Bailey JC, Rohr RC. Air-Borne Contamination Resulting from Transferable Contamination on Surfaces. K-1088. Oak Ridge, Tennessee: Union Carbide Nuclear Company, Oak Ridge Gaseous Diffusion Plant; 24 November 1953.

Keywords: uranium; resuspension factor; airborne radioactive contamination; surface contamination; K-25; concentration; Oak Ridge Gaseous Diffusion Plant; Atomic Energy Commission; AEC

Conversion of 1953 units to modern SI units for resuspension:

1	(dis./min./m.^{3} air)/(dis./min./cm.^{2} surface)
0.016666667	(Bq/m^3 air)/(dis./min./cm.^{2} surface)
1	(Bq/m^3 air)/(Bq/cm.^{2} surface)
1	(cm^2 surface/m^3 air)
0.0001	(m^2 surface/m^3 air)
0.0001	m^{-1}

(dis./min./m.^{3} air) / (dis./min./cm.^{2} surface)	m^{-1}	(10^{-6} m^{-1})	
0.25	2.50E-05	25	low end of resuspension factors, normal operation
1.9	1.90E-04	190	high end of resuspension factors, normal operation
20	2.00E-03	2,000	maximum resuspension factor, short periods
13	1.30E-03	1,300	maximum resuspension factor, fans only
21	2.10E-03	2,100	maximum resuspension factor, fans & vibrations

(dis./min./cm.^{2} surface)	dpm/ 100cm^2	
120	12,000	average transferable activity on beams, window sills, pipes, etc.
20	2,000	average transferable activity for all surfaces in the laboraytory "UF_4 powder being visible on some of these surfaces"

maximum allowable concentration M.A.C. (dis./min./m.^{3} air)	(µCi/cm^3)	(Bq/m^3)	
111	*5.00E-11*	*1.85*	M.A.C. for "uranium" (no enrichment specified)
155	7E-11	*2.59*	NRC 1988 MPC
44	2E-11	*0.74*	NRC 1993 Class Y DAC for U-238
44	2E-11	*0.74*	DOE 1994 Class Y DAC for U-238

Daniel J. Strom, Pacific Northwest National Laboratory, 19 Oct. 2004 strom@pnl.gov

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K-1088

Subject Category: BIOLOGY

UNITED STATES ATOMIC ENERGY COMMISSION

AIR-BORNE CONTAMINATION RESULTING FROM TRANSFERABLE CONTAMINATION ON SURFACES

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November 24, 1953

K-25 Plant
Carbide and Carbon Chemicals Company
Oak Ridge, Tennessee

Technical Information Service, Oak Ridge, Tennessee

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AIR-BORNE CONTAMINATION RESULTING FROM TRANSFERABLE CONTAMINATION ON SURFACES

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Supervised by: H. F. Henry

Safety and Protection Division
W. L. Richardson, Superintendent

A B S T R A C T

A comparison of air-borne activity with transferable surface activity in two contaminated plant locations during normal operation indicates that the ratio of air activity to surface activity is in the range of about 0.25 to 1.9 (dis./min./m.^{3} air)/(dis./min./cm.^{2} surface). This latter figure is considered to be the maximum value of this ratio which might exist for long continued operations at K-25. However, a test designed to indicate the maximum activity which might result from plant operations included the combined action of air circulating fans and equipment vibrations and gave a corresponding ratio of about 20 (dis./min./m^3 air)/(dis./min./cm.^{2} surface) for short periods.

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CARBIDE AND CARBON CHEMICALS COMPANY
A DIVISION OF UNION CARBIDE AND CARBON CORPORATION
K-25 Plant
Oak Ridge, Tennessee

AIR-BORNE CONTAMINATION RESULTING FROM TRANSFERABLE CONTAMINATION ON SURFACES

Introduction

Since the inhalation of uranium probably presents a much greater hazard than does any of the other types of uranium exposure, it is felt that the principal hazard due to transferable uranium contamination over wide areas is that resulting from the possibility that it may become air-borne and thus be inhaled. In order to estimate the relationship between transferable surface contamination and the degree of air-borne activity which can be produced by air currents blowing over these surfaces, some tests were performed in the highly contaminated, abandoned K-1405 Engineering Development Building. In addition, the relationship between air-borne activity and transferable surface activity as experienced during normal operations was determined from survey results obtained in this building and in the K-1131 Feed Manufacture Building where contamination is comparable.

Summary

When the air circulating fans in the K-1405 Building were placed in operation as normally used, the average ratio between air-borne contamination and transferable surface activity was found to be 13 (dis./min./m.^{3})/(dis./min./cm.^{2}); with minor vibrations added to the action of the fans to simulate equipment vibrations, the average ratio increased to approximately 20 (dis./min./m.^{3})/(dis./min./cm.^{2}). With continuing operation of the fans, however, the air-borne activity was found to decrease, presumably as a result of the settling out in areas of small air disturbance, of material which was originally in regions where air currents would cause it to become air-borne.

The ratios of air-borne to transferable surface contamination indicated by these tests are approximately 50 to 75 times the corresponding ratio of 0.25 (dis./min./m.^{3})/(dis./min./cm.^{2}) which has been experienced during normal operations within the building. They may also be compared with the average ratio of 0.64 (dis./min./m.^{3})/(dis./min./cm.^{2}) as shown by long-term samples taken during normal operations over an extended period of time at 2 fixed locations in the K-1131 Feed Manufacture Building, and with the ratio of 1.9 (dis./min./m.^{3})/(dis./min./cm.^{2}) as shown by short-term samples taken uniformly throughout this building.

Other than the long-term sampling in K-1131 and K-1405, the tests were not extensive and were not extended over a period of time; thus, the results should not be considered as necessarily representing accurate quantitative estimates of the relation between air-borne activity and the extent of transferable surface contamination. Similarly, the ratios of air-borne to transferable surface activity found for the operating periods apply only to the conditions considered; however, in view of the rather extreme air disturbance and vibration conditions in the K-1131 Feed Manufacture Building, it is felt that the ratio of 1.9 (dis./min./cm.^{3})/(dis./min./cm.^{2}) shown by samples taken throughout this building, represents nearly the maximum which might result from transferable contamination. This is particularly true since at least some of the air-borne contamination occurring under operating conditions probably results from new releases of material rather than from transferable activity which becomes air-borne.

On the basis of this last ratio, the degree of transferable building-wide surface contamination which would correspond to the M.A.C. of 111 dis./min./m.^{3} for air-borne uranium is 58 dis./min./cm.^{2}; this is equivalent to 1200 counts/min./100 cm.^{2} as obtained by smear samples counted with a Samson alpha survey meter. On the basis of the extreme air contamination conditions produced by the fans and vibration during the tests, the transferable activity corresponding to the M.A.C. for air-borne material is 5.3 dis./min./cm.^{2}.

Description of Tests

Test 1

Before anything was disturbed, a series of air samples was taken at 4 locations in the laboratory and in the room below as shown in the attached sketch, the samplers being directly on the floor or work bench. For clarity, the figure shows a cutaway view of the laboratory. It should be noted, however, that the side of the room where the panel board is located is open except for the space occupied by the panel board itself.

A survey of the transferable activity of dust which had settled out on the surfaces of the laboratory was made by the normal method of rubbing a piece of paper over an area of 100 cm.^{2} and counting the activity picked up with a Samson alpha survey meter. Following the survey, two 16" heater fans and a 24" pedestal fan were turned to maximum velocity with all the building doors and windows closed. The positions of the fans are shown in the sketch. A few minutes after the fans were turned on, a second series of air samples was taken at the same 4 locations. After all of these samples had been obtained, another set of air samples was taken at the same locations with the fans in operation and with pipes and equipment being struck with a meter stick to simulate the effect of vibrations. A railroad locomotive passed the building during this test, adding slightly to the vibration.

The average transferable activity on beams, window sills, pipes, etc., was about 120 dis./min./cm.^{2}, UF_4 powder being visible on some of these surfaces; the average transferable activity for all surfaces in the laboratory was about 20 dis./min./cm.^{2}.* The results of the air samples are given in table 1 from which it may be seen that the average ratio of air-borne activity produced by the fans to transferable surface activity was 13 (dis./min./m.^{3})/(dis/min/cm.^{2}), and that the vibrations increased this by an additional factor of 1.6 to 21 (dis./min./m.^{3})/(dis./min./cm.^{2}). As will be noted in the table, the average air activity produced with both fans and vibrations was approximately 4 times the plant acceptable limit of 1 c/min./ft.^{3}.**

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* 400 c/min./100 cm.^{2} as obtained by smear samples counted with a Samson alpha survey meter (20% geometry).

** This value corresponds to 111 dis./min./m.^{3} or 5 μc/cm.^{3}, the plant acceptable limit for a 40-hour work week.

TABLE 1

AIR SAMPLE RESULTS

TEST 1

Position	Undisturbed		Ratio A/T*	Fans on		Ratio B/T*	Fans on and Vibrations		Ratio C/T*
	c/min./ft.^{3}	dis./min./m.^{3} A		c/min./ft.^{3}	dis./min./m.^{3} B		c/min./ft.^{3}	dis./min./m.^{3} C	
1	0.20	22	1.1	4.06	450	22.5	6.25	694	34.7
2	0.25	28	1.4	3.58	397	19.9	5.51	611	30.6
3	0.04	4.5	0.23	1.40	155	7.8	1.76	195	9.8
4	0.19	21	1.1	0.42	47	2.4	1.43	159	8.0
Avg.	0.17	19	1.0	2.36	262	13.1	3.70	415	20.8

* T = Transferable Activity = 20 dis./min./cm.^{2}.

Test 2

On a second test, the heater blowers had been in constant operation for a number of days and remained in operation throughout the test and the pedestal fan was moved. With the exception of this and the fact that samples were taken approximately 4 feet above the floor and were confined to the laboratory area, the procedure was essentially the same as outlined above. The arrangement of the samplers and the fan is shown in the figure and the results are tabulated in table 2.

TABLE 2

AIR SAMPLE RESULTS

TEST 2

Position	Undisturbed		Ratio A/T*	Fan on		Ratio B/T*	20 min. after Fan on		Ratio C/T*	Fan on and Vibration		Ratio D/T*
	c/min./ft.^{3}	dis./min./m.^{3} (A)		c/min./ft.^{3}	dis./min./m.^{3} (B)		c/min./ft.^{3}	dis./min./m.^{3} (C)		c/min./ft.^{3}	dis./min./m.^{3} (D)	
1	0.33	37	1.9	0.44	49	2.5	0.08	8.9	0.45	5.9	650	32.5
2	0.07	8	0.4	0.17	19	1.0	0.085	9.4	0.47	2.0	222	11.1
5	0.12	13	0.7	0.19	21	1.1	0.089	9.9	0.50	3.3	366	18.3
Avg.	0.17	19	1.0	0.27	30	1.5	0.085	9.4	0.47	3.7	413	20.7

* T = Transferable Contamination = 20 dis./min./cm.^{2}.

Transferable contamination in the affected area was approximately the same as that on the first test, the average being about 20 dis./min./cm.^{2}. Although the original air-borne activity and the average activity produced by vibrations were about the same as in the first test, the activity produced by air currents was much lower, this being attributed to the fact that the heater fans had been in constant operation for a long period of time. Such a decrease with continued air circulation might be anticipated since, presumably, the contaminating material would tend to be removed from regions of high air velocity and to settle in areas of small disturbances. However, if contamination were being continuously added to the surfaces or were being continuously disturbed, as might be the case in some operations, such a marked decrease might not occur.

As will be noted from the data of the above table, 2 sets of samples were taken after the pedestal fan was started and before vibration was added, the time between the beginning of the first and second sets being 20 minutes. As in Test 1, the fan caused an increase in activity; however, after it had been in operation for about 20 minutes, it was found that air contamination had decreased to about half that found on the samples taken before the fan was started, the original contamination being partly attributed to air disturbances produced by the samplers themselves. This decrease with continued fan operation was primarily attributed to the settling out of material in regions of low air disturbance as described above.

Air-borne and Transferable Surface Contamination During Normal Operations

The monthly averages for air-borne activity as indicated by continuous air sampling at a single fixed location in the K-1405 Engineering Development Building and at 2 locations in the K-1131 Feed Manufacture Building during 3-month periods of normal operation are compared in tables 3 and 4 with the average transferable contamination in those locations. The average ratio of air-borne to transferable surface contamination during the above period when K-1405 was in operation was 0.25 (dis./min./m.^{3})/(dis./min./cm.^{2}), whereas a recent corresponding value for the K-1131 Building is 0.64.

The above ratio value for K-1131 is of the same order of magnitude as the ratio of 1.9 (dis./min./m.^{3})/(dis./min./cm.^{2}) indicated for this building by short-term samples taken at points distributed uniformly throughout the building as compared with the surface activity; these results, which are shown in table 5, represent the averages of about 85 samples per month with the sampling periods varied from 5 minutes to 8 hours, and with some of the samples being taken in locations where respiratory protection is routinely worn. Because of the uniformity of distribution of the sample locations within the building, it is felt that these results represent the best available estimate of the over-all air-borne activity, and provide a more significant value for comparison with surface-contamination values, which also represent over-all building averages, than do the continuous samples taken at fixed locations.

The higher values for K-1131 as compared to K-1405 are probably due both to larger releases to the air and to more favorable conditions for the production of air-borne activity from loose contamination, there being considerably more equipment vibration in this location than was normally experienced in K-1405.

It should be noted that a large fraction of the air-borne activity detected during the operating periods could have been due to material released from various systems rather than to transferable activity which became air-borne. The average air-borne activities shown in this report are thus considered as upper limits to those which may have resulted from transferable contamination under the particular conditions considered.

TABLE 3

LONG-TERM AIR-SAMPLE RESULTS AND TRANSFERABLE SURFACE CONTAMINATION IN THE K-1405 ENGINEERING DEVELOPMENT BUILDING

Month	Average Air Activity		Average Transferable		Ratio A/T
	c/min./ft.^{3}	dis./min./m.^{3} (A)	c/min./100 cm.^{2}	dis./min./cm.^{2} (T)	
1	0.059	6.5	480	24	0.27
2	0.054	6.0	320	16	0.38
3	0.033	3.7	660	33	0.11
Avg.					0.25

TABLE 4

LONG-TERM AIR-SAMPLE RESULTS AND TRANSFERABLE SURFACE CONTAMINATION IN THE K-1131 FEED MANUFACTURE BUILDING

Month	Average Air Activity		Average Transferable Surface Activity		Ratio A/T
	c/min./ft.^{3}	dis./min./m.^{3} (A)	c/min./100 cm.^{2}	dis./min./cm.^{2} (T)	
1	0.21	23.3	1200	60	0.39
2	0.52	57.8	1000	50	0.87
3	0.33	36.6	1100	55	0.67
Avg.					0.64

TABLE 5

BUILDING-WIDE AIR CONTAMINATION AND TRANSFERABLE SURFACE CONTAMINATION IN THE K-1131 FEED MANUFACTURE BUILDING

Month	Average Air Activity		Transferable Surface Contamination		Ratio A/T
	c/min./ft.^{3}	dis./min./m.^{3} (A)	c/min./100 cm.^{2}	dis./min/cm.^{2} (T)	
1	2.1	236	2800	140	1.69
2	3.2	353	3100	155	2.28
3	3.1	345	3900	195	1.77
Avg.	2.8	311	3270	163	1.91

Conclusions

From these tests, it appears that temporary air-borne activity may be produced by air currents as a result of the presence of transferable contamination on large fractions of the surfaces in a location. However, the tests were only designed to indicate if the presence of transferable activity could result in a possible air-borne hazard as a result of certain plant operating conditions, and the data should not be considered as representing accurate quantitative estimates of the relation between such air-borne activity and the extent of transferable surface contamination.

Although the comparisons of air-borne and transferable surface contamination during operating periods apply only to the conditions considered, it is believed that the air-borne to surface activity ratio of 1.9 (dis./min./m.^{3})/(dis./min./cm.^{2}) indicated by the samples taken throughout the K-1131 Feed Manufacture Building represents nearly the maximum which might result from transferable contamination in the K-25 Plant, since wind and vibration are considerably more pronounced in this building than in other plant locations and since some of the material probably came from releases occurring during sampling periods.

On the basis of this ratio, the degree of transferable building-wide surface contamination which would correspond to the M.A.C. of 111 dis./min./m.^{3} for air-borne uranium is 58 dis./min./cm.^{2}; this is equivalent to 1200 c/min./100 cm.^{2} as obtained by smear samples counted with a Samson alpha survey meter. On the basis of the extreme air contamination conditions produced by the fans and vibration during the short-term tests, the transferable activity corresponding to the M.A.C. for air-borne material is 5.3 dis./min./cm.^{2}.