

## ENGINEERING AND GINNING

### First Stage Seed-Cotton Cleaning System Total Particulate Emission Factors and Rates for Cotton Gins: Method 17

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#### ABSTRACT

**This report is part of a project to characterize cotton gin emissions from the standpoint of stack sampling. The impetus behind this project was the urgent need to collect additional cotton gin emissions data to address current regulatory issues. A key component of this study was focused on Environmental Protection Agency (EPA) total particulate emission factors. EPA AP-42 emission factors generally are assigned a rating, from A (excellent) to E (poor), to assess the quality of the data being referenced. Current EPA total particulate emission factor ratings for cotton gins are extremely low. Cotton gin data received these low ratings because the data were collected almost exclusively from a single geographical region. The objective of this study was to collect additional total particulate emission factor data for 1<sup>st</sup> stage seed-cotton cleaning systems from cotton gins located in regions across the cotton belt using EPA-approved stack sampling methodology. The project plan included sampling seven cotton gins. Key factors for selecting specific cotton gins included: 1) facility location, 2) production capacity, 3) processing systems, and 4) abatement technologies. All seven gins had 1<sup>st</sup> stage seed-cotton cleaning systems. The average production rate during testing for the seven gins was 31.8 bales/h. The average 1<sup>st</sup> stage seed-cotton cleaning system total particulate emission factor based on seven tests (18 total test runs) was 0.152 kg/227-kg bale (0.334 lb/500-lb bale). This average total particulate emission factor was less than that**

**currently published in 1996 EPA AP-42, which was 0.17 kg/bale (0.36 lb/bale). The 1<sup>st</sup> stage seed-cotton cleaning system emission rate test averages ranged from 1.87 to 8.93 kg/h (4.13-19.68 lb/h).**

U.S. Environmental Protection Agency (EPA) emission factors published in EPA's Compilation of Air Pollution Emission Factors, AP-42 (EPA, 1996b) are assigned a rating that is used to assess the quality of the data being referenced. Ratings can range from A (excellent) to E (poor). Current EPA emission factor quality ratings for total particulate from cotton gins are extremely low. Cotton gin data received these low ratings because they were collected almost exclusively from a single geographical region, far western U.S. (EPA, 1996a). Cotton ginners' associations across the cotton belt, including the National, Texas, Southern, Southeastern, and California associations, agreed that there was an urgent need to collect additional cotton gin emissions data to address current regulatory issues. Working with the cotton ginning associations across the country, state and federal regulatory agencies, Oklahoma State University, and USDA-Agricultural Research Service (ARS) researchers developed a proposal and sampling plan that was initiated in 2008 to address this need for additional data. This report is part of a series that details cotton gin emissions measured by stack sampling. Each manuscript in the series addresses a specific cotton ginning system. The systems covered in the series include: unloading, 1<sup>st</sup> stage seed-cotton cleaning, 2<sup>nd</sup> stage seed-cotton cleaning, 3<sup>rd</sup> stage seed-cotton cleaning, overflow, 1<sup>st</sup> stage lint cleaning, 2<sup>nd</sup> stage lint cleaning, combined lint cleaning, cyclone robber, 1<sup>st</sup> stage mote, 2<sup>nd</sup> stage mote, combined mote, mote cyclone robber, mote cleaner, mote trash, battery condenser, and master trash. This report focuses on total particulate emissions from 1<sup>st</sup> stage seed-cotton cleaning systems.

The 1996 EPA AP-42 average total particulate emission factor for the No. 1 dryer and cleaner was 0.17 kg (0.36 lb) per 217-kg [480-lb] equivalent bale with a range of 0.11 to 0.25 kg (0.24 to 0.54 lb) per bale (EPA, 1996a, b). This average and range was based on seven tests conducted in one geographical location. The

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EPA emission factor quality rating was D, which is the second lowest possible rating (EPA, 1996a).

Seed-cotton is a perishable commodity that has no real value until the fiber and seed are separated (Wakelyn et al., 2005). Cotton must first be processed or ginned at the cotton gin to separate the fiber and seed, producing 227-kg (500-lb) bales of marketable cotton fiber. Cotton ginning is considered an agricultural process and an extension of the harvest by several federal and state agencies (Wakelyn et al., 2005). Although the main function of the cotton gin is to remove the lint fiber from the seed, many other processes also occur during ginning, such as cleaning, drying, and packaging the lint. Pneumatic conveying systems are the primary method of material handling in the cotton gin. As material reaches a processing point, the conveying air is separated and emitted outside the gin through a pollution control device. The amount of dust emitted by a system varies with the process and the condition of the material in the process.

Cotton ginning is a seasonal industry lasting from 75 to 120 days, depending on the size and condition of the crop. Although the trend for U.S. cotton production remained generally flat at approximately 17 million bales per year during the last 20 years, annual production varied greatly for various reasons, including climate and market pressure (Fig. 1). The number of active gins in the U.S. has not remained constant, steadily declining to fewer than 700 in 2011. Consequently, the average volume of cotton handled by each gin has risen and gin capacity has increased to an average of approximately 25 bales per hour across the U.S. cotton belt (Valco et al., 2003, 2006, 2009, 2012).

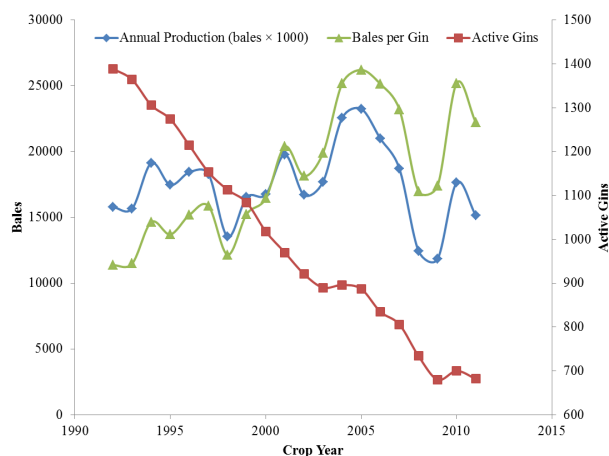


Figure 1. Annual U.S. cotton production, active U.S. gins, and average ginning volume (bales per gin) (NASS, 1993-2012).

The typical cotton gin facility includes: unloading system, dryers, seed-cotton cleaners, gin stands, overflow collector, lint cleaners, battery condenser, bale packaging system, and trash handling systems (Fig. 2); however, the number and type of machines and processes varies. Each of these systems serves a unique function with the ultimate goal of “ginning” the cotton to produce a marketable product. Raw seed-cotton harvested from the field is compacted into large units called “modules” for delivery to the gin. The unloading system removes seed-cotton either mechanically or pneumatically from the module feed system and conveys the seed-cotton to the seed-cotton cleaning systems. Seed-cotton cleaning systems dry the seed-cotton and remove foreign matter prior to ginning. Ginning systems also remove foreign matter and separate the cotton fiber from the seed. Lint cleaning systems further clean the cotton lint after ginning. The battery condenser and packaging systems combine lint from the lint cleaning systems and compress the lint into dense bales for easy transport. Gin systems produce some type of by-product or trash, such as rocks, soil, sticks, hulls, leaf material, and short or tangled immature fiber (motes), as a result of processing the seed-cotton or lint. These streams of by-products must be removed from the machinery and handled by trash collection systems. These trash systems typically further process the by-products (e.g., mote cleaners) and/or consolidate the trash from the gin systems into a hopper or pile for subsequent removal.

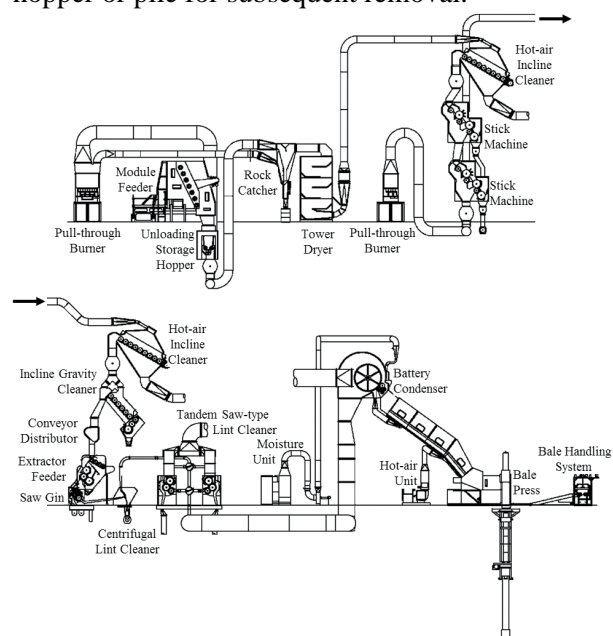
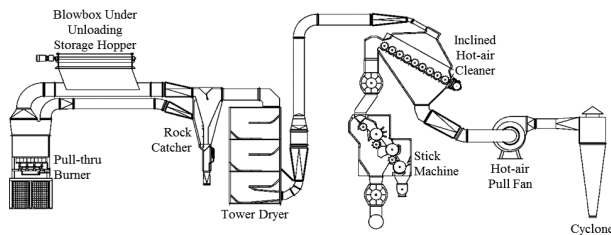


Figure 2. Typical modern cotton gin layout (Courtesy Lummus Corporation, Savannah, GA).

Seed-cotton is cleaned and dried in the seed-cotton cleaning systems. In the typical 1<sup>st</sup> stage seed-cotton cleaning system (Fig. 3), seed-cotton is pneumatically conveyed with heated air from either the feed control or module feeder through a dryer to the seed-cotton cleaning machinery. The seed-cotton is pulled directly into the seed-cotton cleaning machinery and separated from the conveying airstream by the cleaning mechanism (called a “hot-air” cleaner) or separated from the conveying air via a screened separator and dropped into the cleaning machinery. Seed-cotton cleaning machinery includes cleaners or extractors. Each stage often employs two cleaners in series. This system removes foreign matter that includes rocks, soil, sticks, hulls, and leaf material. The airstream from the 1<sup>st</sup> stage seed-cotton cleaning system continues through a centrifugal fan to an abatement system; generally one or more cyclones. This cleaning system might use air heated to 117°C (350°F) at the seed-cotton and air mixing point to accomplish drying during transport (ASABE, 2007). Based on system configuration, the airstream temperature at the abatement device could range from ambient to approximately 50% of the mixing-point temperature. The material handled by the abatement system is typically the same as that removed by the seed-cotton cleaning machinery (rocks, soil, sticks, hulls, and leaf material) and lint extracted with the trash (Fig. 4).



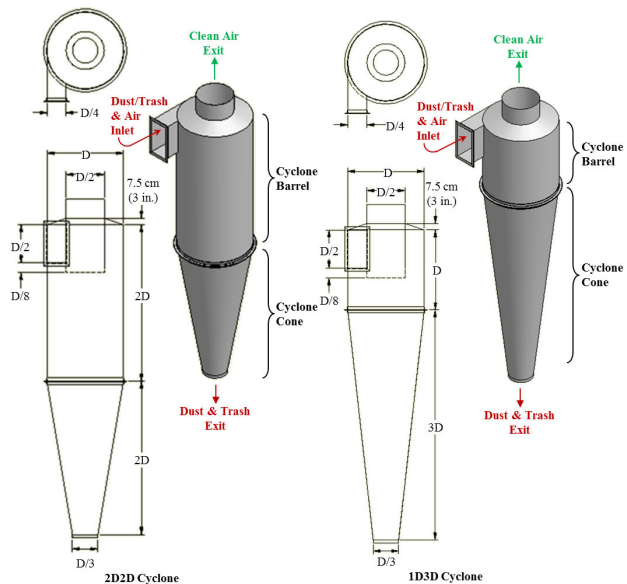
**Figure 3. Typical cotton gin 1<sup>st</sup> stage seed-cotton cleaning system layout (Courtesy Lummus Corporation, Savannah, GA).**



**Figure 4. Photograph of typical trash captured by the 1<sup>st</sup> stage seed-cotton cleaning cyclones.**

Cyclones are the most common particulate matter (PM) abatement devices used at cotton gins. Standard cyclone designs used at cotton ginning facilities are the 2D2D and 1D3D (Whitelock, et al., 2009). The first D in the designation indicates the length of the cyclone barrel relative to the cyclone barrel diameter and the second D indicates the length of the cyclone cone relative to the cyclone barrel diameter. A standard 2D2D cyclone (Fig. 5) has an inlet height of D/2 and width of D/4 and design inlet velocity of  $15.2 \pm 2$  m/s ( $3000 \pm 400$  fpm). The standard 1D3D cyclone (Fig. 5) has the same inlet dimensions as the 2D2D or might have the original 1D3D inlet with height of D and width D/8. Also, it has a design inlet velocity of  $16.3 \pm 2$  m/s ( $3200 \pm 400$  fpm).

The objective of this study was to collect additional total particulate emission factor data for 1<sup>st</sup> stage seed-cotton cleaning systems with cyclones for emissions control at cotton gins located in regions across the cotton belt based on EPA-approved stack sampling methodologies.



**Figure 5. 2D2D and 1D3D cyclone schematics.**

## METHODS

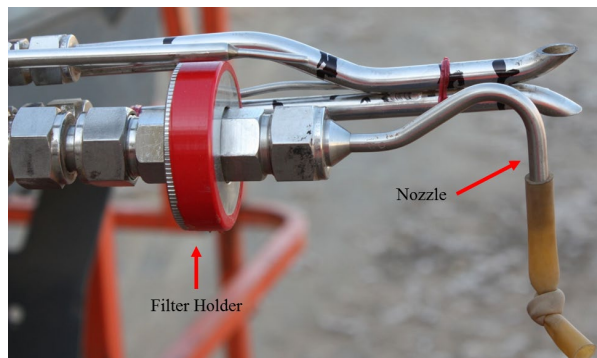
Two advisory groups were established for this project. The industry group consisted of cotton ginning industry leaders and university and government researchers. The air quality group included members from state and federal regulatory agencies, and university and government researchers. Both groups were formed to aid in project planning, gin selection, data analyses, and reporting. The project plan was described in detail by Buser et al. (2012).

Seven cotton gins were sampled across the cotton belt. Key factors for selecting specific cotton gins included: 1) facility location, 2) production capacity, 3) processing systems, and 4) abatement technologies. Operating permits, site plans, and aerial photographs were reviewed to evaluate potential sites. On-site visits were conducted on all candidate gins to evaluate the process systems and gather information including system condition, layout, capacities, and standard operation. Using this information, several gins from each selected geographical region were selected and prioritized based on industry advisory group discussions. Final gin selection from the prioritized list was influenced by crop limitations and adverse weather events in the region.

Based on air quality advisory group consensus, EPA Method 17 (CFR, 1978) was used to sample the 1<sup>st</sup> stage seed-cotton cleaning system at each gin. Method 17 was selected over Method 5 (CFR, 1987) because of the relatively low stack temperatures found at cotton gins. Method 5 requires a heated glass probe and filter holder to maintain the sampled gas temperature of 120°C (248°F). Key benefits of using Method 17 over Method 5 are where particulate concentrations are independent of temperature and the sampled gas contains no liquid droplets or is not saturated with water vapor, the heating systems can be eliminated and sampling can occur at stack temperature with an in-stack filter. Methodology for sampling total particulate called for withdrawing particulate-laden stack gas isokinetically (the velocity of the gas entering the sampler was equal to the velocity of the gas in the stack) through a button-hook nozzle and then collecting particles on an in-stack filter (Fig. 6). The methods for retrieving the filter and conducting acetone washes of the sampling nozzle are described in Method 17 (CFR, 1978). The mass of particulate on the filter and in the nozzle wash was determined by gravimetric analyses. The total particulate mass was determined by summing the mass of particulates on the filter and the front half wash. Stack gas temperature and moisture content were also measured using EPA Method 17.

Only one stack from each 1<sup>st</sup> stage seed-cotton cleaning system was tested. For systems with multiple stacks, it was assumed that emissions from each stack of the system were equivalent. The total particulate emissions for the system were calculated by multiplying the measured emission rates by the total number of cyclones used to control the process tested (EPA, 1996a). To obtain reliable results, the

same technician from the same certified stack sampling company (Reliable Emissions Measurements, Auberry, CA), trained and experienced in stack sampling cotton gins, conducted all the tests at all the cotton gins.



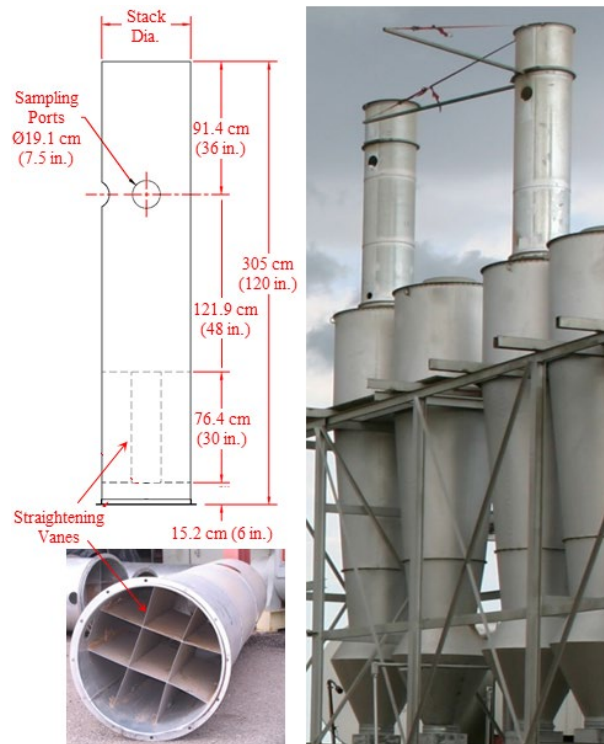
**Figure 6. EPA Method 17 total particulate button-hook nozzle and in-stack filter holder photograph.**

All stack sampling equipment was purchased from Apex Instruments (Fuquay-Varina, NC) and met Method 17 specifications. The sampling media were 47-mm Zefluor filters (Pall Corporation, Port Washington, NY) and the sample recovery and analytical reagent was American Chemical Society certified acetone (A18-4, Fisher Chemical, Pittsburgh, PA; assay  $\geq 99.5\%$ ). Filters, wash tubs, and lids were prelabeled and preweighed and stored in sealed containers at the USDA-ARS Air Quality Lab (AQL) in Lubbock, TX, and then transported to each test site. Prior to testing, the technician calibrated all sampling equipment according to EPA Method 17.

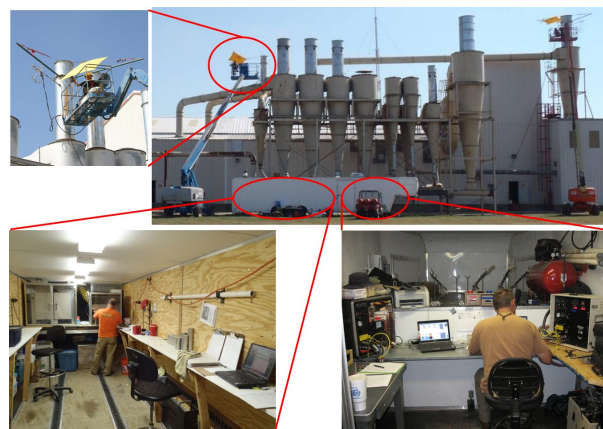
Each cyclone selected for testing was fitted with a cyclone stack extension that incorporated two sampling ports (90° apart) and airflow straightening vanes to eliminate the cyclonic flow of the air exiting the cyclone (Fig. 7). The extensions were designed to meet EPA criteria (EPA, 1989) with an overall length of 3 m (10 ft) and sampling ports 1.2-m (48-in) downstream from the straightening vanes and 0.9-m (36-in) upstream from the extension exit.

The tests were conducted by the technician in an enclosed sampling trailer at the base of the cyclone bank (Fig. 8). Sample retrieval, including filters and nozzle acetone washes, was conducted according to Method 17. After retrieval, filters were sealed in individual Petri dishes and acetone washes were dried on-site in a conduction oven at 49°C (120°F) and then sealed with preweighed lids and placed in individual plastic bags for transport to the AQL in Lubbock, TX for gravimetric analyses. During testing, bale data (ID number, weight, and date/time of

bale pressing) were either manually recorded by the bale press operator or captured electronically by the gin's computer system for use in calculating emission factors in terms of kg/227-kg bale (lb/500-lb bale). Emission factors and rates were calculated in accordance with Method 17 and ASAE Standard S582 (ASABE, 2005).



**Figure 7. Schematic and photographs of stack extensions with sampling port and straightening vanes (rail attached to extension above sampling port, at right, supports sampling probe during testing traverse).**

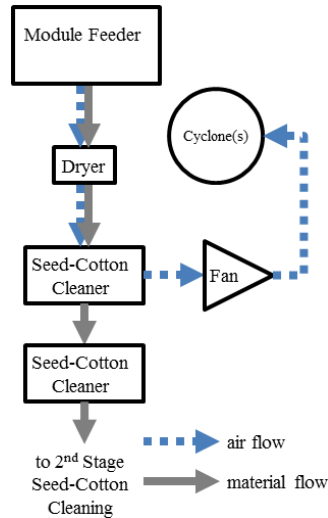


**Figure 8. Clockwise from top right: cotton gin stack sampling with air quality lab trailer and technicians on lifts; certified stack sampling technician in the trailer control room conducting tests; sample recovery in trailer clean room; technician operating the probe at stack level.**

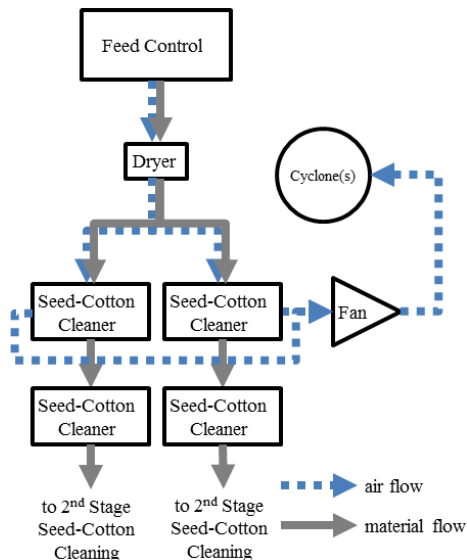
All laboratory analyses were conducted at the AQL. All filters were conditioned in an environmental chamber ( $21 \pm 2^\circ\text{C}$  [ $70 \pm 3.6^\circ\text{F}$ ];  $35 \pm 5\%$  RH) for 48 h prior to gravimetric analyses. Filters were weighed in the environmental chamber on a Mettler MX-5 microbalance (Mettler-Toledo Inc., Columbus, OH;  $1 \mu\text{g}$  readability and  $0.9 \mu\text{g}$  repeatability) after being passed through an antistatic device. The MX-5 microbalance was leveled on a marble table and housed inside an acrylic box to minimize the effects of air currents and vibrations. To reduce recording errors, weights were electronically transferred from the microbalance directly to a spreadsheet. Technicians wore latex gloves and a particulate respirator mask to avoid contamination. AQL procedures required that each sample be weighed three times. If the standard deviation of the weights for a given sample exceeded  $10 \mu\text{g}$ , the sample was reweighed. Gravimetric procedures for the acetone wash tubs were the same as those used for filters.

In addition to gravimetric analyses, each sample was visually inspected for unusual characteristics, such as cotton lint content or extraneous material. Digital pictures were taken of all filters and washes for documentation purposes. After the laboratory analyses were completed all stack sampling, cotton gin production, and laboratory data were merged.

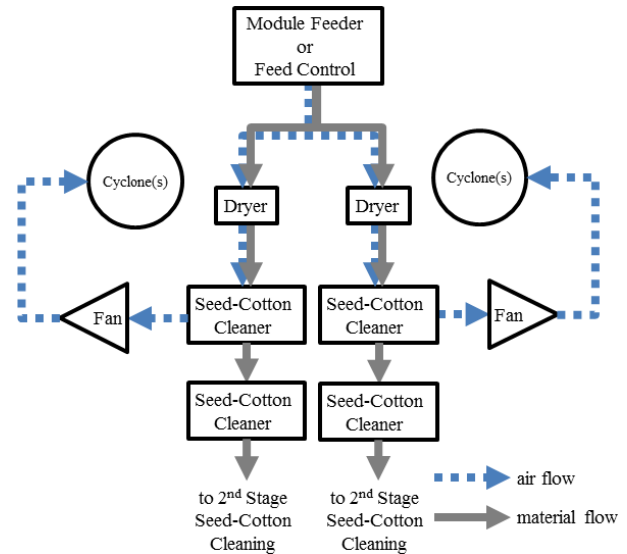
All seven gins (A, B, C, D, E, F, and G) had 1<sup>st</sup> stage seed-cotton cleaning systems. The 1<sup>st</sup> stage seed-cotton cleaning systems sampled were typical for the industry. Gins B, E, and G had similar 1<sup>st</sup> stage seed-cotton cleaning systems (Fig. 9). The seed-cotton material was pneumatically conveyed from the module feeder to a series of seed-cotton cleaners. The material was separated from the airstream by the first cleaner. The air then passed through a fan and exhausted through one or more cyclones. The gin A system used a feed-control unit to regulate the flow of seed-cotton (Fig. 10). The material was conveyed pneumatically from the feed-control unit through a dryer then the material stream was split. The air was separated from each stream by the first set of parallel cleaners. The two airstreams then merged and passed through a fan and exhausted through one or more cyclones. The 1<sup>st</sup> stage seed-cotton cleaning systems at gins D and F were similar to the systems at gins B, E, and G except the material stream was split into two parallel systems after the feed control or module feeder (Fig. 11). The 1<sup>st</sup> stage seed-cotton cleaning system for gin C was similar to the system at gin F except there were separate feed-control units for the parallel systems (Fig. 12).



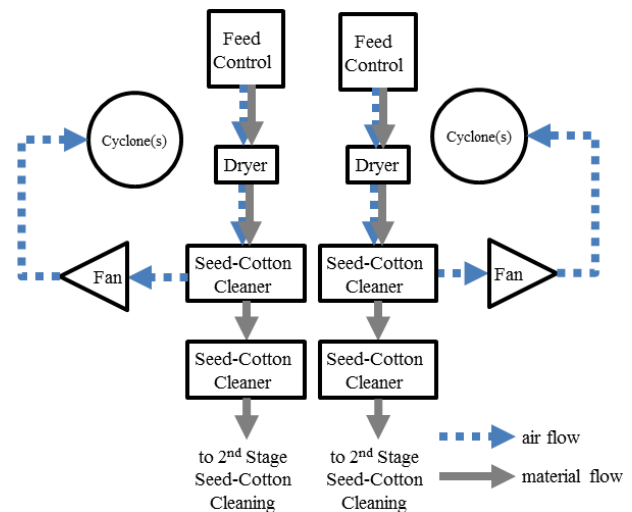
**Figure 9.** Schematic of single stream/single fan 1<sup>st</sup> stage seed-cotton cleaning system fed directly by a module feeder (gins B, E, and G).



**Figure 10.** Schematic of split stream/single fan 1<sup>st</sup> stage seed-cotton cleaning system fed by a feed control (gin A).



**Figure 11.** Schematic of split stream/double fan 1<sup>st</sup> stage seed-cotton cleaning system fed by a feed control (gin D) or fed directly by a module feeder (gin F).



**Figure 12.** Schematic of completely separate systems split stream/double fan 1<sup>st</sup> stage seed-cotton cleaning system fed by a feed control (gin C).

All 1<sup>st</sup> stage seed-cotton cleaning systems sampled utilized 1D3D cyclones to control emissions (Fig. 5), but there were some cyclone design variations among the gins (Table 1 and Fig. 13). All the gins, except gin E, split the system exhaust flow between two cyclones in a dual configuration (side by side as opposed to one behind another). The system airstream for gin E was exhausted through a single cyclone. Inlets on all the 1<sup>st</sup> stage seed-cotton cleaning cyclones were 2D2D type, except the cyclones at gin C that had inverted 1D3D inlets. Expansion chambers were present on

1<sup>st</sup> stage seed-cotton cleaning cyclones at all gins, except gins E and F, which had standard cones. All of the cyclone variations outlined above, if properly designed and maintained, are recommended for controlling cotton gin emissions (Whitelock et al., 2009). The cyclones at gin F had angle-iron welded inside and down the length of the cone (Fig. 14). This is occasionally done by cyclone manufacturers for systems with high particulate loading, especially sand, to encourage material to exit the cyclone more quickly and reduce cone wear; this is not a recommended practice.

Table 1. Abatement device configuration<sup>z</sup> for 1<sup>st</sup> stage seed-cotton cleaning systems tested.

Gin	Cyclone Type	Inlet Design <sup>y</sup>	Systems per Gin	Cyclones per Gin	Configuration	Cone Design	Trash Exit <sup>x</sup>
A	1D3D	2D2D	1	2	Dual	expansion chamber	hopper
B	1D3D	2D2D	1	2	Dual	expansion chamber	auger
C	1D3D	Inverted 1D3D	2	4	Dual	expansion chamber	hopper
D	1D3D	2D2D	2	4	Dual	expansion chamber	hopper
E	1D3D	2D2D	1	1	Single	standard	auger
F	1D3D	2D2D	2	4	Dual	standard	auger
G	1D3D	2D2D	1	2	Dual	expansion chamber	auger

<sup>z</sup> Figures 5 and 13

<sup>y</sup> Inverted 1D3D inlet has duct in line with the bottom of the inlet

<sup>x</sup> Systems to remove material from cyclone trash exits: hopper = large storage container directly under cyclone trash exit; auger = enclosed, screw-type conveyor



Figure 13. Cyclone design variations for the tested systems (left to right): dual configuration that splits flow between identical 1D3D cyclones with 2D2D inlets; 1D3D cyclone with an inverted 1D3D inlet; 1D3D cyclone with 2D2D inlet and expansion chamber on the cone; 1D3D cyclone with 2D2D inlet and standard cone.



Figure 14. Angle-iron welded to the inside surface of cyclone cone at gin F.

## RESULTS

Table 2 shows the test parameters for each Method 17 test run for the 1<sup>st</sup> stage seed-cotton cleaning systems sampled at the seven gins. The average ginning rate for the seven gins was 31.8 bales/h and the test average ginning rate at each gin ranged from 20.1 to 49.8 bales/h (based on 227-kg [500-lb] equivalent bales). The 1D3D cyclones were all operated with inlet velocities within design criteria,  $16.3 \pm 2$  m/s ( $3200 \pm 400$  fpm), except the test runs at gin C and two runs at gin E that were outside the design range due to limitations in available system adjustments. The first run at gin F was omitted from the test average because of ginning issues resulting in an extremely low ginning rate.

There are criteria specified in EPA Method 17 for test runs to be valid for total particulate measurements (CFR, 1978). Isokinetic sampling must fall within the EPA defined range of  $100 \pm 10\%$ . All tests met the isokinetic criteria (Table 2), except run one for gin B and C; these runs were removed from the emissions test averages in Table 3. The stack gas temperatures ranged from 20 to 75°C (67-166°F) and moisture content ranged from 0.3 to 4.6% w.b.

Total particulate emissions data (emission rates and corresponding emission factors) for the 1<sup>st</sup> stage seed-cotton cleaning system are shown in Table 3. The system average emission factor for the seven gins was 0.152 kg/bale (0.334 lb/bale). The test average emission factors ranged from 0.093 to 0.203 kg (0.206-0.447 lb) per bale. The average 1<sup>st</sup> stage seed-cotton cleaning system total particulate emission factor for this project was approximately 93% of that published in the

current 1996 EPA AP-42 for the No. 1 dryer and cleaner (0.17 kg/bale [0.36 lb/bale]) (EPA, 1996a, b), which is an equivalent system to the 1<sup>st</sup> stage seed-cotton cleaning system. The range of test average total particulate emission factors determined for this project and the AP-42 emission factor data range overlapped. The test average emission rates ranged from 1.87 to 8.93 kg/h (4.13-19.68 lb/h).

Figure 15 shows an example of samples recovered from a typical 1<sup>st</sup> stage seed-cotton cleaning system test run. Often, there were cotton lint fibers in the cotton gin cyclone exhausts. Therefore, it was not unusual to find lint fiber on the Method 17 filter or in the front half wash (Fig. 16), which was included in the total particulate emissions.

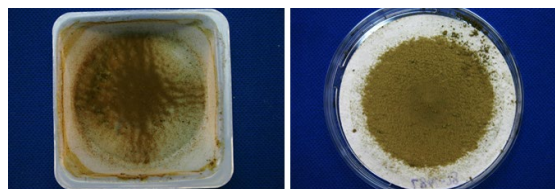


Figure 15. Typical EPA Method 17 filter and sampler head acetone wash from the 1<sup>st</sup> stage seed-cotton cleaning system. From left to right: front half wash and filter.

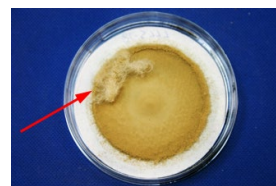


Figure 16. EPA Method 17 filter from the 1<sup>st</sup> stage seed-cotton cleaning system with lint on the filter (indicated by arrow).

Table 2. Cotton gin production data and stack sampling performance metrics for the 1<sup>st</sup> stage seed-cotton cleaning system.

Gin	Test Run	Ginning Rate	Cyclone Inlet Velocity		Isokinetic Sampling	Stack Gas		
			bales/h <sup>z</sup>	m/s		fpm	%	Moisture Content
						% w.b.	°C	°F
A	1	24.8	16.4	3223	102	1.0	20	67
	2	26.9	16.4	3229	101	1.9	23	74
	3	27.8	16.5	3240	99	0.3	25	76
	Test Average	26.5	16.4	3231				
B	1	22.6	17.0	3356	68 <sup>x</sup>	2.9	42	107
	2	25.6	17.2	3377	109	2.7	45	114
	3	13.7	18.0	3547	95	3.2	47	116
	Test Average	20.6	17.4	3427				
C	1	20.2	13.9	2726	113 <sup>x</sup>	3.2	57	135
	2	18.8	13.1	2578	110	4.5	56	133
	3	21.3	13.3	2613	109	4.6	55	131
	Test Average	20.1	13.4	2639				
D	1	38.0	14.9	2939	107	2.9	48	118
	2	34.9	15.1	2966	105	2.8	42	107
	3	37.8	15.0	2946	105	2.9	44	111
	Test Average	36.9	15.0	2950				
E	1	36.2	18.5	3646	100	4.1	50	123
	2	33.0	18.9	3716	106	3.4	45	114
	3	36.8	18.2	3586	110	3.3	55	131
	Test Average	35.3	18.5	3649				
F	1 <sup>y</sup>	3.8	18.5	3642	98	1.6	50	122
	2	48.2	16.3	3213	103	3.4	65	149
	3	51.4	15.5	3047	102	3.3	75	166
	Test Average	49.8	15.9	3130				
G	1	26.0	17.0	3355	99	1.7	44	111
	2	35.5	16.9	3321	92	1.9	45	112
	3	38.6	16.4	3228	99	2.1	45	112
	Test Average	33.4	16.8	3302				
System Average		31.8	16.2	3190				

<sup>z</sup> 227 kg (500 lb) equivalent bales

<sup>y</sup> Test run omitted from test averages because of ginning issues

<sup>x</sup> Did not meet isokinetic sampling rate criteria (100 ± 10%)



**Table 3. Total particulate emissions data for the 1<sup>st</sup> stage seed-cotton cleaning system.**

Gin	Test Run	Emission Rate		Emission Factor	
		kg/h	lb/h	kg/bale <sup>z</sup>	lb/bale <sup>z</sup>
A	1	3.68	8.10	0.148	0.327
	2	5.16	11.38	0.192	0.423
	3	3.11	6.85	0.112	0.247
	Test Average (n=3)	3.98	8.78	0.151	0.332
B	1 <sup>y</sup>	6.92	15.26	0.306	0.674
	2	4.78	10.53	0.186	0.411
	3	3.01	6.63	0.219	0.484
	Test Average (n=2)	3.89	8.58	0.203	0.447
C	1 <sup>y</sup>	2.67	5.89	0.132	0.292
	2	1.76	3.89	0.094	0.207
	3	1.98	4.37	0.093	0.205
	Test Average (n=2)	1.87	4.13	0.093	0.206
D	1	2.62	5.78	0.069	0.152
	2	4.41	9.71	0.126	0.278
	3	3.91	8.61	0.103	0.228
	Test Average (n=3)	3.64	8.03	0.099	0.219
E	1	8.79	19.38	0.243	0.536
	2	6.73	14.83	0.204	0.450
	3	5.86	12.93	0.159	0.351
	Test Average (n=3)	7.13	15.71	0.202	0.446
F	1 <sup>x</sup>	1.51	3.33	0.396	0.874
	2	9.60	21.16	0.199	0.439
	3	8.26	18.20	0.161	0.354
	Test Average (n=2)	8.93	19.68	0.180	0.397
G	1	3.73	8.22	0.143	0.316
	2	5.23	11.53	0.147	0.325
	3	4.12	9.08	0.107	0.235
	Test Average (n=3)	4.36	9.61	0.132	0.292
System Average (n=7)				0.152	0.334

<sup>z</sup> 227 kg (500 lb) equivalent bales

<sup>y</sup> Test run omitted from test averages because isokinetic sampling rate (100 ± 10%) was not met

<sup>x</sup> Test run omitted from test averages because of ginning issues

### SUMMARY

Seven cotton gins with 1<sup>st</sup> stage seed-cotton cleaning systems were sampled using EPA Method 17 to collect additional data to improve the EPA AP-42 total particulate emission factor ratings for cotton gins. The tested systems were similar in design and typical of the ginning industry. The system exhausts were equipped with 1D3D cyclones for emissions control with some variations in inlet and cone design. The average production rate during testing for

the seven gins was 31.8 bales/h. The average 1<sup>st</sup> stage seed-cotton cleaning system total particulate emission factor based on the seven gins tested (18 total test runs) was 0.152 kg/227-kg bale (0.334 lb/500-lb bale). The average 1<sup>st</sup> stage seed-cotton cleaning system total particulate emission factor for this project was approximately 93% of that currently published in the 1996 EPA AP-42, which is 0.17 kg/bale (0.36 lb/bale) (EPA, 1996 a, b). The gin test average emission rates ranged from 1.87 to 8.93 kg/h (4.13-19.68 lb/h).

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