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Latest Updates for the IEC Standards for Active and Passive Dosemeters

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Latest updates for the IEC standards for active and passive dosemeters

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Abstract

This paper presents the standards developed by the International Electrotechnical Commission (IEC) Subcommittee 45B "Radiation protection instrumentation" concerning the active pocket and portable dose (rate) meters and monitors and passive dosimetry systems.

The IEC standards describe the performance requirements and the functional criteria along with the test methods for evaluating the performance of the applicable instrumentation and their compliance with the standard requirements. The standards specify the general characteristics, the general test procedures, the radiation characteristics, as well as the environmental, mechanical, electromagnetic and electric characteristics.

The most recent changes of the standard IEC 62387 (2nd edition is to be published in 2020) covering the dosimetry systems with integrating passive detectors for individual, workplace and environmental monitoring of photon and beta radiation are discussed. The standards for various active meters and monitors as IEC 61526, IEC 60846-1&2, IEC 61005 etc. are also dealt with in short. All these standards were transposed as European EN standards. The standardization of hybrid dosemeters (dosemeters between active and passive) is discussed as outlook.

The criteria and the compliance test methods in the standards discussed in this paper are the results of an optimization, compromise and consensus among the participating experts from many countries searching for acceptable measurement performances that reflect the positions of their national regulatory agencies, the scientific and technological progress of the industry, the testing laboratories capabilities and the end user's needs. These standards provide manufacturers with internationally acceptable requirements and provide consistent test methods for compliance with the stated performance requirements.

Keywords: IEC; standards; dosimetry; dosemeters; monitors

1. Introduction

1.1. IEC and its SC 45B

The International Electrotechnical Commission (IEC) is the world's leading organization that prepares and publishes globally relevant international standards for all electric and electronic devices and systems. It brings together 86 countries (62 Member and 24 Affiliates countries), representing 98% of the world population and 96% of world energy generation. Close to 20 000 experts cooperate on the global IEC platform.

All IEC international standards are fully consensus-based and represent the needs of key stakeholders of every nation participating in IEC work. The IEC standards worldwide serve as basis for national standardization as well as references when drafting international tenders and contracts and for conformity evaluation of instrumentation. In addition, IEC standards are considered by CENELEC (European Committee for Electrotechnical Standardization) for adoption as European standards.

IEC subcommittee 45B "Radiation protection instrumentation" is one of the 207 IEC Technical Committees (TC) and SubCommittees (SC) and prepares standards addressing instrumentation used for:

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- the measurement of ionizing radiation in the workplace, to the public, and in the environment for radiation protection purposes;
- illicit trafficking detection of radioactive material and identification of radionuclides;
- and radiation-based security screening.

SC 45B has 21 participating countries, 14 observer countries, 7 working groups (WG) and close to 150 experts from the world leading testing laboratories, governmental agencies, manufacturers and users. The SC has published more than 55 international standards and technical reports since its creation in 1965.

WG 8 of SC 45B prepares standards on active pocket and portable dose and dose rate meters and monitors and on passive dosimetry systems for photon, beta and neutron radiation that are used for the direct or indirect supervision of dose limits (e.g. for persons or controlled areas), for the characterization of workplaces, etc. The standards specify requirements for the dosemeter, monitor, and, if supplied, for its associated equipment and software, e.g. its readout system.

Previous publications concerning the work of IEC/SC 45B/WG 8 can be found in references (Voytchev et al. 2011, 2016).

1.2. Revisions of the dosimetry standards

The dosimetry standards developed by IEC/SC 45B (see 3.1 to 3.4) are referenced in many national regulation texts. As an example, IEC 62387 (IEC 62387 Ed. 2, 2020) is used for the accreditation of passive dosimetry laboratories and often full conformity to this standard is asked by the regulators. Thus, although all efforts of the experts developing the standards, imperfections can occur that need to be corrected.

A second need for revision is shown by the feedback during the instrument testing according to the standard. Performance criteria could be too tight or not realistic and WG 8 is in close relation to several testing laboratories and manufacturers for tracking such problems; several representatives of these parties are members of WG 8.

A third need for revision is the evolution of the different documents referenced in the IEC standards as the ICRP recommendations (e.g., the need to consider the quantity $H_p(3)$), ICRU recommendation (e.g., the future consideration of new dose quantities (Otto et al., 2018)) or the evolution of the ISO standards describing the testing and calibration procedures.

Last but not least, the technology evolutions and the appearing of the new detection methods (e.g., see 3.3) need to be taken into account.

Thus, the experience shows that after about 4-5 years a standard needs revision that includes both editorial and technical improvements.

2. Standard development

2.1. Starting a new IEC standard project or revision

The development of a new IEC standard or the revision of a previous edition follow a rigid IEC procedure for standard development. A new standard project can be proposed by the NC (National Committee) or the TC/SC secretary. At least 5 different countries need to agree and appoint their experts in order to initiate a new project. Initiation of a standard revision is triggered by the Working Group decision validated by the NCs.

2.2. Stages

The IEC standard development passes through different stages:

- NP (New Project) – approval stage of the new project;
- One or more CDs (Committee Drafts) – preparatory and discussion stage;
- CDV (Committee Draft for Vote) – vote stage among the NCs. This is the last stage for technical comments and changes.

– FDIS (Final Draft International Standard) – the NCs vote to approve the standard. Only editorial comments and changes are accepted.

The standard project is circulated to the SC45B NCs at each stage for comments and suggestions.

At the plenary SC 45B meetings (once every 18 months approximately), all received comments and suggestions, as well as the entire standard project and its relation with other standards, international documents (ICRP, ISO, ICRU, etc.) and scientific publications are discussed in depth in the respective working group.

2.3. Criteria for requirements and test methods

The experts discussing and approving the standard changes are from various origins:

– manufacturers;
– testing laboratories;
– users;
– regulators;
– universities and research institutes.

Thus, in addition to the technical and scientific arguments, the criteria and compliance test methods in the standards discussed in this paper are the result of an optimization, compromise and consensus among the participating experts from many countries searching for acceptable detection performance that reflects the positions of the national regulatory agencies, scientific and technological progress of the industry, testing laboratories capabilities, end user needs, testing cost and the way the instruments are used in the field.

2.4. Standard definition

According to ISO/IEC Directives (ISO/IEC Directives Part 2, 2018), a standard is a document, established by consensus and approved by a recognized body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context.

Adoption of IEC/ISO standards by any country, whether it is a member or not, is entirely voluntary. Thus, it is important to state these standards are not mandatory. However, they can become mandatory indirectly if they are referenced in the national legislation texts.

3. Discussion and results

3.1. IEC 62387 Dosimetry systems with integrating passive detectors

3.1.1. Scope and editions

The standard IEC 62387 (IEC 62387 Ed. 2, 2020) covers the dosimetry systems with integrating passive detectors for individual, workplace and environmental monitoring of photon and beta radiation. It applies to all kinds of passive dosimetry systems that are used for measuring:

– the personal dose equivalent $H_p(10)$ (for individual whole body monitoring),
– the personal dose equivalent $H_p(3)$ (for individual eye lens monitoring),
– the personal dose equivalent $H_p(0.07)$ (for both individual whole body skin and local skin for extremity monitoring),
– the ambient dose equivalent $H^*(10)$ (for workplace and environmental monitoring),
– the directional dose equivalent $H'(3)$ (for workplace and environmental monitoring), or
– the directional dose equivalent $H'(0.07)$ (for workplace and environmental monitoring).

The first edition of this standard was published in 2007 (at that time it was with the number IEC 62387-1), then there was an edition in 2012 (formally this edition was considered as edition 1 since the number changed "-1" being deleted). There were important changes in the 2012 edition that were presented previously (Voytchev et al., 2016).

It is important to note that in many countries, especially the European ones, this standard is used by the regulators for accreditation of passive dosimetry laboratories especially those acting as individual monitoring services (IMS). Thus, full compliance with the standard is often required.

Another important point to mention is that after the IEC publication, the standard was transposed by CENELEC as European EN standard. During the 2 EN transpositions published in 2012 and 2016, important changes were also added that were taken into account for the next IEC editions.

3.1.2. Requirements and methods of tests

Requirements and methods of tests were prepared for the following characteristics:

- Capability of the dosimetry system;
- Requirements to the design of the dosimetry system;
- Effects of radiation not intended to be measured;
- Instruction manual;
- Software, data and interfaces;
- Coefficient of variation;
- Relative response due to non-linearity;
- Overload, after-effects, and reusability;
- Relative response due to mean photon radiation energy and angle of incidence (relative to reference radiation, usually ^{137}Cs);
- Relative response due to mean beta radiation energy;
- Radiation incidence from the side of the dosemeter;
- Response to mixed irradiations (additivity of the indication);
- Total effect due to environmental performance requirements (temperature and relative humidity tests);
- Deviation due to electromagnetic performance requirements;
- Deviation due to mechanical performance requirements (drop test).

This paper will discuss only the recent changes that will be issued in the 2019 edition of the standard.

3.1.3. Energy and angle performance requirement for $H_p(10)$, $H_p(3)$ and $H_p(0.07)$ at low energies

In the previous editions, at low energies (below 65 keV), the energy and angle performance requirement for $H_p(10)$, $H_p(3)$ and $H_p(0.07)$ quantities were slightly increased in relation to the rest of the energy interval up to 1.25 MeV. The energy range was divided into three ranges: (a) from 12 keV to 33 keV the relative response needed to be between 0.67 and 2.0; (b) from 33 keV to 65 keV the relative response needed to be between 0.69 and 1.82; (c) from 65 keV to 1.25 MeV the relative response needed to be between 0.71 and 1.71 – all for angles of incidence from 0° to ±60°. Following the experience of the last years of testing, the requirements can be met by several dosimetry systems. In addition, the requirements to active personal dosemeters, also used for individual monitoring, are uniform within the whole energy and angular range (IEC 61526 Ed.3, 2010). Finally, intercomparison measurements within Europe showed that most of dosimetry systems meet stricter requirements (Stadtmann et al., 2016; EURADOS website).

3.1.4. Mandatory beta energy range for $H_p(0.07)$

The only mandatory mean beta energy for testing $H_p(0.07)$ was 0.8 MeV (that is testing with ^{90}Sr/^{90}Y). The testing energy of 0.24 MeV (^{85}Kr or ^{204}Tl) was now added.

3.1.5. Photon conversion coefficients for $h_{pK}(3;\alpha)$, $h'_K(3;\alpha)$, $h_{pK}(0.07;\alpha)$ and $h'_K(0.07;\alpha)$

Prior to the latest edition of ISO 4037-3 (ISO 4037-3, 2019), IEC 62387 had its own photon conversion coefficients for $h_{pK}(3;\alpha)$, $h'_K(3;\alpha)$, $h_{pK}(0.07;\alpha)$ and $h'_K(0.07;\alpha)$ as they were not available in ISO 4037-3:1999. After the 2019 publication of ISO 4037-3, the values in IEC 62387 were deleted and reference was made to the ISO updated standard.

3.1.6. Distinction between workplace and environmental monitoring

Up to the 2012 edition, there were requirements for the ambient dose equivalent $H^*(10)$ without any particular distinction. Now a distinction between workplace and environmental monitoring was made with the following definitions:

- *workplace monitoring*: area monitoring using dose (rate) measurements made in the working environment (usually contrasted with individual monitoring);
- *environmental monitoring*: area monitoring by the measurement of external dose (rate) in the environment.

Workplace and environmental monitoring are performed in terms of $H'(0.07)$, $H'(3)$ or $H^*(10)$.

For the area dosemeters, the mandatory angular dependence testing is at least up to 60° in two perpendicular planes while for environmental dosemeters this angular testing is up to 120°. The reason is that, for area monitoring, the dosemeters are often mounted on a wall in a building or hand-held, while for environmental monitoring, they can be hung free in the air so the radiation is impinging from a wide angular region.

3.1.7. Maximum overload dose

The maximum overload dose to be tested in the previous editions was 10 Sv (which may be equivalent to the upper dose limit for some dosimetry system while the overload dose test aims to test the instrument behaviour beyond its limit) or 50 Sv (which seems too high following the last discussions and experience). Thus, a compromise maximum overload dose level of 20 Sv was fixed.

3.1.8. Electromagnetic compatibility radio-frequency immunity test

The electromagnetic compatibility radio-frequency immunity test was always difficult to be defined in practical manner since all frequencies from 80 MHz to 2.4 Ghz shall be swept during the dosemeter reading process. In previous editions, arrangements were made for omitting this test if the manufacturer declares that the frequencies have no impact on the dosemeter reading (including a physical explanation). Now a set of the most relevant 15 frequencies often used in industry products such as walkie talkies, mobiles etc. was established (98 MHz, 202 MHz, 434 MHz, 550 MHz, 710 MHz, 873 MHz, 903 MHz, 915 MHz, 947 MHz, 1472 MHz, 1800 MHz, 1890 MHz, 2035 MHz, 2150 MHz and 2450 MHz) for testing at an electric field strength of 30 V/m (at one side of the dosemeter) or 10 V/m (at all sides of the dosemeter).

3.2. IEC 61526 Direct reading personal dose equivalent meters

The standard IEC 61526 (IEC 61526 Ed.3, 2010) covers the direct reading personal dose equivalent meters for measurement of personal dose equivalents $H_p(10)$ and $H_p(0.07)$ for X, gamma, neutron and beta radiations. The last edition of this standard was presented earlier (Voytchev et al. 2016). Now it is to be noted that this standard will be revised in 2020 in order to take into account the quantity $H_p(3)$, to explicitly cover extremity dosemeters for $H_p(0.07)$, to add software requirements as well as to cover the emerging hybrid dosemeters (see 3.3). Finally, it will be harmonized with IEC 62387.

3.3. Dosemeters between active and passive (hybrid)

During the past several years, an increasing number of dosemeters emerged that are between active and passive (they can be called hybrid). These dosemeters have an active dosemeter component with electronics but do not have any direct on-body indication. The recorded dose can be read remotely through wireless connection and can be stored during several days or weeks. A prominent example is the direct ion storage (DIS) dosemeter. The hybrid dosemeters are between the scopes of IEC 62387 and IEC 61526. The provisional decision of WG 8 for such dosemeters is to be covered by the new 4th edition of IEC 61526.

3.4. Active individual monitors

Below are listed a few other types of individual monitors that were standardized by WG 8 (the characteristics of these standards will not be discussed in this paper):

- Ambient and/or directional dose equivalent (rate) meters and/or monitors for beta, X and gamma radiation (IEC 60846-1, 2009) and (IEC 60846-2, 2015);
- Neutron ambient dose equivalent (rate) meters (IEC 61005, 2014);
- Electronic counting dosemeters for pulsed fields of ionizing radiation (IEC TS 62743, 2012);
- Dosemeters for pulsed fields of ionizing radiation (IEC TS 63050, 2019).

4. Conclusions

The IEC standards presented in this paper describe the performance requirements and the functional criteria along with the test methods for evaluating the performance of the applicable instrumentation. The standards specify the general characteristics, the general test procedures, the radiation characteristics, as well as the environmental, mechanical, electromagnetic and electric characteristics.

The criteria and compliance test methods in the standards discussed in this paper are the results of an optimization, compromise and consensus among the participating experts from many countries searching for acceptable detection performances that reflect the positions of the national regulatory agencies, scientific and technological progress of the industry, testing laboratories capabilities and end user needs. These standards provide manufacturers with internationally acceptable requirements and provide consistent test methods for compliance with the stated performance requirements.

The last changes in the standard IEC 62387 covering the dosimetry systems with integrating passive detectors for individual, workplace and environmental monitoring of photon and beta radiation were presented in detail. The latest edition of this standard is expected to be published by the end of 2019.

Standards addressing different active individual monitors were also mentioned.

Dosimetry experts from all over the world are welcomed to participate to the IEC/SC 4B/WG 8 standardization work. The interested professionals have to contact their IEC national committee or the authors of this paper.

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