6.2 Cosmic Radiation

Nesma Airlines shall take account of the in-flight exposure to cosmic radiation of all crewmembers while on duty (including positioning) and shall take the following measures for those crew liable to be subject to exposure of more than 1 millisievert (MSV) per year.

1) Assess their exposure.
2) Take into account the assessed exposure when organizing working schedules with a view to reduce the doses of highly exposed crewmembers.
3) Inform the crewmembers concerned of the health risks their work involves.
4) Ensure that the working schedules for female crewmembers, once they have notified to Nesma Airlines that they are pregnant, keep the equivalent dose to the fetus as low as can reasonably be achieved and in any case ensure that the dose does not exceed 1 MSV for the remainder of the pregnancy;
5) Ensure that individual records are kept for those crewmembers whose are liable to high exposure. These exposures are to be notified to the individual on an annual basis, and also upon leaving Nesma Airlines.

6.2.1 Assessment of Cosmic Radiation

Assessment of exposure level can be made by using the table below or other method acceptable to the Authority.

Table 1 - Hours exposure for effective dose of 1 millisievert (MSV)

Altitude (feet)	Altitude (Km)	Hours at latitude 60oN	Hours at equator
27 000	8.23	630	1330
30 000	9.14	440	980
33 000	10.06	320	750
36 000	10.97	250	600
39 000	11.89	200	490
42 000	12.80	160	420
45 000	13.72	140	380
48 000	14.63	120	350

6.2.2 Working Schedules and Record Keeping

Where in-flight exposure of crewmembers to cosmic radiation is likely to exceed 1 MSV per year Nesma Airlines should arrange working schedules, where practicable, to keep exposure below 6 MSV per year. For the purpose of this regulation crewmembers whose are likely to be exposed to more than 6 MSV per year are considered highly exposed and individual records of exposure to cosmic radiation should be kept for each crewmember concerned.

6.2.3 Explanatory Information

6.2.3.1 Introduction

The radiation we receive comes either from outer space (constant intensity) or from the sun (intensity increasing with solar flare activity). In the first case it is produced when primary photons and particles from outside the solar system interact with components of the earth's atmosphere. In the second we have the release of charged particles. The most harmful are neutrons, protons and gamma radiation, while ultra violet (UV) radiation is insignificant in this context. During the period of high sun activity, the likelihood of solar flares is higher. These flares create an increased flux of charged particles radiation. This flux is nevertheless compensated by the reduction of galactic radiation during this sun activity period, so that the total intensity of cosmic radiation remains reasonably constant. Cosmic radiation follows an 11-year cycle, with the intensity being inversely related to solar activity. The last solar maximum was in 1991 Maximum variation is some 20%.

Natural protection from cosmic radiation is provided by the geomagnetic field and the attenuating effects of the earth's atmosphere. The level of cosmic radiation depends to some extent on the geographical position, but essentially on the altitude above the ground level; the maximum radiation level occurs at about 20,000 m.

Polar Regions have a greater radiation intensity and exposure is more important at higher altitudes.

It is worth noting that natural radiation occurs also at ground level. For example, in parts of Cornwall (UK) the natural radiation level is at about 6 MSV per year and in most of Finland is around 8 MSV per year. Similar levels are reached in Denver and other parts of Colorado (USA).

6.2.3.2 Impact of Radiations on Health

The French DGAC and the IPSN (Institute de la Protectionist de la Sûreté Nucléaire) state that no study as of today showed any measurable effect of radiation levels on crew health sustained in flight. Levels where radiation effects would start to be measurable are estimated to be around 120-150 MSV per year. With regard to flight crew mortality independent analysis of the British Airways pension scheme data and of British Airways own data for the period between 1950 and 1992 shows an increased life expectancy for pilots of between 3 and 5 years when compared to the general population. Death rates from heart disease and all cancers combined were considerably less than for the population of England and Wales. Although rare, death from melanoma (which is directly associated with sun exposure) was the only cause of cancer in excess. Cancers such a leukemia, which may be linked to radiation exposure, was lower within the British Airways pilot population.

As far as the risk of developing cancer induced by radiation exposure is concerned, it has been calculated that an accumulated dose of 5 MSV per year for 20 years increases the risk of developing cancer from 23 % (in the general population) to 23.4 % i.e. a 0.4 % increase in risk over 20 years. Compared with all the other risks encountered during working life, this is very low.

6.2.3.3 Requirements and Legal Issues

International Commission on Radiological Protection (ICRP)

In 1991 the ICRP recommended an occupational exposure limit of 20 MSV per year for exposure of crew to cosmic radiation in jet aircraft.

EURATOM Council Directive 96/29

Article 9 §1 defines the dose limits of ionizing radiation for exposed workers as follows:
"The limit on effective dose for exposed workers shall be 100 MSV in a consecutive five-year period, subject to a maximum effective dose of 50 MSV in any single year. Member States may decide an annual amount."
Particular attention must be paid to Article 42, which specifically refers to the protection of air crew. Article 42 stipulates:
Protection of air crew:
Each Member State shall make arrangements for undertakings operating aircraft to take account of exposure to cosmic radiation of air crew who are liable to be subject to exposure to more than 1 MSV per year. The undertakings shall take appropriate measures, in particular:

- to assess the exposure of the crew concerned,
- to take into account the assessed exposure when organizing working schedules with a view to reducing the doses of highly exposed aircrew,
- to inform the workers concerned of the health risks their work involves,
- to apply Article 10 (Art. 10 refers to special protection during pregnancy and breastfeeding) to female air crew"

ICAO

ICAO rules require that aircraft intended to be operated above 49,000 ft. **(not applicable to Airbus aircraft)** have to be equipped with an instrument to measure and indicate (visible for the flight crew) continuously the dose equivalent radiation.

Conclusions/Recommendation

Estimates and in-service measurements, which are the result of extensive scientific studies and airline experience, show that during flight in commercial jet aircraft the level of exposure to cosmic radiation for flight crews is well below the values specified in existing legislation or guidelines. There are no specific airworthiness requirements related to cosmic radiation that would apply to Airbus aircraft.