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OAK RIDGE NATIONAL LABORATORY
CENTRAL FILES NUMBER
49-1-48

B-137

Date December 31, 1948

Subject Transmittal of Summary Report on the Particle Problem

By C. N. Rucker

To E. P. Johnson

File Particle Problem

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C. N. Rucker

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December 31, 1948

Dr. Ralph P. Johnson
Division of Research
U. S. Atomic Energy Commission
1901 Constitution Avenue
Washington 25, D. C.

Through: Dr. A. H. Holland, Jr.
Office of Research and Medicine
Oak Ridge Operations

Subject: Transmittal of Summary Report on the Particle Problem

Dear Dr. Johnson:

Forwarded herewith are four copies of the Historical Summary Report on the Particle Problem at Oak Ridge National Laboratory.

The report contains a brief summary of the present status of the corrective measures undertaken in connection with the problem, together with a bibliography of the documents pertaining to this subject.

Very truly yours,

OAK RIDGE NATIONAL LABORATORY

Original Signed By
C. N. Rucker

C. N. Rucker
Executive Director

RJMurphy/[illegible]

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OAK RIDGE NATIONAL LABORATORY
CENTRAL FILES NUMBER
49-1-47

B-137

Date December 30, 1948

File

Subject The Particle Problem at ORNL An Historical Summary

Those Eligible To Read The Attached

By

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To

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THE PARTICLE PROBLEM AT OAK RIDGE NATIONAL LABORATORY

AN HISTORICAL SUMMARY

Introduction

Early in 1944 radiation measurements made in the X-10 Area in connection with routine surveys indicated a gradual build-up of general background activity in the downwind direction from the exhaust stack following slug ruptures in the reactor. It was also noted that this background contamination decreased with each subsequent rain. It was not suspected at that time that the origin of this radiation was associated with airborne particles. The failure to recognize the existence of radioactive particles was due, in part, to the fact that adequate instruments were not available. Furthermore, air samples taken in many areas by constant air monitors since the Laboratory began operations in 1943, have indicated no general or gross air contamination much above tolerance except for a few occasions when localized areas were contaminated with radioactive iodine, radioactive phosphorus, or general radioactive fumes.

In May 1948 it was learned that the people 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. With this in mind more emphasis was placed on general area surveys.

In the course of a routine survey on May 20, 1948, the presence of radiation was detected on the platform of one of the service buildings (Paint Shop). The dust and debris in the immediate vicinity of the apparent source of radiation was carefully collected and examined in an effort to

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determine the characteristics of the substance bearing the radioactivity. The results of the preliminary examination revealed that all of the activated material was concentrated in one small particle. Subsequently, other similar particles were located in the vicinity of the cafeteria and the plant laundry.

The fact that isolated particles of very high specific activity were rather widely dispersed over the plant area gave cause for some concern since, in all probability, many of them were airborne.

Preliminary investigations, begun early in June of 1948, indicated the presence of particles in areas of high activity in the vicinity of the reactor off-gas stack. An oil-saturated cloth, placed in the reactor exit air duct near the exhaust fans, was withdrawn after four days in the air stream and found to have an activity of approximately 200 mr/hr at $1\frac{1}{2}$ inches. After 24 hours' decay, the radiation level dropped by a factor of ten. The separated, oil-free sediment from the cloth was examined microscopically and found to be composed of particles having a range in diameter of about 10 - 100 microns.

The cumulative effect of these findings served to emphasize the possibility that there might exist a hazardous condition due to the presence of airborne radioactive particles on the plant site.

Investigation of the Seriousness of the Particle Problem

While the preliminary investigations and observations did not provide sufficient data upon which to base positive conclusions, they did indicate the desirability of securing as soon as possible definite information regarding the seriousness of the problem.

On June 17, 1948, a full-scale investigation of the particle problem was undertaken by the Health Physics Division. Manpower was diverted from certain routine operations to this investigation. This decision was made even though no indication had been found that radioactive particles smaller than 10 microns were settling on the Laboratory grounds. Since the percentage of particles larger than 10 microns which enter the lungs is believed to be very small, it was the general opinion that no serious condition existed because of airborne particles.

Extensive field surveys were undertaken as the first major step in the investigation of the problem, and these surveys disclosed a fairly large number of radioactive particles dispersed throughout the areas surveyed. Special attention was given to freshly graded areas where, it was believed, contamination would not have been tracked or spread by equipment. The number of particles found ranged from one per 50 square feet to only a few in 4,000 square feet. The greatest number per unit area was found in the vicinity of the reactor off-gas stack. Examination of these particles revealed that most of them had a characteristic gray color and a range in size from 90 to 500 microns. It was believed that they originated in the reactor and were airborne from the stack.

The use of 3' x 4' wooden trays with glass wool bottoms to trap and hold airborne particles which might fall on them indicated definitely that at least some particles were airborne. This corroborated results obtained in the survey of freshly graded areas which supposedly could have become contaminated only by airborne particles.

The first evidence of radioactive particles on the wooden trays with glass wool bottoms was found on July 21, following a slug rupture on July 20. An examination of the radioautographs of these trays taken on X-ray film revealed the presence of many specks having a considerable range in activity.

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Study of the X-ray film indicated a range in sizes of the radioactive particles from approximately a micron up to many microns in diameter. This confirmed earlier predictions that where larger particles existed, smaller ones should also be found. Many of these particles fell into the range of size which, according to the data of Dr. Philip Drinkler of Harvard University, could be effectively held up in the lungs. Drinkler's data, however, applies to tobacco smoke, MgO, and $CaCO_3$, and may or may not apply to this problem.

This evidence of particles covering the whole range of sizes from less than one micron to several hundred microns was sufficient to indicate that the problem of air-borne radioactive particles definitely presented a possible health hazard, since it included those particles which could be breathed into the lungs and possibly retained there for a considerable period of time Therefore, it was decided that on the basis of this information, immediate action should be taken to develop methods for maintaining control of the formation and distribution of airborne particles on the plant site.

After considerable discussion of the particle problem with Mr. T. F. Hatch, he made the following statement in a memorandum on the subject: "It cannot be said, from the existing knowledge and data, that a health hazard does or does not exist. Owing to probable requirements of many years to develop proof from experience among exposed individuals, decision must now be made as to corrective measures in the absence of absolute proof. The only proper position, in this situation, is to assume a potential hazard and proceed within reasonable limits to institute corrective measures, and, in addition, set up animal research to study this hazard".

In a meeting of representatives of Oak Ridge National Laboratory with

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members of the Atomic Energy project at the University of Rochester, the opinion was expressed by the Rochester group that "very little if any real hazard to health exists in the present situation, and that shutting down operations would not be warranted." They agreed, however, to undertake a research program to obtain information not presently available but which is necessary for a final evaluation of any hazard which may exist in this connection.

After being told of the particle problem and asked his views, Dr. Shields Warren of the Atomic Energy Commission expressed, in a letter to Dr. K. Z. Morgan on October 21, 1948, the opinion that "the conclusion is justified that no hazard of pulmonary damage or of ultimate production of pulmonary carcinomas exists".

The Full-Scale Program

At a meeting of Laboratory management on August 3, 1948, the following four methods of eliminating the formation and distribution of active particles from the reactor exhaust stack were considered:

(a) The use of uranium oxide slightly enriched in U^{235} instead of solid uranium rods. This method would eliminate the oxidation of the uranium and the subsequent rupture of aluminum cans.

(b) To enclose all of the uranium slugs in aluminum tubes and convert to water-cooling of the reactor.

(c) Complete filtration of all the cooling air from the reactor before it is discharged up the stack.

(d) Recycle and cool the air, filtering only the purge which is discharged up the stack.

Methods (a) and (b) were believed to be impractical under the existing conditions and would require a tremendous amount of engineering and development work before they could be placed in use. In preparation for reaching decisions on methods (c) and (d) information regarding the availability of filtering equipment was requested from various manufacturers.

During the following weeks it was decided that the installation of filters in the exhaust air stream of the reactor would be the most feasible and practical solution to the problem. Consideration was given to the advisability of using 200 Chemical Corps Filters, Type 6, size 24" x 24" x $11\frac{1}{2}$", each with rated air capacity of 600 cfm, in the filtration process. The basis for this recommendation was as follows:

(a) Any open system of removal devices will undoubtedly be followed by a mechanical filter as a final clean-up apparatus before discharge of effluent gases to the atmosphere.

(b) The Chemical Corps Filter has been fabricated on a production basis and found to function satisfactorily under various field conditions.

(c) The Dayton and Hanford plants have obtained good results with it and the primary objection seems to be cost, with disposal following contamination a secondary objection. Techniques for removal and disposal have already been developed and have been in effect for approximately a year at the Dayton plant.

(d) The framework installed can also be used for a glass wool filter instead of the paper type if, in the light of future developments, this is deemed advisable.

(e) The recommended filters were already in production for use at other AEC installations and could be obtained in a minimum amount of time, whereas the other filtering devices for radioactive materials are still, more or less, in the experimental stage.

Using the dioctylphthalate and methylene blue penetration tests, according to information received from the Chemical Corps, results indicate that the CWS filter No. 6 will remove 99.97% of the smoke and dust particles having a median diameter of 0.25 - 0.35 microns from an air stream and will allow the passage of about 3 per 100,000 particles having diameters of 0.8 microns. Larger or smaller particles will be removed with even greater efficiency by CWS #6 paper.

By September 20, 1948, the following program had been formulated for a comprehensive and coordinated attack on the particle problem:

1. <u>Removal of Solid Particles from Reactor Air</u>

   (a) Technical Division - Design and procure cyclones, filters, and electrostatic precipitators to remove dust particles of .1 micron and above. Installation of filters to remove particles to be expedited by all possible means.

   (b) Engineering Division - Design and construct suitable facilities to hold the above equipment on its arrival and install equipment.

   (c) Operations Division - Survey slug channels each day for slugs undergoing swelling. Spray water in exit air duct during dislodging of ruptured slugs. Prepare detailed data on previous slug ruptures.

2. <u>Determination of Other Particle Problems</u>

   (a) Health physics Division - Investigate frequency of particles emitted from other buildings in which large quantities of

[redacted]

radioactive materials are processed. Investigate incinerator to determine if any active material is being burned.

3. Experimental Work on Decontamination

(a) Engineering, Technical, and Health Physics Divisions - Investigate means of decontaminating the process area to remove solid particles from the roads and ground. Determine the effectiveness of wetting and oiling the roads.

(b) Engineering and Safety Departments - Carry out oiling and wetting of roads and sidewalks. Arrange to vacuum areas and decontaminate by dirt removal or covering, grass planting, etc. If necessary to keep dust down, cover roads and any dusty areas with calcium chloride.

4. Policy of Operations

During the interim period until the filters could be installed the reactor was to continue in operation. Since it was believed a large percentage of the particles in the air came from those which had settled out and become airborne again due to the movement of vehicles or wind, the problem could not be solved merely by shutting down the reactor. Every effort was made to detect swelling slugs before they ruptured. Oiling and wetting streets along with decontamination procedures were carried out to reduce the number of airborne particles. While the particles were considered hazardous very little actual data was available to substantiate this belief. In any case, it was believed that the number of particles inhaled by personnel during the interim period would not greatly increase the danger.

The following plan of immediate attack was proposed and adopted:

1. Carry out the following steps to fix the particles that are already

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settled in the X-10 Area so that they would not become airborne repeatedly:

(a) Plant grass

(b) Wash particles off roofs, surfaced roads, etc., with fire hose

(c) Hard surface all permanent roadways and keep other roadways oiled

(d) Block off roadways that are not needed

2. Determine the location of all particle-producing operations and discontinue or postpone these operations (with the exception of the reactor operation) until filters, precipitators, and other particle-removing equipment are installed.

(a) Investigate the advisability of postponing or eliminating the RaLa runs until particle-removing equipment was installed.

(b) Adopt similar precautions regarding other operations, such as redox process, that were believed to contribute to the number of particles in the X-10 Area.

3. Remove ruptured slugs from the reactor only during favorable metoerological conditions and when there were a minimum number of persons in the X-10 Area.

(a) Remove slugs only when there was a wind velocity equal to, or greater than, 8 miles per hour and no inversion. This, in general, precluded a ruptured slug removal operation except during the day shifts of Saturday and Sunday since inversions continue throughout practically every night.

4. During a period of a week following a known slug rupture, discontinue reactor operation when the following conditions exist:

(a) An inversion

(b) A wind velocity less than 5 miles per hour

(c) The wind is blowing from the northeast or east

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This meant that for a week following a slug rupture the reactor would not ordinarily operate at night and it would operate only about half time during the day.

5. Move with maximum reasonable speed to place in service particle removing equipment wherever needed.

6. Use every reasonable means to locate and remove a ruptured slug as soon as it occurred.

7. Begin an investigative nose swabbing program in which approximately 50 selected persons would stop by the Dispensary for a nose swab at the close of each working day. The Health Division was to make the swabs which would be collected, placed in envelopes, and turned over to the Health Physics Division to monitor for beta and gamma activity. (The same 50 persons were to be used throughout the experiment.)

8. It was also decided that chest X-rays would be made for all personnel employed at the Laboratory. These were to be compared with those made at the time of employment with the view of determining if any evidence of particle damage could be detected.

9. The Health Physics Division would continue to collect information concerning the particle problem and determine, if possible, the following:

(a) Origin of particles

(b) Size distribution

(c) Frequency and number

(d) Activity (alpha, beta, and gamma)

(e) Effectiveness of above remedial measures

(d) Extent of hazards involved.

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10. Develop new instruments for measuring the activity leaving the reactor in particulate form, and detect ruptured slugs at the earliest possible date after their occurrence.

Concentrated Study of the Particle Problem and Remedial Action

It was decided to install immediately in the reactor exhaust air duct two thicknesses of American Air Filter Company, FG-50 glass wool filters, followed by Chemical Warfare Service filters No. 6. As soon as the decision was made concerning the types of filters to be installed in the reactor exhaust air stream, design layout of the necessary structure to house the filters was started. The basic layout was presented to the Austin Company for detailed design on September 21 and preliminary grading was begun on September 22 by the J. A. Jones Construction Company. Construction proceeded on two ten-hour shifts daily until the filter house was put into operation on November 15, 1948. Preliminary efficiency tests on the operating filters were started at once.

It now appears that in all probability the present filter system is sufficiently effective to make the electrostatic precipitators unnecessary. The CWS #6 paper, in the manufacturer's efficiency tests using dioctylphthalate smoke, removes 99.97% of the particles of 0.3 microns diameter. In addition, retention of airborne particles of smaller diameters takes place by adsorption, absorption, or some other means not well understood. Data furnished by the Chemical Warfare Service indicates that the efficiency increases as the size of the particles is decreased to the range in which Brownian movement is effective. There appears to be an optimum particle size for which the filters are least efficient. Since this size is in the range of about 0.3 microns and since the filters are supposed to remove 99.97% of the particles in this range, they should have a very high overall efficiency.

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An order has been placed with the Ducon Company of Mineola, New York, for a twelve unit cyclone separator assembly capable of handling the exhaust air from the reactor. The cyclones were originally scheduled to be shipped by December 11, 1948. A preliminary design report for a cyclone building has been completed and transmitted to the Austin Company for preparation of construction drawings. Until it is determined whether installation of the cyclone separator unit is economically warranted, the actual installation of the system will probably be postponed, although consideration is being given to the installation of cyclones to determine their effectiveness in reducing the load on the filters and to obtain operating data.

A thorough survey was made of the possible application of electrostatic precipitators to the X-10 air cleaning problem. These investigations revealed that no performance data was available for this type of filter system operated under conditions requiring as rigid specification as those demanded at the Laboratory. Therefore, there is no assurance that electrostatic precipitators can approach the effectiveness expected of the newly installed filter system.

The installation of electrostatic precipitators is also being postponed until such time as either (a) experience shows that the life of paper filters is so short as to make installation of electrostatic precipitators feasible on a purely economic basis, or (b) there is evidence that the filters are not removing a sufficiently large number of particles. To date, neither condition has been proven to exist by the data available. Nevertheless, electrostatic precipitators may be installed at a later date to reduce the load on the present filters and thus cut down replacement costs. In any case development tests will be conducted on electrostatic precipitators to determine their overall effectiveness in removing radioactive particles from the reactor exit cooling air. The use of improved roughing filters will also be investigated.

Since the reactor was known to be contributing airborne particles and since Hanford experience indicated that chemical operations were another contributing factor, a program of study of the exhaust gases from the various process buildings was set up.

Permanent air cleaning facilities were studied for all contaminated exhaust gases in the area. The contaminated air can be classified as follows:

(a) Dissolver and process off-gases which are highly radioactive and require scrubbing to remove acid gases such as NO_2.

(b) Cell ventilation.

(c) Hood exhaust.

Several collection and decontamination systems have been studied, involving different groupings of buildings. The possibility of materially reducing the flow of contaminated air from each building was considered in order to decrease the size of air cleaning equipment. Air ventialation systems in the past have been designed on the principle of dilution; i.e., the more air ciruclated the better. Now the principle has been changed to call for the circulation of a minimum amount of air and removal of all possible particulate matter and all gaseous impurities before it is exhausted. Tests were conducted, therefore, to reduce materially the flow of contaminated air from each building. In general, the cleaning systems originally planned would consist of the following:

(a) Equipment for Off-Gas Lines - Scrubbers to remove acid gases and traces of soluble gaseous activities such as I^{131}, plus

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additional cleaning for particulate activity along with the cell and hood exhaust air streams.

(b) Cell and Hood Ventilation - A roughing filter similar to the AAF Deep Pocket FG 50, and a finishing filter such as the CWS #6 paper. Depending upon the experience gained with the use of these filters in the reactor air cleaning system and upon experimental data, electrostatic precipitators may be installed.

More recent recommendations follow a somewhat different plan of attack:

(a) For very high level sources not containing excessive corrosive agents or moisture - 1 layer FG 25, 1 layer FG 50, 1 layer CWS #6 paper. (Example - cell ventilating air for 706-D building.) From a longer range economic consideration, the addition of a precipitron type cleaner before the filters may be desirable.

(b) For high volume, low level sources, such as hood air from low and medium level hoods - a precipitron type electrostatic precipitator so modified as to provide negative instead of positive ionization.

(c) For high level sources containing moisture and/or corrosive agents - an electrostatic precipitator. Data is not yet available to ascertain whether a precipitron, plate, or tube type precipitator is the optimum type.

(d) Small volume high level off-gas should not be mixed into or processed in the same system as low level, large volume sources, such as hoods.

The Technical Division plans to establish an experimental program to be instituted as soon as possible to ascertain the relative efficiencies of the various types of filters and electrostatic precipitators.

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An experiment to observe slug ruptures was undertaken. Results of this investigation indicated that slugs swell to the rupture point much more slowly than had been previously thought. In the experiment not one of the heated slugs failed in 30 days' operation test, although each had a drilled hole several hundred times larger than the pin holes which might occur in the welds of metal cases due to faulty canning. Such a comparison suggested that slugs with faulty welds oxidize and swell gradually over a period of many months.

The conclusion drawn from a preliminary study of the possibility of using Brookhaven-type slugs is that considerable development work would be required to perfect new slug fabricating techniques and satisfactory remote control tools. Efforts are now being concentrated on other possible solutinns to the problem.

An instrument for monitoring reactor exhaust air in such a way as to serve as a specific detector for fission gases was developed and fabricated. It is believed that fission gases are produced by fission recoil processes from exposed uranium in the reactor. The monitor, hence, gives a continuous record of the relative area exposed. Since uranium is exposed in the reactor only when a slug is ruptured, it is expected that this instrument, which is now in continuous operation, will give a positive and early indication of any ruptured slug. However, it is not known at present whether or not the monitor will be a good detector for this purpose, since the background contamination is rather high and also because no slug ruptures have occurred since the monitor was installed.

Samplers were installed on the redox operations and the isotope separations building air exhaust lines. Results obtained from these samplers,

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which incorporated a cyclone separator followed by a CWS #6 filter, indicated that the redox process was only a very minor contributor of radioactive particles and that the chemical separations Bldg., 706-D, during the time of a Rala run was a major source, producing particles at a rate greater by several orders of magnitude than any other known source.

Temporary filters had been installed in the dissolver and vessel vent off-gas lines prior to the Rala run on which data was collected; but no filter was installed on the cell ventilation duct. Samples of the exhaust air indicated that the cell ventilation duct carried out activity at a higher level than the other lines. Calculations based on the data obtained in the course of the last Rala run indicate that the following amounts of airborne radioactive particles were discharged:

Cell ventilation duct	15 curies/5 days
Vessel vent line	2 curies/5 days
Dissolver off-gas line	0.5 curies/5 days

The above data clearly established the fact that the Rala production facilities constitute a major source of airborne activity. Design work for a cell ventilation duct filter was started immediately upon the disclosure of these facts. It is expected that this filter system will be installed before the next Rala run.

Dr. R H. Wilson of the Rochester Project visited the Oak Ridge National Laboratory during November 3-7, 1948, for the purpose of collecting samples of airborne particles to take to Rochester for analysis in an effort to determine primarily the particles size distribution. Results of this work have not been reported to date.

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Current Status of the Particle Problem

The reactor exhaust air filter facilities have been completed and are now in operation. Sufficient data for evaluating the efficiency of the filters has not been compiled. Data now being accumulated will serve as a basis for determining whether cyclone separators, or electrostatic precipitators, will need to be installed in series with the present filters to reduce the load. For this use they need be neither extremely high in efficiency nor extremely expensive.

The fixation of particles which have already settled out over the plant area has been completed. Grass has been planted, the roads have been paved, and hosing down of the roads and streets has been accomplished.

Temporary filters have been installed in off-gas lines of the chemical separations building (706-D, Rala). Construction of filter facilities for the cell ventilation air, somewhat similar to those for the reactor, but on a smaller scale, has been started and is scheduled for completion December 31, 1948.

Sampling of exhaust gases from the reactor and chemical separations building will continue until the effectiveness of present filter installations can be ascertained.

Area surveys for particle contamination will continue on a routine basis as a part of the Health Physics program.

The initial program for making chest X-rays for personnel working on the plant site has been completed. According to present plans, a similar series of chest examinations will be made every six months.

The study of blood counts is now in progress and, according to present plans, will continue until sufficient data has been accumulated to evaluate the results.

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The nose swabbing program has been discontinued since no positive evidence of the presence of radioactivity in the lungs was obtained and no reliable quantitative measurements could be made.

Reactor sample stringers of a new design are being developed to decrease the number of particles released directly into the operating area when a stringer is pulled out. A temporary particle collector which eliminates about 90% of the particles has been installed and will be used until a more efficient permanent stringer and collector become available.

Three methods for detecting ruptured or swollen slugs are being developed and are presently under consideration. These are methods which will enable one to detect the defective slugs in an individual row. The method now in use is designed to detect the existence of a ruptured slug somewhere in the reactor. Experimental work to determine the most effective method or combination of methods is expected to begin soon.

Dr. Arthur J. Vorwald of the Trudeau Sanitarium and Mr. T. F. Hatch of the Industrial Hygiene Foundation of America have been engaged as consultants on the biological effects of inhaled radioactive particles.

Conclusions

(a) Most of the effort expended thus far has been concerned mainly with the removal and control of existing particles rather than with the elimination of their sources. The method of attack appeared feasible in view of the urgent nature of the problem. It is deemed advisable that greater emphasis in the future be placed on developing methods for eliminating the source of the particles.

(b) Before any final decision can be made regarding the type and size of the filter systems that will be most feasible for coping with the

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particle problem it will be necessary to accumulate more data on the performance of those systems now in operation.

(c) There is not presently available sufficient and reliable data to permit making a thorough evaluation of the seriousness of the particle problem. Therefore it will be necessary to carry out more tests extended over sufficient time to gain more information regarding the basic problems involved.

(d) There is no positive evidence to lead one to believe that any significant damage has been caused to the personnel and that no appreciable risk is involved in the present plant operations under existing circumstances.

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APPENDIX I

BIBLIOGRAPHY OF IMPORTANT REPORTS AND MEMORANDA ON THE PARTICLE PROBLEM

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48-10-49	2nd Weekly progress Report on Waste Disposal, 10-4-48	S McLain
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ORNL-211	3rd Progress Report on the Particle Problem, 11-48	"

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48-10-75	Recommendation for Pile Operation and Particle Program, 10-6-48	E. O. Wollan F. Western, & J.A. Swartout
48-10-8	Minutes of Conference on Particle Problem of Isotope and Pilot Plant Areas, 9-27-48	S. McLain
48-10-128	Recommendations for Future Rala Runs and Particle Problem, 10-11-48	E. O. Wellan F. Western J. A. Swartout
48-10-167	Particle Removal Test Program - TD-61 10-14-48	S. McLain

[redacted]

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ORNL Cen. Files #	Document Title	Author
48-10-166	Operations Shutdown - Particle Investigation, 10-15-48	L. B. Emlet
48-10-185	Temporary Filters on 706-C and D Bldgs., 10-15-48	S. McLain
48-10-211	Notes on the Particle Problem (Meeting with Univ. of Rochester), 10-19-48	F. Western
48-10-382	Particle Problem Program, 10-29-48	J.A. Swartout F. Western E. O. Wollan
48-10-357	Summary of Conference on Particle Problem, 10-28-48	T. F. Hatch

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FILE Particle Problem

This document consists of 11 pages. This is Copy 1 of 18. Series A.

OAK RIDGE NATIONAL LABORATORY
CENTRAL FILES NUMBER
48-9-123

OAK RIDGE NATIONAL LABORATORY
Division of
Carbide and Carbon Chemicals Corporation
Oak Ridge, Tennessee

ChemRisk Document No. 1316

Contract Number W - 7405, Eng. 26

HEALTH PHYSICS DIVISION

TO: C. N. Rucker

FROM: Karl Z. Morgan

SUBJECT: Remedial Measures Regarding the Particle Problem.

Septem[redacted] DECLASSIFIED

Per Letter Instructions Of TID-1110
D. McGhee
For: N. T. Bray, Supervisor
Laboratory Records Dept.
ORNL

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David K Hamm 4/15/96
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OAK RIDGE NATIONAL LABORATORY

To: C. N. Rucker

From: Karl Z. Morgan

Subject: Remedial Measures Regarding the Particle Problem.

For the past two months the Health Physics Division has devoted considerable effort to the Particle Problem. Some of the data concerning this Particle Problem have been reported. (See Report No. 48-8-86 by K. Z. Morgan; Report No. ORNL-146 by J. S. Cheka and H. J. McAlduff; also attached data sheets.)

At present we have not been able to assess with any accuracy the biological hazard introduced by these particles because sufficient biological experiments have not been undertaken. Some such experiments are being considered at various sites, but since the principal concern is the possibility of the development of cancer at the site of these particles of high specific activity in the lungs, it will require several years of experimentation before the necessary data is accumulated. In the past, only the gross effects have been studied and it has been assumed that the airborne material from broken slugs consisted primarily of radioactive gas and extremely finely divided material that was more or less uniformly distributed in the lung tissue. Calculations based on these assumptions have indicated that at no time has the concentration in the air (at the numerous points of measurement in the X-10 Area) exceeded the daily permissible exposure to the lungs.

Some time ago experiments were undertaken at the University of Chicago in which microgram quantities of plutonium (= 1/16 microcurie) were placed in open wounds of animals. In a period of twenty-four hours approximately fifty percent of the plutonium was translocated from the wound site to other parts of the body. The plutonium that became fixed at the wound site was shown to present a very large probability of the development of cancer at that point. It is not known what minimum concentration of plutonium will produce cancer in such a wound and, likewise, it is not known what the relative sensitivity of lung tissue and skin and muscle tissue is in the production of cancer.

[redacted]

[redacted] [redacted]

Part of the data in the reports referred to above has been obtained at various locations in the X-10 Area by air sucking apparatus, collecting particles by breathing air through a paper filter at approximately ten times the rate of human respiration. The number collected varies considerably with location and with time, from zero to several hundred particles per hour. We can only assume that man, in the same location, would breathe a similar number of particles, some of which would be deposited in the respiratory tract. Our radiographical analysis of these particles indicates that all sizes are being airborne, and so we are led to suppose that particles of various sizes may be deposited in different portions of the respiratory tract. The smaller particles, that have a high probability of reaching the alveoli, fortunately have a very low specific activity and calculation indicates that they would be capable of destroying only a thin layer of cells surrounding them. Whether or not this represents a serious damage no one seems to know.

Our investigation has indicated that some of the larger particles may reach the lower portion of the bronchial tree and be held up there for some time before they are removed by the cilia. Such particles do not remain long enough to introduce any silicosis type hazard. However, they may remain long enough to destroy many hundreds of cells which remain in their neighborhood for a few hours.

In summary, I would like to state that we do not know whether or not a serious hazard exists. We do know that there is a large probability that radioactive particles are being held up in the respiratory system. The very fact that such a hazard, difficult or impossible to assess at this time, exists has led me to suggest that we consider seriously taking positive action that will minimize the possibility of adding to this hazard. I would like to suggest that consideration be given to taking the following remedial measures:

1. Fix the particles that are already settled in the X-10 Area so that they will not be airborne repeatedly.

   ✓ a) Plant grass.

   ✓ b) Wash particles off roofs, hard surface roads, etc. with a fire hose.

   ✓ c) Hard surface all permanent roadways and keep the other roadways oiled.

   ✓ d) Block off roadways that are not needed.

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[redacted]

2. Determine the location of all particle producing operations and discontinue or postpone these operations (with the exception of the pile operation) until filters, precipitators, and other particle removing equipment are installed.

   a) Investigate the possibility of postponing or eliminating the RaLa runs until particle removing equipment is installed.

   b) Adopt similar precautions regarding other operations, such as redox, that are proven to contribute to the number of particles in the X-10 Area.

3. Remove ruptured slugs from the pile only during favorable meteorological conditions and when there are a minimum number of persons in the X-10 Area.

   a) Remove slugs only when there is a wind equal to or greater than 8 miles per hour and no inversion, and when the wind is not blowing over the plant area. This will, in general, preclude a ruptured slug removal operation except during the day shifts of Saturday and Sunday, since inversions continue throughout practically every night.

4. During a period of a week following a known slug rupture, discontinue the pile operation when the following conditions exist:

   a) An inversion.

   b) A wind velocity less than 5 miles per hour.

   c) The wind is blowing from the northeast or east.

   This will mean that for a week following a slug rupture the pile will not ordinarily operate at night and it will operate about half time during the day.

5. Move with the maximum reasonable speed to place in service particle removing equipment wherever needed.

   a) This is a problem for the Engineering Division.

6. Use every reasonable precaution to locate and remove a ruptured slug as soon as it occurs.

   a) This is a problem for the Operations and Engineering Divisions.

[redacted]

[redacted] [redacted]

7. Begin an investigative nose swiping program, in which approximately 50 selected persons would stop by the Dispensary Building for a nose swipe at the close of each work day.

    a) This would be a joint project of the Health Division and the Health Physics Division. The Health Division would collect the swipes which would be collected, placed in envelopes, and turned over to the Health Physics Division to monitor for beta and gamma activity. (The same 50 persons would be used throughout this experiment.)

8. The Health Physics Division should continue to collect information concerning the Particle Problem as follows:

    a) Origin.

    b) Size distribution.

    c) Frequency and number.

    d) Activity (alpha, beta, and gamma).

    e) Effectiveness of above remedial measures.

    f) Hazard involved.

9. Develop new instruments for measuring the activity leaving the pile in particulate form, and detect ruptured slugs at the earliest possible date after their occurrence.

    a) This is a problem primarily for the Physics and Chemistry Divisions.

Perhaps other remedial measures will be suggested when more information becomes available.

Karl Z. Morgan

Karl Z. Morgan

KZM:fsc

[redacted] [redacted]

APPENDIX A

PARTICLES COLLECTED WITH FILTRONS

The values given in the following tables express the number of particles collected over the number of hours the filtron was run. The number of particles collected was determined by placing an X-ray film, protected from radioactive contamination by a sheet of heavy paper, in contact with the filter; exposing the film for 24 hours, and counting the resultant spots on the developed film. All visible spots are counted, representing particles ranging in activity from less than a hundred disintegrations per minute to several thousands of disintegrations per minute.

Many, or most, of the particles collected by the filtron and producing visible spots on the film are too large to have a high probability of being breathed into the lungs if entering the nostrils. It is presumed that other particles of smaller sizes and lower activities which escape observation against the more or less diffuse background of darkened film resulting from the thousands of microscopic or sub-microscopic particles on the filter, may have activities which are individually significant. For the purpose of comparing volumes of air, the filtron has an airflow of some 300 cubic feet per minute; and a man may be expected to breathe from 150 to 300 cubic feet per 8 hour day if moderately active.

[redacted] [redacted]

Particles Collected with Filtrons

Date	706-A		105		104-B		706-D		205		703-B	
	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.
8-4		1/2		0/2		0/2		0/2				
8-5			0/2		0/4							
8-6			0/2	0/2				0/2	0/2	0/2		
8-7							0/2					
8-8							1/2					
8-9					0/4		6/2	0/2	0/2	0/2		
8-10	0/2		0/2	0/2			129/2		0/2			
8-11			0/2	0/2	0/4		0/2	0/2	0/2	0/1		
8-12		1/2	0/2	0/2			3/2	0/2	0/2	0/2		
[illegible]13	0/2	4/2					5/2	2/2	2/2	0/2		
8-14							1/2					
8-15	0/2											
8-16		0/2		1/2			1/2	4/2	0/2	1/2		
8-17	1/2			0/2			0/2		0/2	0/2		
8-18	0/2	0/2	0/2				0/2	57/2	0/2	0/2		
8-19		1/2	0/2				0/2	0/2	0/2	0/2		
8-20		0/2		0/2					0/2			
8-21								0/2				
8-22							0/2					
8-23									6/2			
8-24									2/2	38/2		
8/25									0/2	14/2		
[illegible]26									16/2	14/2		
8-27									11/2	19/2		
8-28												

[redacted] [redacted]

[redacted]

Particles Collected with Filtrons (Continued)

Date	706-A		105		104-B		706-D		205		703-B	
	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.
8-30		2/2										
8-31	2/2	1/2	7/2	29/2		0/1	1/2	1/2		7/2		8/2
9-1	2/3	2/3	13/3	14/3			10/3	12/3	16/3	8/3	12/3	3/3
				10/3								
				3/3								
9-2	5/2	2/2	14/3	2/3	3/2		95/3	5/3	1/3		2/3	
				3700/3				3600/3				
								11/3				
9-3		12/1.5			3/2			28/3				
								5/0.5				
								112/3				
9-4				9/13				4/3				
								11/3				
9-5			1/3				7/3	0/3				
								4/3				
9-6			0/3				2/3	1/3				
								0/3				
9-7	2/2				0/3		10/3	1/3	1/3		2/3	

[redacted] [redacted]

[redacted]

Particle Collection on Frames

Frame	Distance and Direction from 105 Stack	Date Out	Date In	Time	Number of Particles Total	Number of Particles 400 c/m
7	350' SW	6-19	7-22	33 days	45	4
9	75' SSE	6-19	7-22	33 days	119	11
10	150' NNE	7-29	7-30	24 hrs.	63	12
10	150' NNE	7-30	7-30	6 hrs.	12	3
3	900' SW	6-19	8-6	48 days	14	0
5	450' SSE	6-19	8-6	48 days	551*	13
6	500' E	6-19	8-5	47 days	129**	0
8	150' N	6-19	8-6	48 days	261	20
10	150' NNE	7-30	8-4	5 days	4	0
	(Relocation of some)					
1	700' SW	8-3	8-13	10 days	265 *	10
2	1200' S	8-4	8-13	9 days	21	1
3	800' WNW	8-6	8-13	7 days	12	0
4	850' ESE	8-5	8-13	8 days	20	0
5	600' SSE	8-6	8-13	7 days	196*	0
6	650' E	8-5	8-13	8 days	8	0
7	1850' SW	8-5	8-13	8 days	20	0
8	1700' W	8-6	8-13	7 days	15	2
9	1050' NNE	8-5	8-13	8 days	15	0
10	150' NNE	8-4	8-13	9 days	119	3

* These frames were near areas of vehicular traffic, and many particles were probably relocated. This would indicate that roadways inside the plant should be oiled or treated with $CaCl_2$ to immobilize the dust.

** This frame had been used as a foot-bridge and the count is, therefore, unreliable.

[redacted]

Particle Collection on Frames

Particles falling out of the atmosphere are collected on paper placed on the bottoms of 3' x 4' boxes. The dust on the paper is concentrated into an area which can be covered by a sheet of x-ray film, and monitored for radioactive particles by 24 hour exposure in near proximity to the particles. The method is subject to some loss of fallen particles.

The results of two weeks collection are given below. Locations of the frames are relative to the 105 stack.

Dates	700 SW	1200 S	800 WNW	850 ESE	600 SSE	650 E	1850 SW	1700 W	1050 NNE	150 NNE
8/13-20	88	12	27	40	530	124	14	20	37	124
8/20-26	73	29	78	73	2237	659	36	20	87	
8/31 to 9-1	671	165	20	179	1210	135	81	123	39	98
9/1-2	79	21	45	43	*	121	11	25	56	*
9/3-7	237	**	108	**	**	**	**	**	158	**

* Most of the particles involved here are not counted but are estimated at several hundred.

** Collections were not made on account of rain.

[redacted]

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Particles Collected with Constant Air Monitors

The values given in the following table express the number of particles collected by constant air monitors operated continuously over the period indicated. The number of particles collected was determined by 24 hour exposure of an x-ray film in near proximity to the filter used for collection.

The constant air monitors are in relatively sheltered positions compared to other devices used for particle collection, hence the probabilities for collection of larger particles is lower.

For purposes of comparison, the flow of air through a constant air monitor is roughly 50,000 cubic feet per week or 7,000 cubic feet per 24 hour day. While it is estimated that normal breathing rates vary from 150 to 300 cubic feet per 8 hour day.

Constant Air Monitors

Dates	115-B	706-A	735-B
7-12 to 7-19	7	21	9
7-19 to 7-26	142	18	1
7-26 to 8-2	26	2	2
8-2 to 8-9	3	14	5
8-9 to 8-16	0	1	0
8-16 to 8-23	2	2	1
8-23 to 8-30	3	11	33
8-30 to 9-1	0	0	18
9-1 to 9-2	15	27	13

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FILE ~~[illegible]~~ – Waste Disposal

OAK RIDGE NATIONAL LABORATORY
CENTRAL FILES NUMBER
48-9-158

[redacted]

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Date	September 20, 1948
Subject:	Oak Ridge National Laboratory Waste Disposal
To:	C. N. Rucker
From:	S. McLain

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For: W. T. Bray, Supervisor Laboratory Records Dept. ORNL

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This document consists of 9 pages. No. 18 of 30 copies Series A.

To: C. N. Rucker

From: S. McLain

Subject: Oak Ridge National Laboratory Waste Disposal

I. Introduction

This memorandum summarizes the waste disposal problems along with recommendations concerning the action to be taken in solution of these problems. The statements presented in this memorandum are a result of meetings of the Radiation Hazards Committee, the Research Council, conferences with other people, personal opinions, and the Memorandum to C. N. Rucker from Karl Z. Morgan, "Remedial Measures Regarding the Particle Problem", dated September 15, 1948, C. F. 48-9-123.

II. Statement of the Problem

The waste material discharged by the Laboratory at the present time contains excessive amounts of radioactivity in the gaseous, liquid, and solid streams. The removal of these activities will require an extensive research, development, design, and construction program.

The solid particles carried by the air discharged from the pile produces the most hazardous and urgent problem. Next in order of hazard appear to be the solid particles carried by the air and dissolver gases emitted by the isotope operations in Building 706-D and by the Pilot Plant, Building 205. About 25 curies per week are discharged to White Oak Creek in the liquid

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wastes. Most of the solid wastes are buried but apparently some find their way into the incinerator and are emitted as air-borne dusts or become a part of the ash from the incinerator.

The air-borne particles have settled out rendering a large area hazardous since the particles may become air-borne again and inhaled. The elimination of the sources of these particles and the decontamination of the contaminated areas are among our most urgent problems.

III. Action to be Taken

The following paragraphs outline the work to be done by the various divisions of the Laboratory in the solution of these various problems:

a. Solid Particles in Pile Cooling Air

The solid particles in the pile cooling air are believed to be uranium oxide formed when slugs rupture in the pile.

The Technical Division has undertaken the design and procurement through the Engineering Division and Purchasing Department of equipment to remove these particles when formed from the exit air stream. To date bids have been requested from fifteen companies for cyclone type dust separators to remove 80% of particles of ten micron diameter and above. Bids must be submitted not later than September 27. Delivery and installation of this equipment should be completed by January 15. The Technical Division in conjunction with the Austin Company will design the necessary ductwork, and equipment for installation. The installation will be either conducted by the Engineering, Maintenance, and Construction Division or contracted by that division to the J. A. Jones Company.

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The Technical Division will design and the Engineering, Maintenance and Construction Division will procure FG 50 American Air Filter glasswool filters to be backed up by CWS #6 Chemical Warfare Service paper filters. These filters will be placed in the ductwork between the cyclones and the fans with space for an electrostatic precipitator to be installed at a later date between the cyclones and the filters. Data supplied by Mr. J. P. Mitchell, Technical Command, Army Chemical Center, Edgewood, Maryland gives the efficiency of two layers of the F.G. 50 filter as 99.43% and the CWS #6 as 99.995% when filtering 25 cubic feet per minute per square foot of air with methylene blue, .8 micron average diameter, and dioctylphthalate, .3 micron average diameter. The CWS #6 is the best filtering medium available at present. F.G. 50 filters may be obtained and installed in six to eight weeks. Information is being obtained on delivery dates of the CWS #6 filter paper. Actual amounts needed will depend on the physical design adopted. Hanford is taking all the production for the next sixty days but the Chemical Warfare Service has stated they can put on additional shifts and supply the material at an earlier date. Delivery and installation are expected to take about six weeks. The Engineering, Maintenance, and Construction Division will make arrangements for installation of this equipment in conjunction with the designs of the Austin Company.

The Technical Division through the Engineering, Maintenance, and Construction Division will procure an electrostatic precipitator for installation ahead of the filters. Contacts have already been made with several suppliers but additional contacts must be made before adequate specifications can be written. Delivery on this equipment will be at least six months from this date. Since electrostatic precipitators increase in efficiency with decrease in the particle size, the installation of such a device should remove practically all of the small particles from the pile air. It is planned to continue the cyclones for removal of the heavy particles and the filters to remove any particles not picked up due to mechanical or electrical failure of the electrostatic precipitators. With this system practically no particles over .1 micron size will escape.

[redacted]

[redacted]

"c. Hard surface all permanent roadways and keep the other roadways oiled. (The hard surfacing of the roads is being investigated.)

"d. Block off roadways that are not needed."

In addition to the above recommendations the speed of vehicles, particularly patrol cars, should be kept to a minimum. Also all unnecessary traffic in the restricted area should be stopped. This includes all passenger cars, patrol cars, and unnecessary trucking. A speed limit of 15 miles an hour should be strictly enforced in the restricted area and the roads immediately North, East, and South of the area. The Safety Department should coordinate the above work.

b. Solid Particles from Other Sources

The Health Physics Division will investigate the sources of air-borne particles other than the pile. The origin, size distribution, frequency and number, activity (alpha, beta, and gamma), effectiveness of removal measures, and hazards involved will be studied. If desired, help will be obtained from the Physics, Chemistry, Technical and other Divisions in this work. This investigation will include the isotope area, particularly Building 706-D, the Pilot Plant, Building 205, the research laboratories, the tank farm, and the incinerator. The Technical Division in conjunction with the Austin Company will design equipment necessary to remove any air-borne activities found by the survey. At present it appears that dust removal equipment will be required on a high priority basis for the isotope and pilot plant areas.

c. Gaseous Decontamination

The gases being emitted during dissolving operations in the isotope area, Building 706-D, and in the Pilot Plant, Building 205, contain considerable amounts of iodine, nitric oxides, and other gaseous materials. Experimental work to determine the best means of removal of these gaseous materials will be conducted by the Chemistry and Technical Divisions.

Scrubbing with strong basic solutions should remove most of the acid gases. Hanford has contracted with the Air Reduction Company for development work on equipment to remove iodine. The process developed makes use of solid silver nitrate dried on tower packing. The iodine reacts with the silver nitrate to form silver iodide which is then removed by scrubbing with solutions of silver nitrate.

[redacted]

d. Decontamination Procedures

The Engineering, Maintenance, and Construction Division in conjunction with the Technical and Health Physics Divisions will investigate means of decontaminating areas which have become hazardous due to the active air-borne particles. This will include streets, sidewalks, and grass areas. Plans for growing grass on bare areas will be made up by the Engineering Department and arrangements made to cover other areas.

The Health Physics Division will determine the effectiveness of these measures and keep records of the activities of various areas.

The Engineering and Safety Departments will carry out a procedure for oiling and wetting the roads and sidewalks until equipment can be installed to remove the particles being emitted by the pile stack. They will arrange to vacuum the area, decontaminating by dust removal, grass planting, etc., in accordance with procedures developed by the Technical and Health Physics Divisions in conjunction with Engineering Division as outlined above. If necessary calcium chloride will be used to keep the dust on roads and sidewalks down.

In addition to the above, the Health Physics Division aided by the Physics, Chemistry, and Engineering Divisions will complete construction of the large dust collectors. These will be used to study the dust problem in Oak Ridge and other locations.

The Biology and Health Physics Divisions will look into possible locations for investigation of the effects of particles in the lungs. Places with qualified personnel suggested are University of Rochester, Soranac Lake, and the Toxicology Laboratory at the University of Chicago. Rochester has already started work. The Health Department will make daily swipes on about fifty persons.

c. Additional Waste Disposal Facilities

The Technical Division, in cooperation with Engineering, Maintenance, and Construction Divisions, will supply data to the Austin Company for design of a new waste disposal system. The Health Physics Division will continue surveys of the

[redacted]

activity in White Oak Creek and other divisions may be asked to supply information or carry out research of problems arising from the design. The items to be covered by this design work are:

1. Tank Farm

The Technical Division in cooperation with the Operations Division has designed an evaporator to concentrate the highly active wastes which have been sent to tank W-6 for short time storage and decay. The Engineering, Maintenance and Construction Division is making the detailed drawings of this evaporator at the present time. The evaporator is designed to carry out a reduction in volume from 45,000 gallons per week to 2,000 gallons per week. The product from the evaporator can be stored for approximately two years giving a decay of approximately 10^2. The Technical Division will design a suitable drier to further concentrate the waste product from this evaporator to permit canning for permanent storage through burial of the products.

The tank farm facilities are believed to be inadequate to take care of the waste from the new isotope area and the new research area which are being designed. The Austin Company will be asked to carry out a redesign of the tank farm or possibly the design of an entirely new tank farm to handle our future liquid wastes. It should be pointed out that the present tanks were designed for a three-year use and are gunite lined. Since these tanks have been used approximately five years they cannot be expected to last indefinitely and therefore must be replaced.

2. Isotope Area

A new isotope plant is being designed. The Austin Company will be asked to design facilities to handle the waste from this area. To date the Technical Division has made no study of the drawings of this equipment and can make no recommendations to the Austin Company.

3. Research Area

The Austin Company is carrying our a design of new buildings for the research area. They will carry out the design of a waste disposal system for the gases and solids, as well as the liquid wastes from this area.

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[redacted]

4. Incinerator

The Austin Company will be asked to design a new incinerator which will be equipped with scrubbers to remove acid materials from the stack gases and with electrical precipitators and filters to remove all solid air-borne particles.

5. Fissionable Material Recovery

A large amount of fissionable material has been sent to the tank farm and precipitated in the tanks. The Chemistry Division in conjunction with the Technical Division will develop procedures for recovering this material.

6. White Oak Creek

The Health Physics, Engineering, Maintenance, and Construction and Technical Divisions will study the White Oak Creek situation. It is probable that a new dam for an enlarged retention basin will be required, At the present time approximately 25 curies of activity per week is dumped into the creek. The Engineering Division will make arrangements for carrying out the design of this dam.

IV. Operation's Policy

The pile should be kept under operation, at least temporarily. The Operations Division should use extreme care to detect swollen slugs and remove them with the greatest care. The Technical Division along with the Austin Company and Engineering Division should expedite the installation of filters by all possible means.

The question of continued operations of the pile will be reviewed weekly.

Stuart McLain

S. McLain

SM:eg

S E C R E T

[redacted]

OAK RIDGE NATIONAL LABORATORY
CENTRAL FILES NUMBER
48-10-8

Date September 27, 1948

File

Subject: Minutes of Conference on Particle Problem of Isotope and Pilot Plant Areas

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To: (See Distribution)

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This document consists of
4 pages. No. 15
of 24 copies. Series A.

MINUTES OF CONFERENCE ON
PARTICLE PROBLEM OF ISOTOPE AND PILOT PLANT AREAS

Place: 703-A Annex Conference Room

Time: 9:00 A.M., September 24, 1948

Present:
T. W. Hungerford
J. W. Gost
J. A. Lane
S. C. Barnett
F. P. Baranowski
W. G. Stockdale
W. R. Gall
J. D. McKeon (AEC)
W. K. Eister
S. McLain
L. B. Emlet
R. W. Stoughton
F. L. Culler
J. A. Swartout
J. C. Stewart
K. C. Brooks (AEC)

The meeting opened with a discussion of the particle problem which is present in the present isotope area and the pilot plant. Particles may come from the dissolvers, from storage tanks, semi-works, new semi-works, and the circulating air from the pilot plant and isotope buildings. The question was raised who is to do what in the design of facilities to remove the dust particles.

Drawings prepared to show the means to collect the off-gases from the present isotope area were discussed. Since these were prepared prior to the realization of the seriousness of the particle problem, the drawings must be re-examined. The ventilating system was designed to handle 60,000 cfm from the cells and hoods in the 706-C and D buildings.

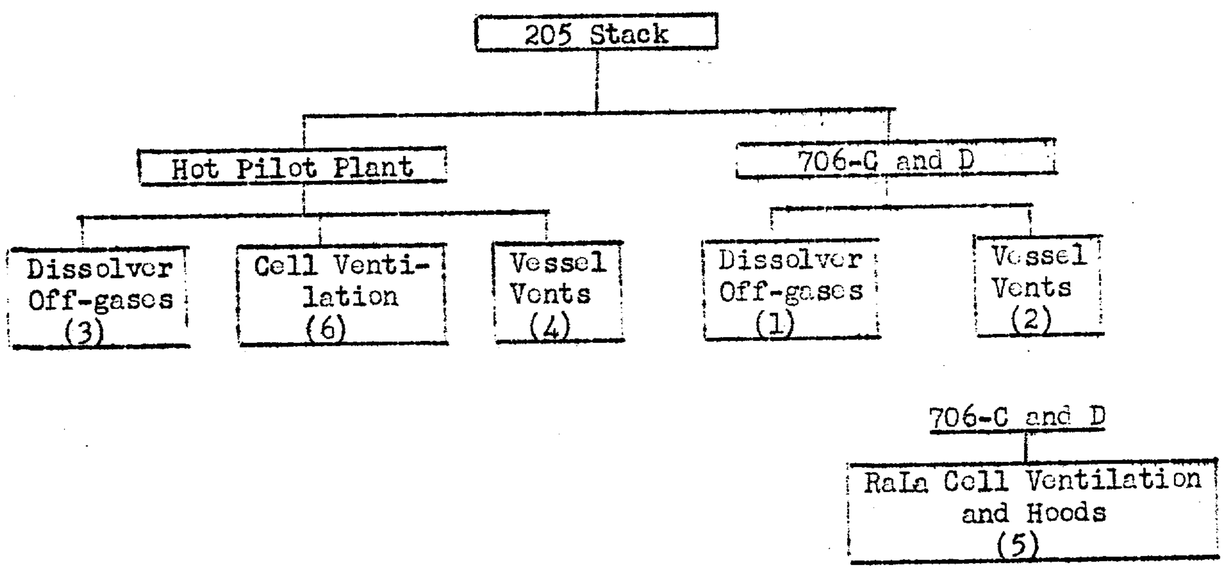
[redacted]

[redacted]

It was estimated the off-gases from the dissolvers and other tanks in the C and D buildings are about 1500 cfm. The Operations Division will measure the off-gases and air during the next Ra La run.

The use of four gallons per minute of caustic is necessary during dissolving to remove the nitric oxides and acid gases present in the off-gas. Air enters the dissolver through non-gasketed joints. The Chemistry Division will investigate the possibility of using sodium thiosulfate or other means for iodine removal. Hanford has been using silver nitrate on an experimental basis.

The sources of contaminated gases and the relative importance are given in the illustration below (1 is most concentrated):



All gases except possibly the pilot plant cell ventilation will have to be cleaned up.

It was decided that the Operations (Emlet) and the Technical Divisions (Culler) will examine the drawings of the new isotope area to check

[redacted]

[redacted]

the ventilation system. The Technical Division (Eister and Winters) will examine the equipment now in buildings 706-C and D. Bids are being let for construction of a new stack by March, 1949. A air purification building will be built as soon as it can be designed and either the present short stack used or a temporary stack set up. Two things must be checked: first, the Engineering, Maintenance and Construction Division (Stewart) will check to determine whether the A. E. C. will require the new stack to be built on a hill; and second, stacks from the old heater plants are available.

The Technical Division (Culler) will go ahead with a design lay-out of the purification system.

It was agreed that the work on the 706-C and D buildings would be assigned:

Technical and Physics	(Winters, Reid, Witkowski) - Samples
Chemistry and Physics	(Swartout) - Analyses
Technical	(Culler) - Design

The incinerator has been examined and found to contain very little contamination.

The Technical (Winters, Culler) and Operations Division (Emlet, Witkowski) are to collect samples from the tank farm. Jetting of material from Argonne containers is to be checked.

Information on burial ground particles is to be supplied McLain by October 1st.

Another meeting will be held to discuss the new isotope area design.

Stuart McLain

Stuart McLain

SMcL:lwb

[redacted]

⑥ FILE Particle Problem

[redacted]

Central Files No.: 48-9-165

This document consists of 7 pages.
Copy 14 of 22 Series B

File SM #2

Date September 28, 1948

Subject PRELIMINARY CALCULATIONS CONCERNING THE PARTICLE PROBLEM

By L. T. Newman

To K. Z. Morgan

OAK RIDGE NATIONAL LABORATORY
CENTRAL FILES NUMBER
48-9-165

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1	Baranowski, P.	
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Preface to B Series Distribution

Recent Health Physics work (ORNL 146) has shown that considerable numbers of radioactive particles are being deposited on the Oak Ridge National Laboratory area, mainly from the pile stack, although there may also be other sources. The present interest in these particles is due to the realization that, if they are inhaled and deposited in the lungs, the radiation in their immediate neighborhood will be rather high, even though the total amount of material (and radiation) is well within tolerance limits. Particles found by Health Physics have been of the order of a few tenths of a millimeter in diameter and have beta counts of 50,000 to 100,000 per minute.

This report was written as a guide for some of the current research and as an aid in estimating the hazard. At the request of Dr. K. Z. Morgan, it is being given wider circulation. It should be understood that more positive information will soon be available from the present work of various groups.

A few minor revisions have been made in the B series of this report.

PRELIMINARY CALCULATIONS CONCERNING THE PARTICLE PROBLEM

This report represents an attempt to collect data of interest to the particle problem, based on previous experience with the behavior of small particles. Most of the material has been discussed with G. E. Boyd, who has made similar calculations and obtained approximately the same answers.

1. Maximum Size of Primary Particle from Pile Stack

Since the air velocity in the stack is 80 to 100 feet per second, the measurements of Martin (Alexander, COLLOID CHEMISTRY, Vol. III, p. 165) can be used to calculate the maximum size of particles which could be blown from the stack. This is of the order of 5 mm. diameter.

This estimate is probably high because there are probably regions of lower velocity where such large particles would settle out before reaching the stack and no correction has been made for the effect of temperature or viscosity. Actually, particles approximately one tenth this size have been found.

[redacted]

2. Minimum Size of Primary Particles from Pile Stack

Since it is unlikely that there is efficient means of particle dispersion in the pile, it seems improbable that there would be many particles smaller than a few microns. Certainly there would be none smaller than the crystallite size of the UO_2, which in the sample of dust examined by X-rays by M. Bredig was of the order of several hundredths of a micron.

3. Distribution of Particles from Pile Stack According to Particle Size

(a) Since the largest particles would require only a few seconds to fall the height of the pile stack, they could not be transported more than 200 feet from the base of the stack, or perhaps 500 feet on a very windy day.

(b) Particles of 500 micron diameter would fall at a rate of 10 to 15 (Alexander, loc. cit.) feet per second and therefore at a wind velocity of 15 miles per hour would be deposited at 350 feet from the stack.

Particles 100 microns in diameter would fall at approximately 2 feet per second and could be deposited up to one half mile from the stack at this wind velocity. The exact pattern of deposition would depend greatly on meteorological conditions.

If any appreciable fraction of 50 slugs has been dispersed over the plant area in particles of this order of size, it could amount to about 100 to 1000 particles per square foot.

(c) Particles of 10 microns or less would require 2 hours or more to fall the height of the stack in still air and would therefore be scattered over a distance of many miles from the stack. Under certain conditions (low wind velocity, coagulation with larger particles, condensation of water on the particle acting as a nucleus, or being caught by a raindrop) smaller particles would be deposited with greater than normal frequency near the pile. Under favorable conditions some of these particles would remain suspended indefinitely.

Project Cirrus is reported to have some information about the trajectories of particles of this order of size.

4. Size of Primary Particles from Other Possible Sources

On the basis of experience a reasonable estimate of the particle size from other possible sources of additional contamination can be made.

(a) Particles resulting from mists from dissolvers will in general be less than 100 microns (calculated from the size of water droplets carried up the stack and the concentration). By and large the particles produced by this method would probably be much smaller than those from the pile stack, say of the order of 0.5 to 5 microns. Moreover, these particles could probably be identified as coming from solution if they could be mounted so they could be observed in the optical microscope due to their spherical or crystalline shape, whereas the particles from the pile would be irregular in shape.

It is the usual experience that when 1% solutions are purposely dispersed with an efficient atomizer, most of the particles are between 0.1 and 0.5 micron. Without an efficient atomizer, the particles would be larger.

On account of the size (calculated above), such particles would be deposited over a fairly large area. Furthermore, particles from dissolvers would consist mainly of uranyl nitrate, which would probably be further disseminated to harmless concentrations by rain. Such particles would seem to be much less dangerous than particles insoluble in water.

(b) An example of a source of very small particles (though limited in amount) of material is the spectrum analysis apparatus. Such a method of dispersion usually produces particles of the order of 0.01 to 0.05 micron in diameter, which are usually aggregated together in small chains.

5. <u>Secondary Particles</u>

(a) Since a particle once deposited is unlikely to be resuspended in the air from the roads, or from construction work, during dry weather, the frequent occurrence of such resuspended particles near the roads (Health Physics data) is evidence that a very considerable number of particles has been dispersed over the area.

(b) In a few cases resuspended particles may be smaller than the original particles, but it is unlikely that any considerable amount of comminution would occur and, in any event, the particles would not be less than 0.05 micron in size, which is the limiting size produced by fairly efficient grinding. Cases where a small radioactive particle becomes attached to a larger non-radioactive particle may also be expected to occur with some frequency, either by coagulation before deposition or resuspension.

(c) The methods suggested by Health Physics (Report No. ORNL 146) would seem to be capable of reducing still further the possibility of resuspension of particles already deposited. Their efficiency should, of course, be checked.

(d) While the frequency of such particles inside buildings is much lower, (Health Physics data) consideration should be given to vacuum dusting (with efficient filtration) and special emphasis on the use of sweeping compounds.

(e) Filters should be installed in air intakes of air conditioning systems. Particles greater than a few microns in size would normally sediment out fairly quickly inside buildings, but might not fall very quickly if there were circulation.

6. <u>Summary of Expected Particle Size and Distribution</u>

(a) On account of the relatively poor dispersion mechanism in the pile, it is to be expected that most of the mass of the material will be in the larger particle sizes, say 100 microns up to a limit which appears to be at about 500 microns from Health Physics measurements. These particles will be too large to be inhaled and will quickly settle out within one half mile of the plant. A small proportion of these particles may be broken up and resuspended from time to time, e.g., from the roads.

(b) A certain proportion of the mass smaller than the above will be dispersed particles of 10 to 100 microns. These particles will be dispersed over a much wider area.

(c) A very small amount of the material will be broken up into many small particles of 10 microns or less. Normally such particles will stay suspended almost indefinitely and only be deposited by coagulation with other particles and then settling, or by acting as a nucleus for a rain drop or being caught by it. This material will, therefore, usually be distributed over a very wide area down wind from the pile - possibly a certain small amount would be carried long distances of the order of 100 miles. Under certain meteorological conditions this material may not be adequately dispersed.

(d) Due to the inefficiency of dispersion, there are probably very few particles less than 1 micron in size.

(e) These suggestions re the normal wide dispersion of the smaller particles are based partly on observations of smelter smoke at Noranda, Que. and Trail, B. C. At the former place the smoke issued from a 400 foot stack and continued to the horizon in a well defined column which gradually increased in size, but did not come down to the ground. Under rather rare meteorological conditions (a few days a year) the smoke settled near the stack. This occurrence was so rare that no damage to vegetation developed. At Trail, B. C., unfavorable meteorological conditions were more frequent, and sufficient damage to vegetation occurred that the company suffered heavy lawsuits. The situation was

[redacted]

corrected by careful control of stack gases and shutting the smelter down under particularly unfavorable meteorological conditions.

7. Effect of Particle Size on Probability of Inhalation

Based on the behavior of small particles in dust removal devices such as cyclones, filters, etc., it is possible to make a reasonable estimate of the probability of inhaling a particle of a given size.

Particles smaller than 1 micron will penetrate practically every opening in the lungs. A certain proportion may go in and come out again (as in exhaled tobacco smoke), but a part will be deposited. So far as is known no measurements have been made of the fraction being deposited, but it would be expected to be at least 50% - based on the behavior of particles in filters.

As the particle size increases from 1 to 10 microns the probability of the particle getting caught in the nose or throat increases rapidly so the likelihood of the particle entering the lungs is reduced to a small value - as a guess, a probability of .01 at 10 microns might be hazarded.

Above 10 microns the probability is very small, but not infinitely small, for particles up to the size of the human alveoli(20 to 30 microns). While the probability of any single particle entering the lungs may be extremely small, exposure of many people over a long time makes it certain to occur occasionally.

Particles up to approximately 100 microns could be caught occasionally in the nose or throat.

8. Probability of Inhaling Particles

(a) While (1) a considerable part of the material is in the form of large particles, which settle out quickly, and are too large to be inhaled and (2) the much smaller amount of material in small particles would be more adequately diluted under most meteorological conditions are rather fortunate occurrences, yet one must be convinced from Health Physics data (loc. cit.) that particles capable of being inhaled occur sufficiently frequently that almost everyone on the plant has inhaled particles.

(b) On account of the wider dispersion of the smaller particles a small, but finite, probability of inhalations may exist over the most of East Tennessee.

9. Comparison with Usual Toxic Dusts

(a) Silicosis is caused by the introduction of great numbers of very small particles (0.05 micron as shown by electron micrographs) into the lungs for long periods of

[redacted]

[redacted]

time. Similarly, beryllium oxide of this size will produce pathological effects. It is found that coarser dusts of these materials (0.5 micron and greater) which are found in other process operations are much less harmful. This evidence is based on work for the Banting Institute, Toronto on silicosis, and on recent project and industrial experience with beryllium oxide.

(b) In the present case, the total effect of all the particles is small and the hazard is caused by the material occurring in one particle rather than being distributed more widely. Under such conditions it is the larger particles (one may be sufficient) which are more dangerous, even though their probability of inhalation is smaller. For this reason the upper limit of dangerous sizes of industrial dust, which is usually given as approximately 2 microns, should not be considered valid with the present material.

It is difficult to estimate accurately the biological hazard from particles of a given size, and it will probably be necessary to determine this by animal experiment.

10. <u>Behavior of Cyclones, Filters, etc. with Respect to Particle Size</u>

If, as seems probable, the most hazardous particles come from the pile*, it is desirable to consider factors concerning the efficiency of various possible devices for removing the dust. Most of the problems will undoubtedly be of an engineering nature and, particularly regarding servicing and maintenance, much more difficult than are usually met with in the use of such equipment. However, the following facts may be of some use in considering the choice of equipment:

(a) <u>Cyclones</u> may be fairly efficient for particles larger than 10 microns, but their efficiency will decrease to zero for particles less than 1 micron.

(b) <u>Fibre filters</u> catch the larger particles on account of (1) their momentum and (2) the stream line containing the partacle approaching closer to the film than the particle radius, and catch the smaller particles (chiefly those less than 0.25 micron) on account of their Brownian movement. There is thus a range of particle sizes (approximately 0.25 to 0.50 micron witch penetrate a filter more readily than other sizes. This information is from V.D.G.I., 80, 593, 1936. As might be expected, the Chemical Warfare Services of Britain, Canada, and the United States have additional and more accurate information on this and other types of filters.

* The importance of resuspended particles would decrease gradually if particles were not being added.

[redacted]

For a given pressure drop the Chemical Warfare filters are much more efficient than glass wool filters.

(c) An efficient means of removing the dust would probably reduce the hazard by a factor of about 1000.

11. <u>Remarks on the Efficiency of Health Physics Collecting Devices with Respect to Particle Size</u>

These remarks are based on previous experience, or simple experiments.

(a) <u>Sedimentation Frames</u>: It is unlikely that sedimentation frames would be effective for particles less than 5 to 10 microns in size, but they should be satisfactory for the larger particles.

(b) <u>Filtron Units</u>: Simple experiments have shown that the small Filtron units have a low efficiency for catching the larger particles due to the horizontal openings and relatively low air velocity. It would appear that they would be reasonably efficient for particles below 10 microns and that the efficiency would decrease to a few percent at 100 microns.

Taking into account that their total rate of sampling is greater than that of human respiration, but that the intake in the latter occurs in about one half the cycle, the collecting efficiency of these units should approximate that of human respiration rather closely. Most of the larger particles would, of course, be caught in the nose or throat.

Another observation of interest with respect to the Filtron unit is that the deposit will be denser immediately over the opening of the vertical suction tube.

(c) For off-plant area collections the sedimentation frames might not be very satisfactory, since all the large particles would have settled out and the small ones would not be collected efficiently.

10-19-48

AIR WAYS COLLECTIONS
(Particles/1000 ft^3 Air)

[illegible]	Hours	#1 703-C	#2 719-A	#3 701-B	#4 706-B	#5 115	#6 Top of Pile	#7 101-B	#8 706-A (Out)	#9 706-A (In)	#10 1200' E	#11 Dog House	#12 105 NW (Out)
-10	47	.013	.013	.026	.013	.039							
-11	24	.0	.101	.177	.126	.101							
-12	19	.064	.064	.095	.032	.064	7.209	.032	0				.351
-12	6	.707	.202	2.020	.910	1.919	.303	.409		.303			.303
-13	24	.404	.025	.152	.177	.202	.275	.126	0				.076
-15	40	0	.045	.091	.015	.091	.288	.106	.015	.045			.015
5-15	10	.303	.242	.242	.242	.364	.788	.364	.242	.182			1.394
5-16	12	.707	2.071	.910	.454	.353	1.061	.152	.152	.152	1.364	.404	.758
6-16	6	.707	.606	0	.202	1.010	.808	.101	.101	.707	.606	.101	0
6-17	12	.152	0	0	.152	.101	.858	0	.202	.202	.101	.303	.050
18-17	12	.050	.101	.050	.050	.505	0	0	0	0	0	0	.050

(1.333 - 2 hours, 706-C)

ChemRisk Document No. 1316

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David R. Hamrin 4/15/96
Technical Information Officer, ORNL Site — Date

FILE Particle Problem

10-19-48

AIR WAYS COLLECTIONS
(Particles/1000 ft^3 Air)

Date	Hours	#1 703-C	#2 719-A	#3 701-B	#4 706-B	#5 115	#6 Top of Pile	#7 101-B	#8 706-A (Out)	#9 706-A (In)	#10 1200' E	#11 Dog House	#12 105 NW (Out)
8-10	47	.013	.013	.026	.013	.039							
10-11	24	.0	.101	.177	.126	.101							
11-12	19	.064	.064	.095	.032	.064	7.209	.032	0				.351
12-12	6	.707	.202	2.020	.910	1.919	.303	.409		.303			.303
12-13	24	.404	.025	.152	.177	.202	.275	.126	0				.076
13-15	40	0	.045	.091	.015	.091	.288	.106	.015	.045			.015
15-15	10	.303	.242	.242	.242	.364	.788	.364	.242	.182			1.394
15-16	12	.707	2.071	.910	.454	.353	1.061	.152	.152	.152	1.364	.404	.758
16-16	6	.707	.606	0	.202	1.010	.808	.101	.101	.707	.606	.101	0
16-17	12	.152	0	0	.152	.101	.858	0	.202	.202	.101	.303	.050
17-17	~~.050~~ 12	~~.101~~ .050	~~.050~~ .101	~~.10~~ .050	.050	.505	0	0	0	0	0	0	.050

(1.333 - 2 hours, 706-C)

A - A.M.
P - P.M.
2 - Swing Shift
3 - Night Shift

FILTRON COLLECTIONS
(Particles/1000 ft^3 air)

Date		706-A	205	105	706-D	104-B	703-B	706-B	Rain	Comments
8/4	P	1.67		0	0	0			.10	
8/5	A			0		0				
8/6	A		0	0						
	P		0	0	0					
8/7	A				0					
8/8	A				1.67					
8/9	A		0		10.0	0				
	P		0		0					
8/10	A	0	0	0	214.9					(C)
	P			0						
8/11	A		0	0	20.0	0			.10	
	P		0	0	167					
8/12	A		0	0	5.00				.10	
	P	1.67	0	0	0					
8/13	A		3.33		8.33				.30	
	P	6.67	0		3.33					
8/14	A				1.67					
8/15	A	0							.40	
8/16	A		0		1.67					(C)
	P	0	1.67	1.67	6.67					
8/17	A	1.67	0		0					(C)
	P		0	0						
8/18	A	0	0	0	0					
	P	0	0		95					

Filtro Collections

Date		706-A	205	105	706-D	104-B	703-B	706-B	Rain	Comments
8/19	A		0	1.67	0					
	P		0	0	0					
8/20	A		0							
	P	0		0						
8/21	P				0					
8/22	A				0					
8/23	A		10.00							
8/24	A		3.33							
	P		63.4							
8/25	A		0							BaLa Run
	P		23.4							
8/26	A		26.67							
	P		23.4							
8/27	A	5.00	31.67							
	P	18.33								
8/28										
8/29										
8/30	P	3.33			6.67					
8/31	A	3.33		11.7	1.67					
	P	1.67	11.7	48.3	1.67	0	0			* Mult. Burst
9/1	A	2.22	17.77	14.4	11.1	44.5	13.3			
	P	2.22	8.89	15.6	13.3	16.7	3.33			
	2			11.1	1.11					
	3			3.33	22.4					
9/2	A	8.33	1.11	15.6	106	5.00	2.22			
	P	3.33		2.22	3.61		2.22			
	2			4110	4060					
	3			260	124					

Filtro[illegible]ollections

Date		706-A	205	105	706-D	104-B	703-B	706-B	Rain	Comments
9/3	A	16.67			15.6	5.00				BaLa Run. Removal
	P	26.67	4.45		31.1	3.33				
	2				33.3					
9/4	P			21.1	4.44					
	2				22.4					
	3				4.45				.20	Roads oiled.
9/5	A			1.11	7.79					
	P				0				.10	
9/6	A			0	2.22					
	2				1.11					
	3				0				.20	
9/7	A	3.33	1.11		11.1	0	2.22		1.00	
	P		41.7		1.11					
9/8	A	3.33	11.11		11.1		7.78		.05	
	P				22.2	7.78	26.7			
	2				Fogged					
9/9	A				50.0	8.89				
	P				11.1					
	2				18.9					
9/10	A				3.33					
	P				11.1					
	2				1.11					
9/11	A				2.22					
	P				3.33					
9/12	A				15.0					
	P				5.56					
9/13										
9/14	2				2.22					
9/15	2				3.33					

Date		706-A	205	105	706-D	104-B	703-B	706-B	Rain	Comments
9/16 - 9/19		---								
9/20	A		4.44							
	P		0		14.4		26.7			Slight Burst.
	2				13.3					Roads oiled.
9/21	A	31.1		13.3	185	0	0			
	P	22.2	0	5.56	14.4	6.66	2.22			
	2				10.0					
	3				8.89					
9/22	A	6.81	4.44	13.3	1.11	6.67	5.55		.05	(C)
	P				13.3		13.3			
	2				22.2					
	3				2.22					
9/23	A		0		10.0	11.1	2.22			
	P				12.2	14.4	8.33			
	2				10.0					
	3				8.89					
9/24	A			3.33	1.11	3.33	4.44			
	P		7.78	2.22	10.0	4.44				
	2				7.78					
	3				10.0					
9/25	A				3.33					
	P				5.56					
	2				5.56					
	3				31.1					
9/26	A				8.89					
	2				5.56					
	3				3.33					
9/27	A	4.44	10.0	2.22	11.1	10.0	3.33			
	P		4.44	16.0	4.44	3.33	5.56			
	2				11.1					
	3				0					

Filtron Collections

Date		706-A	205	105	706-D	104-B	703-B	706-B	Rain	Comments
9/28	A	1.11	4.44		1.11	2.22	0	.	.10	(C)
	P		1.11		0	3.33	2.22			
	2				2.22					
	3				6.67					
9/29	A	0	2.22	7.78	3.33	0	5.56			
	P		2.22	2.22	6.67	0				
	2				1.11					
	3				5.56					
9/30	A		0	10.0	117	4.44				
	P	2.22	1.11			1.11	1.11			
	2				14.4					
	3				0					
10/1	A		6.67		8.89	20.0	1.11			
	P	15.6	11.1		3.33	7.78	0			
	2			11.1	3.33					
	3				8.89					
10/2	A				2.22					
	2				2.22					
	3				8.89					
10/3	A				0					
	2				5.56					
	3				11.1					
10/4	A	3.33		0	2.22	0	0			(CC)
	P		23.4	11.1	7.78	3.33	13.3			
	2				1.11					
	3				8.89					
10/5	A	2.22	2.22		1.11	2.22	0			
	P		1.11	1.11		18.3	0			
	2		1.67	3.33	0			0		
	3				3.33			6.67		

Date		706-A	205	105	706-D	104-B	703-B	706-B	Rain	Comments
10/6	A	1.11	5.56	3.33			4.44	6.67		
	P		5.56	[illegible]	17.8		1.11			
	2		3.33	6.67	6.67					
	3				0					
10/7	A	3.33		4.44	0		0		.10	
	P			0	2.22					
	2				1.11					
	3				4.44					
10/8	A	10.0	1.11	2.22	137		0			
	P		0	0	3.33					
	2		3.33	2.50	3.33					
	3				2.22					
10/9	P				2.22					
	2		3.33	3.33	5.28					
	3				4.44					
10/10	A				0					
	2		6.67	5.00	3.89					
	3				4.44					
10/11	A	0	1.11		2.22		0			
	P		1.11	10.0	2.22		8.33			
	2		2.22	1.67	.55					
	3				5.56					
10/12	A	6.67	2.22	1.11	0		10.0			
	P		0	6.67	2.22		0			
	2		1.67	1.67	0					
	3				0					
10/13	A		2.22	0			0			
	P		0	2.22	0		3.33			
	2				7.78					
	3				0					

Filtron Collections

Date		706-A	205	105	706-D	104-B	703-B	706-B	Rain	Comments
10/14	A	1.11	2.22	3.33	1.11		.83			
	P		4.44		4.44		0			
	2				1.11					
	3				0					
10/15	A	0	3.33	3.33						
	P		0	1.11	10.0					
10/16	Nite	0		.25	0	0	.29	.25		
	Day	0		.61	.61	0	0	.67		
10/17	Nite	0		.55	.53	0	.21	0	1.65	

10-21-48

NATIONAL HEALTH SERVICE COLLECTORS

Particles/ 1000 ft^3

Date	No. 1 706-D E Platform	No. 2 E of 115	No. 3 W of 703-C	No. 4 E corner of 104-B. Duct out window	No. 5 AEC Admin. Bldg. between S1 and S2
9/22/48				—	
9/23					
9/24	—	—	—		
9/25					
9/26					
9/27					
9/28		.840		.070	
9/29					
9/30					
10/1		—			
10/2					
10/3		Plug	.049		
10/4		pulled			
10/5	.887	—		—	
10/6					
10/7					
10/8				.021	
10/9		1.077			
10/10					
10/11					
10/12				—	
10/13			—		
10/14				.014	—
10/15					
10/16 A	.052	.121		.110	
10/16 P	.555	.984		.174	
10/17 A	.139	.145		.058	
10/17 P	.504	5.47		.023	
10/18 A	.156	.070		.029	
10/18 P	.051	.266		.023	
10/19 A	.029	.011		.023	
10/19 P	.249	.608		.035	
10/20 A					—

JSCheka:mco
10/21/48

[redacted]

OAK RIDGE NATIONAL LABORATORY
Division of
Carbide and Carbon Chemicals Corporation
Oak Ridge, Tennessee

Contract Number W - 7405, Eng. 26

HEALTH PHYSICS DIVISION

TO: C. N. Rucker

FROM: Karl Z. Morgan

SUBJECT: Remedial Measures Regarding the Particle Problem.

September 15, 1948

Distribution:

1. [redacted]ucker
2. [redacted]ernett
3. [redacted]
4. [redacted]n
5. [redacted]einberg
6. [redacted]ardwell
7. [redacted]ander
8. [redacted]ohnson
9. E. [redacted]hcraft
10. J. [redacted]wart
11. L. [redacted]
12. M. [redacted]eterson
13. J. [redacted]elton
14. Cl[redacted]ester
15. K. [redacted]organ
16. K. [redacted]organ
17. Ce[redacted] Files
18. Ce[redacted] Files

Receive[redacted]/48 [redacted]ssued: 9/16/48

[redacted]

Fan K Z Morgan

FILE Particles

Rucker, N.
Barnett, S. C.
Barnett, F.P.
File (WR)

PARTICLES/FRAME/24 HR. PERIOD

Frame No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Rain	Comments
Direction	SW	S	NW	SE	SE	E	SSW	W	NNE	NNE	N	SSW	SE	W	SSE	SSE	SSW	NE	NE	N	SE	SE		
Distance (ft.) from 105 stack	700	1200	800	900	600	650	1850	1700	1050	150	55	125	75	160	900	1550	1600	6500	11500	3000	750	325		
6/19																							.20	
6/20																								
6/21																								
6/22																								
6/23																							.70	
6/24																								
6/25																								
6/26																								
6/27																							.10	
6/28																								
6/29																								
6/30																								
7/1																								
7/2																								
7/3																								
7/4																								
7/5																								
7/6																							.05	
7/7																							.20	
7/8																							.20	
7/9																							.70	
7/10																							.40	
7/11																								
7/12																							2.40	
7/13																							.50	
7/14																							.10	
7/18																								
7/20																								
7/21																								
7/22																								
7/23																								
7/25																								
av.			av. 0.29 (6/19–7/25)		av. 10.62 (6/19–7/25)	av. 2.75 (6/19–7/25)	av. 1.36 (6/19–7/22)				av. 5.44 (6/19–7/25)		av. 3.61 (6/19–7/22)											

ChemRisk Document No. 1316

Particles/Frame

Frame No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	rain
7/26																							.10
7/27																							.60
7/28																							.60
7/29																							
7/30										63													
7/31										60													.20
8/1																							
8/2			0.29		10.62	2.75				0.80	5.44												.40
8/3																							.80
8/4																							.10
8/5																							
8/6																							
8/7																							
8/8	26.5																						
8/9		2.33	1.71	2.50	28.0	1.00	2.50	2.18	1.88	13.2													
8/10																							
8/11																							
8/12																							.10
8/13																							.10
8/14																							.30
8/15																							
8/16	12.6	1.7	3.9	5.7	75.7	17.7	2.0	2.9	5.3	17.7													.40
8/17																							
8/18																							
8/19																							
8/20	—	—	—	—	—	—	—	—	—	—													
8/21																							
8/22																							
8/23	12.2	4.8	13.0	12.2	372.8	109.8	6.0	3.3	14.5	57.3													
8/24																							
8/25																							
8/26	—	—	—	—	—	—	—	—	—	—													BaLa Run
8/27																							
8/28																							
8/29	128.0	27.5	3.3	29.8	201.7	122.7	13.5	20.5	6.5	60.2													
9/1	—	—	—	—	—	—	—	—	—	—												8/31 Multiple burst	

articles/Frame

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Rain	
/2	79	21	45	43	375	121	11	25	56	1191														↓ Multi.Burs
/3	295	55	56	202	493	250	30	31	143	2000	1800	1700	2200	2100	122	25	200						.20	BaLa Run. Removal.
9/4																							.10	Roads oiled
/5																							.20	
/6	47.4	11.0	38.4	17.2	20.6	17.8	3.6	2.0	38.8	82.2				75.6	2.8	5.8	3.6						1.00	
/7											27.8	39.3	30.3										.05	
/8																								
/9	36	49	105	92	85	25	48	58	25	126				83	36	46	62						.20	
/10																								
/11	11.0	17.2	7.0	9.0	49.5	18.0	10.2	13.7	15.2	34.7	29.3	33.0	11.5	64.2	25.5	20.0	16.5							
/12																								
/13																								
/14	5				46	42				72	221	110	31	147										
/15	100				104	11				116	191	159	152	120										
/16	91	7.7	16.3	6.7	271	82	14.3	24.3	16.7	18	20	32	18	159	7.7	11.3	10.0	14	19	12	25	74		
/17	120				460	97				37	56	168	95	107										
/18																								
/19	27.0	11.5	8.0	30.0	419	345	9.0	14.0	24.0	134	147	219	112	53.0	28.3	7.3	67.8	12.0	22.2	10.0	49.5	136		
/20																								Roads oiled.
/21																								
/22	34.0	32.3	9.7	33.0	152	28.0	[illegible]0	35.7	15.3	17.3	18.7	433	58.3	19.7	57.3	[illegible].0	20.7	6.7	4.3	3.0		103	.05	
/23																								
/24																								
/25	64.0	14.5	1.0	0.25	15.0	2.0	2.7	9.5	1.2	2.2	5.0	16.5	2.8	2.5	13.5	8.2	4.5	3.0	2.0	3.2		5.8		
/26																								
/27																								
/28										12	12	12	20										.10	
/29	8.3	8.3	10.3	41.0	90.7	212	2.7	17.7	18.7	294	32.5		103	29.7	13.3	7.7	8.7					20.7		
/30												96.0						6.8	12.0	12.2				
/1										140	143		81											
/2																								
/3		2.8	5.8	38.5	39.5	81.5	21.2	12.0	15.2	98.0	255	931												
/4																								
/5										50	51	229	18.8											
/6										28	24	309	25											
/7		6.7	3.0	2.5	11.5	6.3	24.3	8.3	0.7	68	18.5	17.5	43.5	5.5	.75	1.0	2.3	1.0	1.1	1.3	2.0	2.0	.10	
/8																								

Particles/Frame

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Rain	Comments
10/9																								
10/10																								
10/11	2.0	4.5	2.5	11.5	19.5	24.3	2.2	1.5	7.0	110	8.9	108	119	11.0	2.5	2.2	1.3	2.2		1.3	4.6	16.3		
10/12																								
10/13																								
10/14																								
10/15	65	25	24	26	13	6	11	66	4	27	14	20	52	58	5	13	8	6	17	9	4	26		

PARTICLES/FRAME/ 12 HOURS

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Rain	Comments
10/16	A	12	2	4	2	7	17	2	19	10	163	473	53	200	91	1	1	8	9	5	21	53	31		
	P	3	4	4	1	3	2	1	3	0	5	10	6	17	20	2	4	3	2	2	1	3	5		
10/17	A	2	1	1	4	4	4	8	11	1	0	4	7	5	30	4	2	5	10	14	8	3	3		
	P								N O	C O L	L E C	T I O	N -	Rain										1.65	
10/18	A	5.3	0.8	0	1.2	2.0	3.2	0.8	2.0	1.2	9.2	7.2	8.0		41.3	0.8	0	0	0	0	72	1.6	1.6		30 hrs.
	P	14	38	2	8	2		10	8	8	4	368	6	2	4	8	8	2	0	2	6		8		6 hrs.
10/19	A	5	6	2	1	30	1.5	1	10	3	3	16	4	3	0	5	10	3	1	2	2	2.5	3		
	P																								

J. S. Cheka
10/21/48

[redacted]

OAK RIDGE NATIONAL LABORATORY

To: C. N. Rucker

From: Karl Z. Morgan

Subject: Remedial Measures Regarding the Particle Problem.

For the past two months the Health Physics Division has devoted considerable effort to the Particle Problem. Some of the data concerning this Particle Problem have been reported. (See Report No. 48-8-86 by K. Z. Morgan; Report No. ORNL-146 by J. S. Cheka and H. J. McAlduff; also attached data sheets.)

At present we have not been able to assess with any accuracy the biological hazard introduced by these particles because sufficient biological experiments have not been undertaken. Some such experiments are being considered at various sites, but since the principal concern is the possibility of the development of cancer at the site of these particles of high specific activity in the lungs, it will require several years of experimentation before the necessary data is accumulated. In the past, only the gross effects have been studied and it has been assumed that the airborne material from broken slugs consisted primarily of radioactive gas and extremely finely divided material that was more or less uniformly distributed in the lung tissue. Calculations based on these assumptions have indicated that at no time has the concentration in the air (at the numerous points of measurement in the X-10 Area) exceeded the daily permissible exposure to the lungs.

Some time ago experiments were undertaken at the University of Chicago in which microgram quantities of plutonium (≈ 1/16 microcurie) were placed in open wounds of animals. In a period of twenty-four hours approximately fifty percent of the plutonium was translocated from the wound site to other parts of the body. The plutonium that became fixed at the wound site was shown to present a very large probability of the development of cancer at that point. It is not known what minimum concentration of plutonium will produce cancer in such a wound and, likewise, it is not known what the relative sensitivity of lung tissue and skin and muscle tissue is in the production of cancer.

[redacted]

Part of the data in the reports referred to above has been obtained at various locations in the X-10 Area by air sucking apparatus, collecting particles by breathing air through a paper filter at approximately ten times the rate of human respiration. The number collected varies considerably with location and with time, from zero to several hundred particles per hour. We can only assume that man, in the same location, would breathe a similar number of particles, some of which would be deposited in the respiratory tract. Our radiographical analysis of these particles indicates that all sizes are being airborne, and so we are led to suppose that particles of various sizes may be deposited in different portions of the respiratory tract. The smaller particles, that have a high probability of reaching the alveoli, fortunately have a very low specific activity and calculation indicates that they would be capable of destroying only a thin layer of cells surrounding them. Whether or not this represents a serious damage no one seems to know.

Our investigation has indicated that some of the larger particles may reach the lower portion of the bronchial tree and be held up there for some time before they are removed by the cilia. Such particles do not remain long enough to introduce any silicosis type hazard. However, they may remain long enough to destroy many hundreds of cells which remain in their neighborhood for a few hours.

In summary, I would like to state that we do not know whether or not a serious hazard exists. We do know that there is a large probability that radioactive particles are being held up in the respiratory system. The very fact that such a hazard, difficult or impossible to assess at this time, exists has led me to suggest that we consider seriously taking positive action that will minimize the possibility of adding to this hazard. I would like to suggest that consideration be given to taking the following remedial measures:

1. Fix the particles that are already settled in the X-10 Area so that they will not be airborne repeatedly.

    a) Plant grass.

    b) Wash particles off roofs, hard surface roads, etc. with a fire hose.

    c) Hard surface all permanent roadways and keep the other roadways oiled.

    d) Block off roadways that are not needed.

2. Determine the location of all particle producing operations and discontinue or postpone these operations (with the exception of the pile operation) until filters, precipitators, and other particle removing equipment are installed.

   a) Investigate the possibility of postponing or eliminating the RaLa runs until particle removing equipment is installed.

   b) Adopt similar precautions regarding other operations, such as redox, that are proven to contribute to the number of particles in the X-10 Area.

3. Remove ruptured slugs from the pile only during favorable meteorological conditions and when there are a minimum number of persons in the X-10 Area.

   a) Remove slugs only when there is a wind equal to or greater than 8 miles per hour and no inversion, and when the wind is not blowing over the plant area. This will, in general, preclude a ruptured slug removal operation except during the day shifts of Saturday and Sunday, since inversions continue throughout practically every night.

4. During a period of a week following a known slug rupture, discontinue the pile operation when the following conditions exist:

   a) An inversion.

   b) A wind velocity less than 5 miles per hour.

   c) The wind is blowing from the northeast or east.

   This will mean that for a week following a slug rupture the pile will not ordinarily operate at night and it will operate about half time during the day.

5. Move with the maximum reasonable speed to place in service particle removing equipment wherever needed.

   a) This is a problem for the Engineering Division.

6. Use every reasonable precaution to locate and remove a ruptured slug as soon as it occurs.

   a) This is a problem for the Operations and Engineering Divisions.

7. Begin an investigative nose swiping program, in which approximately 50 selected persons would stop by the Dispensary Building for a nose swipe at the close of each work day.

    a) This would be a joint project of the Health Division and the Health Physics Division. The Health Division would collect the swipes which would be collected, placed in envelopes, and turned over to the Health Physics Division to monitor for beta and gamma activity. (The same 50 persons would be used throughout this experiment.)

8. The Health Physics Division should continue to collect information concerning the Particle Problem as follows:

    a) Origin.

    b) Size distribution.

    c) Frequency and number.

    d) Activity (alpha, beta, and gamma).

    e) Effectiveness of above remedial measures.

    f) Hazard involved.

9. Develop new instruments for measuring the activity leaving the pile in particulate form, and detect ruptured slugs at the earliest possible date after their occurrence.

    a) This is a problem primarily for the Physics and Chemistry Divisions.

Perhaps other remedial measures will be suggested when more information becomes available.

Karl Z. Morgan

KZM:fsc

APPENDIX A

PARTICLES COLLECTED WITH FILTRONS

The values given in the following tables express the number of particles collected over the number of hours the filtron was run. The number of particles collected was determined by placing an X-ray film, protected from radioactive contamination by a sheet of heavy paper, in contact with the filter; exposing the film for 24 hours, and counting the resultant spots on the developed film. All visible spots are counted, representing particles ranging in activity from less than a hundred disintegrations per minute to several thousands of disintegrations per minute.

Many, or most, of the particles collected by the filtron and producing visible spots on the film are too large to have a high probability of being breathed into the lungs if entering the nostrils. It is presumed that other particles of smaller sizes and lower activities which escape observation against the more or less diffuse background of darkened film resulting from the thousands of microscopic or sub-microscopic particles on the filter, may have activities which are individually significant. For the purpose of comparing volumes of air, the filtron has an airflow of some 300 cubic feet per minute; and a man may be expected to breathe from 150 to 300 cubic feet per 8 hour day if moderately active.

Particles Collected with Filtrons

Date	706-A		105		104-B		706-D		205		703-B	
	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.
8-4		1/2		0/2		0/2		0/2				
8-5			0/2		0/4							
8-6			0/2	0/2				0/2	0/2	0/2		
8-7							0/2					
8-8							1/2					
8-9					0/4		6/2	0/2	0/2	0/2		
8-10	0/2		0/2	0/2			129/2		0/2			
8-11			0/2	0/2	0/4		0/2	0/2	0/2	0/1		
8-12		1/2	0/2	0/2			3/2	0/2	0/2	0/2		
13	0/2	4/2					5/2	2/2	2/2	0/2		
8-14							1/2					
8-15	0/2											
8-16		0/2		1/2			1/2	4/2	0/2	1/2		
8-17	1/2			0/2			0/2		0/2	0/2		
8-18	0/2	0/2	0/2				0/2	57/2	0/2	0/2		
8-19		1/2	0/2				0/2	0/2	0/2	0/2		
8-20		0/2		0/2					0/2			
8-21								0/2				
8-22							0/2					
8-23									6/2			
8-24									2/2	38/2		
8/25									0/2	14/2		
26									16/2	14/2		
8-27									11/2	19/2		
8-28												

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Particles Collected with Filtrons (Continued)

Date	706-A		105		104-B		706-D		205		703-B	
	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.
8-30		2/2										
8-31	2/2	1/2	7/2	29/2		0/1	1/2	1/2		7/2		8/2
9-1	2/3	2/3	13/3	14/3			10/3	12/3	16/3	8/3	12/3	3/3
				10/3								
				3/3								
9-2	5/2	2/2	14/3	2/3	3/2		95/3	5/3	1/3		2/3	
				3700/3				3600/3				
								11/3				
9-3		12/1.5			3/2			28/3				
								5/0.5				
								112/3				
9-4				9/13				4/3				
								11/3				
9-5			1/3				7/3	0/3				
								4/3				
9-6			0/3				2/3	1/3				
								0/3				
9-7	2/2				0/3		10/3	1/3	1/3		2/3	

[redacted] ~~LIMITED~~

Particle Collection on Frames

Frame	Distance and Direction from 105 Stack	Date Out	Date In	Time	Number of Particles Total	Number of Particles 400 c/m
7	350' SW	6-19	7-22	33 days	45	4
9	75' SSE	6-19	7-22	33 days	119	11
10	150' NNE	7-29	7-30	24 hrs.	63	12
10	150' NNE	7-30	7-30	6 hrs.	12	3
3	900' SW	6-19	8-6	48 days	14	0
5	450' SSE	6-19	8-6	48 days	551*	13
6	500' E	6-19	8-5	47 days	129**	0
8	150' N	6-19	8-6	48 days	261	20
10	150' NNE	7-30	8-4	5 days	4	0
		(Relocation of some)				
1	700' SW	8-3	8-13	10 days	265 *	10
2	1200' S	8-4	8-13	9 days	21	1
3	800' WNW	8-6	8-13	7 days	12	0
4	850' ESE	8-5	8-13	8 days	20	0
5	600' SSE	8-6	8-13	7 days	196*	0
6	650' E	8-5	8-13	8 days	8	0
7	1850' SW	8-5	8-13	8 days	20	0
8	1700' W	8-6	8-13	7 days	15	2
9	1050' NNE	8-5	8-13	8 days	15	0
10	150' NNE	8-4	8-13	9 days	119	3

* These frames were near areas of vehicular traffic, and many particles were probably relocated. This would indicate that roadways inside the plant should be oiled or treated with $CaCl_2$ to immobilize the dust.

** This frame had been used as a foot-bridge and the count is, therefore, unreliable.

Particle Collection on Frames

Particles falling out of the atmosphere are collected on paper placed on the bottoms of 3' x 4' boxes. The dust on the paper is concentrated into an area which can be covered by a sheet of x-ray film, and monitored for radioactive particles by 24 hour exposure in near proximity to the particles. The method is subject to some loss of fallen particles.

The results of two weeks collection are given below. Locations of the frames are relative to the 105 stack.

Dates	700 SW	1200 S	800 WNW	850 ESE	600 SSE	650 E	1850 SW	1700 W	1050 NNE	150 NNE
8/13-20	88	12	27	40	530	124	14	20	37	124
8/20-26	73	29	78	73	2237	659	36	20	87	
8/31 to 9-1	671	165	20	179	1210	135	81	123	39	98
9/1-2	79	21	45	43	*	121	11	25	56	*
9/3-7	237	**	108	**	**	**	**	**	158	**

* Most of the particles involved here are not counted but are estimated at several hundred.

** Collections were not made on account of rain.

Particles Collected with Constant Air Monitors

The values given in the following table express the number of particles collected by constant air monitors operated continuously over the period indicated. The number of particles collected was determined by 24 hour exposure of an x-ray film in near proximity to the filter used for collection.

The constant air monitors are in relatively sheltered positions compared to other devices used for particle collection, hence the probabilities for collection of larger particles is lower.

For purposes of comparison, the flow of air through a constant air monitor is roughly 50,000 cubic feet per week or 7,000 cubic feet per 24 hour day. While it is estimated that normal breathing rates vary from 150 to 300 cubic feet per 8 hour day.

Constant Air Monitors

Dates	115-B	706-A	736-B
7-12 to 7-19	7	21	9
7-19 to 7-26	142	18	1
[illegible]-26 to 8-2	26	2	2
8-2 to 8-9	3	14	5
8-9 to 8-16	0	1	0
8-16 to 8-23	2	2	1
8-23 to 8-30	3	11	33
8-30 to 9-1	0	0	18
9-1 to 9-2	15	27	13

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PROGRESS REPORT ON THE PARTICLE PROBLEM

J.S. Cheka and H.J. McAlduff

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PROGRESS REPORT ON THE PARTICLE PROBLEM

J. S. Cheka and H. J. McAlduff

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PROGRESS REPORT ON THE PARTICLE PROBLEM

Specific activities of three UO_2 particles from the pile exhaust air duct were determined. The particles were isolated from the "junior" filter pad which was removed on July 21. Dimensions were measured by means of a Filar micrometer. The particles were then dissolved on Pt discs with nitric acid. After evaporation, the discs were counted for β-γ and α. β-γ counts were made at 10% geometry and 75% was allowed for back-scatter (Pt between Cd = 70%, and Pb = 80%).[1] For α counts 51% geometry was assumed. Specific activity in $\mu c/\mu^3$ was calculated for both β and α from these measurements. The results appear in Table I.

TABLE I

Specific Activity of Activated UO_2 Particles

Particle	Volume $\mu^3 x10^{-6}$	β and γ c/min(10% geom.)	β and γ $\mu c/\mu^3$	α c/min(51% geom.)	α $\mu c/\mu^3$
12	3.39	6,997	$5.4x10^{-9}$	31	$4.1x10^{-12}$
14	1.47	4,297	$7.6x10^{-9}$	23	$7.3x10^{-12}$
16	3.12	45,612	$3.8x10^{-8}$	44	$6.2x10^{-12}$

A hypothetical particle giving β tolerance* at radius 40 μ contains $1.3x10^{-8}$ $\mu c/\mu^3$.
A hypothetical particle giving α tolerance* at radius 40 μ contains $3.0x10^{-12}$ $\mu c/\mu^3$.

* While true tolerance [redacted]sources is not known, the term as here used indicates a rat[redacted]tion of 0.1 rep of β per gram of tissue or 0.01 re[redacted]am of tissue/day.

The 40 μ radius was chosen because it is the approximate range of Pu α in tissue [2], and within this range β and α exposures will be additive. The above figures show that the α exposure due to a 1 μ^3 particle at 40 μ is about twice "tolerance." The β activity on No. 16 at 40 μ is three times "tolerance." Since the only thing known about the "age" of these particles is that it is at least 15 days, it is likely that No. 12 and 13 are somewhat older. Using the value for No. 16, a 1 μ^3 particle produces radiation of five times "tolerance" at 40 μ.

On August 10, 1948, three areas previously surveyed (approximately June 18, 1948) [3] were probed with V-263's. Sampling areas in each case consisted of three rectangles, 10 feet by 5 feet. Results appear in Table II.

TABLE II

V-263 Survey

Point	Distance from Stack	Description	Particle Density 6/18/48	8/10/48
1	825' WSW	Recent fill (slope)	5/500 ft^2	12/150 ft^2
2	1425' WSW	703-A Annex	2/1000 ft^2	33/150 ft^2
3	425' NE	Flat	6/400 ft^2	32/150 ft^2

The above values do not show actual density of fall because of local characteristics. Point No. 1 showing a comparatively low frequency has a 30° slope, and is subject to erosive washing. Point No. 2 is the roof of 703-A Annex, and it was noted that particles were usually lodged in cracks in the tar or other crevices. Point No. 3 was flat and sparsely grass covered. The threshold sensitivity of the V-263 is approximately 400 c/m, subject to variation due to higher background caused by the less active specks.

Particle collection on ten 3' x 4' frames was continued. These are lined with kraft paper which is covered with fibre-glass. On collection, the paper is removed, the fibre-glass shaken, and the collected dust concentrated to an area which can be covered by a 14" x 17" X-ray film. The film is exposed in contact for 24 hours. Particles were found not to remain in the fibre-glass mat, but to sift through. To confirm this, one mat was exposed to film for 24 hours. No activity was detected.

A calibration of the film sensitivity was made using isolated particles ranging from 10 c/m to 48,000 c/m (at 10% geometry) and exposing in contact for 24 hours. This offers a measure of order of magnitude of the activity of particles detected, though not an accurate measure because of geometry changes due to larger debris on the collecting frames.

The summary of particles detected on these frames appears in Table III.

S[redacted]

TABLE III

Particle Collection on Frames

Frame	Distance and Direction from 105 Stack	Date Out	Date In	Time	Number of Particles Total	Number of Particles > 400 c/m
7	350' SW	6-19	7-22	33 days	45	4
9	75' SSE	6-19	7-22	33 days	119	11
10	150' NNE	7-29	7-30	24 hours	63	12
10	150' NNE	7-30	7-30	6 hours	12	3
3	900' SW	6-19	8-6	48 days	14	0
5	450' SSE	6-19	8-6	48 days	551 *	13
6	500' E	6-19	8-5	47 days	129 **	0
8	150' N	6-19	8-6	48 days	261	20
10	150' NNE	7-30	8-4	5 days	4	0
		(Relocation of some)				
1	700' SW	8-3	8-13	10 days	265 *	10
2	1200' S	8-4	8-13	9 days	21	1
3	800' WNW	8-6	8-13	7 days	12	0
4	850' ESE	8-5	8-13	8 days	20	0
5	600' SSE	8-6	8-13	7 days	196 *	0
6	650' E	8-5	8-13	8 days	8	0
7	1850' SW	8-5	8-13	8 days	20	0
8	1700' W	8-6	8-13	7 days	15	2
9	1050' NNE	8-5	8-13	8 days	15	0
10	150' NNE	8-4	8-13	9 days	119	3

* These frames were near areas of vehicular traffic, and many particles were probably relocated. This would indicate that roadways inside the plant should be oiled or treated with $CaCl_2$ to immobilize the dust.

** This frame had been used as a foot-bridge and the count is, therefore, unreliable.

[redacted]

There were six burst slugs between July 19 and August 3, 1948. There have been none since (as of August 20). Table IV gives wind data covering the periods from July 19 to August 3 and from August 4 to August 13, 1948.

TABLE IV

	N	NE	E	SE	S	SW	W	NW
A. 7/19 to 8/3:								
% of time	4.9	1.2	21.2	10.5	15.4	31.1	15.7	0.0
Av. Vel.(mph)	1.7	4.8	3.6	4.6	2.7	5.5	3.1	——
B. 8/4 to 8/13:								
% of time	11.5	5.1	38.7	5.5	4.6	12.9	20.3	1.4
Av. Vel.(mph)	3.1	3.3	2.8	3.2	1.8	4.7	5.2	6.7

Present data are not extensive enough to determine correlation of scatter with wind distribution.

Filtron samples were taken at several locations, beginning on August 4, 1948. Table V shows the count observed for some of the samplings. The pumps which activate these pieces of equipment draw 5 cfm of air, approximately 300 cf/hr.

[redacted]

TABLE V

Particles Collected with Filtrons

Date	706-A		105		104-B		706-D		205	
	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.
8-4		1/2		0/2		0/2		0/2		
8-5			0/2		0/4					
8-6			0/2	0/2				0/2	0/2	0/2
8-7							0/2			
8-8							1/2			
8-9					0/4		6/2	0/2	0/2	0/2
8-10	0/2		0/2	0/2			129/2		0/2	
8-11			0/2	0/2	0/4		12/2	100/2	0/2	0/1

The values express the number of particles collected (as determined by 24 hours film exposure) over the number of hours the filtron was run.

All of these locations are either at or outside of entrances to the buildings noted, and sample outside air.

There are also three constant air monitors, running 24 hours per day on a 7 day per week basis, drawing 5 cfm of air through a filter. These filters are changed weekly, giving a total air sample of 5.04×10^4 ft^3. These filters have also been radio-autographed since June 7, 1948. Table VI shows particle count on the radio-autographs.

[redacted]

[redacted]

TABLE VI

Active Particle Count on Constant Air Monitors

Period	115-B	735-B	706-A
6-7 to 6-14	0	0	0
6-14 to 6-20	0	0	0
6-28 to 7-6	0	0	0
7-12 to 7-19	7	9	21
7-19 to 7-26	142	1	18
7-26 to 8-2	26	2	2
8-2 to 8-9	3	5	14

All of these collectors are open to the outside air, the ones at 706-A and 115-B are at ground level, and the one at 735-B is on the second floor.

The 105 stack base was entered through the 115 air duct on 8/24/48 to check any possible accumulation of activity. The floor of the stack is almost totally clean except for some rather large gravel. Activity level was $<$ 500 mr/hr (4 1/2 hours after pile shut-down). There was more activity on the duct walls, which seemed to be somewhat oily, and had fine particulate matter adhering to it in spots. Radiation level (by Cutie Pie) was approximately 1500 mr/hr at a few inches from these spots.

REFERENCES:

(1) Report CN-2815.

(2) Central Files No. 48-8-86, by Karl Z. Morgan, "An Estimate of the Exposure from Specks of Insoluble Radioactive Material that May Become Lodged in the Lungs."

(3) Operation Particle, Day Ending 12:00 M, June 18, 1948, by John H. Roberson, dated 6/19/48.

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THE PARTICLE PROBLEM (PROGRESS REPORT #2)

The accumulation of data as to the distribution of radioactive particles on the X-10 area has proceeded as rapidly as personnel and physical limitations will permit. The total number of collection frames in service as of 9-23-48 is 22. Frames have been placed so as to give close coverage in the areas surrounding the 105 stack and the 706-D stack, general coverage of the X-10 areas, while off area locations have been chosen depending on prevailing wind direction, accessibility, and direction from the plant of heavily populated areas As of 9-1-48 the use of fibre glass matting in the frame collectors was discontinued. as it was discovered that the fibre glass was retaining possibly as high as 14.0 to 19.0% of the total number of particles settling on the frames. Since that date a collecting surface of heavy brown wrapping paper has been used, which surface seems to be relatively satisfactory. Some particles are undoubtedly lost when the collecting surfaces are changed, and while preparing the collection for exposure to x ray film The number of particles detected however is thought to be reasonably accurate, and at least indicative of particle distribution.

The summary of particles detected on these frames appears on Table I and IA.

Measureable rainfall during the period 8-3-48 to 9-16-48 was as follows:

Date	Amount in Inches
8-11	0.1
8-12	0.1
8-13	0.3
8-15	0.4
9-4	0.2
9-5	0.1
9-6	0.2
9-7	1.0
9-8	0.05

[redacted]

Table I

Frame Collection Data

Number of Particles Detected / Frame for Period Indicated

Frame #	Distance & Direction from 105 stack	Distance & Direction from 706D stack	8-3 to 8-13	8-13 to 8-20	8-20 to 8-26	8-26 to 9-1	9-1 to 9-2	9-2 to 9-3	9-3 to 9-8	9-8 to 9-9	9-9 to 9-13	9-13 to 9-14	9-14 to 9-15	9-15 to 9-16	TOTALS 8-3 to 9-16
1	700' SW		265	88	73	768	79	295	8	36	44	5	100	91	3039
2	1200' S		21	12	29	165	21	55	55	49	69			23 @	499
3	800' NW		12	27	78	20	45	56	192	105	28			49 @	612
4	900' SE		20	40	73	179	43	203	86	92	32			20 @	788
5	600' SE	275' SSW	196	530	2237	1210	375	493	103	85	198	46	104	271	5848
6	650' E	275' ENE	8	124	659	736	121	250	89	25	72	42	11	82	2216
7	1850' SSW		20	14	36	81	11	30	18	48	41			43 @	342
8	1700' WW		15	20	20	123	25	31	10	58	55			73 @	430
9	1050' NNE		15	37	87	39	56	143	194	25	61			50 @	707
10	150' NNE		119	124	344	361	1191	2000	411	126	139	73	116	18	2022
11	55' N							*1800		167 x	117	221	191	20	*2516
12	125' SSW							*1700		236 x	132	110	159	32	*2369
13	75' SE							*2200		182 x	46	31	152	18	*2629
14	160' W							*2100	378	83	257	147	120	159	*3244
15	900' SSE							* 122	14	36	102			23 @	* 297
16	1550' SSE							* 25	29	46	80			34 @	* 214
17	1600' SSW							*200	18	62	66			30 @	* 376
18	6500' NE													** 14	** 14
19	11500' NE													** 19	** 19
20	3000' N													** 12	** 12
21	750' SE													** 25	** 25
22	325' SE													** 74	** 74

Notes (8-3 to 8-13 column): These data presented in report of 8-30-48. Included for comparison

*Put in service 9-2-48

Roads oiled on 9-6-48

x In service 9-3 to 9-9-48

@ Collection 9-13 to 9-16

** Put in service 9-15-48

[redacted]

TABLE IA

FRAME COLLECTION DATA

Average Number of Particles Detected Daily/Frame for Period Indicated

Frame No.	Distance and Direction	8-3 to 8-13	8-13 to 8-20	8-20 to 8-26	8-26 to 9-1	9-1 to 9-2	9-2 to 9-3	9-3 to 9-8	9-8 to 9-9	9-9 to 9-13	9-13 to 9-14	9-14 to 9 15	9-15 to 9 16
1	700' SW	26.5	12.6	12.2	128.0	79	295	47.4	36	11.0	5	100	91
2	1200'S	2.1	1.7	4.8	27.5	21	55	11	49	17.2			7.7 ***
3	800' NW	1.2	3.9	13.00	3.3	45	56	38.4	105	7			16.3 ***
4	900' SE	2.0	5.7	12.2	29.8	43	203	17.2	92	8			6.7 ***
5	900'SE	19.6	75.7	372.8	201.7	375	493	20.6	85	49.5	46	104	271
6	650' E	.08	17.7	109.8	122.7	121	250	17.8	25	18	42	11	82
7	1850'SSW	2.0	2.0	6.0	13.5	11	30	3.6	48	10.2			14.3 ***
8	1700'W	1.5	2.9	3.3	20.5	25	31	2.0	58	13.7			24.3 ***
9	1050'NNE	1.5	5.3	14.5	6 5	56	143	38.8	25	15.2			16.7 ***
10	150' NNE	11.9	17.7	57.3	60.2	1191	2000	82.2	126	34.7	73	116	18
11	55' N						*1800		27.8x	29.3	221	191	20
12	125 SSW						*1700		39.3x	33	110	159	32
13	75' SE						*2200		30.3x	11.5	31	152	18
14	160' W						*2100	75.6	83	64.2	147	120	159
15	900' SSE						*122	2.8	36	25.5			7.7 ***
16	1550' SSE						*25	5.8	46	20.0			11.3 ***
17	1600' SSW						*200	3.6	62	16.5			10.0 ***
18	6500' NE												**14
19	11500" NE												**19
20	3000' N												**12
21	750' SE												**25
22	325' SE												**74

Roads oiled on 9-6-48

*Put in service 9-2-48

In service 9-3 to 9-9-48

**Put in service 9-15-48

***Collection 9-13 to 9-16

There has been one slug ruptured since August 3, 1948, occuring on 8-31-48. This rupture was detected by visual inspection of the slug channels during the Tuesday morning shutdown of the pile. The pile had been shut down at 0830 8-31-48. At 0900 #2 Fan was shut down with #3 Fan operating at half damper. Under these conditions the air flow through the pile was approximately 50,000 cfm as compared with the normal air flow of 110,000 cfm Removal of the ruptured slug was started at 1400 8-31-48. Great difficulty was experienced in the removal operations, and the pile was down under the above conditions until 0230 on 9-3-48. At this time with the air flow increased to ~ 65,000 cfm the pile was started up and operated at a power level of ~ 2100 K. W. until 0830 9-3-48 when it was again shutdown. The pile was started up at full air flow and power level at 1030 9-3-48.

This rupture was quite severe - best estimates of this incident indicate that five slugs were completely oxidized and three were partially oxidized, the pile age of the slugs being approximately 1,404 days.

An examination of the frame collection data shows a general increase in number of particles collected by the frames during the periods, (8-13 to 8-20) (8-20- to 8-26) and (8-26 to 9-1). The only significant rainfall during this period occurred on 8-15 when .4 inches fell. Unfortunately the discovery of the ruptured slug on 8-31 with the subsequent removal operations makes it difficult to estimate at this time the significance of the relocation of particles due to dry weather conditions as a factor in the particle collection data.

The data is believed to substantiate to some extent the validity of the theory that "bleeding" of relatively small numbers of particles takes place during and after slug removal operations, with the greatest number being ejected when the pile is brought up to full power and full air flow after the shut down.

The following table gives wind data for the periods from 8 4 to 9-18.

Table II

Wind Direction and Velocity

	N	NE	E	SE	S	SW	W	NW
8 4 to 8-13 (A)								
% of time	11.5	5.1	38.7	5.5	4.6	12.9	20.3	1.4
Av. Vel. (mph)	3.1	3.3	2.8	3.2	1.8	4.7	5.2	6.7
8-14 to 8-21 (B)								
% of time	7.7	2.4	35.7	13.7	10.1	17.9	11.3	1.2
Av. Vel. (mph)	1.4	2.0	3.4	2.4	2.3	5.5	2.0	4.5
8 22 to 8-28 (C)	N	NE	E	SE	S	SW	W	NW
% of time	5.7	7.0	34.2	27.2	11.4	12.0	2.5	0
Av. Vel. (mph)	2.4	3.9	2.1	2.9	2.1	2.0	1.0	0
8-29 to 9-4 (D)	N	NE	E	SE	S	SW	W	NW
% of time	12.4	0	45.7	15.5	9.3	10.9	6.2	0
Av. Vel. (mph)	7.8	0	6.5	5.2	2.4	4.5	3.8	0
9-5 to 9-11 (E)								
% of time	0	0	33.1	37.0	12.7	33.8	13.4	0
Av. Vel. (mph)	0	0	5.1	10.1	2.4	5.5	1.8	0

Present data are still not considered sufficiently extensive to determine scatter with wind direction.

The taking of filtron samples was continued in several locations. Table III on the following page shows the count observed for the samplings, the values represented as the number of particles collected (as determined by 24 hour film exposure) over the number of hours the filtron was run each filtron drawing approximately 300 cu. ft./hour. All of these locations with one or two exceptions sample outside air.

An examination of the filtron data shows, with but few exceptions, that the largest number of particles detected by this method are picked up in the 706-D area. At first the number of particles was such as to suspect the relocation of small particles disturbed by vehicular traffic on dusty roads and an investigation of the filtron sampling location indicated that such might be a reasonable assumption.

More recent data especially since the recent dissolving in 706-D (begun 8-25) indicated that this assumption was insufficient to explain these results and those obtained by other methods. Frames #5 and 6, which are located 275' West and East respectively, of the 706-D stack, not only showed a greater rate of increase in particle density than all others, but also the nature of the particles detected by radioautographs was different. The activity of the individual particles was more uniform and few centers of intense activity were present. It also appeared that activity was diffuse in some cases, as if due to a liquid which followed fibers in the fabric of the paper and fibre glass mats.

Consideration had been given to the sampling of the cell ventilation air from 706-D even before the above information became known. On 8 25 a probe was inserted in the exhaust duct of 706-D at a point just prior to the air entering the fan. The probe consists of a cylinder around which is wrapped a 4" x 7" piece of filter paper inserted in the center of the 3' duct, held

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TABLE III - FILTRON COLLECTION

	706-A		205		105				706-D				104-B		703-B	
Date	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	(2)	(3)	A.M.	P.M.	(2)	(3)	A.M.	P.M.	A.M.	P.M.
8-12		1/2	0/2	0/2	0/2	0/2			3/2	0/2						
8-13	0/2	4/2	2/2	0/2					5/2	2/2						
8-14									1/2							
8-15	0/2															
8-16		0/2	0/2	1/2		1/2			1/2	4/2						
8-17	1/2		0/2	0/2		0/2			0/2							
8-18	0/2	0/2	0/2	0/2	0/2				0/2	57/2						
8-19			0/2	0/2	1/2	0/2			0/2	0/2						
8-20		0/2	0/2			0/2										
8-21										0/2						
8-22									0/2							
8-23			6/2													
8-24			2/2	38/2												
8-25			0/2	14/2												
8-26			16/2	14/2												
8-27	3/2	11/2	19/2													
8-28																
8-29																
8-30		2/2								4/2						
8-31	2/2	1/2		7/2	7/2	29/2			1/2	1/2				0/1		8/2
9-1	2/3	2/3	16/3	8/3	13/3	14/3	10/3	3/3	10/3	12/3	1/3		40/3	10/2	12/3	3/3
9-2	5/2	2/2	1/3		14/3	2/3	3700/3		95/3	5/3	3656/3	11/3	3/2		2/3	2/3
9-3	10/2	12/1.5		4/3				234/3	14/3	28/3	57.5	112/3	3/2	3/3		
9-4						19/3				4/3	11/3					
9-5					1/3				7/3	0/3		4/3				
9-6					0/3				2/3		1/3	0/3				
9-7	2/2		1/3	25/2					10/3	1/3			0/3		2/3	
9-8	2/2		10/3						10/3	20/3	Fogged			7/2	7/3	24/3
9-9									45/3	10/3	17/3		8/3			
9-10									3/3	10/3	1/3					
9-11									2/3	3/3						
9-12									9/2	5/3						
9-13									18/3							

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securely in place by a metal rod fastened to an inspection plate 12" x 12". These filters, when removed after various lengths of time (usually for the period from 8-26 to date, 24 hours) were highly radioactive. Depending on operations in 706-D for the period the filter was in the duct, they gave readings from 38-250 mr/hr at 1-1/2" using a Cutie Pie. This amount of activity completely blackened the film surface exposed to the filter.

By 9-23 the first few filters on re-exposure, showed a lessening of the general diffuse " background" which made visible the presence of localized centers of activity. These may be due to the impingement of solid particulate matter, liquid droplets, or both.

The following schedule of 706-D operations for the period 8-25 to 9-3 is presented as being of interest in comparing particles detected in Table III and Table IV.

Date	Shift	Operation
8-25	4-12	Run started, 1st dissolving
8-26	12-8	2nd and 3rd dissolvings
	8-4	Slugs loaded
	4-12	Dissolving
8-27	12-8	Dissolving
	8-4	Dissolving
	4-12	Dissolving
8-28	12-8	Dissolving
	8-4	Slugs loaded —
	4-12	Dissolving
8-29	12-8	Dissolving
	8-4	Dissolving
	4-12	Dissolving
8-30	12-8	Dissolving
	8-4	Loaded slugs
	4-12	Dissolving
8-31	12-8	Last dissolving
9-2	4-12	Evaporation in B-6
9-3	8-4	Final evaporation-**End** of run

Attention is called to the filtron samples of 9-2-48 taken at 105 and 706-D which on exposure to film indicated approximately the same particle count of 3700. Both samples were run for three hours, the one at 706-D from

7:30 to 10:30 P. M. and the 105 ÷ - from 8:40 to 11:40 P. M. Conditions of thermal inversion existed during these hours of sampling with very little air movement being recorded by the recording anemometer. These weather conditions frequently result in the concentration of activity within the X-10 area, as indicated by the similar results of the two filtrons in two different locations, and also by activities previously recorded by the constant air monitors during periods of thermal inversion.

Evidence available to date seems to indicate the possibility of sources of particulate activity other than the 105 stack, probably coming from chemical operations. Whether or not this particulate material is to be regarded in the same light as the particulate material resulting from ruptured slugs has not as yet been determined. The following differences, however, have been noticed. (1) Film which had been exposed to fibre glass matting of the frame collectors showed retention of particles collected both in the 105 area and 706-D area, but did not present similar pictures. While some diffusion and scattering of activity was evident on both films due to the fibre glass, the collector in the vicinity of 706-D showed activity along the lengths of the fibres, which may indicate a flow or absorption of the active material. (2) collections from the pile area show a wide range of activities collected, while those from the 706-D area show a more uniform pattern of activities. (3) particulate material from the 105 area shows a relatively long half life (Report of 8 30-48 on Particle Problem by J. S. Cheka and H. J. McAlduff) while particulate material from 706 D indicates a more rapid decay. For instance a filtron run outside 706-D on 8 11-48 when exposed to film indicated approximately 100 particles. The same filter when re-exposed to film 30 days later showed 41 particles. (4) Samples collected on the frames from the 105 and 706-D areas were leached with water and then treated with HNO_3. The proportion of water soluble to HNO_3 soluble activity was much greater in the samples taken from frames in the vicinity of 706-D than in those taken from the vicinity of 105.

Precipitron samples were run beginning on September 1, 1948. Table IV (pg.11) shows the count observed after film had been exposed to the Al foil for 24 hours. Values expressed are the same as Table III, number of particles detected over time of sample. The precipitrons in use draw approximately 6 cfm.

The filters from three constant air monitors, running continuously and drawing 5 cfm of air, were changed at various intervals and radio-autographed. Table V shows particle count as observed on the exposed film.

TABLE V

Period	115B	706 A	735-B
8-9 to 8 16	0	0	0
8-16 to 8-23	2	2	1
8-23 to 8-30	3	11	33
8-30 to 9-1	0	0	18
9-1 to 9-2	15	13	27
9-2 to 9 7	4	6	70
9-7 to 9 8	2	6	11
9-8 to 9-9*	-	-	-
9-9 to 9 10	-	-	-
9-10 to 9-13*	-	-	-
9-13 to 9-15*	-	-	-

*Invalid due to contamination

Information of A General Nature

Filters that had been in service in the air conditioning units of 104-B, located in the attic about 50 feet from the west end of the building, were exposed to film and examined. The length of time the filters were in service is unknown, but they showed many spots of localized activity.

A filter that had been installed in the door leading to the N-S Hot Labs in 706 D for the period 8-26 to 9-14-48 was exposed to film. The film showed a generally diffuse pattern of activity plus many localized spots of higher activity.

[redacted]

TABLE IV

Precipitron Collections

Date	706-A A.M.	706-A P.M.	205 A.M.	205 P.M.	105 A.M.	105 P.M.	105 (2)	105 (3)	706-D A.M.	706-D P.M.	706-D (2)	706-D (3)	104-B A.M.	104-B P.M.	703-B A.M.	703-B P.M.
9/1	7/3	2/2	6/2	10/2	558/2	332/2			5/2	10/3	8/3					
9/2	5/.5	2/2	1/2	4/1	147/2	117/2			4/3	964/2	0/2	29/2				
9/3	10/2	4/1.5	6/1.5	0/1.5	298/5				40/2	6/2	9/2					
9/4										1/2						
9/5									3/2							
9/6									10/3							
9/7	8/2		11/2	11/2					5/2							
9/8	4/2		5/2						4/2							
9/9									10/3							
9/10										0/2						
9/11										10/2.75						
9/12										3/2						

[redacted]

A program of sampling exhaust air from all stacks in the X-10 Area has been started. The Physics, Chemistry, and Operations Divisions are contributing their resources in the sampling of the various stack effluents.

On 9-17-48 three large dust collecting units were placed in operation. These units filter approximately 250 cfm through a filter area of 34 sq. ft. These are in service at 115 Fan House, 706-D, outside East Platform, and 703-C, Administration Building, and one has been in service at 104-B since 9-15-48. No data concerning their performance is as yet available.

The swabbing of nostrils of people working at various locations in the plant was started at the dispensary on 9-17-48. The cotton at the end of the probe is sliced, spread out and counted at 10% geometry in the beta-gamma counter. After counting they are fastened to cardboard and film placed thereon for 24 hours. In a total of 152 swabbings covering a 3-day period, of significance are the following:

Code	Date	c/m	Particles
#5	9-21-48	21.9	7
#32	9-21-48	68.3	13
#38	9-21-48	68.0	14
#39	9-21-48	25.8	6
#41	9-21-48	13.7	3
#45	9-21-48	7.3	4

Summary

Data collected up to the present time indicates that serveral aspects of the particle problem exist. Pile operation is not the sole primary source of

[redacted]

particulate air contamination. 706-D is another source, and there may be still others. Relocation of particles by wind or traffic in dry weather is a secondary source. The nature, and therefore the hazard, of particles due to chemical operations has not been determined.

The investigation will continue. — 706-C - 706-H ?

H. J. McAlduff

H. J. McAlduff

J. S. Cheka

J. S. Cheka

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THE PARTICLE PROBLEM (PROGRESS REPORT #3)

J.S. CHEKA

and

H. J. McALDUFF

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THE PARTICLE PROBLEM (PROGRESS REPORT #3)

J. S. Cheka and H. J. McAlduff

DEC 9 1948

November , 1948

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THE PARTICLE PROBLEM (PROGRESS REPORT #3)

Considerable data relevant to the particle problem have been collected since the last report (ORNL-172). Steps have also been taken to control sources of particulate contamination. All possible primary sources were shut down for the period 10-15-48 to 10-21-48, to evaluate secondary sources, viz. relocation. Meanwhile, work has been begun on paving of all used thoroughfares, and grassing of all unused areas of the plant. The paving operations were begun on 10-19-48 and were 40% completed as of 11-11-48. The grassing of other plant areas was begun on 10-15-48 and was approximately 75% completed as of 11-11-48. A filter house for decontamination of pile cooling exit air was constructed (starting 9-27-48) at the base of the pile stack. These operations are mentioned because they have a bearing on the trends shown by the data.

Sedimentation frames, of which there are 22, give the most complete geographical coverage, although their results are not as representative of breathable air-borne particulates as those of suction-type air filters. Collection data on these frames have been previously reported through 9-16-48 (ORNL-146 and ORNL-172), but Table I includes a recapitulation of previous results, and is complete through 11-9-48. This allows more ready comparison without cross references. The plan will be followed throughout this report.

Collection had been irregular until the shutdown experiment was begun on 10-15-48. Collections are indicated by lines and, in the case of long periods, average numbers of particles per frame per day are reported. Beginning with the shutdown, collections were made every 12 hours throughout the shutdown period, and for a week thereafter. After 10-28-48, collections were on a 24 hour basis, except when rain makes this operation impossible.

It appears from Table I that the greatest density of fall occurs in frames #10 to #14 which are within 160' of the 105 Stack. The 205 Stack, which collects the off gases from all major chemical operations, is about 180' west of the 105 Stack. High particle frequencies were also noted on Frames #5 and #6 which are approximately 600' southeast and east of the 105 Stack, but bracket the 706-D Stack and Building 706-C at a radius of 300'. The 706-D Stack is a 50' stack which vents cell ventilating air from operations in 706-D Building. High values on the latter frames were noted during the RaLa run, and during iodine runs in 706-C.

The group of all other locations at less than 1000' usually gives slightly higher averages than the group at greater than 1000' but during the period when the pile was first started up after the total shutdown, and the period from November 4 to 6 when a Redox batch required an added evaporation, the group at the greater distance showed the higher particle density.

Time trends also appear, and these can be ascribed to specific operations or conditions in many cases. Data of Table I is repeated in a condensed form in Tables II and II-A. Table II shows averages of periods covered by the same controlling factors as much as possible. The few locations available before the multiple slug rupture of 8-31-48 show low particle densities,

[redacted]

TABLE I
PARTICLES/FRAME/24 HR. PERIOD

[redacted]

Frame No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Rain	Comments
Direction	SW	S	NW	SE	SE	E	SSW	W	NNE	NNE	N	SSW	SE	W	SSE	SSE	SSW	NE	NE	N	SE	SE		
Distance (ft.) from 105 Stack	700	1200	800	900	600	650	1850	1700	1050	150	55	125	75	160	900	1550	1600	6500	11500	3000	750	325		
6/19																							.20	
6/20																								
6/21																								
6/22																								
6/23																								
6/24																							.70	
6/25																								
6/26																								
6/27																								
6/28																							.10	
6/29																								
6/30																								
7/1																								
7/2																								
7/3																								
7/4																								
7/5																								
7/6																								
7/7			average 0.29		average 10.62	average 2.75	average 1.36				average 5.44		average 3.61											
7/8																							.05	
7/9																							.20	
7/10																							.20	
7/11																							.70	
7/12																							.40	
7/13																								
7/14																							2.40	
7/18																							.50	
7/20																							.10	
7/21																								
7/22																								
7/25																								

[redacted]

Particles/[redacted]

Frame No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	rain
7/26																							
7/27																							.10
7/28																							.60
7/29																							.60
7/30										63													
7/31										.60													
8/1																							.20
8/2			0.29		10.62	2.75				0.80	5.44												
8/3																							.40
8/4																							.80
8/5																							.10
8/6																							
8/7																							
8/8	26.5																						
8/9		2.33	1.71	2.50	28.0	1.00	2.50	2.18	1.88	13.2													
8/10																							
8/11																							
8/12																							.10
8/13																							.10
8/14																							.30
8/15																							
8/16	12.6	1.7	3.9	5.7	75.7	17.7	2.0	2.9	5.3	17.7													.40
8/17																							
8/18																							
8/19																							
8/20	—	—	—	—	—	—	—	—	—	—													
8/21																							
8/22																							
8/23	12.2	4.8	13.0	12.2	372.8	109.8	6.0	3.3	14.5	57.3													
8/24																							
8/25																							
8/26	—	—	—	—	—	—	—	—	—	—													BaLa Run
8/27																							
8/28																							
8/29	128.0	27.5	3.3	29.8	201.7	122.7	13.5	20.5	6.5	60.2													
9/1	—	—	—	—	—	—	—	—	—	—													

8/31 Multiple burst

Particles/Frame [redacted] [redacted]

Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Rain	
9/2	79	21	45	43	375	121	11	25	56	1191														↓ Multi. Bur
9/3	295	55	56	203	493	250	30	31	143	2000	1800	1700	2200	2100	122	25	200							BaLa Run. Removal.
9/4																							.20	
9/5																							.10	Roads oiled
9/6	47.4	11.0	38.4	17.2	20.6	17.8	3.6	2.0	38.8	82.2				75.6	2.8	5.8	3.6						.20	
9/7											27.8	39.3	30.3										1.00	
9/8																							.05	
9/9	36	49	105	92	85	25	48	58	25	126	—	—	—	83	36	46	62							
9/10																							.20	
9/11	11.0	17.2	7.0	9.0	49.5	18.0	10.2	13.7	15.2	34.7	29.3	33.0	11.5	64.2	25.5	20.0	16.5							
9/12																								
9/13																								
9/14	5				46	42				73	221	110	31	147										
9/15	100				104	11				116	191	159	152	120										
9/16	91	7.7	16.3	6.7	271	82	14.3	24.3	16.7	18	20	32	18	159	7.7	11.3	10.0	14	19	12	25	74		
9/17	120				460	97				37	56	168	95	107										
9/18																								
9/19	27.0	11.5	8.0	30.0	419	345	9.0	14.0	24.0	134	147	219	112	53.0	28.3	7.3	67.8	12.0	22.2	10.0	49.5	136		
9/20																								Slight burst
9/21																								Roads oiled
9/22	34.0	32.3	9.7	33.0	152	28.0	0	35.7	15.3	17.3	18.7	433	58.3	19.7	57.3	29.0	20.7	6.7	4.3	3.0		103	.05	Filter house con-
9/23																								struction began
9/24																								
9/25	64.0	14.5	1.0	0.25	15.0	2.0	2.7	9.5	1.2	2.2	5.0	16.5	2.8	2.5	13.5	8.2	4.5	3.0	2.0	3.2		5.8		
9/26																								
9/27																								
9/28										12	12	12	20										.10	
9/29	8.3	8.3	10.3	41.0	90.7	212	2.7	17.7	18.7	294	32.5		103	29.7	13.3	7.7	8.7					20.7		
9/30												96.0						6.8	12.0	12.2				
10/1										140	143		81											
10/2																								
10/3		2.8	5.8	38.5	39.5	81.5	21.2	12.0	15.2	98.0	255	931												
10/4																								
10/5										50	51	229	18.8											
10/6										28	24	309	25											
10/7		6.7	3.0	2.5	11.5	6.3	24.3	8.3	0.7	68	18.5	17.5	43.5	5.5	.75	1.0	2.3	1.0	1.1	1.3	2.0	2.0	.10	
10/8																								

S[redacted] S[redacted]

Particles/Frame

Date		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Rain	Comments
10/9																									
10/10																									
10/11		2.0	4.5	2.5	11.5	19.5	24.3	2.2	1.5	7.0	110	8.9	108	119	11.0	2.5	2.2	1.3	2.2		1.3	4.6	16.3		
10/12																									
10/13																									
10/14																									
10/15		65	25	24	26	13	6	11	66	4	27	14	20	52	58	5	13	8	6	17	9	4	26		grassing began

PARTICLES/FRAME/ 12 HOURS

Date		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Rain	Comments
10/16	A	12	2	4	2	7	17	2	19	10	163	473	53	200	91	1	1	8	9	5	21	53	31		
	P	3	4	4	1	3	2	1	3	0	5	10	6	17	20	2	4	3	2	2	1	3	5		
10/17	A	2	1	1	4	4	4	8	11	1	0	4	7	5	30	4	2	5	10	14	8	3	3		
	P								N O	C O L	L E C	T I O	N -	Rain											
10/18	A	5.3	0.8	0	1.2	2.0	3.2	0.8	2.0	1.2	9.2	7.2	8.0		41.3	0.8	0	0	0	0	7.2	1.6	1.6	1.65	30 hrs.
	P	14	38	2	8	2		10	8	8	4	368	6	2	4	8	8	2	0	2	6		8		6 hrs.
10/19	A	5	6	2	1	30	1.5	1	10	3	3	16	4	3	0	5	10	3	1	2	2	2.5	3		paving began

Particles/Frame/12 Hours

Date		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Rain	Comments
10/19	P	1	4	3	1	2	0	0	2	1	6	3	3	1	0	0	0	1	0	1	2	9	13		
10/20	A	2	1	1	2	1	4	5	5	2	1	21	13	2	13	4	4	7	2	0	0	0	0		
	P	1	0	1	1	3	1	0	4	0	1	2	2	7	7	1	1	0	1	2	0	1	1		
10/21	A	5	2	0	0	5	2	0	3	1	1	2	4	4	3	21	3	1	4	2	0	0	0		
	P	8	7	20	12	3	1	2	0	13	38	39	3	5	13	6	3	0	0	1	0	0	3		
10/22	A	5	2	9	9	2	15	25	9	30	319	936	46	154	256	0	2	9	10	4	6	3	7		
	P	3	15	6	20	4	54	6	9	7	72	177	24	943	54	12	12	1	6	2	1	6	6	Trace	Pile Up
10/23	A	6	7	4	5	6	4	15	3	6	2	82	27	9	585	3	4	9	11	11	56	3	1		
	P	2	6	2	14	7	5	2	5	1	107	33	5	2	12	5	8	1	1	0	2	2	16		
10/24	A	0	3	1	2	2	0	1	0	0	11	9	89	4	158	1	0	5	10	0	0	2	1		
	P	1	2	5	4	2	1	4	4	8	6	30	7	8	34	3	3	4	3	2	2	3	1		
10/25	A	8	5	7	30	12	29	40	1	1	9	10	3	3	28	3	2	1	1	0	0	0	1		
	P	4	0	1	2	5	1	5	4	12	19	11	11	0	21	2	6	1	1	2	4	2	1		
10/26	A	22	17	3	6	4	54	3	5	8	0	2	27	1	31	2	1	1	1	1	3	2	6		
	P	5	3	1	10	2	3	6	10	3	9	7	2	2	230	1	2	3	2	3	2	1	1		
10/27	A	5	3	1	1	3	3	39	3	1	7	7	56	1	71	3	2	2	5	3	1	2	1		
	P	2	1	0	0	6	6	0	4	2	2	0	1	6	3	1	0	4	2	0	2	1	0		
10/28	A	4	13	2	0	7	6	37	3	6	191	4	3	11	0	1	4	4	2	1	0	0	4		

Particles/Frame/24 Hours

Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Rain	Comments
10/29	26hr. 27	2	4	0	7	2	2	2	4	2	10	64	12	74	3	2	2	4	1	9	1	9		
10/30	11	6	5	18	137	34	11	4	9	5	3	43	16	53	1	4	8	6	1	3	9	78		
10/31	7	8	1	13	49	8	45	9	4	2	34	48	4	52	2	0	2	3	2	2	9	29	.10	
11/1	4	2	2	5	27	9	1	6	3	42	134	48	226	33	6	4	5	3	4	5	2	6	.10	
11/2	0	0	2	1	14	4	3	4	2	4	64	33	8	63	1	2	2	3	2	0	3	3	.95	
11/3, 11/4	1.0	1.5	0.5	0.5	4.0	5.5	2.5	2.5	1.5	6.0	9.5	9.5	65.5	20.5	9.0	1.0	1.5	0.5	1.0	1.0	1.0	1.0	.60	
11/5, 11/6	14.5	176	18.0	2.5	1.0	7.5	0.5	0.5	40.5	268	274	69.0	—	64.5	—	0.5	1.0	2.5	1.0	61.0	2.0	—	1.50	
11/7, 11/8	20.0	4.5	2.0	12.0	1.0	6.5	6.0	2.0	2.5	21.5	33.5	5.5	13.5	99.0	1.5	5.5	0	2.0	1.5	4.0	1.5	2.5		Slugs pushed Pile down to connect duct
11/9	8	1	5	6	9	5	2	2	2	3	91	14	19	7	6	18	10	1	3	2	10	2	.05	

TABLE II

Average Particles/Frame/Day

Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
Distance	700'	1200'	800'	900'	600'	650'	1850'	1700'	1050'	150'	55'	125'	75'	160'	900'	1550'	1600'	6500'	11 500'	3000'	750'	325'	
Direction	SW	S	NW	SE	SE	E	SSW	W	NNE	NNE	N	SSW	SE	W	SSE	SSE	SSW	NE	NE	N	SE	SE	Comments
Dates																							
6/19- 8/5			0.3		10.6	2.8	1.4				5.4		3.6										Single Collection
8/5-8/26	18.6	2.8	5.9	6.3	148.1*	37.7*	3.4	2.8	6.4	26.1													* BaLa Run began 8/25
8/26-9/3	42.7	30.1	15.1	53.1	259.8	138.4	15.3	22.4	29.8	444.	x 1800	x 1700	x 2200	x 2100	x 122	x 25	x 200						BaLa Run ends 9/2; burst and clean-up 9/31 to 9/3 x - single day 9/2 to 9/3
9/3-10/16	40.1	11.9	12.7	20.0	85.0	49.0	9.6	14.6	15.2	81.0	79.8	168.5	58.3	42.5	13.5	9.2	14.1	o 5.0	o 8.4	o 5.5	o 20.8	o 38.2	o - 9/15 to 10/16
10/16-10/21	9.1	8.7	6.7	5.6	10.4	4.4	4.7	8.5	5.1	14.5	54.3	11.8	9.1	34.9	8.9	5.6	3.8	3.6	4.5	6.2	4.2	6.5	Dead Time
10/22-10/23A	9.3	16.0	12.7	22.7	8.0	48.7	30.7	14.0	28.7	262.0	796.7	58.0	737.3	596.7	10.0	12.0	12.7	18.0	11.3	42.0	8.0	9.3	36 hours-start-up
10/23-11/4	8.7	6.2	3.2	8.9	24.3	14.7	17.0	5.8	5.6	35.7	31.4	37.8	36.3	75.3	3.4	3.5	3.9	7.8	1.8	2.6	3.3	13.2	12 day period
10/4-11/6	14.5	176	18.0	2.5	1.0	7.5	0.5	0.5	40.5	268	274	69		64.5		0.5	1.0	2.5	1.0	61.0	2.0		{205 Evaporation. {Slugs pushed.
11/7-11/9	16.0	3.3	3.0	10.0	3.7	6.0	4.7	2.0	2.3	15.3	52.7	6.3	15.3	68.3	3.0	9.7	3.3	1.7	2.0	3.3	4.3	2.3	

[redacted]

TABLE II-A

Average Particles/Frame/Day

Station	10 - 14	5 and 6	1, 3, 4, 15, 21 and 22	2, 7, 8, 9, 16-20
Distance	< 160' from 105 Stack	300' from 706-D Stack	300' to 1000' from 105 Stack	> 1000' from 105 Stack
Dates				
6-19 to 8-5	4.5 (2)	6.7	.3 (1)	1.4 (1)
8-5 to 8-26	26.1 (1)	92.9	10.3 (3)	3.9 (4)
8-26 to 9-3	1271*	199.	83.2 (4)	53.8 (6)
9-3 to 10-16	86.0	52.5	24.2	10.4
	T O T A L	S H U T	D O W N	
10-16 to 10-21	24.9	7.4	6.8	5.6
	S T A R T - U P	O F	P I L E	
10-22 to 10-23 A (36 hrs)	490	28.3	14.4	22.8
10-23 P to 11-4	43.3	19.5	6.8	6.0
11-4 to 11-6	169. (4)	4.3	9.2 (4)	31.5
11-7 to 11-9	31.6	4.8	6.4	3.6

* Single day on 4.

( ) shows number of frames averaged, when total number was not used.

[redacted]

except the stations near 706-D which caught the beginnings of the RaLa run. The multiple rupture and subsequent removal operation coincided with the end of the RaLa run, and these two apparently provided a large amount of particulate contamination. During the next two week period sedimentation subsided by a factor of 4 or 5. How much of this was due to primary sources, and how much to relocation is difficult to estimate.

The "dead time" (total shutdown) collection dropped by a factor of approximately 3 on the average, but still left a considerable number of particles collected. These can only be attributed to relocation, though this process was probably aided by the construction work, which continued through the period. During the 36-hour period covering the start-up of the pile a large number of particles was released. After this burst of activity particle densities, as indicated by the sedimentation frames, seem to have dropped to about the level of the "dead time" period, except for November 4-6, when the numbers were high.

Filtron data at six locations cover the period beginning August 4. The figures are not strictly comparable, however, since collections previous to 10-15-48 had been in three hour periods, and have been in 12 or 24 hour periods since that time. Table III gives results of all collections through 11-9-48. The early collections indicate that there was little particulate contamination (except from iodine runs in 706-C which discharge all ventilating air through short stacks on the roof of 706-C) before the multiple slug burst in the pile and the RaLa run in 706-D. The extremely large values obtained at 105 and 706-D platform on the swing shift on 9-2-48 coincided with the final evaporation in B-6 and were probably due to it.

Ten airway "sanitizers" were obtained for outside air sampling and one was placed inside 105 Building on top of the pile. This apparatus is a type of vacuum cleaner with a removable fibre bag. It draws 28 cfm of air (subject to verification), and is estimated to capture particles down to 1 μ with 99% efficiency (C. Borkowski). Since the radio-autographic technique is rendered less sensitive by the interposition of the additional paper as absorber, and the corresponding poorer geometry, particle counts by this method are somewhat lower than those obtained when a filter is filmed directly on the collecting surface. Relative detecting efficiency would be a function of the activity of the particles collected. Five of these collectors were placed on 10-8-48, and the rest by 10-15-48. Table IV gives the results of collections with these instruments.

In addition to these are five large air filters, on loan from the U. S. Public Health Service. These have been fitted with 10 ft^2 CWS #6 filter papers. They draw approximately 240 cfm of air. Four of these were put into service around the plant area approximately 9-24-48, and the other at the Atomic Energy Commission Administration Building on 10-14-48. Table V shows the results of collections.

Table VI gives data from 5 electrostatic precipitators during the period 9-1-48 to 10-18-48 and is presented only for comparative purposes. The precipitators have an air flow of approximately 6.5 cfm and cannot be operated continuously due to high voltage breakdown; therefore, the results are not consistent with the continuous sampling devices. The precipitator at 706-D was

[redacted]

TABLE III

FILTRON COLLECTIONS
(Particles/1000^3 Air)

A - A.M.
P - P.M.
2 - Swing Shift
3 - Midnight Shift

Date		706-A	205	105	706-D	104-B	703-B	706-B	Rain	Comments
8/4	P	1.67		0	0	0			.10	
8/5	A			0		0				
8/6	A		0	0						
	P		0	0	0					
8/7	A				0					
8/8	A				1.67					
8/9	A		0		10.0	0				
	P		0		0					
8/10	A	0	0	0	214.9					(c)
	P			0						
8/11	A		0	0	20.0	0			.10	
	P		0	0	167					
8/12	A		0	0	5.00				.10	
	P	1.67	0	0	0					
8/13	A		3.33		8.33				.30	
	P	6.67	0		3.33					
8/14	A				1.67					
8/15	A	0							.40	
8/16	A		0		1.67					(c)
	P	0	1.67	1.67	6.67					
8/17	A	1.67	0		0					(c)
	P		0	0						
8/18	A	0	0	0	0					
	P	0	0		95					
8/19	A		0	1.67	0					
	P		0	0	0					
8/20	A		0							
	P	0		0						
8/21	P				0					
8/22	A				0					
8/23	A		10.00							

[redacted]

Filtron Collections - con't [redacted]

Date		706-A	205	105	706-D	104-B	703-B	706-B	Rain	Comments
8/24	A		3.33							
	P		63.4							
8/25	A		0							
	P		23.4							
8/26	A		26.67							
	P		23.4							
8/27	A	5.00	31.67							
	P	18.33								
8/28										Ba La Run
8/29										
8/30	P	3.33			6.67					
8/31	A	3.33		11.7	1.67					
	P	1.67	11.7	48.3	1.67	0	00			Multi. Burst
9/1	A	2.22	17.77	14.4	11.1	44.5	13.3			
	P	2.22	8.89	15.6	13.3	16.7	3.33			
	2			11.1	1.11					
	3			3.33	22.4					
9/2	A	8.33	1.11	15.6	106	5.00	2.22			
	P	3.33		2.22	3.61		2.22			
	2			4110	4060					
	3			260	124					
9/3	A	16.67			15.6	5.00				
	P	26.67	4.45		31.1	3.33				Removal
	2				33.3					
9/4	P			21.1	4.44					
	2				22.4					
	3				4.45				.20	Roads Oiled
9/5	A			1.11	7.79					
	P				0				.10	
9/6	A			0	2.22					
	2				1.11					
	3				0				.20	
9/7	A	3.33	1.11		11.1	0	2.22		1.00	
	P		41.7		1.11					
9/8	A	3.33	11.11		11.1		7.78		.05	
	P				22.2	7.78	26.7			
	2				Fogged					

[redacted]

Filtron Collections - con't

Date		706-A	205	105	706-D	104-B	703-B	706-B	Rain	Comments
9/9	A				50.0	8.89				
	P				11.1					
	2				18.9					
9/10	A				3.33					
	P				11.1					
	2				1.11					
9/11	A				2.22					
	P				3.33					
9/12	A				15.0					
	P				5.56					
9/13										
9/14	2				2.22					
9/15	2				3.33					
9/16										
9/17										
9/18										
9/19										
9/20	A		4.44							
	P		0		14.4		26.7			Slight burst
	2				13.3					Roads oiled
9/21	A	31.1		13.3	185	0	0			
	P	22.2	0	5.56	14.4	6.66	2.22			
	2				10.0					
	3				8.89					
9/22	A	6.81	4.44	13.3	1.11	6.67	5.55		.05	(C)
	P				13.3		13.3			
	2				22.2					
	3				2.22					
9/23	A		0		10.0	11.1	2.22			
	P				12.2	14.4	8.33			
	2				10.0					
	3				8.89					
9/24	A			3.33	1.11	3.33	4.44			
	P		7.78	2.22	10.0	4.44				
	2				7.78					
	3				10.0					
9/25	A				3.33					
	P				5.56					
	2				5.56					
	3				31.1					

[redacted]

Date		706-A	205	105	706-D	104-B	703-B	706-B	Rain	Comments
9/26	A				8.89					
	2				5.56					
	3				3.33					
9/27	A	4.44	10.0	2.22	11.1	10.0	3.33			
	P		4.44	16.0	4.44	3.33	5.56			
	2				11.1					
	3				0					
9/28	A	1.11	4.44		1.11	2.22	0		.10	(C)
	P		1.11		0	3.33	2.22			
	2				2.22					
	3				6.67					
9/29	A	0	2.22	7.78	3.33	0	5.56			
	P		2.22	2.22	6.67	0				
	2				1.11					
	3				5.56					
9/30	A		0	10.0	117	4.44				
	P	2.22	1.11			1.11	1.11			
	2				14.4					
	3				0					
10/1	A		6.67		8.89	20.0	1.11			
	P	15.6	11.1		3.33	7.78	0			
	2			11.1	3.33					
	3				8.89					
10/2	A				2.22					
	2				2.22					
	3				8.89					
10/3	A				0					
	2				5.56					
	3				11.1					
10/4	A	3.33		0	2.22	0	0			(CC)
	P		23.4	11.1	7.78	3.33	13.3			
	2				1.11					
	3				8.89					
10/5	A	2.22	2.22		1.11	2.22	0			
	P		1.11	1.11		18.3	0			
	2		1.67	3.33	0			0		
	3				3.33			6.67		
10/6	A	1.11	5.56	3.33			4.44	6.67		
	P		5.56	12.2	17.8		1.11			
	2		3.33	6.67	6.67					
	3				0					

[redacted]

Date		706-A	205	105	706-D	104-B	703-B	706-B	Rain	Comments
10/7	A	3.33		4.44	0		0		.10	
	P			0	2.22					
	2				1.11					
	3				4.44					
10/8	A	10.0	1.11	2.22	137		0			(C) spill and decontamination
	P		0	0	3.33					
	2		3.33	2.50	3.33					
	3				2.22					
10/9	P				2.22					
	2		3.33	3.33	5.28					
	3				4.44					
10/10	A				0					
	2		6.67	5.00	3.89					
	3				4.44					
10/11	A	0	1.11		2.22		0			
	P		1.11	10.0	2.22		8.33			
	2		2.22	1.67	.55					
	3				5.56					
10/12	A	6.67	2.22	1.11	0		10.0			
	P		0	6.67	2.22		0			
	2		1.67	1.67	0					
	3				0					
10/13	A		2.22	0			0			
	P		0	2.22	0		3.33			
	2				7.78					
	3				0					
10/14	A	1.11	2.22	3.33	1.11		.83			
	P		4.44		4.44		0			
	2				1.11					
	3				0					
10/15	A	0	3.33	3.33						
	P		0	1.11	10.0	0				

12 Hour Collection:

Date		706-A	205	105	706-D	104-B	703-B	706-B	Rain	Comments
10/16	Nite	0		.25	0	0	.29	.25		Slugs pushed (6 hrs)
	Day	0		.61	.61	0	0	.67		
10/17	Nite	0		.55	.53	0	.21	0	1.65	
	Day	0		4.92	1.16	0	.28	0		
10/18	Nite	1.73		4.10	.21	.61	1.94	1.11		
	Day	1.90		1.52	2.43	.80	0	.28		
10/19	Nite	.54		.28	6.41	.26	.28	.87		
	Day	1.16		3.61	7.83	.30	0	0		

[redacted]

Date		706-A	205	105	706-D	104-B	703-B	706-B	Rain	Comments
10/20	Nite	0		0	0	0	0	.28		
	Day	1.24		0	.74	0	.51	.49		
10/21	Nite	0		0	.30	.58	0	0		
	Day	0		.87	1.47	.35	.33	0		
10/22	Nite	0		0	0	0	0	0		
	Day	.56		0	1.95	0	.58	.28		Pile Up
10/23	Nite	0		0	1.95	0	0	.27		(CC)
	Day	0		1.39	1.95	.28	0	.83		
10/24	Nite	.30		0	0	0	0	0		
	Day	.56		.28	0	0	0	0		
10/25	Nite	.84		2.78	1.39	.56	1.07	.56		
	Day	0		0	1.16	2.05	.26	.56		
10/26	Nite	.53		0	0	0	.87	0		
	Day	1.67		.28	0	0	.28	.28		(R)
10/27	Nite	0		.83	.28	.28	.56	0		(R)
	Day	.83		1.03	1.11	.26	0	.28		

<u>24 Hour Collection:</u>

Date	706-A	205	105	706-D	104-B	703-B	706-B	Rain	Comments
10/28	1.39		0	0	0	0	.56		
10/29	.89		.67	1.93	.23	0	0		(R)
10/30	.14		.55	4.17	.14	0	.67		
10/31	0		.14	0	.14	.14	0	.11	
11/1	0		1.13	1.16	.83	.14	.14	.11	(R)
11/2	0		0	2.45	0	.14	0	.96	
11/3	.42		1.53	2.08	.42	.28	1.4		(R)
11/4	.83		.43	.68	.13	.42	1.55		(R)
11/5	1.53		16.46	11.16	6.39	1.70	9.47	.61	Slugs Pushed
11/6	0		5.97	2.92	0	0	.54	1.50	
11/7	.78		.27	.28	0	0	.26		Pile shut down
11/8	.70		0	.14	.14	.15	.15		(CC) (R)
11/9	1.59		1.12	1.88	.14	.30	.42	.06	(R)

(C) Iodine Run in 706-C.
(R) Redox Dissolving in Building 205.

[redacted] TABLE IV [redacted]

AIR WAY COLLECTIONS
(Particles/1000 ft^3 Air)

Station #	1	2	3	4	5	6	7	8	9	10	11	12
Location	703-C	719-A	701-B	706-B	115	Pile Top	101-B	706-A(out)	706-A(in)	~1200'E	D. H.	105 NW
Distance from Stack	1760'	1220'	825'	550'	60'		500'	760'		2200'	~800'	90'
Direction	W 47°S	S 36°W	S 4°W	S 44°W	E 31°N		E	S 40° E		E 25° N	NW	S 13° E
Date-Hours												
10-10 47	.013	.013	.026	.013	.039							
10-11 24	.0	.101	.177	.126	.101							
10-12A 19	.064	.064	.095	.032	.064	7.209	.032	0				.351
10-12P 6	.707	.202	2.020	.910	1.919	.303	.409		.303			.303
10-13 24	.404	.025	.152	.177	.202	.275	.126	0				.076
10-15A 40	0	.045	.091	.015	.091	.288	.106	.015	.045			.015
10-15P 10	.303	.242	.242	.242	.364	.788	.364	.242	.182			1.394
			S L U G S		P U S H E D							
10-16A 12	.707	2.071	.910	.454	.353	1.061	.152	.152	.152	1.364	.404	.758
			P I L E		D O W N							
10-16P 6	.707	.606	0	.202	1.010	.808	.101	.101	.707	.606	.101	0
10-17A 12	.152	0	0	.152	.101	.858	0	.202	.202	.101	.303	.050
10-17P 12	.050	.101	.050	.050	.505	0	0	0	0	0	0	.050
10-18A 12	0	.050	.050	.252	.505	.505	.101	0	.101	.909	0	0
10-18P 12	.252	.202	.505	1.262	.252	1.010	1.414	.101	.152	.202	.556	.252

AIR WAY COLLECTIONS (Particles/1000 ft^3 Air) (con't)

Station #	1	2	3	4	5	6	7	8	9	10	11	12
Date-Hours												
10-19A 12	.353	.101	.152	.252	.050	.303	.101	0	.152	.101	0	.101
10-19P 12	0	0	0	0	.202	.454	.152	.101		.050	.152	.050
10-20A 12	.707	.202	.050	0	.101	.556	.253	0		.101	.202	.153
10-20P 12	0	0	.101	.050	.152	.707	0	.152		0	.101	.050
10-21A 12	.101	.050	.252	.202	1.465	.606	.505	.202		2.172	.202	.252
10-21P 12	.101	.050	.202	.505	.757	1.565	.101	.202		.050	.050	.152
		P I L E	U P									
10-22A 12	.152	.050	0	.050	.152	.152	.253	0		.202	.152	.101
10-22P 12	.050	0	.202	.505	.353	.353	.050	.202		.050	.050	.152
10-23A 12	.050	.152	.202	.152	0	0	.050	.050		0	.252	.858
10-23P 12	.101	.252	.303	.252	.050	5.88	.050	.657		.050	.101	0
10-24A 12	.050	0	.101	0	.101	.454	.151	.101		.050	0	.050
10-24P 12	.050	.404	.050	0	.252	.353	.252	.202		.050	.050	.303
10-25A 12	.101	.050	.151	.252	.101	.151	.101	0		0	0	.050
10-25P 12	.151	.556	.050	.151	.505	.404	.303	.152		.050	0	.252
10-26A 12	.202	0	.454	.101	.152	.556 *	.303	0		.252	.050	1.212
10-26P 12	0	.151	.151	.151	0	.404	.101	.151		.050	.050	.101
10-27A 12	.151	0	.101	.050	.202	.101	.404	0		.202	.808	0
10-27P 12	0	.101	.404	.151	.101	4.19	.101	.202		0	.050	.101
10-28 15	.121	.040	.081	.121	.202	.040	.202	.323		0	0	0
10-29 24	.050	.025	.050	.050	.404	.884	.025	.202		.050	0	0
10-30 24	.101	.141	.151	.151	.278	.555 ↓	.181	.050		.141	.101	.480

[redacted]

AIR WAY COLLECTIONS (Particles/1000 ft^3 Air) - con't

Station #		1	2	3	4	5	6	7	8	9	10	11	12
Date-Hours													
10-31	24	.101	.101	.050	.025	.227	.960	.101	.126		.050	.101	.252
11-1	24	.050	.328	.101	.101	.505	.252	.025	.050		.025	.126	.101
11-2	24	.151	.050	.076	.177	.278	10.33	.656	.303		.076	.101	.177
11-3	24	.076	0	.025	.076	0	.252	.025	0		0	.050	.025
11-4	24	.076	.050	.050	.025	.177	.227	.025	0		.025	.101	.404
11-5	24	.556	.303	.050	.177	3.131	1.086*	.278	.126		.202	.177	.757
11-6	24	.151	.177	.050	.025	.505	.858	.252	.126		.050	.050	.126
11-7	24	.707	.278	.151	.101	.101	.126	0	.025		.050	.076	.429
11-8	24	.025	.227	.025	0	.101	1.995	0	.151		.151	0	.101
11-9	24	0	.025	.101	.050	3.914	.555	.101	0		.101	.076	.126

— #6 in 105 Hot Lab.

[redacted]

TABLE V

U. S. PUBLIC HEALTH SERVICE COLLECTIONS

Particles/1000 ft^3

Date	No. 1 706-D E Platform	No. 2 E of 115	No. 3 W of 703-C	No. 4 E Corner of 104-B. Duct out window	No. 5 AEC Admin. Bldg. Between S1 and S2
Collection Time - 24 hours:					
9-22-48					
9-23-48					
9-24-48					
9-25-48					
9-26-48					
9-27-48		.840		.070	
9-29-48					
9-30-48					
10- 1-48					
10- 2-48					
10- 3-48		Plug	.049		
10- 4-48		pulled			
10- 5-48	.887				
10- 6-48					
10- 7-48					
10- 8-48				.021	
10- 9-48		1.077			
10-10-48					
10-11-48					
10-12-48					
10-13-48					
10-14-48				.014	
10-15-48					
Collection Time - 12 hours:					
10-16-48 A	.052	.121		.110	
10-16-48 P	.555	.984		.174	
10-17-48 A	.139	.145		.058	
10-17-48 P	.504	5.47	not placed	.023	
10-18-48 A	.156	.070		.029	.00096
10-18-48 P	.051	.266		.023	
10-19-48 A	.029	.011		.023	
10-19-48 P	.249	.608		.035	
10-20-48 A	.046	.168	.046	.035	
10-20-48 P	.052	.110	.017	.006	
10-21-48 A	.064	.151	.046	.133	.0023
10-21-48 P	.185	.376	.098	.116	
10-22-48 A	.040	.064	.052	.017	
10-22-48 P	.151	.162	.017	.098	
Collection Time - 24 hours;					
10-23-48	1.602	.032	.040	.018	
10-24-48	.034	.096	.009	.006	.00012
10-25-48	.073	.141	.020	.018	

US Public Health Service Collections (con't)

Date	No. 1	No. 2	No. 3	No. 4	No. 5
10-26-48	0	.023	.010	0	
10-27-48	.049	.032	.006	.038	
10-28-48	NO COLLECTION				
10-29-48 (39 hrs)	.074	.066	.017	.009	
10-30-48	.194	.129	.384	.058	
10-31-48	.123	.157	.098	.018	
11- 1-48	.367	.127	.083	.009	
11- 2-48	.093	.049	.019	.065	
11- 3-48	.090	.065	.019	.006	
11- 4-48	.463	.812	.034	.012	
11- 5-48	1.543	14.61	.478	1.546	
11- 6-48	1.321	5.05	.037	.034	
11-7-48					
11-8-48 (48 hrs)	.085	.091	.017	.040	
11-10-48 (48 hrs)	.475	.861	.015	.068	

TABLE VI

Precipitron Collections

(Particles/1000 ft^3 Air)

Date	Shift	706-A	706-B	105	706-D	706-C	Comments	Rain
9-1	AM	6	7.5	698	6.2			
	PM	2.5	12.5	415	8.5			
	(2)				6.8			
9-2	AM	25.6	1.3	189	3.4			
	PM	2.6	10.0	150	1236			
	(2)				0			
	(3)				37			
9-3	AM	13	10	1528	51			
	PM	6.8	0		7.7			
	(2)				11.5			
9-4	AM							
	PM				1.3			
9-5	AM				3.9			
9-6	AM				8.5			
9-7	AM	10	14		6.4			
	PM		14					
9-8	AM	5.1	6.4		5.1			
	PM							
9-9	AM				8.5			
9-10	PM				0			
9-11	PM				10			
9-12	PM				3.9			
9-13	AM				0			
9-14 to 9-19	(No Samples)							
9-20	PM		6.4		4.3			
9-21	AM	7.3	7.3	9.0	5.1	17		
[illegible]	PM	5.1	7.3	13.0	6.4	7.7		
	(2)				4.3			
	(3)				6			
9-22	AM		2.6		2.6	7.7		
	PM	5.1		21	5.1	3.8		
	(2)			99	4.3			
	(3)				6.4			
9-23	AM		5.1		2.6	1.3		
	PM				3.4	18		
	(2)				5.1			
	(3)				14			

Date	Shift	706-A	706-B	105	706-D	706-C	Comments	Rain
9-24	AM			14	7.7	6.8		
	PM		0		3.9	19		
	(2)				2.6			
9-25	AM				0.85			
	PM							
	(2)				0			
	(3)				1.7			
9-26	AM			14	1.3			
	PM			17	1.3			
	(2)			5.1	2.6			
	(3)			2.2	1.7			
9-27	AM		0	6.4	2.6	.85		
	PM	1.3	1.3	13.7	0	2.6		
	(2)			26.0	1.7			
	(3)				11.0			
9-28	AM	.85	21			4.3		
	PM		3.9		2.6	5.1		
	(2)							
	(3)				2.6			
9-29	AM	1.3	3.9		0	0		
	PM		7.7		2.6	5.1		
	(2)				.85			
	(3)				2.6			
9-30	AM	1.3	0		1.7	696		
	PM		1.3	100	3.9	0		
	(2)							
	(3)				67			
10-1	AM	3.8	2.6	21	1.3	5.1		
	PM		3.8		2.6	1.3		
	(2)				1.3			
	(3)				0			
10-2	AM				3.4			
	PM			5.1				
	(2)				6.4			
	(3)				3.8			
10-3	AM			5.1	3.8			
	PM							
	(2)				0			
	(3)				3.8			
10-4	AM				3.8	7.7		
	PM		1.7		3.8	0		
	(2)				2.6			
	(3)				0			

Date	Shift	706-A	706-B	105	706-D	706-C	Comments	Rain
10-5	AM	1.3	10		9	2.6		
	PM		3.8			1.3		
	(2)							
	(3)				0			
10-6	AM	3.8		1.3	1.3	2.6		
	PM			1.3	0	7.7		
	(2)				0			
	(3)				1.3			
10-7	AM	5.1				5.1		
	PM				2.6	2.6		
	(2)				3.8			
	(3)				2.6			
10-8	AM	6.4	1.3		2.6	3.8		
	PM		2.6		7.7	129		
	(2)				1.3			
	(3)				2.6			
10-9	AM				1.3			
	PM				0			
	(2)				1.3			
10-10	AM				2.6			
	PM				1.3			
	(2)				1.3			
10-11	AM	1.3	0		2.6			
	PM		2.6		0			
	(2)				1.3			
	(3)				5.1			
10-12	AM	0	2.6		5.1			
	PM		3.8	15	1.3			
	(2)				1.3			
	(3)				3.8			
10-13	AM	1.3	0		0			
	PM		2.6		2.6			
	(2)				0			
	(3)				0			
10-14	AM	1.3	0		1.3			
	PM		0	0	0			
	(2)				0			
	(3)				0			
10-15	AM	0	2.6					
	PM		1.3		.85			
	(2)							
	(3)				0			
10-18	AM	2.6						

operated simultaneously with the filtron, at the same location. An examination of these data indicates that generally the precipitator data shows less particulate material than the filtron collections. This difference is possibly a reflection of continuous sampling vs interrupted sampling more than a comparison of relative collecting efficiencies.

Table VII is a composite, giving the results of collections of all outside continuous collectors. The sedimentation frames are grouped as in Table II-A, and filtrons, airways, and large U.S.P.H.S. collectors are reported as averages of all outside stations. Rainfall and average wind velocity during each collecting period are also noted. Average collections are noted for the five days total shutdown, for the two days following start-up of the pile, and for another five day period subsequent to this. Pertinent activity on the area is noted as "comments." The table starts on 10-15-48 because total coverage had not begun until that time, and comparisons with earlier data would be invalid.

Several interesting indications may be deduced from this table. It first appears that start-up of the pile after a shutdown releases a large number of active particles, most of which seem to be heavy, both by their appearing in the nearest sedimentation frames in very large numbers, and by the fact that the suction-type collectors do not show an increase. It has been estimated that particles of UO_2 as large as 10 microns would be unlikely to be deflected into the suction nozzles. Slug pushing also releases a large number of active particles, most of which are large.

Comparison of figures for total shutdown, with the similar period after shutdown, once the clearing out of the pile was allowed, shows an increase of particles in Group a of the sedimentation frames by a factor of less than 2, no significant change in collections at more distant points, and an actual drop in number of particles picked up by suction-type collectors. This may imply that a large fraction of air-borne active particulates were due to relocation and that the progress of the grassing and paving operations on the area were showing results.

A complicating factor which occurs throughout the period studied is the fact that construction of the filter house proceeded, with the consequent sporadic stirring up of surface earth at the location where a high degree of surface contamination exists. This factor probably accounts for some of the high counts found near the stack even during "dead time."

The average wind velocity also has an effect on collection. Suction type collectors, especially filtrons, show an increase in collection rate, even during "dead time", whenever the average wind velocity reaches 8 m.p.h. Also, during these wind conditions, Group d ($>$ 1000') often shows a higher average collection than Group c ($<$ 1000').

During the period of November 4 to 6, suction-type collectors showed a high degree of air-borne particulate contamination. There was no commensurate rise in frame collections. This fact, together with the fact that most observed spots were of low total activity pointed to a fine mist of chemical wastes.

TABLE VII

Average of Suction Type Air Samplers

Date Time	Sedimentation Frames: Gr. a (5) < 160' from 105 Stack	Gr. b (2) ~300' from 706-D Stack	Gr. c (6) 300' - 1000' from 105 Stack	Gr. d (9) > 1000' from 105 Stack	Air Filters: Filtrons 6 stations	Airways 10 stations	U.S.P.H.S. Collectors 4 Stations	Weather: Rain (inches)	Average Wind Velocity(m.p.h)	Comments
	(Particles/frame/period)				(Particles/1000 ft³)					
10/15 24	34.2	9.5	25.0	17.8					6.7	Grassing beg n.
10/16A 12	196	12	17.1	8.5	.13	.73	.09		2.7	Slugs pushed.
10/16P 12	11.6	2.5	3.0	2.2	.32	.40	.57		6.5	Total shut down.
10/17A 12	9.2	4.0	2.8	6.6	.22	.11	.11			
10/17P 12	N O C O L L E C T I O N - 3 0 H O U R S				1.06	.08	2.00	6.50	9.8	
10/18A 12	16.4	2.6	1.8	1.3	1.61	.19	.09		7.7	
10/18P 12	96	2.0	8.0	9.1	1.16	.50	.11		10.0	
10/19A 12	5.2	15.8	6.1	4.2	1.44	.12	.06		0.4	
10/19P 12	2.6	1.0	4.5	1.2	2.15	.07	.29		8.3	Paving beg n.
10/20A 12	10.0	2.5	1.5	3.0	.05	.18	.07		2.8	
10/20P 12	3.4	2.0	1.0	0.9	.50	.06	.05		7.9	
10/21A 12	2.8	3.5	4.3	1.8	.15	.54	.10		3.5	
10/21P 12	19.6	2.0	8.1	2.9	.47	.22	.19		4.8	
Av. (dead time)	17.7	3.8	4.1	3.3	.83	.23	.33			
10/22A 12	342	8.5	5.5	10.8	0	.11	.04	Trace	2.9	Pile started.
10/22P 12	254	29.0	9.0	6.7	.56	.16	.11		2.5	
10/23A 12	141	5.0	3.7	13.6	.37	.18			1.2	Iodine dissolving.
10/23P 12	32.0	6.2	6.8	3.0	.74	.18	.44		2.7	
Av. (2 da. pile operation)	192	12.1	6.3	8.5	.42	.16	.26			
10/24A 12	54.0	1.0	1.1	2.1	.05	.06			3.4	
10/24P 12	17.0	1.5	2.9	3.6	.14	.16	.04		7.3	
10/25A 12	10.6	20.1	8.2	2.6	1.20	.08			4.0	

Average of Suction Type Air Samplers (con't)

Date	Time	Sedimentation Frames (Particles/frame/period): Gr. a (5) < 160' from 105 Stack	Gr. b (2) ~300' from 706-D Stack	Gr. c (6) 300' - 1000' from 105 Stack	Gr. d (9) > 1000' from 105 Stack	Air Filters (Particles/1000 ft^3): Filtrons 6 Stations	Airways 10 Stations	U.S.P.H.S. Collectors 4 Stations	Weather: Rain (inches)	Average Wind Velocity (m.p.h.)	Comments
10/25P	12	12.4	3.0	2.0	4.0	.67	.22	.07		3.3	
10/26A	12	12.2	29.0	6.7	4.4	.23	.27			7.6	
10/26P	12	50.0	2.5	3.1	3.6	.83	.09	.01		10.0	Redox dissolving
10/27A	12	28.4	3.0	2.1	6.7	.33	.19			4.0	
10/27P	12	2.4	6.0	1.0	1.7	.59	.12	.03		3.4	Redox dissolving
10/28	15	41.8	6.5	1.9	7.8	.33	.11			2.4	
Particles/Frame/24 hours:											
10/29	24	32.4	4.5	7.3	3.1	.62	.09	.04		2.5	Redox dissolving
Av. 10/24 to 10/29	(12 hrs)	26.7	7.4	3.9	3.9	.50	.13	.04			6 day av. - dry weather
10/30	24	24.0	85.5	20.3	5.8	.95	.18	.17		2.2	
10/31	24	28.0	28.5	9.3	8.3	.07	.11	.10	.10	2.3	
11/1	24	96.6	18.0	4.2	3.8	.57	.14	.15	.10	4.2	Redox dissolving
11/2	24	34.4	9.0	1.7	2.2	.43	.20	.06	.95	5.6	
11/3	24	22.2	4.8	1.3	1.4	.97	.03	.03		7.2	Redox dissolving
11/4	24					.67	.09	.33		6.3	Redox dissolving; Redox-ex[...]
11/5	24	169	4.3	7.5	31.5	7.78	.58	4.54	.60	7.8	Slugs pushed; evaporati[...]
11/6	24					1.57	.15	1.61	1.50	13.3	
11/7	24	34.6	3.7	6.6	3.1	.27	.19	.06		9.0	Pile down to connect duct
11/8	24					.21	.08			5.9	Iodine dissolving--Redox dissolving
11/9	24	26.9	7.0	6.2	4.6	.91	.45	.35	.05	3.8	
11/10											

A check showed that during this period a batch being processed by the Redox Group required an extra evaporation, their off-gas being vented through the 205 Stack. This fitted the observation that the highest particle density was noted nearest this stack.

It may be also noted that the three types of air filters used show considerable disagreement. This is partly due to the fact that sampling locations are not usually duplicated. However, a filtron is run near an airway at 706-B, and a filtron is run near a U.S.P.H.S. collector on the 706-D east platform for comparison purposes. In each case the filtron showed the higher relative particle count. This amounted to a factor of about five in both the case of the airway and the large filter. The discrepancy in the case of the airway can partly be explained by the increased absorption of the filter bag, making the radio-autographing technique less sensitive. However, this does not explain the difference obtained with the U.S.P.H.S. filter. The one difference which exists in common is that the air intakes on both the airways (which are placed on stands) and the large filters are five or six feet above the ground, while the filtrons usually sample air within two feet of the ground. Consequently, filtrons may pick up dust which is raised a short distance above ground, but not sufficiently to reach the usual breathing zone.

Other related studies have been made. Some of these have been made by or for this division, and others have been made by the Chemistry, Physics, and Technical Divisions.

A probe was inserted into the air duct to the 706-D Stack. This stack is the outlet for ventilating air from the cells. A filter paper cover for the probe was changed daily during the RaLa run of August 25 - September 2, and for a few weeks thereafter. Although the process takes place in a closed system in apparatus within the cells, and the off-gas passes through a duct to the 205 Stack, enough leakage occurs so that the cell ventilating air carries considerable radioactivity. The probe, intercepting approximately 6 $inches^2$ in the duct of 9 $feet^2$ cross-section area, picked up by impingement enough activity to read approximately 90 mr/hr (by CP π) in a day's time during the RaLa run. Some of this was diffuse, but many points of concentration, due either to particulates or droplets, appeared. Active specks were still obtained from this source six weeks after the completion of the run.

A qualitative test was made to ascertain the relative value of activity due to UO_2 particles of pile origin and to particulates from chemical sources, on sedimentation frames from various locations. This was first suggested by the fact that the size distribution (judged by activity of the specks) was much more uniform in the vicinity of Buildings 706-C and -D than in the vicinity of Building 105. An assumption was made that most particulates of chemical origin would be water soluble, while particles originating in the pile would be relatively insoluble in water, since they consist of UO_2 with occluded FPs. The test consisted of leaching sediment samples from Frame #5 (near the chemical operations), and several of the frames near the pile stack, first with water, and then with nitric acid. After evaporation, these fractions and the insoluble residues were counted for beta and gamma with a mica-window counter. Counts on the insoluble residues were negligible compared to the water and acid-soluble fractions in each case. A sample of solids from the pile air duct and

[redacted]

one of the probe filters from 706-D ventilating air duct were similarly treated. Decay was noted on the several specimens. The results appear in Table VIII.

TABLE VIII

Water and Acid-Soluble Fractions of "Particulates"
c/m (Beta and Gamma)

Code	Source	Water-Soluble Fraction	Acid-Soluble Fraction	Percent of Total	Apparent Half-Life
5-W	#5 Frame	3,602		69	37 days
5-A	#5 Frame		1,606	31	32 days
5-2-W	#5 Frame	2,396		85	48 days
5-2-A	#5 Frame		423	15	30 days
10-W	#10 Frame	855		20	42 days
10-A	#10 Frame		3,413	80	62 days
13-W	#13 Frame	1,955		6.7	33 days
13-A	#13 Frame		27,040	93.3	33 days
14-W	#14 Frame	406		3.0	45 days
14-A	#14 Frame		13,084	97.	48 days
[illegible]-W	105 Air Duct	9,266		2.4	70 days
[illegible]-A	105 Air Duct		370,000	97.6	70 days
D-W	D-probe	365,000		68	16 days
D-A	D-probe		170,600	32	13 Days

The above data do not show any significant difference in the decay rates of any pair of water and acid-soluble fraction. What does appear is that the water-soluble fraction of pile produced particles is small, and differs markedly from that of sediment from #5 Frame. The latter agrees roughly with the impingement samples from D-probe. It also appears that the collections near the 105 Stack also include particulates of chemical origin--probably via the 205 Stack.

During the period 9-17-48 to 11-17-48, a total of 767 nose swab samples were taken at the dispensary from a selected number of people upon completion of the day's work. The cotton swabs were sliced open, counted in a standard beta-gamma counter at 10% geometry, and were then radio-autographed for 24 hours. By this technique particles were detected on 66 samples out of the entire group, or 8.6%. The number of individuals reporting daily for swabbing fluctuated widely from a high of 64 on one day to a low of 8. The daily average for the last five weeks was approximately 14.

Particles were detected on a greater percentage of samples during the period 9-21-48 to 10-8-48 than any other time, but during this period the greatest number of people reported to the dispensary for swabbings. Relatively few particles have been detected since 10-8-48, but during this period the number of people reporting daily has fallen off markedly.

Of the total of 767 swabs, 138 were contributed by a group working in Building 105, with a particle incidence of 12.3%, as compared with an incidence of 7.8% in the remaining 629 swab samples. Air collections taken within 105 have indicated a greater amount of particulates than any other location.

These results give evidence of the presence of air-borne radioactive particulates. The figures do not supply a good measure of the extent of this type contamination, as it is felt that negative results are not conclusive.

On October 16, a group of 14" x 17" X-ray film, wrapped in two thicknesses of 1 mil Al foil and covered with 1/2" plywood boards, were placed on the ground in three radial lines, east, west and south, respectively, of the 105 Stack. They were allowed to remain for 48 hours and then developed. The purpose was to ascertain the density of radioactive particle distribution on the ground at that time. Unfortunately, a 1.65" rain fell on the afternoon of the day the films were set out, and most of them received water damage. A count could not be made, but occasional good films showed densities of dozens of particles per square foot near the 115 and 706-C Buildings, and a few particles were in evidence on films as distant as a mile from the stack.

On November 4-6, R. H. Wilson of Rochester was at the Laboratory with a cascade impactor. During this period five samples were taken with this instrument from the pile exit air duct. This apparatus draws 0.5 cfm of air, and, by varied jet sizes, separates any particulates into four stages by impingement on resin covered glass slides. A fifth stage is supplied by a filter backing the series. The mean size of particles in each fraction is a function of the density of the material. The above mentioned apparatus had been calibrated for UO_2 (specific gravity 10.9). It was estimated that the maximum size of particles of UO_2 taken in by the inlet orifice is 10 microns. The first stage arrests all particles greater than 4 microns, the second fraction has a mean size of 2 microns, the third, 1 micron, and the fourth, 0.7 micron. It was estimated that the fifth stage (filter paper) fraction had a mean size of approximately 0.4 micron. It must be noted that if any active particulates were other than UO_2 the above distribution is invalid.

The slides were to be analyzed for uranium content at Rochester by the spectroscopic method. Beta and gamma counts were taken on the slides and filters. Slides from two runs were radio-autographed before being sent to Rochester. Table IX shows results of beta and gamma counts.

TABLE IX

Beta and Gamma Count on Cascade Impactor Samples

(Figures Indicate c/m at 10% Geometry)

Run Number	Mean Diameter (Microns) > 4	~2	1	0.7	0.4
#1a (15 hour after collection)	1372	272	293	176	843
#1b (73 hour decay)	1096	124	81	46	
#2a (1 hour after collection)	987	625	485	309	1763
#2b (73 hour decay)	531	154	88	48	
#3a	4482	337	284	139	233
#3b (7 hour decay)	4533	357	299	123	236
#4a	6779	531	198	76	96
#4b (7 hour decay)	6635	579	201	61	78
#5a	469	388	412	316	4223
#5b (7 hour decay)	175	94	107	41	263

Run #1 was a 7 hour run under normal operating conditions.
Run #2 was a 14 hour run under normal operating conditions.
Run #3 was a 6 hour, 19' run, pile down, slugs being pushed.
Run #4 was a 51' run, 12' of which was start-up of fans.
Run #5 was a 56' run, power on.

It appears from Runs 1, 2, and 5 that the greatest decay rates occur in the finer fractions. Also, judging from Runs 3 and 4, which showed no significant change in approximately 7 hours, the fast decaying fraction appears when the sampling takes place when the pile is "on", and may be due either to the freshly developed activity in the UO_2 particles or to decay products of gaseous fission products adhering to particles or impinging directly on the slides.

Radio-autographs were made of Groups #1 and #2, A-D. These consisted of 72-hour exposures with Eastman's industrial type K film. This film has not been calibrated, but is the most sensitive X-ray emulsion produced by Eastman. The results appear in Table X.

TABLE X

Radio-Autographs of Cascade Impactor Slides

Sample	Mean Diameter of Particles (microns)	Beta and Gamma c/m (10/5)	Beta and Gamma c/m (10/8)	Number of Particles Detected	c/m/Particle
1A	6	1372	1096	140	7.8
1B	2	272	124	56	2.2
1C	1	293	81	41	2.0
1D	0.7	176	46	15	3.1
2A*	6	987	531	44	12.1
2B	2	625	154	73	11.6
2C	1	485	88	88	1.0
2D	0.7	309	48	38	1.3

* This slide was broken, and impingement design was irregular. It seems that the air stream was destorted, making A and B fraction inaccurate.

These radio-autographs showed a diffuse background in addition to distinct spots. Consequently, c/m/particle as given in the table represents a value greater than that found in the particulates above. This effect was greatest in the finer fractions.

A report from Rochester on uranium content of the various samples has not yet appeared.

An estimate of the probable surface distribution of UO_2 particles of pile origin, vented through the stack was made using a formula from Sturdevant's Engineering Handbook:

$$\text{Mean distance traveled} = \frac{\text{K x wind (mph) x stack height}}{(\text{particle size in } \mu)^2 \text{ x density}} = \frac{2.8 \text{ x mph x } 200'}{\mu^2 \text{ x } 10.9}$$

The figures resulting from this formula approximate those derived from Stoke's law for T = 70°F. A few figures appear in Table XI, below.

TABLE XI

Mean Distance Traveled by UO_2 Particles From 200' Stack at Wind Velocity

Particle Size	1 mph	2 mph	5 mph	10 mph
100 microns	27'	54'	135'	271'
50 "	108'	216'	540'	1084'
25 "	432'	864'	2162'	4336'
10 "	2.7×10^3'	5.4×10^3'	1.35×10^4'	2.70×10^4'
5 "	1.11×10^4'	2.22×10^4'	5.56×10^4'	1.11×10^5'
2 "	6.78×10^4'	1.35×10^5'	3.39×10^5'	6.78×10^5'
1 "	51.4 mi.	103 mi.	257 mi.	514 mi.

[redacted]

It would appear from the above figures that the largest fraction of UO_2 particles less than 10 microns in diameter would fall outside the plant site if the terrain were flat, except when the wind is less than 1 mph. It must be considered, however, that the irregularities of the local topography cause considerable turbulence, and also make the effective stack height a variable. The frequency of windless periods, with their usual accompaniment of thermal inversions, also tend to invalidate this approximation. It may be noted, in this connection, that Frame #20, at 3000' N is at an elevation just less than the top of 105 Stack, and that there are occasionally high collection rates.

The Physics, Chemistry, and Technical Divisions have done considerable work in analysis of the nature and size distribution of particulates at their sources, particularly at the pile. The work of Physics and Chemistry Divisions is being reported in ORNL-197 which will appear soon.

J. S. Cheka

H. J. McAlduff

fsc
11-29-48

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OAK RIDGE NATIONAL LABORATORY
CENTRAL FILES NUMBER
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Subject The Particle Problem at ORNL
An Historical Summary

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THE PARTICLE PROBLEM AT OAK RIDGE NATIONAL LABORATORY

AN HISTORICAL SUMMARY

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Introduction

Early in 1944 radiation measurements made in the X-10 Area in connection with routine surveys indicated a gradual build-up of general background activity in the downwind direction from the exhaust stack following slug ruptures in the reactor. It was also noted that this background contamination decreased with each subsequent rain. It was not suspected at that time that the origin of this radiation was associated with airborne particles. The failure to recognize the existence of radioactive particles was due, in part, to the fact that adequate instruments were not available. Furthermore, air samples taken in many areas by constant air monitors since the Laboratory began operations in 1943, have indicated no general or gross air contamination much above tolerance except for a few occasions when localized areas were contaminated with radioactive iodine, radioactive phosphorus, or general radioactive fumes.

In May 1948 it was learned that the people 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. With this in mind more emphasis was placed on general area surveys.

In the course of a routine survey on May 20, 1948, the presence of radiation was detected on the platform of one of the service buildings (Paint Shop). The dust and debris in the immediate vicinity of the apparent source of radiation was carefully collected and examined in an effort to

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was undertaken by the Health Physics Division. Manpower was diverted from certain routine operations to this investigation. This decision was made even though no indication had been found that radioactive particles smaller than 10 microns were settling on the Laboratory grounds. Since the percentage of particles larger than 10 microns which enter the lungs is believed to be very small, it was the general opinion that no serious condition existed because of airborne particles.

Extensive field surveys were undertaken as the first major step in the investigation of the problem, and these surveys disclosed a fairly large number of radioactive particles dispersed throughout the areas surveyed. Special attention was given to freshly graded areas where, it was believed, contamination would not have been tracked or spread by equipment. The number of particles found ranged from one per 50 square feet to only a few in 4,000 square feet. The greatest number per unit area was found in the vicinity of the reactor off-gas stack. Examination of these particles revealed that most of them had a characteristic gray color and a range in size from 90 to 500 microns. It was believed that they originated in the reactor and were airborne from the stack.

The use of 3' x 4' wooden trays with glass wool bottoms to trap and hold airborne particles which might fall on them indicated definitely that at least some particles were airborne. This corroborated results obtained in the survey of freshly graded areas which supposedly could have become contaminated only by airborne particles.

The first evidence of radioactive particles on the wooden trays with glass wool bottoms was found on July 21, following a slug rupture on July 20. An examination of the radioautographs of these trays taken on X-ray film revealed the presence of many specks having a considerable range in activity.

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Study of the X-ray film indicated a range in sizes of the radioactive particles from approximately a micron up to many microns in diameter. This confirmed earlier predictions that where larger particles existed, smaller ones should also be found. Many of these particles fell into the range of size which, according to the data of Dr. Philip Drinkler of Harvard University, could be effectively held up in the lungs. Drinkler's data, however, applies to tobacco smoke, MgO, and $CaCO_3$, and may or may not apply to this problem.

This evidence of particles covering the whole range of sizes from less than one micron to several hundred microns was sufficient to indicate that the problem of air-borne radioactive particles definitely presented a possible health hazard, since it included those particles which could be breathed into the lungs and possibly retained there for a considerable period of time. Therefore, it was decided that on the basis of this information, immediate action should be taken to develop methods for maintaining control of the formation and distribution of airborne particles on the plant site.

After considerable discussion of the particle problem with Mr. T. F. Hatch, he made the following statement in a memorandum on the subject: "It cannot be said, from the existing knowledge and data, that a health hazard does or does not exist. Owing to probable requirements of many years to develop proof from experience among exposed individuals, decision must now be made as to corrective measures in the absence of absolute proof. The only proper position, in this situation, is to assume a potential hazard and proceed within reasonable limits to institute corrective measures, and, in addition, set up animal research to study this hazard".

In a meeting of representatives of Oak Ridge National Laboratory with members of the Atomic Energy project at the University of Rochester, the opinion was expressed by the Rochester group that "very little if any real hazard to health exists in the present situation, and that shutting down operations would not be warranted." They agreed, however, to undertake a research program to obtain information not presently available but which is necessary for a final evaluation of any hazard which may exist in this connection.

After being told of the particle problem and asked his views, Dr. Shields Warren of the Atomic Energy Commission expressed, in a letter to Dr. K. Z. Morgan on October 21, 1948, the opinion that "the conclusion is justified that no hazard of pulmonary damage or of ultimate production of pulmonary carcinomas exists".

<u>The Full-Scale Program</u>

At a meeting of Laboratory management on August 3, 1948, the following four methods of eliminating the formation and distribution of active particles from the reactor exhaust stack were considered:

(a) The use of uranium oxide slightly enriched in U^{235} instead of solid uranium rods. This method would eliminate the oxidation of the uranium and the subsequent rupture of aluminum cans.

(b) To enclose all of the uranium slugs in aluminum tubes and convert to water-cooling of the reactor.

(c) Complete filtration of all the cooling air from the reactor before it is discharged up the stack.

(d) Recycle and cool the air, filtering only the purge which is discharged up the stack.

Methods (a) and (b) were believed to be impractical under the existing

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conditions and would require a tremendous amount of engineering and development work before they could be placed in use. In preparation for reaching decisions on methods (c) and (d) information regarding the availability of filtering equipment was requested from various manufacturers.

During the following weeks it was decided that the installation of filters in the exhaust air stream of the reactor would be the most feasible and practical solution to the problem. Consideration was given to the advisability of using 200 Chemical Corps Filters, Type 6, size 24" x 24" x $11\frac{1}{2}$", each with rated air capacity of 600 cfm, in the filtration process. The basis for this recommendation was as follows:

(a) Any open system of removal devices will undoubtedly be followed by a mechanical filter as a final clean-up apparatus before discharge of effluent gases to the atmosphere.

(b) The Chemical Corps Filter has been fabricated on a production basis and found to function satisfactorily under various field conditions.

(c) The Dayton and Hanford plants have obtained good results with it and the primary objection seems to be cost, with disposal following contamination a secondary objection. Techniques for removal and disposal have already been developed and have been in effect for approximately a year at the Dayton plant.

(d) The framework installed can also be used for a glass wool filter instead of the paper type if, in the light of future developments, this is deemed advisable.

(e) The recommended filters were already in production for use at other AEC installations and could be obtained in a minimum

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amount of time, whereas the other filtering devices for radioactive materials are still, more or less, in the experimental stage.

Using the dioctylphthalate and methylene blue penetration tests, according to information received from the Chemical Corps, results indicate that the CWS filter No. 6 will remove 99.97% of the smoke and dust particles having a median diameter of 0.25 - 0.35 microns from an air stream and will allow the passage of about 3 per 100,000 particles having diameters of 0.8 microns. Larger or smaller particles will be removed with even greater efficiency by CWS #6 paper.

By September 20, 1948, the following program had been formulated for a comprehensive and coordinated attack on the particle problem:

1. <u>Removal of Solid Particles from Reactor Air</u>

   (a) Technical Division - Design and procure cyclones, filters, and electrostatic precipitators to remove dust particles of .1 micron and above. Installation of filters to remove particles to be expedited by all possible means.

   (b) Engineering Division - Design and construct suitable facilities to hold the above equipment on its arrival and install equipment.

   (c) Operations Division - Survey slug channels each day for slugs undergoing swelling. Spray water in exit air duct during dislodging of ruptured slugs. Prepare detailed data on previous slug ruptures.

2. <u>Determination of Other Particle Problems</u>

   (a) Health physics Division - Investigate frequency of particles emitted from other buildings in which large quantities of

[redacted]

radioactive materials are processed. Investigate incinerator to determine if any active material is being burned.

3. Experimental Work on Decontamination

(a) Engineering, Technical, and Health Physics Divisions - Investigate means of decontaminating the process area to remove solid particles from the roads and ground. Determine the effectiveness of wetting and oiling the roads.

(b) Engineering and Safety Departments - Carry out oiling and wetting of roads and sidewalks. Arrange to vacuum areas and decontaminate by dirt removal or covering, grass planting, etc. If necessary to keep dust down, cover roads and any dusty areas with calcium chloride.

4. Policy of Operations

During the interim period until the filters could be installed the reactor was to continue in operation. Since it was believed a large percentage of the particles in the air came from those which had settled out and become airborne again due to the movement of vehicles or wind, the problem could not be solved merely by shutting down the reactor. Every effort was made to detect swelling slugs before they ruptured. Oiling and wetting streets along with decontamination procedures were carried out to reduce the number of airborne particles. While the particles were considered hazardous very little actual data was available to substantiate this belief. In any case, it was believed that the number of particles inhaled by personnel during the interim period would not greatly increase the danger.

The following plan of immediate attack was proposed and adopted:

1. Carry out the following steps to fix the particles that are already

[redacted]

settled in the X-10 Area so that they would not become airborne repeatedly:

(a) Plant grass

(b) Wash particles off roofs, surfaced roads, etc., with fire hose

(c) Hard surface all permanent roadways and keep other roadways oiled

(d) Block off roadways that are not needed

2. Determine the location of all particle-producing operations and discontinue or postpone these operations (with the exception of the reactor operation) until filters, precipitators, and other particle-removing equipment are installed.

(a) Investigate the advisability of postponing or eliminating the RaLa runs until particle-removing equipment was installed.

(b) Adopt similar precautions regarding other operations, such as redox process, that were believed to contribute to the number of particles in the X-10 Area.

3. Remove ruptured slugs from the reactor only during favorable metoerological conditions and when there were a minimum number of persons in the X-10 Area.

(a) Remove slugs only when there was a wind velocity equal to, or greater than, 8 miles per hour and no inversion. This, in general, precluded a ruptured slug removal operation except during the day shifts of Saturday and Sunday since inversions continue throughout practically every night.

4. During a period of a week following a known slug rupture, discontinue reactor operation when the following conditions exist:

(a) An inversion

(b) A wind velocity less than 5 miles per hour

(c) The wind is blowing from the northeast or east

This meant that for a week following a slug rupture the reactor would not ordinarily operate at night and it would operate only about half time during the day.

5. Move with maximum reasonable speed to place in service particle removing equipment wherever needed.

6. Use every reasonable means to locate and remove a ruptured slug as soon as it occurred.

7. Begin an investigative nose swabbing program in which approximately 50 selected persons would stop by the Dispensary for a nose swab at the close of each working day. The Health Division was to make the swabs which would be collected, placed in envelopes, and turned over to the Health Physics Division to monitor for beta and gamma activity. (The same 50 persons were to be used throughout the experiment.)

8. It was also decided that chest X-rays would be made for all personnel employed at the Laboratory. These were to be compared with those made at the time of employment with the view of determining if any evidence of particle damage could be detected.

9. The Health Physics Division would continue to collect information concerning the particle problem and determine, if possible, the following:

(a) Origin of particles

(b) Size distribution

(c) Frequency and number

(d) Activity (alpha, beta, and gamma)

(e) Effectiveness of above remedial measures

(d) Extent of hazards involved.

10. Develop new instruments for measuring the activity leaving the reactor in particulate form, and detect ruptured slugs at the earliest possible date after their occurrence.

Concentrated Study of the Particle Problem and Remedial Action

It was decided to install immediately in the reactor exhaust air duct two thicknesses of American Air Filter Company, FG-50 glass wool filters, followed by Chemical Warfare Service filters No. 6. As soon as the decision was made concerning the types of filters to be installed in the reactor exhaust air stream, design layout of the necessary structure to house the filters was started. The basic layout was presented to the Austin Company for detailed design on September 21 and preliminary grading was begun on September 22 by the J. A. Jones Construction Company. Construction proceeded on two ten-hour shifts daily until the filter house was put into operation on November 15, 1948. Preliminary efficiency tests on the operating filters were started at once.

It now appears that in all probability the present filter system is sufficiently effective to make the electrostatic precipitators unnecessary. The CWS #6 paper, in the manufacturer's efficiency tests using dioctylphthalate smoke, removes 99.97% of the particles of 0.3 microns diameter. In addition, retention of airborne particles of smaller diameters takes place by adsorption, absorption, or some other means not well understood. Data furnished by the Chemical Warfare Service indicates that the efficiency increases as the size of the particles is decreased to the range in which Brownian movement is effective. There appears to be an optimum particle size for which the filters are least efficient. Since this size is in the range of about 0.3 microns and since the filters are supposed to remove 99.97% of the particles in this range, they should have a very high overall efficiency.

[redacted]

An order has been placed with the Ducon Company of Mineola, New York, for a twelve unit cyclone separator assembly capable of handling the exhaust air from the reactor. The cyclones were originally scheduled to be shipped by December 11, 1948. A preliminary design report for a cyclone building has been completed and transmitted to the Austin Company for preparation of construction drawings. Until it is determined whether installation of the cyclone separator unit is economically warranted, the actual installation of the system will probably be postponed, although consideration is being given to the installation of cyclones to determine their effectiveness in reducing the load on the filters and to obtain operating data.

A thorough survey was made of the possible application of electrostatic precipitators to the X-10 air cleaning problem. These investigations revealed that no performance data was available for this type of filter system operated under conditions requiring as rigid specification as those demanded at the Laboratory. Therefore, there is no assurance that electrostatic precipitators can approach the effectiveness expected of the newly installed filter system.

The installation of electrostatic precipitators is also being postponed until such time as either (a) experience shows that the life of paper filters is so short as to make installation of electrostatic precipitators feasible on a purely economic basis, or (b) there is evidence that the filters are not removing a sufficiently large number of particles. To date, neither condition has been proven to exist by the data available. Nevertheless, electrostatic precipitators may be installed at a later date to reduce the load on the present filters and thus cut down replacement costs. In any case development tests will be conducted on electrostatic precipitators to determine

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their overall effectiveness in removing radioactive particles from the reactor exit cooling air. The use of improved roughing filters will also be investigated.

Since the reactor was known to be contributing airborne particles and since Hanford experience indicated that chemical operations were another contributing factor, a program of study of the exhaust gases from the various process buildings was set up.

Permanent air cleaning facilities were studied for all contaminated exhaust gases in the area. The contaminated air can be classified as follows:

(a) Dissolver and process off-gases which are highly radioactive and require scrubbing to remove acid gases such as NO_2.

(b) Cell ventilation.

(c) Hood exhaust.

Several collection and decontamination systems have been studied, involving different groupings of buildings. The possibility of materially reducing the flow of contaminated air from each building was considered in order to decrease the size of air cleaning equipment. Air ventialation systems in the past have been designed on the principle of dilution; i.e., the more air ciruclated the better. Now the principle has been changed to call for the circulation of a minimum amount of air and removal of all possible particulate matter and all gaseous impurities before it is exhausted. Tests were conducted, therefore, to reduce materially the flow of contaminated air from each building. In general, the cleaning systems originally planned would consist of the following:

(a) Equipment for Off-Gas Lines - Scrubbers to remove acid gases and traces of soluble gaseous activities such as I^{131}, plus additional cleaning for particulate activity along with the cell and hood exhaust air streams.

(b) Cell and Hood Ventilation - A roughing filter similar to the AAF Deep Pocket FG 50, and a finishing filter such as the CWS #6 paper. Depending upon the experience gained with the use of these filters in the reactor air cleaning system and upon experimental data, electrostatic precipitators may be installed.

More recent recommendations follow a somewhat different plan of attack:

(a) For very high level sources not containing excessive corrosive agents or moisture - 1 layer FG 25, 1 layer FG 50, 1 layer CWS #6 paper. (Example - cell ventilating air for 706-D building.) From a longer range economic consideration, the addition of a precipitron type cleaner before the filters may be desirable.

(b) For high volume, low level sources, such as hood air from low and medium level hoods - a precipitron type electrostatic precipitator so modified as to provide negative instead of positive ionization.

(c) For high level sources containing moisture and/or corrosive agents - an electrostatic precipitator. Data is not yet available to ascertain whether a precipitron, plate, or tube type precipitator is the optimum type.

(d) Small volume high level off-gas should not be mixed into or processed in the same system as low level, large volume sources, such as hoods.

The Technical Division plans to establish an experimental program to be instituted as soon as possible to ascertain the relative efficiencies of the various types of filters and electrostatic precipitators.

An experiment to observe slug ruptures was undertaken. Results of this investigation indicated that slugs swell to the rupture point much more slowly than had been previously thought. In the experiment not one of the heated slugs failed in 30 days' operation test, although each had a drilled hole several hundred times larger than the pin holes which might occur in the welds of metal cases due to faulty canning. Such a comparison suggested that slugs with faulty welds oxidize and swell gradually over a period of many months.

The conclusion drawn from a preliminary study of the possibility of using Brookhaven-type slugs is that considerable development work would be required to perfect new slug fabricating techniques and satisfactory remote control tools. Efforts are now being concentrated on other possible solutinns to the problem.

An instrument for monitoring reactor exhaust air in such a way as to serve as a specific detector for fission gases was developed and fabricated. It is believed that fission gases are produced by fission recoil processes from exposed uranium in the reactor. The monitor, hence, gives a continuous record of the relative area exposed. Since uranium is exposed in the reactor only when a slug is ruptured, it is expected that this instrument, which is now in continuous operation, will give a positive and early indication of any ruptured slug. However, it is not known at present whether or not the monitor will be a good detector for this purpose, since the background contamination is rather high and also because no slug ruptures have occurred since the monitor was installed.

Samplers were installed on the redox operations and the isotope separations building air exhaust lines. Results obtained from these samplers, which incorporated a cyclone separator followed by a CWS #6 filter, indicated that the redox process was only a very minor contributor of radioactive particles and that the chemical separations Bldg., 706-D, during the time of a Rala run was a major source, producing particles at a rate greater by several orders of magnitude than any other known source.

Temporary filters had been installed in the dissolver and vessel vent off-gas lines prior to the Rala run on which data was collected; but no filter was installed on the cell ventilation duct. Samples of the exhaust air indicated that the cell ventilation duct carried out activity at a higher level than the other lines. Calculations based on the data obtained in the course of the last Rala run indicate that the following amounts of airborne radioactive particles were discharged:

Cell ventilation duct	15 curies/5 days
Vessel vent line	2 curies/5 days
Dissolver off-gas line	0.5 curies/5 days

The above data clearly established the fact that the Rala production facilities constitute a major source of airborne activity. Design work for a cell ventilation duct filter was started immediately upon the disclosure of these facts. It is expected that this filter system will be installed before the next Rala run.

Dr. R H. Wilson of the Rochester Project visited the Oak Ridge National Laboratory during November 3-7, 1948, for the purpose of collecting samples of airborne particles to take to Rochester for analysis in an effort to determine primarily the particles size distribution. Results of this work have not been reported to date.

[redacted]

Current Status of the Particle Problem

The reactor exhaust air filter facilities have been completed and are now in operation. Sufficient data for evaluating the efficiency of the filters has not been compiled. Data now being accumulated will serve as a basis for determining whether cyclone separators, or electrostatic precipitators, will need to be installed in series with the present filters to reduce the load. For this use they need be neither extremely high in efficiency nor extremely expensive.

The fixation of particles which have already settled out over the plant area has been completed. Grass has been planted, the roads have been paved, and hosing down of the roads and streets has been accomplished.

Temporary filters have been installed in off-gas lines of the chemical separations building (706-D, Rala). Construction of filter facilities for the cell ventilation air, somewhat similar to those for the reactor, but on a smaller scale, has been started and is scheduled for completion December 31, 1948.

Sampling of exhaust gases from the reactor and chemical separations building will continue until the effectiveness of present filter installations can be ascertained.

Area surveys for particle contamination will continue on a routine basis as a part of the Health Physics program.

The initial program for making chest X-rays for personnel working on the plant site has been completed. According to present plans, a similar series of chest examinations will be made every six months.

The study of blood counts is now in progress and, according to present plans, will continue until sufficient data has been accumulated to evaluate the results.

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[redacted]

The nose swabbing program has been discontinued since no positive evidence of the presence of radioactivity in the lungs was obtained and no reliable quantitative measurements could be made.

Reactor sample stringers of a new design are being developed to decrease the number of particles released directly into the operating area when a stringer is pulled out. A temporary particle collector which eliminates about 90% of the particles has been installed and will be used until a more efficient permanent stringer and collector become available.

Three methods for detecting ruptured or swollen slugs are being developed and are presently under consideration. These are methods which will enable one to detect the defective slugs in an individual row. The method now in use is designed to detect the existence of a ruptured slug somewhere in the reactor. Experimental work to determine the most effective method or combination of methods is expected to begin soon.

Dr. Arthur J. Vorwald of the Trudeau Sanitarium and Mr. T. F. Hatch of the Industrial Hygiene Foundation of America have been engaged as consultants on the biological effects of inhaled radioactive particles.

Conclusions

(a) Most of the effort expended thus far has been concerned mainly with the removal and control of existing particles rather than with the elimination of their sources. The method of attack appeared feasible in view of the urgent nature of the problem. It is deemed advisable that greater emphasis in the future be placed on developing methods for eliminating the source of the particles.

(b) Before any final decision can be made regarding the type and size of the filter systems that will be most feasible for coping with the

[redacted]

particle problem it will be necessary to accumulate more data on the performance of those systems now in operation.

(c) There is not presently available sufficient and reliable data to permit making a thorough evaluation of the seriousness of the particle problem. Therefore it will be necessary to carry out more tests extended over sufficient time to gain more information regarding the basic problems involved.

(d) There is no positive evidence to lead one to believe that any significant damage has been caused to the personnel and that no appreciable risk is involved in the present plant operations under existing circumstances.

12-30-48

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APPENDIX I

BIBLIOGRAPHY OF IMPORTANT REPORTS AND MEMORANDA ON THE PARTICLE PROBLEM

ORNL Cen. Files #	Document Title	Author
48-9-148	ORNL Waste Disposal	S. McLain
48-9-254	1st Wky. Progress Rpt. on ORNL Waste Disposal, 9-27-48	S. McLain
48-10-49	2nd Weekly progress Report on Waste Disposal, 10-4-48	S McLain
48-10-132	3rd Weekly Progress Report on Waste Disposal, 10-11-48	S. McLain
48-10-236	4th Weekly Progress Report on ORNL Waste Disposal, 10-18-48	S. McLain
48-10-320	5th Weekly Progress Report on ORNL Waste Disposal , 10-25-48	S. McLain
48-11-17	6th Weekly Progress Report on ORNL Waste Disposal, 11-1-48	S. McLain
48-11-108	7th Weekly Progress Report on ORNL Waste Disposal, 11-8-48	S. McLain
48-11-163	8th Weekly Progress Report on ORNL Waste Disposal, 11-15-48	S. McLain
48-11-244	9th Weekly Progress Report on ORNL Waste Disposal, 11-22-48	S. McLain
48-11-293	10th Weekly Progress Report on ORNL Waste Disposal, 11-29-48	C. E. Winters
48-12-79	11th Weekly Progress Report on ORNL Waste Disposal, 12-6-48	C.E. Winters
48-12-203	12th Weekly Progress Report on ORNL Waste Disposal, 12-21-48	C. E. Winters
ORNL-146	Progress Report on the Particle Problem, 8-30-48	J.S.Cheka & H.J.McAlduff
ORNL-172	2nd Progress Report on the Particle Problem, 9-48	"
ORNL-211	3rd Progress Report on the Particle Problem, 11-48	"

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ORNL Cen. Files #	Document Title	Author
ORNL-215	Technical Division Quarterly Report for Quarter Ending November 30th, 11-30-48	E. C. Miller
ORNL-140	Technical Division Quarterly Report for Quarter Ending 8-31-48	S. McLain
48-8-19	Discussion on Particle Problem, 8-4-48	L.B.Emlet
48-8-86	An Estimate of the Exposure from Specks of Insoluble Radioactive Material that May become Lodged in the Lungs, 8-2-48	K.Z. Morgan
48-9-42	Industrial Hygiene Aspects of the Particle Problem, 9-7-48	H. J. McAlduff
48-9-123	Remedial Measures Regarding the Particle Problem, 9-15-48	K.Z. Morgan
48-9-126	Recommendation for Immediate Solution to Airborne Hazards from the Pile Stack, 9-8-48	J.W. Gost
48-9-140	Particle Problem, 9-20-48	C. N. Rucker
48-9-142	Air Cooling Program, 9-20-48	C. E. Winters
48-9-165	Preliminary Calculations Concerning the Particle Problem, 9-28-48	K. Z. Morgan
48-10-75	Recommendation for Pile Operation and Particle Program, 10-6-48	E. O. Wollan F. Western, & J.A. Swartout
48-10-8	Minutes of Conference on Particle Problem of Isotope and Pilot Plant Areas, 9-27-48	S. McLain
48-10-128	Recommendations for Future Rala Runs and Particle Problem, 10-11-48	E. O. Wellan F. Western J. A. Swartout
48-10-167	Particle Removal Test Program - TD-61 10-14-48	S. McLain

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ORNL Cen. Files #	Document Title	Author
48-10-166	Operations Shutdown - Particle Investigation, 10-15-48	L. B. Emlet
48-10-185	Temporary Filters on 706-C and D Bldgs., 10-15-48	S. McLain
48-10-211	Notes on the Particle Problem (Meeting with Univ. of Rochester), 10-19-48	F. Western
48-10-382	Particle Problem Program, 10-29-48	J.A. Swartout F. Western E. O. Wollan
48-10-357	Summary of Conference on Particle Problem, 10-28-48	T. F. Hatch

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HEALTH PHYSICS DIVISION

THE PARTICLE PROBLEM (PROGRESS REPORT #4)

J. S. CHEKA
H. J. McALDUFF

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HEALTH PHYSICS DIVISION

THE PARTICLE PROBLEM (PROGRESS REPORT #4)

J.S. Cheka and H.J. McAlduff

APR 25 1949

March 7, 1949

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THE PARTICLE PROBLEM (PROGRESS REPORT #4)

The third progress report (ORNL-211) covered particulate sampling through November 9, 1948. The present report records sampling data through January 31, 1949.

During this period the filter house was connected into the pile exit air duct, and put into operation. This entailed a pile shut-down of several days while the ducts were broken through and connected, and also the blowing out of the contaminated concrete dust, pulverized in the course of the operation, from beyond the exit side of the filter. The period also includes two Ra-La runs.

Collection data from 3' x 4' sedimentation frames are shown in Table I. While these collections are not a measure of breathable particle sizes, they do give an indication of the comparative density of particulate contamination - at least as regards solids, such as are produced in the pile. They have been found not to be an indication of chemical-process produced contamination, which presumably occur at their sources in the form of a fine mist.

Allowing for the above mentioned limitations, and the fact that the frequent and heavy rainfall throughout most of this period interfered with collecting efficiency, Table I indicates that a considerable number of particles

[redacted]

The Particle Problem (Progress Report #4)

Table I
Sedimentation Frame Data
Particles/Frames/24 hr. Period

Frame No. / Direction / Dist.(ft) 105 Stack / Date From	To	1 SW 700	2 S 1200	3 NW 800	4 SE 900	5 SE 600	6 E 650	7 SSW 1850	8 W 1700	9 NNE 1050	10 NNE 1500	11 N 55	12 SSW 125	13 SE 75	14 W 160	15 SSE 900	16 SSE 1550	17 SSW 1600	18 NE 6500	19 NE 11500	20 N 3000	21 SE 750	22 SE 325	Rain	
10/23	11/9	10.6	25.6	4.9	8.4	17.9	12.3	12.9	4.5	9.1	59.4	63.7	36.6	32.1	72.8	4.1	4.2	3.5	3.4	1.9	9.9	3.4	11.0	2.70	(1)
11/9	11/11	13.0	1.5	2.0	1.5	2.5	2.5	2.5	2.5	2.0	5.0	3.0	2.5	9.5	22.5	1.0	1.0	18.0	0.5	2.0	1.5	3.0	0.5	.55	(2)
11/11	11/12	5	7	5	4	30	4	6	5	7	9	19	18	7	43	3			3	2	2	11		.2C	
11/12	11/13	2	2	3	9	3	148	3	5	3	17	26	7	9	44	6	11.0		3	4	1	8	4.5		(3)
11/13	11/15	53	1.0	0.5	1.5	4.0	187	5.0	15.5	9.5	9.5	717	5.0	320	51.5	0		0.3	9.5	2.0	3.0	4.0			
11/15	11/16	839	55	114	10	14	12	320	161	103	1496	702	103	491	901	23	15	161	197	175	80.	12	18	.22	
11/16	11/18	39.5	13.0	6.0	36.0	18.0	106.	13.5	44.0	4.5	104	56.0	94.0	15.5		24.5	12.5		2.0	20.5	7.0			3.60	
11/18	11/23	9.6	3.0	2.2	6.6	5.6	8.6	10.0	1.0	1.6	8.6	14.0	19.0	49.8	24.3		4.2		1.4	1.6	1.6	2.4	4.2		
11/23	11/24		2	25	25	14	14	26	12	4	123	148	128	474	275		6		1	54	15	70	24	.91	
11/24	11/26			5.0	3.0		6.0		4.0	1.0									4.0	2.0	2.0	2.5		4.22	
11/26	11/30		8.7	6.5	4.0	34.2	71.2	3.2	5.2	1.5	31.0	39.8	61.7	29.7					3.5	5.2	6.2	10.5	19.2		
11/30	12/2		12.0	18.0	7.0	23.5	10.0		13.0	1.5	13.5	58.5	135	86.5	88.0	1.7			11.0	15.5	3.5	15.0	7.5	1.90	
12/2	12/6		3.5	1.5	6.0	5.0	22.0		2.5	0.3	2.0	61.0	38.0		83.8	3.3			0	1.7	2.0	2.3	6.0	.70	
12/6	12/8			1.5	1.5	12.0		1.6	1.0	1.5	1.5	90.0	43.5	19.5	8.5	0.5			1.0	1.0	0	2.5	4.5		
12/8	12/10			0.5	2.5	9.0		1.0	3.5	2.5	138	47.0	21.5	88.0		1.5	0.7	0	1.5	0.5	0.5	2.5	5.0	1.51	
12/10	12/17			0	0.8	1.9		1.0	0.3	0.1	0.5							0.3	0	0.3	0.3	0.9	1.3	.50	
12/17	12/20			0.7	0.3	1.0		2.3	1.6	0.3	2.3	6.3	1.3					1.7	0.3	0	5.0	1.0	2.3	.31	
12/20	12/23			0.7	1.3	3.7		1.3	2.7	1.0	4.3	1.3	1.3	19.0				3.7	0	0	0.3		1.7	1.75	
12/23	12/27			0.3	2.0	0.5		1.0	2.3	1.0	0.8			2.5				0.8	0.5	0.3	0.3	0.8	1.8	.40	
12/27	12/31			0.5	6.0	1.3		2.5	0.8	0.8	1.3	3.1	7.8	0.8			0.1	0.8	1.0	1.3	2.3	0.8	15.9	3.90	
12/31	1/6			0.7	1.3	0.5		0.8	0.5	0	0	3.3	0.7	6.5		0.3	2.0	0		0.5	0.5		0.5		
1/6	1/7			6	4	1		0	0	2	16	20	1	45		0	2	1		0	4		3		
1/7	1/9										9.5	7.0	2.5	45.5											
1/9	1/10			0.3	1.3	7.0		0.3	0	0	8	5	13	10		0.7	0.3	1.3		0.7	1.7	1.1	6.0		
1/10	1/12			1.0	2.0	3.0		1.0	2.5	2.0	14.5	11.5	5.0	2.5		0	1.0	3.0		1.5	0.5	2.0	18.5	.50	
1/12	1/14			0.5	1.0	7.0		1.0	0	1.5	22.5	5.0	0.5	7.0		0.5	0	0		1.0	1.0	3.5	3.5	(.90)	
1/14	1/19										0.6	1.6	1.8	1.4										3.00	
1/19	1/24			0.1	0	0.5		0.9	0.3	0.3	1.6	4.0	2.8	32.2		0.4	0	0.2		0.2	0.2	0.3	0.4	.70	
1/24	1/28			0.5		2.8		0.3	0.3	0	2.3	4.0	0	72.8		0	4.5	0		0.3	0.8	0.8	5.0		
1/28	2/2			0	0.4	0.8			0	0.2	0	0.6	5.6	1.8		0	0.8	0.4		0.8	0.4	0.6	0.8		

Comments: (1) Average of 17 days (2) Pile down to connect Filter House (3) Pile Started - Filter of contaminated concrete, shattered by the break-through, was vented through the stack immediately after the filter-house was put into operation. This was expected. However, it was somewhat surprising to find that the particles continued to appear in some profusion for many weeks.

Table II is a condensed version of these same data, with the locations re-arranged in order of distance from the pile stack, and the time grouping approximately by months except that shut-down periods are recorded separately. It appears from this table that (1) more than a fourth of the particulates collected in the September-October period were due to re-location, as the total shut-down period caused a drop of less than a factor of four, (2) that the clean-up of the plant area (grassing, paving, etc.) was effective, as shown by comparison of the two shut-down periods, (3) that a large number of active particles were produced during the duct break-through, (4) that the filter system brought about a sizeable diminution of the number of heavy particles (reduction factor > 4 in one month, and > 13 in two months) and (5) that collection rate during January is about one fourth that of the period of total shut-down in October.

It may be noted that frame #11 is on the roof of the fan house, and is perhaps most significant as a measure of the primary source, and #13, which gives the highest recent values is near a concrete walk which was not affected by the paving and grassing operations, and consequently may be a secondary source. It

Table II
Sedimentation Frame Data
(Arranged according to distance from Pile Stack)
Particles/Frame/Day

	11 N 55	13 SE 75	12 SSW 125	10 NNE 150	14 W 160	22 SE 325	5 SE 600	6 E 650	1 SW 700	21 SE 750	3 NW 800	4 SE 900	15 SSE 900	9 NNE 1050	2 S 1200	16 SSW 1550	17 SSW 1600	8 W 1700	7 SSW 1850	20 N 3000	18 NE 6500	19 NE 11500	Rain	Average
6	79.8	58.3	168.5	81.0	42.5	38.2	85.0	49.0	40.1	20.8	12.7	20.0	13.5	15.2	11.9	9.2	14.1	14.6	9.6	5.5	5.0	8.4		36.5
1	54.3	9.1	11.8	14.5	34.9	6.5	10.4	4.4	9.1	4.2	6.7	5.6	8.9	5.1	8.7	5.6	3.8	8.5	4.7	6.2	3.6	4.5	1.65	10.5 (1)
	121.5	98.0	39.2	77.8	118.1	11.1	17.1	15.4	10.4	3.3	5.4	9.4	4.5	10.9	22.9	4.0	3.8	5.3	14.6	12.8	4.7	2.6	3.25	27.9
3	28.4	10.8	8.8	7.8	27.8	2.4	9.4	32.4	8.2*	7.0	3.4	4.4	3.4	3.2	2.6	15.2	15.3*	3.4	3.2	1.6	1.6	2.6	.81	9.2 (2)
0	159.	125.	52.6	122.	116.	13.1	15.8	56.0*	101.	9.0	11.7	9.7	5.4	8.9	9.2*	6.0	53.9*	19.2	24.7	8.9	14.7	18.0	8.95	43.9
1	23.4	23.4	20.4	11.2	66.0*	4.8	4.6	18.0		2.2	1.7	2.9	0.9	0.8	6.3	0.3	1.1	2.3	1.2	1.4	1.1	1.6	7.05	9.3
	4.4	21.6	2.4	4.4		3.1	2.1			1.0	0.6	0.8	0.3	0.4		1.2	0.5	0.4	0.9	0.7		0.5	9.10	2.7

(1) Total Shut Down
(2) Pile down - Connect Filter
* Not complete time

[redacted]

[redacted]

must also be noted that there was considerable rain throughout this period. There is no doubt that this factor reduced the number of particles detected by this method, but it is not clear whether this is due to the washing of the air or the washing off of particles that may have fallen on the frames. It may be noted, however, (Table I) that collections during dry periods, though slightly greater than those when there is rain, also follow the same trend.

The active particles found on the sedimentation frames after the cooling air had been routed through the filter appeared to be pulverized concrete, when viewed under a microscope. There appeared spots of discoloration on most of them. Decay curves run on four samples from two frames near the stacks, collected on December 2, showed an apparent half-life of $\sim$ 120 days during a two month decay. If one uses the rule of thumb that the apparent half-life of a natural agglomeration of fission products is a measure of it's age out of the pile, and considers that the shut-down to connect the filter-house occured less than a month before the date of this collection, it is evident that these samples showed no fresh particles that were passing through or by the filter, but that they consisted of duct contamination loosened by the break-through and connection of the air ducts, and carried by particles of concrete. One would then expect that the duct be cleared of this loose debris in the course of time, and this is what is occurring, as appears in Table II.

[redacted]

Table III
Filtron Data
Particles/1000 ft^3 Air

Date From	Date To	706-A	105	706-D	104-B	703-B	706-B	Remarks
10/23	11/9	0.59	1.75	1.82	0.57	0.27	0.92	
11/9	11/10	1.39	0.56	5.17	0.42	0.56	0.28	
11/10	11/11	3.19	0.71	3.20	0.71	0	0	
11/11	11/12	2.08	4.90	0.70	0.41	2.08	0.42	
11/12	11/13	0.56	0.28	7.57	0	0.56	0	
11/13	11/14	0.14	0	0	0	0.14	0	R
11/14	11/15	2.08	0.97	0.97	0	0.14	0.56	
11/15	11/16	0.14	0.42	0.71	0	0.28	0.28	R
11/16	11/17	0	0.14	0.14	0	0.14	0	
11/17	11/18	0.28	0.83	0.42	0.72	0.83	1.80	RaLa
11/18	11/19	0	0.97	1.81	0.28	0.97	1.67	RaLa
11/19	11/20	3.47	7.08	14.7	0.97	5.42	1.11	RaLa
11/20	11/21	850.	661.	814.	154.	631.	642.	RaLa
11/21	11/22	175.	50.1	31.7	53.6	17.8	42.4	C RaLa
11/22	11/23	4.17	0.14	7.22	0.28	0.14	0.28	
11/23	11/24	0.14	1.39	4.44	0.28	0	0.42	
11/24	11/25	2.50	0.42	7.08	0.42	0.42	0.69	
11/25	11/26	0.28	2.04	3.95	0.42	0.42	4.22	R
11/26	11/27	0	0	0.83	0.14	0.14	0.28	C
11/27	11/28	16.7	0.14	71.9	0.28	0.56	1.63	
11/28	11/29	0.42	0.30	1.59	0.28	1.26	0.42	
11/29	11/30	1.25	0.14	0.82	0	0.28	0.69	CR
11/30	12/2	3.92	0.41	2.18	0.07	0.54	0.27	
12/2	12/3	2.56	0.48	1.55	0.12	0.36	0.4	R
12/3	12/6	0.23	0.32	1.11	0.19	0.18	0.37	C
12/6	12/8	1.25	1.02	2.36	0.4	0.69	0.80	R
12/8	12/10	1.04	0.42	2.08	0.21	0.56	1.04	
12/10	12/13	0.79	0.51	0.65	0.14	0.05	0.37	C
12/13	12/15	0.70	0.69	11.6	0.07	0	0.28	R
12/15	12/17	0.07	0	3.06	0.07	0.07	0.07	
12/17	12/20	0.09	0	1.30	0.09	0	0.09	C
12/20	12/22	0.21	0.28	9.31	0.14	0.14	0.35	
12/22	12/27	2.89	0.09	0.81	0	0.08	2.11	R
12/27	12/29			0.69	0.07	0.14	0.07	
12/29	12/31	9.68		1.30			0.05	RC
12/31	1/3	0.46		0.42	0	0	0.65	C
1/3	1/5	0.35	0.42	0.28	0.07	0	0.21	R
1/5	1/7	2.99	0.21	1.60	0.07	0	0.42	
1/7	1/10	0.93	0.37	1.06	0.05	0.09	0.37	C RaLa
1/10	1/12	1.18	0.55	5.55	0	0	0.28	R RaLa
1/12	1/14	8.26	0.56	98.8	0.21	1.74	0.14	RaLa
1/14	1/17	1.11	0	9.07	0	1.53	1.44	C RaLa
1/17	1/19	0.69	0.14	4.51	0	0.35	0	X
1/19	1/21	1.74	0.21	2.57	0	0.28	0.28	
1/21	1/24	0.05		4.07	0	0.05	0.09	CX
1/24	1/26	7.36		14.79	0.07	0.21	0.14	R
1/26	1/28	0.69		26.88	0.14	0.07	0.07	
1/28	1/31	0		3.94		0.09	0.14	C

R is Redox process dissolving
C is Radio-iodine dissolving
X is Xenon dissolving

The results of filtron collections are given in Table III. From these data two interesting facts are indicated. First, it appears that, except for the two at 706-A and 706-D, the trend of particles collected is down, though the trend is not as evident as in the frame collections. Second, it is quite noticable that the filtrons at 706-A and 706-D respond strongly to chemical operations in 706-C and D buildings. Either or both of them show a strong increase in particles/M ft^3 collected about three days after the start of every Iodine run in C. Three days is the approximate length of the extraction cycle, and the discharge of particulates apparently takes place, not during the slug dissolving, but in the final stages of the process. Two Xenon runs were made, but any effect of these is not distinct because of simultaneous or nearly simultaneous iodine runs. Ra-La runs, because of their magnitude will be considered separately.

The other filter type samplers are the USPHS filters drawing ~ 240 cfm thru 10 ft^2 of filter paper. Results of collections from these appear in Table IV. The figures represent particles per thousand cu ft except those at #5 in Townsite, which are reported in particles per million cu ft. Here again, there seems to be an overall decrease with respect to time, except that #1 at 706-D E. platform shows results which follow operations in 706-C and D buildings. Unfortunately, the shortage of filter paper during November prevented the sort of coverage of the Ra La run which was desired, and the figures shown are averages over prolonged periods, and consequently are not representative of maximum densities of contamination.

Table IV

USPHS Filter Data
(Particles/M ft^3)

Date	#1 706-D E. Platform	#2 E. of 115	#3 W. of 703-C	#4 E. Corner 104-B	#2[1] Scarboro School	#3[1] 2.5 Mi. W	#5 AEC S1-2 (P/M^2 ft^3)
11/2							
11/8							
11/10	.475	.861	.015	.068			
11/11	1.173	.751	.044	.020			2.5
11/12							
11/16	.157	.266	.025	.010			
11/17	.364	.167	.160	.046			82.3
11/22	34.26	43.40					
11/24							
11/30	2.02	.259	8.127	12.20			
12/2	.196	.145	.134	.145			2.8
12/[illegible]	.910	.167	.201	.160			
[illegible]	.741	.127	.035	.041			11.3
12/8	1.074	.221	.176	.089			
12/10	.190	.134	.164	.113			
12/13	.169	.036	.029	.048			3.8
12/15	12.99	.103	.020	.022			
12/17	.350	.035	.026	.017			
12/20	.271	.025	.010	.004			1.4
12/22	1.494	.049	.034	.028			
12/24							
12/27	.090	.014	.323	.006			
12/29	.465	.069	.026	.034			
12/31	.927	.037	.045	.023			0.3
1949							
1/3	.076	.016	.022	.004			
1/5	.035		.011	.008			
1/7	.245	.037	.003	.003			
1/10	.588	.086	.033	.021			1.5
1/12	1.145			.025			
1/14	113.0			.150	0.408	.003	
1/17	1.505			.040			
1/21	.287			.012			
1/24	.641		.011	.008			
1/26	3.858		.014	.006			1.0
1/28	14.66		.009	.002			
1/31	8.609		.040	.006			1.7

[redacted]

[redacted]

Table V

Outside Constant Air Monitor Data - November RaLa Run

		Increase in Counting Rate (c/min)			Weather Data		
Date	Time	115-B 200' N	706-A 350' E	735-B 300' W	Wind Velocity	Wind Direction	Rain
11/17	0001 - 1200	60	----	260	4.7	SW - NE	
	1201 - 2400	1290	----	790	4.7	E (var)	
11/18	0001 - 1200	1380	----	890	3.7	NE	
	1201 - 2400	380	----	230	7.3	E (var)	Tr
11/19	0001 - 1200	----	----	290	6.3	Var	2.80
	1201 - 2400	----	230	110	15.4	E - SW	.32
11/20	0001 - 1200	190	90	330	17.	SW	
	1201 - 2400	1150	840	1290	10.8	SW	
11/21	0001 - 1200	----	0	220	3	SW	
	0101 - 0200	----	200	2100	5	SW	Temperature
	0201 - 0300	----	1810	2300	3	W	Inversion
	0301 - 0400	----	7000	5800	4	W	"
	0401 - 0500	----	15500	3300	3	SW	"
	0501 - 0600	----	14000	8000	8	SW	"
	0601 - 0700	----	4000	4000	2	SW	"
	0701 - 0800	----	0	3500	3	NE	"
	0801 - 0900	----	1000	2000	3	NE	
	0901 - 1000	----	0	0	2	E	
	1001 - 1100	----	0	0	2	E	
	1101 - 1200	----	800	660	3	S (var)	
	1201 - 1300	200	2200	1040	2	S (var)	
	1301 - 1400	0	0	0	3	S (var)	
	1401 - 1500	100	0	0	3	Var	
	1501 - 1600	----	0	0	2	S	
	1601 - 1700	----	300	250	2	E	
	1701 - 1800	----	100	0	4	NE	
	1801 - 1900	----	300	0	3	NE	
	1901 - 2000	----	100	200	2	E	
	2001 - 2100	----	300	50	0	E	
	2101 - 2201	----	0	0	2	NE	
	2201 - 2300	----	400	0	2	Var	
	2301 - 2400	----	0	0	3	S	
11/22	0001 - 1000	1350	480	90	3.0	NE - W	.30

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Table V gives information pertinent to the November Ra La run, which does not appear in the other surveys. In particular, it contains weather data, and rise (in increased c/min) of readings on three constant air monitors at various locations on the area. Though some of the data are missing because of instrumental difficulties, it is evident that the highest degree of contamination occurred during a four-hour period from 0300 to 0700 on November 21. If one assumes that particulate contamination was proportional to total air contamination, it appears that $\sim$70% of the particles appearing on the USPHS collectors were trapped in this period, and consequently the density of particulate air contamination indicated was 719/M ft^3 at 706-D E. platform, and 912/M ft^3 at 115. Filtron samples indicated an even higher concentration.

The inversion which obtained during this high activity seemed to have retained most of the contamination in the valley. Collection at 703-B was almost as high as at 706-D and the one at 104-B, though nearer, was considerably lower.

The D-stack effluent (cell ventilating air) was filtered through a temporary filter during the January Ra La run. It is immediately evident from Tables III and IV that the area contamination was greatly reduced by this filter. Furthermore, Technical Division has estimated the output of D-stack to have been $\sim$15. curies during the November run and less than 0.1 curie during the January run. It may also be noted from these tables that the spread of contamination was

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greatly reduced. During the November run, filtrons showed extremely high particle count throughout the area, whereas in January the count was fairly high at 706-D E. platform, showed a lesser rise at 706-A, but was almost negligible elsewhere. The change is further evident from the three outside constant air monitor data, which appears in Table VI. While these are not strictly comparable with November data of Table V because of some shift in instrument location, the change in the overall picture is quite pronounced.

Two of the USPHS filters were re-located for this run. #2 was taken from Building 115 and placed near the Scarboro School, 6 miles ENE of the plant. # 3 was taken from 703-C and placed 2.5 miles W of the plant. As with the filtrons, the only high figure was obtained at 706-D E. platform. It is significant that #2 filter, 6 miles to the E (1 week collection) showed a higher active particle density than most of the filter type collectors on the plant area (except 706-A and D) for the same period. #3 showed almost no contamination. This is not surprising since the wind was westerly throughout most of the final steps of the run.

The 706-D stack was monitored on the 14th and 15th of January which comprised the end of the run from the volume reduction in B-6 through the end of the waste cycle. A 1" rubber hose was inserted 5' into the stack outlet, and air drawn through it and through a mobile constant air monitor sampling 5 cfm. Filters were changed on this apparatus every two hours from 1030 on 1/14 to 2230 on 1/15. These

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Table VI

Outside Constant Air Monitor Data - January RaLa Run

Date	Time	Increase in Counting Rate (c/min) 105 200' NW	706-A 250' SE	Tank Farm 700' SW	Weather Data Wind Direction	Wind Velocity	Temp. Inver.
1/10	0001 - 1200	870	210	230	E	2.3	.5 hrs.
	1201 - 2400	1520	990	810	S & W	1.8	6 hrs.
1/11	0001 - 1200	700	450	990	W & E	2.2	8 hrs.
	1201 - 2400	720	660	690	SW & W	6.0	2 hrs.
1/12	0001 - 1200	70	360	400	W & NW	9.2	
	1201 - 2400	50	440	30	W	10.2	
1/13	0001 - 1200	30	0	40	W	4.0	
	1201 - 2400	140	70	50	SW	8.9	
1/14	0001 - 1200	290	170	100	W & SW	5.3	
	1201 - 2100	210	260	60	W	4.2	
	2101 - 2400	170	160	90	E	<1	2 hrs.
1/15	0001 - 1100	840	460	440	E	3.3	6 hrs.
	1101 - 1500	0	0	0	SW	6.8	
	1501 - 2000	310	200	240	S	7.4	3 hrs.
	2001 - 2400	380	290	610	SW	10.5	1 hr.
1/16	0001 - 0300	20	0	0	SW	9.8	
	0301 - 1000	590	300	230	W	6.0	
	1001 - 1200	0	0	0	SSW	6.5	

N.B. There was but a trace of rain during the run.

[redacted]

were radioautographed, and a particle count taken. The results appear in Table VII. It appears that the particle count does not follow total activity. It also appears that the particle count does not follow total activity. It also appears that the transfer operations are most productive of particulate contamination, although both the volume reduction and evaporation are also heavy contributors.

In considering all the data pertaining to the January run, two things stand out. First, the activity is all concentrated in a very small area around 706-D, and second, the collections by both the filtron and the USPHS filter are higher than that of the stack sampler. Both of these phenomena point to the building, rather than the stack, as the chief source of active particles. Particles from a 50' stack would show a greater (at least not much less) concentration at some distance rather than near the base, and, at any rate, would not tend to concentrate the effluent at one spot. The November run exhibited these latter characteristics.

A comparison of data obtained with the Airway "Sanitizor" with other methods of collecting, indicates that the Airway is not a particularly good quantitative air sampling instrument. The series wound motor driving the impeller type fan system is sensitive to line voltage fluctuations and filter resistance. Measurements disclosed that a clean unit with new filters had an air capacity of ~ 70 ft^3/min. After several days operation, plugging of the filters from ordinary air

Table VII

D - Stack Monitor - January RaLa Run

Date	Time	C/m Rise Per Period	Particles Per M ft^3	Comments
1/14	1030 - 1230	7000	43.5	Volume reduction B-6
	1231 - 1430	6500	15.0	Volume reduction
	1431 - 1630	Missing		Transfer operation
	1631 - 1830	5000	194. *	Transfer operation
	1831 - 2030	> 10000	500. *	Transfer operation
	2031 - 2231	> 10000	282.	Transfer operation
	2231 - 0031	2500	8.4	Evap. - B-19
1/15	0031 - 0230	1500	50.4	Evap. - B-19
	0231 - 0430	> 10000	33.4	Evap. - B-19
	0431 - 0630	> 10000	45.0	Waste Met. and Neut.
	0631 - 0830	- -	16.7	Waste Met. and Neut.
	0831 - 1030	- -	10.1	Waste Met. and Neut.
	1031 - 1230	- -	10.1	Waste cycle
	1231 - 1430	- -	25.2	Waste cycle
	1431 - 1630	- -	3.4	Waste cycle
	1631 - 1830	- -	63.6	Waste cycle
	1831 - 2030	1000	99.0	Waste cycle
	2031 - 2230	- -	23.5	Waste cycle
		Average	87.7	

* Diffuse activity also

[redacted]

contaminants, had increased the resistance to the extent that capacity was decreased in some instances to as low as 38 ft^3/min. Measurements made over a period of several months indicate that an average air capacity of $\sim$ 56 ft^3/min is a more representative value (under varied atmospheric conditions) than the figure quoted in previous reports; viz. 28 ft^3/min. The filter bags used in the Airway had sufficiently high absorption characteristics so as to make the detection of particles of low activity difficult, using radioautographic techniques. This loss of sensitivity could have been decreased by slitting the bags open and exposing the film directly to the inside surfaces of the bags. This, however, would have introduced the problem of film and developer contamination which could not have been handled with facilities and personnel available.

Although data obtained with these instruments are not directly comparable with those obtained with other filters, they do give a measure of occurrence of the larger particulates, and by comparison in point of time give an indication of the degree of reduction of at least the larger particles. Table VIII shows the results of these collections. It appears that, except for the latter part of November, which included a Ra-La run, averages show a general decline, even when compared to times when the pile was not in operation. The high count of station #5 during the November shut-down was due to the construction operation nearby. #6, inside 105 building, also shows a considerable drop. This follows the clean-up of the building, and the change in techniques of loading and unloading materials from the pile.

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Table VIII
AIRWAY DATA
Particles/M ft^3 Air

ation No.		1	2	3	4	5	6	7	8	9	10	11	12	
ocation		703-C	719-A	701-B	706-B	115	Pile	101-B	706-A	706-A	E	DH	105 NW	
ist.- Stack		1760'	1220'	825'	550'	60'	Top	500'	760'		2200'	800'	90'	
ir. - Stack		W47°S	S36°W	S4°W	S44°W	E31°N		E	(Out)	(In)	E	N		
Date rom	To													Comments
0/16	10/21	.110	.062	.062	.133	.232	.335	.24	.048	.110	.195	.076	.050	Pile down, etc.
0/22	11/8	.076	.073	.054	.054	.194	.687		.062		.037	.050	.127	Pile up
1/8	11/9	0	.012	.050	.025	1.957	.277	.050	0		.050	.038	.063	Pile down - Connect duct
1/9	11/10	.012	.012	0	0	.237	.719	.012	0		.038	.012	.012	
1/10	11/11	.050	0	.038	0	.088	1.023	.025	.050		.025	0	.038	
1/11	11/12	.028	.050	.063	.075	.290	1.092	.050	.038		.063	.038	.088	
1/12	11/13	.050	.012	.025	.025	.050	.215	.025	.025		.025	.025	.013	
1/13	11/14	.025	.050	.113	.038	.341	1.035	.013	.025		.013	.025	.050	
1/14	11/15	.050	.139	.050	.101	.076	.530	.126	.316		.088	.088	.088	Pile up - Duct Connected
1/15	11/16	.038	.063	.088	.164	.114	.341	.151			.076	.151	.126	
1/16	11/17	.025	.025	0	0	.038		0	0		.063	.038	.050	RaLa Run
1/17	11/18	.025	.063	.176	.025	.013		.025	.050		.013	.076	.025	RaLa Run
1/18	11/19	.189	.101	.050	.126	.101		.151	.088		.076	.050	.063	RaLa Run
1/19	11/20	.252	.315	.884	.063	.165	1.465	.025	.063		.025	.076	.076	RaLa Run
1/20	11/21	10.00	9.47	23.98	13.19	33.9	27.9	14.7	17.1		21.3	28.9	24.0	RaLa Run
1/21	11/22	.757	.606	.997	1.439	1.23		.997	.997		.884	.416	2.88	RaLa Run
1/22	11/23	.075	.088	.025	.063	.038		.025	.050		.050	.139	.151	
1/23	11/24	.012	.028	.101	0	.013	0	----	.038		0	0	.076	
1/24	11/25	.025	.038	.012	.038	.050	.202	0	.101		0	.013	.050	
1/25	11/26	0	.101	.050	.050	.076		.038	.025		.063	.013	.025	
1/26	11/27	.025	.038	.025	.038	.038	.454	.038	.126		.025	.038	.050	
1/27	11/28	.025	0	.050	.076	.025	.126	.013	.063		.025	.025	.050	
1/28	11/29	.050	.038	.025	.050	.038	.315	.050	.063		.379	.063	.088	
1/29	11/30	.025	.025	.076	.101	.050	.543	.025	.076		.013	.063	.076	
1/30	12/2	.032	0	.032	.006	.012	.158	.013	.128		.038	.019	.057	
						M A C H I N E S		S E R V I C E D						
2/10	12/13	.013			.009	.004	.013	.021						
2/13	12/15	.019	.026		.013	.026	.044	.032			.013		.026	

Table VIII (Continued)

tation No. Date rom	To	1	2	3	4	5	6	7	8	9	10	11	12	Comments
2/15	12/17	.019	.013		.026	.007	.013	.007			0	0	.007	
2/17	12/20	.004	.004		.021	0	.021	.004			.004	.018	.013	
2/20	12/23	.013	.038		.007	.007	.127	.032			.019	0	.031	
2/23	12/27	.005	.010		.003	.015	.063	.008			.003	.008	.008	
2/27	12/29	.038	.032	.032	.019	.032	.019	.038			.007	.032	.044	
2/29	12/31	0	.007	.013	.007	.038	.032	.007			.013	.007	.007	
2/31	1/3	.009	.009	.009	.009	.030	.030	.021			.009	0	.004	
/3	1/5	.019	.026	.050	.013	0	.057	.007			.019	.050	.038	
/5	1/7	.026	.019	.007	.019	.025	.151	.013			.007	.013	.019	
/7	1/10	.017	.009	.038	0	.004					.013	.013	.038	
/10	1/12	.038	.013	.038	.013	.025		.007			.038	.032	.038	
/12	1/14	.007	.007	.246	.013	.038	.019	.019			.094	.013	.013	
/14	1/17	0	.005	.064	.009	.034	.171	----			----	.013	.039	
/17	1/19	0	0	.007	0	.013	.032	.019			----	.007	.057	
/19	1/21	.013	0	.032	0	.017	.057	0			.013	.025	.007	
/21	1/24		0	.008	.009	.038	.118	0			.017	.004	.013	
/24	1/26		.013	.032	.013	.013	.400	.019			.007	0	0	
/26	1/28	.019	.007	.019	.013	.013	.590	.590			.019	.013	.025	
/28	1/31	.009	0	.009		.004		.013			.004	.004	.013	
							A V E R A G E S							
1/8	1/14	.029	.023	.048	.027	.493	.727	.029	.023		.036	.023	.044	Down time average
1/14	11/30	.725	.695	1.66	.966	2.25		1.10	1.21		1.78	1.88	1.74	Balance of Novembe
1/30	12/31	.014	.015		.011	.014	.052	.016			.010	.012	.021	Average for Decembe
2/31	1/31	.013	.008	.040	.009	.020	.155	.058			.020	.013	.023	Average for January

[redacted]

Table IX
Summary of Collection Data

Date	Sedimentation Frames: (5) Group A 160' From 105 Stack	(2) Group B 300' From 706-D Stack	(6) Group C' 300'-1000' - 105 Stack	(9) Group D 1000' From 105 Stack	Suction Type Collectors: Filtrons 6 Stations	Airways 10 Stations	U.S.P.H.S. Collectors 4 Stations	Weather: Rain (inches)	Average Wind Velocity (mph)	Comments
	(Particles/frame/period)				(Particles/M ft^3)					
10/23 to 11/8	100.8	26.8	11.4	14.6	1.05	0.16	0.47			Average of 16 days
11/9	26.9	7.0	6.2	4.6	0.91	0.45		0.05	3.8	
11/10					1.40	0.07	0.35	0.55	9.1	
11/11	8.5	2.5	3.5	3.5	1.30	0.06	0.50		5.0	
11/12	19.2	17.0	5.6	4.6	1.77	0.15			4.3	
11/13	20.6	75.5	5.3	4.0	1.50	0.06		0.21	5.1	
11/14					0.05	0.14			3.2	(R)
11/15	221.	95.5	11.8	5.7	0.79	0.22			3.7	Pile up - thru
11/16	738.	13.0	169.	141.	0.31	0.25	0.11	tr	6.1	(R) Filterhouse
11/17					0.07	0.05		0.20	5.3	RaLa Begins
11/18	87.4	62.0	26.5	14.6	0.81	0.10		tr	5.3	
11/19					0.95	0.20		3.11	9.5	
11/20					5.46	0.39			15.9	
11/21					625.	40.3		tr	2.8	RaLa Ends
11/22					61.8	2.24	38.8	0.11	4.4	(C)
11/23	23.1	7.1	5.0	3.1	2.04	0.13		0.40	4.3	
11/24	230.	14.0	36. (4)	15.0 (8)	1.11	0.06		tr	3.8	
11/25					1.92	0.07		0.90	2.8	
11/26		6.0	3.5 (3)		1.89	0.09		tr	4.4	(R)
11/27					0.23	0.09		0.71	6.8	(C)
11/28					15.2	0.07		tr	11.3	
11/29					0.71	0.17		3.51	8.0	
11/30	40.1	52.7	10.1 (4)	1.0 (8)	0.53	0.11	1.14		2.2	(C) (R)
12/1									2.3	
12/2	76.3	16.7	9.8	9.4 (6)	1.23	Collectors	0.16		6.6	
12/3					0.93	out of	0.36	0.50	3.9	(R)
12/4						Operation			3.3	
12/5	40.6	13.5	3.8	1.7 (6)	0.40		0.24	0.80	3.1	(C)

Table IX (Continued)

Date	Group A	Group B	Group C	Group D	Filtrons	Airways	U.S.P.H.S.	Rain	Average Wind Velocity	Comments
12/7								0.70	7.9	(R)
12/8	32.6	12.0 (1)	2.1	1.0 (6)	1.04		0.39		10.5	
12/9									4.4	
12/10	73.6	9.0 (1)	4.1	1.3	0.87	—	0.15		3.4	
12/11									6.7	
12/12									4.1	
12/13					0.42	0.02	0.07		3.7	(C)
12/14									9.9	
12/15					2.22	0.04	3.28	0.11	9.8	
12/16								1.40	5.7	
12/17	6.8 (4)	1.9 (1)	0.9 (4)	0.7 (7)	0.56	0.02	0.10		9.2	
12/18								0.50	7.2	
12/19									9.2	
12/20	7.2 (4)	1.0 (1)	1.1 (4)	1.6 (7)	0.26	0.02	0.08		6.5	(C)
12/21									5.0	
12/22					1.74	0.04	0.40	0.31	11.6	
12/23	6.5 (4)	3.7 (1)	1.0 (5)	1.1 (8)					11.5	
12/24								1.50	5.9	
12/25								0.25	13.3	
12/26									3.0	(R)
12/27	3.6 (4)	0.5 (1)	1.0 (5)	0.8 (8)	1.00	0.01	0.11		2.6	
12/28								0.40	5.8	
12/29					0.24	0.06	0.15		9.0	(R) (C)
12/30									9.0	
12/31	3.3 (4)	1.3 (1)	4.7 (5)	1.0 (8)	3.74	0.02	0.26		6.7	
1/1									4.1	
1/2								0.40	6.0	
1/3					0.31	0.02	0.03	0.70	4.2	(C)
1/4								2.80	3.9	
1/5					0.22	0.05	0.02		11.6	(R)
1/6	2.6 (4)	0.5 (1)	0.7 (4)	0.6 (7)					7.4	
1/7	20.5 (4)	1.0 (1)	3.3 (4)	1.3 (7)	0.88	0.03	0.07		3.1	

Table IX (Continued)

Date	Group A	Group B	Group C	Group D	Filtron	Airway	U.S.P.H.S.	Rain	Average Wind Velocity	Comments
1/8									5.0	
1/9	16.1 (4)								2.8	
1/10	9.04	7.0 (1)	1.9 (5)	0.6 (7)	0.48	0.03	0.18		6.0	(C) RaLa Begins
1/11										
1/12	8.4 (4)	3.0 (1)	4.7 (5)	1.6 (7)	1.26	0.05	0.59		7.0	(R)
1/13									7.1	
1/14	8.8 (4)	7.0 (1)	1.8 (5)	0.6 (7)	18.3	0.10	57.3	0.50	5.3	
1/15									7.8	RaLa Ends
1/16									5.4	
1/17					2.19	0.05	0.77	0.50	4.2	(C)
1/18								0.40	14.8	(X)
1/19	1.3 (4)				0.95	0.03			13.4	
1/20								0.30	2.7	
1/21					0.85	0.02	0.20	1.40	2.6	
1/22								0.40	3.7	
1/23									7.2	
1/24	10.2 (4)	0.5 (1)	0.2 (5)	0.3 (7)	0.85	0.02	0.22		5.1	(C) (X)
1/25								0.10	5.6	(R)
1/26					4.51	0.02	1.29	0.20	5.4	
1/27								0.40	13.0	
1/28	19.8 (4)	2.8 (1)	1.6 (3)	0.9 (7)	5.57	0.16	4.89		12.8	
1/29									8.7	
1/30									8.9	
1/31	2.0 (4)	0.8 (1)	0.5 (5)	0.4 (6)	1.04	0.01	2.89	1.00	6.8	
1/1 to 1/31										

Underlined figures indicate dates of collection
Numbers in parentheses indicate # of collectors averaged
(C) indicates radio-iodine dissolving
(R) indicates Redox process dissolving
(X) indicates Radio-Xenon dissolving

Table IX is a condensed summary of all collections. This table again illustrates the factors shown by the previous tables. The most evident of which are that; 1) the pile filter is quite effective in preventing fresh particles from issuing from the pile, 2) that the grassing and paving of the area have cut down the re-location of active particles, and 3) that the chemical separations are the main remaining source of particulate contamination.

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