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Evaluation of Cease Fire CFP 640 for Use in Gloveboxes

Final Report

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1 Executive Summary

A Los Alamos National Laboratory (LANL) task group was established to discuss and evaluate a candidate fire suppression system (FSS) for gloveboxes (GB) and dropboxes (DB, for brevity, this report will simply refer to gloveboxes). Suitability criteria include compliance, compatibility, and capability. LANL contracted with New Mexico Tech (NMT) to quantitatively evaluate the performance of one of those systems including its ability to extinguish GB fires, limit over-pressurization of the GB, etc. Additionally, the results of these experiments provide data points that could be used when fire hazard evaluations (FHEs) are conducted for determining when to require a fire suppression system installation within a GB (as required by NFPA 801, *Standard for Facilities Handling Radioactive Materials*, DOE Standard 1066-2012 *Fire Protection*, and AGS-G010-2011 *Standard of Practice for Glovebox Fire Protection*).

The type of fire suppression systems considered for use in GB's are typically engineered systems that are based on the volume of the enclosure, combustible material, airflow rate, etc. It is also standard practice to conduct fire tests to evaluate the candidate FSS. The airflow and allowable working pressures for a working GB utilized as bounding criteria for fire tests to yield the most conservative and comprehensive fire test plan to suit LANL requirements. As such the fire tests conducted here evaluate the selected FSS performance with regard to affects on the GB environment (i.e., internal pressures and potential loss of GB confinement) and HEPA filters (inlet and outlet). The selected system is the Cease Fire CFP 640 (Appendix A.3). Broadly, the goal for the GB setup was to create a test environment for the FSS that was as close as possible to an actual GB setup at LANL.

Key results include:

- The candidate FSS was able to control and prevent re-ignition of the test fire according to the criteria detailed in UL 300 standard [5].
- The candidate FSS tested had some effect of blocking the exhaust filter.
- In GB fire tests, GB pressure generally rose (reduction in vacuum) as the fires grew, approaching and even momentarily to the point of loss of vacuum. At the moment of FSS discharge, a minor spike in GB pressure was observed. Much more substantial was a reduction in pressure (increase in vacuum) as the GB environment was rapidly cooled. No breach in confinement was observed.
- The FSS automatically deployed by means of a 155°F sprinkler head. Nearby (Fig. 2 (4) and (5)), the temperature at time of deployment was measured to be 360°F, on average across tests.
- The FSS deployment preceded report by Fenwal heat detectors installed within LANL-specified GB thermal wells. The 190°F units did not activate in any of the three fires. In one fire, the 140°F did not activate. In the other two tests, the activation of the 140°F unit followed the FSS discharge — once by 18 seconds, and once by 11 seconds.
- The candidate FSS tested coated the GB floor and contents fairly uniformly, depositing 1–2 mm of dry chemical.

This project supported multiple NMT undergraduate (Chris Schmittle, Dan Puckett, Gabriel Acosta, Ryan Morelli, Andrew Duff, Benjamin Sears, Rebecca Sappington, Keith Sillivent, and John Paul Norman) and graduate students (Sean Coss, Estevan Trujillo, and Jakob Mroczkowski).

2 Methodology

2.0.1 Glovebox Preparation

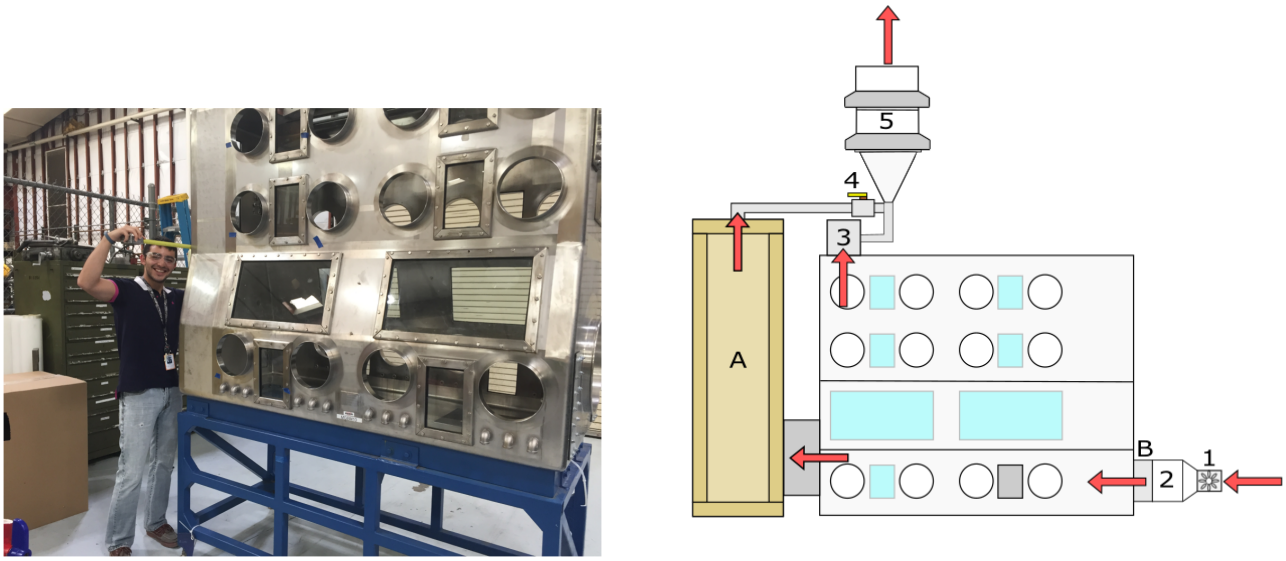
The specific methodology used herein is detailed in the LANL GB Fire Test Plan included in Appendix C. Critical components of the test apparatus are detailed below.

1. The GB used in this work is the same used in prior related experiments [1, 2, 3], adapted for these tests (Fig. 1).
2. The GB has an internal volume of 72 ft^3 and was sealed with a combination of LANL Standard GB Services and custom panels were installed with standard gasket materials or silicone caulk. An additional volume was attached (Fig. 1) to simulate a DB with an overall volume of 100 ft^3. Panels, windows, and other attachments were installed to a torque of 25 in-lbs.
3. Gloves and associated installation hardware were inspected by LANL personnel present during testing.
4. Two identical, inline, 12" electric fans with speed control were selected to pull air through the GB up to or above the target level of 40 CFM. The airflow pathway is described in Figure 1.
5. A ball valve (Fig. 1, right (4)) was adjusted to set the GB vacuum and air flow match levels measured when the GB functions as an isolated airbox (0.60 inAq vacuum and 40 CFM flow).
6. The FSS consisted of a sprinkler head, flexible line, and tank assembled and prepared by the manufacturer. The tank was mounted in a horizontal orientation atop the GB. The sprinkler head was installed through a ceiling service panel (Fig. 2 (5)).

2.0.2 Data Acquisition

Key details of the sensors selected for these tests are described below. Their installation locations are indicated in Figure 2.

1. All sensors used for the purpose of collecting data reported herein are National Institute of Standards and Technology NIST traceable (Appendix B)
2. Three thermocouples T_L (low), T_M (middle), and T_H (high) (Watlow model AB-2005267) were mounted inside the GB along the center line at the heights shown relative to windows & glove ports near, but not in direct contact with the GB wall (Fig. 2 (8)).
3. A fourth thermocouple (Watlow model AB-2005267) was used to measure ambient temperature.



(a) (b)

Figure 1: In (a), the isolated airbox used in these tests is shown before alteration. In (b), a schematic representation of the GB is provided, with emphasis on the airflow pathway. Air enters the GB via the following sequence: through a TSI model 5725 vane anemometer (1), 3" circular-to-square adapter, LANL-supplied Flanders 8" square filter (2), and then through a small volume (B) that also adapts from the square filter geometry to a rectangular opening in the lower corner of the GB. The air exits the GB, first spliting and either exiting through a LANL-supplied, Flanders 8" round filter (3), or else through the ceiling of the attached volume (A) by means of a 2" pipeline with in-line ball valve (4). The flow from these two pathways recombine and passes through a sequence of of reducers (2"–4"–8"–10"–12") and into two, in-line electric fans (Fantech FG 12 EC, (5)), and finally out the 12" bunker exhaust duct.

4. Pressure sensors were attached to a panel adjacent to the GB (Fig. 2 (7)). These sensors were connected to the appropriate components using pressure lines shown in Figure 3.

5. Four pressure sensors were used to redundantly measure the pressure drop across the exhaust filter. These included a pair of differential pressure transmitters (Dwyer model 648B-16, range -2.5–2.5 inAq). For further redundancy, and to accelerate tuning, two Magnehelic pressure gauges were installed in parallel to calibrate the GB vacuum to 0.6±0.01 inAq before beginning data acquisition.

6. Another pair of differential pressure transmitters (Dwyer model 648B-16, range -2.5–2.5 inAq) were used to redundantly measure the GB interior pressure relative to ambient pressure.

7. Wells in the ceiling of the GB allowed installation of two Fenwal sensors ("Detect-A-Fire", Model 27021-0 140°F and 190°F heat detectors (Fig. 2 (4)).

8. A data-logging vane anemometer (TSI model 5725) was sealed to the air inlet and measured flow through the GB (Fig. 2 (9)).

9. Three video cameras (Point Grey Grasshopper3 GS3-PGE-23S6M-C) redundantly observe/record the events inside and in the vicinity of the GB during testing. Two were mounted directly

to the GB at window locations, providing an internal view (Fig. 2 (icons indicate locations)), and a third was mounted some distance away to provide an external view of the GB.

10. A thermal imaging camera (FLIR T640) was used in conjunction with an IR Window (Fluke CV-400 4") installed into a metal plate to provide supplementary information (data collected for submission to LANL in video form — not included in this report, Fig. 3 (far right)).

11. Finally, a digital stopwatch was used to record critical times (Traceable, model 1051).

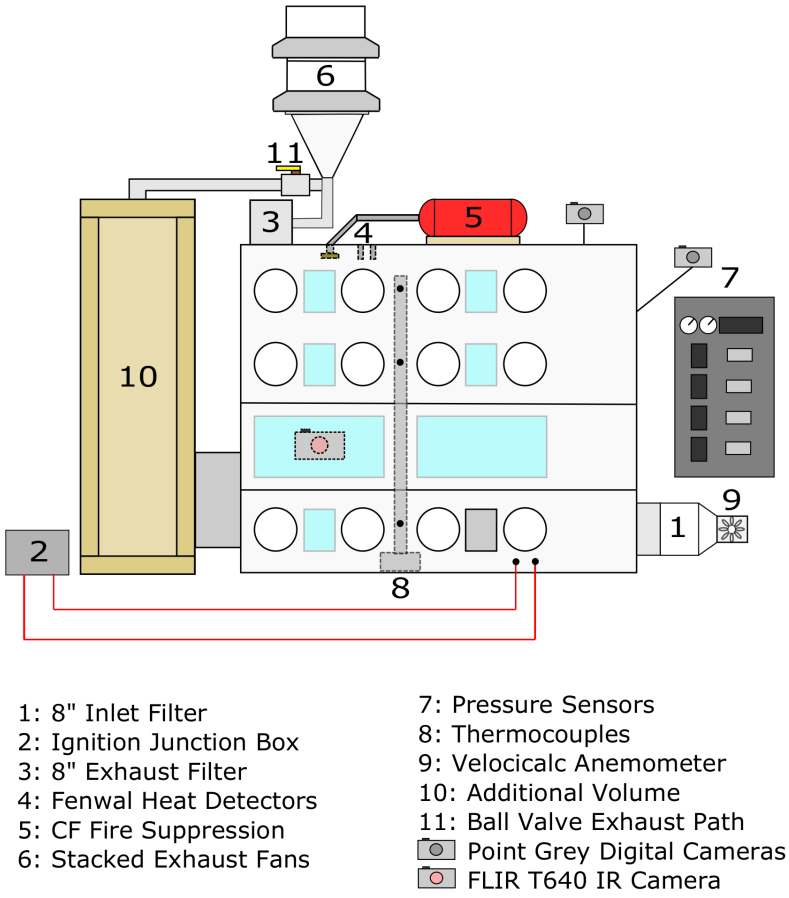


Figure 2: GB schematic of critical sensor locations and the mechanical connection of subsystems.

Figure 3: Left to Right: Pressure Lines (External View), Pressure Lines (Internal View), Pressure Gauges, Anemometer, Infrared Camera.

2.0.3 Controlled Fire Trial Set-up

Consumables and associated components were prepared and installed according to the experimental plan (Appendix C). In summary:

1. The GB was initially washed using a pressure washer, Fantastik cleaner, and Windex and rewashed after any tests producing a considerable soot coating within the GB.
2. Cameras were adjusted to maximize view of the GB floor and set-up area.
3. Using photos as reference, the combustibles were laid out to accurately repeat their arrangement.
4. Igniters were prepared from 22 AWG Nichrome 80 wire cut to a length of 18.84" (selected to achieve desired electrical impedance) and coiled around a 5/16-18 machine screw to produce a uniform coil.
5. Igniter coils installed in two locations — one pair to a wooden crib (UL 1975 [4]) and one to a zippered bag containing alcohol-soaked cheesecloth. The wires to these igniters were connected in parallel to a 12V lead acid battery using alligator clips and fire-proof wire. The igniter coils, alligator clips, and any singed wires were replaced for each successive trial.
6. The igniter leads were connected to a relay within a junction box that could be controlled from the control room.

Figure 4: Arrangement of combustibles in GB.

2.0.4 Experiment Protocol

All experiments were conducted at a pair of bunkers near Torres Lab at the Energetic Materials Research and Testing Center (EMRTC, Fig. 5). The experimental apparatus was installed in one bunker while personnel and control and data acquisition systems were located in the adjacent

bunker during testing. A strict protocol was established to ensure adherence to the experimental plan (Appendix C), relying upon a detailed checklist. Critical test parameters and a record of key events was made using an LANL-approved data sheet is provided in Appendix F). After completion of each test, data was saved to multiple locations, and the GB was cleaned and inspected.

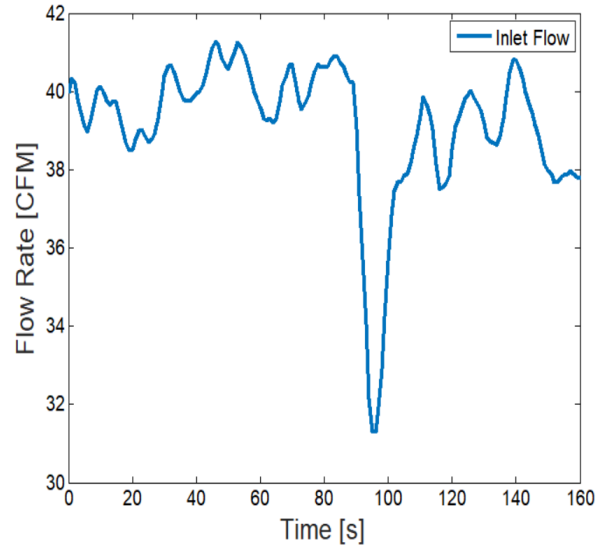
Figure 5: Test location at EMRTC. A pair of bunkers housed the GB and personnel.

3 Results

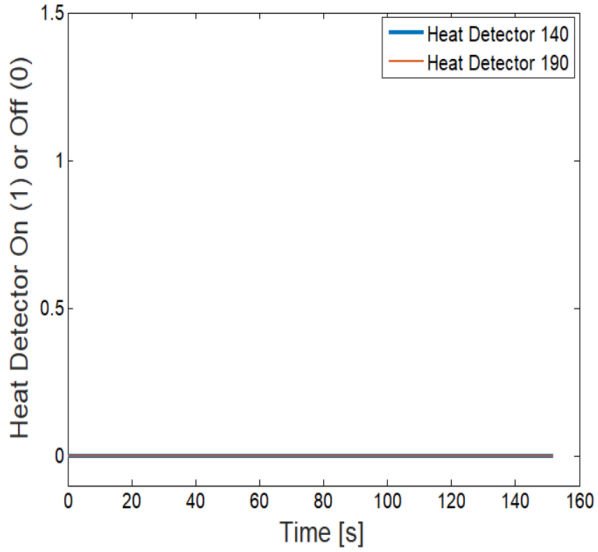
3.1 Baseline Discharge Test

3.1.1 Glovebox Response

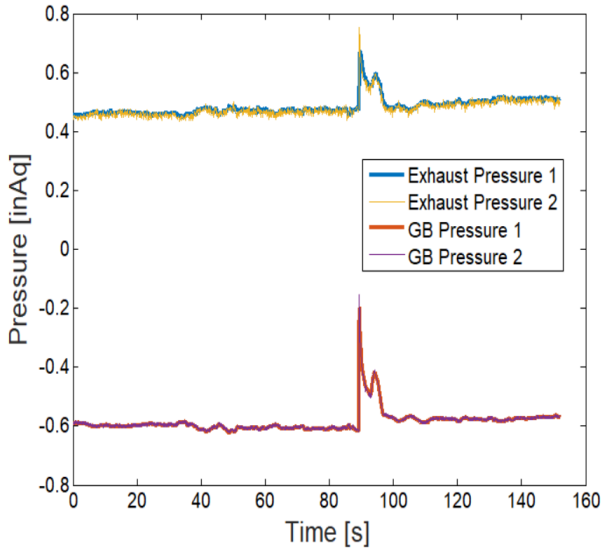
In *Test 1*, the FSS was discharged into the sealed glove box under normal operating pressure and flow conditions where no fire was present. Time histories of the pressures, flow rate, and temperatures are shown in Figure 6. The discharge of the FSS occurred at t=90 s and increased the pressure inside the GB from -0.60 to -0.18 inAq as can be seen in Figure 6(c). The discharge also resulted in a transient drop in flow rate to 31.3 CFM as can be seen in Figure 6(a). The discharge also resulted in a minor decrease in temperature inside the GB as can be seen in Figure 6(d).



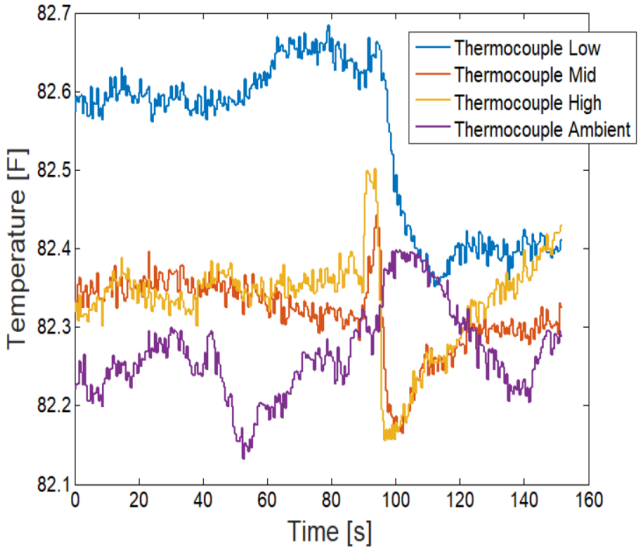
(a) GB Air Flow.



(b) Fenwal Thermal Detector Response.



(c) Pressure Response.



(d) GB Temperature Response.

Figure 6: Measurements of the GB response to the baseline discharge of the selected FSS (*Test 1*).

3.1.2 Dry Chemical Coverage

The dry chemical discharge during *Test 1* was photographed and measured at various locations in the GB (Table 1), as indicated in Figure 7. These photographs obtained after the baseline discharge are shown in Figure 8.

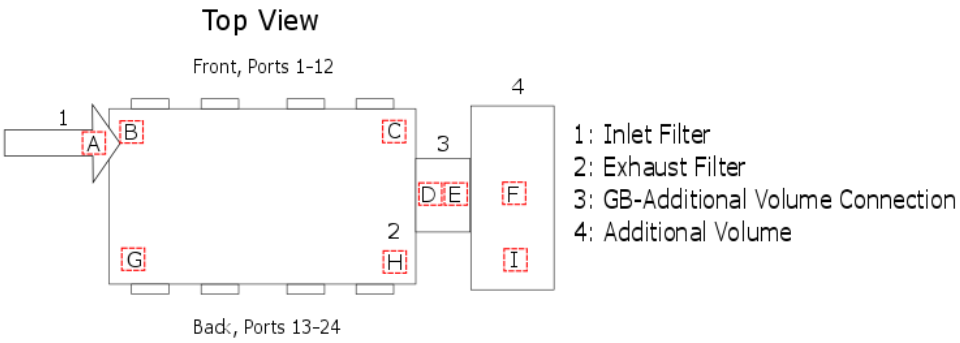
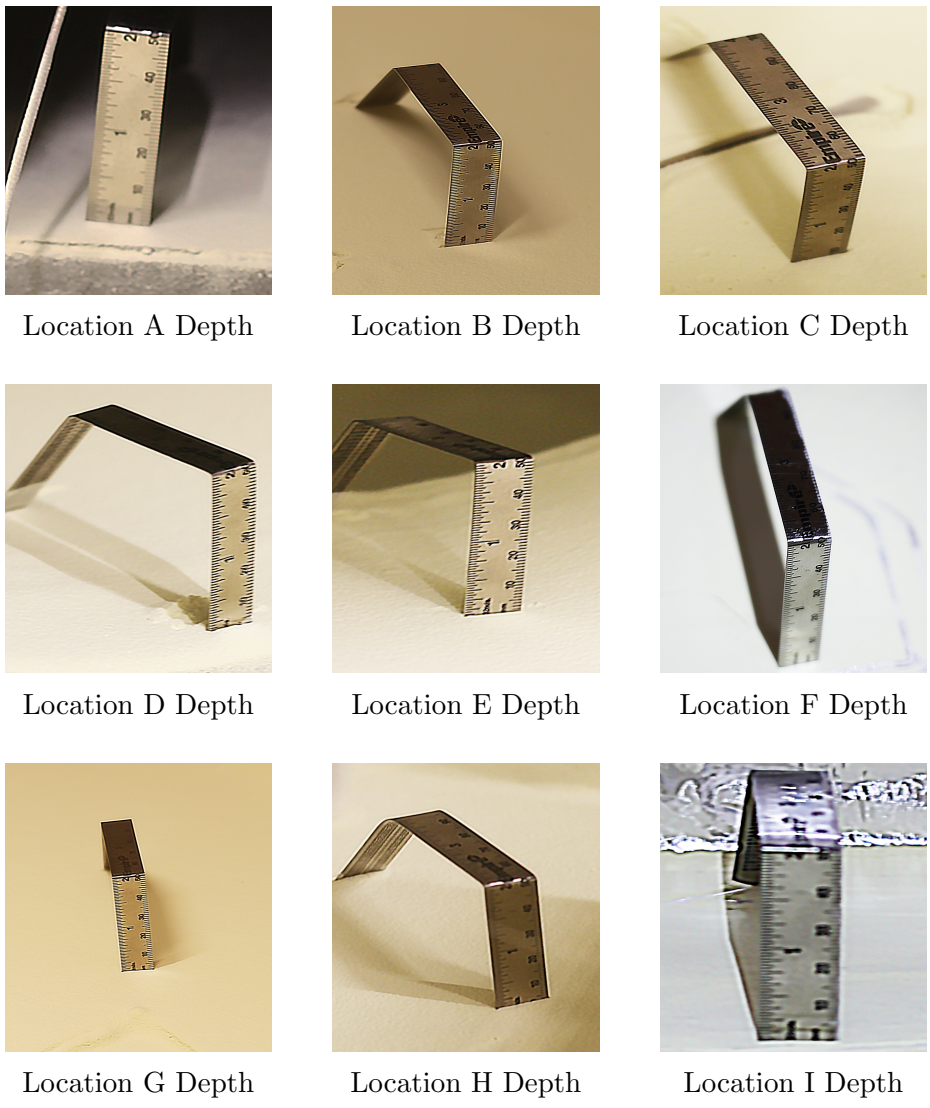


Figure 7: Illustration of locations (A-I) in GB where dry chemical depth was measured and photographed after baseline discharge.

Test 1	
Location	**Depth (mm)**
A	1.5
B	2
C	7
D	3
E	1.5
F	1
G	2
H	3.5
I	1

Table 1: Dry chemical depth for *Test 1* measured at the locations described in Figure 7.



Location A Depth | Location B Depth | Location C Depth

Location D Depth | Location E Depth | Location F Depth

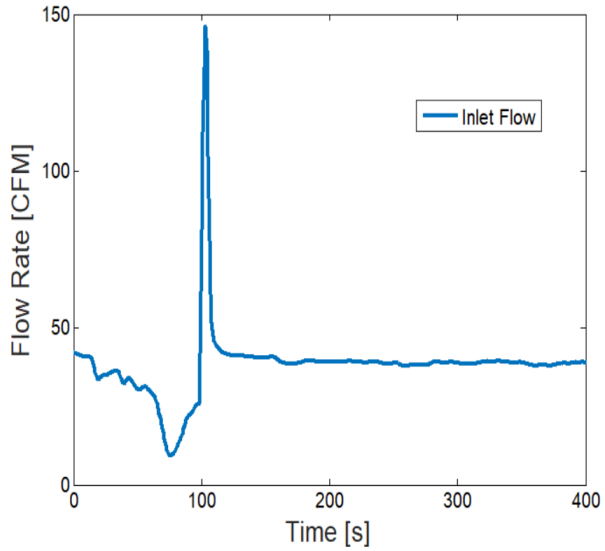
Location G Depth | Location H Depth | Location I Depth

Figure 8: Dry chemical deposition at the conclusion of *Test 1* is measured at various locations, as indicated in Figure 7. The measurement are fairly uniform at 1-2 mm. The key exceptions are 1) that significantly more was present in the locations closest to the sprinkler head (C, H, and D) and 2) very little was present in the inlet duct (A).

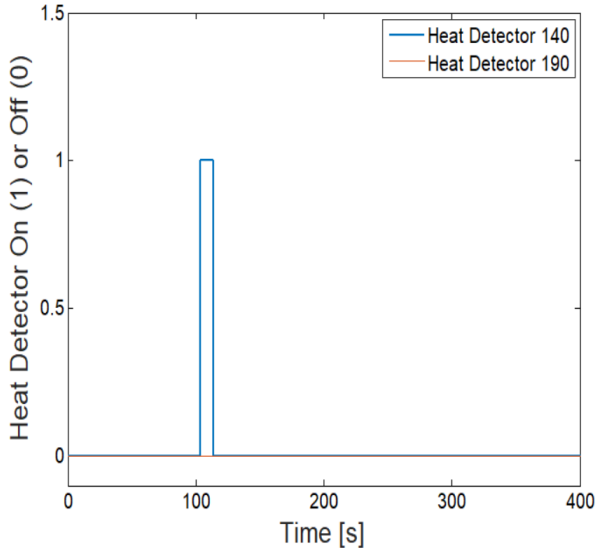
3.2 Fire Response Test

3.2.1 Glovebox Response

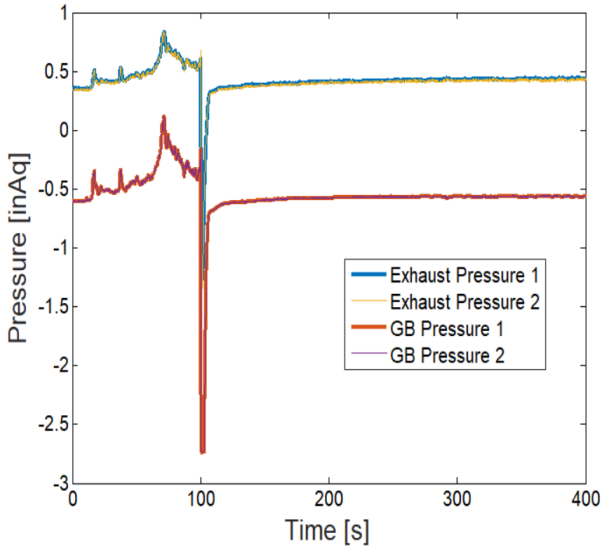
In *Test 2-4*, the GB was loaded with the combustibles shown in Figure 4. The GB was sealed and operating under normal pressure and flow conditions. The reported data begin at the moment the ignitors are activated. The time histories of pressures, flow rate, and temperatures are shown in Figures 9–11. Temperature can be seen to rise until the FSS discharged automatically upon the rupture of the manufacturer-supplied glass bulb. The coverage observed during discharge is shown in Figures 13–15. Critical values for these tests are summarized in Table 2.



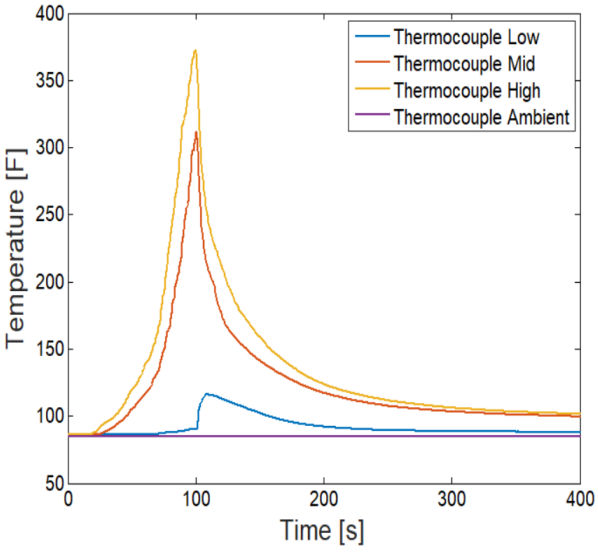
(a) GB Air Flow.



(b) Fenwal Thermal Detector Response.

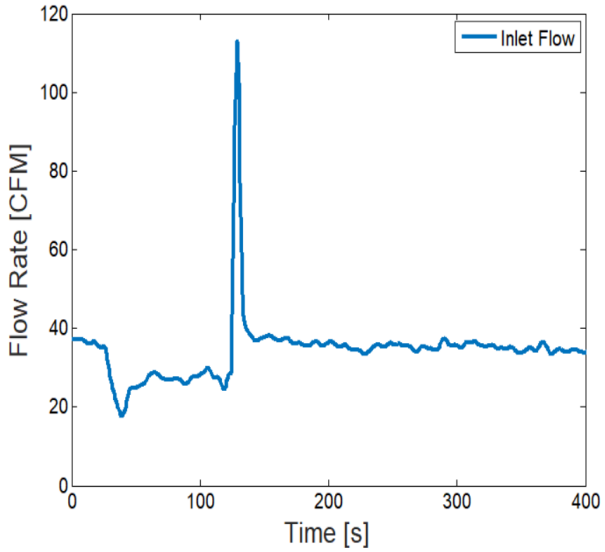


(c) Pressure Response.

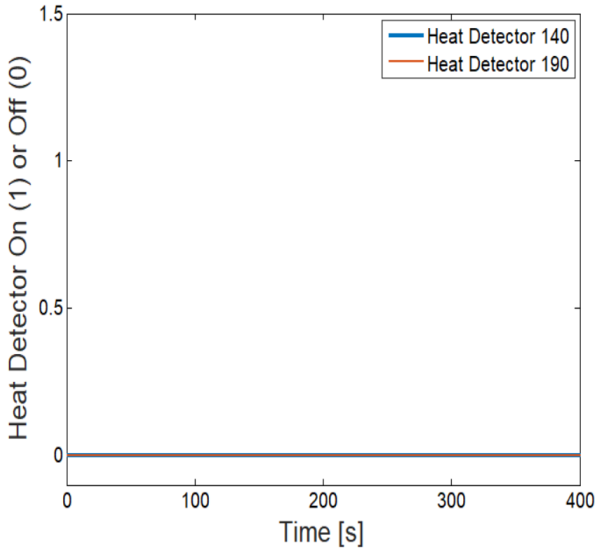


(d) GB Temperature Response.

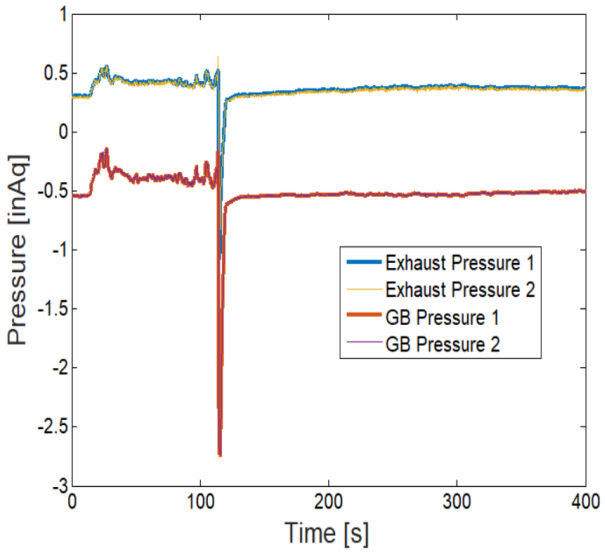
Figure 9: Measurements of the GB response to the discharge of the selected FSS in response to a GB fire (*Test 2*).



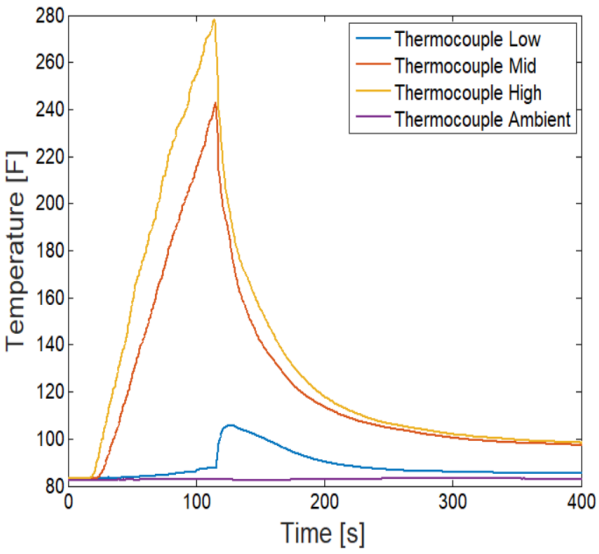
(a) GB Air Flow.



(b) Fenwal Thermal Detector Response.

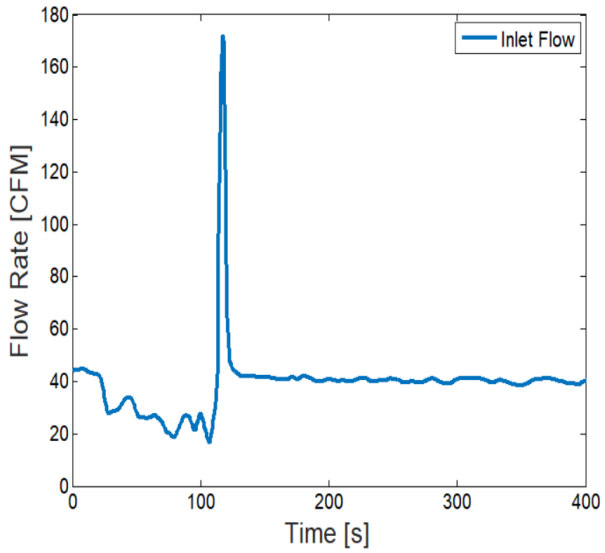


(c) Pressure Response.

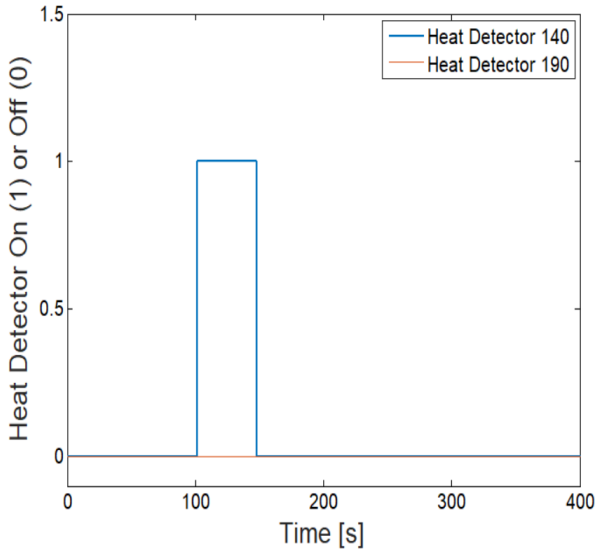


(d) GB Temperature Response.

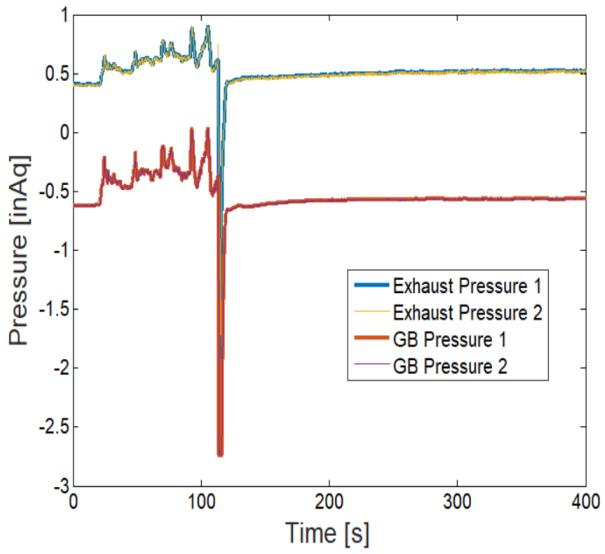
Figure 10: Measurements of the GB response to the discharge of the selected FSS in response to a GB fire (*Test 3*).



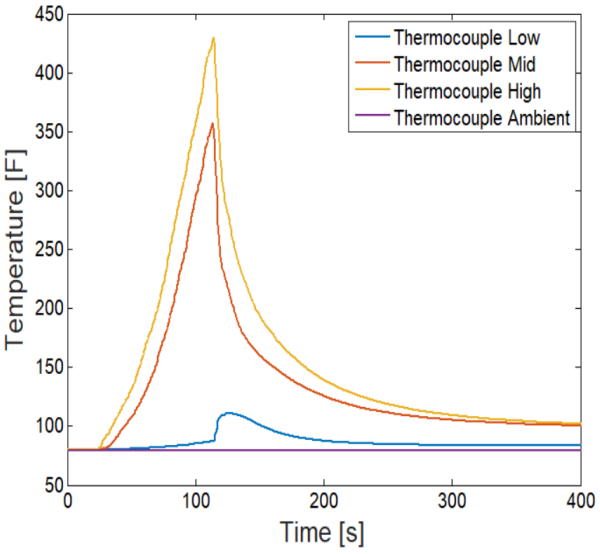
(a) GB Air Flow.



(b) Fenwal Thermal Detector Response.



(c) Pressure Response.



(d) GB Temperature Response.

Figure 11: Measurements of the GB response to the discharge of the selected FSS in response to a GB fire (*Test 4*).

Test (#)	**Purpose**	v_0 (CFM)	v_f (CFM)	P_{GB_0} (inAq)	$P_{GB_{min}}$ (inAq)	$P_{GB_{max}}$ (inAq)	P_{GB_f} (inAq)	P_{EF_0} (inAq)	P_{EF_f} (inAq)	$T_{L_{max}}$ ($^\circ F$)	$T_{M_{max}}$ ($^\circ F$)	$T_{H_{max}}$ ($^\circ F$)	t_{fen} (s)	t_{dis} (s)
1	Baseline	40	38	-0.59	-0.62	-0.18	-0.57	0.45	0.49	82.68	82.4	82.5	N/A	N/A
2	Fire Resp.	42	40	-0.61	-2.56	0.12	-0.56	0.34	0.43	115.9	311.7	372.6	118	100
3	Fire Resp.	37	34	-0.55	-2.74	-0.11	-0.50	0.29	0.37	105.7	243.0	277.9	N/A	115
4	Fire Resp.	45	40	-0.63	-2.74	0.03	-0.56	0.40	0.51	111.3	357.0	429.7	126	115

Table 2: Experimental results are summarized by test. The airflow at the beginning (v_0) and conclusion (v_f) of each trial along with the initial, minimum, maximum, and final pressure for both the GB (P_{GB_0}, $P_{GB_{min}}$, $P_{GB_{max}}$, and P_{GB_f}, respectively) and exhaust filter (P_{EF_0}, $P_{EF_{min}}$, $P_{EF_{max}}$, and P_{EF_f}, respectively). Also listed are the maximum temperatures recorded at the low, medium, and high thermocouples ($T_{L_{max}}$, $T_{M_{max}}$, and $T_{H_{max}}$). Finally, the times at which the 140°F Fenwal heat detector (t_{fen}) and FSS discharge (t_{dis}) occurred are listed. Note that the 190°F Fenwal heat detector never activated during these tests.

3.2.2 Dry Chemical Coverage

The dry chemical discharge was photographed and measured at various locations in the GB (Table 3), as indicated in Figure 12. These results are shown for each of the GB fire tests in Figures 13 – 15.

Location	**Test 2**	**Test 3**	**Test 4**
	Depth (mm)		
A	0	0	0
B	1.5	0.5	2
C	8	4	4
D	4	2	2.5
E	2	1	1
F	1	1	1
G	1.5	1.5	3
H	4.5	4	5
I	1.5	0.5	0.5

Table 3: Dry chemical depth for *Tests 2 – 4* at the locations described in Figure 12.

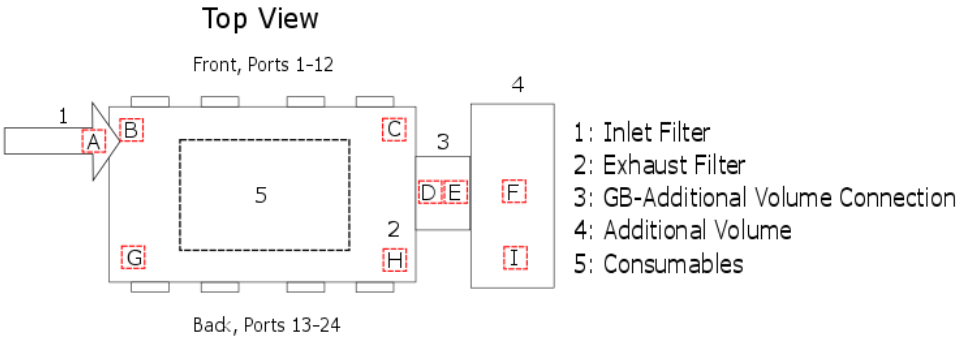
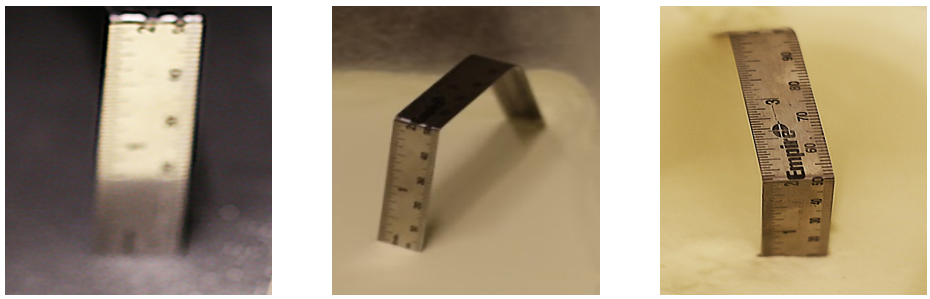
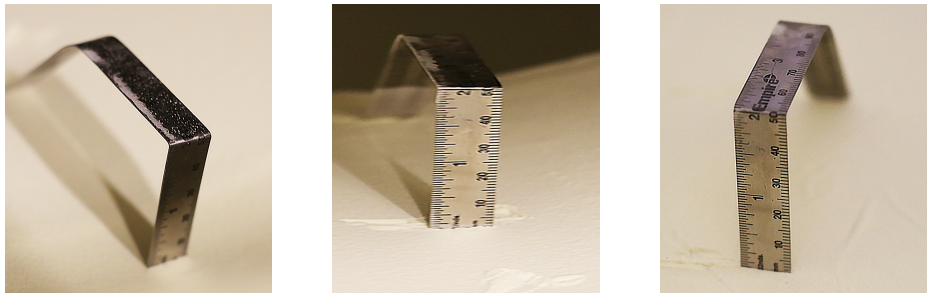


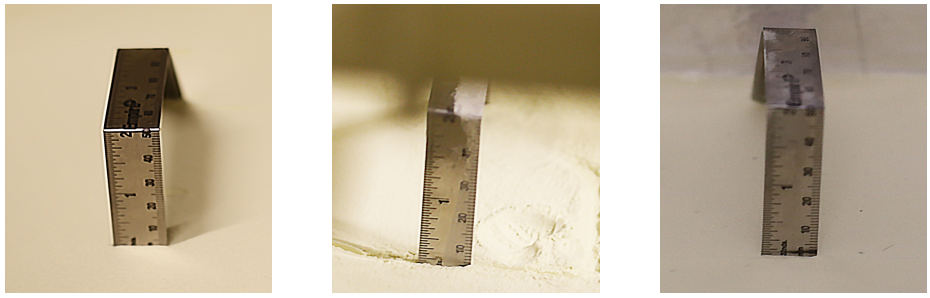
Figure 12: Illustration of locations (A-I) in GB where dry chemical depth was measured and photographed after discharge in response to GB fire.



Location A Depth | Location B Depth | Location C Depth

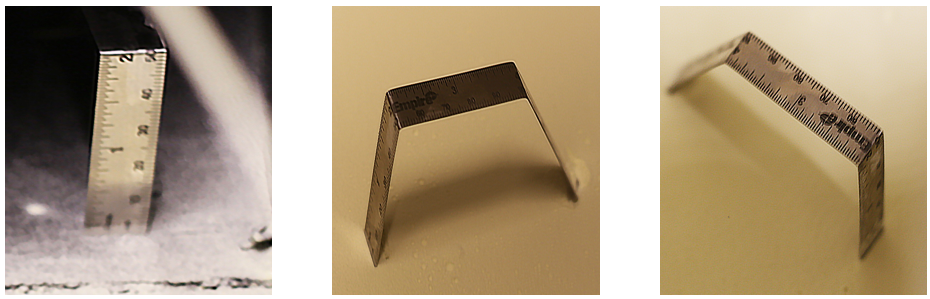


Location D Depth | Location E Depth | Location F Depth

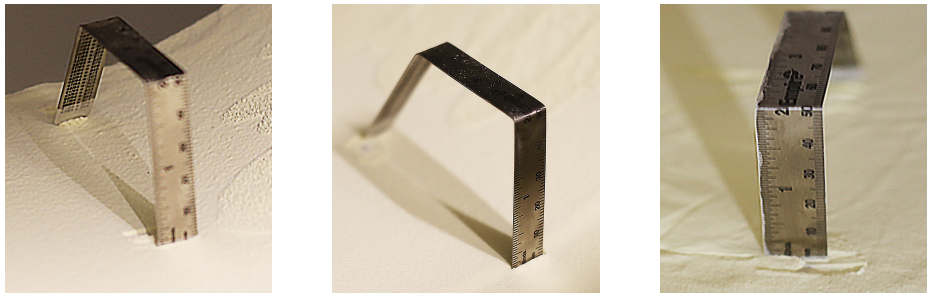


Location G Depth | Location H Depth | Location I Depth

Figure 13: Dry chemical deposition at the conclusion of *Test 2* is measured at various locations, as indicated in Figure 12. The measurement are fairly uniform at 1-2 mm. The key exceptions are 1) that significantly more was present in the locations closest to the sprinkler head (C, H, and D) and 2) very little was present in the inlet duct (A).



Location A Depth | Location B Depth | Location C Depth

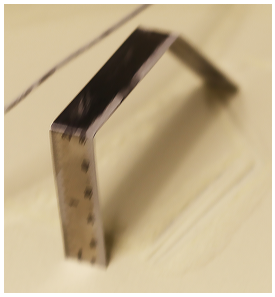


Location D Depth | Location E Depth | Location F Depth

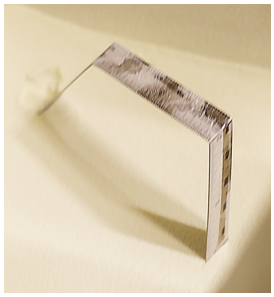
Location G Depth | Location H Depth | Location I Depth

Figure 14: Dry chemical deposition at the conclusion of *Test 3* is measured at various locations, as indicated in Figure 12. The measurement are fairly uniform at 1-2 mm. The key exceptions are 1) that significantly more was present in the locations closest to the sprinkler head (C, H, and D) and 2) very little was present in the inlet duct (A).

Location A Depth



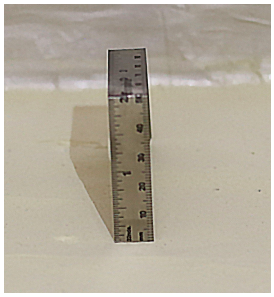
Location B Depth



Location C Depth

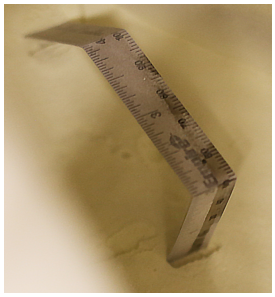
Location D Depth

Location E Depth



Location F Depth

Location G Depth



Location H Depth

Location I Depth

Figure 15: Dry chemical deposition at the conclusion of *Test 4* is measured at various locations, as indicated in Figure 12. The measurement are fairly uniform at 1-2 mm. The key exceptions are 1) that significantly more was present in the locations closest to the sprinkler head (C, H, and D) and 2) very little was present in the inlet duct (A).

3.2.3 Pre- and Post-Mortem GB Photos

Numerous photographs of the GB interior, GB combustibles, and GB filters were taken before and after fire. These images are organized in the Figures 16 – 28.

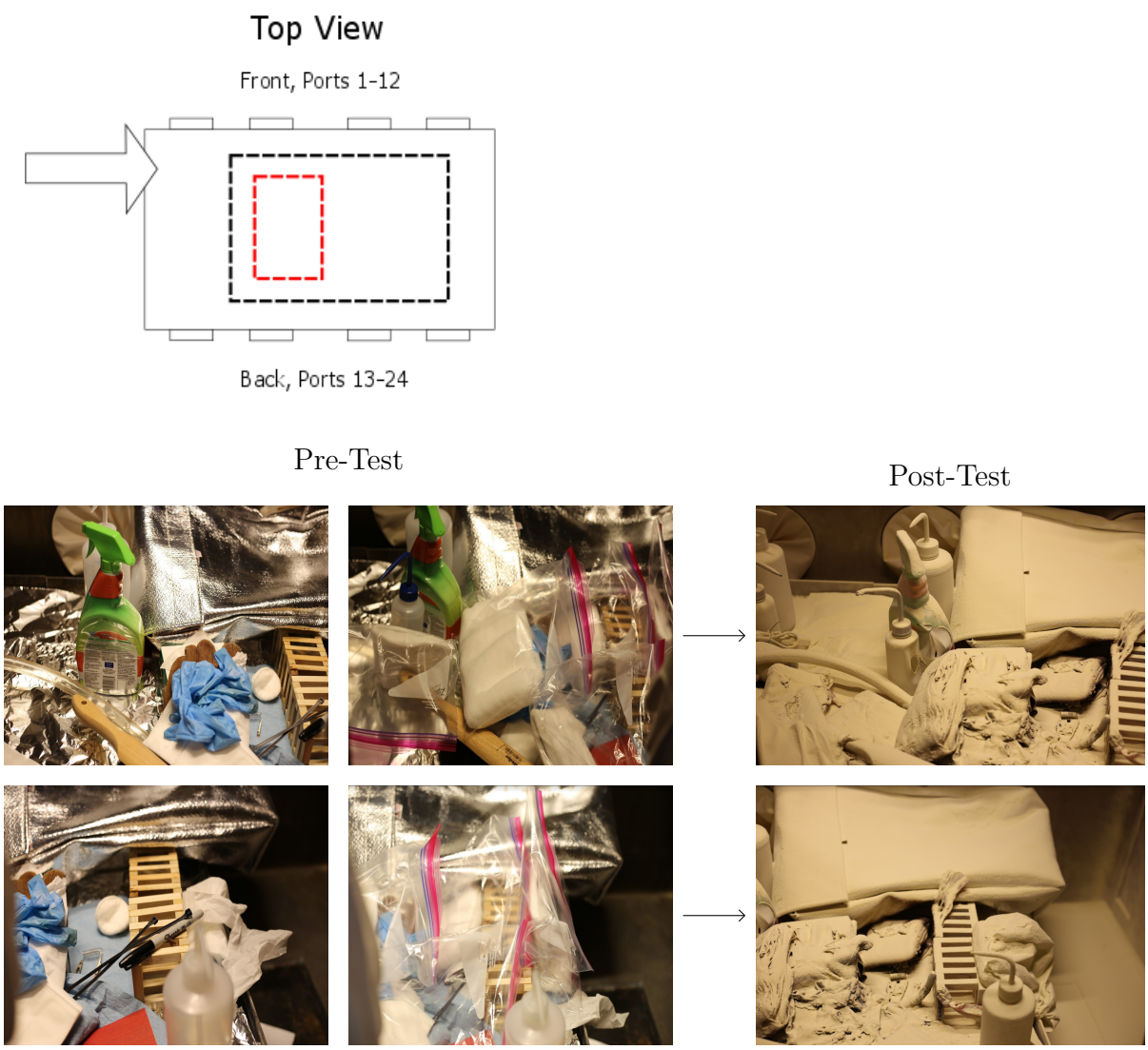


Figure 16: Pre- and post-testing images of consumables placed on the inlet side of the GB from *Test 2*, the first of three test fires. The shown items were located (red dashed line) atop a rack (black dashed line) inside the GB in the schematic above the photographs.

Figure 17: Additional views of GB consumables located on the inlet side after testing (*Test 2*). Some items were in the open (left) and some alcohol-soaked cheesecloth was were stored in a fire resistant bag (right, *Hot-Stop 'L'*, large item pouch, Baker Aviation, Addison, TX)).

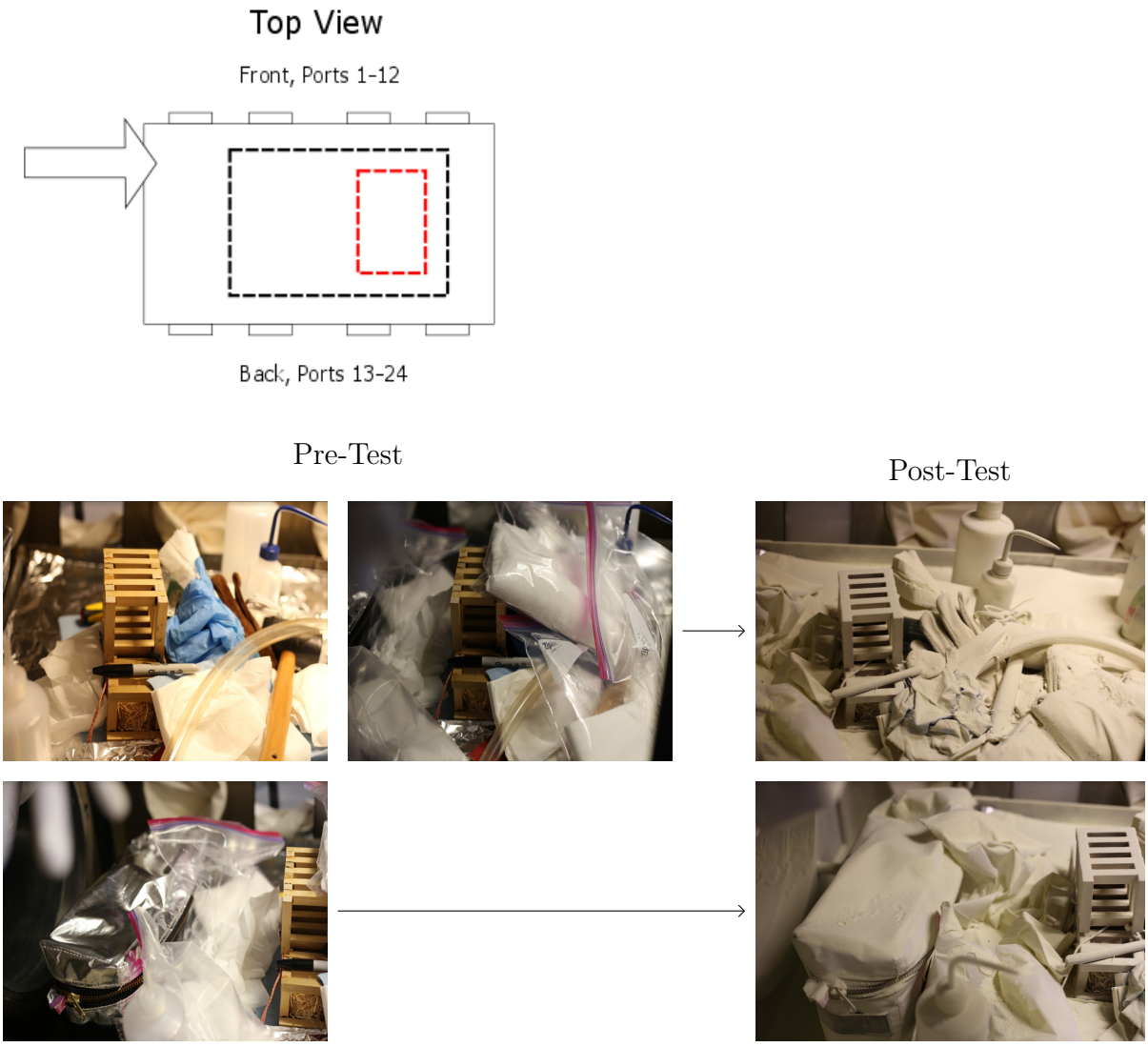


Figure 18: Pre- and post-testing images of consumables placed on the exhaust side of the GB from *Test 2*, the first of three test fires. The shown items were located (red dashed line) atop a rack (black dashed line) inside the GB in the schematic above the photographs.

Figure 19: Additional view of GB consumables located on the exhaust side after testing (*Test 2*).

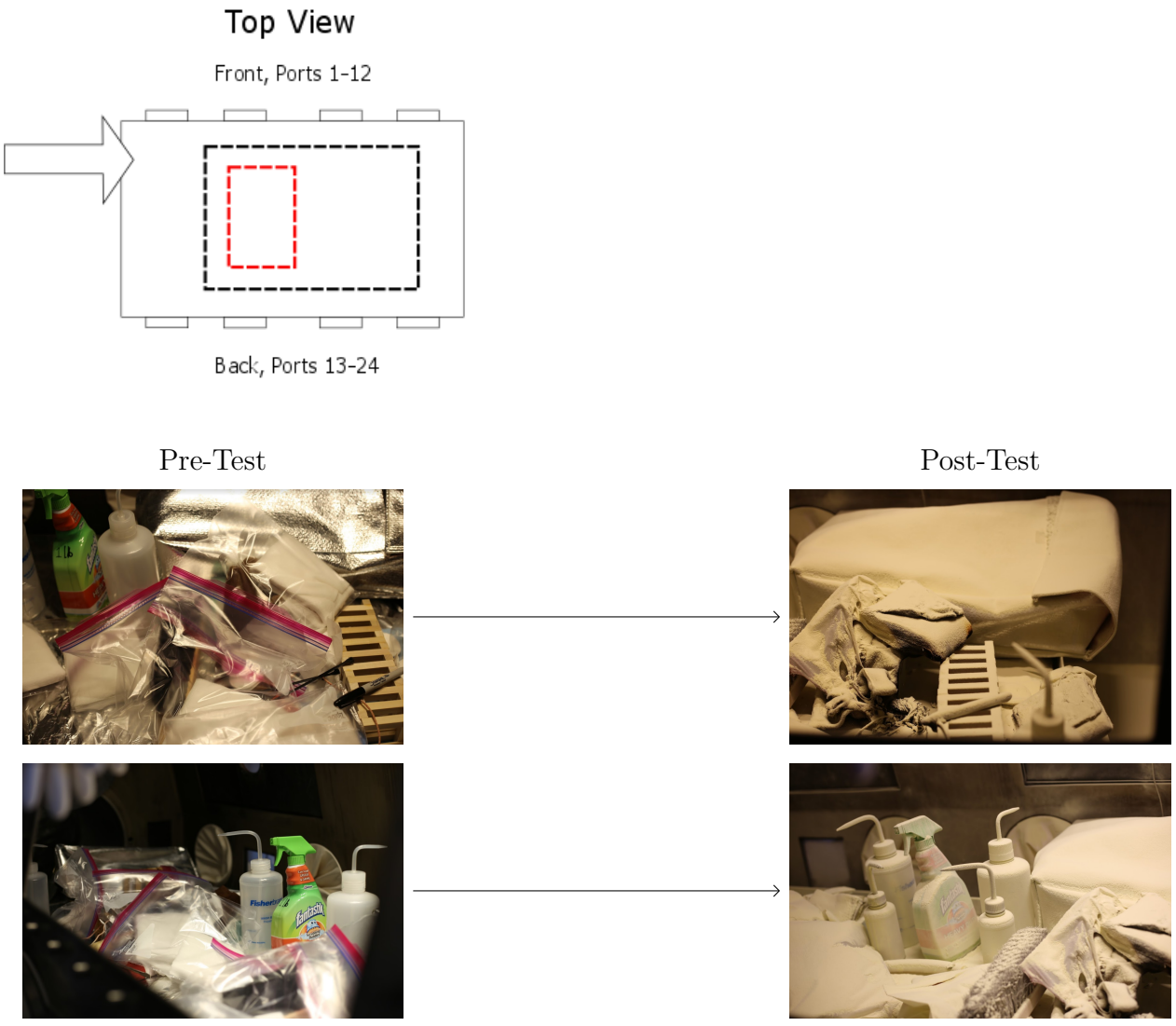
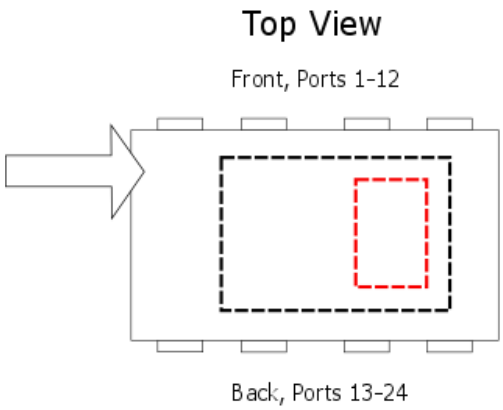


Figure 20: Pre- and post-testing images of consumables placed on the inlet side of the GB from *Test 3*, the second of three test fires. The shown items were located (red dashed line) atop a rack (black dashed line) inside the GB in the schematic above the photographs.

Figure 21: Additional views of GB consumables located on the inlet side after testing (*Test 3*). Some items were in the open (left) and some alcohol-soaked cheesecloth was were stored in a fire resistant bag (right, *Hot-Stop 'L'*, large item pouch, Baker Aviation, Addison, TX).



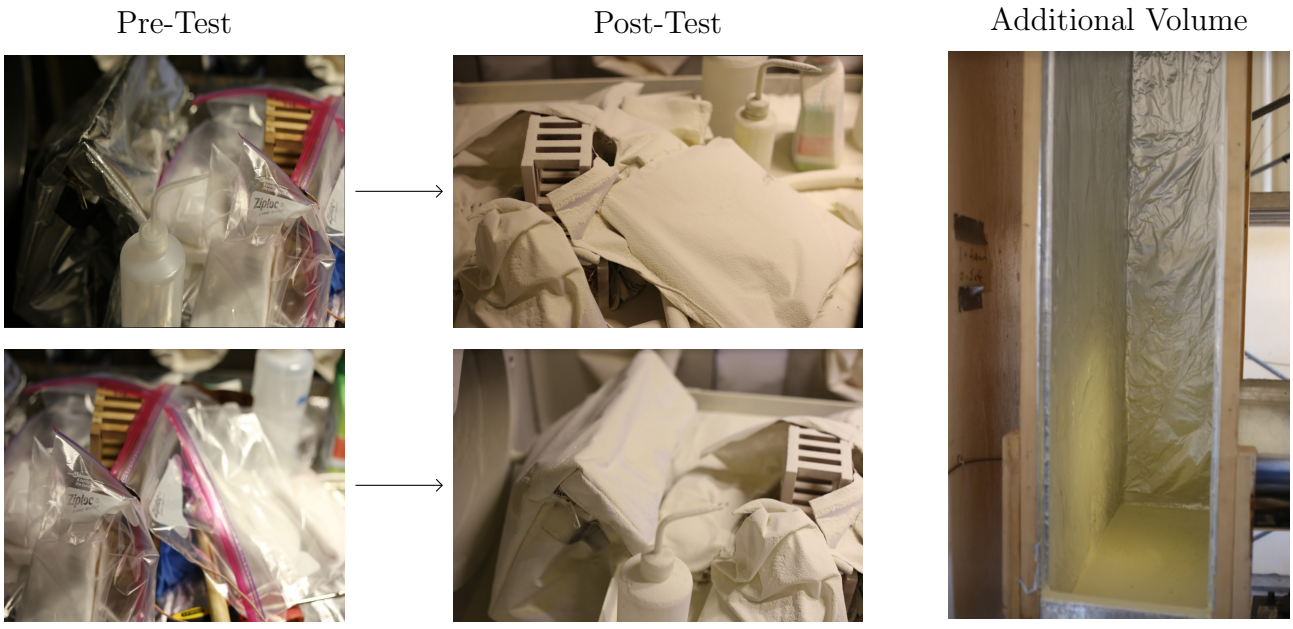


Figure 22: Pre- and post-testing images of consumables placed on the exhaust side of the GB from *Test 3*, the second of three test fires. The shown items were located (red dashed line) atop a rack (black dashed line) inside the GB in the schematic above the photographs. Also shown is the dry chemical deposition in the Attached Volume (right).

Figure 23: Additional view of GB consumables located on the exhaust side after testing (*Test 3*).

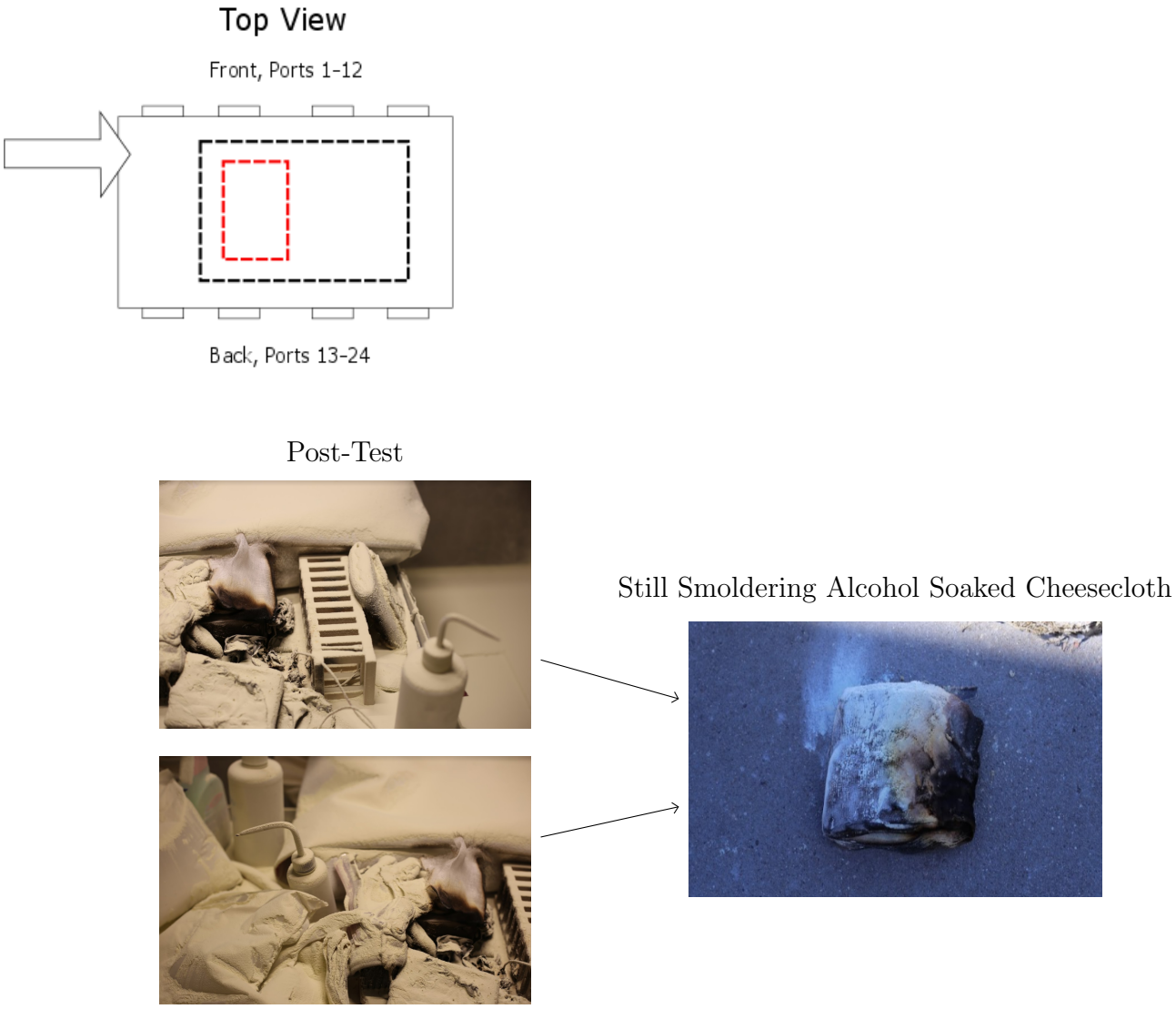
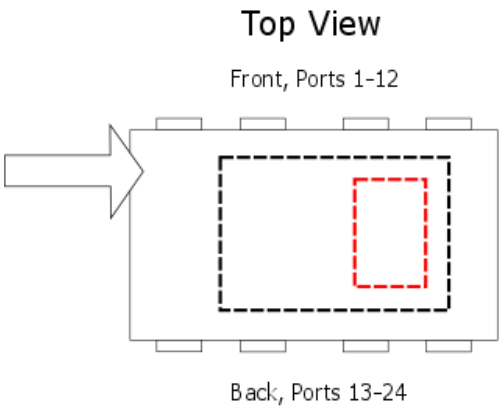


Figure 24: Post-testing images of consumables placed on the inlet side of the GB from *Test 4*, the third of three test fires. The shown items were located (red dashed line) atop a rack (black dashed line) inside the GB in the schematic above the photographs.

Figure 25: Additional views of GB consumables located on the inlet side after testing (*Test 4*). Some items were in the open (left) and some alcohol-soaked cheesecloth was were stored in a fire resistant bag (right, *Hot-Stop 'L'*, large item pouch, Baker Aviation, Addison, TX)).



Post-Test

Additional Volume

Figure 26: Post-testing images of consumables placed on the exhaust side of the GB from *Test 4*, the third of three test fires. The shown items were located (red dashed line) atop a rack (black dashed line) inside the GB in the schematic above the photographs. Also shown is the dry chemical deposition in the Attached Volume (right).

Figure 27: Additional view of GB consumables located on the exhaust side after testing (*Test 4*).

3.3 Inlet and Exhaust Filter Packing

The inlet filter was inspected after each test by LANL representatives. In each case, it was deemed by them to be free from defect and approved for reuse in subsequent tests. The exhaust filter, by contrast, had obvious residue from the FSS dry chemical discharge and combustion products present after each of test. As a result, the exhaust filter was replaced before each subsequent test. The single inlet filter and the four exhaust filters are shown in Figure 28. This visible evidence of exhaust filter packing is consistent with the records of exhaust filter pressure drop and GB airflow shown in Table 2 and Figures 9, 10, and 11.

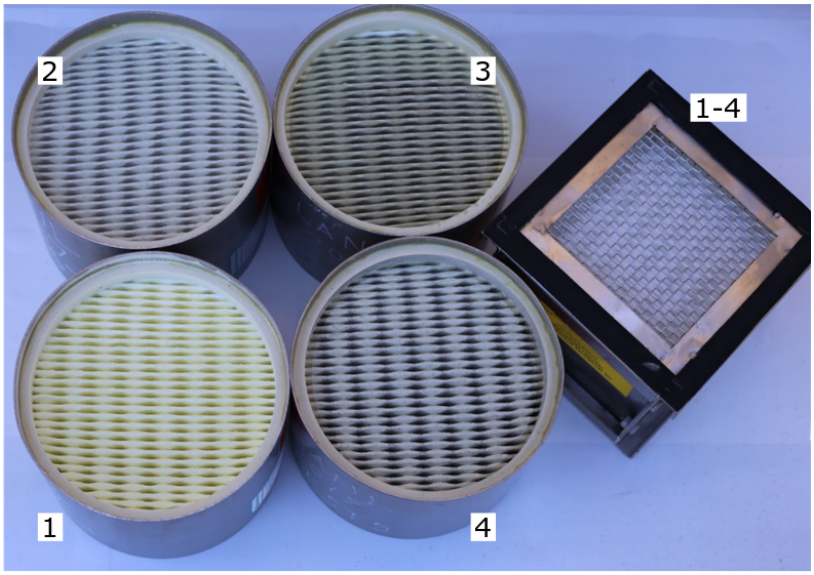


Figure 28: Post-mortem images of inlet and exhaust filters. Exhaust filters were replaced before each of *Tests 1–4*, and are labeled accordingly. The same inlet filter was used in all four tests. Residue is evident on the exhaust filters — a combination of FSS dry chemical and combustion products. No evidence of residue is visible for the inlet filter, despite use for all of *Tests 1–4*.

4 Conclusions

4.1 Effectiveness of FSS in Extinguishing the Test Fire

A consistent finding in the GB fires that have been conducted at NMT in recent years is that the progression of the fire, the degree to which combustibles become involved, etc. are all highly dependent on the arrangement of these items, local airflow, and so forth. Relevant parameters have been chosen either to reflect standard conditions at LANL or to reflect a realistic worst case. As has been observed in prior testing, including in [2, 3], these tests demonstrate the dangers associated with use of flammable liquids in GB's. Video review clearly shows that, relative to the other combustibles, the flammable liquids present in squeeze bottles or absorbed in cheesecloth were primarily responsible for the robust fires that were observed.

The primary point of these tests was to establish whether the LANL-selected FSS was able to extinguish the LANL-prescribed test fire. For the purpose of this assessment, we apply the definition provided in Section 7.13.1 of UL 300 [5]. Quoting directly:

> Upon actuation, the fire shall be extinguished as evidenced by a sharp decrease in temperature and in no instance shall an increase in any temperature occur. Routine fluctuations in recording instruments are to be disregarded. Small residual flames shall self-extinguish with no additional application of extinguishing agent.

It is clear from the plots of temperature provided in Figures 6 and 9–11 that temperatures internal to the GB did sharply decrease after FSS discharge and, noise excluded, monotonically decrease. Furthermore, recorded video shows that flames do rapidly dissipate.

4.2 Environmental Effects on GB

The most salient effects of the fire and subsequent FSS discharge are: 1) an increase in GB pressure by approximately 0.25 inAq at the time of discharge; 2) in *Tests 2–4*, this rise is followed by a much larger amplitude drop in pressure of approximately 2.5 inAq; and 3) this pressure drop is accompanied by a large transient increase in airflow (air is drawn in) and reduction in GB temperature at all measured locations. These subsequent effects are not visible in *Test 1*, as one would expect since the GB internal temperatures were not elevated by a fire. In all tests, there was an increase of both the steady-state GB pressure (reduction in GB vacuum) and exhaust filter pressure differential after discharge compared to the pre-fire/discharge levels. This change can be directly attributed to loading of the exhaust filter by combustion products (*Tests 2–4*) and dry chemical powder (all tests). While not directly relevant to the purpose of these experiments, Fenwal heat detector response was measured; the 140°F Fenwal heat detector is activated in *Tests 2* and *4*, but not in *Test 3* and that the 190°F Fenwal heat detector did not activate in any test.

4.3 Recommendations

The Cease Fire CFP 640 was able to extinguish the test fires and did not result in a GB overpressure (loss of confinement). The dry chemical was deposited in a fairly uniform manner; however, minor

effects on depth seemed to include distance from sprinkler head, airflow, and occlusion by items on the GB floor. The effects of objects occlusion on deposition depth can be seen qualitatively in Figures 16, 18, 20, 22, 24, and 26. The combined effects of airflow and proximity to the sprinkler head on depth can be inferred directly from the reported depths in Table 4. For instance, no substantial deposition was observed in the air inlet (A, both extremely upstream and far from the sprinkler head), less was deposited within the GB at Locations B & G (both upstream and further from the sprinkler head relative to other measured locations within the GB). From that point forward air either exited through the 8" exhaust spool or through a 12" pass through followed by the attached volume and its exhaust line. Progressively the depths decreased (D $\rightarrow$ E $\rightarrow$ F $\rightarrow$ I). These depths are collectively listed for *Tests 1–4* in Table 4.

Flammable-liquid-soaked cheesecloth and other combustibles stored in a LANL-provided fire resistant bag (*Hot-Stop 'L'*, large item pouch, Baker Aviation, Addison, TX)) did not ignite during the fire (Fig. 4 and Figs. 17–25). This result is consistent with the observation that closed metal containers (Vollrath 8802, Vollrath, Sheboygan, WI) protected flammable-liquid-soaked cheesecloth from the GB fire during prior testing [3]. As such, it is clear that containerization of combustibles, even flammable liquids, is efficacious in protecting such items from involvement in a GB fire.

Location	**Test 1**	**Test 2**	**Test 3**	**Test 4**
	Depth (mm)			
A	1.5	0	0	0
B	2	1.5	0.5	2
C	7	8	4	4
D	3	4	2	2.5
E	1.5	2	1	1
F	1	1	1	1
G	2	1.5	1.5	3
H	3.5	4.5	4	5
I	1	1.5	0.5	0.5

Table 4: Dry chemical depth at the locations described in Figure 12.

Future work suggested by these experiments includes exploration of:

- Variation in the type/condition of consumables involved in the GB fire (e.g., oil vapor simulating a hydraulic leak, acetone/oil mix, etc.)
- Characterization of the conditions under which fire self-extinguish
- The efficacy of additional fire-resistant containers for storing flammable liquids, chemical wipes, etc.

4.4 Materials Supplementing this Report

This report will be supplemented by a delivery of raw data, video, and photographic files as well as material samples.

5 Acknowledgements

This work was supported by LANL PO #368937. Substantial contributions were made by the NMT students who were supported by this project. Chris Schmittle and Estevan Trujillo played a critical role in photography and data acquisition. Remote control and miscellaneous electronics work was led by John Paul Norman and Sean Coss. Fabrication and mechanical design was led by Gabriel Acosta, Ryan Morelli, Andrew Duff, Benjamin Sears, and Jakob Mroczkowski. Glovebox and test logistics were led by Keith Sillivent, Rebecca Sappington, and Dan Puckett.

6 References

[1] D. Grow, R. Lumia, and J. Wood *Water Intrusion Effects for Glovebox Gloves, final report, Los Alamos National Laboratory.* September 24, 2014.

[2] D. Grow, J. Kimberley, R. Lumia, and J. Wood *Glovebox Studies: Fire Suppression Experiments, final report, Los Alamos National Laboratory.* October 20, 2015.

[3] D. Grow, J. Kimberley *Evaluation of Glovebox Fires Involving Flammable Liquids and Standard Glovebox Tools, final report, Los Alamos National Laboratory.* September 29, 2016.

[4] Underwriters' Laboratories and Underwriters' Laboratories Staff. *Fire Tests for Foamed Plastics Used for Decorative Purposes. UL 1975:1996.* Northbrook, IL.

[5] Underwriters' Laboratories and Underwriters' Laboratories Staff. *Fire Testing of Fire Extinguishing Systems for Protection of Commercial Cooking Equipment. ANSI/UL 300:2005, rev. 2014.* Northbrook, IL.

Appendices

A Cease Fire CFP 640 Specifications and Installation Instructions

A.1 CeaseFire CFP 640P Data Sheet

Cease Fire
Cease Fire

PDF DATASHEET

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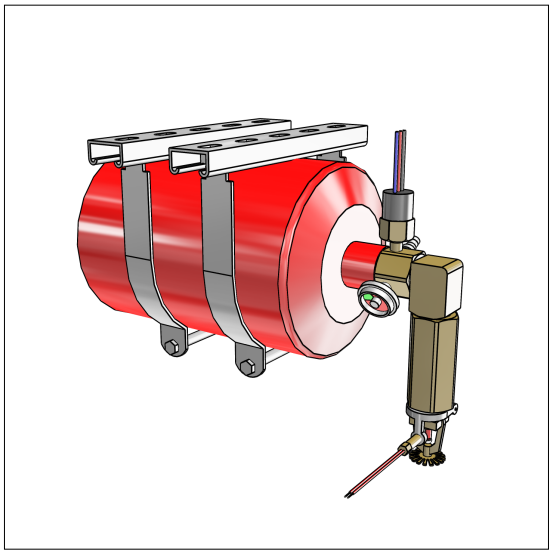
Datasheet creation date: 28/02/2017 18:18



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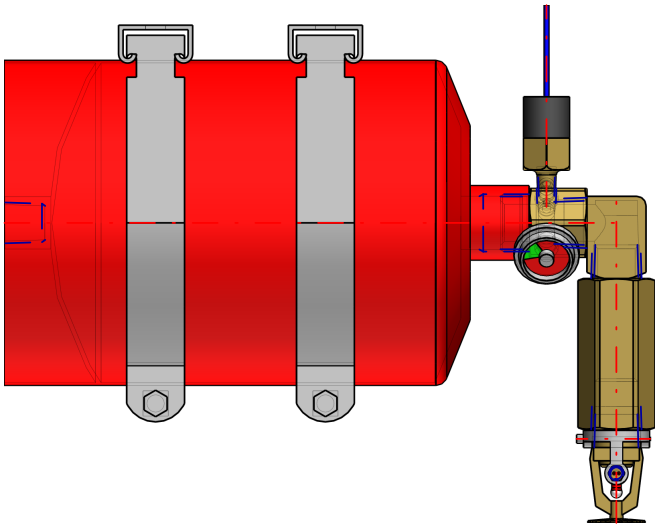
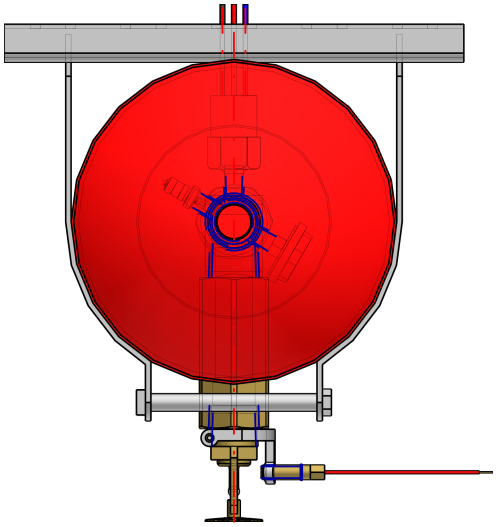
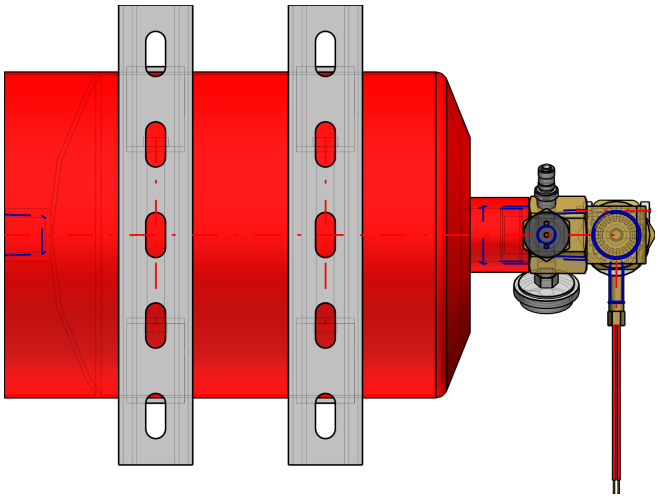






Cease Fire
Cease Fire

PDF DATASHEET

Last Modification (geometry): 16/11/2016 08:56

Datasheet creation date: 28/02/2017 18:18

PN (Part No.)	CFP 640LP
PRODUCT (Product)	CFP 640LP

Last Modification (geometry): 16/11/2016 08:56

Datasheet creation date: 28/02/2017 18:18

Bill of material

N°	Description	Amount
1	CFP 640LP	1

A.2 CeaseFire CFP 640 Manual and Installation Guide

CEASE FIRE®

THE LEADER IN PRE-ENGINEERED FIRE SUPPRESSION TECHNOLOGY

CFP 640

OWNER'S MANUAL
&
INSTALLATION INSTRUCTIONS

Issue Date: 08/02/2016

Revision Date: 08/02/2016
Revision: 0.1

Installation, Inspection and Maintenance Manual for CFP 640
This unit is assembled with UL listed and Factory Mutual approved components
The CFP 640 is built in accordance with NFPA 17, refer to NFPA 17 for installation, maintenance and inspection requirements.

WARRANTY
1-Year Limited Warranty

This Automatic Extinguishing Unit is warranted to the original owner to be free of defects in factory workmanship and material, and against loss of pressure, to the extent as noted within this manual that remanufacturing is required, for a period of one (1) year from date of manufacture, provided that it has not been misused, damaged, or initiated.

The foregoing warranty is expressly in lieu of any other warranties, expressed or implied, including, but not limited to, warranties of merchantability or fitness for a particular purpose. Cease Fire® shall not be responsible for any incidental, contingent, or consequential charges or damages.

"What To Do In A Fire Emergency"

If a fire breaks out:

1. ***Warn Everyone!*** Make certain everyone is clear of the area immediately and remains safely outside.

2. Call the Fire Department ***regardless*** of how small the fire seems to be. Post emergency phone numbers by each telephone.

3. ***Important!*** Locate an exit so you can escape in case the fire should get out of control. Keep low to avoid breathing in smoke and heated fumes that can be fatal.

TYPES OF FIRE CLASSIFICATIONS

Per NFPA Standards:
Class Fires - Class A fires occur in ordinary combustible materials, such as; wood, cloth, paper, rubber, and many plastics.
Class B Fires – Class B fires involve flammable liquids, paints, and lacquers.
Class C Fires – Class C fires involve energized electrical equipment where the non-conductivity of the extinguishing media is of importance.

INSTALLATION INSTRUCTIONS

Cease Fire® System Units were tested by UL for Class A, B and C fires. For total flood applications, the area being protected should be a reasonably tight enclosure where combined openings do not exceed one percent of the total surface area square footage.

Cease Fire® System Units must be hung vertically with the sprinkler deflector pointed downward. The unit is to be used in areas where the temperature falls between -20° and 120° Fahrenheit (-28.9° to 48.89° Celsius). The unit is to be mounted or attached to a secure ceiling, for example; wood, metal, or concrete. Insure there are no obstructions to the free flow operations of the sprinkler head and disbursement of the extinguishment within the enclosure.
Do not mount on suspended ceiling or loose tiles.

The pressure switch on Cease Fire® units is to be installed in accordance with national electrical codes, and any local requirements.

CYLINDER ANCHORING NOTES

1. Anchor each end of strut to the building structure as follows:
   - **WOOD FRAMING** – ¼: DIA x 2" HEX HEAD LAG SCREWS WITH ¾" O.D. WASHERS CONFORMING TO ANSI/ASME B18.2.1, GRADE 1. DRILL 5/32" PILOT HOLE.
   - **STEEL BEAM** – ¼"-20 SELF TAPPING SHEET METAL SCREWS GRADE 5 HEAT TREATED WITH DRILLING TIP AND LEAD THREADS HARDENED TO ROCKWELL C52 (BEAM SHALL BE 1/8" THICK MINIMUM).
   - **CONCRETE** – 3/8" DIA FACTORY MUTUAL APPROVED CONCRETE FASTENER INSTALLED PER MANUFACTURER REQUIREMENTS.
2. ANCHOR CEILING FLANGE TO STRUT WITH FOUR ¼" DIA BOLTS (UNISTRUT PART HHCS025075EG) AND STRUT NUTS (UNISTRUT PART 03300-1420). TORQUE BOLTS PER UNISTRUT REQUIREMENTS.
3. APPLY TEFLON TAPE TO THREADS, AND SCREW CYLINDER HAND TIGHT TO CEILING FLANGE.

NOTE: TWO 6" (MINIMUM) PIECES OF UNISTRUT P3300 (OR EQUIVALENT) (OMIT WHERE FLANGE CAN ANCHOR DIRECTLY TO BUILDING STRUCTURE) ANCHOR THROUGH UNCUT SLOTS IN STRUT.

COVERAGE

The coverage area for Cease Fire® System Units is determined according to the following table:

Coverage Area – Total Flood Applications Class A, B, and C Fires

CFP 640	
	10 ft. high room
Max Volume, Cubic ft.	640 18.12
Max Ceiling Height, ft.	10 3.05
Max Wall Length, ft Meters	8 2.44

Each unit installed for total flooding protection shall be attached to the ceiling and centered within the enclosure or portions of the enclosure which it protects.

Coverage Area – Local Application (i.e. Spot Protection) Class A, B, and C Fires (For Indoor Applications Only)

CFP 640		
	6.1 ft. sprinkler min height	10 ft. sprinkler max height
Max Area, Square ft. Square M	2.5 0.23	2.5 0.23
Sprinkler Height, ft. Meters	6.1 1.86	10.0 3.05

Each unit installed for local application protection shall be mounted with the sprinkled head at a height above the hazard within the table above and centered above the hazard.

PRESSURE SWITCH SPECIFICATION

The Cease Fire® System Units' pressure switch specifications are as follows:

1.	Set Point Range:	2 - 120 PSI (.14 – 8.3 BAR)
2.	Set Point Tolerance:	+- 1 PSI or 5% (.07 BAR)
3.	Max Operating Pressure:	250 PSI (17 BAR)
4.	Proof Pressure:	750 PSI (51 BAR)
5.	Differential:	8-16%
6.	Current Rating:	5 AMP
7.	Voltage Rating:	24 Volts DC or 250 Volt AC
8.	Media Connection:	1/8" NPT Male Brass
9.	Circuit Form:	SPST-NO or SPST-NC
10.	Electrical Connection:	8-32 Screw Terminals
11.	Diaphragm Material:	BUNA N

Cease Fire® System Units come standard with a Pressure Switch that is suggested to be used with a Normally Closed wiring scheme that will close on descending pressure at 95 PSI (6.55 BAR). This configuration is designed to give a signal to indicate when the Cease Fire® System Unit has discharged and/or a leak or drop in pressure has occurred.

SPRINKLER HEAD SPECIFICATIONS

The Cease Fire® System Units' sprinkler head specifications are as follows:

1.	Sprinkler Nominal Temperature Rating:	155°F (68°C)
2.	Sprinkler Temperature Classification:	Ordinary
3.	Maximum Ambient Temperature:	120°F (48.89°C)
4.	Bulb Color:	Red
5.	Glass bulb fluid temperature rating:	-65°F (-55°C)
6.	Hydrostatic test:	500 PSI (34.47 BAR)
7.	Thread Size:	¾" NPT (20 mm BSP)
8.	Spring:	USA Patent No. 4,167,974
9.	Bulb:	USA Patent No. 4,796,710

Cease Fire® System Units come standard with a Sprinkler Head that has a Nominal Temperature Rating of 155°F (68°C).

Cease Fire® System Units also have Sprinkler Head options for Nominal Temperature Ratings of 135 °F (57 °C), 175°F (79°C), 200°F (93°C), and 286°F (141°C).

OPERATIONS

The Cease Fire® Unit is self-activating. Each unit is designed to discharge automatically by means of a thermal sprinkler head rated at 155°F (68°C). The temperature rating for each sprinkler head is stamped on the star shaped deflector in both Fahrenheit and Celsius measurements. The temperature of the sprinkler head is fixed and must be designated at the time of purchase. When the temperature rise to activate the Cease Fire® unit, the sprinkler head opens automatically and dispenses the entire contents in less than 10 seconds onto the fire and throughout the enclosure being protected. If the unit is equipped with the optional pressure switch, a signal is sent at the time of discharge to activate any remaining pre-engineered units protecting the same enclosure as well as any accessory equipment, such as an alarm. Cease Fire® Pre-Engineered Systems containing 2 or more Fire Suppression units shall be wired in such a way that the units will initiate simultaneously as a total flooding system. It is important to avoid exposure to smoke, vapors, and the fire by-products. Ventilate the area thoroughly before reentry.

Cease Fire® recommends that the empty/discharged unit be immediately replaced.

SPECIFICATIONS

1. Operating Pressure: At 70°F/21°C is 175 PSI (12.07 BAR)
2. Storage Temperature: -20° to 120°F / -28.9° to 48.89°C
3. Contents:
    - CF-33 (MAP is the only powder ingredient in excess of 95%, by weight)
    - Vessel test pressure – 480 PSI (33.10 BAR)

INSPECTION, MAINTENANCE, AND REMANUFACTURING

All Cease Fire® Units are to be inspected and maintained in accordance with this manual and/or NFPA 17.

INSPECTION

Cease Fire® recommends that a "quick check" be performed monthly, following the procedures outlined below. Minimal technical knowledge is required to perform this inspection.

INSPECTION STEPS:

a. The unit is in its proper location.

b. Obstructions have not been placed below or alongside the unit.

c. Label is clean and intact.

d. No obvious physical damage or conditions exist that may prevent operations.

e. Pressure is in operable range (see attached Figure 1, Extinguisher Temperature vs. Pressure Graph).

f. If any deficiencies are found, corrective action shall be taken immediately.

g. Personnel making inspections shall keep records for those extinguishing units found to need corrective actions. The report shall be filed with the owner, or designated responsible party.

MAINTENANCE

Cease Fire® requires that semi-annual maintenance be conducted in accordance with this manual by a trained person who has undergone the instructions necessary, or, as required, licensed to reliably perform maintenance. The maintenance shall consist of:

a. Check to see that the hazard has not changed.
b. Examine the container, sprinkler head, head assembly, any auxiliary equipment including pressure switch, wiring, and signaling devices.
c. If an examination of the container reveals corrosion or pitting, the unit should be replaced or returned to the factory for testing. If substantial corrosion is observed on the hanger assembly, the hanger assembly should be replaced.
d. The agent quality and pressure should be checked. If the container shows a loss in net weight of more than 5 percent (see Table 1.1), or a loss in pressure (adjusted for temperature, see Table 1.2) of more than 5 percent, it should be replaced immediately.
e. The fixed temperature sensing element needs replacement only after discharge.
f. When the maintenance of the unit reveals defective parts which could cause an impairment or failure of proper operations, the affected parts shall be replaced.
g. The maintenance report noting an inspector's initials and license number, with recommendations noted if any, shall be filed with the owner, or with the designated responsible party.
h. Cease Fire® recommends that alternate protection acceptable to the authority having jurisdiction be provided.

Table 1.1 - Unit Pressures Adjusted for Temperature

Temperature	Pressure
32°F/0°C	132 PSI (7.9 BAR)
70°F/21°C	175 PSI (12.1 BAR)
100°F/38°C	220 PSI (15.2 BAR)

Table 1.2 - Unit Weights CFP640

Weight Type	Value (lbs/Kg)
Gross Weight	19.25/8.73
Mechanical Parts	9.6/4.4
Weight Maximum	25.25/11.45

REMANUFACTURING

Cease Fire® System Units have a unique blend of patent pending extinguishment agents. *These units can be remanufactured only by Cease Fire®, and are not to be refilled in the field.*

Contact Cease Fire® Corporate for further information.

CLEAN UP AFTER DISCHARGE

Cease Fire® System Units are filled with a Dry Chemical mixture. After discharge, Cease Fire® recommends the following clean up steps:

Dry Chemical/CF33:
Corrosion need not be of concern when accompanied by prompt clean up. For the most part, dry chemical agents can be readily cleaned by wiping and/or vacuuming the exposed materials. Cease Fire® recommends a HEPA Filter vacuum for clean up.

WARNING - *Clean up procedures should be initiated after the fire has been totally extinguished and the area has been ventilated.*

TOXICITY INFORMATION UNIT CONTENTS

Cease Fire® CFP Automatic Fire Extinguisher Units contain CF33 Dry Chemical Agent. General information regarding the extinguishers' contents is as follows. Should more detailed information be required, contact Cease Fire® Corporate.

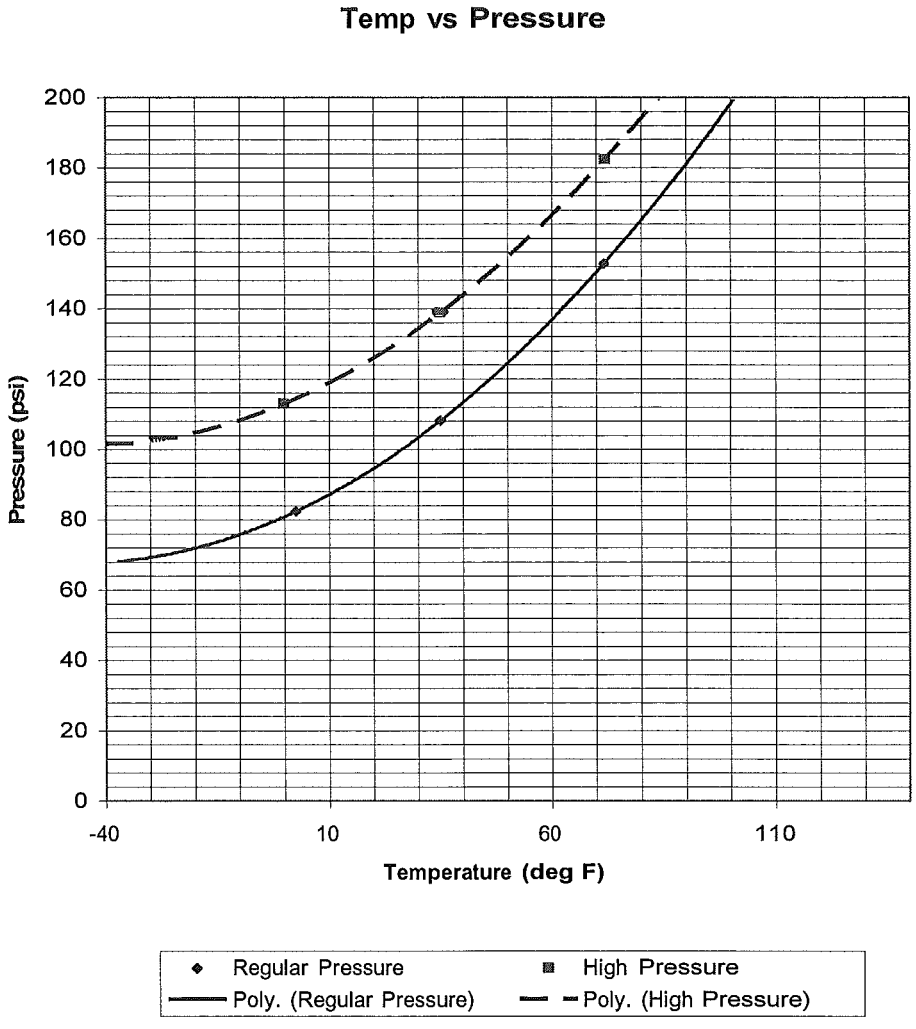
a. Dry Chemical, CF33: Monoammonium Phosphate is considered a non-toxic nuisance dust. CF33 does not possess any toxicological properties, which would require special handling other than good industrial hygiene and safety practices. However, as with any finely divided material, it may produce mild irritation effects, especially when used in an enclosed area. In general, these effects are neither serious nor permanent.

TOXICITY FROM FIRE

"**WARNING**: The concentrated extinguishing agent when applied to fire can produce toxic by-products. Avoid exposure to vapors, fumes, and products of combustion." The majority of deaths during fires are caused by toxic smoke from fire. Nearly all fuels produce potentially lethal gases, such as carbon monoxide. Other burning materials provide their own unique hazards, for example; Class A fires of burning wood and paper produce "Acrolein", Class B fires of burning polyurethane foam produces "Cyanide", and Class C fires of burning PVC cable insulation creates hydrogen chloride gas. The longer the fire burns, the higher the concentration of these types of gases.

BREAKDOWN OF UNITS

STANDARD COMPONENTS	PART NUMBER
ABC Powder	CF-200
DDI Cylinder	CF-600
Coupling	CF-700
4 Inch Extension	CF-711
O-ring	CF-800
155° F Upright Sprinkler Head	CF-900
Low Profile 90° Elbow	CF-950
Tank Valve	CF-1100
Pressure Switch	CF-1201
Plug	CF-1300
Pressure Gauge	CF-1400
Actuator	CF-1600
Actuator Holder	CF-1702
Hanger Flange Assembly	CF-1900
CFP Series Label	CF-2200
CFP Series Owner's Manual	CF-3200



$y = 0.006x^2 + 0.5726x + 80.591$ $y = 0.006x^2 + 0.5311x + 113.03$

$R^2 = 1$ $R^2 = 1$

Revision Records

Old Revision Number	New Revision Number	Section Number/Page Revised	Description of Revision	Revised by	Date
0.1	0.1	Page 14	Updated CF-33 MSDS	Cody Kitterman	12/14/16

MATERIAL SAFETY DATA SHEET
Emergency # (800) 535-5053
811 NE 112th Ave., Suite 104
Vancouver, WA 98684
Toll Free (888) 232-7334

CEASE FIRE DRY AGENT CF-33

SECTION 1 – NAME & HAZARD SUMMARY

Material Name: CEASE FIRE DRY AGENT CF-33
Manufacturer: Cease Fire LLC. Phone (360) 567-0990

SECTION 2 – INGREDIENTS

Cease Fire® System Units were tested and approved by Underwriters Laboratory & Factory Mutual Research Corp., for "Total Flooding" & "Local Application" fire protection of Class A, B and C fires. Cease Fire® has a patent pending Dry Agent that is non-corrosive & non-conductive.

Monoammonium Phosphate (MAP)* Specific formulation of Cease Fire® Dry Agent is PROPRIETARY

SECTION 3 – PHYSICAL DATA

Boiling Point: NA | Specific Gravity (H20 = 1): 1.80 | Vapor Pressure (mm Hg): N/A
Vapor Density (Air – 1): N/A | Solubility In Water: Slightly Water Soluble
Appearance: Yellow Powder | Odor: No Appearable Odor | Melting Point: 374° Fahrenheit / 190° Celsius

SECTION 4 – FIRE & EXPLOSION HAZARD

Flash Point: Noncombustible | Method Used: N/A
Flammable Limits in Air % b Volume: LEL Lower: N/A | UEL Upper: N/A
Auto-Ignition Temperature: N/A
Extinguisher Media: N/A, This Material is a Fire Extinguisher Agent Special Fire Fighting Procedures: N/A
Unusual Fire & Explosion Hazards: N/A

SECTION 5 – REACTIVITY DATA

Stability: Stable | Conditions to Avoid: N/A
Incompatibility (Materials to Avoid): Do Not Mix With Different Types of Dry Chemical Extinguishing Agents.
Hazardous Polymerization: Will Not Occur

SECTION 6 – HEALTH HAZARD ASSESSMENT

Acute: Transient Cough, Irritation of Airways, & Shortness of Breath | Chronic: Pneumonconiosis
Signs & Symptoms of Exposure: Coughing & Irritation of Airways
Medical Conditions Generally Aggravated by Exposure: Asthma, Bronchitis, or Other Respiratory Illness
Chemical Listed as Carcinogen or Potential Carcinogen: N/A
Emergency & First Aid Procedures: Move victims to fresh air. Wash affected area with soap & water. Flush from eyes with large amounts of water for at least 15 minutes. Seek medical attention if necessary.
Routes of Entry: Inhalation, Eyes, Skin, Ingestion

SECTION 7 – SPILL OR LEAK PROCEDURES

Precautions to be Taken in Handling & Storage: Cease Fire Dry Agent CF-33 should be stored only in its original suppression unit.
Other Precautions: None
Steps to be Taken in Case Material is Released or Spilled: Sweep up. Store in covered containers. Do not reuse.

SECTION 8 – SPECIAL PROTECTION INFORMATION

Respiratory Protection: Dust respirator approved by NIOSH / MSHA schedule TC-ZIC
Ventilation: N/A | Local Exhaust: N/A | Mechanical General: N/A | Special: N/A | Other: N/A
Protective Gloves: Sensitive Individuals Should Wear Gloves
Eye Protection: Safety glasses are recommended | Other Protective Clothing or Equipment: N/A
Work / Hygienic Practices: Avoid breathing of dust. Wash off with soap & water.

The information herein is given in good faith but no warrant, expressed or implied, is made.

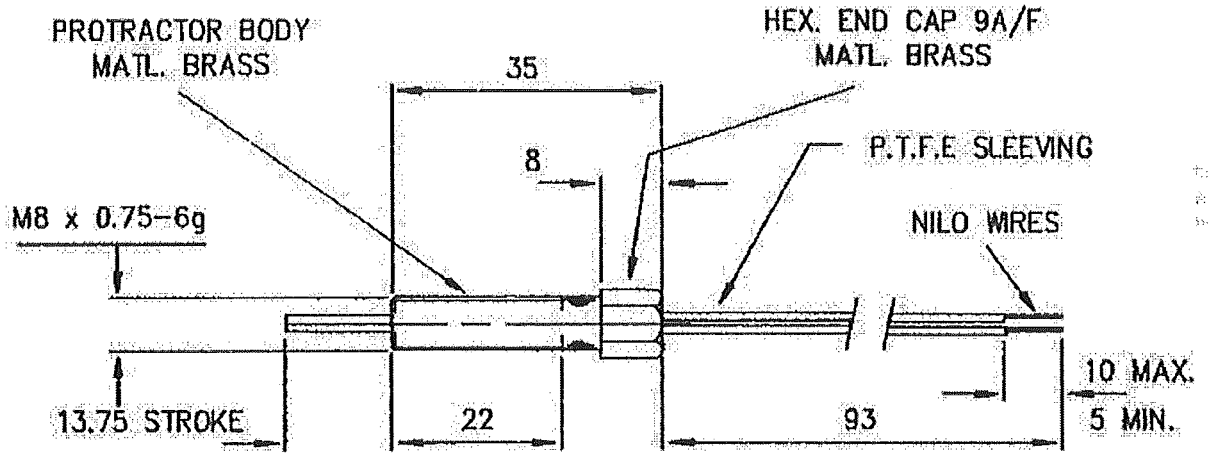
A.3 CeaseFire Manual Actuator Specifications

Cease Fire, LLC
811 NE 112th Avenue
Ste 104
Vancouver, WA 98684
t: 360-567-0990
f: 360-567-1242
i: www.ceasefire.com

CEASE FIRE®

THE LEADER IN PRE-ENGINEERED FIRE SUPPRESSION TECHNOLOGY

CF-1600 Metron Actuator Specifications & Cut Sheet:



All Measurements in drawing are listed in metric.

Nominal Energy:	6 millijoules
Maximum No Fire Current:	30 sec pulse 0.15 A / 0.050 sec pulse 0.3 A
Maximum Monitoring Current:	0.01 A
Actuator Resistance:	0.9 - 1.134 Ohms when used with Potter Panel / Accessories 0.9 - 1.6 Ohms when used with non-validated equipment
Low Temperature Rating:	-40°F / -40°C
High Temperature Rating:	212°F / 100°C
Diameter:	0.315" / 8mm
Length:	0.54" Stroke + 1.38" Body / 13.75mm + 35mm
Unit Weight:	0.5 oz. / 14.18g

CF-1600 Metron Actuator in use with Potter Signal products:

The number of actuators that can be fired from any Potter release panel is determined by the total circuit resistance and the power limitations of the panel outputs. Total circuit resistance is defined as the resistance of the wire and actuators combined. The maximum allowable resistance including all actuators and wire is 19.4 ohms for each output on either Potter panel.

Providing a maximum of 500 feet of 14 AWG wire per circuit:

A maximum of 12 actuators can be connected to each output of the PFC-4410RC.

A maximum of 16 actuators can be connected to each NAC output of the PFC-6075R.

A maximum of 10 actuators can be connected to each I/O circuit of the PFC-6075R.

A maximum of 8 actuators can be connected to the MOM. The power of the MOM shall only be provided by the I/O or NAC circuit of the PFC-6075R that is programmed as a release output.

A maximum of 16 actuators can be connected to each output of the PSN1000 power supply.

NOTE: The maximum number of actuators allowed is dependent on total circuit resistance. The total circuit resistance cannot exceed 19.4 ohms per output, regardless of the number of actuators on the circuit. This means that depending on the resistance of the actuators being used, it may not always be possible to connect the maximum number of actuators to a panel output. When calculating maximum number of actuators in use with a Potter panel, power booster, or accessories; use 0.9 – 1.134 ohms resistance. When using a non-validated piece of equipment 0.9 – 1.6 ohms must be used for resistance calculations.

Hazardous Atmospheres: Incendivity tests in 9% methane/air mixtures have been carried out in accordance with the M and Q Testing Memorandum No.13 published by the U.K. Health and Safety Executive. The tests gave no ignitions in 200 firings.

Actuators have been fired in an explosive gas mixture. The test mixture was 40% hydrogen, 20% oxygen, and 40% nitrogen, as described in Appendix 1, of BASEEFA. Certification Standard SFA3007: 1981. The tests (conducted in the gas mixture giving the most severe conditions specified in accepted standards for apparatus intended to be used in hydrogen/air mixtures) gave no ignitions in 200 firings.

Listings / Approvals: & UL Recognized

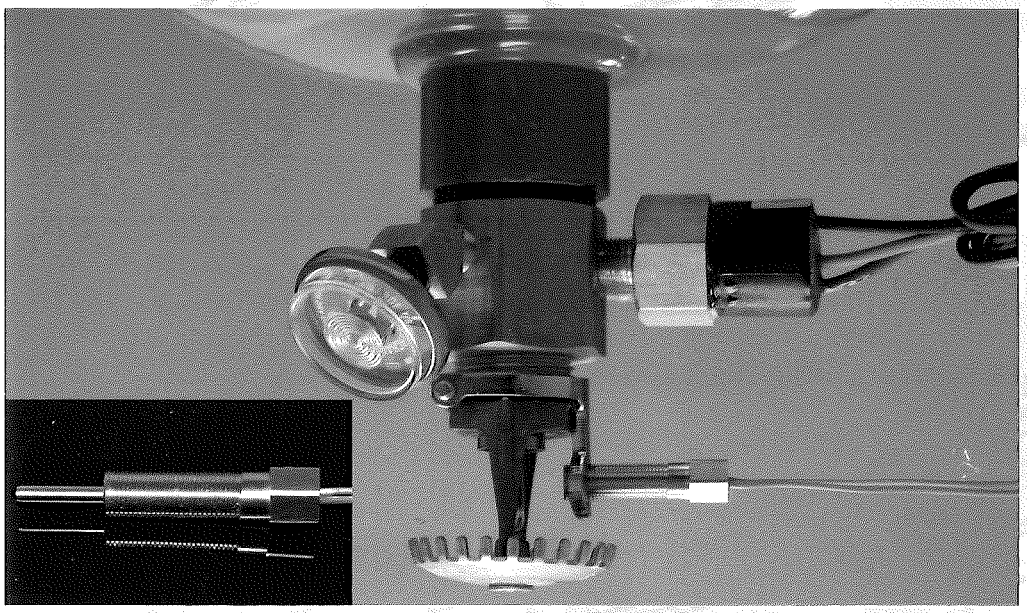
A.4 CeaseFire Manual Actuator Installation Guide

CEASE FIRE

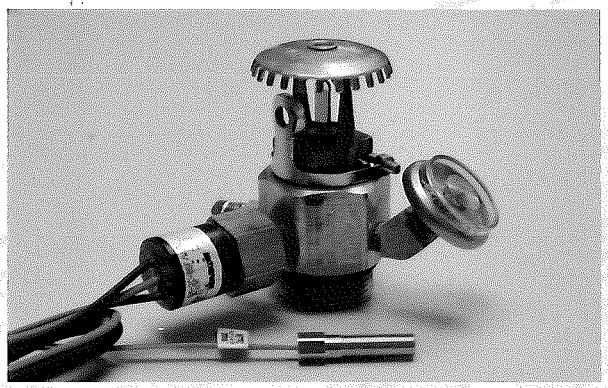
THE LEADER IN PRE-ENGINEERED FIRE SUPPRESSION TECHNOLOGY

Cease Fire Corporate Office
811 NE 112th Avenue, Suite 104
Vancouver, WA 98684
US and Canada 1.888.232.7334
International 1.360.567.0990

ACTUATOR KIT INSTALLATION GUIDE



Proper installation of the actuator kit, along with professional connection to the control panel is of vital importance to the integrity of the suppression system. The actuator kit includes one Actuator, an Actuator Holder and a Fastening Bolt.



The actuator holder and fastening bolt are pre-located on the head assembly.

1) Tighten the fastening bolt.

2) Thread the actuator through the holder as shown in the first image.

The actuator kit is now installed.

B Sensor Calibration/Specification Sheets

TSI P/N 2300157

CERTIFICATE OF CALIBRATION AND TESTING

TSI Incorporated, 500 Cardigan Road, Shoreview, MN 55126 USA
Tel: 1-800-874-2811 1-651-490-2811 Fax: 1-651-490-3824 http://www.tsi.com

ENVIRONMENT CONDITIONS		
TEMPERATURE	74.8 (23.8)	°F (°C)
RELATIVE HUMIDITY	48	%RH
BAROMETRIC PRESSURE	28.88 (978.0)	inHg (hPa)

MODEL	5725
SERIAL NUMBER	T57251511004

☒ AS LEFT
☒ AS FOUND

☒ IN TOLERANCE
☐ OUT OF TOLERANCE

– CALIBRATION VERIFICATION RESULTS –

VELOCITY — **SYSTEM RV01-01** — *Unit: ft/min (m/s)*

#	STANDARD	MEASURED	ALLOWABLE RANGE	#	STANDARD	MEASURED	ALLOWABLE RANGE
1	100 (0.51)	102 (0.52)	95~105 (0.48~0.53)	5	998 (5.07)	989 (5.02)	984~1012 (5.00~5.14)
2	150 (0.76)	151 (0.77)	144~156 (0.73~0.79)	6	1499 (7.61)	1482 (7.53)	1480~1518 (7.52~7.71)
3	200 (1.02)	201 (1.02)	194~206 (0.99~1.05)	7	2992 (15.20)	2979 (15.13)	2958~3026 (15.03~15.37)
4	500 (2.54)	494 (2.51)	491~509 (2.49~2.59)	8	5999 (30.47)	5995 (30.45)	5935~6063 (30.15~30.80)

TEMPERATURE — **SYSTEM RV01-01** — *Unit: °F (°C)*

#	STANDARD	MEASURED	ALLOWABLE RANGE	#	STANDARD	MEASURED	ALLOWABLE RANGE
1	72.3 (22.4)	73.0 (22.8)	70.3~74.3 (21.3~23.5)				

TSI does hereby certify that the above described instrument conforms to the original manufacturer's specification (not applicable to As Found data) and has been calibrated using standards whose accuracies are traceable to the United States National Institute of Standards and Technology (NIST) or has been verified with respect to instrumentation whose accuracy is traceable to NIST, or is derived from accepted values of physical constants. TSI's calibration system is registered to ISO-9001:2015.

Measurement Variable	System ID	Last Cal.	Cal. Due
DC Voltage	E003277	10-19-16	04-30-18
Temperature	E003270	09-20-16	09-20-17
Pressure	E003271	08-15-16	08-15-17

Measurement Variable	System ID	Last Cal	Cal. Due
DC Voltage	E003276	10-19-16	04-30-18
Pressure	E002740	02-09-17	08-31-17

CALIBRATED

July 10, 2017
DATE

Doc ID: CERT_DEFAULT

CERTIFICATE OF CALIBRATION AND TESTING

TSI Incorporated, 500 Cardigan Road, Shoreview, MN 55126 USA
Tel: 1-800-874-2811 1-651-490-2811 Fax: 1-651-490-3824 http://www.tsi.com

ENVIRONMENT CONDITIONS		
TEMPERATURE	74.7 (23.7)	°F (°C)
RELATIVE HUMIDITY	49	%RH
BAROMETRIC PRESSURE	28.89 (978.3)	inHg (hPa)

MODEL	5725
SERIAL NUMBER	T57251511004

☐ AS LEFT ☐ IN TOLERANCE
☒ AS FOUND ☒ OUT OF TOLERANCE

– CALIBRATION VERIFICATION RESULTS –

VELOCITY — SYSTEM RV01-01 — *Unit: ft/min (m/s)*

#	STANDARD	MEASURED	ALLOWABLE RANGE	#	STANDARD	MEASURED	ALLOWABLE RANGE
1	100 (0.51)	98 (0.50)	95~105 (0.48~0.53)	5	999 (5.07)	1008 (5.12)	985~1013 (5.00~5.15)
2	150 (0.76)	149 (0.76)	144~156 (0.73~0.79)	6	1497 (7.60)	1514 (7.69)	1478~1516 (7.51~7.70)
3	199 (1.01)	197 (1.00)	193~205 (0.98~1.04)	7	2991 (15.194)	* 3053 (15.509)	2957~3025 (15.022~15.367)
4	500 (2.54)	498 (2.53)	491~509 (2.49~2.59)	8	6002 (30.49)	* 6201 (31.501)	5938~6066 (30.165~30.815)

TEMPERATURE — SYSTEM RV01-01 — *Unit: °F (°C)*

#	STANDARD	MEASURED	ALLOWABLE RANGE	#	STANDARD	MEASURED	ALLOWABLE RANGE
1	72.3 (22.4)	73.1 (22.8)	70.3~74.3 (21.3~23.5)				

**Indicates Out-of-Tolerance Condition*

TSI does hereby certify that the above described instrument conforms to the original manufacturer's specification (not applicable to As Found data) and has been calibrated using standards whose accuracies are traceable to the United States National Institute of Standards and Technology (NIST) or has been verified with respect to instrumentation whose accuracy is traceable to NIST, or is derived from accepted values of physical constants. TSI's calibration system is registered to ISO-9001:2015.

Measurement Variable	System ID	Last Cal.	Cal. Due
DC Voltage	E003277	10-19-16	04-30-18
Temperature	E003270	09-20-16	09-20-17
Pressure	E003271	08-15-16	08-15-17
DC Voltage	E003276	10-19-16	04-30-18
Pressure	E002740	02-09-17	08-31-17

Chimarra

VERIFIED

July 10, 2017

DATE

DOC ID: CERT_DEFAULT

TSI P/N 2300157

CERTIFICATE OF CALIBRATION

Dwyer Instruments, Inc. P.O. Box 373 Michigan City, IN 46361
Fax: (219) 872-9057 Phone: (219) 879-8000

Customer: New Mexico Tech
Address: 801 Le Roy Pl
Socorro NM 878014681

Accuracy: 8 % of Full Scale

Full Scale Range: 400 Units: PSI

Date July 11, 2017
Due
PO # DP187519
Model # 648B-16
Sales Order # S850639
RMA #
Certificate No.: 17DWY00-0759

This certifies that the instrument listed below has been calibrated using a standard having an accuracy as listed, and is traceable to the NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST).

Master Gage Accuracy: .05 % Full Scale

Calibration Standard Information

	Serial No.	Cert. Rpt. No.	Last Cal. Date
Base:	49357	49357-41744	10/11/16
Module 1:	7798	7798-42805	03/11/17
Module 2:			

Instrument Information

I.D. No. of Instrument being Calibrated
4713112
Customer's I.D. No. (If Different)

Condition Of Meter	x New	After Repair	As Received

Notes:

NEW / AS RECEIVED			AFTER REPAIR	
Customer Gage Setting	Dwyer Master Gage Reading	% Error Full Scale		
-2.5000	2.4706	-0.34%		
-1.2500	1.2664	-0.37%		
0.0000	0.0004	-0.33%		
1.2500	1.2384	-0.37%		
2.5000	2.5106	-0.40%		
		0.00%		
		0.00%		
		0.00%		
		0.00%		
		0.00%		

Signed: Craig E. Maatman

Procedure No.: TC-000-30-B

Customer Please Note: When requesting recalibration please mention the I.D. number of your instrument; when requesting other information on the calibrated instrument please mention the Certificate No.

CERTIFICATE OF CALIBRATION

Dwyer Instruments, Inc. P.O. Box 373 Michigan City, IN 46361
Fax: (219) 872-9057 Phone: (219) 879-8000

Customer: New Mexico Tech
Address: 801 Le Roy Pl
Socorro NM 878014681

Accuracy: 8 % of Full Scale

Full Scale Range: 400 Units: PSI

Date July 11, 2017
Due
PO # DP187519
Model # 648B-16
Sales
Order # S850639
RMA #
Certificate No.: 17DWY00-0758

This certifies that the instrument listed below has been calibrated using a standard having an accuracy as listed, and is traceable to the NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST).

Master Gage Accuracy: .05 % Full Scale

Calibration Standard Information

	Serial No.	Cert. Rpt. No.	Last Cal. Date
Base:	49357	49357-41744	10/11/16
Module 1:	7798	7798-42805	03/11/17
Module 2:			

Instrument Information

I.D. No. of Instrument being Calibrated
4713110
Customer's I.D. No. (If Different)

Condition Of Meter	New	After Repair	As Received
	x		

Notes:

NEW / AS RECEIVED			AFTER REPAIR	
Customer Gage Setting	Dwyer Master Gage Reading	% Error Full Scale		
-2.5000	-2.4618	-0.09%		
-1.2500	-1.2476	-0.11%		
0.0000	0.0000	-0.06%		
1.2500	1.2524	-0.03%		
2.5000	2.4628	0.02%		
		0.00%		
		0.00%		
		0.00%		
		0.00%		
		0.00%		

Signed: Randy E. Maurer

Procedure No.: TC-000-30-B

Customer Please Note: When requesting recalibration please mention the I.D. number of your instrument; when requesting other information on the calibrated instrument please mention the Certificate No.

CERTIFICATE OF CALIBRATION

Dwyer Instruments, Inc. P.O. Box 373 Michigan City, IN 46361
Fax: (219) 872-9057 Phone: (219) 879-8000

Customer: New Mexico Tech
Address: 801 Le Roy Pl
Socorro NM 878014681

Accuracy: 8 % of Full Scale

Full Scale Range: 400 Units: PSI

Date July 11, 2017
Due
PO # DP187519
Model # 648B-16
Sales
Order # S850639
RMA #
Certificate No.: 17DWY00-0757

This certifies that the instrument listed below has been calibrated using a standard having an accuracy as listed, and is traceable to the NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST).

Master Gage Accuracy: .05 % Full Scale

Calibration Standard Information

	Serial No.	Cert. Rpt. No.	Last Cal. Date
Base:	49357	49357-41744	10/11/16
Module 1:	7798	7798-42805	03/11/17
Module 2:			

Instrument Information

I.D. No. of Instrument being Calibrated
4713025
Customer's I.D. No. (If Different)

Condition Of Meter	x New	After Repair	As Received

Notes:

NEW / AS RECEIVED			AFTER REPAIR	
Customer Gage Setting	Dwyer Master Gage Reading	% Error Full Scale		
-2.5000	-2.4644	0.09%		
-1.2500	-1.2619	-0.05%		
0.0000	0.0000	-0.12%		
1.2500	1.2331	-0.20%		
2.5000	2.4429	-0.33%		
		0.00%		
		0.00%		
		0.00%		
		0.00%		
		0.00%		

Signed: Randy E. Mansur

Procedure No.: TC-000-30-B

Customer Please Note: When requesting recalibration please mention the I.D. number of your instrument; when requesting other information on the calibrated instrument please mention the Certificate No.

CERTIFICATE OF CALIBRATION

Dwyer Instruments, Inc. P.O. Box 373 Michigan City, IN 46361
Fax: (219) 872-9057 Phone: (219) 879-8000

Customer: New Mexico Tech
Address: 801 Le Roy Pl
Socorro NM 878014681

Accuracy: .5 % of Full Scale

Full Scale Range: 400 Units: PSI

Date July 11, 2017
Due
PO # DP187519
Model # 648B-16
Sales Order # S850639
RMA #
Certificate No.: 17DWY00-0756

This certifies that the instrument listed below has been calibrated using a standard having an accuracy as listed, and is traceable to the NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST). Master Gage Accuracy: .05 % Full Scale

Calibration Standard Information

	Serial No.	Cert. Rpt. No.	Last Cal. Date
Base:	49357	49357-41744	10/11/16
Module 1:	7798	7798-42805	03/11/17
Module 2:			

Instrument Information

I.D. No. of Instrument being Calibrated
4713111
Customer's I.D. No. (If Different)

Condition Of Meter	x New	After Repair	As Received

Notes:

NEW / AS RECEIVED			AFTER REPAIR	
Customer Gage Setting	Dwyer Master Gage Reading	% Error Full Scale		
-2.5000	-2.4777	0.33%		
-1.2500	-1.2722	0.18%		
0.0000	-0.0001	0.07%		
1.2500	1.2348	-0.01%		
2.5000	2.4855	-0.04%		
		0.00%		
		0.00%		
		0.00%		
		0.00%		
		0.00%		

Signed: Craig E. Messner

Procedure No.: TC-000-30-B

Customer Please Note: When requesting recalibration please mention the I.D. number of your instrument; when requesting other information on the calibrated instrument please mention the Certificate No.

Calibration
Certificate No. 1750.01

Calibration complies with ISO 9001 ISO/IEC 17025 AND ANSI/NCSL Z540-1

Cert. No.: 1043-8297572

Traceable® Certificate of Calibration for 3-Button Stopwatch

Instrument Identification:

Model: 1043 S/N: 170087655 Manufacturer: Control Company

Standards/Equipment:

Description	Serial Number	Due Date	NIST Traceable Reference
Non-contact Frequency Counter	26.6 2025	3/25/17	1000389556

Certificate Information:

Technician: 150 Procedure: CAL-01 Cal Date: 2/07/17 Due Date: 2/07/19

Test Conditions: 24.6°C 59.0 %RH 1011 mBar

Calibration Data: (New Instrument)

Unit(s)	Nominal	As Found	In Tol	Nominal	As Left	In Tol	Min	Max	±U	TUR
Sec/24hr		N.A.		0.000	0.167	Y	-86.400	86.400	0.037	>4:1

This Instrument was calibrated using Instruments Traceable to National Institute of Standards and Technology.

A Test Uncertainty Ratio of at least 4:1 is maintained unless otherwise stated and is calculated using the expanded measurement uncertainty. Uncertainty evaluation includes the instrument under test and is calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement" (GUM). The uncertainty represents an expanded uncertainty using a coverage factor k=2 to approximate a 95% confidence level. In tolerance conditions are based on test results falling within specified limits with no reduction by the uncertainty of the measurement. The results contained herein relate only to the item calibrated. This certificate shall not be reproduced except in full, without written approval of Control Company.

Nominal=Standard's Reading; As Left=Instrument's Reading; In Tol=In Tolerance; Min/Max=Acceptance Range; ±U=Expanded Measurement Uncertainty; TUR=Test Uncertainty Ratio; Accuracy=±(Max-Min)/2; Min = Nominal(Rounded) - Tolerance; Max = Nominal(Rounded) + Tolerance; Date=MM/DD/YY

Nicol Rodriguez, Quality Manager

Aaron Judice, Technical Manager

Maintaining Accuracy:

In our opinion once calibrated your 3-Button Stopwatch should maintain its accuracy. There is no exact way to determine how long calibration will be maintained. 3-Button Stopwatchs change little, if any at all, but can be affected by aging, temperature, shock, and contamination.

Recalibration:

For factory calibration and re-certification traceable to National Institute of Standards and Technology contact Control Company.

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Phone 281 482-1714 Fax 281 482-9448 service@control3.com www.control3.com

Calibration complies with ISO 9001 ISO/IEC 17025 AND ANSI/NCSL Z540-1

ACCREDITED
Calibration
Certificate No. 1750.01

Cert. No.: 1043-8297972

Traceable® Certificate of Calibration for 3-Button Stopwatch

Instrument Identification:

Model: 1043 S/N: 170087992 Manufacturer: Control Company

Standards/Equipment:

Description	Serial Number	Due Date	NIST Traceable Reference
Non-contact Frequency Counter	26.6 2025	3/25/17	1000389556

Certificate Information:

Technician: 150 Procedure: CAL-01 Cal Date: 2/07/17 Due Date: 2/07/19
Test Conditions: 24.6°C 59.0 %RH 1011 mBar

Calibration Data: (New Instrument)

Unit(s)	Nominal	As Found	In Tol	Nominal	As Left	In Tol	Min	Max	±U	TUR
Sec/24hr		N.A.		0.000	0.067	Y	-86.400	86.400	0.037	>4:1

This Instrument was calibrated using Instruments Traceable to National Institute of Standards and Technology.

A Test Uncertainty Ratio of at least 4:1 is maintained unless otherwise stated and is calculated using the expanded measurement uncertainty. Uncertainty evaluation includes the instrument under test and is calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement" (GUM). The uncertainty represents an expanded uncertainty using a coverage factor k=2 to approximate a 95% confidence level. In tolerance conditions are based on test results falling within specified limits with no reduction by the uncertainty of the measurement. The results contained herein relate only to the item calibrated. This certificate shall not be reproduced except in full, without written approval of Control Company.

Nominal=Standard's Reading; As Left=Instrument's Reading; In Tol=In Tolerance; Min/Max=Acceptance Range; ±U=Expanded Measurement Uncertainty; TUR=Test Uncertainty Ratio; Accuracy=±(Max-Min)/2; Min = Nominal(Rounded) - Tolerance; Max = Nominal(Rounded) + Tolerance; Date=MM/DD/YY

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Printed On: July 25, 2017

Report of Calibration

Calib. Date: July 24, 2017

For: CYBERNETICS INC
FOR NM Inst of Mining & Tech
P.O.: 2437
M.O.: G735709
S.O.: 211619
LOT: Z248933

Part Number: AB-2005267
Item Calib.: Thermocouple
ANSI Type: K
ANSI Limit: Standard
Calibrated By: Ruth Kosloske

If deviation reads positive subtract to correct. If deviation read negative, add to correct. All values are positive unless otherwise shown

	Nominal Calibration Temperature ° F	Corrected Temperature ° F	Fahrenheit Deviation	+/- ANSI Limits° F
Sample ID: 141052				
Serial#: 1	600.00 °	598.46	-1.54	4.26
	700.00 °	696.19	-3.81	5.01
	800.00 °	796.38	-3.62	5.76
Sample ID: 141053				
Serial#: 2	600.00 °	598.90	-1.10	4.26
	700.00 °	697.05	-2.95	5.01
	800.00 °	796.63	-3.37	5.76
Sample ID: 141054				
Serial#: 3	600.00 °	598.68	-1.32	4.26
	700.00 °	695.98	-4.02	5.01
	800.00 °	796.25	-3.75	5.76
Sample ID: 141055				
Serial#: 4	600.00 °	599.11	-0.89	4.26
	700.00 °	696.19	-3.81	5.01
	800.00 °	796.21	-3.79	5.76
Sample ID: 141056				
Serial#: 5	600.00 °	598.80	-1.20	4.26
	700.00 °	696.07	-3.93	5.01
	800.00 °	795.47	-4.53	5.76
Sample ID: 141057				
Serial#: 6	600.00 °	599.75	-0.25	4.26
	700.00 °	697.49	-2.51	5.01
	800.00 °	796.40	-3.60	5.76
Sample ID: 141058				
Serial#: 7	600.00 °	598.33	-1.67	4.26
	700.00 °	697.27	-2.73	5.01
	800.00 °	795.34	-4.66	5.76

Calibrated and/or reported in accordance with one or more of the following specifications: ASTM E-207, E-220, E-230, E-644, ISO-10012, and ITS 90.

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ANAB Certified to ISO 14001:2004 — TÜVRheinland Precisely Right.

ANAB Certified to ISO 9001:2008 — TÜVRheinland Precisely Right.

Print Date: July 25, 2017

Report of Calibration

For: CYBERNETICS INC
FOR NM Inst of Mining & Tech
P.O. 2437

S.O. 211619

TRACEABILITY REPORT FOR
Report No. G735709

NIST Sensor:	S283106		
Calibrated on:	August 31, 2016	**Due on:**	August 31, 2017
Instrument:	HP34401A	**DMM #:**	85 7-31-16
Calibrated on:	July 31, 2016	**Due on:**	July 31, 2017
	Humidity: 40		% Nominal
	Ambient Temperature: 72° F		Nominal

Calibration Results and Traceability Approved by
Quality Technician

End Of Report

The expanded calibration uncertainty (k=2) is calculated to be 0.4° C from -196° to 0° C, 0.7° C from 0° to 260° C. and 1° C from 260° to 1093° C.
Calibrated in accordance with the following specifications: ASTM E-207, E-220, E-230, E-644, ISO-10012, and ITS 90.

C Experimental Plan

* Note: One page was set aside for the insertion of a *Job Hazard Analysis* when numbering the pages of this document. This document occupies three pages, creating a two-page discrepancy between nominal and actual page numbers from that point (p. 13) onward.

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TEST PLAN

LANL Glovebox Fire Suppression System Testing

TP-17-63

Client: LANL

Customer: NMT Mechanical Eng. Dept.
David Grow
575-835-5109
david.grow@nmt.edu

Authors: Drs. David Grow, Jamie Kimberley, Wesley Cook & Robert Abernathy

Fund: MBGE40 / MGBE45

2 August 2017

Test Plan

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1. Purpose

Various dry-chemical fire suppression systems are being considered for installation in gloveboxes (GB) and dropboxes (DB) at Los Alamos National Labs (LANL). They are typically engineered systems that are based on the volume of the enclosure, combustible material, air flow rate, etc. Fire tests will be performed to evaluate targeted fire suppression systems (FSS). The maximum airflow rate and minimum allowable working pressures for a working GB will be utilized as bounding criteria for fire tests to yield conservative guidelines relevant to fire test plans at LANL. This work builds on related prior work by this this group and their counterparts at LANL [1-3].

2. Test Overview/Summary:

Fire tests will evaluate dry chemical FSS performance only, and not the performance of any detection systems. Every reasonable effort will be made to make the test setup representative of GB/DB's at LANL. These tests will involve:

- An isolated air GB provided by LANL (Fig. 2).
- GB airflow and vacuum level set to match LANL-provided target values.
- FSS's installed according to manufacturer recommendations.
- Representative combustibles will be arranged within the GB.
- Repeatable initiation of fire using crib prepared according to UL 1975.
- Instrumentation to track timeline temperature, pressure, and airflow in GB during fire and FSS deployment.

Data obtained in these tests will be analyzed and presented to LANL in a final report. Regarding the question of whether the candidate dry-chemical FSS was able to "extinguish" the fire, the temperature data will be reviewed and a determination will be made according to the following definition provided by UL 300, Section 7.13.1 ([4]):

> Upon actuation, the fire shall be extinguished as evidenced by a sharp decrease in temperature and in no instance shall an increase in any temperature occur. Routine fluctuations in recording instruments are to be disregarded. Small residual flames shall self-extinguish with no additional application of extinguishing agent.

3. Location of Test:

The bulk of testing will be conducted at the Torres Compex, "2-Ton" bunker on the EMRTC campus (Fig. 1).

Figure 1. The "2-ton Bunker" near Torres Laboratory. This earth-covered site features a pair of rooms, divided by a robust wall. In the larger room (right) the GB is installed. The smaller room (left) will be exclusively occupied by personnel during testing, allowing safe, remote operation and observation of the experiment.

Figure 2. A steel LANL glove box used for experimentation is shown mounted onto a supporting frame. The box contains rectangular windows mounted to the glove box with steel frames, as well as open circular ports at the bottom, middle and top of the box for the

insertion of hypalon gloves. Open ports for the insertion of instrumentation are located along the bottom of the glove box, below the glove ports and between the windows.

4. Sequence of Steps / Procedures (see Attachment 4 for detailed checklist):

4.1. The GB will be cleaned and accessories (e.g. gloves, windows, and service panels) will be installed according to LANL standard practices. Among these practices, window fasteners will be torqued in a staggered pattern to 25 lb-in.

4.2. Air flow will be controlled using two electric fans in series installed along the exhaust path and monitored using a flow sensor installed along the inlet path. The GB will incorporate a fixed negative pressure differential of 1/4 - 3/4 inches of water column (inAq) and fixed airflow of 25-50 cubic feet per minute (cfm) by means of inlet and exhaust plumbing, directing the air through inlet and exhaust filters (Fig. 3).

4.3. Exhaust through the GB will travel through the ceiling via 8" flanged spool piece (provided by LANL) which will house an inline high-efficiency particulate air (HEPA) air filter, with a pressure transducers mounted downstream from the HEPA filter in existing ¾" national pipe thread (NPT) ports. Exhaust through the GB-attached volume will exit via 2" pipe with in-line ball valve. Pressure drop across this valve will be adjusted until it matches the pressure drop across the GB exhaust spool/filter, as measured by LANL-supplied analog pressure gauges.

4.4. Custom and original service panels will be used to route control, measurement, and FSS (as needed) lines into the GB. These junctions will be sealed by means of thread-seal tape and/or silicone caulk.

4.5. Air-flow, temperature, pressure, and IR sensors will be National Institute of Standards and Technology (NIST) traceable (Fig. 3). Thermocouples T_1, T_2, and T_3 will be mounted inside the GB along the centerline at the heights shown relative to windows & glove ports. GB vacuum level and pressure drop across the exhaust filter will be measured using differential pressure sensors as indicated in Figure 3.

4.6. As per the test matrix, the candidate FSS will be (installed in the GB as per manufacturer specifications) will be verified for readiness for use and connected to remote control lines. Further overlaying the requirements of UL 300 ([4]), installation shall take into consideration the following *Installation Criteria:*

4.6.1. Allow for both the maximum and minimum nozzle heights, with the nozzle positioned in the most difficult locations and orientations allowed by the installation instructions with respect to complying with the fire extinguishment requirements (see UL 300, Section 6.1.6).

4.6.2. To obtain the minimum discharge rate condition, an extinguishing system unit is to be assembled using its maximum piping limitations with respect to number of fittings and size and length of pipe. The cylinder is to be filled to its rated capacity and the cylinder or gas cartridge pressurized with the expellant gas to the normal operating pressure at 70°F (21°C). The cylinder or gas cartridge used for these tests is to be conditioned, after charging, for at least 16 hours at the minimum storage

temperature prior to the test. As an alternative to conditioning at the minimum storage temperature for 16 hours, extinguishing system units that utilize dry nitrogen or dry air as an expellant gas are to be tested by under pressurizing the cylinder or gas cartridge at ambient temperature to simulate the minimum operating temperature (see UL 300, Section 7.5.3).

4.6.3. Nozzles are to be placed at the most difficult location and orientation allowed by the installation instructions with respect to achieving extinguishment (see UL 300, Section 7.5.4).

4.6.4. An extinguishing system unit is to be tested using the maximum coverage limitations specified in the installation instructions (see UL 300, Section 7.6.4).

Given that the largest space to protect at LANL using candidate FSS(s) is a that of a large DB, Installation Criterion 4.6.4 will be interpreted to dictate that the largest relevant LANL DB geometry will be used in the experimental design.

4.7. Under the direction of the designated LANL representative present (hereafter "LANL rep"), quantities of flammable liquids limited to facilitate each test will be removed from their safe storage location and prepared for the test before incorporation into the GB (flammables cabinet in a structure approximately 100 feet from the GB bunker). This will ensure that no additional, stored flammable liquids will become involved in a fire event if the fire does escape the glovebox and facilitate adequate non-contaminated respiratory air for those transferring the flammable liquid or soaking down the cloth.

4.8. Also under the direction of the LANL rep, the following will be carefully arranged in the GB. Locations will be documented to allow repeatability:

- A GB container instrumented with thermocouples.
- A rack with expanded-metal mesh (see Section 6.2) with one or more pans atop it will be included in the GB. A total of approximately 20 one-gallon bags filled with rags soaked in a flammable liquid will be arranged on the rack, the pans, and/or on the GB floor.
- Other combustible items commonly found in GB's (e.g. lab wipes, hand tools, cheesecloth, wash bottles, and flammable liquids (acetone or isopropyl alcohol)).
- Igniters, in the form of heated nichrome wire coils, will be located in wooden cribs, prepared according to UL 1975 specifications and/or attached to other combustibles in the GB to dictate the initial fire behavior.
- Arrangement shall be verified to comply with UL 300, Section 6.1.13 ([4]):

  Appliances equipped with an attached moveable obstruction or fixed obstruction(s), such as a cover, shall be evaluated at worst case fixed obstruction locations in accordance with the applicable subsections of Section 6. The appliance model with an integral moveable obstruction or fixed obstruction(s) or the appliance model and the model of the device providing the obstruction with the corresponding appliance size shall be referenced in the manufacturer's installation instructions.

4.9. After setup is otherwise complete, the ignition power cord for the heater wire will be removed from the safety lockout and connected to the igniter wires. Immediately thereafter, all personnel will leave the bunker containing the GB and enter the adjacent bunker containing data acquisition, monitoring, and control hardware.

4.10. GB flow and pressure will be remotely verified. If not at target levels, testing will be halted until the ventilation system is corrected.

4.11. Data collection will begin and, upon the direction of both the LANL rep and Safety Officer, the fire started remotely by means of the igniter. Data collection shall include pressure, temperature, and airflow. Video will also be recorded (see Figure 3 for additional details).

4.12. In the event that there are no indications that the heater wires functioned:

4.12.1. All connections will be checked (control bunker only) and another attempt to heat the wire and initiate a fire will be made.

4.12.2. If there is still no indication that the wire functioned:

- A 20-minute wait time or until all temperature measurements in the GB drop below at least 60°F (34°C) below the observed auto ignition temperatures of combustibles within the GB (see UL 300, Section 6.1.2, [4]). Thereafter, permission for personnel to approach the test article will be requested from the safety officer. GB active ventilation shall continue throughout the wait time and thereafter.
- The power cable to the igniters will be removed and isolated in the safety lockout.
- The crib and igniter will be isolated from any flammables and inspected.

4.13. The fire will be monitored and when directed by the LANL rep, the FSS will be remotely deployed.

4.14. The LANL rep and Safety Officer will determine when the fire is extinguished. Thereafter, a 20-minute wait time or until all temperature measurements in the GB drop below at least 60°F (34°C) below the observed auto ignition temperatures of combustibles within the GB (see UL 300, Section 6.1.2, [4]).

4.15. Data collection will be stopped at the end of the cooldown period.

4.16. As necessary, smoke will be vented from the test bunker before entry. At the direction of the LANL rep and Safety Officer, personnel will be allowed to re-enter GB bunker.

5. Test Matrix:

Test #	Type of Test	Purpose	Instrumentation	Data Required
1	FSS	FSS, baseline	Provided [1]	NA

2	FSS	“	“	“
3	FSS	FSS, fire response	“	“
4	FSS	“	“	“

6. Construction:

6.1. The GB will be adapted for these experiments using the test stand as shown in Figure 3. The GB has an internal volume of 72 ft^3 (73” x 60” x 32.5”, narrowing to 26”, detailed geometry available upon request). An additional volume (19.7 ft^3) constructed of plywood and lumber attached to acheive a total volume equivalent (91.7ft^3) to that of a target DB at LANL. The attached volume will be connection by a 12” spool and diameter to match exit GB flange.

6.2. Design a rack with dimensions 4’ X 2’ constructed of a 2” X 2” angle steel frame with number 8 expanded metal grid standing 20” inches off the floor of the box. Appurtenances to the GB will be supported by wood frame construction.

6.3. A combination of LANL Standard GB Service panels and custom panels will be installed in the ceiling and walls panels to be able to easily install the variety of fire suppression systems to be evaluated (custom panels will be constructed of mild steel, 14-gauge (0.0747”) or thicker). Numerous authentic service panels are already installed. Gaskets and minimal use of silicone caulk will be used to ensure the system is as air-tight as possible. A custom hatch at the bottom of the GB will allow access for cleaning and placing fire test equipment and media into the GB.

6.4. The GB will be fitted with gloves and associated installation hardware by LANL technicians. Original glass windows will be installed in the original configuration with the exception of one type which will be used to as a blanking plate (additional detail below).

6.5. Install Fenwal "Detect-A-Fire", Model 27021-0 140°F and 190°F heat detectors in the thermal detector wells located in the GB ceiling.

6.6. Windows, gloves and/or glove aperture blanking plates to be affixed to the box per fittings supplied.

6.7. Install pressure transducers with pressure lines as indicated in Figure 3 to measure GB pressure relative to ambient and the pressure drop across the exhaust filter before during and after the fire test.

6.8. Install thermocouples at locations indicated in Figure 3 to measure temperature profile before during and after the fire test.

6.9. Install depth gauges in GB 19.7 ft^3 addition.

6.10. Install one glass observation window with removable internal blanking plate (soot and residue protection) to enable clear vision of GB interior and contents status for the duration of the fire test.

6.11. A custom igniter consisting of nichrome wire fabricated.

6.12. Install selected fire suppression system in GB.

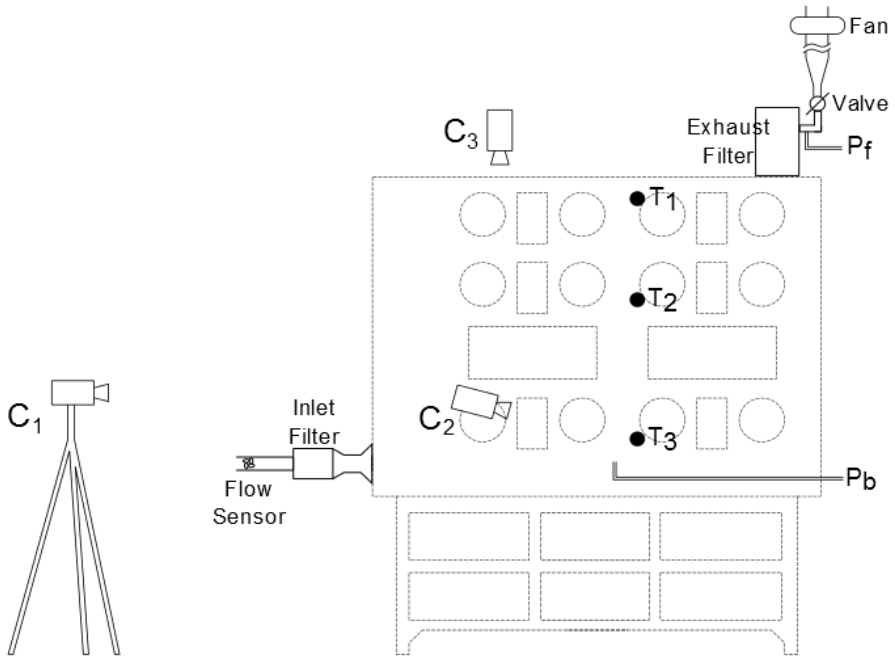

Figure 3. A schematic representation of the glovebox is given, where critical locations for sensors are indicated. One camera will be set back at a distance (C_1), providing an inclusive view of the GB for observing the overall response of the GB to fire and for safety purposes. The remaining cameras will be positioned exterior (just outside of side (C_2) and top (C_3) windows) to the GB providing video recording coverage of the full interior of the GB. Thermocouples are mounted off the side of the glove box interior at the top (T_1), middle (T_2) and bottom (T_3). Pressure gauges will measure the pressure differences across the inlet (P_b) and exhaust (P_f) filters.

7. Firing Detail Schematic:

Not applicable.

8. Energetic Materials:

8.1. Flammable liquids (acetone and isopropanol) will be limited to 500 mL total and stored in sealed container prior to ignition.

9. Instrumentation:

9.1. All instrumentation will be provided by the Robotic Interfaces Lab (Dr. Grow) and Dynamic Deformation and Failure Lab (Dr. Kimberley).

10. Specific Tools and Equipment:

10.1. Forklift

11. Documentation:

11.1. All information will be collected via transcription (written documentation).

12. Instructions for Spill Cleanup and Disposal of any Scrap and Waste A&E: (supplements Attachment 2)

12.1. Any Spilled material deemed unusable will be properly containerized, labeled and stored for later disposal in accordance with local policies and procedures.

13. Specific Hazards: (Include hazards in Safety Data Sheets (SDS))

13.1. See MSDS Forms in Attachment 5.

13.2. Flammable Liquids Safety:

13.2.1. Limit exposure to a minimum number of personnel, for a minimum amount of time, to the minimum amount of the hazardous material consistent with safe and efficient operations.

13.2.2. Personnel Limits – All non-essential personnel will be located in the personnel shelter during all operation involving the handling of energetic material unless prior approval has been granted from the Safety Office.

13.2.3. Explosive Limits – Flammable liquids will be stored in flammables cabinets and the volumes allowed in the GB bunker will be limited to those needed for a single test at any one time.

14. PPE Required:

14.1. Eye protection;

14.2. Work and heat-resistant gloves;

14.3. Splash goggles;

14.4. Lab coats;

14.5. Hardhats and

14.6. Eye-wash station.

15. Emergency Procedures:

General emergency procedures are listed in Attachment 2. Additional procedures specific to these experiments include:

15.1. <u>Acetone Spill</u>

15.1.1. Dilute with water and mop up, or absorb with an inert dry material and place in an appropriate waste disposal container.

15.1.2. Also see Attachment 5, Acetone, Section 6

15.2. <u>Isopropyl Alcohol Spill</u>

15.2.1. Small Spill: Dilute with water and mop up, or absorb with an inert dry material and place in an appropriate waste disposal container.

15.2.2. Large Spill: Flammable liquid. Keep away from heat. Keep away from sources of ignition. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not touch spilled material. Prevent entry into sewers, basements or confined areas; dike if needed. Be careful that the product is not present at a concentration level above TLV. Check TLV on the MSDS and with local authorities.

15.2.3. Also see Attachment 5, Alcohol, Section 6

16. Proposed Test Schedule:

16.1. Test Preparation – Undetermined but no later than 30 September 2017.

16.2. Testing – Undetermined but no later than 30 September 2017.

16.3. Post Test Operations – Undetermined but no later than 30 September 2017.

17. References:

1. D. Grow, J. Kimberley. Evaluation of Glovebox Fires Involving Flammable Liquids and Standard Glovebox Tools, final report, Los Alamos National Laboratory, September 29, 2016.
2. D. Grow, J. Kimberley, R. Lumia, and J. Wood. Glovebox Studies: Fire Suppression Experiments, final report, Los Alamos National Laboratory, October 20, 2015.
3. D. Grow, R. Lumia, and J. Wood. Water Intrusion Effects for Glovebox Gloves, final report, Los Alamos National Laboratory, September 24, 2014.
4. Underwriters Laboratories. Fire Testing of Fire Extinguishing Systems for Protection of Commercial Cooking Equipment. ANSI/UL 300:2005, rev. 2014. Northbrook, IL.
5. EMRTCR 101, Health and Safety
6. EMRTCR 102, Field Laboratory Safety
7. EMRTCR 103, Industrial Safety
8. EMRTCR 201, Grounding Procedures
9. EMRTCR 402, Emergency Action Plan
10. EMRTCR 403, Risk Management
11. EMRTCR 404, Hazardous Waste

18. Attachments:

1. Job Hazard Analysis
2. Safety and General Requirements
3. Site Closure Map
4. Test Checklist
5. Safety Data Sheets

Attachment 1

Job Hazard Analysis

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Job Hazard Analysis

Job Task Name:	LANL Glovebox Fire Studies	**Analysis Date:**	June 8, 2016
Work Area(s):	Torres Complex, 2-ton bunker	**Analysis Type:**	☒ Initial ☐ Re-Evaluation
Company Location:	Socorro, NM	**Next Review Date:**	
JHA Performed by:	David Grow	**Hazard Risk Rating:** (Enter Probability and Severity column and row in applicable block (i.e., D IV))	☒ Low ☐ High ☐ Medium ☐ Extremely High
Task Description:	Conduct fire tests to evaluate outcomes of fires in gloveboxes (GB's)		

Step Number: 1	**Step Description:** Setup	
Hazard Classification: ☐ Chemical ☒ Impact ☐ Explosion ☐ Mechanical ☐ Electrical ☐ Noise ☐ Ergonomic ☐ Radiation ☐ Excavation ☐ Struck Against/By ☐ Fall ☐ Temperature ☐ Fire/Heat ☐ Other ☐ Harmful Dust	**Hazard Description:** 1 - Bodily damage during use of standard hand and power tools during instrumentation setup.	**Safety Procedures:** 1 - Appropriate PPE will be worn; tripping hazards will be minimized; scaffolding will be used to allow safe access to high work points.

Step Number: 2	**Step Description:** Testing	
Hazard Classification: ☒ Chemical ☐ Impact ☒ Explosion ☐ Mechanical ☐ Electrical ☐ Noise ☐ Ergonomic ☐ Radiation ☐ Excavation ☐ Struck Against/By ☐ Fall ☐ Temperature ☒ Fire/Heat ☐ Other ☐ Harmful Dust	**Hazard Description:** 1 - Bodily damage (skin and lungs) caused by contact with Acetone. 2 - Bodily damage caused by unexpected ignition/explosion of flammable liquids. 3 - Smoke inhalation after fire upon bunker re-entry.	**Safety Procedures:** 1 - Appropriate PPE will be worn (chemical-resistant gloves, respirator masks, aprons); flammables stored in chemical storage cabinet. 2 - All non-essential personnel will be located in the personnel shelter during hazardous operations. 3 - Vent bunker, as needed, with fans.

Step Number: 3	Step Description: Post Test	
Hazard Classification: ☐ Chemical ☒ Impact ☐ Explosion ☐ Mechanical ☐ Electrical ☐ Noise ☐ Ergonomic ☐ Radiation ☐ Excavation ☐ Struck Against/By ☒ Fall ☐ Temperature ☐ Fire/Heat ☐ Other ☐ Harmful Dust	**Hazard Description:** 1 - Bodily damage during use of standard hand and power tools during removal and storage of instrumentation.	**Safety Procedures:** 1 - Appropriate PPE will be worn; tripping hazards will be minimized; scaffolding will be used to allow safe access to high work points.

Step Number:	Step Description:	
Hazard Classification: ☐ Chemical ☐ Impact ☐ Explosion ☐ Mechanical ☐ Electrical ☐ Noise ☐ Ergonomic ☐ Radiation ☐ Excavation ☐ Struck Against/By ☐ Fall ☐ Temperature ☐ Fire/Heat ☐ Other ☐ Harmful Dust	**Hazard Description:**	**Safety Procedures:**

Step Number:	Step Description:	
Hazard Classification: ☐ Chemical ☐ Impact ☐ Explosion ☐ Mechanical ☐ Electrical ☐ Noise ☐ Ergonomic ☐ Radiation ☐ Excavation ☐ Struck Against/By ☐ Fall ☐ Temperature ☐ Fire/Heat ☐ Other ☐ Harmful Dust	**Hazard Description:**	**Safety Procedures:**

Risk Assessment Matrix

Severity / Effects of Hazard			Probability: Frequency of Occurrence Over Time				
			A **Frequent** (Continuously experienced)	B **Likely** (Will occur frequently)	C **Occasional** (Will occur several times)	D **Seldom** (Unlikely, can be expected to occur)	E **Unlikely** (Improbable, not possible to occur)
Severity / Effects of Hazard	I	**Catastrophic** (Death, loss of asset or capability)	EH	EH	H	H	M
	II	**Critical** (Severe injury or damage, significantly degraded capability)	EH	H	H	M	L
	III	**Moderate** (Minor injury or damage, degraded capability)	H	M	M	L	L
	IV	**Negligible** (Minimal injury or damage, no impact to capability)	M	L	L	L	L
			EH = Extremely High H = High M = Medium L = Low				

Attachment 2

Safety and General Requirements

Fire Sets:

- The fire set will have a positive interlock (e.g., key/shorting device) which will prevent the inadvertent firing of the system when removed.
- The Ordnance Technician/Gunner will keep the key/shorting device in their possession at all times.
- No duplicate keys or shorting devices will be allowed on site at any time.

Hazardous Waste:

- The use, recovery, collection, transport, and storage of military munitions for Research, Development, Testing and Evaluation (RDT&E) (e.g. safety, developmental testing, surveillance function testing, static fire, or quality control or assurance testing) is considered use for intended purpose and not subject to regulation under Resource Conservation and Recovery Act (RCRA). (Military Munitions Rule (MMR) paragraph 3.B.2.b.)
- As long as all excess energetic material is destroyed on site, and not removed from the test range, it is not considered waste and does not fall under RCRA. (MMR paragraph 10.C.3.)
- Any spilled loose material will be completely gathered up and determined if the material is still usable.
- If the material is still usable, it is not considered waste and should be used or stored as applicable.
- Spilled material deemed unusable will be properly containerized, labeled and stored for later disposal in accordance with local policies and procedures.

Misfire Procedures:

- If there are no indications that the detonator, ignitor, etc., initiated, all connections will be checked (in the bunker or personnel shelter only) to ensure they are connected correctly. If instrumentation does not need to be reset, then another attempt to fire may be made. The engineer/test manager will be consulted prior to attempting to fire again.
- If there is still no indication that the detonator or igniter initiated, begin the applicable wait time as stated below:
    - All electric misfires will include a 15-minute wait time before personnel are permitted to approach the test article, unless determined to be otherwise.
    - All non-electric misfires will include a 30-minute wait time before personnel are permitted to approach the test article, unless determined to be otherwise.
- During the wait time, the engineer/test manager and the ordnance technician will contact the Ordnance Supervisor and Safety Officer, or their designated representatives, to inform them of the misfire and to discuss troubleshooting options.

Emergency Procedures:

- Lightning: (reference procedures in EMRTCR 104)
- Fire:
  - If there is a fire on or near the test pad, all personnel will evacuate to the personnel shelter immediately (or further depending on the severity of the fire) and the safety office will be notified.

WARNING

Personnel WILL NOT fight a fire that could have any remote possibility of involving explosives.

WARNING

Personnel WILL NOT fight a fire that is located off of the test pad. There is a strong possibility of unexploded ordnance being present off of the test pad.

- Unexpected Explosion:
  - All personnel will immediately assemble at the personnel shelter (or other previously identified location) and all personnel accounted for;
  - All personnel will be checked for possible injuries, first aid applied as needed, and the area inspected for remaining hazards by ordnance personnel;
  - Emergency Medical Services will be called for assistance, if needed;
  - The safety office will then be notified immediately.

WARNING

If an explosion involves the Ordnance Technician (or any other personnel) on the test pad, personnel in the personnel shelter must make a determination whether or not it is safe to attempt to treat or assist the individual on the test pad.

Personnel and AA&E Limits:

- Limit exposure to a minimum number of personnel, for a minimum amount of time, to the minimum amount of the hazardous material consistent with safe and efficient operations.
- Personnel Limits – All non-essential personnel will be located in the personnel shelter during all operation involving the handling of energetic material unless prior approval has been granted from the Safety Office.
- Explosive Limits – Only explosives needed for a single test will be allowed on the test pad at any one time.

Indicators for Identifying Abnormal Process Conditions: (applies only to in-process operations)

Attachment 3

Site Closure Map

Local clearance, close gate and clear Torres Firing Pad

Attachment 4

Test Checklist

Test Checklist

Test ID: Date: Time:

Pre-test		
1. LANL personnel inspect gloves for damage & proper installation		
2. LANL personnel install gloves as needed		
3. Replace exhaust filter		
4. Inspect inlet filter, replace as needed		
5. Replace FSS, as needed		
6. Place consumables on floor and/or metal rack of glove box	Amount	
A. Alcohol-soaked cheesecloth in zippered bag (weight dry: weight w/ liquid:)		
B. Metal rack		
C. Screwdrivers		
D. Hammers/Mallets		
E. Horsehair brush		
F. Leather gloves		
G. Kim wipes		
H. Cotton rounds		
I. Sandpaper		
J. Poly bottles		
K. Other:		
L. Other:		
M. Other:		
7. Place and secure igniter nichrome wire to ignition point		
8. Ensure thermocouples (TC's) in prescribed locations		
9. Seal glove box		

10. Ensure gloves are out of box and secured (tied or clamped)	
11. Ensure camera stands and cameras are secured/clamped	
12. Adjust blower speed and ball valves to obtain target flow rate	
13. Adjust pressure drop across GB addition with ball valve to matches the pressure drop across the GB exhaust spool/filter	
14. Record Flowrate and pressure readings from Magnehelic gauges	
15. Ensure live collection from sensors	
Upper TC	
Mid TC	
Lower TC	
GB pressure 1	
GB pressure 2	
Filter pressure 1	
Filter pressure 2	
Fenwal Detect-a-fire	
16. Ensure cameras are on and focused	
Glovebox top view	
Glovebox side view	
Glovebox IR camera	
Site/safety view	
17. Connect external FSS cabling	
18. Obtain approval from LANL quality assurance engineer	
19. Record ambient temperature and relative humidity	
20. Set new test name on flowmeter	
21. Begin recording of flow data and set time zero	
Synchronize with hand timer by audible 3-2-1 countdown	

Turning on glove box lights, also sync'd to countdown	
22. All personnel must enter safety bunker	
23. Obtain approval from LANL quality assurance engineer	
24. Verify all preceding items are checked	
25. Begin recording of data on DAQ, note stopwatch time	
Test	
26. Active set of ignitors	
27. Note time when combustion begins	
27. Note time when glove deterioration evident	
28. Monitor fire - wait for for self-extinguish until directed to deploy FSS	
29. Visually determine when the fire is extinguished and note time	
30. Wait for the fire to be visibly extinguished GB and until either 20 minutes have lapsed or temps drop at least 60°F (34°C) below observed auto ignition temperatures of combustibles	
31. Stop data collection and save data files	
32. Safety officer will clear personnel to leave bunker	
Post Test	
33. Verify Pressure sensors are still operational by comparing to magnehelic	
34. Open glove box	
35. Verify TC's are functioning by comparing after GB begins to cool	
36. Photograph glove box interior	
37. Wearing appropriate PPE, collect samples of residual materials	
38. Wearing appropriate PPE, clean GB floor	
39. Remove spent FSS canister, as needed.	

Attachment 5

Safety Data Sheets

ScienceLab.com
Chemicals & Laboratory Equipment

Health	2
Fire	3
Reactivity	0
Personal Protection	H

Material Safety Data Sheet
Acetone MSDS

Section 1: Chemical Product and Company Identification

Product Name: Acetone

Catalog Codes: SLA3502, SLA1645, SLA3151, SLA3808

CAS#: 67-64-1

RTECS: AL3150000

TSCA: TSCA 8(b) inventory: Acetone

CI#: Not applicable.

Synonym: 2-propanone; Dimethyl Ketone; Dimethylformaldehyde; Pyroacetic Acid

Chemical Name: Acetone

Chemical Formula: C3-H6-O

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call: 1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Acetone	67-64-1	100

Toxicological Data on Ingredients: Acetone: ORAL (LD50): Acute: 5800 mg/kg [Rat]. 3000 mg/kg [Mouse]. 5340 mg/kg [Rabbit]. VAPOR (LC50): Acute: 50100 mg/m 8 hours [Rat]. 44000 mg/m 4 hours [Mouse].

Section 3: Hazards Identification

Potential Acute Health Effects:
Hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation. Slightly hazardous in case of skin contact (permeator).

Potential Chronic Health Effects:
CARCINOGENIC EFFECTS: A4 (Not classifiable for human or animal.) by ACGIH. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Classified Reproductive system/toxin/female, Reproductive system/toxin/male [SUSPECTED]. The substance is toxic to central nervous system (CNS). The substance may be toxic to kidneys, the reproductive system, liver, skin. Repeated or prolonged exposure to the substance can produce target organs damage.

Section 4: First Aid Measures

Eye Contact:
Check for and remove any contact lenses. Immediately flush eyes with running water for at least 15 minutes, keeping eyelids open. Cold water may be used. Get medical attention.

Skin Contact:
In case of contact, immediately flush skin with plenty of water. Cover the irritated skin with an emollient. Remove contaminated clothing and shoes. Cold water may be used.Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention.

Serious Skin Contact:
Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek medical attention.

Inhalation:
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention if symptoms appear.

Serious Inhalation:
Evacuate the victim to a safe area as soon as possible. Loosen tight clothing such as a collar, tie, belt or waistband. If breathing is difficult, administer oxygen. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek medical attention.

Ingestion:
Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention if symptoms appear.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: Flammable.

Auto-Ignition Temperature: 465°C (869°F)

Flash Points: CLOSED CUP: -20°C (-4°F). OPEN CUP: -9°C (15.8°F) (Cleveland).

Flammable Limits: LOWER: 2.6% UPPER: 12.8%

Products of Combustion: These products are carbon oxides (CO, CO2).

Fire Hazards in Presence of Various Substances: Highly flammable in presence of open flames and sparks, of heat.

Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available. Slightly explosive in presence of open flames and sparks, of oxidizing materials, of acids.

Fire Fighting Media and Instructions:
Flammable liquid, soluble or dispersed in water. SMALL FIRE: Use DRY chemical powder. LARGE FIRE: Use alcohol foam, water spray or fog.

Special Remarks on Fire Hazards: Vapor may travel considerable distance to source of ignition and flash back.

Special Remarks on Explosion Hazards:
Forms explosive mixtures with hydrogen peroxide, acetic acid, nitric acid, nitric acid + sulfuric acid, chromic anydride, chromyl chloride, nitrosyl chloride, hexachloromelamine, nitrosyl perchlorate, nitryl perchlorate, permonosulfuric acid, thiodiglycol + hydrogen peroxide, potassium ter-butoxide, sulfur dichloride, 1-methyl-1,3-butadiene, bromoform, carbon, air, chloroform, thitriazylperchlorate.

Section 6: Accidental Release Measures

Small Spill:
Dilute with water and mop up, or absorb with an inert dry material and place in an appropriate waste disposal container.

Large Spill:
Flammable liquid. Keep away from heat. Keep away from sources of ignition. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not touch spilled material. Prevent entry into sewers, basements or confined areas; dike if needed. Be careful that the product is not present at a concentration level above TLV. Check TLV on the MSDS and with local authorities.

Section 7: Handling and Storage

Precautions:
Keep locked up.. Keep away from heat. Keep away from sources of ignition. Ground all equipment containing material. Do not ingest. Do not breathe gas/fumes/ vapor/spray. Wear suitable protective clothing. In case of insufficient ventilation, wear suitable respiratory equipment. If ingested, seek medical advice immediately and show the container or the label. Avoid contact with skin and eyes. Keep away from incompatibles such as oxidizing agents, reducing agents, acids, alkalis.

Storage:
Store in a segregated and approved area (flammables area) . Keep container in a cool, well-ventilated area. Keep container tightly closed and sealed until ready for use. Keep away from direct sunlight and heat and avoid all possible sources of ignition (spark or flame).

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective threshold limit value. Ensure that eyewash stations and safety showers are proximal to the work-station location.

Personal Protection:
Splash goggles. Lab coat. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Vapor respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits:
TWA: 500 STEL: 750 (ppm) from ACGIH (TLV) [United States] TWA: 750 STEL: 1000 (ppm) from OSHA (PEL) [United States] TWA: 500 STEL: 1000 [Austalia] TWA: 1185 STEL: 2375 (mg/m3) [Australia] TWA: 750 STEL: 1500 (ppm) [United Kingdom (UK)] TWA: 1810 STEL: 3620 (mg/m3) [United Kingdom (UK)] TWA: 1800 STEL: 2400 from OSHA (PEL) [United States]Consult local authorities for acceptable exposure limits.

Section 9: Physical and Chemical Properties

Physical state and appearance: Liquid.

Odor: Fruity. Mint-like. Fragrant. Ethereal

Taste: Pungent, Sweetish

Molecular Weight: 58.08 g/mole

Color: Colorless. Clear

pH (1% soln/water): Not available.

Boiling Point: 56.2°C (133.2°F)

Melting Point: -95.35 (-139.6°F)

Critical Temperature: 235°C (455°F)

Specific Gravity: 0.79 (Water = 1)

Vapor Pressure: 24 kPa (@ 20°C)

Vapor Density: 2 (Air = 1)

Volatility: Not available.

Odor Threshold: 62 ppm

Water/Oil Dist. Coeff.: The product is more soluble in water; log(oil/water) = -0.2

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water.

Solubility: Easily soluble in cold water, hot water.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Excess heat, ignition sources, exposure to moisture, air, or water, incompatible materials.

Incompatibility with various substances: Reactive with oxidizing agents, reducing agents, acids, alkalis.

Corrosivity: Non-corrosive in presence of glass.

Special Remarks on Reactivity: Not available.

Special Remarks on Corrosivity: Not available.

Polymerization: Will not occur.

Section 11: Toxicological Information

Routes of Entry: Absorbed through skin. Dermal contact. Eye contact. Inhalation.

Toxicity to Animals:
WARNING: THE LC50 VALUES HEREUNDER ARE ESTIMATED ON THE BASIS OF A 4-HOUR EXPOSURE. Acute oral toxicity (LD50): 3000 mg/kg [Mouse]. Acute toxicity of the vapor (LC50): 44000 mg/m3 4 hours [Mouse].

Chronic Effects on Humans:
CARCINOGENIC EFFECTS: A4 (Not classifiable for human or animal.) by ACGIH. DEVELOPMENTAL TOXICITY: Classified Reproductive system/toxin/female, Reproductive system/toxin/male [SUSPECTED]. Causes damage to the following organs: central nervous system (CNS). May cause damage to the following organs: kidneys, the reproductive system, liver, skin.

Other Toxic Effects on Humans:
Hazardous in case of skin contact (irritant), of ingestion, of inhalation. Slightly hazardous in case of skin contact (permeator).

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans:
May affect genetic material (mutagenicity) based on studies with yeast (S. cerevisiae), bacteria, and hamster fibroblast cells. May cause reproductive effects (fertility) based upon animal studies. May contain trace amounts of benzene and formaldehyde which may cancer and birth defects. Human: passes the placental barrier.

Special Remarks on other Toxic Effects on Humans:
Acute Potential Health Effects: Skin: May cause skin irritation. May be harmful if absorbed through the skin. Eyes: Causes eye irritation, characterized by a burning sensation, redness, tearing, inflammation, and possible corneal injury. Inhalation: Inhalation at high concentrations affects the sense organs, brain and causes respiratory tract irritation. It also may affect the Central Nervous System (behavior) characterized by dizzness, drowsiness, confusion, headache, muscle weakeness, and possibly motor incoordination, speech abnormalities, narcotic effects and coma. Inhalation may also affect the gastrointestinal tract (nausea, vomiting). Ingestion: May cause irritation of the digestive (gastrointestinal) tract (nausea, vomiting). It may also

affect the Central Nevous System (behavior), characterized by depression, fatigue, excitement, stupor, coma, headache, altered sleep time, ataxia, tremors as well at the blood, liver, and urinary system (kidney, bladder, ureter) and endocrine system. May also have musculoskeletal effects. Chronic Potential Health Effects: Skin: May cause dermatitis. Eyes: Eye irritation.

Section 12: Ecological Information

Ecotoxicity:
Ecotoxicity in water (LC50): 5540 mg/l 96 hours [Trout]. 8300 mg/l 96 hours [Bluegill]. 7500 mg/l 96 hours [Fatthead Minnow]. 0.1 ppm any hours [Water flea].

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The product itself and its products of degradation are not toxic.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:
Waste must be disposed of in accordance with federal, state and local environmental control regulations.

Section 14: Transport Information

DOT Classification: CLASS 3: Flammable liquid.

Identification: : Acetone UNNA: 1090 PG: II

Special Provisions for Transport: Not available.

Section 15: Other Regulatory Information

Federal and State Regulations:
California prop. 65: This product contains the following ingredients for which the State of California has found to cause reproductive harm (male) which would require a warning under the statute: Benzene California prop. 65: This product contains the following ingredients for which the State of California has found to cause birth defects which would require a warning under the statute: Benzene California prop. 65: This product contains the following ingredients for which the State of California has found to cause cancer which would require a warning under the statute: Benzene, Formaldehyde Connecticut hazardous material survey.: Acetone Illinois toxic substances disclosure to employee act: Acetone Illinois chemical safety act: Acetone New York release reporting list: Acetone Rhode Island RTK hazardous substances: Acetone Pennsylvania RTK: Acetone Florida: Acetone Minnesota: Acetone Massachusetts RTK: Acetone Massachusetts spill list: Acetone New Jersey: Acetone New Jersey spill list: Acetone Louisiana spill reporting: Acetone California List of Hazardous Substances (8 CCR 339): Acetone TSCA 8(b) inventory: Acetone TSCA 4(a) final test rules: Acetone TSCA 8(a) IUR: Acetone

Other Regulations:
OSHA: Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200). EINECS: This product is on the European Inventory of Existing Commercial Chemical Substances.

Other Classifications:

WHMIS (Canada):
CLASS B-2: Flammable liquid with a flash point lower than 37.8°C (100°F). CLASS D-2B: Material causing other toxic effects (TOXIC).

DSCL (EEC):
R11- Highly flammable. R36- Irritating to eyes. S9- Keep container in a well-ventilated place. S16- Keep away from sources of ignition - No smoking. S26- In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.

HMIS (U.S.A.):

Health Hazard: 2

Fire Hazard: 3

Reactivity: 0

Personal Protection: h

National Fire Protection Association (U.S.A.):

Health: 1

Flammability: 3

Reactivity: 0

Specific hazard:

Protective Equipment:
Gloves. Lab coat. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Wear appropriate respirator when ventilation is inadequate. Splash goggles.

Section 16: Other Information

References:
-Material safety data sheet issued by: la Commission de la SantÃ© et de la SÃ©curitÃ© du Travail du QuÃ©bec. -The Sigma-Aldrich Library of Chemical Safety Data, Edition II. -Hawley, G.G.. The Condensed Chemical Dictionary, 11e ed., New York N.Y., Van Nostrand Reinold, 1987. LOLI, RTECS, HSDB databases. Other MSDSs

Other Special Considerations: Not available.

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Last Updated: 05/21/2013 12:00 PM

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Material Safety Data Sheet
Isopropyl alcohol MSDS

Section 1: Chemical Product and Company Identification

Product Name: Isopropyl alcohol

Catalog Codes: SLI1153, SLI1579, SLI1906, SLI1246, SLI1432

CAS#: 67-63-0

RTECS: NT8050000

TSCA: TSCA 8(b) inventory: Isopropyl alcohol

CI#: Not available.

Synonym: 2-Propanol

Chemical Name: isopropanol

Chemical Formula: C3-H8-O

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call: 1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Isopropyl alcohol	67-63-0	100

Toxicological Data on Ingredients: Isopropyl alcohol: ORAL (LD50): Acute: 5045 mg/kg [Rat]. 3600 mg/kg [Mouse]. 6410 mg/kg [Rabbit]. DERMAL (LD50): Acute: 12800 mg/kg [Rabbit].

Section 3: Hazards Identification

Potential Acute Health Effects:
Hazardous in case of eye contact (irritant), of ingestion, of inhalation. Slightly hazardous in case of skin contact (irritant, sensitizer, permeator).

Potential Chronic Health Effects:
Slightly hazardous in case of skin contact (sensitizer). CARCINOGENIC EFFECTS: A4 (Not classifiable for human or animal.) by ACGIH, 3 (Not classifiable for human.) by IARC. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Classified Reproductive system/toxin/female, Development toxin [POSSIBLE]. The substance may be toxic to kidneys, liver, skin, central nervous system (CNS). Repeated or prolonged exposure to the substance can produce target organs damage.

Section 4: First Aid Measures

Eye Contact:
Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Cold water may be used. Get medical attention.

Skin Contact:
Wash with soap and water. Cover the irritated skin with an emollient. Get medical attention if irritation develops. Cold water may be used.

Serious Skin Contact: Not available.

Inhalation:
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention if symptoms appear.

Serious Inhalation:
Evacuate the victim to a safe area as soon as possible. Loosen tight clothing such as a collar, tie, belt or waistband. If breathing is difficult, administer oxygen. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek medical attention.

Ingestion:
Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention if symptoms appear.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: Flammable.

Auto-Ignition Temperature: 399°C (750.2°F)

Flash Points: CLOSED CUP: 11.667°C (53°F) - 12.778 deg. C (55 deg. F) (TAG)

Flammable Limits: LOWER: 2% UPPER: 12.7%

Products of Combustion: These products are carbon oxides (CO, CO2).

Fire Hazards in Presence of Various Substances:
Highly flammable in presence of open flames and sparks, of heat. Flammable in presence of oxidizing materials. Non-flammable in presence of shocks.

Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available. Explosive in presence of open flames and sparks, of heat.

Fire Fighting Media and Instructions:
Flammable liquid, soluble or dispersed in water. SMALL FIRE: Use DRY chemical powder. LARGE FIRE: Use alcohol foam, water spray or fog.

Special Remarks on Fire Hazards:
Vapor may travel considerable distance to source of ignition and flash back. CAUTION: MAY BURN WITH NEAR INVISIBLE FLAME. Hydrogen peroxide sharply reduces the autoignition temperature of Isopropyl alcohol. After a delay, Isopropyl alcohol ignites on contact with dioxgenyl tetrafluorborate, chromium trioxide, and potassium tert-butoxide. When heated to decomposition it emits acrid smoke and fumes.

Special Remarks on Explosion Hazards:
Secondary alcohols are readily autooxidized in contact with oxygen or air, forming ketones and hydrogen peroxide. It can become potentially explosive. It reacts with oxygen to form dangerously unstable peroxides which can concentrate and explode during distillation or evaporation. The presence of 2-butanone increases the reaction rate for peroxide formation. Explosive in the form of vapor when exposed to heat or flame. May form explosive mixtures with air. Isopropyl alcohol + phosgene forms isopropyl chloroformate and hydrogen chloride. In the presence of iron salts, thermal decompositon can occur, whicn in some cases can become explosive. A homogeneous mixture of concentrated peroxides + isopropyl alcohol are capable of detonation by shock or heat. Barium perchlorate + isopropyl alcohol gives the highly explosive alkyl perchlorates.

It forms explosive mixtures with trinitromethane and hydrogen peroxide. It produces a violent explosive reaction when heated with aluminum isopropoxide + crotonaldehyde. Mixtures of isopropyl alcohol + nitroform are explosive.

Section 6: Accidental Release Measures

Small Spill:
Dilute with water and mop up, or absorb with an inert dry material and place in an appropriate waste disposal container.

Large Spill:
Flammable liquid. Keep away from heat. Keep away from sources of ignition. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not touch spilled material. Prevent entry into sewers, basements or confined areas; dike if needed. Be careful that the product is not present at a concentration level above TLV. Check TLV on the MSDS and with local authorities.

Section 7: Handling and Storage

Precautions:
Keep away from heat. Keep away from sources of ignition. Ground all equipment containing material. Do not ingest. Do not breathe gas/fumes/ vapor/spray. Avoid contact with eyes. Wear suitable protective clothing. In case of insufficient ventilation, wear suitable respiratory equipment. If ingested, seek medical advice immediately and show the container or the label. Keep away from incompatibles such as oxidizing agents, acids.

Storage:
Store in a segregated and approved area. Keep container in a cool, well-ventilated area. Keep container tightly closed and sealed until ready for use. Avoid all possible sources of ignition (spark or flame).

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective threshold limit value. Ensure that eyewash stations and safety showers are proximal to the work-station location.

Personal Protection:
Splash goggles. Lab coat. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Vapor respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits:
TWA: 983 STEL: 1230 (mg/m3) [Australia] TWA: 200 STEL: 400 (ppm) from ACGIH (TLV) [United States] [1999] TWA: 980 STEL: 1225 (mg/m3) from NIOSH TWA: 400 STEL: 500 (ppm) from NIOSH TWA: 400 STEL: 500 (ppm) [United Kingdom (UK)] TWA: 999 STEL: 1259 (mg/m3) [United Kingdom (UK)] TWA: 400 STEL: 500 (ppm) from OSHA (PEL) [United States] TWA: 980 STEL: 1225 (mg/m3) from OSHA (PEL) [United States]Consult local authorities for acceptable exposure limits.

Section 9: Physical and Chemical Properties

Physical state and appearance: Liquid.

Odor:
Pleasant. Odor resembling that of a mixture of ethanol and acetone.

Taste: Bitter. (Slight.)

Molecular Weight: 60.1 g/mole

Color: Colorless.

pH (1% soln/water): Not available.

Boiling Point: 82.5°C (180.5°F)

Melting Point: -88.5°C (-127.3°F)

Critical Temperature: 235°C (455°F)

Specific Gravity: 0.78505 (Water = 1)

Vapor Pressure: 4.4 kPa (@ 20°C)

Vapor Density: 2.07 (Air = 1)

Volatility: Not available.

Odor Threshold:
22 ppm (Sittig, 1991) 700 ppm for unadapted panelists (Verschuren, 1983).

Water/Oil Dist. Coeff.: The product is equally soluble in oil and water; log(oil/water) = 0.1

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water, methanol, diethyl ether, n-octanol, acetone.

Solubility:
Easily soluble in cold water, hot water, methanol, diethyl ether, n-octanol, acetone. Insoluble in salt solution. Soluble in benzene. Miscible with most organic solvents including alcohol, ethyl alcohol, chloroform.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Heat, Ignition sources, incompatible materials

Incompatibility with various substances: Reactive with oxidizing agents, acids, alkalis.

Corrosivity: Non-corrosive in presence of glass.

Special Remarks on Reactivity:
Reacts violently with hydrogen + palladium combination, nitroform, oleum, COCl2, aluminum triisopropoxide, oxidants Incompatible with acetaldehyde, chlorine, ethylene oxide, isocyanates, acids, alkaline earth, alkali metals, caustics, amines, crotonaldehyde, phosgene, ammonia. Isopropyl alcohol reacts with metallic aluminum at high temperatures. Isopropyl alcohol attacks some plastics, rubber, and coatings. Vigorous reaction with sodium dichromate + sulfuric acid.

Special Remarks on Corrosivity: May attack some forms of plastic, rubber and coating

Polymerization: Will not occur.

Section 11: Toxicological Information

Routes of Entry: Absorbed through skin. Dermal contact. Eye contact. Inhalation.

Toxicity to Animals:
WARNING: THE LC50 VALUES HEREUNDER ARE ESTIMATED ON THE BASIS OF A 4-HOUR EXPOSURE. Acute oral toxicity (LD50): 3600 mg/kg [Mouse]. Acute dermal toxicity (LD50): 12800 mg/kg [Rabbit]. Acute toxicity of the vapor (LC50): 16000 8 hours [Rat].

Chronic Effects on Humans:
CARCINOGENIC EFFECTS: A4 (Not classifiable for human or animal.) by ACGIH, 3 (Not classifiable for human.) by IARC. DEVELOPMENTAL TOXICITY: Classified Reproductive system/toxin/female, Development toxin [POSSIBLE]. May cause damage to the following organs: kidneys, liver, skin, central nervous system (CNS).

Other Toxic Effects on Humans:
Hazardous in case of ingestion, of inhalation. Slightly hazardous in case of skin contact (irritant, sensitizer, permeator).

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans:
May cause adverse reproductive/teratogenic effects (fertility, fetoxicity, developmental abnormalities(developmental toxin)) based on animal studies. Detected in maternal milk in human.

Special Remarks on other Toxic Effects on Humans:
Acute Potential Health Effects: Skin: May cause mild skin irritation, and sensitization. Eyes: Can cause eye irritation. Inhalation: Breathing in small amounts of this material during normal handling is not likely to cause harmful effects. However, breathing large amounts may be harmful and may affect the respiratory system and mucous membranes (irritation), behavior and brain (Central nervous system depression - headache, dizziness, drowsiness, stupor, incoordination, unconciousness, coma and possible death), peripheral nerve and senstation, blood, urinary system, and liver. Ingestion: Swallowing small amouts during normal handling is not likely to cause harmful effects. Swallowing large amounts may be harmful. Swallowing large amounts may cause gastrointestinal tract irritation with nausea, vomiting and diarrhea, abdominal pain. It also may affect the urinary system, cardiovascular system, sense organs, behavior or central nervous system (somnolence, generally depressed activity, irritability, headache, dizziness, drowsiness), liver, and respiratory system (breathing difficulty). Chronic Potential Health Effects: May cause defatting of the skin and dermatitis and allergic reaction. May cause adverse reproductive effects based on animal data (studies).

Section 12: Ecological Information

Ecotoxicity: Ecotoxicity in water (LC50): 100000 mg/l 96 hours [Fathead Minnow]. 64000 mg/l 96 hours [Fathead Minnow].

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The product itself and its products of degradation are not toxic.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:
Waste must be disposed of in accordance with federal, state and local environmental control regulations.

Section 14: Transport Information

DOT Classification: CLASS 3: Flammable liquid.

Identification: : Isopropyl Alcohol UNNA: 1219 PG: II

Special Provisions for Transport: Not available.

Section 15: Other Regulatory Information

Federal and State Regulations:
Connecticut hazardous material survey.: Isopropyl alcohol Illinois toxic substances disclosure to employee act: Isopropyl alcohol Rhode Island RTK hazardous substances: Isopropyl alcohol Pennsylvania RTK: Isopropyl alcohol Florida: Isopropyl alcohol Minnesota: Isopropyl alcohol Massachusetts RTK: Isopropyl alcohol New Jersey: Isopropyl alcohol New Jersey spill list: Isopropyl alcohol Director's list of Hazardous Substances: Isopropyl alcohol Tennesee: Isopropyl alcohol TSCA 8(b) inventory: Isopropyl alcohol TSCA 4(a) final testing order: Isopropyl alcohol TSCA 8(a) IUR: Isopropyl alcohol TSCA 8(d) H

and S data reporting: Isopropyl alcohol: Effective date: 12/15/86 Sunset Date: 12/15/96 TSCA 12(b) one time export: Isopropyl alcohol SARA 313 toxic chemical notification and release reporting: Isopropyl alcohol

Other Regulations:
OSHA: Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200). EINECS: This product is on the European Inventory of Existing Commercial Chemical Substances.

Other Classifications:

WHMIS (Canada):
CLASS B-2: Flammable liquid with a flash point lower than 37.8°C (100°F). CLASS D-2B: Material causing other toxic effects (TOXIC).

DSCL (EEC):
R11- Highly flammable. R36- Irritating to eyes. S7- Keep container tightly closed. S16- Keep away from sources of ignition - No smoking. S24/25- Avoid contact with skin and eyes. S26- In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.

HMIS (U.S.A.):

Health Hazard: 2

Fire Hazard: 3

Reactivity: 0

Personal Protection: h

National Fire Protection Association (U.S.A.):

Health: 1

Flammability: 3

Reactivity: 0

Specific hazard:

Protective Equipment:
Gloves. Lab coat. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Wear appropriate respirator when ventilation is inadequate. Splash goggles.

Section 16: Other Information

References: Not available.

Other Special Considerations: Not available.

Created: 10/09/2005 05:53 PM

Last Updated: 05/21/2013 12:00 PM

The information above is believed to be accurate and represents the best information currently available to us. However, we make no warranty of merchantability or any other warranty, express or implied, with respect to such information, and we assume no liability resulting from its use. Users should make their own investigations to determine the suitability of the information for their particular purposes. In no event shall ScienceLab.com be liable for any claims, losses, or damages of any third party or for lost profits or any special, indirect, incidental, consequential or exemplary damages, howsoever arising, even if ScienceLab.com has been advised of the possibility of such damages.

GC ELECTRONICS

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MSDS Number: 275
Revision Date: 01/29/2013
Supersedes Date: 02/19/2010

MATERIAL SAFETY DATA SHEET

Complies with OSHA Hazard Communication Standard 29 CFR 1910.1200

Product Name: SILICONE SEALANT/ADHESIVE

SECTION 1. PRODUCT AND COMPANY IDENTIFICATION

Product Type: Solvent Release Adhesive RTV
Product Name: **SILICONE SEALANT/ADHESIVE**
Part Number(s): 19-158
19-159

Emergency Contact: Chemtrec
Phone: (800) 424-9300

HMIS III RATINGS

Health: 1
Flammability: 0
Physical Hazard: 1

HMIS uses a numbering scale ranging from 0 to 4 to indicate the degree of hazard. A value of zero means that the substance possesses essentially no hazard; a rating of four indicates high hazard.

SECTION 2. COMPOSITION

Single or Mixture: Mixture
Chemical Identification: Organopolysiloxane mixture

Hazard Component(s)/(CAS NO.): No hazardous materials present
(See Section 8 of this MSDS for Exposure Guideline)

SECTION 3. HAZARDS IDENTIFICATION

Hazards Classification: None (based on IMO)
Fire and Explosion Not considered flammable nor combustible, but will burn if involved in a fire.

Potential Health Effect
Inhalation: Vapor overexposure may cause drowsiness, injure blood and liver, and may irritate eyes, nose and throat
Skin Contact: On direct contact uncured product or its vapor may cause slight irritation to skin.
Eye Contact: On direct contact uncured product or its vapor may cause slight irritation to eyes.
Ingestion: No information is available

SECTION 4. FIRST AID MEASURES

Inhalation: Remove to fresh air
Skin Contact: Immediately remove product from skin with dry cloth or towel, and wash exposed area with detergent
Eye Contact: Immediately flush with plenty of water for at least 15 minutes and promptly call a physician
Ingestion: Wash out mouth with water provided person is conscious. Never give anything by mouth to an unconscious person. Call a physician immediately.

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Product Name: SILICONE SEALANT/ADHESIVE

SECTION 5. FIRE FIGHTING MEASURES

Flash Point (method used): Not applicable (Solid)
Flammable Limits: Lower: Not determined Upper: Not determined
Extinguishing Media: Foam, dry chemical or carbon dioxide or fine water spray
Special Fire Fighting Procedure: None
Unusual fire and explosion Hazard: None

SECTION 6. ACCIDENTAL RELEASE MEASURES

Steps to be taken in case material is released or spilled:
Shut off all ignition sources
Contain the spill or leak.
Scrape up with cardboard or rag and place in container.

SECTION 7. HANDLING AND STORAGE

Precaution to be taken in handling and storing:
Keep container closed when not in use.
Store in a cool place.
Keep away from heat, sparks and flame.
Do not lay the container on its side.
Use only with adequate ventilation
Avoid contact with eyes and skin
Keep out of reach of children.
Contact lens wearers take appropriate precaution

**** Information about the emptied container ****
Do not re-use this container
Keep away from heat, sparks and flame
Do not puncture or cut this container, and do not weld on or near this container.

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Product Name: SILICONE SEALANT/ADHESIVE

SECTION 8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Exposure Guidelines:
Vendor Guide; 3ppm (TWA), 10 ppm (STEL)
AIHA WEEL*; 10 ppm (TWA)
[Methylethylketoxime; decomposed product]
(*AIHA WEEL ■ American Industrial Hygiene Association Workplace Environmental Exposure Level)

Respiratory Protection (Specific Type): Use air-supplied breathing apparatus unless local exhaust ventilation is adequate or decomposed product is within AIHA guideline

Ventilation: Local Exhaust Required

Mechanical (general): Adequate ventilation system

Special: Unknown

Other: Pay attention to ventilation such as local exhaust, mechanical and/or leave door open for at least 24 hours after application.

Protective Gloves: Plastic Film or rubber gloves

Other Protective Clothing or Equipment: Eyewash equipment

Work/Hygienic Practices: Wash hands after handling.
Keep away from heat and flame
Avoid Contact with eyes and prolonged or repeated skin contact.
Avoid prolonged breathing vapor.

SECTION 9. PHYSICAL AND CHEMICAL PROPERTIES

Boiling Point:	Not applicable
Vapor Pressure:	Negligible (25°C)
Vapor Density (air■1):	>1
Specific Gravity:	1.05 (25°C)
Melting Point:	Not applicable
Evaporation Rate:	<1 (Butyl Acetate■1)
Solubility in Water:	Not soluble
Appearance (color)	See Cartridge
Appearance (form):	Paste
Odor:	Oxime odor

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Product Name: SILICONE SEALANT/ADHESIVE

SECTION 10. STABILITY AND REACTIVITY

Stability: Stable
Condition to Avoid: Exposure to air or moisture until ready to use - causes curing and methylethylketoxime vapor to form gradually
Incompatibility (Material to Avoid): Water or moisture
Hazardous Decomposition or By-Product: Water, moisture, or humid air can cause Methylethylketoxime Thermal breakdown of this product during fire or very high heat condition may evolve the following hazardous decomposition product: Carbon oxides and traces of incompletely burned carbon compounds. Silicone dioxide. Nitrogen oxides. Formaldehyde
Hazardous Polymerization: Will Not Occur
Conditions to Avoid: None

SECTION 11. TOXICOLOGICAL INFORMATION

Skin Irritation:	No information is available See OTHER INFORMATION
Eye irritation:	No information is available See OTHER INFORMATION
Sensitization:	No information is available See OTHER INFORMATION
Acute Toxicity (LD50):	No information is available See OTHER INFORMATION
Acute Toxicity (LC50)	No information is available See OTHER INFORMATION
Subacute Toxicity:	No information is available See OTHER INFORMATION
Chronic Toxicity:	No information is available. See OTHER INFORMATION
Carcinogen:	NTP: Not Listed IARC: Not Listed: OSHA Regulated: Not Listed See OTHER INFORMATION
Mutagenicity:	No information is available See OTHER INFORMATION
Other Information:	**Additional Information** Methyl Ethyl Ketoxime (MEKO) — Decomposition product Material will generate MEKO on exposure to humid air, gradually. Male rodents exposed to MEKO vapor at high concentration throughout their lifetime developed liver cancer. But relevance to humans is uncertain now. Please read the detail information to MEKO below.
Skin Irritation:	Causes mild irritation. Can be absorbed through the skin
Eye Irritation:	Causes severe irritation
Acute Oral Tox:	LD50 (rat) = 4ml/kg.
Acute Inhalation Tox:	LC50 (rat) = >4.8 mg/l /4HR
Inhalation Tox:	Shows narcotic action at high concentration. May produce blood effects
Skin Sensitization:	Positive (guinea pig)
Neurotoxicity:	High dose can product transient and reversible change in neurobehavioral function. No evidence of cumulative neurotoxity was detected.
Carcinogenicity:	Liver carninomas were observed in a lifetime inhalation study (ca.2 years) in which mice and rats were exposed. These carcinomas were statistically increased in males at concentration of 735 ppm. Relevance to humans is uncertain now MEKO

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Product Name: SILICONE SEALANT/ADHESIVE

SECTION 11. TOXICOLOGICAL INFORMATION (CONTINUED)

Mutagenicity: Not considered mutagenic based on several in vitro and vivo studies.
Other Chronic Study: Degenerative effects on the olfactory epithelium of nasal passages occurred in a concentration related manner in males and females of mice and rats at MEKO concentration of 15,75 and 375 ppm.
Workplace Environmental Exposure: Exposure Level AIHA WEEL: 10 ppm (TWA)

SECTION 12. ECOLOGICAL INFORMATION

Biodegradation: Not applicable
Bioaccumulation: No information is available
Aquatic Toxicity: No information is available
Other Information: None

SECTION 13. DISPOSAL CONSIDERATION

Can be land-filled for cured product or burned in a chemical incinerator equipped with an afterburners and scrubber
Do not dispose the emptied container unlawfully.
Observe all federal, state, and local laws.

SECTION 14. TRANSPORTATION INFORMATION

US DOT & CANADA TDG SURFACE
Valuation.....: Not regulated for transport

Transport by sea IMDG-Code
Valuation.....: Not regulated for transport

Air transport ICAO-TI/IATA-DGR
Valuation.....: Not regulated for transport

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Product Name: SILICONE SEALANT/ADHESIVE

SECTION 15. REGULATORY INFORMATION

Toxic Substances Control Act (TSCA) Status: Listed on the TSCA inventory

European Inventory Of Existing Commercial Chemical Substances (EINECS) Status:
Listed on the EINECS

Labeling According To EC-Regulations Required:
Symbol: Not required
R-Phrase: Not required
S-Phrase: Not required
Contains: None

Superfund Amendments and reauthorization to of 1986 (SARA) Title III Section 313 Supplier Notification:
This regulation required submission of annual reports of toxic chemical(s) that appear in section 313 of the emergency planning and community Right-To-Know Act of 1986 and 40 CFR 372. This information must be included in all MSDS's that are the toxic chemical(s) contained in this product are:

Chemical Name(CAS No.) And Contents: None

California Proposition 65:
This regulation requires a warning for California Proposition 65 Chemical(s) under the stature.

The California Proposition 65 Chemical(s) contained in this product are:
Chemical Name/(CAS No.) And Contents: None

SECTION 16. DISCLAIMER

GC Electronics believes that the information contained herein is accurate and reliable as of the date of this material safety data sheet, but no representation guarantee or warranty, express or implied, is made as to the accuracy, reliability or completeness of the information. Persons receiving information are encouraged to make their own determination as to the information's suitability and completeness for their particular application.
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Attachment 6

Tailgate Briefing

NEW MEXICO TECH
Energetic Material s Research and Testing Center

Tailgate Briefing Form

TEST INFORMATION					
Date:		Time:		Briefed By:	
Site:				Test Title;	
Test Manager:				Field Crew Lead:	
Ordnance:				Safety:	

WEATHER					
Temp:		Wind:	Direction:		Precip:	
			Speed:		Cloud %:	

TOPICS COVERED					
	Planned Site Activities		Chemical Hazards		Buddy Team Procedures
	Physical Hazards		PPE Required		Emergency Procedures
	Biological Hazards		Explosive Hazards		First Aid Procedures
	Heat/Cold Stress		Respiratory Hazards		Site Access / Clearances
	Site Communications		Decon Procedures		Other: Describe Below

Other:

BRIEFING ATTENDEES			
Printed Name	Signature	Printed Name	Signature

By signing above, I certify that I have been breifed on and understand the information above.

NOTE: Tailgate briefings may need/have attachments from Ordnance or Instrumentation. Ensure all Tailgate Briefing forms are available if questions arise.

Attachment 7

Reviewed and Accepted List

Engineer	**Print** Robert Abernathy **Sign** Robert J Abernathy	**Date** 11 Aug 2017
Ordnance	**Print** N/A **Sign**	**Date**
Instrumentation	**Print** N/A **Sign**	**Date**
Field Supervisor	**Print** N/A **Sign**	**Date**
Safety	**Print** E. PACCETTI **Sign**	**Date** 8/10/17

The above blocks need to be signed off on only if they are pertinent to the project (e.g., Field Supervisor signs off if there are TRO's involved)

R.C. Eric Hyatt 8/11/17

Attachment 8

Revision Listing

Reason for revision:							
Engineer Signature and Date:							
Safety:		**Ord:**		**Inst:**		**Field:**	
Reason for revision:							
Engineer Signature and Date:							
Safety:		**Ord:**		**Inst:**		**Field:**	
Reason for revision:							
Engineer Signature and Date:							
Safety:		**Ord:**		**Inst:**		**Field:**	
Reason for revision:							
Engineer Signature and Date:							
Safety:		**Ord:**		**Inst:**		**Field:**	
Reason for revision:							
Engineer Signature and Date:							
Safety:		**Ord:**		**Inst:**		**Field:**	

D Data Sheets

E Tailgate Safety Briefing

NEW MEXICO TECH

Tailgate Briefing Form

TEST INFORMATION

Date:	8/14/17	Time:	8:30 AM	Briefed By:	D. GROW
Site:	2-TON			Test Title;	
Test Manager:				Field Crew Lead:	
Ordnance:	N/A			Safety:	

WEATHER

Temp:	74 - 90 °F	Wind:	Direction:	NE	Precip:	20%
			Speed:	5-10	Cloud %:	

TOPICS COVERED

X	Planned Site Activities	X	Chemical Hazards	X	Buddy Team Procedures
X	Physical Hazards	X	PPE Required	X	Emergency Procedures
X	Biological Hazards	X	Explosive Hazards	X	First Aid Procedures
X	Heat/Cold Stress	X	Respiratory Hazards	X	Site Access / Clearances
X	Site Communications	X	Decon Procedures		Other: Describe Below

Other:

BRIEFING ATTENDEES

Printed Name	Signature	Printed Name	Signature
JAmie Kimberley		Andrew Duff	
Wesley Cook		Sean Coss	
James Narun		Tristan Karns	
John Paul Norman		Ralph Clayton	
Esteven Trujillo		Westin Whitlock	
Rebecca Sappington		Cody Kittleman	
Christopher Schmittle		David Grow	
Dan Puckett		Szymon Turel	
Keith Sillivent			

By signing above, I certify that I have been briefed on and understand the information above.

NOTE: Tailgate briefings may need/have attachments from Ordnance or Instrumentation. Ensure all Tailgate Briefing forms are available if questions arise.

NEW MEXICO TECH

Tailgate Briefing Form

TEST INFORMATION

Date:	8/15/17	Time:	12:45	Briefed By:	David Grow
Site:	Torres, 2-ton			Test Title;	
Test Manager:	David Grow			Field Crew Lead:	
Ordnance:	N/A			Safety:	

WEATHER

Temp:	90	Wind:	0-6	Direction:	0-6 mph W	Precip:	20
				Speed:	West	Cloud %:	10

TOPICS COVERED

DC	Planned Site Activities	DC	Chemical Hazards	DC	Buddy Team Procedures
DC	Physical Hazards	DC	PPE Required	DC	Emergency Procedures
DC	Biological Hazards	DC	Explosive Hazards	DC	First Aid Procedures
DC	Heat/Cold Stress	DC	Respiratory Hazards	DC	Site Access / Clearances
DC	Site Communications	DC	Decon Procedures	DC	Other: Describe Below

Other:

BRIEFING ATTENDEES

Printed Name	Signature	Printed Name	Signature
Ralph Clayton		Ben Sears	
James Narum		Esteban Trujillo	
Hannah Ekblad		Christopher Schmitt	
Szymon Turel		John Paul Norman	
Justin Whitlock		Dan Puckett	
Cody Kittleman		Andrew Date	
James Street		Sean Goss	
Lenny Fontana		Rebecca Sappington	
Keith Sillivent		Wesley Cook	

By signing above, I certify that I have been breifed on and understand the information above.

NOTE: Tailgate briefings may need/have attachments from Ordnance or Instrumentation. Ensure all Tailgate Briefing forms are available if questions arise.

NEW MEXICO TECH

Tailgate Briefing Form

TEST INFORMATION

Date:	8/16/17	Time:		Briefed By:	David Grov
Site:	Torres 2-ton			Test Title;	Glovebox FSS
Test Manager:	David Grov			Field Crew Lead:	N/A
Ordnance:	N/A			Safety:	Wes Cook

WEATHER

Temp:	High 91	Wind:	Direction:	6 mph	Precip:	0
			Speed:	NNW	Cloud %:	9

TOPICS COVERED

DG	Planned Site Activities	DG	Chemical Hazards	DG	Buddy Team Procedures
DG	Physical Hazards	DG	PPE Required	DG	Emergency Procedures
DG	Biological Hazards	DG	Explosive Hazards	DG	First Aid Procedures
DG	Heat/Cold Stress	DG	Respiratory Hazards	DG	Site Access / Clearances
DG	Site Communications	DG	Decon Procedures	DG	Other: Describe Below

Other:

BRIEFING ATTENDEES

Printed Name	Signature	Printed Name	Signature
Ralph Clayton	Ralph Clayton	W. Henson	Will Henson
Tristan Vacas	Tristan Vacas	Keith Sillivent	Keith Sillivent
Ben Sears	Ben Sears	Ryan C Morelli	Ryan C Morelli
Chris Schuttle	Chris Schuttle	Wesley Cook	Wesley Cook
Gabriel Acosta	Gabriel Acosta	James Narum	
Dan Puckett	Dan Puckett	Brett Noakes	
Rebecca Sappington	RSth	Parker Fellows	
Esteban Trujillo	Esteban Trujillo		
John Paul Norman			

By signing above, I certify that I have been breifed on and understand the information above.

NOTE: Tailgate briefings may need/have attachments from Ordnance or Instrumentation. Ensure all Tailgate Briefing forms are available if questions arise.

F Experimental Data Sheets

* Note: This document refers to a *Test 2*, which was aborted. To simplify the presentation of the results, the aborted test is not referred to in the report. Hence, the data sheet labeled *Test 3* herein, is referred to in the report as *Test 2*. This offset holds for the successive data sheets.

Emergency Contact Information:

911 or (575) 835-5555

Glovebox Fire Suppression: Test # 1

Test Conditions

Test Conductor Name	Date	Test Location	Success	Aborted
Ralph Clayton	8/14/17	2-Ton	✓	

Safety Officer Name	Start Time	10:56
Wesley Cook	Ignition Time	NA
Quality Assurance Rep. Name	End Time	11:35
James Narum		

Relevant Environmental Conditions

Relative Humidity:	Room Temperature:
35%	82° F

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make Dwyer Model 6488-16	4713111	0
2. Make " Model "	4713110	1
3. Make " Model "	4713025	2
4. Make " Model "	4713112	3

Digital Timer	Serial Num	Calib. Date
1. Make Control Co Model 1043	170087992	2/7/2015

Air Flow meter	Serial Num	DAQ channel
1. Make TSI Model 5725	TSI-25151100Y	NA

Thermographic Camera	Serial Num	File Name
1. Make NA Model		

Thermocouples **	Serial Num	DAQ channel
1. Make Omega Model HB20052	1 *	0
2. Make " Model "	2 *	1
3. Make " Model "	3 *	2
4. Make " Model "	4 *	3

** Lot number # 248933

* Sample ID 141052, 141053, 141054, 141055

Fenwal Heat Detector	Serial Num	DAQ channel
1. Make Fenwal Model ~~28021~~	28021	
2. Make Fenwal Model ~~28021~~	28021	

not used in test ~~JM~~ 9/14/17

Cameras	Serial Num	
1. Make Point Grey Model Grasshopper	14273764	top
2. Make " Model "	14273944	side
3. Make " Model "	17274307	overview
4. Make NA Model NA		

Glove Installation

Glove/cover installed	LANL insp	Port #
8YLX3052		1
"		2
"		3
"		4
8X1532		5
"		6
"		7
"		8
"		9
"		10
"		11
"		12

Glove/cover installed	LANL insp	Port #
8YLX3032		13
"		14
"		15
"		16
8Y1532		17
"		18
"		19
"		20
"		21
"		22
"		23
"		24

Time & Description of Critical Events

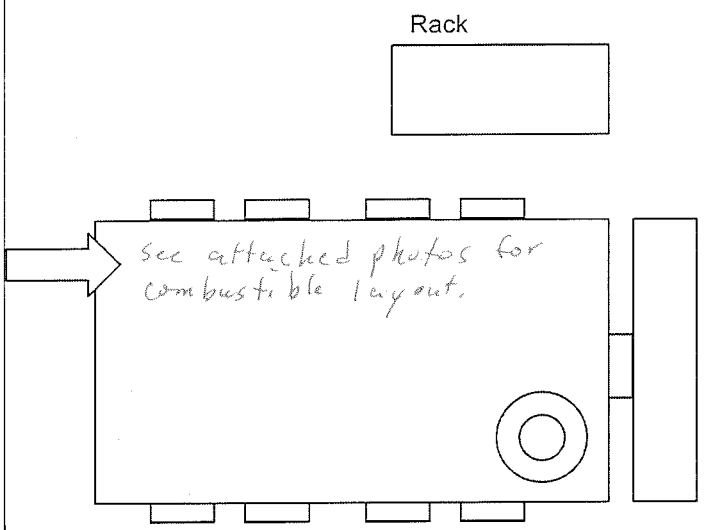
Ignition Time: N/A
Breach Time: N/A
140 Fenwal Detection Time: N/A
190 Fenwal Detection Time: N/A
Other key times:

Miscellaneous Notes

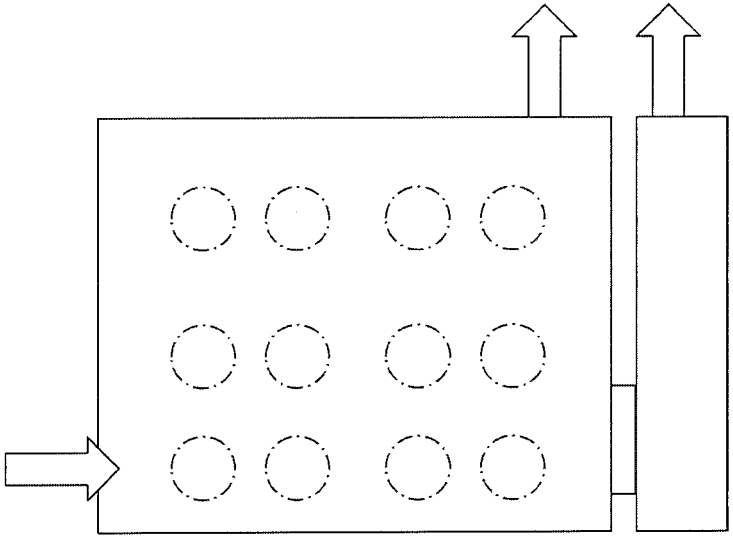
1. Discharged ceasefire system and recorded Glovebox pressure & airflows.

Combustibles Layout

GB Floor (Top View)



GB Floor (Side View)



Legend (enumerate combusibles, indicate location). Sketch in attached wooden volume if applicable.

A. Alcohol/Cheesecloth *
B. Metal Rack
C. Screwdrivers (2)
D. Hammers/Mallets (1)
E. Horsehair brush (1)
F. Leather glove (2)
G. Kim wipes 2 boxes (40 g out)
H. Cotton rounds (5)
I. Sandpaper 1 sheet
~~J. Poly bottles~~ not used 5/16/17
K. blue sheet (4)
L. tie wrap (4)
M. tygon tube (1)
N. Rubber gloves (1 pair)
O. Fire bag (1) * * (2)
P. Sharpie (2)
Q Poly bottles 2 100 ml empty
R. Poly bottles 2 500 ml empty
S. Poly bottles 2 250 ml (50 ml alcohol)

* 5 bags @ each crib with 10 ml acetone & ≈ ½ roll ~~Kim wipes~~ cheese cloth 5/16/17

* * In fire bag: brush (1)
hammer (1)
screw driver (2)
Kim wipes out (20 g)
leather gloves (2)
rubber gloves (1 pair)
electric cord (1)
handle
bag with 10 ml acetone & ≈ ½ roll cheese cloth

Revision History	
Revision & Justification	Authorized Signatures

Emergency Contact Information:
911 or (575) 835-5555

aboard @ 6:00

Glovebox Fire Suppression: Test #2

began recording data 5:45

Test Conditions

Test Conductor Name	Date	Test Location	Success	Aborted
Ralph Clayton	8/14/17	2-ton		✓

Safety Officer Name: Wesley Cook

Quality Assurance Rep. Name: James Narum

Start Time	17:48
Ignition Time	~~17:59~~
End Time	17:59

Relevant Environmental Conditions

Relative Humidity: 32 %	Test failed due to improper ignitor wiring.
Room Temperature: 86 °F	

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make Dwyer Model 648B-16	4713111	Ø
2. Make " Model "	471311Ø	1
3. Make " Model "	4713Ø25	2
4. Make " Model "	4713112	3

Digital Timer	Serial Num	Calib. Date
1. Make Control Co Model ~~1044~~ 1043 8/14/19	170087992	2/7/2016

Air Flow meter	Serial Num	DAQ channel
1. Make TSI Model ~~1043~~ 5725 8/14/17	T5725151ØØ4	N/A

Thermographic Camera	Serial Num	File Name
1. Make ____ Model ____		

Thermocouples **	Serial Num	DAQ channel
1. Make Watlow Model AB20Ø52 67	1 *	0
2. Make " Model "	2 *	1
3. Make " Model "	3 *	2
4. Make " Model "	4 *	3

** Lot number Z248633 — * Sample ID 141052, 141053, 141054, 141055

Fenwal Heat Detector	Serial Num	DAQ channel
1. Make Fenwal Model 28021		AI 1 (140°)
2. Make Fenwal Model 28021		AI Ø (140°)

Cameras	Serial Num	
1. Make Point Grey Model Grasshopper	14273764	top
2. Make " Model "	14273944	side
3. Make " Model "	17274307 (8/14/17)	overview
4. Make N/A Model N/A		

Glove Installation

Glove/cover installed	LANL insp	Port #
8XLY3032		1
"		2
"		3
"		4
8X1532		5
"		6
"		7
"		8
"		9
"		10
"		11
"		12

Glove/cover installed	LANL insp	Port #
8XLX3032		13
"		14
"		15
"		16
8X1532		17
"		18
"		19
"		20
"		21
"		22
"		23
"		24

Time & Description of Critical Events

Ignition Time: N/A

Breach Time: N/A

140 Fenwal Detection Time: N/A

190 Fenwal Detection Time: N/A

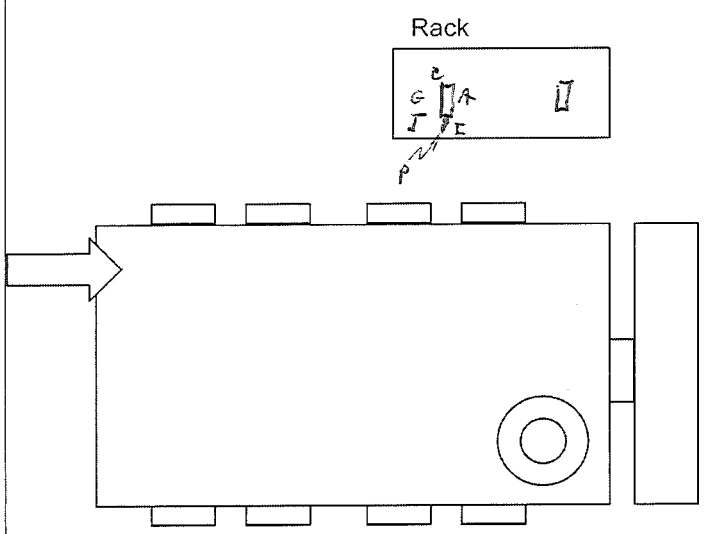
Other key times:

Miscellaneous Notes

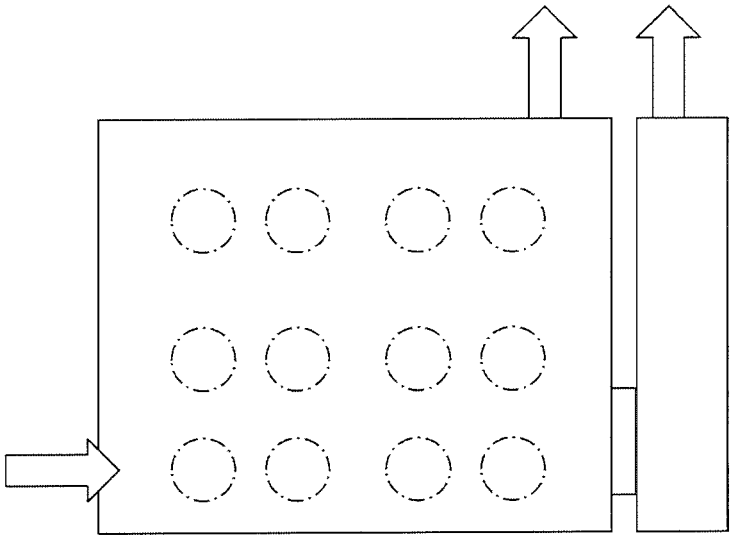
1. Ignitor failed aborted test.

Combustibles Layout

GB Floor (Top View)



GB Floor (Side View)



Legend (enumerate combusibles, indicate location). Sketch in attached wooden volume if applicable.

* A. Alcohol/Cheesecloth 10 bags 10 ml acetone wipes ≈ ½ roll Kim wipes cheese cloth
B. Metal Rack
C. Screwdrivers (2)
D. Hammers/Mallets (1)
E. Horsehair brush (1)
F. Leather glove (2)
G. Kim wipes 2 boxes (40g out)
H. Cotton rounds
I. Sandpaper
J. Poly bottles
K. blue shuttle (4)
L. tie wrap (4)
M. fuse tube (1)
N. rubber gloves (1 pair)
O. fire bags (2)
~~P. Acetone Sealed bags 10 bags 10 ml acetone ≈ ½ roll Kim wipes~~ 5/14/17
P. Q. Sharpie (2)
Q. Poly bottles 2 ~~500~~ 1000 ml empty
R. Poly bottles 2 500 ml empty
S. Poly bottles 2 250 ml (50 ml alcohol)

* 5 bags @ each crib

in fire bag
brush (1)
hammer (1)
screw driver (2)
Kim Wipes out - (2 0g)
leather gloves - 2
rubber gloves - 7 pair
electric cord - 1
needle
1 bag with 10 ml acetone & ≈ ½ roll cheese cloth

Revision History	
Revision & Justification	Authorized Signatures

Emergency Contact Information:

911 or (575) 835-5555

Glovebox Fire Suppression: Test #103

18:17 started data collection started ignition 18:18 flame 18:19

Test Conditions

Test Conductor Name	Date	Test Location	Success	Aborted
Ralph Clayton	8/14/17	2-Ton	✓	

Safety Officer Name	Start Time	18:16
Wesley Cook	Ignition Time	18:18
Quality Assurance Rep. Name	End Time	18:39
James Narum		

Relevant Environmental Conditions

Relative Humidity:	
31%	
Room Temperature:	
86 °F	

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make Dwyer Model 648B-16	4713111	0
2. Make " Model "	4713110	1
3. Make " Model "	4713025	2
4. Make " Model "	4713112	3

Digital Timer	Serial Num	Calib. Date
1. Make Control Co Model 1043	170087992	2/7/2018

Air Flow meter	Serial Num	DAQ channel
1. Make TSI Model 5725	TS725151104	N/A

Thermographic Camera	Serial Num	File Name
1. Make Model		

Thermocouples **	Serial Num	DAQ channel
1. Make Watlow Model AB2K0S267	1 *	0
2. Make " Model AB2J0S267	2 *	1
3. Make " Model "	3 *	2
4. Make " Model "	4 *	3

** Z248933 lot number * Sample ID 141052 141053 141054 ~~141055~~ 141055 8/16/17

Fenwal Heat Detector	Serial Num	DAQ channel
1. Make Fenwal Model 28021		AI1
2. Make Fenwal Model 28021		AI0

Cameras	Serial Num	
1. Make Point Grey Model Grasshopper	14273764	top
2. Make " Model "	14273544	side
3. Make " Model "	17274307	overview
4. Make N/A Model N/A		

140

190

Glove Installation

Glove/cover installed	LANL insp	Port #
SYLY3052		1
"		2
"		3
"		4
8YL532		5
"		6
"		7
"		8
"		9
"		10
"		11
"		12

Glove/cover installed	LANL insp	Port #
SYLY3052		13
"		14
"		15
"		16
8YL532		17
"		18
"		19
"		20
"		21
"		22
"		23
"		24

Time & Description of Critical Events

Ignition Time: 18:17 started igniter

Breach Time: N/A

140 Fenwal Detection Time: 18:19

190 Fenwal Detection Time: N/A

Other key times: Visible flame 18:18

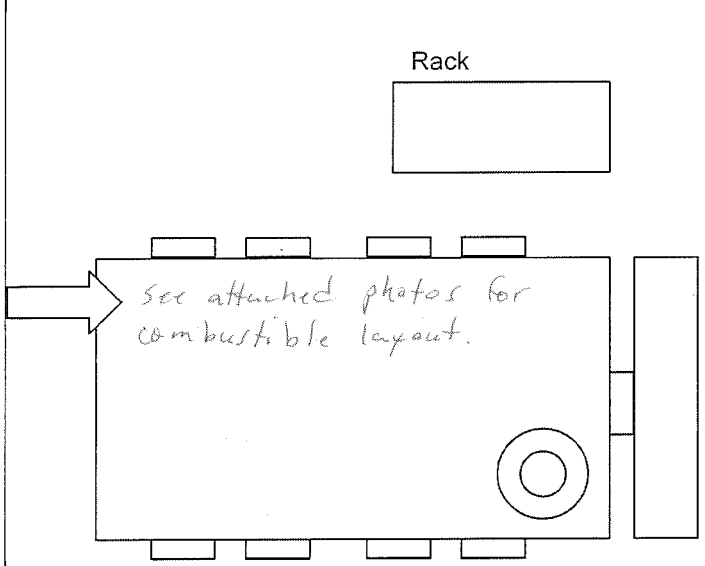
Fire suppression system discharged at 18:19

Miscellaneous Notes

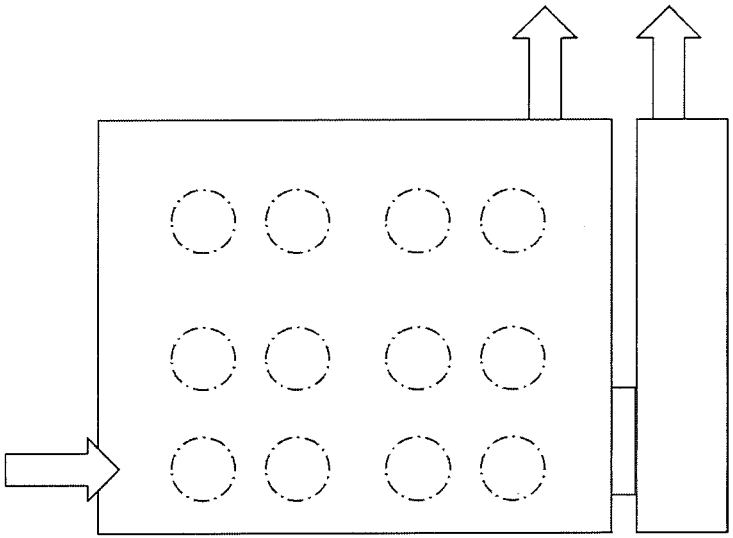
18:19 140° Fenwal tripped FSS discharged Fire out. The FSS discharged just before the 140° fenwal tripped.

Combustibles Layout

GB Floor (Top View)



GB Floor (Side View)



Legend (enumerate combusibles, indicate location). Sketch in attached wooden volume if applicable.

A. Alcohol/Cheesecloth *
B. Metal Rack
C. Screwdrivers (2)
D. Hammers/Mallets (1)
E. Horsehair brush (1)
F. Leather glove (2)
G. Kim wipes 2 bags (
H. Cotton rounds (8)
I. Sandpaper 1 sheet
~~J. Poly bottles~~ not used on 5/16/17
K. blue sheet (4)
L. tie wrap (4)
M. tygon tube (1)
N. rubber gloves (1 pair)
O. Fire bag (1) 5/16/17 **
P. Sharpie (2)
Q. Poly bottles 2 1000 ml empty
R. Poly bottles 2 500 ml empty
S. Poly bottles 2 250 ml (50 ml alcohol)

* 5 bags @ each crib with 10 ml acetone & ≈ ½ roll ~~Kim Wipes~~ Cheese cloth 5/16/17

** In fire bag: brush (1)
hammer (1)
screw driver (2)
Kim wipes out (20g)
Leather gloves (2)
rubber gloves (1 pair)
electric cord (1)
handle
1 bag with 10 ml acetone & ≈ ½ roll cheese cloth

Revision History	
Revision & Justification	Authorized Signatures

Emergency Contact Information:

911 or (575) 835-5555

Glovebox Fire Suppression: Test # 004

Test Conditions

13:53 recording ends

Test Conductor Name	Date	Test Location	Success	Aborted
Ralph Clayton	~~8/14/17~~ 8/15/17	2-ton	✓	

Safety Officer Name: Wesley Cook

Quality Assurance Rep. Name: James Nurum

Start Time	13:50 8/15/17
Ignition Time	~~13:53~~ 13:54 8/15/17
End Time	~~13:56~~ 14:16 8/15/17

Relevant Environmental Conditions

Relative Humidity: 28%

Room Temperature: 63 °F

13:56 FSS discharged Fenwal did not trig.

Sensor Characteristics

Pressure Sensors		Serial Num	DAQ channel
1. Make Dwyer	Model 648B-16	4713111	0
2. Make "	Model "	4713118	1
3. Make "	Model "	4713025	2
4. Make "	Model "	4713112	3

Digital Timer		Serial Num	Calib. Date
1. Make Control Co	Model 1043	170087992	2/7/2019

Air Flow meter		Serial Num	DAQ channel
1. Make TSI	Model 5725	TS725151104	N/A

Thermographic Camera		Serial Num	File Name
1. Make	Model		

Thermocouples **		Serial Num	DAQ channel
1. Make Watlow	Model AB20052G7	1 *	
2. Make "	Model "	2 *	
3. Make "	Model "	3 *	
4. Make "	Model "	4 *	

** Z248933 lot number * sample ID

Fenwal Heat Detector		Serial Num	DAQ channel
1. Make Fenwal	Model 28021		AI 1
2. Make Fenwal	Model 28021		AI 0

Cameras		Serial Num	
1. Make Point Grey	Model Grasshopper	14273764	top
2. Make "	Model "	14273944	side
3. Make "	Model "	17274307	overview
4. Make N/A	Model N/A		

141052
141057
141054
141055

top
middle
bottom
ambient

140°
140°

Glove Installation

Glove/cover installed	LANL insp	Port #
84LY 3032		1
"		2
"		3
"		4
84 1532		5
"		6
"		7
"		8
"		9
"		10
"		11
"		12

Glove/cover installed	LANL insp	Port #
84LY 3032		13
"		14
"		15
"		16
84 1532		17
"		18
"		19
"		20
"		21
"		22
"		23
"		24

Time & Description of Critical Events

Ignition Time: 13:53 started ignitors

Breach Time: N/A

140 Fenwal Detection Time: N/A

190 Fenwal Detection Time: N/A

Other key times:

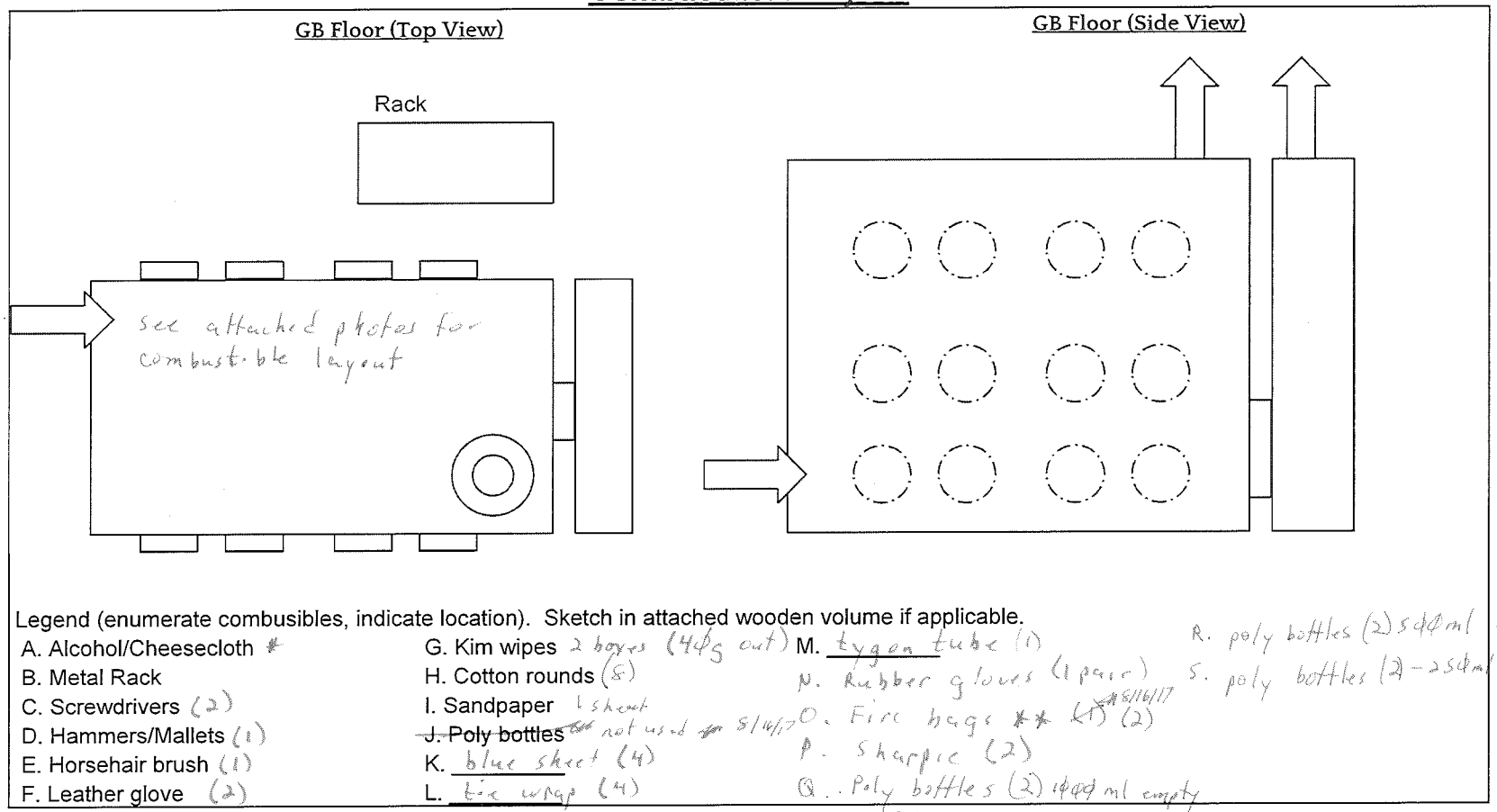
visible flame 13:54

Fire suppression system discharged at 13:55

Miscellaneous Notes

1. See Attached photos for combustible layout.

Combustibles Layout



Legend (enumerate combusibles, indicate location). Sketch in attached wooden volume if applicable.

A. Alcohol/Cheesecloth *
B. Metal Rack
C. Screwdrivers (2)
D. Hammers/Mallets (1)
E. Horsehair brush (1)
F. Leather glove (2)
G. Kim wipes 2 boxes (40 g out)
H. Cotton rounds (5)
I. Sandpaper 1 sheet
~~J. Poly bottles~~ not used 5/16/17
K. blue sheet (4)
L. tie wrap (4)
M. tygon tube (1)
N. Rubber gloves (1 pair) 5/16/17
O. Fire bags ** (4) (2)
P. Sharpie (2)
Q. Poly bottles (2) 1000 ml empty
R. poly bottles (2) 500 ml empty
S. poly bottles (2) - 250 ml (50 ml alcohol)

* 5 bags @ each crib with 10 ml acetone & ≈ ½ roll ~~Kim wipes~~ Cheese cloth 5/16/17

** In fire bags: brush (1)
hammer (1)
screw driver (2)
Kim wipes out (20 g)
Leather gloves (2)
rubber gloves (1 pair)
electric cord (1)
handle
1 bag with 10 ml acetone & ≈ ½ roll cheese cloth

Revision History	
Revision & Justification	Authorized Signatures

Emergency Contact Information:

911 or (575) 835-5555

Glovebox Fire Suppression: Test # 005

start recording data @ 9:35

Test Conditions

Test Conductor Name	Date	Test Location	Success	Aborted
Ralph Clayton	8/16/17	2-ton	✓	

start agitator @ 9:36

@ 9:37 170° F oven

@ 9:38 FSS discharged

Safety Officer Name	Start Time	9:33
Wesley Cook	Ignition Time	9:36
Quality Assurance Rep. Name	End Time	9:48
James Narum		

Relevant Environmental Conditions

Relative Humidity:	Room Temperature:
25%	80° F

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make Dwyer Model 648B-16	0	
2. Make " Model "	1	
3. Make " Model "	2	
4. Make " Model "	3	

Digital Timer	Serial Num	Calib. Date
1. Make Control Co Model 1043	170087992	2/7/2019

Air Flow meter	Serial Num	DAQ channel
1. Make TSI Model 5725	T57251511004	N/A

Thermographic Camera	Serial Num	File Name
1. Make Model		

Thermocouples	Serial Num	DAQ channel
1. Make Model		
2. Make Model		
3. Make Model		
4. Make Model		

Fenwal Heat Detector	Serial Num	DAQ channel
1. Make Fenwal Model 28021		AI 1
2. Make Fenwal Model 28021		AI 0

Cameras	Serial Num	
1. Make Point Grey Model Grasshopper	14273764	top
2. Make " Model "	14273944	side
3. Make " Model "	17274307	overview
4. Make N/A Model N/A		

140°

140°

Glove Installation

Glove/cover installed	LANL insp	Port #
8YLY 3032		1
"		2
"		3
"		4
8Y1532		5
"		6
"		7
"		8
"		9
"		10
"		11
"		12

Glove/cover installed	LANL insp	Port #
8YLY 3032		13
"		14
"		15
"		16
8Y1532		17
"		18
"		19
"		20
"		21
"		22
"		23
"		24

Time & Description of Critical Events

Ignition Time: 9:36 started ignitor

Breach Time: N/A

140 Fenwal Detection Time: 9:37

190 Fenwal Detection Time: N/A

Other key times:

visible flame 9:36

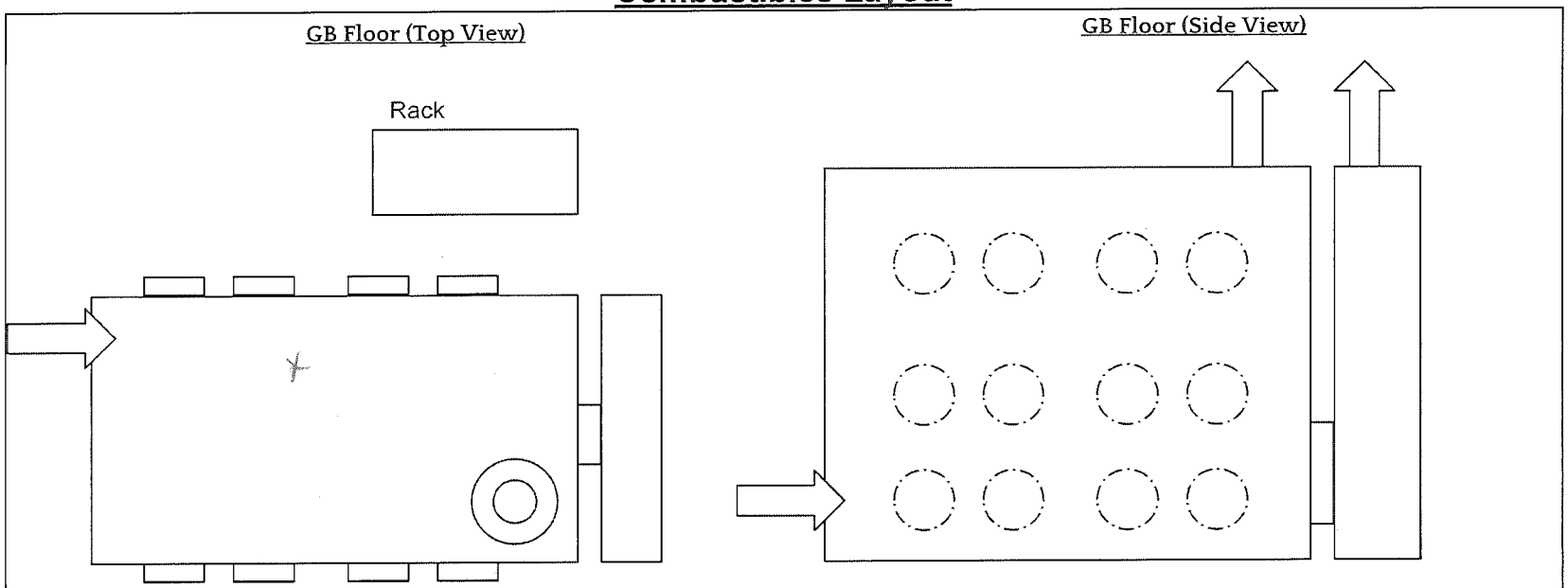
Fire suppression system discharged at 9:38

Miscellaneous Notes

1. See attached photos for combustible layout.
2. Gloves in ports 9 & 10 were sucked into glovebox.
3. One bag of acetone soaked Kim wipes on north crib (furthest away from FSS head) continued to smolder after FSS discharge.
4. Smoldering ½ roll of ~~Kim wipes~~ cheese cloth 9/16/17 was removed from glove box before depth measurements were taken.

* See photos for combustible material layout (photos attached)

Combustibles Layout



Legend (enumerate combusibles, indicate location). Sketch in attached wooden volume if applicable.

* A. Alcohol/Cheesecloth 10 bags	G. Kim wipes 2 boxes (40g out)	M. bygun tube (1)
B. Metal Rack	H. Cotton rounds (8)	N. Rubber gloves (1 pair)
C. Screwdrivers (2)	I. Sandpaper 1 sheet	O. fire bag ** (1)** (2)
D. Hammers/Mallets (1)	~~J. Poly bottles~~ not used 5/16/17	P. sharpie (2)
E. Horsehair brush (1)	K. blue shirt (4)	Q. Poly bottles 2 1000ml empty
F. Leather glove (2)	L. tie wraps (4)	

R. poly bottles 2 500ml empty
S. poly bottle 2 250ml (50ml alcohol)

* 5 bags @ each crib with 10ml acetone & ≈ ½ roll ~~Kim wipes~~ 5/16/17 Cheese cloth

** In Fire bag:
brush (1)
hammer (1)
screw driver (2)
Kim wipes out (20g)
leather gloves (2)
rubber gloves (1 pair)
electric cord (1)
handle
1 bag with 10ml acetone & ≈ ½ roll cheese cloth

Revision History	
Revision & Justification	Authorized Signatures