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Cost effective electronic device for detecting, measuring and visual monitoring of radiation doses

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Abstract

Ionization Radiation is one of the major concerns for using nuclear energy. It carries more than 10eV energy which is enough to ionize atoms and molecules and break chemical bonds. Radioactive materials emit alpha, beta, or gamma radiation, positrons, and photons, respectively. The use of ionization radiation offers several advantages like the sterilization of foods, medical devices, laboratory, research, agricultural fields and many other industrial applications. A Cobalt-60 source having present capacity of 140kCi has been used in this investigation. Survey meter can measure the level of radioactive contamination, radiation dose rate in a certain place. Few devices which can visualize the distribution of radiation intensity were already developed. However, the above mentioned devices cannot identify the locations of the radiation sources.

At present, Robots are being used for highly radioactive sources to measure its intensity at its close position where radiation workers cannot safely enter but it is very expensive, not user friendly and difficult to handle due to its heavy weight and modern technology. Gamma ray protective cameras are also very costly. In the research, the information of complete dose levels of source room have been obtained with the help of Amber Dosimeter during the application of source and developed cost effective electronic device for detecting, measuring and visual, monitoring of radiation doses. Through the developed device, the position of highly radioactive sources (Cobalt-60) is visualized and detected during its applications with the help of a Closed Circuit (CC) camera shielded by a Lead (Pb) box in a way that the lenses of the camera are placed toward mirror to take fix and video images of source and its room. CC Camera is connected with the computer in a safe zone of control room to visual monitoring the real situation inside the source room.

Keywords: Ionizing radiation monitoring, Cobalt-60 source, CC camera, cost effective, radioactive contamination, amber dosimeter

1. Introduction

Radiation is defined as the emission or transmission of energy in the form of waves or particles through space or through a material medium. Radiation is categorized as (i) Ionizing (ii) Non-ionizing depending on the energy of the radiated particles. Ionizing radiation carries more than 10eV which is enough to ionize atoms and molecules and break chemical bonds. This is an important distinction due to the large difference in harmfulness to living organisms. A common source of ionizing radiation is radioactive materials that emit alpha, beta, or gamma radiation, consisting of helium nuclei, electrons or positrons, and photons, respectively

Radioactivity is a natural phenomenon and natural sources of radiation are features of the environment. Radiation and radioactive material may also be of artificial origin and they have many beneficial applications, including uses in power generation, medicine, industry, agriculture, and research. Exposure

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of human tissues or organs by radiation can induce the death of cells on a scale that can be extensive enough to impair the function of the exposed tissue or organ. Effects of this type are called ‘deterministic effects’ are clinically observable in an individual only if the radiation dose exceeds a certain threshold level. Above this threshold level of dose, a deterministic effect is more severe for a higher dose.

There are several devices to measure radioactivity. One popular device is Survey Meter which can measure the level of radioactive contamination, radiation dose rate in a certain place. However, it cannot identify the locations of the radiation sources. Few devices which visualize radiation intensity distribution have already been developed. Laboratory counters which is used to identify and quantity of radioactive material, and Personnel Dosimeter is used to measure the accumulated dose to individuals working the radiation environment.

At present, robots are using for highly radioactive sources to measure its intensity at its close position where a radiation worker cannot safely enter. But Robots are very expensive and very difficult to handle due to its heavy weight. In Bangladesh, few highly radioactive sources are using for research and commercial irradiation of food and medical products. Gamma ray protective cameras are also very costly.

The application of gamma radiation is becoming more widespread every year. Over the past four decades, there has been a continuous and significant growth in the development and application of radiation techniques. The use of gamma radiation offers several advantages, such as continuous operation, minimum time requirement, less atmospheric pollution, curing at ambient temperatures and increased design flexibility through process control. Gamma Radiation can also be used for the sterilization of food and medical devices.

In this investigation, an electronic device has been developed and connected with the computer which is placed in control room (safe zone) for visual monitoring of highly radioactive source. In our study, a gamma irradiation facility of Bangladesh Atomic Energy Commission (BAEC) has been used which is situated at the Institute of Radiation and Polymer Technology (IRPT), Atomic Energy Research Establishment (AERE), Savar, Dhaka, Bangladesh. The source was established in 2010. The initial activity of the source was 350 kCi but the present capacity is 140 kCi. Amber Dosimeters have also been used to find out the radiation level in the source room during its application with time duration.

2. Method and Materials

The dose levels of Cobalt-60 source (350 kCi Gamma irradiation plant) at IRPT, AERE are measured from different points of source room by using Amber Dosimeter and Ultra-Violet Spectroscopy. Amber dosimeters have been kept in five groups (Five Amber dosimeter in each group) at the five places of source room at a time as group identity 1 to 5 for 15, 30, 60, 120, and 180 minutes respectively. After all necessary protective measures, the source has been pulled up from the source pool (water) and put in the proper place for 15 minutes. After 15 minutes the source has been pulled down to put inside the source pool (water) and Amber dosimeter of group identity-1 is collected safely. The repeated works are done for group identity 2, 3, 4 and 5 after the time duration of 30, 60, 120 and 180 minutes respectively. The dose levels were then calculated in the laboratory of IRPT with the help of Ultra-Violet Spectroscopy and standard charts. The obtained dose levels of different points of Gamma irradiation source room have been analyzed.

The investigation for visual monitoring of source and source room has been carried out by developing the electronic device with the help of computer, closed circuit (CC) camera, stainless steel frame with bolts, Lead box, Lead mirror, electrical cable, cable connector and Amber Dosimeters. Some basic tools were also used to develop the device and measure dose levels which are basic electrical tools and devices, survey meter, dosimeter. A lead box is fabricated from the lead sheet measuring 180 x 135 x 175 mm with the thickness of 25 mm (Fig.2).

The objective to place CC camera is to monitor the source visually to observe the real situation inside the source room. The CC camera of electronic device is shielded by fabricated Lead (Pb) box so that the lens of the camera can visualise Lead glass. It is kept in mind to place the CC camera that the radiation cannot fall directly on lens; hence it cannot be damaged due to high radiation effect. During the application of the source, the source is pulled out from the source pool (water) and CC camera is able to take the fix and video images which can be monitor visually and detecting the source position for the times of operation and the real situation of the source room. In order to investigate the effectiveness of the developed device the video and fixed images are closely observed with different angles, rotation and zooming. A block diagram of the developed device is shown Fig.1.

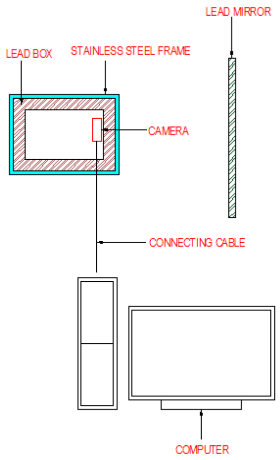

Fig.1. Block diagram of the developed device

Fig.2. Lead Box with Stainless steel frame

3. Cost Analysis

Cost analysis of the developed system has been carried out and detailed are shown in Table 1. It is evident that within 550 USD the device has been developed, which is more economic than the existing devices. The materials are very common and available in the local market of Dhaka, Bangladesh. The required materials are economic and fabrication of required frame and box is not so complicated. The developed device is not that much sophisticated than the existing devices.

Table 1. Cost analysis of the device

Sl.	Item	Cost (USD)
1	CC Camera	60.00
2	Lead Box	100.00
3	Computer	325.00
4	Cable with connector	25.00
5	Stainless steel Frame	15.00
6	Fabrication	25.00
Total		550.00

4. Result

The dose rates obtained from the amber dosimeter with the help of standard chart and Ultra-Violet Spectroscopy of laboratory of IRPT. The results are plotted in the graph and found linear along with time duration. The doses are found 2.09 KGy, 4.49 KGy, 8.23 KGy, 16.23KGy and 22.52 KGy with respect to time duration of 15, 30, 60,120, and 180 minutes respectively.

During visual monitoring, when the source was pulled out the screen was slightly pinkish blurred with some noise in the screen, but no permanent damage was noticed. This noise also can be considered an indication of presence of Gamma irradiation of Co-60 source.

In this investigation maximum duration of use of device was three hours and we did not found any abnormalities with the devices and no damage was found at all in the system.

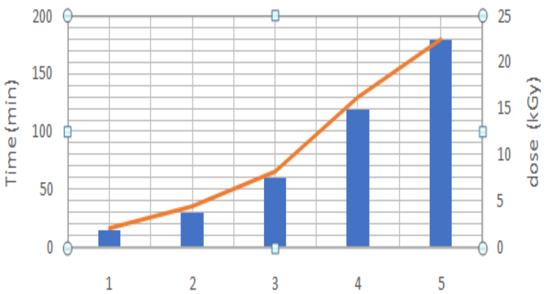

Fig.3. Time VS Dose Graph

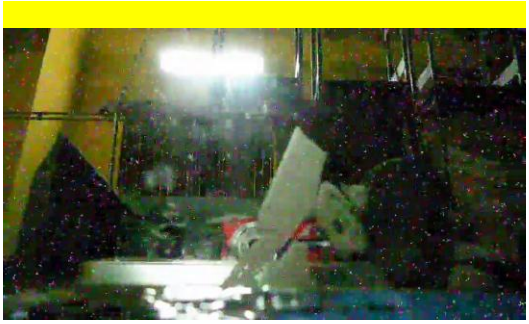

Fig.4. Footage captured from the device

5. Discussion

The study is performed for maximum duration of three hours. For practical uses, further study may be carried out to use the device for longer period of time in similar range of radiation doses.

It has been found that the developed device is less expensive than the existing devices and easy to manufacture even in the developing countries of the world.

In our study, the device is placed manually but it can be possible to place the device by incorporation of remote control programming system which may be further scope of research connected to this study.

As the signal of the camera did not disappear completely during the test so it is not considered as complete failure, however, picture quality degraded. The radiation effect on camera sensors is beyond the scope of this study. The objective of the study is to make the device as economic as possible, so "radiation hardened" Charged Coupled Device (CCD) sensors are also not taken into consideration.

However, for the use of regular basis the effect of radiation on the camera sensors should be investigated further. Hence the camera can be used for general viewing for the period of three hours but device may get or may not get any problem to perform continuous visual monitoring the source for a longer period of time.

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