Dosimeters

Depending on the option selected, the Model 6600 is capable of reading EXTRAD (Chipstrates) and DXTRAD (Ringlets) Extremity Dosimeters, as well as Whole Body and Environmental TLD Cards. This section describes each of these types of dosimeters.

Whole Body and Environmental Dosimeters

Whole Body and Environmental Dosimeter Assemblies consist of two parts, a TLD Card and a Holder. The TLD card consists of four TL hot-pressed chips mounted between two PTFE sheets or mounted on Kapton[Kapton] on an aluminum substrate, identified by a peelable label with an ID Number appearing in both numeric and barcode formats. One corner of the card is notched to insure proper insertion into the holder and correct orientation when being read in the Card Reader. The aluminum substrate can be color anodized for identification. A typical card is shown in Figure 1.2.

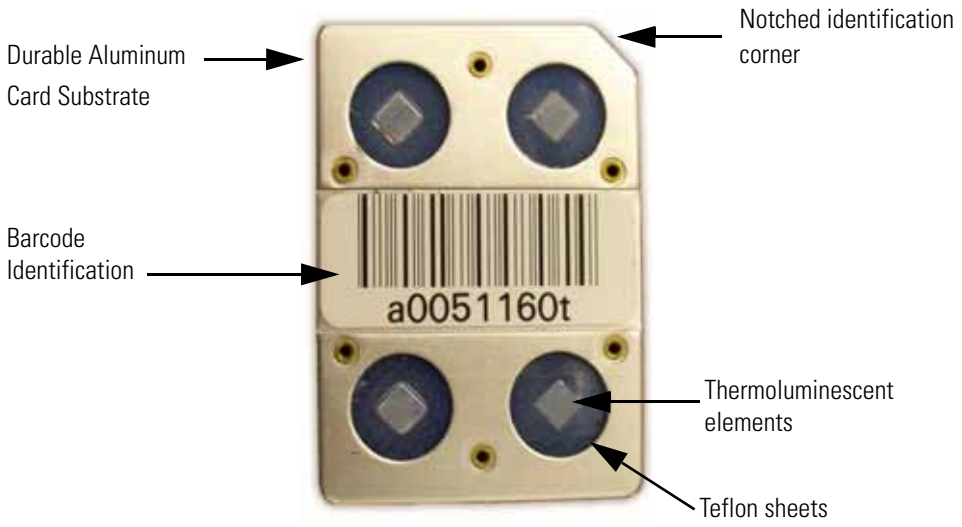

Figure 1.2. Typical TLD Card

While the basic Dosimeter Assembly design is standardized, the filtration media and thickness and the TL chips can be specifically selected from a variety of materials to provide measurement of a wide range of radiation types and energies. The readings can then be processed by a Dose computation algorithm for an accurate measurement of dose equivalence.

The Holder protects the card from environmental damage and retains the filtration media that attenuate the various radiation types to provide selective entrapment in the TL material. This difference in radiation absorption allows determination of Shallow, Deep, and Lens of the Eye doses as well as some energy discrimination.

The TLD Card Holder (Figure 1.3) is made of durable, tissue-equivalent, ABS plastic, and is gasketted and sealed to retain the card in a light and moisture excluding environment.

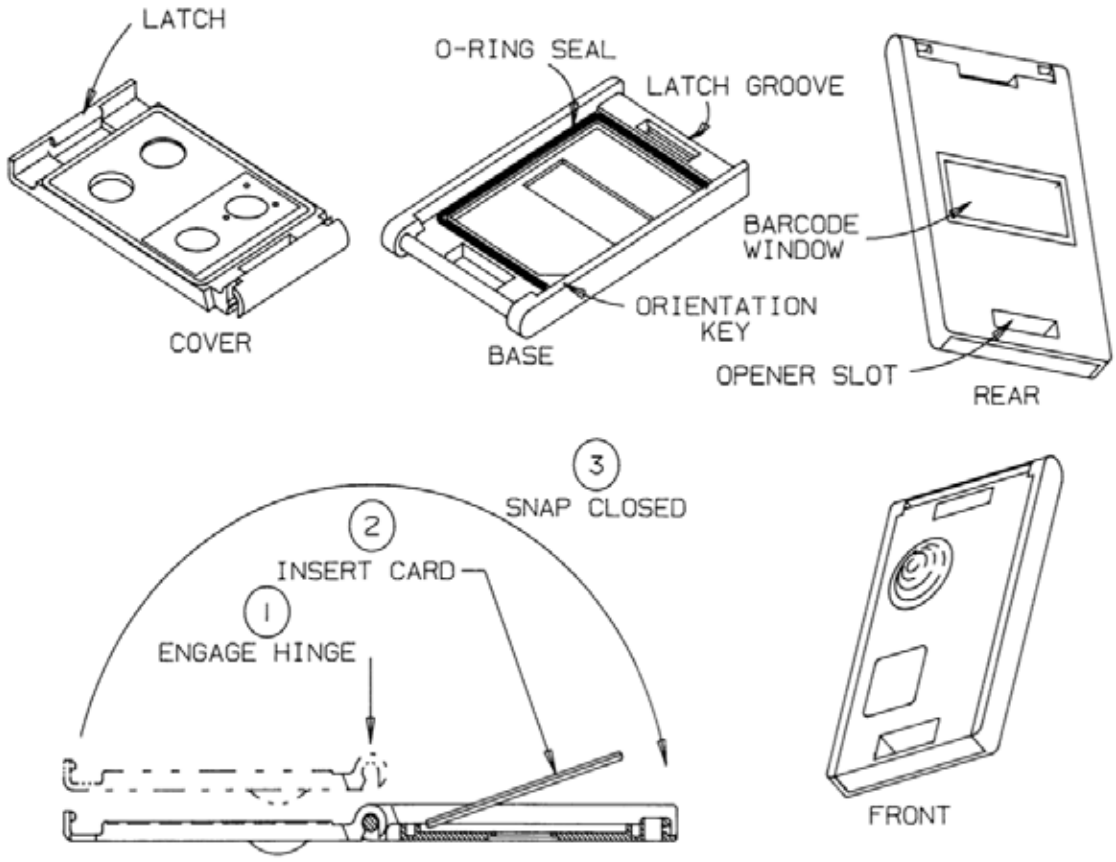

Figure 1.3. Typical TLD Card Holder

The design is tamper-resistant and tamper-evident, yet is opened quickly and easily by means of a manual Holder Opener or by an Automatic Holder Opener. The front and back halves may be either hinged or hooked together. The card cavity contains an orientation notch so that a card cannot be inserted incorrectly.

Body attachment can be by belt loop or by clip, and it can be worn as part of a typical Employee Identification Badge. Holders can be color coded by means of an optional silk screen process in one area; ten colors are available.

The Manual Holder Opener (Figure 1.4) is a small, hand-held device that the operator inserts into the open end of the holder and with mild thumb pressure on the button releases the latch and opens the holder.

Figure 1.4. Manual Holder Opener

The Automatic Holder Opener is a small, rectangular, bench-top instrument. When the operator inserts the latch-end of the holder into an opening on the front, the opener automatically senses the presence of the holder and moves a plunger into place to exert pressure on the latch and open it. The TL card then drops into a chute for operator retrieval.

Personnel Dosimeter

A typical Personnel dosimeter holds two to four TL elements encapsulated between two sheets of Teflon 0.0025 inches (10 mg/cm^2) thick and mounted on an aluminum substrate.

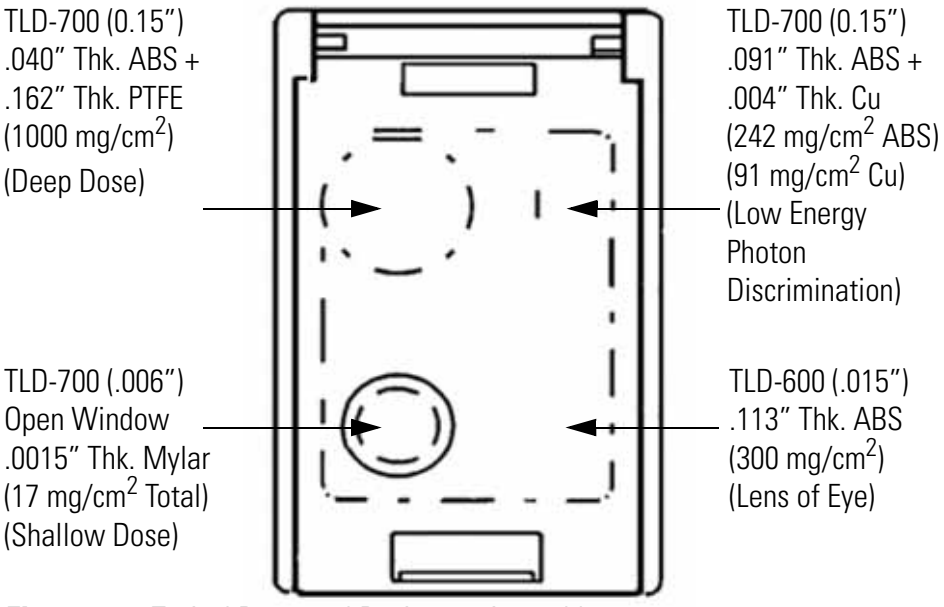

Figure 1.5. Typical Personnel Dosimeter Assembly

Figure 1.5 shows a popular Personnel Dosimeter Assembly, which is a combination of 8814 Holder and TLD-7776 card. Three of the elements are fabricated from TLD-700 in either of two thicknesses: 0.15 mm (0.006") or 0.38 mm (0.015"), and one from TLD-600, 0.38 mm (0.015") thick.

Each element/filter combination performs a specific function, as follows:

- The TLD-700 element in position 1 is 0.38 mm thick, covered with 242 mg/cm^2 ABS plastic and 91 mg/cm^2 copper filtration. It is used for low energy photon discrimination and measurement of the dose equivalent Hp (3), (the dose equivalent of the eye).

- The TLD-700 element in position 2 is 0.38 mm thick, with 1000 mg/cm^2 combined PTFE/ABS filtration (107 mg/cm^2 ABS + 893 mg/cm^2 PTFE filters). It measures the Hp(10), (deep dose).

- The thinner TLD-700 element in position 3 is 0.15 mm thick, with 0.06 mm aluminized Mylar filtration. It determines the Hp (0.07), (shallow dose.) The total filtration for this element, combining the PTFE card encapsulation and the aluminized Mylar filter, is 17 mg/cm^2.

- The TLD-600 element in position 4 is 0.38 mm thick, with 300 mg/cm^2 ABS plastic filtration. It measures the Hp (10) (lens of the eye) and neutron dose.

Environmental TL Dosimeter
Like the Personnel Dosimeter, the commonly used Environmental Dosimeter card can be made with two to four TL elements. It consists of either a type 8855 or type 8858 TLD Dosimeter Holder with either TLD-100H or TLD-700H material. All TL elements (chips) are fabricated from (^{7}LiF:Mg,Cu,P). They are 0.388 mm (0.015 inch) thick and 3.6 mm (0.142 inch) diameter.

EXTRAD Extremity Dosimeters

A complete extremity dosimeter, EXTRAD, features the following components:

- Detector/TL element
- Shield/filter
- Identification
- Attachment device

A Chipstrate (Figure 1.6) consists of a Kapton® base with a TL element (in the form of chip or powder) and a barcode ID bonded to it. The TL elements used in the Extremity Dosimeters are the same as those used in the Personnel dosimeters, enabling Photon, Beta, or Neutron measurement.

Figure 1.6. Common EXTRAD Extremity Dosimeter

The TL elements are either LiF:Mg,Ti (TLD-100, TLD-600 or TLD-700) or CaF^2:Mn (TLD-400) hot-pressed chips of various thicknesses (depending on the particular dosimeter type). All elements are mounted on an inert substrate (Kapton® base) for mechanical support.

The Chipstrate is then inserted into a pouch with or without filter and then sealed, which is then attached to a devise that attaches to personnel.

Reading Chipstrates

To read Chipstrates, first insert up to two of them into a carrier (Figure 1.7) that has the same general configuration as a standard TLD card. The Reader then can read the Chipstrates, along with the Chipstrate IDs and carrier ID. WinREMS SQL automatically associates dose information from each Chipstrate with its ID.

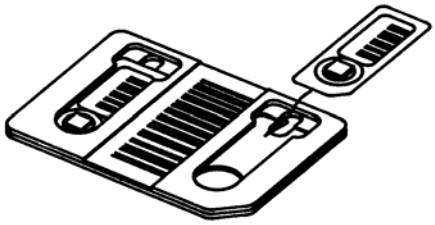

Figure 1.7. EXTRAD Carrier Card

The TL elements used in EXTRADs are identical to those used in personnel dosimeters. This enables photon, beta, and perhaps neutron measurement. One pouch can carry up to two Chipstrates throughout a monitoring period to obtain multiple types of radiation measurement.

Thermo Fisher Scientific uses a proprietary bonding method the attach TL elements to the substrate. To assure full integrity of the bonding process, samples were tested for hundreds of reader-reuses under normal laboratory conditions.

Unlike a standard TLD card, the TLD detector (element) is not covered by Teflon film. This reduces the shielding to reach an ideal filtration of 5-10 mg/cm^2 for a difficult beta monitoring. The proprietary bonding process eliminates the need for Teflon encapsulation.

Body Attachment

Before issuing Chipstrates to the wearer, place the selected quantity of one or two in a plastic pouch or finger stall, which is then hermetically heat-sealed for environmental protection. The pouches feature slots for inserting adjustable-length straps (Figure 1.8) to fit comfortably around fingers or other body parts.

Users can barcode pouches, or may have clear plastic on one side to facilitate barcode-reading before removal. When a field assignment cycle completes, pouches are cut and discarded, and Chipstrates are extracted for insertion into carrier cards. The bands can be saved for reuse.

EXTRAD Carrier Cards

EXTRAD Carrier Cards (Figure 1.7) each hold up to two Chipstrates to enable processing in the Model 6600 PLUS hot gas TLD Readers. Carrier Cards feature the same configuration as Whole Body Dosimeter Cards. This design uniformity enables one Reader to read both Chipstrates and 8800 Series Cards. Operators can insert and remove Chipstrates using ordinary tweezers.

DXTRAD Extremity Dosimeters

The DXTRAD Extremity Dosimeter, as shown in Figure 1.8, is another type of Extremity Dosimeter available with this system. A TLD element (chip or powder) is bonded to Kapton film, and a flat ring bonds to the DuPont™ Kapton® surrounding the TL detector. The flat ring is marked with a unique 5-digit identification number, visible in both barcode and numeric format. This forms a Ringlet assembly. A plastic cap, pressed into the recess, hermetically seals the TL chip and provides 2X magnification to aid in reading the Ringlet ID. The complete assembly is referred as DXTRAD.

In this application, typical TLD elements include 0.015" thick TLD-100 chips and TLD-700H bonded powder. Others are available.

The finger ring band is made of durable, low density polypropylene plastic and is adjustable to fit finger sizes from 16 to 28 mm in diameter. It is available in a variety of colors to identify different body areas or monitoring periods. A manual fixture is designed to insert and remove the ringlet and cap. The completed assembly may be sterilized using hot (up to 120° C steam) or cold procedures.

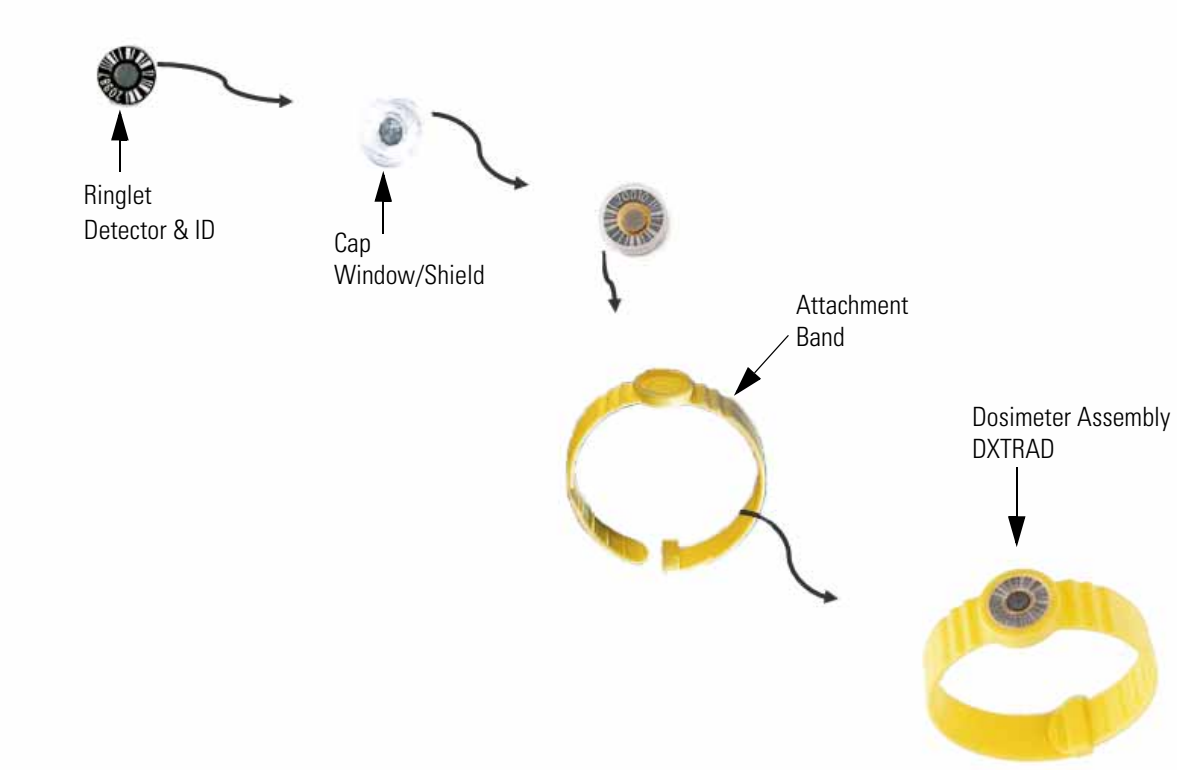

Figure 1.8. Common DXTRAD Extremity Dosimeter

DXTRAD Carrier Cards

DXTRAD Carrier Cards (Figure 1.9) each hold up to four Ringlets to enable processing in the Model 6600 PLUS hot gas TLD Readers. Carrier Cards feature the same configuration as Personnel Dosimeter Cards. This design uniformity enables one Reader to read both Ringlets and 8800 Series Cards.

Figure 1.9. DXTRAD Carrier Card (one element using position 2)

Instrument Performance Specifications

Dynamic Range:

- Seven decades.

Reference Light stability (short term):

- Less than 1.01.0% variation (based on 1 standard deviation of 10 consecutive readings).

TTP reproducibility:

- ±1° C.

High Voltage stability (short term):

- ±0.005%.

Linearity:

- Less than 1% deviation.

Dark Current (background noise):

- Less than 1 µGy ^{137}Cs equivalent dark current.
- Stability better than 1.0 µGy (based on 1 standard deviation of 10 consecutive measurements).

Warm-up time:

- 20 minutes.

Throughput (with standard heating profile):

- TLD Cards: 70140 per hour
- Chipstrates: 140280 per hour
- Ringlets: 280560 per hour

TTP capabilities:

- Preheat temperature: 20° C to 200° C
- Preheat time: 0 to 218 sec.
- Acquisition time: 10 to 300 sec.
- Temperature rate: 1 to 30° C/sec.
- Acquisition temperature: up to 300° C (option to 400° C)
- Post-read anneal temperature: to 400° C
- Post-read anneal time: 0 to 218 sec.

Dosimetric Performance Specifications

The following performance characteristics have been experimentally determined using both Harshaw TLD standard LiF:Mg,Ti and LiF:Mg,Cu,P cards and the standard TTPs at normal laboratory conditions.

Radiation types and energies:

- Photon: Greater than 10 keV
- Neutron: Thermal to 100 MeV
- Beta: Greater than 200 keV

Linear Measurement range:

- LiF:Mg,Ti

  10 μGy (1 mrad) to 1 Gy (100 rad)

- LiF:Mg,Cu,P

  5 μGy (0.5 mrad) to 20 Gy (2000 rad)

Supralinear Measurement range:

- LiF:Mg,Ti

  1 Gy (100 rad) to100,000 Gy (2,000 rad)

Tissue equivalence:

- Nearly tissue equivalent

Fading (using total integral):

- LiF:Mg,Ti - Without thermal treatments or fading correction: less than 20% in 3 months.
- With fading correction algorithm, glow curve batch deconvolution, or application of preheat:

  less than 5% in 3 months.

- LiF:Mg,Cu,P - No fade using the recommended preheat TTP.

Repeatability:

- Less than 2% variation (based on one standard deviation for 10 sequential measurements at 1 mGy (100 mrad) ^{137}Cs).

Minimum detectability:

- For LiF:Mg,Ti, less than 10 µGy (1 mrad) based on 2.26 x a 95% confidence of 10 repeated evaluations of an unexposed dosimeter).
- For LiF:Mg,Cu,P, less than 5 uGy (0.5 mrad) based on 2.26 x a 95% confidence of 10 repeated evaluations of an unexposed dosimeter).