EPD/HB/40521/000

EPD MK2

Beta/Gamma Sensitive
Electronic Personal Dosemeter

Technical Manual

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Thermo Electron Corporation
Sopers Lane, Poole, Dorset BH17 7ER. England.
Tel:01202 782740 Fax: 01202 782056

MANUFACTURERS DETAILS

Manufacturer's Address

Thermo Electron Corporation
Environmental Instruments Division
Radiation Measurement & Protection
Sopers Lane
Poole
Dorset
United Kingdom
BH17 7ER

e-mail: service.epd.uk@thermo.com

Tel. (01202) 782740
Fax. (01202) 782056

USA Sales Office

Thermo Electron Corporation
Environmental Instruments Division
Radiation Measurement & Protection
105C Hembree Park Drive
Roswell
Georgia 30076
U.S.A.

e-mail: epdsupport.rmp@thermo.com

Tel. 770 521 4500
Fax. 770 521 4535

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CONTENTS

Page

CONTENTS

CONTENTS

GLOSSARY

/h	Per hour
°C	Degrees Celsius
ADS	Approved Dosimetry Service (or System)
CRC	Cyclic Redundancy Check. Error checking code.
dB(A)	Decibels - 'A' weighted scale (sound intensity)
DC	Direct Current
DDE	Deep Dose Equivalent (alternative nomenclature for $H_p(10)$)
Dose	The accumulated dose to which alarm thresholds apply, intended for tactical dose monitoring (eg. per day, per week, per shift etc)
Double-press	Pressing the button twice in quick succession
EEPROM	Electrically Erasable Programmable Read Only Memory
EPD	Electronic Personal Dosemeter
EPDS	Electronic Personal Dosimetry System
eV	Electron Volt
Gy	Gray, SI unit of dose
HEX	Hexadecimal
$H^{\underline{10}}$	EPD LCD nomenclature for personal dose (Hp(10))
$H^{\underline{07}}$	EPD LCD nomenclature for personal dose (Hp(0.07))
$H^{\underline{10}}$/h	EPD LCD nomenclature for dose rate (Hp(10)/h)
$H^{\underline{07}}$/h	EPD LCD nomenclature for dose rate (Hp(0.07)/h)
Hp(10)	Personal dose equivalent at a depth of 10mm of tissue ('penetrating', 'deep' or 'whole body' dose).
$H_p(0.07)$	Personal dose equivalent at a depth of 0.07 mm of tissue ('superficial', 'shallow' or 'skin' dose).
Hp(10)/h	Hp(10) dose rate
$H_p(0.07)$/h	Hp(0.07) dose rate
ICRU	International Commission on Radiation Units
ID	Identification
IR	Infra-red
IrDA	Infra-red Data Association
keV	Kilo Electron Volt
LCD	Liquid Crystal Display
LED	Light Emitting Diode
Long Press	Pressing and holding the button
LTC	Lithium Thionyl Chloride (Sulphurous Oxychloride, $SOCl_2$)
MeV	Mega Electron Volt
m	metre/milli
mm	millimetre
nm	nanometre
NRPB	National Radiological Protection Board - the statutory authority for radiological protection in the UK
PCB	Printed Circuit Board

Glossary (continued)

PTB	The Physikalisch-Technische Bundesanstalt, Braunschweig and Berlin. The national institute of natural and engineering sciences and the highest technical authority for metrology and physical safety engineering of the Federal Republic of Germany.
SDE	Shallow Dose Equivalent (alternative nomenclature for $H_p(0.07)$)
ppm	Parts per million
RAM	Random Access Memory
rem	A unit of dose equivalent, equal to 10mSv
RFI	Radio Frequency Interference
Short-press	A short press and release of the button
Sv	Sievert, SI unit of dose equivalent
T	Tesla
TLD	Thermoluminescent Dosemeter
Total Dose	Intended to be a secure record of the total accumulated dose received since Dosemeter issue - alarms do not apply to total dose.
User ID	A numeric code of up to 12 digits that may be written to the EPD to define the current user or wearer. By convention a value of FFFFFFFFFFFF is written to EPDs not currently issued to a wearer.
User Name	A character string of up to 22 characters that may be written to the EPD and used as a second or supplementary Wearer Identity (Supplementary to user ID).
Wearer ID	Alternative terminology for the User ID.
Wearer Name	Alternative terminology for the User Name.

WARNINGS

Radioactive Contamination

DURING OPERATIONAL USE THE EPD MAY BECOME EXPOSED TO RADIOACTIVE CONTAMINATION. THE EPD MUST BE SUBJECT TO ALL RELEVANT DECONTAMINATION PROCEDURES LAID DOWN BY THE RADIOLOGICAL PROTECTION AUTHORITY.

Lithium Thionyl Chloride Batteries

LITHIUM THIONYL CHLORIDE* (LTC) BATTERIES ARE POTENTIALLY DANGEROUS. THEY MAY LEAK TOXIC SUBSTANCES THAT CAN BE HARMFUL. READ AND TAKE NOTE OF THE MANUFACTURERS WARNINGS ON THE BATTERY CASE. READ ALSO THE DETAILED LTC BATTERY WARNINGS IN THIS HANDBOOK.

* Sulphurous Oxychloride, $SOCL_2$

Cautions

EPD batteries

Batteries are susceptible to fire and abuse. Some manufacturers provide batteries with a safety vent, which allows a controlled release of electrolyte if fire and abuse conditions prevail. If the EPD has been damaged in a manner that could affect the battery, care must be exercised during battery removal. The battery may have vented into the EPD case and caused the EPD to become pressurised.

EPD Battery Cap

Take care when removing the EPD battery cap, the battery cap may spring free with unexpected force.

SECTION 1

INTRODUCTION

This handbook is for the Thermo Electron Corporation Electronic Personal Dosemeter (EPD), Beat/Gamma variant, Mks 2.0, 2.1, 2.2 & 2.3. The EPD Mk2 family is lighter and slimmer than the original Mk1 EPD and has new micro-circuitry, case design and software. The Mk2 EPDs also have a number of enhanced dosimetry features and user functions. To simplify nomenclature the term EPD has been used throughout this handbook and should be read to signify the EPD Mk2 Beta/Gamma dosemeter.

1.1 General

The EPD is a personal radiation monitor that detects and measures beta and gamma radiation. Radiation that is detected by the EPD is processed to give an indication of penetrating dose, superficial dose and the dose rates. This information is displayed to the user via an LCD display on the top of the EPD.

The EPD contains three silicon diode detectors. Each detector feeds a chain of dedicated amplifiers and counter circuits to measure soft gamma, hard gamma and beta radiation. The outputs from each detector chain are processed to calculate and display penetrating and superficial dose and dose rate. Other functions include: EEPROM storage of detected radiation, annunciation of alarm conditions (LED and sounder), Infra-red (IR) communication and a user interface comprising an LCD display and button. Each of the above functions is described in detail in this handbook.

The EPD has a rich feature set which can be configured to the users requirements over the IR communication link using suitable software such as EasyEPD2. These configuration options are explained in this handbook but the user is also referred to the EasyEPD2 User Manual which describes the parameters in more detail and how they are accessed. Note that a few parameters are accessible only by the manufacturer and must be determined before delivery takes place (calibration lock and PTB Approval are examples). These manufacturer settings may constrain what the end user can configure in the EPD, see section 4.5.2.

1.2 EPD Major Characteristics

Major Characteristics relating to the EPD are listed in Table 1.1.

Table 1.1 - EPD Major Characteristics

Item	Characteristic
Power	One AA battery, either a standard Alkaline (1.5 V) battery or high energy Lithium Thionyl Chloride (LTC) (3.6 V).
Weight	95 gms (including LTC battery and clip).
Dimensions	86 x 62 x 18.5 mm (excluding clip).
Alarm sounder	98 - 101 dB on loud 4kHz setting. Quiet and 2 kHz settings available. Dose-chirp function on Hp(10) dose.

The EPD also has the following major features:

- Improved immunity to radio frequency interference (RFI).
- Display Backlight.
- EPD communication via an infra-red interface up to a range of approximately 1 metre.
- Improved dose profile facility.
- Real-time dose chirp (adjustable).
- Password protected dose store for ADS functions.
- Extended systems integration facilities.
- Count down timer and alarm.

Appendix C is a summary of the general physical & functional characteristics of the EPD.

1.3 Brief Functional Description

The EPD is a highly sophisticated device sensitive to gamma and X-rays (photons), and beta radiation (energetic electrons) in the following energy range:

gamma, X-rays : 15 keV to 10 MeV

Beta radiation: 250 keV to 1.5 MeV (mean energy)

A full list of radiological characteristics and specifications can be found in Appendix A to this Handbook.

Radiation detected by the three silicon diode detectors is combined to give the following dose equivalents (as defined by ICRU Document 47):

(i) Hp(10) personal dose equivalent at a depth of 10mm of tissue ('penetrating', 'deep' or 'whole body' dose).

(ii) $H_p(0.07)$ personal dose equivalent at a depth of 0.07 mm of tissue ('superficial', 'shallow' or 'skin' dose).

The EPD calculates both the accumulated dose and the dose rate for Hp(10) and Hp(0.07). These, and other data, are stored in an internal store (EEPROM) within the EPD. A button in the EPD case allows the user to retrieve this data from store, select a range of displays, acknowledge alarms and perform user control functions. Data is displayed to the user on a LCD display on the top of the EPD (see Figure 2.1). To minimise the loss of data from battery or other failure, data is saved to secure memory within the EPD every 15 minutes.

Data is written to and read from the EPD via an integral infra-red communications interface. The Thermo supplied ***EasyEPD2*** program reads and writes data to the EPD via the Infra-red communications link and displays the data in a PC window. Thermo also produces a range of Access Control Systems for use with the EPD.

Dose is accumulated separately in the EPD in three stores: ***Dose***, ***Total Dose*** and ***ADS Dose***. The use of several stores allows dose to be recorded over differing periods, for example the ***Dose*** store may be used for each job or task performed (and reset after each), whilst the ***Total Dose*** records the total or aggregate dose from all the jobs or tasks performed. **ADS Dose** is a password-protected dose store intended for 'legal dosimetry' applications. Note that audible alarms are given if either the accumulated dose or dose rates exceed programmable threshold levels. Dose alarms are raised against the ***Dose*** store only.

The EPD is a sealed unit and is splash-proof. The unit will withstand short periods of immersion in water but is not designed for prolonged immersion under pressure. General maintenance is confined to:

- Removing/replacing the EPD battery,
- Removing/replacing the EPD clip assembly,
- Clearing fault conditions (where possible),
- Checking the functionality and calibration of the EPD,
- Keeping the unit clean.

Note:

1. This manual deals with Sieverts (Sv) throughout. To convert to rem multiply all values by 100.

SECTION 2

GETTING STARTED

This section describes the general procedures that must be carried out to ensure that the EPD is set-up correctly and is functionally operational.

2.1 Setting-up

The EPD requires very little setting-up. Setting-up is primarily confined to:

1. Unpacking the EPD,
2. Inserting the battery,
3. Checking the initialisation sequence,
4. Checking the default settings,
5. Performing a confidence test.

A general view of the EPD is shown in Figure 2.1. External features are described in Table 2.1.

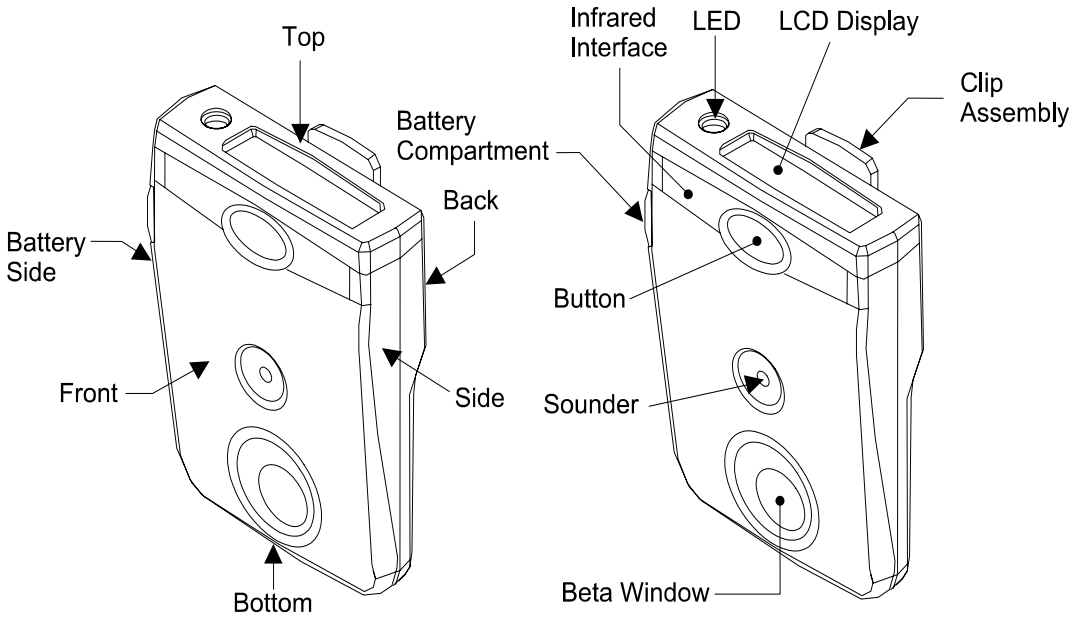


Figure 2.1 - External View Of The EPD

Feature	Description

Battery Compartment	Houses an Alkaline AA battery (1.5 V) or a Lithium Thionyl Chloride (LTC) AA battery (3.6 V).
Infra-red Interface	Infra-red communications interface to the EPD.
Button	User interface for EPD control, alarm acknowledgement and LCD display selection.
Sounder	Provides an audible indication of an EPD alarm.
Beta Window	Allows beta particles to pass through the case to the Beta detector.
LCD Display	Displays EPD parameters and/or functionality as selected by the button.
Alarm LED	Provides a visual indication of an EPD alarm.
Clip Assembly	Provides a means of attaching the EPD to clothing, or for attaching a lanyard as an alternative means of wearing the EPD.

Table 2.1 - EPD External Features

2.1.1 Unpacking The EPD

There are no special unpacking instructions. Depending on customer requirements the EPD may, or may not, be shipped with a battery and/or a clip assembly. Alternatively, the EPD may be shipped with just a lanyard plate and lanyard (see Section 6.3). The battery, if supplied, may be a LTC or Alkaline type.

2.1.2 The EPD Battery

WARNING

LITHIUM THIONYL CHLORIDE* (LTC) BATTERIES ARE POTENTIALLY DANGEROUS. THEY MAY LEAK TOXIC SUBSTANCES THAT CAN BE HARMFUL. READ AND TAKE NOTE OF THE MANUFACTURER'S WARNINGS ON THE BATTERY CASE. READ ALSO THE DETAILED LTC BATTERY WARNINGS ON PAGE 6.2 OF THIS HANDBOOK.

* Sulphurous Oxychloride, $SOCl_2$)

General Precautions and Instructions

Always fit new undamaged batteries of the correct type (see section 6.2). A time interval of at least 10 seconds must elapse between removal and replacement of the EPD battery (this allows the internal circuits of the EPD to power-down).

The EPD is fitted with either a security-type (tamper-proof) battery cap or a coin-release battery cap, depending on customer requirements (see Figure 2.2). The security-type battery cap restricts unauthorised removal of the cap and requires a special tool. The coin type battery cap should be rotated using a small coin circa 20 mm diameter and 2 mm thick.

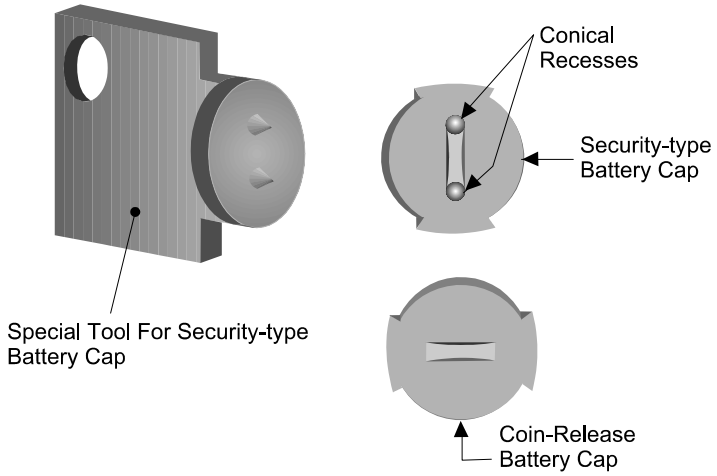


Figure 2.2 - Battery Cap Types and Special Tool

The battery cap also provides the return path for the EPD's power supply.
Therefore, during fitment of either type of battery cap the EPD will begin its start-up sequence (see Section 2.1.3). If the battery cap is not fitted cleanly and contact is temporarily broken, the software initialisation process may not be successful. Under these circumstances it is essential that the battery cap is removed and that a time interval of at least 10 seconds elapses before any attempt is made to refit the battery cap.

Inserting/Replacing The EPD Battery

Caution:
Take care when removing the EPD battery cap, the cap may spring free with unexpected force.

To set up the EPD for operational use the battery must be inserted/replaced in accordance with the following procedure:

(i) Read and observe the General Precautions and Instructions at the beginning of this section. If necessary remove the battery cap from the case as described in (ii) and (iii) below.

(ii) If the battery cap is of the ***security type***, locate the two pips of the special tool into the two conical recesses in the battery cap. If the battery cap is of the ***coin type***, locate the coin in the groove in the battery cap.

(iii) Maintain steady pressure on the special tool or coin so as to keep it fully engaged in the battery cap and rotate the battery cap through approximately 85° in a counter-clockwise direction (to remove cap, see Figure 2.3). If a battery is already fitted, the cap will normally release from the case under the action of the battery cap compression spring.

Note: Do not attempt to rotate the cap beyond the design point (approximately 85 degrees) or beyond the point where the resistance of the end-stop is felt.

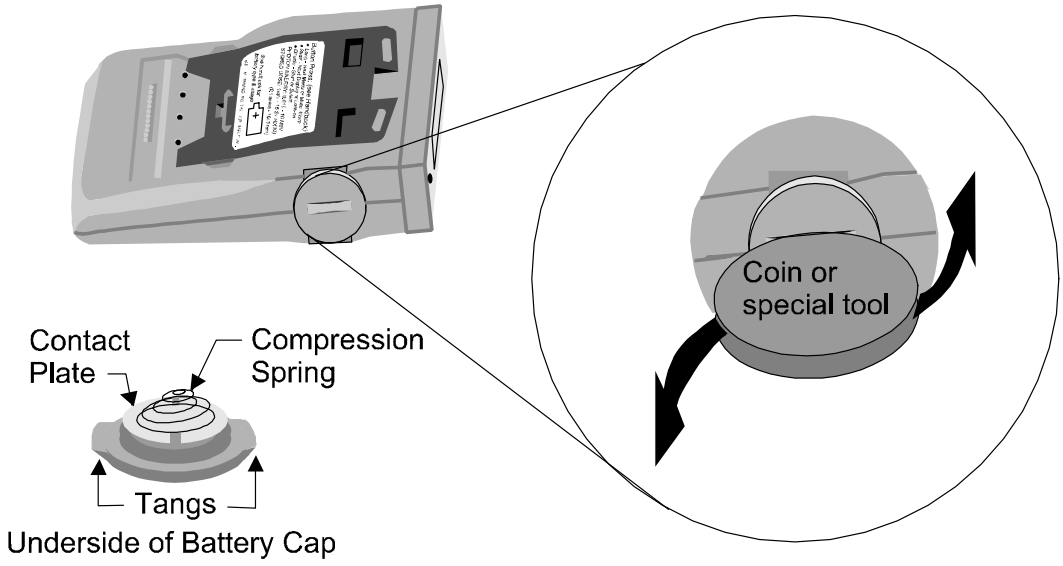


Figure 2.3 - Battery Cap Removal

(iv) Remove the existing battery (if fitted). Insert a new (or replacement) battery into the battery compartment as shown in Figure 2.4.

Note: The battery must be inserted anode (+) first.

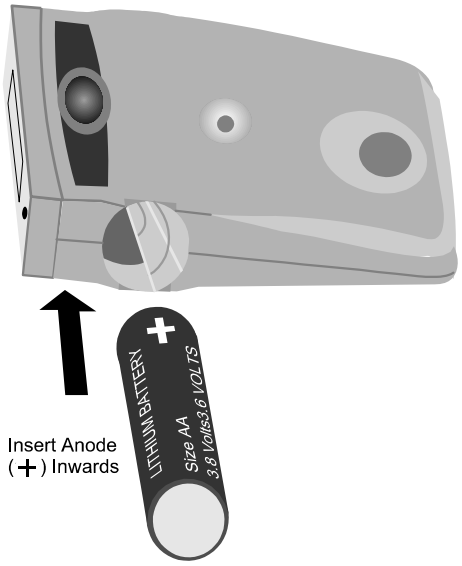


Figure 2.4 - Inserting The EPD Battery

(v) To fit the battery cap, first locate it against the special tool or coin, as appropriate) and align the battery cap tangs with the recesses in the EPD body. Push the battery cap into the battery compartment opening, ensuring that:

a) the body of the battery cap, which houses the (-) electrode contact plate, is fully engaged within the battery compartment,

b) the cap sits flush with the body of the EPD.

(vi) Using the special tool or coin, as required, maintain pressure on the battery cap (against its compression spring), and rotate the battery cap in a clockwise direction, through approximately 85°, to its end-stop. Rotate the cap slowly to the point where the resistance of the end stop is felt. Avoid use of excessive force.

2.1.3 Start-up Sequence

When a battery is inserted into the EPD, fitment of the battery cap will automatically initiate the start-up sequence. The start-up sequence is as follows:

1. '8888' is shown on the display for approximately three seconds;

2. internal software initialisation, which checks the state of the EPD (such as the internal bus, internal memory, each detector amplifier and counter chain, etc.);

3. confidence test sequence, see section 2.1.4 below.

If the confidence tests pass, the EPD default display will appear. The EPD default display is preset at the factory to show Hp(10) (the penetrating or deep dose) or to another default display as specified by the customer.

If a fault code is displayed, or the start-up sequence repeats, try a fresh battery. If problems persist, refer to section 5.

2.1.4 EPD Confidence Test

The EPD has a built-in confidence test facility. This runs automatically at startup following battery change. When enabled, this test can also be run at any time during operational use as a check that the EPD is functioning correctly. The confidence test is selected by scrolling through the EPD LCD displays to the CONFIDENCE TEST menu (see Section 3.5.7). Throughout the confidence test the heart-beat (activity) indicator flashes once per second. The confidence test can be stopped at any time by pressing the button.

The confidence test sequence is as follows. This test sequence is automatic and should be visually confirmed as each step initiated:

1. All segments of the display are activated for approximately 5 seconds. This allows the user to check that all segments are functional (see Figure 3.2).

2. The alarm will sound and the LED will flash for approximately 2 seconds. This indicates that the sounder and LED are functional.

3. The all-segment display will disappear. The alarm will continue to sound and the LED will continue to flash, at an increased rate, for approximately 6 seconds. This indicates that all LCD segments can be turned off, and that the tone frequencies are functional.

4. The all-segment display will reappear for approximately 5 seconds and the LED will slow flash.

5. The all-segment display will disappear and the default display will appear. This indicates that the confidence test has been successfully completed and that the EPD is ready for operational use.

2.1.5 Issuing an EPD

In order to issue an EPD (i.e. assign it to a person) the EPD should be configured with a numerical User ID and optionally with a User Name. There is a similar, but separate, configuration for Approved Dosimetry Service (ADS). The User Name and numerical ID can only be configured via the IR communications link.

Controlled and ADS User IDs can be viewed via the EPD's LCD display. Detailed instructions to display User IDs are given in Section 3.5.

2.1.6 Wearing an EPD

The EPD should be worn under the direction of the health physicist. For most operating conditions it is recommended that the EPD be worn on the outside of any protective clothing (see Figure 2.5). Note that the button should be facing outwards.

Wearing the EPD on the outside of protective clothing has the major advantage that the user can read the EPD's LCD display and operate the button as required. Typically, the EPD should be worn on the chest or the waist. The type of outer protective clothing will determine how the EPD is attached (i.e. the EPD clip or lanyard). For example, if the protective clothing has no breast pocket (or the use of a belt is prohibited) the lanyard may be the most practical method of wearing the EPD.

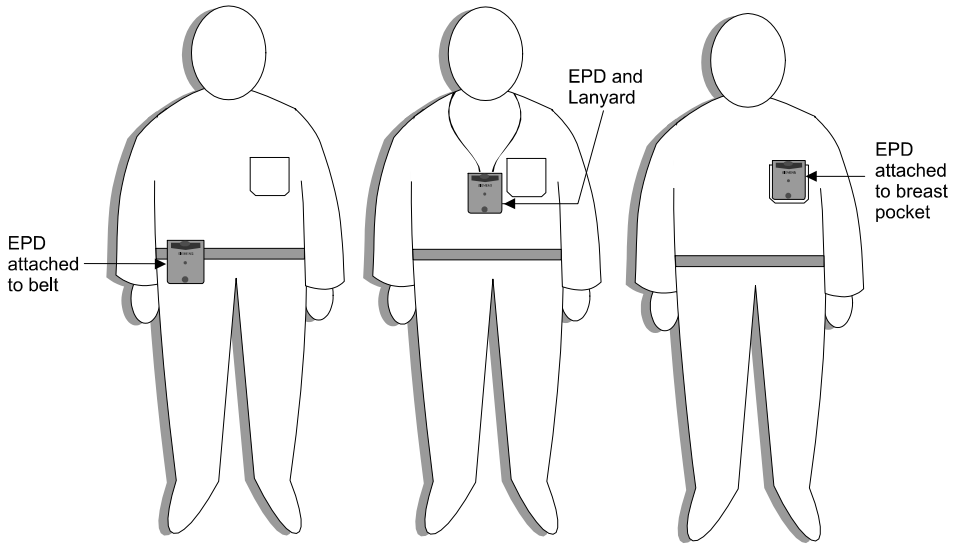


Figure 2.5 - Wearing An EPD

Note: The lanyard cannot be fitted without first removing the lanyard plate (see Section 6.3.1).

When the EPD is worn on the outside of protective clothing, to minimise the risk of contamination of the EPD, consideration should be given to wearing the EPD in a suitably-sealed plastic bag.

WARNING

DURING OPERATIONAL USE THE EPD MAY BECOME EXPOSED TO RADIOACTIVE CONTAMINATION. THE EPD MUST BE SUBJECT TO ALL RELEVANT DECONTAMINATION PROCEDURES LAID DOWN BY THE RADIOLOGICAL PROTECTION AUTHORITY.

SECTION 3

OPERATING INSTRUCTIONS

This section explains the essential functions performed by the EPD and describes operating instructions that will allow the user to display data, acknowledge alarms and operate the EPD.

3.1 LCD Display and Backlight

A custom-designed LCD display on the top of the EPD provides a visual interface for viewing dose and other EPD data. The EPD display is illustrated in Figure 3.2, which shows all segments in the on state. All segments are activated in this way temporarily during the start-up sequence, and during user initiated *Confidence Test*, (see Section 3.5.7). On completion of the start-up sequence or *Confidence Test* the default display will appear.

The default display is preset at the factory to show Hp(10) (the penetrating or deep dose), or another default display as specified by the customer. The default display can also be changed by the customer after delivery, to any display shown in Figure 3.4. Default settings and other display controls are changed using a suitable IR communications link and software (e.g. ***EasyEPD2***). For example, the display can be configured to display values in either Sieverts or rems.

The EPD is provided with many different displays in order to provide a powerful 'stand-alone' facility for users not having direct access to communications software such as ***EasyEPD2***. However for many users the sheer number of displays available may lead to confusion and Thermo has therefore provided a facility for unwanted or unnecessary displays to be disabled.

Backlight Operation

The EPD is equipped with a display backlight to enable the display to be read in the dark. The following points should be noted:

- The backlight will only function if it is enabled over the IR communications link.
- The backlight only operates for a short period after the button is pressed. This is to conserve battery life.
- When the backlight is enabled but currently off, the first short press of the button serves only to activate the backlight and does not cause a change of display selection. This may cause confusion in bright day-time conditions when the backlight effect is not apparent and the user may assume that a button press operation has somehow been 'lost'.

- The backlight activation causes a temporary alarm muting effect, see section 3.2.5.

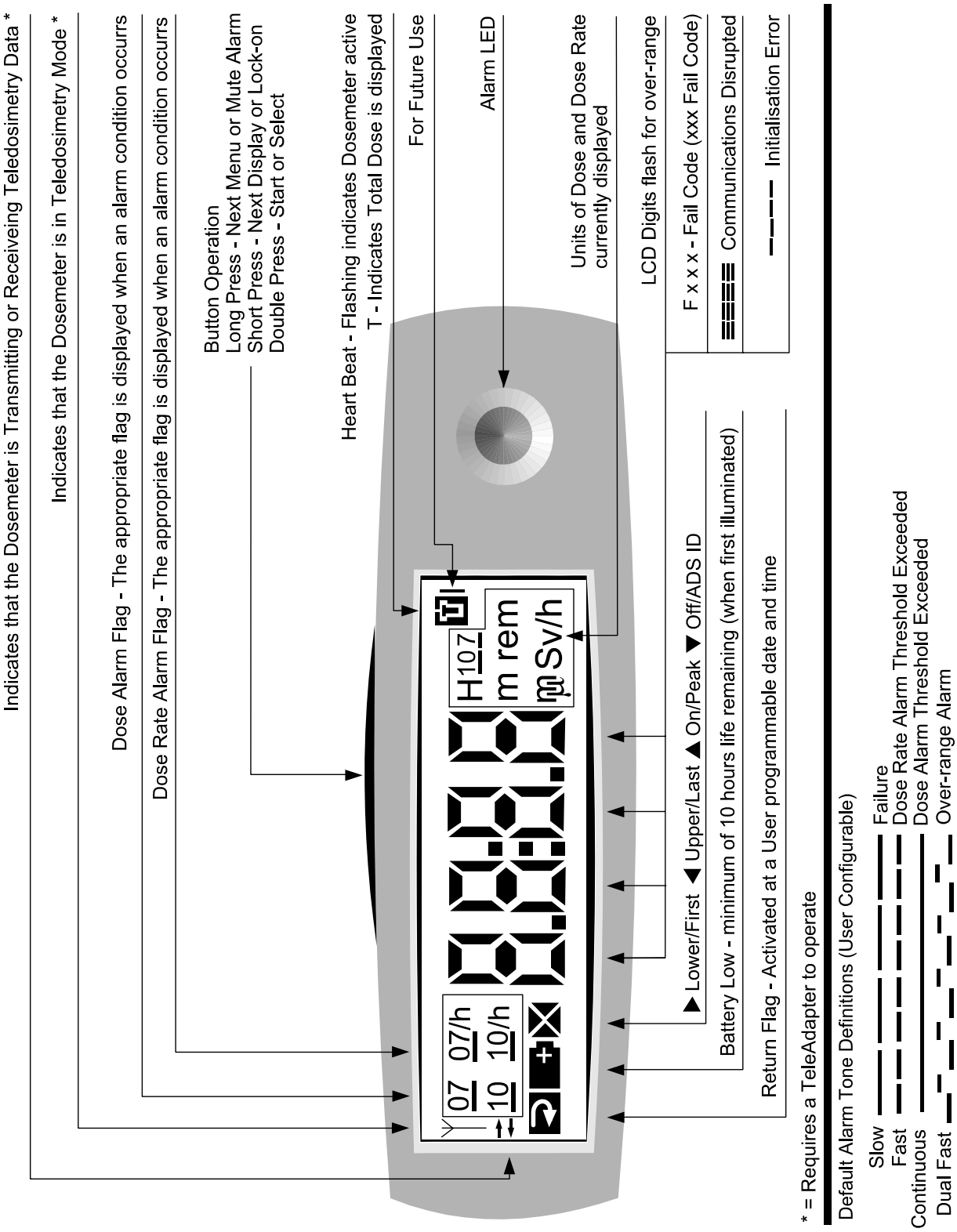


Figure 3.2 - LCD Display Segments

3.2 Audible And Visible Alarms

3.2.1 Alarm features

Overview

The EPD contains a sounder and alarm LED (see Figure 3.1), which are activated together when certain alarm conditions occur. Alarms are also indicated in various ways on the LCD. Under alarm conditions the LED illuminates red and the sounder sounds at 4 kHz or 2 kHz with an intensity of between 98 to 101 dBA (4 kHz Loud) at 20 cm.

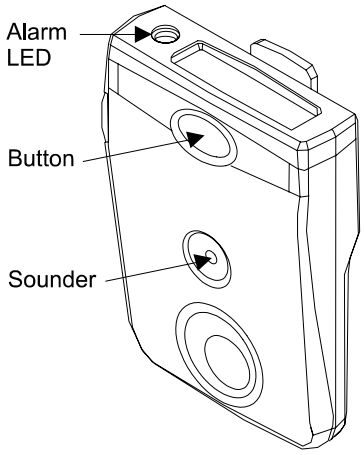


Figure 3.1 - Alarm LED And Sounder

It is possible to disable the sounder and/or LED so that only one or neither will activate, but alarm flags on the LCD remain until the condition is normalised. The alarm sounder can be configured for quieter operation, for example, for office or hospital environments.

Alarms are acknowledged by pressing the button (long press). This action will extinguish the alarm LED and mute the sounder. It is possible to disable the mute function, via the EPD IR communications link (see section 3.2.5).

Note that certain operations and events will automatically mute the audible alarm for a short period, because of the high electrical current required. These are as follows. The period of interruption to the sound output is also given:

Operation or event.	Typical mute period.
Communication over the IrDA link	1 second or more, depending upon the application.
Communications over the teledosimetry link.	Less than a second.
Backlight activated (from the button).	Default display timeout (typically 10 seconds), during which the backlight is on.
Battery test (typically every 15 minutes).	Less than 1 second.

Alarm Configuration

The EPD is able to initiate alarms for a number of different operational conditions. The nature of any alarm is shown on the LCD display by an alarm flag (see Figure 3.2) or, in the case of an over-range alarm, by a flashing LCD display. Faults are shown as a letter 'F' followed by 3 digits.

There are a number of options that can be set for each alarm, for example, tone, frequency and volume. The various options are defined in Tables 3.1 and 3.2. The sounder, LED and mute facilities can only be configured via the IR communications link. The configurations can be set independently for each alarm event recognised by the EPD (see Table 3.3).

Note that alarm duration is set in increments of 4 seconds. Assuming an alarm is not acknowledged then following this period the alarm is replaced by a single beep every 30 seconds. This feature avoids wasting battery power. The timeout can be disabled if desired and the alarm output is not then so curtailed.

Alarm Feature	Configuration Options
Volume	Loud*/Quiet
LED	Enabled/Disabled
Sound	Enabled/Disabled
Tone	High*/Low frequency
User Silence (Mute)	Enabled/Disabled
Alarm Sound	Options (table 3.2)
Duration	Continuous (0) or up to 17 minutes

Table 3.1 - Alarm Configuration Options

Alarm Sound
Off
Continuous Single Tone
Continuous Dual Tone Slow
Continuous Dual Tone Fast
Intermittent Single Tone Slow
Intermittent Single Tone Fast
Intermittent Double Beep Slow
Intermittent Double Beep Fast

Table 3.2 - Alarm Sounds

Note: High Frequency = 4 kHz (approximately)
Low Frequency = 2 kHz (approximately)

* To obtain the loudest alarm output it is necessary to configure the alarm to Loud and High frequency.

The different alarm events identified by the EPD are listed in Table 3.3. This table also shows the default alarm configurations set by Thermo at manufacture.

The following alarms are regenerated after a reset (e.g. battery change):

- Over Range Alarm
- Dose Alarms
- Return Alarm
- Battery Alarm (after 1 minute)
- Dose Rate Alarm (if the condition persists)

Alarm Priorities

It is possible for more than one alarm condition to prevail at any one time. In this event the sounder output is determined by the highest priority prevailing alarm. Alarms are prioritised as defined in Table 3.3, Priority 1 being the highest priority.

An active alarm can be superseded by the following events:

- A higher priority alarm is activated (the new alarm starts).
- The user mutes alarms with a long button press (all mute-able alarms are muted).
- Alarms are cleared via the communications links.
- A self-cancelling condition de-activates the alarm (e.g. falling dose-rate).

Care should be taken if the alarm configurations are altered from the defaults set by Thermo and the following points should be noted:

1. The alarm priorities are fixed and cannot be altered by the user.
2. If the Alarm Type is OFF, or both LED and Sounder are disabled, then the alarm type is effectively removed from the list.
3. If the LED (or sounder) *only* is disabled then the LED (or sounder) output for an active lower priority alarm will be masked (not output).
4. A short duration high priority alarm can curtail the output of a long duration low priority alarm.

In general therefore the higher priority alarms should not be configured with either a short duration, or with LED or sounder disabled, unless the lower priority alarms are also configured this way.

Priority	Alarm/Event	Alarm Tone	Frequency	Volume
1	EPD Failure Alarm.	Intermittent Single Slow Tone — — — —	High	Loud
2	Over-range Alarm.	Continuous Dual Fast Tone _-_-_-_-_	High/Low	Loud
3	Hp (10) Dose Alarm (2)	Continuous Single Tone _____	High	Loud
4	Hp (0.07) Dose Alarm	Continuous Single Tone _____	High	Loud
5	Hp (10) Dose Alarm (1)	Continuous Single Tone _____	High	Loud
6	Hp (10)/h Dose Rate Alarm (2)	Continuous Single Tone _____	High	Loud
7	Hp (0.07)/h Dose Rate Alarm	Intermittent Single Fast Tone _ _ _ _ _ _	High	Loud
8	Hp (10)/h Dose Rate Alarm (1)	Intermittent Single Fast Tone _ _ _ _ _ _	High	Loud
9	Battery Alarm	Intermittent Single Slow Tone — — — —	Low	Quiet
10	Return Alarm	Intermittent Single Slow Tone — — — —	Low	Quiet
11	Count Down Alarm	Continuous Single Tone _____	High	Loud
12	Abuse Alarm	Intermittent Single Slow Tone — — — —	Low	Quiet

Table 3.3 - Default Alarm Tones

3.2.2 Dose Alarms

Dose alarms are checked and updated every second, except at low dose rates where this period increases to a maximum of 14 seconds. Alarms can be adjusted or inhibited via the IR communications link.

Dose alarms are calculated against a preset alarm threshold set in the EPD. When the dose equals or exceeds the dose threshold the LED will illuminate, the sounder will activate and the appropriate alarm flag on the LCD will be displayed. Note that it is dose and not total dose that is compared with the threshold.

The alarm may be muted by pressing and holding the button, unless alarm mute (user silence) is inhibited.

The four most significant digits of the alarm thresholds can be viewed on the EPD LCD and changed using the function button (see Section 3.5.8).

3.2.3 Dose Rate Alarms

Dose rate alarms are checked and updated every second, except at low dose rates where this period increases to a maximum of 14 seconds. Alarms can be adjusted or inhibited via the IR communications link.

The dose rate alarms can be made to work with hysteresis, i.e. the alarm 'off' threshold is lower than the alarm 'on' threshold. The alarm 'off' threshold can be set in the EPD over the same range as can the alarm 'on' threshold. As the dose rate rises above the alarm 'on' threshold the LED will flash and the sounder is activated (see Figure 3.3). The alarm may be muted by pressing and holding the button, unless alarm mute (user silence) is disabled. The alarm will self-cancel when the dose rate falls below the alarm 'off' threshold.

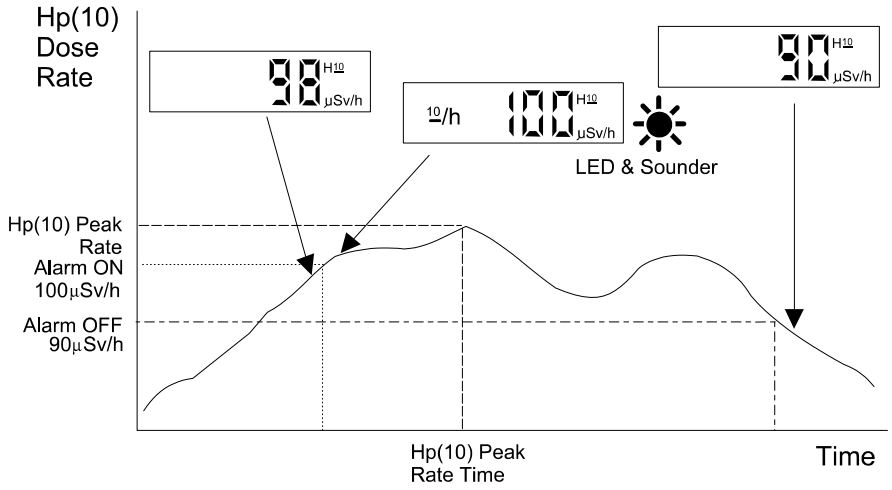


Figure 3.3 - Dose Rate Alarm Example

The four most significant digits of the alarm ‘Off’ and the alarm 'On' thresholds can be viewed on the EPD LCD and, if user has authority to modify the thresholds, changed using the function button (see Section 3.5.9).

3.2.4 Over-Range Indication

If a dose rate exceeds 1Sv/h, or if a dose store increments above 1.0Sv, an over-range alarm will occur. The sounder (if enabled) will sound and the LED will flash (if enabled). The over-range alarm will also cause the LCD display to flash every second.

Notes:

1. The over-range alarm condition is latched and the LCD will continue to flash even after a temporary dose-rate over-range condition has cleared. The over-range conditions are recorded in the EPD EEPROM and must be cleared over the IR communications link before the display will stop flashing.
2. The over-range alarm can be muted (if enabled). The EPD audible and Led alarm will not recur after muting should over-range conditions re-occur (e.g. in the case of a second dose-rate over-range alarm), until the latched condition has been cleared over the IR communications link. However the LCD will continue to flash.
3. For software version 11 and later EPDs the over-range indication on the LCD may be configured to operate in either of two ways. By default the LCD will alternate between the current display selection and a blank display. The alternative configuration causes the LCD to alternate between the current display selection and 9999.
4. The ADS dose over-range alarm only operates if the unit is ADS issued.

3.2.5 Alarm Muting

Alarm conditions cause the sounder to be activated and the alarm LED to illuminate, subject to these facilities being enabled for the alarm. The appropriate LCD alarm flag is always activated. The user can silence (mute) the alarm by pressing and holding the button, provided mute is enabled on the alarm. This will also extinguish the Alarm LED. However the LCD alarm flag remains set until such time as the alarm condition is cleared.

Dose rate alarms are self muting when the dose rate falls below the alarm 'off' threshold level. Similarly dose alarms are self muting if the dose is cleared or the thresholds suitably increased over the IR communications link.

Note that *if* the display backlight is enabled a short press of the button turns the back-light on and temporarily silences any active alarm. This is because the EPD unit battery cannot supply sufficient current for both backlight and sounder together. After the display timeout period the backlight is automatically turned off and the sounder re-enabled. Thus a short press may appear to mute the alarm and confuse the user under such conditions. It is necessary therefore for the user to remember that a long press is required to mute the alarm.

3.3 Button Operation and Display Selection

The EPD will display a range of data to the user. The data displayed is selected by use of the button. The full range of displays is arranged on a two dimensional grid, as shown in Figure 3.4. There are a number of menus, each having a top-level display. Menus are changed by holding down the button (Long Press). This navigates the user down the left hand side of Figure 3.4. Once the desired menu has been reached the button must be released. Then, by a series of short presses, the user can navigate across Figure 3.4 until the desired display within the current menu has been reached.

Any displays that are disabled are removed from the sequence. Some displays are usefully disabled if their retention might confuse the wearers of the EPD. Other displays should be disabled if their retention might cause an operational risk, for example, the ability to zero dose or adjust alarm thresholds. Such display configuration is easily done using the **EasyEPD2** software package. A batch write facility is available in **EasyEPD2** to enable the speedy configuration of a number of EPD units.

Some displays allow the user to change the status or operation of the EPD. For example, the user can start, stop and reset the countdown timer. In general, these operations are activated by “double-pressing” the button. To prevent unwanted user intervention (e.g. to prevent the user resetting count-down timer) the EPD can be configured to disable any (or all) of the displays shown in Figure 3.4. Display configuration changes can only be carried out via the IR communications link.

3.4 LCD Display Lock-on Facility

Any new display selected using the button remains visible for a set period of time, (Thermo default time-out is 10 seconds), before returning to the default display. Some display selections (marked * in Figure 3.4) can be 'locked-on', i.e. the return to the default display is suspended. This facility is especially useful when displaying dose-rate or when using the count down alarm. If a lock-on facility is available it must be accepted quickly - when a colon (:) appears just before the selected display times-out. The colon will only appear for approximately two seconds. To accept the lock-on facility, press the button when the colon appears. If the lock-on facility is not required, allow the selected display to time-out. To deselect the lock-on facility press the button. The display will move on to the next display selection but will thereafter revert to the default display after time-out.

The seconds count-down timer lock-on facility operates in a slightly different manner to that described above. In this instance the lock-on facility is available when the colon disappears. This only occurs for the count-down timer display and, again, is just before the display times out. To accept the lock-on facility, press the button when the colon disappears. If the lock-on facility is not required, allow the selected display to time-out.

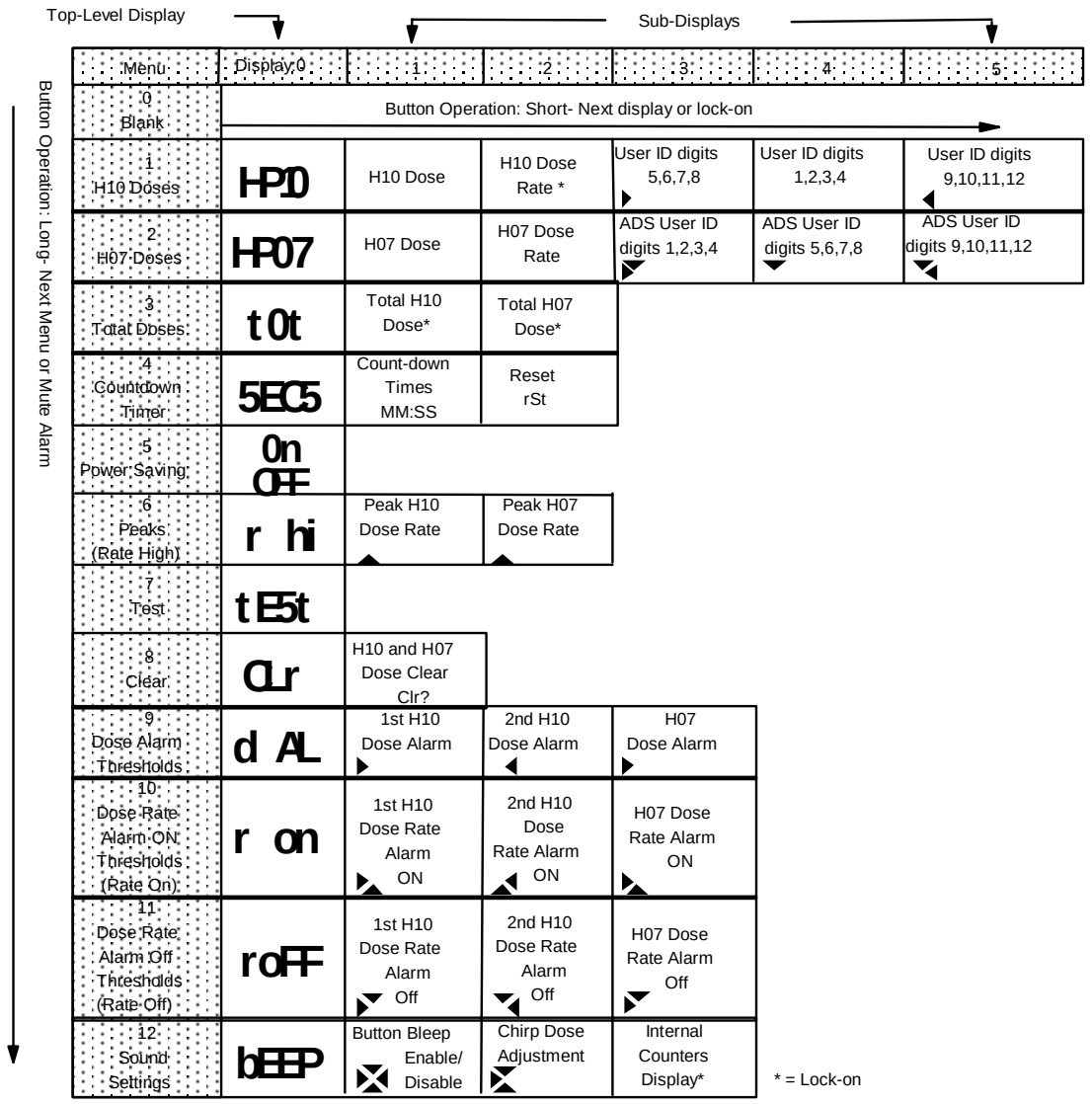


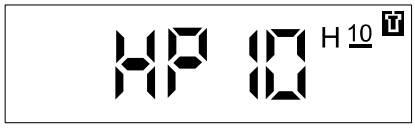
Figure 3.4 - LCD Display Selections

3.5 Display Options and Button Functions

The following sections describe typical displays that a user may see within each of the menus shown in Figure 3.4. This description assumes that all displays are enabled. The user may have access to any (or none) of the displays, depending on how the EPD has been configured. To call up a top-level display, press and hold the button until the relevant top-level display appears. Any sub-displays are selected either by short-pressing, or double-pressing, the button within the display default time-out.

3.5.1 Displaying Hp (10) Dose, Dose Rate and User ID.

To display Hp(10) doses, press and hold the button until this top-level display appears:

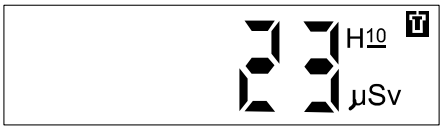


Three sub-displays are available (in the following sub-display order):

- Hp (10) Dose
- Hp (10)/h Dose Rate
- User ID Digits

Hp (10) Dose Display

Short-press the button to display the current dose. This dose parameter is used for tactical dose monitoring (e.g. per task etc.).



Display Range: 0µSv to >16Sv (auto ranging)

Note: Over-range (> 1.0 Sv) is indicated with a flashing LCD display (see section 3.2.4).

H_p(10)/h Dose Rate Display

Short-press the button again to display the current Hp(10)/h dose rate. Only the first two significant figures of the dose rate are displayed, the actual reading is rounded down.

Display Range: 0µSv/h to >4Sv/h (auto ranging)

Note: Over-range (> 1.0 Sv/h) is indicated with a flashing LCD display, see section 3.2.4. This condition is latched to warn the user that the dose value may be inaccurate.

User ID Digits

Short-press the button again to display the user identity number (User ID). This is a 12-digit number that is shown on three separate displays - the High 4 digits, the Middle 4 digits and the Low 4 digits. Short-press the button to display each of the remaining User ID digit displays. The User ID cannot be changed using the button. By convention a non-issued EPD is given a User ID = FFFFFFFFFFFF. Typically, a User ID will have fewer than 12 digits, but it must be an integer between 1 and 999999999999. For example, a User ID = 9012 will be shown on the LCD display as follows:

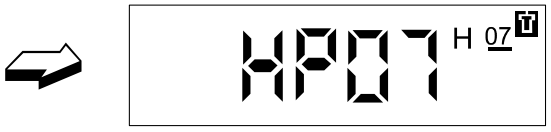
(First Display) (Second Display) (Third Display)

In systems using 8 or fewer digits for the User ID it is usual to disable and thereby remove the unused displays (e.g. the first and second display in the above example).

For software version 11 and later the first 12 characters of the wearer name may be displayed on the EPD LCD in place of the wearer ID. The character representation on a seven segment display is necessarily limited, see table in Appendix C.

3.5.2 Displaying Hp(0.07) Doses, Dose Rate and ADS User ID

To display Hp(0.07) doses, press and hold the button until this top-level display appears:

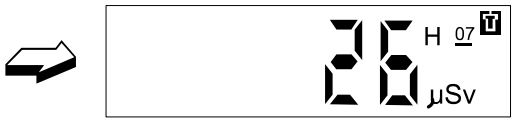


Three sub-displays are available (in the following sub-display order):

- Hp(0.07) Dose
- Hp(0.07)/h Dose Rate
- ADS User ID Digits

Hp(0.07) Dose Display

Short-press the button to display the current dose. This dose parameter is used for tactical dose monitoring (e.g. per task etc.).

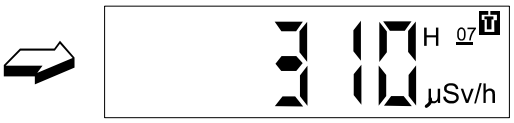


Display Range: 0µSv to >16Sv (auto ranging).

Note: Over-range (> 1.0 Sv) is indicated with a flashing LCD display, see section 3.2.4.

Hp(0.07)/h Dose Rate Display

Short-press the button again to display the current Hp(0.07)/h dose rate. Only the first two significant figures of the dose rate are displayed, the actual reading is rounded down



Display Range: 0µSv/h to >4.0Sv/h (auto ranging).

Note: Over-range (> 1.0 Sv/h) is indicated with a flashing LCD display, see section 3.2.4. This condition is latched to warn the user that the dose value may be inaccurate.

ADS User ID Digits

An additional User ID is provided, called Approved Dosimetry Service (ADS) User ID. This is password-protected and is used by ADS systems for “permanent” issue EPDs. The ADS User ID may be displayed in a similar fashion to the User ID.

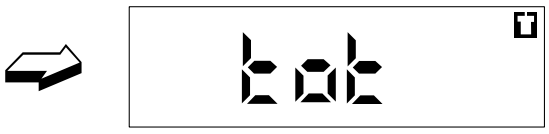
Short-press the button again to display each of the remaining ADS User ID digit displays. A non-issued EPD may have an ADS User ID = FFFFFFFFFFFF. Typically, an ADS User ID will have fewer than 12 digits, but it must be an integer between 1 and 999999999999. For example, an ADS User ID = 3324 will be shown on the LCD display as follows:

(First Display) (Second Display) (Third Display)

In systems using 8 or fewer digits for the ADS User ID it is usual to disable and thereby remove the unused displays (e.g. the first and second display in the above example).

3.5.3 Displaying Total Dose

To display total dose, press and hold the button until this top-level display appears:

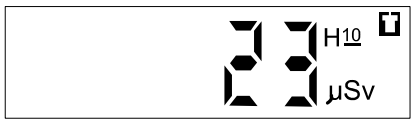


Two sub-displays are available (in the following sub-display order):

- Hp(10) Total Dose
- Hp(0.07) Total Dose

Hp(10) Total Dose

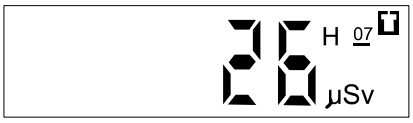
Short-press the button to display the total Hp(10) dose.



Display Range: Hp(10) 0µSv to >16Sv (auto ranging).

Hp(0.07) Total Dose

Short-press the button again to display the total Hp(0.07) dose.



Display Range: Hp(0.07) 0µSv to >16Sv (auto ranging).

Each display represents a record of the total dose received by the EPD over multiple tasks (e.g. per day, per week etc.).

3.5.4 Starting/Stopping The Seconds Count Down Timer

To start/stop the seconds count-down timer, press and hold the button until this top-level display appears.

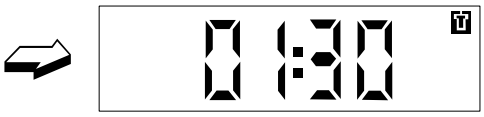
Two sub-displays are available (in the following sub-display order):

- Count-down Time MM:SS
- Reset (rSt)

The count-down timer is a useful facility for activities where actions need to be completed within known time periods. The User may start, stop and reset the count down timer using the button. When the timer expires the appropriate alarm is sounded. The count down time period is pre-set and can only be adjusted via the IR communications link.

Count-Down Time

Short-press the button to display the 'Count-Down Time' (which indicates the count down time period, or the remaining count down time available).



Double-press the button to start the digits counting down to zero. The display is in units of minutes and seconds. The maximum count down time available is 99 minutes, 59 seconds.

The count down function continues when the display reverts to the default display after the display timeout period. However it is useful to 'lock on' to this display as described in section 3.4.

Stopping the Timer

To stop the timer double-press the button again. The digits will stop decreasing.

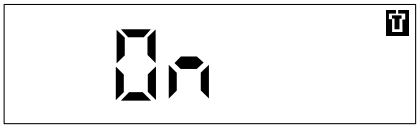
Reset

Short-press the button to select the display shown opposite. Double press the button and the display will flash.

Double-press the button again to confirm the reset (the display will show the reset time at its reset value). The timer may now be started as described above.

3.5.5 Turning the EPD off

To turn the unit off, press and hold the button until the word 'On' appears:



Only one sub-display is available:

- On/Off

This function enables the EPD to be placed in sleep or OFF mode. In OFF mode power consumption is reduced considerably and the EPD stops measuring radiation.

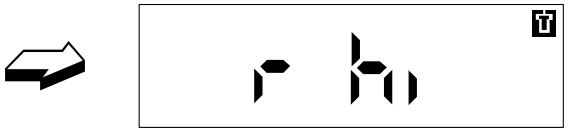
Assuming that the display shows On, double-press the button. The display will change to “OFF” (flashing). Double-press the button again to confirm the request. The display will change to the word “OFF” (not flashing), confirming that the unit is in OFF mode and not measuring radiation.

To return to operating mode press and hold the button. The display will revert to the default display.

Note: ON/OFF control via the button may be inhibited by the appropriate setting of the EPD internal configuration via the IR communications link.

3.5.6 Displaying Peaks (Rate High)

To display peaks (high rate), press and hold the button until this top-level display appears:



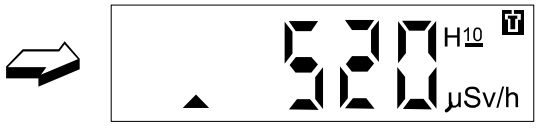
Two sub-displays are available (in the following sub-display order):

- Peak Hp(10)/h Dose Rate
- Peak Hp(0.07)/h Dose Rate

These displays show the highest dose rate that the EPD has measured since the peaks were last cleared. The peak dose rates measured are recorded for penetrating and superficial dose rates, together with the times at which these rates occurred (to a resolution of 1 second).

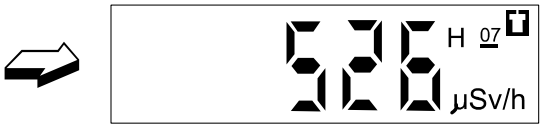
Peak Hp(10)/h Dose Rate

Short-press the button to display the Peak Hp(10)/h Dose Rate:



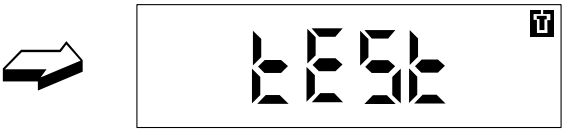
Peak Hp(0.07)/h Dose Rate

Short-press the button again to display Peak Hp(0.07)/h Dose Rate:



Note: Peaks can only be cleared via the IR communications link.

3.5.7 EPD Confidence Test



To perform the EPD confidence test, press and hold the button until this top-level display appears:

Only one sub-display is available:

- Test

This test can be run at any time during operational use as a confidence check that the EPD is functioning correctly. Throughout the confidence test the heart-beat (activity) indicator flashes once per second. The confidence test can be stopped at any time by pressing the button.

Note: During the EPD confidence test a brief detector test is performed, during which dose accumulation is momentarily inhibited (1 to 2 ms approximately).

Double-press the button. The EPD will commence its confidence test routine, as follows:

1. The all-segment display is displayed for approximately 5 seconds. This allows the user to check that all segments are functional (see Figure 3.2).
2. The alarm will sound and the LED will flash for approximately 2 seconds. This indicates that the sounder and LED are functional.
3. The all-segment display will disappear. The alarm will continue to sound and the LED will continue to flash, at an increased rate, for approximately 6 seconds. This indicates that the LCD segments can be turned off, and that the tone frequencies are functional.
4. The all-segment display will reappear for approximately 5 seconds and the LED will slow flash.
5. The all-segment display will disappear and the default display will appear. This indicates that the confidence test has been successfully completed and that the EPD is ready for operational use.

Upon completion of the confidence test, the unit reverts to the default display. If the confidence test is unsuccessful a letter ‘F’ followed by three digits is displayed. Note the failure codes and refer to Section 5 (Failure Modes and Fault Diagnosis).

3.5.8 Clearing Dose Displays

To clear dose displays, press and hold the button until this top-level display appears:

Only one sub-display is available

- Clr?

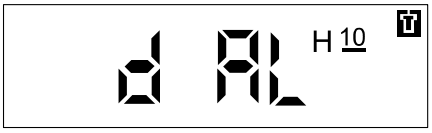
This mode is used to clear the Hp(10) and Hp(0.07) doses.
Note: The total doses are not cleared.

Press the button once to select the display shown opposite.

Double-press the button again and the display will flash. Double-press the button again to confirm the request. The display will change to 0000 and return to the default display. The Hp(10) and Hp(0.07) doses have now been cleared.

3.5.9 Displaying/Setting Dose Alarm Thresholds

To display and/or set dose alarm thresholds, press and hold the button until this top-level display appears:



Three sub-displays are available (in the following sub-display order):

- 1st Hp(10) Dose Alarm
- 2nd Hp(10) Dose Alarm
- Hp(0.07) Dose Alarm

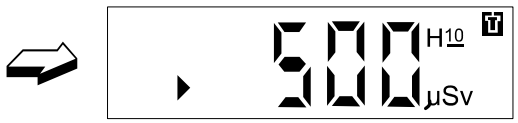
The EPD can be used as a ‘personal alarming’ dosemeter, with alarm thresholds for accumulated dose alarms. This mode displays the current settings for the dose alarm thresholds. The alarm threshold can be modified by the user, if required, but only when the default setting is set to ‘adjustable’. The user is barred from modifying the threshold if the default is set to ‘not adjustable’. These default settings can only be set via the IR communications link.

There are two Hp(10) alarm thresholds and a single Hp(0.07) alarm threshold that can be displayed and modified. The 2nd Hp(10) dose alarm has the higher priority

and should always be set to a higher value than the 1st Hp(10) alarm. The accumulated dose alarm thresholds can be set using the button as follows:

1st & 2nd Hp(10), Hp(0.07): 10μSv, 50μSv, 100μSv, 500μSv, 1mSv, 5mSv, 10mSv, 50mSv, 100mSv, 500mSv, 1.0Sv.

Example of 1st Hp(10) Dose alarm threshold display set at a default value of 500μSv:



Other values for the dose alarm thresholds may be set via the IR communications link.

Changing The Dose Alarm Thresholds

To change the 1st Hp(10) dose alarm threshold select the display above and double-press the button. The display will change to the following with the digits flashing:

Alarm Set Limits: 10μSv to 1Sv.

Pressing the button will increase the alarm threshold in the following steps: 10μSv, 50μSv, 100μSv, 500μSv, 1mSv, 5mSv, 10mSv, 50mSv, 100mSv, 500mSv, 1.0Sv. When the required threshold is reached double-press the button to confirm the value and the flashing display will stop.

If you start to change the threshold and change your mind this option can be aborted, as follows:

Short-press the button until the following is displayed (letters flashing). Double-press the button to confirm that you wish to escape and return to the previous alarm threshold.

If the “ESC” screen is displayed and the button is not pressed, after default time-out the display will return to the dose alarm threshold that was being set-up. Again, if the button is not pressed, the display will return to the default screen after a further time-out period.

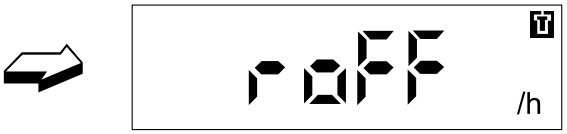
3.5.10 Displaying/Setting Dose Rate Alarm On/Off Thresholds

To display and/or set dose rate alarm ON thresholds, press and hold the button until this top-level display appears:

Three sub-displays are available (in the following sub-display order):

- 1st Hp(10)/h Dose Rate Alarm ON
- 2nd Hp(10)/h Dose Rate Alarm ON
- Hp(0.07)/h Dose Rate Alarm ON

To display and/or set dose rate alarm OFF thresholds, press the button until this display appears:



Three sub-displays are available:

- 1st Hp(10)/h Dose Rate Alarm OFF
- 2nd Hp(10)/h Dose Rate Alarm OFF
- Hp(0.07)/h Dose Rate Alarm OFF

The EPD can perform the role of a 'personal alarming' EPD with alarm thresholds for dose rate. There are two Hp(10)/h dose rate alarms and a single Hp(0.07)/h dose rate alarm that can de displayed. The 2nd Hp(10)/h dose alarm has the higher priority and should always be set to a higher value than the 1st Hp(10)/h alarm. The alarm thresholds can be modified by the user, if required, but only when the EPD default setting is set to 'adjustable'. The user is barred from modifying the thresholds if the EPD default is set to 'not adjustable'. These default settings can only be set via the IR communications link.

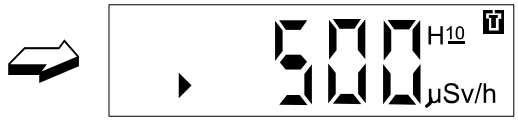
The dose rate alarm thresholds can be set using the button as follows:

> 10μSv/h, 50μSv/h, 100μSv/h, 500μSv/h, 1mSv/h, 5mSv/h, 10mSv/h, 50mSv/h, 100mSv/h, 500mSv/h, 1.0Sv/h

Other values for the dose rate alarm thresholds may be set via the IR communications link.

Note: To avoid false alarms due to counting statistics it is recommended that the Hp(0.07)/h dose rate alarm is not set to less than 100μSv/h

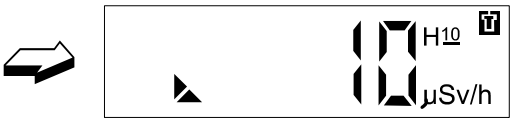
Example 1st $H_p(10)$/h dose rate on alarm threshold display set at a default value of 500μSv/h:



'On' and 'Off' alarm thresholds allow hysteresis for dose rate alarms, see section 3.5.1. If hysteresis is not to be used the 'On' and 'Off' thresholds should be set to the same value.

***Changing the Dose Rate Alarm Thresholds (ON and OFF)*:**

To change the 1st $\dot{H}_p(10)$/h dose rate on alarm threshold, for example, select the above display and double-press the button. The display will change to the following and the digits will flash:



Alarm Set Limits: 10μSv/h to 1Sv/h

Pressing the button will increase the alarm threshold in the following steps: 10μSv/h, 50μSv/h, 100μSv/h, 500μSv/h, 1mSv/h, 5mSv/h, 10mSv/h, 50mSv/h, 100mSv/h, 500mSv/h, 1.0Sv/h. When the required threshold is reached double-pressing the button to confirm the value and the flashing display will stop.

If you start to change the threshold and change your mind this option can be aborted, as follows:

Short-press the button until the following is displayed (letters flashing). Double-press the button to confirm that you wish to escape and return to the previous alarm threshold.

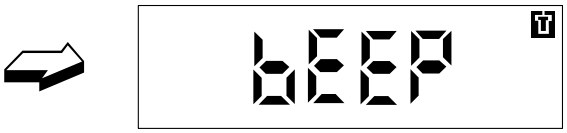
If the 'ESC' screen is displayed and the button is not pressed, after default time-out the display will return to dose alarm threshold that was being set-up. Again, if the button is not pressed, the display will return to the top level default screen after a further time out period.

Notes:

1. The ‘On’ threshold must always be greater than or equal to the ‘Off’ threshold.
2. If an attempt is made to set the ‘On’ threshold below the ‘Off’ threshold the ‘Off’ threshold will be set automatically to the same value as the ‘On’ threshold.
3. If an attempt is made to set the ‘Off’ threshold above the ‘On’ threshold the ‘Off’ threshold will be set automatically to the same value as the ‘On’ threshold.

3.5.11 Setting The Sounder

To change the EPD sounder settings, press and hold the button until this top-level display appears:



Three sub-displays are available (in the following sub-display order):

- Button Beep Enable/Disable
- Dose Chirp Adjustment
- Internal Counters Display

Note: This option will not enable/disable the alarm sounder. Enabling/disabling the sounder under alarm conditions can only be set via the IR communications link (see Section 3.2.4).

Button Beep Enable/Disable

The EPD can be configured to beep every time the button is pressed. This feature may be toggled 'on' and 'off' via the button, or via the IR communications link (i.e. ***EasyEPD2***).

Note: If the button beep has been disabled via the button any subsequent initialisation of the EPD will revert the button beep to ON (enabled). If the button beep has been disabled via the IR communications link, the button beep will remain disabled regardless of any subsequent EPD initialisation.

Short-press the button to display the button beep enable/disable window. To configure the beep feature 'off' or 'on' double-press the button while the EPD is displaying

the following displays.

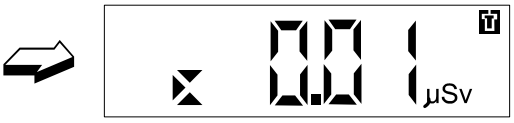
Button Beep Enabled

Button Beep Disabled

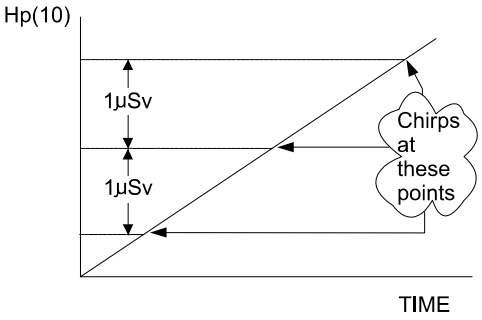
Dose Chirp Adjustment

The EPD can be configured to give a warning chirp at every preset increment in Hp(10)/h, penetrating (deep) dose. This increment can be set between 0.01μSv and 100μSv, or disabled by setting the increment to 0.

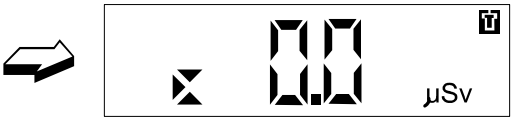
Short-press the button to display the current dose per chirp:



An increment set to 1μSv is shown opposite. With a chirp sensitivity of 1μSv/chirp and a dose rate of 10mSv/h the sounder will average 2.8 chirps every second.



To change the chirp rate, double-press the button at current dose chirp display. The display digits will flash.



Dose Chirp Limits: 0.01μSv to 100μSv.
Note: 0 = Off (no chirp function).

Pressing the button will increase the dose per chirp in the following increments: 0.0μSv, 0.01μSv, 0.05μSv, 0.1μSv, 0.5μSv, 1.0μSv, 5μSv, 10μSv, 50μSv, 100μSv. When the required sensitivity is reached “double-pressing” the button will confirm the value and the flashing display will stop.

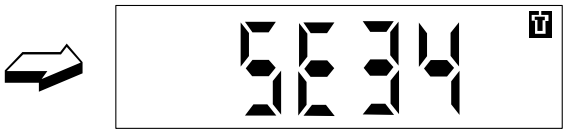
If you start to change the sensitivity, and change your mind, the option can be aborted. Short-press the button until the following is displayed (letters flashing).

Double-press the button to confirm you want to return to the previous chirp sensitivity. To switch off the dose chirp double-press the button when 0.0 μSv is displayed.

If the “ESC” screen is displayed and the button is not pressed, after default time-out the display will return to dose chirp adjustment display. Again, if the button is not pressed, the display will return to the top level default screen after a further time out period.

Internal Counters Display

Short-press the button to display the current internal counters display.



The display is in hexadecimal format and shows the last digit of: hard gamma (HG), soft gamma (SG), full beta (FB) and beta compensation (BC) counts respectively. This display is intended for test purposes and may be useful for identification of faults or operational problems.

SECTION 4

TECHNICAL DESCRIPTION

This section provides a technical description of the EPD and contains a summary of the EPD's radiological features together with a summary of the EPD's electrical, mechanical and environmental characteristics.

4.1 General

The EPD is of rugged construction and is suitable for most conditions that can reasonably be expected in industrial environments. The radiological features of the EPD are summarised below (a full radiological specification is given in Appendix A to this handbook):

- Sensitivity to X and γ radiation, β particles
- Multiple PIN diode detectors
- 4 channel parametric algorithm processing
- Direct readout of personal dose equivalents Hp(10) (penetrating/deep/whole body) and Hp(0.07) (superficial/shallow/skin)
- Neutron response <2%
- Meets relevant parts of BS-EN-ISO61526 for dose equivalent monitors (unless otherwise specified)
- Dose display and storage 0µSv to >16Sv (0.0 mrem to > 1600 rem) auto ranging
- Resolution for dose display 1µSv (0.1mrem) at levels up to 10mSv (1 rem)
- Resolution for dose storage 1/64µSv
- Dose rate display 0µSv/h to >4Sv/h auto ranging, resolution 2 most significant digits or 1µSv/h at lower levels (10µSv/h for Hp(0.07)/h)
- Dose rate peak store 0µSv/h to >4Sv/h resolution 1µSv/h

4.2 Electrical Description

4.2.1 Electrical Characteristics

Power Supply: One AA Lithium Thionyl Chloride (LTC) battery 3.6 V), giving typically 5 months continuous operation at an average dose rate <5μSv/h with the alarm sounding <5 hours total during battery life.

or:

One standard AA Alkaline battery (1.5 V), giving typically 55 days continuous operation at an average dose <5μSv/h with the alarm sounding <2 hours total during battery life.

Confidence Test: Activated on start-up and by the button when the CONFIDENCE TEST mode is called-up (see Section 3.5.7).

Detector Test: Performed during the start-up sequence and as a background test, and under demand via the IR interface . Normal dose processing is inhibited during detector test for a period of 1 to 2 ms.

Battery Test: Configurable time interval between 1 to 60 minutes. (15 minutes recommended).

Alarm sounder : 98 dB(A) to 101 dB(A) at 20 cm (4kHz loud mode)
80 dB(A) to 90 dB(A) at 20cm (4kHz quiet mode).

4.2.2 Battery Management

The EPD circuitry is designed to operate at 3.6V DC. The EPD can be powered by either a 3.6V Lithium Thionyl Chloride (LTC) (Sulphurous Oxychloride, $SOCL_2$) battery or a standard 1.5V AA Alkaline type battery.

The EPD software runs an internal battery condition test at regular intervals (between 1 and 60 minutes). This time interval is factory preset to 15 minutes and should not be adjusted except following consultation with Thermo Electron.

EPDs prior to software version 11:

If a 1.5V Alkaline battery is installed the EPD automatically switches-in a step-up converter to maintain the 3.6V operating voltage. The step-up converter is also switched in as the LTC battery runs down. However, the EPD will not start up if it

is fitted with a LTC battery that has been discharged sufficiently to require the step-up converter to operate.

Operationally, as the voltage from either battery type falls, a series of preset voltage thresholds operate as follows:

(i) The internal step-up converter is switched in to maintain the voltage at the EPD's operating level.

(ii) As the battery voltage under load continues to fall, the low battery alarm flag is activated to indicate when a minimum of 10 hours battery life is remaining. Different thresholds are automatically selected for LTC or alkaline batteries.

(iii) As the battery voltage under load finally falls below tolerance the EPD resets (blank display). In some cases the EPD may reset repeatedly, giving rise to a quiet ticking sound. The EPD battery must be replaced.

EPDs from software version 11 onwards:

These EPDs have the step-up converter permanently activated to maintain the required circuit operating voltage as either the Lithium or the Alkaline battery voltage falls. The EPD makes the following information available over the IR comms link:

- Type of battery currently fitted: Low volts (Alkaline) or high voltage (Lithium Thionyl Chloride)
- The current battery voltage (measured at the last battery load test – normally every 15 minutes)
- The current regulated circuit voltage (measured within the last 14 seconds)
- The battery voltage threshold at which the battery low warning is raised for low voltage (Alkaline battery)*
- The battery voltage threshold at which the battery low warning is raised for high voltage (Lithium battery)*

* These thresholds should not normally require adjustment and any adjustment considered should first be agreed with Thermo Electron.

The battery low alarm and LCD segment are activated when the battery voltage falls below the appropriate battery low threshold. The EPD will continue to run normally thereafter for a period of at least 10 hours, though this may be shortened by continuous audible alarm output. When the EPD is no longer able to continue correct processing it enters a hardware reset state in which intermittent audible alarms are output until such time as the battery nears complete discharge state. This may continue for several minutes or longer. As the sound is initiated by the hardware it cannot be muted by pressing the button, but only by removing the battery.

Additional information and warnings relating to the EPD battery are given in Section 6.2.

4.2.3 On / Off Operating Modes

The EPD has an ON/OFF power saving facility, in which the detectors are turned off, which is intended for short-term storage (e.g. overnight). In the power saving mode the LCD will display OFF (i.e. the EPD is off - see also Section 3.5.5). In the EPD OFF condition battery drain is reduced to approximately 20% of the drain when the EPD is in the ON condition (i.e. fully operational). The EPD does not measure radiation when it is OFF.

Alternative OFF Display

EPDs of software version 11 and later may be configured to display a 4 digit Hexadecimal value instead of the OFF display. The 4 digit hex value may be written using suitable software, e.g. EasyEPD2. This facility is to provide customers with the option of having the EPD display the Calibration due date when the EPD is Off. So for example, 2512 could mean calibrate on 25th December.

4.3 Mechanical Description

4.3.1 Mechanical Characteristics And Dimensions

Display and function control:	Single button on the front of the EPD (recessed to prevent inadvertent operation).
Case material :	High impact Polycarbonate/ABS blend.
Clip :	High impact plastic clip assembly comprising:
	♦ spring clip
	♦ lanyard plate,
Weight :	95 gm including LTC battery and clip. 88 gm with lanyard plate only (clip removed).
Dimensions :	See Figure 4.1.

4.3.2 Brief Mechanical Description

The EPD is of semi-modular construction and comprises an inner conductive liner, an outer case assembly and lid. The inner liner houses the EPD's electronic components. The outer case, consisting of a moulded front and back, fits around the inner liner and is fused together to provide physical protection. The lid, which is fitted to the top of the outer case, has a tight tolerance and is locked in place as an integral part of the EPD assembly. The outer case and lid are designed not to come apart.

The complete assembly is engineered to house functional and operation components (e.g. EPD battery, LCD display, button, alarm LED, alarm sounder, IR communications link and beta window (see Figure 2.1). Externally, the outer case is contoured to receive, and lock in place, a clip assembly (see Section 6.3). Essentially, component replacement is limited to the EPD battery, battery cap and clip assembly.

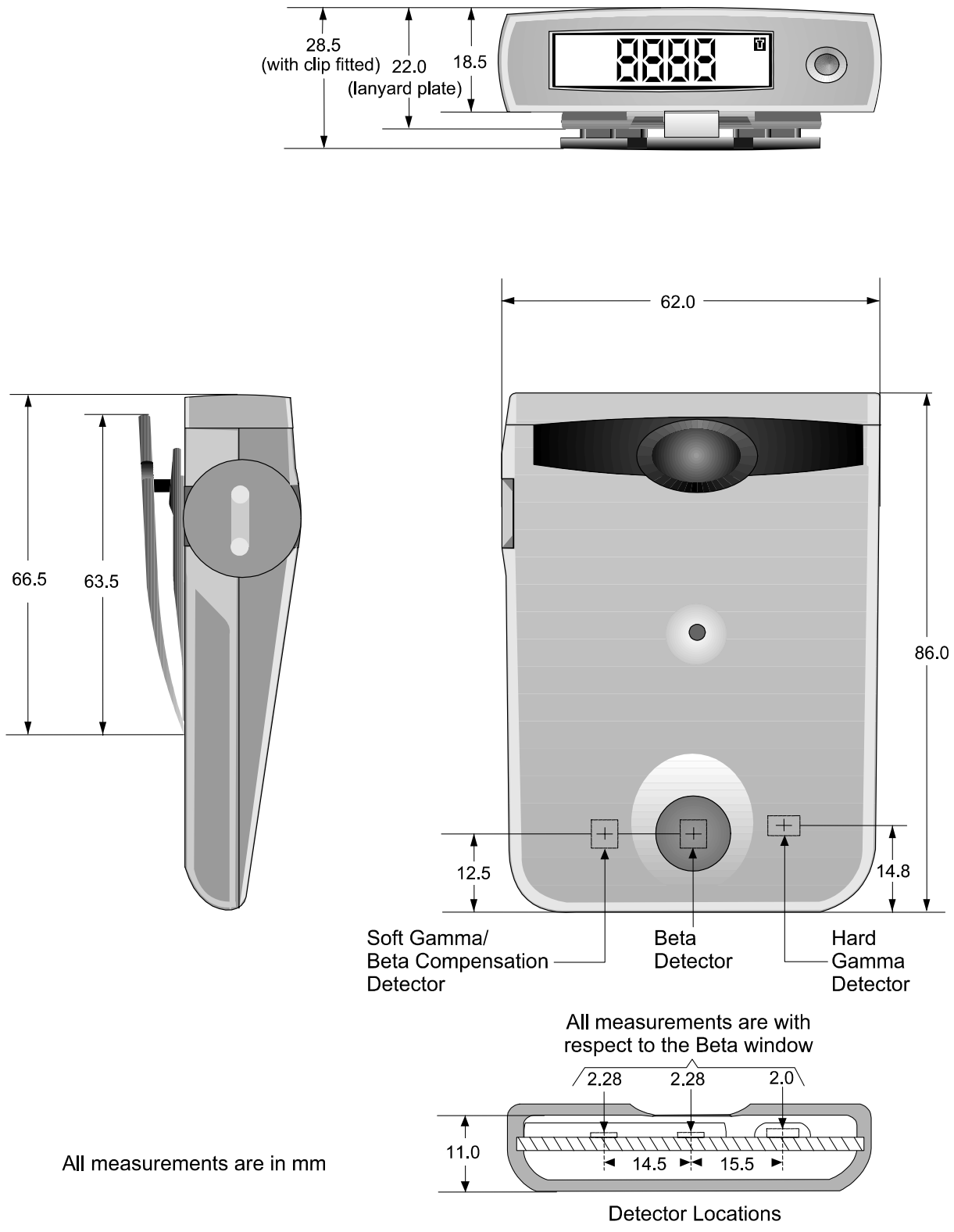


Figure 4.1 - EPD Dimensions

4.4 Environmental Description

4.4.1 Environmental Characteristics

Operating Temperature :	-10°C to +40°C.
Storage:	-25°C to +70°C.
Humidity:	20% to 90% RH non condensing.
Protection:	IP55. Total protection against dust and against low pressure jets of water from all directions.
Vibration:	IEC 1526 2g, 15 min, 10 - 33 Hz
Shock:	1.5 m drop on each surface onto concrete.
EMI/EMC:	Exceeds MIL STD 461D RS103 (see Appendix B).

4.4.2 Brief Environmental Description

The EPD is designed for use in the following environments:

- Office and Laboratory environment,
- Industrial environments,
- Hospitals
- Military environments (including dockyards and shipping - but excluding exposure to salt water and extremes in military environment).

4.5 Infra-red Interface

The EPD contains an infra-red interface (see Figure 4.2) which can optically communicate (read and write) to PC-based hardware using a suitable infra-red communications program. This interface is compatible with IrDA level 1 protocol.

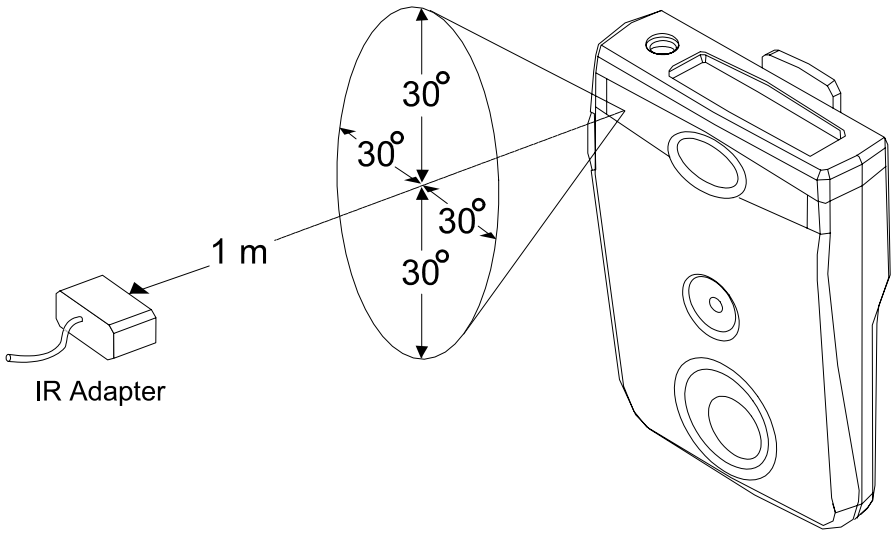


Figure 4.2 - EPD Infra-Red Interface

4.5.1 Communicating With The EPD

The EPD electronically stores dose and dose rate data, together with other information that is required to control and configure the EPD. Communication with the EPD is essential in order to read data from store and to write data to store so that EPD parameters, operational control and general functionality can be set.

During the read/write process the EPD can be configured for any (or all) of the display selections shown in Figure 3.4 to be made available to the user, as required. Only limited functions can be configured via the EPD button.

On the front of the EPD there is an IR communications link for reading and writing data. Communication with the EPD is usually via an IR adapter, which is connected to a host PC. ***EasyEPD2*** is a Thermo PC-based software product for maintaining, configuring and reading EPDs. The IR communication range is up to 1m, over an angle of ±30° from the normal to the front of the EPD.

After any successful communication via the IR communications link the EPD will show the default display. There is a time-out from the last communication after which the EPD reverts to normal display. There is also an inhibit timer that prevents an EPD from re-establishing communications immediately after

communications are completed. This gives the user time to remove the EPD from the IR field. The EPD continues to measure radiation during communication.

4.5.2 EPD Configuration via the IR Communications Links

Communication via the EPD's IR communications link will allow access to the following EPD functions and displays:

- Default Display
- User Identification
- Dose and Dose Rate
- Alarms and Alarm Thresholds
- Counts
- Dose Quality
- Control of the EPD
- Status
- Scratch Pad
- Timed Events
- Dose Profile
- Special Total Dose Store
- ADS Issue
- Calibration Parameters

Access to these configuration parameters is restricted as follows:

1) CALIBRATION FACTORS:

Write access to calibration parameters is prevented unless the EPD is configured by the manufacturer with calibration parameters unlocked (default is locked). If the calibration parameters are unlocked then suitable s/w available through Thermo can adjust the 'gains' of the EPD calibration within specified % limits from the original manufacturer's calibration.

2) PTB APPROVED EPD

The Physikalisch-Technische Bundesanstalt (PTB), Braunschweig and Berlin, is the national institute of natural and engineering sciences and the highest technical authority for metrology and physical safety engineering of the Federal Republic of Germany.

EPDs supplied to Germany and elsewhere under PTB approval are specially configured by the manufacturer to ensure certain functions cannot be enabled, as follows:

Alarm Configuration

Alarms cannot be configured Off, be disabled, set to quiet or low frequency. This ensures that Alarm sound level is >85dB(A) at 30cm from the EPD. The alarm times cannot be set to less than 10 minutes.

The following Alarm Control settings may also not be changed from the factory configuration: Battery alarm level 1, Battery Alarm Level 2, Battery Type Discriminator, Regulated voltage alarm level.

LCD, Decimal Point position and display units.

PTB EPDs are configured such that the settings for decimal places, dose units, off display, wearer display, overrange flashing, and 1 minute logging, cannot be changed.

EPDs are factory configured to the required Display Settings and then 'locked' in that condition. This configuration is required for PTB approved EPDs.

Calibration Factors

Beta/Gamma EPDs are supplied with calibration factors locked.

Any attempt to configure PTB Approved EPDs contrary to this specification will fail. If the configuration is attempted using EasyEPD2 then EasyEPD2 will display gives the error message 2 28.

4.6 EPD Internal Processing & Facilities

This section describes the internal processing performed by the EPD and the facilities provided over the IR communications link.

4.6.1 Memory Characteristics:

Memory Retention:	10-year data retention.
Dose Profile History:	Settable interval from two seconds to 35 hours. Stores transitions of Hp(10) and Hp(0.07) at a resolution of 1μSv. Store for up to 579 records for transitions up to 127 μSv or less.
Dose Store (short term):	Hp(10) and Hp(0.07). Can be reset after each controlled area entry, day, month (etc) by health physics staff or dose management system, according to local procedures.
Total Dose Store:	Separate total dose store.
Special Total Dose Store:	12 entries, e.g. for automatic recording of end of month dose etc.
Event Log:	23 entries for time recording of alarms etc., for incident assessments.
ADS Dose Store:	Approved Dosimetry Service (Record of Dose) dose memory area with password protection.
Peak Dose Rates:	Peak dose rates with time of occurrence.
Storage Times:	1 second resolution.
Alarm Flags:	Various alarm and fault flags.
Timer:	Count-down timer configurable up to 1 hour 39 minutes and 59 seconds (1 second resolution).
Return for Read:	Programmable warning.

4.6.2 Alarm Characteristics:

Alarms:	2 each Hp(10) dose and dose rate alarms 1 each Hp(0.07) dose and dose rate alarms
Dose and Dose Rate Alarms:	0µSv to 16Sv and 0µSv/h to 16µSv/h resolution V 1/64µSv and 1µSv/h Recommended minimum settings to avoid false alarm 7µSv/h Hp(10)/h and 100µSv/h Hp(0.07)/h
Alarm Types:	Audible and visual alarms for dose, dose rate, count-down timer, read time and failure mode. Alarms are configurable via the IR communications link.
Tones:	High/low tones, loud/quiet volume in seven combinations of continuous or fast/slow intermittent.
Hp(10) Dose Chirp:	Settable from 0.01 µSv/chirp to 100 µSv/chirp.

4.6.3 Default Display

The default display is initially factory preset to read Hp (10) (the penetrating or deep dose), or to an alternative default display as specified by the customer. User-selected displays have a time-out period, which can be set between 10 to 99 seconds. This time-out is the period of time that any display selected by the user will stay active before reverting to the default display. The time-out period may be adjusted via the IR communications link. The default display can be changed to any of the displays shown in Figure 3.4, again, via the IR communications link.

4.6.4 User Identification

The EPD retains details relating to the current user and the number of times that the EPD has been issued. Wearer details comprise the user's identification number (i.e. the User ID) and the User Name The User Name can be a string of up to 22 characters. By convention, an un-issued EPD User ID is set to all 'F's (FFFFFFFFFFFF). Typically, a User ID will have fewer than 12 digits, but it must be an integer between 1 and 999999999999. A full description of User IDs is given in Sections 3.5.1 and 3.5.2.

User identification can only be set via the IR communications link.

4.6.5 Dose and Dose Rate

The EPD calculates dose and dose rate. Dose is accumulated in 3 stores: ***Dose***, ***Total Dose*** and ***ADS Dose***. Dose rate is the current rate calculated by the EPD.

Dose

The EPD displays Hp(10) (penetrating or deep) dose and Hp(0.07) (superficial or shallow) dose. ***Dose*** is regarded as a short-term record of dose received, usually associated with the issue of an EPD. It is this value that is compared with dose alarm thresholds and an alarm raised if the value exceeds the thresholds. The EPD records ***Dose, Total Dose*** and ***ADS Dose*** in units of 1/64μSv, although this is displayed as a decimal equivalent. Total Dose is a store providing a long-term record of dose accumulated by the EPD. The LCD display can be set to auto-range between 1μSv to 16Sv (maximum resolution 1μSv).

Accumulated dose is written to non-volatile memory at least every 15 minutes. Therefore is a reset occurs, due to the battery cap being removed or the EPD being heavily dropped, or a passivated battery fitted, up to 15 minutes of accumulated dose may be lost. Such events however are detected and a count of resets provided as quality data associated with the accumulated dose, see section 4.6.7.

Note that from software version 11 EPDs it is possible to configure the EPD to make additional logs to the non-volatile memory at 1 minute intervals if the dose received in the preceding minute exceeds 1 uSv.

Display characteristics that can be set are:

Units	Sv or rem
Decimal Places:	2 or 3 decimal places
Resolution:	μSv or mSv
Default Time:	10 to 99 seconds

Note: For Gamma dose, two counts are approximately equivalent to 1/64μSv and for Beta dose one count is approximately 1/6μSv. To avoid statistical inaccuracies doses should only be displayed in micro sieverts (or 0.1 rem), but when summing a number of doses the full resolution should be used to minimize rounding errors.

Dose Rate

This is the current dose rate as calculated by the EPD. It may be viewed on the display or read via the IR communications link. Dose rates are calculated using an averaging algorithm to reduce statistical variations to within ±20% under most conditions. This results in increased averaging time constants at low dose rates.

Averaging time constants used to calculate penetrating dose rate Hp(10)/h maximise at 60 seconds below 70uSv/h and therefore the statistical errors increase as the dose rate drops below 70uSv/h. Additional processing is used to provide faster response but with reduced accuracy when rapid changes in dose rate are observed. The algorithm is a compromise that reduces statistical errors but gives a fast response time. The dose rate displays on the LCD are limited to 2 significant digits.

Longer time constants have to be used when averaging the beta dose due to the lower sensitivity of the beta detectors. The time constant used maximises at 100 seconds below 1mSv/h. Due to limitations in the processing and memory available, this time constant cannot be reduced when rapid changes are observed, and the Hp(0.07)/h dose rate is approximated as the sum of Hp(10)/h and the beta dose rate. This approximation means that at low gamma energies (below 50 keV) the Hp(0.07)/h dose rate typically under-responds by up to 25% in comparison to the Hp(0.07) dose response. However, above 25 keV the dose rate response remains within ±30% accuracy criteria.

Peak Dose Rate

The highest dose rate calculated by the EPD since this value was last cleared is termed the peak dose rate. The peak dose rates and the times at which these peak rates occur are recorded and can be displayed on the LCD or read over the IR communications link.

Note: Peak dose rate times are stored to 1 second resolution.

4.6.6 Counts

The EPD has four internal counters:

- HG: Hard Gamma
- SG: Soft Gamma
- FB: Full Beta
- BC: Beta Compensating

These record the pulses output by each of the radiation detectors.

The EPD calculates the Hp(10) and Hp(0.07) doses by weighted summing (ratios set during calibration) of the counts received on the four detector channels.

Counts can only be read via the IR communications link, although the least significant digits are visible on the internal counts display (section 3.5).

4.6.7 Dose Quality Flags

There are 7 dose quality flags set within the EPD. Dose quality can only be read and cleared via the IR communications link. They are normally cleared with the dose and detector counters at the start of an Issue period, e.g. by Access Control or Issue/Return software. In 'dose of record' systems, EPD dose, detector counters and quality factors are all read together and stored on the system database to allow later integrity checking of the dose recorded. The dose quality flags are as follows:

(i) Reset Count

The reset count is a count of the number of times the unit has been reset, either by:

(a) removing and re-fitting the battery, or battery cap,

(b) use of an unsuitable or passivated Lithium battery,

(c) by a commanded reset via the IR communications link,

(d) by a software reset,

(e) by a fault condition.

Note that the EPD loses recent dose received since the last log of dose to non-volatile memory, as described in section 4.6.5.

(ii) Knock Time Seconds

The EPD detectors are susceptible to large mechanical shocks. This is overcome by detecting the shock with a piezo 'knock' detector. The EPD continues to accumulate dose during the shock period, but at the dose rate that was present immediately before the knock was detected. However, if the dose rate is greater than approximately 4mSv/h the counts caused by the knock will be small relative to the radiation counts and therefore all counts are used in the calculation of dose. Knock Time is the time period over which knock processing has taken place. Continuous Knock detection for greater than 15 seconds will cause an abuse alarm (see ***Abuse Warning***).

(iii) Dose Over-range

The dose over-range flag indicates that one of the dose stores has exceeded 1Sv (100 rem) . Dose continues to accumulate above this value to a maximum of 16.777215 Sv (1677.7215 rem).

(iv) Dose Rate Over-range

The dose rate over-range flag indicates that the dose rate has exceeded 1Sv/h (100 rem/h) at some time in the past, (i.e. the recorded dose may be inaccurate, probably low, due to non-linearity at high dose rates).

(v) Counter Over-range

The counter over-range flag indicates that at least one detector has exceeded the maximum count rate expected (300,000 counts/second - gamma counters and 26,000 counts/second - beta counters). A possible cause for this flag to set is that the unit has either been exposed to some kind of extreme interference or has developed a fault.

(vi) Abuse Warning

The abuse warning indicates that an abuse alarm has been activated. An abuse alarm is activated if mechanical knocks are detected continuously for greater than 15 seconds (see ***Knock Time Seconds***)

(vii) CRC Failure

The CRC failure flag is set as a result of an integrity check on a set of data indicating that the EPD detected a checksum error in the dose data. Checksum failures are corrected by retrieving the last stored dose from secure store (EEPROM). During the correction process up to 15 minutes of dose may be lost.

(viii) Low Voltage (EPD software version 11 and later)

The EPD analogue circuitry detected a low supply voltage condition.

(ix) Detector Fault (EPD software version 11 and later)

The EPD ‘flash LED’ detector test failed.

4.6.8 Dose And Dose Rate Alarm Processing

The EPD performs alarm processing as described in this section. The occurrence of a dose or dose-rate alarm is recorded by the following internal flags. These flags make it easy for applications s/w to determine over the IR communications link whether an alarm has occurred during an issue period. The flags are therefore normally cleared over the IR communications link at the start of an issue period:

- Three Dose alarm flags indicate that a dose has exceeded the corresponding dose alarm thresholds. There are 1st and 2nd dose alarms for Hp(10) and a single dose alarm for Hp(0.07).

- Three Dose rate alarm flags indicate that a dose rate has exceeded the dose rate alarm thresholds. There are 1st and 2nd dose rate alarms for Hp(10)/h and a single dose rate alarm for Hp(0.07)/h. The dose-rate flags are not cleared automatically when the dose-rate falls below the reset threshold.

The 2nd alarm threshold (dose or dose rate) always has a higher priority than the 1st alarm threshold. The 1st alarm threshold can be considered as a warning value and the 2nd alarm threshold as a critical value. Therefore, the 2nd alarm threshold should always be set to the higher value.

Dose rate alarms can be configured to work with hysteresis. That is, the Hp(10)/h 1st and 2nd dose alarms and the Hp(0.07)/h dose rate alarm are each provided with separate ON and OFF thresholds. When the dose rate equals or exceeds the alarm ON threshold the EPD will set an alarm flag and the sounder will sound and the LED flash (if enabled). The alarm is self-cancelling when the dose rate falls below the alarm OFF threshold, but the alarm flag remains set.

Alarm thresholds are set via the IR communications link, or by the button if the user is granted authority (see Figure 3.4), to any value in the following ranges:

1st & 2nd Hp(10)/h	0μSv/h to 16.777215 Sv/h
Hp(0.07)/h	0μSv/h to 16.777215 Sv/h
1st & 2nd Hp(10)	1μSv to 16.777215 Sv
Hp(0.07)	1μSv to 16.777215 Sv

It is not recommended to set dose rate alarms to less than 7uSv/h (Hp10)/h or 100μSv/h Hp(0.07)/h as the statistical errors on the dose rate reading at these levels will be greater than ±50%, and false alarms may occur in normal background radiation conditions.

4.6.9 EPD Operating Status

The EPD retains information regarding its status. EPD status can only be read via the IR communications link. Status information provided is:

- EPD Run Times
- EPD State
- Alarms
- Warnings
- Faults
- Event history

EPD 'Run' and Off times

The EPD contains an accurate clock (±30 ppm) and records the elapsed time, both for operating (Run Time) and in 'OFF' Mode. Times are recorded to a resolution of 1 second. The OFF time is the number of seconds that the detectors have been switched off (while the power has been present).

Note: When power is removed, or a reset occurs, the EPD clock reverts to a value of up to 15 minutes prior to its value on power loss or reset.

EPD State

The EPD retains a record of the following information:

1. **Issue Count**. This is the number of times the EPD has been issued.
2. **Issued**. This is the present state of the issued flag, either EPD Issued or EPD Not Issued.
3. **Detectors State**. This is the current state of the EPD's operating mode, i.e. ON or OFF.

Alarms

The EPD retains a record defining which of the following alarms has occurred. The record is normally cleared by system software at the start of an issue period:

1. **3 Dose Alarm Flags** As section 4.6.8
2. **3 Dose Rate Alarm Flags**. As section 4.6.8
3. **Return For Read**. The EPD clock has exceed the Return For Read time.

Faults

The EPD retains a record of the following faults flags:

1. **Event Logged**. An event (possibly but not necessarily a fault) has been logged in the EPD's event store.
2. **Connection Failed**. Communication with the EPD failed.
3. **Cal Factors Bad**. The EPD calibration factors failed a CRC check and cannot be recovered from secure store.
4. **EEPROM Fail**. An un-recoverable EPD secure store failure occurred.

5.	**Bad Sectors**.	The number of bad EPD secure store sectors. There is a maximum of nine spare sectors.
6.	**Detector Test Fail**.	The EPD detector test was run and the number of counts received were less than required to pass the test.
7.	**Detector Threshold Fail**.	The EPD detector thresholds failed to load successfully
8.	**Radio Fail**.	Reserved for future use.
9.	**Other Fault**.	A fault occurred causing the EPD to reset.
10	**Disabled**.	The EPD is not calculating dose.

4.6.10 Dose Profile

The EPD stores Hp(10) and Hp(0.07) dose to a resolution of 1μSv in non-volatile store so that a profile of the dose over time can be recreated. The interval between stores is set-up via the IR communications link.

Both Hp(10) and Hp(0.07) dose information is stored as a dose profile, the minimum interval between entries in the dose profile is adjustable between 2 seconds to 35 hours, in 2 second intervals. The store holds up to 579 records for transitions up to 127 μSv or less.

Note: A dose profile interval of zero seconds turns off the dose profile function.

Dose profile can only be read via the IR communications link. Dose profile may be synchronised to a particular time in the future, e.g. hourly logging on the hour.

Note: The EPD has no concept of real-time but maintains a one-second tick that is valid as long as the EPD is powered and not reset.

4.6.11 Event History Store

The EPD logs up to 23 events in non-volatile store, together with a time stamp. These comprise alarm and fault events see tables 4.1 and 5.2. From software version 11, EPD ON and OFF events are also recorded (see Table 4.1).

Note: The Event History time store wraps round after 194 days of operation. After this time previous event-associated day/date(s) cannot be considered as accurate. In addition elapsed time during loss of power is not recorded.

Events On

Code	Text as displayed by EasyEPD2
200	Failure Alarm on
201	Over Range Alarm on
202	Hp10 Dose Alarm 2 on
203	Hp07 Dose Alarm on
204	Hp10 Dose Alarm 1 on
205	Hp10 Rate Alarm 2 on
206	Hp07 Rate Alarm on
207	Hp10 Rate Alarm 1 on
208	Battery Alarm on
209	Return for read Alarm on
210	Count Down Alarm on
211	Abuse Alarm on
219	Detectors ON*

* Version 11 and later software only

Events Off

Code	Text as displayed by EasyEPD2
220	Clear Faults
221	Over Range Alarm off
222	Hp10 Dose Alarm 2 off
223	Hp07 Dose Alarm off
224	Hp10 Dose Alarm 1 off
225	Hp10 Rate Alarm 2 off
226	Hp07 Rate Alarm off
227	Hp10 Rate Alarm 1 off
228	Battery Alarm off
229	Return for read Alarm off
230	Count Down Alarm off
231	Abuse Alarm off
239	Detectors OFF*

Other Events

Code	Text as displayed by EasyEPD2
240	Power Converter Switched On
241	Power Up Cold Start
242	Power Up Warm Start

Table 4.1 (3 parts) EPD Events logged to the Event History Store.

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SECTION 5

EPD FAULTS and RECOVERY ACTIONS

5.1 Overview

This section identifies the fault conditions that can occur and describes the recovery procedure (if any) to be taken to restore the EPD to operational use.

The section is organised as follows:

1. Fault indication via sounder, alarm Led, LCD.
2. Internal logging of fault conditions.
3. Blank display and other “uncontrolled” faults.
4. Communications Error over the IR link.
5. LCD Display error codes.
6. Recovery Procedures.

5.2 Visual and Audible Fault Indication

An EPD failure is usually indicated by a visual and audible alarm. In most instances the EPD will display an error code on the LCD and the LED will flash. The default audible alarm is as follows:

Alarm rate: —— —— —— —— **slow intermittent rate**

If alarm mute is enabled for the fault alarm the sounder can be silenced and the alarm Led extinguished by the action of pressing and holding the button. The fault alarm can also be set to self mute after a timeout period in order to preserve battery life. If this happens the unit will give a short sound every 30 seconds thereafter.

An EPD conveys faults to the user by a number of displays, e.g.:

- Initialisation Error (−−−− on the LCD)
- Communications Error (≡≡≡≡ on the LCD)
- Error Code (Fxxx on the LCD)
- Blank Display
- Other faults (e.g. display lock-up, no heartbeat etc.)

5.3 Internal Logging of Fault Conditions

5.3.1 EPD Status Faults Record

The EPD logs data to an internal data record in EEPROM, to indicate that faults have occurred. These faults are as follows:

1. **Event Logged**. An event (dose alarm or a fault) has been logged in the EPD's event history store.
2. **Communication Error**. Communication with the EPD failed, typically the unit was removed from the IR media prematurely.
3. **Cal Factors Bad**. The EPD calibration factors failed a CRC check and cannot be recovered from secure store.
4. **EEPROM Fail**. An un-recoverable EPD secure store failure occurred.
5. **Bad Sectors**. The number of bad EPD secure store sectors. There is a maximum of nine spare sectors.
6. **Detector Test Fail**. The EPD detector test was run and the number of counts received were less than required to pass the test.
7. **Detector Threshold Fail**. The EPD detector thresholds failed to load successfully
8. **Radio Fail**. Reserved for future use.
9. **Other Fault**. A fault occurred causing the EPD to reset.
10. **Disabled**. The EPD is 'Off' (not calculating dose).

This data may be read and cleared via the IR communications link & EasyEPD2.

5.3.2 Event History store

The EPD logs up to 23 events in a non-volatile store, together with a time stamp. The Event History store is accessible when the EPD is interrogated over the IR communications link (e.g. by ***EasyEPD2)***. Alarm and fault events are recorded, see Tables 4.1 and 5.2.

The store comprises a circular 'buffer', the latest event over-writing the oldest.

Note: The date/time data field wraps round after 194 days of operation. After this time previous event-associated day/date(s) cannot be considered as accurate. In addition elapsed time during loss of power is not recorded.

5.3.3 Dose Quality Factors

A number of faults and events are counted and recorded in association with the measured dose. They are zeroed when the dose is zeroed and are subsequently read with the dose. These are referred to as the dose quality factors and are described in section 4.6.7. Non-zero dose quality factors imply that there may be an error in the dose reading due to the way the product has been used, rather than due to a fault within the unit. For example, the battery cap may have been used or a passivated battery fitted, causing a reset and potentially lost dose.

5.4 Blank LCD Display and Other Faults

It may also be possible for the EPD to fail without producing or displaying an error code, or causing an alarm, for example due to failure of the micro-controller or digital circuit. A list of such faults and the recommended course of action is given in the table below.

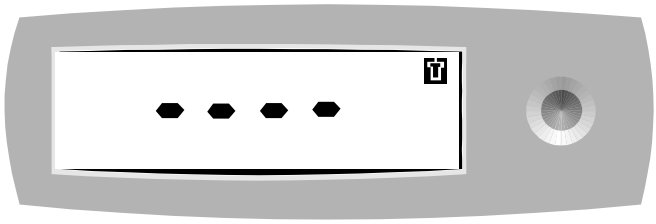
Symptom	Likely Cause	Recommended Action
Blank Screen Nothing displayed on the LCD, not even 'Heart Beat' indication	Battery Failure	♦ Attempt to communicate with the EPD via the IR communications link to prove diagnosis. ♦ Remove old and Insert new battery and restart unit- see section 2.1.2. ♦ Communicate with the EPD via the IR communications link to access stored data.
Nothing displayed after battery is inserted/ replaced.	Battery cap not corrected seated or battery out of specification	♦ Remove and replace battery cap (see Section 2.1.2). ♦ Use a recommended battery.
Static Screen 'Heart Beat' indication not flashing	1 second timer error	♦ Attempt to communicate with the EPD via the IR communications link. ♦ Replace battery and restart unit- see section 2.1.2. ♦ Communicate with the EPD via the IR communications link to access stored data. ♦ If there is still no 'Heart Beat' contact supplier.
Faulty Button Cannot mute alarm using button	Muting Disabled	♦ Communicate with EPD via the IR communications link. ♦ Clear alarm conditions. ♦ Enable muting if required.
No response to button	Hardware fault	♦ Communicate with the EPD via the IR communications link to access stored data. ♦ Contact supplier.
Faulty Sounder No audible alarm during Confidence Test	Hardware fault	♦ Contact supplier.
Sound fails to operate in alarm condition	Sounder Disabled	♦ Enable sounder if required

Faulty LED No visual alarm during Confidence Test LED fails to operate in alarm condition	Hardware fault LED Disabled	♦ Contact supplier. ♦ Enable LED if required
Faulty Display Missing or additional segments on LCD display	Hardware fault	♦ Confirm fault by running a CONFIDENCE TEST ♦ Contact supplier.

Table 5.1 - Blank LCD & other faults

5.5 Initialisation Error (LCD - - - -)

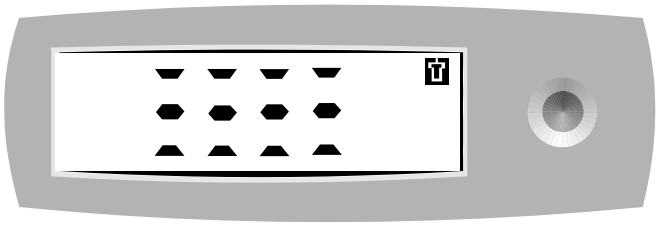
A series of single dashes appearing on the LCD display indicates an initialisation error following a reset or battery change:



Initialisation errors typically refer to corruptions to data in the EPD's non volatile memory (EEPROM). These are faults the user cannot usually repair. Follow the procedures defined in section 8 to extract data and to recover normal operation where possible.

5.6 Communications Error (LCD ≡≡≡≡)

A series of triple dashes appearing on the LCD display indicates a communications error:



This condition usually occurs when a data write operation fails to complete. The typical cause is that the EPD unit is removed from the IR field before a critical write operation has completed, for example an Issue of the EPD to a person.

The error (which is accompanied by an audible alarm) alerts the user that the EPD is not in a valid operational state. However as described above, the cause is a user / operational problem and not a fault in the EPD.

An EPD will only raise this condition if it is first triggered by the system software, in effect a message is passed to the EPD saying: "raise an alarm if the following write operations don't complete successfully within 'N' seconds." If the condition does occur then it is necessary to train the users not to remove the EPD from the

IR field until indicated (i.e. by the system, through displays, Leds etc.). However the EPD communications software is tolerant of short duration loss of connection.

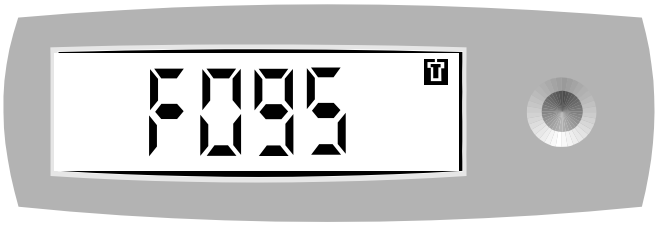
If the condition does occur it is normal for system software to clear the alarm and LCD display automatically when the EPD is re-presented to the IR media. The system software then checks the status of the EPD, completes any necessary data write operations, advises the user what to do, and clears the alarm. The display then returns to normal.

If the condition arises regularly then this may indicate a problem in the design of the system software, i.e. the user interface.

If the user or system fails to clear the alarm in the way described above, then the condition can easily be cleared using EasyEPD2.

5.7 LCD Display Error Codes

Faults that exhibit a known condition are normally indicated on the EPD LCD as 'F' followed by a 3-digit error. The error code number is also logged in the Event History store, with date/time data. As an example the following shows fault F095:



A list of EPD error codes is given in Table 5.2. They are divided into blocks according to the software module that generates them.

Epd Action
This describes what the EPD does in addition to attempting to display the fault and record the fault in the event history store.

5.8 Recovery Procedures

5.8.1 Logging Faults / Extracting Data

All faults other than the communications error described in section 5.6 should be logged using the standard Form in the Appendices. This form may be used to log single or multiple faults. The completed form should be copied to the supplier of the EPD (Thermo or other supplier / Distributor).

If the unit is in operational use it is recommended that as much fault and operational data as possible is extracted from the unit, via the LCD and using EasyEPD2. The extent that this is possible will depend upon the nature of the fault. Note that for many faults button/display operation and IR communications are unaffected. This includes many Fxxx codes displayed on the LCD. Data should be extracted and logged as follows:

1. Display fault code or indication (Fxxx, ----).
2. Internal faults logged in the EPD Status Faults record.
3. Contents of internal Event History store.
4. Dose and peak dose-rate/time data (if a spurious dose fault is suspected).
5. Dose profile data (if a spurious dose fault is suspected).

Where possible the data should be obtained as screen dumps from EasyEPD2 and attached to the completed Fault Log Form (Appendix D).

If a faulty unit is to be returned to Thermo it must be returned in a fully decontaminated and reasonably clean condition. The battery must be removed but kept with the unit. The date of installation of the battery should be marked on the battery.

5.8.2 Clearing faults

The steps required to clear a fault are as follows:

1. Extract data and fault information and complete a Fault Log Form, Appendix D.

2. Identify the fault type in Tables 5.1 or 5.2 and take the recommended action. This will range from resetting the unit (removing, then replacing the battery), to returning the unit to the supplier (Thermo or other Supplier or Distributor).

3. If the unit is to be restored to operational use, clear down all faults on display and in the Fault Status Record, using EasyEPD2. This is to ensure that any subsequent faults are detected.

Control Module

Code	Text as displayed by EasyEPD2	EPD Action	Recommended Customer Action	Remarks
010	Control Module Error - Critical	Comms only	Reset unit. Return to supplier if recurs.	More than 2 consecutive resets. Cause of reset to be identified.
011	Control Module Watchdog Timed Out	Reset	-ditto-	S/W processing fault, possibly micro-controller fault.
012	Control Module CRC Failure		Return to supplier.	Supplier to re-initialise EPD EEPROM and re-calibrate
013	Control Module RAM Failure	Halt	Reset unit. Return to supplier if recurs.	Only runs from self-test, typically every 15 minutes. Other problems may well occur before this time.
014	Control Module Stack Overflow	Reset	-ditto-	Only runs from self-test, typically every 15 minutes. Other problems may well occur before this time.
015	Control Module Asic Fault	Halt	Return to supplier.	This test performs a read/write test on the digital ASIC. Unrecoverable — other knock on errors may occur. Replace ASIC
016	Control Module Unexpected Battery Low	Logged in Event Store	Return to supplier if occurs regularly. **See Note 1 below.**	Texas chip has flagged bat low or has reset and (Power converter is off and no reset)

Note 1. This fault can occur when the battery cap is fitted if intermittent contact occurs. In this event remove the battery cap, wait at least 10 seconds, then fit the battery cap again.

Comms Module

Code	Text as displayed by EasyEPD2	EPD Action	Recommended Customer Action	Remarks
020	Comms Module Error			Reserved for future use

Services Module

Code	Text as displayed by EasyEPD2	EPD Action	Recommended Customer Action	Remarks
030	Service Module stCalData CRC faulty		Reset unit. Return to supplier if recurs.	
031	Service Module stRateThres CRC faulty		Reset unit. Return to supplier if recurs.	
032	Service Module stDoseThres CRC faulty		Reset unit. Return to supplier if recurs.	
033	Service Module stDoseSummary CRC faulty		Reset unit. Return to supplier if recurs.	
034	Service Module stAdsData CRC faulty		Reset unit. Return to supplier if recurs.	
035	Service Module Seconds Timer Array overflow	Reset	Reset unit. Return to supplier if recurs.	This indicates a software fault.
036	Service Module Fine Timer Array overflow	Reset	Reset unit. Return to supplier if recurs.	This indicates a software fault.
037	Service Module Long Timer Array overflow	Reset	Reset unit. Return to supplier if recurs.	This indicates a software fault.

User I/F Module

Code	Text as displayed by EasyEPD2	EPD Action	Recommended Customer Action	Remarks
040	User Interface Module Error			Reserved for future use

Sounder Module

Code	Text as displayed by EasyEPD2	EPD Action	Recommended Customer Action	Remarks
050	Sounder Module Error			Reserved for future use

EEPROM Module

Code	Text as displayed by EasyEPD2	EPD Action	Recommended Customer Action	Remarks
060	EEPROM no more spare sectors available	Write aband oned.	Return to supplier	All 9 spare sectors have been used. This fault is unlikely to occur in normal operation. Tests have shown that the EEPROMs are very resilient (> 1 million bit toggles).
061	EEPROM bad sector, requested sector number is invalid		Return to supplier	This fault is unlikely to occur.
062	EEPROM bad sector access table entry (number is invalid)		Return to supplier	This fault is unlikely to occur, Sector Access Table is corrupted or EEPROM read failed
063	EEPROM could not read from the sector access table area		Return to supplier	Executes a Deferred Log Fault with RECOVERED option with the given fault code but only if the EEPROM fail bit is not set. If the EEPROM fail bit is set the fault is ignored to stop the error store being flooded with EEPROM faults.
064	EEPROM could not read the next entry		Return to supplier	-ditto-
065	EEPROM could not reallocate data to a good sector		Return to supplier	-ditto-
066	EEPROM could not write next entry		Return to supplier	-ditto

Data Module

Code	Text as displayed by EasyEPD2	EPD Action	Recommended Customer Action	Remarks
070	Data Module Error			Reserved for future use

Counts Module

Code	Text as displayed by EasyEPD2	EPD Action	Recommended Customer Action	Remarks
081	Unexpected Texas chip reset (Battery Low but no Batt Low Status)		Reset unit. Return to supplier if recurs.	No Longer Used
082	Consecutive Drop (more than 15 seconds)			No Longer Used
083	Counts not latched yet no drop occurred	Reset into comms mode only — counts processing disabled.	Return to supplier	ASIC or interface to ASIC may be faulty. The only reason to not-latch the counts would be that a knock has occurred.
084	Counts Processing time inconsistent	Reset	Reset unit. Return to supplier if recurs.	Unlikely to occur unless clock overflows. This is not possible unless clock is written with new value or incremented at wrong rate.
085	Count too large (HG or SG > 300,000) or (FB or BC > 26,000)	Reset	- Ditto -	This fault can occur by inputting a very large number of counts (only possible under test conditions or severe interference).
086	Detector threshold load failed	Reset into comms mode only — counts processing disabled.	Reset unit. Return to supplier if recurs.	Texas chip or associated circuits may be faulty.
087	A calibration value is out of range	Counts processing disabled	Return to supplier	Display will indicate dashes, but error code can be extracted from error log. An error status bit is also set. This fault will be picked up on power-up, writing cal. factors or thresholds, or switching from OFF to ON mode.
088	Abuse alarm (more than 15 consecutive seconds of knocks)	None-continues normal processing	Clear with EasyEPD. Return to supplier if recurs when unit not knocked.	Check knock detector

Code	Text as displayed by EasyEPD2	EPD Action	Recommended Customer Action	Remarks
090	Hard Gamma detector fail*	None- continues normal processing	Reset unit. Return to supplier if recurs.	Only the first detector to fail is logged.
091	Soft Gamma detector fail*	None- continues normal processing	-ditto-	-ditto-
092	Full Beta detector fail*	None- continues normal processing	-ditto-	-ditto-
093	Beta Compensating detector fail*	None- continues normal processing	-ditto-	-ditto-
094	CRC error - Dose Alarm Thresholds	Logs fault and performs reset without doing log first. This means that good data is read back from the EEPROM. For the ADS and Dose data, the QF bits are also set. This is done by reading the data from EEPROM, setting the bit, calculating the new checksum, restoring the data to EEPROM and then doing a reset. The correct values will then be restored on program restart.	Reset unit. Return to supplier if recurs.	Indicates corruption of data in RAM. Up to 15 mins of dose could be lost.
095	CRC error - Rate Alarm Thresholds	-ditto-	-ditto-	-ditto-
096	CRC error - ADS Data	-ditto-	-ditto-	-ditto-
097	CRC error - Calibration Factors	-ditto-	-ditto-	-ditto-
098	CRC error - Dose Data	-ditto-	-ditto-	-ditto-

* only the first detector to fail is logged

IRDA Module

Code	Text as displayed by EasyEPD2	EPD Action	Recommended Customer Action	Remarks
100	IRDA Module Error			Reserved for future use

Table 5.2 EPD Faults Logged to History Event Store.

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SECTION 6

MAINTENANCE

This section describes the maintenance that may be required for the EPD. Maintenance is limited to general cleaning, removing/replacing the EPD battery and removing/replacing the EPD clip assembly. Limited maintenance can also be carried to clear fault conditions and check the functionality of the EPD.

6.1 Calibration

The EPD is calibrated by a highly sophisticated automatic system consisting of several radioactive sources. Calibration is performed during manufacture and is expected to remain unchanged throughout the life of the EPD - provided the EPD remains undamaged.

Thermo normal policy is to supply EPDs with the calibration factors locked to prevent their subsequent modification, other than by Thermo. However where expressly requested by customers in their purchase order, EPDs may be supplied with the calibration factors in the unlocked sate. This is to enable such customers to modify the calibration of these EPDs. In such cases the customers attention is drawn to the following Disclaimer:

DISCLAIMER

The EPDs within this shipment have been calibrated using the factors as defined on the supplied Calibration Certificate. As the calibration is NOT LOCKED Thermo has no control over any subsequent adjustments made by the end user to these factors. Thermo can therefore not warrant the calibration of these EPDs once they have left the factory. As such, Thermo accepts no liability for the accuracy of the radiological response of these EPDs.

EPD calibration may be checked using a Thermo irradiator, or by exposure to a known radiation field, in a manner approved by the appropriate regulating authority or local rules. It is recommended that calibration is checked annually.

A change in EPD calibration is usually indicative of a fault in the EPD and, due to the complexity of achieving calibration over the full energy range, it is recommended that any EPDs that fail calibration checks are returned to Thermo for repair, recalibration or replacement.

During calibration the calibration constants, and the threshold levels for each of the four channels are set. The threshold levels determine the minimum pulse size that will be considered a "count". The calibration constants ensure that the channels are combined in the correct fashion to give correct dose readings.

Calibration Constants. Calibration constants convert the counts accumulated on the four detector channels into dose equivalents. These constants are:

HGSens10

SGSens10

HGSens07

SGSens07

FBSens07

BCSens07

Where EPDs are provided with calibration in the unlocked state (see above), it is these six factors which may be adjusted within the defined percentages from the manufacturers original calibration. These ‘gain’ adjustments are made using software facilities available via Thermo Electron but should only be considered in consultation with Thermo.

Detector Thresholds. Detector thresholds discriminate between radiation pulses received by the EPDs detectors. These thresholds are set as course and fine values measured as:

Hard Gamma (HG)

Soft Gamma (SG)

Full Beta (FB)

Beta Compensating (BC)

From software version 11 the detector thresholds were changed to improve the precision and accessible range. No facilities are provided to adjust the detector thresholds and these can only be set by the manufacturer.

EPD calibration may be checked using a Thermo irradiator, or by exposure to a known radiation field, in a manner approved by the appropriate regulating authority or local rules. It is recommended that calibration is checked annually.

A change in EPD calibration is usually indicative of a fault in the EPD and, due to the complexity of achieving calibration over the full energy range, it is recommended that any EPDs that fail calibration checks are returned to the manufacturer for repair or replacement.

6.2 The EPD Battery

The EPD can use either a Lithium Thionyl Chloride (LTC) 3.6 V battery or a standard 1.5 V AA battery (see Section 4.2). A battery change is within the scope of any competent user. However, care must be taken when replacing the EPD battery (see Section 6.2.3).

If the EPD is to be stored for a prolonged period of time the EPD battery should be removed. There is no definitive battery installation period. The best philosophy to adopt is: *if in doubt - remove the battery*.

6.2.1 Replacement Batteries

Replacement batteries must be suitable for installation into the EPD. On no account must excessive force be used to insert the battery into its compartment. The following are recommended replacement batteries:

Sonnenschien - Lithium 3.6 V (SL-760)

Duracell/Procell - Alkaline 1.5 V (MN 1500)

Other AA batteries may be suitable, but Thermo should first be consulted, especially in the case of Lithium batteries. The user is also advised that:

1. The length of the battery including the battery anode (pip) should be in the range of 49.0 mm to 51.0 mm.
2. The diameter of the battery should be in the range of 13.9 mm to 14.6 mm.
3. The diameter of the anode pip should be less than 5.7 mm. The battery compartment has a feature to prevent reverse connection of the battery, and an anode pip of more than 5.7mm diameter may fail to connect.
4. Battery life may differ from specification.

Detailed procedures for inserting/replacing the EPD are given in Section 2.1.2.

6.2.2 Battery Leakage

Batteries that become expended should not be left in the EPD as they may leak, especially LTC batteries. Batteries should also be removed from any EPD that is going to be left non-operational for any length of time to avoid the possibility that leakage may occur and damage the EPD.

6.2.3 Lithium Thionyl Chloride Battery Warning

Lithium Thionyl Chloride (LTC) (Sulphurous Oxychloride, $SOCl_2$) batteries are potentially dangerous and can be harmful. The following warnings are to be observed when inserting/replacing the EPD battery.

WARNING
Lithium Thionyl Chloride Batteries

1. Lithium Thionyl Chloride battery contents are potentially toxic, flammable and explosive.

2. Lithium Thionyl Chloride batteries should not be:

- ♦ short circuited or charged under any circumstances.
- ♦ used in excess of +70°C and never exposed to temperatures in excess of +100°C.
- ♦ opened, punctured, crushed or tampered with.

3. Batteries in storage should be kept in an isolated, dry, well ventilated cool environment and kept out of direct sunlight. Storage temperatures should be below +30°C.

4. Batteries are susceptible to fire and abuse. Some manufacturers provide batteries with a safety vent, which allows a controlled release of electrolyte if these conditions prevail. If the EPD has been damaged in a manner that could affect the battery, care must be exercised during battery replacement. The battery may have vented into the EPD case and caused the EPD to become pressurized.

5. Electrolyte leakage can normally be detected by the smell of sulphur dioxide and/or the presence of electrolyte solutes. If a leakage is suspected:

   (i) the battery should be removed from the EPD using protective clothing, gloves, and goggles.

   (ii) the battery should be placed in a self-sealing polythene bag (or equivalent) and disposed of in the correct manner (see below).

   (iii) Wash with copious amounts of water any areas that come into contact with the electrolyte, especially the skin. Seek medical advice if electrolyte comes in contact with the eyes.

6. Batteries must be disposed of in accordance with the manufacturer's recommendation and Local/National regulations.

7. If LTC batteries are to be transported by aircraft the batteries must be in their correct packaging.

6.2.4 Replacing the EPD Battery

The EPD is fitted with either a security type (tamper-proof) battery cap or a coin-release battery cap, depending on customer requirements. The security type battery cap helps to prevent unauthorised removal of the cap and requires a special tool (see Section 2, Figure 2.2). During fitment of the battery cap the EPD will begin its initialisation sequence. This is intentional and performs the function of EPD start-up. The procedure to replace/insert an EPD battery is described in Section 2.1.2. The initialisation/start-up sequence is described in Section 2.1.3.

6.3 EPD Clip Assembly

Depending on customer requirements, the EPD may (or may not) be fitted with a clip assembly. The clip assembly comprises a lanyard plate and a spring clip, which allows the user to attach the EPD to an outer garment (see Section 2.1.6). The clip assembly is attached to the EPD by the lanyard plate. The lanyard plate slots into a recess in the EPD case (see Figure 6.1). Retaining lugs secure the lanyard plate in position.

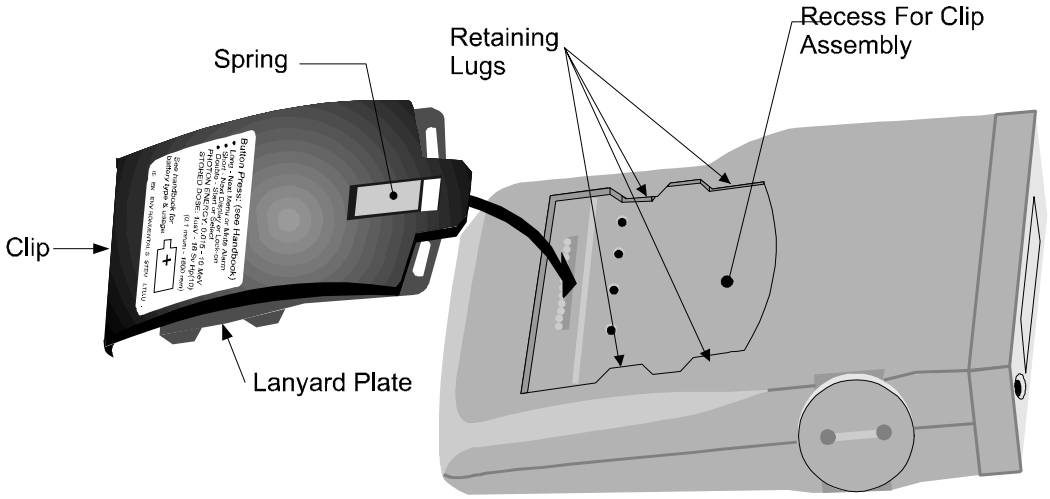


Figure 6.1 - EPD Case Clip Assembly Recess

The lanyard plate may not be fitted with the spring clip (again depending on customer requirements) (see Figure 6.3). This makes the unit more comfortable to wear with the lanyard, when the clip is not required. If the EPD is shipped with the spring clip fitted to the lanyard plate it should be considered as an integral item. Removal of the clip from the lanyard plate is not recommended.

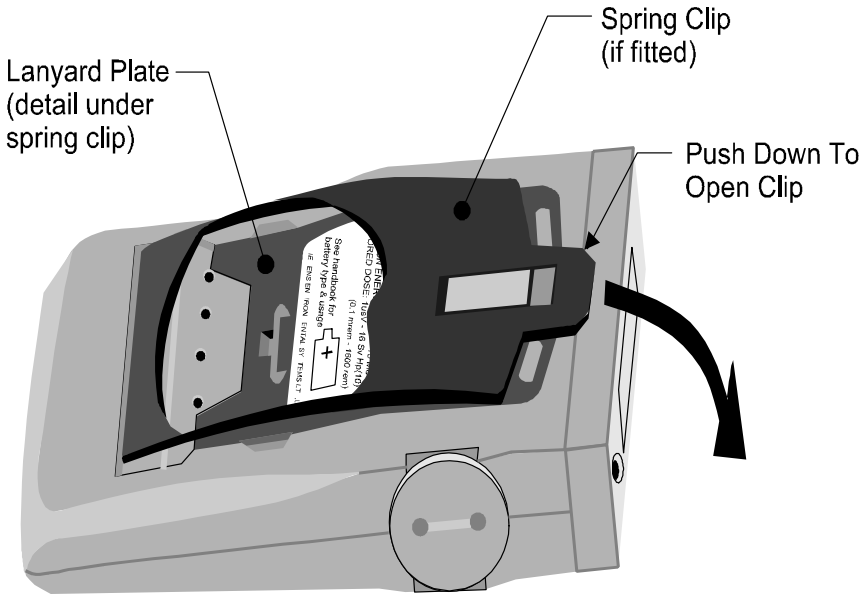


Figure 6.2 - EPD With Clip Assembly

6.3.1 Removing the EPD Lanyard Plate/Clip Assembly

To remove the lanyard plate/clip assembly, proceed as follows:

1. If the spring clip is fitted to the lanyard plate, open the jaws of the clip by pushing downwards (see Figure 6.2) to give access to the lanyard plate. A view of the lanyard plate (spring clip removed) is shown in Figure 6.3. Note the tang on the lanyard plate (it is not necessary to remove the spring clip from the lanyard plate in order to gain access to the tang).

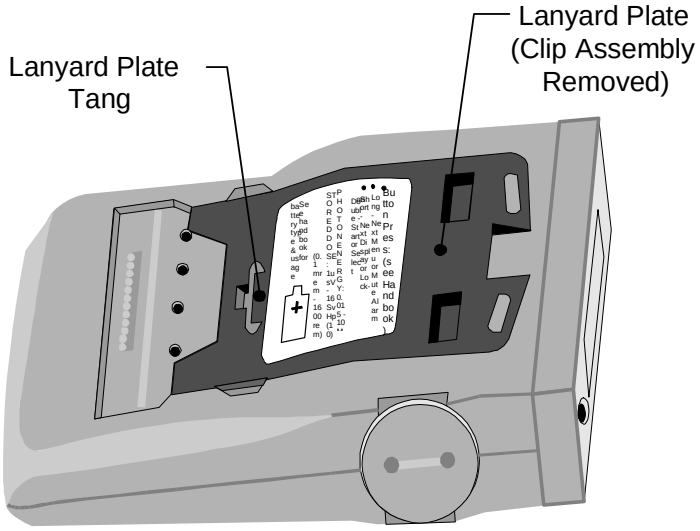
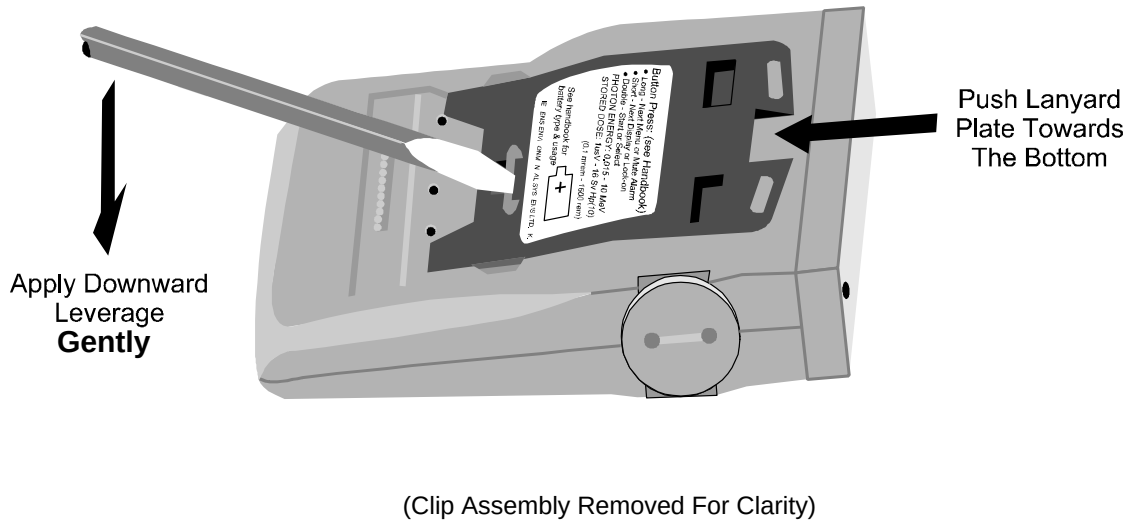


Figure 6.3 - EPD With Lanyard Plate

2. Insert a screwdriver, with a blade width of 3 to 4 mm, under the lanyard plate tang and apply **gentle** downward leverage on the screwdriver (see Figure 6.4). At the same time, push the lanyard plate towards the bottom of the EPD so as to disengage the lanyard plate from the retaining lugs. Remove the lanyard plate.



(Clip Assembly Removed For Clarity)

Figure 6.4 - Removing The EPD Lanyard Plate/Clip Assembly

6.3.2 Replacing The EPD Lanyard Plate/Clip Assembly

Set the lanyard plate into the recess on the rear of the EPD body. This will be found to be much easier if the clip and lanyard plate is kept slightly open using a suitable small separator. The plate should sit with its lugs in the lug recesses. Push the plate towards the top of the EPD (LCD end), ensuring that the retaining lugs engage in position in the clip assembly recess. Check that the lanyard plate is locked in position (the plate remains in position when the assembly is pushed towards the bottom of the EPD).

6.4 Cleaning

The EPD is a sealed unit and has protection against dust and low pressure jets of water from all directions. The unit will not withstand prolonged immersion under pressure. Cleaning should be carried out if the unit requires general cleaning, if the EPD battery has leaked or if the unit has come into contact with radioactive contamination.

6.4.1 General Cleaning

The unit should be cleaned with warm soapy water. Use a neutral water-based detergent, other detergents may damage or attack the EPD's outer plastic coating. A small brush should be used to clean any crevices in the case moulding. After cleaning dry the EPD with a soft cloth. During cleaning, water may enter the alarm sounder aperture. The sounder aperture is watertight, although water ingress may deaden the alarm. Any water should be shaken or blown out of the sounder aperture to restore the alarm noise level.

6.4.2 Radiological Cleaning

WARNING

DURING OPERATIONAL USE THE EPD MAY BECOME EXPOSED TO RADIOACTIVE CONTAMINATION. THE EPD MUST BE SUBJECT TO ALL RELEVANT DECONTAMINATION PROCEDURES LAID DOWN BY THE RADIOLOGICAL PROTECTION AUTHORITY.

If radioactive deposits are present the unit should be decontaminated by carefully wiping it over using a disposable cloth or tissue dampened with a detergent solution and a small brush as described above, or alternatively by using a disposable 'sticky wipe rag'. The unit should afterwards be checked with a sensitive radiation monitor to ensure satisfactory decontamination has been achieved.

6.4.3 Cleaning after a Battery Leakage

Any leakage of the EPD battery must be treated with extreme caution. In most instances battery leakage will be confined within the EPD battery compartment. Minor leakage (light smearing) may be removed with a proprietary cotton bud moistened with a water-based detergent. However, if doubt exists as to the extent of the leakage the EPD should be considered as unusable and the manufacturer contacted for advice.

6.4.4 Periodic Cleaning

The EPD should be cleaned by wiping it over periodically with a cloth lightly dampened with a solution of water and up to 5% of a neutral water-based detergent.

APPENDIX A

RADIOLOGICAL SPECIFICATIONS

The following specifications quoted apply under standard conditions of 20°C.

Energy response

♦	Photon Hp(10)	±50% 15keV to 17keV (Ref. Cs-137) ±20% 17keV to 1.5MeV (Ref. Cs-137) ±30% 1.5MeV to 6MeV (Ref. Cs-137) ±50% 6MeV to 10MeV (Ref. Cs-137)
♦	Photon Hp(0.07)	±30% 20keV to 6MeV (Ref. Cs-137) ±50% 6MeV to 10MeV (Ref. Cs-137)
♦	Beta Hp(0.07)	±30% 250keV to 1.5MeV average beta energy (ref: Sr-90)

Angular response

♦	Hp(10) Cs-137	±20% up to ±75°
♦	Hp(10) Am-241	±50% up to ±75°
♦	Hp(0.07) Sr-90	±30% up to ±55°

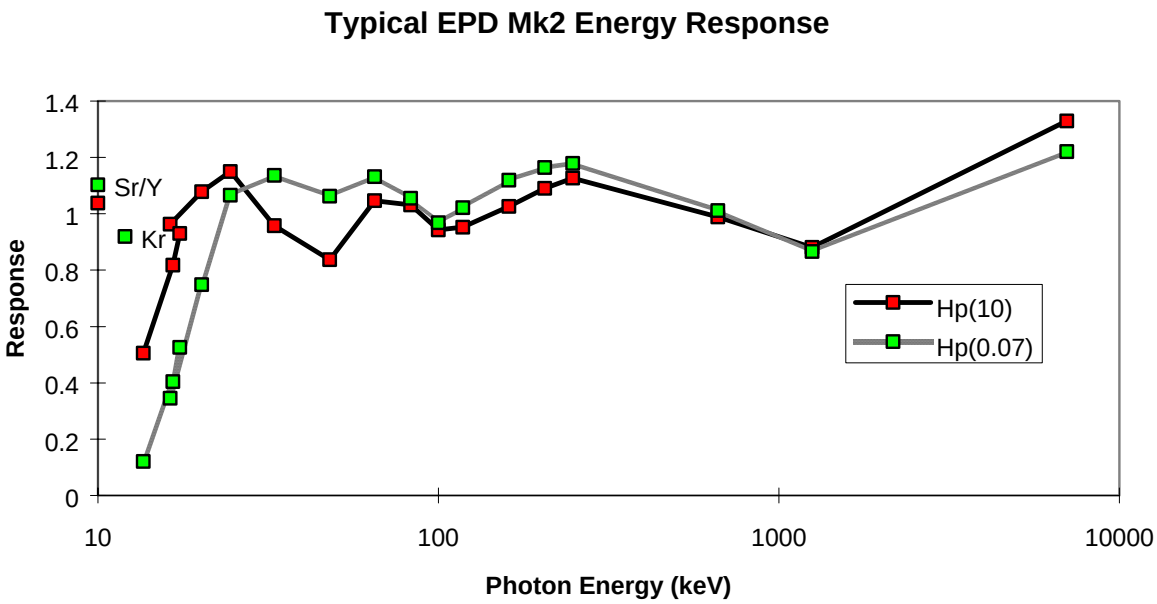
Accuracy

♦	Hp(10) Cs-137	±10%
♦	Hp(0.07) Sr-90	±20%

Dose rate linearity

♦	Hp(10) Cs-137	±10% <0.5Sv/h ±20% 0.5Sv/h to 1Sv/h ±30% 1Sv/h to 2Sv/h
♦	Hp(0.07) Sr-90	±20% <1Sv/h

APPENDIX A


Typical EPD Mk2 Energy Response
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Response
Sr/Y
Kr
Hp(10)
Hp(0.07)
10
100
1000
10000
Photon Energy (keV)

APPENDIX B

ELECTROMAGNETIC COMPATIBILITY

Standard Test

The EPD was tested to the following specification with no failures:

Test Type	Specification	Test	Frequency Range	Level	Notes
Radiated Susceptibility E-Field	Mil Std 461D	RS103	10kHz – 40 GHz	200V/m	
Radiated Susceptibility E-Field	Def Stan 59-41	DRS02	14kHz – 18GHz	200V/m	
Radiated Susceptibility H-Field	Mil 461D	RS101	30Hz – 100KHz	See Chart 1	Note 1
Electrostatic Discharge	EN61000-4-2	ESD	N/A	8KV	
Radiated Electric Field Emissions	EN 50081-1	N/A	30MHz – 1 Ghz	30dB below Limit	
Radiated Susceptibility E-Field High Field	Spot Frequencies CW	N/A	100kHz–40 Ghz	See Chart 2	Note 2
Radiated Susceptibility E-Field High Field	Spot Frequencies CW with 1kHz 1 μS square wave	N/A	500MHz–40 Ghz	See Chart 3	Note 2

Notes:

1. The limits are as Mil461D (Army) between 30Hz and 1kHz. Between 1kHz and 100kHz the limit is increased by 20 dB.

2. The units were tested up to the point of failure or to the maximum field attainable in the test configuration.

Graphs follow:

APPENDIX B

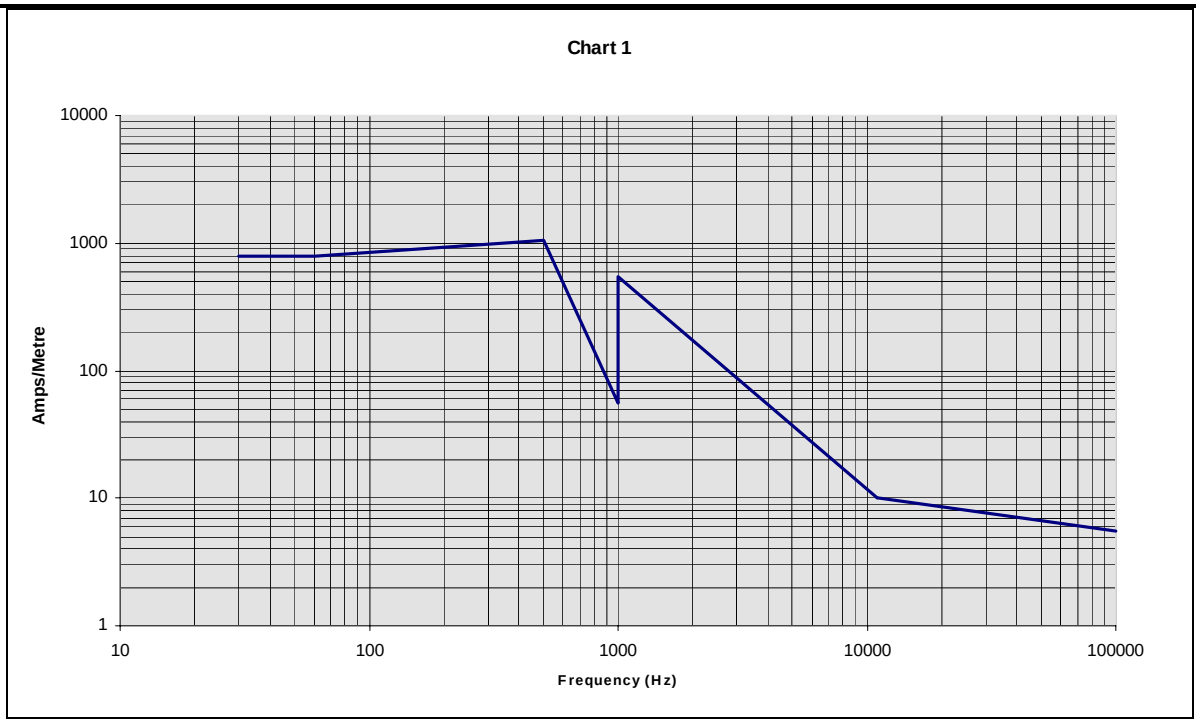


Chart 1. The tested Mk2 EPDs were not susceptible to H-field radiation below the above graph.

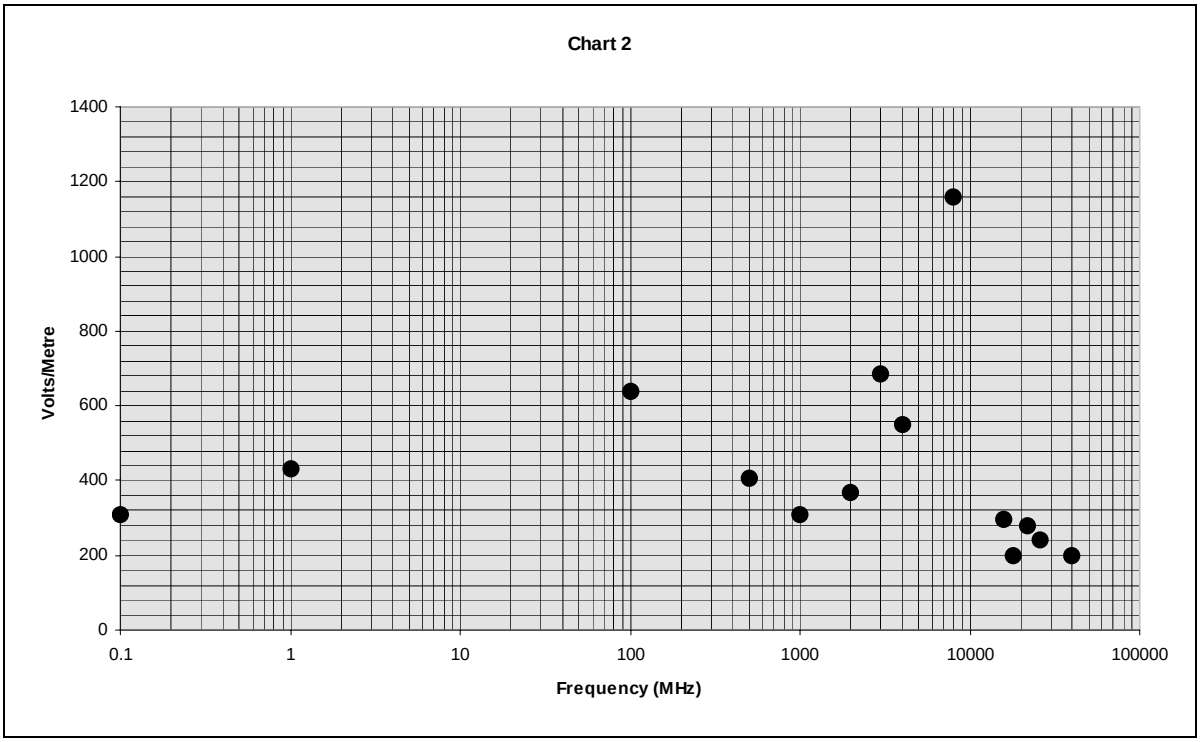


Chart 2. The tested Mk2 EPDs were not susceptible to E-field radiation below the above spot frequencies (100kHz-100GHz carrier wave).

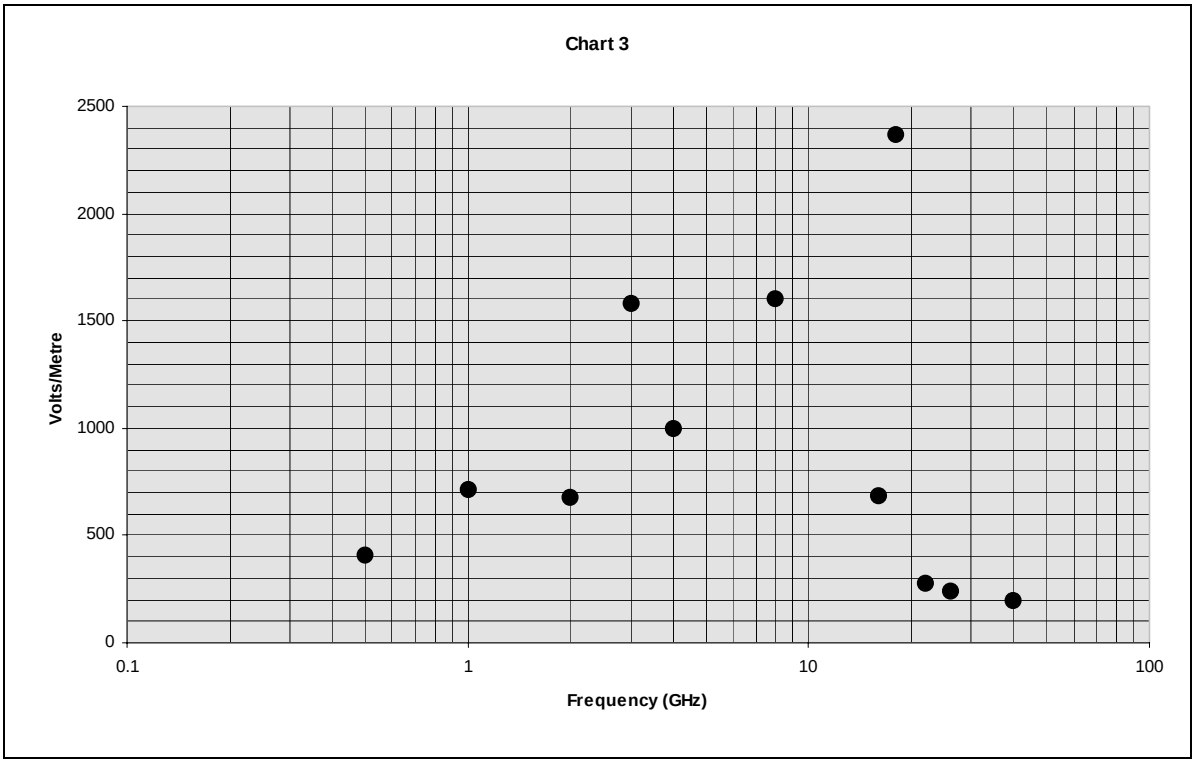


Chart 3. The tested Mk2 EPDs were not susceptible to E-field radiation below the above spot frequencies (0.1GHz - 100GHz pulsed 1kHz 1µS)

APPENDIX B

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APPENDIX C

SUMMARY OF GENERAL PHYSICAL & FUNCTIONAL CHARACTERISTICS

Feature		Characteristic
Battery	Type	1.5V Alkaline AA or 3.6V Lithium Thionyl Chloride (LTC) AA batteries. (Observe Manufacturers warnings.)
	Dimensions	Diameter : 13.9 to 14.6 mm, Length: 49.0 to 51.0 mm.
	Typical Life	5 months (LTC), 55 days (Alkaline), continuous operation, depending upon usage (dose-rate, alarms etc.).
	Test	Battery tested nominally Every 15 minutes. Warning raised with 10 hours + remaining.
	On/Off control.	Via button and communications interface, when enabled.
	Access	'Bayonet' style rotating battery cap with coin and security options. Environmental and EMC seal.
Sounder	Output (Alarms)	98 dB(A) to 101 dB(A), at 20cm (4kHz loud).
		80 dB(A) to 90 dB(A), at 20cm (4kHz quiet).
	Configuration (per alarm)	High/low tone, loud/quiet/off volume control in seven combinations of continuous or fast/slow intermittent. User mute enable/disable control.
	Dose Chirp	'Real time' chirp function with programmable sensitivity (0.01 μSv/chirp to 100 μSv/chirp).
		From firmware version 11 the chirp uses the loud alarm setting. Earlier versions use the quiet setting.
Mechanical	Weight	95 gm including LTC battery and clip. 88 gm with lanyard plate only.
	Dimensions	86 x 63 x 18.5 mm (28.5 mm with clip).
	Construction	Plastic case (Polycarbonate / ABS blend). RFI screened case and LCD Window, contributing to excellent RFI immunity.
	Case colours	Agate grey, Melon Yellow, Nato Green. Other case colours are available, consult manufacturer.
	Clip	High grip, removable clip with 'break-away' attachments for lanyard strap.

APPENDIX C

Feature		Characteristic
	Drop	1.5m, each face to concrete.
	Button	Sealed and recessed to prevent inadvertent operation. Tactile, with button beep facility (sounder).
	Teledosimetry	May be attached to Thermo teledosimetry adapter using clip attachment features.
Environmental	Temperature	-10°C to +40°C (operating), -25°C to 70°C (storage).
	Humidity	20% to 90% RH non-condensing
	Sealing	IP55
	Vibration	2g, 15 min, 10 - 33 Hz
Communicat-ions & Internal Data	Type	IR communication to front of unit, range up to 1m. May use standard IrDA adapters (physical level 1) with Thermo supplied DLL and application s/w as required (EasyEPD2, Access Control s/w etc.). Also provides IR communication to rear or unit for teledosimetry applications (two way data transfer).
	Memory	Large non-volatile store for dosemeter control parameters, dose data storage, dose profile, system scratchpad etc. 10-year data retention.
	Issue / Return	Issue and return times of circa 1 second (EPD communications time only).
	Incident assessment	Internal event & alarm historical log. 23 entries (for time recording of alarms etc.). Peak dose-rate recording.
	Dose Profile	Interval programmable from two seconds to 35 hours. Stores Hp(10) and Hp(0.07) to a resolution of 1μSv. Up to 579 records for transitions up to 127 μSv or less but extending greatly in zero fields.
Alarms & Other Functions	Alarms	2 x Hp(10) dose and dose rate alarms. 1 x Hp(0.07) dose and dose rate alarms. Count down alarm (stop-watch). Return for read alarm. Fault alarms. Over-range alarms. Dose-rate and over-range alarm status is latched for subsequent system analysis.
	Special Total Dose Store	12 entries (for recording end of month dose etc)
	Count-down Timer	Configurable up to 1 hour 39 minutes and 59 seconds (1 second resolution).

In built Integrity Checks	Detector Test	Regular 'flash LED' detector test, also available on demand over the communications link, at time of issue. The test takes approximately 1 to 2 ms, during which time normal dose measurement is inhibited.
	Non volatile store.	Dose data copied to non-volatile store every 15 minutes (and more regularly to dose profile).
	Processing / Memory checks.	Critical data areas, dose stores, calibration factors, communications data, are all protected by powerful 16 bit polynomial crc (Cyclic Redundancy Check).
	Calibration.	EPDs normally supplied with Calibration factors in the 'locked' state and only changeable by Thermo. On request Thermo will supply units with calibration factors unlocked.
	Dose Data verification	User 'dose' readings also include detector counts and associated 'quality' data such as impact counts, reset counts, fault data. Dose and count data may be 'sensibility' tested .
ADS Facilities	ADS Issue	EPD may be 'permanently' issued by ADS but also used on an access control system (by the same wearer).
	ADS Store	Dose and supporting data is accumulated in an additional password protected ADS store.
System Integration Facilities	Messaging Interface	A powerful and efficient messaging interface allows fast and secure data transfer and speedy issue and return times. Data is protected by 16 bit crc. Issue and Return times take circa 1 second. Returns take longer if extensive dose profile data is being extracted.
	EPD Identity	Every EPD has a unique serial number provided on the case label (numeric and bar-coded) and duplicated in internal memory. The latter is accessible over the communications link.
	Mark Number	Every EPD is manufactured to a defined Mark Number which is detailed on the case label and duplicated in internal memory. The latter is accessible over the communications link.
	Wearer ID (User ID)	12 character numeric wearer ID, displayable on EPD LCD (both control and ADS wearer IDs). By convention the wearer ID for a non-issued EPD is set to FFFFFFFFFFFF.
	Wearer Name	22 character wearer name (may be used but is not essential). For version 11 firmware and later the first 12 characters of the wearer name may be displayed

		on the EPD LCD in place of the wearer ID, see section 3.5.1. The character representation on a seven segment display is necessarily limited, see table below.
	Controls	Various controls are possible over the communications interface to configure displays, sounder operation, detector and self test, clear dose and detector counts, analyse and clear faults, set alarm thresholds and alarm characteristics, turn the EPD On or Off, enable and disable controls via the button, adjust the dose profile and special store operation.
	Scratch Pad	A large scratch pad is available in the non-volatile store to support various system applications. This is especially useful for non-networked reader stations and can be used to store wearer access data, interim dose readings, worker access permissions etc.
	Teledosimetry	Virtually all data accesses and transfers available over the normal IR link are also available over the teledosimetry interface.
	Operational issues.	During critical data writes (e.g. issues and returns) the EPD can be triggered to alarm if the worker removes the EPD from the IR media before the communication completes. In this case the sounder is activated and ≡≡≡≡ shown on the display. System software can activate the sounder and alarm LED to communicate normal completion (short beep and flash) or failure (long sound and alarm LED).

	#		#		#		#		#		#
A a		B b		C c		D d		E e		F f	
G g		H h		I i		J j		K k		L l	
M m		N n		O o		P p		Q q		R r	
S s		T t		U u		V v		W w		X x	
Y y		Z z									
0		1		2		3		4		5	
6		7		8		9					

#: Seven Segment Display representation of the character(s) to the left.

WEARER NAME: EPD LCD LETTER REPRESENTATION

APPENDIX D

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APPENDIX D

EPD FAULT LOG FORM

SEE OVER

APPENDIX D

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EPD FAULT LOG FORM

Owning Organisation:					Site or Location:	
REPORT NO.:	Related / Repeated Report Nos.:					
Raised By:	Date: / / dd/mm/yyy		Contact / Telephone No:			
EPD Supplier (Thermo or Distributor):			Form Returned to:			
BATTERY Type (Alkaline or LTC):		**Manufacturer:**		**Supplied by:**		
EPD Serial No.s:						
Date/Time fault occurred:						
Fault type, e.g. Display fault Code:						
Customer fault reference:						
EPD returned to supplier ?						
Date battery installed ?						
Do IR communications still work ?						
EPD Status Faults attached ? *						
Event History attached ? *						
Dose Profile attached ? *						

*** Extracted from EasyEPD2**

DESCRIPTION OF FAULT:

DETAIL OF ACTIONS TAKEN TO RECTIFY FAULT :

Did fault recur after battery replacement or EPD Reset:

CONDITIONS PRIOR TO FAULT (Environment etc):

FURTHER DETAILS MAY BE GIVEN ON REVERSE

FOR MANUFACTURERS USE **Rec'd:** **Assessed by:**

Notes:

EPD FAULT LOG FORM

INDEX