

Development of a Flame Propagation Test Method for Structural Composite Materials in Inaccessible Areas

The Sixth Triennial International Fire & Cabin Safety Research Conference

October 25-28, 2010 – Atlantic City, NJ, USA

Robert I. Ochs, FAA Fire Safety Team AJP-6322



Federal Aviation
Administration



Introduction

- **Carbon fiber composites are being used more frequently in aerospace applications**
 - Increased strength
 - Lower density
 - Better corrosion resistance
- **New designs of commercial transport airplanes include primary structure constructed from carbon fiber composites**
- **Current FAR's do not require flammability testing for fuselage skins or structures, as traditional designs are inherently non-flammable**
- **To continue with the FAA's efforts to enhance in-flight fire safety, materials in inaccessible areas of the cabin should meet a flammability test based on the "block of foam" fire source**



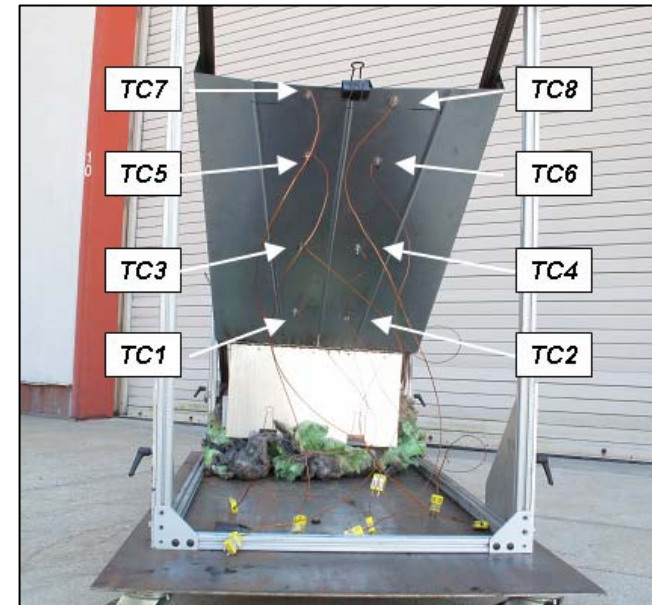
Objective

- **Develop a standardized laboratory-scale flammability test method to determine the flame propagation resistance of structural composite materials**
- **Test should correlate with an intermediate-scale test using the block of foam fire source**
 - Thermal/acoustic insulation
 - Ducting
 - Wire insulation



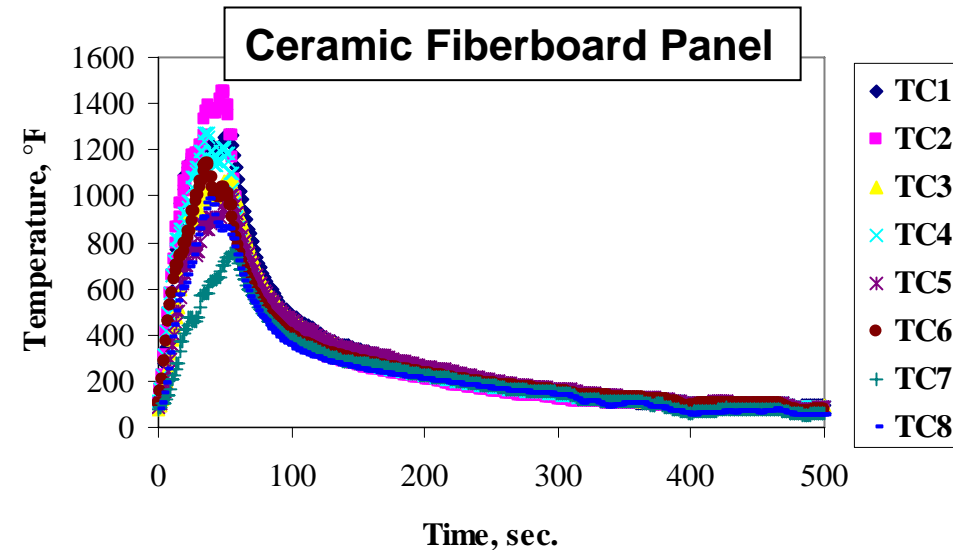
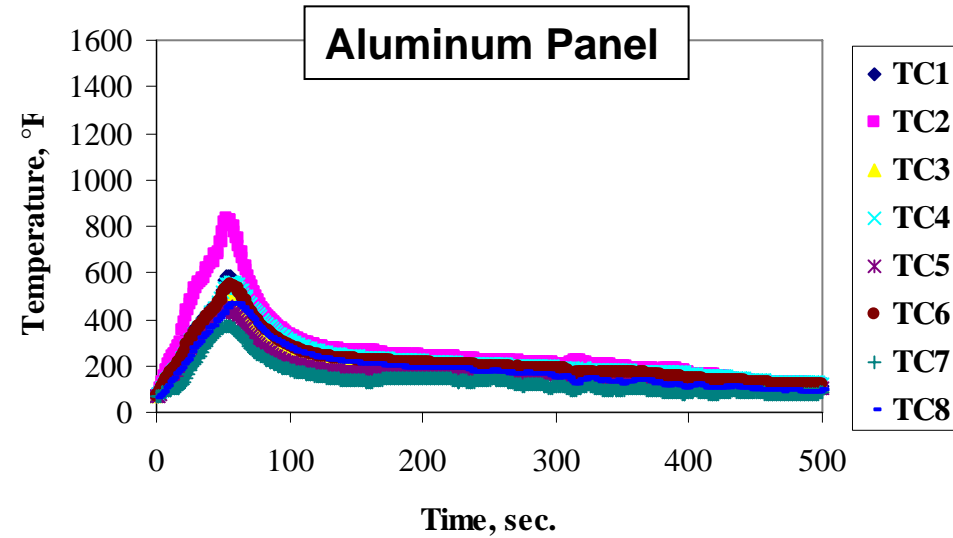
Intermediate Scale Test Rig

- A sample holder was constructed to simulate an inaccessible area in an aircraft cabin
- Flat panels of composite material were tested due to the high cost of curved panels
 - Panel dimensions 18"x48"x1/8"
- The angle of incidence can be varied
 - 30° chosen for strong flame impingement and buoyancy assisted propagation
- 4" x 4" x 9" untreated urethane foam block fire source
 - 10 mL heptane soaked into bottom of foam block to promote uniform burning
- Thermocouples measure inboard panel temperature to assess flame propagation



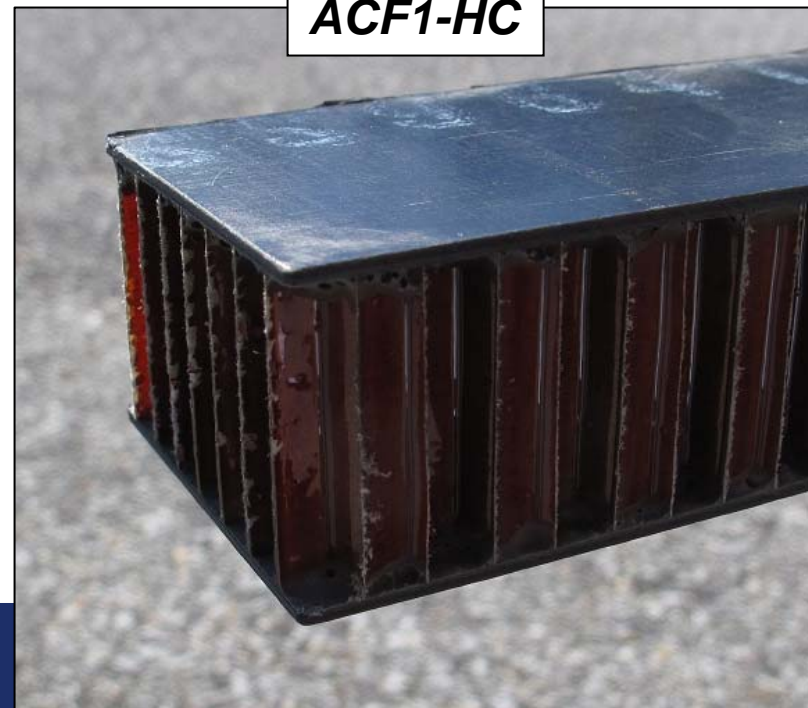
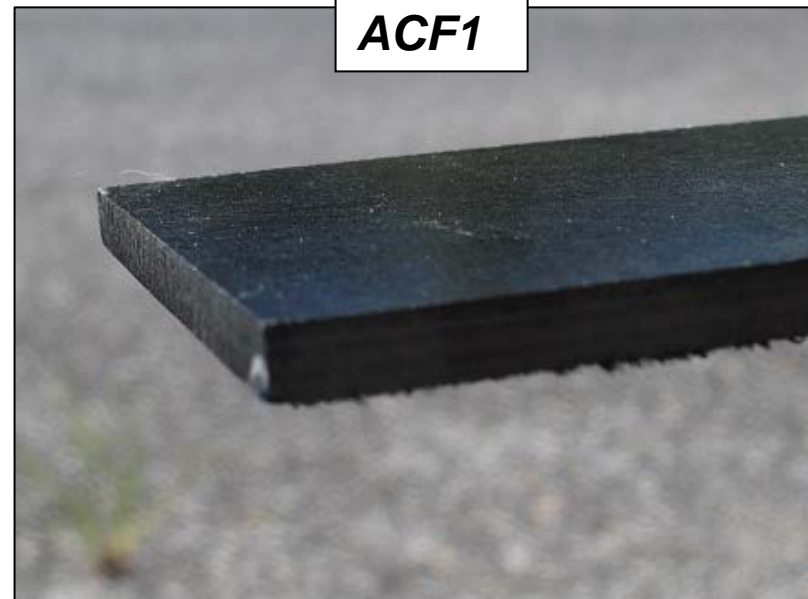
Baseline Test

- Baseline tests were run with panels of aluminum and ceramic fiberboard
- Temperature profiles were measured for duration of foam block burning
- Peak temperature is indicative of conductivity of panel
- Peak width indicates duration of burning event



Composite Materials

- **Non-aerospace composites**
 - GAR10: glass-cloth laminate with epoxy resin binder
 - GRP: glass-reinforced polyester sheet
 - FLXCF: flexible fine weave carbon fiber sheet
 - RGDCF: rigid woven carbon fiber sheet
- **Aerospace grade composites**
 - ACF1: carbon/epoxy panel 16 plies unidirectional tape, 320 g/m² aerial weight, prepregged with amine cured, toughened 356°F epoxy resin system
 - ACF2: carbon/epoxy panel unidirectional carbon tape, 1.79 g/cm³ density, prepregged with a toughened, 365°F cure epoxy system
 - ACF3: carbon/epoxy panel woven carbon fabric, 193 g/m² aerial weight prepregged with 250°F cure epoxy system
 - ACF1-HC: 4 plies of ACF1 prepreg bonded with film adhesive to both sides of a 1" thick, .25" cell size honeycomb core, total sample thickness 1 1/16"



Intermediate Scale Tests

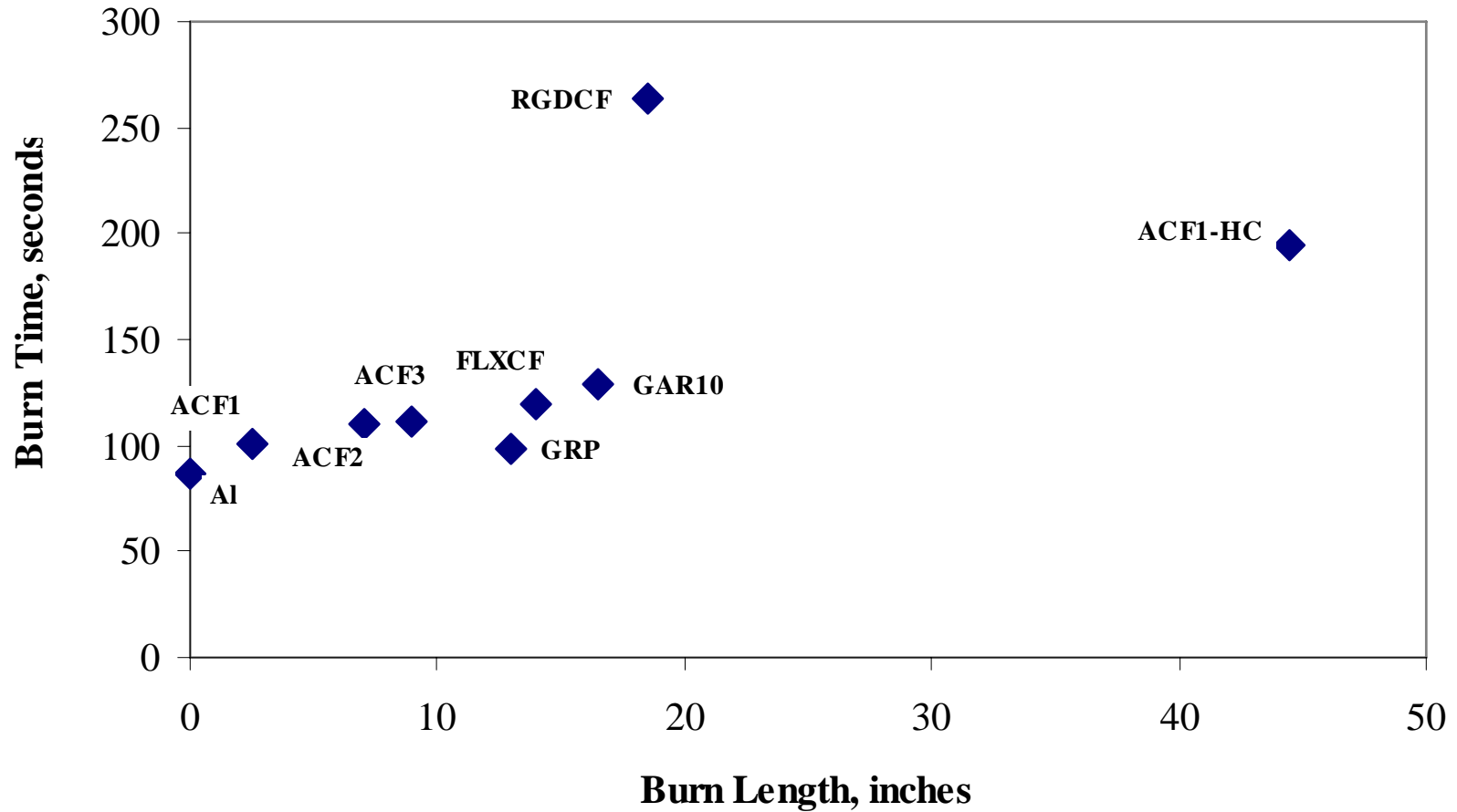
ACF1



ACF1-HC



Intermediate Scale Test Results

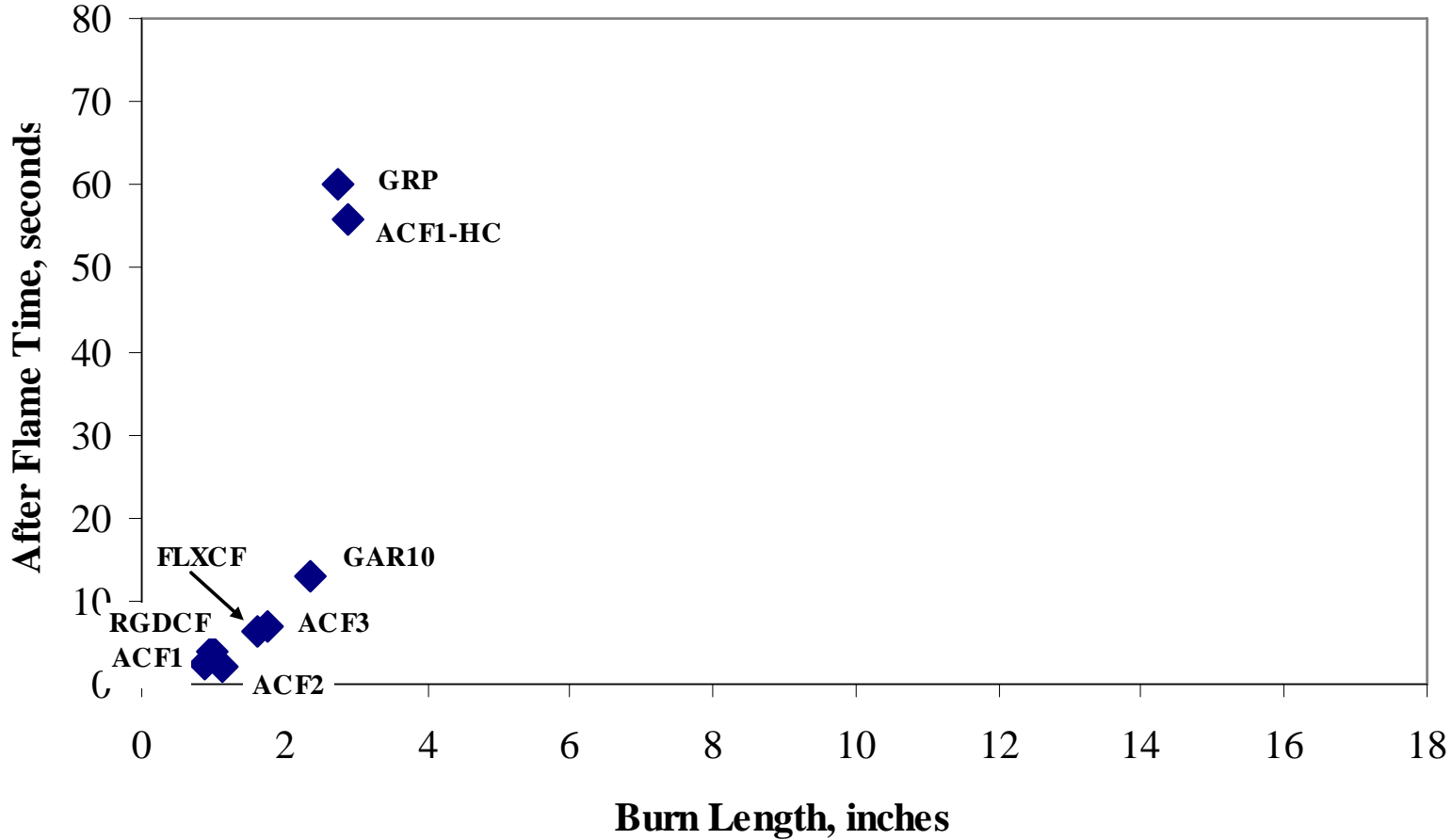


Radiant Panel Test Series #1

- R&D Panel at FAATC Bldg 217
- Radiant heat panel set to 1.5 BTU/ft²s at “zero position”
- Sample holder frame used to align samples with plane of “zero position”
 - Sample size 11”W x 24”L
- Test parameters
 - 1 min pre-heat of sample
 - 15 sec. flame impingement

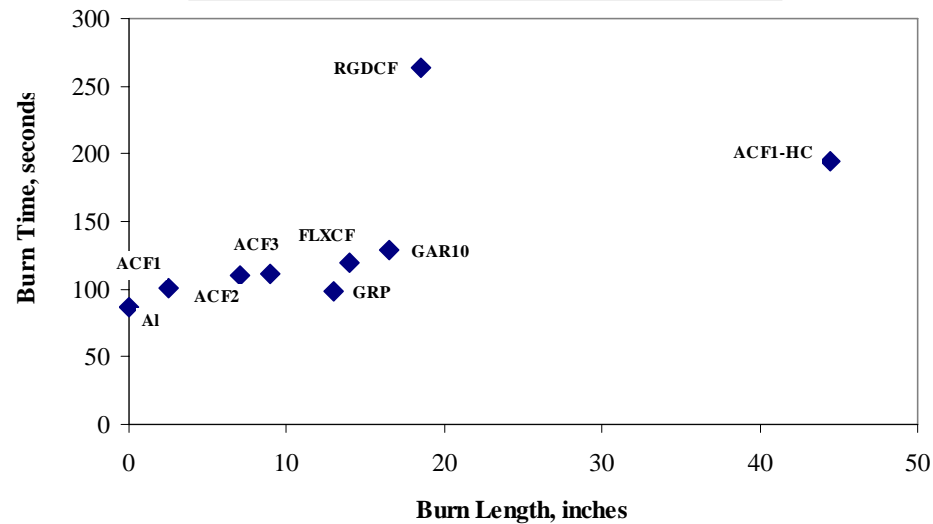


Radiant Panel Test Series #1 Results

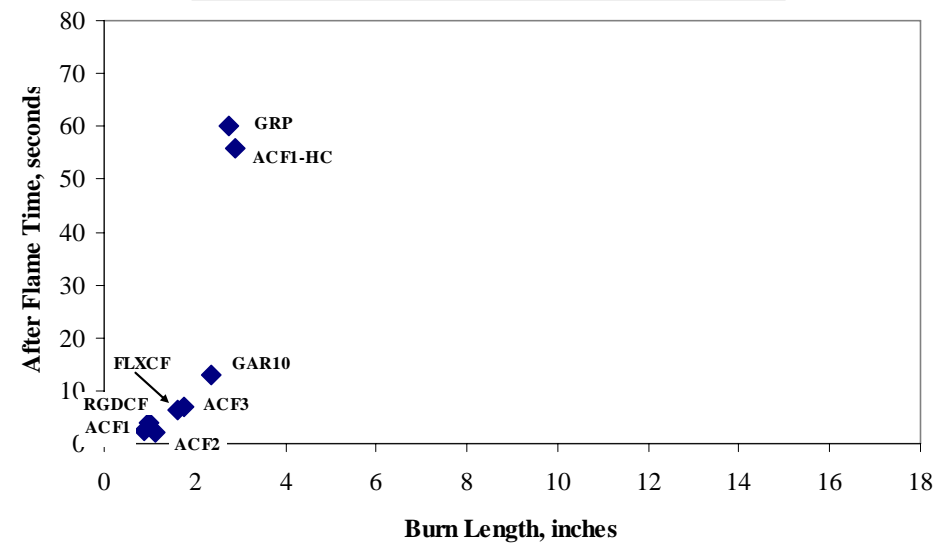


Radiant Panel Test Series #1 Results

Intermediate Scale Results



Radiant Panel #1 Results



Radiant Panel Test Series #2

- R&D Panel at FAATC Bldg 217
- Radiant heat panel set to 1.5 BTU/ft²s at “zero position”
- Sample holder frame used to align samples parallel to radiant panel
 - 6 ¼” distance from panel
 - Sample intersects with “zero plane” at “zero position”
 - Sample size 11”W x 24”L
- Test parameters
 - 1 min pre-heat of sample
 - 15 sec. flame impingement



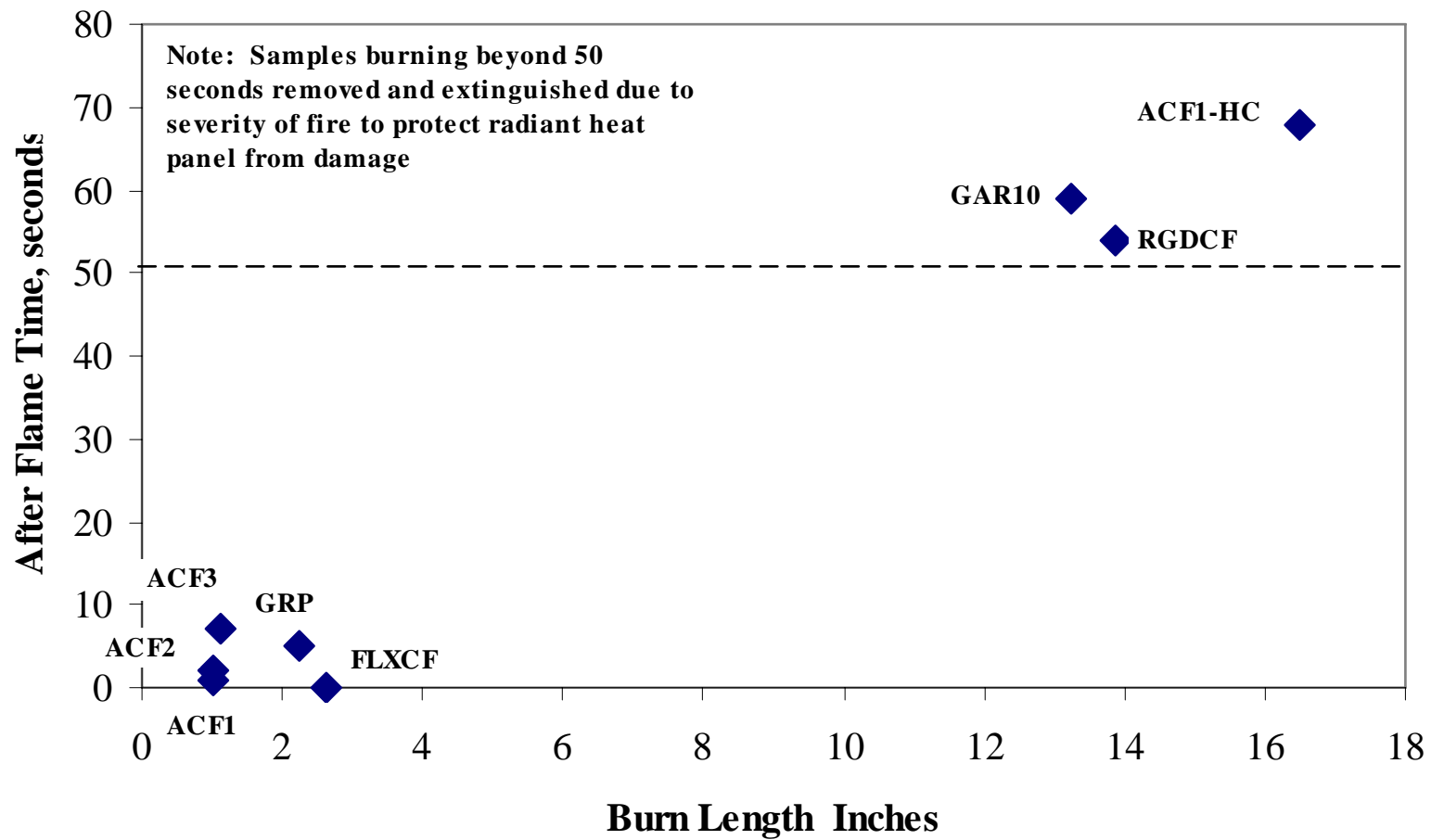
Configurations 1 vs 2, RGDCF

RGDCF Radiant Panel #1

RGDCF Radiant Panel #2

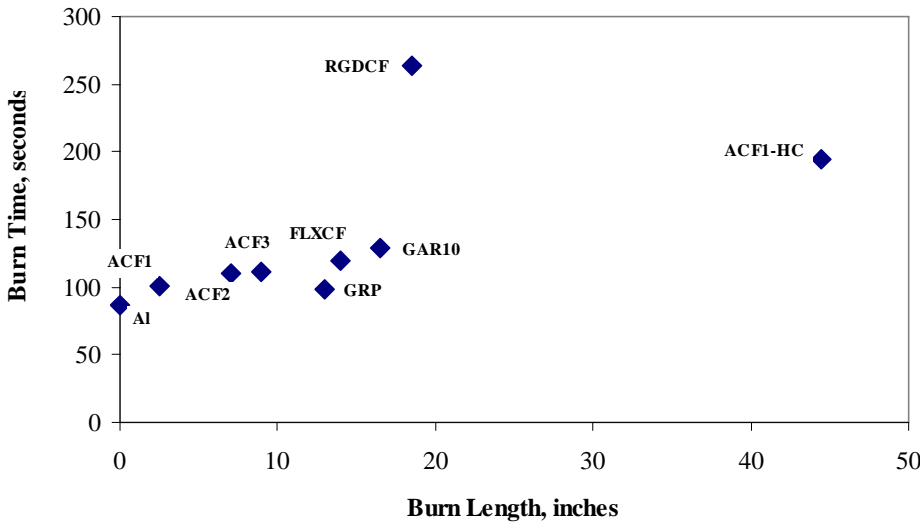


Radiant Panel Test Series #2

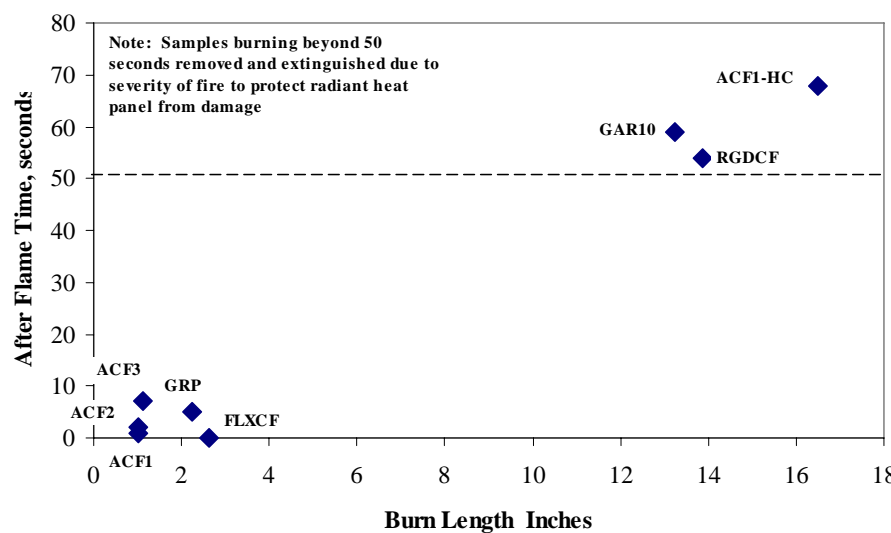


Radiant Panel Test Series #2 Results

Intermediate Scale Results



Radiant Panel #2 Results



Summary

- **An intermediate-scale test rig was developed and was successful in simulating the effects of a moderately severe hidden fire on the inboard side of a composite fuselage.**
- **A variety of composite materials, including aerospace grade and non-aerospace grade samples, were tested on the intermediate scale test rig and ranked according to their ability to propagate flames from the foam block hidden fire source.**
- **As expected, the solid laminate aerospace composite materials outperformed the non-aerospace composites. The aerospace composite sandwich panel, however, was the worst performer, due to the thin structural layers backed by an insulating honeycomb core.**

Summary (cont.)

- **The test results emphasized the importance of qualifying the material and the sample configuration.**
- **The radiant panel apparatus, when calibrated to 1.5 BTU/ft²s with a one minute pre-heat, 15 second flame impingement, and sample orientation parallel to and six and one quarter inches from the radiant heat panel, was successful in replicating the fire worthiness ranking from the intermediate scale test.**
- **An appropriate pass-fail criteria would be a burn length not to exceed two inches and an after flame not to exceed ten seconds.**

Questions?

Contact:

Robert I. Ochs

DOT/FAA Technical Center

Building 287

Aircraft Components Fire Test Facility

Atlantic City Int'l Airport, NJ 08405

phone: (609) 485-4651

fax: (609) 646-5229

robert.ochs@faa.gov

<http://www.fire.tc.faa.gov>