

Vertical Flame Propagation Test Method Update

Presented to: International Aircraft Materials
and Systems Fire Test Forum

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Date: June 13, 2023



**Federal Aviation
Administration**

Vertical Flame Propagation (VFP)

Proposed new test method for non-metallic, extensively used materials located in inaccessible areas, i.e.:

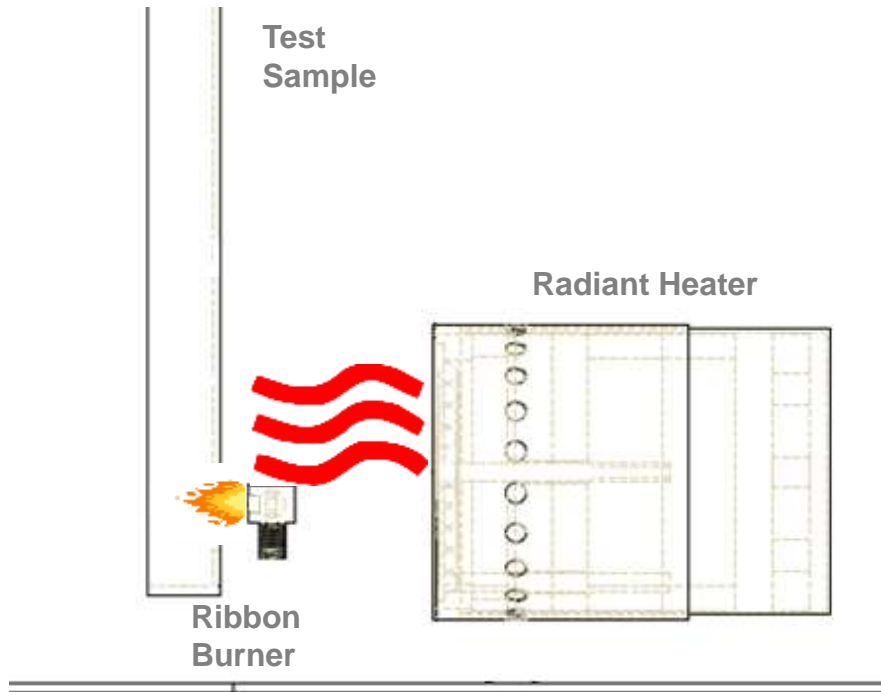
- Composite skin, structure, and sub-components

- Wires (insulations/jackets/sleeving)

- Duct materials



Basic Components of the Test



- An electric coil radiant heater is mounted vertically and opposite a 6-inch by 12-inch sample
- A methane/air ribbon burner impinges on the lower portion of the test sample, initiating material combustion while continuously exposed to the radiant heat from the heater
- The burner flame is translated away from the test sample after 30 seconds
- The test is allowed to continue until all material combustion has ceased
- The sample is then removed from the test frame and a post test burn length measurement is made

Topics Today

- **Review of the VFP Inter-Lab Study 1 & Results (Round Robin 1)**
- **Purpose of Inter-Lab Study 2 (Round Robin 2)**



Inter-Lab Study 1

- **Purpose: Do all of the machines produce the same burn lengths?**
 - Currently there are 3 VFP Manufacturers
 - Marlin Engineering
 - Deatak
 - Concept Equipment
- **Two analyses were completed through statistical software: SPSS**
 - The difference in burn length between 3 VFP machines made by 3 different manufacturers
 - The difference in burn length between different VFP machines all made by one manufacturer



Inter-Lab Study 1

The Round Robin will need to be split into two studies to be able to properly analyze without an abundance of variables.

- **Study to Compare Differently Manufactured VFP's**

- Tina will test and measure in each machine to remove the variable of different users testing with the machine. This will remove “perception of burn length” between users and method of testing.
- Independent Variable: Manufacturer A, Manufacturer B, Manufacturer C
- Dependent Variable: Burn Length

- **Study to Compare One Type of Manufactured VFP with Multiple Machines Used**

- One type of manufactured machine is analyzed for the four different locations
- Independent Variable: Lab 1, Lab 2, Lab 3, Lab 4
- Dependent Variable: Burn Length



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Study to Compare VFP Manufacturers

- 10 Samples per Machine
- 3 VFP Machines Total



Marlin Engineering



Concept Equipment



Deatak

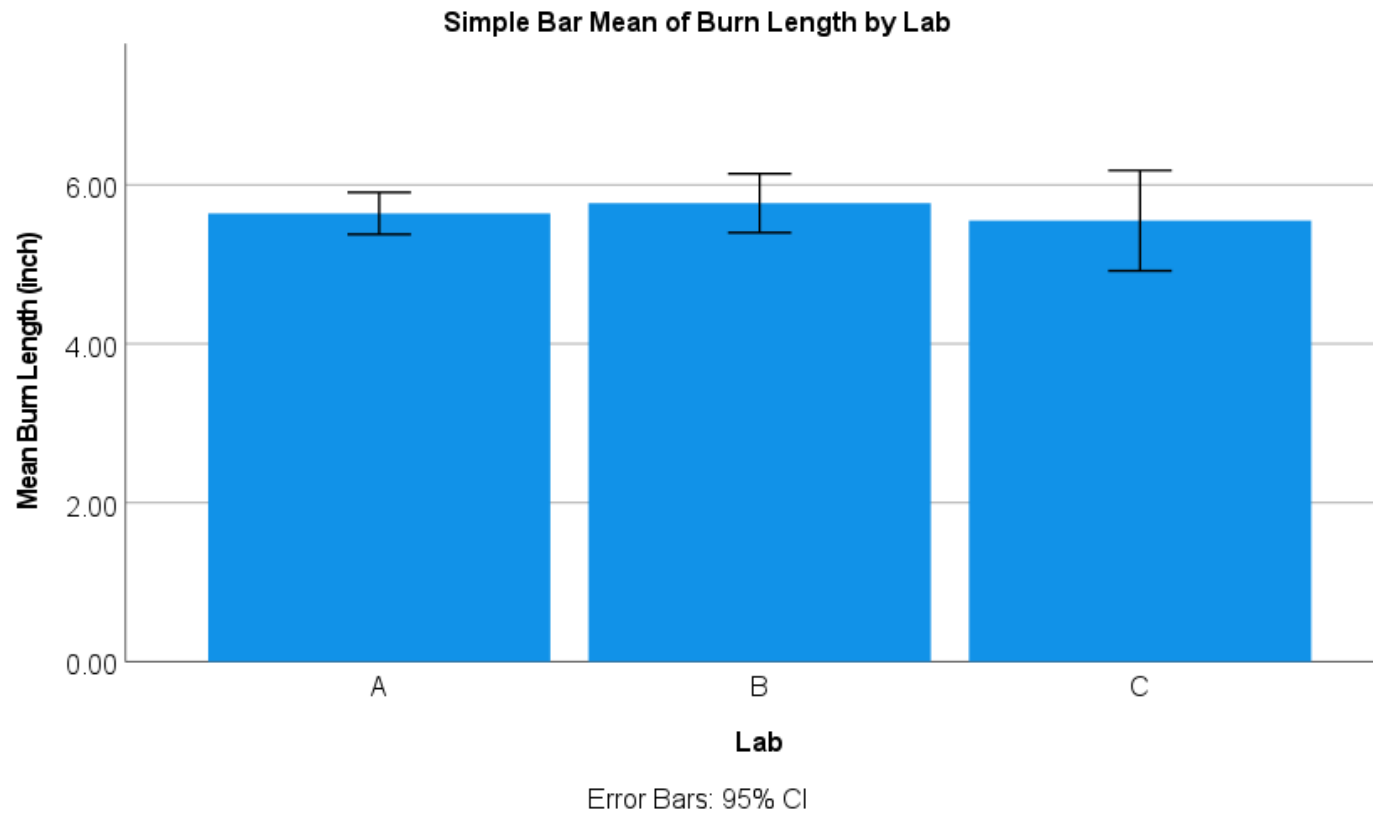


Study to Compare VFP Manufacturers

- **One-Way Between-Subjects ANOVA** was used to compare the burn lengths produced by each machine
 - **p-value** : the probability that there is no significant difference in burn length between the three labs
 - We used a 95% confidence interval
 - F value : the ratio of the between group variation and within group variation



Between Manufacturers A, B, and C



Study to Compare VFP Manufacturers

- **One-way, between-subjects ANOVA**
 - There are no statistically significant differences in burn length between the differently manufactured VFPs, $F(2,27) = 0.309$, $p = 0.737$.
 - Material 1/32 inch thick

Machine	Mean	SD	n
Manuf. A	5.64	0.369	10
Manuf. B	5.77	0.519	10
Manuf. C	5.55	0.883	10

There was one outlier, assessed by boxplot, and is included in the ANOVA. Data was normally distributed for each group assessed by Shapiro-Wilk test ($p > .05$)



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- Independent Variable: Manufacturer A, Manufacturer B, Manufacturer C
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- **Study to Compare One Type of Manufactured VFP with Multiple Machines Used**

- One type of manufactured machine is analyzed for the four different locations
- Independent Variable: Lab 1, Lab 2, Lab 3, Lab 4
- Dependent Variable: Burn Length



Study to Compare Multiple Machines Made by One Manufacturer

- **Material 1/32 inch thick**
 - Independent Variables: Lab 1, Lab 2, Lab 3, Lab 4
 - Dependent Variable: Burn Length
- **Material 1/16 inch thick**
 - Independent Variables: Lab 1, Lab 2, Lab 3, Lab 4
 - Dependent Variable: Burn Length



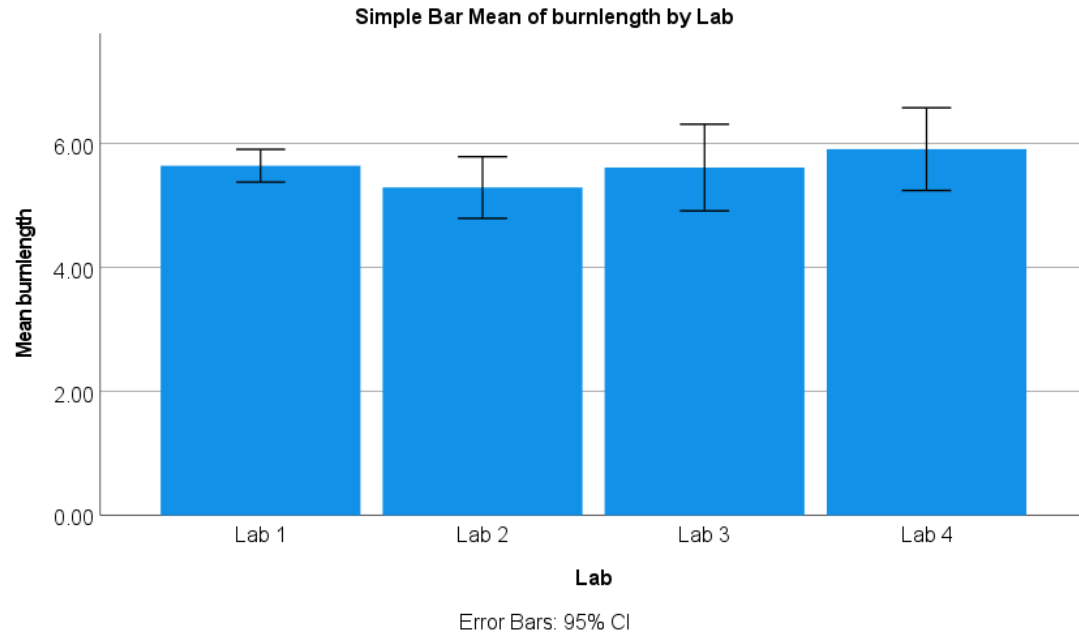
Study to Compare Multiple Machines Made by One Manufacturer

- **Welch's ANOVA was used to compare the burn lengths produced by each machine**
 - A standard ANOVA could not be completed because equal variances is not assumed through Levene's test. A modified ANOVA (Welch ANOVA) was used.
 - **p-value** : the probability that there is no significant difference in burn length between the three labs
 - We used a 95% confidence interval



Study to Compare Multiple Machines Made by One Manufacturer

Material 1/32 inch thick

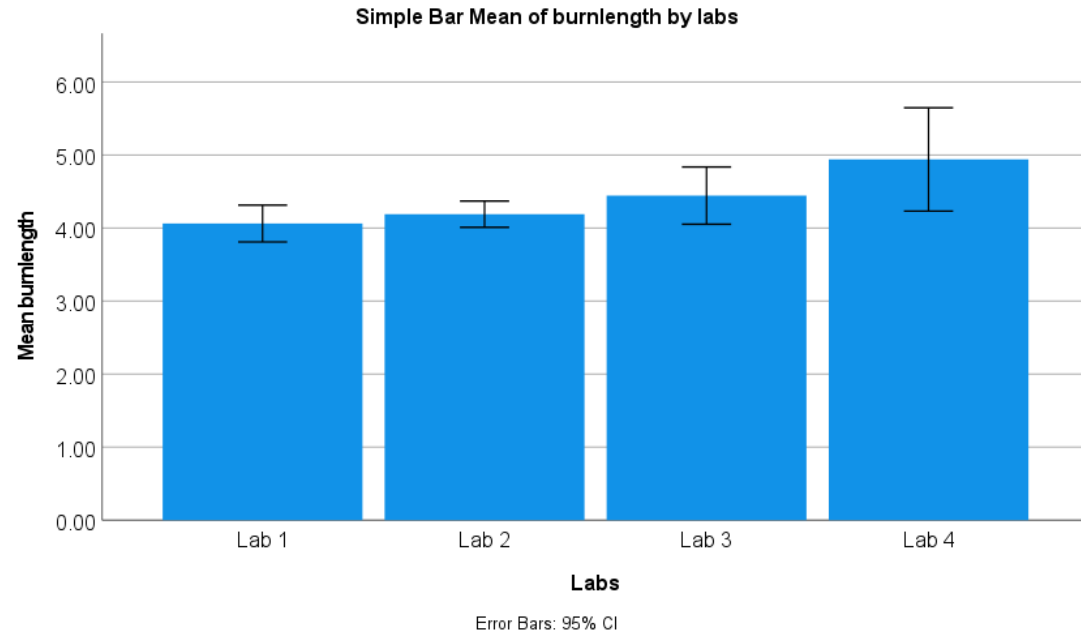


- The differences in mean burn length between the labs were not statistically significant, Welch's $F(3, 17.650) = 0.998$, $p = .417$.



Study to Compare Multiple Machines Made by One Manufacturer

Material 1/16 inch thick



- The differences in mean burn length between the labs were not statistically significant (?), Welch's $F(3, 18.669) = 2.838$, $p = .066$.



Inter-Lab Study 1 Summary

- **Comparing VFP manufacturers**
 - Material 1/32 inch thick
 - No statistically significant difference was found in burn length between the three manufactured machines ($F(2,27) = 0.309, p = 0.737$)
- **Comparing 4 labs with 1 manufactured VFP**
 - Material 1/32 inch thick
 - No statistically significant difference was found in burn length (Welch's $F(3, 17.650) = 0.998, p = .417$)
 - Material 1/16 inch thick
 - (?) Statistically significant difference was found in burn length (Welch's $F(3, 18.669) = 2.838, p = .066$)

Inter-Lab Study 2

- **VFP Burn Length Definition**
 - The burn length is the posttest measurement of the length of the burned surface of the test sample, parallel to the long edge (12-inch dimension). For the purposes of this test method, the burn length is considered to be the length where the outermost layer of the material has been burned away, breached, or opened, indicating that volatiles have escaped the material at that location and could have been ignited.



Burn Length Definitions in the Handbook

- **Adjusted Bunsen Burner**

- 1.2.4 Burn Length Burn length is the distance from the original specimen ~~edge to~~ **of** the farthest evidence of damage to the test specimen due to that area's combustion **burning both downward and upward** including areas of partial consumption, charring, or embrittlement but not including areas sooted, stained, warped, or discolored nor areas where material has shrunk or melted away from the heat.

- **VFP Composites**

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Inter-Lab Study 2

- **The purpose of the study is to test the definition of burn length upon perception**
- *1.2.4 Burn Length. Burn length is the distance of the farthest evidence of damage to the test specimen due to that area's combustion burning both downward and upward including areas of partial consumption, charring, or embrittlement but not including areas sooted, stained, warped, or discolored nor areas where material has shrunk or melted away from the heat*



Questions?

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