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Intercalibration of the Major North American Networks Employed in Monitoring Airborne Fission Products

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Physical Chemistry Branch
Chemistry Division

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CONTENTS

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Simultaneous collections of airborne fission products on filters identical to those used by the major air monitoring networks presently operating in North America were made by NRL at Washington,D.C. during June 1963. The filters were returned to each of the cooperating agencies for evaluation of their gross radioactivity content. The results were returned to the U.S. Naval Research Laboratory for tabulation and evaluation.

The relative interconversion factors which are derived from the experimentally determined radioactivity concentrations are as follows: U.S. Public Health Service Radiation Surveillance Network, 1.00; Canadian Radiation Protection Division Network, 1.28; U.S. A.E.C. Health and Safety Laboratory 80th Meridian Network, 1.29; Mexican Radiation Protection Program Network, 1.58; and U.S. Public Health Service National Air Sampling Network, 1.77. The variable associated with the volume of air sampled has been eliminated in this study; the above factors relate solely to the evaluation of the combined effect of filter performance and counting techniques employed by the various networks.

Recommendations toward improving the reliability of the radioactivity data from air-monitoring networks have been made and a simple procedure suggested for future intercalibrations.

INTRODUCTION

In 1962 the U.S. Naval Research Laboratory undertook the intercalibration of several systems employed in monitoring the fission product radioactivity in the atmosphere (1,2). As a result, the U.S. Public Health Service, in its series of reports entitled "Radiological Health Data" issued monthly by the Division of Radiological Health (Radiological Health Data and Reports Staff), has been able to draw reasonable contour maps of the concentrations of gross β activity in the air over the United States and Canada from measurements made by networks in these areas.

At the request of the Comision Nacional de Energia Nuclear of Mexico (Laboratorio de Desechos Radiactivos) and the U.S. Public Health Service (Radiological Health Data and Reports Staff), this Laboratory agreed to run another intercalibration so that useful contour maps of airborne radioactivity could be drawn for the entire North American continent.

In order to make this study as complete as possible, the organizations responsible for the following systems were invited to participate; all took part in this study (no NRL systems were included because NRL is no longer conducting any network operations):

1. Radiological Protection Program, National Commission of Nuclear Energy, Mexico.
2. Radiation Surveillance Network, U.S. Public Health Service.
3. Health and Safety Laboratory, 80th Meridian Program, U.S. Atomic Energy Commission.
4. Air Monitoring Program of the Radiation Protection Division, Department of National Health and Welfare, Canada.
5. National Air Sampling Network, U.S. Public Health Service.

The procedures in use by each of the systems are indicated in Appendix A. The only variance from those procedures has been in the use of intercalibrated positive-displacement blowers to collect the required samples; in essence, this study compares the combined effect of the filter behavior and the counting procedures in current use by each network.

EXPERIMENTAL PROCEDURE

Sample Collections

Samples of airborne fission products were collected by use of positive-displacement blowers on filter materials supplied by the cooperating

NRL Problem A02-13; Project RR 004-02-42-5151. This is a final report on this phase of the problem; work on other phases is continuing. Manuscript Submitted October 9, 1963.

organizations and with filter holders of approximately the same area and geometrical shape as those used by the various networks. The five air sampling units were installed in three louvered shelters located side by side on the roof of a building at the U.S. Naval Research Laboratory, Washington, D.C. The samplers were situated about 25 feet above the ground; the filtered exhaust was directed upward and away from the filters so that recycling of filtered air was extremely unlikely. Photographs of the equipment layout and the individual air sampling devices are shown in Figs. 1 through 4.

Collections of about 24 hours duration ending at approximately 1500 local time (Eastern Daylight Time) were made during each weekday; three-day (approximately 72 hours) collections were made over weekends. The period of operation was from May 31 to June 24, 1963, resulting in 4 three-day collections and 12 one-day collections from each sampler. Unfortunately, equipment malfunction (a slipping V-belt drive) invalidated collections made for evaluation by the Canadian procedure during the period May 31 to June 7 (5 collections).

Each of the filter systems was directly calibrated against the same flowmeter (Fischer and Porter Flowrator) of 55 cubic feet/minute capacity; a comparison of the flow rate vs pressure drop across the filter was used to monitor the blower performance. For four of the units a vacuum gauge having a range of 0 to 30 cm Hg was employed; on the HASL unit a gauge having a range of 0 to 80 inches of water was used. The calibration of each system was checked one or more times each week against the flowmeter. The average of the initial and final flow rates for each collection was used to calculate the volume of air sampled by each filter.

A description of the air sampling systems employed at NRL for the collection of samples for this intercalibration is given in Table 1. Included in the table is some information on the filter characteristics when employed in these units at NRL. It should be noted that these blower units are

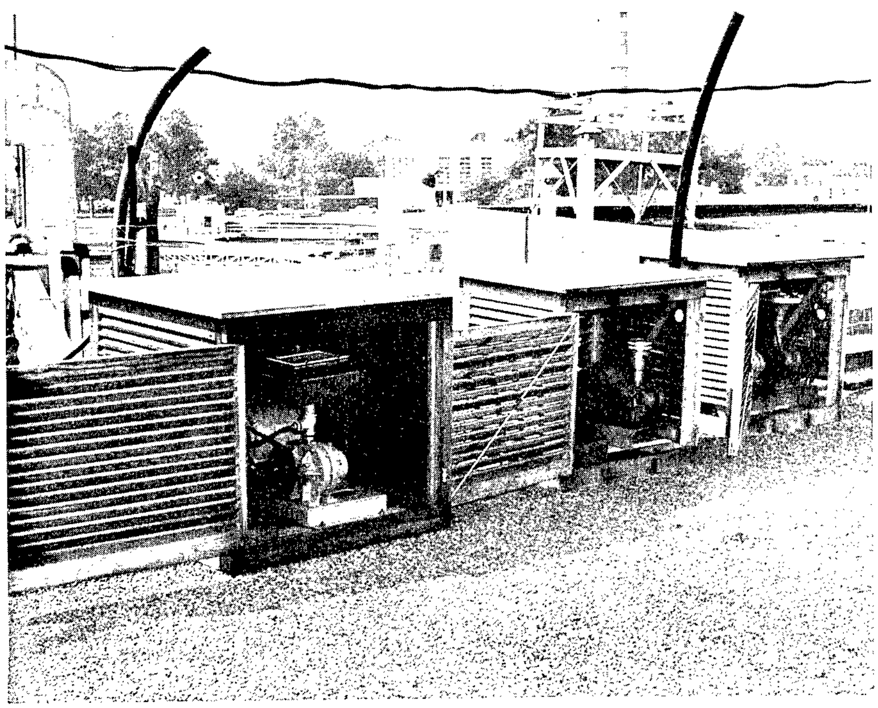

Fig. 1 – Photograph of air sampling units located on roof of building at NRL, Washington, D.C.

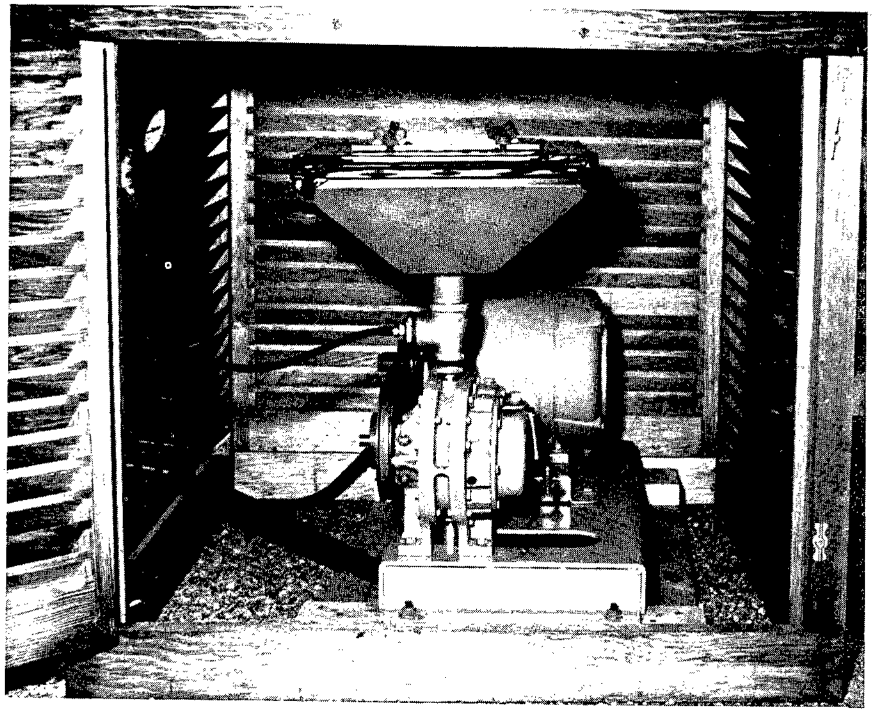

Fig. 2 — Unit employed for collection of samples for evaluation by the Radiological Protection Program, Mexico City

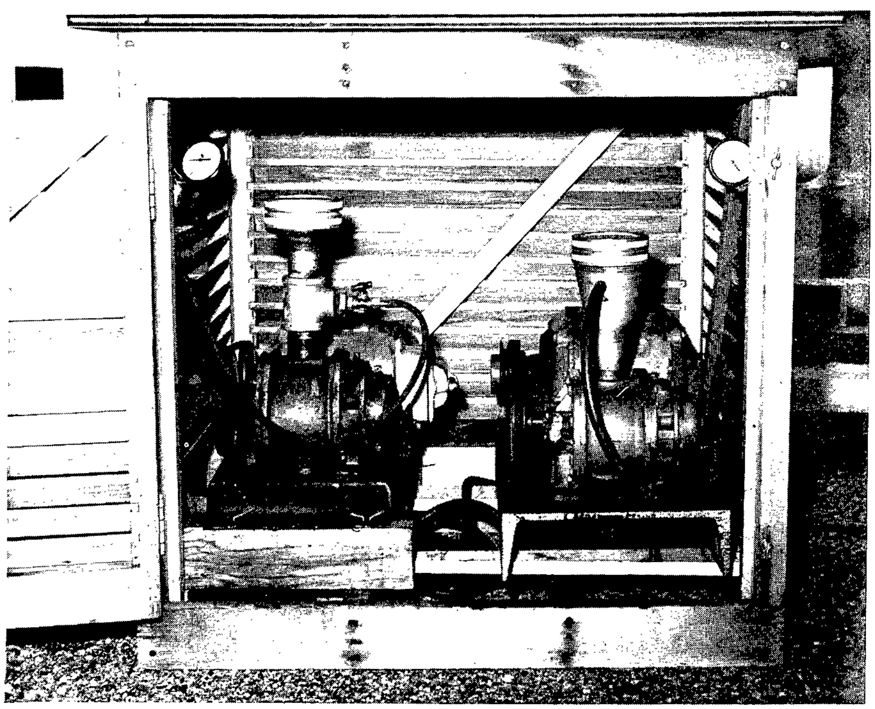

Fig. 3 — Units employed for collection of samples for evaluation by Radiation Surveillance Network, USPHS (on left), and Radiation Protection Division, Ottawa, Canada

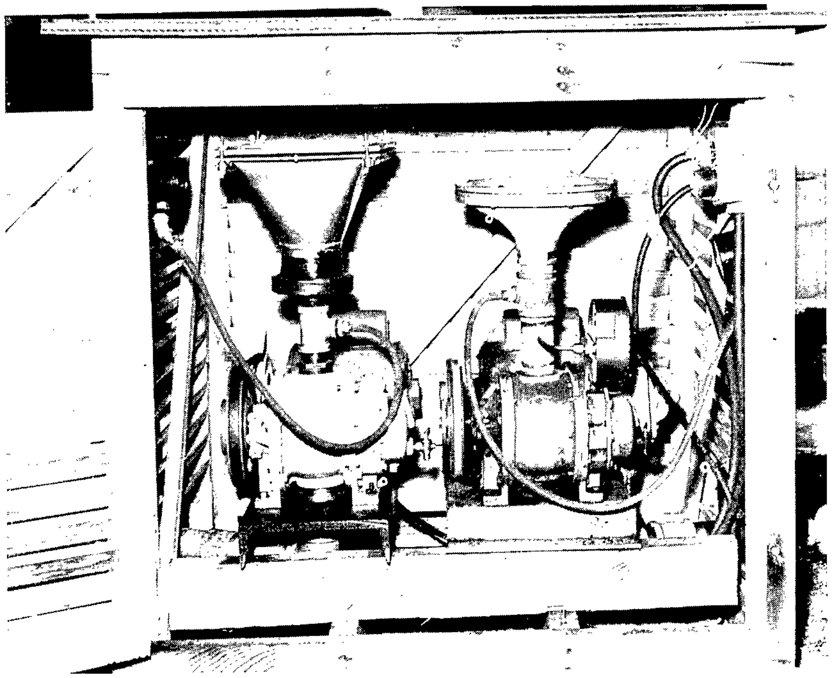

Fig. 4 — Units employed for collection of samples for evaluation by National Air Sampling Network, USPHS (on left), and Health and Safety Laboratory, USAEC, 80th Meridian Network

not necessarily the same as those used by the various networks and hence this information applies only to the NRL units.

Sample Evaluation at NRL

In order to determine the reliability of the sampling procedure, the fission product content of each sample was determined at 16 to 18 hours (or 66 to 68 hours for collections ending on Friday) after termination of the collection. This was done by following the rate of decay of several of the samples during the initial 16-hour period after collection to determine the correction required for the remaining thoron daughter products (ThB and ThC) after which the other samples were evaluated on these counters and the appropriate corrections applied. The correction for the thoron contribution was always small (less than 7 percent) and its variation between the several samples whose decay was measured in parallel was such that the error introduced in the relative fission product counts was less than one percent. In each case the samples were counted while in thin glassine or plastic envelopes which were employed to prevent loss of activity through handling or during shipment.

This preliminary data is contained in Table 2, where the corrected activity in counts per minute per cubic meter of air is given for each sample. A correction for the effective areas of the various filters relative to the counter area has been applied. These area correction factors are as follows: Canadian filter (4-inch diameter), 3.16; PHS-Radiation Surveillance System filter (4-inch diameter), 3.26; Mexican filter (6 × 9 inches), 13.68; HASL filter (8-inch diameter), 14.16; and PHS National Air Sampling Network filter (8 × 10 inches), 21.16. A small counter intercalibration factor has also been applied, where required. No attempt has been made to convert the counts per minute to disintegrations per minute; this step was omitted deliberately to avoid any question of prejudice in interpreting the activity data submitted by the various participating networks.

Sample Evaluation by the Standard Network Procedure

Upon completion of the preliminary evaluation at NRL, the filters were air mailed in four shipments to each of the cognizant organizations for

TABLE 1
Description of Air Filter Systems Employed for Sample Collection in the NRL Intercalibration Program

System	Equipment						System Characteristics						
	Blower*		Filter				Vacuum Reading (cm Hg)		Airflow (CFM)		Average Linear Velocity through Filter (ft/min)	Filter Retentivity at Average Linear Velocity (%)	
	Type	Rotation Rate (RPM)	Type	Size (inches)	Effective Area		Initial	After 24 hours	Initial	After 24 hours		Fission Products	RaBC
					In²	cm²							
Mexico Radiation Protection Program Network	AF-315	1765	Glass fiber (Staplex TFA 69 GF)	6 x 9	40.3	260	3.2	3.4	32.1	31.9	114	100	>99
Canada Radiation Protection Division Network	AF-24	1270	Glass fiber (Hurlburt 934AH)	4" dia.	9.30	60.0	12.5	14.4	19.6	18.2	293	100	>99
U.S.A.E.C. HASL 80th Meridian Network	AF-24	1225	Polystyrene (Microsorban)	8" dia.	41.7	269.	2.1	2.3	29.9	29.7	103	100	95-98
U.S.P.H.S. Radiation Surveillance Network	AF-24	1245	Cellulose-Carbon Impregnated (MSA BM-2133)	4" dia.	9.61	62.0	4.2	3.8	28.5	28.9	430	90-95	80-85
U.S.P.H.S. National Air Sampling Network	AF-24	1500	Glass fiber (MSA 1106BH)	8 x 10	62.3	402.	3.3	3.7	31.3	31.0	72	100	>99

*Roots-Connersville rotary-positive blowers.

evaluation by their standard procedures, as outlined in Appendix A. The radioactivity data were returned to NRL for tabulation and interpretation.

RESULTS

The results of the preliminary evaluations made at NRL are contained in Table 2; the various activity ratios are listed in Table 3. While the primary purpose of this initial evaluation was to demonstrate the equivalence of the samples from the various units, it is evident that samples from certain of the units varied in a systematic way from the others. The obvious sources of inconsistency have been eliminated by the rechecking of flow and counter calibrations and investigating the possibility of leaks or of the recycling of filtered air; furthermore, the counting rates are sufficiently high that statistical variations in the counts cannot be a factor. It should be noted that only a single radioactivity measurement was made of a 2-inch circular area in the approximate center of each filter; thus preferential deposition of dust on certain areas of the filter could cause a bias in the results reported here. It may therefore be concluded that the effect is due principally to differences in filter behavior, and as such would be inherent in the sampling systems under study; however, some small differences could be attributed to the effect of absorption of β activity by the plastic envelopes in which the samples were counted.

Agreement is satisfactory between the three systems which employ similar filter media (Canada, Mexico, and PHS-NASN). The lower radioactivity concentrations found for the PHS-RSN filter relative to the others are not unexpected because of the known greater penetration of this filter by radioactive particles and its greater self-absorption of emitted β activity; this was observed in the previous study (1). The HASL polystyrene

TABLE 2

Data Collected at NRL on Filters Exposed in the Intercalibration Experiment (May 31-June 24, 1963)

Collection ending	Length (hours)	Weather	Mexican System					Canadian System*				
			Airflow (CFM)		Volume	Activity†		Airflow (CFM)		Volume	Activity†	
			Initial	Final	(m³)	c/m	c/m/m³	Initial	Final	(m³)	c/m	c/m/m³
June 3	70.75	rain	32.1	31.6	3831	8163	2.13	–	–	–	–	–
4	23.67	rain	32.1	32.1	1291	439	0.34	–	–	–	–	–
5	23.75	clear	32.1	32.0	1294	4424	3.42	–	–	–	–	–
6	23.83	shower	32.1	31.9	1297	2806	2.16	–	–	–	–	–
7	23.75	clear	32.0	31.9	1290	3584	2.71	–	–	–	–	–
10	71.83	cloudy	32.2	31.8	3908	6778	1.73	22.1	20.6	2608	4638	1.78
11	23.75	clear	32.1	32.1	1295	6172	4.77	19.9	19.1	787	3662	4.65
12	23.92	cloudy	32.1	31.9	1301	4655	3.58	18.6	18.2	748	2615	3.50
13	23.92	cloudy	32.1	31.9	1301	2665	2.05	19.6	18.5	775	1538	1.98
14	23.92	cloudy	32.2	31.9	1304	4492	3.44	19.4	18.4	768	2512	3.27
17	71.92	cloudy	32.0	31.6	3888	15437	3.97	24.0	20.7	2731	10518	3.85
18	23.92	cloudy	32.2	31.7	1299	6156	4.74	19.8	16.4	737	3415	4.63
19	23.92	cloudy	32.1	31.7	1297	6327	4.88	19.8	17.2	753	3576	4.75
20	23.92	clear	32.1	31.8	1299	4872	3.75	19.7	18.8	782	3110	3.98
21	23.92	rain	32.1	32.0	1304	2360	1.81	19.9	19.1	794	1388	1.75
24	67.42	clear	32.1	31.5	3645	15356	4.21	24.1	21.7	2623	9761	3.72

Collection ending	Length (hours)	Weather	HASL System					USPHS-RSN System					USPHS-NASN System				
			Airflow (CFM)		Volume	Activity†		Airflow (CFM)		Volume	Activity†		Airflow (CFM)		Volume	Activity†	
			Initial	Final	(m³)	c/m	c/m/m³	Initial	Final	(m³)	c/m	c/m/m³	Initial	Final	(m³)	(m³)	c/m/m³
June 3	70.75	rain	29.9	29.6	3578	6797	1.90	28.8	29.0	3476	6157	1.77	31.2	30.7	3723	8555	2.30
4	23.67	rain	29.9	29.6	1197	292	0.24	28.4	27.8	1131	260	0.23	31.0	31.0	1247	381	0.31
5	23.75	clear	30.0	29.8	1207	3653	3.03	27.4	26.4	1086	3040	2.80	31.3	30.9	1256	4338	3.45
6	23.83	shower	29.8	29.8	1207	1978	1.64	26.8	29.2	1134	2012	1.77	31.2	30.9	1258	2505	1.99
7	23.75	clear	30.0	29.8	1207	2872	2.38	28.7	29.1	1166	2552	2.19	31.2	30.8	1251	3688	2.95
10	71.83	cloudy	30.0	29.8	3651	5848	1.60	28.7	29.3	3541	4920	1.39	31.3	30.8	3791	6919	1.83
11	23.75	clear	30.0	29.8	1207	5695	4.72	28.9	29.4	1176	4320	3.67	31.3	31.0	1258	6522	5.18
12	23.92	cloudy	30.0	29.8	1216	3638	2.99	29.0	28.9	1177	3205	2.72	31.2	30.9	1262	4672	3.70
13	23.92	cloudy	29.8	29.8	1212	2267	1.87	29.0	29.2	1183	1930	1.63	31.4	31.0	1268	2683	2.12
14	23.92	cloudy	29.8	29.9	1214	4118	3.39	28.9	29.5	1187	3200	2.70	31.2	30.8	1261	4761	3.78
17	71.92	cloudy	29.9	29.7	3643	12618	3.46	29.0	29.2	3556	11006	3.10	31.3	30.7	3791	16501	4.35
18	23.92	cloudy	29.8	29.4	1204	4801	3.99	28.9	29.6	1190	4861	4.08	31.2	30.9	1263	6509	5.15
19	23.92	cloudy	30.0	29.8	1216	5161	4.24	28.9	29.6	1190	4718	3.96	31.4	31.0	1269	6871	5.41
20	23.92	clear	29.9	29.6	1210	4176	3.45	28.8	29.6	1186	3793	3.20	31.3	31.2	1270	5434	4.28
21	23.92	rain	29.9	29.6	1210	1831	1.51	28.8	28.9	1173	1758	1.50	31.4	31.2	1273	2397	1.88
24	67.42	clear	29.6	29.4	3381	11764	3.48	29.0	29.7	3364	10952	3.26	31.6	30.7	3571	16335	4.57

*Microsorban filter employed for weekend (3-day) collections on Canadian unit

†Counter efficiency toward 1 Mev β particles was approximately 18%

Table 3
Activity Concentration Ratios of Samples Collected and Evaluated at NRL

Collection ending	Relative to PHS-RSN				Relative to PHS-NASN			Other		
	Mexico	Canada	HASL	PHS-NASN	Mexico	Canada	HASL	Mexico/Canada	Mexico/HASL	Canada/HASL
June 3	1.20	–	1.07	1.30	0.93	–	0.83	–	1.12	–
4	1.48	–	1.04	1.35	1.10	–	0.77	–	1.42	–
5	1.22	–	1.08	1.23	0.99	–	0.88	–	1.13	–
6	1.22	–	0.93	1.12	1.09	–	0.82	–	1.32	–
7	1.24	–	1.09	1.35	0.92	–	0.81	–	1.14	–
10	1.24	1.28	1.15	1.32	0.95	0.97	0.87	0.97	1.08	1.11
11	1.30	1.27	1.29	1.41	0.92	0.90	0.91	1.03	1.01	0.99
12	1.32	1.29	1.10	1.36	0.97	0.95	0.81	1.02	1.20	1.17
13	1.26	1.21	1.15	1.30	0.97	0.93	0.88	1.04	1.10	1.06
14	1.27	1.21	1.26	1.40	0.91	0.87	0.90	1.05	1.01	0.96
17	1.28	1.24	1.12	1.40	0.91	0.89	0.80	1.03	1.15	1.11
18	1.16	1.13	0.98	1.26	0.92	0.90	0.77	1.02	1.19	1.16
19	1.23	1.20	1.07	1.37	0.90	0.88	0.78	1.03	1.15	1.12
20	1.17	1.24	1.08	1.34	0.88	0.93	0.81	0.94	1.09	1.15
21	1.21	1.17	1.01	1.25	0.96	0.93	0.80	1.03	1.20	1.16
24	1.29	1.14	1.07	1.40	0.92	0.81	0.76	1.13	1.21	1.07
Average	1.26	1.22	1.09	1.32	0.95	0.91	0.83	1.03	1.16	1.10
Standard Deviation of the Mean	± 0.019	± 0.016	± 0.023	± 0.019	± 0.016	± 0.013	± 0.012	± 0.014	± 0.026	± 0.021
No. of Measurements	16	11	16	16	16	11	16	11	16	11
Standard Deviation of a Single Measurement	± 0.075 (6.0%)	± 0.054 (4.4%)	± 0.091 (8.3%)	± 0.078 (5.9%)	± 0.063 (6.6%)	± 0.044 (4.9%)	± 0.049 (5.9%)	± 0.048 (4.6%)	± 0.104 (9.0%)	± 0.070 (6.4%)

filters, which also appear low relative to the glass fiber filters, exhibit a visibly spotty deposit of dust which results from use of a perforated sheet metal filter support rather than a screen. Since the β counters see only a small fraction of the surface, the random positioning of the spots of collected activity relative to the counter window would be expected to cause a somewhat larger variation in those activity ratios involving the HASL filters. These samples also show a nonuniformity in dust loading across the filters with a lighter color near the center where the β activity was monitored. Radioactivity measurements of other areas indicated the center not to be representative of the entire sample but to have lower activity. This variation should not have been a factor in the later measurement at the Health and Safety Laboratory since there the entire filter was evaluated by gamma counting.

It is also evident in Table 2 that with the 24-hour collections dust loading has not caused an appreciable change in the flow rate. The change has averaged less than 2 percent during the 24-hour period for all filters except the 4-inch glass fiber filter used in the Canadian system, where a 7 percent decrease was noted. For three-day collections on the Canadian unit, 4-inch Microsorban (polystyrene) filters were employed to prevent overloading of the blower and motor. These filters exhibited a 10 to 20 percent decrease in flow during the weekend collections, while none of those of larger area showed an appreciable change in flow. The carbon-loaded 4-inch cellulose filters (MSA-2133) employed by the PHS-Radiation Surveillance Network generally showed a slight increase in flow with time; as noted in the previous intercalibration study (1), this is due to loss of the carbon impregnant. In accordance with the PHS-RSN instructions, the carbon-impregnated surface of the filter was faced toward the downstream (exhaust) side of the filter holder, permitting entrainment of the carbon particles in the filtered air stream.

The activity concentrations reported by the participating agencies for the parallel samples collected at NRL are contained in Table 4. All

TABLE 4
Air Concentrations of Fission Product Radioactivity Reported by Parent Organizations from Analysis of Air Filters Exposed at Washington, D.C.

Collection Ending	Activity Concentrations ($\mu\mu c/m^3$)				
	Mexico	Canada*†	PHS-RSN*	PHS-NASN*	HASL
June 3	7.23	–	4.58	7.8	5.99
4	1.45	–	0.82	1.36	0.96
5	10.30	–	7.74	13.0	9.32
6	7.32	–	4.73	8.1	5.49
7	9.63	–	6.08	10.7	7.38
June 10	5.73	4.14	3.72	6.6	4.86
11	16.10	12.83	10.11	19.4	14.27
12	11.84	8.64	7.29	13.7	9.86
13	7.02	5.09	4.33	7.9	5.81
14		11.52	8.01	13.5	9.32
June 17	–	7.97	8.34	14.9	11.03
18	–	14.40	10.21	18.7	13.77
19	–	15.75	10.63	19.5	14.31
20	–	11.52	8.57	15.5	12.15
21	–	5.72	4.00	6.7	4.86
June 24	–	10.89	8.65	15.9	11.70

*Extrapolated to time of collection.
†Based on new standardization effective Sept. 1, 1963.

results are based on the measured volume of air reported by NRL and the gross β activity (or its equivalent) reported by the network following its usual procedure. The lack of data for the Canadian program during the period of May 31 to June 7 was due to improper operation of the collection equipment; missing data from the Mexican program during the period of June 13 to 24 was due to malfunction of the counting equipment. Sufficient information is available from each network and covering a reasonably wide variation in activity concentration for the results to give a statistically significant intercomparison of counting techniques.

The ratios of the reported activity concentrations are listed in Table 5 for each collection together with the mean, the standard deviation of the mean, and the standard deviation of a single comparison between each of the network procedures. The relative activity concentrations or intercomparison factors are as follows: Radiation Surveillance Network, 1.00; Canadian Network, 1.28 ± 0.049 (standardization effective 1 September 1963); HASL 80th Meridian Network, 1.29 ± 0.022; Mexican Network, 1.58 ± 0.038; and National Air Sampling Network, 1.77 ± 0.020. The Canadian/RSN intercalibration factor would have been 1.64 ± 0.063 rather than 1.28 ± 0.049, on the basis of the standardization in effect prior to September 1963; this value compares favorably with the factor 1.54 ± 0.021 obtained in the 1962 intercalibration (1,2). These factors can be used for interrelating the results reported by the various networks to the extent that the on-site measurement of air volumes sampled are reliable.

The above factors ideally are applicable only to a fission product conglomerate of the same age distribution as that sampled in June of this year; as a practical matter, however, the β energy spectrum of the present mixture will not change significantly with a further increase in age so that these factors should continue to be useful until some change is made in the counting procedure of the various networks or until fresh fission debris is introduced into the atmosphere. The minimum age of any debris in the atmosphere in June 1963 was over five months; the

TABLE 5
Activity Concentration Ratios of Parallel Samples Evaluated by the Various Participating Organizations

Collection Ending	Relative to PHS-RSN				Relative to PHS-NASN			Other		
	Mexico	Canada	HASL	PHS-NASN	Mexico	Canada	HASL	Mexico/Canada	Mexico/HASL	Canada/HASL
June 3	1.58	–	1.31	1.70	0.93	–	0.77	–	1.21	–
4	1.77	–	1.17	1.66	1.07	–	0.71	–	1.51	–
5	1.33	–	1.20	1.68	0.79	–	0.72	–	1.11	–
6	1.55	–	1.16	1.71	0.90	–	0.68	–	1.33	–
7	1.58	–	1.21	1.76	0.90	–	0.69	–	1.30	–
June 10	1.54	1.11	1.31	1.77	0.87	0.63	0.74	1.39	1.18	0.85
11	1.59	1.27	1.41	1.92	0.83	0.66	0.74	1.25	1.13	0.90
12	1.62	1.19	1.35	1.88	0.86	0.63	0.72	1.36	1.20	0.88
13	1.62	1.18	1.34	1.82	0.89	0.64	0.74	1.37	1.21	0.88
14	–	1.44	1.16	1.69	–	0.85	0.69			1.24
June 17	–	0.96	1.32	1.79	–	0.53	0.74	–	–	0.72
18	–	1.41	1.35	1.83	–	0.77	0.74	–	–	1.05
19	–	1.48	1.35	1.83	–	0.81	0.73	–	–	1.10
20	–	1.34	1.42	1.81	–	0.74	0.78	–	–	0.95
21	–	1.43	1.22	1.68	–	0.85	0.73	–	–	1.18
June 24	–	1.26	1.35	1.84	–	0.68	0.74	–	–	0.93
Average	1.58	1.28	1.29	1.77	0.89	0.71	0.73	1.34	1.24	0.97
Standard deviation of mean	± 0.038	± 0.049	± 0.022	± 0.020	± 0.026	± 0.031	± 0.007	± 0.032	± 0.041	± 0.047
No. of measurements	9	11	16	16	9	11	16	4	9	11
Standard deviation of a single measurement	± 0.114 (7.2%)	± 0.161 (12.6%)	± 0.088 (6.8%)	± 0.080 (4.5%)	± 0.078 (8.8%)	± 0.104 (14.6%)	± 0.027 (3.7%)	± 0.063 (4.7%)	± 0.123 (9.9%)	± 0.155 (16.0%)

average age was considerably longer due to the dominance of older fission products in the stratospheric reservoir. Radiochemical analysis of a collection made in May 1963 gave apparent ages of 7 months based on Sr^{89}/Sr^{90} and 11 months based on Ce^{144}/Sr^{90} activity ratios, while such a short-lived isotope as Ce^{141}(33 day half-life) was not detected.

As a further check on the NRL sampling procedure, a comparison of the disintegration rates (dis/min/m^3) reported by the parent networks and the preliminary counting rates (counts/min/m^3) obtained at NRL on the same samples was made. The results listed in Table 6 indicate no gross changes took place in the samples between the two measurements (as might be occasioned by loss of material from the filter during transit); the standard deviation of the ratio between pairs of measurements is in the expected range (about ±10%) and is similar to that found in the previous study (1).

CONCLUSIONS AND RECOMMENDATIONS

Realistic interconversion factors have been derived for comparing the radioactivity concentrations reported by the major air monitoring systems in operation in North America. These factors, which assume an accurate on-site evaluation of the volume of air sampled, are as follows: U.S. Public Health Service Radiation Surveillance Network, 1.00; Canadian Radiation Protection Division Network, 1.28; U.S.A.E.C. Health and

TABLE 6
Comparison of Network Evaluations of Activity Concentrations* with NRL Preliminary Evaluations of the Same Samples

Collection Ending	Mexico	Canada	PHS-RSN	PHS-NASN	HASL
June 3	7.54	–	5.75	7.53	7.00
4	9.47	–	7.91	9.74	8.88
5	6.69	–	6.14	8.37	6.83
6	7.52	–	5.93	9.04	7.44
7	7.89	–	6.16	8.05	6.89
June 10	7.35	5.17	5.94	8.01	6.75
11	7.49	6.13	6.11	8.31	6.72
12	7.34	5.49	5.95	8.22	7.33
13	7.60	5.71	5.90	8.27	6.90
14		7.83	6.59	7.93	6.11
June 17	–	4.60	5.97	7.60	7.08
18	–	6.91	5.56	8.06	7.67
19	–	7.37	5.96	8.00	7.50
20	–	6.43	5.95	8.04	7.83
21	–	7.26	5.92	7.91	7.15
June 24	–	6.51	5.89	7.72	7.47
Average	7.65	6.31	6.10	8.18	7.22
Standard deviation of mean	± 0.25	± 0.30	± 0.13	± 0.14	± 0.15
No. of Measurements	9	11	16	16	16
Standard deviation of a single measurement	± 0.75	± 1.00	± 0.53	± 0.54	± 0.61
	(9.8%)	(15.8%)	(8.7%)	(6.6%)	(8.4%)

*Activity Concentration (dis/min/m^3) relative to NRL Preliminary Evaluation (counts/min/m^3).

Safety Laboratory 80th Meridian Network, 1.29; Mexican Radiation Protection Program Network, 1.58; and U.S. Public Health Service National Air Sampling Network, 1.77. These factors have been determined for a fission product mixture having no component less than 5 to 6 months old and an average age near one year; they should continue to be reasonably accurate as the present mixture ages and in the absence of further introduction of fresh debris into the atmosphere.

All of the networks considered in this study employ sampling units whose flow characteristics have been calibrated so that some measure has been obtained of the volume of air sampled. However, it is suggested that some uncertainties and possible inaccuracies could be eliminated by the use of constant speed electric motors and positive-displacement blowers for air sampling purposes. The use of high efficiency filters is also recommended.

Since no further additions of fresh radioactivity to the atmosphere are anticipated in the near future (except possibly from French tests) as a result of the test ban treaty, it is recommended that the present procedure in use by some networks of extrapolating the measured radioactivity to the time of collection be discontinued. With old fission debris which undergoes little decay in the period between collection and evaluation, the error introduced by extrapolation will in general exceed that resulting from neglect of the decay. This error can be particularly serious when the period between successive counts is much shorter than the elaspsed time between sample collection and counting. It is suggested, however, that occasional samples and certainly those exhibiting unusually high radioactivity values be checked for decay to ascertain if fresh fission debris have been released to the atmosphere.

It is further considered that with a few minor changes more significant radioactivity data can be obtained which will be of greater use to certain areas of geophysical research as well as in the evaluation of potential health hazards. These changes would involve the use of longer counting periods to decrease the statistical error in counting, the reduction of counter backgrounds and, as mentioned, previously, the use of filters of high retentivity and of blowers of stable flow performance.

Until such time as a universally accepted standard is agreed upon, it is recommended that periodic rechecks of network intercalibrations be conducted. This can be readily performed for those systems employing highly retentive filters by having each laboratory in succession evaluate the radioactivity of a series of similar filter samples containing old fission debris following which the results can be tabulated and interconversion factors determined; an additional correction factor would be required for those systems employing a less effective filter.

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APPENDIX A
DESCRIPTION OF AIR-MONITORING PROCEDURES AND TECHNIQUES

RADIATION SURVEILLANCE NETWORK, DIVISION OF RADIOLOGICAL HEALTH, U.S. PUBLIC HEALTH SERVICE

Daily 24-hour air samples are collected by a high-volume air sampler (centrifugal-type blower) with a 4-inch diameter carbon-loaded cellulose dust filter (Mine Safety Appliances BM-2133) at approximately 70 sites in the United States (including Alaska, Hawaii, Puerto Rico, and Guam), by personnel of the local health departments. After a preliminary on-site evaluation, the filters are forwarded to the central laboratory of the Radiation Surveillance Network for a more refined measurement using a 7-1/2-inch-diameter thin-window (4.5 mg/cm^2) gas flow proportional counter. Samples are counted 3 days after collection and recounted 7 days later. The Way-Wigner formula ($At^{1.2}$ = constant) is employed to extrapolate to the time of collection.

The exposed filters contained in glassine envelopes are counted for a period of one minute on a counter whose background is approximately 500 counts/minute. A $Sr^{90}(Y^{90})$ standard of known disintegration rate and of the same geometrical shape and size as the filter is employed for calibration.

The volume of air sampled is estimated from the average of the initial and final air flow rates as determined by measurement with a calibrated orifice plate and rotameter-type flow gauge. The sampling rate averages about 2000 cubic meters per day.

MEXICAN RADIOACTIVE FALLOUT PROGRAM, RADIOLOGICAL PROTECTION PROGRAM, NATIONAL COMMISSION OF NUCLEAR ENERGY, MEXICO

Samples of airborne radioactivity are collected at ground level at 12 sites in Mexico by drawing air 24 hours a day, 3 or 4 days a week, through 6 × 9-inch high efficiency glass fiber filters (Staplex

TFA-69 GF) using high-volume samplers (centrifugal-type blowers). After each 24-hour period, the filter is removed and airmailed to the Laboratorio de Desechos Radiactivos (CNEN) in Mexico City for assay of gross β activity.

A 1-1/8-inch-diameter disk is removed from each filter and the total β activity measured with a gas flow proportional counter having a background of 2 counts per minute. Counting is done 4 to 7 days following collection to permit decay of radon and thoron daughters; a preset count of 1000 or 2000 is employed. A Tl^{204} source is used for standardization purposes. The activity is not extrapolated to the time of collection.

The volume of air sampled is estimated from the average of the initial and final air flow rates as determined by measurement with a calibrated orifice plate and rotameter-type flow gage. The sampling rate ranges from 1800 to 2000 cubic meters (S.T.P.) per day and is a function of the altitude of the collecting site.

CANADIAN RADIOACTIVE FALLOUT STUDY PROGRAM, DEPARTMENT OF NATIONAL HEALTH AND WELFARE, OTTAWA, CANADA

Ground level air samples are collected at 24 stations in Canada on high efficiency 4-inch-diameter filters (Hurlbut 934AH glass fiber filters) through the use of positive displacement blowers (Roots-Connersville Type AF-24). The equipment is operated by meteorologists of the Meteorological Branch of the Department of Transport. Air filters are replaced daily and forwarded to the Radiation Protection Division Laboratory in Ottawa for analysis.

A 2-inch-diameter disk is removed from each filter paper and the total β activity measured in a thin end-window Geiger flow-counter system employing a preset count of 1000. The counter is calibrated with a standard source consisting of a similar piece of fresh filter paper containing a known amount of Sr^{90} in equilibrium with Y^{90}. Corrections are made to the observed count to allow for background counting rate, counter efficiency, self-absorption of radiation by the filter, and the relative areas of counted sample and original filter paper. The samples are counted several times on successive days and the counting rate projected back to that existing at the end of the collection period.

The volume of air sampled is calculated from the sampling data sent in by the meteorologist and from the mean flow rate through the filter paper as experimentally determined in Ottawa. The average flow rate used in calculating the total volume of air sampled is the mean flow rate found from a series of flow rate versus time curves over a time interval of 24 hours. The sampling rate averages about 650 cubic meters per day.

THE 80TH MERIDIAN (WEST) SAMPLING PROGRAM, HEALTH AND SAFETY LABORATORY, DIVISION OF BIOLOGY AND MEDICINE, U.S. ATOMIC ENERGY COMMISSION

Ground level air samples are collected at 14 sites near the 80th meridian west and also at Mauna Loa, Hawaii, through the cooperation of local agencies or organizations at each site. The sampling procedure involves drawing air continuously through 8-inch-diameter high-efficiency polystyrene (Microsorban) filters by use of positive displacement blowers (Roots-Connersville Type AF-24) with filter changes on the 1st, 8th, 15th, and 22nd of each month. Samples are airmailed to the Health and Safety Laboratory in New York for analysis.

The exposed filters contained in plastic envelopes are gamma counted on a 10 × 20 cm sodium iodide crystal, obtaining both total gamma activity and the fraction of the gamma activity with energies above 1 Mev. The ratio of these two values gives an indication of the age of the debris collected and also gives a factor which is required for subsequent conversion of gamma activity to equivalent β activity; this factor varies from 1.5 to 3.0, being larger for older fission product mixtures. The mean counting efficiency for the HASL system toward gamma's emitted by fission products is about 35 percent.

The air flow is monitored by means of a Dwyer Magnehelic pressure gauge (range 0 to 80 inches of water) from which daily readings of pressure are made. These values together with air temperature measurements are used to calculate the total volume of air sampled during the collection period. The sampling rate is approximately 1200 cubic meters per day.

NATIONAL AIR SAMPLING NETWORK, DIVISION OF AIR POLLUTION, U.S. PUBLIC HEALTH SERVICE

The National Air Sampling Network makes collections of airborne particulate matter for general air pollution studies, including radioactive contamination, at 260 sites in the United States on a random basis. Continuous 24-hour samples are collected at the active stations on high efficiency glass fiber filters (Mine Safety Appliances 1106BH) and sent to the Laboratory of Engineering and Physical Sciences (Air Quality Section), Robert A. Taft Sanitary Engineering Center at Cincinnati, Ohio, for analysis.

After aging for four or more days to permit decay of the natural radioactivity, each filter is placed under a 7-1/2-inch-diameter thin-window (0.9 mg/cm^2) gas flow proportional counter and its β activity evaluated during a single 1- or 2-minute counting period. Corrections are applied for the counter background (about 300 c/m), for the counting efficiency relative to Tl^{204} (or RaD+E) standards, for the effective area of the filter counted, and for self-absorption of radiation by the filter. Some filters are recounted 4 to 7 days later to permit estimation of the radioactivity at the time of collection by extrapolation.

The volume of air sampled is estimated from the average of the initial and final air flow rates as determined by measurement with a calibrated orifice plate and rotameter-type gauge. The sampling rate averages about 2200 cubic meters per day.