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PROJECT REPORT PR-2011-00: ALTERNATIVE PM10 ESTIMATION METHODS FOR EVAPORATIVE COOLING TOWER AIR POLLUTION PERMIT APPLICATIONS

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1.0 Introduction:

The prediction of particulate emissions from water droplets which escape from evaporative cooling towers, or cooling tower drift, for air pollution permit applications has been the subject of significant discussion over the last few years.

The emission factors for particulate matter (PM) and sub 10 micro-meter particulate matter (PM10) cooling tower drift provided by the US EPA in their list of emission factors for use as reference values in publication AP-42 have low confidence ratings, of D and E, and may be substituted by alternate values when available.

Research conducted around the year 2000 for the California Energy Commission has shown that the methods commonly used employing the factors from AP-42 significantly over-predict the emissions of PM, and thus PM10.

New regulatory efforts use PM10 to predict sub 2.5 micro-meter particulates (PM2.5), so over-prediction of any PM can lead to erroneous predictions, further complicating the air pollution control permitting situation.

The author performed a literature review study in 2007, with reference to the physics of droplet formation, and showed that cooling tower drift lacked the proper atomization to produce sufficiently small droplets to create significant amounts of PM10, let alone PM2.5 due to the lack of sufficient shear stress in the formation of the drift droplets.

2.0 Conclusion:

Accurate prediction of PM, PM10, and PM2.5 from cooling tower drift droplets will show that cooling tower drift plays a very minor role in emissions of particulates.

In the case of a conventionally fired power plant using fossil fuels, the potential to emit particulates from the combustion processes is far greater than from cooling tower drift, and some regulatory agencies are now accepting PTE / PSD calculations based upon models first published in 2002, which more accurately predict such emissions than the previous method using the factors published in AP-42.

3.0 Discussion:

Stationary emission sources are regulated under the Clean Air Act, and construction and operating permits are now consolidated as Title V permits by the US EPA and the various state agencies who act for them.

The levels of emissions to be allowed by the permit are calculated in the Prevention of Significant Deterioration (PSD) analysis, and the applicant's calculations must be approved by the regulators.

The primary resource for PSD analyses is AP-42, Compilation of Air Pollutant Emission Factors. AP-42 traces its roots back to before the Clean Air Act of 1970… AP-42 has the blessing of being an official EPA publication, but it is not the official first choice for estimation of emissions.

The AP-42 emission factors for particulate matter from cooling tower drift are acknowledged by the EPA to be of rather low accuracy, having ratings of D & E on a scale where A is the most reliable, and anything below C is wide open to challenge.

According to the United States Air Force Center for Engineering and the Environment (USAFCEE) website:

… the hierarchy of preferred emission estimating methods, with the most preferred listed first, is:

- Use of source test data;
- Use of published emission factors;
- Material balance; and
- Engineering judgment.

Given that there have been significant advances in cooling tower technology since 1970, and that many of the more advanced concepts such as improved drift eliminators have been implemented since the EPA last studied cooling tower particulate emissions circa 1991, there are better estimation methods available to permit applicants today.

Reisman & Frisbie published their results in 2001 & 2002 (see abstract here: http://www.energy.ca.gov/sitingcases/palomar/documents/applicants_files/Data_Request_Response/Air Quality/Attachment 4-1.pdf) first for the California Energy Commission, then in a peer-reviewed journal published by the American Institute of Chemical Engineers. They concluded that 85% by mass of the solids contained in drift droplets coalesces into particles sized greater than 10 μ in diameter, based upon the data which they collected for cooling towers operating at 7,700 ppm TDS. For higher levels of TDS, the percentage of PM10 from drift droplets decreases asymptotically, as can be seen in the reprinted graph used in the comparison example below.

Since 2002, the Reisman/Frisbie method has begun to be used in Title V permit applications in various jurisdictions, especially where salt water is used in the cooling water systems, and thus run through evaporative cooling towers.

The author has seen permit approved applications from 7 states and the Commonwealth of Puerto Rico where the applicants have used the Reisman-Frisbie method to estimate PM10 emissions from cooling tower drift droplets.

As a side note, the EPA is not necessarily in any way expediting revisions of the rules for cooling towers. The most recent revision on hexavalent chromium was initiated in 1994, and finalized as regulation in 2010.

4.0 Comparison:

Example: For an 8 mgd sea water cooling tower with induced draft, the AP-42 PM10 emissions due to drift are:

8,000,000 gal/day x 1.7 lb/1,000 gal x 35,000 ppm TDS = 476 lb/day

350 operating days/year @ 2,000 lb/ton = 83.3 tons/year

This would trigger a finding that the cooling tower is a major source of PM10, as the estimated emissions exceed 15 TPY. The EPA does acknowledge that this is a conservative estimation, based upon the assumption that 100% of the TDS reports to PM10 when the drift droplets dry out.

The San Francisco Bay Area Air Quality Management District (BAAQMD) allows some corrections to the AP-42 calculation:

Drift factor: 0.008% wt of circulating volume (modern drift eliminators allow 0.005% to as little as 0.0005% drift)

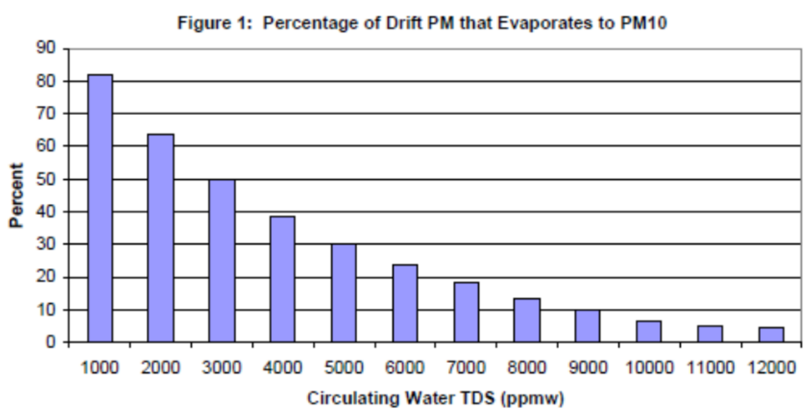
PM10 = 50% of drift solids

So, the above example converts to:

8,000,000 gal/day x 8.33 lb/gal x 0.008% x 35,000/1,000,000 x 50% = 93.3 lb/day

or 16.3 tons per year > 15 TPY, still a major source.

Using the Reisman-Frisbie model, we get the following:



Extrapolating the graph out to 35,000 shows that we are on the asymptote, and that ~3% of the drift will report to PM10

8,000,000 gpd x 8.33 lb/gal x 0.008% x 35,000/1,000,000 x 3% = 5.6 lb/day

or ~1 TPY for a 350 day operating year, a ***minor*** source of PM10 emissions

It is much less difficult to obtain an operating permit for a minor source, which is why we need to be as accurate as possible when estimating the emissions from cooling tower drift.

Appendices:

From AP-42:

The general equation for emissions estimation is:

E = A x EF x (1-ER/100)

where:

- E = emissions;
- A = activity rate;
- EF = emission factor, and
- ER =overall emission reduction efficiency, %

AP-42, *Compilation of Air Pollutant Emission Factors*, has been published since 1972 as the primary compilation of EPA's emission factor information. It contains emission factors and process information for more than 200 air pollution source categories. A source category is a specific industry sector or group of similar emitting sources. The emission factors have been developed and compiled from source test data, material balance studies, and engineering estimates. The Fifth Edition of AP-42 was published in January 1995. Since then EPA has published supplements and updates to the fifteen chapters available in ***Volume I, Stationary Point and Area Sources***.

The references for Section 13.4 are dated between 1987 and 1991

Prevention of Significant Deterioration (PSD) Basic Information

What Does PSD Require?

Prevention of Significant Deterioration (PSD) applies to new major sources or major modifications at existing sources for pollutants where the area the source is located is in attainment or unclassifiable with the National Ambient Air Quality Standards (NAAQS). It requires the following:

1. installation of the "Best Available Control Technology (BACT)";
2. an air quality analysis;
3. an additional impacts analysis; and
4. public involvement.

What is PSD's Purpose?

PSD does not prevent sources from increasing emissions. Instead, PSD is designed to:

1. protect public health and welfare;
2. preserve, protect, and enhance the air quality in national parks, national wilderness areas, national monuments, national seashores, and other areas of special national or regional natural, recreational, scenic, or historic value;
3. insure that economic growth will occur in a manner consistent with the preservation of existing clean air resources; and
4. assure that any decision to permit increased air pollution in any area to which this section applies is made only after careful evaluation of all the consequences of such a decision and after adequate procedural opportunities for informed public participation in the decision making process.

What is BACT?

BACT is an emissions limitation which is based on the maximum degree of control that can be achieve. It is a case-by-case decision that considers energy, environmental, and economic impact. BACT can be add-on control equipment or modification of the production processes or methods. This includes fuel cleaning or treatment and innovative fuel combustion techniques. BACT may be a design, equipment, work practice, or operational standard if imposition of an emissions standard is infeasible.

The RACT/BACT/LAER Clearinghouse (RBLC) database contains information on what has been required as BACT in air permits.

What is an Air Quality Analysis?

The main purpose of the air quality analysis is to demonstrate that new emissions emitted from a proposed major stationary source or major modification, in conjunction with other applicable emissions increases and decreases from existing sources, will not cause or contribute to a violation of any applicable NAAQS or PSD increment.

Generally, the analysis will involve (1) an assessment of existing air quality, which may include ambient monitoring data and air quality dispersion modeling results, and (2) predictions, using dispersion modeling, of ambient concentrations that will result from the applicant's proposed project and future growth associated with the project.

Class I areas are areas of special national or regional natural, scenic, recreational, or historic value for which the PSD regulations provide special protection. The Federal Land Manager (FLM), including the State or Indian governing body, where applicable, is responsible for defining specific Air Quality Related Values (AQRV's) for an area and for establishing the criteria to determine an adverse impact on the AQRV's. If a FLM determines that a source will adversely impact AQRV's in a Class I area, the FLM may recommend that the permitting agency deny issuance of the permit, even in cases where no applicable increments would be exceeded. However, the permitting authority makes the final decision to issue or deny the permit.

What is PSD Increment?

PSD increment is the amount of pollution an area is allowed to increase. PSD increments prevent the air quality in clean areas from deteriorating to the level set by the NAAQS. The NAAQS is a maximum allowable concentration "ceiling." A PSD increment, on the other hand, is the maximum allowable increase in concentration that is allowed to occur above a baseline concentration for a pollutant. The baseline concentration is defined for each pollutant and, in general, is the ambient concentration existing at the time that the first complete PSD permit application affecting the area is submitted. Significant deterioration is said to occur when the amount of new pollution would exceed the applicable PSD increment. It is important to note, however, that the air quality cannot deteriorate beyond the concentration allowed by the applicable NAAQS, even if not all of the PSD increment is consumed.

What Additional Impacts Analysis are Required?

The additional impacts analysis assesses the impacts of air, ground and water pollution on soils, vegetation, and visibility caused by any increase in emissions of any regulated pollutant from the source or modification under review, and from associated growth. Associated growth is industrial, commercial, and residential growth that will occur in the area due to the source.

Reference:

Calculating realistic PM_{10} emissions from cooling towers

1. Joel Reisman,
2. Gordon Frisbie

Article first published online: 20 APR 2004

DOI: 10.1002/ep.670210216

The Reisman-Frisbie method has been used for approved permits in:

Mississippi

Michigan

Maryland

California

Texas

Idaho

Florida

Puerto Rico

From a Mississippi permit approval:

- Cooling Towers – The drift emissions from the cooling towers are limited to the particulate associated with dissolved solids in liquid droplets that become entrained in the air stream exiting the cooling tower. The particle size distribution is dependent on several factors including the design of the cooling tower, the drift eliminators, and the concentration of dissolved solids in the recirculating water (e.g., higher concentrations of dissolved solids may result in fewer particles below 2.5 microns aerodynamic diameter). Based on the Reisman and Frisbie method, "Calculating Realistic PM_{10} Emissions from Cooling Towers" (Reisman and Frisbie, 2002), $PM_{2.5}$ emissions would be less than 2% of the PM_{10} emissions at the assumed TDS concentration. This ratio would hold despite variance in circulation rates or expected TDS concentrations of the cooling tower. Accordingly, this represents a reliable statistical relationship over the operating range of the cooling towers. Therefore, 2% of the PM_{10} represents a reasonable and conservative proxy and surrogate for $PM_{2.5}$ from the cooling towers.

Pre-Construction Review and Preliminary Determination of Approval for Mississippi Power Company, Kemper IGCC Facility Facility No. 1380-00017, Technical Review by Krystal Rudolph; Air Quality Analysis By Bruce Ferguson, December 17, 2009