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Technical Report

Application of a pedestrian portal monitor at Madrid International Airport in Spain

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ABSTRACT

Three pedestrian portal monitor systems, designed to detect illicit trafficking or inadvertent movement of radioactive materials carried by passengers at airports, have been evaluated. The systems were supplied by three manufacturers: Bicron, Exploranium and Thermo-Eberline. In an initial evaluation, conducted at the Laboratory of Nuclear Engineering of the School of Civil Engineering, it was observed that the FHT-1372 system manufactured by Thermo-Eberline gave a more sensitive response and allowed the measurement of total photon dose rate and artificial photon dose rate. Therefore, this system was installed at Barajas International Airport in Madrid in 2002 for a period of 108 days in order to select an appropriate investigation level (defined as the radiation level that is selected as the trigger for further investigation). During this period 1,339,931 passengers were screened and a total of 39 alarms were triggered, 5 of which with a value 10 times the mean value of the natural background from photon radiation (which was 85 nSv/h), and no alarms exceeded 100 μSv/h at 1 m distance, which is the level of response for legal transport of radioactive materials set by the International Atomic Energy Agency (IAEA). An investigation level of approximately 1.3 times the natural background was finally selected. This value coincides with the results obtained in the ITRAP (Illicit Trafficking Radiation Detection Assessment Program) carried out by the IAEA.

1. Introduction

Pedestrian monitors are designed to detect the presence of radioactive material being carried by pedestrians as they pass between or near radiation detectors. The pedestrian monitor systems operate by measuring the gamma and/or neutron radiation level while a person occupies the detection area. The system then compares this level to an alarm threshold that is usually a function of the natural background radiation that has been measured previously and updated while the search area was unoccupied (IAEA, 2006).

There are three types of alarms (IAEA, 2002): a) false alarms caused by statistical fluctuations in the background radiation, b) innocent/nuisance alarms resulting from the presence of radionuclides used for medical treatment, naturally occurring radioactive materials (NORM), and legal shipments of radioactive materials and, c) real alarms caused by an actual increase in the radiation intensity, resulting from inadvertent movement or illicit trafficking of radioactive materials.

A compromise must be reached in establishing a practical alarm threshold so that radioactive materials being inadvertently moved or illicitly trafficked can be detected (real alarm), at the same time as providing an acceptably low innocent/nuisance alarm rate, without causing too many false alarms (IAEA, 2002).

In this paper, we present the experimental studies undertaken in the application of a pedestrian portal monitor from April to August 2002 at Barajas International Airport in Madrid. The results obtained in the ITRAP (Illicit Trafficking Radiation Detection Assessment Program) (Beck, 2000) were tested in order to establish if the investigation level for monitoring of pedestrian set at 1.2 times the natural background was adequate at this International airport for the selected detecting system. Although pedestrian monitors are installed around the world in a large number of airports, only detailed information about the operation of pedestrian portal monitors at Vienna International Airport has been found in papers published in International literature (Duftschmid, 2002; Schrenk et al., 2005).

2. Experimental section

2.1. Detecting systems

Three pedestrian portal monitors were tested at the Laboratory of Nuclear Engineering of the School of Civil Engineering of the Polytechnic University of Madrid to select one to be installed at

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Table 1
Characteristics of gamma detectors of the detecting systems.

Manufacturer	Model	Type of detector[a]	Detector size (mm)	Detector volumen (L)	Output of each system (units)[b]
Bicron	APM	NaI(Tl)	75 × 75	0.33	Count rate (cps)
Exploranium	GR-606	PS	800 × 250 × 50	10	Count rate (cps)
Thermo-Eberline	FHT-1372	PS	220 × 220 × 100	4.84	Count rate (cps)/photon dose rate (nSv/h)

[a] NaI(Tl) = sodium iodide, PS = plastic scintillator.
[b] Calibration factor for FHT-1372: 5,000E-02 nSv/h*s.

Madrid International Airport. The pedestrian portal monitors were: APM Automobile & Personnel Monitor (Bicron), GR-606 (Exploranium) and FHT-1372 (Thermo-Eberline). Table 1 gives an overview of some of the characteristics of the gamma detectors of these detecting systems (neutron detectors were not considered in these systems for this study).

2.2. Material

Six different gamma radioactive sources were used in the laboratory tests: ^{241}Am (42 kBq), ^{137}Cs (30 kBq), ^{60}Co (40 kBq), uranium mineral (circa 50 kBq), thorium mineral (circa 30 kBq) and ^{226}Ra (40 kBq). Artificial sources (^{241}Am, ^{137}Cs and ^{60}Co) were used because they are recommended for alarm testing in gamma energy range from 60 keV to 1.3 MeV (Table 2) in International standards (see for example: IEC, 2006; ISO, 2004). Uranium mineral, thorium mineral and ^{226}Ra were natural sources available in the laboratory.

2.3. Investigation level and alarm threshold

The investigation level was defined as the radiation level selected as the trigger for further investigation. The selection of a particular investigation level means that the alarm threshold can be expressed in terms of multiples of background, or as a multiple of the background standard deviation count rate. Using results from the ITRAP field tests for pedestrian monitor system, an investigation level of 1.2 times the natural background was selected as adequate (Beck, 2000)

$$T = 1.2 \cdot N \tag{1}$$

where T is the alarm threshold in a 1-s time interval based on the averaged background, and N is the background (counts in 1 s).

A typical alarm threshold implemented in commercial RPM is based on the background counts in a set time interval and the associated variations or fluctuations. A typical gross-count threshold is calculated as (Ely et al., 2006)

$$T = N + K\sqrt{N} \tag{2}$$

where $\sqrt{N}$ is the best estimation of the background standard deviation for Poisson statistics, and the constant K is a multiplier ("sigma multiplier") that determines the threshold value above background in units of background standard deviation.

Substituting (1) with (2), it is possible to convert the recommended investigation level from multiples of background to threshold value above background in units of background standard deviation as follows:

$$K = 0.2 \cdot \sqrt{N} \tag{3}$$

For a typical detector system with 1000 cps (counts per second) as background, means that an investigation level value of 1.2 times the background would correspond to about 7 standard deviation (IAEA, 2002; ISO, 2004).

3. Laboratory tests

3.1. Background and alarm threshold determination

Background was determined in the three detecting systems. Total photon dose rate was also determined using the FHT-1372. Alarm threshold was expressed as the background standard deviation for each pedestrian monitor using Equation (3).

3.2. Artificial photon dose rate triggering with FHT-1372

In the case of the FHT-1372 system, the triggering of the artificial photon dose rate alarm using artificial (^{137}Cs and ^{60}Co) and natural (uranium, thorium, and ^{226}Ra) sources was verified.

3.3. Verification of alarms

For each detecting system an alarm threshold was set determined as above described. In this test, a person walked through the systems at an average speed of 1.2 m/s, carrying natural (uranium, thorium and ^{226}Ra) and artificial (^{60}Co, ^{137}Cs and ^{241}Am) sources at a height of 1 m above ground as the IAEA (2006) recommended. The performance of each system was determined using the sigma multiplier:

Table 2
Results of verifying alarms in the three pedestrian monitors compared in this study.

Source	Primary energies (keV)	APM Bicron			GR-606 Exploranium			FHT-1372 Thermo-Eberline		
		C−N (cps)	I	I/K	C−N (cps)	I	I/K	C−N (cps)	I	I/K
^{241}Am	59.5	115	5.1	1.1	1153	15	1	108	2.8	< 1
^{137}Cs	662	118	5.2	1.2	1341	18	1.2	1885	49.1	6.4
^{60}Co	1173, 1333	150	6.6	1.5	1580	21	1.4	1373	36.8	4.8
Uranium		331	14.6	3.2	2278	21	1.4	1233	32.1	4.2
Thorium		170	7.5	1.7	1252	17	1.1	1187	30.9	4.0
^{226}Ra		208	9.2	2.0	1326	17	1.1	1062	27.7	3.6
Threshold value (K)[a]		4.5			15			7.7		

[a] Threshold value above background in units of background standard deviation.