

# FLAMMABILITY TEST REPORT

TEST REPORT #1325.3R, Rev IR

# HOT-STOP® 'L' LITHIUM ION FIRE CONTAINMENT KIT POWERPLANT FIRE PENETRATION

HOT-STOP® is a registered trademark of Industrial Energy Products, Inc.

Prepared for

### INDUSTRIAL ENERGY PRODUCTS, INC.

56 Newcomer Rd, Mount Joy, PA 17552

Report #1325.3R, Rev IR Page 1 of 19



#### **REVISION HISTORY**

REV.	DESCRIPTION	Date	Approval
IR	Initial Release.	May 18, 2018	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.

Report #1325.3R, Rev IR Page 2 of 19



#### **TABLE OF CONTENTS**

1.0	INTRODUCTION	. 4
2.0	SCOPE OF TESTING	. 5
3.0	REFERENCES	. 5
4.0	TEST FACILITES	. 5
5.0	TEST SUMMARY	. 5
6.0	TEST SAMPLES	. 6
7.0	FLAME PRE-CALIBRATION	. 7
8.0	TEST SET-UP	.8
9.0	FIRE RESISTANCE TEST	.9
10.0	FIRE PROOF TEST	12
11.0	FLAME POST-CALIBRATION	14
12.0	CONCLUSION	15
Appen	dix A Test Data Sheet	16
	TABLE OF FIGURES	
Figure	1 - Example of Containment Kit	4
_	2. Carlin 200 CRD (Modified Gun-Type Oil Burner)	
_	3. Front Face (Inside of Bag)	
_	4. Back Face (Outside of Bag)	
Figure	5. Pre-Calibration Temperature Graph	. 7
Figure	6. Pre-Calibration Heat Flux Graph	. 7
Figure	7. Pre-Calibration Flame Profile	. 8
Figure	8. Test Set-up (Front Face)	. 8
Figure	9. Test Set-up (Back Face)	. 9
Figure	10. Flame Applied to Test Sample	. 9
Figure	11. Back-side Shrinking and Melting	10
Figure	12. Front-Side Test Results	10
Figure	13. First Layer Peeled Away	11
Figure	14. Back-side Test Results	11
_	15. Back-side Shrinking and Melting	
_	16. Front-Side Test Results	
_	17. First Layer Peeled Away	
_	18. Back-side Test Results	
_	19. Post-Calibration TemperatureGraph	
Figure	20. Post-Calibration Flame Profile	15



#### 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.

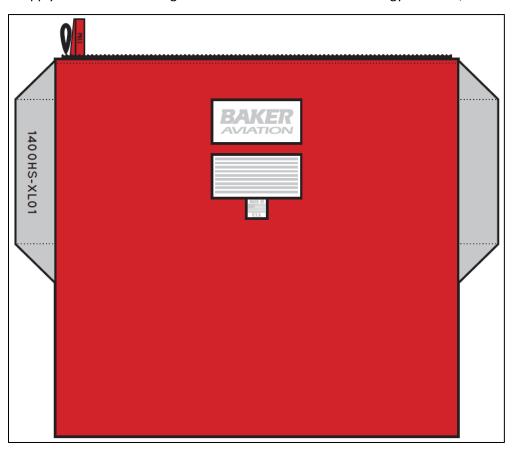


Figure 1 - Example of Containment Kit

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.

Report #1325.3R, Rev IR Page 4 of 19



#### 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

#### 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.	Powerplant Installation and Propulsion System Component Fire
20-135	Protection Test Methods, Standards, and Criteria
DOT/FAA/AR-00/12;	Aircraft Materials Fire Test Handbook; Powerplant Fire Penetration
Chapter 12	Test

#### 4.0 TEST FACILITES

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

Aeroblaze Laboratory 12819 Harmon Rd. #575 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/ft²-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 $^{\circ}$  '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 4. Back Face (Outside of Bag)

Report #1325.3R, Rev IR Page 6 of 19



#### 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.

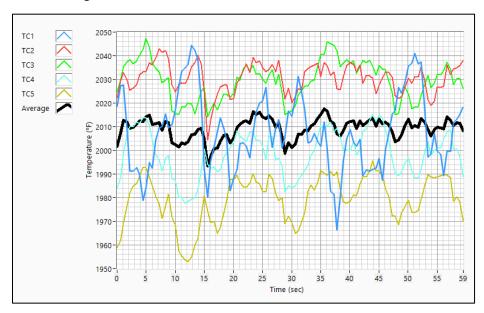


Figure 5. Pre-Calibration Temperature Graph

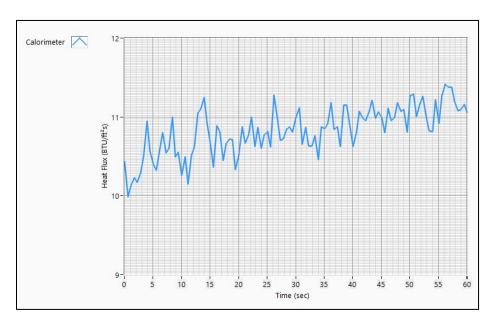


Figure 6. Pre-Calibration Heat Flux Graph

Report #1325.3R, Rev IR Page 7 of 19



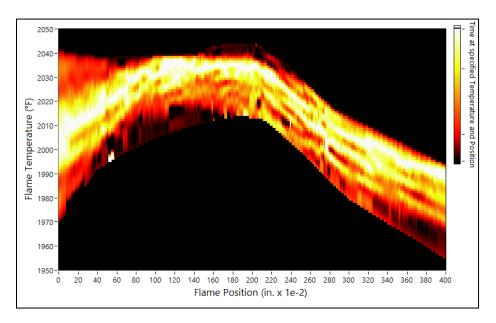


Figure 7. Pre-Calibration Flame Profile

#### 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 8. Test Set-up (Front Face)

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

Report #1325.3R, Rev IR Page 8 of 19





Figure 9. 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 10. 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.

Report #1325.3R, Rev IR Page 9 of 19



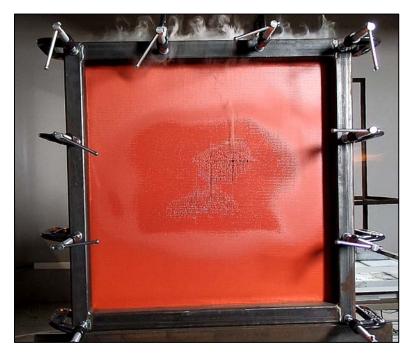


Figure 11. Back-side Shrinking and Melting

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 12. Front-Side Test Results

Report #1325.3R, Rev IR Page 10 of 19



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



Figure 13. 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 14. Back-side Test Results

Report #1325.3R, Rev IR Page 11 of 19

Page 12 of 19



#### 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.

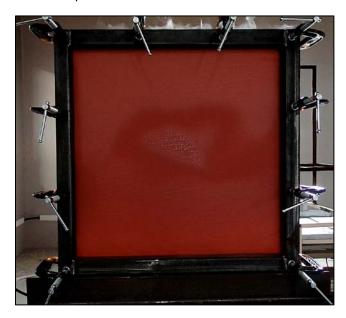


Figure 15. Back-side Shrinking and Melting

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.

Report #1325.3R, Rev IR



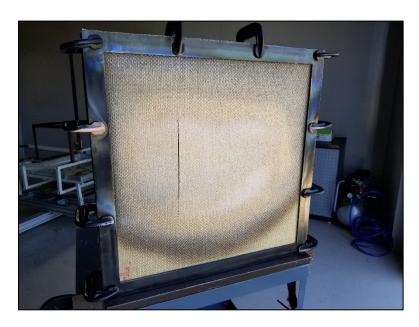


Figure 16. Front-Side Test Results

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



Figure 17. 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.

Report #1325.3R, Rev IR Page 13 of 19





Figure 18. Back-side Test Results

#### 11.0 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  $2,015\,^{\circ}F$ .

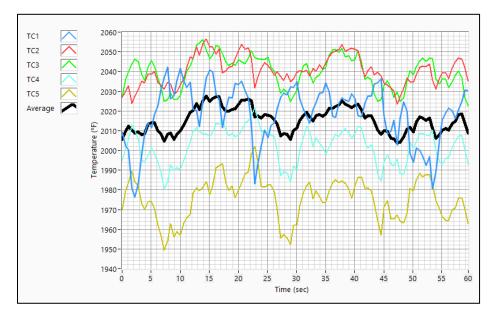


Figure 19. Post-Calibration TemperatureGraph

Report #1325.3R, Rev IR Page 14 of 19



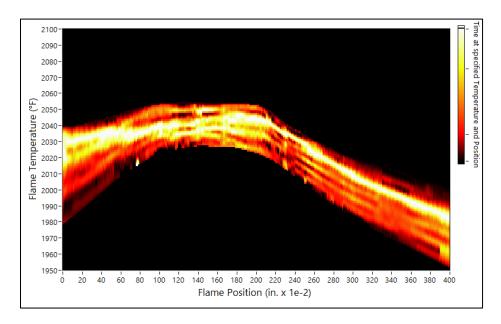


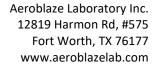
Figure 20. Post-Calibration Flame Profile

#### 12.0 CONCLUSION

The HOT-STOP® 'L' Fire Containment Kit successfully prevented the high-intensity flame from penetrating through its wall. The Containment Kit passed both the five-minute Fire Resistant test and the fifteen minute Fire Proof 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 Sheet







+1 (817) 668-0628

Aeroblaze Laboratory

Customer Information  Industrial Energy Products, Inc. 56 Newcomer Road Mount Joy, PA 17552  Flame Temperature: 2000 °F ± 100 °F  Heat Flux Density: 9.3 Btu/ft²-sec or 4,500 BTU/hr minim  Sample  Flame Time (minsec)  Burnthrough? (Yes/No)  Backside Ignition? (Yes/No)  1 5:00  No  No  No  2 15:00  No  No  No  Acceptance Criteria  Result & Designation  Acceptance Criteria  Result & Designation  Fire-Resistant: 5 minutes  »Fire-Proof: 15 minutes  Fire-Proof: 15 minutes  Fire-Proof: 15 minutes  Fire-Proof: 15 minutes (fire-resistant) and second sample tested for 15 minutes (fire-proof).		rplant Fire	renetra	ition les	t Kesu	Its		ΓR# 1325.3
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/ft²-sec or 4,500 BTU/hr minim  Sample Flame Time (min-sec)  Burnthrough? (Yes/No)  Backside Ignition? (Yes/  1 5:00  No  No  No  No  Acceptance Criteria  Result & Designation  Le sample must withstand flame penetration and not hibit backside ignition for the required test time.  Fire-Proof: 15 minutes  Fire-Proof: 15 minutes  Fire-Proof: 15 minutes  The results of this test report have been obtained in compliance with the listed requirements and/or specifications. Amendment levels are that of the renderents on the date testing was performed, unless otherwise specified. This test report shall not be reproduced, except in full, without written app Aeroblaze Laboratory Inc. The test results relate only to the items tested.  Approval: Auditor. Flame Time (min-sec)  Burnthrough? (Yes/No)  Backside Ignition? (Yes/No)  No  No  No  No  No  Acceptance Criteria  Result & Designation  X Fire-Pro  FAII  The results of this test report have been obtained in compliance with the listed requirements and/or specifications. Amendment levels are that of the renderents on the date testing was performed, unless otherwise specified. This test report shall not be reproduced, except in full, without written app Aeroblaze Laboratory Inc. The test results relate only to the items tested.  Approval: Auditor. Faither and the report shall not be reproduced, except in full, without written app Aeroblaze Laboratory Inc. The test results relate only to the items tested.	egulation:	14 CFR 25.1191(b)(1)	Criteria:	Advisory Circula	No. 20-135	Proced	ure:	Advisory Circular No. 20-1
Flame Temperature: 2000 °F ± 100 °F		Customer Inform	ation			Sa	mple N	Notes
Sample Flame Time (minsec) Burnthrough? (Yes/No) Backside Ignition? (Yes/  1 5:00 No No  2 15:00 No No  3  Acceptance Criteria  Result & Designation  With stand flame penetration and not whibit backside ignition for the required test time.  Fire-Resistant: 5 minutes  Fire-Proof: 15 minutes (fire-resistant) and second sample tested for 15 minutes (fire-proof).	In	56 Newcomer R	oad					
1 5:00 No No No  2 15:00 No No No  3	Flame T	emperature: 2000 °	F ± 100 °F	Heat Fl	ux Density:	9.3 Btu/ft	²-sec o	or 4,500 BTU/hr minim
Acceptance Criteria  Result & Designation  FAII  FIRE-Resistant: 5 minutes  Fire-Proof: 15 minutes  Fire-Proof: 15 minutes  Wotes:  Irist sample tested for 5 minutes (fire-resistant) and second sample tested for 15 minutes (fire-proof).  The results of this test report have been obtained in compliance with the listed requirements and/or specifications. Amendment levels are that of the mendments on the date testing was performed, unless otherwise specified. This test report shall not be reproduced, except in full, without written apple Aeroblaze Laboratory Inc. The test results relate only to the items tested.  Fested by: Andrew Feghali & Leslie Gardner 17-May-18  Approval: Ambrew Feghali & Leslie Gardner 17-May-18	Sample	Flame Time	(min:sec)	Burntl	nrough? (Yes	/No)	Backside Ignition? (Yes/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  **Fire-Proof: 15 minutes  Notes:  irst sample tested for 5 minutes (fire-resistant) and second sample tested for 15 minutes (fire-proof).  The results of this test report have been obtained in compliance with the listed requirements and/or specifications. Amendment levels are that of the mendments on the date testing was performed, unless otherwise specified. This test report shall not be reproduced, except in full, without written appropriate the state only to the items tested.  The results of this test report have been obtained in compliance with the listed requirements and/or specifications. Amendment levels are that of the mendments on the date testing was performed, unless otherwise specified. This test report shall not be reproduced, except in full, without written appropriate tested by: Andrew Feghali & Leslie Gardner 17-May-18  Approval:  **Approval: **Approval	1	5:00	)	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  **Fire-Proof: 15 minutes  **Notes:*  Inst sample tested for 5 minutes (fire-resistant) and second sample tested for 15 minutes (fire-proof).  The results of this test report have been obtained in compliance with the listed requirements and/or specifications. Amendment levels are that of the mendments on the date testing was performed, unless otherwise specified. This test report shall not be reproduced, except in full, without written appropriate the sample only to the items tested.  The results of this test report have been obtained in compliance with the listed requirements and/or specifications. Amendment levels are that of the mendments on the date testing was performed, unless otherwise specified. This test report shall not be reproduced, except in full, without written appropriate the sample of the items tested.  The results of this test report have been obtained in compliance with the listed requirements and/or specifications. Amendment levels are that of the mendments on the date testing was performed, unless otherwise specified. This test report shall not be reproduced, except in full, without written appropriate the sample of the items tested.  The results of this test report have been obtained in compliance with the listed requirements and/or specifications. Amendment levels are that of the mendments on the date testing was performed, unless otherwise specified. This test report shall not be reproduced, except in full, without written appropriate the sample of the items tested.  The results of this test report have been obtained in compliance with the listed requirements and/or specifications. Amendment levels are that of the mendments of the items tested in the items tested.	2	15:0	0	No			No	
The sample must withstand flame penetration and not exhibit backside ignition for the required test time.  »Fire-Resistant: 5 minutes  »Fire-Proof: 15 minutes  ———————————————————————————————————	3	-		-			-	
**Spire-Resistant: 5 minutes  **Fire-Proof: 15 minutes  **Whotes:  **Ire-Proof: 15 minutes  **Ire-Proof: 15 minutes (fire-proof).  **Ire-Resistant: X Fire-Proof: X Fire-Proof: 15 minutes (fire-proof).  **Ire-Resistant: X Fire-Proof: 15 minutes (fire-proof).  **Ire-Proof:		Acceptance	Criteria			Re	sult &	Designation
The results of this test report have been obtained in compliance with the listed requirements and/or specifications. Amendment levels are that of the mendments on the date testing was performed, unless otherwise specified. This test report shall not be reproduced, except in full, without written appropriate the specified of the stressults relate only to the items tested.  Tested by: Andrew Feghali & Leslie Gardner 17-May-18  Approval: Ambre Feghali & Leslie Gardner 17-May-18	exhibit back »Fire-Re	side ignition for the sistant: 5 minutes		9000-000000	X			FAII nt X Fire-Pro
The results of this test report have been obtained in compliance with the listed requirements and/or specifications. Amendment levels are that of the mendments on the date testing was performed, unless otherwise specified. This test report shall not be reproduced, except in full, without written appropriate the produced of the second of	Notes:	or marked frame we will be	16.		<b>.</b>	16 45		<i>(C.</i>
11 0 0000 7	The results of mendments on	this test report have been on the date testing was performed.	obtained in complia rmed, unless other Aeroblaze Laborat	nce with the listed re vise specified. This te ory Inc. The test resu	quirements and st report shall ru lts relate only to	/or specificati ot be reprodu the items tes	ons. Ame	endment levels are that of the ept in full, without written appr
				7-1VIAY-10	Approva	1000	Feghal	11/000

Report #1325.3R, Rev IR Page 17 of 19

TP-12-01, Rev-





+1 (817) 668-0628 info@aeroblazelab.com www.aeroblazelab.com Aeroblaze Laboratory 12819 Harmon Rd. #575 Fort Worth, TX 76177 USA

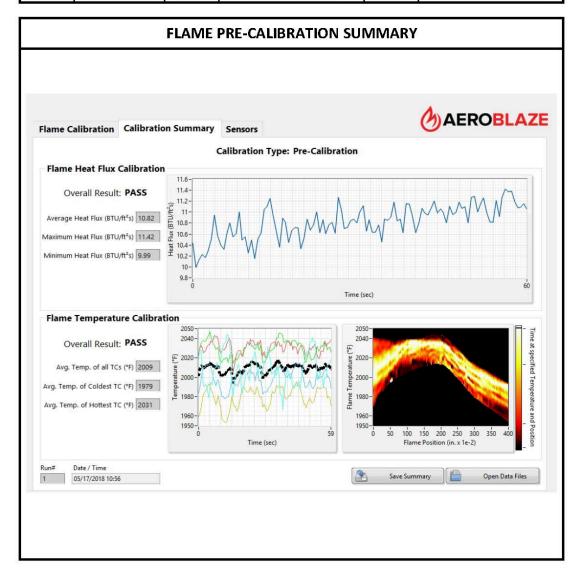
**Powerplant Fire Penetration Test Results** 

TR# 1325.3

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

Procedure:

Advisory Circular No. 20-135



TP-12-01, Rev-

Report #1325.3R, Rev IR Page 18 of 19





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

## FLAME POST-CALIBRATION SUMMARY **AEROBLAZE** Flame Calibration Calibration Summary Sensors Calibration Type: Post-Calibration Flame Temperature Calibration € 2075-Overall Result: PASS Avg. Temp. of all TCs (°F) 2015 2025 2000 Avg. Temp. of Coldest TC (°F) 1975 Avg. Temp. of Hottest TC (°F) 2040 100 150 200 250 300 Date / Time Save Summary Open Data Files 05/17/2018 13:17

#### - END OF REPORT -

TP-12-01, Rev-

Report #1325.3R, Rev IR Page 19 of 19