The *Journal of Cotton Science 18:216–225 (2014)*
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ENGINEERING AND GINNING

Overflow 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 overflow 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. Three of the seven gins had overflow systems where the exhaust airstreams were not combined with other major systems. Another sampled gin had an overflow system where the exhaust was combined with a trash handling system prior to the cyclone. In terms of capacity, the three gins were typical of the industry, averaging 24.8 bales/h during testing. Some 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 overflow system average emission factors for PM_{10} and total particulate were 0.013 kg/227-kg bale (0.029 lb/500-lb bale) and 0.033 kg/bale (0.072 lb/bale), respectively. The system average PM_{10} emission factor was higher than the emission factor currently published in EPA AP-42, whereas the system average total particulate emission factor was about equal to the AP-42 factor. Overflow system PM_{10} emission rate test averages ranged from 0.12 to 0.42 kg/h (0.26-0.93 lb/h). The ratio of overflow system PM_{10} to total particulate was 40.3%.

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.

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The 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 overflow systems.

The 1996 EPA AP-42 average PM_{10} emission factor for the overflow fan was 0.012 kg (0.026 lb) per 217-kg (480-lb) equivalent bale with a range of 0.0020 to 0.017 kg (0.0045-0.038 lb) per bale (EPA, 1996a, b). This average and range was based on four 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 average total particulate emission factor for the overflow fan was 0.033 kg (0.071 lb) per bale with a range of 0.0050 to 0.059 kg (0.011-0.13 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).

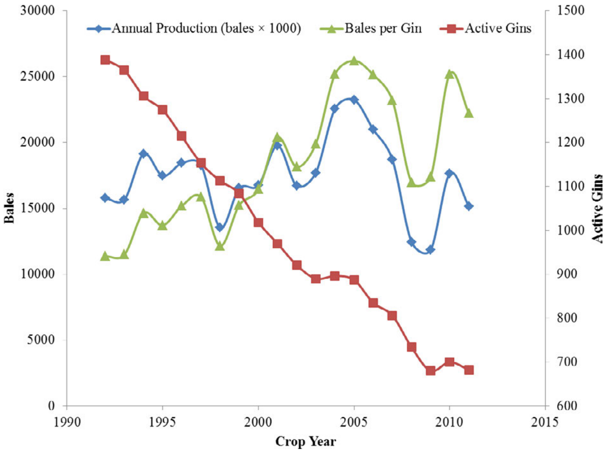

Figure 1. Annual U.S. cotton production, active U.S. gins, and average ginning volume (bales per gin) (NASS, 1993-2012).

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.

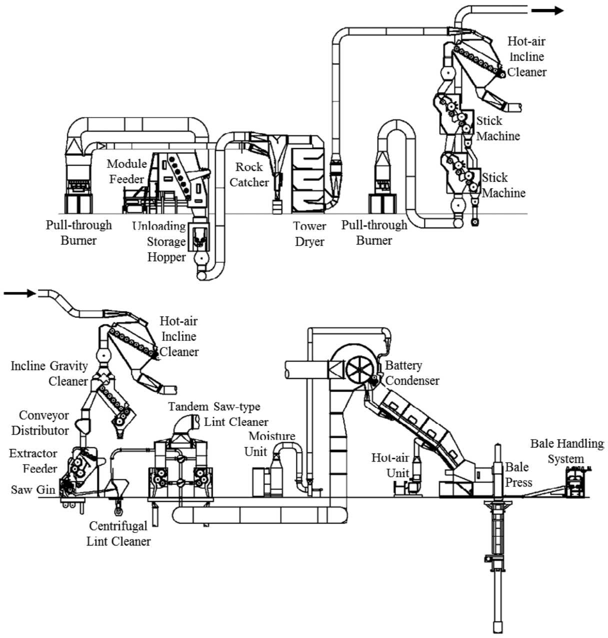

Figure 2. Typical modern cotton gin layout (Courtesy Lummus Corporation, Savannah, GA).

Overflow systems (Fig. 3) follow the seed-cotton cleaning systems and are used to help maintain proper flow of seed cotton to the gin stands. Seed cotton drops from the last stage of seed-cotton cleaning into the conveyor distributor where it is distributed to the extractor feeders that meter cotton to each gin stand (cotton gins typically split the seed cotton among multiple, parallel gin stands). Excess seed cotton in the conveyor distributor is conveyed to the overflow system storage hopper, recirculated pneumatically, and dropped back into the conveyor distributor via a screened separator as needed. The airstream from the screened separator of the overflow system continues through a centrifugal fan to one or more particulate abatement cyclones. The material handled by the overflow system cyclones typically includes soil, small leaf, and lint fiber (Fig. 4).

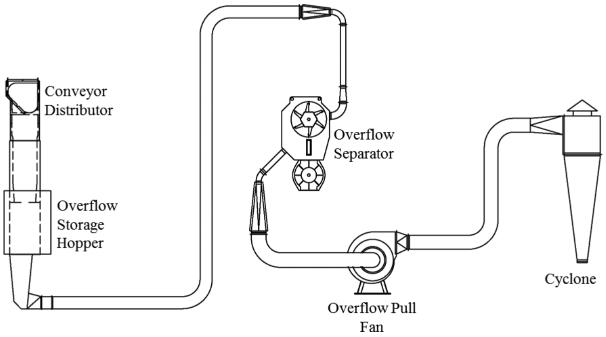

Figure 3. Typical cotton gin overflow system layout (Courtesy Lummus Corporation, Savannah, GA).

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 4. Photograph of typical trash captured by the overflow system cyclones.

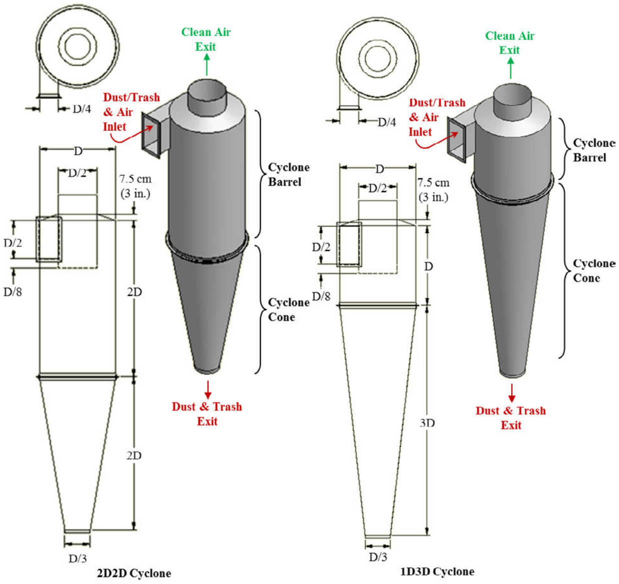

Figure 5. 2D2D and 1D3D cyclone schematics.

The objective of this study was to collect additional PM$_{10}$ emission factor data for overflow 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 overflow 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.

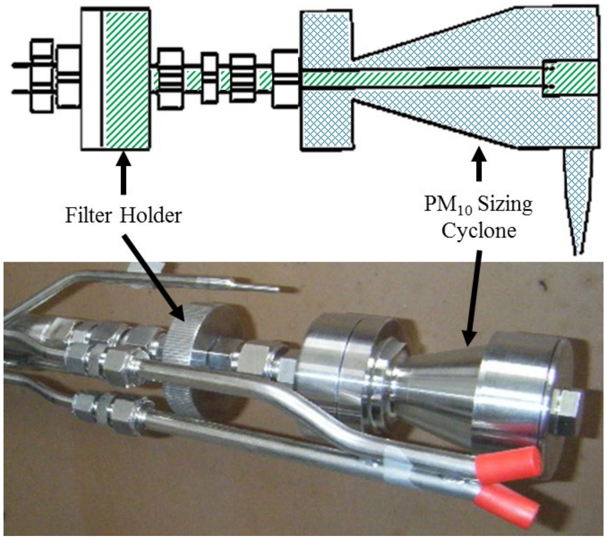

Figure 6. EPA Method 201A PM$_{10}$ sizing cyclone and in-stack filter holder schematic (CFR, 2010) and photograph (▨ ≤ 10 µm, ▦ > 10 µm).

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]).

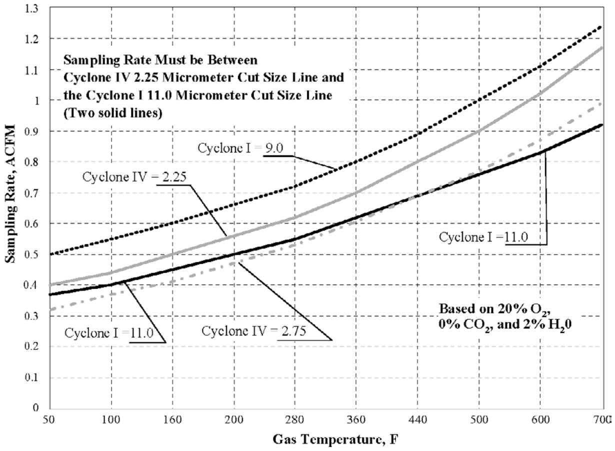

Figure 7. Acceptable sampling rate for sizing cyclones (CFR, 2010) Cyclone I = PM$_{10}$ sizing cyclone (gas temperatures for the overflow systems tested ranged from 16 to 36°C [61-96°F]).

Only one stack from each overflow 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).

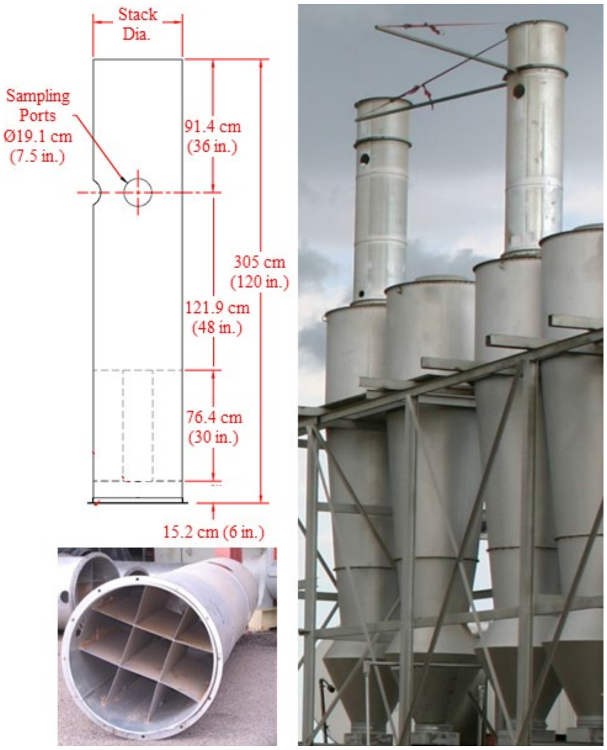

Figure 8. Schematic and photographs of stack extensions with sampling ports and staightening vanes (rail attached to extension above sampling port; at right, supports sampling probe during testing traverse).

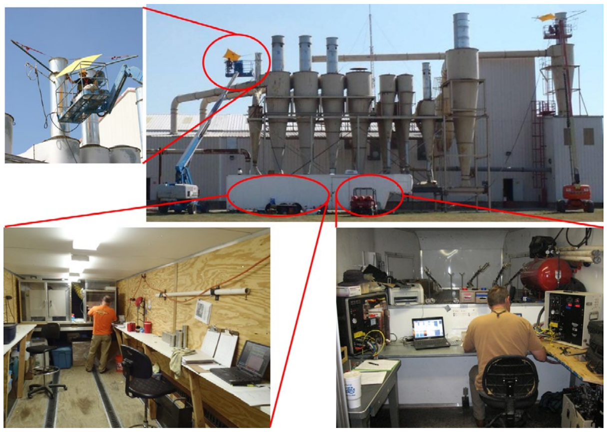

Figure 9. Clockwise from top right: cotton gin stack sampling with air quality lab trailer and technicians on lifts; certified stack sampling technician in the trailer control room conducting tests; sample recovery in trailer clean room; technician operating the probe at stack level.

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 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 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.

Three of the seven sampled gins had overflow systems where the exhaust airstreams were not combined with other major systems. One sampled gin had an overflow system where the exhaust was combined with a trash handling system prior to the cyclone. The overflow systems sampled were typical for the industry. The overflow systems at gins A and E were similar (Fig. 10). Excess seed cotton in the conveyor distributor dropped into the overflow system hopper where it was picked up and pneumatically conveyed to the overflow system screened separator. The seed cotton was separated from the conveying airstream by the separator and dropped back into the conveyor distributor. The conveying air from the overflow system separator then passed through a fan and exhausted through one or more cyclones. Gin C utilized two, separate and parallel, overflow systems with separate fans and emissions control cyclones (Fig. 11). It is not unusual at gins for exhaust airstreams from different systems to be combined before the fan and cyclone(s). The gin C overflow systems exhaust airstreams were combined with a relatively minor system (extractor feeder dust) before the fan. The overflow system at gin D was similar to the systems at gins A and E, except material from a significant trash system (mote trash) was combined with the exhaust airstream of the system (Fig. 12). Because the mote trash system combined with the gin D overflow system could significantly affect the overflow system emissions, the data for the gin D system was not included in the system averages in Tables 2, 3, and 4.

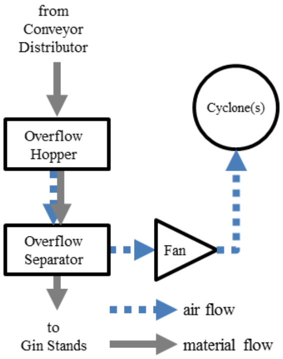

Figure 10. Schematic of single stream/single fan overflow system (gins A and E).

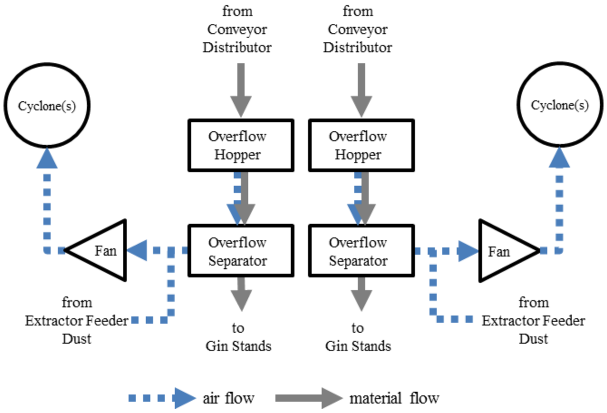

Figure 11. Schematic of split stream/double fan overflow system combined with extractor feeder dust (gin C).

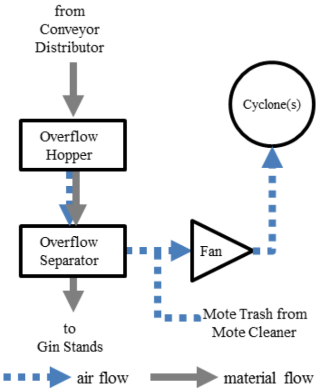

Figure 12. Schematic of single stream/single fan overflow system combined with mote trash (gin D).

All overflow 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). Gins C and D 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 gins A and E was exhausted through a single cyclone. Inlets on all the overflow cyclones were inverted 1D3D type, except gin D that had 2D2D inlets. Expansion chambers were present on overflow cyclones at gins A and D, and gins C and E 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).

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.

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

Gin	Cyclone Type	Inlet Design[y]	Systems per Gin	Cyclones per Gin	Configuration	Cone Design	Trash Exits to[x]
A	1D3D	inverted 1D3D	1	1	Single	expansion chamber	hopper
C	1D3D	inverted 1D3D	2	4	Dual	standard	hopper
D	1D3D	2D2D	1	2	Dual	expansion chamber	hopper
E	1D3D	inverted 1D3D	1	1	Single	standard	auger

[z] Figures 5 and 13

[y] Inverted 1D3D inlet has duct in line with the bottom of the inlet

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

Table 2. Cotton gin production data and stack sampling performance metrics for the overflow 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
A	1	26.8	17.5	3437	101	10.0	12.9	0.456	18	65
	2	15.0	17.4	3430	101	9.9	13.0	0.457	16	61
	3	22.9	17.3	3400	100	10.1	12.7	0.448	16	61
Test Average		21.6	17.4	3422						
C	1	24.4	17.5	3453	94	10.4	12.2	0.430	30	87
	2	20.7	17.6	3472	94	10.4	12.1	0.429	31	89
	3	21.3	18.0	3537	92	10.4	12.2	0.430	32	90
Test Average		22.1	17.7	3487						
D	1	29.4	16.9	3317	99	10.7	11.7	0.413	32	89
	2	30.9	16.2	3189	97	10.5	12.1	0.428	33	92
	3	32.0	16.4	3235	96	10.4	12.2	0.431	33	92
Test Average[x]		30.8	16.5	3247						
E	1	24.4	16.9	3317	96	10.6	11.9	0.419	31	89
	2	29.1	16.9	3325	100	10.4	12.4	0.437	33	92
	3	38.9	16.3	3203	104	10.4	12.5	0.442	36	96
Test Average		30.8	16.7	3282						
System Average		24.8	17.3	3397						

[z] 227 kg (500 lb) equivalent bales

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

[x] Omitted from system averages because exhaust airstream combined with trash system exhaust

Table 3. PM$_{10}$ emissions data for the overflow systems.

Gin	Test Run	Emission Rate		Emission Factor	
		kg/h	lb/h	kg/bale[z]	lb/bale[z]
A	1	0.39	0.86	0.015	0.032
	2	0.29	0.64	0.019	0.043
	3	0.36	0.80	0.016	0.035
Test Average (n=3)		0.35	0.76	0.017	0.036
C	1	0.43	0.96	0.018	0.039
	2	0.40	0.89	0.020	0.043
	3	0.43	0.95	0.020	0.045
Test Average (n=3)		0.42	0.93	0.019	0.042
D	1	1.47	3.25	0.050	0.110
	2	0.82	1.81	0.027	0.059
	3	1.63	3.59	0.051	0.112
Test Average (n=3)[y]		1.31	2.88	0.043	0.094
E	1	0.089	0.20	0.0036	0.0080
	2	0.11	0.24	0.0038	0.0084
	3	0.15	0.34	0.0040	0.0087
Test Average (n=3)		0.12	0.26	0.0038	0.0084
System Average (n=3)				0.013	0.029

[z] 227 kg (500 lb) equivalent bales

[y] Omitted from system averages because exhaust airstream combined with trash system exhaust

Table 4. Total particulate emissions data for the overflow systems.

Gin	Test Run	Emission Rate		Emission Factor	
		kg/h	lb/h	kg/bale[z]	lb/bale[z]
A	1	1.40	3.09	0.052	0.115
	2	1.16	2.55	0.077	0.171
	3	1.20	2.64	0.052	0.115
Test Average (n=3)		1.25	2.76	0.061	0.134
C	1	0.64	1.42	0.026	0.058
	2	0.78	1.71	0.038	0.083
	3	0.70	1.54	0.033	0.072
Test Average (n=3)		0.71	1.56	0.032	0.071
D	1	2.21	4.88	0.075	0.166
	2	1.66	3.66	0.054	0.119
	3	2.27	5.01	0.071	0.156
Test Average (n=3)[y]		2.05	4.51	0.067	0.147
E	1	0.12	0.27	0.0051	0.011
	2	0.14	0.32	0.0049	0.011
	3	0.20	0.44	0.0051	0.011
Test Average (n=3)		0.16	0.34	0.0050	0.011
System Average (n=3)				0.033	0.072

[z] 227 kg (500 lb) equivalent bales

[y] Omitted from system averages because exhaust airstream combined with trash system exhaust

RESULTS

Table 2 shows the test parameters for each Method 201A test run for the overflow systems sampled. The system average ginning rate was 24.8 bales/h and the test average ginning rates at each gin ranged from 21.6 to 30.8 bales/h (based on 227-kg [500-lb] equivalent bales). The capacity of gins sampled was representative of the industry average, approximately 25 bales/h. The 1D3D cyclones were all operated with inlet velocities within design criteria, 16.3 ± 2 m/s (3200 ± 400 fpm).

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$_{10}$ tests. 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. All test runs met the criteria. Sampling rates ranged from 11.9 to 13.0 standard l/min (0.419-0.457 standard ft^3/min). The stack gas temperatures ranged from 16 to 36°C (61-96°F).

PM$_{10}$ emissions data (ginning and emission rates and corresponding emission factors) for the overflow systems are shown in Table 3. The system average PM$_{10}$ emission factor was 0.013 kg/bale (0.029 lb/bale). The test average emission factors ranged from 0.0038 to 0.019 kg (0.0084-0.042 lb) per bale and emission rates ranged from 0.12 to 0.42 kg/h (0.26-0.93 lb/h). Total particulate emissions data (ginning and emission rates and corresponding emission factors) for the overflow systems are shown in Table 4. The system average total particulate emission factor was 0.033 kg/bale (0.072 lb/bale). The test average emission factors ranged from 0.0050 to 0.061 kg (0.011-0.134 lb) per bale. The test average total particulate emission rates ranged from 0.16 to 1.25 kg/h (0.34-2.76 lb/h). The ratio of PM$_{10}$ to total particulate was 40.3% (the ratio calculated using Tables 3 and 4 might vary slightly from that listed due to rounding).

The average overflow system total particulate emission factor for this project was approximately equal to the EPA AP-42 published value for the overflow fan, which is an equivalent system to the overflow system (EPA, 1996a, b). The range of total particulate emission factors determined for this project and the range of AP-42 emission factor data overlapped. The average overflow system PM_{10} emission factor for this project was 1.12 times the EPA AP-42 published value for the overflow fan. The test average PM_{10} emission factor range also overlapped with the AP-42 emission factor data range.

Figure 14 shows an example of samples recovered from a typical overflow system test run. Often, there were cotton lint fibers, which have cross-sectional diameters much greater than 10 µm, 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 sample shown in Fig. 15, lint fibers passed through the PM_{10} cyclone and collected 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.

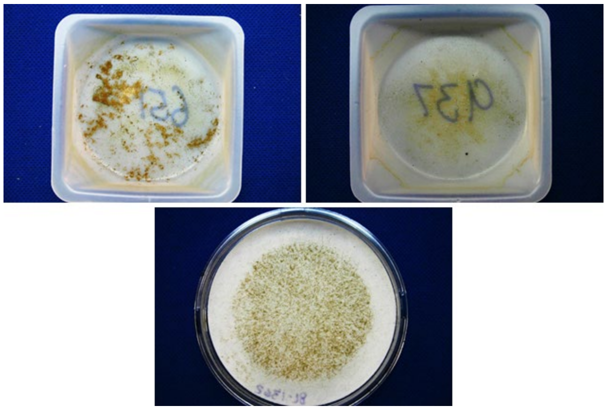

Figure 14. Typical EPA Method 201A filter and sampler head acetone washes from the overflow system. Clockwise from top left: > 10 µm wash, ≤ 10 µm wash, and filter.

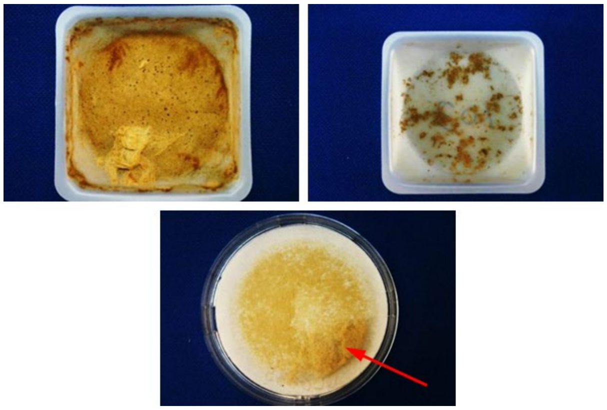

Figure 15. EPA Method 201A filter and sampler head acetone washes from the overflow system with lint fiber on the filter (indicated by arrow). Clockwise from top left: > 10 µm wash, ≤ 10 µm wash, and filter.

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. Three of the seven gins had overflow systems where the exhaust airstreams were not combined with other major systems. Another sampled gin had an overflow system that the exhaust was combined with a trash handling system prior to the cyclone. 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. In terms of capacity, the three gins were typical of the industry, averaging 24.8 bales/h during testing. Some 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 overflow system emission factors for PM_{10} and total particulate were 0.013 kg/227-kg bale (0.029 lb/500-lb bale) and 0.033 kg/bale (0.072 lb/bale), respectively. The system average PM_{10} emission factor was higher than the emission factor currently published in EPA AP-42, whereas the system average total particulate emission factor was about equal to the AP-42 factor. Gin test average PM_{10} and total particulate emission rates ranged from 0.12 to 0.42 kg/h (0.26-0.93 lb/h) and 0.16 to 1.25 kg/h (0.34-2.76 lb/h), respectively. Based on the overflow system average emission factors, the ratio of PM_{10} to total particulate was 40.3%.

ACKNOWLEDGMENTS

The authors appreciate the cooperating gin managers and personnel who generously allowed and endured sampling at their gins. In addition, we thank California Cotton Ginners' and Growers' Association, Cotton Incorporated, San Joaquin Valleywide Air Pollution Study Agency, Southeastern Cotton Ginners' Association, Southern Cotton Ginners' Association, Texas Cotton Ginners' Association, Texas State Support Committee, and The Cotton Foundation for funding this project. The authors also thank the Cotton Gin Advisory Group and Air Quality Advisory Group for their involvement and participation in planning, execution, and data analyses for this project that is essential to developing quality data that will be used by industry, regulatory agencies, and the scientific community. The advisory groups included: the funding agencies listed above, California Air Resources Board, Missouri Department of Natural Resources, National Cotton Council, National Cotton Ginners' Association, North Carolina Department of Environment and Natural Resources, San Joaquin Valley Air Pollution Control District, Texas A&M University, Texas Commission on Environmental Quality, USDA-NRCS National Air Quality and Atmospheric Change, and U.S. Environmental Protection Agency (national, Region 4 and 9).

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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