N. AEROSOL SAMPLING: MINIMIZING PARTICLE LOSS FROM CASSETTE BYPASS LEAKAGE

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Adapted from Baron [1]

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## 1. INTRODUCTION

The plastic two- and three-piece cassettes commonly used for collection of personal samples of airborne dust in the Americas are prone to bypass leakage if the cassettes are not properly assembled. A cross sectional view of these cassettes is given in Figure 1 [2]. If the pressure used to put the cassettes together is insufficient, or not properly applied, the base and mating piece may not make a proper seal with the filter, permitting sampled aerosol to leak around the filter as illustrated in Figure 2 [2]. Leakage around the filter will result in a loss of dust that should have been collected on the filter, resulting in a measurement that underestimates the concentration of the aerosol sampled. Anecdotal indications of this bypass leakage have cropped up from time to time, indicating that bypass leakage continues to be a problem when these cassettes are improperly assembled.

Van den Heever, in an investigation of the leakage problem, presented data on cassettes using a pressure drop measurement to indicate leakage [3]. The average pressure drop for a specific cassette/filter combination was measured for a number of “good” cassettes and then any decrease in pressure drop observed for assembled cassettes was attributed to bypass leakage. The decrease in pressure drop correlated well with reduced sample collection. Establishment of this baseline pressure drop when only assembling a few cassettes was cumbersome and a more direct measure of leakage was needed. A nylon cassette designed to replace the 37-mm cassette for the South African market was shown to have reduced likelihood of leakage; the nylon cassette had a rubber seal for the filter edge and a base that screwed to the cap.

Recently, Baron and coworkers developed and evaluated a leak test using ambient aerosol to assess bypass leakage [1, 2, 4]. The test, performed with an optical particle counter or a condensation particle counter, enabled the aerosol concentration upstream and downstream of a cassette to be measured. The specific procedure was as follows:

a. Using the optical or condensation particle counter, measure the ambient particle number concentration at the test location for a fixed time period (1-2 min). The particle counter should be capable of detecting submicrometer particles.

b. Attach cassette to be tested to inlet of the particle counter and make a second concentration measurement. Keep connections to minimum volume and leak free.

c. If the percent downstream concentration relative to ambient concentration is >1%, the cassette is poorly sealed. A value of <0.2% can routinely be achieved with a good assembly technique. The only exception appears to be for fibrous (e.g., glass, ceramic) filters without binder. The leak test still works in that a leak is detected, but fibers released from the filter cause overestimation (as much as 20-fold) of the leak rate.

The approximate cost required to setup the pressure drop leak test system is about $500 (the cost of the micromanometer), while the cost to setup the optical or particle count systems is >$1900. Although particle count systems are more expensive, they require less initial setup time and can be used for other industrial hygiene purposes, e.g., environmental monitoring and respirator fit testing (PortaCount, TSI, Inc. St. Paul, MN).

The particle leak test does not provide a direct measure of the airflow through the leak because particles contained in the sampled aerosol can be collected on the edge of the filter, on the cassette walls, or on the backup pad as illustrated in Figure 2. The particles lost from the filter can bounce or be re-entrained from the filter surface or they can stick if the particles are liquid. Therefore it is difficult to use the leak test results to predict the amount of material lost during sampling with a leaking cassette. Under a worst case scenario, the loss from the filter can be about 4 times the percent leakage by the particle count leak test. Thus, with a 1% measured leak rate, about 4% of larger (> 2 µm) solid particles can be lost in or through the leak.

Filters normally used for industrial hygiene sampling are efficient enough to collect particles from the sampled air with very high efficiency (>99.9%) [1]. Any particles detected downstream are assumed to be from leakage. The test will not work if low efficiency filters or polycarbonate straight-pore (Nuclepore) filters are used, because these will allow some particles to pass directly through the filter. Glass or ceramic fiber filters without binder will release fibers inside the leak and result in an overestimate of the leak size. With relatively large leaks using these fiber filters, the downstream concentration can be larger than the upstream concentration.

Assembly of press-fit cassettes should be performed using a press. This allows an even, selected, and repeatable pressure to be applied across the surface of the cassette. Too high a pressure will cut the filter or crack the cassette, while too low a pressure will result in a bypass leak around the filter. Approximately 70 lbs pressure was found to produce a good seal in 25-mm acrylic-copolymer cassettes [2], but optimum pressure must be established for each cassette/filter/backup pad combination. A pneumatic press designed for cassette-closing (APCSCLSR-2, about $2200, Omega Specialty, Chelmsford MA) has been used successfully for this purpose, though other pneumatic or hydraulic presses can also be used.

Tests of several manufacturer’s pre-assembled cassettes indicated these are well-sealed. However, hand assembly of cassettes and even press-assembled cassettes of unusual combinations of filters and backup pads produced high rates of leakage [1]. In these cases, a quality control process including leak testing should be implemented to ensure proper cassette assembly.

The appropriate sample size for testing batches of items are described in MIL-STD-105E [5]. If leak test is treated as a pass/fail test of cassette quality, tables are available to determine the sample size necessary to achieve an acceptable failure rate for an entire batch. For example, to achieve a one percent "average outgoing quality" (average failure rate of one percent) for a batch of 51 to 90 cassettes, a sample of 13 should be tested and produce no failures. If one or more of the 13 cassettes fail, the entire batch of cassettes must be tested or the batch discarded.

The leak test results in a small quantity of background aerosol (typically from less than 3 L of air) being collected on the filter. Field blanks should also be leak tested in the same manner to correct for this small amount of background material.

The particle count leak test should be performed prior to sampling. It was found that soot particles can clog the leak and prevent detection of particles downstream even though loss of material from the filter occurred during sampling. Thus, a negative leak test after sampling is not a guarantee that leakage did not occur. Another approach sometimes used to check for leakage after sampling is to observe the sealing area at the edge of the filter for improper compression or for particle deposits. These post-sampling tests can indicate when samples should be rejected, but are not generally recommended because they are subject to false negative results.

## 2. FIGURES

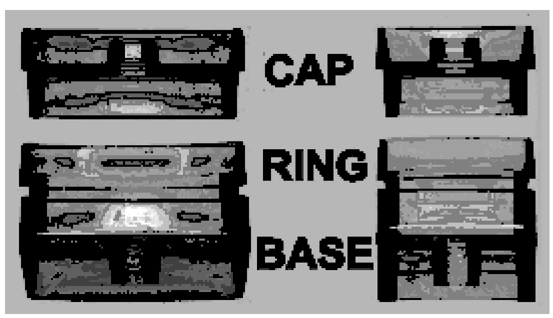


Figure 1. Picture of a 37-mm and a 25-mm cassette cut in half. The cut cassette surfaces are colored black for easier visualization. Bypass leakage can occur around the filter edge where the seal is formed [2].

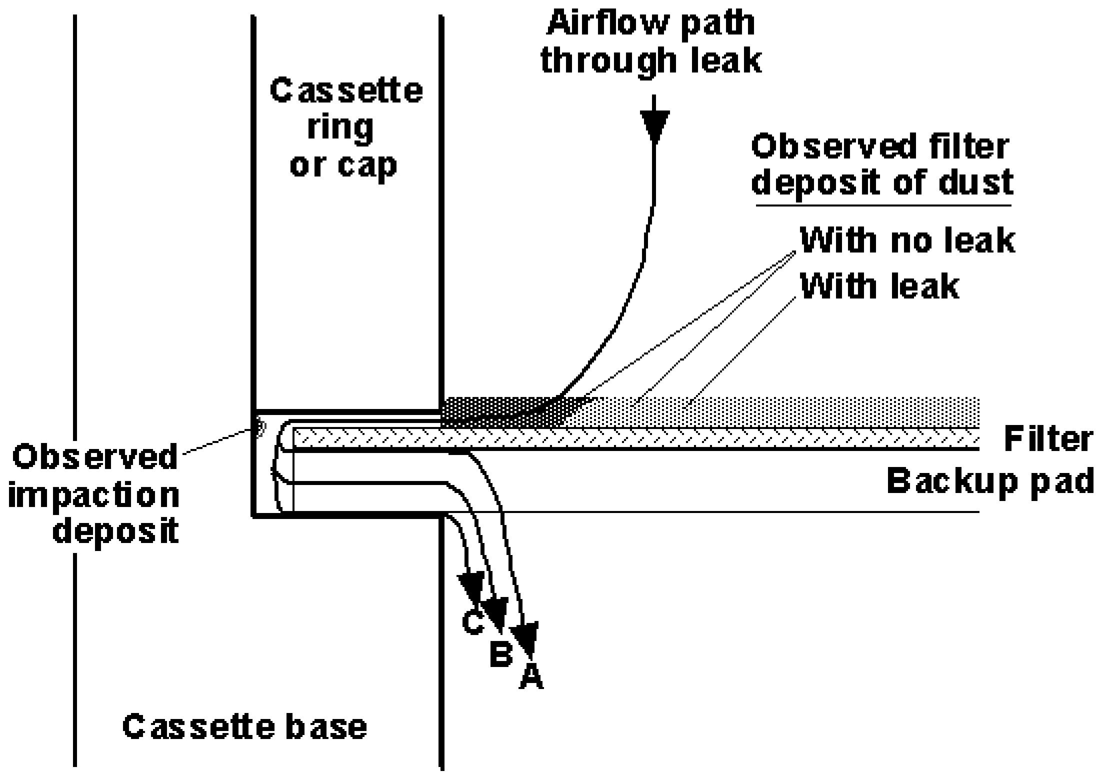


Figure 2. Schematic of filter seal region showing paths of airflow through leak. When a leak is present, the observed dust deposit indicates loss of material near edge of filter. Some of this lost material is found deposited on the cassette wall. The flow path through or around the backup pad appears to take some combination of Paths A, B, and C [2].

3. REFERENCES


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