

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



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1151 BOSTON-PROVIDENCE TURNPIKE, NORWOOD, MASS. 02062

17741

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 TestsI. 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 following 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, plasticizers, 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 turbulence 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 $7\frac{1}{4}$ inches of wire from which all but $2\frac{1}{2}$ 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 $5\frac{1}{2}$ 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

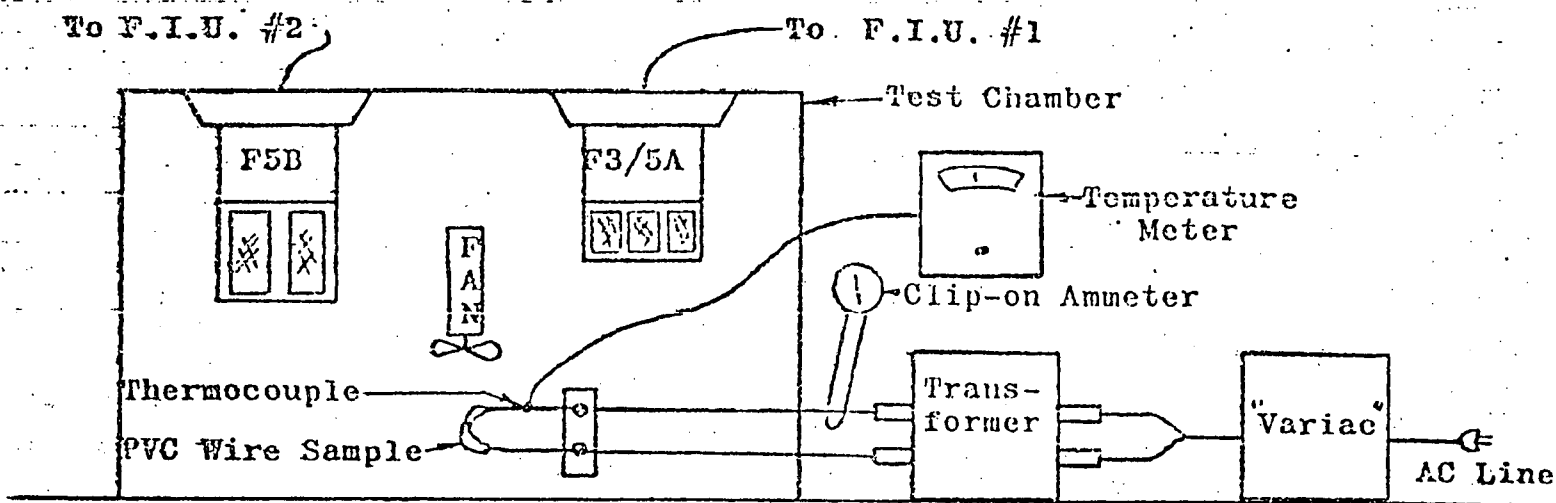


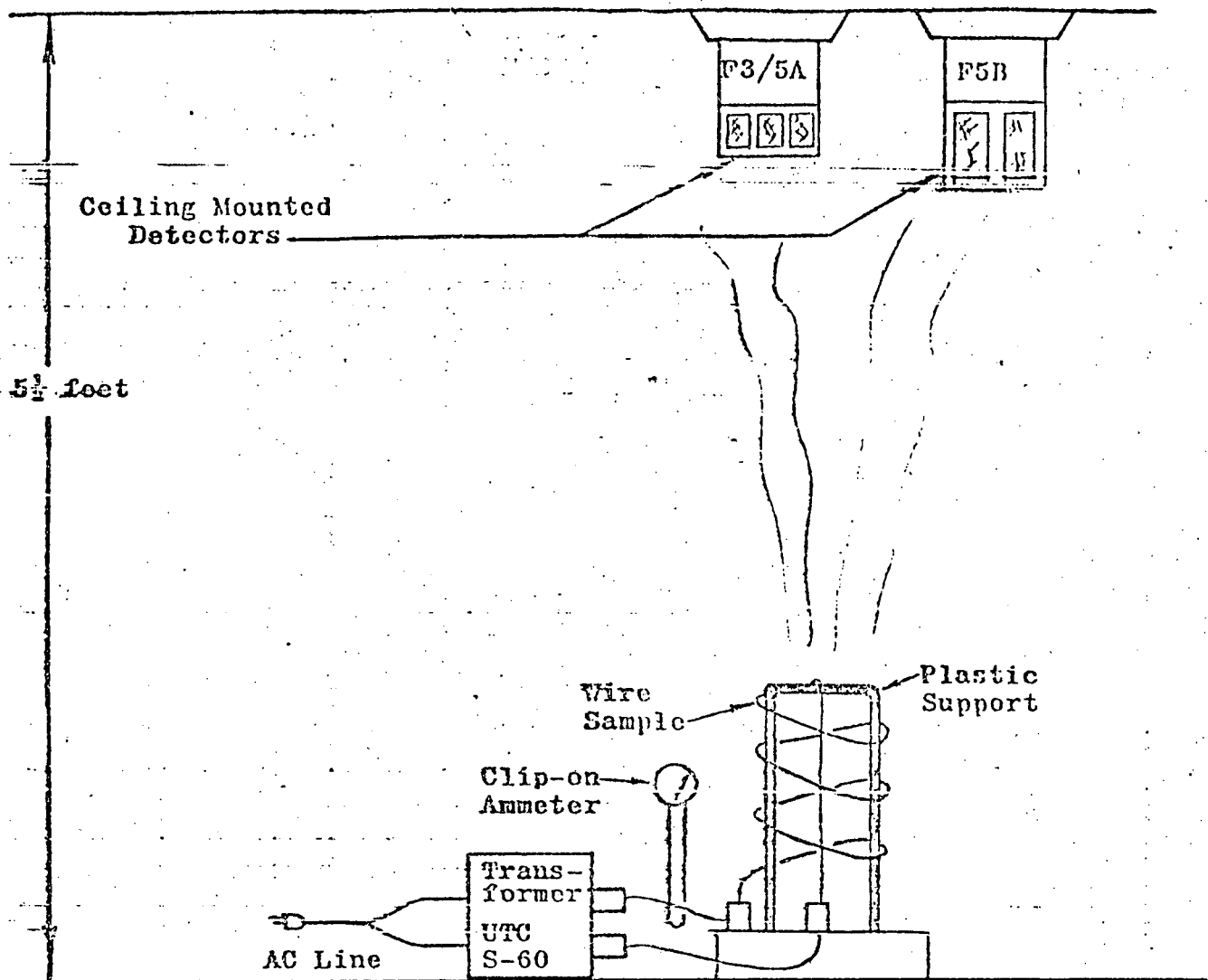
FIGURE 1

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 7 $\frac{1}{4}$ " long with 2 $\frac{1}{2}$ " 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.
Birnback	7316	16	80°C	2500V	60a.	9 ft.
Plastic Wire & Cable	1011	20	80°C	600V	35a.	4 1/2 ft.

FIGURE 4



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 jacketed 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)

August 23, 1978

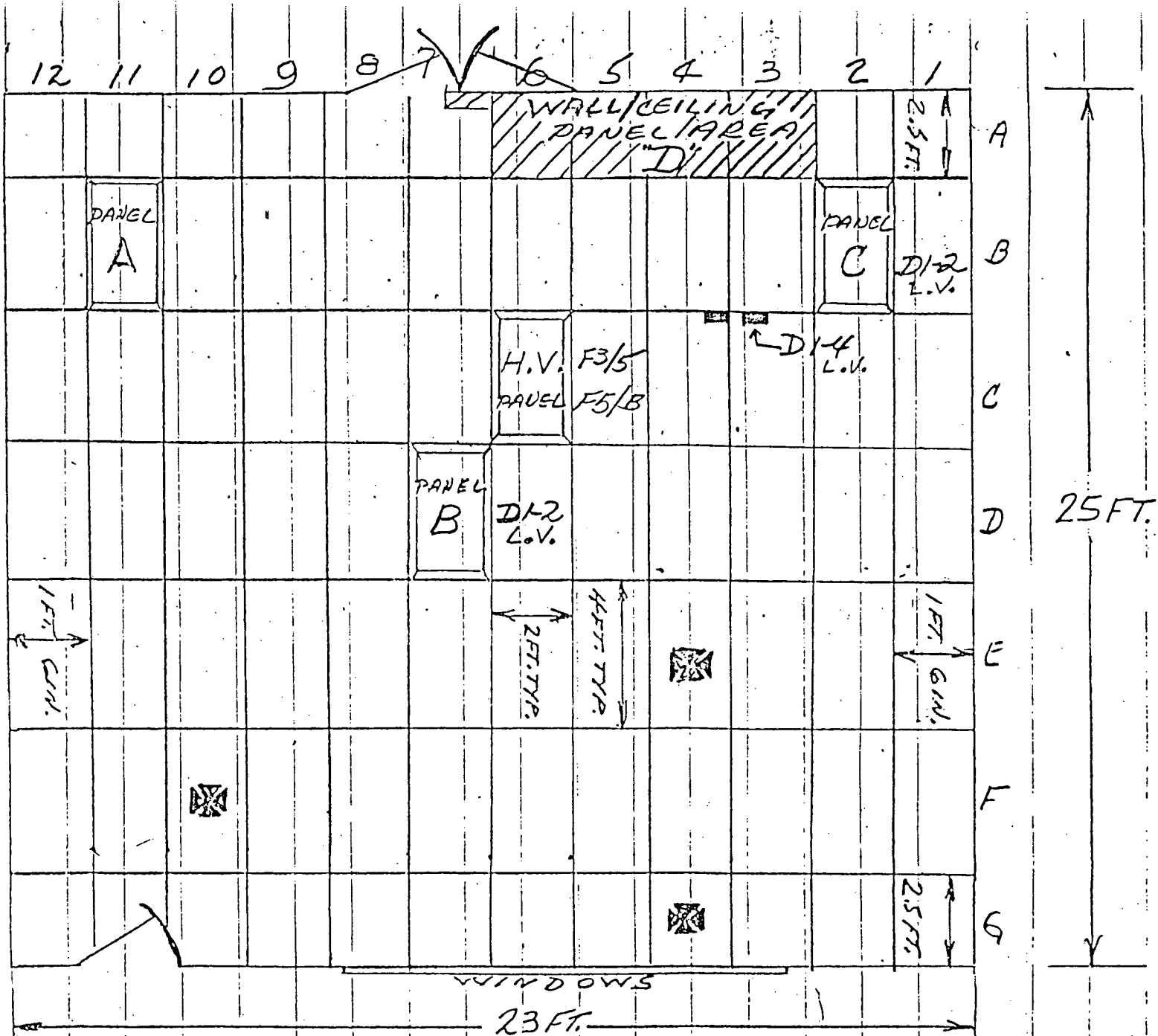
The conclusions reached from our testing would indicate that this material is extremely easy to respond to for ionization detectors due to the large amount of very active particles generated. This applies to either smoldering fires or from flame.

Sincerely,

PYR-A-LARM, INC.

William J. Collins
William J. Collins

WC:er
Attachment



FIRE TEST ROOM LAYOUT

FIRE SITES

SCALE $\frac{1}{4}'' = 1.0'$
CEILING HGT. = 10'

RESPONSE OF F5B IONIZATION DETECTOR

TN-12A

TO

VARIOUS BURNING MATERIALS

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 black	*.0001 .0006	Carbonized 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 blue green	.0003 .0003 .0004	Carbonized Carbonized 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 Polyethyleneterephthalatfilm	.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 red	.0003	Carbonized
transp. with protective metal cover	.0004	Carbonized
Neoprene (Artificial Rubber)	
57° Shore	.0006	Carbonized
70° Shore	.0009	Carbonized
Shellac Paper	.0004	Carbonized
Silicone Rubber	.0011	Carbonized
Trafoboard	.0008	Carbonized
<u>Liquids:</u>		
(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