A SIMPLE DEVICE FOR GRAVIMETRIC SAMPLING

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In view of the increased importance attached to the gravimetric sampling of airborne dust in mines and other working places, it was recently decided to start regular gravimetric sampling in the experimental animal dusting rooms in this Unit. As no suitable sampling instrument was available, a Hexhlet dust sampler was modified by fitting it with a probe in place of the elutriator. This instrument has also been used to collect samples of airborne particulate matter from within chimney stacks and exhaust ducts and also unelutriated samples of dust from the air in working places.

When it was decided to start regular gravimetric dust sampling in the experimental animal dusting rooms of this Unit (Webster, 1954), the first decision to be made was what instrument should be used. The instrument had to have the following features. First, it had to be able to withdraw a volume of several cubic metres of air with a dust concentration of about 50 mg./m.\(^3\) from inside the dust rooms, each of which has a volume of approximately 1,000 cu. ft. (28-3m.\(^3\)), with as little disturbance to the ambient dust concentration as possible. Secondly, it had to operate from outside the rooms through a small port in the door, as once dusting has started it is not convenient to enter the rooms to take samples. Thirdly, the instrument had to be light and portable enough to be handled by a young girl operator and still be capable of taking several samples a day. As the samples are required for controlling the dust concentrations in important animal experiments, it was further desirable that their evaluation should be simple and rapid in order that any irregularities could be corrected with the minimum delay. Finally, it was very desirable that the instrument should be able to run unattended for periods of an hour or more at a constant rate, or have some other means of automatically recording the volume of air it had sampled. This would allow the operator to evaluate a sample while the instrument is taking the next one.

Several types of instrument were considered, but none had all the desirable features enumerated above. It was therefore decided to adapt and develop the well-known Hexhlet sampler (Wright, 1954), especially as a compressed air system was already installed to operate the dust dispersal system of the rooms. This instrument has the attributes of a high, regulated sampling rate, lightness, and the ability to run unattended, and it is, moreover, commercially available. Furthermore, it is a well-tried instrument with which the author is thoroughly familiar under a wide range of conditions.

Basically, the new instrument is a normal Hexhlet with the elutriator removed and replaced by a special probe. A standard 2-in. (5-08 cm.) pipe coupling is welded concentrically to the probe, and this permits the instrument to be screwed on to a short stub of 2-in. (5-08 cm.) pipe attached to the outside of the room or other place to be sampled (Figs. 1 and 2). The resulting connexion is simple and eminently practical and holds the instrument firmly while such operations as filter changing take place.

The probe is made of brass pipe, 1 in. (2-5 cm.) internal diameter, polished inside and out (Fig. 1). For convenience of carrying and cleaning and to allow adjustment for special purposes (vide infra), it is made in two pieces which are joined by a coupling. This joint and the connexion to the body of the instrument are made air-tight by suitable rubber washers. In order to reduce losses in the probe to a minimum, it has a simple entry fairing (Fig. 3), which brings the air in and accelerates it smoothly down the pipe. Because of the high sampling rate (100 litres/min.), the air velocity down the probe is also fairly high, viz. about 700 ft./min. This means that the average time that any particle is in the probe is less than one-fifth of a second, and consequently losses due to settling are very low. When sampling in the open, only half the probe need be used and
The losses are still further reduced. As a precaution against dust retention due to condensation of moisture and the natural tendency of dust to migrate to a cold surface, the probe is, where possible, warmed well above the atmospheric temperature before use.

The normal filter used in this type of work is the Soxhlet thimble. It has the advantage that it is self-supporting and may be used several times before it becomes clogged. Because of the humidity of the air sampled and the hygroscopic nature of the thimble itself, it has to be dried and weighed before and after use, following a standard procedure. The standard procedure adopted in this laboratory is to dry the thimbles at 110°C. for 10 minutes and allow them to cool in a desiccator filled with silica gel for 10 minutes. The actual weighing is carried out on an enclosed balance maintained at a constant low humidity by trays of silica gel. The weight taken is that recorded exactly 60 seconds after removal from the desiccator.

A natural extension to the use of this instrument has been the gravimetric sampling of industrial atmospheres where fumes and fine dust are present. In this case, depending on the concentration of the particulate matter, it may be necessary to reduce the length of the thimble (Balashov, Brading, and Rendall, 1961) or replace it altogether by a flat disc of Esparto or other similar air-filtering paper held in a special holder (Roach, personal communication, 1961). The prime consideration is to reduce the ratio of the weight of the filter medium to the amount of dust collected. For particularly accurate work, especially where subsequent composition analysis is involved, Millipore ashless filter papers may be used.

A still further field of application is the sampling of ventilation ducts and chimney stacks, where extreme accuracy is not required. In these cases, the instrument is screwed directly on to a stub of 2-in. (5.08 cm.) pipe welded to the duct or the outside casing of the stack (Fig. 4). If the particulate concentration is likely to be high, as it often is in stacks, it may be preferable to use a lower sampling rate (50 litres/min.). This is readily achieved by changing the critical orifice of the Hexhlet.

When sampling in ducts and other places where the air velocity must be taken into account, i.e., where it is in excess of about 500 ft./min., the entry
fairing on the probe must be removed and replaced by a restrictive orifice. These restrictive orifices are designed to increase the velocity of entry into the probe to match the velocity of the airflow outside. In this way isokinetic conditions of sampling are maintained to a reasonable degree. The diameters of the orifice may be calculated to give any required entry velocity, but a convenient set has nominal velocities of 1,000, 2,000, and 4,000 ft./min. (Fig. 1). The orifices are held in the probe by small set screws to avoid having to cut deep screw threads, which would disturb the air flow into the probe when it is used fully open.

For the type of work and particle size for which the instrument is intended, the orifices may be used at \( \pm 30\% \) of their normal velocities without introducing too serious sampling errors (Davies, 1954; Withers, 1946). This allows the set described above to cover the range of velocities of 700 to 5,200 ft./min. The range below 700 ft./min. is covered by using the probe without a restrictive orifice.

To permit sampling in stacks and other places, where it is not possible to align the instrument directly into the airflow, a port has been cut in the side of the probe. In order to adjust the direction of the port in relation to the direction of the airflow, a lock nut has been included in the coupling on the probe. The side port will accept the restrictive orifices in the same way as the end of the probe, but when it is in use the normal air entry must be closed by means of a plug. In the same way, the right angle port must be plugged when the normal point of entry is used. Losses in the probe are increased when the side port is used, mainly due to impingement of particles on the side of the tube opposite the port. However, the small amount of dust collecting here can generally be removed by a small paint brush and added to the bulk of the dust in the filter.

Although the probe described was designed specifically for taking samples from static air, it is clear that probes designed for other purposes could equally well be fitted to the instrument. In all cases, however, advantage can be taken of the fact that the instrument measures the volume of air sampled before it passes through the filter and not after, as in the more conventional sampling probes. Thus, the effects of resistance due to the build-up of dust on the filter can be ignored for a longer time. This in turn means that filter resistance can be allowed to build up to a far higher level than usual and a heavier sample can be obtained on the filter paper.

References
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