International Aircraft Materials Fire Test Working Group Meeting

Task Group Session on Revised Cargo Liner Test

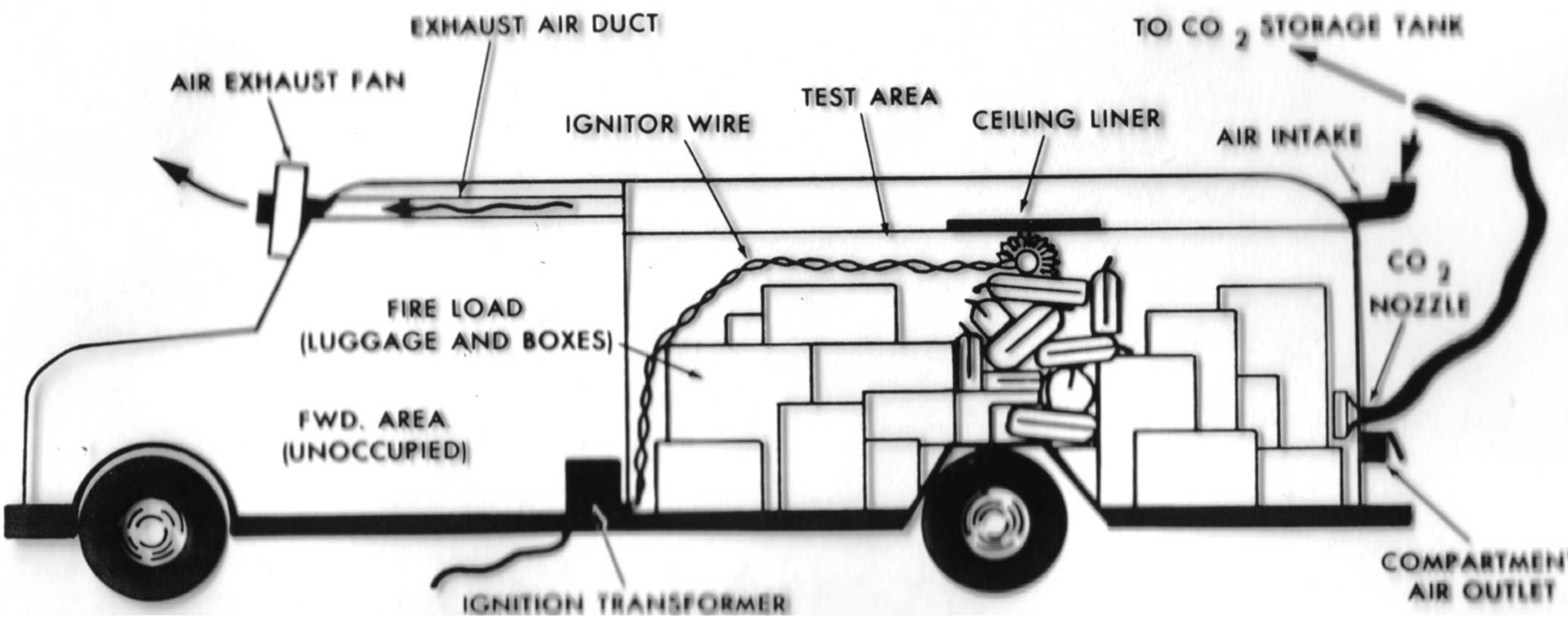
Presented to: IAMFTWG, Savannah, GA

By: Tim Marker, FAA Technical Center

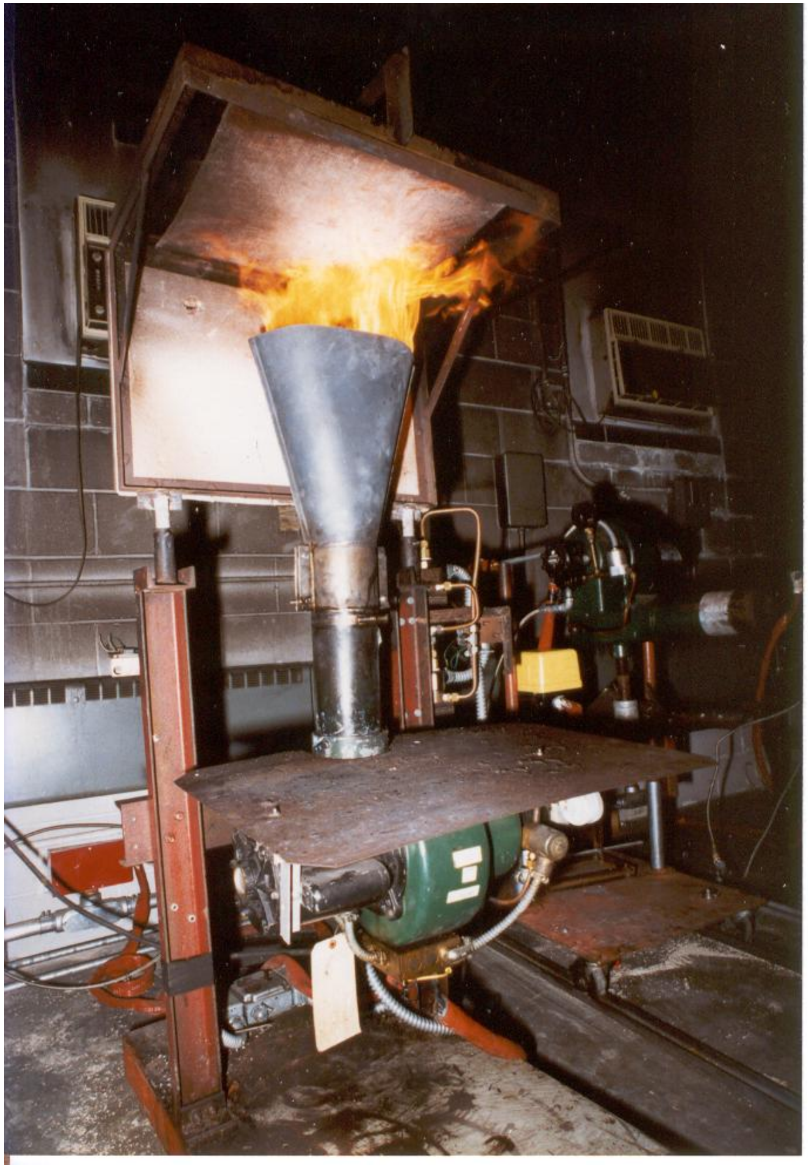
Date: March 1-2, 2011

Saudi Arabia Airlines L-1011 Accident, 1980

School-Bus Tests at FAATC



Cargo liner Flame Penetration Test Using Oil Burner



Possible New Appendix F Structure

Appendix F Part I: Requirements for In-Flight Fire Threats

A. Radiant Panel (insulation, ducting, wiring, composite fuselage)

B. Oil Burner – cargo liner

C. Fire Containment

D. Bunsen burner

Appendix F Part II: Requirements for Postcrash Fire Threats

A. OSU

B. Oil Burner – seats

C. Oil Burner - insulation

D. Escape Slide radiant heat

E. Oil Burner – seat structure

Part IB. Oil Burner Test for Cargo Liners

X.1 Scope

X.2 Definitions

X.3 Apparatus

X.4 Test Specimens

X.5 Specimen Conditioning

X.6 Preparation of Apparatus

X.7 Flame Calibration

X.8 Procedure

X.9 Alternate Methodology for Testing Cargo Liner Design Details

X.10 Report

X.11 Requirements

Part X (For New Appendix F)
Oil Burner Test for Cargo Liners

X.1 Scope

X.1.1 This test method evaluates the flame penetration resistance capabilities of aircraft cargo compartment lining materials utilizing a high-intensity open flame to show compliance to the requirements of FAR 25.855.

X.2 Definitions

X.2.1 Burnthrough

Burnthrough is defined as flame penetration of the test specimen or the development of a visible breach, opening, gap, fissure, or any void through which a flame penetrates during a test. The development of any such void that allows flame passage during the test period shall be cause for failure.

X.2.2 Specimen Set

A specimen set consists of three or more replicates of a ceiling and sidewall cargo liner panel installation.

X.3 Apparatus

X.3.1 Test Specimen Frame

The test specimen frame is shown in figures X-1 through X-3. The specimen frame will be mounted on a rolling platform or device capable of being moved into position during testing. The rolling platform and specimen frame must also be capable of rolling away from the burner to prevent specimen exposure during warmup.

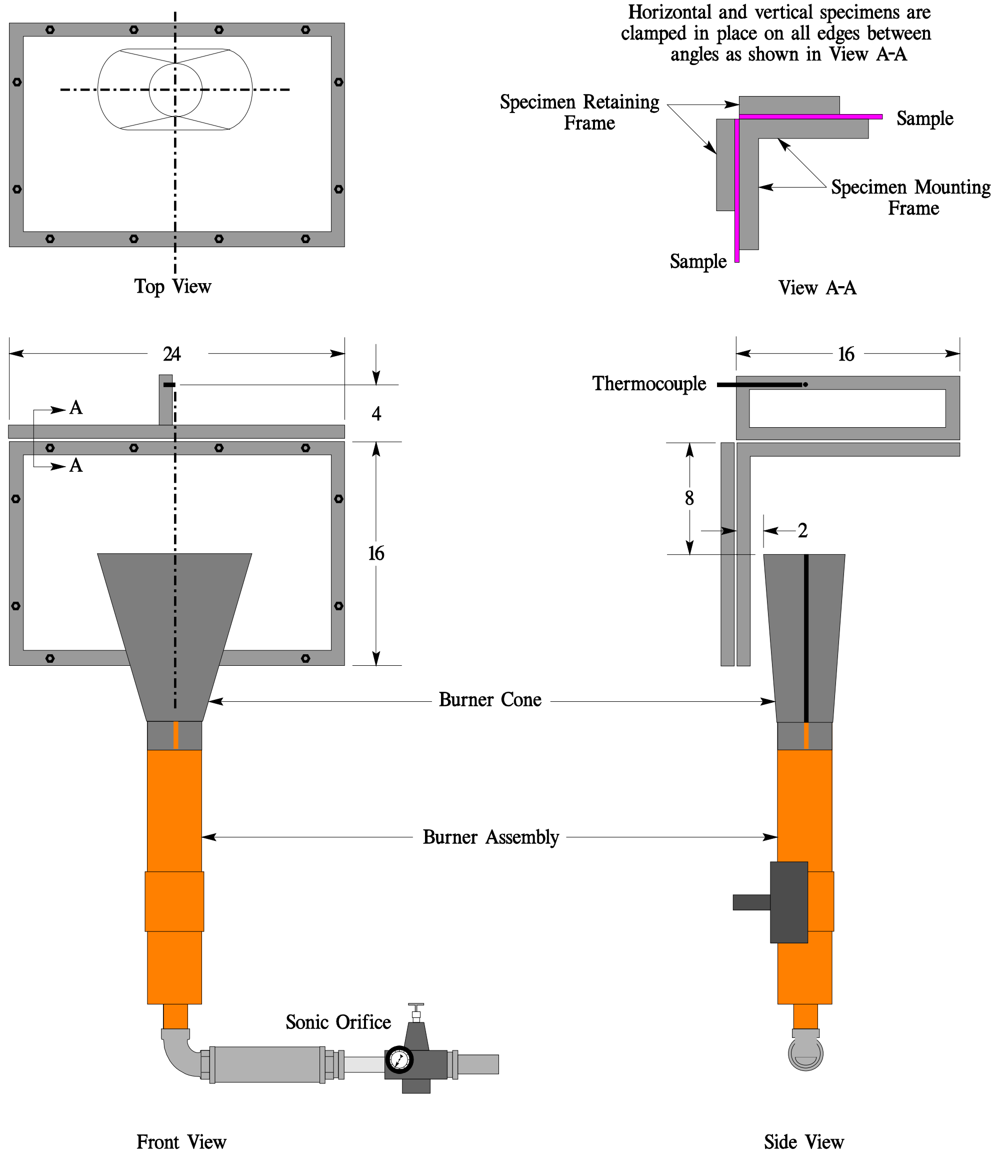


Figure X-1. Test Apparatus for Horizontal and Vertical Mounting for Cargo Liner Oil Burner Testing

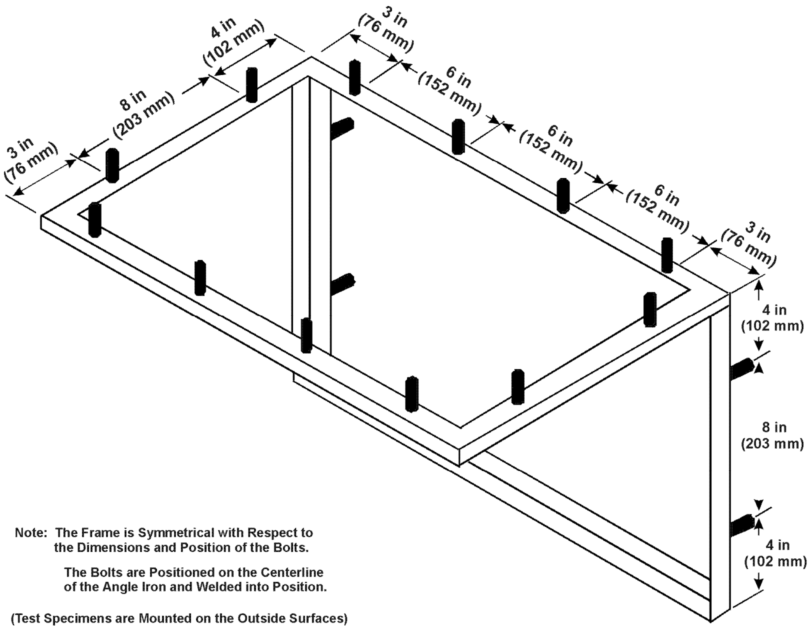


Figure X-2. Cargo Liner Test Specimen Frame

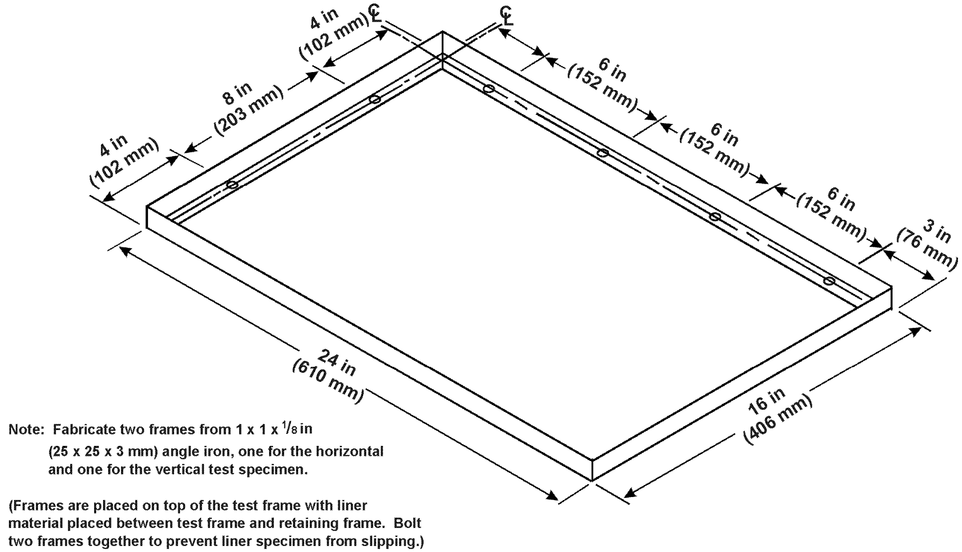


Figure X-3. Cargo Liner Test Specimen Retaining Frame

X.3.2 Test Burner

The test burner shall be a gun-type, using a pressurized, sprayed fuel charge in conjunction with a ducted air source to produce the burner flames. An interchangeable, screw-in fuel nozzle will be used to produce the conically-shaped fuel charge from a pressurized fuel source. A pressurized air source controlled via a regulated sonic orifice will supply the combustion air. The combustion air will be ducted through a cylindrical draft tube containing a series of diffusing vanes. The diffused combustion air will mix with the sprayed fuel charge in a bell-shaped combustion cone. The fuel/air charge will be ignited by a high-voltage spark electrode pair positioned in the vicinity of the fuel spray nozzle. Flame characteristics can be adjusted by varying the pressure of the regulated air into the sonic orifice (refer to more detailed section NG of the "report on new Appendix F" for details on the components and construction of this burner).

X.3.2.1 Fuel Nozzle

A fuel nozzle will be provided to maintain the fuel pressure to yield a nominal 2 ± 0.1 gal/hr (0.126 ± 0.0063 liter/min) fuel flow (see Chapter X Supplement).

X.3.2.2 Fuel Type (may not be necessary)

Either number 2 Grade kerosene or American Society for Testing and Materials (ASTM) D2 fuel (number 2 Grade fuel oil) will be used.

X.3.3 Thermocouples

The seven thermocouples to be used for calibration will be 1/16-inch (1.6-mm) ceramic packed, metal sheathed type K (Chromel-Alumel), grounded junction thermocouples with a nominal 30 AWG size conductor. The seven thermocouples will be attached to a steel angle bracket to form a thermocouple rake for placement in the test stand during burner calibration, as shown in figure X-4 (discuss possibility of switching to 1/8 inch thermocouples).

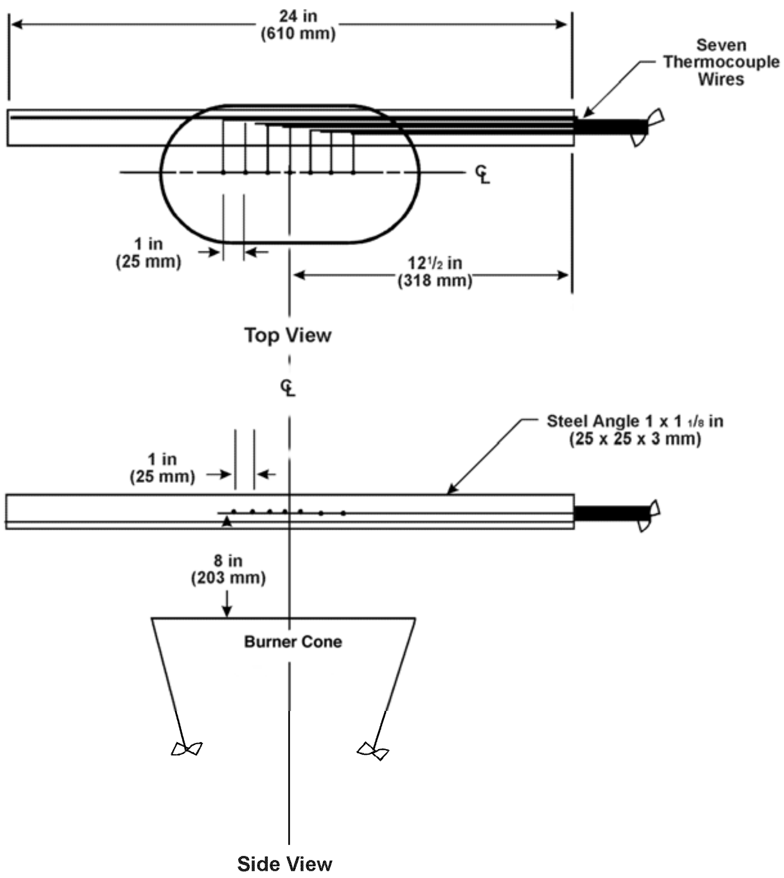


Figure X-4. Top and Side View of Thermocouple Rake Bracket

X.3.4 Instrumentation

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

X.3.4.1 Timing Device

A stopwatch or other device, accurate to within 1 second/hour, will be provided to measure the time of application of the burner flame, the material flaming time, and the burnthrough time.

X.3.4.2 Anemometer

A vane-type air velocity sensing unit will be used to monitor the flow of air inside the test chamber when the ventilation hood is operating.

X.4 Test Specimen(s)

X.4.1 Specimen Configuration

Each cargo liner panel type and thickness will be tested. The cargo liner used in the construction of test specimens must be identical to the in-service liner in both material type and thickness, since certain thicknesses of liner may react quite differently than others. Thicker liners release significantly more amounts of heat than do thinner liners. Thinner (conventional type) liners contain less reinforcement, thereby providing less structural support. Alternatively, it is permissible to test the thinnest and thickest liners to substantiate the performance of a thickness in between the two limits.

X.4.1.1 Ceiling and sidewall liner panels may be tested individually provided a baffle of fire-resistant material, such as Kaowool or Marinite, is used to simulate the missing panel.

X.4.2 Specimen Number

A minimum of three specimens or specimen sets for each panel type or design configuration will be prepared for testing.

X.4.3 Specimen Size

The specimens to be tested will measure 16 ± 1/8 inches (406 ± 3 mm) by 24 ± 1/8 inches (610 ± 3 mm).

X.5 Specimen Conditioning

X.5.1 The specimens will be conditioned at 70° ± 5°F (21° ± 2°C) and 55% ± 10 % relative humidity for a minimum of 24 hours prior to testing.

X.6 Preparation of Apparatus

X.6.1 Level and center the sample holder frame assembly to ensure alignment with respect to the burner cone.

X.6.2 Turn on the ventilation hood for the test chamber. Do not turn on the pressurized burner air. Measure the airflow in the test chamber using a vane-type anemometer or equivalent measuring device. The vertical air velocity within 12 inches from the test specimen mounting frame will be less than 50 ft/min (25.4 cm/second). The horizontal air velocity within 12-inches of the test specimen mounting frame will be less than 25 ft/min (12.7 cm/second).

X.6.3 Sonic Burner

X.6.3.1 Volumetric Air Flow

The combustion make-up air for the burner is controlled via the regulated sonic orifice. Specifically, the air flow rate is controlled by adjusting the upstream pressure using a regulator (i.e., higher pressure = higher flow rate). Historical data and practice using traditional motor-driven blower-style gun burners have determined the air velocities exiting the burner draft tube into the combustion cone to be in the range of 1460 to 1720 ft/min. These measurements were found using a vane-style anemometer, housed within a 27.5-inch long test pipe with an inside diameter of 2.75 inches. The anemometer was positioned at the end of the test pipe, which was secured to the draft tube exit (figure?). This 1460 to 1720 ft/min measurement range was obtained when the intake air velocity was adjusted to the prescribed range of 1550 to 1800 ft/min. When using the sonic burner, an inlet pressure range of 41 to 49 lbs/in^2 was found to yield the identical 1460 to 1720 ft/min air velocity range exiting the draft tube.

X.6.3.2 Fuel Flow Calibration

If a calibrated flow meter is not available, measure the fuel flow using a graduated cylinder of appropriate size. With the pressurized combustion air source off, turn on the fuel valve solenoid, making sure the igniter system is off. Collect the fuel by placing a plastic or rubber tube over the fuel nozzle and into the graduated cylinder for a 2-minute period. Ensure that the flow rate is 2 ± 0.1 gal/hr (0.126 ± 0.0063 L/min). See supplemental information.

X.7 Flame Calibration

X.7.1 Sonic Burner

X.7.1.1 Examine and clean the burner cone of any evidence of buildup of productions of combustion, soot, etc. Soot build-up inside the cone may affect the flame characteristics and cause calibration difficulties. Since the burner cone may distort with time, dimensions should be checked periodically.

X.7.1.2 Mount the thermocouple rake on a rolling stand that is capable of being quickly moved into position over the burner. Move the rake into calibration position and check the distance of each of the seven thermocouples to ensure that they are located 8 ± 1/8 inches (203 ± 3 mm) from the horizontal plane of the burner exit. Also check the location of the thermocouple tips to ensure all seven are located along the burner cone centerline (long axis of burner cone opening). The thermocouple rake measuring system must incorporate “detents” that ensure proper alignment of the thermocouple rake with respect to the burner cone, so that rapid positioning of the rake can be achieved during the calibration procedure (see figure X-7). Once the proper position is established, move the thermocouple rake away, and then move back into calibration position to re-check distances. When all distances and positions are confirmed, move thermocouple rake away from burner.

X.7.1.3 While the thermocouple rake is away from the burner, turn on the pressurized air, fuel flow and igniters to light the burner. Allow it to warm up for a period of 2 minutes. After warm-up, move the thermocouple rake into calibration position and allow 1 minute for thermocouple stabilization, then record the temperature of each of the 7 thermocouples once every second for a period of 30 seconds. Remove thermocouple rake from calibration position and turn off burner. Calculate the average temperature of each thermocouple over this period and record. The average temperature of each of the seven thermocouples must be 1800°F (982°C) ± 100°F.

X.7.1.4 If the temperature of each of the seven thermocouples is not within the specified range, repeat sections X.7.1.1 through X.7.1.3 until all temperatures are within the calibration range. A slight adjustment of the internal stator orientation and distance from the end of the draft tube may be necessary to achieve the required temperatures.

X.7.1.5 Calibrate prior to each test until consistency has been demonstrated. After consistency has been confirmed, several tests can be performed with calibration conducted before and after the tests. See supplemental information for recommendations on achieving calibration.

X.8 Procedure

X.8.1 Examine and clean the cone of soot deposits and debris.

X.8.2 Mount the sidewall and/or ceiling cargo liner specimen(s) on the respective frame(s) and secure to the test frame(s) using the retaining frame(s). Bolt the retaining frame(s) and the test frame(s) together. Verify that the horizontal test frame is level.

X.8.3 Mount the thermocouple or thermocouple rake $4 \pm 1/8$ inches (102 ± 3 mm) above the upper surface of the horizontal ceiling panel test specimen. Ensure that the thermocouple is properly centered over the burner cone exit. If the thermocouple rake is being used, position the center thermocouple (thermocouple number 4) over the center of the burner cone exit.

X.8.4 Move the test specimen frame away from the burner so that the burner flame does not impinge on the test specimen during the warmup period. Turn on the burner and allow it to stabilize for a period of 2 minutes.

X.8.5 Move the test specimen frame into the test position over the burner.

X.8.6 Start the timing device when the test specimen frame is fully in the test position.

X.8.7 Record the temperature of the thermocouple (thermocouple number 4, if using the thermocouple rake also used for calibration) at least once a second for the duration of the test.

X.8.8 Expose the test specimen(s) to the flame for 5 minutes or until flame penetration occurs.

X.8.9 Turn off the burner to terminate the test.

X.9 Alternate Methodology for Testing Cargo Liner Design Details

X.9.1 Testing of patch repairs

The cargo liner used in the construction of test specimens for evaluating patch repairs must be identical to the in-service liner in both material type and thickness, since certain thicknesses of liner may react quite differently than others. Thicker liners release significantly more amounts of heat than do thinner liners. Thinner (conventional type) liners contain less reinforcement, thereby providing less structural support to which the repair unit can adhere. If a patch is intended for use on a variety of liner thicknesses, tests should be run for each thickness. As an alternative, tests may be run on the minimum and maximum thicknesses of liners that the repair patch will be used on in service to alleviate the testing of all thicknesses within this range. Similarly, if there are several variants of a particular liner resin structure (i.e., fiberglass reinforcement with several slightly different epoxy resins), it is only necessary to test the generic construction (fiberglass/epoxy) and not every single resin type. See Handbook Chapter 15 for more specific instructions. (should Handbook Chapter 15 be referenced?)

X.9.1.1 Liner Repair Burnthrough Resistance Specimen

A flat sheet of material, identical to that used in the construction of the repair unit (patch), must be tested for resistance to burnthrough in the ceiling position of the cargo liner test apparatus. Follow test procedures specified in X.8.1 through X.8.9

X.9.1.2 Liner Repair Adhesion Specimen

The repair patch must be placed over the standard simulated damage area in the sample liner. The damage area must measure 5 by 5 inches with a width of 1 inch, in the form of an L-shape, and positioned according to figure X-5. The placement of the repair patch in this location has been shown to be the most severe. Follow test procedures specified in X.8.1 through X.8.9.

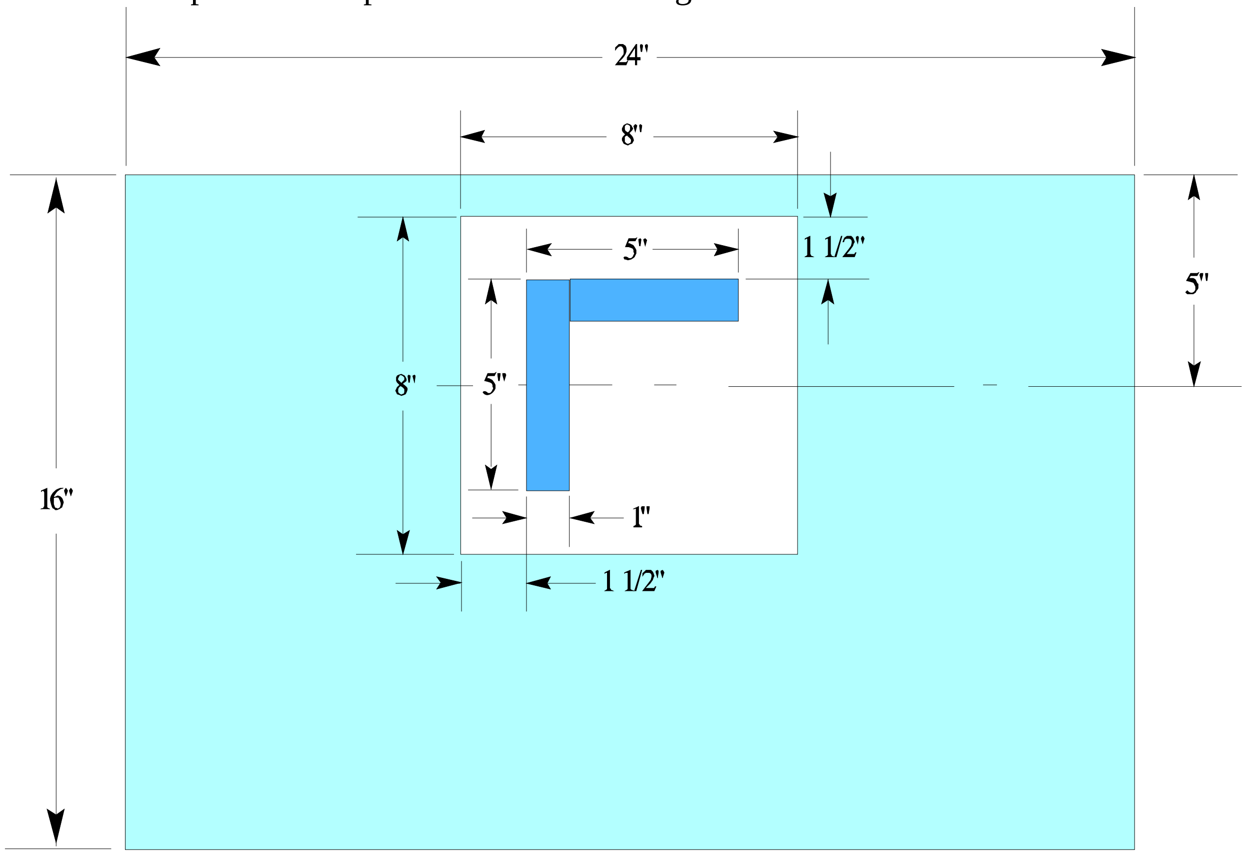


Figure X-5. Patch Location Over Standard Damage Area in Liner Sample

X.9.1.3 Liner Repair Shingling Specimen

Two 4- by 4-inch patches must be overlapped by 1 inch and placed over the standard damage area in the sample liner. The damage area must measure 1 by 5 inches and be positioned as shown in figure X-6. Follow test procedures specified in X.8.1 through X.8.9.

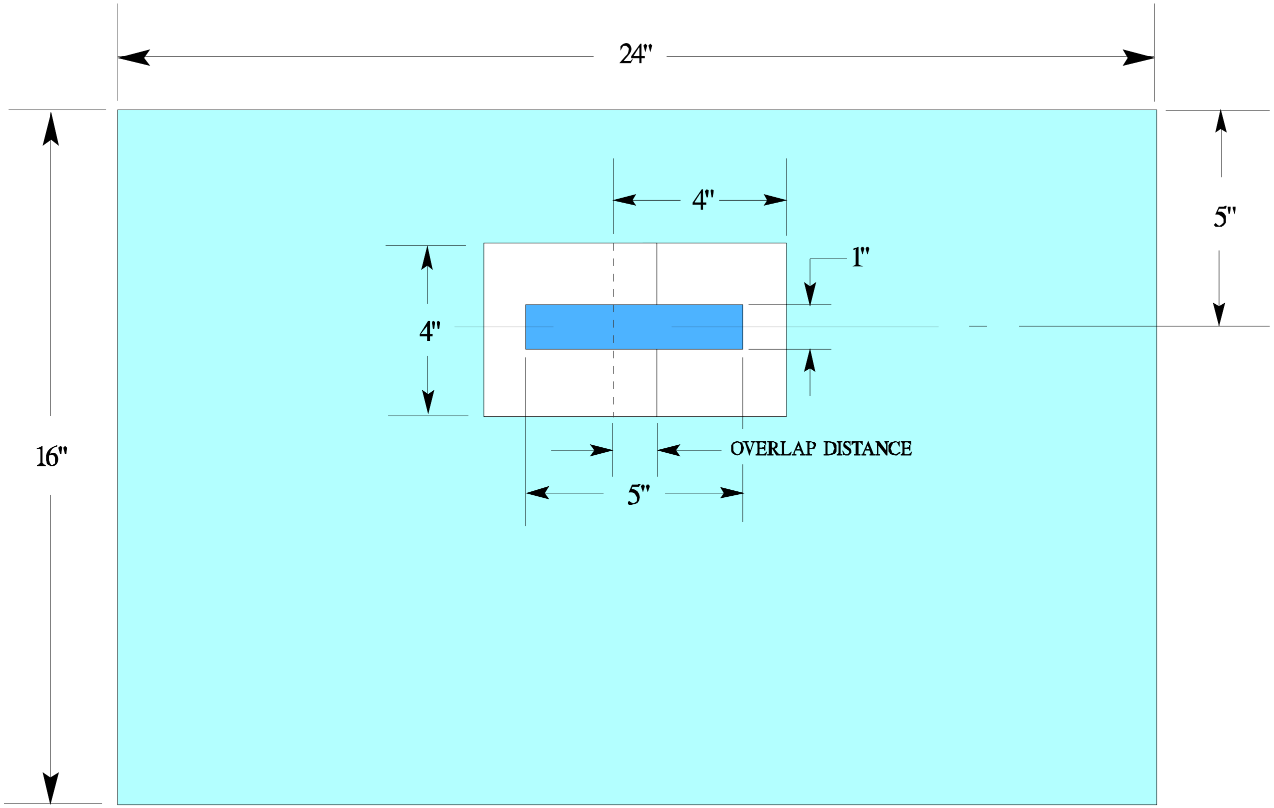


Figure X-6. Overlapped Patches for Shingling Test

X.9.2 Testing of Seams, Joints, and Corners

Cargo compartment design typically involves the mounting of protective liner sheet or panel materials over the aircraft structure that comprise the compartment floors, ceiling, and sidewalls. Seams and joints formed at the junction of two or more liner panels are common. It is important that the entire lining system, including the means of attachment at seams and joints, maintain the burnthrough resistant capabilities of the compartment in the event of a fire. For this reason, all seams, joints, corners, and associated attachment mechanisms must be tested.

The cargo liner used in the construction of test specimens for evaluating seams and joints must be identical to the in-service liner in both material type and thickness, since certain thicknesses of liner may react quite differently than others. Thicker liners release significantly more amounts of heat than do thinner liners, while thinner (conventional type) liners contain less reinforcement, thereby providing less structural support to which the seam or joint attachment mechanism can adhere. If an attachment mechanism is intended for use on a variety of liner thicknesses, tests should be run for each thickness. As an alternative, tests may be run on the minimum and maximum thicknesses of liners that the attachment mechanism will be used on in service to alleviate the testing of all thicknesses within this range. Similarly, if there are several variants of a particular liner resin structure (i.e., fiberglass reinforcement with several slightly different epoxy resins), it is only necessary to test the generic construction (fiberglass/epoxy) and not every single resin type.

X.9.2.1 Seams, Joints, Fastening Systems Located in Compartment Ceiling

Seams and joints formed by butting or overlapping liner materials, including all associated fasteners located in the ceiling position of the cargo compartment shall be tested in the horizontal test specimen mounting frame. The seam detail shall be positioned longitudinally, extending the length of the liner and centered over the burner cone (figure X-7). Follow test procedures specified in X.8.1 through X.8.9.

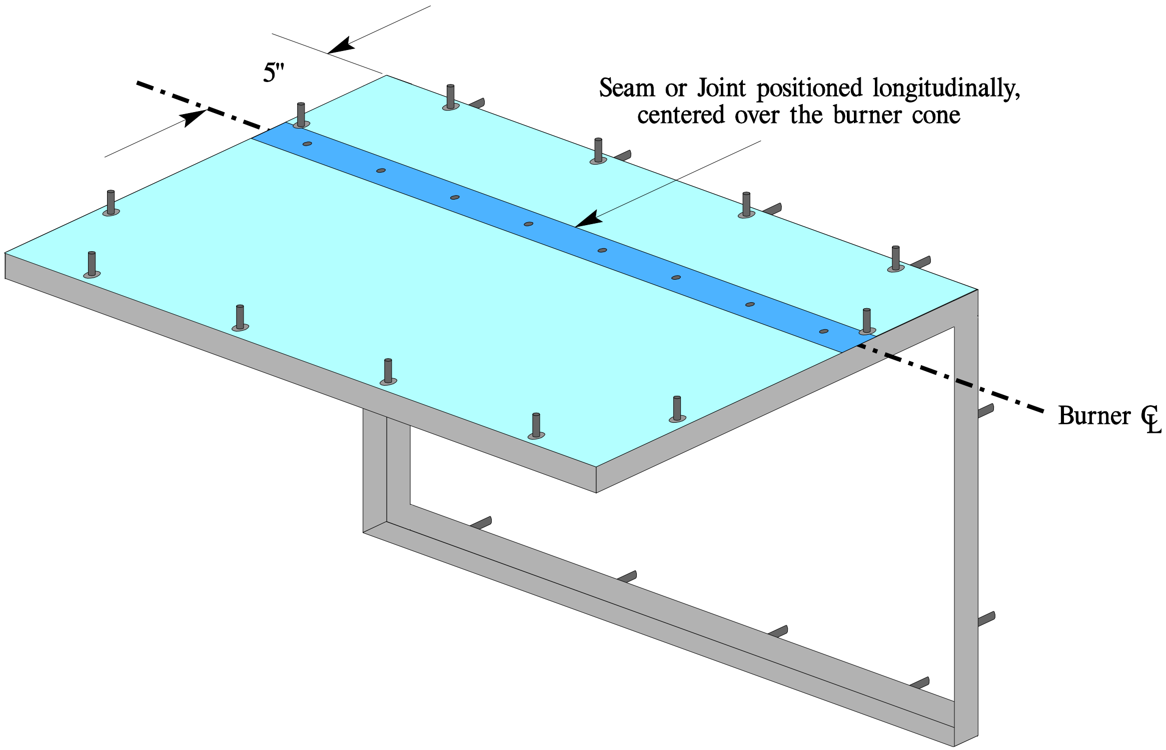


Figure X-7. Arrangement for the Testing of Seams and Joints in the Compartment Ceiling

X.9.2.2 Seams, Joints, Fastening Systems Located in Compartment Sidewall

Seams or joints formed by butting or overlapping liner materials (including all associated fasteners) located in the sidewall position of the cargo compartment shall be tested in the vertical test specimen mounting frame. The seam detail shall be positioned longitudinally, 2 inches from the top of the vertical test specimen liner edge (Figure X-8). Some sidewall seam or joint details may be too wide to fit into the vertical specimen area without clearance issues. This can be rectified by moving the seam detail lower, provided the upper edge of the detail is situated 1.5 inches from the top edge (Figure X-9). Follow test procedures specified in X.8.1 through X.8.9.

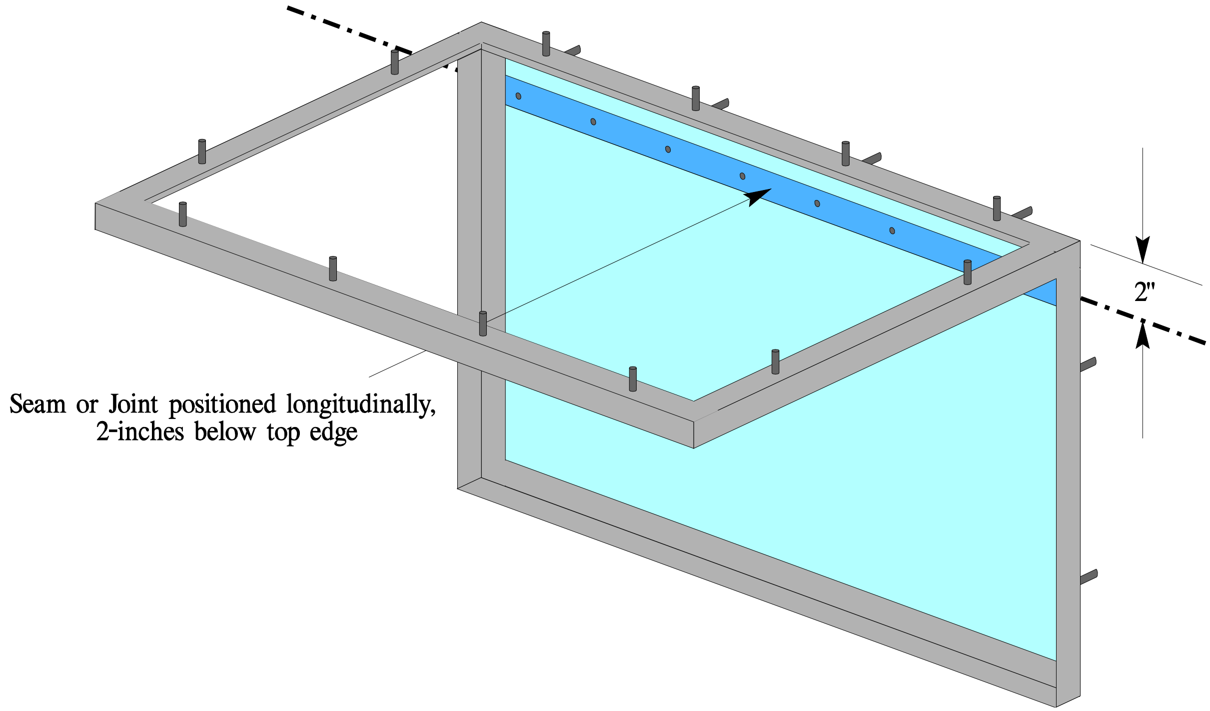


Figure X-8. Arrangement for the Testing of Seams and Joints in the Compartment Sidewall

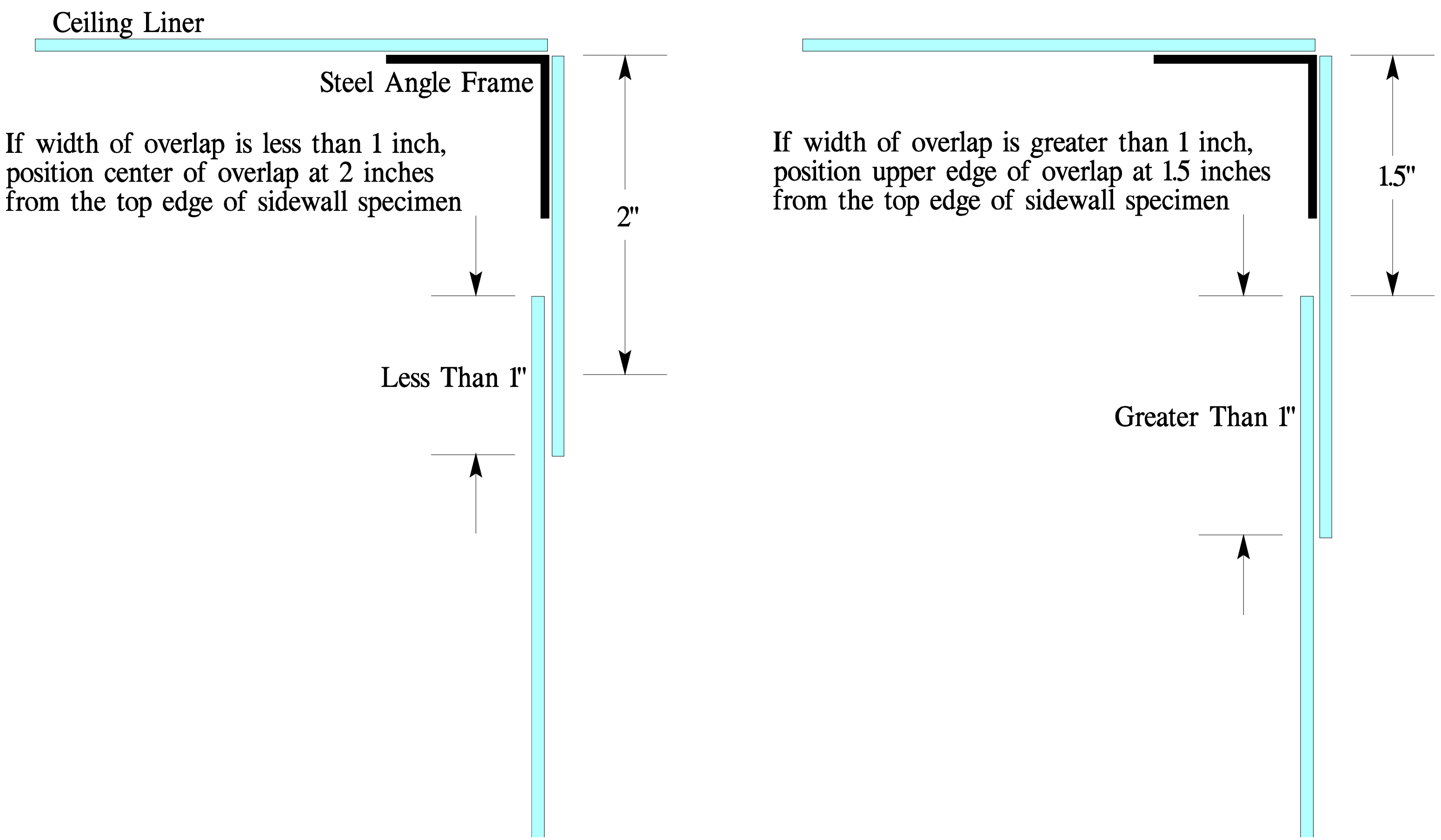


Figure X-9. Methodology for the Testing of Seams and Joints in the Compartment Sidewall

X.9.2.3 Corner Joints

The testing of corner joints formed at the intersection of ceiling and sidewall liners will require the test specimen mounting frame to be modified. The corner member of the test specimen mounting frame shall first be removed (figure X-10). Follow test procedures specified in X.8.1 through X.8.9.

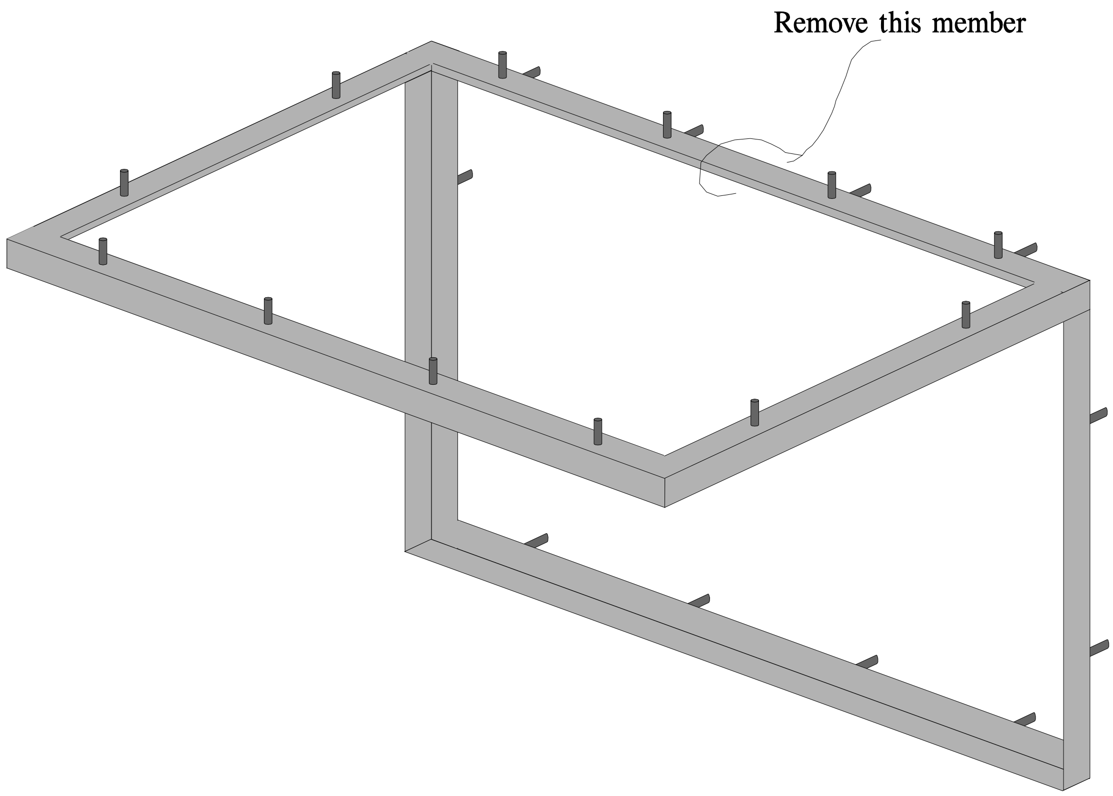


Figure X-10. Modified Test Specimen Mounting Frame for Corner Testing

X.9.3 Testing of Lighting Fixtures and Lamp Assemblies

The material that comprises the fire barrier used in design features such as recessed lighting fixtures and pressure relief valves will be tested as a flat sheet, 16 inches by 24 inches, in the same manner as a typical cargo liner specimen. If the design feature will be used only in a sidewall location in service, the flat sheet of representative material may be tested in the sidewall location of the test apparatus. Similarly, if the design feature will be used in the ceiling location of the cargo compartment in service, the representative material must be tested in the ceiling location of the apparatus.

X.10 Report

X.10.1 Report a complete description of the material(s) being tested, including manufacturer, thickness, etc.

X.10.2 Report the orientation of the panels tested (i.e., ceiling and/or sidewall).

X.10.3 Record any observations regarding the behavior of the test specimen during flame exposure, such as delamination, resin ignition, smoke, etc., and the time each event occurred.

X.10.4 Report the time of occurrence of flame penetration, if applicable, for each of the three specimens tested.

X.10.5 If flame penetration does not occur, report the maximum backside temperature and time of occurrence.

X.10.6 Provide a record of burner calibration.

X.11 Requirements

X.11.1 None of the three test specimens tested will burn through within the 5-minute flame exposure.

X.11.2 Each of the three specimens tested will not exceed 400°F at the backside temperature monitored during flame exposure.

X.11.3 Test specimens that pass in the ceiling orientation may be used as a sidewall panel without further test.

X.11.4 For the patch adhesion test, the patch must be intact after the 5-minute flame exposure.

Chapter X Supplement (Advisory Circular?)

This supplement contains advisory material pertinent to referenced paragraphs.

X.3.2 The basic burner, including description of components, assembly, and recommended settings is described in detail in Chapter NG of the (report on new Appendix F), dated (insert date of report) report number xxxx.

X.3.2.1 A Monarch 80-degree AR or 80°R nozzle, nominally rated at 2.25 gal/hr (0.142 L/min) at 100 lb/in^2 (0.69 MPa) and operated at 85 lb/in^2 (0.59 MPa) gauge, has been found satisfactory to maintain a fuel flow of 2 gal/hr (0.126 L/min) and produce a proper spray pattern. A Monarch 80-degree CC nozzle, nominally rated at 2 gal/hr at 100 lb/in^2 and operated between 95 and 105 lb/in^2 gauge, is also acceptable. Minor deviations to the fuel nozzle spray angle, fuel pressure, or other parameters of the nozzle are acceptable if the fuel flow rate, flame temperature, and burner heat flux conform to the requirements of section 8.6 of the handbook.

X.3.2.2 Number 2 Grade diesel fuel, Jet A, or the international equivalent is the recommended fuel because it has been found to produce satisfactory results if the flow rate and inlet airflow conform to the requirements of sections 8.6 and 8.7 of the handbook.

X.3.3 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 in order 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.

X.3.4.2 The Omega microprocessor-based portable air velocity kit, model HH-142, is a recommended unit. The kit includes a vane-type air velocity sensor, hand-held digital readout displaying air velocity, extension rods, and a 9-volt lithium battery. Since the unit monitors air velocity in FPM or MPS ± 1 percent reading accuracy, necessary conversions must be made to attain airflow values.

X.6.3.2 When collecting fuel during the fuel flow calibration check, it is important to establish a steady stream of fuel before starting the measurement process. A 10-second period is recommended.

X.7.1.4 Following are recommendations for achieving calibration temperatures:

1. Set the stabilizer 3.25 ± 0.25 inches from the end of the draft tube.
2. Rotate the ignitor to the 6 o'clock and 9 o'clock position (viewpoint: looking toward the stabilizer from the end of the draft tube).
3. Set the air pressure to 41 to 49 lbs/in^2.
4. Seal all possible air leaks around the burner cone and draft tube area.
5. Replace thermocouples after 50 hours of use.

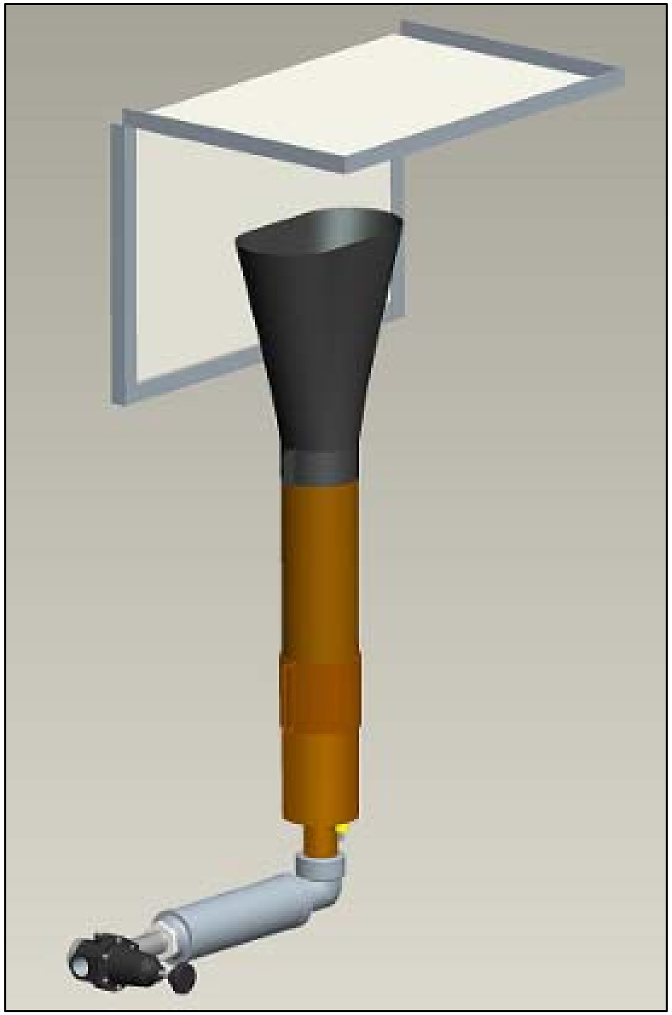
X.7.1.1 A stainless steel wire brush is one possible cleaning tool. Soot buildup inside the burner cone can affect the flame characteristics and cause calibration difficulties. Since the burner cone may distort with time, dimensions will need to be checked periodically.

X.8.2 In order to expedite the specimen mounting process, several clamps can be used (in lieu of the attaching nuts) to attach the retaining frame to the test specimen frame, provided the test specimen frame bolts properly align with the holes in the retaining frame. Ensure that all four mating surfaces of the retaining frame are in contact with the specimen, and that sufficient clamping pressure is applied to prevent movement of the sample.

X.9.2 Test procedures for cargo liner design features are described in FAA Technical Note DOT/FAA/CT-TN88/33, dated September 1988. The sample holder frame must not add reinforcement to any construction that does not exist as installed in the aircraft.

X.9.3 Test procedures for cargo liner design features such as lighting fixtures are described in FAA Technical Note DOT/FAA/CT-TN88/33, dated September 1988.

X.11.2 A brief, 15-second autoignition of the backface (cold side) of the test specimen is acceptable, provided the 400 ^{o}F criteria is not exceeded. Occasionally, the back face ignition is due to the test flame wrapping around the sample holder, directly igniting back side outgases. This is not considered a failure, but may void the test. Baffling or skirts mounted to the sample holder may be used to prevent this occurrence. Burnthrough occurs only if the flame from the burner passes through the specimen or voids created; panel shifting, twisting or pulling out of the frame creating voids through which flames may pass should be considered a failure.



Planned Activities

Complete construction of apparatus using sonic burner parts from Marlin Engineering

Conduct temperature calibrations with set-up parameters obtained from seat burner trials

Begin test trials using various cargo liner samples from Mc Gill:

- Type 1076D, woven fiberglass cloth reinforced polyester cargo side wall liner (BMS 8-2) .020 and .045 thickness, used in 737 models
- Type 1367A 040, woven fiberglass cloth reinforced phenolic, high impact resistant, low smoke and toxicity cargo liner with white Tedlar® on the face side. Qualified to Boeing specification BMS 8-223 Cl 2 Gr B Types 13 thru 40, McDonnell Douglas DMS 2419 Cl 1 (Ty 13-40), and Airbus 2550 M1M 000800; used in 757 models

Compare results with FAATC Park burner apparatus

Conduct Round Robin?