IV. ENVIRONMENTAL DATA

Environmental Concentrations

Dust levels measured in cotton manufacturing areas can be influenced by such factors as the type of sampler used for the measurements, the duration of the sampling period, the location of the sampler relative to the dust-producing operations, the type and grade of cotton being processed, the type of operation being carried out on the cotton, the speed at which equipment is operated, air conditioning, location of air inlets, and the dust controls that are in effect for the operation being studied. Because of the number of variables involved, it is hard to arrive at general figures for dustiness which might be representative of the cotton industry as a whole. [127]

It is the usual practice to consider dust levels for the various processing operations separately. Operations usually considered are listed in Table IV-1. As cotton moves down the processing line to the final finished product, each processing operation removes undesirable trash and short fibers from the cotton. All operations may not be found in a single manufacturing plant.

TABLE IV-1

COTTON PROCESSING OPERATIONS

Growing and harvesting
Ginning
Opening, cleaning, and picking
Carding
Drawing and roving
Spinning, winding, and twisting
Spooling, beaming, and slashing
Weaving

from reference 128

Other than esthetics, primary interest in dust levels in cotton production areas relates to the prevalence or prevention of byssinosis. In early studies, the best correlation between the prevalence of the disease and the dust levels was found when the dust level was characterized by the middle-sized particles of relatively high protein content. [85] In more recent studies, the combined levels of middle-sized and fine dust appears to provide an even better correlation with byssinosis incidence. [11,13,129] The prevalence of byssinosis has little relationship to the fiber content of the air although fibers may represent a large percentage of the total mass of airborne material. [85,130] Also, this percentage is variable, depending on cotton type and grade, type of operation, and dust control techniques.

For all of these reasons, until recently there has been little uniformity in methods used to measure dust levels in the mills. Initially the high volume total mass sampler was employed for dust level measurements, [48,124] but more recently, samplers which measure only the smaller sizes of the dust have been used. The vertical elutriator of Lumsden and Lynch [124] in theory excludes all particles having aerodynamic diameters greater than 14.8 μm; the horizontal elutriator of Roach and Schilling [85] segregates the particles into coarse, medium, and fine sized fractions; and a personal sampling method [124,128] collects particles 29 μm and smaller. Although it would seem that the results from these different sampling methods cannot be compared, because of the nature of the cotton dust it is possible to make a rough comparison of results from the various methods. Using a cascade impactor, Lynch [124] measured an aerodynamic mass median diameter for cotton dust (excluding lint) of 4.5 μm with a geometric standard deviation of 3.0. This was the average of four long-term samples. Data reported by Merchant [131] on the size distribution of dust collected by the vertical elutriator of Lumsden and Lynch indicate that more than 80% of the particles have diameters of <3 μm.

Since the dust particles are generally relatively small and the main difference in the theoretical collecting ability of the three size-selective samplers is in the collection of the larger sizes of particles, rough agreement between the results from different investigators using the different sampling methods could be anticipated.

Table IV-2 lists crude average cotton dust levels as reported in the literature for various processing operations. This table is not complete; it makes no attempt to differentiate either between levels measured with or without controls, or between the grades of cotton being processed. It also does not take into account the variability of the individual dust samples as reported by the different investigators.

TABLE IV-2

GROSS AVERAGE COTTON DUST LEVELS REPORTED BY VARIOUS INVESTIGATORS

Operation	Investigator		Dust (mg/cu m)	Dust Excluding Lint (mg/cu m) Fixed Sampler	Personal Sampler
Ginning	El Batawi et al	[109]	15		
	Gilson et al	[31]		6-57 (RS)	
	Khogali	[111]		0.6 (RS)	
	Barnes & Simpson	[112]	20		
Opening	Hammad & Corn	[130]	7.1	3.0 (RS)	
	Hatcher & Lyons	[133]			3.1
	Merchant	[131]		1.6 (L)	
	Anglin	[134]		0.3 (L)	
	Silverman	[135]	17.2		
Picking	Lynch	[124]	6.6	0.7 (L)	2.5
	Hatcher & Lyons	[133]			1.3
	Merchant	[131]		1.7 (L)	
	Hammad & Corn	[130]	1.4	1.1 (RS)	
	Silverman	[135]	3.8		
Carding	Lynch	[124]	5.0	0.3 (L)	3.0
	Hammad & Corn	[130]	1.2	0.6 (RS)	
	Wood & Roach	[11]	1.6	1.0 (RS)	
	Merchant	[131]		1.8 (L)	
	Hatcher & Lyons	[133]			1.9
	Anglin	[134]		0.4 (L)	
	Silverman	[135]	4.1		
Drawing	Hammad & Corn	[130]	3.2	0.7 (RS)	
	Merchant	[131]		0.8 (L)	
	Anglin	[134]		0.4 (L)	
	Lynch	[124]	3	0.3 (L)	2.1
	Silverman	[135]	3.5		
Roving	Merchant	[131]		0.5 (L)	
	Silverman	[135]	4.0		
Spinning	Lynch	[124]	4.0	0.2 (L)	0.7
	Merchant	[131]		0.3 (L)	
	Hammad & Corn	[130]	1.8	0.3 (RS)	
	Silverman	[135]	1.5		

TABLE IV-2 (Continued)

GROSS AVERAGE COTTON DUST LEVELS REPORTED BY VARIOUS INVESTIGATORS

Operation	Investigator		Dust (mg/cu m)	Dust Excluding Lint (mg/cu m) Fixed Sampler	Personal Sampler
Wind & Twist	Lynch	[124]	14.3	0.3 (L)	1.2
	Merchant	[131]		0.3 (L)	
	Silverman	[135]	0.7		
Weaving	Lynch	[124]	1.4	0.4 (L)	0.8
	Merchant	[131]		1.1 (L)	
	Silverman	[135]	3.1		

Note: (L) Refers to vertical elutriator of Lumsden and Lynch. [124]
(RS) Refers to horizontal elutriator of Roach and Schilling. [85]
Measurement includes fine and medium size particles.

The table is useful in indicating the general trend of dustiness in various operations in the processing of cotton. For example, neglecting ginning (since the levels reported are not necessarily representative of the United States operations), it can be seen that the greatest respirable hazard based on dust, excluding lint, is associated with opening, picking, and carding. For these three areas typical respirable dust levels are about 1.5 mg/cu m. As will be discussed in the following section, dust control can appreciably reduce this level. It also appears that the personal sampler consistently measures dust levels higher than those determined using either the vertical or the horizontal elutriators. This observation was also noted in a study by Curtis et al [132] in a mattress factory. When the results of sampling with vertical elutriators are compared with results from personal samplers, the elutriator samples give on the average results which are about 65% of those measured with personal samplers. Although some of this difference could reflect a true difference due to the movement of the workers from one location to another during their work shift, the consistently higher personal sampler results suggest significant differences in the results indicated by the two samplers. This is also borne out by studies on an isolated draw frame reported by Barr et al. [127] A series of five measurements were made using a vertical elutriator, a personal sampler, and an OSHA general area sampler side by side. The results are shown below.

	mean concentration, mg/cu m	std deviation
Vertical elutriator	0.17	0.04
OSHA general area sampler	0.38	0.03
Personal sampler (stationary)	0.36	0.18

In this case the result determined with the vertical elutriator is 44% of that obtained by the personal sampler. However, no epidemiological studies have been completed which report prevalence of byssinosis with dust levels determined by personal sampling.

A series of samples taken at a single location can vary with time as a result of changes in operating conditions, with the presence or absence of local disturbances, and also with unknown or very obscure variables. On the other hand, a series of samples collected in the same work area at the same time will not necessarily give similar results. For example, measurements made in a large cardroom containing 40 cards before and after installation of dust control equipment gave results indicating greatly reduced dust concentrations (from 10-0.86 mg/cu m total dust) at two sampling locations in the room, but a much smaller percent reduction (from 10-2.97 mg/cu m) at a third location. [127] Prior to the test there was no reason to expect pronounced differences in the results for the three locations. It was concluded that the dust level at the high location resulted from the influx of dust from some other source in the mill.

Feasibility of Control

Control of dust levels in cotton-processing operations can be achieved by changing or treating the raw material which is the source of the dust, by changing the process which produces the dust, or by removing the dust from the air once it is generated.

The transition from natural to synthetic fibers in the past decade has resulted in lower byssinosis-producing dust levels in those mills using synthetics or blends. Merchant et al [18] reported a median dust level of 0.485 mg/cu m for 493 samples collected in mills working with pure cotton and a median dust level of 0.163 mg/cu m for 237 samples collected from mills using blends of natural and synthetic fibers. The synthetic fibers are virtually trash free and thus contribute little to the total sample collected. [136] It would be expected that, as the synthetic content of the raw material increased, the dust levels in most work areas would decrease.

A second method of changing the raw material is through the improvement of growing techniques to reduce the trash content of the cotton. Approaches such as developing cotton varieties which shed their bracts prior to maturation and harvest or the development of dwarf determinant cottons with increased fruiting potential compared to the production of vegetative parts [137] offer future potential methods of dust control, but at present these approaches are not feasible. There is little doubt that exposure to cotton dust trash has been greatly augmented by the replacement of handpicking by machines. [138] Studies are in progress to find new chemicals which will more efficiently defoliate cotton and reduce the trash content of the harvested seed cotton. [137]

A third method of changing the raw material is by steaming. Studies of this technique indicated that steaming could reduce the toxic effect of the cotton dust without rendering the cotton unsuitable for processing. [94] Some investigators conclude that the byssinosis-producing dusts are not removed or detoxified, but are just made to adhere more firmly to the cotton fibers; therefore the byssinosis problem is not solved but only moved from the opening, picking, and carding areas to the winding and weaving operations. [139] However, recent studies in a cotton spinning plant do not show an increase in downstream dust levels when processing steamed cotton. [140] Thus, while steaming may not be at this time a feasible alternative to dust control, it may become effective as a supplementary control method after further development. [140] Work is also in progress on improved ginning methods to allow for more efficient trash separation and/or fractionation. [137]

There appears to be little that can be done now to change the process in which cotton fibers are formed into yarn and woven into cloth in order to control dust production. The cotton manufacturing process is essentially one of fiber cleaning and alignment with the desired goal of removing all material in the cotton except the mature fibers. The dust in the cotton is thus an unwanted byproduct which must be dealt with. It is possible that the ginning process could be changed, and work is being actively pursued along these lines [137]; but at present process change does not appear to be a feasible alternative to dust control.

There are also a number of environmental factors which can be adjusted to some extent to control dust levels. As the opening and cotton cleaning machinery more efficiently removes trash and dust from the cotton stock, the release of this material into the work areas diminishes. Thus, dust levels in the picking room, cardroom, and subsequent operations can be reduced by better cleaning of the cotton in the opening and cleaning line. [141]

Decreasing the production machine density in a work area should decrease the dust levels in that area also. Conversely, if the machines are crowded together, higher dust levels would be expected. Dust emission is also increased by higher card speeds. Improperly or poorly maintained production machinery can also lead to higher dust levels. Hocutt [141] reports that cardroom dust levels are lower when the cards are well maintained and properly operated with alert operating personnel using precise machine settings.

Large central air-conditioning systems will tend to even out dust concentrations over the entire mill. [141] Of course, this might create new problems instead of getting rid of one, since it would cause increased dust level in some area while decreasing those in others. However, air-conditioning a textile mill does provide some dust control, but the control is incidental and the increased dust load in the air-conditioning unit will result in increased maintenance costs and impede the performance of the air conditioner. Dust is removed by the washer, a unit which acts as the primary humidifier and heat exchanger in the air-conditioning system. The washer is about 25% efficient for large particles [141] and much less efficient for smaller ones. Reliance on the air conditioner for dust control means that the dust must travel through the work area to reach the air-conditioner inlet, usually located on one wall of the room. Thus, the very nature of the system makes it inefficient for dust reduction or removal.

The capture and removal of dust from the air after it has been generated from the cotton represents the most widespread and efficient method of dust control at the present time. Table IV-3 gives summarized results from a study conducted recently by Barr et al [127] on the effectiveness of dust controls in mills having different degrees of dust control and processing varying grades of cotton. These results serve only to indicate the ranges of concentrations which may be expected for the different operations, with and without dust controls.

It appears that in some instances there may be dust concentrations (<0.5 mg/cu m) near cotton processing operations without dust control devices, but this would be the exception rather than the rule.

TABLE IV-3

RANGE OF TYPICAL LINT AND DUST CONCENTRATIONS

Operation	Total (mg/cu m)	Dust excluding lint (mg/cu m)*
Picking, no control	-	0.6 - 1.6
Picking, control	0.4 - 0.7	0.3 - 0.4
Opening and picking, no control	1.5 - 9.1	0.2 - 1.9
Opening and picking, control	-	0.3 - 0.5
Carding, no control	5.2 - 21.2	0.3 - 5.4
Carding, control	0.5 - 8.4	0.1 - 4.2

*As measured by the vertical elutriator

from reference 127

In a study of four cards, Wood and Roach [11] found dust removal to be less effective than indicated in Table IV-3; total dust levels ranged from 4.2-5.8 mg/cu m without dust extraction to 1.3-4.3 mg/cu m with dust extraction.

Efficient dust removal in cotton processing areas depends on two factors. First, there must be effective dust-capturing devices located at the points where dust could be generated. The captured dust is then transported away from the point of generation to a point where it can either be discharged to the outside atmosphere or removed by some means from the carrier air stream. Direct discharge of the captured dust to the outside atmosphere is not practical for two reasons. The dust is emitted in sufficient quantity to quickly produce its own air pollution problem outside, and some will probably find its way back into the work area negating the effect of the dust capture mechanisms. A second and often more compelling reason for not directly discharging into the atmosphere is the loss of conditioned air which must be replaced by new, heated or cooled makeup air. The quantities of air required for effective dust capture are large enough so that the usual practice is to recycle this air volume within the mill. [127]

Air which receives dust at one point and is cleaned at another point during complete recirculation will with time reach an equilibrium dust concentration. With ideal mixing, this concentration will equal the cleaned air dust concentration plus the ratio of the dust production rate divided by the recirculated air flow rate. [127] With good dust capture (low dust production rate) or a large recirculating air flow rate the concentration of dust in the air which is returned to the workroom will eventually determine the concentration of dust in that space. The isolation of dusty operations, successful in controlling dust exposures in other industries, has not been widely adopted in cotton mills.

In one study, dust concentrations in the return air were reported by Hammad and Corn [130] as 0.21 mg/cu m in the picking areas; 0.20 mg/cu m in the carding, drawing, and roving areas; and 0.13 mg/cu m in the spinning, spooling, and winding areas. Measurements made by Barr et al [127] ranged from 0.10-0.26 mg/cu m, depending on the type of air cleaning equipment in use. All samples were collected with a high volume sampler but the particles penetrating the air cleaners would be primarily in the respirable size range so that these values would most likely approximate measurements made with a vertical elutriator.

These studies [127,130] show that with highly efficient dust collection and removal it is possible to achieve dust levels of about 0.15 mg/cu m to 0.2 mg/cu m in some cotton mills where complete recirculation of the interior air is required. However, individual factors of each mill such as machinery type, condition, location, and isolation (or lack of it) may make achievement of this goal quite difficult in many cases. Also, since there is generally some leakage of air out of the mill as a result of work areas being kept at a positive pressure, [127] dust concentrations in the replacement outside air could become a significant factor when attempting to maintain interior concentrations below 0.2 mg/cu m.

Average suspended particle mass concentrations range from 0.01 mg/cu m in remote, nonurban areas to 0.06 mg/cu m in near-urban locations. In urban areas concentrations range from 0.06 to 0.22 mg/cu m depending on the size of the city and its industrial activity. In heavily polluted areas values up to 2.0 mg/cu m have been reported. [142] In the textile center of Greenville, SC, the median airborne particulate concentration measured in 1966 was 0.084 mg/cu m, and the 90% concentration was 0.15 mg/cu m. [99] High particulate loading in makeup air, whether cotton dust or not, would be measured as cotton dust due to the nonspecificity of dust measurement techniques.

In summary, it would appear from existing data that engineering controls can reduce dust levels in the working environments of opening, picking, carding, drawing, and combing areas below 0.5 mg/cu m as measured by the vertical elutriator. Equipment and systems that will maintain this dust level are commercially available. [127]

Consistently achieving levels of 0.2 mg/cu m would be more difficult particularly in the opening, picking, and carding areas. In general, systems designed to meet this concentration would have to have improved dust capture devices. Also dust collectors highly efficient in the removal of fine particles would be required. Both high-efficiency filtration and electrostatic precipitators are possible techniques to give the high degree of cleaning required, although there is some uncertainty as to whether present filter designs are capable of meeting a 0.2 mg/cu m concentration under all operating conditions. In general, meeting a 0.2 mg/cu m level as measured by the vertical elutriator in the working environments of opening, picking, and carding is now technically feasible but commercially available dust control equipment may not yet be obtainable.

Achieving a dust level of 0.1 mg/cu m would be even more difficult than attaining 0.2 mg/cu m for the same reasons given above. Also since 0.1 mg/cu m is in the range of community air levels for many small cities, makeup air in those areas would have to be meticulously cleaned before being used. The feasibility of achieving a level of 0.1 mg/cu m as measured by the vertical elutriator in the operating areas of opening, picking, carding, drawing and combing is not now evident using commercially available dust removal equipment. [127]

Environmental Sampling

The amount of dust suspended in the air is measured by drawing a known volume of air through a collector, assessing the amount of dust so collected, and expressing the results in terms of the amount of dust per unit volume of air. The concentration is generally reported as mass concentration although it sometimes might be more relevant to express the results in terms of the number or the surface area concentration of the particles. [143] Either by design or through imperfections in instrumentation, particles of different sizes, shapes, or densities are collected with different efficiencies. Therefore, it must be remembered that no two techniques of dust collection will give identical results. Because of their greater simplicity, gravimetric methods are most frequently used for measuring the concentration of cotton dust.

Gravimetric dust measuring techniques can be classified in terms of the size of particles collected (such as total-dust or size-selective sampling) and in terms of instrument location (area samplers and personal samplers). A total-dust sampler is a single stage collector and presumably captures all the particulate matter in a given volume of air. The actual proportion of particles collected, however, depends on both the orientation of the dust sampler inlet and the inlet velocity. In open-faced total-dust samplers an upward facing inlet results in oversampling, and a downward facing inlet results in undersampling. [124,128] The latter orientation also suffers from the danger of losing some of the collected dust when the filter is removed from the sampler. A sampler inlet in the vertical plane will collect a variable proportion of the larger particles depending upon the sampler inlet velocity and the air velocities in the vicinity of the sampler. [128]

Among the total-dust samplers that have been used to sample cotton dust are high volume samplers operating at flow rates of from 40-60 cu ft/min which deposit the collected particles on an 8 in. x 10 in. fiber glass filter. [48,94,124,127] In addition, small battery-powered sampling pumps equipped with polyvinyl chloride membrane filters in three-piece cassettes have been used. These pumps are usually operated at sampling rates of 1.5-2.0 liters/min [48,127,144] or with a critical orifice at 7.4 liters/min. [127,133,144] The cassette filter, when operating at a flow rate of 7.4 liters/min in a fixed location, is known as an OSHA Area Sampler. [144] When operating at a flow rate of 1.5 liters/min, it corresponds to conditions specified by OSHA for personal sampling. [144]

A variety of size-selective instruments have been used for dust sampling in textile plants. The hexhlet samplers used in the British studies [85,125] separate the dust into fine (<7 μm diameter), medium (7 μm to 2 mm), and coarse (>2 mm) size ranges. The instrument normally has a horizontal parallel plate elutriator at the inlet end which passes no dust >7.1 μm aerodynamic diameter. To measure the coarse dust, the horizontal elutriator is removed and replaced by a 2-mm x 2-mm mesh screen made from 0.2 mm diameter wire. Fly and lint collected on the screen are periodically wiped off, weighed, and reported as coarse dust. Medium dust is determined by the difference between the dust passing the screen (fine plus medium) and that passing the horizontal elutriator (fine dust). Some investigators refer to <7μm dust as respirable and <2 mm dust as fine [65] or fly-free. [126]

The first size-selective sampler described by US investigators was a high volume sampler fitted with a cyclone-type size-selector in front of the collecting filter. [124] This sampler had a perforated metal screen surrounding the cyclone entrance, and a small amount of air was drawn off through a filter at the bottom of the cyclone to retain fly. This sampler, which separated the dust into lint, middle, and respirable fractions with an aerodynamic cut-off diameter of 10 μm, [94] was considered to be too bulky for routine use in cotton mills. [124] Another size-selective sampling unit which has been used in American cotton mills is a personal sampler with an attached elutriating section having a size cut-off of about 29 μm aerodynamic diameter. [124]

Perhaps the most feasible sampler is the one developed by Lumsden and Lynch which uses the principle of vertical air elutriation and operates at a higher air volume than is possible with a personal sampler. [124] This sampler is sketched in Figure XII-2. The vertical elutriator cotton dust sampler was developed to have a size cut-off at 15 μm; the cut-off may be changed, however, by using a different air flow through the instrument.

A practical problem with size-selective samplers is that as a smaller size cut-off is used, the amount of dust collected decreases. [128] As weight is proportional to the cube of particle diameter, the mass of dust passing through the size-selector drops off rapidly as cut-off diameter is decreased. Where gravity elutriation is the principle used in size selection, an additional problem arises because the air flow through a given sampler must be proportional to the reciprocal of the square of the cut-off diameter. A reduction in cut-off diameter from 15 μm to 10 μm would require reducing the sampling rate more than 50%. The amount of dust collected in a sampler will, therefore, decrease rapidly as cut-off size is lowered. As the samples become smaller, weighing becomes more difficult. Some comparisons of dust concentrations measured by various samplers have been given in Tables IV-2 and IV-3.

Dust sampling procedures must be designed so that dust concentrations are measured accurately and consistently. Ideally, in order to determine the concentration of dust which is likely to enter the worker's respiratory system, it would be desirable to collect a personal dust sample near his breathing zone. In order for such a measurement to provide a meaningful result, however, the sample collected must correspond closely to that on which the hygiene standards are based. Since all the data obtained for prevalence of byssinosis versus dust concentration have been obtained from area sampling of dusts and most have involved size-selective sampling by instruments not readily adaptable for personal sampling, it is evident that dust concentrations measurements will have to be based on area sampling until adequate means of personal sampling for exposure to cotton dust are developed, and dose-response relationships based on such sampling methods are obtained.

If the fraction of respirable dust in a work area were a constant percentage of the total dust, it might be feasible to determine the respirable/total ratio by making measurements with suitable samplers (vertical elutriator for respirable dust and OSHA area samples for total-dust, for example) and then use this ratio to calculate the respirable dust obtained in a sample collected with a personal sampler. Unfortunately, this fraction varies considerably from area to area [85,124,127,145] and, much more importantly as shown in Table IV-4, it varies within an area even when similar materials are being processed. In textile plants personal samplers also suffer from drafts and air gusts which can either add or remove fly and lint from the face of the sampler.

TABLE IV-4

RESPIRABLE AND TOTAL COTTON DUST LEVELS REPORTED
AT DIFFERENT LOCATIONS WITHIN A CARDROOM
AND WHEN PROCESSING SIMILAR MATERIALS

Material Processed	Dust Concentration (mg/cu m)		Ratio Respirable/ Total (%)
	Respirable	Total	
Middling cotton*	0.44	0.73	60.3
	0.50	0.91	54.9
	0.42	1.49	28.2
	0.50	0.97	51.5
Strict low middling cotton**	1.15	11.89	9.5
	0.62	5.21	11.9
Strict low middling cotton heated at 325 F for 5 min.**	0.61	3.42	17.8
	0.34	2.32	14.7
Strict low middling cotton steamed at 212 F for 30 min.**	0.31	2.87	10.8
	0.51	1.25	40.8
Strict low middling cotton subjected to steaming cycle in bale**	0.23	1.91	12.0
	0.22	1.61	13.7
Strict low middling cotton steamed continuously at 212 F for 5 min.**	0.37	2.47	15.0
	0.20	1.96	10.2
	0.21	3.23	6.5
Strict low middling cotton steamed in production model steamer for 7 min.**	0.23	2.19	10.5
	0.26	2.70	9.6
	0.22	2.03	10.8
Strict low middling cotton steamed in production model steamer for 5 min.**	0.25	1.42	17.6
	0.31	1.62	19.1
	0.32	2.32	13.5
	0.68	7.77	8.8
	0.68	7.69	8.8

*Measurements at different locations within a cardroom [127] (respirable dust measured by vertical elutriator).

**Average measurements when processing similar materials [94] (respirable dust <10 μm measured by cyclone sampler).

These problems associated with the use of personal samplers might be alleviated with the addition of a small elutriator to the sampler. Such a sampler has been described, [124] but it had an aerodynamic cut-off diameter of 29 μm. According to John Lumsden of the North Carolina Department of Human Resources in a 1974 communication to NIOSH, a similar device with a cut-off diameter of 15 μm operating at a flow rate of 0.42 liters/minute is being evaluated. Should this device prove adequate for use as a personal sampler, the data it provides could perhaps replace or supplement data obtained with area samplers.

A modification of a dust sampler [146] in which dust is impacted on Mylar disc between a C14 source and a Geiger-Mueller tube has been described by Neefus. [147] The quantity of dust collected is determined by the reduction in beta ray counts between the beginning and the end of the sampling period. By attaching a vertical elutriator, only <15 μm dust is collected. (Apparently dust below 0.2 μm is also not determined). This device has the advantage of permitting measurement of short-term samples (on the order of 7 min.), as well as avoiding the time-consuming weighing procedure. The author [147] reported excellent agreement between results obtained with this instrument and those obtained with the Lumsden-Lynch unit. [124]

Until suitable personal samplers are available, however, the determination of dust concentrations should be made using the vertical elutriator operating at a flow rate of 7.4 liters/minute. Sampler locations should be selected to provide a representative sample of air to which the workers are exposed.

Sampling should be performed in distinct operating areas of the plant (opening, picking, carding, etc). Samples should be taken in each area at a minimum of five different sites representative of the area. The normalcy of the typical operation at the time of sampling is very critical to results and should be considered as important as frequency of sampling. For large areas (greater than 5000 sq ft), additional sampling sites should be selected with good industrial hygiene judgment. Placement of sampling equipment should be away from machinery and unnatural drafts. Exposure areas should be sampled every 6 months and whenever production techniques or mechanical ventilation changes are made.

If workers are not employed in the same area for most of the shift, a time-weighted average should be used to determine whether their exposure is within recommended limits. The time-weighted average is determined in the usual way, that is by summing the products of each fraction of the working shift by the dust concentration during that fraction of the shift (see Appendix I).