Smoke Generator Handbook for Cargo Smoke Detection Certification

Presented to: International Aircraft Systems Fire Protection Working Group

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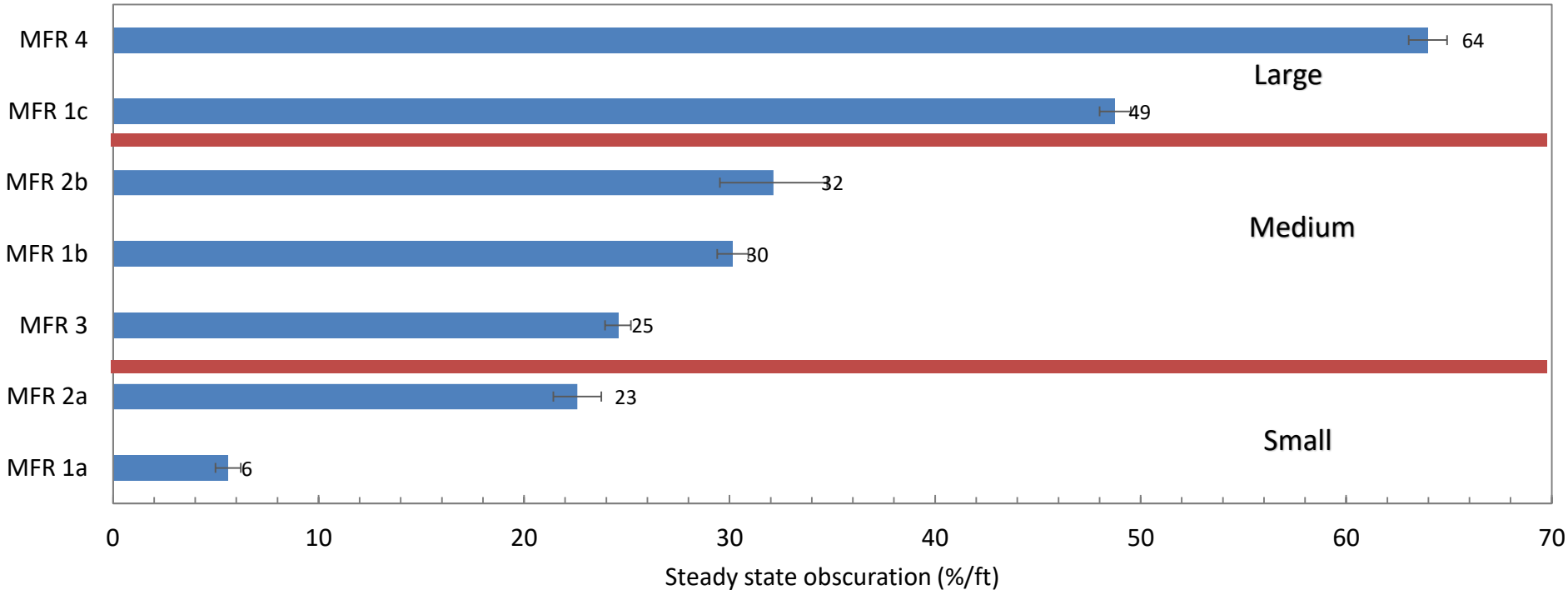
Federal Aviation Administration

Overview

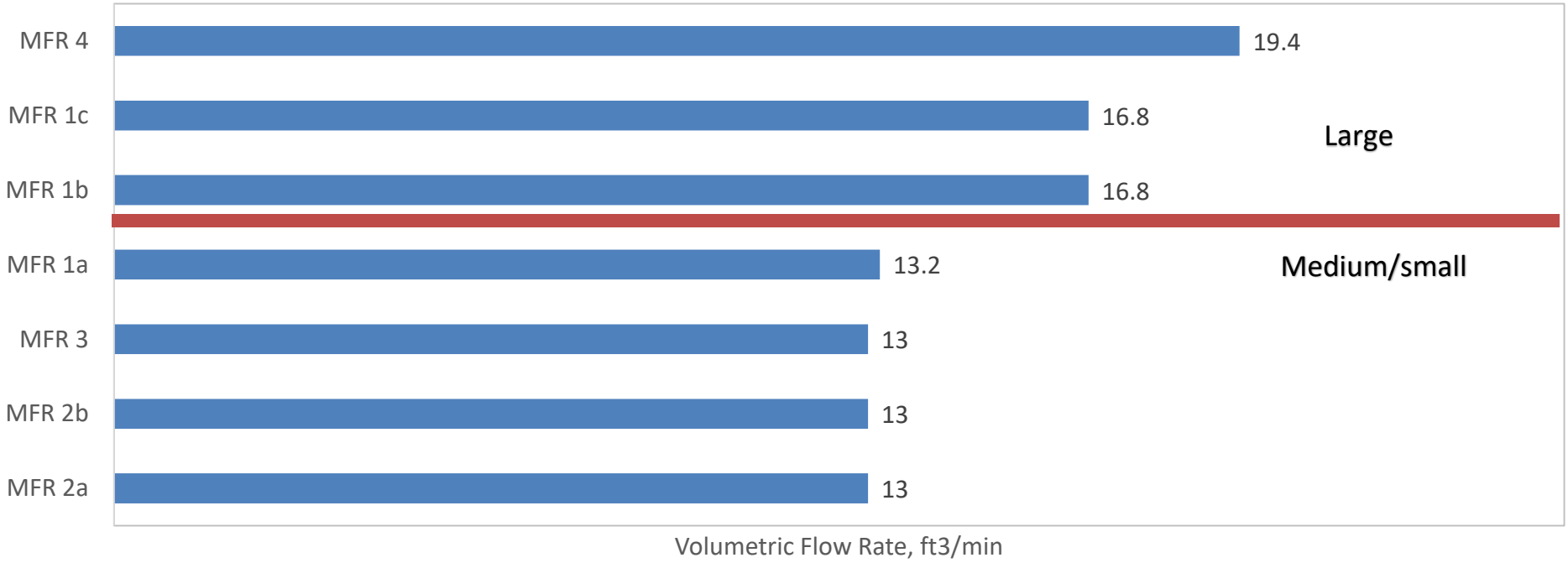
- Quantified important smoke generator parameters for cargo smoke detection – small and full scale tests
- Quantitative analysis of smoke generators used for certification – four airframe manufacturers
- Next steps - handbook
  - Quantify requirements in handbook for future smoke detection certification
  - Create list of smoke generators and prescribed settings that adhere to requirements

Smoke Production



The average steady-state light obscuration of the tested aerosols was 32%/ft with a standard deviation of the means of 17%/ft

Smoke Transport



The average volumetric flow rate was 15ft^3/min with a standard deviation of 2.6ft^3/min

§ 25.858 Cargo or baggage compartment smoke or fire detection systems

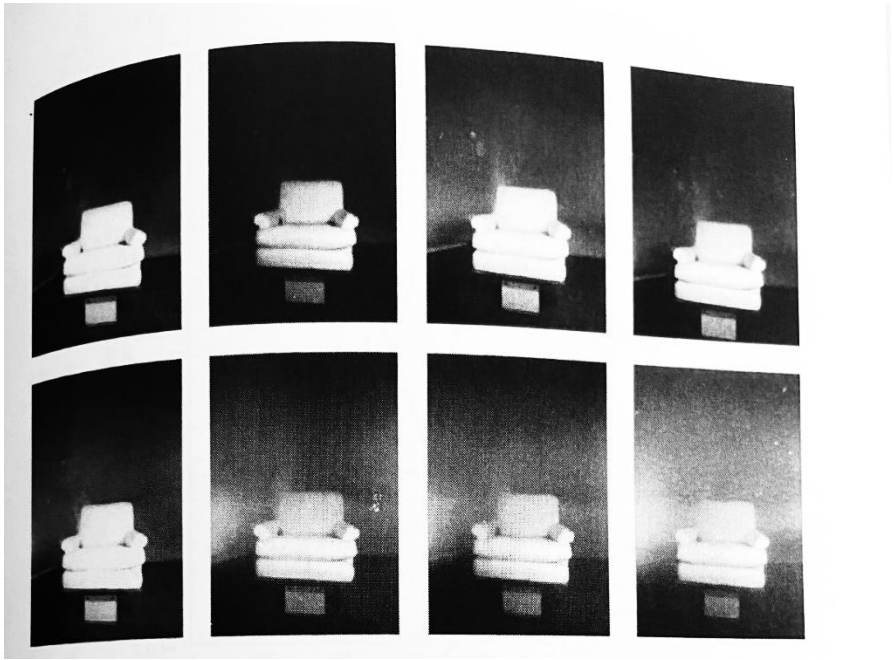
- If certification with cargo or baggage compartment smoke or fire detection provisions is requested, the following must be met for each cargo or baggage compartment with those provisions:
  - **(a)** The detection system must provide a visual indication to the flight crew within one minute after the start of a fire. **(diffusion flame, smoldering, or premixed flame?)**
  - **(b)** The system must be capable of detecting a fire at a temperature significantly below that at which the structural integrity of the airplane is substantially decreased. **(How much heat flux to decrease integrity? What does this look like in terms of smoke generators? Does it change with cargo compartment volume?)**

AC 25-9A 10 Smoke Detection Tests

- **a.** Background.
- **(1)** Smoke or fire detection system should provide a warning before the fire
  - **(i)** Develops into an uncontrollable or uncontainable condition, or
  - **(ii)** Damages liners, wiring, equipment, structure, essential equipment, or critical systems. **(How much heat flux to decrease integrity? What does this look like in terms of smoke generators? Does it change with cargo compartment volume?)**
- **(2)** A smoldering fire producing a small amount of smoke in conjunction with the applicable detection time has been selected as a fire or failure condition that could be detected early enough to ensure that the fire and smoke procedures would be effective. Subjective judgment, considering the failure, size of compartment, materials contained in the compartment, and the containment methods and procedures, is needed to assess the significance of a small amount of smoke.

Smoldering Fire in Closed Space

- **Smoldering can initiate or can follow the death of a diffusion flame**
- **Diffusion flame examples are building fires, forest fires, or lit matches**



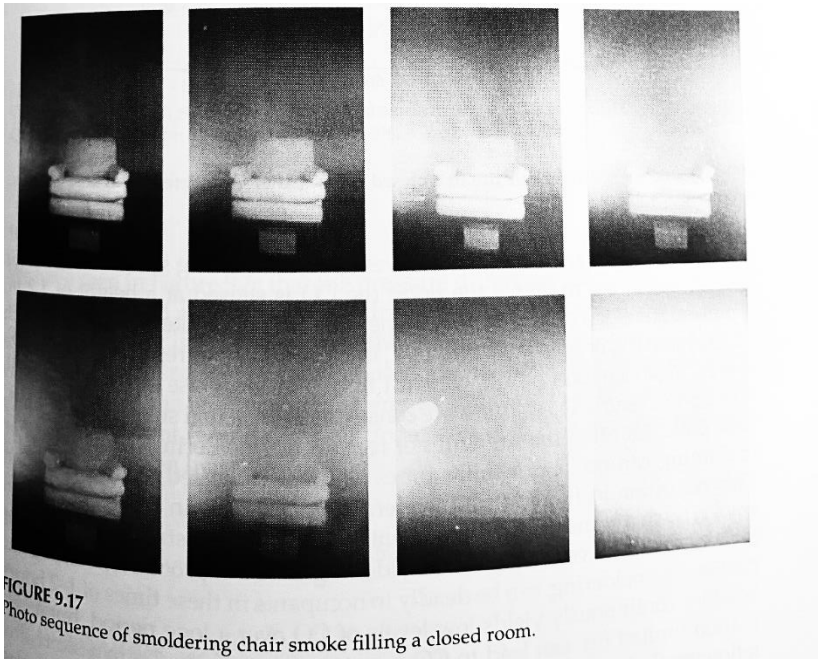


FIGURE 9.17
Photo sequence of smoldering chair smoke filling a closed room.

Class A non hazmat smoldering fire in 8.8 m x 2.4 m high room over 67 minutes

James Quintiere - Principles of Fire Behavior Second Edition

FAA Materials Handbook
Oil Burner Test for Cargo Liner

8.7 Calibration

8.7.4 Move the burner into test position and adjust the air intake to produce a heat flux of 7.5 BTU/(ft² second) (8.6 W/cm²) or greater.

8.10 Requirements

8.10.1 None of the three samples tested will burn through within the 5-minute flame exposure.

8.10.2 Each of the three samples tested will not exceed 400°F (204°C) at the backside temperature monitored during flame exposure

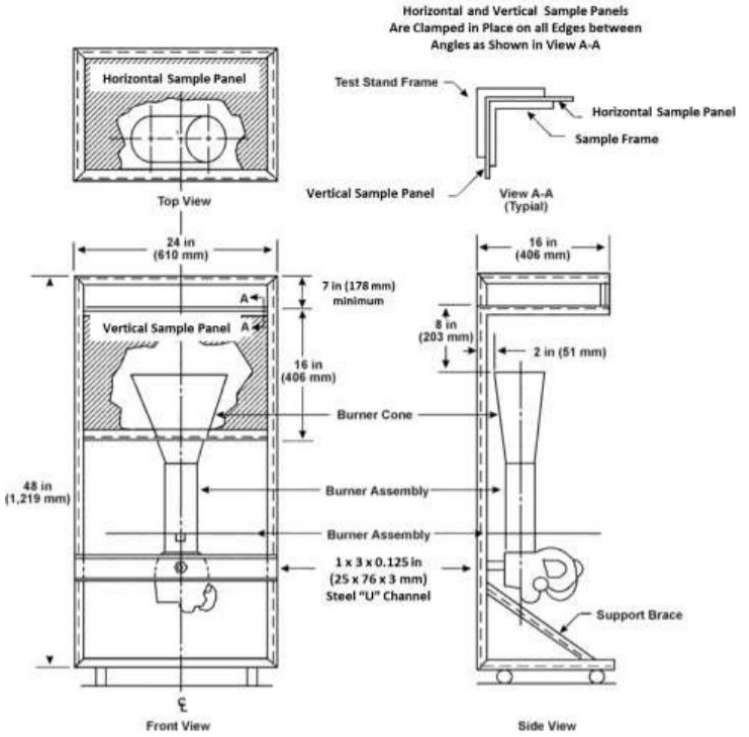
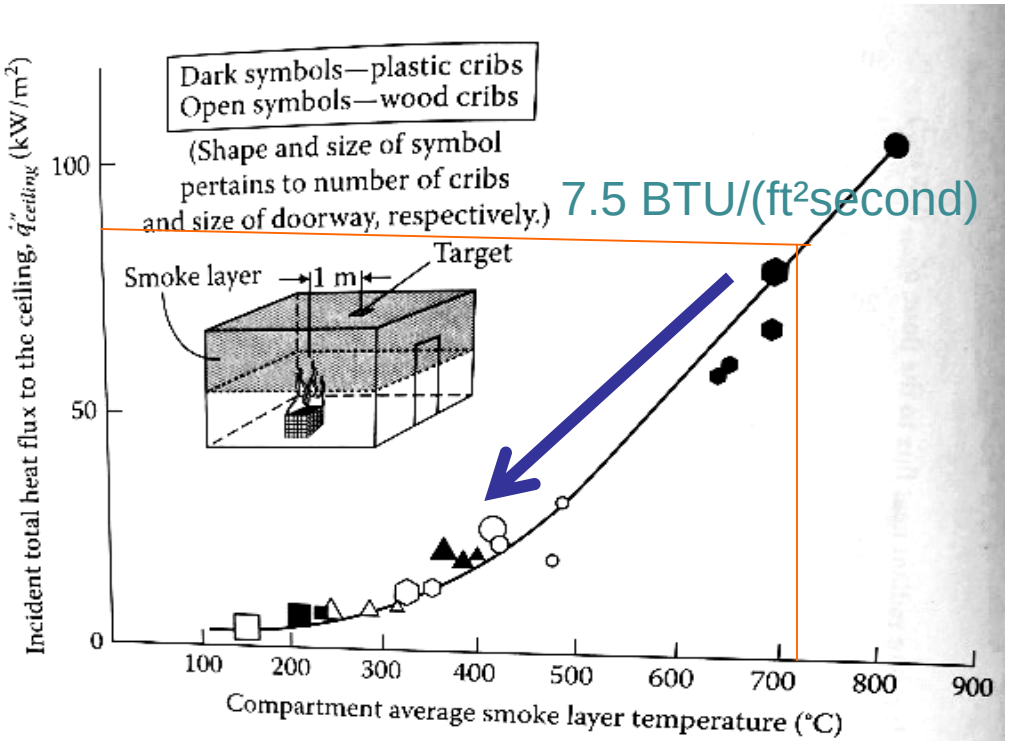


Figure 8-4. Test Apparatus for Horizontal and Vertical Mounting for Cargo Liner Oil Burner Testing

Ceiling Heat Flux and Temperature

- Smoke layer temperature is correlated to heat flux
- “temperature significantly below that at which the structural integrity of the airplane is substantially decreased” CFR 25.858



Ceiling heat flux versus compartment average smoke layer temperature

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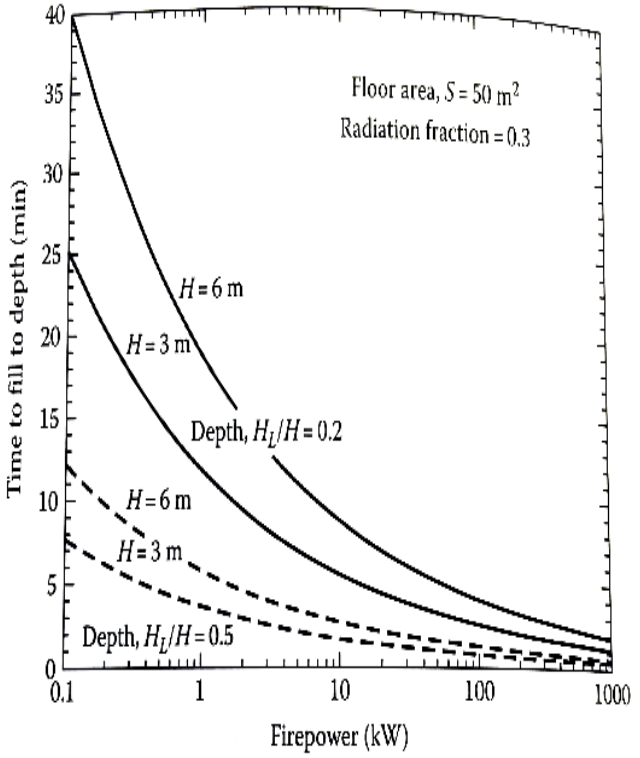
Smoke Fill by Volume

- Time for smoke layer to fill depends on the volume and ceiling height
- Smoke layer temperature is correlated to heat flux
- <u>Volume affects ceiling heat flux</u>



Time for smoke filling to various depth in a room heights 3 and 6 m with a floor area of 50 m²

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Conclusion

- Fires begin similarly in either a small or large cargo compartment
- CFR says one minute after the start of the fire and significantly before the structural integrity decreases
- The heat requirement should depend on the cargo compartment's resistance to a fire
  - In other words, the aerosol transport (volumetric flow rate) should depend on the cargo compartment volume

Next Steps

- Quantify requirements in handbook for future smoke detection certification
  - Aerosol transport, volumetric flow rate
    - Two requirements depending on cargo volume
  - Total aerosol production, steady state light obscuration
    - Single requirement regardless of cargo volume
- Create list of smoke generators and prescribed settings that adhere to requirements

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