BAKER INDUSTRIES

Pyrotronics

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August 7, 1979

U. S. Nuclear Regulatory Commission
Division of Fuel Cycle and Material Safety
Washington, D. C. 20555

Attention: James A. Jones

Reference: Control No. 97991

Dear Jim:

I have enclosed the report by Western Radiation Consultants on the Model DI-4A I.C.S.D.

If you have any qeustions or require further data, please contact me.

Sincerely,

Robert E. Butchko
Chief Radiation Protection Officer

REB:lg

Enclosure

The attached data are submitted in support of an application for ammendment to Pyrotronics NRC Distribution and Manufacturing Licenses for Ionization Chamber Smoke Detectors containing ^{241}Am.

The new Pyrotronics model, DI-4A, contains two sources with nominal activities of 0.4μCi each. Model DI-4A is an industrial type smoke detector.

The sources are identical to sources used in previously licensed Pyrotronics models.

External radiation exposure levels were measured for model DI-4A.

The unit was dropped 100 times from a height of 8 ft onto a concrete surface.

WESTERN RADIATION CONSULTANTS, INC. Industrial, Medical, Environment

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EXTERNAL RADIATION EXPOSURE RATES

The external radiation exposure rates at the surface and 5 cm and 25 cm from the surface of Pyrotronics Model DI-4A ionization chamber smoke detector were measured using a Ge(Li) detector with a multi-channel analyzer system. A 0.0111 μCi ^{241}Am standard was counted using the same system. A conversion factor, the ratio of calculated exposure rate to count rate summed over eleven channels, was determined.

Exposure rate at 5 cm from standard source:

Source activity 0.0111 μCi

36% of ^{241}Am disintegrations produce a 60 keV gamma photon

Exposure rate = ϕ(energy fluence) x μ/ρ (mass absorption coefficient)

$$= \frac{0.0111\ \mu Ci \times 2.2 \times 10^{6}\ d/m\text{-}\mu Ci \times 0.36 \times 60\ keV/\gamma \times 60\ m/h}{4\pi\ (5cm)^2 \times 6.24 \times 10^{8}\ keV/erg \times 86.9\ erg/g\text{-}R}$$

$$= 1.88 \times 10^{-6}\ R\text{-}g/h\text{-}cm^2 \text{ at } 5\ cm$$

μ/ρ = 0.0292 cm^2/g (1970 edition of the Radiological Health Handbook)

Exposure rate (R/h) = $1.88 \times 10^{-6} R\text{-}g/h\text{-}cm^2 \times 0.0292\ cm^2/g$

$= 5.48 \times 10^{-8}$ R/h = 5.48×10^{-2} μR/h

Net count rate summed over eleven channels - 78.5

Standard deviation = 5%

Conversion factor = 5.48×10^{-2} μR/h/78.5 c/m

$= 6.98 \times 10^{-4}$ μR/h/c/m

The exposure rates from the units are directional. The source is centrally located in the unit, however the exposure rates vary somewhat due to differences in shielding by components of the detector.

Table 1

Measured Exposure Rates

Model DI-4A

(See Figures 1 and 2)

	Exposure Rate (μR/h)		
Detector Position	surface	5cm	25cm
front	4.20	0.92	0.077
back	7.86	1.21	0.064
side 1	0.98	0.11	0.02
side 2	1.21	0.20	0.02
side 3	1.06	0.27	0.03
side 4	0.77	0.29	0.03
side 5	0.53	0.12	0.02
side 6	0.94	0.17	0.02
Packaged Detector			
side a	2.12	0.86	0.063
side b	4.37	0.64	0.056
side c	0.41	0.04	<0.01
side d	0.22	0.08	0.03
side e	0.58	0.10	0.02
side f	0.64	0.07	0.01

Figure 1

External Radiation Levels (μR/h)

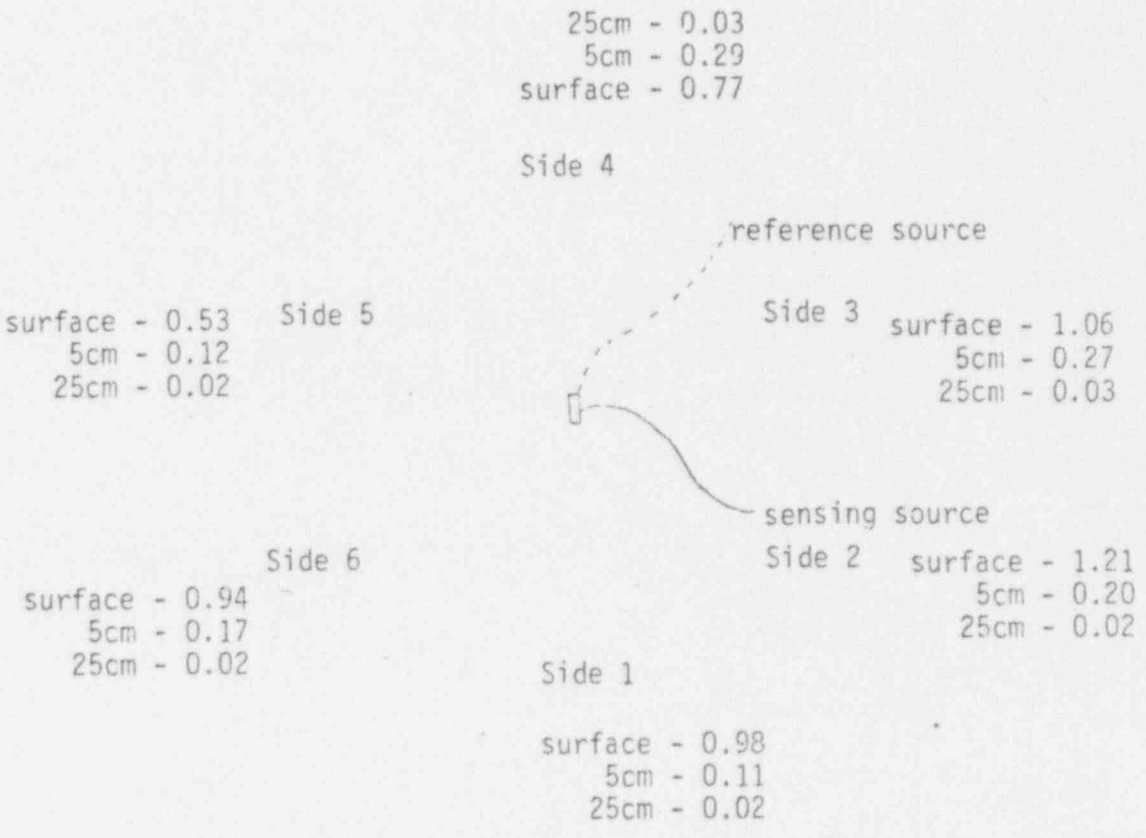
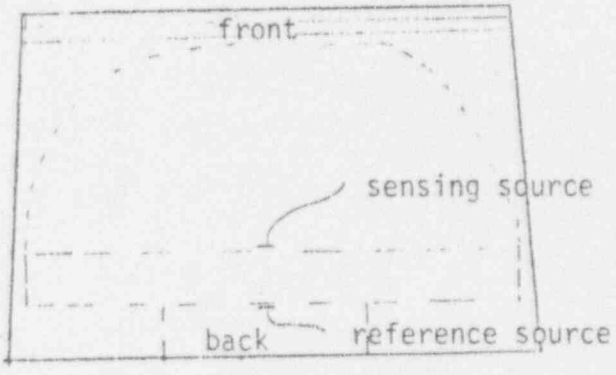


Figure 2

External Radiation Levels (μR/h)

25cm - 0.077
5cm - 0.92
surface - 4.20



surface - 7.86
5cm - 1.21
25cm - 0.064

ESTIMATED ANNUAL RADIATION EXPOSURES

All exposure calculations are based on the maximum measured exposure rates.

1. Individual in protected building

   a. Whole body exposure in normal use.

   Maximum measured exposure rate at 25cm = 0.077μR/h

   Estimated annual exposure (assuming 8 hour per day)

   0.077 μR/h x 8 h/d x 365 d/y = 0.2 mR/y

   25 cm was used as the distance as it is the greatest distance for which the exposure rate was measured. A more reasonable distance would be 1 m. The annual exposure rate at 1 m is approximately:

   $0.2 \text{ mR/y} \times \left(\frac{25 + 2 \text{ cm}}{100 + 2 \text{ cm}}\right)^2 = 0.02 \text{ mR/y}$

   In the extreme case of the units being situated at 1 meter directly above a bed occupied 24 hours per day, 365 days per year the total annual exposure would not exceed 0.05 mR/y.

   b. Individual installing units

      1) Whole body exposure

      Assume an individual spends 200 hours per year installing these units and whole body distance, 25 cm. Maximum measured exposure rate at 25 cm from smoke detector - 0.077 μR/h

      0.077 μR/h x 200 h/y = 0.02 mR/y

      2) Exposure to hands

      Maximum measured exposure rate at surface of the unit - 7.86 μR/h

      7.86 μR/h x 200 h/y = 2 mR/y

Prototype Test

The unit was dropped from a height of 8 ft onto a concrete floor 100 times. The outside of the unit was wiped prior to the drop test. Both sources were wiped after the unit had been dropped 100 times.

After 5 drops the reference chamber cover came off exposing the reference source. After 20 drops the screen over the sensing chamber broke off exposing the sensing source. There was no apparent damage to either the sources or the source mounts. The sources remained firmly attached to the mount; the source mount was securely attached to the base of the unit after 100 drops.

It is improbable that accidental abuse of the detector would result in loss of a source or impairment of source integrity.

The wipes were counted in a low background gas flow counter. The wipe of the outside of the unit prior to the drop test showed no significant contamination (< 1 pCi). A wipe of the sensing source showed 2 pCi removable alpha contamination. The reference source wipe indicated 10 pCi removable alpha contamination.