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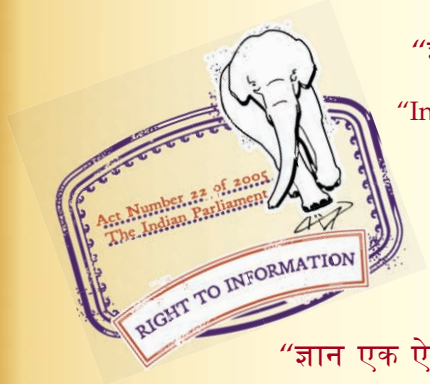
IS 11866 (1987): Alpha, Beta, and Alpha-beta Contamination meters and Monitors [LITD 8: Electronic Measuring Instruments, Systems and Accessories]



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"ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है"
Bhartṛhari—Nītiśatakam
"Knowledge is such a treasure which cannot be stolen"

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IS : 11866-1987
IEC Pub 325 (1981)
(Reaffirmed 2006)

Indian Standard

SPECIFICATION FOR ALPHA, BETA, AND ALPHA-BETA CONTAMINATION METERS AND MONITORS

(IEC Title : Alpha, Beta and Alpha-Beta Contamination Meters and Monitors)

UDC 539'12'074

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 9

February 1988

UDC 539·12·074

Indian Standard

SPECIFICATION FOR ALPHA, BETA, AND ALPHA-BETA CONTAMINATION METERS AND MONITORS

(IEC Title : Alpha, Beta and Alpha-Beta Contamination Meters and Monitors)

National Foreword

This Indian Standard which is identical with IEC Pub 325 (1981) 'Alpha, beta and alpha-beta contamination meters and monitors', issued by the International Electrotechnical Commission (IEC) was adopted by the Indian Standards Institution on the recommendation of the Nuclear Instrumentation Sectional Committee and approval of the Electronics and Telecommunication Division Council.

Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.

Cross References

In this standard, the following International Standards are referred to. Read in their respective place the following :

International Standard	*Corresponding Indian Standard*
IEC Pub 38 (1983) IEC Standard voltages	IS : 585-1962 Voltages and frequeney for ac transmission and distribution systems (revised)
IEC Pub 50 (391) (1975) International Electrotechnical Vocabulary : Detection and measurement of ionizing radiation by electric means	IS : 1885 (Part 63) - 1985 Electrotechnical vocabulary: Part 63 Nuclear instrumentation
IEC Pub 50 (392) (1976) International Electrotechnical Vocabulary : Nuclear Instrumentation — Supplement to Chapter 391	
IEC Pub 68-2-27 (1972) Basic environmental testing procedures, Part 2 : Tests — Test Ea : Shock	IS : 9000 (Part 7/Sec 1)-1979 Basic environmental testing procedures for electronic and electrical items: Part 7 Impact test, Section 1 Shock
IEC Pub 86 (1982) Primary batteries	IS : 203-1972 Dry batteries for flashlights
IEC Pub 181 (1964) Index of electrical measuring apparatus used in connection with ionizing radiation	—
IEC Pub 181A (1965) First supplement	—
IEC Pub 278 (1968) Documentation to be supplied with electronic measuring apparatus	IS : 6756-1972 Technical documentation to be supplied with electronic measuring equipment
IEC Pub 293 (1968) Supply voltages for transistorized nuclear instruments	—

The technical committee responsible for the preparation of this standard has reviewed the provision of these IEC standards and has decided that they are acceptable for use in conjunction with this standard.

Only the English language text of the International Standard has been retained while adopting it in this Indian Standard.

Adopted 28 January 1987

Gr 9

BUREAU OF INDIAN STANDARDS
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CONTENTS

CHAPTER I: GENERAL

1. Scope

1.1 This standard is applicable to radiation meters and monitors designed to measure or detect surface contamination by alpha and/or beta radiation emitting nuclides and which comprise at least:

- a detection sub-assembly (comprising counter tube, scintillation detector, semiconductor detector, etc.), which may be connected either rigidly or by means of a flexible cable or incorporated into a single assembly with
- a measuring sub-assembly.

Radiation meters and monitors are defined in Amendment No. 1 to IEC Publication 181: Index of Electrical Measuring Apparatus Used in Connection with Ionizing Radiation, as follows:

Radiation meter

An assembly including one or several radiation detectors and associated sub-assemblies or basic function units and designed to measure quantities connected with ionizing radiation (activity, exposure rate, etc.).

(Radiation) monitor

A radiation meter provided with means for giving perceptible warning (generally optical or acoustical) that the quantity connected with ionizing radiation exceeds some adjustable predetermined value or that the measured value is not within some adjustable predetermined limits.

1.2 The standard is applicable in its entirety to:

alpha surface contamination meters;
- alpha surface contamination monitors:
- beta surface contamination meters;
- beta surface contamination monitors;

as defined below:

Alpha (beta, alpha-beta) surface contamination meter

An assembly including one or more radiation detectors and associated sub-assemblies or basic function units and designed to measure alpha (beta, alpha-beta) activity per unit surface area associated with the contamination of the surface under examination.

Alpha (beta, alpha-beta) surface contamination monitor

Alpha (beta, alpha-beta) activity meter provided with means for giving perceptible warning (generally visual or audible) that the indicated activity per unit surface area associated with the contamination of the surface under examination exceeds some adjustable predetermined value or that the measured value is not within some adjustable predetermined limits.

1.3 The standard is also applicable to special-purpose assemblies and to assemblies specifically designed for a surface of a particular nature (e.g. laundry, floors). However, some of the requirements may need to be amended or supplemented according to the particular requirements applicable to such assemblies.

1.4 If an assembly has been designed to carry out combined functions, it shall comply with the requirements pertaining to these different functions. If, on the other hand, it has been designed to perform one function, and, in addition, it is also capable of carrying out other functions, then it shall comply with the requirements for the first function, and it would be desirable for it to comply with requirements pertaining to the others.

2. Object

To lay down standard requirements; to give examples of acceptable methods; to specify general characteristics, general test conditions, radiation characteristics, electrical safety and environmental characteristics, and also the identification certificate.

The requirements given below pertain to assemblies as defined in Clause 1. It is possible, however, to use assemblies which do not meet the requirements set out below when such requirements are not deemed essential for a given purpose. In such cases, the requirements to be applied to the assemblies shall be specified by agreement between the manufacturer and the user, but the methods used for the determination of the characteristics of the assemblies shall conform with this standard.

3. Terminology

The general terminology concerning the detection and measurement of ionizing radiation and nuclear instrumentation is given in IEC Publications: I.E.V. 50(391)*, I.E.V. 50(392)**; 181, 181A***, and Amendment No. 1 to Publication 181.

For the purposes of this publication, the following definitions apply:

3.1 *Effective range of measurement*

The range of counts per unit time within which the requirements of this standard are met.

3.2 *Surface activity response*

The response of the detector used in conjunction with the assemblies under the given geometrical conditions specified by the manufacturer, expressed in counts per unit time, corrected for background, divided by the conventionally true activity per unit area, together with the name of the radionuclide used, e.g.:

$$\text{Surface activity response } (s^{-1}\ Bq^{-1} \cdot cm^2) \text{ or } (s^{-1}\ \mu Ci^{-1} \cdot cm^2) \text{ name of radionuclide} = \frac{\text{count rate (in counts} \cdot s^{-1})}{\text{surface activity (in Bq} \cdot cm^{-2}) \text{ or (in } \mu Ci \cdot cm^{-2})} \text{ name of radionuclide}$$

3.3 *Thin radioactive source*

A radioactive source, the thickness of which, including any protective cover, is sufficiently small to ensure that absorption within the material of the source of the radiation of interest, emitted by radioactive material, is negligible.

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* International Electrotechnical Vocabulary, Chapter 391: Detection and Measurement of Ionizing Radiation by Electric Means.

** Chapter 392: Nuclear Instrumentation.

*** First supplement to IEC Publication 181.

3.4 *Response time*

The time taken to indicate 63% of an instantaneous change in the level of contamination being measured.

3.5 *Total equivalent thickness*

The thickness, generally expressed in mass per unit area that a particle (alpha or beta), emitted normally from the contaminated 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 window which protects it from contamination.

3.6 *Error of indication*

The difference between the indicated activity per unit area and the conventionally true activity per unit area at the point of measurement.

3.7 *Relative error of indication*

The quotient, expressed as a percentage, of the error of indication divided by the conventionally true activity per unit area.

3.8 *Relative intrinsic error*

The relative error of indication of an assembly referred to a specified reference radionuclide under specified reference conditions.

3.9 *Coefficient of variation V*

Ratio (V) of the standard deviation (σ) to the value of the arithmetic mean ($\bar{x}$) of a set of n measurements (x_i) given by the following formula:

$$V = \frac{\sigma}{\bar{x}} = \frac{1}{\bar{x}} \sqrt{\frac{1}{n-1} \sum_{1}^{n} i \, (x_i - \bar{x})^2}$$

3.10 *Minimum detectable activity per unit area*

That activity per unit area giving an indication which corresponds to twice the standard deviation of the indication given by a specified background count rate for a given measuring time or time constant of the ratemeter.

This activity per unit area shall be expressed in $Bq \cdot cm^{-2}$ or ($\mu Ci \cdot cm^{-2}$).

3.11 *Conventionally true value of a quantity*

The conventionally true value of a quantity is the best estimate of the value of that quantity. This will usually be the value determined by, or traceable to, a secondary or primary standard or by a reference instrument which has been calibrated against a secondary or primary standard.

Units

In this standard, the units used are the multiples and sub-multiples of units of the International System of Units (SI)*. For the radiation quantities and dosimetric terms, the

* International Bureau of Weights and Measures: The International System of Units (SI), third edition, 1977.

values expressed in the old units (**curie, rad**, rem) are also indicated in brackets. The following non-SI units are also used:

Time: years, days, hours (h), minutes (min).
For *energy:* electron-volt (eV) (1 eV = $1.602 \cdot 10^{-19}$ J).

Definitions of the radiation quantities and dosimetric terms are given in Document 45(I.E.V. 391–392) (Secretariat)211.

4. Tests

4.1 *Qualification tests*

Qualification tests are performed in order to verify that the requirements of a specification are fulfilled.

Qualification tests are subdivided into type tests, acceptance tests and routine tests.

4.2 *Type test*

"A test of one or more devices made to a certain design to show that the design meets certain specifications" (I.E.V. 151-04-15).

4.3 *Routine test*

"A test to which each individual device is subjected during or after manufacture to ascertain whether it complies with certain criteria" (I.E.V. 151-04-16).

4.4 *Acceptance test*

"A contractual test to prove to the customer that the device meets certain conditions of its specification" (I.E.V. 151-04-20).

5. Classification of assemblies

Assemblies are classified:

5.1 According to the type of radiation as:

- alpha contamination meters or monitors
- beta contamination meters or monitors
- alpha-beta contamination meters or monitors.

5.2 According to their use as:

- installed assemblies
- transportable assemblies
- portable assemblies.

5.3 According to their power supplies:

- mains
- primary or secondary batteries.

CHAPTER II: SURFACE CONTAMINATION METERS AND MONITORS

SECTION ONE – GENERAL REQUIREMENTS

6. **Detection sub-assemblies**

Detection sub-assemblies shall be so designed that in operation the sensitive volume of the detector can be placed less than 5 mm, in the case of alpha detectors, and less than 20 mm, in the case of beta detectors, from the surface under examination.

The nature and thickness of the material that has to be traversed by an alpha or beta particle in order to reach the sensitive volume of the detector (i.e. the window material and thickness) shall be stated in terms of equivalent mass per unit area.

For a beta detector, the requirements of Clause 20 will be met, in general, with windows the mass per unit area of which does not exceed 35 $mg \cdot cm^{-2}$. When response is required to beta-emitting radionuclides having maximum beta energies less than or equal to 250 keV, e.g. ^{14}C and ^{35}S, the mass per unit area shall not exceed 5 $mg \cdot cm^{-2}$.

If the sensitive surface of the detector is provided with a protective grille, this should not obscure more than 20% of the window area (indoor use), or 45% of the window area (general use). The nominal value shall be stated by the manufacturer.

Both the total area and the sensitive area of the detection sub-assembly shall be stated.

If the detector requires a supply of counting gas, the manufacturer shall state the type of gas supply required and the flow rate.

7. **Ease of decontamination**

The assembly shall be so constructed that its decontamination is facilitated. It is recommended that it be provided, for example, with a smooth non-porous external surface which is free from crevices. Alternatively, it shall be possible to use at least the measuring sub-assembly when placed in a thin and flexible envelope which is either disposable or easy to decontaminate and which is provided with transparent parts to permit the instrument scale to be read.

8. **Sealing**

For assemblies intended for outdoor use, the manufacturer shall state the precautions that have been taken to prevent the ingress of moisture.

9. **Alarm threshold** (This clause is applicable to monitors only)

A monitor shall include circuits necessary for tripping an alarm at one or more thresholds. The number of tripping levels shall be subject to agreement between manufacturer and user.

The values of alarm threshold shall be given either as percentages of ranges of adjustment or in terms of the units of the display.

All trip units shall be capable of convenient operational checking by means of test signals or through the use of radioactive sources.

The range of adjustment shall be specified and the value of the alarm threshold shall be capable of being adjusted to any point within this range. It shall not be possible to incapacitate the alarm by any means such as setting the alarm thresholds beyond range limits. If a mute facility is provided it shall automatically reset when the alarm condition ceases.

Alarm threshold adjustments shall not be easily accessible to the operator. For transportable and installed assemblies there shall be at least one set of contacts available, operated by the trip unit, for external alarm purposes. They shall be operational under normal operating conditions. For portable assemblies, this facility may be provided by agreement between the purchaser and the manufacturer.

10. Local indication

10.1 *For contamination meters*

In addition to the visual indication of count rate, an audible indication of count rate shall be provided. There shall be a facility for muting this indication.

10.2 *For monitors*

In addition to the audible indication of count rate above, there shall be either an audible indication of contamination above a certain pre-set value or visual indication. Although the audible indication may be produced by the same transducer as the indication of count rate, it shall be distinctly different from this indication.

11. Effective range of measurement

For linearly scaled assemblies, the effective range of measurement shall be from 10% to 100% of each range.

For logarithmically scaled assemblies, the effective range of measurement shall be between one-third of the least significant decade and full scale.

For digitally scaled assemblies, the effective range of measurement shall be from the start of the second least significant digit to the full range of indication available.

The manufacturer shall state the effective range of measurement for each scale range. For assemblies with more than one scale range, the useful ranges of measurement shall overlap.

For beta contamination meters provided with linear scales the most sensitive range shall have a maximum reading corresponding to a count rate of at least five counts per second.

For alpha contamination meters provided with linear scales the most sensitive range shall have a maximum reading corresponding to a count rate of at least one count per second. In this case it must be recognized, however, that the requirements on statistical fluctuation (Clause 26) and response time (Clause 27) cannot both be met for count rates less than three counts per second.

12. **Display**

Instrument indications shall be expressed in counts per unit time.

13. **Mechanical shocks**

Portable assemblies shall be able to withstand without damage mechanical shocks from all directions involving a peak acceleration of 300 $m \cdot s^{-2}$ ($\sim 30\ g$) for a time interval of 18 ms, the shape of the shock being semi-sinusoidal (see IEC Publication 68-2-27: Basic Environmental Testing Procedures, Part 2: Tests – Test Ea: Shock).

14. **Setting up and maintenance facilities for electronic equipment**

In addition to an adequate instruction and maintenance manual, all assemblies shall be provided with sufficient easily accessible test points to facilitate setting up and fault location, together with, where necessary, maintenance aids such as extension printed wiring boards, extension leads and special maintenance tools.

SECTION TWO – GENERAL TEST PROCEDURES

15. **General**

With the exception of the routine tests described in Sub-clauses 20.2 and 22.3.2, all tests enumerated in the following clauses are to be considered as "type tests".

Nevertheless, some of these tests may, by agreement between the manufacturer and purchaser, be considered to be acceptance tests. Unless otherwise specified, the requirements corresponding to the tests shall be met over the whole effective range of measurement of the instrument.

16. **Basic principles**

16.1 *Standard test conditions*

Standard test conditions are defined in Table I. The tests described in this standard may be classified according to whether or not they are performed under standard test conditions.

16.2 *Tests performed under standard test conditions*

Tests which are performed under standard test conditions are listed in Table II which indicates, for each characteristic, the requirement (permissible variation in indication) and the sub-clause where the corresponding test method is described.

16.3 *Tests performed with variation of influence quantities*

These tests are intended to determine the effects of variations in influence quantities, and are given in Table III with the range of variation of each influence quantity and limits of consequent variation in the indication of an assembly.

In order to test the effect of variation in any one of the influence quantities listed in Table III, all other influence quantities shall be maintained within the limits for standard test conditions given in Table I, unless otherwise specified in the test procedure concerned.

In order to simplify these tests, for each individual principal influence quantity, only the routine test concerning the intrinsic error need be performed.

Other aspects of the performance of the assembly need to be tested with variation of influence quantities only if it is considered that the routine test specified will not give a representative indication.

16.4 *Permissible variation in indication with variation of influence quantity*

For each influence quantity taken separately and with the remaining influence quantities maintained within the ranges given in Table I, a nominal operating range is defined within which the variation in indication shall remain within the limits stated by the manufacturer, which limits shall in no case exceed the values laid down in Table III. The variation is determined in relation to the value fixed in the reference condition.

These tests are intended as sampling tests, the fraction of assemblies sampled being fixed by agreement between the manufacturer and the user.

TABLE I

Reference conditions and standard test conditions

Influence quantity	Reference conditions	Standard test condition
Warm-up time	15 min	≥15 min
Ambient temperature	20 °C	18 °C to 22 °C
Relative humidity	65%	55% to 75%
Atmospheric pressure	101.3 kPa	86 kPa to 106 kPa
Power supply voltage	Nominal power supply voltage U_N	Nominal power supply voltage $U_N \pm 1\%$
Power supply frequency	Nominal frequency f	Nominal frequency f ±2%
Power supply waveform	Sinusoidal	Total harmonic distortion lower than 5%
Ambient gamma radiation	Absorbed dose rate in air less than 0.2 $\mu Gy \cdot h^{-1}$ (20 $\mu rad \cdot h^{-1}$)	Absorbed dose rate in air less than 0.25 $\mu Gy \cdot h^{-1}$ (25 $\mu rad \cdot h^{-1}$)
Electromagnetic field of external origin	Negligible	Less than the lowest value that causes interference
Magnetic induction of external origin	Negligible	Less than twice the induction due to the earth's magnetic field
Orientation of the assembly	To be stated by the manufacturer	Stated orientation ±2°
Setting of instrument controls	Set up for normal operation	Set up for normal operation
Contamination by radioactive materials	Negligible	Negligible

TABLE II

Tests performed under standard test conditions

Characteristic under test	Requirement	Method of test (clause/sub-clause)
Surface activity response	To be stated by the manufacturer	20.2
Dependence of response on source position	To be stated by the manufacturer	21
Relative intrinsic error *	Within ±25%	22.3
Minimum detectable activity per unit area of reference nuclide	To be stated by the manufacturer	22.4
Statistical fluctuations	Coefficient of variation less than 20%	26.2
Response time	Less than 4 s	27.2
Alarm trip level drift (maximum value)	±20% of set point level over a period of 24 h	29.2

* This value is additional to the uncertainty in the conventionally true activity per unit area of the test sources.

TABLE III

Tests performed with variation of influence quantities

Influence quantity	Range of values of influence quantity	Limits of variation indication	Method of test (clause/sub-clause)
Radiation energy:			
Alpha meters and monitors	No specification		-
Beta meters and monitors	At least over the range of values of E_{max} from 0.4 MeV to 1.0 MeV	To be stated by the manufacturer	23.2.2
Ambient gamma radiation:	Absorbed dose rate in air of:		
Alpha meters and monitors	Up to 10 mGy·h^{-1} (1 rad·h^{-1})	±25%	24.2.1
Beta meters and monitors	Up to 10 μGy·h^{-1} (1 mrad·h^{-1})	To be stated by the manufacturer	24.2.2
Dual purpose (alpha and beta meters and monitors)	Up to 10 μGy·h^{-1} (1 mrad·h^{-1})	To be stated by the manufacturer	24.2.2
Beta radiation	In the presence of a ^{90}Sr/^{90}Y source of not less than 3.7 MBq at a distance equal to or greater than 5 cm	Alpha meters and monitors: ±25% Dual purpose (alpha and beta) meters and monitors: to be stated by the manufacturer	24.3
Alpha radiation	Alpha emitter of ^{239}Pu or ^{241}Am at a distance of 1 cm from the probe	Beta meters and monitors: to be stated by the manufacturer	24.4

TABLE III *(continued)*

Influence quantity	Range of values of influence quantity	Limits of variation of indication	Method of test (clause/sub-clause)
Neutrons	No specification		
Inherent background	Absorbed gamma dose rate in air 0.2 $\mu Gy \cdot h^{-1}$ (20 $\mu rad \cdot h^{-1}$)	Count rate to be stated by the manufacturer	25
Warm-up (portable assemblies)	1 min 3 min	±25% [1] ±10% [1]	30
Ambient temperature [2]	Indoor use: +10 °C to +35 °C Outdoor use [2]: −10 °C to 45 °C	±15% [1] ±20% [1]	33.2
Relative humidity	Up to 90% at 30 °C	±10% [1]	34.2
Supply voltage: *a)* a.c. mains	From 88% U_N to 110% U_N (U_N = nominal supply voltage)	±10%	35.2
b) primary batteries	After 24 h continuous use	±10% of the initial indication	35.4
c) secondary batteries	After 12 h continuous use	±10% of the initial indication	35.4
Overload	Activity corresponding to 100 times the activity that would give full scale deflection on each range	To remain in excess of full scale for 5 min	32.2
Storage	−25 °C to +50 °C	To meet the limits of this specification	36

[1] Of the indication under standard test conditions.
[2] Assemblies intended for temperate climates. For hotter and colder climates, different limits may be specified. For assemblies intended for operation at very low temperature, means of heating the batteries may be provided.

16.5 *Test sources*

For the purposes of this standard, sources shall be mounted on a material having a low coefficient of back-scatter, e.g., plastic or aluminium. The test sources used shall be such that the conventionally true activity per unit area of each source is known within 10% in absolute terms and ±5% relative to other source activities of the same test set. The design and construction of test sources shall take into account the work of ISO/TC 85/SC 2.

16.6 *Reference radionuclides*

16.6.1 *Alpha emitters*

The reference radionuclide is ^{241}Am or ^{239}Pu.

16.6.2 *Beta emitters*

The reference radionuclide is ^{204}Tl.

If the probe is designed to be used for the measurement of beta particles of maximum energy less than 250 keV, the reference radionuclide shall be ^{14}C.

17. **Background**

The background indicated by the instrument shall be subtracted from the observed signal by any procedure including calculation.

18. **Statistical fluctuations**

For any test involving the use of radiation, if the magnitude of the statistical fluctuations of the indication, arising from the random nature of the emission of radiation alone, is a significant fraction of the variation of the indication permitted in the test, then sufficient readings shall be taken to ensure that the mean value of such readings may be estimated with sufficient precision to demonstrate compliance with the requirement in question. The interval between such readings shall be at least three times the response time to ensure that the readings are statistically independent.

SECTION THREE – RADIATION CHARACTERISTICS

19. **General**

The manufacturer shall state the distance between the front face of the detector and the active surface of the test source to be used for the determination of the radiation characteristics of the assembly.

20. **Surface activity response**

20.1 *Requirements*

The measurement of surface activity response (see Sub-clause 3.2) is a routine test and shall be performed on each production assembly. The manufacturer shall then state in the test certificate the surface activity response of the assembly to the appropriate reference radionuclide.

20.2 *Methods of measuring the surface activity response*

Whenever a suitable source is available, the test specified in Sub-clause 20.2.1 shall be employed. In other circumstances the test specified in Sub-clause 20.2.2 shall be used instead.

20.2.1 It is strongly recommended that the surface activity response of the detection sub-assembly be measured with a thin, uncollimated source with an area larger than that of the detector and whose activity per unit area is known to within 10% in absolute terms. Where a thin source is not available, an alternative source whose surface emission rate per unit area is known to within 10% in absolute terms may be used.

20.2.2 In the absence of a source with an area sufficient to meet the requirement of Sub-clause 20.2.1, a source of smaller area than the detector may be used, provided measurements are taken at a sufficient number of positions of the source for the total of all measurements made to provide a measure of the surface activity response with a comparable accuracy.

21. Dependence of response on source position

Small area ("point") sources are frequently used for checking the constancy of the response of a surface contamination meter or monitor.

The response of the detection sub-assembly to such a "point" source, situated on the surface under examination will, in general, vary with the position of the source relative to the probe and the transmission of the grille.

The manufacturer shall state:

21.1 The variation in the response of the probe with respect of the position of the source relative to the window of the probe.

21.2 The radiation transmission of the protective grille.

22. Relative intrinsic error

22.1 *Mode of expression*

The relative intrinsic error E, of the indication of the instrument, expressed in per cent is given by the relationship:

$$E\,(\%) = \frac{S' - S}{S} \cdot 100$$

where S is the surface activity response for a reference radionuclide, established in Sub-clause 20.1 and S' is the measured surface activity response to the same radionuclide measured by the test given in Sub-clause 22.3.

22.2 *Requirements*

Under standard test conditions the relative intrinsic error E, in the indication of the assembly to the relevant reference radionuclides shall not exceed $\pm 25\%$ over the whole of the effective range of measurement.

Note. — This error does not include the uncertainty in the value of the conventionally true surface activity per unit area for the test source used (see Sub-clause 16.5).

22.3 *Method of test*

A type test shall be carried out on at least one assembly of the series and the routine test shall be performed on each assembly.

22.3.1 *Type test*

For assemblies provided with substantially linear scales, the type test shall consist of measurements of the relative intrinsic error carried out on all ranges, and on at least three points on each of them, at about 85%, 60% and 30% of the scale maximum.

For assemblies with substantially logarithmic scales, or with digital presentation, the test shall be performed for at least three values in each decade of the effective range of measurement.

At least the tests corresponding to the lowest and highest indications shall be performed with test sources.

Tests at intermediate indications may be performed by means of electronic pulse injection in which case the requirements of Sub-clause 22.3.3 shall apply.

22.3.2 *Routine test*

For assemblies with substantially linear scales, the routine test shall be performed at one point on each range between 50% and 75% of the scale maximum. For assemblies with a substantially logarithmic graduation or digital presentation, the test shall be performed for one value in each decade of the effective range of measurement.

At least one of these tests shall be performed with a test source. The remaining tests may be performed by means of electronic pulse injection, in which case the requirements of Sub-clause 22.3.3 shall apply.

22.3.3 *Electronic method of test*

In the event that the full range of count rates required for the above test cannot be provided by the test sources, it is permissible to substitute an equivalent electrical test in order to determine the relative intrinsic error at the count rates that cannot be provided by the sources of radiation.

The electrical signal must be of a form to simulate as closely as possible the form of signal delivered by the detector and shall be injected at a point that will test the whole of the assembly apart from the detector itself.

If I is the indicated count rate when the assembly is subjected to the reference radiation source available, then an electrical signal shall be injected such as to produce the same indication, I.

Let this signal be Q.

Then if another indication i is produced by an input q, the relative intrinsic error E is given by:

$$E\,(\%) = \left(\frac{iQ}{qI} - 1\right) \cdot 100$$

and the observations must be within the limits given in Sub-clause 22.2 above.

If the electrical method of test is used, this should be stated in the accompanying documents.

22.3.4 *Method of interpretation of observations*

In determining whether the requirements of Sub-clause 22.2 are met, it is necessary to make allowances for the uncertainty in the values of the conventionally true activity per unit area of the test sources employed.

If the observations fall within both of the following limits, the requirements of Sub-clause 22.2 can be considered to be met:

i) no single observed value of E shall exceed $\pm 35\%$;
ii) the difference between any of the observed values of E shall not exceed 50%.

22.4 *Minimum detectable activity per unit area*

The minimum detectable activity per unit area (see Sub-clause 3.10) for the relevant reference radionuclides in a gamma radiation background at the upper limit of standard test conditions, i.e. 250 $nGy \cdot h^{-1}$ (25 $\mu rad \cdot h^{-1}$) shall be stated by the manufacturer.

23. Variation of response with radiation energy

23.1 *Alpha contamination meters or monitors*

No specification.

23.2 *Beta contamination meters or monitors*

23.2.1 *Requirements*

In addition to the measurement specified in Sub-clause 20.2, the surface activity response of the assembly shall be measured with beta emitters of at least three different maximum energies distributed as follows:
- one not more than 0.4 MeV
- one between 0.4 MeV and 1 MeV
- one not less than 1 MeV.

As a guide, suitable radionuclides are:
^{14}C (maximum beta energy 0.155 MeV, half-life 5730 years);
^{35}S (maximum beta energy 0.167 MeV, half-life 87.1 days);
^{147}Pm (maximum beta energy 0.22 MeV, half-life 2.6 years);
^{185}W (maximum beta energy 0.43 MeV, half-life 74 days);
^{36}Cl (maximum beta energy 0.714 MeV, half-life $3.08 \cdot 10^5$ years);
^{204}Tl (maximum beta energy 0.77 MeV, half-life 3.8 years);
^{210}Bi (maximum beta energy 1.17 MeV, half-life 5 days);
^{89}Sr (maximum energy 1.46 MeV, half-life 51 days).

The manufacturer shall state:
a) the radionuclides for which the surface activity response has been measured;
b) the value of surface activity response for each one of them;
c) the value of surface activity response for ^{204}Tl;
d) the beta particle maximum energy below which the surface activity response falls to less than 5% of the surface activity response to ^{204}Tl.

23.2.2 *Method of test*

The method of measurement of surface activity response for each radionuclide used shall be in accordance with the requirements of Sub-clause 20.2.

Whenever a suitable source is available, the test specified in Sub-clause 20.2.1 shall be employed. In other circumstances the test specified in Sub-clause 20.2.2 shall be used instead.

24. Response to other ionizing radiations

24.1 *General*

Assemblies for the measurement of surface contamination shall be designed to reduce as far as possible the influence of other ionizing radiation.

It is recommended that a beta probe be provided with some form of shutter to make it possible to distinguish beta radiation from gamma radiation.

The shutter thickness shall be stated in terms of equivalent mass per unit area.

24.2 *Gamma radiation*

24.2.1 *Alpha contamination meters and monitors*

a) First, the detector shall be subjected to a gamma absorbed dose rate in air of not less than 10 $mGy \cdot h^{-1}$ (1 $rad \cdot h^{-1}$) provided as below, and the count rate noted.

b) Second, the detector shall be irradiated with a test source of alpha radiation of such an activity as to give an indication on the most sensitive range of the assembly (or within the lowest decade in the case of a logarithmic scale) and the count rate noted.

c) It shall then be subjected to a gamma absorbed dose rate in air of not less than 10 $mGy \cdot h^{-1}$ (1 $rad \cdot h^{-1}$) at the same time as it is irradiated with the test source of alpha radiation. The same source configurations shall be used as for the measurements in *a)* and *b)* above. The count rate shall remain within the limits specified in Table III.

The reason for this test is that some types of alpha contamination measuring assemblies are affected indirectly by gamma radiation in that, although the gamma radiation itself does not produce any indication, the sensitivity to alpha radiation may be altered in these conditions.

The absorbed dose rates given above shall be provided by a sealed source of ^{60}Co.

24.2.2 *Beta contamination meters and monitors*

The detector shall be irradiated at a gamma absorbed dose rate in air of not less than 10 $\mu Gy \cdot h^{-1}$ (1 $mrad \cdot h^{-1}$) and the count rate noted. The result shall be given in counts per unit time for a gamma absorbed dose rate in air of 10 $\mu Gy \cdot h^{-1}$ (1 $mrad \cdot h^{-1}$).

The absorbed dose rate given above shall be provided by a sealed source of ^{60}Co.

24.3 *Beta radiation (for alpha contamination meters and monitors)*

A source of ^{90}Sr ^{90}Y of activity not less than 3.7 MBq (100 μCi) with no transverse dimension more than 10 mm shall be used.

a) First, place the test source of alpha radiation at a point 5 mm in front of the detector and note the count rate. For this test, the source of alpha radiation shall have dimensions that are small compared with the window area of the detector and a sufficiently low activity for the reading to be in the most sensitive range of an assembly with linear scales, or the most sensitive decade for an assembly with a logarithmic scale or digital display.

b) Second, without moving either the detector or the alpha source, place the beta source at a distance of 50 mm in front of the detector.

The count rate shall remain within the limits specified in Table III.

24.4 *Alpha radiation (for beta contamination meters and monitors)*

This test is only applicable to probes having an equivalent window thickness having a mass per unit area less than 5 $mg \cdot cm^{-2}$.

A thin source of an alpha emitter, for example ^{239}Pu or ^{241}Am shall be placed at a distance of not more than 10 mm from the surface of the probe. The covering of the source, if any, shall have an equivalent thickness of less than 1 $mg \cdot cm^{-2}$.

The response shall be given in counts per unit time per unit activity of the alpha emitter.

24.5 *Neutrons*

A test for neutron response is not mandatory and need only be carried out if this requirement is specified. The nature of the test shall be subject to agreement between the manufacturer and the user.

25. Inherent background count rate

The count rate due to the background for a gamma absorbed dose rate in air of not more than 0.2 $\mu Gy \cdot h^{-1}$ (20 $\mu rad \cdot h^{-1}$) shall be stated by the manufacturer.

SECTION FOUR – ELECTRICAL CHARACTERISTICS

26. Statistical fluctuations

26.1 *Requirements*

Owing to the random nature of alpha and beta particle emission, the indications of a contamination meter fluctuate about an average value.

The coefficient of variation of the indication due to these random fluctuations shall be less than 20%.

This requirement applies to any contamination level exceeding that corresponding to the following indications:

- linear scales:
  one-third of the scale maximum on the most sensitive range;
- logarithmic scales:
  three times the lowest significant graduation on the scale;
- digital display:
  ten times the value of the least significant digit.

This does not preclude the possibility of having selectable time constants, not all of which need meet this requirement.

The manufacturer shall state which time constants meet this requirement.

26.2 *Method of test*

Expose the assembly to a source of radiation giving an indication between one-third and one-half of scale maximum on the most sensitive range (linear scale) or the most sensitive decade (logarithmic scale) or an indication of the figure one in the second least significant digit (digital displays).

Take a series of at least 20 readings of the indication of the assembly at convenient time intervals. In order that the readings shall be substantially independent from one another, this time interval shall be not less than that corresponding to three times the time constant of the measuring assembly. Find the mean value and the coefficient of variation of all the readings taken. The coefficient of variation so determined shall lie within the limits of Sub-clause 26.1.

27. Response time

27.1 *Requirements*

The response time shall be such that, if there is a sudden change in the contamination being measured, the indication will reach the following value in less than 4 s:

$$N_i + \frac{63}{100}(N_f - N_i)$$

where N_i is the initial indication and N_f the final indication. The response time shall be stated by the manufacturer.

27.2 *Method of test*

The test may be carried out either with a suitable source of radiation or by the injection of a suitable electrical signal into the input of the measuring assembly.

For linearly scaled assemblies, the difference between the initial and final count rates shall be at least half of the maximum reading on the range under test. (Since in practice the response time will decrease with decreasing sensitivity, the requirement of this specification will be met by a test on the lower range.)

For logarithmically scaled assemblies, the initial and final count rates shall differ by a factor of 10 or more. The lower count rate shall not exceed one-third of the least significant complete decade.

Measurements shall be made for both an increase and a decrease in count rate indication.

If the electrical method of test is employed, the injected signals shall correspond to the above requirements.

For the increasing count rate test, the assembly shall be subjected first to the higher count rate and the indication N_f noted.

The assembly shall then be subjected to the lower count rate for a time sufficient for the indication N_i to reach a steady value and this indication noted.

The count rate shall then be changed as quickly as possible to that corresponding to the indication N_f and the time taken to reach the value given by the formula in Sub-clause 27.1 measured.

The decreasing count rate test shall be performed in the same way with the count rates corresponding to N_f and N_i interchanged.

28. Inter-relationship between response time and statistical fluctuations

The response time and coefficient of variation of the statistical fluctuations are inter-dependent characteristics, acceptable limits for which are given in Clauses 26 and 27.

For high contamination levels, it is recommended that, whenever possible, the response time be reduced, while conforming to the limits laid down for the statistical fluctuations.

If the limits in Clauses 26 and 27 can be met with a response time of not more than one second, it is preferable to reduce the statistical fluctuations rather than to reduce the response time below 1 s.

For contamination levels below those for which the above requirements can be met, the manufacturer shall state the appropriate values of the coefficient of variation and response time.

29. Alarm threshold drift

This clause is applicable to monitors only.

29.1 *Requirements*

For an assembly whose alarm threshold (trip threshold) has been determined by means of a radioactive source or a pulse generator, if 80% of the threshold value is applied for 24 h, no tripping shall occur. If 120% of the threshold value is applied, tripping shall occur within 1 min.

29.2 *Method of test*

For an assembly where the alarm threshold may be set at different values, this test should be carried out on each appropriate decade on a logarithmically scaled assembly and on each appropriate range of a linearly scaled assembly where the setting is dependent on the range setting.

Because of the random nature of radiation emission, the test should be carried out using a pulse generator of uniformly spaced pulses, in place of the detection sub-assembly.

Let S be the set point value of the alarm threshold under test and X the pulse rate to which S corresponds (according to the data supplied by the manufacturer).

The following conditions shall be satisfied:

29.2.1 With the trip not activated, apply a pulse rate of 0.8 X. No trip shall occur for a period of 24 h with the threshold value set at S.

29.2.2 With the trip not activated, apply a pulse rate of 1.2 X and ensure that the assembly trips within 1 min. This test shall be repeated at least 4 times at time intervals T to $2T$ where T is at least 6 h.

30. Warm-up time test (for portable assemblies)

With the assembly previously switched off for a period sufficient for the internal temperature of the assembly to be in equilibrium with the ambient air temperature, expose the detector to an appropriate source of radiation. Switch on the assembly and take readings every

20 s from 40 s to 300 s after switching on: 15 min after switching on, take at least ten readings and take the mean value of these as the "final value" of the indication.

The difference between the final value and the values read from the curve at 1 min and 3 min shall lie within the limits specified in Table III.

31. Resolution time

The loss in count rate due to the resolution time of the assembly should not exceed 20% of the true count rate at any point of the effective range of measurement. If this limit is exceeded, the meter scale shall be marked accordingly.

When not taken into account by the graduation, the resolution time shall be stated by the manufacturer.

32. Overload protection

32.1 *Requirements*

For activities greater than that corresponding to full-scale deflection, the indication of the assembly shall be out of scale at the higher end of the scale range and shall remain so. For assemblies with more than one scale range, this requirement shall apply to each scale range.

32.2 *Method of test*

Compliance with this requirement is tested by submitting the assembly for 5 min to an activity of at least 100 times that corresponding to full-scale deflection of each scale.

33. Ambient temperature

33.1 *Requirements*

Over the range of temperature specified in Table III, the indication shall remain within the limits specified in that table.

33.2 *Method of test*

It will normally be necessary to carry out this test in a climatic box. A reference source shall be used to provide some indication. It is not, in general, necessary to control the humidity of the air in the box unless the assembly is particularly sensitive to changes in humidity. In this case the effect should be noted.

The temperature should be maintained at each of its extreme values for at least 4 h and the indication of the assembly measured during the last 30 min of this period.

34. Relative humidity

34.1 *Requirements*

The indication of the assembly shall not vary by more than 10% from that obtained under standard test conditions for any value of relative humidity up to 90%. A test of this

influence quantity is only required if the effects of relative humidity are considered to be significant.

34.2 *Method of test*

The test may be carried out at a single temperature of 30 °C, using a climatic box. The permitted variation of ±10% in the indication is additional to the permitted variation due to the effects of temperature alone.

35. Power supply

35.1 *Mains operation*

Mains operated assemblies shall be designed to operate from single-phase supply voltage in one of the following categories, in accordance with IEC Publication 293: Supply Voltage for Transistorized Nuclear Instruments *:

Series I–220 V
Series II–120 V and/or 240 V

The assemblies shall be capable of operating from mains with a supply voltage tolerance of +10% and –12% and a supply frequency of 60±3 Hz or 50±3 Hz.

35.2 *Mains operation test*

Expose the detector to appropriate sources of radiation of sufficient activity to give a count rate corresponding to approximately two-thirds full-scale deflection on the most and on the least sensitive range or decade respectively.

Note the indication with the supply voltage at its nominal value.

Note the indication with the supply voltage 10% above and 12% below the nominal value.

These shall not differ from those at the nominal supply voltage by more than 10%.

35.3 *Battery operation*

When power is supplied by primary batteries, the capacity of these shall be such that after 40 h of intermittent use ** or 24 h of continuous use without the threshold trip operating, the indication of the assembly does not differ by more than 10% from the initial value.

When power is supplied by secondary batteries, the capacity of these shall be such that after 12 h of continuous operation, the indicated reading value does not differ from the initial reading by more than 10%.

Facilities shall be provided to check the battery condition under maximum load.

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* IEC Publication 293 (1968) makes reference to the third edition of IEC Publication 38: IEC Standard Voltages. Table I in that edition is however superseded by Amendment No. 1 (August 1977) in which 220 V is no longer recommended for new systems. (230 V is recommended instead.) IEC Publication 293 may eventually be amended accordingly.

** Intermittent use, means periods of use of 4 h separated by intervals of at least 1 h, giving a total on-time of 40 h.

The minimum battery check indication for which the performance of the assembly will remain within the requirements of this specification shall be clearly marked on the meter scale.

When primary batteries are used these should be preferably of R 20 type defined in IEC Publication 86: Primary Cells and Batteries. The nominal voltage of R 20 type is 1.5 V.

Batteries may be connected in any desired manner but shall be individually replaceable; the correct polarity shall be clearly indicated on the assembly by the manufacturer.

If secondary batteries are used, it shall be possible to recharge the batteries from the mains supply in 16 h.

The use of a device which switches off the charger when the complete charge is obtained is recommended.

35.4 *Method of test for battery-supplied assembly*

New primary batteries or fully charged secondary batteries of the type recommended by the manufacturer shall be used for this test. Expose the detector to appropriate sources of radiation of sufficient activity to give a count rate corresponding to approximately two-thirds full scale deflection on the most sensitive and on the least sensitive scale ranges respectively. If a loudspeaker is fitted to this assembly it shall be switched on. The threshold trip shall not be operating.

Take the mean of 10 consecutive readings of count rate in each case. Leave the assembly continuously working in front of those sources for 24 h (for primary battery operated assemblies) or 12 h (for secondary battery-operated assemblies). At the end of this time, again take the mean of 10 consecutive readings of count rate in each case. These mean values shall not differ from those obtained at the beginning by more than 10%.

36. Storage

All assemblies designed for use in temperate regions shall be designed to operate within the specifications of this standard following storage (or transport) for a period of at least three months in the manufacturer's packaging at a temperature from –25 °C to +50 °C without batteries.

In certain circumstances, more severe specifications may be required such as capability for withstanding air transport at low ambient pressure.

37. Identification certificate

An identification certificate shall accompany each assembly giving at least the following information *:

37.1 In respect of the measuring sub-assembly:

37.1.1 Manufacturer's name or registered trade mark.

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* See IEC Publication 278: Documentation to be Supplied with Electrical Measuring Apparatus.

37.1.2 Type of the sub-assembly and serial number.

37.1.3 Scale limits for each measuring range.

37.1.4 *Effective range of measurement.* This information shall be given for each probe intended for use with the assembly.

37.2 In respect of each detection sub-assembly:

37.2.1 The information in Sub-clause 37.1.

37.2.2 Surface activity response for a specific nuclide.

37.2.3 Response as a function of beta radiation energy (for beta detectors).

37.2.4 Dependence of response on source position.

37.2.5 Total and sensitive area of the detector window.

37.2.6 Materials of the wall between the source and sensitive volume of the detector and mass per unit area of each of them in $mg \cdot cm^{-2}$.