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Control Systems

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Elutriated cotton dust levels in the picking and garnetting areas of the Atlanta Federal Penitentiary have been significantly reduced by application of cotton dust control systems. Average levels of 250 and 640 micrograms/cubic meter (ug/m^3) of elutriated dust have been recorded in the picker and garnett rooms respectively. The control systems associated with these levels are discussed with respect to the prison operation and to the proposed cotton dust standard.

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AN EVALUATION OF COTTON DUST CONTROL SYSTEMS

in the

PICKING AND GARNETTING AREAS OF THE ATLANTA
FEDERAL PENITENTIARY

James A. Gideon
Alvin J. Johnson

DISCLAIMER

Mention of company name or product does not constitute
endorsement by the National Institute for Occupational
Safety and Health.

ABSTRACT

Elutriated cotton dust levels in the picking and garnetting areas of the
Atlanta Federal Penitentiary have been significantly reduced by application
of cotton dust control systems. Average levels of 250 and 640 micrograms/
cubic meter ($\mu g/m^3$) of elutriated dust have been recorded in the picker and
garnett rooms respectively. The control systems associated with these levels
are discussed with respect to the prison operation and to the proposed cotton
dust standard.

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INTRODUCTION

Cotton yarn manufacture (opening through carding) includes operations designed to open the cotton from the tightly packed bale, remove some of the "trash," and align the cotton fibers for spinning. Mattress manufacture (garnetting) also employs operations to open the cotton, remove the "trash," and form the cotton into a "lap" for mattresses. The combination of abrasive crushing action by the process machinery and the turbulent action of the process air can result in substantial quantities of fine, airborne dust. The dust particles ("trash") that are of concern from an occupational health viewpoint are those that result from cotton by-products (such as bracts from the plant, bacteria, or dirt) and produce byssinosis. Effective engineering controls on the cotton processing equipment are necessary to avoid the emission of unacceptable levels of this "trash" cotton dust into the workplace.

The amount of trash dust resulting from cotton processing operations depends, in part, on the amount of trash in the cotton. In general, the cotton used in mattress manufacturing will be of a lower quality than the cotton used in yarn manufacturing, and will contain more waste material.

A NIOSH-funded study was initiated in 1973 to document and evaluate existing technology for controlling cotton dust (1). Dust control systems for opening through carding, drawing, and combing were evaluated. This study indicated that working room dust levels could be reduced to 500 $\mu g/m^3$ with available control technology. Following this study, an assessment was made of the picker and garnett room dust control systems at the Atlanta Federal Penitentiary. This later assessment was made to verify results of the original study and to determine the effectiveness of the dust control systems in meeting the proposed cotton dust standard of 200 $\mu g/m^3$.

This report describes the configuration and effectiveness of the dust control systems used in the picker and garnett areas of the Atlanta Federal Penitentiary.

METHOD

Total dust levels were measured in both the picker and garnett rooms with a portable dust monitor to determine the general dust levels and to establish locations for sampling. Standard vertical elutriators with PVC filters were used for sampling, with their intakes located from $4\frac{1}{2}$ to 6 feet from the floor. Samples were taken over several days for approximately 5 hours per day. Samples were collected for the most part in areas judged to be representative of worker locations. A few samples were taken at the locations representing the highest room concentrations, but not necessarily where workers would be exposed. All filters were weighed before sampling and analyzed gravimetrically following sampling. After weighing, the filters from the garnett room were extracted and analyzed for boric acid (which is used as a mattress flame retardant) with a standard wet chemistry technique.

Duct air velocities were measured with a pitot tube using standard measurement techniques.

PICKER ROOM

DESCRIPTION OF PROCESS AND CONTROLS

Picking is the second step in the conventional production of cotton yarn from bulk cotton. The picker accepts bulk cotton that has been opened and partially cleaned and further cleans and forms the cotton into a lap for carding. A detailed description of the picking process is provided by Hamby (2).

The picker room is approximately 70 feet wide by 105 feet long and contains six two-beater pickers, a picker feed system, a Superior cleaner, a waste opener, a waste feeder, two bag filters, two cleaning condensers, and the filtration and air washer systems. Cotton is pneumatically conveyed from a remote opening operation through a cleaning condenser and into a feed blender. From the feed blender, the cotton is passed through a Superior cleaner into a reserve hopper and is conveyed to an overhead cleaning condenser and onto a rake distributor which feeds the pickers. The cotton flow is shown schematically in Figure 1. The picker room typically processes around 300 lb/hr of new medium quality (15/16 inch to 1-1/16 inch staple) cotton for the 6 pickers.

The dust controls for the waste feeder and feed blender are partial enclosure hoods which capture dust by drawing air inward through the blender openings and, to some extent, through other openings in the feeder and cleaner structure.

A typical hood is shown in Figure 2.

The picker feed conveyor and feed hoppers use complete enclosure with a number of four-inch exhaust ports in the conveyor cover to achieve even distribution of exhaust air (2,000 - 4,000 cfm total exhaust). These hood and enclosure applications are typical of a dust control system in which the dust generated within the hood or machine is prevented from escaping by an inward flow of air.

The picker operation depends on an internally generated air flow for cleaning and for forming the tufts of bulk cotton into a lap. The air flow is generated by internal fans which originally discharged the air into an integral filter, as shown in Figures 3 and 4. Improved picker dust control has been accomplished by removing the relatively inefficient internal filters and exhausting the picker directly to the main dust control system (one exhaust duct per beater with about 2,150 cfm per duct). The exhaust air flow is matched to the picker air flow, which is fixed by the lap thickness and density requirements. A typical picker-exhaust system connection is shown in Figure 5.

The air used to transport the cotton from the opening process to the picker room and from the feed blender to the picker feeder is also discharged into the dust control system. Originally, this air was discharged into two bag filters in the room. These filters are no longer used but provisions are

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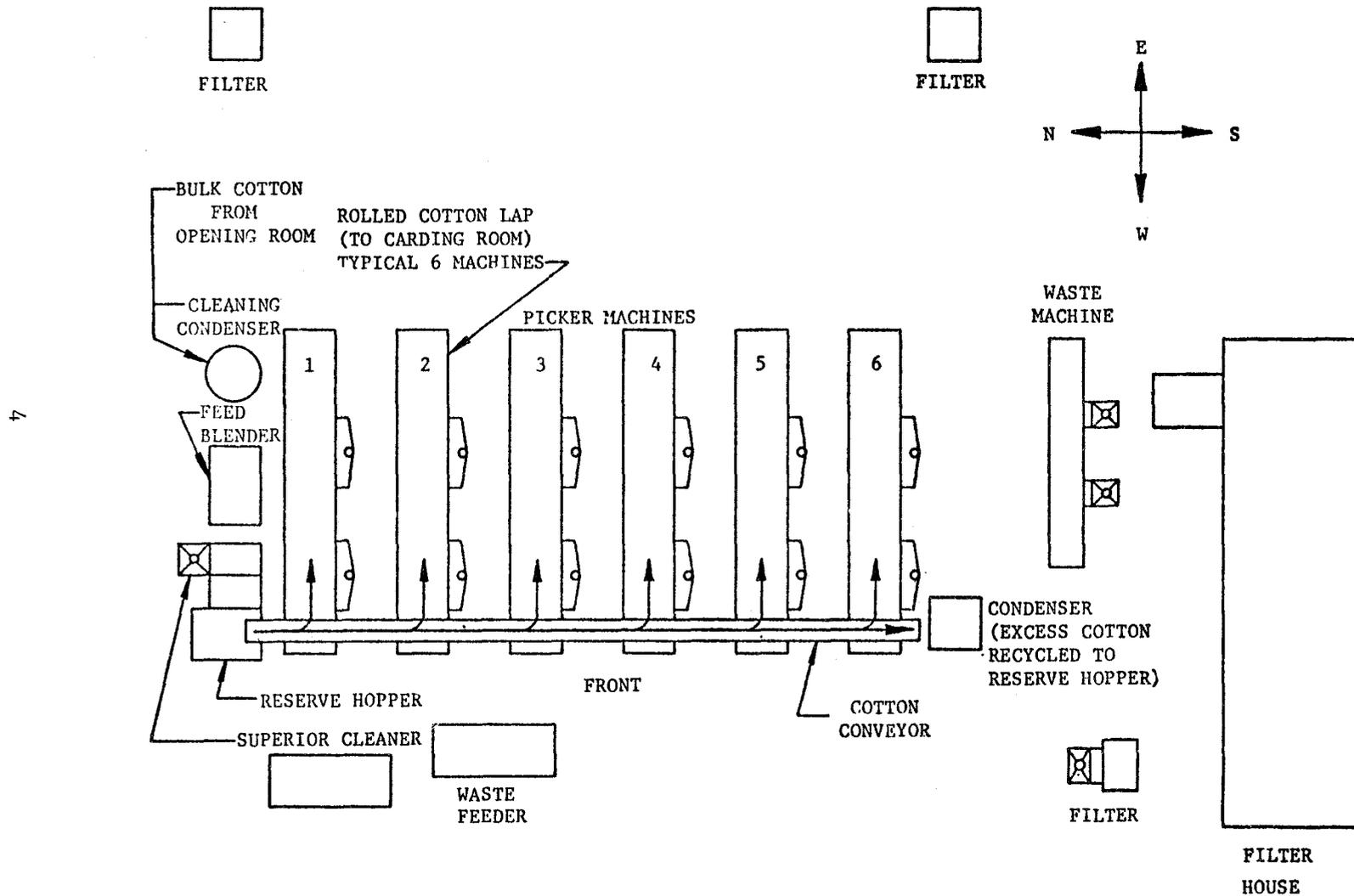
Figure 1. Picker Room Cotton Flow Schematic

Cotton Inlet

Cotton Outlet
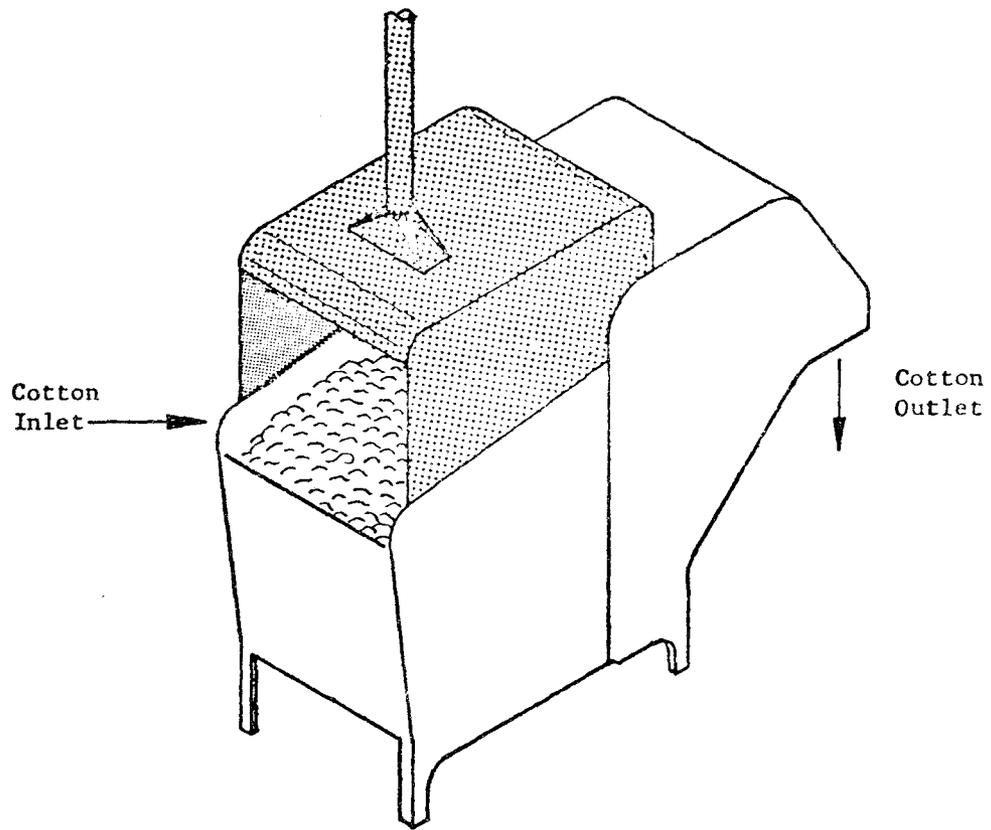
From Hocutt, et al.

Figure 2. Typical Feeder Hood

(Dust Control System Exhaust Connects Here)

Filter (Removed for Dust Control System)
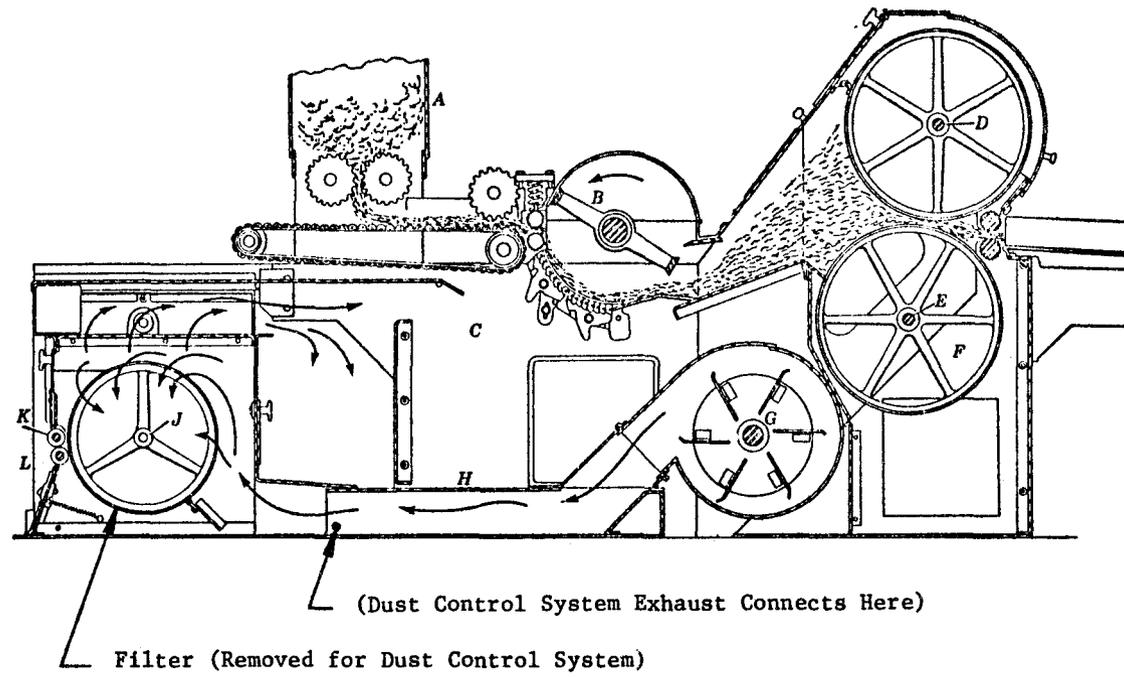
Figure 3. Picker filter and air flow.

Figure 4. Picker

Q = 1500 CFM/Aspirator (Typical)
Duct Velocity = 2500-3000 FPM

Cotton
Inlet

Chute

Reserve
Box

Aspirator Fan Discharge

Figure 5. Typical exhaust connection
for two-beater picker.

retained for their use in the event of a dust control system malfunction. Total air flow in the dust control system is 43,000 cfm.

The process and exhaust air is filtered with three automatically cleaned (Cam-Vac) primary filters followed by a manually cleaned secondary Vee-Cell filter. The secondary filter is a TRK Micromat lint filter medium on a wire mesh backing. The air to filter ratio in the secondary filter is about 130 cfm per square foot of filter.

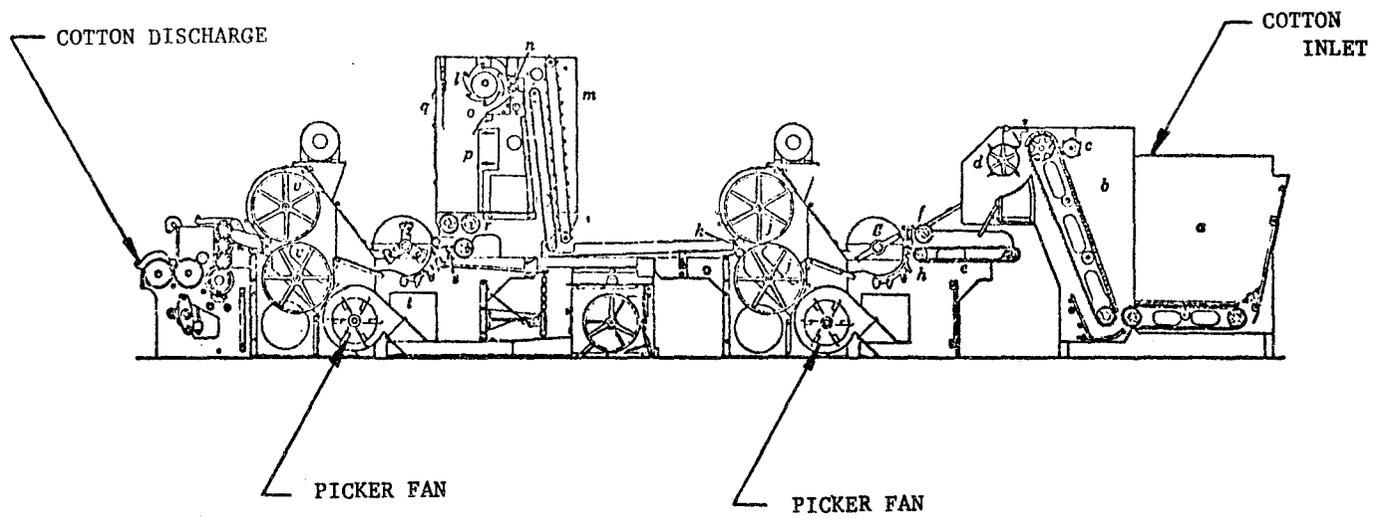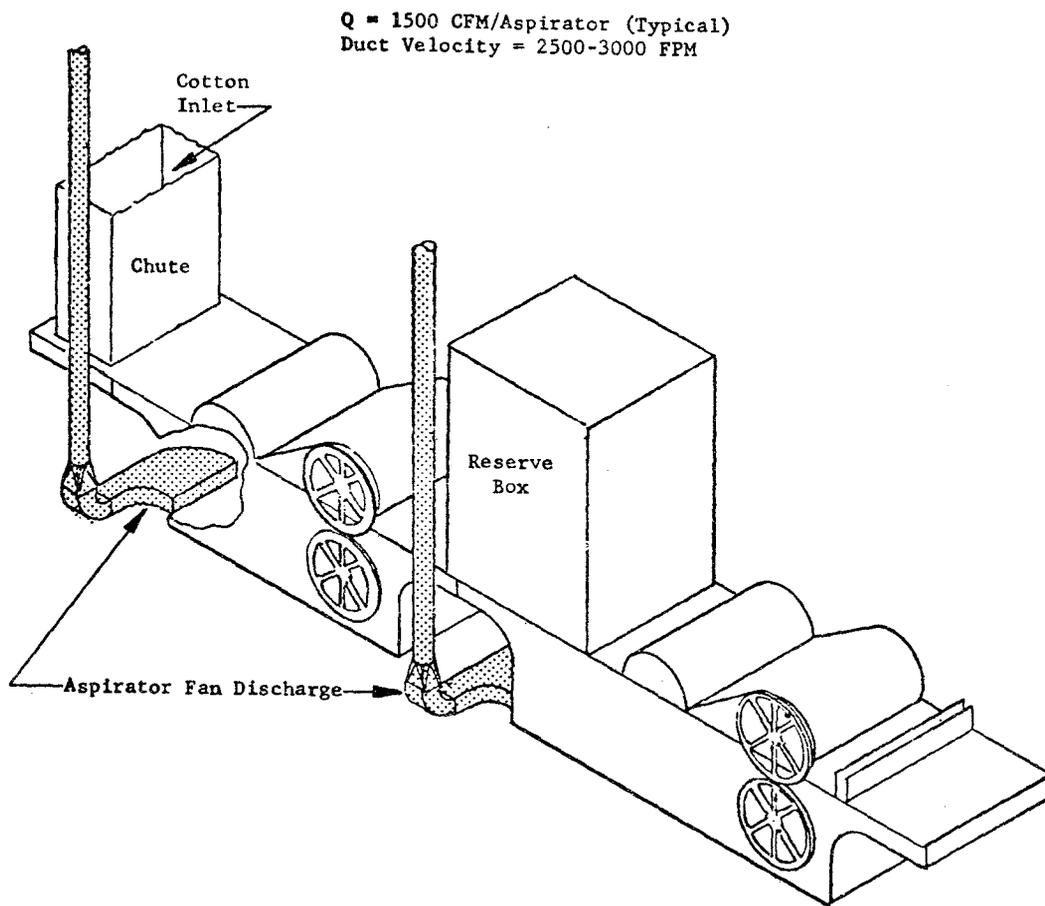Filtered air is discharged from the secondary filter into a plenum where a portion of the air is returned to the room through an air washer. The remaining air is returned directly through louvered doors in the plenum wall or is exhausted directly to the outside depending on temperature and humidity conditions. The air flow split provides for a by-pass of air flow in excess of the washer capacity and for outside make-up air. A schematic of the dust control system is provided in Figure 6.
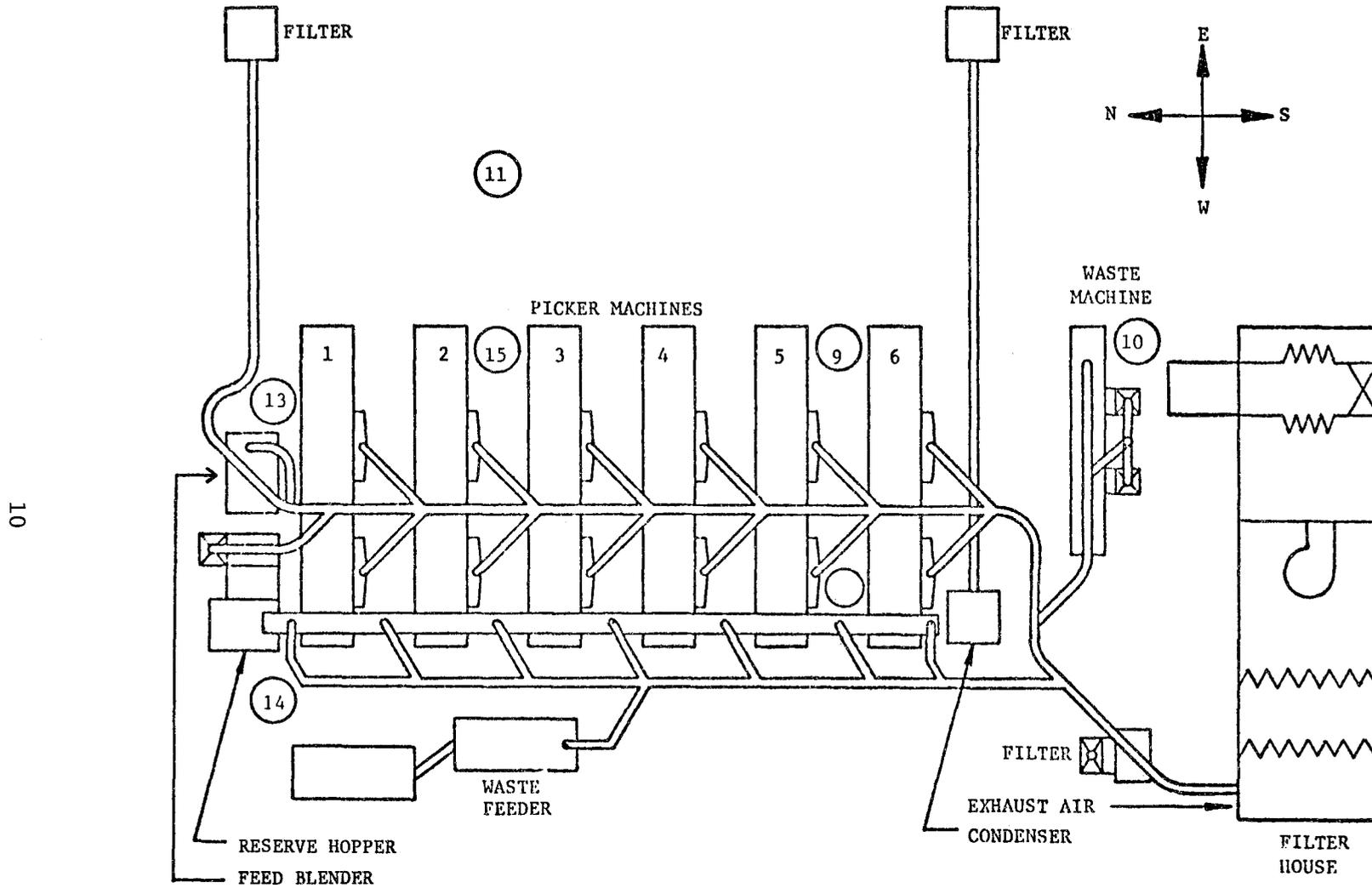
ASSESSMENT RESULTS AND DISCUSSION

A total of three separate evaluations of the picker room dust levels have been made. The first was performed prior to installation of the dust control system in 1975. The second was performed immediately following installation of the dust control system, and the third (in August 1976, of most concern in the present study) approximately one year after installation. In all three cases, samples were taken and analyzed as previously described. The dust levels prior to installation of the dust control system ranged from 430 to 1650 $\mu mg/m^3$ as measured by the vertical elutriator. The measurement locations are shown in Figure 7, and the sampling results are given in Table 1. Following installation of the dust control system, a second set of measurements gave dust levels of 350 to 520 $\mu g/m^3$. Cotton quality and processing rates were unchanged from the initial measurements.

During the second evaluation listed above, the control system was found to be operating at approximately 56,000 cfm total air flow, which is well above the balance point at which system exhaust air matches beater fan air. A total system flow of approximately 45,000 cfm corresponds to the system balance point. A third evaluation (in August 1976) was performed in a manner identical to those described above, after a system balance had been achieved and the secondary filter was being cleaned every other day. Total system air flow was measured at approximately 43,000 cfm in the third evaluation. The dust levels ranged from 130 to 570 $\mu g/m^3$ with an average of 250 $\mu g/m^3$ as seen in Table 2 and Figure 6.

The 450 $\mu g/m^3$ average noted in the second evaluation (after installation but before optimization of the control system) showed a clear improvement over the uncontrolled level (880 $\mu g/m^3$). The results were consistent with those reported by Hocutt, et al.

The 250 $\mu g/m^3$ average noted during the third evaluation was somewhat lower than might be expected based on the relatively minor changes that were made between the second and third evaluations. The same cotton quality and process rates were being used in both cases. The improved filter cleaning technique

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FILTER

FILTER

E

N ← → S

W

⑪

WASTE
MACHINE

⑩

PICKER MACHINES

| 1 | 2 | ⑮ | 3 | 4 | 5 | ⑨ | 6 |

⑬

⑭

WASTE
FEEDER

FILTER

EXHAUST AIR
CONDENSER

FILTER
HOUSE

RESERVE HOPPER

FEED BLENDER

Encircled numbers refer to
sampling locations (elutriators)

Figure 6. Picker room air flow schematic.
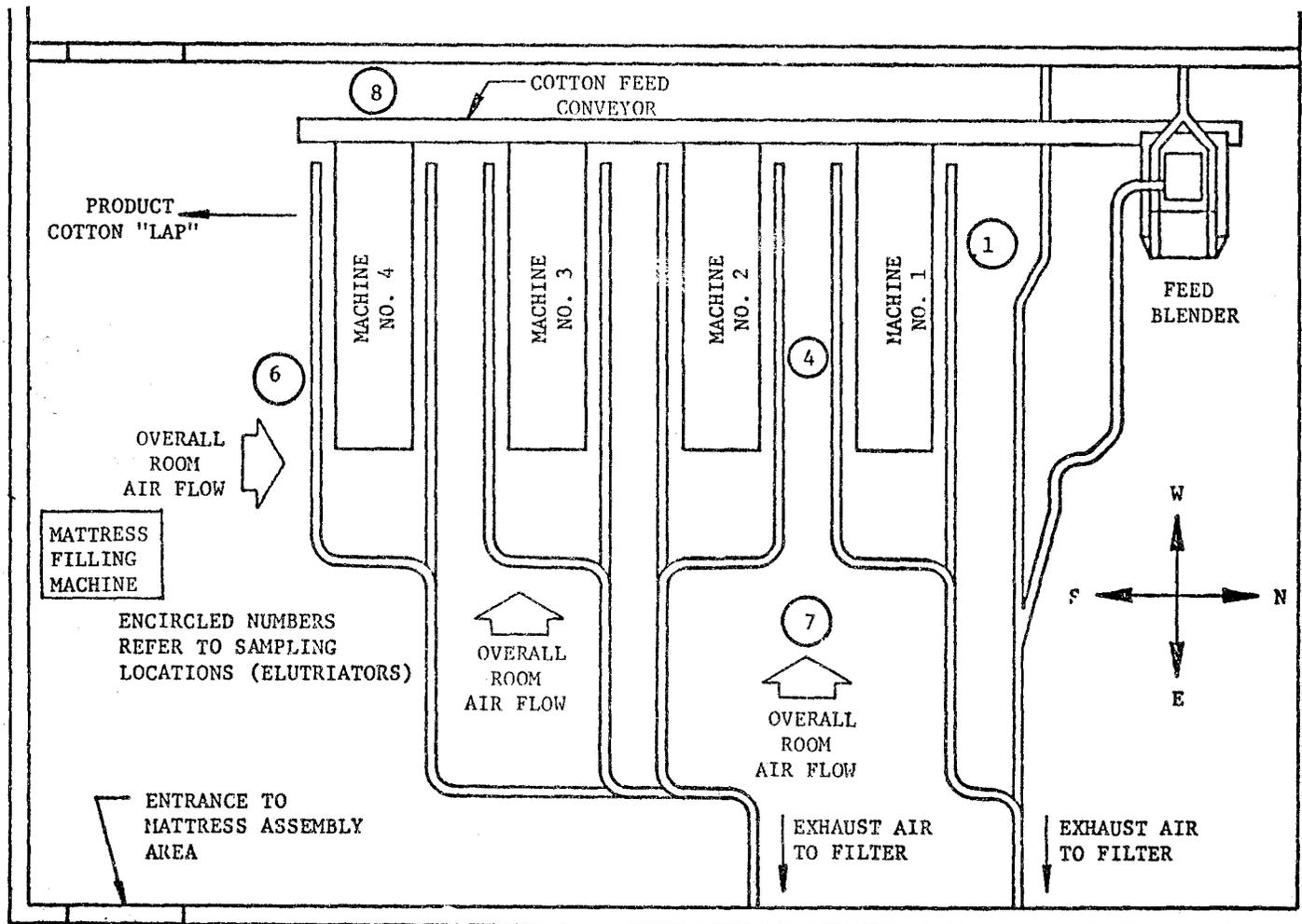
TABLE 1

SUMMARY OF HISTORICAL PICKER ROOM COTTON DUST LEVELS

SAMPLE LOCATION (1.)	DUST CONCENTRATION MICROGRAMS/METER^3		
	BEFORE CONTROLS	AFTER CONTROLS, NOT BALANCED	AFTER CONTROLS, BALANCED (2)
9	430	420	160
10	440	350	250
11	-	-	200
12	970	520	180
13	650	430	210
14	910	490	560
15	-	-	150
Mean Level	880	440	250

(1) Refer to Figure 6.

(2) Refer to Table II.

TABLE 2

COTTON DUST LEVELS AT THE PICKER ROOM
IN THE ATLANTA FEDERAL PENITENTIARY

SAMPLING LOCATION (1)	COTTON DUST LEVEL MICROGRAMS/CUBIC METER			
	SAMPLE 1	SAMPLE 2	SAMPLE 3	AVERAGE
19	190	150	150	160
23	270	230	240	250
11	170	170	200	180
24	230	220	170	210
13	140	240	240	210
12	550	570	570	560
15	170	150	130	150

Average for picker room -   250 micrograms/cubic meter

(1) Refer to Figure 6.

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undoubtedly provided some improvements, as did the optimization of the air flows in the dust control system. Also, the cotton itself might have been cleaner, although there is no direct evidence that this was the case.

Table 1 shows the dust levels before and after installation of the picker dust control systems, and after balancing the dust control systems. A statistical evaluation of the picker room data from the third study is also included in Appendix A. As shown, the mean picker room cotton dust level TWA is 246 $\mu g/m^3$ with a 95 percent upper confidence limit of 307 $\mu g/m^3$. Recalculation of the dust level omitting the 560 $\mu g/m^3$ level found near the reserve hopper gives a mean dust level TWA of 195 $\mu g/m^3$ with a 95 percent upper confidence limit of 235 $\mu g/m^3$. This calculation would apply if improved dust collection were achieved on the reserve hopper or feed blender (which should be possible by increasing the exhaust air flow or redesigning the hood/enclosure). A third calculation of the dust level made by applying weighting factors based on the operator's normal positions in the room gave a mean dust level TWA of 194 $\mu g/m^3$ with a 95 percent upper confidence limit of 225 $\mu g/m^3$. Thus, although a picker room mean cotton dust level TWA at or below 200 $\mu g/m^3$ can be calculated by omitting the high dust level found near the reserve hopper, in no case is the room mean dust level TWA below 200 $\mu g/m^3$ with 95 percent confidence.

Overall, the picker room dust control system is typical of current good industrial control technology. The hooding and dust capture devices generally represent good design practice. Some improvement in duct design could be made, (e.g., the picker feed exhaust ducts tended to clog due to the use of blast gates for balancing). Some improvement could also be made in the feed system enclosure and the picker hopper enclosure. In particular, because the feed system diverter gates formed part of the enclosure, a large opening in the enclosure resulted when these gates opened to feed individual pickers. Given the tendency of the exhaust ducts to plug, the net effect could be significant emissions to the workplace.

The filtration system was not evaluated. However, there is a general consensus that improved air filtration systems are necessary to achieve any significant improvement in the control provided by current technology. Improvements in the picker room filtration system would probably be necessary in order to maintain picker room dust levels consistently below 200 $\mu g/m^3$.

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GARNETT ROOM

DESCRIPTION OF PROCESS AND CONTROLS

Garnetting is a process which takes bulk cotton and transforms it into a mat
suitable for mattress padding. Scrap or recycled cotton is often used in
garnetting operations.

The Atlanta garnett room is approximately 60 feet by 130 feet in size and con-
tains four Franklin-Miller garnetting machines, a filling machine, and a feed
blender. Opened cotton is pneumatically transported to the room and fed to
each garnetting machine by a conveyor belt feed system. Each machine adds a
layer of cotton to a continuous lap which moves from machine 1 to machine 4
(Figure 7). The final lap is cut into mattress-sized pieces as it comes out
of machine 4, near location 6, and is taken to the filling machine area in
the same room. The normal operator positions are in locations 6 and 7.

The rated process capacity is 1200 lb/hour of feed cotton. The actual rate
(including downtime) averages about 900 lb/hour. The feed cotton contains
50 percent 3/3 linters and 50 percent unused strict middlin cotton (15/16 inch
staple). Boric acid is added as a flame retardant to the cotton lap at an
18.75 percent add-on rate. The boric acid is added to the lap from a hopper
located at the garnett discharge. In order to make the boric acid stick to the
cotton, 2.50 gallons per 900 lb cotton of a lightweight naphthenic oil (K Pale
#40) is sprayed on the cotton prior to addition of the boric acid.

The net effect of the ventilation system used to control dust in the garnett
room is something between general ventilation and local exhaust ventilation,
as indicated in Figures 7 and 8. Each garnetting machine has a ten-inch duct
extending the length of the machine (total of eight ducts), with a number of
four-to six-inch exhaust ducts extending vertically from each ten-inch duct.
The exhaust ducts, as indicated in Figure 8, are typically two-to three-foot
sections cut off at a 45 degree angle. Rather than function as an efficient
local exhaust hood, these exhaust ducts create an overall flow of relatively
clean room air across the work stations and toward the dust-producing parts of
the machines, thus reducing operator exposure to dust. Assuming a cross-
sectional area of 1,500 ft^2 for the room and an exhaust of 15,000 cfm from the
garnetting machines, the net overall room flow would be about 10 ft/min. This
value is small compared to normal room air currents. An order-of-magnitude
increase in exhaust air would be required to produce an effective general room
ventilation system with a steady flow of clean air past the operators and into
the equipment.

Partial enclosure of the garnett machines in combination with efficiently de-
signed local exhaust hoods would certainly reduce the requirements for exhaust
air. Clearly, access to the equipment for maintenance purposes would be a major
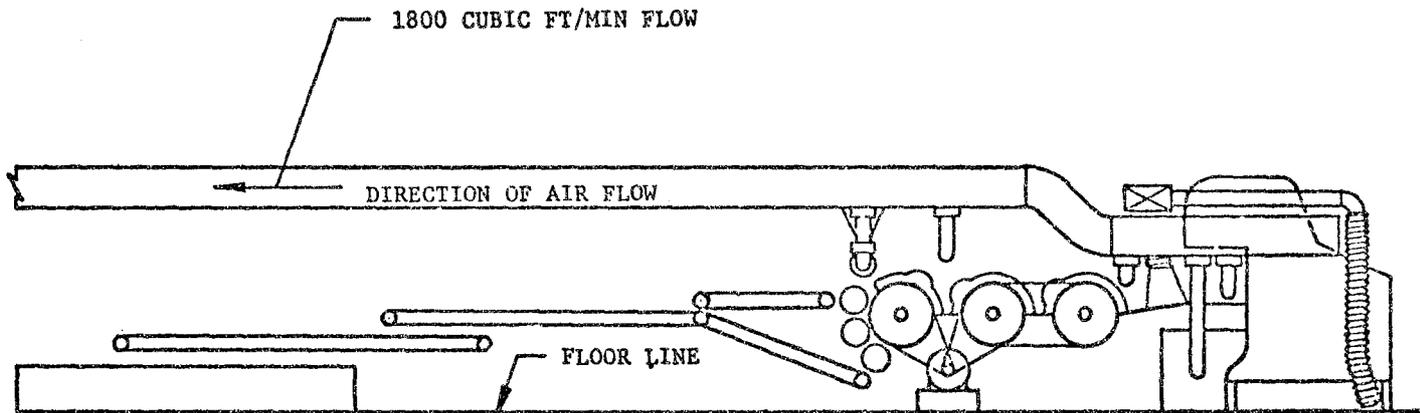concern if the equipment were partially enclosed.

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1800 CUBIC FT/MIN FLOW

DIRECTION OF AIR FLOW

FLOOR LINE

Figure 8. Garnett Machine Dust Control Ductwork

ASSESSMENT RESULTS AND DISCUSSION

The mean dust level in the garnett room was about 10 mg/m^3 prior to the installation of any controls. After installation of the initial control system, the level was 2 - 3 mg/m^3. The most recent study (August 1976) showed a room level of 650 μg/m^3 of elutriated dust. The dust levels at the outlet of the filtered process air (in the room adjoining the garnett room) was 190 μg/m^3. Thirty μg of elutriated boric acid/m^3 was entrained with the garnett room cotton dust, on the average. Table 3 and 4 show these results.

The only significant recognized difference between the garnett room evaluation which showed 2 - 3 mg of dust/m^3 and the most recent study which showed 650 μg/m^3 is the use of the wetting oil/boric acid system. The wetting oil that is used to improve boric acid adherence to the cotton lap may be effective in reducing cotton dust levels as well as boric acid dust levels.

Although the 650 μg/m^3 dust level is good when compared to typical industrial garnetting operations, it is the author's opinion that the dust control capture devices used in the garnetting machines could be substantially improved. The plain end side ducts are inefficient in directing the capture air flow and with regard to system pressure drop. Some type of hooding or partial machine enclosure should be used to more effectively apply the exhaust air flow to the machine emission points. Experimentation would be necessary to determine an optimum configuration and air flow.

The filtration system appeared to be efficient due to the general cleanliness of the filter discharge area. However, a quantitative judgment was not possible due to lack of inlet conditions. The filter discharge concentration of 190 μg/m^3 is slightly less than the proposed 200 μg/m^3. Considerably more efficient filtration would be required to meet the proposed 200 μg/m^3 standard. In fact, meeting such a standard in the Atlanta garnetting operation would be a difficult and expensive process, requiring substantial improvements in both pick up (as noted) and filtration of the cotton dust.

The results from the Atlanta garnett room studies are likely to be somewhat better than typical industrial garnetting operations since the Atlanta operation uses a higher grade of cotton (all new cotton with no floor sweepings or recycled scrap) than typical industry. Even if compliance with a given cotton dust standard could be demonstrated at Atlanta for a certain process/control combination, then that particular process/control combination would not necessarily apply to all of industry because of the difference in feed cotton.

TABLE 3

COTTON DUST LEVELS AT THE GARNETTING ROOM
IN THE ATLANTA FEDERAL PENITENTIARY

A. GARNETTING ROOM

SAMPLING LOCATION (1)	COTTON DUST LEVEL MICROGRAMS/CUBIC METER			
	SAMPLE 1	SAMPLE 2	SAMPLE 3	AVERAGE
1	1050	620	530	730
4	-	-	840	840
6	800	500	630	640
7	570	670	300	510

Average for Garnetting Room - 650 micrograms/cubic meter

B. RETURN AIR FROM THE GARNETTING ROOM FILTER

SAMPLING LOCATION (1)	COTTON DUST LEVEL, MICROGRAMS/CUBIC METER
2	160
3	210

Average for Return Air - 190 micrograms/cubic meter

(1) Refer to Figure 7.

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TABLE 4

GARNETTING ROOM ELUTRIATED BORIC ACID,
ATLANTA FEDERAL PENITENTIARY

A. GARNETTING ROOM

SAMPLING LOCATION (1)	BORIC ACID LEVEL, MICROGRAMS/CUBIC METER			
	SAMPLE 1	SAMPLE 2	SAMPLE 3	AVERAGE
1	60	70	10	50
4	--	--	10	10
6	50	20	20	30
7	10	10	5	8

Average Boric Acid - 30 micrograms/cubic meter

B. RETURN AIR FROM THE GARNETTING ROOM FILTER SYSTEM

SAMPLING LOCATION (1)	BORIC ACID LEVEL, MICROGRAMS/CUBIC METER
2	10
3	3

Average Boric Acid - 7 micrograms/cubic meter

(1) Refer to Figure 7.

CONCLUSIONS

- The picker dust control system provides a significant improvement in room dust levels and is operating essentially as designed.

- The picker dust control system at the Atlanta Federal Penitentiary is able to control elutriated cotton dust to the $200 - 300$ $\mu g/m^3$ level. It is possible to calculate a mean room dust level of 200 $\mu m/m^3$ by omitting the high dust levels near the feed blender but the room mean dust level is still not statistically (95 percent confidence level) below 200 $\mu g/m^3$.

- The garnetting dust control system provides an order-of-magnitude reduction in dust levels compared to an uncontrolled operation. However, the garnetting dust control system could be substantially improved in efficiency of dust capture at the source.

- The garnetting dust control system will not achieve a 200 $\mu g/m^3$ cotton dust level as designed and currently operated and would require substantial improvement to do so.

- Boric acid dust does not appear to be a problem in the garnetting room.

RECOMMENDATIONS

- The frequency and rate of filter cleaning in both the picking and garnetting systems should be reduced, consistent with proper operation of the system blower, in order to increase filter efficiency.

- Filter efficiency tests should be performed to determine the optimum filter pressure drop and to determine the effect of the cotton dust level in the filtered return air on the room concentration.

- The cause of the high levels of cotton dust in the picker room near the reserve hopper should be investigated, and appropriate corrective action should be taken.

- Covers should be installed over the picker feed conveyor cover openings caused by the cotton diverter gate operation.

- The blast gates should be removed from the picker feed conveyor exhaust ducts and the exhaust ducts resized if necessary.

- The garnetting dust capture system should be redesigned to increase capture efficiency.

REFERENCES

1. Hocutt, R. H., H. S. Barr, J. B. Smith. "Cotton Dust Controls in Yarn Manufacturing," DHEW Publication No. 71-114 (1974).

2. Hamby, D. S. (Ed), "The American Cotton Handbook," Interscience Publishers (1966).

APPENDIX A

STATISTICAL TREATMENT OF THE PICKER ROOM COTTON
DUST DATA, ATLANTA FEDERAL PENITENTIARY

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APPENDIX A

STATISTICAL TREATMENT OF THE PICKER ROOM COTTON
DUST DATA, ATLANTA FEDERAL PENITENTIARY

INTRODUCTION

This attachment contains a statistical evaluation of the Atlanta cotton dust
data prepared by the National Institute for Occupational Safety and Health,
Division of Technical Services, Statistical Services Branch. Only the data
collected in the picker room has been analyzed. The garnetting room is ex-
cluded because all data values exceed the proposed standard. The return air
from the garnetting room is also excluded due to lack of data. The method of
statistical analysis, results, and conclusions are given. Also included are
some additional points which should be considered in interpreting the results.
The main question addressed in the statistical analysis was whether the avail-
able data provides assurance that the proposed daily time-weighted average
personal exposure standard of 200 $\mu g/m^3$ was met on any of three sampling days.

PROTOCOL

The proposed standard for cotton dust exposure is a time-weighted average of
the exposures a single worker receives during the course of an eight-hour work
day. The proposed level of the standard is 200 g/m . Because the standard is
based on a time-weighted average, and appropriate procedure for analysis is to
compute time-weighted averages for each day and to construct confidence inter-
vals about the computed values. A summary statement of the individual conclusions
can then be made.

A problem encountered with the proposed method of analysis is the lack of repli-
cations; that is, the absence of measurements duplicated at each location on
each day. This makes it impossible to use the sampling data itself to estimate
the variation which is due to experimental error. This estimate is required to
construct the desired confidence intervals.

In a memorandum by Dr. Laurence J. Doemeny (NIOSH, Division of Physical Sciences
and Engineering) dated March 1, 1977, a theoretical derivation for estimating
the variance of a sample concentration is presented. This formula is as follows:

$$\text{Var } (x) = \frac{1}{V^2 t^2} \left\{ \sigma^2_{M_f} + \sigma^2_{M_i} + (\Delta M)^2 \left[\frac{\sigma^2_V}{V^2} + \frac{\sigma^2_t}{t^2} \right] \right\}$$

where x = concentration ($\mu g/m^3$)

    V = sampling rate (m^3/min)

    t = sampling time (min)

    M_f = final filter weight (μg)

    M_i = initial filter weight (μg)

    ΔM = weight of dust sample (μg)

    $\sigma^2_{M_f}$ = variance of final weight (μg^2)

    $\sigma^2_{M_i}$ = variance of initial weight (μg^2)

    σ^2_V = variance of sampling rate ($(m^3/min)^2$)

    σ^2_t = variance of sampling time (min^2)

It should be noted that $\Delta M = M_f - M_i = xVt$.

The following values are assigned to parameters in the above equation based on estimates provided by Dr. Doemeny.

$$\sigma^2_{M_f} = (50 \; \mu g)^2 = 2500 \; \mu g^2$$

$$\sigma^2_{M_i} = (50 \; \mu g)^2 = 2500 \; \mu g^2$$

$$\frac{\sigma^2_V}{V^2} = (0.05)^2 = 0.0025 = \text{(coefficient of variation of sampling rate)}^2$$

$$\sigma^2_t = (2 \; min)^2 = 4 \; min^2$$

We feel that the scientific investigations performed to estimate these values have provided valid results. Also, where a range of values was given, the more conservative value was chosen to avoid underestimation of the variances. Thus, the equation can now be written as:

$$\text{Var}(x) = \frac{1}{V^2 t^2} \left\{ 5000 + (xVt)^2 \left[0.0025 + (4/t^2) \right] \right\}$$

The formula used to compute the time-weighted average is

$$\bar{x}_w = \frac{\sum\limits_{i=1}^{7} w_i x_i}{\sum\limits_{i=1}^{7} w_i} \, ,$$

where w_i = time-weight assigned to location i

x_i = sample concentration at location i.

The formula for the estimated variance of the time-weighted average is

$$s_{\bar{x}_w}^2 = \left[\sum\limits_{i=1}^{7} w_i^2 \, \text{Var}(x_i) \right] / \left[\left(\sum\limits_{i=1}^{7} w_i \right)^2 \right]$$

A one-sided confidence interval for $\bar{x}_w$ is then defined by

$$\bar{x}_w + Z_{1-\alpha} \, s_{\bar{x}_w}$$

For this report, $\alpha = 0.05$ was chosen to provide a $(1 - \alpha) \times 100\%$ upper confidence limit. Thus, there is 95% confidence that an employee's true daily average exposure level is below the calculated upper limit on that particular sampling day (assuming a time-exposure pattern corresponding to the chosen weights).

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RESULTS

The data is presented in Tables A and B. Table A contains the sampling times, sample concentrations, and estimated standard deviations for each location on each day. Location numbers correspond to those shown in the floor plan furnished in Figure 6. The flow rates of the elutriators are listed by location in Table B.

Table C shows the three weighting schemes used in the computation of time-weighted averages and upper confidence limits. The results of the computations are given in Table D.

The first weighting scheme consists of equal weights for all locations. This is identical to computing unweighted averages. Under this scheme, the time-weighted averages ranged from 243 to 247 $\mu g/m^3$. The corresponding 95% upper confidence limits range from 263 to 268 $\mu g/m^3$.

The next group of weights was also based on equal time spent at each position, except for the feed blender which was omitted from the average. Under this weighting scheme, the time-weighted averages ranged from 188 to 195 $\mu g/m^3$. The smallest 95% upper confidence limit was 209 $\mu g/m^3$.

The third scheme of weights also excludes the feed blender area. In addition, it is assumed that the total amount of time spent between the picker machines is equivalent to the time spent in each of the other locations. Under these assumptions, the time-weighted averages are 194, 203, and 208 $\mu g/m^3$ with 95% upper confidence limits of 222, 224, and 239 $\mu g/m^3$, respectively.

CONCLUSION

Using the sets of weighting factors presented in Table C, it is not possible to conclude with 95% confidence that the true daily average exposures for a single wokrer were under the proposed standard on any of the three days which were sampled. There are several points which should be considered before accepting this as an ultimate result.

1) The time-weight factors are only estimates. It is possible that there exists a set of weights for which the proposed standard is being met. A time-motion study would be required to validate any set ot these weighting factors.

2) Because the 95% upper confidence limits are reasonably close to the proposed standard, the use of administrative control to lower the exposure times of the workers might prove to be useful in meeting the standard.

3) A 50% action level would be exceeded for any set of weights.

SUMMARY

Based on the data and the weights assigned to each sampling location, it is not possible to conclude with 95% confidence that the proposed standard was met on any of the three days. Points relevant to the results are discussed as part of the conclusions.

REFERENCES - APPENDIX A

1. Hocutt, et al., Cotton Dust Controls in Yarn Manufacturing, NIOSH Technical Information Report No. 74-114.

2. The American Cotton Handbook, Volume I, Third Edition, Interscience Publishers.

3. Cotton Dust - Proposed Standards for Exposure and Notice of Hearing. Federal Register, Tuesday, December 28, 1976, Part III.

TABLE A

CONCENTRATIONS, SAMPLING TIMES AND STANDARD DEVIATIONS OF
CONCENTRATION FOR COTTON DUST STUDY

LOCATION	SAMPLE	CONCENTRATION (μg/m^3)	SAMPLING TIME (MIN)	STANDARD DEVIATION (μg/m^3)
9	1	190	300	32
	2	150	395	24
	3	150	250	37
10	1	270	310	32
	2	230	385	26
	3	240	255	38
11	1	170	297	32
	2	170	395	25
	3	200	265	36
12	1	230	315	32
	2	220	390	26
	3	170	265	36
13	1	140	290	34
	2	240	435	25
	3	240	265	39
14	1	550	324	40
	2	570	435	36
	3	570	270	45
15	1	170	285	36
	2	150	430	24
	3	130	255	39

TABLE B

SAMPLING RATES FOR EACH LOCATION IN THE COTTON DUST STUDY

LOCATION	SAMPLING RATES	
	(m^3/min)	(liters/min)
9	0.00772	7.72
10	0.00775	7.75
11	0.00770	7.70
12	0.00756	7.56
13	0.00724	7.24
14	0.00745	7.45
15	0.00718	7.18

TABLE C

WEIGHTS ASSIGNED FOR SAMPLING LOCATIONS

LOCATION	WEIGHTING SCHEME		
	1	2	3
9	1	1	1/3
10	1	1	1
11	1	1	1
12	1	1	1/3
13	1	1	1
14	1	0	0
15	1	1	1/3

TABLE D

TIME-WEIGHTED AVERAGES, STANDARD DEVIATIONS AND 95% UPPER CONFIDENCE
LIMITS FOR EACH SAMPLE UNDER THREE WEIGHTING SCHEMES

Weighting Scheme	SAMPLE 1			SAMPLE 2			SAMPLE 3		
	TWA	SD	UCL	TWA	SD	UCL	TWA	SD	UCL
1	246	13	267	247	10	263	243	15	268
2	195	14	218	193	10	209	188	15	213
3	194	17	222	203	13	224	208	19	239