
Challenges and Problems in Performing a CPM BACT Analysis

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Prepared by:

Ali Farnoud ▪ Consultant
Pradnya Kulkarni ▪ Consultant
Clay Raasch ▪ Upper Midwest Operations Director

Trinity Consultants
12770 Merit Drive
Suite 900
Dallas, TX 75251
www.trinityconsultants.com
(214) 972-6100

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ABSTRACT

Condensable Particulate Matter (CPM) can represent a significant portion of Particulate Matter (PM) emissions from a heated exhaust. Since CPM can readily convert to submicron particles in the atmosphere under low temperature, CPM analysis can be a major component of the analysis of PM-2.5 emissions (such as Best Available Control Technology analysis) in the near future. While representing a client and at the request of a state agency, Trinity performed a Best Available Control Technology (BACT) analysis for CPM emissions. Currently, information is limited on CPM emissions and performance of potential CPM control technologies. This research elaborates the challenges in developing BACT analysis for CPM and presents a detailed review of literature available to industry and consultants.

INTRODUCTION

Of all the air pollutants in the environmental and occupational settings, Particulate Matter (PM) has received special attention because of its effect on visibility, strong evidence of adverse health effects, and association with cancer. Efforts to regulate particles suspended in the atmosphere were in effect as early as early 1900's and particle pollution was one of the first issues addressed after the establishment of the Environmental Protection Agency (EPA)¹. Despite the long history of research and regulation behind this pollutant, the complex nature of airborne particles still makes its regulation extremely difficult. EPA introduced National Ambient Air Quality Standard (NAAQS) for airborne particles by regulating annual and 24-hour total suspended particulate (TSP) in 1971 and in 1987 revised these to PM-10 standards². However, the most challenging particle standard was introduced in 1997 when EPA regulated much finer particles by setting a NAAQS for particles with an aerodynamic diameter less than 2.5 μm . In its Statement of Need, EPA indicated that due to enough scientific data the coarse and the fine fractions of PM-10 could be considered separately and as a result, established the new PM-2.5 standard³. EPA set the 24-hour standard for PM-2.5 at 65 $\mu\text{g}/\text{m}^3$ and the annual standard at 15 $\mu\text{g}/\text{m}^3$. In 2006, EPA revised these standards to 35 $\mu\text{g}/\text{m}^3$ (24-hr) and 15 $\mu\text{g}/\text{m}^3$ (annual)⁴. Establishing the PM-2.5 standard also increases the importance of condensable particulate matter (CPM) as a subcategory of PM-2.5 especially in control technology analyses for New Source Review (NSR) purposes like the Best Available Control Technology (BACT) analysis, since CPM comprises a considerable fraction of PM-2.5 and it can be converted to submicron particles under certain environmental conditions.

While the efficiency of the control equipment is mainly determined by the ability to remove larger particles, submicron particles become increasingly important when PM-2.5 is being removed. Under current regulations, setting a condensable PM-2.5 limit is not required. However, every BACT analysis needs to include this limit by 2011. While representing a client, Trinity Consultants was required by a state agency to evaluate different control technologies for CPM emissions. This research elaborates the challenges in developing BACT analysis for CPM and presents a review of literature available to the industry and environmental consultants.

DISCUSSION

Developments in CPM Quantification Methods

To standardize the quantification of CPM emissions, EPA promulgated Method 202 – Determination of Condensable Particulate Emissions from Stationary Sources in 40 CFR Part 51, Appendix M. This method contains several optional procedures that were intended to accommodate the various test methods used by State and local regulatory agencies at the time Method 202 was being developed. However, this Method 202 had several limitations such as when the same source was tested with different combinations of the optional procedures, the CPM emissions data varied largely. Further, the use of water filled impingers to cool stack gas containing SO₂, NO₂, or soluble organic gases caused positive CPM biases. As a result, many sources reported very high emissions of CPM that were caused largely due to the aqueous phase oxidation of soluble gases. Although the method recommended purging of the impinger solutions with nitrogen to reduce this positive bias, since the aqueous phase reactions start instantaneously, purge efficiencies were limited to 80 – 90%⁵. Recently on March 25, 2009, EPA proposed a new optimized Method 202 that uses dry impingers instead of water filled impingers to collect CPM. The stack gas is cooled to ambient temperature by installing a condenser prior to the impingers. The proposed method reduced the artifact caused by formation of sulfuric acid by at least 90% compared to the recommended procedures of the existing Method 202. As mentioned later in the discussion, most of the CPM emission factors presented in AP-42 are E-rated emission factors indicating the lack of reliable data for CPM¹³. Accurate test methods are essential to develop accurate emission factors and prepare accurate emission inventories. Although the proposed Method 202 still has some limitations such as high amount of moisture may still reintroduce water in the dry impingers leading to absorption of highly soluble gases, it may lead to better emission factor development and consequently better emission standards that are indicative of the actual impact of the source on ambient air quality.

What has EPA said about CPM Control?

EPA Fact Sheets: EPA has provided a series of fact sheets on control devices that are used by the industry and environmental consultants especially in writing BACT analyses. EPA factsheets do not contain information on the removal efficiency of the submicron particles. However, the EPA website recognizes that nucleation of the CPM will create submicron particles⁶. The available information on fine particles is usually limited to particles smaller than 2.5 µm diameter and not necessarily submicron particles. For instance, the EPA fact sheet on cyclones estimates a PM-2.5 collection efficiency of 0 to 40 percent for cyclone and 20 to 70 percent for high-efficiency cyclone and no information is available specifically for nucleated or submicron particles⁷. EPA's fact sheet on baghouses refer to new baghouses as control devices with efficiencies between 99 to 99.9%⁸. However, for submicron particles that these efficiencies may be much lower⁹. The fact sheet on dry wire-plate ESPs is a very well organized fact sheet which

categorizes control efficiency based on the application and particle size¹⁰. However, control efficiency of submicron particles nucleated from CPM cannot be directly estimated from this fact sheet. CPM usually converts to filterable PM at lower temperature and control efficiency for dry ESPs drops significantly at these low temperatures¹¹. Therefore, the range of efficiency values provided in this fact sheet can overestimate the control of nucleated particles substantially.

AP-42: While AP-42 provides emission factors for condensable fraction of PM, it does not provide guidance on the typical control efficiencies for CPM or submicron particles. Most of the CPM emission factors presented in AP-42 are E-rated emission factors which show the lack of reliable data for CPM¹³.

OAQPS: EPA Air Pollution Control Cost Manual has been prepared by the Office of Air Quality Planning and Standards (OAQPS) to help the industry estimate the cost of installing pollution control devices. Cost of CPM control specifically has not been addressed in the OAQPS manual¹².

Control Cost and Cost-Effectiveness Considerations

One element common to many CPM BACT analyses is an estimate of the cost—and cost-effectiveness—of add-on control equipment. In a BACT analysis, various control technologies may be compared based on the cost to remove one ton of pollutant. In a CPM BACT analysis, calculating the cost per ton of CPM removed for a control equipment can be challenging. Most particulate control devices are tested, designed, and built to remove filterable particles. Therefore, to evaluate the efficiency of a control device like electrostatic precipitators (ESP), fabric filters, or cyclones for CPM removal, it should be assumed that some portion of the CPM is converted to filterable particles. Due to the very complex nature of nucleation and condensation and numerous precursors for new particle formation, it is difficult to determine the portion of CPM that will condense to form filterable particulate. Additionally, consideration should be given to maintenance of the equipment that may be needed due to condensation of other pollutants in the exhaust gas. Since data is lacking on performance and efficiency of these control equipment for CPM control, comparison of various control technologies is challenging.

CONCLUSION

Condensable fraction of particulate matter is receiving increasing attention due to the introduction of PM-2.5 standards. While representing a client, Trinity Consultants was required by a state agency to analyze the applicable control technology for CPM emissions. Having investigated the available data in different EPA manuals, we believe that the body of data on CPM and submicron particles is very limited. EPA fact sheets on pollution control equipment have limited data on the issue of submicron particles. Reliable data for emission factors in AP-42 are lacking. Data are also limited on estimating the cost of control for CPM controls. Since the issue of submicron particle

control has been widely attended to in scientific literature, US EPA in AP-42 should develop new guidelines based on the scientific literature to better quantify the emissions and control of CPM.

REFERENCES

1. Bachmann, J.; *J. Air & Waste Manage. Assoc.* **2007**, *57*, 652–697.
2. U.S. EPA website, History of PM Standards, <http://epa.gov/pm/history.html> Accessed in March, **2009**.
3. U.S. EPA website, Statement of Need for the Proposed Regulations, <http://www.epa.gov/ttn/oarpg/naaqsf/ria/riach-02.pdf> Accessed in March, **2009**.
4. Federal Register, Vol. 71, No. 200. National Ambient Air Quality Standards for Particulate Matter, October 17, **2006**.
5. Richards, J., Holder T., Goshaw, D.; *AWMA Hazardous Waste Combustion Specialty Conference.* **2005**
5. U.S. EPA website, Characteristics of Particles - Particle Formation <http://www.epa.gov/apti/bces/module3/formation/formate.htm> Under Homogenous and Heterogeneous Nucleation
6. EPA Air Pollution Control Technology Fact Sheet, EPA 452/F-03-005, <http://www.epa.gov/ttn/catc/dir1/fcyclon.pdf> Accessed in March **2009**.
7. EPA Air Pollution Control Technology Fact Sheet, EPA 452/F-03-025, <http://www.epa.gov/ttn/catc/dir1/ff-pulse.pdf> Accessed in March **2009**.
8. Hinds, W.C. *Aerosol Technology: Properties, Behavior, and Measurement of Airborne Particles.* Second Edition. John Wiley & Sons, Inc. 1998, p. 198.
9. EPA Air Pollution Control Technology Fact Sheet, EPA 452/F-03-028, <http://www.epa.gov/ttn/catc/dir1/fdespwpl.pdf>
10. White, H.J. *Industrial Electrostatic Precipitation.* Reading, MA: Addison-Wesley Publishing Company, **1963**.
11. EPA/452/B-02-001, EPA Air Pollution Control Cost Manual, Office of Air Quality Planning and Standards, U.S. EPA, Sixth Edition, January **2002**.
12. AP-42, <http://www.epa.gov/ttn/chief/ap42/> Accessed in March **2009**.