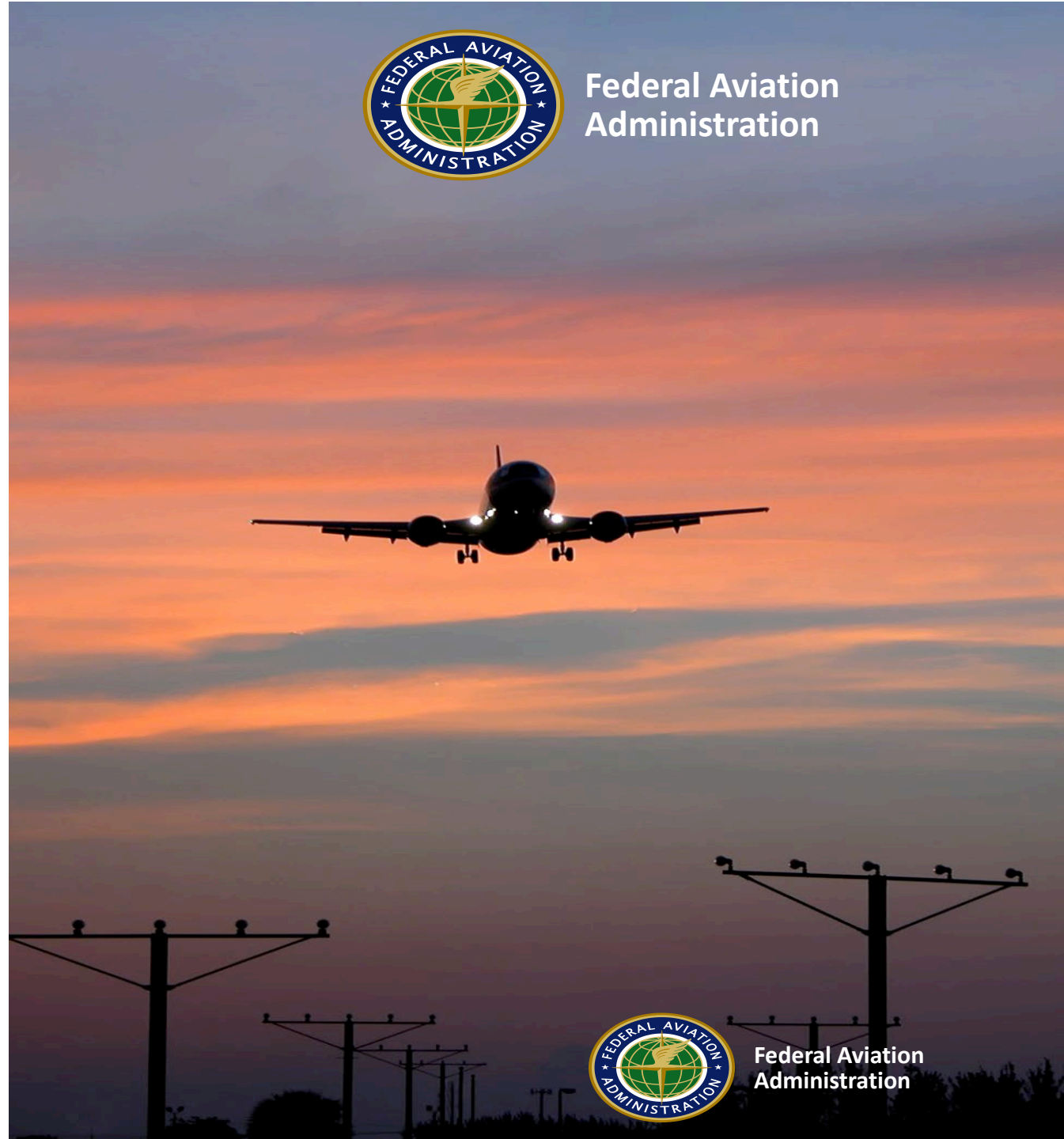


Vertical Flame Propagation Test

Presented to: The Tenth Triennial International Fire & Cabin
Safety Research Conference
By: Tina Emami
Date: October 20, 2022



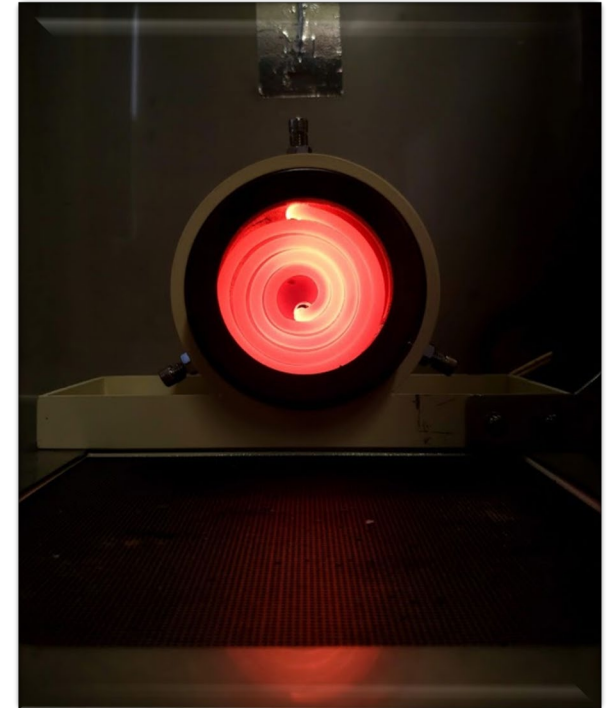
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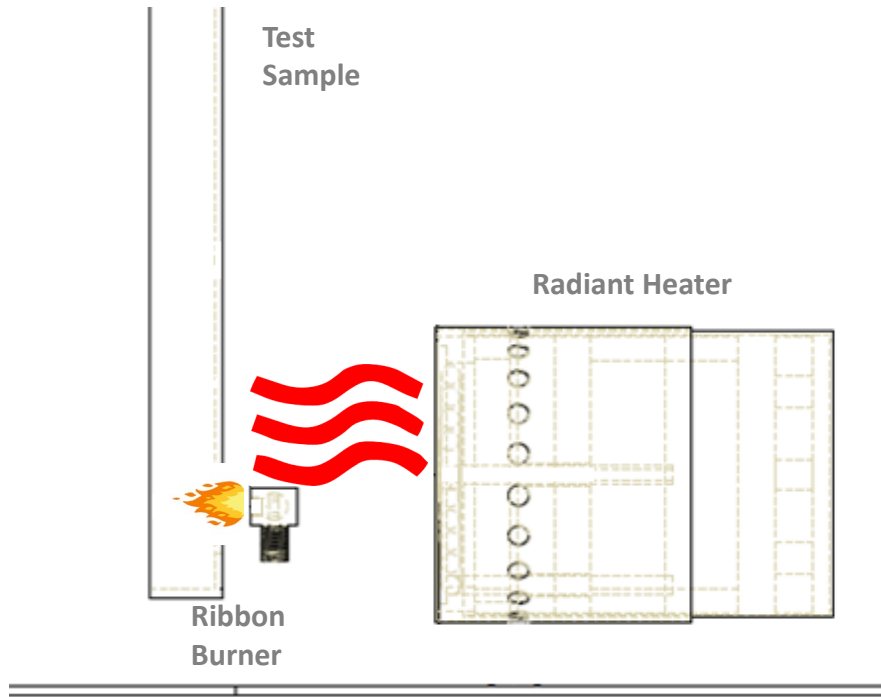
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Vertical Flame Propagation (VFP)

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



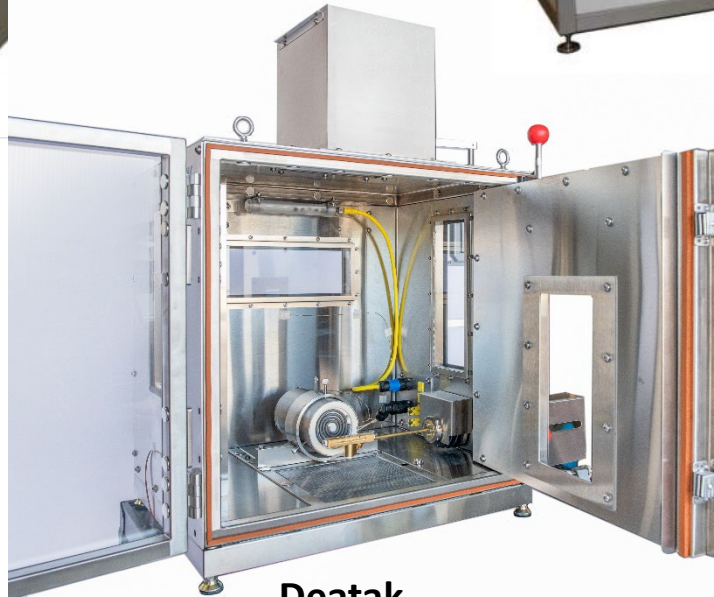
VFP Manufacturers



Marlin Engineering



Concept Equipment



Deatak



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Agenda

- Wire Sleeving
- Wire Testing
- Material Performance Testing



Wire Sleeving

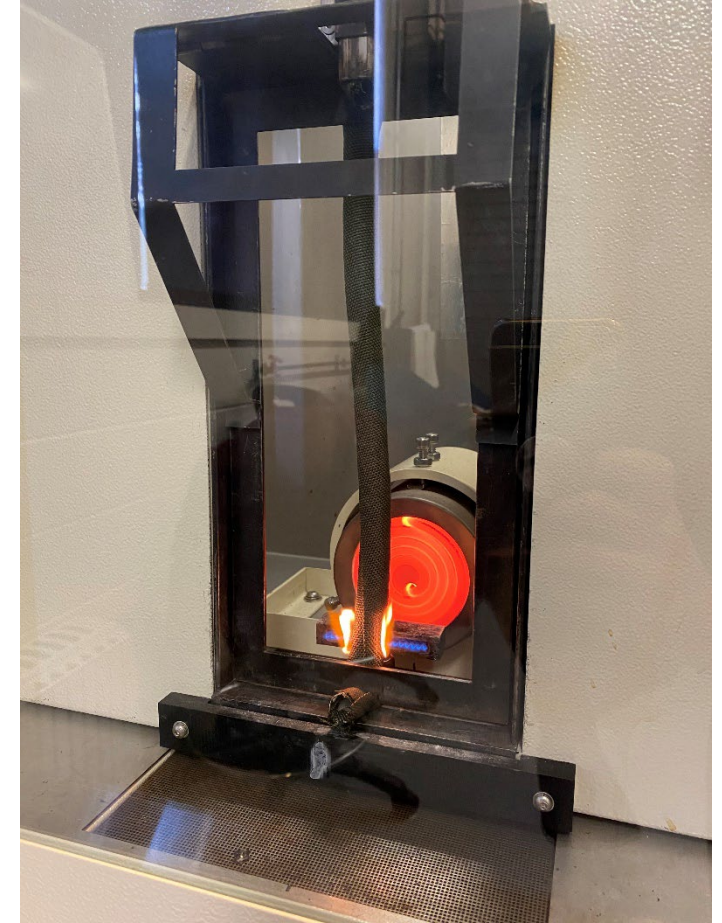
Around Non-Conductive Rod



Alone in Front of Marinite Board

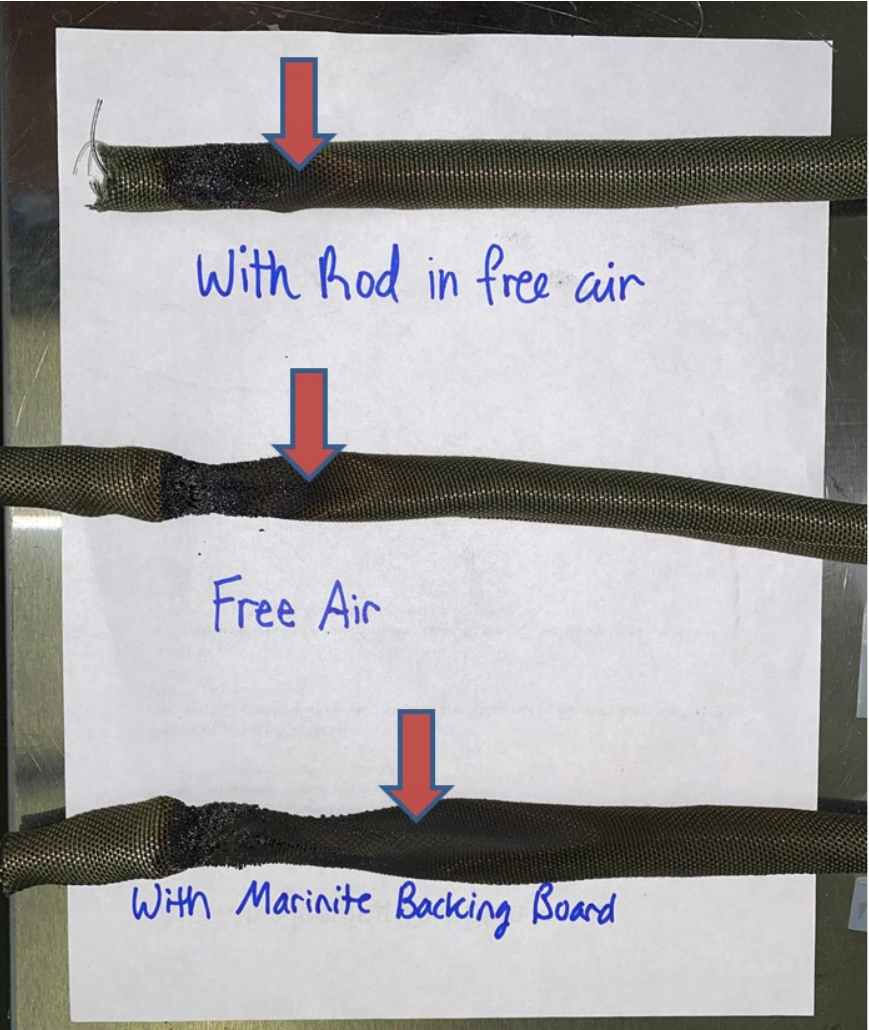


Alone in Sample Holder



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Wire Sleeving



| Method | Burn Length (inches) |
|-------------------------------------|----------------------|
| With Non-Conductive Rod in Free Air | 1.06 |
| In Free Air | 1.37 |
| With Marinite Board | 2.28 |



What does this mean?

- In order to quantify the different methods of testing sleeving material, a “realistic” scenario was mocked up inside of the VFP
- A bundle of wires was placed inside the sleeve material in question and placed in front of aircraft insulation



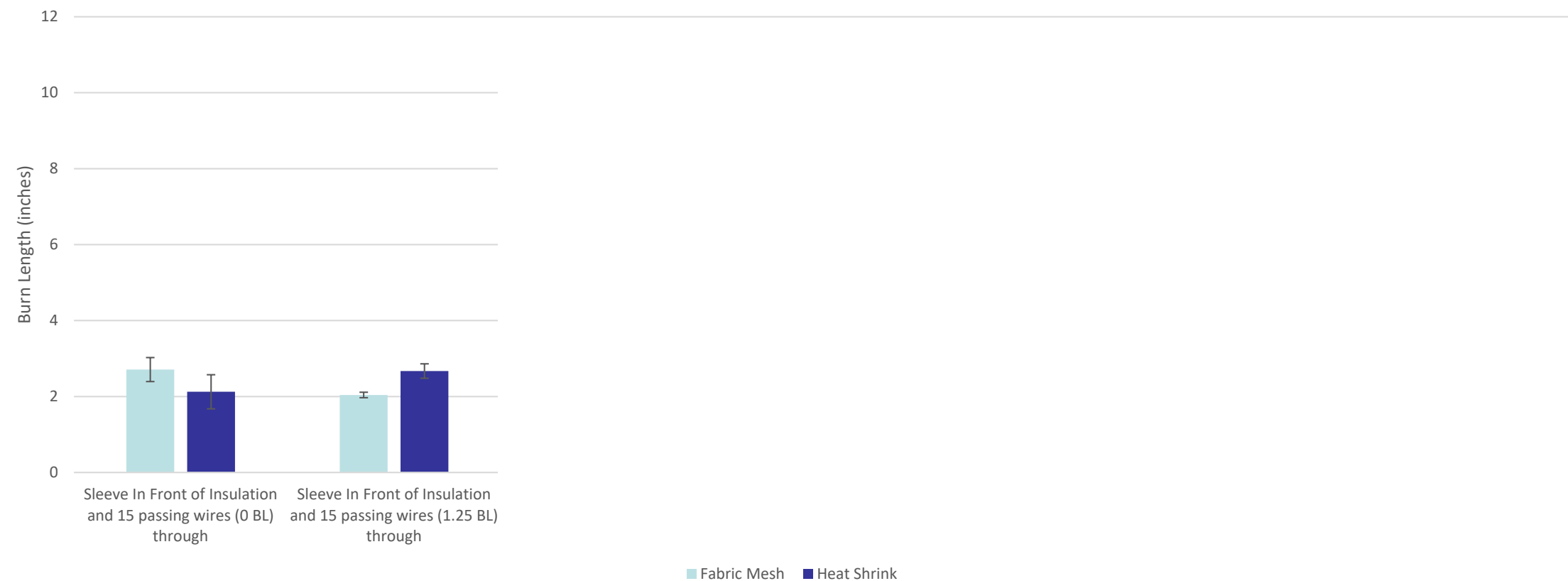
Sleeving Tests

- **The sleeving material was tested in 3 ways**
 - A bundle of 15 passing wires through the sleeve material in front of aircraft insulation
 - The sleeve by itself in front of aircraft insulation
 - The sleeve by itself in front of Marinite
- **Two sleeve material types were tested**
 - Woven fabric
 - Heat shrink

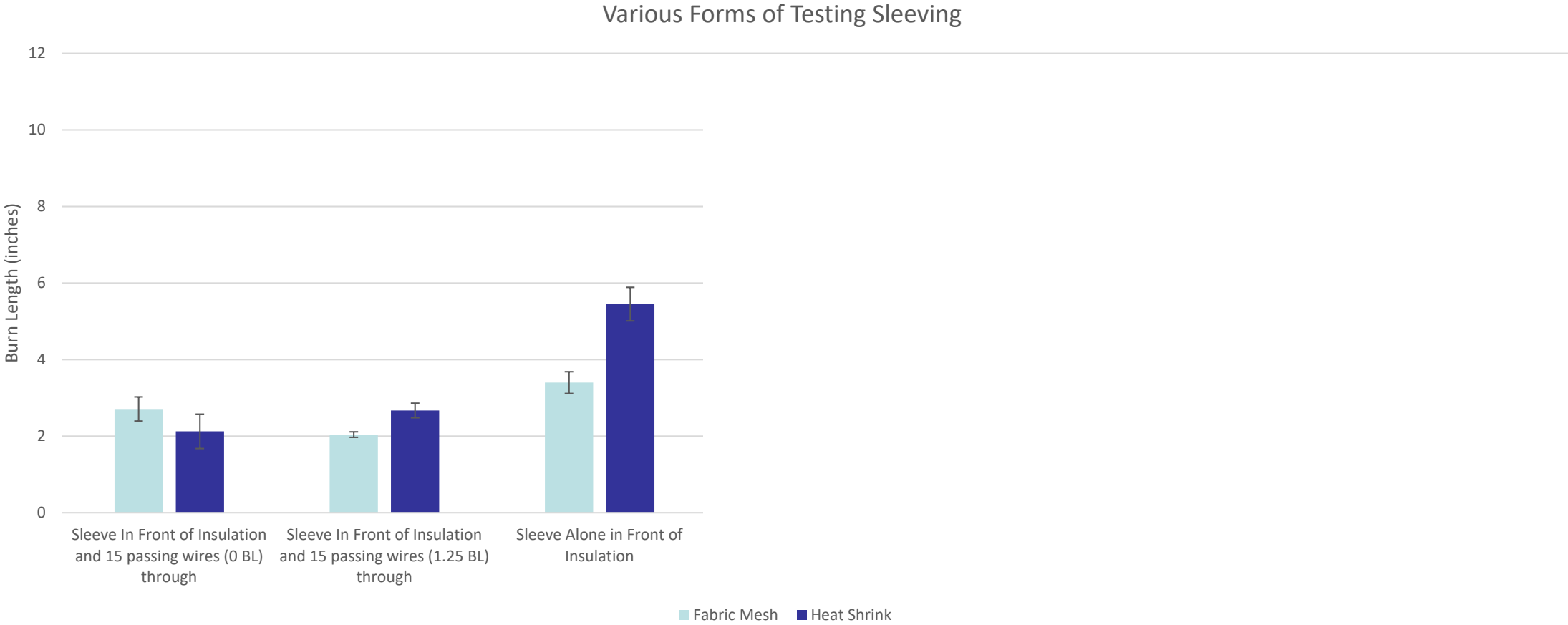


Sleeving Testing

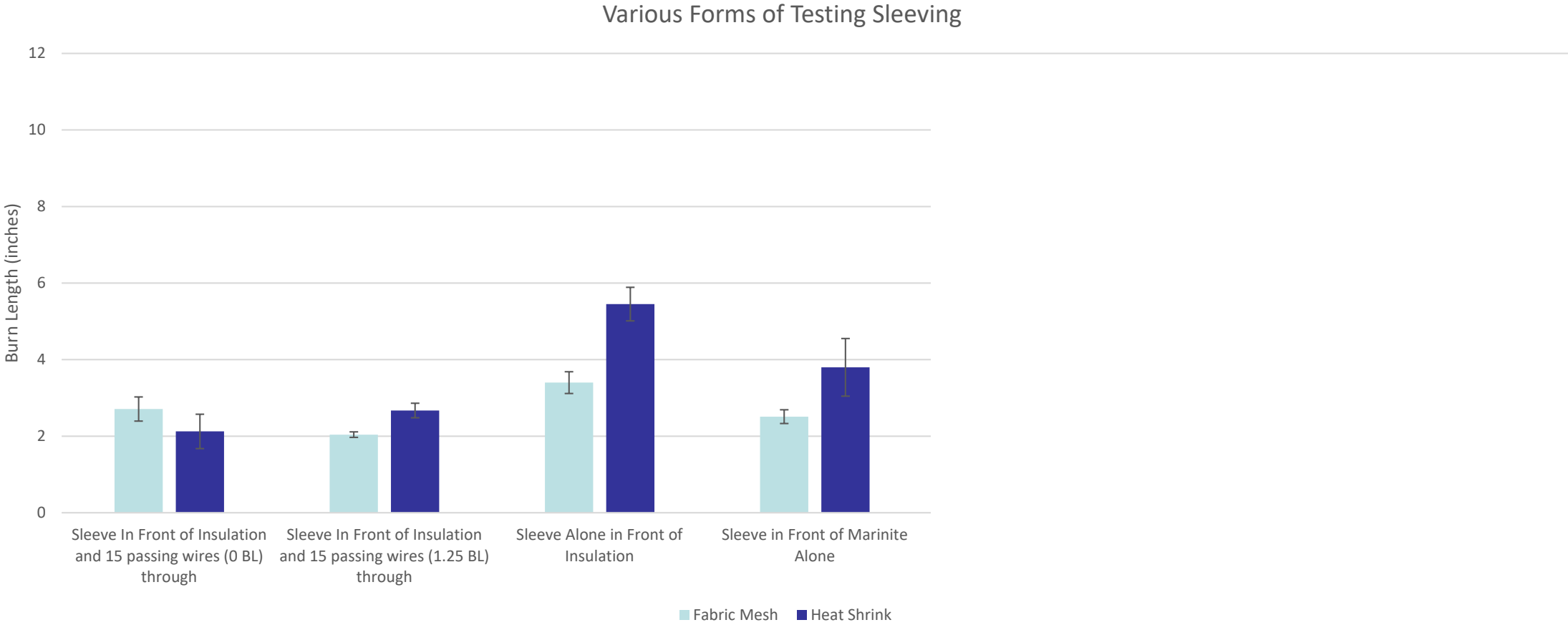
Various Forms of Testing Sleeving



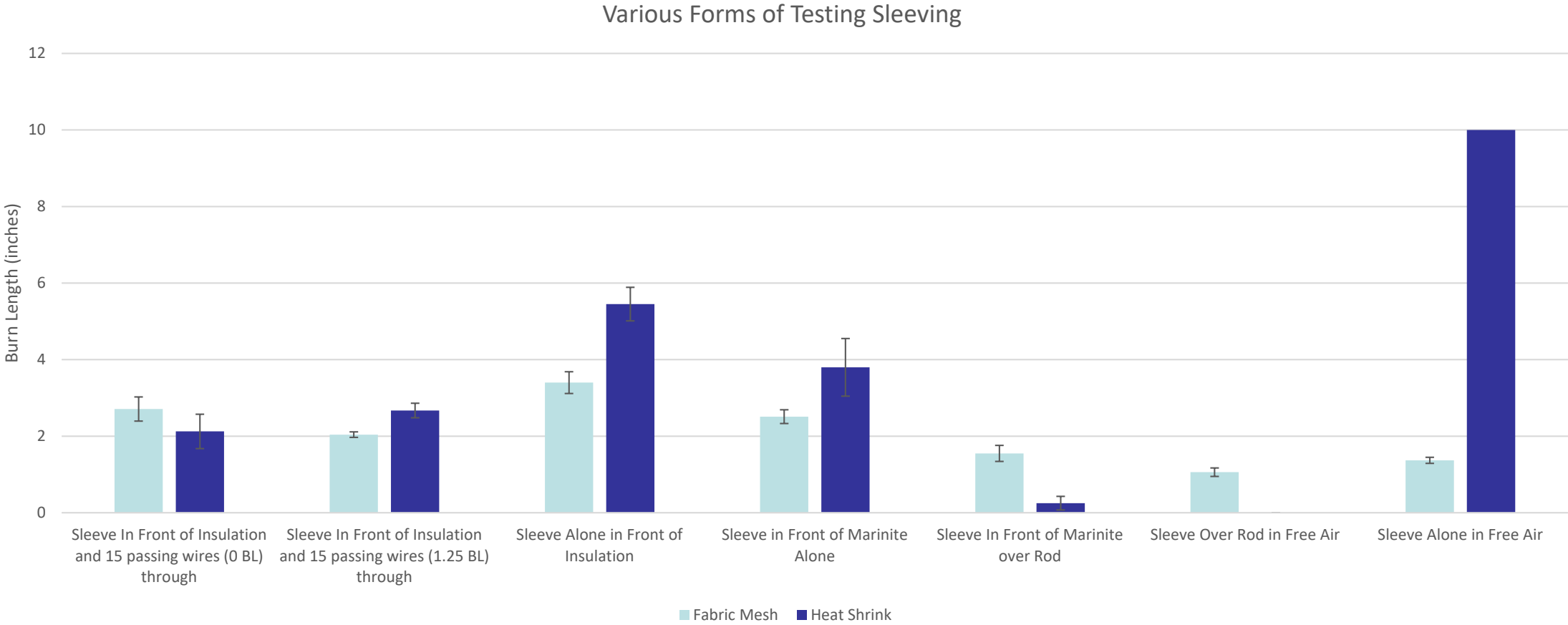
Sleeving Testing



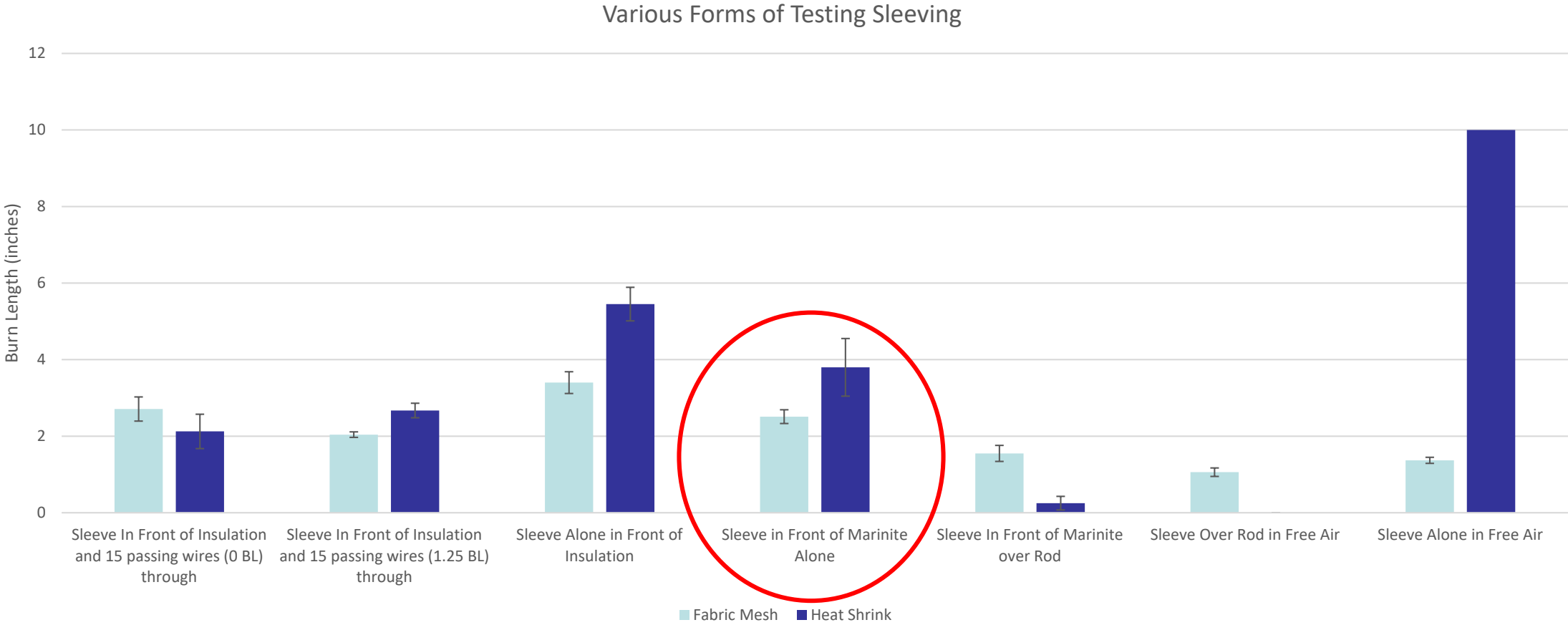
Sleeving Testing



Sleeving Testing



Sleeving Testing



Sleeving Testing Compared



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Refractory Board

- If moving forward with testing sleeving over Marinite, the refractory board would need to be standardized through
 - Thickness
 - Density
 - Thermal conductivity
 - 0.12 W/mK at 205 °C



Sleeving Moving Forward

- Testing more types of sleeving can assist with this study
- Testing sleeving materials in the MCC will continue to validate their VFP performance



Agenda

- ~~Wire Sleeving~~
- Wire Testing
- Material Performance Testing

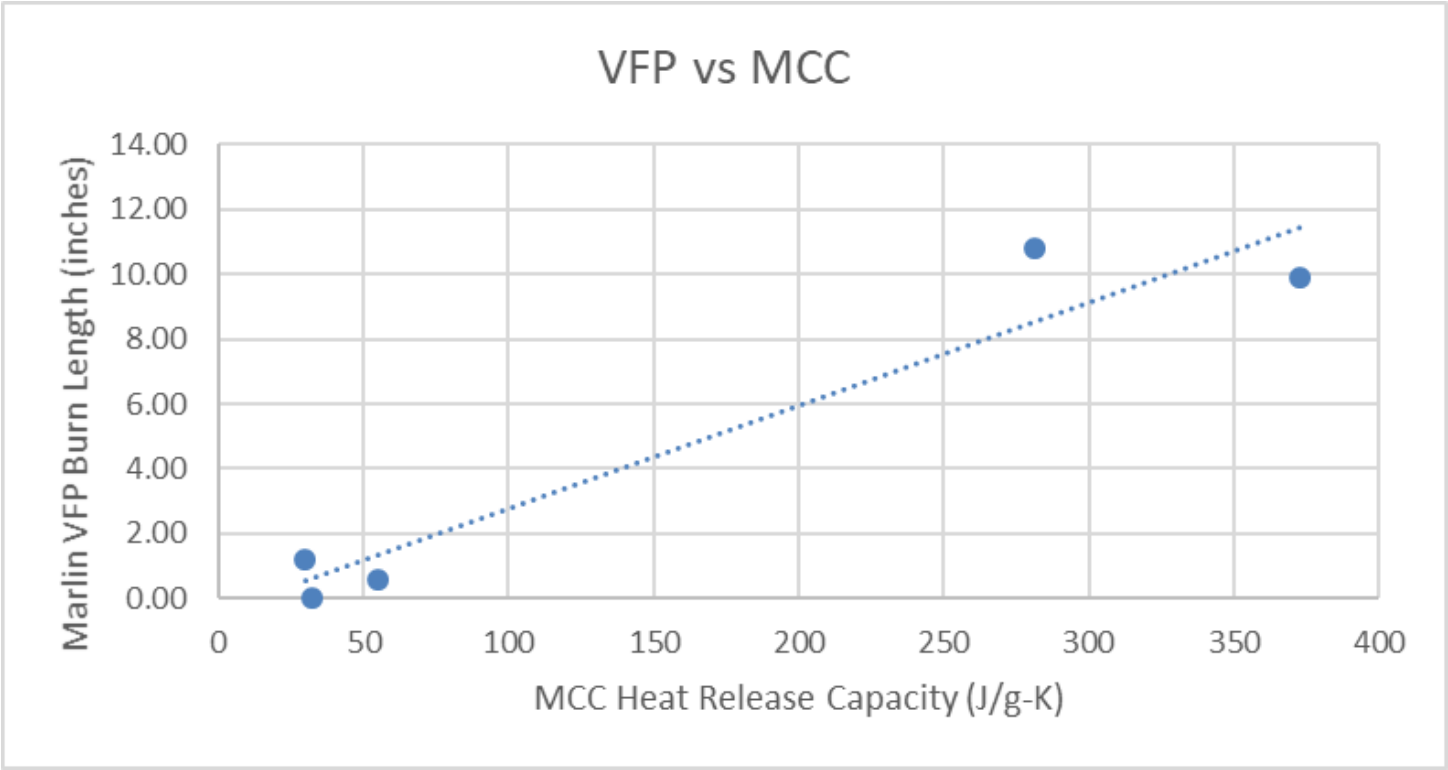


Wire Insulation Testing – What We Know

- Testing has been completed to understand that testing 3 wires is more repeatable than testing 5. This is also desirable by industry.
- Using Marinite as a backing board produces a significant difference in the burn length of the material, and is required here
 - Many wires actually have 0 inch burn length or less than 1 inch burn length with this method still. It is not an impossible test this way.
- Reference VFP Presentation of June 2018 and October 2017 for details



VFP vs. MCC Data



Agenda

- ~~Wire Sleeving~~
- ~~Wire Testing~~
- Material Performance Testing



Material Performance Testing

- In order to better quantify how materials perform in the VFP, a set of selected materials were tested in all the FAR tests
 - OSU
 - 12 second VBB
 - Radiant Panel
 - Smoke Test
- How they performed in these tests were compared to the VFP burn length



Material Performance Testing

Materials were chosen based on good, medium, and bad performance

| Material |
|--|
| Polytetrafluoroethylene Filled with Glass 25% |
| Polyvinylchloride – Unplasticized |
| Polyetherimide |
| Fabric Reinforced Phenolic |
| Carbon Fiber Epoxy Resin |
| Hexafluoropropylenevinylidene fluoride copolymer |



“FAR Score”

- The first method of determining a material’s “FAR Score” is to give the material a “1” if it passed a test and a “0” if it failed

| Test | Score Weight |
|---------------|--------------|
| 12-sec VBB | 1 |
| OSU | 1 |
| Radiant Panel | 1 |
| Smoke Test | 1 |



“FAR Score”

- Examples:

| Material | VBB 12-sec | OSU | Radiant Panel | Smoke Test | “FAR Score” |
|----------|------------|-----|---------------|------------|-------------|
| A | 1 | 0 | 1 | 0 | 0.5 |

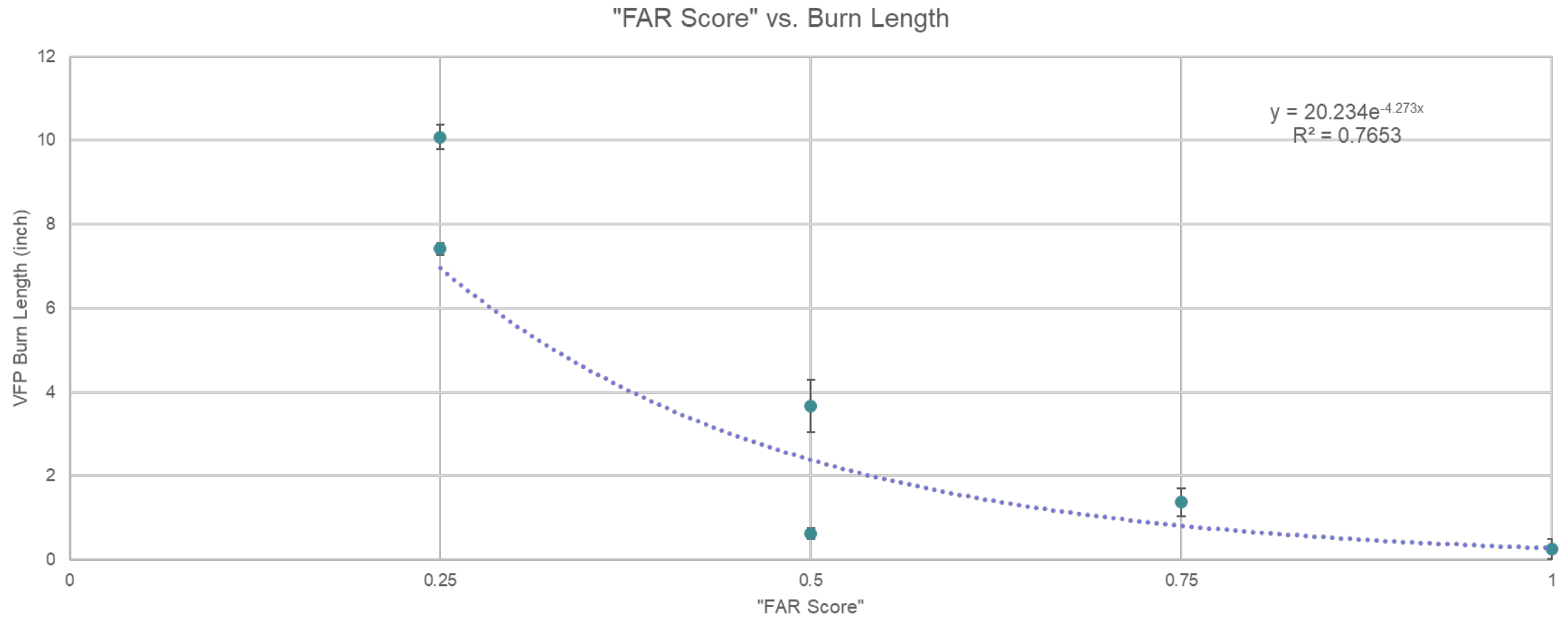
$$\text{“FAR Score”} = (1 + 0 + 1 + 0) / 4 = 0.5$$

| Material | VBB 12-sec | OSU | Radiant Panel | Smoke Test | “FAR Score” |
|----------|------------|-----|---------------|------------|-------------|
| B | 0 | 0 | 0 | 1 | 0.25 |

$$\text{“FAR Score”} = (0 + 0 + 0 + 1) / 4 = 0.25$$



"FAR Score" vs. Burn Length



Differently Defined “FAR Score”

| Pass/Fail Points | Score Weight |
|--------------------------------|--------------|
| VBB – Flame Time | 1 |
| VBB – Drip Flame Time | 1 |
| VBB – Burn Length | 1 |
| OSU – Max Heat Released | 1 |
| OSU – Total 2min Heat Released | 1 |
| Radiant Panel – After Flame | 1 |
| Radiant Panel – Burn Length | 1 |
| Smoke Test | 1 |

8 Total Points towards “FAR Score”



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“FAR Score”

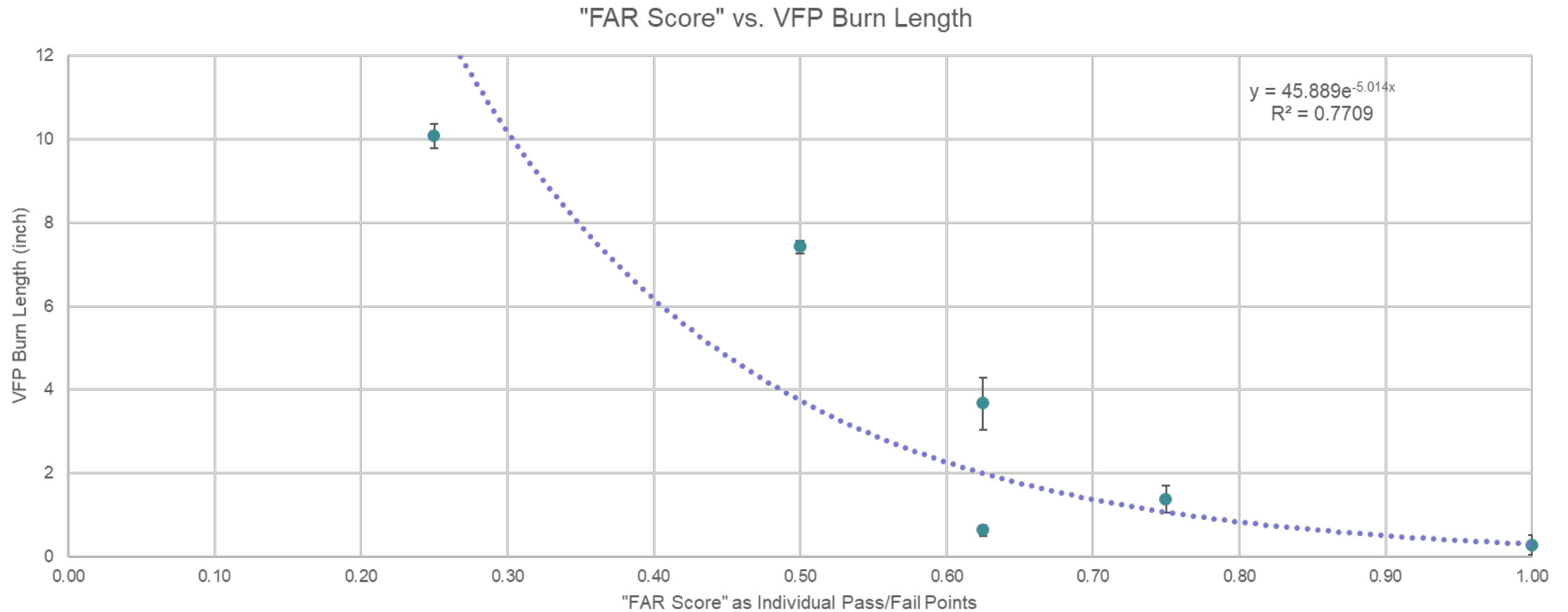
- The first method of determining a material’s “FAR Score” is to give the material a “1” if it passed a test and a “0” if it failed
- Example:

| Pass/Fail Points | Score Weight |
|--------------------------------|--------------|
| VBB – Flame Time | 0 |
| VBB – Drip Flame Time | 1 |
| VBB – Burn Length | 1 |
| OSU – Max Heat Released | 0 |
| OSU – Total 2min Heat Released | 0 |
| Radiant Panel – After Flame | 0 |
| Radiant Panel – Burn Length | 1 |
| Smoke Test | 1 |

$$\text{“FAR Score”} = (0+1+1+0+0+0+1+1)/8 = 0.50$$



"FAR Score" vs. VFP Burn Length



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Questions?

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