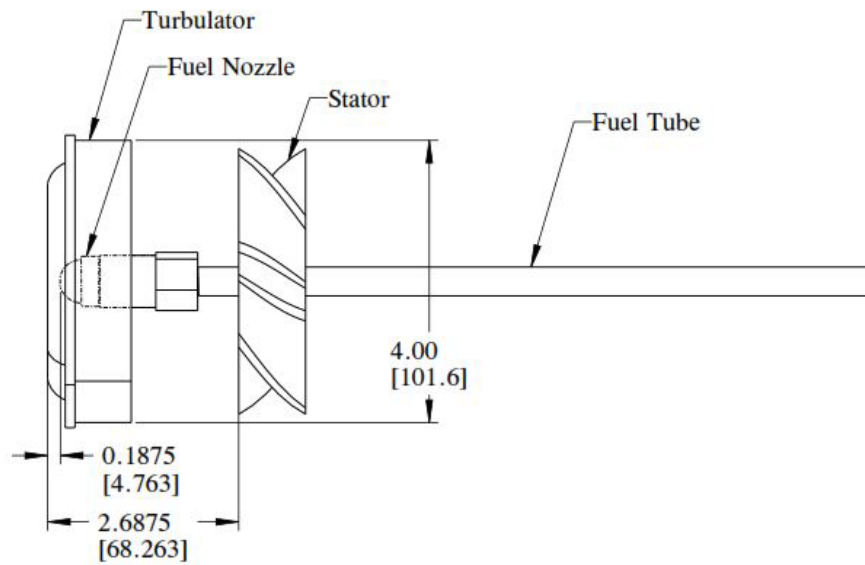


Figure A5-7. Fuel nozzle and stator locations

A5.5.4.2.2 Stator Axial Position

The line running through the set screw and geometric center of the stator will be used as a reference for properly orienting the rotational position of the stator. The stator must be positioned so the reference line angle is 0 degrees (12 o'clock) from the zero position when looking into the burner draft tube (see figure A5-8).

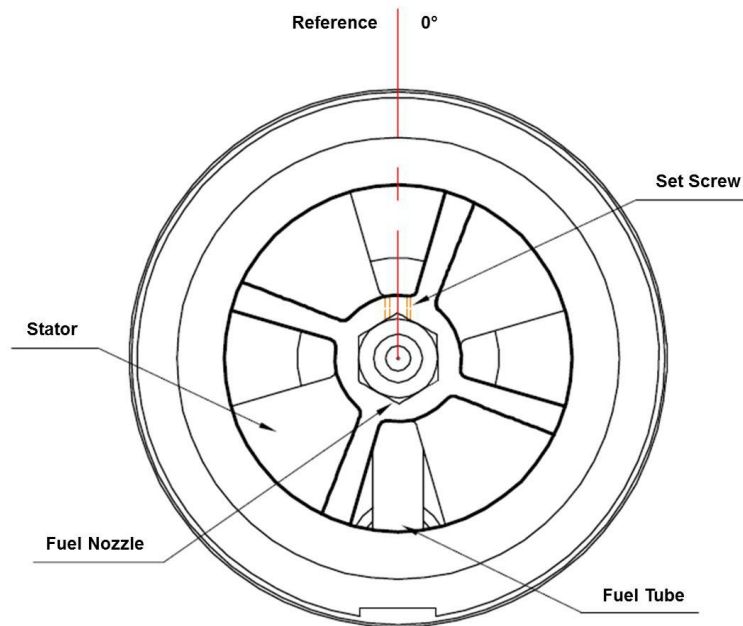


Figure A5-8. Stator axial position

A5.5.4.3 Spark Plug

A high-voltage oil burner ignition transformer with an output of 10 kilovolts is used to create an arc across an automotive-type spark plug mounted in the burner extension cone.

A5.5.4.3.1 Spark Plug Gap

The spark plug gap (distance) between the two electrodes must be 0.100 inches (2.5 mm), as shown in figure A5-9.

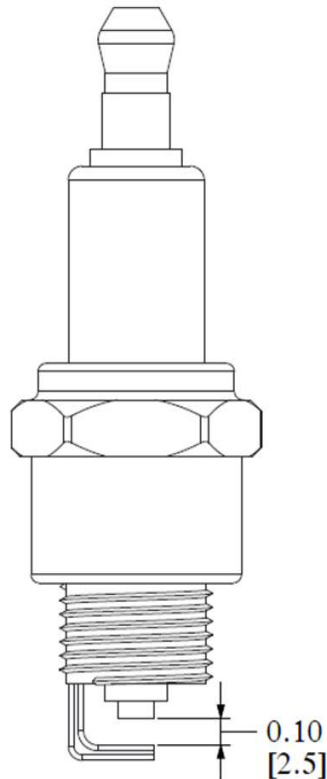


Figure A5-9. Spark plug gap measurement

A5.5.4.4 Spark Plug Wire Routing

The length and arrangement of the spark plug wire must be monitored to prevent heat damage during flame-temperature validation and testing. Once the burner is ignited, the outside surface temperature of the burner cone will increase rapidly, becoming capable of damaging the wire if it comes in contact with the cone. The spark plug wire should be carefully routed to prevent contact with the cone or other hot surfaces and should also be shielded in a heat-resistant covering to further protect it from convective heat damage from the burner flames. The wire can be routed as shown in figure A5-10, in which it does not contact any components in the vicinity of the burner cone.

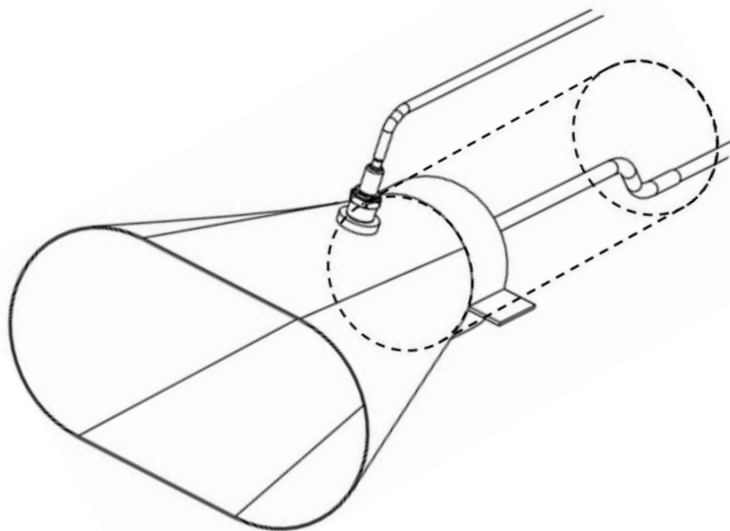


Figure A5-10. Proper routing of the spark plug wire

A5.5.4.5 Volumetric Airflow Control

The volumetric airflow is controlled via a regulated sonic nozzle. Adjust the upstream supply air pressure to $60 \text{ lb/in}^2 \pm 2 \text{ lb/in}^2$ ($0.41 \pm 0.014 \text{ MPa}$). The intake air temperature must be maintained within the range of 40°F to 60°F (4°C to 16°C). For more details, refer to appendix K, section K.3.2, Combustion Airflow Control.

A5.5.4.6 Fuel-Flow Calibration

If a calibrated flow meter is not available, measure the fuel flow directly using a length of Tygon tubing and an appropriately sized graduated cylinder. Slip the Tygon tubing over the end of the fuel nozzle, making certain to establish a good seal. Direct the exit of the Tygon tubing into a small bucket or other collection basin. Turn on the fuel solenoid, making sure the ignition system is off. After establishing a steady stream of fuel flow, simultaneously direct the tubing exit into the graduated cylinder while beginning the stopwatch or timing device. Do not disturb or move the tube while collecting fuel in the graduated cylinder. Collect the fuel for a 2-minute period, making certain to immediately remove the graduated cylinder from the fuel stream at precisely 2 minutes. Calculate the flow rate and ensure that it is $6.0 \pm 0.2 \text{ gal/hr}$ ($22.68 \text{ L/hr} \pm 0.756 \text{ L/hr}$). If the flow rate is not within tolerance, adjust the fuel pressure accordingly. Record the fuel pressure necessary to achieve the required fuel flow. The recorded fuel pressure must be monitored and maintained during burner operation and fluctuate no more than $\pm 2 \text{ lb/in}^2$ ($\pm 0.0138 \text{ MPa}$) during flame-consistency validation and sample testing. A flame-temperature validation or sample test will be void should the fuel pressure fluctuate outside of this range.

during either procedure. The temperature of the fuel must be maintained within the range of 32°F to 52°F (0°C –11°C).

NOTE: When collecting fuel during the fuel-flow calibration check, it is important to establish a steady stream of fuel before starting the measurement process. The tube may need to fill with fuel directly above the fuel nozzle before a steady stream of fuel will flow freely from the tube end because of the inclined orientation of the insulation test burner. It is recommended the fuel flow steadily from the tube end for a minimum 10-second period before collecting fuel in the graduated cylinder.

A5.6 Burner Flame Consistency Validation

A5.6.1 Sonic Burner

The sonic burner used in the test must be checked to ensure the proper flame temperature is being produced for consistent and accurate test results.

A5.6.1.1 Move the test-sample apparatus from the test position to the warmup position. Examine and clean the burner cone of any evidence of buildup of combustion products, such as soot. Soot buildup inside the cone may affect the flame characteristics and cause flame temperature validation difficulties. Check to ensure the burner cone dimensions are within specified tolerances before flame validation.

A5.6.1.2 Mount the thermocouple rake on a movable stand that is capable of being quickly translated into position in front of the burner. Move the rake into the flame-validation position and check the distance of each of the seven thermocouples to ensure that they are located 4 ± 0.125 inches (102 ± 3 mm) from the vertical plane of the burner cone exit. Ensure that the horizontal centerline of the thermocouples is offset 1 ± 0.063 inch (25.4 ± 1.6 mm) above the horizontal centerline of the burner cone (see figure A5-4). Place the center thermocouple (thermocouple number 4) in front of the center of the burner cone exit. Note that the movable thermocouple rake stand must incorporate detents that ensure proper centering of the thermocouple rake with respect to the burner cone so that rapid positioning of the rake can be achieved during the validation procedure. Once the proper position is established, move the thermocouple rake away, and move back into the flame-temperature validation position to recheck distances. When all distances and positions are confirmed, move the thermocouple rake away from the burner.

A5.6.1.3 While the thermocouple rake is away from the burner, turn on the spark plug, pressurized air, and fuel flow; light the burner. Allow burner to warm up for 2 minutes. After warmup, move the thermocouple rake into position and allow 1 minute for thermocouple stabilization, then record the temperature of each of the seven thermocouples once every second for 30 seconds. Remove the thermocouple rake from the flame-temperature validation position and turn off the burner. Calculate the average temperature of each thermocouple over this period and record. Although not a requirement for testing, the recommended average temperature of each of the seven thermocouples should be 1900°F $\pm$ 100°F (1038°C $\pm$ 55°C). The burner should be rechecked to ensure it is configured properly if temperatures are measured outside of this recommended range. A

flame that appears biased to one side, or produces significantly higher temperatures on one end of the flame validation thermocouple rake, may indicate that an adjustment of the fuel nozzle, internal stator orientation, or distance from the end of the draft tube may be necessary if the adjustments are within allowable tolerances. If no problems are found with the burner, any thermocouple reading outside of this range may require replacement. It is recommended that the burner flame temperature be validated at the beginning and end of each day testing is performed.

NOTE 1: The thermocouples are subjected to high temperature durations during calibration. Because of this type of cycling, the thermocouples may degrade with time. Small but continuing decreases or extreme variations in temperature or no temperature reading at all are signs that the thermocouple or thermocouples are degrading or open circuits have occurred. In this case, the thermocouple or thermocouples should be replaced to maintain accuracy in calibrating the burner. It is recommended that a record be kept for the amount of time the thermocouples are exposed to the oil burner's flame.

NOTE 2: The sonic burner is sensitive to proper alignment of the fuel nozzle. It is crucial that the fuel nozzle be aligned to the geometric center of the turbulator. A slight adjustment of the fuel tube between the stator and fuel nozzle may be required to obtain an even temperature profile across the thermocouple rake. The center point of the nozzle where the fuel exits should not deviate more than 0.0625 inch from the geometric center of the turbulator exit plane when looking into the burner draft tube. This should be performed only after checking the burner for proper configuration.

A5.7 Test Procedure

A5.7.1 Secure the two insulation blanket test samples to the test frame. The insulation blankets should be attached to the test rig's center vertical former using four spring clamps positioned as shown in figure A5-6 (according to the criteria of paragraph A5.4.4 of this chapter).

A5.7.2 Ensure that the vertical plane of the burner cone is at a distance of 4 ± 0.125 inches (102 ± 3 mm) from the outer surface of the horizontal stringers of the test-sample frame, and that the burner and test frame are both situated at a 30° angle with respect to horizontal.

A5.7.3 When ready to begin the test, move the test samples away from the burner test position to the warmup position so that the flame will not impinge on the samples prematurely. Turn on and light the burner, and allow it to stabilize for 2 minutes.

A5.7.4 To begin the test, move the test frame containing the insulation samples into the test position in front of the burner, and simultaneously start the timing device.

A5.7.5 Expose the test samples to the burner flame for 4 minutes, and then turn off the burner. Immediately move the test-sample frame out of the test position away from the burner.

A5.7.6 Determine (if applicable) the burnthrough time or the point at which the heat flux exceeds $2.0 \text{ Btu/ft}^2\text{-sec}$ (2.27 W/cm^2) on either of the two HFGs.

A5.8 Report

A5.8.1 Identify and describe the sample being tested.

A5.8.2 Report the number of insulation blanket samples tested.

A5.8.3 Report the burnthrough time (if any) and the maximum heat flux on the back face of the insulation blanket test sample, and the time at which the maximum occurred.

A5.9 Requirements

A5.9.1 Each of the three sets of insulation blanket test samples must not allow fire or flame penetration in less than 4 minutes.

A5.9.2 Each of the three sets of insulation blanket test samples must not allow more than 2.0 Btu/ft²-sec (2.27 W/cm²) on the cold side of the insulation samples at a point 12 inches (30.5 cm) from the face of the test rig.

A5.9.3 If one or more sample sets fails to meet the above requirements, it is possible to run additional tests if 80 percent or more of the total number of sample sets meet the requirements. For example, if one of the three original sample sets fails the test requirement, two additional passing tests can be conducted for a total of four passing tests in five opportunities (4/5 = 80%).

NOTE: The additional testing is intended for materials that typically meet the test requirements but experience an unexpected failure for unknown reasons. These failures, often referred to as rogue failures, are unanticipated and cannot be explained. Additional testing should not be viewed as a technique for meeting the requirement with inferior materials.