SPECIFICATION

Electronic Personal Dosimeter

1. Scope

This specification describes the requirements for a light weighted compact, Electronic Personal Dosimeter (EPD), measuring and displaying the personal equivalent dose rate and the accumulated dose with an accuracy of ±20 % and triggers alarm once pre-set limits are exceeded to protect the end user against over exposure. The EPD shall be sensitive to gamma and X-rays, as well as to beta radiation. The EPD is intended for use in Colombia.

2. Applicable Documents

The following documents shall be applicable for this Specification to the extent specified hereinafter:

In the event of conflict between the documents listed above and the content of this Specification, the content of this Specification shall take precedence to the extent of the conflict.

3. Definitions, Acronyms, and Abbreviations

The following definitions, acronyms, and abbreviations shall apply throughout this Specification unless defined otherwise hereinafter:

EPD - Electronic Personal Dosimeter

Hp(10) - Personal equivalent dose rate for strongly penetrating radiation

Hp(0.07) - Personal equivalent dose rate for weakly penetrating radiation

4. Requirements

4.1. Functional and Performance Requirements

The system shall meet the following functional and performance requirements:

4.1.1. The EPD shall measure, calculate and display the strength of the radiation field in personal equivalent dose rate Hp(10) and Hp(0.07), as well as dose units to inform the user on its actual exposure level,
4.1.2. the dose rate and dose modes shall have a minimum of two preset able warning levels to setup the EPD for different tasks,
4.1.3. the detectors shall be sensitive to continuous X-ray, gamma and beta radiation,
4.1.4. it shall be light-weighted, self-contained and shall have a clip and a strap to get comfortable worn on all kind of working and protecting suits,
4.1.5. it shall have a minimum amount of buttons to make it easy to get operated,
4.1.6. it shall have a compact and rugged design with digital display to indicate required information in all modes of operation and under all operating conditions,
4.1.7. alarm indicators shall inform the user whenever the radiation is exceeding the preset alarm levels for safety, and
4.1.8. it shall have an outer surface that is easy to decontaminate.

4.2. Technical Requirements

The System shall meet the following technical requirements:

4.2.1. Essential features

The essential features for the EPD are:

- Personal equivalent dose rate Hp(10) for gamma and x-rays and Hp(0.07) for beta radiation
- Personal equivalent doses, related to both dose rate modes
- Giving alarm in case dose rate or dose exceeding preset safety thresholds

4.2.2. Safety requirements

The equipment shall meet the following safety requirements given in IEC 61508-1, 61508-2, 61508-3. It is recommended, the equipment be European "CE" rated (or equivalent), and marked accordingly; i.e., meets all the essential "Health and Safety" requirements of the European Directive(s) 93/68/EEC that provide for the CE marking, or equivalent.

4.2.3. Minimum buttons to operate

The EPD shall have a minimum number of buttons for operation. Examples of good practice are 1-3 buttons. All buttons should be clearly marked. The start-up and shutdown buttons shall be protected against unintentional operation.

4.2.4. Physical dimensions and mass

Outside dimensions shall not exceed a volume of 120 cm^3 and the mass shall be less than 100 g with built in batteries.

4.2.5. Data

The EPD shall provide the possibility to record measured data and to read them out on the instrument as well as with specific software installed on a PC. Data transfer shall happen via serial cable or wireless via infrared or blue tooth interface.

4.2.6. Multilanguage support

The measurement results shall be displayed in SI units. All additional information on the display or in the menu shall be in in English language.

4.2.7. Detector(s)

For dose rate measurement in the required range adequate detectors or a single detector shall be used, having the following requirements:

4.2.7.1. Sensitive to continuous X-ray and gamma radiation;
4.2.7.2. Sensitive to beta radiation;
4.2.7.3. The instrument shall be self-contained, i.e. neither external detector(s) nor cables for routine operation are allowed.

4.2.8. Display

The EPD display shall meet the following display requirements:

(a) The measurement data shall be presented in digital form on an LCD display or equivalent;
(b) The display shall have an adequate size to guaranty a clear reading and visibility of the dose, dose rate and menu items (digit size 5 mm or more) as well as the unit of the dose or dose rate;
(c) The display shall show the battery status;
(d) The EPD live status should be indicated to assure that the system is active. (i.e., not frozen LCD display)
(e) The information on the display shall be readable under all operating conditions; a background light activated automatically or manually is an advantage.

4.2.9. Start-up

The EPD shall have the following start-up and shutdown characteristics:
(a) The instrument shall have buttons to turn the unit on and off;
(b) The warm up time shall be less than one minute for initial operation when the instrument is in equilibrium with ambient temperature;
(c) The instrument shall run through a self-test procedure and shall display possible errors;
(d) During Start-up sequence display should show firmware version and battery status.

4.2.10. Modes of operation

4.2.10.1. Essential for the EPD is to have two modes of operation, the personal equivalent dose rate mode and the mode of the accumulated equivalent doses:
4.2.10.2. Each mode shall measure, calculate and display Hp(10) for strongly penetrating radiation, such as gamma and X-ray, and Hp(0.07) for weakly penetrating radiation, such as beta radiation,
4.2.10.3. For each of these modes adjustable alarm thresholds shall be available;
4.2.10.4. The EPD shall allow for manually switching between both modes.

4.2.11. The dose rate mode

The EPD's dose rate mode shall have the performance characteristics as listed below:
(a) The EPD shall have a dose rate displayed in SI units;
(b) The equipment shall measure and display the personal equivalent dose rate Hp(10) for gamma and X-rays, and Hp(0.07) for beta radiation;
(c) The EPD shall provide dose rate readings with an internal resolution of at least 1 µSv/h, and a resolution for storage of at least 20 nSv/h ;

(d) The dose rate displayed shall be at least from 0 µSv/h up to 4 Sv/h or more;
(e) The upper operating range shall be 50 Sv/h or more;
(f) If the measurement exceeds the upper operating, or display range, an over range indication on the display shall be displayed;
(g) The EPD shall measure photon energy ranges at least from 15 keV up to 10 MeV for Hp(10);

(h) The EPD shall measure beta particle energy ranges from at least 250 keV up to 1.5 MeV for Hp(0.07);
(i) The dose rate Hp(10) accuracy for Cs-137 at room temperatures shall be ±10 %. The required accuracies of the Hp(10) measurements between 0,03 μSv/h and 4 Sv/h, and within the energy ranges from 17 keV to 10 MeV are given in table 1;
(j) The dose rate Hp(0.07) accuracy for Cs-137 and Sr-90/Y-90 shall be ±15 % and ±20 %, respectively. The required accuracy of the Hp(0.07) measurement, between 0,03 μSv/h and 1 Sv/h, and within the energy ranges from 250 keV to 1.5 MeV are given in table 2.

Energy response Hp(10) Cs-137	Energy range	Dose rate linearity Hp(10) Cs-137	Dose rate
±20%	17 kev – 1.5 MeV	±10 %	< 0.5 Sv/h
±30 %	1.5 -6 MeV	±20%	0.5 – 1 Sv/h
±50 %	6 – 10 MeV	±30 %	1 – 2 Sv/h
		±50 %	2 – 4 Sv/h

Table1

Energy response Hp(0.07)Sr90/Y90	Energy range	Dose rate linearity Hp(10) Cs-137	Dose rate
±30%	250 kev–1.5MeV	±20 %	< 1 Sv/h

Table 2

4.2.12. Personal equivalent gamma dose

The instrument shall provide readings of the accumulated personal equivalent gamma dose:
(a) The dose shall be displayed in SI units based on the measured personal equivalent gamma dose rate H*(10) or H*(0.07);
(b) The minimum resolution of the readings shall be in μSv;
(c) The accuracy of the reading of the H*(10) dose shall be within
±20 % of the actual accumulated dose for photon radiation in an energy range from 20 keV up to 1.5 MeV;
(d) The accuracy of the reading of the H*(0.07) dose shall be within
±30 % of the actual accumulated dose for beta radiation in an energy range from 250 keV up to 1.5 MeV
(e) The operating and display range shall be from 0 μSv up to 15 Sv or more for continuous radiation fields;

4.2.13. Alarm indicators and alarm thresholds

The EPD shall have audible and visual alarm indications. The visual alarm indications shall be a light indication and indications or messages displayed on the screen:
(a) The EPD shall provide alarm if the Hp(10) dose or dose rate is exceeding the pre-warning or warning threshold;
(b) The EPD shall provide alarm if the Hp(10) dose is exceeding the pre-warning or warning threshold;

(c) The EPD shall provide alarm if the Hp(0.07) dose rate or dose are exceeding the warning thresholds.
(d) Alarm thresholds for the dose rate, and dose shall be adjustable through the instrument's menu or via PC,
(e) The EPD shall have different modes of sound for Hp(10) and Hp(0.07) alarms, battery warning and system failure.
(f) Acoustic alarms shall have a minimum intensity of 95 dBA.

4.2.14. Communication ports and service software with remote assistance

The data transfer between the EPD to a PC shall happen via standard communication interfaces (e.g. infrared or USB cable). On demand specific software shall be available to read out the instrument's history, and to create operation orientated detector setups.

4.2.15. Power supply

The equipment shall meet the following power supply requirements:
(a) The instrument shall be powered by standard, commercial available batteries, or by rechargeable batteries;
(b) The EPD shall have a minimum operation time of 150 days at continuous, non-alarming conditions;
(c) Low battery warning shall be displayed and acoustic indicated minimum 5 hours before battery is empty;
(d) For standard batteries a label with the built-in direction of the batteries shall be on the instrument's housing;
(e) Wrongly built in batteries shall not damage the instrument;
(f) For EPDs with rechargeable batteries chargers (100-230V, 50-60 Hz) shall be delivered.

4.2.16. Mechanical

4.2.16.1. Vibration

Equipment shall be able to tolerate vibration with acceleration of 1 g in the frequency range of 10–500 Hz. When packed for transport, EPDs shall be resistant to harmonic loadings corresponding to conditions of transportation, i.e. to acceleration of 2 g in the frequency range of 10–33 Hz.

4.2.16.2. Microphonics/impacts

Since the EPDs may be sensitive to vibrations such as those that may occur from low intensity impacts of sudden contact with hard surfaces, they shall tolerate such impacts according to IEC 60068-2-75, i.e., remain unaffected by the impacts of 0.2 J to each side of the housing.

4.2.16.3. Shock

EPDs shall be tolerant to mechanical shocks (half-sine) from all directions at an acceleration of 30g over a time interval of 6 ms, in accordance with IEC 60068-2-27.

4.2.16.4. Drop

EPDs shall be resistant to drop from one meter onto a concrete surface in their transport cases, and from 0.5 m without a transport case

4.2.17. Electromagnetic interferences

4.2.17.1. Electrostatic discharge and radiofrequency

EPD shall be tolerant of exposure to electrostatic discharges at intensities of up to 6 kV for contact and 8 kV for air.

4.2.17.2. The EPD's response shall not be affected by radio-frequency (RF) fields over a range of 80 MHz–2500 MHz at the intensity of 10 volts per meter (V/m). Due to possible interference with mobile or satellite phones, the intensity of 50 V/m should not affect normal operation.

4.2.17.3. Radiated emission

Because of the nature of their intended use and by their design, EPDs can be used in many different environments, often in combination with other types of security instruments or infrastructure. RF emissions from an EPD should be below the level that can interfere with other instruments located in the same area of use. The emission limits when measured at three meters are as given in Table 1.

TABLE 1. RADIATED EMISSION VALUES

Emission Frequency Range (MHz)	Field Strength (μV/m)
33 - 88	100
88 - 216	150
216 - 960	200
Above 960	300

4.2.17.4. Magnetic field

EPDs shall tolerate exposure to constant magnetic field intensity of 10 Gauss (800 A/m) in three orthogonal directions to the main axis of the instrument.

4.2.18. Environment:

4.2.18.1. Temperature:

EPDs shall be able to be switched on and be tolerant to ambient temperature from –10 to +50°C. The instruments should be resistant and tolerant to rapid temperature changes within the temperature range from –10 to +50 °C.

4.2.18.2. Humidity:

EPDs shall withstand condensing moisture. The EPD shall remain fully functional and tolerant to relative humidity of up to 90% at 40°C.

4.2.18.3. Degree of protection – ingress rating

The housing of the EPDs shall meet ingress protection rating IP55 according to IEC 60529 requirements, i.e., dust proof and water projected by a nozzle (6.3 mm) against enclosure from any direction shall have no harmful effects.

4.2.19. Reliability:

4.2.19.1. Lifetime

The normal operating period or lifetime of an instrument is the

period of time after an ample initial trial use or burn-in, where the effects of wear are negligibly small and quality has leveled off to a constant failure rate with regard to time. The lifetime of the EPD shall be at least 10 years.

4.2.19.2. Mean time between failures

Mean time between failures (MTBF) shall be at least four years

4.2.19.3. Mean time to repair

The manufacturer shall be committed assuring that the mean time to repair (MTTR) be a maximum of four weeks.

4.2.19.4. Availability of spare parts and maintenance services

The vendor (manufacturer) shall be committed to ensure the availability of spare parts and maintenance services for the entire lifetime of the EPD.

4.2.20. Documentation

The manufacturer shall provide the documentation specified below, in English language, and if available and requested in other IAEA (International Atomic Energy Agency) languages.

4.2.20.1. Technical specification

(a) Type of instrument, purpose, types of radiation to be measured;

(b) Complete description of the instrument with general technical data, including optimum configuration, type of radiation detector and its size, range of personal equivalent dose rates, reference point(s), modes of operation, alarm initiation algorithms, kinds of alarm, markings, power supply, mechanical, environmental and electrical characteristics, electromagnetic compatibility, reliability and any other relevant information.

(c) Complete description of test methods used, or references to international standards used

4.2.20.2. Manuals and Check-lists

(a) The manufacturer shall provide user manuals, software manuals, maintenance manuals, as well as system configuration(s).

(b) The manufacturer shall provide a quick start manual, a list of recommended spare parts, and a trouble-shooting guide.

4.2.20.3. Periodic test procedures

The manufacturer shall provide a test procedure for the verification of all relevant parameters. The manufacture should provide an initial calibration service with certificates for each instrument.

4.2.20.4. Factory test report

The manufacturer shall provide a test report for all factory tests conducted on each individual instrument.

4.2.20.5. Certificates and legalization:

In order to ensure reliable and safe operation, the manufacturer should provide a valid safety certificate and, preferably, a type test certificate of compliance with the relevant national/international standards. Additional test protocols from a recognized institution may be required.

The manufacturer is entirely responsible for providing all documentation/certification necessary to allow legal export and use

of an instrument in the country of use. This may include, for example, export licenses, type test certification with subsequent entry into a State's register of measuring instruments and initial metrological (secondary standard laboratory) verification of the instrument's characteristics.

5. Marking

The System shall have all safety markings in English language.

Instruments shall be clearly marked with designation of the type, model, manufacturer and serial number. The reference point(s) of the instrument's detector (each one for every embedded detector) should also be indicated.

6. Packing

The System, for the shipment by air to the End-User, shall be packed in accordance with international standards that are applicable for the shipment by air of this kind of equipment.

7. Quality Requirements

7.1. The System shall be manufactured, shipped and installed in accordance with the Contractor's ISO quality assurance system or an equivalent recognized quality assurance system. This quality control system must ensure testing of instruments occurs at least to the standards comparable to the IAEA's Nuclear Security Team (NST) 'Acceptance Test Protocol'. Detailed information about the IAEA's acceptance test will be provided upon request.

7.2. The Contractor shall document the compliance with this quality assurance system for the acceptance testing of instruments. Results obtained by the Contractor shall be attached to each batch of instruments delivered to IAEA.

7.3. Warranty on instruments shall be for a minimum of 2 years on labour and parts.

8. Testing and Acceptance

8.1. The Equipment, prior to shipment, shall be tested for conformance of the System with manufacturer's performance specifications and the minimum requirements specified herein.

8.2. Equipment will only be accepted (paid for) after passing the NST 'Acceptance Test Protocol' to be performed at the IAEA. Upon request, copies of acceptance test results may be obtained from the IAEA.

8.3. Where a new model of the instrument has not previously been tested by NST for compliance with IAEA procurement specifications and NST 'Acceptance Test Protocol', a sample instrument must be provided to the IAEA for evaluation as part of the bid.

9. Installation and Training

No requirements to Contractor regarding installations and training.

10. Maintenance and support scheme

The Contractor should have a qualified authorized representative in Colombia, and if not possible in South America, to provide after-sales services and spare parts. Details of the representatives are to be given along with the quote.

11. Deliverable Data Items

The Contractor shall provide complete sets of operation and servicing manuals and technical drawings in the English language, and if available and requested in other IAEA languages.
