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ENGINEERING AND GINNING

Unloading 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 unloading 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 unloading systems that used pneumatic conveyance and had exhaust airstreams that were not combined with another system. In terms of capacity, the three gins were typical of the industry, averaging 26.1 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 unloading system average emission factors for PM_{10} and total particulate were 0.107 kg/227-kg bale (0.237 lb/500-lb bale) and 0.131 kg/bale (0.289 lb/bale), respectively. The system average PM_{10} emission factor was higher and the system average total particulate emission factor was about the same as those currently published in EPA AP-42. Unloading system PM_{10} emission rate test averages ranged from 1.16 to 3.99 kg/h (2.57-8.79 lb/h). The ratio of unloading system PM_{10} to total particulate was 81.9%.

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-µm (PM_{10}) aerodynamic equivalent diameter for 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 and 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,

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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 unloading systems.

The 1996 EPA AP-42 average PM_{10} emission factor for the unloading fan was 0.056 kg (0.12 lb) per 217-kg (480-lb) equivalent bale with a range of 0.024 to 0.10 kg (0.053-0.22 lb) per bale (EPA, 1996a, 1996b). This average and range was based on five 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 unloading fan was 0.13 kg (0.29 lb) per bale with a range of 0.041 to 0.18 kg (0.090-0.40 lb) per bale. This average and range was based on eight 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 about 25 bales per hour across the U.S. cotton belt (Valco et al., 2003, 2006, 2009, 2012).

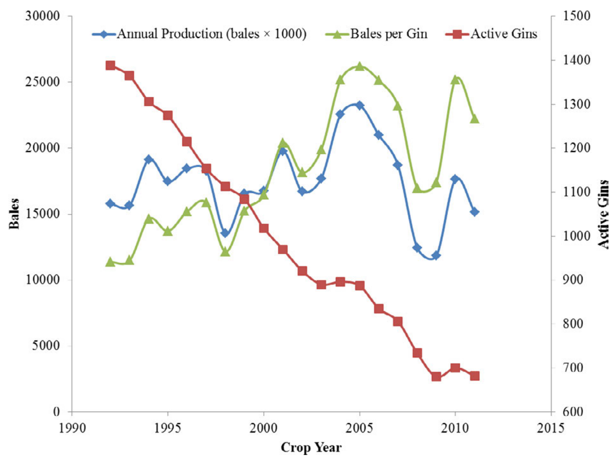

Figure 1. Annual U.S. cotton production, active U.S. gins, and average ginning volume (bales per gin) (NASS, 1993-2012).

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.

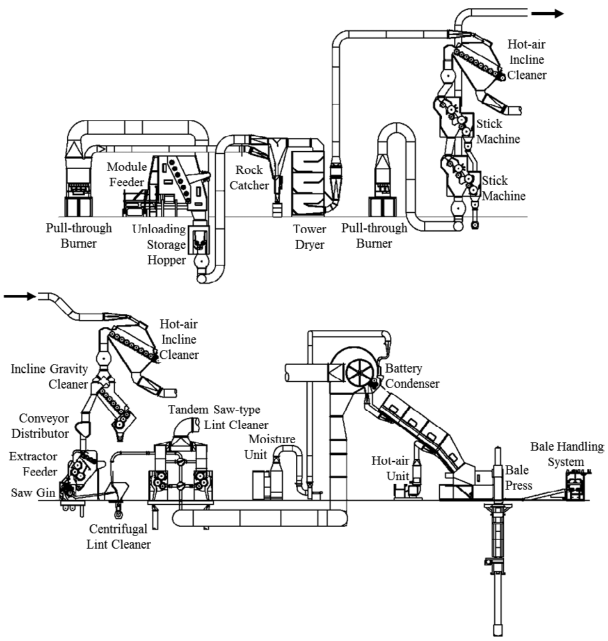

Figure 2. Typical modern cotton gin layout (Courtesy Lummus Corporation, Savannah, GA).

The typical unloading system at a cotton gin employs a module feeder, which mechanically breaks apart the module (Fig. 3). The seed cotton is then mechanically conveyed directly to a feed control device or mechanically conveyed to a heated-air suction pick-up, then pneumatically conveyed to an unloading system screened separator where the seed cotton is removed from the airstream and dropped into a feed control device. Often between the module feeder and feed control, the pneumatic system will flow through a rock and green boll trap to remove these and other heavy objects from the seed cotton. Very little seed cotton is transported from the field in cotton trailers, but when trailers are used the seed cotton is pneumatically unloaded via a telescoping suction pipe. The airstream from the unloading system screened separator continues through a centrifugal fan to one or two particulate abatement cyclones. The unloading system may use air heated up to 117 ºC (350 ºF) at the seed cotton and air mixing point to accomplish drying during transport (ASABE, 2007). Based on system configuration, the air stream temperature at the abatement device could range from ambient to about 50% of the mixing point temperature. The material handled by the unloading cyclones typically includes soil and small leaves, but can also contain larger material like rocks, sticks, and hulls (Fig. 4). Some unloading systems do not utilize a feed control device in which case the module feeder supplies seed cotton directly into the 1st stage seed-cotton cleaning system via a similar heated-air suction pick-up. These types of unloading systems do not require unloading system cyclones.

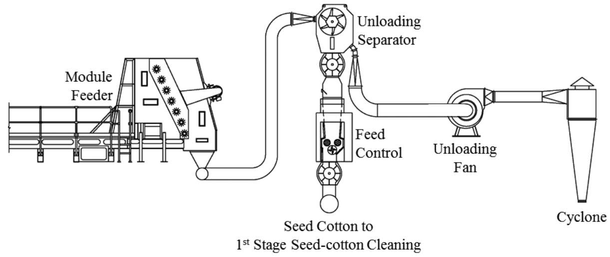

Figure 3. Typical cotton gin unloading system layout (Courtesy Lummus Corporation, Savannah, GA).

Figure 4. Photograph of typical trash captured by the unloading 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 may 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).

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

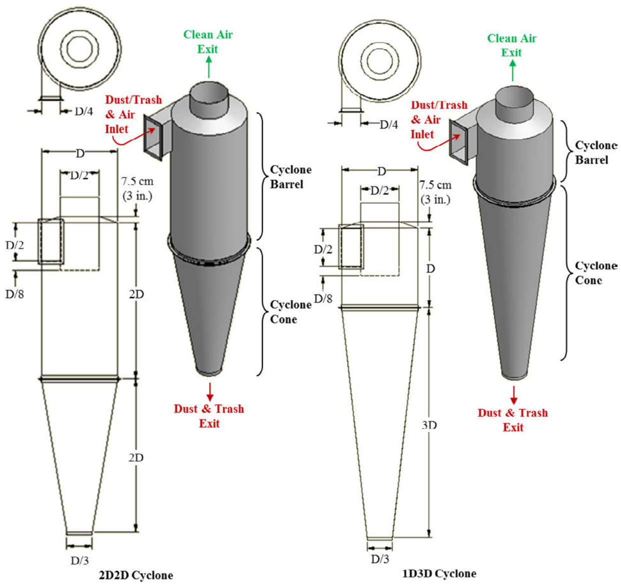

Figure 5. 2D2D and 1D3D cyclone schematics.

METHODS

Two advisory groups were established for this project. The industry group consisted of cotton ginning industry leaders and university and government researchers. The air quality group included members from state and federal regulatory agencies and university and government researchers. 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 unloading 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-µm 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.

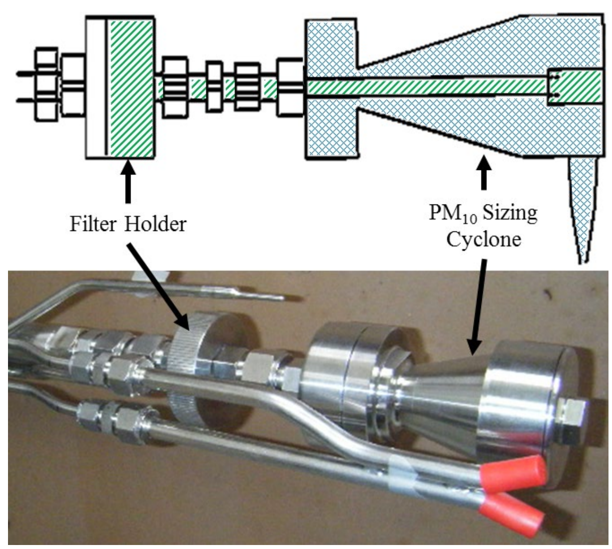

Figure 6. EPA Method 201A PM_{10} sizing cyclone and in-stack filter holder schematic (CFR, 2010) and photograph (≤ 10 µm, > 10 µm).

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 µm 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]).

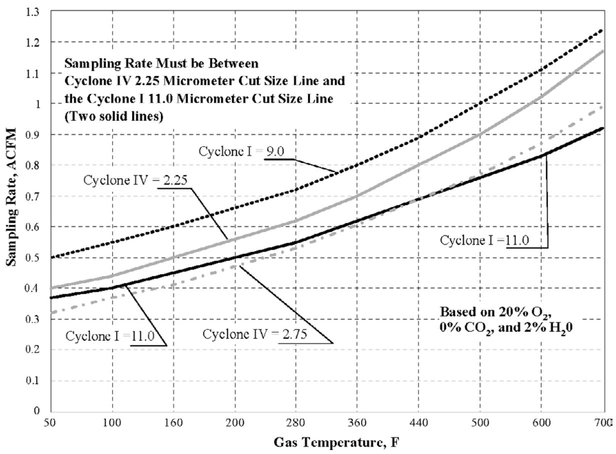

Figure 7. Acceptable sampling rate for sizing cyclones (CFR, 2010) Cyclone I = PM_{10} sizing cyclone (Gas temperatures for the unloading systems ranged from 14 to 27°C [57-80°F]).

Only one stack from each unloading 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 µm 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 and lids were pre-labeled, pre-weighed, 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.

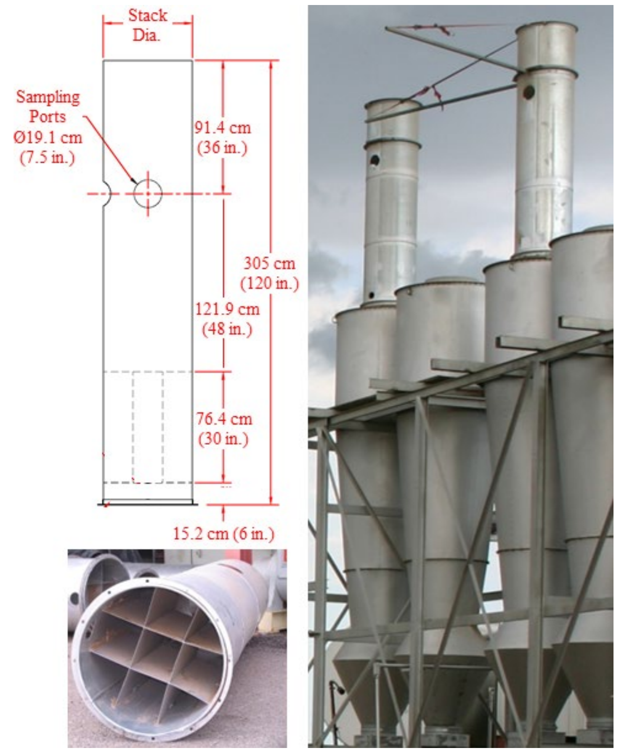

Figure 8. Schematic and photographs of stack extensions with sampling ports and staightening vanes (rail attached to extension above sampling port, at right, supports sampling probe during testing traverse).

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 pre-weighed 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).

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.

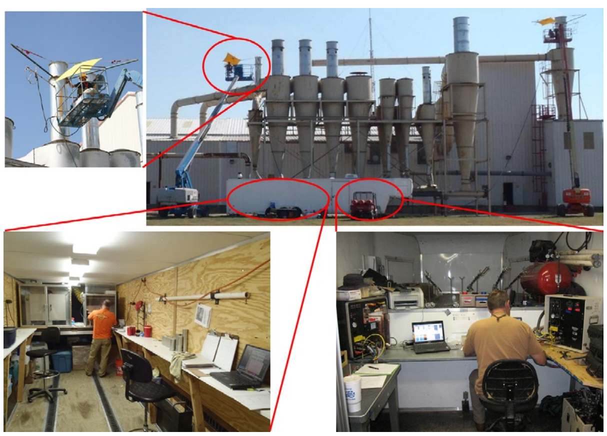

Figure 9. Clockwise from top right: cotton gin stack sampling with air quality lab trailer and technicians on lifts; certified stack sampling technician in the trailer control room conducting tests; sample recovery in trailer clean room; technician operating the probe at stack level.

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 gins had unloading systems that used pneumatic conveyance and had exhaust airstreams that were not combined with another system. The unloading systems sampled were typical for the industry. Gins A and D had similar unloading systems (Fig. 10). The seed-cotton material in a tightly packed module was picked apart by the rotating spiked cylinders of the module feeder and then conveyed pneumatically from the module feeder to the feed control unit. At the feed control unit, the seed cotton was separated from the conveying air by a screened separator and dropped into the feed control that regulated the flow of seed cotton to the remainder of the gin plant. The airstream then passed through a fan and exhausted through one or more cyclones. The gin C system was similar, except after the module feeder the material and conveying airstream was split and proceeded to two, separate and parallel, feed control units with separate fans and emissions control cyclones (Fig. 11).

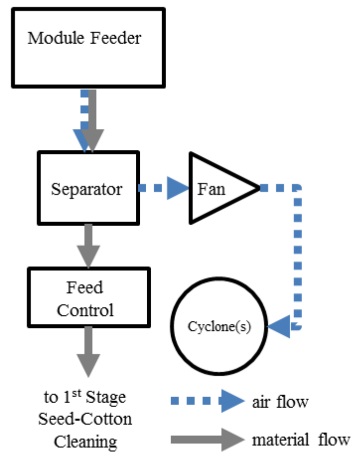

Figure 10. Schematic of single stream unloading system (gins A and D).

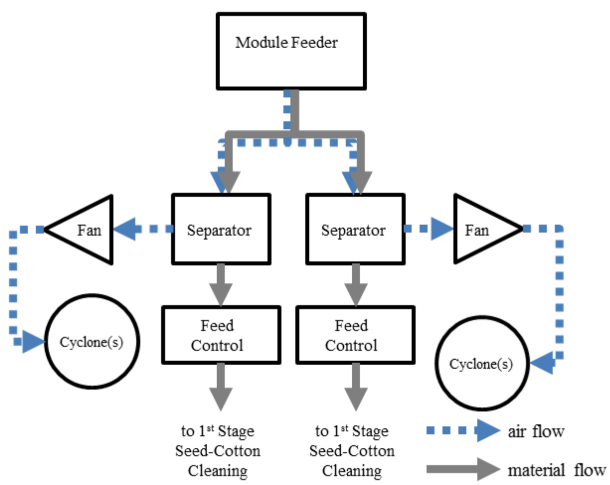

Figure 11. Schematic of split stream unloading system (gin C).

All unloading systems sampled utilized 1D3D cyclones to control emissions (Table 1 and Fig. 5 and 12). All the gins split the system exhaust flow between two cyclones in a dual configuration (side-by-side as opposed to one-behind-another). Inlets on all the unloading cyclones were 2D2D type. Expansion chambers were present on unloading cyclones at all gins. All of the cyclone configurations outlined above, if properly designed and maintained, are recommended for controlling cotton gin emissions (Whitelock et al., 2009).

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

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

[z] Figures 5 and 12

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

Figure 12. 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.

RESULTS

Table 2 shows the test parameters for each Method 201A test run for the unloading systems sampled at the three gins. The system average ginning rate was 26.1 bales/h and the test average ginning rates at each gin ranged from 19.1 to 35.6 bales/h (based on 227-kg [500-lb] equivalent bales). Test run three for gin D was omitted from all test and system averages because of inconsistent gin operation. 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).

Table 2. Cotton gin production data and stack sampling performance metrics for the unloading 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	24.1	17.9	3530	102	9.7	13.4	0.475	16	61
	2	23.0	18.2	3581	96	9.9	12.9	0.455	14	57
	3	23.2	17.6	3455	99	10.0	12.8	0.452	14	57
Test Average		23.4	17.9	3522						
C	1	19.3	17.4	3428	99	10.4	12.0	0.425	25	76
	2	19.3	17.3	3405	99	10.4	12.0	0.424	26	79
	3	18.7	17.1	3367	89[w]	10.9	11.2	0.396	27	80
Test Average		19.1	17.3	3400						
D	1	34.9	14.8	2911	109	10.0	12.5	0.443	25	76
	2	36.4	14.7	2901	115[w]	9.7	13.1	0.462	25	76
	3[x]	17.4	14.2	2805	114[w]	9.9	12.6	0.444	24	75
Test Average		35.6	14.8	2906						
System Average		26.1	16.6	3276						

[z] 227 kg (500 lb) equivalent bales

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

[x] Test run omitted from test averages because of inconsistency in gin operation during test

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

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 also obtain total filterable particulate, sampling must be within 90 to 110% of isokinetic flow. This criterion was not met for one test run for gin C or two test runs for gin D; thus the data associated with these runs were omitted from the total particulate test averages. Sampling rates ranged from 11.2 to 13.4 standard l/min (0.396-0.475 standard ft^3/min). The stack gas temperatures ranged from 14 to 27°C (57-80°F).

PM_{10} emissions data (ginning and emission rates and corresponding emission factors) for the unloading systems are shown in Table 3. The system average PM_{10} emission factor was 0.107 kg/bale (0.237 lb/bale). The test average emission factors ranged from 0.050 to 0.160 kg (0.109-0.353 lb) per bale and emission rates ranged from 1.16 to 3.99 kg/h (2.57-8.79 lb/h). Total particulate emissions data (ginning and emission rates and corresponding emission factors) for the unloading systems are shown in Table 4. The system average total particulate emission factor was 0.131 kg/bale (0.289 lb/bale). The test average emission factors ranged from 0.068 to 0.174 kg (0.150-0.383 lb) per bale. The test average total particulate emission rates ranged from 1.60 to 5.25 kg/h (3.52-11.58 lb/h). The ratio of PM_{10} to total particulate was 81.9% (the ratio calculated using tables 3 and 4 may vary slightly from that listed due to rounding).

The average unloading system total particulate emission factor for this project was approximately equal to the EPA AP-42 published value for the unloading fan (EPA, 1996a, 1996b). The range of test average total particulate emission factors determined for this project fell within the range of AP-42 emission factor data. The average unloading system PM_{10} emission factor for this project was 1.97 times the EPA AP-42 published value for the unloading fan. The test average PM_{10} emission factor range and the AP-42 emission factor data range overlapped.

Figure 13 shows an example of samples recovered from a typical unloading 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

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

Gin	Test Run	Emission Rate, kg/h	Emission Rate, lb/h	Emission Factor, kg/bale[z]	Emission Factor, lb/bale[z]
A	1	1.31	2.89	0.054	0.120
	2	0.95	2.10	0.041	0.091
	3	1.23	2.71	0.053	0.117
Test Average (n=3)		1.16	2.57	0.050	0.109
C	1	2.29	5.04	0.118	0.261
	2	3.22	7.11	0.167	0.369
	3	3.64	8.03	0.195	0.429
Test Average (n=3)		3.05	6.73	0.160	0.353
D	1	4.33	9.55	0.124	0.274
	2	3.64	8.04	0.100	0.221
	3[y]	2.47	5.45	0.142	0.313
Test Average (n=2)		3.99	8.79	0.112	0.247
System Average (n=3)				0.107	0.237

[z] 227 kg (500 lb) equivalent bales

[y] Test run omitted from test averages because of inconsistency in gin operation during test

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

Gin	Test Run	Emission Rate, kg/h	Emission Rate, lb/h	Emission Factor, kg/bale[z]	Emission Factor, lb/bale[z]
A	1	1.49	3.28	0.062	0.136
	2	1.40	3.08	0.061	0.134
	3	1.91	4.21	0.082	0.182
Test Average (n=3)		1.60	3.52	0.068	0.150
C	1	2.93	6.45	0.151	0.334
	2	3.78	8.34	0.196	0.433
	3[x]	4.21	9.28	0.225	0.497
Test Average (n=2)		3.35	7.39	0.174	0.383
D	1	5.25	11.58	0.151	0.332
	2[x]	4.49	9.90	0.123	0.272
	3[xy]	3.01	6.63	0.173	0.381
Test Average (n=1)		5.25	11.58	0.151	0.332
System Average (n=3)				0.131	0.289

[z] 227 kg (500 lb) equivalent bales

[y] Test run omitted from test averages because of inconsistency in gin operation during test

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

Method 201A. However, in the samples shown in Fig. 14, 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.

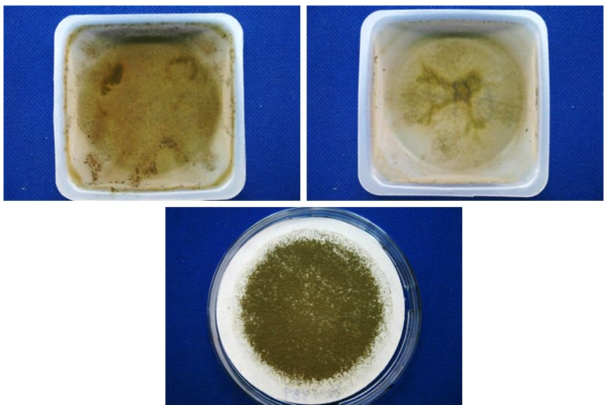

Figure 13. Typical EPA Method 201A filter and sampler head acetone washes from the unloading system. Clockwise from top left: > 10 µm wash, ≤ 10 µm wash, and filter.

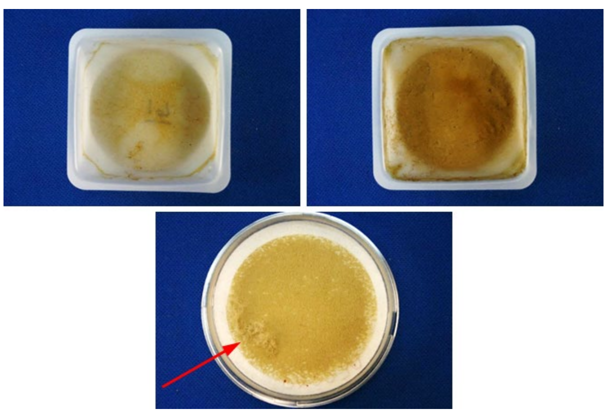

Figure 14. EPA Method 201A filter and sampler head acetone washes from the unloading system with lint fiber on the filter (indicated by arrow). Clockwise from top left: > 10 µm wash, ≤ 10 µm wash, and filter.

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 unloading systems that used pneumatic conveyance and had exhaust airstreams that were not combined with another system. 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 26.1 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 unloading system average emission factors for PM_{10} and total particulate were 0.107 kg/227-kg bale (0.237 lb/500-lb bale) and 0.131 kg/bale (0.289 lb/bale), respectively. The system average PM_{10} emission factor was higher and the system average total particulate emission factor was about the same as those currently published in EPA AP-42. Gin test average PM_{10} and total particulate emission rates ranged from 1.16 to 3.99 kg/h (2.57-8.79 lb/h) and 1.60 to 5.25 kg/h (3.52-11.58 lb/h), respectively. Based on the unloading system average emission factors, the ratio of PM_{10} to total particulate was 81.9%.

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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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