RADIATION DOSE MEASUREMENT USING IONIZATION CHAMBER AS A LabVIEW RECORDER

Patcharin Naemchanthara[1], Ekachai Hoonnivathana[2], and Kittisakchai Naemchanthara[3*]

[1]Department of Materials Engineering, Faculty of Engineering, Kasetsart University, Bangkok, 10900

[2]Department of Physics, Faculty of Science, Kasetsart University, Bangkok, 10900

[3]Department of Physics, Faculty of Science, King Mongkut's University of Technology Thonburi, Bangkok, 10140

[*]E-mail: puri_kit@hotmail.com

ABSTRACT

The purpose of this research was to apply the LabVIEW program to control an ionization chamber for the measurement of radiation dose. Radiation dose of Cs-137 was measured at different distances of 1.0, 1.5, 2.0 and 2.5 m. The results obtained from LabVIEW were compared with those of a manual system. The percentage difference of dose rate obtained from LabVIEW and the manual system was found to be less than 3%. This research work indicated that the LabVIEW can be used in assisting the measurement of radiation dose. Furthermore, by using LabVIEW to control the ionization chamber, the time used for each measurement of radiation dose was found to be reduced by about 50-60 min compared with that of the manual system.

Keywords: LabVIEW, ionization chamber, radiation dose

Introduction

Nowadays, radiation applications are widely used in various works, such as food industries, research, jewellery and medicine, etc. (Lucio et al., 2012).The radiation dose used for each application is important. The ionization chamber is one type of the detectors widely used for the dose measurement dose in the hospitals and radiation metrology laboratories (Silva et al., 2014). For each measurement of radiation dose rate using ionization chamber, a lot of data need to be recorded. The precision measurement where the data is acquired with a high temporal resolution pose a challenge with respect to streaming and saving the data correctly (Czerwinski and Lene, 2011). Many researchers try to develop methodology for recording the data from ionization chamber

using MATLAB software (Attarakin et al., 2012; Tharwat et al., 2014; Joshi et al., 2014). LabVIEW is a program often used to control the data acquisition and streaming (Wagner et al., 2010). It features exceptional compatibility with general hardware. It offers easy to use construction of graphical user interface. Furthermore, LabVIEW can be used for computing and recording a numerous data in a short time. In recent years, the Office of Atoms for Peace (OAP) of Thailand has performed the measurement of radiation dose rate with an ionization chamber and recorded the data a manual system. The data obtained from the manual system for each radiation dose rate takes a long time. The purpose of this paper is to program LabVIEW software into conventional measurement of radiation dose rate of OAP to control an ionization chamber to reduce the time of measurement. The radiation dose rate of gamma ray from ^{137}Cs was measured at different distances. The results were compared with those of the manual system. The reduced time for each measurement after using LabVIEW is also presented.

Methods

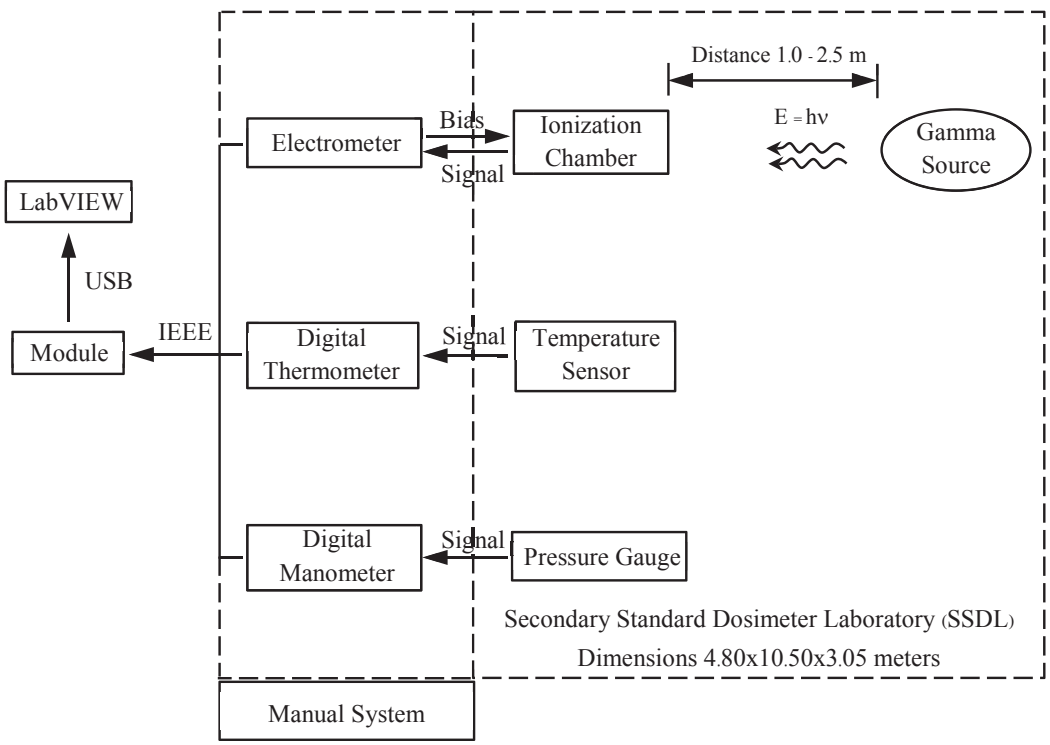

Figure 1 Schematic diagram of the experimental setup.

Figure 1. shows the schematic diagram of the experimental setup for the measurement of radiation dose rate. The ionization chamber (PTW, Germany, LS01), with the shape of a thin sphere was used as a detector. The chamber wall is made of polyacetal resin with an inner diameter of 140 mm and a wall thickness of 3 mm. It has a sensitive volume of 1000 ml. The central collecting electrode is made of styrofoam coated with graphite. Gamma radiation source was ^{137}Cs with a dose rate of 345.60 mR/hr which was contained in a gamma-calibrator (Buchler, OB85). An electrometer (Keithley, 6517B) was used to measure the ions in the chamber and operated at -300 V. A digital thermometer (Yokogawa, 7563) and a digital manometer (Yokogawa, 2655) were used for temperature and pressure measurements, respectively. The ionization chamber, gamma radiation source, temperature sensor and pressure gauge were located in the Secondary Standard Dosimeters Laboratory. For manual system, the ions, temperature and pressure as measured by electrometer, digital thermometer and digital manometer, respectively, the operator has to collect the data and process the data to obtain the radiation doss rate of the gamma by manual.

In this work LabVIEW 8.5 software (National instruments) was programmed to control electrometer, digital thermometer and digital manometer for the measurements of ion, temperature and pressure, respectively. The electrometer, digital thermometer and digital manometer were connected to LabVIEW via IEEE-488 interface and USB port. The gamma radiation dose rate was measured at different distances of 1.0, 1.5, 2.0 and 2.5 m. For each distance, the measurements were carried out for 5 times and average radiation dose rate was reported. The results on radiation dose rate obtained from LabVIEW were then compared with those obtained from the manual system. The gamma radiation dose rate measurements were also carried out at low doses, using the Pb filters with thicknesses of 20 and 39 mm to attenuate the gamma radiation.

Results and Discussion

Table 1 shows the average dose rates of gamma ray at different distances as measured using LabVIEW and the manual system. The variation of the dose rate as a function of the distance from the source of gamma ray to the ionization chamber is shown in Figure 2. For each distance, the time used for ions counting by electrometer was 5 min. In the case of manual system, the operator has to process the ions data by

manual. The total time (ions counting time plus processing time) used by manual as seen in Table 1 is 63.12 min. However, when LabVIEW is used to process the data, the processing time is only 20s. Therefore, the total time for the measurement of dose rate is 5.20 min.

Table 1 Dose rates of gamma ray measured at different distances from the gamma source.

Distance (m)	LabVIEW		Manual		% Difference of dose rate	Reduced time (min)
	Ave. dose rate (mR/hr)	Time (min)	Ave. dose rate (mR/hr)	Time (min)		
1.0	345.60	5.20	347.48	63.12	0.54	58.32
1.5	219.06	5.20	220.75	63.12	0.77	58.32
2.0	85.56	5.20	86.68	63.12	1.30	58.32
2.5	69.60	5.20	67.62	63.12	2.89	58.32

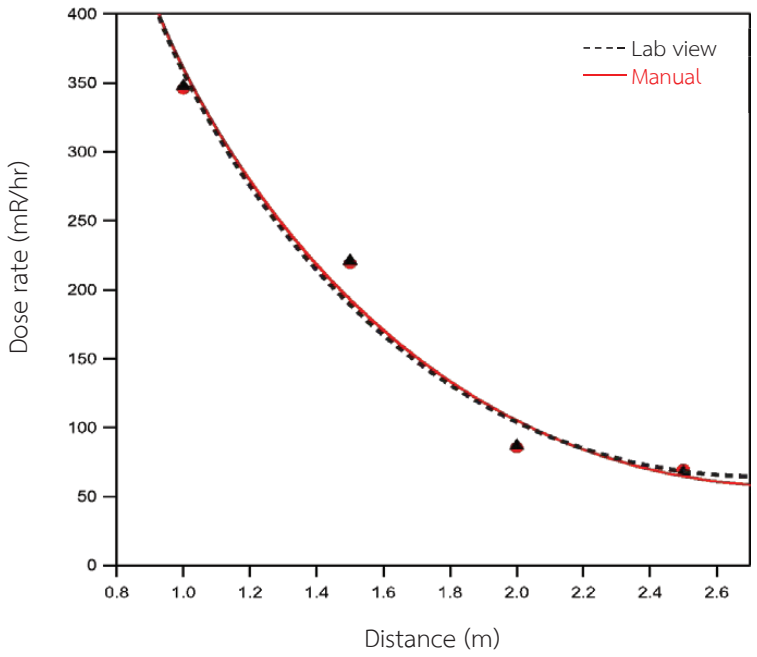

Figure 2 Variations of the dose rate as a function of the distance from the source to detector as measured using LabVIEW and manual system.

Further gamma radiation dose rate measurements were carried out at a low radiation dose rate using a Pb filter as an attenuator to reduce the radiation dose rate at the detector. For Pb filter with a thickness of 20 mm, the results on the dose rate measurements at different distances from the gamma source are shown in Table 2. The variation of the dose rate as a function of the distance from the source of gamma ray to the ionization chamber is shown in Figure 3.

Table 2 Dose rates of gamma ray measured at different distances from the gamma source with a 20 mm thick Pb filter.

Distance (m)	LabVIEW		Manual		% Difference of dose rate	Reduced time (min)
	Ave. dose rate (mR/hr)	Time (min)	Ave. dose rate (mR/hr)	Time (min)		
1.0	32.22	8.50	32.17	75.38	0.16	67.28
1.5	20.54	8.50	20.52	75.38	0.10	67.28
2.0	7.46	8.50	7.38	75.38	1.08	67.28
2.5	6.30	8.50	6.26	75.38	0.64	67.28

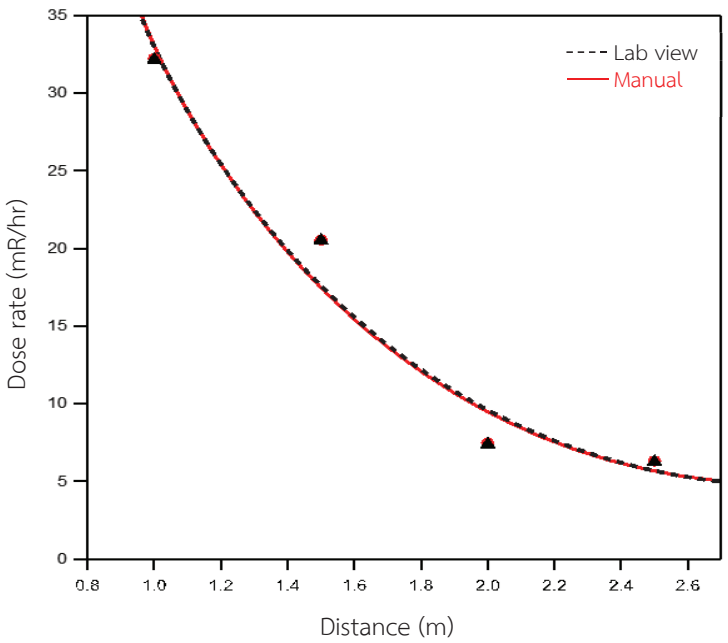

Figure 3 Variations of the dose rate as a function of the distance from the source to detector as measured using LabVIEW and manual system with a 20 mm thick Pb filter.

For Pb filter with a thickness of 39 mm, the results on the dose rate measurements at different distances from the gamma source are shown in Table 3. The variation of the dose rate as a function of the distance from the source of gamma ray to the ionization chamber is shown in Figure 4.

Table 3 Dose rates of gamma ray measured at different distances from the gamma source with a 39 mm thick Pb filter.

Distance (m)	LabVIEW		Manual		% Difference of dose rate	Reduced time (min)
	Ave. dose rate (mR/hr)	Time (min)	Ave. dose rate (mR/hr)	Time (min)		
1.0	3.46	17.20	3.43	95.15	0.87	78.35
1.5	1.66	17.20	1.67	95.15	0.60	78.35
2.0	1.02	17.20	1.04	95.15	1.94	78.35
2.5	0.60	17.20	0.59	95.15	1.68	78.35

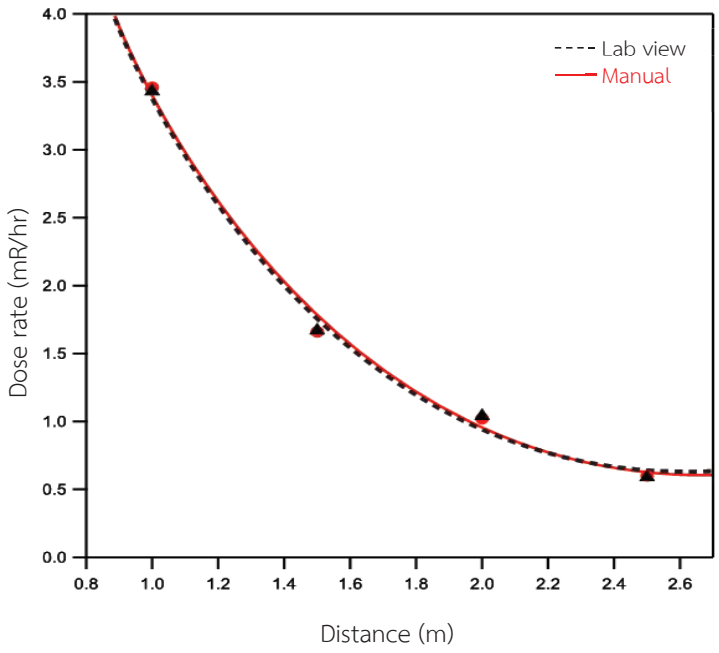

Figure 4 Variations of the dose rate as a function of the distance from the source to detector as measured using LabVIEW and manual system with a 39 mm thick Pb filter.

It is seen from Table 1 that the gamma dose rate decreased rapidly with increasing distance from the gamma source to the detector. The results are in good agreement with those reported in (Strohmaier and Zwierzchowski, 2011). However, when the gamma radiation dose rate was initially reduced by using a Pb filter then the dose rate measurements were performed. It is seen from Tables 2 and 3 that the gamma dose rate decreased slowly with increasing distance. The results agree well with those reported in (Sensing, 2007). Furthermore, it is confirmed that a thicker Pb filter can absorb more gamma radiation. It is well known that when the gamma ray passes through an absorber it interacts with the absorber and lost the energy (Delaney, 1992). It can be observed from tables 1-3 that, in most cases, the dose rates are different by less than 1%. The maximum difference of the dose rate measurement for LabVIEW and manual system was found to be 2.89% at a distance of 2.5 m and without a Pb filter. It is worth to point out that in all cases of the dose rate measurements, the time used for each measurement using LabVIEW is less than that of the manual system by about 50-60 min. The results obtained in this work indicated that LabVIEW could be used for computing and recording the data in the measurements of radiation dose rate with shorter time compared with the manual system.

Conclusions

The main objective of this work is to develop a software program using LabVIEW for the measurement of radiation dose rate. With this software program the time for measurement of each condition was reduced by about 50-60 min from that of the manual system. However, the accuracy of radiation dose rate measurement using LabVIEW is in good agreement with that of the manual system. It is shown that LabVIEW could be used for recording the data in the measurement of radiation dose rate with shorter time.

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