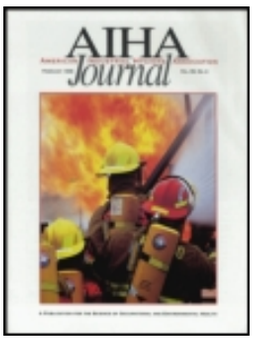

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Field Testing of New Aerosol Sampling Method With a Porous Curved Surface as Inlet

AUTHORS
Brian C. Hauck[a]
Sergey A. Grinshpun[a]*
Auvo Reponen[a,b]
Tiina Reponen[a,c]
Klaus Willeke[a]
Robert L. Bornschein[a]

[a]Department of Environmental Health, University of Cincinnati, P.O. Box 670056, Cincinnati, OH 45267-0056, sergey.grinshpun@uc.edu;
[b]On leave from National Public Health Institute, Kuopio, Finland;
[c] On leave from Kuopio Regional Institute of Occupational Health, Kuopio, Finland

A new aerosol sampling method, utilizing a porous curved surface as the sampling inlet, has recently been developed. Previous laboratory evaluations of this method have demonstrated its important features, such as low wind sensitivity and good filter collection uniformity. In this study a prototype incorporating the new method was evaluated in the field as a stationary and personal sampling device. The small sampler, utilizing a 25-mm filter is called the button aerosol sampler and was evaluated for collecting total airborne dust and fungal spores. The study was performed in nine poorly maintained inner-city houses during environmental cleanups at different cleanliness levels. The button sampler was used in parallel with the standard 37-mm closed-face filter cassette. Four collocated samplers of each type were tested at all sites as stationary samplers, and three samplers of each type were tested at two sites as personal samplers. Aerosol samples were collected on filters and analyzed using the gravimetric method for total dust and epifluorescence microscopy for fungal spores. The average particle concentration values measured with the button sampler and with the standard sampling cassette were found to correlate well within ranges of 10^1–10^3 μg/m^3 for total dust and 10^3–10^5 spores/m^3 for airborne fungi. The measurement results obtained with the new button sampler showed lower intersample variations of the measured concentration levels and higher uniformity of the particle deposits on the filters than those obtained with the standard cassette.

Keywords: aerosol, dust, fungi, inlet, sampling

Exposure of workers and dwelling residents to airborne particulates may increase morbidity.[1] Fungal spores are frequently an important component of the total particulate load. Exposure to fungi may cause both allergic diseases and nonallergic health effects and is associated with asthma, chronic bronchitis, allergic alveolitis, and respiratory symptoms.[2–4] Because of the potential health effects the accurate measurement of dust and its biological components is of great importance.

The sampling efficiencies of available stationary and personal aerosol samplers (e.g., the 37-mm standard filter cassette) are known to be highly wind sensitive.[5–7] Some available samplers are also known for significant nonuniformity and high variability of the particulate deposits on their filters, caused by air turbulence and wind currents in the sampled environment.[7,8] A new aerosol sampling method, utilizing a porous curved surface inlet, has been developed by the authors to overcome these deficiencies.[6] In laboratory studies it has been shown to provide uniform particle deposition on filters and low sensitivity to variations in wind direction and magnitude.[6] The small sampler utilized with this method has been named the button aerosol sampler.

In this study the button sampler has been field

*Author to whom correspondence should be addressed.
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tested side by side with the 37-mm closed-face filter cassette (henceforth referred to as the standard cassette) in indoor air environments contaminated with total dust and fungal spores generated from cleanup operations. The cleanups were performed in a poorly maintained inner-city housing area of Cincinnati, Ohio, during an ongoing environmental study. Stationary and personal aerosol sampling phases were incorporated into this field study to evaluate the performance of the new aerosol sampler in both sampling situations.

MATERIALS AND METHODS

Button Sampler

The prototype of the new button sampler is shown schematically in Figure 1. The inlet is formed from a portion of a spherical shell with numerous, identical, evenly spaced holes that act as sampling orifices. A 25-mm filter is placed directly behind the inlet to avoid transmission losses in the sampler before the particles reach the collector. The uniform distribution of the orifices on the curved inlet surface results in uniform distribution of the sampled particles on the filter surface. The parameters considered for the sampler prototype design were the filter diameter, subtended angle of the spherical shell, porosity of the spherical surface, hole size, and sampling flow rate. The air velocity through the orifices of the curved inlet surface is high enough to create sufficient pressure drop for even air- and particle flow distributions. The orifice hole size and porosity have to be selected depending on the particle size of interest.[6] The wind tunnel evaluation of the first prototype of the button sampler (hole size = 254 μm, porosity = 19%) has shown that its aspiration efficiency varies from about 30% for 38 μm particles to about 50% for 17 μm particles, when the sampler faces the wind.[6] In addition, the button sampler minimizes the sampling of very large particles, i.e., particles above about 100 μm. This is a benefit, for example, in work environments involving machining fluids, where splashing may form large aerosol droplets. As a trade-off between average sampling inlet velocity and hole size, a curved screen with 9% porosity and 178-μm diameter holes was chosen for this study. The average air velocity through the orifices was thus 2.7 m/sec at the stationary sampler flow rate of 10 L/min and 0.5 m/sec at the personal sampler flow rate of 2 L/min. In this study the button sampler was evaluated in indoor environments with low air velocities near the sampler (typically ≪1 m/sec). The calculated pressure drop (ca. 10 Pa) through the screen of the button sampler was significantly higher than the velocity pressure (<1 Pa) of the surrounding air. Thus, the design of the sampling inlet assures an even distribution of air and particles over the entire porous surface of the button sampler.

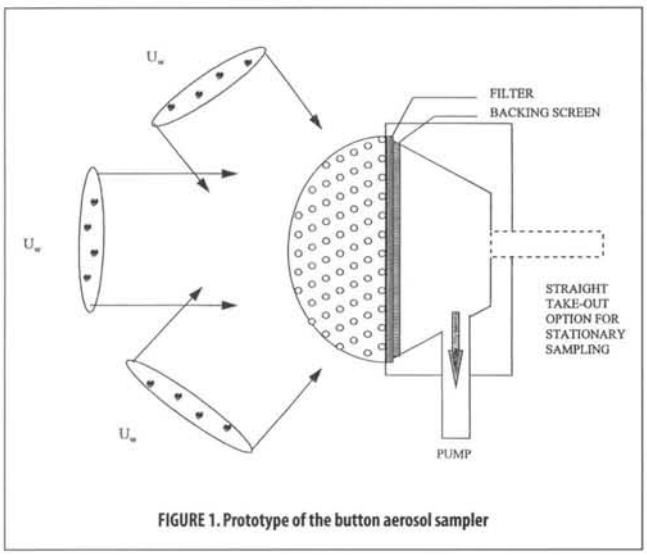

FIGURE 1. Prototype of the button aerosol sampler

Test Sites

Home environmental cleaning was conducted as part of the "Treatment of Lead-Exposed Children" study in Cincinnati, Ohio.[9] These cleanup operations aerosolized significant amounts of particulates from surfaces, thus providing suitable conditions to test the button aerosol sampler. An elevated concentration of airborne total dust was expected in these environments. Also, the concentration of airborne fungal spores was expected to be relatively high, as high humidity levels and interior water damage at the housing sites promoted the growth of fungi.

The test sites consisted of nine separate dwellings (Sites 1 to 9) that were categorized into the following housing classes: multiple family houses, single family houses, row houses, and two-three story apartment buildings. Stationary indoor measurements were taken in either the living room or a bedroom of the houses. In sites where personal sampling occurred, the workers spent time in all parts of the houses. When the work occurred on more than one floor of the dwelling, the stationary samplers were moved as the cleaning workers changed floors.

The environmental cleaning operation was performed by teams of three to five workers who followed detailed cleaning protocols to purge the dwellings of all surface contamination. Furniture in each room was moved and all surfaces including walls, window frames, and window wells were cleaned with sanitizing solution. Special focus was placed on the cleaning of carpeted areas because of the potential accumulation of lead deep in the fibers. Carpeted areas were vacuumed using commercial vacuum cleaners equipped with high-efficiency particulate air filters. This vacuuming was conducted three separate times at a rate of 3 minutes per square yard.[9] Cleaning was sequenced to avoid passing through rooms already cleaned and proceeded so that common areas and the entryway to the dwelling were cleaned last.[9] There were specific cleaning protocols for wood, tile, vinyl, and linoleum floors in addition to carpets. Each cleaning job lasted from 4 to 5 hours.

Test Protocol

Field testing was conducted in two sampling phases, stationary and personal. The stationary sampling phase was performed in the indoor air environments of seven houses (Sites 1 to 7). The button sampler was tested side by side with the standard cassette. The personal sampling phase was performed in two houses (Sites 8 and 9). For control purposes, stationary sampling was performed at the same sites in parallel with the personal samplers.

Stationary Sampling

The indoor stationary samples were taken in the centers of rooms where major cleaning work was being accomplished. Three collocated groups of samplers (A, B, and C), each comprising four identical devices, were employed in parallel, being exposed to the same air environments during the entire time of the cleanup. Group A consisted of button samplers operated at a flow rate, Q_{BUTTON}, of 10 L/min, which corresponded to a suction velocity through the holes on the curved inlet surface, U_{BUTTON}, of ca. 2.7 m/sec. In Group B, standard cassettes were operated at a flow rate, Q_{STAND}, of the same 10 L/min, which corresponded to a suction velocity

through the closed-faced inlet, U_{STAND}, of ca. 13 m/sec. Group C consisted of standard cassettes operated at a flow rate of 2 L/min so that their suction velocity was 2.7 m/sec, matching Group A. Table I summarizes the conditions under which the three groups were used. All samples in this series of experiments were collected onto commercially available PVC filters with 0.8 µm pore size (polyvinyl chloride filter, Costar, Cambridge, Mass.). This filter material was chosen to avoid potential errors caused by variations in moisture on the filters when analyzing them gravimetrically.[10]

TABLE I. Indoor Stationary Sampling Procedures

Sample Group	Inlet Type	Flow Rate (L/min)	Suction Velocity (m/sec)	Average Sampling Time (hours)
A	button sampler	10	2.7	4
B	standard cassette	10	13	4
C	standard cassette	2	2.7	4

The open inlet areas, S_i, of the two inlets differ by a factor of about five, 63 mm² for the button sampler and 12 mm² for the standard cassette, which results in the difference in average suction velocities, ($U = Q/S_i$), when $Q_{BUTTON} = Q_{STAND}$. It was found that the suction velocity of a standard cassette operated at 2 L/min is about the same as that of the button sampler operated at 10 L/min. Among other parameters, the suction velocity through the inlet orifices affects the inlet sampling efficiency and filter deposition characteristics of the samplers.[5,11] Therefore, side-by-side comparisons of the button and standard samplers were performed at the same average inlet velocity (Groups A and C). The usually accepted condition for the comparison of two samplers, however, is their operation in parallel (Groups A and B) at the sample flow rate.[12] Therefore, the button sampler at 10 L/min was compared with the standard cassette operated at two flow rates—its nominal flow rate of 2 L/min and at the increased rate of 10 L/min.

Two electrically driven high-volume air pumps (Model 0522-V3-G18DX, Gast, Benton Harbor, Mich.) with a suction flow rate of 40 L/min each were used for Groups A and B to operate four parallel samplers simultaneously. A sampling train with four branches of sampling lines was attached to each pump, and balanced flow was achieved by using tubing of identical diameter and length in each branch. Each branch was calibrated separately using an electronic soap bubble meter (Mini Buck, AP Buck Inc., Orlando, Fla.). Thus, a sufficiently stable flow rate of 10 ± 1 L/min was achieved for all samplers of Groups A and B. Samples in Group C were collected using individual battery-powered air pumps (Model 224-PCXR4, SKC Inc., Eighty Four, Pa.) operated at 2 ± 0.5 L/min. The flow rate was calibrated before and after sampling, and an average of these two flow rates was calculated. The average value was within the above indicated ranges, i.e., 10 ± 1 L/min for Groups A and B and 2 ± 0.5 L/min for Group C. All samplers were mounted on a stand that ensured the same inlet orientation of 90° to the vertical and at an elevation of 1.0 m above the floor level.

Personal Sampling

The scope of the personal sampling phase conducted at Sites 8 and 9 was limited to two sites and total dust sampling only. Each worker of the team donned two of the same battery-powered sampling pumps operated at 2 ± 0.5 L/min and wore them for the entire cleaning routine: one pump was equipped with a button sampler and the other with a standard cassette, and both inlets were clipped on the lapel in the workers' breathing zone.[13] For control purposes, stationary sampling was performed at the same sites in parallel with personal ones.

Analytical Methods

After the sampling the filters were analyzed to determine the concentrations of total dust and fungal spores measured by each aerosol sampler.

Total Dust Analysis

Filters from air samples were gravimetrically analyzed using National Institute for Occupational Safety and Health Method 0500.[10] An analytical balance (Six Place Micro Balance, Mettler, Toledo, Ohio) of 1 µg sensitivity was used to weigh the sample filters before and after aerosol sampling. Thus, the measured mass concentration of the total dust was determined for each sampler with a specific flow rate and sampling time. Before weighing, the filters were equilibrated in an environmentally controlled area for at least 2 hours. The filters were passed over a radiation source to minimize errors caused by static electricity. The limits of detection for gravimetric analysis of total dust, calculated for the 4-hour sampling period, were approximately 60 µg/m³ at 2 L/min and 13 µg/m³ at 10 L/min.

Fungal Spore Analysis

At sites where significant fungal contamination was expected, the filter samples were also analyzed for fungal spores. The mean diameter of most fungal spores is in the range of 2 to 3 µm, and their density is close to 1 g/cm³.[14] Therefore, these particles are essentially without inertia for the test conditions. Also, the size distribution of airborne fungal spores is probably more narrow than that of the total dust.

Fungal spores collected on the sample filters were analyzed using the widely accepted CAMNEA technique (Collection of Airborne Microorganisms on Nuclepore Filters, Estimation and Analysis).[15] The spores were first dispersed by agitating the PVC filter in a 5-mL solution of 0.01% Tween. The total count was determined by staining the spores with acridine orange and counting them under an epifluorescence microscope (Leitz, Laborluxs, W. Nuhsbaum Inc., McHenry, Ill.). Particle count concentration was determined for each sampler operated at a specific flow rate and sampling time. The limits of detection for fungal spore counting, calculated for the 4-hour sampling period, were about 3700 spores/m³ at 2 L/min and 740 spores/m³ at 10 L/min.

Particle Count Distribution on the Filters

To demonstrate the contrasting collection characteristics of the new button sampler and the standard filter cassette with respect to the particle surface density on the filters, a particle count distribution of each filter deposit was determined for six selected filter samples taken with three samplers of each type. The filters were mounted on a glass slide and cleared using 1.515 refractive index immersion oil, so that the individual particles could be viewed under a light microscope. Instead of PVC filters, mixed cellulose ester filters were used for these experiments because of their suitability for analysis by light microscopy.[16]

The spatially varying particle surface density was determined with a light microscope (Labophot-2, Nikon Corp., Tokyo, Japan) at a magnification of ×100, by traversing across the entire filter and counting the number of particles in each microscopic field.

Each microscopic counting area was 0.50 mm^2. The metric ruler on the microscope's stage was used to determine the radial coordinate, r, of the specific field on the round filter. Nondimensional radial coordinates (r/R_{FILTER}) were used to compare the particle counts across the filters. The radius of the button filter is R_{FILTER} = 25 mm/2 = 12.5 mm, and that of the standard cassette is R_{FILTER} = 37 mm/2 = 18.5 mm. The individual particle count in each field, N, has been expressed relative to the maximal measured count in the filter, N_{MAX}, (N/N_{MAX} = 0 to 1).

Statistical Analysis

All statistical analyses were performed using SAS software.[17] Linear regression analysis was performed with the concentrations measured by the button sampler as the dependent variable and concentrations by the standard filter cassette as the independent variable. This analysis was accomplished separately for each group (A, B, and C). The regression lines were forced through the origin, as it was assumed that the performances of each sampler was comparable in low-concentration air environments. The Shapiro-Wilk[17] statistical method was applied to test for normality. As this statistical test was unable to prove normality, the nonparametric Wilcoxon test was applied, and the significance of the difference between the concentrations obtained with the two sampling devices was determined for each test.

Results and Discussion

Stationary Sampling

Total Dust

The values of the total dust mass concentration measured with the button sampler and the collocated standard filter cassette are plotted against each other in Figure 2 for two situations: when both types of samplers were operated at the same flow rate ($Q_{BUTTON} = Q_{STAND}$, Figure 2A) and at the same suction velocity ($U_{BUTTON} = U_{STAND}$, Figure 2B). The results of one to four measurements (each representing two collocated samplers) are shown for each site. This comparison demonstrates reasonably good agreement. The Wilcoxon test showed that the data obtained with the two sampling devices were not significantly different from each other. This is portrayed in Figures 2A and 2B by a narrow distribution of most of the points around the 1:1 line. The following exceptions are, however, noted in Figure 2A: the data obtained in Site 7 and one out of four values measured in Site 3. These data points are near the detection limit of the standard cassette, while still well above the detection limit of the button sampler. Figure 2B also shows that one out of four data points obtained from Site 3 is essentially below the 1:1 line. The regression lines calculated for the logarithmic transformed values of the mass concentrations, C_M, are shown as dotted lines in Figure 2, and their equations are:

for Figure 2A: $$\log C_{M,BUTTON} = 0.997 \times \log C_{M,STAND} \quad (1)$$

for Figure 2B: $$\log C_{M,BUTTON} = 0.929 \times \log C_{M,STAND} \quad (2)$$

The regression lines had a p-value of 0.0001, and correlation coefficients of 0.969 and 0.967 and were found to be in close parallel with the 1:1 reference line. This agreement is consistent with previous laboratory experiments in which the concentration of particles collected with the button sampler in a wind tunnel was compared with that of the standard cassette at relatively low wind velocities of 1 m/sec to 2 m/sec using three monodisperse aerosols.[6]

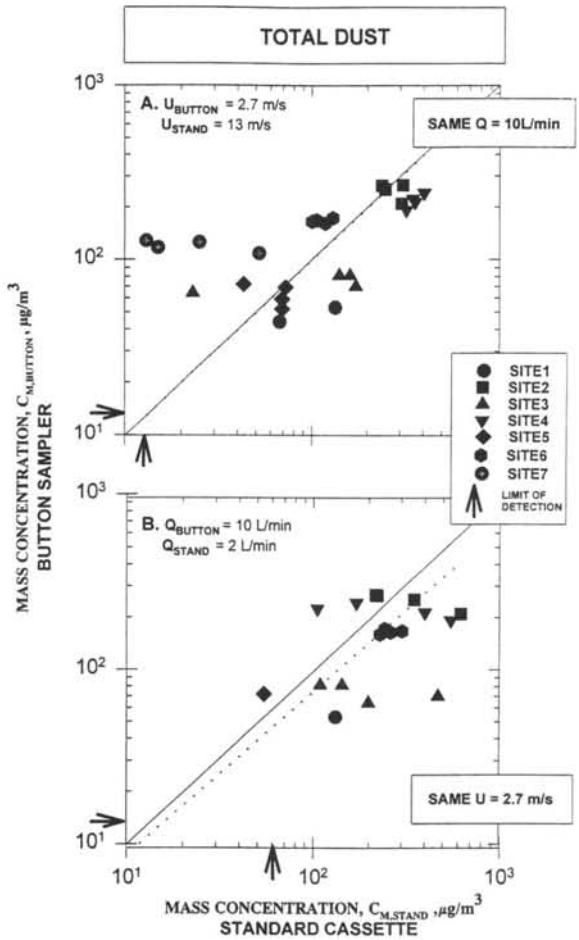

FIGURE 2. Comparison of the mass concentration of total dust measured with the button aerosol sampler at Q = 10 L/min and the standard closed-face cassette operated at (A) 10 L/min and (B) 2 L/min. The reference line (—) corresponds to $C_{M,BUTTON} = C_{M,STAND}$ and the calculated regression line (- - -) corresponds to Equation 1 for (A) and Equation 2 for (B).

Differences in the particle mass concentrations obtained in the various sites (favoring either the button sampler or standard cassette) can be explained by the wide variation in the airborne particle size distributions from one site to another. Cleaning activities are known to aerosolize particles covering a wide size range, especially particles larger than 10 µm.[18] The 178-µm pore size of the button sampler minimizes the collection of larger particles. The particle cut size (at which 50% of the particles are retained by the inlet's external surface) is well below the physical hole size because of the interception of the particles by the hole perimeter, ca. 50 to 100 µm. When sampling with the 4-mm inlet of the closed-face standard cassette, the interception mechanism does not affect the retention efficiency for workplace aerosols. Another parameter that affects the particle penetration through the inlet is particle inertia, which can be quantified by the aspiration efficiency for both samplers. A laboratory evaluation of the button sampler[6] has shown that the effect of inertial impaction is not dependent on the wind velocity for this sampler. In contrast, the aspiration efficiency of the standard cassette was found to be highly dependent on wind velocity.[6] Because of the wide range of field conditions during sampling and between samples, the measured differences in concentration cannot be attributed to specific parameters.

At sites where the clean-up operation released a high percentage of larger particles, the particle penetration through the small screen holes is expected to be lower than that through the 4-mm hole of the closed-faced cassettes. As the particle mass is proportional to the cube of the particle size, this results in undersampling of the total particle mass. Therefore, the data at $C_M=10^2–10^3$ $\mu g/m^3$ are skewed in favor of the standard cassette. Several data points obtained at low aerosol concentrations demonstrate an opposite tendency. As was mentioned before, these data were collected primarily in Site 7 and are close to the detection limit of the standard cassette. The interior sampling location, turbulence level, and natural ventilation were considerably different from site to site, all having an effect on the size distribution of the airborne particles.

It is expected that by varying the pore size and porosity, the inlet screens can be developed for the button sampler to satisfy the respirable, thoracic, and inhalable definitions of the American Conference of Governmental Industrial Hygienists.[19]

Fungal Spores

Scatter plots similar to the ones for total dust are shown in Figure 3 for the fungal spore sampling data. The Wilcoxon test showed again that the concentrations obtained with the two samplers were not significantly different from each other. As seen in Figures 3A and 3B, most of the data points are narrowly distributed around the 1:1 line. The calculated regression for the number concentration of fungal spores, C_N, lines are shown as dotted lines in Figure 3.

$$\text{For Figure 3A:}\quad \log C_{N,BUTTON} = 0.988 \times \log C_{N,STAND} \qquad (3)$$

$$\text{For Figure 3B:}\quad \log C_{N,BUTTON} = 0.970 \times \log C_{N,STAND} \qquad (4)$$

At a p-value of 0.0001 and correlation coefficients 0.988 and 0.979, the spore concentrations were comparable for the two types of samples, operated at either the same flow rate or the same suction velocity. Fungal spores are essentially monodisperse as single particles while total dust is polydisperse. Mechanical disturbances of indoor surfaces during cleaning[20] and demolition[21] may aerosolize large (>5 μm) nonbiological particles, with single or aggregated fungal spores attached to them. Therefore, the fungal spore sampling data follow the same particle-size dependent variations in sampled values as the total dust data. In addition, the accuracy of the analytical techniques used for spore counting is considerably lower than the accuracy of the gravimetric techniques used for the total dust measurements. This explains the rather high variation of the data shown in Figure 3.

Intersample Variation

The intersample variation, i.e., the differences in value between samples in the same location under identical sampling conditions, was estimated for each test group of four collocated button samplers and four collocated standard cassettes. The measurement results obtained with the standard cassette showed significant divergence when sampling both for total dust (e.g., 69% for Site 7), and for fungal spores (e.g., 70% for Site 2), as seen in Figures 2 and 3. The average standard deviations of measured concentration values presented in these figures were calculated as

$$\frac{1}{n}\sum_{i=1}^{n}\frac{\sigma_i}{\bar{C}_i} \qquad (5)$$

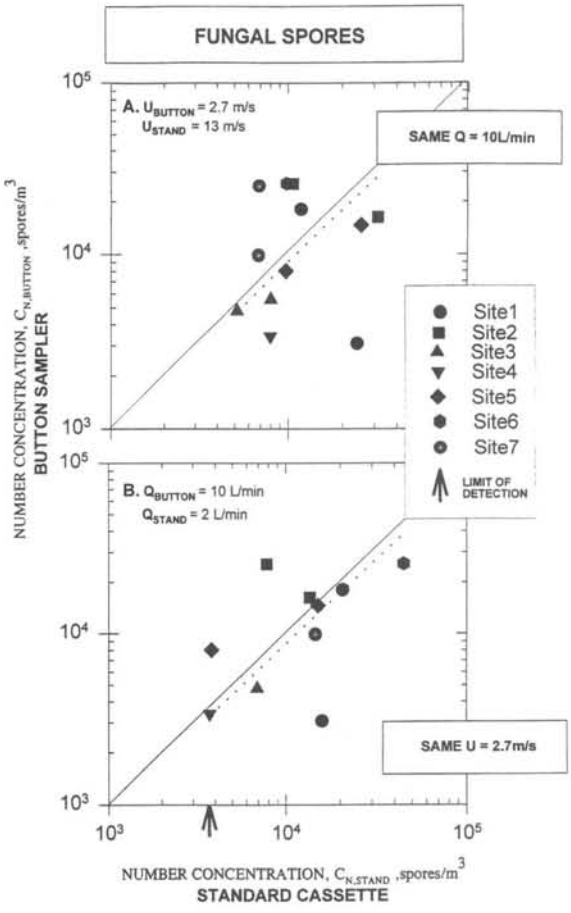

FIGURE 3. Comparison of the fungal spore concentration measured with the button aerosol sampler at Q = 10 L/min and the standard closed-face cassette operated at (A) 10 L/min and (B) 2 L/min. The reference line (—) corresponds to $C_{N,BUTTON} = C_{N,STAND}$ and the calculated regression line (- - -) corresponds to Equation 3 for (A) and Equation 4 for (B).

and results are shown in Table II. Here n is the number of sites (n = 9), σ_i is the standard deviation obtained at site i, $\bar{C}_i$ is the mean of the particle concentration obtained at site i (the mass concentration for the total dust and to the number concentration for fungal spores). The button sampler is found to have lower intersample variation than the standard filter cassette at both sampling flow rates of 2 and 10 L/min. This indicates that the button sampler measured the ambient particle concentration with higher precision than did the standard cassette.

TABLE II. Average Percentage Standard Deviation of Concentration: Intersample Variation Among Stationary Sample Groups Collected in Identical Conditions

	Button Sampler at 10 L/min	Standard Cassette at 10 L/min	Standard Cassette at 2 L/min
Sampling for total dust	10	33	100
Sampling for fungal spores	37	43	61

Note: Matched sampling conditions have same flow rate, sampler type, and location.

The difference in intersample variations of the two samplers appears to result from the effect of local air currents on the samplers' performance. The workers' activities in the room create turbulent airflows in the vicinity of each sampler. Thus, the local wind velocity near each sampler constantly changes. This affects the sampling efficiencies of the standard cassettes, as they are wind dependent and known to be highly sensitive to air turbulence.[22] Therefore, the use of several cassettes leads to a high intersample variation. At the same time, the button sampler has low wind sensitivity, so its sampling efficiency is not significantly affected by the local airstreams. Thus, it shows much lower intersample variation than the standard cassette.

The intersample variation of the standard cassette sampler is seen to increase when the flow rate is reduced from 10 to 2 L/min (both for fungal spores and total dust). This can also be attributed to the effect of ambient air turbulence on the sampling efficiency. The authors believe that this effect is more pronounced for the standard cassette at lower sampling flow rates.

The intersample variation values for the fungal spores at sampling flow rate of 10 L/min are higher than those determined for the total dust samples, as shown in Table II. This can be explained as resulting from the relatively low fungal spore concentrations found in these sampling locations, which were close to the analytical limit of detection. Thus, the difference between the button sampler and the standard cassette becomes less pronounced. At 2 L/min the count is so low that the intersample variation cannot be compared.

Particle Count Distribution

The top photograph of Figure 4 depicts the centrally clustered particle distribution on a filter when the sample is collected with a standard cassette. In contrast, the button sampler filter has a homogeneous spread of particles over its surface, as seen in the bottom photograph of Figure 4. This sampling was performed at $Q_{BUTTON} = Q_{STAND} = 10$ L/min.

Relative particle count distributions on the filters of the button sampler and the standard cassette, operated in the above conditions, are presented in Figure 5. It is seen that the distribution obtained with the standard filter cassette clustered heavily near the center of the filter, while the button sampler distribution was highly uniform over the entire collection surface.

Good collection uniformity on the filter surface of the button sampler is an important feature that makes this aerosol sampler more desirable than the standard cassette. This feature had been shown earlier through laboratory wind tunnel testing[6] and has been confirmed through field testing.

Personal Sampling

Personal sampling was limited to two sites (Sites 8 and 9), and the filters were analyzed for total dust only. This phase of the field study was performed to test the button sampler not only as a stationary but also as a personal sampler. Thus, this part of the study relates to the practice of using an available personal sampling device also as a stationary sampler.[23]

Similar to the stationary sampling tests, the total dust mass concentration measurements with the button sampler were compared with parallel measurements with the standard filter cassette when all samplers were operated at the same flow rate; in this case, however, all samplers were operated at 2 L/min. The data from each worker's set of personal samples (button versus standard) are shown in Figure 6. As seen, there is reasonably close agreement among the personal samples, as demonstrated by the narrow distribution of points around the 1:1 reference line.

At Site 8 the total dust concentration measured by the personal samplers was about the same as that obtained by the stationary ones. At Site 9 higher levels of dust were measured by the personal samplers. This is because Site 9 contained many small rooms, and the workers conducted only a minor fraction of their activity in the same room where the stationary sampling was performed. The authors deduce from these comparisons that the button sampling method is acceptable for both personal and stationary monitoring.

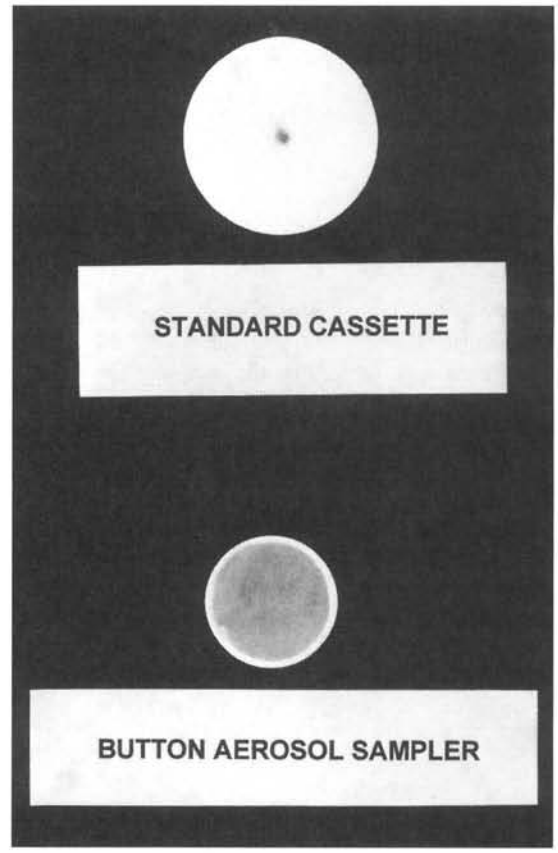

FIGURE 4. Photographs of filters after sampling for total dust with the 37-mm standard closed-face cassette and the button aerosol sampler at Q = 10 L/min.

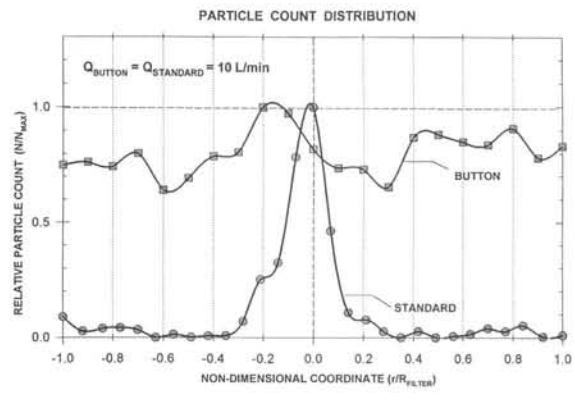

FIGURE 5. Particle count distributions of total dust on filters collected with the standard closed-face cassette and the button aerosol sampler. Each point presents the average of counts from three filters.

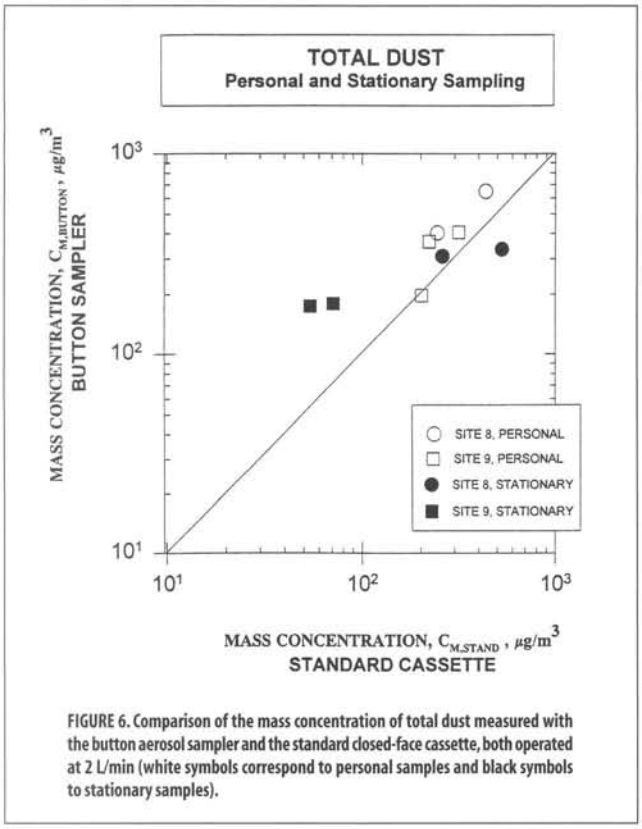

FIGURE 6. Comparison of the mass concentration of total dust measured with the button aerosol sampler and the standard closed-face cassette, both operated at 2 L/min (white symbols correspond to personal samples and black symbols to stationary samples).

CONCLUSIONS

Field testing of the new aerosol sampling method with a porous curved surface as the inlet has shown significant advantages of the button aerosol sampler over the standard filter cassette as an indoor aerosol monitor. The total dust mass concentration data and fungal spore count concentration data obtained with the button sampler have been found to have lower intersample variation. The particles appeared to have a more uniform count distribution on the filter of the button sampler than on the filter of the standard cassette. This suggests that because of its unique design the button aerosol sampler can measure the ambient particle concentration more precisely than the standard cassette. The uniform collection characteristics of the button sampler make it suitable for those methods that require a uniform particle distribution on the filter. The field evaluation of the button sampling method confirms conclusions made earlier through laboratory evaluations. Further work is required to test this method over a wide range of sampling and ambient parameters, including inlet porosity and orifice sizes. In particular, it is desirable to design the inlet screens such that the aerosol penetration characteristics match those of inhalable, thoracic, and respirable particle sampling standards.

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