Attachment
Director of NRR, USNRC
December 31, 1979

# PYRALARM DETECTORS F3/5A AND F5B

## (SENSITIVITY TO POLYVINYLCHLORIDE COMBUSTION)

from

PYROTRONICS, INC.

SUBSIDIARY OF BAKER INDUSTRIES, INC.

2343 MORRIS AVENUE

UNION, N. J. 07083

SERIAL NO. 17741

FEBRUARY 23, 1967

FACTORY MUTUAL ENGINEERING CORPORATION

1151 BOSTON-PROVIDENCE TURNPIKE, NORWOOD, MASS 020



8001100 516

FACTORY MUTUAL ENGINEERING CORPORATION

1151 BOSTON-PROVIDENCE TURNPIKE, NORWOOD, MASS. 02062

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February 23, 1967

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## I INTRODUCTION

The Pyralarm detectors respond to aerosol products of combustion. From many combustibles these airborne products are light, invisible and rise rapidly to the detector from thermal lift. Detector response is often very quick.

Other combustibles have products of combustion that are much larger and heavier, and are readily visible. If there is little thermal lift, these products rise slowly, drift horizontally and tend to stratify. Products of polyvinylchloride insulation combustion are examples. With these, Pyralarm response is not nearly as quick; and, in fact, some questioned whether the Pyralarm might be insensitive to these products.

The purpose of this re-examination was to determine if there is something so unusual about PVC combustion that the Pyralarm ignores it. The answer is negative. Pyralarm will respond to PVC combustion when the products reach the detector. This is also true of approved spot type smoke detection devices in general.

## II TESTS

### A General

1. These were run at the Pyrotronics plant in Union, N. J. Tests produced products of PVC combustion two ways: (1) by electrically overloading PVC insulated wire to produce smoke; (2) by placing pieces of the insulation on a hot surface until smoke resulted.

2. Four brands of wire were tested: Alpha, Belden, Birnback and Plastic Wire & Cable. In all, eight different types and sizes were tested. These ranged from No. 16 to No. 22 AWG, having 60-105°C temperature, 200-1000 volts and 17-35 ampere ratings.

3. Both Pyralarm detectors F3/5A and F5B were tested.

B Results

1. There was a noticeable difference among the four brands tested; probably as a result of different plasticizer and pigment. However, in no case did the Pyralarm fail to operate when the products got there.

2. Sometimes, the response appeared slow - on the order of a couple minutes - and the test area was uncomfortably smokey at floor level. However, observation at detector level showed a practically clear atmosphere around the detector.

3. Other details are on file; but are unnecessary for the purpose of this report.

III CONCLUSION

Pyralarm detectors F3/5A and F5B are sensitive to products of "polyvinylchloride" insulation combustion.

EWC/bc

TESTS AND REPORT BY : E. W. Cray

# P. V. C. Smoke Tests

## I. INTRODUCTION

Pyrotronics has received word from the field that our ionization detectors do not respond to combustion particles from burning Poly-Vinyl Chloride (PVC) insulation.

On February 7, 1967 tests were run at Pyrotronics Inc., in both the Engineering Laboratory and a full scale test area. These tests confirmed to Pyrotronics, and demonstrated to Mr. E. W. Cray of Factory Mutual Engineering Division, that our ionization detectors do respond to combustion particles given off by burning Poly-Vinyl Chloride (PVC) insulation. The followiug is a detailed report of the various tests that were performed.

## II. PVC WIRE ANALYSIS

Preliminary to running new performance tests, certain data was obtained from manufacturers as to the chemical composition of PVC insulation.

The basic PVC resin is non-combustible, according to a representative of Alpha Wire Corp and accounts for 60% to 80% of the compound, depending upon the desired voltage and temperature characteristics. PVC resin, when heated to about 370°F, gives off Hydrogen Chloride gas. The stabilizers, platicizers, and inert fillers which are Hydro-Carbon compounds provide the combustion particles which can be detected.

Another manufacturer, Plastic Wire & Cable Corporation, supplied the actual ingredients of the insulation of one of our test samples. While the actual mixture ratio is confidential, the compounds are listed below:

PVC Resin
Tri Cresyl Phosphate
Phthalate Ester
Tri-basic Lead Sulphanate
Clay

Samples of wire from Alpha Wire Corporation, Belden Manufacturing Company, Birnbach Radio Corporation, and Plastic Wire & Cable Corporation were obtained and prepared for testing.

## III. CONTROLLED LABORATORY TESTS

The apparatus used for those tests performed in the Engineering Laboratory consisted of a test chamber 16" x 11" x 6½" (0.67 cubic feet) into which one each of the F5B and F3/5A detectors were installed. Each detector was connected to a separate Fire Indicating Unit. A small fan was installed to create a mild air turbulance to produce a uniform distribution of combustion particles. A thermocouple type temperature measuring device was used to measure wire temperature. The PVC test samples were introduced at the bottom center of the test chamber, as shown in Figure 1. External to the test chamber was a transformer driven by a "variac" so that the current through the wire samples and thus the rate of burn could be varied. This current was indicated on a clip-on ammeter indicated in the table of Figure 2.

Prior to testing the PVC insulation, various other combustible products including tobacco, paper, cardboard, corrugated, wood, punk sticks, and cotton lint were tested. Both detectors responded within 15 seconds. The PVC test samples consisted of 7¼ inches of wire from which all but 2½ inches of insulation was removed. The overload current listed in the table was passed through each of the 8 samples. In all cases both detectors responded within 1 minute after current was applied. The wire temperature ranged from 325°F to 350°F, at the time of response to smoke, dependent on the sample tested.

## IV. FULL SCALE TESTS

The apparatus used in the full scale tests consisted of various ceiling mounted detectors wired into separate zones of a fire detecting system. The samples to be tested were draped upon a plastic insulating support which was placed on a table 5½ feet from the ceiling. The wire was connected to a transformer secondary (UTC S-60) whose primary was connected directly to the AC line. (Figure 3.) As in the laboratory tests, the rate of burn was controlled by varying the current through the PVC samples. The current magnitude was controlled by varying the wire length. Wire lengths and overload currents are noted in Figure 4. In all cases our ionization detectors responded before any of the photoelectric detectors which were also connected to the system.

In addition to burning PVC insulation by a wire overload, small PVC pellets were dropped on a hot plate. This smoke was also detected first by the ionization detectors and second by the photoelectric devices.

## V. CONCLUSION

The conclusion reached from these tests is that while the response of the ionization detectors to PVC smoke is slower than the response to other combustion products, the ionization detectors do respond as fast or faster than presently marketed photoelectric detectors.

## APPARATUS USED FOR TESTS PERFORMED

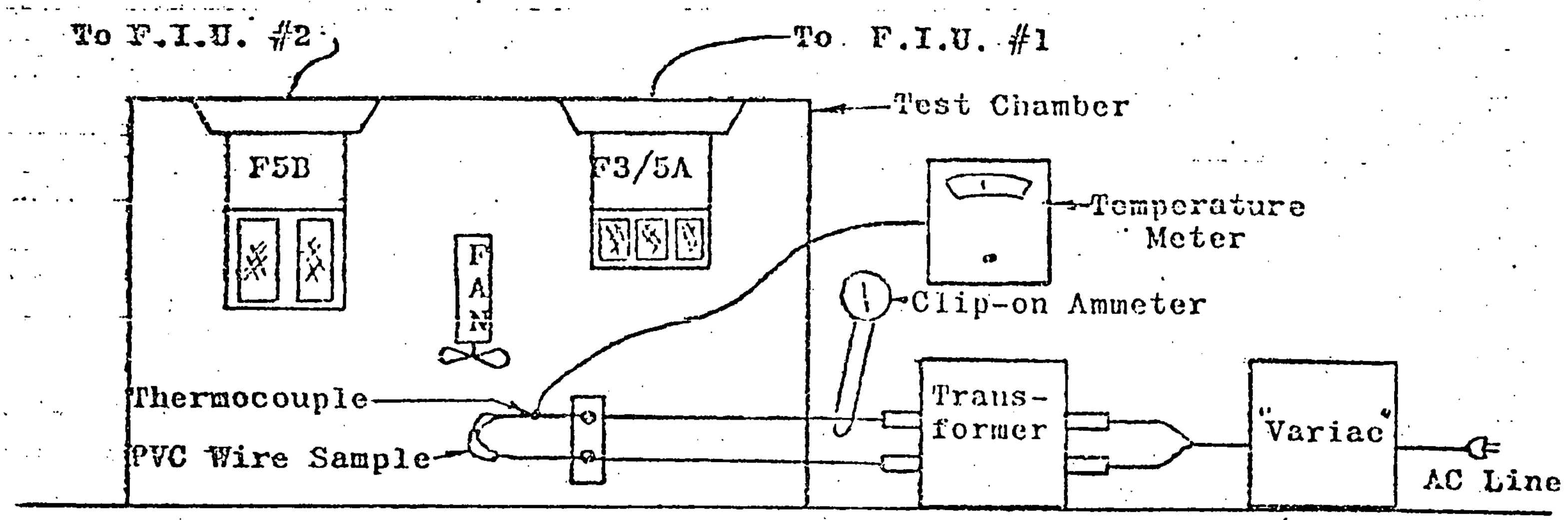


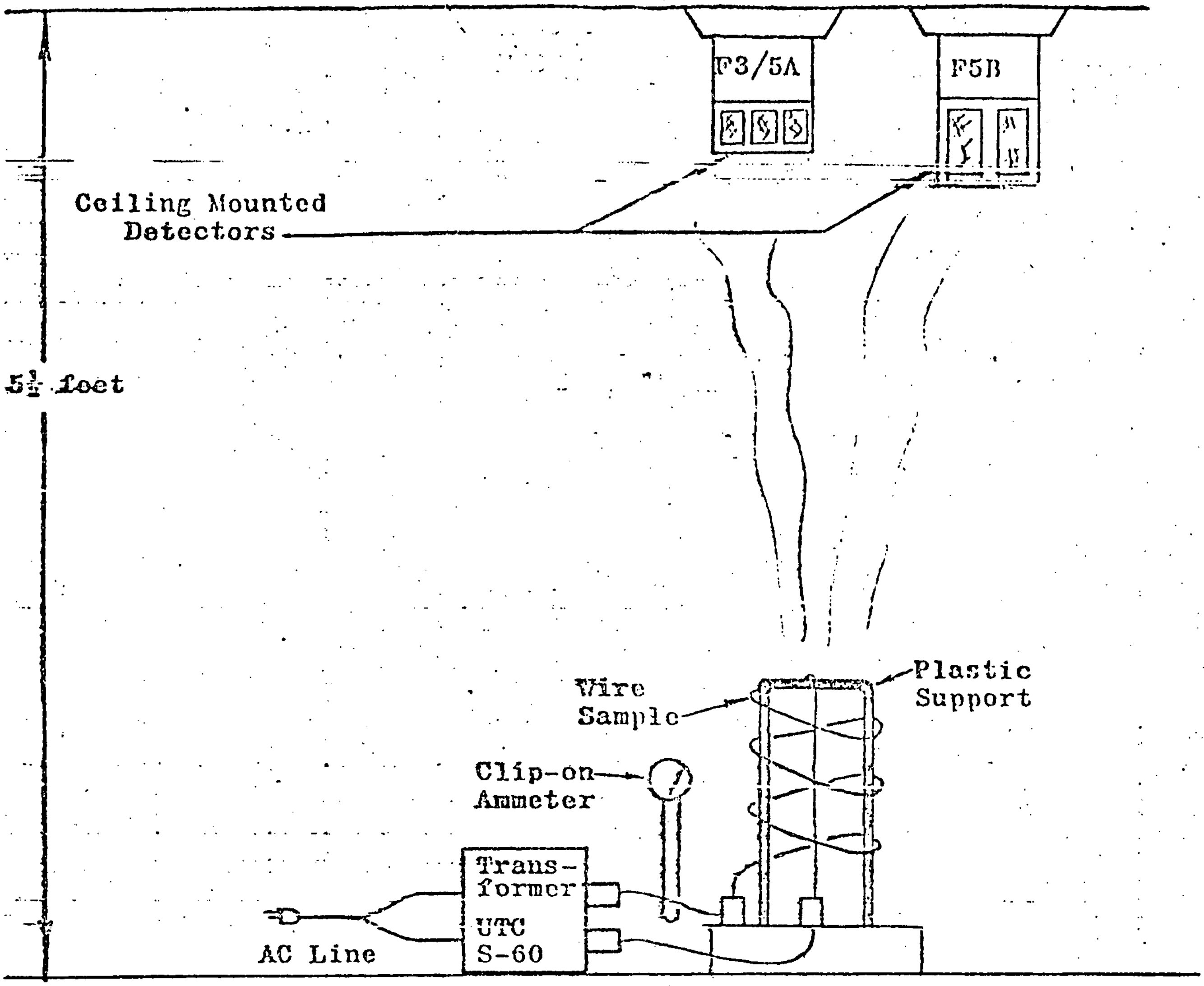

FIGURE 1

## WIRE SAMPLES * FOR CONTROLLED LABORATORY TESTS

| MFR. | PART NUMBER | WIRE SIZE AWG | TEMP. RATING | VOLTAGE RATING | OVERLOAD TEST CURRENT |
|---|---|---|---|---|---|
| Plastic Wire & Cable | 1011 | 20 | 80°C | 600V | 20a. |
| Belden | 8522 | 18 | 80°C | 1000V | 25a. |
| Birnbach | 7195 | 22 | 105°C | 600V | 17a. |
| | 7316 | 16 | 80°C | 2500V | 35a. |
| Alpha | 3073 | 20 | 105°C | 600V | 20a. |
| | 1555 | 18 | 80°C | 1000V | 25a. |
| | 1857 | 18 | 105°C | 600V | 25a. |
| | 1172 | 22 | 60°C | 200V | 17a. |

* Each wire test sample was 7¼" long with 2½" of insulation

FIGURE 2




APPARATUS USED FOR TESTS PERFORMED

IN FULL SCALE TESTS

FIGURE 3

WIRE SAMPLES FOR FULL SCALE TESTS

| MFR. | PART NUMBER | WIRE SIZE AWG | TEMP. RATING | VOLTAGE RATING | OVERLOAD TEST CURRENT | WIRE LENGTH |
|---|---|---|---|---|---|---|
| Alpha | 1857 | 18 | 105°C | 600V | 50a. | 8 ft. |
| Birnbach | 7316 | 16 | 80°C | 2500V | 60a. | 9 ft. |
| Plastic Wire & Cable | 1011 | 20 | 80°C | 600V | 35a. | 4½ ft. |

FIGURE 4

BAKER INDUSTRIES

# Pyr-A-Larm, Inc.

8 Ridgedale Avenue, Cedar Knolls, New Jersey 07927
(201) 267-1300 Cable Address: Baker Pyro

August 23, 1978

Subject: Fire Detectors

In regard to your letter to Mr. Lloyd Drahos, Pyrotronics dated July 28, 1978 project No. 5506-00 concerning your request for detector sensitivity response to burning E.P.R. chlorosulfonated polyethylene jacked cables, we hereby submit the following information.

It has been shown that as little as 1-1/2 oz. of E.P.R. smoldered on a 750°F hot plate will alarm all ionization detectors whether high voltage or low voltage. The same applies to Pyrotronics photoelectric detectors either high or low voltage. (See figure 1 for fire test room size, fire sites and detector locations).

The burning of E.P.R. in an alcohol bath to simulate flame from other sources and to demonstrate the effect of flame on E.P.R. produces different results. Because E.P.R. will not sustain flame in itself, clean burning alcohol is used because it produces no added smoke. This decomposition of E.P.R. will produce a quick response from all ionization detectors either low or high voltage but because the smoke generated is a very small amount, a considerably large fire would be necessary to produce the amount necessary to alarm photoelectric detectors, also the time period would be considerably longer. By referring to figure 1, the detectors involved, namely the high voltage F3/5A, would respond to approximately 2.5% smoke obscuration. The high voltage F5-B would respond to 2% to 2.5%. The low voltage detectors, namely the D1-2 and D1-4, would require approximately 2-1/2% obscuration to alarm also. The amount of fuel, although very small (approximately 2 oz. for smoldering fires and several pieces 3 inches long in flaming alcohol), produced a response in our fire test facility in approximately 30 seconds to 2-1/2 minutes, depending on fire site and detector location. (See figure 1)

The conclusions reached from our testing would indicate that this material is extremely easy to respond to for ionization detectors due to the large amount of very active particles generated. This applies to either smoldering fires or from flame.

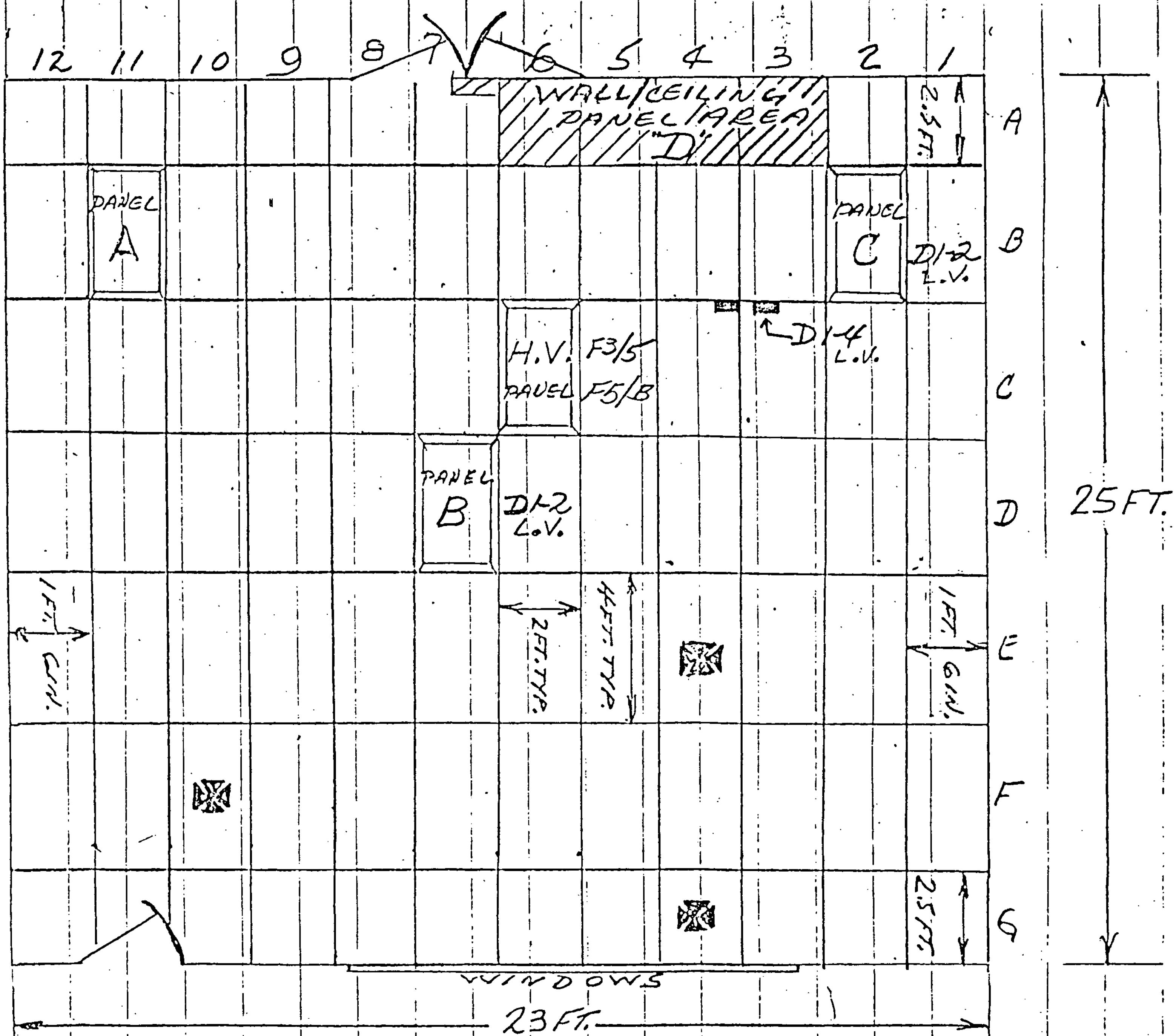
Sincerely,

PYR-A-LARM, INC.

William J. Collins

William J. Collins

WC:er
Attachment




FIRE TEST ROOM LAYOUT

FIRE SITES

SCALE 1/4" = 1.0'
CEILING HGT. = 10'

FIG. 1

Technical Bulletin
Published by Pyrotronics Engineering Department

Pyrotronics A Division of Baker Protective Services, Inc. 8 Ridgedale Avenue, Cedar Knolls, New Jersey 07927

# RESPONSE OF F5B IONIZATION DETECTOR TO VARIOUS BURNING MATERIALS

TN-12A

This report deals with a large number of materials of which the buildings, stored goods or elements of individual objects to be protected may consist. For each material, the quantity in grams (gm) is given, which, when burned in a container of 1 cubic foot volume and homogenous distribution of the ensuing combustion gases, will alarm an F5B detector with standard sensitivity of 50 volts.

These values were experimentally determined in a miniature fire-chamber, having a volume of 2 cubic feet. Solid materials were burned without open flame by putting them on an asbestos plate, heated to approximately 650°C (1200°F). The average time for alarming the various solid materials was 10 seconds. Liquid materials were burned in a porcelain container by dipping a glowing wire into the liquid; evaporation was substantially reduced by this method. The average time for alarm was 20 seconds.

The tests described above provide reproducible results, but cannot be applied in practice without further consideration, because the conditions which are valid for laboratory tests are not usually present in a practical situation. For example, the combustion gases will not be uniformly distributed in the entire room, the distance from the source of the fire to the detector is considerably greater and in a fire outbreak it is likely that several materials are burned simultaneously (container, floor, etc.).

The list provides comparative values of the required quantity of burned material needed to alarm the detector. Generally, it can be stated that the quantities of material necessary for alarming the detector are not substantially different, with the exception of those materials, which, when burned, transform into other chemical compounds (alcohol, acetone). The average for solid materials is .0008 $gm/ft.^3$

S.R. 7-10-67

| Material Burned | | Quantity Burned in $gm/ft^3$ | Type of Combustion |
|---|---|---|---|
| <u>Materials of Vegetable Origin</u>: | | | |
| Grain | Barley | .0016 | Carbonized |
| | Oats | .0012 | Carbonized |
| | Corn | .0015 | Carbonized |
| Rubber | | .0006 | Carbonized |
| Resins | Soldering resin | .0005 | Carbonized |
| Wood | Conifers | .0006 | Carb, embers |
| Wood | Hard Wood | .0011 | Carb, embers |
| Cork | | .0006 | Carb, embers |
| Linen + Glue | | .0004 | Flame |
| Wick | Spindle string | .0027 | Carb, embers |
| Paper | Glued writing paper | .0004 | Carb, embers |
| | Filter paper | .0005 | Carb, embers |
| Tobacco | | .0015 | Carb, embers |
| <u>Materials of Animal or Mineral Origin</u>: | | | |
| Asphalt | | .0024 | Carbonized |
| Felt | | .0004 | Carbonized |
| Putty | | .0037 | Carbonized |
| Cowhide | | .0003 | Carbonized |
| Horsehair | | .0003 | Carbonized |
| Sulphur | | *.0001 | Flame |
| <u>Textiles</u>: | | | |
| Cotton | | .0003 | Flame |
| Artificial Silk | | .0019 | Flame |
| Silk | | .0006 | Flame |
| Wool | | .0003 | Flame |

* = greater than

| Material Burned | | Quantity Burned in $gm/ft^3$ | Type of Combustion |
|---|---|---|---|
| <u>Paints</u>: | | | |
| Baking Varnish | Alkyd/Carbamid resin combination brown | *.0001 | Carbonized |
| | black | .0006 | Carbonized |
| Synthetic Resin Varnish | Alkyd Resin | .0020 | Carbonized |
| Nitro Varnish | Cellulose/Synthetic Resin combination | .0014 | Carbonized |
| <u>Electrical Insulation Materials</u>: | | | |
| Cellophane | | .0003 | Carbonized |
| <u>Wire Insulation</u>: | | | |
| Enamel Insulation of copper wires | | .0004 | Carbonized |
| Oil Varnished Wire with double artificial silk insulation (flame proof) | | .0004 | Carbonized |
| Polyvinylacetate | | .0002 | Carbonized |
| Polyvinylchloride | red | .0003 | Carbonized |
| | blue | .0003 | Carbonized |
| | green | .0004 | Carbonized |
| Thermoplastic, single insulation (flame-proof) | yellow/red | .0002 | Carbonized |
| Lacquered glass wool | | .0014 | Carbonized |
| Mica/Asphalt combination | | .0006 | Carbonized |
| Spaghetti Tube, oil impregnated, organic fabric | | .0005 | Carbonized |
| <u>Artificial Resin Materials, Pressed Layers</u>: | | | |
| Phenolic Resin with fabric | | .0006 | Carbonized |
| Phenolic Resin with paper | | .0003 to .0009 | Carbonized |
| Phenolic Resin with asbestos fabric | | .0034 | Carbonized |
| Oil glass silk | | .0009 | Carbonized |
| Oil silk | | .0004 | Carbonized |

| Material Burned | | Quantity Burned in $gm/ft^3$ | Type of Combustion |
|---|---|---|---|
| Oil fabric | | .0004 | Carbonized |
| Organic glass | Plexiglass | .0014 | Carbonized |
| Paper-mica-paper | | .0011 | Carbonized |
| Mylarfoil Polyethyleneterephtalatfilm | | .0040 | Carbonized |
| Polyethylene | | .0003 | Carbonized |
| Polyamid | Rilsan | .0003 | Carbonized |
| | Nylon | .0011 | Carbonized |
| Polyester-foamfabric | | .0009 | Carbonized |
| Polystyrol | High Impact Material | .0005 | Carbonized |
| Polyvinychlorid | Scotch-Tape | .0003 | Carbonized |
| | red | .0004 | Carbonized |
| | transp. with protective metal cover | .0004 | Carbonized |
| Neoprene (Artificial Rubber) | $57^{o}$ Shore | .0006 | Carbonized |
| | $70^{o}$ Shore | .0009 | Carbonized |
| Shellac Paper | | .0004 | Carbonized |
| Silicone Rubber | | .0011 | Carbonized |
| Trafoboard | | .0008 | Carbonized |
| Liquids: | | | |
| (With all liquids evaporation had no influence on the detector) | | | |
| Alcohol, medical purpose | | .1270 | Flame |
| Acetone | | .0340 | Flame |
| Gasoline | | .0038 | Flame |
| Lead Gasoline | | *.0043 | Flame |
| Benzol, pure | | .0013 | Flame |
| Dioxan | | .0425 | Flame |
| Nitrothinner | | *.0043 | Flame |
| Kerosene | | *.0043 | Flame |

| Material Burned | Quantity Burned in gm/ft$^3$ | Type of Combustion |
|---|---|---|
| Carbontetrachloride | *.0043 | Slight Fl. |
| Trichlorethylene | .0635 | Flame |
| <u>Oils and Greases</u>: | | |
| Diesel Oil | *.0043 | Flame |
| Hydraulic Oil | *.0043 | Flame |
| Engine Oil | *.0043 | Flame |
| Spindle Oil | *.0043 | Flame |
| Vaseline Oil | *.0043 | Flame |
| Ball Bearing Grease | .0005 | Flame |