0**UNITED STATES ATOMIC ENERGY COMMISSION****NYO-1525****HIGH EFFICIENCY COLLECTION OF RADIOACTIVE
DUST**

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HIGH EFFICIENCY COLLECTION OF RADIOACTIVE DUST

By Knowlton J. Caplan

The widespread handling of large amounts of radioactivity in recent years has created many problems in the field of dust control and dust collection. A considerable amount of research on filter media was conducted, under the cloak of secrecy, during the war years. This research, however, applied mainly to the category of materials known as air filters, rather than to the industrial dust collector. Most of the commercially available dust collectors fail to meet, in one respect or another, the very stringent requirements imposed by the collection of radioactive materials.

The purpose of this paper is to give the results of practical experience at one atomic energy installation, rather than to review the problems of the atomic energy industry as a whole.

REQUIREMENTS FOR DUST COLLECTORS

The requirements for dust collectors on radioactivity service are very stringent. One of the major items is high efficiency. The extremely low tolerance for amounts and concentrations of stack discharges, the valuable nature of the materials handled, and the fact that many such materials are "accountable" in the security sense combine to make the problem of efficiency indeed important. Fortuitously for purposes of generalization, it frequently happens that the more highly radioactive is the material handled, the less quantity (by weight) is handled. It may be said with a fair degree of safety that the required efficiency for most dust collectors on radioactivity duty is on the order of 99.99 per cent or better and is almost always higher than 99.9 per cent.

A second problem confronting the engineer is the question of maintenance. Low maintenance requirements are always desirable, of course, but when the collected material is radioactive, the question assumes added importance. The usual protection of personnel by shielding, remote operation, etc., does not apply very well to maintenance of the "hot" equipment itself unless full-remote operation and maintenance are used. Since full-remote installations are tremendous in cost, resort is frequently made to the practice of limiting the time which a worker may spend in a given area.

Maintenance work on or in a dust collector may well fall within this "restricted time" category. The maintenance man may need protection against dust and/or gas, as well as the time protection against external

radiation. When it is realized that the operation of changing the bags in a conventional cloth screen dust collector may expend the daily radiation tolerance of 20 or more men, the importance of low frequency, speed, and ease of maintenance is evident.

Also important is the factor of low holdup of material in the collector, since excessive amounts of material in the collector will increase the amount of radiation and reduce the allowable working time.

The third major problem arises from the fact that it is not permissible to throw away any appreciable amount of radioactivity, neither in the air, in the water, nor on the land. Thus even throwaway filters, if loaded with radioactive dust, would have to be burned in an incinerator in turn equipped with some fume-scrubbing device, or disposed in special burial grounds. This same factor often prohibits the use of wet collectors where they might otherwise be applicable, because the contaminated water effluent would require further chemical treatment to a rather complete degree in order to avoid stream pollution.

It would appear that the radioactivity of the dust in itself has little or no effect on the collection and filtration mechanism per se, at least with materials of rather low specific activity.

METHODS OF TEST

In field application, the absolute amount of material discharged from a ventilation stack is the item of primary interest, for both atmospheric pollution and material accountability reasons. Most of the effort expended in the testing of collectors is therefore devoted to the measurement of the contaminant concentration in the discharge stack.

Many papers have been written developing the theory of sampling high-velocity gas streams for particulate matter.^{1,2,3,4,5,6,7,8} The main conclusions of these researches and discussions are that the sample should be extracted from the duct through a sharp-edged nozzle pointing upstream and that the sampling velocity should match the duct velocity. Accordingly, an isokinetic sampling head was developed, in which the filter medium was incorporated in the head itself, in order to minimize any losses in sample because of small dust particles adhering to the interior of the sample tube. A drawing of the sampling head itself is shown in Fig. 1.

The head is mounted on the end of a 3/8-in. OD brass tube shaped like a Pitot tube. A 3-in. capped pipe nipple (close nipple) welded to the stack at a suitable location provides a satisfactory sample port through which this head may be inserted.

A metered volume of air is drawn through the sampler by a small air pump. The volume rate of the sample is adjusted so that the velocity at the sample nozzle will be substantially equal to the duct velocity as determined by Pitot-tube traverse. A set of four or five interchangeable nozzles with various internal diameters, plus a possible variation in sampling rate between 0.2 and 1.0 cfm, enables a wide range of duct velocities to be covered.

Since collectors on this duty are usually provided with stacks tall enough to get above the roof lines in the vicinity, it is no problem to find a suitable sampling location in a section of straight duct 7.5 diameters or more downstream from the nearest elbow or other obstruction.

The filter medium commonly used is a 1 1/8-in. diameter Whatman No. 41 paper. The amount of material collected is determined either by suitable counting techniques described in the literature or by chemical analysis.^{9,10,11}

In spite of the fairly voluminous literature describing the proper techniques for duct sampling, it is with surprising frequency that one encounters reports of such tests made with standard industrial hygiene equipment originally designed for taking samples of room air. The magnitude of the errors introduced by the use of such unsuitable techniques may be considerable and theoretically would be influenced by the velocity of the air stream, the size and shape of the particulate matter being sampled, and the configuration of the sampling head being used. Accordingly a few tests have been made here in order to demonstrate the presence of such errors. The results are shown in Table 1.

Table 1--Comparison of Isokinetic vs. "Regular" Samples

Test No.	Type of Sampling Head			Duct velocity, fpm
	Isokinetic	Regular	Ratio, isokinetic/regular	
1 (10 samples)	1.08	0.607	1.78	1400
2 (5 samples)	9.18	1.09	8.40	2900

The samples shown in the column headed "Regular" were taken with a head usually used for taking samples of room air. The sample head is essentially the same as the rear portion of the isokinetic head previously shown, except that it has a face opening of 1-in. ID, rather than a restricted nozzle. Air velocities at the face of the sample opening are usually on the order of 100 fpm. For these tests, the regular sample head was held at the same location as the isokinetic head, but at right angles to the direction of the air stream. Errors of a similar type will be introduced with other types of standard industrial hygiene equipment, such as the electrostatic precipitator or the Greenburgh-Smith impinger.

In the data reported later concerning efficiency of dust collectors, no attempt was made to sample the "dirty" side of the collector, because adequate sampling equipment was not available and for other technicological reasons. The equipment previously described is not adequate for sampling streams containing large amounts of dust, primarily because the filter plugs too rapidly. Efficiency calculations were made on a weight basis by the following procedure.

1. The effluent stream was sampled continuously for a period of several hours or more to integrate changes caused by variation in dust load on the system.
2. The amount of material collected by the dust collector during the test period was weighed.
3. The percentage of material passing the dust collector was calculated. Efficiency calculations were made by subtracting the per cent passed from 100.

EXPERIENCE WITH DUST COLLECTORS

Of the commercially available dust collectors, one type which meets the requirements outlined above in a fairly satisfactory manner is based on the Hersey principle of reverse-jet cleaning. This type of collector has an efficiency as high as, if not higher than, the conventional cloth bag or cloth screen collector, and it avoids the puff of dust commonly experienced after rapping or shaking the conventional cloth screen or bag. Pressure drop through the collector is relatively constant and therefore tends toward better over-all operation of the exhaust system. Bag changing is more rapid, and mechanical maintenance is relatively simple. Material holdup, in terms of amount of material on the bags, is less, primarily because of the smaller area of bag surface. If this type of collector can be operated at an air-to-bag ratio of 20 cfm/sq ft (as it can on most dusts), it is more economical of floor space than the conventional bag collector.

The typical construction of collectors of this type is illustrated in Fig. 2.

Although the illustration shows a single-bag unit, the assembly may be built of multiple bags. Bag diameters range from 8 to 36 in. In the type shown here, the inside of the bag is the dirty side, the dust-laden air entering at the top of the collector. The blow ring around the outside of the bag travels up and down, guided by guide shoes running on vertical rails. Another model provides a freely suspended blow ring, suspended from the chains alone, the drive being actuated by a reversing motor to enable change in direction of travel. The latter model seems to be more free of mechanical difficulties.

The blow ring is supplied with air at about 2 to 3 psig, which is discharged through a narrow slot on the internal periphery of the ring, against and through the bag. This reverse jet of air blows dust out of and off the interior of the bag, resulting in a constant cleaning action. The fact that the internal diameter of the ring is slightly less than the diameter of the bag also creates a small flexing motion in the bag, aiding in the removal of caked or flocculated dust. Figure 3 will aid in the understanding of this arrangement.

Experience to date has failed to reveal any satisfactory filter media for this type of collector other than a true wool felt. This phenomenon is explained on the basis that woven materials exert their filtering action by first gradually bridging over the space between the

fibers with a "filter cake" of the dust being collected; the collected material itself is the true filter. The action of the reverse-jet cleaning air is to continually destroy these bridges between the fibers, and the woven-filter media continually leaks dust. With the wool felt, on the other hand, dust particles evidently permanently lodge in the larger interstices, and once the media is "primed," the action of the blow ring establishes an equilibrium condition which makes for constant pressure drop and filtration efficiency.

Some of the most important of the operational characteristics of this dust collector are shown in the following curves. Since it is a well recognized fact that the operation of any collector is highly dependent upon the nature of the dust collected, this data should not be interpreted in quantitative terms where other dusts are involved. The characteristics shown here, however, are fairly typical for most of the applications of this filter within the author's experience.

One of the most important characteristics is shown in Fig. 4. The dust handled in this case was electrically fused dolomite, showing the particle-size analysis indicated. It will be noted that more than 24 hr of running time was required to establish an equilibrium condition of the felt. In some instances, the time required to reach final equilibrium was as long as 250 hr. The leakage of dust through the collector may be considerable until the equilibrium conditions are reached.

Figure 5 illustrates a typical variation of bag pressure drop with dust loading. The interesting feature is that the curve appears to become asymptotic in nature at extremely high loadings. This phenomenon is probably due to two factors: (a) the dust tends to flocculate in the air at the higher concentrations, and (b) the thicker (and more flocculated) layer of dust on the inside of the bag makes the cleaning action of the blow ring relatively more effective.

Figure 6 illustrates the variation of pressure drop through the bag with the air velocity. The curve is typical of dusts which seem to cake or flocculate; dry, noncaking dusts give more of a straight-line relationship.

Actual efficiency tests of various collectors are shown in Table 2. Unfortunately, detailed information on particle-size distribution of these dusts cannot be presented at this time, but all these materials are of the nature of fine industrial dusts, having a large fraction in the range of hygienic significance in the small micron sizes.

It will be of interest to point out that collector no. 1 was replaced by collector no. 2 on the same duty. The volume handled by the dust control system was more than doubled, with an increased use of floor space for the dust collector of about 50 per cent. The changing of bags on unit no. 1 expended the daily radiation tolerance of 20 men, while the same job may be done by two men on collector no. 2.

Collector no. 4 is used as a final cleaner on a pneumatic conveyor system and represents the highest effluent concentration from this type of collector in the author's experience. The high discharge concentration is possibly caused by the frequent excessive bag pressures of 10 in. w.g., with subsequent distortion and straining of the felt fibers, in combination

with the high grain loading. It will be noted that unit no. 2 has a lower effluent concentration, even though the dust loading and filter ratios are both higher.

Collector no. 5 is shown merely for purposes of comparison. This filter consists of a heavy housing supporting a porous carbon cylinder with 3/4-in. walls. The maximum pore size of the carbon is stated to be 5 μ . This collector is used only in very small sizes on small process gas streams and would be extremely difficult to use as a dust collector in the usual industrial sense. The data are presented merely for comparison purposes as a nearly "perfect" filter.

SUMMARY

The nature of the problem of radioactive dust collection has been reviewed. The objects of prime importance are high efficiency, low (and easy) maintenance, and small amounts of waste which might require special disposal.

Methods of test using the isokinetic principle have been described. Data have been presented showing errors involved when conventional room air sampling equipment is used.

The method of operation and some of the operating characteristics of the Hersey reverse-jet filter have been described and compared to other types of collectors in terms of applicability to radioactivity service.

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REFERENCES

1. American Society of Mechanical Engineers, Power Test Code 21, "Test Code for Dust Separating Apparatus" (1941).
2. Andersen, E., The Determination of Industrial Gas Dispersoids, Trans. Am. Inst. Chem. Engrs., 34: 589 (1938).
3. Bubar, H. H., "Dust Problems" (1946).
4. Bubar, H. H., Relative Merits of Large and Small Sampling Nozzles for Dust Determinations, Combustion, 13: 39 (1942).
5. C. E. Lapple and C. B. Shepherd, Calculation of Particle Trajectories, Ind. Eng. Chem., 32: 605 (1940).
6. C. E. Lapple, Mist and Dust Collection, Heating, Piping and Air Conditioning, 17: 587 (1944).
7. P. H. Hardie, Résumé of Methods for Measuring Flue Dust, Trans. Am. Soc. Mech. Engrs. (1937).
8. Western Precipitation Corporation, "Methods for Determination of Velocity, Volume, Dust and Mist Content of Gases," Bulletin WP50 (1936).

9. H. Carmichael and P. R. Tunnicliffe, Measurement of Alpha-Active Dust in the Atmosphere, J. Ind. Hyg. Toxicol., 30: 211 (1948).
10. G. Koval, "Determination of Particulate Air-borne Long Lived Activity," MDDC-1503, U. S. Atomic Energy Commission (1945).
11. A. H. Jaffey et al., "A Manual on the Measurement of Radioactivity," MDDC-388, U. S. Atomic Energy Commission (1946).

Table 2

Type collector	Air-to-bag ratio, cfm/sq ft	Bag pressure, in. w.g.	Loading, grains/cu ft	Effluent, grains/1000 cu ft	Efficiency, %
1. Conventional cloth screen collector*	1.67	5.5	1.0	0.480	99.952
2. Reverse-jet felt, same dust as no. 1	27.7	6.5	32.4	0.411	99.998
3. Reverse-jet felt	21.4	3.5	0.07	0.0378	99.946
4. Reverse-jet felt (pneumatic conveyor after-cleaner)	15.9	4 - 10	14.0	1.08	99.992
5. Porous carbon, 3/4 in. thick	10.8	6 - 12	8.6	0.0468	99.9995

*The bags were well loaded and not rapped during the period of test.

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Fig. 1--Cross section of isokinetic sample head.

Fig. 2--One type of Hersey reverse-jet filter.
Courtesy of Pulverizing Machinery Co.

Fig. 3--Cross section showing blow-ring contact with bag.

Fig. 5--Pressure drop vs. grain loading.

Fig. 6--Pressure drop vs. air flow.

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