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DRY SCRUBBER UNIT FOR LOW-LEAK VENTILATION SYSTEMS

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Radiation Laboratory**

**DRY SCRUBBER UNIT
FOR LOW-LEAK VENTILATION SYSTEMS**

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Research and Development

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TID-4500 (19th Ed.)

UNIVERSITY OF CALIFORNIA

Lawrence Radiation Laboratory
Berkeley, California

Contract No. W-7405-eng-48

DRY SCRUBBER UNIT FOR LOW-LEAK VENTILATION SYSTEMS

Jensen Young, Wayne T. Pearce, and Thomas C. Parsons

August 7, 1963

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October 8, 1963

ERRATA

TO: All recipients of UCRL-10953 UC-41 Health and Safety
FROM: Technical Information Division
SUBJECT: UCRL-10953, "Dry Scrubber Unit for Low-Leak Ventilation Systems," Jensen Young, Wayne T. Pearce, and Thomas C. Parsons, August 7, 1963.

Please make the following corrections on subject report:

Page 3 ✓ Second paragraph, term (f) should read:

be inexpensive enough..... unit,

Page 9 ✓ 5th paragraph - line 9 to end of paragraph should read:

and smoke problems were reduced..... Survey readings on the dry scrubber were about 250 mr/hr of γ radiation twenty-nine days after the end of the run.

Pages 6 and 8 - Insert new pages 6 and 8 to correct Figs. 2 and 3.

DRY SCRUBBER UNIT FOR LOW-LEAK VENTILATION SYSTEMS

Jensen Young, Wayne T. Pearce, and Thomas C. Parsons

Lawrence Radiation Laboratory
University of California
Berkeley, California

August 7, 1963

ABSTRACT

To "air-condition" primary enclosures of 4-ft and 6-ft water neutron facilities used when separating and purifying transcurium elements, an improved dry scrubber unit has been developed and tested at the Lawrence Radiation Laboratory in Berkeley. Construction of the unit, laboratory tests, and operating data are described.

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GENERAL

Transcurium elements are prepared at Berkeley within the water-shielded cave facility.¹ In the exhaust system of the primary enclosure, contamination hazards are reduced by means of a low-leak ventilation system. This low-leak ventilation equipment, which air cleans the exhaust gases and "air conditions" the enclosure's atmosphere with a wet-type scrubber, has been described previously by Thaxter, et al.² A previous small dry-type scrubber unit for this system was reported by Spencer, et al.³ Here, we critically examine the previous types of scrubbers and then describe a new dry scrubber unit that offers several improvements.

DEVELOPMENT

Concomitant with a need to maintain low-leak enclosures is the problem of removal of chemical vapors and smokes. The worst offender is ammonium chloride smoke which occurs when ammonia gas or ammonium hydroxide vapors are mixed with hydrochloric acid vapors. If this smoke is not removed rapidly by means of scrubbers, it may build up enough to totally obscure vision in the primary enclosure. Our experiences with scrubbers on the air recycling train on previous cave runs indicated the following:

(a) The wet scrubber, using a buffered scrubber solution, gave us excellent control over corrosive vapors and ammonium chloride smoke. The air recirculation rate was high enough to clear out smoke within a matter of minutes. For extended runs, these were excellent tools. However, they have a few drawbacks. They are expensive to fabricate, they require constant vigilance, maintenance is a tedious job, and decontamination is virtually impossible. In addition, the cave operators sometimes complained of condensate in the box which probably came from the scrubber effluent.

(b) With the variety of programs now being handled in the new neutron facility, our experience indicated that it was much better to use a scrubber for each new cave box for each new program. This would eliminate cross-contamination and the tedious job of reconditioning old scrubbers.

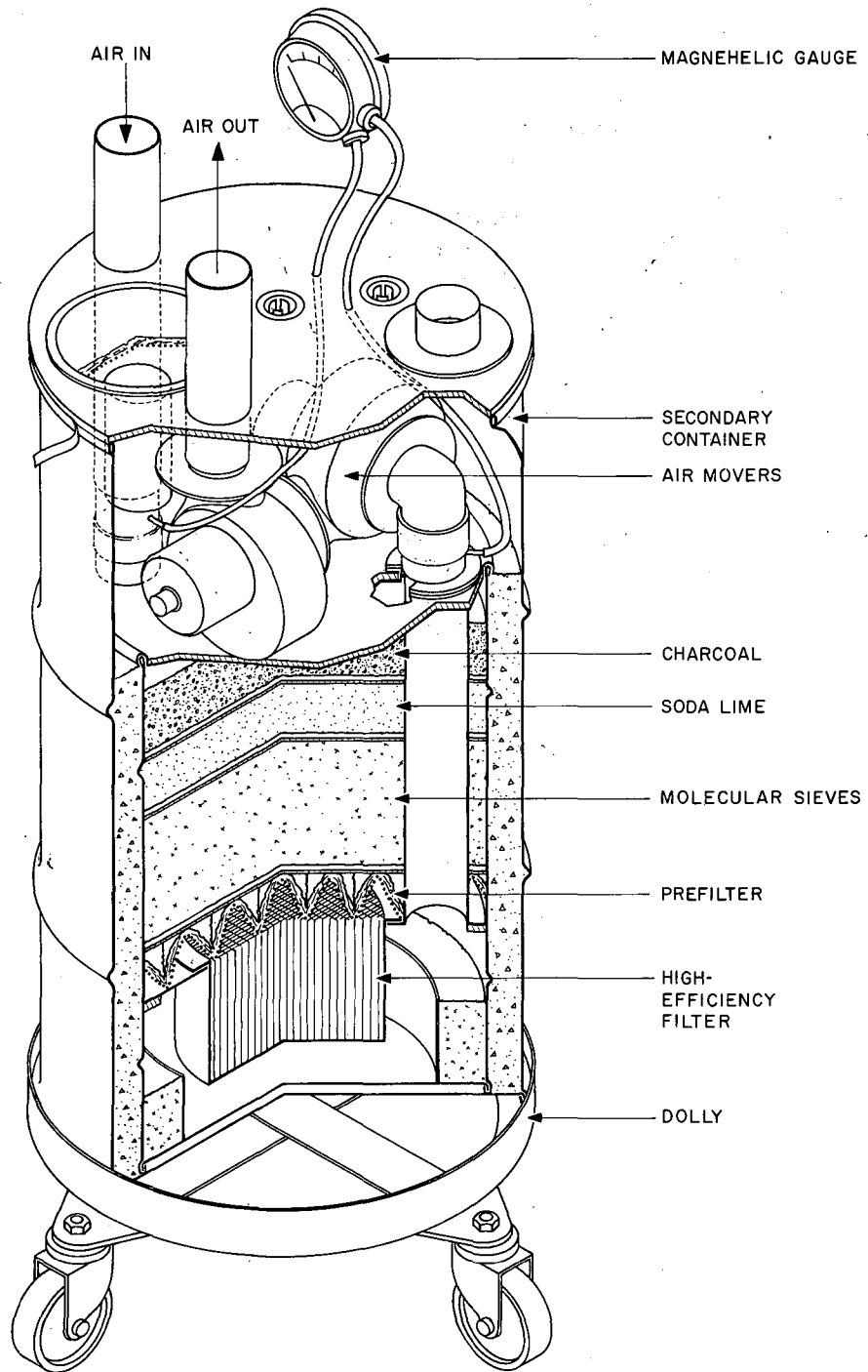
(c) The "Spencer" dry scrubber brought out the fact that chemistry in the cave boxes is now much more contained than previously. The "open-pot" chemistry is almost a thing of the past. "Air conditioning" the box, therefore, should be somewhat easier. The "Spencer" scrubber had many good features: it was small, compact, and easily disposed of. A new one could be readily used for each new program. With this unit, the box atmosphere remained at a low humidity as long as the molecular sieves were not expended. The main drawback of this unit was that the air recycling rate was very slight; any immediate smoke problem would overwhelm the pumping capacity of the unit. Also, smoke removal was dependent upon action by adsorption of the offending chemicals with the dry scrubber charge. With this slow recycling speed, this would call for almost 100% gas adsorption with each pass.

Our answer to developing a new scrubber was to incorporate the best features of the wet and dry type units. Our design criteria for the scrubber were that we wanted it to:

- (a) be fabricated from stock parts as much as possible,
- (b) eliminate close tolerances in design,
- (c) be compact,
- (d) be easily disposed of as active waste,
- (e) reduce maintenance to
- (f) be inexpensive enough to be used as a "one-shot" unit,
- (g) adsorb radioactive gases (I^{131}),
- (h) remove ammonium chloride smoke by filtration with deep beds,
- (i) adsorb water vapor,
- (j) adsorb acid vapors,

(k) have high recirculation rates; then, the "one-pass" efficiency of the scrubber for any offending substance could be low. With the high recirculation rates, the contaminant would pass through the unit many times. After enough passes, its concentration in the air stream should be drastically reduced.

Our dry scrubber is designed around a stock 15-gal drum. Two small high-static-suction variable-speed blowers in series are used as air movers. These are the type 6S Util-A-Set units, 5,000 rpm, manufactured by the ILG Electric Ventilating Company. The dry-charge consists of the following (from bottom of the can upwards) (see Fig. 1).



MUB-2018

Fig. 1. Cutaway drawing of dry-scrubber unit.

(a) A cylindrical high-efficiency filter is used for fine-particulate removal. This is the Mine Safety Appliances Company filter CU 85202 rated at 99.97% efficiency for 0.3- μ diam di-octylphthalate smoke at the rated air-flow of 50 cfm.

(b) A pleated PF 105 fiberglass prefilter is used for large-particulate removal.

(c) 20 pounds of molecular sieves, Linde Company, type 13X, are used for water vapor, ammonia, and miscellaneous gas removal.

(d) Nine pounds of soda lime are used for acid-vapor removal.

(e) Ten pounds of activated coconut charcoal are used for radioactive gas removal.

This 15-gal unit is encased by concrete in a 30-gal drum. The concrete acts as shielding; the larger drum acts as a secondary enclosure. The complete unit can be further contained within a 55-gal drum. This would be necessary to package the unit as radioactive waste for land burial. Should the penetrating radiation through the 55 gal drum be sufficiently high, lead-or concrete, or both, can be used to encase the unit.

LABORATORY TESTS

Our biggest concern in the concept of this scrubber unit was to make sure that ammonium chloride smoke would not rapidly plug up the high-efficiency filter. To evaluate this problem, we generated large quantities of smoke in an enclosure by mixing known quantities of concentrated ammonium hydroxide with concentrated hydrochloric acid. We recycled the smoke through the scrubber unit with a single air mover and noted the change in pressure drop.

In the first test, the pressure drop increased about two-fold at 15 cfm after we had mixed a total of 100 ml of ammonium hydroxide with 100 ml of hydrochloric acid. This result was encouraging since we believed that this amount of smoke would never be generated during a "hot" run.

We next subjected a new unit to a more severe test. We evaporated 100 ml of hydrochloric acid directly into the unit. This saturated it with hydrochloric acid vapors. We then exposed the unit overnight to smoke generated from vapors of 75 ml of ammonium hydroxide and 50 milliliters of hydrochloric acid. This slow generation of smoke should cause a more uniform plugging action.

Pressure drop versus air flow curves is shown on Fig. 2. Line (a) represents the initial condition of the unit. Line (b) represents the condition after the overnight exposure to smoke. We note a three-fold increase in pressure drop for a given air flow.

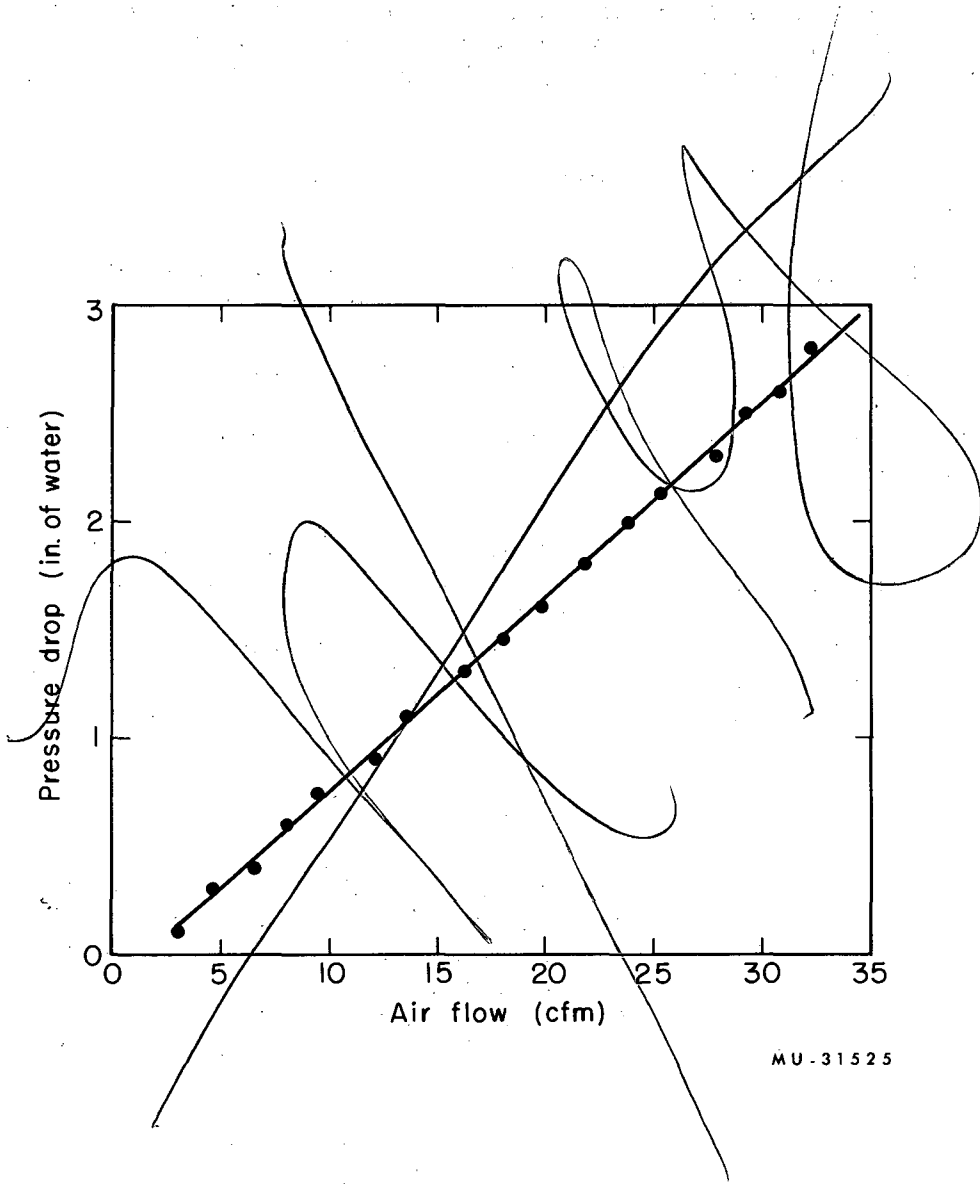
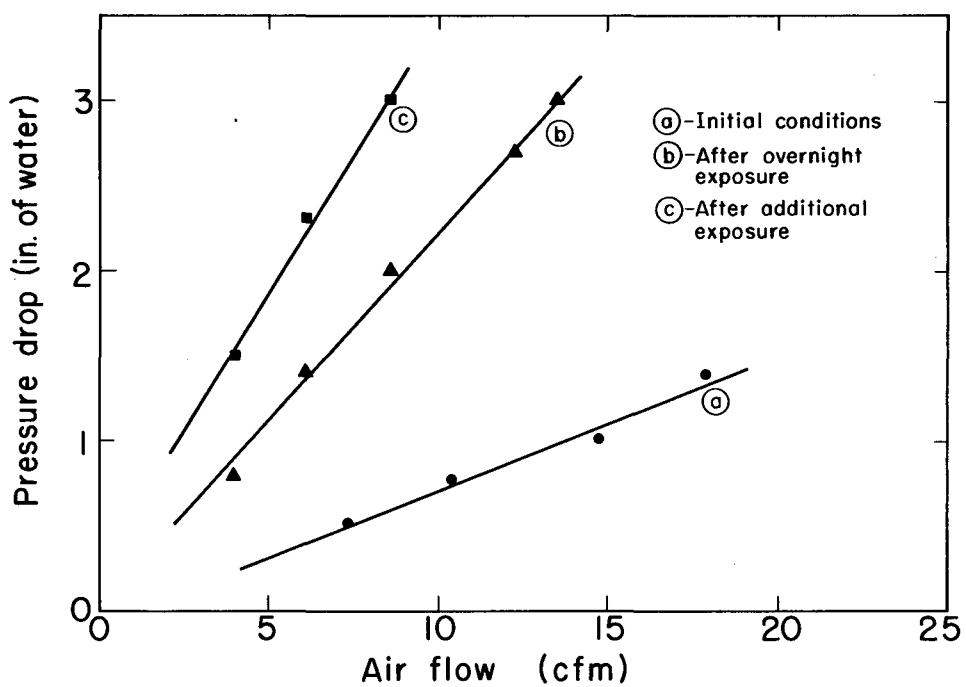


Fig. 2. Relation of pressure drop to air flow for scrubber when exposed to smokes and acid fumes.



MU-31526

Fig. 2. Relation of pressure drop to air flow for scrubber when exposed to smokes and acid fumes.

Line (c) represents the condition after an additional exposure to smoke from 75 ml of ammonium hydroxide and 75 ml of hydrochloric acid. The pressure drop has increased about five-fold.

Our conclusion after this series of tests was that the unit has a large capacity for smoke removal, and that under actual operating conditions it should not plug up. Nevertheless, we planned to install a standby unit during the "hot" run.

We next evaluated the water-adsorption capacity of the type 13X molecular sieves and found they adsorb about 24% of their own weight of water vapor. The total amount of water vapor that might be generated during a "hot" run is hard to predict. It arises from two sources: from the water vapor in the air which leaks into the enclosure, and from that generated from open reagent bottles, hot baths, evaporators, etc. Both sources are highly variable by their nature. If the enclosure is truly "low-leak" throughout the run, the amount of water vapor present from leakage air will be minimized. If the leak rate increases for any reason, the amount of water vapor will also increase.

We planned to use 20 lb of sieves in each scrubber unit. The water pickup, therefore, should be about five pints of water. We "guesstimated" that if the leak rate was less than 2 l/min the sieves should last approximately 40 days. Since each "hot" run was estimated to last only half this time, the sieves should have the capacity to pick up water from other sources. However, should the sieves become expended during the run, this would not seriously affect operations in the cave enclosure. We planned to use a refrigerated water condenser unit as part of the air recycling system. This in itself would aid in maintaining a low humidity in the enclosure. If necessary, we could always switch over to the standby scrubber unit.

Figure 3 shows the relation of the pressure drop to air flow of the assembled scrubber unit with both air movers connected in series. The maximum air flow was about 32 cfm.

FIELD TESTS

During a one-month period between February and March, 1963, capsule number UCRL-1B-145 was processed in the 4-ft water neutron facility. About 30 μg of Cf^{252} and about 60 mg Cm^{244} were recovered along with varying amounts of the other transcurium elements. Our first dry-scrubber unit was used as the primary "air conditioner" for the low-leak cave enclosure. Large volumes of ammonium chloride smoke were generated during the operation because ammonia gas was used rather than ammonium hydroxide in the chemical processing. During the periods of heavy smoke formation, we turned the air movers on the scrubber to high speed. The smoke cleared in a matter of minutes with a maximum air flow of about 20 cfm. The scrubber was used continuously throughout the run, and the differential pressure across the scrubber increased only a few tenths of an inch water gauge from its initial reading.

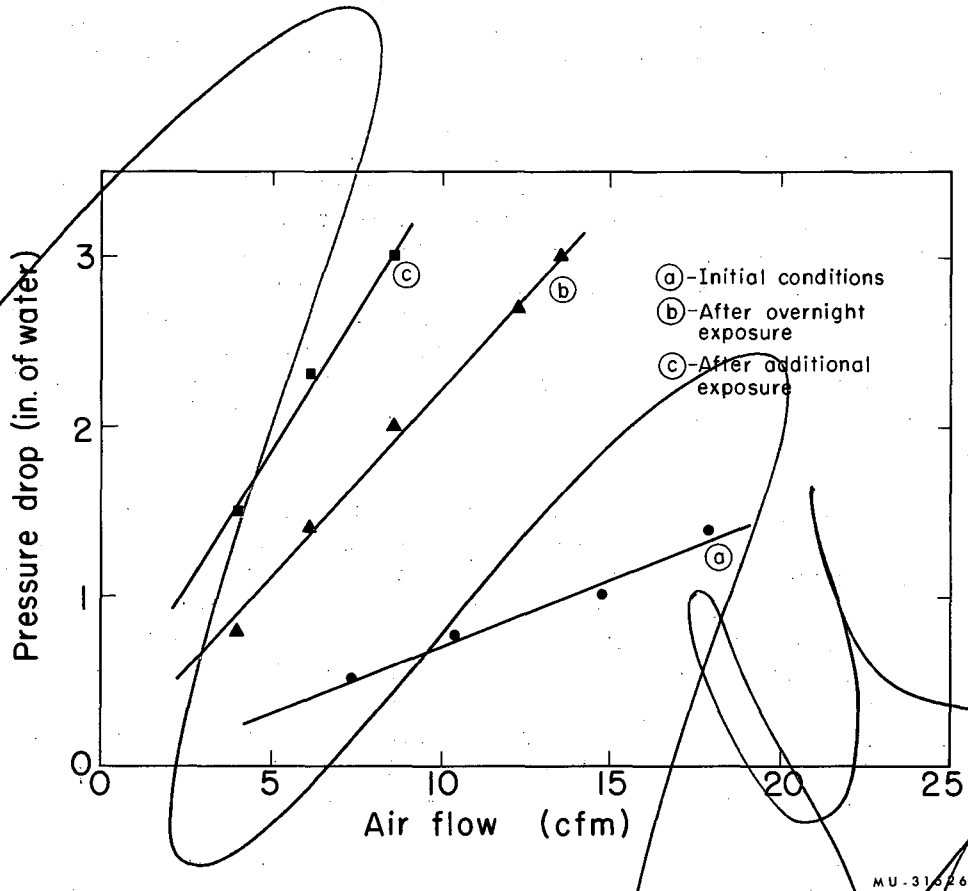
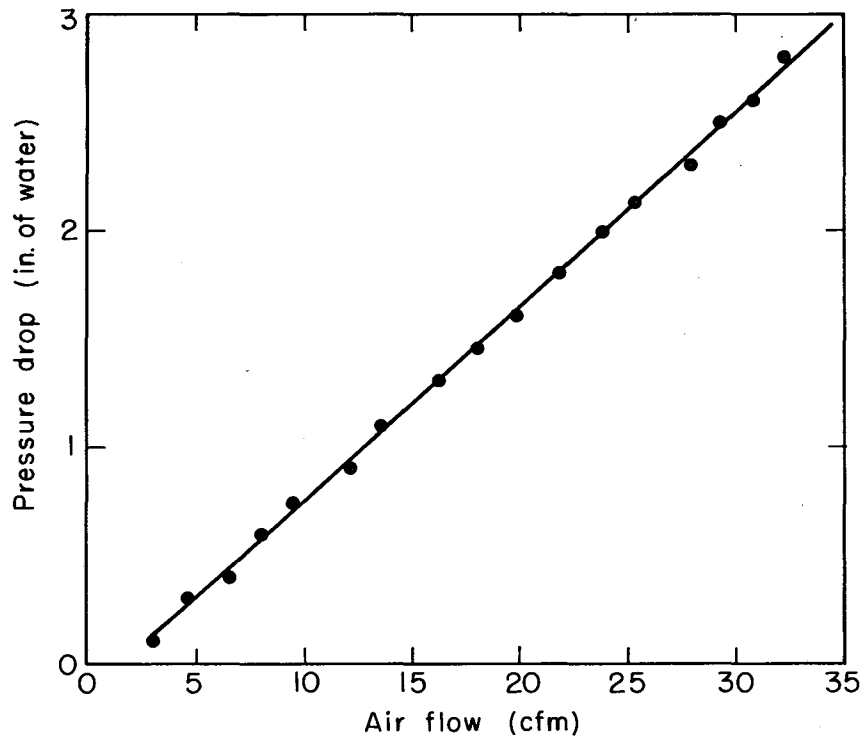


Fig. 3. Relation of pressure drop to air flow.

MU-31626



MU-31525

Fig. 3. Relation of pressure drop to air flow.

The molecular sieves, however, were expended during the latter half of the run. This was not detrimental to the cave operations, so the standby unit was not used. At the completion of the run, no corrosion was evident in the cave enclosure. The highest survey reading on the scrubber unit was 30 mr/hr of γ radiation through the concrete shielding.

In March, 1963, the curium and plutonium processed from the previous cave run were recapsuled for shipment back to the Materials Test Reactor. A low-leak shielded Berkeley Box was fabricated for the operation along with a dry scrubber. All ventilation aspects of this run were satisfactory.

In April, 1963, the Cf²⁵² separated from the February run was reprocessed for the separation of Es²⁵³. A low-leak cave enclosure along with a dry scrubber were utilized again in the 4-ft water neutron facility. Towards the latter part of the run, which lasted about a month, the sieves were expended. Again, we felt this was not detrimental to cave operations. The large refrigerated water condenser installed in the air recycling system maintained the enclosure's environment at a low humidity. Again no corrosion was noted in the enclosure's equipment, and the pressure drop across the scrubber changed very slightly. Survey readings on the scrubber were about 10 rem neutrons (1 rem equals about 7×10^3 n/cm²/sec).

During May and June, 1963, capsule number DOR-1-4 was removed from the Engineering Test Reactor and processed in the 4-ft water neutron facility. A low-leak enclosure and dry scrubber were used. About 1 g of Cm²⁴⁴ and small quantities of the transcurium elements were processed. Smoke formation was not as prominent on this run as during the February run. The molecular sieves again were expended early. At the completion of the run, the pressure drop across the scrubber had increased a few tenths of an inch water gauge, no corrosion was evident in the primary enclosure, and survey readings showed about 150 mr/hr of γ radiation through the shielding.

During July, 1963, the 6-ft water neutron facility was put into operation to process capsule number UCRL-29. This capsule originally contained 2.5 g of Am²⁴¹ and was bombarded at the MTR for 5 years. Over two grams of fission products were separated along with about 140 milligrams Cm²⁴⁴, 30 μ g Cf²⁵², and small amounts of the other transcurium elements. A low-leak enclosure and dry-scrubber unit were fabricated and used for the processing. The dry scrubber again performed a satisfactory "air conditioning" job even though the molecular sieves were expended early. Corrosion and smoke problems were reduced to a minimum. ~~At the end of the run,~~ Survey readings on the dry scrubber were about 250 mr/hr of γ radiation. Twenty-nine days after the end of the run.

EVALUATION

The dry scrubber has been used successfully for the past six months on cave runs and has proved itself workable, reliable, portable, and easily disposable. We have had no operating difficulties with the unit. The life of the molecular sieves for adsorbing water vapor has varied with each run. However, this is not detrimental since the large refrigerated water condenser in

the air recycling system maintains a low humidity within the enclosure.

The cost for each unit is estimated at \$350.00 for labor and materials. For the job it performs in the separation of the transcurium isotopes, we feel that this is a good investment. The units are economical enough to be used as "one-shot" installations.

ACKNOWLEDGMENTS

The authors acknowledge the administrative backing and moral support of P. W. Howe. We are indebted to J. T. Haley for field evaluations of the units.

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