ARTICLE IN PRESS

Radiation Physics and Chemistry xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Radiation Physics and Chemistry

journal homepage: www.elsevier.com/locate/radphyschem

Evaluation of scattered radiation emitted from X-ray security scanners on occupational dose to airport personnel

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ARTICLE INFO

Keywords:
Backscattered radiation
Airport security scanners
Occupational dose

ABSTRACT

Based on security issues and regulations airports are provided with luggage cargo scanners. These scanners utilize ionizing radiation that in principle present health risks toward humans. The study aims to investigate the amount of backscatter produced by passenger luggage and cargo toward airport personnel who are located at different distances from the scanners. To approach our investigation a Thermo Electron Radeye-G probe was used to quantify the backscattered radiation measured in terms of dose-rate emitted from airport scanners, Measurements were taken at the entrance and exit positions of the X-ray tunnel at three different distances (0, 50, and 100 cm) for two different scanners; both scanners include shielding curtains that reduce scattered radiation. Correlation was demonstrated using the Pearson coefficient test. Measurements confirmed an inverse relationship between dose rate and distance. An estimated occupational accumulative dose of 0.88 mSv/y, and 2.04 mSv/y were obtained for personnel working in inspection of carry-on, and cargo, respectively. Findings confirm that the projected dose of security and engineering staff are being well within dose limits.

1. Introduction

Sharjah international airport (SIA) the main international airport for the Emirate of Sharjah, is one of the major airports in the United Arab Emirates. In 2015, the airport passed 10.039 million passengers, a 5.5% traffic increase comparing to 2014. The aircraft movement also increased by 1.23% comparing to 2014. Since 2009, Sharjah international airport was considered the second largest Middle East airfreight hub in respect to cargo capacity and continuing to grow.

Given the busy nature of this airport, it is clear that there should be great demand for security checks of passenger luggage and cargo, mainly to avoid transporting illegal goods as well as in respect of fraud and weaponries (Hupe and Ankerhold, 2006). Ionizing radiation detection is the most utilized method for luggage inspection in airports, used successfully over many years (Hupe and Ankerhold, 2006), allowing safe examination without causing any physical damage (Pourtaghi et al., 2014). However, the usage of ionizing radiation, in this case X-rays, necessitates certain occupational care, particularly in respect of airport personnel including security staff and engineers who maintain such luggage scanning machines.

Ionizing radiation can potentially produce serious biological damage over a period of time, with the possibility of chromosomal abnormalities, associated cancer induction, cataract formation and dermal and thyroid damage (Hupe and Ankerhold, 2006). Appropriate shielding allows safe examination, mitigating risk to large extent (Pourtaghi et al., 2014). Dose-rates due to scattered radiation from luggage scanners are of course expected to be within limits. However, for an accurate assessment sensitive measuring probes are required. Background radiation, should also be excluded, and probe needs to be calibrated. Given the increasingly high workloads of the X-ray tubes at Sharjah international airport, the total radiation time will almost certainly have lead to greater receipt of scattered radiation. Shielding curtains are designed to reduce backscatter radiation to low levels, however this does not necessarily mean zero scattered dose (Mihic et al., 2012). Nevertheless, it would be reasonable to assume that if the shielding curtains at the entrance/exit of the inspection X-ray tube were properly closed during beam on of an inspected item, the scattered radiation rate near the X-ray unit would be within the background range.

Considering the use of the typical (polymethyl methacrylate) Plexiglas tunnel of cargo luggage scanners at Sharjah international airport in addition to the increased workload for the carry-on luggage scanners, the authors also aim to evaluate the impact of the radiation protection status of airport personnel.

Plexiglas does not provide shielding its purpose being to ensure safe distance of the security personnel away from the entrance/exit of the

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http://dx.doi.org/10.1016/j.radphyschem.2017.03.002
Received 28 June 2016; Received in revised form 27 February 2017; Accepted 2 March 2017

X-ray inspection tube. Thus, Plexiglas is designed to prevent operators from putting their hands beyond the lead curtains, which often happens during rush hours to speed up the flow. This said, engineers who maintain cargo luggage scanners equipped with the Plexiglas panels still need to work in close proximity with the scanner, which demands close inspection. Detachment distance in carry-on and cargo can be expected to have an impact in terms of increased radiation protection in according with the ALARA principle. This will also be investigated.

2. Material and methods

2.1. Dosimeter cross-calibration

A Thermo Electron Radeye-G probe was used to measure the backscatter radiation from airport luggage scanners. It is highly sensitive around 0.17 cps/mSv/h with a measuring range of 0.5 μSv/h or 500 mSv/h (Radeye-G manual). A Cesium-137 point source was used to cross calibrate the Radeye-G dosimeter against a standard SONDE VLD probe. The SONDE VLD is capable of measuring background levels starting from 10 nSv/h. A setup demonstration of the point source, the standard dosimeter, and the Radeye-G probe is shown in Fig. 1. Lead blocks were used to eliminate scattering radiation from the point source. Both Radeye-G and the standard probe were placed at 0, 50, and 100 cm from the ^{137}Cs point source, where three repetitive measurements were taken at each distance.

2.2. Airport luggage scanners

The experiment was conducted in two different areas on two different luggage scanners. The first area was the large Smith (HI-SCAN 10080 EDX-2, Wiesbaden, Germany) cargo loading scanner located on the underground floor that houses two X-ray tubes. The second luggage scanner is a medium sized Smith (HI-SCAN 100100V) scanner located on the ground floor housing a X-ray tube which is typically used to inspect carry-on bags.

2.2.1. Cargo-luggage scanner

The HI-SCAN 10080 EDX-2 makes use of a dual view X-ray system to improve the evaluation process dramatically. This system said to achieve the highest rate of detection in its class with a tunnel opening of ~3 m long, 2 m width, ~2 m height, and a screening rate of up to 1800 luggage items per hour.

2.2.2. Carry-on scanner

The HI-SCAN 100100V is a compact X-ray security screening system with tunnel dimensions of < 4 m long, 1.2 m width, and ~2 m height.

The extent of scattered radiation emitted by both scanners was measured at three different distances: 0, 50, and 100 cm from the shielding curtain at the entrance and exit of the scanners, Fig. 2. Three repetitive measurements were taken at each location. The background radiation was also measured at different points throughout the airport away from the scanners, to be subtracted from the measured radiation emitted from the scanners. The allowable whole-body exposures can then be calculated in units of (μSv/h) and matched with the recommended values by the American Conference of Governmental Industrial Hygienists (ACGIH).

2.3. Luggage type and backscatter radiation

The impact of luggage type and resultant scattered radiation is also examined in this study. This correlation is determined by tabulating the quantity and type of luggage (boxes or bags) scanned per load. The time of total exposure for each load is also noted.

2.4. Statistical analysis

The Pearson coefficient test (r) is used herein for correlation between scattered radiation and the distance from scanner curtain. In addition, correlation will be examined between luggage type and backscatter from the Smith cargo scanners. Descriptive statistics will be generated to describe study sample and variables, which include mean, standard deviations (SD), and ranges.

3. Results and discussions

3.1. Dosimeter cross-calibration

As referred to in the materials and methods section, the Radeye-G probe was cross calibrated against a standard dosimeter. A correction factor (CF) was established by dividing the measurement of the standard probe (SONDE VLD) by the Radeye-G probe at 0, 50, and 100 cm from the point source i.e., ^{137}Cs. The following are the CFs: 1.00, 0.83, and 0.80 at 0, 50, 100 cm distances, respectively. Every measured point has been converted from μR/h to μSv/h i.e., dividing by 100. The background radiation at the ground floor in the airport ranged between (0.05, and 0.06) μSv/h, while that in the underground cargo scanner area ranged between 0.06 and 0.07 μSv/h.

3.2. Airport luggage scanners

3.2.1. Carry-on scanner

The backscattered radiation was measured at the entrance and exit of the X-ray tunnel at three different distances from the shielding curtain. The mean and standard deviation was calculated for each site at each distance producing values of 0.56 ± 0.03, 0.38 ± 0.03, and 0.26 ± 0.04 at 0, 50, and 100 cm on the entrance side, respectively. Overall smaller values were seen on the exit side of the tunnel with values 0.44 ± 0.04, 0.39 ± 0.02, and 0.09 ± 0.01, respectively (Fig. 3). Every measured data was corrected using the associated CF and background was subtracted. Data are shown in units of μSv/h.

Fig. 3 shows the strong negative correlation between dose-rate and distance at both ends of the tunnel, namely the entrance and exit. Fig. 4 confirms the overall drop of mean scattered radiation dose-rate at the exit and entrance of the tunnel, showing strong agreement with the finding reported by Mihic et al. (2012). The error bar indicates the standard deviation between the three repeat measurements at each distance.

Fig. 1. Demonstrates the cross calibration procedure setup, with the standard probe (A), and Radeye G probe (B).