Radiological Monitoring Equipments at Medical Workplace

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ABSTRACT

The use of radiology for diagnostic and therapeutic purposes is so well established that it is difficult to imagine contemporary medical profession without it. However, the nature, frequency and accuracy of individual monitoring must be determined with deliberation of the magnitude and possible fluctuations of radiation exposure levels and the likelihood and magnitude of potential exposures. Different types measuring devices are available commercially for personal and work place monitoring. The article aims to discuss various available monitoring devices as it is important to utilise these at medical workplaces so that absorbed dose to tissues of occupationally exposed individuals can be assessed and thus can report and investigate over exposures and recommend necessary remedial measures urgently.

Keywords: Film badges; Thermo luminescent dosimeters

INTRODUCTION

The Federal Radiation Protection Code requires that a monitoring device be worn or carried by an occupationally exposed individual for the purpose of measuring the radiation exposure received.[1] The nature, frequency and accuracy of individual monitoring shall be determined with consideration of the magnitude and possible fluctuations of exposure levels and the likelihood and magnitude of potential exposures.

The personnel monitoring is crucial to observe and control individual doses regularly in order to ensure compliance with the stipulated dose limits and thus can report and investigate over exposures and recommend necessary remedial measures urgently. Personnel monitoring aims to maintain life time cumulative dose records of the users of the service. Hence, the radiation received by all the radiation workers during their work should be regularly monitored and a complete up to date record of these doses should be maintained.[2]

Monitoring of radiation exposure is required for healthcare or laboratory workers in non-emergency environments (radiology, nuclear medicine and radiation oncology) that may contain radiation, workers in emergency environments that may contain radiation and workers in industrial environments where radiation is used i.e. nuclear power plant workers or employees at radiation sterilizing facilities.[3] Medical radiation exposures are intended to provide direct benefit to the patient. When the exposure is justified and the use optimized, the dose is considered to be as low as is compatible with the medical purposes.[4]

The dose is the sum of the body dosimeter deep dose plus internal effective dose equivalent from ingested or inhaled radionuclides. Dose limits for adult workers, minor workers, declared pregnant women, and members of the public issued according to Environmental Health and Safety, Stanford University, Stanford California[5] is described in table 1.

Personnel monitoring is usually done by employing Film badges, Thermo luminescent dosimeters (TLD) or optically stimulated luminance dosimeter (OSL), and pocket dosimeter.[2]

Thermoluminescent dosimeters (TLDs) and films badges are wearable devices that measure ionizing radiation exposure levels. These instruments are often worn by personnel near the torso as this represents the primary location of body mass and organs, but they may also be attached to objects. These devices typically remain in place for extended intervals to assess cumulative exposure. They are considered 'delayed read' dosimeters as the instruments must be processed post-exposure to obtain dosage measurements.[6]

TLD AND FILM BADGES

Film Badge

The film badge dosimeter is a personal dosimeter used for monitoring cumulative radiation dose due to ionizing radiation. It is a film wrapped in light-tight paper and is mounted in plastic. Badges are checked periodically, and the degree of exposure of the film indicates the cumulative amount of radiation to which the wearer has been exposed.[7]

Flat badges are usually worn on the torso, at the collar or chest level, but can be worn on the belt, or forearm. Ring shaped badges can be worn on the finger when dose to the finger may exceed dose to the badge worn elsewhere on the body Radiation Detection Devices.[8]

Thermoluminescent Dosimeter (TLD)

Thermoluminescent dosimeters (TLDs) are crystalline solids that trap electrons when exposed to ionizing radiation and can be calibrated to give a reading of radiation level. Film badges are most often worn by hospital staff potentially exposed to x-rays or researchers working with higher energy beta emitters. TLDs are most often worn by persons exposed to a variety of isotopes such as found in nuclear medicine or the cyclotron facility. All dosimeters are processed by a contractor. They are collected the first week of every wear period. Most monitors can read as low as 10 millirem.[7] Limitation of TLD is delay between exposure and dose reading due to central processing of TLDs.[7]

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Some crystals, such as LiF, store ionizing radiation energy when valence electrons are moved to higher energy "traps" within the crystal matrix. The trapped electrons are released by heating the crystal. When they return to the lower valence energy level, the difference in energy is released as visible light. The amount of visible light released is proportional to the radiation dose absorbed by the crystal. The process is called thermoluminescent dosimetry.[5]

Pocket Dosimeters

Film and TLD will not show accumulated exposure immediately. In addition to the regular film badges, the radiation doses received by the radiation worker can be assessed by wearing a pocket dosimeter, which gives instantaneous radiation exposure. This is very useful in non-routine work, in which the radiation levels vary considerably and may be quite hazardous. The main advantage of pocket dosimeter lies in its ability to provide instant on the spot check of radiation dose received by the personnel. Suitable protective measures can be undertaken immediately to minimize future exposures. The dose can be read off directly by the person during or after any radiation work.[2]

Digital Electronic Dosimeter

Another type of pocket dosimeter is the Digital Electronic Dosimeter. These dosimeters record dose information and dose rate. These dosimeters most often use Geiger-Muller counters. The output of the radiation detector is collected and, when a predetermined exposure has been reached, the collected charge is discharged to trigger an electronic counter. The counter then displays the accumulated exposure and dose rate in digital form. Some Digital Electronic Dosimeters include an audible alarm feature which emits an audible signal or chirp with each recorded increment of exposure. Some models can also be set to provide a continuous audible signal when a preset exposure has been reached. This format helps to minimize the reading errors associated with direct reading pocket ionization chamber dosimeters and allows the instrument to achieve a higher maximum readout before resetting is necessary.[9]

Environmental monitoring program focus on estimating radiation doses that are or could be received by population or unspecified individuals as a result of natural or manmade radiation condition. Facility or work place monitoring provide information about conditions within buildings and in the vincity of processes presenting radiological hazards.[10]

Ionization Chambers

An ionization chamber is a device which measures the amount of ionization created by charged particles passing through a volume of gas enclosed in a vessel. If an electric field be maintained in a gas by a pair of electrodes, the positive and negative ions will drift apart inducing charges on the electrodes. In their traversal the ions may undergo recombination processes, and the charge collected by the electrodes alone will result in the ionization current measured in the external circuit. When every ion is collected, with no loss due to recombination, the maximum current is obtained called saturation current which will be proportional to the intensity of radiation.[11]

	Whole body dose in one year	Other limits
Adult workers	5 rem	Lens 15 rem each year. Skin, organ, extremities in one year: 50 rem
Minor workers	10% of Adult Limit	10% of Adult Limit
Declared pregnant woman	0.5 rem fetal dose	50 millirem fetal dose each month. Skin, lens, extremities: same as adult worker
Members of the public	0.1 rem	2 mrem in one hour

Table-1: Dose limits for adult workers, minor workers, declared pregnant women, and members of the public (According to Environmental Health and Safety, Stanford University, Stanford California).

Group	Type of Detectors	Detection	Use	Characteristics
Gas Filled Detectors	Ionization Chambers	α, β, γ	Radiation Survey	- Accurate Dose Measurements, Slow Response, Non-Pulse Type
	Proportional Counters BF3 & He-3 gases	α, β, n	α, β contamination n Survey	Good α, β, n Discriminations
	Geiger Counters	β, γ	Radiation Survey	Reliable, Inexpensive High Dead Time saturation
Scintillation Counters	NaI (Tl)	γ	Nuclear Spectroscopy Lab-use and Survey	Higher Efficiency & Lower Energy Resolution. Rapid Response. Expensive.
	ZnS	α	Survey	Detect α only
	Liquid Scintillators	Low β Energies	Contamination C-14, H-3, ...	High Efficiency, Expensive
Semi-Conductor Detectors	Germanium Detectors (Ge(Li), HPGe) & Si (Li)	X-ray γ	Nuclear Spectroscopy Lab-use	Higher Energy Resolution & Lower Efficiency. Need N2 Cooling
	Silicon Surface Barrier Detectors	α & Charged Particles	Nuclear Spectroscopy Lab-use	Good Energy Resolution

Table-2: Different types of radiation monitors along with type of radiation detector[13]

Scintillation detectors

Scintillates are one of the oldest types of radiation detector because measurements could be made with photographic film. Images could be collected or intensity measurements could be made. Measurements were also made with the human eye observing the brightness of frequency of flashes in the scintillator. Nowadays the light output is converted into voltage pulses that are processed in the same way as pulses from proportional counters, semiconductor detectors etc. The whole point of scintillation detectors is that we want to produce a large light output in the visible range.[12]

Different types of radiation monitors along with type of radiation detector are summarised in table 2.

In order to provide an accurate estimate of personal risk, radiation badges are to be used at all times when working with radiation. It is also important to turn in the radiation badges on time. The accuracy of the readings depends on the timely processing of the dosimeter.

The Radiation Safety Officer (RSO) reviews dosimetry records when they are received from the dosimetry vendor. Any exposures exceeding the established ALARA levels

are investigated to determine whether corrective action can eliminate or reduce exposures for all concerned. The circumstances surrounding most cases of excessive radiation exposures are often readily mitigated. Individuals can request their personal records at any time, and written dose estimates will be provided by the RSO.[14]

CONCLUSION

It is important that medical personnel working in radiology, nuclear medicine and radiation oncology that may contain radiation exposure should use their ring badges, whole body film badges and/or TLD badges to avoid excessive radiation dose. The selection of the particular type of monitor to be used i.e. ionization chambers, proportional chambers, GM-tubes or scintillation detectors should be determined by the type of radiation, its energy, and whether it is more likely to involve high or low amounts of activity.

REFERENCES

1. Cameron JR, Suntharalingam N. A Comparison of TLD and film for personal dosimetry pg451-55. http://www.irpa.net/irpa1/cdrom/VOL.1/R1_71.PDF
2. Radiation therapy. Available at: http://www.radiation-therapy-review.com/Personnel_Monitoring.html
3. Radiation Detection Devices Guidance on Diagnosis and Treatment for Healthcare Providers. Available at: http://www.remm.nlm.gov/civilian.htm
4. Fluoroscopy Radiation Safety Training Manual. Available at: https://www.case.edu/ehs/Training/RadSafety/fluoro.htm
5. Radiation Safety Manual (Revised March 2010) Updated January 2015 Environmental Health and Safety, Stanford University, Stanford California
6. Guidance on Diagnosis and Treatment for Healthcare Provider: Radiation Detection Devices. Available at: http://www.remm.nlm.gov/civilian.htm
7. TLD and Film Badges Information. http://www.globalspec.com/learnmore/manufacturing_process_equipment/personal_protective_equipment/tld_film_badges
8. Radiation protection guidance for hospital staff. Available at: https://web.stanford.edu/dept/EHS/prod/researchlab/radlaser/Hospital_Guidance_document.pdf
9. https://www.ndeed.org/EducationResources/CommunityCollege/RadiationSafety/radiation_safety_equipment/pocket_dosimeter.htm
10. Kenneth L. Miller. CRC Handbook of Management of Radiation Protection Programs, Second Edition. Available at: https://www.crcpress.com/CRC-Handbook-of-Management-of-Radiation
11. Nuclear Radiation Detectors - Springer Available at: www.springer.com/cda/content/.../cda.../9783642386602-c1.pdf
12. Scintillation Detectors In:Radioisotopes and Radiation Methodology https://www.science.mcmaster.ca/medphys/images/files/courses/4R06/note4.pdf
13. Radiation Detectors. Available at: qa.ff.up.pt/radioquimica/Textos_apoio/Radiation%20Detectors.pdf
14. Radiation Standards In: Fluoroscopy Radiation Safety Training Manual. Available at: https://www.case.edu/ehs/Training/RadSafety/fluoro.htm

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