MEASUREMENTS OF COSMIC-RAY DOSES IN COMMERCIAL AIRLINE CABINS

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INTRODUCTION

Cosmic radiation doses which aircrew and air passengers receive in airplanes have been calling attention in many countries especially in the last decade. In this relation, various types of information had been reported on cosmic radiation intensity. In Japan, the cosmic radiation intensity had been measured in commercial airline cabins as well as chartered flights(1-3). While the intensity depends on altitude, geomagnetic latitude(or cutoff rigidity), and temporal variation of the solar activity, their doses are often speculated based on paper records on airflights combined with the intensty-altitude relationship(4). In this study, however, efforts were made to estimate more realistic integrated doses in airline cabins based on actual on-board measurements which had been conducted several dozens of times in each year(e.g., 45 times in 1994 and 27times in 1995).

MEASUREMENTS AND EMPIRICAL FORMULA

The measurements were done by the uses of several kinds of spherical scintillation spectrometers, an ionization chamber, neutron detectors and personal dosimeters. The main device was a scintillation spectrometer which accomodated a 3" ϕ NaI(Tl) spherical detector, and signal components above 3MeV were regarded as cosmic contribution. The neutron contribution was estimated based on intercomparison tests between an ionization chamber and Bonner sphere neutron detectors on board a DC-8 chartered flight(2-3). The results showed that the neutron dose is about 40% of observed charged particle doses with small deviations. The results also suggested that the integrated cosmic radiation dose(D) can be practically expressed in terms of flight time at the main flight altitude(T) plus 10 minutes, dose rate factor(R) and correction factors as follows:

$$D= [R(T + 10)/60] \times F_g \times V_t$$

where F_g is a correction factor due to geomagnetic latitude(F_g =1.1 - 0.95), and V_t is another correction factor due to solar activity(V_t =1.15 - 0.85). R is the dose rate as a function of altitude as presented in Table 1. The uncertainty of obtained results was estimated to be less than 5%.

Table 1. Cosmic radiation dose rates at various altitude.

Altitude(kilo feet)	19	22	25	28	31	33	35	37	39
Dose rate R(μ Sv/h)	0.38	0.57	0.83	1.12	1.42	1.62	1.83	2.03	2.23

ESTIMATED DOSE RATES

In case realistic integrated doses should be evaluated, attention must be paid to flight direction, too. That is because airflight time is considerably influenced by wind such as the westerly. Such was studied in east-west flights(Tokyo-Matsuyama), north-south flights (Tokyo-Hokkaido as well as Tokyo-Okinawa) along with other short distance flights. The mean doses and their ranges were 1 μ Sv(0.7-1.5 μ Sv), 1.5 μ Sv(1.0-1.8 μ Sv) , 2.5 μ Sv(2-3 μ Sv), and negligible(less than 0.5 μ Sv), respectively. Figure 1 compares the integrated doses between eastward(from Tokyo to Matsuyama: against the westerly) and westward(from Matsuyama to Tokyo: with the westerly) flights. It is clearly demonstrated that the integrated dose depend on both flight altitude and flight direction.

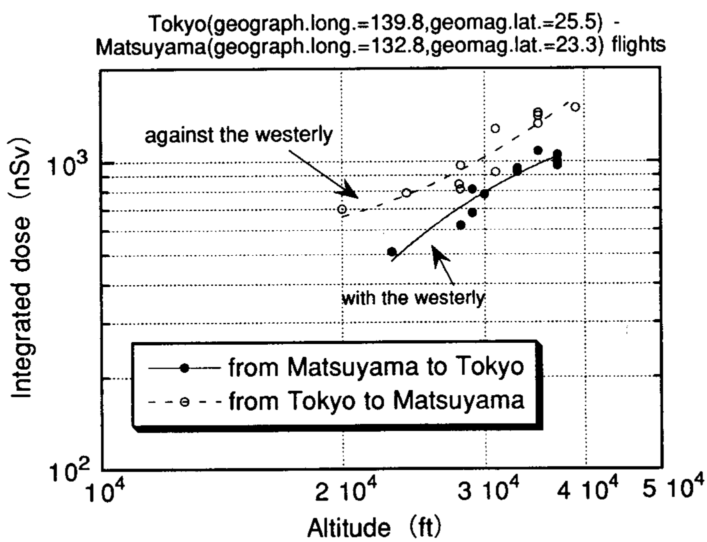

Figure 1. Dose rates measured on board commercial airline cabins in 1992-93.

As for domestic flights in Japan, it was obtained that a typical integrated dose in short flights (Tokyo-Osaka, Osaka-Kyusyu, etc.), middle flights(Tokyo-Hokkaido, Tokyo-Kyusyu, etc) and long flights(Tokyo-Okinawa, Hokkaido-Okinawa) were ~0.5 μ Sv, ~1.5 μ Sv and ~ 3 μ Sv, respectively. International flights were also studied, and comparison between Japan-Europe routes, one via Anchorage and another via Singapore, was possible. Generally, the dose level estimated here are lower than other reported ones. Figure 2 compares altitude dependence of the dose equivalent rates in NCRP report and that of actually measured ones.

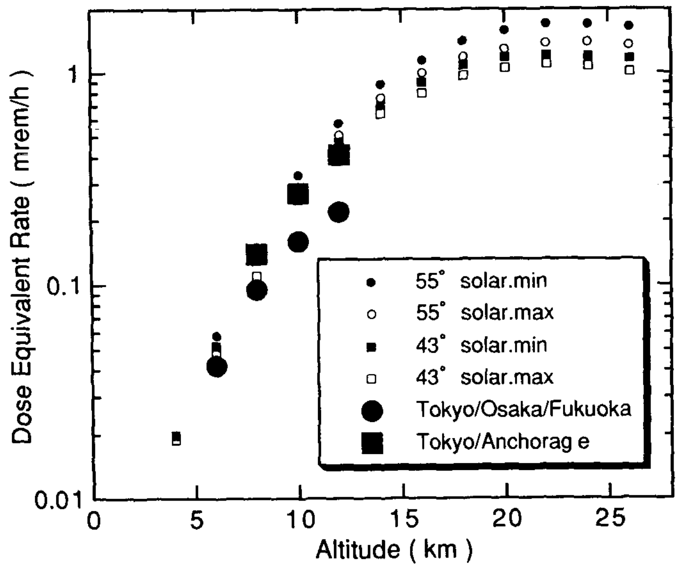

Figure 2. Dose equivalent rate in old unit at 5 cm depth in a 30 cm slab of tissue. NCRP values for Solar maximum and solar minimum are compared to 1000 km flights within Japan along with polar flight which passed Anchorage in Alaska.

CONCLUSION

To discuss the dose limit for aircrew and passengers, care must be paid not only to boarding hours but also to flight routes which reflect many other factors. As present data are based on numbers of actual commercial flights, it will contribute to find proper countermeasures to avoid over exposure.

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