Dosimetry for exposures to cosmic radiation in civilian aircraft - Part 4: Validation of codes (ISO 20785-4:2019)

EESTI STANDARDI EESSÕNA	NATIONAL FOREWORD
See Eesti standard EVS-EN ISO 20785-4:2021 sisaldab Euroopa standardi EN ISO 20785-4:2021 ingliskeelset teksti.	This Estonian standard EVS-EN ISO 20785-4:2021 consists of the English text of the European standard EN ISO 20785-4:2021.
Standard on jõustunud sellekohase teate avaldamisega EVS Teatajas.	This standard has been endorsed with a notification published in the official bulletin of the Estonian Centre for Standardisation and Accreditation.
Euroopa standardimisorganisatsioonid on teinud Euroopa standardi rahvuslikele liikmetele kättesaadavaks 04.08.2021.	Date of Availability of the European standard is 04.08.2021.
Standard on kättesaadav Eesti Standardimis- ja Akrediteerimiskeskusest.	The standard is available from the Estonian Centre for Standardisation and Accreditation.

Tagasisidet standardi sisu kohta on võimalik edastada, kasutades EVS-i veebilehel asuvat tagasiside vormi või saates e-kirja meiliaadressile standardiosakond@evs.ee.

ICS 13.280, 49.020

EUROPEAN STANDARD

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EUROPÄISCHE NORM

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English Version

Dosimetry for exposures to cosmic radiation in civilian aircraft - Part 4: Validation of codes (ISO 20785-4:2019)

Dosimétrie pour l'exposition au rayonnement cosmique à bord d'un avion civil - Partie 4: Validation des codes (ISO 20785-4:2019)

(ISO 20785-4:2019)

This European Standard was approved by CEN on 25 July 2021.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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European foreword

The text of ISO 20785-4:2019 has been prepared by Technical Committee ISO/TC 85 "Nuclear energy, nuclear technologies, and radiological protection” of the International Organization for Standardization (ISO) and has been taken over as EN ISO 20785-4:2021 by Technical Committee CEN/TC 430 “Nuclear energy, nuclear technologies, and radiological protection” the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by February 2022, and conflicting national standards shall be withdrawn at the latest by February 2022.

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Endorsement notice

The text of ISO 20785-4:2019 has been approved by CEN as EN ISO 20785-4:2021 without any modification.

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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 of 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 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, *Radiological protection*.

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] the European Union (EU) introduced a Basic Safety Standards Directive[2] (BSS) which included exposure to natural sources of ionizing radiation, including cosmic radiation, as occupational exposure for aircrew. International guidance was also provided by the IAEA Safety Standards Series[3]. This action was confirmed by ICRP Publications 103[4] and 132[5], and the EU BSS[6] was revised. The Directive requires account to be taken of the exposure of aircraft crew liable to receive more than 1 mSv per year. It then identifies the following four protection measures:

i) to assess the exposure of the crew concerned;

ii) to take into account the assessed exposure when organising working schedules with a view to reducing the doses of highly exposed crew;

iii) to inform workers concerned with the health risks involved in their work; and

iv) to apply the same special protection during pregnancy to female crew in respect of the ‘child to be born’ as to other female workers.

The EU Council Directive has to be incorporated into laws and regulations of EU Member States and has to be 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 equivalent dose (to the fetus) and effective dose. The cosmic radiation exposure of the body is essentially uniform and the maternal abdomen provides no effective shielding to the fetus. As a result, the magnitude of equivalent dose to the fetus can be put 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 dosemeters for routine use are thus not needed nor practical, The preferred approach for the assessment of doses of aircraft crew, where necessary, is to calculate directly the effective dose rate, as a function of geographic location, altitude and solar cycle phase, and to fold these values with flight and staff roster information to obtain estimates of effective doses for individuals. This approach is supported by guidance from the ICRP in Publication 75[7] and Publication 132[5], and the ICRU in Report 84[8].

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. Effective dose is not directly measurable. The operational quantity of interest is ambient dose equivalent, *H*(10)*. Indeed, as indicated in particular in ICRU Report 84, the ambient dose equivalent is considered to be a conservative estimator of effective dose if isotropic irradiation can be assumed. The operational quantity ambient dose equivalent is a good estimator of effective dose and equivalent dose to the fetus 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 radiation workers. 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 the results can be compared to measurements traceable to national standards. The validation of calculations of ambient dose equivalent for a particular calculation method may be taken as a validation of the calculation of effective dose by the same code. 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 fetus 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 radiation workers.

The route dose is the best estimate of ambient dose equivalent for the actual route recorded for the aircrew. However, the actual route flown for that specific flight may vary due to weather, scheduling, etc.

It should be noted that this document addresses galactic cosmic radiation (GCR) only. First discovered by Victor Hess more than 100 years ago, GCR is a well understood and permanent source of ionizing radiation both on Earth and in flight. GCR can be modelled with reasonable precision and accuracy. It should be recognized that there are other sources of radiation that are intermittent. These sources cannot currently be modelled prior to their occurrence, and are not a subject of this document. These sources include solar proton events (often called solar particle events), solar neutron events, solar gamma events, solar magnetic storms that alter the magnetic shielding and terrestrial gamma flashes which are associated with some lightning. Exposures can also occur from shipments of radioactive material and also from any medical procedures required as a condition of employment for aircrew. These intermittent sources can produce radiation exposures that exceed limits for both aircrew and members of the public.

In order to adequately address the total radiation exposure for occupational workers and for members of the public who fly, radiation exposure to intermittent sources needs to be addressed after an event occurs with either radiation monitoring or with modelling.

Dosimetry for exposures to cosmic radiation in civilian aircraft —

Part 4: Validation of codes

1 Scope

This document is intended for the validation of codes used for the calculation of doses received by individuals on board aircraft. It gives guidance to radiation protection authorities and code developers on the basic functional requirements which the code fulfils.

Depending on any formal approval by a radiation protection authority, additional requirements concerning the software testing can apply.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

ISO 20785-1, *Dosimetry for exposures to cosmic radiation in civilian aircraft — Part 1: Conceptual basis for measurements*

ISO 20785-2, *Dosimetry for exposures to cosmic radiation in civilian aircraft — Part 2: Characterization of instrument response*

ISO 20785-3, *Dosimetry for exposures to cosmic radiation in civilian aircraft — Part 3: Measurements at aviation altitudes*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 20785-1, ISO 20785-2, ISO 20785-3 and the following apply.

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

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

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

3.1 Quantities and units

3.1.1
particle fluence
fluence
Φ
quotient of dN by da, where dN is the mean number of particles incident on a sphere of cross sectional area da, thus

$$\Phi = \frac{\mathrm{d}N}{\mathrm{d}a}$$

