33 Radiation Safety Arrangements for Exposure to Cosmic Radiation

Scope

1. Cosmic radiation originates primarily from outside our solar system as a result of events such as super-nova explosions and to a lesser extent from atomic reactions in the Sun. The Earth's atmosphere substantially shields the Earth from cosmic radiation and at sea level cosmic radiation is a very small contributor to natural background radiation levels. The radiation dose received from cosmic radiation increases with altitude and at typical cruising levels the intensity of cosmic radiation is approximately 100 times greater than at sea level. The longer an individual travels on an aircraft, the higher the altitude of the aircraft and the closer to the north and south poles, the greater the radiation dose from exposure to cosmic radiation.

2. This Chapter describes the radiological requirements for assessment and control of exposure of aircrew to cosmic radiation. General information and instruction on the hazards associated with cosmic radiation, personnel duties and responsibilities and statutory and MOD mandatory requirements are provided in the body of the Chapter. The RPA is to be consulted for specific advice on exposure to cosmic radiation.

Statutory Requirements

3. In addition to the general requirements of the Health and Safety at Work etc. Act 1974 and the Management of Health and Safety at Work Regulations 1999, the following specific legislation applies directly or is applied indirectly through parallel arrangements designed to achieve equivalent standards:

a. Air Navigation (Cosmic Radiation: Protection of Air Crew and Space Crew and Consequential Amendments) Order 2019 (parallel arrangements); and

b. Military Aviation Authority Regulatory Articles (FLY 2000 Series).

Duties

Commanding Officer (CO) and Head of Establishment (HoE)

4. Duties as detailed in Chapter 39 apply.

Nature of Cosmic Radiation

5. Cosmic radiation is the collective term for radiation which comes from the Sun (solar component) and from galaxies outside our Solar System (galactic component). Cosmic radiation is ionising and consists of a complex mix of charged particles, photons and neutrons. The intensity of cosmic radiation depends on a number of factors, including altitude and latitude, and variations occur with the stages of the solar cycle.

6. On entering the Solar System, the lower energy galactic particles are deflected away from the Earth by the solar wind, therefore at times of greatest solar activity, cosmic radiation dose rates in the Earth's atmosphere are actually reduced. Solar activity follows a 22-year cycle, consisting of two 11-year cycles separated by the regular reversal of the Sun's magnetic field. Cosmic radiation dose rates will vary over this cycle, up to approximately 25% above the mean dose at solar minimum and 25% below the mean dose at solar maximum.

7. In the event of a solar flare, charged particles are ejected from the sun and, depending on direction of travel, may collide with the Earth. These solar particle events occur on average about once a year and result in a sudden increase in radiation levels for a brief period of time (hours or days).

8. Detailed advice on the radioactive nature and properties of cosmic radiation may be sought from the RPA.

Hazards

9. The cosmic radiation field is complex, with many types of ionising radiation and a wide range of energies. Examples of the radiation encountered at altitude are photons (X-rays and gamma rays), neutrons, protons, electrons and positrons.

Assessment of Exposure to Cosmic Radiation

10. The Air Navigation Order requires the CO to make an assessment of occupational radiation dose from exposure to cosmic radiation when in flight for air crew who are liable to be subject to cosmic radiation exposures in excess of 1 mSv per year. Aircrew includes flight crew, cabin crew and any person employed by the aircraft operator to perform a function onboard the aircraft while it is in flight. A year is defined as any twelve-month period, not a calendar year.

11. Dose assessment can be undertaken by issuing personal dosimetry to individual aircrew or through use of computer modelling. The computer modelling programmes currently available (CARI-7, EPCARD, SIEVERT PN, PCAire) assess radiation dose for each individual flight based on flight time, altitude and departure / destination airports. Examples of typical doses received during flight calculated using computer modelling are given at Annex A to this chapter.

12. For those aircrew, or groups of aircrews, with the potential to receive greater than 1 mSv per year, there is a requirement to record the radiation exposure. This record can either be in the form of the radiation dose to aircrew for a specified flight (including a list of those on the flight) or individual aircrew dose records. An estimation of aircrew likely to exceed 1 mSv per year based on typical flying altitude and hours flown can be made using the graph given at Annex B to this chapter.

13. Once an employee has notified the operator in writing that they are pregnant, the operator must ensure that the radiation dose to the foetus is less than 1 mSv over the declared term of the pregnancy. Exposure to cosmic radiation is fairly uniform through the body and the abdomen provides no effective shielding from cosmic radiation, therefore the magnitude of radiation dose to the foetus can be equated to that received by the mother. Within the military, the current policy is that female aircrew are grounded on declaration of pregnancy as a consequence of other risk factors. Provided this policy remains in place there is no requirement to undertake further dose assessment for this group of personnel.

14. Dose assessment and recording is not required where studies have identified that the radiation dose to individual staff is less than 1 mSv per year.

Example Doses Received from Cosmic Radiation During Flights

1. Typical radiation doses for aircrew on flights starting from London and flying to various destinations are given in table A1. Each flight assumes arrival at their maximum altitude 30 minutes after take off and commencing descent 30 minutes before landing. All doses are for return journeys and are calculated using computer modelling programme CARI-6. The errors given in the dose calculations are as a result of uncertainties in flight times.

Table A1. Radiation doses flying from London to given destinations

Destination	**Maximum Altitude (ft)**	**Time of flight each way (minutes)**	**Dose (μSv)**
Mount Pleasant	35000	1000 ±120	94 ± 12
Mount Pleasant	30000	1000 ± 120	64 ± 8
Washington	35000	540 ± 60	89 ± 10
Istanbul	20000	180 ± 30	4 ± 1
Berlin	20000	120 ± 30	3 ± 1
Bahrain	35000	300 ± 60	30 ± 7
Kuwait	35000	300 ± 60	31 ± 7
Basra	35000	300 ± 60	32 ± 8
Tanzania (Dodoma)	35000	780 ± 120	68 ± 11
Cyprus (Paphos)	30000	180 ± 30	11 ± 3
Las Vegas	40000	720 ± 60	171 ± 16
Sydney	40000	1260 ± 60	186 ± 10

Estimation of Aircrew Cosmic Radiation Exposure

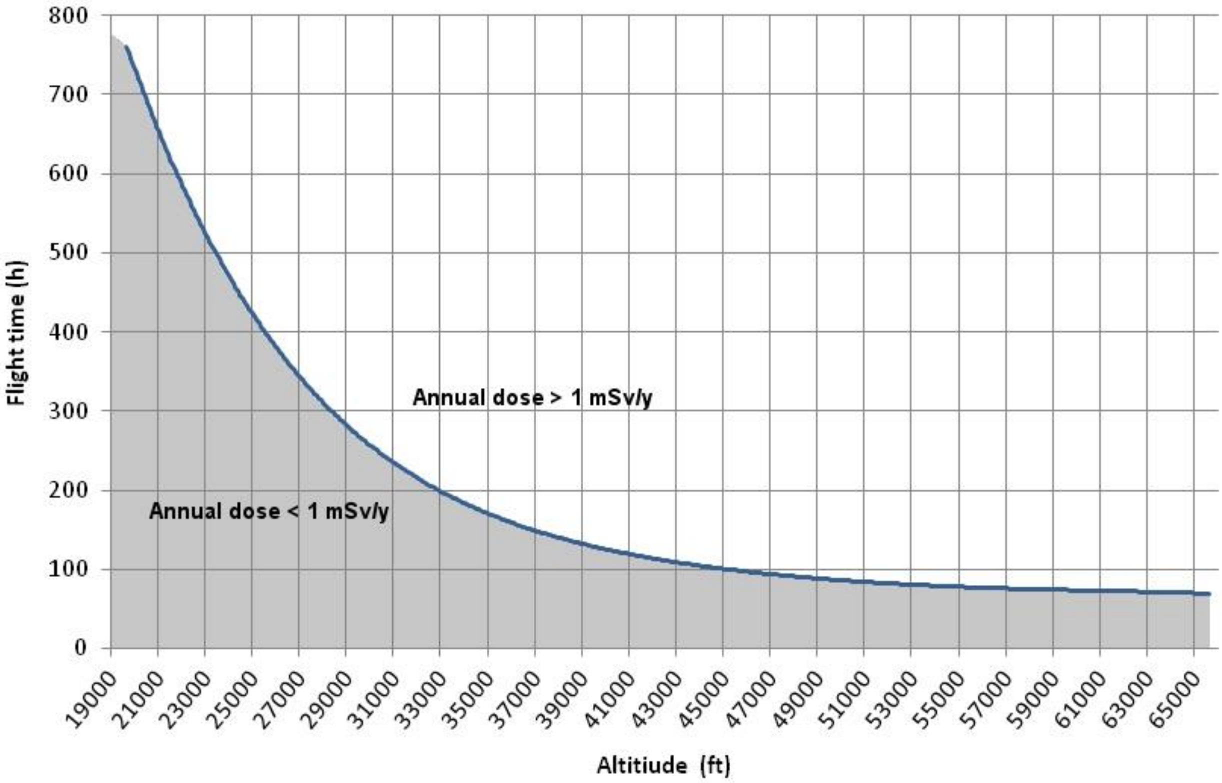

Figure B-1 Curve representing the 1 mSv threshold for identifying aircrew who may require further dose assessment based on number of flight hours and cruising altitude[1].

This graph should be used as a guide only to identify if it is likely that aircrew are likely to exceed 1 mSv/y. Some routes my result in doses above or below 1 mSv based on hours flown.

Example:

Aircrew routinely flying at FL250 (25 000 ft) would need to be flying in excess of 300 hours to receive a dose of 1 mSv or above.

[1] Source: German Commission on Radiological Protection