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ENGINEERING AND GINNING

Mote Cleaner 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 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. Also, some commonly used cotton gin systems were not represented or were combined with another system under a single emission factor in AP-42. There were no 1996 EPA AP-42 emission factors published for mote cleaner systems. The objective of this study was to collect PM_{10} emission factor data for mote cleaner 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. Two of the seven gins had mote cleaner systems. The exhaust from one of the mote cleaner systems was combined with the module feeder dust system. The ginning rate of the two gins averaged 36.0 and 46.2 bales/h during testing for the stand-alone mote cleaner system and mote cleaner and module feeder dust system, respectively. 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 average measured PM_{10} and total particulate emission factors for the stand-alone mote cleaner system were 0.050 kg/227-kg bale (0.109 lb/500-lb bale) and 0.090 kg/bale (0.199 lb/bale), respectively. The ratio of mote cleaner system PM_{10} to total particulate was 54.9%. The PM_{10} emission rate averaged 1.79 kg/h (3.95 lb/h) for the stand-alone mote cleaner system. The average measured PM_{10} and total particulate emission factors for the mote cleaner system combined with the module feeder dust system were 0.071 kg/bale (0.157 lb/bale) and 0.109 kg/bale (0.241 lb/bale), respectively. The ratio of PM_{10} to total particulate for the mote cleaner system combined with the module feeder dust system was 65.1%. The PM_{10} emission rate averaged 3.27 kg/h (7.21 lb/h) for the combined mote cleaner and module feeder dust system.

U.S. Environmental Protection Agency (EPA) emission factors were published in EPA's Compilation of Air Pollution Emission Factors, AP-42 (EPA, 1996b). These factors were assigned a rating from A (Excellent) to E (Poor) that is used to assess the quality of the data being referenced. In the 1996 EPA AP-42, there are emission factors for particulate matter with a particle diameter less than or equal to a nominal 10-mm (PM_{10}) aerodynamic equivalent diameter listed for 11 common cotton gin systems. Cotton gin data received these low ratings because they were collected almost exclusively from a single geographical region (EPA, 1996a). The AP-42 data are limited in that

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some systems commonly used in cotton gins are not represented or are combined with another system under a single emission factor (e.g., 1st and 2nd stage lint-cleaning systems are represented by lint cleaners). 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 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 mote cleaner systems.

There were no 1996 EPA AP-42 factors for mote cleaner systems. The mote cleaner system would be similar to the combination of the mote fan and mote trash fan listed in AP-42 (EPA, 1996a, b). The AP-42 average PM_{10} emission factor for the mote fan was 0.060 kg (0.13 lb) per 217-kg [480-lb] bale with a range of 0.023 to 0.14 kg (0.050-0.30 lb) per bale. This average and range was based on six tests conducted in one geographical location. The AP-42 PM_{10} emission factor for the mote trash fan was 0.0095 kg (0.021 lb) per bale with a range of 0.0021 to 0.018 kg (0.0046-0.040 lb) per bale and was based on three tests from one geographical region. The AP-42 total particulate emission factor for the mote fan was 0.13 kg (0.28 lb) per bale with a range of 0.045 to 0.47 kg (0.099-1.0 lb) per bale. This average and range was based on nine tests conducted in one geographical location. The AP-42 total particulate emission factor for the mote trash fan was 0.035 kg (0.077 lb) per bale with a range of 0.025-0.051 kg (0.055 to 0.11 lb) per bale and was based on three tests. The EPA PM_{10} and total particulate emission factor quality ratings for both the mote fan and mote trash fan were 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 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).

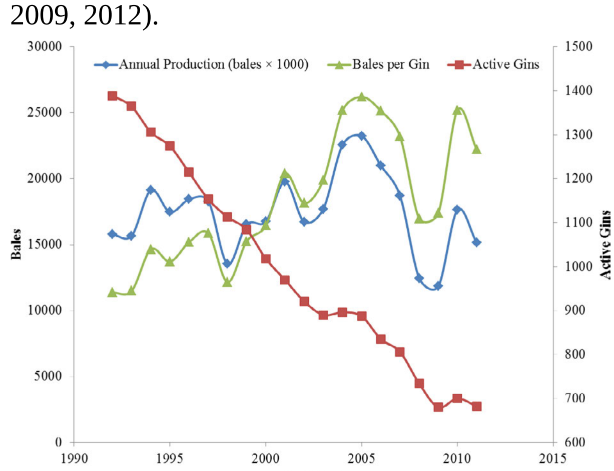

Figure 1. Annual U.S. cotton production, active U.S. gins, and average ginning volume (bales per gin) (NASS, 1993-2012).

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.

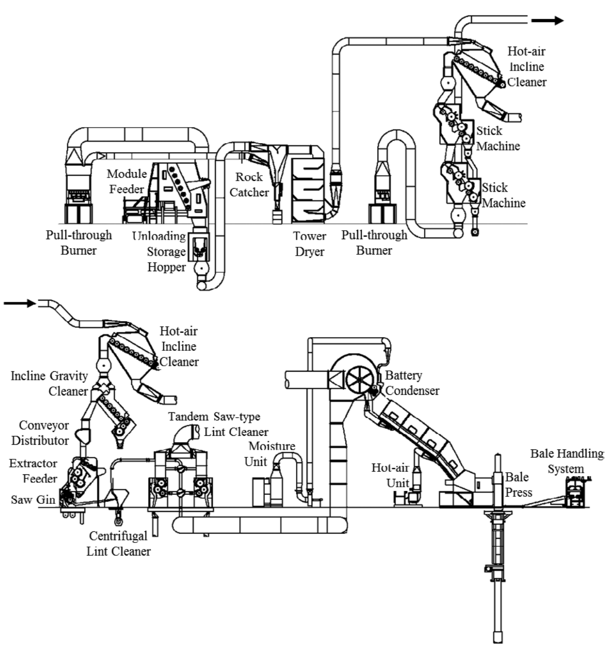

Figure 2. Typical modern cotton gin layout (Courtesy Lummus Corporation, Savannah, GA).

Material captured by cyclones that handle airstreams laden with greater amounts of lint (battery condenser, lint cleaning, and mote system cyclones), referred to as "motes", has considerable value, especially when cleaned in a device similar to a seed-cotton cleaning machine; the mote cleaner. In mote cleaner systems (Fig. 3) the material is pneumatically conveyed from the trash exit of the cyclones to a screened separator where the motes are separated from the conveying airstream and dropped into the mote cleaner. The airstream from the screened separator continues through a centrifugal fan to one or two particulate abatement cyclones. A branch of the pneumatic system between the separator and fan is often utilized to pick up, by suction, the mote trash from the mote cleaner trash exit. The material handled by the mote cleaner system cyclones typically includes small leaf trash, soil, and some lint fibers (Fig. 4).

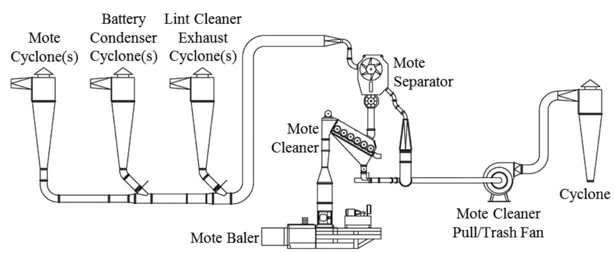

Figure 3. Typical cotton gin mote cleaner system layout (Courtesy Lummus Corporation, Savannah, GA).

Figure 4. Photograph of typical trash captured by the mote cleaner 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).

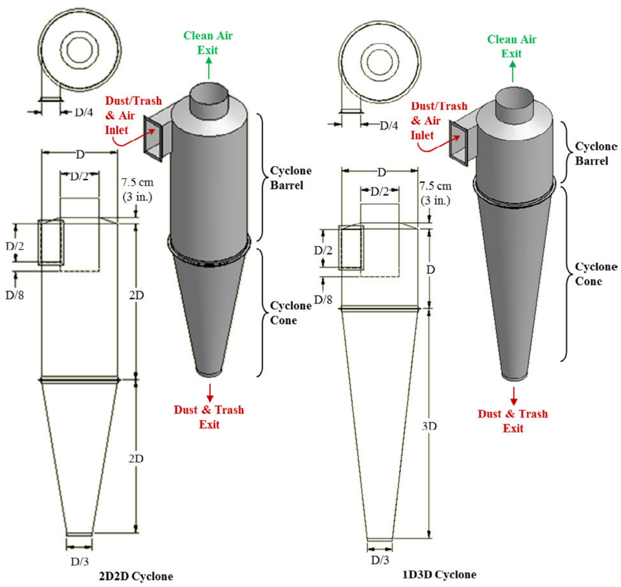

Figure 5. 2D2D and 1D3D cyclone schematics.

The objective of this study was to collect PM_{10} emission factor data for mote cleaner 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 mote cleaner system at the two gins. 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.

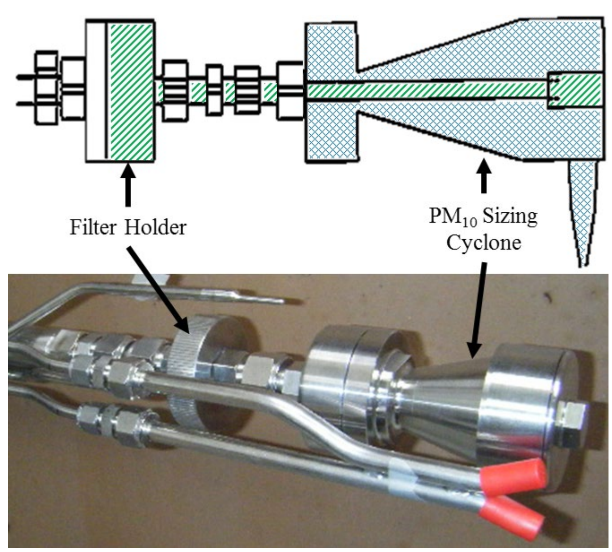

Figure 6. EPA Method 201A PM_{10} sizing cyclone and in-stack filter holder schematic (CFR, 2010) and photograph (▨ ≤ 10 µm, ▩ > 10 µm).

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]).

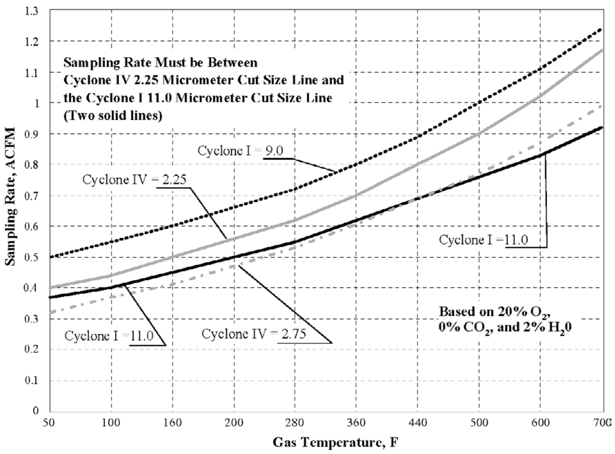

Figure 7. Acceptable sampling rate for sizing cyclones (CFR, 2010) Cyclone I = PM_{10} sizing cyclone (gas temperatures for the mote cleaner systems ranged from 27 to 35°C (81-95°F]).

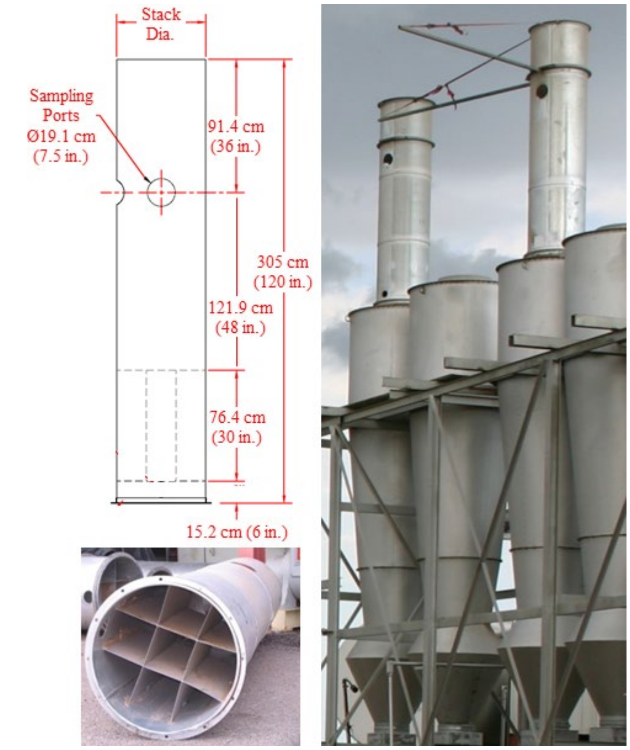

Figure 8. Schematic and photographs of stack extensions with sampling ports and staightening vanes (rail attached to extension above sampling port; at right, supports sampling probe during testing traverse).

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.

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 the cotton gins. 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).

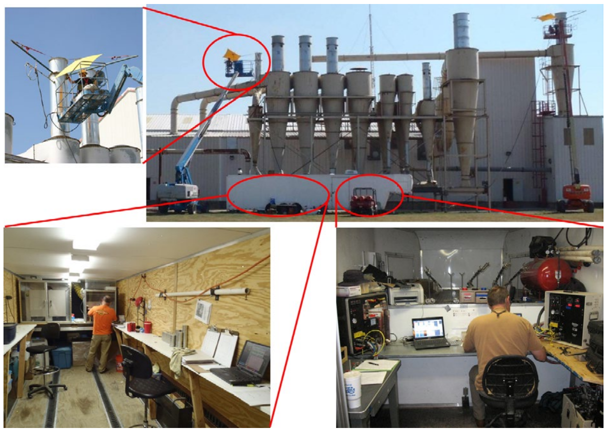

Figure 9. Clockwise from top right: cotton gin stack sampling with air quality lab trailer and technicians on lifts; certified stack sampling technician in the trailer control room conducting tests; sample recovery in trailer clean room; technician operating the probe at stack level.

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.

Two of the seven gins had mote cleaner systems. The mote cleaner systems sampled were typical for the industry. At gin G (Fig. 10), the motes were pneumatically conveyed from the trash exit of the lint handling cyclones (mote, lint cleaning, and battery condenser systems) to the mote cleaner. At the mote cleaner, the motes were separated from the conveying airstream by a screened separator and dropped into the cleaner. The airstream from the screened separator continued through a centrifugal fan to a cyclone. The mote trash was picked up from the trash exit of the mote cleaner and combined with the exhaust airstream from the screened separator prior to the inlet of the fan. The mote cleaner system at gin F was essentially the same, except a conveying airstream from a system that captured dust generated at the module feeder (module feeder dust system) was combined with the exhaust airstream before the fan (Fig. 11). The addition of the module feeder dust system could significantly influence the particulate matter test results for the gin F mote cleaner system; therefore, no system averages were calculated.

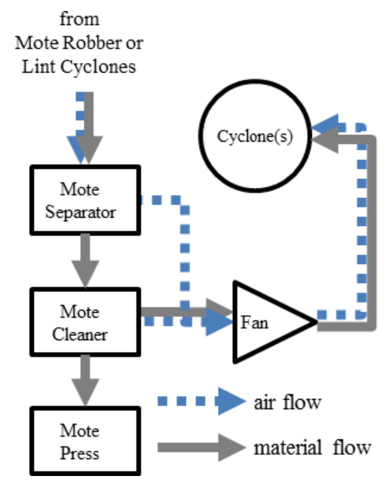

Figure 10. Schematic of mote cleaner system (gins G).

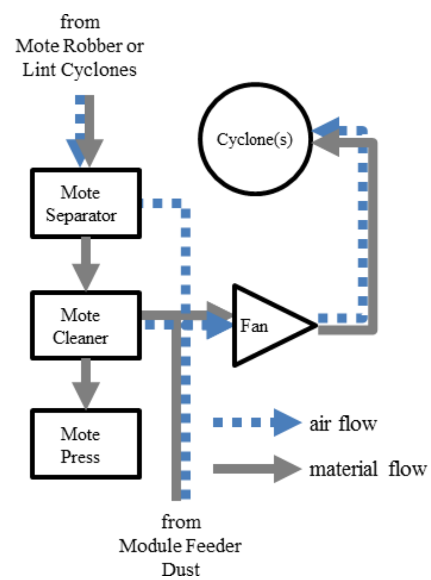

Figure 11. Schematic of mote cleaner system combined with module feeder dust system (gin F).

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

Gin	Cyclone Type	Inlet Design	Systems per Gin	Cyclones per Gin	Configuration	Cone Design	Trash Exits to[y]
F	1D3D	2D2D	1	1	single	standard	auger
G	1D3D	2D2D	1	1	single	standard	auger

[z] Figures 5 and 12

[y] Systems to remove material from cyclone trash exits: auger = enclosed, screw-type conveyor

The mote cleaner systems sampled at both gins F and G utilized single 1D3D cyclones to control emissions (Table 1 and Figs. 5 and 12). The mote cleaner cyclone design for both systems included a 2D2D inlet and standard cone. These cyclone configurations, if properly designed and maintained, are recommended for controlling cotton gin emissions (Whitelock et al., 2009).

Figure 12. Cyclone design for the tested systems: 1D3D cyclone with 2D2D inlet and standard cone.

RESULTS

Table 2 shows the test parameters for each Method 201A test run for the mote cleaner systems sampled. The average ginning rate for the gin F combined mote cleaner and module feeder dust system was 46.2 bales/h and ranged from 39.0 to 50.5 bales/h (based on 227 kg [500 lb] equivalent bales). The average ginning rate for the gin G mote cleaner system was 36.0 bales/h and ranged from 35.0 to 37.0 bales/h. The 1D3D cyclone at gin F was operated with inlet velocities within design criteria, 16.3 ± 2 m/s (3200 ± 400 fpm). The cyclone at gin G was operated outside the design range due to limitations in available system adjustments.

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 Method 201a to obtain total filterable particulate, sampling must be within 90 to 110% of isokinetic flow. This criterion was not met for the first test run for gin F; thus the data associated with this run were omitted from the total particulate test averages. Sampling rates ranged from 10.2 to 13.3 standard l/min (0.359-0.470 standard ft^3/min) for the gin F system and 12.2 to 12.6 standard l/min (0.430-0.446 standard ft^3/min) for the gin G system. The stack gas temperatures ranged from 33 to 35°C (91-95°F) for the gin F system and 27 to 29°C (81-84°F) for the gin G system.

No system averages were calculated because the gin F mote cleaner system was combined with a module feeder dust system that could significantly affect the mote cleaner system emissions. PM_{10} emissions data (ginning and emission rates and corresponding emission factors) for the mote cleaner systems are shown in Table 3. The average PM_{10} emission factor for the combined mote cleaner and module feeder dust system at gin F was 0.071 kg/bale (0.157 lb/bale) and ranged from 0.068 to 0.077 kg (0.149-0.170 lb) per bale. The average PM_{10} emission rate for gin F was 3.27 kg/h (7.21 lb/h). The PM_{10} average emission factor for the mote cleaner system at gin G was 0.050 kg/bale (0.109 lb/bale) and ranged from 0.044 to 0.055 kg (0.097-0.121 lb) per bale. The average PM_{10} emission rate for gin G was 1.79 kg/h (3.95 lb/h). Total particulate emissions data (ginning and emission rates and corresponding emission factors) for the mote cleaner systems are shown in Table 4. The average total particulate emission factor for gin F was 0.109 kg/bale (0.241 lb/bale) and ranged from 0.107 to 0.112 kg (0.237-0.246 lb) per bale. The average total particulate emission rate for gin F was 5.45 kg/h (12.02 lb/h). The average total particulate emission factor for gin G was 0.090 kg/bale (0.199 lb/bale) and ranged from 0.081 to 0.097 kg (0.178-0.213 lb) per bale. The average total particulate emission rate for gin G was 3.26 kg/h (7.18 lb/h). The ratios of PM_{10} to total particulate for gins F and G were 65.1 and 54.9%, respectively (ratios calculated using Tables 3 and 4 might vary slightly from those listed due to rounding).

The average mote cleaner total particulate emission factor determined for gin G (the stand-alone mote cleaner system) was about 56% of the combined EPA AP-42 published values for the mote fan and mote trash fan (EPA, 1996a, b), which would be similar to the mote cleaner system. The range of total particulate emission factors determined for gin G fell within the range of AP-42 emission factor data for the mote fan and was higher than the range for the mote trash fan. The average mote cleaner PM_{10} emission factor for gin G was about 72% of the combined EPA AP-42 published values for the mote fan and mote trash fan. The range of PM_{10} emission factors for gin G also fell within the AP-42 PM_{10} emission factor range for the mote fan and was also higher than the range for the mote trash fan.

Table 2. Cotton gin production data and stack sampling performance metrics for the mote cleaner 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
F[x]	1	39.0	18.3	3593	87[w]	10.7	10.2	0.359	33	91
	2	49.1	18.2	3585	90	10.3	12.7	0.449	34	93
	3	50.5	18.2	3575	95	10.0	13.3	0.470	35	95
Test Average		46.2	18.2	3584						
G	1	35.0	20.8	4103	93	10.4	12.2	0.430	29	84
	2	37.0	21.0	4143	96	10.1	12.6	0.446	28	82
	3	36.0	20.7	4084	94	10.3	12.2	0.431	27	81
Test Average		36.0	20.9	4110						

[z] 227 kg (500 lb) equivalent bales
[y] slpm = standard l/min, scfm = standard ft^3/min
[x] Mote cleaner system exhaust was combined with a module feeder dust system exhaust
[w] Did not meet total particulate isokinetic sampling rate criteria (100 ± 10%)

Table 3. PM_{10} emissions data for the mote cleaner systems.

Gin	Test Run	Emission Rate		Emission Factor	
		kg/h	lb/h	kg/bale[z]	lb/bale[z]
F[y]	1	3.02	6.65	0.077	0.170
	2	3.37	7.43	0.069	0.151
	3	3.43	7.55	0.068	0.149
Test Average (n=3)		3.27	7.21	0.071	0.157
G	1	1.53	3.38	0.044	0.097
	2	2.04	4.49	0.055	0.121
	3	1.80	3.97	0.050	0.110
Test Average (n=3)		1.79	3.95	0.050	0.109

[z] 227 kg (500 lb) equivalent bales
[y] Mote cleaner system exhaust was combined with a module feeder dust system exhaust

Table 4. Total particulate emissions data for the mote cleaner systems.

Gin	Test Run	Emission Rate		Emission Factor	
		kg/h	lb/h	kg/bale[z]	lb/bale[z]
F[y]	1[x]	4.60	10.14	0.118	0.260
	2	5.48	12.07	0.112	0.246
	3	5.42	11.96	0.107	0.237
Test Average (n=2)		5.45	12.02	0.109	0.241
G	1	2.83	6.24	0.081	0.178
	2	3.58	7.90	0.097	0.213
	3	3.36	7.42	0.094	0.206
Test Average (n=3)		3.26	7.18	0.090	0.199

[z] 227 kg (500 lb) equivalent bales
[y] Mote cleaner system exhaust was combined with a module feeder dust system exhaust
[x] Test run omitted from test averages because isokinetic sampling rate (100 ± 10%) was not met

Figure 13 shows an example of samples recovered from a typical mote cleaner 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. 14, 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.

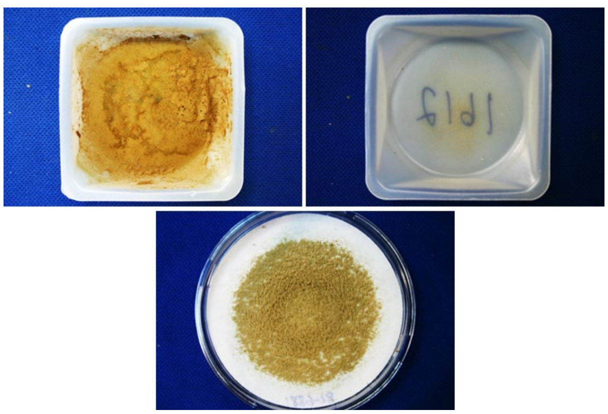

Figure 13. Typical EPA Method 201A filter and sampler head acetone washes from the mote cleaner system. Clockwise from top left: > 10 µm wash, ≤ 10 µm wash, and filter.

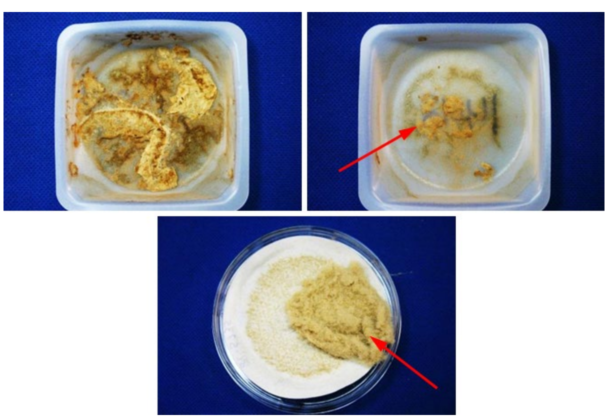

Figure 14. EPA Method 201A filter and sampler head acetone washes from the mote cleaner system with lint fiber in the ≤ 10 µm wash and on the filter (indicated by arrows). Clockwise from top left: > 10 µm wash, ≤ 10 µm wash, and filter.

SUMMARY

Seven cotton gins across the U.S. cotton belt were sampled using EPA Method 201A to collect data to fill the data gap that exists for cotton gin emissions data and improve the EPA AP-42 PM_{10} emission factor quality ratings for cotton gins. Two of the seven gins had mote cleaner systems. The tested systems were similar in design and typical of the ginning industry, but the exhaust from one of the mote cleaner systems was combined with the module feeder dust system. Both systems were equipped with 1D3D cyclones for emissions. The ginning rate of the two gins averaged 36.0 and 46.2 bales/h during testing for the stand-alone mote cleaner system and combined mote cleaner and module feeder dust system, respectively. 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 mote cleaner system average emission factors for PM_{10} and total particulate based on the tests from the stand-alone mote cleaner system (3 total test runs) were 0.050 kg/227-kg bale (0.109 lb/500-lb bale) and 0.090 kg/bale (0.199 lb/bale), respectively. The test average PM_{10} and total particulate emission rates for the stand-alone mote cleaner system were 1.79 kg/h (3.95 lb/h) and 3.26 kg/h (7.18 lb/h), respectively. The ratio of mote cleaner system PM_{10} to total particulate was 54.9%. The average emission factors for PM_{10} and total particulate based on the tests from the combined mote cleaner and module feeder dust system (three total test runs) were 0.071 kg/bale (0.157 lb/bale) and 0.109 kg/bale (0.241 lb/bale), respectively. The test average PM_{10} and total particulate emission rates for the combined mote cleaner and module feeder dust system were 3.27 kg/h (7.21 lb/h) and 5.45 kg/h (12.02 lb/h), respectively, and the ratio of PM_{10} to total particulate was 65.1%.

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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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