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INTERIM REPORT ON THE GLOVE BOX FIRE CONTROL STUDIES

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DISCLAIMER

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INTRODUCTION

Several glove box fires have occurred at HAPO. Except for a moderate spread of contaminants through glove and panel failure the incidents have not been serious.

However the possibility of temporarily or permanently losing an entire production or research facility because of a relatively small fire must be appreciated.

A recent fire at HAPO illustrates the problem. During a welding operation a spark dropped into the glove box and two small fires occurred, which in turn ignited the inlet filter. Openings in the hood caused by the fire and attempts to extinguish it, allowed contamination to spread to adjacent rooms and the corridor.

Loss - Government:	Fire: One filter	$12
	Decontamination:	$3000 - $4000

Hood panels, gloves, and plastic bags are combustible. Paper cartons, and tissues accumulate during normal work procedures. Oils and solvents used as coolants, lubricants, or controlled temperature mediums are sources of combustion. A constant fire hazard exists because of the pyrophoric nature of the metals and alloys undergoing fabrication. Because of criticality considerations, product recovery, and spread of contamination many standard fire fighting techniques are unacceptable. For these reasons a limited program was undertaken by Plutonium Metallurgy Operation to determine the best methods of controlling glove box fires.

EQUIPMENT

All tests were conducted in a steel hood with a gloved plexiglass front panel, Figure 1. The glove box was connected to the main hood exhaust system and fitted with standard 8 x 8 x 6 inch CWS inlet and exhaust filters. The exhaust filter was fitted with a transparent plexiglass chamber so that any fire, smoke or unusual occurrance in the filter could be visually observed. Magnehelic pressure gauges were installed to measure the pressure differential between the hood and the laboratory as well as to measure the pressure drop across the exhaust filter. Argon was available to the hood so that inert conditions could be simulated. During the course of the experiments it was found advantageous to imbed a thermometer in the exhaust filter. The rising filter temperature predicted the pending failure. Copper water lines were installed on the down stream side of the exhaust filter to lower the temperature of the air passing into the main exhaust system.

TESTS

Oil, trash, and metal fires were investigated. Peanut oil was used primarily although lard oil and transformer oil were also investigated. Trash fire was a general category including combustible hood parts, gloves, bags, and paper products normally found in hoods. Magnesium turnings were used in all metal fires.

Our very first efforts were to determine the flash temperature, ignition temperature, and auto-ignition temperature of peanut oil under conditions normally found in PMO hoods. These temperatures were determined, but simultaneously a major problem was uncovered.

The "protexol" treated CWS exhaust filters rapidly saturated with oil vapors, the vapors ignited causing filter failure, and allowed the fire to pass into the exhaust system. This seriously limited the type and magnitude of fires which could be set in subsequent experiments.

OIL FIRES

In a typical oil fire 250 ml of peanut oil was heated in a glass beaker and either ignited with a striker at 365 C or allowed to spontaneously ignite at 395 C. At 250 C the heated oil began to smoke. The evolution of vapors became more and more vigorous as the ignition temperature was approached.

Following are various methods used to extinguish oil fires, and some comments on their effectiveness.

1. Smothering with glass cloth - A blanket of clean glass cloth was draped over the burning beaker of oil. This method was effective on small fires contained in a beaker or tray but would not be adequate on a fire spread over a large area.

2. Smothering with sand - this was considered because sand is normally available in hoods to control metal fires. The sand sank without affecting the burning oil. If enough sand were used the oil bath temperature might be lowered below ignition temperature.

3. Flooding hood with argon - A beaker of peanut oil was ignited then the inlet filter was blanked and argon was bled into the test hood (volume approximately 18 cu. ft.) at 25 CFH. The fire was not appreciably retarded in the time it took the hood exhaust filter to reach critical temperature.

4. CO_2 - The carbon dioxide extinguisher was located inside the glove box and discharged directly into the closed volume. The fire was extinguished but the glove box became pressurized. Contamination of surrounding areas would probably have resulted if the glove box had contained plutonium.

5. Dry Chemical - Oil burning in a beaker was repeatedly extinguished by sprinkling a few grams of dry chemical on the surface. 2½ pound dry chemical extinguisher was stored inside the glove box and manipulated through the hood gloves. The dry chemical extinguisher extinguished all types of oil fires without pressurizing the glove box. Poor visibility due to smoke sometimes made it hazardous to reach through the hood gloves while looking for the extinguisher. A method was developed to introduce the dry chemical into the hood through a fitting installed on the hood panel. The female half of a quick-connector was mounted on a coupling extending through and welded to the hood wall, Figure 2. Inside the glove box a 4 inch section of 3/8 inch copper tubing was connected to the coupling. The exist end of the tubing was flattened to form a fan-shaped slit approximately 3/64 inch wide. The tubing was bent so as to direct the dry

chemical at the ceiling where it diffused and fell like rain. When the male half of the quick connector is removed a spring loaded seal in the female half maintains a contamination barrier. The male half of the quick connector was threaded to fit the nozzle of the fire extinguisher. Snapping together the mating parts allows entry of the dry chemical into the hood. The connector described in Figure 2 has been established as a Hanford standard. Reference HW-4587-S.

Several tests were run using lard oil or a mixture of two parts lard oil and one part perchlorethylene. The characteristics of lard oil were very similar to peanut oil. In tests using the lard oil-perchlorethylene mixture the perchlorethylene boiled off at a relatively low temperature so in each test it was essentially a lard oil fire. The dry chemical extinguisher was found to be the most efficient means of extinguishing lard oil fires.

TRASH FIRES

In a typical test ice cream cartons and tissues were piled on the hood floor and a gauntlet glove or plastic bag suspended above them. The burning paper products ignited the glove or plastic bag. The dry chemical extinguisher, as described on the oil fire tests, rapidly and completely extinguished this type fire.

METAL FIRE

The third type of fire considered was the metal fire. Magnesium turnings were piled on the hood floor and ignited with a Prest-O-Lite torch. The dry chemical extinguisher was not effective on this type of fire, instead it seemed to contribute to the fire.

The most efficient method was to cover the burning turnings with MgO sand. This has been the standard method to handle plutonium chip fires for several years. The sand actually smothers the fire. A sizeable portion of unburned turnings were always recovered. Met-L-X, a metal fire extinguisant used on uranium and zirconium fires, was adequate but not as effective as MgO sand.

Steel containers, painted red, are filled with MgO sand and mounted inside the glove box, Figure 3. The sand containers are stoppered to prevent moisture pick up. Removing the container from the mounting bracket automatically removes the stopper.

GLOVE BOX PANELS

Several plastics and other materials of construction used as the transparent panels on glove boxes were tested for flammability.

The burning rates and self-extinguishing properties were verified using the technique described in ASTM specification D-635-44. Rohm and Haas grades II UVA and 500%, and Homalite CR-39 were evaluated.

Grade II UVA is the standard optical quality plexiglass that has been used for all glove box panels in the 231-Z Building, it will support combustion.

Grade 5009 is a self-extinguishing plastic. It will not support combusion itself but will burn in a fire supported from another source. Grade 5009 has recognized fabrication disadvantages. It is softer and consequently more succeptable to scratches and it is slightly less resistant to chemical attack.

Homolite CR-39 will support combustion but burns at about one-fourth the rate of II UVA. It has thermal shock properties akin to glass. While it is burning small embers spall and spew in all directions. It is quite likely that in a Homolite paneled glove box a fire would cause a panel to crack losing the contamination barrier earlier than normal. Homolite's principle feature is that it is harder and more resistant to chemical attack. It too, however, is difficult to fabricate and its selection would be based on some specific need.

The gloved front panel of the fire test hood was removed and replaced with solid panels of plexiglass grade 5009, II UVA, Homolite, and safety plate glass. The solid panels were clamped to the hood frame with the intention of setting rather large fires and comparing the time required for the contamination barrier to fail. Unfortunately in every test the exhaust filter failed prior to the test panel requiring shutdown before any conclusive results could be obtained.

DRY CHEMICAL DISPERSION

Tests were conducted to determine the effective dispersion of dry chemical fire extinguishers in a large hood. The hood used was the general purpose hood in Cell 4 with floor dimensions of 144 inches x 45 inches. The extinguishers were discharged through the quick connector described previously. The connector was located in various positions around the hood, but always pointing toward the top of the hood at an angle of approximately 45° and with the outlet approximately 14 inches from the hood floor. The hood floor was covered with circular pieces of filter paper located on a 12 in. by 11 in. grid. A four pound, Safe-t-Meter, fire extinguisher was completely discharged and the dry chemical allowed to settle. Each piece of filter paper was weighed, giving the amount of dry chemical located at that point and this figure converted to a concentration in grams/square inch by using the filter paper area. From this data topographical type curves were drawn showing the dry chemical's distribution in the hood.

It was determined experimentally that it took approximately 0.09 grams/square inch of dry chemical to extinguish an alcohol fire, and on this basis 0.10 grams/square inch was called safe.

Four tests were performed. The first with the discharge nozzle in the center of the side of the hood parallel to the ends. This left large unsafe areas at either end, see Figure 4A. The second test was conducted with the discharge nozzle located at one end of the hood with the nozzle pointing parallel to the sides, Figure 4B. This left an unsafe zone at the opposite end and a smaller one near the center of the hood. In the third test the nozzle was returned to the center of the hood, but inclined 45° toward one end. This covered the end toward which the nozzle pointed quite well but left most of the other half as an unsafe zone, Figure 5A. The fourth test was identical to the third except that there was an air flow of approximately 50 CFM through the glove box during the test, Figure 5B.

DEMONSTRATIONS

Although many problems remain unsolved it was felt that a point had been reached where information gathered up to this time could be evaluated and distributed. A series of demonstrations were scheduled. Approximately 200 people have witnessed and participated in the fire demonstrations. This includes most all outer area firemen, PMO personnel, radiation monitors, maintenance normally assigned to 231-Z, and the Research and Development group located in 234-5 Building.

A typical demonstration for fire department personnel is outlined below.

A. A brief review of fires experienced by PMO, and of major fires occurring in offsite AEC installations.

B. An explanation of the purpose, principle, and design features of glove boxes, problems in manipulating through hood gloves, transfer techniques, and criticality.

C. A discussion of the types of fires likely to occur, such as metal, oil, trash, and hood filters.

D. Types of extinguishers, the availability, practicality, and an outline of practices employed offsite.

E. Results of PMO tests conducted in fire control hood.

F. Demonstration of recommended techniques on metal, oil, and alcohol type fires.

G. Discussion of unsolved problems, such as filter fires, materials of construction, alarm systems, etc.

H. Demonstrate the burning characteristics of various plastics. Exhibit of exhaust filters which have failed in service.

I. Tour of 231-Z Building, to show variety of hooded equipment, fire potential connected with various metal fabricating processes, special or unique problems associated with specific equipment, and duct level problems.

J. Discussion of suggestions.

Probably the principle benefit realized from this undertaking was the increased cooperation and understanding between the fire department and operating personnel. The fire department has an extremely difficult and challenging responsibility to provide protection to the laboratory and manufacturing facilities. Failure to appreciate their problems and extend full cooperation would make it difficult to provide the necessary protection.

Demonstrations such as those described above allow the fire department to keep abreast of the ever changing problem, maintain familiarity with buildings, prepare practical pre-fire plans, and suggest remedies to existing fire hazards.

CONCLUSIONS AND RECOMMENDATIONS

1. Equip glove boxes with quick couplings for dry chemical type extinguishers. Although the exact area that each coupling would adequately protect under the variety of conditions that glove boxes operate has not been determined preliminary tests indicate that each coupling could be expected to cover 18 square feet of glove box floor. (See tests).
2. Store conspicuous containers of MgO sand, Figure 3, inside glove boxes for metal fires.
3. Discourage use of CO_2 extinguishers for hood fires.
4. Minimum storage of solvents inside glove boxes.
5. Limit the maximum operating temperature for peanut oil baths to 300 C.
6. Identify duct level filter cages as to the specific glove boxes they serve.
7. Outline first floor room and corridor plan on duct level floor to assist firemen and others unfamiliar with the building in determining their location.
8. Schedule periodic meetings with the fire department.
9. Provide for reasonably easy removal of glove box exhaust filters for inspection following a fire.
10. Good housekeeping inside glove boxes is the most effective single method to minimize the fire hazard.

FUTURE PLANS

1. Evaluate the use of a wire mesh pre-filter ahead of the exhaust filter as a mist eliminator and a fire stop.
2. Determine what can be done to prevent or extinguish a filter fire.
3. Determine what should be done to hood and room exhausts while a hood fire is in progress.
4. Determine what should be done if the fire passes the hood exhaust filter into the building exhaust ducts.
5. Decide if there is a real advantage between various grades of plexiglass used as glove box panels.
6. Determine what can be done to minimize damage if fire breaks out off shift and goes undetected.
7. Determine how unusual hazards such as high voltage, criticality, and vacuum systems affect recommended procedures.

8. Develop a flexible entry for dry chemical that would allow variable direction of the extinguishment.

9. Evaluate the technique of blanking the inlet filter and purging the glove box at a high rate with inert gas as an automatic or semi-automatic fire control measure.

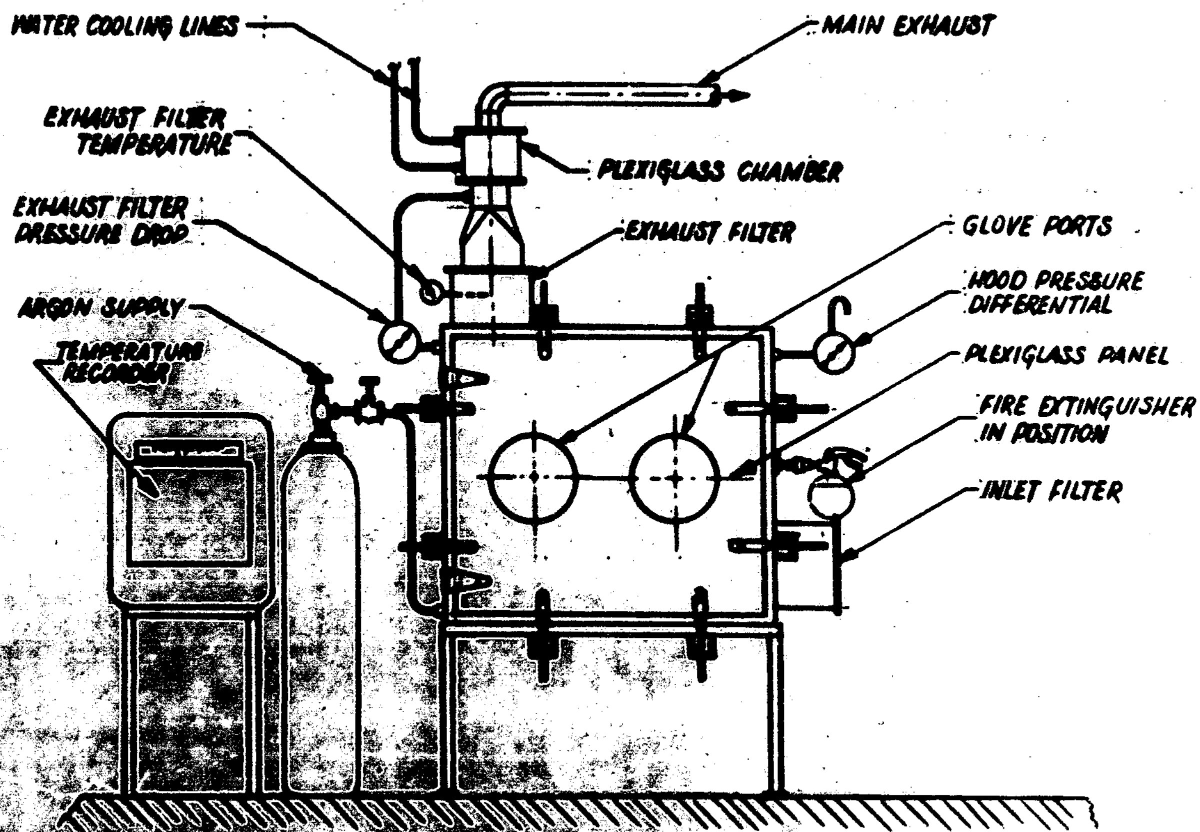

FIGURE 1
Glove box used for fire control tests

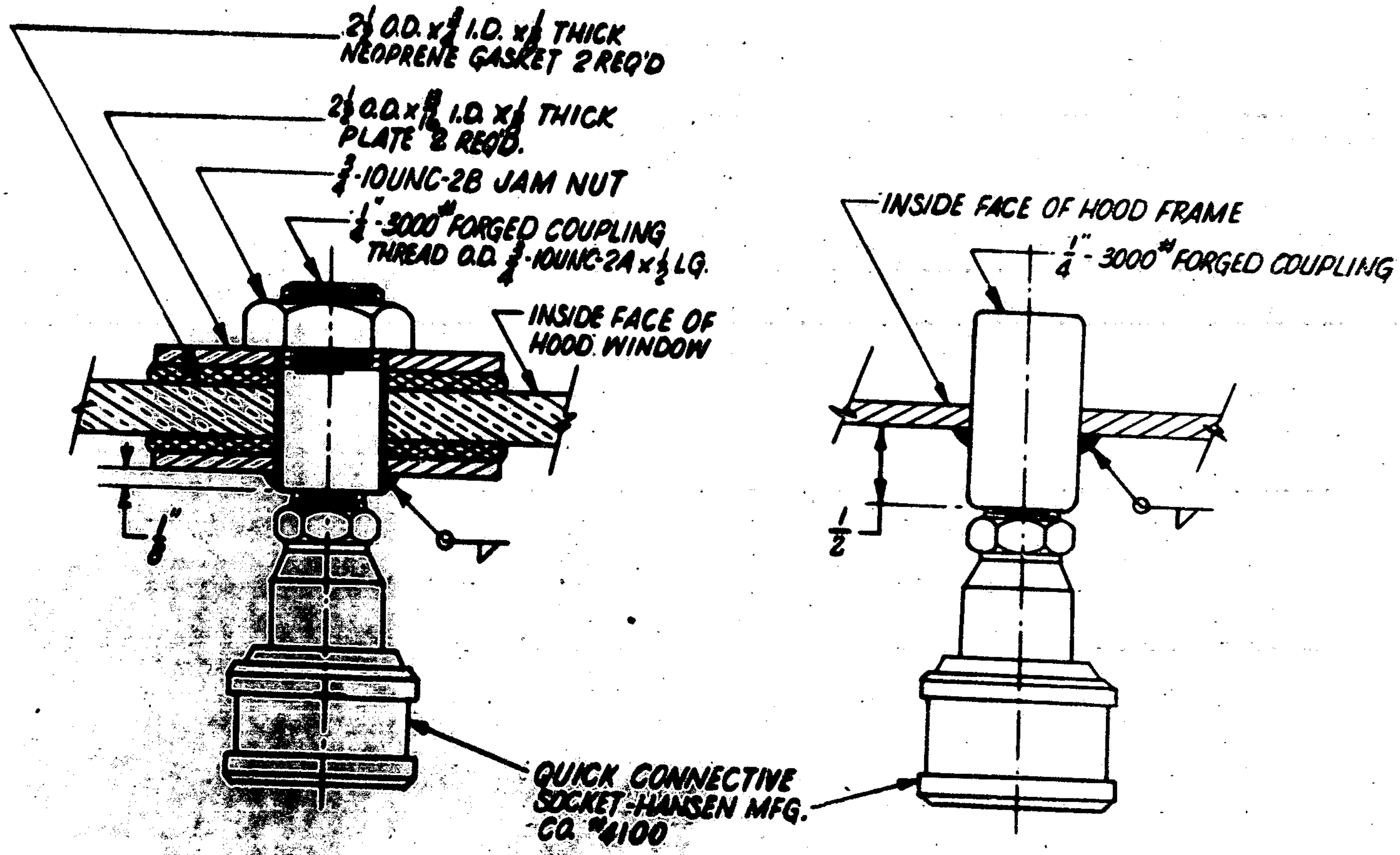

FIGURE 2

Details for installing fire extinguisher fitting on either a plexiglass or a steel hood panel

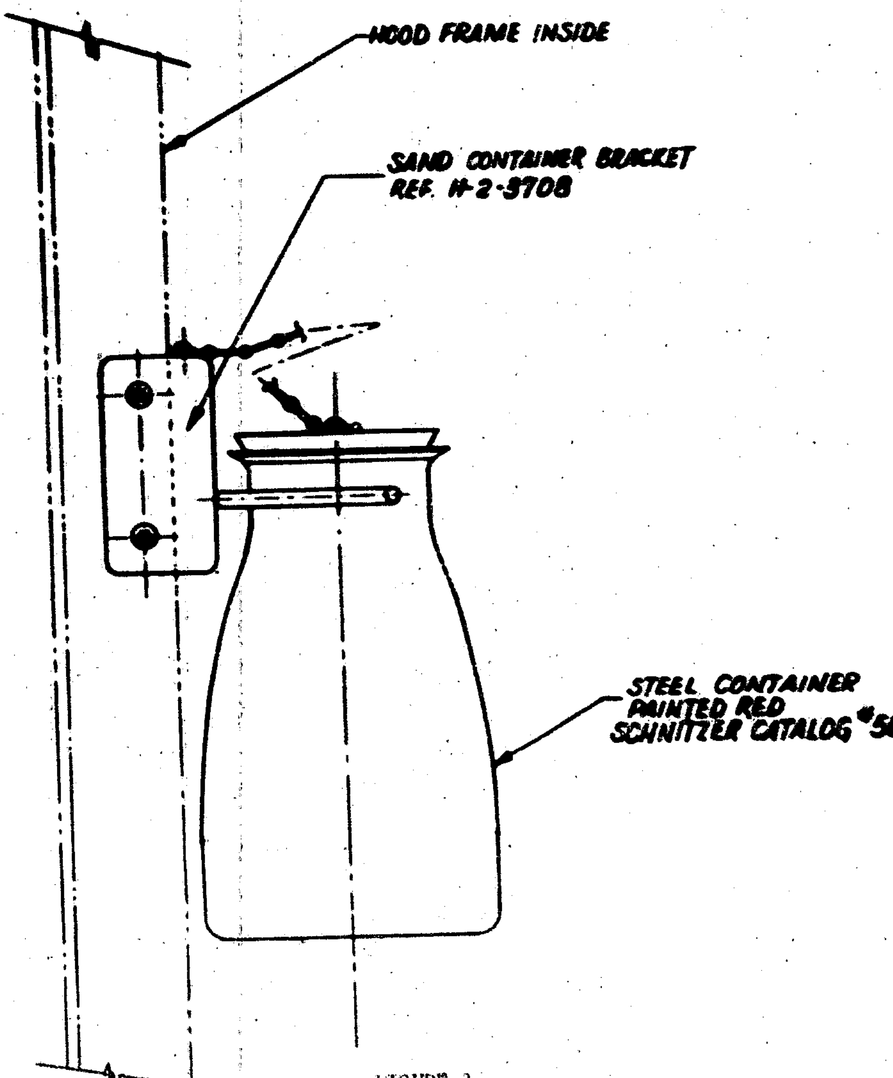

FIGURE 3

Steel container mounted inside the glove box
filled with M[illegible] sand

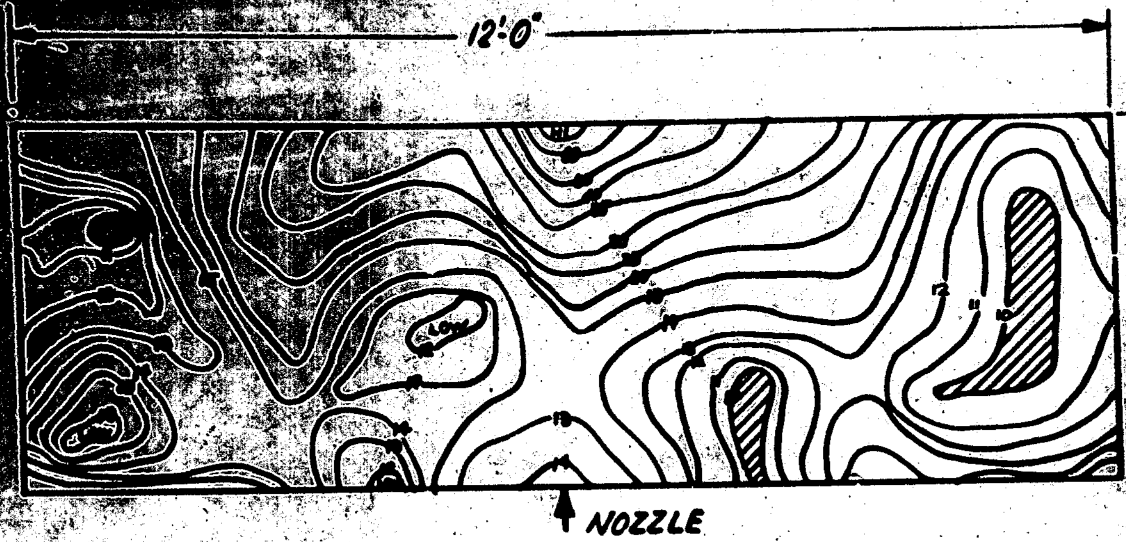

FIGURE 4a

Dry chemical dispersion pattern on the glove box floor after completely discharging a four pound extinguisher with the nozzle position as shown. Contour lines shown are in grams x 10^{-2} per square inch. Shaded areas are unsafe zones.

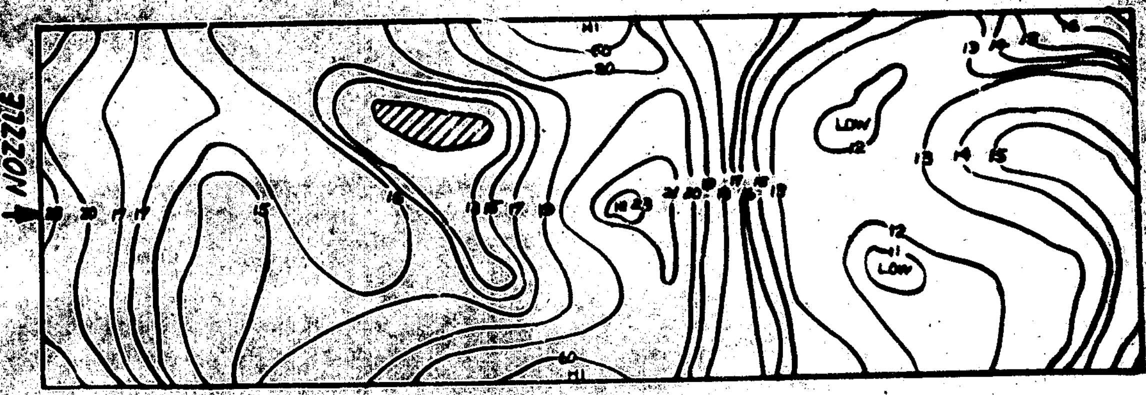

FIGURE 4b

Dispersion pattern with nozzle relocated

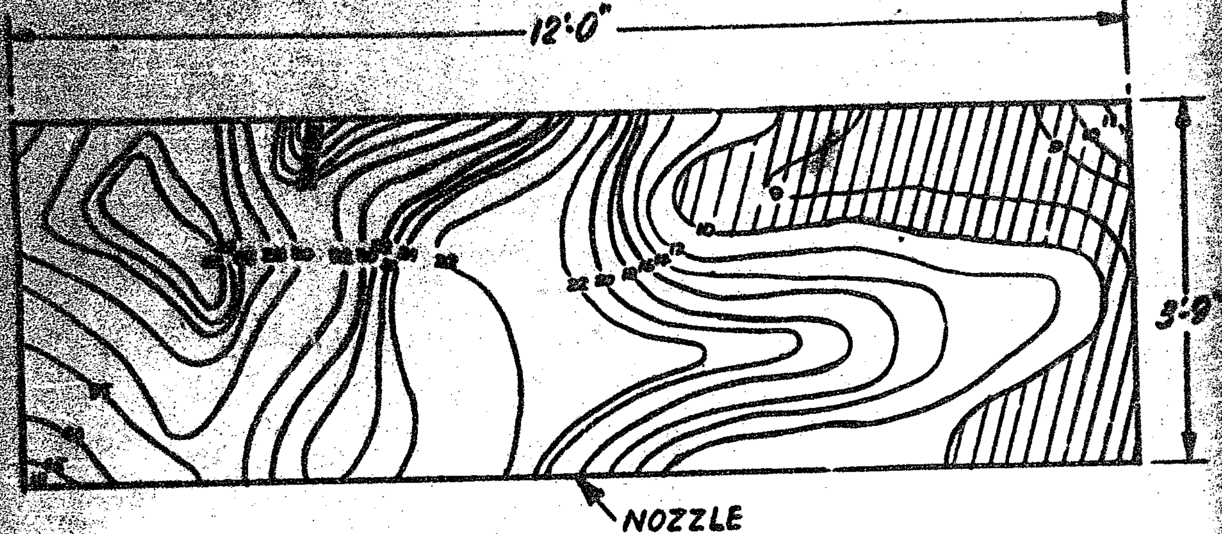

FIGURE 5a

Dry chemical dispersion pattern with nozzle located in the center but pointed toward one end. Contour lines shown are in grams x 10^{-2} per square inch. Shaded areas are unsafe zones

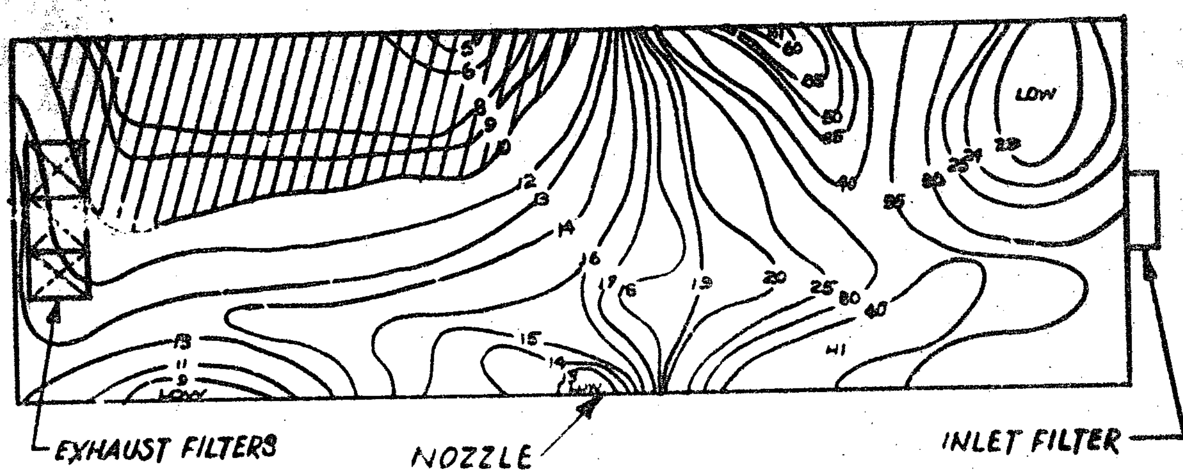

FIGURE 5b

Dry chemical disper[illegible] pointed toward inlet filter. Approximately [illegible] glove box during the test.