

Panasonic DOSIMETRY

fast, easy,
reliable, accurate, & convenient



Panasonic TLD technology provides the advantages of excellent reproducibility and dosimeters which are reusable and unaffected by long storage periods.

Panasonic TLD systems incorporate state-of-the-art design, allowing fast throughput and providing unsurpassed quality assurance.



Panasonic
TLD systems offer:

- READERS
- IRRADIATORS
- BADGES
- HANGERS

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Panasonic

TLD Badge Systems - OVERVIEW

Panasonic TLD Badge Systems can be used for personnel, extremity and environmental monitoring in the field of radiation. They are suitable for use not only in large facilities, such as a nuclear power plant, but in mid or small size facilities such as a hospital or a laboratory.

TL BADGE MATERIALS	TL badge's use tissue-equivalent ($\text{Li}_2\text{B}_4\text{O}_7:\text{Cu}$) and highly sensitive ($\text{CaSO}_4:\text{Tm}$), making it possible to precisely measure various kinds of radiation over a wide range of doses and energies.
BADGE -FEED MECHANISM	Panasonic TLD Readers utilize "Auto Feed." TL Badges can be fed into the reader without the necessity for manual operations such as opening the case and taking out the elements.
HEATING METHOD	Panasonic TLD Readers utilize the Optical Heating method (Non-Contact) to read the TL badges accurately, easily, quickly, and reliably.
PROCESSING TIME	One thin TLD element can be heated in 0.8 second by the flashing light of a special tungsten lamp. The processing time is very short, and the total time for one 4 element badge is: TLD Reader Model UD-7900: approximately 20 seconds TLD Reader Model UD-716AGL: approximately 35 seconds
MEASUREMENT METHOD	Both the photon-counting method and the current integration method are employed to precisely detect the thermoluminescence throughout a wide range of doses. Low Signals: Photon Counting Method Large Signals: Current Integration Method
PREHEATING AND ANNEALING	Preheating and annealing functions are included in the main read cycle.
ID CODE READING	Optical Reading
SELF CHECK FUNCTIONS	The TLD Readers are equipped with microcomputers which control self-checking functions and all automatic functions, such as annealing of the TL badges for repeat use, reading of the ID code, and sensitivity adjustment for correction by the built-in reference light source.
INTERFACE	The TLD Readers are also equipped with an interface for transmitting the data to outside equipment such as a computer or a printer.

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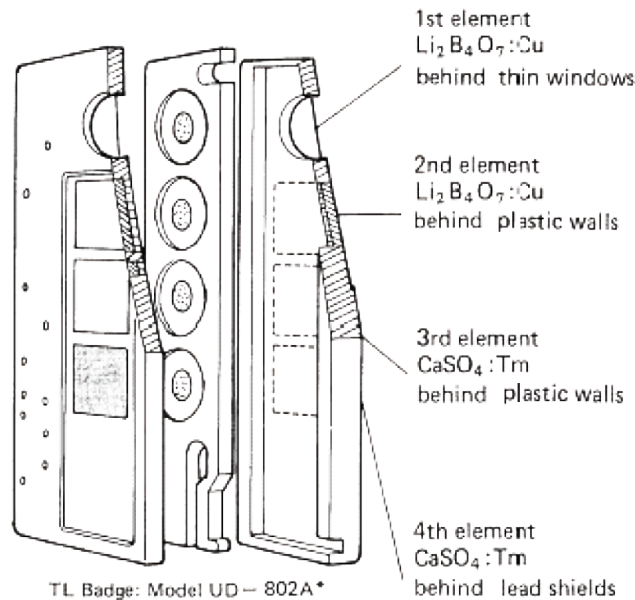
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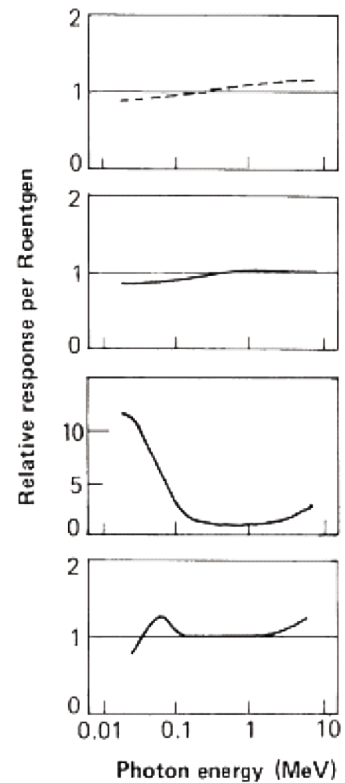
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TLD Badge Systems: Overview

Construction of the model UD-802A, a typical TL badge, and the energy responses of each element.



* There are several models in the UD - 800 series.
Please request details concerning other models.



Element No.	Purpose	Thermoluminescent material	Radiation Shield	Measurement range
1st element	Skin dose	$\text{Li}_2\text{B}_4\text{O}_7:\text{Cu}$	Thin window	10 mRem ~ 1000Rem 100 μSv ~ 10 Sv
2nd element	10keV ~ 10 MeV	$\text{Li}_2\text{B}_4\text{O}_7:\text{Cu}$	Plastic	10mR ~ 1000R 100 μSv ~ 10 Sv
3rd element	25 keV ~ 10 MeV	$\text{CaSO}_4:\text{Tm}$	Plastic	1mR ~ 50R 10 μSv ~ 500mSv
4th element	25 keV ~ 10 MeV	$\text{CaSO}_4:\text{Tm}$	Lead + Plastic	1mR ~ 50R 10 μSv ~ 500mSv

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Advanced Thermoluminescent System

The Panasonic TL-Badge is a small, reliable dosimeter designed for superior accuracy, easy handling, cleanliness and resistance to mechanical impact.

Thin elements of tissue-equivalent $\text{Li}_2\text{B}_4\text{O}_7:\text{Cu}$ and ultra-sensitive $\text{CaSO}_4:\text{Tm}$ are encapsulated within a case containing the appropriate filters and optical ID-code.



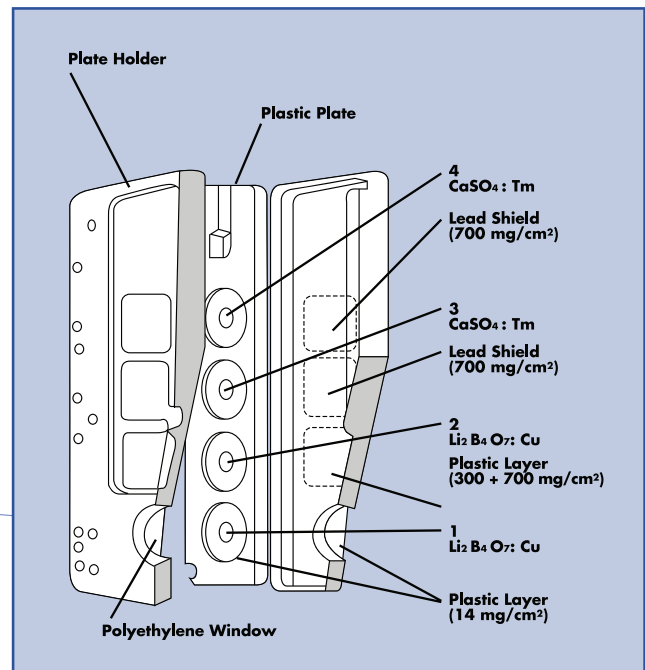
This design has superior detection level, tissue-equivalence, and angular dependence compared to other dosimeters.

Panasonic TLDs have two different phosphors, allowing energies and particles to be detected.

DOSIMETER CONSTRUCTION

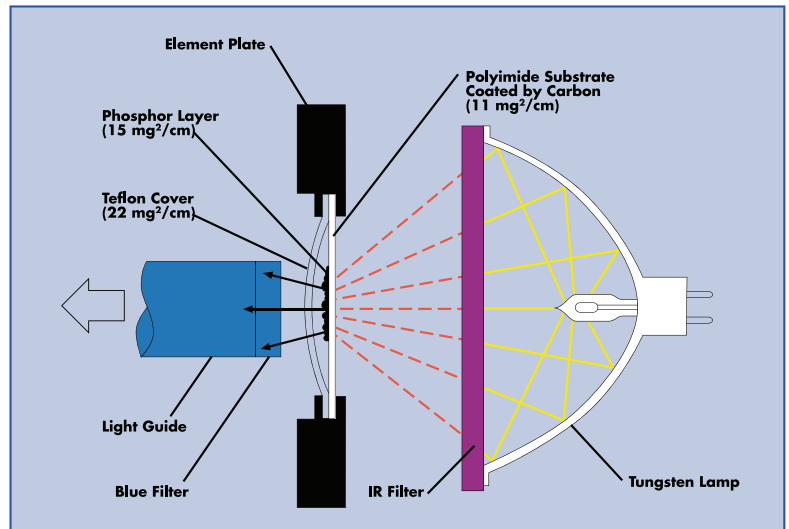
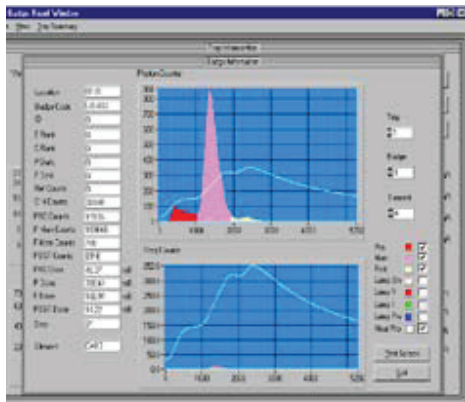
Typical configuration is a four-element plate enclosed with plastic and lead filters.

This composite design ensures accurate calibration.

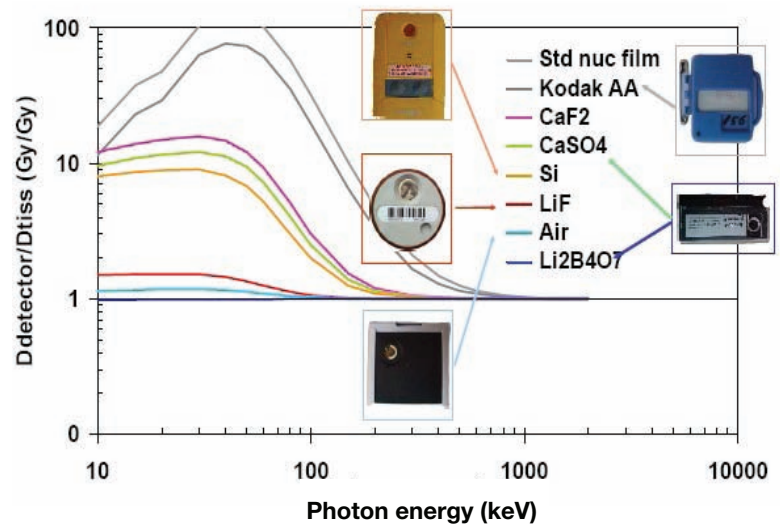


Optical Heating System

Non-contact heating method utilizing a halogen lamp. The temperature is localized to the TL-element (no heat spread through the reader). Three consecutive lamp pulses are applied to each TL-element to pre-heat, read and anneal it in under 30 seconds without gas or annealing ovens. Typical processing cycle is up to 160 dosimeters /hour. Typical reader display (below) shows standard glow-curve and temperature profile.



Characteristics



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Composite Type TL Badge

This composite type dosimeter with a maximum of 4 elements can be read by ALL Panasonic TLD Readers.

Many types of TL Badges are available to measure various radiation exposures (γ rays, x-rays, Beta-rays and neutron rays) through suitable combinations of phosphors and filtrations. This small, very reliable dosimeter is designed not only for superior characteristics as a dosimeter but also to include other desirable properties, such as ease of handling, cleanliness, resistance to mechanical impact, etc.

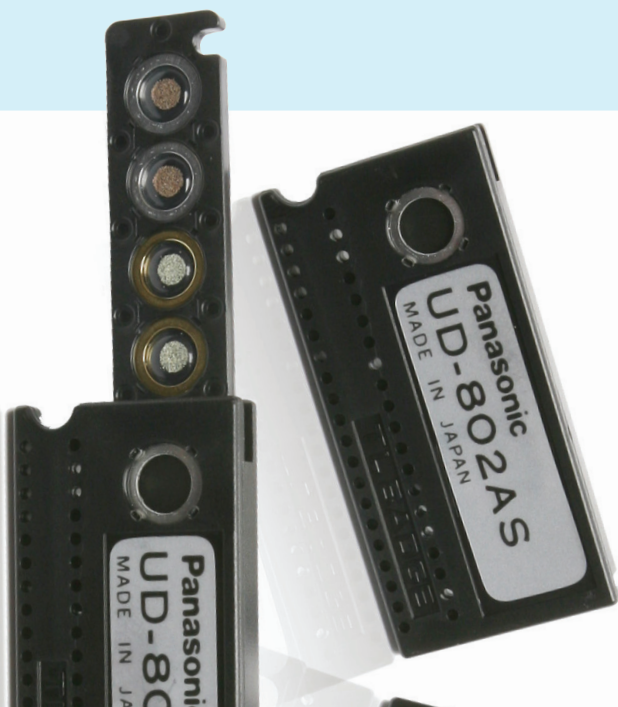
In the detection part, a specially developed phosphor $\text{Li}_2\text{B}_4\text{O}_7:\text{Cu}$ and a highly sensitive phosphor $\text{CaSO}_4:\text{Tm}$, both formed to a thin element, are used. They are especially engineered for optical heating.



$\text{Li}_2\text{B}_4\text{O}_7:\text{Cu}$ has a radiation response characteristic which is very close to that of human tissue, and responds precisely to X rays and γ rays over a wide range of energies. Furthermore, because the element is very thin, the skin dose can be measured.

$\text{CaSO}_4:\text{Tm}$ on the other hand has very high sensitivity and very small doses can be detected with this phosphor. Also low-energy X rays and γ rays can be detected separately by utilizing the energy characteristics of the phosphor.

Elements are encased in a holder. The ID number is coded by punched holes, and they are read automatically by the reader. A hanger with clip is used for wearing.



FEATURES

UD-800 series

- Tissue equivalent lithium borate phosphor ($\text{Li}_2\text{B}_4\text{O}_7:\text{Cu}$) delivers a flat energy response over a low-to-high energy range.
- Enriched lithium borate phosphors (^7Li / ^6Li) are available for neutron dosimetry.
- Highly sensitive calcium sulphate phosphor ($\text{CaSO}_4:\text{Tm}$) allows precise measurement of low doses.
- Filtration: Thin plastic window or thick plastic window or metal shields (Al, Pb, Cd and Sn) can be mounted on the holder depending on badge application.
- Energy dependence is low and sensitivity is high.
- Skin doses can be measured.
- ID codes of upto 7 digits can be punched .
- A locking mechanism prevents accidental contamination of the badge detection portion
- Small and lightweight



SPECS

UD-800 series

Type	Composite type up to 4 elements
Number code	Punched holes, 7 digits
Phosphors	$^n\text{Li}_2\text{}^n\text{B}_4\text{O}_7:\text{Cu}$ $^6\text{Li}_2\text{}^{10}\text{B}_4\text{O}_7:\text{Cu}$ $^7\text{Li}_2\text{}^{11}\text{B}_4\text{O}_7:\text{Cu}$ $\text{CaSO}_4:\text{Tm}$
Measurable Radiation Types	X rays, γ rays; 10KeV ~10MeV Skin dose Neutron dose
Measurement Range	1mR ~1000R (X · Y) (10 μ Sv - 10Sv)
Spurious Signal	Undetectably small
Dimensions and Weight	49 x 23 x 6 mm approx. 5g



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Compact Type Automatic Reader with Glow Curve Display

UD-716AGL TLD Reader: automatically reads the “UD-800Series” of TLD badges.

The Panasonic compact automatic TLD reader provides a cost-effective solution for small to medium dosimetry services or serves as a backup to the larger UD-7900M reader.

Its advanced optical heating system and design means that it can be conveniently situated in most office or laboratory environments as gas supplies and annealing ovens are not required.

One-touch operation with advanced self-checking functions means minimal operational training is required.

Both the photon-counting method (pulse-counting) for small signals and the current integration method for large signals are employed to precisely detect the thermo luminescence throughout a wide range from low doses to high doses.

The reader is equipped with self-checking functions for the optical path, sensitivity of PM tube, heating stability, etc. It also performs automatic functions such as annealing of the TL badges for repeat use, optical reading of the ID code, and sensitivity adjustment correction by the built-in reference light source.



UD-736AB

UD-716AGL

FEATURES

UD-716

- **Optical Heating System:** Extremely fast non contact heating requiring no gas or annealing ovens. The heat is localized for high operational reliability.
- **Simplified Operation:** One-press automatic start. Minimal training for operators and technicians. Very easy to service and maintain.
- **Batch Measurement** With the reader connected to Magazine Changer UD-736AB (option), batch measurement of 200 badges is possible. This saves time as there is no need to manually feed badges into reader
- **Glow curve** display is available. Glow signal output terminals are included in the standard specification. No external monitor required.
- **Easy connections to host computer** using a RS-232C interface.
- **Calculations:** Capable of measuring data correction and performing average and standard deviation calculations, saving valuable time.
- **Compact and Light Weight** The unit can be easily transported for field applications.

SPECS

UD-716

Applicable TL Badge	UD-800 series (All Panasonic TLD Badges)
Heating Method	Optical Heating System (Non Contact)
Measuring Range	Li ₂ B ₄ O ₇ 10mR ~ 1000R (100μSv ~ 10 Sv) CaSO ₄ 1mR ~ 50R (10μSv ~ 500mSv)
Measuring Time	Approx. 35 sec. for 4-element badge (2 hours / 200 badges)
TL Badge Loading	Automatic loading with magazine 50 per magazine With Magazine Changer 50 per magazine x4 magazines =200
Weight and Dimensions	UD-716AGL: Approx. 42kg Approx. 622(W) x 322(H) x 418(D) mm UD-736AB: Approx. 18kg Approx. 400(W) x 180(H) x 490(D) mm

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Computerized Type TL Badge Automatic Reader with Built-In Auto-changer

The UD-7900 Reader automatically reads all “UD-800 Series” TL Badges with high reproducibility and precision. Using the non-contact optical heating method, the reader can measure a large number of TL badges at high speed with reliability.

Both the photon-counting method (pulse-counting) for small signals and the current integration method for large signals are employed to precisely detect the thermoluminescence throughout a wide range from low to high doses.

The reader is equipped with self-checking functions for the optical path; sensitivity of PM tube, heating stability etc. It also performs automatic functions such as annealing of the TL badges for repeat use, optical reading of the ID code, and sensitivity adjustment correction by the built-in reference light source.

Pre-heating, annealing, and ID code optical reading are also incorporated.



FEATURES

UD-7900

- **Optical Heating System**, (Non-Contact)
Extremely fast non contact heating requiring no gas or annealing ovens. The heat is localized for high operational reliability.
- **Simplified Operation** One-press automatic start. Minimal training for operators and technicians. Very easy to service and maintain.
- **Batch Measurement With the Built In Auto-changer** batch measurement of 500 badges is possible . This saves time as there is no need to manually feed badges into reader
- **Selectable Heating Mode** Digital heating control of power and time. UD-710A and UD-716A heating emulation. No need to change hardware, connections, or lamp.
- **Built in Glow Curve Interface.**
- **Built in Electronic Real Time Measurement of Heating Temperature Profile.**
- **Power Supply** (factory preset)
100/115/220/230/240V AC/50-60Hz
- **Windows based Control Software** ; PC and Monitor are included
- **Communications** to Host PC or Mainframe is easy through built in RS232 Interface
- **Uses field proven and reliable UD-710/UD-730 mechanics**

SPECS

UD-7900

Applicable TL Badge	UD-800 series (All Panasonic TLD Badges)
Heating Method	Optical Heating System (Non Contact)
Measuring Range	Li ₂ B ₄ O ₇ 10mR ~ 1000R (100μSv ~ 10 Sv) CaSO ₄ 1mR ~ 50R (10μSv ~ 500mSv)
Measuring Time	Fast Mode (UD-710) - Approx. 20 sec. for 4-element badge Slow Mode (UD-716) - Approx. 35 sec. for 4-element badge
TL Badge Loading	Automatic loading with Built In Auto-changer for 10 magazines 50 badges per magazine x10 magazines = 500 badges/loading
Weight and Dimensions	Approx. 150kg Approx. 1000(W) x 850(H) x 430(D) mm

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Computerized Type Automatic Irradiator with Built-In Auto-changer

The Model UD-794 Thermoluminescent Dosimeter (TLD) Irradiator is a system designed to irradiate dosimeters. The irradiator consists of a Gamma radiation source, shielding material, a channel inside the shield in which to position and irradiate the dosimeter, a mechanism by which to move the dosimeter from its tray, an attenuator, a control panel, and safety interlocks. All components are inside a self-contained unit, constructed of sheet metal panels for safety.

The source used in the device meets special form encapsulation criteria and is permanently mounted inside a shield that completely surrounds the source. An attenuator allows for delivery of a low or high dose rate to the dosimeter. The dosimeter channel runs through the shield, allowing exposure to occur. A motor-driven lift mechanism moves the dosimeter into and out of the shield, up the channel. The control panel, integrated with the system computer, shows system status.

With the built in Auto-Changer which can accommodate 10 magazines of 50 TL Badges each, batch irradiation of 500 badges is possible.



FEATURES

UD-794

- **Simplified Operation** - Automatic irradiation can be started by just pressing one key. This simplifies training for operators/technicians.
- **Batch Irradiation** - With the Built In Auto-changer, batch irradiation of 500 badges is possible.
- **Radioactive Isotope** - ^{137}Cs (nominal 2.0 Curies). 74GBq Standard. Other activities are available.
- **Half Life** - 30 years
- **External Radiation Level** - Less than 0.5 mR/hr ($5\mu\text{Sv/hr}$) at a distance of 30 cm from surface of shield.
- **High Dose Rate** - Approx. 30mR/sec ($300\mu\text{Sv/sec}$)
- **Cycle Time** - Dose dependent
- **Power Supply** (*Factory Preset*) 100/115/220/230/240V AC/50-60Hz
- **Windows based Control Software** - PC and Monitor are included
- **Communications** - to Host PC or Mainframe through built in RS232 Interface

SPECS

UD-794

Applicable TL Badge	UD-800 series (All Panasonic TLD Badges)
TL Badge Loading	Automatic loading with Built In Auto-changer for 10 magazines 50 badges per magazine x10 magazines =500 badge capacity
Weight and Dimensions	Approx. 300kg Approx. 1000(W) x 1120(H) x 550(D)mm

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Alarm Pocket Dosimeter

Fig.1 Energy Response

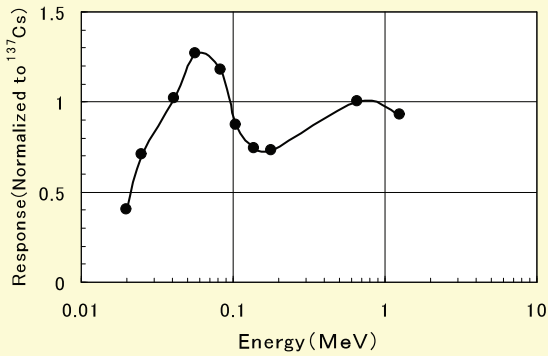
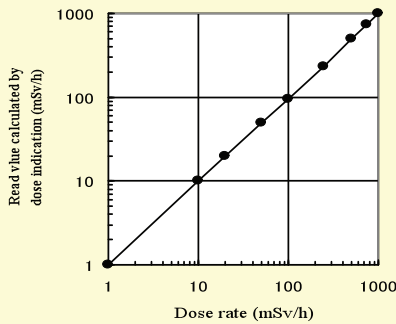


Fig.2 Dose Rate Linearity



APPEARANCE



Fig.3 Gamma Ray Angular Response (¹³⁷Cs)

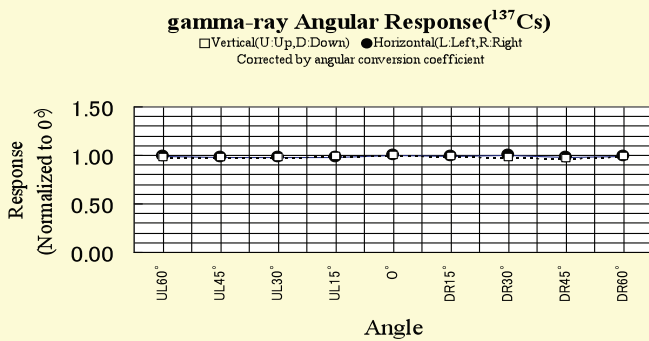
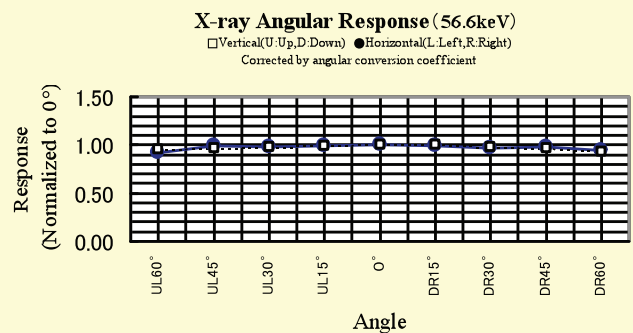


Fig.4 X-ray Angular Response



1) Mechanical

Material : Plastic covered by gild
 Dimensions : approx. 54 mm(W)
 91 mm(H)
 17 mm(T)
 Weight : approx. 80g (including battery)

2) Display

LCD

1.Main display : 7segment x 4digits (for dose)
 0.000mSv - 9.999mSv (0.001 mSv unit)
 10.00mSv - 99.99mSv (0.01 mSv unit)
 100.0mSv - 999.9mSv (0.1 mSv unit)
 1000mSv - 9999mSv (1mSv unit)

2.Sub display : 7segment x 4digits (for use time)
 00:00 -99:59 (min. unit)
 100 - 9999 (hour unit)

3.Alarm display : [BATT] , [ALARM] and [TIME]

LED

1.Red LED (for ALARM)

3) Buzzer

Sound Level : 60dB at 20cm

4) Communication

Method : IrDA
 Distance : 10 - 30cm
 Speed : 9600bps

5) Power Supply

Main Battery

1. Type : Lithium(CR2477)
 2. Lifetime : approximately
 3 months of continuous operation at
 no alarm and communication

Back-up Battery (no-need replacement)

1.Type : Rechargeable Lithium - ion
 2.Lifetime : approx. 10 hours after charged over
 100 hours by main battery

6) Operation

Switch : 3 push switches

Items :

1.Power ON/OFF
 2.Setting the alarm set value
 3.Communication by IrDA

7) Function

Click Sound : Generated every 0.001mSv(fixed)
 Alarm :

1.Dose : beep 20sec.
 LED and [ALARM] continue until switch
 operation

2.Time : beep 20sec.
 LED and [TIME] continue until switch
 operation

3.Battery : beep 10sec.
 LED continue until switch operation
 [BATT] continue until changing battery

Setting Mode : below items changeable by switches
 or IrDA

1.Dosimeter No. : 0000-9999

2.Dose Alarm : 0.000-999.9mSv

3.Time Alarm : 00:00-99:59

Dose Record : memorize last 3 times "Dose" and
 "Time"

8) Environment Resistance

Operating Temperature : 0 - 40 °C

Storage Temperature : -10 - 50 °C

Humidity : 20 - 90 % non-condensing

Waterproof : No

Drop : Once on each 6 face from 1.5m to plank floor

Static electricity : Less than 10kV

Electromagnetic field : 10 V/m 30MHz - 100MHz

9) Radiation Performance

Detectable Radiation : Hp(10) from X and Gamma-
 ray(25 keV - 1.5 MeV)

Detector : Silicon semiconductor

Accuracy of measurement : within +10 %

(above 0.01 mSv at ¹³⁷Cs)

Energy Response : within +30 % (30 keV - 1.5 MeV)

Dose Rate Linearity : within +20 %

(0.1 mSv/h - 1 Sv/h at ¹³⁷Cs)

Angular Response : within +20 % (up to 60° up and
 low, left and right at ¹³⁷Cs)

within + 50 % (up to 60° up
 and low, left and right at ²⁴¹Am)

Statement concerning the Panasonic **UD-802A** Dosimeter and the Panasonic **UD-700** Readers

1. Design Concept.

The choice of the heating method in a TLD Reader will almost completely characterize the complete system in terms of measurement and reliability. Furthermore, as personal monitoring services are under pressure to quickly and reliably process many dosimeters each day, handling and loading of dosimeters with minimum precaution is paramount.

In order to release the stored energy in a TL-detector, it is necessary to subject the detector to special conditions not found during its wear-term. In conventional TLD, this necessitates applying a controlled temperature rise up to around 400°C.

The heat source should be located outside the field of view of the photomultiplier to avoid thermal noise. The applied heat should be isolated from the reader components to avoid mechanical disruption and, in the case of multi-element dosimeters, from TL-elements adjacent to the heated element to avoid induced fading.

The TL-materials should be constructed to allow for handling without risk of contamination by dirt, sweat, grease and other factors capable of generating false signals when heated.

Filtering materials, especially metals, have a large impact on angular response and should be minimised and where possible, incorporated into the dosimeter rather than the holder for (a) reduction in measurement uncertainty and (b) automation in packaging.

Materials with low effective atomic numbers will ensure a flat energy response over all occupational energies and reliable calibration at dose equivalent quantities. Combining these materials with other materials in a four-element dosimeters will give a discriminating dosimeter, providing information on energy.

One of the original heating systems used a contact or hot-planchette system. The requirement was for the TLDs be clean and to have full surface contact with the planchette.

In 1968, a stream of hot nitrogen gas was proposed for heating TLDs. This was adopted by manufacturers as the gas better fits the various shapes of the TL-detector and is a non-contact system. It remained for manufacturing designs to try to eliminate spread of the gas throughout the reader although it is agreed that a steady flow of nitrogen through the reader on a 24 hour basis may be necessary to eliminate air impurities.

The evolution of the non-contact heating system was realized in the form of optical heating. The requirement here was for elimination of the gas supply and its potential heat spread into other areas of the Reader.

The idea of an optical heating system is in itself not a new one but required the development of a TL-detector with infra-red absorber.

Panasonic has developed an optical heating method which can heat the Panasonic thin-element TLD to 360°C within 2 seconds by IR radiation from a tungsten lamp. Digital heat-profiles are generated and controlled by direct heat-flux measurement. An important feature of this method is that an extremely localized area can be exclusively heated very quickly without heating the surrounding parts. For this reason, the dosimeter materials need not be heat resistant and the reader is freed from extraneous heat which often causes mechanical or electronic malfunctions.

2. Optical Heating System

Construction

Figure 1 shows a cross-sectional diagram of the TL-element and optical heating system. The TL-element is composed of a single layer of phosphor granules, approximately $90\mu\text{m}$ each and covering an area 3mm in diameter, bonded onto a polyimide substrate film and enclosed in a transparent Teflon cover of depth $22\text{mg}/\text{cm}^2$. A thin layer of carbon of depth $11\text{mg}/\text{cm}^2$ on the opposite side of the film acts as an infra-red absorber. Up to four of these elements are mounted onto a solid polycarbonate plate of dimensions $12\times 48\times 1.8\text{mm}$.

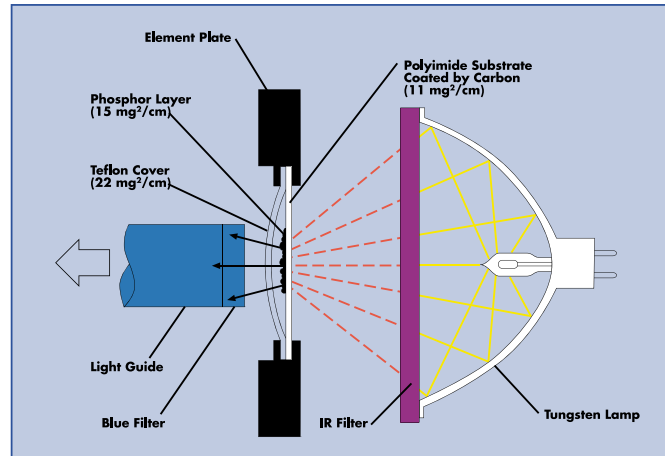


Figure 1 – Structure of Optical Heating System and Dosimeter Element

Pulsed light from the lamp is focused onto the TL- element. Typically, three pulses of duration 0.1sec to 0.4sec will induce three TL-peaks. The first is a very small and rapidly decaying low-energy peak. The second is a dominant and stable peak at about 210°C . The third is the product of the release of the deep energy traps, effectively annealing the element for re-issue.

The combination of the rapidity and localization of the applied heat together with its subsequent absorption means that the element can be exclusively heated without effect to the surrounding parts.

Figure 2 shows the three peaks with the main peak highlighted in yellow from approximately 1 to 2sec into the reading process. Superimposed here are the lamp voltage and current waveforms. It was found that heating rates can be changed by manipulating the lamp voltage from 4 to 14v with the areas of the glowcurves remaining constant. Shown here is a 5volt pulse, considered to be optimum for response stability as a function of repeatability.

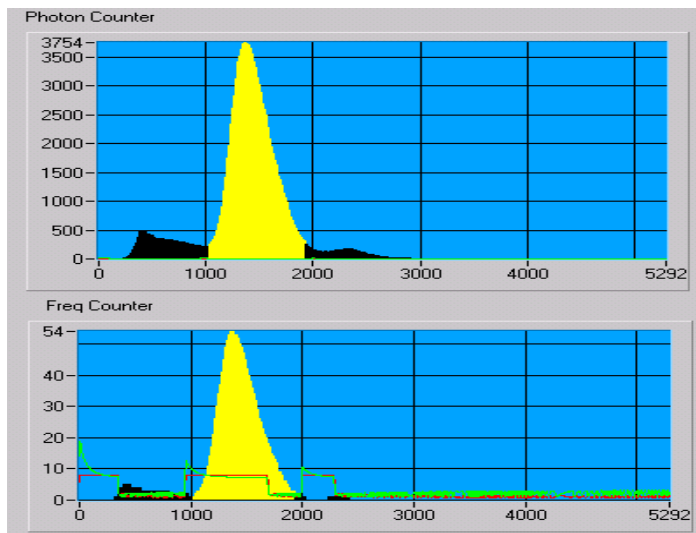


Figure 2 – Glow Curves of Lithium Borate:Cu as a function of applied lamp pulse.

As the lamp is effectively a radiation source emitting short bursts of high energy, a heat flux sensor was chosen as a means of measuring the heat transfer to the TL-element. This typically consists of a thermopile for registering actual heat flux surrounded by a resistance temperature sensor for temperature compensation. Heat flux is the rate of energy transfer per unit area. Whereas temperature is dependant upon the material present, heat flux measures the energy crossing a boundary and is therefore not restricted by the thermal mass of the system

Figure 3 shows first the heating profile superimposed over the glowcurve and then the temperature file as a function of temperature over time. The 3 glowcurve peaks are reached at about 120°C, 220°C and 350°C.

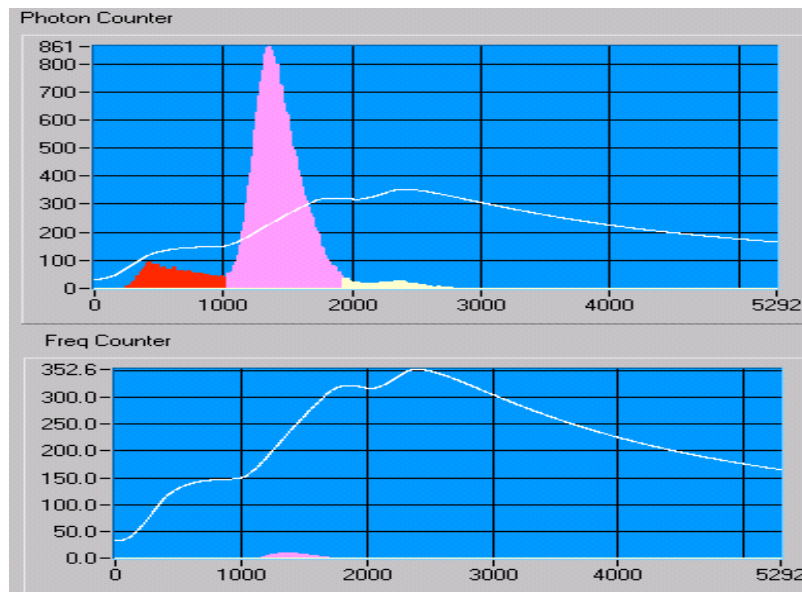


Figure 3– Heating profile as a function of time and temperature

3. TL Materials.

Figure 4 shows the response of several commercially-available TL materials as a function of absorbed dose in material/ tissue. It can be seen that the over-response at low energies increases as a function of effective atomic number Z, e.g. Li-fluoride=8.4, Al-oxide=11.3, Ca-Sulphate=15.3 compared with tissue=7.4 etc.

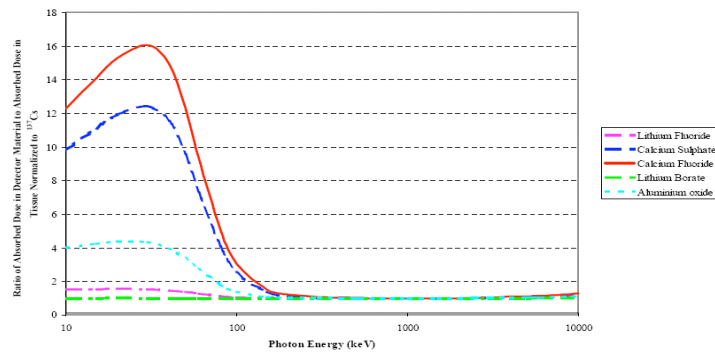


Figure 4 – Energy Response of Phosphors

Figure 5 shows how the response of these TL-materials compare with several common detectors. The over-response at energies <100keV can be seen for non-tissue-equivalent materials.

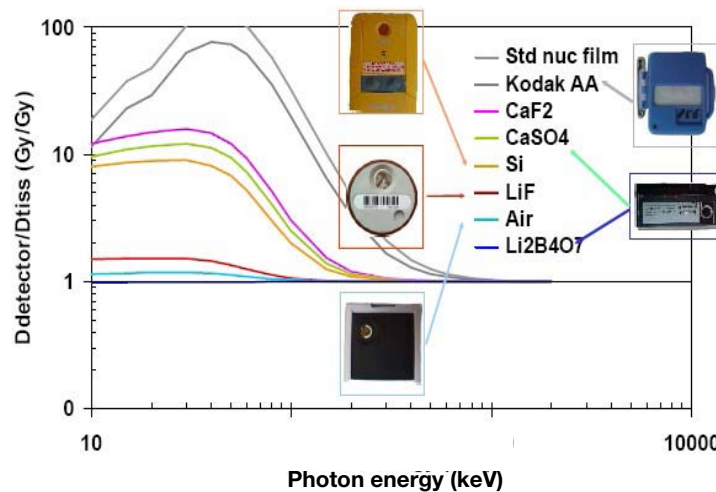


Figure 5 – Absorption of common detectors relative to soft tissue

Scientists at the Panasonic Central Research Laboratories in Osaka have developed an efficient ${}^6\text{Li}_2\text{}^7\text{B}_4\text{O}_7\text{:Cu}$ preparation exhibiting maximum TL efficiency where the atomic ratio of B/Li = 2 using a sintering method. This ratio also resulted in virtually zero absorption of moisture (Figure 7). ${}^6\text{Li}_2\text{}^7\text{B}_4\text{O}_7\text{:Cu}$ is 7.3 – very similar to tissue ~ 7.4.

Response of the phosphor at < 100keV is a function of effective atomic Number Z_{eff} .

The TL signal is optimum for photomultiplier tubes at 365nm wavelength. (Figure 6). A preparation of $\text{CaSO}_4\text{:Tm}$ was also researched and developed. The over-response of $\text{CaSO}_4\text{:Tm}$ ($Z_{\text{eff}} \sim 15.3$) is used to advantage as shown in Section 4.

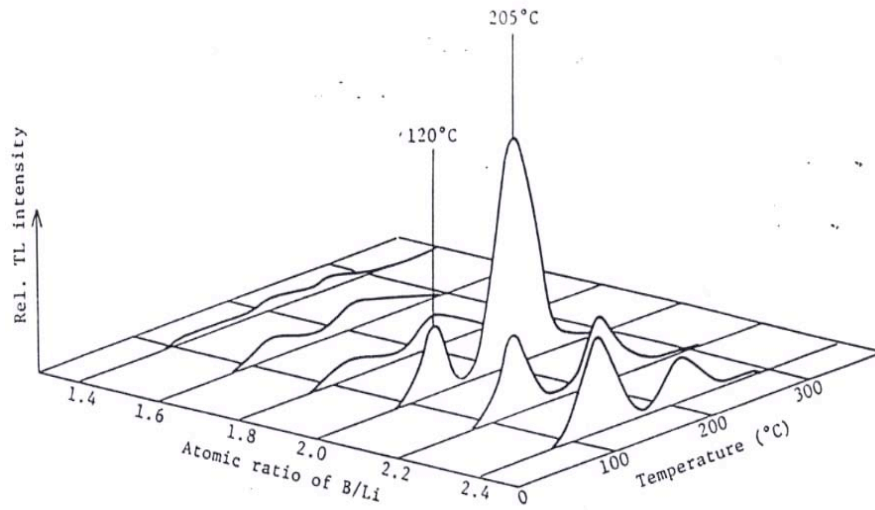


Figure 6 - Glowcurves of 0.03wt% Cu-activated lithium borate at various B/Li atomic ratios

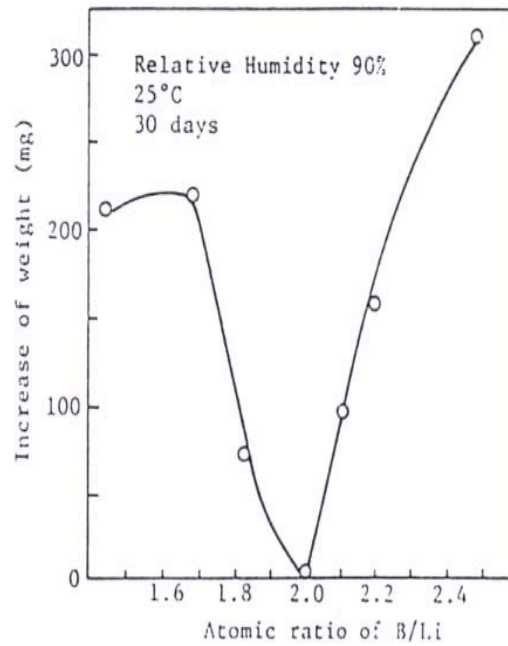


Figure 7 - Change of phosphor weight due to moisture absorption in Cu-activated lithium borate phosphors with various B/Li atomic ratios.

4. Discrimination and Algorithm

Dosimeters with 2 or less elements are known as non-discriminating dosimeters. This means that (a) no information about energy is available and (b) non-tissue-equivalent phosphors cannot accurately report unknown irradiations <100keV.

The flat response of $\text{Li}_2\text{B}_4\text{O}_7:\text{Cu}$ means that, in its simplest form, the dosimeter/reader can be calibrated at a single-point irradiation in dose-equivalent units. The addition of $\text{CaSO}_4:\text{Tm}$ under a combination of plastic and lead allows the dosimeter to be exploited for energy and angular information.

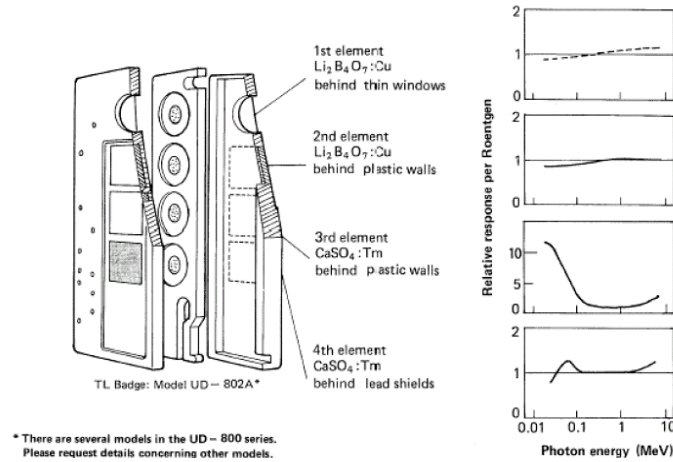


Figure 8 – Dosimeter Construction..

Panasonic and users have developed dose algorithms based on the dose response of the four elements E1, E2, E3 and E4 in various holders.

The algorithm uses the element response ratios $E1/E2$, $E2/E3$, $E3/E4$, $E1/E4$ and $(E2-E4)/(E1-E4)$, allowing the users to calculate $H_p(0.07)$, $H_p(10)$, $H_p(3)$ and also to identify particles and energies as a result of the algorithm.

Alternatively, the user can generate their own dose response algorithm particular to their own dosimeter/holder combination. Because the UD-802A has built-in filters, simple plastic holders can be sourced and algorithms simply built.

Step 1 – The dosimeter/holder combination is irradiated with ^{137}Cs to calibrate the TLD Reader to match the deep dose equivalent for Element 2 and for Element 3.

Step 2 – The dosimeter/holder combination is irradiated and read for several lower energies (figure 9)

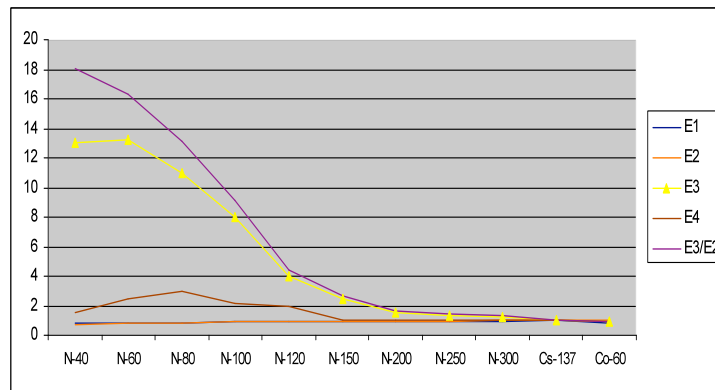


Figure 9 – Chart of element responses as a function of radiation energy.

Step 3 – Calculate and plot the ratio of Element 3/Element 4 as a function of Element 2 (Figure 10)

Step 4 – Add trendline and curve fit to a minimum of two orders.

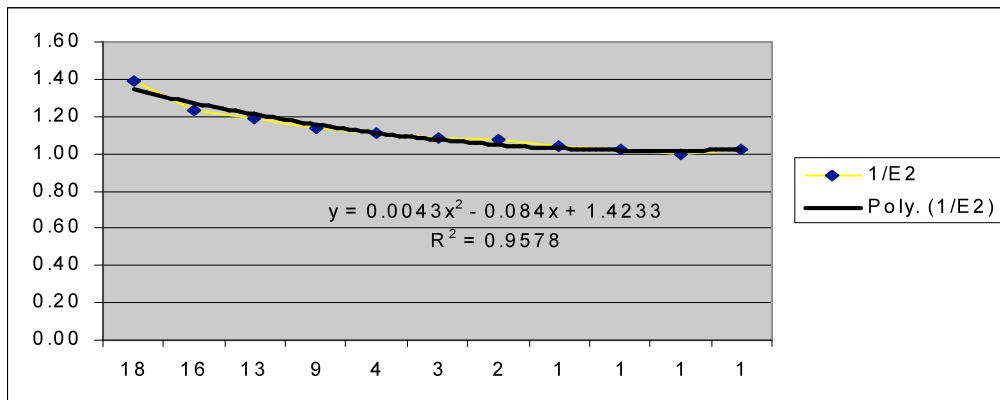


Figure 10 – Curve fit of $1/E2$ as a function of Element ratios .

Finally, for any four-element dosimeter readout, the true deep-dose response can be calculated as a function of $E2^*$ ($0.0043x^2 - 0.084x + 1.4233$) (example only).

The energy approximation can also be obtained from the same $E3/E2$ ratio.

5. Dosimeter Construction.

To eliminate human errors in handling at the dosimetry laboratory and wearing, Panasonic designed an element card that is permanently encapsulated. This has the following advantages:

- The dosimeter is extremely robust inside and outside its wearing holder and can be mailed/handled securely.
- The dosimeters built-in filters eliminate most shielding variations experienced in the other forms using holders with metal shields.
- The dosimeter lends itself to automatic packing/wrapping or any form of simple plastic holder.

Finally, the dosimeter has a unilateral construction - front and back (Figure 11).

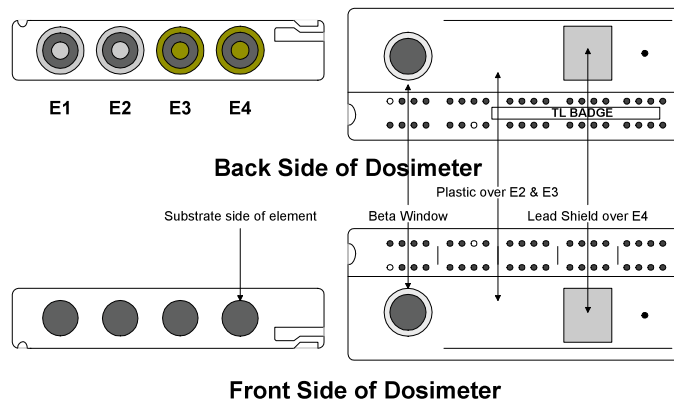


Figure 11 – Dosimeter construction

It should be noted that Element 1 ($\text{Li}_2\text{B}_4\text{O}_7:\text{Cu}$) is attenuated by only 14 mg/cm^2 plastic whilst the actual phosphor layer itself of $\sim 90\mu\text{m}$, rendering it almost ideal for superficial dose measurement.

6. General Characteristics

Response stability:

Under normal operating conditions, the UD-802A dosimeter shows a very stable dose response for more than 1,000 cycles of exposure readings – ideal for correction factor application.

Reproducibility: $\text{Li}_2\text{B}_4\text{O}_7:\text{Cu} \pm 5\%$
 $\text{CaSO}_4:\text{Tm} \pm 2.5\%$

Fading: <5%/year (corrected)

Angular dependence: The UD-802A will have some dependency on the construction of the holder, but for the standard Panasonic holder UD-874ATM at 0 – 60° irradiation to the following energies:

75keV Element 2 : 1.0 to 1.10. Element 4 : 1.0 to 1.20

^{60}Co Element 2 : 1.0 to 1.05 . Element 4 : 1.0 to 1.10

The high over-response at 60° to 75keV on Element 4 is a function of some secondary-electron activity of the Pb-filter and it is used to advantage in algorithms to detect angular irregularities.

Detectable Dose: 0.01mSv with 95% confidence

Dose Confirmation: Four glowcurves per dosimeter – each glowcurve counts digitally sampled at 22msec intervals.

7. Readers

The optical heating system described in Section 1 has been installed in a variety of readers such as:

UD-716AGL Desktop reader

UD-7900M Automatic reader

The most advanced TLD reader for large scale processing is the UD-7900M.

Figure 12 – UD-7900M Automatic TLD Reader.



Additionally, an automatic irradiator UD-794D based on the UD-7900M mechanics and utilizing a 74GBq source is available with a 500 dosimeter loading. A custom designed shield and shutter reduces the background radiation to levels generally acceptable to an office environment use. The user can program one irradiation across all dosimeters or store profiles for a different irradiation for every dosimeter.

8. Manufacturing

The dosimeters are irradiated with a ^{137}Cs source and the responses are calculated by comparing the irradiated value and read value from a TLD Reader standardized with reserved calibration TLDs. The dosimeters are ranked according to the response of each element (Q, R and S-codes) and then selected according to the standard deviation of each individual element compared to the mean response for that same element (Q and R-codes) in order to unify their sensitivities. Only T-codes are not ranked but selected according to the response.

All Dosimeters have sequential seven-digit ID Codes specified by the user when ordered.

Panasonic dosimeters are delivered and stored in magazines holding 50 dosimeters at a time. The magazine slots are keyed for correct dosimeter insertion. The magazines are inserted into the TLD readers for processing.

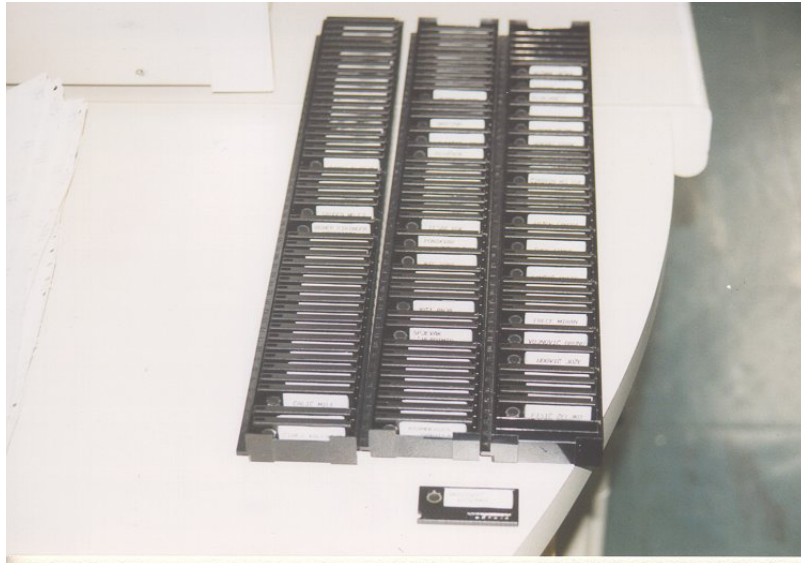


Figure 13 –Dosimeter Magazines

9. References

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