

# Radiation protection instrumentation — Portable potential alpha energy meter for rapid measurements in mines

# Committees responsible for this British Standard

The preparation of this British Standard was entrusted to Technical Committee NCE/2, Health Physics Instrumentation, upon which the following bodies were represented:

- AEA Technology
- Association of University Radiation Protection Officers
- British Nuclear Fuels plc
- British Steel plc
- Department of Trade and Industry (National Physical Laboratory)
- Electricity Association
- GAMBICA (BEAMA Ltd.)
- Health and Safety Executive
- Institute of Physical Sciences in Medicine (IPSM)
- Institute of Physics
- Institution of Nuclear Engineers
- Ministry of Defence
- National Radiological Protection Board
- Society for Radiological Protection

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# Contents

|                                                                                                                                    | Page               |
|------------------------------------------------------------------------------------------------------------------------------------|--------------------|
| Committees responsible                                                                                                             | Inside front cover |
| National foreword                                                                                                                  | ii                 |
| <hr/>                                                                                                                              |                    |
| Section 1. General                                                                                                                 |                    |
| 1.1 Scope and object                                                                                                               | 1                  |
| 1.2 Normative references                                                                                                           | 1                  |
| 1.3 General characteristics                                                                                                        | 1                  |
| 1.4 Terminology and units                                                                                                          | 2                  |
| <hr/>                                                                                                                              |                    |
| Section 2. Technical characteristics                                                                                               |                    |
| 2.1 General                                                                                                                        | 3                  |
| 2.2 Technical characteristics of the sampling<br>and detection sub-assemblies                                                      | 4                  |
| 2.3 Technical characteristics of the control and<br>measurement sub-assemblies                                                     | 4                  |
| <hr/>                                                                                                                              |                    |
| Section 3. Test procedures                                                                                                         |                    |
| 3.1 General                                                                                                                        | 5                  |
| 3.2 Performance characteristics                                                                                                    | 6                  |
| 3.3 Electrical characteristics                                                                                                     | 8                  |
| 3.4 Environmental characteristics                                                                                                  | 9                  |
| 3.5 Tests of the sampling assembly                                                                                                 | 9                  |
| <hr/>                                                                                                                              |                    |
| Section 4. Documentation                                                                                                           |                    |
| 4.1 Type tests report                                                                                                              | 11                 |
| 4.2 Identification certificate                                                                                                     | 11                 |
| <hr/>                                                                                                                              |                    |
| Annex A (informative) Methods for measuring<br>the potential alpha energy concentration (PAEC)<br>of airborne radon decay products | 13                 |
| <hr/>                                                                                                                              |                    |
| Table 1 — Reference conditions and standard test conditions                                                                        | 11                 |
| Table 2 — Tests performed under standard test conditions                                                                           | 11                 |
| Table 3 — Tests performed with variation of influence<br>quantities                                                                | 12                 |
| Table 4 — Tests of the air circuit                                                                                                 | 12                 |
| <hr/>                                                                                                                              |                    |
| List of references                                                                                                                 | Inside back cover  |

# National foreword

This British Standard has been prepared under the direction of the Engineering Sector Board and is the English language version of IEC 1263:1994 *Radiation protection instrumentation — Portable potential alpha energy meter for rapid measurements in mines*, published by the International Electrotechnical Commission (IEC).

IEC 1263 was produced as a result of international discussions in which the United Kingdom took an active part.

**Cross-references**

| International Standard | Corresponding British Standard                                                                                                                                                                                                                                                           |
|------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| IEC 50(151):1978       | BS 4727 <i>Glossary of electrotechnical, power, telecommunication, electronics, lighting and colour terms</i><br>Part 1 <i>Terms common to power, telecommunications and electronics</i><br>Group 02:1980 <i>Electrical and magnetic devices terminology</i><br>(Technically equivalent) |
| IEC 68                 | BS 2011 <i>Environmental testing</i>                                                                                                                                                                                                                                                     |

The Technical Committee has reviewed the provisions of ISO 50(391):1975, IEC 50(392):1976, IEC 181A:1965 and IEC 777:1983, to which normative reference is made in the text, and has decided that they are acceptable for use in conjunction with this standard.

A British Standard related to ISO 2889:1975 is BS 5243:1975 *General principles for sampling airborne radioactive materials*.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

**Compliance with a British Standard does not of itself confer immunity from legal obligations.**

**Summary of pages**

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 14, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

## Section 1. General

### 1.1 Scope and object

This standard sets forth the requirements for a portable instrument for the rapid measurement of the volume potential alpha energy due to the decay products of radon  $^{222}\text{Rn}$  in the air of underground mines.

The volume potential alpha energy (potential alpha energy concentration-PAEC) is measured in the air of mines mainly to estimate the exposure of miners. Such measurements may also be required for the assessment of other occupational exposures.

The requirements given in this standard specify general characteristics, general test procedures, radiation characteristics, electrical, mechanical, safety and environmental characteristics and also identification certificates.

The requirements of this standard are applicable in accordance with the general principles for sampling airborne radioactive materials of ISO 2889.

### 1.2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 50(151):1978, *International Electrotechnical Vocabulary (IEV) — Chapter 151: Electrical and magnetic devices*.

IEC 50(391):1975, *International Electrotechnical Vocabulary (IEV) — Chapter 391: Detection and measurement of ionizing radiation by electric means*.

IEC 50(392):1976, *International Electrotechnical Vocabulary (IEV) — Chapter 392: Nuclear instrumentation — Supplement to Chapter 391*.

IEC 68, *Environmental testing*.

IEC 181A:1965, *First supplement to IEC 181 (1964): Index of electrical measuring apparatus used in connection with ionizing radiation*.

IEC 777:1983, *Terminology, quantities and units concerning radiation protection*.

ISO 2889:1975, *General principles for sampling airborne radioactive materials*.

### 1.3 General characteristics

The standard is applicable to equipments designed for monitoring volume potential alpha energy by grab sampling of mixtures of radon  $^{222}\text{Rn}$  daughters.

The short-lived radionuclides of potential health-hazard concern include  $^{218}\text{Po}$  (RaA),  $^{214}\text{Pb}$  (RaB),  $^{214}\text{Bi}$  (RaC), and  $^{214}\text{Po}$  (RaC'). Decay products emit both alpha and beta radiations with different half-lives and either radiation may be employed in determining volume potential alpha energy.

High efficiency and low background alpha detectors are commonly used, which allow two measurement procedures:

- gross alpha count methods, where the total alpha activity is measured,
- and alpha spectrometric methods, where the activities of each alpha emitter are measured.

The method of measurement depends on the exact objective, but the recommendations here are for a general purpose instrument to be used for radiological protection in underground mines and also in other working places.

Practically all methods used are based on the analysis of the activity collected on a filter.

Many methods of measurement have been described, but they are all based on exact or approximate solution of the equations governing radioactive decay and growth of radon decay products (see Annex A).

The different approximate methods optimize sampling, waiting and counting time intervals to yield maximum sensitivities in the measurement of radon daughters concentrations. One-count, two-count and three-count methods may be implemented in the instrument. One-count methods, generally based on gross alpha counting, are often used, especially in underground mines, for their simplicity. To improve accuracy and rapidity of operating procedures, two uncorrelated counts may be used. The value of the potential alpha energy concentration, expressed in appropriate units, is determined with an inherent uncertainty which is influenced by the degree of radioactive equilibrium between the individual radon daughters concentrations in the sampled atmosphere. The inherent uncertainty of different methods can be theoretically stated.

**The three-count methods allow the carrying out of measurements generally without inherent uncertainty.**

## 1.4 Terminology and units

The general terminology concerning detection and measurement of ionizing radiation and nuclear instrumentation is given in IEC 50, Chapters 391 and 392, and IEC 181A. Other terms about protection from radiation are in IEC 777. A special terminology is also included in this standard.

### 1.4.1 Potential alpha energy

The Potential Alpha Energy (PAE) is the total alpha energy released by the short-lived radon daughters in the decay chain to  $^{210}\text{Pb}$ .

The Potential Alpha Energy Concentration (PAEC) corresponds to the total potential alpha energy produced by the complete decay to  $^{210}\text{Pb}$  of any combination of short-lived radon decay products present in one cubic meter of air.

The SI unit of this quantity is  $\text{J}\cdot\text{m}^{-3}$ .

### 1.4.2 Portable potential alpha energy meter

In this standard the term "Portable Potential Alpha Energy meter" means an instrument intended for monitoring the Potential Alpha Energy Concentration by grab sampling of mixtures of radon daughters.

It shall be capable of providing rapid results so as to allow monitoring of Potential Alpha Energy Concentration during a working shift, in different working areas of the mines.

The implemented methods may be decided between manufacturer and purchaser.

### 1.4.3 Aerosols

Suspension of fine solid or liquid particles in air, with dimensions generally in the 0,01 to 10  $\mu\text{m}$  range. The sizes of the carrier aerosol, to which most of radon daughters are attached, are generally in the 0,1  $\mu\text{m}$  to 0,3  $\mu\text{m}$  range.

A small fraction of radon daughters may not become attached to airborne particles and this quantity is often referred to as the unattached fraction.

### 1.4.4 Active deposit

Solid short-lived radioactive decay products of  $^{222}\text{Rn}$  ( $^{218}\text{Po}$ ,  $^{214}\text{Pb}$ ,  $^{214}\text{Bi}$ ,  $^{214}\text{Po}$ ) deposited on surfaces or collected on filters.

### 1.4.5 Thin radioactive source

For the purpose of this standard, the following definition shall apply for a thin radioactive source: a radioactive source the thickness of which is sufficiently small to ensure that absorption of alpha radiation emitted by the radioactive material within the source material is negligible.

### 1.4.6 Surface emission rate of a source

The number of alpha or beta particles emerging from the front face of the source in unit time.

### 1.4.7 Total equivalent window thickness

The equivalent thickness, generally expressed in mass per unit area that a particle (alpha or beta) emitted normally from a surface, crosses in order to reach the sensitive volume of the detector. This thickness includes the distance covered in air plus the detector window thickness and, sometimes, the thickness of any screen fitted over the detector.

The SI-unit of mass per unit area is:  $\text{kg}\cdot\text{m}^{-2}$ .

This standard uses the sub-multiple unit:  $\text{mg}\cdot\text{cm}^{-2}$ .

### 1.4.8 Conventionally true value of a quantity

The best estimate of the true value of the quantity ( $Q$ ) used for calibration of equipment; this value and its uncertainty shall be determined from a secondary or primary standard, or by a reference instrument which has been calibrated against a secondary or primary standard.

### 1.4.9 Error of indication

The difference between the indicated value and the conventionally true value at the point of measurement.

### 1.4.10 Relative error of indication

The quotient, expressed as a percentage, of the error of indication by the conventionally true value.

### 1.4.11 Relative intrinsic error

The relative error of indication of an assembly with respect to a specified value under specified reference conditions.

### 1.4.12 Coefficient of variation

The ratio  $V$  of the standard deviation  $s$  to the value of the arithmetic mean  $\bar{x}$  of a set of  $n$  measurements  $x_i$ , given by the following formula:

$$V = s/\bar{x} = \bar{x}^{-1} [(n-1)^{-1} \sum_{i=1}^n (x_i - \bar{x})^2]^{1/2}$$

### 1.4.13 Units

This standard uses the International System of units (SI-units). For radiation quantities the values expressed in units in temporary use (for example, rad) are also indicated in brackets. The following non-SI units of practical importance will also be used where appropriate:

- for time: hours, minutes;
- for energy: MeV