### Vertical Bunsen Burner Testing of 3-D Printed Material

Presented to: International Aircraft Materials Fire Test Forum By: Steve Rehn Date: 10/30/2018



# Introduction

- Test basic 3-D printed material in Vertical Bunsen Burner
- 12" × 3" × 0.060" Samples
- Need to find "borderline" material that may show differences in printing method
- Four Materials
  - Ultem 9085, Nylon-12, Polycarbonate, and PC-ABS
- Printed in 3 orientations

- Flat (XY), Sideways (YZ), and Standing (ZX)





- 0.060" (1.5mm)
- 6 layers
  - 0.01" Slice Height
  - +45/-45
- Solid
- Built in X-Y plane (printed flat)





- 0.060" (1.5mm)
- 300 layers
- 0.01" Slice Height
- Solid
- Built in Y-Z plane (printed sideways)





- 0.060" (1.5mm)
- 1200 layers
- 0.01" Slice Height
- Solid
- Built in Z-X plane (printed standing)



## **Ultem 9085 Printed Flat (XY direction)**



10/30/2018



### **Ultem 9085 Printed Sideways (YZ direction)**





### **Ultem 9085 Printed Standing (ZX direction)**



10/30/2018

















### **XY-Direction**

#### **YZ-Direction**



### **ZX-Direction**



10/30/2018

















- On some 60-second tests, material would melt down to the burner
- Never any flame time when this happened, charred plastic blocked most of the flame
- Flame time seemed to depend on the shape of the material as it melted and where it pushed the Bunsen burner flame







## Polycarbonate



### **XY-Direction**

**YZ-Direction** 

**ZX** Direction





#### **Polycarbonate 12-Second Vertical Bunsen Burner**





## Polycarbonate

#### \*samples that did not need to be extinguished



**XY-Direction** 



**YZ-Direction** 



**ZX** Direction

• Flames extinguished because of dripping

10/30/2018



## **PC-ABS**







**ZX** Direction



## **PC-ABS**

- XY direction had 118s flame time, 8.2 in. burn length, lots of drip flame time
- Tested YZ and ZX directions and had to extinguish the flames
- Not a good candidate for further testing







# Nylon-12



### XY-Direction\*

**YZ-Direction** 

**ZX** Direction

10/30/2018



#### Nylon-12 12-Second Vertical Bunsen Burner



10/30/2018



# Nylon-12

- Drip flame time was difficult to measure because there were several drips that needed to be added together
- Flames extinguished because of dripping



**YZ-Direction** 



**ZX** Direction



#### **Microscale Combustion Calorimetry of 3-D Printed Materials**





**3D Printed Material MCC Data** 



# **Conclusion and Future Work**

- Ultem 9085 is the only "good" material so far
  - Showed very minor differences in printing orientation
- Nylon-12 potentially showed a difference in printing orientation
  - Need to test XY orientation and more samples of other orientations
- Need to test different infill % next
  - More air inside sample could allow more burning
- Antero 800NA PEKK based thermoplastic
  - Available on Fortus 450MC
  - Could be good flame-resistant material to test



# **Questions?**

### Contact:

Steven Rehn Federal Aviation Administration William J. Hughes Technical Center Fire Safety Branch, Bldg. 203 Atlantic City Int'l Airport, NJ 08405 (609) 485-5587 steven.rehn@faa.gov



