FAA Fire Test Burner Apparatus Description

Federal Aviation Administration

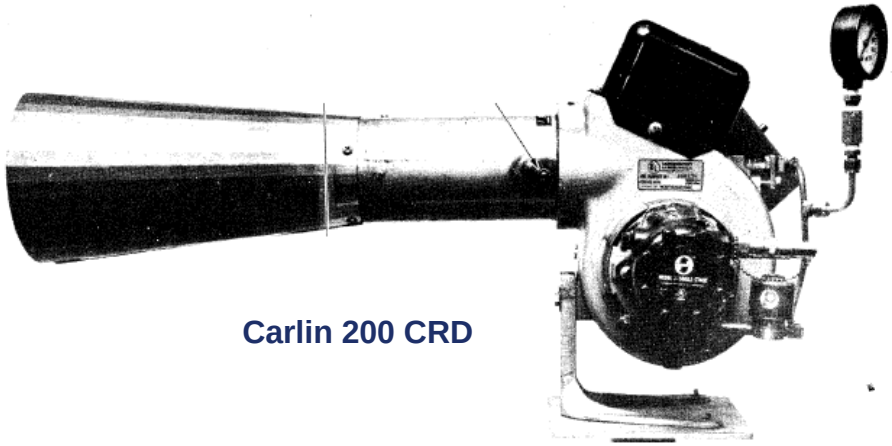
FAA Fire Safety Overview

February 7 2012 – Singapore

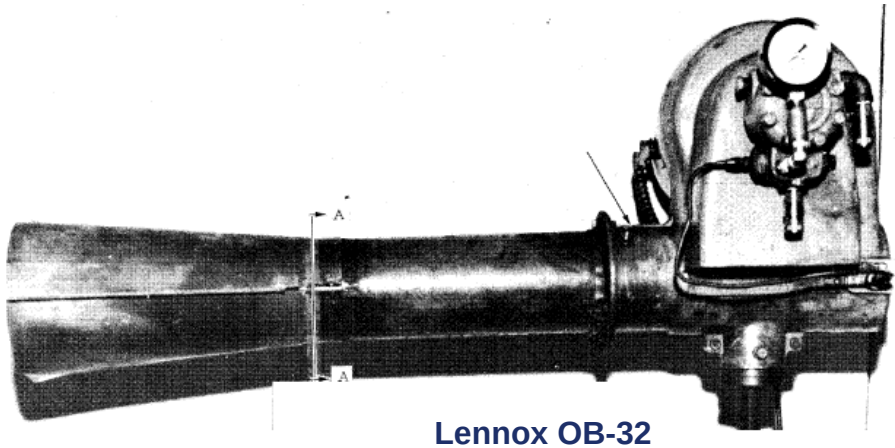
Robert I. Ochs, FAA Fire Safety, ANG-E212

Introduction

- **The FAA has utilized various forms of a modified home heating oil burner for aircraft material and system fire testing**
  - The flame produced by this type of burner is used to simulate the effects of a severe fire in a controlled laboratory-scale test
- **As aircraft fire safety evolved over the past 50 years, more test methods were developed that employed the oil burner as the test apparatus**
  - Powerplant components and firewalls
  - Cargo compartment liners
  - Seat cushions
  - Thermal acoustic insulation
- **At the same time, the oil burners specified in the regulations went out of production and were no longer obtainable**
  - Newer oil burners were specified and considered equivalent if the required heat flux and temperature could be achieved



Carlin 200 CRD



Lennox OB-32

Park DPL 3400

Evolution

Powerplant Components (1950's)

- Multiple acceptable burners
- Various testing configurations
- Various test materials
  - Metallic components, firewalls, hoses, etc
- Requirements
  - 2000°F, 9.3 BTU/ft^{2}s

Cargo Liner (1984)

- Multiple acceptable burners
- Single testing configuration
- Single test material
  - Thin, flat fire barriers
- Requirements
  - 1700 ± 100°F, 8.0 ±0.5 BTU/ft^{2}s
  - Exit air velocity

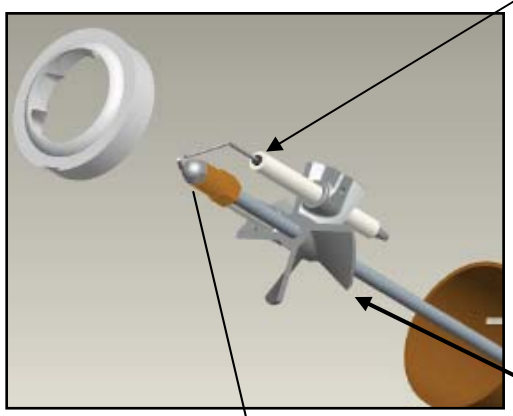
Seat Cushion (1984)

- Multiple acceptable burners
- Single testing configuration
- Single test material
  - Thick, soft cushions
- Requirements
  - 1900 ± 100°F, 10.5 ±0.5 BTU/ft^{2}s

Thermal Acoustic Insulation (2008)

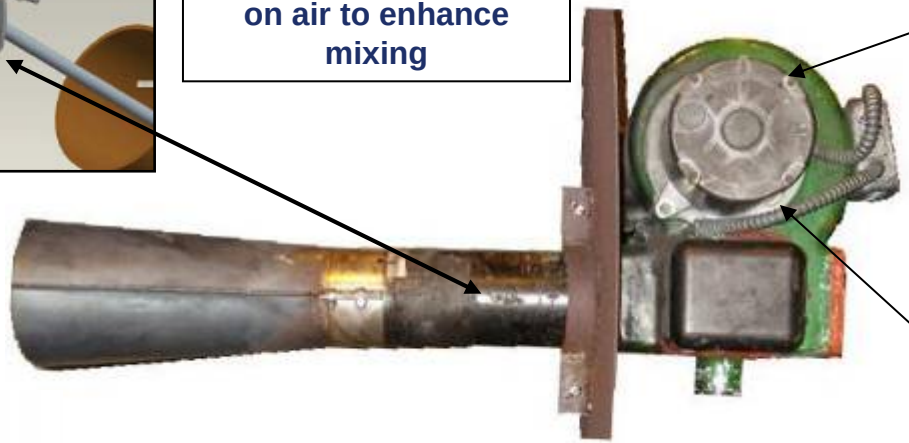
- Single acceptable burner
- Single testing configuration
- Single test material
  - Thin, flexible fire barriers
- Requirements
  - 1900 ± 100°F, 16.0 ±0.5 BTU/ft^{2}s
  - Inlet air velocity

Operating Principles



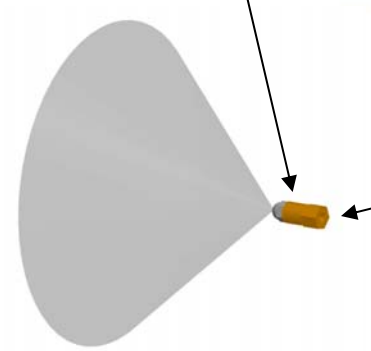
Igniters provide spark for ignition of fuel/air mixture

Internal components force swirling motion on air to enhance mixing



Electric motor connected to a blower wheel accelerates air from intake port down the draft tube

Electric motor provides shaft power to mechanical fuel pump to pressurize fuel



Fuel nozzle produces conical fuel spray pattern

Internal Components

- Stator and turbulator cause air flow to swirl in opposite directions, causing shearing and mixing of fuel droplets with air
- Position of these components has been found to have an impact on burner performance
- Some test methods have specific settings for these components
- Spray nozzle uniformity has been found to be an issue, nozzles can be rotated to get more uniform flame temperatures

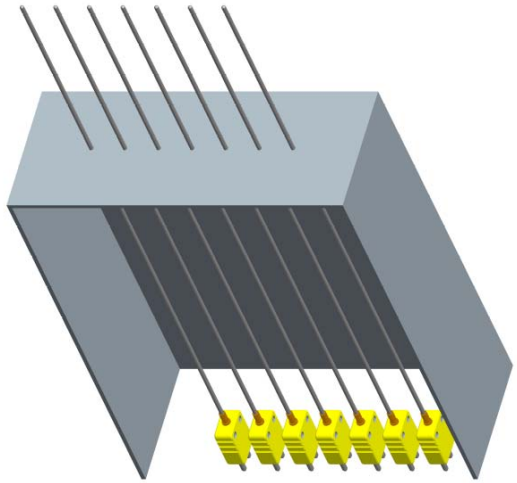
Stator

Turbulator

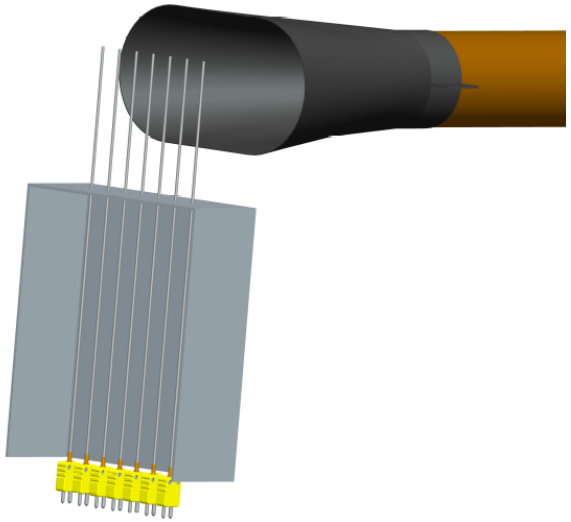
Nozzle

Flame Temperature Measurement

- **K-type thermocouples are used to measure flame temperature**
  - A thermocouple “rake” is made to measure time-averaged temperature at 7 locations
  - Position of rake in relation to burner cone exit plane depends on test method

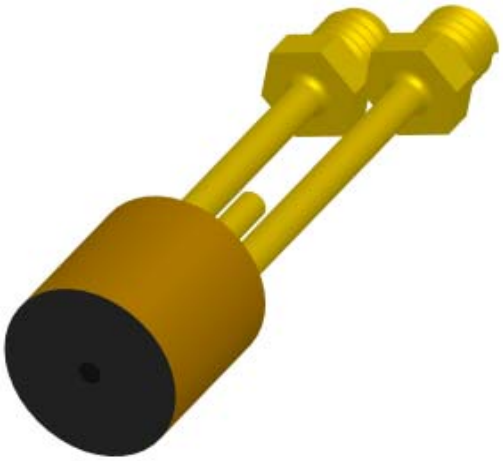


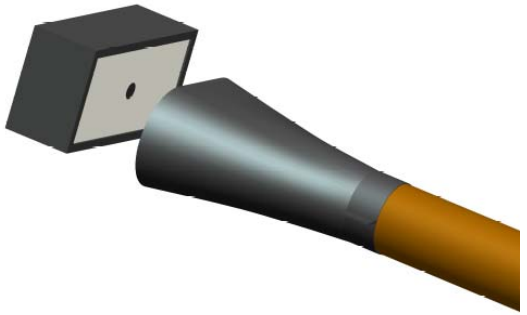
- **Flame temperature requirements vary for each test method**
  - Seats: 1800°F avg
  - Cargo Liners: 1600°F avg
  - T/A Insulation: 1900°F avg



Flame Heat Flux Measurement

- **A Gardon Gauge is used to measure the flame heat flux**
  - 0-15 BTU/ft^{2}s range
  - Water cooled
- **Gauge is mounted in a ceramic insulating block**
- **Position of center of gauge relative to cone exit plane depends on test method**
- **Heat flux value depends on test method**
  - Seats: 10 BTU/ft^{2}s
  - Cargo Liners: 7.5 BTU/ft^{2}s
  - T/A Insulation: 16 BTU/ft^{2}s



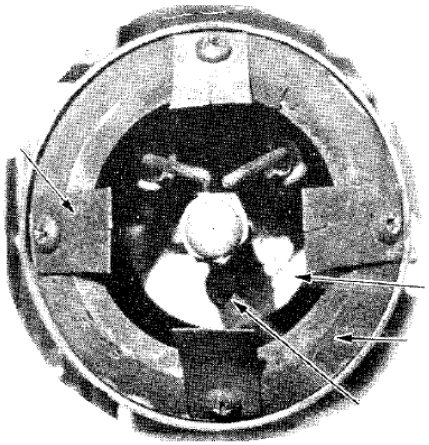


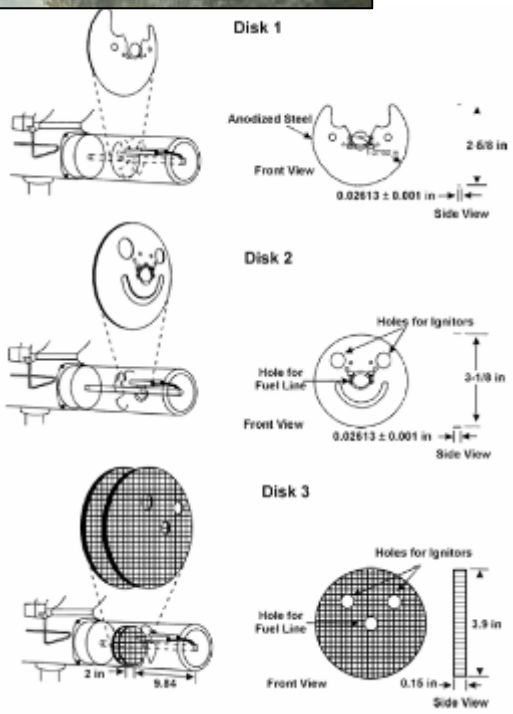
Burner Operation

- **Each test method has specific burner settings**
  - Air flow rate
  - Fuel flow rate
- **Check with test method description to determine proper burner operational parameters**
  - Fire test handbook:
    - http://www.fire.tc.faa.gov/handbook.stm
      - Chapter 7: Seat Cushion Flammability
      - Chapter 8: Cargo Liner Burnthrough
      - Chapter 24: Insulation Burnthrough
    - Descriptions of specific apparatus, burner orientation, test specimen holders, test calibration and procedure

Lessons Learned Over the Years

- **Not all burners are created equal**
- **Configuration of burner components can drastically alter flame**
- **Burner air flow can have a significant effect on test results, especially for lighter weight materials**
- **It's an oil burner, not precision lab equipment!**





Genesis of the Next Generation Fire Test Burner

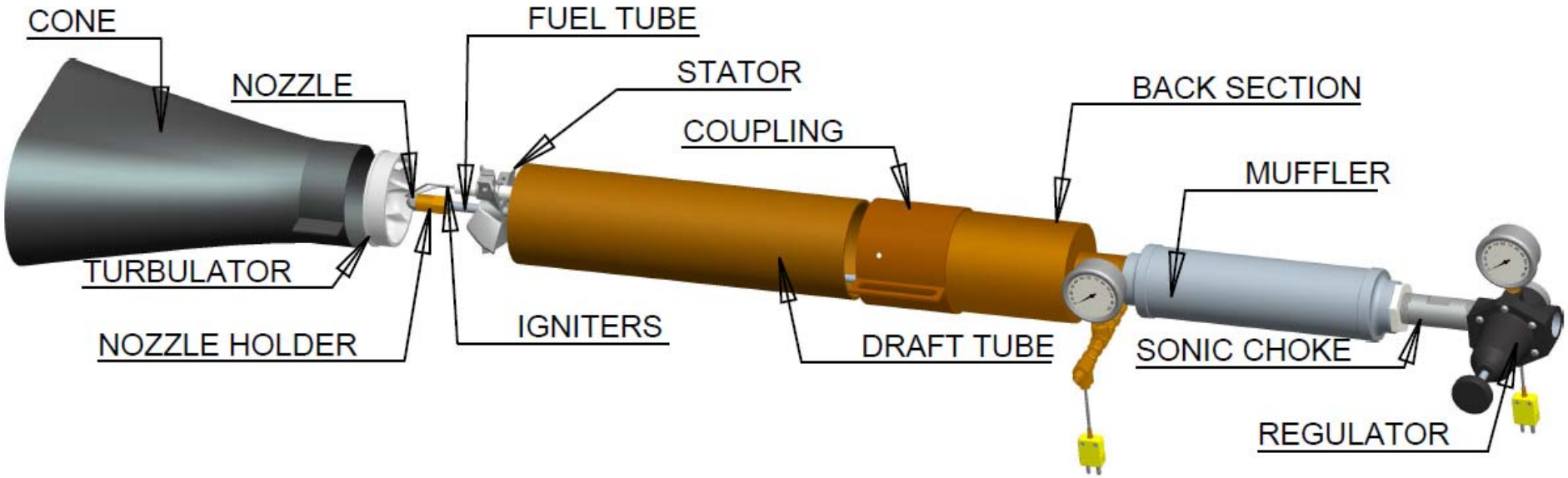
- **During development and implementation of the Thermal Acoustic Insulation Burnthrough Rule, it was discovered that the Park DPL 3400 was no longer in production**

- **Options**
  - Find another commercial off the shelf oil burner
  - Develop a new burner that will not suffer the same fate

Objectives

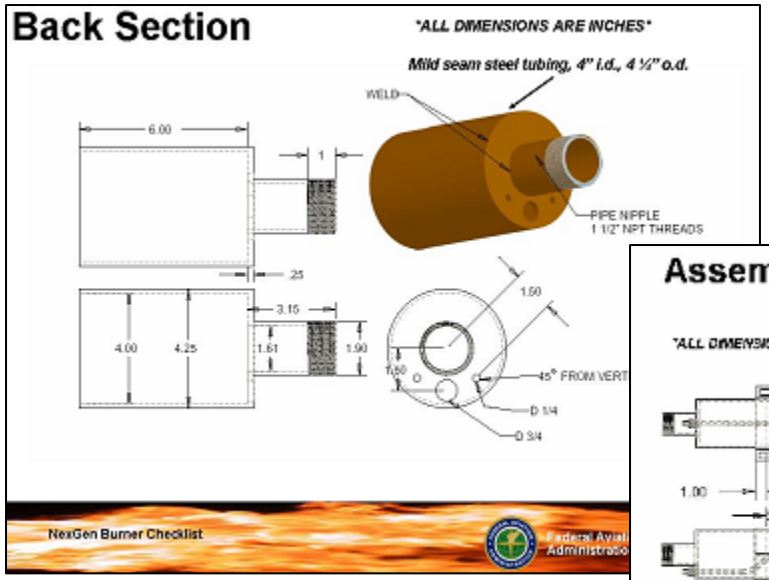
- **Design a fire test burner that can be constructed in-house with easily obtainable components**
  - Simple design
  - Simple operation
  - Simple maintenance
- **Burner output must be comparable to the Park DPL 3400**
- **Burner should achieve a higher level of repeatability and reproducibility**
- **Burner should be versatile and easily adaptable to any of the fire tests calling for a “modified gun-type burner”**

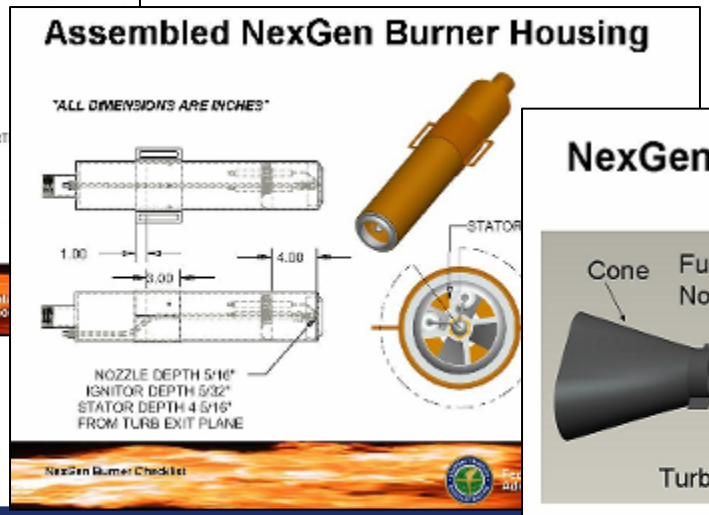
NexGen Burner Design

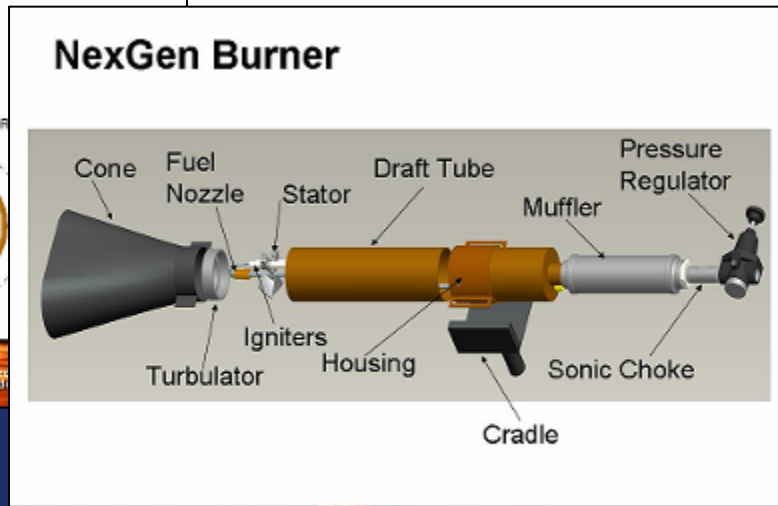


NexGen Drawings

- **Drawings are available online at**
  http://www.fire.tc.faa.gov/pdf/materials/NexGenPlans.pdf







Burner Control

Air Flow

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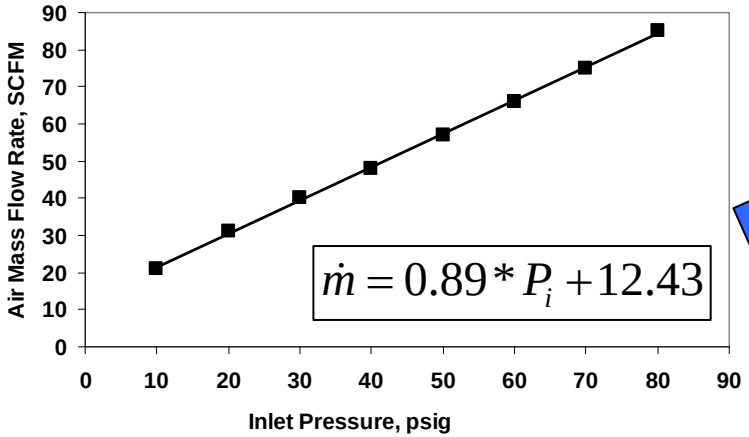

Fuel Flow

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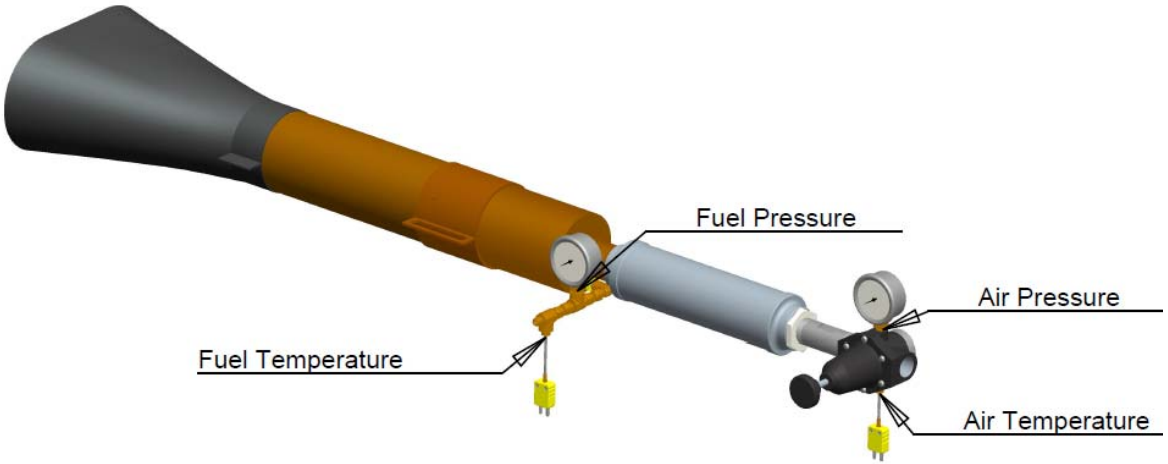
Regulated and conditioned air and fuel to burner

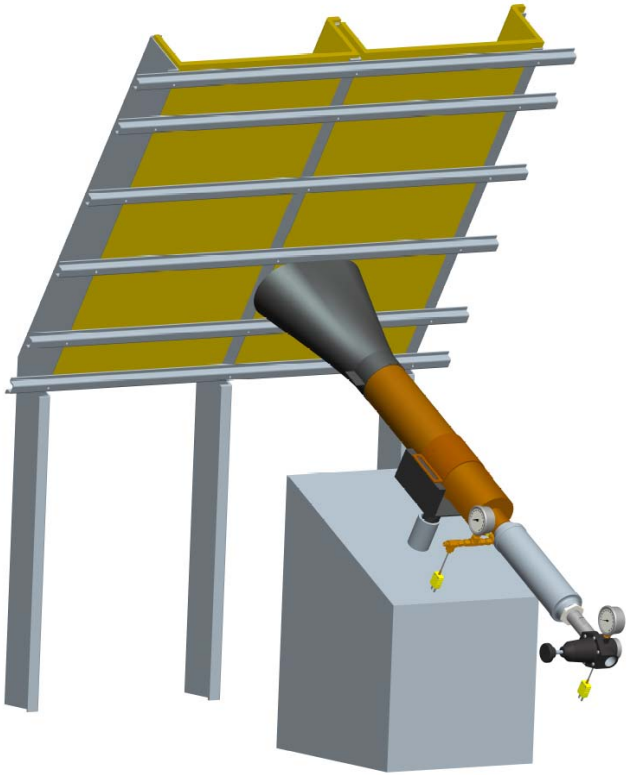
Air & Fuel Measurement

- **Air**
  - Flow controlled by pressure regulator and sonic choke
  - Must check regulator output pressure
  - Temperature monitored by thermocouple
- **Fuel**
  - Flow controlled by pressure of fuel tank
  - Must check pressure at back of burner
  - Temperature monitored by thermocouple
  - Fuel volume flow rate is measured with a graduated cylinder and a stopwatch to obtain mL/min



Thermal/Acoustic Insulation Burnthrough

14 CFR 25.856(b)

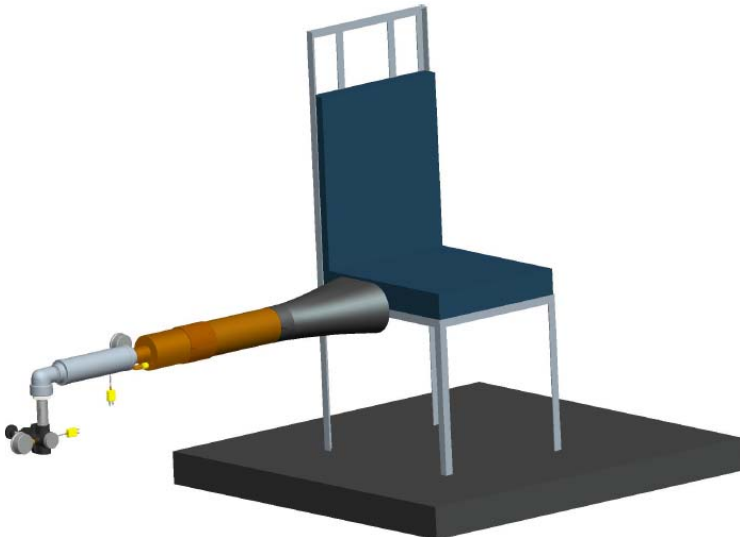


Cargo Liner Burnthrough

14 CFR 25.855

Seat Cushion Flammability

14 CFR 25.853



NexGen Burner Calibration

- **For the NexGen burner, the heat flux measurement has been removed from the calibration procedure**
  - Heat flux transducers measure instantaneous heat flux at a very small point in the flame
  - Specifically, Gardon gauges were designed and are intended for measuring intense thermal radiation only
    - Use in an intense, mixed-mode heat transfer environment introduces significant measurement uncertainty
  - Since all inlet parameters and burner dimensions are fixed, no adjustments can be made to achieve a specified heat flux

- **Flame temperature is measured and used to determine proper burner output**
  - 1/8” S.S. sheathed ceramic packed K-type thermocouples

- **Ultimate test of similarity between Park DPL 3400 and NexGen was comparative burnthrough and seat cushion testing**

Fire Test Burner - Summary

- **The FAA fire test burners are used for testing materials to a severe fire threat**
- **Different types of oil burners may be found in laboratories depending on test being run**
- **Be sure to check Fire Test Handbook and AC material for proper burner configurations**

FAA Fire Test Burner Test Methods

Federal Aviation Administration

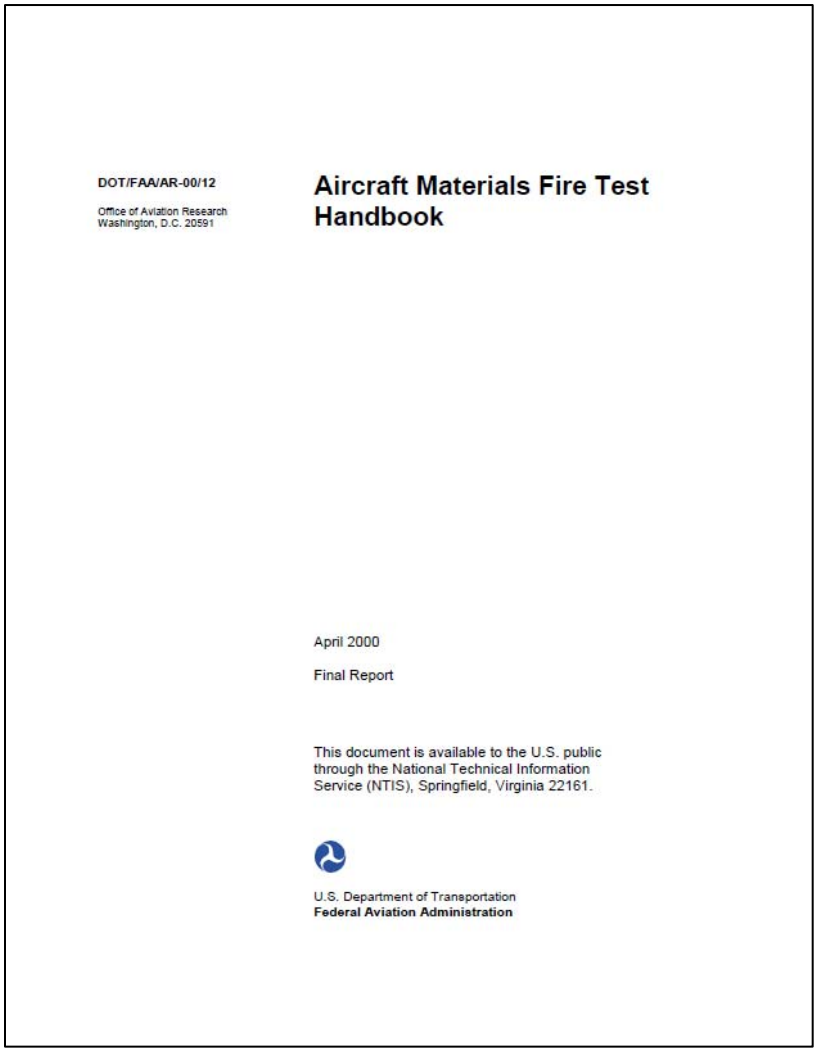
FAA Fire Safety Overview

February 7 2012 – Singapore

Robert I. Ochs, FAA Fire Safety, ANG-E212

FAA Fire Test Handbook

- **Contains all FAA Fire test methods**
  - Information in handbook is constantly updated
  - Handbook test methods are preferred over what is written in rule
- **Chapters that use oil burner:**
  - 7: Seat Cushions
  - 8: Cargo Liners
  - 24: T/A Insulation



DOT/FAA/AR-00/12

Office of Aviation Research
Washington, D.C. 20591

Aircraft Materials Fire Test Handbook

April 2000

Final Report

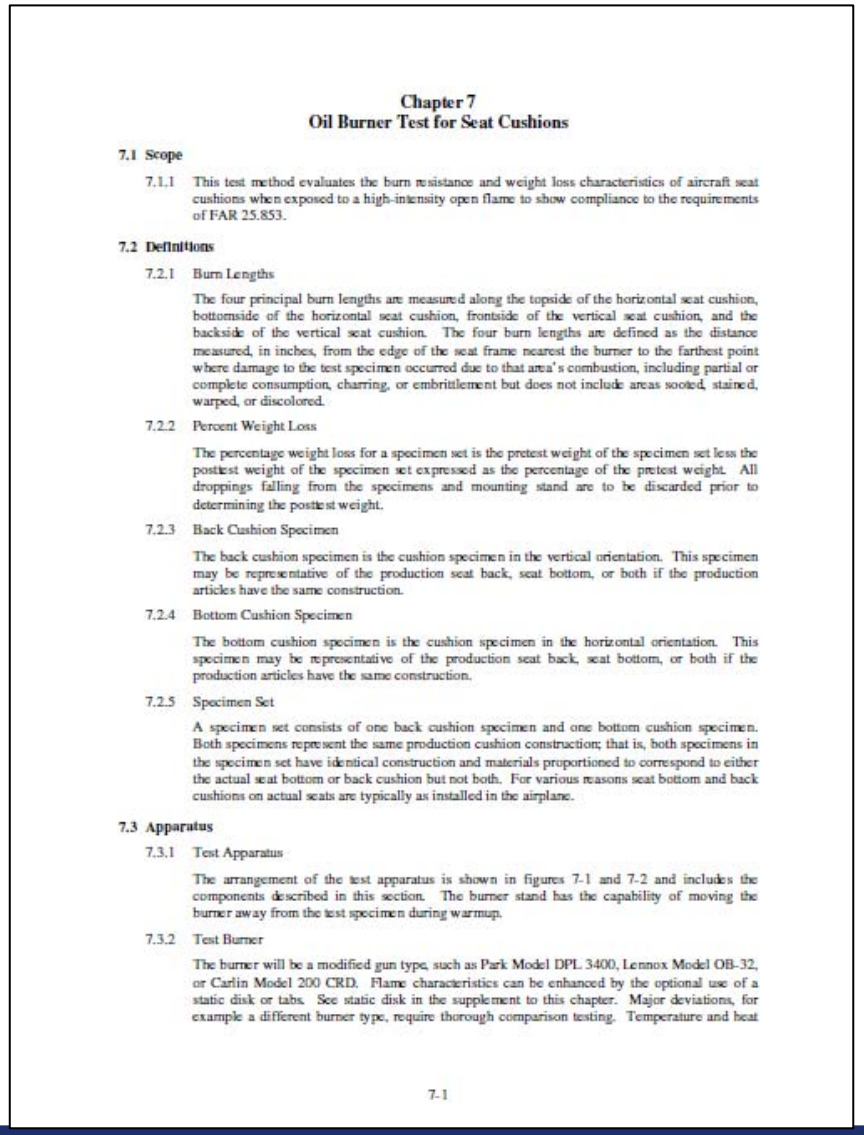
This document is available to the U.S. public through the National Technical Information Service (NTIS), Springfield, Virginia 22161.

U.S. Department of Transportation
Federal Aviation Administration

Chapter 7 – Seat Cushion

- **This test method evaluates the burn resistance and weight loss characteristics of aircraft seat cushions when exposed to a high-intensity open flame to show compliance to the requirements of FAR 25.853.**

- **Test Parameters:**
  - Burn Length
  - % Mass Loss



Chapter 7
Oil Burner Test for Seat Cushions

7.1 Scope

7.1.1 This test method evaluates the burn resistance and weight loss characteristics of aircraft seat cushions when exposed to a high-intensity open flame to show compliance to the requirements of FAR 25.853.

7.2 Definitions

7.2.1 Burn Lengths

The four principal burn lengths are measured along the topside of the horizontal seat cushion, bottomside of the horizontal seat cushion, frontside of the vertical seat cushion, and the backside of the vertical seat cushion. The four burn lengths are defined as the distance measured, in inches, from the edge of the seat frame nearest the burner to the farthest point where damage to the test specimen occurred due to that area's combustion, including partial or complete consumption, charring, or embrittlement but does not include areas sooted, stained, warped, or discolored.

7.2.2 Percent Weight Loss

The percentage weight loss for a specimen set is the pretest weight of the specimen set less the posttest weight of the specimen set expressed as the percentage of the pretest weight. All droppings falling from the specimens and mounting stand are to be discarded prior to determining the posttest weight.

7.2.3 Back Cushion Specimen

The back cushion specimen is the cushion specimen in the vertical orientation. This specimen may be representative of the production seat back, seat bottom, or both if the production articles have the same construction.

7.2.4 Bottom Cushion Specimen

The bottom cushion specimen is the cushion specimen in the horizontal orientation. This specimen may be representative of the production seat back, seat bottom, or both if the production articles have the same construction.

7.2.5 Specimen Set

A specimen set consists of one back cushion specimen and one bottom cushion specimen. Both specimens represent the same production cushion construction; that is, both specimens in the specimen set have identical construction and materials proportioned to correspond to either the actual seat bottom or back cushion but not both. For various reasons seat bottom and back cushions on actual seats are typically as installed in the airplane.

7.3 Apparatus

7.3.1 Test Apparatus

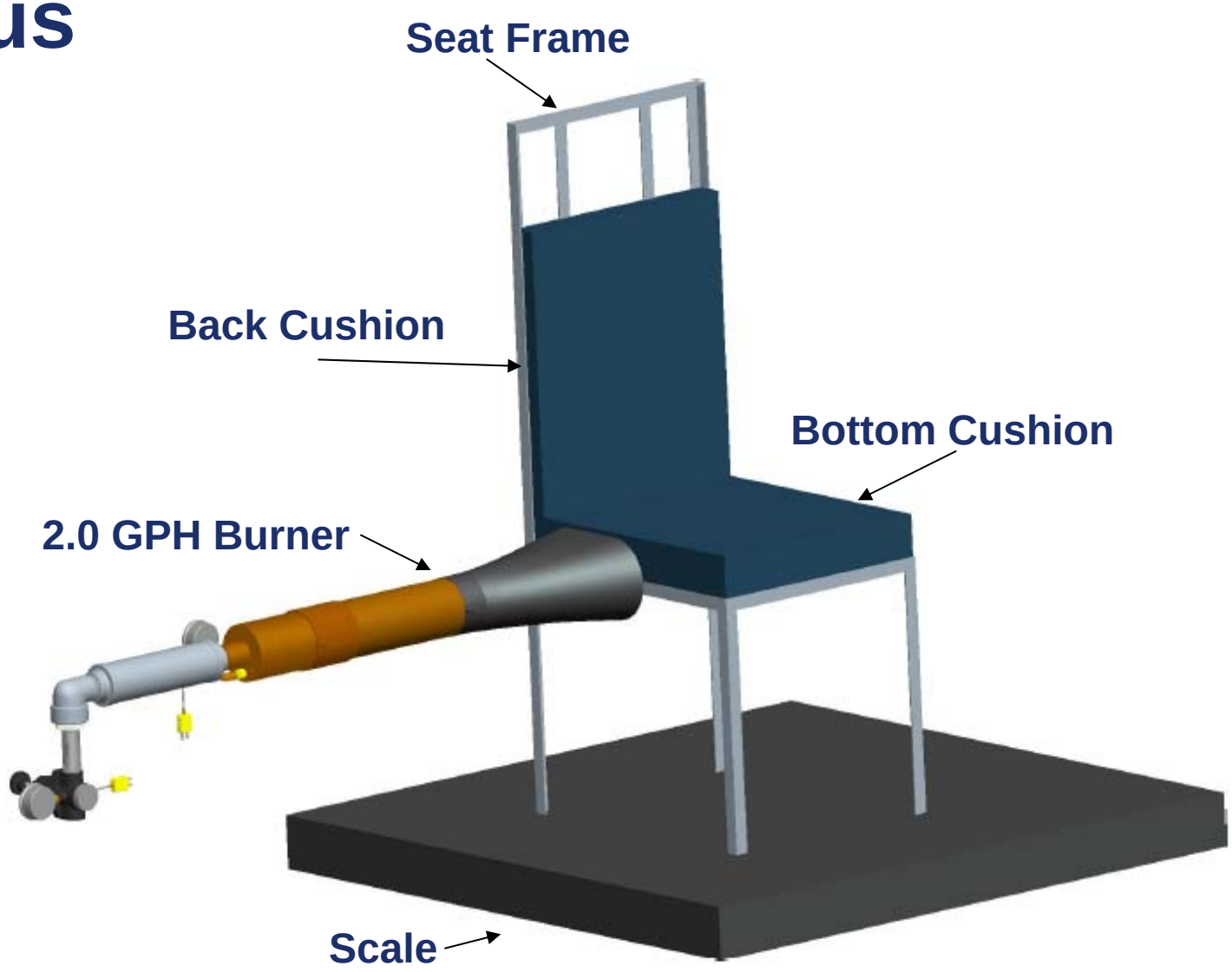
The arrangement of the test apparatus is shown in figures 7-1 and 7-2 and includes the components described in this section. The burner stand has the capability of moving the burner away from the test specimen during warmup.

7.3.2 Test Burner

The burner will be a modified gun type, such as Park Model DPL 3400, Lennox Model OB-32, or Carlin Model 200 CRD. Flame characteristics can be enhanced by the optional use of a static disk or tabs. See static disk in the supplement to this chapter. Major deviations, for example a different burner type, require thorough comparison testing. Temperature and heat

7-1

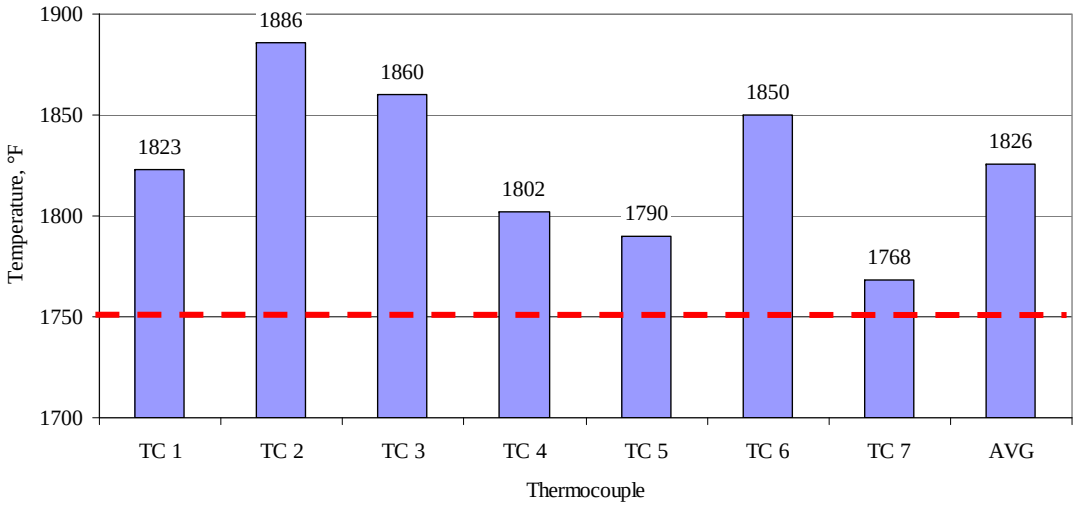
Apparatus



Calibration

- **Flame Temperature**
  - Seven K-type, metal sheathed, ceramic insulated thermocouples are placed in a rake, 1” apart and 4” from the burner cone exit plane
  - After a 2 minute warmup period, TC rake is placed in flame and soaked for 1 minute
  - A 30-sec average is taken for each thermocouple, and the average must be greater than 1750°F on 2 TC’s and 1800°F on the remaining 5 TC’s

- **Flame Heat Flux**
  - A Gardon gauge type heat flux sensor is used to measure heat flux
  - After a 2 minute warmup period, the gauge is placed in flame and soaked for 1 minute
  - A 30-sec average is taken of the heat flux, and a minimum average value of 10 BTU/ft^{2}s must be achieved



Test Specimens

- **A sample set consists of**
  - one seat bottom (horizontal)
    - 18” x 20” x 4”
  - one seat back (vertical)
    - 18” x 25” x 2”
- **A minimum of 3 sample sets will be tested**
- **Each specimen will be constructed of the principal components and assembly of the production seat cushion**
  - Foam core
  - Flotation material
  - Fire block material
  - Dress covering
  - Seams
- **Weakest point of cushion will be exposed directly to burner flame**
- **Specimens will be conditioned for a minimum of 24 hours before testing**

Test Procedure

- Record weight of each component (back and bottom cushion) to the nearest 0.02 pound.
- Align seat frame with cushion according to Chapter 7
- Position seat away from burner flame, fire burner for 2 minutes to warm up
- Position the seat in front of burner flame at 2 minutes and expose for an additional 2 minutes, then turn off the burner
- The test is over when the seat cushion has self extinguished OR after 5 minutes from burner shut-off
- Record the final weight at test termination and extinguish gently if necessary
- Measure burn lengths on top, bottom, back and front of each component
- A sample set of 3 tests will be run for each cushion configuration

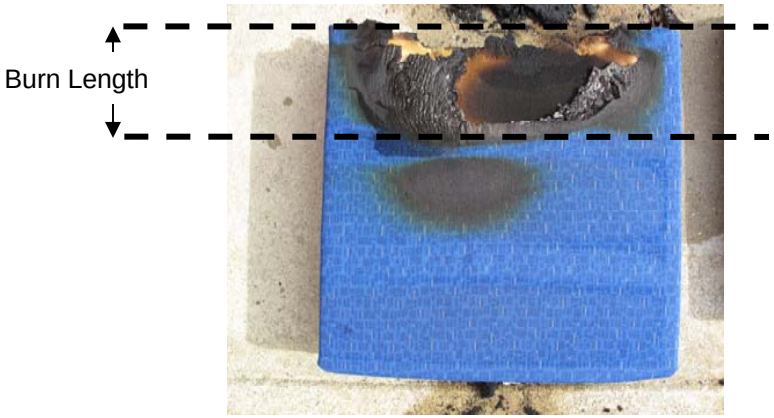
Test Criteria

- **The % mass loss is calcualted for each test**

$$\frac{\left(m_{initial} - m_{final}\right)}{m_{initial}} \times 100$$

- **The average % of the 3 tests run can not exceed 10% and 2 of the 3 tests must not exceed 10%**

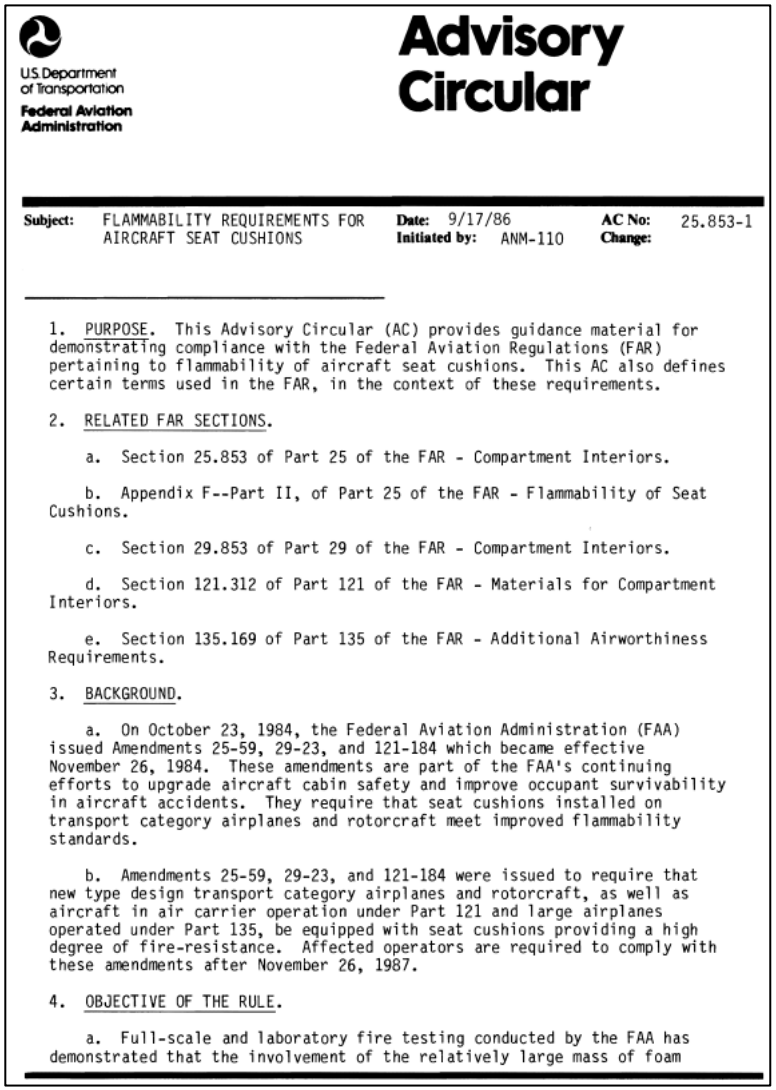
- **The average burn length may not exceed 17 inches in any direction, and 2 out of the 3 samples tested must not exceed 17 inches**



Advisory Material: Seat Cushion Test

- **AC 25.853-1 - Flammability Requirements for Aircraft Seat Cushions**

- **Gives advice on test conduct, sample preparation, burner calibration, etc.**



U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: FLAMMABILITY REQUIREMENTS FOR AIRCRAFT SEAT CUSHIONS
Date: 9/17/86 **Initiated by:** ANM-110
AC No: 25.853-1 **Change:**

1. PURPOSE. This Advisory Circular (AC) provides guidance material for demonstrating compliance with the Federal Aviation Regulations (FAR) pertaining to flammability of aircraft seat cushions. This AC also defines certain terms used in the FAR, in the context of these requirements.

2. RELATED FAR SECTIONS.

a. Section 25.853 of Part 25 of the FAR - Compartment Interiors.

b. Appendix F--Part II, of Part 25 of the FAR - Flammability of Seat Cushions.

c. Section 29.853 of Part 29 of the FAR - Compartment Interiors.

d. Section 121.312 of Part 121 of the FAR - Materials for Compartment Interiors.

e. Section 135.169 of Part 135 of the FAR - Additional Airworthiness Requirements.

3. BACKGROUND.

a. On October 23, 1984, the Federal Aviation Administration (FAA) issued Amendments 25-59, 29-23, and 121-184 which became effective November 26, 1984. These amendments are part of the FAA's continuing efforts to upgrade aircraft cabin safety and improve occupant survivability in aircraft accidents. They require that seat cushions installed on transport category airplanes and rotorcraft meet improved flammability standards.

b. Amendments 25-59, 29-23, and 121-184 were issued to require that new type design transport category airplanes and rotorcraft, as well as aircraft in air carrier operation under Part 121 and large airplanes operated under Part 135, be equipped with seat cushions providing a high degree of fire-resistance. Affected operators are required to comply with these amendments after November 26, 1987.

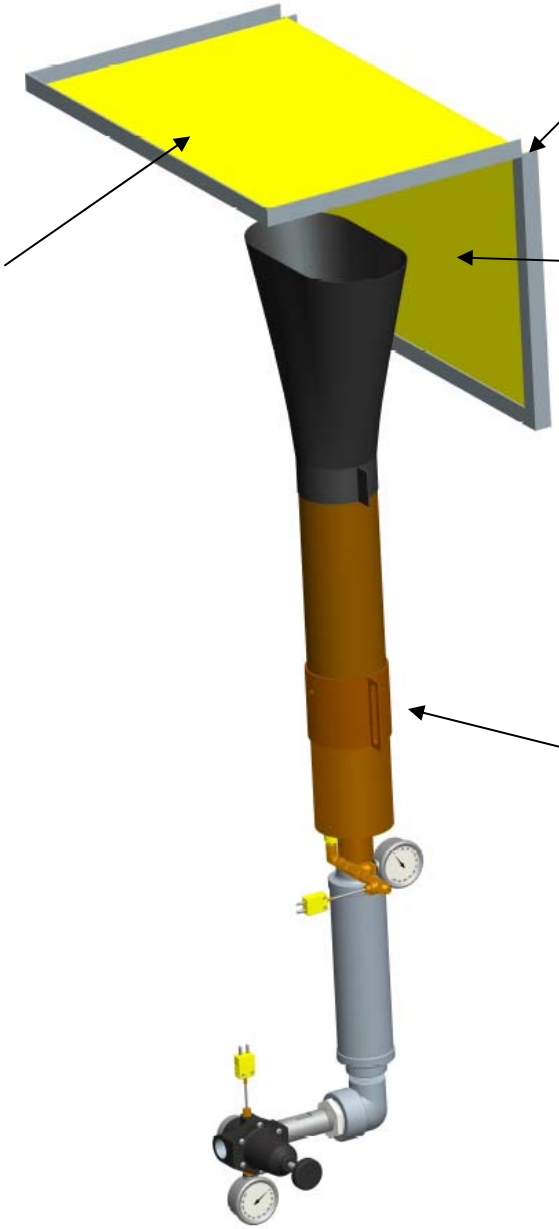
4. OBJECTIVE OF THE RULE.

a. Full-scale and laboratory fire testing conducted by the FAA has demonstrated that the involvement of the relatively large mass of foam

Chapter 8 – Cargo Liner Burnthrough

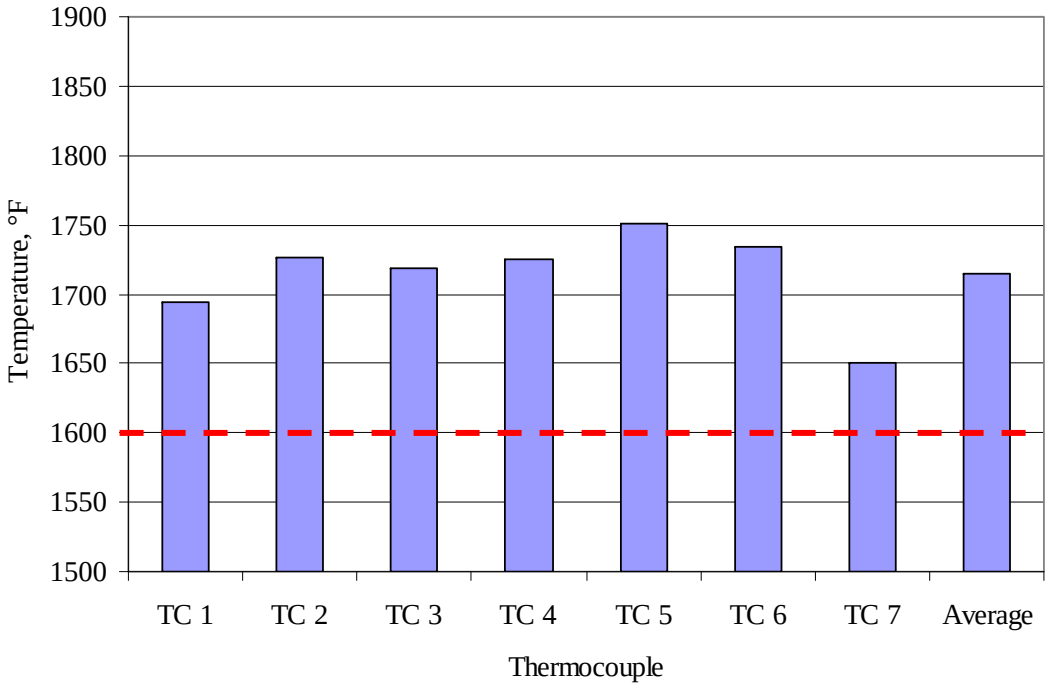
- **This test method evaluates the flame penetration resistance capabilities of aircraft cargo compartment lining materials utilizing a high-intensity open flame to show compliance to the requirements of FAR 25.855**
- **Test Parameters:**
  - Time to Burnthrough
  - Time to Backside Temperature >400°F

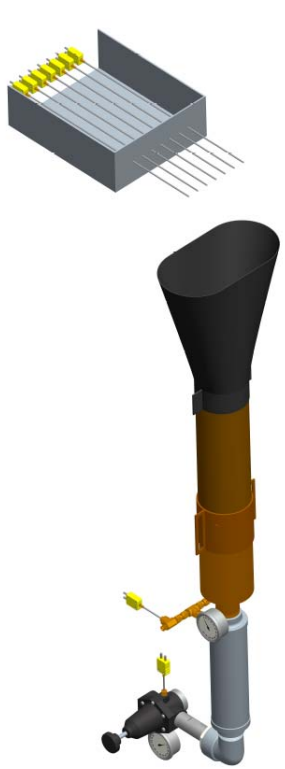
Apparatus


Sample Holder
Ceiling Test Sample
Sidewall Test Sample
2.0 GPH Burner

Calibration

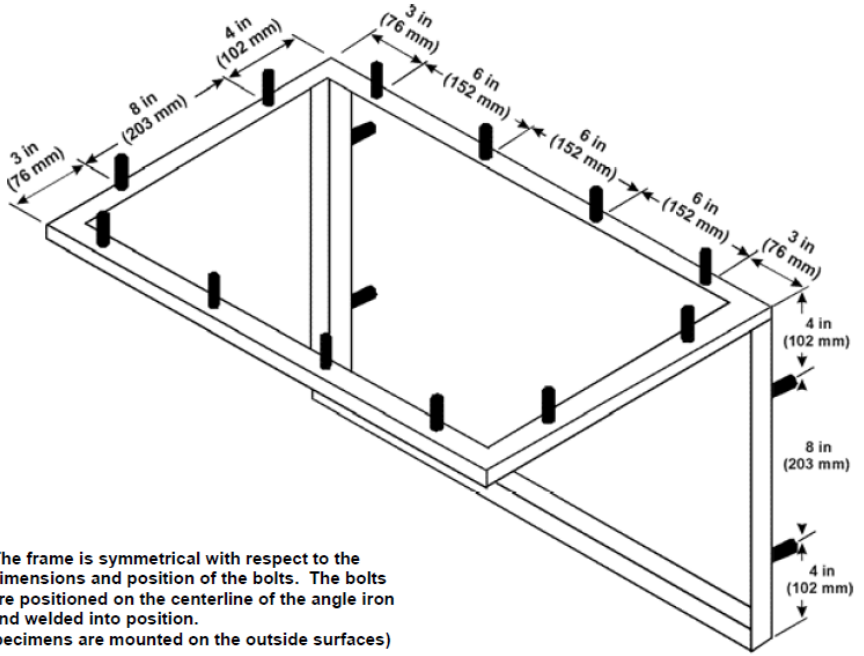
- **Flame Temperature**
  - Seven K-type, metal sheathed, ceramic insulated thermocouples are placed in a rake, 1” apart and 4” from the burner cone exit plane
  - After a 2 minute warmup period, TC rake is placed in flame and soaked for 1 minute
  - A 30-sec average is taken for each thermocouple, and the average must be greater than 1600°F
- **Flame Heat Flux**
  - A Gardon gauge type heat flux sensor is used to measure heat flux
  - After a 2 minute warmup period, the gauge is placed in flame and soaked for 1 minute
  - A 30-sec average is taken of the heat flux, and a minimum average value of 7.5 BTU/ft^{2}s must be achieved





Test Specimens

- **Each cargo liner panel type and design configuration is tested**
  - Design features such as corners, joints, seams, lamp assemblies, pressure relief valves, temperature sensors, etc., that may affect the capability of the cargo compartment to safely contain a fire
- **A specimen consists of a ceiling panel and a sidewall panel**
- **A minimum of 3 specimens or specimen sets for each panel type or design configuration will be tested**
- **The specimens will measure 16” by 24”**
- **The specimens will be conditioned for at least 24 hours prior to testing**

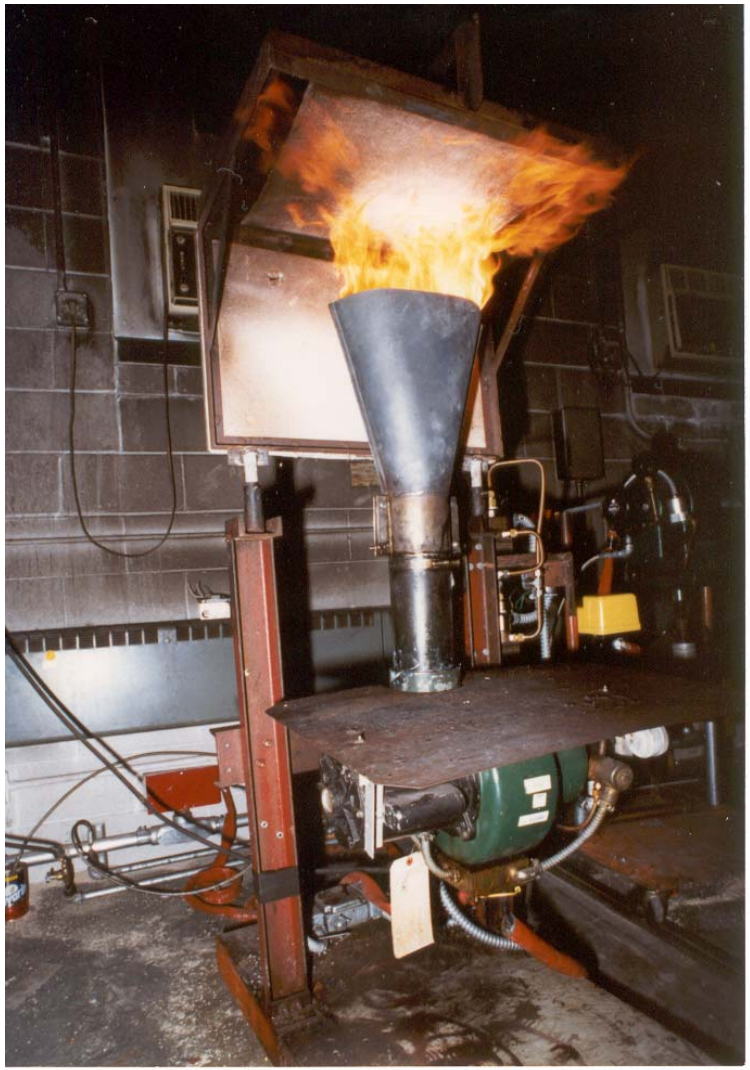


Note: The frame is symmetrical with respect to the dimensions and position of the bolts. The bolts are positioned on the centerline of the angle iron and welded into position.
(Test specimens are mounted on the outside surfaces)

Figure 8-2. Cargo Liner Test Specimen Frame

Procedure

- **Mount the ceiling and sidewall specimens into the test frame and secure in place with retaining frame**
- **Move the test frame away from the burner, fire the burner for 2 minutes to warm up**
- **After 2 minutes, position the test frame over the burner and expose the specimens for 5 minutes OR until flame penetration occurs**
- **Note the time to specimen burn-through OR time to backside temperature exceed 400°F**



Test Criteria

- None of the specimens can have burnthrough in less than 5 minutes
- None of the specimens can have a backside temperature over 400°F in the 5 minute period
- Specimens that pass the ceiling orientation can be used for the sidewall without further test

Chapter 15 – Cargo Liner Repairs

- **This test method gives certification test procedures for repair of damaged cargo liners which would include, but not be limited to, ceiling and sidewall liners, pressurized cylinder cover liners, fabric liners, and compartment separation liners. Repairs should not be made to areas of the cargo liner that are designed for blowout in case of decompression.**

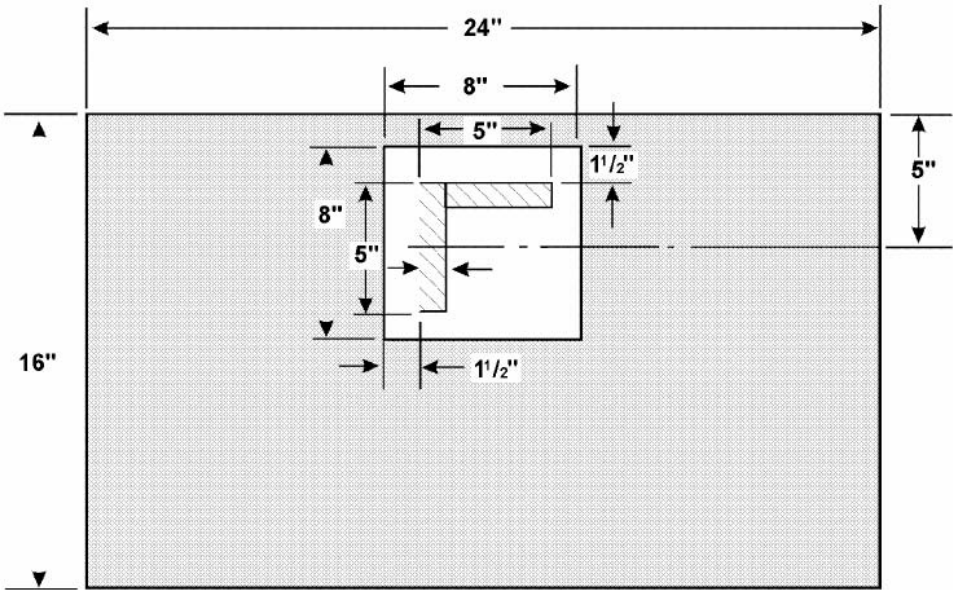


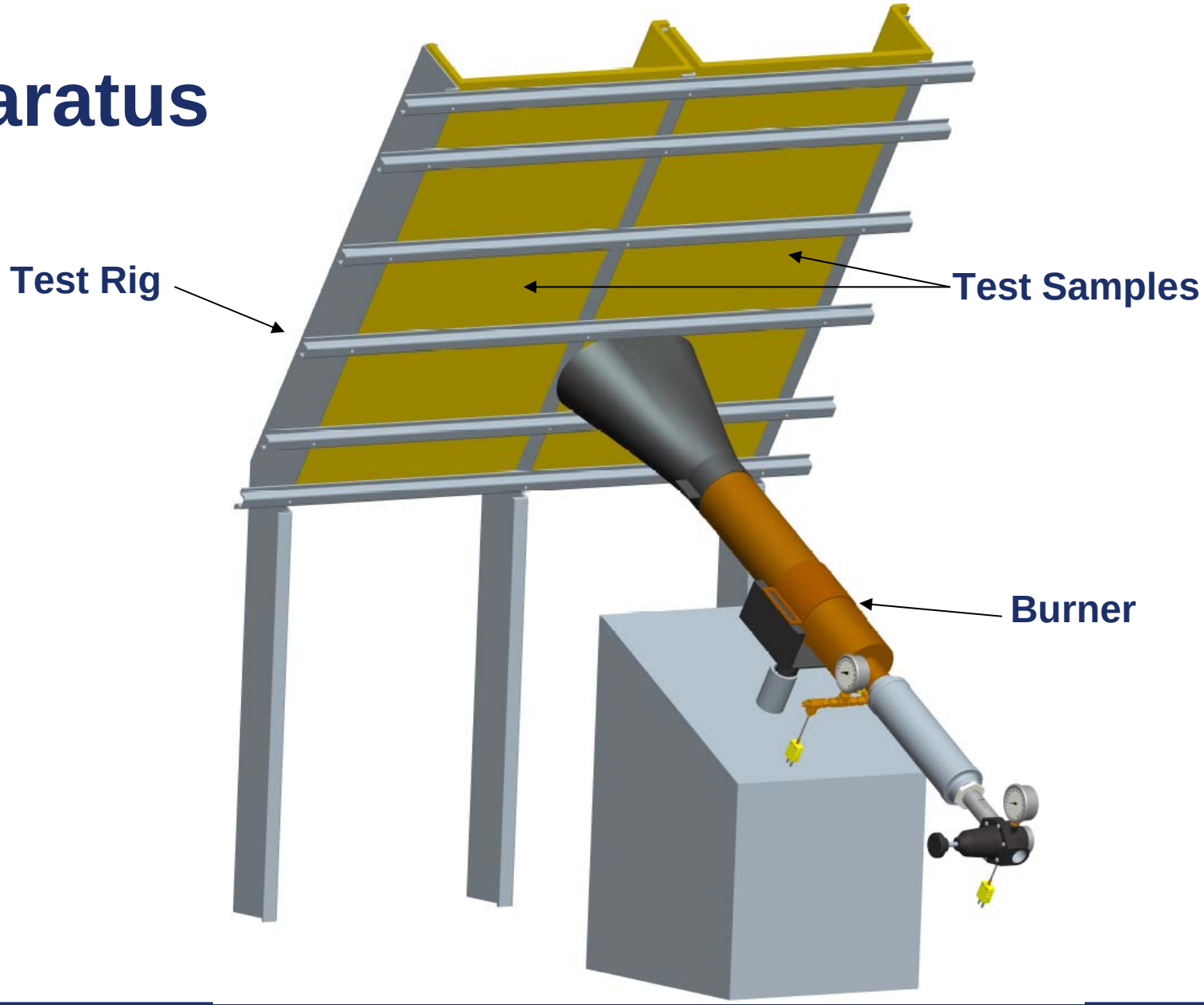
Figure 15-2. Eight- by Eight-Inch Patch Over Standard Damage

Chapter 24 – Insulation Burnthrough

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

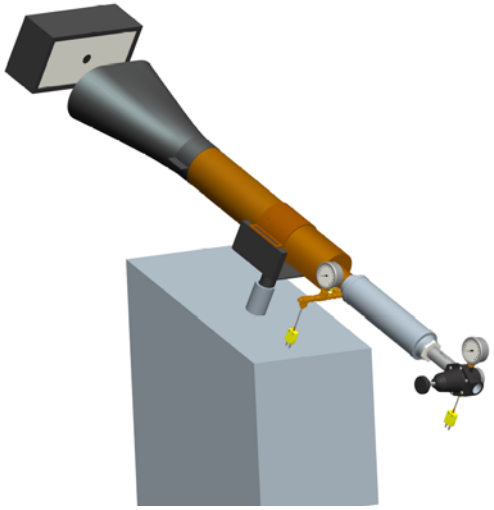
- **Test Parameters**
  - Time to Burnthrough
  - Time to Backside Heat Flux >2.0 BTU/ft^{2}s

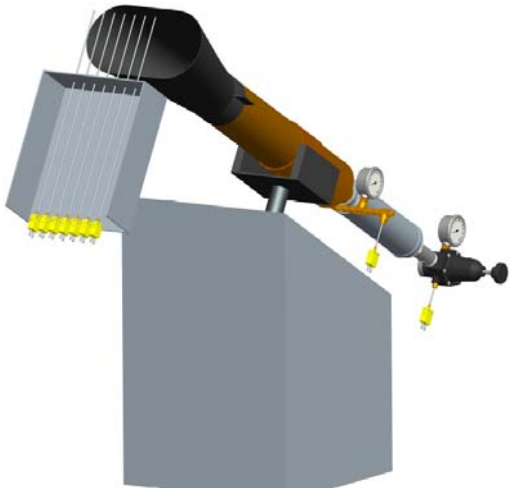
Apparatus

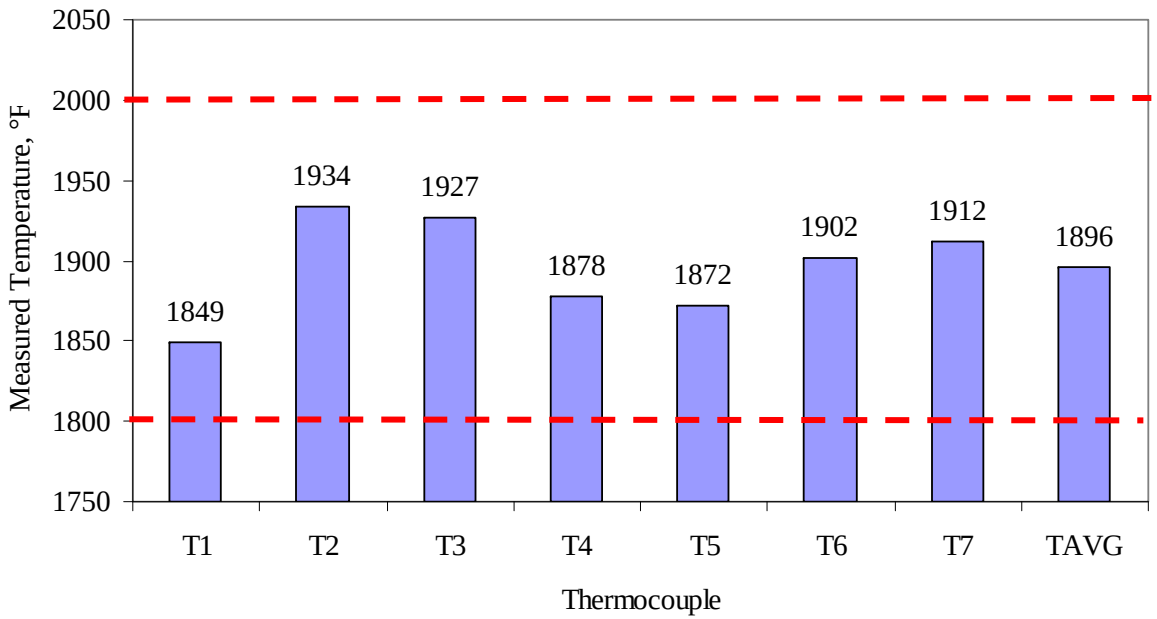


Calibration

- **Flame Temperature**
  - Seven K-type, metal sheathed, ceramic insulated thermocouples are placed in a rake, 1” apart and 4” from the burner cone exit plane
  - After a 2 minute warmup period, TC rake is placed in flame and soaked for 1 minute
  - A 30-sec average is taken for each thermocouple, and the average must be 1900°F +/- 100°F (1800°F-2000°F)
- **Flame Heat Flux**
  - A Gardon gauge type heat flux sensor is used to measure heat flux
  - After a 2 minute warmup period, the gauge is placed in flame and soaked for 1 minute
  - A 30-sec average is taken of the heat flux, and an average value of 16 BTU/ft^{2}s +/- 0.8 BTU/ft^{2}s must be achieved







Test Specimens

- **A minimum of 3 specimen sets of the same configuration will be tested**
  - A specimen set consists of 2 insulation blankets (left and right)
- **The samples will measure 32” wide by 36” long**
- **Each specimen is constructed from the principal components for a production blanket**
  - Insulation
  - Fire barrier
  - Moisture barrier film
  - Seams and closures
- **The specimens will be conditioned for a minimum of 24 hours before testing**

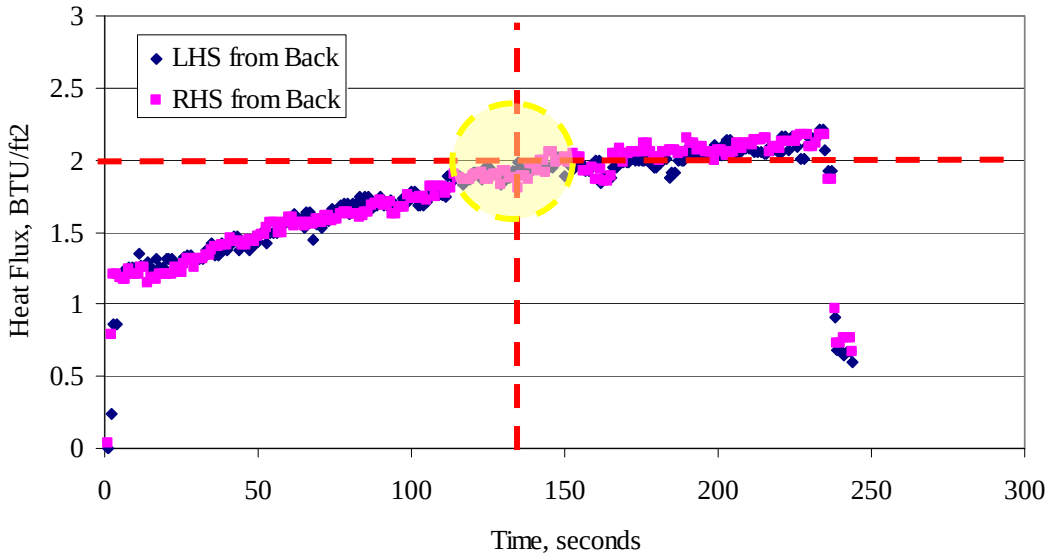
Procedure

- Attach the insulation blankets to the test frame using spring clamps, follow advisory material for attachment methods
- Position test rig away from burner, fire the burner for 2 minutes to warm-up
- At 2 minutes, position the test rig in front of the burner flame, exposing the blankets to the flame
- Expose the specimens to the flame for 4 minutes
- Terminate the test at 4 minutes OR when burn through occurs

Test Criteria

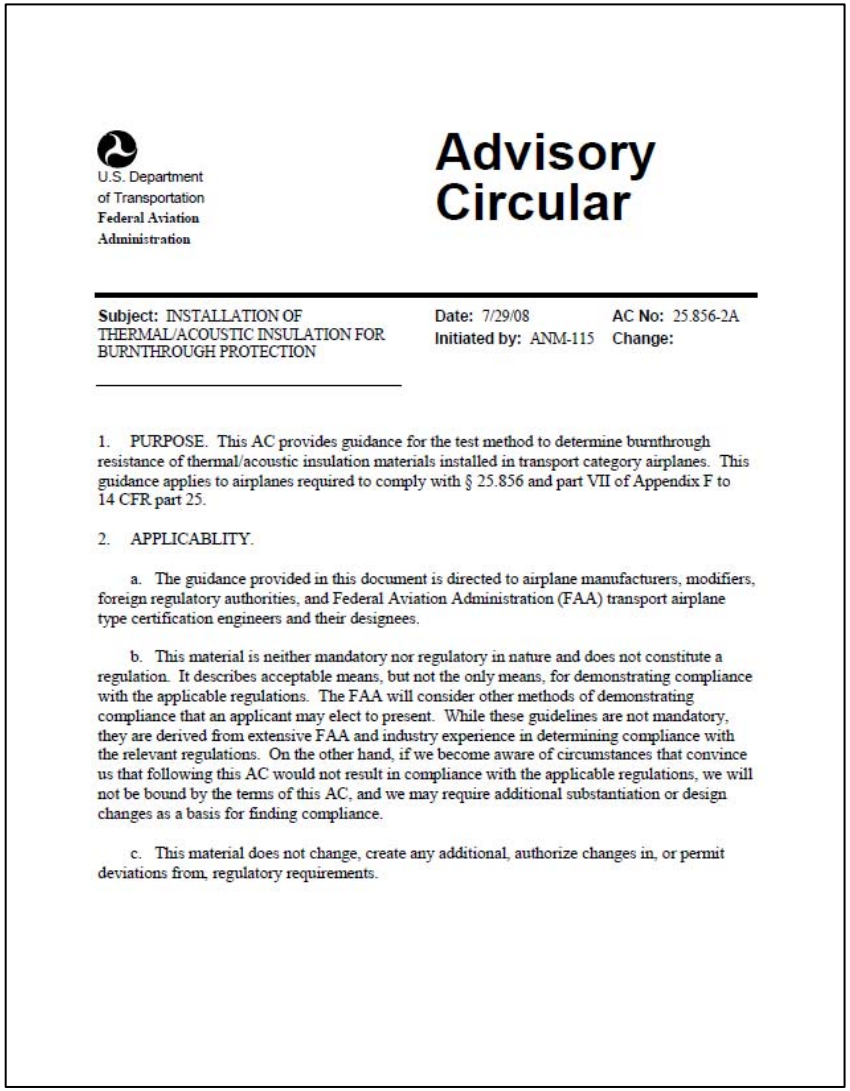
- **Each of the two blanket specimens tested must not allow fire or flame penetration in less than 4 minutes**

- **Each of the two blanket specimens must not allow more than 2.0 BTU/ft²s on the back side (inboard) of the specimens in the 4 minute test period**



Advisory Circular – Insulation Burnthrough Test

- **AC 25.856-2A**
- **This AC provides guidance for the test method to determine burnthrough resistance of thermal/acoustic insulation materials installed in transport category airplanes. This guidance applies to airplanes required to comply with § 25.856 and part VII of Appendix F to 14 CFR part 25.**
- **Describes acceptable attachment methods, overlap, insulation that does not require testing, etc.**
- **Includes NexGen burner as equivalent to Park burner**



U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: INSTALLATION OF THERMAL/ACOUSTIC INSULATION FOR BURNTHROUGH PROTECTION

Date: 7/29/08 **AC No:** 25.856-2A
Initiated by: ANM-115 **Change:**

1. PURPOSE. This AC provides guidance for the test method to determine burnthrough resistance of thermal/acoustic insulation materials installed in transport category airplanes. This guidance applies to airplanes required to comply with § 25.856 and part VII of Appendix F to 14 CFR part 25.

2. APPLICABLITY.

a. The guidance provided in this document is directed to airplane manufacturers, modifiers, foreign regulatory authorities, and Federal Aviation Administration (FAA) transport airplane type certification engineers and their designees.

b. This material is neither mandatory nor regulatory in nature and does not constitute a regulation. It describes acceptable means, but not the only means, for demonstrating compliance with the applicable regulations. The FAA will consider other methods of demonstrating compliance that an applicant may elect to present. While these guidelines are not mandatory, they are derived from extensive FAA and industry experience in determining compliance with the relevant regulations. On the other hand, if we become aware of circumstances that convince us that following this AC would not result in compliance with the applicable regulations, we will not be bound by the terms of this AC, and we may require additional substantiation or design changes as a basis for finding compliance.

c. This material does not change, create any additional, authorize changes in, or permit deviations from, regulatory requirements.

AC 25.856-2A

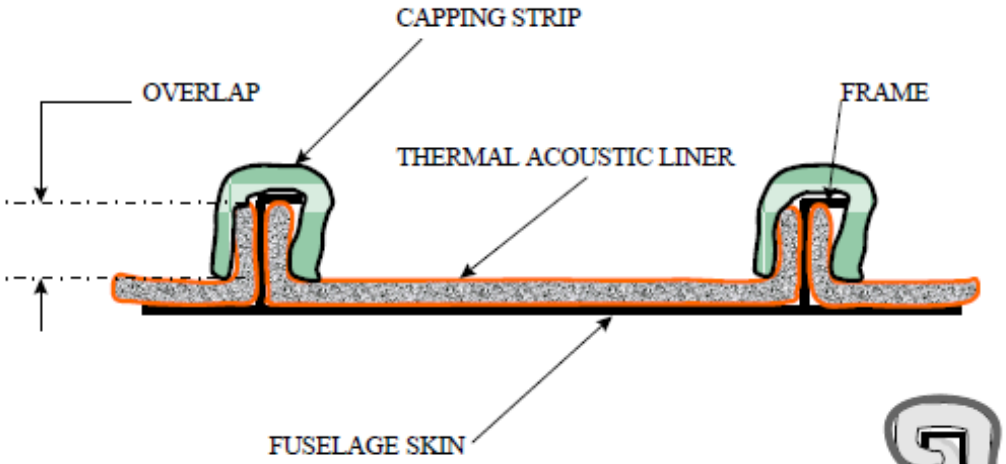


Figure 1. Overlap

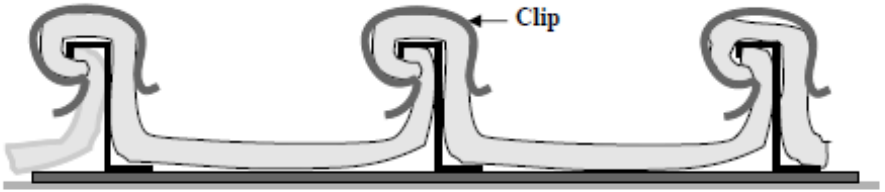


Figure 9. Over Frame Blanket Installation

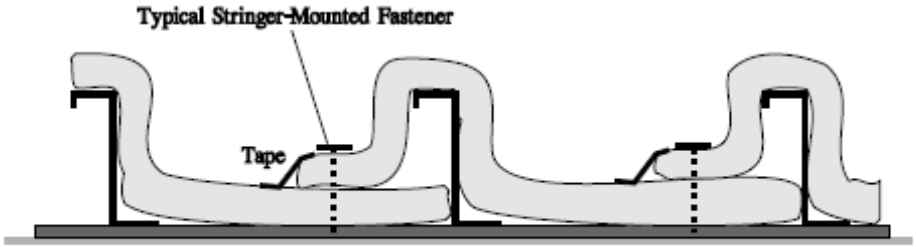


Figure 10. Stringer-Mounted Fastener

Questions?

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