IEC 62438

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Radiation protection instrumentation – Mobile instrumentation for the measurement of photon and neutron radiation in the environment

Instrumentation pour la radioprotection – Instrumentation mobile pour la mesure des rayonnements gamma et neutroniques dans l'environnement

IEC 62438:2010

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CONTENTS

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RADIATION PROTECTION INSTRUMENTATION – MOBILE INSTRUMENTATION FOR THE MEASUREMENT OF PHOTON AND NEUTRON RADIATION IN THE ENVIRONMENT

FOREWORD

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International Standard IEC 62438 has been prepared by subcommittee 45B: Radiation protection instrumentation, of IEC technical committee 45: Nuclear instrumentation.

This standard cancels and replaces IEC 61134, issued in 1992. The scope of IEC 61134 was restricted to exploration for geological deposits of potassium, uranium and thorium. IEC 62438 incorporates the range of currently available detector technologies and incorporates neutron monitoring. This standard also relates to a wide range of mobile platform applications including environmental, emergency response, security in addition to geological.

The text of this standard is based on the following documents:

FDIS	Report on voting
45B/633/FDIS	45B/636/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

RADIATION PROTECTION INSTRUMENTATION – MOBILE INSTRUMENTATION FOR THE MEASUREMENT OF PHOTON AND NEUTRON RADIATION IN THE ENVIRONMENT

1 Scope and object

This International Standard is applicable to mobile radiation detection systems used for the detection, quantification and identification of photon and/or neutron emitters in the environment. This includes point and distributed radiation sources.

The object of this standard is to:

- establish definitions;
- establish minimum requirements for the instrumentation;
- establish requirements for deployment and operations;
- provide test and calibration methods; and
- provide guidance to procurement for appropriate equipment.

In general, mobile instrumentation systems for nuclear radiation measurements in the environment are comprised of detectors, detector signal processors, position sensing devices, on-board data recording, operational monitoring, and real time display/alarm capabilities. In addition, advanced systems may provide data streams that can be transmitted by telemetry to operations centres.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-393:2003, *International Electrotechnical Vocabulary (IEV) – Chapter 393: Nuclear instrumentation – Physical phenomena and basic concepts*

IEC 60050-394:2007, *International Electrotechnical Vocabulary (IEV) – Part 394: Nuclear instrumentation – Instruments, systems, equipment and detectors*

IEC 60068-1:1988, *Environmental testing – Part 1: General and guidance*

IEC 60068-2-6:2007, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-14:2009, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60068-2-30:2005, *Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

IEC 60086 (all parts), *Primary batteries*

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*

IEC 60973:1989, *Test procedures for germanium gamma-ray detectors*

IEC 61010-1:2001, *Safety requirements for electrical equipment for measurement, control and laboratory use*

IEC 62534, *Radiation protection instrumentation – Highly sensitive hand-held instruments for neutron detection of radioactive material*[1]

ISO 4037 (all parts), *X and gamma reference radiation for calibrating dosemeters and doserate meters and for determining their response as a function of photon energy*

ISO 6980 (all parts), *Nuclear energy – Reference beta-particle radiation*

3 Terms, definitions and nomenclature

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. Except as specified below, all technical terms are as defined in IEC 60050, particularly for radiation quantities and dosimetric terms defined in IEC 60050-393 and IEC 60050-394.

3.1.1 mobile detection system

mobile detection systems consist of a suitable number of radiation detectors mounted on an transportable platform, which are capable of making measurements while moving (see Figure 1).

NOTE This may include but is not limited to fixed and rotary winged aircraft, surface vehicles, ocean towing, and amphibious vehicles.

3.1.2 energy resolution

the full width in percent or keV at half maximum at a defined total absorption peak (see Annex A)

3.1.3 background (intrinsic, platform and cosmic)

the measured count rate from photons in an energy spectrum or a given energy window or the measured count rate from neutrons from the detection system, platform and cosmic radiation (see Annex A)

3.1.4 positional reference

the spatial reference which defines the location of the detection system in terms of a coordinate system and where necessary, altitude and the height above the surface

3.1.5 area of investigation

the area from which 90 % of the detected photons and neutrons of interest are emitted, assuming a planar surface of uniform activity

3.1.6 sampling interval

the time in seconds between the start of consecutive data samples or measurements. This is also known as the integration time

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1 To be published.

3.1.7 reference soil or surface

an area of soil or surface that has been characterized for empirical calibration of the mobile system (see Annex C)

3.1.8 platform

for the purposes of this standard, platform refers to carrying system including aircraft, truck or person

3.2 Test nomenclature

3.2.1 qualification tests

tests performed in order to verify that the requirements of a specification are fulfilled. Qualification tests are divided into type tests and routine tests.

a) **type test**: A test of one or more devices made to a certain design to show that the design meets certain specifications.

b) **routine test**: A test to which each individual device is subjected during or after manufacture to ascertain whether it complies with certain criteria.

3.2.2 acceptance test

a contractual test to prove to the customer that the device meets certain conditions of its specifications

[IEV 151-04-20]

4 General system configuration

The measurement system should consist of:

- A primary detection system that has variable sampling intervals (typically between 1 s and 5 s) providing sufficient detector response to enable the detection, identification, and quantification of radionuclides of interest.
- Navigation system to continuously measure the position of the detection system, enabling spatial resolution for mapping. For ground systems inertial navigation may be required in areas where there is poor GPS coverage.
- Power supply for the detection system that may be part of the mobile platform or self-contained.
- Multi-channel analyzer(s) for photon pulse height analysis with algorithms to provide radionuclide identification.
- A data acquisition system that collects and stores radiation detection data, positional information, time, and provides user interface and real-time display.
- Software for data viewing and basic analysis.

The measurement system may also include:

- A neutron detector to record the gross neutron count rate.
- For airborne systems these should also include radar altitude and may also include ambient temperature, humidity and pressure, wind speed and direction.

For information purposes, primary detection systems comprise large volume NaI(Tl) detectors, although other scintillators may also be considered. For emergency response purposes, organic scintillators may also be considered for mapping total gamma emission.

Figure 1 provides an example of a typical detection system.

Examples of detector deployment are given in Table 1 below.

Table 1 – Typical detector deployment for different applications

Application	Typical instrument deployment	Example radionuclides of interest
Baseline environmental survey	NaI(Tl) and/or HPGe	^{137}Cs, ^{60}Co, U, Th, K,
Geological survey	NaI(Tl)	U, Th, K
Emergency response	NaI(Tl), HPGe, organic scintillator, ^{3}He proportional counters, other suitable neutron detectors, and/or any combination	^{137}Cs, ^{60}Co, ^{241}Am, Pu, ^{131}I, neutrons

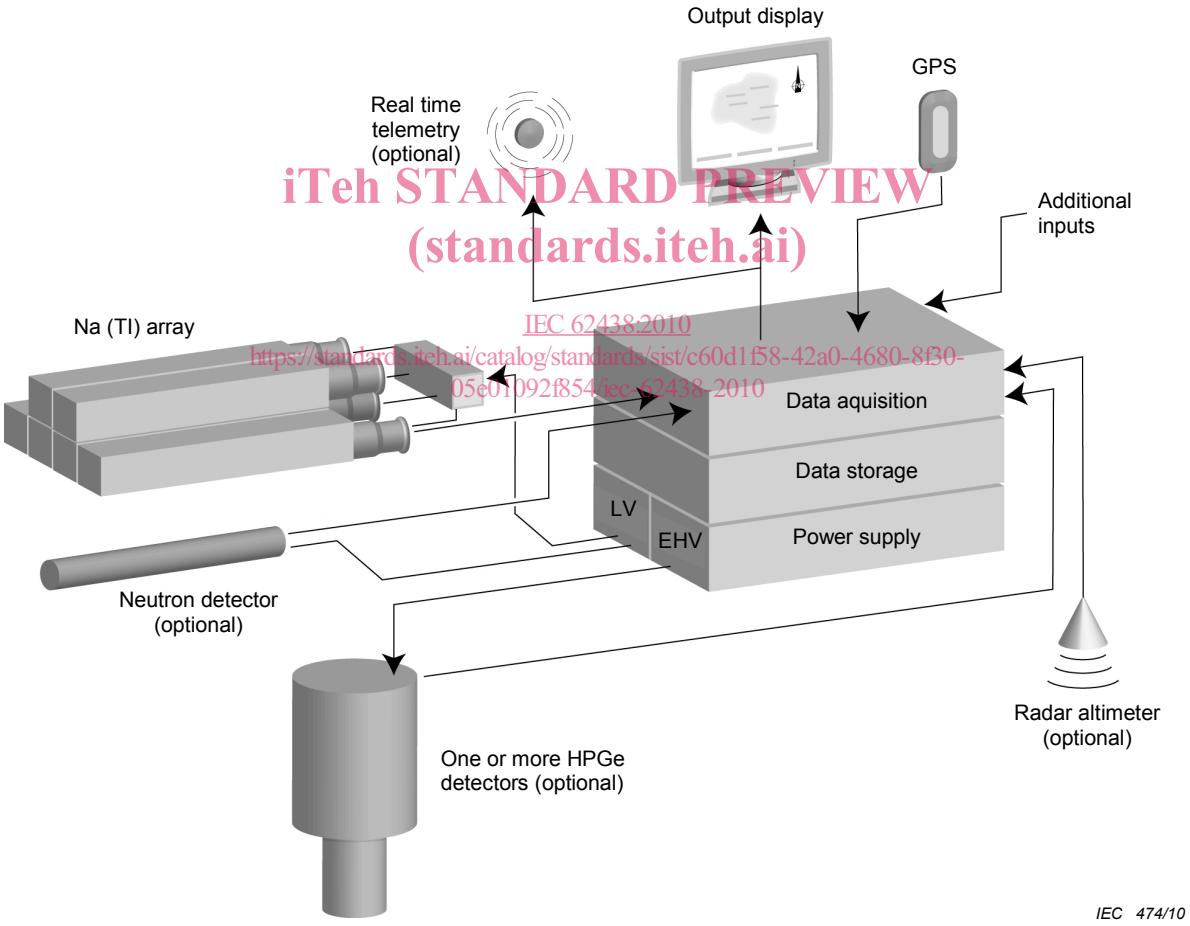

Figure 1 – Schematic diagram of the typical components of a mobile platform system

5 General requirements

5.1 Power supply

The system should be designed to accept universal power 12-48 V d.c. and/or 100-240 V a.c. (50-60 Hz).

5.2 Battery power supply

When power is supplied by batteries, the capacity of these shall be such that, after at least 8 h of continuous use during operation under standard test conditions, the indication of the assembly shall remain within ±10 %, other functions remaining within specification. Batteries as specified in IEC 60086 shall be used.

5.3 Cabling and connections

Connectors and cabling shall be used that are appropriate for the platform and deployment.

5.4 Shock (operating)

The system shall withstand shocks of 300 ms^{-2} (see Table 4).

5.5 Vibration (operating)

The system shall withstand and operate during vibration at 10-55 Hz, with a total displacement of 0,075 mm at 10 ms^{-2} (see Table 4).

5.6 Vibration (non-operating)

The system shall perform within specification after being subjected to vibration (see Table 4).

5.7 Water resistance

Externally mounted detectors shall be water resistant.

5.8 Spectrometric systems

For low resolution detectors such as NaI(Tl), the analogue to digital converter (ADC) shall have a minimum of 512 channels. For medium resolution detectors such as Cadmium Zinc Telluride (CZT), the ADC shall have a minimum of 1 024 channels. For high resolution detectors such as HPGe, the ADC shall have a minimum of 4 096 channels.

6 Classification of the performance characteristics

The limits of variation in the indication of an assembly are specified for each performance characteristic in Tables 4 to 5 and in the appropriate subclauses. For some applications it may not be deemed essential for an assembly to meet all the requirements set out below. In such cases, the requirements to be applied to the assemblies may be specified by agreement between the manufacturer and the purchaser, but the determination of the characteristics of the assemblies shall conform to the methods given in the present standard.

If the mass, overall dimensions, installation and construction of the instruments do not allow carrying out the tests of the complete system as a whole by means of the existing test equipment, then each component may be tested separately in conformity with the present standard followed by a complete check of the entire system under normal installation and operating conditions. The procedure used for the test shall be specified.

7 General test procedures

7.1 Nature of tests

Unless otherwise specified in the individual clauses, all the tests enumerated in this standard shall be considered type tests (see 3.2.1). Certain tests may be considered acceptance tests by agreement between the manufacturer and the purchaser (see 3.2.2).

7.2 Reference conditions and standard test conditions

Reference conditions are given in the second column of Table 3. Except where otherwise specified, the tests in this standard shall be carried out under the standard test conditions given in the third column of Table 3. For those tests carried out under standard test conditions given in Table 4 the values of temperature, pressure and relative humidity at the time of test shall be stated and the appropriate corrections made to give the response under reference conditions.

For those tests intended to determine the effects of variations in the influence quantities given in Table 3, the tests listed in Table 5 all other influence quantities shall be maintained within the limits for standard test conditions given in Table 4, unless otherwise specified in the test procedure concerned.

7.3 Position of assembly for purposes of tests

For all tests involving the use of radiation, the reference point of the assembly shall be placed at the point where the conventionally true value of the quantity to be measured is known, and in the orientation of the assembly indicated by the manufacturer.

7.4 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 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 measurements may be estimated with sufficient accuracy to determine whether the requirements for the characteristic under test are met. The interval between such readings shall be sufficient to ensure that the readings are statistically independent.

7.5 Reference radiation

Unless otherwise specified in the individual methods of test, all tests involving the use of gamma radiation shall be carried out with the nuclide ^{137}Cs, ^{60}Co and/or ^{241}Am (see Table 3). All tests requiring a neutron source shall be carried out with unmoderated ^{252}Cf. The nature, construction and conditions of use of the radiation sources shall be in accordance with ISO 4037 for photon radiation and ISO 6980 for neutron radiation.

8 General performance specification and testing requirement

8.1 Power supply

8.1.1 Requirements

The mobile system should be designed to accept universal power 12-48 V d.c. and/or 100-240 V a.c. (50-60 Hz). The indication shall not vary by more than ±10 % over the range of supply voltages.

8.1.2 Test method

Place the mobile system in a field of gamma radiation of energy of interest (e.g. ^{137}Cs or ^{60}Co) such that the assembly gives an indication that is approximately three times the background count rate in the channels corresponding to the total absorption peaks. For each test accumulate a minimum of 10 000 pulses in the total absorption peak.

With the supply voltage at its nominal value, determine the mean indication (total absorption peak area) given by the assembly. Determine the mean indication with the supply voltage 10 % above the nominal value and also the mean indication with the supply voltage 12 % below the nominal value. These mean values shall not differ from that obtained with nominal