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The Large Scale Personal Monitoring Service Using The Latest Personal Monitor GLASS BADGE

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ABSTRACT

In 2001, the Glass Badge - using silver-activated phosphate glass and solid state nuclear track detector - has been introduced as the major monitor of personal monitoring service in Japan. To develop the personal monitor that is suitable for large scale monitoring service, the establishment of the design concept about not only radiological characteristics but also comprehensive reliability as the monitoring service is very important.

The Glass Badge was designed to measure 10keV-10MeV range of photon, 300keV-3MeV range of beta and 0.025eV-15MeV range of neutron. And the dose estimation algorism and or automatic measurement systems were developed too. As the result of measurement, Hp(10) and or Hp(0.07), effective dose, equivalent dose and so on are reported.

In this presentation, the basic design concept of Glass Badge and its characteristics, outline of monitoring service systems are reported.

Keywords : personal monitor, glass dosimeter, radio-photoluminescence, neutron, solid state nuclear track detector

INTRODUCTION

History of glass dosemeter is long, that had been appeared as an accidental dosemeter for the first time in 1953[1]. Because of high level pre-dose, the phosphate glass of those days was not suitable for usual low dose level monitoring. But improvement for component of the glass material by Yokota[2] in '60s, it was put to practical use as a personal monitor. Though this dosemeter had dominant point on dosimetry, it could not spread because of handling difficulties in measurement. As the result it was only used for continuously in the part of country. Newly developed dosimetry system[3,4] in '80s which used pulsed ultraviolet ray by nitrogen gas laser and further improved glass material attracted attention again[5,6], as it enabled eliciting inherent features of the glass.

In 2001, the Glass Badge - using silver-activated phosphate glass and solid state nuclear track detector - has been introduced as the major monitor of personal monitoring service in Japan. In addition to superior characteristics for dosimetry, performance to be able to treat lot of data safety and swiftly becomes so important to keep comprehensive reliability in large scale personal monitoring service.

The glass dosemeter(GD-450) used for Glass Badge and the automatic reader(FGD-650) were developed especially to introduce them into large scale personal monitoring service. At the same time the dose estimation algorism and the automatic monitoring service systems using Glass Badge were designed, and a monitoring service center was constructed newly. To develop the personal monitor that is suitable for large scale monitoring service, the establishment of the design concept which considers not only radiological characteristics but also comprehensive reliability as the monitoring service is very important.

In this presentation, the basic design concept of Glass Badge and its characteristics, outline of monitoring service systems are reported.

DESIGN CONCEPT

(1) Basic concept

(a)In personal monitoring service facilities, lots of dosemeter are treated every day. The data matching of personal information and measured data for each customer is required a handled percent reliability to report correct result. Therefore dosemeter(GD-450) and automatic reader(FGD-650) were designed that enables to link these data automatically just in measurement.

(b)Glass Badge was designed to measure photon, beta and neutron. And GD-450 was designed to measure only photon and beta radiations. By excluding the neutron measurement from GD-450 function, it needs not cadmium filter which is generally used to thermal neutron measurement. As the result good precision for photon and beta measurement is expected in mixture field usage such a photon and neutron because no capture gamma rays from cadmium filter incident to glass elements.

(c)Solid state nuclear track detector(SSNTD) by ADC plastic which is loaded to Glass Badge is used to neutron measurement. Because of no sensitivity of ADC plastic to photon and beta radiations, SSNTD provide good precision for neutron measurement in mixture field usage such as (b).

(2)Concept for photon dosimetry

Materials and thickness of filters were designed to cover 10keV-10MeV energy range of photon measurement. This energy range is enough to measure the exposure of typical radiation field worker in medical, industrial, nuclear power station and so on except special field such as large accelerator facilities.

(3)Concept for beta dosimetry

(a)Materials and thickness of filters were designed to keep the energy of 300keV as the detectable lower limit for beta energy. Generally most closed part of body to beta emitter will be hands and or arms. But skin of these pert are covered by gloves and or clothes, and it is rare except a face to be exposed to beta ray directly. Therefore basically under 300keV beta ray is able to ignore by consideration of skin dead layer and several ten cm distance from beta emitter to skin such a face.

(b)Detectable dose limit for over 500keV energy beta ray was designed to make sure of 0.5mSv. To consider shielding effect of gloves and or clothes, generally contribution of under 500keV energy beta ray to dose equivalent Hp(0.07) is able to ignore.

(4)Concept for neutron dosimetry

ADC plastic SSNTD which is loaded to Glass Badge is adopted in neutron monitoring overall. This SSNTD was already developed as the wide-energy range neutron monitor WNP(Wide Range Neupit)[7]. WNP has two kind of charged particle radiator - BN and polyethylene – to cover wide energy range of neutron measurement such as 0.025eV to 15MeV continuously.

EXPERIMENTAL

To design dose estimation algorism, Glass Badge which is placed on PMMA slab phantom was irradiated lots kind energy of X rays, gamma rays and beta rays. From 12keV to 201keV energy of X rays and gamma rays emitted from ^{137}Cs, ^{60}Co and ^{16}N gamma source were irradiated to Glass Badges to design the algorism for photons. Some kinds of beta rays which have 0.54MeV, 1.3MeV, 1.6MeV and 2.0MeV residual maximum energy each were irradiated to design the algorism for beta rays too.

Basic dose estimation algorism for photon is as follows;

$$Hp(d)i = \sum(NADj \bullet Cij) \qquad (1)$$

where *Hp(d)i* is personal dose equivalent for 1cm depth and or 70micrometer depth, *NADj* is net appearance dose for each filter position j and *Cij* is the constant. (*NAD* is the equal to the value which is subtracted background from reading value by calibrated reader.) And values of each *Cij* are determined by experimental result.

Each characteristic such as energy dependency, angular dependency and so on were estimated by formula (1). The dose equivalent of irradiated Glass Badge in each experiment was calculated by formula (1), and such a relative response to normalized standard radiation was calculated.

RESULT and DISCUSSION

(1)GD-450

Figure 1 shows the schematic structure of developed glass dosemeter GD-450. Two plastic filters and three metal filters composition enables to measure 10keV-10MeV photon and 300keV-3MeV beta radiation. GD-450 size is 45mm x 13mm x 5mm and 5g weight, and to achieve good angular dependence each metal filter shape is like ring to encircle glass element as shown in figure 2.

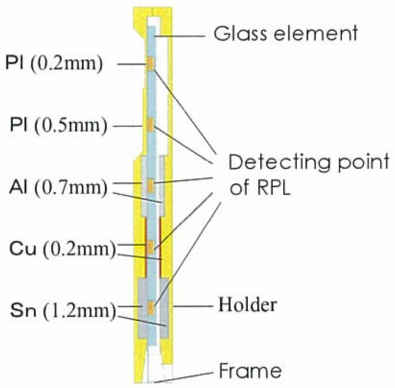

Figure 1. Schematic structure of GD-450

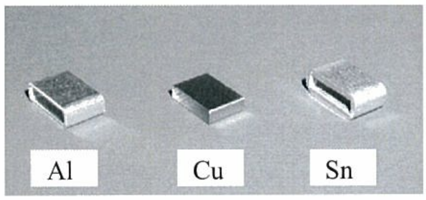

Figure 2. Schematic of metal filters in GD-450

(2)FGD-650

Figure 3 shows an exterior of developed automatic reader FGD-650 and server computer system. In this FGD-650 repetitious pulsed ultraviolet laser beam stimulation enables to measure radio-photoluminescence from each filter part of glass element as the extremely stable output.

Two thousand of GD-450 dosemeters are measurable continuously by five containers – four handled dosemeters are loaded to each – are loaded to the reader at once. And twelve seconds reading time per dosemeter enables to conclude two thousand dosemeters measurement less than seven hours by automatically.

Figure 3. Exterior of automatic reader FGD-650 and server computer system

A dose estimation algorism is programmed in server computer to estimate large number of data which is measured by plural number of reader at once.

(3)Characteristics of Glass Badge

(a)Energy dependency

Figure 4 shows energy dependency of Glass Badge as the result of Hp(10) and Hp(0.07) estimation for photon by formula (1). Glass Badge enables to estimate 10keV-10MeV energy range of photon with good precision, and formula (1) need not incident energy information. Therefore Glass Badge enables to estimate dose equivalent precisely if there are deferent energy photon incidence at same wearing term of dosemeter.

(b)Angular dependency

Figure 5 shows angular dependency of Glass Badge for photons. Ring shape metal filter showed figure 2 contribute effectively to achieve good precision.

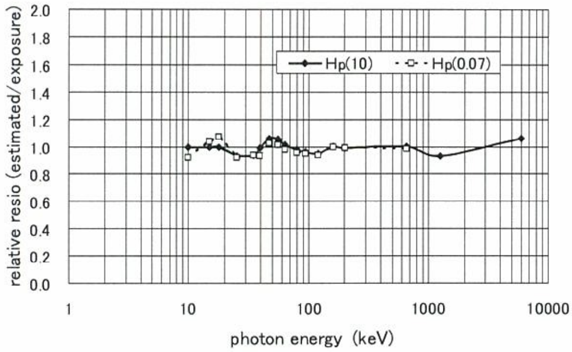

Figure 4. Energy characteristics of Glass Badge for photons

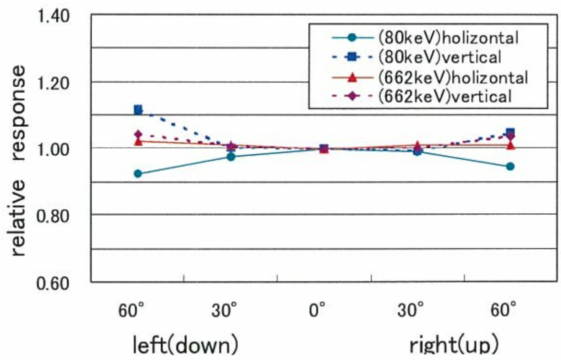

Figure 5. Angular dependency of Glass Badge for photons,.

(c)Detectable dose limit

Figure 6 shows detectable dose limit of Glass Badge for cesium gamma rays. An excellently stable sensitivity of glass element and reading system by pulsed ultraviolet laser beam enables to 0.014 mSv detectable dose limit with 95% confidence.

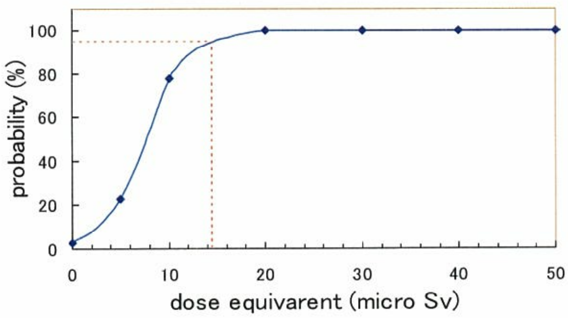

Figure 6. Detectable dose limit of Glass Badge for cesium gamma rays.

(d)Monitoring service center

The full automatic monitoring service systems which were certified as ISO 9001 Quality System is operating in newly constructed monitoring center. And a calibration laboratory which was accredited as to meet requirements of Measurement Law is in here too.

To achieve reasonable monitoring service, all of process for monitoring service such as Glass Badge assembling and or disassembling, rinse and pre-heating of glass element, annealing and pre-dose measurement of glass element and so on were automated.

CONCLUSIONS

GD-450 dosemeter and FGD-650 automatic reader which were devised to enable safety and swiftness handling of data were newly developed with making use of inherent features of glass material. Including developed dose estimation algorism, Glass Badge dosimetry systems enabled to provide personal monitoring result with excellent precision.

In personal monitoring center that based on the Glass Badge dosimetry systems, comprehensively hi-reliability monitoring service is in present to large numbers of customer.

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