Emission Factors for First- and Second-Pick Pima Cotton

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ABSTRACT. EPA’s Region 9, which includes the major Pima production areas of California and Arizona, raised the concern of possible emission factor differences between first- and second-pick Pima cotton. Anecdotal evidence indicated that some complaints of excessive particulate emissions from Pima gins have arisen from the processing of second-pick cotton. A large amount of emission factor information has been developed over the past 20 years for cotton gins. While some of these data probably include some second-pick upland cotton, most of the upland cotton is harvested once-over with no second picking. There have also been emission factor data gathered for Pima gins, but none of these data can be verifiably attributed to second-pick Pima cotton. Due to the market value of the Pima fiber, there is a significant amount of second-pick Pima cotton ginned each year in EPA Region 9. A study was conducted at a commercial roller gin during the 2001 ginning season to determine what differences there were, if any, between the emission factors for first- and second-pick Pima cotton. Source testing was conducted on the first seed-cotton cleaning and drying system, which is one of the heaviest in terms of particulate emissions. This replicated source test showed that all measured emission parameters were lower for second-pick Pima cotton. This result indicates that there is no need for separate particulate emission factors for first- and second-pick Pima. This test also indicates that emissions determined by current EPA-approved source sampling methods may be overestimating emission levels by as much as 1.5 times. A final result is that the levels of PM_{2.5} (particles whose diameter is less than or equal to 2.5 \mu m) are less than 0.5% of the total emissions for either first- or second-pick Pima.

Keywords. AP-42, Emission factors, Particulate matter, Pima cotton, PM_{2.5}, PM_{10}.

The handling of material removed from seed cotton, lint, and motes during the ginning process is an integral aspect of the ginning operation. This removed material, commonly referred to as trash, waste, or cotton gin by-products, typically consists of burrs, leaves, unopened bolls, lint, seed, motes, rocks, and soil. Prior to mechanized harvesting, any centralized waste collection was done primarily as a means of conveniently handling and disposing of the material. However, as mechanized harvesting methods and accelerated harvesting and ginning rates were introduced, the amount of waste collected per unit time dramatically increased (Baker and Stedronsky, 1967). During the 1960s, various local, state, and federal agencies adopted air pollution control regulations that placed an increased emphasis on controlling particulate matter (PM) emissions from cotton gins. Cotton gins utilize large volumes of air for conveyance, drying, and material separation, which require efficient methods of removing gin waste and PM from the conveying air.

The small-diameter cyclone, as it was originally known, was and remains the most successful and common device used to separate gin waste and PM from the conveying air used in cotton gins. Baker and Stedronsky (1967) evaluated the cyclone design in terms of total collection efficiency, weight of PM emitted per weight of total cotton waste processed, and weight of PM suspended in a given volume of air. They concluded that this cyclone design (later called the 2D-2D design) would maintain total collection efficiencies of 99.9% or greater over a wide range of operating conditions and gin waste sizes. The 2D-2D design became the early industry standard for collecting PM from gin plant air-handling systems. Kirk et al. (1979) reported that, with the Clean Air Act of 1979, the Environmental Protection Agency (EPA) would require states to establish air quality compliance regulations in their State Implementation Plans (SIPS). Kirk et al. (1979) studied an 8 bales/h gin and a 30 bales/h gin to quantify their emissions. All representative exhausts in these gins were evaluated to determine total suspended particulate (TSP) emissions. Results were reported in terms of concentration (mass of PM per unit volume of air), rate (mass of PM per unit time), and emission factor (mass of PM per bale of lint cotton produced). Kirk et al. (1979) commented that, based on their measurements, some gins would not meet existing emission concentration and process weight regulations applied in some SIPS, and that more work needed to be conducted on gin air-pollution-abatement devices.

Parnell and Davis (1979) reported test results on an alternate cyclone design that later came to be called the 1D-3D cyclone. They reported that the 1D-3D design was more efficient than the 2D-2D design in reducing fine PM...
emission concentrations from a California oil mill. Gillum et al. (1981) tested the collection efficiency of cyclones on the first-stage lint-cleaner exhaust at a commercial gin plant. Collection efficiencies were found to be 97%. These efficiencies were much greater than the lint baskets that are commonly used on lint-cleaner exhausts across the Cotton Belt.

In the late 1970s, the EPA conducted source tests on commercial cotton gins in Arizona and California to determine total emissions from several representative gins (Cotton Gin Emission Tests, 1978; Emission Test Report, 1978). Initial results were reported in terms of TSP mass per hour, and were compared against allowable emission rates calculated with various applicable process-weight equations in use at the time. All gin sources tested by the EPA exceeded their process-weight emission limitations by a factor of 2 or more (Gillum et al., 1981), even though their exhausts were controlled by efficient cyclones.

These early EPA gin emission measurements, combined with other information, led to the development of cotton-gin TSP emission factors known as AP-42 factors (U.S. EPA, 1985). AP-42 gin emission factors are commonly used by various regulatory agencies to estimate emission rates and/or emission concentrations from particular gin plants to determine whether a gin is in compliance with its operating permit. Additional source testing, most notably in California, has led to a recent review and updating of the AP-42 emission factors (U.S. EPA, 1996). These factors include estimates for TSP and PM$_{10}$ (those particles whose diameter is equal to or less than 10 µm) that are reported only in terms of pounds of PM emitted per bale of lint cotton processed. These emission factors apply to gins processing both upland and Pima cottons.

The primary regulated pollutant emitted by cotton gins is PM less than or equal to 10 µm aerodynamic equivalent diameter (AED), referred to as PM$_{10}$ (40 CFR Part 50, 1999). However, some states are still regulating TSP. According to the EPA’s Emission Factor Documentation for Cotton Ginning (U.S. EPA, 1996), PM$_{10}$ emission factors were primarily determined by the California Air Resources Board’s (CARB) Method 501. CARB’s Method 501 is similar in function to EPA’s Method 201a (40 CFR Part 51, 2002). Method 201a utilizes a cyclone to collect larger particles while allowing smaller particles to pass through the cyclone and be collected on a filter. According to the EPA guidelines for Method 201a, the cyclone performance characteristics are defined as a $d_{50}$ (also referred to as cutpoint) equal to 10.0 ± 1.0 µm and a slope of 1.5 ± 0.1.

These PM$_{10}$ methods are used to determine emission concentrations associated with individual process stream exhausts. The emission concentrations are then used with the respective airflow and ginning rates to determine PM$_{10}$ emission factors. The use of these sampling methods leads to questions as to whether the resulting PM$_{10}$ emission values are overestimated, considering research reported by Buser et al. (2001). Figure 1 shows the errors associated with the interaction of particle-size distribution (PSD) characteristics and an ambient PM$_{10}$ sampler’s performance characteristics.

Buser et al. (2001) defined this error in terms of the ratio of the theoretical sampler to true concentration, where true concentration refers to the mass of particles with AED less than or equal to 10 µm. In figure 1, the geometric standard deviation (GSD) of the dust is held constant at 2.0 µm for the four defining sets of PM$_{10}$ sampler performance characteristics, which define the acceptable concentrations for PM$_{10}$, and PSD mass median diameters (MMD), ranging from 1 to 40 µm. In general terms, when the ratio is less than 1.0, the current method of sampling PM$_{10}$ underestimates the concentration of PM less than or equal to 10 µm AED, and when the ratio is greater than 1.0, the sampler overestimates the concentration of PM less than 10 µm AED. For example, if a PSD were characterized by an MMD of 10 µm AED and a GSD of 2.0, then the acceptable range of PM$_{10}$ concentrations would be 142 to 158 µg/acm. However, if a PSD were characterized by an MMD of 20 µm AED and a GSD of 2.0, then the acceptable range of PM$_{10}$ concentrations would be

![Figure 1. Theoretical ratios of PM$_{10}$ sampler to true PSD concentrations (PSD - GSD = 2.0) (Buser et al., 2001).](image-url)
158 to 209 µg/acm. Buser et al. (2001) further concluded that if the GSD were less than 2.0, then the errors would increase. In addition, since the range of acceptable d_{50} values for Method 201a is broader than that for the ambient PM_{10} sampler, the range of acceptable or expected concentration measurements will be larger.

Most upland cotton across the Cotton Belt is currently once-over harvested and then plowed under or shredded. However, Pima cottons, because of their more indeterminate plant and production habits, are usually picked a second time before stalk destruction. There was a concern raised by EPA’s Region 9, which includes the major Pima production areas of California and Arizona, of emission factor differences between first- and second-pick Pima cotton. It was EPA Region 9’s opinion that gin particulate emissions are significantly higher for second-pick, as compared to processing first-pick Pima cotton. This was based on undocumented comments received by EPA Region 9 from some members of the cotton industry. While the data, from which AP-42 emission factors (U.S. EPA, 1996) were developed, contain some source test measurements from Pima gins, there is no clear delineation of first-pick versus second-pick emission factors.

The objectives of this study were to determine: (1) if there are differences in PM emission factors for first- and second-pick Pima cotton, (2) if there are differences in PM_{10} emission factors as determined by EPA’s Method 201a source sampling guidelines and by alternate particle-size analysis, and (3) PM_{2.5} emission factors using particle-size analysis.

**MATERIALS AND METHODS**

The general procedure was: (1) select a commercial Pima gin whose ginning equipment and Pima producer-customer base are generally representative of the existing Pima ginning industry; (2) perform replicated particulate-emission measurements using federally certified methods while processing identifiable first- and second-pick Pima cotton; (3) analyze the particulate in the sample train wash and on the filter media used in the certified-method tests using Coulter Counter particle-sizing methods; (4) develop first- and second-pick Pima sampler and true emission factors from these replicated measurements and compare the second-pick emission factors to the first-pick emission factors in terms of PM emissions. It was EPA Region 9, which includes the major Pima production areas of California and Arizona, of emission factor differences between first- and second-pick Pima cotton. This was based on undocumented comments received by EPA Region 9 from some members of the cotton industry. While the data, from which AP-42 emission factors (U.S. EPA, 1996) were developed, contain some source test measurements from Pima gins, there is no clear delineation of first-pick versus second-pick emission factors.

The source-sampling results were used to make a standard comparison of the first- and second-pick emission factors. The Cooperating gin was Anderson Clayton Corporation’s Idria Gin #1, a roller-gin plant, located in the San Joaquin Valley of California. A specific Pima producer was selected whose production was large enough so that the first- and second-pick Pima seed cotton used for the test could be harvested from the same field. Hence, all of the seed cotton was the same variety and was grown under the same production practices, the only differences being first or second pick.

**SOURCE SAMPLING**

The gin’s #1 pre-cleaning exhaust was selected for source sampling. This system’s exhaust is controlled by a set of four 1.12 m (44 in.) diameter 1D-3D cyclones with traditional 1D-3D inlets. This is the gin’s second exhaust, and it handles heated air from the first seed-cotton drier. The #1 pre-cleaning system incorporates an incline cleaner and a stick machine to remove waste from the seed cotton. Typically, this is one of the heavier loaded high-pressure gin exhausts in terms of PM emissions.

A candy-cane-shaped circular duct was attached to the exit tube of one of the four 1D-3D cyclones and continued vertically to the ground. Source sampling was conducted through two sample ports cut into the candy-cane duct. The sample ports were located three diameters upstream and eight diameters downstream from the nearest airflow disturbance. A 12-point traverse sampling scheme (six points per port) was utilized for each sampling run in accordance with EPA’s Method 201a guidelines.

An EPA Method 201a (40 CFR 51, 2002) sampling train was utilized to determine the mass of TSP and PM_{10} emitted from the cyclone selected for testing. The sample train consisted of a stainless-steel nozzle, stainless-steel Anderson PM_{10} cyclone separator, glass-fiber filter, stainless-steel probe, and cooled impingers. The sampling train can be divided into three essential components in regards to PM mass: cyclone wash, post-cyclone wash, and filter. In order to determine the TSP mass, all three mass components were added together. PM_{10} mass was determined by adding the mass of the post-cyclone wash and mass of PM on the filter. All tests were conducted isokinetically. Six test runs were performed for both the first- and second-pick Pima cotton, for a total of twelve test runs.

Idria Gin #1’s production data were used to determine bale production rates in terms of the number of 227 kg (500 lb) bales per hour. Production rates were kept as constant as possible during the tests, with source testing conducted over a two-day period. The first-pick Pima cotton was processed on the first day, and the second-pick cotton on the second day. This timing was used so that, with stable weather conditions, both cottons would be processed under the same environmental conditions. All TSP and PM_{10} emission factors for the source sampling tests were calculated using the following equation:

$$\text{EF} = \frac{\text{Mass}_{PM} \times \text{Area}_{exhaust} \times \text{CF}}{\text{Rate}_{processing} \times \text{Time}_{sampling} \times \text{Area}_{nozzle} \times \text{IV}} \quad (1)$$

where:
- EF = emission factor (kg/bale, or lb/bale)
- Mass_{PM} = mass of PM (kg, or lb)
- Area_{exhaust} = exhaust area (3428 cm², or 3.69 ft²)
- CF = conversion factor (0.06, or 0.132)
- Rate_{processing} = processing rate (bales/h)
- Time_{sampling} = sampling time (min)
Area_{nozzle} = \text{nozzle area (cm}^2, \text{ or ft}^2) \\
IV = \text{isokinetic variation (\%)}

TSP and PM_{10} emission factors for first- and second-pick Pima cotton were determined for each test run. The emission factors for each run were multiplied by 4 (the number of cyclones associated with the system) to obtain a total emission factor for the #1 pre-cleaning system. Certified source-test contractors (AIRx Testing, Ventura, Cal.) conducted the source sampling and data reduction.

**Particle-Size Analysis**

A Coulter Counter Multisizer (CCM) (Beckman Coulter, 2001) was used to perform particle-size analysis. The CCM uses the Coulter electric sensing zone principle to determine particle-size count. Particulate matter is dispersed in an electrically conductive fluid (electrolyte). This electrolyte is forced through a small aperture in an insulated wall. Electrodes located on either side of this aperture produce a constant, controlled electric-current flow through the aperture. As each particle suspended in the electrolyte enters the aperture, it displaces a volume of electrolyte equal to its own volume. This momentarily increases the impedance of the aperture proportionally to the volume of electrolyte displaced. The increased impedance produces a current flow into an amplifier. The current fluctuation is converted into a voltage pulse that is directly proportional to the volume of the particle. The pulses generated by the particles are counted, and the pulse height is analyzed to determine particle volume (Redwine and Lacey, 2001).

The electrolyte used for particle-size analysis with the CCM was 5% lithium chloride/methanol. The electrolyte was pre-filtered using a filtration system that removed all particles larger than 0.2 \( \mu \)m. A background count of the filtered electrolyte was made with the CCM to ensure that there was no particulate contamination of the electrolyte. We viewed as acceptable a background count of less than 300 particles per cm\(^3\) of electrolyte analyzed.

The CCM process of analyzing loaded filters generally consists of the following steps: (1) cut a 2 cm diameter sample from a heavily loaded area of the filter; (2) place the sample in a 100 mL beaker with 50 mL of electrolyte; (3) place the beaker in an ultrasonic bath for 5 min; (4) filter the solution through a 100 \( \mu \)m mesh filter to remove particles greater than 100 \( \mu \)m; (5) gradually insert the filtered solution (via pipette) into clean electrolyte that is being monitored by the CCM until the particle concentration is approximately 5% to 10% (during this step, approximately 300,000 particles will be metered through a 100 \( \mu \)m aperture tube by the CCM to generate a PSD); and (6) repeat step 5 three times, and average the results using the CCM software.

Typically, CCM particle-size analysis is performed using Teflon or poly-web filters, not glass-fiber filters. The primary reason for this is that blank Teflon or poly-web filters have low particle background counts, whereas glass-fiber filters have a very high particle background count. The MMD of the glass fiber particles is approximately 5.0 \( \mu \)m equivalent spherical diameter (ESD), according to Buser (2003).

The results of a CCM particle-size analysis are PSDs in the form of particle volume versus ESD. To convert the PSD results to particle volume versus AED, the ESD was multiplied by the square root of particle density (Parnell et al., 1986). To convert the PSD to particle mass, the particle volume must be multiplied by the particle density; however, this conversion does not impact the PSD characteristics of MMD or GSD. Due to the relatively small amounts of PM contained in the sampling train washes and on the glass-fiber filters, no average particle densities were obtained for these tests. Based on research conducted by Buser (2003) that focused on determining cotton-gin PSD characteristics and particle densities of dust particles less than 100 \( \mu \)m prior to entering the abatement devices, the average particle density used in the Idria Gin #1 tests was assumed to be 1.96 g/cm\(^3\). Results obtained from the CCM analysis and adjusted for particle density included: \( d_{50} \) (MMD), \( d_{84.1} \), \( d_{15.9} \), percent of PM less than 10 \( \mu \)m, and the percent of particles less than 2.5 \( \mu \)m. The GSD was calculated as the square root \( d_{84.1} \) divided by \( d_{15.9} \) (Hinds, 1999).

The percentages of particles less than 10 \( \mu \)m and less than 2.5 \( \mu \)m, determined by the CCM method for the cyclone wash, post-cyclone wash, and filters, were multiplied by the corresponding masses of PM reported by Airx Testing (Ventura, Cal.) to determine the true PM\(_{10}\) and PM\(_{2.5}\) masses. The masses corresponding to PM\(_{10}\) for the cyclone wash, post-cyclone wash, and filters were added together in order to determine the true total PM\(_{10}\) mass. The same process was used to determine the true total PM\(_{2.5}\) mass. Equation 1 and total PM\(_{10}\) and PM\(_{2.5}\) masses were used to determine the corresponding emission factors. Theses emission factors were multiplied by 4 to determine the true total emission factors for Idria Gin #1’s first pre-cleaning system. The multiplication was necessary because only one of the four cyclones on the pre-cleaning system was sampled.

**Results and Discussion**

Table 1 lists the parameter values used in calculating the source sampling and true emission factors. Airx Testing (Ventura, Cal.) provided the parameter values, except for the PM percentages, which were determined by particle-size analyses. Table 2 provides a summary of the particle-size distribution analyses. The PROC Mixed (Littell et al., 1996) procedure in SAS was used to compare the PSD characteristics associated with first- and second-pick Pima cotton. The test data were categorized by three class variables: (1) harvest (first or second pick); (2) sample location (cyclone wash, post-cyclone wash, or filter); and (3) test number (replication). Test number was treated as a random effect, while harvest and sample location were treated as fixed effects.

There were no harvest-by-location interaction effects that were significant at \( \alpha = 0.05 \) for any of the PSD characteristic measurements. The effect due to sample location was much more significant than the effect due to harvest for the MMD, percent PM\(_{10}\), and percent PM\(_{2.5}\). Therefore, the effects due to harvest were analyzed within sample location. As expected, the percent PM\(_{10}\) and percent PM\(_{2.5}\) were larger for the PM captured on the filters than for the PM associated with the two washes. Generally, there were no significant effects (\( \alpha = 0.05 \)) between first- and second-pick Pima cotton for the PSD characteristics of any sample location; however, there were a few exceptions. There were significant differences in GSD values due to harvest for the cyclone and post-cyclone washes. Although differences were detected in the GSD values, the differences are relatively small (i.e., 1.9 and 1.8 for first and second pick,
Particle-size distribution characteristics as determined by Coulter Counter analysis for Idria Gin #1’s first seed-cotton cleaning and drying system exhaust.

Table 2

<table>
<thead>
<tr>
<th>Nozzle Area (cm²)</th>
<th>Isokinetic Variation (%)</th>
<th>Weight (g)</th>
<th>PM10 (%)</th>
<th>PM2.5 (%)</th>
<th>MSE</th>
<th>p-value (b)</th>
<th>F value</th>
</tr>
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<td>9.0 a</td>
<td>1.344</td>
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<td>15.6 b</td>
<td>2.884</td>
<td>0.0147</td>
<td>6.61</td>
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<td></td>
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<tr>
<td>Cyclone</td>
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<td>18.8 a</td>
<td>6.373</td>
<td>0.1855</td>
<td>1.83</td>
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<td></td>
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<td>1.6 a</td>
<td>1.000</td>
<td>0.1042</td>
<td>2.79</td>
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<td>1.8 a</td>
<td>0.003</td>
<td>&lt;0.0001</td>
<td>27.29</td>
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<td>PM10 (%)</td>
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<td>0.2038</td>
<td>1.69</td>
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</table>

[a] Means between first and second pick followed by the same letter are considered non-significant at the 5% level using Duncan’s multiple-range test.
[b] The p-value is the test of significance of means being equal in the PROC Mixed procedure of SAS. Any p-value greater than 0.05 was considered to be non-significant between first and second pick.
[c] MMDs reported in terms of aerodynamic equivalent diameter with a particle density of 1.96 g/cm³.

respectively) and are minor in comparison to the post-wash MMD differences. The main significant differences detected between first and second pick were found to be MMD and percent PM2.5 for the post-cyclone wash. Both the MMD and percent PM2.5 associated with the post-cyclone wash were significantly smaller (α = 0.05) for the second-pick Pima cotton as compared to the first-pick cotton.

Equation 1 was used to calculate the source sampling TSP and PM10 emission factors using the data provided in table 1 and the processing rates provided in table 3. Further, the true PM10 and PM2.5 emission factors were calculated as previously described using the information provided in tables 1 and 3. Table 3 includes the source sampling emission factors for TSP and PM10, the source sampling ratio of PM10 to TSP, the true PM10 and PM2.5 emission factors, and the true ratio of PM10 to TSP and PM2.5 to TSP. The PROC Mixed (Littell et al., 1996) procedure in SAS was used to compare the emission factors and emission-factor ratios associated with first- and second-pick Pima cotton.

There were no significant differences (α = 0.05) in the processing rates between first- and second-pick Pima cotton (16.60 and 16.36 bales/h, respectively). This was expected due to an on-site inspection of the cotton modules used for testing. All cotton in the test modules had been properly harvested, tARP-ed, and stored prior to ginning, and showed no signs of any unusual conditions. It was essential to have equivalent processing rates for the first- and second-pick cotton so that any differences in emission factors could be attributed to the cotton itself, and not to any other factor.

The PM10 source sampling emission factors and corresponding PM10 to TSP ratios (table 3) were significantly higher for first-pick Pima cotton, compared to second-pick cotton (0.2163 to 0.1629 kg/bale, and 63% to 56%, respectively). No significant differences (α = 0.05) were detected between first- and second-pick Pima cotton TSP, true PM10, or true PM2.5 emission factors, and no differences were detected between the true PM10 or PM2.5 to TSP ratios. The data does, however, show a trend of lower emission factors and smaller emission-factor ratios for second-pick Pima cotton as compared to first-pick cotton.

The PM10 emission factors and PM10 to TSP ratios determined by source sampling and particle-size analyses were compared to determine if these test data followed the theoretical errors associated with the current federal guidelines of measuring PM10 via source sampling, as described by Buser et al. (2001). The PM10 emission factors for the Idria Gin #1 dryer and cleaner system, as given in table 3, were significantly higher than the emission factors determined by particle-size analyses for both first- and second-pick Pima cotton (0.2163 to 0.1399 kg/bale, and 0.1629 to 0.1056 kg/bale, respectively). The PM10 to TSP ratios were also significantly higher than the ratios determined by particle-size analyses for both first- and second-pick Pima cotton (63.1% to 40.8%, and 56.1% to 35.9%, respectively). The ratio of the PM10 emission factors to the PM10 emission...
The first objective of the test was to determine if emission factors associated with second-pick Pima cotton were significantly higher than for first-pick Pima cotton. The source testing was conducted on the gin’s #1 dryer and cleaner system, which, according to AP-42, is expected to be one of the heaviest loaded exhausts in a gin. Test results showed that there were no significant differences between emission factors associated with first-pick and second-pick Pima cotton. In fact there was a tendency for the second-pick emission factors to be lower than the first-pick emission factors; however, all measured TSP and PM\(_{10}\) emission factors were higher than the corresponding AP-42 average values.

A second objective of this study was to determine if there were differences in the PM\(_{10}\) emission factors determined by using EPA’s Method 201a source sampling guidelines and CCM particle-size analyses. A third test objective was to determine PM\(_{2.5}\) emission factors using particle-size analyses. The PM\(_{2.5}\) to TSP emission factor ratios were determined to be 0.22% and 0.16% for first-pick and second-pick Pima cotton, respectively. The PM\(_{10}\) source sampling emission factors were about 1.55 times higher than the emission factors determined by particle-size analyses. This overestimation agrees with the theoretical analyses of the errors by Buser et al. (2001), which was associated with interaction of PSD and sampler performance characteristics. This error implies that if any regulatory agency utilizes emission factors determined by source sampling to regulate a gin’s #1 pre-cleaning system exhaust, then they are forcing it to comply with regulations that are at least 155% more stringent than regulations placed on a facility emitting PM with an MMD less than or equal to 10 \(\mu\)m. This type of measurement inequity means that the EPA method is inaccurate in determining emissions and ineffective in protecting air quality.

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