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Title: Evaluation of Glovebox Fires Involving Flammable Liquids and Standard Glovebox Tools Final Report

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Los Alamos NATIONAL LABORATORY

Evaluation of Glovebox Fires Involving Flammable Liquids and Standard Glovebox Tools

Final Report

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1 Purpose

This research effort was commissioned to examine factors related to loss of containment due to fire within a glovebox (GB). Tests consisted of multiple trials with varying initial conditions. Combustible levels and types were chosen to reflect realistic operation conditions (including worst-case scenarios), involving flammable liquids, GB tools, and other combustible items commonly found in GBs at Los Alamos National Labs (LANL).

2 Scope

These experiments focus on loss of the GB containment barrier through fire-related loss of a glove, cracked or lost window, or fire-related failure of the HEPA filter. No radioactive materials are involved or considered in these experiments. Fires are quantified as to their duration, heat produced, and peripheral effects on components associated with the GB. The GB environment is quantified in terms of temperature, pressure, and air flow.

3 Glovebox and Data Acquisition Setup

This section provides a summary of the apparatus used, the measurements made, experimental procedures, and steps associated with data processing. Additional details are included in the test plan, which is included in Appendix A.

The GB used in these experiments was provided by LANL (Fig. 1, right). NMT fabricated a test stand, ductwork, and various minor components required to facilitate the various sensors used. The resulting apparatus is illustrated in Figure 1 (left).

3.1 Glovebox Preparation

Key details of the GB preparation are:

1. The GB has an internal volume of 72 ft^3 and was sealed with a combination of LANL-standard services panels and custom panels constructed by NMT. Interfaces were sealed using LANL-standard gasket materials or silicone caulk. Bolts used in affixing panels and windows were tightened to 25 in-lbs using a LANL-provided, calibrated torque wrench.

2. LANL-standard glass windows were used as view ports for video/image capture, with one exception; IR images were obtained through a 4" diameter Fluke IR Window incorporated into a steel blanking plate.

3. Gloves and associated installation hardware were inspected by LANL personnel. For clarity, the individual ports of GB are numbered as described in Figure 2.

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 (Fantech FG 12 EC, Appendix B).

5. Air travels into the GB via a sequence of: TSI model 5725 vane anemometer, 3” circular flange, LANL-supplied Flanders 8” square HEPA filter, through a custom ducta and into a rectangular panel opening in the lower corner of the GB.

6. The air exits the GB through a sequence of: 8” spool sealed to the GB by means of a neoprene gasket, LANL-supplied, Flanders 8” round HEPA filter, 2” ball valve, 2”, 4”, 8”, 10”, and 12” diameter duct reducers, 12” diameter exhaust line, the inline fans described above, and finally through the 12” diameter bunker exhaust duct (Fig. 2).

7. Air flow was adjusted to achieve an initial GB vacuum of 0.6 inAq, corresponding to an air flow of approximately 35–40 CFM.

8. An aerosol-based fire suppression system was installed for emergency use in the event of a catastrophic fire event.

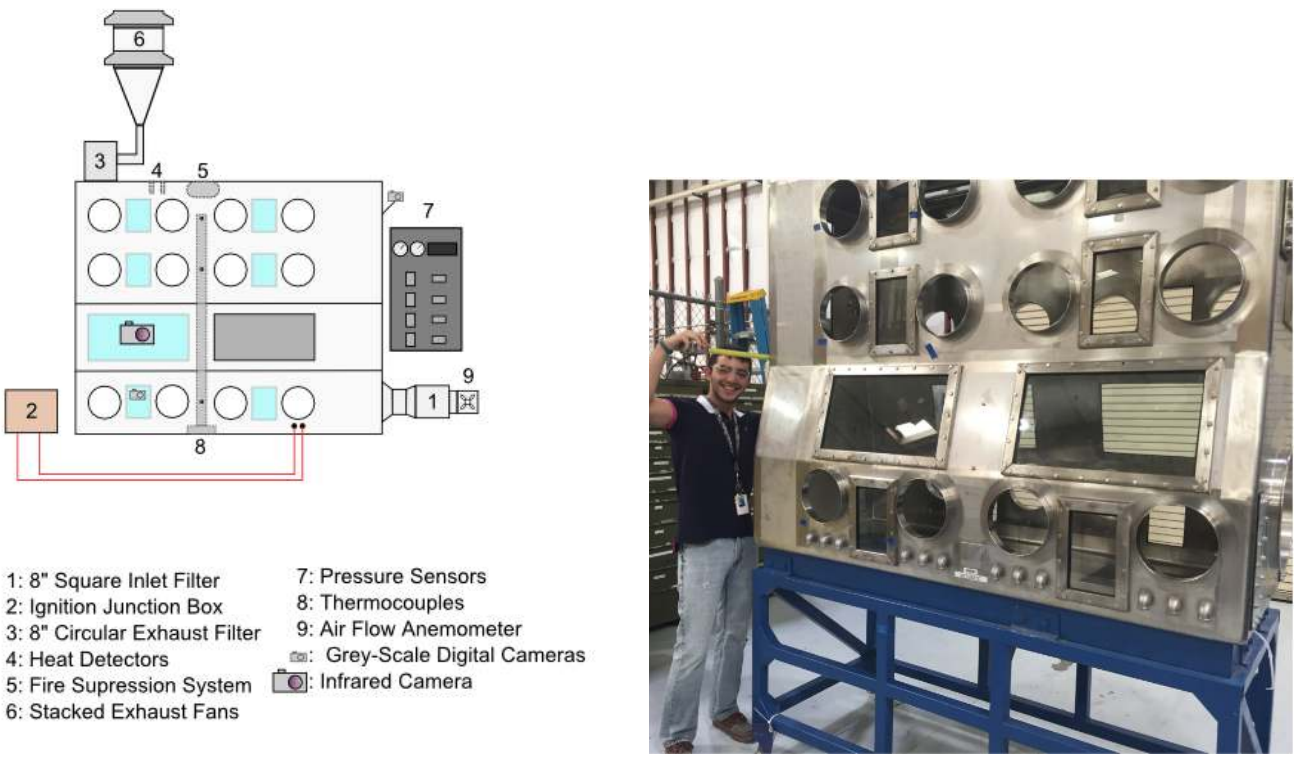


Figure 1: Main glovebox and peripheral component setup.

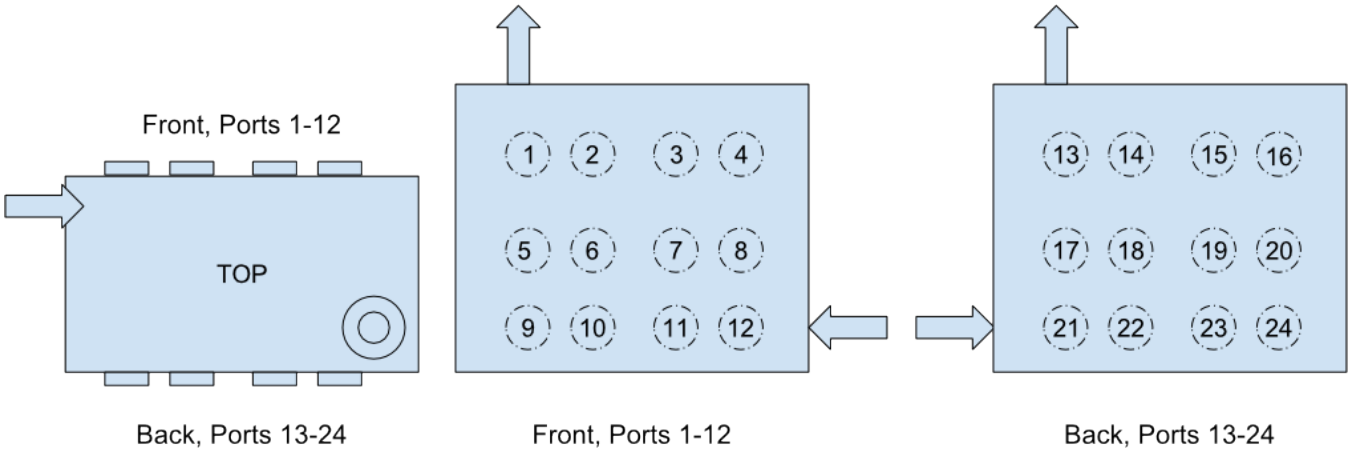


Figure 2: Glovebox glove port numbering scheme.

3.2 Data Acquisition

Sensors were installed, located as indicated in Figure 1 (left), where:

1. All sensors used in the experimental apparatus are National Institute of Standards and Technology (NIST) traceable, except where noted. Calibration sheets are included in Appendix C.

2. Thermocouples T1, T2, and T3 (Omega model XC-20-K-120-CAL-3) 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.

3. Thermocouple T4 (Omega model XC-20-K-120-CAL-3) was used to measure temperature in the bunker containing the GB.

4. A pair of differential pressure transmitters were used to redundantly measure the pressure drop across the exhaust filter (Dwyer model 648B-05, range 0–+2.5 inAq, Fig. 3 (a)).

5. A pair of differential pressure transmitters were used to redundantly measure the GB interior pressure relative to ambient pressure (Dwyer model 648B-15, range -1–+1 inAq, Fig. 3 (a)).

6. For further redundancy, and to accelerate tuning, two analog pressure gauges were installed in parallel to calibrate the GB pressure drop to approximately 0.5" ±0.01 inAq gauge pressure before beginning data acquisition. (Dwyer, model 2302 Magnehelic, non-NIST-traceable, Fig. 3 (a)).

7. LANL-provided wells in the ceiling of the GB allowed installation of Fenwal sensors ("Detect-A-Fire", Model 27021-0) 140°F and 190°F heat detectors.

8. A data-logging vane anemometer was sealed to the air inlet and measured flow through the GB (TSI model 5725, Fig. 3 (b)). Note this measurement assumes no alternate air path, making this measure inaccurate in the event of a breach.

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

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 reference images for object temperatures in comparison to one another during testing (Fig. 3 (c)).

11. Relative humidity in the bunker was recorded using a digital humidity sensor (AcuRite, model 00613, non-NIST-traceable).

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

(a) (b) (c)

Figure 3: Sensor details including: (a) custom tubing allows measurement at multiple GB locations while the lines are protected from soot entering, ultimately terminating at a pressure transducer panel; (b) vane anemometer; and (c) infrared camera.

3.3 Controlled Fire Trial Set-up

1. The GB was initially washed and rewashed after any tests producing a considerable soot coating within the GB using a pressure washer, Fantastik cleaner, and Windex.
2. The video camera mounted in the upper window on the short side of the GB was positioned to entirely capture the GB floor and setup area.
3. Using a live feed from the camera, an overlay was developed using transparent sheet laid over the computer monitor in the adjacent bunker and tracing the object placement. This overlay was used in the successive trails of each condition to ensure consistency of combustible placement.
4. Two 22 AWG Nichrome 80 igniter wires were cut to a length of 18.84" and were coiled around a 5/16-18x1-1/2" screw (Fig. 4).
5. The igniter coils were connected in parallel to a 12V car battery using alligator clips and fire-proof wire. The circuit was connected to a relay within a junction box and remained in the normally off position until activated from the control room.
6. The igniter coils, alligator clips, and any singed wires were replaced for each successive trial.
7. A portion of the GB floor was covered with aluminum foil to facilitate faster cleanup. A thin-wire basked was placed atop this to assist in the arrangement of combustibles.
8. Combustibles and associated components were prepared and installed according to the experimental plan.

Figure 4: Ignitors were prepared from 22 AWG Nichrome wire.

3.4 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 adjacent to another, wherein personnel and instrumentation/control hardware were located during testing. A strict protocol was established to ensure that the experimental plan was followed closely without variation, relying upon a detailed checklist (Appendix A). Critical test parameters and a record of key events was made using an LANL-approved data sheet (Appendix D). After each experiment, data were saved to multiple locations, the GB was cleaned, and inspected.

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

4 Glovebox Combustibles

Eleven unique configurations of standard GB combustibles (Tables 1–4) were determined by LANL-representative Ralph Clayton (Certified Fire Protection System Engineer and LANL Cognizant Fire System Engineer) and categorized as Conditions 1-11. For all but one condition, three trials were run, with the combustible layout and combustible quantity unchanged between trials (Fig.6). The combustibles in each trial were placed in a manner simulating where items might be located during actual GB use (i.e. leather gloves were placed between the GB gloves as opposed to on the opposite side of the GB, as this would be an accessible location during actual GB use). The first several conditions were set up to resemble what were predicted to be worst-case scenarios in terms of combustible placement. Later conditions were then arranged to identify arrangements for which combustibles might not support a fire capable of breaching the GB.

Table 1: Glovebox Consumables Used.

Combustible	**Mass**	**Image**
Half-package Cheesecloth (71” x 8”) Brand: Pure Acres Farm	1.09oz (15.5g)	
Horsehair Brush Brand: Quickie Jobsite	9.28oz (263g)	
Lab Wipes Brand: Kimtech	5.57oz (158g)	
XL Leather Gloves Brand: Wells Lamont	2.5oz (72g) ea.	

Table 2: Glovebox Consumables Used (cont.).

Consumable	**Mass**	**Image**
Oak Dowel (3ft.)	5.96oz. (169g)	
Power Cord (3ft.) Brand: HDX	2.6oz (74g)	
Rubber Mallet Brand: Pittsburgh	19.9 oz. (564g)	
Sheet of Sandpaper (9”x11”) Brand: 3M	0.5oz (2g)	

Table 3: Glovebox Consumables Used (cont.).

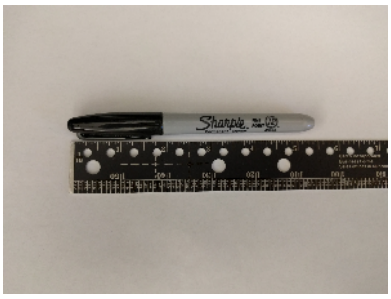
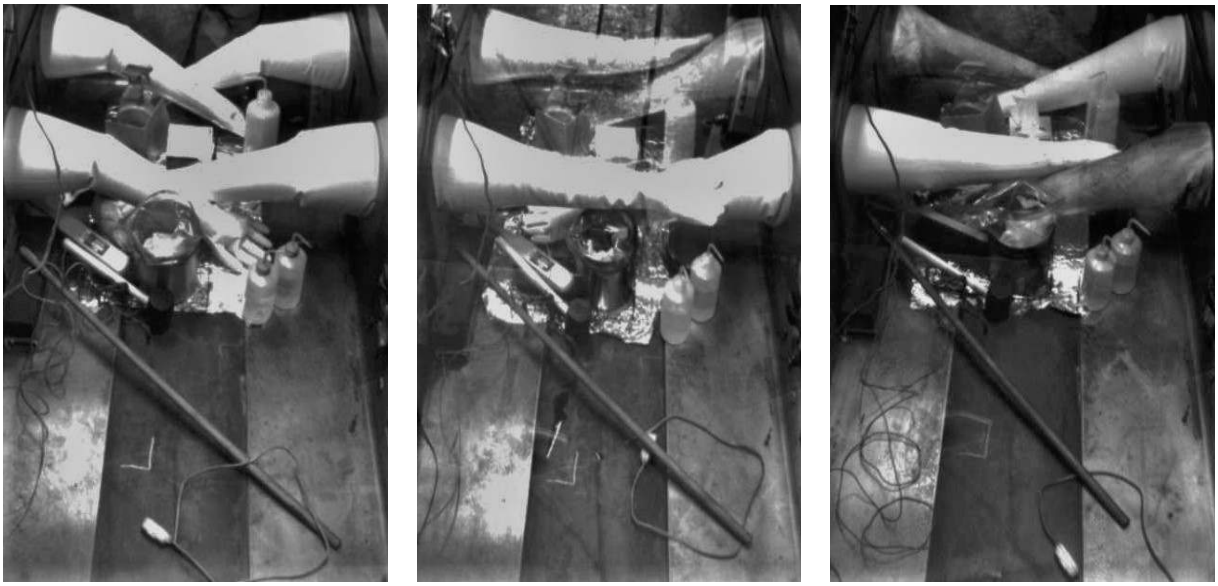
Consumable	**Mass**	**Image**
Screwdriver Brand: Pittsburgh	3.35oz. (95g)	
Permanent Marker Brand: Sharpie	0.33oz. (9.3g)	
Polymer Tubing Brand: Tygon	9.74oz. (276g)	
250mL Wash Bottle Brand: Nalgene	1.27oz. (36g)	

Table 4: Glovebox Consumables Used (cont.).

Combustible	**Mass**	**Image**
500mL Wash Bottle Brand: Nalgene	1.73oz. (49g)	
1000mL Wash Bottle Brand: Nalgene	3.77oz. (107g)	
Sealable Plastic Bag Brand: Ziploc	.30oz. (8.6g)	

To a significant extent, the particular layouts chosen were informed by two sets of preliminary experiments. The first of these preliminary experiments were conducted to evaluate the response of glove material specimens subjected to a range of thermal environments in order to determine the levels of thermal exposure that could cause rupture of specimens of the same material/thicknesses utilized in the full-scale experiments. The details of these experiments are presented in Appendix E. The results indicate that Hypalon gloves of 15 mil and 30 mil thickness begin to decompose and may rupture when exposed to temperatures greater than 500 °F. The second set of preliminary experiments focused on determining the combustion properties (e.g., ignition temperature) of various items commonly found in LANL gloveboxes. The details of these experiments are presented in Appendix F. From these tests, the combustibles that were readily ignitable and or burned at temperatures high enough to affect glove integrity (i.e., $\geq$500 °F) were identified to be: cotton, leather gloves, polypropylene bottles, sandpaper, spray cleaner bottle, mallet heads, horsehair, and



(a) Condition 01 Trial 1 (b) Condition 01 Trial 2 (c) Condition 01 Trial 3

Figure 6: Example of condition repeatability between trials.

sandpaper.

For all tests, shop towels were placed beneath the igniter coils to encourage the presence of an initial flame. Except where noted, the bag containing "unused" cheesecloth wetted with isopropanol alcohol was placed directly above the coils, serving as the primary combustible, and is therefore hereafter frequently referred to as the "ignition bag". Preparation of these bags was based on an LANL limits for isopropanol in GBs. This was provided as 38 cc per 100 ft^3 of interior volume. Given that the GB used in these experiments has an volume of 72 ft^3, this was reduced to 27 cc. Two-thirds of the allowable isopropanol (19 cc) was used to wet the "new" cheesecloth, which was left in the original folded (compact) state. One third of the allowable (8 cc) was used to wet the "used" cheesecloth, which was unfolded and wadded (Fig. 7). These quantities of alcohol were weighed using a precision digital scale and added immediately before each trial (14.44g and 6.08g). This assumes a density of 0.76 g/cc was determined on site using the same scale: 388 g for 500 mL. A 125 mL squeeze bottle held an additional 125 mL of isopropanol. Other squeeze bottles were prepared as follows: one 500 mL left empty; two 250 mL, filled to 3/4 volume with water (Fig. 7).

Test results are categorized by Conditions 01-11 in the section that follows. Results include: pressure, temperature, air flow, and thermal detector data along with optical and IR images.

5 Fire Setup Conditions and Results

Results for each trial, organized by condition, are included in the subsections that follow. Roughly, the conditions are ordered from more to less severe fires, not in the order they were actually executed. Key results are highlighted in Table 5. Comprehensive before and after images associated with each condition are also included Appendix G.

For the purposes of this report, we define a **breach** as an opening, of any size, that creates a

Figure 7: Glovebox combustibles including the prepared "ignition bags", wire basket, and the squeeze bottles marked according to their preparation.

pathway for air to travel into or out of the GB, other than by means of the inlet and exhaust lines. It follows that a small breach might not result in loss of the GB containment barrier.

5.1 Condition 01

Layout

The combustible materials identified in the previous section were placed on the floor of the glovebox in locations represented schematically in Figure 8. Readily combustible materials such as cotton rounds, sandpaper, a polypropylene bottle partially filled with alcohol, and lab wipes were placed in close proximity to the ignition source to draw the fire towards the open steel canister. Other combustibles which were not expected to ignite as readily, such as the horsehair brush and mallet, were also placed between the ignition source and canister to test whether they could sustain a flame during a particularly robust fire and supply a steady flame to the steel canister. Gloves from ports 9, 10, 23, and 24 were pulled into the GB, simulating having two adjacent GB workers leaving both sets of glove in an active GB environment. An image of the actual layout before commencement of each trial is shown in Fig. 9.

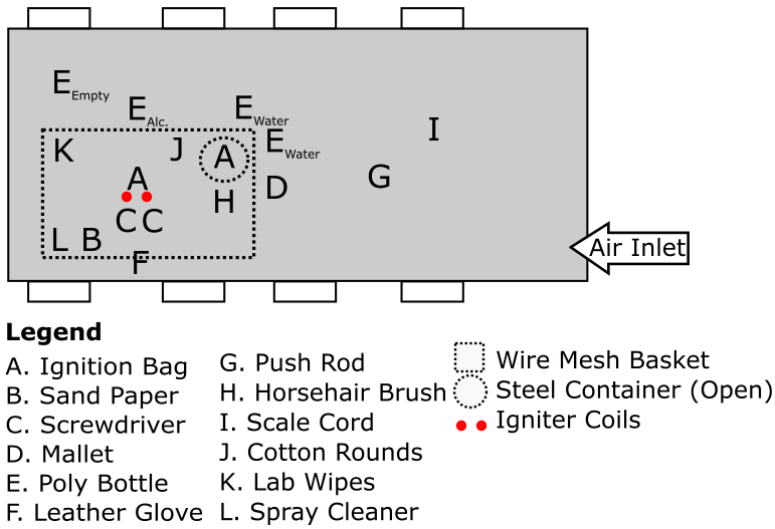
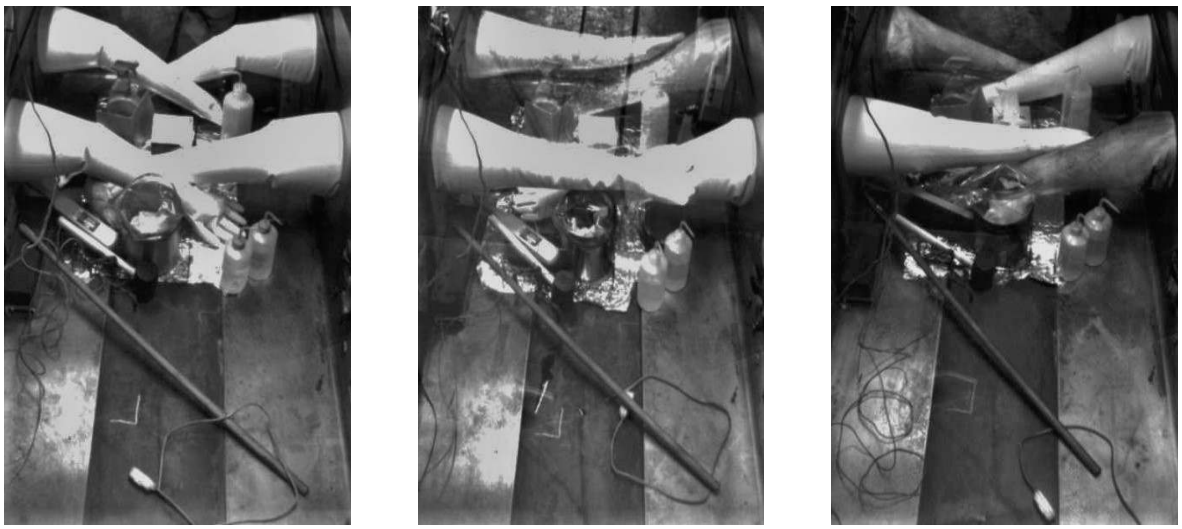


Figure 8: Combustibles layout for Condition 01.

Results

Data obtained during the three trials of Condition 01 are presented in Figure 10. The ignitors were activated at time $t = 0$ s, and the temperature began to increase after some combustible materials in the GB ignited. For Trial 1, a breach occurred at $t = 68$ s, as indicated by the sudden changes in pressures (Fig. 10(d)) and an associated drop in flow rate (Fig. 10(g)). At the time of the breach for Trial 1, the highest measured temperature in the GB was approximately 100°F, and neither of the heat detectors had activated. After breach, the temperature inside the GB continued to rise due to the burning of combustibles as well as the gloves themselves and the 140°F thermal detector did eventually activate. Similar behavior is observed in the other trials of this condition. The 190°F heat detector activated only during Trial 3. In all three trials, the final GB vacuum was essentially lost (no more than 0.02 inAq)

Ultimately, two of the four gloves left inside the GB were breached for all trials, and the majority of the glove attached to port 10 was consumed in each case, as can be seen in the postmortem images of Figure 11. This Figure also shows that the open steel canisters failed to prevent the flames interacting with the ignition bags within the canister (note the burned/charred material in (a) and (b)). In Trials 1 and 2, The combustion of the Port 10 glove served as a bridge for the fire to involve the wetted cheesecloth within the canister. Postmortem images of many of the combustible materials and gloves are presented in Appendix G.



(a) (b) (c)

Figure 9: The state of the GB prior to the fire for Condition 01 is shown for each of the three associated trials (a–c).

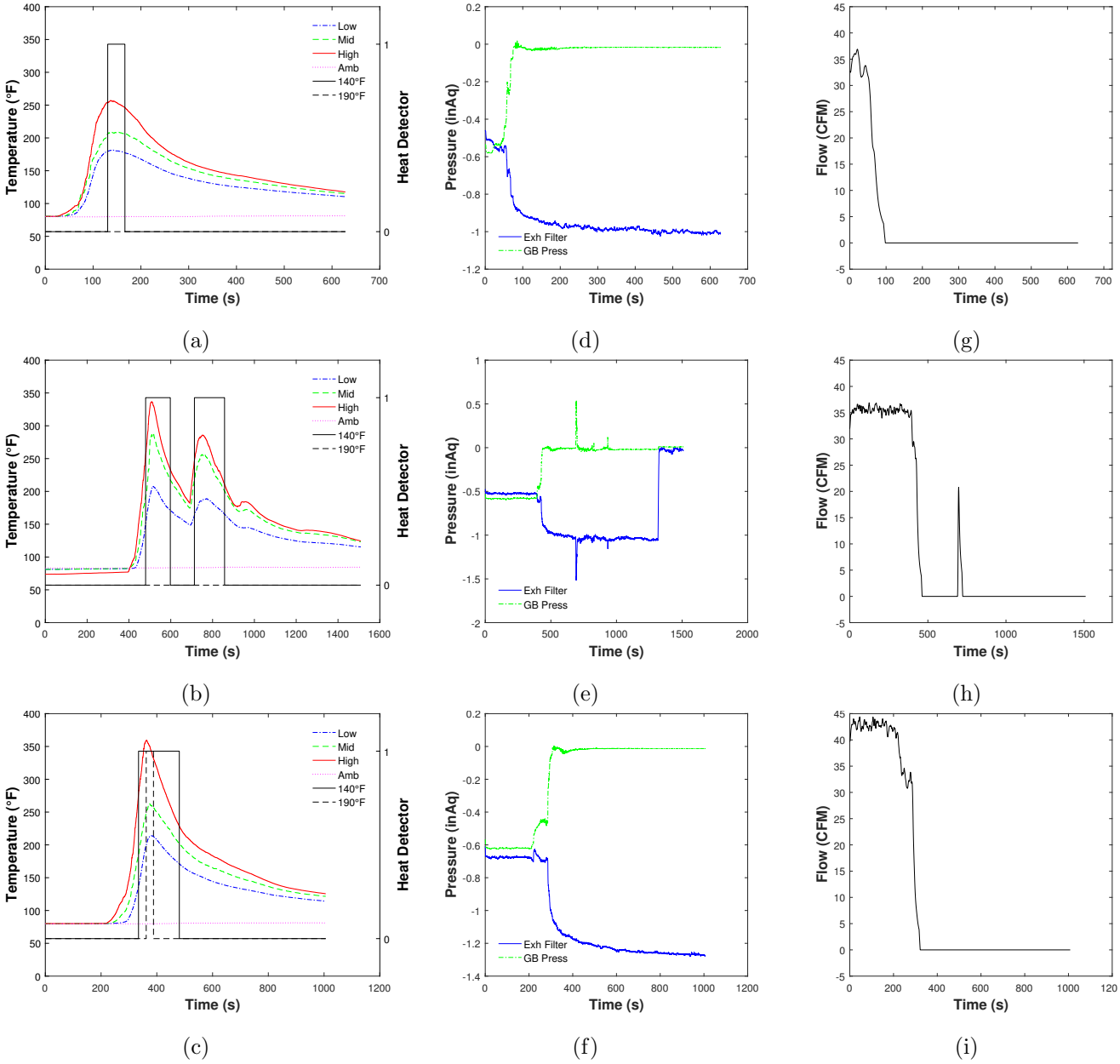


Figure 10: Condition 01 results: temperature and Fenwal activation (a–c), pressure (d–f), and air flow (g–i) are shown for each of three trials.

(a) (b) (c)

Figure 11: The state of the GB after the fire for Condition 01 is shown for each of the three associated trials (a–c).

5.2 Condition 02

Layout

The layout of the combustibles for this condition may be seen in Figures 12 and 13. This layout featured many of the more readily combustible items placed just outside the mesh basket containing from the ignition bags. Less readily combustible items (wooden dowel and extension cord) were placed further away, simulating a typical arrangement during actual GB usage. Again, Port 9, 10, 23, and 24 gloves were pulled into the GB.

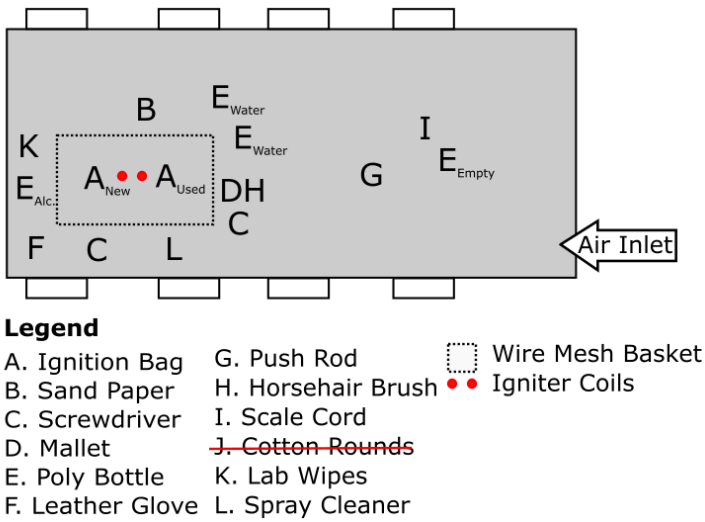
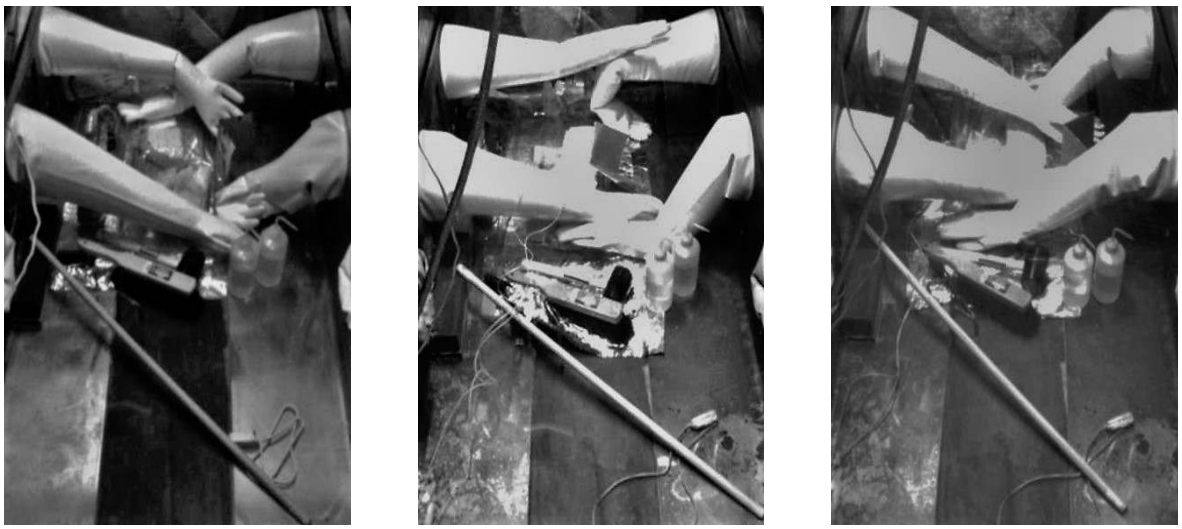


Figure 12: Combustible Layout for Condition 02. Cotton rounds were excluded.

Results

Data obtained during the three trials of Condition 02 are presented in Figure 14. The ignition bag readily ignited and the resulting fire spread quickly. The gloves in Ports 10 and 24, which were near to the "used" cheesecloth, breached in each of the three trials while the combustibles on the other side of the GB were less involved. A localized increase in air flow was again seen to accelerate the fire at the time and location of glove breach. This resulted in significant burning of the combustibles and gloves near Ports 10 and 24, as seen in left side of images in Fig. 15 (a–c).



(a) (b) (c)

Figure 13: The state of the GB prior to the fire for Condition 02 is shown for each of the three associated trials (a–c).

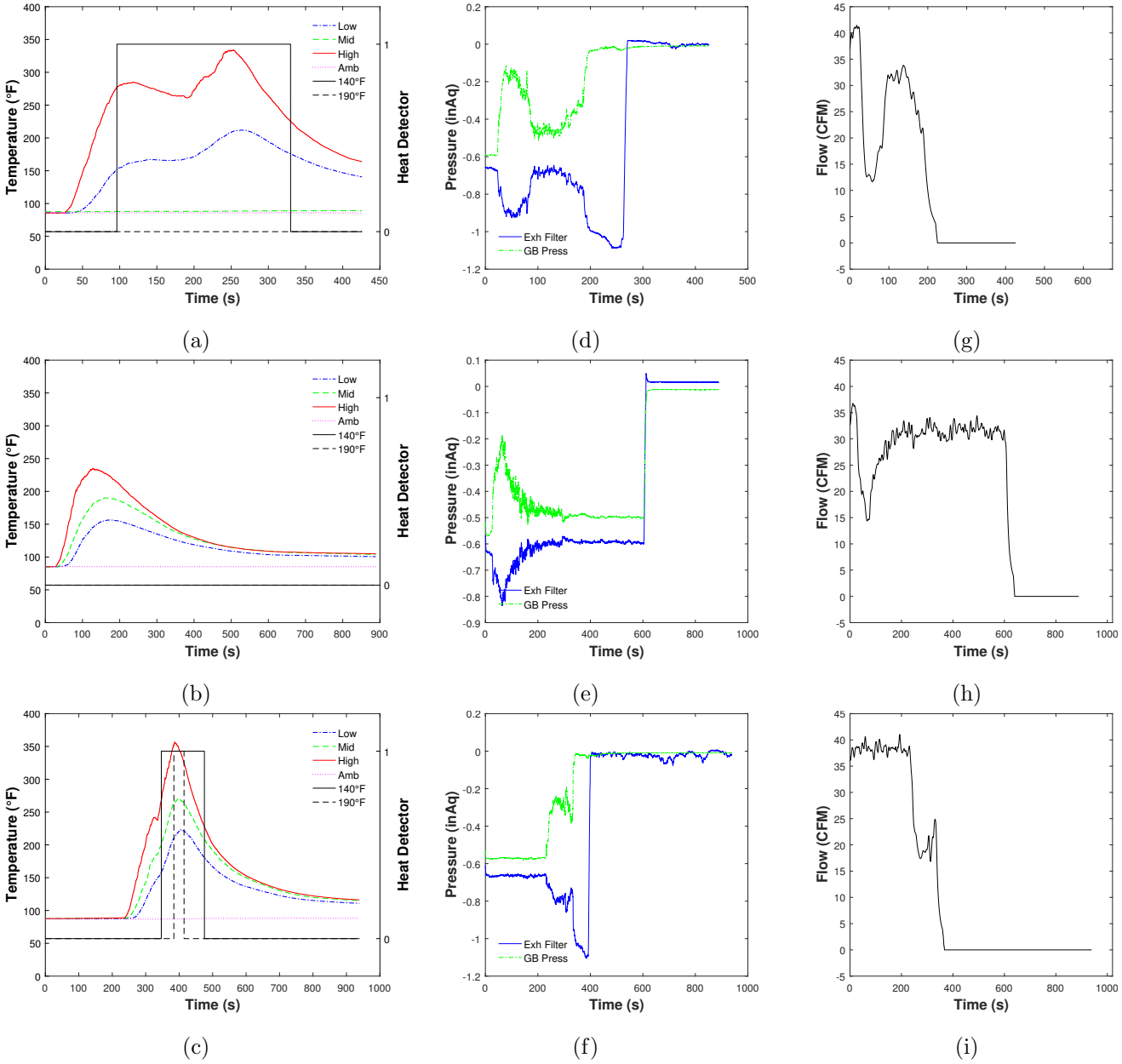
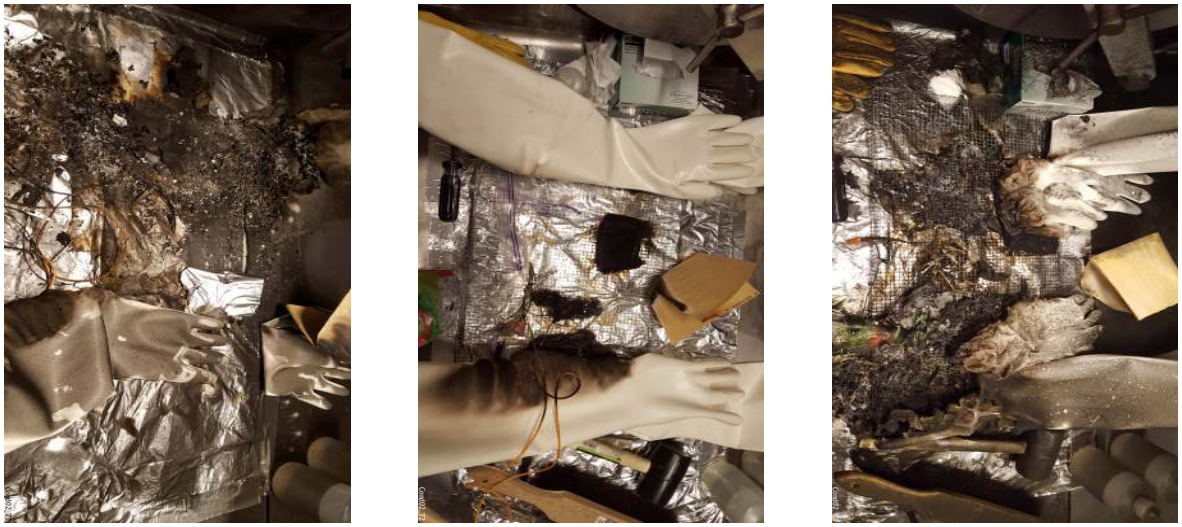


Figure 14: Condition 02 results: temperature and Fenwal activation (a–c), pressure (d–f), and air flow (g–i) are shown for each of three trials.



(a) (b) (c)

Figure 15: The state of the GB after the fire for Condition 02 is shown for each of the three associated trials (a–c).

5.3 Condition 03

Layout

The primary difference between Condition 03 and 02 was the ignitor locations. One was placed in direct contact with the underside of a horsehair brush, both placed atop a shop towel. The other ignitor was placed in contact with a bag of "new" cheesecloth. The bag of "used" cheese cloth was placed a short distance away, next to the rubber mallet. In question was the ability of the fire to spread to and involve this bag and/or ultimately produce a fire of relatively long duration before self extinguishing. The layout of the combustibles for this condition may be seen in Figures 16 and 18.

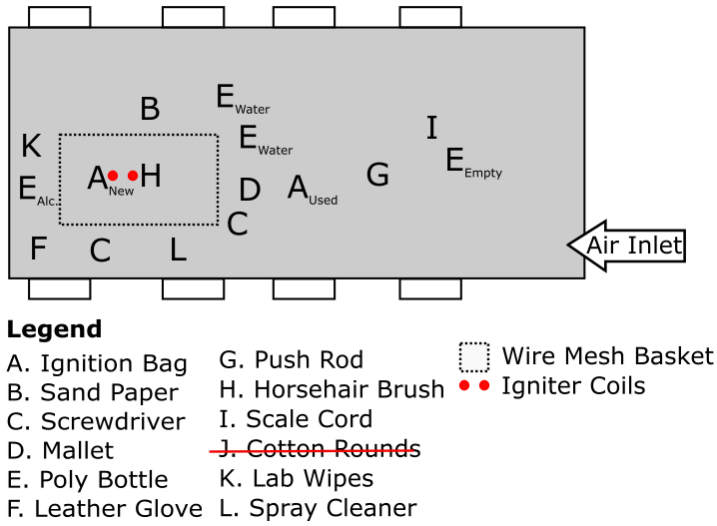


Figure 16: Combustible Layout for Condition 03. Cotton rounds were excluded.

Results

Data obtained during the three trials of Condition 03 are presented in Figure 17. The horsehair brush did not support significant combustion. In Trial 1, the ends of the horsehair brush burned, but self-extinguished before ever producing a visible flame. The bag of "new" cheesecloth consistently produced flame that spread to other combustibles. In two of the three trials, significant glove involvement was observed (Fig. 19).

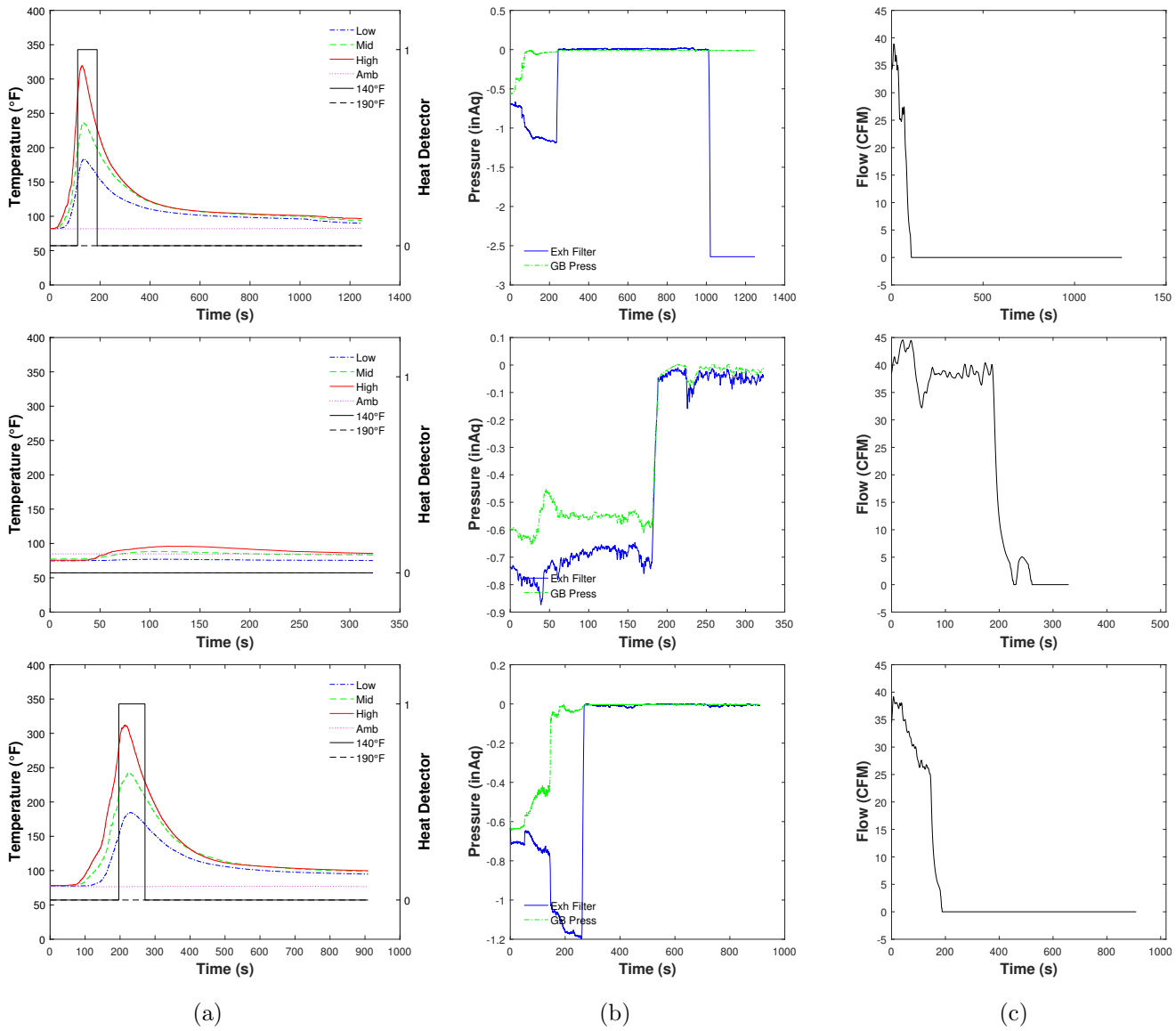
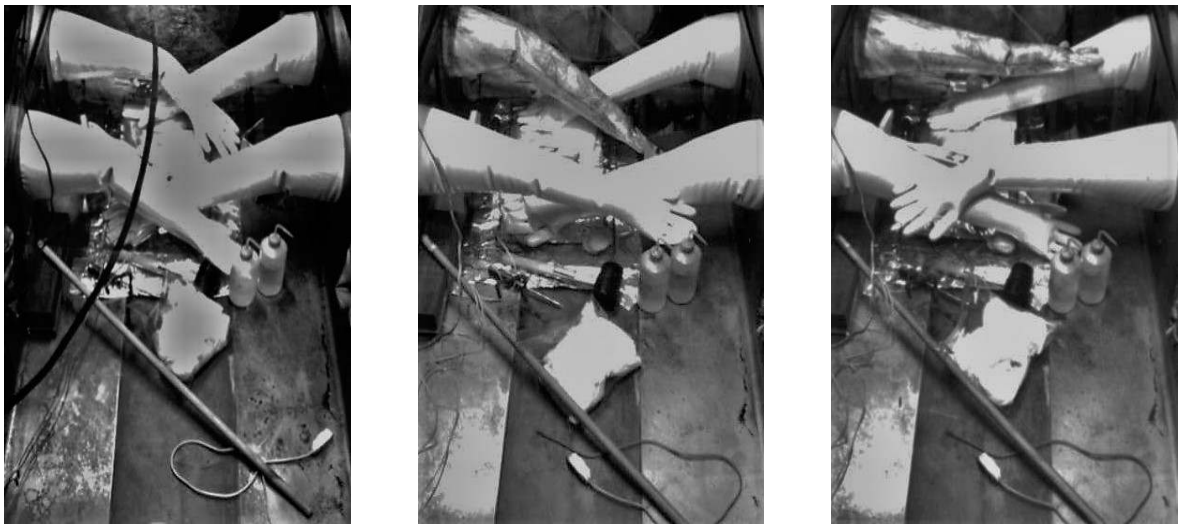
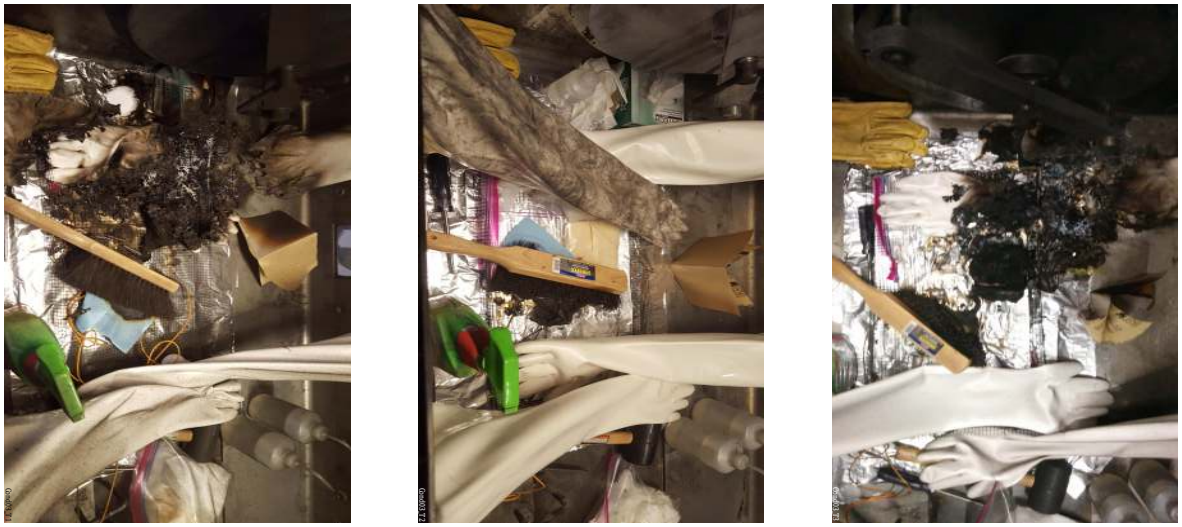


Figure 17: Condition 03 results: temperature and Fenwal activation (a), pressure (b), and air flow (c) are shown for each of three trials.



(a) (b) (c)

Figure 18: The state of the GB prior to the fire for Condition 03 is shown for each of the three associated trials (a–c).



(a) (b) (c)

Figure 19: The state of the GB after the fire for Condition 03 is shown for each of the three associated trials (a–c).

5.4 Condition 04

Layout

Condition 04 involved the same steel canister used in Condition 01 along with a second steel canister. Both canisters contained ignition bags of used alcohol soaked cheesecloth and a lid was placed on top of each. Sandpaper on top of a shop towel was used as the point of contact with the ignitors in front of both steel canisters. For this condition two new items, sharpie markers and flexible polymer tubing, were also introduced. Unlike the prior conditions, only two gloves (Ports 9 and 10) were left in the GB. The layout of the combustibles for this condition may be seen in Figures 20 and 22.

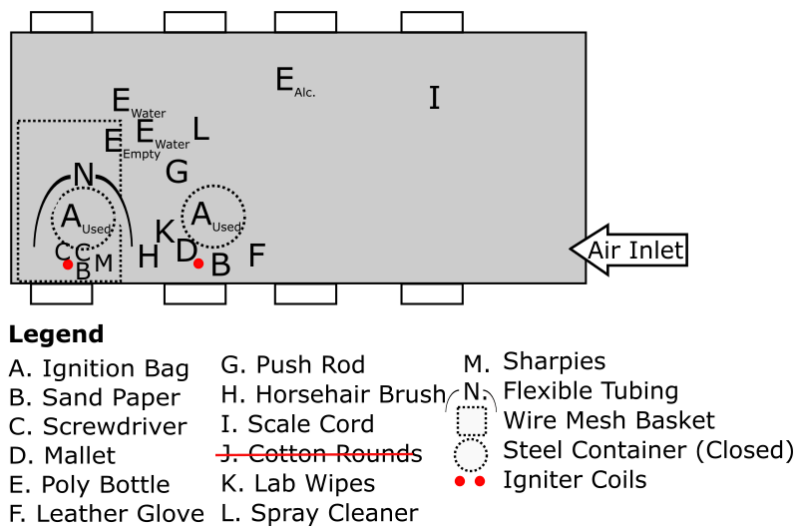


Figure 20: Combustible Layout for Condition 04. Cotton rounds were excluded.

Results

Data obtained during the three trials of Condition 04 are presented in Figure 21. The ignitors did produce fire on the sandpaper, which spread readily to the tubing, but not past the steel canisters in front of the sandpaper. While the fire was unable to engage the ignition bags within the closed steel containers, sufficient heat transfer occurred between the container and the bags, melting of the plastic. The tubing readily caught flame when ignited though the flame was prevented from traveling along the length of the tubing as the tubing melted in on itself. The glove located in Port 9 directly over the fire was breached in each trial (Fig. 23).

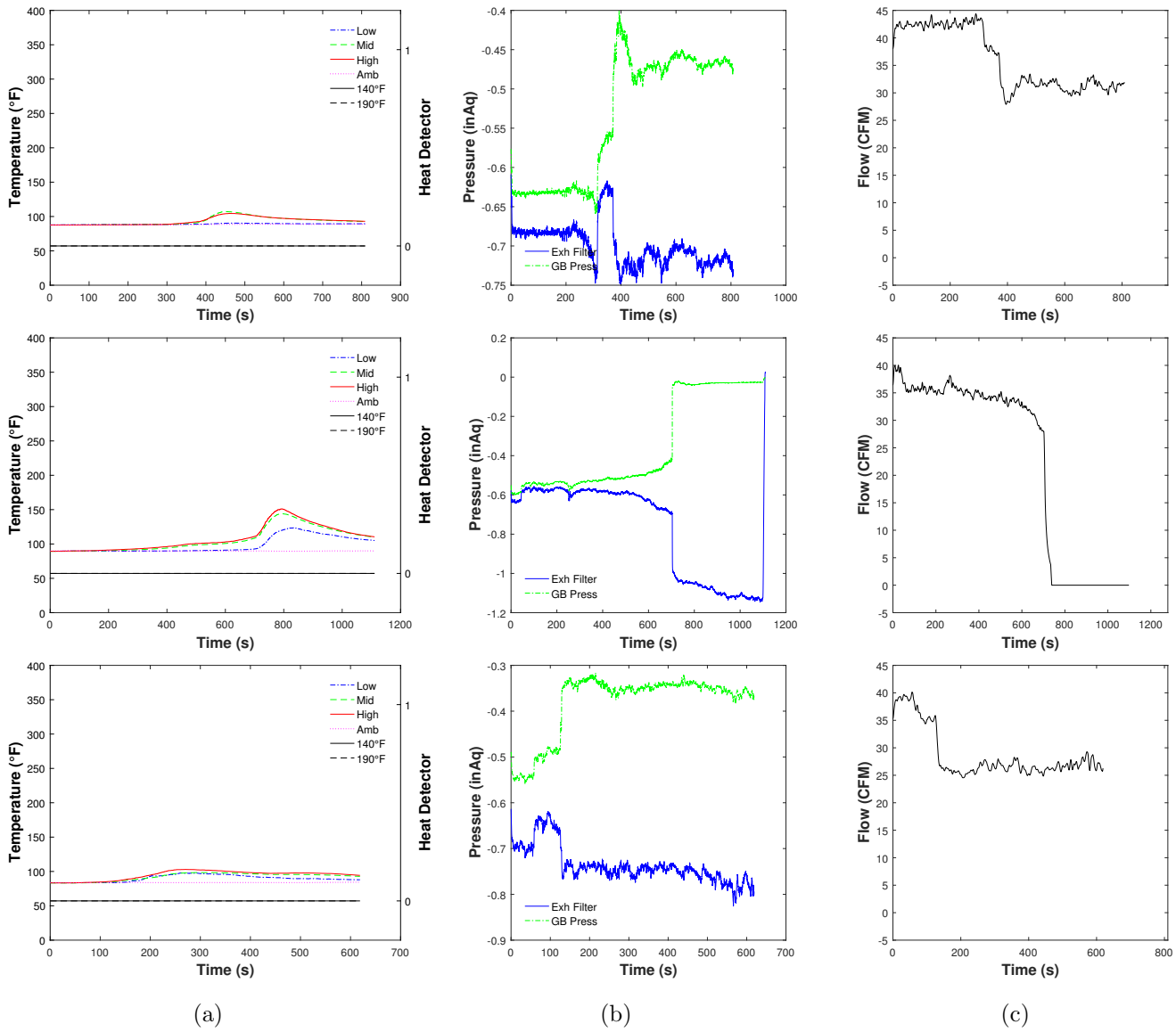
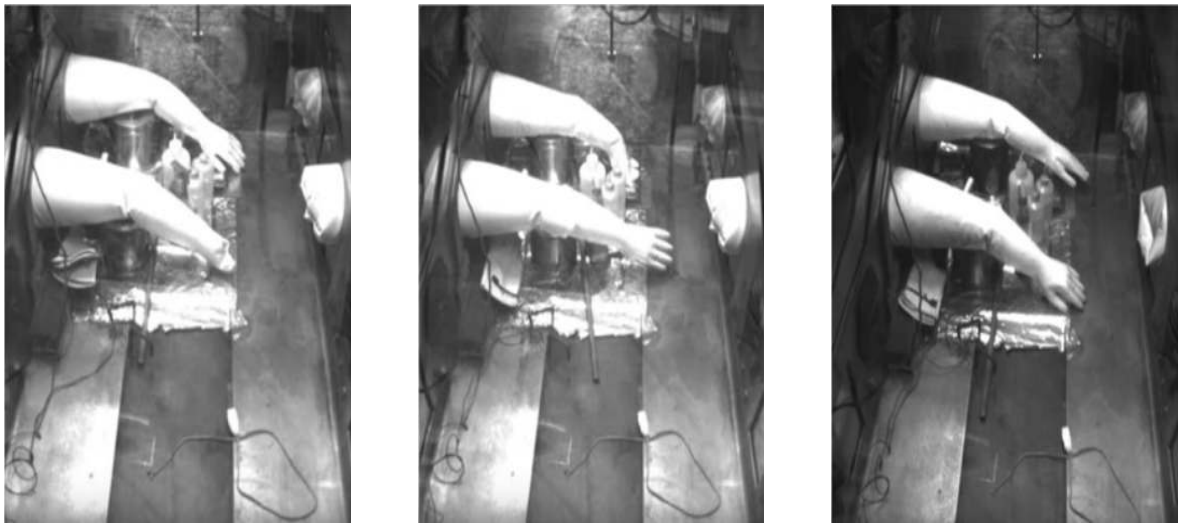


Figure 21: Condition 04 results: temperature and Fenwal activation (a), pressure (b), and air flow (c) are shown for each of three trials.



(a) (b) (c)

Figure 22: The state of the GB prior to the fire for Condition 04 is shown for each of the three associated trials (a–c).

(a) (b) (c)

Figure 23: The state of the GB after the fire for Condition 04 is shown for each of the three associated trials (a–c).

5.5 Condition 05

Layout

Condition 05 followed the pattern of the prior two, investigating other ignitor locations. Here, a horsehair brush (bristles down) and mallet were arranged in contact with the ignitors. Crumpled cheesecloth was placed beneath the brush and mallet to encourage a flame. Readily igniting combustibles including cotton rounds, lab wipes, sandpaper, and the polypropylene bottle of alcohol were placed near the brush and mallet. The bags containing cheesecloth were placed further away from the rest of the materials to gauge the potential distance a produced flame could spread. The two gloves in Ports 23 and 24 were tied outside the GB for this trial to simulate the presence of a single GB worker. Finally, the polypropylene bottle was placed near the hand of the Port 9 glove as opposed to the left side of the glove as the glove hand appeared to more readily ignite in the prior trials. The layout of the combustibles for this condition may be seen in Figures 24 and 26.

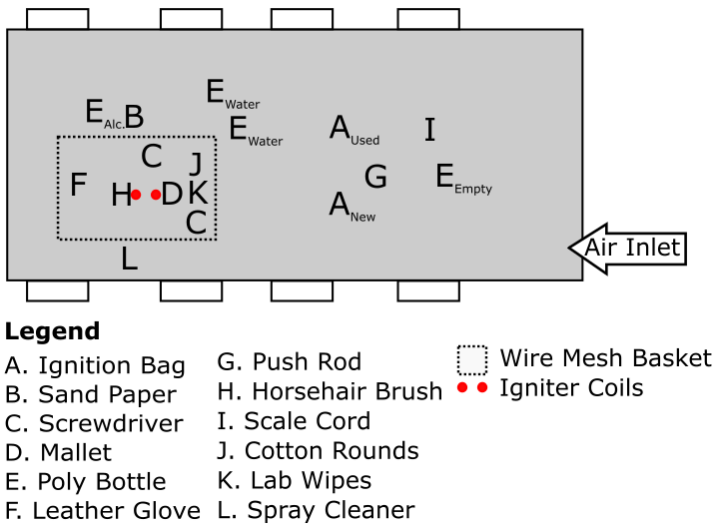
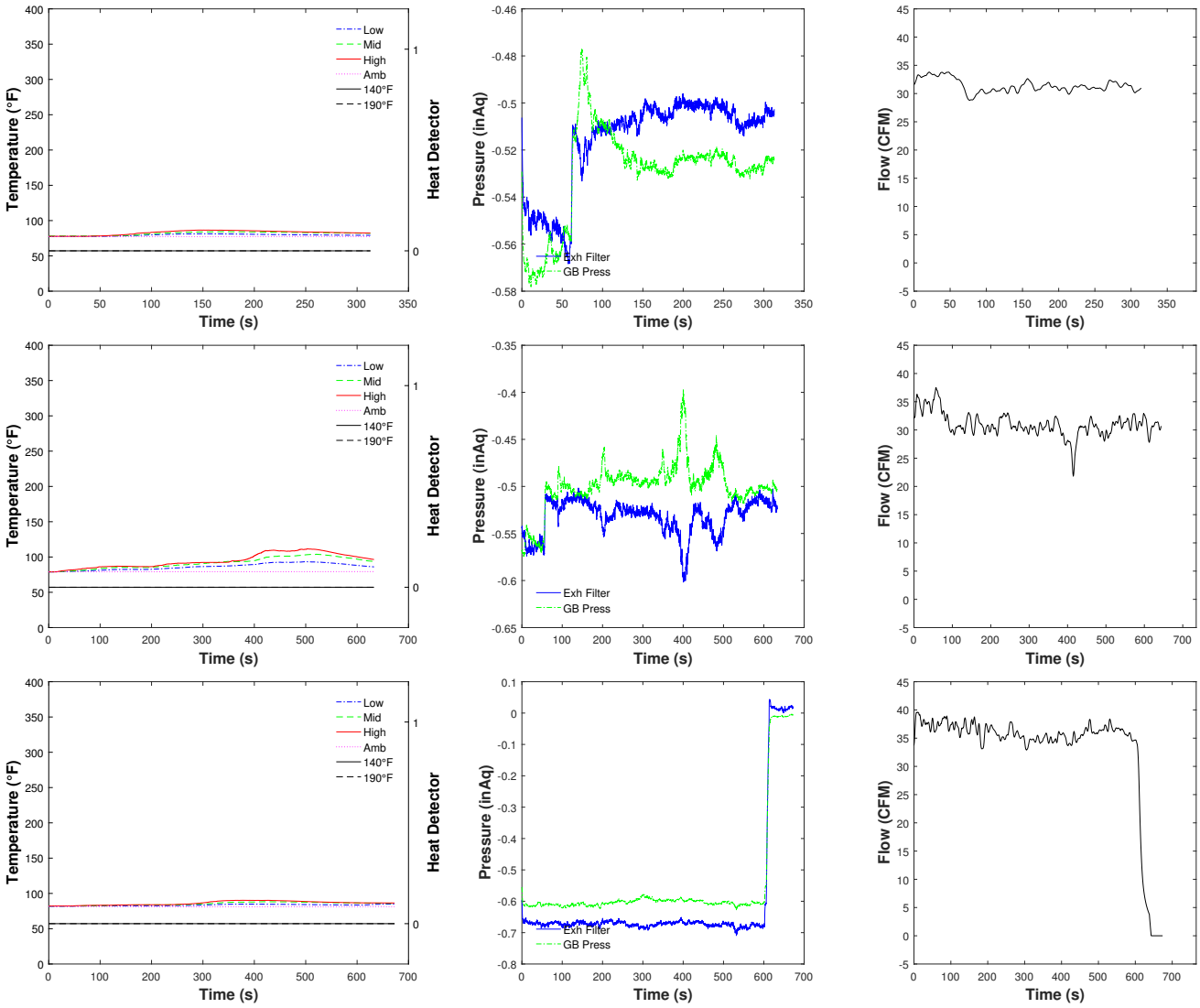


Figure 24: Combustible Layout for Condition 05.

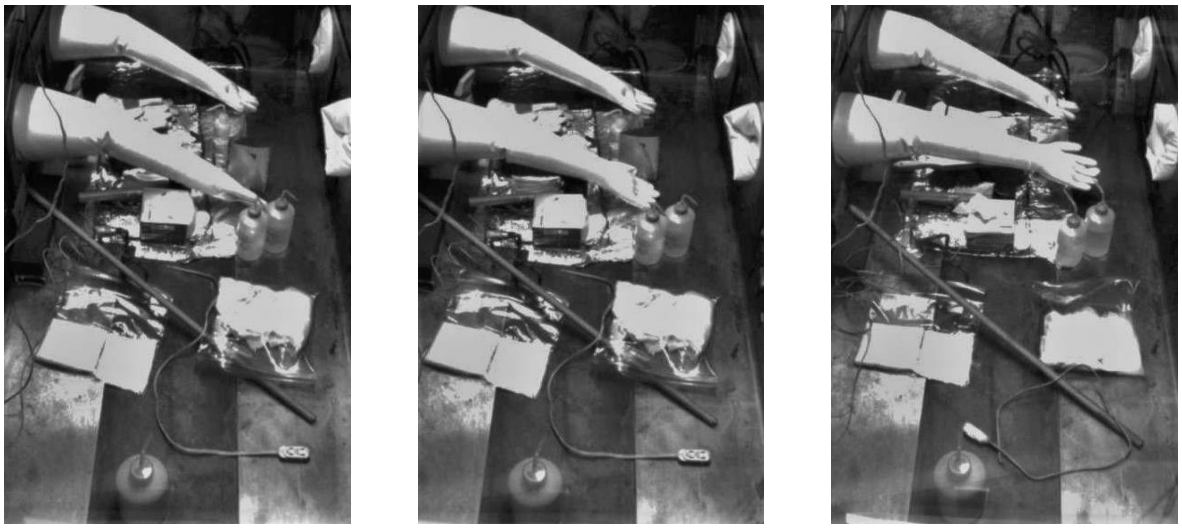
Results

Data obtained during the three trials of Condition 05 are presented in Figure 25. While the crumbled cheesecloth beneath the mallet and brush ignited, the brush and mallet themselves did not support a flame. The the bristles of the horsehair brush sustained a light amount of scorching but did not burn due to the density of the hairs preventing a sufficient flow of oxygen. The rubber head of the mallet appeared to not transfer heat enough to threaten the wooden handle of the mallet or other nearby combustibles (Fig. 27).



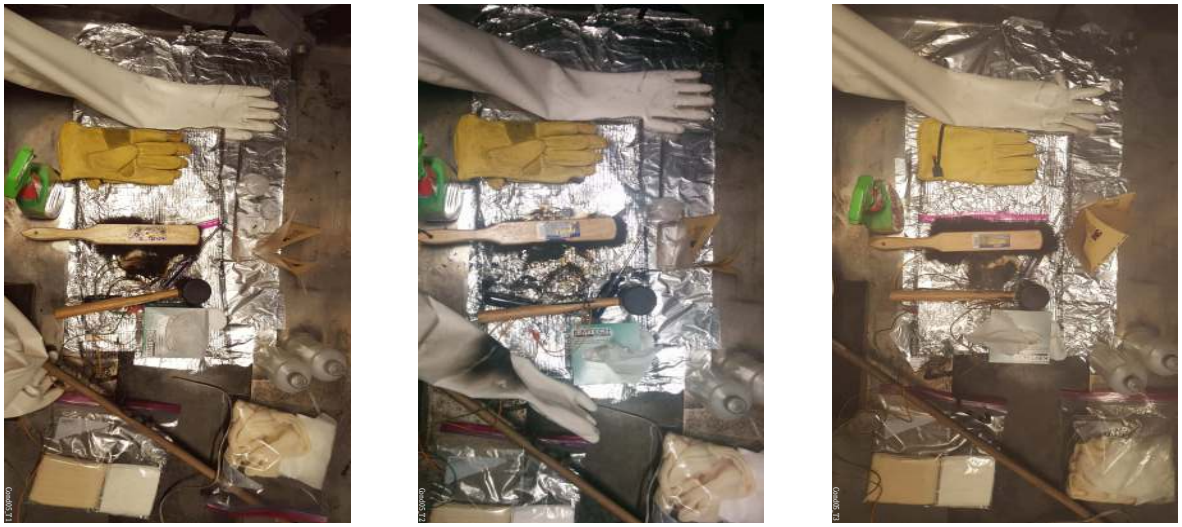
(a) (b) (c)

Figure 25: Condition 05 results: temperature and Fenwal activation (a), pressure (b), and air flow (c) are shown for each of three trials.



(a) (b) (c)

Figure 26: The state of the GB prior to the fire for Condition 05 is shown for each of the three associated trials (a–c).



(a) (b) (c)

Figure 27: The state of the GB after the fire for Condition 05 is shown for each of the three associated trials (a–c).

5.6 Condition 06

Layout

Condition 06 again used the horsehair brush and mallet as the combustibles in contact with the ignition coils. The two screwdrivers were adjusted from the previous condition, one being placed by the horsehair brush and the other outside of the wire mesh basket by the wooden handle of the mallet. The two gloves in Ports 9 and 10 were again left within the GB. Finally, the polypropylene bottle with alcohol was moved approximately 6 inches way from the Port 9 glove hand to test whether it would still engage with the glove in the case of a fire. All of the other combustibles were placed as in Condition 05. The layout of the combustibles for this condition may be seen in Figures 28 and 30.

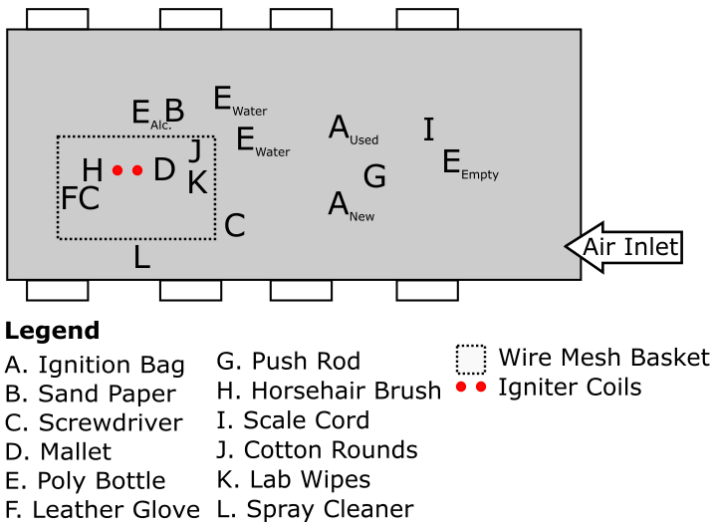
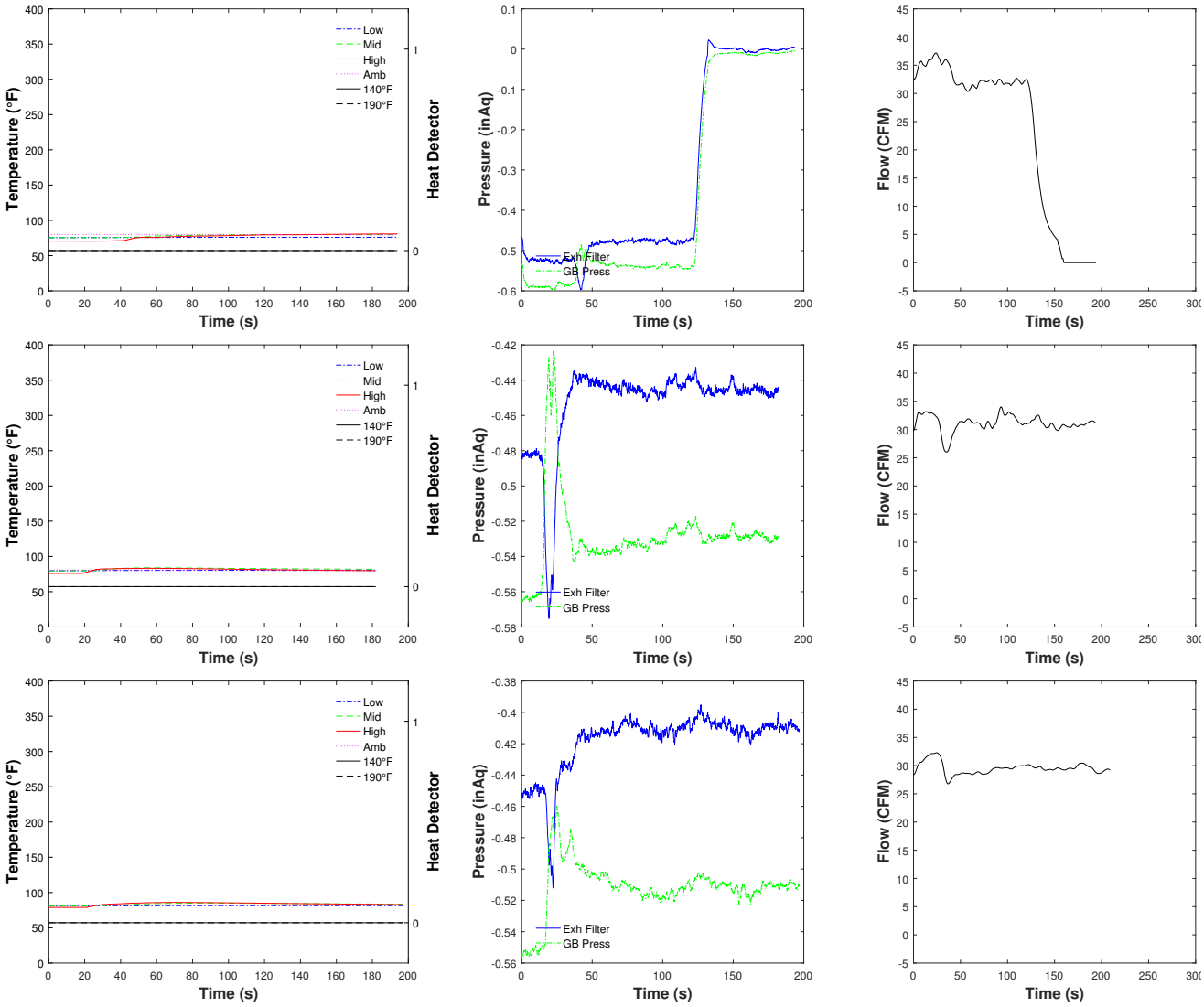


Figure 28: Combustible Layout for Condition 06.

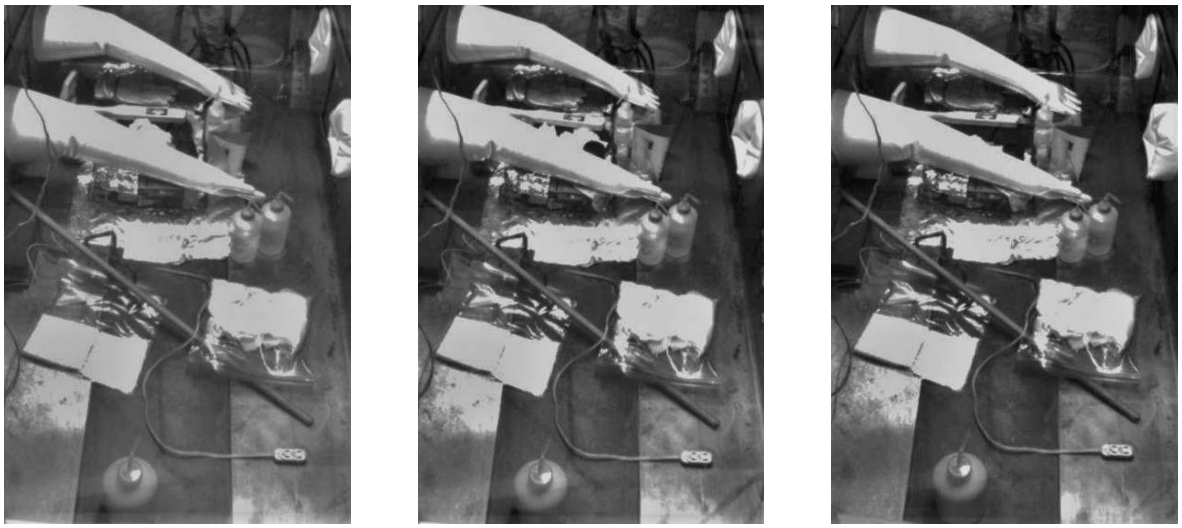
Results

Data obtained during the three trials of Condition 06 are presented in Figure 29. Condition 06, like Condition 05 , did not produce a sufficient flame to spread to surrounding combustibles. The ignitors only singed the mallet handle and tips of the horsehair brush. The horsehair brush required a larger flame to sustain a fire that could spread to other combustibles. The mallet proved to be a poor ignition source for a large fire. The Hypalon gloves were never involved (Fig. 31).



(a) (b) (c)

Figure 29: Condition 06 results: temperature and Fenwal activation (a), pressure (b), and air flow (c) are shown for each of three trials.



(a) (b) (c)

Figure 30: The state of the GB prior to the fire for Condition 06 is shown for each of the three associated trials (a–c).

(a) (b) (c)

Figure 31: The state of the GB after the fire for Condition 06 is shown for each of the three associated trials (a–c).

5.7 Condition 07

Layout

Condition 07 continued to investigate whether or not GB combustibles other than the ignition bags could start and sustain a GB fire. Because neither the mallet or horsehair brush were able to sustain a hazardous fire, the box of lab wipes and the empty polypropylene bottle were placed in contact with the ignition sources (both of these had proved ignitable, with a sustained flame during preliminary testing and early GB fire trials). The polypropylene bottle of alcohol was placed above the box of lab wipes and the cotton rounds to see if a fire would be capable of jumping from the ignition source to a flammable combustible via common cleaning supplies. The other combustibles were moved to a closer proximity of the ignition source to determine whether a flame could travel from these combustibles to a GB glove. The two gloves in Ports 9 and 10 were left within the GB. The layout of the combustibles for this condition may be seen in Figures 32 and 34.

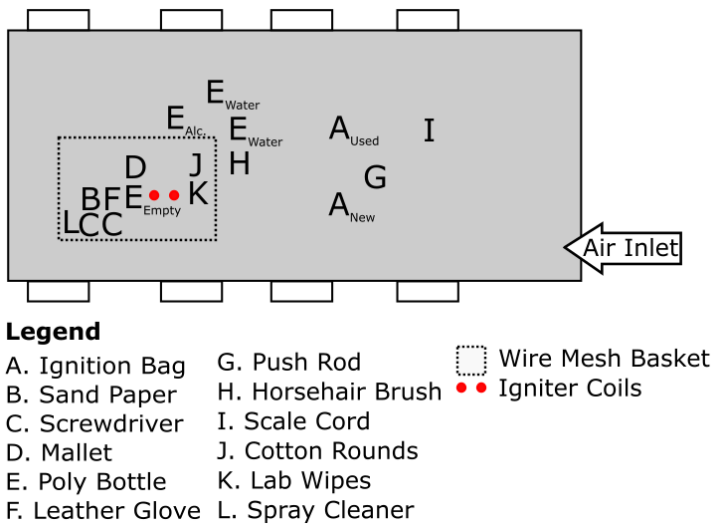


Figure 32: Combustible Layout for Condition 07.

Results

Data obtained during the three trials of Condition 07 are presented in Figure 33. The coils melted into the polypropylene bottle in Trial 3, but no flame was generated. Neither the Port 9 or 10 gloves breached in any of the trials (Fig. 35).

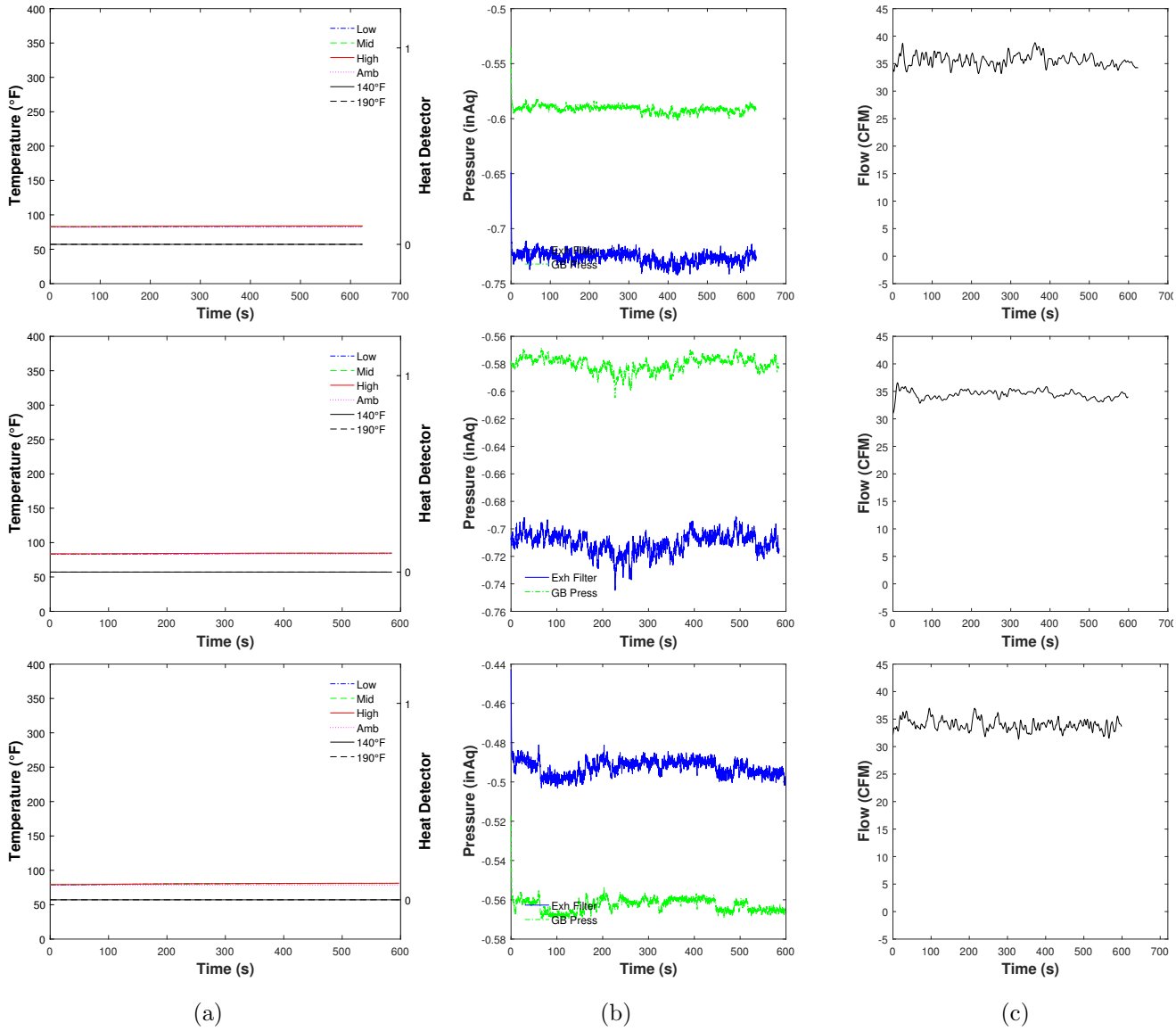
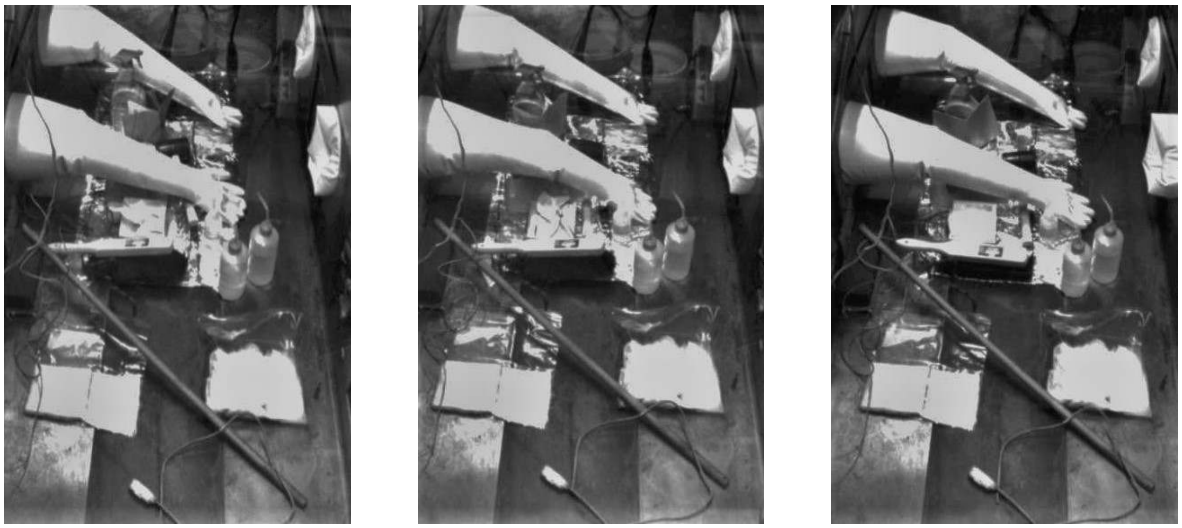


Figure 33: Condition 07 results: temperature and Fenwal activation (a), pressure (b), and air flow (c) are shown for each of three trials.



(a) (b) (c)

Figure 34: The state of the GB prior to the fire for Condition 07 is shown for each of the three associated trials (a–c).

(a) (b) (c)

Figure 35: The state of the GB after the fire for Condition 07 is shown for each of the three associated trials (a–c).

5.8 Condition 08

Layout

Condition 08 continued the use of various combustibles as the point of contact with the ignition coils. The first ignitor had sandpaper placed under it with the pair of screwdrivers placed on top of the coil. The second ignitor also had sandpaper placed under and had the pair of leather gloves placed on top. The steel canisters were reintroduced to hold the ignition bags. The steel canister in front of the Port 10 glove was surrounded by the majority of the combustibles including the wipes, the mallet, and sharpie markers. The second steel canister had the horsehair brush placed next to it. The wooden dowel was placed across the hairs of the horsehair brush and between the wipes and polypropylene bottle to test whether it would act as a bridge for the fire across the GB in the case of a fire. The gloves in Ports 9 and 10 were left in the GB. The layout of the combustibles for this condition may be seen in Figures 36 and 38.

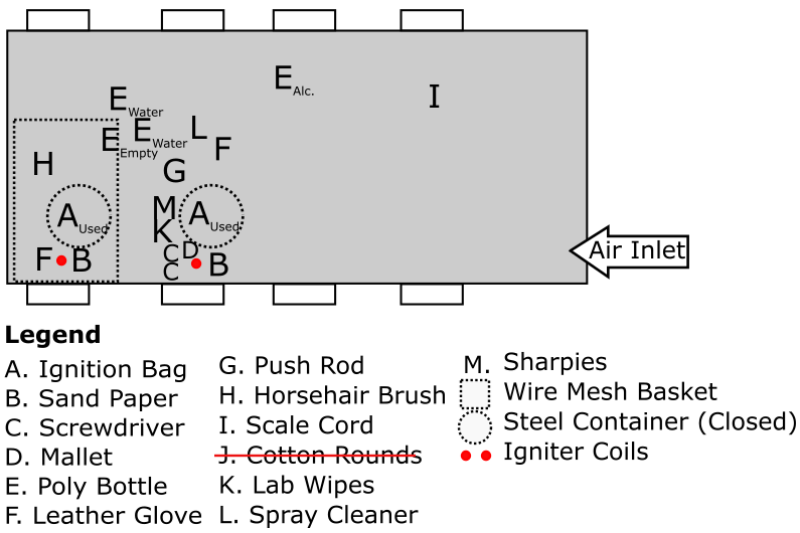


Figure 36: Combustible Layout for Condition 08. Cotton rounds were excluded.

Results

Data obtained during the three trials of Condition 08 are presented in Figure 37. This condition did not result in any sustained fire. The leather gloves failed to ignite due to the lack of oxygen able to flow under the leather gloves. While the coil in contact with the screwdrivers melted the handle, the melting of the plastic over the coil seems to have prevented further oxygen flow (Fig. 39) and prevented ignition.

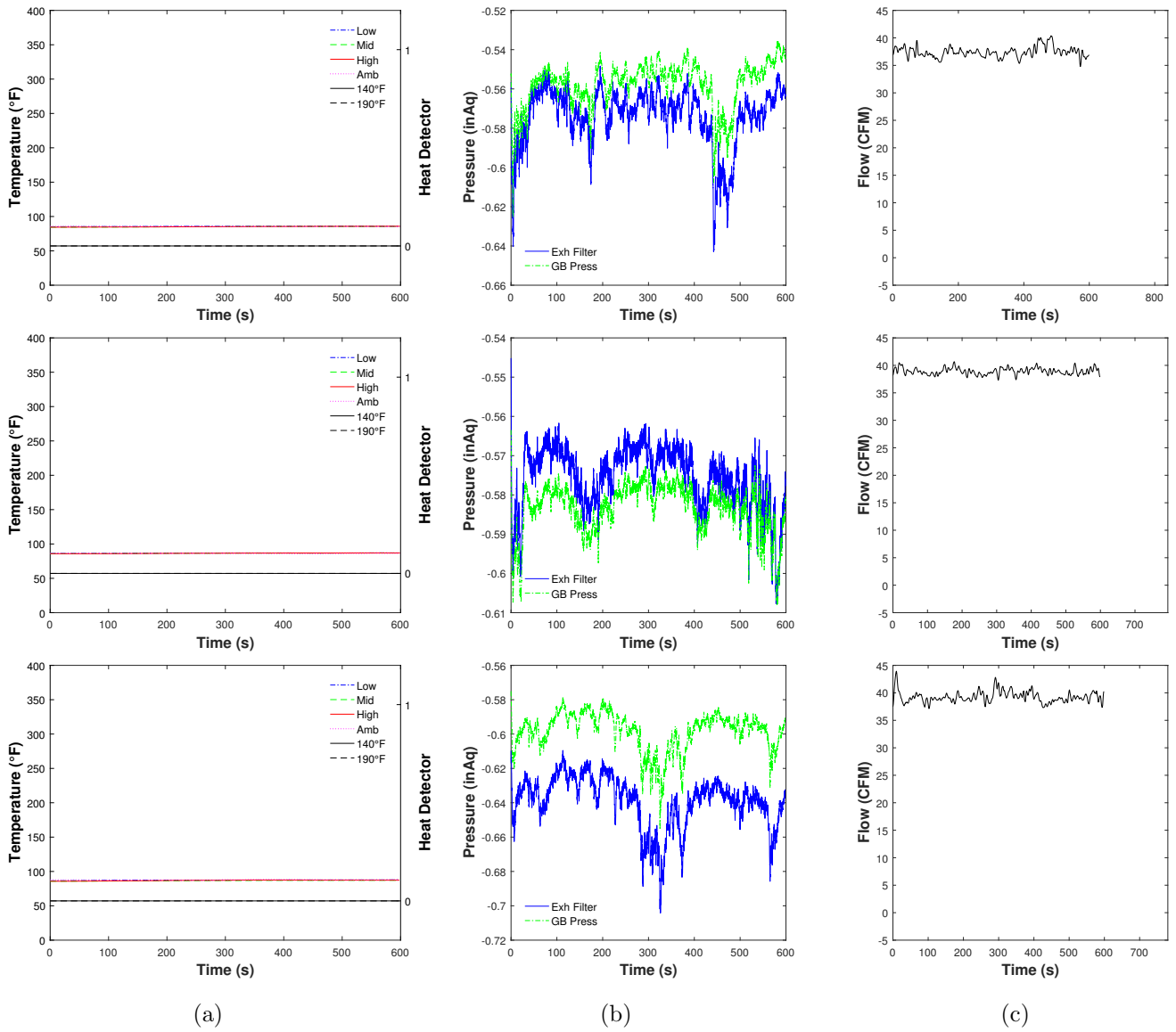
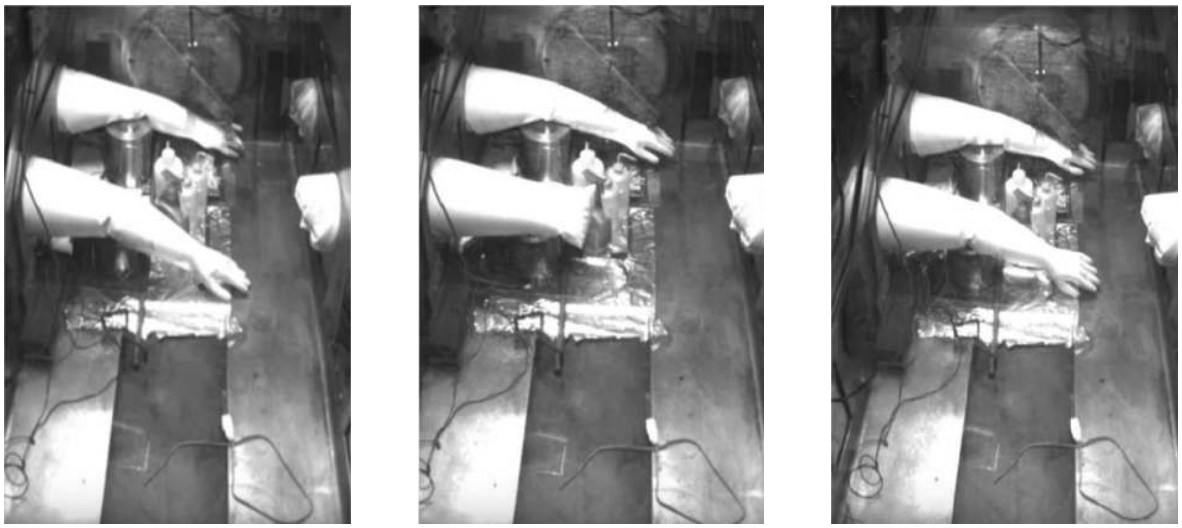


Figure 37: Condition 08 results: temperature and Fenwal activation (a), pressure (b), and air flow (c) are shown for each of three trials.



(a) (b) (c)

Figure 38: The state of the GB prior to the fire for Condition 08 is shown for each of the three associated trials (a–c).

(a) (b) (c)

Figure 39: The state of the GB after the fire for Condition 08 is shown for each of the three associated trials (a–c).

5.9 Condition 09

Layout

For Condition 09 gloves attached to ports 5, 6, 9, and 10 were placed in glove port covers. The combustibles were then all placed in a dense configuration near these ports, with focus on investigating the ability of the port covers to prevent a breach in the case of a very robust fire. Along with easily ignited combustibles like lab wipes and sandpaper, the polypropylene bottle with alcohol and Tygon tubing were also placed near the ignitors. Additionally a pile of burnt GB gloves was placed a few feet away from the ignitors to observe if these would become involved in a robust fire. This condition modeled a nearly worst-case scenario in terms of combustible layout in which a GB might occur, placing highly combustible combustibles in close proximity to one another. The layout of the combustibles for this condition may be seen in Figures 40 and 42.

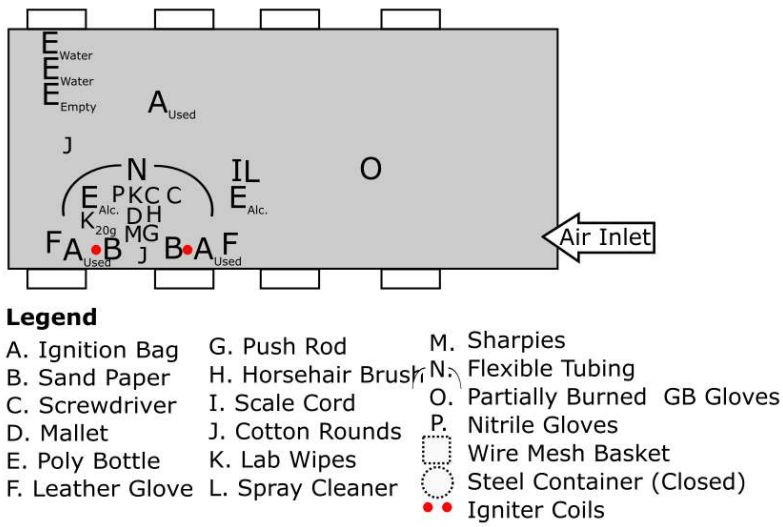
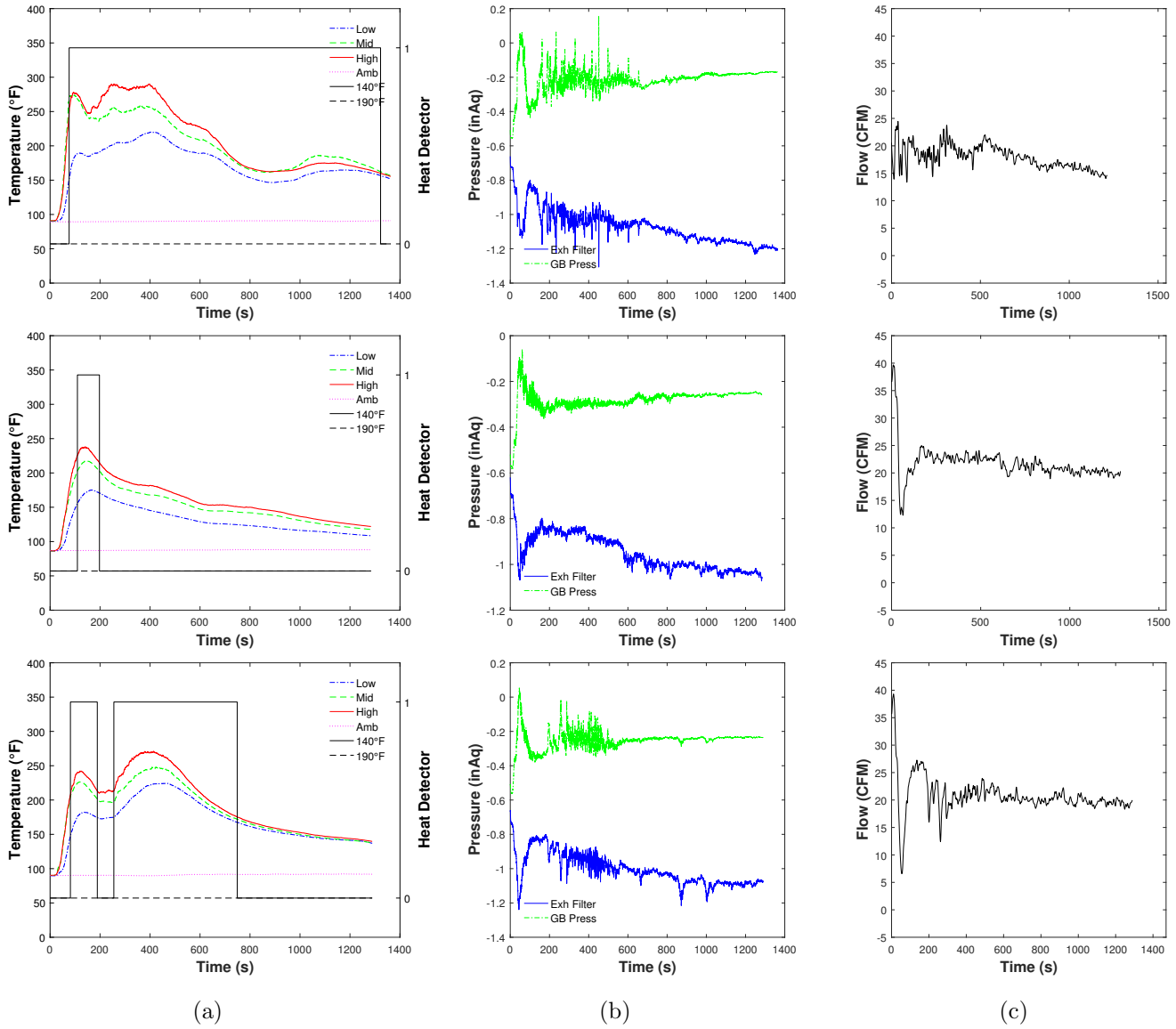


Figure 40: Combustible Layout for Condition 09.

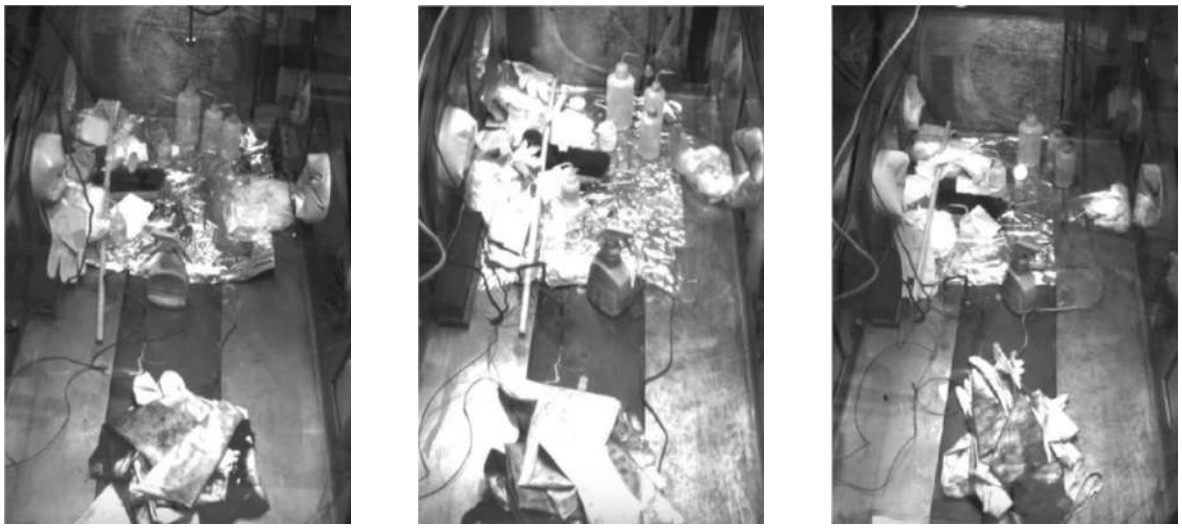
Results

Data obtained during the three trials of Condition 09 are presented in Figure 41. The large assortment of readily flammable combustibles allowed for the fire to readily spread to less readily flammable combustibles such as the horsehair brush (Fig. 43). The glove attached to Port 10 was breached in each of the three trials. The robust fire resulted in a cracked port window in two of the three trials and also reached high enough to damage the gloves in Ports 5 and 6 above Port 9 and 10. Though the Port 10 glove was breached, the puncture was small and the port cover restricting the size of the effective breach such that GB vacuum was maintained to a significant degree (0.2 inAq, on average).



(a) (b) (c)

Figure 41: Condition 09 results: temperature and Fenwal activation (a), pressure (b), and air flow (c) are shown for each of three trials.



(a) (b) (c)

Figure 42: The state of the GB prior to the fire for Condition 09 is shown for each of the three associated trials (a–c).

(a) (b) (c)

Figure 43: The state of the GB after the fire for Condition 09 is shown for each of the three associated trials (a–c).

5.10 Condition 10

Layout

Condition 10 was only run for a single trial. For this condition an array of readily igniting combustibles were placed around the ignition coils. These combustibles included nitrile gloves, lab wipes, sand paper, sharpie markers, and a horsehair brush. An open steel canister with an ignition bag was placed next to these combustibles to see how well it could prevent damage to the ignition bag from sustained heat during a robust fire. For this condition the gloves were again placed in port covers and a pile of burned gloves was placed a few feet away from the ignition location. The layout of the combustibles for this condition may be seen in Figures 44 and 46 (a).

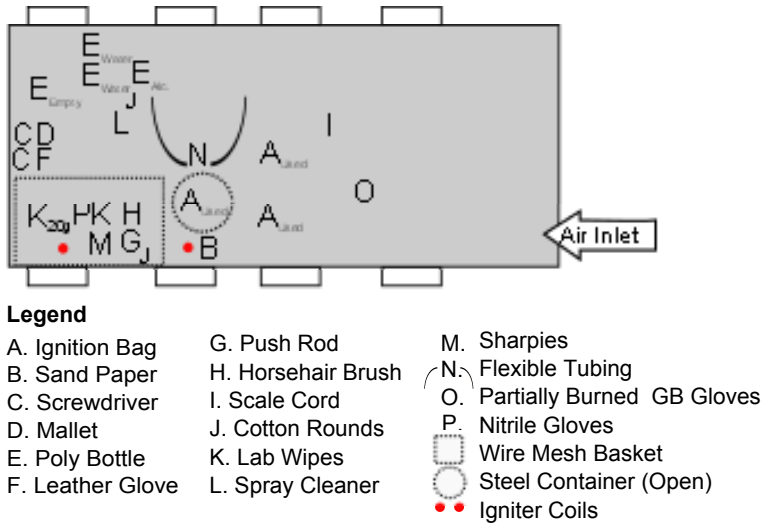
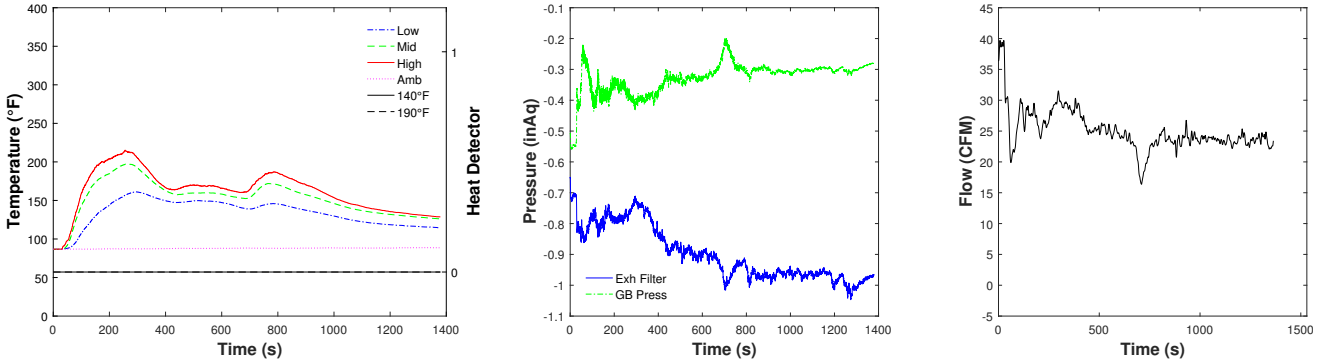


Figure 44: Combustible Layout for Condition 10.

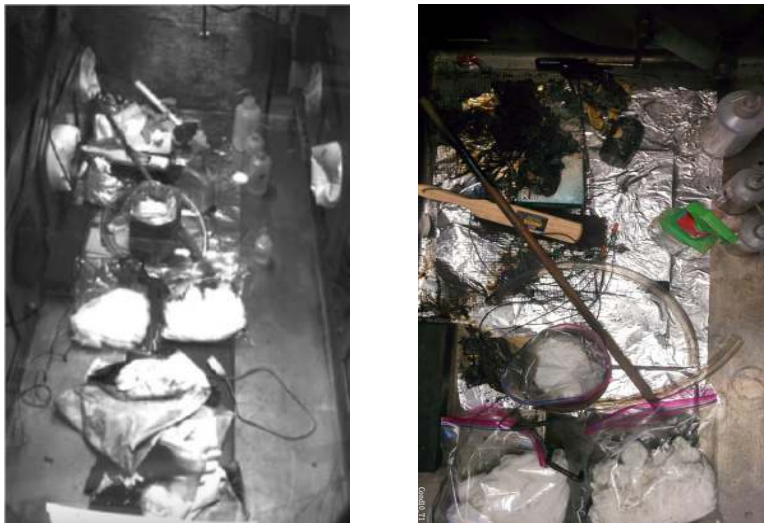
Results

Data obtained during under Condition 10 are presented in Figure 45. While a substantial fire was produced, there was no apparent breach. The combustibles near the ignitor were able to sustain a fire which significantly burned both the horsehair brush as well as the handle of the rubber mallet (Fig. 46 (b)). A significant reduction in GB pressure is shown in the pressure trace, but this may have been due to exhaust filter packing, in turn decreasing the air flow in the GB. Additional trials under this condition were not conducted, as perturbations were requested by LANL personnel, creating Condition 11.



(a) (b) (c)

Figure 45: Condition 10 results: temperature and Fenwal activation (a), pressure (b), and air flow (c).



(a) (b)

Figure 46: The state of the GB prior to (a) and after (b) the fire for Condition 10 is shown.

5.11 Condition 11

Layout

Condition 11 included two steel canisters with alcohol-soaked cheese cloth. These containers remained closed for the duration of the trials. An ignition coils were placed under a pile of 20g of loose wipes in front of each container. For Trials 2 and 3 a bridge of loose lab wipes was laid between the ignitors so that a flame on either side would spread to the other side. A square of sandpaper and a screwdriver were placed next to each container and the polypropylene bottles, including the bottle with alcohol were placed between the containers. The gloves were placed in port covers and were retracted from the GB working environment to simulate a situation in which workers had already left the GB and some ignition source was left active. The layout of the combustibles for this condition may be seen in Figures 47 and 49.

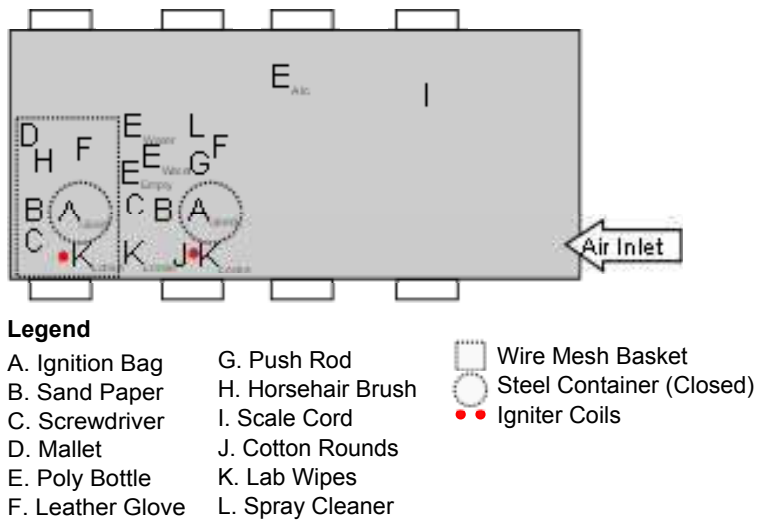
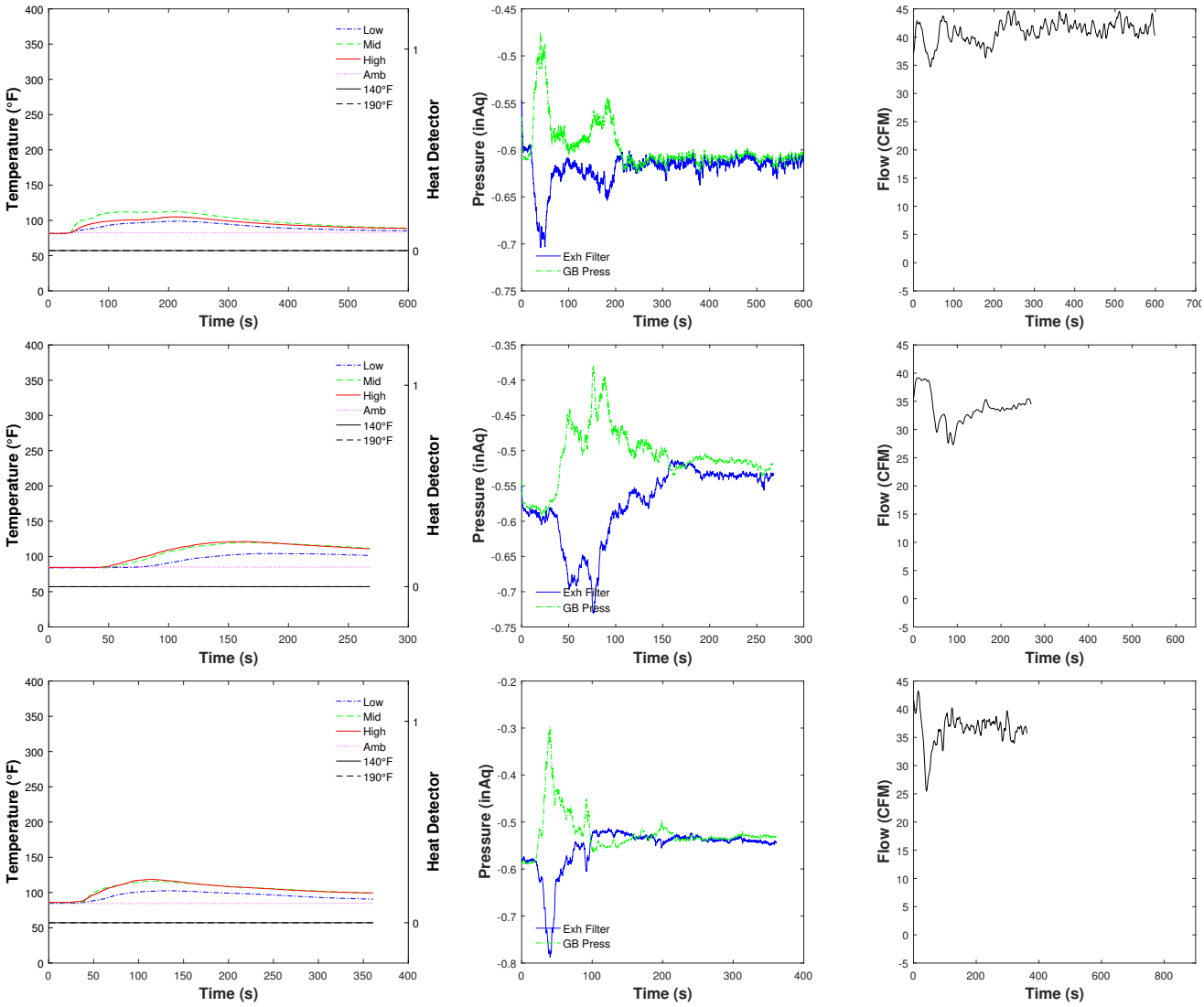


Figure 47: Combustible Layout for Condition 11.

Condition 11 Results

Data obtained during the three trials of Condition 11 are presented in Figure 48. Fire damage was prarily to sandpaper and lab wipes, which had been placed in contact with the ignitors (Fig. 50). In part, it appears the locations of the metal containers prevented the flames from scattering across the GB floor and resulted in the flame quickly self-extinguishing. A breach was observed in Trail 1 (Port 10), but not in the other two trials.



(a) (b) (c)

Figure 48: Condition 11 results: temperature and Fenwal activation (a), pressure (b), and air flow (c) are shown for each of three trials.

(a) (b) (c)

Figure 49: The state of the GB prior to the fire for Condition 11 is shown for each of the three associated trials (a–c). Note that the containers, in some cases were opened and/or emptied at the discretion of safety officer before the photo was taken.

(a) (b) (c)

Figure 50: The state of the GB after the fire for Condition 11 is shown for each of the three associated trials (a–c).

5.12 Data Summary Table

In the following table, the included variables are defined as follows:

- *Glove State*: the state of gloves installed in Ports 9, 10, 23 and 24. Gloves attached to all other ports were tied or clamped out.
- *Can State*: when used, whether the cans were open or covered with lid.
- *Flame*: time at which flame was first visible.
- *Breach*: time at which a breach is evident upon review of the GB pressure data.
- *140 det.*: activation time 140°F thermal detector. In some cases, the detector may have activated, deactivated after temperature drop, and reactivated again later. Only the first activation time is listed.
- *190 det.*: activation time 190°F thermal detector.
- t_L: time when maximum temperature was observed on the low thermocouple.
- T_L: maximum temperature was observed on the low thermocouple.
- t_M: time when maximum temperature was observed on the middle thermocouple.
- T_M: maximum temperature was observed on the middle thermocouple.
- t_H: time when maximum temperature was observed on the upper thermocouple.
- T_H: maximum temperature was observed on the upper thermocouple.
- P_{Go}: initial GB pressure.
- P_{Gf}: final GB pressure.

Table 5: Summary of results.

Cond./ Trial		Glove State	Can State	Flame (s)	Breach (s)	140° det.(s)	190° det.(s)	t_L (s)	T_L ($^\circ F$)	t_M (s)	T_M ($^\circ F$)	t_H (s)	T_H ($^\circ F$)	P_{Go} (inAq)	P_{Gf} (inAq)
	1	4 in	open	27–604	68	131	-	142	181	151	209	137	257	-0.58	-0.02
1	2	rest tied		394–1441	429	480	-	516	208	518	287	510	337	-0.59	-0.02
	3			212–1006	287	334	362	381	214	373	263	362	359	-0.62	-0.01
	1	4 in	–	24–297	195	96	-	264	212	420	89	253	334	-0.59	-0.03
2	2	rest tied		22–412	-	-	-	174	156	161	190	129	235	-0.57	-0.50
	3			233–398	335	347	384	404	223	397	271	387	357	-0.57	-0.02
	1	4 in	–	26–432	83	110	-	135	183	131	237	129	320	-0.56	-0.01
3	2	rest tied		37–	187	-	-	113	77	109	88	119	96	-0.60	0.00
	3			37–301	146	197	-	230	185	224	243	214	312	-0.64	0.00
	1	all out	closed	278–780	316	-	-	469	90	455	107	461	104	-0.63	-0.48
4	2			19–	703	-	-	835	124	793	144	794	151	-0.60	-0.03
	3			17–	126	-	-	261	98	297	98	270	103	-0.55	-0.35
	1	2 in	–	55–153	-	-	-	149	81	173	84	151	87	-0.56	-0.52
5	2	rest tied		19–585	-	-	-	500	93	520	104	502	112	-0.57	-0.50
	3			125–	-	-	-	672	85	421	88	377	90	-0.55	-0.61
	1	2 in	–	40–180	-	-	-	191	76	159	80	193	81	-0.53	-0.01
6	2	rest tied		28–74	-	-	-	93	80	56	84	53	83	-0.56	-0.53
	3			29–91	-	-	-	90	81	90	85	71	86	-0.56	-0.51
	1	2 in	–	7–	-	-	-	622	83	622	84	602	84	-0.59	-0.59
7	2	rest tied		–	-	-	-	585	84	572	85	445	85	-0.58	-0.58
	3			7–63	-	-	-	512	81	598	81	591	81	-0.56	-0.57
	1	2 in	closed	–	-	-	-	505	86	589	85	590	86	-0.59	-0.54
8	2	rest tied		–	-	-	-	566	87	568	87	570	87	-0.60	-0.58
	3			–	-	-	-	597	88	597	87	382	87	-0.61	-0.59
	1	all out	open	14–1364	51	76	-	406	220	93	275	256	290	-0.55	-0.17
9	2			16–1258	46	109	-	169	175	143	218	141	238	-0.57	-0.25
	3			15–1289	51	81	-	467	224	434	248	414	271	-0.56	-0.23
10	1	all out	open	32–1379	63	-	-	293	161	266	197	256	215	-0.54	-0.28
	1	all out	open	27–489	150	-	-	219	99	214	113	208	105	-0.61	-0.61
11	2			38–230	-	-	-	185	104	164	120	162	121	-0.57	-0.52
	3			20–204	-	-	-	135	103	121	116	114	119	-0.59	-0.53

6 Conclusions

Key findings from these experiments include:

- The potential for robust fires involving only standard GB tools and combustibles was observed, especially when flammable-liquid-soaked materials were involved.
- Both 15 mil and 30 mil Hypalon gloves, when directly exposed to the fire were breached. Moreover, once ignited, they were significant contributors to GB fires.
- Tying gloves outside the GB is not sufficient to prevent a breach when a robust fire exists.
- The use of port covers did not have an evident effect in preventing glove breach compared to tying them outside the GB. They did, however, assist in reducing airflow into the GB in the event of a breach.
- All fires eventually appeared to self-extinguish.
- Flammable-liquid-wetted items, lab wipes, markers, the flexible hose and Hypalon gloves were observed to be significantly consumed in/contribute to some fires. Other combustibles and tools tended to not get fully involved in the fire and readily self-extinguished.
- The fire did not spread to other piles of combustibles when separated by approximately 6 inches, even though the piles may have included flammable-liquid-soaked materials in open bags.
- In the majority of cases where a glove breach occurred, this came before fire detection by either the 140 or 190°F Fenwal Detect-a-Fire thermal detectors, installed within a thermal detector well, activated.
- The 140°F Fenwal Detect-A-Fire thermal detector, installed within a thermal detector well, did not activate until at least 15 seconds after an ambient temperature of 140°F was recorded.
- The 190°F Fenwal Detect-A-Fire thermal detector, installed within a thermal detector well, did not activate until an ambient temperature over 300°F was recorded.
- The localized influx of air created by the breach was shown to locally intensify the fire.

The results of these experiments may provide data that could be used when fire hazards evaluations (FHEs) are conducted for determining when to require a fire suppression system to be installed within a GB (as required by NFPA 801, *Standard for Facilities Handling Radioactive Materials* , DOE Standard 1066-2012 *Fire Protection* and American GB Society (AGS) Standard AGS G-101 *Standard on GB Fire Protection).*

Interpretation of pressure and air flow data after GB breach (e.g. to assess exhaust filter packing) must take into consideration two artifacts of the breach. First, after a breach occurs, the air flow reading becomes inaccurate as other (non-measured) pathways for air ingress originate. Secondly, the fans are controlled to maintain the desired fan speed; however, the resulting airflow depends on load. Upon breach, one source of a pressure drop is significantly bypassed (across inlet filter), increasing air flow and thus the measured pressure change across the exhaust filter.

7 Recommendations

Given the observed robust fires resulting from some of the conditions explored herein, it is recommended that:

- Non-containerized flammable liquids be limited in quantity within the GB.
- Methods for containerizing or segregating other readily combustible materials (e.g. lab wipes, markers, and poly hose) should be explored.
- GB gloves are stored outside of the GB - either tied or otherwise constrained.
- The performance of non-Hypalon gloves during GB fires should be explored.
- Fire suppression or inert atmospheres be considered where administrative controls cannot ensure compliance with the above.
- A more immediate and sensitive method of fire detection be used in conjunction with fire suppression systems when installed.

8 Acknowledgments

This work was funded by LANL/LANS Subcontract No. 368937. These funds, in part, supported multiple undegraduate and graduate students at New Mexico Tech who were given an opportunity present at the 2016 summer LANL Student Symposium. The posters prepared for that event are included in Appendix H. The authors wish to credit these students: Krishan Bhakta, Jakub Mroczkowski, John Paul Norman, Dan Puckett, Maria Ruiz, Christopher Schmittle, Kenneth Smith, and Chris White for their tremendous efforts in assisting with the preparation, execution, and analysis of these experiments. This work would not have been possible without a close collaboration with LANL program managers, scientists, and engineers — particularly, Judy Eglin, Ralph Clayton, Jim Narum, Bill Wolfe, Stacey Talachy, Bob Hanson, and Stephen Ney.

A Test Plan

NEW MEXICO TECH
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TEST PLAN

LANL Glovebox Fire Studies

TP-16-30

Client: LANL

Customer: NMT ME dept.
David Grow
575-835-5109
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Authors: Drs. David Grow, Jamie Kimberley, & Robert Abernathy

Fund: MBGE10 / MGBE20

21 June 2016

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1. Test Overview/Summary:

1.1. The necessity to install fire suppression systems (FSS's) in gloveboxes (GB's) is under investigation. The hazards associated with a fire depend on many material and human factors. Tests will consist of multiple trials with variations in the type, quantity, and arrangement of contained consumables as well as variables related to airflow in the GB. These tests will focus on scenarios that are severe, but bounded and informed by existing practices at LANL to yield the most conservative and comprehensive fire test plan to suit Los Alamos National Labs (LANL) requirements. Parameters varied in these experiments will include:

- GB air flow
- GB vacuum level
- Type, quantity, and arrangement of consumables
- Arrangement of consumables relative to GB gloves

Details of planned measurements are included hereafter. The focus of this work relates to the time the data collection and analysis is to establish:

- GB conditions match target levels
- Timeline of GB fire progression versus key events including fire ignition, triggering of heat detectors, glove breach, etc.
- Temperature distribution within the glovebox over time
- Relationship between fire size and temperatures at various locations
- How above can be used to evaluate thermal detector response.

2. Location of Test: (Include location test and test preparation activities)

2.1. Torres Compex, 2-ton bunker (Fig. 1).

3. Sequence of Steps / Procedures:

3.1. See Attachment 2 for checklist.

3.2. The GB will incorporate a fixed negative pressure differential of $^1/_4$ - $^3/_4$ inches of water column (inAq) and fixed air flow 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).

3.3. Exhaust 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.

3.4. Custom and original service panels will be used to route control and measurement lines into the GB. These junctions will be sealed by means of thread-seal tape and/or silicone caulk.

3.5. 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.

3.6. Air flow will be controlled using an electric fan installed along the exhaust path and monitored using a flow sensor installed along the inlet path (prior to air heating and contamination.

3.7. 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.

3.8. Consumables arranged on the GB floor (or elevated rack), which include tools commonly found in GB's (e.g. mallet, screwdriver, cheesecloth, wash bottles, flammable liquids (acetone or alcohol), horsehair brush, wooden push rod, lab wipes, leather gloves, sandpaper, and cleaning spray), will be ignited by means of a heated nichrome wire. This wire will be attached to a sealed bag containing solvent-soaked cheesecloth.

3.9. After setup is essentially complete, the power cord for the heater wire will be removed from the safety lockout and connected. Immediately thereafter, all personnel will leave the bunker containing the GB and enter the adjacent bunker containing data acquisition and control hardware.

3.10. From the control bunker, the data acquisition will be started and thereafter, the fire started by means of the nichrome wire.

3.11. The fire will be monitored until it self-extinguished, creates a GB breach by burning a hole in a glove (or otherwise), or is deemed to have reached a dangerous level. In the event of the last case, the fire will be extinguished by first, cutting air flow to the GB, and if needed by deploying the installed FSS (Stat-X aerosol agent).

3.12. The Stats-X FSS will be mounted in the top center of the glovebox.

3.13. Quantitative measurements of pressure, temperature, and airflow will be made during testing using instrumentation prepared by Dr. Grow, NMT Mechanical Engineering Department.

3.14. Between two and four cameras will be used to observe/record the events inside the glovebox during testing. One camera will be set back at a distance, providing an inclusive view of the GB for observing the overall response of the GB to fire and for safety purposes. The remaining camera(s) will will be positioned exterior to the GB providing video recording coverage of the full interior of the GB (or key areas, windows and fields of view TBD).

3.15. As necessary, smoke will be vented from the test bunker before entry.

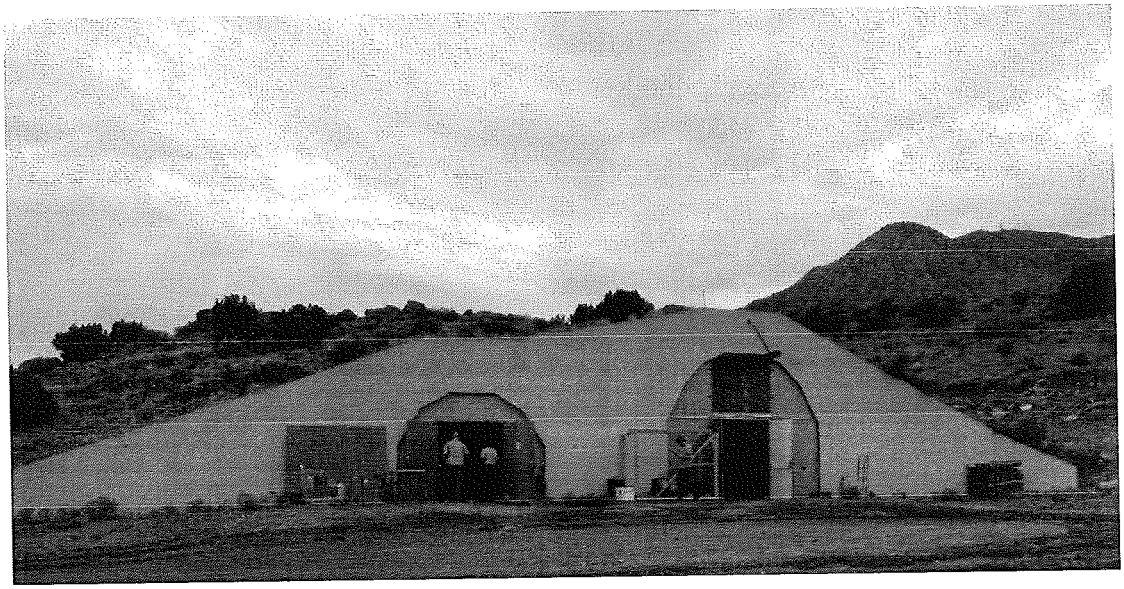

Figure 1. The "2-ton Bunker" near Torres Laboratory. This earth-covered site features a pair of rooms, divided by a robust wall. In the larger room (right) the GB is installed. The smaller room (left) will be exclusively occupied by personnel during testing, allowing safe, remote operation and observation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

Figure 2. A LANL-supplied GB, installed at NMT attached to an NMT-constructed stand, which will be used to conduct the experiments detailed in this plan.

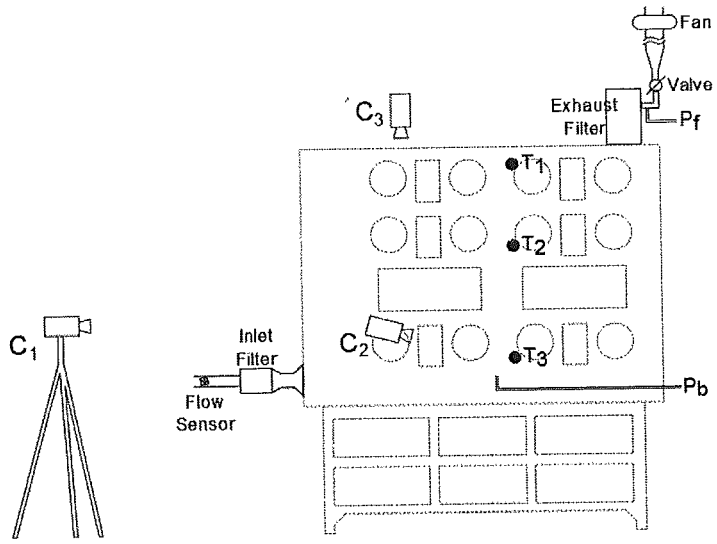

Figure 3. Glovebox Schematic (not to scale). Shown are the planned locations of three thermocouples (T_1, T_2, T_3) which measure temperature at various heights, pressure-sensing lines (P_b and P_f). The GB vacuum will be measured by comparing ambient (P_a, not shown) relative to P_b and exhaust filter pressure drop will be measured using P_f relative to P_b. Also shown are the locations of other key components. Grayscale cameras will provide a wide view (C_1) of the GB and a view of the GB floor (C_3). An infrared camera will be used to measure temperatures in the GB from a side view (C_2). Not shown are the FSS and Fenwal heat detectors which are installed near the center of the GB ceiling.

5. Test Matrix:

Test #	Type of Test	Purpose	Instrumentation	Data Required	Filter Type‡
1-3	Fire	C1*, E1**	Provided †	NA	
4-6	Fire	C1, E2	"	"	
7-9	Fire	C2, E1	"	"	
10-12	Fire	C2, E2	"	"	
13-15	Fire	C3, E1	"	"	
16-18	Fire	C3, E2	"	"	

* Consumables Arrangement 1 (likewise for other arrangements); **Environment 1 (air flow / vacuum, likewise for other selections); † Instrumentation will be provided by the Robotic Interfaces Lab (Dr. Grow); ‡alternatives to quality-assured LANL inlet and exhaust filters may be considered.

6. Construction: (Includes tables, stands, excavations, building erections etc.)

6.1. The GB will be adapted for these experiments using the test stand as shown in Figure 1. The GB has an internal volume of 72 ft^3 (73" x 60" x 32.5", narrowing to 26", detailed geometry available upon request).

6.2. 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.

6.3. The GB will be fitted with gloves and associated installation hardware by LANL personnel. 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).

6.4. 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.

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

6.6. 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.

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

6.8. 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.

6.9. Install selected fire suppression system in GB.

7. Energetic Materials:

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

8. Instructions for Spill Cleanup and Disposal of any Scrap and Waste A&E:

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

9. Indicators for Identifying Abnormal Process Conditions: (Include observations that indicate something did not occur as planned or expected)

9.1. The GB fails to achieve the target flow rate and pressure. If this occurs, testing will be halted until the ventilation system is corrected.

9.2. The heater wire fails to initiate a fire.

10. Misfire Procedures: (Include test specific procedures along with the following)

10.1. If there are no indications that neither the primary nor secondary (backup) heater wires functioned, all connections will be checked (control bunker only) to ensure they are connected correctly and another attempt to heat the wire and initiate a fire will be made.

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

- A 15-minute wait time will be observed before personnel are permitted to approach the test article.
- GB active ventilation shall continue throughout the wait time and thereafter.
- The power cable to the ignitors will be removed and isolated in the safety lockout.
- The heater wire circuit will be isolated from any flammables and inspected.

11. Instrumentation:

11.1. The Robotic Interfaces Lab will provide instrumentation for the experiments, which will include pressure, temperature, air flow and heat detector measurements (Figure 3)

11.2. Measurement and Test Equipment (M&TE) usage log

M&TE Number:	
Manufacturer:	Date Last Calibrated:
Item Name:	Calibration Expiration Date:
Serial Number:	M&TE Owner:
Model Number:	

12. Specific Hazards: (Include Safety Data Sheet energetic hazards and any hazards associated with the test itself)

12.1. Falling tools/objects.

12.2. Burning of the body from ignited flammable mixture.

12.3. Lung damage from inhaling acetone vapors.

12.4. Eye damage from acetone if splashed into eyes.

12.5. Fragmentation caused by over-pressurization of the GB.

13. Emergency Procedures:

13.1. Lightning:

- If lightning is observed or detected within 7 miles, operations will be prepared to be shut down in the event the storm approaches to within 5 miles.
- If lightning is detected within five 5 miles, all personnel will seek shelter immediately for a minimum of 30 minutes, and until 30 minutes after the last lightning strike outside 5 miles.

13.2. Fire:

- If there is a fire on or near the test pad (outside of the GB), 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.

13.3. 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.

13.4. First Aid Measures;

- See Attachment 4, Acetone SDS, Section 4.
- Review these hazards and procedures during tailgate meeting.

13.5. Acetone Spill

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

CAUTION

When cleaning up a spill, the use of splash goggles, lab coat, gloves and vapor respirator should be used as necessary.

14. PPE Required: (Include setup, test and post-test operations)

14.1. Hearing protection;

14.2. Eye protection;

14.3. Work gloves; for mechanical/hotwork

14.4. Splash goggles;

14.5. Lab coats;

14.6. Vapor respirators;

14.7. Safety-toed shoes;

14.8. Hardhats and

14.9. Eye-wash station.

15. Personnel and A&E Limits:

15.1. 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.

15.2. 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.

15.3. 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.

16. Specific Tools and Equipment Permitted for Use: (Includes power tools, heavy equipment, Fire Sets, etc.)

16.1. Forklift.

17. Documentation: (Includes video, reports, etc.)

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

18. Schedule:

18.1. Test Preparation – Undetermined but no later than 30 September 2016

18.2. Testing – Undetermined but no later than 30 September 2016

18.3. Post Test Operations – Undetermined but no later than 30 September 2016

19. Budget:

19.1. $15,000

20. Job Hazard Analysis (JHA): See Attachment 1

21. Site Closure: TBD

22. References: See Attachment 8

- SOP 101, *EMRTC Health and Safety Program*
- SOP 102, *EMRTC Field Laboratory Safety*
- SOP 103, *Industrial SAfety*
- SOP 104, *Electrical Storm Procedures*
- SOP 401, *Industrial Security Standard Practice Procedures*
- SOP 402, *Emergency Action Plan*
- SOP 403, *EMRTC Risk Management*

23. Attachments.

1. Job Hazard Analysis
2. Test Checklist
3. Data Sheet
4. Site Closure Map
5. Safety Data Sheets
6. Tailgate Briefing
7. Revision List
8. Standard Operating Procedures

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))	[X] 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)
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

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 of glove box	Amount	
A. Alcohol-soaked cheesecloth in zippered bag (weight dry: weight w/ liquid:)		
B. Sand-paper		
C. Screwdrivers		
D. Hammers/Mallets		
E. Poly bottles		
F. Leather Gloves		
G. Polypropylene Rod		
H. Horse hair brush		
I. Benchtop scale components		
J. Markers		
K. Cotton Rounds		
L. Kim Wipes		
7. Place and secure igniter nichrome wire to ignition bag		
8. Ensure thermocouples (TC's) in prescribed locations		

9. Seal glovebox	
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. Record Flowrate and pressure readings from Magnehelic gages	
14. 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	
15. Ensure cameras are on and focused	
Glovebox top view	
Glovebox side view	
Glovebox IR camera	
Site/safety view	
16. Connect external FSS cabling	
17. Obtain approval from LANL quality assurance engineer	
18. Record ambient temperature and relative humidity	
19. Set new test name on flowmeter	
20. 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	
21. All personnel must enter safety bunker	
22. Obtain approval from LANL quality assurance engineer	
23. Verify all preceding items are checked	
24. Begin recording of data on DAQ, note stopwatch time	
Test	
25. Active primary/secondary ignitors	
26. 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 10 minutes after fire is visibly extinguished GB to cool	
31. Safety officer will clear personnel to leave bunker	
Post Test	
32. Verify Pressure sensors are still operational by comparing to magnehelic	
33. Open glovebox	
34. Verify TC's are functioning by comparing after GB begins to cool	
35. Photograph glove box interior	
36. Wearing appropriate PPE, collect samples of residual materials	
37. Wearing appropriate PPE, clean GB floor	
38. Remove spent FSS canister, as needed.	

Attachment 3

Test Data Sheet

Emergency Contact Information:

911 or (575) 835-5555

Glovebox Fire Suppression: Experiment #__

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted

Safety Officer Name

Quality Assurance Rep. Name

Start Time	
Ignition Time	
End Time	

Relevant Environmental Conditions

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make_____ Model _____		
2. Make_____ Model _____		
3. Make_____ Model _____		
4. Make_____ Model _____		

Digital Timer	Serial Num	Calib. Date
1. Make_____ Model _____		

Air Flow meter	Serial Num	DAQ channel
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_____ Model _____		
2. Make_____ Model _____		

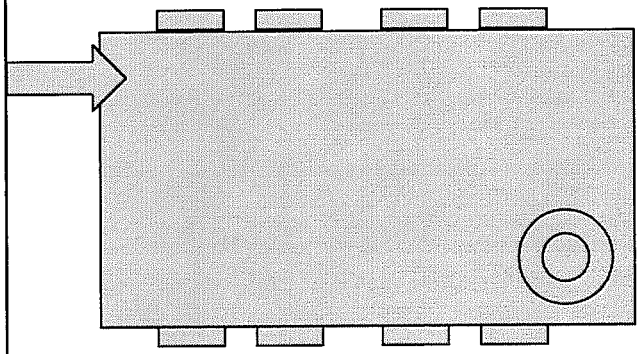
Cameras	Serial Num	
1. Make_____ Model _____		
2. Make_____ Model _____		
3. Make_____ Model _____		
4. Make_____ Model _____		

Glove Installation

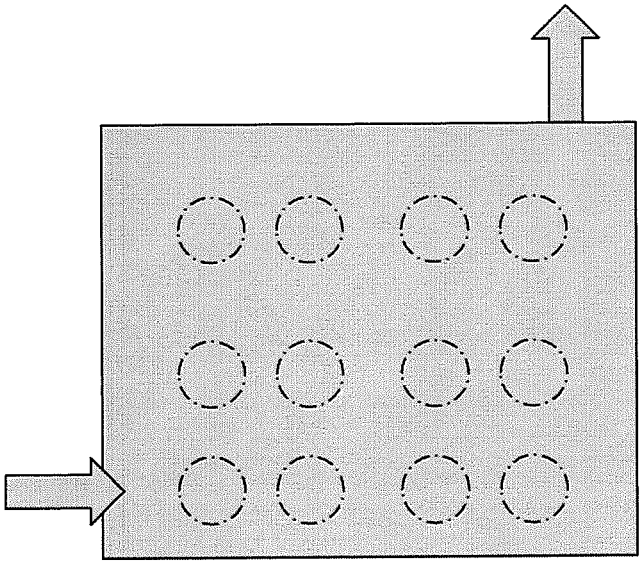
Glove/cover installed	LANL insp	Port #	Glove/cover installed	LANL insp	Port #
		1			13
		2			14
		3			15
		4			16
		5			17
		6			18
		7			19
		8			20
		9			21
		10			22
		11			23
		12			24

Time & Description of Critical Events	Miscellaneous Notes
Ignition Time: 500 degrees at glove (approx) Time: Breach Time: 140 Fenwal Detection Time: 190 Fenwal Detection Time: Other key times:	

GB Floor (Top View)



GB Floor (Side View)



Legend:

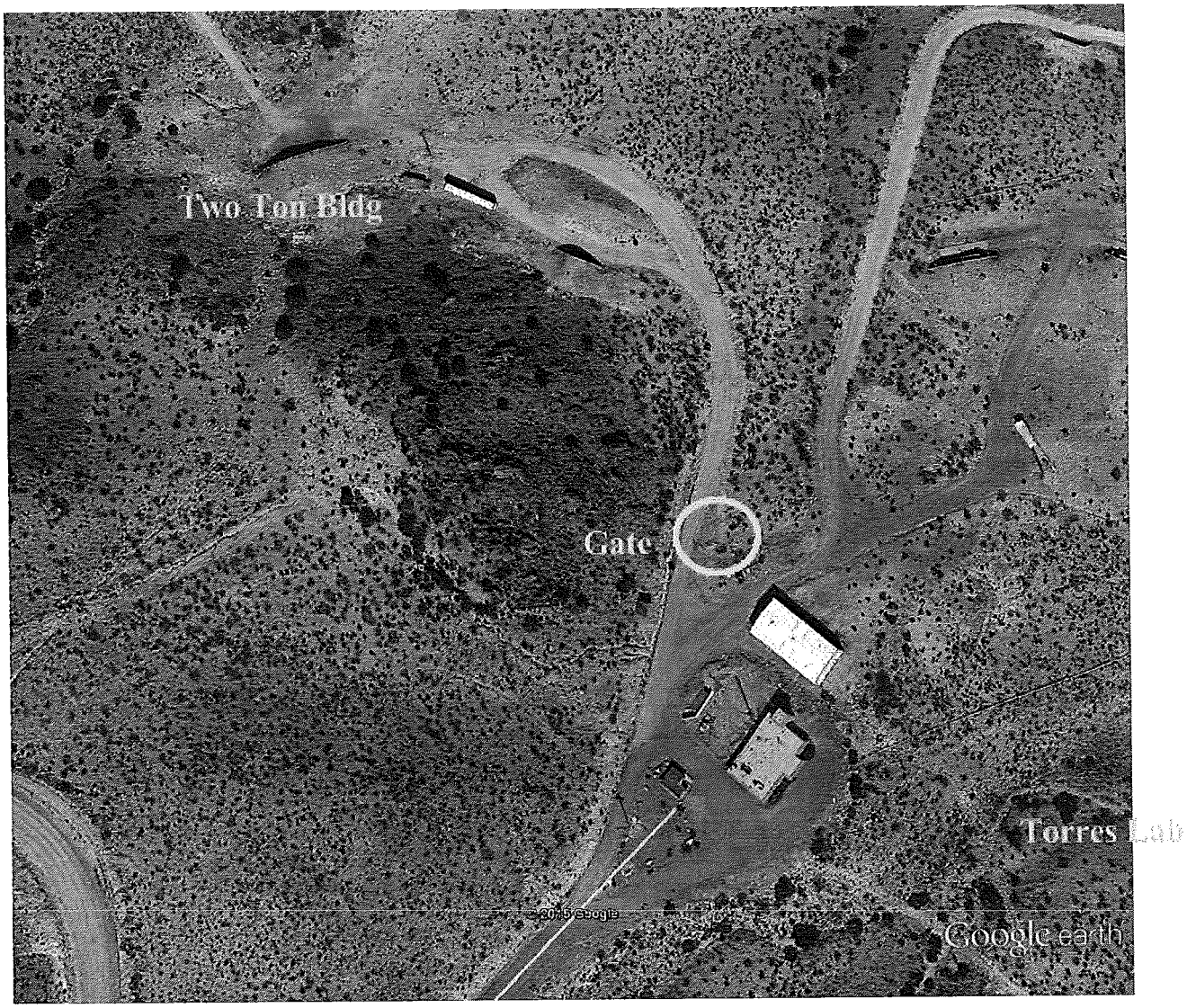
A. Ignition bag
B. Sand paper
C. Screwdriver
D. Mallet
E. Poly Bottle
F. Leather glove
G. Push Rod
H. Horsehair brush
I. Scale cord
J. Cotton rounds
K. Kim wipes

Revision History	
Revision & Justification	Authorized Signatures

Attachment 4

Site Closure Map

Site Closure Map

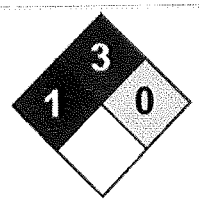


Local clearance, close gate and clear Torres Firing Pad

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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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	**Emergency Contact:**	**Chemtrec**
Product Name:	**SILICONE SEALANT/ADHESIVE**	**Phone:**	**(800) 424-9300**
Part Number(s):	**19-158**		
	19-159		

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 carcinomas 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 statute.

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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Stat-X®

MATERIAL SAFETY DATA SHEET

Fireaway
5852 Baker Road
Minnetonka, MN 55345

MSDS# 004
DATE: 1/11

For information only, call 1-952-935-9745. For emergencies, call CHEMTREC: DOMESTIC NORTH AMERICA 800-424-9300 INTERNATIONAL 703-527-3887 (COLLECT).

1. PRODUCT

Stat-X® Condensed Aerosol Generators - Models 30 thru 2500.

2. COMPOSITION/INFORMATION ON INGREDIENTS

Components – Chemical (Hazardous Components ≥ 1%)	CAS#	COMMENTS:
Potassium Nitrate	7757-79-1	Components are blended and pressed into a highly stable, molded form. Molded composition is contained within a sealed double-walled stainless steel housing – no environmental exposure.
DCDA	461-58-5	
Organic Resin	9003-35-4	
Appearance & Odor:		Beige to white in color. No odor.
Auto-Ignition Temperature:		300°C
Solubility in Water:		Slightly Soluble

3. HAZARD IDENTIFICATION

Possible exposure to aerosol suppression agent if generator is activated. May cause temporary, mild irritation of mucous membrane if inhaled.

4. FIRST AID MEASURES

Contact Method:	Procedure:
Inhalation	Remove to fresh air
Eye Contact	Flush with water
Skin Contact	Wash with soap and water.
Ingestion	Not a likely route of exposure.
Seek medical attention for further treatment, observation, and support if necessary.	

5. FIRE FIGHTING MEASURES

In the event of a fire, evacuate the area and inform emergency services. Ignition of Stat-X produces a fire-suppression aerosol. Water may be used as an additional suppression agent.

6. ACCIDENTAL RELEASE MEASURES

If these devices are spilled they can be safely recovered by hand and should be inspected for damage prior to repacking. Suspect or damaged articles should be labeled and consigned for correct destruction.

7. HANDLING AND STORAGE

Store in temperate conditions. Avoid shock, electric currents, static discharge, excessive heat and extended periods of storage at temperatures greater than 65°C.

8. EXPOSURE CONTROL/PERSONAL PROTECTION

Respiratory Protection	Ventilate area completely after discharge. Do not enter area prior to complete venting of enclosure. Use filter mask as necessary during clean-up.
Hand Protection	Wear gloves if handling generators prior to cooling.
Eye Protection	Safety glasses are advisable.
Skin Protection	N/A

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance:	Stainless Steel Cylinder up to 270 mm in length

10. STABILITY AND REACTIVITY

These devices are extremely stable below 125°C. They should be protected from fire, sources of electrical power, shock, and high temperatures.

11. TOXOCOLOGICAL INFORMATION

Toxic by-products of combustion are extremely low. Main by-products are listed below with 15-minute TWA values for a maximum 100g/m^3 concentration in a hermetically sealed volume.

Gas	15 minute Time Weighted Average in parts per million
NO_2	1.08
NO	0.97
CO	84.20

12. ECOLOGICAL INFORMATION

These devices are sealed and present no ecological hazards. The aerosol produced upon ignition has no global warming potential and an ozone depletion potential = 0.

13. DISPOSAL CONSIDERATIONS

Comply with all local, state, and federal/international regulations.

14. TRANSPORT INFORMATION

UN Number: 3178	Shipping Limitations:	
UN Classification: 4.1 Flammable solid, inorganic, n.o.s. (fire suppressant containing potassium nitrate)	Cargo Air	Max single packaging – 100 kgs.
Packaging Group: III	Passenger Air	Max single packaging – 25 kgs.
Division 4.1 articles present no significant hazard as packaged for transport.		

15. REGULATORY INFORMATION

S15	Keep away from heat
S33	Take precautionary measures against risk of static discharge
S35	This material and its container must be disposed of in a safe way
S38	In case of insufficient ventilation wear suitable respiratory equipment
S39	Wear eye/face protection

16. OTHER INFORMATION

Comply with manufacturer's installation and maintenance procedures.

Disclaimer:
The information contained herein is accurate to the best knowledge and belief of Fireaway Inc., and is intended to describe the product for health, safety, and environmental requirements only. It is not intended and should not be construed as a warranty. Consult Fireaway for further information.

Attachment 6

Tailgate Briefing Form

NEW MEXICO TECH
ENERGETIC MATERIALS 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** **Sign**	**Date**
Ordnance	**Print** **Sign**	**Date**
Instrumentation	**Print** **Sign**	**Date**
Field Supervisor	**Print** **Sign**	**Date**
Safety	**Print** **Sign**	**Date**

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)

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:**	

Attachment 9

Standard Operating Procedures

(hundreds of pages - available in hard or soft copy by request)

B Fan Documentation

Installation and Operation Manual
Manuel d'installation et d'opération
Manual de Instalación y Mantenimiento

Item #: 490095
Rev Date: 2016-06-01

FG EC Series

Inline Centrifugal Fans with EC Motors

Ventilateur Centrifuge en ligne avec Moteur EC

Ventilador centrífugo en línea con motor EC

United States
10048 Industrial Blvd., Lenexa, KS, 66215
Tel.: 800.747.1762 • Fax: 800.487.9915

Canada
50 Kanalflakt Way, Bouctouche, NB, E4S 3M5
Tel.: 800.565.3548 • Fax: 877.747.8116

Fantech Inc. certifies that the FG EC Series shown herein is licensed to bear the AMCA Seal. The ratings shown are based on tests and procedures performed in accordance with AMCA Publication 211 and comply with the requirements of the AMCA Certified Ratings Program.

Fantech Inc. certifie que les ventilateurs de la série FG EC décrits aux présentes portent le sceau de l'ACMA. Les caractéristiques indiquées sont fondées sur les essais et procédures effectués conformément aux publications 211 de l'ACMA, et répondent aux exigences du programme de certification des caractéristiques.

Fantech Inc. certifica que los modelos que aparecen en este documento están autorizados para llevar el sello de AMCA. Las clasificaciones se basan en pruebas y procedimientos realizados de acuerdo con el documento AMCA 211 y en cumplimiento con los requisitos del programa AMCA para la certificación.

To ensure quiet operation of ENERGY STAR® qualified inline and remote fans, each fans shall be installed using sounds attenuation techniques appropriate for the installation. For bathroom and general ventilation applications, at least 8 feet of insulated duct shall be installed between the exhaust or supply grilles(s) and the fan. For kitchen range hood remote ventilation applications, where metal duct is generally required by code, a metal sound attenuator shall be installed between the range hood and the fan.

Pour assurer un fonctionnement silencieux des ventilateurs et des ventilateurs à distance qualifiés ENERGY STAR®, chaque ventilateurs doit être installé en utilisant des techniques d'atténuation du son appropriées pour l'installation. Pour les applications de salles de bain et les applications de ventilation générales, au moins 8 pieds de conduits flexible isolé doivent être installées entre les grilles d'évacuation et d'approvisionnement du ventilateur. Pour les applications de hotte de cuisinière à distance, où un conduit en métal est généralement requis par le code du bâtiment, un atténuateur acoustique en métal doit être installé entre la hotte et le ventilateur.

Para asegurar una operación silenciosa de los ventiladores en línea certificados ENERGY STAR, cada ventilador debe instalarse utilizando técnicas de atenuación de sonido apropiadas para cada caso. Para baños y aplicaciones comunes de ventilación se recomienda instalar por lo menos 8' de ducto flexible con aislamiento entre la rejilla de expulsión y/o inyección y el ventilador. Para campanas de cocina con un ventilador de extracción remoto, done se usa por código ducto rígido, se recomienda instalar un atenuador de sonido entre la campana y el ventilador.

fantech®
a systemair company

Note	Warning / Important note	Information	Technical information	Practical tip

1. The compactness of the FG EC series, plus the adaptability to be mounted in any position, permits easy installation. This straight-thru air flow fan can be mounted at any angle from horizontal to vertical.

2. Because this unit has rotating parts, safety precautions should be exercised during this phase of installation, operation and maintenance.

3. **CAUTION:** For General Ventilation Use Only. Do Not Use To Exhaust Hazardous Or Explosive Material and Vapors.

4. Remove unit from package and inspect within 15 days after receipt. If damaged, report damage to carrier. Do NOT operate this unit with visible damage to the blower or impeller assembly.

5. For FG Series fans, if bracket is used to mount fan, refer to illustration 1. If suspending fan with hanger straps, refer to illustration 2.

6. To attach duct work, use duct tape at inlet and outlet to assure good seal. If using FANTECH FC clamps: attach FC clamps and insert screws through clamp into inlet and outlet flanges.

CAUTION: Use 1/2" sheet metal screws to secure duct work to inlet and outlet. It is critical that the screw penetrate the metal of the inlet flange but not so far as to bind the impeller. It may be necessary to angle screws away from impeller.
CAUTION: If not using FANTECH FC clamps use 1/4" screws.

7. Screen guards must be installed when fan will be within reach of personnel, within seven (7) feet of working area, or when advisable for safety.

8. FGC EC models are factory wired with a power cord. Do not use an extension cord with these models. Do not operate any fan with a damaged cord or plug. Discard fan or return to an authorized service facility for examination and/or repair. Do not run cord under carpeting. Do not cover cord with throw rugs, runners, or similar coverings. Do not route cord under furniture or appliances. Arrange cord away from traffic area and where it will not be tripped over.

9. An appropriate duct termination device (roof cap, wall cap, louvered shutters, etc.) are to be used with this fan.

1. Le caractère compact des appareils de séries FG EC, ainsi que leur adaptabilité à être montés dans n'importe quelle position, facilite leur installation. Ces ventilateurs à flot d'air direct peuvent être montés à n'importe quel angle, de l'horizontal à la verticale.

2. Étant donné ses parties amovibles, certaines précautions doivent être prises lors de l'installation, l'opération et l'entretien.

3. **ATTENTION**: "Pour usage de ventilation générale seulement.Ne pas utiliser pour l'évacuation de matériaux et de vapeurs dangereux ou explosifs."

4. Enlever l'appareil de l'emballage et l'inspecter dans les quinze jours qui suivent sa réception. S'il est endommagé, en avertir le transporteur. C'est important qu'on N'UTILISE PAS ce ventilateur s'il y a de dommage visible à l'impulseur ou au ventilateur.

5. Pour les ventilateurs de modèle FG, on utilise un support pour installer le ventilateur, se référer à la figure 1. Si le ventilateur va être suspendu au moyen de courroies, voir la figure 2.

6. Pour attacher les conduits, utiliser du ruban pour conduits à l'entrée et à la sortie afin d'assurer une adhésion hermétique. Pour les ventilateurs modèle FG, fixer les attaches FANTECH FC et insérer les vis à travers les attaches dans les collerettes de l'entrée et de la sortie.

ATTENTION: Utiliser des vis de 1/2 pouce pour métal pour fixer les conduits à l'entrée et à la sortie. Il est absolument nécessaire que les vis pénètrent le métal de la collerette d'entrée sans toutefois obstruer l'impulseur. Il pourrait être nécessaire de fixer les vis à un angle qui leur permettraient d'éviter l'impulseur. **ATTENTION: Si vous n'utilisez pas de colliers de commande du ventilateur Fantech, utilisez des vis de** 1/4 **pouce.**

7. Des gardes de sécurité doivent être installés lorsque le ventilateur sera accessible par le personnel, dans un rayon de moins de sept pieds de l'aire de travail, ou lorsqu'il est jugé nécessaire pour fins de sécurité.

8. Les modèles FGC EC sont précâblés à l'aide d'un cordon d'alimentation. Ne pas utiliser de rallonge électrique avec ces modèles. Ne jamais utiliser un ventilateur avec un cordon ou une prise endommagée. Jeter le ventilateur ou retournez à une installation de service autorisée pour un examen et/ou une réparation. Ne pas passer le cordon sous un tapis. Ne pas couvrir le cordon de carpettes, de protège-tapis, ou des revêtements similaires. Ne pas passer le cordon sous les meubles ou appareils électroménagers. Placez le cordon loin de la zone de circulation où personne ne trébuchera dessus.

9. Un dispositif d'extrémité pour conduit approprié (chapeau de toit, obturateur mural, obturateur à persiennes, etc.) doit être utilisé avec ce ventilateur.

1. La Serie FG EC es compacta y adaptable para montar en cualquier posición, por lo cual es fácil de instalar. Este ventilador de flujo axial se puede montar a cualquier ángulo, desde horizontal hasta vertical.

2. Debido a que esta unidad tiene piezas rotativas, hay que tomar precauciones de seguridad durante la instalación, operación y mantenimiento.

3. **PRECAUCION**: "Sólo para Ventilación en General. No trate de Utilizarse como Extractor de materiales y Vapores Peligrosos o Explosivos."

4. Saque la unidad del paquete e inspecciónela antes de vencidos los 15 días de su recibo. Si está dañada, informe al transportista. Hay que NO USAR este ventilador si hay daños visibles al impulsor o al soplador.

5. Para los ventiladores Modelo FG, si han de montarse en un soporte, refiérase a la Ilustración 1. Si ha de colgarse un ventilador con tirantes, refiérase a la Ilustración 2.

6. Para conectar tramos de conductos, use cinta para conductos a la entrada y a la salida para asegurar un buen sello. Para ventiladores Modelo FG, conecte abrazaderas FANTECH FC e inserte tornillos a través de la abrazadera a las bridas de entrada y salida.
PRECAUCION: Utilice tornillos de 1/2 pulgada para hojalata para fijar el conducto a la entrada y salida. Es esencial que los tornillos penetren el metal de la brida de entrada pero no al extremo de obstruir el impulsor. Puede que sea necesario inclinar los tornillos para desviarlos del impulsor. **PRECAUCION: Si no se usa anillos de control de ventilador Fantech, se debe usar tornillos de** 1/4 **pulgada.**

7. Hay que instalar pantallas de guarda donde el ventilador quede al alcance del personal, a menos de 213 cm del puesto de trabajo o bien cuando sea aconsejable desde el punto de vista de seguridad.

8. Los modelos FGC EC vienen provistos de fábrica con un cable de alimentación. No usar alargador con estos modelos. No opere ningún ventilador si el cable o enchufe está dañado. Deseche el ventilador o devuélvalo a un centro de servicio autorizado para su examen y/o reparación. No instale el cable debajo de la alfombra. No cubra el cable con alfombras, alfombrillas o revestimientos similares. No instale el cable debajo de muebles o electrodomésticos. Coloque el cable lejos del área de tráfico y donde no se pueda tropezar.

10. Usar un dispositivo protector adecuado a la salida del conducto (tapa de techo, tapa de pared, tapa tipo persiana) con este ventilador.

WARNINGS

1. WARNING! TO REDUCE THE RISK OF FIRE, ELECTRIC SHOCK, OR INJURY TO PERSONS - OBSERVE THE FOLLOWING:

a. Use this unit only in the manner intended by the manufacturer. If you have any questions, contact your manufacturer's representative.
b. Before servicing or cleaning unit, switch power off at service panel and lock the service disconnecting means to prevent power from being switched on accidentally. When the service disconnecting means cannot be locked, securely fasten a prominent warning device, such as a tag, to the service panel. For FGC corded models unplug the fan from the power supply.
c. Installation work and electrical wiring must be done by qualified person(s) in accordance with all applicable codes and standards, including fire-rated construction.
d. Sufficient air is needed for proper combustion and exhausting of gases through the flue (chimney) of fuel burning equipment to prevent back drafting. Follow the heating equipment manufacturer's guideline and safety standards such as those published by the National Fire Protection Association (NFPA), and the American Society for Heating, Refrigeration and Air Conditioning Engineers (ASHRAE), and the local code authorities.
e. When cutting or drilling into wall and ceiling, do not damage electrical wiring and other hidden utilities.
f. Ducted fans must always be vented to the outdoors.
g. If this unit is to be installed over a tub or shower, it must be marked as appropriate for the application and be connected to a GFCI (Ground Fault Circuit Interrupter) – protected branch circuit.
h. NEVER place a switch where it can be reached from a tub or shower.

2. WARNING! Check voltage at the fan to see if it corresponds to the motor name plate.

ADVERTISSEMENTS

1. AVERTISSEMENTS POUR RÉDUIRE LES RISQUES D'INCENDIE, DE DECHARGE ELECTRIQUE OU RISQUE DE BLESSURES. SUIVEZ LES CONSEILS SUIVANTS:

a. Utiliser seulement l'appareil tel que prévu par le fabricant. Communiquer avec le représentant du fabricant pour toute question.
b. Avant de procéder à l'entretien ou au nettoyage de l'appareil, coupez l'alimentation au panneau de service et verrouiller le dispositif de sectionnement pour éviter une mise sous tension accidentelle de l'appareil. S'il est impossible de verrouiller le dispositif de sectionnement, fixez un dispositif d'avertissement (comme une étiquette) bien en vue sur le panneau de service. Débranchez les modèles FGC de la prise électrique.
c. Les travaux d'installation et de raccordement électrique doivent être effectués par des personnes qualifiées conformément aux codes et normes applicables, y compris les codes de protection contre les incendies.
d. Un apport d'air suffisant est nécessaire pour assurer la combustion convenable et l'échappement des gaz par le conduit d'air (cheminée) de l'appareil de combustion afin d'empêcher le refoulement d'air. Conformez-vous aux lignes directrices émises par le fabricant du matériel thermique, aux mesures de sécurité comme celles publiées par la National Fire Protection Association (NFPA), l'American Society for Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) et aux règlements locaux.
e. En taillant ou en perforant les murs et les plafonds, attention de ne pas endommager les fils électriques ou autres appareils dissimulés.
f. Les ventilateurs doivent toujours être ventilés vers l'extérieur.
g. Si l'appareil doit être installé au-dessus d'une baignoire ou d'une douche, il doit porter une inscription à cet effet et être relié à un disjoncteur de fuite de terre du circuit de dérivation protégé.
h. NE JAMAIS installer un interrupteur où il pourrait être accessible d'un bain ou d'une douche.

2. ATTENTION : Vérifier le voltage afin de voir s'il correspond à celui indiqué sur la plaque du moteur.

ADVERTENCIAS

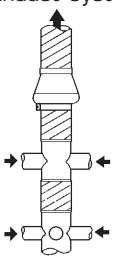
1. ADVERTENCIA: PARA REDUCIR EL RIESGO DE INCENDIO, CONMOCION ELECTRICA O LESIONES A PERSONAS, OBSERVE LO SIGUIENTE:

a. Sólo utilice esta unidad en la forma contemplada por el fabricante. Si tiene cualquier pregunta, diríjase al representante del fabricante.
b. Antes de darle mantenimiento o limpiar la unidad, apague la fuente de energía en el panel de servicio y bloquee los medios de desconexión del servicio para evitar que se vuelva a conectar a la fuente de energía accidentalmente. Cuando no se puedan bloquear los medios de desconexión del servicio, adhiera firmemente al panel de servicios, en un lugar prominente, un rótulo o una etiqueta a tal efecto. Desenehufe los modelos FGC de la fuente de alimentacion.
c. Los trabajos de instalación y cableado deben ser realizados por personal calificado conforme todos los códigos y normas del caso incluso construcción contra incendiós.
d. Se necesita tener suficiente aire para lograr una combustión adecuada y expulsar los gases mediante el conducto de humos (chimenea) del equipo de quema de combustible para evitar el efecto de contra-tiro. Observe las pautas provistas por el fabricante del equipo de calefacción y las normas de seguridad tales como las publicadas por el National Fire Protection Association (NFPA) y American Society for Heating Refrigeration and Air Conditioning Engineers (ASHRAE), y los códigos locales aplicables.
e. Al cortar o perforar paredes y techos, no dañe el cableado eléctrico y demás servicios ocultos.
f. Los ventiladores con conducto siempre deben tener salida al exterior.
g. Si esta unidad se va a instalar sobre una bañera o una ducha, es necesario marcarla según corresponda a la aplicación y se debe conectar a una derivación protegida por GFCI (interruptor accionado por corriente de pérdida a tierra).
h. JAMAS coloque un interruptor donde pueda alcanzarse desde una bañera o ducha.

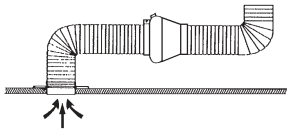
2. ¡ADVERTENCIA! Revise el voltaje entrante al ventilador para constatar que corresponda al que indica la placa de fábrica.

INSTALLATIONS

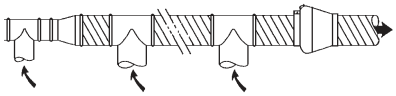
Exhaust system



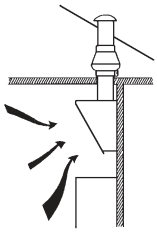
Ceiling exhaust system



Horizontal installation



Exhaust system



INSTALLATION DIAGRAM FOR MODEL FG DUCT FANS

1. When installing, keep the number of elbows and bends to a minimum. If necessary, long radius elbows or bends are recommended.
2. Duct sealant, caulk, or tape should be applied to all seams to prevent air leakage and maximize air performance.
3. Flex, spiral, or snap lock ducting may be used. If using rigid duct, Fantech FC clamps are recommended to connect duct work to the fan (see illustration 2).

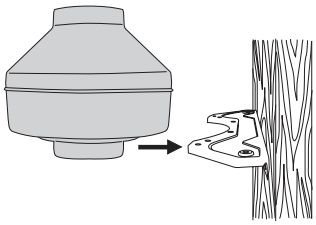
FC clamps make an air tight seal at the connection points and reduce vibrations transmitted throughout the duct system.

4. To minimize static pressure losses and promote adequate airflow, minimize duct run lengths where possible. If using flex duct, keep duct runs straight and taut.
5. If installing in an unconditioned space, covering the fan with insulation is recommended to prevent condensation from forming.
6. For general ventilation applications, at least 8 ft of insulated flexible duct shall be installed between the exhaust or supply grille(s) and the fan.

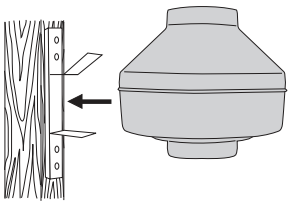
The ducting from this fan to the outside of the building has a strong effect on the air flow, noise and energy use of the fan. Use the shortest, straightest duct routing possible for best performance, and avoid installing the fan with smaller ducts than recommended. Insulation around the ducts can reduce energy loss and inhibit mold growth. Fans installed with existing ducts may not achieve their rated air flow.

Illustration 1

Fan bracket should be installed, then fan mounted directly to bracket using sheet metal screws.

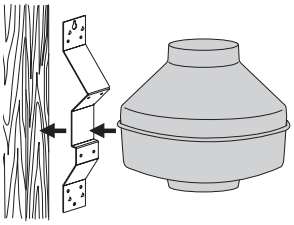


Models
- 4XL EC



Models
- 6M EC
- 10 EC
- 8 EC

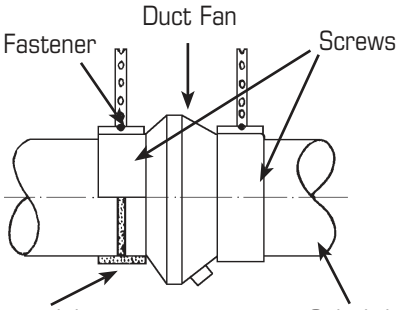
Mount bracket to fan first!



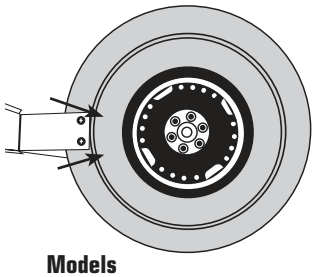
Models
- 12 EC
- 12XL EC

Illustration 2

Fans may be suspended without special mounting brackets.



Mounting Bracket & Screw Locations for FG

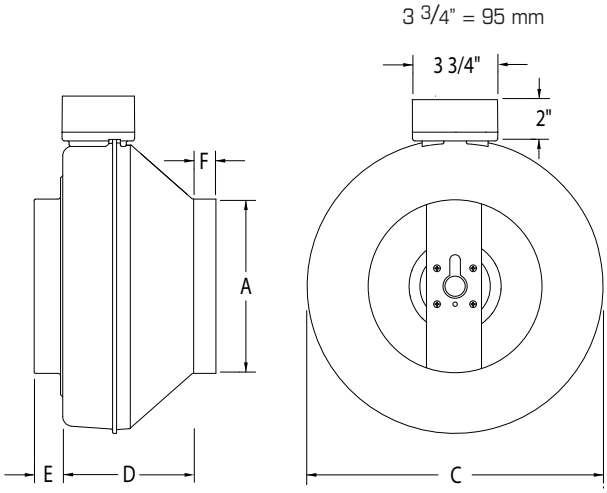


Models
- 6M EC
- 8 EC
- 10 EC

DIMENSION MODEL FG EC

Model	A	C	D	E	F
4 XL EC	4	8 1/2	6 1/2	1	1
6M EC	6	13 1/8	6 5/8	1	1
8 EC	8	13 3/8	6	1 1/8	1 1/8
10 EC	10	13 3/8	4 11/16	1 1/8	1
12 EC	12	16	8 1/4	1 1/16	1 3/16
12XL EC	12	16	8 1/4	1 1/16	1 3/16

Dimensions are in inches.



For connection to a building management system

WARNING

To Reduce The Risk Of Electric Shock, Connect the FGC to a properly grounded outlet only.

SPECIAL WIRING PRECAUTIONS

All installation should be wired according to the following diagrams.
Failure to comply will cause the motor to "hum" or not work.

Maximum torque that can be applied to the terminal block screws is 0.79 Nm (7 lb-in).

NOTE

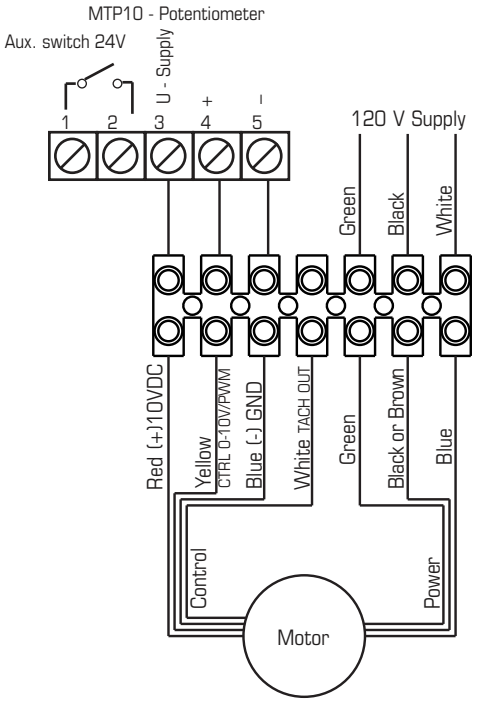
Model FGC EC comes pre-wired with three prong power cord.

NOTE

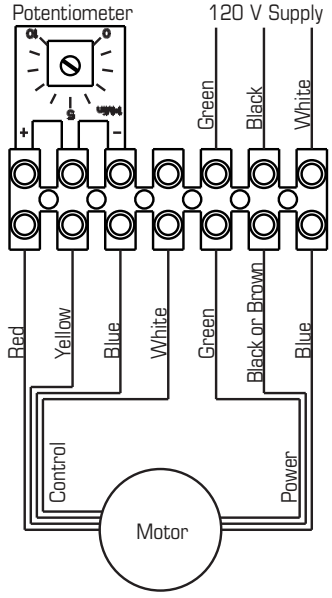
Remove this potentiometer to facilitate installation of a building management system or external motor speed control. Refer to diagrams on the left for wiring instructions.

INSTRUCTION FOR ALL MODEL FG EC FANS

With external motor speed controller



Without external motor speed controller



TROUBLESHOOTING

If fan fails to operate, please check the following:

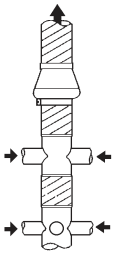
a. Consult wiring diagrams included to ensure proper connections.
b. To ensure proper contact, check motor lead wiring, incoming supply wiring connections.
c. If possible, use a meter to test for continuity between fan leads.

MAINTENANCE

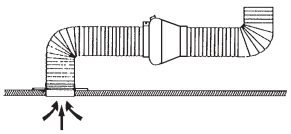
1. Since fan bearings are sealed and have been provided with an internal lubricating material, no lubrication is necessary.
2. Once a year, clean the impeller. No other maintenance is required.

INSTALLATIONS

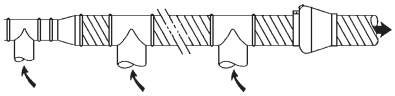
Système d'évacuation



Système d'évacuation au plafond



Installation horizontale



Système d'évacuation

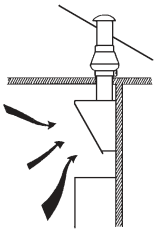


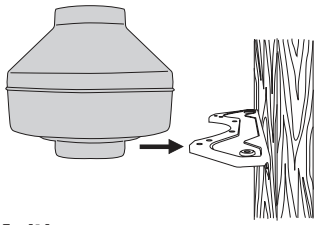
DIAGRAMME D'INSTALLATION ET DE RACCORDEMENT POUR LES VENTILATEUR À CONDUITS MODÈLE FG

1. Lors de l'installation, maintenir le nombre de coudes et de courbe à un minimum. Si nécessaire, des coudes ou des courbes à long rayon sont recommandés
2. Scellant adhésif, calfeutrage ou un ruban devraient être appliqués à tous les joints pour éviter les fuites d'air et optimiser la performance de l'air.
3. Conduits flexibles, en spiral ou en verrou d'accrochage peuvent être utilisés. Si vous utilisez un conduit rigide, les pinces de raccordement FC de Fantech sont recommandées pour relier les conduits au ventilateur (voir illustration 2).
   Les pinces FC créent un joint étanche à l'air au niveau des points de raccordement et réduisent les vibrations transmises à travers le réseau de conduits.
4. Pour minimiser les pertes de pression statique et de promouvoir une ventilation adéquate, minimisez les longueurs des conduits où possible. Si vous utilisez un conduit flexible, garder les canalisations droites et tendues.
5. En cas d'installation dans un espace non conditionné, recouvrir le ventilateur avec un isolant est recommandé pour éviter la formation de condensation.
6. Pour les applications de ventilation générale, un minimum de 8 pi de conduit flexible isolé doit être installé entre la grille (les grilles) d'évacuation ou d'alimentation et le ventilateur.

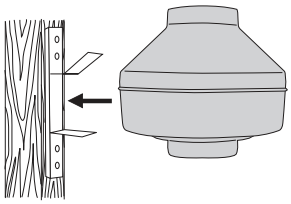
Le conduit de raccordement de ce ventilateur avec l'extérieur de l'immeuble a un effet important sur le débit d'air, le bruit et la consommation d'énergie du ventilateur. Veuillez utiliser le conduit le plus court et le plus droit possible pour obtenir un rendement optimal, et évitez d'installer des conduits plus petits que recommandé pour le ventilateur. L'isolation autour des conduits peut réduire les pertes d'énergie et empêcher la moisissure. Les ventilateurs installés avec des conduits existants pourraient ne pas offrir le débit d'air nominal.

Figure 1

Le support du ventilateur devrait être installé, puis le ventilateur devrait être placé directement sur le support au moyen de vis pour le métal.

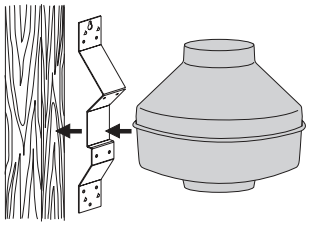


Modèle
- 4XL EC



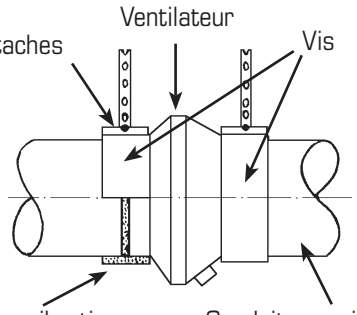
Modèle
- 6M EC
- 10 EC
- 8 EC

D'abord, attacher le support au ventilateur!

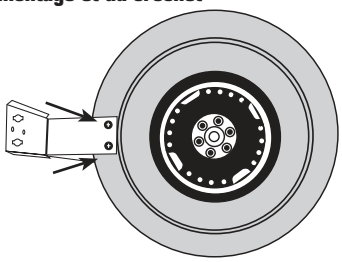


Modèle
- 12 EC
- 12XL EC

Figure 2



Placement des vis de montage et du crochet

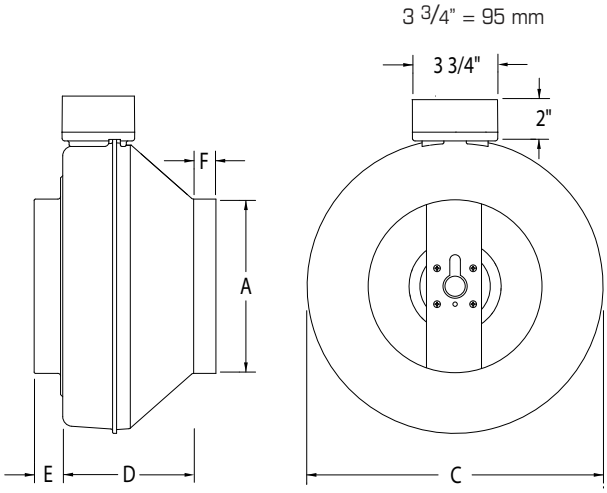


Modèle
- 6M EC
- 8 EC
- 10 EC

DIMENSIONS MODÈLE FG EC

Modèle	A	C	D	E	F
4 XL EC	4	8 1/2	6 1/2	1	1
6M EC	6	13 1/8	6 5/8	1	1
8 EC	8	13 3/8	6	1 1/8	1 1/8
10 EC	10	13 3/8	4 11/16	1 1/8	1
12 EC	12	16	8 1/4	1 1/16	1 3/16
12XL EC	12	16	8 1/4	1 1/16	1 3/16

Dimensions en pouces.



ATTENTION

Afin de réduire le risque de choc électrique, reliez les modéles FGC à une prise de courant avec une misc à la terre conforme aux normes.

PRÉCAUTIONS POUR L'INSTALLATION ÉLECTRIQUE

Toute installation devrait être branchée selon les diagrammes suivants. Sinon, le moteur pourrait émettre un vrombissement ou ne pas fonctionner. Le couple maximal qui peut être appliqué aux vis du bornier est de 0.79 Nm (7 lb-in).

NOTEZ

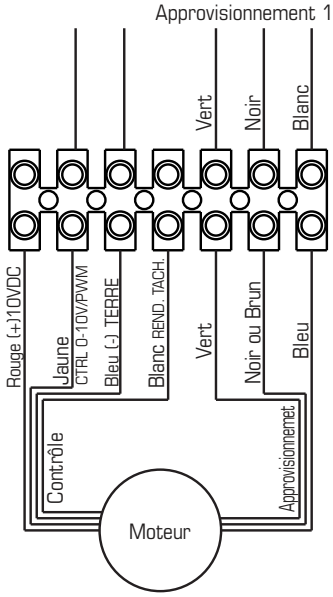
Retirer ce potentiomètre pour faciliter l'installation d'un système de gestion du bâtiment ou de contrôle de vitesse du moteur externe. Reportez-vous aux diagrammes sur la gauche pour obtenir des instructions de câblage.

NOTEZ

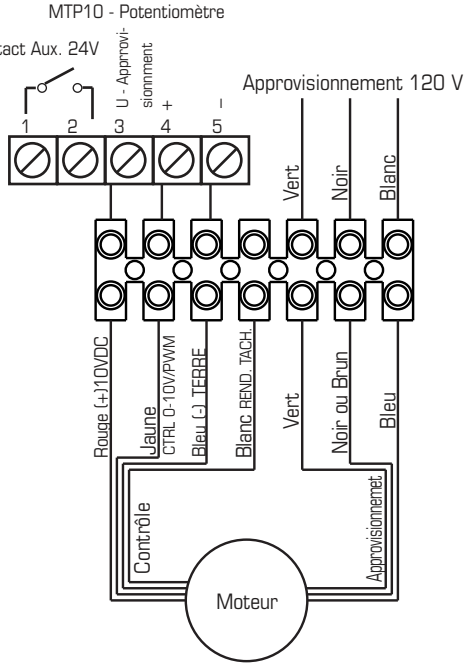
Les modèles FGC EC sont fournis avec une prise de courant à trois pointes.

INSTRUCTION DES VENTILATEURS MODÈLES FG EC

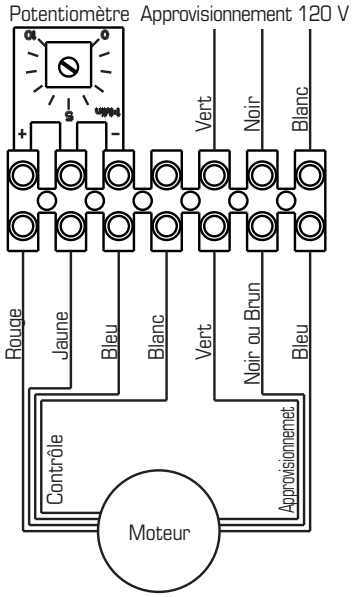
Pour le raccordement à un système de gestion de bâtiment



Avec contrôle de vitesse externe



Sans contrôle de vitesse du moteur externe



EN CAS DE DIFFICULTÉS

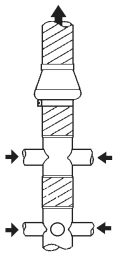
1. Si le ventilateur cesse de fonctionner, vérifier ce qui suit:
   a. Consulter le diagramme de raccordement électrique inclus afin d'assurer les bons raccords.
   b. Pour assurer un contact approprié, vérifier le fil principal du moteur et les fils d'approvisionnement.
   c. Si possible, utiliser un multimètre pour vérifier la continuité entre les connecteurs du ventilateur.
2. Si le ventilateur ne fonctionne toujours pas, consulter le représentant FANTECH pour instructions quant au retour et au remplacement.

ENTRETIEN

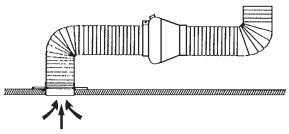
1. Puisque les roulements du ventilateur sont scellés et qu'ils comportent déjà un lubrifiant interne, aucune lubrification n'est nécessaire.
2. Au moins une fois par année, nettoyer l'impulseur.

INSTALACIONES

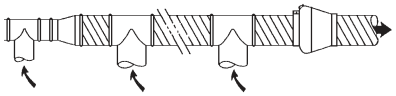
Sistema de escape



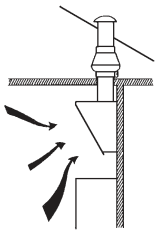
Escape montado en el cielo raso



Instalación horizontal



Sistema de escape



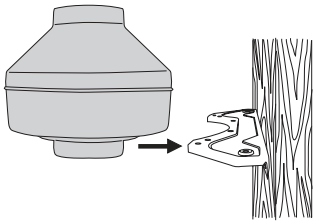
DIAGRAMAS DE INSTALACION Y CABLEADO DE VENTILADORES MODELO FG PARA CONDUCTOS

1. Al instalar, mantener el número de codos y curvas en un mínimo. Si necesarios se recomiendan codos o curvas de radio largo.
2. Sellador de conductos, masilla o cinta deben aplicarse a todas las juntas para evitar fugas de aire y maximizar el rendimiento del aire.
3. Flex, espiral o complemento de ducto tipo “snap lock” se pueden utilizar. Si utiliza conducto rígido, se recomienda Fantech FC abrazaderas para conectar los conductos al ventilador (vea la ilustración 2).
   FC abrazaderas crea un sello hermético de aire en los puntos de conexión y reducir las vibraciones transmitidas en todo el sistema de conductos.
4. Para minimizar las pérdidas de presión estática y la promoción de una ventilación adecuada se recomienda minimizar las tiradas de ductos donde posibles. Si está usando conductos flexibles, mantenga el ducto recto.
5. Si se instala en un espacio no acondicionado, se recomienda que se cubra el ventilador con aislamiento para evitar la formación de condensación.
6. Para las aplicaciones generales de ventilación de deberá instalar por lo menos 8 pies de ducto flexible con aislamiento entre la rejilla(s) de escape o suministro y el ventilador.

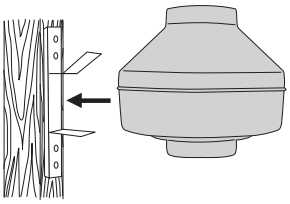
El conducto que va de este ventilador al exterior del edificio tiene un fuerte impacto en el flujo del aire, el ruido y la energía del ventilador. Utilice el enrutamiento del conducto más corto y recto posible para obtener un mejor rendimiento, y evite instalar el ventilador con conductos más pequeños de lo recomendado. La aplicación de un aislante alrededor de los conductos puede reducir la pérdida de energía y evitar la creación de moho. Los ventiladores que se instalen usando los conductos existentes pueden no alcanzar su flujo de aire nominal.

Ilustración 1

Se debe instaler primero el soporte del ventilador y después montarse éste directamente en el soporte con tornillos para hojalata.

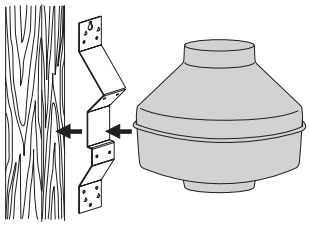


Modelo
- 4XL EC



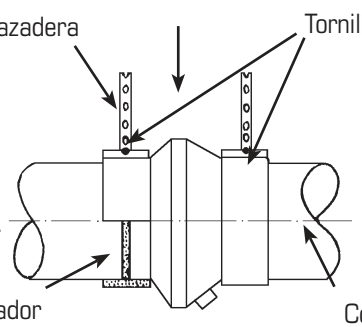
Modelo
- 6M EC
- 10 EC
- 8 EC

Primero, montar el soporte al ventilador!

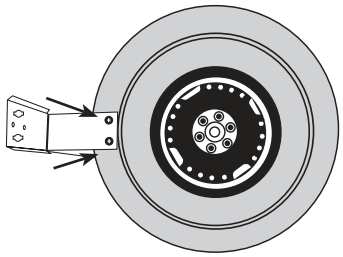


Modelo
- 12 EC
- 12XL EC

Ilustración 2



Soporte Montura Y Tornillo Localización

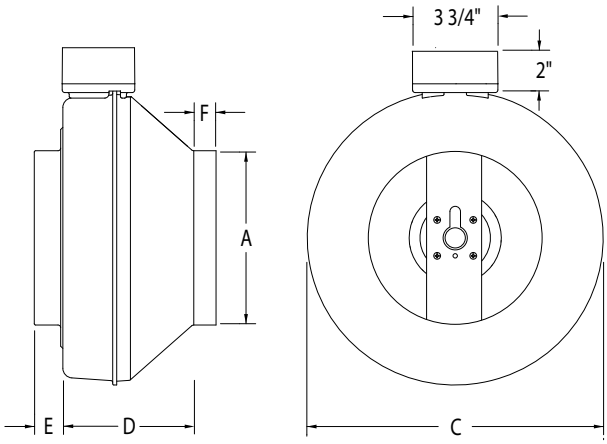


Modelo
- 6M EC
- 8 EC
- 10 EC

DIMENSIONSES DEL MODELO FG EC

Modelo	A	C	D	E	F
4 XL EC	4	8 1/2	6 1/2	1	1
6M EC	6	13 1/8	6 5/8	1	1
8 EC	8	13 3/8	6	1 1/8	1 1/8
10 EC	10	13 3/8	4 11/16	1 1/8	1
12 EC	12	16	8 1/4	1 1/16	1 3/16
12XL EC	12	16	8 1/4	1 1/16	1 3/16

Dimensiones en pulgadas.



ADVERTENCIA

Para reducir el riesgo de descarga eléctrica, conecte los modelos FGC con un enchufe correctamente puesto a tierra, solamente.

PRECAUCIONES ESPECIALES PARA CABLEADO

Toda le instalación debe cablearse conforme los diagramas que siguen. De lo contrario, el motor cimbrará sin girar.

El par máximo que se puede aplicar a los tornillos de la caja de bornes es de 0.79 Nm (7 lb-in).

NOTA

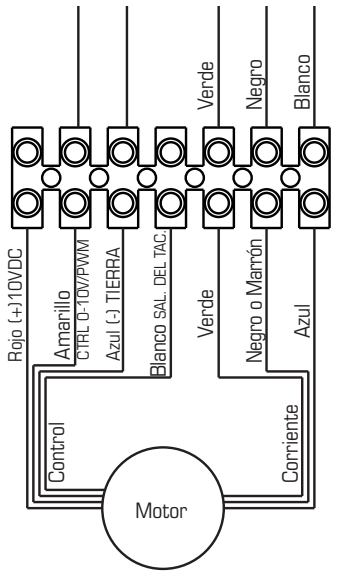
FGC EC modelo vienna con los alambre pre-encorvado Con un enchufe de tres diente

NOTA

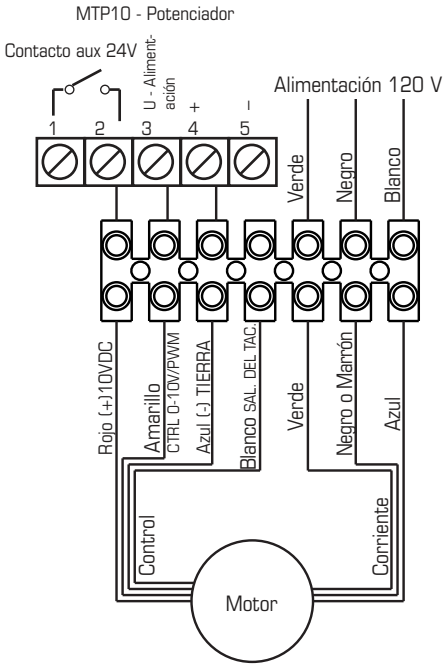
Eliminar este potenciómetro para facilitar la instalación de un sistema de gestión de edificios o de control de velocidad del motor externo. Consulte los diagramas de la izquierda para ver las instrucciones de cableado.

INSTRUCCIONES DE LOS VENTILADORES MODELO FG EC

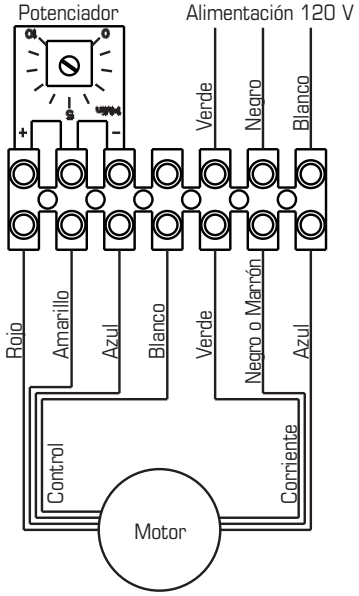
Para la conexión a un sistema de gestión de edificios



Con control de velocidad externo



Sin control de velocidad externo



ANALISIS DE FALLAS

1. Si el ventilador deja de funcionar, favor comprobar lo siguiente:
   a. Consulte los diagramas de cableado adjuntos para comprobar las conexiones correctas.
   b. Para asegurar el buen contacto compruebe los cables del motor y la alimentación.
   c. Si es posible, use un ohmiómetro para comprobar la continuidad entre contactos del ventilador.
2. Si el ventilador sigue sin funcionar, pida al representante de Fantech instrucciones de devolución/reemplazo.

MANTENIMIENTO

1. No hay necesidad de lubricación, ya que los rodamientos del ventilador están sellados y vienen cargados de lubricante.
2. Por lo menos una vez al año, limpie el impulsor.

WARRANTY

Five (5) Year Warranty

This warranty supersedes all prior warranties

DURING ENTIRE WARRANTY PERIOD:
Fantech will repair or replace any part which has a factory defect in workmanship or material. Product may need to be returned to the Fantech factory, together with a copy of the bill of sale and identified with RMA number.

FOR FACTORY RETURN YOU MUST:

- Have a Return Materials Authorization (RMA) number. This may be obtained by calling Fantech either in the USA at 1.800.747.1762 or in CANADA at 1.800.565.3548. Please have bill of sale available.
- The RMA number must be clearly written on the outside of the carton, or the carton will be refused.
- All parts and/or product will be repaired/replaced and shipped back to buyer; no credit will be issued.

OR
The Distributor may place an order for the warranty part and/or product and is invoiced. The Distributor will receive a credit equal to the invoice only after product is returned prepaid and verified to be defective.

FANTECH WARRANTY TERMS DO NOT PROVIDE FOR REPLACEMENT WITHOUT CHARGE PRIOR TO INSPECTION FOR A DEFECT. REPLACEMENTS ISSUED IN ADVANCE OF DEFECT INSPECTION ARE INVOICED, AND CREDIT IS PENDING INSPECTION OF RETURNED MATERIAL. DEFECTIVE MATERIAL RETURNED BY END USERS SHOULD NOT BE REPLACED BY THE DISTRIBUTOR WITHOUT CHARGE TO THE END USER, AS CREDIT TO DISTRIBUTOR'S ACCOUNT WILL BE PENDING INSPECTION AND VERIFICATION OF ACTUAL DEFECT BY FANTECH.

THE FOLLOWING WARRANTIES DO NOT APPLY:

- Damages from shipping, either concealed or visible. Claim must be filed with freight company.
- Damages resulting from improper wiring or installation.
- Damages or failure caused by acts of God, or resulting from improper consumer procedures, such as:
  1. Improper maintenance
  2. Misuse, abuse, abnormal use, or accident, and
  3. Incorrect electrical voltage or current.
- Removal or any alteration made on the Fantech label control number or date of manufacture.
- Any other warranty, expressed, implied or written, and to any consequential or incidental damages, loss or property, revenues, or profit, or costs of removal, installation or reinstallation, for any breach of warranty.

WARRANTY VALIDATION

- The user must keep a copy of the bill of sale to verify purchase date.
- These warranties give you specific legal rights, and are subject to an applicable consumer protection legislation. You may have additional rights which vary from state to state.

Limitation of Warranty and Liability

This warranty does not apply to any Fantech product or part which has failed as a result of faulty installation or abuse, incorrect electrical connections or alterations made by others, or use under abnormal operating conditions or misapplication of the product or parts. We will not approve for payment any repair not made by us or our authorized agent without prior written consent. The foregoing shall constitute our sole and exclusive warranty and our sole exclusive liability, and is in lieu of any other warranties, whether written, oral, implied or statutory. There are no warranties which extend beyond the description on the page hereof. In no event, whether as a result of breach of contract, or warranty or alleged negligence, defect incorrect advice or other causes, shall Fantech be liable for special or consequential damages, including, but not limited to, loss of profits or revenue, loss of use of equipment or any other associated equipment, cost of capital, cost of substitute equipment, facilities or services, downtime costs, or claims of customers of purchase for such damages. Fantech neither assumes or authorizes any person to assume for it any other liability in connection with the sale of product(s) or part(s). Some jurisdictions do not allow the exclusion or limitation of incidental or consequential damages so the above limitations and exclusions may not apply to you.

Warning

Fantech products are designed and manufactured to provide reliable performance, but they are not guaranteed to be 100% free from defects. Even reliable products will experience occasional failures and this possibility should be recognized by the user. If these products are used in a life support ventilation system where failure could result in loss or injury, the user should provide adequate backup ventilation, supplementary natural ventilation, failure alarm system, or acknowledge willingness to accept the risk of such loss or injury.

GARANTIE

Garantie de 5 ans

Cette garantie remplace toutes les garanties précédentes.

DURANT TOUTE LA PÉRIODE DE GARANTIE:
Fantech s'engage à réparer ou à remplacer toute pièce présentant un défaut d'usine en matière de qualité d'exécution ou de matériau. Il sera peut être nécessaire de retourner le produit à l'usine Fantech, accompagné d'une copie du contrat de vente et du numéro d'autorisation de retour.

POUR RETOURNER UN PRODUIT À L'USINE, VOUS DEVEZ:

- Obtenir un numéro d'autorisation de retour; pour ce faire, communiquer avec Fantech aux États-Unis au numéro 1.800.747.1762, ou au Canada, au numéro 1.800.565.3548. Veuillez avoir votre contrat de vente à portée de la main.
- S'assurer que le numéro d'autorisation de retour est lisible sur l'extérieur de la boîte, sinon la boîte sera refusée.
- Toutes les pièces et/ou le produit seront réparés ou remplacés puis retournés à l'acheteur. Aucun crédit ne sera accordé.

OU
Le Distributeur peut commander une pièce ou un produit couvert par la garantie; la facture lui sera envoyée. Le distributeur ne sera crédité du montant de sa facture qu'après que le produit a été retourné port payé et qu'il a été trouvé défectueux.

LES TERMES DE LA GARANTIE DE Fantech NE PRÉVOIENT PAS DE REMPLACEMENT SANS FRAIS AVANT QUE LA PIÈCE OU LE PRODUIT DÉFECTUEUX AIT ÉTÉ INSPECTÉ. LES PRODUITS OU PIÈCES REMPLACÉS AVANT L'INSPECTION DE LA DÉFECTUOSITÉ SERONT FACTURÉS ET LE MONTANT DU CRÉDIT EST FONCTION DE L'INSPECTION DE LA PIÈCE OU DU PRODUIT RETOURNÉ. LE DISTRIBUTEUR NE DOIT PAS REMPLACER SANS FRAIS POUR L'UTILISATEUR FINAL L'ÉQUIPEMENT DÉFECTUEUX RETOURNÉ PAR L'UTILISATEUR FINAL, CAR LE COMPTE DU DISTRIBUTEUR NE SERA CRÉDITÉ QU'APRÈS L'INSPECTION ET LA VÉRIFICATION PAR FANTECH DE LA DÉFECTUOSITÉ.

LES GARANTIES NE S'APPLIQUENT PAS DANS LES CAS SUIVANTS:

- Dommages dus au transport (dissimulés ou visibles). Les réclamations doivent être faites à la compagnie de fret.
- Dommages dus au mauvais câblage ou à l'installation inappropriée.
- Dommages ou défectuosité causés par une calamité naturelle ou résultant d'une procédure irrégulière de l'acheteur, notamment :
  1. Entretien irrégulier
  2. Mauvais usage, usage abusif, usage anormal ou accident
  3. Tension ou courant électrique incorrect
- Enlèvement ou toute modification du numéro de contrôle ou de la date de fabrication de l'étiquette Fantech
- Toute autre garantie expresse, écrite ou implicite, pour les dommages accidentels ou indirects, perte de biens, de recettes, manque à gagner ou coûts relatifs à la dépose, à l'installation ou à la réinstallation, en cas de violation de garantie.

CERTIFICATION DE LA GARANTIE:

- L'utilisateur doit conserver une copie du contrat de vente pour confirmer la date d'achat.
- Les présentes garanties vous donnent des droits spécifiques reconnus par la loi et sont régies par les lois sur la protection du consommateur appropriées. Il est possible que différents états offrent d'autres droits.

Limites de garanties et de responsabilités

Cette garantie ne s'applique à aucun produit de Fantech ou à aucune pièce détachée dont la défectuosité relève d'une erreur d'installation ou d'abus ou de mauvaise installation électrique ou dut à des modifications extérieures ou utilisées dans des conditions anormales ou encore une mauvaise installation du produit ou des pièces détachées. Nous n'approuverons aucun remboursement pour des réparations qui ne sont pas effectuées par un agent américain ou un agent autorisé sans un accord écrit. Ce dernier constituera notre seule et exclusive garantie et notre seule exclusive responsabilité et tient lieu de toute autre garantie ou bien écrite ou orale implicite ou statuaire. Aucune garantie ne s'appliquera au-delà des descriptions faites de la page ci-dessus. En aucun cas, que ce soit pour une rupture de contrat ou de garanties ou des dommages dut à la négligence ou a des conseils incorrects ou autres causes, Fantech ne pourra être tenu pour responsable des dommages particuliers ou consécutifs, incluant mais pas limités aux pertes et profits ou bénéfices perte de matériel ou autres matériels associés. Coût du capital, coût des équipements de remplacement, matériels ou services, coût de temps d'arrêt ou les réclamations des clients pour de tels dommages. Fantech ne délègue ou autorise aucune personne d'assumer sa responsabilité sur la vente du produit ou des pièces détachées. Certaines juridictions ne permettent pas l'exclusion de la limitation des dommages accidentels ou consécutifs ainsi ces limitations ci-dessus et les exclusions ne s'appliquent pas à vous.

Avertissement

Les produits de Fantech sont conçus et fabriqués pour produire des performances fiables, mais il n'y a aucune garantie qu'ils soient 100% sans défaut. Les plus produits les plus fiables ont occasionnellement des défectuosités et cette possibilité devraient être reconnu par les usagers. Si ces produits sont utilisés comme une source de ventilation ou leur panne risque de mettre en danger des vies humaines ou entraîner des blessures, les usagers devront avoir une source de ventilation de secours en addition à une ventilation naturelle, le défaut de système d'alarme ou la connaissance de ces conditions entraînent sa responsabilité envers de telles pertes ou blessures.

GARANTIA

Garantia de Cinco (5) Años

Esta garantia de sin efecto cualquier otra garantia anterior

DURANTE EL PERÍODO INTEGRO DE LA GARANTÍA:
Fantech reparará o reemplazará toda parte que presente un defecto en el material o en la mano de obra. Es posible que el producto deba ser devuelto a la fabrica Fantech, juntamente con una copia de la constancia de compraventa e identificado con el número de RMA.

PARA DEVOLUCIÓN A FÁBRICA USTED DEBE:
- Tener un número de Autorización de Devolución de Material (RMA). Esto se puede obtener llamando a Fantech ya sea en los Estados Unidos al 1.800.747.1762
- en Canadá al 1.800.565.3548. Tenga a mano la constancia de compraventa.
- El número de RMA deberá estar claramente escrito en la parte exterior de la caja, de lo contrario la caja será rechazada.
- Todas las partes y/o el producto serán reparados/reemplazados y devueltos al comprador; no se otorgará crédito.

O BIEN
El Distribuidor puede colocar una orden por la parte y/o producto en garantía y facturarla/o. El Distribuidor recibirá un crédito igual a la factura sólo después de que se haya devuelto el producto con pago previo y con verificación de defecto.

LAS CONDICIONES DE LA GARANTÍA DE FANTECH NO CONTEMPLAN EL REEMPLAZO SIN CARGO ANTES DE REALIZAR LA INSPECCIÓN PARA DETECTAR DEFECTOS. LOS REEMPLAZOS EMITIDOS ANTES DE INSPECCIONAR POR DEFECTOS SON FACTURADOS, Y EL CRÉDITO ESTÁ A LA ESPERA DE INSPECCIÓN DEL MATERIAL DEVUELTO. EL MATERIAL DEFECTUOSO DEVUELTO POR LOS USUARIOS FINALES NO DEBERÁ SER REEMPLAZADO POR EL DISTRIBUIDOR SIN CARGO PARA EL USUARIO FINAL, YA QUE EL CRÉDITO DE LA CUENTA DEL DISTRIBUIDOR ESTARÁ A LA ESPERA DE INSPECCIÓN Y VERIFICACIÓN DEL DEFECTO REAL POR FANTECH.

LAS SIGUIENTES GARANTÍAS NO SE APLICAN:
- Daños durante el envío, ya sean encubiertos o visibles. Se deberá presentar el reclamo a la compañía transportadora.
- Daños ocasionados por cableado o instalación indebidos.
- Daños o fallas causados por hechos fortuitos, u ocasionados por procedimientos impropios por parte del usuario, tales como:
  1. Mantenimiento indebido
  2. Uso indebido, abuso, uso anormal o accidente y
  3. Tensión o corriente eléctrica incorrecta.
- Remoción o modificación realizada al número de control del rótulo de Fantech o de la fecha de fabricación.
- Toda otra garantía, expresa, implícita o escrita, daños y perjuicios, pérdida de propiedad, de ingresos, o de beneficios, o costo de remoción, instalación o reinstalación por incumplimiento de la garantía.

VALIDACIÓN DE LA GARANTÍA
- El usuario debe conservar una copia de la constancia de compraventa para verificar la fecha de compra.
- Estas garantías le otorgan derechos legales específicos, y están sujetas a una legislación aplicable para protección del consumidor. Usted puede tener derechos adicionales que varían de estado en estado.

Limitacion de Garantia y Responsabilidad Civil

Esta garantía no cubre ningún producto o pieza de Fantech que haya fallado por mala instalación, abuso, conexión eléctrica incorrecta o por alteraciones hechas por terceros, o por utilización bajo condiciones anormales de operación, o por aplicación incorrecta del producto o de las piezas. Nosotros no aprobamos el pago de ninguna reparación que no se haya realizado por nosotros o por nuestro agente autorizado previo consentimiento por escrito. Lo que antecede constituirá nuestra única y exclusiva garantía y nuestra única y exclusiva responsabilidad; y obra en lugar de cualquier otra garantía, ya sea escrita, verbal, tácita o estatutaria. No hay ninguna garantía que vaya más allá de lo que está descrito en esta página. Bajo ninguna circunstancia responderá Fantech, ya sea por incumplimiento de contrato o garantía ni por alegada negligencia, defecto, consejos incorrectos u otra causa, por daños especiales o consiguientes, incluso, pero no de manera única, pérdida de ganancias o ingresos, equipo cesante o cualquier otra pérdida relativa a equipos asociados; el costo del capital, costo de equipos, instalaciones o servicios sustitutos, tiempo ocioso o reclamos de clientes por compras incurridas por tales daños. Fantech ni asume ni autoriza a ninguna persona a que asuma a su nombre ninguna otra responsabilidad relativa a la venta de productos o piezas. Debido a que algunos distritos jurisdiccionales no permiten la exclusión o limitación por daños incidentales o consiguientes, puede que las limitaciones y limitaciones antes descritas no lo afe cten a Ud.

Advertencia

Aunque los productos de Fantech están diseñados y son fabricados para un rendimiento seguro, no garantizamos que estén libres de defectos al 100%. Hasta productos confiables a veces fallan; y el usuario debe reconocer esta posibilidad. Si estos productos se utilizan en un sistema de ventilación vital en donde una falla pudiera dar lugar a pérdidas o lesiones, el usuario debe disponer de una ventilación adecuada de reserva, ventilación natural suplemental, sistema de alarma de fallas, o expresar su voluntad de aceptar el riesgo de tales pérdidas o lesiones.

NOTES

NOTES

NOTAS

Fantech reserves the right to make technical changes.
For updated documentation please refer to www.fantech.net

Fantech se réserve le droit de faire des changements techniques. Pour de la documentation à jour, s'il vous plaît se référer au www.fantech.net

Fantech se reserva el derecho de hacer modificaciones técnicas en cualquier momento. Para obtener la documentación actualizada, por favor consulte www.fantech.net

fantech®
a systemair company

C Sensor Calibration Documents

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	74.4 (23.6)	°F (°C)
RELATIVE HUMIDITY	51	%RH
BAROMETRIC PRESSURE	28.75 (973.6)	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)	100 (0.51)	95~105 (0.48~0.53)	5	999 (5.07)	1005 (5.11)	985~1013 (5.00~5.15)
2	150 (0.76)	152 (0.77)	144~156 (0.73~0.79)	6	1501 (7.63)	1512 (7.68)	1482~1520 (7.53~7.72)
3	200 (1.02)	199 (1.01)	194~206 (0.99~1.05)	7	2995 (15.21)	2988 (15.18)	2961~3029 (15.04~15.39)
4	500 (2.54)	503 (2.56)	491~509 (2.49~2.59)	8	6016 (30.56)	6016 (30.56)	5952~6080 (30.24~30.89)

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

#	STANDARD	MEASURED	ALLOWABLE RANGE	#	STANDARD	MEASURED	ALLOWABLE RANGE
1	73.0 (22.8)	73.6 (23.1)	71.0~75.0 (21.7~23.9)				

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-9001:2008.

Measurement Variable	System ID	Last Cal.	Cal. Due
DC Voltage	E003277	06-16-15	12-16-16
Temperature	E003270	09-22-15	09-22-16
Pressure	E003271	08-26-15	08-26-16
DC Voltage	E003276	06-16-15	12-16-16
Pressure	E002740	02-22-16	08-22-16

CALIBRATED

June 15, 2016
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: Accounts Payable
801 Leroy Pl
Socorro, NM 87801

Date August 12, 2015
Due August 11, 2016
PO # DP167168
Model # 648B-15
Sales Ord. # S430294
RMA # N/A
Certificate No.: 15DWY00SB-0045

Accuracy: 0.8 **% of Full Scale**

Full Scale			
Pressure Reading:	2	Units:	IN W. C.
Current Reading:	20	Units:	mA

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: .06 **% Full Scale**

Calibration Standard Information

	Serial No.	Cert. Rpt. No.	Last Cal. Date
Base:	49315	49315-28770	07/27/15
Module 1:	10669	10669-42066	03/02/15
Module 2:			

Condition Of Meter	x New	After Repair	As Received

Instrument Information

I.D. No. of Instrument being Calibrated
4914183
Customer's I.D. No. (If Different)

Notes:

NEW / AS RECEIVED			AFTER REPAIR	
Actual Gage Pressure Setting	Current Reading (mA)	Full Scale mA Error (%)		
-1.0006	4.01000	0.09%		
-0.5002	8.00200	0.02%		
0.0000	12.00700	0.04%		
0.5003	16.01100	0.05%		
1.0003	20.00500	0.02%		

Signed: Jennifer Estep

Procedure No.: TC-00030

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: Accounts Payable
801 Leroy Pl
Socorro, NM 87801

Date August 12, 2015
Due August 11, 2016
PO # DP167168
Model # 648B-15
Sales Ord. # S430294
RMA # N/A
Certificate No.: 15DWY00SB-0046

Accuracy: 0.8 **% of Full Scale**

Full Scale			
Pressure Reading:	2	Units:	IN W. C.
Current Reading:	20	Units:	mA

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: .06 **% Full Scale**

Calibration Standard Information

	Serial No.	Cert. Rpt. No.	Last Cal. Date
Base:	49315	49315-28770	07/27/15
Module 1:	10669	10669-42066	03/02/15
Module 2:			

Condition Of Meter	x New	After Repair	As Received

Instrument Information

I.D. No. of Instrument being Calibrated
4514088
Customer's I.D. No. (If Different)

Notes:

NEW / AS RECEIVED			AFTER REPAIR	
Actual Gage Pressure Setting	Current Reading (mA)	Full Scale mA Error (%)		
-1.0002	3.97300	-0.16%		
-0.5006	7.97800	-0.11%		
0.0001	11.99600	-0.03%		
0.4997	15.99900	0.01%		
1.0005	20.00000	-0.02%		

Signed: Jennifer Estep

Procedure No.: TC-00030

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: Accounts Payable
801 Leroy Pl
Socorro, NM 87801

Date August 12, 2015
Due August 11, 2016
PO # DP167168
Model # 648B-05
Sales Ord. # S430294
RMA # N/A
Certificate No.: 15DWY00SB-0047

Accuracy: 0.8 **% of Full Scale**

Full Scale			
Pressure Reading:	2.5	Units:	IN W.C.
Current Reading:	20	Units:	mA

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: .06 % Full Scale

Calibration Standard Information

	Serial No.	Cert. Rpt. No.	Last Cal. Date
Base:	49315	49315-28770	07/27/15
Module 1:	15366	15366-42095	04/01/15
Module 2:			

Condition Of Meter	x New	After Repair	As Received

Instrument Information

I.D. No. of Instrument being Calibrated
4614118
Customer's I.D. No. (If Different)

Notes:

NEW / AS RECEIVED			AFTER REPAIR	
Actual Gage Pressure Setting	Current Reading (mA)	Full Scale mA Error (%)		
0.000	4.000	0.00%		
0.502	7.221	0.05%		
1.002	10.416	0.02%		
1.502	13.612	0.00%		
2.008	16.854	0.02%		
2.503	20.024	0.03%		

Signed:

Procedure No.: TC-00030

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: Accounts Payable
801 Leroy Pl
Socorro, NM 87801

Date August 12, 2015
Due August 11, 2016
PO # DP167168
Model # 648B-05
Sales Ord. # S430294
RMA # N/A
Certificate No.: 15DWY00SB-0048

Accuracy: 0.8 **% of Full Scale**

Full Scale			
Pressure Reading:	2.5	Units:	IN W.C.
Current Reading:	20	Units:	mA

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: .06 **% Full Scale**

Calibration Standard Information

	Serial No.	Cert. Rpt. No.	Last Cal. Date
Base:	49315	49315-28770	07/27/15
Module 1:	15366	15366-42095	04/01/15
Module 2:			

Condition Of Meter	x New	After Repair	As Received

Instrument Information

I.D. No. of Instrument being Calibrated
0115016
Customer's I.D. No. (If Different)

Notes:

Actual Gage Pressure Setting	NEW / AS RECEIVED Current Reading (mA)	Full Scale mA Error (%)	AFTER REPAIR	
0.000	4.079	0.49%		
0.505	7.299	0.42%		
1.007	10.480	0.22%		
1.504	13.642	0.10%		
2.003	16.835	0.10%		
2.502	20.037	0.15%		

Signed: Jeff Easley

Procedure No.: TC-00030

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.

OMEGA ENGINEERING, INC.
An OMEGA Technologies Company

Form:053-0005-3 Rev.C

Certificate Of Calibration

for

New Mexico Tech, Mechanical Engineering

Cust. P.O. #: DP165668
Test Item: XC-20-K-120-CAL-3

Report #: OS- N000003732
WO : N000003732

Recal Date: Per System Application

Ref. I.D.: C11120

CAL-3

Omega Engineering, Inc. certifies that the above instrumentation has been calibrated and tested to **meet or exceed** the published specifications. This calibration and testing was performed using instrumentation and standards that are traceable to the **National Institute of Standards and Technology**. Calibration has been performed in compliance with ISO 10012-1, ISO 9001 and ANSI/NCSL Z540-1-1994 as well as ASTM E 230 and ANSI MC96.1. This Certificate/Report shall not be reproduced, except in full, without written consent of Omega Engineering Inc.

Test Conditions: Temperature 74°F Relative Humidity 50%
Procedure used: QAP-2100
The maximum calibration uncertainty is calculated to be 0.3C from -25C to 500 C and 0.55C from 500C to 1100C.
INSTRUMENTS USED:

MODEL	SERIAL#	CAL DUE DATE	N.I.S.T. NUMBERS
Phillips PM2534	DM574003	05/05/16	NNCL-100-06
RTD (Burns)	745098	06/08/16	NNPR-100-01
RTD (Burns)	765565	06/08/16	NNPR-100-05
RTD (Burns)	765566	06/08/16	NNPR-100-06
TRCIII	I-0012	06/11/16	NNCL-098-31
DP251	2193-022-2473	06/05/16	NNDP-100-10

Probe No.	Nominal Temperature	Actual Test Temperature	Indicated Temperature
1	212 °F	212.0 °F	212.3 °F
1	392 °F	392.0 °F	391.7 °F
1	752 °F	752.0 °F	753.0 °F

Brian Arnone
Metrology Technician
Calibration Date: 07-29-15

Carl G. Mueller Jr.
Quality Assurance Inspector

OMEGA Engineering, Inc., One Omega Circle, P.O. Box 336, Bridgeport, NJ 08014-0336 Telephone: **(856) 467-4200** • FAX: **(856) 467-1212**
www.omega.com e-mail: info@omega.com

WCS - 0638A

OMEGA ENGINEERING, INC.
An OMEGA Technologies Company

Form:053-0005-3 Rev.C

Continued Report # OS- N000003732

Probe No.	Nominal Temperature	Actual Test Temperature	Indicated Temperature
2	212 °F	212.0 °F	212.3 °F
2	392 °F	392.0 °F	391.7 °F
2	752 °F	752.0 °F	752.9 °F
----------	----------	----------	----------
3	212 °F	212.0 °F	212.3 °F
3	392 °F	392.0 °F	391.8 °F
3	752 °F	752.0 °F	753.1 °F
----------	----------	----------	----------
4	212 °F	212.0 °F	212.3 °F
4	392 °F	392.0 °F	391.8 °F
4	752 °F	752.0 °F	753.0 °F
----------	----------	----------	----------
5	212 °F	212.0 °F	212.2 °F
5	392 °F	392.0 °F	391.8 °F
5	752 °F	752.0 °F	753.0 °F
----------	----------	----------	----------
6	212 °F	212.0 °F	212.4 °F
6	392 °F	392.0 °F	392.0 °F
6	752 °F	752.0 °F	753.0 °F
----------	----------	----------	----------
7	212 °F	212.0 °F	212.3 °F
7	392 °F	392.0 °F	391.8 °F
7	752 °F	752.0 °F	753.1 °F

OMEGA Engineering, Inc., One Omega Circle, P.O. Box 336, Bridgeport, NJ 08014-0336 Telephone: **(856) 467-4200** • FAX: **(856) 467-1212**
www.omega.com e-mail: info@omega.com

OMEGA ENGINEERING, INC.
An OMEGA Technologies Company

Form:053-0005-3 Rev.C

Continued Report # OS- N000003732

Probe No.	Nominal Temperature	Actual Test Temperature	Indicated Temperature
8	212 °F	212.0 °F	212.3 °F
8	392 °F	392.0 °F	391.8 °F
8	752 °F	752.0 °F	753.1 °F

OMEGA Engineering, Inc., One Omega Circle, P.O. Box 336, Bridgeport, NJ 08014-0336 Telephone: **(856) 467-4200** • FAX: **(856) 467-1212**

www.omega.com e-mail: info@omega.com

Extended Calibration Certificate

Customer Name:	INSTRUMART		
Customer Address:	35 GREEN MOUNTAIN DRIVE SOUTH BURLINGTON, VT. 05403		
Customer P.O. #:	PO107896		
Notification Number:	NA	Condition Received:	IN TOLERANCE
Model Number:	T640	Received Date:	04/22/2016
Serial Number:	55909287	Calibration Interval:	12 MONTHS
Calibration Date:	04/22/2016	Calibration Due:	04/22/2017

It is hereby certified that the above equipment was calibrated by FLIR Systems, Inc. using NIST traceable equipment as listed below and meets FLIR Systems, Inc. calibration specifications.

FLIR Systems, Inc. imaging radiometers are calibrated for either absolute or relative temperature measurements or both. This process is accomplished by characterizing the detector response to a series of known temperature "blackbodies." During the calibration process, the radiometer signal processor's output is calibrated so that it has a direct correlation to the temperature differences created by the various blackbodies.

FLIR Systems, Inc. recommends that its radiometric products be re-calibrated annually.

Calibration Procedure – QOP-72-04

Phone: 866-FLIR-911 option 2 • Fax: 603-324-7702 • Email: CCare@flir.com

Model: T640 Serial Number: 55909287

As Received Calibration Data

Calibration Conditions:

Temperature: *26.6°C* Humidity: *33%*

Lens: *FOL25*

Range	Nom Temp/Tol (°C)	Measured Temperature	Difference	Status
- 40°C - 150°C	2.0°C / ± 2.00°C	1.9°C	-0.1°C	PASS
- 40°C - 150°C	35.0°C / ± 2.00°C	35.6°C	0.6°C	PASS
- 40°C - 150°C	55.0°C / ± 2.00°C	55.8°C	0.8°C	PASS
- 40°C - 150°C	80.0°C / ± 2.00°C	80.8°C	0.8°C	PASS
- 40°C - 150°C	110.0°C / ± 2.20°C	110.0°C	0.0°C	PASS
- 40°C - 150°C	150.0°C / ± 3.00°C	152.0°C	2.0°C	PASS
100°C - 650°C	110.0°C / ± 2.20°C	110.0°C	0.0°C	PASS
100°C - 650°C	150.0°C / ± 3.00°C	151.0°C	1.0°C	PASS
100°C - 650°C	200.0°C / ± 4.00°C	200.0°C	0.0°C	PASS
100°C - 650°C	250.0°C / ± 5.00°C	251.0°C	1.0°C	PASS
100°C - 650°C	280.0°C / ± 5.60°C	281.0°C	1.0°C	PASS
100°C - 650°C	350.0°C / ± 7.00°C	351.0°C	1.0°C	PASS
100°C - 650°C	500.0°C / ± 10.00°C	503.0°C	3.0°C	PASS
100°C - 650°C	600.0°C / ± 12.00°C	604.0°C	4.0°C	PASS
300°C - 2000°C	350.0°C / ± 7.00°C	351.0°C	1.0°C	PASS
300°C - 2000°C	500.0°C / ± 10.00°C	502.0°C	2.0°C	PASS
300°C - 2000°C	600.0°C / ± 12.00°C	603.0°C	3.0°C	PASS
300°C - 2000°C	700.0°C / ± 14.00°C	699.0°C	-1.0°C	PASS
300°C - 2000°C	850.0°C / ± 17.00°C	849.0°C	-1.0°C	PASS
300°C - 2000°C	1100.0°C / ± 22.00°C	1105.0°C	5.0°C	PASS
300°C - 2000°C	1500.0°C / ± 30.00°C	1499.0°C	-1.0°C	PASS

Approvals:

Calibration Technician:

Quality Technician:

Phone: 866-FLIR-911 option 2 • Fax: 603-324-7702 • Email: CCare@flir.com

Model: T640 Serial Number: 55909287

As Left Calibration Data

Calibration Conditions:

Temperature: *25.9°C* Humidity: *35%*

Lens: *FOL25*

Range	Nom Temp/Tol (°C)	Measured Temperature	Difference	Status
- 40°C - 150°C	2.0°C / ± 2.00°C	2.0°C	0.0°C	PASS
- 40°C - 150°C	35.0°C / ± 2.00°C	35.5°C	0.5°C	PASS
- 40°C - 150°C	55.0°C / ± 2.00°C	55.7°C	0.7°C	PASS
- 40°C - 150°C	80.0°C / ± 2.00°C	80.7°C	0.7°C	PASS
- 40°C - 150°C	110.0°C / ± 2.20°C	110.0°C	0.0°C	PASS
- 40°C - 150°C	150.0°C / ± 3.00°C	152.0°C	2.0°C	PASS
100°C - 650°C	110.0°C / ± 2.20°C	110.0°C	0.0°C	PASS
100°C - 650°C	150.0°C / ± 3.00°C	151.0°C	1.0°C	PASS
100°C - 650°C	200.0°C / ± 4.00°C	200.0°C	0.0°C	PASS
100°C - 650°C	250.0°C / ± 5.00°C	251.0°C	1.0°C	PASS
100°C - 650°C	280.0°C / ± 5.60°C	281.0°C	1.0°C	PASS
100°C - 650°C	350.0°C / ± 7.00°C	351.0°C	1.0°C	PASS
100°C - 650°C	500.0°C / ± 10.00°C	503.0°C	3.0°C	PASS
100°C - 650°C	600.0°C / ± 12.00°C	604.0°C	4.0°C	PASS
300°C - 2000°C	350.0°C / ± 7.00°C	351.0°C	1.0°C	PASS
300°C - 2000°C	500.0°C / ± 10.00°C	502.0°C	2.0°C	PASS
300°C - 2000°C	600.0°C / ± 12.00°C	603.0°C	3.0°C	PASS
300°C - 2000°C	700.0°C / ± 14.00°C	699.0°C	-1.0°C	PASS
300°C - 2000°C	850.0°C / ± 17.00°C	849.0°C	-1.0°C	PASS
300°C - 2000°C	1100.0°C / ± 22.00°C	1105.0°C	5.0°C	PASS
300°C - 2000°C	1500.0°C / ± 30.00°C	1499.0°C	-1.0°C	PASS

Approvals:

Calibration Technician:

Quality Technician:

Phone: 866-FLIR-911 option 2 • Fax: 603-324-7702 • Email: CCare@flir.com

Note that customer Calibration services are performed using one or more of the blackbodies listed in the table below. FLIR Systems, Inc. blackbodies are measurement standard calibrated by FLIR or the OEM manufacturer

Cal ID #'s	M&TE Equipment Used	Recall Date	Certification #
53050	BlackBody Source	Aug-16	CC-15-002
53053 / 53054	BlackBody Source	Jun-16	CC-15-001
53055 / 53056	BlackBody Source	Nov-16	CC-15-004
53059 / 53060	BlackBody Source	Nov-16	CC-15-005
53061 / 53062	BlackBody Source	Nov-16	CC-15-006
53063 / 53064	BlackBody Source	Nov-16	CC-15-007
53067 / 53068	BlackBody Source	Nov-16	CC-15-008
53069 / 53070	BlackBody Source	Nov-16	CC-15-009
53243 / 53244	BlackBody Source	Nov-16	CC-15-010
53071 / 53074	BlackBody Source	Nov-16	CC-15-011

Cal ID #'s	M&TE Equipment Used	Recall Date	Certification #
53083 / 53085	BlackBody Source	Nov-16	CC-15-012
53129 / 53131	BlackBody Source	Nov-16	CC-15-013
53128 / 53130	BlackBody Source	Nov-16	CC-15-014
53223 / 53226	BlackBody Source	Nov-16	CC-15-015
53230 / 53228	BlackBody Source	Nov-16	CC-15-016
53222 / 53225	BlackBody Source	Nov-16	CC-15-017
53221 / 53224	BlackBody Source	Nov-16	CC-15-018
53098 / 53096	BlackBody Source	Nov-16	CC-15-019
53097	BlackBody Source	Nov-16	CC-15-020
53231	BlackBody Source	Nov-16	CC-15-021

The devices listed in the table below are used in the calibration of the blackbodies listed in the table above.

Equipment	Serial Number	Traceable NIST Report Number	Last Cal Date	Next Cal Date	Cal Ratio
ASL PRT T-100-450 (ID # 53355)	B507995	RD19702	10/12/2015	10/12/2016	80:1
ASL Digital Indicator F150 (ID # 53357)	59143	RD19702 / 30570	10/12/2015	10/12/2016	80:1
Thermocouple JMS TYPE "S" (ID # 53356)	43039-1-2	30570	10/12/2015	10/12/2016	5:1
Thermocouple JMS TYPE "B" (ID # 73621)	142848-1-1	30570	10/12/2015	10/12/2016	5:1

Phone: 866-FLIR-911 option 2 • Fax: 603-324-7702 • Email: CCare@flir.com

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

Cert. No.: 1045-7493688

Traceable® Certificate of Calibration for Watr/Shock Res Stpwch

Manufactured for and distributed by: Thomas Scientific, Box 99, 99 High Hill Road, Swedeboro, NJ 08085-0099 U.S.A.

Instrument Identification:

Model: 1235C26 S/N: 160274632 Manufacturer: Control Company

Standards/Equipment:

Description	Serial Number	Due Date	NIST Traceable Reference
Non-Contact Frequency Counter	26.66887	5/15/16	1000374678

Certificate Information:

Technician: 150 Procedure: CAL-01 Cal Date: 3/12/16 Due Date: 3/12/18

Test Conditions: 24.8°C 48.0 %RH 1013 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	0.233	Y	-8.640	8.640	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 Watr/Shock Res Stpwch should maintain its accuracy. There is no exact way to determine how long calibration will be maintained. Watr/Shock Res Stpwchs 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.

CONTROL COMPANY 4455 Rex Road Friendswood, TX 77546 USA
Phone 281 482-1714 Fax 281 482-9448 service@control3.com www.control3.com

D Experimental Data Sheets

In this appendix, the data sheets recorded during testing are included. Note that test results are included in this report in a non-chronological order. The mapping between test and condition/trial number is given in Table 6.

Table 6: Conversion between condition and trial to test number.

Condition/Trial	**Test Number**
Cond01_T1	19
Cond01_T2	20
Cond01_T3	21
Cond02_T1	1
Cond02_T2	2
Cond02_T3	4
Cond03_T1	5
Cond03_T2	6
Cond03_T3	7
Cond04_T1	28
Cond04_T2	29
Cond04_T3	30
Cond05_T1	11
Cond05_T2	14
Cond05_T3	15
Cond06_T1	8
Cond06_T2	9
Cond06_T3	10
Cond07_T1	16
Cond07_T2	17
Cond07_T3	18
Cond08_T1	25
Cond08_T2	26
Cond08_T3	27
Cond09_T1	34
Cond09_T2	35
Cond09_T3	36
Cond10_T1	32
Cond11_T1	22
Cond11_T2	23
Cond11_T3	24
Aborted	3, 12, 13, 31, 33

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

Glovebox Fire Suppression: Experiment # 01

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted
David Grow	6/22/16	Torres, 2-ton	✓	

Safety Officer Name: Jamie Kimberley

Quality Assurance Rep. Name: Bob Hanson

Start Time	3:39
Ignition Time	3:43
End Time	3:50

(Airflow out, DAQ stop)

Relevant Environmental Conditions

84.7° in bunker
26% rel. humidity

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make: Dwyer Model: 648B-05	4614118	A0
2. Make: Dwyer Model: 648B-15	4514088	A1
3. Make: Dwyer Model: 648B-05	0115016	A2
4. Make: Dwyer Model: 648B-15	4914183	A3

Digital Timer	Serial Num	DAQ channel
1. Make: Thomas Model: Traceabl	160274632	N/A

Air Flow meter	Serial Num	DAQ channel
1. Make: TSI Model: 5725	1511004	N/A

Thermocouples	Serial Num	DAQ channel
1. Make: Omega Model: XC20KI20Cal	3732-1	T1
2. Make: Omega Model: XC20KI20Cal	3732-2	T2
3. Make: Omega Model: XC20KI20Cal	3732-4	T3
4. Make: Omega Model: XC20KI20Cal	3732-8	T4

Fenwal Heat Detector	Serial Num	DAQ channel
1. Make: Fenwal Model: 140 deg.	28021-5	D0
2. Make: Fenwal Model: 190 deg.	28021-5	D1

Cameras	Serial Num	DAQ channel	
1. Make: Point Grey Model: Grasshopper 3	14273764	N/A	[long side]
2. Make: Point Grey Model: Grasshopper 3	14273944	N/A	[short side]
3. Make: Point Grey Model: Grasshopper 3	15383782	N/A	[safety]
4. Make: FLIR Model: T640	55909287	N/A	[IR]

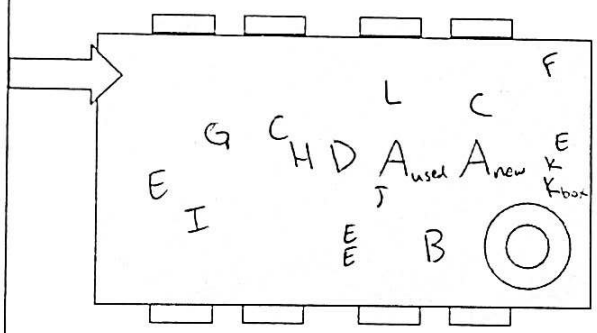
Glove Installation

Glove/cover installed	LANL insp	Port #	Glove/cover installed	LANL insp	Port #
8UY2030		1	8UY2030		13
"		2	"		14
"		3	"		15
"		4	"		16
"		5	"		17
"		6	"		18
"		7	"		19
"		8	"		20
8Y1532		9	"		21
8Y3032		10	"		22
8UY2030		11	8Y3032		23
"		12	8Y1532		24

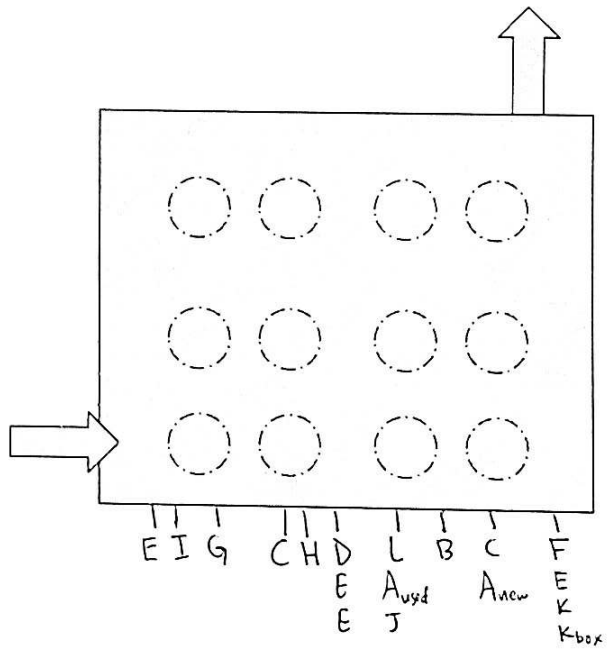
Time & Description of Critical Events *	Miscellaneous Notes
Ignition Time: 184 s – flame visible	Ralph Clayton 6/27/16
500 degrees at glove (approx) Time: N/A, MAX = 334°F (high T/C)	
Breach Time: 345 s	
140 Fenwal Detection Time: 254 s	
190 Fenwal Detection Time: N/A	
Other key times:	

* time = 0 determined by DAQ start

GB Floor (Top View)



GB Floor (Side View)



Legend:

- ~~A~~. Ignition bag
- ~~B~~. Sand paper
- ~~C~~. Screwdriver
- ~~D~~. Mallet
- ~~E~~. Poly Bottle
- ~~F~~. Leather glove
- ~~G~~. Push Rod
- ~~H~~. Horsehair brush
- ~~I~~. Scale cord
- J. Cotton rounds
- ~~K~~. Kim wipes
- ~~L~~. Fantastik

Revision History	
Revision & Justification	Authorized Signatures

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

Glovebox Fire Suppression: Experiment # 02

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted
Jamie Kimberley	6/23/16	Torres, 2-ton	✓	

Safety Officer Name: David Grow

Quality Assurance Rep. Name: Bob Hanson

Start Time	12:35
Ignition Time	12:35
End Time	12:50 (Airflow cut, DAQ stop)

Relevant Environmental Conditions

84.6° in bunker
31% rel. humidity

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make: Dwyer Model: 648B-05	4614118	A0
2. Make: Dwyer Model: 648B-15	4514088	A1
3. Make: Dwyer Model: 648B-05	0115016	A2
4. Make: Dwyer Model: 648B-15	4914183	A3

Digital Timer	Serial Num	DAQ channel
1. Make: Thomas Model: Traceabl	160274632	N/A

Air Flow meter	Serial Num	DAQ channel
1. Make: TSI Model: 5725	1511004	N/A

Thermocouples	Serial Num	DAQ channel
1. Make: Omega Model: XC20KI20Cal	3732-1	T1
2. Make: Omega Model: XC20KI20Cal	3732-2	T2
3. Make: Omega Model: XC20KI20Cal	3732-4	T3
4. Make: Omega Model: XC20KI20Cal	3732-8	T4

Fenwal Heat Detector	Serial Num	DAQ channel
1. Make: Fenwal Model: 140 deg.	28021-5	D0
2. Make: Fenwal Model: 190 deg.	28021-5	D1

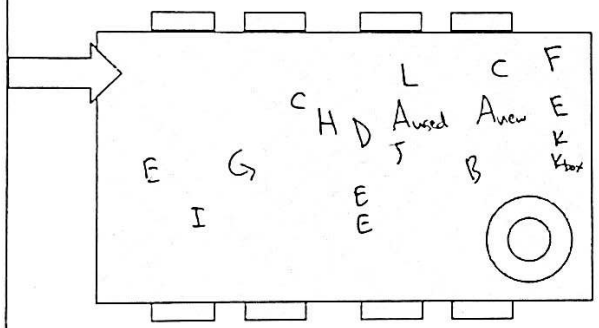
Cameras	Serial Num	DAQ channel
1. Make: Point Grey Model: Grasshopper 3	14273764	N/A
2. Make: Point Grey Model: Grasshopper 3	14273944	N/A
3. Make: Point Grey Model: Grasshopper 3	15383782	N/A
4. Make: FLIR Model: T640	55909287	N/A

Glove Installation

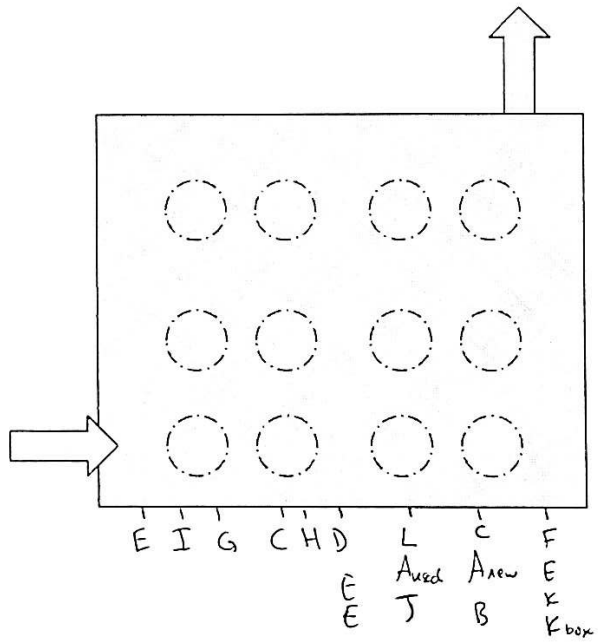
Glove/cover installed	LANL insp	Port #	Glove/cover installed	LANL insp	Port #
8UY2030		1	8UY2030		13
"		2	"		14
"		3	"		15
"		4	"		16
"		5	"		17
"		6	"		18
"		7	"		19
"		8	"		20
8Y1532		9	"		21
8Y3032		10	"		22
8UY2030		11	8Y3032		23
"		12	8Y1532		24

Time & Description of Critical Events	Miscellaneous Notes
Ignition Time: 53 s, flame visible	Ralph Clayton 6/23/14
500 degrees at glove (approx) Time: N/A, 235°F max (high T/C)	Ralph Clayton
Breach Time: N/A	
140 Fenwal Detection Time: N/A	
190 Fenwal Detection Time: N/A	
Other key times:	

GB Floor (Top View)



GB Floor (Side View)



Legend:

- ~~A~~. Ignition bag
- ~~B~~. Sand paper
- ~~C~~. Screwdriver
- ~~D~~. Mallet
- ~~E~~. Poly Bottle
- ~~F~~. Leather glove
- ~~G~~. Push Rod
- ~~H~~. Horsehair brush
- ~~I~~. Scale cord
- J. Cotton rounds
- ~~K~~. Kim wipes
- ~~K~~. Fantastik

Revision History	
Revision & Justification	Authorized Signatures

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

Glovebox Fire Suppression: Experiment # 03

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted
Jamie Kimberley	6/23/16	Torres, 2-ton		✓

Safety Officer Name	
David Grow	
Quality Assurance Rep. Name	
Bob Hanson	

Start Time	3:04
Ignition Time	N/A
End Time	N/A

Relevant Environmental Conditions

86.8° in bunker
27% rel. humidity

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make: Dwyer Model: 648B-05	4614118	A0
2. Make: Dwyer Model: 648B-15	4514088	A1
3. Make: Dwyer Model: 648B-05	0115016	A2
4. Make: Dwyer Model: 648B-15	4914183	A3

Digital Timer	Serial Num	DAQ channel
1. Make: Thomas Model: Traceabl	160274632	N/A

Air Flow meter	Serial Num	DAQ channel
1. Make: TSI Model: 5725	1511004	N/A

Thermocouples	Serial Num	DAQ channel
1. Make: Omega Model: XC20K120Cal	3732-1	T1
2. Make: Omega Model: XC20K120Cal	3732-2	T2
3. Make: Omega Model: XC20K120Cal	3732-4	T3
4. Make: Omega Model: XC20K120Cal	3732-8	T4

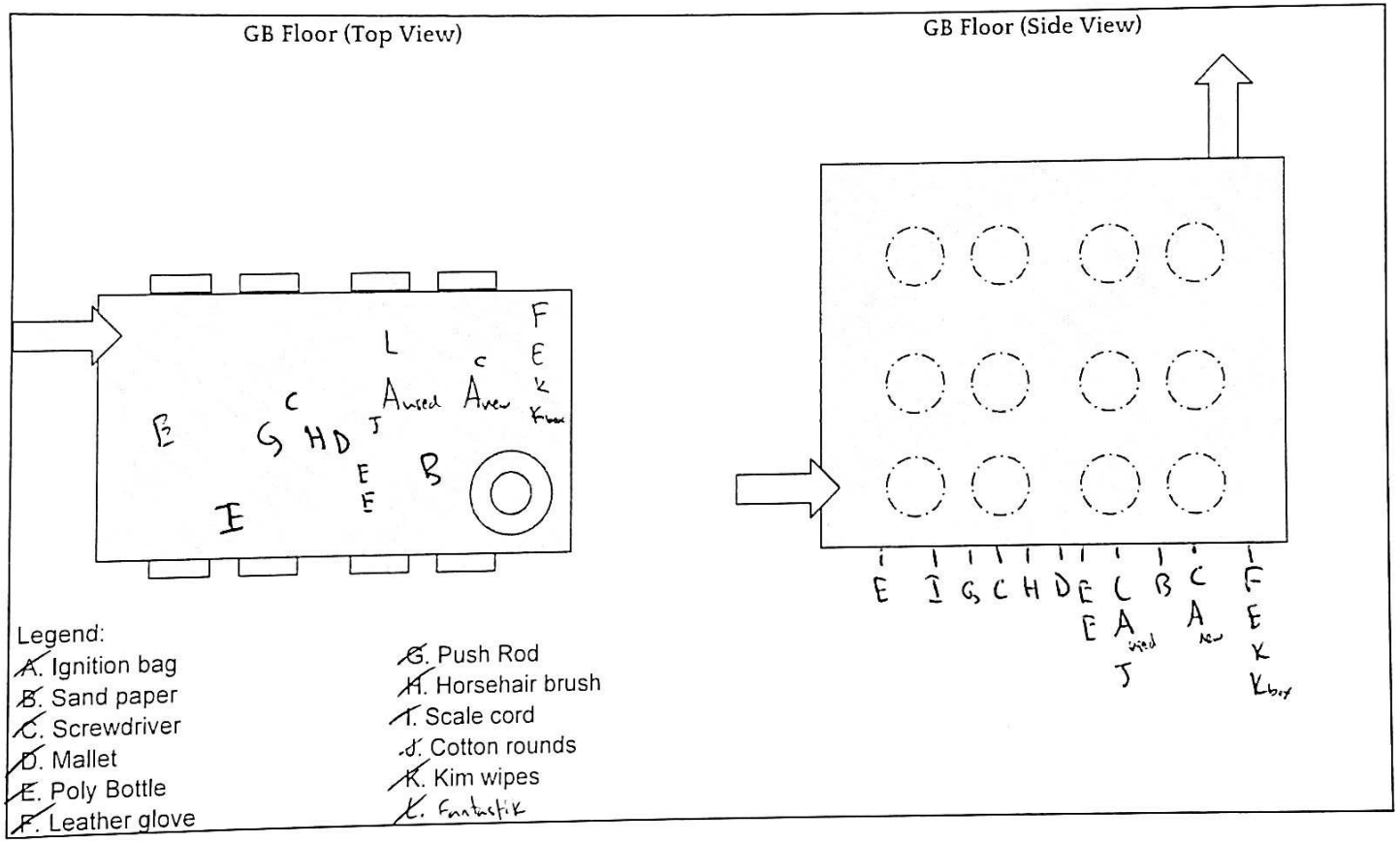
Fenwal Heat Detector	Serial Num	DAQ channel
1. Make: Fenwal Model: 140 deg.	28021-5	D0
2. Make: Fenwal Model: 190 deg.	28021-5	D1

Cameras	Serial Num	DAQ channel
1. Make: Point Grey Model: Grasshopper 3	14273764	N/A
2. Make: Point Grey Model: Grasshopper 3	14273944	N/A
3. Make: Point Grey Model: Grasshopper 3	15383782	N/A
4. Make: FLIR Model: T640	55909287	N/A

Glove Installation

Glove/cover installed	LANL insp	Port #	Glove/cover installed	LANL insp	Port #
8UY2030		1	8UY2030		13
"		2	"		14
"		3	"		15
"		4	"		16
"		5	"		17
"		6	"		18
"		7	"		19
"		8	"		20
8Y1532		9	"		21
8Y3032		10	"		22
8UY2030		11	8Y3032		23
"		12	8Y1532		24

Time & Description of Critical Events		Miscellaneous Notes
Ignition Time:	Failure to ignite → aborted	Incorrect ignitor wiring
500 degrees at glove (approx) Time:	N/A	
Breach Time:	N/A	
140 Fenwal Detection Time:	N/A	Ralph Clayton
190 Fenwal Detection Time:	N/A	Ralph Clayton 6/27/16
Other key times:	N/A	


GB Floor (Top View)
GB Floor (Side View)
Legend:
A. Ignition bag
B. Sand paper
C. Screwdriver
D. Mallet
E. Poly Bottle
F. Leather glove
G. Push Rod
H. Horsehair brush
I. Scale cord
J. Cotton rounds
K. Kim wipes
L. Fantastik

Revision History	
Revision & Justification	Authorized Signatures

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

Glovebox Fire Suppression: Experiment # 04

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted
Jamie Kimberley	6/23/16	Torres, 2-ton	✓	

Safety Officer Name: David Grow

Quality Assurance Rep. Name: Bob Hanson

Start Time	3:13
Ignition Time	3:22
End Time	3:34

(Airflow cut, DAQ stop)

Relevant Environmental Conditions

86.9° in bunker
26% rel. humidity

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make: Dwyer Model: 648B-05	4614118	A0
2. Make: Dwyer Model: 648B-15	4514088	A1
3. Make: Dwyer Model: 648B-05	0115016	A2
4. Make: Dwyer Model: 648B-15	4914183	A3

Digital Timer	Serial Num	DAQ channel
1. Make: Thomas Model: Traceabl	160274632	N/A

Air Flow meter	Serial Num	DAQ channel
1. Make: TSI Model: 5725	1511004	N/A

Thermocouples	Serial Num	DAQ channel
1. Make: Omega Model: XC20K120Cal	3732-1	T1
2. Make: Omega Model: XC20K120Cal	3732-2	T2
3. Make: Omega Model: XC20K120Cal	3732-4	T3
4. Make: Omega Model: XC20K120Cal	3732-8	T4

Fenwal Heat Detector	Serial Num	DAQ channel
1. Make: Fenwal Model: 140 deg.	28021-5	D0
2. Make: Fenwal Model: 190 deg.	28021-5	D1

Cameras	Serial Num	DAQ channel
1. Make: Point Grey Model: Grasshopper 3	14273764	N/A
2. Make: Point Grey Model: Grasshopper 3	14273944	N/A
3. Make: Point Grey Model: Grasshopper 3	15383782	N/A
4. Make: FLIR Model: T640	55909287	N/A

Glove Installation

Glove/cover installed	LANL insp	Port #	Glove/cover installed	LANL insp	Port #
8UY2030		1	8UY2030		13
"		2	"		14
"		3	"		15
"		4	"		16
"		5	"		17
"		6	"		18
"		7	"		19
"		8	"		20
8Y1532		9	"		21
8Y3032		10	"		22
8UY2030		11	8Y3032		23
"		12	8Y1532		24

Time & Description of Critical Events

Ignition Time: 257 s, flame visible

500 degrees at glove (approx) Time: N/A, 357°F max (high T/C)

Breach Time: 353 s.

140 Fenwal Detection Time: 367 s.

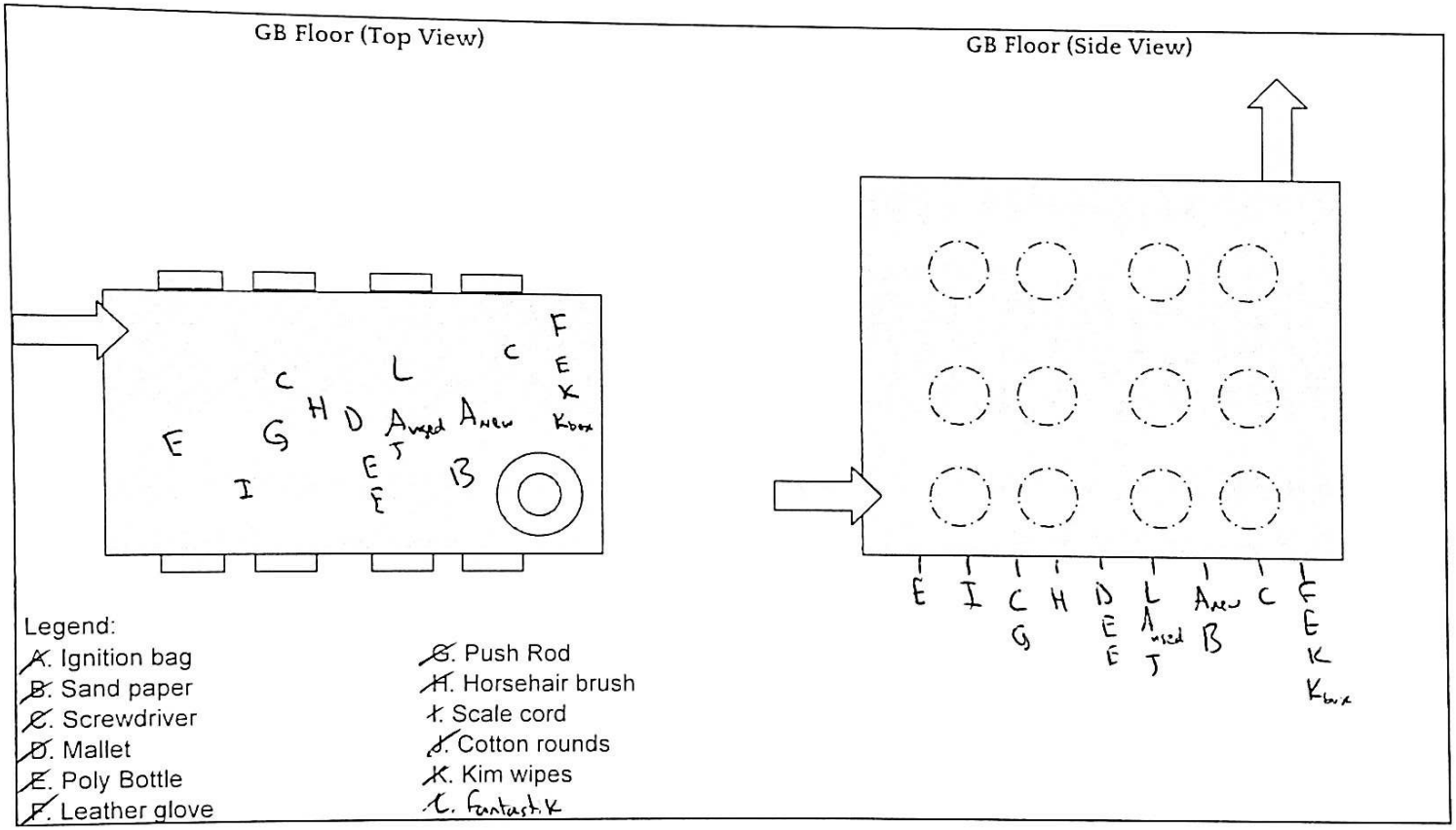
190 Fenwal Detection Time: 404 s.

Other key times:

Miscellaneous Notes

106088

Ralph Clayton 6/27/14



Legend:

- ~~A~~. Ignition bag
- ~~B~~. Sand paper
- ~~C~~. Screwdriver
- ~~D~~. Mallet
- ~~E~~. Poly Bottle
- ~~F~~. Leather glove
- ~~G~~. Push Rod
- ~~H~~. Horsehair brush
- ~~I~~. Scale cord
- ~~J~~. Cotton rounds
- ~~K~~. Kim wipes
- ~~L~~. Fantastik

Revision History	
Revision & Justification	Authorized Signatures

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

Glovebox Fire Suppression: Experiment # 05

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted
Jamie Kimberley	6/24/16	Torres, 2-ton	✓	

Safety Officer Name
Jamie Kimberley

Quality Assurance Rep. Name
Jacob Romero

Start Time	10:34
Ignition Time	10:35
End Time	10:41

(self-extinguished)

Relevant Environmental Conditions

81.5° in bunker
35% rel. humidity

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make: Dwyer Model: 648B-05	4614118	A0
2. Make: Dwyer Model: 648B-15	4514088	A1
3. Make: Dwyer Model: 648B-05	0115016	A2
4. Make: Dwyer Model: 648B-15	4914183	A3

Digital Timer	Serial Num	DAQ channel
1. Make: Thomas Model: Traceabl	160274632	N/A

Air Flow meter	Serial Num	DAQ channel
1. Make: TSI Model: 5725	1511004	N/A

Thermocouples	Serial Num	DAQ channel
1. Make: Omega Model: XC20KI20Cal	3732-1	T1
2. Make: Omega Model: XC20KI20Cal	3732-2	T2
3. Make: Omega Model: XC20KI20Cal	3732-4	T3
4. Make: Omega Model: XC20KI20Cal	3732-8	T4

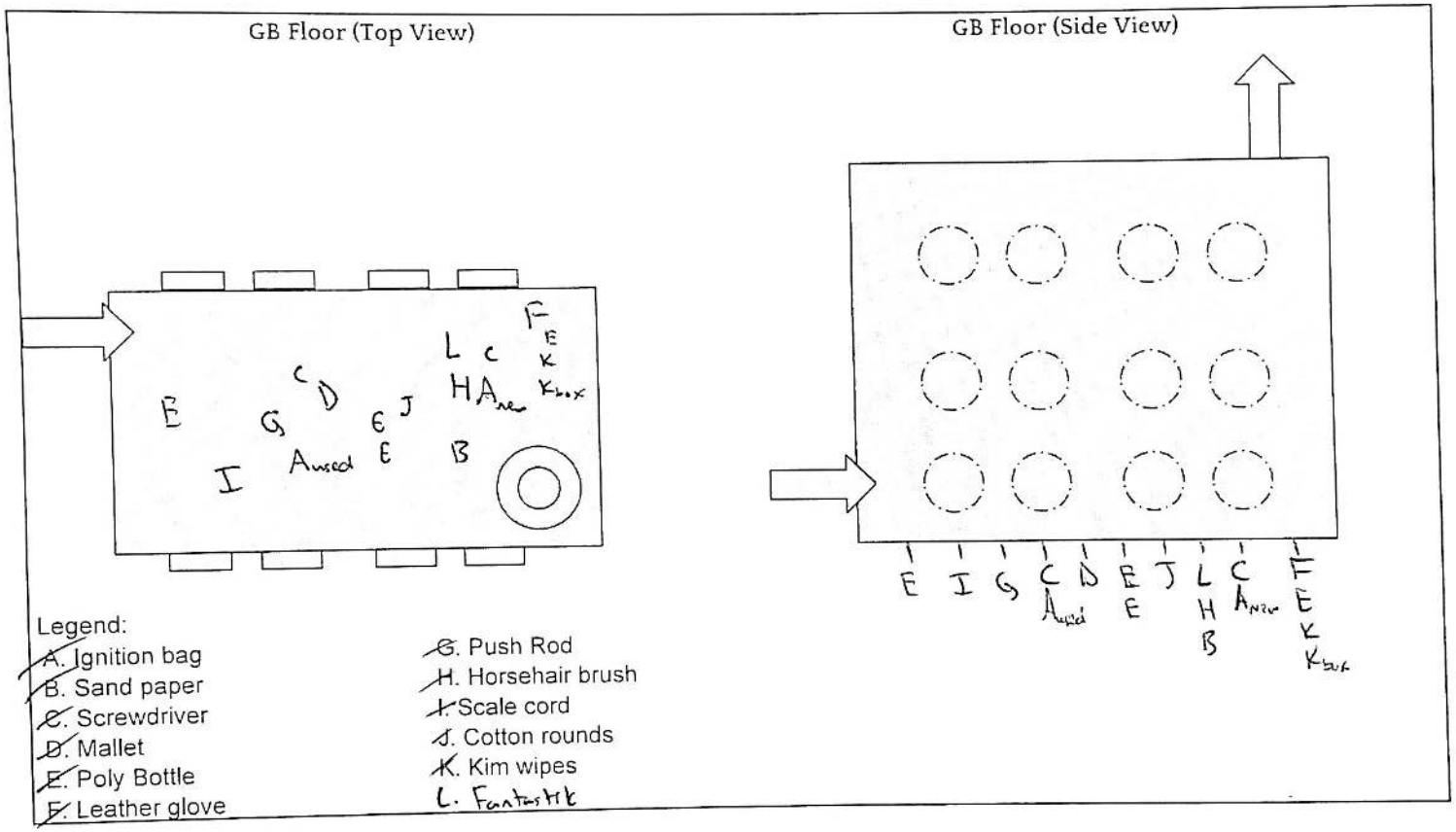
Fenwal Heat Detector	Serial Num	DAQ channel
1. Make: Fenwal Model: 140 deg.	28021-5	D0
2. Make: Fenwal Model: 190 deg.	28021-5	D1

Cameras	Serial Num	DAQ channel
1. Make: Point Grey Model: Grasshopper 3	14273764	N/A
2. Make: Point Grey Model: Grasshopper 3	14273944	N/A
3. Make: Point Grey Model: Grasshopper 3	15383782	N/A
4. Make: FLIR Model: T640	55909287	N/A

Glove Installation

Glove/cover installed	LANL insp	Port #	Glove/cover installed	LANL insp	Port #
8UY2030		1	8UY2030		13
"		2	"		14
"		3	"		15
"		4	"		16
"		5	"		17
"		6	"		18
"		7	"		19
"		8	"		20
8Y1532		9	"		21
"		10	"		22
8UY2030		11	DG 6/27 ~~815~~ 8Y1532		23
"		12	"		24

Time & Description of Critical Events	Miscellaneous Notes
Ignition Time: 64 s, flame visible 500 degrees at glove (approx) Time: N/A, 320°F max (high T/C) Breach Time: 52 s. 140 Fenwal Detection Time: 140 s. 190 Fenwal Detection Time: N/A Other key times:	Ralph Clayton Ralph Clayton 6/27/16


GB Floor (Top View)
GB Floor (Side View)
Legend:
A. Ignition bag
B. Sand paper
C. Screwdriver
D. Mallet
E. Poly Bottle
F. Leather glove
G. Push Rod
H. Horsehair brush
I. Scale cord
J. Cotton rounds
K. Kim wipes
L. Fantastik

Revision History	
Revision & Justification	Authorized Signatures

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

Glovebox Fire Suppression: Experiment # 06

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted
David Grow	6/24/16	Torres, 2-ton	✓	

Safety Officer Name: Jamie Kimberley

Quality Assurance Rep. Name: Jacob Romero

Start Time	2:13
Ignition Time	2:15
End Time	2:16

(self-extinguished)

Relevant Environmental Conditions

84.7° in bunker
31% rel. humidity

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make: Dwyer Model: 648B-05	4614118	A0
2. Make: Dwyer Model: 648B-15	4514088	A1
3. Make: Dwyer Model: 648B-05	0115016	A2
4. Make: Dwyer Model: 648B-15	4914183	A3

Digital Timer	Serial Num	DAQ channel
1. Make: Thomas Model: Traceabl	160274632	N/A

Air Flow meter	Serial Num	DAQ channel
1. Make: TSI Model: 5725	1511004	N/A

Thermocouples	Serial Num	DAQ channel
1. Make: Omega Model: XC20K120Cal	3732-1	T1
2. Make: Omega Model: XC20K120Cal	3732-2	T2
3. Make: Omega Model: XC20K120Cal	3732-4	T3
4. Make: Omega Model: XC20K120Cal	3732-8	T4

Fenwal Heat Detector	Serial Num	DAQ channel
1. Make: Fenwal Model: 140 deg.	28021-5	D0
2. Make: Fenwal Model: 190 deg.	28021-5	D1

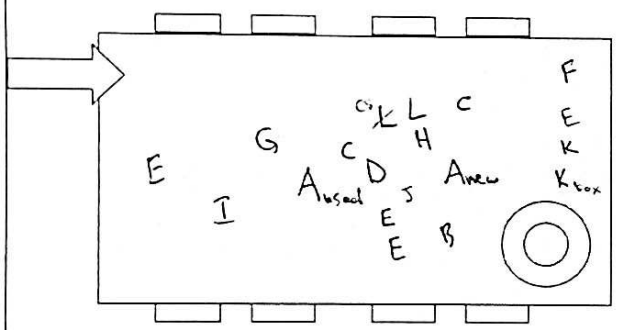
Cameras	Serial Num	DAQ channel
1. Make: Point Grey Model: Grasshopper 3	14273764	N/A
2. Make: Point Grey Model: Grasshopper 3	14273944	N/A
3. Make: Point Grey Model: Grasshopper 3	15383782	N/A
4. Make: FLIR Model: T640	55909287	N/A

Glove Installation

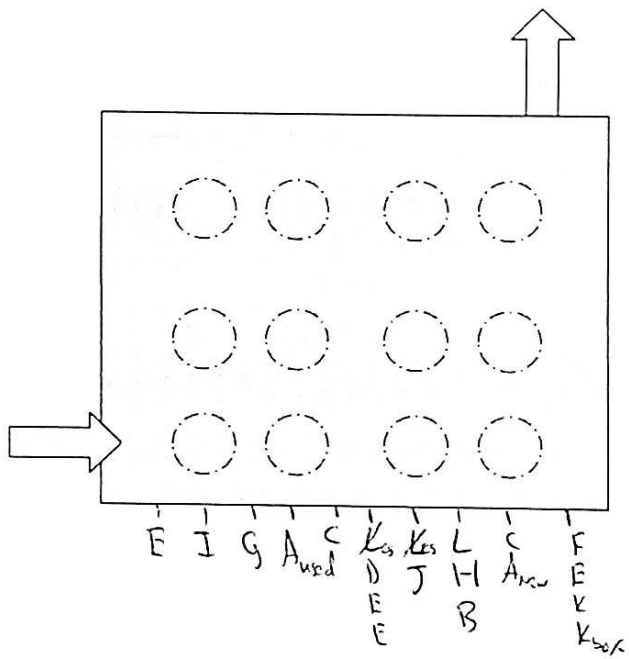
Glove/cover installed	LANL insp	Port #	Glove/cover installed	LANL insp	Port #
8UY2030		1	8UY2030		13
"		2	"		14
"		3	"		15
"		4	"		16
"		5	"		17
"		6	"		18
"		7	"		19
"		8	"		20
8Y1532		9	"		21
"		10	"		22
8UY2030		11	8Y1532		23
"		12	"		24

Time & Description of Critical Events	Miscellaneous Notes
Ignition Time: 875, flame visible	166098
500 degrees at glove (approx) Time: N/A, 96°F max (high T/C)	Ralph Clayton
Breach Time: N/A	6/07/2016
140 Fenwal Detection Time: N/A	
190 Fenwal Detection Time: N/A	
Other key times:	

GB Floor (Top View)



GB Floor (Side View)



Legend:

- ~~A~~. Ignition bag
- ~~B~~. Sand paper
- ~~C~~. Screwdriver
- ~~D~~. Mallet
- ~~E~~. Poly Bottle
- ~~F~~. Leather glove
- ~~G~~. Push Rod
- ~~H~~. Horsehair brush
- ~~I~~. Scale cord
- ~~J~~. Cotton rounds
- ~~K~~. Kim wipes
- ~~L~~. Fantastik

Revision History	
Revision & Justification	Authorized Signatures

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

Glovebox Fire Suppression: Experiment # 07

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted
Ralph Clayton	6/27/16	Torres, 2-ton	✓	

Safety Officer Name	David Grow
Quality Assurance Rep. Name	Jim Narum
Start Time	9:03
Ignition Time	9:04
End Time	9:08 (self-extinguished)

Relevant Environmental Conditions

78.8° in bunker
53 % rel. humidity

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make: Dwyer Model: 648B-05	4614118	A0
2. Make: Dwyer Model: 648B-15	4514088	A1
3. Make: Dwyer Model: 648B-05	0115016	A2
4. Make: Dwyer Model: 648B-15	4914183	A3

Digital Timer	Serial Num	DAQ channel
1. Make: Thomas Model: Traceabl	160274632	N/A

Air Flow meter	Serial Num	DAQ channel
1. Make: TSI Model: 5725	1511004	N/A

Thermocouples	Serial Num	DAQ channel
1. Make: Omega Model: XC20KI20Cal	3732-1	T1
2. Make: Omega Model: XC20KI20Cal	3732-2	T2
3. Make: Omega Model: XC20KI20Cal	3732-4	T3
4. Make: Omega Model: XC20KI20Cal	3732-8	T4

Fenwal Heat Detector	Serial Num	DAQ channel
1. Make: Fenwal Model: 140 deg.	28021-5	D0
2. Make: Fenwal Model: 190 deg.	28021-5	D1

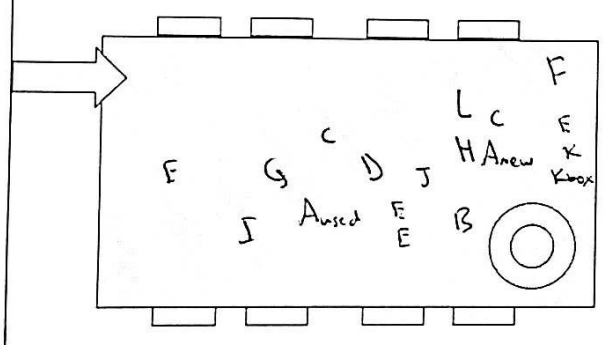
Cameras	Serial Num	DAQ channel
1. Make: Point Grey Model: Grasshopper 3	14273764	N/A
2. Make: Point Grey Model: Grasshopper 3	14273944	N/A
3. Make: Point Grey Model: Grasshopper 3	15383782	N/A
4. Make: FLIR Model: T640	55909287	N/A

Glove Installation

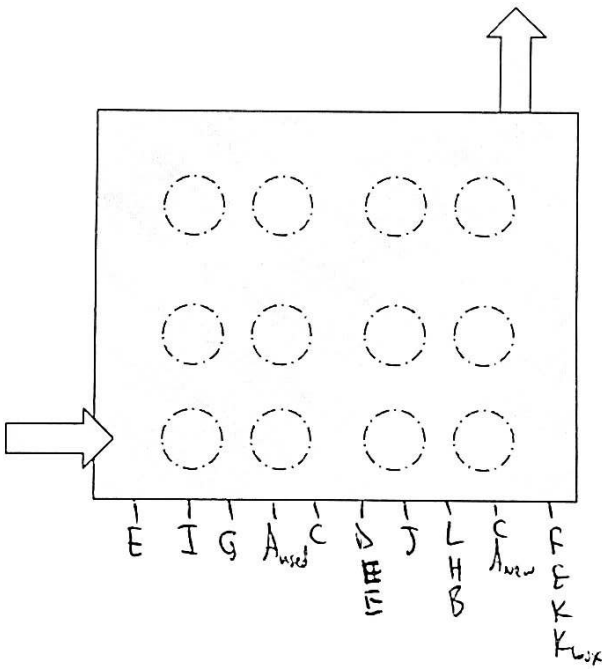
Glove/cover installed	LANL insp	Port #	Glove/cover installed	LANL insp	Port #
8UY2030		1	8UY2030		13
"		2	"		14
"		3	"		15
"		4	"		16
"		5	"		17
"		6	"		18
"		7	"		19
"		8	"		20
8Y1532		9	"		21
"		10	"		22
8UY2030		11	8Y1532		23
"		12	"		24

Time & Description of Critical Events	Miscellaneous Notes
Ignition Time: 68s flame visible 500 degrees at glove (approx) Time: N/A, 312°F max (high T/c) Breach Time: 135s 140 Fenwal Detection Time: 216s 190 Fenwal Detection Time: N/A Other key times:	Ralph Clayton 106098 6/07/16

GB Floor (Top View)



GB Floor (Side View)



Legend:

~~A~~. Ignition bag
~~B~~. Sand paper
~~C~~. Screwdriver
~~D~~. Mallet
~~E~~. Poly Bottle
~~F~~. Leather glove
~~G~~. Push Rod
~~H~~. Horsehair brush
~~I~~. Scale cord
~~J~~. Cotton rounds
~~K~~. Kim wipes
~~L~~. Fantastik

Revision History	
Revision & Justification	Authorized Signatures

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

Glovebox Fire Suppression: Experiment # 08

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted
Ralph Clayton	6/27/16	Torres, 2-ton	✓	

Safety Officer Name: David Grow

Quality Assurance Rep. Name: Jim Narum

Start Time	12:31
Ignition Time	12:32
End Time	12:33

(self-extinguished)

Relevant Environmental Conditions

79.6° in bunker
48% rel. humidity

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make: Dwyer Model: 648B-05	4614118	A0
2. Make: Dwyer Model: 648B-15	4514088	A1
3. Make: Dwyer Model: 648B-05	0115016	A2
4. Make: Dwyer Model: 648B-15	4914183	A3

Digital Timer	Serial Num	DAQ channel
1. Make: Thomas Model: Traceabl	160274632	N/A

Air Flow meter	Serial Num	DAQ channel
1. Make: TSI Model: 5725	1511004	N/A

Thermocouples	Serial Num	DAQ channel
1. Make: Omega Model: XC20K120Cal	3732-1	T1
2. Make: Omega Model: XC20K120Cal	3732-2	T2
3. Make: Omega Model: XC20K120Cal	3732-4	T3
4. Make: Omega Model: XC20K120Cal	3732-8	T4

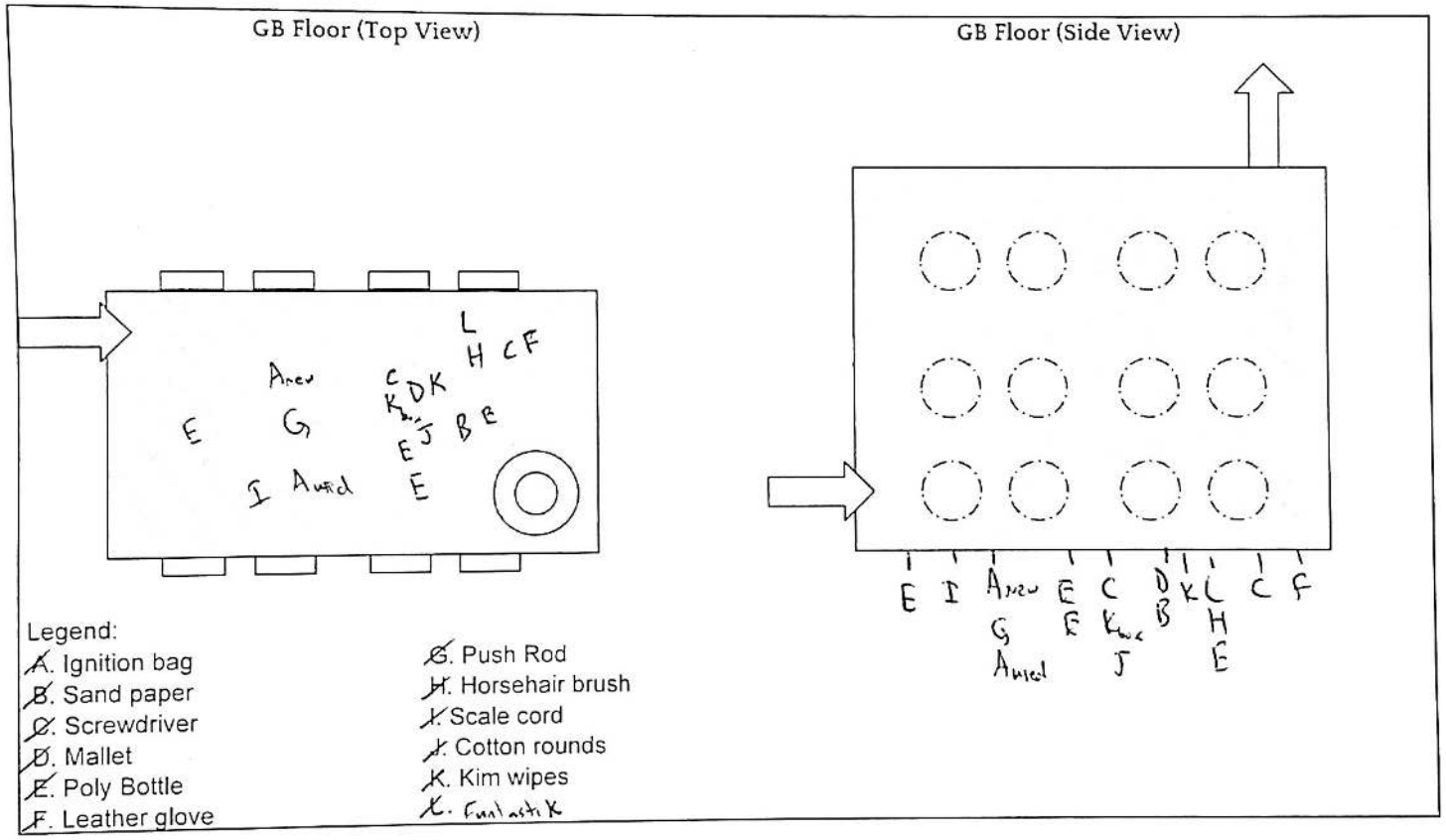
Fenwal Heat Detector	Serial Num	DAQ channel
1. Make: Fenwal Model: 140 deg.	28021-5	D0
2. Make: Fenwal Model: 190 deg.	28021-5	D1

Cameras	Serial Num	DAQ channel
1. Make: Point Grey Model: Grasshopper 3	14273764	N/A
2. Make: Point Grey Model: Grasshopper 3	14273944	N/A
3. Make: Point Grey Model: Grasshopper 3	15383782	N/A
4. Make: FLIR Model: T640	55909287	N/A

Glove Installation

Glove/cover installed	LANL insp	Port #	Glove/cover installed	LANL insp	Port #
8UY2030		1	8UY2030		13
"		2	"		14
"		3	"		15
"		4	"		16
"		5	"		17
"		6	"		18
"		7	"		19
"		8	"		20
8Y1532		9	"		21
"		10	"		22
8UY2030		11	8Y1532		23
"		12	"		24

Time & Description of Critical Events	Miscellaneous Notes
Ignition Time: 56 s flame visible 500 degrees at glove (approx) Time: N/A, 81°F max (high T/c) Breach Time: N/A 140 Fenwal Detection Time: N/A 190 Fenwal Detection Time: N/A Other key times:	106098 Ralph Clayton 6/27/2016


GB Floor (Top View)
GB Floor (Side View)
Legend:
A. Ignition bag
B. Sand paper
C. Screwdriver
D. Mallet
E. Poly Bottle
F. Leather glove
G. Push Rod
H. Horsehair brush
I. Scale cord
J. Cotton rounds
K. Kim wipes
L. Fuel matrix

Revision History	
Revision & Justification	Authorized Signatures

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

Glovebox Fire Suppression: Experiment #09

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted
Ralph Clayton	6/27/16	Torres, 2-ton	✓	

Safety Officer Name: David Grow

Quality Assurance Rep. Name: Jim Narum

Start Time	2:31
Ignition Time	2:32
End Time	2:32

(self extinguished)

Relevant Environmental Conditions

80.3° in bunker
48% rel. humidity

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make: Dwyer Model: 648B-05	4614118	A0
2. Make: Dwyer Model: 648B-15	4514088	A1
3. Make: Dwyer Model: 648B-05	0115016	A2
4. Make: Dwyer Model: 648B-15	4914183	A3

Digital Timer	Serial Num	DAQ channel
1. Make: Thomas Model: Traceabl	160274632	N/A

Air Flow meter	Serial Num	DAQ channel
1. Make: TSI Model: 5725	1511004	N/A

Thermocouples	Serial Num	DAQ channel
1. Make: Omega Model: XC20K120Cal	3732-1	T1
2. Make: Omega Model: XC20K120Cal	3732-2	T2
3. Make: Omega Model: XC20K120Cal	3732-4	T3
4. Make: Omega Model: XC20K120Cal	3732-8	T4

Fenwal Heat Detector	Serial Num	DAQ channel
1. Make: Fenwal Model: 140 deg.	28021-5	D0
2. Make: Fenwal Model: 190 deg.	28021-5	D1

Cameras	Serial Num	DAQ channel
1. Make: Point Grey Model: Grasshopper 3	14273764	N/A
2. Make: Point Grey Model: Grasshopper 3	14273944	N/A
3. Make: Point Grey Model: Grasshopper 3	15383782	N/A
4. Make: FLIR Model: T640	55909287	N/A

Glove Installation

Glove/cover installed	LANL insp	Port #	Glove/cover installed	LANL insp	Port #
8UY2030		1	8UY2030		13
"		2	"		14
"		3	"		15
"		4	"		16
"		5	"		17
"		6	"		18
"		7	"		19
"		8	"		20
8Y1532		9	"		21
"		10	"		22
8UY2030		11	8Y1532		23
"		12	"		24

Time & Description of Critical Events

Ignition Time: 59s, flame visible

500 degrees at glove (approx) Time: N/A, 84°F max (high T/C)

Breach Time: N/A

140 Fenwal Detection Time: N/A

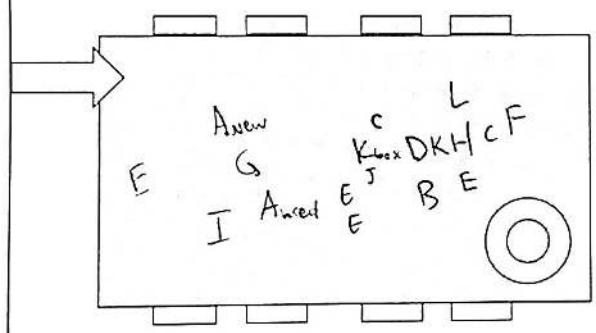
190 Fenwal Detection Time: N/A

Other key times:

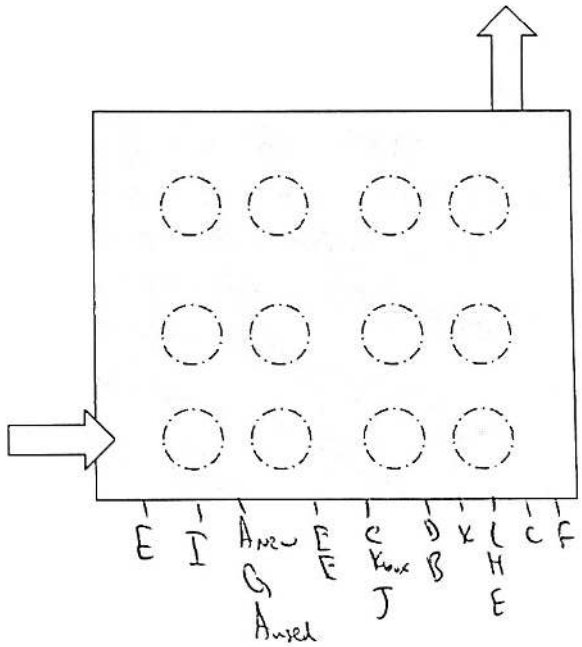
Miscellaneous Notes

#106095 Ralph Clayton 6/27/2016

GB Floor (Top View)



GB Floor (Side View)



Legend:

- ~~A~~. Ignition bag
- ~~B~~. Sand paper
- C. Screwdriver
- ~~D~~. Mallet
- ~~E~~. Poly Bottle
- ~~F~~. Leather glove
- ~~G~~. Push Rod
- ~~H~~. Horsehair brush
- ~~I~~. Scale cord
- ~~J~~. Cotton rounds
- ~~K~~. Kim wipes
- ~~L~~. Fantastic

Revision History	
Revision & Justification	Authorized Signatures

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

Glovebox Fire Suppression: Experiment # 10

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted
Ralph Clayton	6/27/16	Torres, 2-ton	✓	

Safety Officer Name: David Grow

Quality Assurance Rep. Name: Jim Narum

Start Time	3:00
Ignition Time	3:00
End Time	3:01 (self-extinguished)

Relevant Environmental Conditions

82.0° in bunker
47% rel. humidity

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make: Dwyer Model: 648B-05	4614118	A0
2. Make: Dwyer Model: 648B-15	4514088	A1
3. Make: Dwyer Model: 648B-05	0115016	A2
4. Make: Dwyer Model: 648B-15	4914183	A3

Digital Timer	Serial Num	DAQ channel
1. Make: Thomas Model: Traceabl	160274632	N/A

Air Flow meter	Serial Num	DAQ channel
1. Make: TSI Model: 5725	1511004	N/A

Thermocouples	Serial Num	DAQ channel
1. Make: Omega Model: XC20KI20Cal	3732-1	T1
2. Make: Omega Model: XC20KI20Cal	3732-2	T2
3. Make: Omega Model: XC20KI20Cal	3732-4	T3
4. Make: Omega Model: XC20KI20Cal	3732-8	T4

Fenwal Heat Detector	Serial Num	DAQ channel
1. Make: Fenwal Model: 140 deg.	28021-5	D0
2. Make: Fenwal Model: 190 deg.	28021-5	D1

Cameras	Serial Num	DAQ channel
1. Make: Point Grey Model: Grasshopper 3	14273764	N/A
2. Make: Point Grey Model: Grasshopper 3	14273944	N/A
3. Make: Point Grey Model: Grasshopper 3	15383782	N/A
4. Make: FLIR Model: T640	55909287	N/A

Glove Installation

Glove/cover installed	LANL insp	Port #	Glove/cover installed	LANL insp	Port #
8UY2030		1	8UY2030		13
"		2	"		14
"		3	"		15
"		4	"		16
"		5	"		17
"		6	"		18
"		7	"		19
"		8	"		20
8Y1532		9	"		21
"		10	"		22
8UY2030		11	8Y1532		23
"		12	"		24

Time & Description of Critical Events

Ignition Time: 60 s, flame visible

500 degrees at glove (approx) Time: N/A, 86°F max (high T/C)

Breach Time: N/A

140 Fenwal Detection Time: N/A

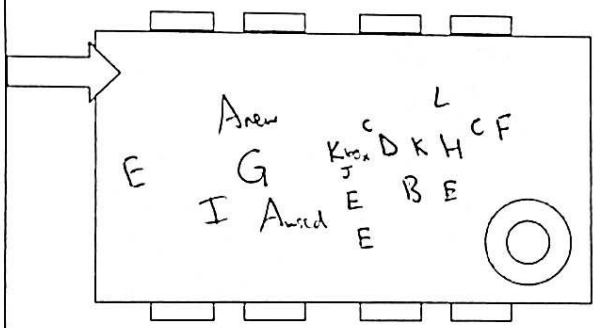
190 Fenwal Detection Time: N/A

Other key times:

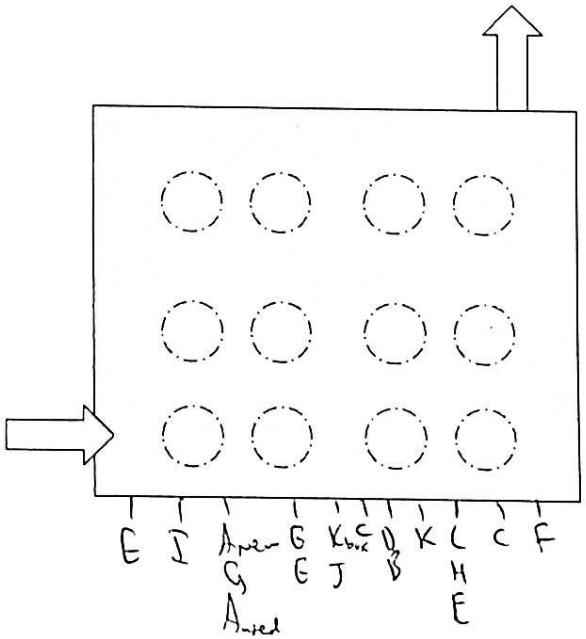
Miscellaneous Notes

106098 Ralph Clayton 6/27/2014

GB Floor (Top View)



GB Floor (Side View)



Legend:

- ~~A~~. Ignition bag
- ~~B~~. Sand paper
- ~~C~~. Screwdriver
- ~~D~~. Mallet
- ~~E~~. Poly Bottle
- ~~F~~. Leather glove
- ~~G~~. Push Rod
- ~~H~~. Horsehair brush
- ~~I~~. Scale cord
- ~~J~~. Cotton rounds
- ~~K~~. Kim wipes
- ~~L~~. Franklin

Revision History	
Revision & Justification	Authorized Signatures

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

Glovebox Fire Suppression: Experiment # 11

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted
Ralph Clayton	6/28/16	Torres, 2-ton	✓	

Safety Officer Name: David Grow

Quality Assurance Rep. Name: Jim Norum

Start Time	8:22
Ignition Time	8:22
End Time	8:25

Relevant Environmental Conditions

78.0° in bunker
50 % rel. humidity

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make: Dwyer Model: 648B-05	4614118	A0
2. Make: Dwyer Model: 648B-15	4514088	A1
3. Make: Dwyer Model: 648B-05	0115016	A2
4. Make: Dwyer Model: 648B-15	4914183	A3

Digital Timer	Serial Num	DAQ channel
1. Make: Thomas Model: Traceabl	160274632	N/A

Air Flow meter	Serial Num	DAQ channel
1. Make: TSI Model: 5725	1511004	N/A

Thermocouples	Serial Num	DAQ channel
1. Make: Omega Model: XC20K120Cal	3732-1	T1
2. Make: Omega Model: XC20K120Cal	3732-2	T2
3. Make: Omega Model: XC20K120Cal	3732-4	T3
4. Make: Omega Model: XC20K120Cal	3732-8	T4

Fenwal Heat Detector	Serial Num	DAQ channel
1. Make: Fenwal Model: 140 deg.	28021-5	D0
2. Make: Fenwal Model: 190 deg.	28021-5	D1

Cameras	Serial Num	DAQ channel
1. Make: Point Grey Model: Grasshopper 3	14273764	N/A
2. Make: Point Grey Model: Grasshopper 3	14273944	N/A
3. Make: Point Grey Model: Grasshopper 3	15383782	N/A
4. Make: FLIR Model: T640	55909287	N/A

Glove Installation

Glove/cover installed	LANL insp	Port #	Glove/cover installed	LANL insp	Port #
8UY2030		1	8UY2030		13
"		2	"		14
"		3	"		15
"		4	"		16
"		5	"		17
"		6	"		18
"		7	"		19
"		8	"		20
8Y1532		9	"		21
"		10	"		22
8UY2030		11	8Y1532		23
"		12	"		24

Time & Description of Critical Events

Ignition Time: 73 s, flame visible

500 degrees at glove (approx) Time: N/A, 87°F max (high T/C)

Breach Time: N/A

140 Fenwal Detection Time: N/A

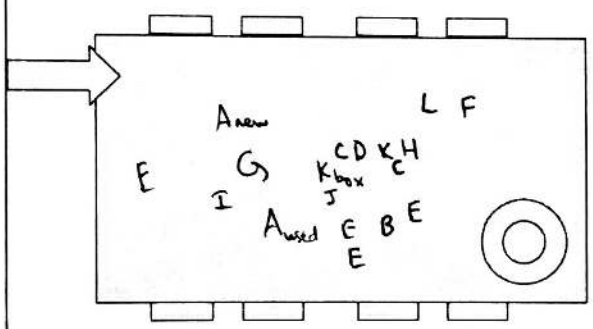
190 Fenwal Detection Time: N/A

Other key times:

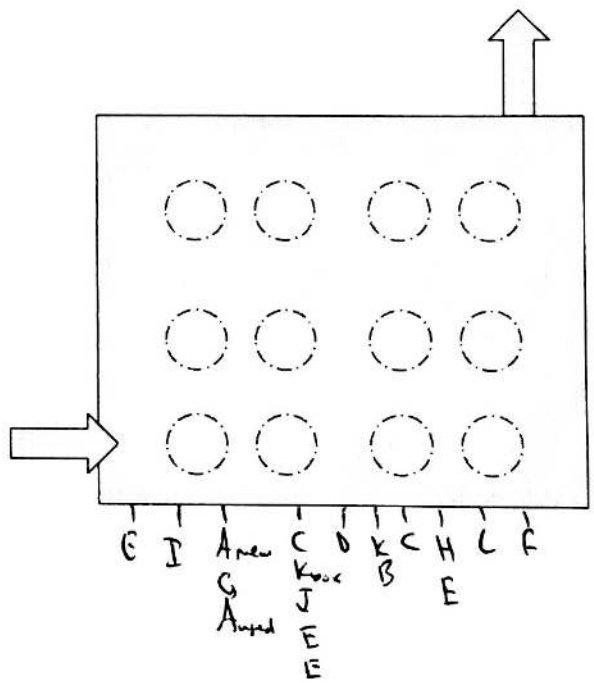
Miscellaneous Notes

Ralph Clayton 106098 6/28/2016

GB Floor (Top View)



GB Floor (Side View)



Legend:

- ~~A~~. Ignition bag
- ~~B~~. Sand paper
- ~~C~~. Screwdriver
- ~~D~~. Mallet
- ~~E~~. Poly Bottle
- ~~F~~. Leather glove
- ~~G~~. Push Rod
- ~~H~~. Horsehair brush
- ~~I~~. Scale cord
- ~~J~~. Cotton rounds
- ~~K~~. Kim wipes
- ~~L~~. Fantastik

Revision History	
Revision & Justification	Authorized Signatures

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

Glovebox Fire Suppression: Experiment # 12

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted
Ralph Clayton	6/28/16	Torres, 2-tank		✓

Safety Officer Name	
David Gross	
Quality Assurance Rep. Name	
Jim Navarrete	

Start Time	9:18
Ignition Time	N/A
End Time	N/A

Relevant Environmental Conditions

77.6° in bunker
49% rel. humidity

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make: Dwyer Model: 648B-05	4614118	A0
2. Make: Dwyer Model: 648B-15	4514088	A1
3. Make: Dwyer Model: 648B-05	01.15016	A2
4. Make: Dwyer Model: 648B-15	4914183	A3

Digital Timer	Serial Num	DAQ channel
1. Make: Thomas Model: Traceabl	160274632	N/A

Air Flow meter	Serial Num	DAQ channel
1. Make: TSI Model: 5725	1511004	N/A

Thermocouples	Serial Num	DAQ channel
1. Make: Omega Model: XC20K120Cal	3732-1	T1
2. Make: Omega Model: XC20K120Cal	3732-2	T2
3. Make: Omega Model: XC20K120Cal	3732-4	T3
4. Make: Omega Model: XC20K120Cal	3732-8	T4

Fenwal Heat Detector	Serial Num	DAQ channel
1. Make: Fenwal Model: 140 deg.	28021-5	D0
2. Make: Fenwal Model: 190 deg.	28021-5	D1

Cameras	Serial Num	DAQ channel
1. Make: Point Grey Model: Grasshopper 3	14273764	N/A
2. Make: Point Grey Model: Grasshopper 3	14273944	N/A
3. Make: Point Grey Model: Grasshopper 3	15383782	N/A
4. Make: FLIR Model: T640	55909287	N/A

Glove Installation

Glove/cover installed	LANL insp	Port #	Glove/cover installed	LANL insp	Port #
EUY2030		1	EUY2030		13
"		2	"		14
"		3	"		15
"		4	"		16
"		5	"		17
"		6	"		18
"		7	"		19
"		8	"		20
EY1532		9	"		21
"		10	"		22
EUY2030		11	EY1532		23
"		12	"		24

Time & Description of Critical Events

Ignition Time: N/A

500 degrees at glove (approx) Time:

Breach Time:

140 Fenwal Detection Time:

190 Fenwal Detection Time:

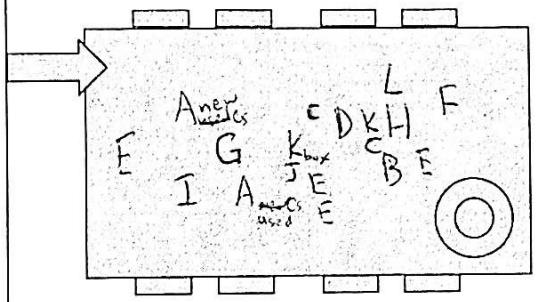
Other key times:

No ignition

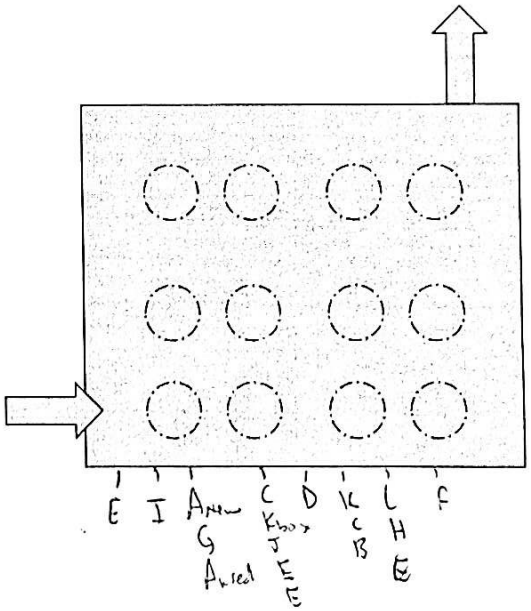
Miscellaneous Notes

Ralph Clayton 6/28/2016
7060 98

GB Floor (Top View)



GB Floor (Side View)



Legend:

A. Ignition bag
B. Sand paper
C. Screwdriver
D. Mallet
E. Poly Bottle
F. Leather glove
G. Push Rod
H. Horsehair brush
I. Scale cord
J. Cotton rounds
K. Kim wipes
L. Fantastik

Revision History	
Revision & Justification	Authorized Signatures

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

Glovebox Fire Suppression: Experiment # 13

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted
Ralph Clayton	6/28/16	Torres, 2-ton		✓

Safety Officer Name: David Grow

Quality Assurance Rep. Name: Jim Narvin

Start Time	9:36
Ignition Time	N/A
End Time	N/A

Relevant Environmental Conditions

77.9° in bunker
49% rel. humidity

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make: Dwyer Model: 648B-05	4614118	A0
2. Make: Dwyer Model: 648B-15	4514088	A1
3. Make: Dwyer Model: 648B-05	0115016	A2
4. Make: Dwyer Model: 648B-15	4914183	A3

Digital Timer	Serial Num	DAQ channel
1. Make: Thomas Model: Traceabl	160274632	N/A

Air Flow meter	Serial Num	DAQ channel
1. Make: TSI Model: 5725	1511004	N/A

Thermocouples	Serial Num	DAQ channel
1. Make: Omega Model: XC20K120Cal	3732-1	T1
2. Make: Omega Model: XC20K120Cal	3732-2	T2
3. Make: Omega Model: XC20K120Cal	3732-4	T3
4. Make: Omega Model: XC20K120Cal	3732-8	T4

Fenwal Heat Detector	Serial Num	DAQ channel
1. Make: Fenwal Model: 140 deg.	28021-5	D0
2. Make: Fenwal Model: 190 deg.	28021-5	D1

Cameras	Serial Num	DAQ channel
1. Make: Point Grey Model: Grasshopper 3	14273764	N/A
2. Make: Point Grey Model: Grasshopper 3	14273944	N/A
3. Make: Point Grey Model: Grasshopper 3	15383782	N/A
4. Make: FLIR Model: T640	55909287	N/A

Glove Installation

Glove/cover installed	LANL insp	Port #	Glove/cover installed	LANL insp	Port #
GUY2030		1	GUY2030		13
"		2	"		14
"		3	"		15
"		4	"		16
"		5	"		17
"		6	"		18
"		7	"		19
"		8	"		20
EY1532		9	"		21
"		10	"		22
GUY2030		11	EY1532		23
"		12	"		24

Time & Description of Critical Events

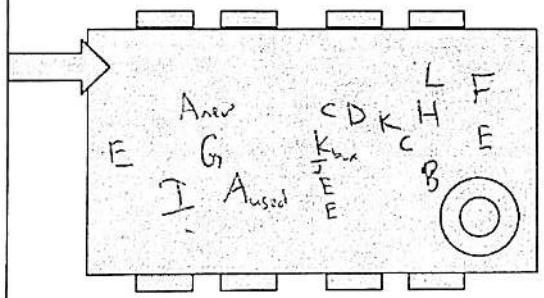
Ignition Time: N/A
500 degrees at glove (approx) Time:
Breach Time:
140 Fenwal Detection Time:
190 Fenwal Detection Time:
Other key times:

No ignition

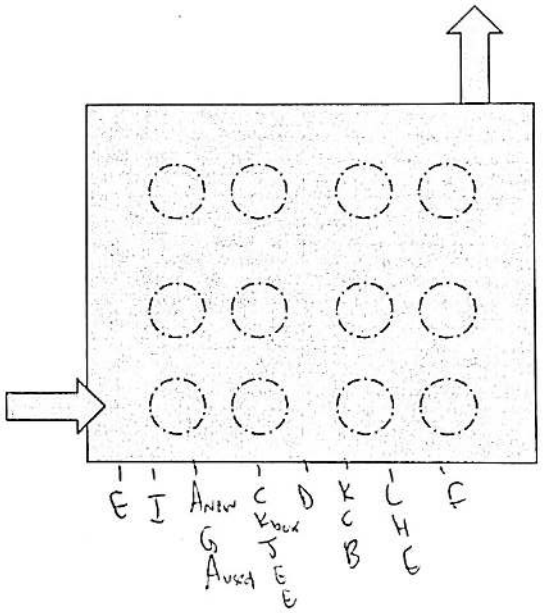
Miscellaneous Notes

106098, Ralph Clayton 7/13/2016
Ralph Clayton

GB Floor (Top View)



GB Floor (Side View)



Legend:

- A. Ignition bag
- B. Sand paper
- C. Screwdriver
- D. Mallet
- E. Poly Bottle
- F. Leather glove
- G. Push Rod
- H. Horsehair brush
- I. Scale cord
- J. Cotton rounds
- K. Kim wipes
- L. Fantastik

Revision History	
Revision & Justification	Authorized Signatures

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

Glovebox Fire Suppression: Experiment # 14

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted
Ralph Clayton	6/28/16	Torres, 2-ton	✓	

Safety Officer Name: David Grant

Quality Assurance Rep. Name: Jim Arrum

Start Time	11:49
Ignition Time	11:50
End Time	12:00

Relevant Environmental Conditions

79.1° in bunker
48% rel. humidity

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make: Dwyer Model: 648B-05	4614118	A0
2. Make: Dwyer Model: 648B-15	4514088	A1
3. Make: Dwyer Model: 648B-05	0115016	A2
4. Make: Dwyer Model: 648B-15	4914183	A3

Digital Timer	Serial Num	DAQ channel
1. Make: Thomas Model: Traceabl	160274632	N/A

Air Flow meter	Serial Num	DAQ channel
1. Make: TSI Model: 5725	1511004	N/A

Thermocouples	Serial Num	DAQ channel
1. Make: Omega Model: XC20K120Cal	3732-1	T1
2. Make: Omega Model: XC20K120Cal	3732-2	T2
3. Make: Omega Model: XC20K120Cal	3732-4	T3
4. Make: Omega Model: XC20K120Cal	3732-8	T4

Fenwal Heat Detector	Serial Num	DAQ channel
1. Make: Fenwal Model: 140 deg.	28021-5	D0
2. Make: Fenwal Model: 190 deg.	28021-5	D1

Cameras	Serial Num	DAQ channel
1. Make: Point Grey Model: Grasshopper 3	14273764	N/A
2. Make: Point Grey Model: Grasshopper 3	14273944	N/A
3. Make: Point Grey Model: Grasshopper 3	15383782	N/A
4. Make: FLIR Model: T640	55909287	N/A

Glove Installation

Glove/cover installed	LANL insp	Port #	Glove/cover installed	LANL insp	Port #
BUY2030	B	1	BUY2030	B	13
"	B	2	"	B	14
"	B	3	"	B	15
"	B	4	"	B	16
"	B	5	"	B	17
"	B	6	"	B	18
"	B	7	"	B	19
"	B	8	"	B	20
BY1532	B	9	"	B	21
"	B	10	"	B	22
BUY2030	B	11	BY1532	B	23
"	B	12	"	B	24

Time & Description of Critical Events

Ignition Time: 87 s, flame visible

500 degrees at glove (approx) Time: N/A, max 112°F (ch. T/C)

Breach Time: 413 s

140 Fenwal Detection Time: N/A

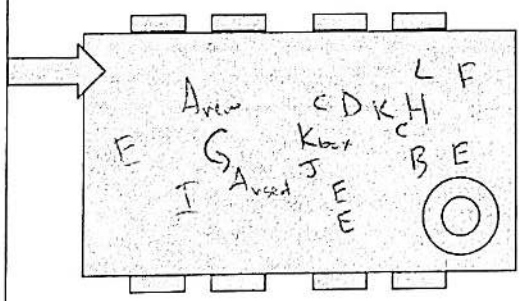
190 Fenwal Detection Time: N/A

Other key times:

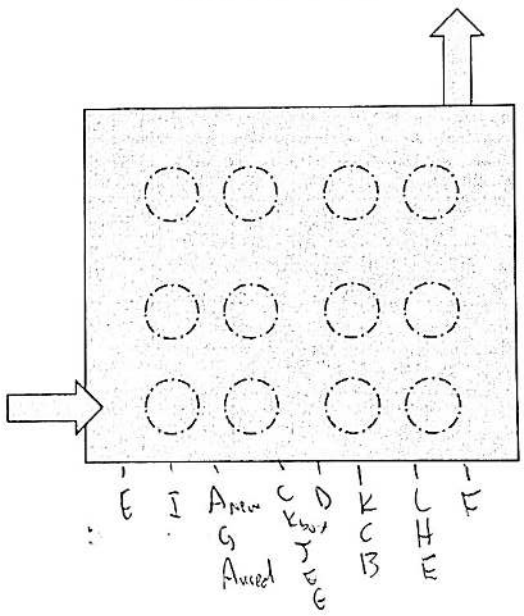
Miscellaneous Notes

B Ralph Clayton 6/28/2016
106096

GB Floor (Top View)



GB Floor (Side View)



Legend:

A. Ignition bag
B. Sand paper
C. Screwdriver
D. Mallet
E. Poly Bottle
F. Leather glove
G. Push Rod
H. Horsehair brush
I. Scale cord
J. Cotton rounds
K. Kim wipes
L. Fantastik

Revision History	
Revision & Justification	Authorized Signatures

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

Glovebox Fire Suppression: Experiment #15

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted
Ralph Clayton	6/20/16	Torres, 2-ton	✓	

Safety Officer Name: David Grow

Quality Assurance Rep. Name: Jim Narum

Start Time	1:50
Ignition Time	1:55
End Time	2:02

Relevant Environmental Conditions

81.1° in bunker
43% rel. humidity

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make: Dwyer Model: 648B-05	4614118	A0
2. Make: Dwyer Model: 648B-15	4514088	A1
3. Make: Dwyer Model: 648B-05	0115016	A2
4. Make: Dwyer Model: 648B-15	4914183	A3

Digital Timer	Serial Num	DAQ channel
1. Make: Thomas Model: Traceabl	160274632	N/A

Air Flow meter	Serial Num	DAQ channel
1. Make: TSI Model: 5725	1511004	N/A

Thermocouples	Serial Num	DAQ channel
1. Make: Omega Model: XC20K120Cal	3732-1	T1
2. Make: Omega Model: XC20K120Cal	3732-2	T2
3. Make: Omega Model: XC20K120Cal	3732-4	T3
4. Make: Omega Model: XC20K120Cal	3732-8	T4

Fenwal Heat Detector	Serial Num	DAQ channel
1. Make: Fenwal Model: 140 deg.	28021-5	D0
2. Make: Fenwal Model: 190 deg.	28021-5	D1

Cameras	Serial Num	DAQ channel
1. Make: Point Grey Model: Grasshopper 3	14273764	N/A
2. Make: Point Grey Model: Grasshopper 3	14273944	N/A
3. Make: Point Grey Model: Grasshopper 3	15383782	N/A
4. Make: FLIR Model: T640	55909287	N/A

Glove Installation

Glove/cover installed	LANL insp	Port #	Glove/cover installed	LANL insp	Port #
8UY2030		1	8UY2030		13
"		2	"		14
"		3	"		15
"		4	"		16
"		5	"		17
"		6	"		18
"		7	"		19
"		8	"		20
8Y1532		9	"		21
"		10	"		22
8UY2030		11	8Y1532		23
"		12	"		24

Time & Description of Critical Events

Ignition Time: 285 s, flame visible

500 degrees at glove (approx) Time: N/A, 90°F max (high t/c)

Breach Time: N/A

140 Fenwal Detection Time: N/A

190 Fenwal Detection Time: N/A

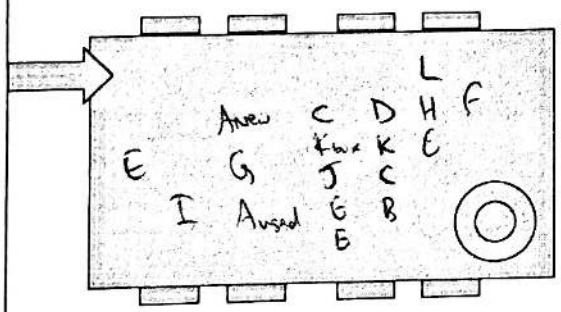
Other key times:

Miscellaneous Notes

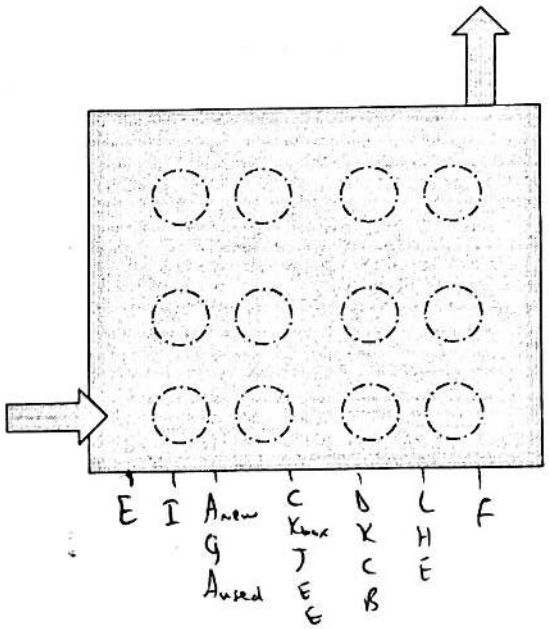
134.5° measurement (max spatially) of glove interior using hand held

Ralph Clayton, 106098, 6/28/2016

GB Floor (Top View)



GB Floor (Side View)



Legend:

A. Ignition bag
B. Sand paper
C. Screwdriver
D. Mallet
E. Poly Bottle
F. Leather glove
G. Push Rod
H. Horsehair brush
I. Scale cord
J. Cotton rounds
K. Kim wipes
L. Contact HK

Revision History	
Revision & Justification	Authorized Signatures

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

Glovebox Fire Suppression: Experiment #16

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted
Ralph Clayton	6/28/16	Torres, 2-ton	✓	

Safety Officer Name: David Grow

Quality Assurance Rep. Name: Jim Narum

Start Time	2:50
Ignition Time	~~2:50~~ DE 6/28 N/A
End Time	3:01

Relevant Environmental Conditions

82.0° in bunker
39 % rel. humidity

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make: Dwyer Model: 648B-05	4614118	A0
2. Make: Dwyer Model: 648B-15	4514088	A1
3. Make: Dwyer Model: 648B-05	0115016	A2
4. Make: Dwyer Model: 648B-15	4914183	A3

Digital Timer	Serial Num	DAQ channel
1. Make: Thomas Model: Traceabl	160274632	N/A

Air Flow meter	Serial Num	DAQ channel
1. Make: TSI Model: 5725	1511004	N/A

Thermocouples	Serial Num	DAQ channel
1. Make: Omega Model: XC20K120Cal	3732-1	T1
2. Make: Omega Model: XC20K120Cal	3732-2	T2
3. Make: Omega Model: XC20K120Cal	3732-4	T3
4. Make: Omega Model: XC20K120Cal	3732-8	T4

Fenwal Heat Detector	Serial Num	DAQ channel
1. Make: Fenwal Model: 140 deg.	28021-5	D0
2. Make: Fenwal Model: 190 deg.	28021-5	D1

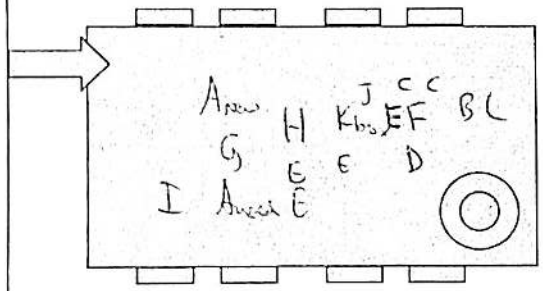
Cameras	Serial Num	DAQ channel
1. Make: Point Grey Model: Grasshopper 3	14273764	N/A
2. Make: Point Grey Model: Grasshopper 3	14273944	N/A
3. Make: Point Grey Model: Grasshopper 3	15383782	N/A
4. Make: FLIR Model: T640	55909287	N/A

Glove Installation

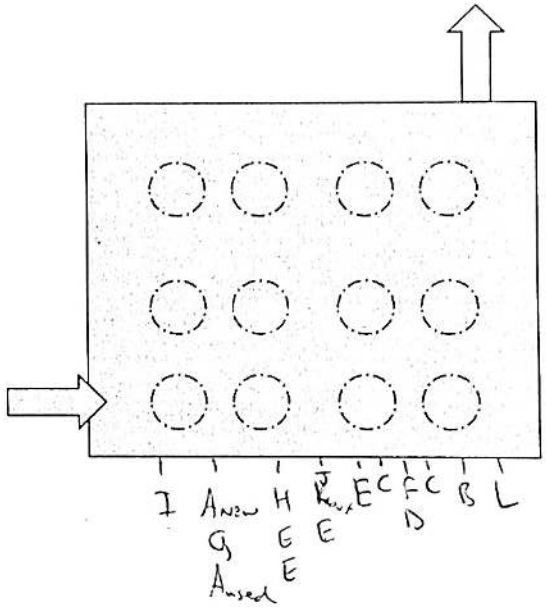
Glove/cover installed	LANL insp	Port #	Glove/cover installed	LANL insp	Port #
8UY2030	RB	1	8UY2030	RB	13
"	RB	2	"	RB	14
"	RB	3	"	RB	15
"	RB	4	"	RB	16
"	RB	5	"	RB	17
"	RB	6	"	RB	18
"	RB	7	"	RB	19
"	RB	8	"	RB	20
841532	RB	9	"	RB	21
"	RB	10	"	RB	22
8UY2030	RB	11	841532	RB	23
"	RB	12	"	RB	24

Time & Description of Critical Events	Miscellaneous Notes
Ignition Time: N/A 500 degrees at glove (approx) Time: N/A, 84°F max (high T/C) Breach Time: N/A 140 Fenwal Detection Time: N/A 190 Fenwal Detection Time: N/A Other key times:	RB Ralph Clayton, 106098, 6/23/2016 Ralph Clayton

GB Floor (Top View)



GB Floor (Side View)



Legend:

- A. Ignition bag
- B. Sand paper
- C. Screwdriver
- D. Mallet
- E. Poly Bottle
- F. Leather glove
- G. Push Rod
- H. Horsehair brush
- I. Scale cord
- J. Cotton rounds
- K. Kim wipes
- L. Fun tack

Revision History	
Revision & Justification	Authorized Signatures

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

Glovebox Fire Suppression: Experiment #_17

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted
Ralph Clayton	6/28/16	Torres, 2-tox	✓	

Safety Officer Name: David Grow

Quality Assurance Rep. Name: Jim Narum

Start Time	3:50
Ignition Time	N/A
End Time	4:01

Relevant Environmental Conditions

82.8° in bunker
38 % rel. humidity

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make: Dwyer Model: 648B-05	4614118	A0
2. Make: Dwyer Model: 648B-15	4514088	A1
3. Make: Dwyer Model: 648B-05	0115016	A2
4. Make: Dwyer Model: 648B-15	4914183	A3

Digital Timer	Serial Num	DAQ channel
1. Make: Thomas Model: Traceabl	160274632	N/A

Air Flow meter	Serial Num	DAQ channel
1. Make: TSI Model: 5725	1511004	N/A

Thermocouples	Serial Num	DAQ channel
1. Make: Omega Model: XC20K120Cal	3732-1	T1
2. Make: Omega Model: XC20K120Cal	3732-2	T2
3. Make: Omega Model: XC20K120Cal	3732-4	T3
4. Make: Omega Model: XC20K120Cal	3732-8	T4

Fenwal Heat Detector	Serial Num	DAQ channel
1. Make: Fenwal Model: 140 deg.	28021-5	D0
2. Make: Fenwal Model: 190 deg.	28021-5	D1

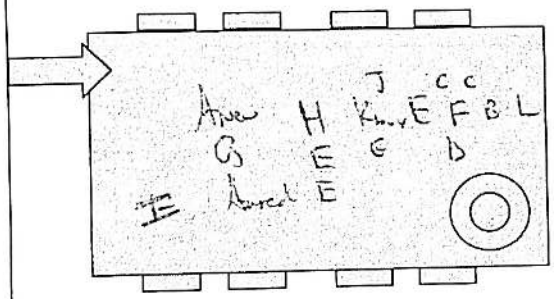
Cameras	Serial Num	DAQ channel
1. Make: Point Grey Model: Grasshopper 3	14273764	N/A
2. Make: Point Grey Model: Grasshopper 3	14273944	N/A
3. Make: Point Grey Model: Grasshopper 3	15383782	N/A
4. Make: FLIR Model: T640	55909287	N/A

Glove Installation

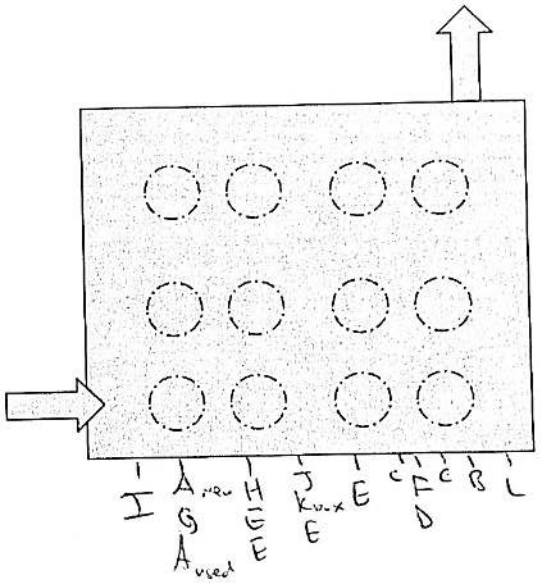
Glove/cover installed	LANL insp	Port #	Glove/cover installed	LANL insp	Port #
EUY2030		1	EUY2030		13
"		2	"		14
"		3	"		15
"		4	"		16
"		5	"		17
"		6	"		18
"		7	"		19
"		8	"		20
EY1532		9	"		21
"		10	"		22
EUY2030		11	EY1532		23
"		12	"		24

Time & Description of Critical Events	Miscellaneous Notes
Ignition Time: N/A	RP Ralph Chystan, 106098, 6/28/2016
500 degrees at glove (approx) Time: N/A, 85°F max (high T/C)	
Breach Time: N/A	
140 Fenwal Detection Time: N/A	
190 Fenwal Detection Time: N/A	
Other key times:	

GB Floor (Top View)



GB Floor (Side View)



Legend:

A. Ignition bag
B. Sand paper
C. Screwdriver
D. Mallet
E. Poly Bottle
F. Leather glove
G. Push Rod
H. Horsehair brush
I. Scale cord
J. Cotton rounds
K. Kim wipes
L. Fastbrite K

Revision History	
Revision & Justification	Authorized Signatures

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

Glovebox Fire Suppression: Experiment # 18

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted
David Grow	6/29/16	Torres, 2-ton	✓	

Safety Officer Name	Ralph Clayton
Quality Assurance Rep. Name	Rick Hinckley

Start Time	9:19
Ignition Time	
End Time	9:30

Relevant Environmental Conditions

78.4° in bunker
47% rel. humidity

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make: Dwyer Model: 648B-05	4614118	A0
2. Make: Dwyer Model: 648B-15	4514088	A1
3. Make: Dwyer Model: 648B-05	0115016	A2
4. Make: Dwyer Model: 648B-15	4914183	A3

Digital Timer	Serial Num	DAQ channel
1. Make: Thomas Model: Traceabl	160274632	N/A

Air Flow meter	Serial Num	DAQ channel
1. Make: TSI Model: 5725	1511004	N/A

Thermocouples	Serial Num	DAQ channel
1. Make: Omega Model: XC20K120Cal	3732-1	T1
2. Make: Omega Model: XC20K120Cal	3732-2	T2
3. Make: Omega Model: XC20K120Cal	3732-4	T3
4. Make: Omega Model: XC20K120Cal	3732-8	T4

Fenwal Heat Detector	Serial Num	DAQ channel
1. Make: Fenwal Model: 140 deg.	28021-5	D0
2. Make: Fenwal Model: 190 deg.	28021-5	D1

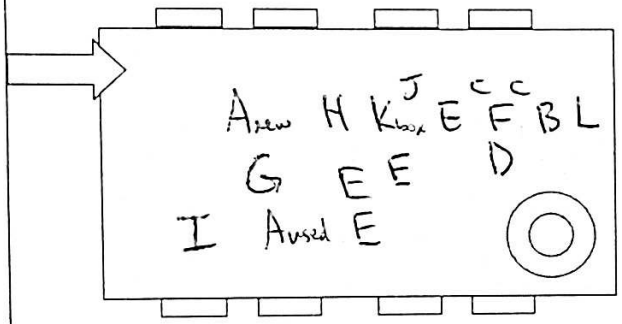
Cameras	Serial Num	DAQ channel
1. Make: Point Grey Model: Grasshopper 3	14273764	N/A
2. Make: Point Grey Model: Grasshopper 3	14273944	N/A
3. Make: Point Grey Model: Grasshopper 3	15383782	N/A
4. Make: FLIR Model: T640	55909287	N/A

Glove Installation

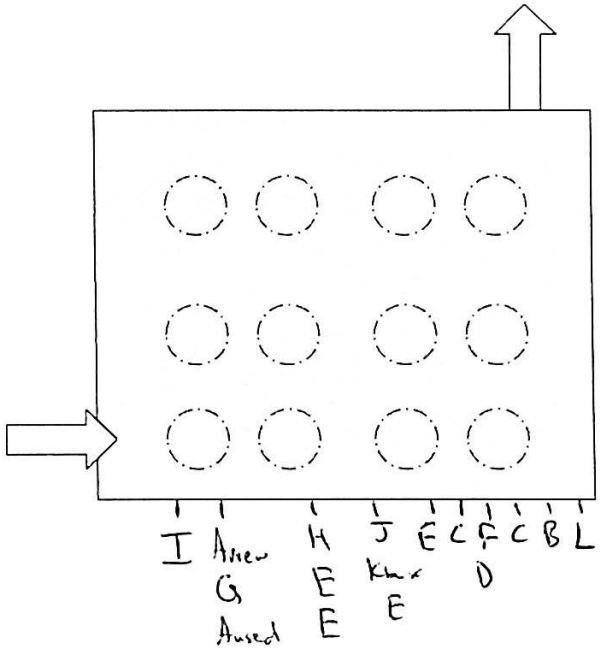
Glove/cover installed	LANL insp	Port #	Glove/cover installed	LANL insp	Port #
8UY2030	RH	1	8UY2030	RH	13
"	RH	2	"	RH	14
"	RH	3	"	RH	15
"	RH	4	"	RH	16
"	RH	5	"	RH	17
"	RH	6	"	RH	18
"	RH	7	"	RH	19
"	RH	8	"	RH	20
8Y1532	RH	9	"	RH	21
"	RH	10	"	RH	22
8UY2030	RH	11	8Y1532	RH	23
"	RH	12	"	RH	24

Time & Description of Critical Events	Miscellaneous Notes
Ignition Time: 47 s, flame appears 500 degrees at glove (approx) Time: N/A, 81°F max (high T/C) Breach Time: N/A 140 Fenwal Detection Time: N/A 190 Fenwal Detection Time: N/A Other key times:	Coil appear to have melted into contact w/ GB floor, possibly reducing heat b/c of shorting.

GB Floor (Top View)



GB Floor (Side View)



Legend:

- ~~A~~. Ignition bag
- ~~B~~. Sand paper
- ~~C~~. Screwdriver
- ~~D~~. Mallet
- ~~E~~. Poly Bottle
- ~~F~~. Leather glove
- ~~G~~. Push Rod
- ~~H~~. Horsehair brush
- ~~I~~. Scale cord
- ~~J~~. Cotton rounds
- ~~K~~. Kim wipes
- ~~L~~. Fantastik

Revision History	
Revision & Justification	Authorized Signatures

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

Glovebox Fire Suppression: Experiment # 19

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted
David Grow	6/29/16	Torres, 2-tow	✓	

Safety Officer Name: Ralph Clayton

Quality Assurance Rep. Name: Rick Hinckley

Start Time	~~10:45~~ DG 6/29 10:42
Ignition Time	10:43 flame visible
End Time	10:53

Relevant Environmental Conditions

79.6° in bunker
46 % rel. humidity

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make: Dwyer Model: 648B-05	4614118	A0
2. Make: Dwyer Model: 648B-15	4514088	A1
3. Make: Dwyer Model: 648B-05	0115016	A2
4. Make: Dwyer Model: 648B-15	4914183	A3

Digital Timer	Serial Num	DAQ channel
1. Make: Thomas Model: Traceabl	160274632	N/A

Air Flow meter	Serial Num	DAQ channel
1. Make: TSI Model: 5725	1511004	N/A

Thermocouples	Serial Num	DAQ channel
1. Make: Omega Model: XC20K120Cal	3732-1	T1
2. Make: Omega Model: XC20K120Cal	3732-2	T2
3. Make: Omega Model: XC20K120Cal	3732-4	T3
4. Make: Omega Model: XC20K120Cal	3732-8	T4

Fenwal Heat Detector	Serial Num	DAQ channel
1. Make: Fenwal Model: 140 deg.	28021-5	D0
2. Make: Fenwal Model: 190 deg.	28021-5	D1

Cameras	Serial Num	DAQ channel
1. Make: Point Grey Model: Grasshopper 3	14273764	N/A
2. Make: Point Grey Model: Grasshopper 3	14273944	N/A
3. Make: Point Grey Model: Grasshopper 3	15383782	N/A
4. Make: FLIR Model: T640	55909287	N/A

Glove Installation

Glove/cover installed	LANL insp	Port #
8UY2030	RH	1
"	RH	2
"	RH	3
"	RH	4
"	RH	5
"	RH	6
"	RH	7
"	RH	8
8Y1532	RH	9
"	RH	10
8UY2030	RH	11
"	RH	12

Glove/cover installed	LANL insp	Port #
8UY2030	RH	13
"	RH	14
"	RH	15
"	RH	16
"	RH	17
"	RH	18
"	RH	19
"	RH	20
"	RH	21
"	RH	22
8Y1532	RH	23
"	RH	24

Time & Description of Critical Events

Ignition Time: 305, visible flame

500 degrees at glove (approx) Time: N/A, 257°F max (high T/C)

Breach Time: 405

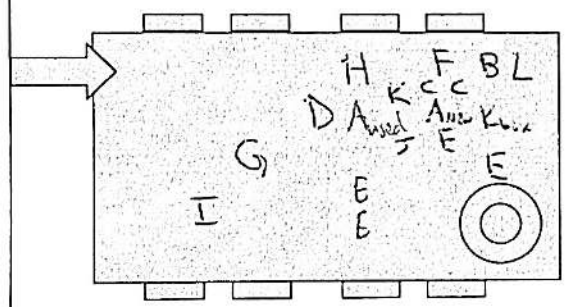
140 Fenwal Detection Time: 1456 s. (stop @ 1816 s.)

190 Fenwal Detection Time: N/A

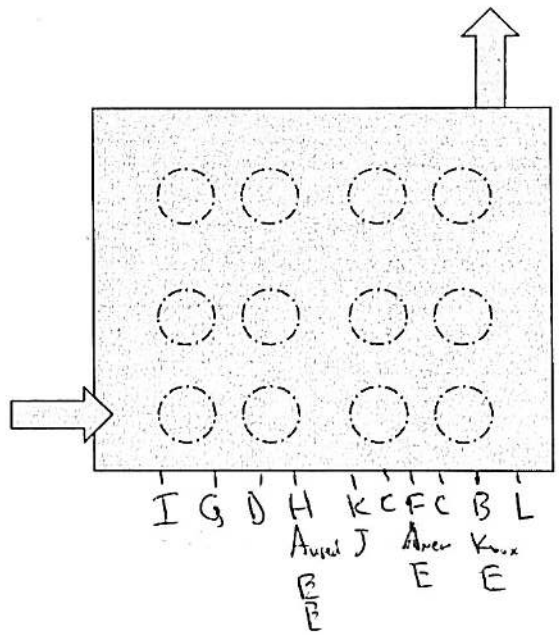
Other key times:

Miscellaneous Notes

GB Floor (Top View)



GB Floor (Side View)



Legend:

- ~~A~~. Ignition bag
- ~~B~~. Sand paper
- ~~C~~. Screwdriver
- ~~D~~. Mallet
- ~~E~~. Poly Bottle
- ~~F~~. Leather glove
- ~~G~~. Push Rod
- ~~H~~. Horsehair brush
- ~~I~~. Scale cord
- ~~J~~. Cotton rounds
- ~~K~~. Kim wipes
- ~~L~~. fantastik

Revision History	
Revision & Justification	Authorized Signatures

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

Glovebox Fire Suppression: Experiment # 20

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted
David Grow	6/29/16	Torres, 2-tori	✓	

Safety Officer Name: Ralph Clayton

Quality Assurance Rep. Name: Rich Hinkley

Start Time	2:35
Ignition Time	2:42
End Time	3:01

Relevant Environmental Conditions

82.0° in buncher
37% rel. humidity

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make: Dwyer Model: 648B-05	4614118	A0
2. Make: Dwyer Model: 648B-15	4514088	A1
3. Make: Dwyer Model: 648B-05	0115016	A2
4. Make: Dwyer Model: 648B-15	4914183	A3

Digital Timer	Serial Num	DAQ channel
1. Make: Thomas Model: Traceabl	160274632	N/A

Air Flow meter	Serial Num	DAQ channel
1. Make: TSI Model: 5725	1511004	N/A

Thermocouples	Serial Num	DAQ channel
1. Make: Omega Model: XC20K120Cal	3732-1	T1
2. Make: Omega Model: XC20K120Cal	3732-2	T2
3. Make: Omega Model: XC20K120Cal	3732-4	T3
4. Make: Omega Model: XC20K120Cal	3732-8	T4

Fenwal Heat Detector	Serial Num	DAQ channel
1. Make: Fenwal Model: 140 deg.	28021-5	D0
2. Make: Fenwal Model: 190 deg.	28021-5	D1

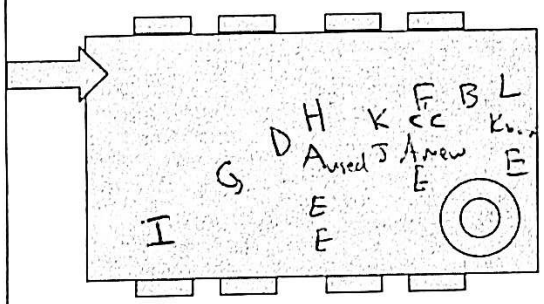
Cameras	Serial Num	DAQ channel
1. Make: Point Grey Model: Grasshopper 3	14273764	N/A
2. Make: Point Grey Model: Grasshopper 3	14273944	N/A
3. Make: Point Grey Model: Grasshopper 3	15383782	N/A
4. Make: FLIR Model: T640	55909287	N/A

Glove Installation

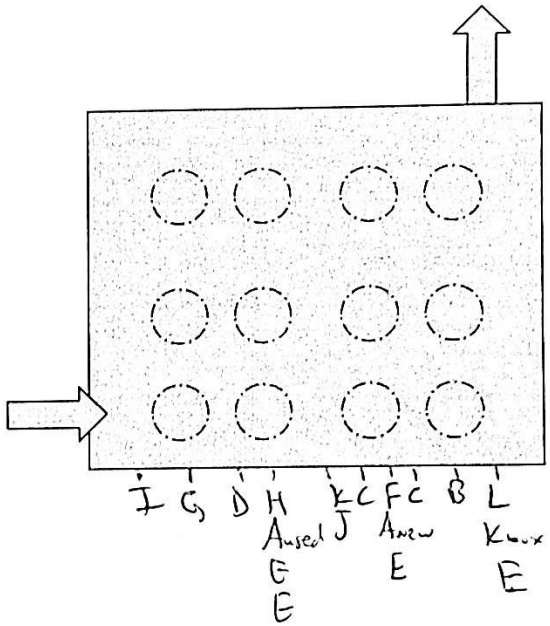
Glove/cover installed	LANL insp	Port #	Glove/cover installed	LANL insp	Port #
8UY2030	RH	1	8UY2030	RH	13
"	RH	2	"	RH	14
"	RH	3	"	RH	15
"	RH	4	"	RH	16
"	RH	5	"	RH	17
"	RH	6	"	RH	18
"	RH	7	"	RH	19
"	RH	8	"	RH	20
8Y1532	RH	9	"	RH	21
"	RH	10	"	RH	22
8UY2032	RH	11	8Y1532	RH	23
"	RH	12	"	RH	24

Time & Description of Critical Events	Miscellaneous Notes
Ignition Time: 460 s., flame visible 500 degrees at glove (approx) Time: N/A, 337°F max (high t/c) Breach Time: 475 s, pressure drop 140 Fenwal Detection Time: ON: 539 s. OFF: 657 s. 190 Fenwal Detection Time: N/A ON: 772 s. OFF: 916 s. Other key times:	Fire seems prolonged by involvement of alcohol bottle Verify time offset rel. to flow sensor

GB Floor (Top View)



GB Floor (Side View)



Legend:

- ~~A.~~ Ignition bag
- ~~B.~~ Sand paper
- ~~C.~~ Screwdriver
- ~~D.~~ Mallet
- ~~E.~~ Poly Bottle
- ~~F.~~ Leather glove
- ~~G.~~ Push Rod
- ~~H.~~ Horsehair brush
- ~~I.~~ Scale cord
- ~~J.~~ Cotton rounds
- ~~K.~~ Kim wipes
- ~~L.~~ Fantastik

Revision History	
Revision & Justification	Authorized Signatures

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

Glovebox Fire Suppression: Experiment #21

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted
David Grow	6/30/16	Torres, 2-ton	✓	

Safety Officer Name: Ralph Clayton

Quality Assurance Rep. Name: Rick Hinkley

Start Time	9:13
Ignition Time	9:18
End Time	9:31

flame visible

Relevant Environmental Conditions

79.3° in bunker
39% rel. humidity

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make: Dwyer Model: 648B-05	4614118	A0
2. Make: Dwyer Model: 648B-15	4514088	A1
3. Make: Dwyer Model: 648B-05	0115016	A2
4. Make: Dwyer Model: 648B-15	4914183	A3

Digital Timer	Serial Num	DAQ channel
1. Make: Thomas Model: Traceabl	160274632	N/A

Air Flow meter	Serial Num	DAQ channel
1. Make: TSI Model: 5725	1511004	N/A

Thermocouples	Serial Num	DAQ channel
1. Make: Omega Model: XC20K120Cal	3732-1	T1
2. Make: Omega Model: XC20K120Cal	3732-2	T2
3. Make: Omega Model: XC20K120Cal	3732-4	T3
4. Make: Omega Model: XC20K120Cal	3732-8	T4

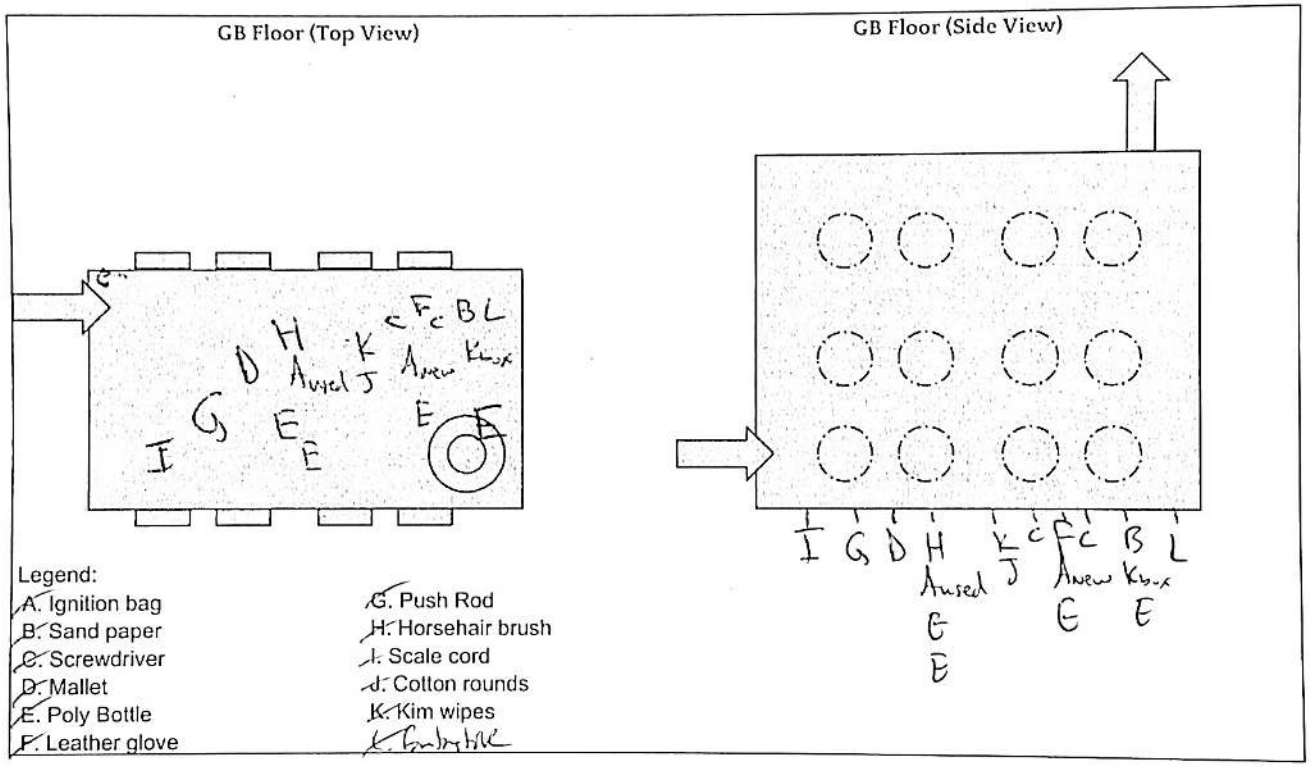
Fenwal Heat Detector	Serial Num	DAQ channel
1. Make: Fenwal Model: 140 deg.	28021-5	D0
2. Make: Fenwal Model: 190 deg.	28021-5	D1

Cameras	Serial Num	DAQ channel
1. Make: Point Grey Model: Grasshopper 3	14273764	N/A
2. Make: Point Grey Model: Grasshopper 3	14273944	N/A
3. Make: Point Grey Model: Grasshopper 3	15383782	N/A
4. Make: FLIR Model: T640	55909287	N/A

Glove Installation

Glove/cover installed	LANL insp	Port #	Glove/cover installed	LANL insp	Port #
QUY2030	RH	1	QUY2030	RH	13
"	RH	2	"	RH	14
"	RH	3	"	RH	15
"	RH	4	"	RH	16
"	RH	5	"	RH	17
"	RH	6	"	RH	18
"	RH	7	"	RH	19
"	RH	8	"	RH	20
871532	RH	9	"	RH	21
"	RH	10	"	RH	22
QUY2030	RH	11	871532	RH	23
"	RH	12	"	RH	24

Time & Description of Critical Events	Miscellaneous Notes
Ignition Time: 285 s, flame appears	
500 degrees at glove (approx) Time: N/A, 359°F max (hi-T/C)	
Breach Time: 350 s.	
140 Fenwal Detection Time: 405 on — 552 s. off	
190 Fenwal Detection Time: 433 s. on - 459 s. off	
Other key times:	


GB Floor (Top View)
GB Floor (Side View)
Legend:
A. Ignition bag
B. Sand paper
C. Screwdriver
D. Mallet
E. Poly Bottle
F. Leather glove
G. Push Rod
H. Horsehair brush
I. Scale cord
J. Cotton rounds
K. Kim wipes

Revision History	
Revision & Justification	Authorized Signatures

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

Glovebox Fire Suppression: Experiment # 22

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted
David Grow	6/30/16	Torres, 2-ton	✓	

Safety Officer Name: Ralph Clayton

Quality Assurance Rep. Name: Rich Hinkley

Start Time	1:49
Ignition Time	1:49
End Time	2:00

flame visible

Relevant Environmental Conditions

82.8° in bunker
36% rel. humidity

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make: Dwyer Model: 648B-05	4614118	A0
2. Make: Dwyer Model: 648B-15	4514088	A1
3. Make: Dwyer Model: 648B-05	0115016	A2
4. Make: Dwyer Model: 648B-15	4914183	A3

Digital Timer	Serial Num	DAQ channel
1. Make: Thomas Model: Traceabl	160274632	N/A

Air Flow meter	Serial Num	DAQ channel
1. Make: TSI Model: 5725	1511004	N/A

Thermocouples	Serial Num	DAQ channel
1. Make: Omega Model: XC20K120Cal	3732-1	T1
2. Make: Omega Model: XC20K120Cal	3732-2	T2
3. Make: Omega Model: XC20K120Cal	3732-4	T3
4. Make: Omega Model: XC20K120Cal	3732-8	T4

Fenwal Heat Detector	Serial Num	DAQ channel
1. Make: Fenwal Model: 140 deg.	28021-5	D0
2. Make: Fenwal Model: 190 deg.	28021-5	D1

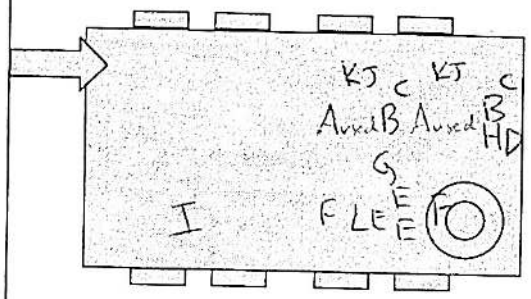
Cameras	Serial Num	DAQ channel
1. Make: Point Grey Model: Grasshopper 3	14273764	N/A
2. Make: Point Grey Model: Grasshopper 3	14273944	N/A
3. Make: Point Grey Model: Grasshopper 3	15383782	N/A
4. Make: FLIR Model: T640	55909287	N/A

Glove Installation

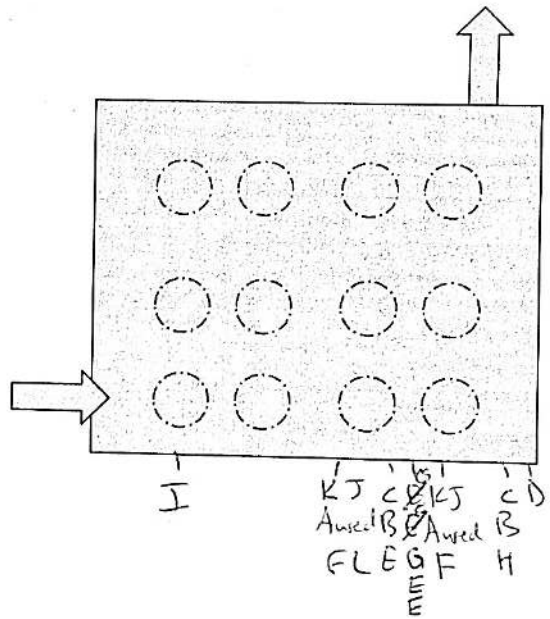
Glove/cover installed	LANL insp	Port #	Glove/cover installed	LANL insp	Port #
8UY2030	RH	1	8UY2030	RH	13
"	RH	2	"	RH	14
"	RH	3	"	RH	15
"	RH	4	"	RH	16
"	RH	5	"	RH	17
"	RH	6	"	RH	18
"	RH	7	"	RH	19
"	RH	8	"	RH	20
8Y1532 w/ copper	RH	9	"	RH	21
" w/ copper	RH	10	"	RH	22
8UY2030	RH	11	8Y1532 w/ copper	RH	23
"	RH	12	" w/ copper	RH	24

Time & Description of Critical Events	Miscellaneous Notes
Ignition Time: 45s, flame visible	Stamped metal w/ clamp strap port cover, hereafter "Type A" installed on ports 23 & 9
500 degrees at glove (approx) Time: N/A, 113°F max (middle t/c)	CNC'd metal w/ bolted clamp port cover, hereafter "Type B" installed on ports 24 & 10
Breach Time: N/A	
140 Fenwal Detection Time: N/A	
190 Fenwal Detection Time: N/A	
Other key times:	

GB Floor (Top View)



GB Floor (Side View)



Legend:

- ~~A.~~ Ignition bag
- ~~B.~~ Sand paper
- ~~C.~~ Screwdriver
- ~~D.~~ Mallet
- ~~E.~~ Poly Bottle
- ~~F.~~ Leather glove
- ~~G.~~ Push Rod
- ~~H.~~ Horsehair brush
- ~~I.~~ Scale cord
- ~~J.~~ Cotton rounds
- ~~K.~~ Kim wipes
- ~~L.~~ Fantastik

Revision History	
Revision & Justification	Authorized Signatures

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

Glovebox Fire Suppression: Experiment # 23

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted
David Grow	6/30/16	Torres, 2-ton	✓	

Safety Officer Name: Ralph Clayton

Quality Assurance Rep. Name: Rick Hindley

Start Time	2:59	
Ignition Time	3:00	flame visible
End Time	3:04	

Relevant Environmental Conditions

83.9° in bunker
33% rel. humidity

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make: Dwyer Model: 648B-05	4614118	A0
2. Make: Dwyer Model: 648B-15	4514088	A1
3. Make: Dwyer Model: 648B-05	0115016	A2
4. Make: Dwyer Model: 648B-15	4914183	A3

Digital Timer	Serial Num	DAQ channel
1. Make: Thomas Model: Traceabl	160274632	N/A

Air Flow meter	Serial Num	DAQ channel
1. Make: TSI Model: 5725	1511004	N/A

Thermocouples	Serial Num	DAQ channel
1. Make: Omega Model: XC20KI20Cal	3732-1	T1
2. Make: Omega Model: XC20KI20Cal	3732-2	T2
3. Make: Omega Model: XC20KI20Cal	3732-4	T3
4. Make: Omega Model: XC20KI20Cal	3732-8	T4

Fenwal Heat Detector	Serial Num	DAQ channel
1. Make: Fenwal Model: 140 deg.	28021-5	D0
2. Make: Fenwal Model: 190 deg.	28021-5	D1

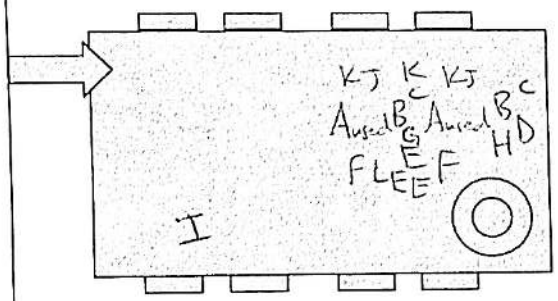
Cameras	Serial Num	DAQ channel
1. Make: Point Grey Model: Grasshopper 3	14273764	N/A
2. Make: Point Grey Model: Grasshopper 3	14273944	N/A
3. Make: Point Grey Model: Grasshopper 3	15383782	N/A
4. Make: FLIR Model: T640	55909287	N/A

Glove Installation

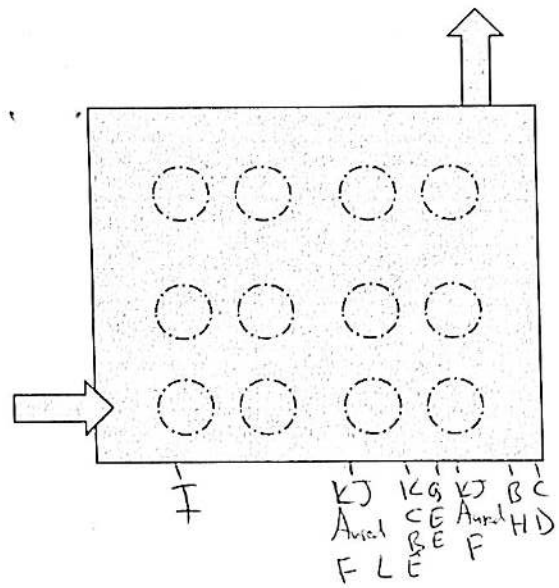
Glove/cover installed	LANL insp	Port #	Glove/cover installed	LANL insp	Port #
8UY2030	RH	1	8UY2030	RH	13
"	RH	2	"	RH	14
"	RH	3	"	RH	15
"	RH	4	"	RH	16
"	RH	5	"	RH	17
"	RH	6	"	RH	18
"	RH	7	"	RH	19
"	RH	8	"	RH	20
8Y1532 w/ cover A	RH	9	"	RH	21
" w/ cover B	RH	10	"	RH	22
8UY2030	RH	11	8Y1532 w/ cover A	RH	23
"	RH	12	" w/ cover B	RH	24

Time & Description of Critical Events		Miscellaneous Notes
Ignition Time:	43 s., flame visible	(2) 20g of Kim Wipes arranged slightly different - distributed between ports 9 & 10 to create bridge for fire
500 degrees at glove (approx) Time:	N/A, 121°F max (high T/C)	
Breach Time:	N/A	
140 Fenwal Detection Time:	N/A	
190 Fenwal Detection Time:	N/A	
Other key times:		

GB Floor (Top View)



GB Floor (Side View)



Legend:

- A. Ignition bag
- B. Sand paper
- C. Screwdriver
- D. Mallet
- E. Poly Bottle
- F. Leather glove
- G. Push Rod
- H. Horsehair brush
- I. Scale cord
- J. Cotton rounds
- K. Kim wipes
- L. Fantastik

Revision History	
Revision & Justification	Authorized Signatures

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

Glovebox Fire Suppression: Experiment # 24

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted
David Grow	6/30/16	Torres, 2-ton	✓	

Safety Officer Name: Jamie Kimberley

Quality Assurance Rep. Name: Rick Hinckley

Start Time	3:57
Ignition Time	3:58
End Time	4:04

Relevant Environmental Conditions

84.9° in burner
32 % rel. humidity

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make: Dwyer Model: 648B-05	4614118	A0
2. Make: Dwyer Model: 648B-15	4514088	A1
3. Make: Dwyer Model: 648B-05	0115016	A2
4. Make: Dwyer Model: 648B-15	4914183	A3

Digital Timer	Serial Num	DAQ channel
1. Make: Thomas Model: Traceabl	160274632	N/A

Air Flow meter	Serial Num	DAQ channel
1. Make: TSI Model: 5725	1511004	N/A

Thermocouples	Serial Num	DAQ channel
1. Make: Omega Model: XC20K120Cal	3732-1	T1
2. Make: Omega Model: XC20K120Cal	3732-2	T2
3. Make: Omega Model: XC20K120Cal	3732-4	T3
4. Make: Omega Model: XC20K120Cal	3732-8	T4

Fenwal Heat Detector	Serial Num	DAQ channel
1. Make: Fenwal Model: 140 deg.	28021-5	D0
2. Make: Fenwal Model: 190 deg.	28021-5	D1

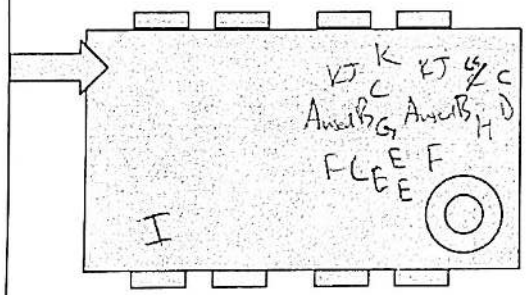
Cameras	Serial Num	DAQ channel
1. Make: Point Grey Model: Grasshopper 3	14273764	N/A
2. Make: Point Grey Model: Grasshopper 3	14273944	N/A
3. Make: Point Grey Model: Grasshopper 3	15383782	N/A
4. Make: FLIR Model: T640	55909287	N/A

Glove Installation

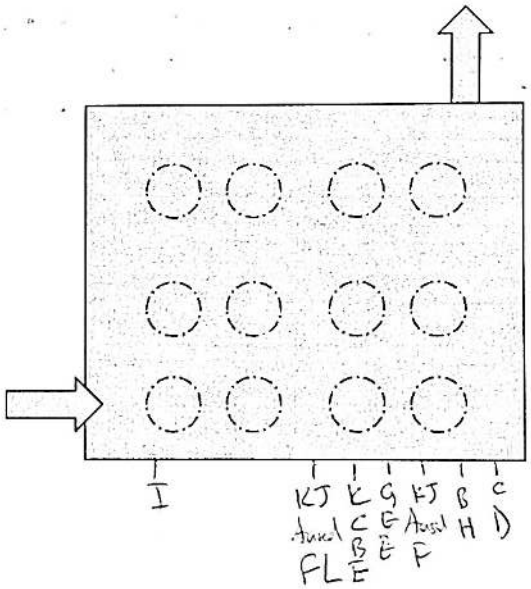
Glove/cover installed	LANL insp	Port #	Glove/cover installed	LANL insp	Port #
8LY2030	RH	1	8LY2030	RH	13
"	RH	2	"	RH	14
"	RH	3	"	RH	15
"	RH	4	"	RH	16
"	RH	5	"	RH	17
"	RH	6	"	RH	18
"	RH	7	"	RH	19
"	RH	8	"	RH	20
8Y1532 w/cover A	RH	9	"	RH	21
" w/cover B	RH	10	"	RH	22
8LY2030	RH	11	8Y1532 w/cover A	RH	23
"	RH	12	" w/cover B	RH	24

Time & Description of Critical Events	Miscellaneous Notes
Ignition Time: 30 s. flame visible 500 degrees at glove (approx) Time: N/A, 119°F max high T/C Breach Time: N/A 140 Fenwal Detection Time: N/A 190 Fenwal Detection Time: N/A Other key times:	(2) 20g. of Kim Wipes arranged slightly different - distributed between ports 9 & 10 to create bridge for fire

GB Floor (Top View)



GB Floor (Side View)



Legend:

- A. Ignition bag
- B. Sand paper
- C. Screwdriver
- D. Mallet
- E. Poly Bottle
- F. Leather glove
- G. Push Rod
- H. Horsehair brush
- I. Scale cord
- J. Cotton rounds
- K. Kim wipes
- L. Fantastik

Revision History	
Revision & Justification	Authorized Signatures

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

Glovebox Fire Suppression: Experiment # 25

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted
David Grow	7/11/16	Torres, 2-tom	✓	

Safety Officer Name: Jamie Kimberley

Quality Assurance Rep. Name: Bob Hanson

Start Time	7/11/16	10:34
Ignition Time		~~10:~~ N/A
End Time		10:52

no flame visible

Relevant Environmental Conditions

85.9° in bunker
20 % rel. humidity

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make: Dwyer Model: 648B-05	4614118	A0
2. Make: Dwyer Model: 648B-15	4514088	A1
3. Make: Dwyer Model: 648B-05	0115016	A2
4. Make: Dwyer Model: 648B-15	4914183	A3

Digital Timer	Serial Num	DAQ channel
1. Make: Thomas Model: Traceabl	160274632	N/A

Air Flow meter	Serial Num	DAQ channel
1. Make: TSI Model: 5725	1511004	N/A

Thermocouples	Serial Num	DAQ channel
1. Make: Omega Model: XC20KI20Cal	3732-1	T1
2. Make: Omega Model: XC20KI20Cal	3732-2	T2
3. Make: Omega Model: XC20KI20Cal	3732-4	T3
4. Make: Omega Model: XC20KI20Cal	3732-8	T4

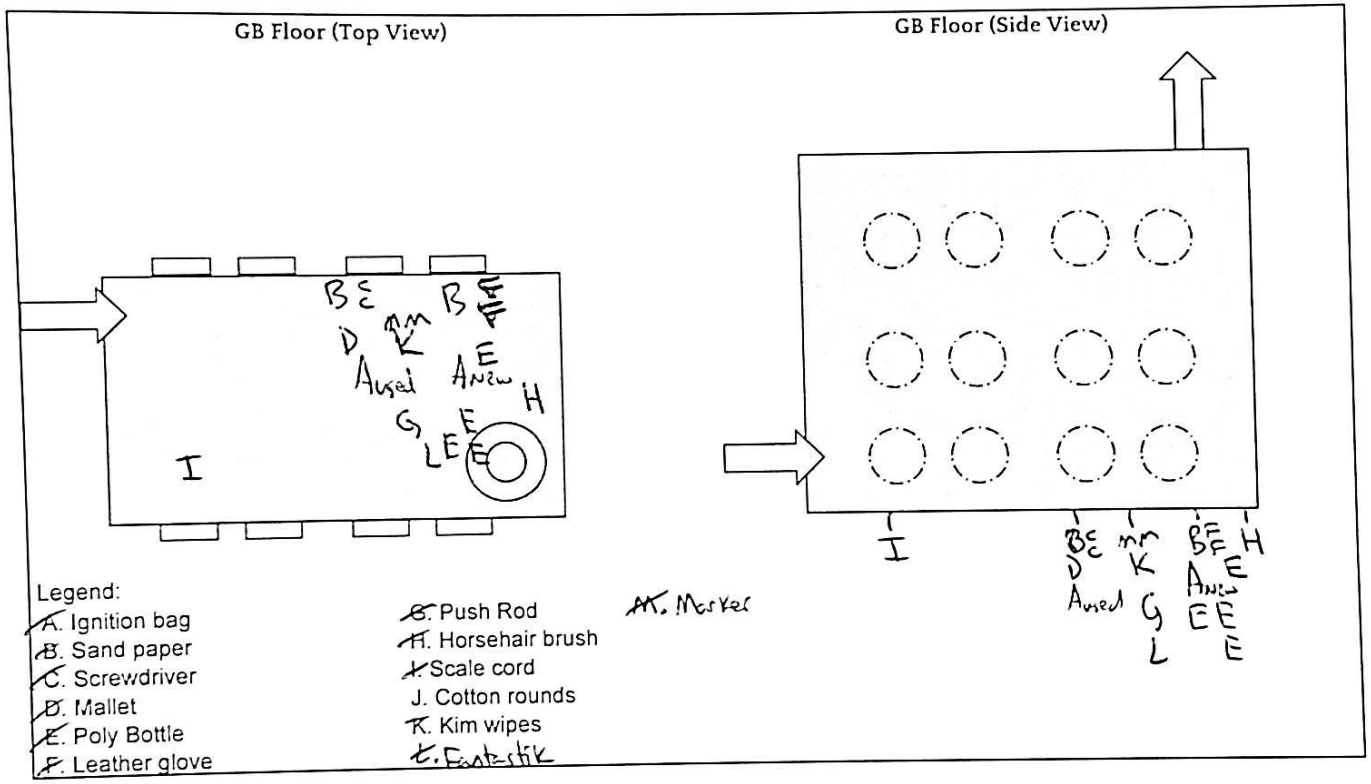
Fenwal Heat Detector	Serial Num	DAQ channel
1. Make: Fenwal Model: 140 deg.	28021-5	D0
2. Make: Fenwal Model: 190 deg.	28021-5	D1

Cameras	Serial Num	DAQ channel
1. Make: Point Grey Model: Grasshopper 3	14273764	N/A
2. Make: Point Grey Model: Grasshopper 3	14273944	N/A
3. Make: Point Grey Model: Grasshopper 3	15383782	N/A
4. Make: FLIR Model: T640	55909287	N/A

Glove Installation

Glove/cover installed	LANL insp	Port #	Glove/cover installed	LANL insp	Port #
8UY2030	RDH	1	8UY2030	RDH	13
"		2	"		14
"		3	"		15
"		4	"		16
8Y1532 w/cover A		5	"		17
" w/cover B		6	"		18
8UY2030		7	"		19
"		8	"		20
8Y1532		9	"		21
"		10	"	RDH	22
8UY2030		11	8Y1532 w/cover A	~~w/cover A~~ DC 7/11/16	RDH 23
"	RDH	12	" w/cover B	~~w/cover B~~ DC 7/11/16	RDH 24

Time & Description of Critical Events		Miscellaneous Notes
Ignition Time:	N/A - no flame visible	Robert Hanson #301775 RDHanson 7/11/16
500 degrees at glove (approx) Time:	N/A, max temp 86° (low T/C)	
Breach Time:	N/A	
140 Fenwal Detection Time:	N/A	
190 Fenwal Detection Time:	N/A	
Other key times:		


GB Floor (Top View)
GB Floor (Side View)
Legend:
A. Ignition bag
B. Sand paper
C. Screwdriver
D. Mallet
E. Poly Bottle
F. Leather glove
G. Push Rod
H. Horsehair brush
I. Scale cord
J. Cotton rounds
K. Kim wipes
L. Fantastik
M. Marker

Revision History	
Revision & Justification	Authorized Signatures

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

Glovebox Fire Suppression: Experiment #26

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted
David Grow	7/11/16	Torres, 2-ton	✓	

Safety Officer Name: Jamie Kimberley

Quality Assurance Rep. Name: Bob Hanson

Start Time	11:31	
Ignition Time	N/A	No flame visible
End Time	11:43	

Relevant Environmental Conditions

85.9° in bunker
20% rel. humidity

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make: Dwyer Model: 648B-05	4614118	A0
2. Make: Dwyer Model: 648B-15	4514088	A1
3. Make: Dwyer Model: 648B-05	0115016	A2
4. Make: Dwyer Model: 648B-15	4914183	A3

Digital Timer	Serial Num	DAQ channel
1. Make: Thomas Model: Traceabl	160274632	N/A

Air Flow meter	Serial Num	DAQ channel
1. Make: TSI Model: 5725	1511004	N/A

Thermocouples	Serial Num	DAQ channel
1. Make: Omega Model: XC20K120Cal	3732-1	T1
2. Make: Omega Model: XC20K120Cal	3732-2	T2
3. Make: Omega Model: XC20K120Cal	3732-4	T3
4. Make: Omega Model: XC20K120Cal	3732-8	T4

Fenwal Heat Detector	Serial Num	DAQ channel
1. Make: Fenwal Model: 140 deg.	28021-5	D0
2. Make: Fenwal Model: 190 deg.	28021-5	D1

Cameras	Serial Num	DAQ channel
1. Make: Point Grey Model: Grasshopper 3	14273764	N/A
2. Make: Point Grey Model: Grasshopper 3	14273944	N/A
3. Make: Point Grey Model: Grasshopper 3	15383782	N/A
4. Make: FLIR Model: T640	55909287	N/A

Glove Installation

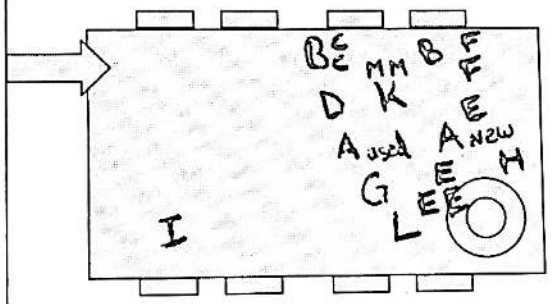
Glove/cover installed	LANL insp	Port #	Glove/cover installed	LANL insp	Port #
8UY2030	RDH	1	8UY2030	RDH	13
"	RDH	2	"		14
"	RDH	3	"		15
"	RDH	4	"		16
8Y1532 w/cover A	RDH	5	"		17
" w/cover B	RDH	6	"		18
8UY2030	RDH	7	"		19
"	RDH	8	"		20
8Y1532	RDH	9	"		21
"	RDH	10	"		22
8UY2030	RDH	11	8Y1532 w/cover A		23
"	RDH	12	" w/cover B	RDH	24

Time & Description of Critical Events	
Ignition Time:	N/A, no flame visible
500 degrees at glove (approx) Time:	N/A, max temp 87° (low T/C)
Breach Time:	N/A
140 Fenwal Detection Time:	N/A
190 Fenwal Detection Time:	N/A
Other key times:	N/A

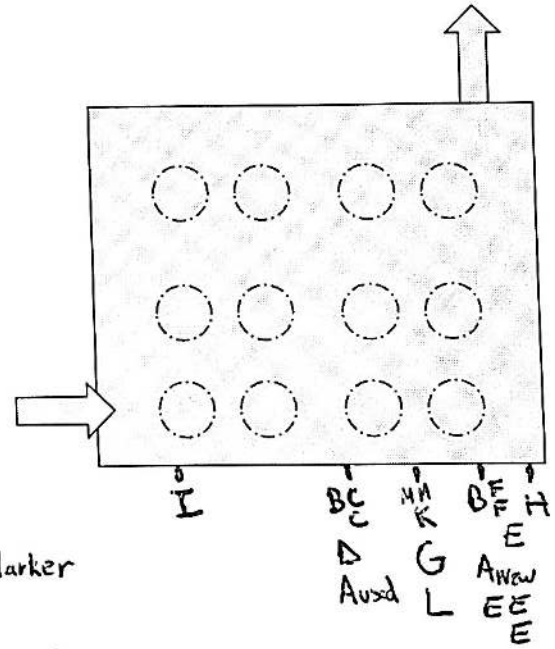
Miscellaneous Notes

Robert Hanson # 301795 RDHanson 7/11/16

GB Floor (Top View)



GB Floor (Side View)



Legend:

A. Ignition bag
B. Sand paper
C. Screwdriver
D. Mallet
E. Poly Bottle
F. Leather glove
G. Push Rod
H. Horsehair brush
I. Scale cord
J. Cotton rounds
K. Kim wipes
L. Fantastik
M. Marker

Revision History	
Revision & Justification	Authorized Signatures

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

Glovebox Fire Suppression: Experiment # 27

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted
David Grow	7/11/16	Torms, 2-ton	✓	

Safety Officer Name		
Jamie Kimberley	Start Time	1:57
Quality Assurance Rep. Name	Ignition Time	N/A
Bob Hanson	End Time	2:10

no flame visible

Relevant Environmental Conditions

87.1° in bunker
16 % rel. humidity

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make: Dwyer Model: 648B-05	4614118	A0
2. Make: Dwyer Model: 648B-15	4514088	A1
3. Make: Dwyer Model: 648B-05	0115016	A2
4. Make: Dwyer Model: 648B-15	4914183	A3

Digital Timer	Serial Num	DAQ channel
1. Make: Thomas Model: Traceabl	160274632	N/A

Air Flow meter	Serial Num	DAQ channel
1. Make: TSI Model: 5725	1511004	N/A

Thermocouples	Serial Num	DAQ channel
1. Make: Omega Model: XC20K120Cal	3732-1	T1
2. Make: Omega Model: XC20K120Cal	3732-2	T2
3. Make: Omega Model: XC20K120Cal	3732-4	T3
4. Make: Omega Model: XC20K120Cal	3732-8	T4

Fenwal Heat Detector	Serial Num	DAQ channel
1. Make: Fenwal Model: 140 deg.	28021-5	D0
2. Make: Fenwal Model: 190 deg.	28021-5	D1

Cameras	Serial Num	DAQ channel
1. Make: Point Grey Model: Grasshopper 3	14273764	N/A
2. Make: Point Grey Model: Grasshopper 3	14273944	N/A
3. Make: Point Grey Model: Grasshopper 3	15383782	N/A
4. Make: FLIR Model: T640	55909287	N/A

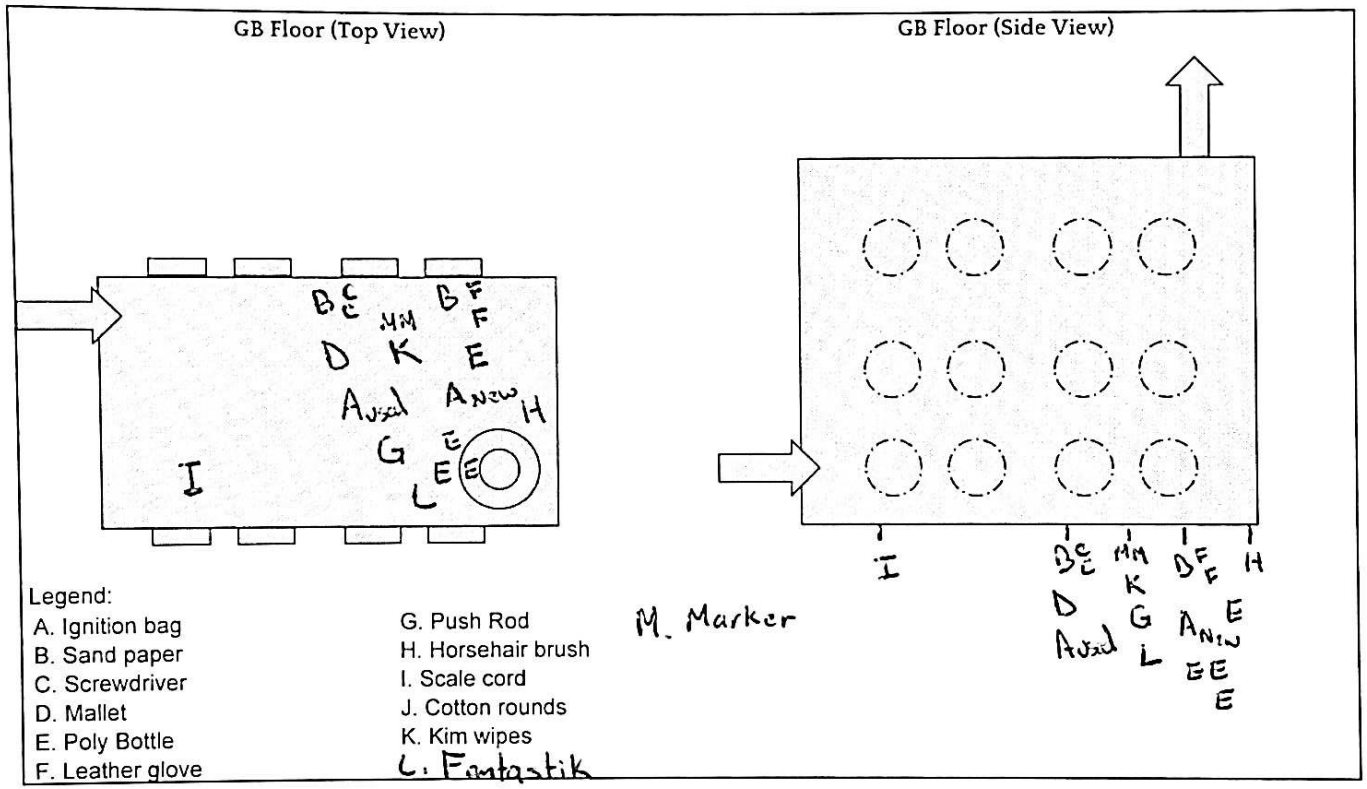
Glove Installation

Glove/cover installed	LANL insp	Port #	Glove/cover installed	LANL insp	Port #
8UY2030	RDH	1	8UY2030	RDH	13
"		2	"		14
"		3	"		15
"		4	"		16
8Y1532 w/cover A		5	"		17
" w/cover B		6	"		18
8UY2030		7	"		19
"		8	"		20
8Y1532		9	"		21
"		10	"		22
8UY2030		11	8Y1532 w/cover A		23
"	RDH	12	" w/cover B	RDH	24

Time & Description of Critical Events	
Ignition Time:	N/A no flame visible
500 degrees at glove (approx) Time:	N/A, 88° max temp (low t/c)
Breach Time:	N/A
140 Fenwal Detection Time:	N/A
190 Fenwal Detection Time:	N/A
Other key times:	

Miscellaneous Notes

Robert Hanson #301795 [signature] 7/11/16


GB Floor (Top View)
GB Floor (Side View)
Legend:
A. Ignition bag
B. Sand paper
C. Screwdriver
D. Mallet
E. Poly Bottle
F. Leather glove
G. Push Rod
H. Horsehair brush
I. Scale cord
J. Cotton rounds
K. Kim wipes
L. Fantastik
M. Marker

Revision History	
Revision & Justification	Authorized Signatures

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

Glovebox Fire Suppression: Experiment # 28

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted
David Grow	7/11/16	Torres, 2-ton	✓	

Safety Officer Name: Jamie Kimberley

Quality Assurance Rep. Name: Bob Hanson

Start Time	2:46
Ignition Time	~~3:01~~
End Time	3:01

2:51 DG 7/12/16 flame visible

Relevant Environmental Conditions

88.0° in bunker
16 % rel humidity

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make: Dwyer Model: 648B-05	4614118	A0
2. Make: Dwyer Model: 648B-15	4514088	A1
3. Make: Dwyer Model: 648B-05	0115016	A2
4. Make: Dwyer Model: 648B-15	4914183	A3

Digital Timer	Serial Num	DAQ channel
1. Make: Thomas Model: Traceabl	160274632	N/A

Air Flow meter	Serial Num	DAQ channel
1. Make: TSI Model: 5725	1511004	N/A

Thermocouples	Serial Num	DAQ channel
1. Make: Omega Model: XC20KI20Cal	3732-1	T1
2. Make: Omega Model: XC20KI20Cal	3732-2	T2
3. Make: Omega Model: XC20KI20Cal	3732-4	T3
4. Make: Omega Model: XC20KI20Cal	3732-8	T4

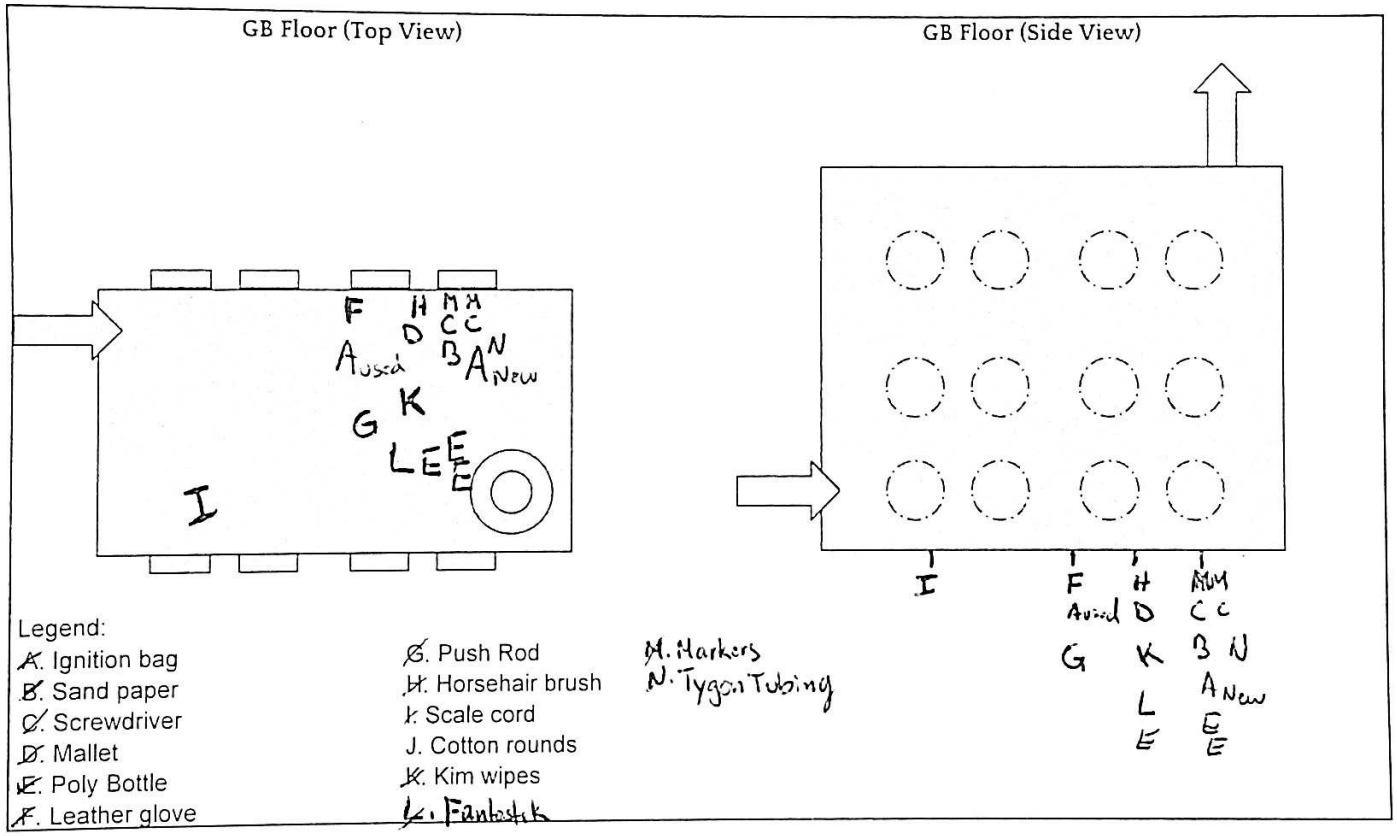
Fenwal Heat Detector	Serial Num	DAQ channel
1. Make: Fenwal Model: 140 deg.	28021-5	D0
2. Make: Fenwal Model: 190 deg.	28021-5	D1

Cameras	Serial Num	DAQ channel
1. Make: Point Grey Model: Grasshopper 3	14273764	N/A
2. Make: Point Grey Model: Grasshopper 3	14273944	N/A
3. Make: Point Grey Model: Grasshopper 3	15383782	N/A
4. Make: FLIR Model: T640	55909287	N/A

Glove Installation

Glove/cover installed	LANL insp	Port #	Glove/cover installed	LANL insp	Port #
8U42030	RDH	1	8U42030	RDH	13
"		2	"		14
"		3	"		15
"		4	"		16
8Y1532 w/cover A		5	"		17
" w/cover B		6	"		18
8U42030		7	"		19
"		8	"		20
8Y1532		9	"		21
"		10	"		22
8U42030		11	8Y1532 w/cover A		23
"	RDH	12	" w/cover B	RDH	24

Time & Description of Critical Events	Miscellaneous Notes
Ignition Time: 310 s. flame visible 500 degrees at glove (approx) Time: N/A, max temp 107° (mid T/c) Breach Time: 433 s. 140 Fenwal Detection Time: N/A 190 Fenwal Detection Time: N/A Other key times:	Robert Hanson #301795 RDHanson 7/11/16



Legend:

- A. Ignition bag
- B. Sand paper
- C. Screwdriver
- D. Mallet
- E. Poly Bottle
- F. Leather glove
- G. Push Rod
- H. Horsehair brush
- I. Scale cord
- J. Cotton rounds
- K. Kim wipes
- L. Fantastik
- M. Markers
- N. Tygon Tubing

Revision History	
Revision & Justification	Authorized Signatures

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

Glovebox Fire Suppression: Experiment # 29

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted
David Grow	7/11/16	Torres, 2-ton	✓	

Safety Officer Name: Jamie Kimberlyn

Quality Assurance Rep. Name: Bob Hanson

Start Time	3:43
Ignition Time	3:46
End Time	4:04

Relevant Environmental Conditions

88.8° in bunker
16 % rel. humidity

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make: Dwyer Model: 648B-05	4614118	A0
2. Make: Dwyer Model: 648B-15	4514088	A1
3. Make: Dwyer Model: 648B-05	0115016	A2
4. Make: Dwyer Model: 648B-15	4914183	A3

Digital Timer	Serial Num	DAQ channel
1. Make: Thomas Model: Traceabl	160274632	N/A

Air Flow meter	Serial Num	DAQ channel
1. Make: TSI Model: 5725	1511004	N/A

Thermocouples	Serial Num	DAQ channel
1. Make: Omega Model: XC20K120Cal	3732-1	T1
2. Make: Omega Model: XC20K120Cal	3732-2	T2
3. Make: Omega Model: XC20K120Cal	3732-4	T3
4. Make: Omega Model: XC20K120Cal	3732-8	T4

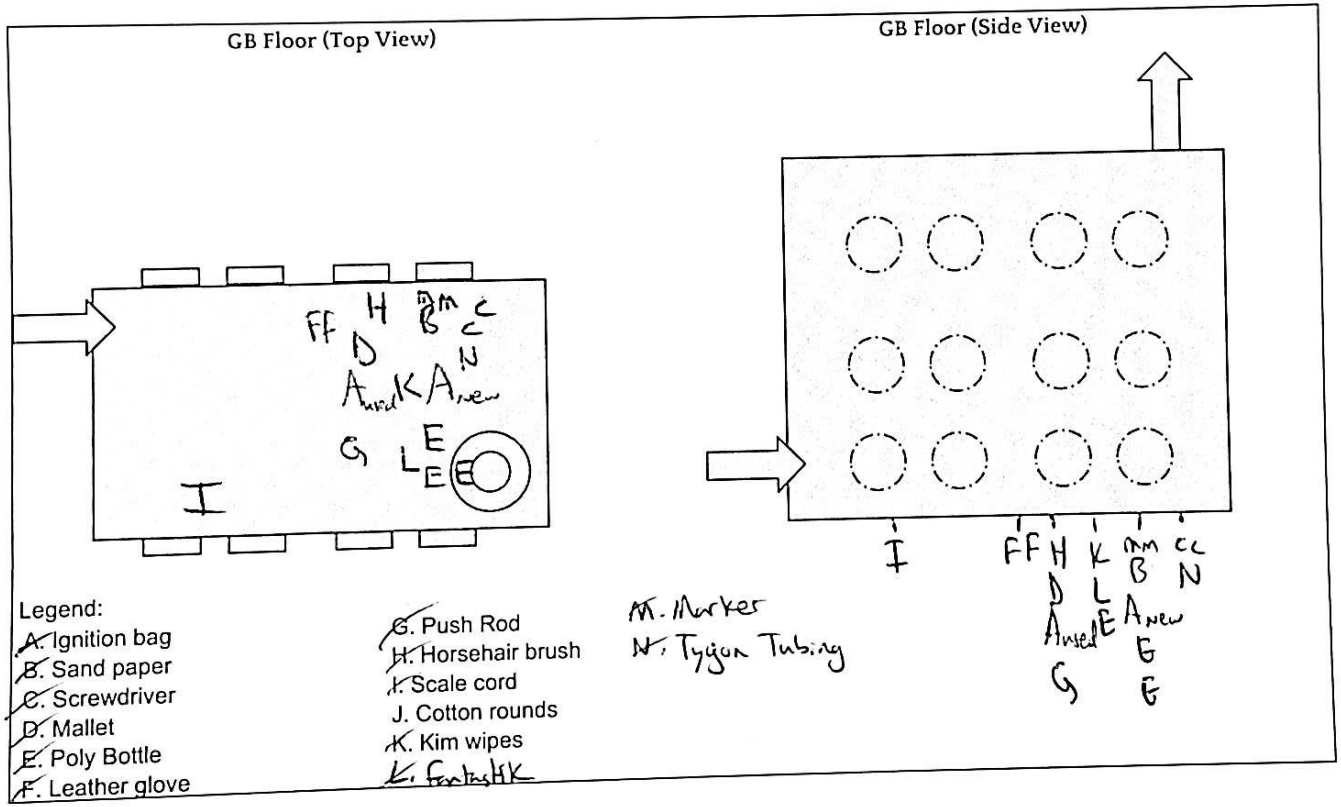
Fenwal Heat Detector	Serial Num	DAQ channel
1. Make: Fenwal Model: 140 deg.	28021-5	D0
2. Make: Fenwal Model: 190 deg.	28021-5	D1

Cameras	Serial Num	DAQ channel
1. Make: Point Grey Model: Grasshopper 3	14273764	N/A
2. Make: Point Grey Model: Grasshopper 3	14273944	N/A
3. Make: Point Grey Model: Grasshopper 3	15383782	N/A
4. Make: FLIR Model: T640	55909287	N/A

Glove Installation

Glove/cover installed	LANL insp	Port #	Glove/cover installed	LANL insp	Port #
8UV2030	RDH	1	8UV2030	RDH	13
"		2	"		14
"		3	"		15
"		4	"		16
8Y1532 w/cover A		5	"		17
" w/cover B		6	"		18
8UY2030		7	"		19
"		8	"		20
8Y1532		9	"		21
"		10	"		22
8UY2030		11	8Y1532 w/cover A		23
"	RDH	12	" w/	RDH	24

Time & Description of Critical Events	Miscellaneous Notes
Ignition Time: 156 s.	Robert Hanson # 301795 7/11/16
500 degrees at glove (approx) Time: N/A, max temp 151° (hot T/C)	
Breach Time: 856 s.	
140 Fenwal Detection Time: N/A	
190 Fenwal Detection Time: N/A	
Other key times:	


GB Floor (Top View)
GB Floor (Side View)
Legend:
A. Ignition bag
B. Sand paper
C. Screwdriver
D. Mallet
E. Poly Bottle
F. Leather glove
G. Push Rod
H. Horsehair brush
I. Scale cord
J. Cotton rounds
K. Kim wipes
L. Fantastik
M. Marker
N. Tygon Tubing

Revision History	
Revision & Justification	Authorized Signatures

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

Glovebox Fire Suppression: Experiment #030

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted
JAMie Kimberlay	7/12/16	2-70N	✓	

Safety Officer Name: JACOB

Quality Assurance Rep. Name: BOB HANSON

Start Time	9:01
Ignition Time	9:04
End Time	9:14

Relevant Environmental Conditions

83.8° in bunker
16% rel. humidity

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make: Dwyer Model: 648B-05	4614118	A0
2. Make: Dwyer Model: 648B-15	4514088	A1
3. Make: Dwyer Model: 648B-05	0115016	A2
4. Make: Dwyer Model: 648B-15	4914183	A3

Digital Timer	Serial Num	DAQ channel
1. Make: Thomas Model: Traceabl	160274632	N/A

Air Flow meter	Serial Num	DAQ channel
1. Make: TSI Model: 5725	1511004	N/A

Thermocouples	Serial Num	DAQ channel
1. Make: Omega Model: XC20K120Cal	3732-1	T1
2. Make: Omega Model: XC20K120Cal	3732-2	T2
3. Make: Omega Model: XC20K120Cal	3732-4	T3
4. Make: Omega Model: XC20K120Cal	3732-8	T4

Fenwal Heat Detector	Serial Num	DAQ channel
1. Make: Fenwal Model: 140 deg.	28021-5	D0
2. Make: Fenwal Model: 190 deg.	28021-5	D1

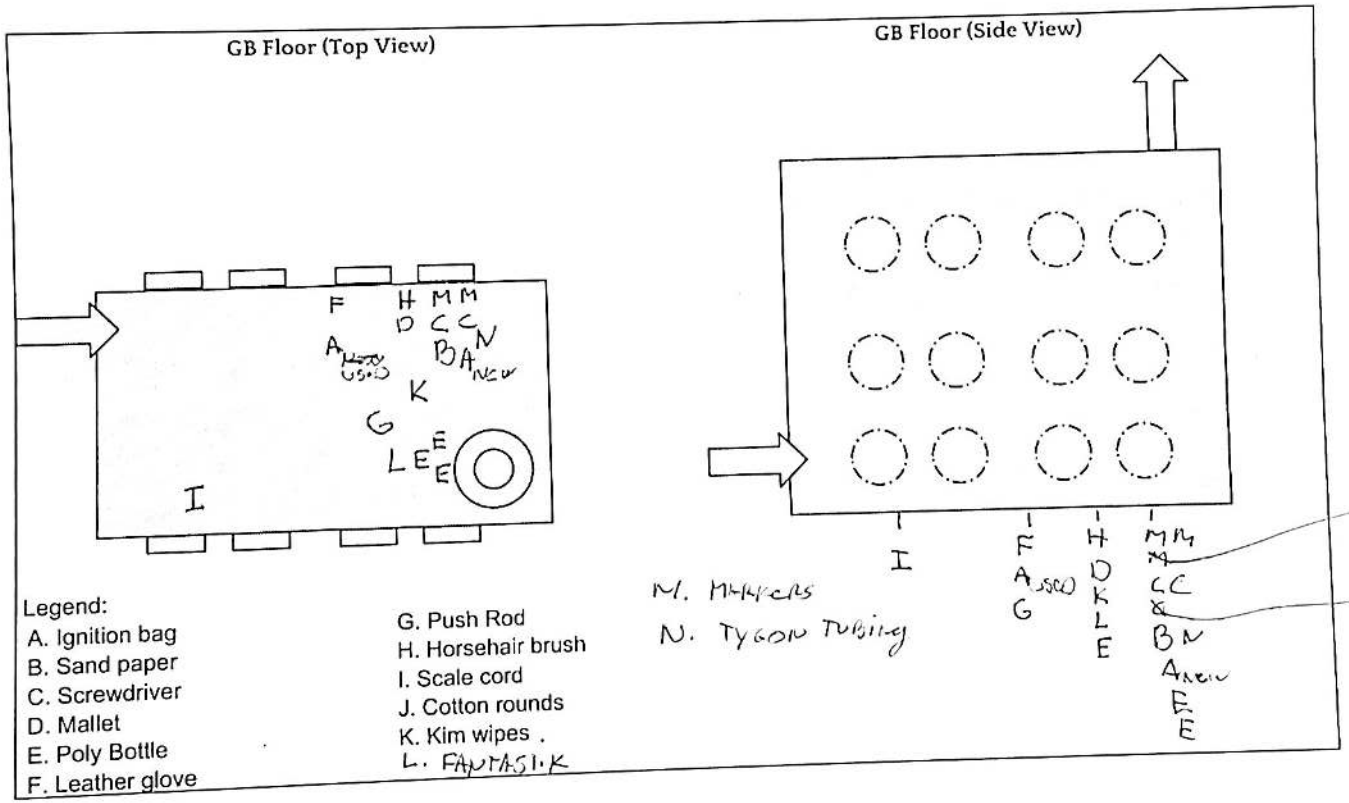
Cameras	Serial Num	DAQ channel
1. Make: Point Grey Model: Grasshopper 3	14273764	N/A
2. Make: Point Grey Model: Grasshopper 3	14273944	N/A
3. Make: Point Grey Model: Grasshopper 3	15383782	N/A
4. Make: FLIR Model: T640	55909287	N/A

Glove Installation

Glove/cover installed	LANL insp	Port #	Glove/cover installed	LANL insp	Port #
BUY 20 30	RDH	1	BUY 20 30	RDH	13
"		2	"		14
"		3	"		15
"		4	"		16
BY 15 32 Cover A		5	"		17
" Cover B		6	"		18
BUY 20 30		7	"		19
"		8	"		20
BY 15 32 New		9	"		21
" used		10	"		22
BUY 20 30		11	BY 15 32 Cover A		23
"	RDH	12	" Cover B	RDH	24

Glove out

Time & Description of Critical Events	Miscellaneous Notes
Ignition Time: 191 s.	Robert Hanson # 301795 7/12/14
500 degrees at glove (approx) Time: N/A, max temp 103° (high T/C)	
Breach Time: 288 s.	
140 Fenwal Detection Time: N/A	
190 Fenwal Detection Time: N/A	
Other key times:	


GB Floor (Top View)
GB Floor (Side View)
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M. MARKERS
N. TYGON TUBING
J.
J.
7/12/16
Legend:
A. Ignition bag
B. Sand paper
C. Screwdriver
D. Mallet
E. Poly Bottle
F. Leather glove
G. Push Rod
H. Horsehair brush
I. Scale cord
J. Cotton rounds
K. Kim wipes .
L. FANTASTIK

Revision History	
Revision & Justification	Authorized Signatures

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

Glovebox Fire Suppression: Experiment #031

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted
Jamie Kimberley	7/12/16	2-TON		X

Safety Officer Name: Jakub Mratkowski

Quality Assurance Rep. Name: BOB Hansen

Start Time	10:51
Ignition Time	~~[illegible]~~ N/A
End Time	11:04

DG 7/12/16

Relevant Environmental Conditions

85.7° in bunker
16% rel. humidity

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make: Dwyer Model: 648B-05	4614118	A0
2. Make: Dwyer Model: 648B-15	4514088	A1
3. Make: Dwyer Model: 648B-05	0115016	A2
4. Make: Dwyer Model: 648B-15	4914183	A3

Digital Timer	Serial Num	DAQ channel
1. Make: Thomas Model: Traceabl	160274632	N/A

Air Flow meter	Serial Num	DAQ channel
1. Make: TSI Model: 5725	1511004	N/A

Thermocouples	Serial Num	DAQ channel
1. Make: Omega Model: XC20K120Cal	3732-1	T1
2. Make: Omega Model: XC20K120Cal	3732-2	T2
3. Make: Omega Model: XC20K120Cal	3732-4	T3
4. Make: Omega Model: XC20K120Cal	3732-8	T4

Fenwal Heat Detector	Serial Num	DAQ channel
1. Make: Fenwal Model: 140 deg.	28021-5	D0
2. Make: Fenwal Model: 190 deg.	28021-5	D1

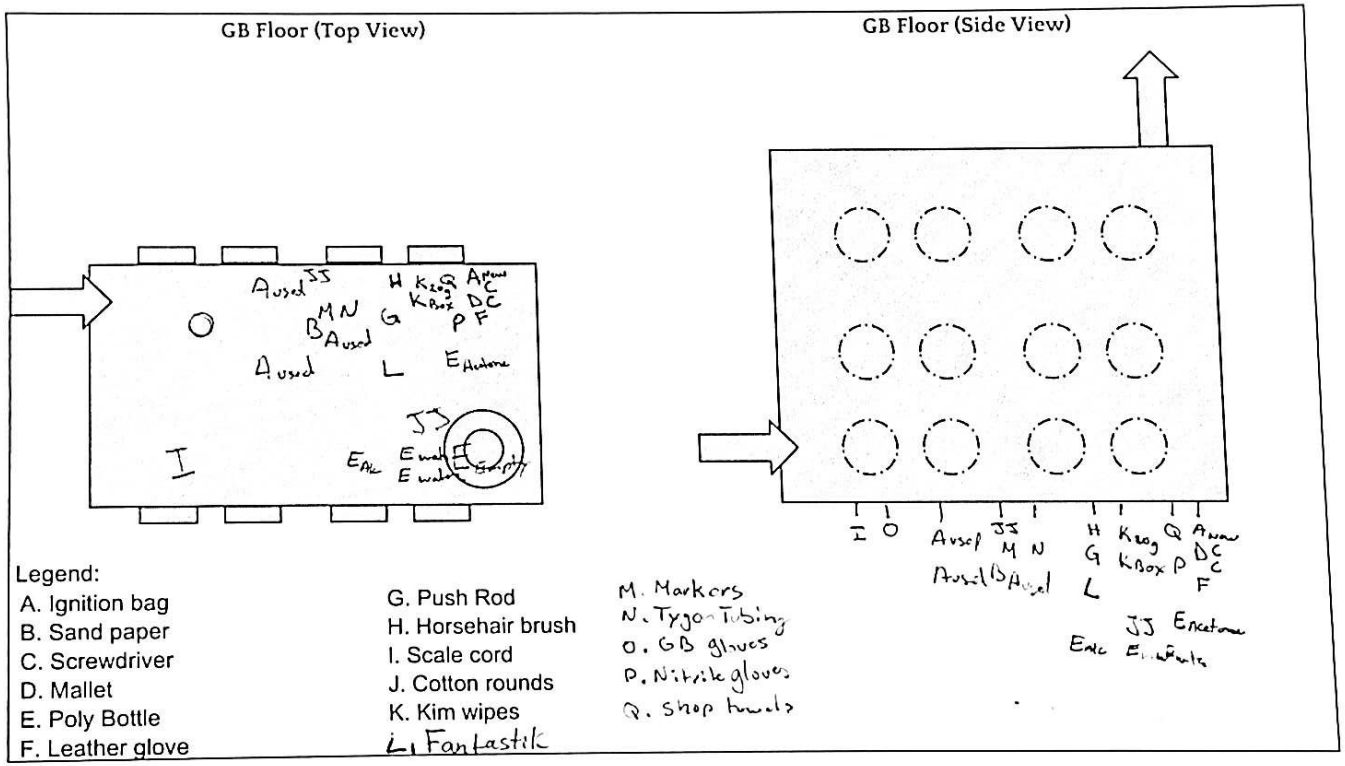
Cameras	Serial Num	DAQ channel
1. Make: Point Grey Model: Grasshopper 3	14273764	N/A
2. Make: Point Grey Model: Grasshopper 3	14273944	N/A
3. Make: Point Grey Model: Grasshopper 3	15383782	N/A
4. Make: FLIR Model: T640	55909287	N/A

Aborted

Glove Installation

Glove/cover installed	LANL insp	Port #	Glove/cover installed	LANL insp	Port #
8U420'30		1	8U420'30		13
"		2	"		14
"		3	"		15
"		4	"		16
8Y1532 w/cover A		5	"		17
" w/cover B		6	"		18
8U420'30		7	"		19
"		8	"		20
8Y1532		9	"		21
"		10	"		22
8U420'30		11	8Y1532 w/cover A		23
"		12	" w/cover B		24

Time & Description of Critical Events	Miscellaneous Notes
Ignition Time: 500 degrees at glove (approx) Time: Breach Time: 140 Fenwal Detection Time: 190 Fenwal Detection Time: Other key times:	Robert Hanson #301795 7/12/16


GB Floor (Top View)
GB Floor (Side View)
Legend:
A. Ignition bag
B. Sand paper
C. Screwdriver
D. Mallet
E. Poly Bottle
F. Leather glove
G. Push Rod
H. Horsehair brush
I. Scale cord
J. Cotton rounds
K. Kim wipes
L. Fantastik
M. Markers
N. Tygon Tubing
O. GB gloves
P. Nitrile gloves
Q. Shop towels

Revision History	
Revision & Justification	Authorized Signatures

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

Glovebox Fire Suppression: Experiment # 032

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted
David Grew	7-12-16	2-Ton	X	

Safety Officer Name: Jamie Kimberley

Quality Assurance Rep. Name: Bob Hanson

Start Time	11:24
Ignition Time	11:27
End Time	11:49

Relevant Environmental Conditions

86.4° in Lunker
16% rel. humidity

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make: Dwyer Model: 648B-05	4614118	A0
2. Make: Dwyer Model: 648B-15	4514088	A1
3. Make: Dwyer Model: 648B-05	0115016	A2
4. Make: Dwyer Model: 648B-15	4914183	A3

Digital Timer	Serial Num	DAQ channel
1. Make: Thomas Model: Traceabl	160274632	N/A

Air Flow meter	Serial Num	DAQ channel
1. Make: TSI Model: 5725	1511004	N/A

Thermocouples	Serial Num	DAQ channel
1. Make: Omega Model: XC20K120Cal	3732-1	T1
2. Make: Omega Model: XC20K120Cal	3732-2	T2
3. Make: Omega Model: XC20K120Cal	3732-4	T3
4. Make: Omega Model: XC20K120Cal	3732-8	T4

Fenwal Heat Detector	Serial Num	DAQ channel
1. Make: Fenwal Model: 140 deg.	28021-5	D0
2. Make: Fenwal Model: 190 deg.	28021-5	D1

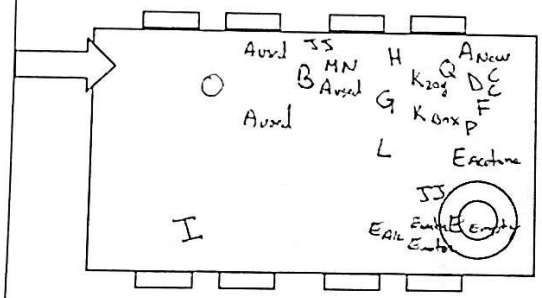
Cameras	Serial Num	DAQ channel
1. Make: Point Grey Model: Grasshopper 3	14273764	N/A
2. Make: Point Grey Model: Grasshopper 3	14273944	N/A
3. Make: Point Grey Model: Grasshopper 3	15383782	N/A
4. Make: FLIR Model: T640	55909287	N/A

Glove Installation

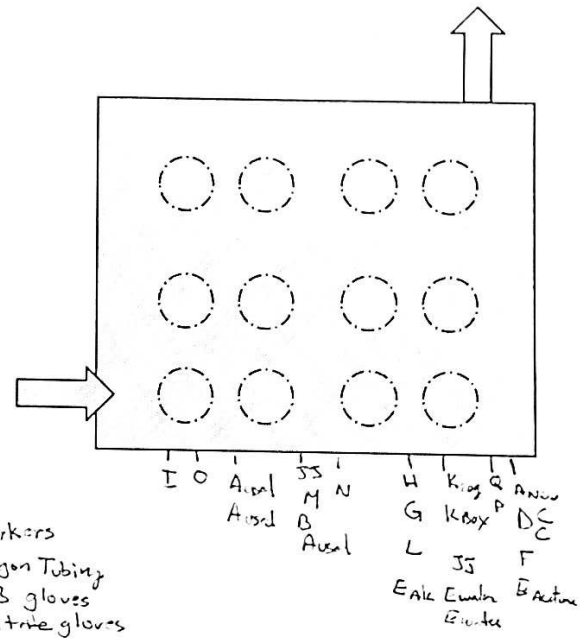
Glove/cover installed	LANL insp	Port #	Glove/cover installed	LANL insp	Port #
8UY2030	RDH	1	8UY2030	RDH	13
"		2	"		14
"		3	"		15
"		4	"		16
8Y1532 w/cover A		5	"		17
" w/cover B		6	"		18
8UY2030		7	"		19
"		8	"		20
8Y1532		9	"		21
"		10	"		22
8UY2030		11	8Y1532 w/cover A		23
"	RDH	12	" w/cover B	RDH	24

Time & Description of Critical Events	Miscellaneous Notes
Ignition Time: 158 s. 500 degrees at glove (approx) Time: N/A, max temp 215° (high T/C) Breach Time: 163 s. 140 Fenwal Detection Time: N/A 190 Fenwal Detection Time: N/A Other key times:	Robert Harson # 301795 7/12/16

GB Floor (Top View)



GB Floor (Side View)



Legend:

A. Ignition bag
B. Sand paper
C. Screwdriver
D. Mallet
E. Poly Bottle
F. Leather glove
G. Push Rod
H. Horsehair brush
I. Scale cord
J. Cotton rounds
K. Kim wipes
L. Funtoli:K
M. Markers
N. Tygon Tubing
O. GB gloves
P. Nitrile gloves
Q. Shop towels

Revision History	
Revision & Justification	Authorized Signatures

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

Glovebox Fire Suppression: Experiment #033

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted
David Grow	7/12/16	Torres, 2-ton		✓

Safety Officer Name: Jamie Kimberley

Quality Assurance Rep. Name: Bob Hanson

Start Time	1:57
Ignition Time	N/A
End Time	2:09

Relevant Environmental Conditions

88° in bunker
16% rel. humidity

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make: Dwyer Model: 648B-05	4614118	A0
2. Make: Dwyer Model: 648B-15	4514088	A1
3. Make: Dwyer Model: 648B-05	0115016	A2
4. Make: Dwyer Model: 648B-15	4914183	A3

Digital Timer	Serial Num	DAQ channel
1. Make: Thomas Model: Traceabl	160274632	N/A

Air Flow meter	Serial Num	DAQ channel
1. Make: TSI Model: 5725	1511004	N/A

Thermocouples	Serial Num	DAQ channel
1. Make: Omega Model: XC20K120Cal	3732-1	T1
2. Make: Omega Model: XC20K120Cal	3732-2	T2
3. Make: Omega Model: XC20K120Cal	3732-4	T3
4. Make: Omega Model: XC20K120Cal	3732-8	T4

Fenwal Heat Detector	Serial Num	DAQ channel
1. Make: Fenwal Model: 140 deg.	28021-5	D0
2. Make: Fenwal Model: 190 deg.	28021-5	D1

Cameras	Serial Num	DAQ channel
1. Make: Point Grey Model: Grasshopper 3	14273764	N/A
2. Make: Point Grey Model: Grasshopper 3	14273944	N/A
3. Make: Point Grey Model: Grasshopper 3	15383782	N/A
4. Make: FLIR Model: T640	55909287	N/A

Glove Installation

Glove/cover installed	LANL insp	Port #
8UY2030	RDH	1
"		2
"		3
"		4
8Y1532 w/cover A		5
" w/cover B		6
8UY2030		7
"		8
8Y1532		9
"		10
8UY2030		11
"	RDH	12

Glove/cover installed	LANL insp	Port #
8UY2030	RDH	13
"		14
"		15
"		16
"		17
"		18
"		19
"		20
"		21
"		22
8Y1532 w/cover A		23
" w/cover B	RDH	24

Time & Description of Critical Events

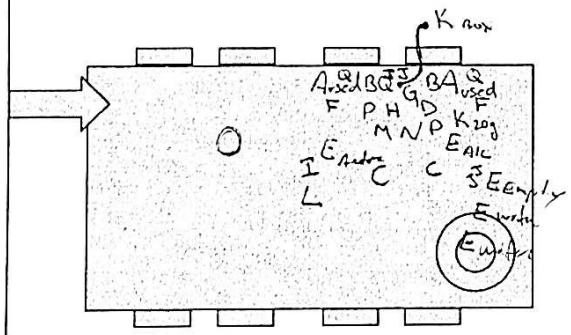
Ignition Time:
500 degrees at glove (approx) Time:
Breach Time:
140 Fenwal Detection Time:
190 Fenwal Detection Time:
Other key times:

Aborted

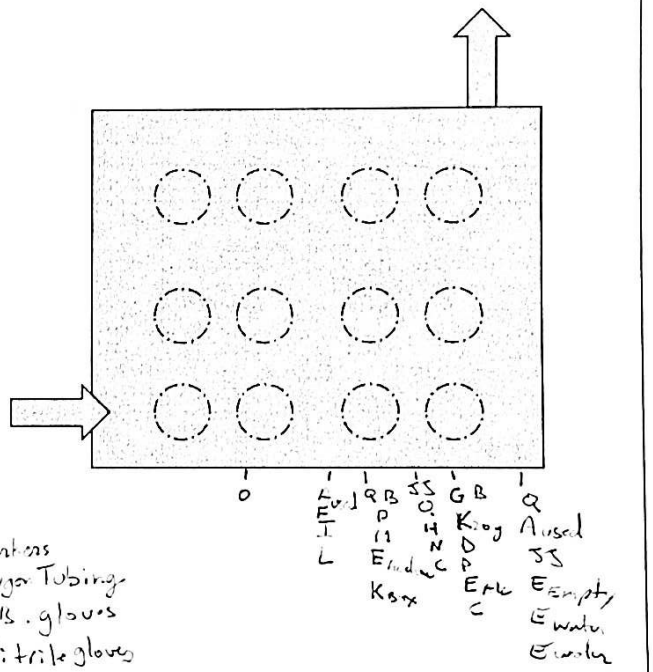
Miscellaneous Notes

Robert Hanson #301795 RD Hanson 7/12/16

GB Floor (Top View)



GB Floor (Side View)



Legend:

A. Ignition bag
B. Sand paper
C. Screwdriver
D. Mallet
E. Poly Bottle
F. Leather glove
G. Push Rod
H. Horsehair brush
I. Scale cord
J. Cotton rounds
K. Kim wipes
L. Fantastik
M. Markers
N. Tygon Tubing
O. GB. gloves
P. Nitrile gloves
Q. Shop towels

Revision History	
Revision & Justification	Authorized Signatures

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

Glovebox Fire Suppression: Experiment #_034

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted
David Grow	7/12/16	Torres, 2-foot	✓	

Safety Officer Name: Jamie Kimberley

Quality Assurance Rep. Name: Bob Hanson

Start Time	2:28
Ignition Time	2:31
End Time	2:53

Relevant Environmental Conditions

89° in bucket
16% rel. humidity

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make: Dwyer Model: 648B-05	4614118	A0
2. Make: Dwyer Model: 648B-15	4514088	A1
3. Make: Dwyer Model: 648B-05	0115016	A2
4. Make: Dwyer Model: 648B-15	4914183	A3

Digital Timer	Serial Num	DAQ channel
1. Make: Thomas Model: Traceabl	160274632	N/A

Air Flow meter	Serial Num	DAQ channel
1. Make: TSI Model: 5725	1511004	N/A

Thermocouples	Serial Num	DAQ channel
1. Make: Omega Model: XC20K120Cal	3732-1	T1
2. Make: Omega Model: XC20K120Cal	3732-2	T2
3. Make: Omega Model: XC20K120Cal	3732-4	T3
4. Make: Omega Model: XC20K120Cal	3732-8	T4

Fenwal Heat Detector	Serial Num	DAQ channel
1. Make: Fenwal Model: 140 deg.	28021-5	D0
2. Make: Fenwal Model: 190 deg.	28021-5	D1

Cameras	Serial Num	DAQ channel
1. Make: Point Grey Model: Grasshopper 3	14273764	N/A
2. Make: Point Grey Model: Grasshopper 3	14273944	N/A
3. Make: Point Grey Model: Grasshopper 3	15383782	N/A
4. Make: FLIR Model: T640	55909287	N/A

Glove Installation

Glove/cover installed	LANL insp	Port #	Glove/cover installed	LANL insp	Port #
8UY2030	RDH	1	8UY2030	RDH	13
"		2	"		14
"		3	"		15
"		4	"		16
8Y1532 w/cover A		5	"		17
" w/cover B		6	"		18
8UY2030		7	"		19
"		8	" 7/13/16		20
** 8Y1532 w/cover A		9	"		21
** " w/cover B		10	" DG		22
8UY2030		11	8Y1532 ~~w/cover A~~		23
"	RDH	12	" ~~w/cover B~~	RDH	24

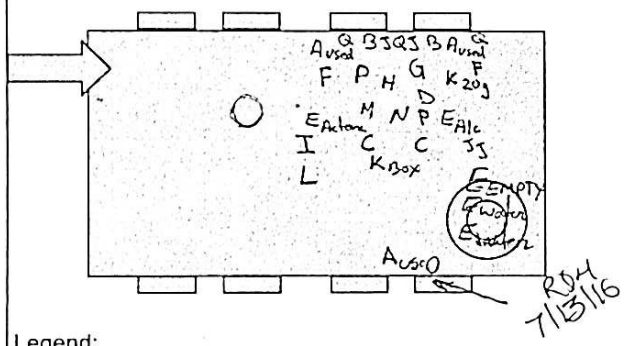
DG 7/13/16

Time & Description of Critical Events	Miscellaneous Notes
Ignition Time: 164 s., flame visible	Robert Hanson #301795 7/12/16
500 degrees at glove (approx) Time: N/A, max temp 290° (high) 7/6	
Breach Time: 251 s. (subs. to	
140 Fenwal Detection Time: 226 s (through 1473 s.)	
190 Fenwal Detection Time: N/A	
Other key times:	

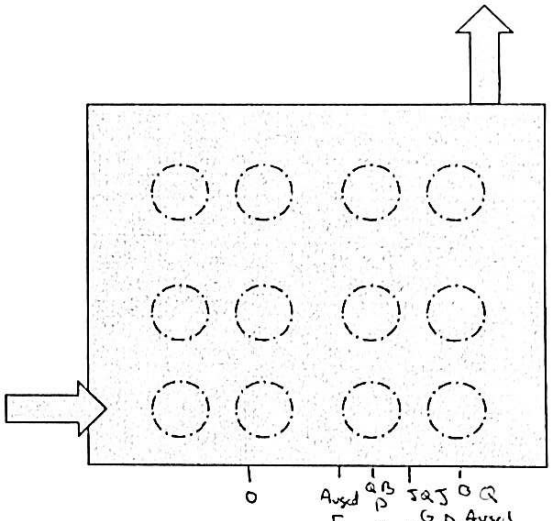
* initially mis-recorded location of glove port covers
DG 7/13/16

7/13/16

GB Floor (Top View)



GB Floor (Side View)



Legend:

A. Ignition bag
B. Sand paper
C. Screwdriver
D. Mallet
E. Poly Bottle
F. Leather glove
G. Push Rod
H. Horsehair brush
I. Scale cord
J. Cotton rounds
K. Kim wipes
L. Footstalk
M. Markers
N. Tygon Tubing
O. GB gloves
P. Nitrile gloves
Q. Shop towels

Revision History	
Revision & Justification	Authorized Signatures

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

Glovebox Fire Suppression: Experiment #2035

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted
DAVID GROW	7/13/16	2-TON	✓	

Safety Officer Name: JAMIE KIMBORLY

Quality Assurance Rep. Name: BOB HANSON

Start Time	11:07
Ignition Time	11:11
End Time	11:32

Relevant Environmental Conditions

85.9°F

16% RH

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make: Dwyer Model: 648B-05	4614118	A0
2. Make: Dwyer Model: 648B-15	4514088	A1
3. Make: Dwyer Model: 648B-05	0115016	A2
4. Make: Dwyer Model: 648B-15	4914183	A3

Digital Timer	Serial Num	DAQ channel
1. Make: Thomas Model: Traceabl	160274632	N/A

Air Flow meter	Serial Num	DAQ channel
1. Make: TSI Model: 5725	1511004	N/A

Thermocouples	Serial Num	DAQ channel
1. Make: Omega Model: XC20K120Cal	3732-1	T1
2. Make: Omega Model: XC20K120Cal	3732-2	T2
3. Make: Omega Model: XC20K120Cal	3732-4	T3
4. Make: Omega Model: XC20K120Cal	3732-8	T4

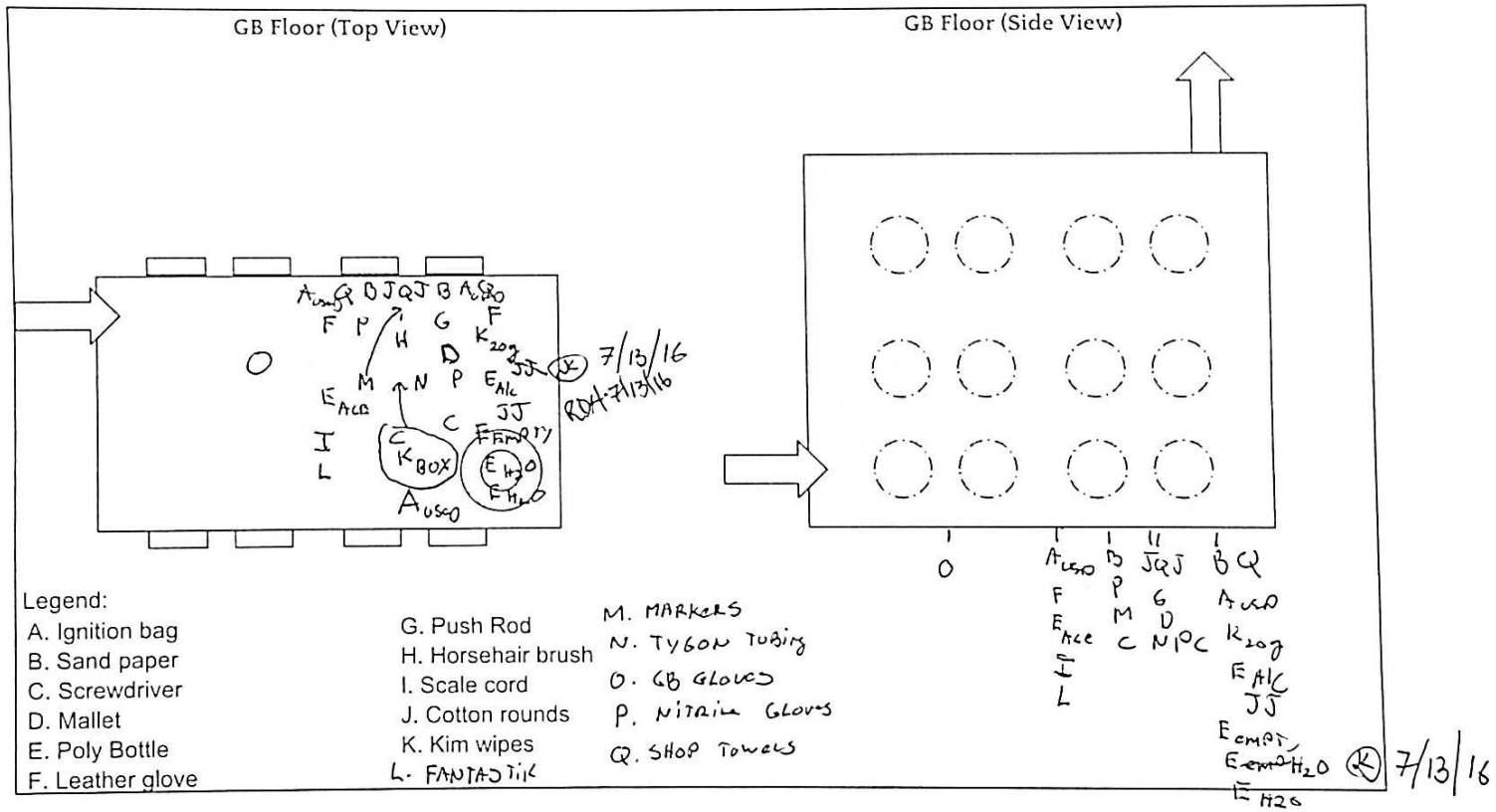
Fenwal Heat Detector	Serial Num	DAQ channel
1. Make: Fenwal Model: 140 deg.	28021-5	D0
2. Make: Fenwal Model: 190 deg.	28021-5	D1

Cameras	Serial Num	DAQ channel
1. Make: Point Grey Model: Grasshopper 3	14273764	N/A
2. Make: Point Grey Model: Grasshopper 3	14273944	N/A
3. Make: Point Grey Model: Grasshopper 3	15383782	N/A
4. Make: FLIR Model: T640	55909287	N/A

Glove Installation

Glove/cover installed	LANL insp	Port #	Glove/cover installed	LANL insp	Port #
8UY 20 30	RDH	1	8UY 20 30	RDH	13
"		2	"		14
"		3	"		15
"		4	"		16
8Y 15 32 w/ cover A		5	"		17
" New w/ cover B		6	"		18
8UY 20 30		7	"		19
"		8	"		20
8Y 15 32 w/ cover A		9	"		21
" New w/ cover B		10	"		22
8UY 20 30		11	8Y 15 32		23
"	RDH	12	"	RDH	24

Time & Description of Critical Events	Miscellaneous Notes
Ignition Time: 210 s.	Robert Hanson #301795 RD Hanson 7/13/16
500 degrees at glove (approx) Time: N/A, max temp 238° (high TC)	
Breach Time: 220 s.	
140 Fenwal Detection Time: 304 s (thru 393 s)	
190 Fenwal Detection Time: N/A	
Other key times:	



Legend:

A. Ignition bag
B. Sand paper
C. Screwdriver
D. Mallet
E. Poly Bottle
F. Leather glove
G. Push Rod
H. Horsehair brush
I. Scale cord
J. Cotton rounds
K. Kim wipes
L. FANTASTIK
M. MARKERS
N. TYGON TUBING
O. GB GLOVES
P. NITRILE GLOVES
Q. SHOP TOWELS

Revision History	
Revision & Justification	Authorized Signatures

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

Glovebox Fire Suppression: Experiment #036

Experimental Conditions

Test Conductor Name	Date	Experiment Location	Success	Aborted
David Grow	7-13-16	2-TON	✓	

Safety Officer Name: Jakub Mroczkowski

Quality Assurance Rep. Name: Bob Hanson

Start Time	2:39
Ignition Time	2:42
End Time	3:03

Relevant Environmental Conditions

88.9° in bunker
16% rel. humidity

Sensor Characteristics

Pressure Sensors	Serial Num	DAQ channel
1. Make: Dwyer Model: 648B-05	4614118	A0
2. Make: Dwyer Model: 648B-15	4514088	A1
3. Make: Dwyer Model: 648B-05	0115016	A2
4. Make: Dwyer Model: 648B-15	4914183	A3

Digital Timer	Serial Num	DAQ channel
1. Make: Thomas Model: Traceabl	160274632	N/A

Air Flow meter	Serial Num	DAQ channel
1. Make: TSI Model: 5725	1511004	N/A

Thermocouples	Serial Num	DAQ channel
1. Make: Omega Model: XC20K120Cal	3732-1	T1
2. Make: Omega Model: XC20K120Cal	3732-2	T2
3. Make: Omega Model: XC20K120Cal	3732-4	T3
4. Make: Omega Model: XC20K120Cal	3732-8	T4

Fenwal Heat Detector	Serial Num	DAQ channel
1. Make: Fenwal Model: 140 deg.	28021-5	D0
2. Make: Fenwal Model: 190 deg.	28021-5	D1

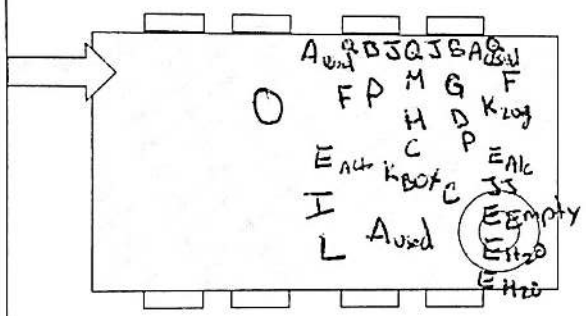
Cameras	Serial Num	DAQ channel
1. Make: Point Grey Model: Grasshopper 3	14273764	N/A
2. Make: Point Grey Model: Grasshopper 3	14273944	N/A
3. Make: Point Grey Model: Grasshopper 3	15383782	N/A
4. Make: FLIR Model: T640	55909287	N/A

Glove Installation

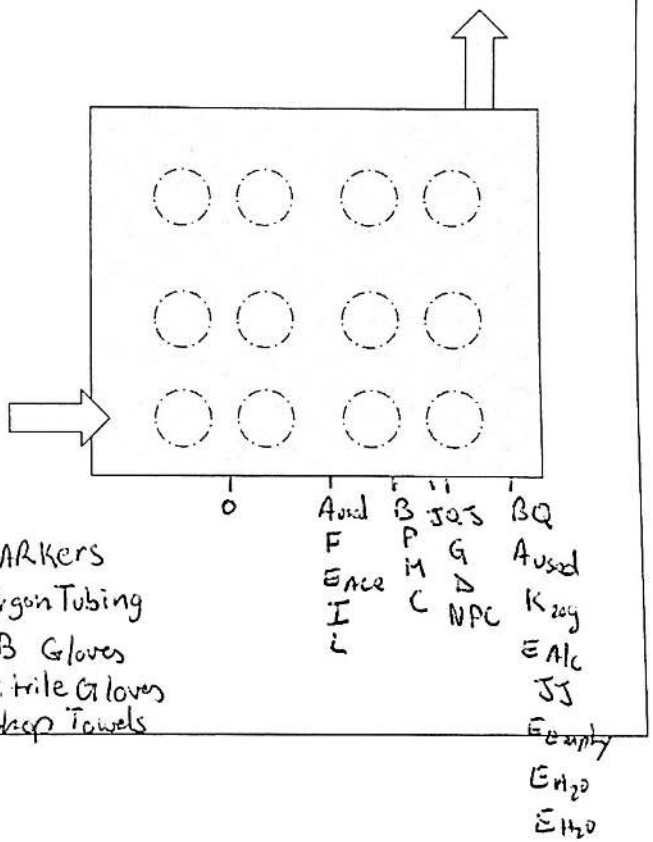
Glove/cover installed	LANL insp	Port #	Glove/cover installed	LANL insp	Port #
8U42030	RDH	1	8U42030	RDH	13
"		2	"		14
"		3	"		15
"		4	"		16
8Y1532 w/cover A		5	"		17
w/cover B		6	"		18
8U42030		7	"		19
"		8	"		20
8Y1532 w/cover A		9	"		21
" w/cover B		10	"		22
8U42030		11	8Y1532		23
"	RDH	12	"	RDH	24

Time & Description of Critical Events	Miscellaneous Notes
Ignition Time: 163 s., flame visible 500 degrees at glove (approx) Time: 177 s. Breach Time: N/A, max temp 271° (high T/C) 140 Fenwal Detection Time: on for two windows: {231-339 s. / 405-897 s} 190 Fenwal Detection Time: N/A Other key times:	Robert Hanson #301795 RDH 7/13/16

GB Floor (Top View)



GB Floor (Side View)



Legend:

A. Ignition bag
B. Sand paper
C. Screwdriver
D. Mallet
E. Poly Bottle
F. Leather glove
G. Push Rod
H. Horsehair brush
I. Scale cord
J. Cotton rounds
K. Kim wipes
L. Fantastik
M. MARKers
N. Tygon Tubing
O. GB Gloves
P. Nitrile Gloves
Q. Shop Towels

Revision History

Revision & Justification	Authorized Signatures

E Glove Material Heat Exposure Testing

Background

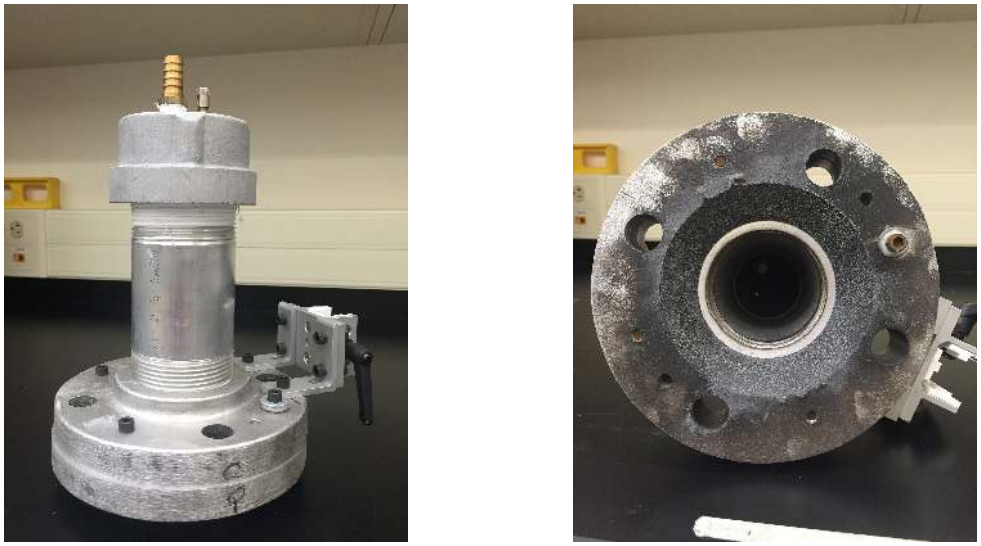
Experiments were designed to determine the response of glovebox golves to a range of thermal exposure. The overarching goal was to determine what thermal environment could lead to a breach/rupture of gloves. Instead of performing full-scale tests, a specimen holder was designed to test 4 in. diameter (100mm) circular coupons. The specimen holder was a sealed system designed to apply a positive (gage) pressure test specimen. This replicated the negative pressure environment a glove would be subjected to under normal operating conditions. Any thermal induced softening of the material would result in the specimen expanding *towards* the flame/heat source, as would be the case of an a fire inside the glovebox. A picture of the specimen holder is shown in Figure 51. Glove specimens were clamped in the specimen holder resulting in a sealed chamber, and then the apparatus pressurized to ∼+1 inAq. A port on the specimen holder was connected to ballast tanks with an approximate volume of 20 gal (40 liters) to minimize temperature-induced changes in pressure inside the specimen holder. A pressure transducer was connected a port on the specimen holder to measure pressure during each experimental run. This allowed for temperature-induced variations in pressure to be quantified. Additionally, ruptures of the glove specimens could be identified by a drop in pressure to near zero inAq. A thermocouple was placed in contact with the external side (nearest to heat source) of the glove specimen, and surface temperature was recorded for the duration of each experiment run. In order to vary the temperature that the specimen was exposed to, the test specimen was located at different distances from the burner (measured from the top of the burner to the specimen). Figure 52 shows the variation in temperature with distance from the top of the heat source (Meker burner). This figure shows that for distances between 2 and 4 inches from the burner, the temperature is approximately 2100 °F and there is little variation in temperature. As the distance from the burner increases the temperature decreases until it plateaus at 250 °F at distances greater than 14 inches. The experiment setup is shown in Figure 53(a) including the Meker burner (lower left), support stand, and specimen holder (upper right) Figure 53(b) shows the burner located beneath the specimen holder during an experiment.

Experiments were conducted on specimens cut from new Hypalon® gloves of two thicknesses (15 mil and 30 mil). Gloves were placed in the specimen holder and placed at a specified distance (10, 11, 12, or 14 in.) from the burner. At time $t = 0$ s, the burner was placed under the specimen. The pressure in the specimen holder was monitored until a drop in pressure corresponding to rupture was observed. At this point in time the burner was extinguished, removing the external source of heat. The results of these experiments are presented in the following sections.

Experimental Results

15 mil thickness Hypalon specimen, 10 in. above the burner

Temperature and pressure histories of an experiment on a 15 mil thickness specimen are shown in Figure 54(a). After the burner is placed under the specimen at t =0 (reference image of the specimen is shown in (b)) the pressure and specimen surface temperature rise. The surface temperature of the specimen reached a maximum of 539 °F at 13.3s, the pressure measured 1.07 inAq at that



(a) (b)

Figure 51: Side (a) and bottom (b) views of the specimen holder.

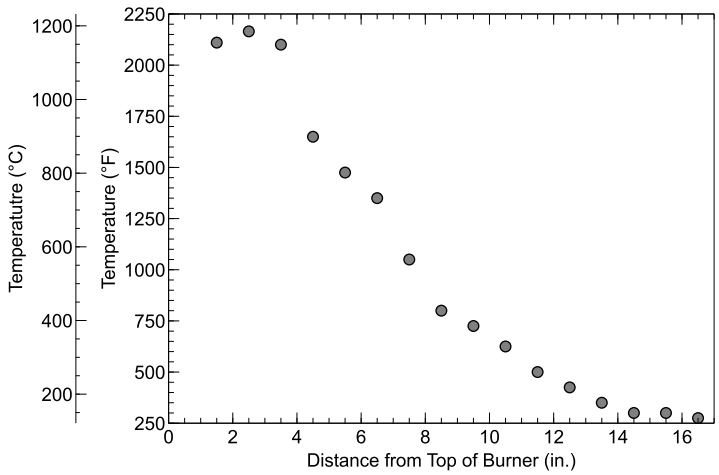
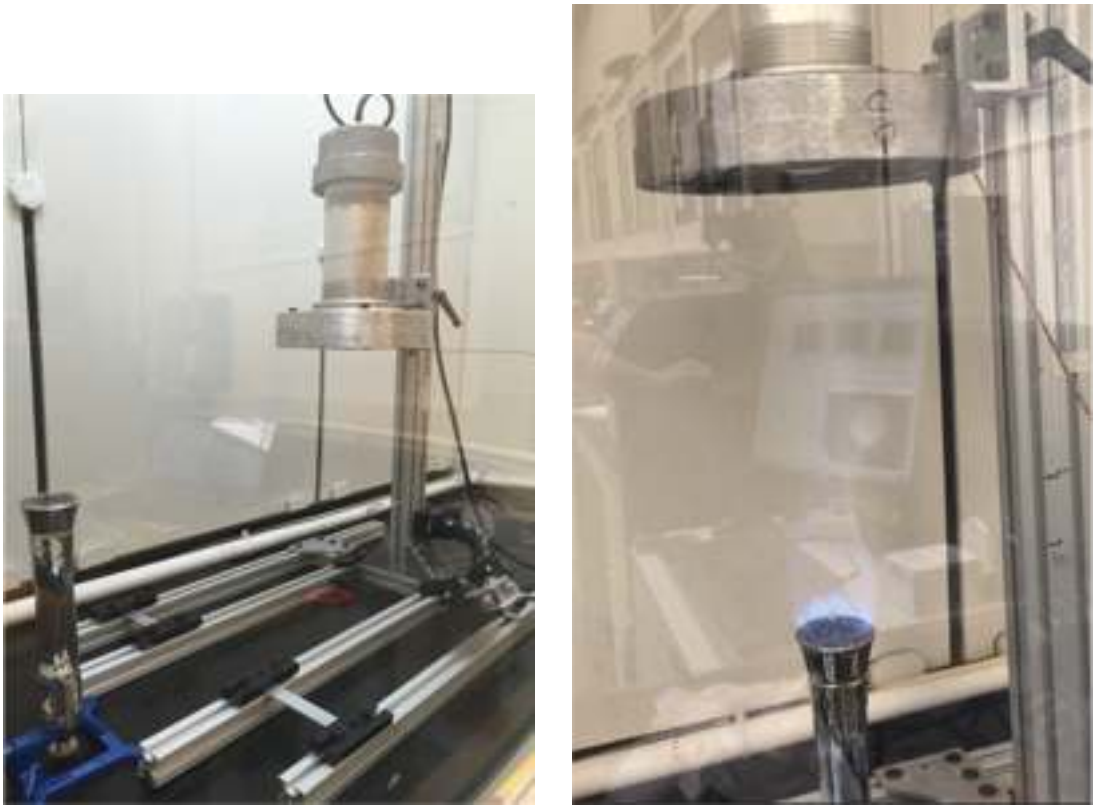


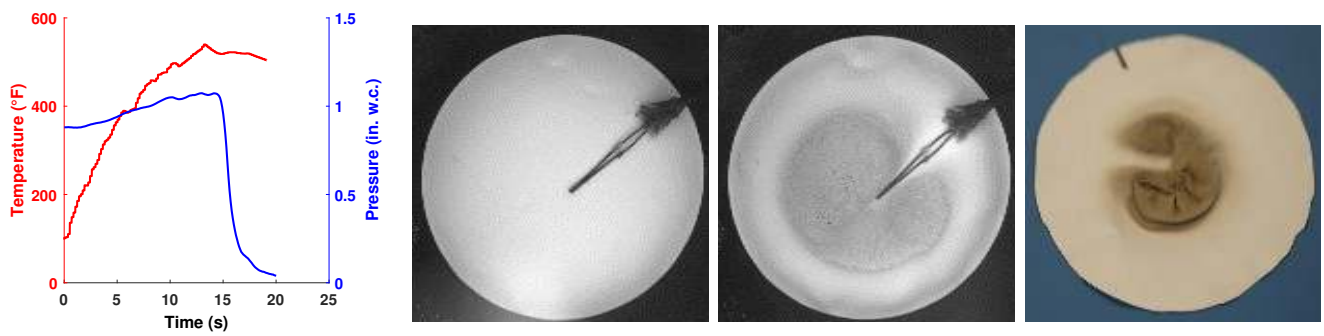
Figure 52: Temperature variation of heat source with distance from the top of the burner.



(a) (b)

Figure 53: Images of Experimental setup showing: (a) specimen holder, test stand, and Meker burner, (b) experimental components in place during an experiment.

time. Shortly after this maximum in temperature is reached, the pressure dropped to near zero (t= 14.8s) indicating a rupture of the glove. Figure 54(c) shows an image of the specimen at the time corresponding to the drop in pressure. Here, we observe a change in color and surface appearance as bubbles and pinholes formed on the specimen at a corresponding temperature of 519 °F. An image of the specimen after removal from the specimen holder is shown in Figure 54(d), showing discoloration, surface bubbling, and residual deformation. The material that shows color change etc also exhibits reduced materials stiffness as compared with the pristine material. This indicates that the material is experiencing some heat induced decomposition, which is further supported by the presence of bubbles on the surface of the specimen.

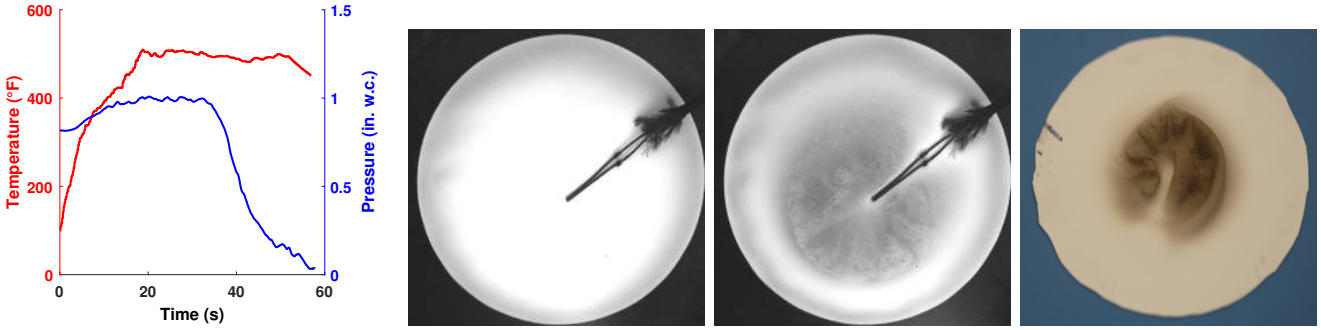


(a) (b) (c) (d)

Figure 54: Experimental results for a 15 mil thickness specimen at a distance of 10 in. from burner. (a) Temperature and pressure history, (b) image showing initial state at t=0, (c) image showing changes in surface appearance (t= 14.8), (d) image of the specimen after removal from the specimen holder, showing significant changes in the specimen color and shape.

15 mil thickness Hypalon specimen, 11 in. above the burner

Temperature and pressure histories of an experiment on a 15 mil thickness specimen placed 11 inches above the burner are shown in Figure 55(a). After the burner is placed under the specimen at t =0 (reference image of the specimen is shown in (b)) the pressure and specimen surface temperature rise. The surface temperature of the specimen reached a maximum of 509 °F at 18.9s, the pressure measured 1.0 inAq at that time. After this, the temperature remained mostly constant, and bubbles appeared on the surface of the specimen at 19.8 seconds. A drop in pressure was observed at t= 34.4 s, indicating a rupture of the glove (corresponding temperature was 492 °F). After the specimen ruptured, a change in surface color and texture (shown in Figure 55(c)) was observed at t=43.7 s. An image of the specimen after removal from the specimen holder is shown in Figure 55(d), showing discoloration, surface bubbling, and residual deformation. The region of the specimen that exhibits color change etc also has reduced material stiffness as compared with the pristine material. This indicates that the material is experiencing some heat induced decomposition, which is further supported by the presence of bubbles on the surface of the specimen.

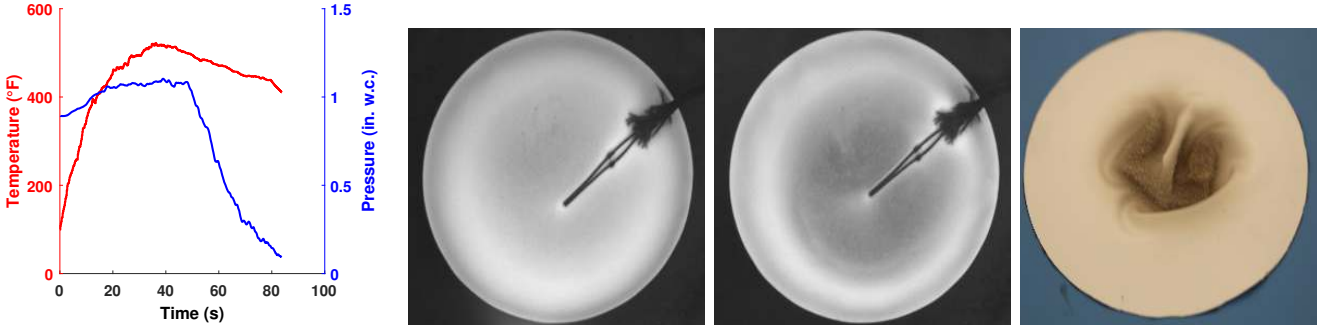


(a) (b) (c) (d)

Figure 55: Experimental results for a 15 mil thickness specimen at a distance of 11 in. from burner. (a) Temperature and pressure history, (b) image showing initial state at t=0, (c) image showing changes in surface appearance (t= 43.7), (d) image of the specimen after removal from the specimen holder, showing significant changes in the specimen color and shape.

15 mil thickness Hypalon specimen, 12 in. above the burner

Temperature and pressure histories of an experiment on a 15 mil thickness specimen placed 12 inches above the burner are shown in Figure 56(a). After the burner is placed under the specimen at t =0 s the pressure in the specimen holder and specimen surface temperature increase. The surface temperature of the specimen reached a maximum of 522 °F at t=36.2 s, the pressure measured 1.09 inAq at that time. After this, the temperature began to decrease slowly, and bubbles appeared on the surface of the specimen at t=35.5 s. The pressure in the specimen holder began to drop at t= 48.6 s (corresponding temperature was 496 °F), the pressure continued to drop over the next thirty seconds, indicating a rupture of the specimen. After the specimen ruptured, a change in surface color and texture were observed, shown in Figure 56(c). An image of the specimen after removal from the specimen holder is shown in Figure 56(d), showing discoloration, surface bubbling, and residual deformation. The material that shows color change etc also exhibits reduced material stiffness as compared with the pristine material. This indicates that the material is experiencing some heat induced decomposition, which is further supported by the presence of bubbles on the surface of the specimen.

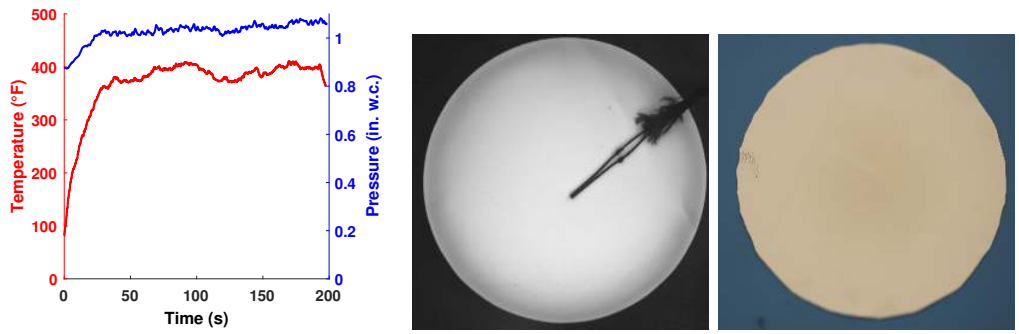


(a) (b) (c) (d)

Figure 56: Experimental results for a 15 mil thickness specimen at a distance of 12 in from burner. (a) Temperature and pressure history, (b) image showing initial state at t=0, (c) image showing changes in surface appearance, (d) image of the specimen after removal from the specimen holder, showing significant changes in the specimen color and shape.

15 mil thickness Hypalon specimen, 14 in. above the burner

Temperature and pressure histories of an experiment on a 15 mil thicknesss specimen placed 14 inches above the burner are shown in Figure 57(a). After the burner is placed under the specimen at t =0 s the pressure in the specimen holder and specimen surface temperature increase. After the initial rise the pressure remains nominally constant in the range of 1.0-1.1 inAq, and the temperature varied slightly in the range of 371-409 °F. Figure 57(b) shows the specimen at t=180 s, just after teh maximum temperature was reached, indicating no change in surface appearance. The experiment was terminated at t =$\sim$ 200 s, and no loss of pressure was observed. No damage to the specimen was observed, and the specimen shown by Figure 57(c) appears identical to a pristine sample.



(a) (b) (c)

Figure 57: Experimental results for a 15 mil thickness glove at a distance of 14 in. from burner. (a) Temperature and Pressure history, (b) image showing lack of change in specimen surface appearance (t= 180 s), (c) image of the specimen after removal from the specimen holder, showing no changes in the specimen color and shape.

30 mil thickness Hypalon specimen, 10 in. above the burner

Temperature and pressure histories of an experiment on a 30 mil thickness specimen placed 10 inches above the burner are shown in Figure 58(a). Figure 58(b) shows an image of the specimen as the burner was placed under it at t=0 seconds. The surface temperature reached a maximum of 622°F at t=20.5 seconds. Charring, bubbling, and bulging of the specimen was observed soon after the maximum temperature was reached; flame also appeared on the thermocouple at 30.0s (Figure 58(c)). The specimen caught fire at t = 30.9s as shown in Figure 58(d). The specimen continued to burn and pressure dropped rapidly at t=34.7s (Figure 58(e)) indicating a rupture of the specimen. The burner was turned off once breech was detected and the specimen was allowed to burn on its own until it was extinguished with a puff of air at t =$\sim$ 48 s. The specimen suffered severe deformation, discoloration, and a large hole can be seen in the lower left of Figure 58(f). Figure 58(g) shows the specimen after removal from the specimen holder, significant charring and deformation are observed.

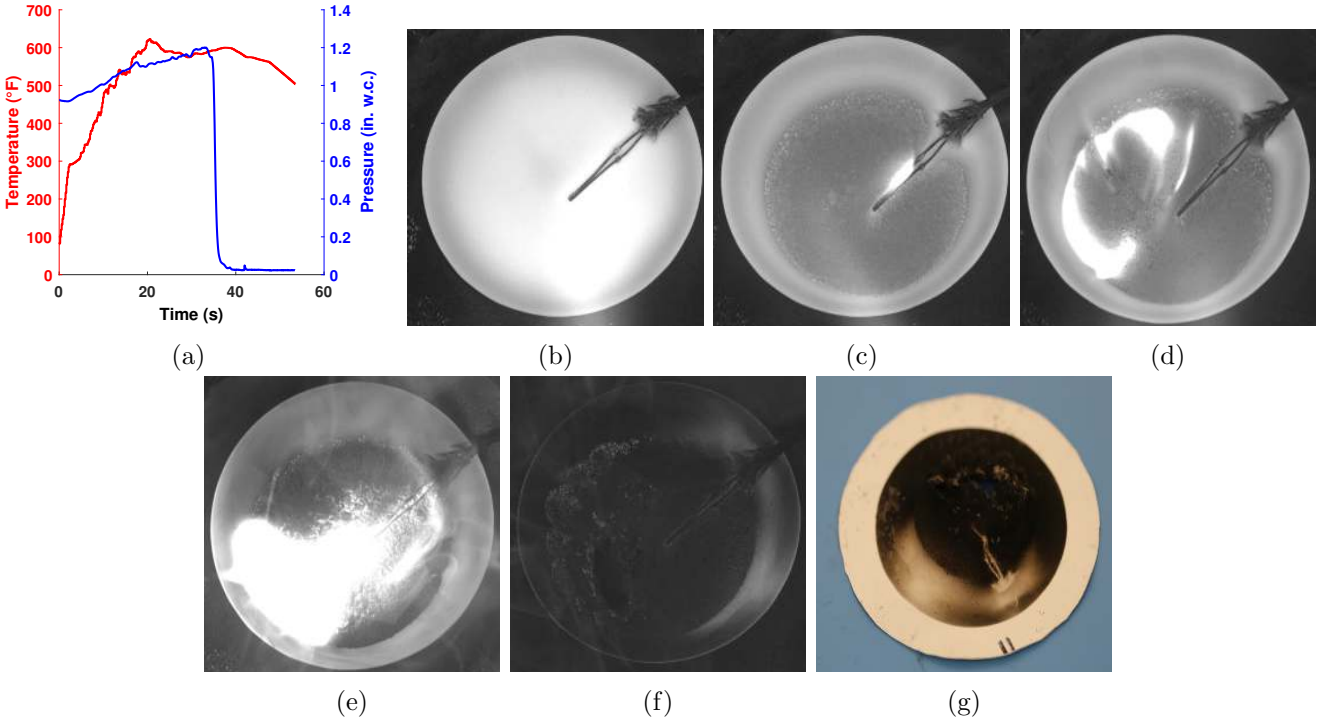
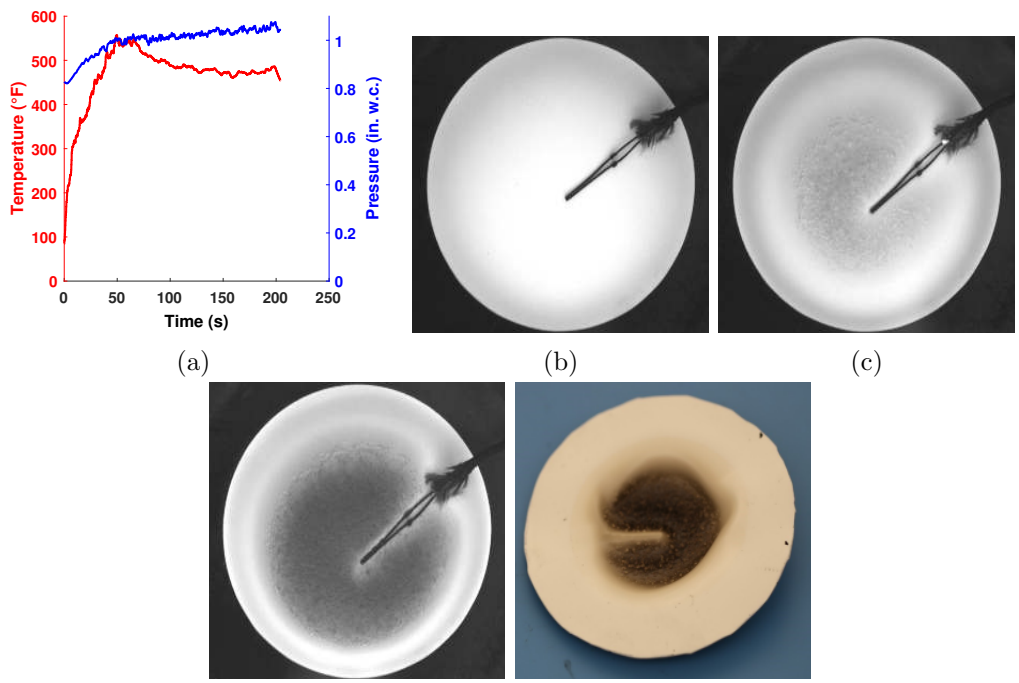


Figure 58: Experimental results for a 30 mil thickness specimen at a distance of 10 in. from burner. (a) Temperature and Pressure history, (b) an image of the specimen as the burner was placed at t=0 seconds. (c) image showing charring, bubbling, and bulging of the specimen soon after the maximum temperature was reached t=30.0s, (d) Image showing that the specimen caught fire at t=30.9s. (e) Image showing specimen burning at time of rupture (t=34.7s), (f) Image showing severe discoloration and damage of the specimen (note large hole in lower left) after the specimen was extinguished at $t =\sim 48$ s. (g) Shows the specimen after removal from the specimen holder, significant charring and deformation are observed.

30 mil thickness Hypalon specimen, 11 in. above the burner

The burner was placed under the sample at $t = 0$ s, at which time the pressure and temperature began to rise as seen in Figure 59(a). The surface temperature reached a maximum of 557 °F at $t =$ 49.6 seconds with a corresponding pressure of 1.01 inAq. Also at this time, bubbles were seen at the specimen surface, whcih continued to spread and covered a large portion of the specimen at t =51.9 s (Figure 59(c)). Shortly thereafter, charring and bulging were observed (Figure 59(d)). Despite significant charring, discoloration, and deformation, the glove specimen did not rupture during the duration of the experiment (∼180 s) as indicated by the nominally constant pressure. Figure 59(e) is a photograph of the specimen after removal from the specimen holder showing residual deformation and discoloration. It is worth noting that the areas of the specimen that were exposed to the heat were less compliant than the original specimen, and had a somewhat brittle feel to them.



(a) (b) (c)

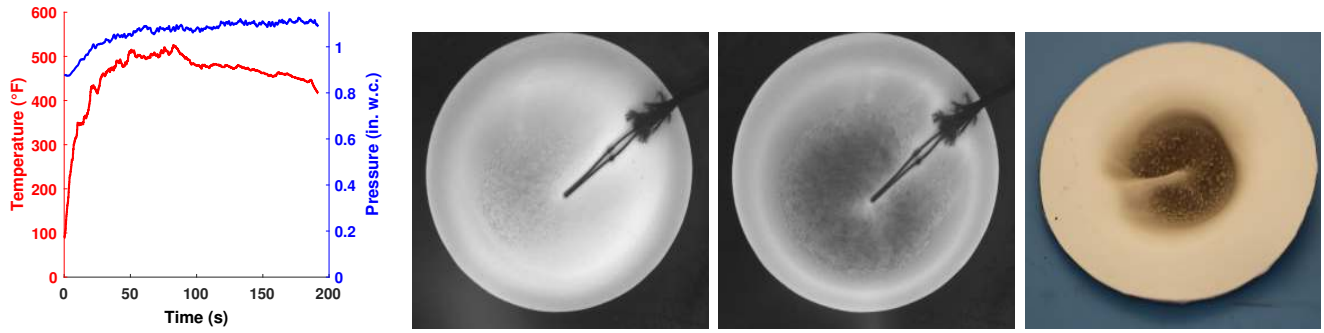
(d) (e)

Figure 59: Experimental results for a 30 mil thickness specimen at a distance of 11 in. from burner. (a) Temperature and pressure history, (b) an image of the specimen as the burner was placed at t=0 seconds. (c) image showing charring, bubbling, and bulging of the specimen at t= 51.9 s, and (d) image showing discoloration of the specimen shortly thereafter. (e) Shows the specimen after removal from the specimen holder, significant charring and deformation are observed.

30 mil thickness Hypalon specimen, 12 in above the burner

The burner was placed under the sample at $t = 0$ seconds at which time the pressure and temperature began to rise as seen in Figure 60(a). The pressure remained nominally constant in ranging from 1.01-1.12 inAq for the duration of the experiment (∼180 s). Changes in the specimen surface were noted at t=53.7 s (Figure 60(b)) with a corresponding temperature of 502 °F. A maximum temperature of 525°F was achieved at t = 84.0 s, and more discoloration and deformation of the

sample is observed at this time Figure 60(c)). Figure 60(d) is a photograph of the specimen after removal from the specimen holder showing residual deformation and discoloration.

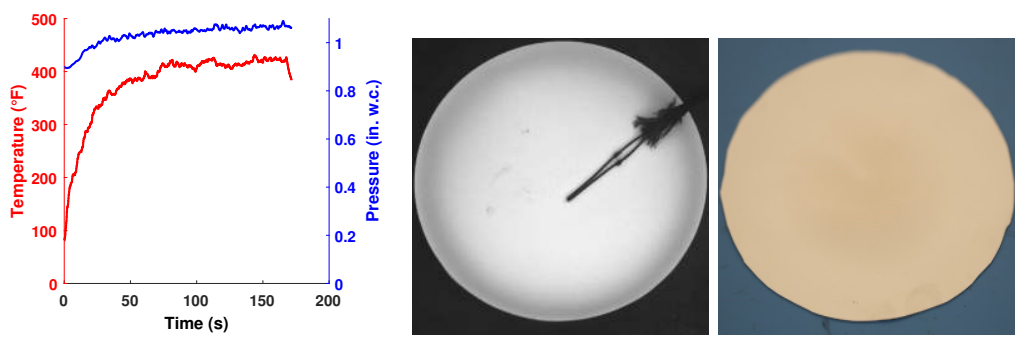


(a) (b) (c) (d)

Figure 60: Experimental results for a 30 mil thickness specimen at a distance of 12 in. from burner. (a) Temperature and pressure history, (b) image showing changes in surface appearance (t= 53.7), (c) image showing further discoloration on the specimen at the time (t=84 s) corresponding to maximum temperature, (d) image of the specimen after removal from the specimen holder, showing significant changes in the specimen color and shape.

30 mil thickness Hypalon specimen, 14 in. above the burner

The burner was placed under the specimen at $t = 0$ s. After an initial increase, there were small variations of pressure within a range of 1.02–1.08 inAq over the duration of the experiment (∼170 s). The maximum temperature reached was 431 °F, and no change in the specimen surface was observed at this time (Figure 61(b)). Figure 61(c) shows the specimen after removal from the specimen holder illustrating that the heat exposure resulted in no physical change in the specimen.



(a) (b) (c)

Figure 61: Experimental results for a 30 mil thickness specimen at a distance of 14 in. from burner. (a) Temperature and pressure history, (b) image showing the specimen surface at the time corresponding to the maximum temperature, (d) image of the specimen after removal from the specimen holder, showing no change in specimen appearance.

Summary

The results of the experiments presented above are summarized in Table 7. Timing of critical events, such as appearance of bubbles on the specimen surface and rupture are noted. Relevant temperature and pressure data are also summarized. These results indicate a few critical aspects of the response of Hypalon glove material when exposed to a high temperature environment. Glove specimens began to show changes in surface appearance (appearance of bubbles on surface) when the temperature at the specimen surface was 530 ± 32 °F, regardless of specimen thickness. The bubbles are likely the result of the glove material decomposing and off-gassing. In the case of the 15 mil thickness gloves, specimens ruptured shortly after bubbling was observed. The ruptures are likely the result the bubbles growing in size, eventually forming pinholes through the thickness of the specimen. It should be noted that the specimens did not need to ignite in order to cause a perforation of the specimen. Specimens located 10, 11 and 12 inches from the burner ruptured, while the specimen located 14 inches from the burner did not rupture; in fact no change in surface appearance was observed.

The 30 mil thickness specimens exhibited a different post-bubble response with only the specimen located 10 inches from the burner (i.e. highest surface temperature) resulting in rupture. There was a longer delay between surface bubbling and rupture than was observed in the 15 mil thickness specimens. This specimen also ignited before the specimen ruptured. While the 30 mil thickness specimens located 11 and 12 inches from the burner did show surface bubbling corresponding to thermal breakdown, neither specimen ruptured. Examination of the specimens after testing revealed that a slightly hard layer of melted material had formed on the rear of the specimen. This layer may have acted to seal the rear surface of the specimen by forming a barrier that bubbles could not penetrate. The specimen located 14 inches from the burner did not rupture, and did not exhibit any change in surface characteristics.

In general the 30 mil thickness glove materials proved more resistant to thermal-induced rupturing as compared with the 15 mil thickness glove material. It was shown to be possible to rupture a 15 mil thick glove without igniting the glove, while the only test case that resulted in a rupture of a 30 mil thickness specimen also showed the specimen igniting several seconds before eventual rupture. Furthermore, it was observed that 30 mil thickness specimens could be exposed to temperatures high enough to cause decomposition (bubbling), yet not rupture. Thus, it is possible that the 30 mil gloves rupture by burning through the specimen material, while the 15 mil thickness specimens could be ruptured by small bubbles formed by thermal off-gassing expanding and causing pinholes through the specimen thickness. We also note that thermal decomposition and the appearance of surface bubbles was observed in all experiments with a maximum temperature exceeding ∼500 °F.. Lastly, we can state that specimens subjected to temperatures below 400 °F experienced no thermal damage, staying below this threshold should prevent damage and potential rupture of either thickness glove materials.

Specimen		Heat Source		Surface Temp.	Pressure			Bubble		Rupture	
Test ID	**Thickness (mil)**	**Distance (in.)**	**Duration (s)**	**Max (°F)**	**Initial (inAq)**	**Max (inAq)**	**Final (inAq)**	**Temp (°F)**	**Time (s)**	**Temp (°F)**	**Time (s)**
HY1510-04	15	10	18.8	540	0.88	1.07	0.06	517	12.2	519	16.4
HY1511-01	15	11	51.9	509	0.82	0.99	0.05	508	19.8	492	46.2
HY1512-01	15	12	79.7	522	0.089	1.1	0.14	518	35.5	496	52.5
HY1514-01	15	14	100.3	411	0.88	1.08	1.06	No	No	No	No
HY3010-03	30	10	38.5	621	0.91	1.19	0.02	583	18.5	1.15	35.9
HY3011-01	30	11	186.3	557	0.83	1.07	1.04	557	49.8	No	No
HY3012-01	30	12	184.6	525	0.87	1.23	1.1	502	53.7	No	No
HY3014-01	30	14	170.9	431	0.89	1.08	1.06	No	No	No	No

Table 7: Summary of glove material heat exposure tests

F Glovebox Combustible Materials Testing

Introduction

LANL has provided a list of combustible items routinely found in gloveboxes. These items include: wood-handled mallet, screwdrivers, cheesecloth, wash bottles, horsehair brush, wooden push rod, lab wipes, leather gloves, sandpaper, and cleaning spray. Each of these items will have different autoignition temperatures, flashpoints, and combustion temperatures depending on the materials of which they are made. For some of the constituent materials, such as polypropylene and cotton, these temperature data are readily available in the open literature. However, for other materials, such as cowhide, the temperature data is not readily available. Thus it was decided to conduct a series of experiments to determine the ignition and combustion temperatures of the items/materials listed above. In all cases, it is expected that combustion temperatures will depend not only on parameters intrinsic to a material, but also a particular objects form as well as environmental conditions.

Terminology

1. *Flash Point*: The flash point is the lowest temperature at which enough vapor forms above a combustible substance and to ignite in air when exposed to an ignition source (Merriam-Webster.com). Solid fuels ignite when they are melted and vaporized or when they undergo heat decomposition into vapors [4]. The fire point is the point where enough of the substance has pyrolyzed to sustain a flame for at least 5 seconds; generally, the fire point is assumed to be 50 °F above the flash point [9].

2. *Auto-ignition Temperature*: The auto-ignition temperature is the lowest temperature at which a combustible substance when heated takes fire in air without an ignition source, such as a flame, and continues to burn (Merriam-Webster.com).

3. *Combustion Temperature*: The combustion temperature is the temperature at which an object burns. The rate of energy release from a fuel depends on the mass of the object, the surface area of the object, and the availability of oxygen [8].

Experimental Methods

For each experiment, the test article was attached to a frame in a fume hood at a fixed distance of 3"above a natural gas Meker burner (Fig. 1). An IR (FLIR T640) and a grayscale camera (Point Grey, Grasshopper 3) were positioned to record each trial. A total of three K-type thermocouples were used to measure the temperature at the underside of the test article (exposed to flame) and above the test article (individual thermocouples located 1.5" and 2.5" above the upper surface). The burner was ignited and placed under the test article of interest. If the test article ignited, the temperature at the time of ignition was recorded as the "Flash point temperature". After the test article was sufficiently involved in flame, the burner was removed and test articles were allowed to burn until they either self-extinguished or reached an apparent steady-state of self-sustained combustion, after which time they were manually extinguished.

Results

The data collected from literature and experimentation are presented in Table 8. In some cases, test articles ignited very rapidly, with ignition temperatures being measured at under 200 °F. It should be noted that ignition was so rapid that this measurement may under-predict the actual ignition temperature given the non-zero response time of the instrument. Other materials were very slow to ignite. Combustion temperatures were equally widely spread.

Of particular note for the full scale experiments are objects which do not self-extinguish and/or burn at >500 °F. These materials present the most likely threat to glove integrity. With this in mind, the following categories can be assembled from these experiments:

1. Items/materials that burned $\geq$ 500 °F:
    - Cotton
    - Leather
    - Polypropylene
    - Sandpaper
    - Spray Cleaner bottle
    - Black, red, and yellow mallet heads
2. Combustibles that ignited quickly:
    - Cotton
    - Horsehair
    - Sandpaper

A few additional noteworthy observations were that: 1) Polypropylene had the most consistent flame, 2) Some materials (e.g. sandpaper and cheesecloth) burned up quickly seeming to produce much heat, 3) Some materials tended to self-extinguish (e.g. mallet handles and black rubber mallet head), 4) The cleaning spray would not ignite while full

References

[1] Babrauskas, V., Ignition of Wood: A Review of the State of the Art, pp. 71-88 in Interflam 2001, Interscience Communications Ltd., London (2001). `https://doctorfire.com/wood_ign.pdf`

[2] Transport Information Service. Gesamtverband Der Deutschen Versicherungswirtschaft, n.d. Web. 18 May 2016. `http://www.tis-gdv.de/tis_e/ware/fasern/baumwoll/baumwoll.htm#temperature`

[3] Drysdale, D., Yudong, L. Measurement of Ignition Temperature of Wood. The International Association for Fire Safety Science: Asia-Oceania Symposium on Fire Science & Technology 1 (1992): 380-385. Web. 18 May 2016. `http://www.iafss.org/publications/aofst/1/380/view`

[4] National Fire Protection Association Staff. NFPA 921. National Fire Protection Association (2004): 15-19. Web. 23 May 2016

	From References		Tested	
Material	**Auto-ignition Temp. (°F)**	**Flash Point °F Temp. (°F)**	**Flash Point Temp. (°F)**	**Combust. Temp. Temp. (°F)**
Cotton [2]	765	392	166	906
Horsehair	unknown	unknown	159	381
Leather	unknown	unknown	1748	723
Polypropylene rod [7]	730	500	1051	981
Sandpaper	unknown	unknown	261	1000
Spray Bottle (w/ solution)	unknown	unknown	Did not ignite	N/A
Spray Bottle (empty)	unknown	unknown	400	1554
Black mallet head	unknown	unknown	705	400-600
Red mallet head	unknown	unknown	367	750
Yellow mallet head	unknown	unknown	383	800
Wood [1], [3]	572-662	428-500	285	400-500

Table 8: Summary of ignition/combustion temperature data.

[5] MSDS CAS No. unknown; Redwood Plastics Corporation: Woodland, Washington, USA, October 2006. Web. 23 May 2016. `http://web.mit.edu/rocketteam/www/usli/MSDS/Polycarbonate.pdf`

[6] MSDS CAS No. 47162; A&C Plastics, Inc.: Houston, Texas, USA, December 2002. Web. 23 May 2016. `http://www.acplasticsinc.com/techSheets/MSDS_Makrolon_GP.pdf`

[7] MSDS CAS No. 9010-79-1; Indian Oil Corporation Limited: Baholi, Panipat, India, January 2009. Web. 18 May 2016. `https://www.iocl.com/products/Polypropylene(Comopolymer).pdf(accesed05-18-16)`

[8] `http://civil.iisc.ernet.in/~manohar/Fire/Part-11_Notes-4.pdf`

[9] `http://www.nttworldwide.com/tech2212.htm`

G Comprehensive Post-Mortem Photography

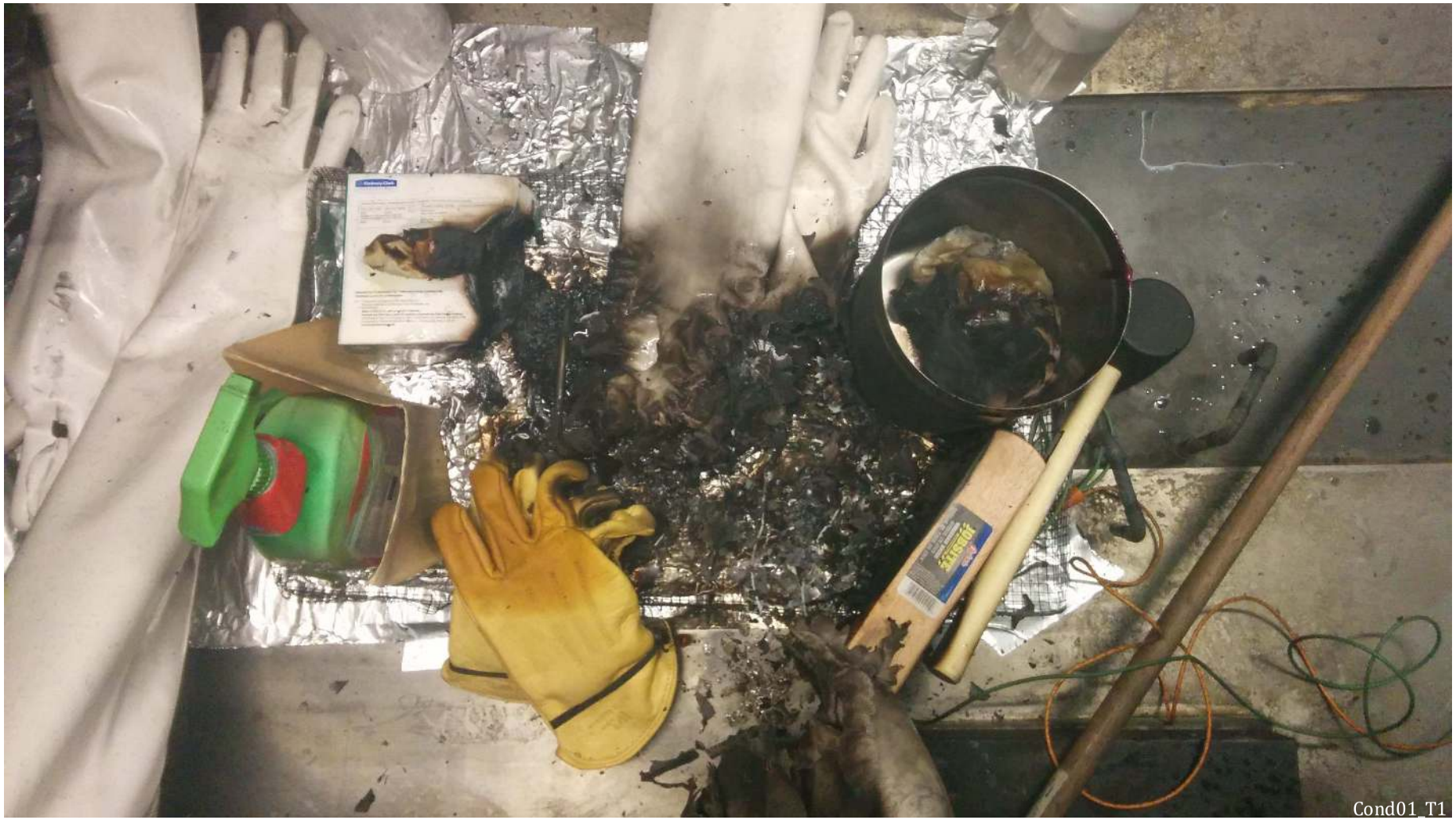


Figure 62: Condition 01 Trial 1. A robust fire consumed the cheesecloth inside the fire resistant container and severely damaged several gloves.

Figure 63: Condition 01 Trial 1. Cheesecloth, gloves, and screwdrivers around the container were burned.

Figure 64: Condition 01 Trial 1. The horsehair brush and task wipes also contributed to burning gloves.

Figure 65: Condition 01 Trial 1. With the lid off, the fire resistant container did little to protect its contents from fire.

Figure 66: Condition 01 Trial 1. The exhaust filter packed with soot from the involvement of gloves in a fire.

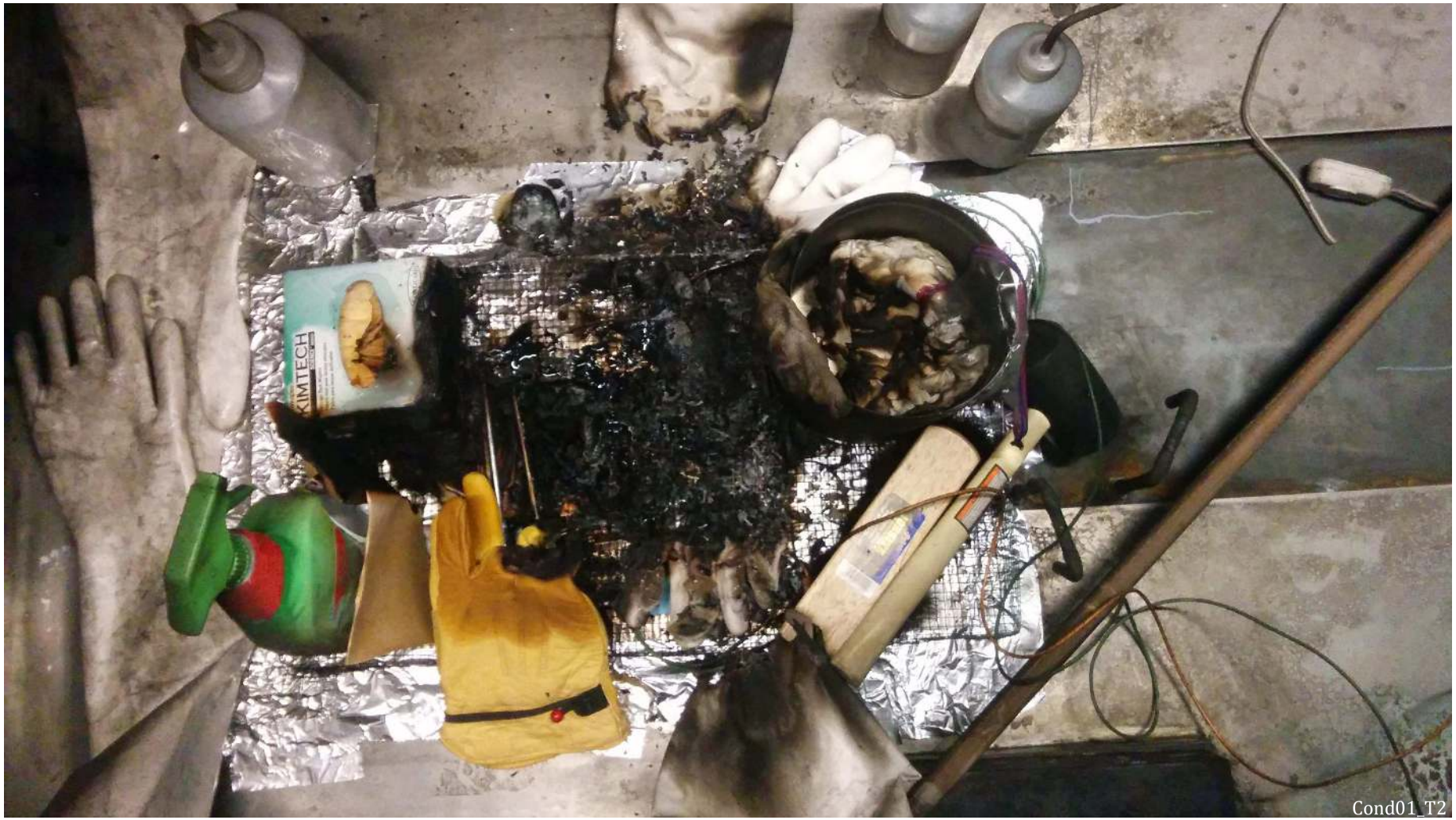


Figure 67: Condition 01 Trial 2. A robust fire burned several gloves and consumables, including cheesecloth in the fire resistant container.

Figure 68: Condition 01 Trial 2. Task wipes, screwdrivers, sandpaper, and the Fantastik bottle participated in the fire.

Figure 69: Condition 01 Trial 2. Burning of cheesecloth in the open container, the horsehair brush, and leather gloves led to a large breach in a glove.

Figure 70: Condition 01 Trial 2. The open container did little to stop the cheesecloth inside from participating.

Figure 71: Condition 01 Trial 2. The entire hand and wrist of the port 9 glove were consumed.

Figure 72: Condition 01 Trial 2. The wrist of the port 23 glove deteriorated in the fire.

Figure 73: Condition 01 Trial 3. A large fire destoyed several gloves and consumables.

Figure 74: Condition 01 Trial 3. The Fantastik bottle, horsehair brush, task wipes, and gloves were all burned.

Figure 75: Condition 01 Trial 3. The leather gloves deteriorated severely.

Figure 76: Condition 01 Trial 3. The fingers of the Port 10 Glove were detached and melted onto the alcohol bottle.

Figure 77: Condition 02 Trial 1. A robust fire was produced that severely damaged several gloves. (Burnt consumables were removed before photo)

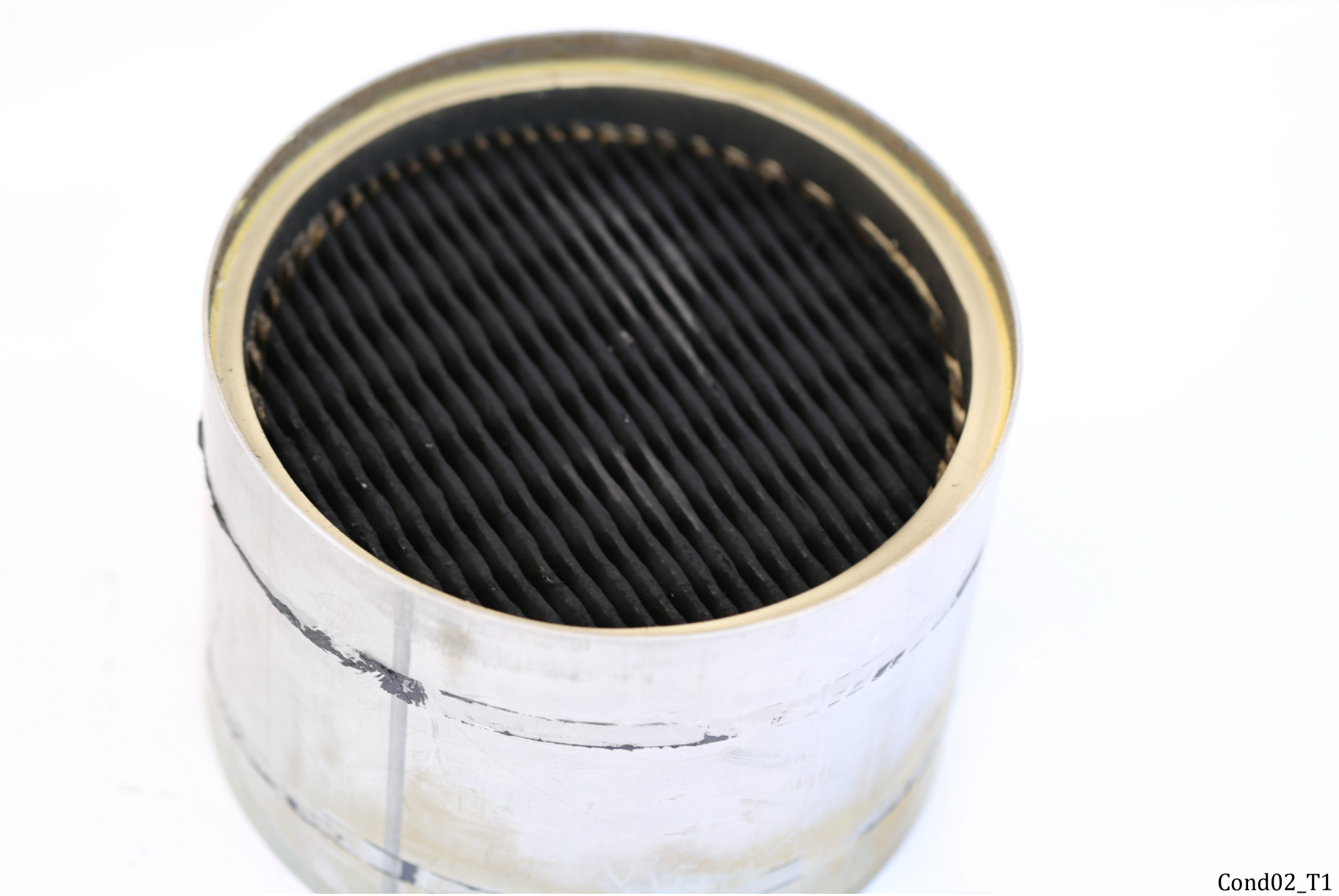


Figure 78: Condition 02 Trial 1. Involvement of gloves caused the exhaust filter to pack.

Figure 79: Condition 02 Trial 1. Bubbling and cracking are apparent on the port 10 glove.

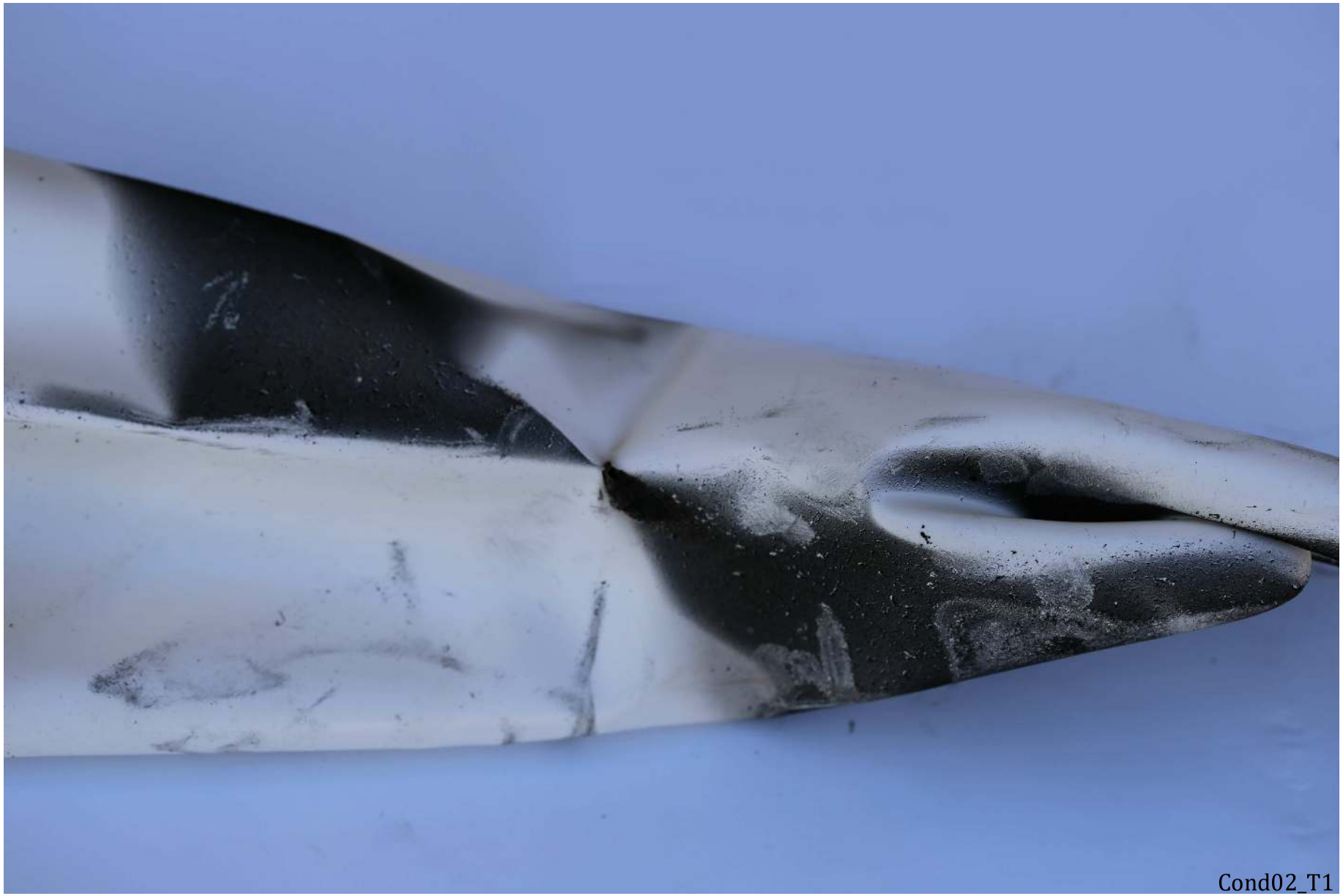


Figure 80: Condition 02 Trial 1. Charring is apparent on the port 23 glove

Figure 81: Condition 02 Trial 1. The hand on the port 24 glove completely deteriorated.

Figure 82: Condition 02 Trial 2. A smaller fire was produced, consuming the cheesecloth and damaging several gloves.

Figure 83: Condition 02 Trial 2. Minor damage to the Fantastik bottle is apparent.

Figure 84: Condition 02 Trial 2. Cheesecloth was completely burned.

Figure 85: Condition 02 Trial 2. Minor charring is apparent on the edge of the sandpaper.

Figure 86: Condition 02 Trial 2. Bubbling and minor cracking occured on the port 10 glove.

Figure 87: Condition 02 Trial 2. Charring occured on the fingers of the port 30 glove. Burnt cheesecloth is melted to the fingers.

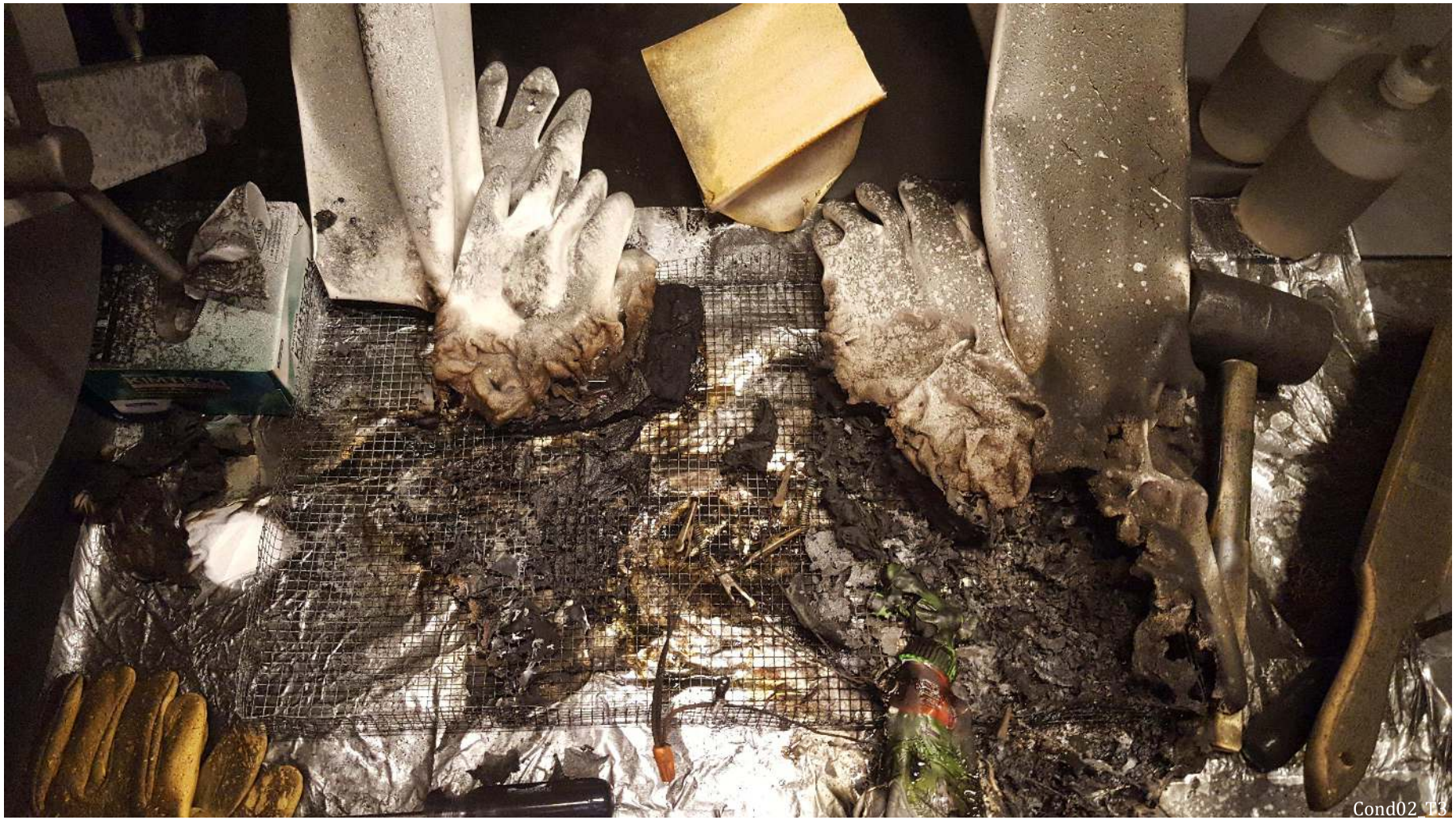


Figure 88: Condition 02 Trial 3. A robust fire consumed gloves and consumables.

Figure 89: Condition 02 Trial 3. The Fantastik bottle and cheesecloth contributed to the burning of gloves.

Figure 90: Condition 02 Trial 3. Not all consumables present engaged in the fire. Some charring is visible on the mallet, screwdrivers, and leather gloves.

Figure 91: Condition 02 Trial 3. The fingers on the port 9 glove were consumed.

Figure 92: Condition 02 Trial 3. The hand and part of the sleeve on the port 10 glove were severely damaged.

Figure 93: Condition 02 Trial 3. The port 10 ring was blackened and partially melted.

Figure 94: Condition 02 Trial 3. Minor bubbling is apparent on the port 24 glove.

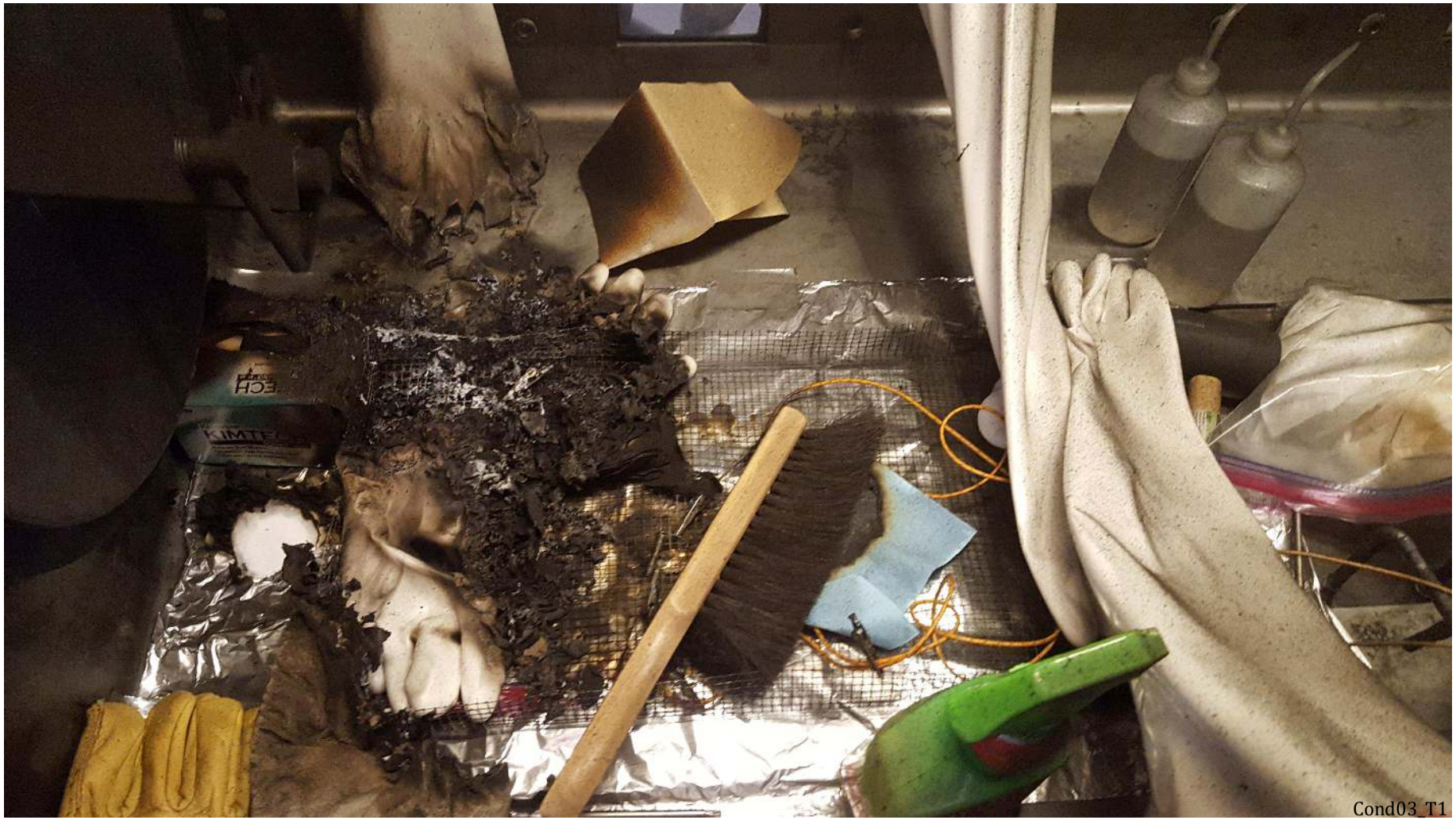


Figure 95: Condition 03 Trial 1. An isolated fire severly damaged gloves and several consumables.

Figure 96: Condition 03 Trial 1. Stacked task wipes and shop towels contributed to the burning of gloves.

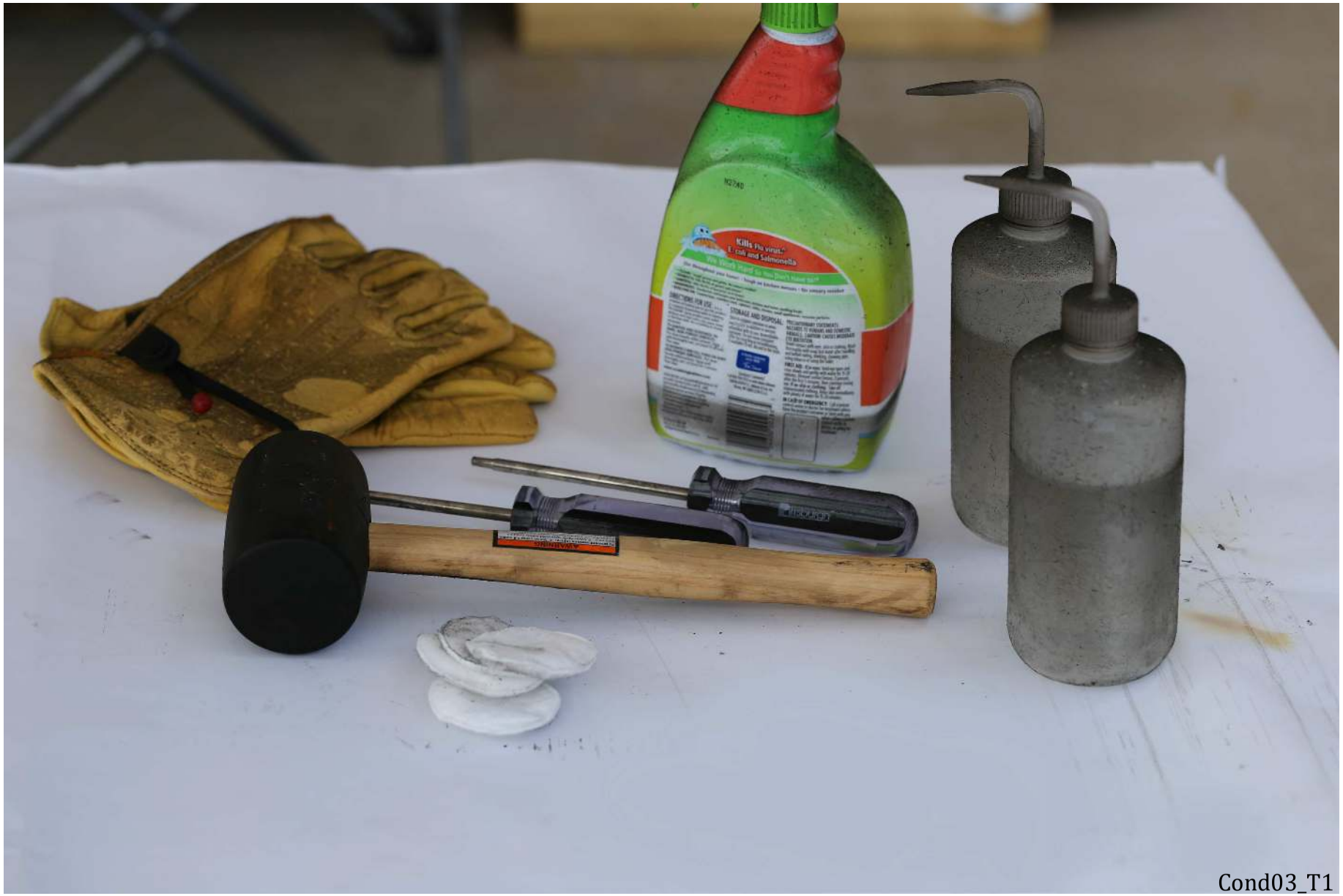


Figure 97: Condition 03 Trial 1. Consumables placed far from igniters remained undamaged.

Figure 98: Condition 03 Trial 1. The alcohol bottle melted slightly but did not ignite.

Figure 99: Condition 03 Trial 1. The horsehair brush was singed and the hair melted.

Figure 100: Condition 03 Trial 1. The box of task wipes was thoroughly burnt.

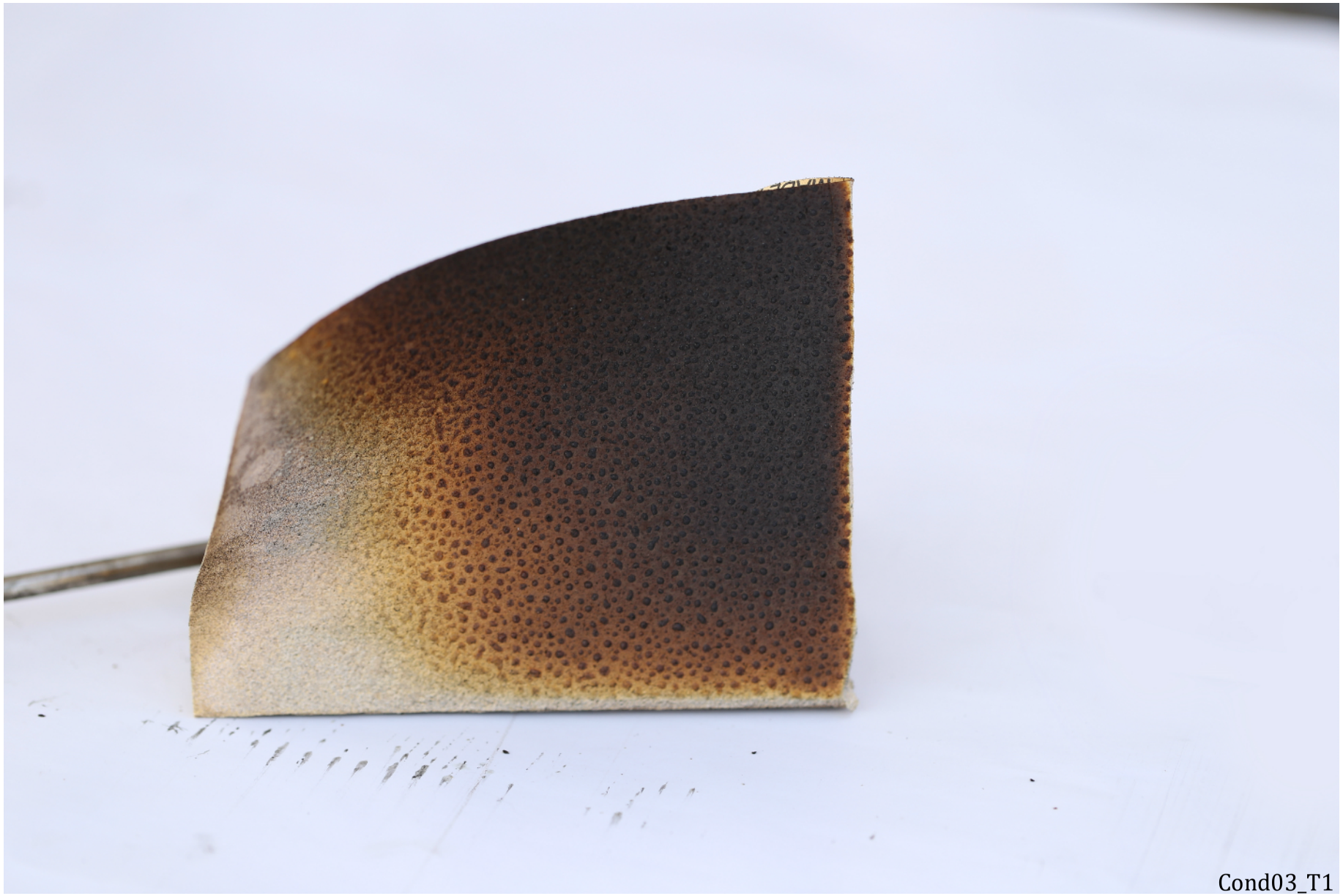


Figure 101: Condition 03 Trial 1. Sandpaper was singed.

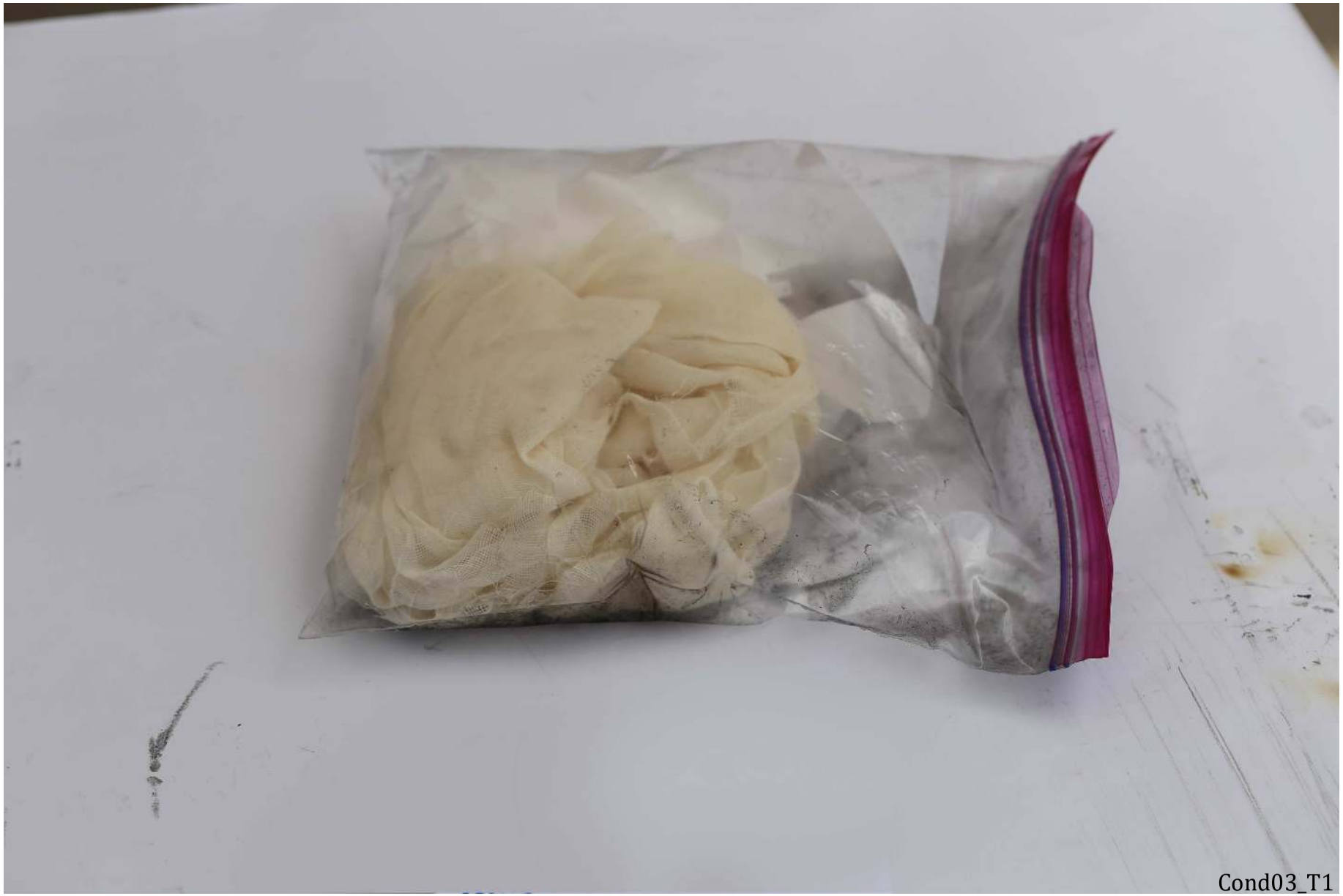


Figure 102: Condition 03 Trial 1. The isolated bag of used cheesecloth did not participate.

Figure 103: Condition 03 Trial 1. The hand of the port 9 glove was consumed.

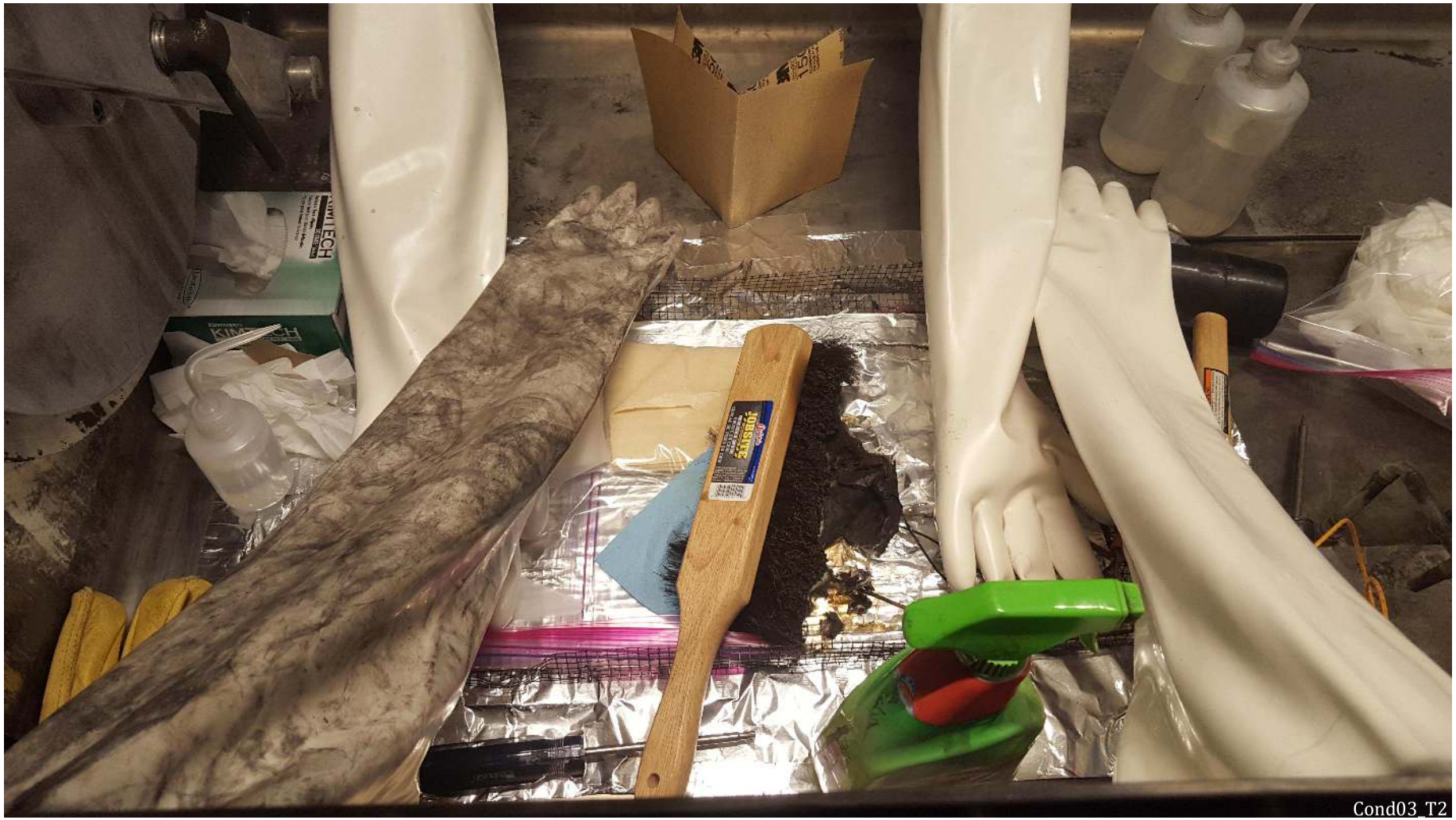


Figure 104: Condition 03 Trial 2. A small fire inflicted no damage to the gloves.

Figure 105: Condition 03 Trial 2. The horsehair brush was only slightly singed.

Figure 106: Condition 03 Trial 3. An isolated fire led to significant damage of two gloves.

Figure 107: Condition 03 Trial 3. Many consumables were not damaged.

Figure 108: Condition 03 Trial 3. The alcohol bottle melted slightly but did not ignite.

Figure 109: Condition 03 Trial 3. The horsehair brush was singed.

Figure 110: Condition 03 Trial 3. The box of task wipes burned thoroughly.

Figure 111: Condition 03 Trial 3. Condition 01 Trial 1. The fingers on the port 9 glove were consumed.

Figure 112: Condition 03 Trial 3. The wrist of the port 10 glove sustained minor damage.

Figure 113: Condition 03 Trial 3. Minor Damage was inflicted on the fingers of the port 23 glove.

Figure 114: Condition 03 Trial 3. The hand of the port 24 glove sustained significant damage.

Figure 115: Condition 04 Trial 1. A small fire damaged several consumables and gloves.

Figure 116: Condition 04 Trial 1. Tygon tubing, a marker,and sandpaper contributed to the fire.

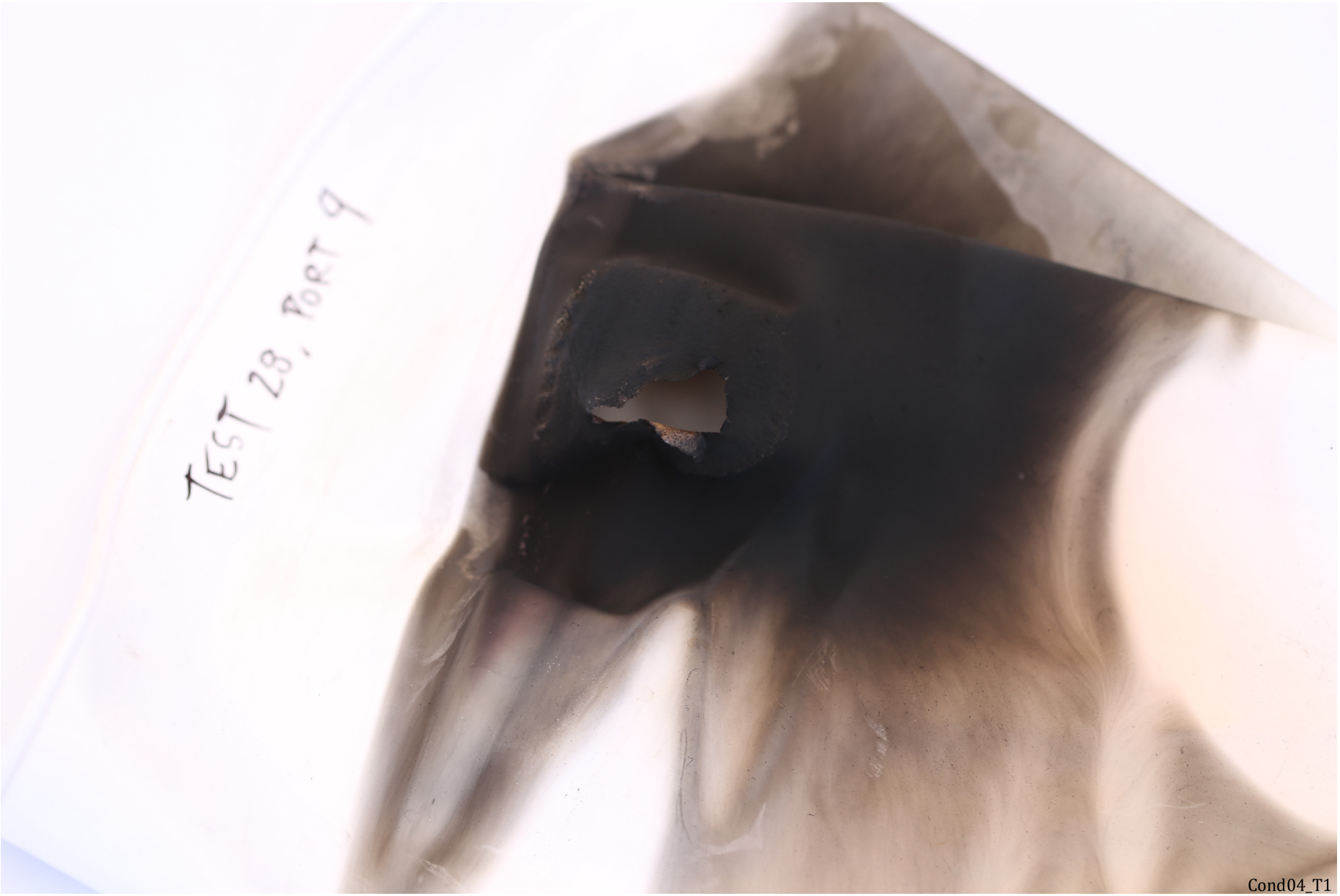


Figure 117: Condition 04 Trial 1. A small hole was evident in the port 9 glove.

Figure 118: Condition 04 Trial 1. Charring, bubbling, and cracking occurred near the ring of the port 9 glove.

Figure 119: Condition 04 Trial 2. A small fire inflicted damage on several consumables and gloves.

Figure 120: Condition 04 Trial 2. The involvement of gloves caused the exhaust filter to pack.

Figure 121: Condition 04 Trial 2. Tygon tubing, the mallet handle, and the horsehair brush participated.

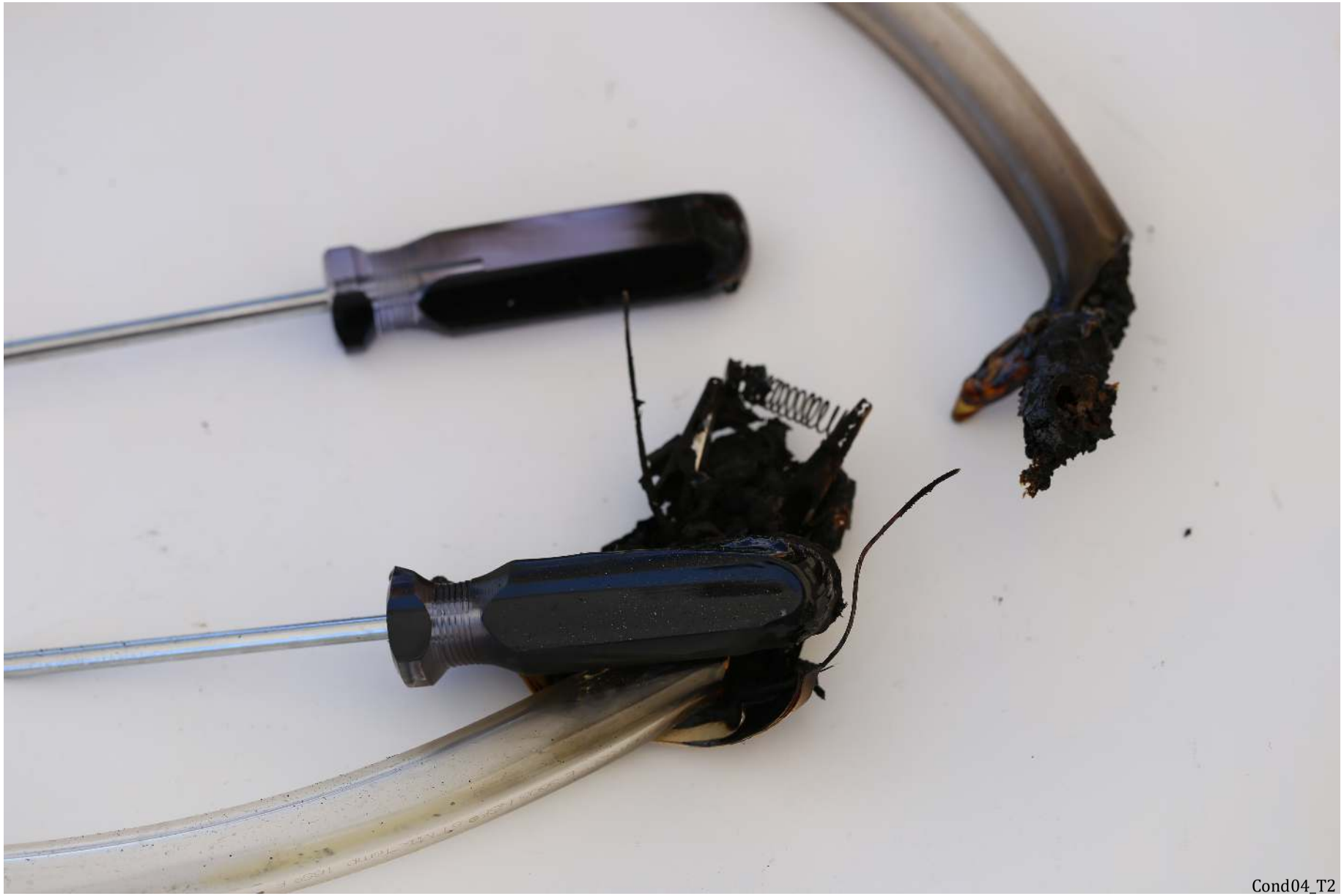


Figure 122: Condition 04 Trial 2. Tygon tubing burned but the flame did not travel along the tubing.

Figure 123: Condition 04 Trial 2. The mallet handle sustained a fire and was nearly completely charred.

Figure 124: Condition 04 Trial 2. Horsehair was singed.

Figure 125: Condition 04 Trial 2. The contents of the fire resistant container did not burn. The bag melted slightly.

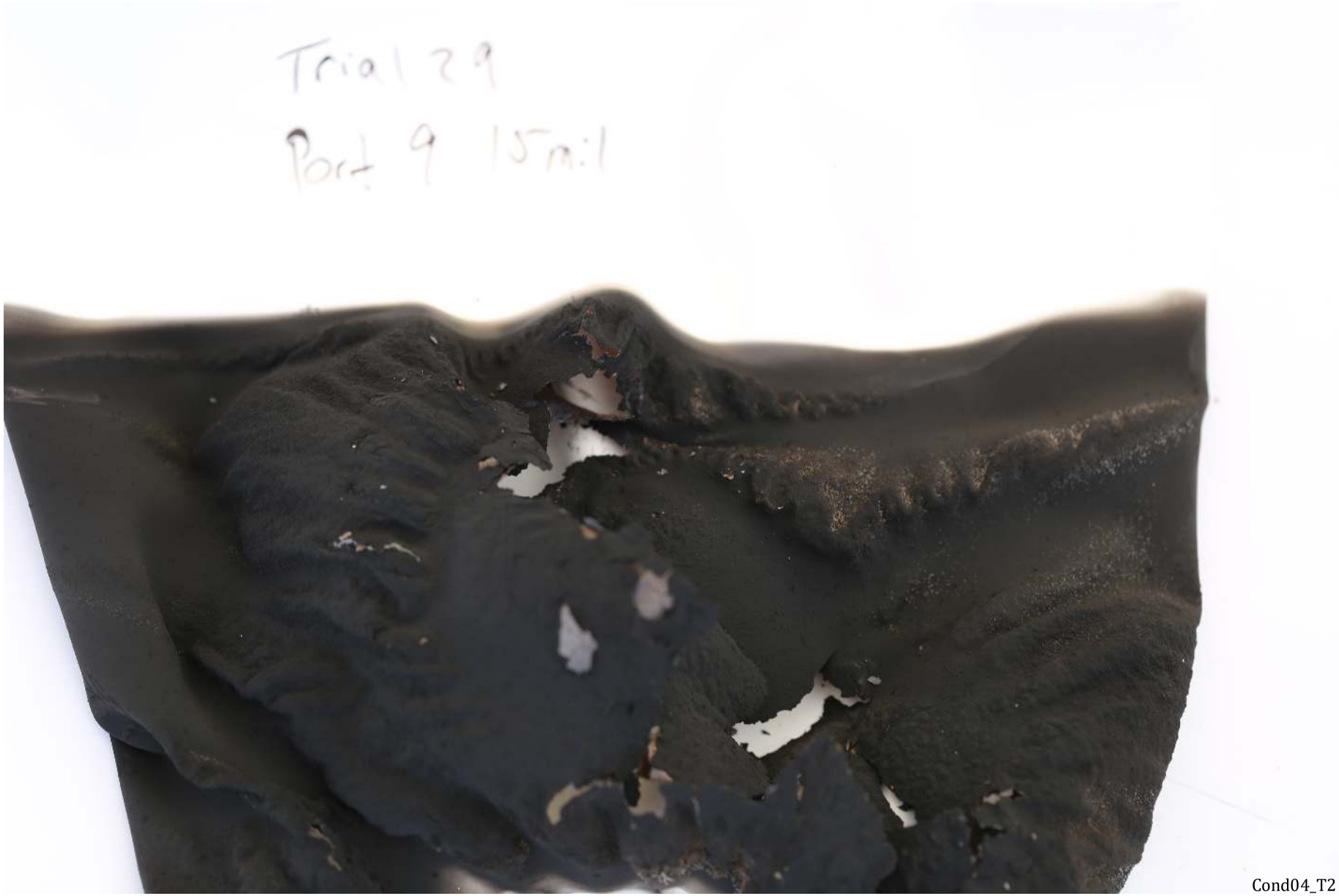


Figure 126: Condition 04 Trial 2. The port 9 glove was charred and cracked near the ring.

Figure 127: Condition 04 Trial 3. A small fire damaged consumables and a single glove.

Figure 128: Condition 04 Trial 3. Tygon tubing, horsehair, and sandpaper contributed to the fire.

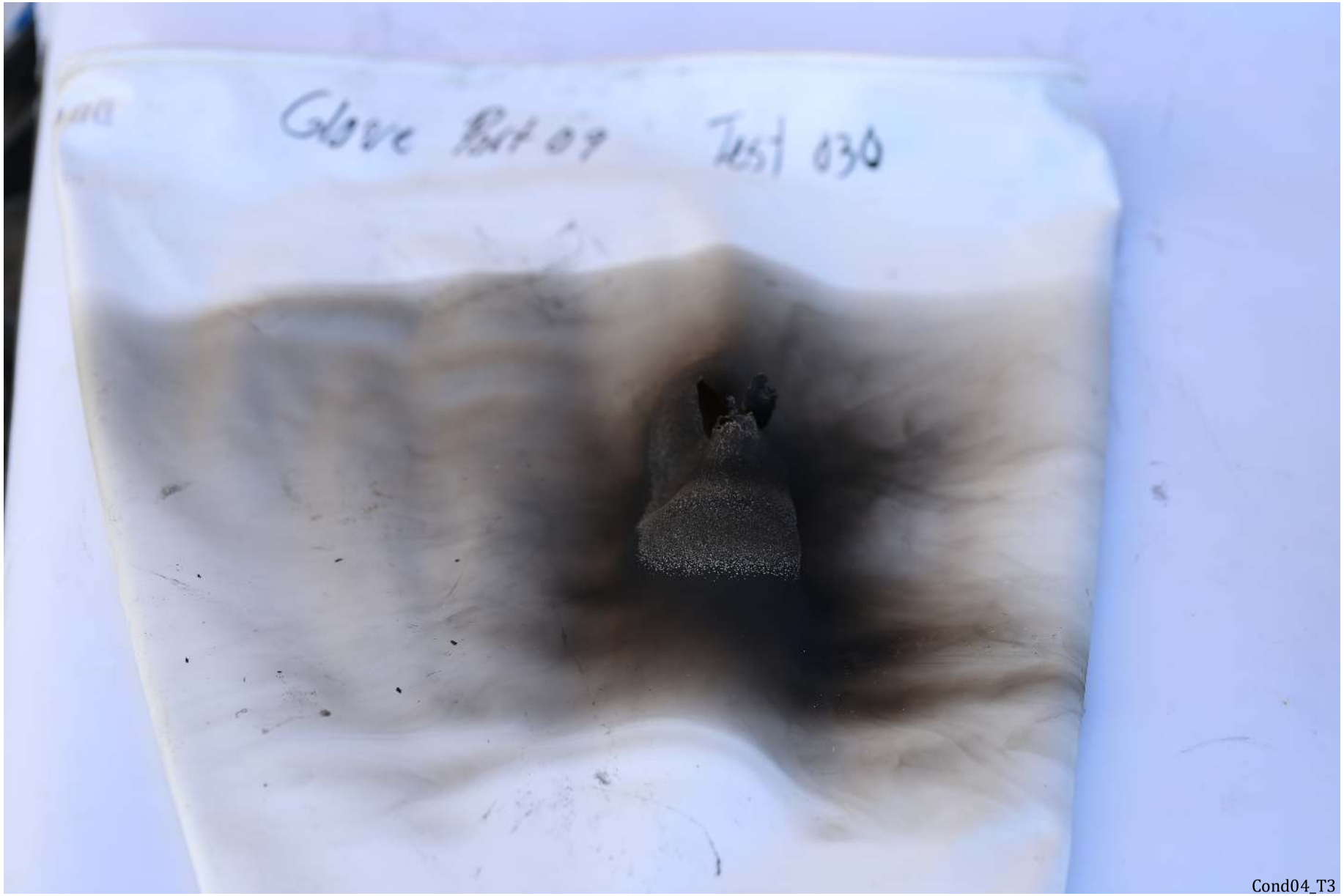


Figure 129: Condition 04 Trial 3. A small hole was burned in the port 9 glove near the ring.

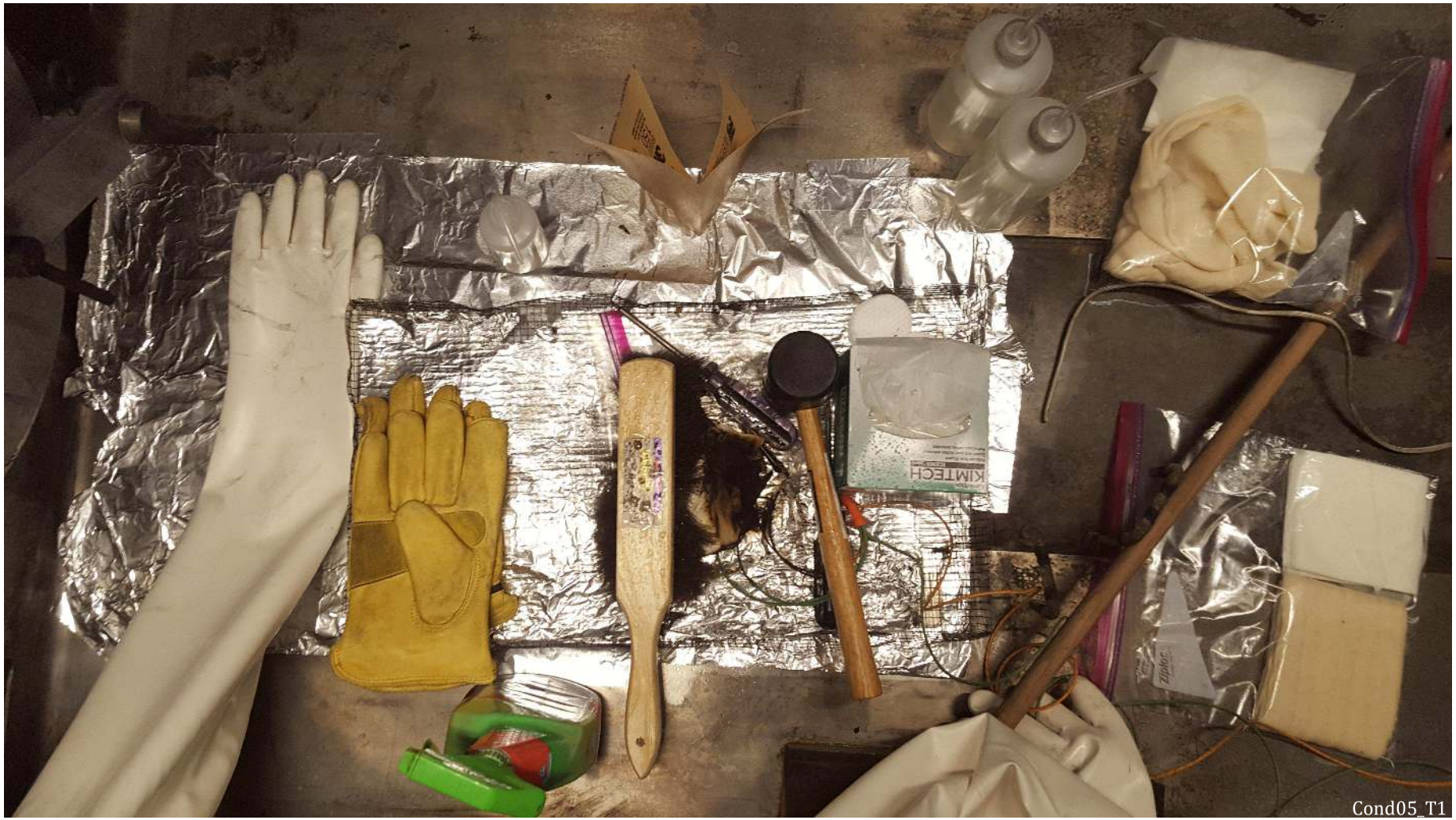


Figure 130: Condition 05 Trial 1. A small fire damaged several consumables.

Figure 131: Condition 05 Trial 1. Crumpled task wipes burned.

Figure 132: Condition 05 Trial 1. The horsehair brush was slightly singed.

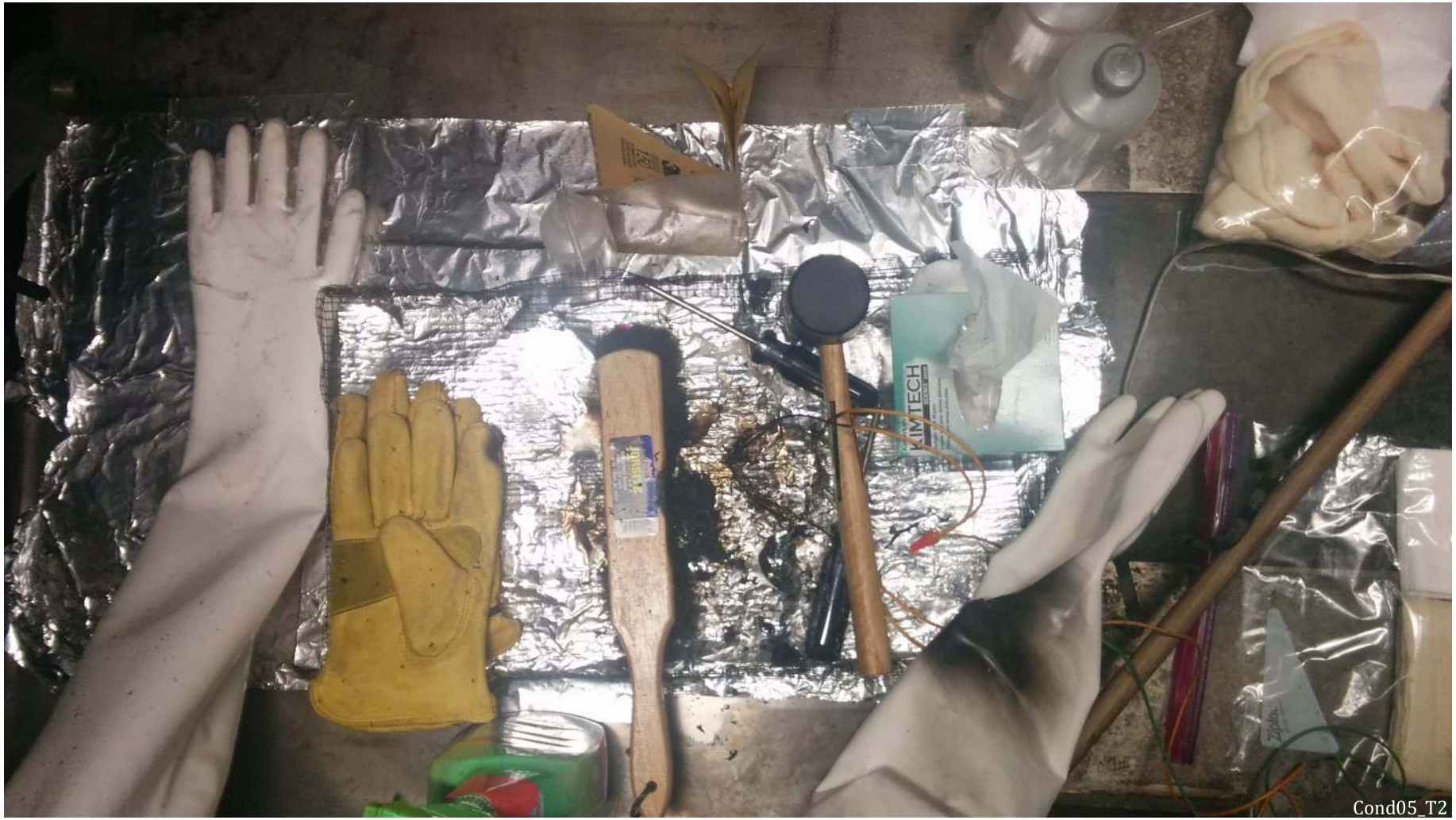


Figure 133: Condition 05 Trial 2. A small fire damaged several consumables and caused a small glove breach.

Figure 134: Condition 05 Trial 2. Many consumables were not damaged.

Figure 135: Condition 05 Trial 2. The horsehair brush was singed.

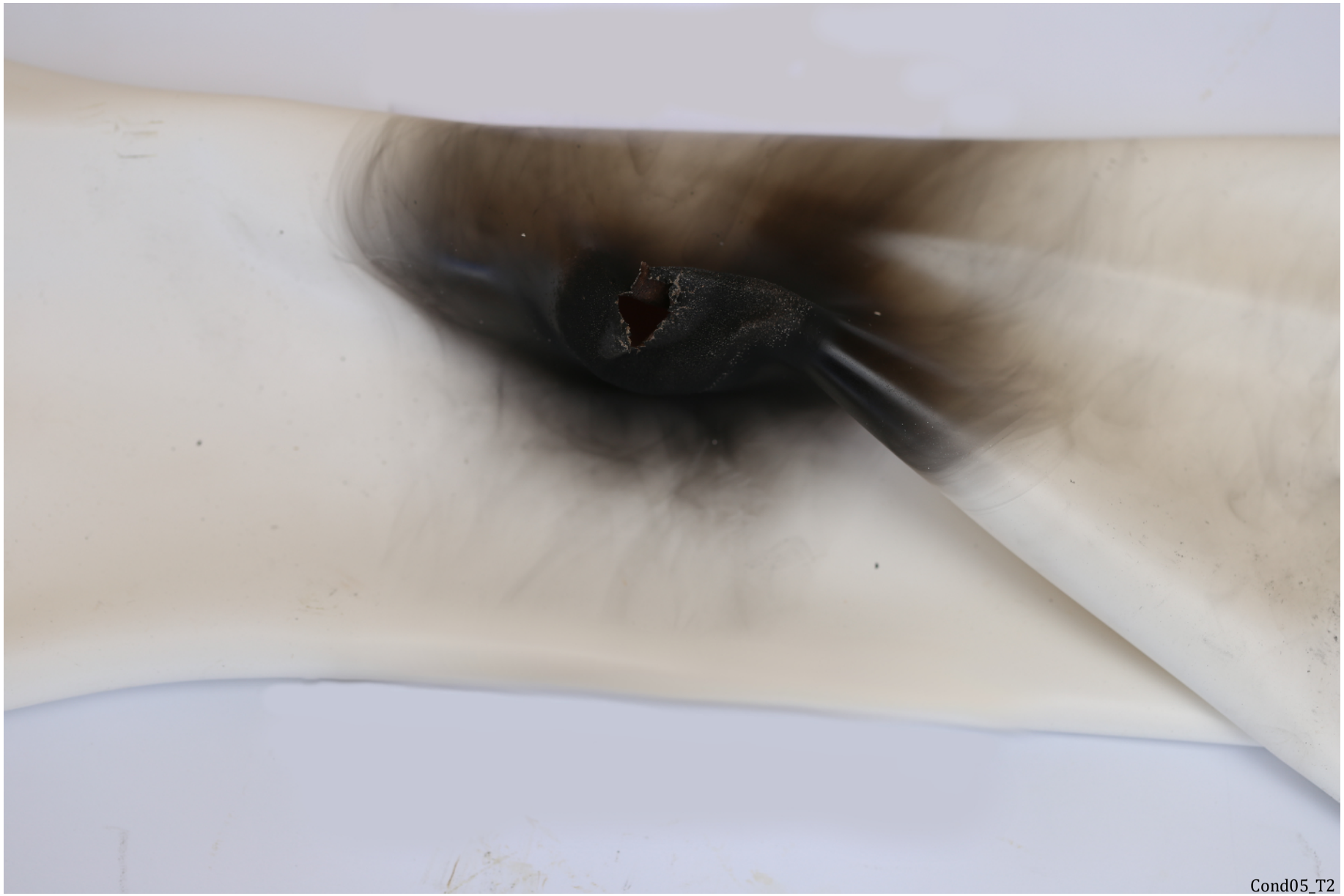


Figure 136: Condition 05 Trial 2. A small hole was burned in the port 10 glove.

Figure 137: Condition 05 Trial 3. A small fire damaged several consumables.

Cond05_T3

Figure 138: Condition 05 Trial 3. The horsehair brush was lightly singed.

Figure 139: Condition 05 Trial 3. Task wipes were burned.

Figure 140: Condition 05 Trial 3. The handle of the mallet was burned.

Figure 141: Condition 05 Trial 3. Screwdrivers were charred.

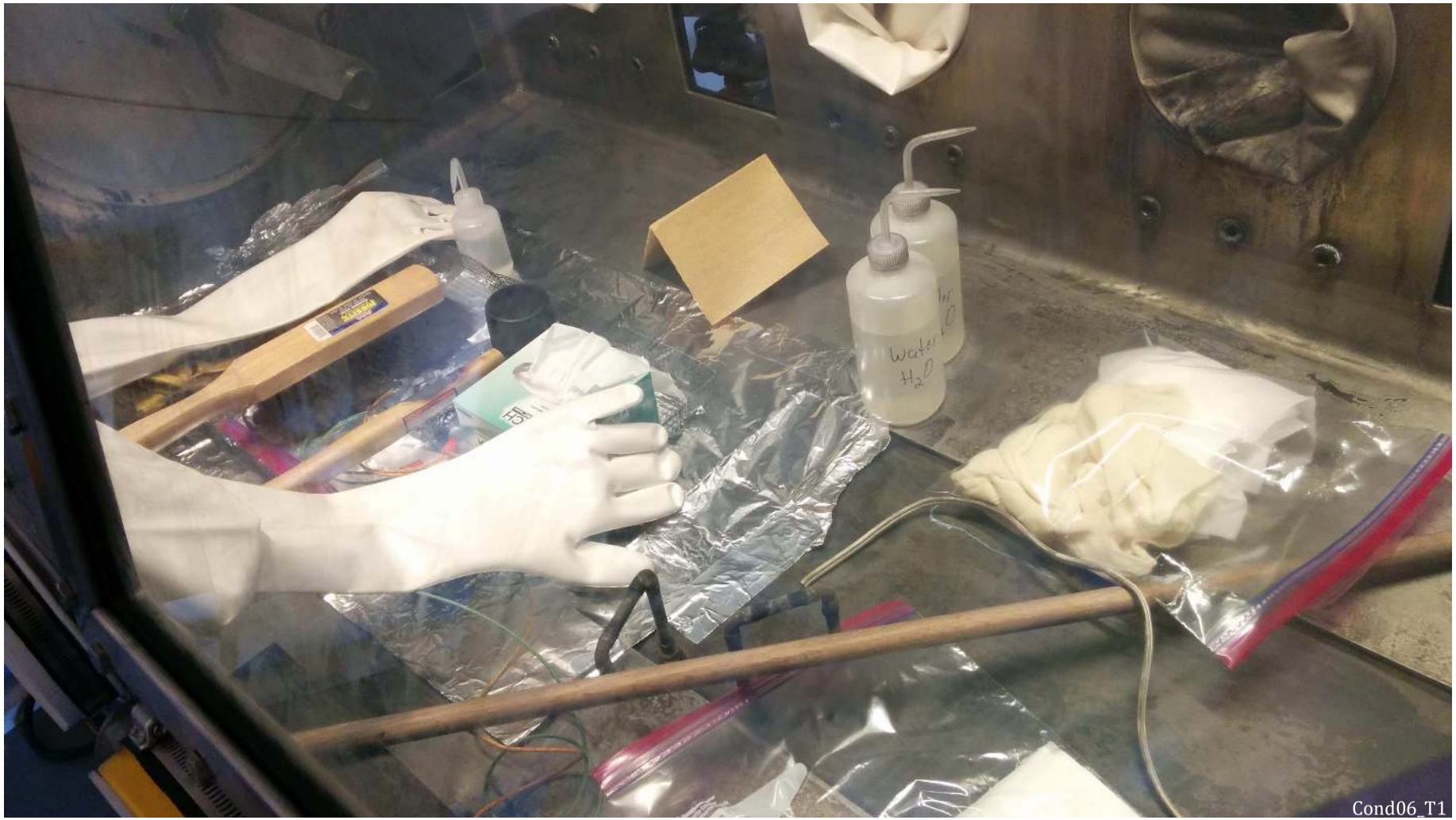


Figure 142: Condition 06 Trial 1. A small fire produced little damage.

Figure 143: Condition 06 Trial 1. The horsehair brush and mallet were lightly singed.

Figure 144: Condition 06 Trial 2. A small fire did little damage.

Figure 145: Condition 06 Trial 2. The horsehair brush was lightly singed.

Figure 146: Condition 06 Trial 3. A small fire did little damage.

Figure 147: Condition 06 Trial 3. The horsehair brush was lightly singed and task wipes were burned.

Figure 148: Condition 07 Trial 1. No consumables appear burned.

Figure 149: Condition 07 Trial 1. The igniter melted a small hole in the empty polypropylene bottle.

Figure 150: Condition 07 Trial 2. Consumables sustained very little damage.

Figure 151: Condition 07 Trial 2. Igniters burned a large hole in the empty polypropylene bottle.

Figure 152: Condition 07 Trial 2. The box of task wipes was singed.

Figure 153: Condition 07 Trial 3. No consumables appear burned.

Figure 154: Condition 07 Trial 3. The empty polypropylene bottle melted slightly where in contact with the igniter.

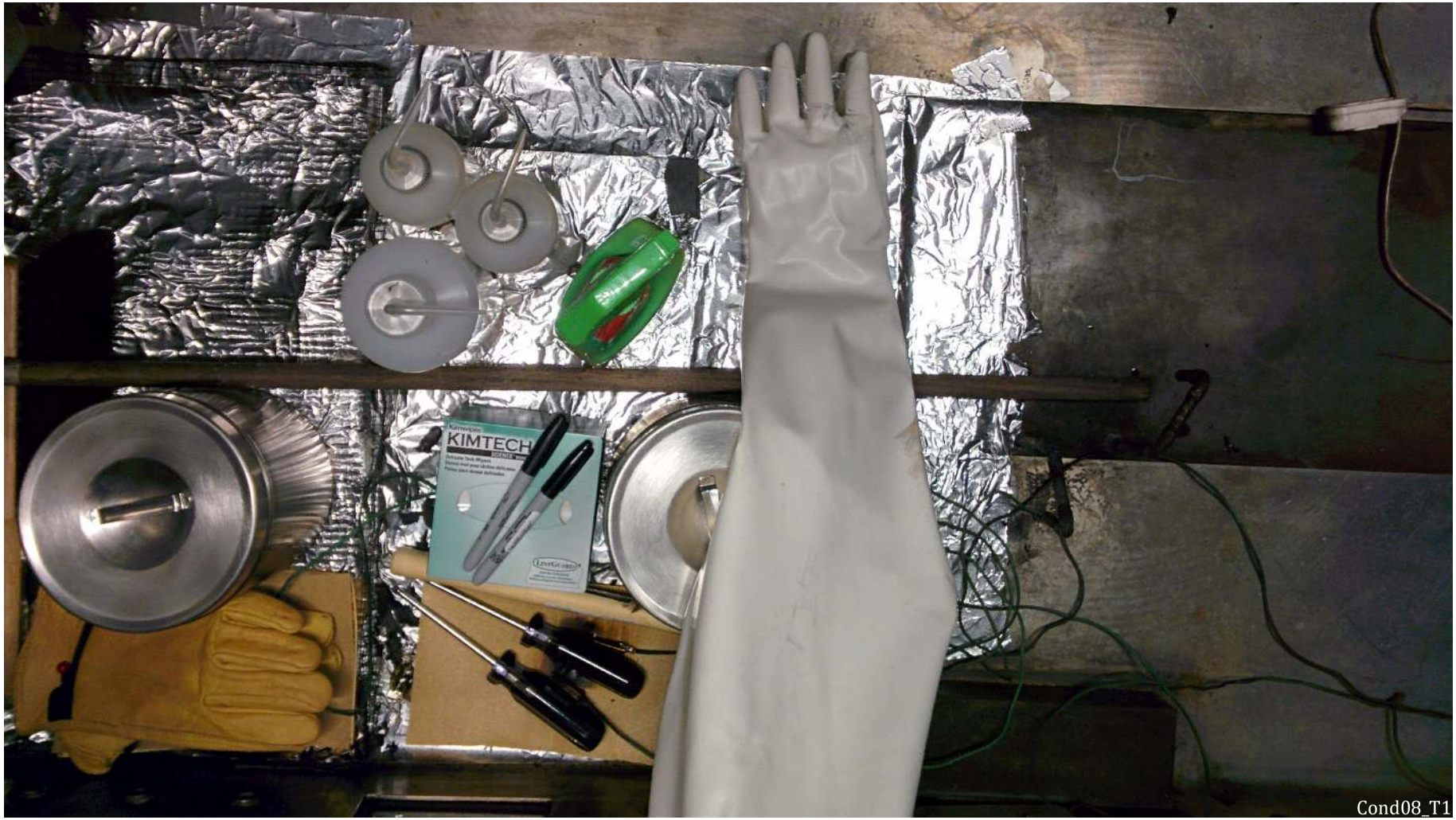


Figure 155: Condition 08 Trial 1. Consumables sustained very little damage.

Figure 156: Condition 08 Trial 2. Consumables sustained little damage.

Figure 157: Condition 08 Trial 2. Leather gloves exhibit slight charring.

Figure 158: Condition 08 Trial 2. A hole was burned through the sandpaper where it contacted the igniter.

Figure 159: Condition 08 Trial 2. Screwdrivers charred and melted where they contacted the igniter.

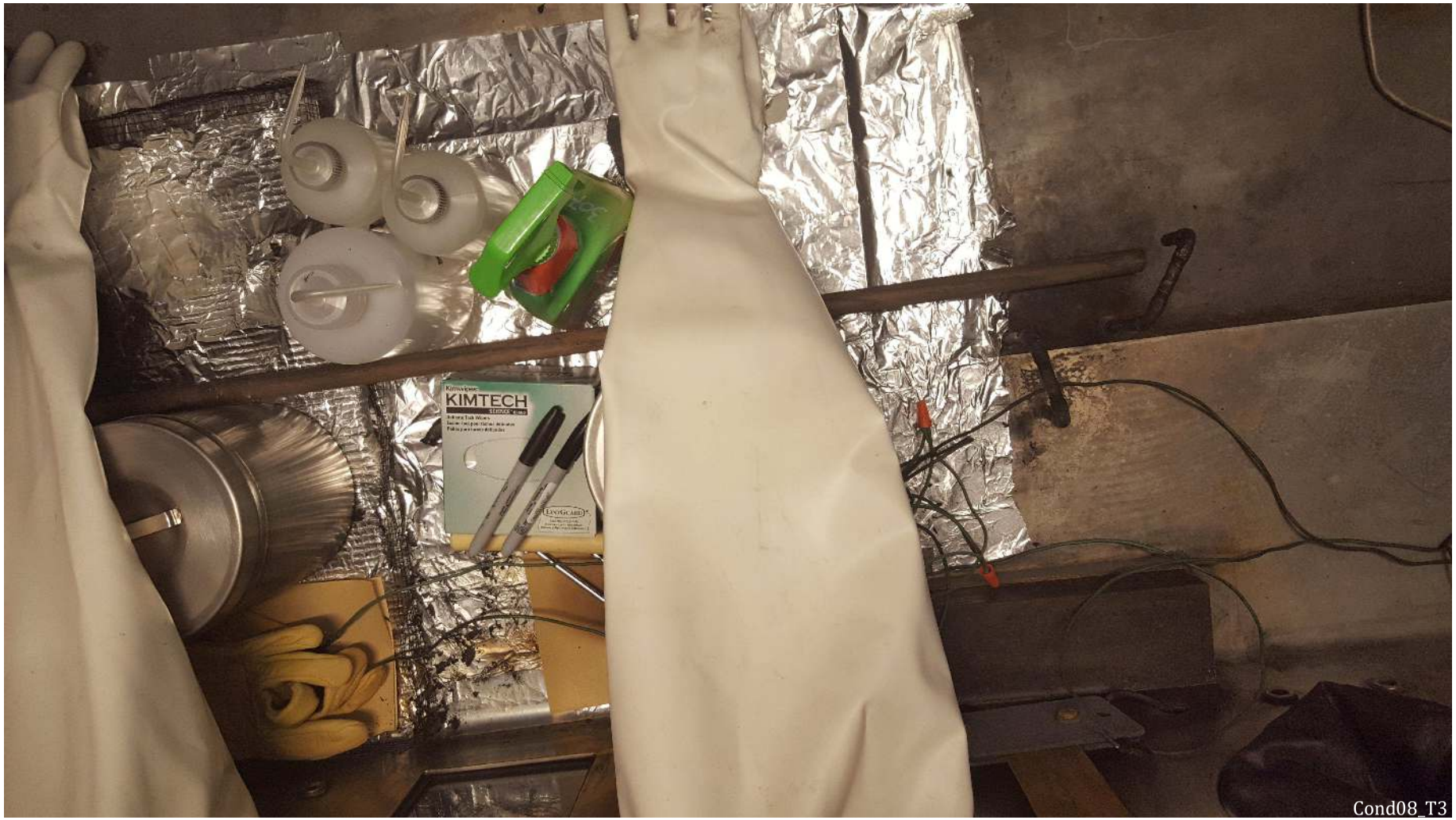


Figure 160: Condition 08 Trial 3. Minor damage to consumables occurred.

Figure 161: Condition 08 Trial 3. Leather gloves exhibit isolated charring where they contacted the igniter.

Figure 162: Condition 08 Trial 3. Holes burned through the sandpaper where it contacted the igniters.

Figure 163: Condition 08 Trial 3. Screwdrivers were charred and melted where they contacted with igniters.

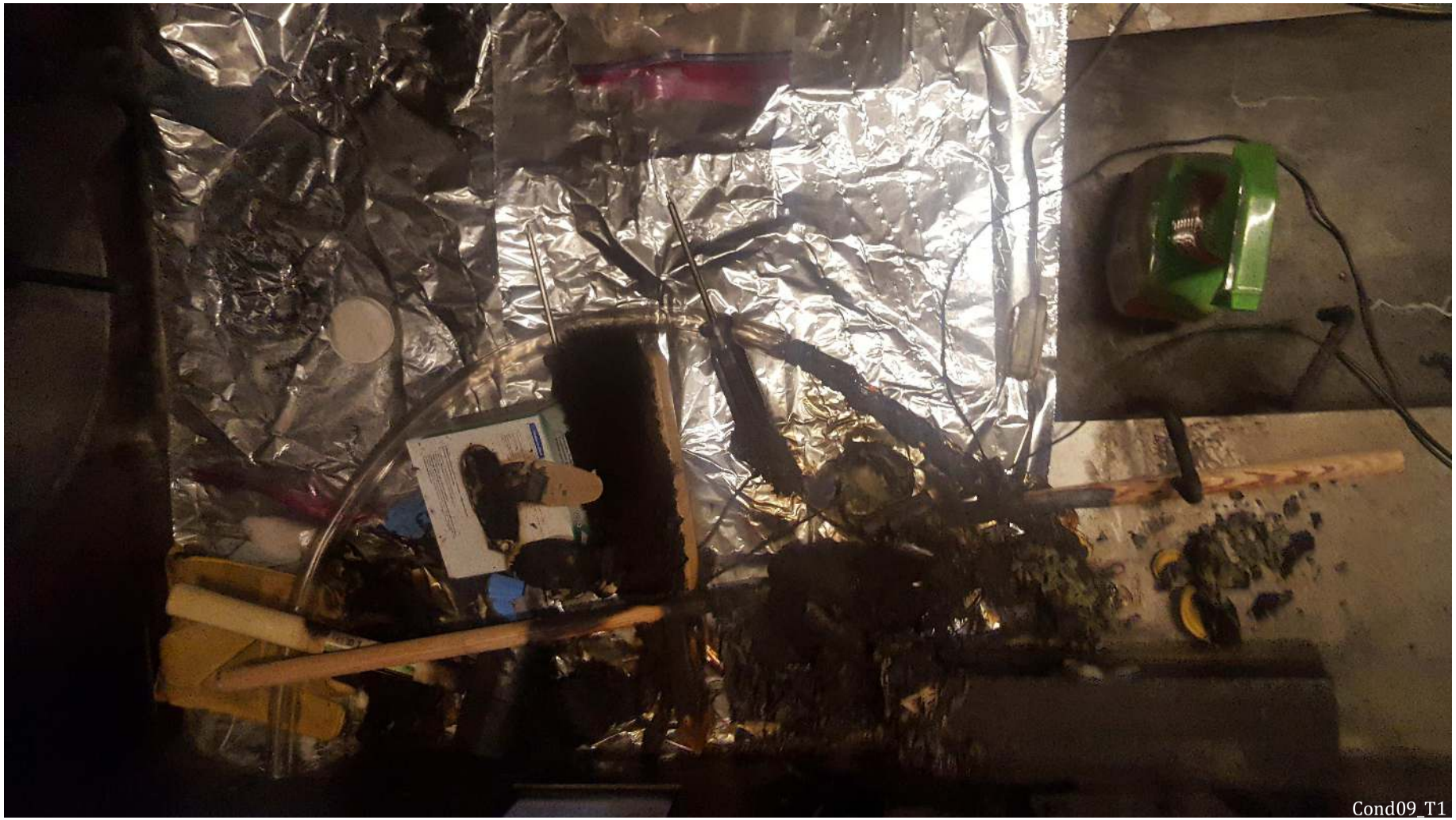


Figure 164: Condition 09 Trial 1. Consumables were severly burned and the fire breached gloves in port covers.

Figure 165: Condition 09 Trial 1. Enough soot was produced to sufficiently pack the exhaust filter.

Figure 166: Condition 09 Trial 1. The horsehair brush, screwdrivers, mallet, and wooden dowel were all charred and burned.

Figure 167: Condition 09 Trial 1. Task wipes, leather gloves, and nitrile gloves contributed to the fire.

Figure 168: Condition 09 Trial 1. Fire burned and traveled along the Tygon tubing.

Figure 169: Condition 09 Trial 1. A bag of used cheesecloth was blackened slightly but the cheesecloth did not ignite.

Figure 170: Condition 09 Trial 1. The port 10 glove (Inside port cover) burned severely.

Figure 171: Condition 09 Trial 1. The port 10 ring was blackened and melted.

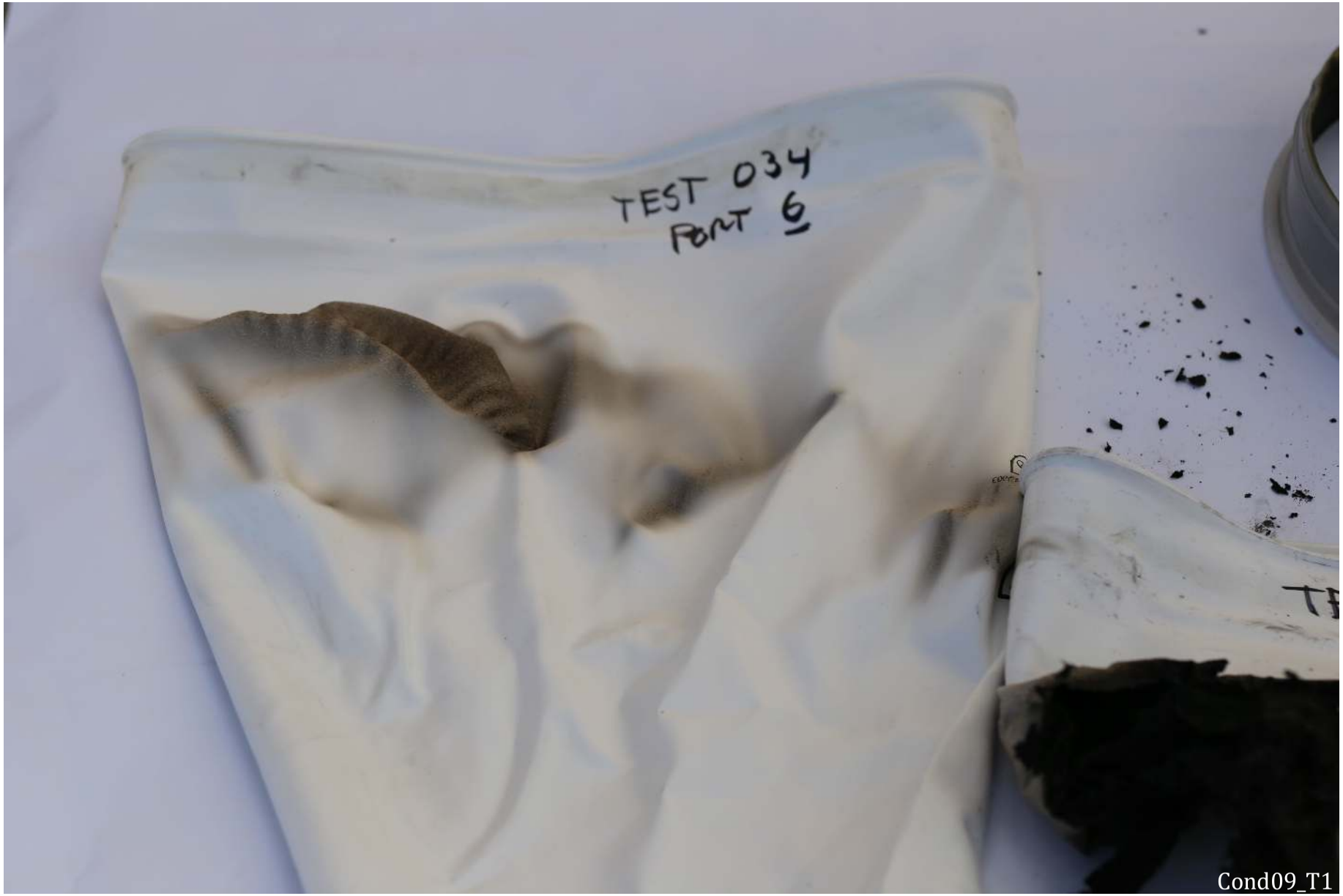


Figure 172: Condition 09 Trial 1. The port 6 glove sustained slight damage near the ring.

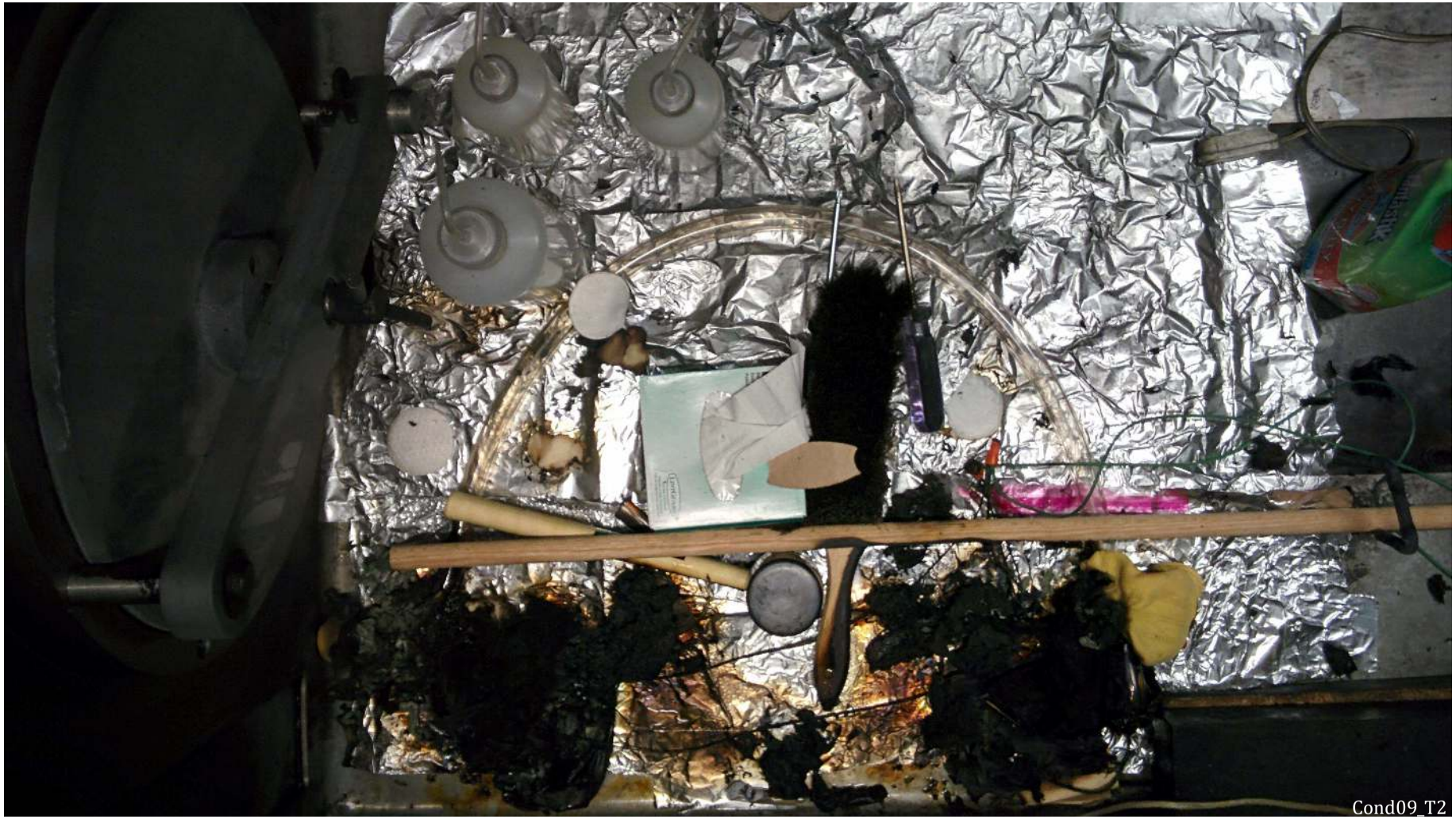


Figure 173: Condition 09 Trial 2. Consumables were burned severely and several gloves in port covers were breached.

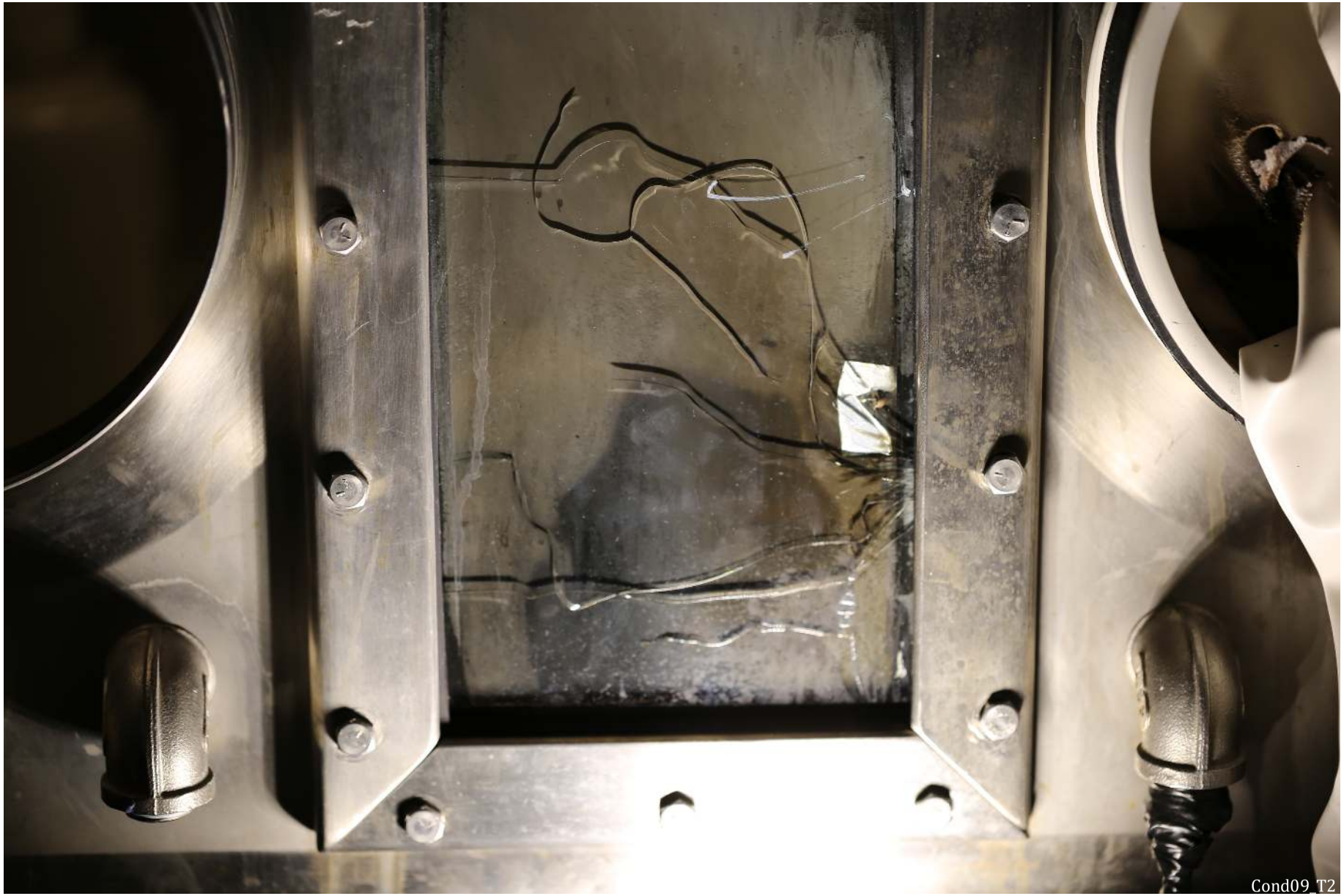


Figure 174: Condition 09 Trial 2. The fire cracked the window between port 9 and port 10.

Figure 175: Condition 09 Trial 2. The horsehair brush, mallet handle, Tygon tubing, leather gloves, and task wipes were consumed in the fire.

Figure 176: Condition 09 Trial 2. A marker was involved in the fire.

Figure 177: Condition 09 Trial 2. The port 7 glove was damaged near the port ring.

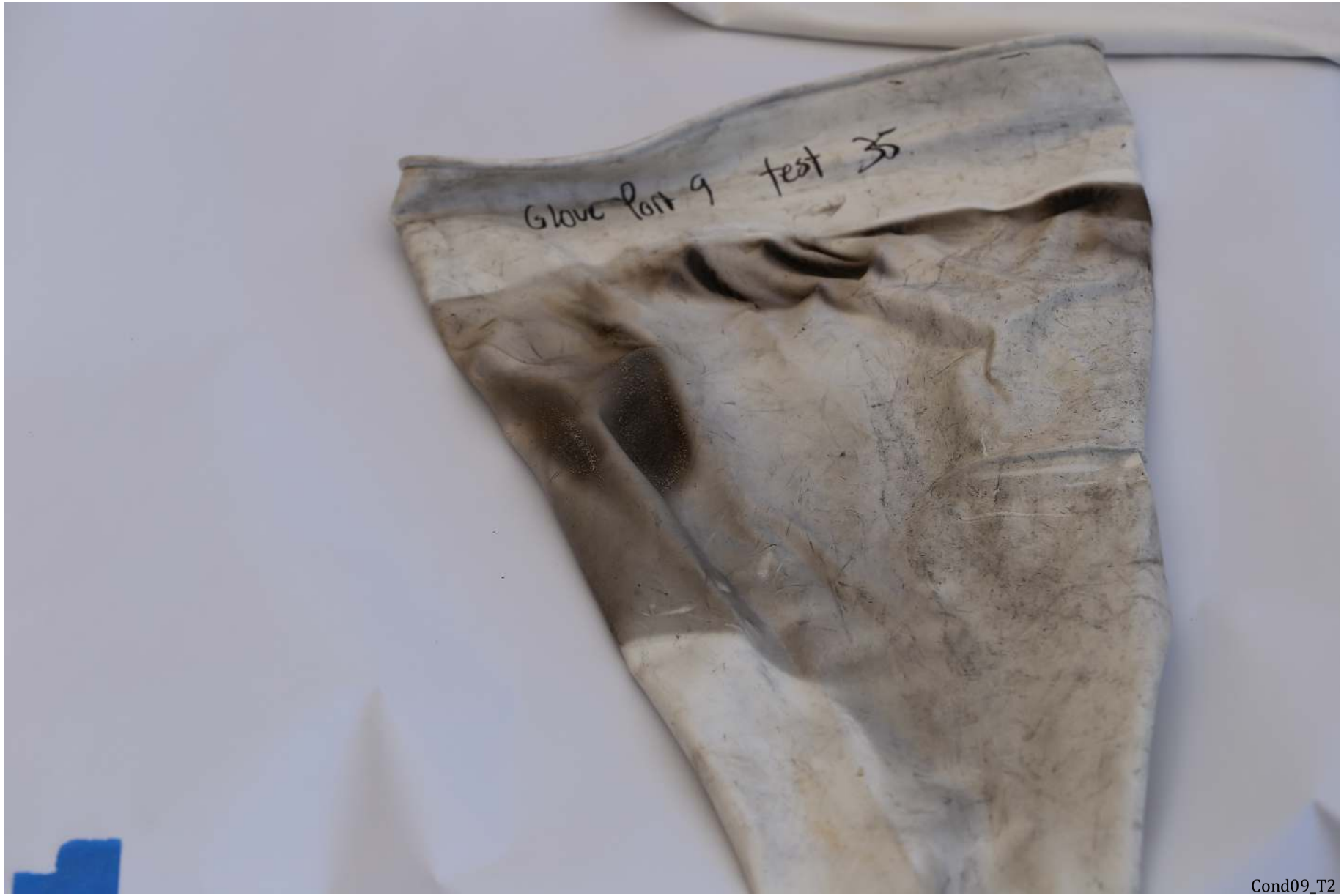


Figure 178: Condition 09 Trial 2. The port 9 glove exhibits bubbling near the ring.

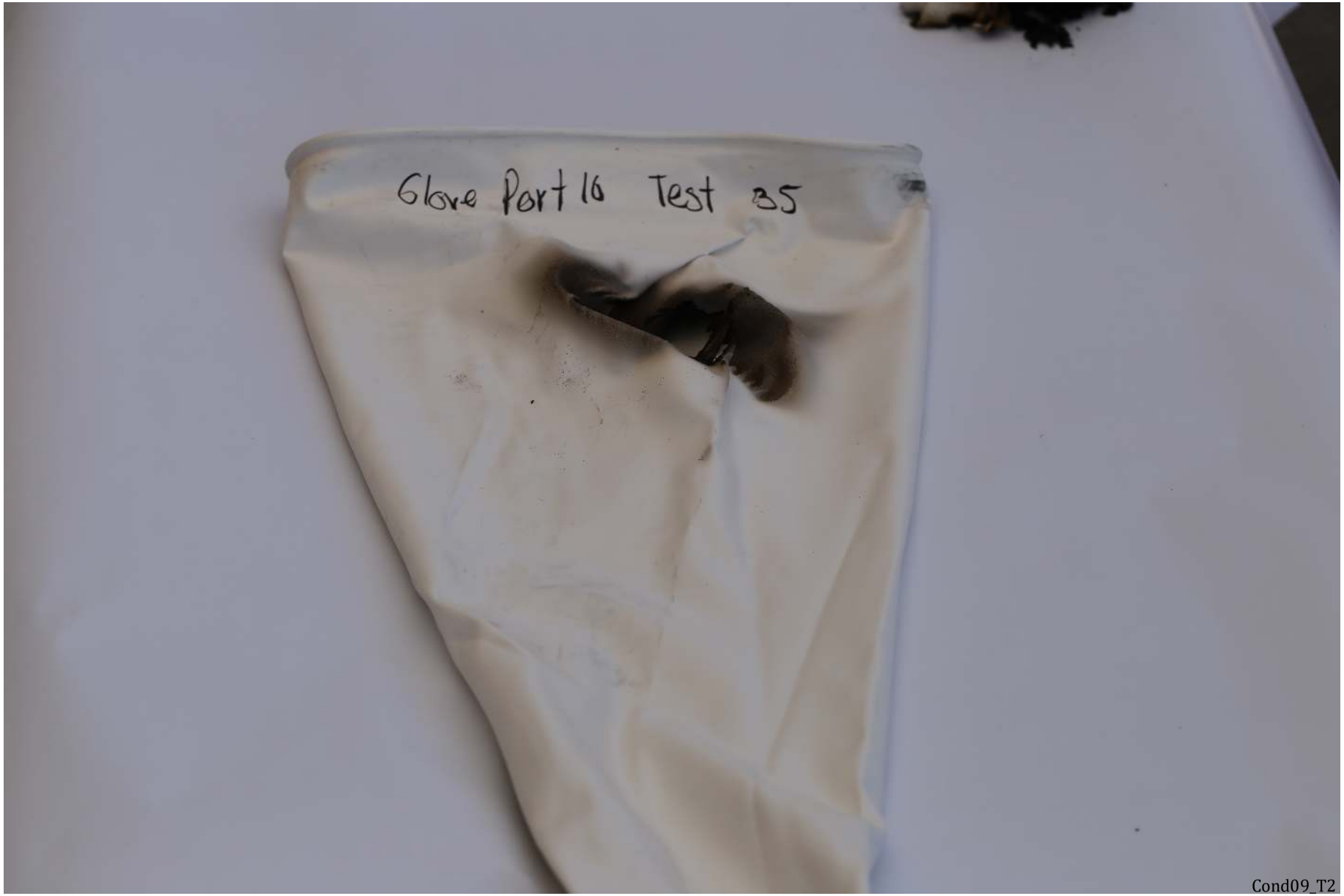


Figure 179: Condition 09 Trial 2. A small hole was burned in the port 10 glove near the ring.

Figure 180: Condition 09 Trial 2. The port 10 ring was damaged along the edge.

Figure 181: Condition 09 Trial 3. Consumables were burned and several gloves inside port covers were breached.

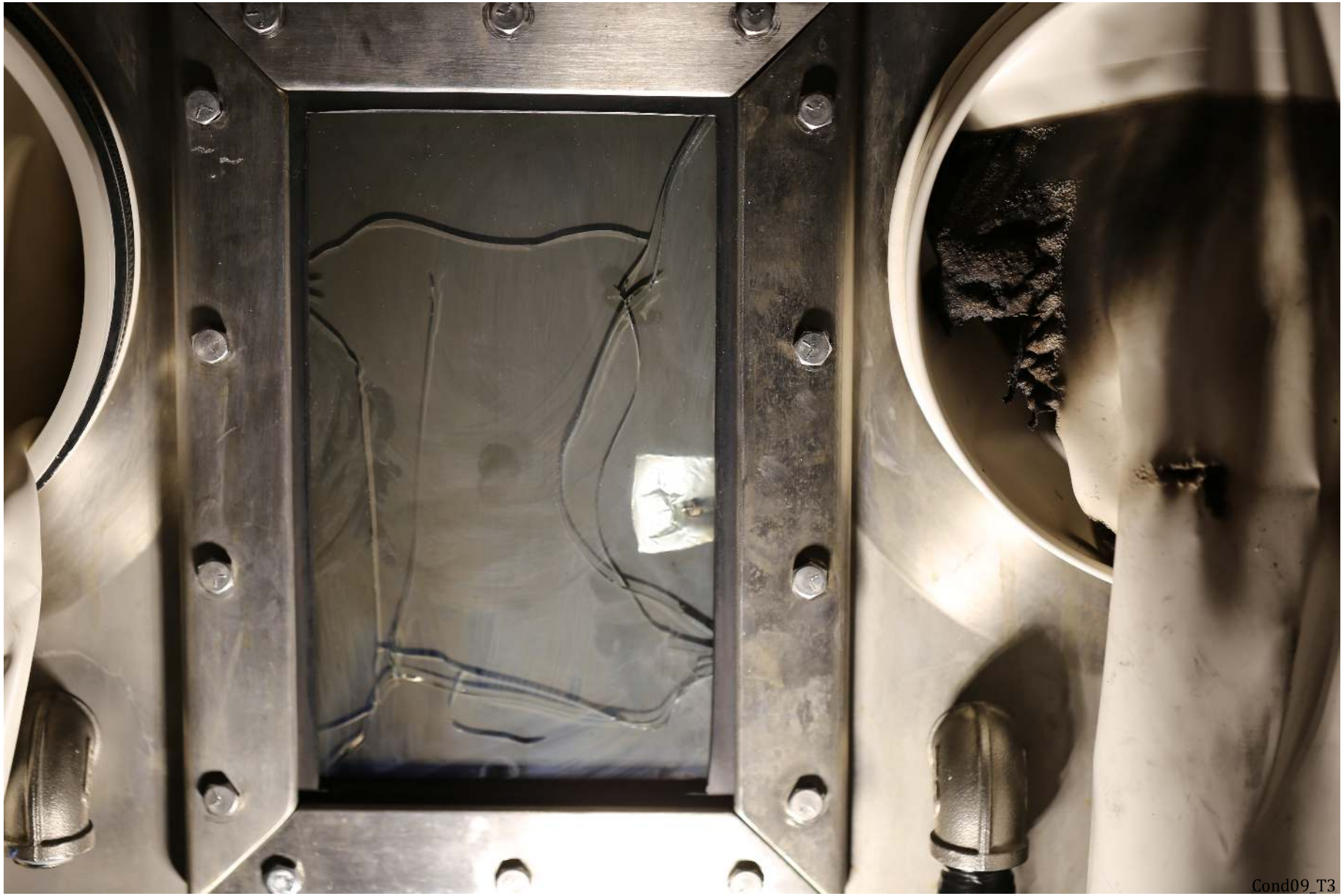


Figure 182: Condition 09 Trial 3. The window between port 9 and port 10 cracked.

Figure 183: Condition 09 Trial 3. The horsehair brush, mallet, dowel, and leather gloves were burned.

Figure 184: Condition 09 Trial 3. Task wipes, sandpaper, and markers were also burned.

Figure 185: Condition 09 Trial 3. The port 6 glove sustained slight damage near the port ring.

Figure 186: Condition 09 Trial 3. The port 10 glove sustained a substantial breach near the port ring.

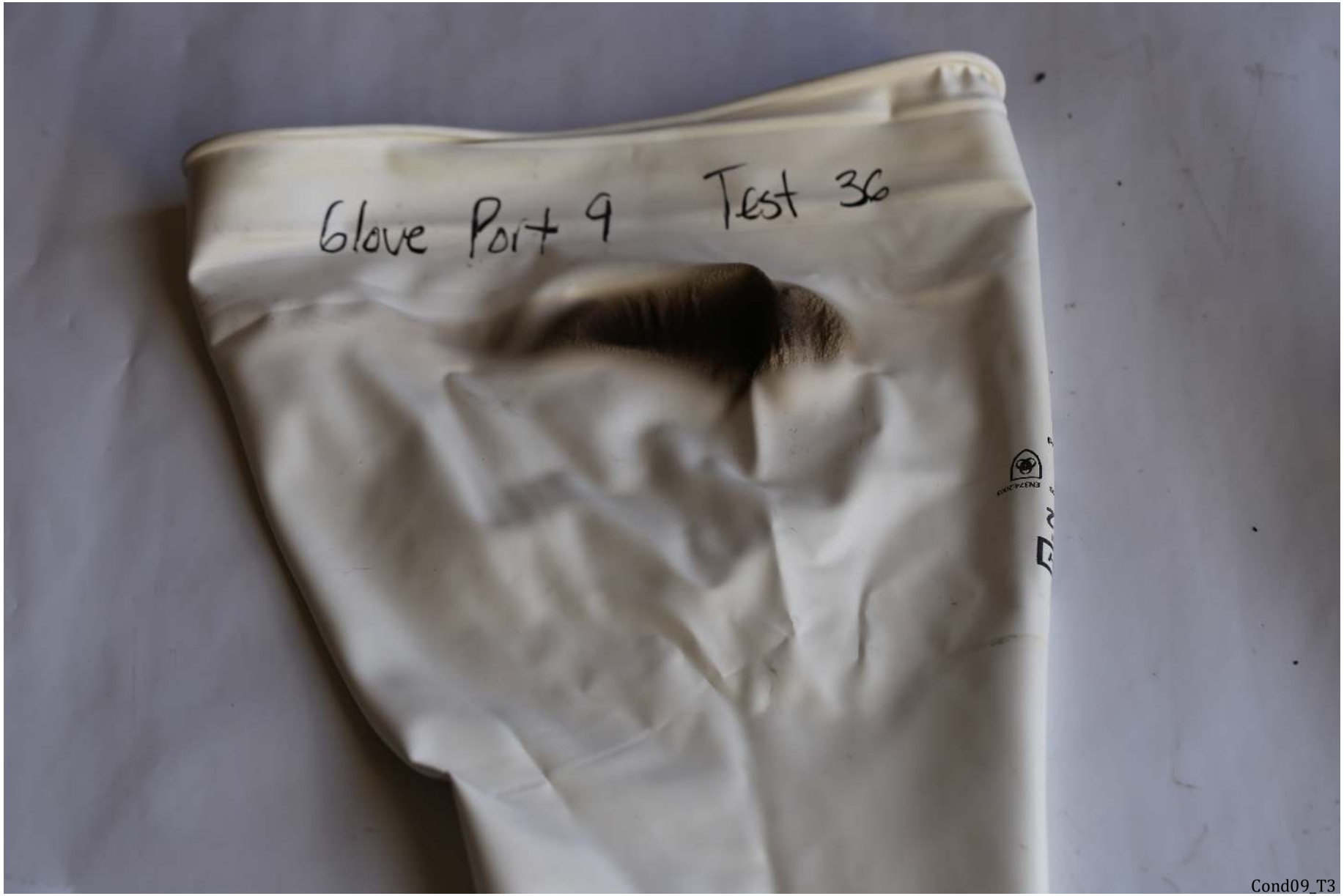


Figure 187: Condition 09 Trial 3. The port 9 glove exhibits bubbling near the ring.

Figure 188: Condition 09 Trial 3. The port 5 glove was blackened and sustained a possible small breach.

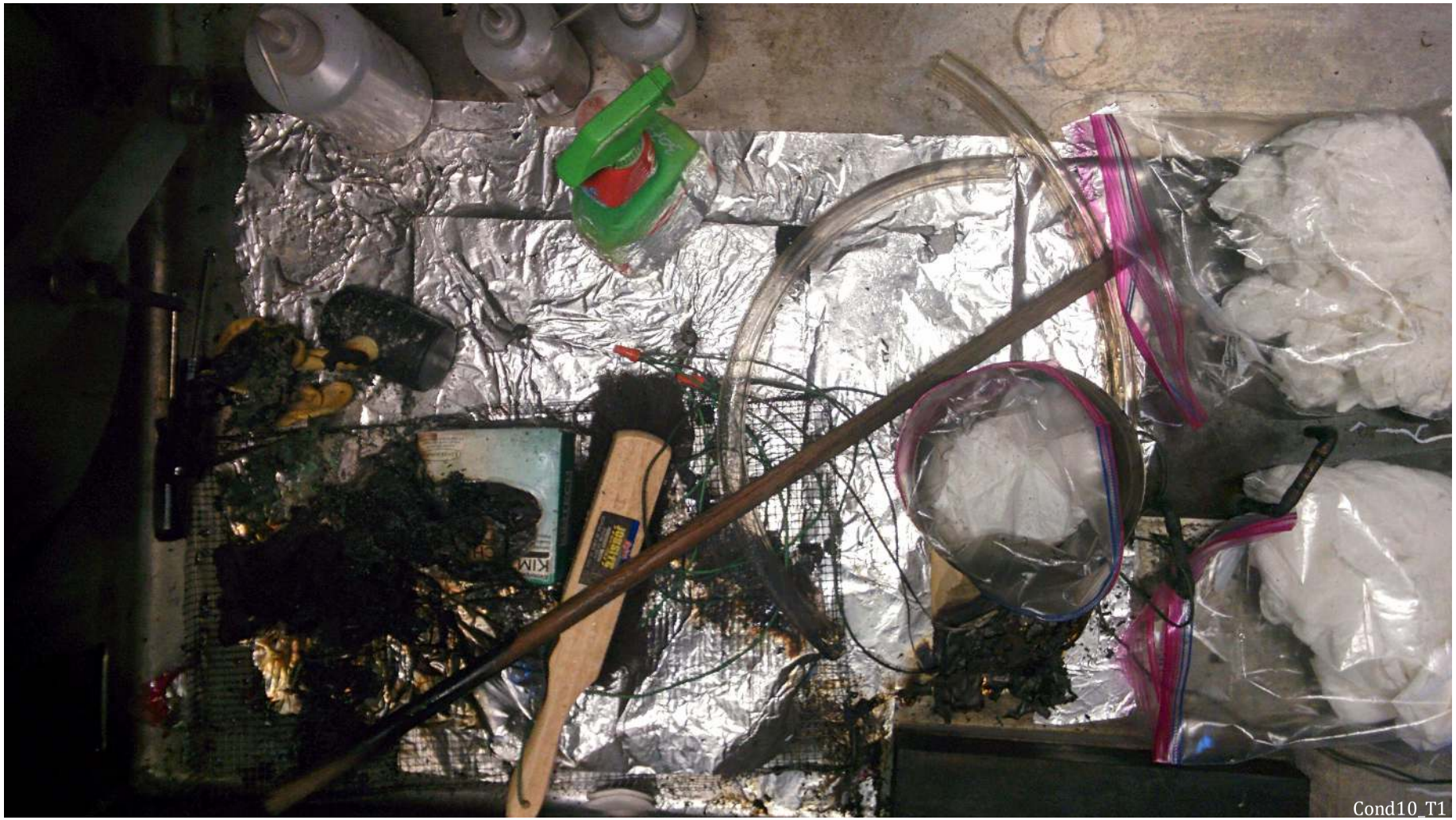


Figure 189: Condition 10 Trial 1. A farily large fire burned many consumables but did not travel across the GB.

Figure 190: Condition 10 Trial 1. Gloves piled across the GB from the igniters were not involved.

Figure 191: Condition 10 Trial 1. Task wipes, rags, horsehair,and screwdrivers participated.

Figure 192: Condition 10 Trial 1. The contents of the fire resistant container did not burn. Tygon tubing burned but the fire remained isolated.

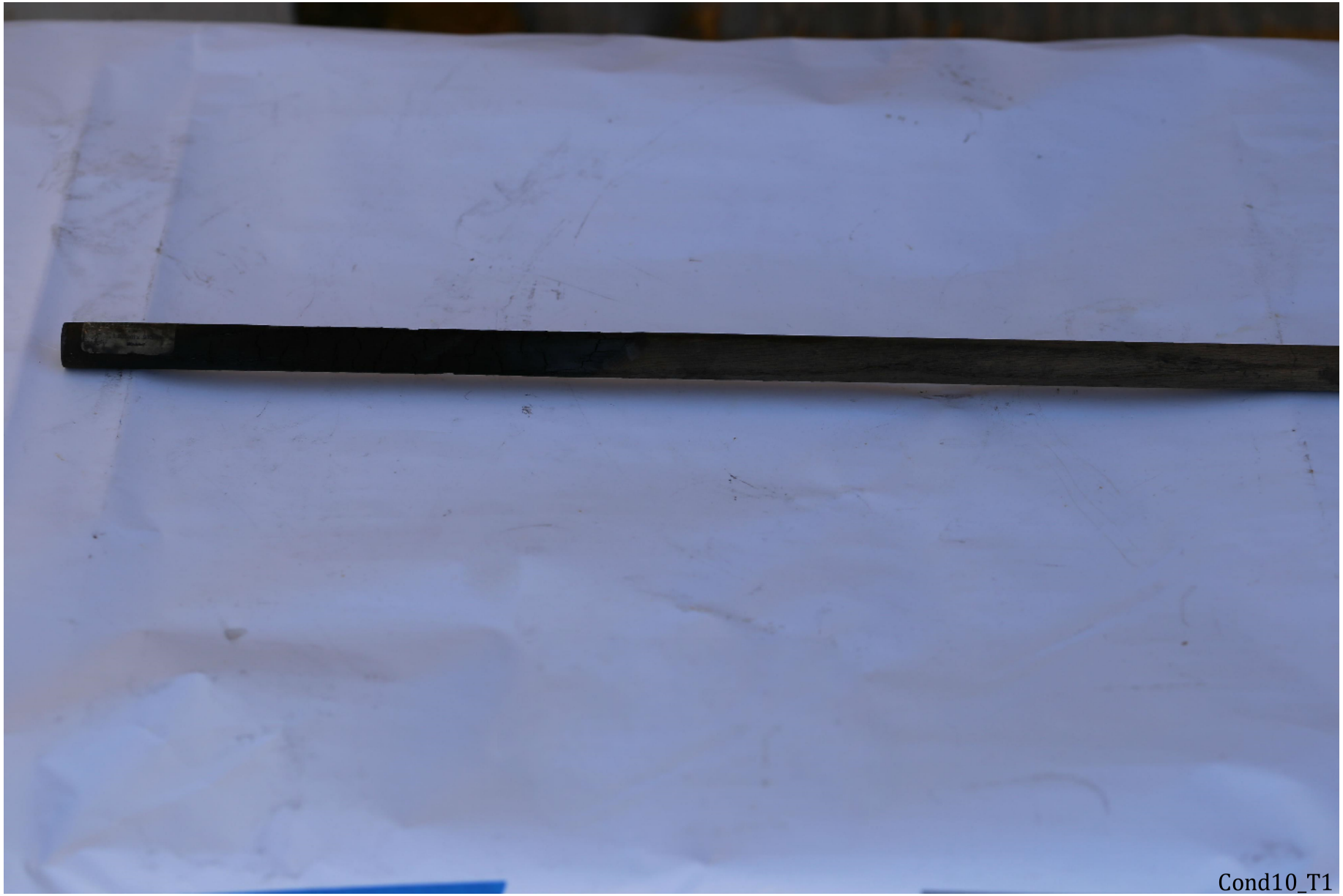


Figure 193: Condition 10 Trial 1. The wooden dowel caught fire and charred thoroughly.

Figure 194: Condition 11 Trial 1. With the lids on, fire resistant containers prevented the contents from participating.

Figure 195: Condition 11 Trial 1. The port 10 glove sustained slight damage.

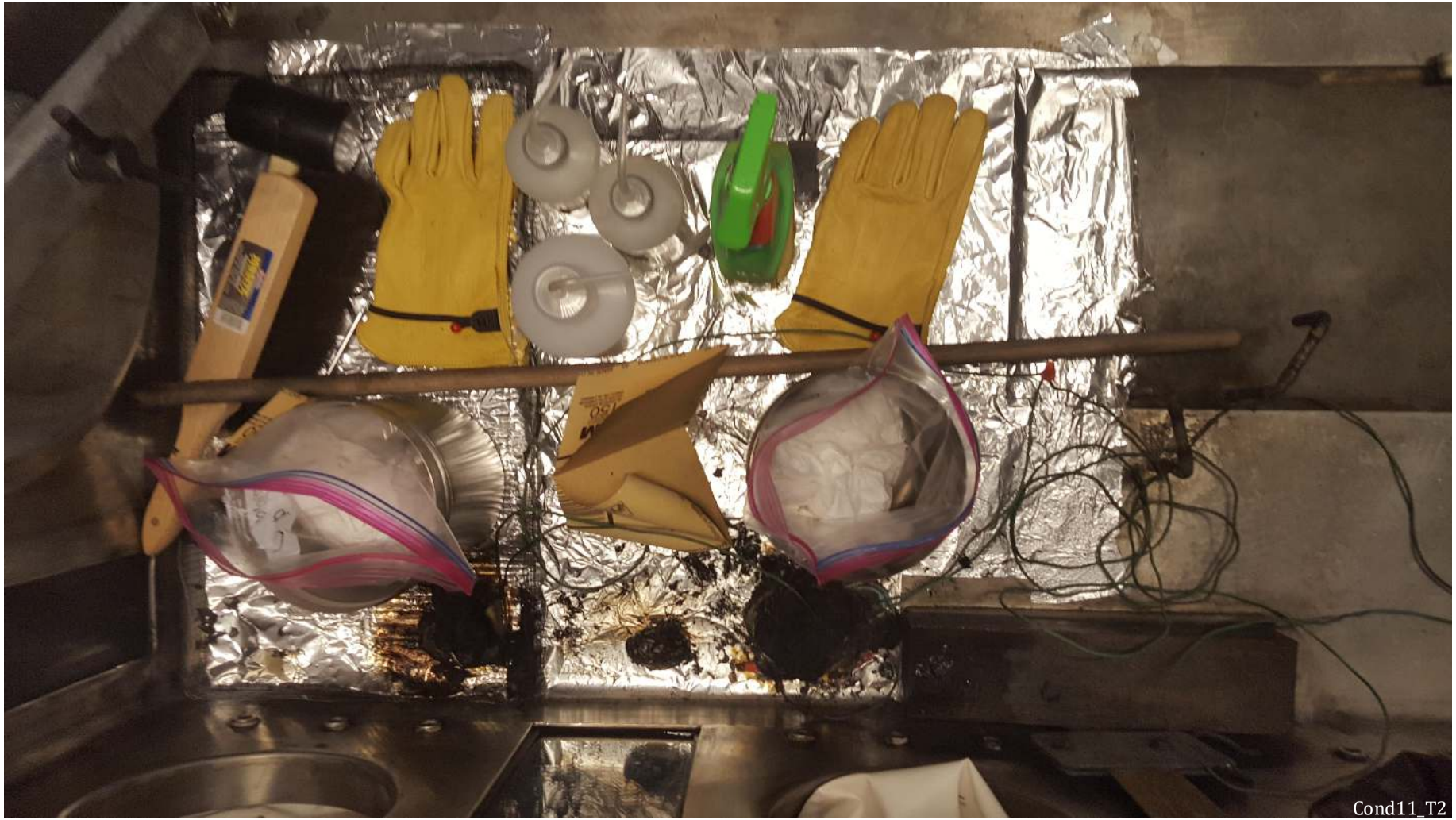


Figure 196: Condition 11 Trial 2. Some consumables were burned but the cheesecloth inside the fire resistant containers did not participate.

Figure 197: Condition 11 Trial 2. Sandpaper, task wipes, and a shop towel were burned.

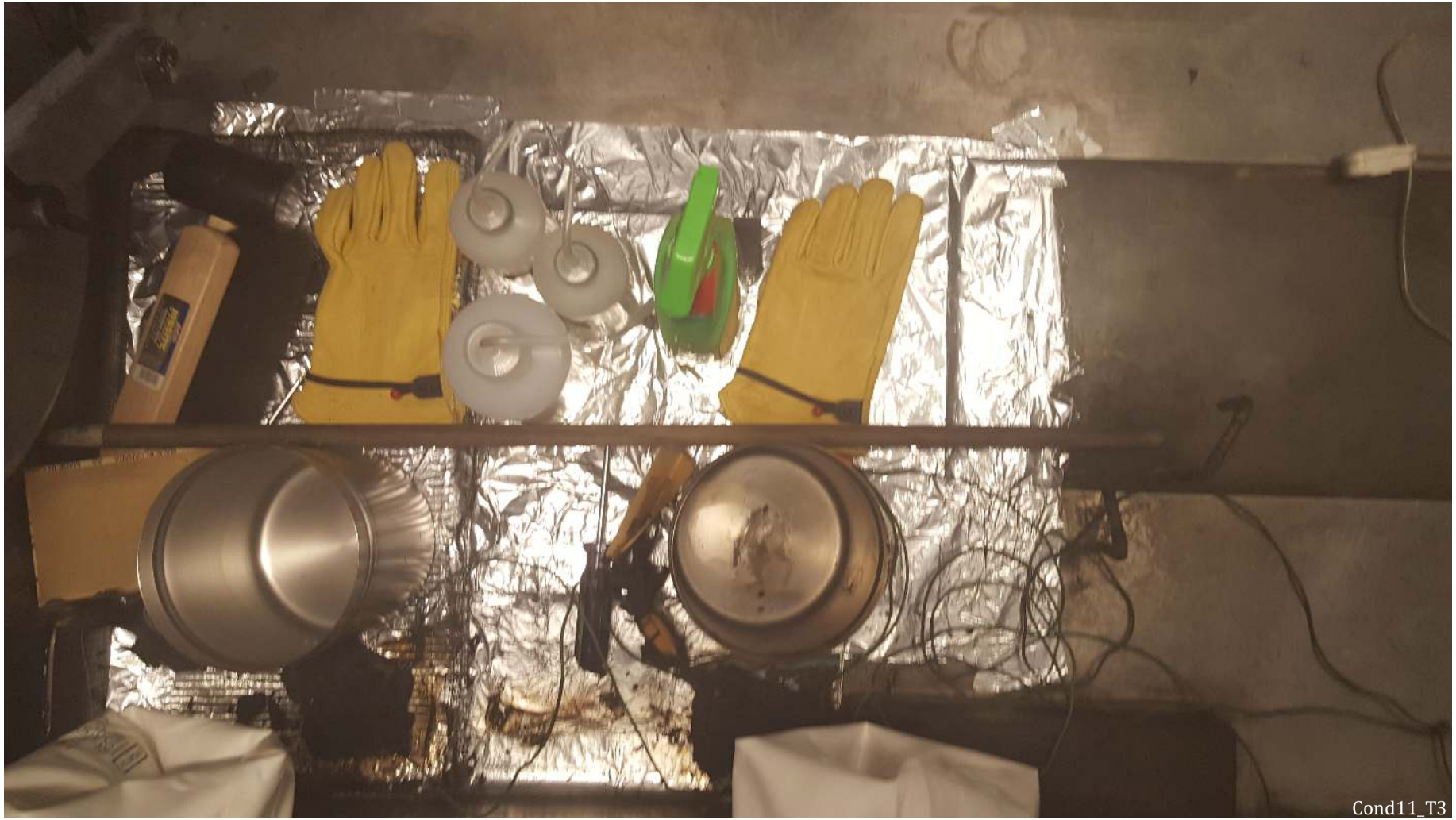


Figure 198: Condition 11 Trial 3. Consumables were burned but the cheesecloth inside the containers did not participate.

Figure 199: Condition 11 Trial 3. Sandpaper, task wipes, and a shop towel were burned.

Figure 200: Filters from the first seven trials exhibit different amounts of packing based largely on glove involvement in fires.

Figure 201: Inlet filters did not pack as quickly as exhaust; the same filter was often used for multiple consecutive trials.

H Student Symposium Posters

Glovebox Combustion Experiments

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Dan L. Puckett, Maria Ruiz, Christopher Schmittle, Jamie Kimberley and David Grow
New Mexico Tech, Department of Mechanical Engineering

LA-UR-16-25381

Instrumentation / Setup

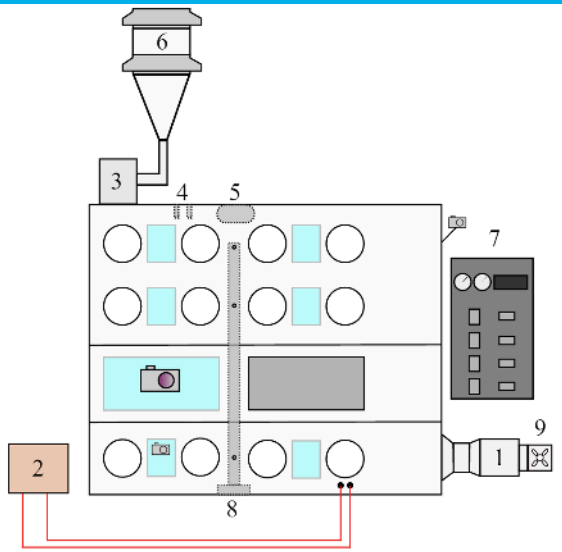

Figure 1. Glovebox configuration in bunker.

1: 8" Square Inlet Filter
2: Ignition Junction Box
3: 8" Circular Exhaust Filter
4: Heat Detectors
5: Fire Supression System
6: Stacked Exhaust Fans
7: Pressure Sensors
8: Thermocouples
9: Velocicalc Anemometer
: Greyscale Digital Cameras
: Infrared Camera

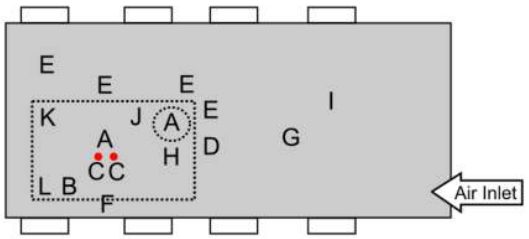

Figure 2. Representative layout of consumables.

A. Ignition Bag
B. Sand Paper
C. Screwdriver
D. Mallet
E. Poly Bottle
F. Leather Glove
G. Push Rod
H. Horsehair Brush
I. Scale Cord
J. Cotton Rounds
K. Kim Wipes
L. Fantastik Cleaner
Wire Mesh Basket
Steel Container (Closed)
Igniter Coils

Objective

Experiments were conducted to investigate how glovebox (GB) fires involving common GB contents can result in a GB breach through glove loss. Various quantitative measures were made to generate data for use in fire hazards evaluations (FHEs) and/or for determining when to require a fire suppression system to be installed within a GB.

Methodology

- Each trial involved consumables arranged on the GB floor to target various fire scenarios.
- Before each trial, the exhaust fan speed was adjusted to reach a GB vacuum of ½ inAq.
- Remote fire ignition (nichrome heater coils), fire monitoring, and data collection were facilitated in a bunker adjacent to the GB.
- Pressure, temperature, and air-flow data were collected during the experiment, along with visible and infrared camera imaging.

Results

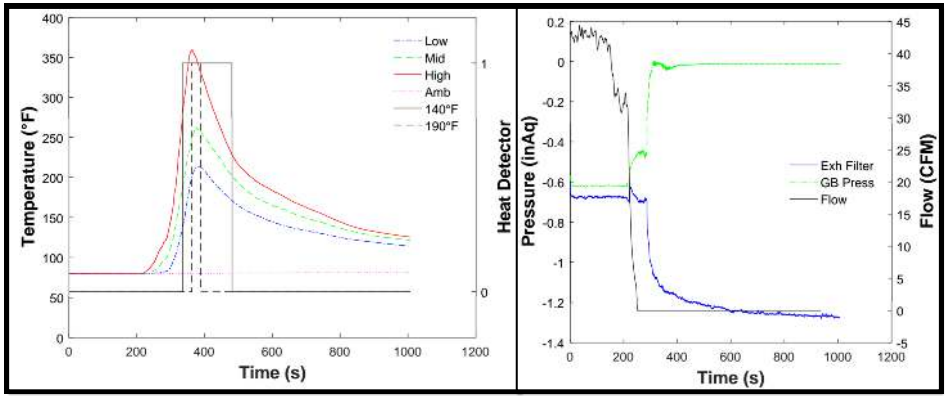

Figure 3. Representative dataset of quantitative measurements captured

Various arrangements of common GB contents could contribute to a fire substantial enough to breach in a glove.
Depending on the stored state of the glove, breach could result in either partial or essentially complete loss of GB vacuum (Figure 3).
A total of 31 successful trials were run.
Glove breaches occurred in 14+ trials, often more than one glove was breached in a single trial.
Heat detectors were sensitive to only a subset of these 14 trials (140 degree unit responded to 9 trials, the 190 unit to 2 trials). The detector would sometimes, but not usually precede the breach.
Glove breach was shown to potentially accelerate combustion due to increased, localized air flow (Figure 4).
Hypalon gloves added significantly to an existing fire, being extensively consumed in some cases.
All fires eventually self extinguished (up to 22 minutes).
The fire was not observed to spread to other piles of combustibles, when separated from other combustibles by a foot or so, even though the piles may have included flammable liquid soak materials in open bags.
Other readily igniting consumables included laboratory wipes, polypropylene bottles, and horsehair brushes.
Mallet head, leather gloves, scale cord, all-purpose cleaner, and screwdriver typically did not participate significantly in the fire.
Distance of consumables from the fire and containment played a major role in determining their participation.

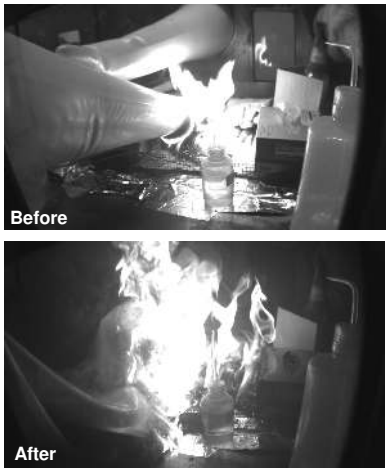

Figure 4. Fire before & after breach. External oxygen flow through the breach simultaneously strengthened the fire, leading to a more rapid consumption of the breached glove.

Figure 5. Typical state of GB contents after fire. Damage is localized and extent of combustion varies.

Degradation of Hypalon Gloves Exposed to Flame

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New Mexico Tech, Department of Mechanical Engineering

LA-UR-16-25337

Introduction

Hypalon gloves are part of the confinement barrier to protect personnel for exposure to radioactive contamination and exposure.

Tests were performed to evaluate the integrity of the gloves under heat exposure to understand their response to a potential fire within a GB.

Experimental Setup

Figure 1. Support Stand & Pressure Vessel.

Methods

- 4 in. diameter circular specimens were cut from 15 mil thickness (HY15) and 30 mil thickness (HY30) Hypalon gloves.
- Specimens were loaded into the test apparatus and pressurized to approximately +1 inAq to simulate negative pressure in a sealed glovebox.
- Tests were performed at heights of 10", 11", 12", and 14" to provide a target range of temperatures at the surface of the specimen.
- A NIST traceable pressure transducer and thermocouple were used to monitor the pressure in the vessel and glove temperature.
- Images of the specimen were recorded during the experiment to evaluate qualitative changes in the specimen during exposure to flame.

Results

The figures below show representative results for 15 mil and 30 mil specimens placed 10" (Fig. 2 & 4) and 11" above the burner (Fig. 3 & 5). Key findings include:

- 15 mil and 30 mil specimens breached when exposed to temperatures over 500 and 600 F, respectively.
- 30 mil gloves were not only more durable but even able to temporarily withstand combustion before breach.
- Failure process: specimens began to blister/bubble on the surface, followed by charring, and in some instances igniting.
- No damage or color change were observed on specimens of either thickness at 14" above the burner (approx. 400 F).

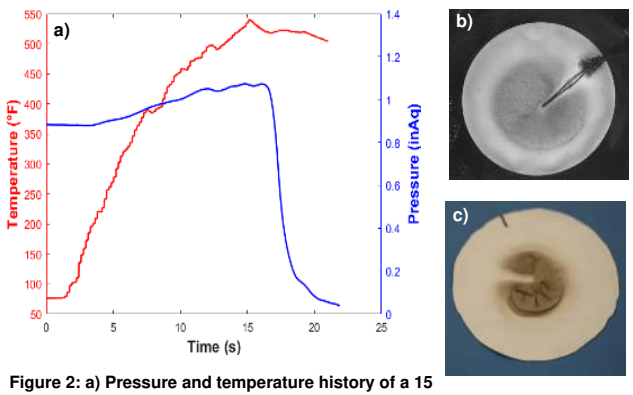

Figure 2: a) Pressure and temperature history of a 15 mil Hypalon specimen placed 10" above the burner; b) relatively uniform change in color, bubbling, and pinholes present on specimen's surface before breach; c) specimen deformed and changed color during flame exposure.

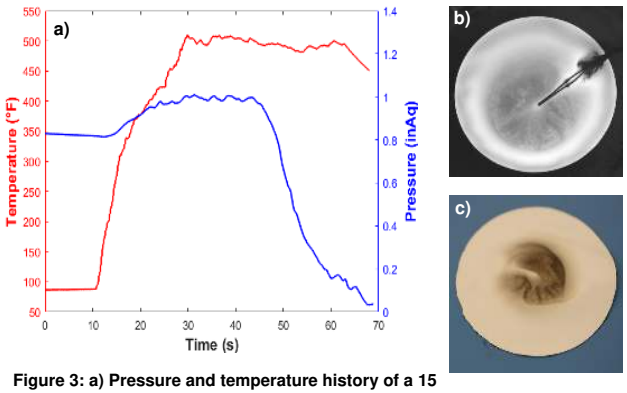

Figure 3: a) Pressure and temperature history of a 15 mil Hypalon glove 11" above the burner; b) bubbling and pinholes present on specimen's surface before breach; c) specimen deformed and changed color during flame exposure.

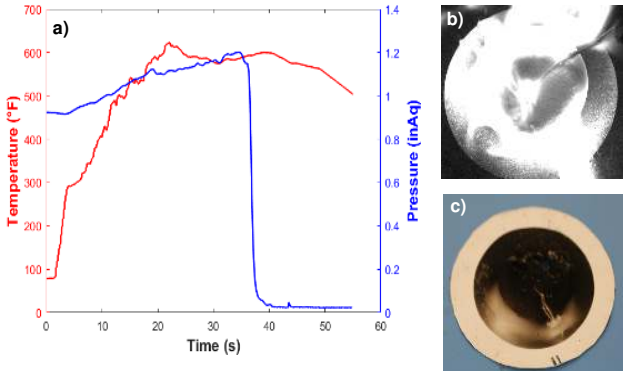

Figure 4: a) Pressure and temperature history of a 30 mil Hypalon glove 10" above the burner; b) ignition on specimen's surface before breach; c) large hole, extensive embrittlement and charring, and bulging evident on specimen during flame exposure.

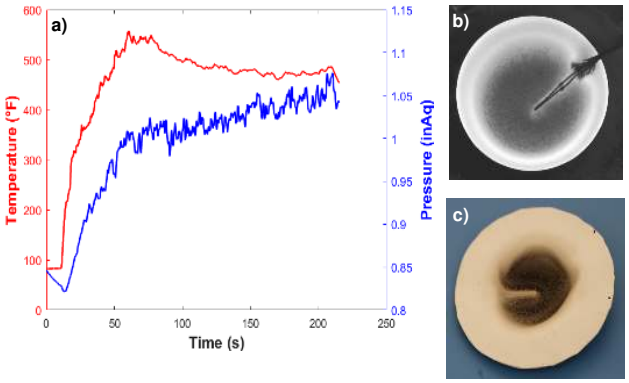

Figure 5: b) Pressure and temperature history of a 30 mil Hypalon glove 11" above the burner; b) transformation in color and bubbling on specimen, no breach; c) pronounced deformation and charring during flame exposure.

Glovebox Combustion Experiments (Cont.)

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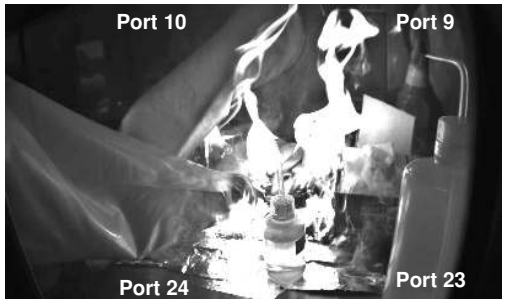
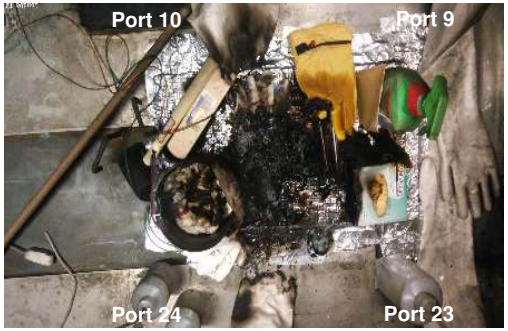
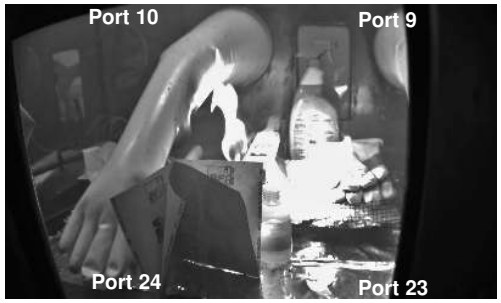
LA-UR-16-25381

Four Gloves in GB





Two Gloves in GB



Gloves Covered, out of GB

Post-Mortem

GB fire led to cracked window and ruptured glove

Post-mortem mallet, brush, Kim wipes, and gloves

Polypropylene bottle

Open steel canister

Breached glove with surface bubbling

Tygon Tubing

Pair of Screwdrivers

Cond. #	Location of Alc. Soaked Cheesecloth in Bag	Glove Conditions (Blue=No Breach, Orange=Breach)				Max Temp. (°F)	Critical Times (min:sec)		Heat-Detector Activ. (min:sec)	
		Port 9	Port10	Port 23	Port 24		Flame	Breach	140°	190°
1	Contacting coils	In	In	In	In	359.41	4:43	5:57	6:45	7:12
2	Contacting coils	In	In	In	In	356.79	4:13	5:54	6:06	6:43
3	Contacting coils	In	In	In	In	319.58	0:56	1:53	2:19	No
4	Closed canister near coils	In	In	Out	Out	151.08	2:34	13:58	No	No
5	Far from coils	In	In	Out	Out	111.53	1:49	10:14	No	No
6	Far from coils	In	In	Out	Out	86.04	0:58	No	No	No
7	Far from coils	In	In	Out	Out	83.98	0:22	No	No	No
8	Closed canister near coils	In	In	Out	Out	87.05	No	No	No	No
9	Near coils	Covered	Covered	Out	Out	290.21	2:44	3:21	3:45	No
10	Open canister near coils	In	In	Covered	Covered	215.13	2:43	3:38	No	No
11	Open canister near coils	Covered	Covered	Covered	Covered	115.01	0:51	2:54	No	No