Aeroblaze Laboratory Inc.
12819 Harmon Rd, #575
Fort Worth, TX 76177
www.aeroblazelab.com

FLAMMABILITY TEST REPORT

TEST REPORT #1325.3R, Rev A

HOT-STOP® 'L'

LITHIUM ION FIRE CONTAINMENT KIT

POWERPLANT FIRE PENETRATION

Prepared for

INDUSTRIAL ENERGY PRODUCTS, INC.

56 Newcomer Rd, Mount Joy, PA 17552

REVISION HISTORY

REV.	DESCRIPTION	Date	Approval
IR	Initial Release.	May 18, 2018	A. Feghali
A	Added 30 minute powerplant test results.	March 19, 2019	A. Feghali

The changes made in the most recent release/revision are indicated in the body of the document using a vertical bar in the right margin.

TABLE OF CONTENTS

Aeroblaze Laboratory Inc.
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1.0 INTRODUCTION

Lithium Ion battery powered electronic devices have been identified as in-flight fire hazards due to the potential battery malfunctions that can result in toxic smoke, violent fires, and explosions. These fires are difficult to contain inside an aircraft or in sensitive environments. To make matters worse, many smart phones and laptops are now waterproof – thus preventing water from reaching the cells of the battery.

The HOT-STOP® 'L' Fire Containment Kit is a well-known solution which has safely contained fires, explosions and toxic smoke emissions from Lithium Ion powered devices without the aid of a water supply. HOT-STOP® is a registered trademark of Industrial Energy Products, Inc.

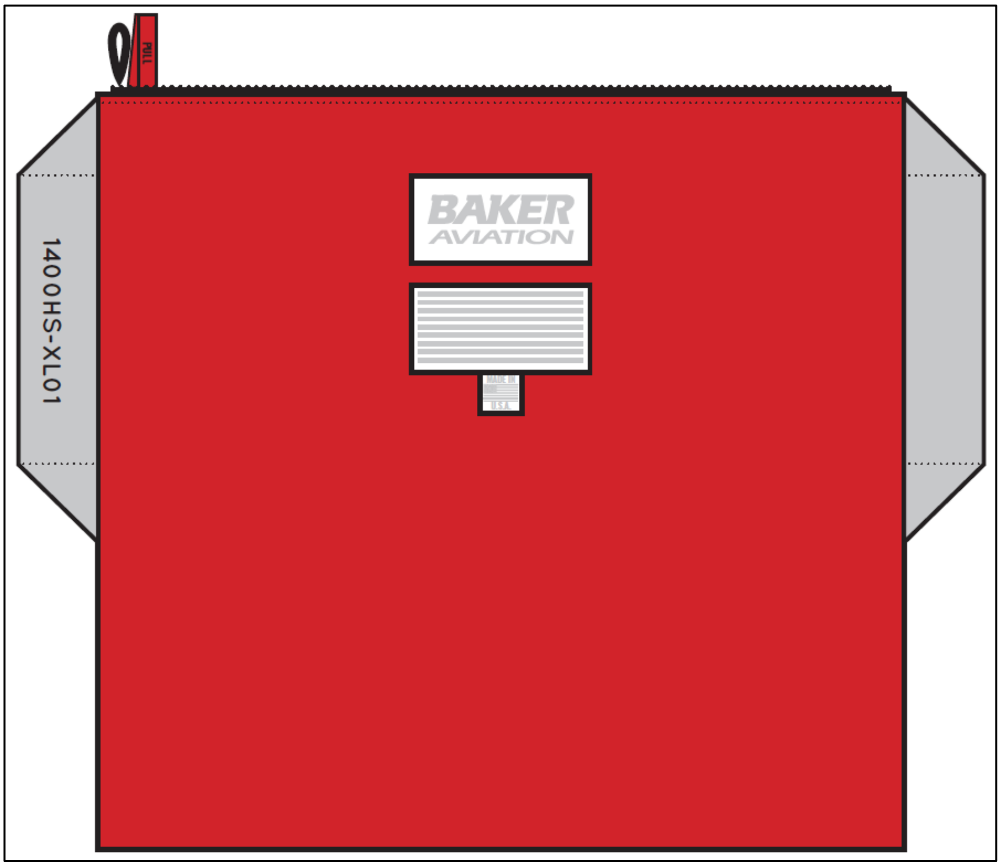

Figure 1 - Example of Containment Kit

To prove the effectiveness of the containment kit against newer, more powerful and waterproof devices, testing must be performed to show that the kit continues to contain battery explosions and subsequent fires.

2.0 SCOPE OF TESTING

Sample ID	Test	Designation
01	Powerplant Fire Penetration: 5 min	Fire Resistant
02	Powerplant Fire Penetration: 15 min	Fire Proof
03	Powerplant Fire Penetration: 30 min	N/A

3.0 REFERENCES

14 CFR 1.1	Code of Federal Regulations; Title 14: Aeronautics and Space; Subchapter A: Definitions and General Requirements; Part I: Definitions and Abbreviations; Section 1.1: General Definitions
Advisory Circular No. 20-135	Powerplant Installation and Propulsion System Component Fire Protection Test Methods, Standards, and Criteria
DOT/FAA/AR-00/12; Chapter 12	Aircraft Materials Fire Test Handbook; Powerplant Fire Penetration Test

4.0 TEST FACILITES

All testing was conducted at the following FAA-listed test laboratory:

Aeroblaze Laboratory
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Fort Worth, TX 76177 USA

5.0 TEST SUMMARY

The Powerplant Fire Penetration test is used to demonstrate compliance with the aircraft powerplant (i.e. engine) fire protection requirements of the FAA. There are two types of fire protection designations as defined by 14 CFR 1.1:

1. **Fire Resistant:** the capacity to withstand the heat associated with fire at least as well as *aluminum alloy* in dimensions appropriate for the purpose for which they are used.
2. **Fire Proof:** the capacity to withstand the heat associated with fire at least as well as *steel* in dimensions appropriate for the purpose for which they are used.

The standard test used to determine the fire protection designations is detailed in FAA Advisory Circular (AC) No. 20-135, titled "*Powerplant Installation and Propulsion System Component Fire Protection Test Methods, Standards, and Criteria*" and DOT/FAA/AR-00/12; Chapter 12, titled "*Aircraft Materials Fire Test Handbook; Powerplant Fire Penetration Test*". The test utilizes a modified gun-type oil burner which is calibrated to provide a high-intensity flame with a minimum average flame temperature of 2,000 °F and minimum heat transfer rate of 4,500 BTU/hr or 9.3 BTU/ft^2-sec.

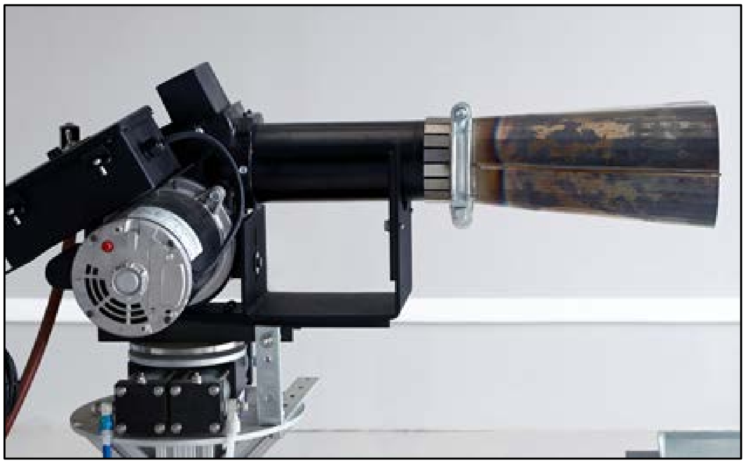

Figure 2. Carlin 200 CRD (Modified Gun-Type Oil Burner)

The sample under test must withstand this high-intensity flame for either five minutes to be designated “Fire Resistant” or fifteen minutes to be designated “Fire Proof”.

6.0 TEST SAMPLES

Two sheets of material with dimensions 24” x 24” were provided by the manufacturer. These sheets of material represented a build-up of the HOT-STOP® 'L' Fire Containment Kit’s wall. The flame was applied to the face of the sample simulating the inside of the bag in order to test the bag’s burn-through resistance.

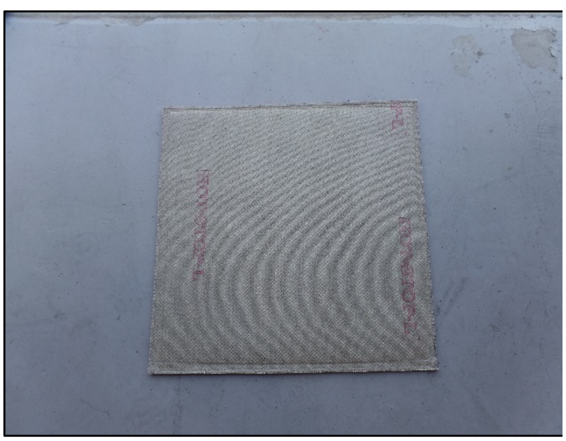

Figure 3. Front Face (Inside of Bag)

Figure 4. Back Face (Outside of Bag)

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7.0 FLAME PRE-CALIBRATION

The burner was first calibrated per the instructions of AC 20-135 and FAA Fire Test Handbook Chapter 12 to achieve the proper flame conditions. The pre-calibration average temperature was 2,009 °F and the average heat flux was 10.82 BTU/ft^2-sec (as calibrated with the calorimeter device described in AC 20-135). The measured heat flux was approximately 16% higher than required, resulting in a more severe flame.

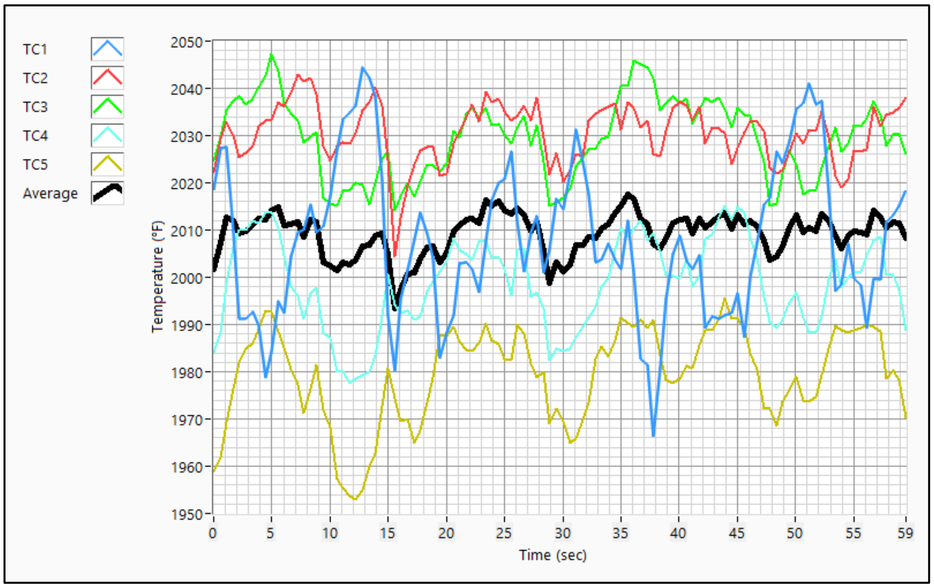

Figure 5. Pre-Calibration Temperature Graph (5-min & 15-min test)

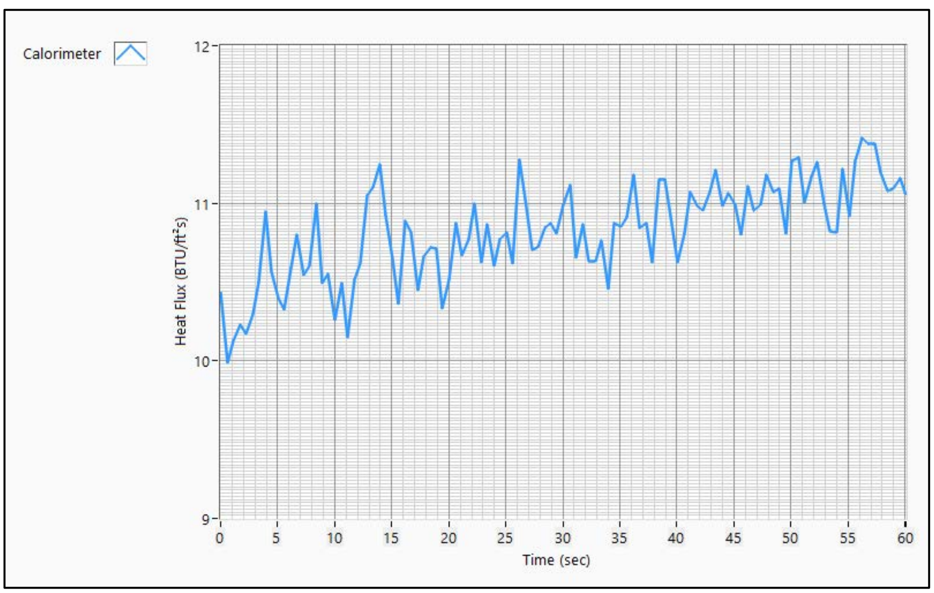

Figure 6. Pre-Calibration Heat Flux Graph (5-min & 15-min test)

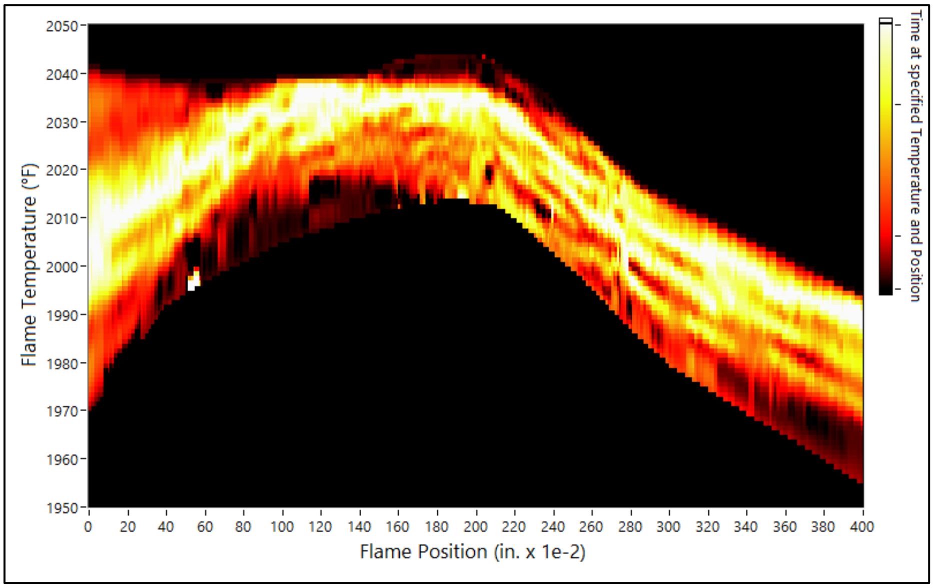

Figure 7. Pre-Calibration Flame Profile (5-min & 15-min test)

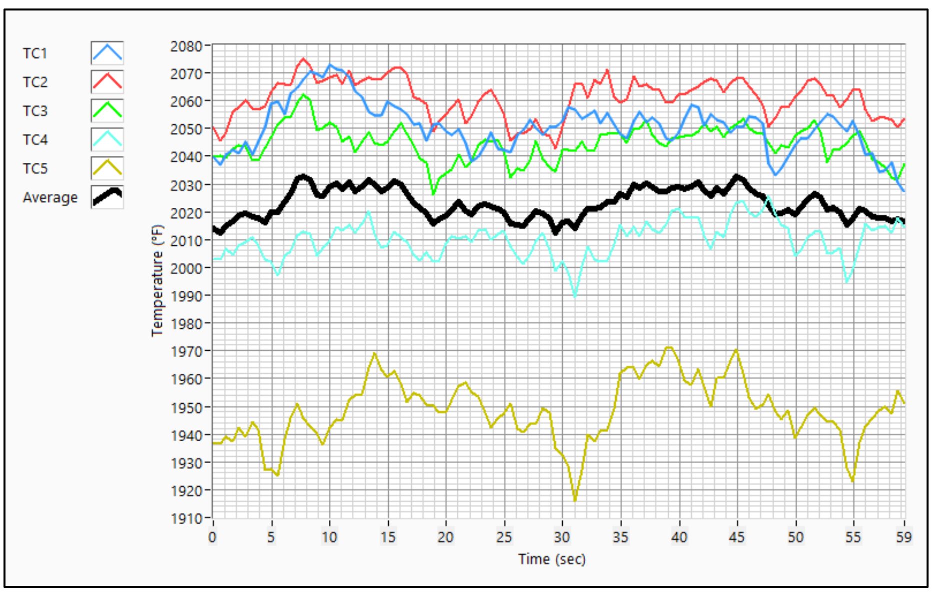

Figure 8. Pre-Calibration Temperature Graph (30-min test)

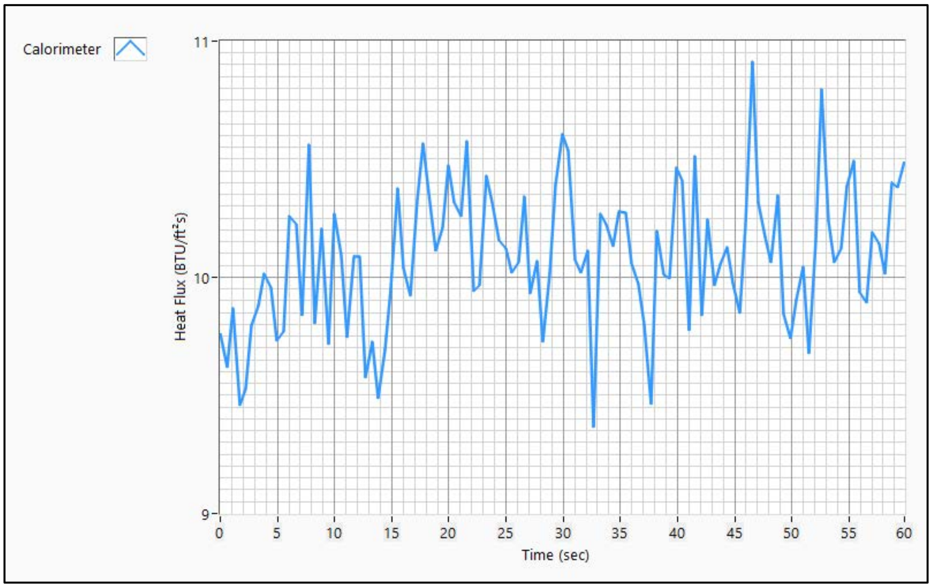

Figure 9. Pre-Calibration Heat Flux Graph (30-min test)

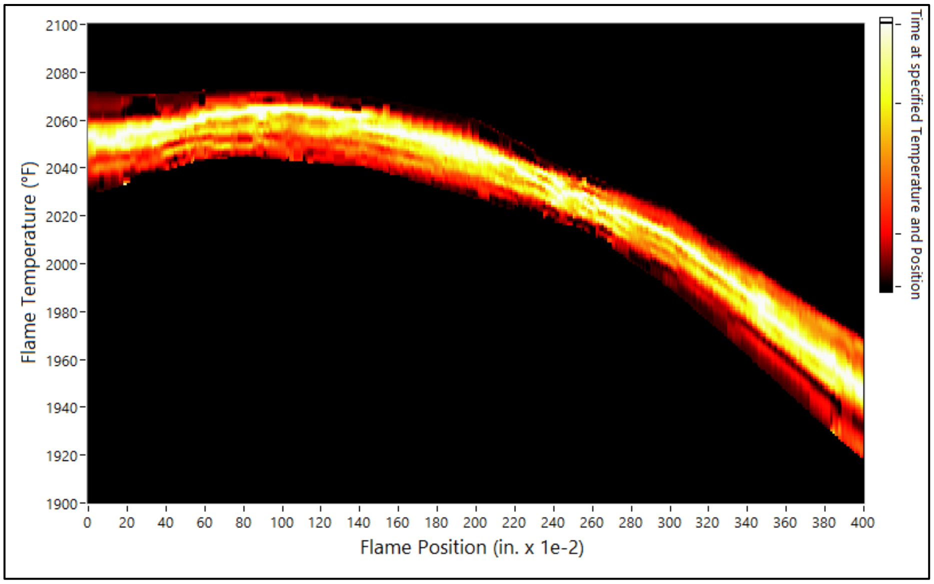

Figure 10. Pre-Calibration Flame Profile (30-min test)

8.0 TEST SET-UP

Following the successful flame calibration, the first test sample was mounted in the fixture with the face representing the inside of the containment kit facing the flame.

Figure 11. Test Set-up (Front Face)

A camera was set up behind the sample facing the outer side of the containment kit.

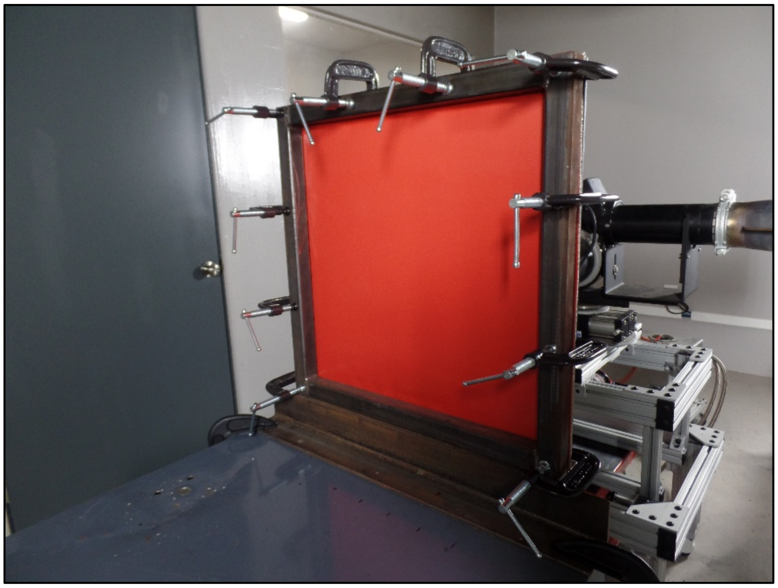

Figure 12. Test Set-up (Back Face)

9.0 FIRE RESISTANCE TEST

Following a two-minute burner warm-up, the burner flame was positioned in front of the center of the test sample at four inches.

Figure 13. Flame Applied to Test Sample

At approximately 1:53 (mm:ss) the back side of the sample began to shrink and melt from the heat.

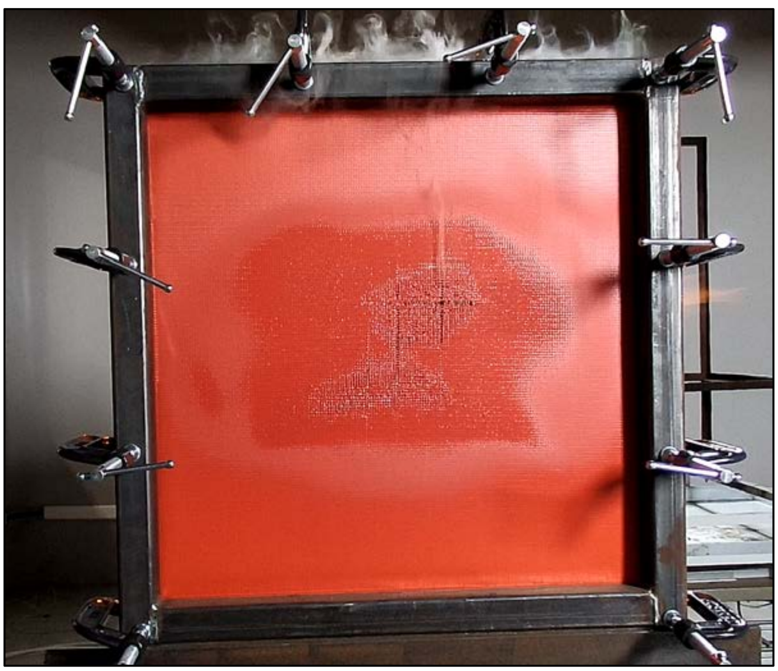

Figure 14. Back-side Shrinking and Melting

The flame was applied for five minutes, then the burner was shut off and rotated out of position. No flame penetration or back-side burning occurred during testing. After examining the test sample, it was determined that the flame had only damaged the first layer of the inner material.

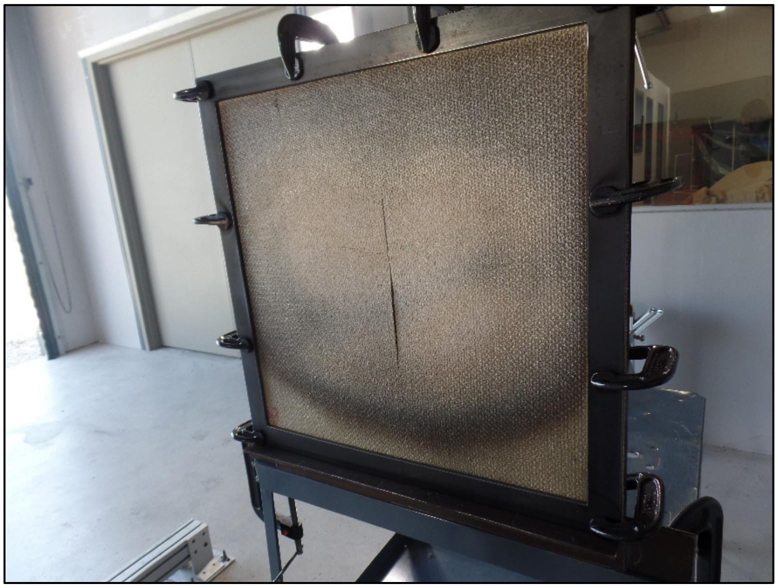

Figure 15. Front-Side Test Results

After peeling away the first layer, it was observed that no damage had occurred to the following layer.

Figure 16. First Layer Peeled Away

No damage was found in the back layer of the material other than the melting of the thin aesthetic layer from the heat. A dull pen tip was unable to push through the material from the back side, indicating that it had not been severely damaged.

Figure 17. Back-side Test Results

10.0 FIRE PROOF TEST

Following the successful results of the Fire Resistant test, the Fire Proof test was attempted on a new test sample. The burner was again warmed-up for two-minutes, then the flame was positioned in front of the center of the test sample at four inches.

At approximately 1:27 (mm:ss) the back side of the sample began to shrink and melt from the heat similar to the first sample that was tested.

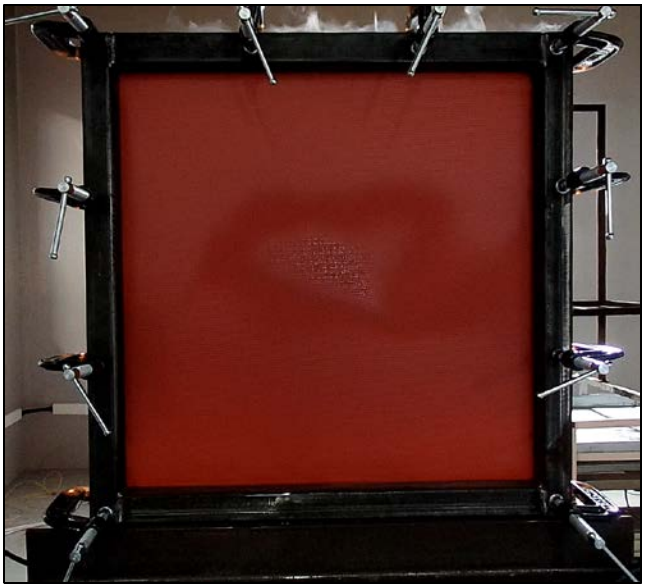

Figure 18. Back-side Shrinking and Melting

The flame was applied for fifteen minutes, then the burner was shut off and rotated out of position. No flame penetration or back-side burning occurred during testing. After examining the test sample, it was determined that the flame had only damaged the first layer of the inner material, similar to the first sample that was tested.

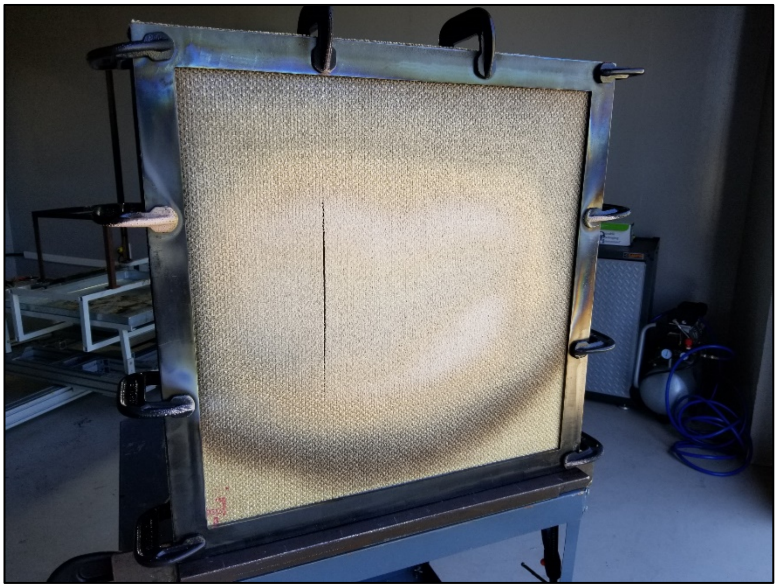

Figure 19. Front-Side Test Results

After peeling away the first layer, it was observed that no damage had occurred to the following layer.

Figure 20. First Layer Peeled Away

No damage was found in the back layer of the material other than the melting of the thin aesthetic layer from the heat. A dull pen tip was unable to push through the material from the back side, indicating that it had not been severely damaged.

Figure 21. Back-side Test Results

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11.0 EXTENDED FIRE PROOF TEST

Following the successful results of the Fire Proof test, an extended Fire Proof test was attempted on a new test sample at double the time of the Fire Proof test. The burner was again warmed-up for two-minutes, then the flame was positioned in front of the center of the test sample at four inches.

The back side of the sample began to shrink and melt from the heat similar to the other samples that were tested.

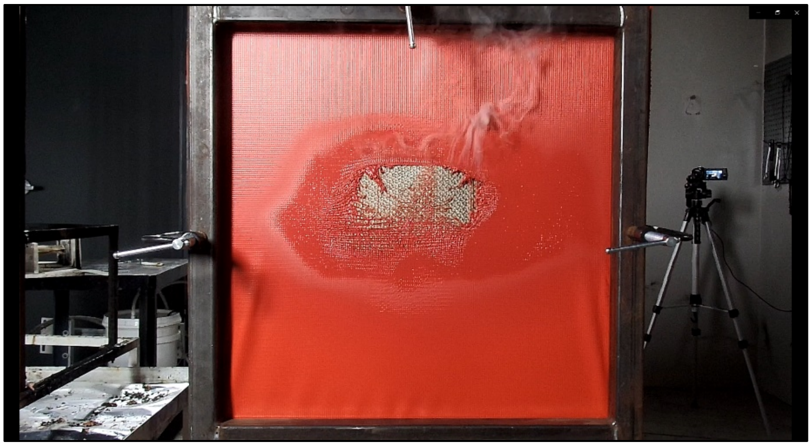

Figure 22. Back-side Shrinking and Melting

The flame was applied for thirty minutes, then the burner was shut off and rotated out of position. No flame penetration or back-side burning occurred during testing. After examining the test sample, it was determined that the flame hadn't penetrated the inner layer.

Figure 23. Front-Side Test Results

After peeling away the first layer, it was observed that no damage had occurred to the following layer.

Figure 24. First Layer Peeled Away

No damage was found in the back layer of the material other than the melting of the thin aesthetic layer from the heat. A dull pen tip was unable to push through the material from the back side, indicating that it had not been severely damaged.

Figure 25. Back-side Test Results

12.0 FLAME POST-CALIBRATION

Following the successful tests, the flame temperature calibration was re-run to ensure proper flame temperature throughout the tests. The average flame post-calibration temperature was 2,015 °F.

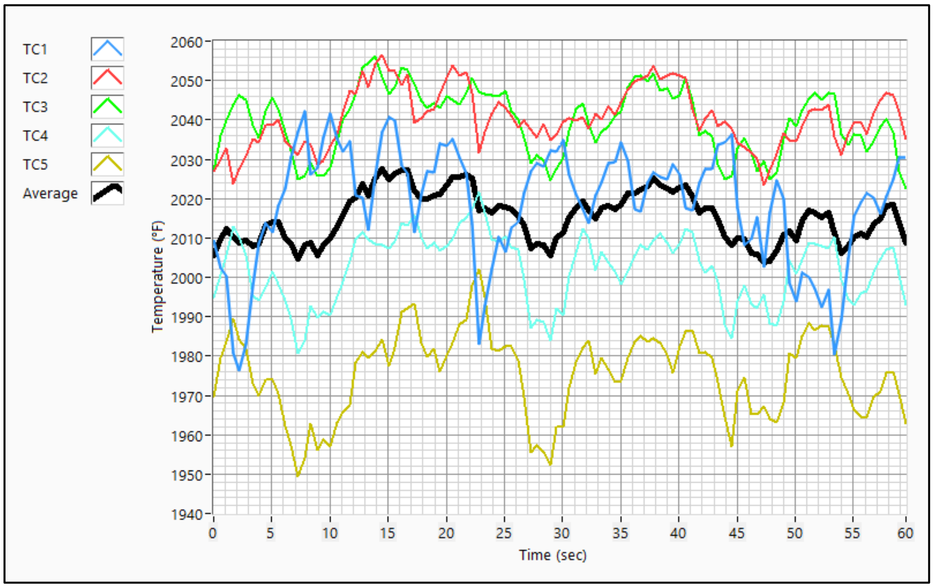

Figure 26. Post-Calibration Temperature Graph (5-min & 15-min test)

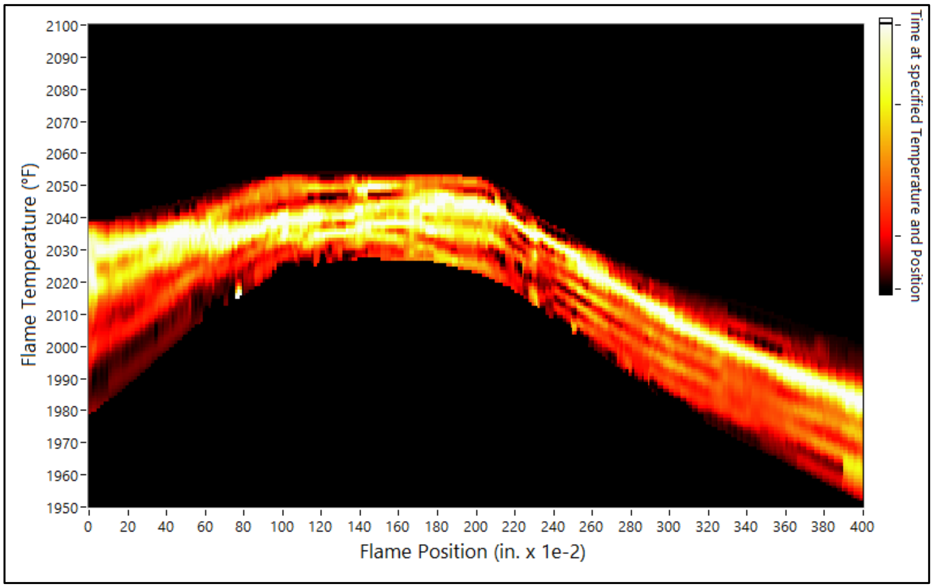

Figure 27. Post-Calibration Flame Profile (5-min & 15-min test)

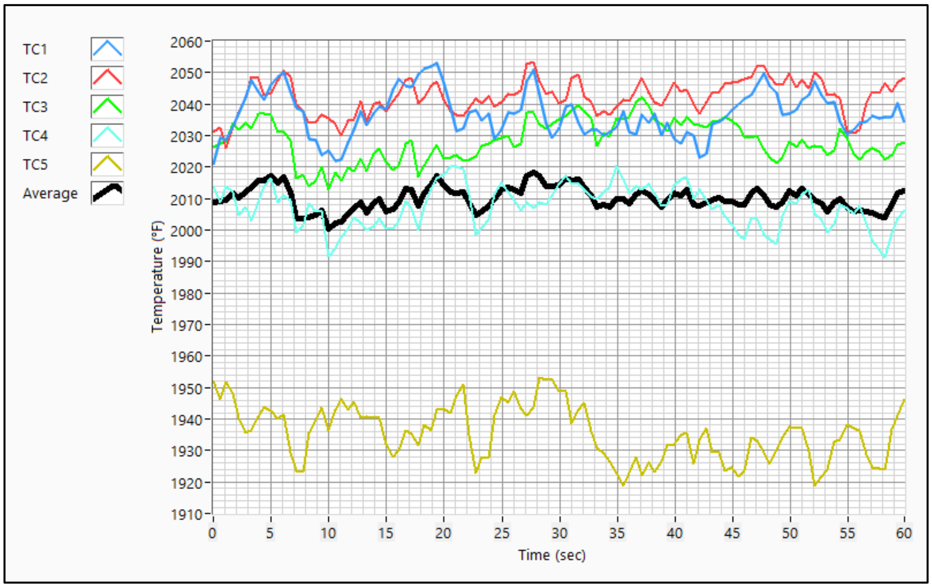

Figure 28. Post-Calibration Temperature Graph (30-min test)

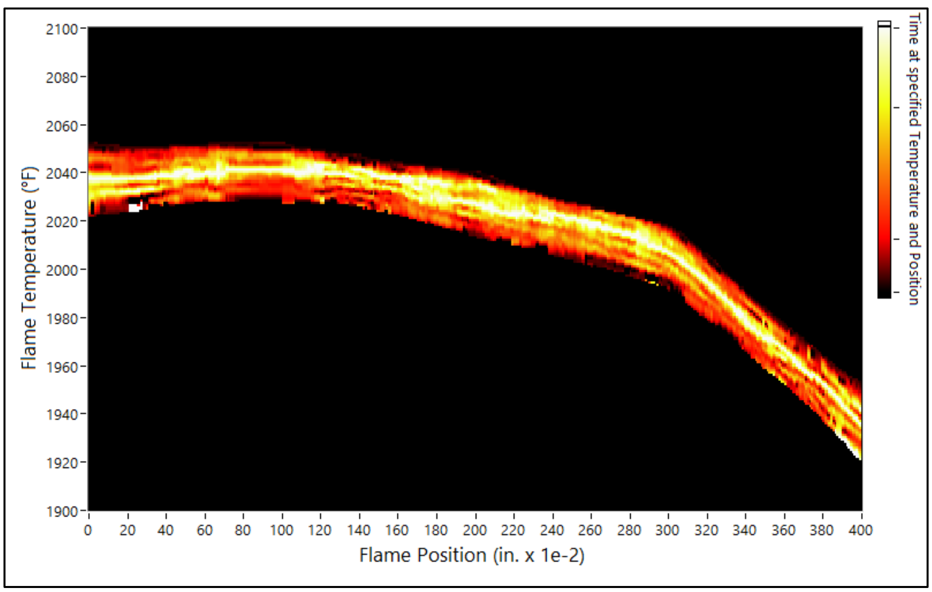

Figure 29. Post-Calibration Flame Profile (30-min test)

13.0 CONCLUSION

The HOT-STOP® 'L' Fire Containment Kit successfully prevented the high-intensity flame from penetrating through its wall. The Containment Kit passed the five-minute Fire-Resistant test, the fifteen minute Fire Proof test, and the extended 30 minute test. Following the results of this testing, the HOT-STOP® 'L' Fire Containment Kit can be considered Fire Proof as defined by the Code of Federal Regulations (14 CFR 1.1) and as demonstrated by the Federal Aviation Administration’s (AC 20-135) test procedure. Based on the 14 CFR 1.1 definition of Fire Proof, the HOT-STOP® 'L' Fire Containment Kit has the capacity to withstand the heat associated with fire at least as well as steel in dimensions appropriate for the purpose for which it is used (14 CFR 1.1).

Appendix A
Test Data Sheets

Aeroblaze Laboratory Inc.
12819 Harmon Rd, #575
Fort Worth, TX 76177
www.aeroblazelab.com

+1 (817) 668-0628
info@aeroblazelab.com
www.aeroblazelab.com

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12819 Harmon Rd. #575
Fort Worth, TX 76177 USA

Powerplant Fire Penetration Test Results

TR# 1325.3

Regulation:	14 CFR 25.1191(b)(1)	**Criteria:**	Advisory Circular No. 20-135	**Procedure:**	Advisory Circular No. 20-135

Customer Information	Sample Notes
Industrial Energy Products, Inc. 56 Newcomer Road Mount Joy, PA 17552	Hot-Stop® 'L' Lithium Ion Fire Containment Kit Flat Sheet of Kit Wall Build-up

Flame Temperature: 2000 °F ± 100 °F | Heat Flux Density: 9.3 Btu/ft^2-sec or 4,500 BTU/hr minimum

Sample	Flame Time (min:sec)	Burnthrough? (Yes/No)	Backside Ignition? (Yes/No)
1	5:00	No	No
2	15:00	No	No
3	-	-	-

Acceptance Criteria

The sample must withstand flame penetration and not exhibit backside ignition for the required test time.
- »Fire-Resistant: 5 minutes
- »Fire-Proof: 15 minutes

Result & Designation

[X] PASS [ ] FAIL

[ ] Fire-Resistant [X] Fire-Proof

Notes:
First sample tested for 5 minutes (fire-resistant) and second sample tested for 15 minutes (fire-proof).

Tested by: Andrew Feghali & Leslie Gardner 17-May-18
Lab Manager & Lab Engineer

Approval: Andrew Feghali 17-May-18
Andrew Feghali, Lab Manager

TP-12-01, Rev -

1 of 3

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info@aeroblazelab.com
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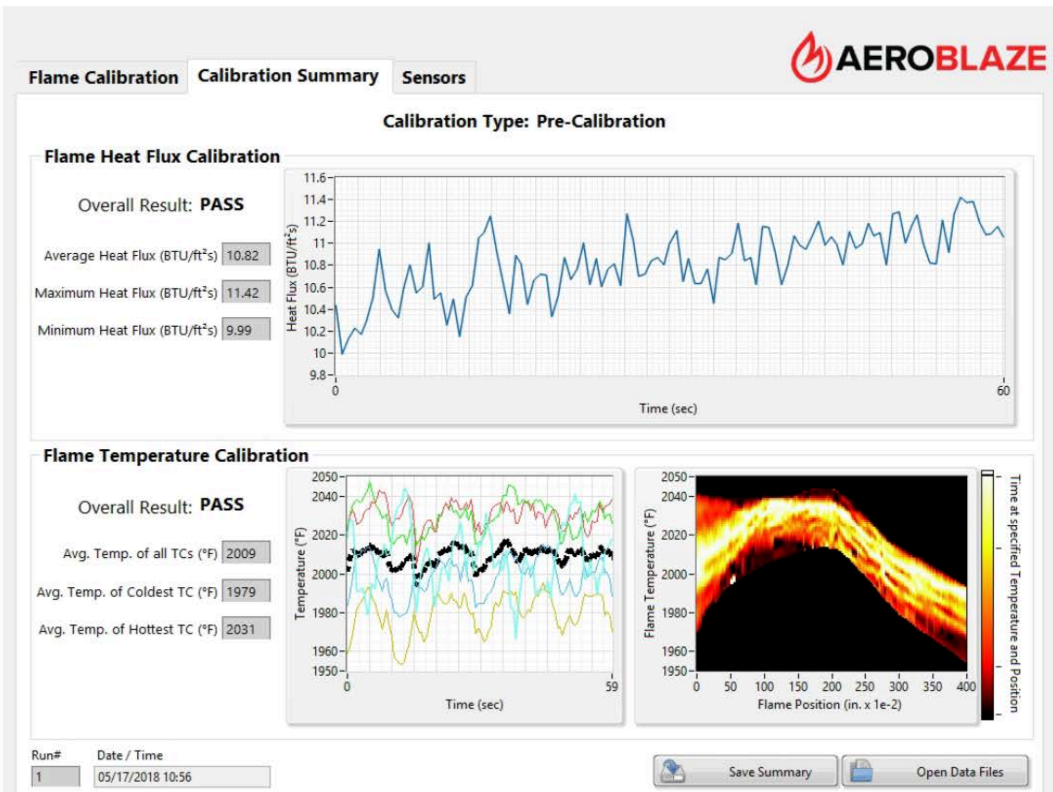
Powerplant Fire Penetration Test Results					TR# 1325.3
Regulation:	14 CFR 25.1191(b)(1)	**Criteria:**	Advisory Circular No. 20-135	**Procedure:**	Advisory Circular No. 20-135

FLAME PRE-CALIBRATION SUMMARY



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Powerplant Fire Penetration Test Results				TR# 1325.3	
Regulation:	14 CFR 25.1191(b)(1)	**Criteria:**	Advisory Circular No. 20-135	**Procedure:**	Advisory Circular No. 20-135

FLAME POST-CALIBRATION SUMMARY

Flame Calibration | Calibration Summary | Sensors

AEROBLAZE

Calibration Type: Post-Calibration

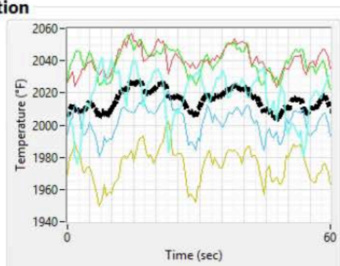
Flame Temperature Calibration

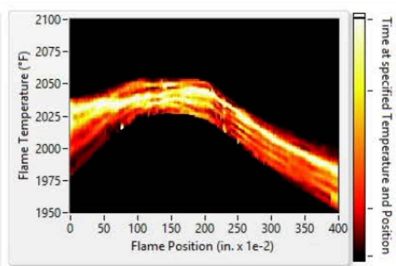
Overall Result: **PASS**

Avg. Temp. of all TCs (°F) 2015

Avg. Temp. of Coldest TC (°F) 1975

Avg. Temp. of Hottest TC (°F) 2040





Run# 1

Date / Time 05/17/2018 13:17

Save Summary | Open Data Files

- END OF REPORT -

TP-12-01, Rev -

3 of 3

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Report # 1325.5

Powerplant Fire Penetration Test Results

Regulation:	14 CFR 25.1191(b)(1)	Criteria:	Advisory Circular No. 20-135	Procedure:	Advisory Circular No. 20-135

Customer Information	Sample Notes
Industrial Energy Products, Inc. 56 Newcomer Road Mount Joy, PA 17552	Hot-Stop® 'L' Lithium Ion Fire Containment Kit Flat Sheet of Kit Wall Build-up

Flame Temperature: 2000 °F ± 100 °F | Heat Flux Density: 9.3 Btu/ft^2-sec or 4,500 BTU/hr minimum

Sample	Flame Time (min:sec)	Burnthrough? (Yes/No)	Backside Ignition? (Yes/No)
1	30:00	No	No

Acceptance Criteria	Result & Designation
The sample must withstand flame penetration and not exhibit backside ignition for the required test time. »Fire-Resistant: 5 minutes »Fire-Proof: 15 minutes	[X] PASS [ ] FAIL [X] Fire-Resistant [X] Fire-Proof

Notes:
None

The results of this test report have been obtained in compliance with the listed requirements and/or specifications. Amendment levels are that of the current amendments on the date testing was performed, unless otherwise specified. This test report shall not be reproduced, except in full, without written approval from Aeroblaze Laboratory Inc. The test results relate only to the items tested.

Tested by: Andrew Feghali & Clay Johnson 11-Mar-19
Lab Manager & Lab Technician

Approval: Andrew Feghali 19-Mar-19
Andrew Feghali, Lab Manager

TP-12-01, Rev -

+1 (817) 668-0628
info@aeroblazelab.com
www.aeroblazelab.com

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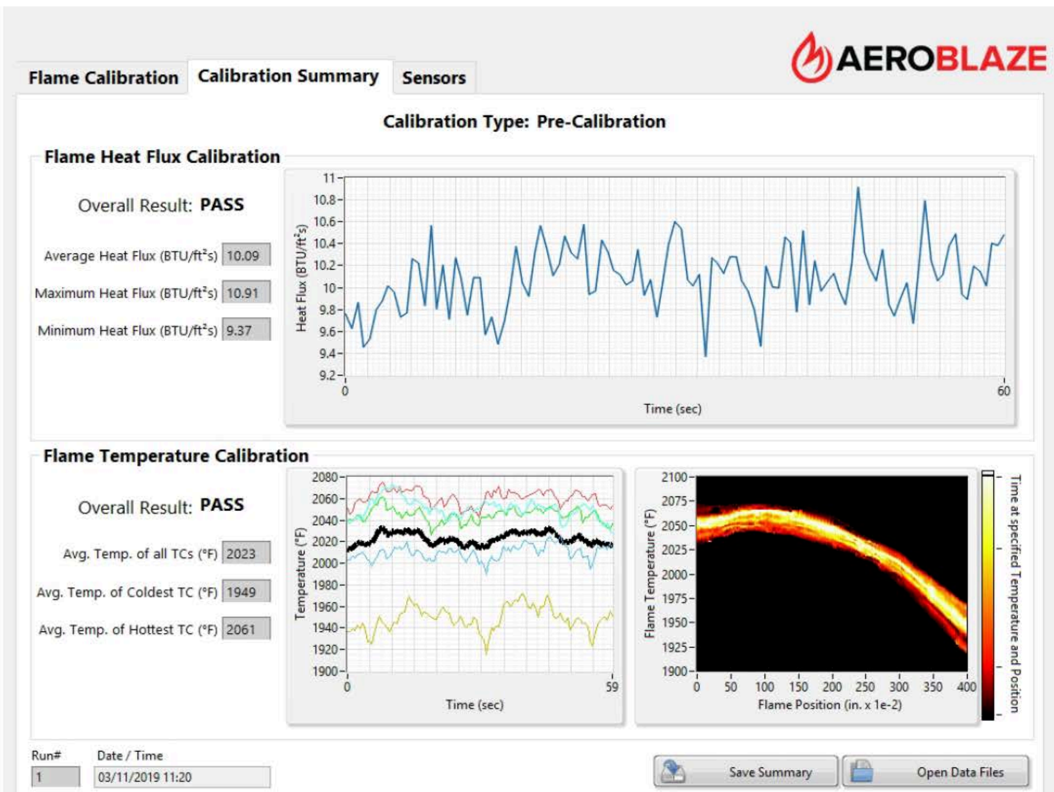
Report # 1325.5

Powerplant Fire Penetration Test Results

Regulation:	14 CFR 25.1191(b)(1)	Criteria:	Advisory Circular No. 20-135	Procedure:	Advisory Circular No. 20-135

FLAME PRE-CALIBRATION SUMMARY



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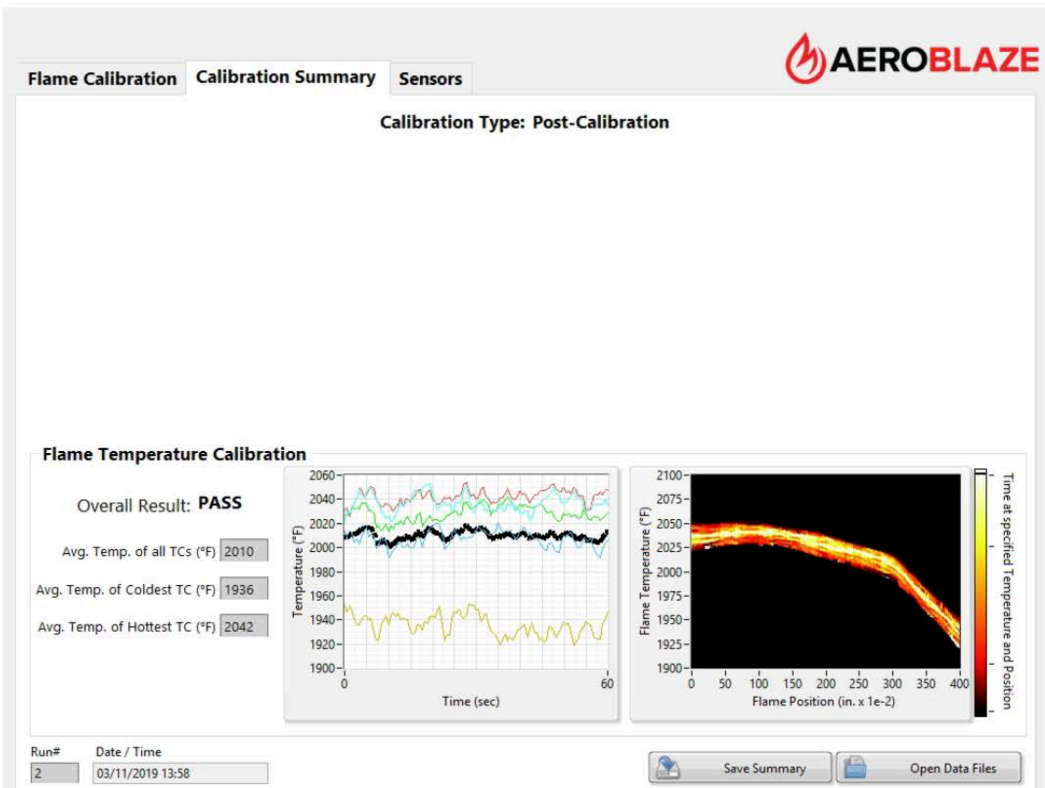
Powerplant Fire Penetration Test Results

Regulation:	14 CFR 25.1191(b)(1)	Criteria:	Advisory Circular No. 20-135	Procedure:	Advisory Circular No. 20-135

FLAME POST-CALIBRATION SUMMARY



TP-12-01, Rev -