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ENGINEERING AND GINNING

Master Trash System PM_{10} Emission Factors and Rates for Cotton Gins: Method 201A PM_{10} Sizing Cyclones

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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 EPA emission factors for particulate matter with a particle diameter nominally less than or equal to 10 µm (PM_{10}). The 1996 EPA AP-42 emission factors were assigned quality ratings, from A (Excellent) to E (Poor), to assess the quality of the data being referenced. Emission factor quality ratings for cotton gins were extremely low. Cotton gin data received these low ratings because they were collected almost exclusively from a single geographical region. The objective of this study was to collect additional PM_{10} emission factor data for master trash systems at cotton gins located in regions across the cotton belt based on EPA-approved stack sampling methodology, Method 201A. The project plan included sampling seven cotton gins 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. Five of the seven gins had master trash systems. In terms of capacity, the five gins were typical of the industry, averaging 36.2 bales/h during testing. Some test runs were excluded from the test averages because they failed to meet EPA Method 201A test criteria. Also, other test runs, included in the analyses, had cotton lint fibers that collected in the ≤ 10 µm samples. This larger lint material can affect the reported emissions data, but EPA Method 201A does not suggest methods to account for these anomalies. The master trash system average emission factors for PM_{10} and total particulate were 0.056 kg/227-kg bale (0.123 lb/500-lb bale) and 0.152 kg/bale (0.335 lb/bale), respectively. The system average PM_{10} emission factor was higher and the system average total particulate emission factor was lower than those currently published in EPA AP-42. Master trash system PM_{10} emission rate test averages ranged from 1.39 to 4.18 kg/h (3.06-9.21 lb/h). The ratio of master trash system PM_{10} to total particulate was 36.9%.

U.S. Environmental Protection Agency (EPA) emission factors published in EPA's Compilation of Air Pollution Emission Factors, AP-42 (EPA, 1996b) were 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 particulate matter with a particle diameter less than or equal to a nominal 10-mm (PM_{10}) aerodynamic equivalent diameter from cotton gins are extremely low. Cotton gin data received these low ratings because they were collected almost exclusively from a single geographical region (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 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

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systems covered in the series include: unloading, 1st stage seed-cotton cleaning, 2nd stage seed-cotton cleaning, 3rd stage seed-cotton cleaning, overflow, 1st stage lint cleaning, 2nd stage lint cleaning, combined lint cleaning, cyclone robber, 1st stage mote, 2nd stage mote, combined mote, mote cyclone robber, mote cleaner, mote trash, battery condenser, and master trash. This report focuses on PM_{10} emissions from master trash systems.

The 1996 EPA AP-42 PM_{10} average emission factor for the master trash fan was 0.034 kg (0.074 lb) per 217-kg (480-lb) equivalent bale with a range of 0.017 to 0.051 kg (0.038-0.11 lb) per bale (EPA, 1996a, b). This average and range was based on two tests conducted in one geographical location and the EPA emission factor quality rating was D, which is the second lowest possible rating (EPA, 1996a). The AP-42 total particulate average emission factor for the master trash fan was 0.24 kg (0.54 lb) per bale with a range of 0.060 to 0.57 kg (0.13-1.3 lb) per bale. This average and range was based on four tests conducted in one geographical location and the EPA emission factor quality rating was also D.

Seed cotton is a perishable commodity that has no real value until the fiber and seed are separated (Wakelyn et al., 2005). Cotton must 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 with the ginning season 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 about 17 million bales per year during the last 20 years, production from one year to the next often 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).

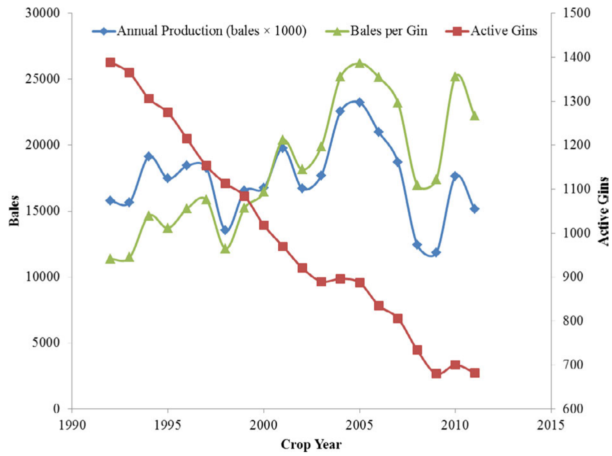

Figure 1. Annual U.S. cotton production, active U.S. gins, and average ginning volume (bales per gin) (NASS, 1993-2012).

Typical cotton gin processing systems include: 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 can vary. 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 assist with drying the seed cotton and remove foreign matter prior to ginning. Ginning systems also remove foreign matter and separate the cotton fiber from 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 efficient transport. Cotton gin systems produce some type of by-products 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.

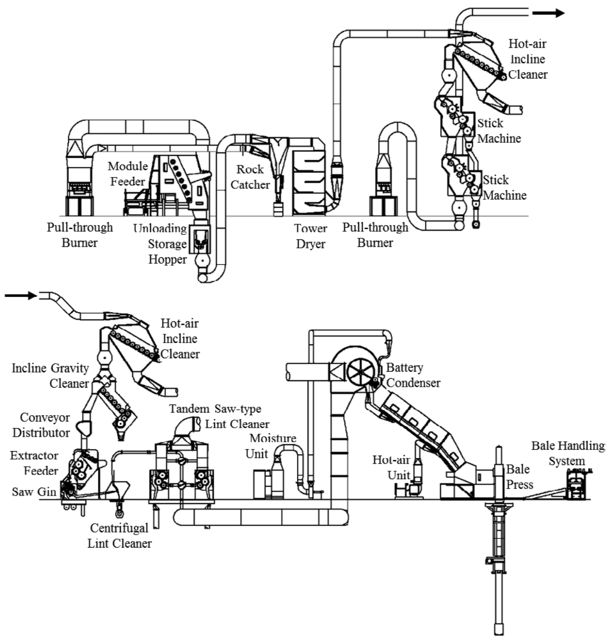

Figure 2. Typical modern cotton gin layout (Courtesy Lummus Corporation, Savannah, GA).

Gin systems produce a by-product or trash as a result of processing the cotton, lint, or further processing a by-product. In each case, the stream of trash must be removed from the machinery and handled by trash systems (Fig. 3). Typically, all trash at gins is consolidated into one storage area for subsequent removal. In some cases, the particulate abatement cyclones for different gin systems are located over a trash hopper and thus a main trash system is not necessary. In many other cases, a master trash system will pull trash from systems throughout the gin—precleaning trash conveyors, gin stands trash conveyor, and the main trash conveyor often located under the unloading system, seed-cotton cleaning system, overflow system, and other systems particulate abatement cyclones. The trash is pneumatically conveyed to one or two master trash cyclones located over either a storage hopper or a trash pile. Master trash system cyclones are often heavily loaded, handling all types of trash encountered by the gin systems (rocks, soil, sticks, hulls, leaf material, and lint). A photograph of the material typically collected by the master trash system is shown in Fig. 4.

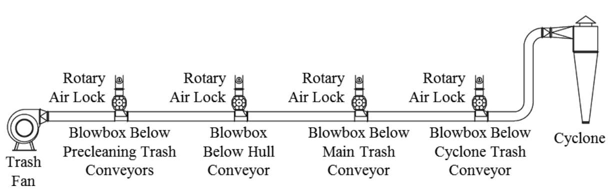

Figure 3. Typical cotton gin master trash system layout (Courtesy Lummus Corporation, Savannah, GA).

Figure 4. Photograph of typical trash captured by the master trash system cyclones.

Cyclones are the most common particulate matter 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 ± 2 m/s (3000 ± 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 ± 2 m/s (3200 ± 400 fpm).

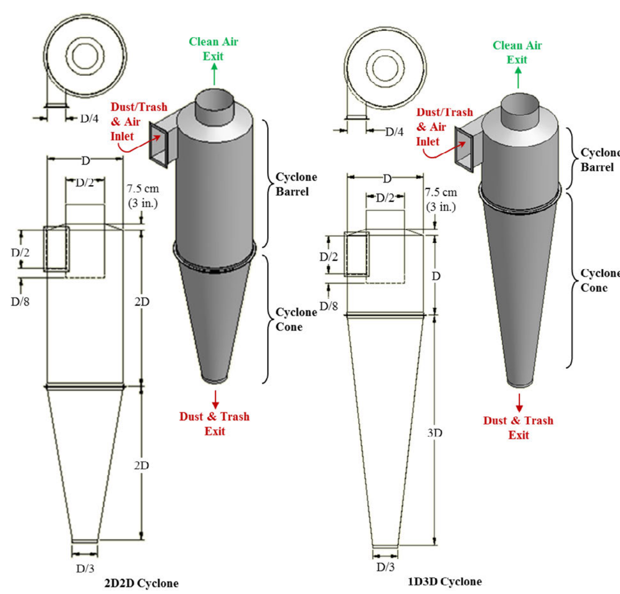

Figure 5. 2D2D and 1D3D cyclone schematics.

The objective of this study was to collect additional PM_{10} emission factor data for master trash systems with cyclones for emissions control at cotton gins located in regions across the cotton belt based on EPA-approved stack sampling methodologies.

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. These groups were formed to aid in project planning, gin selection, data analysis, 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 201A was used to sample the master trash system at each gin. Method 201A was revised in 2010 to incorporate options for $PM_{2.5}$ (particulate matter with particle diameter less than or equal to a nominal 2.5-mm aerodynamic equivalent diameter) sampling (CFR, 2010); these revisions did not affect the PM_{10} stack sampling methodology used in this project. Method 201A is a constant sampling-rate procedure. For the PM_{10} sampling methodology, the particulate-laden stack gas was withdrawn isokinetically (the velocity of the gas entering the sampler was equal to the velocity of the gas in the stack) through a PM_{10} sizing cyclone and then collected on an in-stack filter (Fig. 6). The methods for retrieving the filter and conducting acetone washes of the sizing cyclone are described in detail in Method 201A (CFR, 2010). The mass of each size fraction was determined by gravimetric analysis and included: > 10 µm (PM_{10} sizing cyclone catch acetone wash) and ≤ 10 µm (PM_{10} sizing cyclone exit acetone wash and filter). The PM_{10} mass was determined by adding the mass of particulates captured on the filter and the ≤ 10 µm wash. Total particulate was determined by adding the PM_{10} mass and the mass of the > 10 µm wash.

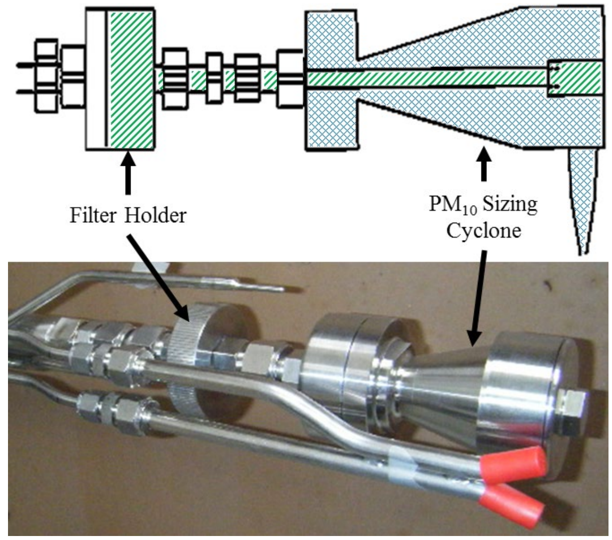

Figure 6. EPA Method 201A PM_{10} sizing cyclone and in-stack filter holder schematic (CFR, 2010) and photograph (≤ 10 µm, > 10 µm).

Figure 7 shows the performance curves for the Method 201A sizing cyclones. To measure PM_{10}, the method requires selecting a gas sampling nozzle to achieve a sampling rate that produces a cut size between 9.0 and 11.0 mm at the stack gas temperature. For this study, Method 201A was specifically used to collect filterable PM_{10} emissions (solid particles emitted by a source at the stack and captured in the ≤ 10 µm wash and on the filter [CFR, 2010]).

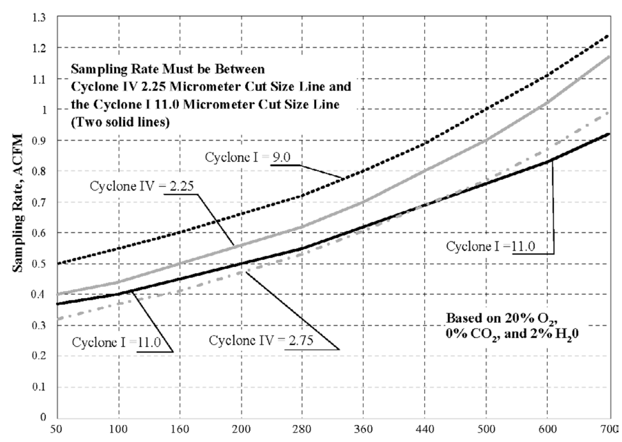

Figure 7. Acceptable sampling rate for sizing cyclones (CFR, 2010) Cyclone I = PM_{10} sizing cyclone (gas temperatures for the master trash systems tested ranged from 21 to 39°C (70-103°F]).

Only one stack from each master trash system was tested. For systems with multiple stacks, it was assumed that emissions from each stack of the system were equivalent and the total emissions 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 the tests at all seven cotton gins.

All stack sampling equipment, including the sizing cyclone, was purchased from Apex Instruments (Fuquay-Varina, NC) and met specifications of Method 201A. 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 ≥ 99.5%). Filters and wash tubs with lids were prelabeled, 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 certified stack testing technician calibrated and checked all sampling equipment according to EPA Method 201A.

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. 8). 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 certified stack sampling technician in an enclosed sampling trailer at the base of the cyclone bank (Fig. 9). Sample retrieval, including filters and sampler head acetone washes, was conducted according to Method 201A. 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 201A and ASAE Standard S582 (ASABE, 2005).

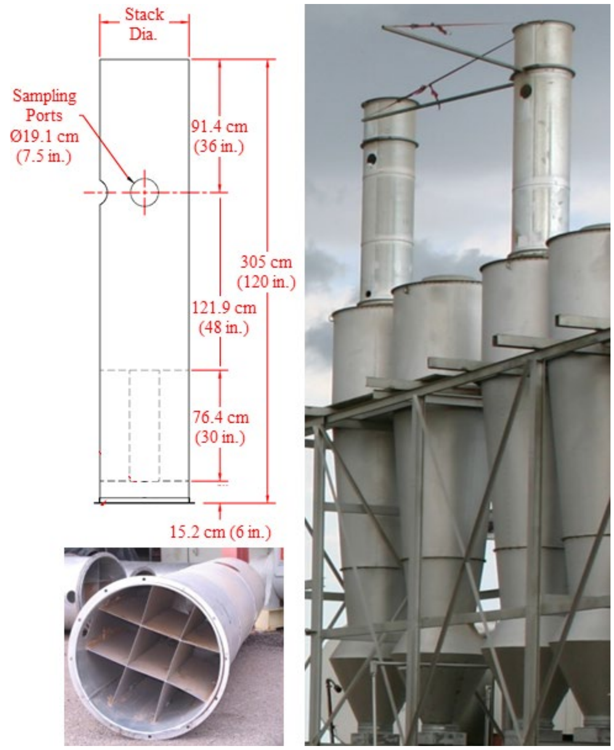

Figure 8. Schematic and photographs of stack extensions with sampling ports and staightening vanes (rail attached to extension above sampling port; at right, supports sampling probe during testing traverse).

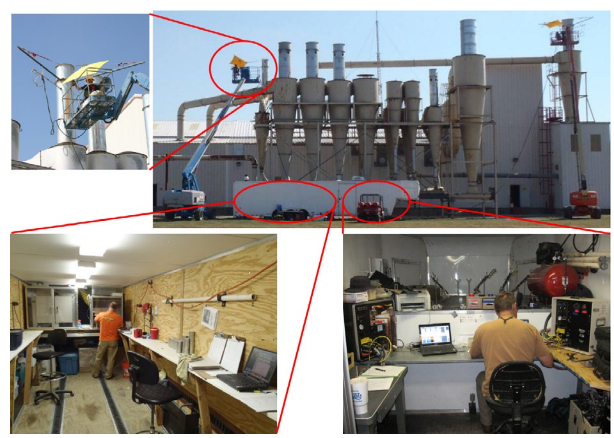

Figure 9. Clockwise from top right: cotton gin stack sampling with air quality lab trailer and technicians on lifts; certified stack sampling technician in the trailer control room conducting tests; sample recovery in trailer clean room; technician operating the probe at stack level.

All laboratory analyses were conducted at the AQL. All filters were conditioned in an environmental chamber (21 ± 2°C [70 ± 3.6°F]; 35 ± 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 µg readability and 0.9 µg repeatability) after being passed through an anti-static 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 µg, 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 prior to further analyses. After the laboratory analyses were completed, all stack sampling, cotton gin production, and laboratory data were merged.

Five of the seven gins had master trash systems. The master trash systems sampled were typical for the industry, but varied among gins. The master trash systems at gins B, E, F, and G handled all the material generated from processing the cotton through the gin that was considered trash. This material was picked up at individual machines within the gin plant and/or at the main trash auger under the cyclones outside of the gin and pneumatically conveyed to one or more cyclones above a trash pile or trash hopper. The master trash system at gin D did not handle trash from all of the gin systems, but consolidated and conveyed material from the unloading systems, two 2nd stage seed-cotton cleaners, four feeder and gin stand systems, and four centrifugal lint cleaners before the 1st stage lint-cleaning systems.

Four of the five master trash systems sampled utilized 1D3D cyclones to control emissions (Fig. 5), but there were some cyclone design variations among those gins (Table 1 and Fig. 10). The system airstream for gins B and G was exhausted through a single cyclone. Gins D and F split the system exhaust flows between two cyclones in a dual configuration (side by side as opposed to one behind another). Inlets on the master trash cyclones for gins B, D, F, and G were 2D2D type. Expansion chambers were present on master trash cyclones at gins B and D. The cyclones on the master trash systems for gins F and G had standard cones. All of the cyclone configurations outlined above, if properly designed and maintained, are recommended for controlling cotton gin emissions (Whitelock et al., 2009). The cyclone on the master trash system for gin E was not a 1D3D cyclone (Fig. 10). This cyclone had proportional dimensions of about ½D2D with a square inlet that measured approximately ¼D on each side and had a standard cone with a narrow trash exit. Although the gin E master trash system was not equipped with a 1D3D cyclone, the system was sampled and included in the emissions analyses with the other four master trash systems that were equipped with 1D3D cyclones.

Figure 10. 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 2D2D inlet and expansion chamber on the cone; 1D3D cyclone with 2D2D inlet and standard cone; ½D2D cyclone with a square inlet measuring about ¼D on a side.

Table 1. Abatement device configuration[z] for master trash systems tested.

Gin	Cyclone Type	Inlet Design[y]	Systems per Gin	Cyclones per Gin	Configuration	Cone Design	Trash Exits to[x]
B	1D3D	2D2D	1	1	single	expansion chamber	auger
D	1D3D	2D2D	1	2	dual	expansion chamber	hopper
E	½D2D	square	1	1	single	standard	auger
F	1D3D	2D2D	1	2	dual	standard	auger
G	1D3D	2D2D	1	1	single	standard	hopper

[z] Figures 5 and 10

[y] Square inlet design had cross-section approximately one-fourth the cyclone diameter on a side

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

RESULTS

Table 2 shows the test parameters for each Method 201A test run for the master trash systems sampled at the five gins. The system average ginning rate was 36.2 bales/h and the test average ginning rates at each gin ranged from 26.5 to 49.0 bales/h (based on 227-kg [500-lb] equivalent bales). The 1D3D cyclones were all operated with inlet velocities within design criteria, 16.3 ± 2 m/s (3200 ± 400 fpm), except the test runs at gin B that were outside the design range due to limitations in available system adjustments. The inlet velocity for the ½D2D cyclone at gin E ranged from 10.8 to 12.0 m/s (2134-2360 fpm) for the test runs.

There are criteria specified in EPA Method 201A for test runs to be valid for PM_{10} or total particulate measurements (CFR, 2010). Isokinetic sampling and PM_{10} aerodynamic cut size must fall within EPA defined ranges (100 ± 20% and 10.0 ± 1.0 µm, respectively) for valid PM_{10} test runs. All tests met both criteria (Table 2). To use the method to obtain total filterable particulate also, sampling must be within 90 to 110% of isokinetic flow. This criterion was not met in the second and third test runs for gin E, the first test run for gin F, or the second test run for gin G; thus the data associated with these runs were omitted from the total particulate test averages. Sampling rates ranged from 11.4 to 13.3 standard l/min (0.404-0.469 standard ft^3/min). The stack gas temperatures ranged from 21 to 39°C (70-103°F). Test run one for gin D was omitted from all test and system emissions data averages in Tables 3 and 4, because of a laboratory error with the filter.

Table 2. Cotton gin production data and stack sampling performance metrics for the master trash systems.

Gin	Test Run	Ginning Rate bales/h[z]	Cyclone Inlet Velocity		Isokinetic Sampling %	Aerodynamic Cut Size D_{50} PM_{10} µm	Sampling Rate[y]		Stack Temperature	
			m/s	fpm			slpm	scfm	°C	°F
B	1	20.5	18.5	3650	109	10.3	12.7	0.448	38	101
	2	31.0	18.3	3611	95	10.2	12.9	0.454	39	102
	3	27.9	18.4	3629	96	10.1	13.0	0.458	39	103
Test Average		26.5	18.4	3630						
D	1	36.0	15.6	3067	91	9.8	13.3	0.469	29	85
	2	35.0	15.6	3069	100	10.4	12.1	0.428	28	82
	3	34.9	15.3	3010	100	10.4	11.8	0.417	21	70
Test Average		35.3	15.5	3049						
E	1	35.9	12.0	2360	104	10.1	12.7	0.449	31	87
	2	34.3	11.2	2199	113[x]	10.1	12.8	0.453	32	89
	3	35.4	10.8	2134	115[x]	10.1	12.8	0.451	34	92
Test Average		35.2	11.3	2231						
F	1	51.1	15.0	2947	115[x]	10.0	13.3	0.469	32	90
	2	46.0	16.5	3244	102	10.2	13.0	0.459	35	94
	3	50.0	16.7	3295	97	10.5	12.5	0.442	36	97
Test Average		49.0	16.1	3162						
G	1	35.1	16.3	3207	92	10.5	11.6	0.410	22	71
	2	36.8	16.6	3273	89[x]	10.7	11.4	0.404	24	74
	3	32.6	16.4	3238	93	10.5	11.9	0.420	25	77
Test Average		34.9	16.5	3239						
System Average		36.2	15.6	3062						

[z] 227 kg (500 lb) equivalent bales

[y] slpm = standard l/min, scfm = standard ft^3/min

[x] Did not meet total particulate isokinetic sampling rate criteria (100 ± 10%)

Table 3. PM_{10} emissions data for the master trash systems.

Gin	Test Run	Emission Rate		Emission Factor	
		kg/h	lb/h	kg/bale[z]	lb/bale[z]
B	1	0.97	2.14	0.047	0.104
	2	1.57	3.46	0.051	0.112
	3	1.63	3.59	0.058	0.128
Test Average (n=3)		1.39	3.06	0.052	0.115
D	1[y]	0.49	1.08	0.014	0.030
	2	1.46	3.22	0.042	0.092
	3	1.60	3.53	0.046	0.101
Test Average (n=2)		1.53	3.37	0.044	0.096
E	1	1.83	4.04	0.051	0.113
	2	2.00	4.41	0.058	0.128
	3	1.58	3.49	0.045	0.099
Test Average (n=3)		1.80	3.98	0.051	0.113
F	1	4.89	10.79	0.096	0.211
	2	4.04	8.90	0.088	0.194
	3	3.59	7.92	0.072	0.159
Test Average (n=3)		4.18	9.21	0.085	0.188
G	1	2.08	4.59	0.059	0.131
	2	1.81	3.99	0.049	0.109
	3	1.12	2.47	0.034	0.076
Test Average (n=3)		1.67	3.68	0.048	0.105
System Average (n=5)				0.056	0.123

[z] 227 kg (500 lb) equivalent bales

[y] Test run omitted from test averages because of a laboratory error with the filter

Table 4. Total particulate emissions data for the master trash systems.

Gin	Test Run	Emission Rate		Emission Factor	
		kg/h	lb/h	kg/bale[z]	lb/bale[z]
B	1	2.31	5.09	0.113	0.248
	2	3.72	8.20	0.120	0.265
	3	3.73	8.23	0.134	0.295
Test Average (n=3)		3.25	7.17	0.122	0.269
D	1[y]	0.91	2.02	0.025	0.056
	2	2.30	5.06	0.066	0.145
	3	2.33	5.13	0.067	0.147
Test Average (n=2)		2.31	5.09	0.066	0.146
E	1	7.75	17.09	0.216	0.476
	2[x]	6.87	15.15	0.200	0.441
	3[x]	6.47	14.25	0.183	0.403
Test Average (n=1)		7.75	17.09	0.216	0.476
F	1[x]	13.67	30.14	0.268	0.590
	2	10.40	22.93	0.226	0.498
	3	9.00	19.85	0.180	0.397
Test Average (n=2)		9.70	21.39	0.203	0.448
G	1	6.27	13.82	0.178	0.393
	2[x]	6.30	13.89	0.171	0.378
	3	4.10	9.04	0.126	0.277
Test Average (n=2)		5.18	11.43	0.152	0.335
System Average (n=5)				0.152	0.335

[z] 227 kg (500 lb) equivalent bales

[y] Test run omitted from test averages because of a laboratory error with the filter

[x] Test run omitted from test averages because isokinetic sampling rate (100 ± 10%) was not met

PM_{10} emissions data (ginning and emission rates and corresponding emission factors) for the master trash systems are shown in Table 3. The system average PM_{10} emission factor was 0.056 kg/bale (0.123 lb/bale). The test average emission factors ranged from 0.044 to 0.085 kg (0.096-0.188 lb) per bale and emission rates ranged from 1.39 to 4.18 kg/h (3.06-9.21 lb/h). Total particulate emissions data (ginning and emission rates and corresponding emission factors) for the master trash systems are shown in Table 4. The system average total particulate emission factor was 0.152 kg/bale (0.335 lb/bale). The test average emission factors ranged from 0.066 to 0.216 kg (0.146-0.476 lb) per bale. The test average total particulate emission rates ranged from 2.31 to 9.70 kg/h (5.09 to 21.39 lb/h). The test average total particulate emission factor for gin E with the ½D2D cyclone and low inlet velocity was 0.216 kg/bale (0.476 lb/bale). If the gin E tests were dropped, the total particulate emissions system average would be reduced to 0.136 kg/bale (0.299 lb/bale). The test data for gin E with the ½D2D cyclone and low inlet velocity was included in all system averages because the PM_{10} emissions test average for gin E was similar to the system average, despite the fact that the total emissions test average for gin E was highest. The ratio of PM_{10} to total particulate was 36.9% (the ratio calculated using Tables 3 and 4 might vary slightly from that listed due to rounding).

The average master trash system total particulate emission factor for this project was about 62% of the EPA AP-42 published value for the master trash fan (EPA, 1996a, b). The range of total particulate emission factors determined for this project fell within the range of AP-42 emission factor data. The average master trash system PM_{10} emission factor for this project was 1.67 times the EPA AP-42 published value for the master trash fan. The test average PM_{10} emission factor range overlapped with the AP-42 emission factor data range.

Figure 11 shows an example of samples recovered from a typical master trash system test run. Often, there were cotton lint fibers, which have cross-sectional diameters much greater than 10 mm, in the cotton gin cyclone exhausts. Therefore, it was not unusual to find lint fiber in the > 10 µm wash from Method 201A. However, in the samples shown in Fig. 12, lint fibers passed through the PM_{10} cyclone and collected in the ≤ 10 µm wash and on the filter. This type of material carryover can bias the gravimetric measurements and affect reported PM_{10} emission data. EPA Method 201A does not suggest methods to account for these anomalies. Thus, no effort was made to adjust the data reported in this manuscript to account for these issues.

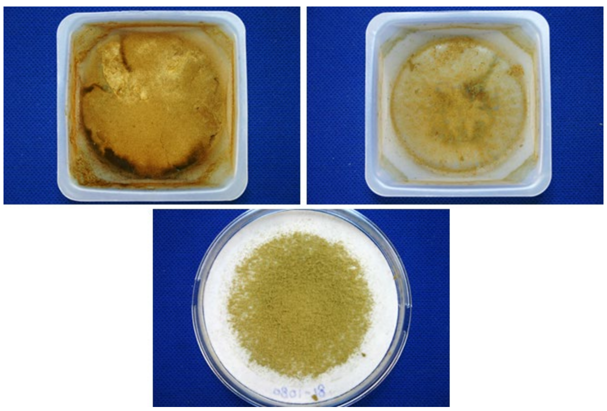

Figure 11. Typical EPA Method 201A filter and sampler head acetone washes from the master trash system. Clockwise from top left: > 10 µm wash, ≤ 10 µm wash, and filter.

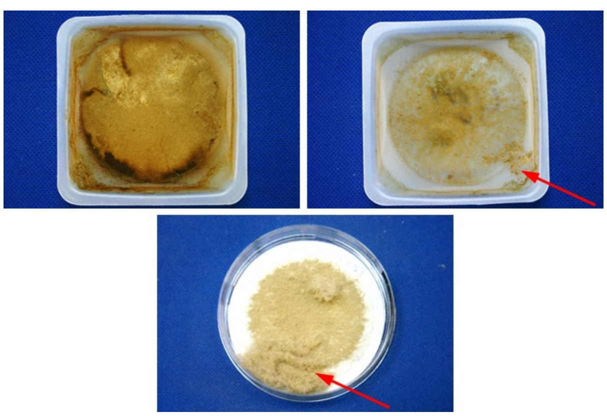

Figure 12. EPA Method 201A filter and sampler head acetone washes from the master trash system with lint fiber in the ≤ 10 µm wash and on the filter (indicated by arrows). Clockwise from top left: > 10 µm wash, ≤ 10 µm wash, and filter.

SUMMARY

Seven cotton gins across the U.S. cotton belt were sampled using EPA Method 201A to collect additional data to improve the EPA AP-42 PM_{10} emission factor quality ratings for cotton gins. Five of the seven gins had master trash systems. The tested systems were similar in design and typical of the ginning industry. All the systems were equipped with 1D3D cyclones for emissions control with some slight variations in inlet and cone design, except for one system that was equipped with a ½D2D cyclone. In terms of capacity, the five gins were typical of the industry, averaging 36.2 bales/h during testing. Some test runs were excluded from the test averages because they failed to meet EPA Method 201A test criteria. Also, other test runs, included in the analyses, had cotton lint fibers that collected in the ≤ 10 µm samples. This larger lint material can affect the reported emissions data, but EPA Method 201A does not suggest methods to account for these anomalies. The master trash system average emission factors for PM_{10} and total particulate were 0.056 kg/227-kg bale (0.123 lb/500-lb bale) and 0.152 kg/bale (0.335 lb/bale), respectively. The system average PM_{10} emission factor was higher and the system average total particulate emission factor was lower than those currently published in EPA AP-42. The gin test average PM_{10} and total particulate emission rates ranged from 1.39 to 4.18 kg/h (3.06-9.21 lb/h) and 2.31 to 9.70 kg/h (5.09-21.39 lb/h), respectively. Based on the master trash system average emission factors, the ratio of PM_{10} to total particulate was 36.9%.

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DISCLAIMER

Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the Oklahoma State University or U.S. Department of Agriculture. Oklahoma State University and USDA are equal opportunity providers and employers.

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