PARTICULATE AIRBORNE CONTAMINATION AT START-UP OF THE EBWR

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Associated with the initial full power operations of the Experimental Boiling Water Reactor were high levels of radioactive airborne particulate matter found within the reactor shell. Concentrations up to 5×10^{-7} μc/cc were measured. As this activity was not predicted from the borax experiments, there was an immediate concern as to its presence.

Questions to be answered were three: (1) what was the major radioisotope (or isotopes) accounting for the activity; (2) from which component of the plant was the activity escaping; and (3) (depending upon answers one and two) how could the level be reduced.

Identification of the major contaminant was conducted by decay studies and gamma pulse height analysis. It was found that about 99 per cent of the activity had a 32-min half life and had gamma energies of 1.4, 1.0, and 0.46 Mev. This fits very well the corresponding data reported for the isotope Cs^{138}. Cesium-138 beta decays to the stable isotope Ba^{138} and is the daughter of the beta decay of Xe^{138}.

The above evidence pointed to the possibility that the activity was escaping from one or more of the reactor components as xenon gas and was then decaying to the particulate Cs^{138}. It would be expected that if Cs^{138} were present there should also be other xenon daughters plus some associated krypton daughters. With this lead a radiochemical analysis of the filter papers was conducted and the isotopes given in Table 1 were identified.

Table 1 — ISOTOPES IDENTIFIED FROM RADIOCHEMICAL ANALYSIS OF FILTER PAPERS

Isotope	Concentration, μc/cc	Per cent of maximum permissible level (MPL)*
Cs^{138}	5×10^{-7}	1.0
Sr^{89}	1×10^{-10}	0.5
Sr^{90}	Tracer	≪1
Ba^{140}	2×10^{-11}	≪1

*Obtained or calculated from data in National Bureau of Standards Handbook 52.

Table 1 shows that although the total activity concentration is much higher than normally tolerated, the levels are not excessive when MPL's are considered. In spite of this, it was decided to spend every effort to reduce the activity concentrations.

Before considering from which component the activity was escaping, a very general view of the EBWR Plant should be considered (see Fig. 1).

The EBWR Plant differs from standard power plants only in the use of a reactor to produce steam in place of a boiler. The steam formed in the reactor vessel, about 20 Mw, is collected above the core and brought through the steam dryer. A portion of the steam goes directly to the turbine and then to the condenser. The remaining steam bypasses the turbine and passes directly to the condenser, the amount bypassed being inversely proportional to the demand of the generator. From the condenser the condensate is returned to the reactor via the feed water pumps to complete the cycle. In the design it was realized that gases would be present in the system and would tend to collect in the condenser. The expected gases were oxygen and hydrogen from the dissociation of steam, and air due to "in leakage." To remove these gases and also to keep the condenser under a slight negative pressure, an air ejector system was introduced at the top of the condenser. Sampling showed that the activity within the shell was due to leakage from this air ejector.

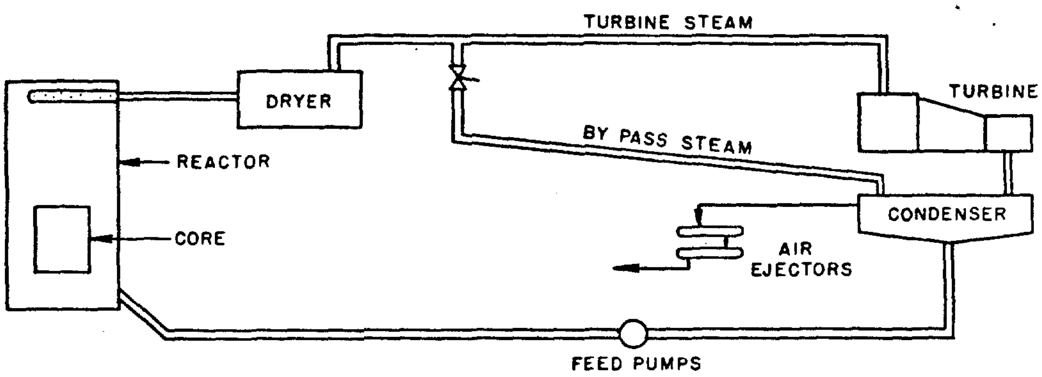

Fig. 1—General view of EBWR.

To determine just which radioisotopes were leaking from the ejector, numerous samples of the ejector gases were collected and analyzed utilizing decay schemes and gamma pulse height analysis. From the results of these analyses, the following isotopes were definitely identified:

Xe^{133}	Xe^{138}	Cs^{138}	Kr^{85}	Kr^{88}
Xe^{135}	Cs^{137}	Ba^{139}	Kr^{87}	Rb^{89}

The identified isotopes may better be seen from Fig. 2, which shows the isotopes as they would be seen on a chart of the nuclides. The absence of several of the expected isotopes is easily explained. First, it must be remembered that the data are from gamma analysis and some of the radioisotopes have only betas associated with their decay. Others were not identified due to low specific activities. Among those which were not identified but were expected are Xe^{137}, Cs^{139}, and Cs^{135}.

From the evidence so far presented it was concluded that the gaseous fission products xenon and krypton were escaping from the air ejectors. After the gases escaped they decayed to the particulate radioisotopes. Due to half life and specific activity considerations, the major contaminant found on filter samples taken within the EBWR shell was Cs^{138}. Other contaminants were present but to a much lesser degree.

One may ask the question, how are the gaseous fission products reaching the air ejectors when the fuel elements are supposedly well clad. To date this question has not been satisfactorily answered; however, there have been several mechanisms suggested. These are as follows:

1. During the autoclave testing of the elements, some were found to be faulty (having leaks). These faulty elements uranium contaminated the autoclave which in turn possibly cross contaminated the accepted elements. The amount of uranium contamination needed was calculated to be approximately 35 mg.
2. The gases could be diffusing through the Zircaloy cladding.
3. The Zircaloy cladding could have contained some natural occurring uranium.

It must be remembered that these are merely possibilities and none have been proven or disproven to date.

The first suggestion to remedy the shell airborne activity was to stop the air ejector leakage and pass the ejector exhaust directly to the building stack. This would result in stack activity which when considering MPL's would be quite acceptable; however, there are several low level counting labs located within a half mile of the EBWR Building, which under proper meteorological conditions could be effected. As a compromise a "Vapor Recovery System" was

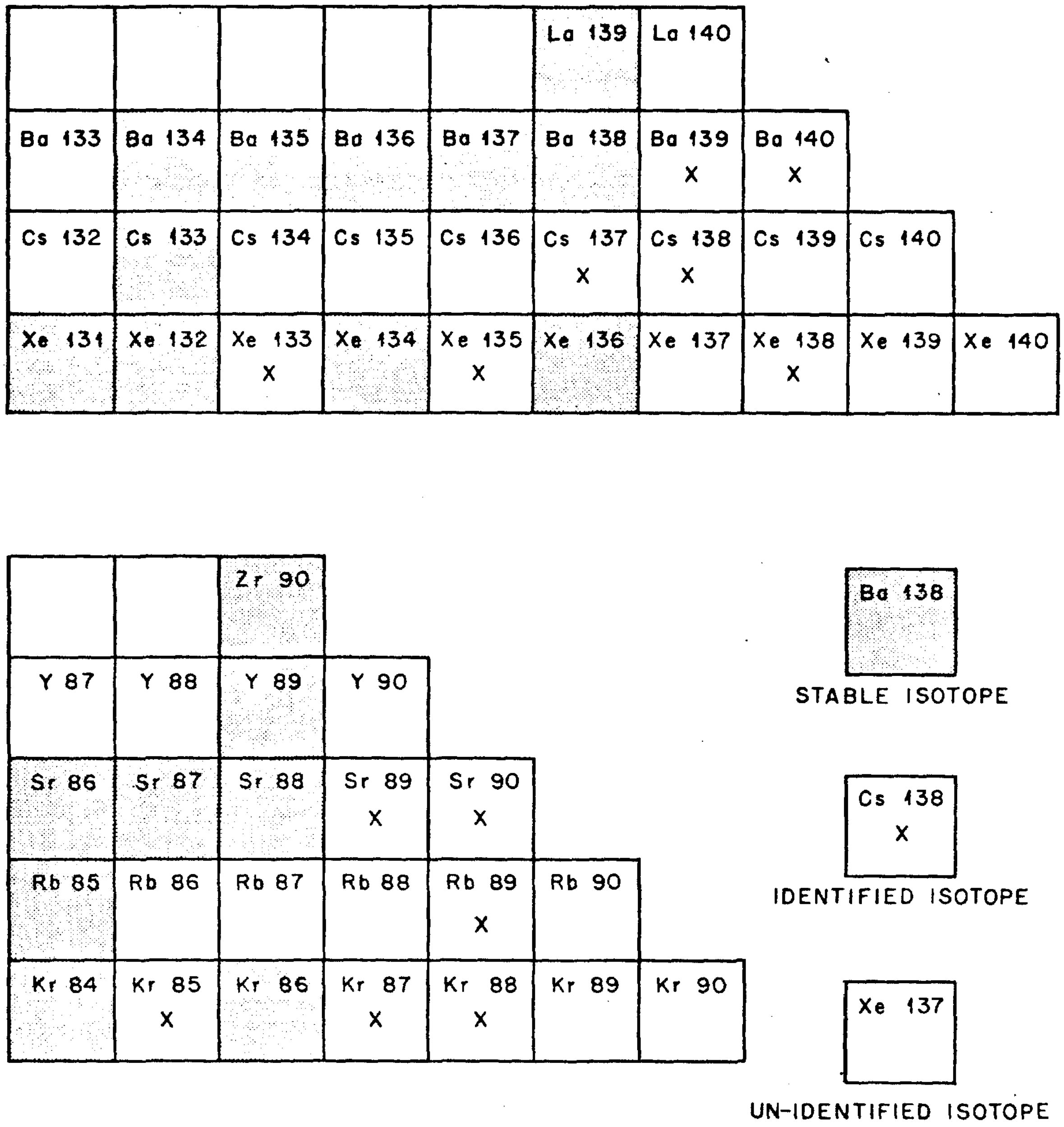

Fig. 2—Radioisotopes identified.

suggested in which the activity would be held up. It was found that the use of the vapor recovery system as a whole reduced the stack activity by a factor of 10 when compared to exhausting the activity directly to the stack. A sketch of the system is seen in Fig. 3.

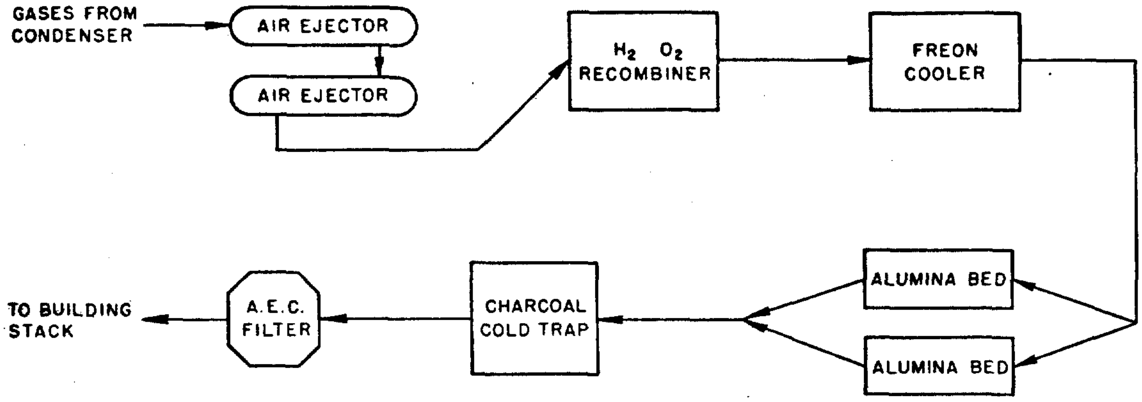

Fig. 3—Vapor recovery system.

The gases from the air ejector (about 2 cfm) are first brought through a recombiner in which the oxygen and hydrogen are united. The gases then are brought through a Freon cooler in which the water vapor is condensed. Then the water and particulate activities are trapped in an alumina bed. The remaining gases are circulated to a charcoal cold trap where they are adsorbed. The main purpose of this charcoal trap is to give the gases additional hold-up time for decay. Then the decayed gases are filtered and exhausted from the building by way of the stack. As mentioned above the vapor recovery system as a whole reduced the stack activity by a factor of 10. It was found that the alumina beds contributed a factor of 5 and the charcoal trap a factor of 2.

With this system in use the shell airborne activity was reduced to about 3.5×10^{-9} $\mu c/cc$; again about 99 per cent of the activity is due to Cs^{138}, and represents less than 1 per cent of MPL.

In conclusion, it has been shown that if monitoring is conducted in the early stages of a power plant utilizing reactor steam and if proper steps are taken to iron out the bugs, the plant can be operated without releasing excessive airborne contamination.

AIR CLEANING ACTIVITIES AT ANL

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Since the last Air Cleaning Conference at Argonne in September 1955, there have been no major air cleaning developments at the Laboratory. However, I would like to discuss the status of some of the air cleaning systems we have mentioned previously and describe what we are doing or planning to do in some of our new facilities.

1 FUEL FABRICATION FACILITY

At the last conference, A. B. Shuck of Argonne described the Fuel Fabrication Facility, then under construction, which will be a plant for the development and fabrication of reactor fuel components containing plutonium and U^{233}.

The building is divided into three areas: the Administrative, Technical, and Fabrication Areas. Each area will be isolated from the other by means of air locks.

The static pressure in the Administrative Area will be maintained at +0.05 in. water, relative to the Technical Area which will be at 0.05 in. wg below ambient barometric pressure. The Fabrication Area will be kept at −0.075 in. wg relative to the Technical Area.

Operations in the Fabrication Area will include all the common metallurgical manipulations such as, alloying, melting, casting, heat treating, pressing, extruding, and rolling, in addition to machining, welding, and brazing. All work will be done in large hoods with gloves on both sides and all hoods will be interconnected to facilitate the passage of material from one operation to another.

Some of the hoods will contain an air atmosphere while others, because of the pyrophoric nature of some of the alloys that will be used, will contain an inert atmosphere; helium, in this case.

The ventilation of the Fabrication Facility will consist of a once-through system for the hoods, a standby purge system should a break occur and a once-through filtered air system to exhaust the room air and ventilate the equipment located beneath the primary hoods; such as, vacuum pumps, motors, and other accessory equipment.

Air to the hoods will pass through 12- by 12- by 6-in. high efficiency filters at the hood inlet and outlet and again through high efficiency filters in the fan loft. The small filters at the hood will be changed from within the hood. Final filtration for the purge system will be through two banks of high efficiency noncombustible media filters in series. The first filter of each series will be changed by the bag technique.

The first stage of the construction work is complete. The ventilation equipment, including filter banks, blowers, and ducts up to the Fabrication Room, are installed and have been helium, leak tested. However, some difficulty has been encountered in obtaining a contractor for the fabrication of hoods and the inert gas system. Argonne was unable to obtain acceptable bids from a general contractor and has found it necessary to subcontract the work.

Contracts for fabrication and the erection of hoods and process equipment are out for bids. Separate contracts must be let for pipe fitting, connecting the existing duct to the hoods, electrical work, and painting. It is expected that the job will be completed Feb. 1, 1959.

2 SENIOR CAVE

In October 1956, the Laboratory let a contract for a Senior or Hot Chemistry Cave for use by our Chemical Engineering Division and construction is now under way. This cave has been designed to handle up to 10,000 (1 Mev gamma) curies of irradiated plutonium and the associated mixed fission products. Both wet and dry chemistry and high-temperature operations will be performed in the cave.

The cave will consist of approximately 640 sq ft of operating area (manipulator side of cave); 860 sq ft of service area back of cave, and approximately 180 sq ft of cell area. The air, after being rough prefiltered upon entering the building, will be fed to the operating room, thence to the service area to the rear of the cave, and then to the isolation room where it will pass through high efficiency filters and into the cells.

High efficiency filters located at the cave will be used to filter the inlet air to the cells for two reasons; first, to avoid the possibility of dumping unfiltered air from the cells to the operating or service areas through the isolation rooms, should some occurrence in the cell result in a pressure buildup great enough to overcome the 0.8 in. wg negative that will be maintained in each cell and, second, to remove as much of the atmospheric dust from the supply air as possible and, thereby, delay as long as possible the changing of the high efficiency filters on the exhaust system which will involve working with highly gamma and alpha contaminated filters.

The air supply to the operating area of the cave, that is, the area where the manipulator controls will be located and, therefore, the personnel load will be heaviest, will be 1520 cfm with an additional expected leakage of approximately 240 cfm. An additional 240 cfm leakage is expected into the service area. This leakage will result because of the intention to keep the operating and service areas negative with respect to the corridor. The 1520 cfm supply will be shut off automatically whenever the doors to the operating or the service areas are opened to assure a flow in through the doors at all times. The 1520 cfm supply will be reduced should experience indicate leakage through the walls or doors is greater than now anticipated. Both the operating and service areas will be air-conditioned by means of packaged air conditioners in each area.

The air cleaning system to be used on the exhaust air from the cave will consist of double filtration through high efficiency noncombustible filters. The first filter will be shielded since it probably would be highly contaminated should a fire occur. Provision will also be made for future shielding of the second filter should the first fail. Should contamination result, of course, remote changing of the filters will be necessary.

The technique to be used for the remote changing is that described at the last Air Cleaning Conference by R. A. Blomgren of Argonne. This method involves the pushing of the contaminated filter out of the exhaust system into a metal disposal container with a clean replacement filter by means of a hydraulic ram. Special gaskets on the filter keep the opening sealed at all times although air flow continues at all times through the filters.

3 INERT GAS CAVE

Another facility still in the planning stage is the addition to our existing cave facility. The addition will be an inert gas cave for work on one million curie fuel elements of 1 Mev gamma energy. The conventional air flow pattern from the office space, to the operating area, to the service area, to the equipment repair section of the cave will be used. The air, before entering the equipment repair area of the cave, will pass through high efficiency filters for the same reasons stated for the Chemical Engineering cave. The air from the equipment repair cell, which is back to back with the inert gas cell, will be double filtered through high efficiency filters, with the first filter located in the cave itself and the secondary filters in the fan loft.

The helium atmosphere cell, which may also be used with an air atmosphere, will have a 1000 cfm exhaust blower in operation at all times. When the cell is used with an air atmosphere, the air will exhaust through a high efficiency filter located in the cell then to a second high efficiency filter in the fan loft. For inert operation of the cave, the blower would remain in operation but the duct would be sealed off at the cell by an O-ring gasketed butterfly valve. Should a sensing device, which will be located in the cell, detect a rise in the static pressure in the cell as a result of a break or rupture of the shield (the cell will be maintained at a negative static during normal operation), the butterfly valve will open exposing the cell to the 1000 cfm exhaust blower assuring a flow in through all cracks or openings.

The philosophy of operation dictates that everything within the cell, including all tools, supplies, and wastes, will be canned before removal. This includes the high efficiency prefilter in the cell which will be changed remotely by means of slave robots. The push-through technique will be used on the secondary filters in the fan loft.

4 PREFILTER EVALUATION

In addition to those new facilities, we are still working on the evaluation of hood prefilters; that is, trying to determine what they do for us and whether they do it economically.

The original philosophy at Argonne, when our large 200 Area buildings were being designed, was that the air should be prefiltered at the hoods for two main reasons: (1) To remove as much of the atmospheric dust as possible from the exhaust air and, thereby, prolong the life of the final AEC filter, and (2) To retain as much of the activity at the hood and, thereby, reduce contamination of the duct work.

Since then, there has been considerable discussion concerning the justification for these filters. As a result of this, we have undertaken a study that we hope will give us some of the answers.

As a little background, the air flow through a typical laboratory is as follows: the supply air to the building passes through two banks of filters in the basement; Type PL-24, manufactured by American Air Filter, the first bank using 5-ply paper and the second bank using 10-ply paper. The air then passes through heating and cooling coils to the offices, corridors, and laboratories, with the air to the offices and corridors then passing into the laboratories and with the laboratory air out through 25FG prefilters in the hoods to the final filters in the fan loft.

We are attempting to determine where the dirt comes from that is retained on the various filters. What percentage of it passes through our fresh air cleaning filters, what percentage of it is carried into the laboratories by people in the building, and what percentage is generated in the laboratories by the various operations going on there. In addition, we are trying to determine what amount and size distribution of airborne particulate is removed by each of the four filters the air passes through as it makes its cycle through the building. Knowing this, we would have a basis for decisions on new buildings as well as existing facilities.

The first portion of the study has been under way now for approximately two months. Four days each week, for over 23 hr per day, air samples are taken at six locations in the air stream as it passes through the building.

The samplers are Sutorbilt Constant Flow Units, designed by Dr. L. Silverman, with which we use MSA 1106-B filter paper. This paper was selected because of its high efficiency and also because of the very slight absorption of water vapor and resultant weight gain during sampling. Since we are determining dust loads by weighing the filters, this was an important consideration. The fact that desiccation is not necessary has saved us considerable time.

Sample stations are located just upstream of the first (5-ply) inlet filter; between the first and second inlet filters; just downstream of the second (10-ply) inlet filter; in a laboratory adjacent to a hood; just upstream of the final filter; and just downstream of the final filter servicing that hood. With these sample locations, we have all filters bracketed and, in addition, have sample locations that will give us an indication of the dust loading that occurs as the air moves from the supply outlets in the offices, corridors, and laboratories to the hoods.

We had hoped, originally, that this first phase of the study would have been completed by now; however, difficulties have arisen and delays have resulted.

Because of the high flow of air through the Silverman Sampler Head, averaging about 30 m^3/hr, the paper has torn or has been drawn in from the edge seal permitting air to bypass the filters occasionally. Whenever this occurs, the sample must be thrown out and at least one efficiency determination sacrificed although absolute dust load values for the untorn filters are still of value. Another bit of difficulty was caused by a fine break in a rotameter on the sampler head downstream of the final filter which made uncertain the accuracy of a number of the samples and, of course, the efficiencies based on them.

However, from our results to date, we know that the fresh air entering the buildings has a dust loading ranging from 30 to 215 $\mu g/m^3$ with an average of 82 $\mu g/m^3$.

As the air passes through the 5-ply filter, it is cleaned with an efficiency varying from 35 to 81 per cent, with an average of 58.8 per cent by weight. The second bank of filters, although of 10-ply material, has an average efficiency of 25.4 per cent, less than half that of the 5-ply because the 5-ply removes the larger particles and the efficiency of the 10-ply is then based on a smaller particle size.

The combined average efficiency for the 5 and 10-ply filters is 68.8 per cent for the removal of atmospheric dust.

The efficiency of the 25FG prefilters in the hoods will be determined in the second phase of the work. Since the exhaust from the hood combines with the exhaust from another hood and a laboratory bypass before reaching the next sample location, the samples taken at that location are not truly representative of the air passing through the hood prefilters in question.

Results for the final filter are still inconclusive because of the rotameter failure.

One unexpected result, so far, has been the fact that about 50 per cent of the time the air in the laboratory has apparently been cleaner than the air passing through the second of the supply air filters. This we believe is due to the cleaning effect of the heating and cooling coils through which the air must pass before reaching the laboratories. We are now attempting to determine whether we are correct in this assumption.

Now that the sampling program is moving smoothly, we hope to soon start making some size determinations of the dust at the same locations where we presently have our samplers—using both the Millipore filter-optical microscope and the electron microscope techniques.

AIR SAMPLING IN RELATION TO THE METEOROLOGICAL PROGRAM AT BNL

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The Meteorology Group at the Brookhaven National Laboratory has been studying dispersion of atmospheric pollutants in the lower 400 ft of the atmosphere since 1947.

The group was originally formed at Brookhaven because of a dispersion problem which dealt with the release of Ar^{41} from the 355-ft stack of the nuclear reactor. The reactor is air-cooled, and even though the air is filtered before and after leaving the core, one of the constituents of the air, namely argon, becomes radioactive. The Meteorology Group was established for the purpose of determining the pattern of the diffusion of the invisible Ar^{41} under different weather conditions and the extent of ground-level concentrations downstream from the reactor stack.

To solve this problem, a program was formulated which revolved about the measurement of certain basic meteorological elements as well as atmospheric sampling. Two meteorological towers, (Fig. 1) modeled after those at Hanford, were built and equipped with instruments for sensing the wind direction, wind speed, and the temperature at several levels in the vertical to 410 ft and across a horizontal span of 900 ft. The data from the instruments on the towers were and continue to be transmitted by underground cables to the main building 720 ft from the towers and are charted on a recording panel (Fig. 2). The 410-ft tower is equipped with an Army M-1 smoke generating system to produce an oil-fog which is forced up a 20-in. diameter stack attached to one leg of the tower to a height of 355 ft (Fig. 3). The oil-fog particles have a mean radius of 0.3 μ, ranging from 0.05 to 3.0 μ, and behave as a true aerosol. The oil-fog can be observed visually, photographed, and measured.

Three photoelectric densitometers are used in determining ground-level concentrations. They use the principle of the right-angle scattering of light and have several ranges of sensitivity. They consist basically of a light source, a black chamber, and a photocell (Fig. 4).

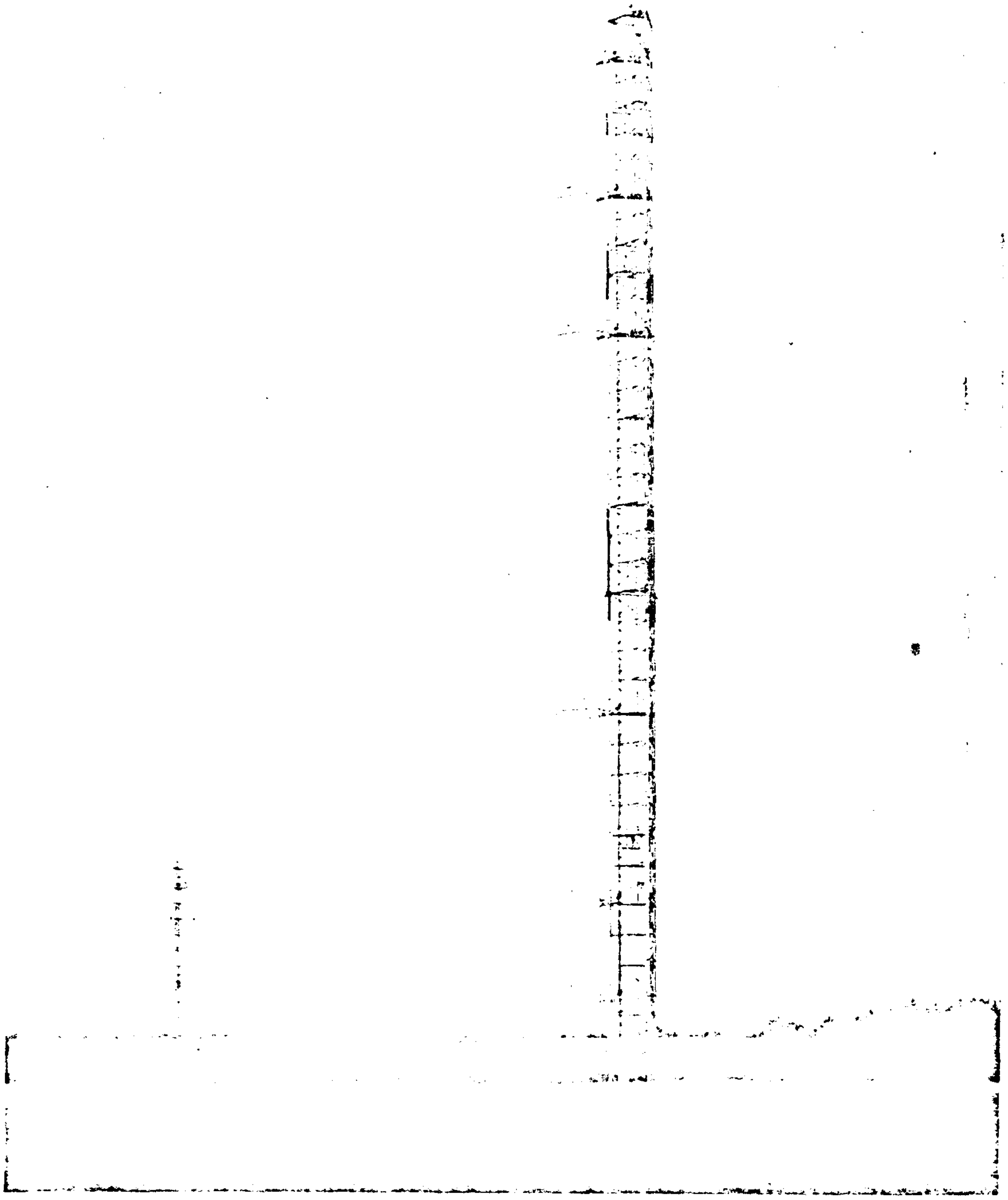


Fig. 1—Meteorological towers.

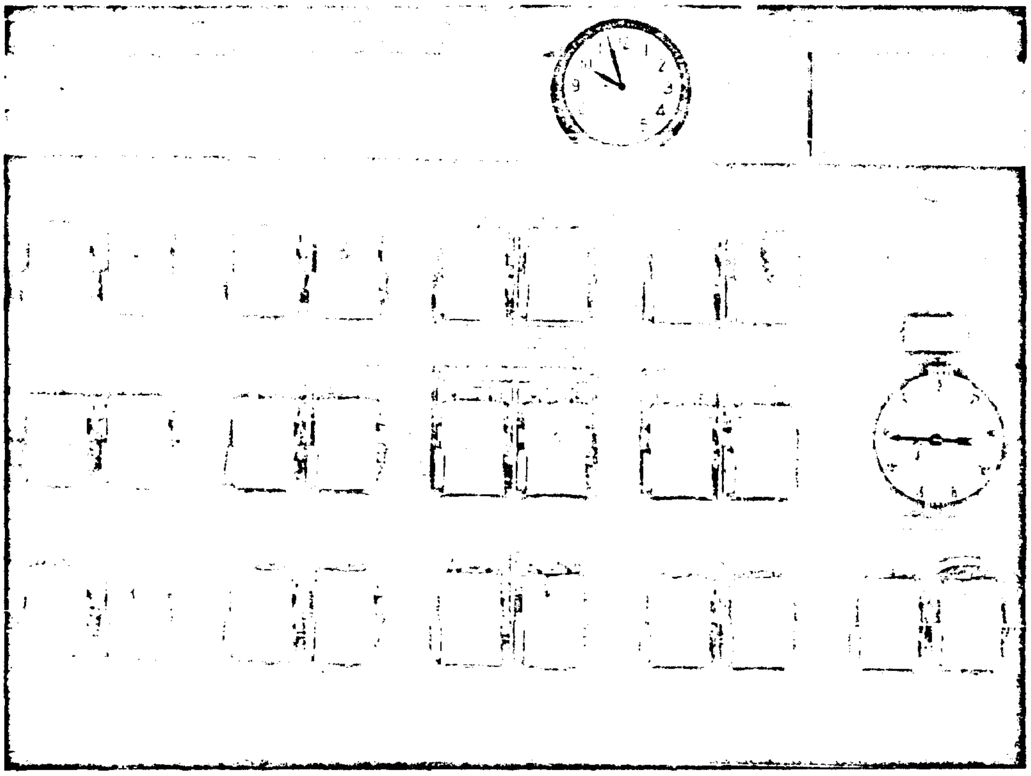


Fig. 2—Recording panel for meteorological towers.

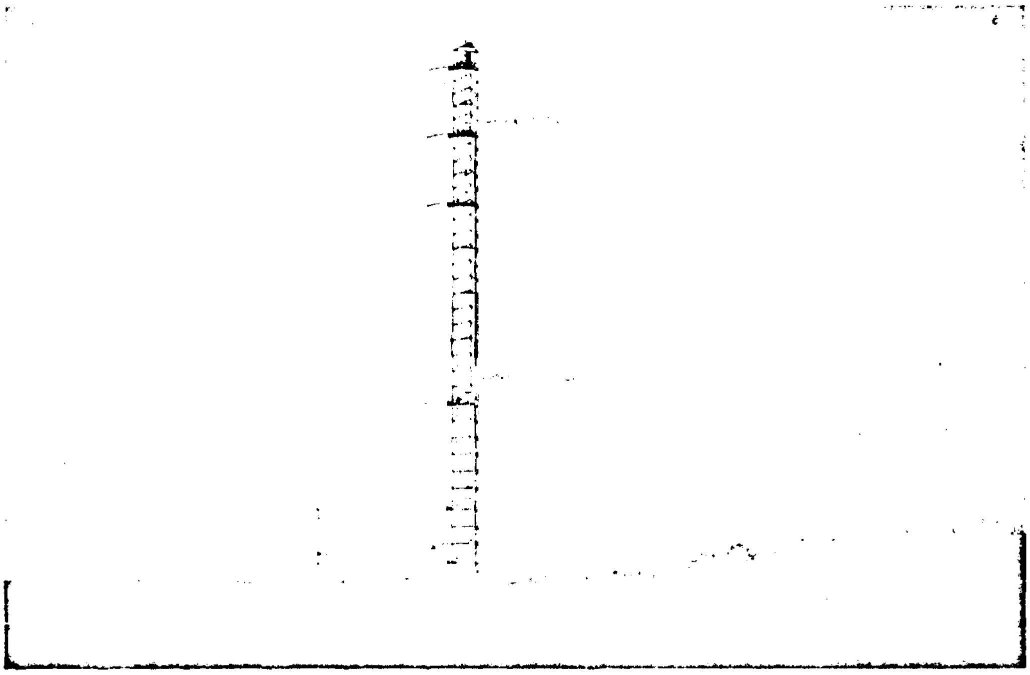


Fig. 3—Oil-fog from 410-ft tower.

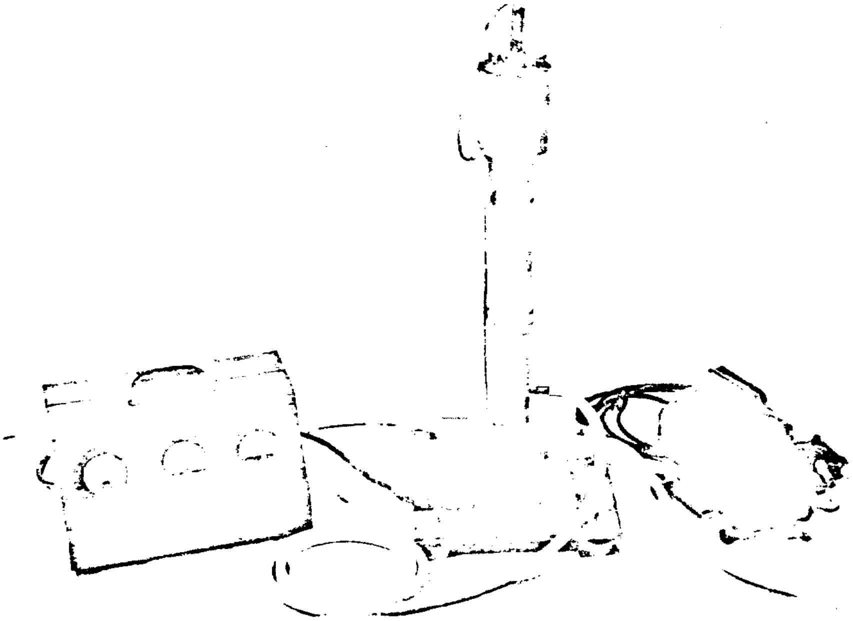


Fig. 4—Photoelectric densitometers.

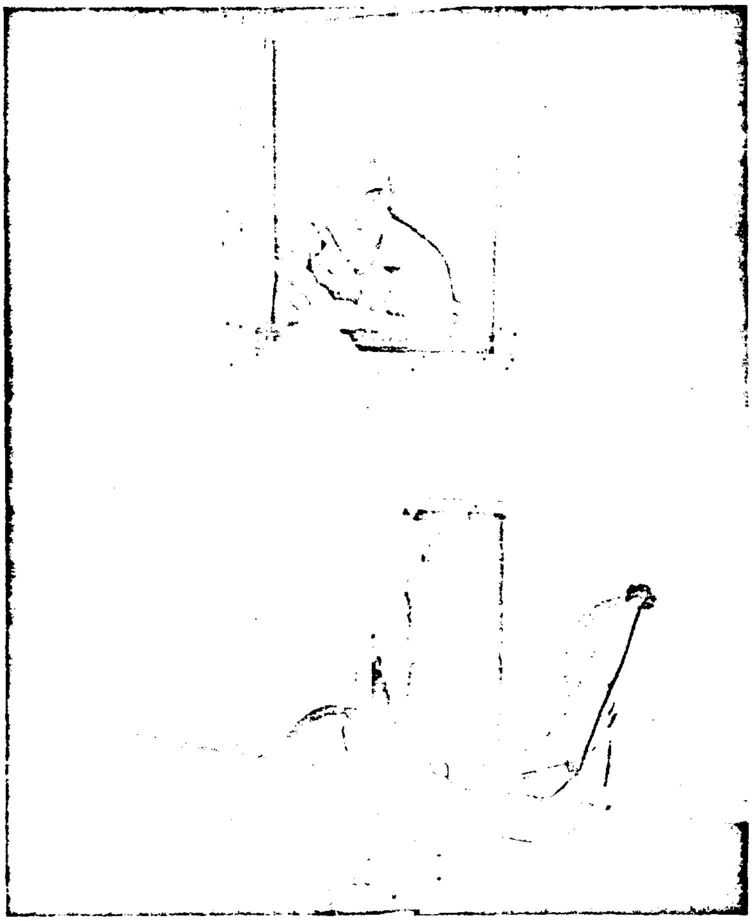


Fig. 5—Calibrating room.

These densitometers are calibrated before and after each smoke run in a special calibrating room of known volume (Fig. 5). A miniature smoke generator is used to produce a known concentration of oil-fog in the room, and by taking a series of readings at various concentrations, a calibration can be obtained.

Cost and maintenance of a complete densitometer with its accessories prevent the use of many of these devices. Therefore, a less expensive method of sampling concentrations downstream from the stack was needed. The oil used in producing the fog fluoresces when excited by ultraviolet light; therefore, some method of collecting the oil-fog for measurement later seemed desirable. After much detailed study, the Millipore filter produced by the Lovell Chemical Company was selected. A filter holder, (Fig. 6) developed at Brookhaven, consists of a modified A-N connector and a sintered glass filter used as backing for the fragile Millipore filter. Each filter and holder is checked for flow rate and pressure drop before being used in the field. This filter, together with its holder, has been used with several types of vacuum pumps.

The need for an inexpensive, portable d-c sampling unit led to the development of the first of the samplers (Fig. 7). This unit consists of a 6-volt car battery, a small vacuum pump and motor (Trico) together with the filter and holder. Many of these units can be made, used, and maintained at relatively small cost. The Meteorology Group has used 20 of these units satisfactorily in field sampling. This and all other units mentioned have been checked for reliability in the calibrating room and are all trustworthy devices.

The main objections to this particular sampler are that it is heavy (approximately 55 lb), the batteries need recharging after each hour of sampling time, and the pump is designed for intermittent use and should be cooled. However, all of these difficulties can be coped with and the unit is still being used with satisfactory results.

It is also desirable to make measurements of the concentration of oil-fog aloft in the smoke stream itself. Many fruitless hours were spent in devising some method of raising an entire unit which would consist of power supply, vacuum source, and filter components or various combinations of ground and airborne components. It was finally decided that the first method was the best, since it eliminated equipment such as tubes and power lines. However, most of the sampling devices were too heavy or too expensive to be carried aloft.

A light weight (1.8 lb) model airplane engine, attached to a Dewey and Almy #8000 Kytoon was finally adapted for use in airborne sampling (Fig. 8(a)). The first model employed part of the air intake from the engine as a source of vacuum. This model was used several times with success. However, the flow rate through the filter was very small (0.1 cfm at 0.6 in. Hg). This meant long sampling periods which were not convenient. The second model (Fig. 8(b)) used a stripped-down vacuum pump of the ground-level sampler driven by the model airplane engine. This increased the air flow through the filter to 0.3 cfm at 4.5 in. Hg. However, the weight increased from 1.8 to 3.4 lb and required the use of two model 8000 Kytoons. A third and final revision to the airborne sampler was made (Fig. 8(c)). This unit includes two airplane engines, one serving as a vacuum pump and the other as a driver. The entire air intake is utilized from the driven engine and the device can pull 0.3 cfm at 2.7 in. Hg. It weighs 2.7 lb complete with fuel, and has been used successfully in smoke runs during inversion conditions.

The most difficult problems in the use of these airborne units are the start-up on cold mornings and the effects of temperature change as they rise vertically. The first of these problems has been solved by the use of small electric starters. The propeller is attached to the shaft of the motor and electrically turned as fuel and air are fed to the engine. As soon as the engine starts it is pulled away from the starter and adjusted for proper mixture. The problem of temperature change has not been solved entirely as yet, but it is not a very serious one if the proper mixture of fuel and air is attained before ascent.

A versatile automatic sampling device has recently been developed at Brookhaven (Fig. 9). It consists of three main sections: (1) a sampling unit which has ten solenoid valves connected to a main chamber, (2) a basic timing unit which has interchangeable motors and several cams, and (3) a program unit consisting of a plug board and control relays. The unit allows for various sampling cycles, time delays, and sampling periods.

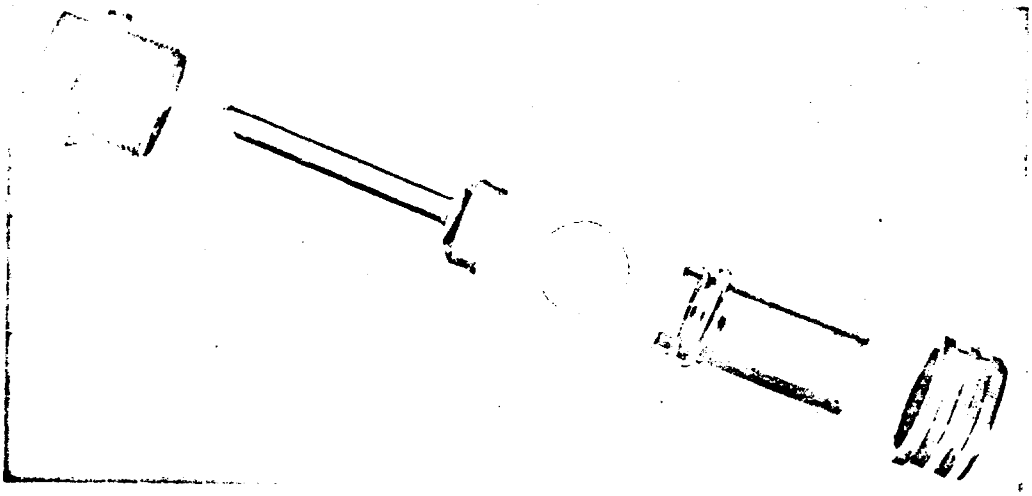


Fig. 6—Filter holder.

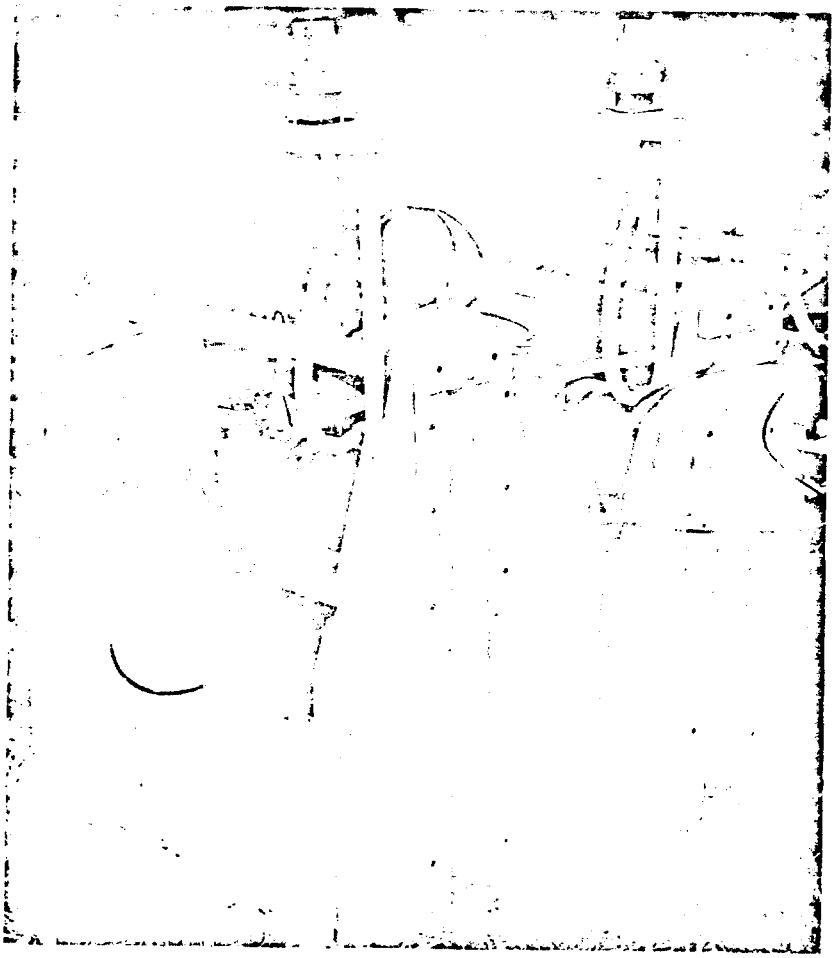
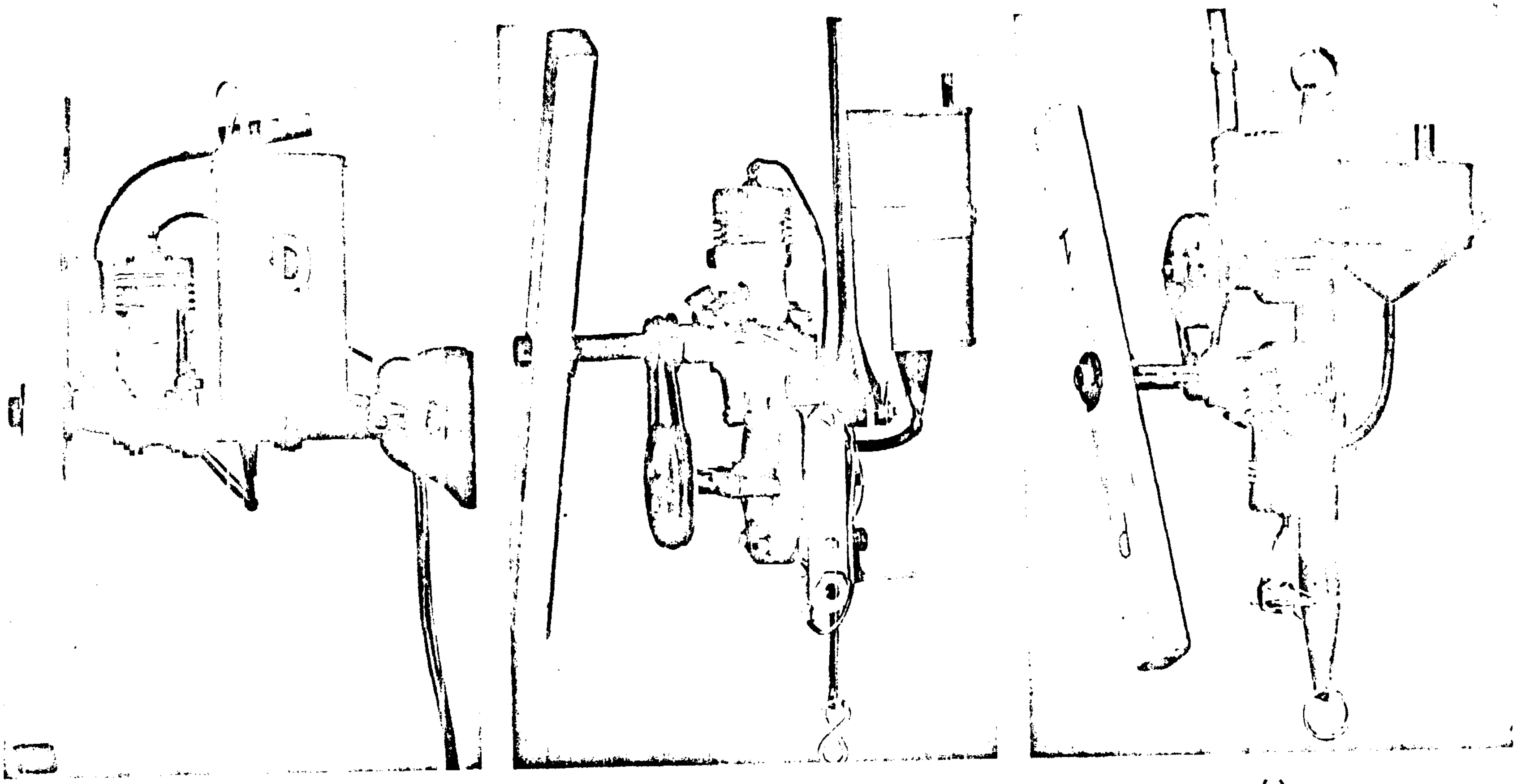


Fig. 7—Portable d-c sampling unit.



(a) (b) (c)

Fig. 8—Airborne samplers: (a) First model, (b) Second model, (c) Third model.

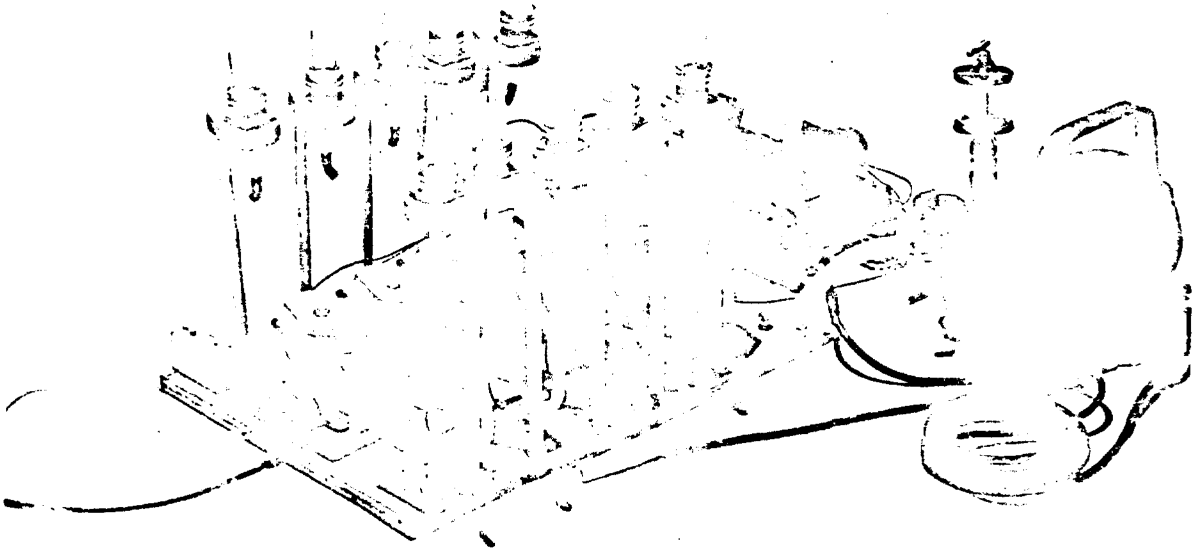


Fig. 9—Automatic sampling device.

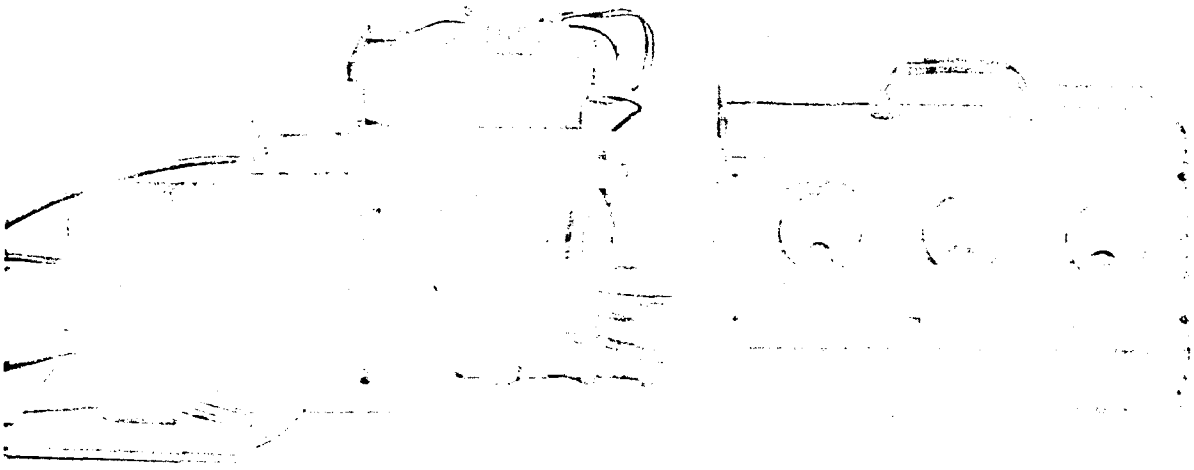


Fig. 10—Fluorometer.

The analysis of the material collected on the filter is accomplished by fluorometric techniques. As was mentioned earlier, the oil used in these tests is fluorescent under ultraviolet light. A fluorometer (Fig. 10) is used to determine the amount of filtered oil present. It consists of a sliding chamber, which holds the sample, two glass filters, a photocell, and an amplifier and meter. The oil on the filter is "washed out" by immersing the filter in 1 ml of benzol for a given time interval (45 sec). The source of ultraviolet light is a G.E. 4-watt hairpin germicidal lamp. The first glass filter, a Corning #5860, removes visible light and allows only the ultraviolet light from the lamp to reach the sampling chamber. The second glass filter, a Corning #3484 located below the sample, removes all of the ultraviolet light and transmits only the fluorescent light to a #929 phototube. The signal from the phototube is amplified and indicated on an appropriate meter. Various controls and adjustments have been incorporated into the system to insure stable and reliable readings. Cleanliness must be strictly adhered to in such a system. Each filter holder unit must be carfully washed and kept clean until sampling time. Background tests are run on all glass holders used in the sampling chamber. These are tedious and time consuming duties, but ones which must be performed.

Many criticisms have been made concerning the washing out procedure. However, investigations prove this technique has given satisfactory results. Many filter tests have been made in the calibrating room, where the filters were exposed to the same oil-fog concentrations, and after the washing out procedure had been completed, the indicated fluorescence of the oil and benzol was identical. The instrument is calibrated by sampling prepared solutions of oil and benzol to determine meter readings vs strength of solution.

The most recent sampler, presently under investigation, is a new jet air sampler. The ejected stream from a small container of Freon gas is passed through a small venturi tube creating a usable vacuum. The air sampling rate is controlled by choice of orifice between the venturi and the Freon container. The unit uses a regular Millipore filter to sample particulate matter and a standard impinger for sampling gases. It is a small unit weighing less than two pounds. Investigations of air flow and pressure drop are being made at the present time.

The future sampling program at Brookhaven will consist of continued measurements of ground-level and airborne concentrations of oil-fog in stable and unstable smoke trails. Other studies involve new techniques of filtration in relation to ragweed pollen collection during the late summer months. Measurements of total amounts of pollen are being made at several levels in a vertical plane and investigations are being made of total amounts captured from a forced draft blown over the collecting slides and filters. Meteorological measurements and oil-fog sampling at relatively long distances are being planned in the near future utilizing a helicopter for airborne use.

TWO GAS CLEANING PROBLEMS AT THE IDAHO CHEMICAL PROCESSING PLANT SITE

D. M. Paige, P. N. Kelly, and E. S. Grimmett
Idaho Chemical Processing Plant

INTRODUCTION

The Idaho Chemical Processing Plant has been principally engaged in recovery of uranium from spent reactor fuel of the aluminum-uranium alloy, aluminum clad type exemplified by the Materials Testing Reactor. However, the two gas cleaning problems to be discussed are not directly connected with this process. One of these problems is associated with the recently installed process for the recovery of radioactive barium from short-cooled (one or two days) MTR elements. This process is popularly known among AEC people as RaLa. The problem here is the removal of iodine from the dissolver off-gas.

The second gas cleaning task is associated with the proposed fluidized bed calcining of our liquid radioactive waste solutions. This process is scheduled to go into operation sometime in 1959.

1 IODINE REMOVAL FROM RaLa OFF-GAS

The RaLa process[1] briefly consists of the following simplified steps:

1. Caustic dissolution of the aluminum
2. Separation of uranium particulates
3. Acid dissolution of the uranium
4. Precipitation and separation of the barium and strontium
5. Separation of barium from strontium by sodium dichromate selective precipitation
6. Metathesis of the barium to the nitrate
7. Drying to final product barium nitrate

It was planned to vent the process directly to a tall stack when meteorological conditions were favorable or store a portion of the off-gas in a 1500 scf gas holder until favorable conditions arose. However, when actual runs were started, it was determined by stack monitoring that the bulk of the iodine was not evolved during the caustic dissolution, the caustic neutralization, and the acid dissolution as had been expected. Instead, the iodine (approximately 300 curies over the period) continued to evolve for days and even weeks after completion of a processing batch. It may be noted here that the xenon gas evolved during processing as expected. To more effectively control the evolved iodine from RaLa processing, study was undertaken.

Off-gas studies were divided into two general phases: (1) tie up the iodine in solution to prevent its elution as a gas, and (2) absorb iodine from the off-gas stream by means of an additional scrubber or scrubbers, a silver nitrate reactor, or some other means such as carbon beds. Concerning the first phase of study, no chemical additive compatible with the flowsheet was found that would theoretically tie up the iodine in solution any better than the caustic used for dissolution. This part of the study was entirely a literature search. However, operational means for reducing the evolved iodine were found. These included, (1) limiting the disturbance of vessel solutions, (2) lowering the jetting temperature of the caustic slurry, and (3) limiting decontamination work. Also the addition of 0.1M/liter of sodium thiosulfate to the 1.0M sodium hydroxide scrubber solution aided in scrubber efficiency.

For the second phase of the off-gas study, that of determining the best means for removing iodine from the off-gas system, an experimental facility was built. Summarily, the system provided for drawing four parallel sample lines from the off-gas line at the in-cell scrubber exit. Flow in these parallel lines was controlled between 1 and 5 scfh compared to 15 scfm in the main line. The driving force in the system was a nitrogen jet, and gas drawn through the system was returned to the off-gas line. Gas scrubbing bottles of 500 ml capacity with gas entry through a fritted glass disc were used for experimental lines, and standard 1-in. pipes were used for solid bed experiments. Piping to the experimental lines was $\frac{1}{8}$-in. tubing.

Experiments conducted during RaLa run 003RP began using 0.1M $Na_2S_2O_3$–1.0M NaOH to determine if successive scrubbers of that media would be effective and in general to determine something of the nature of the iodine in the off-gas. Further experiments were conducted to compare the thiosulfate caustic medium with other type solutions and with solid beds. All experiments were made on one RaLa run since we have made a very limited number of runs.

Table 1—RESULTS: RaLa RUN 003RP, BEGUN APR. 5

Experimental test	1					
Time interval	1245, Apr. 5 → 2205, Apr. 5—9.67 hr					
Description	Four series 0.1M $Na_2S_2O_3$–1.0M NaOH scrubbers					
Flow	5 scfh					
Iodine absorbed						
Scrubber position	A	B	C	D		
mc/hr	0.366	0.0611	0.0306	0.0207		
Experimental test	2					
Time interval	2205, Apr. 5 → 1245, Apr. 6—14.67 hr					
Description	Four series 0.1M $Na_2S_2O_3$–1.0M NaOH scrubbers					
Flow	5 scfh					
Iodine absorbed						
Scrubber position	A	B	C	D		
mc/hr	0.577	0.176	0.0806	0.0746		
Experimental test	3					
Time interval	1300, Apr. 6 → 1400, Apr. 6—1.0 hr					
Description	Three series 0.1M $Na_2S_2O_3$–1.0M NaOH scrubbers					
Flow	5 scfh					
Iodine absorbed						
Scrubber position	A	B	C			
mc/hr	0.0873	0.0465	0.0309			
Experimental test	4 (4, 5, and 6 are parallel lines)					
Time interval	1040 Apr. 9 → 1530, Apr. 9—4.83 hr					
Description	Six series 0.1M $Na_2S_2O_3$–1.0M NaOH scrubbers					
Flow	5 scfh					
Iodine absorbed						
Scrubber position	A	B	C	D	E	F
mc/hr	0.0667	0.0280	0.0188	0.0173	0.0129	0.0132
Experimental test	5					
Time interval	Same as 4					
Description	Two series 1M NaOH scrubbers					
Flow	5 scfh					
Iodine absorbed						
Scrubber position	A	B				
mc/hr	0.0125	0.00862				
Experimental test	6					
Time interval	Same as 4					
Description	Two series ~2% NaOCl scrubbers					
Flow	5 scfh					
Iodine absorbed						
Scrubber position	A	B				
mc/hr	0.0323	0.0162				

Table 1—(Cont'd)

Experimental test	8 (8, 9, and 11 are parallel lines)					
Time interval	1030, Apr. 10 → 1530, Apr. 10—5.0 hr					
Description	Six series 0.1M $Na_2S_2O_3$–1.0M NaOH scrubbers					
Flow	2.5 scfh (Data normalized to correspond to 5 scfh flow)					
Iodine absorbed						
Scrubber position	A	B	C	D	E	F
mc/hr	0.0874	0.0384	0.0169	0.0174	0.0206	0.0206

Experimental test	9	
Time interval	Same as 8	
Description	Two series 0.1M $Na_2S_2O_3$ scrubbers	
Flow	5 scfh	
Iodine absorbed		
Scrubber position	A	B
mc/hr	0.0419	0.0366

Experimental	11	
Time interval	Same as 8	
Description	Two series CCl_4 scrubbers	
Flow	3.5 scfh (Data normalized to correspond to 5 scfh flow)	
Iodine absorbed		
Scrubber position	A	B
mc/hr	0.147	0.000094

Experimental test	12 (12, 13, and 14 are parallel lines)									
Time interval	1215, Apr. 12 → 1600, Apr. 12—3.75 hr									
Description	Ten series 0.1M $Na_2S_2O_3$–1.0M NaOH scrubbers									
Flow	5 scfh									
Iodine absorbed										
Scrubber position	A	B	C	D	E	F	G	H	I	J
mc/hr	0.411	0.0611	0.0371	0.0373	0.0263	0.0251	0.0181	?	0.0101	0.00902

Experimental test	13		
Time interval	Same as 12		
Description	12 in. of carbon in 1-in. D pipe followed by two series 1.0M $Na_2S_2O_3$–1.0M NaOH scrubbers		
Flow	5 scfh		
Iodine absorbed			
Scrubber position	A (Carbon Bed)	B	C
mc/hr	No analysis	0.00166	0.000862

Experimental test	14		
Time interval	Same as 12		
Description	18 in. of ¼-in. ceramic Raschig rings coated with $AgNO_3$ in 1-in. D pipe followed by two series 0.1M $Na_2S_2O_3$–1.0M NaOH scrubbers		
Flow	5 scfh		
Iodine absorbed			
Scrubber position	A ($AgNO_3$ Bed)	B	C
mc/hr	No analysis	0.00142	0.000137

Experimental test	16 (16, 17, 18, and 19 are parallel lines)		
Time interval	1100, Apr. 16 → 1515, Apr. 16—4.25 hr		
Description	18 in. of ¼-in. tygon Raschig rings in 1-in. D pipe followed by two series 0.1M $Na_2S_2O_3$–1.0M NaOH scrubbers		
Flow	5 scfh		
Iodine absorbed			
Scrubber position	A (Tygon Bed)	B	C
mc/hr	No analysis	0.280	0.0626

Table 1 — (Cont'd)

Experimental test	17		
Time interval	Same as 16		
Description	18 in. of copper turnings in 1-in. D pipe followed by two series 0.1M $Na_2S_2O_3$ – 1.0M NaOH scrubbers		
Flow	5 scfh		
Iodine absorbed			
Scrubber position	A (Copper Bed)	B	C
mc/hr	No analysis	0.655	0.103
Experimental test	18		
Time interval	Same as 16		
Description	Gas passed over solid iodine so that "carrier" iodine would be added to stream, followed by two series 0.1M $Na_2S_2O_3$ – 1.0M NaOH scrubbers		
Flow	5 scfh		
Iodine absorbed			
Scrubber position	A	B	
mc/hr	0.690	0.103	
Experimental test	19		
Time interval	Same as 16		
Description	Two series 0.1M $Na_2S_2O_3$ – 1.0M NaOH		
Flow	5 scfh		
Iodine absorbed			
Scrubber position	A	B	
mc/hr	0.819	0.017	
Experimental test	20		
Description	Blank for laboratory analysis check		
mc/hr	0.000111		

2 DISCUSSION OF RESULTS

By intercomparison of the data obtained from parallel scrubber experiments the following list indicates the relative apparent efficiency of scrubbers. These comparisons were made relative to the $Na_2S_2O_3$ – NaOH scrubber as previously stated.

silver nitrate (heated)*
carbon*
carbon tetrachloride
sodium thiosulfate 0.1M – sodium hydroxide 1.0M
sodium thiosulfate 0.1M
sodium hypochlorite 2 per cent
sodium hydroxide 1M
Tygon (polyvinyl chloride) packing*
copper packing*

3 CONCLUSIONS

Our tentative conclusions are to use $Na_2S_2O_3$ – NaOH scrub in the present equipment in place of the original NaOH scrub and to install a cleanup carbon bed at a later date. Carbon tetrachloride was discarded on the basis of volatility and toxicity. Since silver nitrate must be heated to be effective, it was felt that the possible hydrogen explosion hazard was not worth the risk. The present in-cell scrubber has an estimated efficiency of 95 per cent for iodine absorption and it is hoped that the carbon bed will increase this so that RaLa runs can be made even under unfavorable weather conditions.

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*Success of solid bed scrubbers was deduced by the amount of iodine picked up on the $Na_2S_2O_3$ – NaOH scrubbers immediately following the solid scrubber in question.

4 GAS CLEANING PROBLEMS EXPECTED IN THE FLUIDIZED BED CALCINATION OF RADIOACTIVE WASTE SOLUTIONS

Investigators generally agree that the problems of storing radioactive liquid wastes could be simplified if these wastes could be converted to a free-flowing granular solid.

A potentially attractive method of converting liquid waste into granular solid was first demonstrated by workers at Argonne National Laboratory[2] and later proposed by the Idaho Chemical Processing Plant Technical Group[3-5] as a process for aluminum waste calcining. This process involves the direct calcination of the waste solution from processing aluminum fuel elements in a fluidized bed reactor. It may be possible to process wastes from zirconium or stainless steel fuel element processing by the same means. The solutions are sprayed through a combination air-liquid spray nozzle into a solids bed, fluidized with air, at a temperature of between 400°C and 600°C. At the temperature of operation, water is instantaneously flashed off, and in the case of aluminum fuel wastes the nitrate anion content decomposes to oxides of nitrogen, the cations forming metallic oxides. Solids formed by the reaction are fluidized by the air and eventually escape through an overflow pipe in the middle of the vessel. When equilibrium operation is reached, the amount of solids escaping is equal to the convertible solid content of the aqueous feed solution introduced. An average volume reduction of seven-fold is thereby obtained.

Heat is supplied to the calciner by means of heat transfer surfaces placed directly in the bed and possibly heated by means of circulated NaK metal. The NaK is heated in an oil-fired heater which is connected by appropriate controls to the calciner. Operation would be automatic.

Figure 1 shows a simplified equipment flowsheet.

Preliminary study has indicated that one of the major problems connected with this operation will be a suitable treatment of the off-gas (~2000 cfm) such that disposal can be made safely to the atmosphere. Since only limited technical time has been available for this work, the present discussion will attempt only to point out the major problems and some of the possible solutions to be studied in detail.

The gas cleaning problems can be broken down into five items: (1) particulate matter, (2) volatile fission products, (3) volatile nonradioactive material, (4) oxides of nitrogen, (5) steam.

Steam can, of course, be removed by condensation and possible re-evaporation in existing equipment until suitable for dumping to waste wells. At the present time, the concept for disposal of oxides of nitrogen is to allow escape to the atmosphere via our off-gas stack assuming that they are low enough in fission product contamination. However, if it is necessary to recover part or all of the nitric acid, this will be accomplished by standard equipment.

The only volatile nonradioactive material found so far has been mercury and this can be handled by providing a take-off at a low, cool point in the system. Possibly the mercury can be reused as a catalyst in the HNO_3 dissolution step.

Work at Argonne National Laboratory and the Idaho Chemical Processing Plant indicate that the only volatile fission product is ruthenium tetroxide. Experimental data obtained have indicated that nearly 100 per cent will volatilize from the calciner. Some experimental work has been done along the lines of preventing volatilization by providing a nonoxidizing atmosphere; however, with little apparent success.

The present thinking is that the RuO_4 must be removed from the off-gas in some manner. Success has been obtained in a condenser scrubber. One run has been made using cold ruthenium where up to 95 per cent was removed. However, this work and hot work at Argonne National Laboratory has indicated that extensive study of the problem will be required before a method for removal up to 99+ per cent can be devised. Another solution being considered is a quick quench of the off-gases. However, no experimental work has been done as yet.

Perhaps the most formidable problem will be the complete removal of particulate material since each particle is sure to contain some of all fission products. It has been fairly well established that a simple cyclone or cyclones in service will knock out most of the larger particles. The problem would therefore resolve itself into removing particles whose size ranges from 100 mesh down to submicron. A study will shortly be made on the experimental calciner to determine this range using a cascade impactor.[6] Preliminary experiments have been performed using mesh and Raschig ring packing. This data has indicated efficiencies up to the range of 90 per cent. However, reliable results have been difficult since obtaining representative samples of the gases and solids has been difficult due to the high temperature

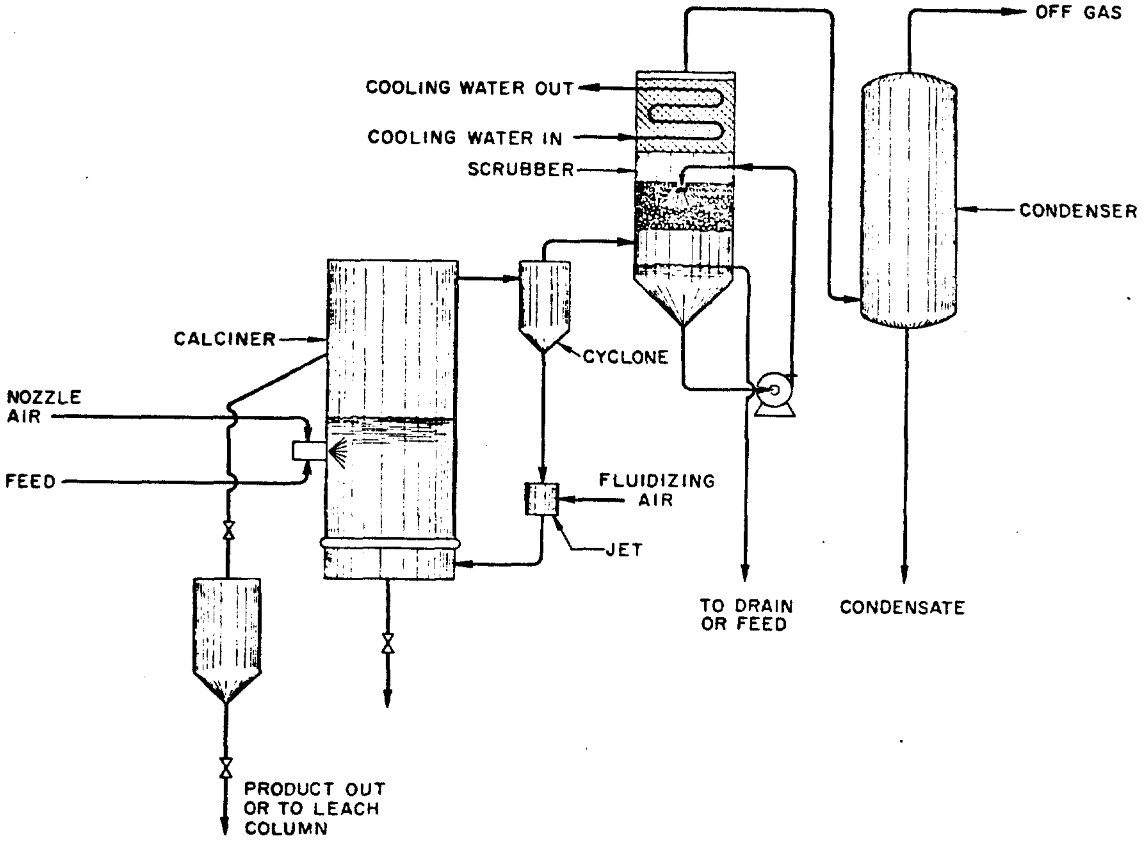

Fig. 1—Calcining equipment, Chemical Engineering Laboratory.

A proposal based on present knowledge would seem to indicate that particulates could be removed by an efficient scrubber design followed by a positive filter such as a CWS filter. We are planning to study such scrubber designs as packed scrubbers (Raschig rings, Beryl saddles, and mesh) Pease Anthony scrubber, multistage wet collectors and others as may be suggested.

The successful solution of this gas treatment problem seems to be the key to the whole calciner operation, and therefore will involve a very intensive engineering study over the next year at the Idaho Chemical Processing Plant.

REFERENCES

1. B. M. Legler et al., Pilot Plant Development of a Process for Separating Barium-140 from MTR Fuel, IDO-14344, 1955.
2. S. Lawroski et al., Argonne National Laboratory Chemical Engineering Division Summary Report, January to March, 1955, ANL-5422.

3. E. S. Grimmett, Waste Calcination and Fission Product Recovery Facilities, ICPP, PTR-106, 1956.
4. J. I. Stevens et al., Preliminary Process Criteria and Designs for Waste Calcining Facilities at the Idaho Chemical Processing Plant, PTR-177, 1957.
5. E. S. Grimmett, Calcination of Aluminum Type Reactor Fuel Wastes in a Fluidized Bed, PTR-212, 1957.
6. J. A. Brink, Jr., A Cascade Impactor for Adiabatic Measurement, Monsanto Chemical Company Research Department, Everett, Mass., Paper given at anual AIChE Meeting, December 1956.

AIR CLEANING ACTIVITIES AT BRUSH BERYLLIUM COMPANY

Hal J. Shafer
Brush Beryllium Company

We, at Brush Beryllium, have most of the air problems of chemical firms and foundries, as well as some peculiar to our own field. We do not deal with radioactive material. Our product, beryllium, produced by the sulfate-fluoride process, a process generally accepted to produce high purity metal, appears to be toxic in most of its compounds to certain people, and I believe it is more of an allergy than a definite intolerance by human beings in general. Consequently, we have the problem of careful ventilation and air cleaning.

Safe operation requires that we keep our beryllium concentrations to very low levels, not more than 2 $\mu g/m^3$ of general plant air, and 0.01 $\mu g/m^3$ in the air outside the plant. Air sampling at numerous points within the plant, as well as outplant air sampling, is a continuous program with us.

We follow conventional, as well as specialized, practices in the design of hoods, conveying duct work, and especially the cleaning of the air before it is finally discharged into a stack. All equipment, such as tanks, must be ventilated, and all outplant air ends up in the stack. The stack at our new plant is 300 ft high and the height of our present stack at the Alloy Division is 175 ft.

We usually use two cleaning stages, i.e., preliminary cleaning by one collector and final cleaning by a back-up cleaner. In the wet collection this consists of a primary scrubber handling the concentrated fumes, and the secondary scrubber handling the effluent from the primary scrubber as well as the less concentrated fumes from the secondary hooding, if required.

We believe in primary hooding 100 per cent. Secondary hooding or enclosures are used only as a safety measure, or where it is impossible to collect the fumes or dust at the source of liberation. Also, scrubbers are more efficient when handling concentrated fumes rather than fumes diluted with ordinary room air.

Our machine shop is located in our Cleveland Plant. In this operation we grind the vacuum-cast billets produced at the Luckey Plant in a series of attrition mills. This material is then pressed into approximate shapes in sintering furnaces. From there, the pure metal is machined to various shapes as required by the Atomic Energy Commission as well as industry.

All of the machines, such as lathes, mills, and saws, are equipped with ingenious pickup points immediately at the tool itself. The capture velocity is about 15,000 ft/min. This air, plus dust and chips, is precleaned by the use of multiple high velocity, high efficiency cyclones. These cyclones are backed up either by bag collectors or electrostatic precipitation.

Collection of dust from our electric arc furnace for the production of beryllium alloys is accomplished by the use of a dry type bag collector and backed up by a polishing filter, also of the cloth type. The temperature of the effluent leaving the furnace bay is from 500°F to 600°F, and the temperature entering the first collector is as high as 370°F. This presented quite a problem of bags scorching, with the resultant bag failure. We used Orlon bags, but they seemed to shrink and tear at this temperature. After numerous approaches, we decided to try evaporative cooling. This is accomplished by the use of air atomizing nozzles. We use 50-lb water pressure and 60-lb air pressure. Four nozzles are used and are automatically controlled by the temperature of the effluent entering the first collector. This controller is set at about 215°F, which is safe for Orlon bags and also for fire resistant cloth sateen bags, which we have been testing the last several months. This system has been in use about six months with very good results. We have replaced only a few bags which failed at the seams, due to shaking, but none has failed because of the temperature. Also, the water vapor in the gas stream seems to agglomerate the dust particles and improve collection. Although the dust collected may contain as high as 20 per cent water solubles in the form of carbonates, no trouble has been experienced from this source. The average loading is about 1 g/cu ft but varies considerably during the cycle.

In one of the final stages of our sulfate-fluoride process, we deal with beryllium fluoride and its other components directly. In our process we use a 5-ft packed tower with 1-in. Raschig rings backed up by an irrigated type electrostatic precipitator of our own design.

We will have five fluoride furnaces, the fumes of which go first through the packed towers and then through electrostatic precipitation. This precipator is unique inasmuch as it will be five single tube units operated from a common unit developing the required 75 kv.

We plan on using 10-in. tubes, 12 ft long and in this stage to pick up only what the scrubber misses, which is some ammonium fluoride and beryllium fluoride. Both of these compounds are highly corrosive, and very valuable, so collection is a desirable as well as an economic venture.

Our ventilation system, as well as our various types of air cleaning equipment, requires continuous policing by visual inspection as well as logs of pressure drops. Some of this equipment is provided with recording manometers. Naturally, immaculate housekeeping is a must.

We also continue to improve our method of collection, and this usually results in lower air counts which, of course, is our ultimate goal.

AIR CLEANING ACTIVITIES OF THE BERYLLIUM CORPORATION

A. Epstein
Beryllium Corporation

During the refining of beryllium metal from its ore, we generate the gamut of physical airborne contaminants. Dusts are evolved at crushers and mills, fumes at metal reduction furnaces, mists are produced at agitated reaction and leaching vessels, and gases and vapors must be handled from sintering and calcining operations. All these are the unwelcome legacy of the beryllium producer.

At our new plant near Hazleton, Pa., where nuclear grade metal will be made for the Atomic Energy Commission, we have installed air cleaning devices for the control of these different contaminants. Selection of these units was based on the usual considerations coupled with a number of criteria that are perhaps unique to our kind of industry. We evaluated the usual problems of dust loading and particle size, temperature and moisture content, abrasiveness and corrosiveness, ad infinitum, plus the always present and sometimes decisive consideration of cost. But in addition to these deliberations, we were heavily influenced by both the recognized toxicity of the collected material and the known value of its re-introduction to the process flow stream. Consequently it became important to consider ease of disposal as well as efficiency of collection. These factors, individually or combined, in more than one instance forced the abandonment of an accepted method of materials handling in favor of a technique that otherwise might be considered less desirable.

For example, pneumatic conveying at first seemed like an excellent method of transferring submicron size BeO from a calciner to a storage bin. But simple calculation based on expected dust loading indicated that despite high efficiency collection, the amount of material still escaping would be intolerable. We substituted a completely enclosed jacketed screw conveyor and eliminated part of the system dust loading.

Conversely, for a series of covered leach tanks to be maintained at a slightly negative pressure, a collector with an efficiency of 80 per cent was considered adequate. And with this wet type unit, we keep recirculating until the liquor has achieved a predetermined concentration, when it is simply pumped into one of the leach tanks that it serves.

Again, where widely separated ventilated equipment could be linked in regard to contamination potential, it was necessary to evaluate the cost of additional sheet metal and its effect on fan size and horsepower against the cost of multiple air cleaning units.

This approach was used during repeated reviews of equipment layout and process flow with good results. On the first go-round we came up with 23 individual air cleaning units, and by final design time this number had been reduced to the 11 units now installed.

Because of the variations in the characteristics of the particulate matter we collect, these 11 units include a venturi agglomerator, cyclones, hydraulic and packed towers, wet cell absorbers, and reverse jets.

Where practicable we have arranged for more than a single cut at our contaminated exhaust. For example, where temperature dictated the use of a wet scrubber with known inadequate efficiency, we mixed this unit discharge with high volumes of dry contaminated air and took a second cut at the combination with a high efficiency dry collector.

All the units are arranged with the exhausters on the clean air side so that everything before the inlet to the fan is under negative pressure. Each of the exhaust fans discharges into a common manifold duct which extends around the perimeter of the building. The manifold duct which receives the essentially clean combined effluent from the individual systems is itself carried to a final clean-up filter.

This last air cleaner, which is equipped for application of asbestos floats as a filter aid, is itself under negative pressure through the operation of a final exhauster. This high-capacity fan is located at the base of, and discharges into a stack 200 ft high.

Our boiler plant consists of three 10,000 lb/hr steam generators equipped with forced draft fans rated at 15,000 cfm each. The opportunity offered by this appreciable amount of hot flue gas could not be ignored, and we decided to combine the boiler and dust collection system effluents. We expect that, under most meteorological conditions, this added thermal influence will give us a considerable increase in effective stack height.

To eliminate the possibility of generating back pressures in the boiler breeching, our final fan discharge was designed and fabricated as an eductor nozzle which will develop negative pressures in the breeching in excess of what might be achieved from natural thermal effect. Dampers are installed in each boiler smoke box for control against excessive combustion chamber draft.

The manifold duct, final clean-up filter, and large exhauster were all intentionally sized for 150 per cent of calculated design capacities. This was done for little added cost and was easily justified by the flexibility it provides.

However, to minimize the added operating costs for make-up air (especially during the winter season) imposed by this oversizing, a simple but effective scheme was devised. Because our perimeter walls are completely of masonry without sash, and since we expect the occupational activity to be other than sedentary, we decided we could effectively heat the building and furnish make-up air simultaneously with an overhead distribution system. This was accomplished by installation of 10 coil and fan units with motorized face and bypass dampers across the blast coil, and full size fresh air and return air dampers in the unit intake box. These air handling units are equipped with swivel elbow outlets and double deflection discharge louvers for directional control.

A simple thermostat actuates the face and bypass damper at the blast coil to maintain predetermined temperatures. The opposed action dampers in the intake box are modulated by static pressure regulators to maintain a slightly negative pressure within the plant. Thus the amount of fresh air we temper through our units is directly dependent on the amount of air being exhausted. When our exhaust systems are inoperative, the pressure regulators will set the dampers for 100 per cent recirculation.

Because much of the duct work in the plant required interior protective linings, special emphasis was placed on methods of fabrication and installation. We decided on a modular arrangement with a 10-ft maximum section length. For straight duct work up to 12 in. in diameter, longitudinal joints are of double lock seam construction. Girth joints are of the Van Stone type with flanged ends, slip-on "O" rings and either rubber or asbestos gasketing. The larger duct work and the fittings and transition pieces of all sizes are of welded construction with angle rings welded at the ends for transverse joining. All the sheet metal is supported by wraparound tension straps without penetration of the duct walls. Capped nipples to accommodate pitot tubes and sampling probes were included in the original fabrication of the duct work. Although the "balanced system" concept was used as a basis for design, we still included a number of blast gates at critical points. Some additional adjustability was achieved by specifying variable pitch sheaves for all fan motor drives.

Finally, if we assume that everything we have talked about is perfectly planned and executed, there still remains the single most important preliminary prerequisite for successful dust control design. Without the judicious selection of process equipment, all subsequent efforts are doomed to dismal failure. If the equipment is wrong, the battle is lost before it has begun. The right selection is not always the more expensive choice.

And here the Industrial Hygiene Engineer, out of his element, must be supported not only by his technically expert co-workers, but also by the members of Management, who in the final analysis must assume responsibility for the success or failure of the complete operation. We of the Beryllium Corporation sincerely feel that our Hazleton Project is just such a culmination of concentrated cooperative effort.

AIR CLEANING ACTIVITY AT OAK RIDGE GASEOUS DIFFUSION PLANT

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Since there are several locations at Oak Ridge Gaseous Diffusion Plant where fluorine is a component of a waste gas, there exists a problem of disposal of this gas in a safe manner. When the fluorine concentration is low or when small flows or short periods of time are involved, such waste gases may be vented to atmosphere. To dispose of this fluorine without the necessity of dumping into the atmosphere, a method of reaction between preheated fluorine and superheated steam has been employed. This method is described by S. H. Smiley and C. R. Schmitt.[1] They investigated this reaction using undiluted fluorine and air-diluted fluorine in concentrations varying from 13 per cent to 75 per cent and determined conditions for maximum conversion of fluorine to hydrogen fluoride.

A reactor in which fluorine gas was consumed in a reaction with oxides of uranium has been described in a paper by Clouse, Dykstra, and Thompson.[2] Though primarily used as a part of a uranium recovery process, it showed one means of reacting fluorine with uranium compound which results in the formation of a useful product and the removal of fluorine from feed gas. In this process, the dry oxide is fed directly to a screw type reactor and is treated at a high temperature with fluorine gas.