REGULATION OF AIR POLLUTION FROM COTTON GINS

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Abstract

The regulation of sources of air pollution has become more and more dependent upon the results of dispersion modeling with respect to maximum predicted off-property concentrations. When these predicted concentrations exceed the maximum ambient levels as defined by the state and EPA, the source is required to provide a solution that will result in lower predicted concentrations. This becomes difficult when the maximum ambient concentrations standards are extremely conservative and/or do not apply equally to all sources. This paper looks specifically at a cotton gin that cannot meet the required TSP (total suspended particulate) ambient levels based on modeling, due to inequitable enforcement of ambient standards.

Introduction

The Clean Air Act (CAA) is the predominate piece of legislation that provides guidance to the states in controlling sources of air pollution. These regulatory programs have traditionally fallen into three categories; prohibition of new and existing sources emitting pollution that exceeds the ambient air quality levels set to protect public health, more stringent controls and permitting requirements for new sources, and the addressing of specific pollution problems such and hazardous air pollutants and visibility impairment (Brownell, 1999). Related to all of these categories, are the national ambient air quality standards (NAAQS). These standards address pollution that endangers public health and welfare.

Six pollutants have been established as criteria pollutants: sulfur dioxide (SO_2), nitrogen dioxide (NO_2), particulate matter (PM), carbon monoxide (CO), ozone (O_3), and lead (Pb). Specific concentration levels are set for each of these pollutants by both a primary and a secondary standard. George T. Wolff, Chair of the Environmental Protection Agencies (EPA) Clean Air Scientific Advisory Committee (CASAC), in a written statement to the House Subcommittee on Energy and Environment, describes the purpose of the two standards. He states that the primary standards are set to protect public health, and the secondary standards are set to protect against adverse welfare effects which include protection of plants, animals, ecosystems, visibility, etc. He further states that the primary NAAQS are required to be set at a level sufficient to protect public health with an adequate margin of safety for the benefit of any sub-populations. The primary NAAQS are therefore health based standards.

The primary air pollutant of concern in the regulation and permitting of cotton gins is PM. Prior to 1987, the NAAQS for PM was based upon measurements of total suspended particulate (TSP). [TSP is particulate matter less than a nominal 40 µm aerodynamic equivalent diameter (AED)]. The primary and secondary NAAQS were 24-hour average concentrations of 260 µg/dscm (dry standard cubic meter) and 150 µg/dscm, respectively (Perkins, 1974). The NAAQS were revised in 1987 with the primary and secondary NAAQS being changed to 24-hour average concentrations of 150 µg/dscm of PM less than 10 micrometers AED (PM10). The sampling of PM subsequent to the change in the NAAQS was performed with Federal Reference Method (FRM) PM10 samplers with performance characteristics described as log-normal with a cut-point of 10 ± 0.5 µm (AED) and a slope of 1.5 ± 0.1 (Parnell, 2000).

It should be emphasized that measurements of TSP concentrations include the fraction of PM defined as PM10. However, the PM10 measurements with FRM PM10 samplers exclude a portion of PM larger than 10µm AED but not all. Hence, PM10 concentration measurements are impacted by the particle size distributions of the PM present in the ambient air. Several states have established primary NAAQS of 150 µg/dscm of TSP or PM10. It is our contention that when a state limits the off-property concentration of PM to 150 µg/dscm of TSP or PM10, **the state is inappropriately regulating agriculture.**

Our research has demonstrated that the particle size distribution (PSD) of PM from cotton gins will typically have a mass median diameter (MMD) of 20 µm with a geometric standard deviation (GSD) of 2.0, whereas PM sampled in urban areas will typically have MMD = 5µm with a GSD = 1.5. Measurements of ambient concentrations of urban PM having these characteristics with side-by-side TSP and PM10 samplers will yield the same concentration. However, measurements of ambient concentrations of agricultural PM having the characteristics described above with side-by-side TSP and PM10 samplers will yield dramatically different concentrations. In effect, a coal-fired power plant emitting PM described as "urban" will be allowed to emit much more PM10 per unit time than a cotton gin because of the difference in PSD.

States, when establishing state air quality guidelines, must set state NAAQS at levels that are at least as stringent as those established by the EPA NAAQS, but may apply levels that are more stringent. The ongoing trend when applying these standards, is to require sources to demonstrate, either through sufficient sampling or dispersion modeling results, that the emissions from the source do not result in off-property concentrations that exceed the levels set by the primary NAAQS.

New Mexico NAAQS

This paper will examine an ongoing cotton gin permitting process in the state of New Mexico. The New Mexico Environmental Improvement Board (NMEIB) chooses to apply both a TSP and a PM10 standard. Both standards are set at a level of 150 µg/dscm 24 hour concentration. Additionally, background concentrations of 47 µg/dscm , TSP, and 35 µg/dscm, PM10 are assumed. The standards must be expressed in terms of actual cubic meters based on the location in question. This involves expressing the dry standard concentration, which is based on sea level elevation and a standard temperature of 70°F, in terms of an actual concentration that is based on the elevation and standard temperature of a specified location. The change in elevation results in changes in air density. The standards in terms of standard cubic meters are based on a standard air density. Air density can be determined using equation 1.

$$\rho_{air} = \frac{P \bullet M.W.}{R \bullet T} \qquad \text{(Equation 1)}$$

where

> ρ_{air} = density of air (lb/ft^3)
> P = pressure (psi)
> T = temperature (°R)
> M.W. = molecular weight of air = 28.96 (lb/lbmol)
> R = ideal gas law constant = 10.73 (psi*ft^3)/(lbmol*R)

At sea level, assuming standard temperature (70°F = 530 °R) and standard pressure (1 atm or 14.7 psi) the air density (standard air density) is 0.075 lb/ft^3. The site of interest is at an elevation of 4000 feet, or 1219 meters. Based on this elevation and an adiabatic lapse rate of 1°C per 100 meters, the pressure at elevation can be determined using equation 2.

$$\ln P_2 = -3.422 \bullet \ln\left(\frac{298}{298 - 0.01 \cdots} \right) \qquad \text{(Equation 2)}$$

where

P₂ = pressure at elevation above sea level (atm)
z = elevation (meters)

Using equation 2 and substituting in for z = 1219 meters, P_2 is calculated to be 0.867 atm, or 12.7 psi. Using equation 1 with P equal to 12.7 psi and T equal to 530 °R (70°F) and solving for ρ_{air}, we get 0.064 lb/ft³. The air density at elevation along with standard air density can be used to convert a concentration in terms of mass per dry standard cubic meter (mass/dscm) to a concentration in terms of mass per actual cubic meter (mass/acm), by use a simple ratio as expressed in equation 3.

$$\frac{mass}{acm} = \left(\frac{\rho_{actual}}{\rho_{standard}}\right)\frac{mass}{dscm} \qquad \text{(Equation 3)}$$

For our site the density ratio is equal to 0.853 (0.064 / 0.075). Therefore, 150 µg/dscm is equal to 128 µg/acm. This means that off-property 24 hour concentrations of TSP and PM10 cannot exceed the difference between the New Mexico NAAQS (NMNAAQS) and the background levels (in terms of mass per actual cubic meter) , or 88 µg/acm TSP (150–47=103 µg/dscm) and 98 µg/acm PM10 (150-35=115 µg/dscm), respectively.

Demonstrating NMNAAQS Compliance

The initial attempts in the permitting process included both modeling and sampling work. The early modeling iterations indicated that the gin's emissions did result in concentrations off-property that exceeded the NMNAAQS. Those on the gin side involved in the permitting procedure felt that the modeling results misrepresented actual gin emissions and off-property concentrations, and as a result on-site sampling was performed. Downwind concentration data for approximately 20 time periods was collected. The time periods were 8-hour intervals. The maximum 24 hour average concentration was determined by averaging the 3 consecutive, highest concentration values.

The maximum 24-hour TSP concentration sampled was reported to be 146.8 µg/acm (Fritz, 2000). The measured concentrations are assumed to have sampled the background levels. Modeling was also performed for the same time periods utilizing meteorological data collected on site. The highest predicted 24-hour TSP concentration was 140.4 µg/acm (Fritz, 2000). This does not include the background concentration of 47 µg/dscm (40 µg/acm), so the corrected modeled concentration was 180 µg/acm TSP. The sampling results indicated that the TSP NMNAAQS were exceeded by less than 20 µg/acm (NOTE: The NMNAAQS is 150 µg/dscm or 128 µg/acm), while the modeling results based on the same time period indicated an exceedence of almost 60 µg/acm.

The sampling and modeling results for PM10 were 77.6 µg/acm and 96 µg/acm, respectively. The PM10 background for this site was 35 µg/dscm or 30 µg/acm. Accounted for background, sampled and modeled 24-hour average concentrations were 78 ug/acm and 126 µg/acm, respectively. The sampling and modeling data both indicate compliance with the PM10 NMNAAQS. The demonstrated compliance to the PM10 NMNAAQS using the measured concentrations did not meet the NMEIB requirements for permitting the gin. The permitting process now hinges upon demonstrating compliance of both the TSP and PM10 NMNAAQS through dispersion modeling.

The modeling of the gin required inputs of building parameters, emitting points and associated parameters, boundary lines, and meteorological data. The meteorological data were provided by the NMEIB. The source inputs were provided by the gin. The gin was modeled as if it were operating during four consecutive months, October through the following January. Modeling results indicated a maximum off-property 24-hour TSP concentration of 377 µg/acm, not including background. This exceeded the

NMNAAQS for TSP of 88 µg/acm (background subtracted). As a consequence of these results, the gin was required to determine appropriated modifications needed to result in off-property modeled concentrations below the NMNAAQS.

One solution suggested by good engineering practice would be to determine required outlet stack heights that would sufficiently increase the plume rise enough to provide adequate dispersion to lower the predicted downwind concentrations below the NMAAQS. Initial stack heights ranged from 5.2 meters to 9.1 meters. Incremental stack height adjustment and subsequent model iterations demonstrated that increasing all stacks by 12 meters resulted in a maximum 24-hour TSP off-property concentration of 85 µg/acm. While this meets the NMNAAQS, it is not a practical solution.

Another possible solution was the purchase of surrounding land to provide a buffer zone. The buffer would provide a greater downwind distance for plume travel, and thus more pollutant dispersion. Using the model and setting up a receptor grid surrounding the gin property, the downwind distance at which the maximum 24-hour TSP concentration is below 88 µg/acm was determined. Modeling results indicated that at 900 meters downwind, the TSP NMNAAQS were met. Presently, the gin owns 200 meters in the downwind direction, but would need an additional 700 meters. Again, this was not a practical solution.

Alternatively, modifying the modeled emission rate to represent actual total mass emitted by the gin was examined as a means of reducing predicted downwind concentrations. The gin was modeled as an 18 bale-per-hour (bph) plant, operating 24-hours a day, every day from October 1 through January 31. Under these operating conditions, 51840 bales of cotton would be ginned with no "down time". This gin processed approximately 19000 bales in the 2000/2001 season. As mentioned, the gin was previously modeled as operating continually for four months. A more probable operating scenario would be 10 to 12 hours per day during the first month, 20 to 22 hours per day for the next two months, and back to 10 to 12 hours during final month to complete ginning. For the gin presently under consideration, incorporating this type of schedule would result in a maximum, 24-hour, TSP, off-property, predicted concentration of approximately 290 µg/acm, which still does not meet the TSP NMNAAQS. NOTE: Assuming the emitted TSP is 37% PM10, the maximum 24 hour PM10 concentration under this same scenario would be around 107 µg/acm, which only exceeds that NMNAAQS of 98 µg/acm (background subtracted) by 9 µg/acm.

The final approach we took is to look at decreasing the emission rate by adding additional controls. The gins emission rates are based upon emissions sampling data, but correspond very closely to AP-42 emission factor value of 3.05 lbs/bale. In order the meet the NMNAAQS of 88 µg/acm 24 hour TSP (as discussed above), the gin would have to add controls that would effectively reduce the emission factor to around 0.7 lbs/bale (TSP). Based on research by Flannigan (1997), by applying the available controls that would provide maximum emissions reduction, the minimum emission factor that could be obtained is approximately 1.8 lb/bale (TSP) or 0.7 lb/bale (PM10). In order for this gin to reduce its PM emission rate to the required level, either new control technologies would have to be devised, or presently available controls that are either unsafe or prohibitively expensive would have to be installed. This option is clearly not acceptable either.

To illustrate the inequities of the requirement of a primary NAAQS of 150 µg/dscm or 128 µg/acm **TSP or PM10**, we chose to compare cotton gin results with those of a hypothetical power plant. A 1000 megawatt coal-fired power plant (30% efficiency) in compliance with the new source performance standard (NSPS) of 0.03 lb/Mbtu (pounds per million Btu) would have an annual emission rate of 1500 tons of particulate, all of which is PM10. On the other end of the spectrum, our cotton gin typically

produces 19000 bales per year, and has an emission factor, based on AP-42, of 3.05 lbs/bale TSP. Based on the 19000 bales produced, the gin would have an annual emission rate of 29 tons of TSP, 37% of which is PM10. Our cotton gin emits 10.7 tons of PM10 per year, as compared to 1500 tons of PM10 per year for the 1000 MW power plant. The power plant is unaffected by the TSP NMNAAQS because all the PM emitted is PM10. The off-property, modeled, 24-hour PM10 concentration limit for a power plant at this site would be 98 μg/acm. On the other hand, cotton gins emit TSP so they must meet the TSP NMNAAQS of 88 μg/acm. If the gin meets the TSP NMNAAQS, it will automatically meet the PM10 NMNAAQS. In fact, assuming that 37% of the TSP is PM10, the "effective" PM10 NMNAAQS for cotton gins is 32 μg/acm (37% of 88 μg/acm), which is nearly equal to the New Mexico assumed PM10 background concentration of 30 μg/acm (35 μg/dscm). This means that power plants are actually allowed to have higher off property concentrations of PM10 than cotton gins in the state of New Mexico. This is inequitable treatment of the cotton gins.

Other examples of permitted particulate sources in New Mexico are feedlots and dairy feeding operations. The AP-42 emission factor for feedlots is 280 lbs TSP per 1000 head per day. There is no published AP-42 emission factor for dairy feeding operations, but California uses the feedlot emission factor of 280 lbs/1000HD/day. The gin we are working is bordered by both a feedlot and a dairy feeding operation. No information on the exact size of these operations is known. For comparison purposes, if it were assumed that each had 2000 head, each operation would emit 560 lbs/day, 102 tons TSP per year. Feedyard TSP emissions are 25% PM10, so the annual PM10 emissions for each of these operations would be 26 tons/year, over twice what the gin emits.

Looking at each of the above mentioned emitting sources in terms of hourly emission rates, the power plants emits 342 lbs/hour (all PM10), the feedyard and dairy feeding operation emit 23 lbs/hour TSP (6 lbs/hour PM10), and the gin, operating at 18 bph emits 55 lbs/hour TSP (20 lbs/hour PM10). It should be noted that the power plant, the feedyard and the dairy all operate 24 hours a day, 365 days per year, while the gin operates only 4 months out of the year with several of the months operations being only partial days. Of all of these sources, the cotton gin is the only source unable to gain an operating permit.

Conclusions

It is not the intent of this paper to advocate special treatment for cotton gins in the permitting process, but to advocate equitable treatment. As it stands, the NMNAAQS for TSP does not impact the larger sources such as power plants, whose primary emissions are PM10, but has a significant impact on cotton gins. In fact, the TSP standard requires gins to meet a more stringent level of protection to public health than the power plant. It is interesting to note that the federal NAAQS no longer include a TSP standard but replaced it with PM10 citing that TSP was used an indicator of the PM10 present. It is also interesting to note that the initial primary TSP standard was 260 μg/dscm, not the much more conservative NMNAAQS value of 150 μg/dscm. The NMNAAQS for TSP, at the very least, needs to be evaluated as to the intent of setting such a stringent level. If TSP was originally intended to be an indicator for PM10, why is the NMNAAQS for PM10 equal to, and not significantly less than, the TSP standard. If New Mexico were to regulate the power plants at the same level of protection as cotton gins, the power plant would have to meet a property line standard of 32 μg/acm (not including background) PM10. As it stands, the NMNAAQS do not provide for equal levels of protection with respect to different sources.

References

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