

# Vertical Flame Propagation (VFP)

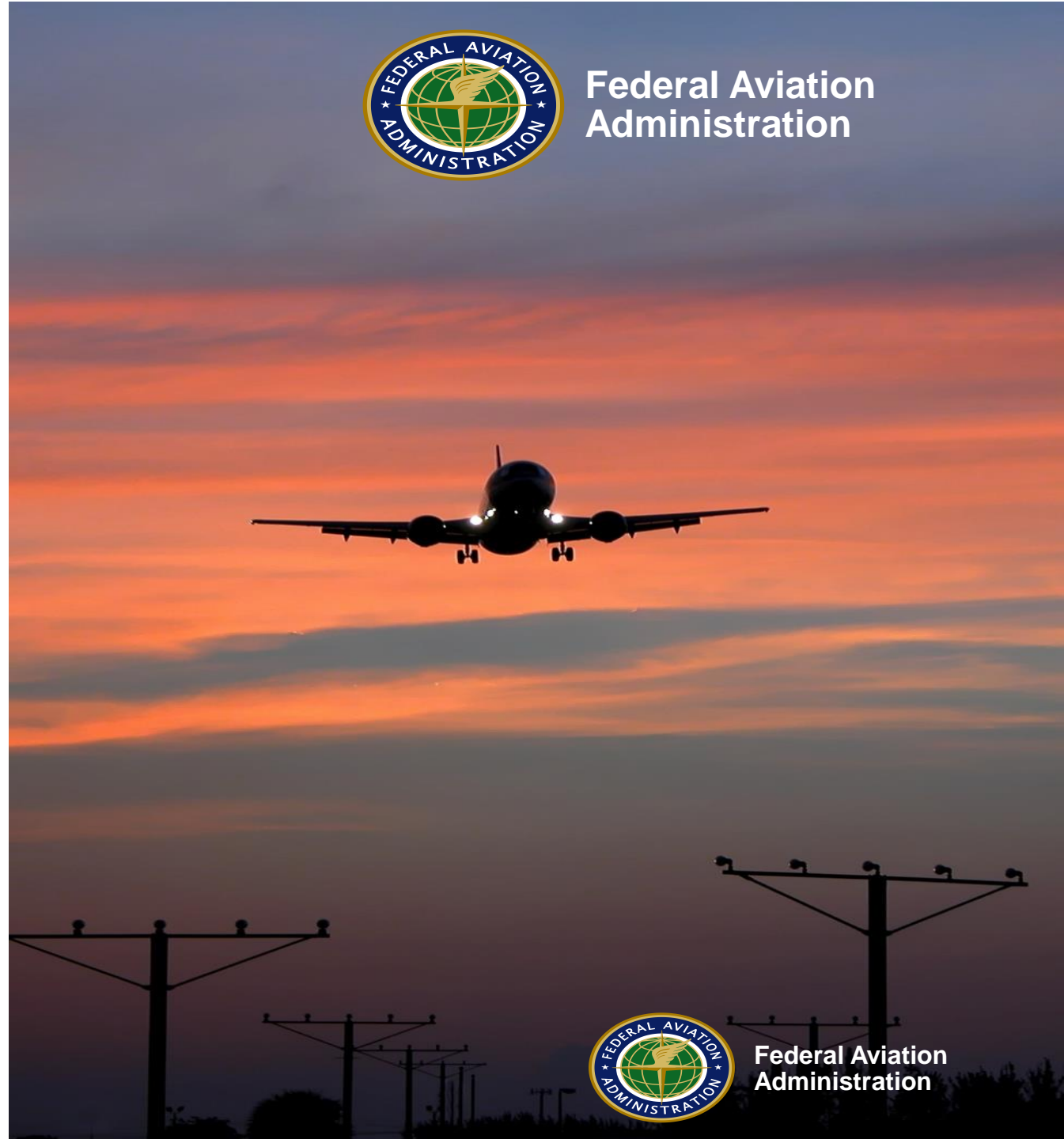
Presented to: IAMFTF, Cologne, Germany

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# Introduction

- The Vertical Flame Propagation (VFP) test is designed to test composite structure components and other non-metallic, extensively used parts in inaccessible areas. These include:
  - Composite Fuselage
  - Wiring
  - Ducting
  - Sleeving
- This test method was developed from values established with the intermediate scale foam block test.



# Background Composites

- Carbon fiber composites are being used more frequently in aerospace applications
  - Increased strength
  - Lower density
  - Better corrosion resistance
- Currently, we are gathering material for the Round Robin in order to test repeatability
- We need to determine a pass/fail criteria and find a material that will help determine this.



# Background Wiring

- 60-degree Bunsen Burner test does not represent a proper real-world representation
  - This test also does not accommodate bundles of wire

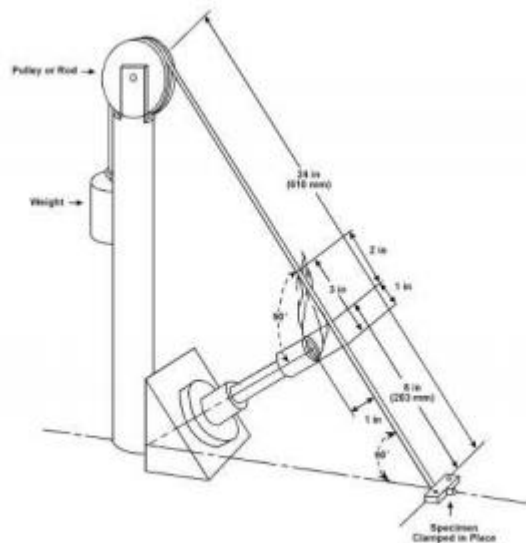


Figure 4-1. 60-Degree Electrical Wire Bunsen Burner Test Setup



# Background Wiring

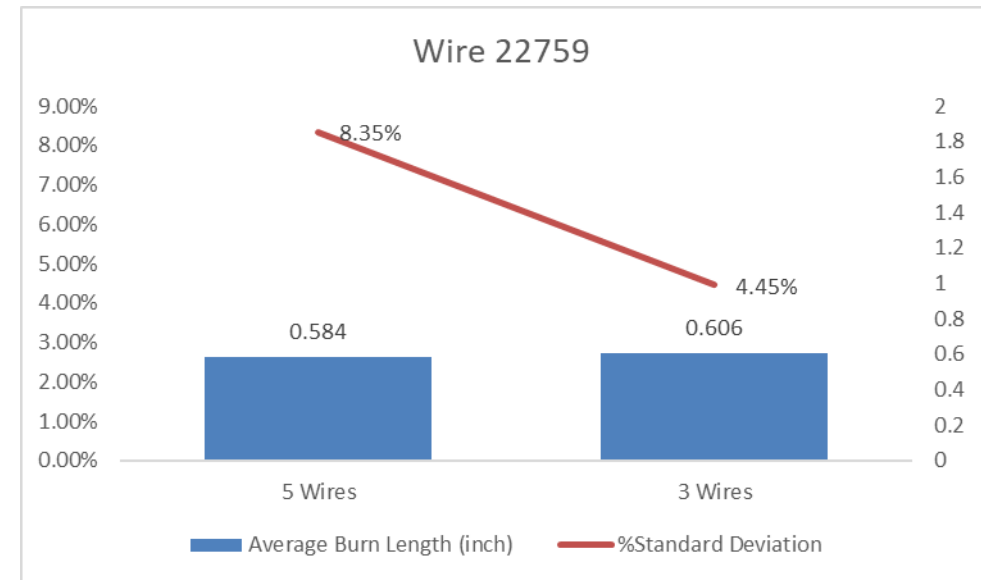
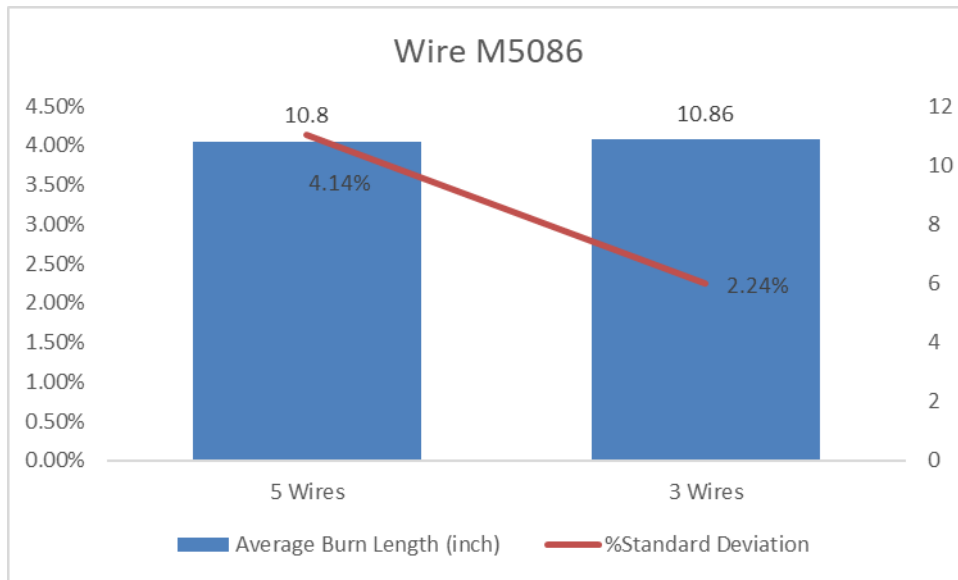
## Wire M81044

- Bunsen Burner Test burn length = 1.93 in.
- New VFP burn length = 9.75 in.
  - With an average after flame of 1min 54 sec



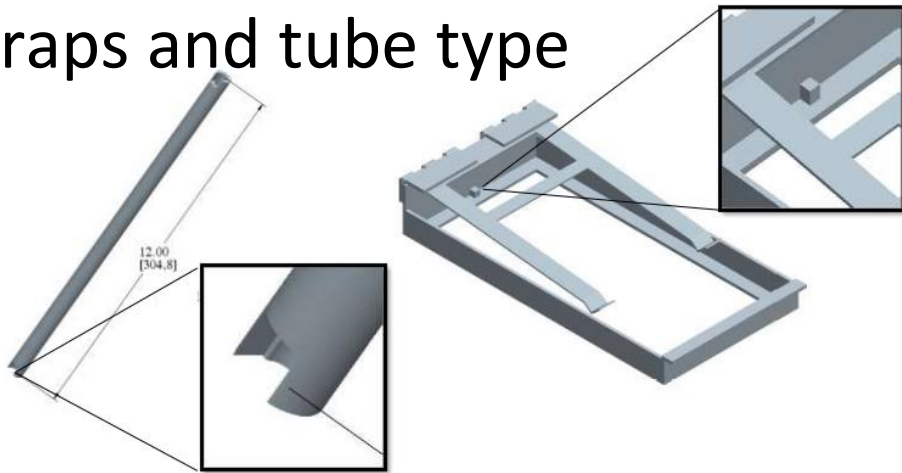
# Background Wiring

- Testing has been done to show that the VFP tests were more repeatable when testing with 3 wires than with 5.
- Two examples are shown below. Each test is an average of 5 runs.



# Background Sleeving

- No current test method
- Securing samples during testing
  - Alumina substrate
- Sample holder accommodates wraps and tube type

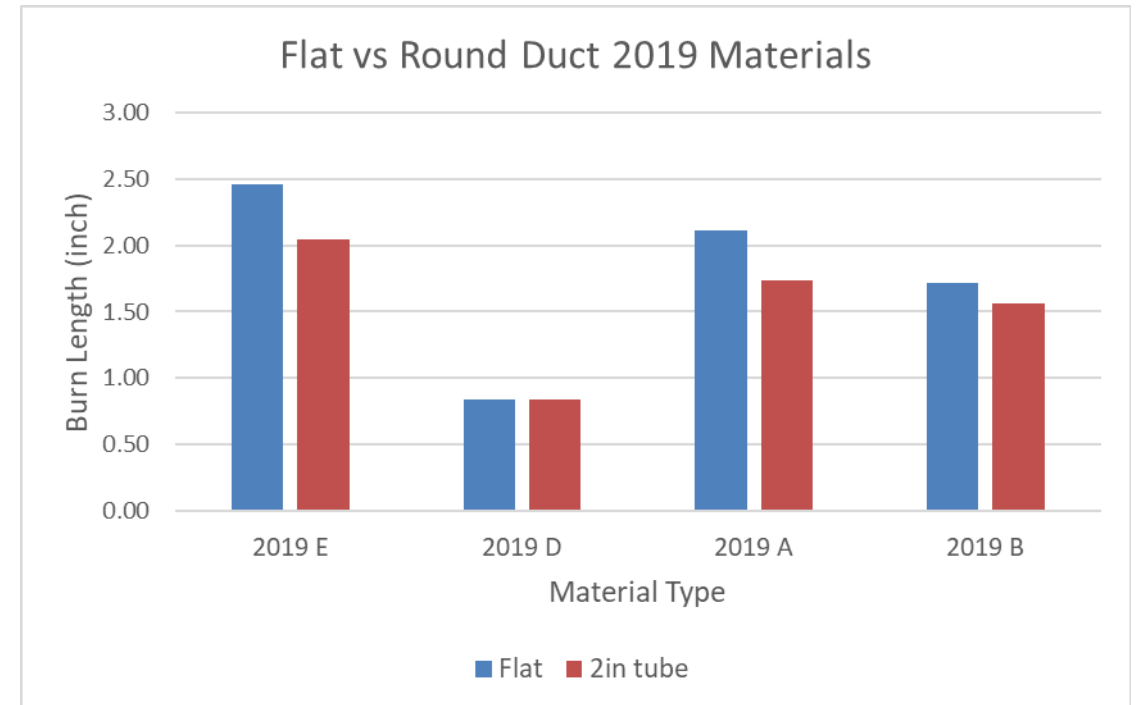
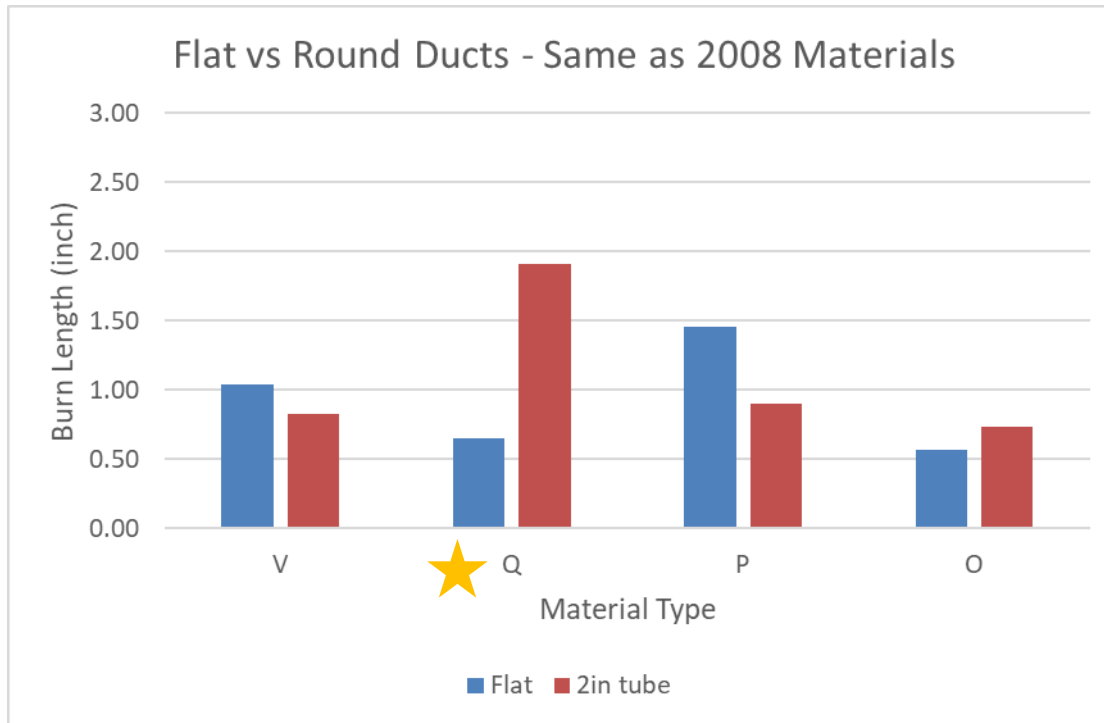


Alumina rod with key way notch and proposed sample holder with positioning tabs.



# Background Ducting

*Materials V, Q, P, and O correspond to John Reinhardt's "Development of an Improved Fire Test Method for Aircraft Ducting Materials", 2008. All tests were conducted using VFP 3 heater assembly.*



★ Material Q was not a round duct but a 2 inch square cross section



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# Varying Foam Duct Testing

- Various tests performed of a foam duct material
  - Flat:  $\frac{1}{2}$ " thickness
  - Flat:  $\frac{1}{4}$ " thickness (*still to come*)
  - Round: 1", 2", 3" Diameter ducts of  $\frac{1}{4}$ " thickness
  - Round: 4" Diameter of  $\frac{1}{4}$ " thickness
  - Round: 4" Diameter of  $\frac{1}{2}$ " thickness (*still to come*)
  - Half: 4" Diameter of  $\frac{1}{4}$ " thickness (*still to come*)
  - Half: 4" Diameter of  $\frac{1}{2}$ " thickness (*still to come*)



# Testing the Larger Round Ducts

- Notches were cut into samples in order to secure them into the sample holder



# Testing the Larger Round Ducts



# Comparison of Tubes of Different Diameters

- 30 samples of each diameter were tested: 1", 2", 3", 4"
- All these samples had a wall thickness of  $\frac{1}{4}$ ".
- The tubes are formed with an unsealed crease in the back. The 1" tubes were tested as-is and they spread open at the seams while burning.
- Because this didn't portray the tube shape as we wanted, we began taping the backs of the tubes to seal for diameters 2", 3" and 4"



# Comparison of Tubes of Different Diameters

- The 1" diameter tube post test, spread open at the seam. Un-taped back seal.
- 30 Tests were conducted
  
- Average 2.44 inch burn length
- 5.6% Standard Deviation



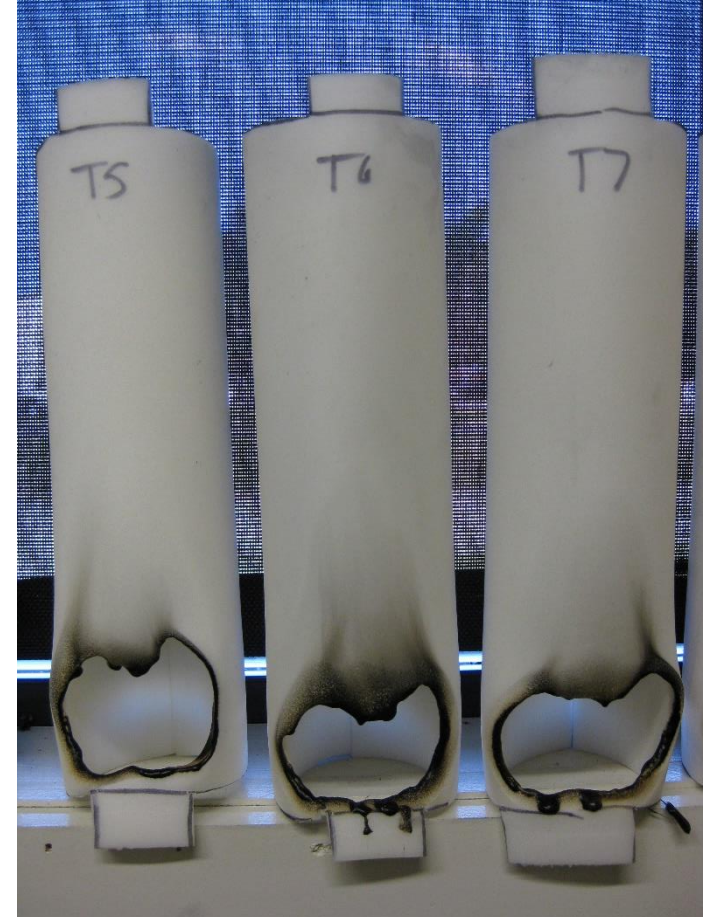
# Comparison of Tubes of Different Diameters

- The 2" diameter tube post test, with the back seal taped.
- 30 tests were conducted
- **Average 1.75 inch burn length**
- **20% Standard Deviation**
- The higher standard deviation might be due to the material sagging and drooping post test.
- The fire would either spread horizontally or vertically giving the highest burn length of 2.59 inches and a low of 1.34 inch.



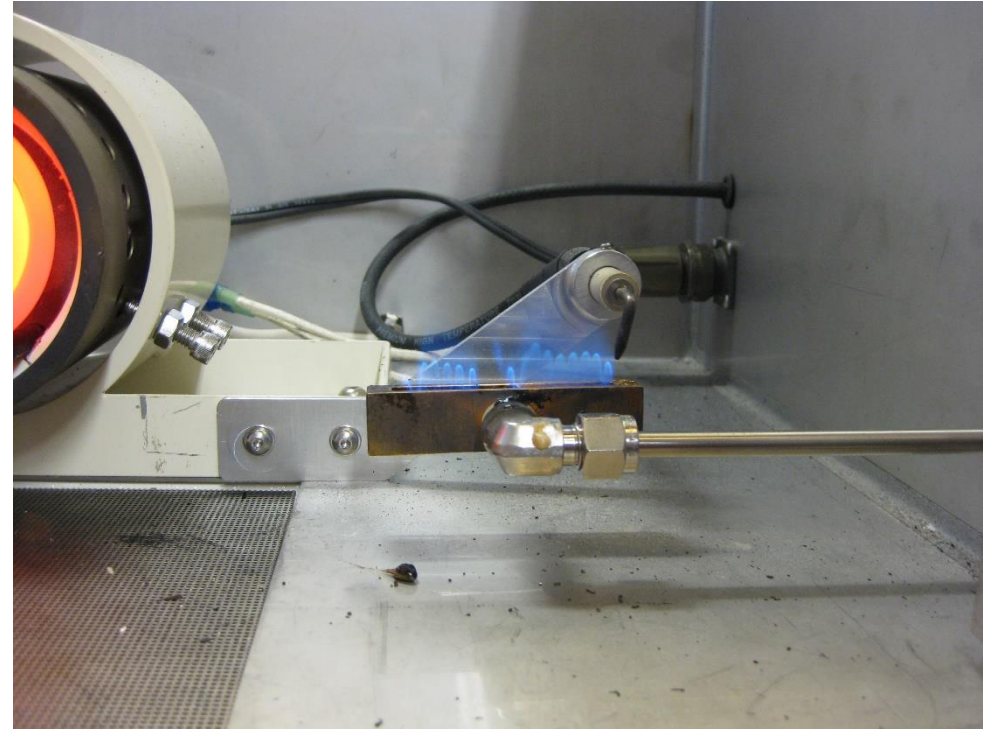
# Comparison of Tubes of Different Diameters

- The 3" diameter tube post test, with the back seal taped.
- 30 Tests were conducted
- Average 2.0 inch burn length
- 8.1% Standard Deviation



# Comparison of Tubes of Different Diameters

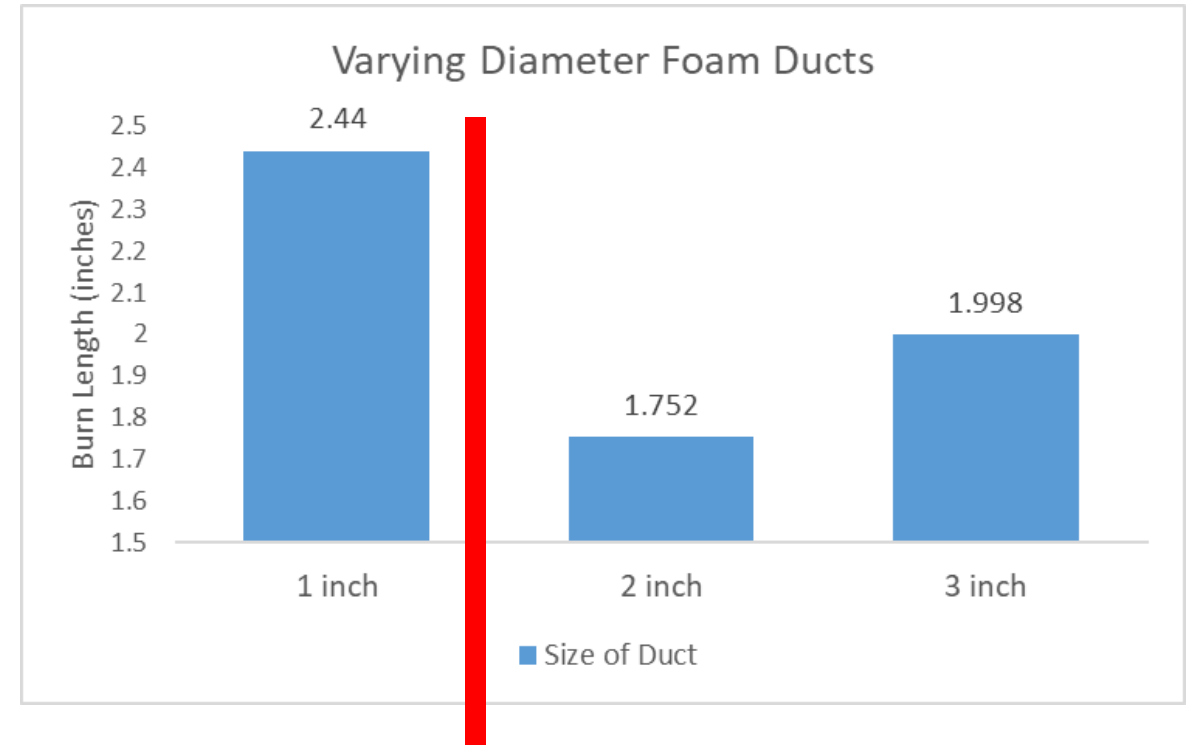
- Larger diameter tubes expanded and melted into the ribbon burner
- Testing with 4inch and larger diameter tubes of melting material is not recommended





# Comparison of Tubes of Different Diameters

- The 1inch diameter duct is not comparable to the other two because the backs were not taped closed
- The larger diameter 3inch duct had a slightly higher burn length than the 2inch diameter duct



# Continuing This Testing

- **Comparison of flat vs round foam ducts**
  - Can compare this after testing flat  $\frac{1}{4}$ " thick sheets
- **Comparison of full tubes vs half tubes**
  - This is only if we are able to test the 4-inch ducts again at a shorter ignition time to protect the ribbon burner
  - 4" Diameter full vs half,  $\frac{1}{2}$ " thick
  - 4" Diameter full vs half,  $\frac{1}{4}$ " thick
- **Comparison of tubes of different wall thicknesses**
  - 4" Diameter,  $\frac{1}{2}$ " vs  $\frac{1}{4}$ "
  - Again, only if we are able to test the 4-inch ducts again at a shorter ignition time to protect the ribbon burner



# Wire Testing

- Purchased wire M81044
  - In sizes: 4, 6, 10, 12, 14, 16, 20, 22
  - Burn Length of 14 gauge wire average = 9.875 inch
- Need to design a sample holder for varying size wires
- Plan to test the wires in order to understand the relationship of burn length vs gauge

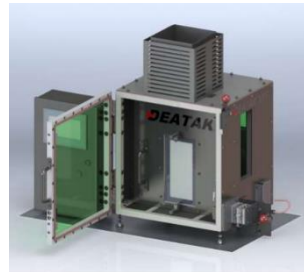


# Building a Heater with Industry

- Met with the VFP manufacturers to design a uniform radiant heater
- Incorporated a Heat Flux Gauge method to calibrate the radiant heater before testing
- FAA and Manufacturers agreed on specifications for this uniform heater



Concept Equipment Ltd.



Deatak



Marlin Engineering





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