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Dosimetry for exposures to cosmic radiation in civilian aircraft —

Part 1: Conceptual basis for measurements

Dosimétrie pour l'exposition au rayonnement cosmique à bord d'un avion civil —

Partie 1: Fondement théorique des mesurages

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 85, *Nuclear energy, nuclear technologies, and radiological protection*, Subcommittee SC 2, *Radiation protection*.

This third edition cancels and replaces the second edition (ISO 20785-1:2012), which has been technically revised. The main changes are as follows:

— revision of the terms and definitions;

— updated references.

A list of all the parts in the ISO 20785 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Aircraft crews are exposed to elevated levels of cosmic radiation of galactic and solar origin and secondary radiation produced in the atmosphere, the aircraft structure and its contents. Following recommendations of the International Commission on Radiological Protection (ICRP) in Publication 60[1], confirmed by Publication 103[2], the European Union (EU) introduced a revised Basic Safety Standards Directive[3] and International Atomic Energy Agency (IAEA)[4] issued a revised Basic Safety Standards. Those standards included exposure to natural sources of ionizing radiation, including cosmic radiation, as occupational exposure. The EU Directive requires account to be taken of the exposure of aircraft crews liable to receive more than 1 mSv per year. It then identifies the following four protection measures:

a) to assess the exposure of the crew concerned;

b) to take into account the assessed exposure when organizing working schedules with a view to reducing the doses of highly exposed crews;

c) to inform the workers concerned of the health risks their work involves; and

d) to apply the same special protection during pregnancy to female crews in respect of the "child to be born" as to other female workers.

The EU Council Directive has already been incorporated into laws and regulations of EU Member States and is being included in the aviation safety standards and procedures of the Joint Aviation Authorities and the European Air Safety Agency. Other countries such as Canada and Japan have issued advisories to their airline industries to manage aircraft crew exposure.

For regulatory and legislative purposes, the radiation protection quantities of interest are the equivalent dose (to the foetus) and the effective dose. The cosmic radiation exposure of the body is essentially uniform and the maternal abdomen provides no effective shielding to the foetus. As a result, the magnitude of equivalent dose to the foetus can be set equal to that of the effective dose received by the mother. Doses on board aircraft are generally predictable, and events comparable to unplanned exposure in other radiological workplaces cannot normally occur (with the rare exceptions of extremely intense and energetic solar particle events). Personal dosimeters for routine use are not considered necessary. The preferred approach for the assessment of doses of aircraft crews, where necessary, is to calculate directly the effective dose per unit time, as a function of geographic location, altitude and solar cycle phase, and to combine these values with flight and staff roster information to obtain estimates of effective doses for individuals. This approach is supported by guidance from the European Commission and the ICRP in Publications 75[5] and 132[6].

The role of calculations in this procedure is unique in routine radiation protection and it is widely accepted that the calculated doses should be validated by measurement. The effective dose is not directly measurable. The operational quantity of interest is ambient dose equivalent, $H^*(10)$. In order to validate the assessed doses obtained in terms of effective dose, calculations can be made of ambient dose equivalent rates or route doses in terms of ambient dose equivalent, and values of this quantity determined from measurements. Traceability should be provided for a reasonable number of particle types and energies of the atmospheric radiation field, corrections included for differences between the calibration fields and the total atmospheric radiation field, and related uncertainties properly taken into account. The validation of calculations of ambient dose equivalent for a particular calculation method may be taken as a validation of the calculation of the effective dose by the same computer code, but this step in the process may need to be confirmed. The alternative is to establish a priori that the operational quantity ambient dose equivalent is a good estimator of effective dose and equivalent dose to the foetus for the radiation fields being considered, in the same way that the use of the operational quantity personal dose equivalent is justified for the estimation of effective dose for ground-based radiation workers.

The radiation field in aircraft at altitude is complex, with many types of ionizing radiation present, with energies ranging up to many GeV. The determination of ambient dose equivalent for such a complex radiation field is difficult. In many cases, the methods used for the determination of ambient dose

equivalent in aircraft are similar to those used at high-energy accelerators in research laboratories. Therefore, it is possible to recommend dosimetric methods and methods for the calibration of dosimetric devices, as well as the techniques for maintaining the traceability of dosimetric measurements to national standards. Dosimetric measurements made to evaluate ambient dose equivalent should be performed using accurate and reliable methods that ensure the quality of readings provided to workers and regulatory authorities. This document gives a conceptual basis for the characterization of the response of instruments for the determination of ambient dose equivalent in aircraft.

Requirements for the determination and recording of the cosmic radiation exposure of aircraft crews have been introduced into the national legislation of EU Member States and other countries. Harmonization of methods used for determining ambient dose equivalent and for calibrating instruments is desirable to ensure the compatibility of measurements performed with such instruments.

This document is intended for the use of primary and secondary calibration laboratories for ionizing radiation, by radiation protection personnel employed by governmental agencies, and by industrial corporations concerned with the determination of ambient dose equivalent for aircraft crews.

Dosimetry for exposures to cosmic radiation in civilian aircraft —

Part 1: Conceptual basis for measurements

1 Scope

This document specifies the conceptual basis for the determination of ambient dose equivalent for the evaluation of exposure to cosmic radiation in civilian aircraft and for the calibration of instruments used for that purpose.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at http://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1 General terms

3.1.1
calibration
operation that, under specified conditions, establishes a relation between the conventional quantity, H_0, and the indication, G

Note 1 to entry: A calibration can be expressed by a statement, calibration function, calibration diagram, calibration curve, or calibration table. In some cases, it can consist of an additive or multiplicative correction of the indication with associated measurement uncertainty.

Note 2 to entry: Calibration should not be confused with adjustment of a measuring system, often mistakenly called "self-calibration", or with verification of calibration.

Note 3 to entry: Often, the first step alone in the above definition is perceived as being calibration.

3.1.2
response
response characteristic
R
quotient of the indication, G, or the corrected indication, G_{corr}, and the conventional quantity value to be measured

Note 1 to entry: To avoid confusion, it is necessary to specify which of the quotients, given in the definition of the response (to G or to G_{corr}) is applied. Furthermore, it is necessary, in order to avoid confusion, to state the quantity to be measured, for example: the response with respect to fluence, R_{Φ}, the response with respect to kerma, R_K, the response with respect to absorbed dose, R_D.