DOSITEC® *Making radiation detection devices since 1980*

K8 Nuke Safeguard User's Guide

(Size 25 mm x 39 mm x 12 mm; weight 13 grams)

Features

- Ideal device for detecting Dirty Bombs & other sources of radiation
- Meets NCRP Report No. 138 Management of Terrorist Events Involving Radioactive Material
- Capable of detecting low level of radiation and very small amounts of radioactive materials
- Minimize exposure from unexpected radioactive sources
- Developed and tested with NIST traceable sources
- Meets EMC Directive Standards

Description

K8 is a personal radiation indicator. It can detect low level radiation and very small amount of radioactive materials nearby. This highly sensitive miniature device can help a person to minimize radiation exposure from unexpected sources presence.

Application

Homeland Security Personnel	First Responders
Custom & Cargo Inspectors	Border Patrols
Airline & Airport Workers	Package Handlers
Nuclear Medicine Patients	Hospital Workers
Researchers & Environmentalists	General Public

Users

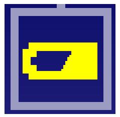
Thousands of K8 devices were distributed to general public individuals, state agent & troopers, firefighters, pilots, border patrols, cargo and port inspectors, hospital medical doctors and radiological technicians, thyroid cancer patients, researchers, low level nuclear waste handlers, casino security personnel and etc.

Symbols

The device has three LED indications:

 Green flash Capture pulses including natural radiation

 Red flash High-level radiation presence

 Yellow flash Change the battery

Leave the area if red LED flashes indicating radiation level is higher than normal presence.

Dositec, Inc. 63 South Street, Hopkinton, MA 01748 USA www.dositec.com Mailto: info@dositc.com

K8 Nuke Safeguard Specifications

Detector	Solid-state Si-detector.
Detection	Gamma (γ) & X-rays; 30keV - 6.2MeV Electrons & Beta (β) particles; 550keV and up
Sensitivity	1 green flash per sec. in a 20µSv/h ^{137}Cs field
Alarm threshold	20µSv/hr (2mR/h)
Warning signals	Red LED flashes & audible alarm beeping
Audible sound	Approx. 80dB@10 cm.
Battery	One CR2032 standard lithium battery
Battery life	1500 hrs in background radiation environment
Battery low indication	Yellow LED flashes with 12 hours warning
Power switch	A slide switch to turn unit on/off
Power indication	3 LEDs blink briefly while turning on
Natural radiation	Green LED flashes approx. every 1 to 5 min.
Relative humidity	Up to 95%
Operating temperature	-20°C to +50°C
CE Marking	Yes
Packaging	High impact plastic
Clip	Spring loaded clip with teeth for easy grip
Size (approx.)	25 mm x 39 mm x 12 mm (1"x1.5"x0.475")
Weight (approx.)	13 grams (1/2 oz)
Ruggedness	Exceeds drop test requirements of ANSI 13.27

All Specifications are subject to change without notice.

Product View

Operations

Slide power switch to " I " position to turn unit on. K8 is now ready for use. Note: 3 LEDs blink briefly while turning on.

In ON mode, the unit should respond to natural background radiation and give out green flash every 1 to 5 minutes.

Battery Replacement

Change battery when yellow LED starts to flash. Steps are as follows:

a) Remove two screws from the cover.
b) Slide the battery out
c) Push in a new CR2032 lithium battery
d) Put cover and screws back
e) The unit is ready for use

Important Safety Information

- Keep at minimum of 20 cm away from microwave, cellular phone or any high RF generators such as TV remote controls, 2-way radios, etc.
- Drops or mechanical impacts would trigger LED flashes.

Dirty Bomb - Likelihood of Radionuclides Being Used

There are not very many common radionuclides with significant gamma or x-ray emissions < 45 keV. Some of these are I-125 (60 day half life, about 30 keV, about 7%); I-129 (2E7 year half life, 40 keV, about 9%); Ba-140 (13 day half-life, 30 kev, about 11%, but also emits several high energy gammas at higher yields). There are a number of other radionuclides that emit photons at low energy (e.g., 30 keV x-rays from Cs-137 decay), but they are accompanied by high energy gamma radiation that is more important.

The likelihood of radionuclides being used in a dirty bomb depends significantly on availability. Possible nuclides that are available because of their rather common usage, in addition to Cs-137 and Co-60, are Ir-192 (a common source material used in industrial radiography); I-131(relatively short-lived, but produced in moderate amounts for medical therapy; one could accumulate multi-Curie amounts without much difficulty; might be desirable because of its volatility and potential for thyroid uptake); Ra-226 (naturally occurring - there may be a number of stockpiles of radium that has been used in various medical, research, and defense applications in the past and is no longer used); mixed fission products that include radionuclides such as Cs-137, Sr-90, Zr-Nb-95, etc. (the terrorist would have to have access to spent reactor fuel or reprocessing byproducts to obtain these materials); uranium-235 and/or plutonium-239 (other plutonium isotopes also possible; while enriched forms of these fissile materials are suited to nuclear bomb type devices, they could also be used to enhance contamination and radiotoxicity in a "dirty bomb"; these materials are more available since the breakup of the Soviet Union). Clearly there are many other possibilities, depending on the connections that terrorists might establish. The distance to yield 2mR/h from one Curie of these isotopes is as follows:

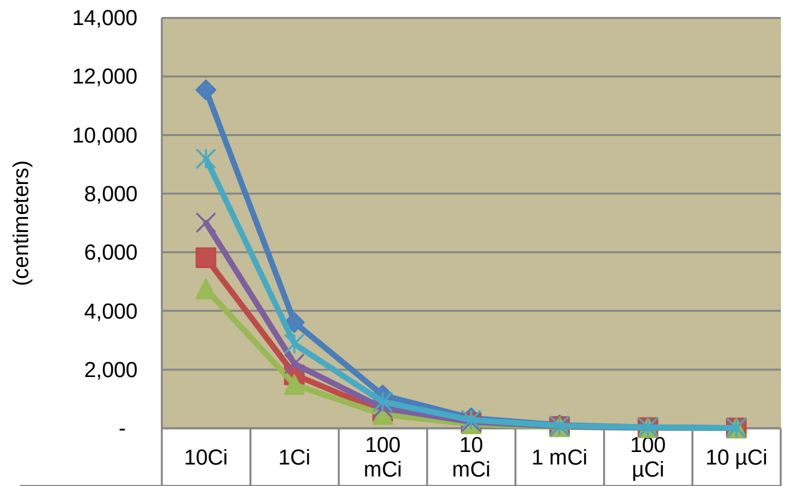
Nuclide	Distance in feet to yield 2mR/h from 1Ci
Co-60	83.6
C3-137	42.1
I-131	34.4
Ir-192	50.8
Ra-226	66.6

K8 Detection Capability

With 30 keV to 10 MeV detection range capability, it detects both low energy emission radionuclides such as I-125 & Pd-103 commonly used in nuclear medicine and radiation therapy in hospitals, and high energy ones such as Cs-137, Co-60, Ir-192, I-131, U-235, & Ra-226. It also detects high energy beta emitters: Y-90 & P-32. Such radionuclides are possible for use in a dirty bomb.

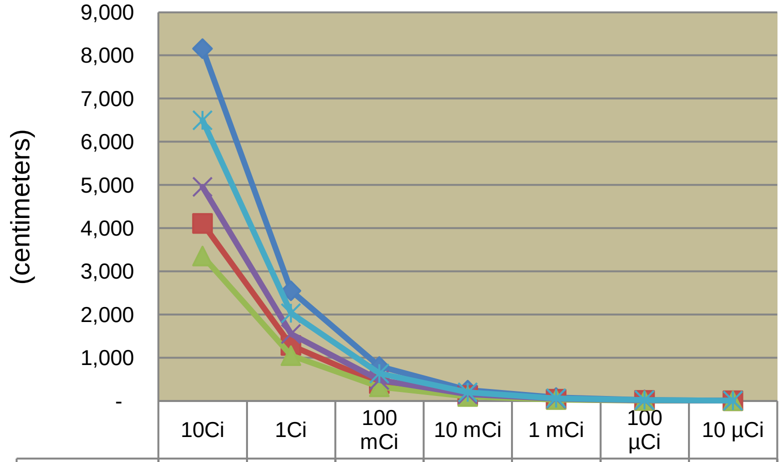
It is capable of detecting very small amounts of radioactive materials within a reasonable distance, e.g.,Green LED flashes approx. every 5 sec., at 7.5cm away from a 10µCi Cs-137 and 15 cm away from a 10µCi Co-60. The level of the radiation is low, about 5µSv/h, which is way below the United State Federal Gov't 10 CFR 20 1301(a)(2) Subpart D imposed limit, 2mrem/hr. Varies activity/detection distances are shown below.

Distance in centimeters to yield 10µSv/h



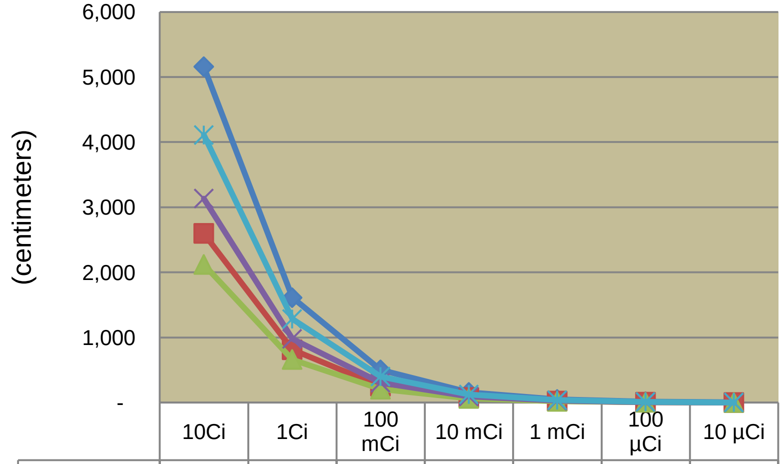
	10Ci	1Ci	100 mCi	10 mCi	1 mCi	100 µCi	10 µCi
Co-60	11,535	3,605	1,126.	352.01	110.00	34.38	10.74
Cs-137	5,812	1,816	567.54	177.36	55.42	17.32	5.41
I-131	4,745	1,483	463.39	144.81	45.25	14.14	4.42
Ir-192	7,009	2,190	684.48	213.90	66.84	20.89	6.53
Ra-226	9,189	2,872	897.36	280.42	87.63	27.39	8.56

Distance in centimeters to yield 20µSv/h



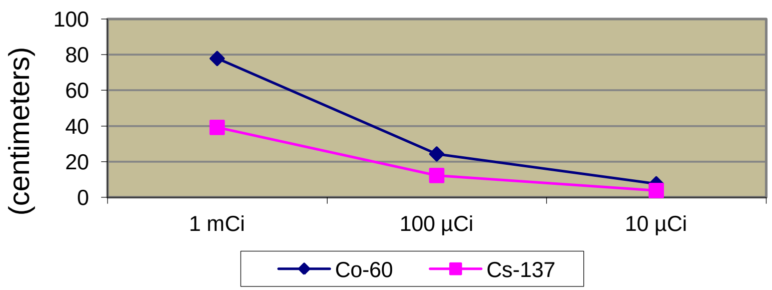
	10Ci	1Ci	100 mCi	10 mCi	1 mCi	100 µCi	10 µCi
Co-60	8,156	2,549	796.52	248.91	77.78	24.31	7.60
Cs-137	4,109	1,284	401.31	125.41	39.19	12.25	3.83
I-131	3,355	1,049	327.67	102.40	32.00	10.00	3.12
Ir-192	4,956	1,549	484.00	151.25	47.27	14.77	4.62
Ra-226	6,498	2,030	634.53	198.29	61.97	19.36	6.05

Distance in centimeters to yield 50µSv/h

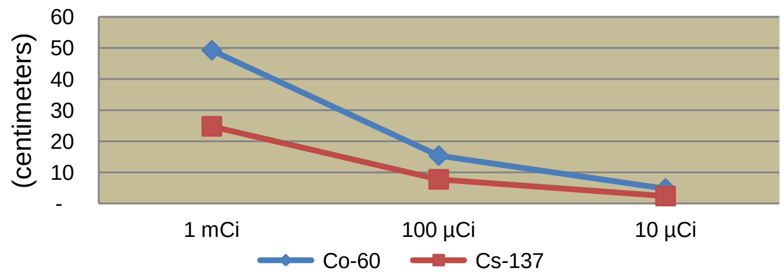


	10Ci	1Ci	100 mCi	10 mCi	1 mCi	100 µCi	10 µCi
Co-60	5,159	1,612	503.76	157.43	49.20	15.37	4.80
Cs-137	2,599	812	253.81	79.32	24.79	7.75	2.42
I-131	2,122	663	207.24	64.76	20.24	6.32	1.98
Ir-192	3,135	980	306.11	95.66	29.89	9.34	2.92
Ra-226	4,109	1,284	401.31	125.41	39.19	12.25	3.83

Distance in centimeters to yield 20µSv/h



Distance in centimeters to yield 50µSv/h



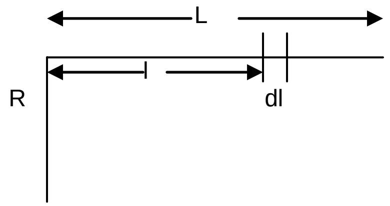
K8 Alarms to a High Speed Moving ^{60}Co Source

The K8 PRI would alarm when the alarm point is set at 5 mrem/hr, and a vehicle, traveling at 65 miles per hour and carrying a small volume Co-60 source passes by the K8. In the calculation the static source response time data obtained by testing to fit the response time, t_r, to a power function as follows:

$$t_r = 7.645X^{-0.4328} \quad (1),$$

where X is the exposure rate, in mR/hr, and T_r is in seconds.

As the vehicle travels along a straight line at a constant velocity, the dose point is assumed to lie at some perpendicular distance, R, from the line of travel of the vehicle; the vehicle is assumed to travel a particular distance L from its start point to a point opposite the dose point and at the intersection of the vehicle line of travel and the perpendicular line from the dose point.



The length l defines the variable distance of the vehicle from the intersection of the lines as shown above. The element dl represents a differential length element and is related to vehicle velocity, v, and elapsed time, t, by

$$l = vt,$$

and $$dl = vdt.$$

Note that for calculation purposes it doesn't matter whether the vehicle travels from right to left or from left to right. The distance from source to dose point is given by $x = (R^2 + v^2t^2)^{0.5}$. The approach used was to a select a particular source activity and a fixed value of R, to determine the maximum value of x that would yield an exposure rate of 5 mR/hr, and to calculate the associated value of L from the Pythagorean theorem. This value of L represents a particular travel time given by ulim=L/v. The average value of the detector alarm response time, $T_{r,mean}$ was then determined using a weighted mean calculation. The weighting factor used in this calculation was the exposure during the differential time interval dt. The calculation was carried out according to

$$T_{r,mean} = \frac{\int_0^{u\lim} t_r X dt}{\int_0^{u\lim} X dt} \quad (2).$$

When equation (1) is used for t_r, and exposure rate is given by

$$X = \frac{\Gamma A}{R^2 + v^2t^2} \quad (3),$$

equation (2) becomes

$$T_{r,mean} = \frac{\int_0^{u\lim} 7.645\left(\frac{\Gamma A}{R^2 + v^2t^2}\right)^{0.5672} dt}{\int_0^{u\lim} \frac{\Gamma A}{R^2 + v^2t^2} dt} \quad (4),$$

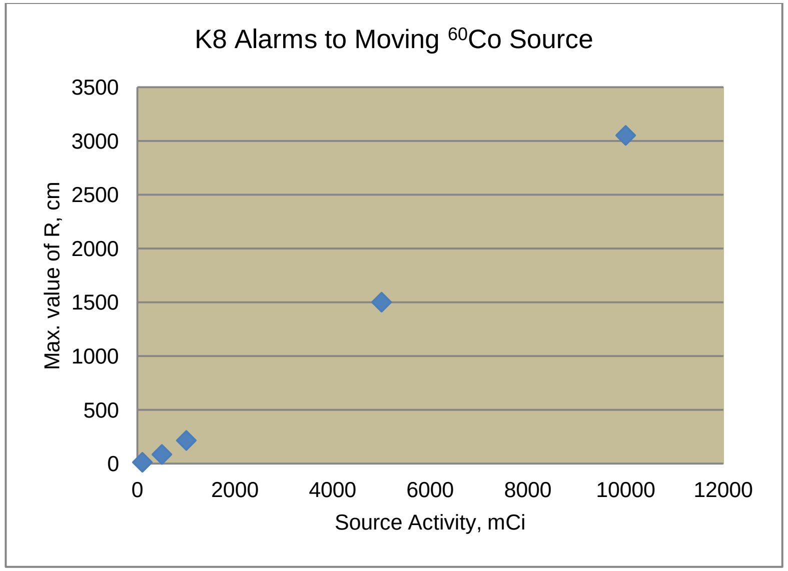
where Γ is the gamma ray exposure rate constant for Co-60, 1.32×10^4 $mRh^{-1}mCi^{-1}cm^2$. Source activity was in mCi, the vehicle velocity was taken as 1.047×10^7 cm/hour (65 mph), and the time variable was expressed in hours.

If the determined value of $T_{r,mean}$ was less than or equal to two times the value of ulim, then I assumed the dosimeter alarmed (two times ulim yields a total travel distance of 2L, which is appropriate since the vehicle can move an equal distance away from the dose point as traversed toward the dose point while still yielding a dose rate exceeding 5 mrem/hr). Various values of R were tried with different source strengths to establish the maximum value of R at which the dosimeter would alarm. Results are given below for source activities of 100 mCi, 500 mCi, 1000 mCi (1 Ci), 5000 mCi (5 Ci), and 10,000 mCi (10 Ci).

Source Activity, mCi	2xULIM, sec.	$T_{r,mean}$, sec.	Max. value of R, cm (ft)
100	0.70	0.70	12 (0.4)
500	0.78	0.77	85 (28)
1000	1.12	1.12	215 (7.0)
5000	2.28	2.27	1500 (49)
10,000	2.84	2.81	3050 (100)

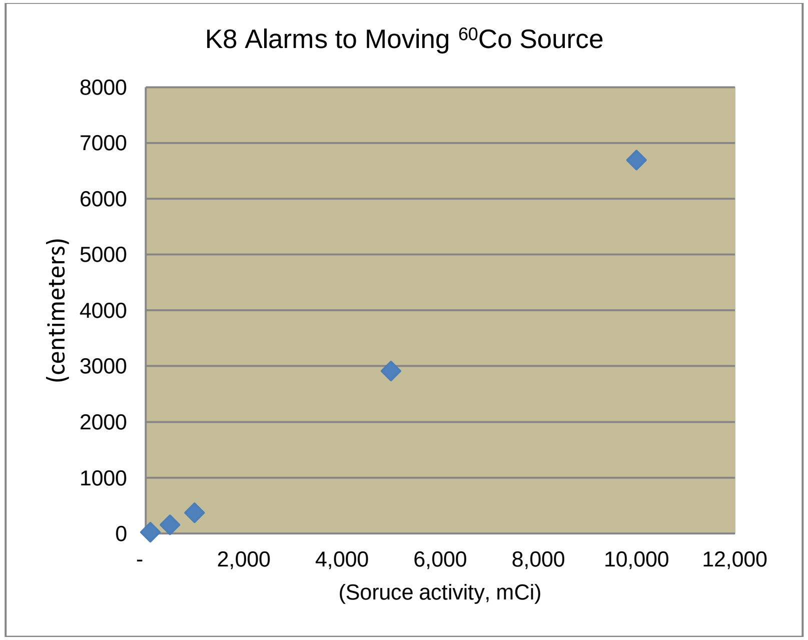
In the above calculations assumed that 1 mR is equivalent to 1 mrem, and did not account for any radiation shielding that might be present.

Estimate of distance, R, for an alarm threshold of 50μSv/h (5mR/h)



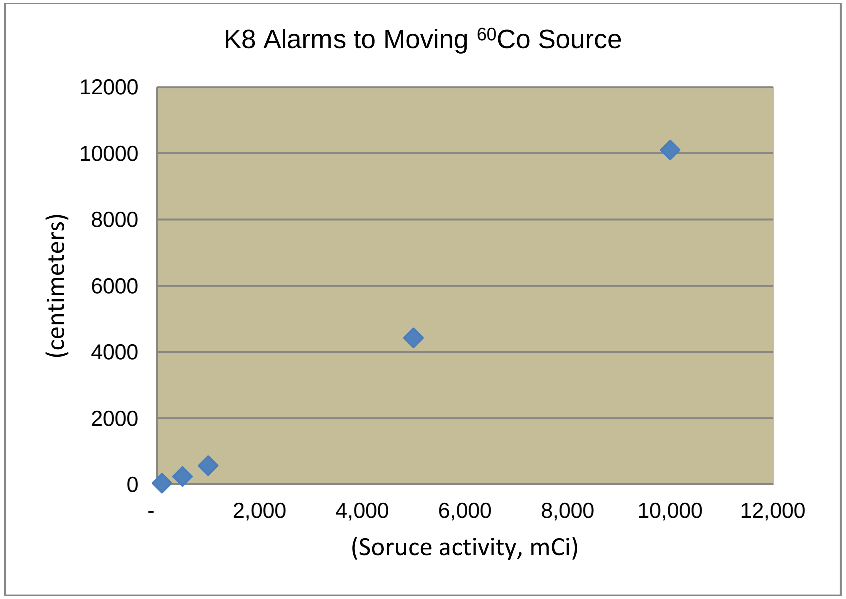
Estimate of distance, R, for an alarm threshold of 20μSv/h (2mR/h)

Source Activity, mCi	2xULIM, sec.	$T_{r,mean}$, sec.	Max. value of R, cm (ft)
100	0.56	0.55	21.4 (0.70)
500	1.25	1.25	154 (5.05)
1000	1.77	1.75	370 (12.1)
5000	3.95	3.91	2910 (95.5)
10,000	5.59	5.45	6690 (220)



Estimate of distance, R, for an alarm threshold of 10μSv/h (1 mR/h)

Source Activity, mCi	2xULIM, sec.	$T_{r,mean}$, sec.	Max. value of R, cm (ft)
100	0.79	0.79	32.3 (1.06)
500	1.77	1.76	234 (7.68)
1000	2.50	2.47	562 (18.4)
5000	5.59	5.52	4422 (145)
10,000	7.90	7.70	10,100 (331)



Background Radiation

Radiation from the stars, including our sun, ultimately reaches the surface of the earth and produces part of the natural background radiation dose that we all receive. This cosmic radiation produces an average dose of about 30 mrem (300 μSv or 0.3 mSv) per year to each individual in the U.S.A., although the dose may range from about 25 to 50 mrem per year depending on the elevation above sea level. Additionally, naturally occurring radioactive materials in the earth's crust produce some gamma radiation that constitutes, on average, also about 30 mrem (300 μSv or 0.3 mSv) per year to an individual; this dose may vary from about 15 mrem per year to 60 mrem per year, depending on the composition of the earth's crust in particular areas. Considering these two components of natural radiation, we each receive about 60 mrem per year from so-called external radiation. This translates to an average dose rate of about 6.8 microrem per hour (6.8 μrem/h or 0.068 μSv/h).

The largest source of radiation exposure from natural sources in the U.S.A. is the radioactive gas, radon, which is inhaled and which decays to additional radioactive products that produce dose within the respiratory tract. This source accounts for an annual dose of about 200 mrem (2000 μSv or 2 mSv) per individual.

We also receive some radiation dose from other naturally occurring radionuclides that accumulate in our bodies, primarily from the foods we eat. These radionuclides add approximately 40 mrem (400 μSv or 0.4 mSv) per year to the individual dose.

K8 can sense natural background radiation and gives out green pulses every 1 to 5 minutes.

Radiation from Nuclear Medicine

Nuclear medicine uses radionuclides introduced into the body as an important tool for diagnosis of certain adverse medical conditions and sometimes for therapeutic treatments of diseased tissues in the body. The most commonly used diagnostic radionuclide is a particular form of technetium referred to as Tc-99m. It emits gamma rays that are used in the diagnostic procedures.

Doses from diagnostic procedures may range from less than 100 mrem (1 mSv) to about 1.5 rem (15 mSv). Depending on what procedures are done, dose rates close to the body of the person being diagnosed may be a few mrem/hour (10s of μSv/h) following a procedure and will decrease with passing time.

One of the most common applications of radionuclides in therapy is the administration of radioactive iodine to patients who have either hyperthyroidism or thyroid cancer. If the patient is released from the hospital a general governing rule is that the dose rate at one meter (about one yard) from the patient should not exceed 5 mrem/hour (50 μSv/h). The intent of limiting the dose rate is to keep doses to others exposed to the patient to an acceptable level.

K8 would be an ideal device for those patients to keep away from their family members, friends and/or pets.

Radiation Dose Limits

Occupational

Radiation workers are allowed to receive doses that are higher than those applicable to the general public but low enough to ensure that their work environment is as safe as typical environments experienced by employees who are not radiation workers. In the U.S.A. most radiation workers are allowed to receive an annual effective whole body dose up to 5 rem (50 mSv), although typical doses are much less than this. For certain emergency situations greater doses could be allowed. Additional annual limits apply to limited portions of the body – e.g., 50 rem (500 mSv) to the body extremities, 50 rem (500 mSv) to the skin, 15 rem (150 mSv) to the lens of the eye.

Non-occupational

For individual members of the public who are not radiation workers, regulating and recommending agencies in the U.S.A. have promoted more severe dose restrictions than apply to radiation workers. In particular, members of the public should not receive an annual effective dose in excess of 100 mrem (1 mSv) as a consequence of operation of a licensed facility that possesses and/or uses radiation sources. This dose is considered in excess of the background dose that accrues from natural sources and any doses received as a result of the medical applications of radiation for diagnosis or therapy. Under some circumstances allowances may be made for a particular individual member of the public to receive a higher annual dose, up to 500 mrem (5 mSv).

NCRP Report No. 138

NCRP REPORT No. 138

Management of Terrorist Events Involving Radioactive Material

Recommendations of the NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS

Issued October 24, 2001

National Council on Radiation Protection and Measurement
7910 Woodmont Avenue / Bethesda, Maryland 20814-3095

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"The NCRP recommends that an ambient dose rate of approximately 0.1 mSv/h is suitable initial alarm level. This is a value significantly higher than natural background so that false positive indications are avoided, but not so high that an emergency responder is likely to receive an exposure that would approach the annual limit for a member of the general public if exposed in areas below this value."

CE Mark – Declaration of Conformity

Declaration of Conformity
Europe

Dositec, Inc. declares under our sole responsibility that the product:

Nuke Safeguard

is in conformity with the European Electromagnetic Compatibility (EMC) Directive 89/336/EEC. The following standards were utilized.

EMC Directive Standards

EN 61326: A1: 1998 and A2:2001

Measurement and Technical Report N° 04176-10 dated November 2003 following the provision of The Electromagnetic Compatibility Directive, 89/336/EEC.

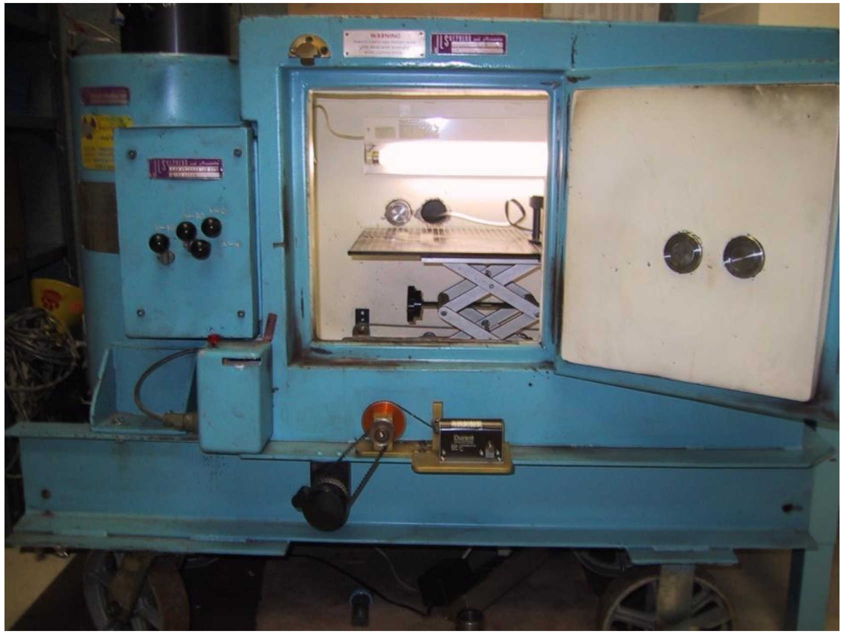
Authorized Person

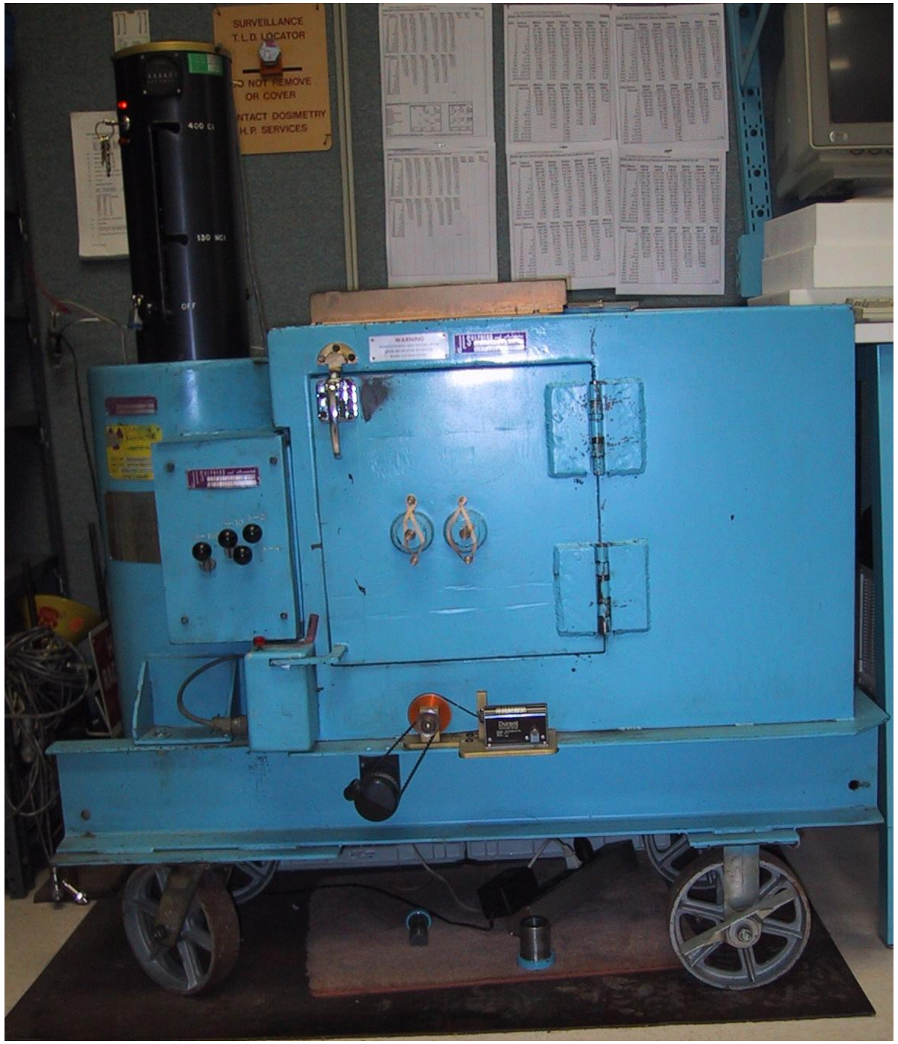
Sam S. Hsu,Ph.D.
President
Dositec, Inc.

NIST Traceable ^{137}Cs Sources

NIST traceable 130mCi and 400 Ci ^{137}Cs Sources were used to develop K8 Nuke Safeguard.

Shepherd Model 89, Serial Number 8181, Model 78-2M, Serial Number 9076, Model 154, and Serial Number 20082. NIST reports DG8639/87 and DG 8640/87 identify the chambers used. The calibrator is as shown below.





K8 Packaging