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Dosimetry for exposures to cosmic radiation in civilian aircraft —

Part 4:
Validation of codes

Dosimétrie pour les expositions au rayonnement cosmique à bord d'un avion civil —

Partie 4: Validation des codes

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Foreword

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This second edition cancels and replaces the first edition (ISO 20785-4:2019), of which it constitutes a minor revision.

The main change is the revision of terms and definitions.

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 BSS[6] was revised by EU.

ICRP[1] [4] has defined the exposure to cosmic radiation as an existing exposure situation, because the source exists before protection decisions can be made. In addition, exposure of aircraft crew to cosmic radiation is occupational, and thus employers have a role to play in protection, even if options are limited in this case[5]. There is no contradiction in this, as occupational exposures can occur in existing exposure situations, and this does not imply that protection measure cannot be planned.

The EU 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:

a) to assess the exposure of the crew concerned;

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

c) to inform workers concerned with the health effects involved in their work;

d) 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 should be incorporated into laws and regulations of EU Member States and would be included in the aviation safety standards and procedures of the European Air Safety Agency. Other countries, such as Canada[7] and Japan[8], have issued advisories to their airline industries to manage aircraft crew exposure.

For regulatory and legislative purposes, the radiation protection quantities of interest are dose to the foetus and 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 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 dosimeters 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[9] and Publication 132[5], and the ICRU in Report 84[10].

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. 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 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 radiation workers.