Results of the EAN survey on the regulatory approach to radiological protection of aircraft crew

Sylvain ANDRESZ, Pascal CROÜAIL, CEPN, France

Introduction

The Earth is continuously exposed to high-energy particles that come from space or the sun. These particles interact with the atomic constituents of the atmosphere and produce a 'cascade' of secondary particles that contributes to cosmic radiation exposure. Thus, cosmic radiation exposure decrease in intensity with depth in the atmosphere: from 7 µSv/h at aircraft altitude (11,000 km) to 0.05 µSv/h at sea level. As certain cosmic radiations are also electrically charged, cosmic radiation exposure depends on latitude (see Figure 1) and solar activity.

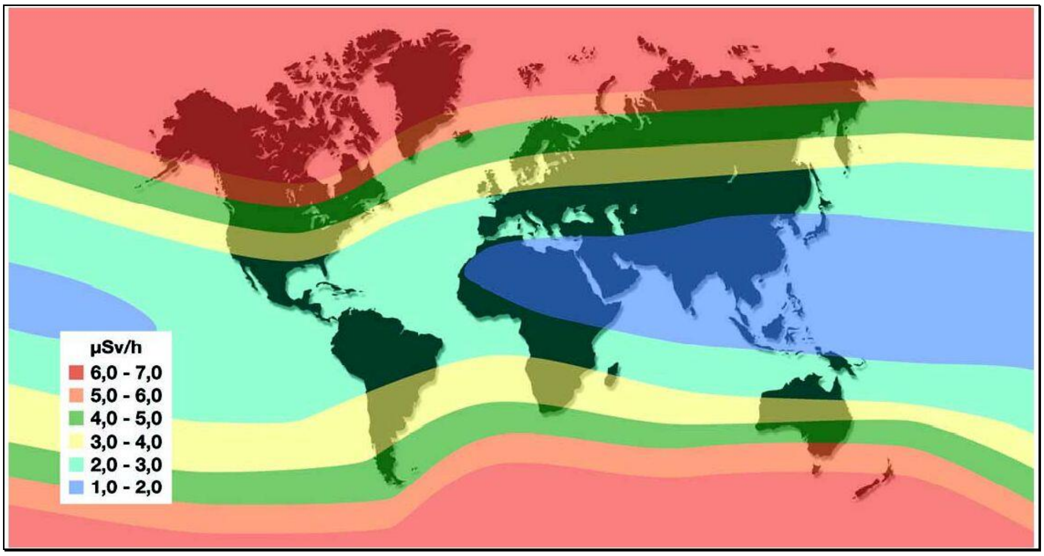

Figure 1. – Geomagnetic shielding of cosmic radiation: ambient dose rate by latitude at 11.000 meters altitude on December 2002.

The International Commission of Radiological Protection stated in 1990 (ICRP Publication 60) that aircraft crews exposed to cosmic radiation should be recognized as occupationally exposed workers, and, retrospective assessments of dose undertaken since then using computer programs show that aircraft crew have one of the largest collective doses among occupationally exposed workers.

Between December 2010 and January 2011, the European ALARA Network performed a survey on the regulatory requirements for aircraft crew. The survey also aimed to gather numerical data about the exposure of aircraft crew in the individual countries.

1. Questions

The survey was drafted as follow:

1. Is there a regulation concerning radiation protection requirements for aircraft crew in your country?
2. If yes:
    - What are the main requirements?
    - What are the means and tools used to assess aircrew's exposure?
    - Is there a specific dose criteria defined for aircraft crew?
3. Could you provide data on the number of aircrew exposed, maximum annual level of exposure, average annual level of exposure, etc.?

2. Results of the survey

Requirements

Abbreviation used in Table 1:

- **A**: **A**ssessment of individual dose of aircraft crew using dedicated software.
- **I**: **I**nformation about cosmic radiation are provided by operating management (airlines) to the aircraft crew.
- **Sch**.: **Sch**eduling; taking into account the individual assessment of exposure when the operating management is planning flight schedules. A dose constraint can be implemented.
- **Prg**. Requirements are in place to limit the exposure of female aircraft crew after declaration of **preg**nancy (embryo/foetus is considered as a member of the public with a dose limit of 1 mSv/year). Generally airline companies have provision in place (ground duties) to ensure the criterion of 1 mSv is not exceeded.

The requirements apply if the annual dose is above 1 mSv.

Table 1. – Synthesis of the regulatory requirements for aircraft crew

Country	Regulation and requirements	Assessment of exposure (software)	Dose criteria
Belgium	Royal Decree of July 20, 2001, § 4 and 9. ***Requirements*: A, I, Sch., Prg**.	Graphics to assess whether aircrews are likely to receive more than 1 mSv/y If > 1 mSv/year use IASON-FREE, PCAIRE, CARI or GLOBALOG	If > 6 mSv/year: medical surveillance, reporting of monthly dose and adjustment of flight time or route dose.
Czech Republic	Regulation No. 307/2002 ***Requirements*: A, I, Sch., Prg**.	CARI-6	If > 6 mSv/year, all the requirements for cat. A worker shall apply.
Denmark	*Guidelines on the Control of Exposure to Cosmic Radiation of Aircrew in the Nordic Countries* ***Requirements*: A, I, Sch., Prg**.	EPCARD, CARI-6, FREE	Objective is to limit the number of people > 6 mSv/year.
Finland	Radiation Act 1991/592 - Chapter 12, Radiation Decree 1991/1512 - Chapter 7, Guide ST 12.4 - Radiation safety in aviation ***Requirements*: A, I, Sch., Prg**.	CARI-6	Aircraft crew annual dose should not exceed 6 mSv.
France	Labour Code (article R.4451-140 to R.4451-144), Order of 8 December 2003 ***Requirements*: A, I, Sch., Prg**.	SIEVERT (www.sievert-system.org)	-
Germany	Radiation Protection Ordinance, § 103 ***Requirements*: A, I, Sch., Prg**	Graphics, then if > 1 mSv/year , assessment using an approved code: EPCARD, PCAIRE or FREE	If > 6 mSv/year: medical check-up.
Greece	Radiation Protection Regulation, § 1.2.5 ***Requirements*: A, I, Sch., Prg**	Assessment with computer code	Aircraft crew annual dose should not exceed 6 mSv.
Ireland	Ionising Radiation Order, SI No. 125 of 2000, Guidance note for air operators – 2008 ***Requirements*: A, I, Sch., Prg**.	CARI-6 or EPCARD	If > 6 mSv/year: additional protective measure.
Italy	Legislative Decree No. 230 Chapter III - Article 10 ***Requirements*: A, I, Sch., Prg**.	CARI-6	One company has an internal action level at 3 mSv/year.
Lithuania	Law on Radiation Protection, Hygiene Standard HN 73:2001, Hygiene Standard HN 85:2003 ***Requirements*: A, I, Sch., Prg**.	CARI-6	Aircraft crew annual dose should not exceed 6 mSv. If > 6 mSv/year, all the requirements for cat. A worker shall apply.
Slovenia	RP and Nuclear Safety Act § 45 and 46 ***Requirements*: A, I, Sch. (dose limit at 6 mSv), Prg.**	CARI-6	Dose constraint is 2 mSv/year (3 mSv/year in 2009). Dose limit: 6 mSv/year (cat.

Country	Regulation and requirements	Assessment of exposure (software)	Dose criteria
			B workers)
Sweden	Directive EEC 3922/91 and subpart D, OPS 1.390 ***Requirements***: still those from JAR-OPS1: **A** if > 6 mSv/year.	CARI-6	-
The Netherlands	Radiation Protection Decree of 16 July 2011 - Chapter VIII - Article 111 ***Requirements*****: A, I, Sch., Prg.**	CARI-6	If > 6 mSv/year: limiting flight time/route dose
United Kingdom	Air Navigation (Cosmic Radiation) Order 2000 ***Requirements*****: A, I, Sch., Prg.**	Not specified. CAA guidance allows any validated software, including including CARI, EPCARD, SIEVERT and PCAIRE	-

For every country that responded, the regulations on radiation protection of aircraft crew are national regulations, except for Sweden, which has implemented the international recommendations JAR-OPS 1. For most regulations, the main requirements for aircraft crew above 1 mSv/year are assessing of dose (A), information (I), taking into account individual exposure when planning flight schedule (Sch.) and limiting the exposure of pregnant aircraft crew (Prg.).

According to the answers, the annual dose of 6 mSv is viewed differently depending the countries:

- Some countries consider it as a “dose constraint”, or a dose reference level, that should not be exceeded. This is implemented in Denmark, Finland, Greece, Italy and Lithuania and ensure by limiting flight time and route exposure.
- Other countries add specific requirements for individuals above 6 mSv/y, for example monthly reporting, or requirements for cat. A workers. In Belgium, Czech Republic, Germany, Ireland and the Netherlands, 6 mSv/year is regarded as an “action level”.
- It should be noted that Slovenia have implemented a dose constraint of 2 mSv/year and an Italian company (Italfly) have an internal dose constraint at 3 mSv/year.

Exposure data

The data received are generally an annual dose distribution for the aircraft crew of the country. Extracted from these data, Table 2 and Figure 2 below present the mean and maximum annual effective dose. The complete data can be found in the results of the survey available on the EAN website[1].

Table 2. – Some numerical data regarding the exposure of aircraft crew.

Country	Number of exposed individuals	Mean annual effective dose (mSv)	Maximum annual effective dose (mSv)
Belgium	2,912	1.27	4.77
Czech Republic	2,158	1.09	3.85
Denmark	3,824	1.8	6.0
France	19,830	2.2	5.5
Germany	36,596	2.3	7.0
Ireland	9,726	N/A	N/A
Lithuania	213	N/A	N/A
Slovenia	322	1.16	1.74
Sweden	1,431	2.55	5.43
The Netherland	11,100	1.73	4.55
United Kingdom	about 40,000	about 2	N/A

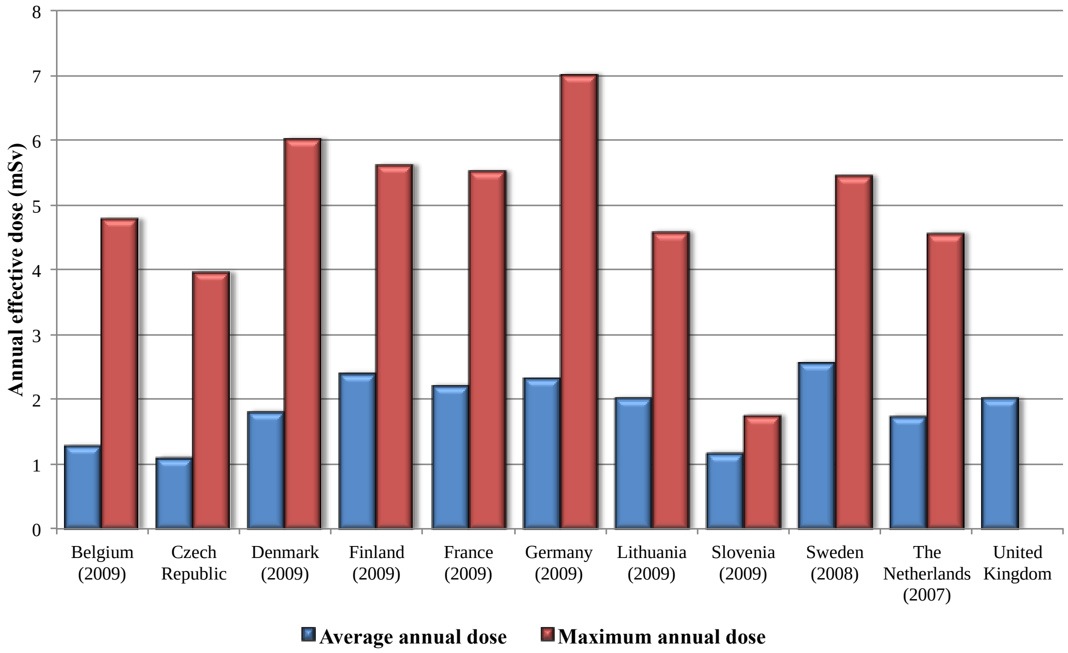

Figure 2. – Average and maximum annual effective dose due to cosmic radiation for aircraft crew.

Depending on the size of the national airline industry, the number of exposed aircraft crew varies from 213 in Lithuania to about 40,000 in Germany and United Kingdom.

[1] http://www.eu-alara.net/index.php/surveys-mainmenu-53/36-ean-surveys/275-aircraft-crew.html

The mean annual effective dose varies from 1 mSv (Czech Republic) to 2.5 mSv (Finland and Sweden). The highest effective dose is 7 mSv/year for a German aircraft crew but is generally less than 6 mSv/year. Apart from exceptional circumstances, such as fierce solar eruptions, it is almost impossible for aircraft crew to receive doses higher than 10 mSv/year.

Conclusion

The regulations regarding the radiological protection of aircraft crew are broadly similar in the responding countries, and are in line with current international recommendation (ICRP, Euratom). It can be noted that there are different interpretations of the significance of 6 mSv/year, ie in terms of whether it is viewed as a constraint or as a practical limit.

Acknowledgment

The authors would like to acknowledge and thank the following persons, who kindly answered to this request:

Belgium	S. Pepin (Federal Agency for Nuclear Control) stephane.pepin@fanc.fgov.be
Czech Republic	J. Kropáček (SUJB) jan.kropacek@sujb.cz
Denmark	K. Breddam (National Institute for Radiation Protection) krb@sst.dk
Finland	M. Lehtinen (Radiation and Nuclear Safety Authority) maaret.lehtinen@stuk.fi
France	O. Guzman (French Nuclear Safety Authority) olvido.guzman@asn.fr
Germany	G. Frasch (Federal Office for Radiation Protection) gfrasch@bfs.de
Greece	V. Kamenopoulou (Greek Atomic Energy Commission) vkamenop@eeae.gr
Ireland	J. Duffy (Radiation Protection Institute of Ireland) jduffy@rpii.ie
Italy	S. Risica (National Institute of Health) serena.risica@iss.it
Lithuania	J. Ziliukas (Radiation Protection Centre) j.ziliukas@rsc.lt
Slovenia	T. Šutej (Slovenian Radiation Protection Administration) tomaz.sutej@gov.si
Sweden	J. Lillhök (Swedish Radiation Safety Authority) jan.lillhok@ssm.se
The Netherlands	C. Timmermans (Nuclear Research and consultancy Group) timmermans@nrg.eu
United Kingdom	P. Shaw (Public Helath England) peter.shaw@phe.gov.uk