Radiological Protection Institute of Ireland

An Institiúid Éireannach um Chosaint Raideolaíoch

Guidance Notes for Air Operators

GUIDANCE NOTES

TO ASSIST AIR OPERATORS TO COMPLY WITH REGULATIONS GOVERNING OCCUPATIONAL EXPOSURE OF AIR CREW TO COSMIC RADIATION

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What are these guidance notes?

Council Directive 96/29/Euratom establishes a common framework for radiation protection legislation in the European Union and explicitly covers work activities where "the presence of natural radiation sources leads to a significant increase in the exposure of workers". The Directive identifies cosmic radiation as a natural radiation source, which may lead to a significant increase in occupational exposure. The Directive is implemented in Ireland by S.I. No. 125 of 2000[1] and sets down Regulations for the protection of air crew from exposure to cosmic radiation. The Radiological Protection Institute of Ireland (RPII), as the statutory body for matters to do with ionising radiation in Ireland, is assigned particular responsibilities under these Regulations.

The Regulations apply to work activities involving the operation of aircraft pursuant to an Air Operator's Certificate (AOC) issued by the Irish Aviation Authority. The Regulations require that each air operator evaluate the extent of exposure to air crew from cosmic radiation. These guidance notes set out the steps that may be followed by air operators, hereafter referred to as the operator, to demonstrate compliance with the Regulations.

What is cosmic radiation?

The earth is continuously bombarded by high energy sub-atomic particles originating from either the sun, when it is termed solar radiation, or from outside the solar system, when it is termed galactic radiation. Collectively these particles are referred to as cosmic radiation.

Cosmic radiation is absorbed by the earth's atmosphere whereby its intensity and power diminish rapidly with decreasing altitude below around 15,200 m (~50,000 feet). Thus, at sea level the effects of cosmic radiation are about 70 times less than those experienced at an altitude of around 21,300 m (~70,000 feet). It follows that as we climb in altitude, our exposure climbs as well.

[1] The Radiological Protection Act, 1991, (Ionising Radiation) Order, 2000, Statutory Instrument Number 125 of 2000. (S.I. No. 125 of 2000).

The intensity of cosmic radiation is also influenced by the earths magnetic field, which can deflect the particles. Deflection is greatest at the equator where the magnetic field is strongest, whereas at the poles there is little deflection and the cosmic radiation can penetrate deeper into the atmosphere.

Galactic radiation is more energetic than solar radiation and for that reason is also more penetrating than solar radiation. Therefore, at aviation altitudes the cosmic radiation field is principally determined by the galactic component.

The solar component of cosmic radiation can be increased by solar flares that tend to follow a cycle of highs and lows over an 11 year period. Solar flares are sudden eruptions from the surface of the sun and may result in a rapid increase in cosmic radiation intensity in the earths atmosphere, usually lasting a few hours. Major solar flares are rare and of these only a small fraction result in increased intensity of cosmic radiation at aviation altitudes. Furthermore, because of the relatively low energy of the solar particles, solar flares have only a minor effect on cosmic radiation intensity at altitudes lower than 15,200 m (50,000 feet). For aircraft operating routinely above this altitude, however, the increases in cosmic radiation associated with solar flares must be taken into consideration when assessing the cosmic radiation dose received by air crew.

Further information on cosmic radiation can be obtained from a number of websites including:

- Federal Aviation Administration www.faa.gov;
- Association of Flight Attendants www.unitedafa.org/cmt/shs/rad/radiation.asp; and
- www.aircrewhealth.com/topics/hazards/radiation.

What are the units of radiation dose?

When ionising radiation impinges on human tissue it may cause harm. A measure of the biological harm caused by radiation is termed 'effective dose' (hereafter referred to as the dose) which is measured in units called the sievert.

Divisions of the sievert are commonly used. One sievert (Sv) = 1,000 millisieverts (mSv) and 1 mSv = 1,000 microsieverts (μSv).

S.I. No. 125 of 2000 specifies a dose limit for members of the public of 1 mSv per year. Therefore the Regulations apply to those air crew liable to receive doses greater than 1 mSv in a 12 month period. The Regulations specify a dose limit for workers of 20 mSv in a 12 month period.

Appendix A gives the typical doses that are likely to be received by air crew for various routes.

What air crew exposures are likely to be of concern?

Current scientific evidence suggests that air crew who fly exclusively below altitudes of 8,000 m (~26,200 feet) are unlikely to receive cosmic radiation doses in excess of 1 mSv in any 12 month period. Therefore, an 8,000 m (~26,200 feet) altitude limit can be used to identify those staff liable to receive in excess of 1 mSv over 12 months. Consequently, only those air crew who fly at altitudes above 8,000 m come within the scope of the Regulations.

Furthermore, aircraft operating above 15,200 m (~50,000 feet) are required by the JAR-OPS Regulations[2] to be equipped with cosmic radiation detection and measurement equipment. Above this altitude increased cosmic radiation due to high levels of solar activity caused by solar flares must be taken into account when determining air crew doses.

[2] The Operation's Division of the Joint Aviation Authorities (JAA) has developed Joint Aviation Requirements (JARs) covering many areas of aviation safety including exposure to cosmic radiation. More information on the work of the JAA can be found at www.jaa.nl.

As an operator what do I have to do?

Each operator is required to carry out an evaluation of the exposure of its air crew from cosmic radiation. This evaluation must be carried out once. However, if at some future time there is a change to work practices, for example if new routes are added, then the evaluation will need to be repeated. The evaluation should be forwarded to the RPII within three months of completion.

The purpose of such an evaluation is to determine if the work carried out by the operator falls within the scope of the Regulations. In particular the purpose of the evaluation is to:

- identify air crew liable to receive in excess of 1 mSv in any period of 12 months (Category B workers); and
- identify air crew liable to exceed 6 mSv in any period of 12 months (Category A workers);

Where the evaluation shows that air crew are liable to receive doses of greater than 1 (mSv) in any 12 month period, the operator must:

- inform the air crew on the risks involved;
- assess the exposure to individual air crew;
- maintain records of such assessments;
- make available such records to the air crew concerned;
- provide to the RPII summaries of the dose records as given in Schedule 1 of these notes;
- take special provisions relating to female air crew on declaration of pregnancy; and
- take additional protective measures in relation to air crew liable to receive cosmic radiation doses in excess of 6 mSv in any 12 month period.

How do I categorise workers?

For the purpose of calculating air crew radiation doses a distinction is drawn between two categories of air crew. These are:

Category B workers

These are air crew liable to receive between 1 mSv and 6 mSv in a calendar year. For these, the operator may opt to assess radiation doses using a simplified calculation based on annual averaged route doses and group roster data. For such assessments the annual average route dose should be calculated for the calendar year using the annual heliocentric potential, which is usually available towards the end of January of the following year. Exposures are then calculated for groups of air crew likely to receive similar exposure, rather than for individual crew members. The groups must be defined on the basis of similar work rosters. The operator must maintain a record of such groupings, which must be available to the air crew concerned and by an Inspector of the RPII, on request.

Where the operator opts for group assessments, the calculation must be performed on the basis of the maximum dose to any individual member of the group and this figure must be recorded for each member of the group.

Where, on the basis of the annual calculation, it is shown that any individual or group receives in excess of 5 mSv, the operator should reassess the doses for the individuals concerned according to the procedures set out below.

Category A workers

These are air crew liable to receive in excess of 6 mSv in any 12 month period. Female air crew on declaration of pregnancy, are treated in the same way as this group. The dose assessment must be based on monthly averaged route doses and individual roster data. Route doses must be calculated for each month using the heliocentric potential for that month. The monthly route doses are then combined with air crew roster data to derive the doses to individual air crew members. Each month the operator must derive the cumulative exposure over the previous 12-month period by summing the 12 monthly values. The assessment must be calculated individually for each crew member taking into account the actual flying record for that individual.

How are the doses to air crew calculated?

For aircraft flying at altitudes above 8,000 m (~26,200 feet) and below 15,000 m (~50,000 feet) (i.e. the air crew are likely to receive an annual dose in excess of 1 mSv, but the aircraft is not required to be equipped with cosmic radiation detection equipment) it is recommended that assessment of each individual air crew dose be determined by combining route dose with crew roster data. Route dose estimates can be calculated using computer programs specifically designed for that purpose. The computer programs EPCARD (European Package for the Calculation of Aviation Route Doses) and CARI[3]-6 have been approved by the European Commission[4]. The RPII recognises a dose assessment carried out using either of these two programs. For information purposes, a comparison of route doses calculated by EPCARD and CARI-6 is given in Appendix-A.

EPCARD was developed by GSF, the National Research Centre for Environment and Health, Institute of Radiation Protection, in Neuherberg, Germany and can be downloaded from their website www.gsf.de/epcard2.

CARI-6 was developed by the Civil Aerospace Medical Institute in the United States and can be downloaded from their website www.cami.jccbi.gov.

[3] CARI are the initials of the former name (Civil Aeromedical Research Institute) of the Civil Aerospace Medical Institute in the United States.

[4] Cosmic Radiation Exposure of Air Crew. Compilation of measured and calculated data. Issue No. 140. European Commission, 2004.

What data is needed for the EPCARD and CARI-6 computer programs?

Typical flight profiles rather than actual flight data are used as input data into EPCARD or CARI-6. Typical flight profiles must be defined individually for each route and should be based on historic flight data. Each typical profile will include

- the origin and destination airports;
- the number of en route altitudes;
- the time to climb to the first en route altitude;
- the en route altitudes;
- the time spent at each en route altitude;
- the time to descend to the destination airport; and
- the heliocentric potential.

Route profile information must be reviewed periodically by the operator and updated as necessary to ensure it remains current. Route profile information must be made available to the air crew concerned and to an inspector of the RPII, on request.

What are air crew entitled to know?

For air crew flying at altitudes over 8,000 m (~26,200 feet) the operator is required to provide each staff member with information about the risks associated with exposure to cosmic radiation. In addition, the operator is required to keep records relating to the dose assessment referred to above and shall, if requested by a member of the air crew concerned, make available to that staff member a copy of the dose record kept in relation to him/her for the purpose of the Regulations.

The RPII may assess the adequacy of the information provided to air crew by operators. As a guideline, this information may include

- the nature of cosmic radiation;
- the units of radiation dose;
- the factors that influence cosmic radiation intensity (latitude, altitude, solar cycle);

- the legal framework governing occupational exposure to radiation, in particular the requirements for the protection of air crew from cosmic radiation;
- how cosmic radiation is measured;
- the health risks associated with exposure to radiation;
- the protection measures relevant to cosmic radiation; and
- the protective measures necessary for pregnant air crew.

Are there additional measures required for some air crew?

Pregnant member of air crew

As soon as pregnancy is declared the operator must ensure that the conditions of employment are such that the dose to the pregnant member of air crew is unlikely to exceed 1 mSv during the remainder of the pregnancy. This provides the same level of protection for the unborn child as is provided for members of the public. This additional level of protection may be provided by changes to the working schedules of the air crew concerned.

Category A workers:

As Category A workers are at increased risk from radiation, additional levels of protection are required. For example, Category A radiation workers are subject to routine medical surveillance; their medical records must be kept until they reach the age of 75; and the radiation doses they receive must be closely monitored. (The specific requirements for Category A workers are set out in articles 25, 26 and 27 of S.I. No. 125 of 2000). In addition the operator is required to minimise the radiation dose to the workers by organising work schedules with a view to reducing their exposure to cosmic radiation.

What information must be made available to the RPII?

The operator must have in place written procedures for the assessment of radiation doses. These shall be made available to an inspector of the RPII, on request.

The operator must compile a summary of air crew doses annually in accordance with Schedule 1 at the end of these notes.

The operator must submit a copy of this summary to the RPII within three months of the end of each calendar year.

The operator must ensure that adequate records are kept, so as to ensure the traceability of radiation dose assessments and to allow recalculation of any individual crew dose by an RPII inspector.

What records do I have to maintain?

The operator must maintain a record of dose assessments for all air crew liable to receive a dose in excess of 1 mSv in any 12 month period. The type of information to be recorded is given in Schedule 2, which illustrates an acceptable format for such records. These records must be retained for the minimum periods set out in Table 1. Route profile information must also be made available to the air crew concerned and to an Inspector of the RPII, on request.

Table 1

Maintenance of Dose Records

Exposure Category	Period for Which Records Need to be Retained
Crew who receive < 6 mSv in a 12 month period (Category B)	5 years from the date to which the record refers
Crew who receive or are liable to receive in excess of 6 mSv in a 12 month period (Category A)	until the crew member attains, or would have attained, the age of 75 years or for a period of 30 years from the last year in which that crew member received a dose in excess of 6 mSv, if this is later.

Records must include sufficient information to allow any of the individual dose assessments to be recalculated within the time periods specified in Table 1.

An operator must make available all records and documented procedures to an RPII Inspector, on request.

Surveillance

Records and written procedures referred to in these notes are subject to audit by an Inspector of the RPII.

Schedule 1

Format of the Annual Dose Summary to be Provided to the RPII

Report for calendar year _____

Registered name of operator _____

AOC number (where appropriate) _____

For air crew in receipt of cosmic radiation doses greater than 6 mSv in any 12 month period ending during the reporting period (calendar year):

- indicate the number of crew,
- list individual monthly doses.

For air crew in receipt of cosmic radiation doses between 1 to 6 mSv during the reporting period (calendar year):

- indicate the number of crew corresponding to each dose band.

Dose Band	Number of crew
1 to 2 mSv	
2 to 4 mSv	
4 to 6 mSv	
Total	

Schedule 2

Format of Individual Dose Records

The information to be retained on the individual dose record is set out as follows:

Operator	Registered name of operator
	AOC number (where appropriate)

Crew Member	Name of crew member
	Date of birth
	Gender
	Employment category (flight deck crew/ cabin crew)

Dose Assessment Record

Route dose assessment basis (monthly or annual)
Crew dose assessment basis (group or individual)
Route dose assessment method (e.g. EPCARD, CARI 6)
Assessment period (year for annual assessment and Year/ Month for monthly assessment)

Route	Route dose per flight	number of flights	Sub total
annual/ monthly total			

Cumulative Dose Record (applicable only to monthly assessments, i.e. category 2)

Assessment period (month/ year)	Dose Received for Assessment Period	Cumulative dose during the previous 12 months

Appendix A

Examples of sample route doses calculated using CARI-6 and EPCARD.

Table 1. Comparison of calculated effective route doses calculated by CARI-6 and EPCARD on selected routes. The doses are valid for solar modulation conditions at the indicated date. (EC, 2004).

Flight route	Date	Dose (μSv) EPCARD	Dose (μSv) CARI-6
Copenhagen - Bangkok	31 December 1998	30.2	26.3
Paris-NewYork	21 August 1998	43.7	35.4
Paris-Prague	31 January 1995	3.6	3.0
Frankfurt-New York	27 October 1997	43.0	32.0
Madrid-Paris	27 April 2001	3.5	3.5
Madrid-New York	28 April 2001	24.3	21.9
Madrid-Stockholm	21 August 2001	12.0	11.8

Table 2. Sample route doses

Route	Maximum Cruise Altitude	Flight Duration in Minutes	Dose per Flight (μSv)
Dublin - London	33,000 ft	46	1.6
Dublin - Paris	35,000 ft	82	4.9
Dublin - Munich	37,000 ft	116	8.7
Dublin - Stockholm	33,000 ft	140	9.4
Dublin - Rome	37,000 ft	170	13
Dublin - New York	39,000 ft	425	48
Dublin - Los Angeles	39,000 ft	640	66

Route doses, in table 2, have been calculated using CARI-6 based on typical flight profiles for each route and assuming a heliocentric potential of 500 MV.

Glossary of terms

Air crew: Means the cabin and flight crew of an aircraft operated by an air operator or an undertaking in the State which operates an aircraft.

Air operator: Means the holder of an Air Operator's Certificate issued by the Irish Aviation Authority in accordance with the Irish Aviation Authority (Air Operator's Certificate) Order, 1999 (S.I. No. 420 of 1999)

Category A Worker: The legislation classifies a worker who is liable to receive a dose greater than 6 mSv per year as a Category A worker. As these workers are at increased risk, additional protection is required. For example, Category A workers are subject to ongoing personnel monitoring and routine medical surveillance, the records for which must be kept until the worker reaches the age of 75. The specific requirements for Category A workers are set out in articles 25, 26 and 27 of S.I. No. 125 of 2000.

Category B Worker: An exposed worker who is not classified as a Category A worker, i.e. is not liable to receive a dose greater than 6 mSv per year.

Evaluation and Dose Summaries: The evaluation is carried out by the Air Operator to determine if air crew are liable to receive a dose greater than 1 mSv in a 12 month period and therefore come within the scope of the regulations. This evaluation can be done by determining if air crew fly at altitudes over 8,000 m.

If air crew fly above 8,000 m altitude then they come within the scope of the regulations and the Air Operator is required to assess the exposure of air crew annually, maintain records and submit summaries of the dose records to the RPII within 3 months of the end of each calendar year.

Exposure: Means the process of being exposed to ionising radiation

Exposed workers: Means persons, either self-employed or working for an employer, who are subject to an exposure incurred at work from work activities liable to result in doses exceeding the dose levels equal to the dose limits for members of the public.

Heliocentric potential: This is an index of solar activity. During times when the sun is active the heliocentric potential is high this means that the intensity of cosmic radiation is low. Conversely when the solar activity is low then the heliocentric potential will also be low and the intensity of the cosmic radiation will be high.

Ionising radiation: Means the transfer of energy in the form of particles or electromagnetic waves of a wavelength of 100 nanometers or less, or a frequency of 3×10^{15} hertz or more, capable of producing ions directly or indirectly.

Natural radiation sources – means sources of radiation from natural terrestrial or cosmic origin.

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Mission Statement

"In the three year period from 2008 to 2010 the RPII will grow the level of awareness and implementation of the measures needed to protect people in Ireland from the harmful effects of ionising (and non-ionising) radiation through scientifically based regulation, monitoring and advice."

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