DESIGN AND OPERATION OF A LARGE SAND BED FOR AIR FILTRATION*

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Abstract

DESIGN AND OPERATION OF A LARGE SAND BED FOR AIR FILTRATION. Large sand beds to filter exhaust air from radiochemical separation plants have performed satisfactorily for 13 years at the Savannah River Plant. The beds are 100 × 240 × 8 feet deep and are made from layers of sized sands and gravels. Activity penetrates only to the smallest-mesh (30-50) sand; about 1000 curies of gamma activity is estimated to be in the bed. Filtering efficiency has remained at 99%. Resistance to air flow has increased in the beds throughout the years of operation. Some increased pressure drop resulted from groundwater leaking into the sand. Air flows have generally been maintained in excess of 115000 ft^3/min. Filter differential pressures currently are in the range of 8 to 10 inches of water.

INTRODUCTION

Two chemical separations facilities at the Savannah River Plant (SRP) are used to separate and purify the products of the SRP reactors. These processes are 1) recovery of unconsumed uranium, 2) separation of plutonium, and 3) separation of special isotopes Operations are carried out in two large fuel reprocessing "canyon" buildings, located in F and H Areas Figure 1 shows a cross section of the reprocessing building, and that portion of the exhaust air system that goes to the sand filter The initial steps of the separations process are performed in the hot canyon, steps involving lower radiation levels are in the warm canyon

Separate air supply and exhaust systems are provided for the canyons, the center sections (occupied by personnel), and the plutonium finishing areas. Exhaust air from the canyons goes through a sand filter to remove particulate radioactivity and then to a 200-foot stack. Part of the air from the center sections goes directly to high-efficiency filters and then to the stack, the other part passes through process areas and combines with the canyon air Vessels in the canyons are ventilated by a process vessel vent system that exhausts through a dehumidifier, heater and fiberglass filter before entering the sand filter. Air from the plutonium finishing areas is triple filtered through high-efficiency filters and part is exhausted directly, the remainder enters the sand filter for additional activity removal

SUMMARY

Large sand beds, one each for F and H Areas, have satisfactorily filtered exhaust air for 13 years Filtering efficiency has remained greater than 99% with acceptable increases in differential pressure

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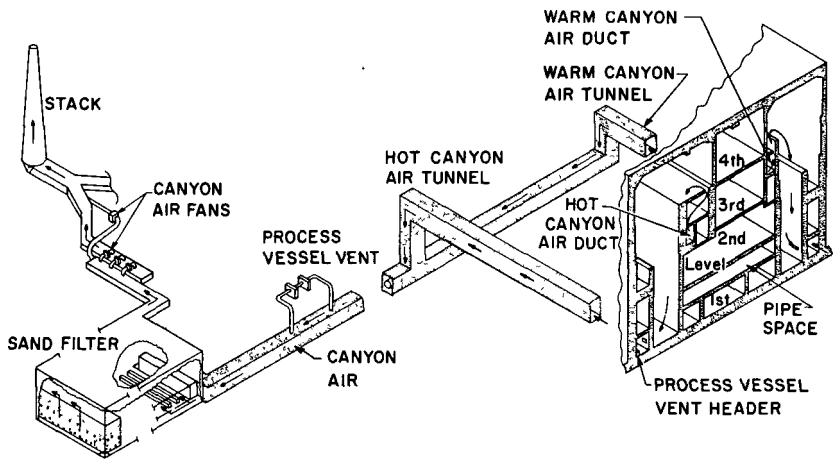


FIG. 1. Sand filter supply and exhaust system.

Activity has penetrated only to the smallest mesh (30-50) sand, about 1000 curies of gamma activity is estimated to be in the bed. Filtering efficiency has gradually improved, probably because dust accumulation has created a finer filter medium Air flow has ranged from 100,000 to 130,000 cubic feet per minute throughout the years of operation Filter differential pressures have increased slightly because of dust accumulation and occasionally because of water inleakage.

SAND FILTER DESIGN

The sand filters are 100 feet wide, 240 feet long, and 8 feet deep. Only the roof section is above ground level, and it is supported by columns that extend through the filter bed The sides are waterproofed concrete. General construction of a filter is shown in figure 2.

The bed is made from layers of sands and gravels in graduated sizes The largest rocks (1-1/4" to 3" diameter) are supported on special tiles (shown in detail on figure 2) which distribute the air from 12 tunnels connecting to the main supply tunnel. Progressing from the

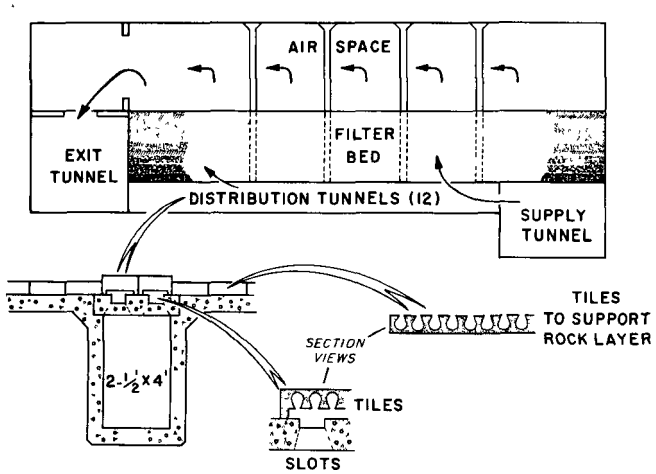


FIG. 2. Sectional view of sand filter.

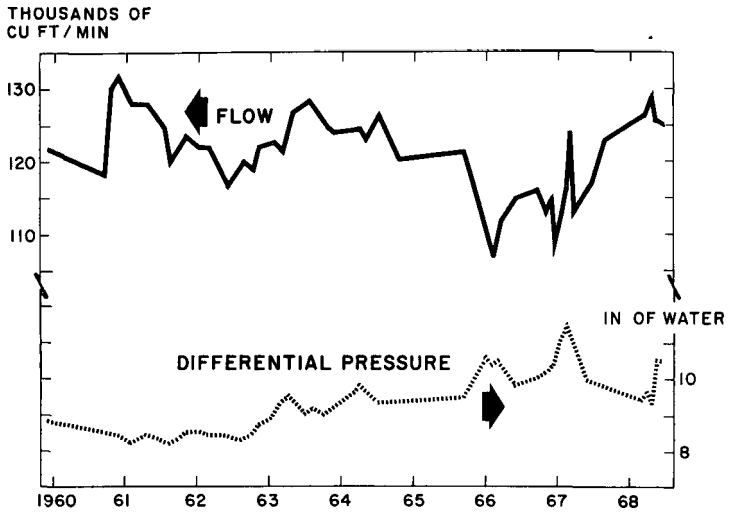


FIG. 3. Filter differential pressure changes.

bottom to top, the air passes through layers of successively smaller particle-size until the primary filter medium (30-50 mesh sand, 3 feet deep) is reached Coarser sand and gravel top the bed to prevent loss of sand through entrainment. Air passes through exit ports into an exhaust tunnel and then to a 200-foot stack A filter bypass tunnel is provided, but has never been used. Sumps are provided in the supply and exhaust tunnels to collect any condensed moisture.

OPERATING EXPERIENCE

The sand filter in F Area has been in continuous operation since 1954 and in H Area since 1955 at a nearly constant superficial velocity of 4.7 ft/min.

Operation and Problems

There have been variations in air flow rates from about 100,000 to 130,000 cu ft/min which are attributed to changes in differential pressure. Figure 3 shows the change in

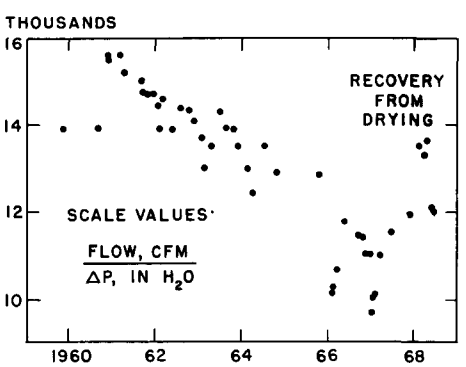


FIG. 4. Flow per inch of differential pressure.

differential pressure through the F Area filter since 1960 Increased differential pressure is attributed to two causes 1) ground water inleakage which may have resulted in some permanent compaction of the bed, and 2) dust accumulation

A relatively abrupt increase in pressure drop across the filter in F Area prompted comprehensive investigation in 1966-1967 Flow measurements were refined, pressure differentials checked, and dew point instruments employed to determine moisture content Excessive moisture was indicated, so the filter was inspected Cracks were found in the concrete side walls above the bed (above the 1/4 inch gravel) through which ground water could enter, and stains on the walls indicated that seepage had occurred The bed had settled about 3 inches Earth was excavated from around the walls and all cracks were repaired, the space was not backfilled, thus preventing further inleakage An effort was made to dry the sand by heating the incoming air but the temperature attainable was limited by process restrictions in the separations plant About 15% less pressure drop was realized in several months A plot of the time versus flow per inch of differential pressure, figure 4, shows the recovery in 1968 after drying

Sampling of the filter input air indicated dust accumulates at about 2 lb/day routinely, the dust may well function as a filter aid Dust is present because some escapes the canyon inlet air filters, over the years it has accumulated on process equipment Higher dust loading rates to the sand filter occur when extensive equipment movement disturbs the dust deposits in the canyon and when other special work is performed, e g , in the exit air tunnels Slow deterioration of concrete also contributes No steps have been taken to change the dust accumulation rate.

Radioactivity Filtration

Radiation from the gamma emitters deposited in the sand is measured routinely by inserting an ion chamber into monitor tubes which pass through the bed A typical radiation survey is shown in figure 5, intensity has ranged to twice that shown The intensity varies with cooling time and type of material processed as well as processing rate

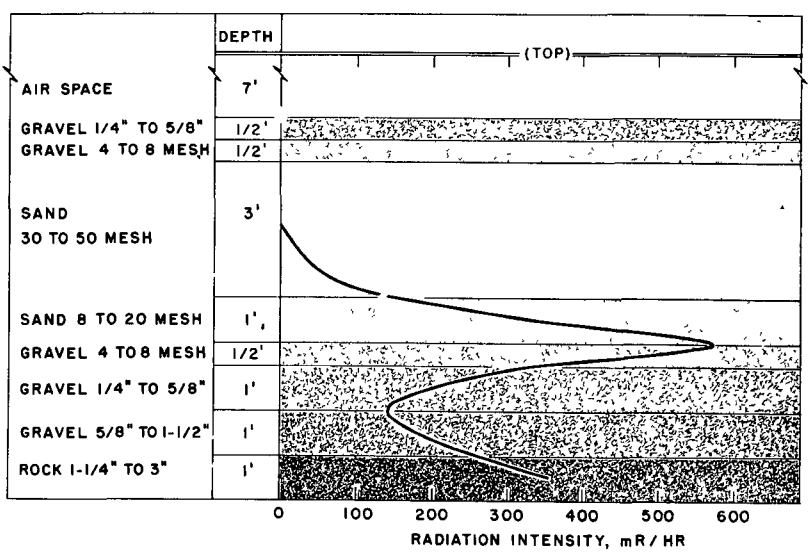


FIG. 5. Typical radiation intensity in a sand filter.

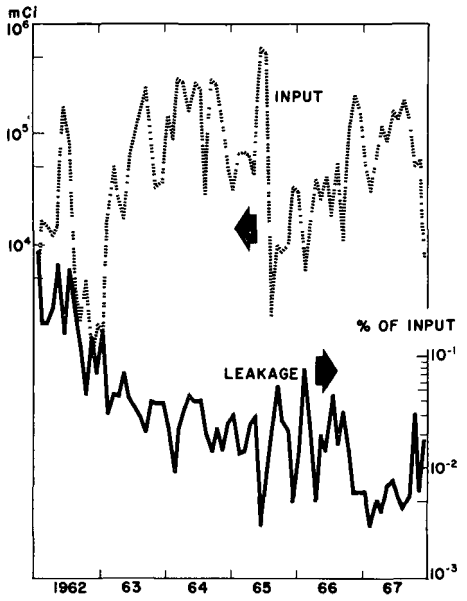


FIG. 6. Beta-gamma activity input and leakage.

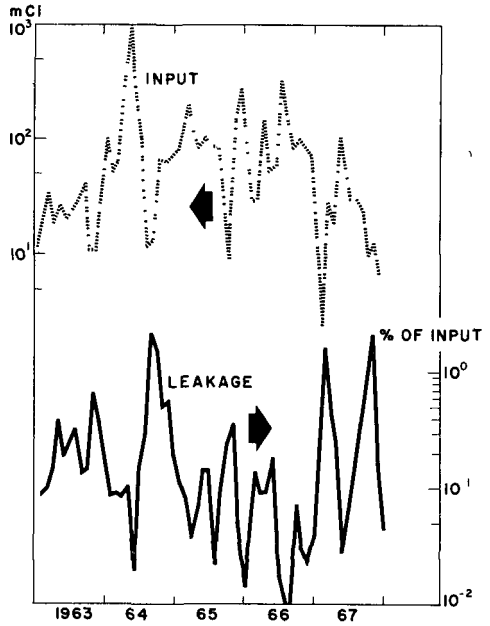


FIG. 7. Alpha activity input and leakage.

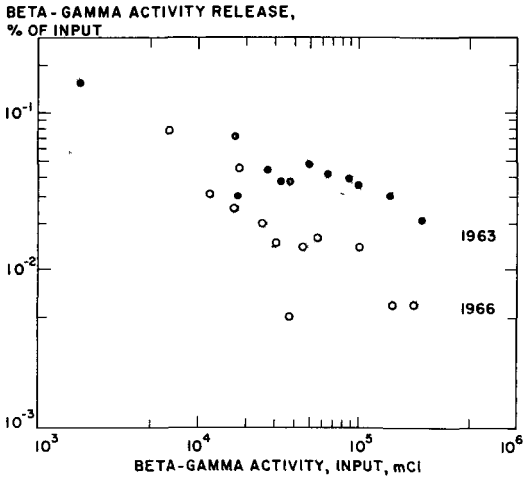


FIG. 8. Beta-gamma activity filtration improvement.

The air entering and leaving the filter is monitored constantly to determine the input and output of radioactivity Annual input of gamma emitters is about 1000 to 2000 curies Gamma pulse height analyses indicate that the emitters are fission product Ce, Ru, and Zr-Nb The nuclides present will vary depending upon the material being processed Figures 6 and 7 show activity input and leakage for nonvolatile beta and alpha emitters from 1962 through 1967 These data indicate that the filter efficiency improves with time The relation between input and leakage of the nonvolatile beta emitters better emphasizes the filtration improvement, figure 8 illustrates this with two years' data selected to show best correlation Release is a

function of two variables, filter inventory and instantaneous input High instantaneous input gives a lower percentage release while high inventory gives a more constant release This indicates that inventory is the prime contributor to activity release.

Figure 8 further indicates that data from an operating filter should not be used for predicting the release from a new filter A new filter should be tested for release and, if necessary, steps taken to improve filtration before active operation begins.

DISCUSSION

C. CHEEVER: Were the individual sand grains regular or irregular in shape?

G. H. SYKES: We only washed the sand; we did not shape it. I assume that the grains were irregular.

C. CHEEVER: Have you any recommendations for improving the efficiency of new sand-bed filters?

G. H. SYKES: I think they should be pre-loaded with dust.

R. I. NEWMAN: Why were only some of the exit-gas streams passed through the filters and on what basis was your selection made? Has any study been made of relative costs (initial and operating) of sand versus HEPA glass filters?

G. H. SYKES: Regarding the exit gases, some of those which do not pass through the filters show merely trace levels of contaminants; in any case, they do pass through other filters. In another case, air from the plutonium finishing areas is passed through separate, high-efficiency filters three times. Air from work areas occupied by personnel also has an extremely low activity not necessitating sand filtration. Air is not passed through the sand filters unless this is really necessary, since lower air velocities and volumes mean better filtration.

I do not know of any comparison of filter costs.

H. A. MOREWITZ: How did you decide on the number and thicknesses of the sand layers, type of medium, etc. in order to predict that they would perform the functions allotted to them?

G. H. SYKES: Our filter was constructed many years ago and I do not know all details of the design studies. Du Pont had already constructed a filter at Hanford, based on data in its possession, and I believe that our filter was based to a large extent on the design of this one.