Vertical Bunsen Burner Testing of 3-D Printed Material

Presented to: International Aircraft Materials Fire Test Forum
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Introduction

- **Test basic 3-D printed material in Vertical Bunsen Burner**
- **Ultem 9085 Material**
  - Flame retardant high-performance thermoplastic
- **12” × 3” × 0.0625” Samples**
- **Printed in 3 orientations**
  - Flat (XY), Sideways (YZ), and Standing (ZX)

- Thickness: 1.5, 2.5, 6.0 mm from Policy Statement → **3 factors**

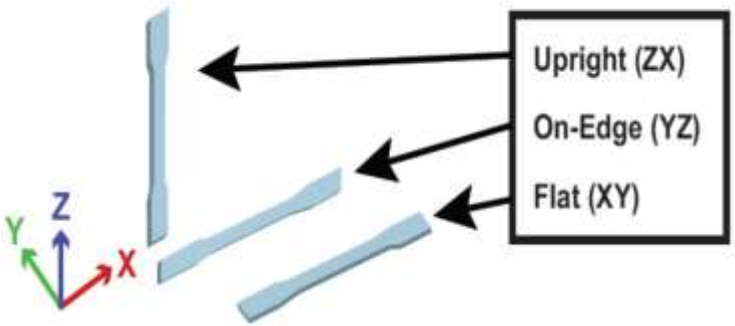
- Filling (1): 100 % primarily to be used for cabin parts, other grades → **1 factor**

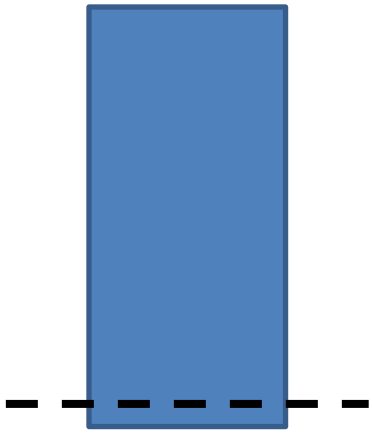
- Direction: 1. print in x/y plane and build-up in z, 2. print in z/x plane and build-up in y, 3. print in y/z plane and build-up in x → **3 factors**

- Filling (2): +45°/-45° vs. 0°/90° for print in x/y plane and build-up in z →**2 factors for x/y only**

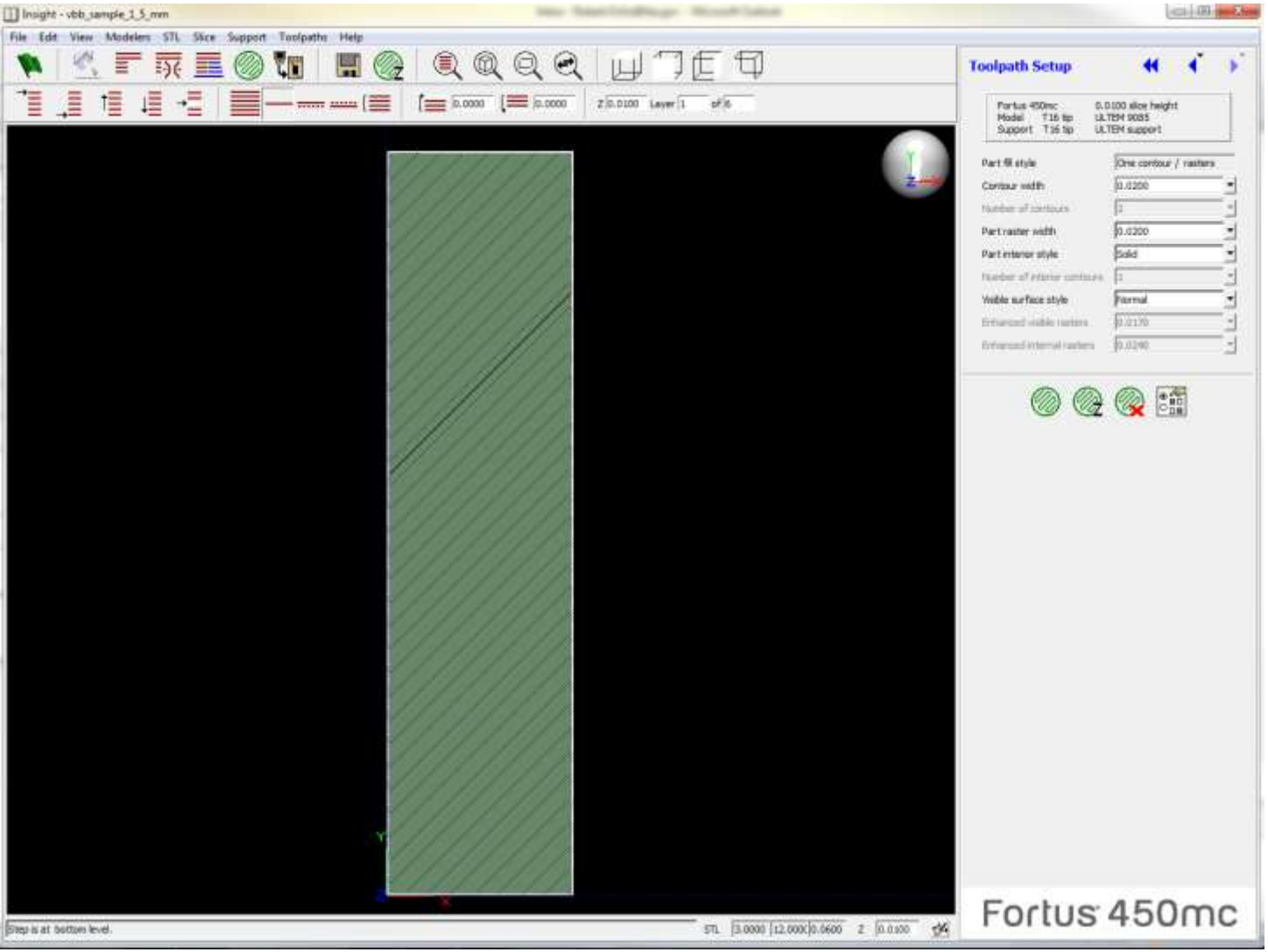
→ 3*3+1=10 specimen sets with 5 samples each

→ 60 s VBB

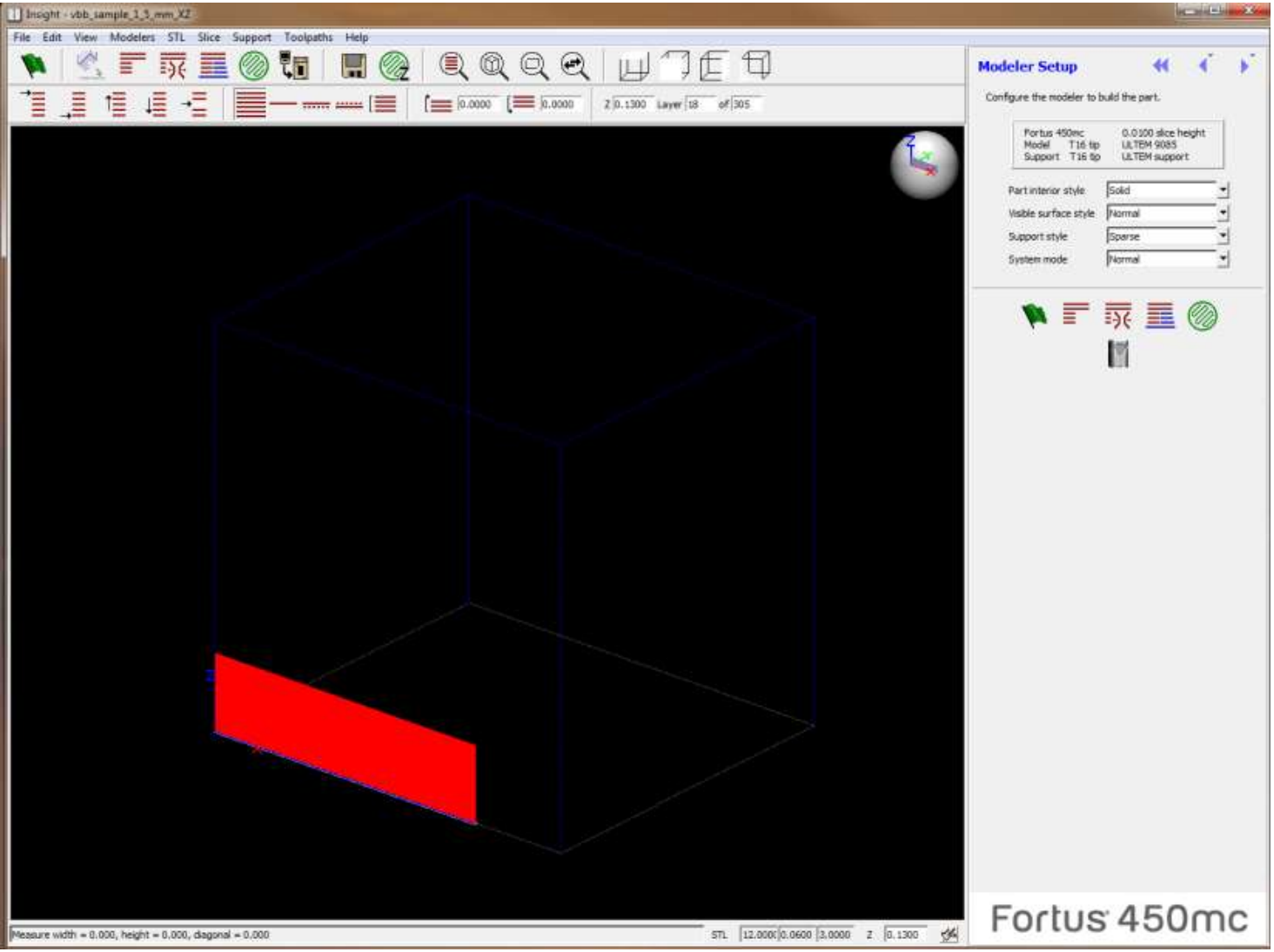




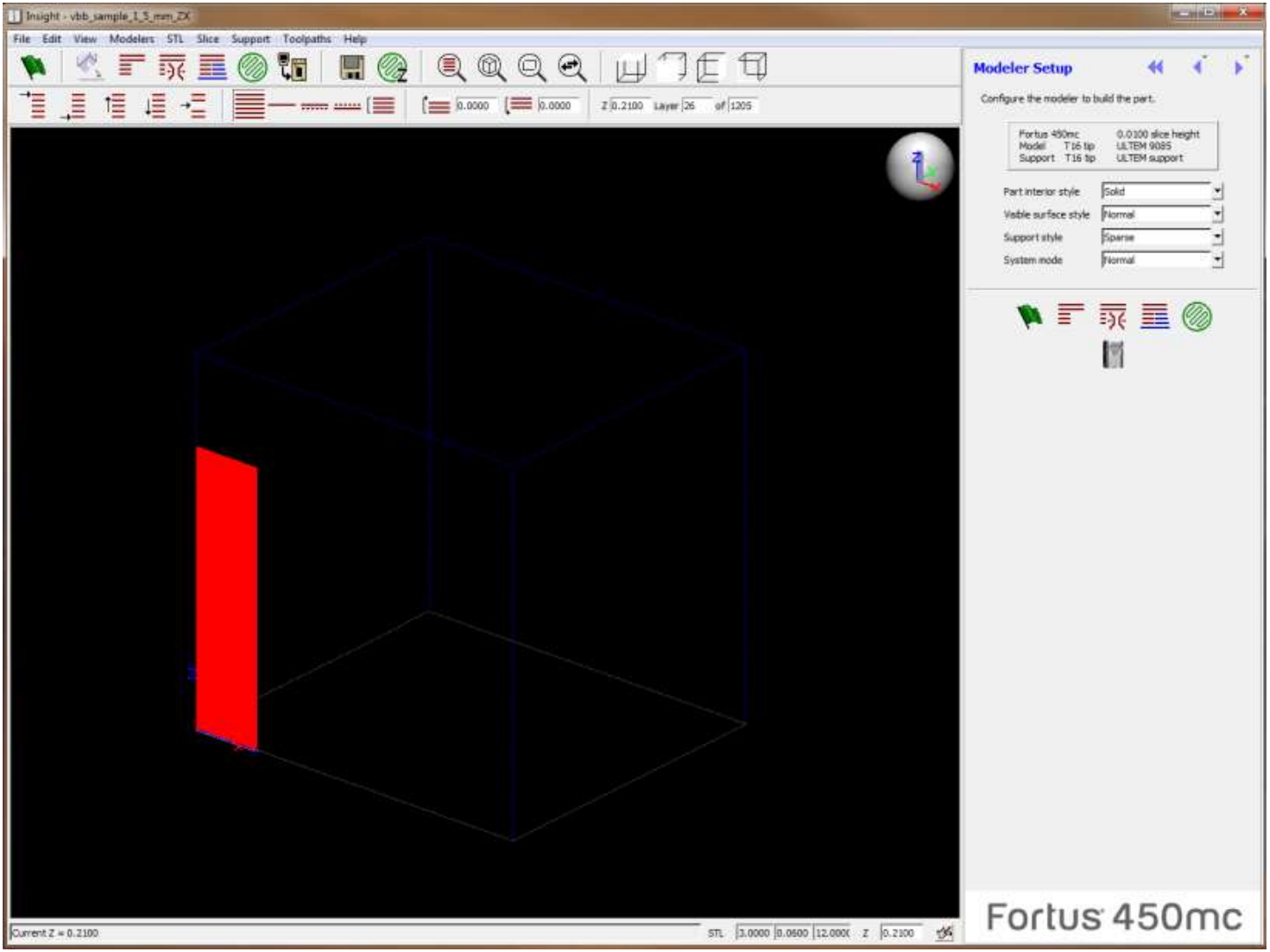
test open edge



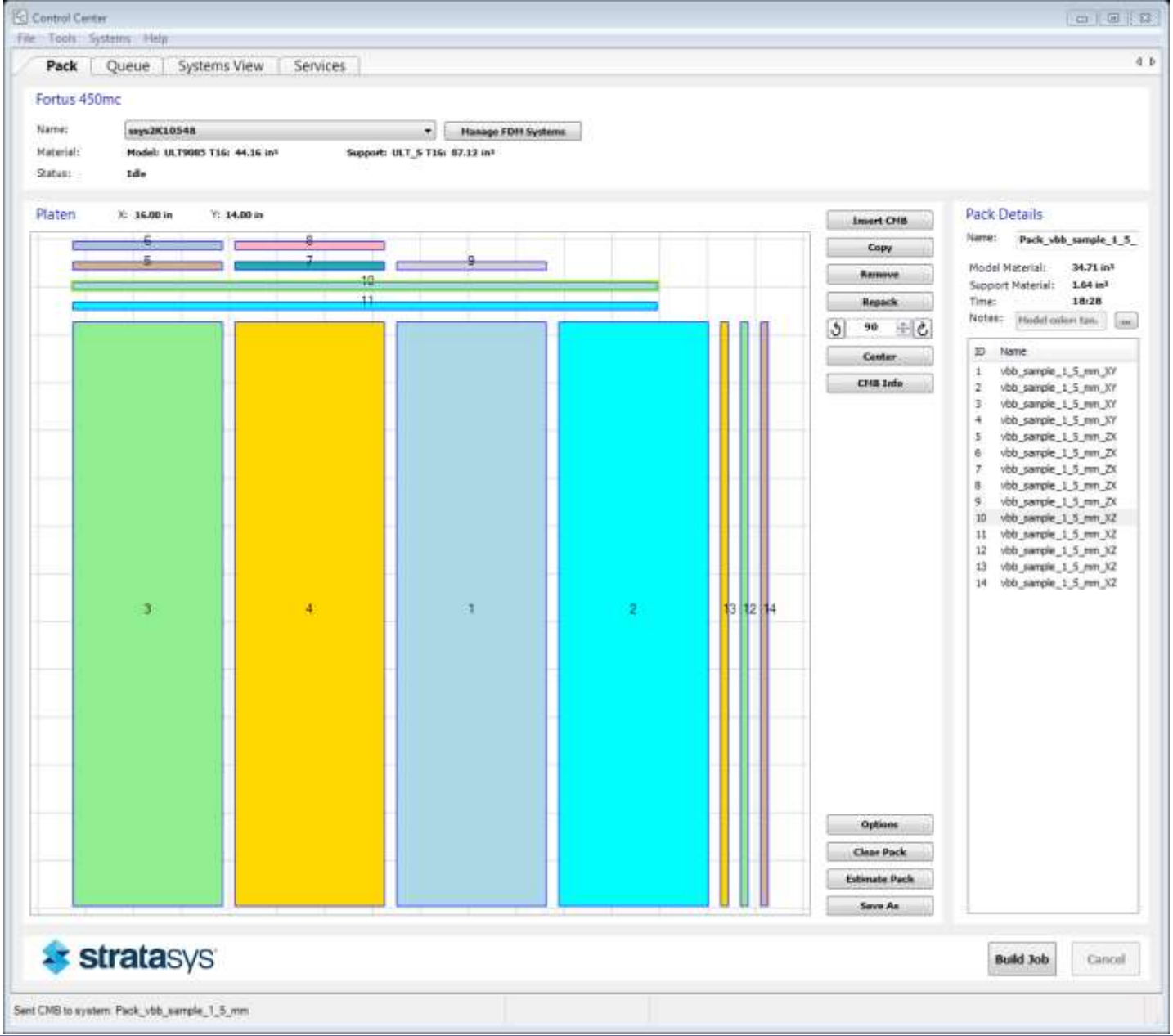
- 1/16” (1.5mm)
- 6 layers
- 0.01” Slice Height
- +45/-45
- Solid
- Built in X-Y plane



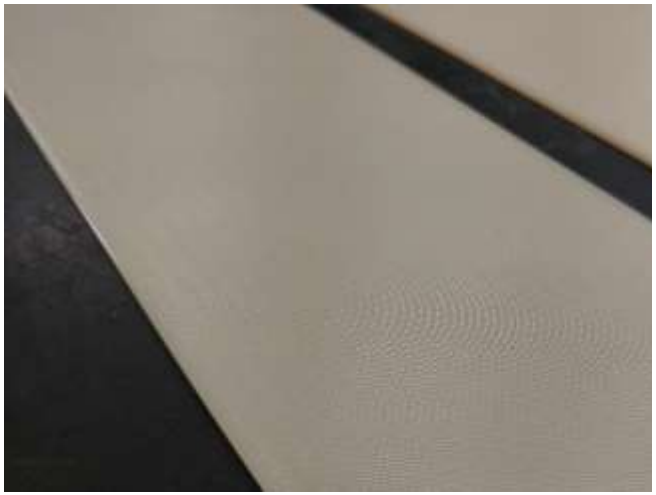
- **1/16” (1.5mm)**
- **300 layers**
- **0.01” Slice Height**
- **Solid**
- **Built in Y-Z plane**

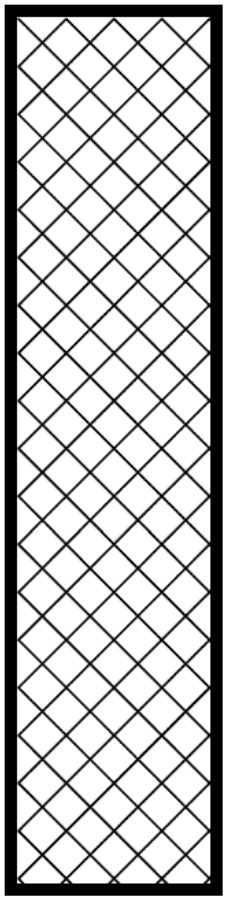


- **1/16” (1.5mm)**
- **1200 layers**
- **0.01” Slice Height**
- **Solid**
- **Built in Z-X plane**

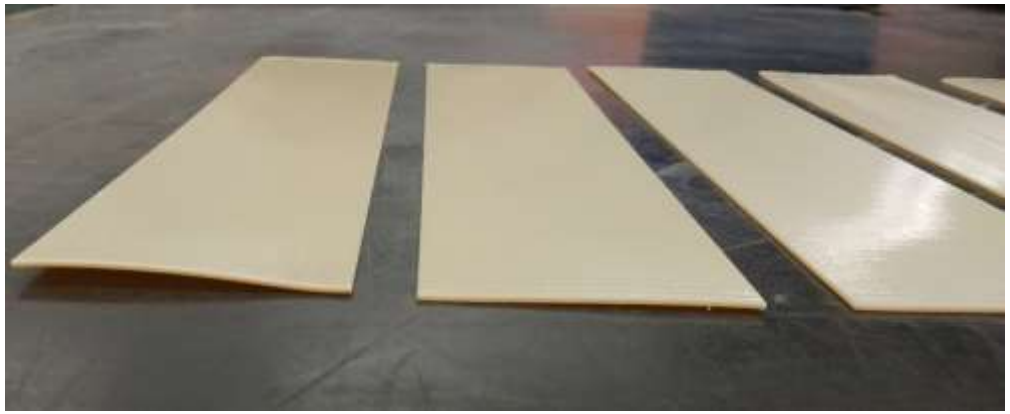

Control Center
File Tools Systems Help
Pack
Queue
Systems View
Services
Fortus 450mc
Name:
sys2K10548
Manage FDM Systems
Material:
Model: ULT9085 T16: 44.16 in³
Support: ULT_S T16: 87.12 in³
Status:
Idle
Platen
X: 16.00 in
Y: 14.00 in
Insert CMB
Copy
Remove
Repack
90
Center
CMB Info
Options
Clear Pack
Estimate Pack
Save As
Pack Details
Name:
Pack_vbb_sample_1_5_
Model Material:
34.71 in³
Support Material:
1.64 in³
Time:
18:28
Notes:
ID
Name
1 vbb_sample_1_5_mm_XY
2 vbb_sample_1_5_mm_XY
3 vbb_sample_1_5_mm_XY
4 vbb_sample_1_5_mm_XY
5 vbb_sample_1_5_mm_ZX
6 vbb_sample_1_5_mm_ZX
7 vbb_sample_1_5_mm_ZX
8 vbb_sample_1_5_mm_ZX
9 vbb_sample_1_5_mm_ZX
10 vbb_sample_1_5_mm_XZ
11 vbb_sample_1_5_mm_XZ
12 vbb_sample_1_5_mm_XZ
13 vbb_sample_1_5_mm_XZ
14 vbb_sample_1_5_mm_XZ
stratasys
Build Job
Cancel
Sent CMB to system: Pack_vbb_sample_1_5_mm

Printed Flat (XY direction)

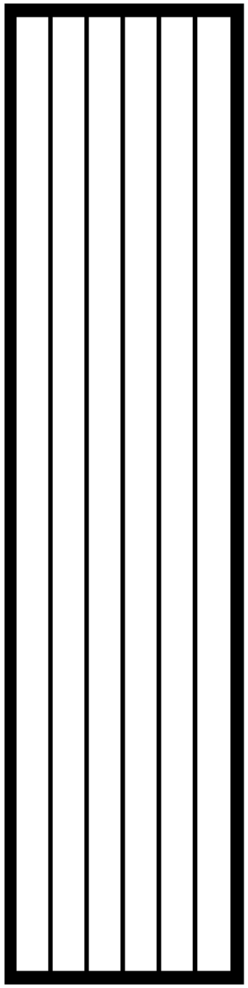




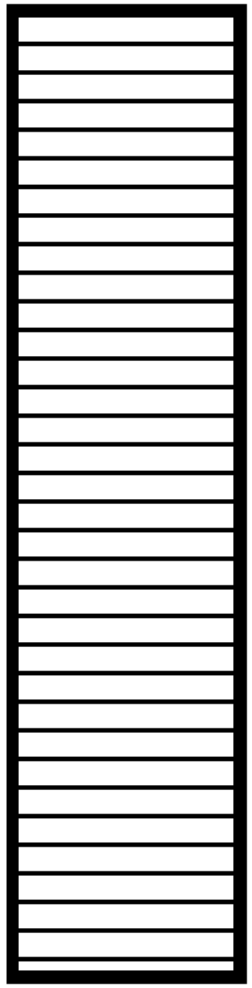
Printed Sideways (YZ direction)



- Printed with no supports

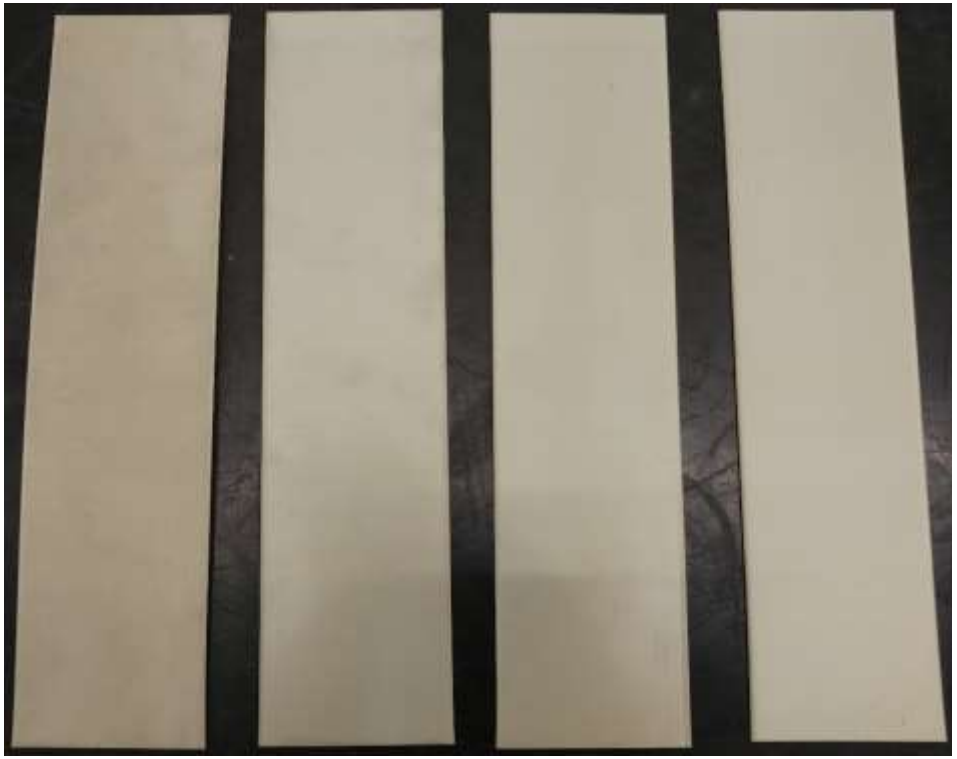


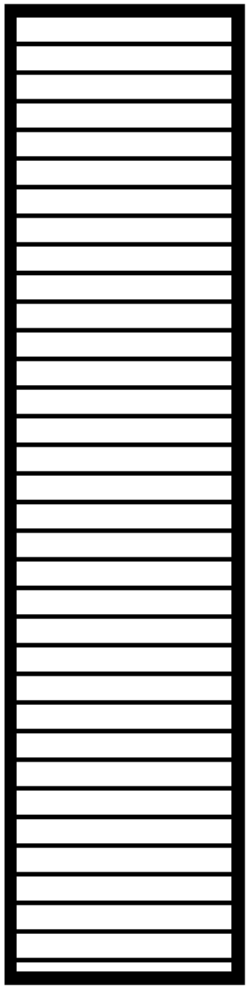
Printed Standing (ZX direction)



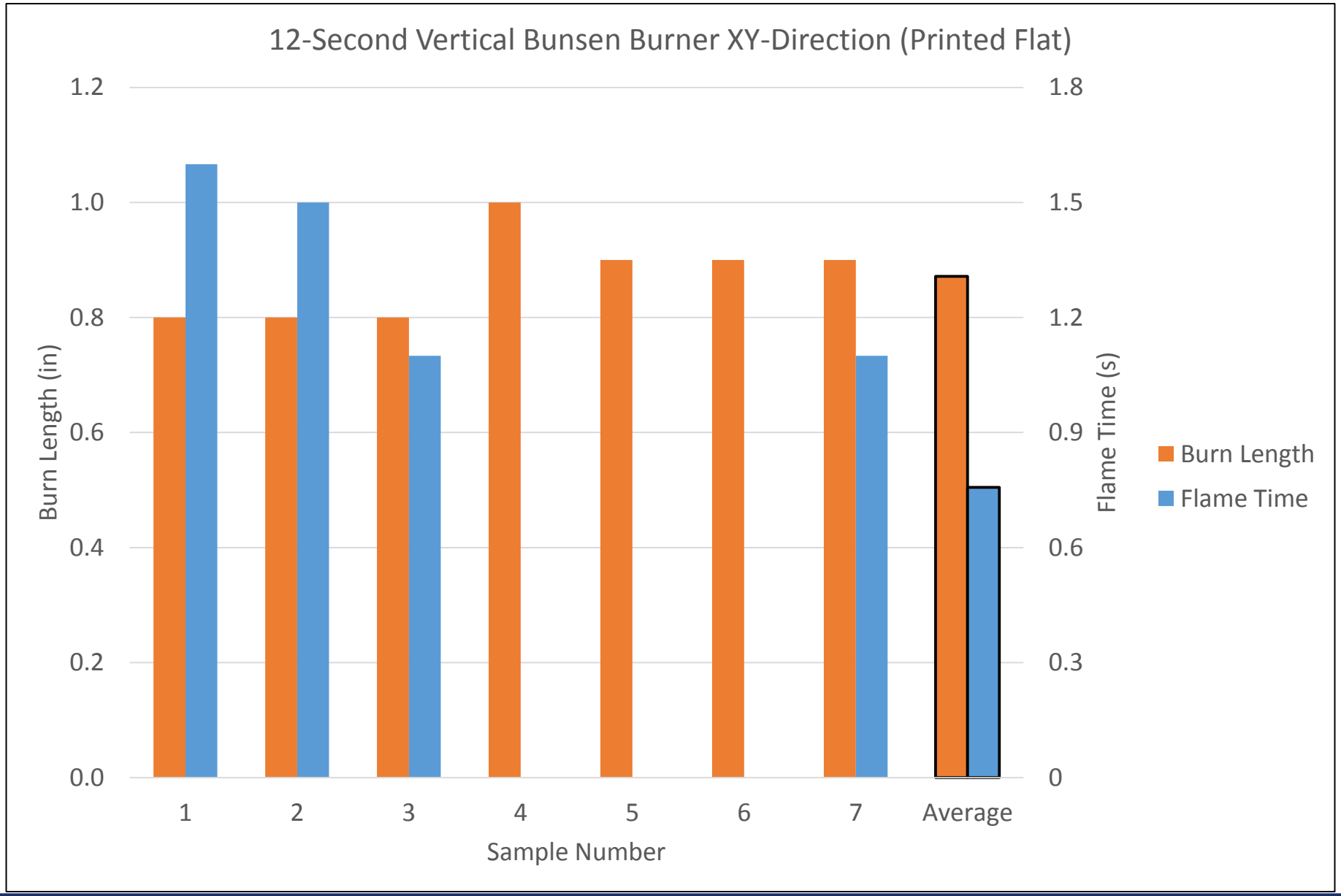
- Printed with no supports
- Samples were cut shorter to fit in sample holder

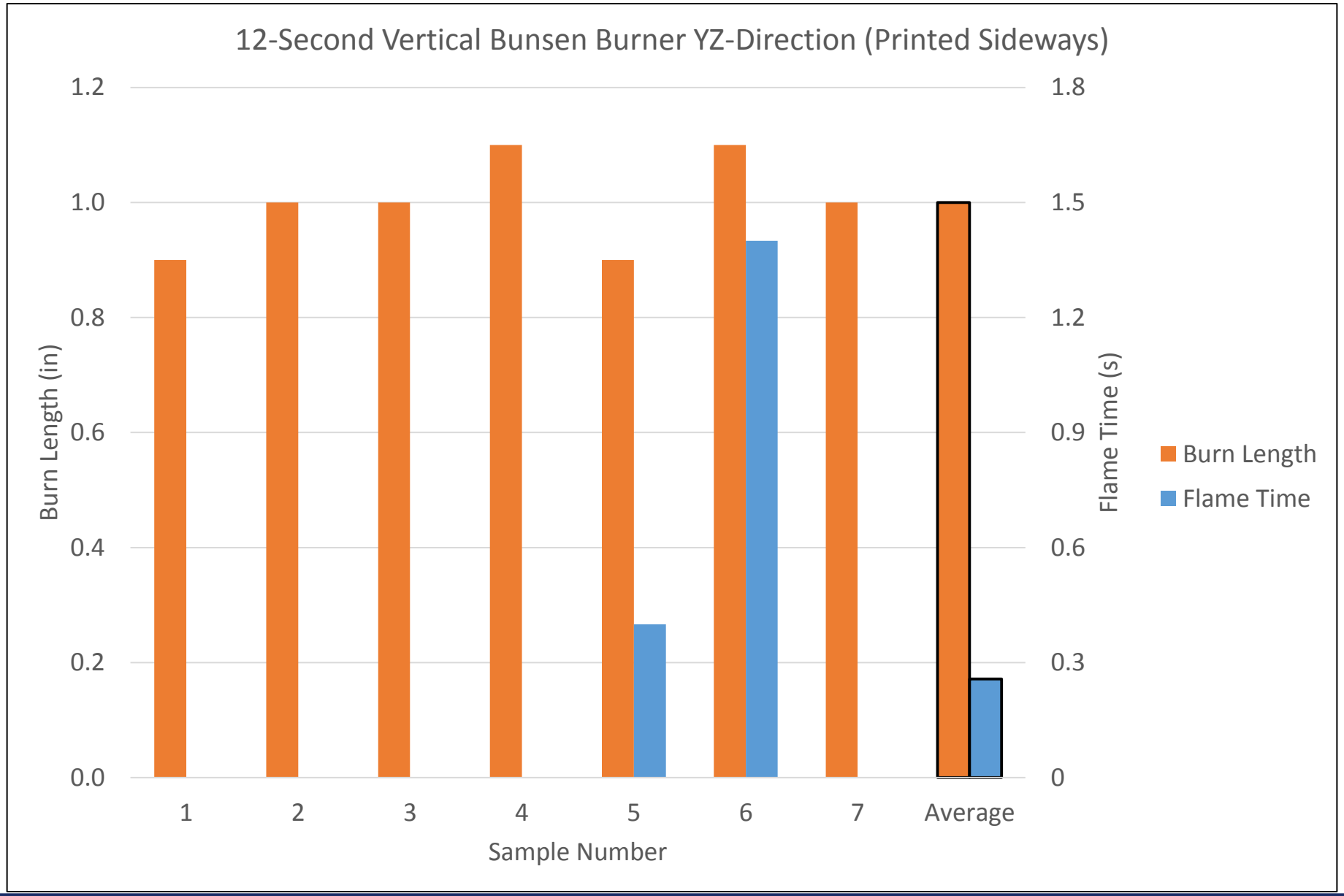
Printed Standing (with supports)

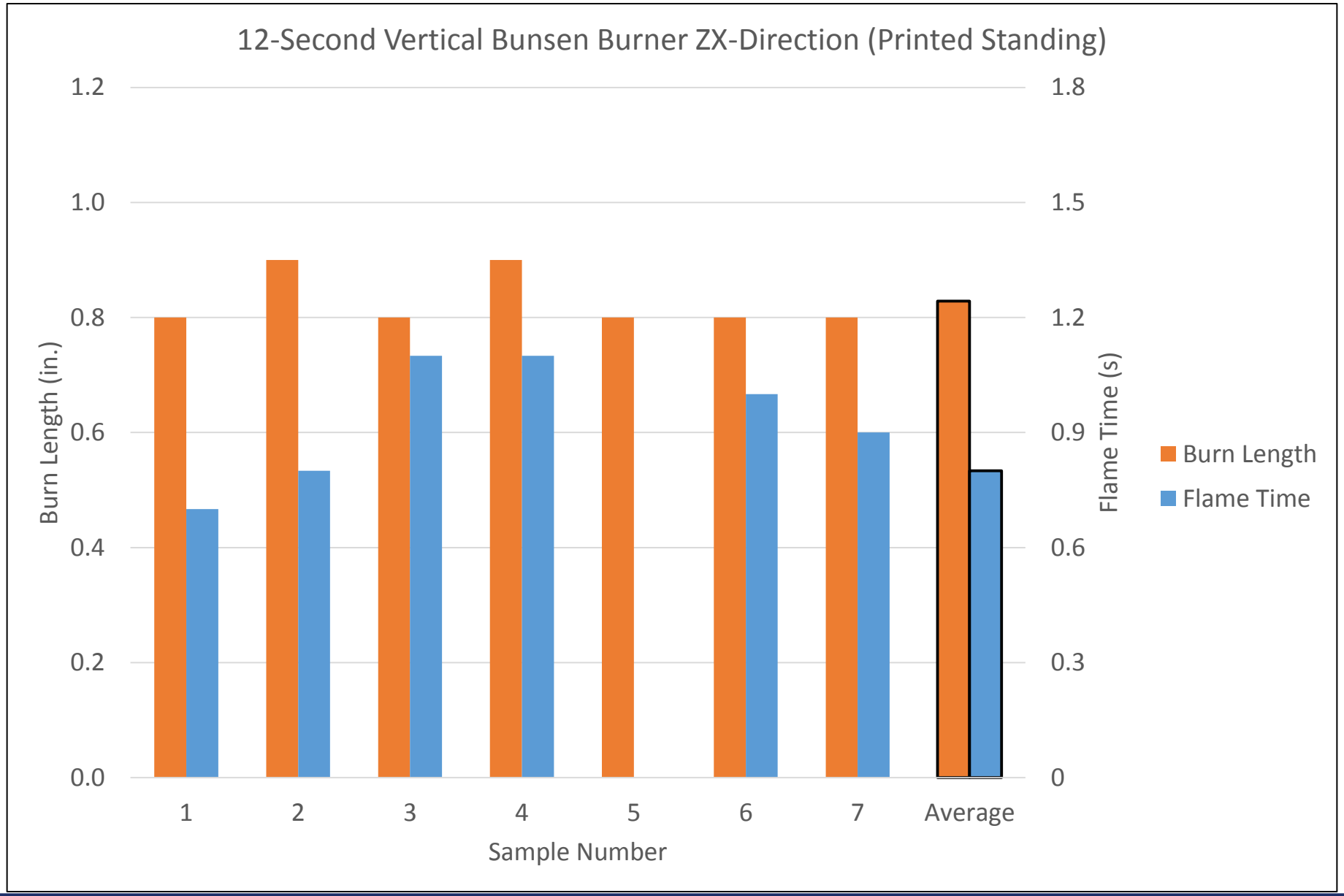


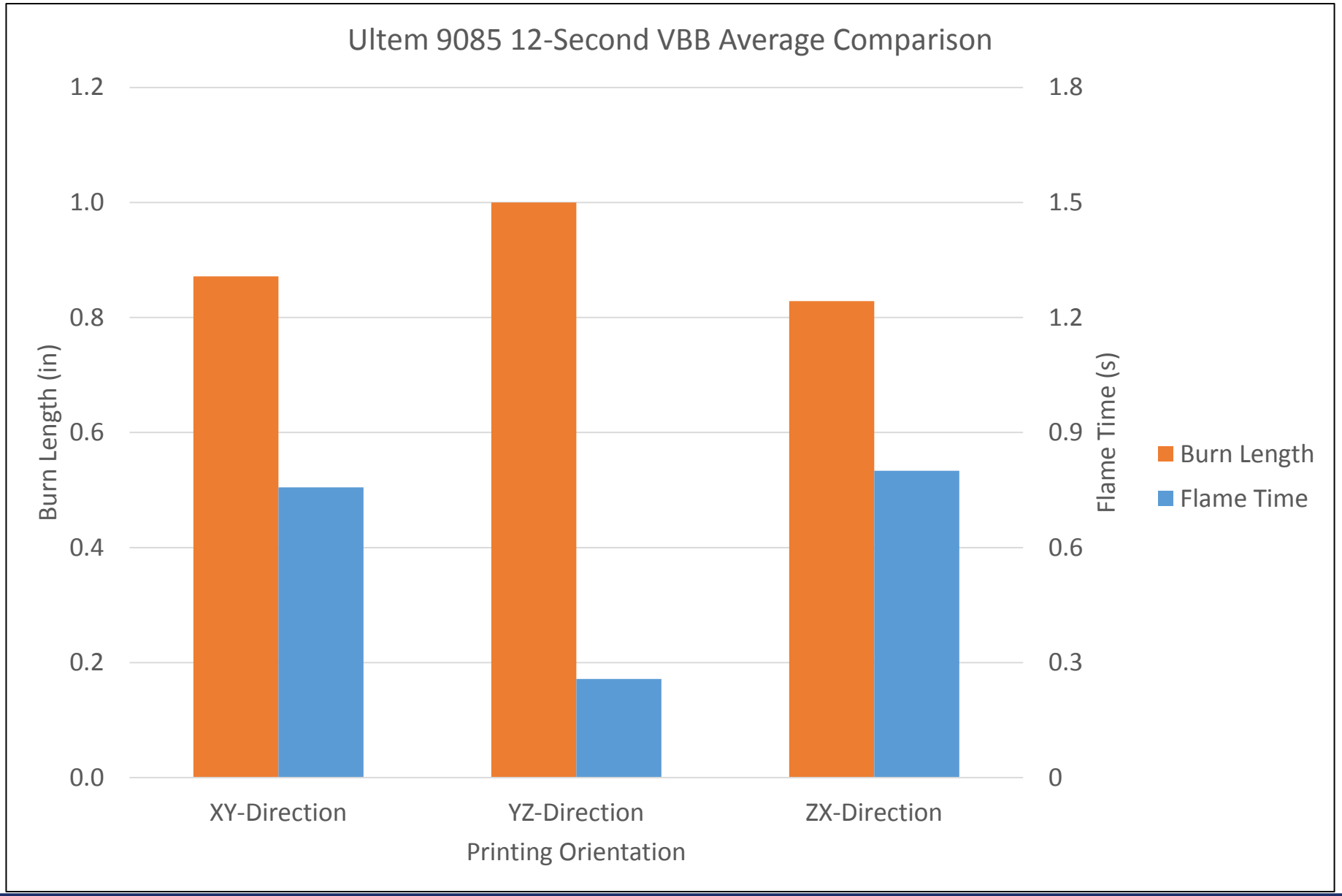


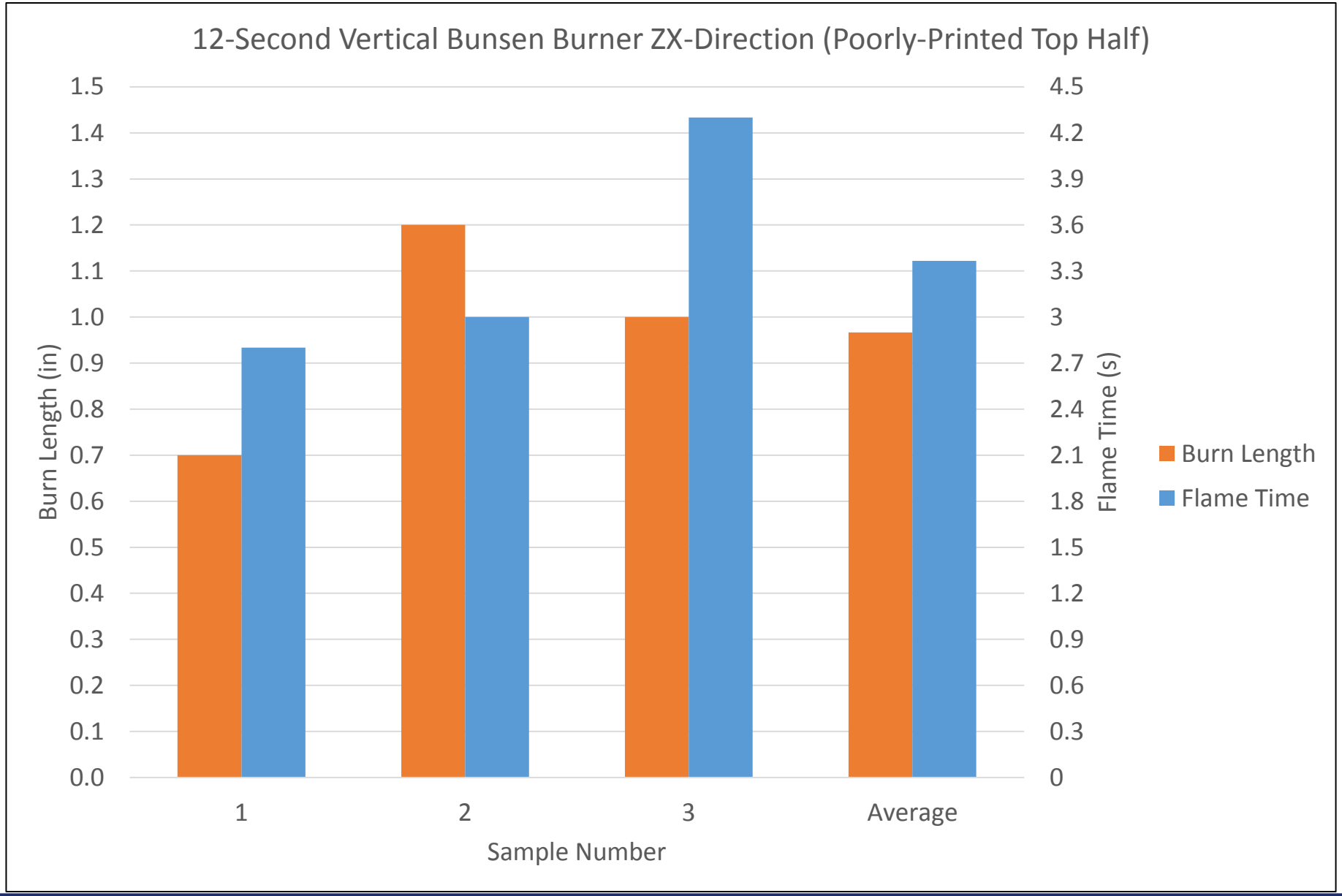
Support material →

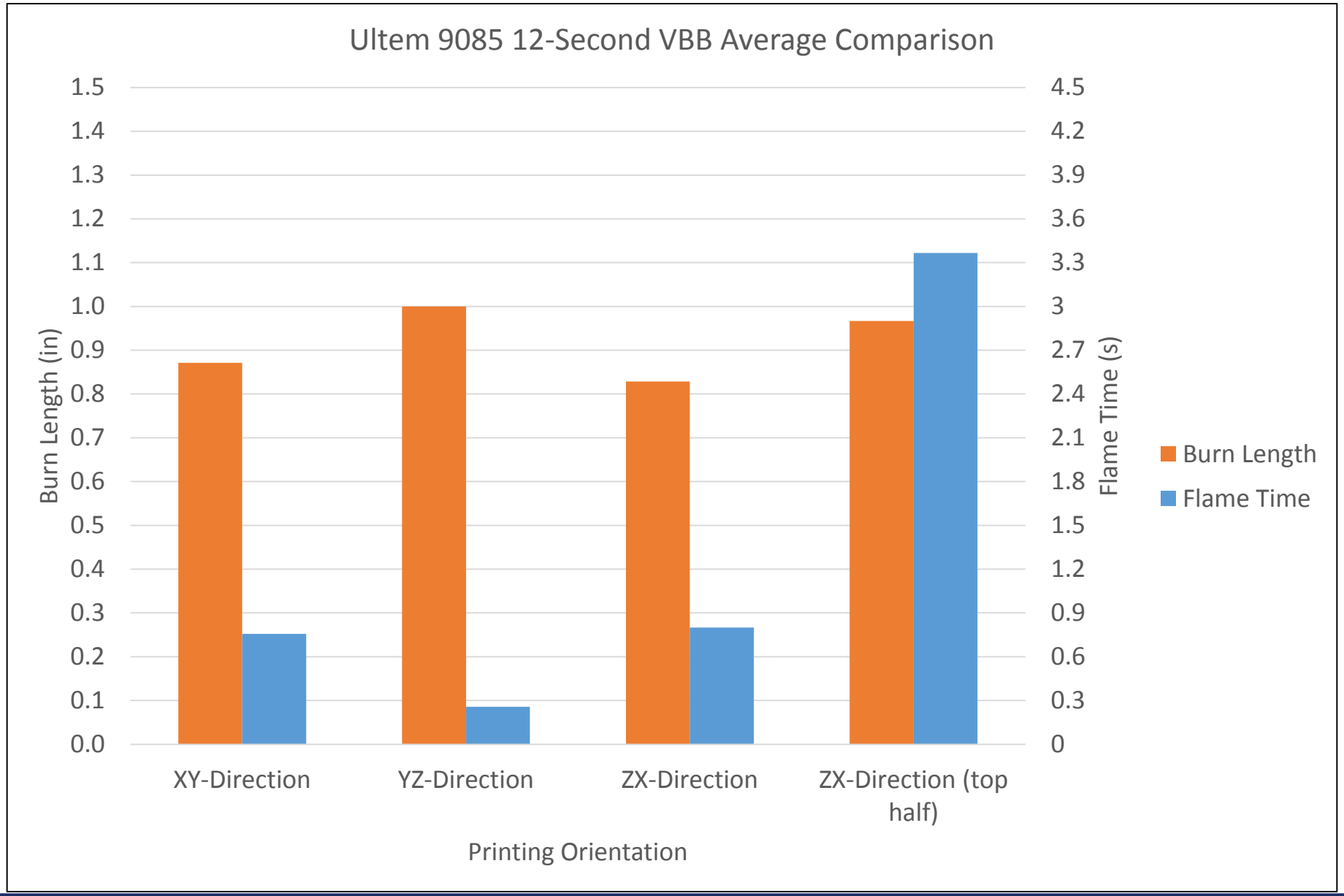

12-Second Vertical Bunsen Burner XY-Direction (Printed Flat)
Burn Length (in)
Flame Time (s)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1.8
1.5
1.2
0.9
0.6
0.3
0
1
2
3
4
5
6
7
Average
Sample Number
Burn Length
Flame Time


12-Second Vertical Bunsen Burner YZ-Direction (Printed Sideways)
Burn Length (in)
Flame Time (s)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1.8
1.5
1.2
0.9
0.6
0.3
0
1
2
3
4
5
6
7
Average
Sample Number
Burn Length
Flame Time

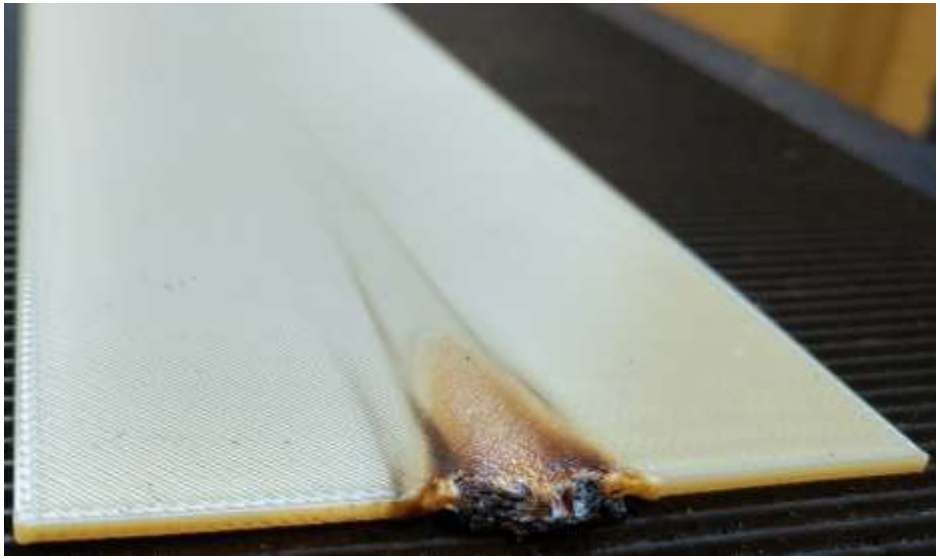

12-Second Vertical Bunsen Burner ZX-Direction (Printed Standing)
Burn Length (in.)
Flame Time (s)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1.8
1.5
1.2
0.9
0.6
0.3
0
1
2
3
4
5
6
7
Average
Sample Number
Burn Length
Flame Time


Ultem 9085 12-Second VBB Average Comparison
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Burn Length (in)
1.8
1.5
1.2
0.9
0.6
0.3
0
Flame Time (s)
XY-Direction
YZ-Direction
ZX-Direction
Printing Orientation
Burn Length
Flame Time

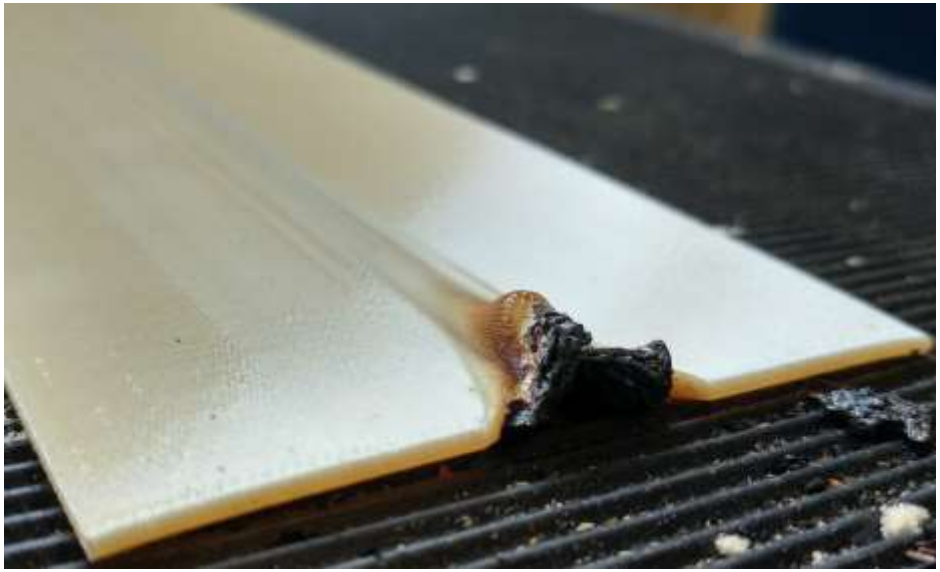

12-Second Vertical Bunsen Burner ZX-Direction (Poorly-Printed Top Half)
Burn Length (in)
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Flame Time (s)
4.5
4.2
3.9
3.6
3.3
3
2.7
2.4
2.1
1.8
1.5
1.2
0.9
0.6
0.3
0
1
2
3
Average
Sample Number
Burn Length
Flame Time


Ultem 9085 12-Second VBB Average Comparison
Burn Length (in)
Flame Time (s)
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
4.5
4.2
3.9
3.6
3.3
3
2.7
2.4
2.1
1.8
1.5
1.2
0.9
0.6
0.3
0
XY-Direction
YZ-Direction
ZX-Direction
ZX-Direction (top half)
Printing Orientation
Burn Length
Flame Time

XY-Direction

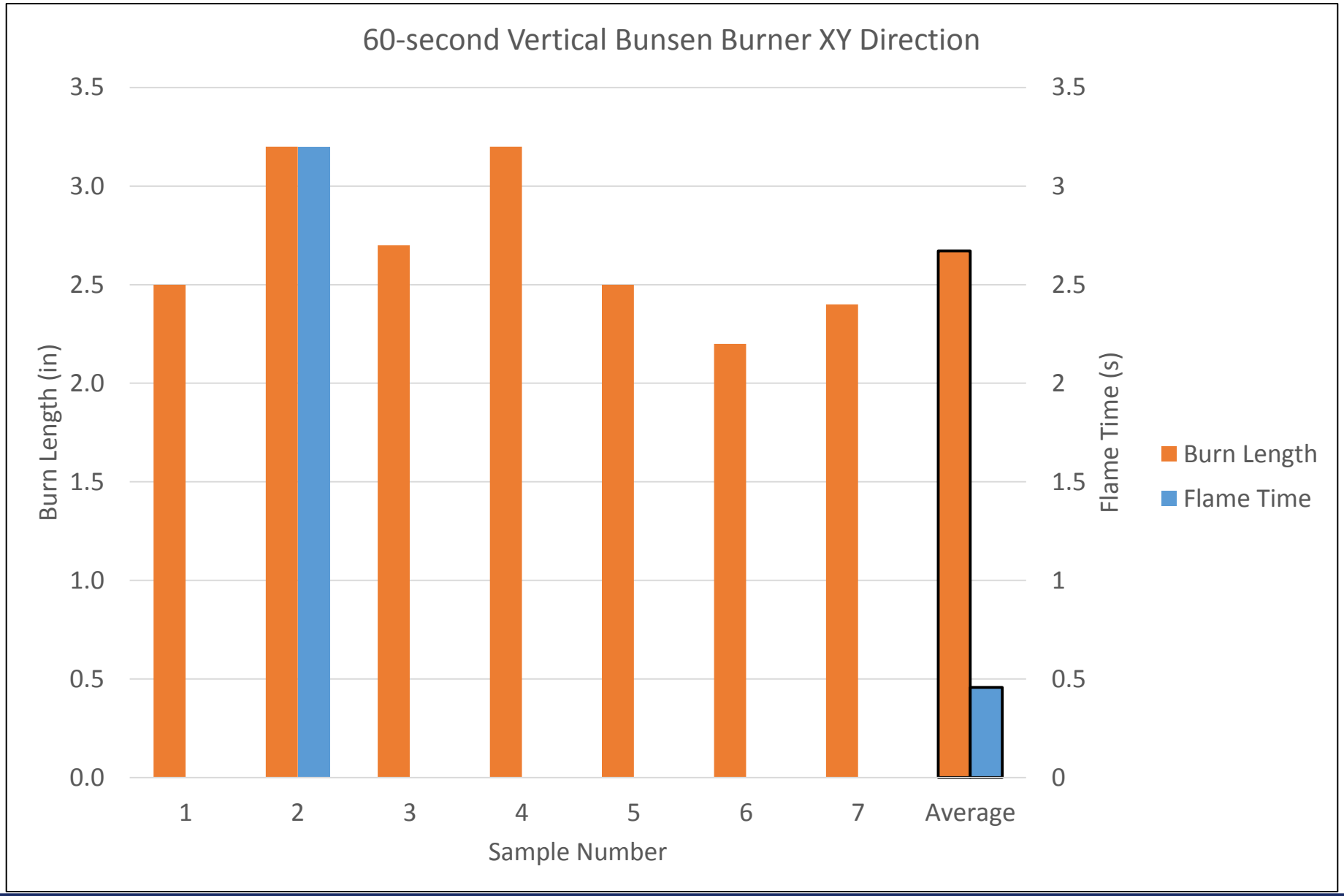


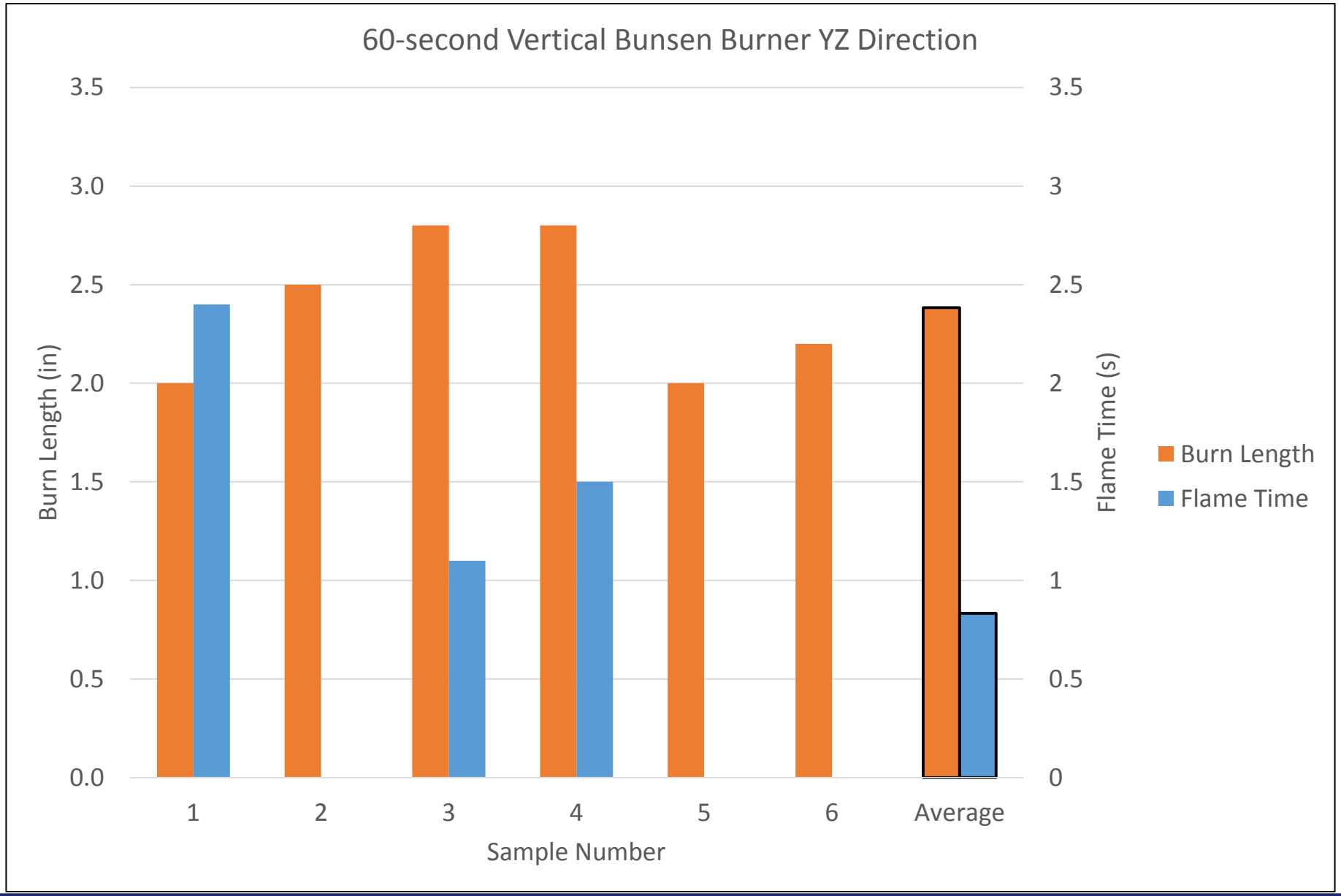
YZ-Direction

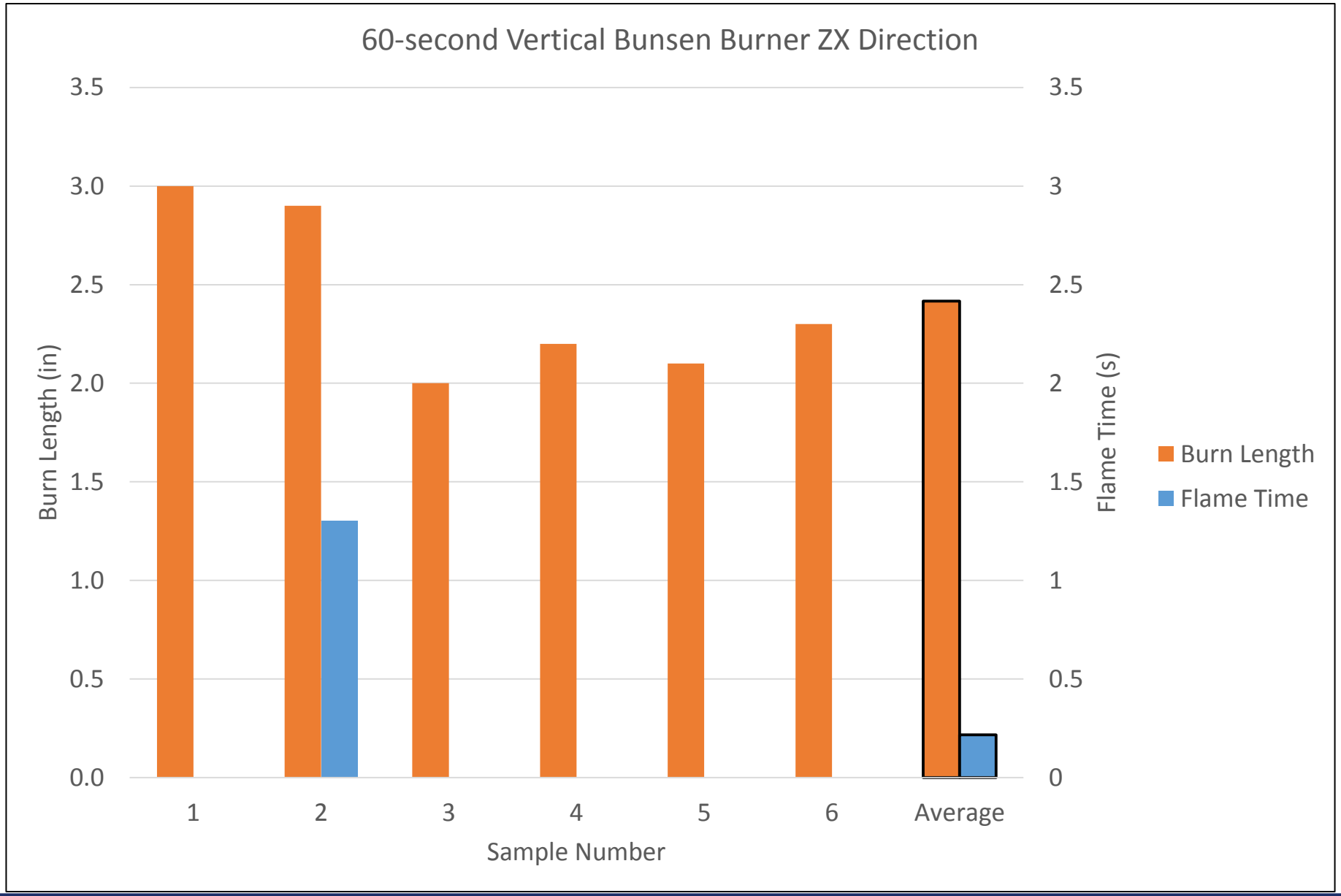


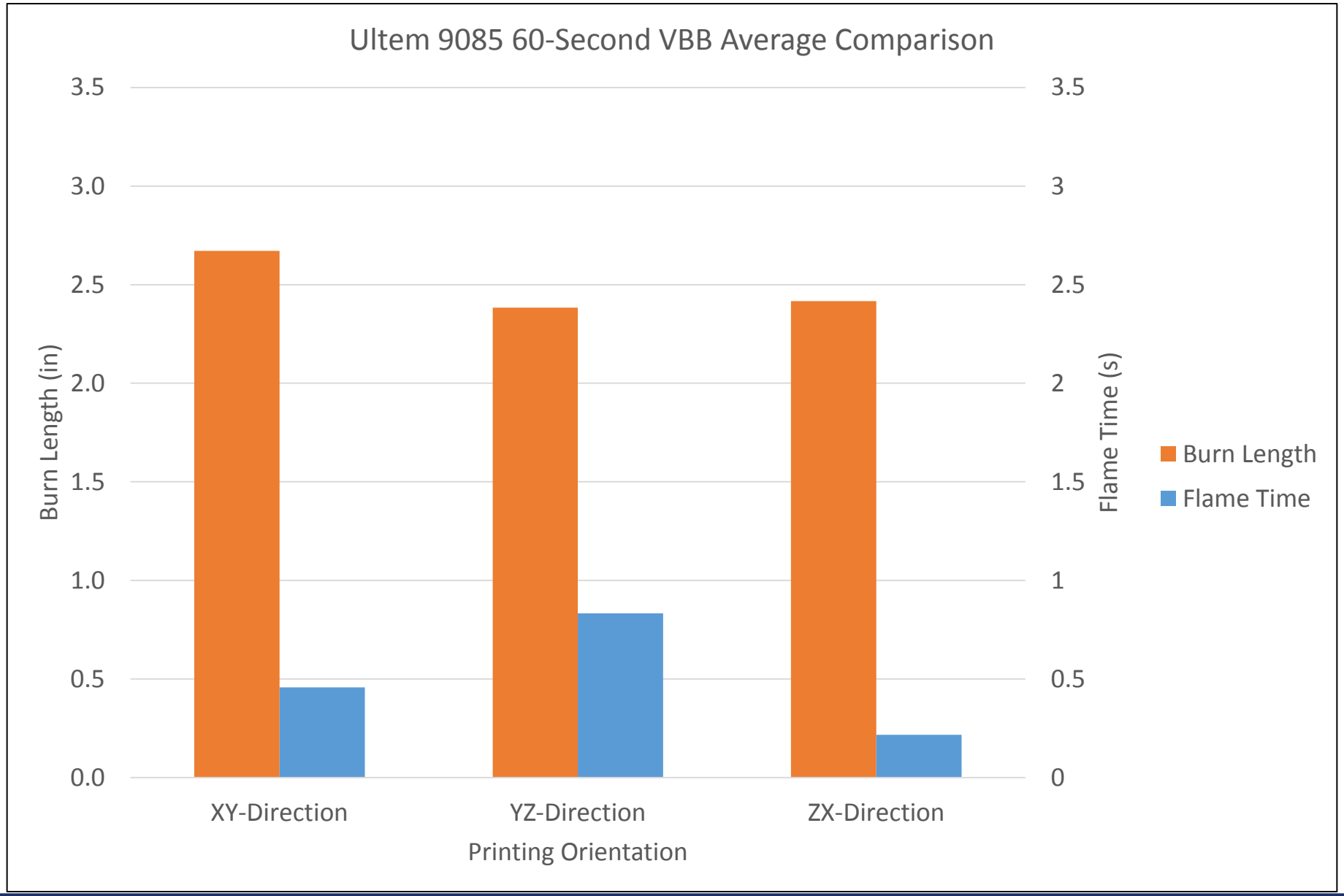
ZX-Direction (bottom half)

ZX-Direction (top half)


60-second Vertical Bunsen Burner XY Direction
Burn Length (in)
Flame Time (s)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
3.5
3
2.5
2
1.5
1
0.5
0
1
2
3
4
5
6
7
Average
Sample Number
Burn Length
Flame Time


60-second Vertical Bunsen Burner YZ Direction
Burn Length (in)
Flame Time (s)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
3.5
3
2.5
2
1.5
1
0.5
0
1
2
3
4
5
6
Average
Sample Number
Burn Length
Flame Time


60-second Vertical Bunsen Burner ZX Direction
Burn Length (in)
Flame Time (s)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
3
2
1
0
1
2
3
4
5
6
Average
Sample Number
Burn Length
Flame Time


Ultem 9085 60-Second VBB Average Comparison
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Burn Length (in)
3.5
3
2.5
2
1.5
1
0.5
0
Flame Time (s)
XY-Direction
YZ-Direction
ZX-Direction
Printing Orientation
Burn Length
Flame Time

- 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

Conclusion

- **Testing showed good repeatability when testing same orientation**
- **12-second VBB**
  - Fewer samples with flame time for YZ-direction than others
  - Longer flame time when more surface area is exposed (top half of ZX-direction)
- **60-second VBB**
  - More samples with flame time for YZ-direction than others
- **Flame time seemed dependent on how the shape of the material changed as it melted**

Questions?

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