UPDATE ON THE ASAE PROPOSED STANDARD X-578: COTTON GINS – METHOD OF UTILIZING EMISSION FACTORS IN DETERMINING EMISSION PARAMETERS

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Abstract

State air pollution regulatory agency (SAPRA) permit engineers are required to perform in-depth analyses of cotton gin emissions. This analysis may include calculations of emission rates and concentrations of all point sources using emission factors. The primary regulated pollutant emitted by cotton gins is particulate matter (PM) less than 10 micrometers aerodynamic equivalent diameter (AED), referred to as PM_{10}. In some states, emissions of total suspended particulate matter (TSP) are regulated. The results of a permit engineer's analyses are incorporated into a permit so the facility may operate. The goal of the SAPRA is to protect the public. The permit approved by the SAPRA permit engineer specifies the allowable emission rate for the facility. Consulting engineers working with cotton ginners and permit engineers must develop air pollution abatement systems that comply with SAPRA regulations while minimizing cost. A proposed engineering practice standard was developed to define the operations of a cotton gin with engineering data that can be used by both consulting and permit engineers such that cotton gins are fairly and appropriately regulated.

Introduction

State Air Pollution Regulatory Agencies (SAPRA) regulate the air pollution associated with cotton gins. Numerous instances of unfair and inappropriate regulatory actions in a number of different states have been reported. These actions came to the attention of the ASAE PM50 Cotton Engineering Committee in 1998 and the committee perceived that these problems were due to a lack of understanding of how to properly utilize cotton gin emission factors in determining emission parameters. The view of the PM50 committee members was that an ASAE engineering practice standard could be used to educate SAPRA permit and consulting engineers and SAPRA enforcement personnel to facilitate the appropriate regulation of cotton gins. A PM50 subcommittee chaired by Dr. Calvin Parnell was formed to develop the engineering practice standard. Members of this subcommittee include: SAPRA permit engineers; cotton ginning engineers from the three USDA, ARS Cotton Ginning Research Laboratories; engineers and officers associated with the national and state cotton ginning associations; scientist and officers representing the National Cotton Council; and faculty from the Department of Agricultural Engineering, Texas A&M University. A list of the subcommittee members is included in the appendix. The draft of the standard reviewed by the PM50 subcommittee at the subcommittee meeting held during the Beltwide Cotton Production and Research Conferences on January 11, 2001 is also included in the appendix.

It is anticipated that the procedures and data included in this proposed standard will aid permit and consulting engineers in calculating various air pollution parameters for cotton gins, such as daily and seasonal TSP and PM_{10} emission rates, point source emission concentrations, and point source emission rates. Further, these procedures could be utilized by consultants when responding to notice of violations, recommending modifications to existing ambient air pollution control systems, or designing and developing new air pollution abatement systems in order to comply with SAPRA regulations. Regulators could use the data and procedures when reviewing permits or investigating complaints against a permitted facility. The proposed standard also establishes preferred terminology for use in air pollution engineering.

The purpose of paper is to introduce the proposed standard and to provide additional examples of how this standard will aid the cotton ginning community.

Discussion/Application

Equipment and equipment arrangements can vary widely from gin to gin. The number of process streams and air flow rates and emission factors for each process stream are generally included in a gins permit. Permits are typically developed by consulting engineers and approved by a SAPRA engineers. There are no requirements that either the SAPRA engineers or the consulting engineers use the exact data presented in this standard. In fact, it is likely that the gin description and corresponding flow rates and emission factors for each process stream specified in a permit for a specific gin will differ from the examples presented in this standard. However, the methods presented in this standard for calculating emission parameters, such as emission concentrations and rates, should be followed and based on the specified air flow rates and emission factors for the gin in question.

To illustrate the appropriate calculations of PM emissions parameters, the concept of a "standard gin" with an air pollution abatement system described as baseline best available control technology (BBACT) is utilized in this standard. Flannigan, et al (1997) was the first to describe the standard gin approach in developing the least-cost air pollution abatement system for a cotton gin. Gins will commonly have the basic systems described in the standard gin such as unloading, pre-cleaning, lint/seed separation (ginning), lint cleaning, and packaging (baling) with BBACT control devices on each of the exhausts. However, a specific gin may have more or fewer stages of pre-cleaning or lint cleaning and other process streams described in the standard gin may not exist in a particular gin due differing methods of material conveying; such as mechanical or gravity fed systems. In addition, a specific gin may have exhaust control devices, which differ from BBACT. Deviations in a specific gins equipment setup must be considered before using the procedures presented in this engineering practice standard.

The term "process stream" used throughout this paper and the proposed standard, refers to sum of all equipment which is performing the same task and running in parallel. For example, if a 20 bale/hr gin is utilizing to two 10 bale/hr gin stands and each gin stand is followed by a one stage of lint cleaning, then the process stream associated with the 1st stage of lint cleaning would correspond to both lint cleaners which are running in parallel. The emission factors associated with a process stream are not changed by increasing the number machines running in parallel; therefore, in the previous example the emission factor associated with two lint cleaners is exactly the same as the emission factor for a gin utilizing one lint cleaner. The air flow rates associated with the process streams are directly affected by the number of machines running in parallel. For example, a lint cleaner following a 10 bale/hr gin stand may require an air flow of 10,500 cfm, if this gin stand and lint cleaner are run in parallel with an additional gin stand and lint cleaner (same capacity) then the total air flow rate associated with the lint cleaner process steam would be 21,000 cfm (2*10,500).

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In 1996, the EPA AP-42 emission factor guidelines for cotton gins were changed. The 10 process streams that were included in the 1988 AP-42 were reduced to 8 and the total emission factor for the gin was increased from 2.24 pounds of total suspended particulate matter (TSP) per bale of cotton processed (lb_{TSP}/bale) to 3.05 lb_{TSP}/bale. The 1996 AP-42 combined the emission factors for the 1st and 2nd stage lint cleanings into one emission factor and excluded the emission factor for the unloading separator. The authors felt that there was merit to having 10 process streams rather than 8 and chose to merely increase the 1988 AP-42 process stream emission factors by a factor of 3.05/2.24. Hence, this ASAE voluntary standard has 10 process streams, each having an associated emission factor.

An example of how to use "standard gin" data to calculate emission concentrations, emission rates, and emissions inventories is provided in section 6 of the proposed standard. Included in this example is the following scenario: the gin must reduce its emission rate by SAPRA mandate. A systematic procedure for finding the least-cost method of complying with the SAPRA mandate is presented. The underlying premises in this example are as follows: the consulting engineer has a goal of a least-cost solution for his client; the permit engineer has a goal of compliance with the SAPRA rules and regulations; and that the rules and regulations were developed by interdisciplinary efforts with protecting the public health and welfare as the goal.

A general misperception associated with emission factors is that the AP-42 gives a facility a "right" to emit PM. The AP-42 is a set of guidelines set forth by the EPA, which may or may not be the same levels used in permitting a facility. The assumption is made in this proposed ASAE engineering practice standard that the 3.05 lb_{TSP}/bale total emission factor corresponds to a gin with 10 process streams and a BBACT air pollution abatement system. A BBACT air pollution abatement system consists of 1D-3D or 2D-2D cyclones on all centrifugal fan process streams and covered condenser drums on all vane axial fan systems.

The example presented in the draft standard used "standard gin" data. How do these procedures apply to a gin that has more or fewer than 10 process streams? The procedures are used in the same manner. The differences in the engineering calculations between the "standard gin" and a gin with more or fewer process streams are accounted for by appropriately adjusting the emission factors and air flow rates associated with the additional or fewer process streams. For a gin that has fewer process streams than the "standard gin", the emission factor and air flow for the eliminated process stream (the process stream which is shown in the "standard gin, but not present in the current gin configuration) would be omitted from the procedures presented in the application section of the proposed standard. For a gin that has more process streams than the "standard gin", an additional emission factor and airflow would be added to the procedures presented in section 6 of the proposed standard. Therefore, a gin with additional process streams will have a higher total emission factor and a gin with fewer process streams will have a lower total emission factor than the 1996 AP-42 guideline of 3.05 lb_{TSP}/b. For example, if a gin uses a 3rd stage of lint cleaning, the emission factor guideline would be 3.25 lb_{TSP}/b.

The following examples illustrate how to implement the procedures presented in the proposed standard for gins with more or fewer process streams than the "standard gin".

Example No. 1

Consider a 30 bale per hour picker type cotton gin, which only uses one stage of lint cleaning. The two main differences between this example and the example presented in the proposed standard are: 1) a higher ginning rate and 2) the gin has 9 process streams instead of 10 process streams. Assuming the actual air flow rates are not known, the first step is to determine the airflow rates for the 9 process streams. The simplest method of calculating these rates is to utilize the total air flow equation presented in section 5.4 of the proposed standard and the "% flow" numbers presented in Table 1 and 2 of the proposed standard. The "% flow" numbers must be modified, so that the numbers associated with process stream 9, total axial fan, and total are 0, 30, and 85%, respectively. These "% flow" numbers must be change because the original numbers, as presented in the proposed standard, are based on power consumption for gins with 10 process streams. Next, the modified emission factors presented in Table 3 of the proposed standard are adjusted. The emission factors for process stream 9, total axial fan, and total are changed to 0, 1.36, 2.85, respectively. Now that the air flow rates and emission factors are adjusted, the emission rates and emission concentrations can be calculated in exactly the same manner as shown in section 6 of the proposed standard. The calculated emission parameters for this example are shown in Table 1.

Example No. 2

Consider a 30 bale per hour picker type cotton gin, which uses three stages of lint cleaning. The two main differences between this example and the example presented in the proposed standard are: 1) a higher ginning rate and 2) the gin has 11 process streams instead of 10 process streams. Assuming the actual air flow rates are not known, the first step is to determine the airflow rates for the 11 process streams. The simplest method of calculating these rates is to utilize the total air flow equation presented in section 5.4 of the proposed standard and the "% flow" numbers presented in Table 1 and 2 of the proposed standard. The "% flow" numbers must be modified to include an additional process stream. This is relatively easy when utilizing assumption 5.4.14 of the proposed standard, which states; "the volume-rate-of-flow associated with each stage of lint cleaning and battery condenser process streams are equal". Using this assumption, the "% flow" numbers for process stream 11 (3rd lint cleaner), axial fan total, and total would be 15, 60, and 115%, respectively. Remember that the "% flow" numbers relate to the "standard gin", so it is logical to have numbers greater than 100%. Next the modified emission factors presented in Table 3 of the proposed standard are adjusted. An additional emission factor must be added for process stream 11. The most logical number to use is 0.20 lb_{TSP}/b , which is the same emission factor used for process stream number 9 (2nd stage of lint cleaning). Neither the 1988 nor the 1996 AP-42 provide emission factor guidelines for a 3rd stage of lint cleaning. Therefore, the best number available for a 3rd stage of lint cleaning is the emission factor for the 2nd stage of lint cleaning. Modifications must also be made to the axial fan total and total emission factors, which are 1.76 and 3.25 pounds per bale, respectively. Now that the air flow rates and emission factors are adjusted, the emission rates and emission concentrations can be calculated in exactly the same manner as shown in section 6 of the proposed standard. The calculated emission parameters for this problem are shown in Table 2.

The methods presented in examples 1 and 2 can be used to estimate emission parameters, based on adjusting the proposed standard procedures, for any gin setup that differs from the equipment setup associated with the "standard gin". However when adjusting the procedures to account for more of fewer process streams, the assumptions associated with the process need to be carefully reviewed. For example; if a gin mechanically conveys the trash to the trash pile or hopper (instead of pneumatically conveying the material, which is done in the "standard gin") through the used of an auger, conveyer belt, or some other means, there is most likely an emission factor, emission rate, and emission concentration that should be accounted for in the process. When accounting for differences between the "standard gin" and specific gin setups, cases such as adding or eliminating one stage of lint cleaning and/or eliminating the overhead distributor separator process stream can be accomplished using the procedures presented in Examples 1 and 2.

Disclaimer

Mention of a trade name, propriety product or specific equipment does not constitute a guarantee or warranty by the United States Department of Agriculture and does not imply approval of a product to the exclusion of others that may be suitable.

Table 1. Emission Parameters based on a 30 bale per hour picker gin with 1 stage of lint cleaning.

Process	%Flow	Flow (cfm)	EF (lbs/bale)	ER (lbs/hr)	EC (mg/m^3)	Strategy Based on EF	EC
1	11%	22346	0.44	13.07	156	2	
2	11%	22346	0.25	7.35	88	3	
3	10%	21229	0.14	4.08	51		
4	10%	20112	0.05	1.63	22		
5	2%	4678	0.23	6.94	396		2
6	10%	20112	0.11	3.27	43		
7	2%	4678	0.27	8.17	466	3	1
CF Total	55%	115500	1.48	44.52	103		
8	15%	31500	1.10	33.09	280	1	3
9	0%	0	0				
10	15%	31500	0.26	7.76	66	3	
AF Total	30%	63000	1.36	40.85	173		
Total	85%	178500	2.85	85.37	128		

Table 2. Emission Parameter based on a 30 bale per hour picker gin with three stages of lint cleaning.

Process	%Flow	Flow (cfm)	EF (lbs/bale)	ER (lbs/hr)	EC (mg/m^3)	Strategy Based on EF	EC
1	11%	22346	0.44	13.07	156	2	
2	11%	22346	0.25	7.35	88	3	
3	10%	21229	0.14	4.08	51		
4	10%	20112	0.05	1.63	22		
5	2%	4678	0.23	6.94	396		2
6	10%	20112	0.11	3.27	43		
7	2%	4678	0.27	8.17	466	3	1
CF Total	55%	115500	1.48	44.52	103		
8	15%	31500	1.10	33.09	280	1	3
9	15%	31500	0.20	6.13	52		
11	15%	31500	0.20	6.13	52	3	
10	15%	31500	0.26	7.76	66		
AF Total	60%	126000	1.77	53.10	113		
Total	115%	241500	3.25	97.63	108		

Appendix: Proposed ASAE Standard X-578

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Cotton Gins - Method of Utilizing Emission Factors in Determining Emission Parameters

1. Purpose and Scope

1.1. State air pollution regulatory agency (SAPRA) permit engineers are required to perform in-depth analyses of cotton gin emissions. This analysis may include calculations of emission rates and concentrations of all point sources using emission factors. The primary regulated pollutant emitted by cotton gins is particulate matter (PM) less than 10 micrometers aerodynamic equivalent diameter (AED), referred to as PM_{10}. In some states, emissions of total suspended particulate matter (TSP) are regulated. The results of a permit engineer's analyses are incorporated into a permit so the facility may operate. The goal of the SAPRA is to protect the public. The permit approved by the SAPRA permit engineer specifies the allowable emission rate for the facility. Consulting engineers working with cotton ginners and permit engineers must develop air pollution abatement systems that comply with SAPRA regulations while minimizing cost. The purpose of this engineering practice is to define the operations of a cotton gin with engineering data that can be used by both consulting and permit engineers such that cotton gins are fairly and appropriately regulated. Included in the scope of this proposed standard are standardize procedures for calculating emission concentrations from given (permitted) emission factors and emission factors from measured emission concentrations. In addition, procedures for calculating daily and seasonal emission rates are included.

Emission factors, specified in a permit, are approximate seasonal averages of the mass of particulate matter (PM) emitted per bale of cotton processed at a gin for a specified air pollution abatement system. EPA published emission factors in AP-42 (1988, 1996) to be used as guidelines in the permitting process for cotton gins. It is generally assumed that AP-42 emission factors corresponding to PM emissions of a "standard gin" equipped with baseline best available control technology (BBACT). The current total AP-42 (1996) emission factor for a cotton gin is 3.05 pounds of TSP (1.13 pounds of PM_{10}) per bale processed. The PM_{10} fraction of TSP is 37% (AP-42, 1996). Emission factors are dependent upon the number of process streams, volume rate of each process stream and the abatement system used. More sophisticated and costly abatement systems will have lower emission factors. The appropriate use emission factors in the engineering calculations of emission rates and concentrations for a cotton gin are demonstrated in this proposed standard.

The 1988 AP-42 defined a total emission factor of 2.24 pounds (TSP) per bale for a "standard gin" with 10 process streams. The most recent AP-42 (1996) listed a total emission factor of 3.05 pounds (TSP) per bale for a cotton gin with only 8 process streams. In this ASAE proposed standard, the 1996 AP-42 has been modified to include emission factors corresponding to the more typical 10 process streams that characterize standard cotton ginning operations with an air pollution abatement system corresponding to BBACT.

In order to illustrate the methodology used to make the appropriate engineering calculations associated with the permitting of a cotton gin, flow rates for each process stream are required. The best flow rate data would be accurate measurements from the existing system. For proposed cotton gins, design flow rates should be used. In the absence of either measured or designed flow rates, a modified flow-rate model (FRM) (Flannigan, 1997) is introduced in this proposed standard as approximate air flow-rates for each process stream. Each gin is different and the quantity of air used by each process stream will vary. Hence, care must be used when using the modified FRM to permit a cotton gin.

It is anticipated that the procedures and data included in this proposed standard will aid permit and consulting engineers in calculating various air pollution parameters, such as daily and seasonal TSP and PM_{10} emission rates, point source emission concentrations, and emission rates, which may be used for dispersion modeling calculations. Consultants representing cotton gins should utilize the presented calculation methods as a basis in preparing air pollution permit applications for their customers. Further, these procedures should be utilized by consultants when responding to notice of violations, recommending modifications to existing ambient air pollution control systems, or designing and developing new air pollution abatement systems in order to comply with SAPRA regulations. Regulators should use the data and procedures when reviewing permits or investigating complaints against a permitted facility.

This proposed standard establishes preferred terminology for use in air pollution engineering and defines terms which may not have air pollution related definitions in a desktop dictionary.

2. Normative References

The following proposed standard constitute provisions of an engineering practice for the appropriate calculations of emission rates and concentrations for cotton gins in the U.S. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this engineering practice are encouraged to investigate the possibility of applying the most recent editions of the standards and references indicated below. Standards organizations maintain registers of currently valid standards.

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3. Definitions

3.1. Abatement: reducing missions.

3.2. Aerodynamic Equivalent Diameter (AED): The AED of a particle is the diameter of a sphere with unit density (density of water) that will settle in still air at the same rate as the particle in question.

3.3. Airborne Particulates: TSP, PM_{10}, and $PM_{2.5}$ found in the atmosphere as solid particles or liquid droplets. Chemical composition of particulates varies widely, depending on location and time of year. Airborne particulates include, but are not limited to: windblown dust, emissions from industrial processes, and motor vehicle or non-road engine exhausts.

3.4. Air Pollutant: Any substance in air that could, in high enough concentrations, harm man, animals, vegetation, or material. Pollutants may include almost any natural or artificial composition of airborne matter capable of being airborne. They may be in the form of solid particles, liquid droplets, gases, or in combination thereof. Generally, they fall into two main groups: (1) those emitted directly from identifiable sources and (2) those produced in the air by interaction between two or more primary pollutants, or by reaction with normal atmospheric constituents, with or without photo-activation. Air pollutants are often grouped in categories for ease in classification; some of the categories are: solids, sulfur compounds, volatile organic chemicals, PM, nitrogen compounds, oxygen compounds, halogen compounds, radioactive compounds, and odors.

3.5. Air Pollution: is the presence in the outdoor atmosphere of any one or more substances or pollutants in quantities, which are or may be harmful or injurious to human health or welfare, animal or plant life, or property (health effects standard), or unreasonably interfere with enjoyment of life or property, including outdoor recreation (nuisance standard).

3.6. Air Pollution Abatement System: Devices used to remove PM from an exit air stream to bring emissions into compliance with regulations.

3.7. Air Pollution Control Device: see air pollution abatement system.

3.8. Air Quality: is a term that is indicative of the quantity of pollutants present to which people, animals, plants, and property are exposed relative to EPA standards.

3.9. Air Quality Standards: are standards that limit either the emission rate or the ambient concentration. New Source Performance Standards are used to limit concentrations of pollutants exiting abatement equipment. National Ambient Air Quality Standards (NAAQS) are ambient concentrations that cannot be exceeded.

3.10. Air Quality Control Region: A federally designated area that is required to meet and maintain federal ambient air quality standards; may include nearby locations in the same state or nearby states that share common air pollution problems.

3.11. Air Quality Criteria: the levels of pollution and lengths of exposure above, which adverse health and welfare effects may occur.

3.12. Allowable Emission Rates (AER): Allowable pollutant emission rates (usually in terms of mass per unit time) are determined by SAPRA's in the form of permitted emission factors.

3.13. Ambient Air: any unconfined portion of the atmosphere; open air; outside surrounding air; air that is accessible to the public.

3.14. Ambient Air Quality Standards: see: criteria air pollutants and National Ambient Air Quality Standards.

3.15. Ambient Monitoring: all forms of monitoring conducted beyond the immediate influence of a discharge source.

3.16. Attainment: this term by itself refers to the successful achievement of the attainment objectives. In brief, attainment means that area contamination has been reduced to or below the level of the cleanup standard.

3.17. Attainment Area: A geographic area were levels of a criteria air pollutant meet the health-based primary standard (NAAQS) for the pollutant. An area may have an acceptable level for one criteria pollutant, but may have unacceptable levels for others. Thus, an area could be both attainment and non-attainment at the same time. Attainment areas are defined using federal pollution limits set by EPA. An area considered as having air quality as good or better than the NAAQS as defined in the Clean Air Act.

3.18. Attainment Objectives: Attainment objectives refer to a set of site descriptors and parameters together with standards as to what the desired level should be for the parameters. These are usually decided upon by the courts and responsible parties. For example, these objectives usually include the chemicals to be tested, the cleanup standards to be attained, the measures or parameters to be compared to the cleanup standard, and the level of confidence required if the environment and human health are to be protected.

3.19. Baseline BACT (BBACT): is the minimum air pollution abatement strategy that will be approved as BACT (in some states). For cotton gins, this is defined as high efficiency cyclones (1D3D or 2D2D) on all centrifugal fan exhausts and covered condenser drums with 70-100 fine-mesh screens on all axial fan exhausts.

3.20. Best Available Control Technology (BACT): An emission limitation based on the maximum degree of emission reduction (considering energy, environmental, and economic impacts) achievable through application of production processes and available methods, systems, and techniques. BACT does not permit emissions in excess of those allowed under any applicable Clean Air Act provisions. Use of the BACT concept is allowable on a case-by-case basis for major, new, or modified emissions sources in attainment areas and applies to each regulated pollutant. Although not published, an upper limit of $10,000 per ton of reduced emissions has been used in some states for BACT.

3.21. Best Available Control Measures (BACM): A term used to refer to the most effective measures (according to EPA guidance) for controlling small or dispersed particulates and other emissions from sources such as roadway dust, soot and ash from woodstoves and open burning of rush, timber, grasslands, or trash.

3.22. Clean Air Act (CAA): Originally passed in 1963, it is the federal law that provides the enabling legislation for regulating air pollution. States will have State CAA that provides enabling legislation for the respective Local and State Air Pollution Regulatory Agencies (SAPRA). The current national air pollution control program is based on the 1970 version of the law. Substantial revisions in federal law were made by the 1990 Clean Air Act Amendments (CAAA).

3.23. Concentration: The relative amount of a pollutant mixed with air. An example is five ppm of carbon monoxide or 150 micrograms of PM_{10} per dry, standard cubic meter of air.

3.24. Contaminant: any physical, chemical, biological, or radiological substance or matter that has an adverse effect on air, water, or soil.

3.25. Contamination: Introduction into water, air, and soil of microorganisms, chemicals, toxic substances, wastes, or wastewater in a concentration that makes the medium unfit for its next intended use. Also applies to surfaces of objects, buildings, and various household and agricultural use products.

3.26. Criteria Air Pollutants: The 1970 amendments to the Clean Air Act required EPA to set National Ambient Air Quality Standards for certain pollutants known to be hazardous to human health. EPA identified and set standards to protect human health and welfare for six pollutants: ozone, carbon monoxide, total suspended particulates, sulfur dioxide, lead, and nitrogen oxide. The term, "criteria pollutants" is derived from the requirement that EPA must describe the characteristics and potential health and welfare effects of these pollutants. It is on the basis of these criteria that standards are set or revised.

3.27. Diffusion: The movement of suspended or dissolved particles (or molecules) from a more concentrated to a less concentrated area. The process tends to distribute the particles or molecules more uniformly. (Diffusion is sometimes used as a synonym for dispersion.)

3.28. Dispersion Model: a mathematical prediction of how pollutants from a discharge or emission source will be distributed in the surrounding environment under given conditions of wind, temperature, humidity, and other environmental factors.

3.29. Emission Cap: A limit designed to prevent projected growth in emissions from existing and future stationary sources from eroding any mandated reductions. Generally, such provisions require that any emission growth from facilities under the restrictions be offset by equivalent reductions at other facilities under the same cap. (See: emissions trading)

3.30. Emission: The release or discharge of a substance into the environment. Generally, refers to the release of gases or particulates into the air.

3.31. Emission Concentration: the mass of PM per unit volume of carrier gas, usually expressed in terms of milligrams per dry, standard cubic meter. Emission concentrations may be determined by source sampling at the emitting point of the abatement device using "source" sampling methods or may be determined utilizing the emission factor plus the flow rate as described in this standard.

3.32. Emission Factors: are ratios of pollutant rates and processing rates, usually expressed as kilogram or pounds of PM emitted per bale of lint cotton processed (kg/bale, lb/bale).

3.33. Emission Inventory: an estimate of the amount of pollutants emitted into the atmosphere from major mobile, stationary, area wide, and natural source categories over a specific period of time, such as a day or a year. For a cotton gin, the emissions inventory could reflect the total annual $PM_{2.5}$, PM_{10}, TSP, or NO_x emitted per year (tones/yr, tons/yr).

3.34. Emission Offset: also referred to as emission trading, a rule making concept whereby approval of a new or modified stationary source of air pollution is conditional on the reduction of emissions from other existing stationary sources of air pollution. These reductions are required in addition to reductions required by BACT.

3.35. Emission Rate: the mass of a pollutant emitted per unit of time. Emission rate can be expressed in mass per hour, mass per day or mass per year. Examples: 2 pounds of PM_{10} per hour from process stream #1; 20 tons of PM_{10} per year from the gin. (This latter example is sometimes referred to as the emission inventory.)

3.36. Emission Standards: government standards that establish limits on discharges of pollutants into the environment (usually in reference to air). (See Air Quality Standards.)

3.37. Emissions Trading: The creation of surplus emission reductions at certain stacks, vents or similar emissions sources and the use of this surplus to meet or redefine pollution requirements applicable to other emissions sources. This allows one source to increase emissions when another source reduces them, maintaining an overall constant emission level. Facilities that reduce emissions substantially may "bank" their "credits" or sell them to other facilities or industries.

3.38. Fine Particle: PM less than 2.5 mm aerodynamic equivalent diameter (AED).

3.39. Ginning Capacity: The maximum amount of cotton lint processed per unit of time, usually in terms of bales per hour. Cotton gins are seasonal operations and may only be in operation for 1 to 4 months during an entire year. In addition, cotton gins usually operate less than 24 hours per day, due to maintenance and cleaning requirements.

3.40. Health Effects Standard: is the presence in the outdoor atmosphere of any one or more substances or pollutants in quantities, which are or may be harmful or injurious to human health or welfare, animal or plant life, or property.

3.41. Inlet Loading Rates: the total amount of material in the air stream per unit volume of carrier gas entering an air pollution control device.

3.42. Loading: the quantity of a substance entering the environment (soil, water, or air).

3.43. Lowest Achievable Emission Rate (LAER): Under the Clean Air Act, the rate of emissions that reflects (1) the most stringent emission limitation in the implementation plan of any state for such source unless the owner or operator demonstrates such limitations are not achievable; or (2) the most stringent emissions limitation achieved in practice, whichever is more stringent. A proposed new or modified source may not emit pollutants in excess of existing new source standards. LAER is accomplished utilizing the maximum achievable control technology (MACT).

3.44. Maximum Achievable Control Technology (MACT): is the level of control associated with the lowest achievable emission rate (LAER) and is used for polluters in non-attainment areas of a regulated pollutant. There is generally no consideration for economic reasonableness for this level of control.

3.45. National Air Quality Standards (NAAQS): permissible levels of criteria air pollutants established by the EPA to protect public health and welfare.

3.46. New Source: any stationary source built or modified after publication of final or proposed regulations that prescribe a given standard of performance.

3.47. Non-Attainment Area: An area that does not meet one or more of the National Ambient Air Quality Standards for the criteria pollutants designated in the Clean Air Act. A geographic area in which the level of a criteria air pollutant is higher than the level allowed by the federal standards. A single geographic area may have acceptable levels of one criteria air pollutant but unacceptable levels of one or more other criteria air pollutants; thus, an are can be both attainment and non-attainment at the same time.

3.48. Notice of Deficiency: A SAPRA request to a facility owner or operator requesting additional information before a preliminary decision on a permit application can be made.

3.49. Notice of Violation (NOV): a formal notice issued to a party detected to be in violation of the CAA, of a rule, or a SAPRA regulation.

3.50. Nuisance Standard: is the presence in the outdoor atmosphere of any one or more substances or pollutants in quantities, which unreasonably interfere with enjoyment of life or property, including outdoor recreation.

3.51. Offsets: A concept whereby emissions from proposed new or modified stationary sources are balanced by reductions from existing sources to stabilize total emissions. (see: emissions trading)

3.52. PM_{10}: is a pollutant, which is a subset of TSP. In general, samplers designed to measure ambient TSP concentrations can be characterized by a log-normal distribution with a nominal 45 µm cut-point. Federal Reference Method (FRM) samplers used to measure PM_{10} concentrations are designed with a pre-separator characterized by a log-normal distribution having a 10 ± 0.5 µm cut-point with a slope of 1.5 ± 0.1. A measure of TSP concentrations should include all PM_{10}. It is usually assumed that a PM_{10} concentration will be a measure of the mass of solid or liquid matter suspended in the atmosphere less than 10 micrometers AED. PM_{10} particles can penetrate to the deeper portions of the lung, affecting sensitive population groups such as children and individuals with respiratory ailments.

3.53. $PM_{2.5}$: is a pollutant, which is a subset of PM_{10}. In general, samplers designed to capture PM_{10} particles will capture $PM_{2.5}$. In contrast to PM_{10} samplers, $PM_{2.5}$ samplers capture particulate matter less than 2.5 µm "by design". This means that all PM captured by $PM_{2.5}$ samplers is classified as PM less than 2.5 µm AED. There are no performance standards for $PM_{2.5}$ samplers. It is assumed that measured $PM_{2.5}$ concentrations accurately reflect the concentration of particles in the ambient air that are less than 2.5 µm AED.

3.54. PM Loading Rates: are usually specified for PM_{10} and/or $PM_{2.5.}$ It is the total amount of PM in the air stream per unit volume of carrier gas entering an air pollution control device.

3.55 Particulates: fine liquid or solid particles such as dust, smoke, mist, fumes, or smog, found in air or emissions.

3.56. Particulate Matter (PM): particulate matter includes dust, soot, and other tiny bits of solid materials that are released into and move around in the air. PM_{10} is a criteria air pollutant.

3.57. Permit: An authorization, license, or equivalent control document issued by EPA or an approved state agency to implement the requirements of an environmental regulation.

3.58. Picker Cotton Gin: Cotton gins processing cotton harvested by a cotton picker. There is approximately 75 to 200 pounds of cotton gin by-products (CGBP) or foreign matter (sticks, leaves, bract, and soil) and 600 to 800 pounds of cotton seed per 500-pound bale of cotton lint processed by a picker cotton gin.

3.59. Point Source: is the specific point of origin where pollutants are emitted into the atmosphere such as from a single cyclone, also referred to as process stream or emission point.

3.60. Primary Standard: a pollution limit based on health effects; primary standards are set for criteria air pollutants.

3.61. Process Stream Emission Factor: the emission factor associated with a single process stream; typically associated with the individual fan systems in a cotton gin.

3.62. Reasonably Available Control Technology (RACT): is the level of pollution control required to achieve a specified emission rate for new or modified sources in non-attainment areas. This control method is not as sophisticated as the BACT and must include consideration for economic reasonableness. Some states use a cost of $2000 per ton of reduced emissions as the upper limit for control costs for RACT.

3.63. SAPRA's: State Air Pollution Regulatory Agencies. In Texas, the SAPRA is the Texas Natural Resource Conservation Commission (TNRCC). In Oklahoma, the SAPRA is the Department of Environmental Quality (DEQ). Some states have local air pollution control districts (LAPRD's) such as Arizona and California. These LAPRD's may have the same authority as SAPRAs.

3.64. Secondary Standard: a pollution limit based on environmental effects such as damage to property, plants, visibility, etc; secondary standards are set for criteria air pollutants.

3.65. Source: Any area, equipment, or facility from which air pollutants are released. Sources that are fixed in space are stationary sources; sources that move are mobile sources. Sources may be point (cotton gins, grain elevators, etc.) or area sources (cattle feedyards, fields where disking or harvesting are ongoing, lagoons, etc.).

3.66. Source Sampling: the direct measurement of the PM concentrations leaving an abatement device.

3.67. Standard Cotton Gin: consists of ten processing systems, which correspond to ten emitting points. The processes includes: (1) the unloading system, (2) first push/pull, (3) second push/pull, (4) distributor separator, (5) overflow separator, (6) master trash, (7) mote system, (8) first-stage lint cleaning, (9) second-stage lint cleaning, and (10) battery condenser.

3.68. Stripper Cotton Gins: Cotton gins, which process cotton harvested by a cotton stripper. There is approximately 400 to 900 pounds of cotton gin by-products (CGBP) or foreign matter (sticks, burs, leaves, bract, and soil) and 600 to 800 pounds of cotton seed per 500-pound bale of cotton lint processed by a stripper cotton gin.

3.69. Total Emission Factor: The emission factor for a plant and represents the sum of all process emission factors associated with a facility. Total emission factors for cotton gins are given in AP-42.

3.70. Total Suspended Particulate (TSP): is the total PM in sampled air and is computed as the mass of collected particles divided by the volume of air sampled, corrected to standard conditions and expressed in micrograms per dry-standard cubic meter ($\mu g/m^3$).

4. Laws and Regulations

Federal regulations establish the basis of air pollution control in the United States. Several pieces of federal legislation have created agencies, such as the EPA, allocated funding, and granted state agencies the right to develop more stringent rules and regulations in an effort to reduce emissions. All federal, state, and local laws, rules, and regulations governing cotton gin emissions should be followed. Necessary approvals and permits for ambient air pollution control system should be secured from accountable authorities.

Air Quality Act (AQA), 1967
Clean Air Act (CAA), 1963
Clean Air Act Amendments (CAAA), 1970
Clean Air Act Amendments (CAAA), 1977
Clean Air Act Amendments (CAAA), 1990

5. Cotton Gins

5.1 Cotton Gin Classification

Cotton gins can generally be classified in two categories; picker or stripper. These classifications are dependant on the harvesting method used in the area supplying cotton to the gin. Picker gins process cotton with less trash than stripper gins. (Gin trash will be referred to as cotton gin by-products (CGBP) in this proposed standard.) Therefore, stripper gins require a larger volume of air for materials handling and more seed cotton cleaning equipment than picker gins with the same processing rate (bales/hour). In general, the materials handling systems following the gin stand (where lint/seed separation occurs) are the same for picker and stripper gins. The mass of cotton lint plus trash handled by a stripper gin will be the same as that handled by a picker gin. Within each of these categories, gin configurations can greatly differ in terms of capacity, ginning equipment, material handling systems, etc. Hence, the total airflow rate and airflow rate associated with each exhaust (process stream) may vary between gins.

5.2. The Standard Gin

For the purposes of this ASAE proposed standard and to illustrate the engineering data and engineering calculations associated with the analysis of PM emissions from a cotton gin, a "standard gin" will be defined and used. This standard gin has 10 process streams (exhaust points). Figure 1 shows the standard gin flow diagram. Centrifugal fans are used for 7 of the process streams (exhausts 1 - 7), including; the materials handling systems prior to lint/seed separation plus the trash and mote fans. Vane-axial fans are used for the 3 materials handling systems associated with the process streams following lint/seed separation (exhausts 8 - 10). These include first and second stages of lint cleaning and the battery condenser exhausts.

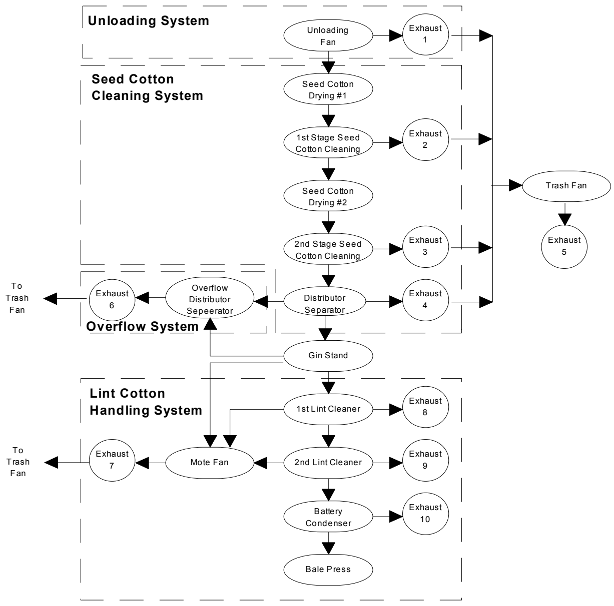

Figure 1. Material Handling System in a Standard Cotton Gin.

5.3. Processing (Ginning) Rate

The processing rate or ginning rate is a measure of the number of 227 kg (500 lb) bales of lint fiber produced by a gin per unit time. It is usually expressed in bales per hour (bales/hr). One gin descriptor that is often used as a approximate ginning rate is the number of gin stands and the advertised ginning rate for the gin stands. Processing rates should not be based on manufacturers rates. A cotton gin with 3 gin stands, each capable of processing 10 bales-per-hour (b/h), may not be capable of processing 30 b/h. Processing (ginning) rates for a specific cotton gin may be limited by the unloading system, baling system or process stream design flaws. The processing rate can be determined as follows:

$$PR_k = \frac{P_k}{[T_k]}$$

where,

PR = ginning rate, bales per hour;
P = number of bales processed in time T, bales;
T = time the gin was processing cotton, hours; and
k = day of ginning.

Ginning rates will vary during the season. It is likely that the gin will want to permit their facility at a ginning rate (GR) that is slightly higher than the actual highest processing rate, determined by the above equation, for each day of the season. This will allow the gin some flexibility for improvements of the ginning system while not exceeding the permitted allowable emission rate (AER). An alternative processing rate can be determined by dividing the seasonal bales ginned by the hours of operation during the season. This ginning rate will likely be lower than any processing rate and less useful.

$$GR \geq PR_k$$

where,

GR = the ginning rate used for permitting purposes, bales per hour; and
Prk = the processing rate for day 'k' during the season, bales per hour.

5.4. Calculating exhaust airflow rates for the "Standard Gin"

The following assumptions describe the operation of a "standard gin":

5.4.1. A stripper gin will process 998 kg (2200 lb) of material (seed cotton) consisting of 363 kg (800 lb) of seed and 408 kg (900 lb) of CGBP (trash) to produce a 227 kg (500 lb) bale of cotton lint.

5.4.2. A picker gin will process 680 kg (1500 lb) of material consisting of 363 kg (800 lb) of seed and 91 kg (200 lb) of CGBP to produce a 227 kg (500 lb) bale of cotton lint.

5.4.3. The first and second stages of seed cotton cleaning (push pull fans) remove all but 22.7 kg (50 lb) of CGBP per bale of cotton lint for both the picker and stripper gins.

5.4.4. Of the CGBP removed by the first and second push pull systems, 50% will be removed by the first stage of seed cotton cleaning and the other 50% will be removed by the second stage of seed cotton cleaning.

5.4.5. The distributor conveys 612 kg (1350 lb) of material per bale for both picker and stripper gins.

5.4.6. The overflow system must be capable of conveying 612 kg (1350 lb) of material per bale.

5.4.7. The mote system conveys 34 kg (75 lb) of material per bale.

5.4.8. All of the CGBP contained in the incoming seed cotton will be conveyed by the trash fan.

5.4.9. Both stages of lint cleaning utilize the same size condenser drums, process the same amount of material, and have the same airflow rates.

5.4.10. All centrifugal fan materials handling systems have a minimum volume-rate-of flow of 1.87 m^3 of air/kg of material (30 ft^3 of air/lb of material).

5.4.11. The first and second stages of lint cleaning and the battery condenser utilize vane-axial flow fans.

5.4.12. The total airflow for the centrifugal fan system will account for 55% and 60% of the total airflow for the standard picker and stripper gins, respectively (based on horsepower requirements).

5.4.13. The total airflow for the vane-axial fan systems will account for 45% and 40% of the total airflow rate for the standard picker and stripper gins, respectively (based on horsepower requirements.

5.4.14. The volume-rate-of-flow associated with each stage of lint cleaning and battery condenser process streams are equal.

The total volume-rate-of-flow of a gin's materials handling system will be constant for a specific gin but will vary from gin to gin depending upon the engineering design. In the absence of measured data, the following total flow rate estimate may be used for a "standard gin" with 10 process streams:

$$Q_T = Q_{EST} * GR$$

where

Q_T = total airflow rate used by a cotton gin, m^3/min (cfm);
Q_{EST} = estimated airflow required to process one bale per hour, m^3/min/bale/hr (cfm/bale/hr); and
GR = ginning rate, bales/hr

The value generally associated with Q_{EST} for "picker gins" is 198 m^3/min/bale/hr (7,000 cfm/bale/hr) and 227 m^3/min/bale of lint cotton/hr (8,000 cfm/bale of lint cotton/hr) for "stripper gins". In general, stripper gins will be handling 318 kilograms (700 pounds) per bale more foreign matter (CGBP) than will picker gins. The difference in the two estimates is a consequence of the additional CGBP per bale handled by stripper gins.

The following equation can be used to estimate minimum airflow rates per bale-per-hour (bph) for process streams 1-7 (centrifugal fan systems):

$$q_i = m_i * R_i$$

where

q = exhaust airflow rate, m^3/min/bph (ft^3/min/bph);
m = mass of material conveyed by a process stream, kg/bale (lb/bale);
R = minimum volume of air per mass of material, m^3/kg (ft^3/lb); and
i = process stream, i =1-7.

Table 1 lists the minimum flow rates per bph for process streams 1-7 (centrifugal fan exhausts) for a standard gin processing stripper and picker cottons. Percentages of total flow for each process stream are also included.

Table 1. Estimated airflow rates associated with centrifugal fan systems in the "standard gin".

	Qty. of Material Conveyed, kg/bale (lb/bale)		Volume-Rate of Flow, m^3/kg	Est. Airflow Rate, m^3/min/bale/hr (cfm/bale/hr)		Percent of Total Airflow Rate,% [1]	
Exhaust	**PG**	**SG**	**(ft^3/lb)**	**PG**	**SG**	**PG**	**SG**
1	680 (1500)	998 (2200)	1.87 (30)	21.8 (770)	29.4 (1040)	11	13
2	680 (1500)	998 (2200)	1.87 (30)	21.8 (770)	29.4 (1040)	11	13
3	646 (1425)	805 (1775)	1.87 (30)	17.8 (630)	24.9 (880)	9	11
4	612 (1350)	612 (1350)	1.87 (30)	19.8 (700)	15.9 (560)	10	7
5	91 (200)	408 (900)	1.87 (30)	4.0 (140)	11.3 (400)	2[2]	5
6	612 (1350)	612 (1350)	1.87 (30)	19.8 (700)	18.1 (640)	10	8
7	34 (75)	34 (75)	1.87 (30)	4.0 (140)	4.5 (160)	2[2]	2[2]
Total	--	--	--	109.0 (3850)	133.7 (4720)	55	60

[1]Airflow rates and percent of total airflow rates were determined by estimating a Q_i for each process exhaust, using the "standard gin" assumptions and then these values were adjusted so that the percent total equaled to 55 and 60% for picker and stripper gins, respectively.
[2]These estimates were further adjusted based on the recommended velocity and estimated pipe size (Q = 4000 ft/min * p/4 * 1ft^2).

The axial flow fan systems for the "standard gin" include two stages of lint cleaning and one battery condenser. Based on our assumptions, each stage of lint cleaning and the battery condenser will have an equal volume-rate-of-flow. The following equation should be used to estimate the airflow rates per bph associated with the vane axial fan systems of the standard gin:

$$q_i = \frac{Q_{EST} * PAF}{3}$$

where,

q = exhaust airflow rate per bale per hour, m^3/min/bph (ft^3/min/bph);
Q_{EST} = total airflow rate per bph used by a cotton gin, m^3/min/bph (cfm/bph);
PAF = percent of total airflow utilized in the axial flow fan systems;
i = process stream, i =8-10.

Table 2 shows the estimated airflow rates per bph and the respective percentages of total flow per bph for the axial flow fan systems of the "standard gin" processing picker and stripper cotton:

Table 2. Estimated airflow rates associated with vane axial fan systems in the "standard gin".

	Est. Airflow Rate, m^3/min/bale/hr (cfm/bale/hr)		Percent of Total Airflow Rate, %	
Exhaust	**Picker Gin**	**Stripper Gin**	**Picker Gin**	**Stripper Gin**
8	29.7 (1050)	30.2 (1067)	15	13
9	29.7 (1050)	30.2 (1067)	15	13
10	29.7 (1050)	30.2 (1067)	15	13
Total	89.2 (3150)	90.6 (3200)	45	40

An estimate of the exhaust airflow rate, for a "standard" cotton gin processing cotton with a ginning rate of GR may be determined as follows:

$$Q_i = q_i * GR$$

where,

Q_i = total airflow rate for a cotton gin exhaust, m^3/min (cfm); and
i = process stream, i =1-10.

5.5. Estimating Emission Factors for the Process Streams

In the "standard gin", there are 7 centrifugal fan exhausts and 3 axial flow fan exhausts with a BBACT air pollution abatement system. The 1988 AP-42 provided emission factors for 10 process streams with a total TSP emission factor of 1.02 kg/bale (2.24 lb/bale), corresponding to a BBACT abatement system. However, the current 1996 AP-42 only provides emission factors for 6 centrifugal fan exhausts and 2 axial flow fan exhausts or 8 process streams with a total TSP emission factor of 1.39 kg/bale (3.05 lb/bale) for a gin with BBACT. The following equation was utilized to distribute the total 1996 AP-42 emission factor to 10 process streams.

$$EF_i = EF_{i1988} * \left(\frac{TEF_{1996}}{TEF_{1988}}\right)$$

where

EF = modified 1996 AP-42 process stream emission factor;
EF_{1988}= 1988 AP-42 process stream emission factor;

TEF_{1988} = total 1988 AP-42 TSP emission factor
TEF_{1996} = total 1996 AP-42 TSP emission factor; and
i = process stream, i =1-10.

The 1988 AP-42, 1996 AP-42 and modified 1996 AP-42 emission factors for the 10 process streams are shown in Table 3. We propose that the modified 1996 AP-42 emission factors be used for the "standard gin" calculations.

Table 3. Cotton gin emission factors.

Exhaust	1988 AP-42 Emission Factors, kg/bale (lb/bale)	1996 AP-42 Emission Factors Original, kg/bale (lb/bale)	1996 AP-42 Emission Factors Modified, kg/bale (lb/bale)
1	0.145 (0.32)	0.13 (0.29)	0.20 (0.44)
2	0.081 (0.18)	0.16 (0.36)	0.11 (0.25)
3	0.045 (0.10)	0.11 (0.24)	0.06 (0.14)
4	0.018 (0.04)		0.02 (0.05)
5	0.077 (0.17)	0.25 (0.54)	0.11 (0.23)
6	0.036 (0.08)	0.03 (0.07)	0.05 (0.11)
7	0.090 (0.20)	0.13 (0.28)	0.12 (0.27)
CF Total	0.492 (1.09)	0.81 (1.78)	0.68 (1.49)
8	0.367 (0.81)	0.50 (1.10)	0.50 (1.10)
9	0.068 (0.15)		0.09 (0.20)
10	0.086 (0.19)	0.08 (0.17)	0.12 (0.26)
AF Total	0.521 (1.15)	0.58 (1.27)	0.71 (1.56)
Total	1.013 (2.24)	1.39 (3.05)	1.39 (3.05)

5.6. TSP Emissions Inventory

Two equations may be used to determine the annual TSP emissions inventory. They are as follows:

$$EI_{TSP} = \frac{TEF_{1996} * GR * SL}{CF_1}$$

where,

EI_{TSP} = TSP emissions inventory for a given cotton gin, tonnes/year (tons/year);
TEF_{1996} = 1996 AP-42 TSP total emission factor, kg/bale (lb/bale);
SL = seasonal length, hours/year; and
CF_1 = conversion factor, 1000 kg/tonne (2000 lbs/ton).

$$EI_{TSP} = \frac{TEF_{1996} * TBPS}{CF_1}$$

where,

TBPS = total bales ginned per season.

5.7. Emission Concentrations

Some states limit the emission concentrations that may be emitted from any specific exhaust to less than 230 mg/dscm (0.1 grains per dry standard cubic foot (gr/dscf)). The following equation may be used to calculate the concentration that would be expected from any one of the ten process streams given the emission factor and flow rate:

$$L_i = \frac{EF_i * CF_2}{Q_i}$$

where,

L = emission concentration, mg/m^3;
EF = emission factor (See table 3), kg/bale;
Q = volume rate of flow, m^3/min;
CF_2 = conversion factor (10^6/60); and
i = process stream, i=1-10.

5.8. Allowable Emission Rates

Allowable emission rates are required as input parameters in dispersion modeling, which is used as a regulatory tool in determining property line emission concentrations. States may require TSP and/or PM_{10} property line concentrations. The following equations should be used to calculate the allowable emission rates that would be expected from any one of the ten process streams given the emission factor and ginning rate:

$$AER_{TSP_i} = EF_i * GR$$

where,

AER_{TSP} = allowable TSP emission rate, kg/hr (lb/hr);
EF = permit allowable emission factor, kg/bale (lb/bale); and
i = process stream, i = 1-10.

$$AER_{PM10_i} = AER_{TSP_i} * CF_3$$

where,

AER_{PM10} = allowable PM_{10} emission rate, kg/hr (lb/hr); and
CF_3 = currently 0.37, based on the 1996 AP-42 (This conversion factor may change in accordance with future research. Current emission factor guidelines for this factor should be used).

6. Applications

Consider two 20 bale-per-hour (bph) cotton gins. One is processing picker and one, stripper cotton. To illustrate the application of engineering data and calculations presented in this ASAE proposed standard, a hypothetical scenario will be presented and Tables 4 and 5 will be used to illustrate the approach that should be used by the engineers working as a consultant with the ginner as a client and as a permit engineer with the SAPRA. It should be emphasized that the consulting engineer has a goal of a least-cost solution for his client. The permit engineer has a goal of compliance with the SAPRA rules and regulations. The rules and regulations were developed by interdisciplinary efforts with protecting the public health and welfare as the goal.

For the purposes of this scenario, these gins have BBACT air pollution abatement systems and 10 process streams. The total flow used by the 20 bph picker gin is 3965 cubic meters per minute (cmm) (140,000 cfm); by the stripper gin is 4530 cmm (160,000 cfm), using the total air flow equation presented in section 5.4. These total flows can be used with "%Flow" numbers in Tables 1 and 2 to estimate the flow rates for each process stream. With the appropriate emission factor (EF), emission rates and concentrations can be calculated as shown in Tables 4 and 5. The emission factors used are those presented in Table 3 as modified 1996 AP-42 emission factors. Emission concentration and allowable TSP emission rate calculations utilize the equations presented in sections 5.7 and 5.8, respectively. In order to illustrate the economics associated with the utilization of this ASAE proposed standard, the following assumptions and approximations will be used: (1) the gins will operate for 1000 hours (a 20bph gin will process 20,000 bales per season); (2) cyclones cost $1/cfm without replacing the fans and $2/cfm replacing the fans; and (3) the requirement of BACT has an economic limit of $10,000 per ton of reduced emissions.

Table 4. Emission parameters based on a 20 bale per hour picker gin.

						Strategy Based on	
Process	**%Flow**	**Flow (cfm)**	**EF (lbs/bale)**	**ER (lbs/hr)**	**EC (mg/m^3)**	**EF**	**EC**
1	11%	14897	0.44	8.71	156	2	
2	11%	14897	0.25	4.90	88	3	
3	10%	14153	0.14	2.72	51		
4	10%	13408	0.05	1.09	22		
5	2%	3119	0.23	4.63	396		2
6	10%	13408	0.11	2.18	43		
7	2%	3119	0.27	5.45	466	3	1
CF Total	55%	77000	1.48	29.68	103		
8	15%	21000	1.10	22.06	280	1	3
9	15%	21000	0.20	4.08	52		
10	15%	21000	0.26	5.17	66	3	
AF Total	45%	63000	1.57	31.32	133		
Total	100%	140000	3.05	61.00	116		

Table 5. Emission parameters based on a 20 bale per hour stripper gin.

						Strategy Based on	
Process	**%Flow**	**Flow (cfm)**	**EF (lbs/bale)**	**ER (lbs/hr)**	**EC (mg/m^3)**	**EF**	**EC**
1	13%	20934	0.44	8.71	111	2	
2	13%	20934	0.25	4.90	63	3	
3	11%	16890	0.14	2.72	43		
4	8%	12846	0.05	1.09	23		
5	5%	8564	0.23	4.63	144		3
6	8%	12846	0.11	2.18	45		
7	2%	2988	0.27	5.45	487	3	1
CF Total	60%	96000	1.48	29.68	83		
8	13%	21333	1.10	22.06	276	1	2
9	13%	21333	0.20	4.08	51		
10	13%	21333	0.26	5.17	65	3	
AF Total	40%	64000	1.57	31.32	131		
Total	100%	160000	3.05	61.00	102		

6.1. Scenario: The Gin Must Reduce its Emission Rate by SAPRA Mandate.

In this scenario, the SAPRA permit engineer is requiring that the PM emission rate be reduced by 10 %. The question is how do we comply with the SAPRA mandate? The consulting engineer must find the least cost method of reducing the PM emission rate by 10%. For both the stripper and picker gins, the new allowable emission factor has been reduced from 1.39 kg/b (3.05 lb/b) to 1.25 kg/b (2.75 lb/b) (TSP). The engineering approach is to install more costly and efficient PM controls. The question that the consulting engineer must address is for what process stream or streams should the more efficient PM controls be used to comply with the mandate?

One approach that SAPRAs have used when a gin was perceived to be in violation of the state's clean air act has been to require that all the covered condenser drums controls be replaced by cyclones. Covered condenser drums are used for PM controls (BBACT) for the 1st and 2nd stage lint cleaner and battery condenser (process streams 8, 9, and 10). This approach seems logical in that covered condenser drums are perceived to be 50% efficient while cyclones are over 90% efficient.

In general, only high efficiency 1D3D or 2D2D cyclones are approved as controls for a cotton gin because they are perceived to be the "most efficient" for any exhaust. This perception is not correct. 1D2D or Barrel cyclone designs will likely be more efficient for process steams conveying high concentrations of trash and/or lint fiber. Process streams 8, 9, and 10 typically have high concentrations of lint fiber. When 1D3D and 2D2D cyclones are used for process streams having high concentrations of lint fiber, the lint fiber in the process stream tends to collect near the trash exit cycling without exiting. This action dramatically reduces collection efficiency of 1D3D and 2D2D cyclone designs. This phenomenon does not occur in 1D2D or Barrel cyclone designs. The 1D2D and Barrel cyclone designs are less efficient than 1D3D or 2D2D designs when collecting fine dust only.

The development of the 1D2D and Barrel cyclone designs were based upon the possible retrofit of axial flow exhausts i.e. replacing covered condenser drums with cyclones without having to replace the fans. The pressure drop of the 1D2D and Barrel cyclones operating at design velocity is approximately 3.8 centimeters (1.5 inches) water gage whereas the pressure drop of the 2D2D and 1D3D cyclones exceeds 10 centimeters (4 inches) water gage. If the SAPRA engineer required that only 1D3D cyclones be used, the axial flow fans would have to be replaced with in-line centrifugal fans. This is not an inexpensive process and it is not the most logical engineering solution based upon data provided in Tables 4 and 5.

Alternative #1: The cost of replacing covered condenser drums with 1D3D cyclones and all axial flow with inline centrifugal fans would be approximately $127,000 ($2/cfm * 63,500 cfm) for either the picker or stripper gin. If we were to assume that the cyclones were 90% efficient and the covered condenser drums were 50% efficient, the reduction of PM emitted would be 12.56 tons (TSP) per season or 4.65 tons of PM_{10}. The cost per ton of reduced PM_{10} emissions would be $27,300 (127,000/4.65). This cost exceeds the BACT limit of $10,000 per ton of reduced emissions.

Alternative #2: (Note that for both Tables 4 and 5, process stream 8 has the highest emission factor.) If only process stream 8 (1st stage lint cleaner) were to be retrofitted with a 1D2D cyclone (without replacing the axial flow fan), the reduction of PM emitted would be 8.8 tons (TSP) per season or 3.26 tons PM_{10} at a cost of approximately $21,000. The cost per ton of reduced emissions is $6,450. The emission factor for this alternative is 2.17 lb/b which is a 29% reduction. However, if the axial flow fan for this exhaust were replaced, the cost per ton of reduced emissions would be $12,900 per ton of reduced emissions.

Alternative #3: Considering a strategy based upon emission concentrations, a different approach may be used. The highest concentration for the picker and stripper gins is the mote fan (process stream #7). If a series cyclone system and/or a baffle pre-separator followed by a cyclone were to be designed to replace the existing system, it is estimated that the concentration emitted by the final control would be less than 69 mg/m^3 (0.01 gr/ft^3). Would this be sufficient to meet the 10% reduction and would the cost of this air pollution abatement strategy be less than $10,000 per ton of reduced emissions?

The emission rate for process stream #7 for picker and stripper gins is 2.72 tons per season prior to the change. With a resulting concentration of 69 mg/m^3, the emission rate would be 0.4 tons per season. This is a reduction of 2.32 tons (TSP) per year of the previous total of 30.5 tons per year. This reduction (7.6%) would not achieve the goal of a 10% reduction. The cost would be $3100 or $3600 per ton of reduced emissions.

The emission rate for process stream #5 for picker and stripper gins is 2.31 tons. Using a similar approach, the resulting concentration of 69 mg/m^3, would result in a emission rate of 0.4 tons and 1.1 tons for picker and stripper gins, respectively. For the picker gin strategy of replacing single cyclones for the mote and trash fans with more sophisticated abatement strategy of a series system, the total reduction of TSP would be 4.64 tons (15%) at a cost of $6,200. The PM_{10} reduction would be 1.72 tons. The cost per ton of reduced emissions would be $3,600. For the stripper gin strategy of replacing single cyclones for the mote and trash fans with more sophisticated abatement strategy of a series system, the total reduction of TSP would be 3.12 tons (10%) at a cost of \$11,600. The PM_{10} reduction would be 1.15 tons. The cost per ton of reduced emissions would be \$10,000.

6.2. Discussion

The least costly approach to reduce the emission rate by 10% would be to place a more sophisticated air pollution abatement system on both the trash and mote fans (process streams #5 and #7) for both picker (\$6,200) and stripper gins (\$11,600). The stripper gin costs are significantly higher because of the increased air flow required to handle the increased trash per bale.

The second least costly approach would be to replace the covered condenser drums for the 1st stage lint cleaner process stream (#8) with a 1D2D cyclone. This approach utilizing the 1D2D cyclone may not require replacing axial flow with in-line centrifugal fans. This cost would be \$21,000 or \$6,450 per ton of reduced emissions. If the axial flow fan had to be replaced, the cost would be \$42,000 or \$12,900 per ton of reduced emissions. The reduction achieved with this approach would be 29%.

The most costly approach would be to replace all covered condenser drums with 1D3D cyclones. This approach would require all axial flow fans to be replaced with in-line centrifugal fans. The cost is estimated to be \$127,000 or \$27,300 per ton of reduction in PM_{10}.