RADIATION EXPOSURE OF PASSENGERS TO COSMIC RADIATION

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The main aim of the present study is to review exposure of Egyptian Passengers to cosmic radiation during their flight. Effective dose to passengers was computed by computer Code CARI-6 during either short route, medium route or long route. Recommended average number of flights per year was calculated based up on dose constraints to public.

1- INTRODUCTION

Radiation field produced by cosmic radiations in the earth's atmosphere is very complex and is significantly different from that found in the nuclear industry and other environments at ground level. Passengers are exposed to high levels of ionizing radiations increase rapidly with altitude These radiations are of galactic and solar origin (cosmic) and due to secondary radiations produced in the atmosphere and aircraft structure. Primary cosmic radiation mainly consists of protons, alpha particles and heavier ions, the energy of which can be very high. The galactic component is stable, while the solar component depends on the solar activity, which varies with an 11 year cycle. The charged particles move around and interact with the terrestrial magnetic field to from the magnetosphere, at altitudes below a few earth radii (one earth radius is 6370 km). This explains the presence of polar cones centered on the earth s magnetic poles. Secondary particles (neutrons, ions, electrons, gamma rays, munos etc) are produced upon interactions of cosmic ions and atoms in the earth's atmosphere. The shielding is most effective at the equator and decreases at higher latitudes, essentially disappearing near the poles. Cosmic particles flux intensity depends on the solar activity. The radiation field at aircraft altitudes consists of neutrons, protons, and neutral and charged pions. The effective dose is estimated using various experimental and calculational techniques. Dose received during several Egypt Air flights, was computed using CARI-6 code. Calculations were performed during short route, medium and long route on mostly regular passenger flights of Egypt Air Company. The altitude, latitude, and flight times for any individual passengers of Egypt airline are all variable. It is only possible to estimate some average values for these variables. The estimates below are conservative and can be regarded as upper limits. The stated doses are the occupational exposure to cosmic radiation, in addition to the cosmic radiation received by the rest of the population at sea level.

The routes flown by domestic airlines can be broadly classified as main trunk routes and feeder routes, characterized by the type of aircraft flown. The smaller aircraft on feeder routes are generally required to observe an upper altitude limit of about 7.5 kilometers (25 000 feet). The routes are typically short and aircraft will be at the maximum altitude for only a fraction of each flight. In many cases, they will not reach this altitude as the flights are of short duration. The flying hours of each passenger will be only a fraction of their working hours. following latest recommendations of the International Commission on Radiological Protection in publication 103 (ICRP), the value of the dose constraints to be used for optimization of radiological protection for a single source should be less than 1 mSv/y and the value of no more than about 0.3 mSv/y would be appropriate. Following the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCAR 2004) effective dose equivalents from cosmic radiation in excess of 1 mSv. Passengers are exposed to much higher dose rate which vary according to the flight altitude and to a smaller extent, the latitude and solar activity. Assuming that the average altitude of commercial flights is 8 km, the average dose equivalent rate would be about 2 μSv/h. The neutron component contributes about 60% of the total. Bouville and Lowder used both measurements and calculations to derive expressions of the altitude

$$E_N(z) = E_N(0)\exp(\alpha_N . z) \quad (1)$$

$$E_N(z) = E_N(0)[b_N \exp(\beta_N . z)] \quad (2)$$

Equation (1) applies for $z < 2$ km and Equation (2) applies for $Z > 2$ km.
Here; $E_N(z)$ is the effective dose rate in μSva^{-1} for neutron component,
$E_N(0)$ is the reference value at sea level $E_N(0) = 30\ \mu\ Sva^{-1}$, $\alpha_N = 1.0\ km^{-1}$, $b_N = 2.0$, & $\beta_N = 0.70\ km^{-1}$

2. DOSE CONSTRAINTS

The dose limit to member of the public is 1mSv/a the recommended value for the dose constraints ICRP 60 (1990) is 0.3 mSv/a

In general, the value of the dose constraints to use in the optimization of radiological protection for any single source should be less 0.3 mSv/a for calculations of dose received by some Egypt Air flight passengers using CARI-6, calculations were performed during, short route, medium route, long rout on mostly regular passenger flights of Egypt Air Company further are recommended average number of flights per year was calculated using the following equations.

$$the\ number\ of\ flights\ per\ year = \frac{value\ \ dose\ constrain}{effective\ dose\ per\ flight} = \frac{0.3\ m\ Sv}{Df}$$

where D_f is the effective dose per flight.

3. MATERIAL AND METHODS

3.1 Thermo-Luminescence Dosmietry

Thermoluminescent (TL) detectors are nowadays commonly applied in the dosimetry of ionizing radiation. It is not possible to directly relate the amount of light released from a TL detector to radiation exposure, the signal of TL detectors can be related to absorbed dose.

3.2 Computer Program CAIR-6

CAIR-6 (Civil Aero medical Research Institute) calculates the effective dose from galactic cosmic radiation received by an adult on a nonstop aircraft flight during any month from January 1958 to the present, Ferrari et al (1997) .It can also calculate the effective dose rate from galactic radiation at any specific location in the atmosphere at altitude up to about 67298 feet. The effective dose to a pregnant woman from galactic radiation is a good estimate of the equivalent dose to the concept us. The program takes into account the effects of solar activity, the geomagnetic field and the galactic radiation level for the data or dates selected by the user. Radiation from the solar particle events is not taken into account by the program Ferrari et al (1996).

3.3 Flight Profiles

Aircraft flight information is contained in the form of user - entered ,flight –entered and flight profiles stored collectively in files with the extension BIG. The program prompts the user to enter a file name with the extension BIG .The user then enters one or more flight profiles in the BIG file Up to 16 BIG files can be managed at any time. We have successfully used BIG files with almost 30000 flight profiles. Unused BIG files should be removed from the directory to avoid problems with limit. This will also conserve disk space. Another name for saving disk space is to remove unwanted flights from BIG files with a text editor Fig (1). Schematic diagram of computer program for calculating flight radiation dose is provided CARI-6 Fig (1). Theoretical calculations for exposure levels on board of aircraft by computer code CARI-6.

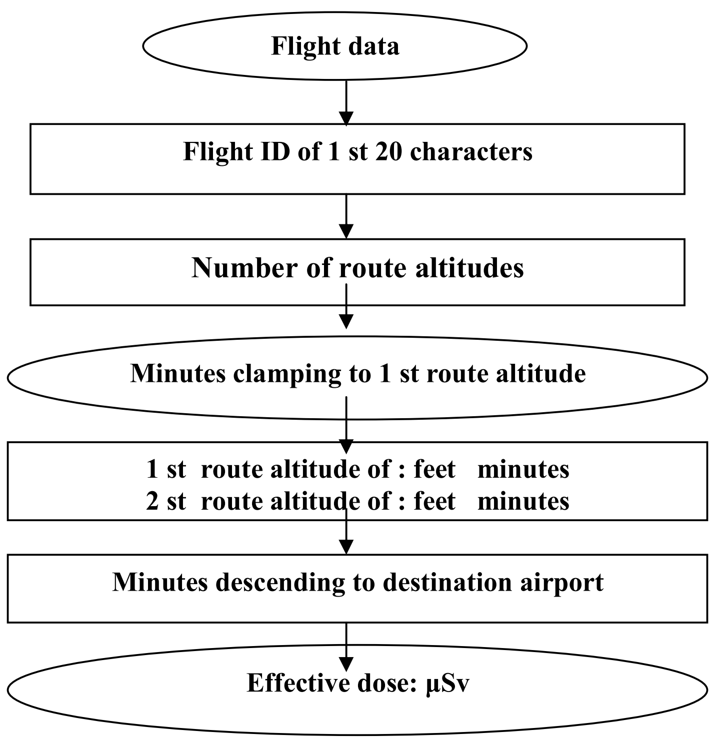

Fig 1. Schematic diagram of computer program for calculating flight radiation dose CARI-6

RESULTS AND DISCUSSION

Tables (1&2) calculate the annual effective dose using computer code CARI-6 and number of recommended flights per year in (the short, domestic route).

Table 1. Computed effective dose for passenger by computer Code CARI-6 for some domestic flights.

Flight route	Altitude (ft) x10^3	Duration time (h)	Effective dose (μSv)	Number of recommended flights per year
Cairo-Marsa Alam–Cairo	24	2.15	3.05	98
Cairo–Luxor-Cairo	24	2.10	1.09	275
Cairo–Aswan-Cairo	25	2.00	1.56	192
Cairo–Alexandria–Cairo	25	1.00	1.64	182
Cairo-Hurghada- Cairo	25	2.00	2.08	144
Cairo–Sharm el Sheikh –Cairo	26	1.30	1.04	288

Table 2. Computed effective dose for passenger in medium route by computer Code CARI-6 Regional routes.

Flight route	Altitude (ft) x10^3	Duration time (h)	Effective dose (μSv)	Number of recommended flights per year
Cairo- Damascus-Cairo	31	3.00	5.48	54
Aswan –Jeddah-Cairo	32	4.00	6.00	50
Sharm-Riyadh-Cairo	33	5.10	9.06	33
Sharm- Khartoum- Cairo	34	4.10	8.10	37
Cairo- Kuwait-Cairo	34	5.00	9.42	31
Cairo- Sharjah- Cairo	34	4.12	7.96	37
Sharm-Bahrain- Cairo	35	10.0	24.81	12
Cairo- Dubai- Cairo	35	7.06	14.96	20
Cairo –Abu-Dhabi -Cairo	37	6.10	13.16	22
Cairo- Doha -Cairo	35	7.00	16.81	17
Cairo-Tunis -Cairo	37	5 .00	14.75	20
Cairo-Casablanca -Cairo	36	6.06	16.08	18
Cairo –Muscat –Cairo	35	7.00	26.23	9

Table 3.1 Computed effective dose for passenger in long route by computer Code CARI-6 International routes.

Flight route	Altitude (ft)	Duration time (h)	Effective dose (μSv)	Number of recommended flights per year
Cairo-Roma-Cairo	35000	6.00	16.04	18
Cairo- Madrid-Cairo	35000	8.00	23.12	12
Cairo-Frankfurt-Cairo	36000	9.00	33.1	9
Cairo-Paris -Cairo	36000	9 .00	29.64	10
Cairo-London -Cairo	37000	8 .00	47.74	6
Cairo-Geneva-Cairo	38000	8.10	31.48	9
Cairo –Düsseldorf-Munich -Cairo	38000	11.00	37.5	8
Cairo-Moscow -Cairo	38000	13 .00	110.46	2
Cairo-Abidjan -Cairo	39000	12.00	33.52	8

Table (3.2) Computed effective dose for passenger in Long route by computer Code CARI-6, International routes.

Flight route	Altitude (ft)X 10^3	Duration time (h)	Effective dose (μSv)	Number of recommended flights per year
Cairo-Montreal –Cairo	36	16.08	96.81	3
Cairo –Johannesburg-Cairo	37	16.00	42.52	7
Cairo- Beijing –Cairo	38	19.35	68.43	4
Cairo-New York-Cairo	38	26 .00	164.14	1
Cairo-Bombay-Cairo	38	18 .00	40.84	7
Cairo- Bangkok –Cairo	39	27.05	77.58	3
Cairo –Tokyo-Cairo	39	31.00	137.88	2
Cairo-Dubai –Singapore –Melbourne –Dubai –Cairo	40	23.30	114.82	2
Cairo –Hong Kong -Cairo	40	28.00	71.26	4
Cairo-Osaka-Cairo	40	32.00	145.14	2

CONCLUSION

Cosmic radiation is a natural phenomenon to which we are all subjected. However, the greatly elevated dose rates found at the altitudes at which commercial

aircraft fly should be deemed occupational exposure for the aircrew, in line with the latest ICRP Recommendations.
Under current flying conditions, passengers group most highly exposed to occupational radiation. The passengers on long route are exposed to doses probably 10 times those received by short route.
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Reduction of cosmic radiation dose rates in aircraft by shielding is not practical. Reduction by flying at lower altitudes is feasible, but would probably not be considered an option by commercial airlines. The only viable option for limiting the cosmic ray doses received by aircrew is to limit their flying hours

The factors effecting in the effective dose is altitude (where increase in altitude produces increase in effective dose), latitude (the geomagnetic latitude and its effect on the effective dose), and the duration time of flight (increasing in time duration due to increasing effective dose).

The value of the dose constraints to use in the optimization of radiological protection for a single source should be less than 1mSv/y and the value of no more than about 0.3 mSv/y would be appropriate. The calculation perform to the average number of allowed flight per year is 196 for the short routes, the number of allowed flight per year is 27 for the middle east, the number of allowed flight per year is 9 for the European country with duration time less than 16 hours and the number of allowed flight per year is 3 flight for the European country more than 16 hours (long route).

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