HEALTH PHYSICS ASSOCIATES LTD.

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RADIATION SAFETY EVALUATION

REPORT

for

FIREX SMOKE DETECTOR

FX-Models

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HEALTH PHYSICS ASSOCIATES LTD. CONSULTANTS IN RADIATION SAFETY

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FIREX SMOKE DETECTOR

RADIATION SAFETY PRODUCTION MODEL TESTING

A preproduction model of the basic smoke detector with final design components manufactured by Firex was received. This detector was given the following set of tests in August, 1977.

I - As received Contamination and Radiation Level.

Smear tests of the outer surfaces were taken and counted in a low background windowless gas flow proportional counter. Counts were taken of both alpha particle and beta particle contamination. The alpha background runs about one count per hour and the beta background 28 ± 8 counts per minute, which puts the alpha detection level at about 2×10^{-8} microcuries. Initial external gamma measurements were made with a vibrating reed ionization chamber detector (Victoreen 440). Background level with this instrument tends to be about 0.2 mR/hr in our laboratory limiting the survey sensitivity to levels greater than 0.1 mR/hr at an inch.

II - Shock and Impact Test.

The shock test consists of five drops from a height of two (2) meters onto a concrete slab. This is followed by surface wipe test and visual inspection.

III - Immersion Test

The device is immersed in Methanol for a period of 48 hours with periodic agitation. Following this the entire volume is evaporated and the residue counted in the gas flow proportional counter.

IV - Low Background Gamma Exposure Rate Determination

The smoke detector was placed with its source at 6 cm from the center of a 3"x3" NaI (Tl) detector in a copper shield in a 6" lead shield of a low background scintillation spectrometer with a nuclear data 512 channel pulse height analyzer. From this data was calculated the dose rate at 5 and 25 cm from the front face of the smoke detector.

FIREX SMOKE DETECTOR
RADIATION SAFETY PRODUCTION MODEL TESTING

V - High Temperature Test

The detector is subjected to 1000°F for an hour. The furnace is preheated to temperature and the detector, enclosed in a stainless steel closed beaker, is placed inside. The temperature is allowed to rise to furnace temperature and maintained for an hour. Following this, the beaker is removed from the furnace and allowed to cool to room temperature in air. Wipe samples are taken of the furnace carrier and the detector ion chamber. Finally the ion chamber is dismantled and the source checked directly with wet leak test.

TEST RESULTS ON PRODUCTION MODEL AUGUST, 1977

I -As received Contamination and Radiation Level

Net alpha count of 0 counts per minute not significantly different from background.
Net beta and alpha count of 28.4 ± 6 counts per minute is not significantly different from Beta background of 28 counts per minute.
Gamma level less than 0.1 mR/hr at 1" with vibrating reed air ion chamber.

II -Shock Test

The smoke detector held up reasonably well under shock test of 2 meter drop onto concrete.

The result of the first six drops were only slight cosmetic imperfections on the case. No leakage and no internal rattles were apparent.

The seventh drop resulted in failure of the plastic rods connecting the cover to the base. Unit was still electrically functional and radiologically secure.

The tenth drop resulted in failure of the clip holding the printed circuit board to the base. At this point the unit would no longer have been usable for its intended purpose, but its radioactive source was still contained and there was no direct release path for alpha particles from the ^{241}Americium.

FIREX SMOKE DETECTOR
RADIATION SAFETY PRODUCTION MODEL TESTING

Wipe Test After Shock Run

	Net alpha and beta	Net gamma
Cover	0 ct/min	1 ct/min
Base Assembly	1 ct/min	0 ct/min
Ion Chamber	0 ct/min	0 ct/min

III - Immersion Test

After a 50-hour immersion in methanol with periodic agitation the count rates of the residue of the solvent was:

alpha and beta count rate - not significantly different from background

alpha count rate - not significantly different from background

IV - Gamma Exposure Rate Determination

From the scintillation counter spectrum (see illustration I) we have:

Peak #	Photons/cm^2sec (from graph ÷45.6cm^2 of total)	Photons/cm^2(R/hr)*	R/hr
1	2.52	5×10^6	5.0×10^{-7}
2	19.17	7×10^6	2.74×10^{-6}
3	.160	6×10^6	2.7×10^{-8}

$\bar{x} = 3.27 \times 10^{-6}$R/hr

Total exposure rate at 6 cm is thus 3.3 micro R/hr
Calculated exposure rate at gonadal distance is:

$\left(\frac{200}{6}\right)^{-2} \times 3.3 \times 10^{-6} = 2.9 \times 10^{-9}$R/hr or

1.8 mR gonadal exposure in a 70 year life time directly below detector

* from APEX 176 page 113

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RADIATION SAFETY PRODUCTION MODEL TESTING

V. High temperature Test 1000° for 60 minutes

The first 15 minutes demonstrated considerable evolution of fumes as the plastic ashed. A faulty temperature controller allowed the temperature to rise to 1200° F for the remainder of the test. Oxidation was complete after 15 minutes. (See photo for Test V)

At the end of the test the plastic parts of the detector held together as an ash around its metallic and fiberglas parts.

A wipe of the exposed portions of the ionization chamber (See photo IV) gave:

alpha and beta--No detectable contamination
alpha --No detectable contamination

The ion chamber was then torn free of the PCB board revealing the ^{241}Am source which was still intact in its screw holder. A leak test of the source and holder gave:

alpha and beta--2203 net counts/minute = .00198 uCi beta emitter
alpha --553 ± 10 net counts/minute = .00050 uCi alpha emitter

CONCLUSIONS:

This production model of the Firex smoke detector passes all of the tests described above. It is, in my professional opinion, an item which could be safely marketed with minimal hazard and considerable safety benefit.

August 10, 1977

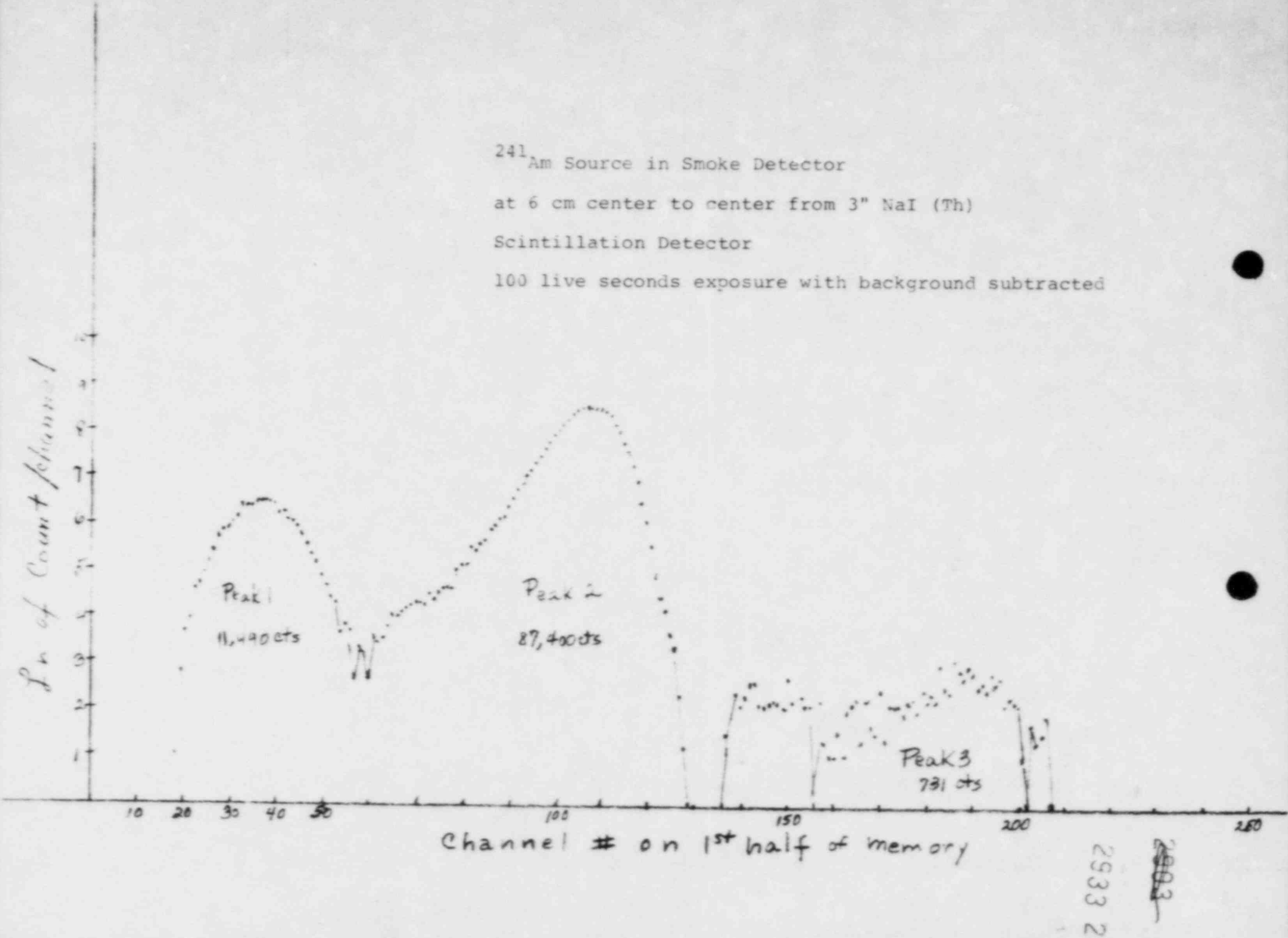
Raymond M. Johnson
Raymond M. Johnson
Certified Health Physicist

^{241}Am Source in Smoke Detector

at 6 cm center to center from 3" NaI (Th)

Scintillation Detector

100 live seconds exposure with background subtracted



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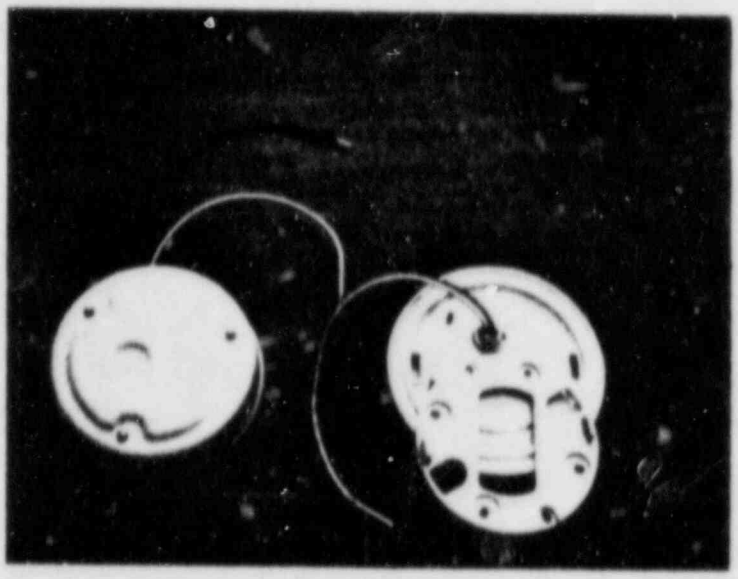
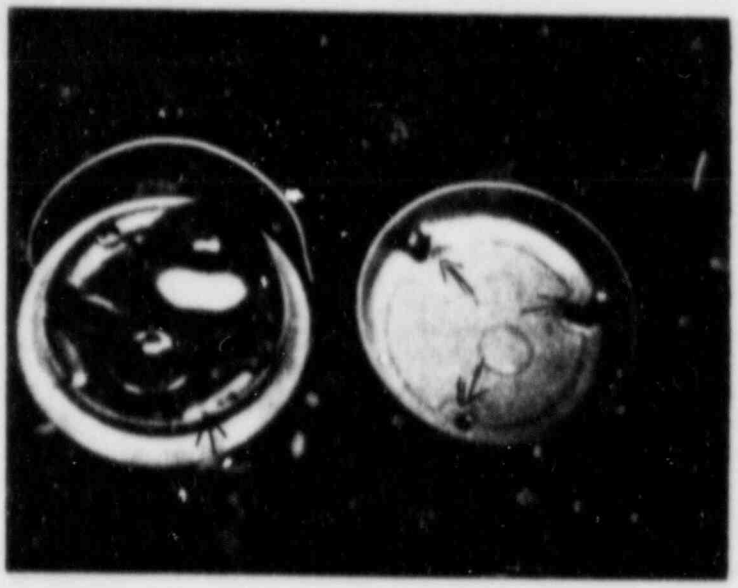
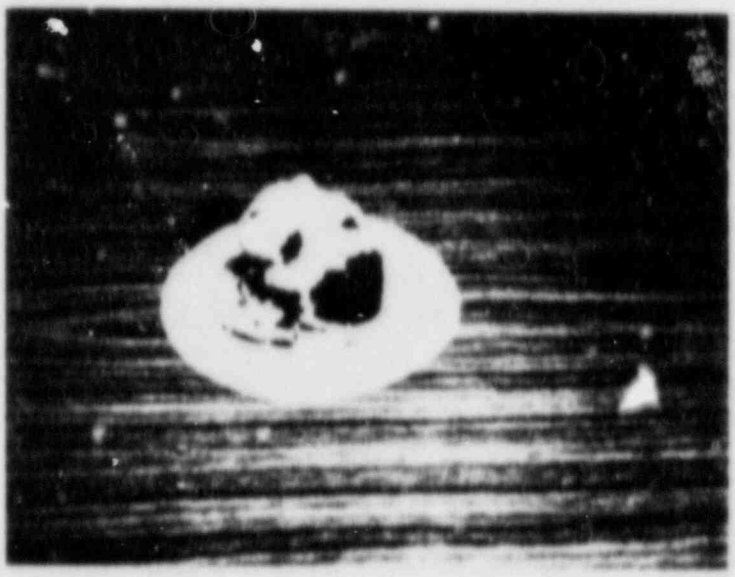


I. Sample Detectors for test



Test II. Unit after Drop test. Arrow points to broken clip to attach PCB to base. After 10th drop, triple arrows show broken posts.

Test V . View in furnace showing A - Ion chamber
B - Alarm unit



Test IV. View after incineration at 1000° for 60 minutes. Arrow points to ion chamber where surface wipe was taken.