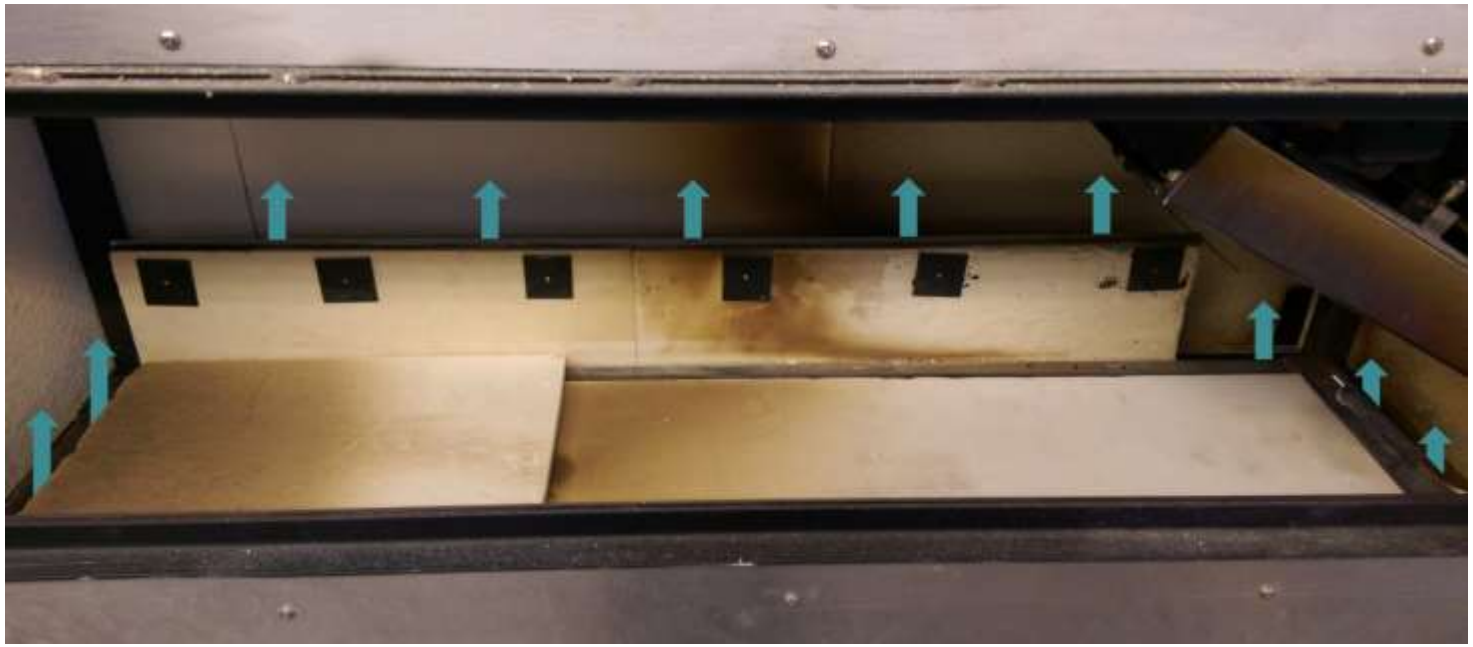
Radiant Panel Update

Presented to: International Aircraft Materials Fire Test Working Group Meeting
By: Steven Rehn
Date: 6/7/2017

Introduction

- **Round Robin results from 2016 varied widely**
- **Biggest difference between machines was the gaps around the drawer which allows outside air to flow in**
- **There is nothing in the rule about what size these gaps should be**



Previous Testing

- **Used metalized PEEK material with too much flame retardant so there was almost no flame propagation or after flame time on any test**
- **Results presented in March 2017 were inconclusive**

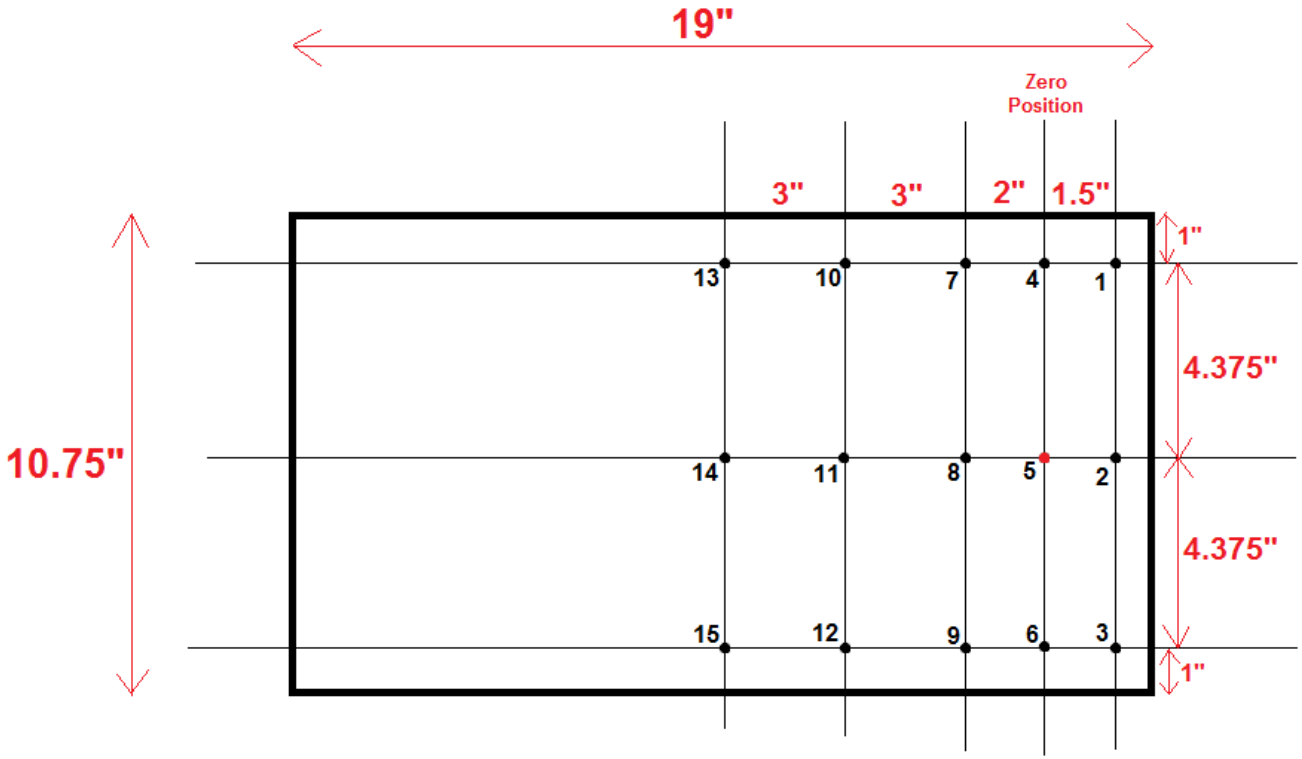
Air Flow Study

- **Experiment to determine the effect these air gaps have on this test method**
- **Goal is to change the handbook to make test results more repeatable across all labs**
- **Changes will likely involve standardizing the size of the air gaps around the drawer**
- **This experiment will determine how best to do that**

Air Flow Study

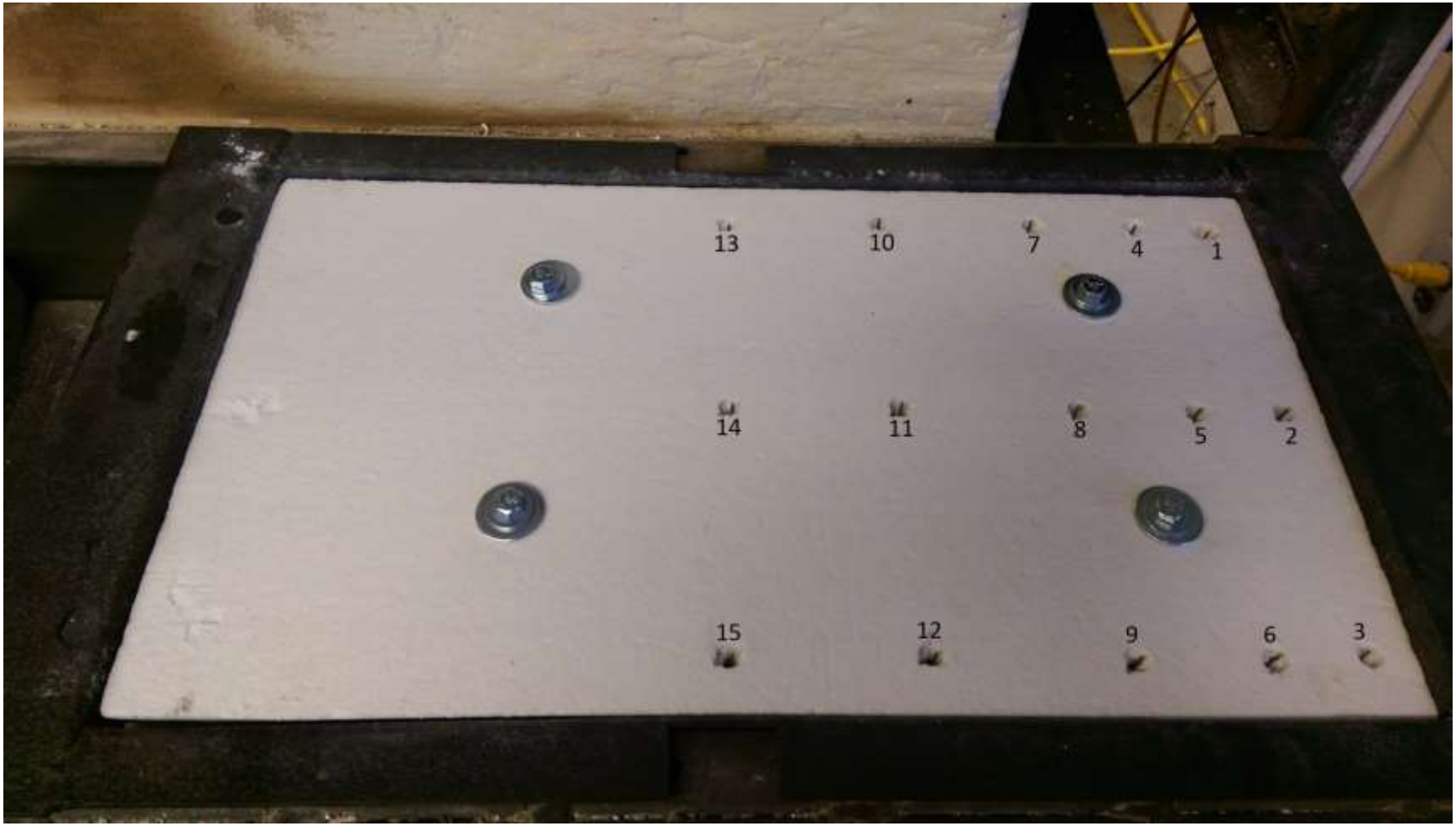
- **Conduct tests with 3 different air gap levels**
  - Fully open (different for each lab)
  - Partially open (1/2” gap in back and both sides)
  - Fully closed
- **Place array of thermocouples in the retaining frame to test how material temperature changes**
- **Material tests with Metalized PEEK – 20 samples per air gap setting for each lab**
- **Four participating labs:**
  - FAA Technical Center – Steve Rehn
  - Boeing – Randy Smith
  - Damping Technologies Inc. (DTI) – Kris Notestine
  - Triumph Insulation Systems (TIS) – Brad Gustavesen

Air Flow Study

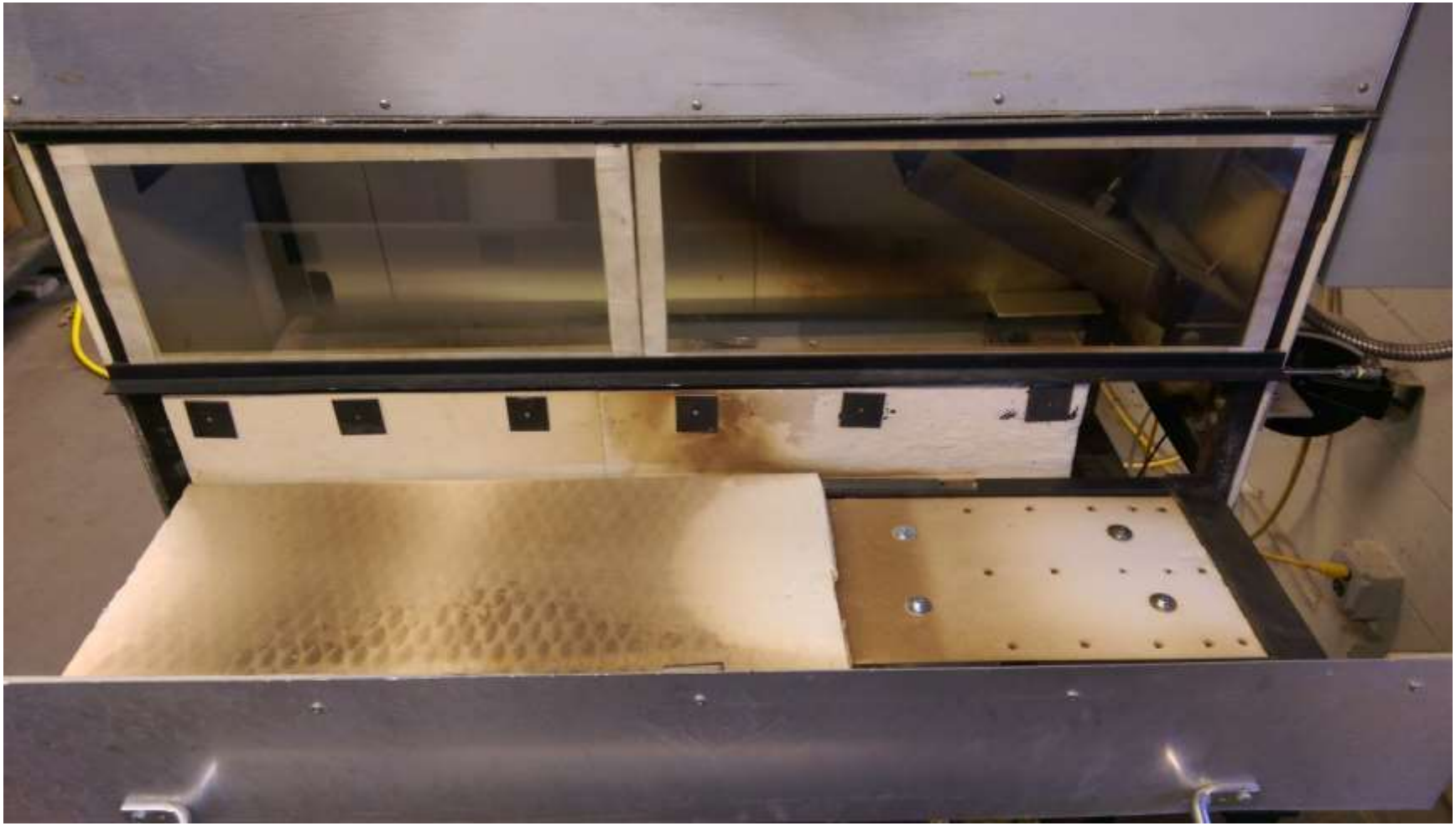


- Array of 15 thermocouples placed inside retaining frame
- Tested at each air-gap configuration
- Calibrated with calorimeter to 1.5 Btu/ft^{2}s each time
- Temperature averaged over 5 minute period
- Array sent around to each lab so there were no differences in thermocouples

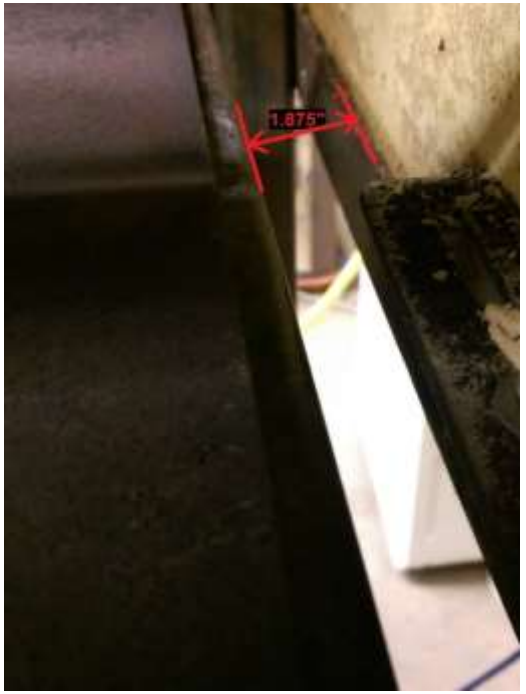
Air Flow Study



Air Flow Study



Fully Open



Left: 2.125”

Rear: 2.25”

Right: 1.875”

	FAA	DTI	Boeing	TIS
Right Gap (in)	1.875	3	2.5	2.5
Left Gap (in)	2.125	8.3	2.5	2.25
Rear Gap (in)	2.25	1.2	0.5	1
Front Gap (in)	0	0	1.5	1.5

Partially Open

½” Gap on each side

Left

Rear

Right

Fully Closed

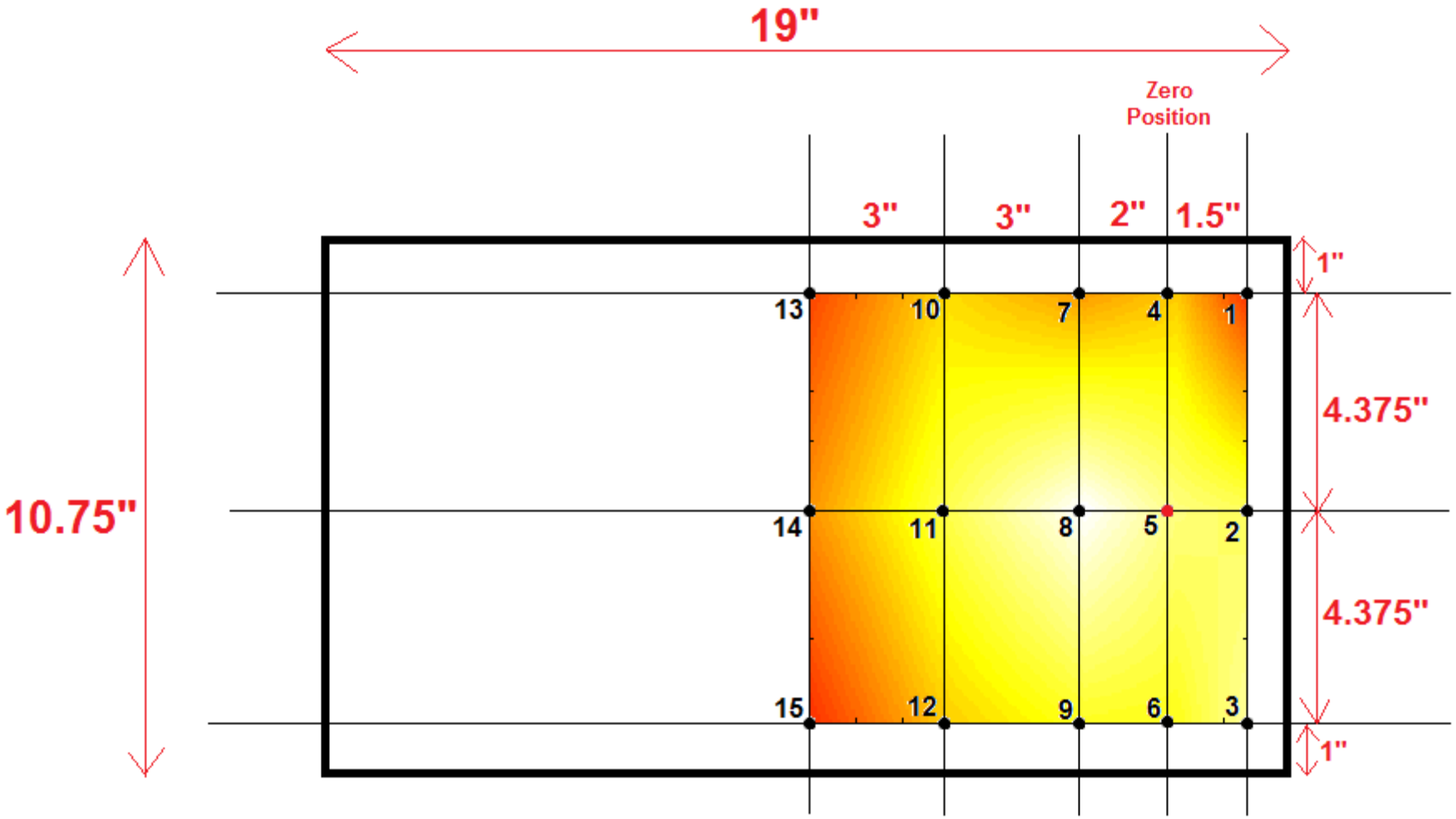
Left

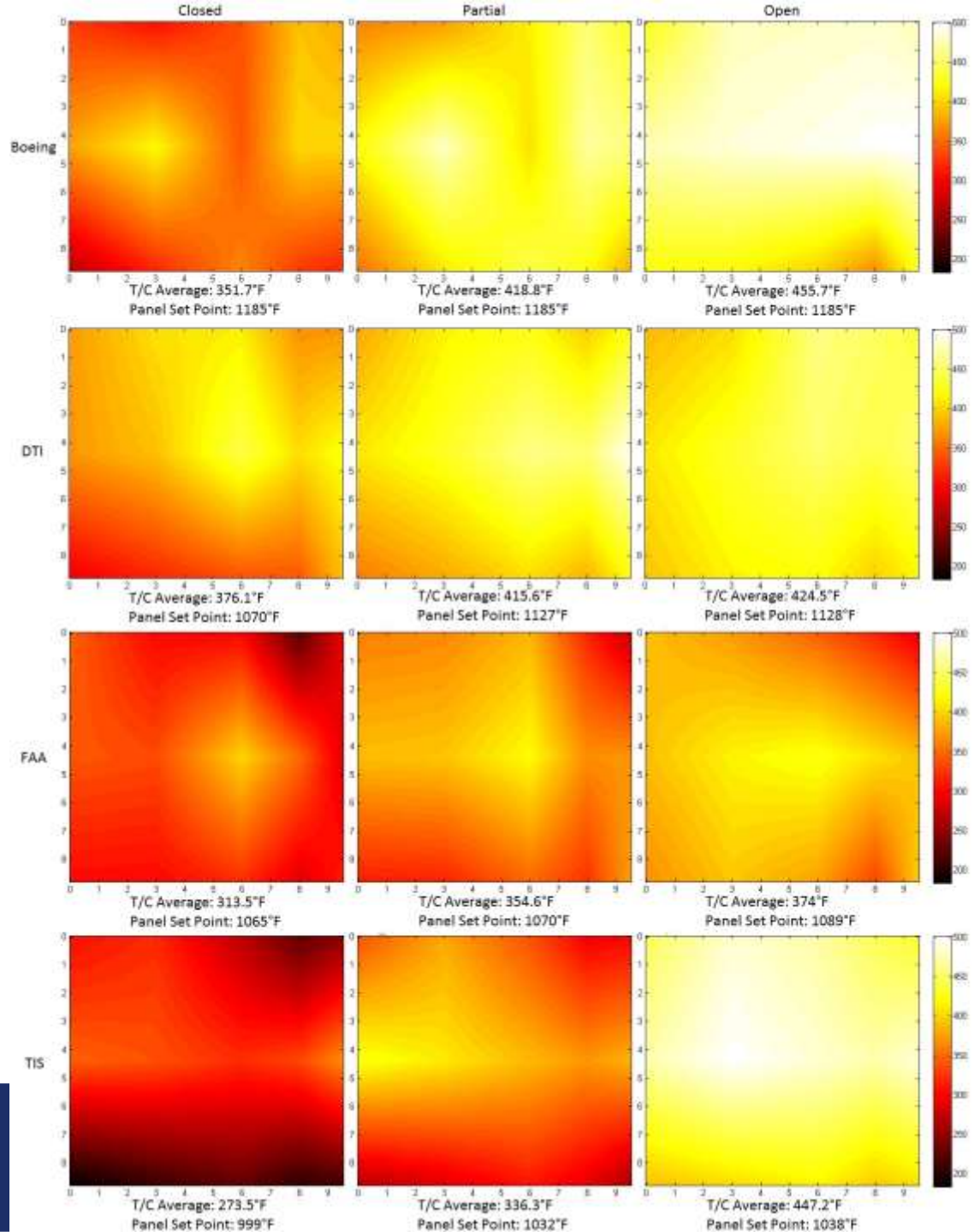
Rear

Right

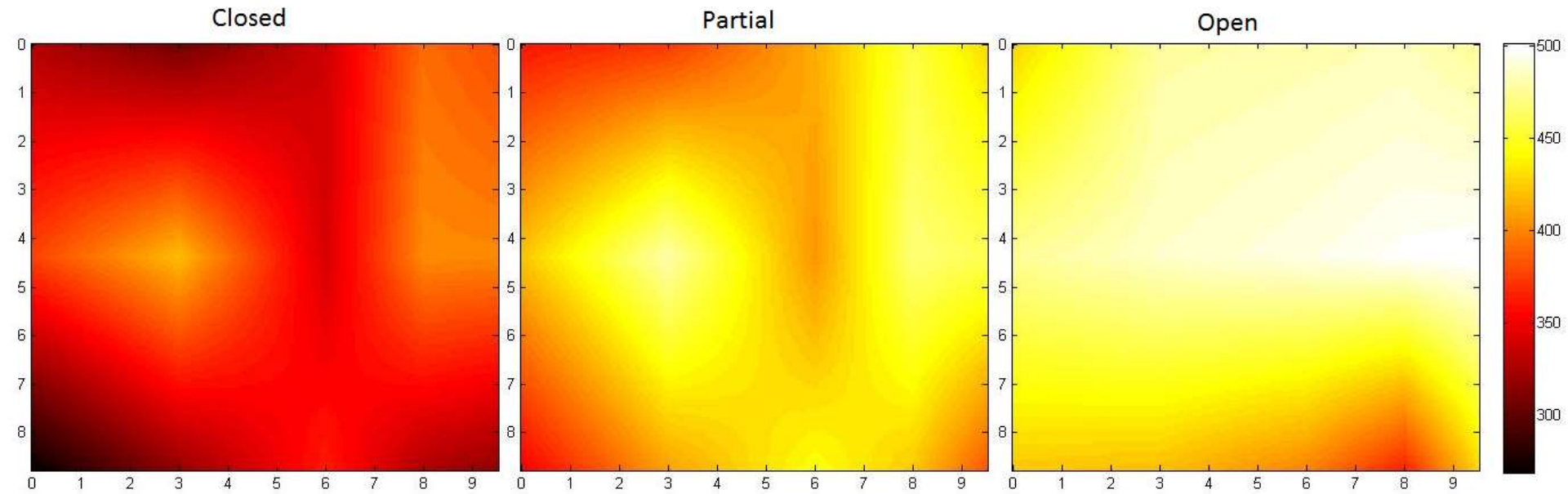
Fully Closed - DTI

Air Flow Study




Closed
Partial
Open
Boeing
T/C Average: 351.7°F
Panel Set Point: 1185°F
T/C Average: 418.8°F
Panel Set Point: 1185°F
T/C Average: 455.7°F
Panel Set Point: 1185°F
DTI
T/C Average: 376.1°F
Panel Set Point: 1070°F
T/C Average: 415.6°F
Panel Set Point: 1127°F
T/C Average: 424.5°F
Panel Set Point: 1128°F
FAA
T/C Average: 313.5°F
Panel Set Point: 1065°F
T/C Average: 354.6°F
Panel Set Point: 1070°F
T/C Average: 374°F
Panel Set Point: 1089°F
TIS
T/C Average: 273.5°F
Panel Set Point: 999°F
T/C Average: 336.3°F
Panel Set Point: 1032°F
T/C Average: 447.2°F
Panel Set Point: 1038°F

Boeing

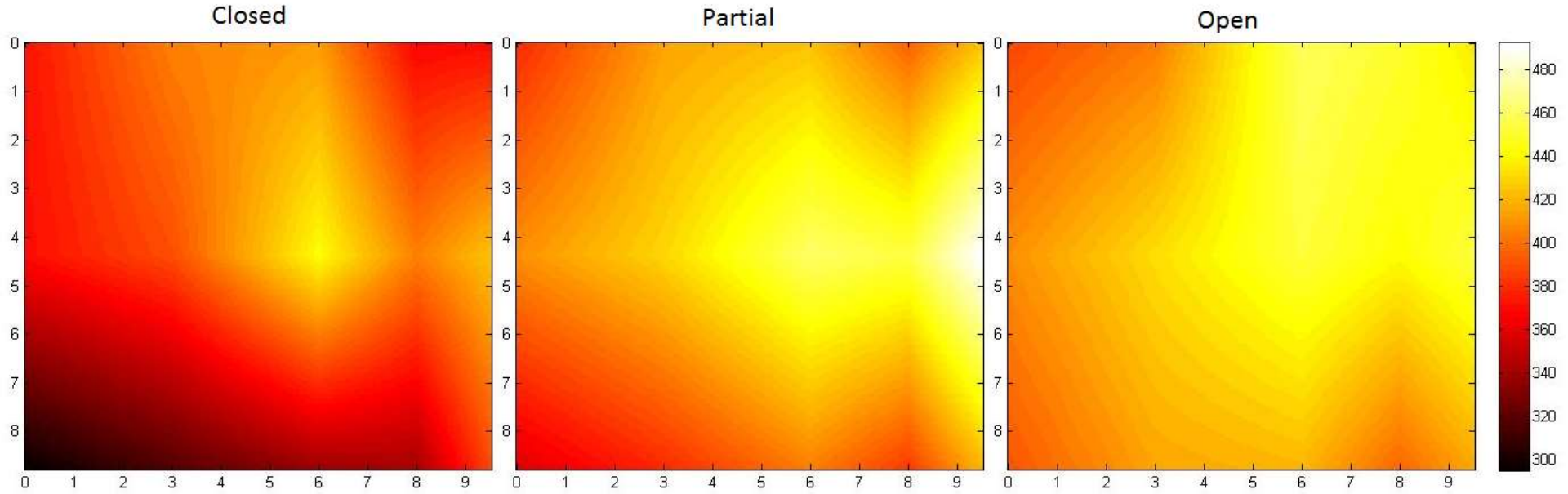


T/C Average: 351.7°F
Panel Set Point: 1185°F
3 Position Check:
Set Point: 1127°F
Position 0: 1.50 Btu/ft^{2}s
Position 1: 1.36 Btu/ft^{2}s
Position 2: 1.37 Btu/ft^{2}s

T/C Average: 418.8°F
Panel Set Point: 1185°F
3 Position Check:
Set Point: 1150°F
Position 0: 1.50 Btu/ft^{2}s
Position 1: 1.48 Btu/ft^{2}s
Position 2: 1.42 Btu/ft^{2}s

T/C Average: 455.7°F
Panel Set Point: 1185°F
3 Position Check:
Set Point: 1170°F
Position 0: 1.50 Btu/ft^{2}s
Position 1: 1.50 Btu/ft^{2}s
Position 2: 1.42 Btu/ft^{2}s

DTI

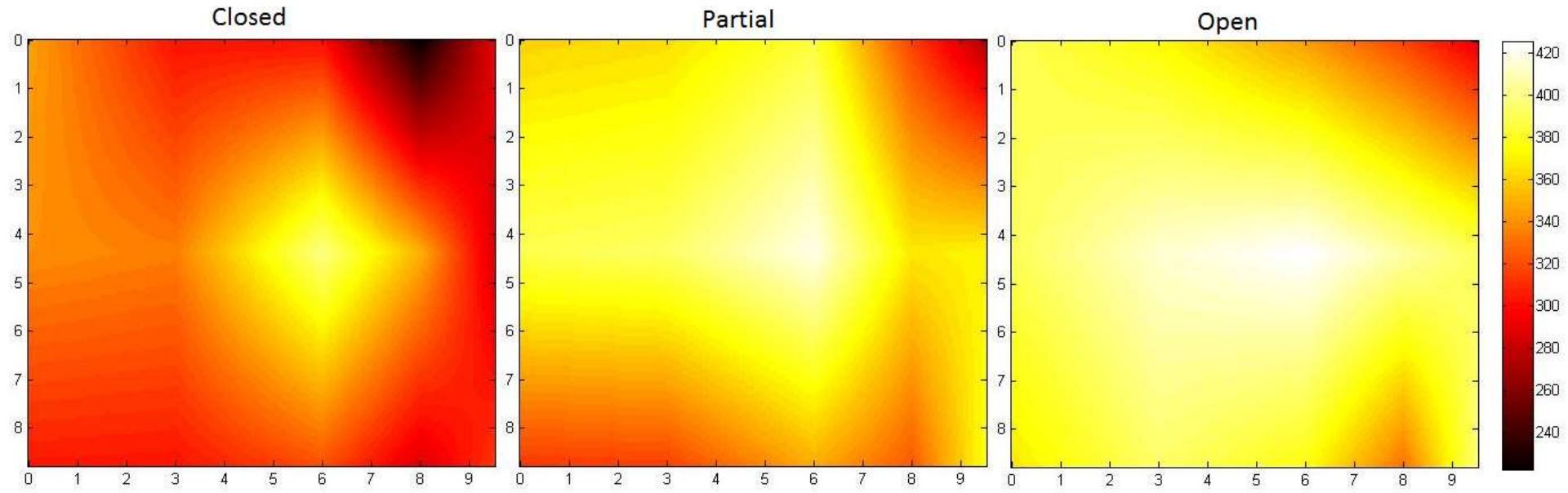


T/C Average: 376.1°F
Panel Set Point: 1070°F
3 Position Check:
Position 0: 1.50 Btu/ft^{2}s
Position 1: 1.43 Btu/ft^{2}s
Position 2: 1.43 Btu/ft^{2}s

T/C Average: 415.6°F
Panel Set Point: 1127°F
3 Position Check:
Position 0: 1.50 Btu/ft^{2}s
Position 1: 1.50 Btu/ft^{2}s
Position 2: 1.45 Btu/ft^{2}s

T/C Average: 424.5°F
Panel Set Point: 1128°F
3 Position Check:
Position 0: 1.50 Btu/ft^{2}s
Position 1: 1.50 Btu/ft^{2}s
Position 2: 1.44 Btu/ft^{2}s

FAA

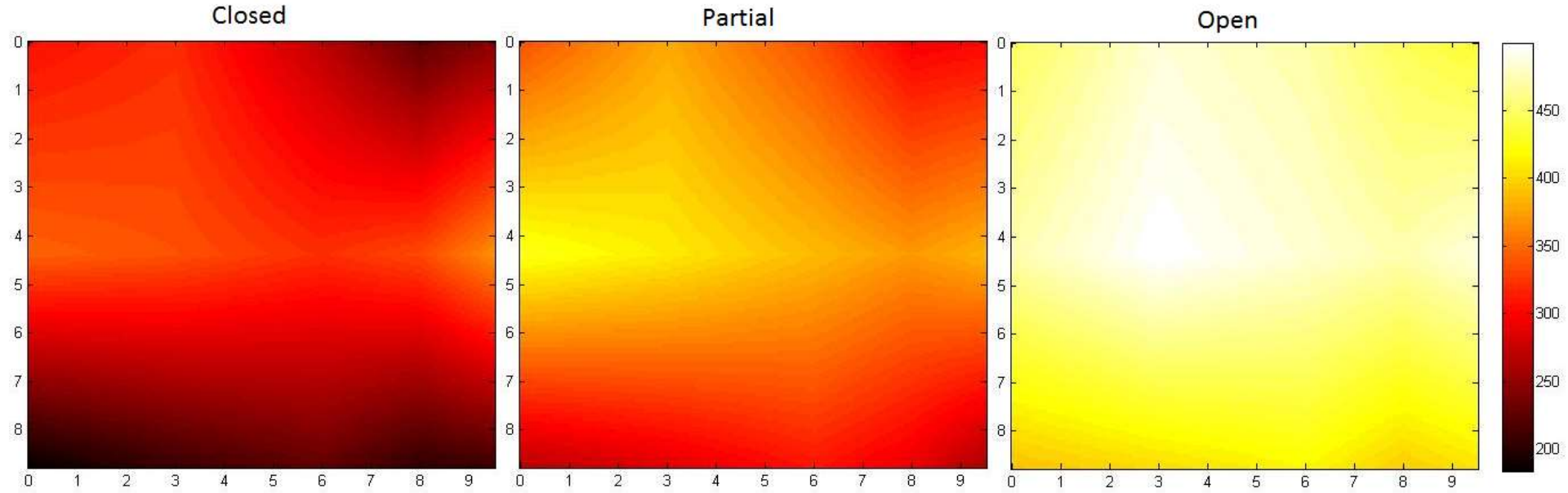


T/C Average: 313.5°F
Panel Set Point: 1065°F
3 Position Check: (old panel)
Set Point: 1107°F
Position 0: 1.497 Btu/ft^{2}s
Position 1: 1.520 Btu/ft^{2}s
Position 2: 1.430 Btu/ft^{2}s

T/C Average: 354.6°F
Panel Set Point: 1070°F
3 Position Check: (old panel)
Set Point: 1108 °F
Position 0: 1.499 Btu/ft^{2}s
Position 1: 1.511 Btu/ft^{2}s
Position 2: 1.440 Btu/ft^{2}s

T/C Average: 374.0°F
Panel Set Point: 1089°F
3 Position Check: (old panel)
Set Point: 1148 °F
Position 0: 1.506 Btu/ft^{2}s
Position 1: 1.503 Btu/ft^{2}s
Position 2: 1.440 Btu/ft^{2}s

Triumph

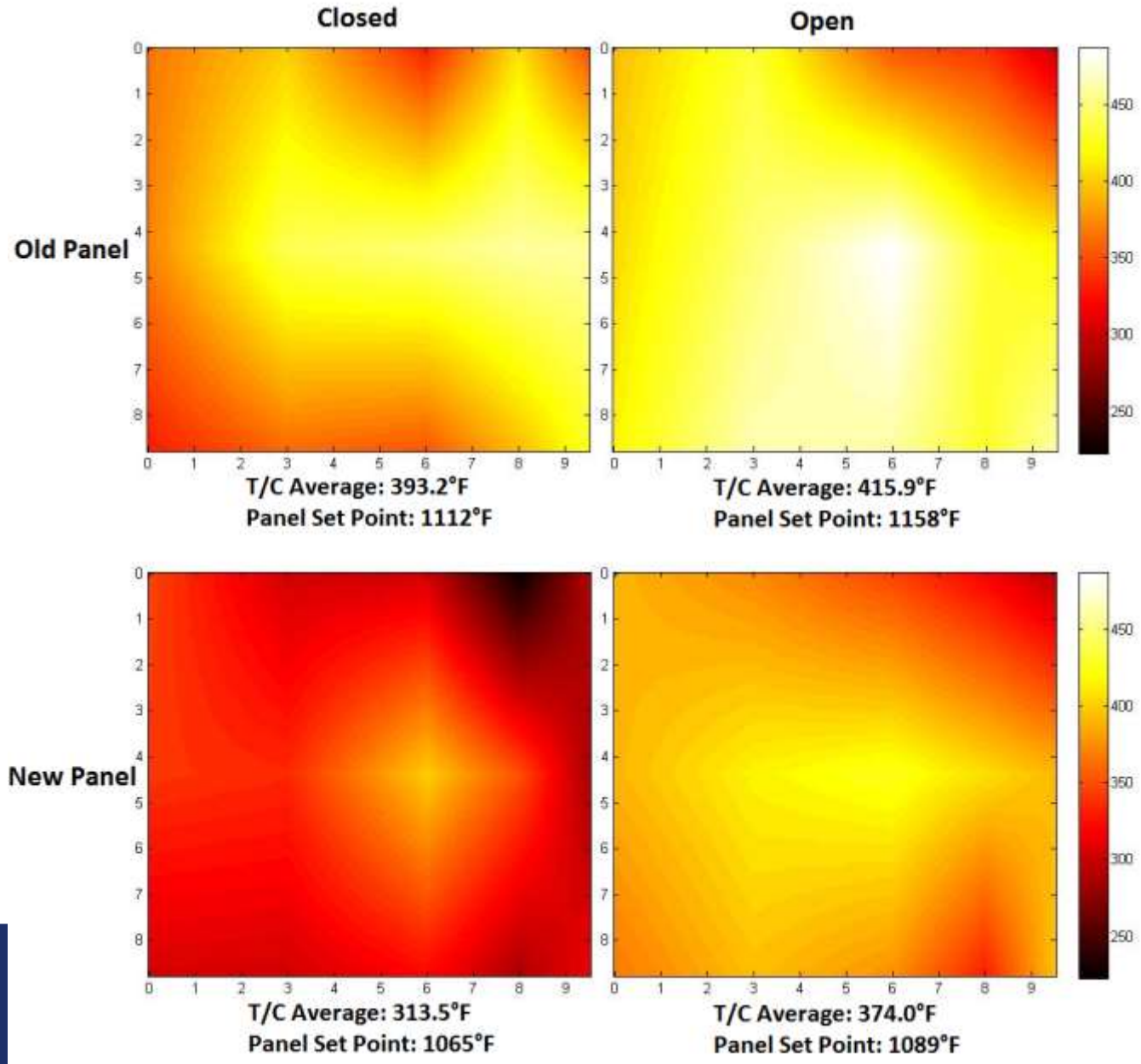


T/C Average: 273.5°F
Panel Set Point: 999°F
3 Position Check:
Position 0: 1.50 Btu/ft^{2}s
Position 1: 1.43 Btu/ft^{2}s
Position 2: 1.35 Btu/ft^{2}s

T/C Average: 336.3°F
Panel Set Point: 1032°F
3 Position Check:
Position 0: 1.50 Btu/ft^{2}s
Position 1: 1.47 Btu/ft^{2}s
Position 2: 1.43 Btu/ft^{2}s

T/C Average: 447.2°F
Panel Set Point: 1038°F
3 Position Check:
Position 0: 1.50 Btu/ft^{2}s
Position 1: 1.46 Btu/ft^{2}s
Position 2: 1.41 Btu/ft^{2}s

FAA Panel Comparison

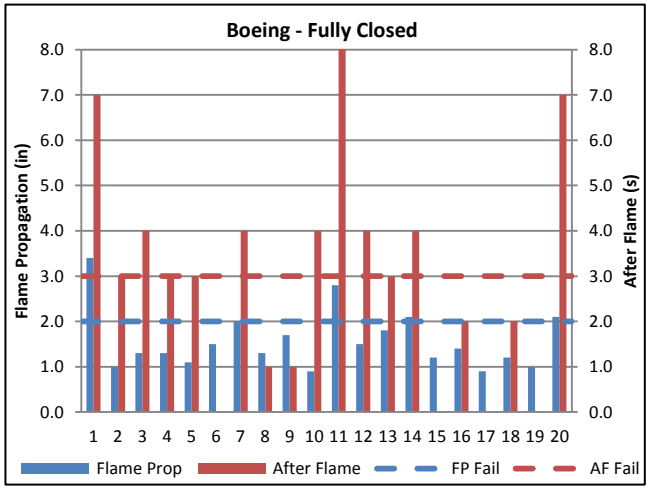


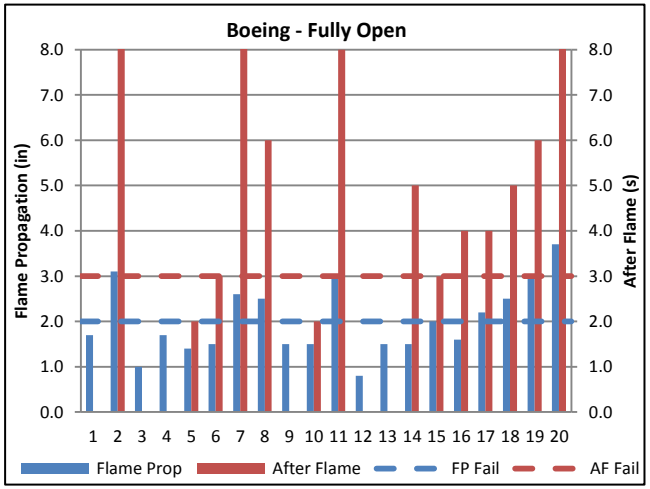
- ~2 year old panel ran at higher set point and produced higher temperatures at the surface of the test sample
- Both calibrated at 1.50 Btu/ft^{2}s
- It's been observed that panels get hotter over time and eventually need to be replaced

Material Tests

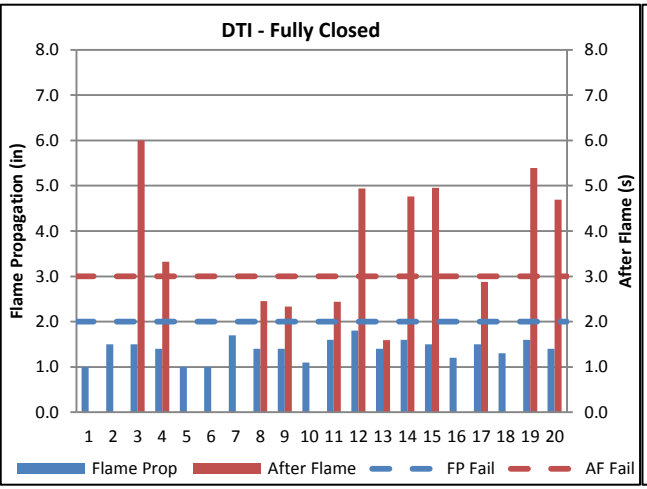
- **20 Metalized PEEK samples per gap setting per lab (60 samples per lab)**
- **Tested fully closed, partially open, and fully open**
- **Boeing was not able to test partially open**

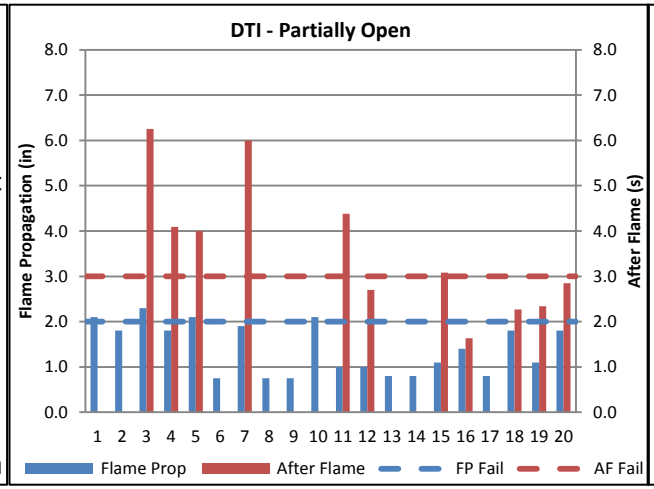
Boeing Results

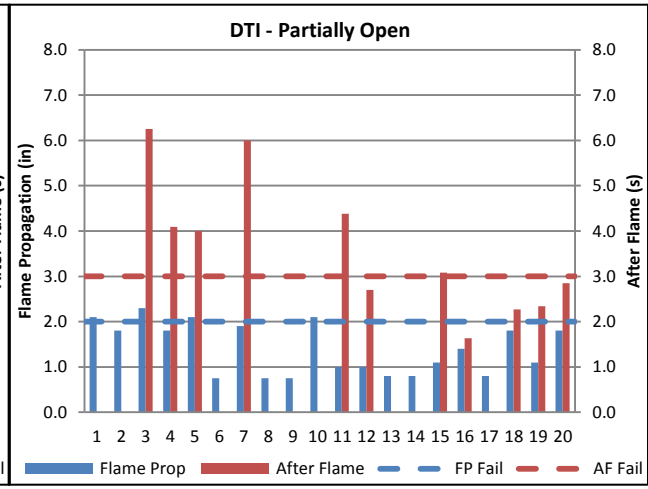




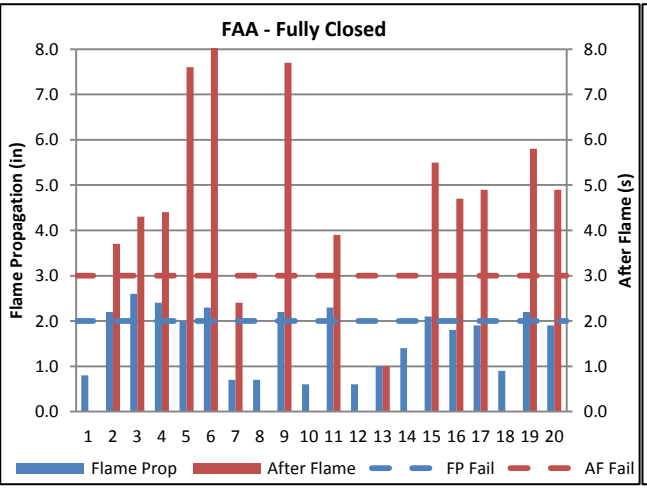
DTI Results

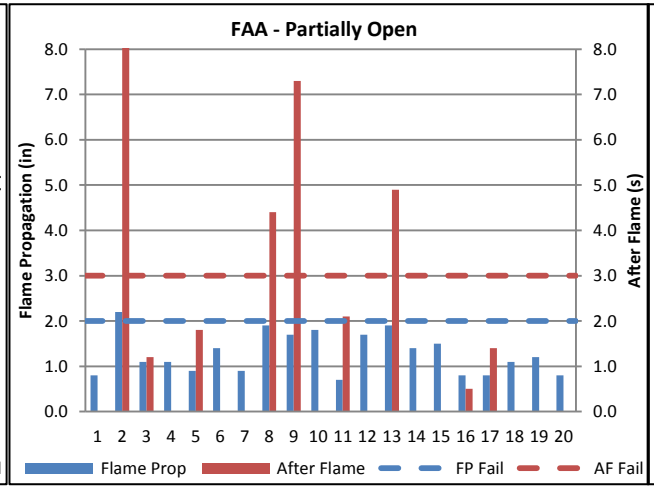

DTI - Fully Closed
Flame Propagation (in)
After Flame (s)
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Flame Prop
After Flame
FP Fail
AF Fail

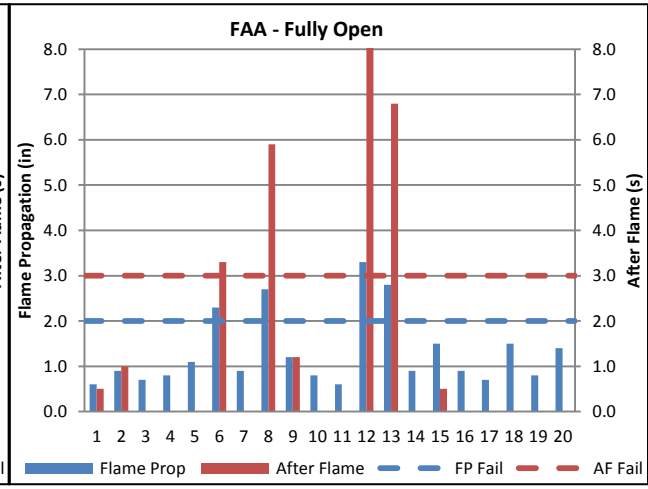

DTI - Partially Open
Flame Propagation (in)
After Flame (s)
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Flame Prop
After Flame
FP Fail
AF Fail


DTI - Partially Open
Flame Propagation (in)
After Flame (s)
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Flame Prop
After Flame
FP Fail
AF Fail

FAA Results


FAA - Fully Closed
Flame Propagation (in)
After Flame (s)
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Flame Prop
After Flame
FP Fail
AF Fail


FAA - Partially Open
Flame Propagation (in)
After Flame (s)
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Flame Prop
After Flame
FP Fail
AF Fail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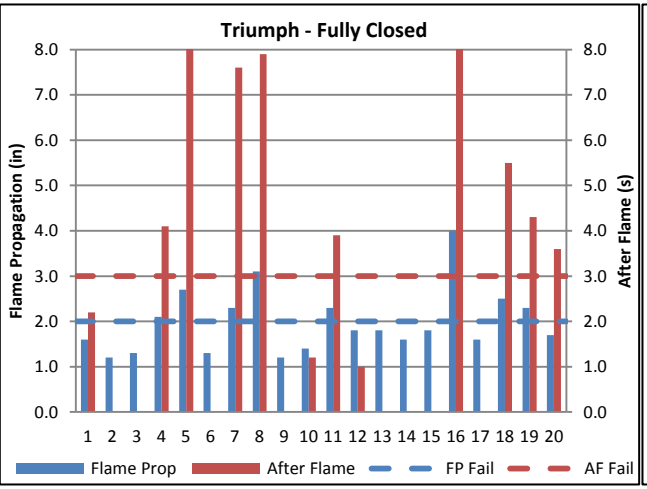
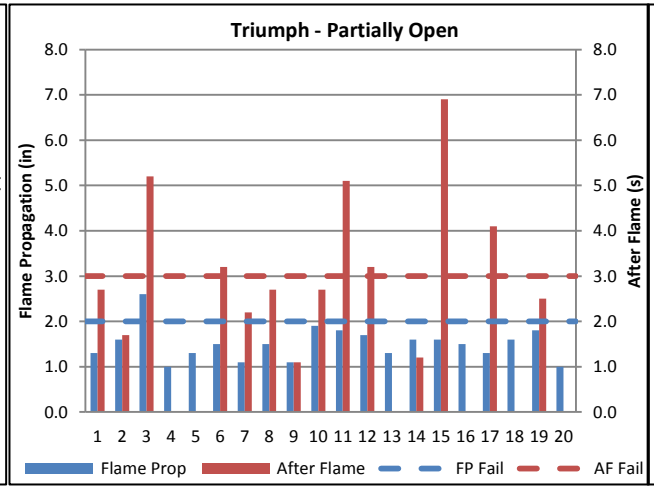
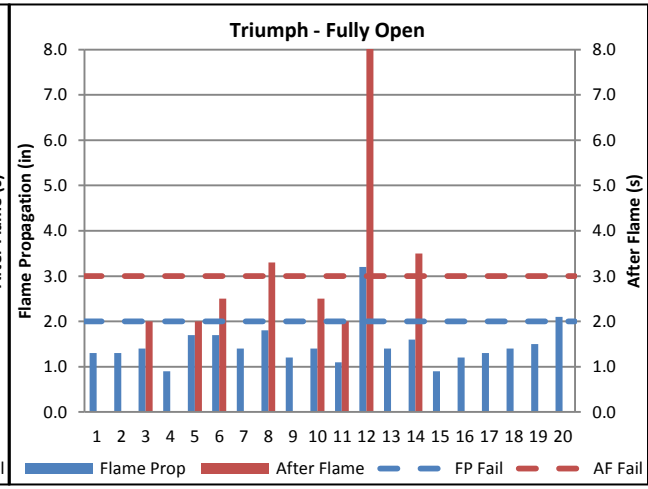
Flame Propagation (in)
After Flame (s)
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Flame Prop
After Flame
FP Fail
AF Fail

Triumph Results







Boeing Statistical Analysis

- **Sent test results to Boeing as planned**
- **Analysis of Variance (ANOVA) and Median testing as appropriate at 5% significance level**
- **Determine if changing air gaps made significant difference in test results**
- **Compared flame propagation, after flame time, and pass/fail numbers**

Radiant Panel Gap Analysis

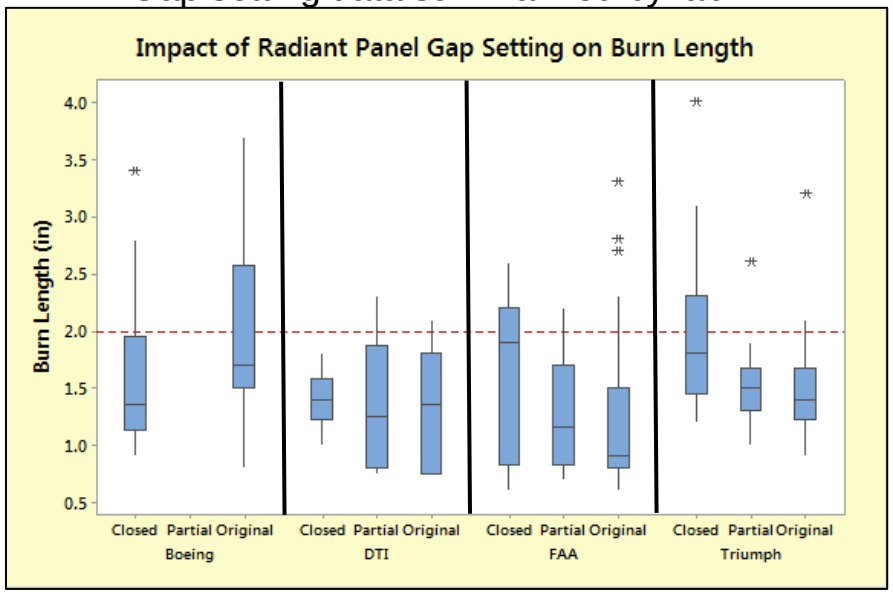
- **Analysis Overview**
  - Experimental “power”
    - Why did we use 20 insulation blankets for each gap setting??
  - Evaluation of continuous variables (burn length, after-flame time)
    - For a given gap setting (closed, partial, original), determine if results from the different labs (Boeing, DTI, FAA, Triumph) can be considered from the same population. If so…
    - Combine the data for each gap setting and then compare the results from each gap setting to the other gap settings to determine if there are differences
      - Perform separate analyses for “Burn Length” and “After Flame Time”
  - Evaluation of pass/fail data (binomial data)
    - Consider results from the perspective of “pass/fail” with respect to the 14 CFR 25.856(a) requirements
  - Evaluation of variation
    - Is there any difference in the *variation* of results (burn length, after-flame time) as a function of gap setting?

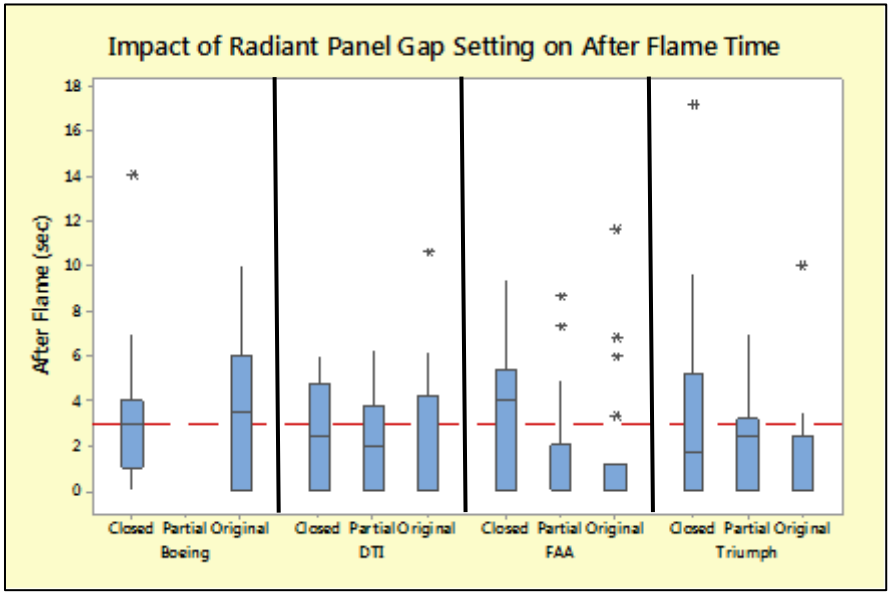
Radiant Panel Gap Analysis

- **Experimental "Power"**
  - Experimental Power = the likelihood an experiment can detect a significant effect or difference when such an effect or difference truly exists
    - Similar to "resolving power" in optical instruments (telescopes, microscopes): the ability of an instrument to resolve 2 points which are closely spaced
      - Optical resolving power …..R = $\frac{1.22\,\lambda}{2n\,\sin\theta}$ (R = minimum distance b/resolvable points, ….)
    - Best "lever" to increase "experimental power" is sample size
  - Numerically…
    - Sample size of 20 insulation blankets per gap setting was selected to achieve
      - Power of 0.8 for a ….
      - detectable difference between gap settings of 1.0 standard deviations with a…
      - significance level of 0.05
- **Key Point**
  - FTWG radiant panel expt is largely insensitive to measurement differences which are <1 std dev
    - Burn Length std dev: ~0.5-0.6 inches
    - After Flame Time std dev: ~2-3 seconds

Radiant Panel Gap Analysis

- **Overview**
  - Gap setting data summarized by lab



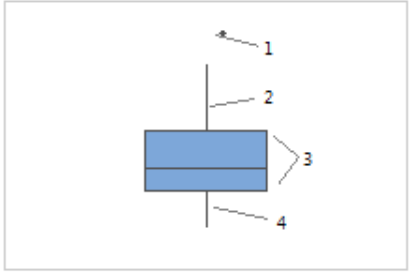


REFERENCE

Boxplot

A graphical summary of the distribution of a sample that shows its shape, central tendency, and variability.

The default boxplot display consists of the following:



1 **Outlier (*)** – Observation that is beyond the upper or lower whisker

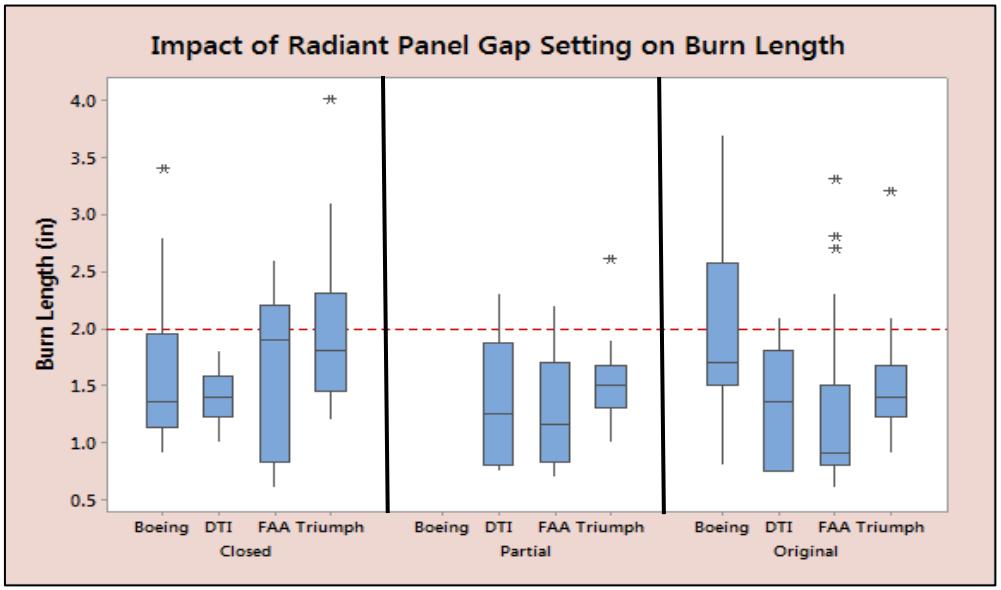
2 **Upper whisker** – Extends to the maximum data point within 1.5 box heights from the top of the box

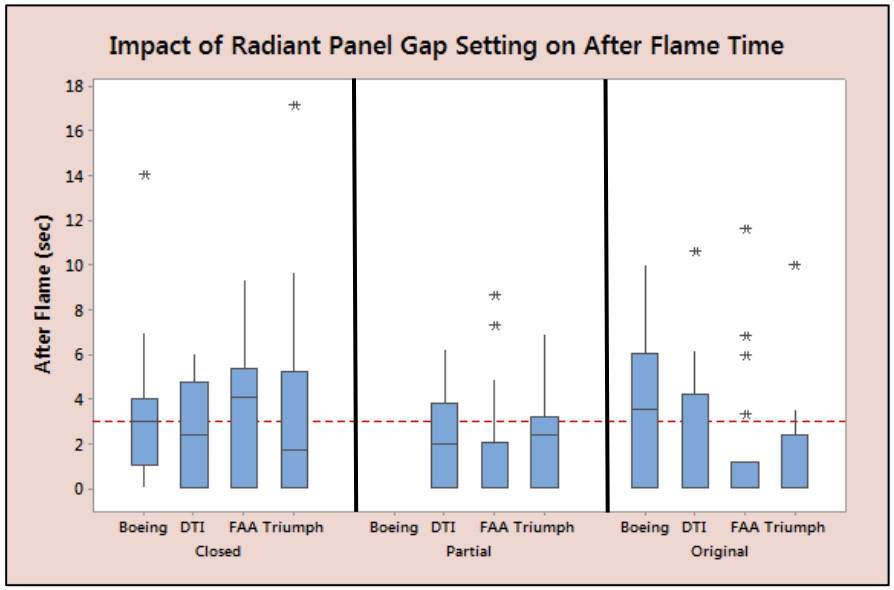
3 **Interquartile range box** – Middle 50% of the data
- Top line – Q3 (third quartile). 75% of the data are less than or equal to this value.
- Middle line – Q2 (median). 50% of the data are less than or equal to this value.
- Bottom line – Q1 (first quartile). 25% of the data are less than or equal to this value.

4 **Lower whisker** – Extends to the minimum data point within 1.5 box heights from the bottom of the box

Radiant Panel Gap Analysis

- **Overview**
  - Lab data summarized by gap setting





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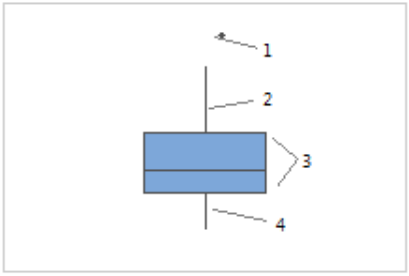

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4 **Lower whisker** – Extends to the minimum data point within 1.5 box heights from the bottom of the box

Radiant Panel Gap Analysis

- **Burn Length/After Flame Time vs. Gap Setting**
  - ANOVA showed for a given gap setting, data from all labs can be considered from a single population
    - After Flame Time better “behaved” than Burn Length
      - Analysis in “Backup” section of presentation
    - Result: Combine data from all labs for subsequent analysis
      - Analysis on following slides

Radiant Panel Gap Analysis

- **Burn Length vs. Gap Setting (All Labs Combined)**

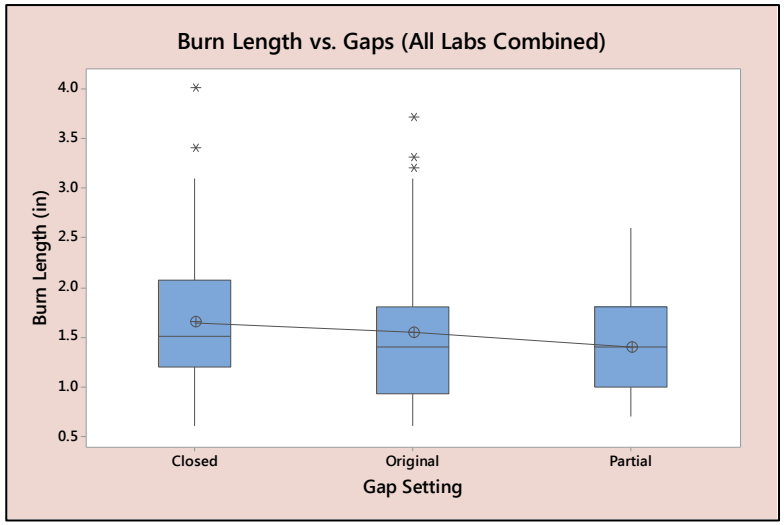
Source	DF	Adj SS	Adj MS	F-Value	P-Value
Gap Setting	2	2.129	1.0645	2.74	0.067
Error	217	84.233	0.3882		
Total	219	86.362			

Grouping Information Using the Tukey Method and 95% Confidence

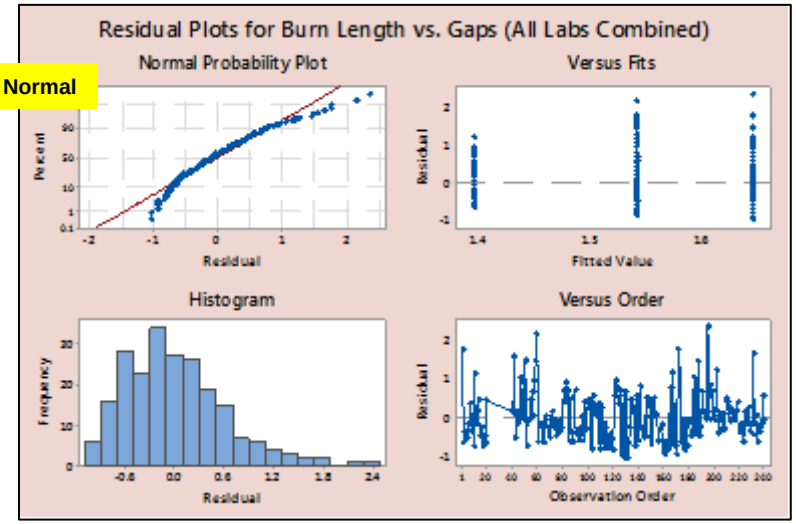
Gap Setting	N	Mean	Grouping
Closed	80	1.6450	A
Original	80	1.5413	A
Partial	60	1.3958	A

Means that do not share a letter are significantly different.

Confirmed by median test



Not Normal



Mood median test for Burn Length (in)
Chi-Square = 1.89 DF = 2 P = 0.390

Gap Setting	N≤	N>	Median	Q3-Q1	Individual 95.0% CIs
Closed	41	39	1.50	0.88	(--*-----)
Partial	36	24	1.40	0.80	(--------*-----)
Original	49	31	1.75	0.60	(------*------------)

1.40 1.75 2.10

Overall median = 1.50

Conclusion: No statistical difference in Burn Length as a function of gap setting (closed, partial, original).

Radiant Panel Gap Analysis

- **After Flame Time vs. Gap Setting (All Labs Combined)**

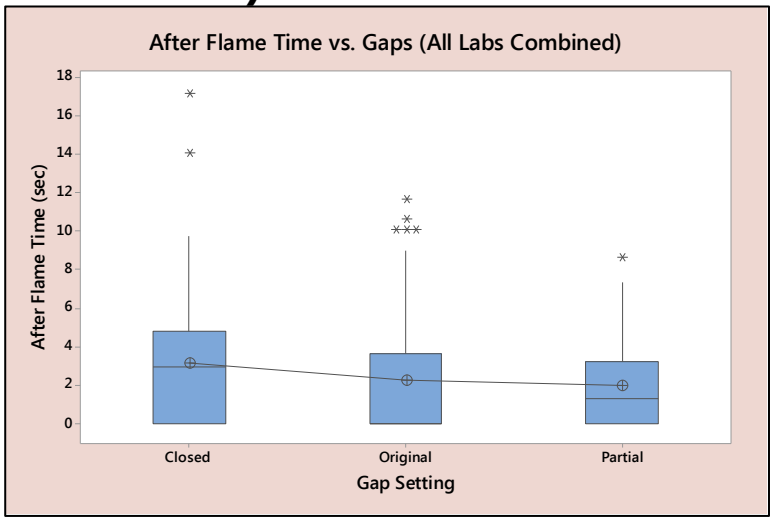
Source	DF	Adj SS	Adj MS	F-Value	P-Value
Gap Setting	2	55.84	27.920	3.16	0.045
Error	217	1918.97	8.843		
Total	219	1974.81			

Grouping Information Using the Tukey Method and 95% Confidence

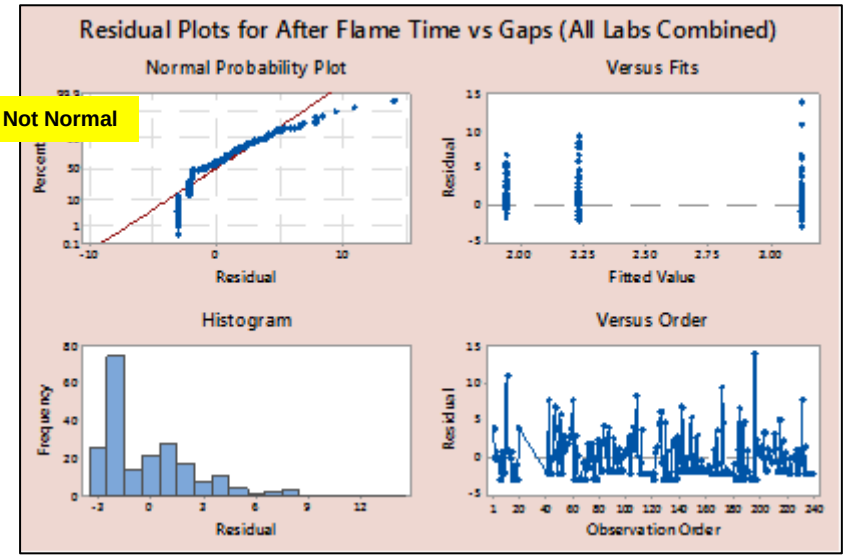
Gap Setting	N	Mean	Grouping
Closed	80	3.124	A
Original	80	2.229	A
Partial	60	1.938	A

Means that do not share a letter are significantly different.

Confirmed by median test



Not Normal



Mood median test for After Flame (sec)
Chi-Square = 5.27 DF = 2 P = 0.072

Gap Setting	N≤	N>	Median	Q3-Q1	Individual 95.0% CIs
Closed	32	48	2.94	4.75	(--------*------)
Partial	32	28	1.30	3.17	(-------*------)
Original	46	34	3.23	2.90	(-------------*---------------)

0.0 1.6 3.2 4.8

Overall median = 1.67

Conclusion: No statistical difference in After Flame Time as a function of gap setting (closed, partial, original).

Pass/Fail Analysis

14 CFR 25.856(a)

14 CFR Part 25 Appendix F
Part VI (h) “Requirements” (1) & (2)

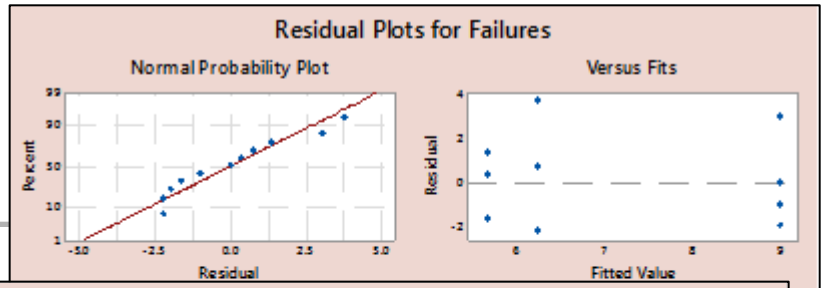
Radiant Panel Gap Analysis

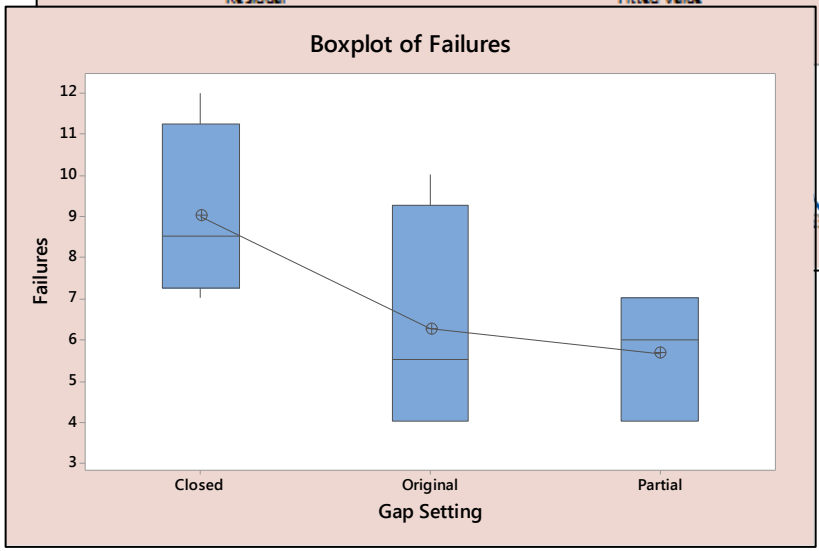
- **Analysis of "Failures" by Gap Setting (All Labs Combined)**
  - "Failure"
    - Assume certification testing. Failure = exceeding allowable burn length (2 inches), after flame time (3 seconds), or both

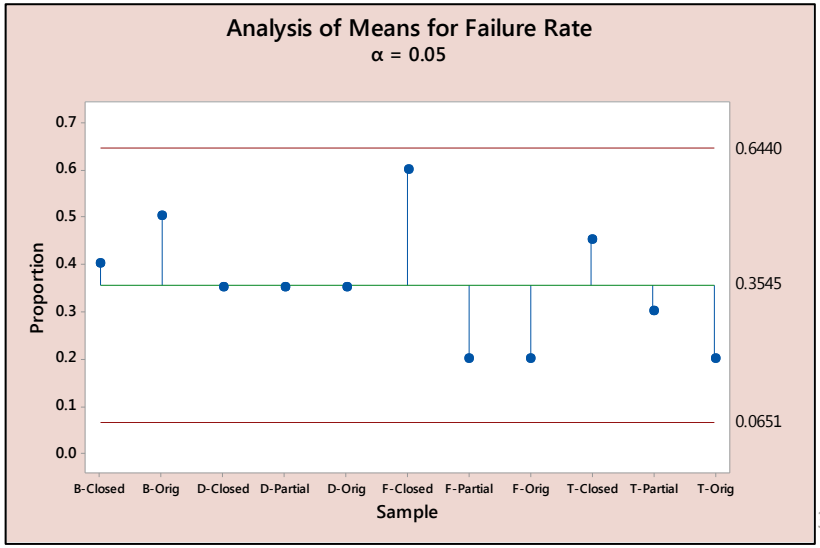
	Gap Setting		
Lab	Closed	Partial	Original
Boeing	8		10
DTI	7	7	7
FAA	12	4	4
Triumph	9	6	4

```
Source        DF  Adj SS  Adj MS  F-Value  P-Value
Gap Setting    2   23.49  11.746     2.16    0.177
Error          8   43.42   5.427
Total         10   66.91

Grouping Information Using the Tukey Method &
95% Confidence

Gap Setting  N   Mean  Grouping
Closed       4   9.00  A
Original     4   6.25  A
Partial      3   5.67  A

Means that do not share a letter are
significantly different.
```

Conclusion: No statistical difference in "Failures" as a function of gap setting (closed, partial, original).







Analysis of Variation by Gap Setting

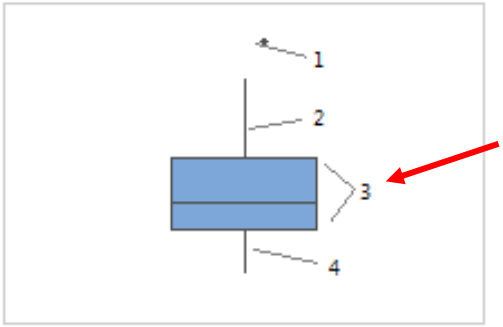
Radiant Panel Gap Analysis

- **Analysis of Variation by Gap Setting (All Labs Combined)**
  - Use “interquartile range” (IQR) as measure of variation
    - IQR = Q3 – Q1 --> Difference between 3rd Quartile (75% of data) and 1st Quartile (25% of data)
    - Shows the “spread” of the middle 50% of the data for a given series of measurements
    - More “robust” measurement of variation than standard deviation, i.e. IQR is less susceptible to outliers

Boxplot

A graphical summary of the distribution of a sample that shows its shape, central tendency, and variability.

The default boxplot display consists of the following:



1 **Outlier (*)** – Observation that is beyond the upper or lower whisker

2 **Upper whisker** – Extends to the maximum data point within 1.5 box heights from the top of the box

3 **Interquartile range box** – Middle 50% of the data
- Top line – Q3 (third quartile). 75% of the data are less than or equal to this value.
- Middle line – Q2 (median). 50% of the data are less than or equal to this value.
- Bottom line – Q1 (first quartile). 25% of the data are less than or equal to this value.

4 **Lower whisker** – Extends to the minimum data point within 1.5 box heights from the bottom of the box

Radiant Panel Gap Analysis

- **Burn Length IQR (All Labs Combined)**

	Burn Length Interquartile Range (IQR) (in)		
Lab	Closed	Partial	Original
Boeing	0.825		1.075
DTI	0.350	1.075	1.050
FAA	1.375	0.875	0.700
Triumph	0.850	0.375	0.450

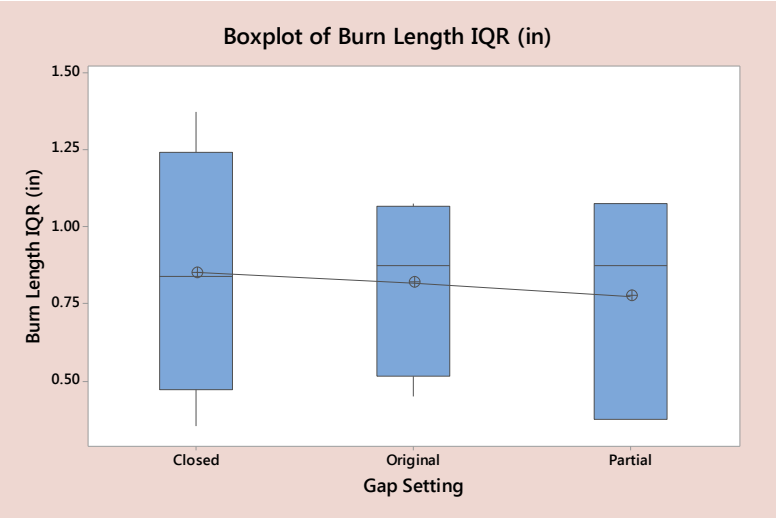
```
Source        DF   Adj SS    Adj MS  F-Value  P-Value
Gap Setting    2  0.00964  0.004822     0.04    0.964
Error          8  1.05547  0.131934
Total         10  1.06511
```

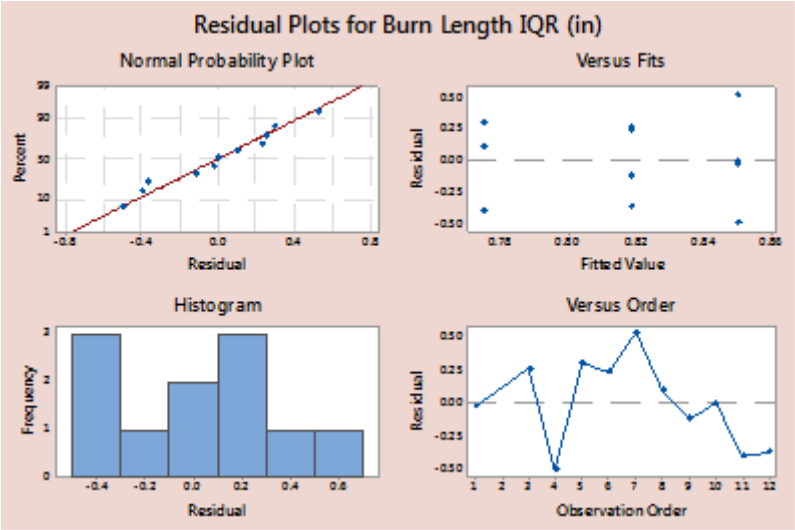
Grouping Information Using the Tukey Method and 95% Confidence

```
Gap Setting  N   Mean  Grouping
Closed       4  0.850  A
Original     4  0.819  A
Partial      3  0.775  A
```

Means that do not share a letter are significantly different.

Conclusion: No statistical difference in Burn Length IQR as a function of gap setting (closed, partial, original).

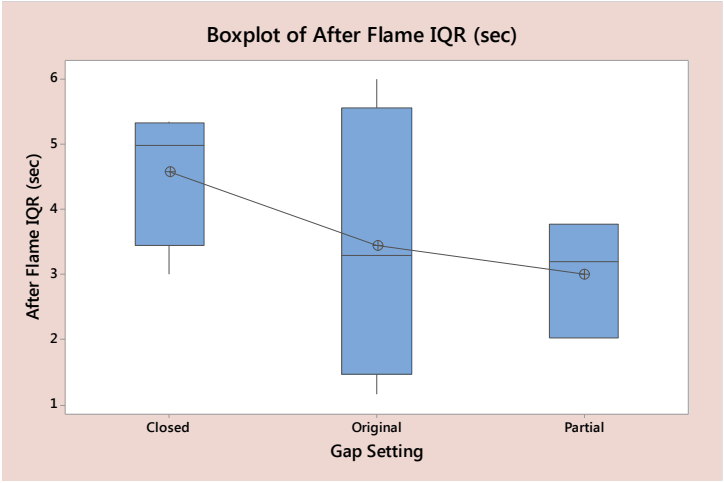




Radiant Panel Gap Analysis

- **After Flame Time IQR (All Labs Combined)**

	After Flame Time Interquartile Range (IQR) (sec)		
Lab	Closed	Partial	Original
Boeing	3.000		6.000
DTI	4.742	3.770	4.213
FAA	5.350	2.025	1.150
Triumph	5.200	3.200	2.375

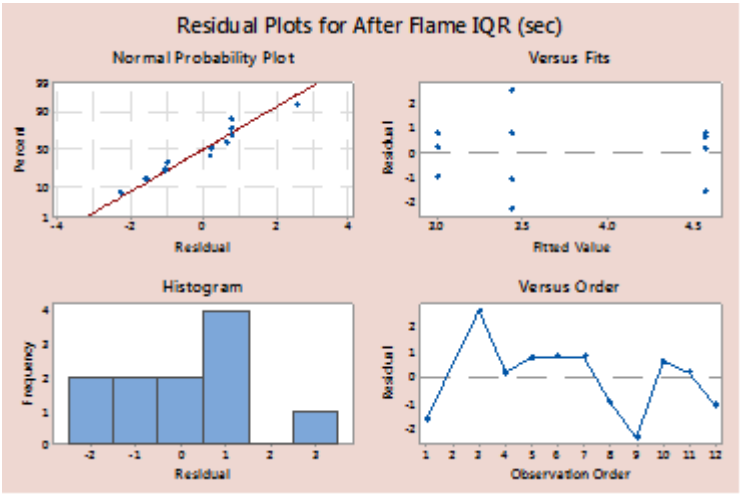



```
Source        DF  Adj SS  Adj MS  F-Value  P-Value
Gap Setting    2   4.798   2.399     1.03    0.400
Error          8  18.613   2.327
Total         10  23.410
```

Grouping Information Using the Tukey Method and 95% Confidence

```
Gap Setting  N   Mean  Grouping
Closed       4  4.573  A
Original     4   3.43  A
Partial      3  2.998  A
```

Means that do not share a letter are significantly different.



Conclusion: No statistical difference in After Flame Time IQR as a function of gap setting (closed, partial, original).

Burn Length Data by Gap Setting

Radiant Panel Gap Analysis

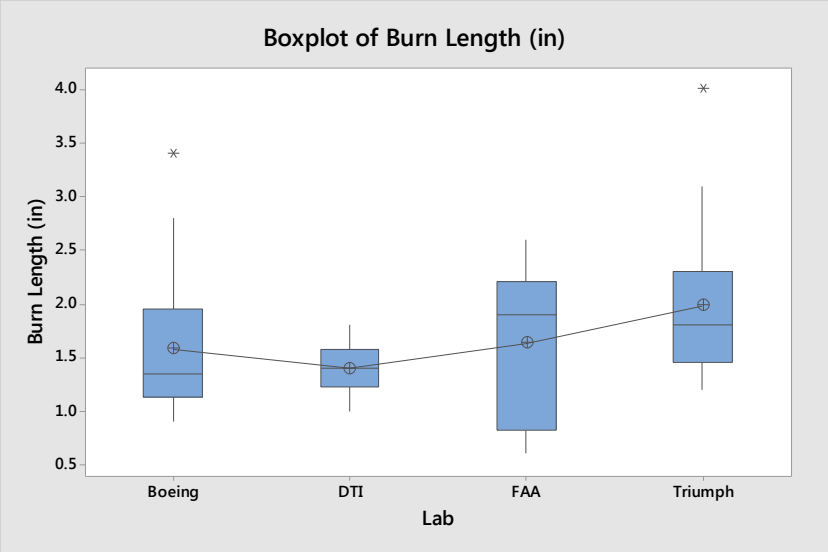
- **Closed Gaps—Burn Length**

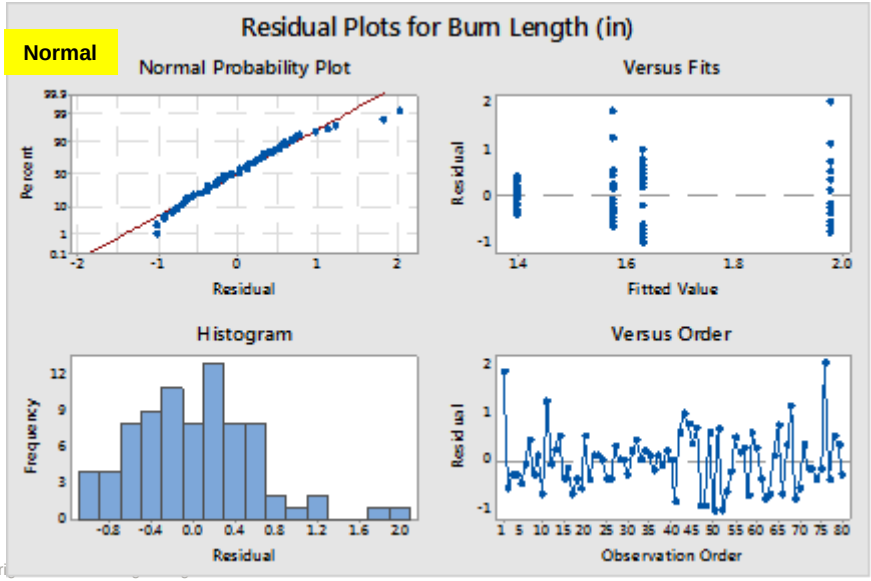
Source	DF	Adj SS	Adj MS	F-Value	P-Value
Lab	3	3.597	1.1990	3.25	0.026
Error	76	28.001	0.3684		
Total	79	31.598			

Grouping Information Using the Tukey Method and 95% Confidence

Lab	N	Mean	Grouping
Triumph	20	1.980	A
FAA	20	1.630	A B
Boeing	20	1.575	A B
DTI	20	1.3950	B

Means that do not share a letter are significantly different.





Mood median test for Burn Length (in)
Chi-Square = 12.56 DF = 3 P = 0.006

Lab	N≤	N>	Median	Q3-Q1	Individual 95.0% CIs
Boeing	13	7	1.35	0.82	(---*---------)
DTI	15	5	1.40	0.35	(-*-)
FAA	8	12	1.90	1.38	(----------*-------)
Triumph	5	15	1.80	0.85	(----*----------)

1.20 1.60 2.00

Overall median = 1.50

Radiant Panel Gap Analysis

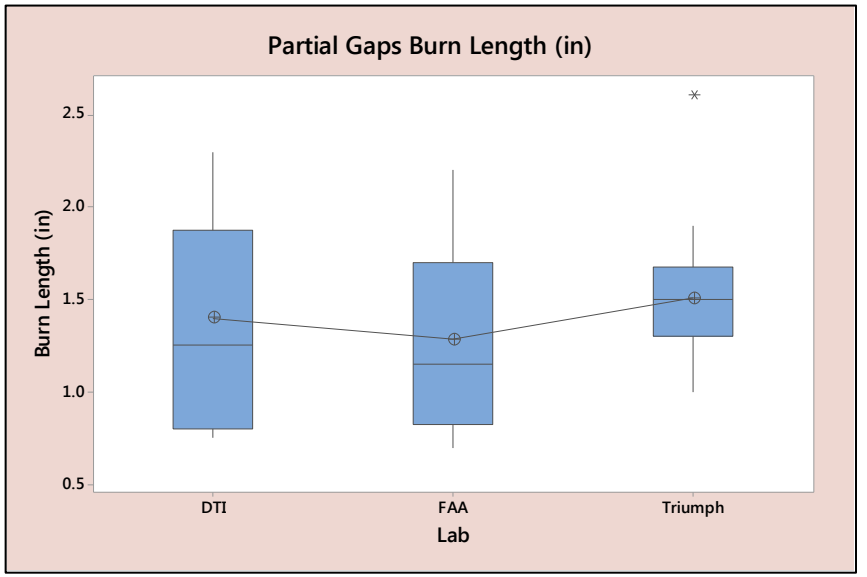
- **Partial Gaps—Burn Length**

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Lab	2	0.4841	0.2420	1.10	0.341
Error	57	12.5924	0.2209		
Total	59	13.0765			

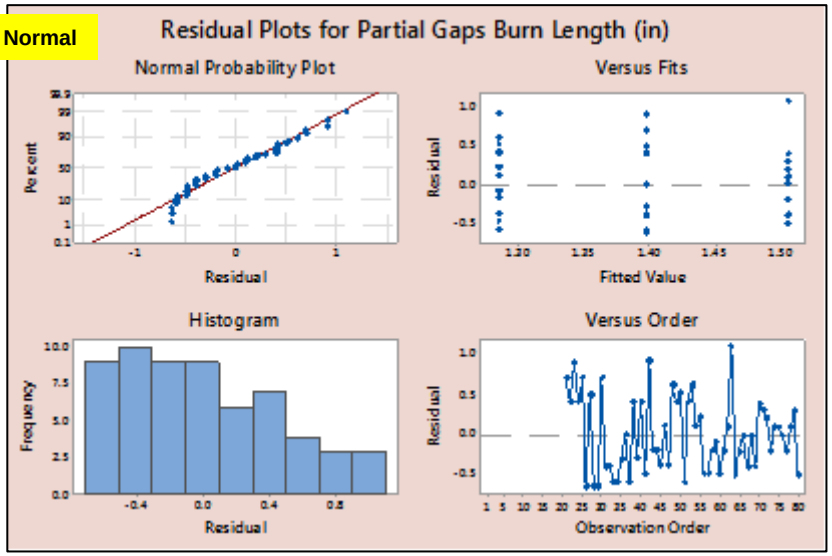
Grouping Information Using the Tukey Method and 95% Confidence

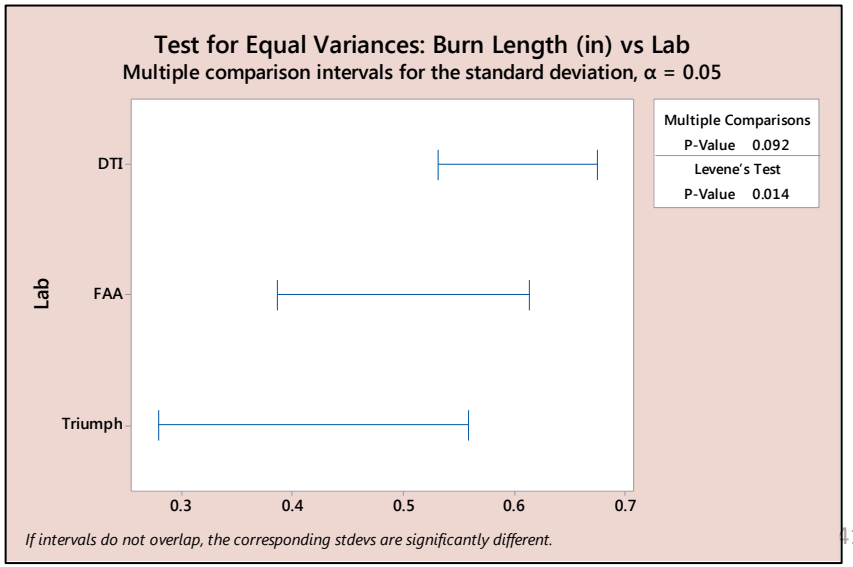
Lab	N	Mean	Grouping
Triumph	20	1.5050	A
DTI	20	1.398	A
FAA	20	1.285	A

Means that do not share a letter are significantly different.



Not Normal





Radiant Panel Gap Analysis

- **Original Gaps—Burn Length**

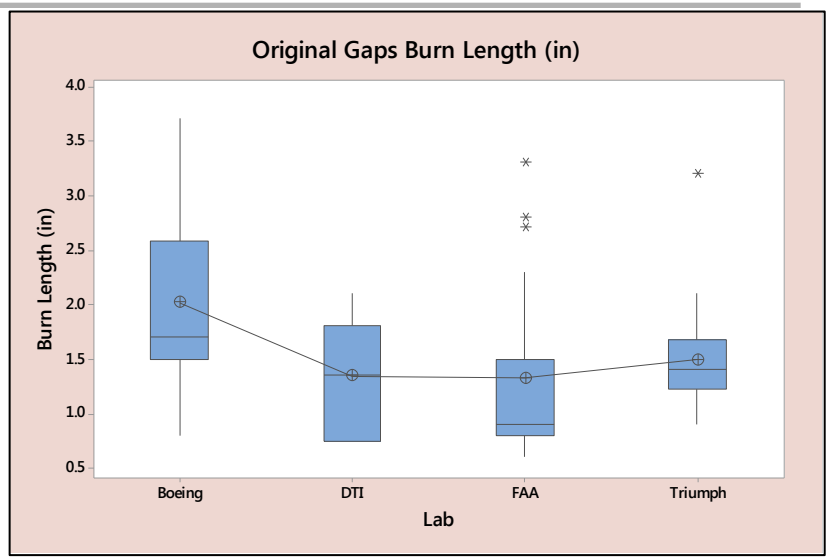
Source	DF	Adj SS	Adj MS	F-Value	P-Value
Lab	3	6.330	2.1101	4.83	0.004
Error	76	33.228	0.4372		
Total	79	39.559			

Grouping Information Using the Tukey Method and 95% Confidence

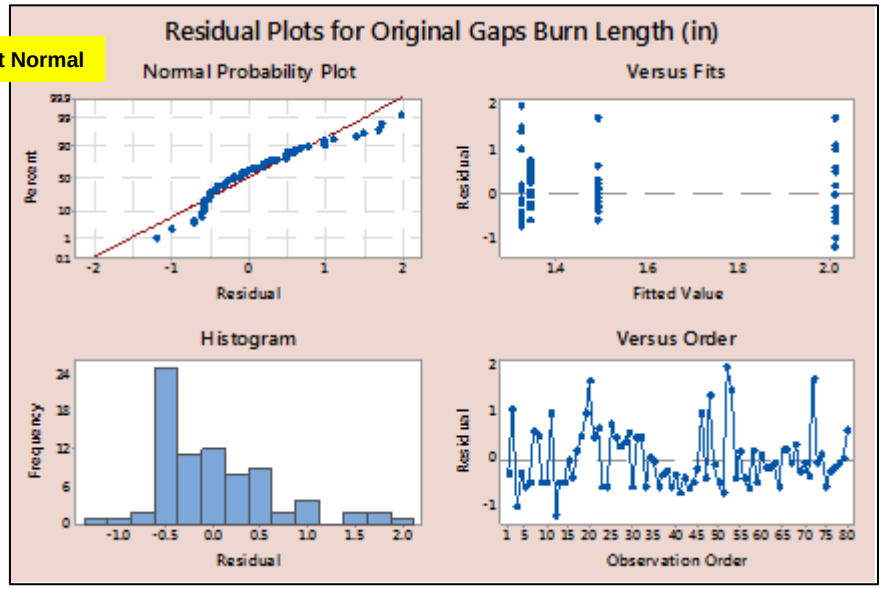
Lab	N	Mean	Grouping
Boeing	20	2.015	A
Triumph	20	1.490	A B
DTI	20	1.340	B
FAA	20	1.320	B

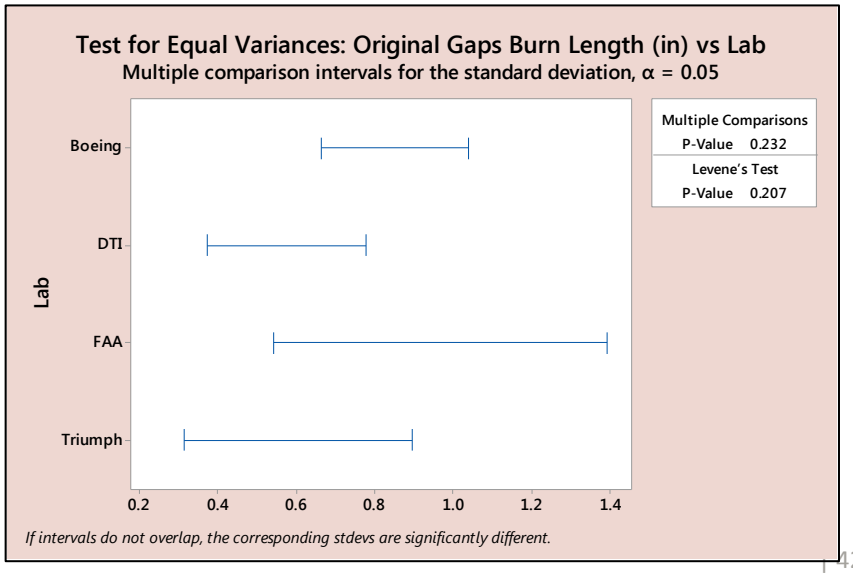
Means that do not share a letter are significantly different.

Confirmed by median test



Not Normal





After Flame Time Data by Gap Setting

Radiant Panel Gap Analysis

Closed Gaps—After Flame Time

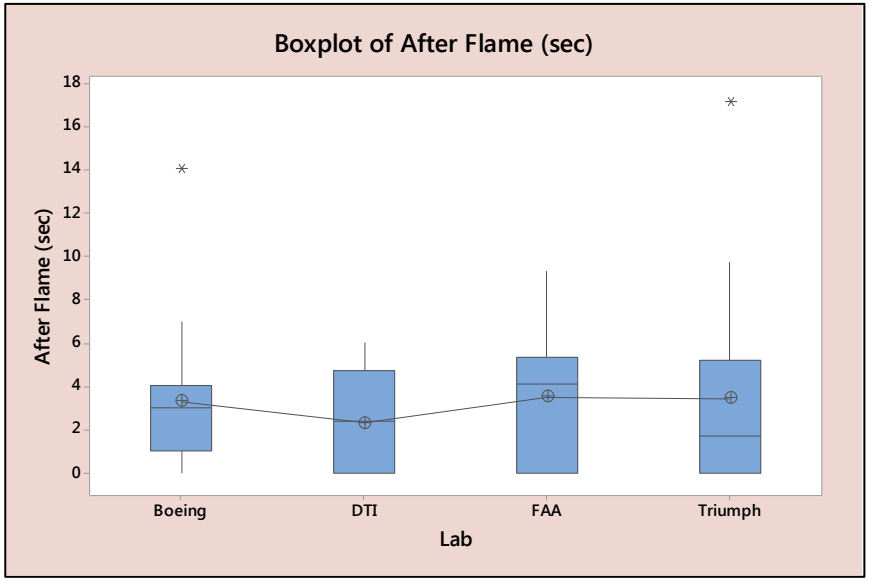
Source	DF	Adj SS	Adj MS	F-Value	P-Value
Lab	3	19.11	6.371	0.58	0.631
Error	76	836.57	11.008		
Total	79	855.69			

Grouping Information Using the Tukey Method and 95% Confidence

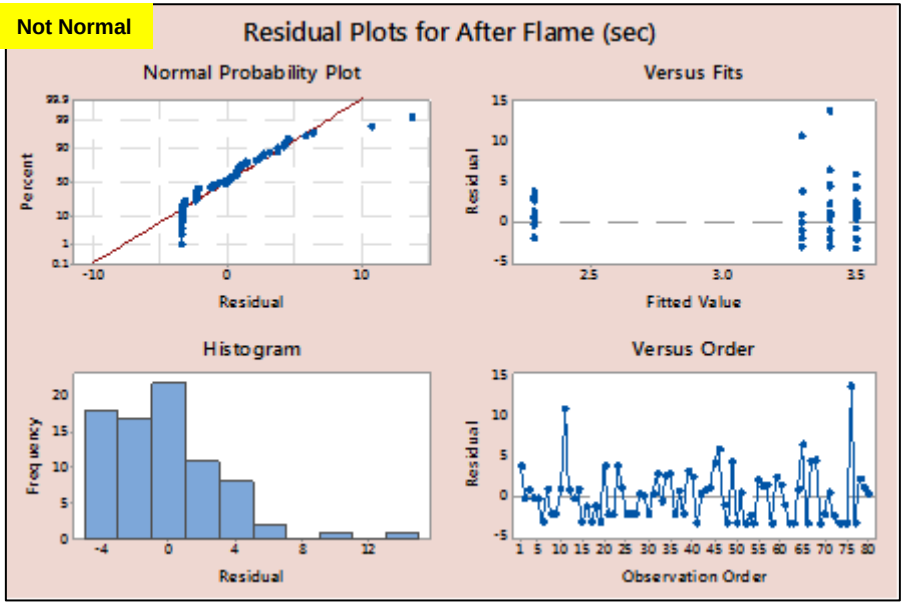
Lab	N	Mean	Grouping
FAA	20	3.505	A
Triumph	20	3.405	A
Boeing	20	3.300	A
DTI	20	2.287	A

Means that do not share a letter are significantly different.

Confirmed by median test



Not Normal



Mood median test for After Flame (sec)
Chi-Square = 3.60 DF = 3 P = 0.308

Lab	N≤	N>	Median	Q3-Q1	Individual 95.0% CIs
Boeing	8	12	3.00	3.00	(----------*------)
DTI	13	7	2.38	4.74	(----------*----------)
FAA	8	12	4.10	5.35	(----------*-----)
Triumph	11	9	1.70	5.20	(----------*----------)

0.0 1.5 3.0 4.5

Overall median = 2.94

Radiant Panel Gap Analysis

- **Partial Gaps—After Flame Time**

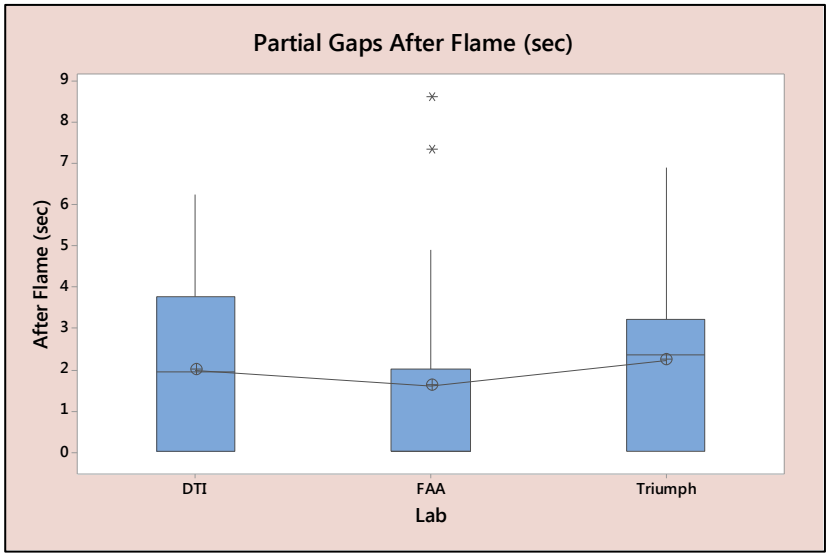
Source	DF	Adj SS	Adj MS	F-Value	P-Value
Lab	2	3.834	1.917	0.37	0.692
Error	57	294.306	5.163		
Total	59	298.140			

Grouping Information Using the Tukey Method and 95% Confidence

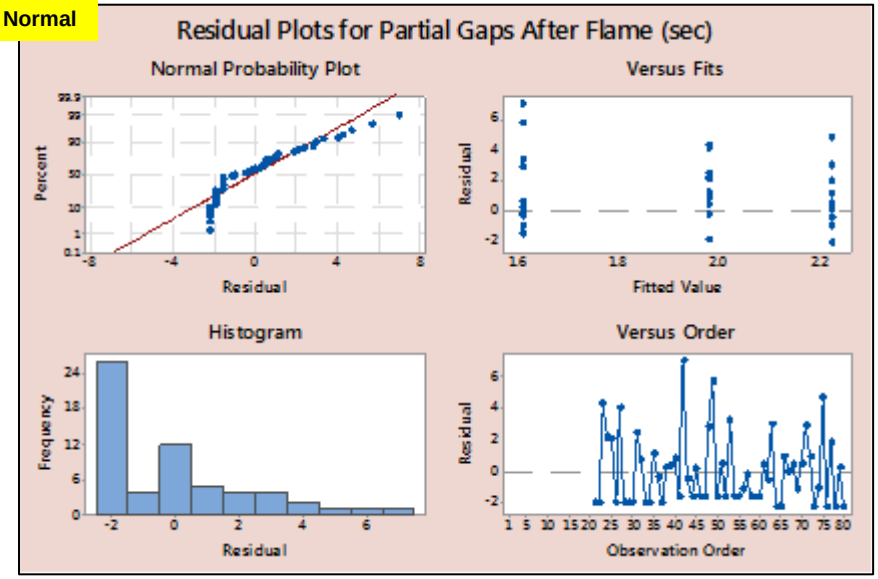
Lab	N	Mean	Grouping
Triumph	20	2.225	A
DTI	20	1.980	A
FAA	20	1.610	A

Means that do not share a letter are significantly different.

Confirmed by median test



Not Normal



Mood median test for After Flame (sec)
Chi-Square = 2.80 DF = 2 P = 0.247

Lab	N≤	N>	Median	Q3-Q1	Individual 95.0% CIs
DTI	9	11	1.95	3.77	(----------*---------)
FAA	13	7	0.00	2.03	*----------)
Triumph	8	12	2.35	3.20	(----------*-------)

0.0 1.0 2.0 3.0

Overall median = 1.30

Radiant Panel Gap Analysis

- **Original Gaps—After Flame Time**

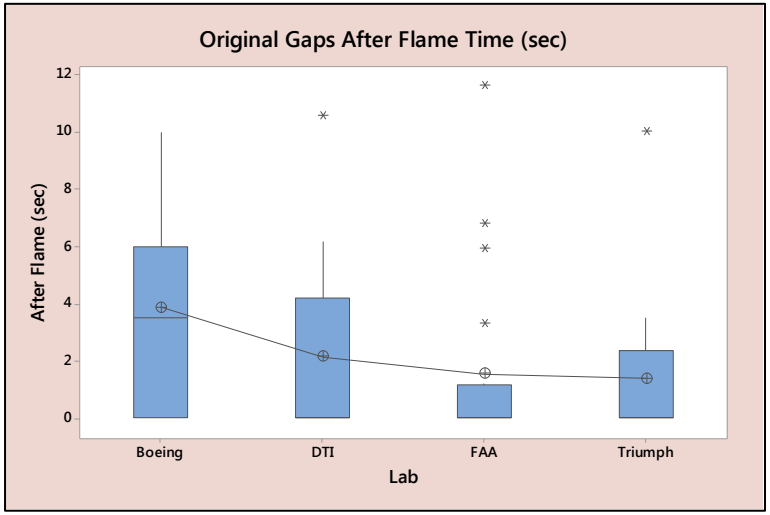
Source	DF	Adj SS	Adj MS	F-Value	P-Value
Lab	3	76.29	25.431	2.81	0.045
Error	76	688.85	9.064		
Total	79	765.15			

Grouping Information Using the Tukey Method and 95% Confidence

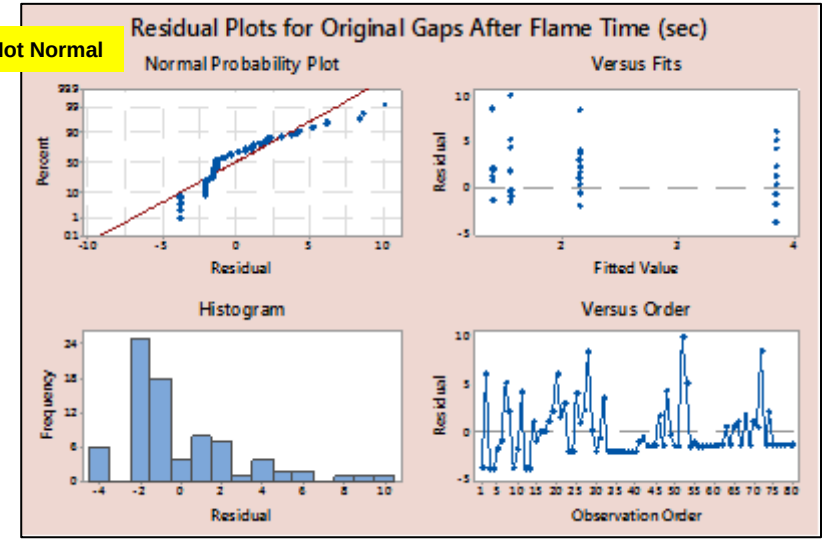
Lab	N	Mean	Grouping
Boeing	20	3.850	A
DTI	20	2.138	A
FAA	20	1.540	A
Triumph	20	1.390	A

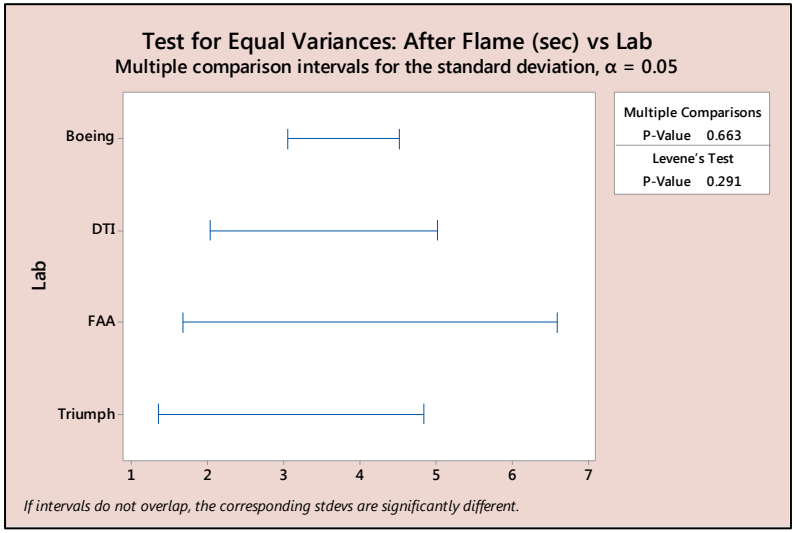
Means that do not share a letter are significantly different.

Confirmed by median test



Not Normal





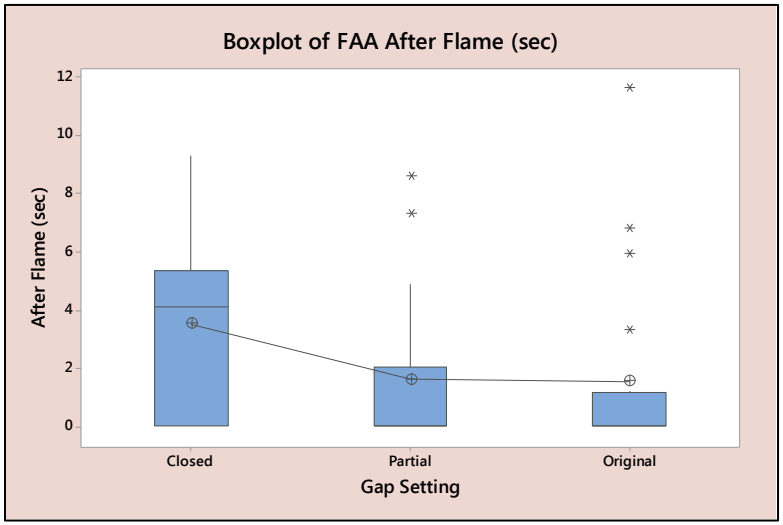
Individial Lab Analysis

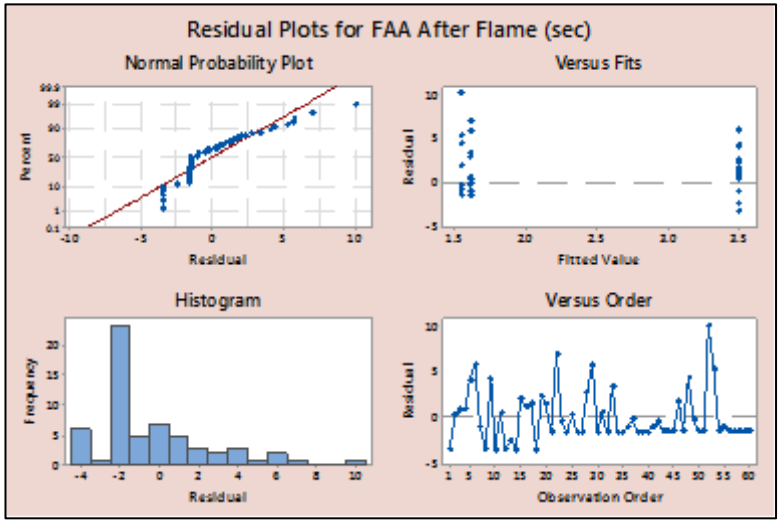
Radiant Panel Gap Analysis

- **FAA: After Flame Time**

```
Source        DF  Adj SS  Adj MS  F-Value  P-Value
Gap Setting    2   49.71  24.857     2.97    0.059
Error         57  477.44   8.376
Total         59  527.15


Gap Setting   N   Mean  StDev      95% CI
Closed       20  3.505  2.950  (2.209, 4.801)
Partial      20  1.610  2.617  (0.314, 2.906)
Original     20  1.540  3.095  (0.244, 2.836)

Pooled StDev = 2.89414

Grouping Information Using the Tukey Method
and 95% Confidence

Gap Setting   N   Mean  Grouping
Closed       20  3.505  A
Partial      20  1.610  A
Original     20  1.540  A

Means that do not share a letter are
significantly different.

Mood median test for After Flame (sec)
Chi-Square = 6.96    DF = 2    P = 0.031

                                    Individual 95.0% CIs
Gap Setting  N≤  N>  Median  Q3-Q1   +---------+---------+---------+------
Closed        6  14    4.10   5.35      (-------------------------*-----)
Partial      12   8    0.00   2.03   *----------)
Original     14   6    0.00   1.15   *-----)
                                    +---------+---------+---------+------
                                   0.0       1.5       3.0       4.5

Overall median = 0.50
```

Not confirmed by median test
Borderline difference with Closed performing worse than Partial and Original (which are “equivalent”).





Radiant Panel Gap Analysis

- **Triumph: Flame Propagation Length**

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Gap Setting	2	3.106	1.5532	5.27	0.008
Error	57	16.800	0.2947		
Total	59	19.906			

Gap Setting	N	Mean	StDev	95% CI
Closed	20	1.980	0.708	(1.737, 2.223)
Partial	20	1.5050	0.3706	(1.2619, 1.7481)
Original	20	1.490	0.495	(1.247, 1.733)

Pooled StDev = 0.542889

Grouping Information Using the Tukey Method and 95% Confidence

Gap Setting	N	Mean	Grouping
Closed	20	1.980	A
Partial	20	1.5050	B
Original	20	1.490	B

Means that do not share a letter are significantly different.

Confirmed by median test

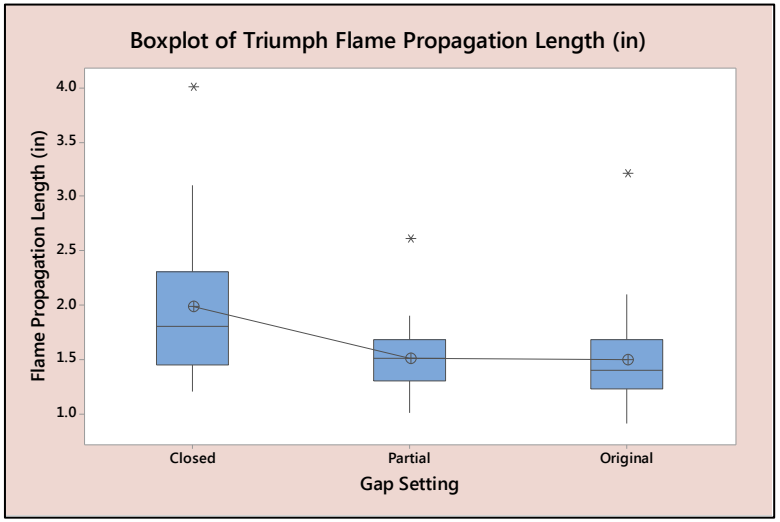
d = (1.98-1.4975)/0.542889 = 0.89

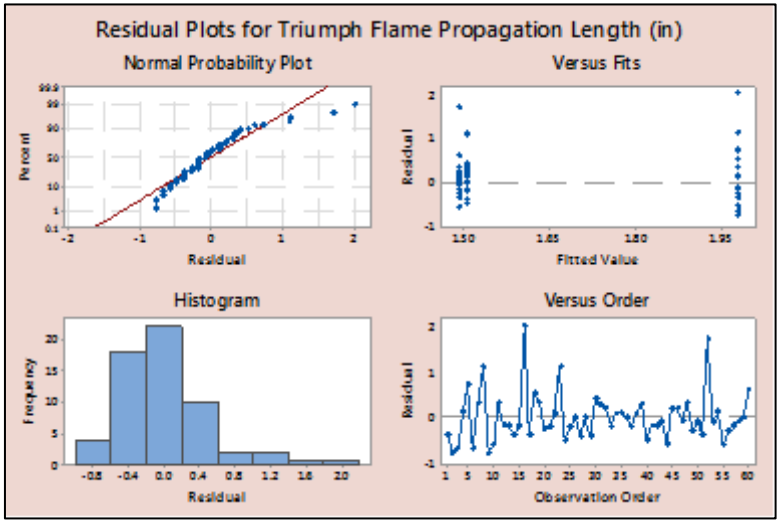
Mood median test for Flame Propagation Length (in)
Chi-Square = 8.40 DF = 2 P = 0.015

Gap Setting	N≤	N>	Median	Q3-Q1	Individual 95.0% CIs
Closed	5	15	1.80	0.85	(------*----------)
Partial	11	9	1.50	0.37	(------*--)
Original	14	6	1.40	0.45	(---*-----)

1.50 1.80 2.10

Overall median = 1.55





Conclusion

- **Thermocouple array showed lowest temperatures when fully closed**
- **Temperature increased with more airflow allowed into chamber**
- **Fully closed performed poorly in 3 position calibration check**
- **Fully closed had the most combined failures**
- **No statistical difference between labs and air gap settings**
  - Analysis was only good up to 1 standard deviation difference
  - Large variance in test data
- **Comparing individual labs showed a few statistical differences between closed and fully open**

Questions?

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