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DETERMINATION OF POTENTIAL  
SOURCES OF AREA ATMOSPHERIC  
RADIO-ACTIVE CONTAMINATION

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Reactor Technology Division

DETERMINATION OF POTENTIAL SOURCES OF  
AREA ATMOSPHERIC RADIO-ACTIVE CONTAMINATION

C. P. Coughlen

DATE ISSUED:

JUN 8 1950

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This document contains restricted data as defined in the Atomic Energy Act of 1954.

## 1.0 INTRODUCTION

In May, 1948 it was learned that personnel at Hanford were somewhat concerned about airborne particles having high specific activities produced in the process of carrying out certain phases of their operations. In view of this it appeared desirable to study quite thoroughly the possibilities of hazards from such airborne activities at the Oak Ridge National Laboratory.

The results of such studies, revealing the presence within the plant area, of radioactive particles, seemed to emphasize the position that there might exist a hazardous condition.

Subsequent investigations by the Health Physics Division proved that radioactive particles, ranging in size from less than one micron to several hundred micron diameter, existed in an appreciable concentration and distribution throughout the plant area. In the absence of biological evidence that the indicated particle concentrations did not constitute a serious health hazard, it was concluded that the problem was sufficiently serious to warrant the expenditure of considerable effort in evaluating and reducing it.

This report is concerned with the results of the efforts expended by the Technical Division toward determining the activity output levels of various potential sources. Two sources proved to be major were evaluated after remedial measures were taken.

The results are reported as area contamination potentials since only the total quantity of active particulate material that issued from each location was determined. No estimate of the fraction of that material which settled within the boundaries of the area is attempted.

The reader is referred to the reports "ORNL-283 (Secret)" by J. S. Cheka and H. J. McAlduff, Jr., and "ORNL-267 (Secret)", Technical Division Quarterly for a more comprehensive survey of the discovery of the problem and the solutions effected.

## 2.0 TEST EQUIPMENT AND TEST PROCEDURES

Sampling equipment consisted simply of CWS filter papers mounted behind Aerotec cyclones, (optional), the sample stream flows being

## 2.0 TEST EQUIPMENT AND TEST PROCEDURES (CONT'D)

effected by Root Conners type blowers or by air jets. Sampling lines projected into the fume lines and were designed to provide fume line conditions of flow at the intake, to provide smooth-wall flow conditions and to give sampling line velocities equal to or slightly greater than the respective fume line velocities. Where possible, sample points were located to provide sufficient straight-line flow upstream to aid in the taking of a representative sample. Filtered sample streams were discharged either to the same fume lines (downstream), to adjacent lines, or to ducts properly equipped for safe discharge.

The equipment was designed to remove particulate matter only, it being considered that active gaseous matter represented no particular hazard for contamination.

Samples were drawn from the lines through the sampling equipment, suitable main line flow and sampling flow measurements being made. The resulting papers and cyclone jar contents were counted in total or in part in the ion chamber. All results were reported on the uniform basis of millicuries of gamma active material of one MEV per photon and one photon per disintegration.

Sampling as much as was possible, was done across each step of each operation to permit the determination of the major contributing operations.

Figure 1 is a schematic sketch of the equipment used.

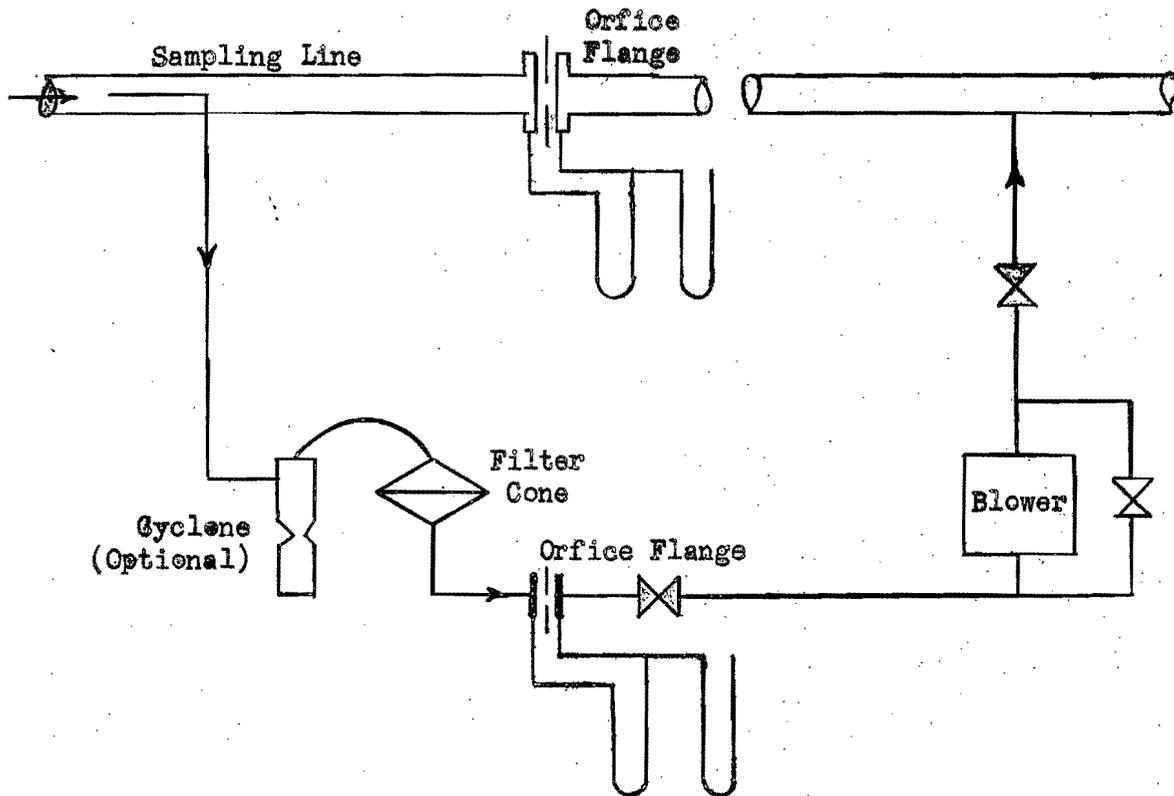
## 3.0 ACTIVE PARTICULATE DISCHARGE MEASUREMENTS

### 3.1 Particulate Discharges from RaLa Operation Fume Lines

Run #28 was sampled partially but will not be reported here. The detailed data resulting may be found in the report "Radiation Hazards Measurements for the Period November 26 to December 3", December 7, 1948 - ORNL Central Files No. 48-12-104. One item of pertinent information resulted. The Cell Ventilation line proved to be a major contributor.

Run #29 was sampled completely - and further, was sampled across each operation. Prior to sampling, a filter house (FG-50 backed by CWS paper) was installed in the Cell Ventilation line.

FIGURE I



SCHEMATIC LAYOUT - EQUIPMENT FOR SAMPLING  
ACTIVE PARTICULATES IN FUME LINES

3.1 Particulate Discharges from RaLa Operation Fume Lines (Cont'd)

Figures 2 to 5 show graphically the outputs of the Dissolver Off-Gas Line, the Vessel Off-Gas Line, the Cell Ventilation Line (before the filters), and the Cell Ventilation Line (after the filters). The curves in each figure represent the cumulative values, of all sampling periods, the decays of each specimen being considered. The bar graphs represent the individual contribution (at the time of removal of the sampling filters and cyclone jars) of each period.

Extensive work was invested in following the decays of each specimen, in the preparation of summary curves, and in the preparation of various comparisons. Little information of value, beyond that appearing on the charts, resulted.

3.2 Particulate Discharge from Iodine 135 Recovery Operations

Run #11, using X-10 slugs, was sampled completely. Figures 6 and 7 show graphically the outputs. The curves and graphs were developed similarly to those presented for RaLa operations.

Figure 8 shows the results obtained for the Cell Ventilation Line only during Run #12, a "double-header" in that two charges of slugs were used. The marked difference in activity output during the centrifuging operations (Run #11 vs. Run #12) may be explained by the inadvertent omission (due to an accident) of the washing of the cake by pipette decantation.

3.3 Particulate Discharge from Iodine 131 Recovery Operations

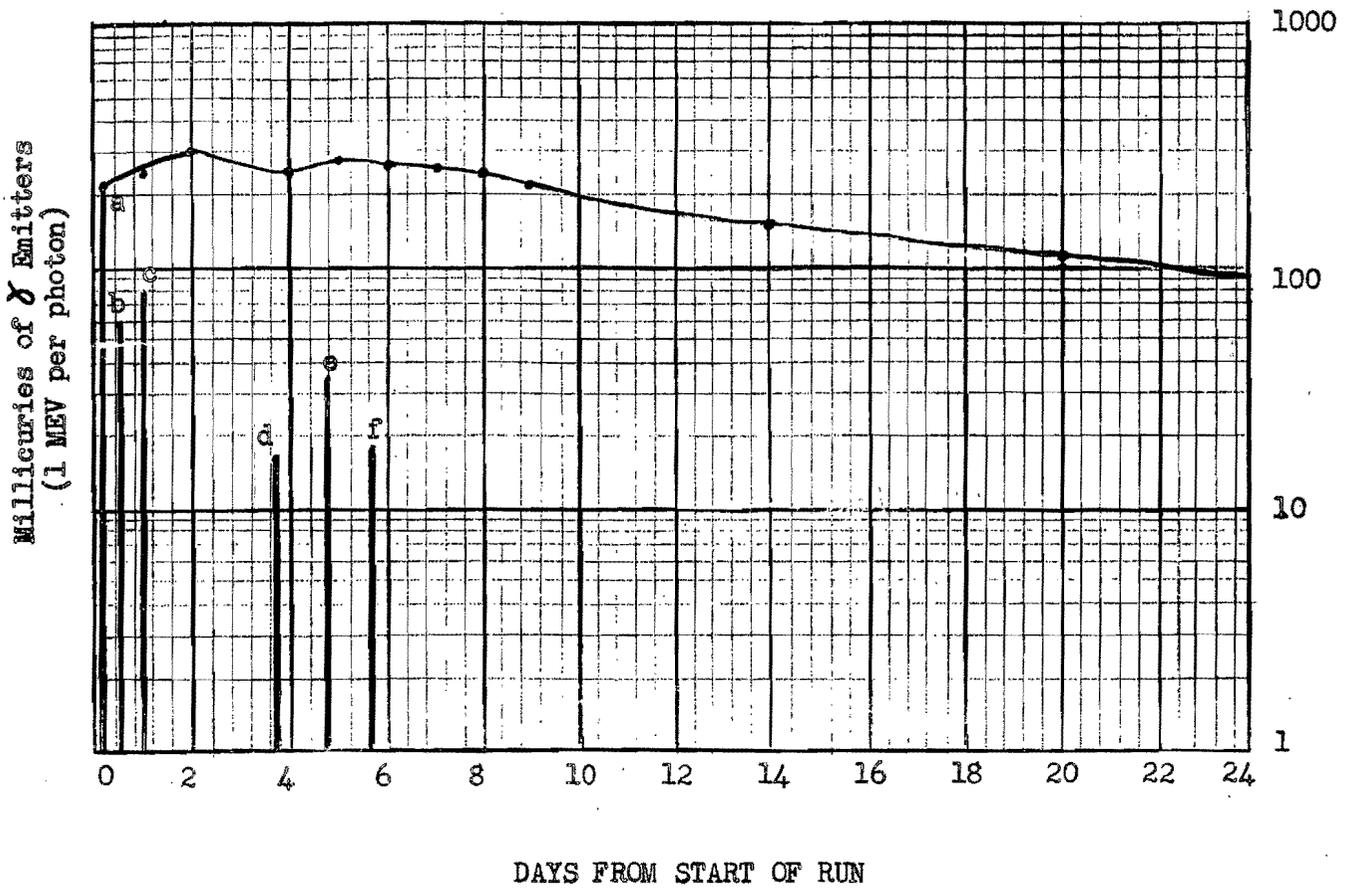
Runs #38 and 39, using X-10 slugs, were sampled completely. Figures 9 and 10 show graphically Run #38 data and Figures 11 and 12 are similar plots for Run #39 data. All values are quite low.

3.4 Particulate Discharge from Hot Pilot Plant Redox Operations

Two runs were sampled completely; one whose charge was made up of slugs 30% from Hanford (70% from ORNL) and another whose charge was 100% Hanford slugs. The dissolver off-gas, vessel off-gas and cell vent lines were sampled. Here the sampling was not coordinated with specific operations. Figures 13 to 15 show graphically the results on the 30% run while Figures 16 to 18 show the results obtained during the 100% Hanford run. (The 100% dissolver values were obtained by Bartholomew et al - M.I.T. Practice School).

FIGURE 2

Dwg.#8870



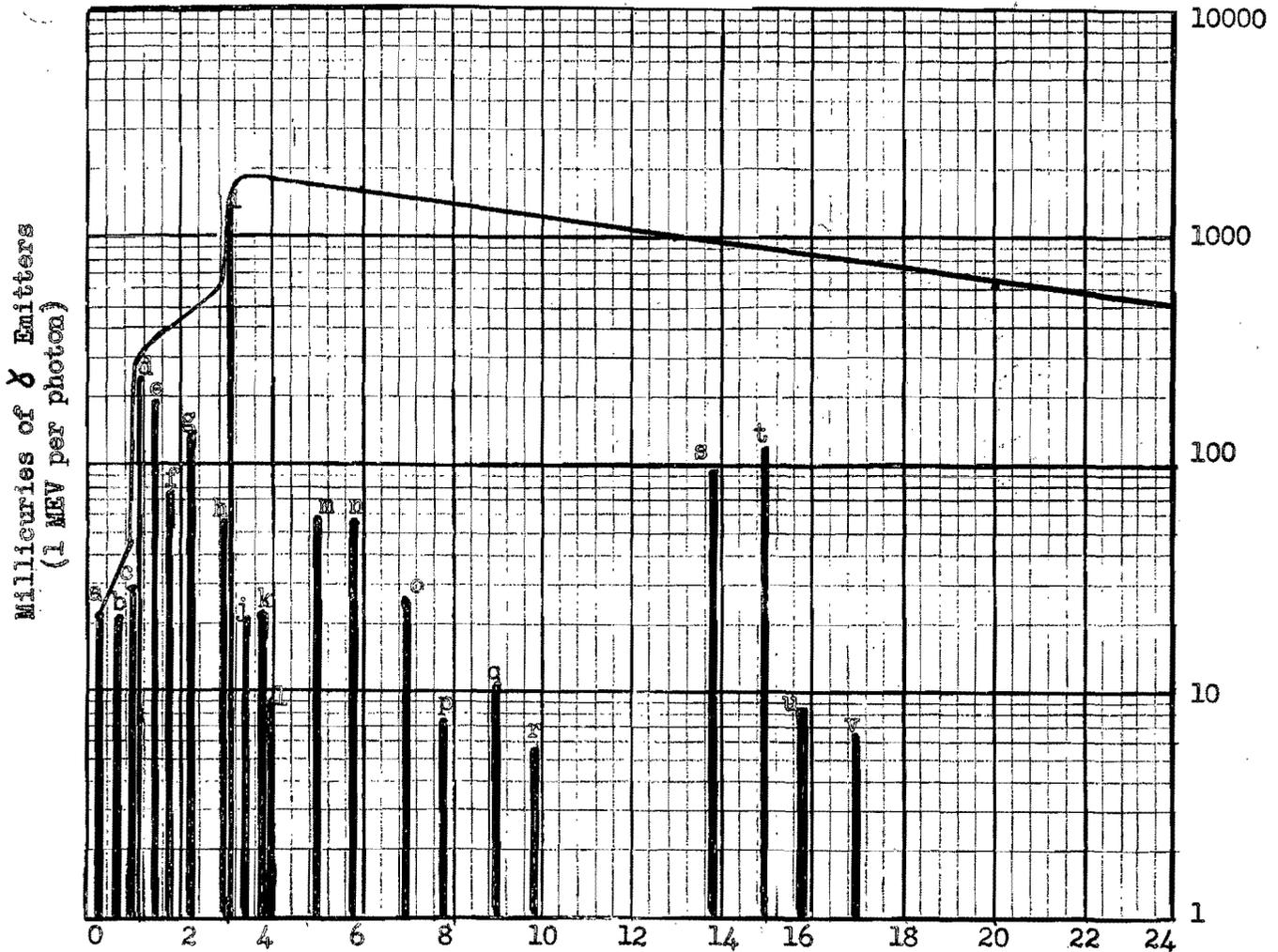
RALA #29 DISSOLVER OFF-GAS PARTICULATE OUTPUT

SAMPLING PERIOD LEGEND

- a - Jacket Removal and Dissolving
- b - Down Period
- c - Heel Dissolving - ( Line down for 63 hours after this period)
- d - Neutralization of 1/2 of Main Waste
- e - Neutralization of Recovery Waste
- f - Vessel Clean-out and Shutdown

FIGURE 3

Dwg. #8871

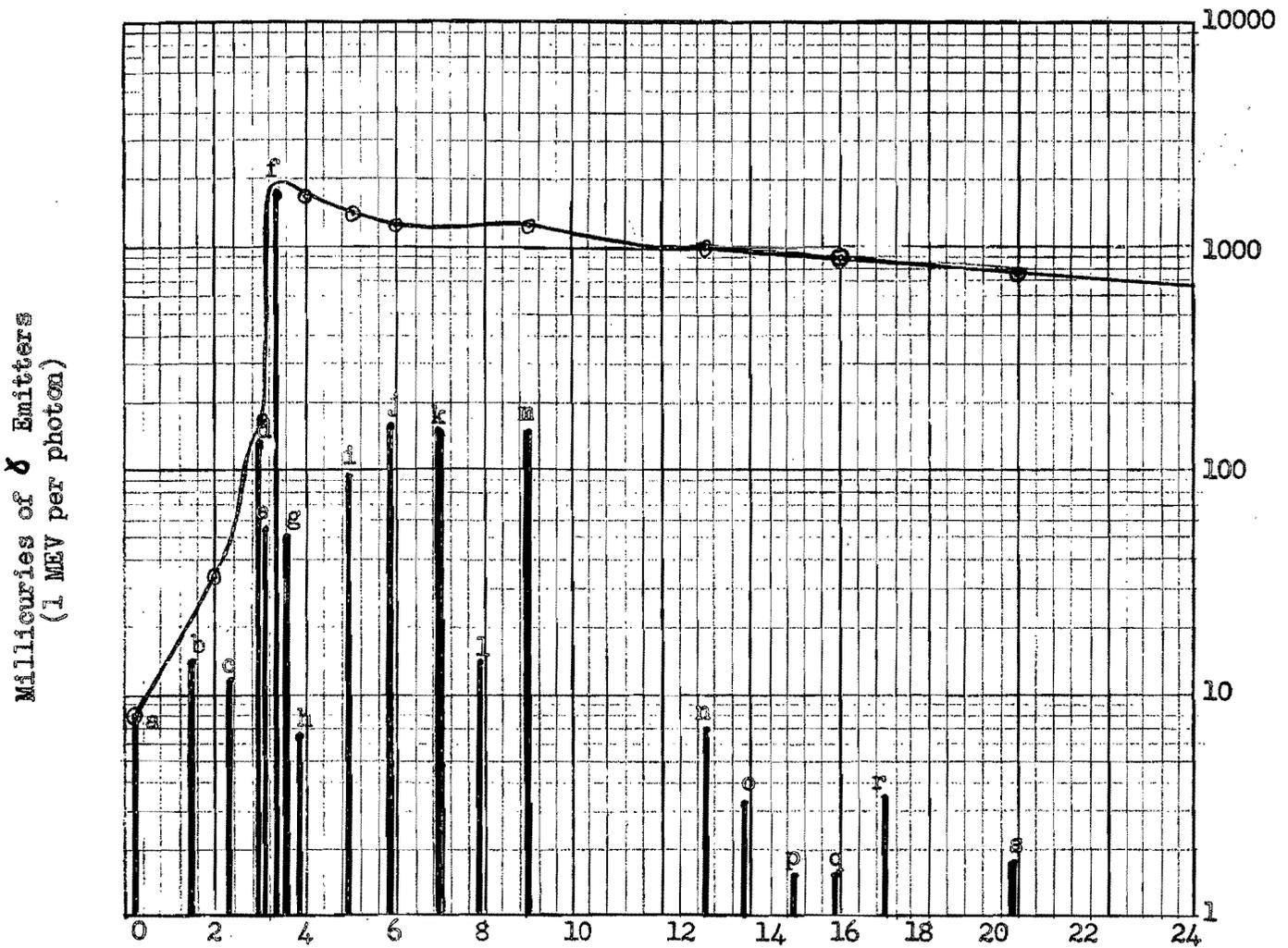


RALA #29 VESSEL OFF-GAS PARTICULATE OUT PUT

SAMPLING PERIOD LEGEND

- a - Digestion
- b - Hot Settling
- c - Cold Settling
- d - Miscellaneous Operations
- e - Heel Operations
- f - Extraction Washes
- g - Metathesis and Washes
- h - Transfer to Cell B and Electrolysis
- i - Transfer to B-6, Sampling and Volume Reduction
- j - Transfer to Glassware and Glassware Operations
- k - Product Evaporation
- l - Waste Neutralization (1/2 of Wastes)
- m - Recovery Cycle of Waste Settlings
- n - Vessel Cleanout and Shutdown
- o, p, q, r, s, t\*, u, v - Shutdown Periods

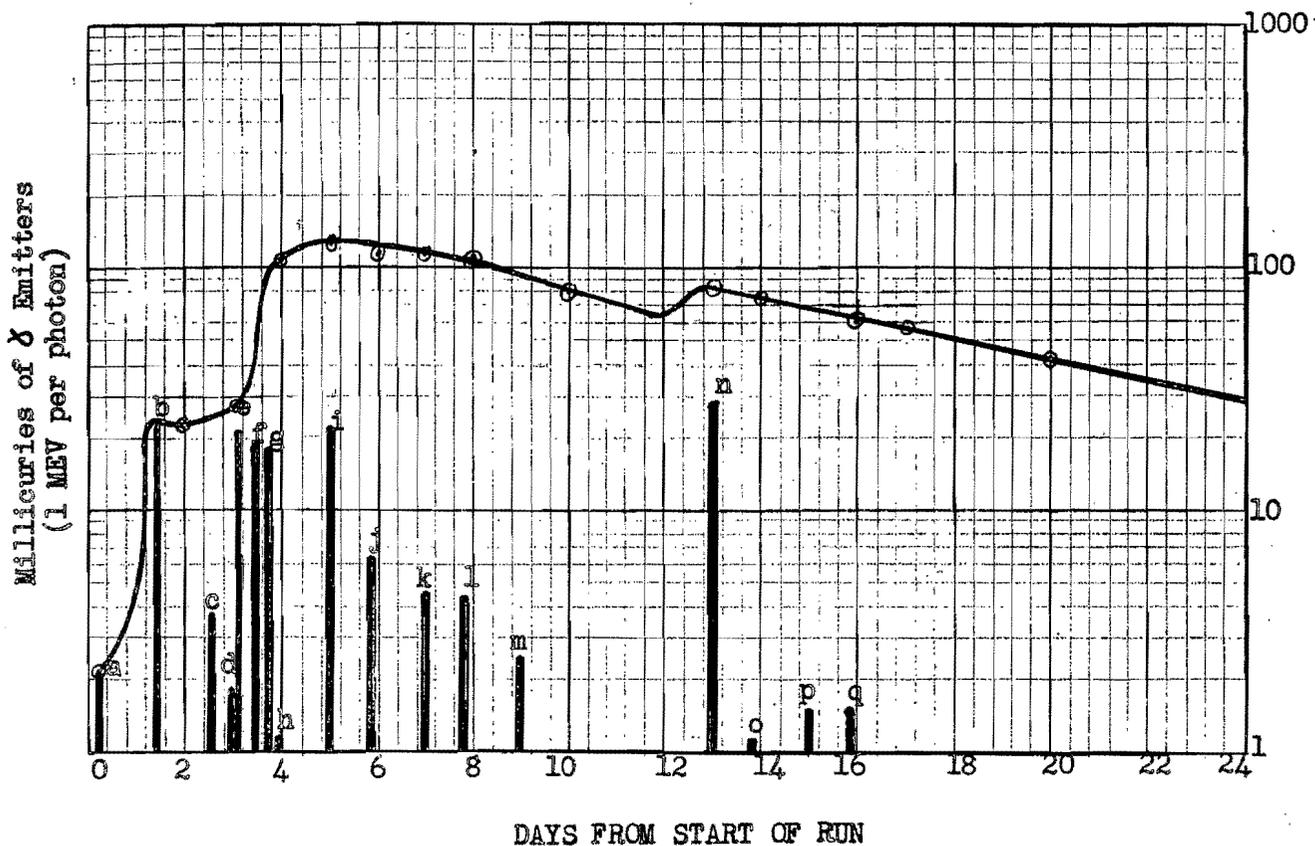
\*- Period "t" probably includes line contamination for other operations.



RAIA #29 CELL VENTILATION - BEFORE FILTERS

SAMPLING PERIOD LEGEND

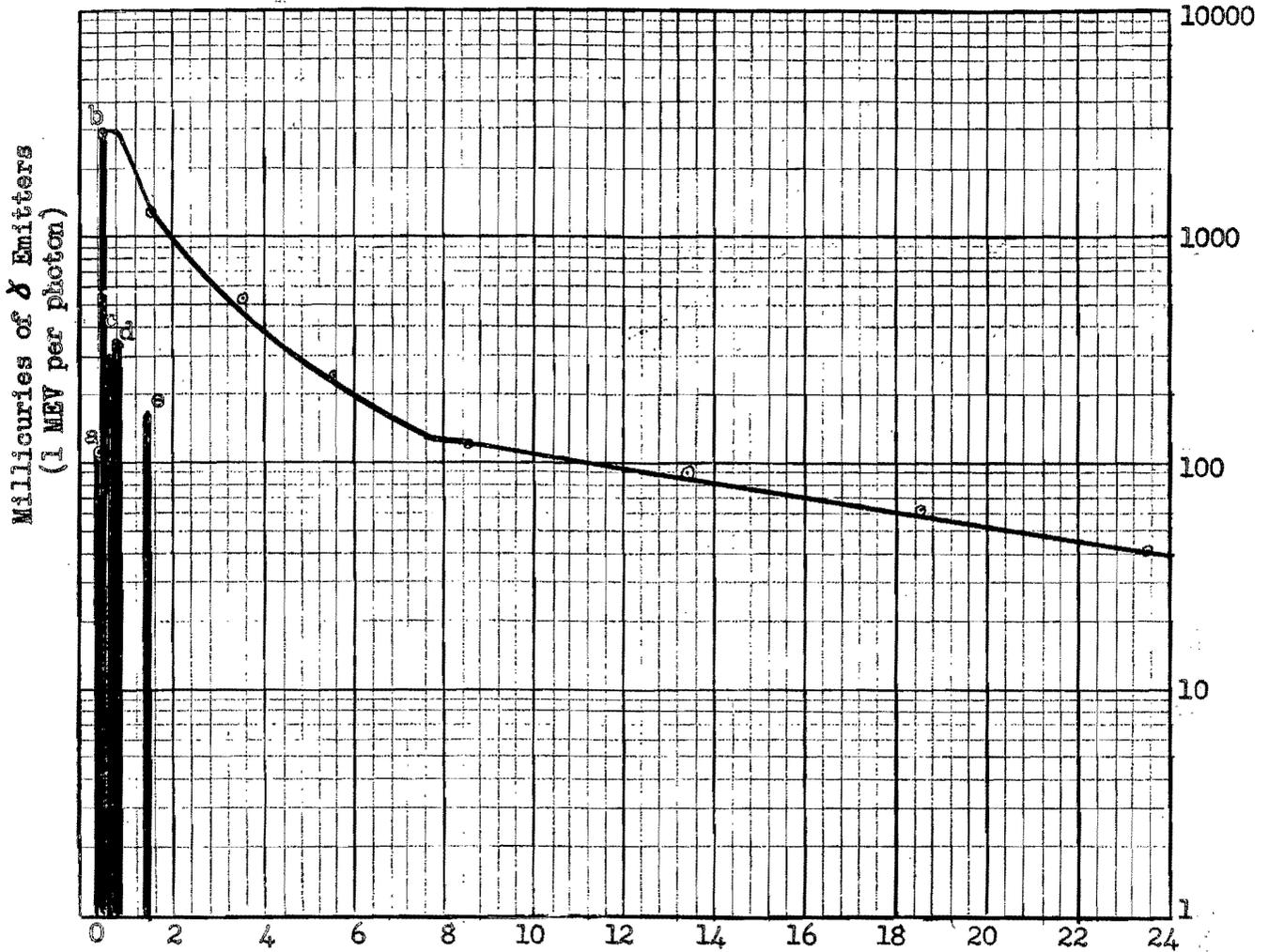
- a - Coating Removal and Slug Dissolving
- b - All other Cell-A Solution Operations
- c - Extraction Washes; Metathesis and washes
- d - Transfer to Cell B; Electrolysis
- e - Transfer to B-6; Volume Reduction
- f - Transfer to Glassware; Glassware Operations
- g - Product Evaporation
- h - Metathesis and Neutralization of Wastes
- i - Remainder of Waste Cycle
- j - Vessel Cleanout and Shutdown
- k, l, m, n, o, p, q, r, s - Shutdown Periods



RALA #29 CELL VENTILATION - AFTER FILTERS

SAMPLING PERIOD LEGEND

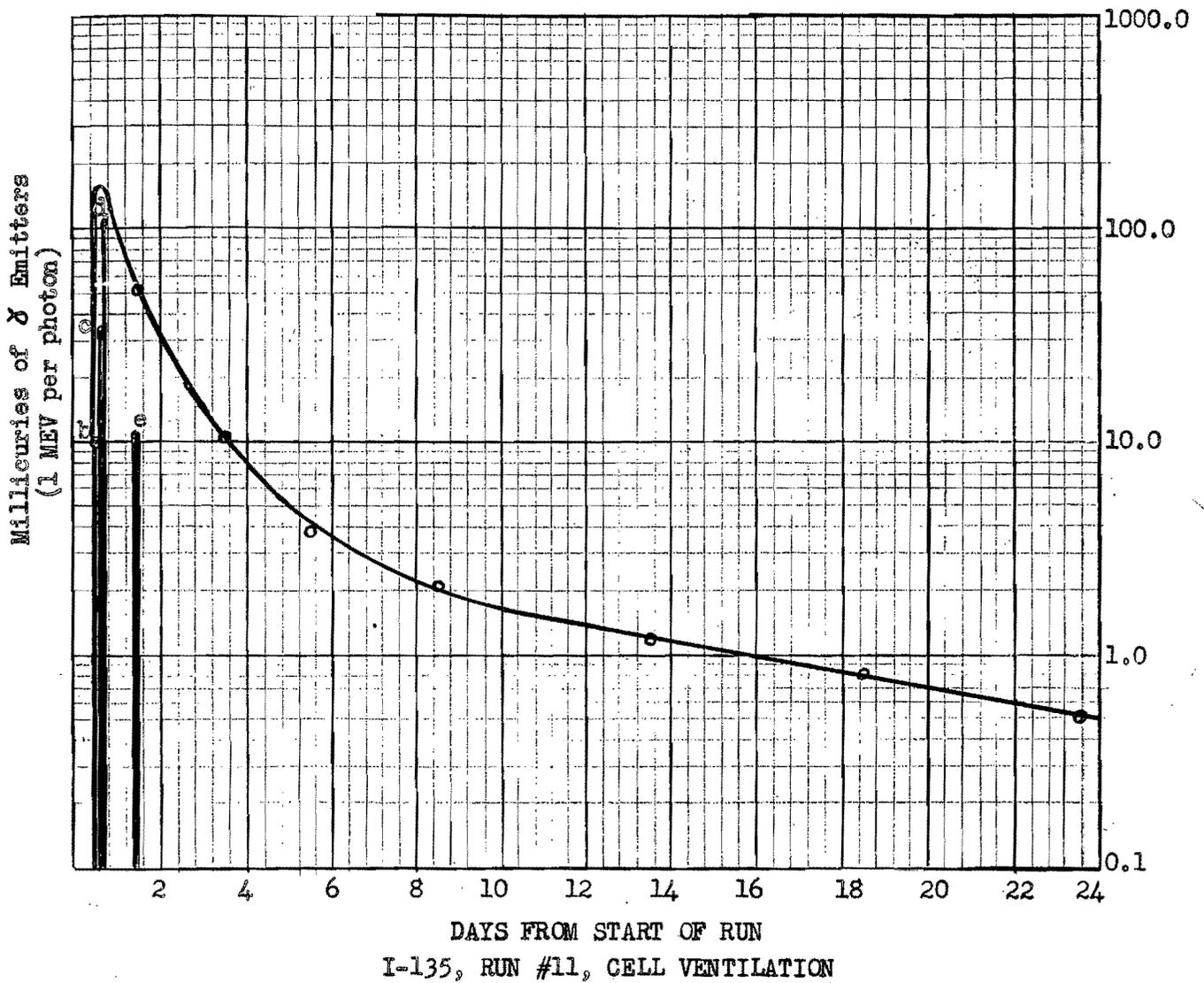
- a - Coating Removal and Slug Dissolving
- b - All other Cell - A: Solution Operations
- c - Extraction Washes; Metathesis and Washes
- d - Transfer to Cell-B; Electrolysis
- e - Transfer to B-6; Volume Reduction
- f - Transfer to Glassware; Glassware Operations
- g - Product Evaporation
- h - Metathesis and Neutralization of Wastes
- i - Remainder of Waste Cycle
- j - Vessel Cleanout and Shutdown
- k, l, m, n, o, p, q - Shutdown Periods



I-135 RUN #11, VESSEL OFF-GAS LINE

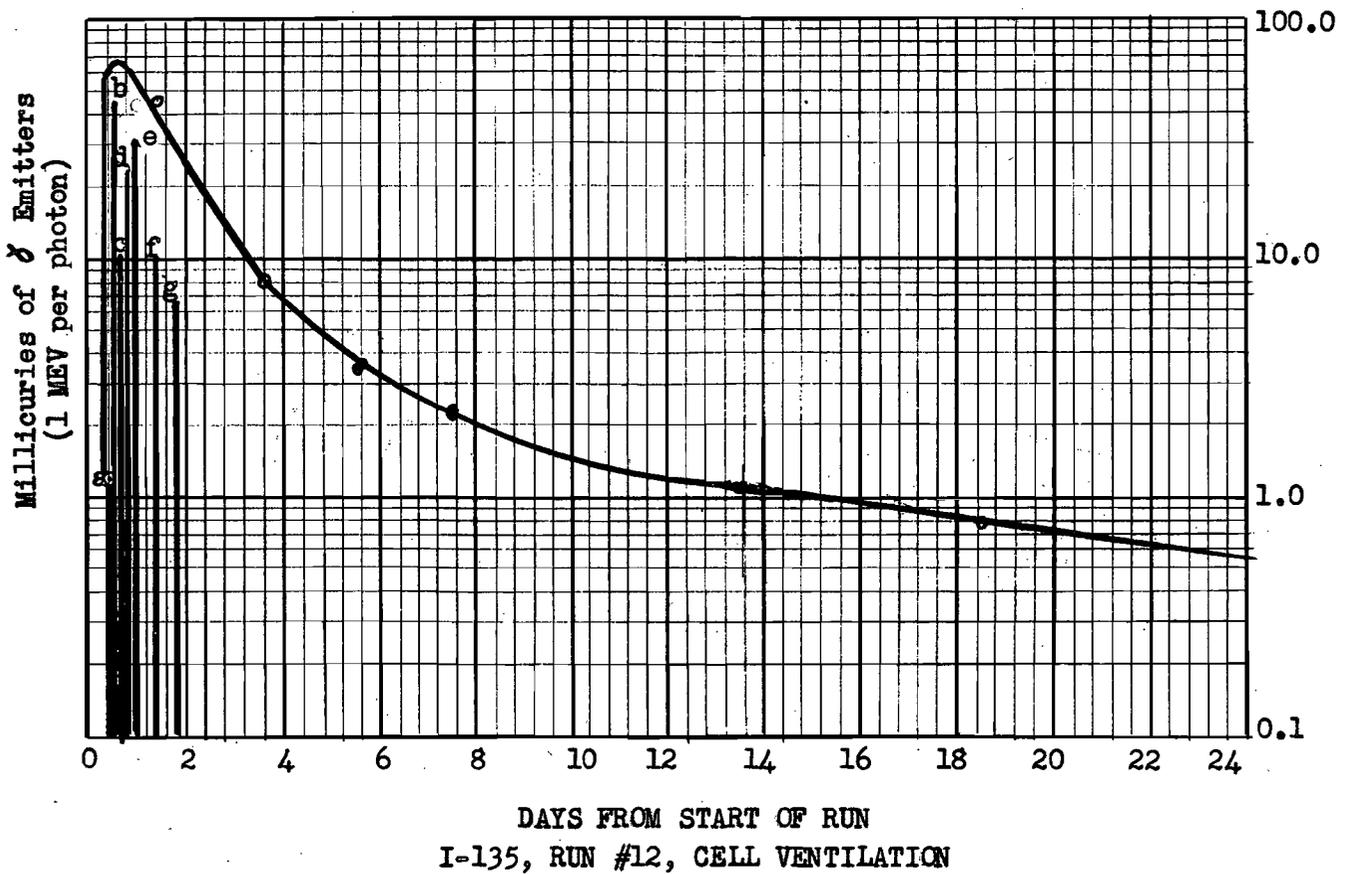
SAMPLING PERIOD LEGEND

- a - Slug Dissolving
- b - Transfer, Oxidation and Distillation
- c - Precipitation
- d - Centrifuging
- e - Waste Dumping, Dismantling and Clean-Up



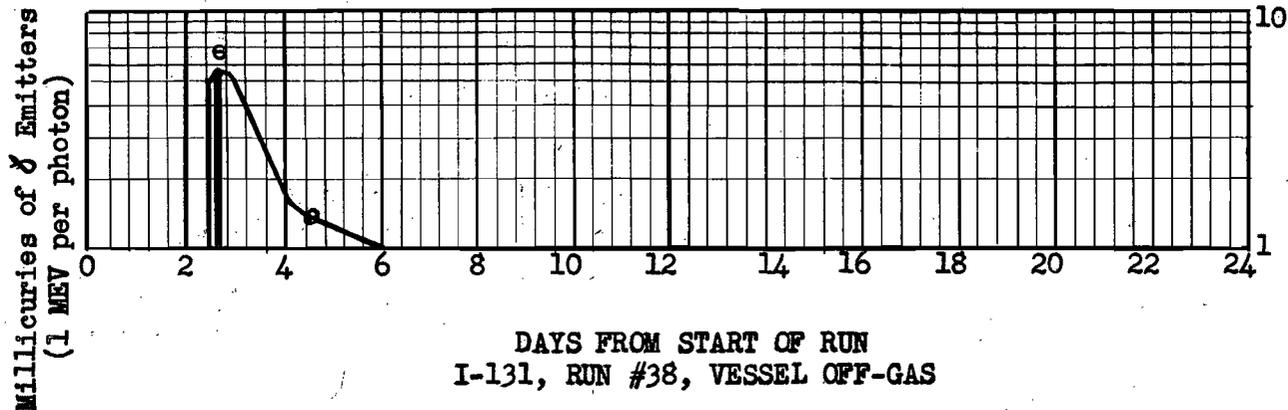
SAMPLING PERIOD LEGEND

- a - Slug Dissolving ( $< 0.1$ )
- b - Transfer, Oxidation and Distillation
- c - Precipitation
- d - Centrifuging
- e - Waste Dumping, Dismantling and Clean-Up



SAMPLING PERIOD LEGEND

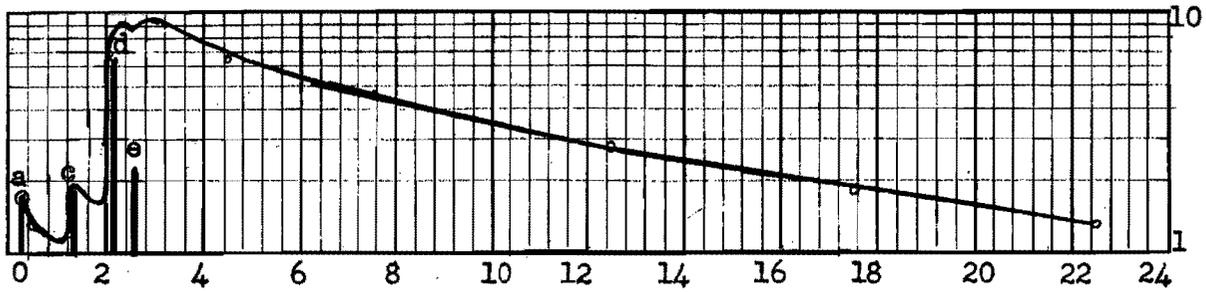
- a - Dissolvings; First Transfer and First Oxidation
- b - First Distillation; First metal Disposal
- c - Second Transfer and Oxidation; Second  $I_2$  Distillation
- d - Precipitation and Cooling
- e - Centrifuging
- f - Dismantling and Clean-Up
- g - Shut-Down



SAMPLING PERIOD LEGEND

- a - Slug Dissolving ( < 1.0)
- b - Steam Sparge ( < 1.0)
- c - Distillations; Initial Evaporation ( < 1.0)
- d - Glassware Operations ( < 1.0)
- e - Final Evaporation
- f - Clean-Up and Shut-Down ( < 1.0)

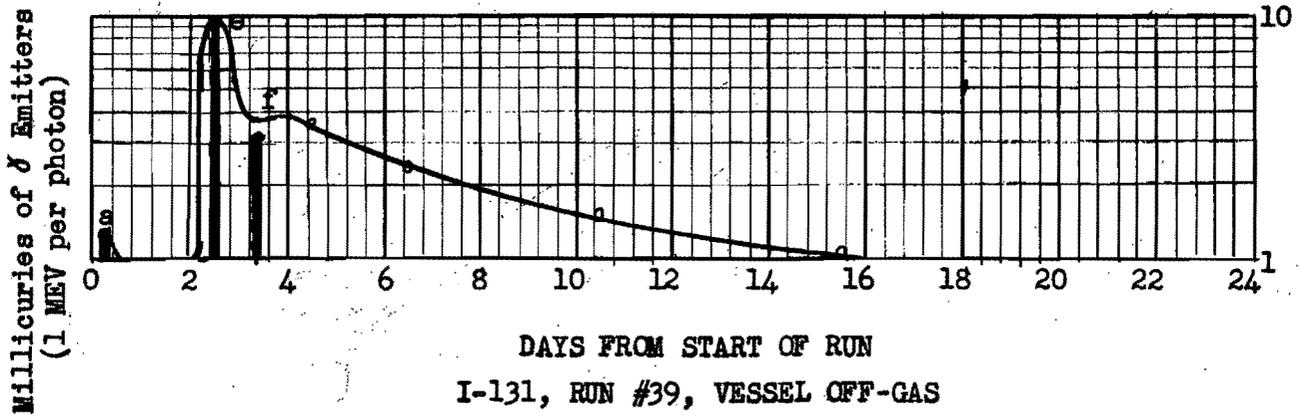
Millicuries of  $\gamma$  Emitters  
(1 MEV per photon)



DAYS FROM START OF RUN  
I-131, RUN #38, CELL VENTILATION

SAMPLING PERIOD LEGEND

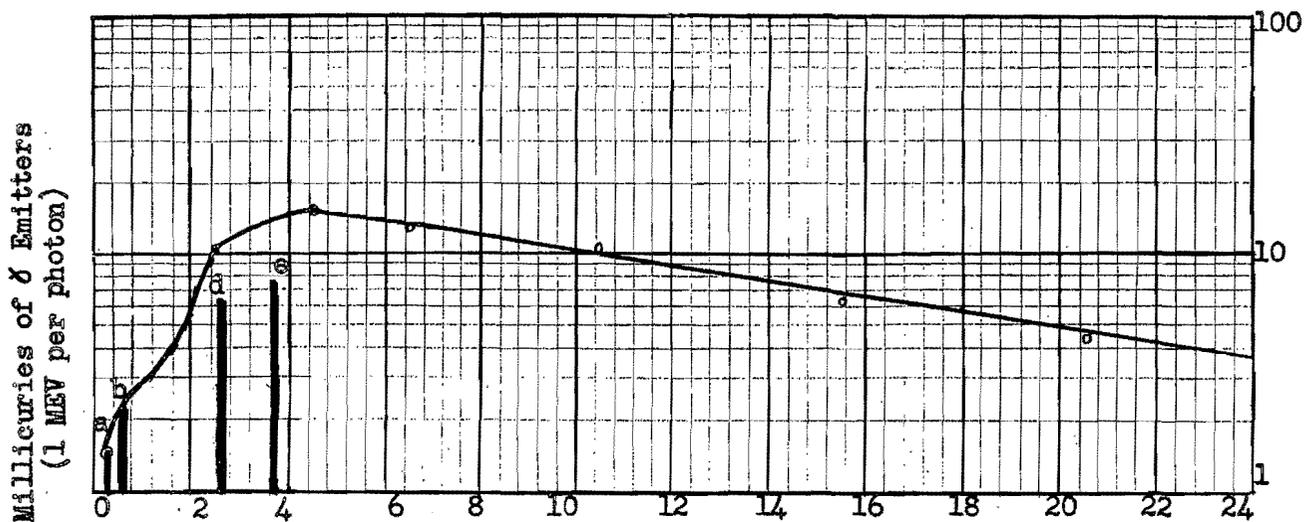
- a - Slug Dissolving
- b - Steam Sparge ( < 1.0)
- c - Distillations; Initial Evaporation
- d - Glassware Operations
- e - Final Evaporation
- f - Clean-Up and Shut-Down ( < 1.0)



SAMPLING PERIOD LEGEND

- a - Slug Dissolving
- b - Steam Sparge (< 1.0)
- c - Distillation; Initial Evaporation (< 1.0)
- d - Glassware Operations (< 1.0)
- e - Final Evaporation
- f - Clean-Up and Shut-Down

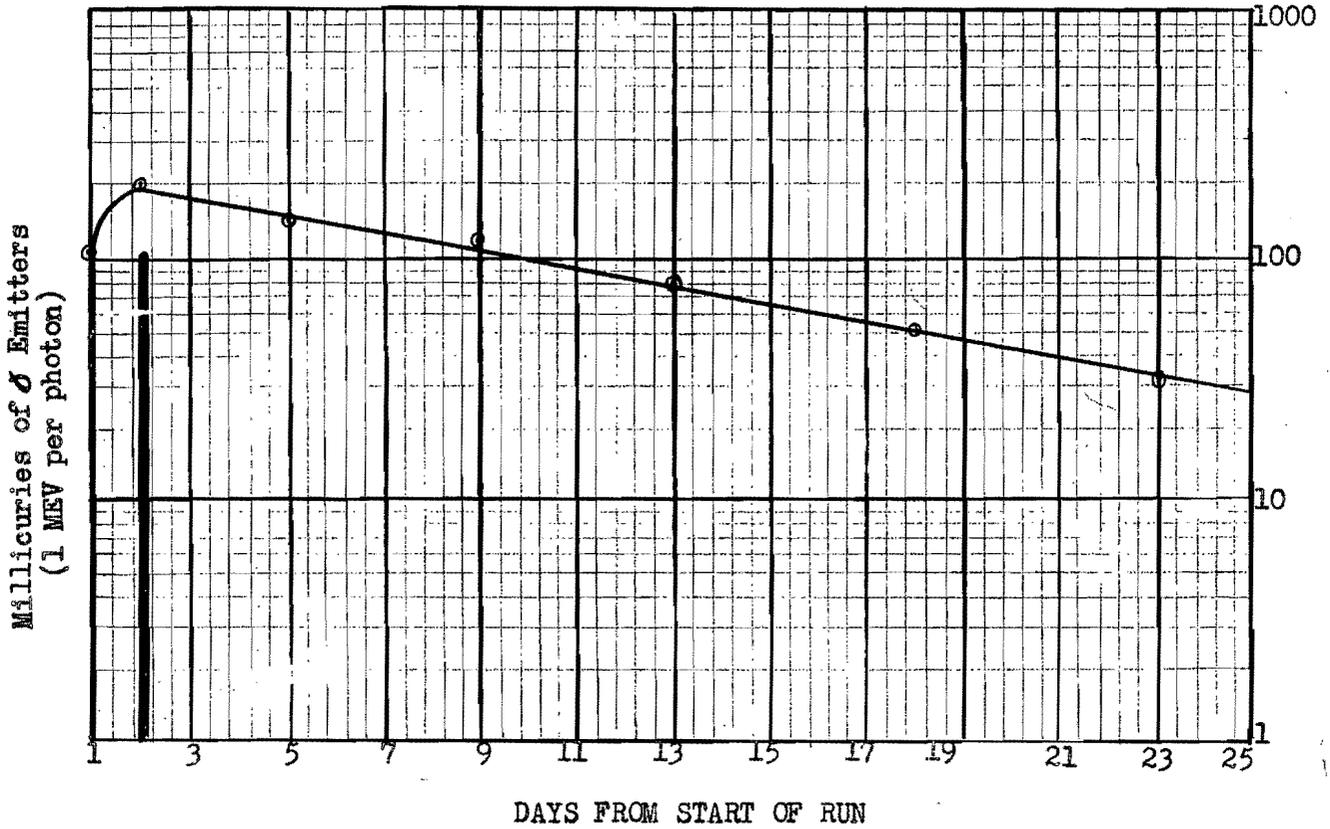
FIGURE 12



DAYS FROM START OF RUN  
I-131, RUN #39, CELL VENTILATION

SAMPLING PERIOD LEGEND

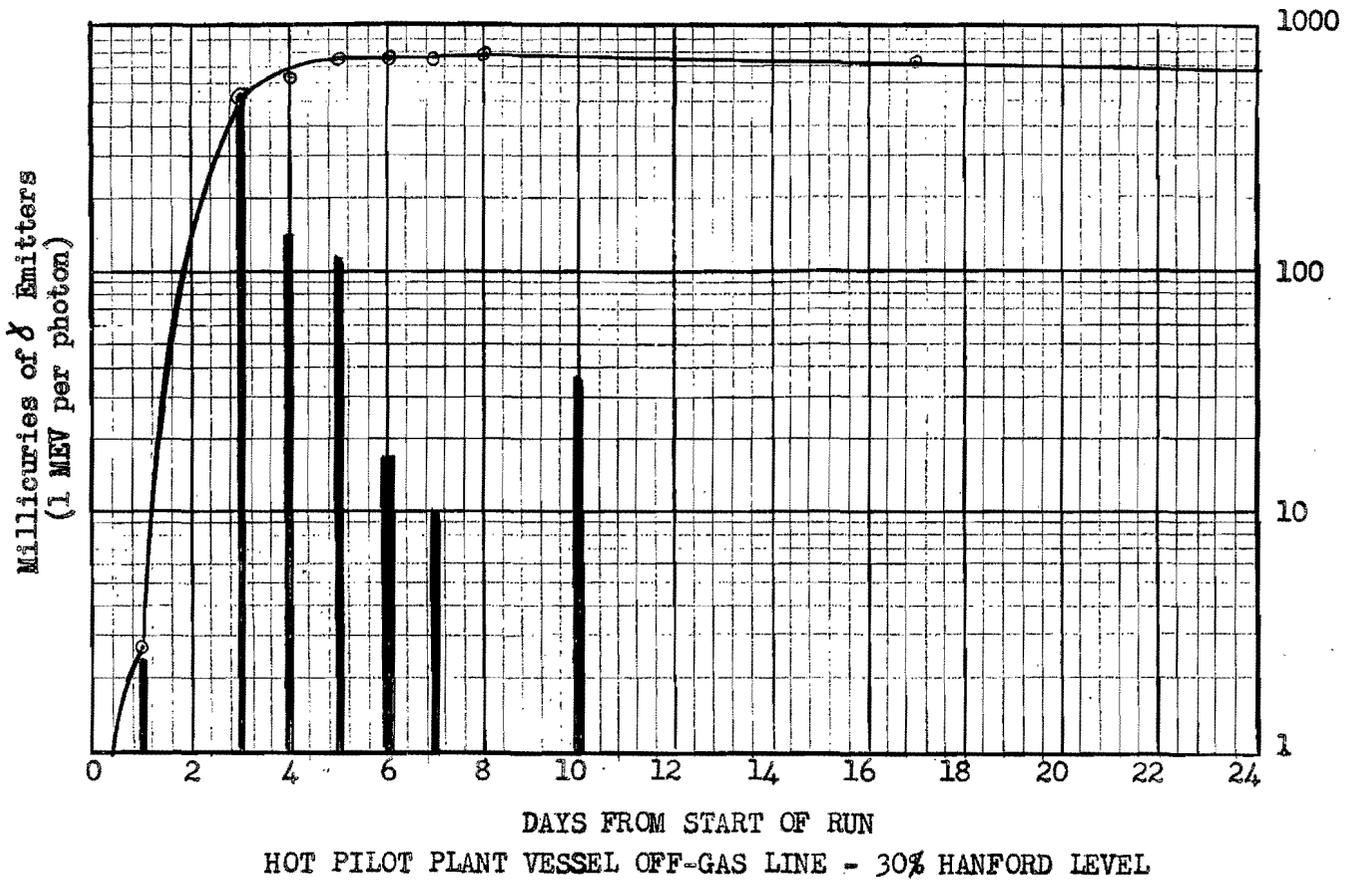
- a - Slug Dissolving
- b - Steam Sparge
- c - Distillations; Initial Evaporation (< 1.0)
- d - Glassware Operations
- e - Final Evaporation
- f - Clean-Up and Shut-Down (< 1.0)



DAYS FROM START OF RUN  
HOT PILOT PLANT DISSOLVER LINE - 30% HANFORD LEVEL

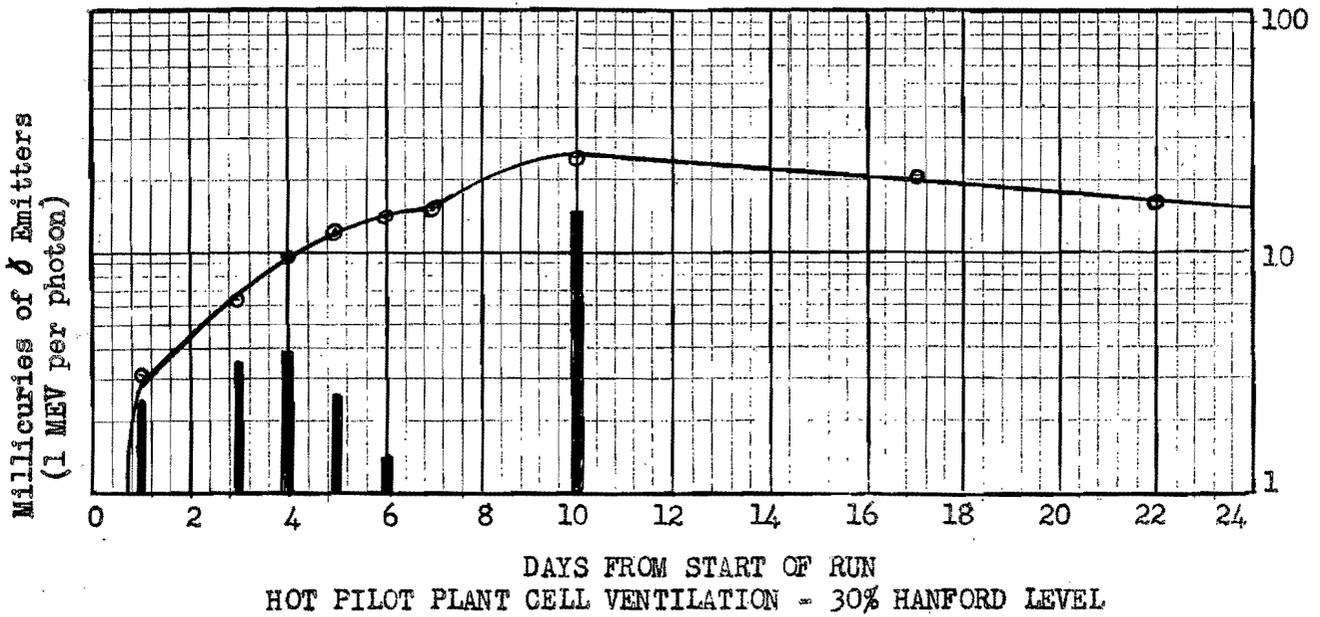
SAMPLING PERIOD LEGEND

Sampling papers were removed periodically during one dissolving cycle.



SAMPLING PERIOD LEGEND

Sampling papers were removed periodically until the completion of the cycle.

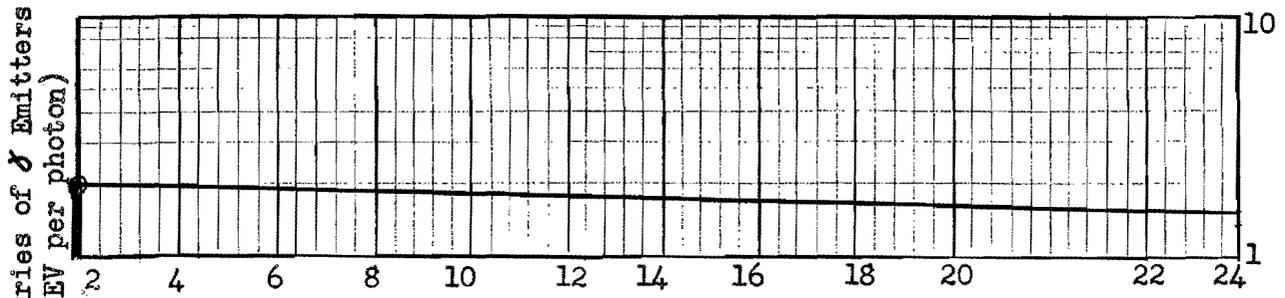


SAMPLING PERIOD LEGEND

Sampling papers were removed periodically until the completion of the cycle.

FIGURE 16

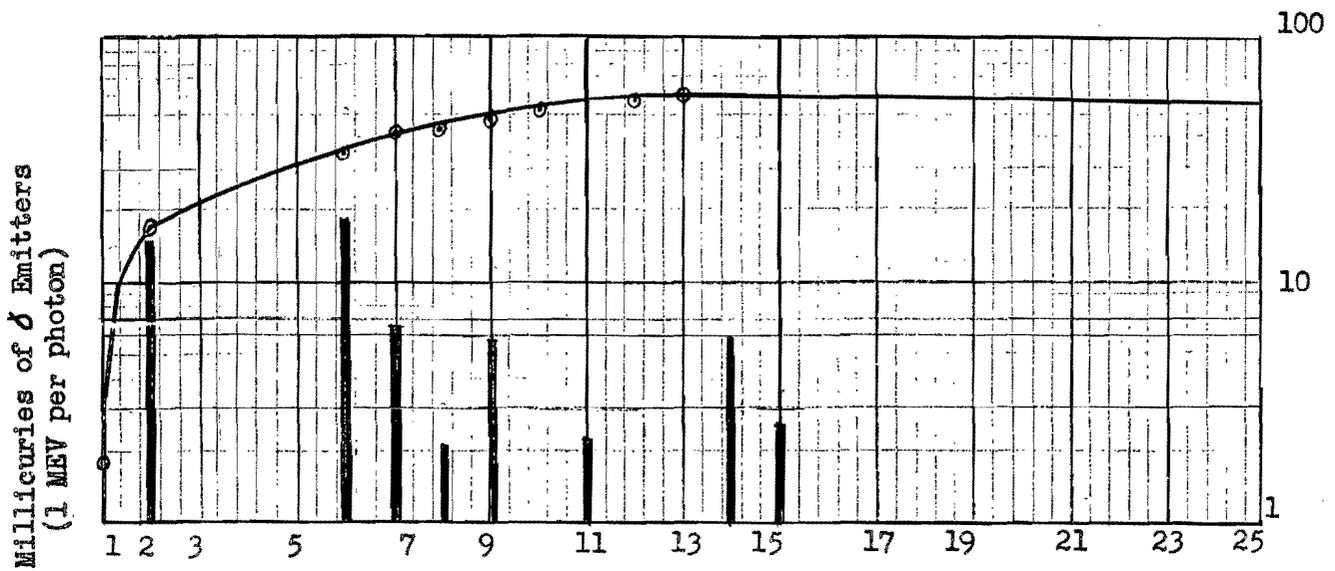
Dwg.#8884



DAYS FROM START OF RUN  
HOT PILOT PLANT DISSOLVER OFF-GAS LINE - 100% HANFORD LEVEL

SAMPLING PERIOD LEGEND

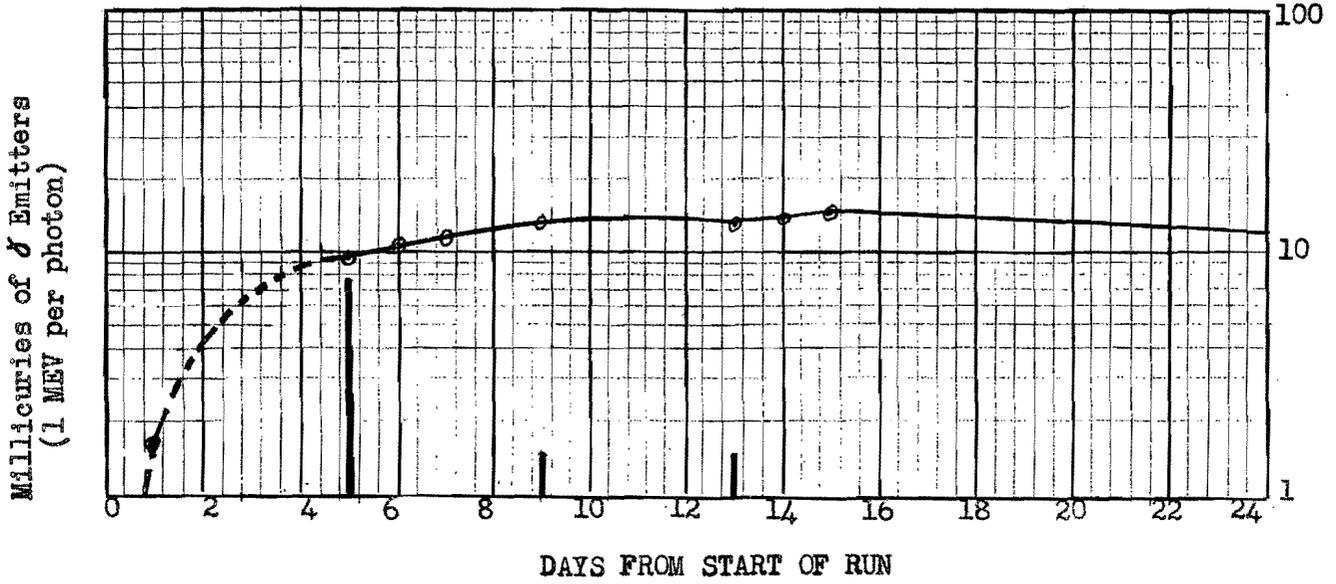
Sampling papers were removed periodically until the completion of the cycle.



DAYS FROM START OF RUN  
HOT PILOT PLANT VESSEL OFF-GAS LINE - 100% HANFORD LEVEL

SAMPLING PERIOD LEGEND

Sampling papers were removed periodically until the completion of the cycle.



HOT PILOT PLANT CELL VENTILATION- 100% HANFORD LEVEL

SAMPLING PERIOD LEGEND

Sampling papers were removed periodically until the completion of the cycle.

3.4 Particulate Discharge from Hot Pilot Plant Redox Operations (Cont'd)

The relatively low activity output at the 100% Hanford level is attributed to the 120 day aging the slugs received as compared to the 40 day aging the slugs received for the 30% run.

3.5 Particulate Discharge from Hot Hoods

Certain hoods were arbitrarily chosen for evaluation as being most likely to have particulates in their discharges. With hood sampling, a departure in technique is represented by the duration of sampling periods - from two to seven days. Also hoods were sampled two or three at a time since a single hood stack usually serves more than one hood. Sample pick-ups were made at the stack discharge points.

The following values are based on gamma-activity, assuming one MEV of gamma energy per disintegration.

TABLE I

Building 706-C

<u>Hood Stack</u>	<u>Maximum Activity Level</u> Mc/Hr.	<u>Average Activity Level</u> Mc/Hr.
Room I, Hoods 1, 2, and 3*	0.008	0.002
Rooms I and II, Hoods 4, 5	0.003(5)	0.001
Room V, Hood 8	0.0009	0.0003
Room IV, Hood 7	0.00009	0.00005
Room V, Hood 8 (Sampled Further)	0.0001	0.0006
	Micro-curies/ft. <sup>3</sup>	Micro-curies/ft. <sup>3</sup>
Air from Room I	0.00002	0.00001
Air from Hoods 1, 2, 3	0.00002	0.00001

---

\* The hood nomenclature is that of drawing Number TD-782.

3.5 Particulate Discharge from Hot Hoods (Cont'd)

TABLE II

Building 205

<u>Hood Stacks</u>	<u>Maximum Activity Level</u> Mc/Hr.	<u>Average Activity Level</u> Mc/Hr.
Room I	0.00002	0.00001
Room II*	0.00002	.00001
Room IV, Hood 3	0.00007(5)	.00006

Note that in the preceding table for Building 706-C the air from Room I shows an activity level very near to that of the air discharged by the stack for hoods 1, 2, and 3 in room I.

Regarding Building 205, a fact worthy of mention is that during the sampling periods the amount of hot material handled by the 205 laboratory was below normal.

All together, eight stacks were sampled, and assuming all these stacks discharged their average activity for one day, the  $\gamma$  activity discharged would be 0.091 millicuries per day.

3.6 Active Gas and Particulate Discharge from Pile and from Pile Filter House

Exact evaluation of the total activity discharge (particulate and decaying gases) from the pile and from the pile filter house is a difficult undertaking. Considerable effort has been expended along this line but the results are hardly conclusive. Various data indicate the particulate output through the filter house is essentially zero; thus a number defining the filter house efficiency possesses academic interest only.

The Health Physics Division has concluded in several reports that the installation of the pile filter house resulted in a material reduction in area contamination. The reader is referred to those reports for further information.

---

\* Hood and room numbers are shown on Drawing Number TD-781

3.6 Active Gas and Particulate Discharge from Pile and from Pile Filter House (Cont'd)

Some but not all of the efforts expended in the subject investigation will be here reported. It should be stressed that the unreported results in no way refute the conclusions about the filter house.

3.6.1 Pile Active Gas Output

The filter house inlet and exit air streams were sampled through a number of CWS #6 filter papers mounted as multi-ply layers in series. The papers were counted and analysed radiochemically by the Chemistry Division for some of the major rare gas fission product chains.

A diagram of the sampling units is shown in Figure 19. The sampling flow was 4.8 c.f.m. out of approximately 100,000 c.f.m. pile air. The first layers of the upstream and downstream units were located 4.8 sec. and 46.3 sec. respectively from the pile exit (the filter house CWS layer is 30 sec. from the pile exit). Flight time through the units (first multi-layer to second multi-layer) was 10.9 sec. The duration of each run was 3 days.

Table III is a summary of the activity observed on the papers two hours after removal from the apparatus. The papers are numbered from left to right as shown in Figure 19.

TABLE III

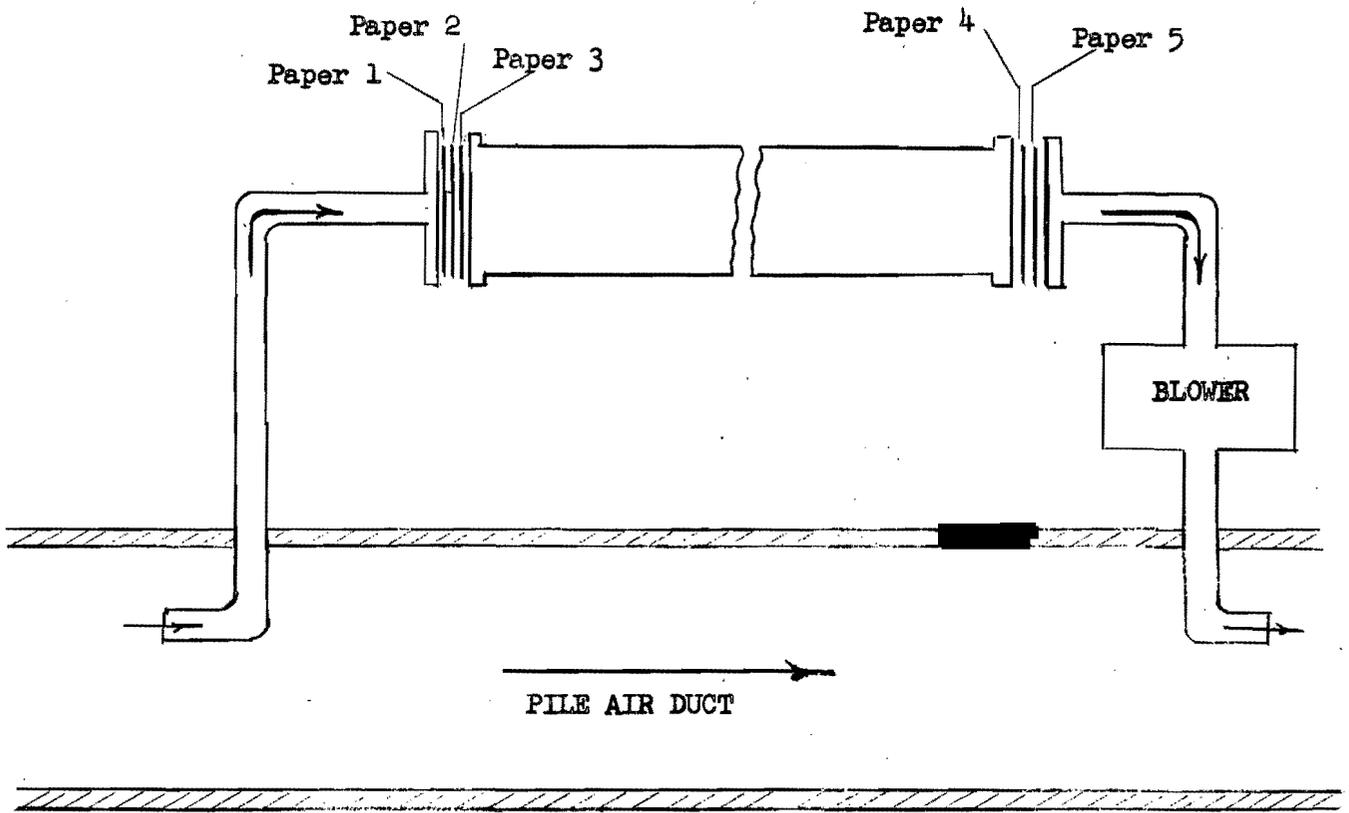
BETA ACTIVITY ON CWS PAPER\*

Second Shelf Counts Per Minute Per Sq. Inch.\*

<u>Paper</u>	<u>House Inlet</u>			<u>House Exit</u>		
	Run 1	Run 2	Run 3	Run 1	Run 2	Run 3
1	29748	134367	43404	5478	4514	4021
2	508	796	579	1086	632	373
3	261	418	423	636	315	---
4	9555	8006	13996	2852	1265	3288
5	----	78	959	----	153	134

\* Total area paper per filter 13.2 sq. inch.

FIGURE 19



FILTER HOUSE SAMPLING UNIT

3.6.1 Pile Active Gas Output (Cont'd)

No quantitative evaluation of the "particulate efficiency" of the filter house was obtained from these data. Using mainly the radiochemical analyses it was possible to calculate the mean pile discharges of Kr 89, Kr 91, Xe 140, and Xe 141. The results of these calculations are given in Table IV.

TABLE IV

	<u>Activity at Pile Exit</u> <u>Curies per day</u>	<u>Activity Test House</u> <u>CWS Layers</u> <u>Curies per day</u>
Kr 89	12.5	12
Kr 91	200	34
Xe 140	45	19.5
Xe 141	150	0.2

The gaseous mothers remaining after the filter house give rise to active particulates. These, however, present no area contamination worry, amounting to but 5 - 10 millicuries per day of short-lived beta emitters and but about one millicurie per day of long-lived beta emitters. Further, particle sizes of the freshly formed material are within the Brownian range and are widely dispersed after exit from the stack.

That the filter house is effectively removing particulates (other than daughters of active gases) is supported by the fact that dust collections ahead of the filter house have yielded detectable quantities of uranium while uranium has never been detected in specimens obtained downstream of the filter house.

Further, the filter papers first in line after the filter house exhibited nothing but normal quantities of decay products (gaseous mothers) on analysis. Also the decay curves of downstream papers agree rather well with the theoretical decays of the daughters (gaseous mothers) present at that point. The upstream papers show a decay much flatter than the theoretical daughter decay.

3.6.2 Radio-Autographs

The best evidence that the filter house is effectively removing gross particles is contained in the radio autographs,

3.6.2 Radio-Autographs (Cont'd)

made by Mr. J. W. Gost, of filter specimens obtained during the work described in the preceding paragraph.

Figure 20 shows the radio-autographs of random specimens from a complete set of papers (upstream and downstream) taken over the same period. Gross particles (defined as those particles other than daughter particles) are characterized by the white specks. The haze effects are attributed to the decay-in-flight daughters of the active gaseous mothers.

3.7 Comparison of Active Particulate Sources

Table V is a convenient listing of the pertinent information for each potential source examined. Some data are included not reported previously.

4.0 ACKNOWLEDGEMENTS

Technical Division personnel participating directly in the development or interpretation of the data reported herein were H. C. Savage, R. H. Wilson, J. W. Hill, A. S. Kitzes, R. B. Callaher, J. D. Flynn, I. Spiewak, R. Smith, A. L. Davis, W. K. Kirkland, J. J. Hairston, G. H. Johnstone, and C. P. Coughlen.

Particular mention is made of G. W. Leddicott of the Chemistry Division, who gave unsparingly of his own time, and of J. W. Gost, Technical Division.

Appreciation is here expressed to O. Sisman and W. G. Stockdale, Technical Division, whose advice proved helpful on a number of occasions.

*C. P. Coughlen*  
C. P. Coughlen

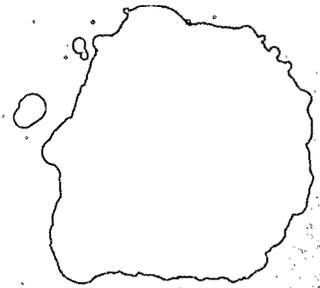
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BEFORE FILTER HOUSE  
SAMPLER →

← AFTER FILTER HOUSE  
SAMPLER



UPSTREAM SANDWICH  
FIRST PAPER

UPSTREAM SANDWICH  
FIRST PAPER

FIGURE  
20

UPSTREAM SANDWICH  
SECOND PAPER

UPSTREAM SANDWICH  
SECOND PAPER

UPSTREAM SANDWICH  
THIRD PAPER

UPSTREAM SANDWICH  
THIRD PAPER

DOWNSTREAM SANDWICH  
FIRST PAPER

DOWNSTREAM SANDWICH  
FIRST PAPER

TABLE V

COMPARISON OF ACTIVE PARTICULATE SOURCES

<u>Source</u>	<u>Air Flow CFM</u>	<u>Activity Concentration mc/ft<sup>3</sup> 1 MEV/photon</u>	<u>Maximum Hourly Output mc 1 MEV/photon</u>	<u>Total Output mc/month 1 MEV/photon</u>	<u>Comments</u>	
<b>Iodine-135 Operations</b>						
Vessel Off-Gas	160	$5.0 \times 10^{-2}$	1200	7600	Research operation now discontinued. Two runs per month. Mostly short-lived activity. One-day old slugs. Vessel line vented through 205 stack.	
Cell Vent	3780	$9.4 \times 10^{-5}$	118	340		
Total				7940		
<b>RaLa Operations</b>						
Cell Vent Before Filter (2440)		$(3.7 \times 10^{-5})$	(247)	(2710)	One run per month. Higher proportion of long-lived activity. Five-day old slugs. A-16 and A-4 lines are vented through 205 stack.	
Cell Vent After Filter 2440		$2.3 \times 10^{-6}$	4.2	165		
A-16 Line 80		$1.1 \times 10^{-3}$	293	2700		
A-4 Line 30		$2.4 \times 10^{-3}$	13.1	422		
Total After Filter				3300		
<b>Redox Operations-Hot Pilot Plant</b>						
<u>30% Hanford Level</u>						
Vessel Off-Gas	130	$4.1 \times 10^{-4}$	7.0	1682	Operations now discontinued. Two runs per month. Long-lived activity only at 100% level. Discrepancy between 30% and 100% Hanford level is caused by 120-day aging at 100% level, and 40-day aging at 30% level. All Hot Pilot Plant lines are vented through 205 stack.	
Dissolver Off-Gas	10	$8.8 \times 10^{-3}$	8.0	424		
Cell Vent 20,000		$8.5 \times 10^{-8}$	0.16	54		
			Total	2160		
<u>100% Hanford Level</u>						
Vessel Off-Gas	110	$2.4 \times 10^{-5}$	0.483	120		
Dissolver Off-Gas	10	$1.1 \times 10^{-4}$	0.067	4		
Cell Vent 20,000		$3.0 \times 10^{-8}$	0.0848	30		
			Total	154		

TABLE V (CONT'D)

COMPARISON OF ACTIVE PARTICULATE SOURCES

<u>Source</u>	<u>Air Flow</u> <u>CFM</u>	<u>Activity</u> <u>Concentration</u> <u>mc/ft<sup>3</sup></u> <u>1 MEV/photon</u>	<u>Maximum</u> <u>Hourly Output</u> <u>mc</u> <u>1 MEV/photon</u>	<u>Total</u> <u>Output</u> <u>mc/month</u> <u>1 MEV/photon</u>	<u>Comments</u>
Pile Air-Before Filter (100,000) After Filters		(3.6 x 10 <sup>-8*</sup> )	(5.0 <sup>†</sup> )	(154*) 1	*Based on total filter house and activity after 156 days of operation. †Includes short-lived activity, but not active gases.
Iodine-131 Operations					
Cell Vent	4320	1.0 x 10 <sup>-6</sup>	0.54	75	Weekly runs. One day old slugs but interior scrubbers are quite effective. Vessel line vented through 205 stack.
Vessel Off-Gas	175	1.4 x 10 <sup>-5</sup>	0.49	42	
Total				117	
Hoods - 706-C	12,000	4.5 x 10 <sup>-9</sup>	0.01	2.3	Activity of room air close to hood stack gas activity.

NOTE: The total hood air discharge for ORNL has been estimated to be 215,000 cfm. If all the hoods were as hot as those in 706 C (doubtful), the total area contamination from this source would be 43 mc/month.