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EFFECTIVE DUST CONTROL SYSTEMS FOR PEANUT GRADING ROOMS

by

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SUMMARY:

Concerns for health and safety of inspectors in peanut grading rooms prompted research to reduce respirable, inhalable and total dust levels. A filtering system was designed to reduce dust concentrations to tolerable levels with an efficiency of 90% to 95% and arrestance of 99% while filtering all of the air every two minutes.

KEYWORDS:

Dust, Peanuts, Grading, Dust Filtering

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ABSTRACT

Federal and State Inspection Service concerns for the health and safety of inspectors in peanut grading rooms prompted research to reduce respirable, inhalable and total dust levels. A filtering system was designed to reduce dust concentrations to tolerable levels. The system utilizes filters with an efficiency of 90% to 95% and arrestance of 99% while filtering all of the air in the grading rooms every two minutes.

INTRODUCTION

Grading operations at peanut buying points involve operations such as sampling, weighing, cleaning, shelling, screening, and splitting the peanuts. Each of these operations either releases previously generated dust, such as the cleaning operation, or creates dust, as occurs with the sheller. Breathing this dust for prolonged periods can pose a health hazard to the peanut inspectors. Federal and State Inspection Service concerns for the health and safety of inspectors at peanut buying points prompted research to reduce dust levels in these grading rooms. Advances in filtering and sampling technology provide the potential to efficiently sample dust levels and design an effective filtering system to reduce dust to tolerable levels. The objective of this research was to design filtering systems effective in reducing respirable dust to tolerable levels.

LITERATURE REVIEW

Dust is classified by size into three primary categories, respirable, inhalable, and total dust (Mody and Jakhete, 1988). Respirable dust refers to those particles small enough to pass through the nose and upper respiratory system and penetrate deep into the lungs. Particles that penetrate deep into the respiratory system are generally beyond the natural clearance mechanisms of the body and are more likely to be retained and cause health problems. These respirable particles are less than 10 µm in diameter with 25% of those particles less than 5 µm and 90% of those particles less than 2 µm being respirable. Inhalable dust consists of the larger size fraction of dust which enters the body but is trapped in the nose, throat, and upper respiratory tract and usually expelled from the body. Total dust includes all airborne particles, regardless of the size or composition.

Not all dust produces the same degree of health hazard. Dust effects on health depend on composition, concentration, particle size and shape, and exposure time. However, increased incidences of chronic bronchitis, asthma provoking allergies, and emphysema have been reported among grain handlers (Cotton and Dosman, 1978; Dopico et al., 1977). In addition, aflatoxin, a carcinogen produced by <u>Aspergillus flavus</u>, has been detected in grain and peanut dust from highly contaminated lots (Sorenson et al., 1984; Silas et al., 1987). Several researchers have reported the incidence of <u>A. flavus</u> in grain dust (Martin and Sauer, 1976; Hill et al., 1984). Hill et al. (1984) showed that about 25% of the <u>A. flavus</u> spores from corn dust were less than about 3 µm in size and would therefore penetrate deep into the lungs. Fungal spores can cause allergies, poisoning, and infections. If spores are present, then aflatoxin may exist or may be produced.

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The Occupational Safety and Health Administration (OSHA) does not have regulations that apply specifically to peanut grading rooms since a significant health risk to workers has not been validated. However, researchers for other commodities have recognized the need for dust reduction to improve working conditions for grain handlers.

Several dust reducing techniques have been used with varying degrees of success. Lai et al. (1981) used oil additives in small grains to reduce dust with some success. Martin and Stephens (1977) used a cyclone dust separator to remove dust generated during corn handling. Brown and Reed (1926) used bag filters and electronic precipitators to control grain dust. Anthony and Columbus (1985) used a suction hood over dust sources to remove cotton gin dust. Because of labor requirements and the numerous dust sources, oil additives were not considered as a solution in this research. Cyclone separators do not remove the small particle sizes of interest and electronic precipitators were not considered to be an economically viable solution to the dust problem in peanut grading rooms. Therefore, other solutions were considered in this research.

PROCEDURES

A laser particle counter (Fig. 1) and a high volume air sampler (Fig. 2) were used to estimate the respirable, inhalable, and total dust levels during the crop year (CY) 1988 peanut season in nine grading rooms within an 80 km radius of the National Peanut Research Laboratory in Dawson, Georgia. The laser particle counter counted the number of particles greater than or equal to 0.5 and 5.0 µm over 1 min sampling periods for about 20 min at a 0.0028 cubic meters per minute flow rate. Sampling at this interval gives 95% confidence in estimating the 0.5 µm particles within 1000 of their actual value and the 5.0 µm within 100 of their actual value. The laser particle counter compared the effectiveness of different air flow rates and filter efficiencies. Also, since 1 min sampling periods were used, the contribution of different grading components to dust levels and the effect of dust filters cycling on and off were determined. The 0.5 µm and larger particles estimated the amount of respirable dust, including mold spores, while the 5.0 µm and larger particles estimated the inhalable dust. Aflatoxin levels in the dust were not determined; however, it was assumed that if the particle size range that includes mold spores was filtered, then the risk of aflatoxin is reduced. Fig. 3 shows the particle size ranges observed in this research.

The high volume sampler collected the total dust deposited on a 0.2 µm filter over a 24 h time period at a flow rate of 1.2 cubic meters per min. This sampler compared the total reduction in dust levels achieved by different filtering systems.

Most grading rooms were monitored for at least six days. The filtering system was run every other day resulting in three days with the filtering system operating and three days with the dust filter turned off. The number of samples graded per day and the time each piece of grading equipment was used was recorded for the appropriate sampling device. The samplers were placed away from the dust filters and away from dust sources. The laser particle counter was placed close to the picking table at a height of about one meter. The high volume sampler was placed about 0.5 meters from the floor and adjacent to the picking table.

Since no OSHA standards exist specifically for peanut grading rooms, threshold levels were set based on the response of graders at test sites. When 0.5 µm dust counts, which estimate respirable dust including mold spores, were below 90,000 particles collected in a 1-min period, graders noticed an appreciable difference in air quality. One peanut buying point manager, whose filtering system maintained dust levels below this established threshold, noted that none of his graders missed work during the CY 1988 season for health related problems. Before the dust filtering system was installed, health related absences were common at his facility. The 5.0 µm and total dust values compared the relative effectiveness of the dust filtering systems.

Two concepts of reducing dust levels were tested. One concept eliminated the primary dust sources and the other concept removed the dust after it was suspended in the air using a filter matched with a blower providing a given flow rate. Several dust

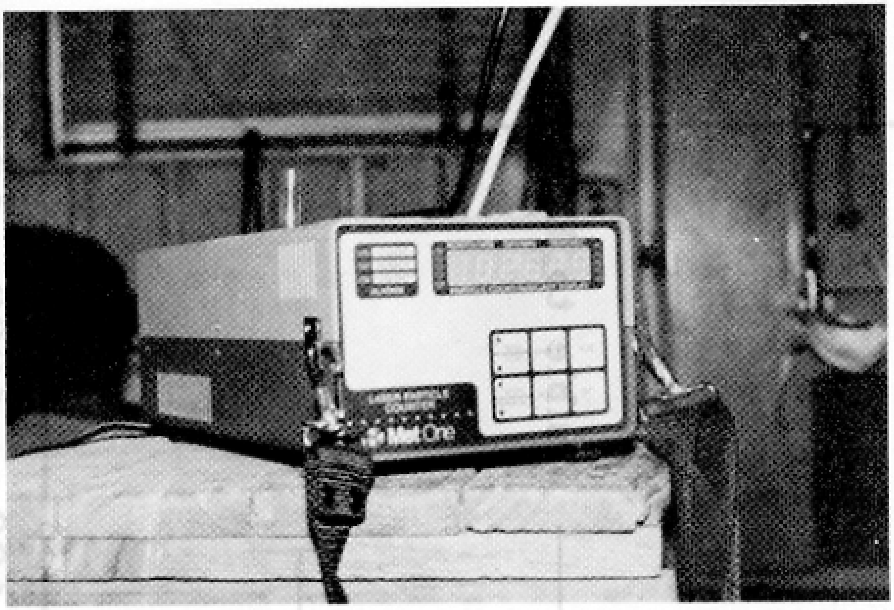

Figure 1. Laser particle counter used to determine the number and size of dust particles.

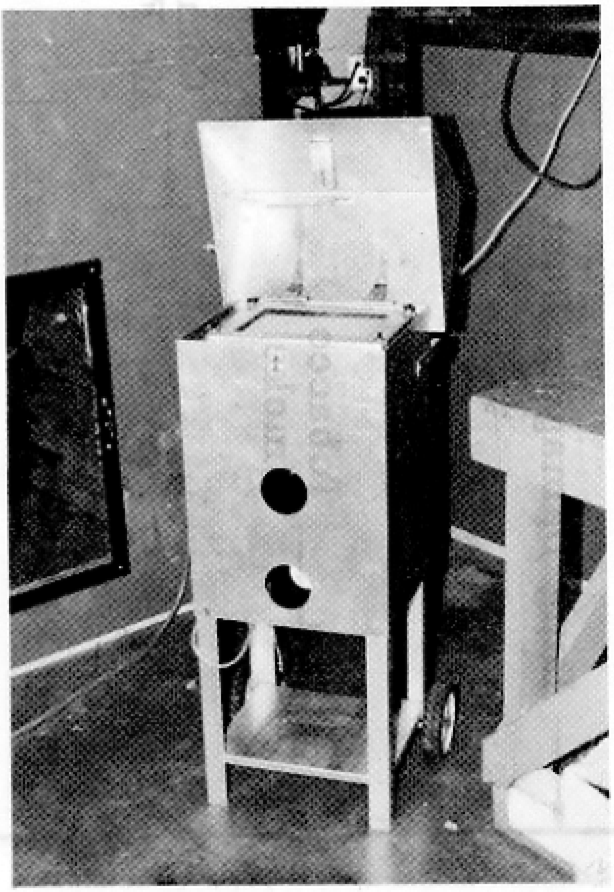

Figure 2. High volume air sampler used to determine the amount of dust deposited over a 24 hour period.

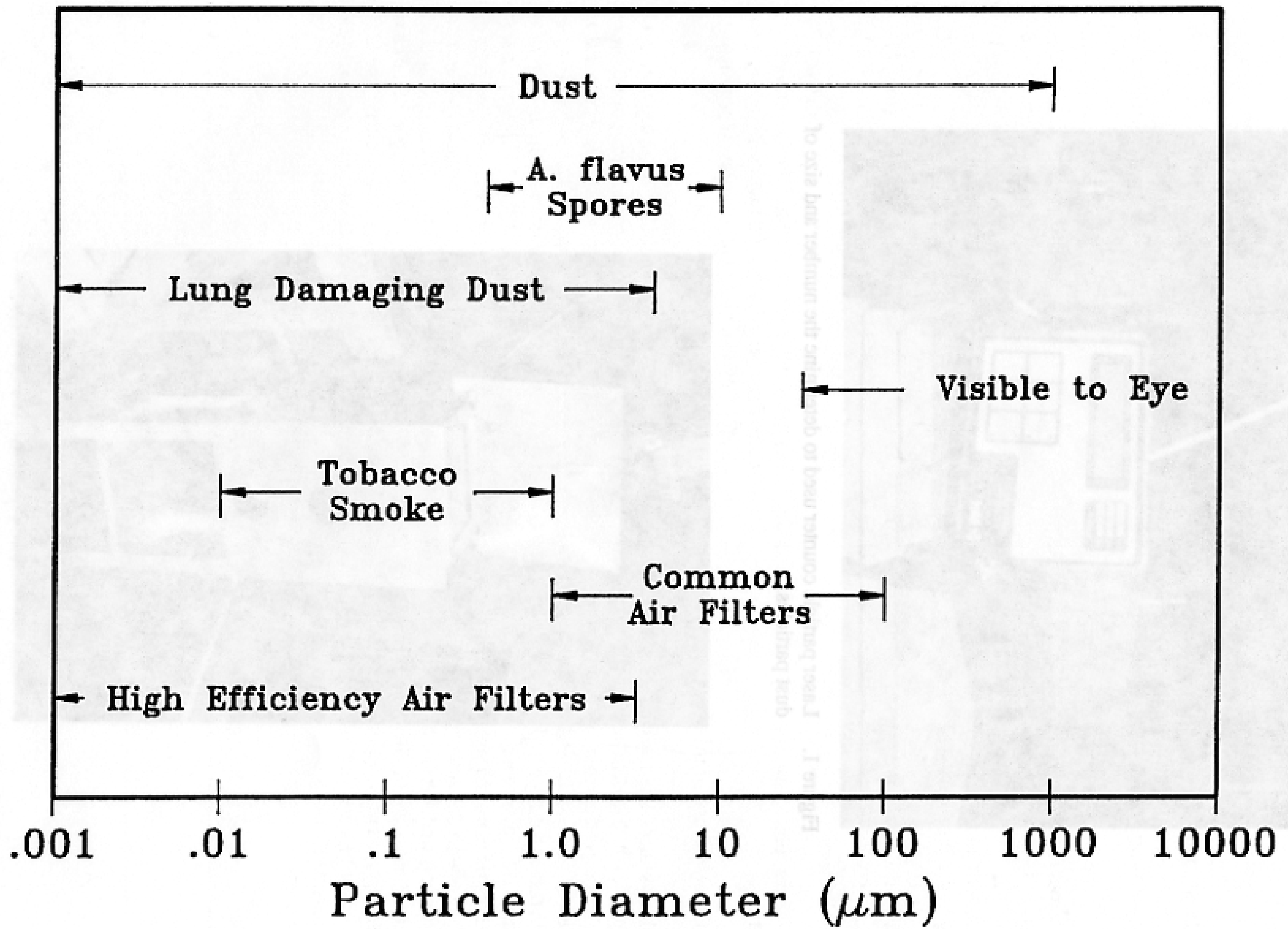

Figure 3. Characteristics of particles and air filters.

removing techniques within each of these concepts were tested in order to develop an effective dust filtering system. These techniques were:

1. Isolation of the primary dust sources, that is the sheller and foreign material machine, to keep dust created from these machines confined to a small area (Fig. 4).

2. Vents placed over the dust sources to remove the dust as soon as it was generated (Fig. 5).

3. A ventilation hood with filters placed over the picking table (Fig. 6).

4. Stand alone filter systems suspended from the ceiling that recirculated and filtered all the air in the room (Fig. 7).

5. Filters placed in existing air conditioning systems.

6. Combinations of the above.

Filters with efficiencies and arrestances ranging from 20% to 99% and flow rates that filtered all of the air in the grading room ranging from 1 to 4 min were tested. Efficiency indicates how many of the small particles the filter will remove and arrestance indicates how many large particles the filter will remove. Efficiency and arrestance are determined in accordance with the American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc. (ASHRAE) standard 52-76 (1976). The flow rate of the filtering system is important because the dust in the air must be removed as fast or faster than it is being created to maintain or create a clean environment.

RESULTS AND DISCUSSION

Initially, eliminating the primary dust sources by isolating the foreign material machine and sheller was examined as an economical approach to reducing dust levels. Table 1 shows that isolating the sources had little effect on the respirable 0.5 µm levels. Reductions of approximately 50% occurred in 5.0 µm and total dust levels. These results indicate that the foreign material machine and sheller are primary dust sources for larger particles, but most of the smaller particles came from other sources. Therefore, additional filtering was necessary.

Two combinations of filter types and air flow rates in stand alone filtering systems (Fig. 7) were tested to determine the type of filter and how often the air in the room needed filtering. Table 2 shows the results of these tests. The high efficiency filter maintained the average 0.5 µm dust levels below the established threshold of 90,000 particles. A greater than 50% reduction in all dust levels was achieved with the high efficiency filter.

A continuously running hood system placed over the picking table with vacuums placed over the foreign material machine and sheller was tested with several different filter types. The results (Table 3) show that the pleated filter in the hood system was the only filter of those tested in this system that reduced 0.5 µm dust levels below 90,000 particles. A significant reduction in 5.0 µm levels was seen with the pleated filters. This system was specially built for this grading room and was part of the central air conditioning system. Therefore, since few grading rooms have central air systems, the system could not be used for all rooms.

Table 1. Effect of isolating the sheller and foreign material machine (FM) on dust levels.

	No. of particles ≥0.5 µm [a]	No. of particles ≥5.0 µm [a]	Total dust levels, (g) [b]
Sheller/FM isolated	86,193	2,905	0.3402
Control	93,906	5,752	0.5575

[a] Average of 1-min sampling intervals.
[b] Total dust collected over 24 h sampling periods.

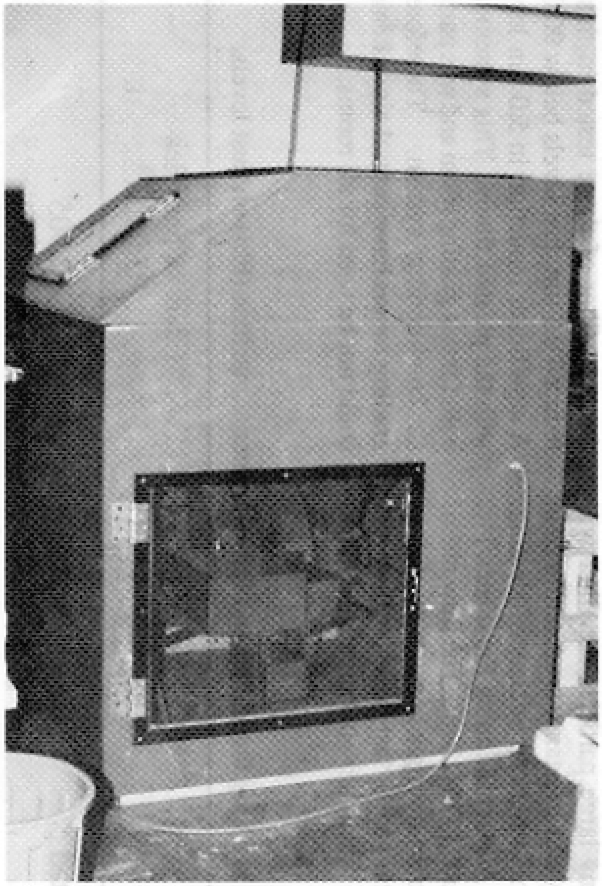

Figure 4. Enclosure used to isolate dust sources.

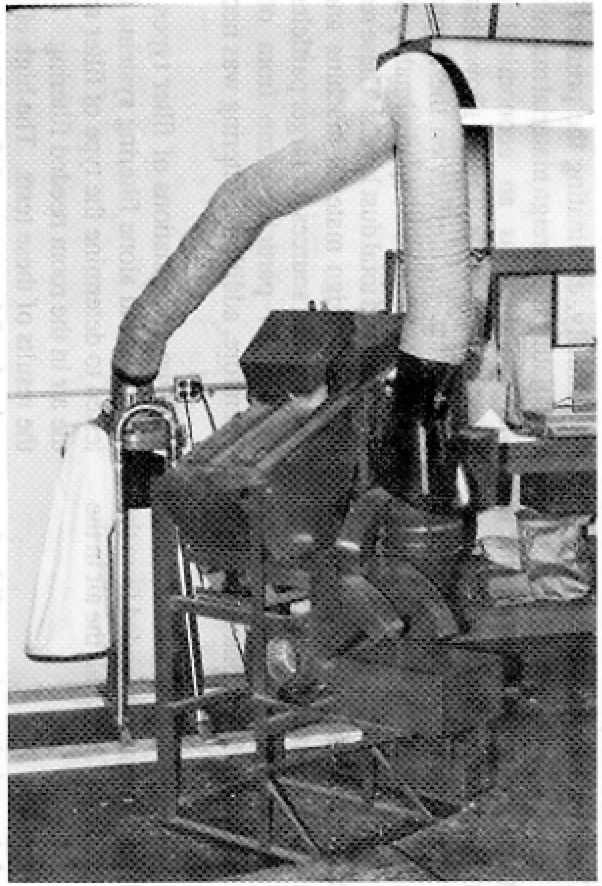

Figure 5. Hood filtering system used to isolate dust sources.

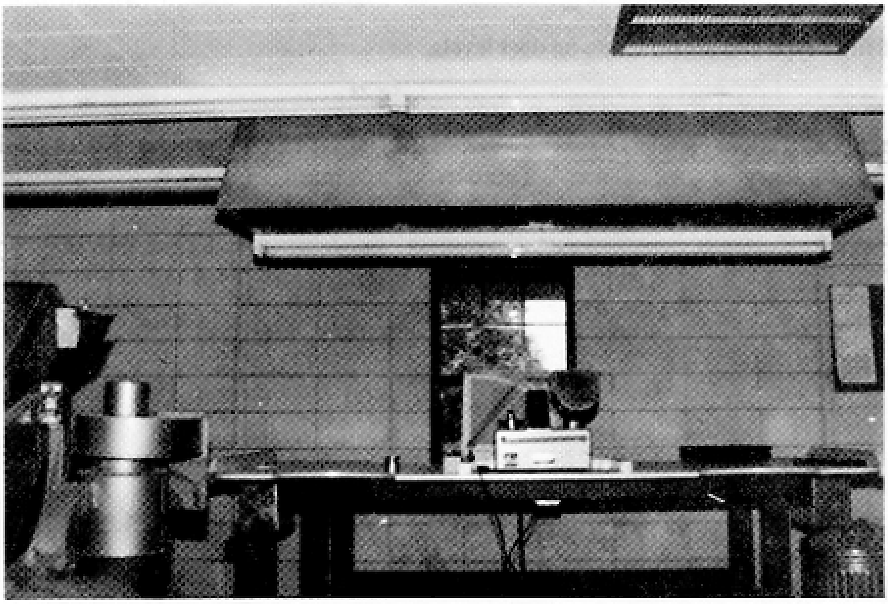

Figure 6. Hood system placed over picking table.

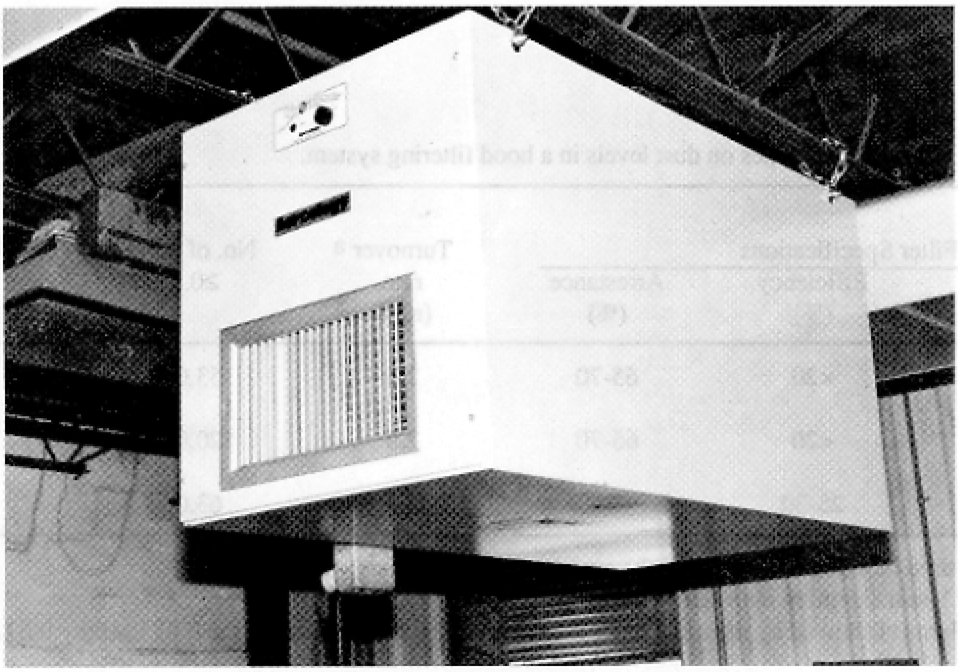

Figure 7. Stand alone filtering system that recirculates and filters all of the air in the room.

Table 2. Effect of filter type and air flow rate on dust levels.

Type	Filter Specifications: Efficiency (%)	Arrestance (%)	Turnover[a] (min)	Flow rate (cfm)	No. of particles ≥0.5 µm[b]	No. of particles ≥5.0 µm[b]	Total dust[c] (g)
Grading/No Filter	–	–	–	–	124,000 A[d]	26,800 A[d]	2.77 A[d]
Bag	65	90-95	0.8	2400	100,000 A	17,000 A	2.4 A
High efficiency			3.2	600	60,000 A	12,800 A	1.0 B
Primary	25-30	94-96					
Secondary	90-95	99					
No Grading/No Filter	–	–	–	–	85,817 A	13,503 A	0.05 C

[a] Amount of time required to filter all of the air in the room one time.
[b] Average of 1-min sampling intervals.
[c] Total dust collected over 24 h sampling periods.
[d] Mean in columns followed by the same letter are not significantly different at the 0.05 level by the L.S.D. procedure.

Table 3. The effect of filter types on dust levels in a hood filtering system.

Type	Filter Specifications: Efficiency (%)	Arrestance (%)	Turnover[a] rate (min)	No. of particles ≥0.5 µm[b]	No. of particles ≥5.0 µm[b]
1 Fiberglass	<20	65-70	2.5	153,000 A[c]	12,000 A[c]
2 Fiberglass	<20	65-70	2.5	120,000 A	9,500 A
Pleated	25-30	95	2.5	63,000 A	4,500 B

[a] Amount of time required to filter all of the air in the room one time.
[b] Average of 1-min sampling intervals.
[c] Mean in columns followed by the same letter are not significantly different at the 0.05 level by the L.S.D. procedure.

Table 4 shows the effects of a filtering system that utilizes an existing central air conditioning system. Two different filter types were used in the system, the conventional fiberglass filter and a pleated filter. Dust levels were not reduced to the established thresholds with either filter type because the air conditioner cycled on and off and did not keep ahead of the dust being created. In addition, the filters were not efficient enough to remove small particles.

It is essential that the rate at which the air is filtered exceeds the rate at which the dust is created. A high efficiency filter effective in removing dust combined with a low flow rate will not adequately remove dust from the air. Table 5 shows that the 0.5 µm dust particles were reduced to only 150,000 particles from 200,000 particles due to a low flow rate in a large room. The 5.0 µm dust was reduced about 30%. The air turnover rate of about 4 min needs to be reduced to about 3 min in order for the high efficiency filter to clean the air at a rate as fast or faster than the dust is being created and maintain 0.5 µm levels below 90,000 particles. The 0.5 µm dust particles at the high flow rate are significantly lower than the control or low flow rate (Table 5). Figure 8 shows the effect of filtering on dust levels.

Dust created by grading equipment is not the only contributor to the respirable 0.5 µm particles. Fig. 9 shows that cigarette smoke causes dramatic increases in respirable dust above tolerance levels while 5.0 µm levels are decreasing. Therefore, if reducing dust levels is a health concern, smoking should be prohibited in grading rooms.

SUMMARY AND RECOMMENDATIONS

There are approximately 600 grading rooms in the peanut producing areas of the U.S. Each room is unique; therefore, one filtering system design may not work for every situation. One general solution that should solve dust problems in most rooms is presented along with results for other specific situations.

The results of this study show two types of systems maintained dust levels below the established threshold of 90,000 particles $\geq$ 0.5 µm in size and reduced inhalable and total dust levels. One system utilized a hood with filters placed over the picking table and included a dust system that removed the dust from the sheller and foreign material cyclones. This system was specifically designed for this grading room and was part of a central air system; therefore, it is not recommended as a solution for most grading rooms.

The most universal solution was a stand alone filtering system that contained a primary and secondary filter. The filters have an efficiency of 90% to 95% and an arrestance of 99%. Although the system worked well in one environment with the air filtered every 3.2 min, other tests showed poor performance with a turnover of 3.8 min. This indicates that a 3.2 min turnover is on the borderline of providing effective filtering. Therefore, to insure an adequate flow rate with high efficiency filters using a safety factor of about 1.5, an air turnover rate of 2 min is recommended. Sample calculations to find the blower size to give an adequate turnover in a room 6.1 meters wide, 6.1 meters long, and 2.4 meters tall is as follows:

6.1 m x 6.1 m x 2.4 m/2 min = 44.7 cubic meters/min.

Therefore, a blower that will supply a 44.7 cubic meters per minute flow rate is needed in this example. The cost of this type of system ranges from about \$900 to \$1500, depending on the room size.

To aid in maintaining a clean environment, the grading room doors should be kept closed and smoking prohibited. Clean filters are a requirement for an effective filtering system; therefore, the system should contain a device such as a manometer that indicates when to change the filters. The filtering system should contain adjustable louvers so air flow can be directed away from the scales to prevent weight fluctuations caused by air movement.

These recommendations are based on systems tested at specific grading rooms. The number of loads graded and the environment in which the grading room is located will change. Therefore, modifications to these recommendations may be needed. For example, if a large number of samples are graded per day and the grading room is located in a windy, dusty location, then a larger blower may be needed to filter the air more frequently.

Table 4. The effect of filter type on dust levels using an existing air conditioning (A/C) system.

Filter Specifications			Turnover[a] rate (min)	No. of particles $\geq 0.5\ \mu m$[b]	No. of particles $\geq 5.0\ \mu m$[b]
Type	Efficiency	Arrestance			
Fiberglass	<20	65-70	1.7	117,000 A[c]	14,000 A[c]
Pleated	25-30	95	1.7	103,000 A	15,300 A

[a] The air was filtered every 1.7 min when the system was running. However, the system only ran when A/C was needed, or approximately 50% of the time.
[b] Average of 1-min sampling intervals.
[c] Mean in columns followed by the same letter are not significantly different at the 0.05 level by the L.S.D. procedure.

Table 5. Effect of inadequate air flow on dust control

Filter Type	Turnover[a] rate (min)	No. of particles $\geq 0.5\ \mu m$[b]	No. of particles $\geq 5.0\ \mu m$[b]	Total dust (g)[c]
None	–	200,000 A[d]	35,000 A[d]	2.7825
High efficiency	3.8	150,000 A	24,000 B	1.8628
High efficiency	3.2	60,000 A	17,800 B	–

[a] Amount of time required to filter all of the air in the room one time.
[b] Average of 1-min sampling intervals.
[c] Total dust collected over 24 h sampling periods.
[d] Mean in columns followed by the same letter are not significantly different at the 0.05 level by the L.S.D. procedure.

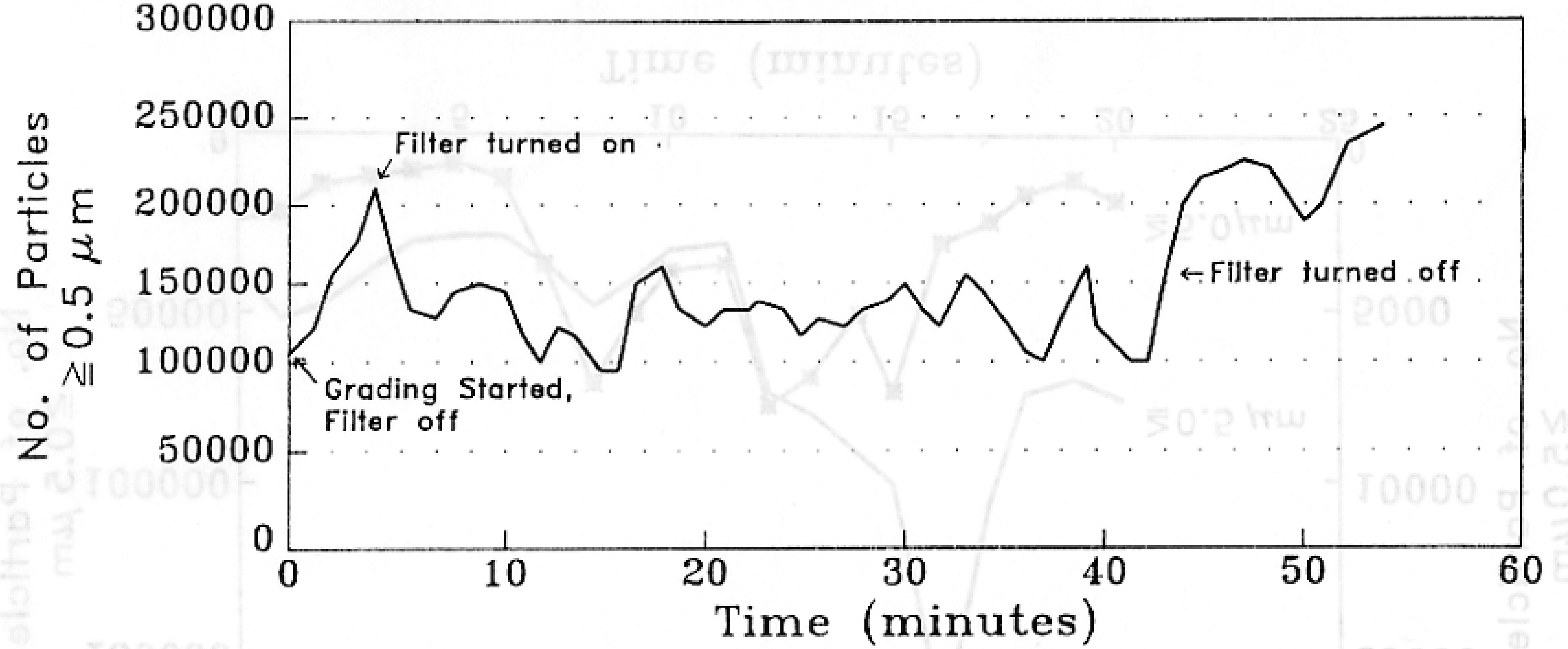

Figure 8. Effect of filtering on dust levels.

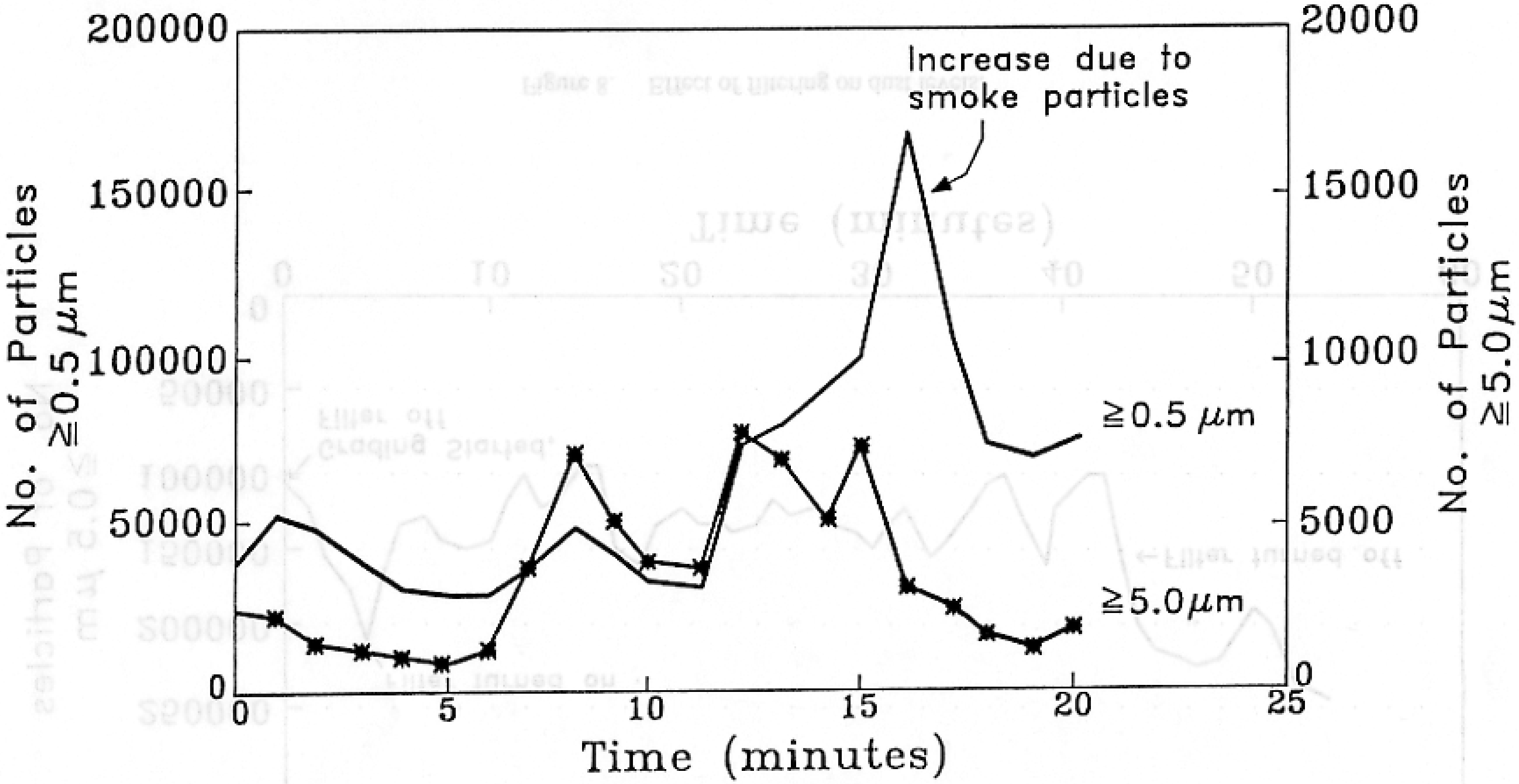

Figure 9. Increase in 0.5 micron particles due to cigarette smoke.

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