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Assessment of Nuclear Moisture Density Gauges at a Secondary Standard Dosimetry Laboratory in Ghana during December 2015–December 2017

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ABSTRACT

Introduction: Nuclear moisture density gauges are widely used in construction industry in different countries across the world, including Ghana, on a large scale. Like all irradiating devices, the nuclear gauges should be subjected to radiation safety assessment based on radiation protection and safety principles. Regarding this, the objective of this research was to investigate the radiation safety of the nuclear moisture density gauges to ensure the absence of any leakages from the radioactive source.
Material and Methods: For the purpose of the study, a survey meter (RADOS-120) was used to measure and record the radiation dose once at a distance of 1 m from the surfaces of all sides of the nuclear moisture density gauge and very close distance from the surfaces of the device. Moreover, the device was examined using radiation contamination test and counts on a standard block.
Results: A total of nine nuclear moisture density gauges manufactured by Troxler Electronics Inc. in the USA were evaluated within a period of 3 years. The minimum and maximum average dose rates were 0.49 and 66.67 µSv/h, respectively. The highest and lowest average dose rates were recorded in 2017 and 2016 on the devices with serial numbers of 38260 and 32839, respectively.
Conclusion: The assessment of the nuclear moisture density gauges under study revealed no radiation contamination leakage. Furthermore, all the evaluated gauges were shown to function properly and were safe for the intended purposes.

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Introduction

In Ghana, nuclear moisture density gauges are widely used in construction industry. These devices are applied to measure the moisture content, density, and compaction of soil, soil-stone aggregates, asphalt-treated bases, and asphalt surfacing of roads [1]. These gauges provide a fast, accurate, and inexpensive way for evaluating the moisture content and density of various building materials.

The nuclear moisture density gauge is a portable device that contains radioactive sources, electronics, and rechargeable battery packs. The serial number of these appliances normally appears on their handle and standard block. Typically, these moisture density gauges contain a gamma-emitting source, such as cesium-137 doped with americium-241/beryllium, which is a neutron emitting source [2-4].

Similar to all irradiation devices, these nuclear moisture density gauges should be examined in terms of radiation safety based on radiation protection and safety principles. The consideration of this issue is even more prominent for these gauges because equipment in the construction industry are liable to frequent movements and sometimes rough handling [5, 6].

Over years, the Radiation Protection Institute (RPI) of the Ghana Atomic Energy Commission (GAEC) has been performing the needed safety assessment on these devices. The RPI usually recommends re-assessment after a period of 1 year possibly in a secondary standard dosimetry laboratory (SSDL) at the RPI of GAEC. During 2015-2017, nine of these density gauges were brought to the RPI for re-assessment.

With this background in mind, the objective of this study was to assess the radiation safety of the nuclear moisture density gauges to ascertain the lack of

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leakage from the radioactive source, as well as proper functioning of the equipment.

Materials and Methods

Materials

The assessments were completed using a Radiagem 2000; model number 76687 survey meter (Canberra Eurisys),; Rados (RDS-120) universal survey meter and Canberra MIP 10 digital model 83021.

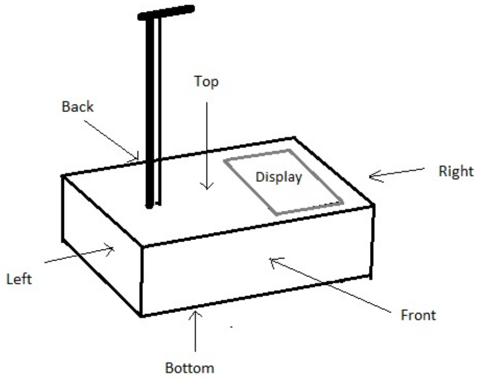

Figure 1. Schematic design of a typical nuclear moisture density gauge showing the directions of the measurements performed at a secondary standard dosimetry laboratory

Methods

Radiation Dose Rate Measurement

First, the nuclear moisture density gauge was placed on a clean, clear, and hard surface, preferably a concrete floor. Subsequently, the lack of any obstruction was ensured (i.e., the walls around the immediate vicinity of the assessment area). This would minimize the scattered radiation recorded during the radiation dose measurements.

With the gauge on the switched OFF mode and source on the SAFE mode, the assessment was carried out by the survey meter. The radiation dose was recorded at a distance of 1 m from the surface on all sides of the nuclear moisture density gauge as shown in Figure 1. Next, we proceeded to measure and record the radiation dose at a distance very close to the surface (but not touching the surface) on all sides of the gauge (Figure 1).

Afterwards, the evaluation was continued using a universal survey meter with the nuclear moisture density gauge switched ON and source is not on safe mode. Again the radiation dose was recorded at a distance of 1 m from the gauge surface on all sides (Figure 1). Similar to the previous step, we proceeded to evaluate and record the radiation dose at a distance very close to the surface (but carefully not touching the surface) of the gauge on all sides as depicted in Figure 1.

Radiation Contamination Tests

In order to perform the radiation contamination test, the nuclear moisture density gauge was placed on a clean, clear, and hard surface, preferably on a concrete floor. With hand gloves on, a separate filter, wipe, or tissue paper was used with the aid of forceps to carefully and systematically swipe the various surfaces of the gauge as illustrated in Figure 1. For each swipe on each surface, the wipe paper was brought very close to the window of the contamination monitor.

Then, the count rate was measured and recorded for that surface utilizing a contamination monitor. The wipe paper was carefully and gently wet with distilled water; subsequently, the procedures outlined above was repeated for all sides of the nuclear gauge (Figure 1), and the measured values were recorded for the wet wipe test.

Assessment by Standard Counts on a Standard Block

The standard block was cleaned, and it was ensured that it contained no debris. Subsequently, it was positioned on a concrete floor without any obstructions in the immediate environment. The nuclear moisture density gauge was placed on the standard block. It is of importance to make sure that the gauge is oriented according to the manual provided by the manufacturer for that model and brand.

With the rod in a safe position, the nuclear moisture density gauge was switched on and allowed to get "conditioned or warmed up" for few minutes. The standard counts were recorded on the nuclear moisture density gauge using appropriate key combinations on the gauge console as mentioned in the manual. This process was continued until the gauge passed or satisfied both moisture standard and density standard counts.

Results

During the study period, two, four, and three Troxlers were assessed at the SSDL of GAEC in 2015, 2016, and 2017, respectively. All the studied nuclear moisture density gauges were manufactured by Troxler Electronics Inc., USA. The gauges evaluated in 2017 belonged to MSF Construction, Queirox Galvao, and EM Geotech companies. The maximum and minimum measured dose rates were estimated at 66.67 and 1.19 µSv/h, respectively.

In 2016, four moisture density gauges were assessed with the maximum and minimum average dose rates of 65.93 and 0.49 µSv/h, respectively. The gauges tested in this year were from Kwality Kontrol and Ghana Highway Authority companies. In 2015, only two nuclear moisture density gauges were evaluated showing the maximum and minimum average dose rates of 66.12 and 1.19 µSv/h, respectively.

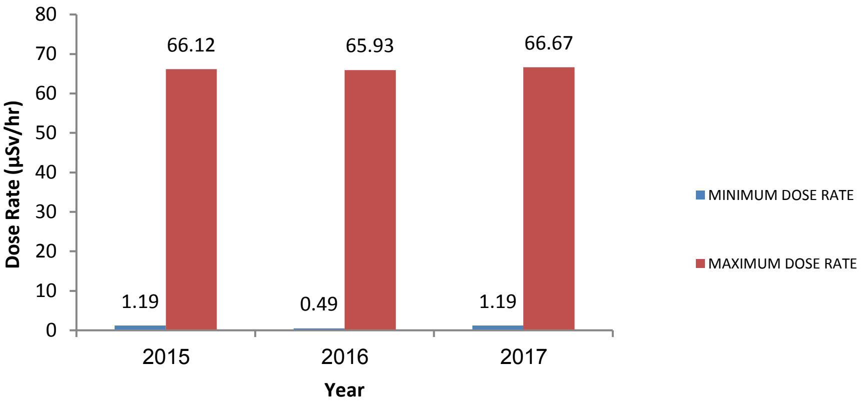

Figure 2. Average dose rate of moisture density gauges during 2015-2017

Discussion

A total of nine nuclear moisture density gauges were brought to the SSDL of GAEC for assessment during the study period. Figure 2 demonstrates that among all the gauges assessed during 2015-2017, the minimum and maximum average dose rates were 0.49 and 66.67 µSv/h, respectively.

As could be seen in Figure 2, the highest and lowest average dose rates were recorded in 2017 and 2016 on the devices with serial numbers of 38260 and 32839, respectively. In addition, the findings revealed no radiation leakage from the nuclear moisture density gauges, and all the devices were found to function properly.

Conclusion

According to the results of safety assessments conducted for the nine nuclear density gauges at the SSDL of the RPI of GAEC, these devices had no radiation contamination or leakage and were functioning well.

Acknowledgment

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