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HEALTH PHYSICS AND SAFETY DIVISION
Informal Report

FINAL REPORT ON AN INTERAGENCY AGREEMENT BETWEEN
U. S. ATOMIC ENERGY COMMISSION and the ENVIRONMENTAL PROTECTION AGENCY

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Introduction

This interagency agreement covered measurements in aircraft with the Brookhaven National Laboratory dose equivalent meter, said measurements being an extension of work previously sponsored by the Federal Aviation Agency (FAA) under interagency agreement FA-SS-71-7. Since the additional FAA flights originally planned for the fall of 1971 did not occur, and since this present interagency agreement was not finalized until February 25, 1972, measurements have been made at ordinary jet altitudes for four values of geomagnetic latitude on flights in Air Force planes arranged for by Environmental Protection Agency (EPA).

The Dose Equivalent Meters

Measurements of dose equivalent on the four flights were made using the Baum dose equivalent meters previously fabricated and used in Alaska under the FAA-AEC interagency agreement. The design principles on which these instruments are based have been discussed in two articles by Baum, et al.^(1, 2) A detailed description of the instrument will be presented in December 1972 at the IAEA Symposium on Neutron Monitoring for Radiation Protection Purposes, in Vienna.

The spherical tissue-equivalent chambers used as sensors in the dose equivalent meters were filled twice during the course of the project. The

instruments were calibrated and adjusted prior to each flight.

The Four Flights

Arrangements were made by EPA (Col. R. Minx) for flights at four different latitudes from northern Maine to southern Florida. These flights were provided by the U. S. Air Force with flight plans that called for east and west courses, with half hour periods at about 10, 20, 30 and 40 thousand foot elevations. The four flights were as shown in Table 1.

Table 1

Flight Locations and Dates

<u>Geomagnetic Latitude</u>	<u>Date</u>	<u>Course</u>
58.0° N	July 18, 1972	E and W of Presque Isle, Maine
50.0° N	June 17, 1972	W of Washington, D.C.
41.7° N	August 30, 1972	W of Jacksonville, Florida
36.7° N	August 29, 1972	E of Eleuthera, B.W.I.

The two-minute data printouts obtained on these flights were processed using the previously developed computer code⁽³⁾ and analyzed as shown in Tables 2, 3, 4 and 5. Data were obtained with two instruments on all flights except that for Presque Isle where only one instrument was operational. The dose equivalent section of the second instrument was out of service during the Jacksonville flight.

Since altitudes for the several flights varied somewhat, the results for each flight have been plotted in Figures 1, 2, 3 and 4. Values of absorbed dose rate and dose equivalent rate at 10, 20, 30 and 40 thousand feet, taken from the curves, are tabulated in Table 6. Computer plots of the two-minute values are shown in Figures 5 to 17.

The error bars shown in Figures 1 to 4 are standard statistical deviations predicted theoretically for this type of instrument. The method used in computing these values of standard deviation will be discussed at the IAEA symposium referred to above.

Analysis of Results

The variation of dose-equivalent with geomagnetic latitude was analyzed using data from Table 6. Since the flights were separated in time, and since an abnormally rapid increase in galactic radiation levels had been observed by Anderson⁽⁴⁾, it seemed desirable to correct the values in Table 6 to a single time such as July 18 when the Presque Isle data were obtained. This was done using the Anderson data and a summary of information on galactic radiation levels from the draft of an upcoming FAA committee report⁽⁵⁾. However, the corrections were 2% or less and not significant compared with the errors of measurement which are estimated to be 15 or 20% at 40,000 feet and probably larger at lower elevations. The results of this analysis are shown in Figure 18 where dose equivalent is plotted against geomagnetic latitude for the four altitudes. The results of a similar analysis of absorbed dose rate values are plotted in Figure 19.

Although a comparison with other results is not a part of this project, such a comparison is being made in connection with the FAA report mentioned above⁽⁵⁾. Preliminary results indicate that agreement among the available experimental and theoretical results is quite good. In particular, we find that the present data fits very well with the results obtained in June 1971 in Alaska at a geomagnetic latitude of 69° N. If we take the Alaska values

of dose equivalent rate for 40,000 and 30,000 feet, and correct them to July 1972 by the same method used above, we obtain 0.72 and 0.32 mrem/h. These fit well with an extrapolation of the 40,000 and 30,000 foot curves of Figure 18 since plots of dose equivalent rate vs. geomagnetic latitude are known to become horizontal above about 65° N.

References

- (1) Baum, J. W., Woodcock, R. C., Kuehner, A. V. "Factors affecting pulse size in tissue-equivalent counters", Proc. of Second Internatl. Conf. on Accelerator Dosimetry and Experience. CONF 691101, Div. of Tech. Information, U.S. Atomic Energy Commission, November 1969.
- (2) Baum, J. W., Kuehner, A. V., Chase, R. L. "Dose equivalent meter designs based on tissue equivalent proportional counters", Health Physics 19, 813-824, 1970.
- (3) Final Report to Federal Aviation Agency on Interagency Agreement FA-SS-71-7.
- (4) Anderson, H. R. "The primary cosmic radiation", Proc. of the Natural Radiation Environment-II, Rice University, Houston, Texas, August 7, 1972 (in press).
- (5) Final Report of Federal Aviation Agency Advisory Panel on Radiobiological Aspects of the SST. (To be submitted to FAA in 1973).

Table 2

Analysis of Presque Isle Flight Data
(geomagnetic latitude = 58° N)

<u>Altitude</u> (feet)	<u>Points</u>	<u>Duration</u> (min)	<u>mrad/h</u>	<u>mrem/h</u>	<u>QF</u>
10,000	86-101	32	0.019	0.042	2.2
20,000	66-83	36	0.063	0.121	1.92
29,500*	39-59	42	0.158	0.266	1.68
40,000	112-126	30	0.392	0.719	1.83

*Plane actually flew about half the time at 29,000 and the rest of the time at 30,000 feet.

n.b. Instrument used was #1-1-1.

Table 1

Analysis of Washington Flight Data
(geomagnetic latitude = 50.0° N)

	<u>Altitude</u> (feet)	<u>Points</u>	<u>Duration</u> (min)	<u>mrad/h</u>	<u>mrem/h</u>	<u>QF</u>
Instrument #1-1-1	10,000	18-31	28	0.021	0.024	1.1
	20,000	35-49	30	0.060	0.083	1.4
	29,000	80-95	32	0.151	0.250	1.66
	41,000	64-76	26	0.353	0.565	1.60
Instrument #2-3-3	10,000	19-32	28	0.022	0.038	1.7
	20,000	36-50	30	0.061	0.103	1.7
	29,000	83-99	34	0.160	0.277	1.73
	41,000	66-79	28	0.377	0.686	1.82
Average of Instruments #1-1-1 and #2-3-3	10,000			0.022	0.031	1.4
	20,000			0.061	0.093	1.5
	29,000			0.155	0.264	1.70
	41,000			0.365	0.626	1.74

Table 4

Analysis of Jacksonville Flight Data
 (geomagnetic latitude = 41.7° N)

	<u>Altitude</u> (feet)	<u>Points</u>	<u>Duration</u> (min)	<u>mrad/h</u>	<u>mrem/h</u>	<u>QF</u>
Instrument #1-1-1	11,000	25-42	36	0.0195	0.0235	1.21
	19,000	44-61	36	0.051	0.078	1.53
	28,000	65-81	34	0.134	0.208	1.55
	39,000	88-105	36	0.294	0.485	1.65
Instrument #2-3-3	11,000	25-44	40	0.029	0.025	0.86
	19,000	47-65	38	0.056	0.067	1.20
	28,000	69-85	34	0.132	0.226	1.71
	39,000	92-110	38	0.286	0.490	1.71
Average of Instruments #1-1-1 and #2-3-3	11,000			0.024	0.024	1.00
	19,000			0.0535	0.0725	1.35
	28,000			0.133	0.217	1.63
	39,000			0.290	0.488	1.68

Table 5

Analysis of Eleuthera Flight Data
(geomagnetic latitude = 36.7° N)

	<u>Altitude</u> (feet)	<u>Points</u>	<u>Duration</u> (min)	<u>mrad/h</u>	<u>mrem/h</u>	<u>QF</u>
Instrument #1-1-1	19,000*	23-32	20	0.046	0.056	1.22
	10,000	35-55	42	0.018	0.020	1.11
	20,000	58-74	34	0.058	0.095	1.64
	30,000	77-93	34	0.153	0.272	1.78
	40,000	97-113	34	0.282	0.457	1.62
	20,000**	118-141	48	0.0545	0.088	1.61
Instrument #2-3-3	19,000*	25-35	22	0.048		
	10,000	39-59	42	0.018		
	20,000	62-78	34	0.054		
	30,000	83-98	32	0.142		
	40,000	104-120	34	0.272		
	20,000**	125-149	50	0.054		
Average of Instruments #1-1-1 and #2-3-3	19,000*			0.047		
	10,000			0.018		
	20,000			0.056		
	30,000			0.148		
	40,000			0.277		
	20,000**			0.054		

* Enroute S.E., average geomagnetic latitude = 38.1° N

** Enroute N.W., average geomagnetic latitude = 38.1° N

n.b. No mrem/h values were obtained with instrument #2-3-3 because amplifiers 2 and 3 failed to operate.

Table 6

Summary of Results

Date:		July 18, 1972		June 17, 1972		August 30, 1972		August 29, 1972	
Geomag. Lat.:		58.0°N		50.0°N		41.7°N		36.7°N	
<u>Altitude</u>	<u>mrad/h</u>	<u>mrem/h</u>	<u>mrad/h</u>	<u>mrem/h</u>	<u>mrad/h</u>	<u>mrem/h</u>	<u>mrad/h</u>	<u>mrem/h</u>	
10,000	0.019	0.042	0.022	0.035	0.020	0.025	0.018	0.025	
20,000	0.063	0.121	0.061	0.105	0.063	0.088	0.058	0.10	
30,000	0.17	0.29	0.168	0.275	0.150	0.245	0.138	0.25	
40,000	0.39	0.70	0.345	0.58	0.31	0.525	0.280	0.475