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## COTTON DUST

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# Dust in Cotton Gins: An Overview

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The results of studies and surveys of air-borne dust conducted in cotton ginneries in the U.S. within the last decade are summarized. Gin dust levels in the major U.S. production areas were found to be in the same range for similarly harvested cotton. Gins processing machine-stripped cotton had higher dust levels than those handling spindle-picked cotton, and roller gins were dustier than saw gins. The location of a gin in relation to its dust and trash collecting equipment outside the gin was of major importance in the occurrence of dust in gins, and the dust content of ambient air outside gins also had a major impact on dust levels within gins. Particulate size, concentration and chemical constituent data are also reported.

The criteria document (1) for a recommended standard for occupational exposure to cotton dust defines cotton dust as dust generated into the atmosphere as a result of the processing of cotton fibers combined with any naturally occurring materials such as stems, leaves, bracts, and inorganic matter which may have accumulated on the cotton fibers during the growing or harvesting period.

Our interest in cotton dust has three aspects. One has to do with the physical effects of cotton dust on the processing performance of cotton in spinning mills. Excessive amounts of cotton dust may cause machinery stoppages and thereby add to product manufacturing costs. The second aspect concerns the health of workers in cotton spinning mills and cotton gins; and the third aspect is that of gin emissions into the ambient atmosphere. The recent U.S. Environmental Protection Agency (EPA) report (2) listing cotton gins as one of the seven

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primary sources of atmospheric arsenic gives an added sense of urgency to the need for careful study of the situation. This report relates to the health of gin employees and is a general summary of our knowledge of dust in and around cotton gins.

There were 2,332 active gins in the U.S. in 1979 (3). These gins with a typical employment of 9 persons per shift, ginned 14,161,000 bales of cotton. These bales may be subdivided by cotton type into about 14,061,000 bales of Upland cotton and 100,000 bales of American Pima cotton. The Upland cottons have shorter, weaker, and higher micronaire fiber than the Pima cottons, and are ginned on gins using the saw-and-rib principle whereas the Pimas are ginned on roller gins that create fewer fiber neps. The method of harvesting cotton offers another interesting way of categorizing the crop; harvesting by spindle-pickers accounted for 62 percent of the crop with stripper-harvesting accounting for 37 percent of the crop. The methods of harvest and ginning will be important as the dust and its composition data are presented.

#### Dust Levels in Ambient Atmosphere

Our first cotton dust measurements were made in 1967 when one of the authors of this paper measured the ambient dust concentrations downwind from three Mississippi cotton gins (4). The results of this study showed that uncontrollable variations in wind direction and velocity during sampling adversely affected the reliability of the measurements and made the data difficult to analyze. It was also found that the airborne dust burden by winds from unpaved approach roads and cotton-trailer parking areas often overshadowed that emitted by the gins. It soon became apparent that the principal impact of gins in Mississippi on ambient air quality was principally that of a nuisance. Improved cyclone collectors and filters were developed and used in gins to eliminate all but the finest of particulates released by cotton during gin processing (5, 6, 7, 8, 9).

Durrenberger (10, 11) in 1973 studied airborne particulates at varying distances from gins in Texas. He developed a prediction equation for estimating the dust concentration in air downwind from gins. The equation was based on ginning rate, foreign matter content of the cotton as harvested, and took into account the amount of emission control equipment in use at the gin. His study showed that the heavier particulates released into the atmosphere fell to earth near the gin but that the finer particles were transported several hundred meters.

#### Dust Levels in Cotton Gins

Airborne dust concentrations inside Midsouth and Texas gins were measured by Wesley (12, 13) in 1972, 1973 and 1974 and are summarized in Table I. The gins did not have the same hourly

TABLE I  
 Representative Dust Levels at Three Locations Within Commercial Cotton Gins in Arkansas,  
 Mississippi, and Texas<sup>a</sup>

Gin	Harvest method	Respirable Dust, mg/m <sup>3</sup>		Lint cleaner		Press		Total Dust, mg/m <sup>3</sup>	
		Console	Lint cleaner	Press	Console	Press	Console	Lint cleaner	Press
1	1972 Miss Spindle	High	0.33	0.84	0.94	ns	ns	ns	ns
		Low	0.20	0.50	0.14	ns	ns	ns	ns
2	1972 Miss Spindle	High	0.76	0.53	0.92	ns	ns	ns	ns
		Low	0.07	0.32	0.08	ns	ns	ns	ns
3	1973 Miss Spindle	High	0.59	1.13	0.51	2.66	3.75	2.49	2.49
		Low	0.13	0.49	0.23	0.45	0.47	0.23	0.23
4	1973 Miss Spindle	High	0.98	1.07	0.97	2.29	3.39	3.49	3.49
		Low	0.37	0.44	0.15	0.49	0.27	0.24	0.24
5	1974 TX Stripper	High	3.78	3.41	5.02	4.93	9.28	6.09	6.09
		Low	1.82	2.04	1.98	1.48	0.97	2.58	2.58
6	1974 TX Stripper	High	3.67	ns	2.53	3.83	ns	2.99	2.99
		Low	1.54	ns	1.21	0.77	ns	0.62	0.62
7	1974 Ark Spindle	High	1.92	0.83	0.50	1.90	1.28	1.23	1.23
		Low	0.45	0.72	0.30	0.41	0.80	0.29	0.29
8	1974 Ark Spindle	High	0.97	0.49	0.43	2.79	1.94	0.96	0.96
		Low	0.66	0.43	0.32	0.34	0.45	0.26	0.26

<sup>a</sup>From Wesley (12).

<sup>b</sup>ns = not sampled.

processing capacity, and the cottons ginned were dissimilar in variety, production history, and method of harvest. The data listed represent high's and low's for individual measurements. Levels of both total dust as measured using a high-volume air sampler and respirable dust as measured using a large vertical elutriator are reported for three distinct areas within the same gin. When the Mississippi gins are considered as a group, the lint cleaner area generally had the highest dust level, while the baling press and console areas had approximately the same dust concentration. The console area of the Arkansas gins generally had the highest dust level, and the press area the lowest. The Texas gins handling stripper-harvested cotton were dustier than the Mississippi and Arkansas gins handling spindle-picked cotton. The lowest levels found in the stripper-cotton gins were higher than the highest dust levels in the gins processing spindle-picked cotton. These data point out that the dust level varies with location inside gin plants as well as the method used to harvest the cotton.

Hughes (14) studied dust levels in a California gin in 1978. He found widely varying dust levels at both the baling press and gin stand areas that were roughly in the same range as in Wesley's Mississippi study, Table II.

Kirk, Leonard, and Brown (15) did an excellent study of dust in New Mexico gins in 1973. They examined roller gins as well as saw gins and found that air in the gin stand area was dustier than air near the baling press in both kinds of gins. They also found that roller gins processing Pima cotton were considerably more dusty than gins processing Acala (upland) spindle-picked cotton, Table II.

A new gin for ginning spindle-picked cotton was constructed in the Mississippi Delta in 1977. The layout of the machinery, doors, and waste collecting system was designed to reduce worker and community exposure to airborne dust by optimizing functional area locations with respect to the prevailing winds from the southwest and northwest. Dust levels were measured in this gin (16) during the peak of the ginning period in 1979, and were found to be:

Ambient upwind, respirable dust	0.053 mg/m <sup>3</sup>
Ambient downwind, respirable dust	0.791 mg/m <sup>3</sup>
Inside the gin, respirable dust at	
Gin stands	0.282 mg/m <sup>3</sup>
Lint cleaners	0.354 mg/m <sup>3</sup>
Baling press	0.289 mg/m <sup>3</sup>

Inside the gin, total dust at

Gin stands	0.500 mg/m <sup>3</sup>
Lint cleaners	0.801 mg/m <sup>3</sup>
Baling press	0.481 mg/m <sup>3</sup>

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Airborne Dust Concentrat  
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State	Year	Gin type	H: m
California <sup>a</sup>	1978	Saw	S
Texas <sup>b</sup>	1974	Saw	S
MS Delta <sup>b</sup>	1975	Saw	S
New Mexico <sup>c</sup>	1973	Saw	S
New Mexico <sup>c</sup>	1973	Roller	S

<sup>a</sup>See Literature Cited (14)

<sup>b</sup>See Literature Cited (15)

<sup>c</sup>See Literature Cited (16)

<sup>d</sup>ns = not sampled.

TABLE II  
Airborne Dust Concentrations in Commercial Gins in Four  
Geographic Areas and in New Mexico From Two Types of Gins

State	Year	Gin type	Harvest method	Location in gin	Dust concentration mg/m <sup>3</sup>	
					Respirable	Total
California <sup>a</sup>	1978	Saw	Spindle	Press-High	1.184	1.926
				Low	0.397	0.646
				Gin High	1.639	2.234
				stands Low	0.347	0.552
Texas <sup>b</sup>	1974	Saw	Stripper	Press High	4.16	ns <sup>d</sup>
				Low	1.87	ns
				Gin High	3.02	ns
				stands Low	2.60	ns
MS Delta <sup>b</sup>	1975	Saw	Spindle	Press High	1.02	ns
				Low	0.07	ns
				Gin High	0.92	ns
				stands Low	0.15	ns
New Mexico <sup>c</sup>	1973	Saw	Spindle	Press Avg	0.56	1.02
				Stand Avg	0.90	1.93
New Mexico <sup>c</sup>	1973	Roller	Spindle	Press Avg	1.75	4.05
				Stand Avg	2.85	6.51

<sup>a</sup>See Literature Cited (14).

<sup>b</sup>See Literature Cited (13).

<sup>c</sup>See Literature Cited (15).

<sup>d</sup>ns = not sampled.

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These data, when compared to data from the other gins fall within the high and low values reported for older gins, handling similar types of cotton. Thus, the low values reported in this paper appear to be the result of ginning relatively clean cottons or from cotton ginned when ambient wind direction was favorable, or both, rather than resulting from an intentional machinery layout pattern.

In summary, dust levels in ginneries may cluster about a central value, but actual values are highly dependent upon the natural, and usually uncontrollable, production and harvesting situation that exists at the time.

#### Composition of Gin Dust

As cotton is brought under the unloading suction telescopes at a gin, one may observe in the load of seed cotton foreign material such as leaf parts; unopened whole bolls; boll fragments; pieces of field weeds, grasses, and vines; soil particles; and sometimes insect residues and evidence of fungal/bacterial infection. Fragments of these materials are carried over into the baled lint in spite of gin efforts to remove them. There are several opportunities in the ginning system for particles of these materials to be released into the atmosphere along with fugitive fibers. Morey's (17) statement that cotton dusts emitted during opening, cleaning, and carding of raw cottons in textile mills should be relatively rich in bract, leaf and weed microparticulate applies equally well to dust in gins.

In his analysis of parts of mature cotton plants, Brown (18) reported constituents in roots, stem, leaves, bolls, seed and lint. In Table III, I have listed his values for leaves and lint which are among the principle components of unginmed cotton. These data do not show the presence of crop protection or harvest aid chemicals.

Wesley and Wall (19) collected and analyzed airborne dust samples collected from three areas within five Mississippi gins in 1975. The general composition of their samples are summarized in Table IV. These data show the dust to be about 30 percent cellulosic, the remainder being soil and other materials. The quantitative elemental analysis of their samples is detailed in Table V. Although the percentages are different, the constituents in these samples of gin dust are very similar to those listed by Brown (18) in whole plant parts. None of the data presented have identified residues from insecticides or harvest aid chemicals. This may be because they were not specifically sought.

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TABLE III  
Chemical Analysis of Leaf and Lint Parts of Mature Cotton Plants<sup>a</sup>  
(percent dry basis)

Constituent	Leaf	Lint
Nitrogen	2.25	0.18
Phosphoric acid	0.48	0.09
Potash	1.09	0.59
Lime	5.28	0.70
Magnesia	0.94	0.14
Iron oxide	0.43	0.16
Soda	0.66	0.07
Sulphuric acid	1.05	0.09
Silica	1.70	0.07
Ash	12.55	1.25
Protein	14.06	1.12
Fiber	8.71	87.02
Fat	8.49	0.61
Carbohydrates	56.19	10.00

<sup>a</sup>After Brown (18).

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Table IV  
Chemical Separation of Cotton Dust Collected in  
Mississippi Gins, Crop of 1975<sup>a</sup>

Material	Composition (percent)
Ash	32.9
Protein	11.8
Moisture	3.4
Water soluble component	12.6
Alcohol soluble component	1.7
Noncellulose organic	24.7
Cellulose	30.5
Residual inorganic	27.1

<sup>a</sup>After Wesley and Wall (19).

TABLE V  
Quantitative Elemental Analysis by X-ray Fluorescence  
of Cotton Dust Collected in Mississippi Gins, Crop of 1975<sup>a</sup>

Element	Percentage	Element	Percentage
Si	7.69	S	0.32
K	1.82	Cl	0.16
Al	1.46	Cu	0.08
Ca	1.15	Ti	0.05
Mg	1.04	Zn	0.05
P	0.52	Mn	0.01
Fe	0.49		

<sup>a</sup>After Wesley and Wall (19).

As pointed out earlier, all U.S. cotton in commercial production is now harvested by machines. The application of harvest-aid chemicals to cause the plants to shed their leaves (defoliation) or to kill and dry the plant (desiccation) are common practices in many areas. Chlorates and organic phosphates are popular defoliant materials and arsenic acid is commonly used as a desiccant.

Paganini (20) in 1966 found arsenic in the air near cotton gins in Texas in concentrations of 0.01-141 ug/m<sup>3</sup> at distances of 150 to 8000 feet from the gin. Schacht and LePori (21) reported on chemical properties of cotton gin waste from six gins in Texas in 1977. They included gins handling only desiccated stripper-harvested and non-desiccated spindle-harvested cotton. They observed a striking difference in arsenic levels in gin wastes from the two areas; the As level from the desiccated cottons was 0.02%, but was only 0.001% from the non-desiccated cottons (Table VI).

Mean Values

Item
Volatile <sup>b</sup>
Carbon
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Nitrogen
Sulfur
Oxygen and error
Arsenic - in ar
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TABLE VI  
Mean Values for Chemical Composition of Ginning Wastes at  
Six Texas Gins, Crop of 1977<sup>a</sup>

Item	Composition, percent
Volatile <sup>b</sup>	85
Carbon	42
Hydrogen	5.4
Nitrogen	1.4
Sulfur	1.7
Oxygen and error	34.5
Arsenic - in areas using arsenical desiccants	0.02
Arsenic - in areas not using arsenical desiccants	0.001

<sup>a</sup>After Schacht and LePori (21).

<sup>b</sup>Heated 7 minutes at 950°C.

Although arsenic was not initially reported in the samples studied by Wesley and Wall, re-examination of one of the samples did show it to be present. The cotton from which this sample came probably had not been desiccated; the arsenic could have had its origin in the soil from earlier days or as fiber residue from chemical pest control during the present cotton-growing season.

#### Present Status and Outlook

We are presently readjusting our research program at the U.S. Cotton Ginning Laboratory at Stoneville, MS, to take advantage of newly developed rapid response instrumentation for measuring airborne dust concentrations, as well as the cotton dust analyzer described by Baker (22). We are expanding cooperative relationships with other USDA-ARS research units to obtain chemical and biological analyses heretofore unavailable to us. We expect to continue our efforts to reduce airborne dusts in the vicinity of cotton gins, and to identify and quantify not only the elements present, but also identify residues from growth regulators, pesticides and herbicides as well as desiccants and defoliant. This work will include analyses of materials remaining on the fibers being baled for commercial use.

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