# Chapter 12
# Powerplant Fire Penetration Test

## 12.1 Scope

12.1.1 This test method is intended to determine the capability of components and constructions to control the passage of fire or its effects in powerplant (engine) compartments and, thereby, to prevent additional hazard to the aircraft.

12.1.2 This test is used to show compliance with FARs 25.867, 25.865, 25.1191, and 25.1193.

## 12.2 Definitions

12.2.1 Firewall

A firewall is a structure designed to prevent a hazardous quantity of air, fluid, or flame from exiting a fire zone in which a fire has erupted and causing hazard to the aircraft. Firewalls must be fireproof.

12.2.2 Fireproof

Per FAR Part 1, (found in Subchapter A—Definitions, Part I—Definitions and Abbreviations) "in designated fire zones means the ability of materials or parts to withstand the heat from a severe fire of extended duration at least as well as steel in dimensions appropriate for their purpose."

12.2.2.1 Materials or parts are demonstrated to be fireproof by meeting requirements of this test for a flame exposure of 15 minutes.

12.2.3 Fire Resistant

Per FAR Part 1, (found in Subchapter A—Definitions, Part I—Definitions and Abbreviations) "with respect to fluid carrying lines, fluid system parts, wiring, air ducts, fittings, and powerplant controls means the capacity to perform the intended functions under the heat and other conditions likely to occur when there is a fire at the place concerned."

12.2.3.1 Materials or parts are demonstrated to be fire resistant by meeting the requirements of this test for a flame exposure of 5 minutes.

12.2.4 Heat Flux Density

The rate of thermal energy transferred per unit area, expressed here in units of Btu/ft$^2$-sec or W/cm$^2$.

## 12.3 Apparatus

12.3.1 Test Burner

The burner will be a modified gun-type oil burner, such as Part Model DPL 3400, Stewart Warner HPR-250 or FR 600, Lennox OB-32, or Carlin 200 CRD. The burner will be calibrated to provide a minimum average flame temperature of 2,000°F (1,093°C) and a minimum heat transfer rate of 4,500 Btu/hr to the Btu heat transfer device described in chapter 11, section 11.3.3.2, or 9.3 Btu/ft$^2$-sec (10.6 W/cm$^2$) as measured by a calorimeter described in section 11.3.3.1.

12.3.1.1 Burner Extension

A stainless steel funnel extension fabricated in accordance with figure 11-1 will be used. The funnel will have an oblong exit 6 inches (152 mm) high by 11 inches (279 mm) wide. The funnel will be installed on the burner with the air tube shown in figure 11-2.

12.3.1.2 Burner Fuel

SAE No. 2 diesel, kerosene, or equivalent will be used for burner fuel.

12.3.2 Thermocouples

A thermocouple rake containing at least five ANSI 22-gauge Chromel-Alumel (Type K) thermocouples sheathed in 1/16 inch (1.6 mm) stainless steel or inconel tubes or equivalent will be provided. The thermocouples will be aligned in a row, 1.0 ± 0.1 inch (25 ± 2 mm) apart.

12.3.3 Heating Rate Measuring Devices

One of the following devices will be used to measure the heating rate of the flame.

12.3.3.1 Btu Heat Transfer Device

A Btu heat transfer device described in Chapter 11, "Power Plant Hose Assemblies Test," figures 11-5 to 11-10, in this handbook may be used.

12.3.3.2 Calorimeter

A calorimeter capable of measuring heat flux densities up to 15 Btu/ft-sec (17 W/cm) may be used. A Hy-Cal model 1300A total heat flux density calorimeter available from Hy-Cal Engineering, Santa Fe Springs, California, or equivalent with water cooling has been found suitable.

12.3.4 Test Stand

A test stand will be provided to maintain the position of the thermocouple rake, calorimeter, or Btu heat transfer device, and test specimen. The test stand will include a provision for either moving the burner out of the test position or moving the test specimen into/out of test position. The test stand will also include a provision for positioning the thermocouple rake or burner extension parallel to the burner face with the thermocouple junctions on the diameter or major axis of the burner extension. A suitable test setup is shown in figure 12-1.

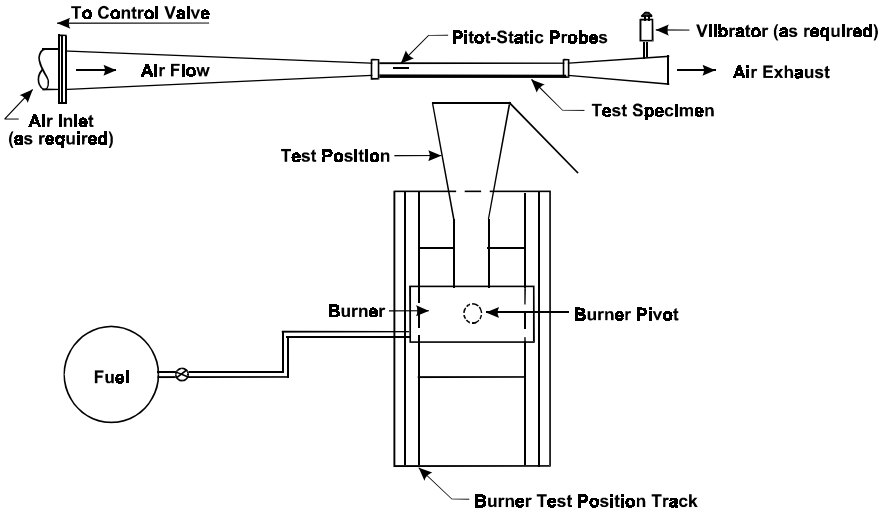


*Figure 12-1. Firewall Penetration Test Setup—Top View*

12.3.5 Timer

A stopwatch or other device, calibrated and graduated to the nearest 1 second, will be used to measure the time of application of the burner flame.

## 12.4 Test Specimens

12.4.1 Specimen Selection

Test specimens will be actual or simulated aircraft hardware, including all combustible materials that are applied to the actual structure in use. Heat flow paths and heat sinks will be as in the production configuration being certified.

12.4.2 Specimen Size

In general, specimen size will be 24 by 24 inches (610 by 610 mm). Larger specimens will be used if required to accommodate a critical design feature of the component. Smaller specimens 10 by 10 inches (254 by 254 mm) may be used if all design features are included and the specimen is representative of the intended use. For a smaller specimen, the backside of the specimen will be protected from exposure to the flame.

## 12.5 Conditioning

12.5.1 Specimen Conditioning

Specimens containing nonmetallic components will be preconditioned if required to simulate the aircraft environment.

## 12.6 Calibration

12.6.1 Place the thermocouple rake on the test stand such that the rake will be above the centerline of the burner or burner extension exit plane when the burner is in calibration position. Connect the thermocouples to a suitable recorder.

12.6.2 Light the burner, allow at least a 5-minute warmup, and move the burner into calibration (see section 12.3.4 for position).

12.6.3 Begin monitoring the temperatures indicated by the thermocouples after 5 minutes. Make adjustments as necessary to either the fuel flow or the airflow to the burner in order to achieve a minimum average thermocouple reading of 2,000°F (1,093°C).

12.6.4 Turn the burner off or move it out of calibration position and remove the thermocouple rake.

12.6.5 Replace the thermocouple rake with the heat flux density measuring device. Follow section 12.6.5.1 if using a water-cooled calorimeter for measuring heat flux density. Follow section 12.6.5.2 if using a Btu heat transfer device for this purpose.

12.6.5.1 If using the water-cooled calorimeter described in section 12.3.3.2, place the calorimeter at the same distance as the thermocouple rake centered over the burner exit.

12.6.5.1.1 Light the burner, allowing at least a 2-minute warmup, and move the burner into the calibration position.

12.6.5.1.2 Measure the heat flux density continuously or at intervals no greater than 10 seconds. If the heat flux density is not at least 9.3 Btu/ft-sec (10.6 W/cm) over a 1-minute period, readjust the burner to achieve the proper heat flux density. If burner adjustments are necessary, remove the heat flux density measuring device and repeat sections 12.6.1 through 12.6.5.1.2.

12.6.5.2 If using the Btu heat transfer device described in section 12.3.3.2, ensure the external surface of the copper tubing on the Btu heat transfer device is clean prior to measuring heat flux. Use fine steel wool to clean the copper tubing. Inspect the tubing bore and remove any corrosion and/or scale accumulation before each test. A .45-caliber pistol

cleaning brush, or equivalent, with an extension has been found suitable for this purpose.

12.6.5.2.1 The calibration setup is shown in figure 11-4. Provide a 5-foot (1.5-m) constant head of water above the heat transfer device and a 2-foot (0.61-m) drop to the end of the tailpipe for adjustment of the water flow rate. Use a 1-gallon (3.8-L) measuring container (a container and a weighing scale are also acceptable). Supply water at a temperature of 50° to 70°F (10° to 21°C). Adjust the water flow rate to 500 lb/hr (227 kg/hr) or 1 gal/min (3.8 L/min).

12.6.5.2.2 Start the water flowing through the Btu heat transfer device. Center the heat transfer tube in the flame at the same location that the specimen will be placed for testing. Allow at least a 2-minute warmup period to stabilize flame conditions before temperature measurements from the thermometers are recorded.

12.6.5.2.3 After the warmup period, record the inlet and outlet temperatures every 30 seconds for a 3-minute period. Determine the rate of Btu increase of the water as follows:

Heat transfer = $146 \times (To - Ti)$ watts (for Celsius)

= $500 \times (To - Ti)$ Btu/hr (for Fahrenheit)

where: To = temperature (°C or °F) at outlet

Ti = temperature (°C or °F) at inlet

12.6.5.2.4 The heat transfer rate output, as determined by the equation shown in section 12.6.5.2.3, will be a minimum of 4,500 Btu/hr (1,314 W). If the heat output from the burner is not above the minimum, make adjustments to the burner and repeat sections 12.6.1 through 12.6.5.2.3.

## 12.7 Procedure

In general, tests will be conducted at ambient conditions. However, special airflow, pressure, vibration, etc., conditions may be required to simulate the actual aircraft operating environment. Load-carrying specimens will be tested with limit loads applied during the test.

12.7.1 Light the burner and allow at least a 2-minute warmup.

12.7.2 Place the test specimen in test position at the same distance from the burner as the thermocouple rake and calorimeter were placed during calibration.

12.7.3 Start the timer when the test specimen is properly positioned with respect to the burner. The critical or representative area of the test specimen will be aligned with the center of the burner.

12.7.4 Terminate the test by moving the burner or test specimen out of the test position after 15 minutes, as required for fireproof materials, or after 5 minutes, as required for fire-resistant materials.

12.7.5 Note the condition of both faces of the test specimen.

12.7.6 Without making adjustments to the burner flame, repeat the temperature measurements described in sections 12.6.1 through 12.6.3. If the average temperature has decreased by more than 150°F (66°C), readjust the burner and repeat the test with a new specimen.

## 12.8 Report

12.8.1 Fully identify the construction being tested and its use.

12.8.2 Describe the test apparatus and burner. Include the average flame temperature and heat flux density (or heat transfer rate) data for pretest calibration and the average temperature for posttest calibration.

12.8.3 Report the time the specimen is exposed to flame and whether the material or part is fireproof or fire resistant.

12.8.4 Describe the test specimen before and after testing.

## 12.9 Requirements

12.9.1 No flame penetration will occur for the duration of the test.

12.9.2 Burning on the backside of the specimen is not acceptable. Significant burning on the side of flame impingement will be investigated to determine if a potential increase in hazard exists. Minor flashing on either side of the specimen is acceptable.

# Chapter 12 Supplement

This supplement contains advisory material pertinent to referenced paragraphs.

12.1.1 Advisory Circular AC20-135, "Powerplant Installation and Propulsion System Component Fire Protection Test Methods, Standards, and Criteria," February 6, 1990.

12.3.1 An SAE AS401B Propane Burner is also acceptable, provided the temperature profile and heat flux density conform to the requirements specified in this test method.

12.3.2 Thermocouples can be either grounded or ungrounded, depending on the type of data system used to monitor thermocouple output. One condition may generate more interference with instrumentation than the other.

12.6.1 If using one of the conversion oil burners described in section 1.1 for this test, the distance used to position the rake, heat flux measuring device, and test specimen will be 4 inches (101.6 mm) from the burner cone exit. If the burner used is an SAE AS401B Propane Burner, the distance used to position the thermocouple rake, etc., may be as close as 2 inches (50.8 mm) from the burner face exit in order to achieve the temperature and heat flux density specified in this test procedure.

12.6.2 If using an SAE AS401B Propane Burner, the flame is not turned off during calibration or test setup. Most test facilities using this burner have provisions for moving the burner in and out of test position. If using a conversion oil burner, most facilities turn the burner on and off to change specimens and calibration equipment. If the burner is turned off at any time, it will be warmed up for a 2-minute period before testing or taking calibration measurements.

12.6.5.1 Operating the calorimeter without water running through it will permanently damage the calorimeter.