RTCA Development of a New Flammability Test for Electronic Equipment

Presented to: Tenth Triennial International Aircraft Fire and Cabin Safety Research Conference
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Introduction

- **RTCA DO-160G is the current international standard for environmental testing of commercial avionics**
- **Section 26, Category C defines the flammability testing requirements for electronic housings and component parts**
- **The goal is to create a new test method that will be simpler and require less total testing while maintaining or improving the level of safety**
- **Change proposals for DO-160H were due October 10, 2022***
  - *Can still make minor changes before April 2023

Current Standards

- **Electronic equipment must be broken down into its individual parts and tested using the various Bunsen Burner tests**

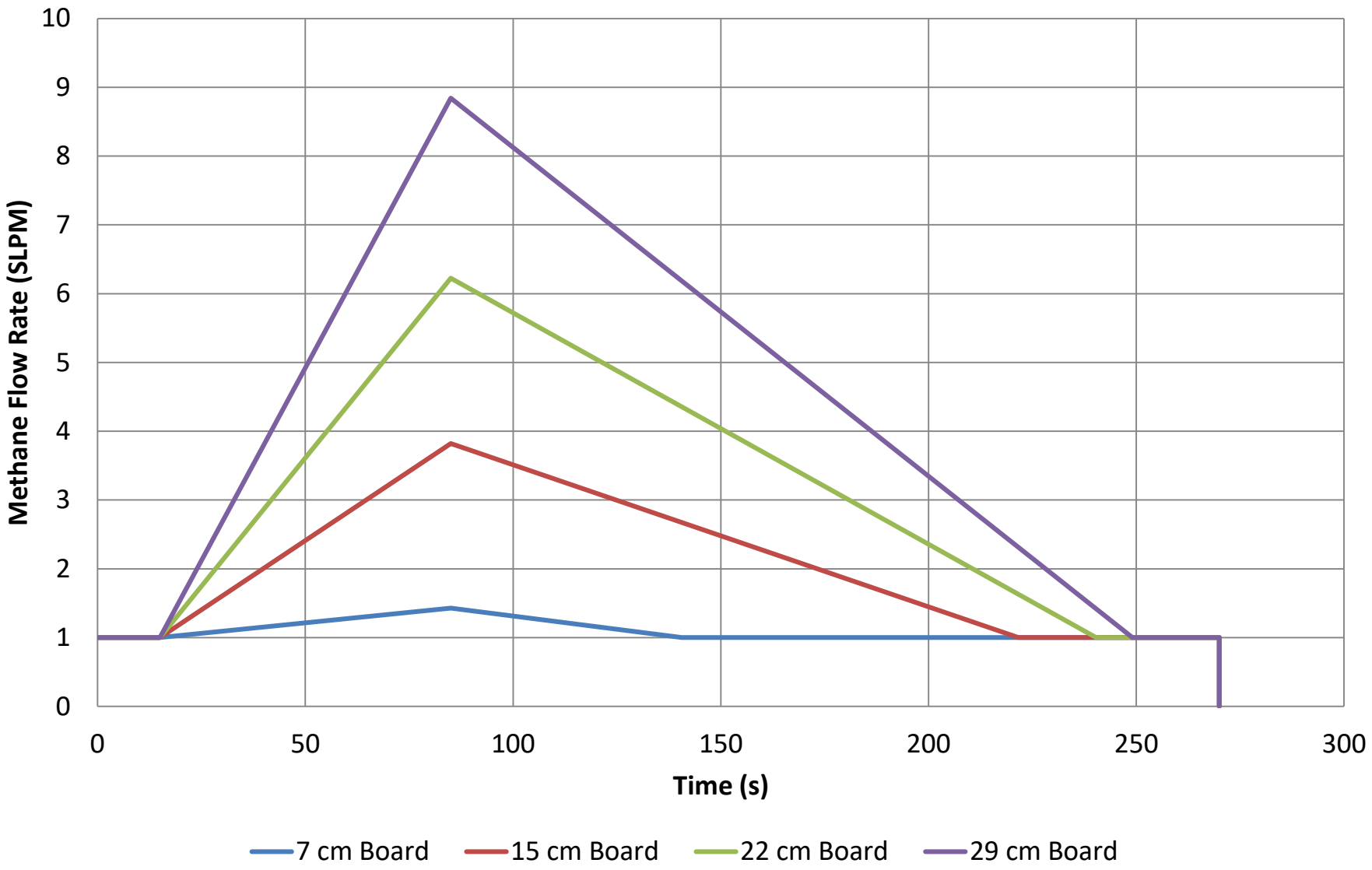
Table 26-2 Type of Test Determination

Components	Method	Paragraph
All materials other than rubber or elastomer parts, wire and cable	Vertical 12 second bunsen burner test	26.6.2
Rubber or elastomer parts	Horizontal bunsen burner test	26.6.3
Wire and cable	60 degree bunsen burner test	26.6.4

- **Small part exemptions**

New Test Method

- Based on telecom industry test ANSI T1.319
- 3/8” stainless steel tube with (11) 7/64” holes places 1/2” apart
- Methane Fuel with variable flow rate controlled by computer program
- Flow rate based on circuit board of certain size burning to completion
- Burner holes can be covered for smaller box or lower flow rates


Scaled Methane Flow Rate Examples
Methane Flow Rate (SLPM)
10
9
8
7
6
5
4
3
2
1
0
0
50
100
150
200
250
300
Time (s)
7 cm Board
15 cm Board
22 cm Board
29 cm Board

Test Procedure

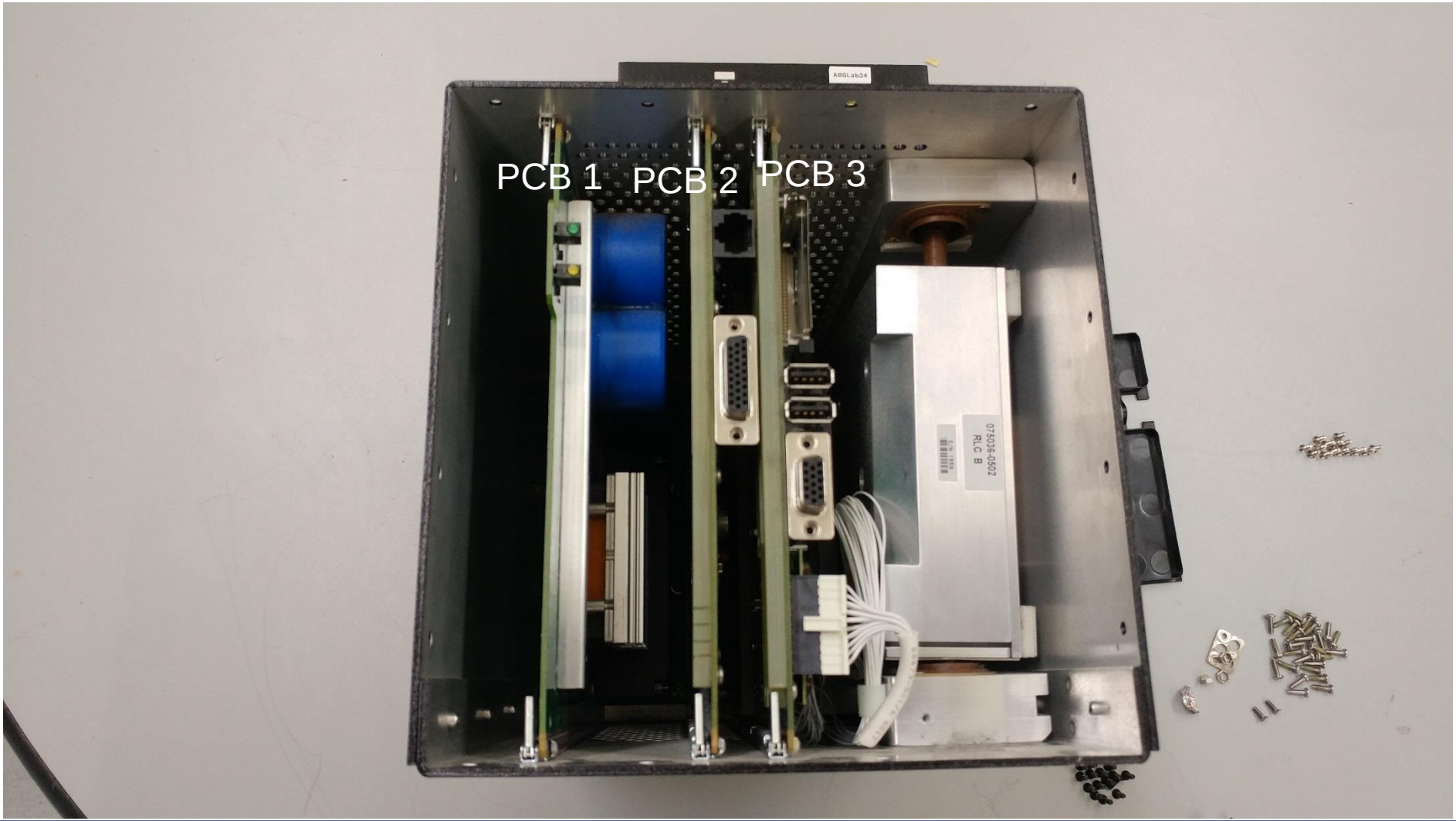
- **Identify printed circuit board (PCB) or other part with the highest fuel load**
- **Remove adjacent PCB and the burner is to be placed in the same general location aimed 45° towards PCB to be tested**
- **Drill 0.75” hole to insert burner**
- **Insert lit burner into enclosure and immediately start 270 s burner program**
- **Evaluate based on pass/fail criteria (maximum 12 second flame outside enclosure)**
- **Certain equipment may require more than one test depending on potential fuel load inside box**

Test Example

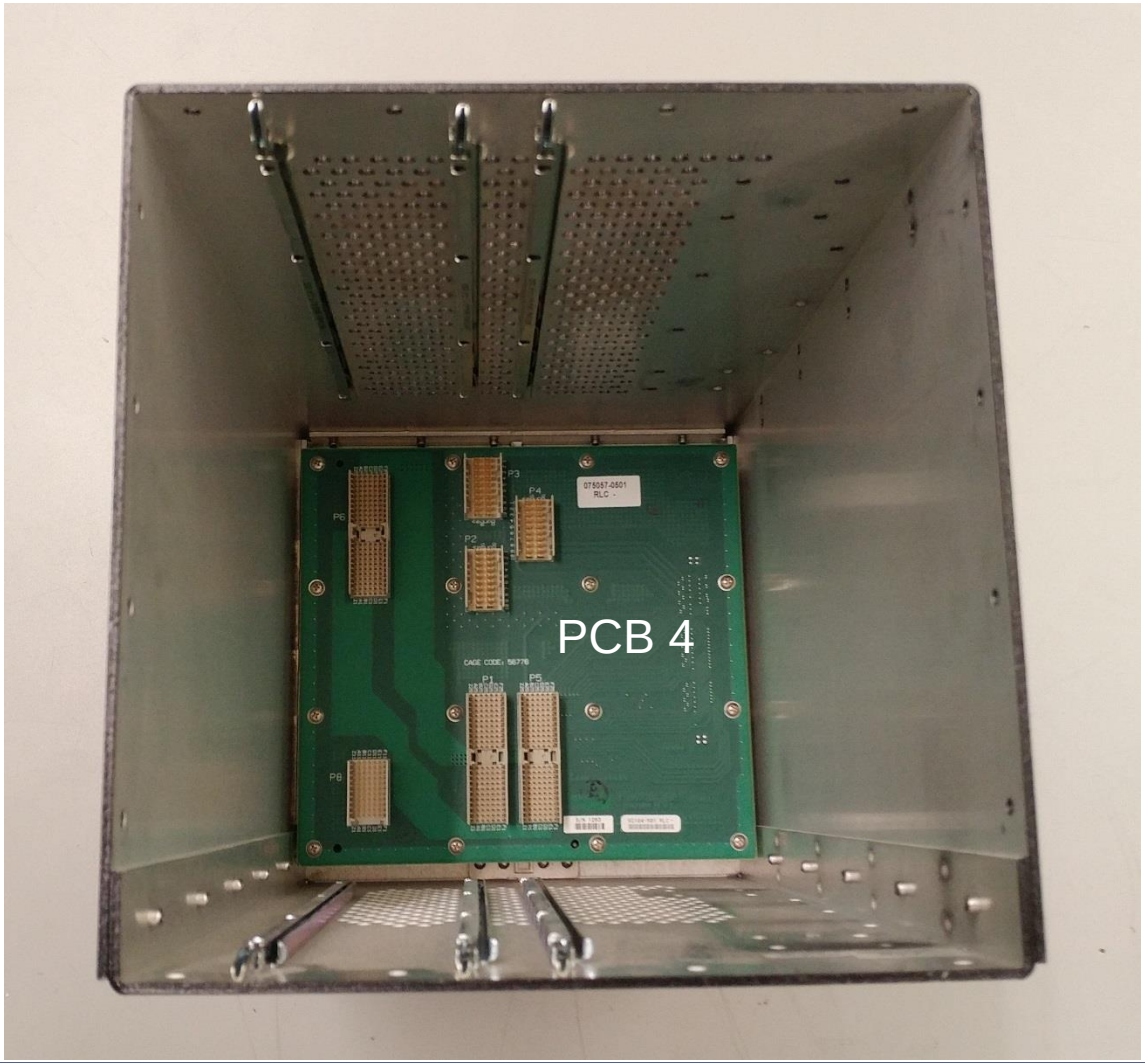
- 12.5” × 7.5” × 7.5” box
- Ventilation on top and bottom only
- 18.6 cm PCB height
- 1 SLPM initial flow rate, 5.02 SLPM max
- Tested as part of a round robin with 4 labs

Test Example

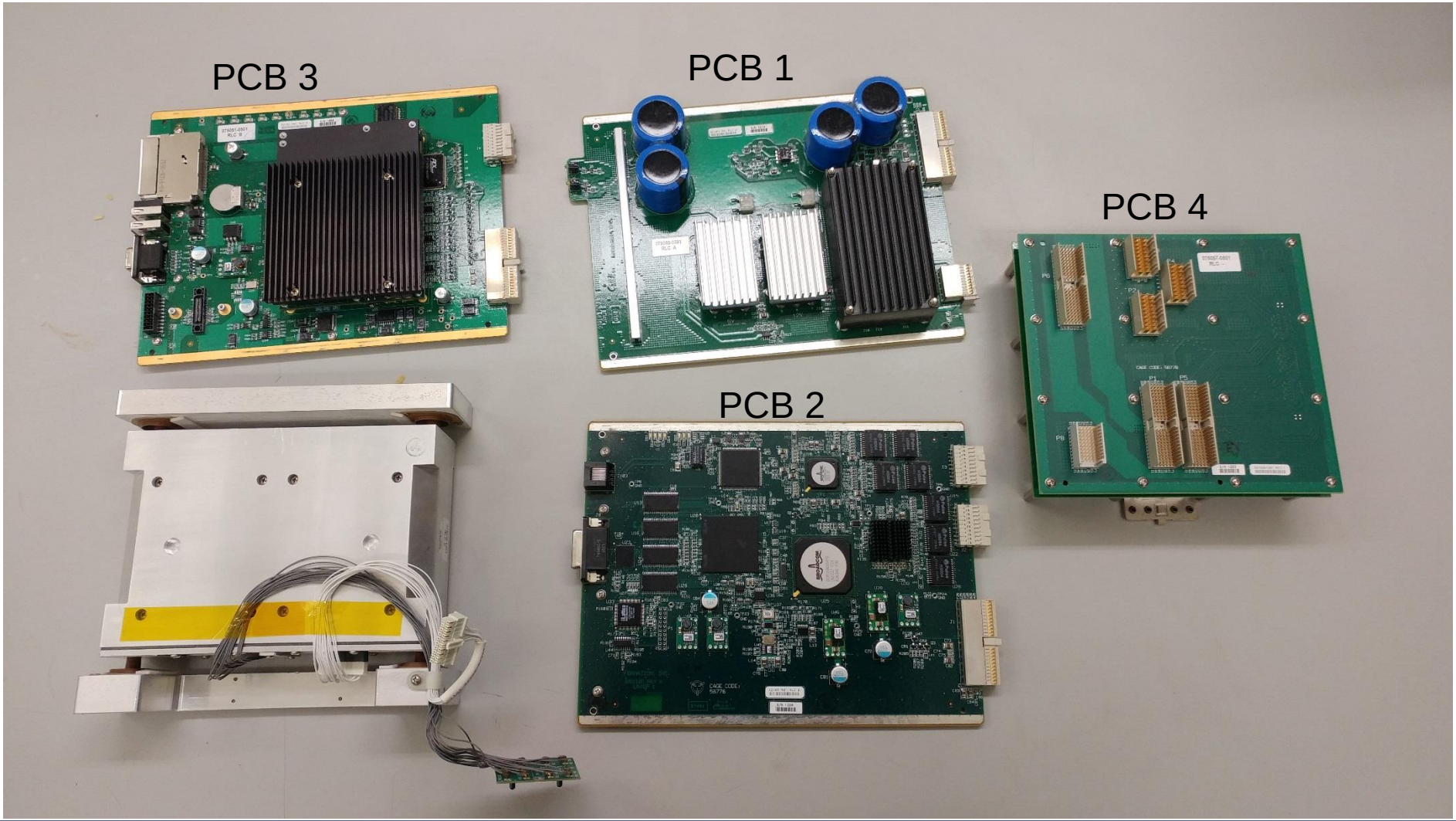
Test Example



Test Example

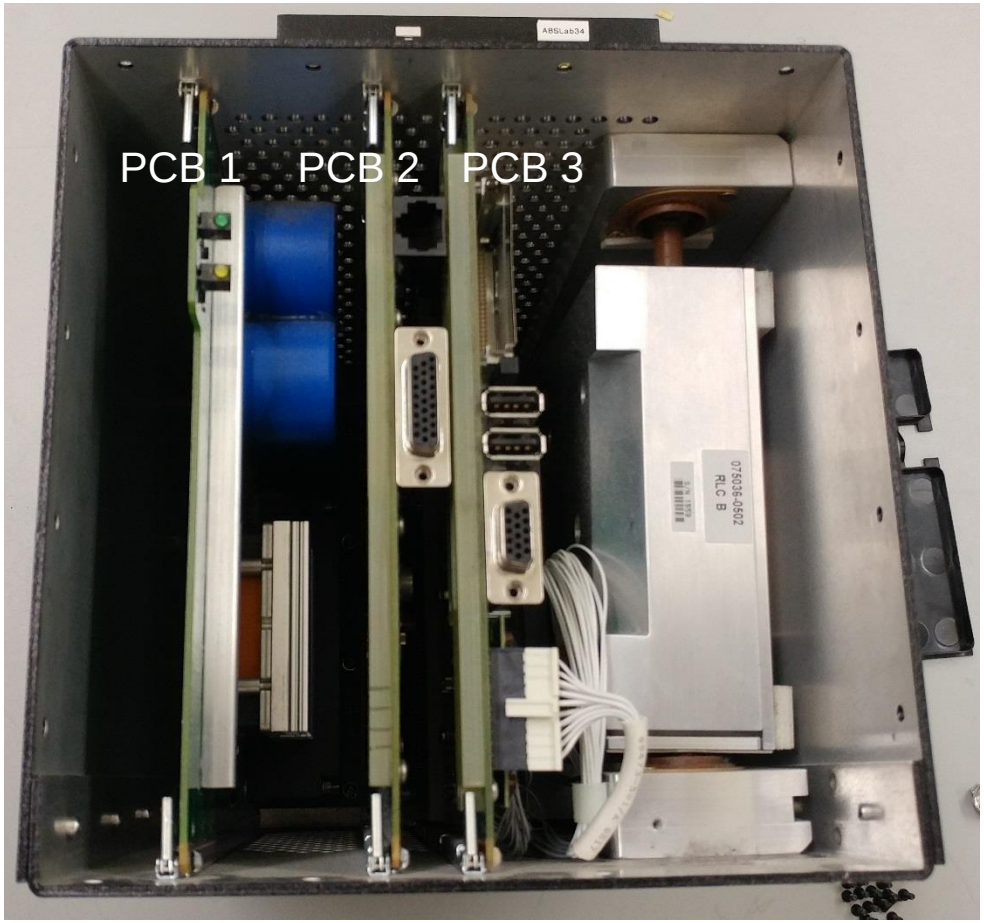


Test Example

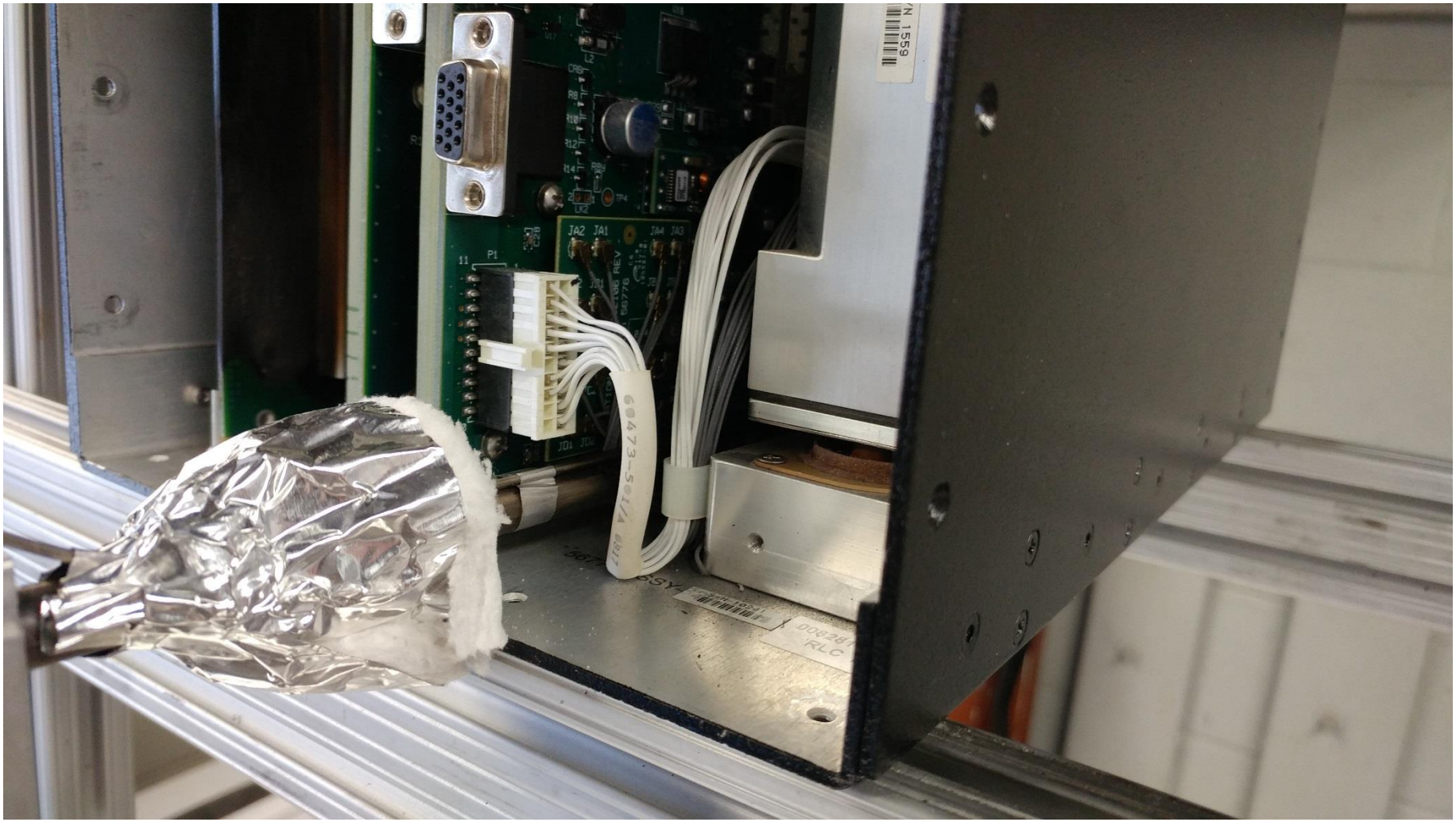


Burner Placement

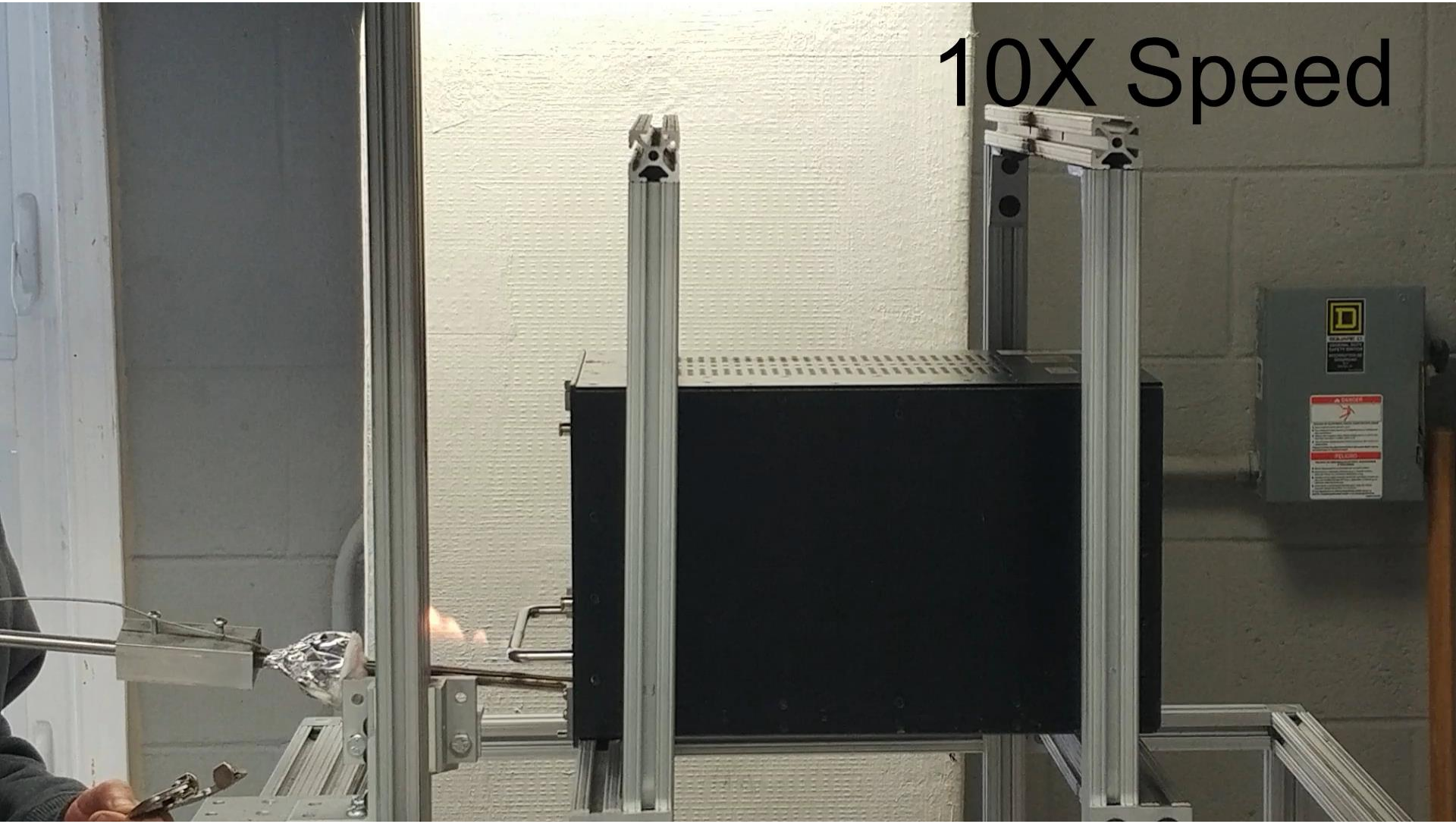
- Likely need two burns to substantiate this equipment
- PCBs are made of same base material, so need to test based on features on PCBs
- Burn 1: PCB 1 due to large capacitors
- Burn 2: PCB 3 due to lithium battery and wire bundle



PCB 3



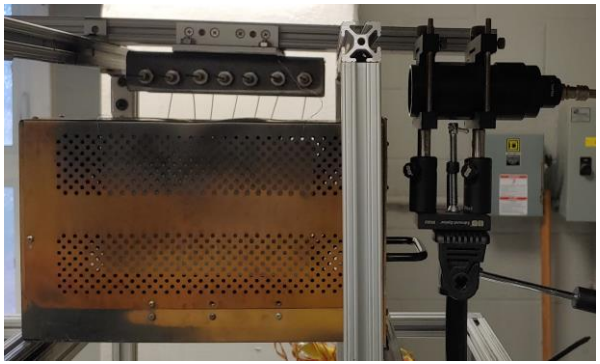
PCB 3: Battery exploded 41 seconds into test, flames escaped for 0.33 seconds, explosion extinguished burner flame



Pass/Fail Criteria

- **Maximum flame time outside of box for 12 seconds**
- **Methods tested:**
  - Visual method with stop watch
  - Indicator material placed above box
  - Thermocouple rake
  - Infrared camera
  - Infrared sensor (photodiode w/ 825 – 875 nm bandpass filter)

Thermocouple Rake



IR Sensor

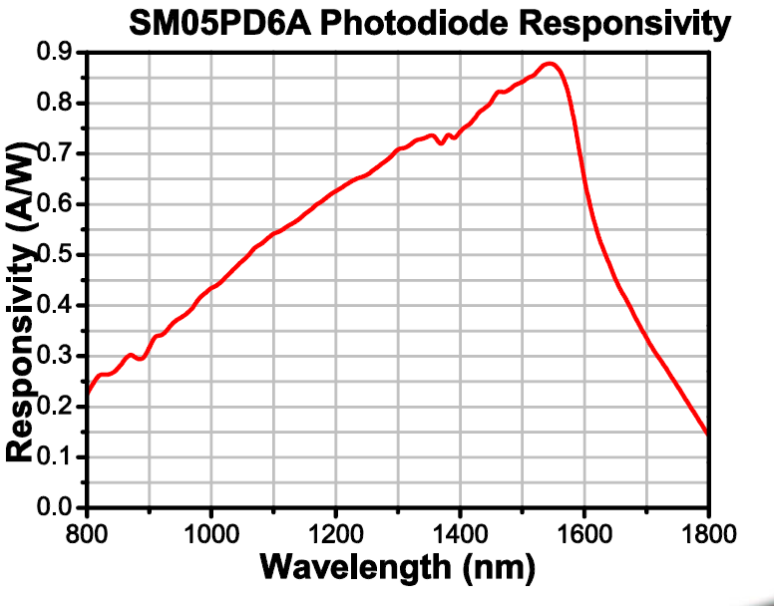
Photodiode #1 Response	Voltage
Smoke	0.01<V<3.73
Flames	0.73<V<10.24

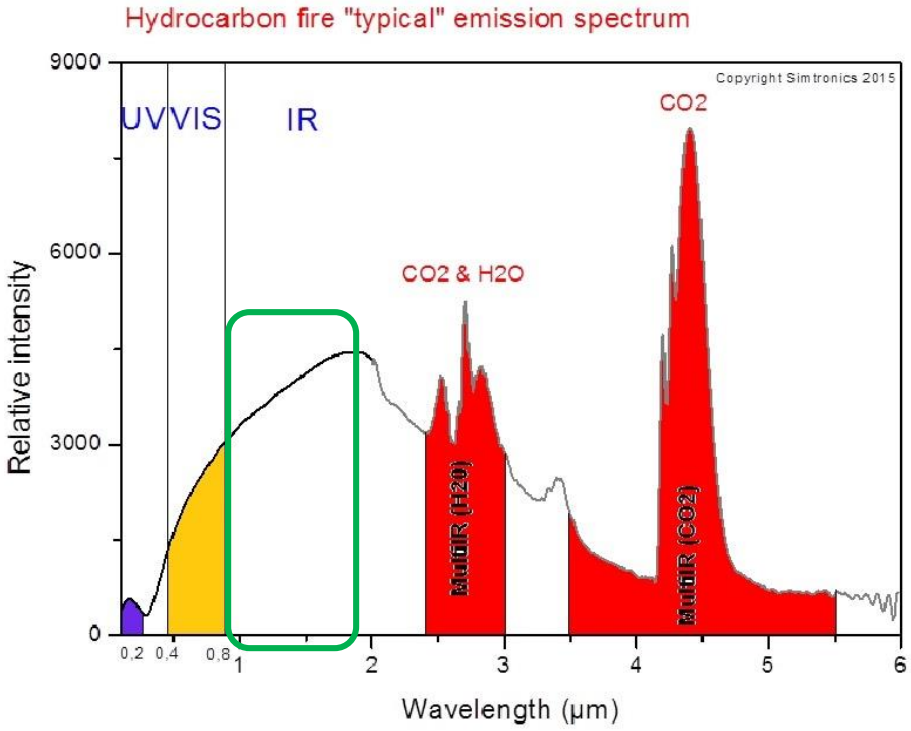
Strategies Tried since May 2022

- Thorlabs IR Ge Photodiode (PD #2)
- LED Flashlight Exploration for Smoke Attenuation
- Thorlabs Visible-Light Si Photodiode with Red-Orange Bandpass Filter (PD #3) and Blue LED
- Camera System with Blue LED

Thorlabs IR Ge Photodiode (PD2)

Thorlabs





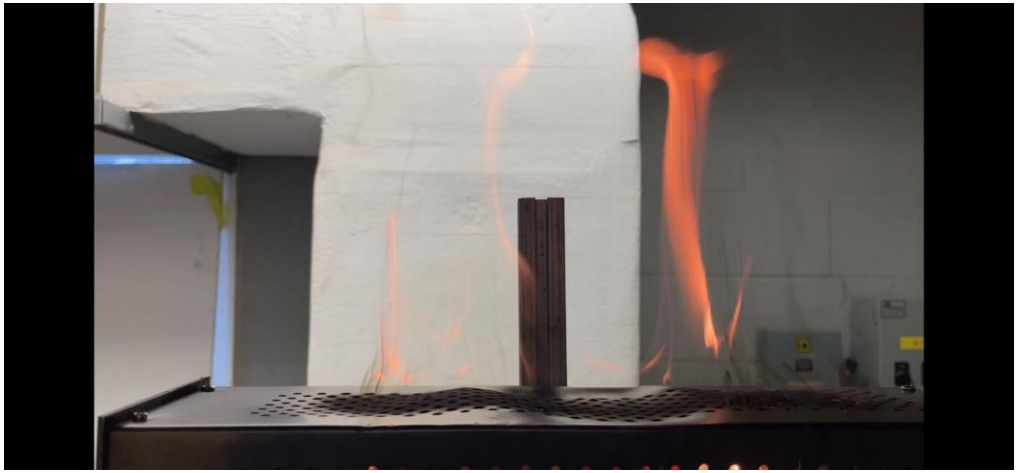
Photodiode #2

PD lens center aligned with top of box and 1” away from box edge

PD sees inside the box

Need more than one PD to cover all sides of box

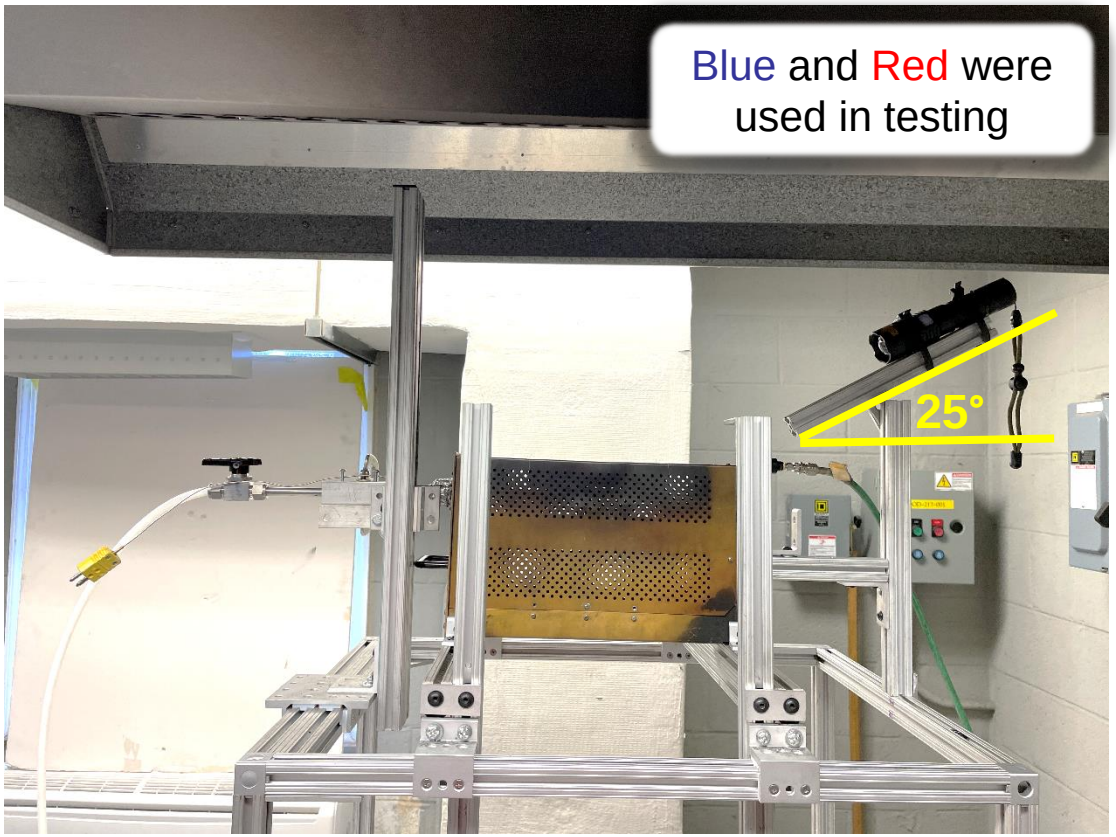
Leaving lights on, translucent flames hard to see



Photodiode #2 Response	Room Lights On, Windows blocked
Smoke Output	0.012 < V < 2.01
Flame Output	0.334 < V < 10.24

LED Flashlight Smoke Attenuation

- PD lens center aligned with top of box and 1” away from box edge
- Flashlight positioned above and behind PD at a 25° downward angle



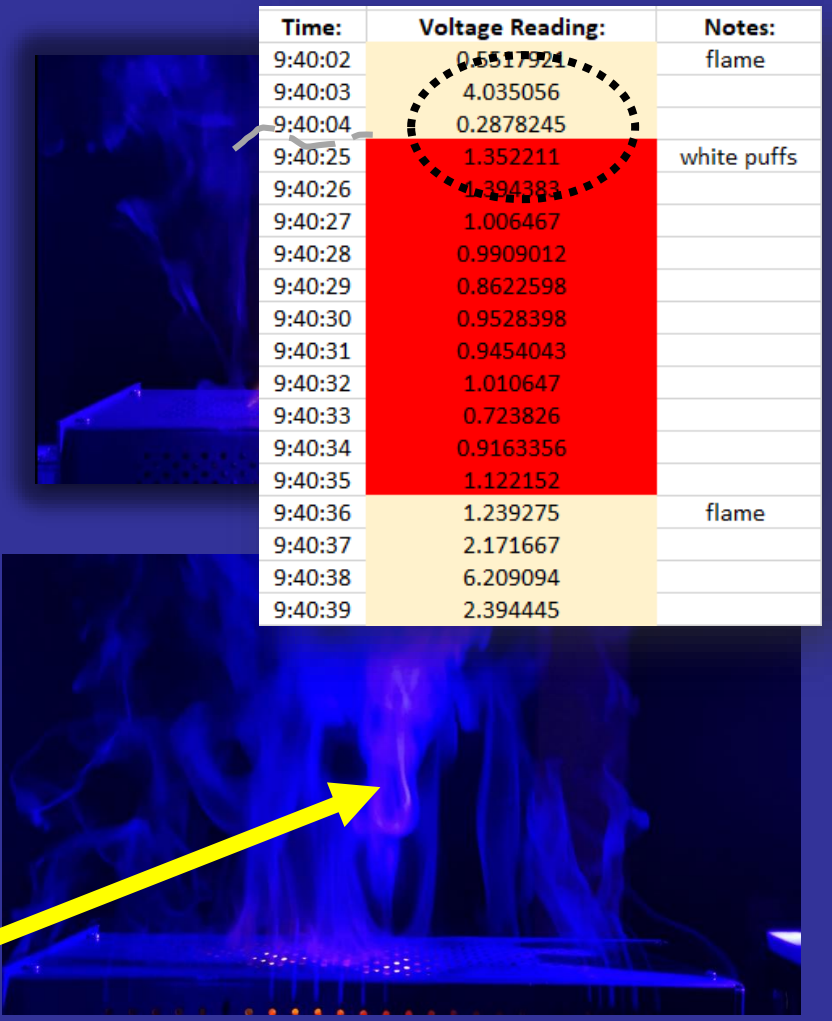
Room lights were turned off, and windows were blocked for these tests

LED Flashlight Smoke Attenuation

- **Findings**

  - \+ – Blue light offered great visual contrast for the human observer. Fire was a deep orange, and translucent flaming could be seen much better than in ambient lighting.

  - – – White cloud like regions could be seen among the smoke, so human observer is unable to tell what this phenomenon is and the PD picks it up (elevated voltage data points)



Time:	Voltage Reading:	Notes:
9:40:02	0.5517921	flame
9:40:03	4.035056	
9:40:04	0.2878245	
9:40:25	1.352211	white puffs
9:40:26	1.394383	
9:40:27	1.006467	
9:40:28	0.9909012	
9:40:29	0.8622598	
9:40:30	0.9528398	
9:40:31	0.9454043	
9:40:32	1.010647	
9:40:33	0.723826	
9:40:34	0.9163356	
9:40:35	1.122152	
9:40:36	1.239275	flame
9:40:37	2.171667	
9:40:38	6.209094	
9:40:39	2.394445	

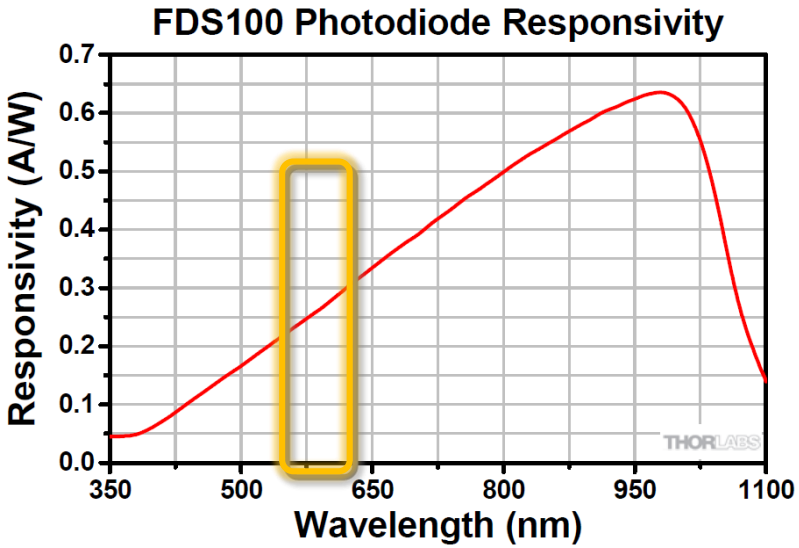
Photodiode #3

- PD lens center aligned 1” above top and 0.5” away from box edge

Mounted Si Photodiode

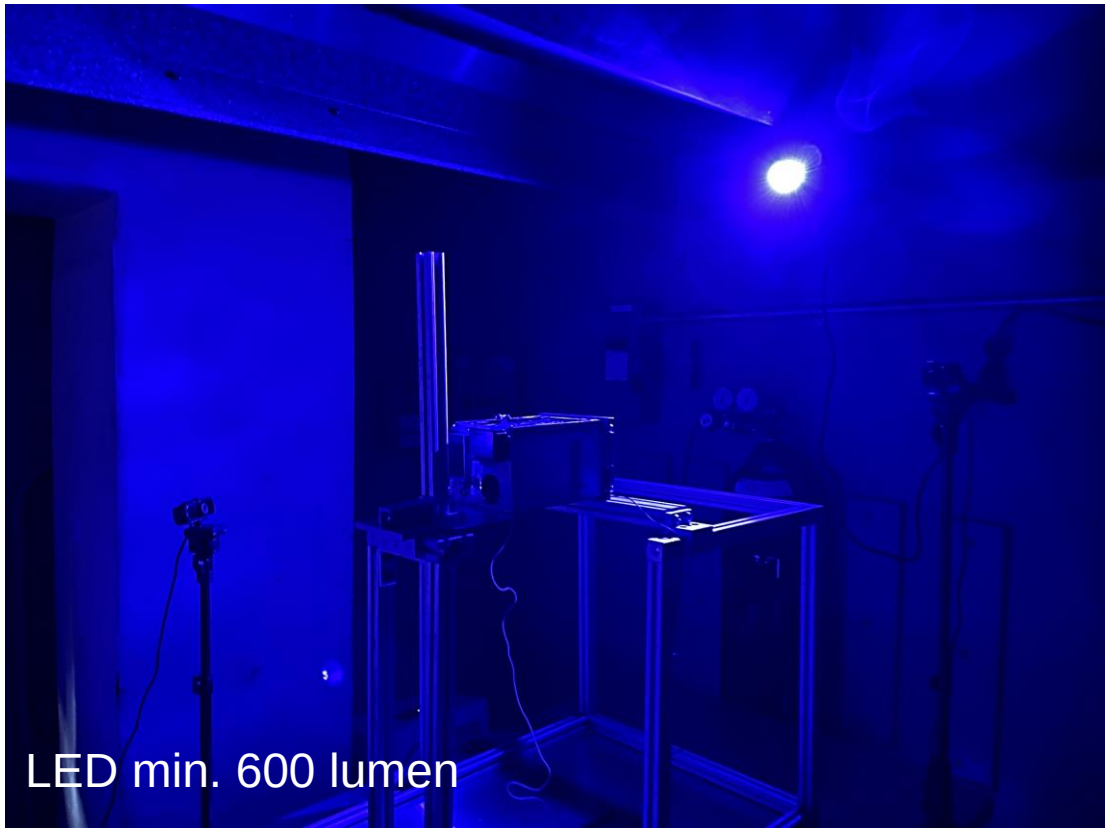
FB600-40 - Ø1" Bandpass Filter, CWL = 600 ± 8 nm, FWHM = 40 ± 8 nm

Thorlabs



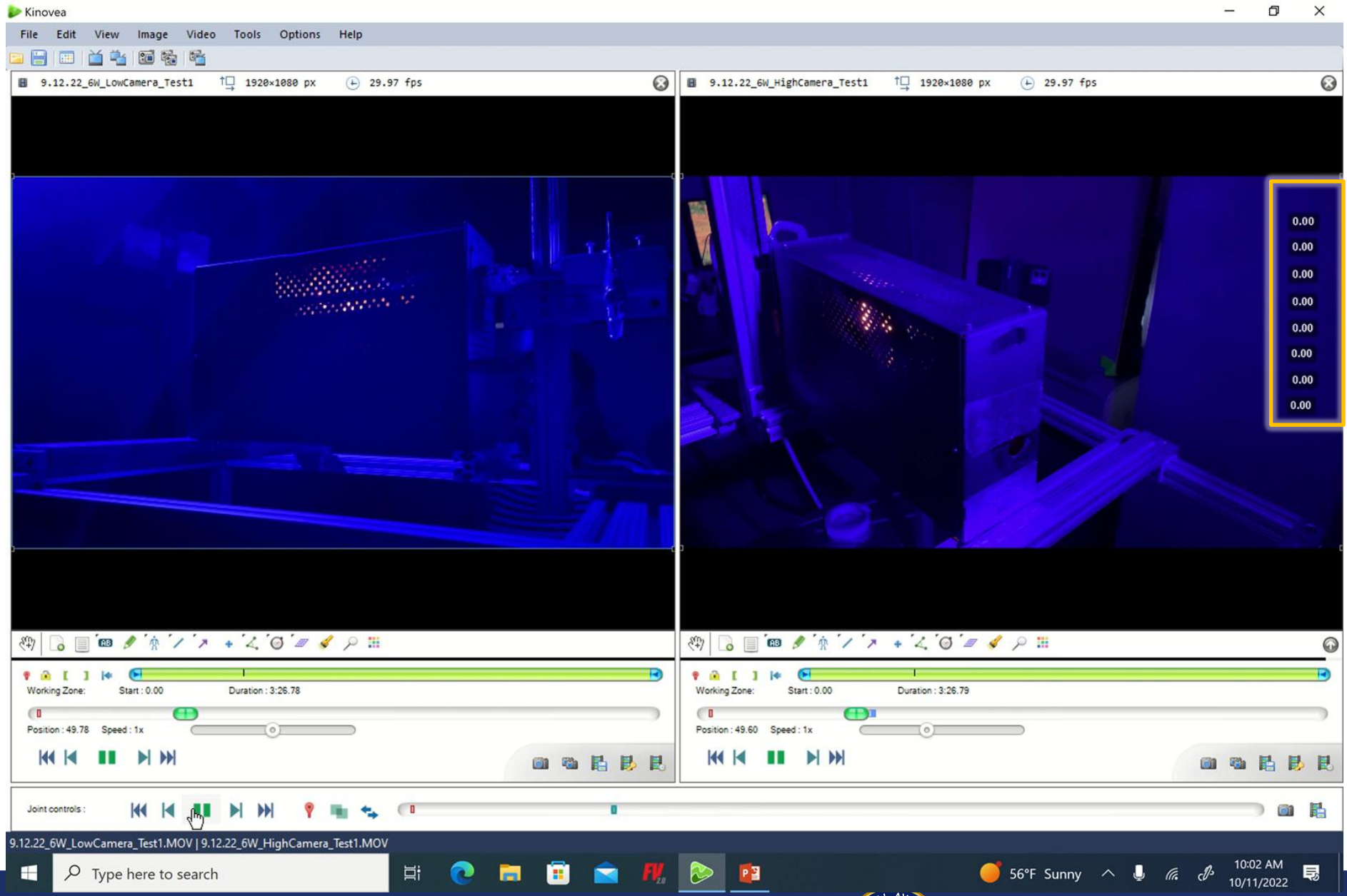
Photodiode #3 Response	Room Lights Off, Windows Blocked, Blue Light
Smoke Output	0.007 < V < 1.13
Flame Output	0.018 < V < 5.397

Camera System



minimum camera requirements:
1080-pixel resolution
30 frames per second (fps)
field-of-view (FOV) of 90 degrees

2 cameras enable video coverage all 6 potentially-vented sides of an enclosure


Kinovea
File Edit View Image Video Tools Options Help
9.12.22_6W_LowCamera_Test1 1920×1080 px 29.97 fps
9.12.22_6W_HighCamera_Test1 1920×1080 px 29.97 fps
0.00
0.00
0.00
0.00
0.00
0.00
0.00
0.00
Working Zone: Start : 0.00 Duration : 3:26.78
Position : 49.78 Speed : 1x
Working Zone: Start : 0.00 Duration : 3:26.79
Position : 49.60 Speed : 1x
Joint controls :
9.12.22_6W_LowCamera_Test1.MOV | 9.12.22_6W_HighCamera_Test1.MOV
Type here to search
56°F Sunny
10:02 AM
10/11/2022

Next Steps

- **Find cameras of better quality**
  - Webcams don't work well in the low-light/blue-light condition
- **Round-Robins:**
  1) To substantiate the video analysis aspect
  2) To validate the test method, pending video analysis success
- **Further standardize the detection method for DO-160 rev H, section 26 for submittal by March 2023**

Questions?

- **Contact Information:**

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