Other Test Method – 36: Method for the Determination of Filterable $PM_{2.5}$ Emissions from Moisture Saturated and/or Droplet-laden Stationary Source Gas Streams (Constant Sampling Rate Procedure)

Note: Please submit a copy, either electronic or paper, of any test report from application of this OTM to EPA's Measurement Technology Group.

Electronic copies should be submitted via email with the subject line "OTM-036" to: EMC@epa.gov

Paper copies should be mailed to:
Measurement Technology Group
Office of Air Quality Planning and Standards
U.S. Environmental Protection Agency (Mail Code E143-02)
Research Triangle Park, NC 27711

This test method is designed to measure filterable particulate matter emissions equal to or less than a nominal aerodynamic diameter of 2.5 micrometers ($PM_{2.5}$) in moisture saturated (wet) and/or droplet-laden gas streams from stationary sources. This method addresses the equipment, preparation, and analysis necessary to measure filterable $PM_{2.5}$ emissions in droplet-laden and/or moisture-saturated gas streams. **You must use this method in combination with Method 202 of 40 CFR Part 51, Appendix M (Method 202) for measuring condensable particulate matter regardless of the temperature of the gas stream.**

A heated probe and filter box for the sampling train is used to vaporize water droplets in the sample gas stream, which may also vaporize volatile particulate matter in the gas stream. This method measures filterable $PM_{2.5}$ particulate matter based on the material passing through a $PM_{2.5}$ cyclone and depositing in the cyclone exit tubing, filter, and front half of the filter holder. This method can also be used to measure total filterable particulate matter based on the material captured in all parts of the sampling train. When used to measure total filterable particulate matter, the results obtained with this method are similar to those measured by Methods 5 and 5B.

This method was submitted by the American Petroleum Industry (API) and the National Council for Air and Stream Improvement (NCASI) to EPA's Office of Air Quality, Planning and Standards – Air Quality Assessment Division – Measurement Technology Group (MTG) for inclusion into the Other Test Method (OTM) category on EPA's Emission Monitoring Center (EMC) website at: http://www.epa.gov/ttn/emc/tmethods.html#CatC/.

The posting of a test method on the OTM portion of the EMC website is neither an endorsement by EPA regarding the validity of the test method nor a regulatory approval of the test method. The purpose of the OTM portion of the EMC website is to promote discussion of developing emission measurement methodologies and to provide regulatory agencies, the regulated community, and the public at large with potentially helpful tools.

Other Test Methods are test methods which have not yet been subject to the Federal rulemaking process. Each of these methods, as well as the available technical documentation supporting them, have been reviewed by the EMC staff and have been found to be potentially useful to the emission measurement community. The types of technical information reviewed include field and laboratory validation studies; results of collaborative testing; articles from peer-reviewed journals; peer- review comments; and quality assurance (QA) and quality control (QC) procedures in the method itself. A table summarizing the available technical information for each method can be found at the link below. The EPA strongly encourages the submission of additional supporting field and laboratory data as well as comments in regard to these methods.

These methods may be considered for use in federally enforceable State and local programs (e.g., Title V permits, State Implementation Plans (SIP)) provided they are subject to an EPA Regional SIP approval process or permit veto opportunity and public notice with the opportunity for comment. The methods may also be considered to be candidates to be alternative methods to meet Federal requirements under 40 CFR Parts 60, 61, and 63. However, they must be approved as alternatives under 60.8, 61.13, or 63.7(f) before a source may use them for this purpose. Consideration of a method's applicability for a particular purpose should be based on the stated applicability as well as the supporting technical information outlined in the table. The methods are available for application without EPA oversight for other non-EPA program uses including state permitting programs and scientific and engineering applications.

As many of these methods are submitted by parties outside the Agency, the EPA staff may not necessarily be the technical experts on these methods. Therefore, technical support from EPA for these methods is limited, but the table contains contact information for the developers so that you may contact them directly. Also, be aware that these methods are subject to change based on the review of additional validation studies or on public comment as a part of adoption as a Federal test method, the Title V permitting process, or inclusion in a SIP.

Method History

Final – 04/07/2016

EPA advises all potential users to review the method and all appendices carefully before application of this method.

Wet Stack Measurement and OTM-036 Caveats and Cautions

Principles of "Wet Stack" Measurement

EPA recognizes the need to measure particulate matter (PM) less than 2.5 micrometers (µm) aerodynamic diameter ($PM_{2.5}$) emissions from industrial sources. Currently, there are no promulgated methods available for the measurement of filterable $PM_{2.5}$ from sources with entrained water droplets (See Method 201A Section 1.5). One common example of a source with entrained moisture droplets is an exit of wet scrubbers, routinely used for emissions control boilers. Entrained water droplets confound the ability of current particulate matter sampling using manual methods and continuous monitoring systems (CEMS) to obtain representative results due to size of the droplet compared to the size of the final dried particle and other practical issues dealing with water droplets themselves.

Note: Entrained water droplets (or a "wet stack") occur when a gas stream is saturated with water and is then cooled. This condition can occur at any moisture range or temperatures between 0 deg F and approximately 220 deg F. Verification of entrained droplets can be done when comparing gravimetric moisture results with calculations based on temperature and pressure (See Section 4.1 of Method 4).

The droplets entrained in the effluent gas streams of saturated sources make representative sampling extremely difficult by presenting a set of challenges not found with traditional testing for filterable $PM_{2.5}$ using Method 201A. The water droplets contain both soluble and insoluble materials that become solid particles as the droplets are emitted to the atmosphere and the water evaporates. As a result, the ultimate dried particle size will be dependent on the concentration and makeup of the materials within the droplet. These water droplets, which will become filterable $PM_{2.5}$ particles, must be extracted from the stack, transported, and dried in a manner representative of emissions to the atmosphere, which presents difficultly due to the size of the water droplets needed. These dried particles must then be size classified as $PM_{2.5}$. The specific mix of soluble and insoluble materials and concentration in water droplets depend on the source (industrial sector, controls, raw materials, etc) and cannot be generalized. Therefore, it is difficult to determine the size range of the water droplets that must be sampled in order to capture the ones that will dry and become $PM_{2.5}$.

Another confounding factor is that particles are measured and regulated based on their aerodynamic diameter, not their physical diameter, and the $PM_{2.5}$ moniker represents a 50% transmission point at nominally 2.5 µm aerodynamic diameter along a penetration curve for a size classification device. Along this curve, the larger particles are not excluded altogether, but are collected with substantially decreasing efficiency and smaller particles are collected with increasing (up to 100%) efficiency. For a more in-depth discussion of these topics, please see the paper titled "Development of Plans for Monitoring Emissions of PM_1, $PM_{2.5}$ and PM_{10} from Stationary Sources with Wet Stacks" by David Leith and Maryanne G. Boundy, located in Appendix H and "2009 Final Report: Integrated Science Assessment for Particulate Matter" (http://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=216546).

In addition to entrained water droplets, the exhaust gas may contain solid particles that are not associated with water droplets. Finally, the exhaust may also contain gaseous organic and inorganic compounds that condense or react to form particles when the gas cools. It is necessary in the measurement of $PM_{2.5}$ from sources with entrained water droplets that both filterable and condensible material are characterized.

A Word of Caution

As discussed above, OTMs are test methods which have not yet been subject to the Federal rulemaking process. For this particular OTM, we have the particular concerns explained in the next section. Additionally, the EPA strongly encourages the submission of additional supporting field and laboratory data as well as comments in regard to these methods.

More Information Needed

The appropriateness of the following aspects of OTM-036 have not yet been assessed. Additional data is needed is these areas before this method can be fully evaluated regarding the issues discussed below. Any data developed during the application of this OTM that may assist in the further evaluation of these unknowns should be submitted to EPA's Measurement Technology Group.

Electronic copies should be submitted via email with the subject line "OTM-036" to: EMC@epa.gov

Paper copies should be mailed to:

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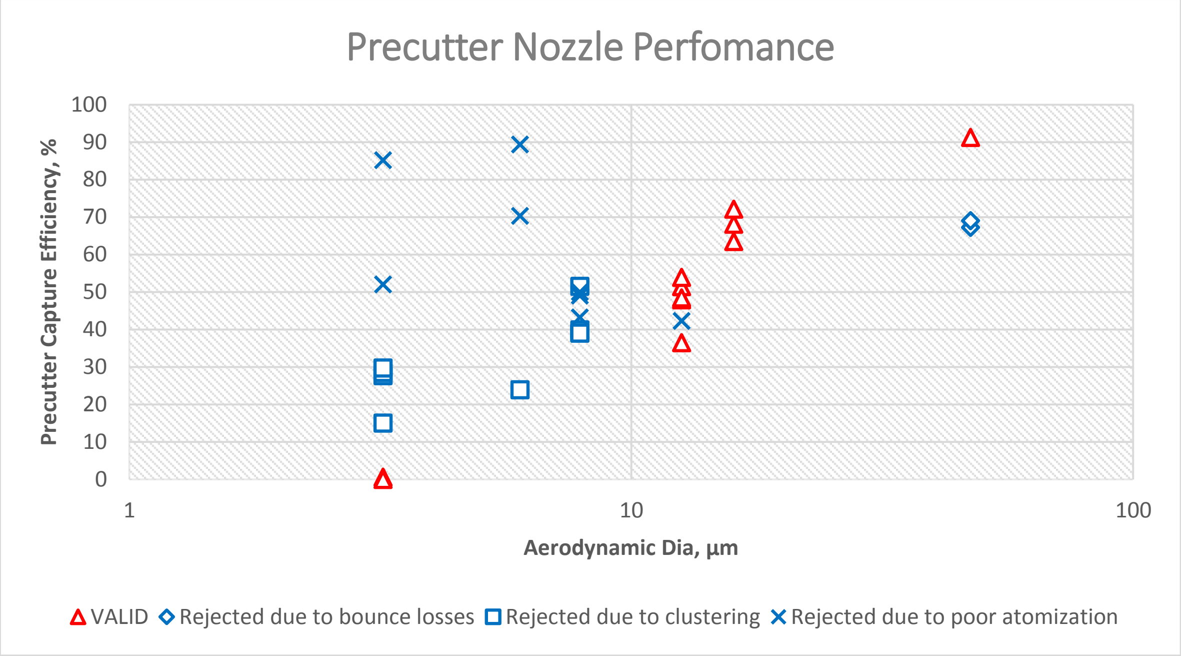
- **Probe transfer efficiency** - If water droplets, which become $PM_{2.5}$, and particles are not being efficiently transferred through the probe, the corresponding $PM_{2.5}$ results would be biased low.
- **Droplet shattering during drying** - More information is needed to determine whether or not water droplets are shattering during the drying process. If this shattering is occurring, it would cause the $PM_{2.5}$ results to be biased high.
- **Probe water droplet residence time** - More information is also needed about the probe water droplet residence time. This aspect of the method is difficult to assess as it is a function of flow rate, probe temperature, probe inside diameter, specific heat of the gas stream and water droplet concentration and size distribution. Improperly low residence time would bias the $PM_{2.5}$ results low.
- **Nozzle -** While nozzle efficiency testing was conducted (See Appendix E, F and G of this document), EPA believes the results were inconclusive due to imprecision of the experimental design and measurements. It should be noted that 27 % of runs were rejected based on test observations of poor PSL atomization or microsphere dispersion, 30 % of the runs were rejected during data analysis for microsphere clustering, and 7 % of the runs were rejected during data analysis for microsphere bounce. After all the various data points were rejected as invalid, the nozzle efficiency curve was determined with only 37% of the

runs. In addition, there was only one run deemed valid in the critical <10um range.



EPA recommends further evaluation of the nozzle efficiency using a vibrating orifice aerosol generator (VOAG) and monodisperse droplets or other experimental design with appropriate data quality indicators for precision.

- **Method 301 Testing –** The Method 301 testing conducted to validate the method using analyte spiking approach did not meet the required number of test runs due to issues with either train setup or train recovery which resulted in damage to the filter. The end user should be aware that during the Method 301 testing the trains were not validated using dynamic spiking, due to the nature of measurement. Instead, a static spike of salt particles were introduced into the nozzle of the sampling trains following sampling of a wet stack as additive to the field runs. This issue was discussed prior to testing with EPA and EPA recognized the extreme difficulty in dynamically spiking water droplets during test runs and agreed to static spiking. The salt particles were nominally less than $PM_{2.5}$, which is substantially smaller than the water droplets that would form $PM_{2.5}$ particles when dried.
- **QA/ QC Procedures -** This version of OTM-036 contains new QA/QC procedures that have not been demonstrated in the field. These new QA/QC procedures may require further study to determine their suitability (i.e., posttest leak check.)

Caveats

- **EPA advises all potential users to review the method and all appendices carefully before application of this method.**
- **End users should be aware that due to the lack of verification and validation for this test method, any data gathered using this test method may be invalidated in the future.**
- **You must use this method in combination with Method 202 of 40 CFR Part 51, Appendix M for measuring particulate matter regardless of the temperature of the gas stream. This method should not be used directly for filterable $PM_{2.5}$ emission limits due to the elevated filtration temperature required.**
- This method may be considered for use in Federally enforceable State and local programs (e.g., Title V permits, State Implementation Plans (SIP)) provided it is subject to an EPA Regional SIP approval process or permit veto opportunity and public notice with the opportunity for comment.
- This method may also be considered to be a candidate for use as an alternative method to meet Federal requirements under 40 CFR Parts 60, 61, and 63. However, any alternative method must be approved under 60.8, 61.13, or 63.7(f) before use for this purpose. Consideration of a method's applicability for a particular purpose should be based on the stated applicability as well as the supporting technical information outlined in the table.
- This method is available for application without EPA oversight for other non-EPA program uses including state permitting programs and scientific and engineering applications.
- This method was submitted by parties outside the Agency, the EPA staff may not necessarily be the technical experts on these methods. Therefore, technical support from EPA for these methods is limited, but the table contains contact information for the developers so that you may contact them directly.
- This method is subject to change based on the review of additional validation studies or on public comment as a part of adoption as a Federal test method, the Title V permitting process, or inclusion in a SIP.

OTHER TEST METHOD 36 - DETERMINATION OF FILTERABLE PM$_{2.5}$ EMISSIONS FROM MOISTURE SATURATED AND/OR DROPLET-LADEN STATIONARY SOURCE GAS STREAMS
(Constant Sampling Rate Procedure)

1.0 Scope and Applicability

1.1 Scope.

This method was developed to describe the procedures that the stack tester (“you”) must follow to measure filterable particulate matter emissions equal to or less than a nominal aerodynamic diameter of 2.5 micrometers (PM$_{2.5}$) from moisture saturated (wet) and/or droplet-laden gas streams from stationary sources.

1.2 Applicability.

This method addresses the equipment, preparation, and analysis necessary to measure filterable PM$_{2.5}$ emissions in droplet-laden and/or moisture-saturated gas streams. You must use this method in combination with Method 202 of 40 CFR Part 51, Appendix M (Method 202) for measuring condensable particulate matter regardless of the temperature of the gas stream. The probe and filter box heat for the sampling train is used in this method to vaporize droplets in the sample gas stream and can also vaporize volatile particulate matter in the gas stream.

This method can be used to measure filterable PM$_{2.5}$ particulate matter based on the material passing through a PM$_{2.5}$ cyclone and depositing in the cyclone exit tubing, filter, and front half of the filter holder. This method can also be used to measure total filterable particulate matter based on the material captured in all parts of the sampling train. When used to measure total filterable particulate matter, the results obtained with this method are similar to those measured by Methods 5 and 5B.

1.3 Responsibility.

You are responsible for obtaining the equipment and supplies you will need to use this method. You must also develop your own procedures for following this method and any additional procedures to ensure accurate sampling and analytical measurements.

1.4 Additional Methods.

To obtain results, you must have a thorough knowledge of the following test methods found in Appendices A-1 through A-3 of 40 CFR Part 60:

(a) Method 1 - Sample and velocity traverses for stationary sources.
(b) Method 2 - Determination of stack gas velocity and volumetric flow rate (Type S Pitot tube).
(c) Method 3 - Gas analysis for the determination of dry molecular weight.
(d) Method 4 - Determination of moisture content in stack gases.
(e) Method 5 - Determination of particulate matter emissions from stationary sources.

You must also have a thorough knowledge of Methods 201A and Method 202 of Appendix M.

1.5 Limitations.

You cannot use this method to measure emissions in which the water droplets present in the gas stream cannot be efficiently evaporated by the probe operated at 160°C ± 14°C (320°F ± 25°F). To measure filterable $PM_{2.5}$ in emissions where water droplets cannot be completely evaporated, we recommend that you use Method 5 of Appendix A-3 to Part 60.

This method cannot be used to traverse vertically in a horizontal duct due to the droplet reservoir. This method is also not applicable for sampling locations subject to cyclonic flow as defined by Method 1.

1.6 Conditions for Using This Method

To use this method as an alternative to Methods 5 or 5B, you must recover the particulate matter collected in the precutter nozzle and probe before the $PM_{2.5}$ cyclone, the $PM_{2.5}$ cyclone, the $PM_{2.5}$ exit tubing, the front half of the filter holder, and the filter. Be aware that this method determines $PM_{2.5}$ filterable emissions by sampling from a recommended maximum of 12 sample points, at a constant flow rate through the train (the constant flow is necessary to maintain the size cut of the cyclone), and with a filter that is in a specific temperature range. In contrast, Methods 5 and 5B trains are operated isokinetically with varying flow rates through the train. Further, to use this method in place of Methods 5 or 5B, you must extend the sampling time so that you collect the minimum mass necessary for weighing each portion of this sampling train.

If you are using this method as an alternative to a test method specified in a regulatory requirement (e.g., a requirement to conduct a compliance or performance test), then you must receive approval from the authority that established the regulatory requirement before you conduct the test. This test method includes a requirement to separately recover the solids captured in (1) the appropriately sized filter, (2) the cyclone exit tube and the front half of the filter holder, (3) the front half of the $PM_{2.5}$ cyclone and the cyclone cup, (4) the probe, and (5) the precutter nozzle. Filterable $PM_{2.5}$ is defined as the material recovered in samples (1) and (2). Total filterable particulate matter (i.e., equivalent to Methods 5 or 5B) is the sum of the material recovered from all five samples.

2.0 Summary of Method

Filterable $PM_{2.5}$ is measured by extracting a gas sample at a predetermined constant flow rate through a heated out-of-stack cyclone and filter. The probe and hot box containing the cyclone and filter are maintained at 160°C ± 14°C (320°F ± 25°F) to ensure that all gas stream droplets have evaporated and only dry particles enter the sizing device. The cyclone separates particles with nominal aerodynamic diameter of 2.5 micrometers. To minimize variations in the isokinetic sampling conditions, you must establish well-defined limits to the sampling rate. After a sample is obtained, remove uncombined water from the particulate matter, and then use gravimetric analysis to determine the particulate mass for each size fraction. The sampling train may be used to measure total filterable PM and filterable $PM_{2.5}$ emissions. Figure 1 of Section 17 presents the schematic of the sampling train.

This method is based on Method 201A. The numbering and sequence of the equations used in this method have been kept the same as Method 201A even though not all of the Method 201A equations and calculations are used in this method. Equations not needed are marked in Section

12. There are differences in the numbering of the sample containers in this method as compared to Method 201A.

3.0 Definitions

3.1 *Condensable particulate matter (CPM)* means material that is vapor phase at stack conditions, but condenses and/or reacts upon cooling and dilution in the ambient air to form solid or liquid PM immediately after discharge from the stack. Note that all CPM is assumed to be in the $PM_{2.5}$ size fraction.

3.2 *Constant weight* means a difference of no more than 0.5 mg or one percent of total weight less tare weight, whichever is greater, between two consecutive weighings, with no less than six hours of desiccation time between weighings.

3.3 *Filterable particulate matter (FPM)* means particles that are emitted directly by a source as a solid or liquid at stack or release conditions and captured on the filter of a stack test train.

3.4 *Field Train Proof Blank.* A train blank collected from a clean, fully-assembled sampling train prior to conducting the first emissions test. The sampling train is assembled, leak checked, and left exposed on the sampling platform for a period of time equal to an actual test run, with a final leak check performed at the conclusion of the exposure time. Samples are collected and processed as would occur for an actual test run.

3.5 *Primary particulate matter (PM)* (also known as direct PM) means particles that enter the atmosphere as a direct emission from a stack or an open source. Primary PM has two components: FPM and CPM. These two PM components have no upper particle size limit.

3.6 *Primary* $PM_{2.5}$ (also known as direct $PM_{2.5}$, total $PM_{2.5}$, $PM_{2.5}$, or combined filterable $PM_{2.5}$ and condensable PM) means PM with an aerodynamic diameter equal to or less than 2.5 micrometers. These solid particles are emitted directly from an air emissions source or activity, or are the gaseous or vaporous emissions from an air emissions source or activity that condense to form PM at ambient temperatures. Direct $PM_{2.5}$ emissions include elemental carbon, directly emitted organic carbon, directly emitted sulfate, directly emitted nitrate, and other inorganic particles (including but not limited to crustal material, metals, and sea salt).

4.0 Interferences

You cannot use this method to measure $PM_{2.5}$ emissions where the water droplets cannot be completely evaporated prior to the $PM_{2.5}$ sizing device.

5.0 Safety

Disclaimer—Because the performance of this method may require the use of hazardous materials, operations, and equipment, you should develop a health and safety plan to ensure the safety of your employees who are on site conducting the particulate emission test. Your plan should conform to all applicable Occupational Safety and Health Administration, Mine Safety and Health Administration, and Department of Transportation regulatory requirements. Because of the unique situations at some facilities and because some facilities may have more stringent requirements than is required by State or federal laws, you may have to develop procedures to conform to the plant health and safety requirements.

6.0 Equipment and Supplies

Figure 2 of Section 17 shows the cyclone head and filter holder arrangement used in this method. The sampling train is the same as Method 5 of Appendix A-3 to Part 60 with the exception of the precutter nozzle and the $PM_{2.5}$ cyclone before the filter holder. The following sections describe the sampling train's primary design features in detail.

6.1 Filterable Particulate Matter Sampling Train Components.

6.1.1 Precutter Nozzle.
You can use glass, quartz, stainless steel (316 or equivalent) or fluoropolymer-coated stainless steel nozzles with a sharp tapered leading edge designed to remove particles and droplets with a 50% cut size equal to or greater than 12 micrometers. The precutter nozzle must meet the design specifications shown in Figure 3 of Section 17. Use a caliper to verify that the dimensions of the precutter nozzle are within ±0.025 cm(0.01 inch) of the design specifications. We recommend that you have a large number of nozzles in small diameter increments available to increase the likelihood of using a single nozzle for the entire traverse.

6.1.2 $PM_{2.5}$ Cyclone.
6.1.2.1. Use stainless steel (316 or equivalent) or fluoropolymer-coated $PM_{2.5}$ cyclones. You may use cyclones constructed of high-temperature specialty metals such as Inconel, Hastelloy, or Haynes 230 (See also Section 8.6.1.). The cyclones must meet the design specifications shown in Figure 7 of Section 17. Use a caliper to verify that the dimensions of the $PM_{2.5}$ cyclone is within ±0.02 cm of the design specifications.

Example suppliers of $PM_{2.5}$ cyclones include the following:

(a) Environmental Supply Company, Inc., 2142 E. Geer Street, Durham, North Carolina 27704. Telephone No.: (919) 956-9688; Fax: (919) 682-0333.

(b) Apex Instruments, 204 Technology Park Lane, Fuquay-Varina, North Carolina 27526. Telephone No.: (919) 557-7300 (phone); Fax: (919) 557-7110.

6.1.2.2. You may use alternative cyclones if they meet the requirements in Development and Laboratory Evaluation of a Five-Stage Cyclone System, EPA-600/7-78-008 (http://cfpub.epa.gov/ols).

6.1.3 Filter Holder.
Use a filter holder that is glass or stainless steel (316 or equivalent). Commercial-size filter holders are available depending upon project requirements, including commercial stainless steel filter holders to support 25-, 47-, or 63-mm diameter filters. Commercial size filter holders contain a fluoropolymer O-ring, a stainless steel screen that supports the particulate filter, and a final fluoropolymer O-ring. Screw the assembly together and attach to the outlet of the $PM_{2.5}$ cyclone. The filter must not be compressed between the fluoropolymer O-ring and the filter housing.

6.1.4 Pitot Tube.
You must use a Pitot tube made of heat resistant tubing. Attach the Pitot tube to the probe with stainless steel fittings. Follow the specifications for the Pitot tube and its orientation to the inlet nozzle given in Section 6.1.1.3 of Method 5 of Appendix A-3 to Part 60.

6.1.5 Probe and Liner.
The probe sheath must be capable of heating the gas stream to 160°C ± 14°C (320°F ± 25°F) to evaporate all gas stream moisture. The probe must have a thermocouple mounted at least three locations and no more than 6 inches from the inlet to the probe. The probe liner must be glass, quartz, Teflon or fluoropolymer-lined. Follow the specifications in Section 6.1.1.2 of Method 5 of Appendix A-3 to Part 60. The probe must be a minimum of four feet long to ensure complete droplet evaporation prior to entry to the cyclone.

6.1.6 Differential Pressure Gauge, Condensers, Metering Systems, Barometer, and Gas Density Determination Equipment.
Follow the requirements in Sections 6.1.1.4 through 6.1.3 of Method 5 of Appendix A-3 to Part 60, as applicable.

6.2 Sample Recovery Equipment.

6.2.1 Filterable Particulate Recovery.
Use the following equipment to quantitatively determine the amount of filterable PM recovered from the sampling train.

(a) $PM_{2.5}$ Cyclone and filter holder brushes.
(b) Wash bottles. Two wash bottles are recommended. Any container material is acceptable, but wash bottles used for sample and blank recovery must not contribute more than 0.1 mg of residual mass to the CPM measurements.
(c) Leak-proof sample containers. Containers used for sample and blank recovery must not contribute more than 0.10 mg of residual mass to the CPM measurements. Sample containers must be rinsed with acetone before use.
(d) Petri dishes. For filter samples; glass or polyethylene, unless otherwise specified by the Administrator.
(e) Graduated cylinders, or balance. To measure condensed water to within 1 ml or 0.5 g graduated cylinders must have subdivisions not greater than 2 ml.
(f) Plastic storage containers. Air-tight containers to store silica gel.

6.2.2 Condensable PM Recovery. You must use this method in combination with Method 202 for measuring condensable particulate matter regardless of the temperature of the gas stream. Refer to section 6.2.1 of Method 202 for the equipment needed for condensable PM recovery.

6.2.3 Analysis Equipment.
(a) Funnel. Glass or polyethylene, to aid in sample recovery.
(b) Rubber policeman. To aid in transfer of silica gel to container; not necessary if silica gel is weighed in the field.
(c) Analytical balance. Analytical balance with a minimum resolution of – or capable of detecting a mass difference as low as 0.0001 g (0.1 mg).
(d) Balance. To determine the weight of the moisture in the sampling train components, use an analytical balance with a minimum resolution of – or capable of detecting a mass difference as low as 0.1 g.
(e) Fluoropolymer beaker liners or glass beakers (or other non-reactive containers).

7.0 Reagents, Standards, and Sampling Media

7.1 Sample Collection.

You must use this method in combination with Method 202 for measuring condensable particulate matter regardless of the temperature of the gas stream. In addition to the specification below, please refer to section 7.1.2 through 7.1.5 of Method 202 for the additional requirements for sample collection.

Use a nonreactive, nondisintegrating glass fiber, quartz, or polymer filter that does not a have an organic binder and meets the requirements of Section 7.1.1 of Method 5. The filter must have an efficiency of at least 99.95 percent (less than 0.05 percent penetration) on 0.3 micrometer dioctyl phthalate particles. You may use test data from the supplier’s quality control program to document the PM filter efficiency.

Note: There is substantial evidence of alkaline material on a majority of glass filter media. In order to avoid the possibility of biased results, some testers have decided to use only quartz filters when performing Method 5.

7.2 Sample Recovery and Analytical Reagents

Please refer to section 7.2 of Method 202 for the requirements for sample recovery and analytical reagents related to Method 202.

7.2.1 Acetone.
Use acetone that is stored in a glass bottle. Do not use acetone from a metal container because it will likely produce a high residue in the laboratory and field reagent blanks. You must use acetone with blank values less than 1 part per million by weight residue. Analyze acetone blanks prior to field use to confirm low blank values.

7.2.2 Particulate Sample Desiccant.
Use indicating type anhydrous calcium sulfate to desiccate samples prior to weighing.

8.0 Sample Collection, Preservation, Storage, and Transport

8.1 Qualifications

This is a complex test method. To obtain reliable results, you should be trained and experienced with stack filtration systems (such as cyclones and filters) and impinger and moisture train systems.

8.2 Preparations

Follow the pretest preparation instructions in Section 8.1 of Method 5 of Appendix A-3 to Part 60.

8.3 Site Setup.

You must complete the following to properly set up for this test:

(a) Determine the sampling site location and traverse points.
(b) Verify the absence of cyclonic flow.
(c) Complete a preliminary velocity profile and select a nozzle(s) and sampling rate.

8.3.1 Sampling Site Location and Traverse Point Determination.

Follow the standard procedures in Method 1 of Appendix A-1 to Part 60 to select the appropriate sampling site. Choose a location that maximizes the distance from upstream and downstream flow disturbances.

> (a) Traverse points. The required maximum number of total traverse points at any location is 12, as shown in Figure 6 of Section 17. You must prevent the disturbance and capture of any solids accumulated on the inner wall surfaces by maintaining a 1-inch distance from the stack wall (0.5 inch for sampling locations less than 36.4 inches in diameter with the Pitot tube and 32.4 inches without the Pitot tube).
> (b) Round or rectangular duct or stack. If a duct or stack is round with two ports located 90° apart, use six sampling points on each diameter. Use a 3x4 sampling point layout for rectangular ducts or stacks. Consult with the Administrator to receive approval for other layouts before you use them.

8.3.2 Cyclonic Flow.

Do not use this method at sampling locations subject to cyclonic flow. Also, you must follow procedures in Method 1 of Appendix A-1 to Part 60 to determine the presence or absence of cyclonic flow and then perform the following calculations:

> (a) As per Section 11.4 of Method 1 of Appendix A-1 to Part 60, find and record the angle that has a null velocity pressure for each traverse point using an S-type Pitot tube.
> (b) Average the absolute values of the angles that have a null velocity pressure. Do not use the sampling location if the average absolute value exceeds 20^{o}. (Note: You can minimize the effects of cyclonic flow conditions by moving the sampling location or, placing gas flow straighteners upstream of the sampling location

8.3.3 Preliminary Velocity Profile.

Conduct a preliminary velocity traverse by following Method 2 of Appendix A-1 to Part 60 velocity traverse procedures. The purpose of the preliminary velocity profile is to determine all of the following:

> (a) The gas sampling rate for the cyclone in order to meet the required particle size cut.
> (b) The appropriate nozzle to maintain the required gas sampling rate for the velocity pressure range and isokinetic range. If the isokinetic range cannot be met (e.g., batch processes, extreme process flow or temperature variation), void the sample or use methods subject to the approval of the Administrator to correct the data. The acceptable variation from isokinetic sampling is 80 to 120 percent and no more than 100 ± 20 percent (two out of 12) sampling points outside of these criteria.
> (c) The necessary sampling duration to obtain sufficient particulate matter catch weights.

8.3.3.1 Preliminary traverse.

You must use an S-type Pitot tube with a conventional thermocouple to conduct the traverse. A Pitot tube mounted on a probe with the precutter nozzle attached must be used for the preliminary traverse. Conduct the preliminary traverse as close as possible to the anticipated testing time on sources that are subject to hour-by-hour gas flow rate variations of approximately ± 20 percent and/or gas temperature variations of approximately ± 28°C (± 50°F). (Note: You should be aware that these variations can cause errors in the cyclone cut diameters and the isokinetic sampling velocities.)

8.3.3.2 Velocity pressure range. Insert the S-type Pitot tube and probe assembly at each traverse point and record the range of velocity pressures measured on the data form in Method 2 of Appendix A-1 to Part 60. You will use this later to select the appropriate nozzle.

8.3.3.3 Initial gas stream viscosity and molecular weight. Determine the average gas temperature, average gas oxygen content, average carbon dioxide content, and estimated moisture content. You will use this information to calculate the initial gas stream viscosity (Equations 3a and 3b) and molecular weight (Equations 1 and 2). (Note: You must follow the instructions outlined in Method 4 of Appendix A-3 to Part 60 or Alternative Moisture Measurement Method Midget Impingers (ALT-008) to estimate the moisture content. You may use a wet bulb-dry bulb measurement or hand-held hygrometer measurement to estimate the moisture content of sources with gas temperatures less than 71°C (160°F).

8.3.3.4 Approximate $PM_{2.5}$ concentration in the gas stream. Determine the approximate concentration for the $PM_{2.5}$ components of the gas stream through qualitative measurements or estimates from previous stack PM emissions tests. Having an idea of the $PM_{2.5}$ concentration in the gas stream is not essential but will help you determine the appropriate sampling time to acquire sufficient $PM_{2.5}$ weight for better accuracy at the source emission level. The collectable $PM_{2.5}$ weight requirements depend primarily on the types of filter media and weighing capabilities that are available and needed to characterize the emissions. Estimate the collectable PM concentrations in the greater than 2.5 micrometer and less than or equal to 2.5 micrometer size ranges. Typical $PM_{2.5}$ concentrations are listed in Table 1 of Section 17. Additionally, relevant sections of AP-42, Compilation of Air Pollutant Emission Factors, may contain particle size distributions for processes characterized in those sections, and Appendix B2 of AP-42 contains generalized particle size distributions for nine industrial process categories (e.g., stationary internal combustion engines firing gasoline or diesel fuel, calcining of aggregate or unprocessed ores). The generalized particle size distributions can be used if source-specific particle size distributions are unavailable. Appendix B2 of AP-42 also contains typical collection efficiencies of various particulate control devices and example calculations showing how to estimate uncontrolled total particulate emissions, uncontrolled size-specific emissions, and controlled size-specific particulate emissions. (http://www.epa.gov/ttnchie1/ap42.)

8.4 Pre-test Calculations.

You must perform pre-test calculations to help select the appropriate gas sampling rate through the$PM_{2.5}$ cyclone ($PM_{2.5}$). Choosing the appropriate sampling rate will allow you to maintain the appropriate particle cut diameter based upon preliminary gas stream measurements, as specified in Table 2 of Section 17.

The gas sampling rate is defined by the performance curve for the $PM_{2.5}$ cyclone, as illustrated in Figure 8 of Section 17. You must select a gas sampling rate such that the cyclone cut point will be in the middle of the acceptable range (2.25-2.75 micrometers). You must use the calculations in Section 8.5 to determine a gas sampling rate that will achieve the appropriate cut size specification for the cyclone.

8.5 Test Calculations.

You must perform all of the calculations in Table 3 of Section 17 and the calculations described in Sections 8.5.1 through 8.5.5.

8.5.1 Assumed Reynolds Number.
You must select an assumed Reynolds number (N_{re}) using Equation 10 and an estimated sampling rate or from prior experience under the stack conditions determined using Methods 1 through 4 to part 60. You will perform initial test calculations based on an assumed N_{re} for the test to be performed. You must verify the assumed N_{re} by substituting the sampling rate ($Q_{2.5}$) calculated in Equation 8 or 9 into Equation 10

8.5.2 Final Sampling Rate.
Recalculate the final $Q_{2.5}$ if the assumed N_{re} used in your initial calculation is not correct. Use Equation 8 or 9 to recalculate the optimum $Q_{2.5}$.

8.5.3 Meter Box ΔH.
Use Equation 11 to calculate the meter box orifice pressure drop (ΔH) after you calculate the optimum sampling rate and confirm the N_{re}.

(Note: The stack gas temperature may vary during the test, which could affect the sample rate due to moisture content of the stack. It is recommended to develop a range of ΔH at 5 deg F increments with the saturated moisture content at those temperatures.)

8.5.4 Choosing a Sampling Nozzle.
Select one or more nozzle sizes to provide for near isokinetic sampling rate (see Section 1.6). This will also minimize any isokinetic sampling error for the particles at each point. Calculate the mean stack gas velocity (v_s) using Equation 13, the nozzle flow rate using equation 8a or 9a,then use Equation 14 to calculate the diameter (D) of a nozzle that provides for isokinetic sampling at the mean v_s at flow Q_{Nozzle}. From the available nozzles one size smaller and one size larger than this diameter, D, select the most appropriate nozzle. Perform the following steps for the selected nozzle.

8.5.4.1 Minimum/maximum nozzle/stack velocity ratio. Use Equation 15 to determine the velocity of gas in the nozzle. Use Equation 16 to calculate the minimum nozzle/stack velocity ratio (R_{min}). Use Equation 17 to calculate the maximum nozzle/stack velocity ratio (R_{max}). Use the stack gas viscosity in this calculation.

8.5.4.2 Minimum gas velocity. If R_{min} is an imaginary number (negative value under the square root function) or if R_{min} is less than 0.5, use Equation 18 to calculate the minimum gas velocity (v_{min}). If R_{min} is ≥ 0.5, use Equation 19 to calculate v_{min}. Use the stack gas viscosity in this calculation.

8.5.4.3 Maximum stack velocity. Use Equation 20 to calculate the maximum stack velocity (v_{max}) if R_{max} is less than 1.5. Use Equation 21 to calculate the stack velocity if R_{max} is ≥ 1.5.

8.5.4.4 Conversion of gas velocities to velocity pressure. Use Equation 22 to convert v_{min} to minimum velocity pressure, Δp_{min}. Use Equation 23 to convert v_{max} to maximum velocity pressure, Δp_{max}.

8.5.4.5 Comparison to observed velocity pressures. Compare minimum and maximum velocity pressures with the observed velocity pressures at all traverse points during the preliminary test.

8.5.5 Optimum Sampling Nozzle.
The nozzle you selected is appropriate if all the observed velocity pressures during the preliminary test fall within the range of the Δp_{min} and Δp_{max}. Make sure the following requirements are met then follow the procedures in Sections 8.5.5.1 and 8.5.5.2.

> (a) Choose an optimum nozzle that provides for isokinetic sampling conditions as close to 100 percent as possible. This is prudent because even if there are slight variations in the gas flow rate, gas temperature, or gas composition during the actual test, you have the maximum assurance of satisfying the isokinetic criteria. Generally, one of the two candidate nozzles selected will be closer to optimum (see Section 8.5.4).
> (b) You are allowed a 16 percent failure rate, rounded to the nearest whole number, of sampling points that are outside the range of the Δp_{min} and Δp_{max}.

8.5.5.1 Pre-check. Visually check the selected nozzle for dents before use.

8.5.5.2 Attach the pre-selected nozzle. Attach the pre-selected nozzle onto the precutter inlet. Use a union and adaptor to connect the $PM_{2.5}$ cyclone inlet to the probe outlet (see Figure 2 of Section 17).

8.6 Sampling Train Preparation.

A schematic of the sampling train used in this method is shown in Figure 1 of Section 17. First, assemble the train and complete the leak check on the entire sampling system. Use the following procedures to prepare the sampling train. (Note: Do not contaminate the sampling train during preparation and assembly. Keep all openings, where contamination can occur, covered until just prior to assembly or until sampling is about to begin.)

Method 202 must be conducted as part of the emission test. Instructions for preparing the Method 202 sampling train are described in Method 202.

8.6.1 $PM_{2.5}$ Cyclone.
Assemble the cyclone. The O-rings used in the cyclone have a temperature limit of approximately 205°C (400°F). Install the cyclone into the heated filter box.

8.6.2 Filterable $PM_{2.5}$ Matter Filter Holder.
Attach the pre-selected filter holder to the end of the $PM_{2.5}$ cyclone (see Figure 2 of Section 17) also in the heated hot box.

8.6.3 Filter.
You must number and tare the filters before use. To tare the filters, desiccate each filter at 20 ± 5.6°C (68 ± 10°F) and ambient pressure for at least 24 hours and weigh at intervals of at least six hours to a constant weight (See Section 3.0 for a definition of constant weight.). Record results to the nearest 0.l mg. During each weighing, the filter must not be exposed to the laboratory atmosphere for longer than two minutes and a relative humidity above 50 percent. Alternatively, the filters may be oven-dried at 104°C (220°F) for two to three hours, desiccated for two hours, and weighed. Use tweezers or clean disposable surgical gloves to place a labeled (identified) and pre-weighed filter in the filter holder. You must center the filter and properly place the gasket so that the sample gas stream will not circumvent the filter.

8.6.4 Moisture Trap.
Follow the procedures in Method 202 of Appendix M for moisture collection.

8.6.5 Leak Check.
Use the procedures outlined in Section 8.4 of Method 5 of Appendix A-3 to Part 60 to leak check the entire sampling system prior to sampling. Specifically perform the following procedures:

8.6.5.1 Sampling train.
You must pre-test the entire sampling train for leaks. The pre-test leak check must have a leak rate of not more than 0.02 actual cubic feet per minute or four percent of the average sample flow during the test run, whichever is less. Additionally, you must conduct the leak check at a vacuum equal to or greater than the vacuum anticipated during the test run. Enter the leak check results on the analytical data sheet (see Section 11.1) for the specific test. (Note: Do not conduct a leak check during port changes.)

8.6.5.2 Pitot tube assembly. After you leak check the sample train, perform a leak check of the Pitot tube assembly. Follow the procedures outlined in Section 8.1 of Method 2 of Appendix A-1.

8.6.6 Probe and Heated Sampling Box.
You must pre-heat the probe and heated sampling box with the cyclone and filter installed to 160°C (320°F). This will ensure evaporation of the gas stream moisture and that only dry particles enter the cyclone and filter. Allow a minimum of 30 minutes (or another empirical derived time to achieve thermal equilibrium) once the oven is at the specified temperature for the cyclone internal temperature to reach 160 °C (320 °F).

8.7 Sampling Train Operation.

Operate the sampling train the same as described in Section 8.5 of Method 5 of Appendix A-3 to Part 60, but use the procedures in this section for isokinetic sampling and flow rate adjustment. Maintain the flow rate calculated in Section 8.5.3 throughout the run, provided the stack temperature is within 3°C (5°F) of the temperature used to calculate ΔH. If stack temperatures vary by more than 3°C (5°F), use the appropriate ΔH value calculated in Section 8.5.3. Determine the minimum number of traverse points as in Figure 6 of Section 17. Determine the minimum total projected sampling time based on achieving the data quality objectives or emission limit of the affected facility. We recommend that you round the number of minutes sampled at each point to the nearest 15 seconds. Perform the following procedures:

8.7.1 Sample Point Dwell Time.
You must calculate the flow rate-weighted dwell time (that is, sampling time) for each sampling point to ensure that the overall run provides a velocity-weighted average that is representative of the entire gas stream. Vary the dwell time at each traverse point proportionately with the point velocity. Calculate the dwell time at each of the traverse points using Equation 24. You must use the data from the preliminary traverse to determine the average velocity pressure (Δp_{avg}). You must use the velocity pressure measured during the sampling run to determine the velocity pressure at each point (Δp_n). Here, N_{tp} equals the total number of traverse points. Each traverse point must have a dwell time of at least two minutes.

8.7.2 Sample Collection.
Collect samples the same as described in Section 8.5 of Method 5 of Appendix A-3 to Part 60, except use the procedures in this section for isokinetic sampling and flow rate adjustment. Maintain the flow rate calculated in Section 8.5 throughout the run, provided the stack

temperature is within 3°C (5°F) of the temperature used to calculate ΔH. If stack temperatures vary by more than 3°C (5°F), use the appropriate ΔH value calculated in Section 8.5.3. Calculate the dwell time at each traverse point as in Equation 24. In addition to these procedures, you must also use running starts and stops if the static pressure at the sampling location is less than minus 5 inches water column. This prevents back pressure from rupturing the sample filter. If you use a running start, adjust the flow rate to the calculated value after you perform the leak check.

8.7.2.1 Level and zero manometers. Periodically check the level and zero point of the manometers during the traverse. Vibrations and temperature changes may cause them to drift.

8.7.2.2 Sampling ports. Clean the sampling ports prior to the test run. This will minimize the chance of collecting deposited material in the nozzle.

8.7.2.3 Sampling procedures. Verify that the probe, cyclone and filter holder are at 160°C ± 14°C (320°F ± 25°F). To begin sampling, remove the protective cover from the nozzle. Position the probe at the first sampling point with the nozzle pointing directly into the gas stream. Immediately start the pump and adjust the flow to calculated isokinetic conditions. Ensure the probe/Pitot tube assembly is leveled. When the probe is in position, block off the openings around the probe and sampling port to prevent unrepresentative dilution of the gas stream. Take care to minimize contamination from the material used to block the sampling port.

(a) Traverse the stack cross-section, as required by Method 1 of Appendix A-1 to Part 60, with the exception that you are only required to sample from a maximum of 12-points (six points per traverse for circular cross-section ducts). Do not bump the nozzle into the stack walls when sampling near the walls or when removing or inserting the probe through the sampling ports. This will minimize the chance of extracting deposited materials.

(b) Record and report the data required on the field test run data sheet having the same entries as the example data sheet shown in Figure 9. Record the initial dry gas meter reading. Then take dry gas meter readings at the following times: the beginning and end of each sample time increment; when changes in flow rates are made; and when sampling is halted. Compare the velocity pressure measurements (Equations 22 and 23) with the velocity pressure measured during the preliminary traverse. Keep the meter box ΔH at the value calculated in Section 8.5.3. If it is not possible to maintain the oven temperature within the specified range, void the run and correct the problem before repeating the run. Record all point-by-point data and other source test parameters on the field test data sheet. Do not leak check the sampling system during port changes.

(c) If the static pressure at the sampling location is less than minus 5 inches water column, maintain flow until the nozzle is completely removed from the sampling port. Under these conditions you must also restart the sampling flow prior to inserting the nozzle into the sampling port during port changes.

(d) Maintain the flow through the sampling system at the last sampling point. At the conclusion of the test, if the static pressure at the sampling location is less than minus 5 inches water column, remove the nozzle, probe, and heated sampling box from the stack while the train is still operating (running stop). Make sure that you do not scrape the

Pitot tube or the nozzle against the port or stack walls. Then stop the pump and record the final dry gas meter reading and other test parameters on the field test data sheet. After you stop the pump, make sure you keep the cyclone head level to avoid tipping dust from the cyclone cup into the filter and/or down-comer line.

8.7.3 Process Data.
You must document data and information on the process unit tested, the particulate matter control system used to control emissions, any non-particulate matter control system that may affect particulate emissions, the sampling train conditions, and weather conditions. Record the site barometric pressure and stack pressure on the field test data sheet. Discontinue the test if the operating conditions may cause non-representative particulate matter emissions.

8.7.3.1 Particulate matter control system data. Use the process and control system data to determine whether representative operating conditions were maintained throughout the testing period.

8.7.3.2 Sampling train data. Use the sampling train data to confirm that the measured particulate emissions are accurate and complete.

8.7.4 Sample Recovery.
Disconnect the probe and remove the cyclone from the sampling box. Seal both ends of the cyclone to prevent particulate matter from entering or leaving the cyclone. After the cyclone is removed, perform a posttest leak check of the sample train from the inlet of the filter through the remainder of the sampling train. You must conduct the leak check at a vacuum equal to or greater than the maximum vacuum achieved during the test run. Enter the results of the leak check onto the field test data sheet. If the leak rate of the sampling train (without the combined cyclone sampling head) exceeds 0.02 actual cubic feet per minute or four percent of the average sampling rate during the test run (whichever is less), the run is invalid and must be repeated.

Connect the outlet of the probe to a jumper and leak check the precutter nozzle and probe at a maximum of 2 in. Hg vacuum to avoid loss of material from the precutter and probe. Enter the results of the leak check onto the field test data sheet. If the leak rate of the precutter nozzle and probe exceeds 0.02 actual cubic feet per minute or four percent of the average sampling rate during the test run (whichever is less), the run is invalid and must be repeated. Seal all openings of sampling train components from which samples will be collected and transport to the sample recovery area.

Recover the captured material from the precutter nozzle, probe, cyclone, cyclone exit tubing, the front half of the filter holder, and the filter. Refer to the following sections for more detailed information.

8.7.4.1 Recover the Method 202 sampling train in accordance with the sample recovery procedures specified in Method 202.

8.7.4.2 Recovery of Filterable PM. Recovery involves the quantitative transfer of particles in the following size range: greater than 2.5 micrometers; and less than or equal to 2.5 micrometers. You must use a nylon or fluoropolymer brush and an acetone rinse to recover particles from the cyclone and filter holder. For sources covered under 40 CFR Part 60, Subpart BB, water is used as the rinse reagent. Use the following procedures for each container:

(a) Container #1, Filter, Filterable Particulate Matter Less Than or Equal to 2.5 Micrometers. Use tweezers and/or clean disposable surgical gloves to remove the filter from the filter holder. Place the filter in the Petri dish that you labeled with the test identification and Container #1. Using a dry brush and/or a sharp-edged blade, carefully transfer any PM and/or filter fibers that adhere to the filter holder gasket or filter support screen to the Petri dish. Seal the container. This container holds particles less than or equal to 2.5 micrometers that are caught on the filter.

(b) Container #2. Rinse, Filterable Particulate Matter Less Than or Equal to 2.5 Micrometers
Place the reagent (and brush cleaning) rinses of the interior surfaces of the inlet side of the filter holder and the exit tube from the PM2.5 cyclone into Container #2. Seal the container and mark the liquid level on the outside of the container. This container holds filterable less than or equal to 2.5 micrometers.

(c) Container #3. Cyclone Rinse, Filterable Particulate Matter Greater than 2.5 Micrometers.
Place the solids from the $PM_{2.5}$ cyclone cup and the reagent (and brush cleaning) rinses of the interior surface of the $PM_{2.5}$ cyclone, into Container #3. Seal the container and mark the liquid level on the outside of the container. This container holds filterable PM greater than 2.5 micrometers.

(d) Container #4. Probe Rinse, Filterable Particulate Matter Greater than 2.5 Micrometers. Place the solids from the probe (and brush cleaning) rinses of the interior surface of the probe into Container #4. Seal the container and mark the liquid level on the outside of the container. This container holds filterable PM greater than 2.5 micrometers.

(e) Container #5. Precutter Nozzle Rinse, Filterable Particulate Matter Greater than 2.5 Micrometers. Place the solids from the precutter nozzle (and brush cleaning) rinses of the interior surface of the precutter nozzle into Container #5. Seal the container and mark the liquid level on the outside of the container. This container holds filterable PM greater than 2.5 micrometers.

(f) Container #6, Acetone field reagent blank. Take approximately 350 ml of the acetone directly from the wash bottle you used and place it in Container #8 labeled "Acetone Field Reagent Blank."

8.7.5 Transport Procedures.
Containers must remain in an upright position at all times during shipping. Samples may be transported and stored at ambient temperatures.

9.0 Quality Control

9.1 Daily Quality Checks.

You must perform daily quality checks of field log books and data entries and calculations using data quality indicators from this method and your site-specific test plan. You must review and evaluate recorded and transferred raw data, calculations, and documentation of testing procedures. You must initial or sign log book pages and data entry forms that were reviewed.

9.2 Calculation Verification.

Verify the calculations by independent, manual checks. You must flag any suspect data and identify the nature of the problem and potential effect on data quality. After you complete the test, prepare a data summary and compile all the calculations and raw data sheets.

9.3 Conditions.

You must document data and information on the process unit tested, the particulate matter control system used to control emissions, any non-particulate matter control system that may affect particulate matter emissions, the sampling train conditions, and weather conditions. Discontinue the test if the operating conditions may cause non-representative particulate matter emissions.

9.4 Field Analytical Balance Calibration Check.

Perform calibration check procedures on field analytical balances each day that they are used. You must use National Institute of Standards and Technology (NIST)-traceable weights at a mass approximately equal to the weight of the sample plus container you will weigh.

9.5 Field Train Proof Blank.

Prior to performing emissions testing, collect the Field Train Proof Method Blank in the following manner. Assemble a sampling train from laboratory cleaned sampling train components on the same sampling platform on which the emissions testing will be performed. Perform a leak check of the assembled sampling train. Leave the assembled sampling train on the sampling platform for a period of time equivalent to an actual test run. At the conclusion of the exposure period perform a second leak check of the sampling train. Disassemble, seal, and transport the sampling train components to the sample recovery area, and recover the samples in the same manner as would be performed for an actual test run as detailed in section 8.7.4.

10.0 Calibration and Standardization

Maintain a log of all filterable particulate matter sampling and analysis calibrations. Include copies of the relevant portions of the calibration and field logs in the final test report.

10.1 Gas Flow Velocities.

You must use an S-type Pitot tube that meets the required EPA specifications (EPA Publication 600/4-77-0217b) during these velocity measurements. You must also complete the following:

(a) Visually inspect the S-type Pitot tube before sampling.
(b) Leak check both legs of the Pitot tube before and after sampling
(c) Maintain proper orientation of the S-type Pitot tube while making measurements.

10.1.1 S-type Pitot Tube Orientation.
The S-type Pitot tube is properly oriented when the yaw and the pitch axis are 90 degrees to the air flow.

10.1.2 Average Velocity Pressure Record.
Instead of recording either high or low values, record the average velocity pressure at each point during flow measurements.

10.1.3 Pitot Tube Coefficient.
Determine the Pitot tube coefficient based on techniques described in Section 10 of Method 2 of Appendix A-1 to Part 60.

10.2 Thermocouple Calibration.

You must calibrate the thermocouples using the procedures described in Section 10.3.1 of Method 2 of Appendix A-1 to Part 60 or Alternative Method 2 Thermocouple Calibration (ALT-011). Calibrate each temperature sensor at a minimum of three points over the anticipated range of use against a NIST traceable thermometer. Alternatively, a reference thermocouple and potentiometer calibrated against NIST standards can be used.

10.3 Precutter and Nozzles.

You may use glass, quartz, stainless steel (316 or equivalent), high-temperature steel alloy, or fluoropolymer-coated nozzles for isokinetic sampling. Make sure that all nozzles are thoroughly cleaned, visually inspected, and calibrated according to the procedure outlined in Section 10.1 of Method 5 of Appendix A-3 to Part 60. The precutter is designed to remove droplets and particles with a 50% cut size equal to 12 micrometers.

10.4 Dry Gas Meter Calibration.

Calibrate your dry gas meter following the calibration procedures in Section 16.1 of Method 5 of Appendix A-3 to Part 60. Also, make sure you fully calibrate the dry gas meter to determine the volume correction factor prior to field use. Post-test calibration checks must be performed as soon as possible after the equipment has been returned to the shop. Your pre-test and post-test calibrations must agree within ± 5 percent.

10.5 Glassware.

Use analytical glassware as specified in Method 202.

11.0 Analytical Procedures

11.1 Analytical Data Sheet.

Record and report all data on the analytical data sheet using the data sheet shown in Figure 9 or a data sheet having similar data entries. Alternatively, data may be recorded and reported electronically using software applications such as the Electronic Reporting Tool located at http://www.epa.gov/ttn/chief/ert/ert_tool.html.

11.2 Dry Weight of PM.

Determine the dry weight of particulate following procedures outlined in this section.

11.2.1 Container #1, Filter, Filterable Particulate Matter Less than or Equal to 2.5 Micrometers. Particulate Matter Captured on Front-Half Filter.
Transfer the filter and any loose particulate matter from the sample container to a tared weighing dish or pan that is inert to solvent or mineral acids. Desiccate for 24 hours in a desiccator containing anhydrous calcium sulfate. Weigh to a constant weight and report the results to the nearest 0.1 mg (See Section 3.0 for a definition of Constant weight.) If constant weight requirements cannot be met, the filter must be treated as described in Section 11.2.1 of Method

202 of Appendix M to this part. Extracts resulting from the use of this procedure must be filtered to remove filter fragments before the filter is processed and weighed.

11.2.2 Container #2, Rinse, Filterable Particulate Matter Less Than or Equal to 2.5 Micrometers. Reagent Rinse of the Exit Tube of the $PM_{2.5}$ cyclone and Front Half of the Filter Holder.
Note the level of liquid in the container and confirm on the analysis sheet whether leakage occurred during transport. If a noticeable amount of leakage has occurred, either void the sample or use methods (subject to the approval of the Administrator) to correct the final results. Quantitatively transfer the contents to a tared, non-reactive container, and evaporate to dryness at room temperature and pressure in a laboratory hood. Desiccate for 24 hours and weigh to a constant weight. Report the results to the nearest 0.1 mg.

11.2.3 Container #3, Cyclone Rinse, Filterable Particulate Matter Greater Than 2.5 Micrometers. Reagent Rinse of the $PM_{2.5}$ Cyclone Cup and the Reagent (and brush cleaning) Rinses of the Interior Surface of the $PM_{2.5}$ Cyclone.
Note the level of liquid in the container and confirm on the analysis sheet whether leakage occurred during transport. If a noticeable amount of leakage has occurred, either void the sample or use methods (subject to the approval of the Administrator) to correct the final results. Quantitatively transfer the contents to a tared, non-reactive container, and evaporate to dryness at room temperature and pressure in a laboratory hood. Desiccate for 24 hours and weigh to a constant weight. Report the results to the nearest 0.1 mg.

11.2.4 Container #4, Probe Rinse, Filterable Particulate Matter Greater Than 2.5 Micrometers. Reagent Rinse of the Probe (and brush cleaning).
Note the level of liquid in the container and confirm on the analysis sheet whether leakage occurred during transport. If a noticeable amount of leakage has occurred, either void the sample or use methods (subject to the approval of the Administrator) to correct the final results. Quantitatively transfer the contents to a tared, non-reactive container, and evaporate to dryness at room temperature and pressure in a laboratory hood. Desiccate for 24 hours and weigh to a constant weight. Report the results to the nearest 0.1 mg.

11.2.5 Container #5, Precutter Nozzle Rinse, Filterable Particulate Matter Greater Than 2.5 Micrometers. Reagent Rinse of the Precutter and Brush Cleaning Rinses.
Note the level of liquid in the container and confirm on the analysis sheet whether leakage occurred during transport. If a noticeable amount of leakage has occurred, either void the sample or use methods (subject to the approval of the Administrator) to correct the final results. Quantitatively transfer the contents to a tared, non-reactive container, and evaporate to dryness at room temperature and pressure in a laboratory hood. Desiccate for 24 hours and weigh to a constant weight. Report the results to the nearest 0.1 mg.

11.2.6 Container #8, Acetone Field Reagent Blank.
Use 150 ml of acetone from the blank container used for this analysis. Transfer 350 ml of the acetone to a clean, non-reactive container. Evaporate the acetone to dryness at room temperature and pressure in a laboratory hood. Following evaporation, desiccate the residue for 24 hours in a desiccator containing anhydrous calcium sulfate. Weigh and report the results to the nearest 0.1 mg.

11.2.7 Notes on Gravimetric Analysis and Containers Used for Sample Analysis.

Accuracy of sample mass determinations is directly correlated to the gravimetric detection limit achievable. The lower the gravimetric detection limit the greater the accuracy of the sample mass determination. Gravimetric detection limits are affected by the environmental conditions in which the mass determinations are made (temperature, humidity, barometric pressure, air movement), static charge accumulation, buoyancy of the sample container and sample substrate, and mass of the container used to hold the sample. A light weight sample container will yield a lower gravimetric detection limit than a heavier sample container (i.e. a fluoropolymer beaker liner with a tare weight of a few grams will have a lower gravimetric detection limit than a 250 ml glass beaker with a tare weight of close to 160 grams). ASTM Standard D 6552 – 06 provides guidance in controlling errors for gravimetric analysis.

12.0 Calculations and Data Analysis

12.1 Nomenclature.

Report results in International System of Units (SI units) unless the regulatory authority that established the requirement to use this test method specifies reporting in English units. The following nomenclature is used.

A = Area of stack or duct at sampling location, square inches.
A_n = Area of nozzle, square feet.
B_{ws} = Moisture content of gas stream, fraction (e.g., 10 percent H_2O is $B_{ws} = 0.10$).
C = Cunningham correction factor for particle diameter, D_p and calculated using the cyclone temperature of 780°R.
$\%CO_2$ = Carbon dioxide content of gas stream, percent by volume.
Ca = Acetone blank concentration, mg/mg.
$C_{fPM_{2.5}}$ = Conc. of filterable $PM_{2.5}$, gr/DSCF.
C_p = Pitot coefficient for the Pitot, dimensionless
$C_{p'}$ = Coefficient for the Pitot used in the preliminary traverse, dimensionless.
C_r= Re-estimated Cunningham correction factor for particle diameter equivalent to the actual cut size diameter and calculated using the actual stack gas temperature, dimensionless.
C_{tf} = Conc. of total filterable PM, gr/DSCF.
$C_1 = -150.3162$ (micropoise)
$C_2 = 18.0614$ (micropoise/$K^{0.5}$) = 13.4622 (micropoise/$R^{0.5}$)
$C_3 = 1.19183 \times 10^6$ (micropoise/K^2) = 3.86153×10^6 (micropoise/R^2)
$C_4 = 0.591123$ (micropoise)
$C_5 = 91.9723$ (micropoise)
$C_6 = 4.91705 \times 10^{-5}$ (micropoise/K^2) = 1.51761×10^{-5} (micropoise/R^2)
D = Inner diameter of sampling nozzle, inches.
D_p = Physical particle size, micrometers.
D_{50} = Particle cut diameter, micrometers.
D_{50-1} = Re-calculated particle cut diameters based on re-estimated C_r, micrometers.
D_{50LL} = Cut diameter for cyclone I (not used for OTM-036) corresponding to the 2.25 micrometer cut diameter for $PM_{2.5}$ cyclone, micrometers.
D_{50N} = D_{50} value for $PM_{2.5}$ cyclone calculated during the Nth iterative step, micrometers.
$D_{50(N+1)}$ = D_{50} value for $PM_{2.5}$ cyclone calculated during the N+1 iterative step, micrometers.
D_{50T} = Cyclone I (not used for OTM-036) cut diameter corresponding to the middle of the overlap zone shown in Figure 7 of Section 17, micrometers.

I = Percent isokinetic sampling, dimensionless.

K_p = 85.49, ((ft/sec)/(pounds/mole -°R)).

M_a = Mass of residue of acetone after evaporation, mg.

M_d = Molecular weight of dry gas, pounds/pound Mole.

mg = Milligram.

mg/L = Milligram per liter.

M_w= Molecular weight of wet gas, pounds/pound mole.

M_1 = Milligrams of PM collected on the filter (Container 1), less than or equal to 2.5 micrometers

M_2= Milligrams of PM recovered from cyclone exit tubing and filter holder (Container 2), less or equal to 2.5 micrometers

M_3 = Milligrams of PM recovered from the cyclone rinse (Container 3), greater than 2.5 micrometers.

M_4= Milligrams of PM recovered from the probe rinse (Container 4), greater than 2.5 micrometers

M_5 = Milligrams of PM recovered from the precutter rinse (Container 5), greater than 2.5 micrometers.

N_{tp} = Number of iterative steps or total traverse points.

N_{re} = Reynolds number, dimensionless.

$\%O_{2,wet}$ = Oxygen content of gas stream, % by volume of wet gas.

> (Note: The oxygen percentage used in Equation 3 is on a wet gas basis. That means that since oxygen is typically measured on a dry gas basis, the measured percent O_2 must be multiplied by the quantity $(1 – B_{ws})$ to convert to the actual volume fraction. Therefore, $\%O_{2,wet} = (1 – B_{ws}) \times \%O_{2,dry}$)

P_{bar} = Barometric pressure, inches Hg.

P_s = Absolute stack gas pressure, inches Hg.

Q_s = Sampling rate for cyclone I to achieve specified D_{50}. (Not used in OTM-036)

Q_{sST} = Dry gas sampling rate through the sampling assembly, DSCFM.

Q_I = Sampling rate for cyclone I to achieve specified D_{50}. (Not used in OTM-036)

$Q_{2.5}$ = Sampling rate for $PM_{2.5}$ Cyclone to achieve specified D_{50}.

Q_{Nozzle} = Actual air flow rate through the nozzle.

R_{max} = Nozzle/stack velocity ratio parameter, dimensionless.

R_{min} = Nozzle/stack velocity ratio parameter, dimensionless.

T_m = Meter box and orifice gas temperature, °R.

t_n = Sampling time at point n, min.

t_r = Total projected run time, min.

T_s = Absolute stack gas temperature, °R.

T_c=Absolute cyclone gas temperature, °R.

t_1 = Sampling time at point 1, min.

v_{max} = Maximum gas velocity calculated from Equations 18 or 19, ft/sec.

v_{min} = Minimum gas velocity calculated from Equations 16 or 17, ft/sec.

v_n = Sample gas velocity in the nozzle, ft/sec.

v_s = Velocity of stack gas, ft/sec.

V_a = Volume of acetone blank, ml.

V_{aw} = Volume of acetone used in sample recovery wash, ml.

V_c = Quantity of water captured in impingers and silica gel, ml.

V_m = Dry gas meter volume sampled, ACF.
V_{ms} = Dry gas meter volume sampled, corrected to standard conditions, DSCF.
V_{ws} = Volume of water vapor, SCF.
V_b = Volume of aliquot taken for IC analysis, ml.
V_{ic} = Volume of impinger contents sample, ml.
W_a = Weight of blank residue in acetone used to recover samples, mg.
Z = Ratio between estimated $PM_{2.5}$ cyclone D_{50} values, dimensionless.
ΔH = Meter box orifice pressure drop, inches W.C.
$\Delta H_@$ = Pressure drop across orifice at flow rate of 0.75 SCFM at standard conditions, inches W.C. (Note: Specific to each orifice and meter box.)
$[(\Delta p)^{0.5}]_{avg}$ = Average of square roots of the velocity pressures measured during the preliminary traverse, inches W.C.
Δp_m = Observed velocity pressure using S-type Pitot tube in preliminary traverse, inches W.C.
Δp_{avg} = Average velocity pressure, inches W.C.
Δp_{max} = Maximum velocity pressure, inches W.C.
Δp_{min} = Minimum velocity pressure, inches W.C.
Δp_n = Velocity pressure measured at point n during the test run, inches W.C.
Δp_1 = Velocity pressure measured at point 1, inches W.C.
γ = Dry gas meter gamma value, dimensionless.
μ_c = Gas viscosity of gas stream in the $PM_{2.5}$ cyclone, micropoise.
μ_s = Gas viscosity of stack gas, micropoise.
θ = Total run time, min.
ρ_a = Density of acetone, mg/ml (see label on bottle).

12.2 Calculations.

Perform all of the calculations found in Table 6 of Section 17. Table 6 of Section 17 also provides instructions and references for the calculations.

12.3 Analyses.

Analyze D_{50} of $PM_{2.5}$ cyclone and the concentrations of the PM in the various size ranges.

12.3.1 D_{50} of $PM_{2.5}$ cyclone.
To determine the actual D_{50} for $PM_{2.5}$ cyclone, recalculate the Cunningham correction factor and the Reynolds number for the best estimate of $PM_{2.5}$ cyclone D_{50}. The following sections describe additional information on how to recalculate the Cunningham correction factor and determine which Reynolds number to use.

12.3.1.1 Cunningham correction factor. Recalculate the initial estimate of the Cunningham correction factor using the actual test data. Insert the actual test run data and D_{50} of 2.5 micrometers into Equation 4. This will give you a new Cunningham correction factor based on actual data.

12.3.1.2 Initial D_{50} for the $PM_{2.5}$ cyclone. Determine the initial estimate for the $PM_{2.5}$ cyclone D_{50} using the test condition Reynolds number calculated with Equation 10 as indicated in Table 3 of Section 17. Refer to the following instructions.

(a) If the Reynolds number is less than 3,162, calculate the D_{50} for the $PM_{2.5}$ cyclone with Equation 34, using actual test data.

(b) If the Reynolds number is greater than or equal to 3,162, calculate the D_{50} for the $PM_{2.5}$ cyclone with Equation 35 using actual test data.

(c) Insert the “new” D_{50} value calculated by either Equation 34 or 35 into Equation 36 to re-establish the Cunningham Correction Factor (C_r). Use the test condition calculated Reynolds number to determine the most appropriate equation (Equation 34 or 35).

12.3.1.3 Re-establish the $PM_{2.5}$ cyclone D_{50}. Use the reestablished Cunningham correction factor (calculated in the previous step) and the calculated Reynolds number to determine D_{50-1}.

(a) Use Equation 37 to calculate the re-established the $PM_{2.5}$ cyclone D_{50-1} if the Reynolds number is less than 3,162.

(b) Use Equation 38 to calculate the re-established the $PM_{2.5}$ cyclone D_{50-1} if the Reynolds number is greater than or equal to 3,162.

12.3.1.4 Establish “Z” values. The “Z” value is the result of an analysis that you must perform to determine if the C_r is acceptable. Compare the calculated $PM_{2.5}$ cyclone D_{50} (either Equation 34 or 35) to the re-established $PM_{2.5}$ cyclone D_{50-1} (either Equation 37 or 38) values based upon the test condition calculated Reynolds number (Equation 10). Follow these procedures.

(a) Use Equation 39 to calculate the “Z” values. If the “Z” value is between 0.99 and 1.01, the D_{50-1} value is the best estimate of the $PM_{2.5}$ cyclone D_{50} cut diameter for your test run.

(b) If the “Z” value is greater than 1.01 or less than 0.99, re-establish a C_r based on the D_{50-1} value determined in either Equations 37 or 38, depending upon the test condition Reynolds number.

(c) Use the second revised C_r to re-calculate the $PM_{2.5}$ cyclone D_{50}.

(d) Repeat this iterative process as many times as necessary using the prescribed equations until you achieve the criteria documented in Equation 40.

12.3.2 Particulate Matter Concentration.
Use the particulate matter catch weights in the cyclone sampling train to calculate the concentration of PM in the various size ranges.

12.4 Reporting.
You must prepare a test report following the guidance in EPA Guidance Document 043, Preparation and Review of Test Reports (December 1998).

12.5 Equations.

Use the following equations to complete the calculations required in this test method.

Molecular Weight of Dry Gas. Calculate the molecular weight of the dry gas using Equation 1.

M_d = 0.44 (%CO_2) + 0.32 (%O_2) + 0.28 (100 - %O_2)- % CO_2) (Eq. 1)

Molecular Weight of Wet Gas. Calculate the molecular weight of the stack gas on a wet basis using Equation 2.

–M_w = M_d (1 – B_{ws}) + 18 (B_{ws}) (Eq. 2)

Stack Gas Stream and $PM_{2.5}$ Cyclone Gas Stream Viscosities. Calculate the stack gas stream viscosity using Equation 3a. This equation uses constants for gas temperatures (T_s) in °R. Calculated the $PM_{2.5}$ cyclone gas stream viscosity using Equation 3b. T_c is the temperature of the $PM_{2.5}$ cyclone (780°R).

$$\mu_s = C_1 + C_2\sqrt{T_s} + C_3 T_s^{-2} + C_4(\%O_{2,wet}) - C_5 B_{ws} + C_6 B_{ws} T_s^2 \quad \text{(Eq. 3a)}$$

$$\mu_c = C_1 + C_2\sqrt{T_c} + C_3 T_s^{-2} + C_4(\%O_{2,wet}) - C_5 B_{ws} + C_6 B_{ws} T_c^2 \quad \text{(Eq. 3b)}$$

Cunningham Correction Factor. The Cunningham correction factor is calculated for a 2.25 micrometer diameter particle. Use the cyclone gas stream viscosity from Equation 3b in this calculation.

$$C = 1 + 0.0057193\left[\frac{\mu_c}{P_s D_{50}}\right]\left[\frac{T_c}{M_w}\right]^{0.5} \quad \text{(Eq. 4)}$$

Equation 5 not used.

Equation 6 not used.

Equation 7 not used.

Sampling Rate Using $PM_{2.5}$ Cyclone. Use the cyclone gas stream viscosity from Equation 3b in this calculation.

For N_{re} Less than 3,162:

$$Q_{2.5} = 0.0060639\left[\frac{\mu_c}{C^{0.4242}}\right]\left[\frac{P_s M_w}{T_c}\right]^{-0.5759}\left[\frac{1}{2.5}\right]^{0.8481} \quad \text{(Eq. 8)}$$

$$Q_{Nozzle} = Q_{2.5}\left[\frac{460+T_s}{460+T_c}\right] \quad \text{(Eq. 8a)}$$

For Nre greater than or equal to 3,162. Use the cyclone gas stream viscosity from Equation 3b in this calculation.

$$Q_{2.5} = 0.007657 \left[\frac{\mu_c}{C^{0.6205}}\right]\left[\frac{P_s M_w}{T_c}\right]^{-0.3795}\left[\frac{1}{2.5}\right]^{1.241} \quad \text{(Eq. 9)}$$

$$Q_{Nozzle} = Q_{2.5}\left[\frac{460+T_s}{460+T_c}\right] \quad \text{(Eq. 9a)}$$

Reynolds Number. Use the cyclone gas stream viscosity from Equation 3b in this calculation.

$$N_{re} = 8.64 \times 10^5 \left[\frac{P_s M_w}{T_s}\right]\left[\frac{Q_{2.5}}{\mu_c}\right] \quad \text{(Eq. 10)}$$

Meter Box Orifice Pressure Drop.

$$\Delta H = \left[\frac{Q_{2.5}(1-B_{ws})P_s}{T_s}\right]^2 \left[\frac{1.083 T_m M_d \Delta H_@}{P_{bar}}\right] \quad \text{(Eq. 11)}$$

Equation 12 not used.

Velocity of Stack Gas.

$$v_s = K_p C_p \left(\sqrt{(\Delta p)}\right)_{avg}\left[\sqrt{\frac{T_s}{P_s M_s}}\right] \quad \text{(Eq. 13)}$$

Calculated Nozzle Diameter for Acceptable Sampling Rate.

$$D = \left[\frac{3.056\, Q_{Nozzle}}{v_s}\right]^{0.5} \quad \text{(Eq. 14)}$$

Velocity of Gas in Nozzle.

$$V_n = \frac{\left(\frac{Q_{Nozzle}}{60\, min/sec}\right)}{A_n} \quad \text{(Eq. 15)}$$

Minimum Nozzle/Stack Velocity Ratio Parameter. Use the stack gas viscosity from Equation 3a for this calculation.

$$R_{min} = \left[0.2457 + \left(0.3072 - \frac{0.2603\mu_s (Q_{Nozzle})^{0.5}}{V_n^{1.5}}\right)^{0.5}\right] \quad \text{(Eq. 16)}$$

Maximum Nozzle/Stack Velocity Ratio Parameter. Use the stack gas viscosity from Equation 3a for this calculation.

$$R_{max} = \left[0.4457 + \left(0.5690 + \frac{0.2603\mu_s(Q_{Nozzle})^{0.5}}{V_n^{1.5}}\right)^{0.5}\right] \qquad \text{(Eq. 17)}$$

Minimum Gas Velocity for R_{min} < 0.5, or an imaginary number (negative value under the square root function).

$$v_{min} = v_n\,(0.5) \qquad \text{(Eq. 18)}$$

Minimum Gas Velocity for $R_{min} \geq 0.5$.

$$V_{min} = v_n\,R_{min} \qquad \text{(Eq. 19)}$$

Maximum Gas Velocity for $R_{max} < 1.5$.

$$V_{max} = v_n\,R_{max} \qquad \text{(Eq. 20)}$$

Maximum Gas Velocity for $R_{max} \geq 1.5$.

$$V_{max} = v_n(1.5) \qquad \text{(Eq. 21)}$$

Minimum Velocity Pressure.

$$\Delta p_{min} = 1.3686x10^{-4}\left[\frac{P_s M_w}{T_s}\right]\left[\frac{v_{min}}{C_p}\right]^2 \qquad \text{(Eq. 22)}$$

Maximum Velocity Pressure.

$$\Delta p_{max} = 1.3686x10^{-4}\left[\frac{P_s M_w}{T_s}\right]\left[\frac{v_{max}}{C_p}\right]^2 \qquad \text{(Eq. 23)}$$

Sampling Dwell Time at Each Point. N_{tp} is the total number of traverse points. You must use the preliminary velocity traverse data.

$$t_n = \left[\frac{C_p\sqrt{\Delta p_n}}{C_p^1\left(\sqrt{\Delta p}\right)_{avg}}\right]\left[\frac{t_r}{N_{tp}}\right] \qquad \text{(Eq. 24)}$$

Equations 25, 26, and 27 not used.

Dry Gas Volume Sampled at Standard Conditions.

$$V_{ms} = \left[\frac{528}{29.92}\right]\left[(\gamma)(V_m)\right]\left[\frac{P_{bar}+\frac{\Delta H}{13.6}}{T_m}\right] \qquad \text{(Eq. 28)}$$

Sample Flow Rate at Standard Conditions.

$$Q_{sST} = \frac{V_{ms}}{\theta} \qquad \text{(Eq. 29)}$$

Volume of Water Vapor.

$$V_{ws} = 0.04707\ V_c \qquad \text{(Eq. 30)}$$

Moisture Content of Gas Stream.

$$B_{ws} = \left[\frac{V_{ws}}{V_{ms}+V_{ws}}\right] \qquad \text{(Eq. 31)}$$

Sampling Rate.

$$Q_{2.5} = \frac{29.92}{528} Q_{sST} \left[\frac{1}{1-B_{ws}}\right]\left[\frac{T_c}{P_s}\right] \qquad \text{(Eq. 32)}$$

(Note: The viscosity and Reynolds Number must be recalculated using the actual cyclone temperature, moisture, and oxygen content.)

Equation 33 not used.

Particle Cut Diameter for $N_{re} < 3{,}162$ for $PM_{2.5}$ Cyclone. C must be recalculated using the actual test run data and a D_{50} for 2.5 micrometer diameter particle size. Use the cyclone gas stream viscosity from Equation 3b in this calculation.

$$D_{50} = 0.0024302 \left[\frac{\mu_c}{Q_{2.5}}\right]^{1.1791} \left[\frac{1}{C}\right]^{0.5} \left[\frac{T_c}{P_s M_w}\right]^{0.6790} \qquad \text{(Eq. 34)}$$

Particle Cut Diameter for $N_{re} \geq 3{,}162$ for $PM_{2.5}$ Cyclone must be recalculated using the actual test run data and a D_{50} for 2.5 micrometer diameter particle size. Use the cyclone gas stream viscosity from Equation 3b in this calculation.

$$D_{50} = 0.019723 \left[\frac{\mu_c}{Q_{2.5}}\right]^{0.8058} \left[\frac{1}{C}\right]^{0.5} \left[\frac{T_c}{P_s M_w}\right]^{0.3058} \qquad \text{(Eq. 35)}$$

PM2.5 cyclone
Re-estimated Cunningham Correction Factor. You must use the actual test run Reynolds Number (N_{re}) value and select the appropriate D_{50} from Equation 33 or 34 (or Equation 37 or 38 if reiterating). Use the cyclone gas stream viscosity from Equation 3b in this calculation.

$$C_r = 1 + 0.0057193 \left[\frac{\mu_c}{P_s D_{50}}\right]\left[\frac{T_c}{M_w}\right]^{0.5} \qquad \text{(Eq. 36)}$$

Re-calculated Particle Cut Diameter for $N_{re} < 3{,}162$.

$$D_{50-1} = 0.0024302 \left[\frac{\mu_c}{Q_{2.5}}\right]^{1.1791} \left[\frac{1}{C_r}\right]^{0.5} \left[\frac{T_c}{P_s M_w}\right]^{0.6790} \qquad \text{(Eq. 37)}$$

Re-calculated Particle Cut Diameter for N_{re} Greater than or Equal to 3,162. Use the cyclone gas stream viscosity from Equation 3b in this calculation.

$$D_{50-1} = 0.019723 \left[\frac{\mu_c}{Q_{2.5}}\right]^{0.8058} \left[\frac{1}{C_r}\right]^{0.5} \left[\frac{T_c}{P_s M_w}\right]^{0.3058} \qquad \text{(Eq. 38)}$$

Ratio (Z) Between D_{50} and D_{50-1} Values.

$$Z = \frac{D_{50-1}}{D_{50}} \qquad \text{(Eq. 39)}$$

Acceptance Criteria for Z Values. The number of iterative steps is represented by N.

$$0.99 \leq \left[Z = \left(\frac{D_{50N}}{D_{50N-1}}\right)\right] \leq 1.01 \qquad \text{(Eq. 40)}$$

Percent Isokinetic Sampling.

$$I = \left[\frac{100(T_s)(V_{ms})(29.92)}{60(v_s)(\theta)(A_n)(P_s)(1-B_{ws})(528)}\right] \qquad \text{(Eq. 41)}$$

Equation 42 not used.
Equation 43 not used.
Equation 44 not used.
Concentration of Total Filterable PM.

$$C_{tf} = \left[\frac{7000}{453{,}592}\right]\left[\frac{M_1+M_2+M_3+M_4+M_5}{V_{ms}}\right] \qquad \text{(Eq. 45)}$$

Equation 46 not used.

Concentration of Filterable $PM_{2.5}$.

$$C_{fPM2.5} = \left[\frac{7000}{453{,}592}\right]\left[\frac{M_1+M_2}{V_{ms}}\right] \qquad \text{(Eq. 47)}$$

This method is designed to determine filterable $PM_{2.5}$ based on the total catch weights in Containers #1 and #2 using Equation 47.

Alternatively, if stack temperature meets filtration temperature as required by the applicable subpart of the standard or method and other requirement as described Section 1.5, sources can measure the total filterable PM by combining the total catch weights in Containers #1, #2, #3, #4, #5 using Equation 45.

13.0 Method Performance

13.1 Reserved

13.2 Not Applicable.

13.3 Field Evaluation

A field evaluation of the revised Method 201A by EPA showed that the detection limit was 2.54 mg for total filterable PM, and 1.35 mg for $PM_{2.5}$. The precision resulting from 10 quadruplicate tests (40 test runs) conducted for the field evaluation was 6.7 percent relative standard deviation. The field evaluation also showed that the blank expected from Method 201A was less than 0.9 mg (EPA, 2010). Similar values are anticipated for this OTM.

14.0 Alternative Procedures

[Reserved]

15.0 Waste Management

[Reserved]

16.0 References

(1) Dawes, S.S., and W.E. Farthing. 1990. "Application Guide for Measurement of $PM_{2.5}$ at Stationary Sources," U.S. Environmental Protection Agency, Atmospheric Research and Exposure Assessment Laboratory, Research Triangle Park, NC, 27511, EPA-600/3-90/057 (NTIS No.: PB 90-247198).

(2) Farthing, et al. 1988a. “PM_{10} Source Measurement Methodology: Field Studies,” EPA 600/3-88/055, NTIS PB89-194278/AS, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711.

(3) Farthing, W.E., and S.S. Dawes. 1988b. “Application Guide for Source PM_{10} Measurement with Constant Sampling Rate,” EPA/600/3-88-057, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711.

(4) Richards, J.R. 1996. "Test protocol: PCA PM_{10}/$PM_{2.5}$ Emission Factor Chemical Characterization Testing," PCA R&D Serial No. 2081, Portland Cement Association.

(5) U.S. Environmental Protection Agency, Federal Reference Methods 1 through 5 and Method 17, 40 CFR Part 60, Appendix A-1 through A-3 and A-6. (6) U.S. Environmental Protection Agency. 2010. “Field Evaluation of an Improved Method for Sampling and Analysis of Filterable and Condensable Particulate Matter.” Office of Air Quality Planning and Standards, Sector Policy and Program Division Monitoring Policy Group. Research Triangle Park, NC 27711.

(6) Air Control Techniques, P.C. “Wet Stack Filterable $PM_{2.5}$ Sampling System Development Report.” Report to the American Petroleum Institute. September 16, 2013.

(7) Air Control Techniques, P.C. “Wet Stack Filterable $PM_{2.5}$ Sampling System, Method 301 Validation Test Report.” Report to the American Petroleum Institute. September 16, 2013.

(8) Air Control Techniques, P.C. “1951 Precutter 50% Cut Size Test Report.” Report to the National Council of Air & Stream Improvement and the American Petroleum Institute. April 9, 2015.

17.0 Tables, Diagrams, Flowcharts, and Validation Data

You must use the following tables, diagrams, flowcharts, and data to complete this test method successfully.

Table 1. Typical PM Concentrations

Particle Size Range	Concentration and% by Weight
Total collectable PM	0.015 grains per Dry Standard Cubic Foot, gr/DSCF
≤ 10 and > that 2.5 micrometers	40% of total collectable PM
≤ 2.5 micrometers	20% of total collectable PM

Table 2. Required Cyclone Cut Diameters (D_{50})

Cyclone	Minimum cut diameter	Maximum cut diameter
$PM_{2.5}$ Cyclone Also termed Cyclone IV	2.25 micrometers	2.75 micrometers

Table 3. Test Calculations

If you are using…	To calculate..	Then use…
Preliminary Data	Dry gas molecular weight, M_d	Equation 1
Dry gas molecular weight (M_d) and preliminary moisture content of the gas stream	Wet gas molecular weight, M_w	Equation 2[a]
Stack gas temperature, oxygen and moisture content of the gas stream	Stack gas viscosity, μ_s	Equation 3a
Cyclone gas temperature	$PM_{2.5}$ Cyclone viscosity μ_c	Equation 3b
Gas viscosity, μ_c	Cunningham correction factor[b], C	Equation 4
D_{50} for $PM_{2.5}$ cyclone and N_{re} < 3,162	Final sampling rate for the $PM_{2.5}$ cyclone, $Q_{2.5}$	Equation 8

D_{50} for $PM_{2.5}$ cyclone and $N_{re} \geq$ 3,162	Final sampling rate for the $PM_{2.5}$ cyclone, $Q_{2.5}$	Equation 9
$Q_{2.5}$ from Equation 29	Verify the assumed Reynolds number, N_{re}	Equation 10

[a] Use Method 4 to determine the moisture content of the stack gas. Use a wet bulb-dry bulb measurement device or hand-held hygrometer to estimate moisture content of sources with gas temperature less than 160°F.

[b] For the lower cut diameter of $PM_{2.5}$ cyclone, 2.25 micrometers

[c] Verify the assumed Reynolds number using the procedure in Section 8.5.1 before proceeding to Equation 11

Table 4. ΔH Values Based on Preliminary Traverse Data

Stack Temperature (°R)	**T_s - 5°**	**T_s**	**T_s + 5°**
ΔH, (inches W.C.)	a	a	a

[a] These values are to be filled in by the stack tester

Table 5 is not used.

Table 6. Calculations for Recovery of $PM_{2.5}$

Calculations	Instructions and References
Average dry gas meter temperature	See field test data sheet
Average orifice pressure drop	See field test data sheet
Dry gas volume (V_{ms})	Use Equation 28 to correct sample volume to standard conditions (68°F, 29.92 inches Hg)
Dry gas sampling rate (Q_{sST})	Must be calculated using Equation 29
Volume of water condensed (V_{ws})	Use Equation 30 to determine the water condensed in the impingers and silica gel combination
Moisture content of stack gas (B_{ws})	Use Equation 31 to calculate
Sampling rate ($Q_{2.5}$)	Use Equation 32 to calculate
Test condition Reynolds Number[a]	Use Equation 10 to calculate the actual Reynolds number with test conditions
Stack gas velocity (V_s)	Use Equation 13 to calculate
Percent isokinetic rate (%I)	Use Equation 41 to calculate

[a] Calculate the Reynolds number at the $PM_{2.5}$ cyclone inlet during the test based on: (1) the sampling rate through the cyclone, (2) the actual gas viscosity for the test at the cyclone, and (3) the dry and wet gas stream molecular weights.

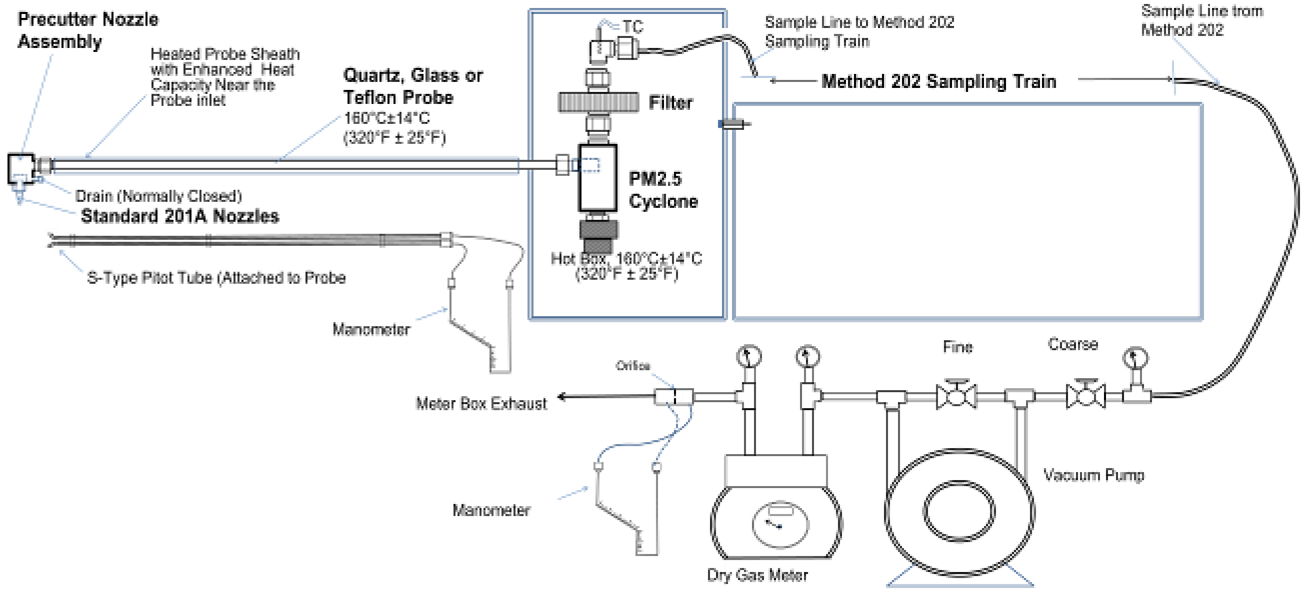


Figure 1. Schematic of the API/NCASI Wet Stack Filterable $PM_{2.5}$ Sampling Train

Figure 2. $PM_{2.5}$ Cyclone Sampling Head and
47 mm Filter Holder (Note: standard connection to $PM_{2.5}$ cyclone is a 5/8” O.D. glass probe liner)

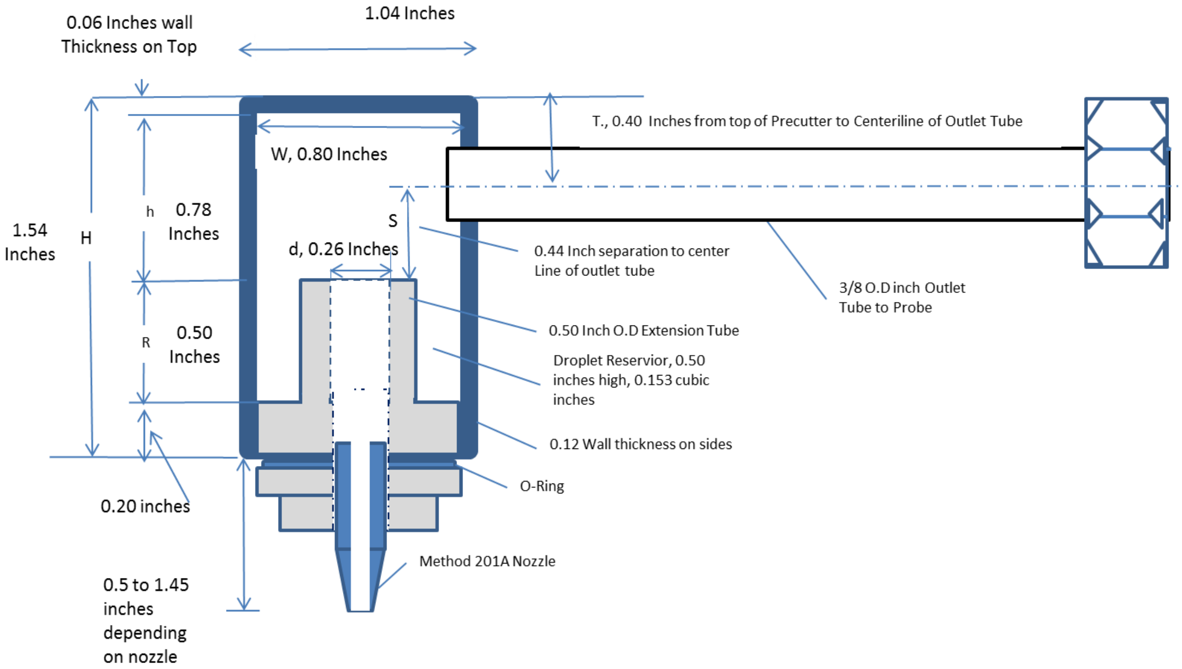


Figure 3. Precutter Nozzle Dimensions

Table 7. Precutter Dimensions, Inches		
Component	Designation	Precutter Nozzle
Precutter Barrel Diameter	W	0.80
Precutter Barrel External Height	H	1.54
Nozzle Support Extension to the Top of the Barrel	h	0.78
Nozzle Support Extension Height	a	0.500
Nozzle Support Extension Orifice Diameter	d	0.260

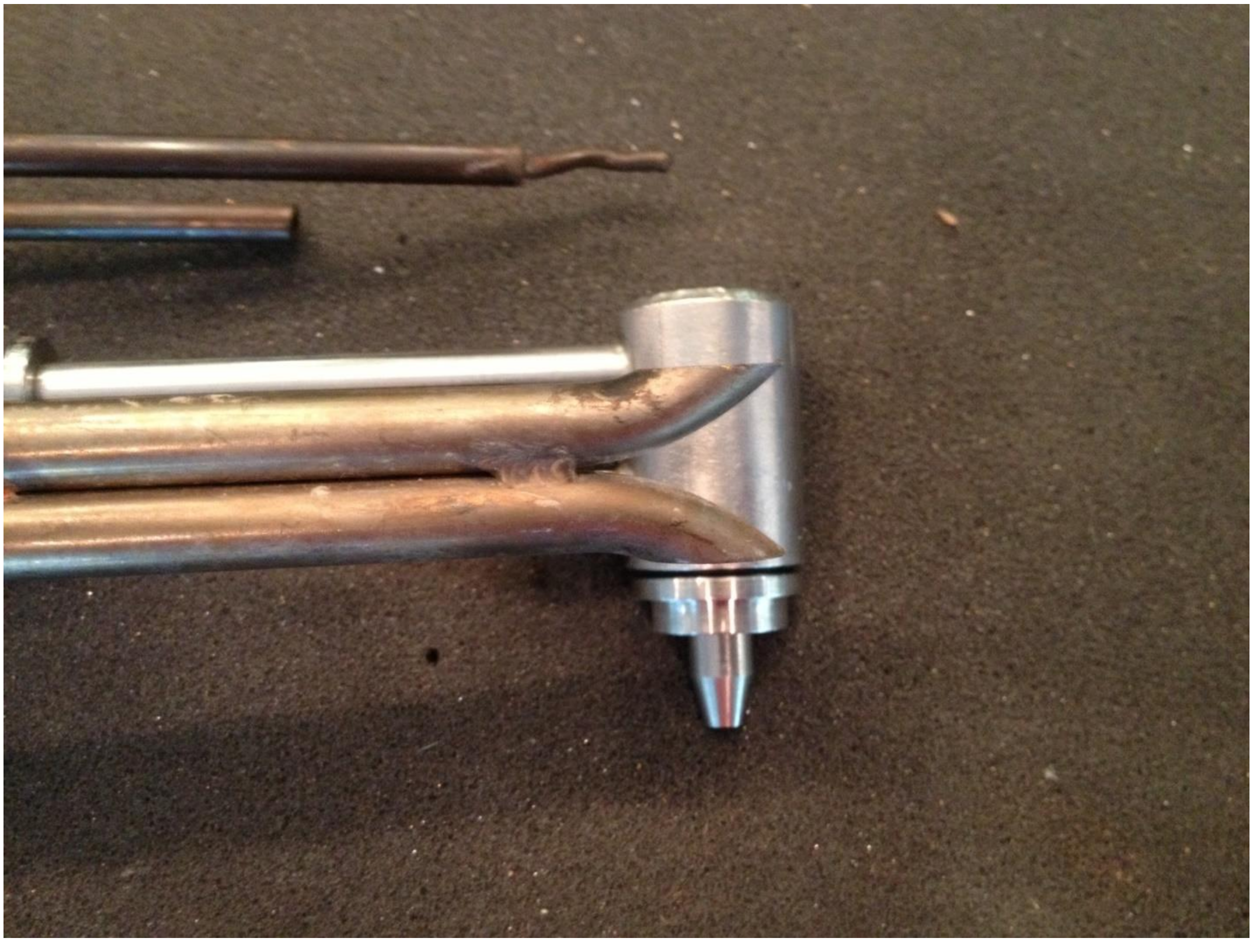


Figure 4. Precutter Nozzle Attached to Method 5 Sampling Probe

Figure 5. Precutter Nozzle with Various Nozzle Sizes

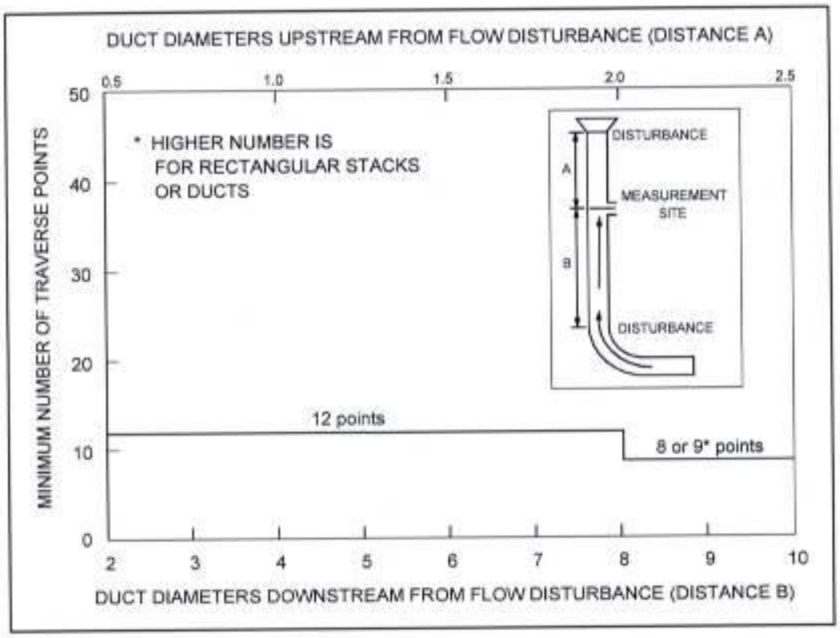
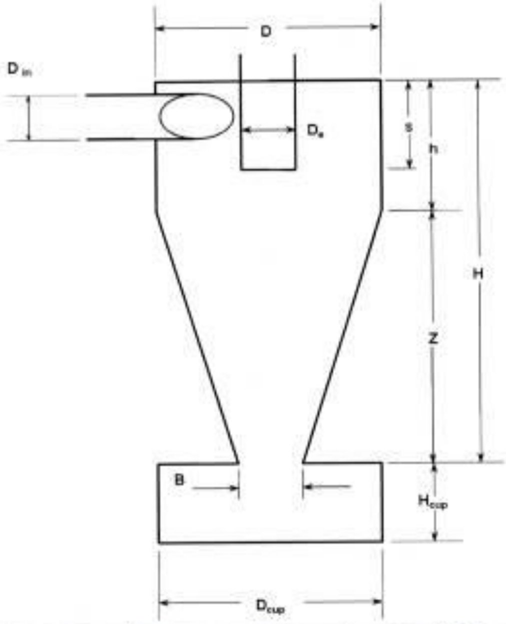
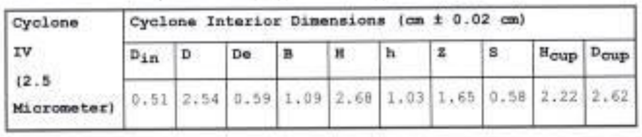


Figure 6. Traverse Points Required by Method 201A





Cyclone IV (2.5 Micrometer)	Cyclone Interior Dimensions (cm ± 0.02 cm)									
	D_{in}	D	De	B	H	h	Z	S	H_{cup}	D_{cup}
	0.51	2.54	0.59	1.09	2.68	1.03	1.65	0.58	2.22	2.62

Design Specifications for Cyclone IV (2.5 Micrometer) Sizing Device

Figure 7. $PM_{2.5}$ cyclone Dimensions

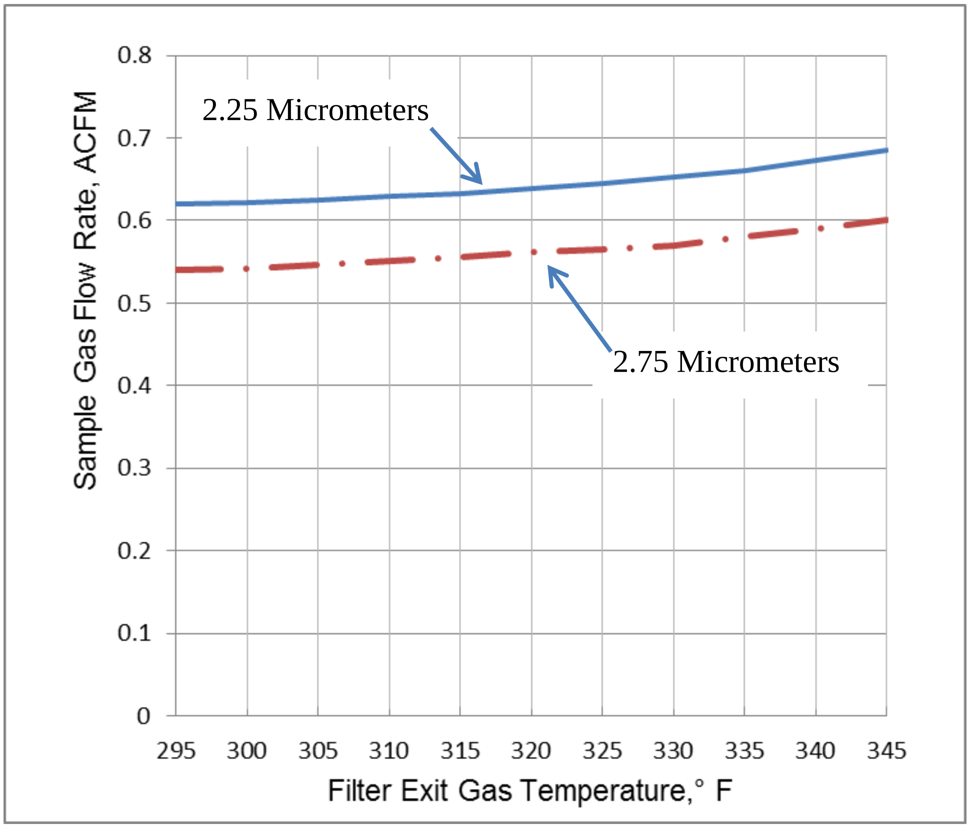
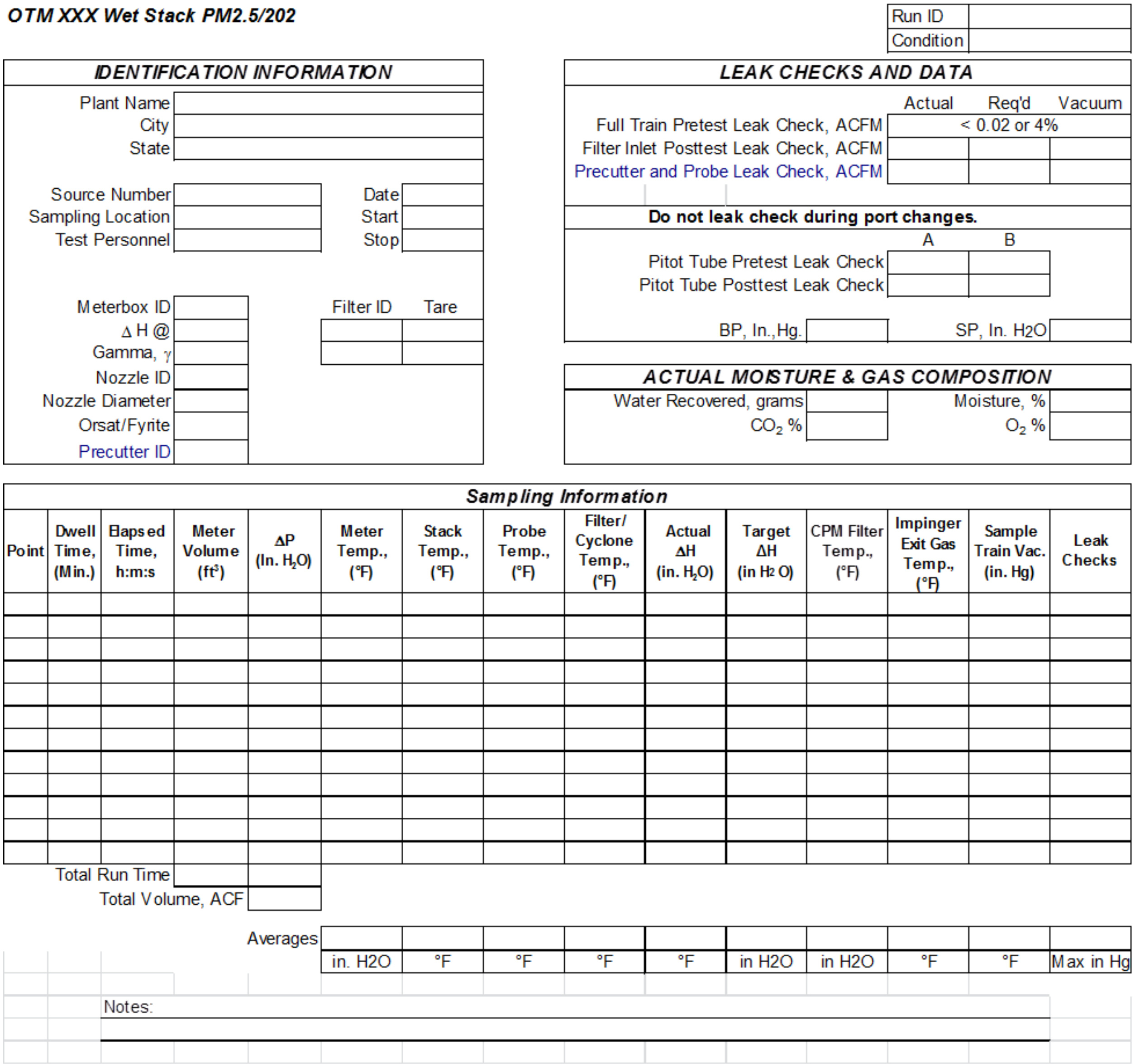


Figure 8. Acceptable Sampling Rate for the $PM_{2.5}$ Cyclone



OTM XXX Wet Stack PM2.5/202

Run ID	
Condition	

IDENTIFICATION INFORMATION

Plant Name			
City			
State			
Source Number		Date	
Sampling Location		Start	
Test Personnel		Stop	

		Filter ID	Tare
Meterbox ID			
ΔH@			
Gamma, γ			
Nozzle ID			
Nozzle Diameter			
Orsat/Fyrite			
Precutter ID			

LEAK CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM		< 0.02 or 4%	
Filter Inlet Posttest Leak Check, ACFM			
Precutter and Probe Leak Check, ACFM			

Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check		
Pitot Tube Posttest Leak Check		

BP, In.,Hg.		SP, In. H2O	

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams		Moisture, %	
CO_2 %		O_2 %	

Sampling Information

Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp., (°F)	Stack Temp., (°F)	Probe Temp., (°F)	Filter/ Cyclone Temp., (°F)	Actual ΔH (in. H_2O)	Target ΔH (in H_2O)	CPM Filter Temp., (°F)	Impinger Exit Gas Temp., (°F)	Sample Train Vac. (in. Hg)	Leak Checks
		Total Run Time												
			Total Volume, ACF											
				Averages										
					in. H2O	°F	°F	°F	°F	in H2O	in H2O	°F	°F	Max in Hg

Notes:

Figure 9. Example Data Sheet

Appendices

A. Letters from API/NCASI and Air Control Techniques

B. Wet Stack Sampling System Development Report

C. Method 301 Test Protocol

D. Method 301 Test Report

E. Precutter Nozzle Cut Size Test Protocol – May 12 2014

F. Precutter Nozzle Cut Size Test Protocol – Revised December 19, 2014

G. Precutter Nozzle Cut Size Test Report

H. Leith, D. and Boundy, M. 2008. "Development of Plans for Monitoring Emissions of PM_1, $PM_{2.5}$ and PM_{10} from Stationary Sources with Wet Stacks," U.S. Environmental Protection Agency, Research Triangle Park, NC 27709

Appendix A

Letters from API/NCASI and Air Control Techniques

energy API

1220 L Street NW
Washington, DC 20005

ncasi

402 SW 140 Terrace
Newberry, FL 32669

Via email: garnett.kim@epa.gov

April 30, 2015

Ms. Kim Garnett
U.S. Environmental Protection Agency
109 T.W. Alexander Drive
Mail Code: E143-02
Research Triangle Park, NC 27709

Re: $PM_{2.5}$ Filterable Test Method for Droplet-Laden and Saturated Stacks
Request for Status as an Other Test Method (OTM)

Dear Ms. Garnett:

Thank you and others in the EPA Measurement Technology Group for your time on April 15 to discuss our proposed $PM_{2.5}$ filterable wet test method and to provide feedback on the pre-cutter nozzle testing. Summarized below is supporting information for advancing the method to Other Test Method (OTM) status. We are also attaching a revised draft test method which incorporates the enhancements that we discussed.

Background

Although a National Ambient Air Quality Standard (NAAQS) for particulate matter 2.5 microns and smaller ($PM_{2.5}$) was promulgated in 1997, EPA has yet to promulgate a method for measuring filterable $PM_{2.5}$ emissions from sources with entrained droplets in their stack gas streams. In place of a promulgated method, EPA's guidance is to measure total filterable PM using Method 5 and report all filterable PM as $PM_{2.5}$. This creates a bias to higher-than-true $PM_{2.5}$ emissions. This is especially problematic because this bias can represent a major fraction of the emissions counted towards the $PM_{2.5}$ 10 tons per year PSD significance level. This bias also causes errors in dispersion modeling used to demonstrate compliance with the $PM_{2.5}$ NAAQS. The recent lowering of the ambient air quality standards for $PM_{2.5}$ has exacerbated the situation, making it extremely difficult for facilities with wet stacks to either stay under the 10 tons per year threshold and/or demonstrate compliance with the ambient $PM_{2.5}$ standards.

Many industrial sectors, including pulp and paper, petroleum, utility, and metallurgical have sources with entrained droplets and are encountering challenges with expansion projects and demonstrating compliance with the ambient $PM_{2.5}$ standards through modeling. Because pulp and papermaking is a water-based process, a significantly large fraction of emission sources at pulp and paper mills are saturated. There is an urgent need for a method which would allow facilities with wet sources to accurately measure their filterable $PM_{2.5}$ emissions.

Method Performance and Need for Field Assessment

Over the past five years, the American Petroleum Institute (API) has spent considerable resources in developing and evaluating a method for measuring wet source $PM_{2.5}$ emissions. The National Council for Air and Stream Improvement, Inc. (NCASI) has also contributed towards this project to enable further refinement and laboratory/field evaluation of this method. Throughout this process, we have had the benefit of feedback and input from EPA's staff with expertise in this area. We have conducted numerous laboratory and field studies.

While we understand that our studies may not have answered all the questions that could be asked, the data from the Method 301 validation tests demonstrate that the precutter nozzle does not stop $PM_{2.5}$ particulate matter. In the 22 test runs (two of the twenty-four were discarded), probe rinse solids accounted for an average of only 8% of the total sampling train particulate matter catch weight and 11.7% of the $PM_{2.5}$ material catch. These test results demonstrate that the trends observed in the December 2014 nozzle tests in the 6 to 10 micrometer size range were due to limitations in the ability to disperse the microspheres—not due to precutter nozzle capture of $PM_{2.5}$ particulate matter. These data are summarized in Table 1.

Table 1. Data from Method 301 Validation Report

Run ID	Total Nozzle (mg)	Cyclone Inlet and Probe (mg)	Cyclone Outlet (mg)	Total Filter (mg)	Total, $PM_{2.5}$ (mg)	Total Catch (mg)	**Nozzle Catch, % of Total**	**Nozzle Catch, % of PM2.5**
U1-1	5	23.7	2.3	31.8	34.1	62.8	**8.0**	**14.7**
U2-1	2	15	2.9	33.1	36	53	**3.8**	**5.6**
S1-1	8.4	17.5	1.3	73.9	75.2	101.1	**8.3**	**11.2**
S2-1	8.8	14.9	2.8	64.4	67.2	90.9	**9.7**	**13.1**
U1-2	6.1	11.2	2.4	16.4	18.8	36.1	**16.9**	**32.4**
U2-2	3.3	7.8	1.1	16.3	17.4	28.5	**11.6**	**19.0**
S1-2	6.7	11.5	2.1	47.6	49.7	67.9	**9.9**	**13.5**
S2-2	6.6	11.5	1.1	48	49.1	67.2	**9.8**	**13.4**
U1-3	3.1	9.9	1	20.9	21.9	34.9	**8.9**	**14.2**
U2-3	1.5	7.4	0.7	21.7	22.4	31.3	**4.8**	**6.7**
S1-3	4.4	9.6	0.9	37.1	38	52	**8.5**	**11.6**
S2-3	2.2	14.1	1.1	30.7	31.8	48.1	**4.6**	**6.9**
U1-4	2.3	7.6	0.7	22.3	23	32.9	**7.0**	**10.0**
U2-4	2.3	7.3	1	23.7	24.7	34.3	**6.7**	**9.3**
S1-4	0.6	7	0.6	26.9	27.5	35.1	**1.7**	**2.2**
S2-4	1.6	5.8	1.2	26.5	27.7	35.1	**4.6**	**5.8**
U1-5	2.9	9.6	0.7	14.7	15.4	27.9	**10.4**	**18.8**
U2-5	1.3	5.4	0.7	15.1	15.8	22.5	**5.8**	**8.2**
S1-5	8.9	10.8	0.9	55	55.9	75.6	**11.8**	**15.9**
S2-5	3.5	12	0.8	5.8	6.6	22.1	**Filter Tear**	
U1-6	2.7	7.3	1.5	29.5	31	41	**6.6**	**8.7**
U2-6	3.2	6.5	1.8	30.1	31.9	41.6	**7.7**	**10.0**
S1-6	2.1	6.7	1.2	37.4	38.6	47.4	**4.4**	**5.4**
S2-6	2.2	4.5	0.6	1.2	1.8	8.5	**Filter Tear**	
						Average	**7.8**	**11.7**

More significantly, it is also worthwhile to note that the Method 301 nozzle catch and efficiency matches the size efficiency curve indicated by the relatively few tests conducted on the EPA's IDS nozzle. The data presented in the February 3, 2015 and the April 9 update of the precutter nozzle report have been converted to penetration efficiency values and plotted along with the penetration efficiency data measured in the EPA-sponsored University of Minnesota tests of the IDS nozzle. As shown in Figure 1, the precutter nozzle penetration efficiencies (ACTPC data points) are very similar to those measured for the IDS nozzle.

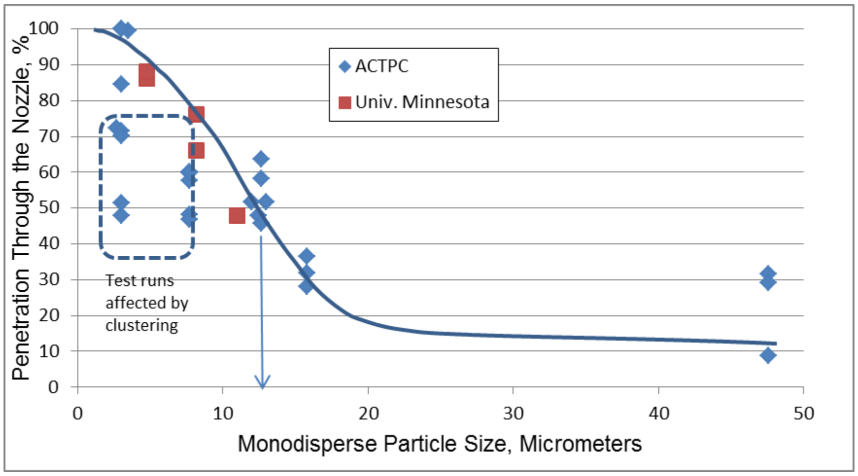


Figure 1. Comparison of Precutter Nozzle and IDS Nozzle Penetration Data

This is logical considering that (1) both the IDS nozzle and the precutter nozzle use basically the same droplet capture technique and (2) there are no aerosol physics mechanisms that are effective for removing droplets in the 1 to 8 micrometer size range under the relatively low velocity conditions existing in either nozzle. Inertial impaction, Brownian diffusion, and electrostatic attraction are all ineffective separation mechanisms in these nozzles.

The precutter nozzle used with the proposed test method is based on similarly designed precutter nozzles in use since the mid-1960's for removal of large particles prior to cascade impactors. For example, EPA document EPA-600/2-77-004 Appendix C published in 1977 shows a similar unit. Apex Instruments, Inc. in Holly Springs, North Carolina still sells a precutter nozzle that is very similar to the one used in the proposed method.

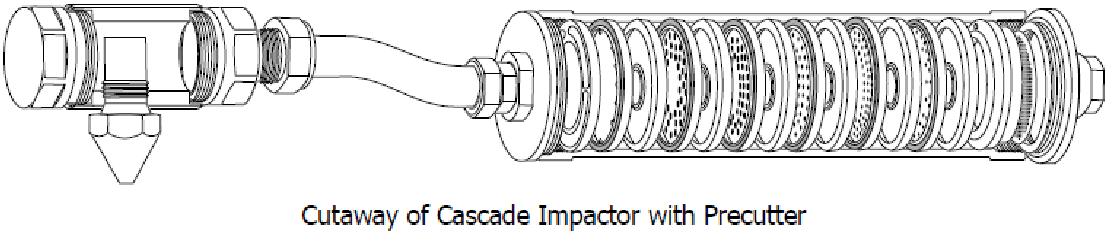


Figure 2. Apex Instruments Precutter Nozzle

The objective of using a cascade impactor is to measure the size distribution over a range of 10 to less than 0.3 micrometers. Obviously, if the precutter removed a significant fraction of the $PM_{2.5}$ particulate matter the results of the cascade impactor tests would be skewed. This has not been reported in over forty years of precutter use with cascade impactors. The precutter used in the proposed method also does not significantly remove $PM_{2.5}$ particles.

We believe that not much more would be gained by additional laboratory testing of the wet stack method. While continued laboratory testing may yield additional insights, it is not expected to answer all remaining questions about droplet behavior in this experimental setup. It is extremely difficult, if not impossible, to simulate droplet behavior in a laboratory environment. Droplet sizing remains a highly qualitative procedure subject to numerous uncertainties. Even computational fluid dynamic (CFD) modeling of droplet behavior can be subject to error due, in part, to (1) the difficulty of defining the initial droplet vectors, droplet velocity distributions, and droplet size distributions at the starting plane of the CFD model and (2) droplet impaction shattering, agglomeration, condensational growth, and re-entrainment within nozzles. Only testing in actual stacks fully takes into account the real-world, hard-to-simulate variables. Therefore, in our judgment, the most effective way to understand the performance of this method would be to publish it as an OTM and thereby encourage its use in the field, in real-world conditions.

Benefits of OTM Status

Making the test method an OTM would encourage the generation of more data, and identification of possible real-world method issues. Emissions data (nozzle rinse vs filter catch weight) from sources having emissions primarily in the <2.5 micrometer size range would help answer questions relative to the precutter nozzle performance. In the absence of an OTM designation, it is unlikely that states would permit facilities to use this method, thus closing the door for a very promising method for measuring $PM_{2.5}$ emissions from wet sources and leaving only EPA's high-biased Method 5 approach.

If sources utilized the OTM, the emissions calculated based strictly on the $PM_{2.5}$ filter, cyclone outlet rinse, and filter holder rinse could be used as the measure of filterable $PM_{2.5}$ particulate matter. Emissions calculated based on the nozzle, probe, and cyclone rinses could be added to the measured filterable $PM_{2.5}$ emissions as a measure of total filterable particulate matter emissions. Accordingly, a regulatory agency or source could still make the assumption that 100% of the filterable particulate matter is filterable $PM_{2.5}$. A wet stack filterable $PM_{2.5}$ test conducted using all of the rinses and the filter is essentially equivalent to a Method 5 test.

The attached draft method has been modified to allow it to also function as a Method 5 equivalent. However, once the wet stack method becomes fully accepted, the filterable $PM_{2.5}$ emissions could be accepted based on only the cyclone outlet rinse, $PM_{2.5}$ filter and the $PM_{2.5}$ filter holder rinse—as the new method is intended. Accordingly, there is no risk to the source or the agency in approving this method as an OTM. The test data can be interpreted in whatever way proves to be most appropriate and representative.

The proposed wet stack filterable $PM_{2.5}$ test method is a logical extension of Method 201A. It uses commercially available components that most testing companies already have available. The few components unique to this method can be obtained economically and quickly from established vendors. The sampling and analysis procedures parallel those of Method 201A. Accordingly, many testing companies could perform this method almost immediately after receiving the method in OTM form. Testing firms that can properly use Method 201A can properly use this proposed method for wet stacks. Real world test data can be compiled in a short period.

It is our intent to utilize this method on a variety of sources in the industry and document its performance so that EPA may promulgate it in the future as a reference method, thus fulfilling EPA's obligation to promulgate reference methods for all criteria pollutants.

API and NCASI appreciate the review, support and feedback provided by EPA thus far in the development of this method. If you have any questions or would like to discuss further, please let us know.

Regards,

Cathe Kalisz

AK Jain

Cathe Kalisz
API

Ashok Jain
NCASI

Attachment – Draft Test Method

Jason DeWees - USEPA
Barrett Parker - USEPA
Chet Wayland - USEPA
Vipin Varma - NCASI
Lee Carlson – NCASI
Gary Mueller - Shell
John Richards – Air Control Techniques, P.C.

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December 21, 2015

Ms. Cathe Kalisz, P.E.
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Re: PM2.5 Filterable Test Method for Droplet-Laden and Moisture Saturated Stacks
Response to EPA's Follow-Up Questions of November 20, 2015

Dear Ms. Kalisz and Mr. Jain:

I have prepared information to help the American Petroleum Institute (API) and the National Council for Air and Stream Improvement (NCASI) respond to questions included in the November 20, 2015 email from Ms. Kim Garnett of the U.S. Environmental Protection Agency (EPA). In her email, Mr. Garnett stated that

> "*The appropriateness of the following aspects of this method was not assessed during this development process. Additional data is needed in these areas before this method can be further evaluated.*"

This letter provides the additional information and data that EPA has requested. I have addressed each topic in the same order as in Ms. Garnett's email.

1. PROBE TRANSFER EFFICIENCY

EPA has asked if PM2.5 losses in the probe could result in a bias to lower-than-true PM2.5 emissions. The information provided below demonstrates that PM2.5 losses in the probe are negligible.

The particles of interest in the sample gas stream entering the probe include solid particles with aerodynamic diameters equal to or less than 2.5 micrometers and liquid droplets less than 20 micrometers that evaporate to leave solid particles with aerodynamic diameters equal to or less than 2.5 micrometers. Both solid PM2.5 particles and droplets up to a size of 20 micrometers are addressed in the following section, which starts with a discussion of physical capture mechanisms and then addresses data from three different sets of tests.

Particle Capture Mechanisms—There are four physical mechanisms that could potentially contribute to the capture of PM2.5 particles and droplets up to 20 micrometers in the probe. All four capture mechanisms are very weak under the conditions present in the probe. These include (1) gravitational settling, (2) inertial impaction, (3) Brownian diffusion, and (4) electrostatic attraction.

Gravitation settling is potentially important only for droplets in the 10 to 20 micrometer size range having terminal settling velocities in the range of 0.31 to 1.2 centimeters per second in still air. Considering that the evaporation time of a 20 micrometer droplet is less than 0.1 second in the probe operating temperature range , there will not be time for significant settling. Turbulent mixing of the sample gas stream passing through the probe will significantly reduce gravitational settling even during the short time period while the droplet evaporates. For small PM2.5 particles with a maximum terminal settling velocity of 0.02 centimeters per second in still air, gravitational settling is negligible in the probe.

Inertial impaction requires significant differences in the velocities of the particle and the impaction target. There are no gas stream turns in the probe; therefore, there are no stationary targets for impaction. At the probe velocities of only 5 to 10 feet per second, even the velocity difference between the particle in the gas stream and the probe surface is too low to cause significant impaction losses of particles and droplets penetrating the precutter.

Brownian diffusion is very limited due to the short residence time in the probe and would only affect the particles in the lower end of the PM2.5 size range. This would only result in mass transfer in the boundary layer in the sample gas stream next to the probe wall. Brownian diffusion related capture would be negligible for droplets up to 20 micrometers and would be low even for particles less than 0.5 micrometers.

Electrostatic attraction is limited due to the lack for forces available to create high static voltage differences between the probe surface and the particles and droplets in the sample gas stream.

Particle capture in the probe is not only limited by the weakness of the four physical capture mechanisms, but also by physical mechanisms that suppress and oppose capture. Capture of particles is suppressed by thermophoresis forces created by the hot walls of the probe. Thermophoresis would drive small particles, such as those with modest Brownian diffusion rates, away from the hot probe surfaces. Particle capture is countered by the reentrainment of particles weakly attached to smooth probe inner surfaces. The sample gas velocities in the probe are more than sufficient to cause reentrainment of particles that have become weakly attached to the probe inner surface.

It is reasonable to expect negligible bias to lower-than-true PM2.5 concentrations due to particle capture in the probe considering the weakness of the physical capture mechanisms available in the probe and the opposing effects of thermophoresis and particle reentrainment. These conclusions have been confirmed by the test data available concerning the wet stack filterable PM2.5 sampling method.

Method 301 Validation Test Program Data—The lack of capture of PM2.5 particles in the probes was clearly demonstrated during the Method 301 validation tests.

As part of these tests, two of the four sampling trains during each of the six test runs were spiked at the precutter inlet with salt-laden droplets passing through a PM2.5 cyclone separator to generate the droplet spike. The PM2.5 droplets had to pass through an 8-foot long probe to reach the PM2.5 cyclone and eventually the PM2.5 filter. The data compiled during these tests and summarized in Tables 1 and 2 indicated that the probe and cyclone inlet catch weights for the spiked sampling trains were similar to the catch weights for the two unspiked sampling trains. This indicates that the spiked PM2.5 droplets were not captured in the probe.

Table 1. Method 301 Validation Test Data[1]

Method 301 Validation Test Runs	Average Probe and Cyclone Inlet Catch Weights, mg	Total PM2.5 Catch Weights, mg
U1-1 and U2-1	19.4	34.1
Spiked, S1-1 and S1-2	16.2	96.0
U1-2 and U2-2	9.5	18.1
Spiked, S1-2 and S2-2	11.5	49.4
U1-3 and U2-3	8.7	22.2
Spiked, S1-3 and S2-3	11.9	34.9
U1-4 and U2-4	7.5	23.9
Spiked, S1-4 and S2-4	6.4	27.6
U1-5 and U2-5	7.5	15.6
Spiked, S1-5 and S2-5	11.4	55.9
U1-6 and U2-6	6.9	31.5
Spiked, S1-6 and S2-6	5.6	38.6

1. Note: These data are averages of data provided in Table 3.4 from the Method 301 Validation Test Program Report and reproduced in Table 2 of this letter report

As indicated in the Method 301 Validation Report previously submitted to EPA, the test method satisfied the bias and precision requirements of Method 301. This would not have been possible if there was significant PM2.5 capture in the probe.

Table 2. Data from Method 301 Validation Report, Table 3-4

Run ID	Total Nozzle (mg)	Cyclone Inlet and Probe (mg)	Cyclone Outlet (mg)	Total Filter (mg)	Total, PM$_{2.5}$ (mg)	Total Catch (mg)	**Nozzle Catch, % of Total**	**Nozzle Catch, % of PM2.5**
U1-1	5	23.7	2.3	31.8	34.1	62.8	**8.0**	**14.7**
U2-1	2	15.0	2.9	33.1	36,0	53	**3.8**	**5.6**
S1-1	8.4	17.5	1.3	73.9	75.2	101.1	**8.3**	**11.2**
S2-1	8.8	14.9	2.8	64.4	67.2	90.9	**9.7**	**13.1**
U1-2	6.1	11.2	2.4	16.4	18.8	36.1	**16.9**	**32.4**
U2-2	3.3	7.8	1.1	16.3	17.4	28.5	**11.6**	**19.0**
S1-2	6.7	11.5	2.1	47.6	49.7	67.9	**9.9**	**13.5**
S2-2	6.6	11.5	1.1	48.0	49.1	67.2	**9.8**	**13.4**
U1-3	3.1	9.9	1	20.9	21.9	34.9	**8.9**	**14.2**
U2-3	1.5	7.4	0.7	21.7	22.4	31.3	**4.8**	**6.7**
S1-3	4.4	9.6	0.9	37.1	38.0	52	**8.5**	**11.6**
S2-3	2.2	14.1	1.1	30.7	31.8	48.1	**4.6**	**6.9**
U1-4	2.3	7.6	0.7	22.3	23.0	32.9	**7.0**	**10.0**
U2-4	2.3	7.3	1.0	23.7	24.7	34.3	**6.7**	**9.3**
bS1-4	0.6	7.0	0.6	26.9	27.5	35.1	**1.7**	**2.2**
S2-4	1.6	5.8	1.2	26.5	27.7	35.1	**4.6**	**5.8**
U1-5	2.9	9.6	0.7	14.7	15.4	27.9	**10.4**	**18.8**
U2-5	1.3	5.4	0.7	15.1	15.8	22.5	**5.8**	**8.2**
S1-5	8.9	10.8	0.9	55	55.9	75.6	**11.8**	**15.9**
S2-5	3.5	12	0.8	5.8	6.6	22.1	**Filter Tear**	
U1-6	2.7	7.3	1.5	29.5	31	41	**6.6**	**8.7**
U2-6	3.2	6.5	1.8	30.1	31.9	41.6	**7.7**	**10.0**
S1-6	2.1	6.7	1.2	37.4	38.6	47.4	**4.4**	**5.4**
S2-6	2.2	4.5	0.6	1.2	1.8	8.5	**Filter Tear**	
						Average	**7.8**	**11.7**

December 2015 Tests Comparing Method 201A with the Proposed Wet Stack Method—During December 2015, Air Control Techniques, P.C. conducted a set of tests to further evaluate probe losses. Polydisperse flyash particles ranging in size from less than 1 micrometer to more than 40 micrometers were used as the challenge material.

The aerodynamic sizes of the dispersed polydisperse flyash particles were accurately determined using a Method 201A sampling train. This is an especially effective means to evaluate the probe losses considering that the Method 201A PM10 cyclone has a well-accepted 50% cut size of 10 micrometers—reasonably close to the 12 micrometer 50% cut size previously measured for the precutter. Accordingly, the size distribution exiting the precutter nozzle should be similar to or slightly more than the greater-than-10 micrometer size fraction recovered from the Method 201A PM10 cyclone.

During the December 2015 tests, both the wet stack filterable PM2.5 sampling train and the Method 201A sampling train operated at a delta H of 0.4 to 0.5 to achieve the 50% cut sizes summarized in Table 3.

Table 3. Sampling Train Operating Conditions

Wet Stack Filterable PM2.5 Sampling Train		Method 201A PM10 and PM2.5 Sampling Train		
Run	PM2.5 Cyclone 50% Cut Size (micrometers)	Run	PM10 Cyclone 50% Cut Size (micrometers)	PM2.5 Cyclone 50% Cut Size(micrometers)
1	2.35	2	10.73	2.26
3	2.96	4	10.80	2.29
5	2.70	6	10.84	2.30
7	2.72	8	10.82	2.29
9	2.67	10	10.92	2.36
11	2.72	12	10.87	2.31
Average	2.69	Average	10.83	2.30

Prior to the start of the test run, the precutter in the wet stack sampling train was thoroughly wetted with tap water to simulate operating conditions in a wet stack. Due to sampling runs of less than 2 minutes, the precutter interior surfaces remained wet during the sampling run.

The wet stack filterable PM2.5 sampling train consisted of the following.

(1) Precutter with an inlet nozzle,
(2) Four foot long probe operating at 67°F,
(3) PM2.5 cyclone and 47-mm filter mounted in a hot box operating at 67°F,
(4) Jumper line to a set of impingers, and
(5) Meter box.

The Method 201A sampling system consisted of the following.

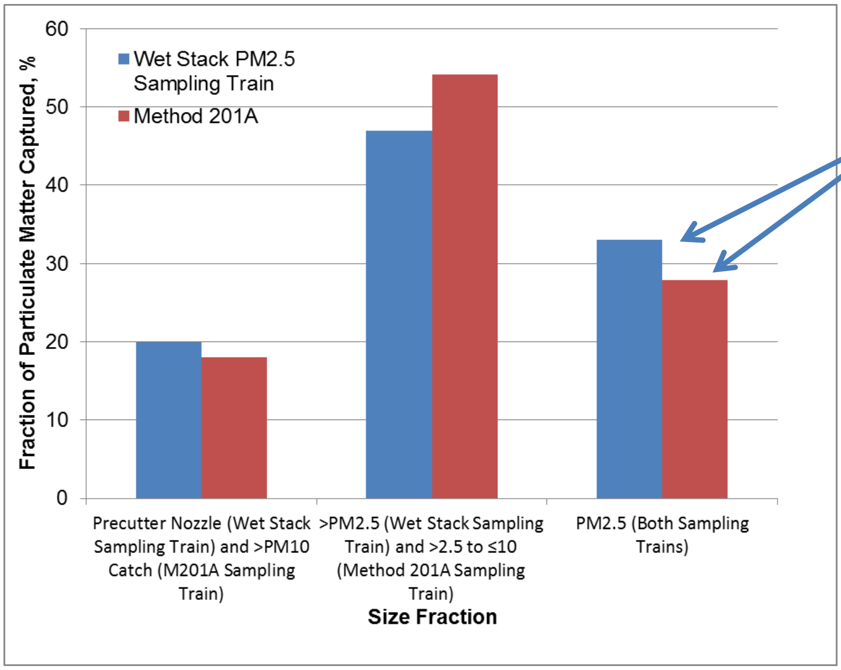
(1) PM10 cyclone with nozzle,
(2) PM2.5 cyclone,
(3) 47-mm filter,
(4) Four foot long sampling probe,
(5) Jumper to a set of impingers, and
(6) Meter box.

Flyash from a coal-fired boiler was aspirated through a set of two mini-impingers to maximize the dispersion of the particles. This is the same dispersion system used on the monodisperse microsphere tests summarized in the January 2015 report.

The adequacy of flyash dispersion was evaluated by light microscopy using a set of 47mm polycarbonate filters at the discharge side of the dispersion system.

The dispersed flyash particles were drawn directly into the nozzles for the wet stack filterable PM2.5 sampling train and the M201A sampling train. The runs alternated between the wet stack filterable PM2.5 sampling train and the Method 201A sampling train. The total sampling train particulate matter catch weights varied from approximately 10 to 100 milligrams per test run.

Following each test, the sampling train was recovered using procedures stated in the applicable method. The results of six tests conducted on each of the sampling trains are summarized in Figure 1 and Table 4. As indicated by the PM2.5 data in the set of columns on the right, there were no significant differences in fraction of particulate matter in the PM2.5 size range when the sample gas stream passed through the probe prior to the cyclone and PM2.5 filter.



No significant difference in the PM2.5 fractions measured with sampling trains with and without a probe prior to the cyclone and filter

Figure 1. Comparison of the Capture of Particulate Matter in the Wet Stack Filterable PM2.5 Sampling Train and in the Method 201A sampling train

Table 4. Comparison of Precutter Nozzle and Method 201A PM10 Cyclone Performance
December 2015 Test Program

Run	Wet Stack Sampling Train Conditions	Precutter Nozzle (mass %)	>PM2.5 Catch from Cyclone (mass %)	PM2.5 on Filter and in Rinses of the Cyclone Outlet Tube and Filter Holder Rinse (mass %)
1	Wet wall	20	41.8	38.2
3	Wet wall	7.4	58.5	34.0
5	Wet wall	20.8	49.1	30.1
7	Wet wall	33.3	42.1	24.6
9	Wet wall	19.5	39.8	40.6
11	Wet wall	19.0	50.4	30.6
Average %		**20.0**	**47.0**	**33.0**
Run	Method 201A Sampling Train Conditions	>PM10 Catch from PM10 Cyclone (mass %)	>PM2.5 and ≤ PM10 Catch from PM10 Cyclone Outlet (mass %)	PM2.5 on Filter, and in Rinses of the PM2.5 Cyclone Outlet Tube and Filter Holder Rinse (mass %)
2	Dry	25.3	62.3	12.3
4	Dry	20.4	47.5	32.1
6	Dry	7.6	65.3	27.1
8	Dry	22.2	51.9	25.9
10	Dry	17.3	45.6	39.6
12	Dry	22.0	52.0	30.0
Average, %		**18.0**	**54.1**	**27.9**

These results summarized in Figure 1 and Table 4 demonstrate that the probe losses for PM2.5 particles are negligible.

December 2015 Tests With and Without a Probe in the Sampling Train of the Proposed Method—Air Control Techniques, P.C. ran an additional set of tests to evaluate probe losses for large diameter material, such as droplets up to a size of 20 micrometers. Based on the precutter size-efficiency curve developed during the tests summarized in January 2015, the mass of particles penetrating the precutter in the 15 to 20-micrometer size range is small. Furthermore, droplets in this size range would quickly evaporate to form particles equal to or smaller than 2.5 micrometers. Nevertheless, a small quantity of droplets in the larger size range could penetrate the precutter and exist at the inlet of the probe for up to 0.1 second.

The potential capture of particles in the 15 to 20-micrometer size range was evaluated using a wet stack filterable PM2.5 sampling train in the following two configurations.

Configuration 1

- Precutter nozzle
- Four-foot long probe
- PM2.5 cyclone and filter
- Impingers
- Meter box

Configuration 2
- Precutter nozzle
- PM2.5 cyclone and filter
- Impingers
- Meter box

In configuration 1, the sample gas passed through the probe prior to entering the cyclone and PM2.5 filter. Configuration 2 was identical, except for the lack of a probe. The same polydisperse flyash particles were used as the challenge material. A set of six test runs, three with configuration 1 and three with configuration 2, were conducted to determine the probe losses and the impact on the measured PM2.5 fractions. The data are summarized in Table 5.

Table 5. Wet Stack Filterable Sampling Train Catch Weights
With and Without a Probe

	Run 1	Run 5	Run 6	Run 2	Run 3	Run 4
Test Conditions						
Probe	No	No	No	Yes	Yes	Yes
Wetted Precutter	Yes	Yes	Yes	Yes	Yes	Yes
Delta H	0.4	0.4	0.4	0.4	0.4	0.4
Catch Weights, milligrams						
Filter	6.1	11.0	12.5	15.4	18.6	5.9
Filter Housing , Cyclone Outlet Rinse	2.5	3.4	1.5	2.6	5.3	3.6
Cyclone Rinse	42.7	72.6	54.4	81.4	66.6	36.5
Probe Rinse	N/A	N/A	N/A	24.2	10.5	4.1
Precutter Rinse	27.3	72.7	41.6	155.3	47.7	38.4
Total Sampling Train	78.6	159.7	110.0	278.9	148.7	88.5
Catch Weights, Percent of Total Sampling Train						
Probe	N/A	N/A	N/A	8.7	7.1	4.6
PM2.5 Filter and Rinses	10.9	9.02	12.7	6.45	16.1	10.7

The probe catch averaged 6.8%, which is an especially low value considering that the concentration of very large particles penetrating the precutter and entering the probe was high and considering that these solid particles had a much a much longer residence time in the probe than evaporating water droplets.

The fractions of the particulate matter in the PM2.5 size range of the two sampling configurations were essentially identical. The fraction of PM2.5 particulate matter with the probe averaged 11.1% of the total mass. The fraction of PM2.5 particulate matter without the probe averaged 10.9% of the total mass.

These results indicate that, even with an especially large particle size distribution, the probe captures little, if any, of the particulate matter that could evaporate to become PM2.5 particles.

Further confirmation of the lack of a probe capture bias will be possible once the method is published as an OTM. There are provisions in the draft method for testing organizations to recover the particulate matter from five separate portions of the sampling train—including the probe. These data from a variety of full scale sources will be more informative than any type of laboratory test program.

Conclusions—The Method 301 validation tests and the supplemental data provided by the December 2015 tests summarized in this letter confirm that there is no significant bias to lower-than-true PM2.5 measurements due to particle capture in the probe.

2. DROPLET SHATTERING DURING DRYING

EPA has asked if droplet shattering potentially occurring during droplet evaporation could contribute to a bias to higher-than-true PM2.5 measurements. The data and information provided in this section demonstrate that this potential bias is insignificant.

It is important to note that the present EPA policy requiring the use of Method 5 for PM2.5 measurements in wet stacks inherently includes a large possible bias to higher-than-true PM2.5 emissions. Very few sources have 100% of the particulate matter in the PM2.5 size range. The primary benefit of the proposed sampling method is to provide a means to obtain more accurate data than are presently available with the Method 5-based approach. Any bias due to droplet shattering, usually termed “Rayleigh shattering,” is small compare to this existing method-related bias.

Rayleigh shattering is important only for those droplets larger than 20 micrometers that can penetrate the precutter. Shattering of droplets less than 20 micrometers only affects the distribution of PM2.5 particles formed in the probe as the sample gas moves toward the PM2.5 cyclone and filter.

The shattering of a droplet with a diameter larger than 20 micrometers could create a bias to higher-than-true PM2.5 reported values by shattering into numerous small droplets, most of which could yield a PM2.5 particle as the droplets evaporate. This creates PM2.5 particles that would otherwise not form in the atmosphere.

Due to the 50% cut size of 12 micrometers achieved by the precutter nozzle, few if any of these droplets larger than 20 micrometers can penetrate to the high temperature probe and undergo Rayleigh shattering. Furthermore, the droplets must have a substantial electrical charge on the surface in order to create the electrostatic repulsive forces that cause shattering as the droplet size decreases during evaporation. Therefore, it is highly unlikely that Rayleigh shattering creates much bias to higher-than-true PM2.5 measurements.

Phase I Laboratory Study—During the Phase I laboratory evaluation, Air Control Techniques, P.C. evaluated the impact of Rayleigh shattering. We used a nephelometer to measure particulate matter concentrations on a second-by-second basis penetrating the PM2.5 cyclone following the injection of droplets of salt water into the inlet of the probe. These tests indicated that PM2.5 particles caused by Rayleigh shattering were at an extremely low concentration and did not affect the PM2.5 test results. The results of these laboratory tests are summarized in the Method Development Report submitted to EPA previously in 2013.

December 2015 Rayleigh Shattering Study—In December 2015, Air Control Techniques, P.C. conducted another series of tests to evaluate the extent of Rayleigh shattering in the wet stack filterable PM2.5 sampling probe. In this second series of tests, the solids accumulating on the PM2.5 filter in the wet stack filterable PM2.5 sampling train were weighed to provide data concerning the fraction of salt injected into the probe inlet as a salt solution that reached the PM2.5 filter as dried solids.

Air Control Techniques, P.C. injected 140 milligrams of salt (14% wt. solution) in large droplets deposited on the inlet to the probe operating at 340-350°F. The PM2.5 cyclone and filter were also operated in this temperature range during these tests. During all three test runs, zero measurable material was found on the PM2.5 filter. This demonstrates that the large droplets in the inlet of the probe do not undergo shattering during evaporation.

The results of both the Phase I tests and the December 2015 droplet shattering tests are not surprising. Substantial electrical charge must be present on the surfaces of the large droplets in order to overcome surface tension forces and to shatter the evaporating droplet due to electrostatic repulsion. It is unlikely that these charges can persist in the high-droplet concentration environment of a saturated or near-saturated stack. Furthermore, the large droplets of possible concern are efficiently removed in the precutter.

Conclusion—The laboratory tests conducted in during Phase I and the supplemental tests in December 2015 demonstrate that Rayleigh shattering has a negligible impact on the measured PM2.5 emissions.

3. PROBE WATER DROPLET RESIDENCE TIME

EPA has asked about probe water droplet residence times and has suggested that this is a function of sample flow rate, probe temperature, probe diameter, specific heat of the gas stream, and water droplet concentration. The information provided below demonstrates that the residence times in the probe are more than sufficient to achieve droplet evaporation under all possible sampling conditions. This conclusion is based on numerous test runs at (1) wet scrubber-equipped catalytic cracker stacks, (2) a wet scrubber-equipped MDF process stack (24 Method 301 validation runs), and (3) numerous laboratory tests in a simulated wet scrubber stack. We have not experienced wet filters in all of the previous work with the wet stack filterable PM2.5 sampling train.

In response to the EPA question, we have further evaluated the required droplet evaporation times. As a starting point, we have calculated the gas stream residence times for probes ranging from 3 feet to 8 feet long with gas flow rates of 0.35 to 0.60 ACFM. The residence times are summarized in Table 6. The calculated residence times are based on a ½ inch inner diameter probe (3/8th inch outer diameter). The volume of the precutter nozzle has not been considered because it is not heated.

0.35 ACFM is the normal sampling rate when the gas stream temperature is close to ambient temperature. 0.60 ACFM is a typical sampling rate when the gas temperature is moderately high for wet stacks.

Table 6. Gas Stream Residence Times in the
Wet Stack Filterable PM2.5 Sampling Train

Probe Length, Feet	Residence Time (Seconds) at 0.35 ACFM	Residence Time (Seconds) at 0.60 ACFM
3	0.70	0.41
4	0.94	0.55
5	1.17	0.68
6	1.40	0.82
7	1.64	0.95
8	1.87	1.09

We have compared the residence times of 0.41 to 1.87 seconds indicated in Table 6 to the calculated droplet evaporation times described by Hinds in Aerosol Technology (Second

Edition). Hinds indicates that, even at 20°C, a 20-micrometer water droplet evaporates completely in 0.31 seconds. At more than 170°C, the evaporation rate is much higher.

The residence times in the probe are much longer than necessary to achieve complete evaporation well before the gas stream enters the PM2.5 cyclone. At 350°F (176°C), complete droplet evaporation is achieved regardless of the sampling rate, probe inside diameter, specific heat of the gas stream, water droplet concentration, and water droplet size distribution penetrating the precutter nozzle.

The adequacy of droplet evaporation is further indicated by the performance of EPA Method 5 at 248 ±25°F. This method is presently required by EPA for sources equipped with wet stacks. Air Control Techniques, P.C. has conducted numerous Method 5 tests on moisture-saturated and droplet-laden stacks without experiencing any droplet evaporation problems. We are not aware of any reported problems with complete droplet evaporation in Method 5 sampling trains operating approximately 100°F colder than the wet stack filterable PM2.5 test method sampling train.

Conclusion—There is sufficient gas stream residence time in the probe to ensure complete evaporation under all possible operating conditions. This is demonstrated by prior experience with the wet stack filterable PM2.5 sampling train and by experience with EPA Method 5 operating at a slightly lower temperature.

4. SAMPLING TRAIN LEAK CHECK PROCEDURES

EPA stated the following at part of the November 20th set of questions.

> “*This method may contain new QA/QC procedures not demonstrated in the field. These new QA/QC procedures may require further study to determine their suitability (i.e., posttest leak check.)*

In previously submitted reports and the draft method, we have proposed a two-step post-test leak check procedure involving (1) disconnecting the sampling train at the PM2.5 filter and leak checking at this point and (2) connecting a jumper to the PM2.5 cyclone outlet and leak checking from the precutter nozzle through the PM2.5 cyclone at a maximum of 2 psig to avoid dislodging solids from the cyclone.

While we continue to believe that this approach is reasonable and effective, we would like to propose an alternative approach that is simpler and more direct. This involves leak checking of the entire sampling train from the inlet to the precutter nozzle through the remainder of the sampling train. We propose to avoid dislodging any particulate matter in the nozzle, probe, PM2.5 cyclone, and connecting tubing by ensuring that following the leak check, the vacuum is released gradually. While releasing the vacuum, the delta H gauge can be monitored to ensure that the re-pressuring air flow rate does into the sampling train not exceed the maximum sample flow rate maintained throughout the test run. To control the re-pressurizing air flow rate, a needle valve (or similar valve) can be used to slowly allow the sampling train to increase in pressure from the leak check vacuum level. A needle valve similar to the one shown in Figure 2 can be attached to the precutter nozzle prior to the start of the post-test leak check to allow for control of the air flow back into the evacuated sampling system.

Figure 2. Precutter Nozzle with Cap Prior to the Attachment of the Needle Valve

By using this simple approach, the entire sampling train can be leak-checked without disturbing the distribution of captured solids in the precutter, probe, cyclone, and filter. This procedure allows the sampling train to be post-test leak-checked in essentially an identical manner to a Method 5 sampling train.

Conclusion—A leak check of the full sampling train is possible without creating a bias to higher-than-true PM2.5 emissions by controlling the rate of air flow back into the evacuated sampling train after the post-test leak check. While metering the air back into the train, the delta H gauge can be monitored to confirm that the air inlet flow rates are at or below the flow rate during the sampling run.

Proposed Addition to the Sampling Method—The post-test leak check procedure described above could be addressed in the following addition to Section 8.7.4 of the draft method.

As Previously Drafted

> ~~Disconnect the probe and remove the cyclone from the sampling box. Seal both ends of the cyclone to prevent particulate matter from entering or leaving the cyclone. After the cyclone is removed, perform a posttest leak check of the sample train from the inlet of the~~

> ~~filter through the remainder of the sampling train. You must conduct the leak rate at a vacuum equal to or greater than the maximum vacuum achieved during the test run. Enter the results of the leak check onto the field test data sheet. If the leak rate of the sampling train (without the combined cyclone sampling head) exceeds 0.02 actual cubic feet per minute or four percent of the average sampling rate during the test run (whichever is less), the run is invalid and must be repeated.~~
>
> ~~Connect the outlet of the probe to a jumper and leak check the precutter nozzle and probe at a maximum of 2 in. Hg vacuum to avoid loss of material from the precutter and probe. Enter the results of the leak check onto the field test data sheet. If the leak rate of the precutter nozzle and probe exceeds 0.02 actual cubic feet per minute or four percent of the average sampling rate during the test run (whichever is less), the run is invalid and must be repeated. Seal all openings of sampling train components from which samples will be collected and transport to the sample recovery area.~~

Proposed Addition to the Draft Method

> At the conclusion of the run, attach a needle valve to the end of the precutter nozzle. Close the needle valve, and then reduce the pressure in the sampling train to a vacuum equal to or greater than the vacuum observed during the test run. If the leak rate of the sampling train exceeds 0.02 actual cubic feet per minute or four percent of the average sampling train during the test run (whichever is less), the run is invalid and must be repeated.
>
> At the conclusion of the leak check, slowly open the needle valve to allow air to enter the sampling train. To avoid disturbing the captured solids in the sampling train, maintain the rate of air flow back into the sampling train at a delta H value that is below the delta H value used during the sampling run.

5. PRECUTTER CUT SIZE

The set of questions provided by EPA in the November 20th email did not address precutter cut size. Nevertheless, there have been previous discussions of this topic. The December 2015 Method 201A/Wet Stack Method comparison tests discussed earlier in this letter provide further insight into the precutter 50% cut size.

During the December 2015 comparison tests, the two different sampling trains summarized below were testing using a polydisperse flyash aerosol.

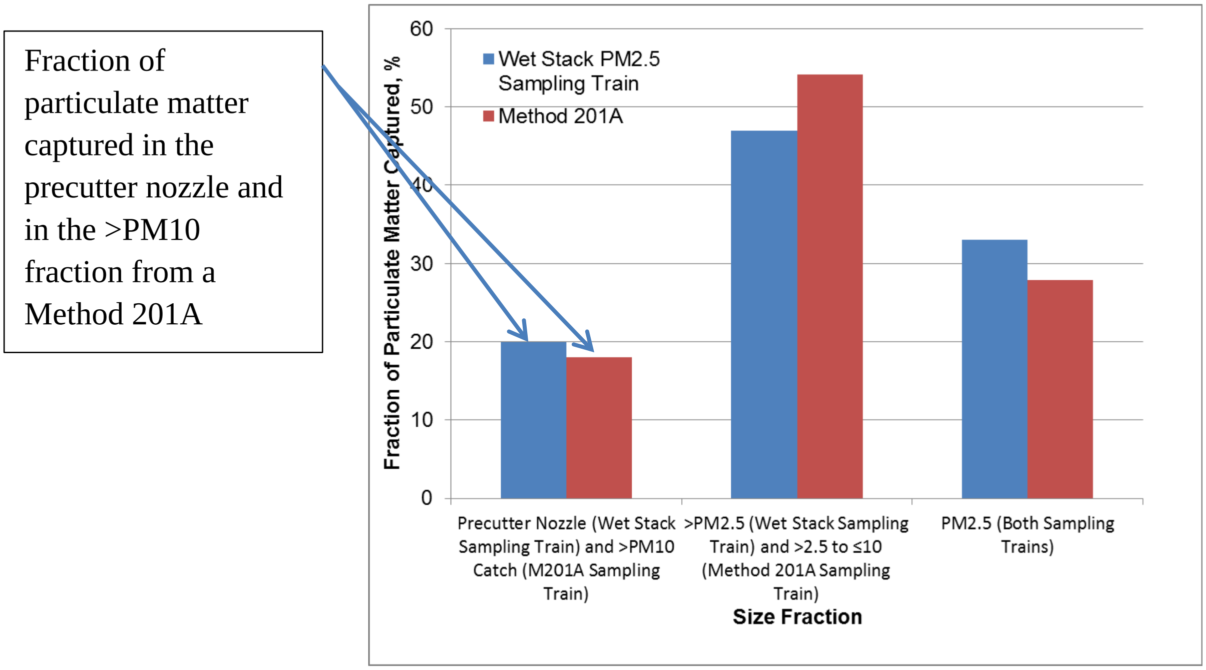
The wet stack filterable PM2.5 sampling train consisted of the following.

(1) Precutter with an inlet nozzle,
(2) Four foot long probe operating at 67°F,
(3) PM2.5 cyclone and 47-mm filter mounted in a hot box operating at 67°F,
(4) Jumper line to a set of impingers, and
(5) Meter box.

The Method 201A sampling system consisted of the following.

(1) PM10 cyclone with nozzle,
(2) PM2.5 cyclone,
(3) 47-mm filter,
(4) Four foot long sampling probe,
(5) Jumper to a set of impingers, and
(6) Meter box.

The fraction of particulate matter captured by the precutter can be directly compared with the greater than PM10 size fraction recovered from the Method 201A PM10 cyclone.



Fraction of particulate matter captured in the precutter nozzle and in the >PM10 fraction from a Method 201A

Figure 3. Comparison of the Capture of Particulate Matter in the Wet Stack Filterable PM2.5 Sampling Train and in the Method 201A Sampling Train (Note: same data as shown in Figure 1)

The wet stack filterable PM2.5 sampling train captured slightly more of the particulate matter larger than the M201A sampling train. This is reasonable considering that the 50% cut size for the wet stack filterable PM2.5 sampling train is 12 micrometers, while the Method 201A PM10 cyclone, as operated in these laboratory tests, had a 50% cut size of 10.8 micrometers.

The wet stack filterable PM2.5 sampling train captured slightly more particulate matter than was captured in the PM2.5 fraction of the M201A sampling train. This is consistent with the 50% cut sizes summarized in Table 1. The wet stack filterable PM2.5 sampling train had a 50% cut size of 2.69 micrometers, while the M201A sampling train had a 50% cut size of 2.3 micrometers.

The December 2015 method comparison test data compiled using the polydisperse particulate matter are entirely consistent with the results of the Method 301 validation tests conducted in 2013. As indicated in Table 2, the total precutter catch weights averaged 7.8% of the total particulate matter and 11.7% of the PM2.5 catch weights in the sampling train. Considering that the indicated 50% cut size of the precutter nozzle is 12 micrometers, it is apparent that most, if not all, of the precutter material captured in the Method 301 tests was large diameter droplets. Very little, if any, PM2.5 particulate matter was captured in the precutter.

Conclusion—The data compiled in these polydisperse aerosol tests and summarized in Table 4 and in Figure 3 demonstrate that the wet stack filterable PM2.5 sampling train precutter does not cause any significant loss of PM2.5 particulate matter. This conclusion is consistent with the previously submitted Method 301 validation test results.

6. SUMMARY

API and NCASI have submitted test data and information that include (1) laboratory-based method development studies, (2) Method 301 validation tests, (3) a precutter nozzle size-efficiency study, and (4) supplemental information concerning the performance characteristics and importance of the wet stack filterable PM2.5 test method. API and NCASI have also provided a draft version of the new method written in a form that parallels Method 201A, to the maximum extent possible. This letter provides the follow-up information that EPA requested in their November 20, 2015 email.

The data and information submitted demonstrate that the wet stack filterable PM2.5 test method provides an accurate and effective means to measure filterable PM2.5 in moisture saturated and/or droplet laden stacks. This method is ready for use as an OTM in a wide variety of applications involving wet scrubber-controlled sources. The April 29th letter that you sent to EPA emphasizes the importance of this method to sources required to prepare accurate emission inventories and dispersion models.

At the present time, EPA policy requires sources to use Method 5 and to assume that 100% of the particulate matter in moisture-saturated or droplet-laden stacks is in the PM2.5 size range.

For many sources, this policy introduces a large bias to higher-than-true PM2.5 emissions, which can create erroneous dispersion modeling results. The wet stack filterable PM2.5 should be published as an OTM to help source operators and regulatory agencies avoid these errors. Publication as an OTM will also encourage method refinements due to its use in a variety of testing applications.

Air Control Techniques, P.C. will be glad to address any questions concerning this additional data and information and concerning the wet stack filterable PM2.5 test method in general.

Sincerely

John Richards

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Appendix B

West Stack Sampling System Development Report

September 16, 2013

WET STACK FILTERABLE PM$_{2.5}$ SAMPLING SYSTEM DEVELOPMENT REPORT

Report Prepared for:

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Report Date: September 16, 2013

TABLE OF CONTENTS

APPENDICES

FIGURES

TABLES

WET STACK FILTERABLE $PM_{2.5}$ SAMPLING SYSTEM DEVELOPMENT REPORT

1. SUMMARY

1.1 PURPOSE AND SCOPE

American Petroleum Institute (API) member companies operate fluid catalytic crackers units (FCCUs) equipped with flue gas desulfurization systems (FGDs). New regulatory programs will require filterable $PM_{2.5}$ emission measurements in the stacks of FGD-equipped FCCUs.

Droplets entrained in the effluent gas streams exiting the FGDs prevent the use of EPA Reference Method 201A[1] for the measurement of filterable $PM_{2.5}$. EPA Reference Method 5B is the only technique available to API member companies to measure total filterable particulate matter data. With Method 5B, total filterable particulate matter serves as a surrogate for filterable $PM_{2.5}$. This Method 5B-based approach is biased to higher-than-true emission rates of $PM_{2.5}$ because a portion of the material measured as total filterable particulate matter is larger than 2.5 micrometers.

This report presents the results of a two-year method development program sponsored by the API. During the latter stages of method development, the National Council for Air & Stream Improvement (NCASI) contributed to this program due to their shared interest in a filterable $PM_{2.5}$ emission test method for wet stacks. In this report, the new method is described as the "WS2.5" with the understanding that EPA will assign a method number as part of their review. The WS2.5 method is intended for use in conjunction with the new EPA Method 202 (previously termed EPA OTM 028) to simultaneously provide filterable and condensable $PM_{2.5}$ emissions matter data in wet stacks. The WS2.5 wet stack sampling system simultaneously provides filterable and condensable $PM_{2.5}$ emissions matter data. If the nozzle, probe, and cyclone solids are also recovered, the total filterable particulate emissions can be calculated as the sum of all material captured in the sampling system. Accordingly, the total particulate matter emissions as measured by the WS2.5 sampling system can be compared directly with EPA Reference Method 5B.

1.2 CONCLUSIONS

The WS2.5 method is designed to provide an accurate means to measure $PM_{2.5}$ particles in gas streams with entrained water droplets. The sampling system captures particles (1) suspended in water droplets, (2) formed from dissolved solids during the in-probe evaporation of water droplets, and (3) present as dry particles in the stack gas stream.

This WS2.5 sampling system studied in these testing programs consisted of (1) a 90 degree curved glass nozzle[2], (2) a probe having probe heaters with sufficient heating capacity to maintain a temperature of 320 ± 25 °F in droplet-laden gas streams, (3) a nitrogen dilution stream[3], and (4) a heated sampling box including a $PM_{2.5}$ cyclone and a $PM_{2.5}$ filter maintained at 320± 25 °F.

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[1] EPA Reference Method 201A was substantially revised and re-promulgated on December 21, 2010.

[2] The 90 degree nozzle was subsequently replaced with a precutter nozzle.

[3] The nitrogen dilution stream was subsequently eliminated based on the results of these tests.

The WS2.5 sampling train operates with sample gas flow rates in the range of 0.4 to 0.65 ACFM at the effluent gas stream temperatures of most wet stacks. Run times vary from two to three hours in order to obtain sufficient $PM_{2.5}$ catch weights. Sample recovery and emission calculations parallel Method 201A. Quality assurance procedures for the WS2.5 sampling system also are patterned after Method 201A.

The WS2.5 wet stack sampling system is designed for use with an EPA Method 202 condensable particulate matter sampling system. The Method 202 sampling train is needed because some residual sulfuric acid vapors and organic particulate matter in the effluent gas stream being sampled can vaporize in the hot probe and filter. The vaporized organic material is captured in the Method 202 filter and impingers.

This sampling train was proposed following completion of (1) an initial laboratory evaluation, (2) field tests at three refineries, and (3) follow-up laboratory testing. The proposed sampling system has been modified in response to the results of these tests. Specifically, the 90 degree curved nozzle was replaced with a precutter, and the nitrogen dilution system was deleted as it was not needed to ensure complete vaporization of the sample stream, and it added considerable complexity to the method. The 90 degree curved nozzle was also replaced with a precutter.[4]

Emission testing companies capable of properly conducting Method 201A will have the necessary experience to conduct the WS2.5 tests. In addition to the standard Method 201A sampling equipment, testing companies will need to have a probe capable of operating at 320 ± 25°F. The WS2.5 sampling system is as practical and economical as Method 201A for dry stacks.

The WS2.5 sampling system can operate well in wet stacks of FGD-controlled catalytic crackers and wet stacks in the Pulp and Paper Industry. The system can operate at conventional Method 201A isokinetic sampling rates of 100 ± 20% and at conventional Method 5B sampling temperatures of 320 ± 25°F, even when the droplet loadings approach an especially high level of 0.40 grams per cubic meter. Both the lab tests and FCCU tests have confirmed the ability of the sampling system to handle high droplet loadings.

The WS2.5 sampling system is not biased to higher-than-true $PM_{2.5}$ emissions due to shattering of the evaporating solids-containing droplets in the hot probe. Laboratory tests demonstrate that shattering of the nearly evaporated droplets injected into the probe does not result in significant levels of $PM_{2.5}$ particles.

The WS2.5 sampling system also is not biased to lower-than-true indicated $PM_{2.5}$ emissions. The probe is similar to a Method 201A probe in order to minimize inertial impaction of droplets and dry particles into droplets that might exist briefly on probe surfaces. The sample gas stream residence time in the probe is less than 0.5 seconds, which minimizes any Brownian diffusion losses to the probe surfaces. This is approximately 5% of the residence time in the dilution tunnel proposed by the EPA for use in their wet stack $PM_{2.5}$ CEMS development project..

The proper retention of $PM_{2.5}$ particles in the gas stream has been confirmed by challenging the nozzle and probe with NIST-traceable monodisperse microspheres. The fraction of the spheres captured on the $PM_{2.5}$ filter and in the $PM_{2.5}$ portion of the cyclone rinse compares favorably with the fraction of spheres successfully dispersed as $PM_{2.5}$ particles. Tests with three types of

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[4] The precutter is discussed in the Method 301 Validation Test Program Report dated May 28, 2013.

NIST-traceable microspheres have demonstrated that the loss of $PM_{2.5}$ particles in the nozzle and probe is small. These tests also suggest that there could be a slight bias to higher-than-true $PM_{2.5}$ levels due to shattering of some particle clusters and agglomerates.

Conclusions based on the three field tests confirm that the WS2.5 wet stack $PM_{2.5}$ sampling system operates properly. The cyclones and filter remained dry in both stacks of the scrubber-controlled systems. There were no problems maintaining proper temperatures or sample flow rates and no problems traversing the stacks. Test personnel were able to traverse the stacks without difficulty.

The need for the WS2.5 sampling system is demonstrated by the results of the parallel testing Method 5B and WS2.5 sampling system testing at three refineries. The measured filterable $PM_{2.5}$ emissions ranged from 6% to 61% of the total filterable particulate matter emissions as measured by Method 5B, demonstrating that the use of Method 5B data as a surrogate for filterable $PM_{2.5}$ introduces a large positive bias into the results. The new sampling method has been prepared in a format that closely parallels Method 201A for dry stack testing and is provided in a separate report. The new sampling method provides a practical, economical, and accurate means of measuring $PM_{2.5}$ emissions form wet stacks and should be adopted by the EPA.

1.3 TEST PROGRAM PARTICIPANTS

The API Project Manager for this testing project is Ms. Cathe Kalisz. The Air Control Techniques, P.C. project manager is Mr. John Richards. Addresses and phone numbers of these individuals are provided below.

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Phil Juneau was responsible for field test program management and coordination with API and plant personnel. Todd Brozell, P.E., Tom Holder, and Danny Speer assisted Phil Juneau with the field test program. John Richards, Todd Brozell, and Phil Juneau conducted the laboratory tests of the WS2.5 wet stack filterable $PM_{2.5}$ sampling system

Resolution Analytics performed the WS2.5 sample analyses. The laboratory manager is Mr. Bruce Nemet.

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Research Triangle Institute provided electron microscopy services for both the laboratory and field testing programs. The laboratory manager is Dr. Owen Crankshaw.

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2. WS2.5 SAMPLING SYSTEM DESIGN CHARACTERISTICS

2.1 PERFORMANCE CRITERIA

The following performance criteria were applied in designing the WS2.5 wet stack filterable $PM_{2.5}$ sampling method.

1. Measurement of filterable $PM_{2.5}$ independently from condensable $PM_{2.5}$
2. Temperatures in the range of 320°F ± 25°F in the probe, $PM_{2.5}$ cyclone, and $PM_{2.5}$ filter, even when sampling gas streams with droplet loadings of 0.40 grams per cubic meter
3. Isokinetic sampling rates in the range of 100% ± 20%
4. Droplet 50% cut point of 20 micrometers in the nozzle
5. Minimal bias to higher-than-true $PM_{2.5}$ emissions caused by evaporative shattering of solids-containing droplets
6. Minimal bias to lower-than true $PM_{2.5}$ emissions caused by $PM_{2.5}$ particle losses in the nozzle or probe
7. Practical and economical stack sampling method that uses readily available commercial equipment

Independent measurement of filterable and condensable $PM_{2.5}$ is needed to allow refineries to evaluate control strategies to minimize $PM_{2.5}$ emissions. Filterable and condensable $PM_{2.5}$ particles form due to quite different mechanisms, and their emission rates are affected by entirely different process and air pollution control system operating parameters.

The temperature range of 320 ± 25°F is consistent with EPA Reference Method 5B, the test method used to measure total filterable particulate matter emissions. This temperature is necessary for the independent measurement of filterable and condensable $PM_{2.5}$. Most condensable vapor remains in the gas phase at 320 ± 25°F. This sampling system temperature ensures that the vapor phase materials passing through the $PM_{2.5}$ filter are captured in the Method 202 impingers used as the back half of the overall sampling system.

An isokinetic sampling rate of 100% ± 20% is needed to ensure consistency with Method 201A. While an isokinetic sampling rate is unimportant for dry $PM_{2.5}$, it is moderately important for particles and droplets larger than 10 micrometers.

A droplet 50% cut point of 20 micrometers in the nozzle is needed to ensure consistency with EPA's $PM_{2.5}$ continuous emission monitor presently under development.

A bias to higher-than-true $PM_{2.5}$ emissions can potentially be caused by Rayleigh shattering of rapidly evaporating droplets containing suspended and dissolved solids. The $PM_{2.5}$ formation rate from surface tension-related phenomenon can significantly exceed the formation rate of $PM_{2.5}$ particles from droplets evaporating slowly in plumes and air masses. This method development program is designed to evaluate the extent of $PM_{2.5}$ formation in the sampling system.

A bias to lower than true $PM_{2.5}$ emissions can potentially be caused by (1) $PM_{2.5}$ particle inertial impaction into droplets in the nozzle and probe, (2) Brownian diffusion of $PM_{2.5}$ particles to the nozzle and probe surfaces, and (3) electrostatic attraction of $PM_{2.5}$ particles with static charge to the nozzle and probe surfaces. This method development program was designed to evaluate the extent of $PM_{2.5}$ losses in the nozzle and probe and to minimize these losses to the maximum extent possible.

Considerable emphasis was placed on the practicality of the sampling equipment. Any manual test method for filterable $PM_{2.5}$ testing should include readily-available stack sampling equipment that can be purchased at reasonable cost. Testing organizations experienced with EPA Method 201A should be able to conduct the test method. To the maximum extent possible, the sample gas flow rates must be sufficient to provide accurately measurable particulate matter catch weights with run durations of equal to or less than three hours. Furthermore, the test method must be compatible with EPA Method 202 used as the “back half” of the overall sampling train.

The data compiled during this method development project show that the wet stack $PM_{2.5}$ sampling system designed and fabricated in this test program met all the performance criteria. This system can be used for sampling FGD-controlled catalytic crackers and other wet scrubber-controlled sources.

2.2 SAMPLING TRAIN

The WS2.5 sampling train used in the method development tests included a nozzle, a heated probe, a heated $PM_{2.5}$ cyclone, a heated 47mm filter, and an EPA Method 202 sampling train. The probe was a 1/2 inch (I.D.) stainless steel tube enclosed in a high temperature probe sheath. While this probe was satisfactory for sources in the refinery industry, a glass probe is more generally applicable for sources with aggressive corrosive contaminants in the gas stream that could attack the metal probe liner and thereby contribute to a bias to higher-than-true reported emissions of filterable particulate matter.

The sample gas stream was maintained at 320 °F ± 25 °F in the probe shown in Figure 2-1 and originally included a high-purity nitrogen injection line. The highpurity nitrogen injection line was included to the inlet of the probe to ensure proper droplet evaporation prior to the cyclone and filter. The field test results demonstrated that the nitrogen dilution line was not needed, even in gas streams with high droplet loadings. There was no difficulty maintaining the necessary probe temperatures as indicated by a set of thermocouples spaced along the entire length of the probe. Accordingly, this part of the sampling system was eliminated to reduce complexity in sample gas flow rate calculations. The nitrogen line continues to be shown in Figures 2-1 through 2-3 because it was evaluated in the field testing programs.

A 90-degree curved nozzle originally proposed by Dr. David Leith of the University of North Carolina at Chapel Hill was used for gas stream sampling in most of the laboratory tests and all of the field tests. The nozzle diameter is designed to provide a 50% cut point at 20 micrometers when the sample gas flow rate is in the appropriate range for the $PM_{2.5}$ cyclone. The nozzle tip is necked down to allow for isokinetic sampling at normal stack velocities. The nozzle cut size curve is illustrated in Figure 2-4.

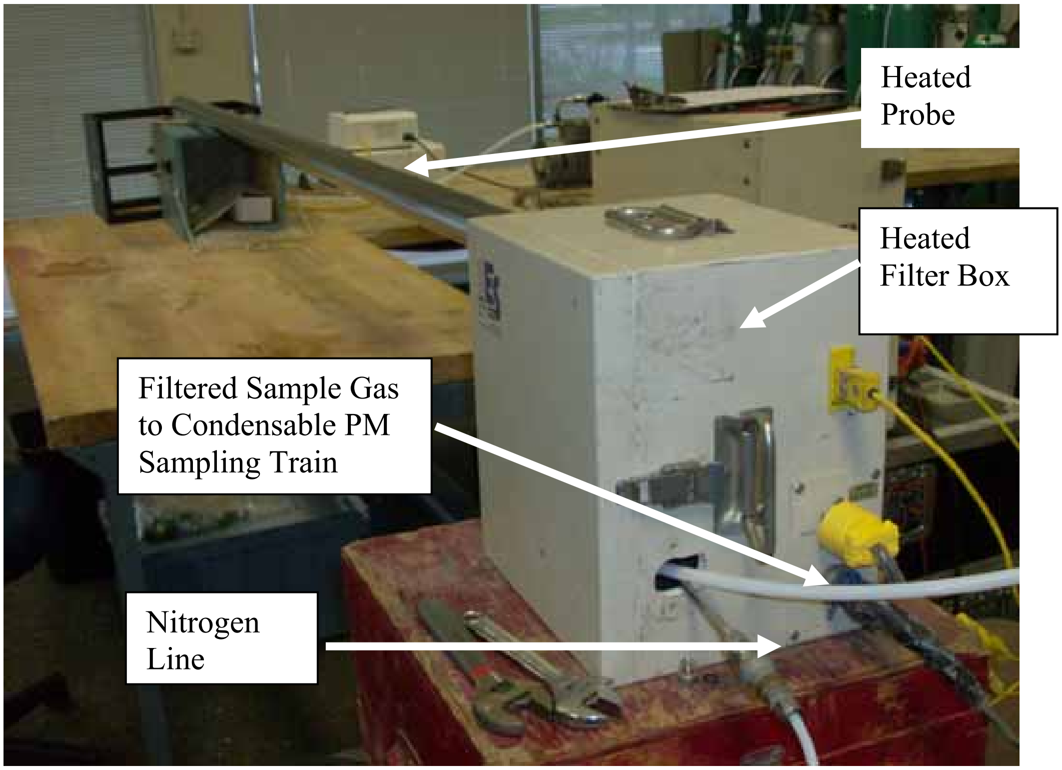

Figure 2-1. Wet Stack $PM_{2.5}$ Sampling System

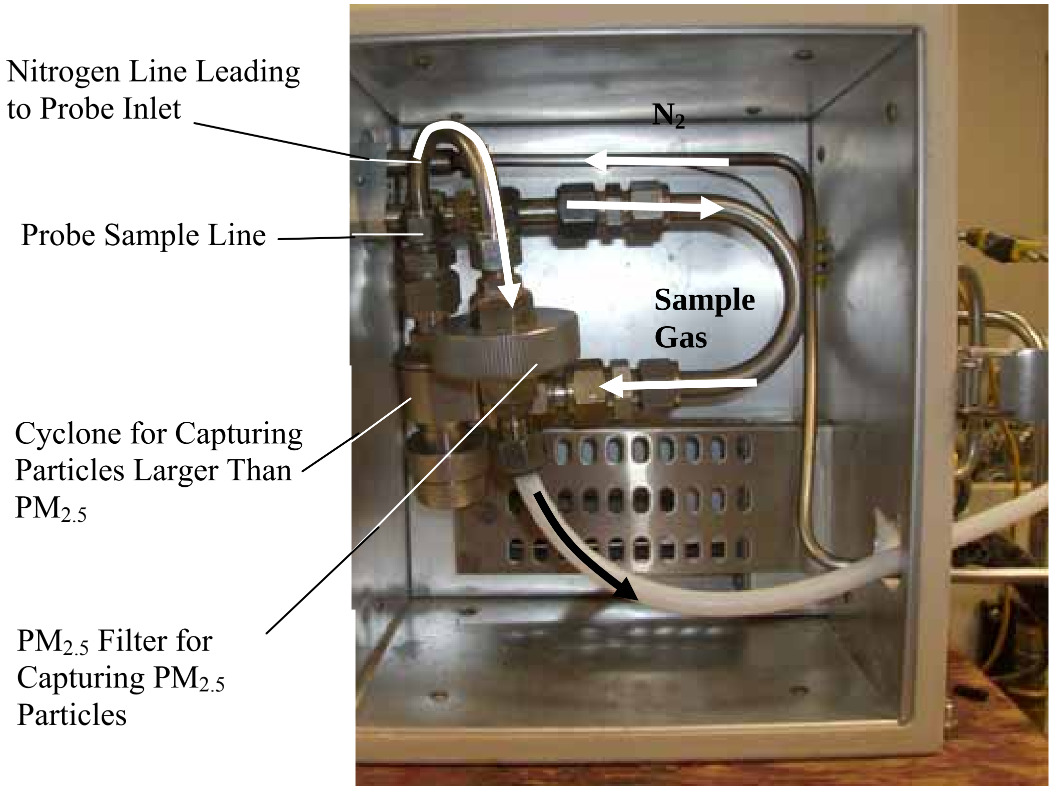

Figure 2-2. Heated Filter Box with Cyclone and $PM_{2.5}$ Filter

While the nozzle performed well in the laboratory tests, testing personnel observed problems in the two field tests of scrubber-controlled systems. Droplets impacting on the exterior surfaces of the nozzle drain downward and are pulled into the nozzle resulting in a bias to higher-than-true total filterable particulate matter emissions. Testing organizations interested in using this method to measure both filterable $PM_{2.5}$ and total filterable particulate matter emissions should not use this nozzle. Instead, the precutter nozzle described in the Method 301 Validation Test Program Report for the WS2.5 wet stack sampling system is recommended.

Figure 2-3. WS2.5 Heated Probe and 90 Degree Curved Nozzle

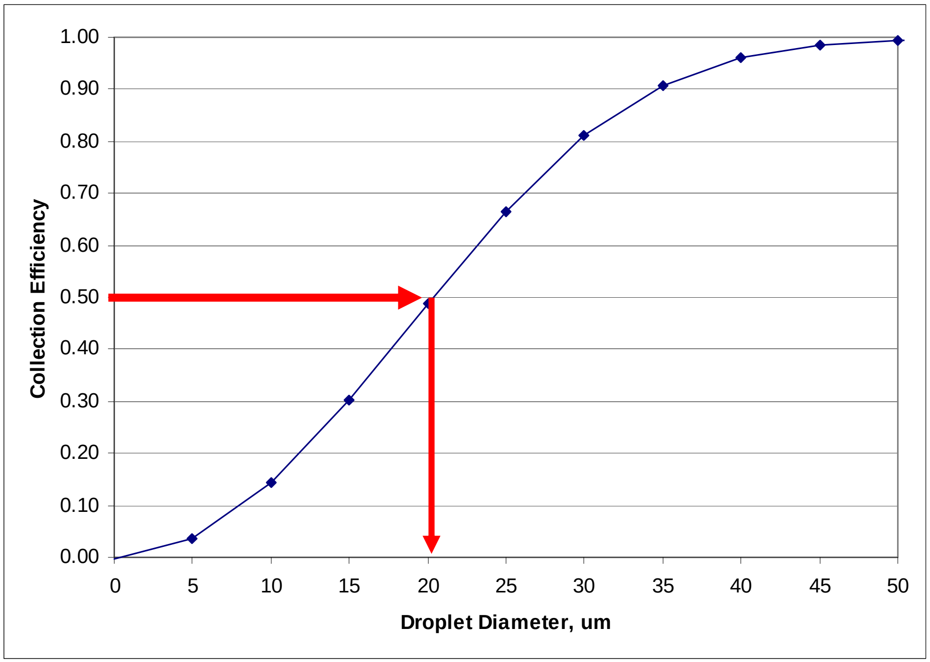

Figure 2-4. Calculated Cut Size for the WS2.5 Sampling System 90 Degree Curved Nozzle

A set of four thermocouples is mounted inside the probe. The thermocouples are monitored by the Method 5B sampling box or a separate set of temperature readouts. Another thermocouple monitors the filter box temperature.

Sample gas flow is maintained within the $PM_{2.5}$ cyclone performance limits as shown in Figure 2-5 from Richards[5] and Method 201A [6]. The sample gas flow rate must be adjusted to maintain a 2.5 ± 0.5 micrometer cut size.

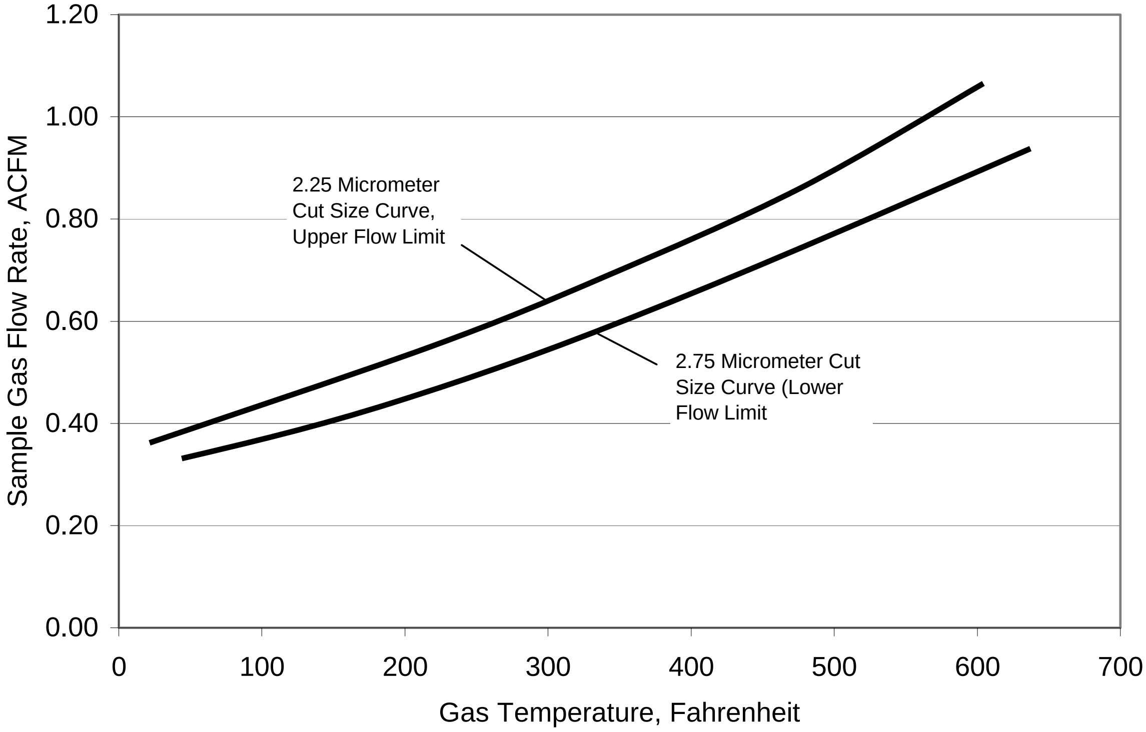

Figure 2-5. Required Sample Flow Rate for the $PM_{2.5}$ Cyclone in the WS2.5 Sampling System

The WS2.5 sampling system can be used to measure both total particulate matter and $PM_{2.5}$ particulate matter. In a manner similar to Method 201A, total particulate matter includes all of the solid material recovered from the nozzle, probe, cyclone, cyclone lines, cyclone cup, $PM_{2.5}$ filter holder (front), and $PM_{2.5}$ filter. The $PM_{2.5}$ particulate matter includes only the solids recovered from the outlet tube of the $PM_{2.5}$ cyclone, the cyclone lines leading to the $PM_{2.5}$ filter holder, the $PM_{2.5}$ filter holder (front half), and the $PM_{2.5}$ filter.

2.3 COMPARISON OF THE WS2.5 SAMPLING METHOD AND OTHER TEST METHODS

The WS2.5 method is a logical extension of EPA Method 201A, which uses two cyclones mounted in series and inserted into the gas stream. Particle separation into the Method 201A

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[5] Richards, J. "Test Protocol: PCA $PM_{10}/PM_{2.5}$ Emission Factor and Chemical Characterization Testing." Portland Cement Association Research Publication SP2081, July 1996.
[6] U.S. EPA. Federal Register, December 21, 2010

PM_{10} (10 to 2.5 micrometers) and $PM_{2.5}$ size fractions occurs at stack temperature. Method 201A cannot be used in saturated or droplet-laden gas streams because of (1) a potential bias to lower-than-true PM_{10} emissions caused by the sizes of droplets entering the probe and (2) the problems caused by condensing of water droplets on the cyclone walls. EPA states the rationale for this limitation to Method 201A in following statement posted on the EPA EMC website (www.epa.gov/ttn/EMC).

> Method 201A cannot be used to measure emissions from stacks that have entrained moisture droplets (e.g., a wet scrubber stack), since these stacks may have water droplets larger than the cut size for the PM10-sizing device. To measure PM10 in stacks where water droplets are known to exist, EPA's Technical Information Document (TID-099-Methods 201 and 201A in Presence of Water Droplets) recommends use of Method 5 of Appendix A to 40 CFR part 60 (or a comparable method) and consideration of the particulate catch as PM10 emissions. U.S.EPA, www.epa.gov/ttn/EMC

In fact, most regulatory agencies also assume that all particulate matter captured in Methods 5 or 5B are in the $PM_{2.5}$ size range. This assumption introduces a significant bias to higher-than-true $PM_{2.5}$ emissions and leads to incorrect emission inventories and ineffective control strategies. A number of organizations are working on dilution tunnel techniques in attempt to form $PM_{2.5}$ particles from droplets in a manner similar to their formation mechanisms in plumes and in the atmosphere. These techniques provide 10 to 60 seconds residence time prior to particle capture. The dilution tunnel sampling systems are inherently large, and there is no distinction between filterable and condensable $PM_{2.5}$.

The WS2.5 sampling system uses rapid evaporation to allow for the formation of $PM_{2.5}$ particles from droplets in the sample gas stream. The rapid evaporation also removes the droplets as inertial impaction targets for $PM_{2.5}$ particles transported in the probe. The gas velocity in the probe is low, thereby minimizing impaction. The gas stream residence time in the probe is short to minimize Brownian Diffusion losses of $PM_{2.5}$ particles to the surfaces of larger particles in the sample gas stream and the probe internal surfaces.

The WS2.5 removes the Method 201A PM_{10} cyclone and moves the $PM_{2.5}$ cyclone from an in-stack position to a heated filter box outside the stack. The WS2.5 nozzle and probe are designed to convert water droplets to dry particles and to minimize the loss of these particles prior to their entry to the $PM_{2.5}$ cyclone.

To evaluate the performance of the WS2.5 sampling system, two primary alternative approaches were reviewed: (1) the use of accurately-sized monodisperse microspheres of known density and (2) the use of in-situ sizing techniques and sample scanning electron microscopy techniques to characterize the particle size distributions of the sample gas stream and the collected samples. Microspheres of known size and density were primarily used; however, some SEM analyses were included for portions of both the laboratory and field studies.

3. LABORATORY EVALUATION

3.1 INITIAL LABORATORY TESTS

A series of tests was conducted to verify that the WS2.5 sampling system performance is consistent with the design objectives stated earlier. Specifically, the laboratory tests concerned the following four specific issues.

1. Temperatures in the range of 320°F ± 25°F in the probe, $PM_{2.5}$ cyclone, and $PM_{2.5}$ filter, even when sampling gas streams with droplet loadings of 0.40 grams per cubic meter
2. Droplet 50% cut point of 20 micrometers in the nozzle
3. Minimal bias to higher-than-true $PM_{2.5}$ emissions caused by evaporative shattering of solids-containing droplets
4. Minimal bias to lower-than true $PM_{2.5}$ emissions caused by $PM_{2.5}$ particle losses in the nozzle or probe

Monodisperse and polydisperse NIST traceable microspheres were dispersed into sample gas streams being tested with the system. Samples of the microspheres having physical diameters from 2 to more than 50 micrometers (physical diameters) were weighed and dispersed in water. The water was atomized in a nebulizer and combined with a heated clean air stream prior to entry into a small mixing/evaporating chamber. A portion of the sample gas stream was pulled into the system nozzle. The remainder of the test gas stream was pulled into a filter. The entire apparatus was maintained at a slight negative pressure to simulate typical stack conditions. The test apparatus is illustrated in Figures 3-1 and 3-2.

Some of these tests used a simulated wet scrubber stack consisting of a 1-foot high packed bed irrigated with recirculated fresh water. A KIMRE composite pad mist eliminator was operated at a gas velocity range similar to mist eliminators used in FGD systems. A blower was used to pull gas through the scrubber mist eliminator and simulated stack. Using this system, it was possible to achieve droplet entrainment levels of 1% to 2% moisture as measured by EPA Reference Method 4. These reentrainment levels are consistent with many full-scale scrubbing systems experiencing significant droplet reentrainment emissions. The simulated scrubber and stack are illustrated in Figures 3-3 and 3-4.

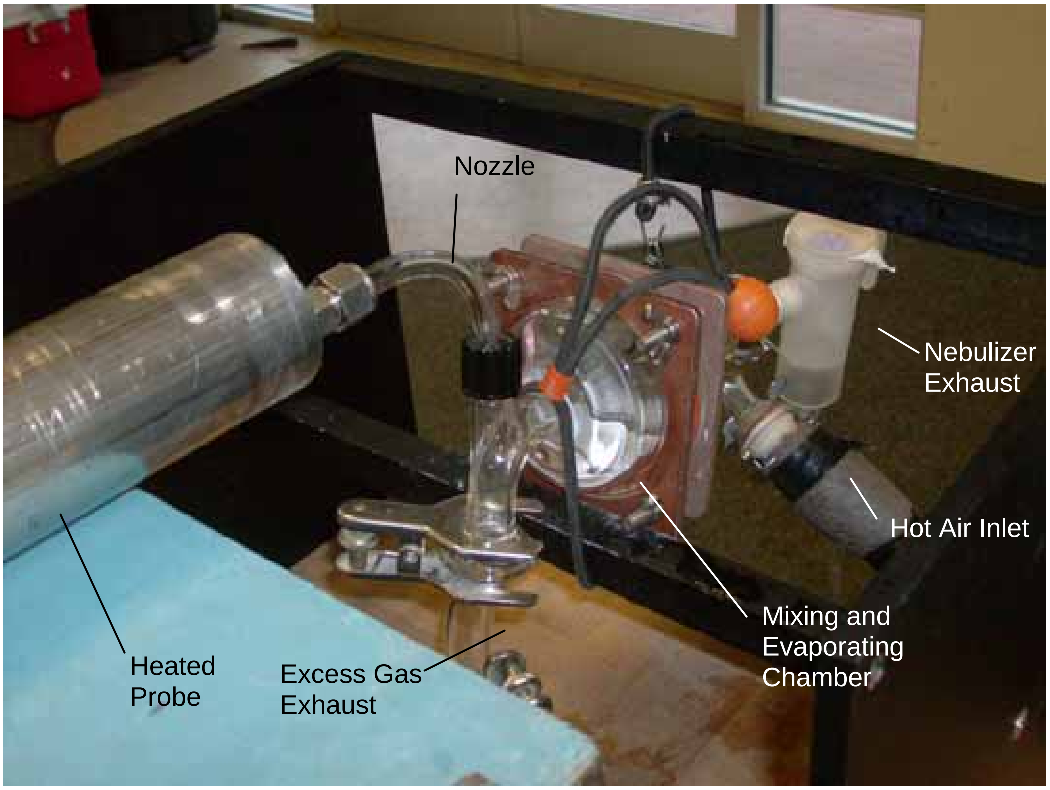


Figure 3-1. WS2.5 Heated Probe, 90 Degree Curved Nozzle, Mixing/Evaporating Chamber, Nebulizer Exhaust, Heated Air Line, and Excess Test Gas Exhaust Line

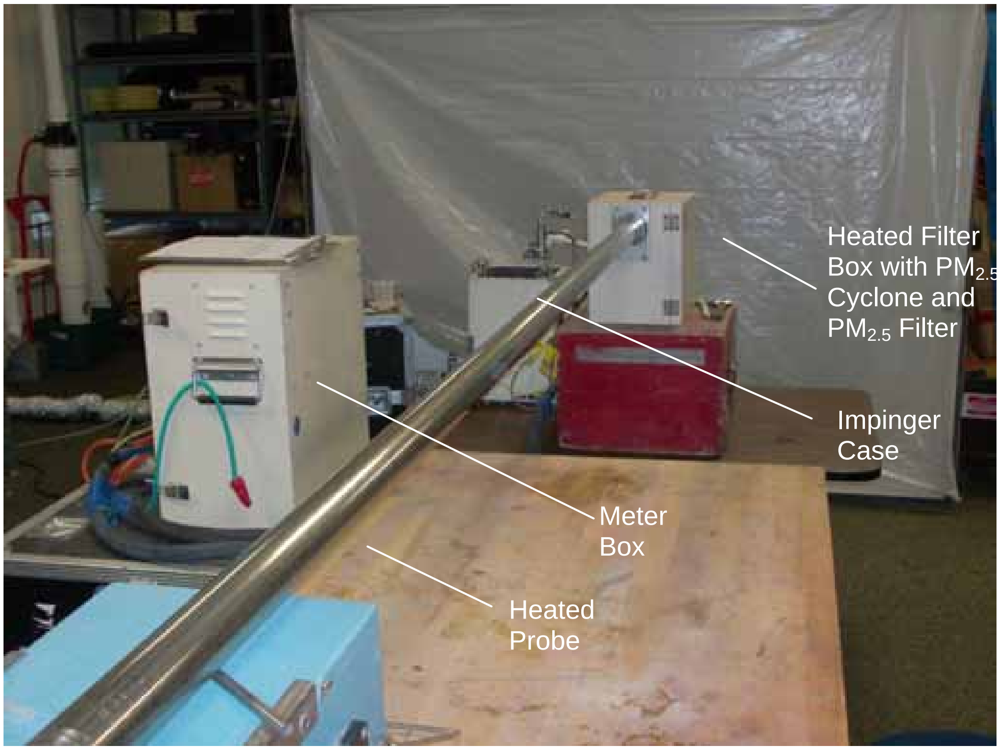


Figure 3-2. WS2.5 Sampling System Heated Probe, Heated Filter Box, Impinger Case and Meter Box

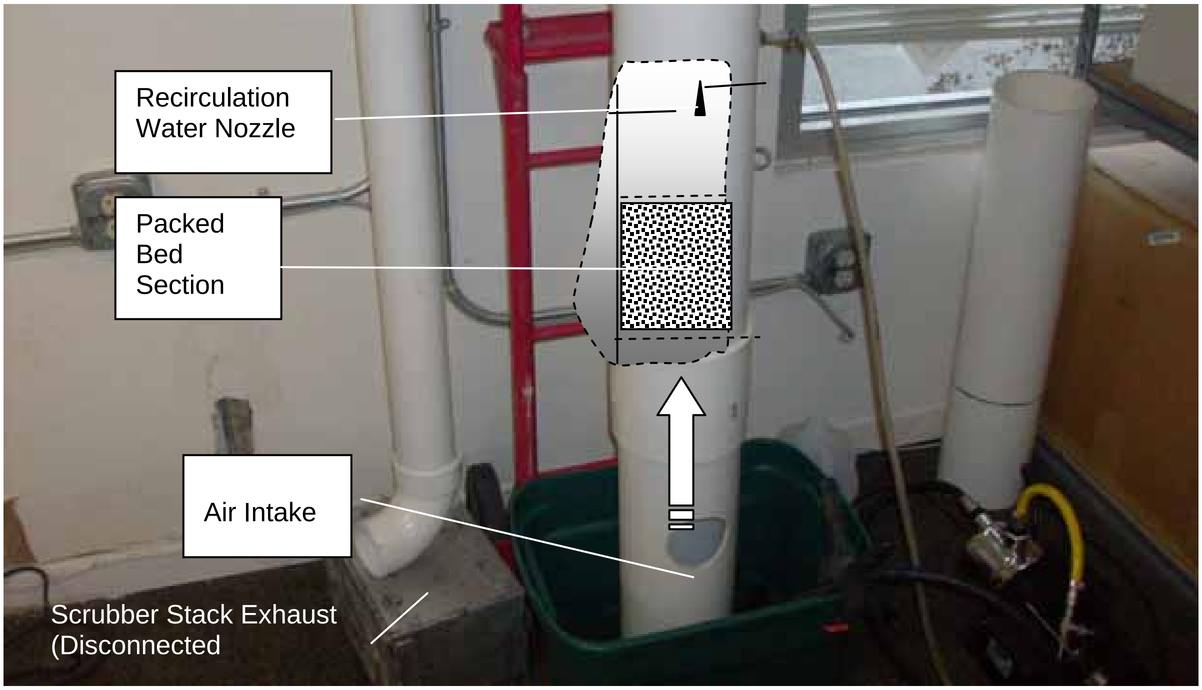


Figure 3-3. Simulated Wet Scrubber (Packed Bed)

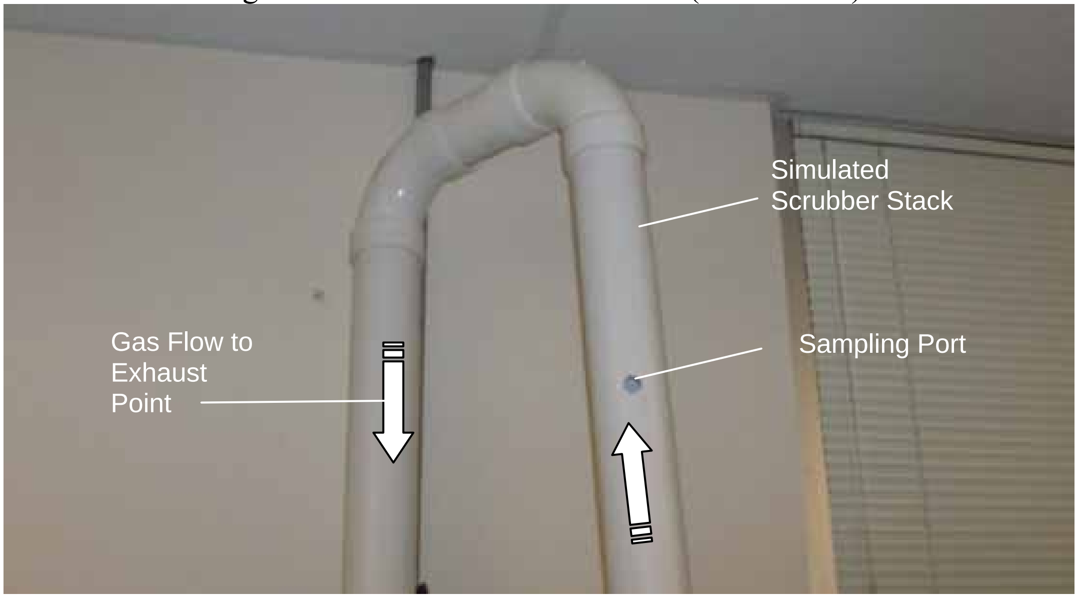


Figure 3-4. Simulated Scrubber Stack and Port

Temperature Stability Tests

During these tests, the probe sampled laboratory air having a temperature of approximately 68°F, and all three thermocouples in the probe were monitored along with one thermocouple in the filter holder. As shown in Figure 3-5, the temperatures throughout the sampling system stayed within the required range with only a brief excursion at the probe inlet.

In the first phase of the test, 1 milliliter of water was injected per minute for a period of five minutes. This quantity is approximately 113% of saturation, a level approximately seven times larger than the normal droplet loadings present in wet stacks with significant liquid reentrainment. As shown in Figure 3-5 (minutes 5 through 10), the temperatures throughout the WS2.5 sampling system stayed within the required range at this very high droplet loading. The droplets evaporated rapidly near the probe inlet and did not reach the middle of the probe. These data indicate that the WS2.5 system probe heaters provide sufficient heating.

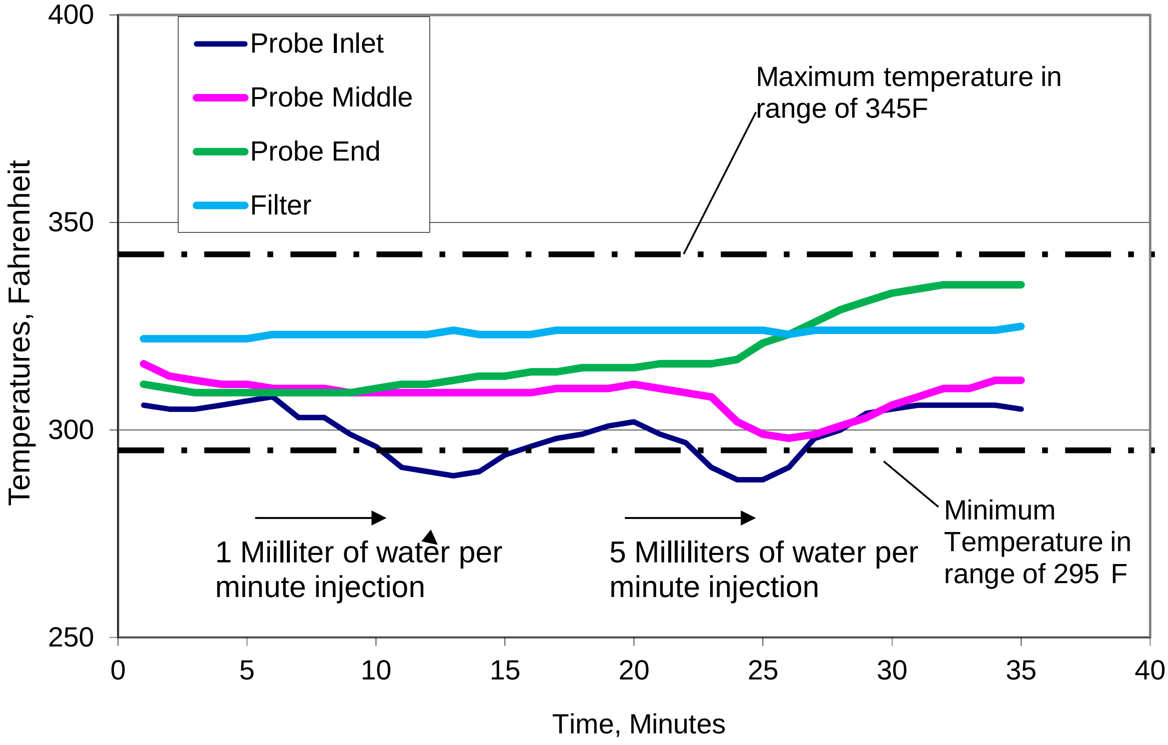


Figure 3-5. Probe and Filter Temperatures at High Droplet Loadings

During the second phase of this test, the droplet loadings were increased to the extremely high rate of 5 milliliters per minute. This is equivalent to 170% saturation, a level approximately 35 times the loadings often measured in stacks with known reentrainment problems. During this part of the test, the probe inlet temperature dropped below the minimum temperature limit, and the temperature in the middle of the probe also approached this limit. Even at these extreme droplet loadings, all portions of the sampling system except the probe inlet remained within the design temperature range. These data confirm the capacity of the probe heaters to handle heavy loadings.

As a follow-up to these temperature stability tests, the probe inlet temperatures were evaluated in a wet scrubber simulator. In this system, the probe was placed in a simulated stack having a moisture level of 101.5% saturation, a level very similar to those at scrubber systems with droplet reentrainment problems. In this test, there was no noticeable trend to lower temperatures over a 30-minute test period. These results suggest that the sampling system will remain within the design temperature range despite the capture of reentrained droplets at levels similar to those in full scale systems.

$PM_{2.5}$ Particle Capture in Probe Droplets

The possible bias to lower than true $PM_{2.5}$ measurement results caused by $PM_{2.5}$ impaction into water droplets, impaction on probe walls, and Brownian diffusion to probe walls was evaluated. The potential bias is probably small because the sample gas velocity is low at 13.81 feet per second (9.4 miles per hour). This is approximately a factor of twenty below the velocity needed to achieve even modest $PM_{2.5}$ particle capture by impaction into wall droplets or the probe walls. The vulnerability to this negative bias is reduced further by the fact that the volume of droplets in the probe is small, and the residence time prior to droplet evaporation is short. The short residence times limited particle losses to the probe wall due to Brownian diffusion and was demonstrated by the droplet injection tests addressed earlier in this report.

During the initial laboratory tests, it was not possible to confirm low-to-negligible capture of dry $PM_{2.5}$ particles in droplets in the probe. Tests using 2.0-micrometer monodisperse glass spheres (3.2 micrometers aerodynamic diameter) were inconclusive. The 2.0-micrometer glass spheres formed clusters of spheres during atomization of solutions containing the spheres. Efforts to increase the intensity of atomization, deagglomeration prior to atomization, static charge neutralization during atomization, and rapid drying of atomized droplets containing the glass spheres were unsuccessful. In each trial, the resulting clusters of 2.0-micrometer spheres were in the range of 5 to 20 micrometers physical diameter (7.9 to 32 micrometers aerodynamic diameter).

Due to the aerosol generation problems during these tests, follow-up tests were conducted during the second full- scale system test program. The follow-up laboratory tests are presented in Section 3.2 of this report. As indicated in these two later sections, the data indicate that $PM_{2.5}$ losses to the wall and/or droplets present in the probe are very small.

$PM_{2.5}$ Formation Due to Droplet Evaporation

The possible bias to higher-than-true $PM_{2.5}$ particulate matter measurements was evaluated by injecting large droplets of a 1-milliliter salt solution into the WS2.5 sampling system operating at normal temperatures and sample gas flow rates. A TECO Dataram nephelometer qualitatively measured the 10-second average $PM_{2.5}$ particulate matter concentrations formed due to droplet evaporation.

The solution contained 10.5 % by weight salt. Each injection introduced 105 milligrams (105,000 micrograms) of solids at the inlet to the WS2.5 probe. The quantity of solids that potentially would be measured as $PM_{2.5}$ was calculated by integrating the difference between the nephelometer data and the background $PM_{2.5}$concentration. The nephelometer data are illustrated in Figure 3-6.

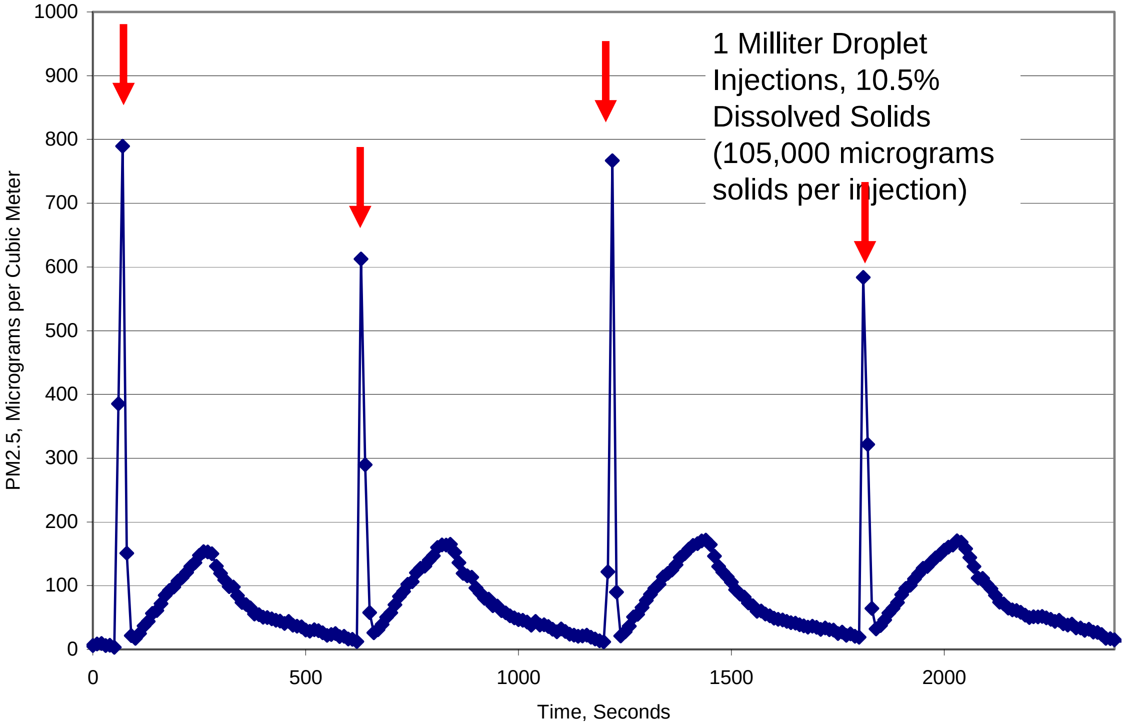


Figure 3-6. Nephelometer $PM_{2.5}$ Concentration Data

The $PM_{2.5}$ concentration profiles in Figure 3-6 indicate that there is an initial surge of $PM_{2.5}$ particles as some of the droplets rapidly evaporate to dryness. There is a second peak that is less intense and slower to form that appears to be due to the reentrainment of dried solids present in the probe due to droplet evaporation on the probe surface.

The total quantity of $PM_{2.5}$ formed from the dissolved solids was 0.013% of the total dissolved solids injected. This result demonstrates that dissolved solids in captured droplets do not result in any appreciable bias to higher-than-true $PM_{2.5}$ particulate matter measurements.

Nozzle Cut Size

A set of polydisperse glass sphere tests was conducted to evaluate the 90 degree curved nozzle 50% cut size. A mixture of water-dispersed spheres was atomized, mixed with a hot high-purity air stream, and entered the WS2.5 nozzle at a velocity of 97 feet per second. The probe was operated at 18 liters per minute with 50% of the flow due to hot dilution nitrogen.

The size distribution of the polydisperse spheres was evaluated using scanning electron microscope photomicrographs of dry samples of the material. As indicated in Figures 3-7 and 3-8, the spheres ranged in size from 5 to more than 50 micrometers physical diameter (7.9 to 80 micrometers aerodynamic diameter).

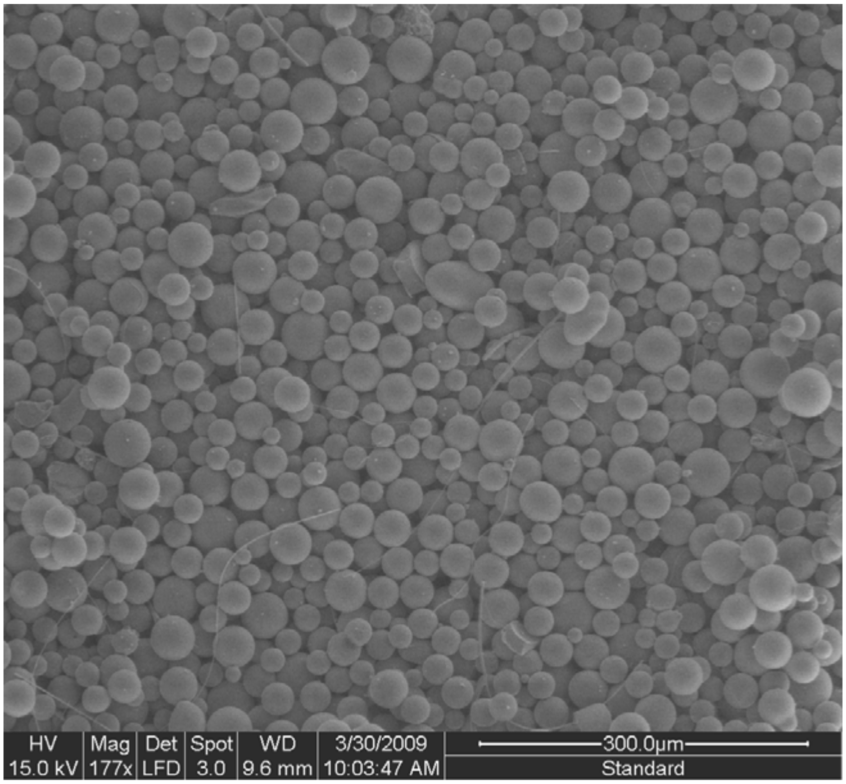


Figure 3-7. Polydisperse Spheres, Wide Field View

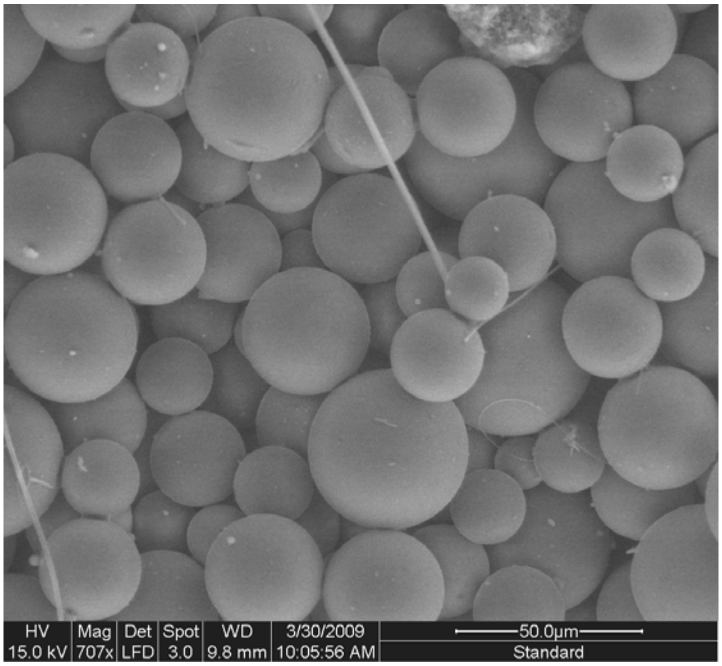


Figure 3-8. Polydisperse Spheres, Close View

Following the test runs, the quantity of material recovered in the nozzle, probe, cyclone and cyclone lines, cyclone cup, and filter were recovered and weighed. The data summarized in Table 3-1 indicate that 38% to 54% of the large diameter material successfully penetrated the nozzle and probe. Based on the mass median diameter of the particulate matter, it is apparent that the capture efficiency in the nozzle and probe are well below the levels predicted from Figure 2-4.

Table 3-1. Solids Partitioning in the WS2.5 Sampling System

Run	Weight Distribution, %				Particle Size Range, Micrometers	Particles Size, Mass Median Diameter
	Nozzle	Probe	Cyclone	Filter		
1	12.0	32.9	54.0	1.1	7.9 to 80	45
2	28.3	28.0	43.7	0	7.9 to 80	45
3	11.8	50.0	38.2	0	7.9 to 80	45
4[1]	0.5	53.1	46.4	0	7.9 to 80	45

1. Spheres were resuspended in dry form rather than in atomized droplets.

The lower-than-anticipated capture efficiency of the nozzle and probe is further indicated by photomicrographs of spheres captured in the $PM_{2.5}$ cyclone body and collection cup. Scanning electron microscope photomicrographs in Figure 3-9, 3-10, and 3-11 demonstrate that many of the spheres reaching the $PM_{2.5}$ cyclone are well above 20 micrometers.

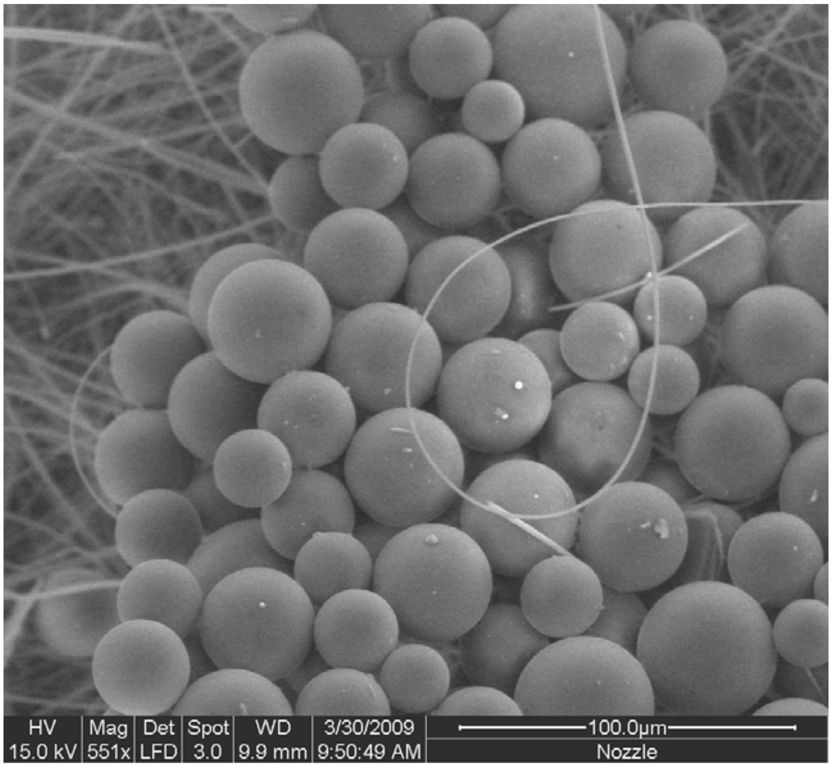


Figure 3-9. Nozzle Run 6, Close View

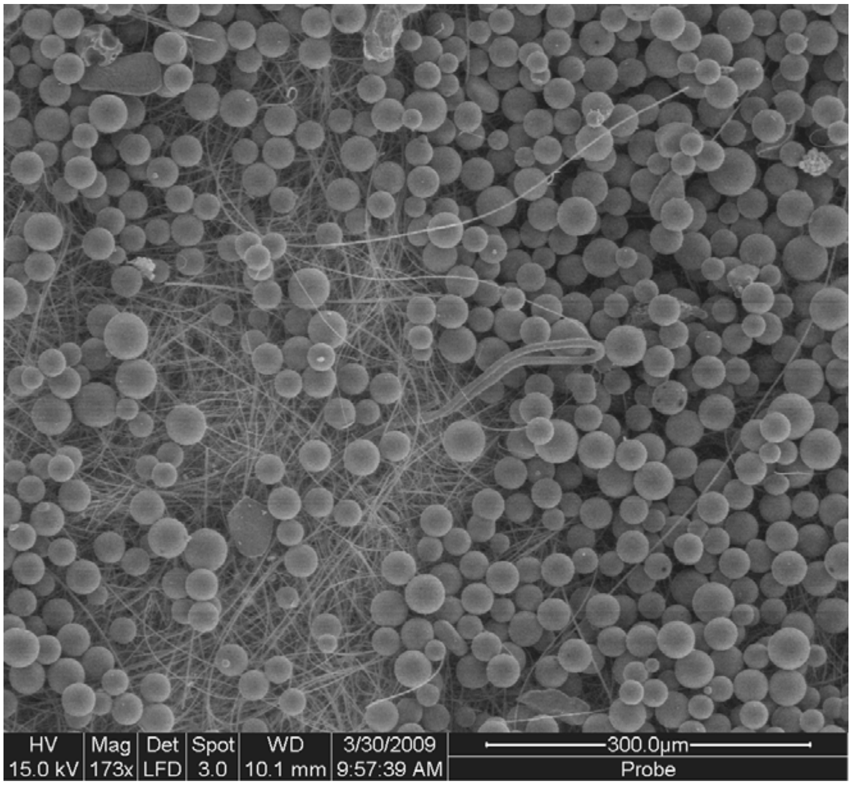


Figure 3-10. Probe Run 6, Wide View

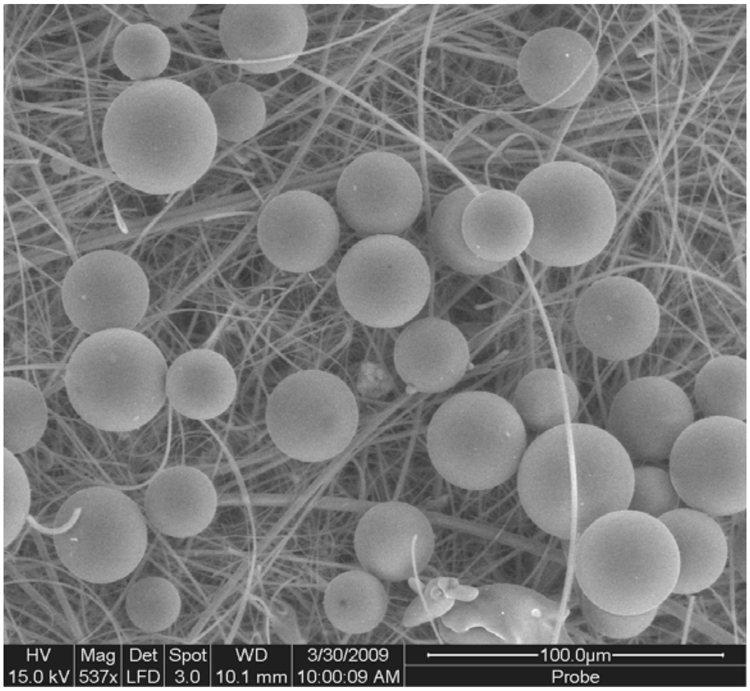


Figure 3-11. Probe Run 6, Close View

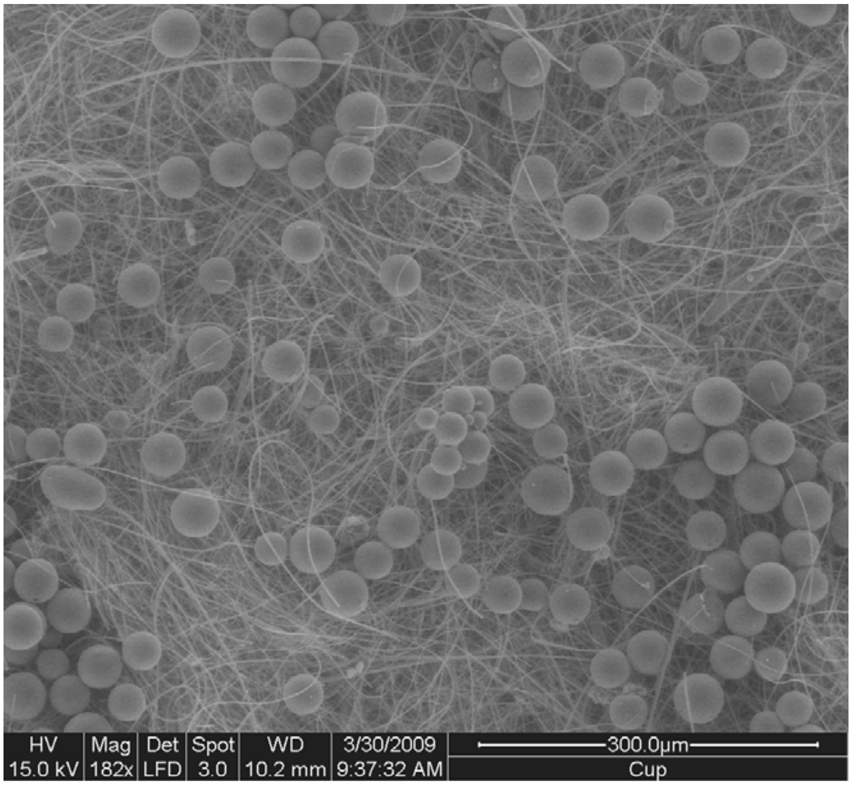


Figure 3-12. Cyclone Cup, Run 6, Wide View

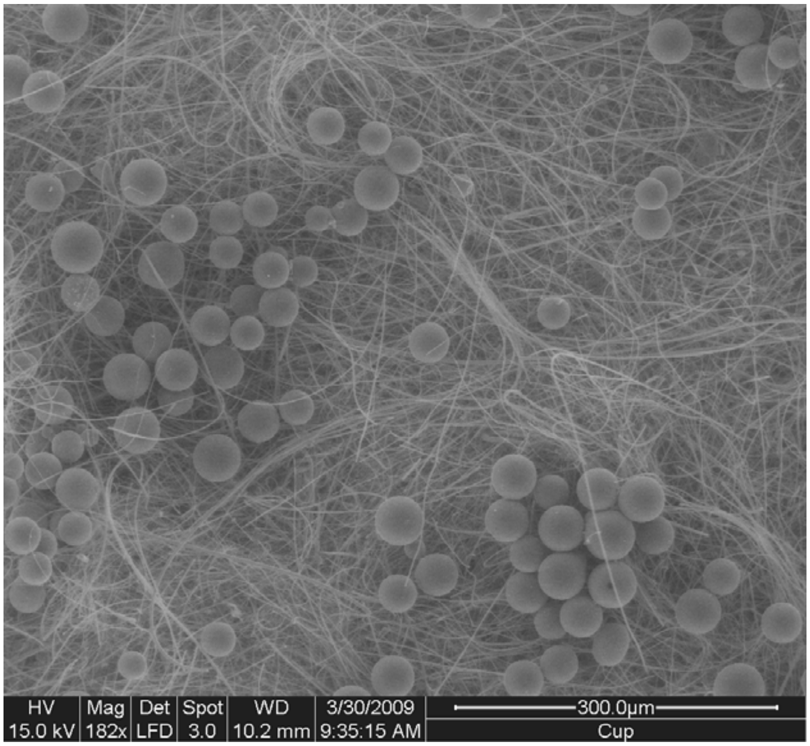


Figure 3-13. Cyclone Cup, Run 6, Wide View

Most of the spheres shown in Figures 3-12 and 3-13 are well above the 20-micrometer aerodynamic size that should be removed in the nozzle and the probe. The quantities of the greater than 20 micrometer sized (aerodynamic diameter) spheres are well below the level expected due to the shape of the theoretical collection efficiency curve shown in Figure 2-4. The large quantities of large spheres confirm the weight distribution data shown in Table 3-1. It is clear that the nozzle and the probe are not capturing relatively larger particles and droplets. This potentially biases the $PM_{2.5}$ filterable particulate matter test results to higher-than-true levels if the cyclone does not stop all of these greater than $PM_{2.5}$-sized particles.

Despite the concern of the possible positive bias, the weight partitioning data and the photomicrographs indicate that the $PM_{2.5}$ cyclone is very effective in capturing large particles. As indicated in Table 3-1, only one of the four test runs had as much as 1% of the solids passing the cyclone to reach the $PM_{2.5}$ filter. In three of the test runs, no detectable material reached the $PM_{2.5}$ filter. Considering that the sampling system inlet had no particles in the $PM_{2.5}$ size range, these results confirm proper performance of the cyclone. The effective performance of the $PM_{2.5}$ cyclone overcomes the low capture efficiency for over-sized particles in the nozzle and probe.

3.2 FOLLOW-UP LABORATORY TEST PROGRAM

Follow-up laboratory tests of the WS2.5 system were conducted following the completion of the field tests at three refinery catalytic cracking units. These follow-up tests focused exclusively on an evaluation of possible $PM_{2.5}$ particle losses to the probe walls and/or droplets present in the inlet portion of the probe.

A high pressure C-type concentric nebulizer atomized high concentration solutions of NIST-traceable monodisperse silica spheres having aerodynamic diameters ranging from 1.44 to 2.20 micrometers. These solutions were injected into a heated chamber that simulated a stack operating at temperatures of 150 to 260°F to maximize evaporation of the sphere-containing droplets. Figures 3-14, 3-15, and 3-16 illustrate the nebulizer, the heated chamber, and the nozzle and probe of the WS2.5 sampling system used in these laboratory tests.

Figure 3-14. Nebulizer and Heated Chamber

Figure 3-15. Heated Chamber and WS2.5 Sampling System Nozzle and Probe

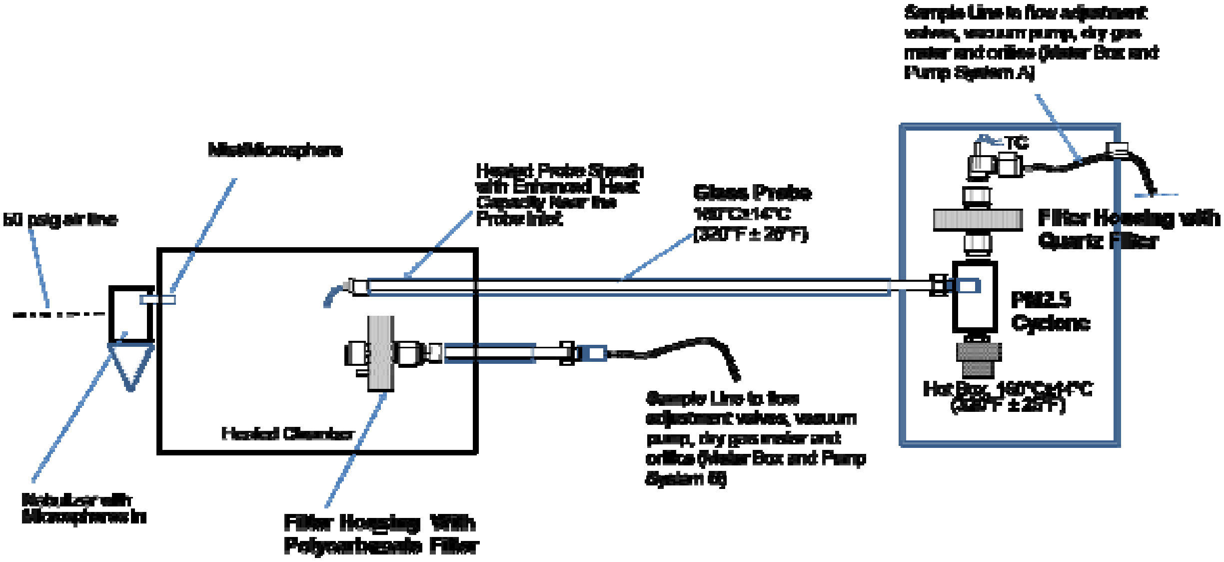


Figure 3-16. WS2.5 Sampling System and Method 17-Type Sampling System in the Heated Chamber with Microsphere Aerosol Mist Injection

Based on previous laboratory tests described in Section 3.1 of this report, it was apparent that spheres less than 2.5 micrometers do not disperse entirely due to either surface tension and/or static charge effects. According, samples of the gas stream near the WS2.5 nozzle were obtained on polycarbonate filters using a second collocated sampling system shown in Figure 3-16. This second filter used an "in-stack" Method 17 configuration to minimize any alteration of the actual size distribution of the clusters of microspheres. The Method 17 filter samples were obtained during very short sampling periods to provide a mono-layer of particles on the filter. Polycarbonate filters with 3.0 micrometer-sized pores were used in these “snapshot” oriented particle size measurements near the inlet to the WS2.5 sampling train nozzle.

The WS2.5 sampling system operated at standard sampling rates to achieve the necessary cyclone 50% cut diameter of approximately 2.5 micrometers. The WS2.5 sampling system probe and hot box operated in the normal temperature range of 320 ± 25°F. Test aerosol catch weights exceeded 10 micrograms in each of the three samples: (1) nozzle and probe, (2) cyclone catch cup and front half tubing, and (3) filter and cyclone back-half tubing. The Method 17 polycarbonate filter samples used for particle size analysis were obtained during 2-3 minute sampling periods conducted during the approximate mid-point of the WS2.5 system test run.

Research Triangle Institute (RTI) analyzed the polycarbonate filters using SEM. Air Control Techniques, P.C. used the RTI photomicrographs to count the number of individual spheres and the particle clusters of two or more spheres on the filter surface. RTI provided photomicrographs with two fields of view: (1) a 50 by 50 micrometer view and (2) a 300 by 300 micrometer view. A minimum of 300 particles and particle clusters were evaluated on each of these photomicrographs shown in Figures 3-17 to 3-20.

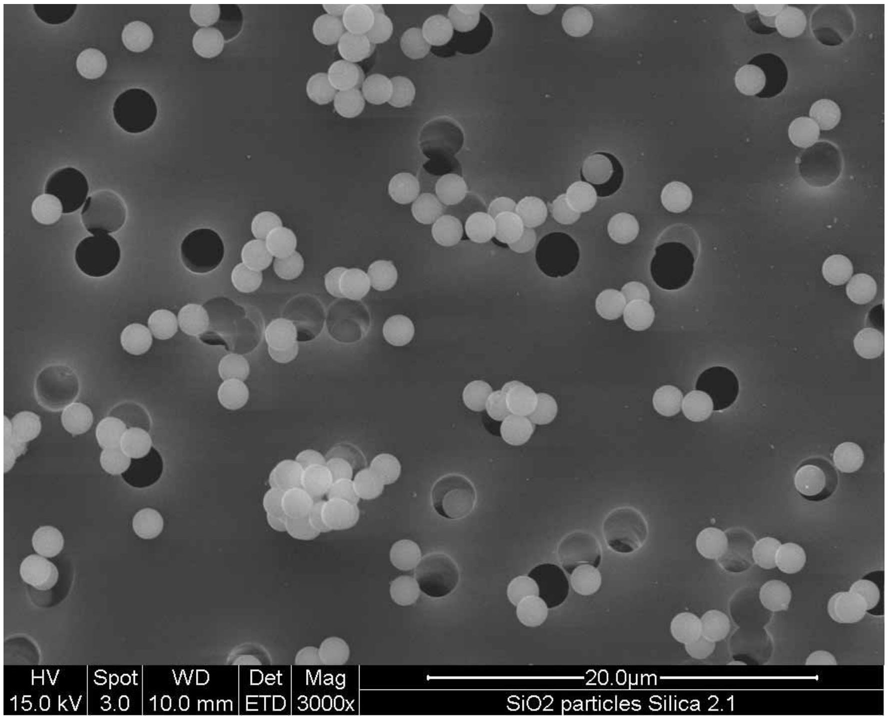


Figure 3-17 Photomicrograph of 2.1 Micrometer Silica Spheres,
50 Micrometer Field-of-View (Method 17 Sampling Train)

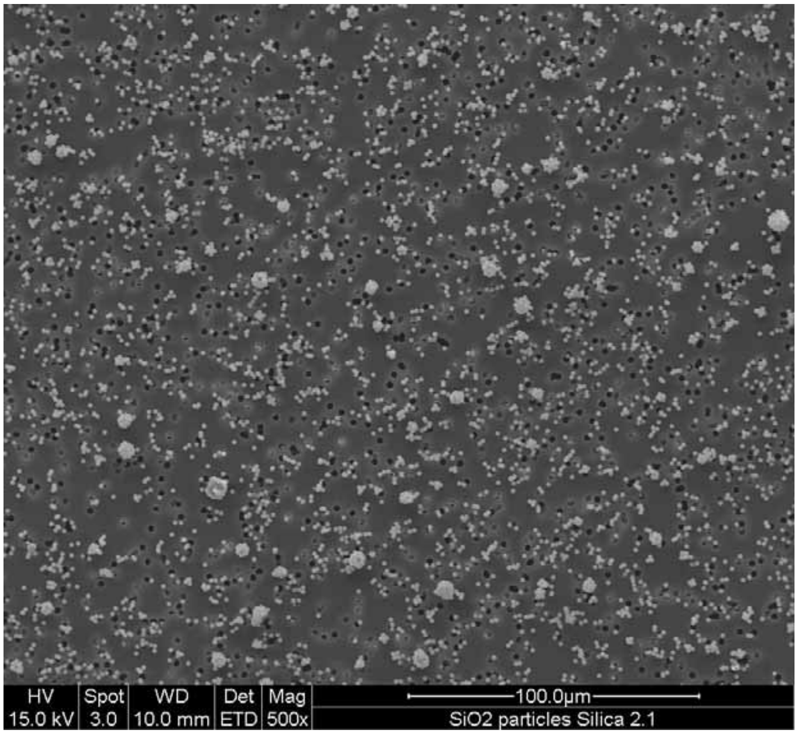


Figure 3-18. Photomicrograph of 2.1 Micrometer Silica Spheres, 300 Micrometer Field-of-View (Method 17 Sampling Train)

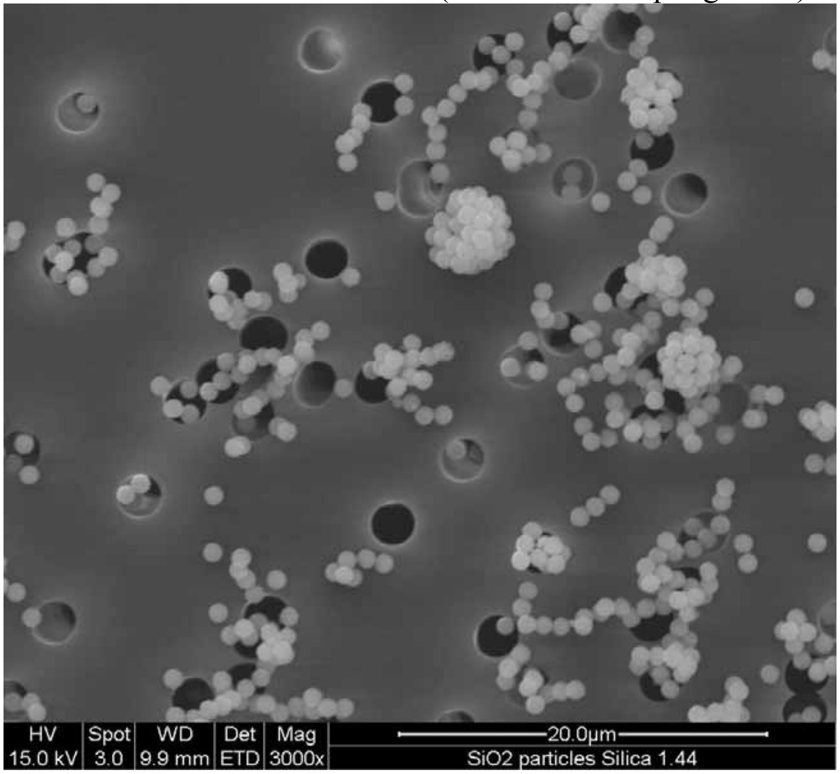


Figure 3-19. Photomicrograph of 1.44 Micrometer Silica Spheres, 50 Micrometer Field-of-View (Method 17 Sampling Train)

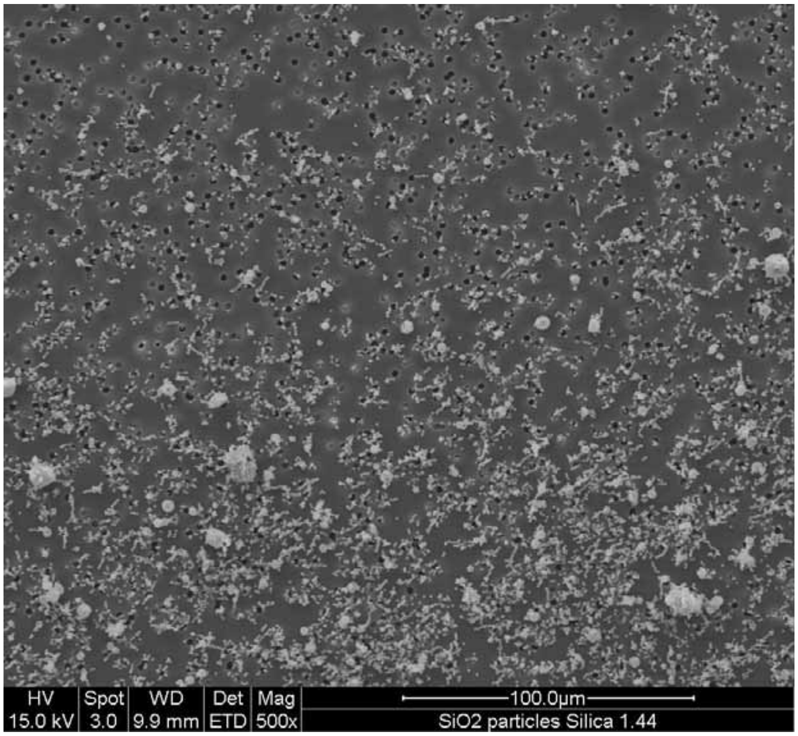


Figure 3-20. Photomicrograph of 1.44 Micrometer Silica Spheres,
300 Micrometer Field-of-View (Method 17 Sampling Train)

The equivalent aerodynamic diameters of the clusters of spheres were calculated. The expected penetration efficiency through the WS2.5 sampling system cyclone was calculated based on the size-penetration curve published in EPA Method 201A. This curve was derived from size-penetration data published between 1978 and 1990 for Cyclone IV in the Southern Research Institute five-stage sampler.

The expected test aerosol partitioning in the WS2.5 sampling train was calculated based on the SEM photograph particle/cluster size counts and the size-penetration curve for the cyclone.

Following each test run, the sample analyses included (1) the fractions of the test aerosol greater than 2.5 micrometers in the probe, nozzle, and cyclone and (2) the test aerosol equal to or less than 2.5 micrometers in the filter and cyclone back-half tubing. The results of these WS2.5 sampling system test runs are summarized in Figure 3-21.

A comparison of the expected and measured PM$_{2.5}$ fractions in the WS2.5 sampling system is summarized in Figure 3-21. It is apparent that slightly lower-than-expected levels were measured for the 2.1 micrometer-sized silica spheres.

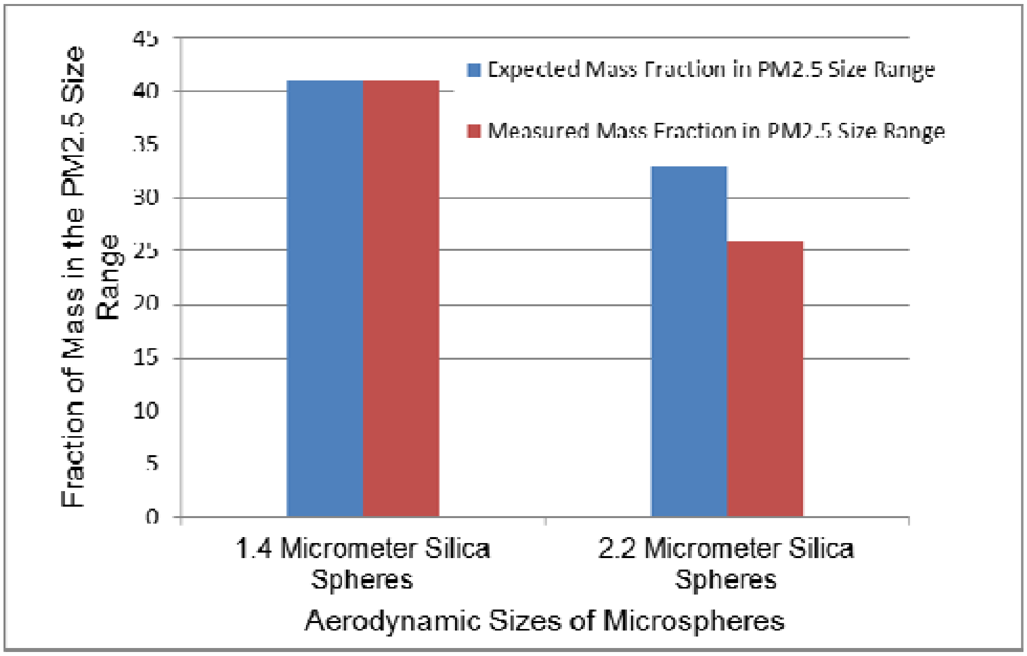


Figure 3-22. Comparison of the Expected and Measured $PM_{2.5}$ Size Fractions

The differences in the expected and measured $PM_{2.5}$ mass fractions could be due to (1) slight non-representative areas of the photomicrographs counted to generate the cluster size distributions or (2) slight differences in the actual versus the assumed cyclone size-penetration curve.

Overall, the follow-up laboratory tests indicate that $PM_{2.5}$ particles losses in the nozzle and probe of the WS2.5 wet stack $PM_{2.5}$ sampling system are small and within the range of measurement error. These results are consistent with field sampling and sample SEM analyses conducted as part of the second refinery test program described in Section 4.3 of this report.

4. CATALYTIC CRACKER STACK TEST PROGRAM

4.1 TEST METHODS

This section summarizes the results of the tests that were completed in August 2009, February 2010, and May 2010 at API member company facilities. During the field test program, two sampling trains were operated simultaneously. A WS2.5 wet stack sampling train measured filterable $PM_{2.5.}$ This sampling system operated in combination with Method 202 for condensable particulate matter. The second sampling train combined EPA Reference Methods 2, 3, 4, and 5B for total filterable particulate matter emissions with EPA 202 for condensable particulate matter emissions. At each facility, three test runs were conducted using both sampling trains.

Flue Gas Velocity and Volumetric Flow Rate Using EPA Method 2

The flue gas velocity and volumetric flow rates during the emission tests were determined according to the procedures outlined in U.S. EPA Reference Method 2. Velocity measurements were made using S-type Pitot tubes conforming to the geometric specifications outlined in Method 2. Accordingly, each Pitot tube was assigned a coefficient of 0.84. Velocity pressures were measured with fluid manometers. Effluent gas temperatures were measured with chromel-alumel thermocouples equipped with digital readouts.

Flue Gas Composition and Molecular Weight Using EPA Method 3

A multi-point, integrated gas sample was extracted from the stack during each run and collected in a leak-free Tedlar® bag. The gas stream oxygen and carbon dioxide content were determined using an Orsat gas analyzer. When available, plant continuous emission monitors were also used to monitor oxygen and carbon dioxide. The flue gas dry molecular weight was calculated in accordance with EPA Reference Method 3.

Flue Gas Moisture Content Using EPA Method 4

The flue gas moisture content during the Method 5B/WS2.5 tests was determined in conjunction with each sampling train and according to the sampling and analytical procedures outlined in EPA Method 4. The impingers were connected in series, and their contents are listed in the EPA Method 202 description. The impingers were contained in an ice bath to assure condensation of the flue gas moisture. Any moisture that was not condensed in the impingers was captured in the silica gel; therefore, all moisture was weighed and entered into moisture content calculations.

Condensable Particulate Matter Using EPA 202

EPA Method 202 was used to measure the condensable particulate matter emissions. The impinger section of the sampling train consisted of a water-cooled indirect heat exchange coil, an initially dry knock-out impinger, an initially dry impinger, a Teflon membrane filter (CPM filter), an impinger containing 100 milliliters of water, and an impinger containing pre-weighed silica gel.

The initial knockout impinger and the initially dry impinger were maintained in a water bath at or below 85°F. The sample gas stream temperature exiting the second impinger and entering the CPM filter was monitored and recorded to ensure that the temperature was at or below 85°F. Following each test run, the sample gas stream moisture captured in the impingers upstream of the CPM filter was purged with ultra-high purity (UHP) nitrogen at a rate of twenty liters per minute for one hour to remove dissolved sulfur dioxide and other soluble gases. A schematic of the Method 202 sampling train is provided in Figure 4-1.

As part of the Method 202 tests, reagent blanks were prepared for the acetone, methylene chloride, and deionized water reagents. A field blank was prepared and analyzed. The sampling train used for the field blank was charged with 100 milliliters of deionized water. The water recovered from the field blank was purged with UHP nitrogen at 20 liters per minute for one hour during the clean-up procedures.

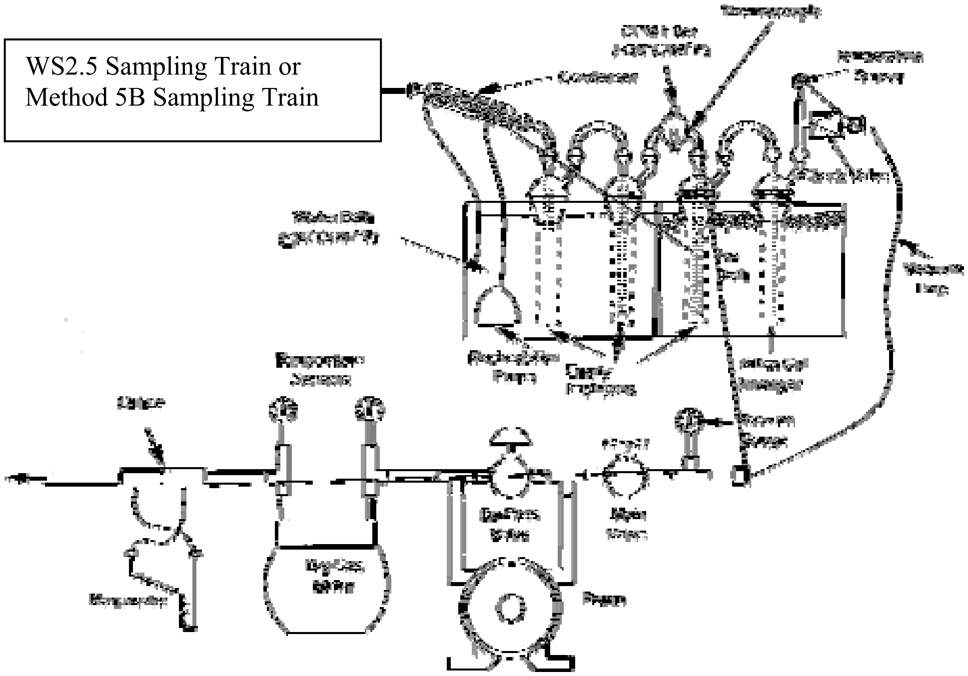


Figure 4-1. Method 202 Condensable Particulate Matter Sampling Train

The data quality objectives for the Method 202 test runs include the following parameters that were monitored and recorded.

- Post run leak check rates equal to or less than 0.02 CFM at maximum run vacuum
- CPM filter temperatures equal to or less than 85°F
- Nitrogen purge at 20 liters per minute for one hour
- Sampling train exit temperatures equal to or less than 68°F

Filterable Particulate Matter Using EPA Method 5B

Sampling System. EPA Reference Method 5B was used to determine the total filterable particulate matter emissions from each source. The testing was conducted in accordance with all applicable EPA sampling and quality assurance requirements. The test program consisted of a set of three test runs at the exhaust stack of each unit. The data quality objectives for the Method 5B tests include the following.

- Isokinetic sampling rates $\geq$ 90% and $\leq$ 110%
- Sample volumes equal to or greater than 50 DSCF
- Post-test leak check equal to or less than 0.02 DSCFM at maximum run vacuum
- No Pitot tube leaks (A and B sides) equal to or greater than 3 inches W.C.
- Sampling train exit temperatures equal to or less than 68°F
- Filter and probe temperature equal to 320±25°F

Samples were withdrawn isokinetically (100% ±10%) from the source using an EPA Method 5B sampling train. The sampling train consisted of a stainless steel nozzle, a heated glass-lined probe with an S-type Pitot tube attached, a glass fiber filter, the Method 202 impinger train, and a metering console. The filterable particulate matter sample was collected on the filter supported by a Teflon® frit and maintained at a temperature of 320±25°F.

Following each test run, the sampling train was sealed and transferred to the recovery area. Each impinger was weighed and compared to the tare weight to determine the increase due to the moisture content of the gas stream. The weight of the condensed moisture was entered into moisture content calculations. The filter was removed from the filter holder and placed in a uniquely identified petri dish. The nozzle, probe, and front half of the filter holder were rinsed with acetone into a uniquely identified glass jar.

EPA Method 5B analytical procedures were used to analyze the filters and front-half acetone rinses for filterable particulate matter. The analytical procedures included drying, desiccating, and weighing with an analytical balance capable of measuring 0.1 milligrams.

Filterable $PM_{2.5}$ Using the WS2.5 Wet Stack Sampling System

The WS2.5 sampling system shown in Figure 4-2 included a nozzle, a heated stainless steel probe, a heated $PM_{2.5}$ cyclone, and a heated 47mm quartz filter. The WS2.5 sampling system was then connected to a Method 202 impinger train. High-purity nitrogen was heated in the probe and entered the gas stream at a point immediately after the nozzle. The nitrogen reduced the sample gas stream moisture content well below 100% relative humidity and helped to rapidly evaporate entrained droplets. The nitrogen injection rate was equal to the sample gas flow rate from the stack. The probe was a 1/2 inch (I.D.) stainless steel tube enclosed in a high temperature probe sheath. The sample gas stream with the nitrogen diluent was maintained at 320°F±25°F in this probe.

Sample gas flow was maintained within the $PM_{2.5}$ cyclone performance limits. The sample gas flow rate was adjusted to maintain a 2.5 ± 0.5 micrometer cut size. A total sample flow rate of approximately 0.32 cubic feet per minute was maintained. The stack sample gas flow rate was approximately 0.16 cubic feet per minute at a 1:1 nitrogen dilution rate.

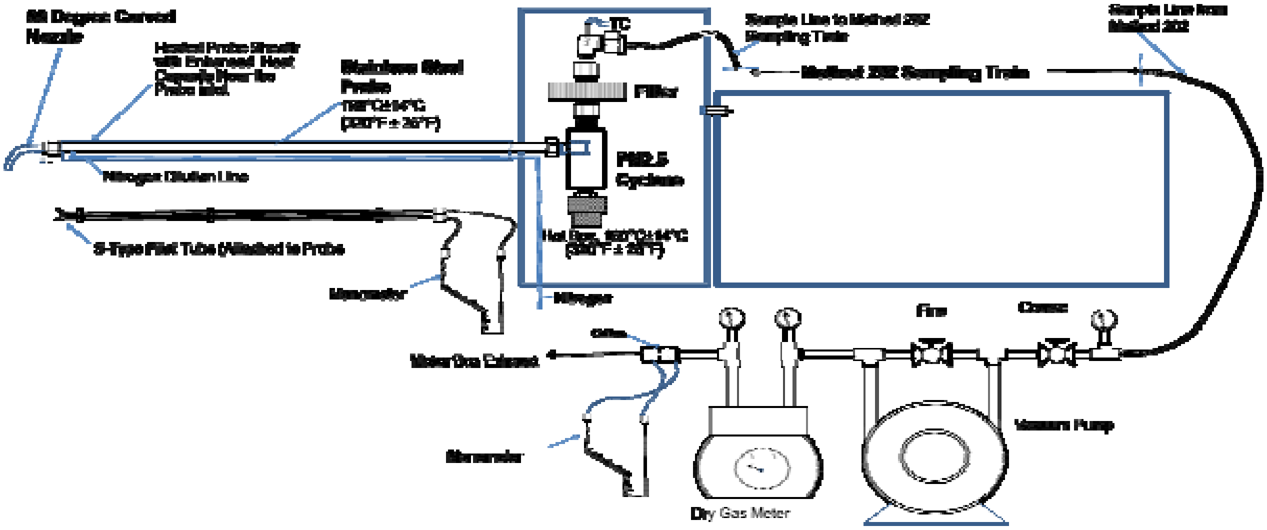


Figure 4-2. WS2.5 Sampling Train Used in FCCU Tests

The WS2.5 sampling system was used to measure both total particulate matter and $PM_{2.5}$. In a manner similar to Method 201A, total particulate matter included all of the solid material recovered from the nozzle, probe, cyclone, cyclone lines, cyclone cup, $PM_{2.5}$ filter holder (front), and $PM_{2.5}$ filter. The $PM_{2.5}$ particulate matter included only the solids recovered from the outlet tube of the $PM_{2.5}$ cyclone, the cyclone lines leading to the $PM_{2.5}$ filter holder, the $PM_{2.5}$ filter holder (front half) and the $PM_{2.5}$ filter.

The data quality objectives for the WS2.5 wet stack sampling system tests included the following.

- Isokinetic sampling rates ≥80% and ≤ 120%
- Stack gas sample volumes equal to or greater than 36 DSCF
- Pre-run leak check rates equal to or less than 0.02 DSCFM at 5 psig (pre-run leak check of entire sampling train)
- Post-run leak check rates equal to or less than 0.02 DSCFM at maximum run vacuum (post-run leak check from outlet of the filter)
- Sampling train exit temperatures equal to or less than 68°F
- Filter and probe temperature equal to 320±25°F

The WS2.5 wet stack sampling system head was recovered using a nylon brush and ultra-pure acetone rinse. The particulate matter was divided into three separate sample jars.

Sample Jar #1, Particulate Matter > 2.5 micrometers

- Solids in acetone rinse of the sampling nozzle
- Solids in acetone rinse of the probe
- Solids in acetone rinse of the $PM_{2.5}$ cyclone cup
- Solids in acetone rinse of the $PM_{2.5}$ cyclone body

Sample Jar #2, Particulate Matter ≤2.5 micrometers

- Outlet tube of the cyclone body
- Solids in inlet pipe to $PM_{2.5}$ filter
- Solids in inlet side of $PM_{2.5}$ filter housing

Sample Jar #3, Particulate Matter ≤ 2.5 micrometers

- $PM_{2.5}$ Filter

The total particulate matter is the sum of all the particulate matter recovered from the cyclone sampling assembly (sample jars #1 through #3). $PM_{2.5}$ particulate matter is the sum of the solids recovered from sample jars #2 and #3.

EPA Method 5 analytical procedures were used to analyze the filter and the front half acetone rinses for particulate matter. Standard EPA procedures were used to recover the samples. Sample recovery was performed in a sheltered location at the facility. Each sampling train was sealed to prevent contamination during transport to and from the clean-up area.

All chemicals used for sampling train preparation, sample recovery, and sample analyses were American Chemical Society (ACS), Optima grade. Deionized water exceeded the American Society for Testing Materials (ASTM) specifications for Type I reagent water.

The samples were uniquely numbered and identified. The test runs for the WS2.5 wet stack and the EPA Method 5B particulate matter sampling systems combined with the Method 202 condensable particulate matter sampling train were designated as follows.

WS2.5 wet stack sampling system – API2.5/202-1, API2.5/202-2, API2.5/202-3

EPA Method 5B sampling system – M5B/202-1, M5B/202-2, M5B/202-3

QA/QC SUMMARY

The tests were conducted using QA/QC procedures established by EPA for Method 5B, 201A and Method 202. Complete records concerning the QA/QC procedures were prepared.

Pre-test and post-test leak checks were conducted on each sampling train used during the test. The observed leak rates were below 0.02 actual cubic feet per minute. It should be noted that the WS2.5 train was post-test leaked checked from the impingers back so as not to displace solids in the $PM_{2.5}$ cyclone.

The dry gas meters were fully calibrated to determine the volume correction factor prior to field use. The post-test calibration checks were performed as soon as possible after the equipment was returned to the laboratory. Pre-and post-test calibrations agreed within ±5 percent. The calibration procedure is documented in Section 3.3.2 of EPA Publication No. 600/4-77-237b.

The scale used at the test location to determine flue gas moisture content was calibrated using a standard set of weights.

4.2. TEST PROGRAM 1, SCRUBBER-CONTROLLED FCCU

System Description

Tests were conducted at a FCCU equipped with a set of electrostatic precipitators followed by an SO_2 spray tower scrubber. During the test program, the plant operated the process and each control unit at approximately the maximum rated capacity.

System Monitoring

Plant personnel monitored and recorded the FCCU process and control equipment systems during the tests to verify representative operations. Data collected during the emission tests are presented in Table 4-1.

Table 4-1. Field Test 1, Selected Operational Parameters

Run #	Date	Time	Coke Burned lbs/hr	Scrubber Oxygen, %	Scrubber Slurry, pH
API 2.5/202-1 & M5B/202-1	8/5/09	1008-1318	35558	4.5	7.45
API 2.5/202-2 & M5B/202-2	8/5/09	1419-1724	35835	4.2	7.40
API 2.5/202-3 & M5B/202-3	8/6/09	0830-1200	34849	4.5	7.4

Sampling Location

The tests were conducted in the FCCU scrubber stack. The stack at the test site has a diameter of 138 inches, and the ports are located 88 feet (7.7 diameters) downstream of the nearest flow disturbance and 21’ 8” feet upstream (1.9 diameters) of the stack discharge. Figure 4-3 provides a sketch of the sampling location and ports.

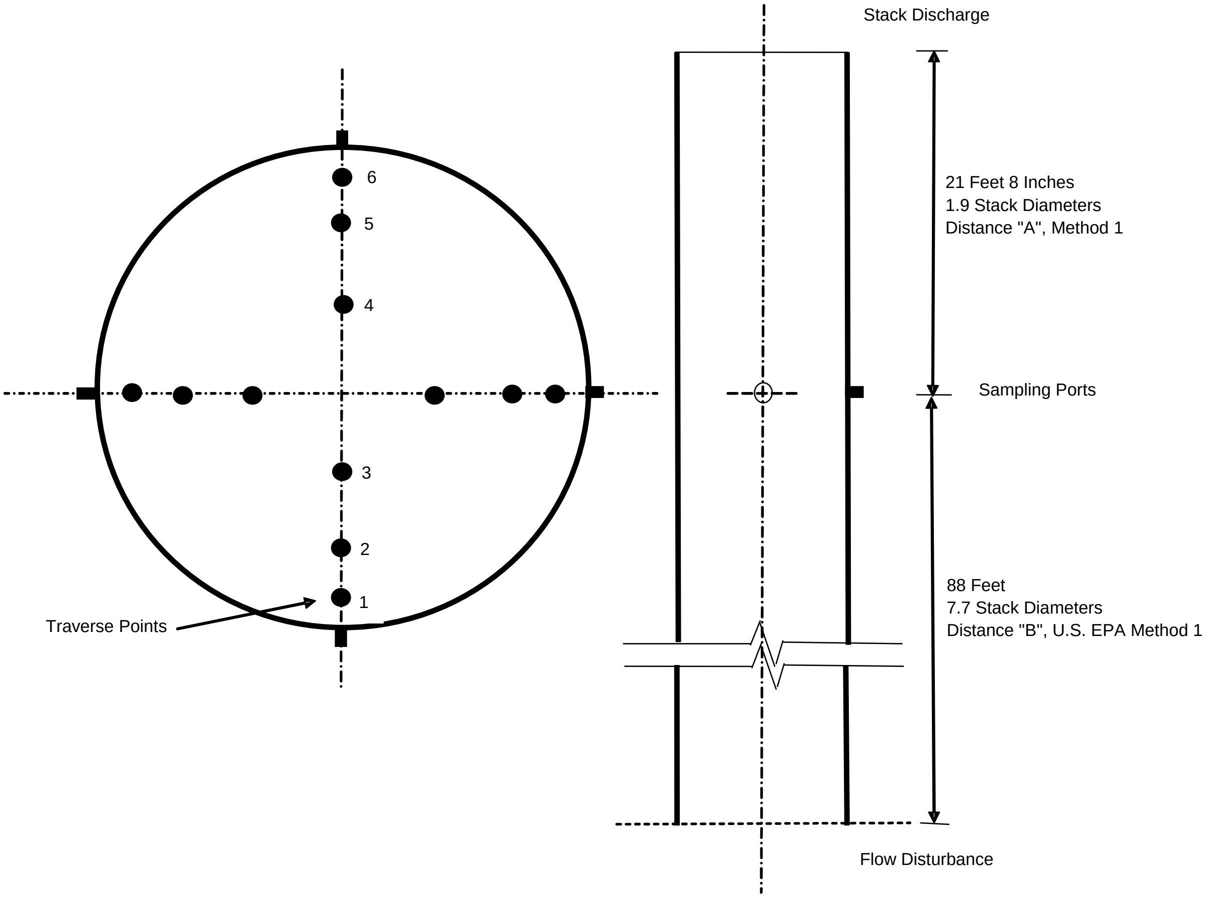


Figure 4-3. Field Test 1, FCCU Stack Sampling Ports (Sketch Not-to-Scale)

The number and location of the sampling and traverse points used in the Method WS2.5/5B tests were determined according to the procedures outlined in U.S. EPA Reference Method 1. There were twelve (12) traverse points and four sampling ports. Each port traverse consisted of 3 sampling points (4 ports, 3 points per port). The specific points sampled across each of the two complete stack traverses were at 4.4%, 14.6%, 29.6%, 70.4%, 85.4%, and 95.6% of the stack diameter, taking into account the length of the port nipple and the stack wall thickness.

During Run 2, microspheres were injected into the nozzle of the WS2.5 sampling train. No spiking was conducted during Runs 1 and 3. The microspheres were used in an attempt to evaluate capture of small particles in the probe. This evaluation was inconclusive due to problems in dispersing the microspheres into the nozzle.

Summary and Discussion of Results

Tables 4-2 and 4-3 present the test results. Emissions are presented in grains per dry standard cubic foot and pounds per hour. Quality assurance data applicable to the emission tests are presented in Tables 4-4 and 4-5.

Table 4-2. Field Test 1, Summary of Results, WS2.5 Method / Method 202

Parameter	API 2.5/202 -1	API 2.5/202-2	API 2.5/202-3	Average
Test date	8/5/09	8/5/09	8/6/09	N/A
Test time	1008-1318	1419-1721	0830-1142	N/A
Flue gas flow, DSCFM	144,800	142,500	157,060	148,120
Total filterable particulate matter emissions				
Concentration, grains/DSCF	0.005	0.010[1]	0.003	0.006
Mass emission rate, lb/hr	6.33	11.7[1]	4.01	5.17
Condensable particulate matter emissions				
Concentration, grains/DSCF	0.008	0.005	0.004	0.006
Mass emission rate, lb/hr	9.87	6.70	5.81	7.46
Filterable $PM_{2.5}$ particulate matter emissions				
Concentration, grains/DSCF	0.0019	0.0005	0.0004	0.0010
Mass emission rate, lb/hr	2.34	0.66	0.60	1.20
Total particulate matter emissions				
Concentration, grains/DSCF	0.013	0.015[1]	0.007	0.010[2]
Mass emission rate, lb/hr	16.2	18.4[1]	9.82	13.0[2]

Notes: [1] Value affected by spike of polydisperse microspheres into the nozzle during run 2.
[2] Based on test runs 1 and 3 only. Run 2 was affected by the microsphere spike.

Table 4-3. Field Test 1, Summary of Results, EPA Method 5B / Method 202

Parameter	5B/202-1	5B/202-2	5B/202-3	Average
Test date	8/5/09	8/5/09	8/6/09	N/A
Test time	1008-1314	1419-1724	0830-1200	N/A
Flue gas flow, DSCFM	143,090	145,970	144,730	144,600
Total filterable particulate matter emissions				
Concentration, grains/DSCF	0.0031	0.0033	0.0033	0.0032
Mass emission rate, lb/hr	3.80	4.15	4.09	4.02
Condensable particulate matter emissions				
Concentration, grains/DSCF	0.0050	0.0070	0.0068	0.0061
Mass emission rate, lb/hr	6.18	8.14	8.40	7.57
Total particulate matter emissions				
Concentration, grains/DSCF	0.0081	0.0098	0.0100	0.0093
Mass emission rate, lb/hr	9.98	12.3	12.5	11.6

Table 4-4. Field Test 1, Quality Assurance Results
WS2.5 Method / Method 202

Parameter	Requirement	API 2.5/202 -1	API 2.5/202-2	API 2.5/202-3
Isokinetic rate, percent	80-120	149.4	147.6	146.0
Pre-test leak check, CFM	<0.02	0.000 @ 15"	0.000 @ 15"	0.000 @ 15"
Post-test leak check, CFM	<0.02	0.000 @ 15"	0.000 @ 15"	0.000 @ 15"
Particle cut size, micrometers	2.25-2.75	2.55	2.54	2.64
Probe Temperature, °F	320±25	309-321	312-320	309-324
Filter, Cyclone Temperature, °F	320±25	301-305	298-305	299-305
CPM filter gas temp., °F	<85˚F	71 – 76	71 – 78	66 – 72
Impinger exit temp., °F	<68˚F	62 – 66	54 – 64	58 – 65
Measured Moisture, %	N/A	22.4	23.0	15.4
Saturation Moisture, %	N/A	22.5	22.5	21.3
Pre-test Pitot tube leak checks[1]				

Note:[1]No Pitot tubes were affixed to the WS2.5 sampling probes.

Table 4-5. Field Test 1, Quality Assurance Results
EPA Method 5B / Method 202

Parameter	Requirement	5B/202-1	5B/202-2	5B/202-3
Isokinetic rate, percent	90-110	100.8	102.9	99.7
Pre-test leak check, CFM	<0.02	0.000 @ 15"	0.000 @ 15"	0.000 @ 12"
Post-test leak check, CFM	<0.02	0.000 @ 8"	0.000 @ 8"	0.000 @ 8"
Probe Temperature, °F	320±25	305-315	306-319	298-324
Filter, Cyclone Temperature, °F	320±25	306-318	307-317	311-329
CPM filter gas temp., °F	<85˚F	75 – 83	76 - 77	64 – 70
Impinger exit temp, °F	<68˚F	63 – 66	62 - 65	59 – 63
Measured Moisture, %	N/A	22.4	22.5	21.8
Saturation Moisture, %	N/A	22.3	22.3	21.4
Pre-test Pitot tube leak check				
Side A (Impact), in. H_2O	0.0 @ ≥3"	0.0 @ 4"	0.0 @ 6"	0.0 @ 6"
Side B (Static), in. H_2O	0.0 @ ≥3"	0.0 @ 5"	0.0 @ 5"	0.0 @ 5"
Post-test Pitot tube leak check				
Side A (Impact), in. H2O	0.0 @ ≥3"	0.0 @ 4"	0.0 @ 4"	0.0 @ 5"
Side B (Static), in. H2O	0.0 @ ≥3"	0.0 @ 4"	0.0 @ 5"	0.0 @ 5"

As indicated in Table 4-4, all three test runs exceeded the maximum isokinetic sampling rate of 120%. This was due to the difficulty of operating two separate sampling computers to perform calculations needed to maintain the necessary cyclone cut size and the isokinetic sampling rate. The two computer systems were needed due to the complexity in sampling system control introduced by the nitrogen dilution line.

The high isokinetic sampling rates reduced the measured mass concentrations in theWS2.5 sampling train. The data sheets for Test Program 1 are provided in Volume I of this report.

4.3 TEST PROGRAM 2, ESP CONTROLLED FCCU

System Description

Tests were conducted at a FCCU equipped with a set of electrostatic precipitators. The primary purpose of these tests was to evaluate the sizes of particles captured in the nozzle, probe, cyclone, and filter.

System Monitoring

Plant personnel monitored and recorded the FCCU process and control equipment systems data during the tests to verify representative operations. Data collected during the emission tests are included in Table 4-6. These data are applicable to test runs 1, 3, and 4. Run 2 was not analyzed because the predicted $PM_{2.5}$ cut size was 2.90 micrometers—a value outside of the 2.25 to 2.75 micrometer cut size range for the WS2.5 sampling method.

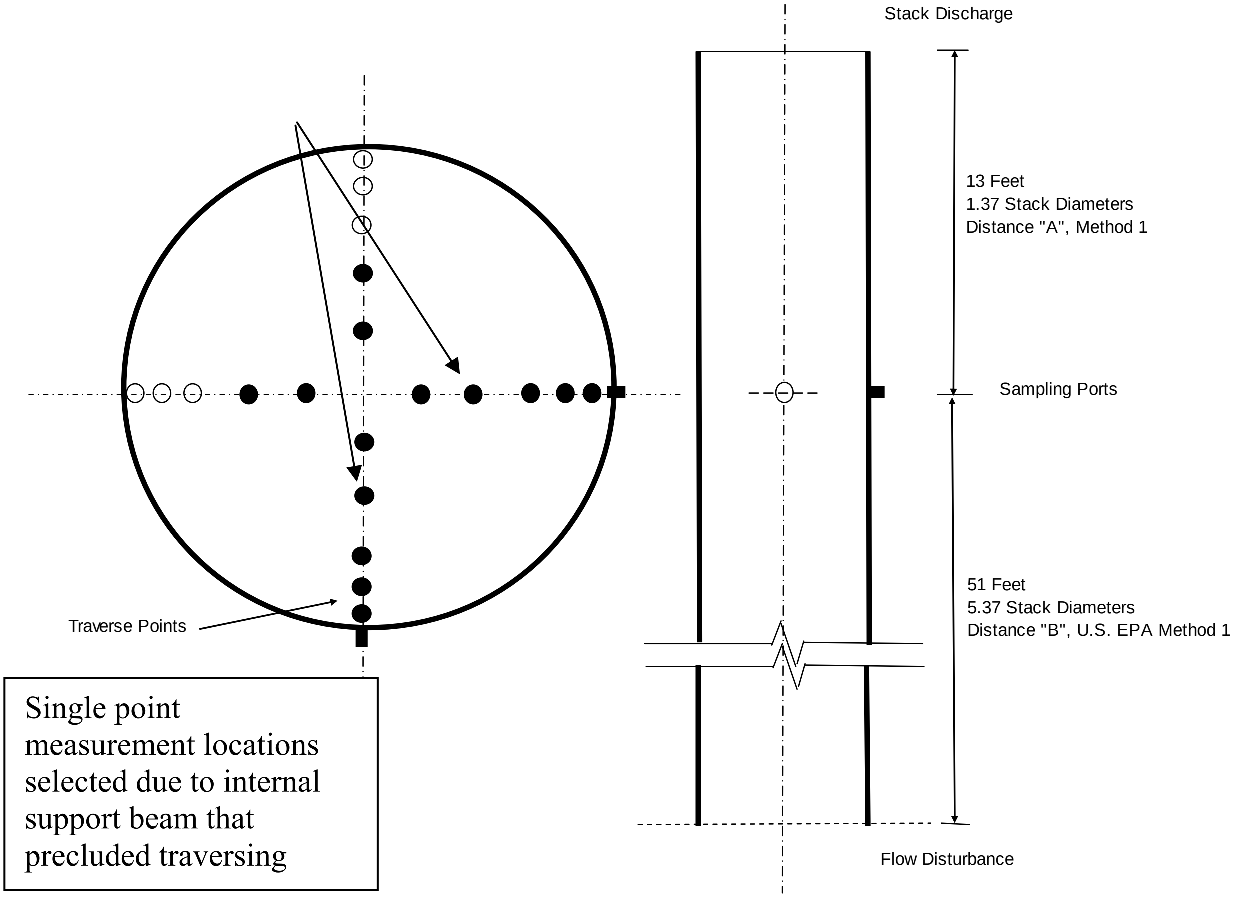
Table 4-6. Field Test 2, Selected Operational Parameters

Run #	Date	Time	Coke Burned lbs/hr	FCCU Feed BPD	SO_2 ppm @ 0% O_2
API 2.5/202-1 & M5B/202-1	2/24/10	958-1304	24,003	41,982	54.4
API 2.5/202-3 & M5B/202-3	2/25/10	0743-1043	23,844	42,482	58.3
API 2.5/202-4 & M5B/202-4	2/25/10	1135-1435	23,845	42,440	63.1

Sampling Location

The tests were conducted in the FCCU ESP stack. The stack diameter is 114 inches, and the ports are located 13 feet (1.37 diameters) downstream of the nearest flow disturbance and 51 feet upstream (5.37 diameters) of the stack discharge. Figure 4-4 provides a sketch of the sampling location, ports, and intended traverse points.

During the first test run, an internal stack support beam was encountered that prevented traversing the stack using the WS2.5 sampling train. Accordingly, both the Method 5B and WS2.5 tests were conducted at a single point that is indicated by the arrow in Figure 4-4. The single-point sampling did not impair the ability to compare the two sampling trains: however, it is not possible to determine if the emissions data from either sampling train were representative of actual emissions from the facility.



Single point measurement locations selected due to internal support beam that precluded traversing

Figure 4-4. Field Test 2, FCCU Stack Sampling Ports (Open and Closed Circles Indicate Method 1 Requires Traverse Points)

Discussion of Results

Tables 4-7 and 4-8 present the test results for the Method 5B/202 and WS2.5/202 sampling trains. Emissions are presented in grains per dry standard cubic foot and pounds per hour.

The filterable $PM_{2.5}$ emission rates were very low during all three of the WS2.5 test runs. Despite the relatively long 180-minute sampling runs, the $PM_{2.5}$ catch weights varied from 0.9 to 1.0 milligrams in the three runs, values that are close to the minimum detectable levels. The filterable $PM_{2.5}$ emission rates measured by the WS2.5 wet stack sampling train were 14% to 27% of the total filterable particulate matter emissions measured in the Method 5B sampling train. These results are consistent with previous tests using the WS2.5 sampling system at a FCCU. These results indicate that the WS2.5 is needed to avoid significant biases to higher-than-true levels inherently involved in using Method 5B total filterable particulate matter emissions as a surrogate for $PM_{2.5}$ filterable particulate matter.

Due to gas flow rate changes and a limited number of sampling nozzle sizes, there were some problems in achieving both the isokinetic sampling rates and $PM_{2.5}$ cut size requirements of the WS2.5 sampling system. During run 2, the $PM_{2.5}$ cut size was 2.90 micrometers, a value that is slightly outside of the desired 2.25 to 2.75 micrometer range. Accordingly, Air Control Technique, P.C. conducted a fourth test run.

The total filterable particulate matter emissions and filterable $PM_{2.5}$ emissions as measured by the WS2.5 wet stack sampling system were calculated based on runs 1, 3, and 4. The average filterable particulate matter emission rate was 4.27 pounds per hour, a value approximately three times higher than the 1.48 pounds per hour emission measured by Method 5B. Considering that the condensable particulate matter concentrations were approximately a factor of ten above the filterable particulate matter concentrations, it is possible that (1) some sulfuric acid or other condensable compound was captured in the long probe and/or cyclone of the WS2.5 sampling system, or (2) some submicrometer-sized ammonium chloride or ammonium sulfate particles penetrated the lightly-loaded Method 5B filter.

As indicated in Tables 4-7 and 4-8, the condensable particulate matter concentrations measured using both sampling systems ranged from 21 to 27 pounds per hour. There were no significant differences introduced by the Method 5B and WS2.5 sampling trains upstream of the Method 202 condensable particulate matter sampling equipment. The quality assurance data for these tests are presented in Tables 4-9 and 4-10.

Table 4-7. Field Test 2, Summary of Results, WS2.5 Method / Method 202

Parameter	API 2.5/202 -1	API 2.5/202 -3	API 2.5/202 -4	Average
Test date	2-24-2010	2-25-2010	2-25-2010	N/A
Test time	0958-1302	0741-1041	1135-1435	N/A
Flue gas flow, DSCFM	77,475	104,188	85,887	89,183
Total filterable particulate matter emissions				
Concentration, grains/DSCF	0.00678	0.00547	0.00464	0.00563
Mass emission rate, lb/hr	4.5	4.9	3.4	4.3
Condensable particulate matter emissions				
Concentration, grains/DSCF	0.0324	0.0307	ND	0.0316
Mass emission rate, lb/hr	21.5	27.4	ND	24.4
Filterable $PM_{2.5}$ particulate matter emissions				
Concentration, grains/DSCF	0.00036	0.00034	0.00033	0.00034
Mass emission rate, lb/hr	0.239	0.299	0.240	0.259
Total particulate matter emissions				
Concentration, grains/DSCF	0.03918	0.03617	ND	0.0377
Mass emission rate, lb/hr	26.0	32.3	ND	29.1

Table 4-8. Field Test 2, Summary of Results, EPA Method 5B / Method 202				
Parameter	5B/202-1	5B/202-3	5B/202-4	Average
Test date	2-24-2010	2-25-2010	2-25-2010	N/A
Test time	0958-1304	0743-1043	1135-1435	N/A
Flue gas flow, DSCFM	81,534	86,511	82,558	83,534
Total filterable particulate matter emissions				
Concentration, grains/DSCF	0.00253	0.00149	0.00224	0.00209
Mass emission rate, lb/hr	1.8	1.1	1.6	1.5
Condensable particulate matter emissions				
Concentration, grains/DSCF	0.03566	0.03484	0.038695	0.0364
Mass emission rate, lb/hr	24.9	25.8	27.4	26.0
Total particulate matter emissions				
Concentration, grains/DSCF	0.03819	0.03633	0.04092	0.03848
Mass emission rate, lb/hr	26.7	26.9	28.9	27.5

Table 4-9. Field Test 2, Quality Assurance Results WS2.5 Method / Method 202				
Parameter	Requirement	API 2.5/202-1	API 2.5/202-3	API 2.5/202-4
Isokinetic rate, %	80-120	117.4	103.4	114.1
Pre-test leak check, CFM	<0.02	0.000 @ 15"	0.000 @ 15"	0.000 @ 15"
Post-test leak check, CFM	<0.02	0.000 @ 15"	0.000 @ 15"	0.000 @ 15"
Particle cut size, micrometers	2.25-2.75	2.66	2.74	2.66
Probe Temperature, °F	320±25	311-424	387-423	362-424
Filter, Cyclone Temperature, °F	320±25	311-328	310-325	312-327
CPM filter gas temp., °F	<85˚F	<61	<58	N/A
Impinger exit temp., °F	<68˚F	<60	< 58	<62
Measured Moisture, %	N/A	16.6	No Data	13.2
Saturation Moisture, %	N/A	100	100	100
Pre test Pitot tube leak checks[1]				

Note: [1]No Pitot tubes were attached to the WS2.5 sampling probes.

Table 4-10. Field Test 2, Quality Assurance Results EPA Method 5B / Method 202

Parameter	Requirement	5B/202-1	5B/202-3	5B/202-4
Isokinetic rate, %	90-110	98.5	98.5	97.9
Pre-test leak check, CFM	<0.02	0.000 @ 13"	0.000 @ 15"	0.000 @ 12"
Post-test leak check, CFM	<0.02	0.000 @ 10"	0.000 @ 8"	0.000 @ 8"
Probe Temperature, °F	320±25	327-333	324-330	302-332
Filter, Cyclone Temperature, °F	320±25	296-315	297-316	297-313
CPM filter gas temp., °F	<85˚F	< 59	< 63	<67
Impinger exit temp, °F	<68˚F	< 53	< 63	< 64
Measured Moisture, %	N/A	12.3	12.7	12.9
Saturation Moisture, %	N/A	100	100	100
Pre test Pitot tube leak check				
Side A (Impact), in. H_2O	0.0 @ $\geq$3"	0.0 @ 3"	0.0 @ 3"	0.0 @ 3"
Side B (Static), in. H_2O	0.0 @ $\geq$3"	0.0 @ 3"	0.0 @ 3"	0.0 @ 3"
Post-test Pitot tube leak check				
Side A (Impact), in. H_2O	0.0 @ $\geq$3"	0.0 @ 3"	0.0 @ 3"	0.0 @ 3"
Side B (Static), in. H_2O	0.0 @ $\geq$3"	0.0 @ 3"	0.0 @ 3"	0.0 @ 3"

Scanning Electron Microscopy

In order to demonstrate that there was no $PM_{2.5}$ particle capture before the filter which that would lead to a negative bias in the sampling results, samples were analyzed from the nozzle, probe, cyclone, and filter of the WS2.5 sampling train and from a collocated in-stack Method 17 filter. These samples were sent to the Research Triangle Institute (RTI) for analysis by scanning electron microscopy (SEM) and energy dispersive X-ray. Based on the SEM analyses, an attempt was made to determine if the $PM_{2.5}$ particles were being captured in the nozzle, probe, or cyclone and thereby contributing to a negative bias in the $PM_{2.5}$ sampling results. The absence of this bias would be demonstrated by (1) the presence of $PM_{2.5}$ particles on the Method 17 stack gas filter sample and (2) the presence of $PM_{2.5}$ particles only on the WS2.5 sampling system filter.

Figures 4-5 and 4-6 show the samples of the particulate matter obtained on the in-stack Method 17 polycarbonate filter. The sampling time was limited to obtain only a thin layer of particles on the filter and to avoid melting the filter in the hot gas stream. The particles sizes can be estimated by comparison with the 50 micrometer size index line shown in the lower right of Figure 4-5 and by comparison with the relatively uniform 3-micrometer-sized pores through the polycarbonate filter surface. In evaluating the particle size range, it is important to note that the observed sizes represent the physical diameters. The equivalent aerodynamic diameters can be calculated by multiplying the observed physical diameter by the square root of the particle density. At an estimated particle density of 2.0 grams/cm^3, the equivalent aerodynamic diameters are 1.4 times the observed physical diameters (an observed particle of 2 micrometers on the photomicrograph has an aerodynamic diameter of 2.8 micrometers).

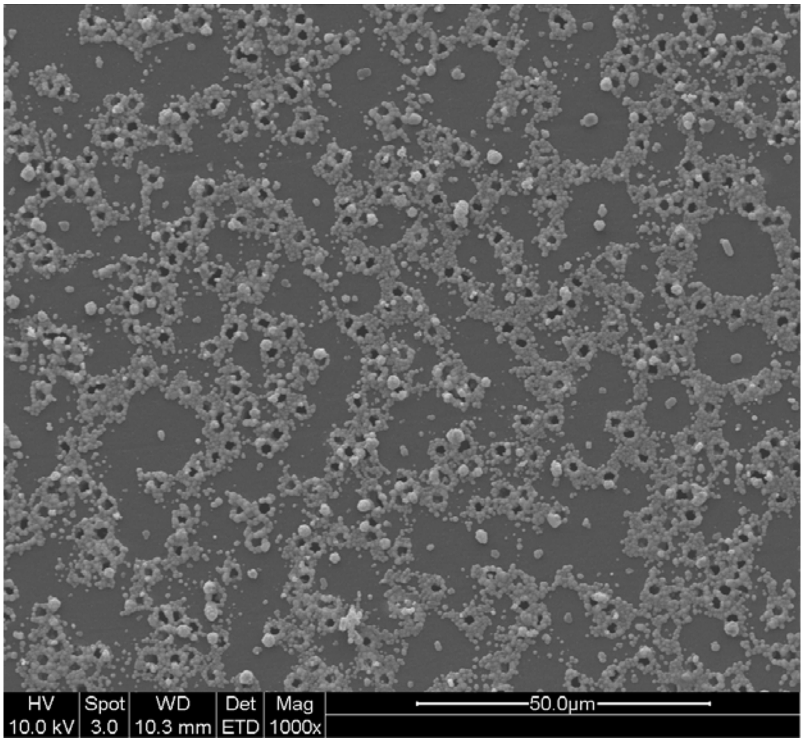


Figure 4-5. Stack Filter Sample, 1000X Magnification

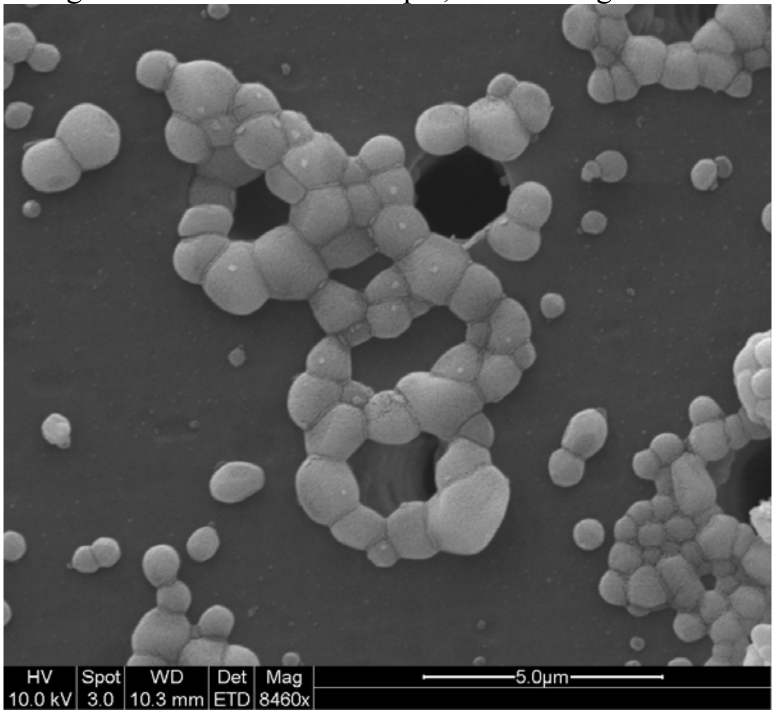
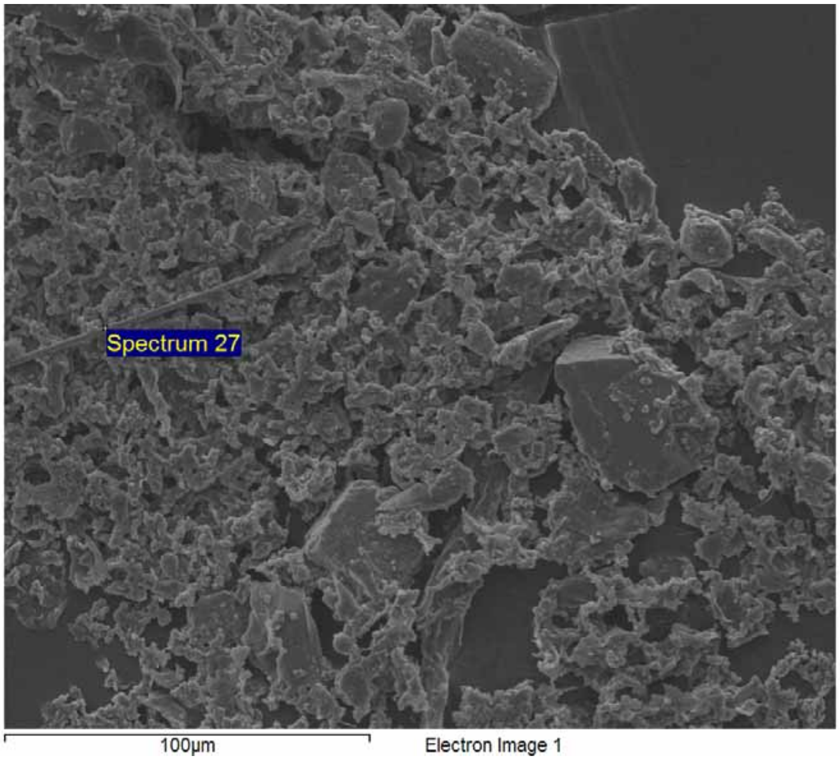


Figure 4-6. Stack Filter Sample, 8,640X Magnification

The electrostatic precipitator stack gas stream appears to have particles having aerodynamic diameters in the range of 1 to 5 micrometers. The clustering of small particles around most of the filter pores is unusual. It is possible that these particles arrived as agglomerates of fused-together particles. The agglomerated characteristics of the material surrounding the pores is shown is Figure 4-5. These clusters of smaller particles could form in the dust layers of the electrostatic precipitator collection plates where electrostatic fields of 10 to 20 kilovolts per centimeter can force the particles together prior to plate rapping. During collection plate rapping, the agglomerates can partially shatter and be reentrained back into the electrostatic precipitator outlet gas stream.

It is also possible that the agglomerates surrounding the filter pores were formed as small particles that were captured one-by-one on the filter surface; however, this filter deposition pattern is not typical of agglomeration around the pores.

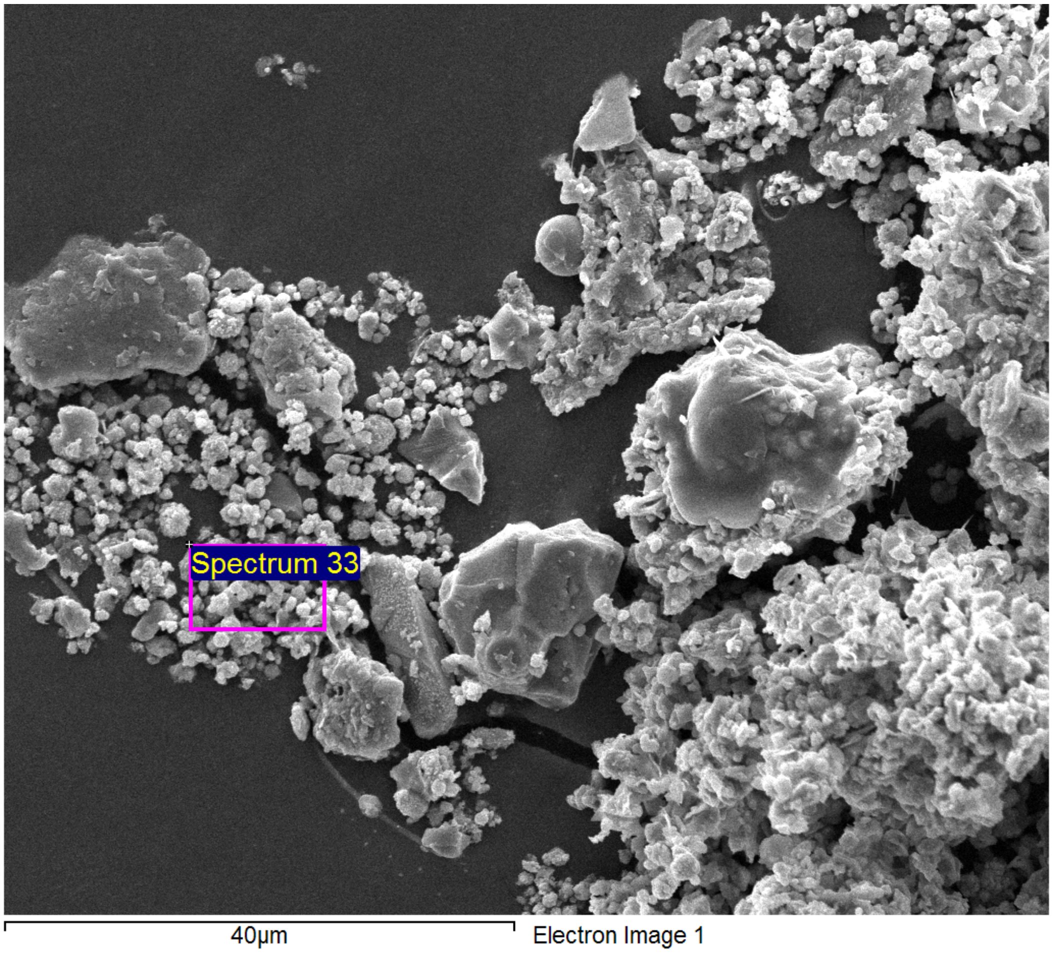
Figures 4-7 and 4-8 show the WS2.5 sampling train nozzle and probe solids. These solids appear as large flakes and sheets of material. The individual particles captured in this part of the sampling train have fused into the flakes and sheets, possibly due to contact with the acetone rinse. The size range of the particles captured in this part of the sampling train cannot be adequately determined from this sample.



Figures 4-7. Probe and Nozzle Rinse

The solids present in the $PM_{2.5}$ cyclone catch cup and rinse are shown in Figure 4-8. This sample has some large flaked material that probably broke off from larger deposits in the probe. There are also a large number of agglomerated catalyst particles in the aerodynamic size range of 2 to 10 micrometers.

There are a large number of discrete particles in the center-left and upper right of the photomicrograph. The physical diameters of these particles range from approximately 1 to more than 5 micrometers. All of the particles having physical diameters smaller than approximately 1.75 micrometers have aerodynamic diameters less than 2.5. The presence of these $PM_{2.5}$ particles in the cyclone cup and front-half rinse clearly indicates that there is some capture of $PM_{2.5}$ particles in this part of the sampling system. The $PM_{2.5}$ fraction of the cyclone cup and front-half rinse is in the range of 1 to 5% of the total mass of the probe rinse. The presence of $PM_{2.5}$ particles in this part of the sampling train is expected considering the particle size-penetration curve shown in Figure 2-4.



Figures 4-8. $PM_{2.5}$ Cyclone Cup and Front Half Rinse

The material present on the $PM_{2.5}$ filter is shown in Figures 4-9 and 4-10. Most of the individual particles and agglomerates of particles appear to be below 2 micrometers and, therefore, have an equivalent aerodynamic size of close to or below 2.5 micrometers. Figure 4-9 illustrates the presence of an agglomerated particle larger than 5 micrometers. This particle either penetrated the $PM_{2.5}$ cyclone or formed on the $PM_{2.5}$ filter from particles less than 2.5 micrometers. The presence of some larger-than-$PM_{2.5}$ particles on the $PM_{2.5}$ filter is expected due to the cyclone particle size-penetration curve shown in Method 201A for the $PM_{2.5}$ Cyclone.

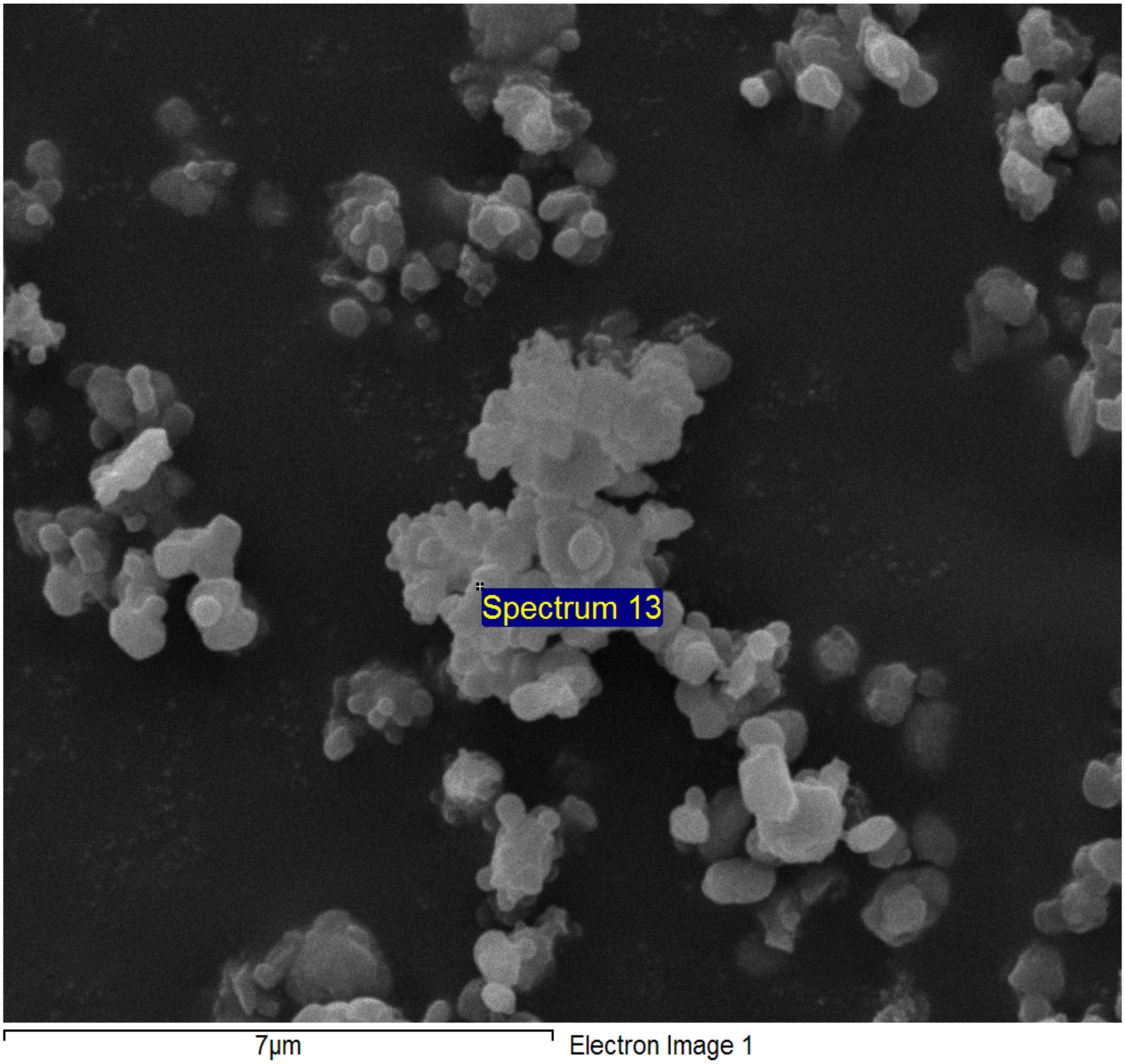


Figure 4-9. $PM_{2.5}$ Filter Sample, Photomicrograph 1

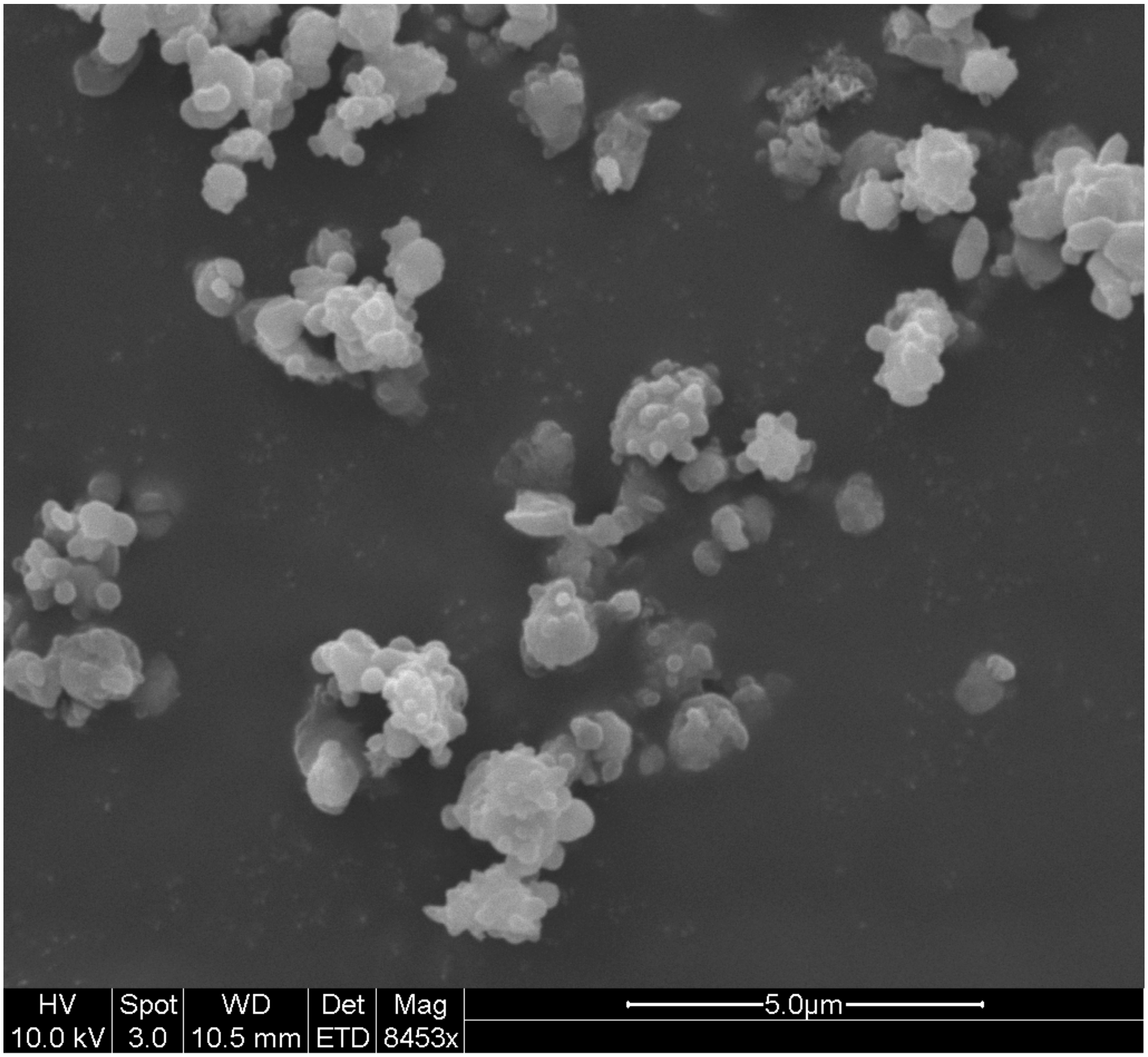


Figure 4-10. $PM_{2.5}$ Filter Sample, Photomicrograph 2.

In summary, the agglomerating characteristics of the particles have limited the usefulness of the SEM analyses to confirm the proper operation of the WS2.5 sampling train. The fraction of the mass less than 2.5 micrometers (aerodynamic) cannot be determined from the Method 17 in-stack polycarbonate filter. The samples from the WS2.5 sampling train $PM_{2.5}$ filter appear to demonstrate that the sampling train is performing properly—most of the $PM_{2.5}$ particles appear to be only in this part of the sampling train; however, the samples from the nozzle/probe and the $PM_{2.5}$ cyclone cup have fused/agglomerated particulate matter, and the initial particle sizes prior to capture in the sampling train cannot be accurately evaluated.

Based on the SEM analyses, it was especially important to conduct additional laboratory tests with NIST-traceable monodisperse spheres to accurately characterize the particle separation characteristics of the WS2.5 sampling train. These additional laboratory tests are discussed in Section 3.2 of this report. The data sheets for Test Program 2 are provided as Volume II of this report.

4.4 TEST PROGRAM 3, SCRUBBER CONTROLLED FCCU

System Description

Tests were conducted at an FCCU equipped with a set of electrostatic precipitators followed by an SO_2 spray tower scrubber.

System Monitoring

Plant personnel monitored and recorded the FCCU process and control equipment systems data during the tests to verify representative operations. Data collected during the emission tests are presented in Table 4-11.

Table 4-11. Field Test 3, Selected Operational Parameters

Run #	Date	Time	Coke Burned lbs/hr	FCC Feed bbl/day	Scrubber Oxygen, %
API 2.5/028-1 & M5B/028-1	5/27/10	9:49-13:54	23,394	33,202	2.9
API 2.5/028-2 & M5B/028-2	5/27/10	14:58-18:07	22,354	32,296	3.1
API 2.5/028-3 & M5B/028-3	5/27/10	20:12-23:18	21,587	32,237	3.2

Sampling Location

The tests were conducted in the FCCU wet scrubber stack. The stack at the test site has a diameter of 98.5 inches, and the ports are located 73.8 feet (9.0 diameters) downstream of the nearest flow disturbance and 79.6 feet upstream (9.7 diameters) of the stack discharge. The stack diameter was confirmed using two separate sets of ports located 90 degrees apart. Figure 4-11 provides a sketch of the sampling location and ports.

The number and location of the sampling and traverse points used in the Method 5B/WS2.5 tests were determined according to the procedures outlined in U.S. EPA Reference Method 1. Eight traverse points were used (4 points in each of 2 traverses). The specific points sampled across each of the two complete stack traverses were at 4.4%, 14.6%, 29.6%, and 70.4% of the stack diameter, taking into account the length of the port nipple and the stack wall thickness.

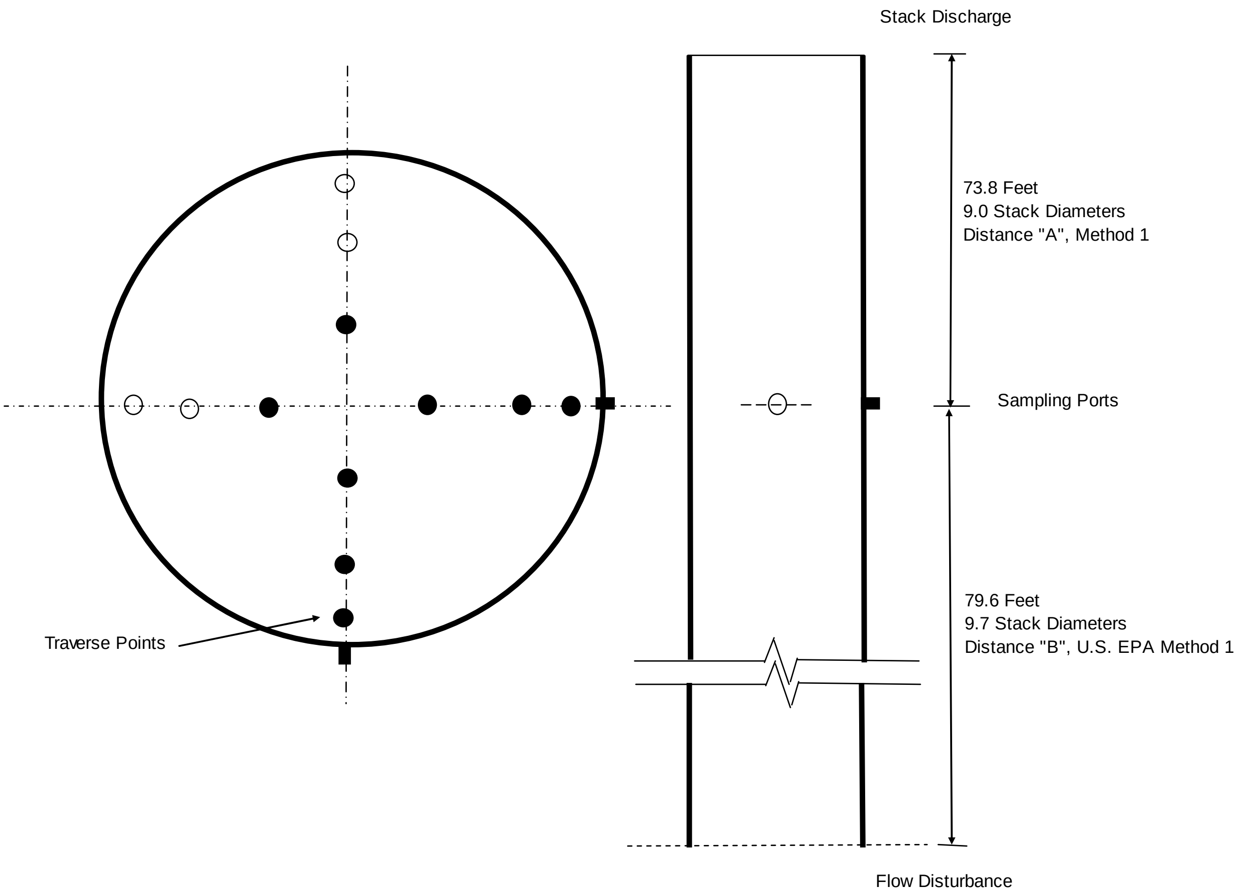


Figure 4-11. Field Test 3, FCCU Stack Sampling Ports (Open and Closed Circles Indicate Method 1 Required Traverse Points)

The normally-sampled points at the 85.4% and 95.6% positions of each traverse (shown as open circles) could not be reached with the presently available WS2.5 sampling probe. The Method 5B and WS2.5 sampling trains traversed the same eight points to facilitate a direct comparison of the test results.

Discussion of Test Results

Tables 4-12 and 4-13 present the test results for the Method 5B/202 and WS2.5 /202 sampling trains. Emissions are presented in grains per dry standard cubic foot corrected to 7% oxygen and in pounds per hour.

Table 4-12. Field Test 3, Summary of Results, EPA Method 5B/Method 202				
Parameter	5B/202-1	5B/202-2	5B/202-3	Average
Test date	5/27/2010	5/27/2010	5/27/2010	NA
Test time	0949-1354	1458-1807	2012-2318	NA
Flue gas flow, DSCFM	96,515	96,667	95,628	96,270
Total filterable particulate matter emissions				
Grains/DSCF @7%O_2	0.0031	0.0023	0.0021	0.0025
Mass emission rate, lb/hr	3.32	2.41	2.18	2.64
Condensable particulate matter emissions				
Grains/DSCF @ 7% O_2	0.0026	0.0018	0.0019	0.0021
Mass emission rate, lb/hr	2.79	1.94	2.03	2.25
Total particulate matter emissions				
Grains/DSCF @ 7% O_2	0.0057	0.0041	0.0040	0.0046
Mass emission rate, lb/hr	6.11	4.35	4.22	4.89

Table 4-13 Field Test 3, Summary of Results, WS2.5 Method / Method 202				
Parameter	API 2.5/202-1	API 2.5/202-2	API 2.5/202-3	Average
Test date	5/27/2010	5/27/2010	5/27/2010	NA
Test time	0949-1353	1458-1805	2012-2313	NA
Flue gas flow, DSCFM	97,190	96,594	96,455	96,746
Total filterable particulate matter emissions				
Grains/DSCF @ 7% O_2	0.0043	0.0045	0.0053	0.0047
Mass emission rate, lb/hr	4.61	4.73	5.54	4.96
Filterable $PM_{2.5}$ particulate matter emissions				
Grains/DSCF @7% O_2	0.0025	0.0031	NA	0.0028
Mass emission rate, lb/hr	2.84	3.34	NA	3.09
Condensable particulate matter emissions				
Grains/DSCF@ 7%O_2	0.0022	0.0051	0.0032	0.0035
Mass emission rate, lb/hr	2.41	5.44	3.35	3.73
Total particulate matter emissions				
Grains/DSCF @7% O_2	0.0065	0.0096	0.0085	0.0082
Mass emission rate, lb/hr	7.03	10.16	8.88	8.69

The measured filterable particulate matter emissions based on EPA Method 5B averaged only 2.64 pounds per hour. The condensed particulate matter measured using Method 202 in the back half of the Method 5B sampling train averaged only 2.25 pounds per hour. These emissions were similar to or below those measured during Test Program 1.

The total particulate matter emissions measured using the WS2.5 sampling system were higher than those measured with Method 5B. The measured emissions of 4.96 pounds per hour are almost twice those measured with Method 5B. There was a bias to higher-than-true total particulate matter emissions due to the movement of solids-containing droplets down the outer surface of the 90 degree curved nozzle in the WS2.5 sampling train. Testing personnel observed these droplets being pulled into the nozzle. This bias is also indicated by the differences in the captured moisture levels during the runs. As indicated in Table 4-14, the captured moisture levels for the WS2.5 sampling train averaged 21.5% by volume, while the levels for the Method 5B train averaged 18.9%. Both trains captured more moisture than possible in a saturated gas stream as expected due to the presence of entrained droplets. The WS2.5 captured a larger quantity of droplets than the Method 5B sampling system. The droplet capture issue was especially significant in Test Program 3 due to the high droplet loadings in the stack of this unit.

Table 4-14. Field Test 3, Captured Moisture Levels, WS2.5 and Method 5B Sampling Trains

Sampling Train	Parameter	Run 1	Run 2	Run 3	Average
Method 5B	Measured Moisture, % Volume	19.5	18.2	18.9	18.9
	Saturation Moisture, % Volume	18.5	18.4	18.1	18.3
	Difference, % Volume	1.0	-0.2	0.8	0.5
WS2.5	Measured Moisture, % Volume	21.7	21.6	21.3	21.5
	Saturation Moisture, % Volume	18.4	18.4	18.4	18.4
	Difference, % Volume	3.3	3.2	2.9	3.1

The excessive moisture levels observed in the WS2.5 test runs would account entirely for the difference in the total filterable particulate matter emission rates if the droplets entrained in the stack gas stream had a total solids content of approximately 0.025% by weight. This total solids concentration is within the typical range.

The behavior of droplets on the WS2.5 sampling system nozzle during the tests at Plant 3 was similar to the conditions observed in the wet stack of Plant 1. The retained/captured droplet condition in Plant 3 was even greater than in Plant 1 due to the significantly greater entrained droplet levels in the stack gas stream of Plant 3.

Based on the results from the wet stack tests at Plant 1 and 3, it was apparent that the small diameter nozzle used in the WS2.5 sampling train is vulnerable to excessive droplet capture. This could be due to water drainage down the sloped nozzle or due to a droplet inertia problem that especially affects the small nozzle. A conventional button hook nozzle would be less vulnerable to this bias to higher-than-true total filterable particulate matter concentrations.

If solids-containing droplets can evaporate to reform entrained solid particles by Rayleigh shattering, the excess droplet capture problem could contribute to a positive bias in the filterable $PM_{2.5}$ emission measurements. However, the laboratory tests conducted previously demonstrated that solid particle formation due to evaporating droplets contributed negligible particulate matter back into the sample gas stream moving through the probe. Accordingly, this bias is limited to total filterable particulate matter measurements and does not affect the accuracy of the $PM_{2.5}$ filterable particulate matter concentrations.

QA/QC Checks for Data Reduction, Validation, and Reporting

Daily quality audits were conducted using data quality indicators that require the review of the recording and transfer of raw data, calculations, and documentation of testing procedures. All data and calculations for airflow rates and isokinetic-sampling rates were recorded manually and then transferred to a portable computer. The calculations were verified by independent, manual checks. Tables 4-15 and 4-16 present QA/QC summaries for the emission test runs.

Table 4-15. Field Test 3, Quality Assurance Results WS2.5 Method / Method 202

Parameter	Requirement	WS2.5/202-1	WS2.5/202-2	WS2.5/202-3
Isokinetic rate, %	80-120	83.2	107.7	102.2
Sample volume, DSCF	>36	42.086	41.368	41.955
Probe temperature, °F	320±25	298-313	312-319	296-309
Filter/cyclone temperature, °F	320±25	314-320	310-320	296-332
Pre-test leak check, CFM	<0.02	0.000 @ 10"	0.000 @ 15"	0.000 @ 15"
Post-test leak check, CFM	<0.02	0.000 @ 10"	0.000 @ 8"	0.000 @ 8"
Particle cut size, micrometers	2.25-2.75	2.55	2.64	2.49
Measured moisture content, %	N/A	21.73	21.63	21.25
Saturation moisture content, %	N/A	18.4	18.4	18.4
CPM filter gas temp., °F	<85˚F	55-67	53-60	53-55
Impinger exit temp., °F	<68˚F	46-55	44 – 56	46 – 60
Pretest Pitot tube leak checks[1]				

[1] No Pitot tubes were attached to the WS2.5 sampling probes.

Table 4-16. Field Test 3, Quality Assurance Results EPA Method 5B / Method 202

Parameter	Requirement	5B/202-1	5B/202-2	5B/202-3
Isokinetic rate, %	90-110	101.1	99.9	97.8
Sample volumes	>50 DSCF	102.335	102.927	99.693
Filter temperature, °F	320±25	304-322	300-331	297-324
Pre-test leak check, CFM	<0.02	0.000 @ 10"	0.000 @ 8"	0.000 @ 14"
Post-test leak check, CFM	<0.02	0.000 @ 10"	0.000 @ 12"	0.000 @ 3"
Measured moisture Content, %	N/A	19.51	18.21	18.91
Saturation moisture Content, %	N/A	18.47	18.35	18.07
CPM filter gas temp., °F	<85˚F	49-67	54-61	49-55
Impinger exit temp, °F	<68˚F	48-59	54-61	44-52
Pre test Pitot tube leak check				
Side A (Impact), in. H_2O	0.0 @ $\geq$3"	0.0 @ 3"	0.0 @ 3"	0.0 @ 3"
Side B (Static), in. H_2O	0.0 @ $\geq$3"	0.0 @ 3"	0.0 @ 3"	0.0 @ 3"
Post-test Pitot tube leak check				
Side A (Impact), in. H_2O	0.0 @ $\geq$3"	0.0 @ 3"	0.0 @ 3"	0.0 @ 3"
Side B (Static), in. H_2O	0.0 @ $\geq$3"	0.0 @ 3"	0.0 @ 3"	0.0 @ 3"

The data sheets for Test Program 3 are provided as the appendix of this report.

5. COMPARISION OF FIELD TEST PROGRAMS 1, 2, AND 3

5.1 COMPARISION OF EMISSIONS

The field tests all show that the total filterable particulate matter collected by the new sampling system is higher than that collected by Method 5B. The results are summarized in Table 5-1. This positive bias is highest for results obtained on wet stacks (Tests 1 and 3) and is believed to be due to excessive droplet capture by the probe nozzle. In addition, partial capture of condensable particulate matter may have occurred in all test programs, particularly in Test 2 where extremely high SO_2 levels were probably accompanied by excess sulfuric acid, which may have condensed to increase the filterable catch for those runs.

The new sampling system does not appear to affect the measured condensable particulate levels as the Method 202 results for both sample systems agree well.

Table 5-1. Combined Data, Test Programs 1, 2, and 3

Plant	Sampling System	Total Filterable Particulate Matter, lbs/hr	Condensable Particulate Matter, lbs/hr	Total Particulate Matter, lbs/hr
1	Method 5B/202	4.00	7.56	11.56
	WS2.5/202	5.17	7.46	12.63
2	Method 5B/202	1.50	26.0	27.5
	WS2.5/202	4.30	24.4	28.7
3	Method 5B/202	2.64	2.25	4.89
	WS2.5/202	4.96	3.73	8.69

The $PM_{2.5}$ emission test results summarized in Table 5-2 indicate that the filterable $PM_{2.5}$ emissions ranged from 6% to 61% of the total filterable particulate matter emissions. The average value for the test program was 30.1%.

Table 5-2. $PM_{2.5}$ Test Results, Test Programs 1, 2, and 3

Plant	Filterable Particulate Matter, lbs/hour	Filterable $PM_{2.5}$ Particulate Matter, lbs/hour	$PM_{2.5}$ % of Total Filterable Particulate
1	5.17	1.20	23.2
2	4.30	0.26	6.0
3	4.96	3.03	61.1
		Average	30.1

Both the Method 5B and WS2.5 sampling trains operated within the 320 ± 25°F temperature range. The WS2.5 sampling train had no significant problems with temperature control despite the heavy droplet loadings in the stack of Plant 3 and the heavy rain hitting the exterior portions of the probe.

5.2 RECOMMENDATIONS CONCERNING THE WET STACK FILTERABLE $PM_{2.5}$ SAMPLING SYSTEM

Based on this development and testing program, Air Control Techniques, P.C. recommends that the wet stack $PM_{2.5}$ sampling system consist of a precutter nozzle, a modified glass-lined probe with high capacity probe electrical resistance heaters, and a heated sampling box with a $PM_{2.5}$cyclone and $PM_{2.5}$ filter. Quartz filters should be used. The sampling system should operate at a sample gas flow rate of 0.4 to 0.65 ACFM and a temperature of 320±25°F. Runs should be two to three hours.

The results of the laboratory and refinery tests demonstrate that the WS2.5 wet stack $PM_{2.5}$ sampling system can meet the following performance objectives of this method development project.

- Isokinetic sampling rates in the range of 100% ± 20%
- Droplet 50% cut point of 20 micrometers in the nozzle and probe
- Temperatures in the range of 320 ± 25°F in the probe, $PM_{2.5}$ cyclone, and $PM_{2.5}$ filter even when sampling gas streams with droplet loadings of 0.40 grams per cubic meter
- Minimal positive bias caused by evaporative shattering of solids-containing droplets
- Measurement of filterable $PM_{2.5}$ independently from condensable $PM_{2.5}$
- Minimal loss of dry $PM_{2.5}$ particles in the nozzle and probe

The WS2.5 wet stack filterable $PM_{2.5}$ sampling method is a logical extension of Method 201A promulgated on December 21, 2010. Testing firms capable of properly using Method 201A will have no difficulty in conducting tests with the WS2.5 sampling train. The probe must be specially constructed; however, all the necessary components for the sampling train are readily available from established testing equipment vendors. The WS2.5 wet stack filterable $PM_{2.5}$ sampling system is compatible with standard EPA-based reference test methods and quality assurance procedures.

The need for the WS2.5 wet stack filterable $PM_{2.5}$ sampling method is clearly demonstrated by the results of the Method 5B and WS2.5 sampling system tests at three refineries. As indicated in Table 5-2, the measured filterable $PM_{2.5}$ emissions ranged from 6 to 61% of the total filterable particulate matter emissions as measured by Method 5B. The use of Method 5B total filterable particulate matter emissions data as a surrogate for filterable $PM_{2.5}$ emissions introduces a large bias to higher-than-true filterable $PM_{2.5}$ emissions.

The WS2.5 wet stack filterable $PM_{2.5}$ sampling method should be adopted by the EPA in order to avoid the development of inaccurate emissions inventories that can contribute to ineffective control strategies for $PM_{2.5}$ reduction.

REFERENCES

1. U.S. EPA, Method 201A - Method for Measurement of PM$_{10}$ and PM$_{2.5}$ Emissions – Promulgated December 21, 2010.

2. U.S. EPA, Method 202 - Method for Measurement of Condensable Particulate Matter – Promulgated December 21, 2010.

3. Richards, J. "Test Protocol: PCA PM$_{10}$/PM$_{2.5}$ Emission Factor and Chemical Characterization Testing." Portland Cement Association Research Publication SP2081, July 1996.

4. Research Triangle Institute, Desert Research Institute, and Baldwin Environmental. "Quality Assurance Project Plat for Pre-field Laboratory Quality Assurance Evaluations of PM$_{2.5}$ Dilution Monitoring Device." February 17, 2009.

VOLUME I

Appendix A – Test Results

Air Control Techniques, P.C.
Plant API Site # 1
Project 1436
Sampling Location FCC Stack

PARAMETER	NOMENCLATURE	API-2.5-1	API-2.5-2	API-2.5-3
Sampling Location				
Date		8/5/2009	8/5/2009	8/6/2009
Run Time	Theta	187.15	177.59	183.96
Nozzle Diameter	inches	0.171	0.173	0.171
Pitot Tube Coefficient	Cp	0.84	0.84	0.84
Meter Calibration Factor	Y	0.9962	0.9962	0.9962
Barometric Pressure, inches Hg	Bp - in Hg	29.60	29.60	29.70
Meter Box Pressure Differential	DH - in. H2O	0.3267	0.3375	0.3200
Volume of Gas Sampled	Vm - cu. ft.	64.376	60.602	62.768
Dry Gas Meter Temperature	Tm - °F	88.9	87.5	74.5
Nitrogen Added	cu. Ft	30.8	29.2	30.3
Total Volume of Gas Metered	cu. Ft	61.077	57.647	61.363
Volume of Gas Sampled, Dry	Vmstd - cu. ft.	30.283	28.426	31.094
Liquid Collected	ml	185.8	180.6	120.4
Volume of Water Vapor	Vwstd - cu. ft.	8.75	8.50	5.67
Moisture Content	%H20	22.41	23.02	15.42
Saturation Moisture	%H20	22.5	22.5	21.3
Dry Mole Fraction	Mfd	0.776	0.775	0.846
Carbon Dioxide	%CO2	14.9	15.5	15.4
Oxygen	%O2	2.8	2.6	2.6
Carbon Monoxide	%CO	0	0	0
Nitrogen	%N2	82.3	81.9	82
Fuel Factor	Fo	1.215	1.181	1.188
Gas Molecular Weight, Dry	Md	30.496	30.58	30.57
Gas Molecular Weight, Wet	Ms	27.696	27.749	28.630
Static Pressure	Pg - in. H2O	-0.15	-0.15	-0.15
Stack Pressure	Ps	29.59	29.59	29.69
Stack Temperature	Ts - °F	144.75	144.83	143.16
Cyclone Temperature		302.8	300.5	303.6
Average Velocity Head	Δp in H2O	0.32	0.31	0.32
Gas Velocity	vs - ft./sec.	34.70	34.20	34.29
Stack Area	As - sq. ft.	103.87	103.87	103.87
Volumetric Air Flow, Actual	Qaw - ACFM	216,228	213,123	213,714
Volumetric Air Flow, Standard	Qsd - DSCFM	144,802	142,508	157,061
Isokinetic Sampling Rate	%I	72.78	71.47	70.09
Total Filterable PM Catch	mg	10	17.7	6
Condensible Particulate	mg	15.6	10.1	8.7
PM2.5 Catch	mg	3.7	1	0.9

Air Control Techniques, P.C.
Plant API Site # 1
Project 1436
Sampling Location FCC Stack

		API-2.5-1	API-2.5-2	API-2.5-3
Total Filterable Particulate Matter Emissions				
Grains/DSCF	gr/DSCF	0.005	0.010	0.003
Grains/DSCF at 7% O2	gr/DSCF@7%O2	0.004	0.007	0.002
Pounds/Hour	lb/hr	6.325	11.738	4.009
Condensible Particulate Matter Emissions				
Grains/DSCF	gr/DSCF	0.008	0.005	0.004
Grains/DSCF at 7% O2	gr/DSCF@7%O2	0.006	0.004	0.003
Pounds/Hour	lb/hr	9.867	6.698	5.813
Filterable PM2.5 Emissions				
Grains/DSCF	gr/DSCF	0.0019	0.0005	0.0004
Grains/DSCF at 7% O2	gr/DSCF@7%O2	0.0014	0.0004	0.0003
Pounds/Hour	lb/hr	2.340	0.663	0.601
Total Particulate Matter Emissions				
Grains/DSCF	gr/DSCF	0.013	0.015	0.007
Grains/DSCF at 7% O2	gr/DSCF@7%O2	0.010	0.011	0.006
Pounds/Hour	lb/hr	16.192	18.436	9.822
Filterable PM2.5/Total Filterable PM Ratio		37.0	5.6	15.0
Cut Sizes				
Gas viscosity, (micropoise)	μ	173.0	172.5	177.6
Gas sampling rate, ACFM	Qs	0.242	0.241	0.230
Reynolds number, (dimensionless)	Nre	2402	2411	2359
Cunningham correction factor	C	1.086	1.086	1.083
PM2.5 cut diameter, (microns)	D50 Nre<3162 - PM2.5	2.55	2.54	2.64
PM2.5 cut diameter, (microns)	D50 Nre>3162 - PM2.5	2.30	2.30	2.36
Percent Difference in D50's	%	0.00	0.54	-0.12
Iterative steps		55	53	64
Iterative steps		2.55	2.53	2.64

Plant Name API Site # 1
City, State N/A
Project # 1436
Test Location FCC Scrubber Stack

PARAMETER	NOMENCLATURE	5B/O28-1	5B/O28-2	5B/O28-3
Date		8/5/2009	8/5/2009	8/6/2009
Run Time	θ	180	180	180
Nozzle Diameter	inches	0.238	0.24	0.238
Stack Area	As - sq. ft.	103.869	103.869	103.869
Pitot Tube Coefficient	Cp	0.84	0.84	0.84
Meter Calibration Factor	Y	0.9941	0.9941	0.9941
Barometric Pressure, inches Hg	Bp - in Hg	29.60	29.60	29.70
Static Pressure	Pg - in. H_2O	-0.15	-0.15	-0.15
Stack Pressure	Ps	29.59	29.59	29.69
Meter Box Pressure Differential	Δ H - in. H_2O	0.55	0.63	0.54
Average Velocity Head	Δ p - in. H_2O	0.3078	0.3214	0.3078
Volume of Gas Sampled	Vm - cu. ft.	81.662	86.592	79.321
Dry Gas Meter Temperature	Tm - °F	90.0	90.5	75.8
Stack Temperature	Ts - °F	144.6	144.7	143.1
Liquid Collected	grams	473.4	503.7	455.9
Carbon Dioxide	% CO_2	14.9	15.5	15.4
Oxygen	% O_2	2.8	2.6	2.6
Carbon Monoxide	% CO	0	0	0
Nitrogen	% N_2	82.3	81.9	82
Fuel Factor	Fo	1.215	1.181	1.188
Volume of Gas Sampled, Dry	Vmstd - cu. ft.	77.205	81.807	77.233
Volume of Water Vapor	Vwstd - cu. ft.	22.321	23.749	21.496
Moisture Content	% H_20	22.43	22.50	21.77
Saturation Moisture	% H_20	22.29	22.34	21.39
Dry Mole Fraction	Mfd	0.777	0.777	0.786
Gas Molecular Weight, Dry	Md	30.50	30.58	30.57
Gas Molecular Weight, Wet	Ms	27.71	27.77	27.88
Gas Velocity	vs - ft./sec.	34.21	34.92	34.00
Volumetric Air Flow, Actual	Qaw - ACFM	213,198	217,654	211,923
Volumetric Air Flow, Standard	Qsd - DSCFM	143,090	145,972	144,732
Isokinetic Sampling Rate	% I	100.8	102.9	99.7
Filterable Particulate Catch	mg	15.5	17.6	16.5
Organic Condensible Catch	mg	0.6	0.6	0.4
Inorganic Condensible Catch	mg	24.6	33.9	33.5
Total Condensible Catch	mg	25.2	34.5	33.9
FILTERABLE PARTICULATE EMISSIONS				
Grains/DSCF	gr/DSCF	0.003098	0.003320	0.003297
Pounds/Hour	lb/hr	3.800	4.154	4.090
CONDENSIBLE PARTICULATE EMISSIONS				
Grains/DSCF	gr/DSCF	0.005037	0.006508	0.006774
Pounds/Hour	lb/hr	6.178	8.143	8.403
TOTAL PARTICULATE EMISSIONS				
Grains/DSCF	gr/DSCF	0.008135	0.009828	0.010071
Pounds/Hour	lb/hr	9.978	12.297	12.493

VOLUME I

Appendix B – Example Calculations

EXAMPLE CALCULATIONS

Run Number: 5B/028-1

Stack Gas Temperature, °R

$$T_s = 460 + ts$$

$$T_s = 460 + 144.6 = 604.6$$

Volume of Dry Gas Sampled at Standard Conditions, Dry Standard Cubic Feet

$$V_{mstd} = [17.64][\gamma][V_m]\left[\frac{\left(P_{bar} + \frac{\Delta H}{13.6}\right)}{T_m + 460}\right]$$

$$V_{mstd} = [17.647][0.9941][81.662]\left[\frac{\left(29.60 + \frac{0.55}{13.6}\right)}{550}\right]$$

$$V_{mstd} = 77.205 \text{ ft}^3$$

Volume of Water Sampled, SCF

$$V_{wstd} = 0.04715 \text{ [Weight of Condensed Moisture]}$$

$$V_{wstd} = 0.04715\ [473.4]$$

$$V_{wstd} = 22.321 \text{ ft}^3$$

Fraction of Water Vapor in Sample Gas Stream

$$\%H_2O = \left[\frac{V_{wstd}}{V_{mstd} + V_{wstd}}\right] \times 100$$

$$\%H_2O = \left[\frac{22.321}{77.205 + 22.321}\right] \times 100$$

$$\%H_2O = 22.43$$

Dry Mole Fraction of Flue Gas

M_{fd} = 1-%H2O/100

M_{fd} = 1-[22.29/100] Must use saturation moisture for Mfd calculation.

M_{fd} = 0.777

Molecular Weight of Sample Gas, Dry

$M_d = 0.44[\%CO_2]+0.32[\%O_2]+0.28[100-\%O_2-\%CO_2]$

$M_d = 0.44[14.9]+0.32[2.8]+0.28[100-2.8-14.9]$

M_d = 30.50 pounds/pound-mole

Molecular Weight of Sample Gas, Actual Conditions

$M_s = [M_d \text{ x } M_{fd}]+[0.18 \text{ x } \%H_2O]$

$M_s = [30.50 \text{ x } 0.777]+[0.18 \text{ x } 22.29]$

M_s = 27.71 pounds/pound-mole

Average Stack Gas Velocity, Feet/second

$$vs = K_p C_p \left(\sqrt{(\Delta p)}\right)_{avg} \left[\sqrt{\frac{T_s + 460}{P_s M_s}}\right]$$

$$vs = (85.49)(0.84)\left(\sqrt{0.3078}\right)\left[\sqrt{\frac{604.6}{(29.59)(27.71)}}\right]$$

vs = 34.21 feet/second

Wet Volumetric Flue Gas Flow Rate at Stack Conditions, Cubic Feet per Minute

$Q_{aw} = 60 \text{ x vs x A}$

$Q_{aw} = 60 \text{ x } 34.21 \text{ x } 103.868907$

$Q_{aw} = 213{,}198$ Actual Cubic Feet per Minute

Dry Volumetric Flue Gas Flow Rate at Standard Conditions, Cubic Feet per Minute

$$Q_{sd} = 60 \times Mfd \times vs \times A \times \left[\frac{528}{ts + 460}\right]\left[\frac{Ps}{29.92}\right]$$

$$Q_{sd} = 60 \times 0.777 \times 34.21 \times 103.868907 \left[\frac{528}{604.6}\right]\left[\frac{29.59}{29.92}\right]$$

$Q_{sd} = 143{,}073$ Dry Standard Cubic Feet per Minute

Isokinetic Sampling Rate, Percent

$$I = \left(\frac{100\ (T_s)(V_{mstd})(29.92)}{(60)(vs)(\theta)(An)(P_s)(M_{fd})(528)}\right)$$

$$I = \left(\frac{100\,(604.6)(77.205)(29.92)}{(60)(34.21)(180)(0.00030895)(29.59)(0.777)(528)}\right)$$

$I = 100.8\ \%$

Filterable Particulate Matter Concentration, Grains per Dry Standard Cubic Foot

$$\text{gr/DSCF} = \left[\frac{CatchWeight(mg/1000)}{V_{mstd}}\right]\left[\frac{7000}{453.592}\right]$$

$$\text{gr/DSCF} = \left[\frac{0.0155}{77.205}\right]\left[\frac{7000}{453.592}\right]$$

$$\text{gr/DSCF} = 0.000310$$

Filterable Particulate Matter Emission Rate, Pounds per hour

$$\text{lb/hr} = \left(\frac{mg/1000}{453.592}\right)\times\left(\frac{Qsd}{Vmstd}\right)\times 60$$

$$\text{lb/hr} = \left(\frac{0.0155}{453.592}\right)\times\left(\frac{143{,}090}{77.205}\right)\times 60$$

$$\text{lb/hr} = 3.80$$

VOLUME I

Appendix C – Field Data

T1 301 T3 313 @ 12:05
T2 285 T4 296

T1 316 T3 335 @ 1305
T2 292 T4 314

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	M2.5-1
Condition	

IDENTIFICATION INFORMATION

Plant Name			
City			
State			
Source Number	FCC Scrubber	Date	8/5/09
Sampling Location	Stack	Start	1008
Test Personnel	TTB	Stop	1318

Meterbox ID	702233
ΔH @	1.703
Gamma, γ	0.9962
Nozzle ID	0.171 API#1
Nozzle Diameter	0.171
Orsat/Fyrite	N/A

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM	0		5

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	N/A	N/A
Pitot Tube Posttest Leak Check	N/A	N/A

Barometric Pressure, In.,Hg. 29.66 Static Pressure, In. W.C. -.15

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams		Moisture, %	
CO_2 %		Md_run	
O_2 %		Mw_run	

Sampling Information / QA Checks

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft³)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Sample Train Vac. (In. Hg)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Probe Temp., (°F)	Filter / Cyclone Temp., (°F)	CPM Filter Temp., (°F)	Dilution Flow Rate, LPM
B	1	16.87	0	760.00	0.37	86	145	2	64 .35	[illegible]	320	305	76	4.66
	2	16.64	16:53	767.05	0.36	87	145	2	64 .35	0.39	312	303	73	4.66
	3	15.44	33:31	772.92	0.31	87	145	2	62	0.34 0.34	315	300	71	4.66
C	1	16.61	48:58	778.241	0.36	89	145	2	63	[illegible] 0.32	319	300	74	4.66
	2	15.93	1:05:36	783.87	0.33	90	145	2	66	0.32	318	303	72	4.65
	3	15.14	1:21:32	789.27	0.26	90	145	2	66	0.32	315	300	73	4.67
D	1	15.44	1:35:40	794.043	0.31	89	145	2	65	0.32	315	302	73	4.67
	2	15.93	1:51:07	799.21	0.33	89	145	2	64	0.32	318	301	74	4.66
	3	13.59	2:07:03	804.50	0.24	89	145	2	63	0.32	309	305	74	4.66
A	1	15.93	2:20:38	808.991	0.33	90	144	2	63	0.32	321	303	75	4.65
	2	16.17	2:36:34	814.43	0.34	90	144	2	64	0.32	321	311	73	4.67
	3	14.91	2:52:45	819.62	0.27	91	144	2	65	0.32	317	305	74	4.67
Total Run Time			3:07:09	824.376										
Total Volume, ACF														
Averages														
					in. H2O	°F	°F			in H2O		%		microns

Run	

T1 309 T3 333
T2 293 T4 299 @ 1503

T1 307 T2 298
T3 336 T4 305 @1620

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	2
Condition	SPIKE Vial #2

IDENTIFICATION INFORMATION

Plant Name			
City			
State			
Source Number	FCC Scrubber	Date	8/5/09
Sampling Location	STACK	Start	1419
Test Personnel	TJB	Stop	1721

Meterbox ID	762233
Δ H @	1.703
Gamma, γ	0.9962
Nozzle ID	APT2
Nozzle Diameter	0.173
Orsat/Fyrite	N/A

Filter ID	Tare
N/A	

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0.000	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM	0.000		5

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	N/A →	→
Pitot Tube Posttest Leak Check	↓	N/A

Barometric Pressure, In.,Hg. 29.6 Static Pressure, In. W.C. -0.15

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams		Moisture, %	
CO_2 %		Md_run	
O_2 %		Mw_run	

Sampling Information / QA Checks

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Sample Train Vac. (In. Hg)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Probe Temp., (°F)	Filter / Cyclone Temp., (°F)	CPM Filter Temp., (°F)	Dilution Flow Rate, LPM
A-1	1	15.45	0:0	824.728	0.34	87	145	2	65	0.32	318	305	74	4.66
2	2	14.97	15:27	829.91	0.32	88	145	2	61	0.33	~~308~~ 329	300	75	4.63
3	3	13.77	30:26	834.96	0.27	86	144	2	64	0.34	320	304	76	4.65
B-1	1	15.45	44:12	839.741	0.34	87	145	2	59	0.34	318	301	74	4.67
2	2	16.11	59:39	844.95	0.37	87	145	2	57	0.34	324	300	72	4.66
3	3	12.98	1:15:46	850.95	0.24	88	145	2	60	0.34	312	299	76	4.68
C-1	1	15.45	1:28:45	854.962	0.34	88	144	2	65	0.34	317	299	78	4.65
2	2	15.45	1:44:11	859.88	0.34	89	145	2	58	0.34	318	298	78	4.66
3	3	14.27	1:59:38	865.67	0.29	88	145	2	54	0.34	315	299	71	4.66
D-1	1	15.22	2:13:54	870.611	0.33	88	145	2	64	0.34	318	298	74	4.65
2	2	14.27	2:29:08	875.88	0.29	87	145	2	61	0.34	321	302	71	4.66
3	3	12.98	2:43:24	880.82	0.24	87	145	2	62	0.34	318	301	43	4.66

Total Run Time 2:56:22 885.322

Total Volume, ACF

Averages							
	in. H2O	°F	°F	in H2O	%		microns

Run	

T_1 332 T_3 329

T_2 311 T_4 348 @ 840

T_1 313 T_3 330 @10:05

T_2 285 T_4 297

Run ID	3
Condition	

Combined Cyclone PM10 & PM2.5 Run Data Sheet

IDENTIFICATION INFORMATION

Plant Name
City
State

Source Number FCC Scrubber
Sampling Location Stack
Test Personnel TB

Date 8/7/09
Start 830
Stop 1142

Meterbox ID 702033
ΔH @ 1.703
Gamma, γ 0.9962
Nozzle ID AP-I-1
Nozzle Diameter 0.171
Orsat/Fyrite N/A

Filter ID	Tare
N/A	

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0.000	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM	0.000		10

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	N/A	N/A
Pitot Tube Posttest Leak Check	N/A	N/A

Barometric Pressure, In.,Hg. 29.7

Static Pressure, In. W.C. 0.15

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams
CO_2 %
O_2 %
Moisture, %
Md_run
Mw_run

Sampling Information / QA Checks

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Sample Train Vac. (In. Hg)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Probe Temp., (°F)	Filter / Cyclone Temp., (°F)	CPM Filter Temp., (°F)	Dilution Flow Rate, LPM
D	1	16:45	0	885800	0.37	70	~~300~~ 144	2	65	0.32	324	300	72	4.66
	2	16:45	16:27	891.38	0.37	70	143	2	61	0.32	320	299	68	4.65
	3	13.25	32:53	896.98	0.24	72	143	2	59	0.32	319	304	67	4.66
C	1	16.22	46:08	901.473	0.36	73	143	2	60	0.32	319	304	66	4.65
	2	16.00	1:02:22	907.02	0.35	74	143	2	65	0.32	317	304	66	4.67
	3	14.05	1:18:22	912.47	0.27	74	143	2	63	0.32	318	304	67	4.65
B	1	15.77	1:32:24	917.191	0.34	74	143	2	58	0.32	309	304	67	4.68
	2	16.45	1:48:10	922.55	0.37	76	149	2	59	0.32	310	304	67	4.66
	3	13.79	2:04:37	927.62	0.26	77	143	2	64	0.32	314	305	67	4.68
A	1	15.77	2:18:25	932.915	0.34	77	143	2	64	0.32	315	305	67	4.69
	2	16.00	2:34:10	938.33	0.35	78	143	2	64	0.32	315	305	68	4.68
	3	13.79	2:50:10	943.83	0.26	79	143	2	60	0.32	309	305	67	4.66

Total Run Time 3:03:58 948

948.568

Total Volume, ACF

Averages						
	in. H2O	°F	°F	in H2O	%	microns

Run

Method 4 - Air Control Techniques, P.C.

Date 8/4/09

Source Information

Client
Plant Name
City, State
Sampling Location FCCU Scrubber Stack

Job # 1436
Process Oil
Personnel TEH

Sampling Information

	API	API	API	
Run Number	2.5/028-1	2.5/028-2	2.5/028-3	
Filter Identification	SF47-873	SF47-874	SF47-875	
Sampling Date	8/5/09	8/5/09	8/6/09	
Recovery Date	"	"	"	

Moisture Data

Impinger 1				
Contents -				
Final Weight, grams	635.0	567.8	566.9	
Initial Weight, grams	460.5	396.9	460.0	
Condensed Water, grams	174.5✓	170.9✓	106.9✓	
Impinger 2				
Contents -				
Final Weight, grams	600.6	607.6	605.5	
Initial Weight, grams	600.6	607.8	605.5	
Condensed Water, grams	0.0✓	−0.2✓	0.0✓	
Impinger 3				
Contents -				
Final Weight, grams	606.9	595.6	607.5	
Initial Weight, grams	607.4	596.2	607.5	
Condensed Water, grams	−0.5✓	−0.6✓	0.0✓	
Impinger 4				
Contents -				
Final Weight, grams	594.5	596.2	594.1	
Initial Weight, grams	593.7	596.1	594.5	
Condensed Water, grams	0.8✓	0.1✓	−0.4✓	
Silica Gel -				
Final Weight, grams	866.5	892.0	880.4	
Initial Weight, grams	855.5	881.6	866.5	
Adsorbed Water, grams	11.0✓	10.4✓	13.9✓	
Total Water, grams	185.8✓	180.6✓	120.4✓	
pH	5.5	5.5	5.5	

Vm(std) = Volume of gas sampled at standard conditions (dscf) = gamma*17.64*Vm*[Pbar+(D H/13.6)]/(Tm+460)
Vwc(std) = volume of water vapor at standard conditions (scf) = 0.04715 * volume of water collected (gms)
Bws = Mole fraction of water vapor = Vwc(std) / (Vm(std) + Vwc(std))
Percent Moisture = 100 * Bws

Purge 1355-1455 1740-1840 1200-1300

Air Control Techniques, P.C.
Isokinetic Sampling Train Field Data Sheet

Job # 1436

Run ID 5B/028-1
Cond.

IDENTIFICATION INFORMATION

Plant
City, State

Test Location SCRUBBER STACK
Personnel DS, JTB, PJ

Date 8509
Start 1008
Stop 1314

Meterbox ID 802012
ΔH@ 1.566
Gamma (Y) 0.9941
Ideal Nozzle 0.312
Nozzle Dia. 0.238
Nozzle ID 1-3
Pitot Tube ID 4A

Filter ID	Tare

K Factor 1.76
TC Readout ID 802012

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Pre Leak Check, ACFM	.000	< 0.02	15
Post Leak Check, ACFM	000		8

	A	B
Pitot Pre Leak Check	✓ @ 4	✓ @ 5
Pitot Post Leak Check	✓ @ 4	✓ @ 4

Static Pressure, In. H_2O -0.15
Barometric Pressure, In. Hg 29.60

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams 473.4
Moisture, % 22.43
CO2 % 14.9
O2 % 2.8

Sampling Information

Port/ Point	Elapsed Time	Volume Metered	ΔP	Meter Temp	Stack Temp	ΔH	Probe Temp	Filter Temp	Exit Temp	Aux Temp	Vac	Lk Chcks
A3	0	641.845	0.34	87	145	0.60	305	308	66	83	3	LC 1
2	15	648.85	0.32	88	144	0.57	307	312	65	80	3	
1	30	655.85	0.27	89	145	0.48	308	317	64	75	3	
B3	45	662.21	0.34	90	145	0.61	311	319	64	77	3	LC-2
2	60/0	669.26	0.37	92	145	0.67	307	317	64	76	3	
1	15	676.66	0.24	91	144	0.43	307	317	64	76	3	
C3	30	682.70	0.34	90	145	0.61	312	315	63	77	3	LC-3
2	45	689.88	0.34	90	145	0.61	315	315	63	78	3	
1	120/0	697.07	0.29	90	145	0.52	315	318	64	80	3	
D3	15	703.65	0.33	91	144	0.59	306	312	65	78	3	LC-4
2	30	710.70	0.29	91	144	0.52	309	306	66	80	3	
1	45	717.29	0.24	91	144	0.43	307	314	66	80	3	
OFF	180	723.507										LC-5
												LC-6
												LC-7
												LC-8

		Averages				Max / Min °F			ISO	High	Total
Vm											
Vmstd		in. H_2O	°F	°F	in. H_2O				%	in. Hg	Cu. Ft.

Air Control Techniques, P.C.
Isokinetic Sampling Train Field Data Sheet

Job # 1436

Run ID 5B/028-2
Cond.

IDENTIFICATION INFORMATION

Plant
City, State

Test Location SCRUBBER STACK
Personnel DLS, TTB, PS

Date 8-5-09
Start 1419
Stop 1724

Meterbox ID 802012
ΔH@ 1.566
Gamma (Y) 0.9941
Ideal Nozzle 0.316
Nozzle Dia. 0.240
Nozzle ID Z-3
Pitot Tube ID 4B

Filter ID	Tare

K Factor 1.94
TC Readout ID 802012

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Pre Leak Check, ACFM	.000	< 0.02	15
Post Leak Check, ACFM	.000		8

	A	B
Pitot Pre Leak Check	✓ @ 6	✓ @ 5
Pitot Post Leak Check	✓ @ 4	✓ @ 5

Static Pressure, In. H_2O -0.15
Barometric Pressure, In. Hg 29.60

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams 503.7
Moisture, % 22.50
CO_2 % 15.5
O_2 % 2.6

Sampling Information

Port/ Point	Elapsed Time	Volume Metered	ΔP	Meter Temp	Stack Temp	ΔH	Probe Temp	Filter Temp	Exit Temp < 68°F	Aux Temp	Vac	Lk Chcks
D3	0	724.577	0.37	89	144	0.69	306	311	65	76	2	LC 1
2	15	732.30	0.37	91	145	0.72	310	314	64	77	2	
1	30	739.98	0.24	91	144	0.47	307	307	64	76	2	
C3	45	746.17	0.36	91	145	0.70	310	309	64	77	2	LC-2
2	60/0	753.69	0.35	90	145	0.68	312	309	64	76	2	
1	15	761.43	0.27	91	144	0.53	313	310	63	76	2	
B3	30	768.18	0.34	91	144	0.66	315	312	64	77	2	LC-3
2	45	775.53	0.37	92	145	0.72	317	314	64	77	2	
1	120/0	783.17	0.26	91	145	0.50	319	317	65	76	2	
A3	15	789.61	0.34	90	145	0.66	318	316	63	76	2	LC-4
2	30	797.11	0.35	89	145	0.68	317	316	62	76	2	
1	45	804.65	0.26	90	145	0.50	319	317	64	76	2	
off	180	811.169										LC-5
												LC-6
												LC-7
												LC-8

Method 5B Probe and Filter Temp 320°F ± 10° F OTM028 Filter Temp < 85° F

		Averages				Max / Min °F			ISO	High	Total
Vm											
Vmstd		in. H_2O	°F	°F	in. H_2O				%	in. Hg	Cu. Ft.

Air Control Techniques, P.C.
Isokinetic Sampling Train Field Data Sheet

Job #	1436

Run ID	5B/028-3
Cond.	

IDENTIFICATION INFORMATION

Plant
City, State

Test Location SCRUBBER STACK
Personnel DLS, TTB, PJ
Date 8-20-09
Start 830
Stop 1200

Meterbox ID	802012
ΔH@	1.566
Gamma (Y)	0.9941
Ideal Nozzle	0.313
Nozzle Dia.	0.238
Nozzle ID	1-3
Pitot Tube ID	4A

Filter ID	Tare

K Factor 1.80
TC Readout ID 802012

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Pre Leak Check, ACFM	.000	< 0.02	12
Post Leak Check, ACFM	.000		8

	A	B
Pitot Pre Leak Check	✓ @ 6	✓ @ 5
Pitot Post Leak Check	✓ @ 5	✓ @ 5

Static Pressure, In. H_2O -0.15
Barometric Pressure, In. Hg 29.70

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams	455.9	Moisture, %	21.87
CO_2 %	15.4	O_2 %	2.6

Sampling Information

Port/ Point	Elapsed Time	Volume Metered	ΔP	Meter Temp	Stack Temp	ΔH	Probe Temp	Filter Temp	Exit Temp < 68°F	Aux Temp	Vac	Lk Chcks
A 3	0	826023	0.35	73	144	0.61	307	324	63	67	3	LC 1
2	15	83287	035	73	143	0.61	298	311	59	64	3	
1	30	83988	031	74	143	054	324	321	59	64	3	
B 3	45	846.50	032	74	143	054	324	321	59	64	3	LC-2
2	60/0	853.25	031	74	143	054	323	322	58	65	3	
1	15	859.89	0.24	74	143	0.42	319	323	58	65	3	
C 3	30	865.78	034	76	143	060	331	321	63	70	3	LC-3
2	45	872.59	032	77	143	056	325	322	61	67	3	
1	120/0	879.48	0.24	78	143	0.42	324	319	62	68	3	
D 3	15	885.31	0.35	78	143	0.62	327	320	63	70	3	LC-4
2	30	89252	0.33	79	143	0.58	325	319	61	68	3	
1	45	899.41	0.25	80	143	0.44	321	312	61	67	3	
OFF	180	905.344										LC-5
												LC-6
												LC-7
												LC-8

Method 5B Probe and Filter Temp 320°F ± 10° F OTM028 Filter Temp < 85° F

		Averages				Max / Min °F			ISO	High	Total
Vm											
Vmstd		in. H_2O	°F	°F	in. H_2O				%	in. Hg	Cu. Ft.

Method 4 - Air Control Techniques, P.C.

Date 8/4/09

Source Information

Client APT

Plant Name

City, State

Sampling Location FCCU Scrubber Stack

Job # 1436

Process

Personnel

Sampling Information

Run Number	m5B/028-1	m5/028-2	m5/028-3	
Filter Identification	RQ5763	RQ5762	RQ5741	
Sampling Date	8/5/09	8/5/09	8/6/09	
Recovery Date	"	"	"	

Moisture Data

Impinger 1
Contents -

Final Weight, grams	830.9	940.2	811.9	
Initial Weight, grams	373.5	459.4	373.4	
Condensed Water, grams	457.4✓	480.8✓	438.5✓	

Impinger 2
Contents -

Final Weight, grams	618.0	609.1	620.9	
Initial Weight, grams	618.0	607.1	620.2	
Condensed Water, grams	0.0✓	2.0✓	0.7✓	

Impinger 3
Contents -

Final Weight, grams	620.1	595.0	620.1	
Initial Weight, grams	619.8	594.3	620.1	
Condensed Water, grams	0.3✓	0.7✓	0.0✓	

Impinger 4
Contents -

Final Weight, grams	610.3	578.0	610.8	
Initial Weight, grams	610.9	577.4	610.3	
Condensed Water, grams	-0.6✓	0.6✓	0.5✓	

Silica Gel -

Final Weight, grams	865.2	915.6	854.3	
Initial Weight, grams	848.9	896.0	838.1	
Adsorbed Water, grams	16.3✓	19.6✓	16.2✓	
Total Water, grams	473.4✓	503.7✓	455.9✓	
pH	5.5	5.0	5.5	

Vm(std) = Volume of gas sampled at standard conditions (dscf) = gamma*17.64*Vm*[Pbar+(D H/13.6)]/(Tm+460)

Vwc(std) = volume of water vapor at standard conditions (scf) = 0.04715 * volume of water collected (gms)

Bws = Mole fraction of water vapor = Vwc(std) / (Vm(std) + Vwc(std))

Percent Moisture = 100 * Bws

purge 1405-1505 1735-1835 1210-1310

Method 3 - Air Control Techniques, P.C.

Identification Information

Client APi
Plant Name
City, State
Personnel

Date 8/5/09
Job 1436
Process Oil
Fuel Type(s)

Run Data

Run Number m5/028-1
Leak √ ✓

Sample Time	Time of Analysis	CO_2	O_2, Reading	O_2, %
1008	1330	14.9	17.7	2.8
↓	↓	14.9	17.7	2.8
1320	1345	14.9	17.7	2.8
	Average	14.9		2.8

F_o 1.215

Orsat ID ACT-1
Bag ID 7

Run Data

Run Number m5/028-2
Leak √ ✓

Sample Time	Time of Analysis	CO_2	O_2, Reading	O_2, %
1419	1730	15.5	18.1	2.6
↓	↓	15.5	18.1	2.6
1723	1745	15.5	18.1	2.6
	Average	15.5		2.6

F_o 1.181

Orsat ID ACT-1
Bag ID 16

Run Data

Run Number m5/028-3
Leak √

Sample Time	Time of Analysis	CO_2	O_2, Reading	O_2, %
0830	1215	15.4	18.0	2.6
↓	↓	15.4	18.0	2.6
1200	1230	15.4	18.0	2.6
	Average	15.4		2.6

F_o 1.188

Orsat ID ACT-1
Bag ID 15

Fuel Factor (F_o) Calculations

$$F_o = \frac{20.9 - \%O_2}{\%CO2}$$

Fuel Type	F_o Range
Coal: Anthracite & Lignite	1.016 - 1.130
Bituminous	1.083 - 1.230
Oil: Distillate	1.260 - 1.413
Residual	1.210 - 1.370
Gas: Natural	1.600 - 1.836
Propane	1.434 - 1.586
Butane	1.405 - 1.553
Wood	1.000 - 1.120
Wood Bark	1.003 - 1.130

VOLUME I

Appendix D – Calibration Data

APEX INSTRUMENTS METHOD 5 PRE-TEST CONSOLE CALIBRATION
USING CALIBRATED CRITICAL ORIFICES
5-POINT ENGLISH UNITS

Meter Console Information	
Console Model Number	522
Console Serial Number	702233
DGM Model Number	RW 110
DGM Serial Number	1014753

Calibration Conditions			
Date	Time	02/11/09	
Barometric Pressure		29.80	in Hg
Theoretical Critical Vacuum[1]		14.07	in Hg
Calibration Technician		DLS	

Factors/Conversions		
Std Temp	528	°R
Std Press	29.92	in Hg
K_1	17.647	oR/in Hg

[1]For valid test results, the Actual Vacuum should be 1 to 2 in. Hg greater than the Theoretical Critical Vacuum shown above.

[2]The Critical Orifice Coefficient, K', must be entered in English units, $(ft^3 \cdot {}^\circ R^{1/2})/(in.Hg \cdot min)$.

Calibration Data										
Run Time	Metering Console					Critical Orifice				
Elapsed	DGM Orifice ΔH	Volume Initial	Volume Final	Outlet Temp Initial	Outlet Temp Final	Serial Number	Coefficient	Amb Temp Initial	Amb Temp Final	Actual Vacuum
(Θ)	(P_m)	(V_{mi})	(V_{mf})	(t_{mi})	(t_{mf})		K'	(t_{amb})	(t_{amb})	
min	in H_2O	cubic feet	cubic feet	°F	°F		see above2	°F	°F	in Hg
18.0	0.28	127.850	133.446	69	70	FO 40	0.2387	68	68	22
12.5	0.61	133.599	139.297	70	71	FO 48	0.3483	68	68	21
9.5	1.10	139.560	145.297	71	71	FO 55	0.4592	68	68	19
10.5	1.80	145.500	153.645	72	73	FO 63	0.5907	68	68	18
5.5	3.40	153.820	159.660	73	73	FO 73	0.8085	68	68	15

Results								
Standardized Data				Dry Gas Meter				
Dry Gas Meter		Critical Orifice		Calibration Factor		Flowrate	ΔH @	
				Value	Variation	Std & Corr	0.75 SCFM	Variation
$(V_{m(std)})$	$(Q_{m(std)})$	$(Vcr_{(std)})$	$(Q_{cr(std)})$	(Y)	(ΔY)	$(Q_{m(std)(corr)})$	(ΔH@)	(ΔΔH@)
cubic feet	cfm	cubic feet	cfm			cfm	in H2O	
5.562	0.309	5.572	0.310	1.002	0.006	0.310	1.636	-0.067
5.657	0.453	5.646	0.452	0.998	0.002	0.452	1.673	-0.030
5.697	0.600	5.658	0.596	0.993	-0.003	0.596	1.739	0.036
8.080	0.769	8.044	0.766	0.996	-0.001	0.766	1.720	0.017
5.810	1.056	5.767	1.049	0.993	-0.004	1.049	1.747	0.044
				0.9962	Y Average		1.703	ΔH@ Average

Note: For Calibration Factor Y, the ratio of the reading of the calibration meter to the dry gas meter, acceptable tolerance of individual values from the average is +-0.02.

I certify that the above Dry Gas Meter was calibrated in accordance with USEPA Methods, CFR Title 40, Part 60, Appendix A-3, Method 5, 16.2.3

Signature

Date 2-11-09

APEX INSTRUMENTS METHOD 5 POST-TEST CONSOLE CALIBRATION
USING CALIBRATED CRITICAL ORIFICES
3-POINT ENGLISH UNITS

Meter Console Information	
Console Model Number	522
Console Serial Number	702233
DGM Model Number	RW 110
DGM Serial Number	961167

Calibration Conditions			
Date	Time	09/02/09	
Barometric Pressure		30.00	in Hg
Theoretical Critical Vacuum[1]		14.2	in Hg
Calibration Technician		DLS	

Factors/Conversions		
Std Temp	528	°R
Std Press	29.92	in Hg
K_1	17.647	oR/in Hg

[1]For valid test results, the Actual Vacuum should be 1 to 2 in. Hg greater than the Theoretical Critical Vacuum shown above.

[2]The Critical Orifice Coefficient, K', must be entered in English units, $(ft^3 \cdot °R^{1/2})/(in.Hg \cdot min)$.

Calibration Data										
Run Time	Metering Console					Critical Orifice				
Elapsed	DGM Orifice ΔH	Volume Initial	Volume Final	Outlet Temp Initial	Outlet Temp Final	Serial Number	Coefficient	Amb Temp Initial	Amb Temp Final	Actual Vacuum
(Θ)	(P_m)	(V_{mi})	(V_{mf})	(t_{mi})	(t_{mf})		K'	(t_{amb})	(t_{amb})	
min	in H_2O	cubic feet	cubic feet	°F	°F		see above2	°F	°F	in Hg
7.0	1.80	209.730	215.222	79	81	FO 63	0.5907	76	76	18.00
7.0	1.80	215.222	220.693	81	81	FO 63	0.5907	76	76	18.00
7.0	1.80	220.693	226.187	81	82	FO 63	0.5907	76	76	18.00

Results								
Standardized Data				Dry Gas Meter				
				Calibration Factor		Flowrate	ΔH @	
Dry Gas Meter		Critical Orifice		Value	Variation	Std & Corr	0.75 SCFM	Variation
$(V_{m(std)})$	$(Q_{m(std)})$	$(Vcr_{(std)})$	$(Q_{cr(std)})$	(Y)	(ΔY)	$(Q_{m(std)(corr)})$	(ΔH@)	(ΔΔH@)
cubic feet	cfm	cubic feet	cfm			cfm	in H2O	
5.408	0.773	5.358	0.765	0.991	-0.003	0.765	1.711	0.003
5.377	0.768	5.358	0.765	0.996	0.003	0.765	1.707	-0.001
5.395	0.771	5.358	0.765	0.993	0.000	0.765	1.706	-0.002
Pretest Gamma	0.9962	% Deviation	0.3	0.993	Y Average		1.708	ΔH@ Average

Note: For Calibration Factor Y, the ratio of the reading of the calibration meter to the dry gas meter, acceptable tolerance of individual values from the average is +-0.02.

I certify that the above Dry Gas Meter was calibrated in accordance with USEPA Methods, CFR Title 40, Part 60, Appendix A-3, Method 5, 16.2.3

Signature

Date 9-02-09

APEX INSTRUMENTS METHOD 5 PRE-TEST CONSOLE CALIBRATION
USING CALIBRATED CRITICAL ORIFICES
5-POINT ENGLISH UNITS

Meter Console Information	
Console Model Number	522
Console Serial Number	802012
DGM Model Number	RW 110
DGM Serial Number	964447

Calibration Conditions			
Date	Time	02/25/09	
Barometric Pressure		30.20	in Hg
Theoretical Critical Vacuum[1]		14.25	in Hg
Calibration Technician		DLS	

Factors/Conversions		
Std Temp	528	°R
Std Press	29.92	in Hg
K_1	17.647	oR/in Hg

[1] For valid test results, the Actual Vacuum should be 1 to 2 in. Hg greater than the Theoretical Critical Vacuum shown above.

[2] The Critical Orifice Coefficient, K', must be entered in English units, $(ft^3 \cdot {}^\circ R^{1/2})/(in.Hg \cdot min)$.

Calibration Data										
Run Time	Metering Console					Critical Orifice				
Elapsed	DGM Orifice ΔH	Volume Initial	Volume Final	Outlet Temp Initial	Outlet Temp Final	Serial Number	Coefficient	Amb Temp Initial	Amb Temp Final	Actual Vacuum
(Θ)	(P_m)	(V_{mi})	(V_{mf})	(t_{mi})	(t_{mf})		K'	(t_{amb})	(t_{amb})	
min	in H_2O	cubic feet	cubic feet	°F	°F		see above2	°F	°F	in Hg
17.5	0.26	507.050	512.531	73	73	FO 40	0.2387	68	68	23
12.5	0.57	512.900	518.638	73	72	FO 48	0.3483	68	68	21
9.0	1.05	519.100	524.552	72	72	FO 55	0.4592	68	68	19
7.0	1.70	524.700	530.158	72	73	FO 63	0.5907	68	68	18
5.0	3.15	530.540	535.859	73	73	FO 73	0.8085	68	68	16

Results								
Standardized Data				Dry Gas Meter				
				Calibration Factor		Flowrate	ΔH @	
Dry Gas Meter		Critical Orifice		Value	Variation	Std & Corr	0.75 SCFM	Variation
$(V_{m(std)})$	$(Q_{m(std)})$	$(Vcr_{(std)})$	$(Q_{cr(std)})$	(Y)	(ΔY)	$(Q_{m(std)(corr)})$	(ΔH@)	(ΔΔH@)
cubic feet	cfm	cubic feet	cfm			cfm	in H2O	
5.484	0.313	5.490	0.314	1.001	0.007	0.314	1.460	-0.105
5.751	0.460	5.722	0.458	0.995	0.001	0.458	1.537	-0.029
5.476	0.608	5.432	0.604	0.992	-0.002	0.604	1.634	0.068
5.485	0.784	5.434	0.776	0.991	-0.003	0.776	1.602	0.037
5.359	1.072	5.313	1.063	0.991	-0.003	1.063	1.594	0.029
				0.994	Y Average		1.566	ΔH@ Average

Note: For Calibration Factor Y, the ratio of the reading of the calibration meter to the dry gas meter, acceptable tolerance of individual values from the average is +-0.02.

I certify that the above Dry Gas Meter was calibrated in accordance with USEPA Methods, CFR Title 40, Part 60, Appendix A-3, Method 5, 16.2.3

Signature

Date 2-25-09

APEX INSTRUMENTS METHOD 5 POST-TEST CONSOLE CALIBRATION
USING CALIBRATED CRITICAL ORIFICES
3-POINT ENGLISH UNITS

Meter Console Information	
Console Model Number	522
Console Serial Number	802012
DGM Model Number	RW 110
DGM Serial Number	964447

Calibration Conditions			
Date	Time	09/03/09	
Barometric Pressure		30.00	in Hg
Theoretical Critical Vacuum[1]		14.2	in Hg
Calibration Technician		DLS	

Factors/Conversions		
Std Temp	528	°R
Std Press	29.92	in Hg
K_1	17.647	oR/in Hg

[1] For valid test results, the Actual Vacuum should be 1 to 2 in. Hg greater than the Theoretical Critical Vacuum shown above.

[2] The Critical Orifice Coefficient, K', must be entered in English units, $(ft^3 * °R^{1/2})/(in.Hg*min)$.

Calibration Data

Run Time	Metering Console					Critical Orifice				
Elapsed	DGM Orifice ΔH	Volume Initial	Volume Final	Outlet Temp Initial	Outlet Temp Final	Serial Number	Coefficient	Amb Temp Initial	Amb Temp Final	Actual Vacuum
(Θ)	(P_m)	(V_{mi})	(V_{mf})	(t_{mi})	(t_{mf})		K'	(t_{amb})	(t_{amb})	
min	in H_2O	cubic feet	cubic feet	°F	°F		see above2	°F	°F	in Hg
7.5	1.70	15.300	21.178	80	80	FO 63	0.5907	76	76	17.00
7.5	1.70	21.178	27.034	80	81	FO 63	0.5907	76	76	17.00
7.5	1.70	27.034	32.941	82	83	FO 63	0.5907	76	76	17.00

Results

Standardized Data				Dry Gas Meter				
				Calibration Factor		Flowrate	ΔH @	
Dry Gas Meter		Critical Orifice		Value	Variation	Std & Corr	0.75 SCFM	Variation
$(V_{m(std)})$	$(Q_{m(std)})$	$(Vcr_{(std)})$	$(Q_{cr(std)})$	(Y)	(ΔY)	$(Q_{m(std)(corr)})$	(ΔH@)	(ΔΔH@)
cubic feet	cfm	cubic feet	cfm			cfm	in H2O	
5.787	0.772	5.741	0.765	0.992	-0.001	0.765	1.615	0.003
5.760	0.768	5.741	0.765	0.997	0.003	0.765	1.613	0.001
5.789	0.772	5.741	0.765	0.992	-0.002	0.765	1.607	-0.004
Pretest Gamma	0.9941	% Deviation	0.1	0.993	Y Average		1.612	ΔH@ Average

Note: For Calibration Factor Y, the ratio of the reading of the calibration meter to the dry gas meter, acceptable tolerance of individual values from the average is +-0.02.

I certify that the above Dry Gas Meter was calibrated in accordance with USEPA Methods, CFR Title 40, Part 60, Appendix A-3, Method 5, 16.2.3

Signature

Date 9-03-09

Type S Pitot Tube Inspection
Air Control Techniques, P.C.

Date 5-06-02

Identification Information

Client IN HOUSE

Plant Name NA

City CARY

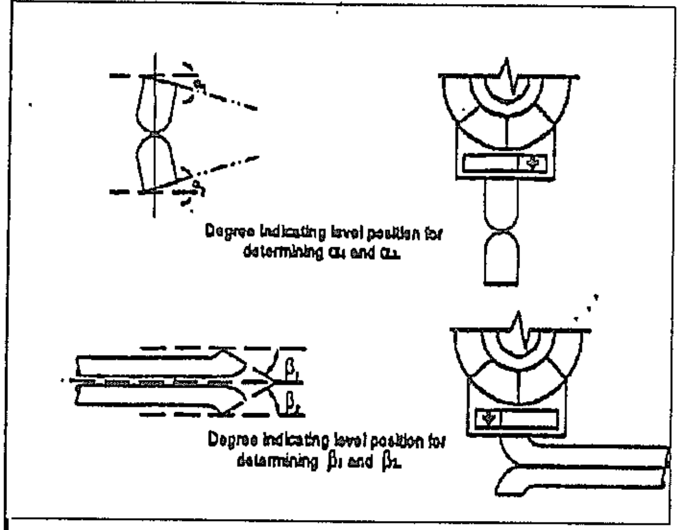
Job NA

Process NA

State NC

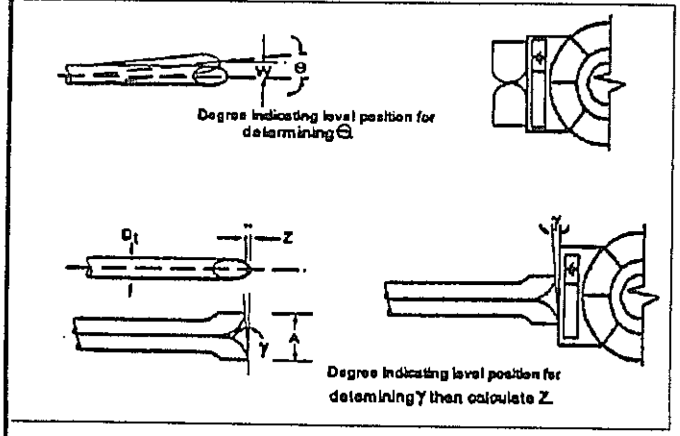
Pitot ID 4A

Inspection Results



Inspection Data

Level and Perpendicular?	YES
Obstruction?	NO
Damaged?	NO
α1 (-10° ≤ α1 ≤ + 10°)	1
α2 (-10° ≤ α2 ≤ + 10°)	0
β1 (-5° ≤ β1 ≤ + 5°)	0
β2 (-5° ≤ β2 ≤ + 5°)	1
γ	0
θ	0
z=A tan γ (≤0.125 inches)	0
w=A tan θ (≤0.03125 inches)	0
D1 (3/16 inch ≤ D1 ≤ 3/8 inch)	0.375
A	0.875
A/2D1 (1.05 ≤ PA/D1 ≤ 1.5)	1.17



Notes

Pitot Coefficient

Coefficient of 0.84 Assigned? YES

Inspection Personnel DLS

Notes

Form ACTPC PI-2

Type S Pitot Tube Inspection
Air Control Techniques, P.C.

Date 5-06-02

Identification Information

Client IN HOUSE

Plant Name NA

City CARY

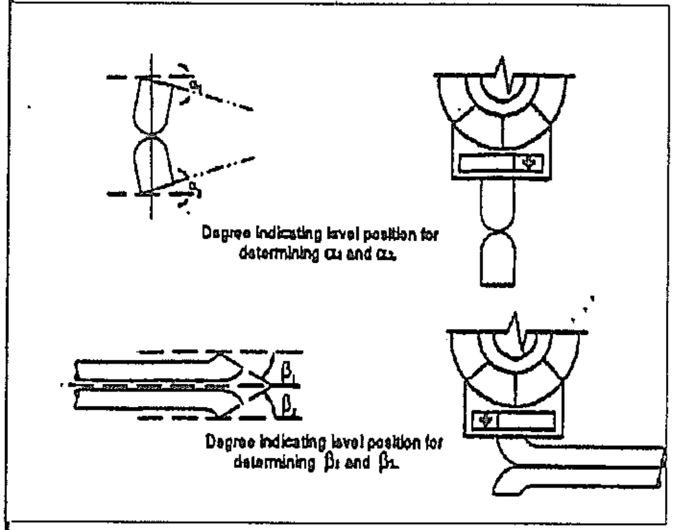
Job NA

Process NA

State NC

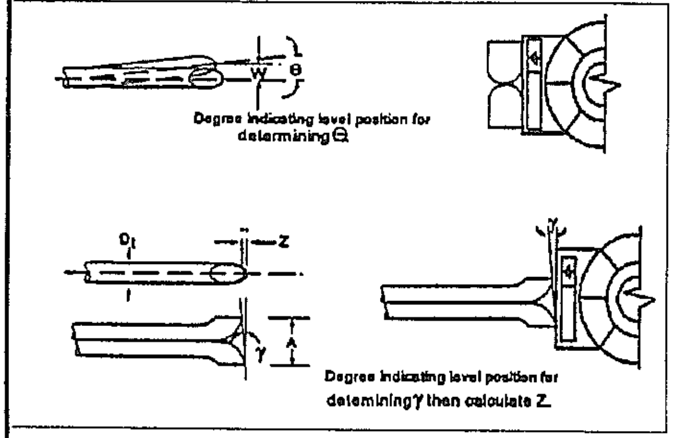
Pitot ID 4B

Inspection Results



Inspection Data

Level and Perpendicular?	YES
Obstruction?	NO
Damaged?	NO
α1 (-10° ≤ α1 ≤ + 10°)	1
α2 (-10° ≤ α2 ≤ + 10°)	0
β1 (-5° ≤ β1 ≤ + 5°)	0
β2 (-5° ≤ β2 ≤ + 5°)	1
γ	0
θ	0
z=A tan γ (≤0.125 inches)	0
w=A tan θ (≤0.03125 inches)	0
D1 (3/16 inch ≤ D1 ≤ 3/8 inch)	0.375
A	0.875
A/2D1 (1.05 ≤ PA/D1 ≤ 1.5)	1.17



Notes

Pitot Coefficient

Coefficient of 0.84 Assigned? YES

Inspection Personnel DLS

Notes

Form ACTPC PI-2

Stainless Steel Nozzle Calibration and Condition
Air Control Techniques, P.C.

Nozzle Set ID	Nozzle ID	Average	Measurements			High-Low	Condition	Date Inspected
			1	2	3			
ACT-N-1	1-1	0.123	0.123	0.124	0.122	0.002	OK	3/11/07
ACT-N-1	1-2	0.180	0.180	0.180	0.181	0.001	OK	3/11/07
ACT-N-1	1-3	0.238	0.238	0.238	0.238	0.000	OK	3/11/07
ACT-N-1	1-4	0.299	0.300	0.300	0.298	0.002	OK	3/11/07
ACT-N-1	1-5	0.368	0.368	0.368	0.368	0.000	OK	3/11/07
ACT-N-1	1-6	0.427	0.427	0.427	0.428	0.001	OK	3/11/07
ACT-N-1	1-7	0.491	0.492	0.491	0.490	0.002	OK	3/11/07

Nozzle Set ID	Nozzle ID	Average	Measurements			High-Low	Condition	Date
			1	2	3			
ACT-N-2	2-1	0.128	0.128	0.127	0.128	0.001	OK	3/11/07
ACT-N-2	2-2	0.177	0.176	0.177	0.178	0.002	OK	3/11/07
ACT-N-2	2-3	0.240	0.240	0.240	0.240	0.000	OK	3/11/07
ACT-N-2	2-4	0.298	0.297	0.298	0.298	0.001	OK	3/11/07
ACT-N-2	2-5	0.373	0.373	0.374	0.373	0.001	OK	3/11/07
ACT-N-2	2-6	0.441	0.440	0.442	0.440	0.002	OK	3/11/07
ACT-N-2	2-7	0.497	0.498	0.497	0.497	0.001	OK	3/11/07

Nozzle Set ID	Nozzle ID	Average	Measurements			High-Low	Condition	Date
			1	2	3			
ACT-N-3	3-1	0.120	0.120	0.121	0.120	0.001	OK	3/11/07
ACT-N-3	3-2	0.189	0.188	0.189	0.189	0.001	OK	3/11/07
ACT-N-3	3-3	0.240	0.240	0.239	0.240	0.001	OK	3/11/07
ACT-N-3	3-4	0.254	0.254	0.254	0.255	0.001	OK	3/11/07
ACT-N-3	3-5	0.365	0.366	0.365	0.365	0.001	OK	3/11/07
ACT-N-3	3-6	0.996	0.996	0.997	0.995	0.002	OK	3/11/07
ACT-N-3	3-7	0.494	0.494	0.494	0.494	0.000	OK	3/11/07

Nozzle Set ID	Nozzle ID	Average	Measurements			High-Low	Condition	Date
			1	2	3			
ACT-N-4	4-1	0.301	0.300	0.301	0.302	0.002	OK	3/11/07
ACT-N-4	4-2	0.178	0.178	0.178	0.177	0.001	OK	3/11/07
ACT-N-4	4-3	0.299	0.299	0.299	0.299	0.000	OK	3/11/07
ACT-N-4	4-4	0.248	0.248	0.248	0.248	0.000	OK	3/11/07
ACT-N-4	4-5	0.364	0.364	0.364	0.363	0.001	OK	3/11/07
ACT-N-4	4-6	0.497	0.496	0.497	0.497	0.001	OK	3/11/07
ACT-N-4	4-7	0.498	0.497	0.498	0.499	0.002	OK	3/11/07

Name DANNY SPEER Signature

Glass Nozzle Calibration and Inspection
Air Control Techniques, P.C.

Nozzle Set ID	Nozzle ID	Average	Measurements			Maximum Variance	Condition	Date Inspected
			1	2	3			
Misc. G	GL 923	0.863	0.863	0.863	0.863	0.000	OK	8/19/08
Misc. G	GL 473	0.996	0.996	0.996	0.996	0.000	OK	8/19/08
Misc. G	GL 475	0.996	0.996	0.996	0.996	0.000	OK	8/19/08
Misc. G	GL 3008	0.997	0.996	0.997	0.997	0.001	OK	8/19/08
Misc. G	GL 474	0.999	0.999	0.999	0.999	0.000	OK	8/19/08
Misc. G	GL 3006	1.020	1.020	1.020	1.021	0.001	OK	8/19/08
Misc. G	GL 471	1.028	1.028	1.027	1.028	0.001	OK	8/19/08
Misc. G	GL 472	1.029	1.029	1.029	1.029	0.000	OK	8/19/08
Misc. G	GL 516	1.042	1.042	1.042	1.042	0.000	OK	8/19/08
Misc. G	GL 517	1.042	1.042	1.042	1.042	0.000	OK	8/19/08
Misc. G	GL 3007	1.050	1.050	1.050	1.050	0.000	OK	8/19/08
Misc. G	GL 3005	1.061	1.061	1.060	1.060	0.001	OK	8/19/08
Misc. G	GL 3010	1.248	1.248	1.248	1.248	0.000	OK	8/19/08
Misc. G	GL 3013	1.255	1.255	1.255	1.255	0.000	OK	8/19/08
Misc. G	GL 3011	1.259	1.259	1.259	1.259	0.000	OK	8/19/08
Misc. G	GL 3014	1.335	1.334	1.335	1.335	0.001	OK	8/19/08
Misc. G	GL 3015	1.343	1.343	1.343	1.344	0.001	OK	8/19/08
Misc. G	GL 519	1.453	1.453	1.453	1.453	0.000	OK	8/19/08
Misc. G	GL 128	1.456	1.456	1.456	1.456	0.000	OK	8/19/08
Misc. G	GL 130	1.459	1.459	1.459	1.459	0.000	OK	8/19/08
Misc. G	GL 520	1.459	1.459	1.459	1.459	0.000	OK	8/19/08
Misc. G	GL 3009	1.574	1.574	1.574	1.574	0.000	OK	8/19/08
Misc. G	GL 102	1.838	1.838	1.838	1.839	0.001	OK	8/19/08
Misc. G	GL 100	1.841	1.841	1.841	1.841	0.000	OK	8/19/08
Misc. G	API-1	0.171	0.171	0.171	0.171	0.000	OK	8/3/09
Misc. G	API-2	0.173	0.173	0.173	0.172	0.001	OK	8/3/09

VOLUME I

Appendix E – Analytical Data

RESOLUTION ANALYTICS, INC.
Specialists in Air Emission Analysis

ANALYTICAL REPORT

- CONDENSIBLE PARTICULATE MATTER
  (EPA METHOD OTM-028)
- PM2.5 FILTERABLE PARTICULATE
  (EPA METHOD OTM-027)
- FILTERABLE PARTICULATE
  (EPA METHOD 5B (40 CFR. PART 60))

CLIENT: AIR CONTROL TECHNIQUES

RFA#: 1436

Chain of Custody

Air Control Techniques, P.C. PAGE 1 of 2

P.O# 9142-1436

Identification Information

Client	API	Job	1436
Plant Name		Process	FCC Scrubber Stack
City			

Run Number	Sample Type	Container	Date Sampled	Notes
M5B/028-1	Front Half Acetone Rinse	250 ml amber jar	8/5/09	
M5B/028-1	Imp Acetone Rinse	250 ml amber jar	8/5/09	
M5B/028-1	Imp MeCl2 Rinse	250 ml amber jar	8/5/09	
M5B/028-1	Imp Soln. + DI Rinse	1L Nalgene Bottle	8/5/09	
M5B/028-1	Filter	Dish	8/5/09	
M5B/028-1	CPM Filter	Dish	8/5/09	
M5B/028-2	Front Half Acetone Rinse	250 ml amber jar	8/5/09	
M5B/028-2	Imp Acetone Rinse	250 ml amber jar	8/5/09	
M5B/028-2	Imp MeCl2 Rinse	250 ml amber jar	8/5/09	
M5B/028-2	Imp Soln. + DI Rinse	1L Nalgene Bottle	8/5/09	
M5B/028-2	Filter	Dish	8/5/09	
M5B/028-2	CPM Filter	Dish	8/5/09	
M5B/028-3	Front Half Acetone Rinse	250 ml amber jar	8/6/09	
M5B/028-3	Imp Acetone Rinse	250 ml amber jar	8/6/09	
M5B/028-3	Imp MeCl2 Rinse	250 ml amber jar	8/6/09	
M5B/028-3	Imp Soln. + DI Rinse	1L Nalgene Bottle	8/6/09	
M5B/028-3	Filter	Dish	8/6/09	
M5B/028-3	CPM Filter	Dish	8/6/09	
API2.5/028-1	Probe & Nozzle Rinse	250ml glass jar	8/5/09	
API2.5/028-1	> 2.5 µm Acetone Rinse	250 ml amber jar	8/5/09	
API2.5/028-1	≤ 2.5 µm Acetone Rinse	250 ml amber jar	8/5/09	
API2.5/028-1	Imp Soln. + DI Rinse	0.5L Nalgene Bottle	8/5/09	
API2.5/028-1	Imp Acetone Rinse	250 ml amber jar	8/5/09	
API2.5/028-1	Imp MeCl2 Rinse	250 ml amber jar	8/5/09	
API2.5/028-1	Filter	Dish	8/5/09	
API2.5/028-1	CPM Filter	Dish	8/5/09	
API2.5/028-2	Probe & Nozzle Rinse	250ml glass jar	8/5/09	
API2.5/028-2	> 2.5 µm Acetone Rinse	250 ml amber jar	8/5/09	
API2.5/028-2	≤ 2.5 µm Acetone Rinse	250 ml amber jar	8/5/09	
API2.5/028-2	Imp Soln. + DI Rinse	0.5L Nalgene Bottle	8/5/09	
API2.5/028-2	Imp Acetone Rinse	250 ml amber jar	8/5/09	
API2.5/028-2	Imp MeCl2 Rinse	250 ml amber jar	8/5/09	
API2.5/028-2	Filter	Dish	8/5/09	
API2.5/028-2	CPM Filter	Dish	8/5/09	
SEE PAGE 2				

Relinquished By: (Signature and Printed Name) Date: 8/11/09

Received By: (Signature & Printed Name Date: 8/11/09

Chain of Custody
Air Control Techniques, P.C. **PAGE 2 of 2**

P. O. # 9142-1436

Identification Information

Client: API
Plant Name:
City:

Job: 1436
Process: FCC Scrubber Stack

Run Number	Sample Type	Container	Date Sampled	Notes
API2.5/028-3	Probe & Nozzle Rinse	500ml glass jar	8/6/09	
API2.5/028-3	> 2.5 µm Acetone Rinse	250 ml amber jar	8/6/09	
API2.5/028-3	≤ 2.5 µm Acetone Rinse	250 ml amber jar	8/6/09	
API2.5/028-3	Imp Soln. + DI Rinse	1 L Nalgene Bottle	8/6/09	
API2.5/028-3	Imp Acetone Rinse	250 ml amber jar	8/6/09	
API2.5/028-3	Imp MeCl2 Rinse	250 ml amber jar	8/6/09	
API2.5/028-3	Filter	Dish	8/6/09	
API2.5/028-3	CPM Filter	Dish	8/6/09	
028-FB	Imp Soln. + DI Rinse	0.5L Nalgene Bottle	8/5/09	
028-FB	Imp Acetone Rinse	250 ml glass jar	8/5/09	
028-FB	Imp MeCl2 Rinse	250 ml amber jar	8/5/09	
028-FB	CPM Filter	Dish	8/5/09	
Blank	Acetone Reagent Blank	250 ml glass jar	8/5/09	
Blank	MeCl2 Reagent Blank	250 ml glass jar	8/5/09	
Blank	H2O Reagent Blank	0.5L Nalgene Bottle	8/5/09	
Blank	CPM Filter Blank	Dish	8/5/09	
Run 1	FCC Scrubber H2O	1 L Glass Jar	8/5/09	Total Solids Analysis
Run 2	FCC Scrubber H2O	1 L Glass Jar	8/5/09	Total Solids Analysis
Run 3	FCC Scrubber H2O	1 L Glass Jar	8/6/09	Total Solids Analysis

Relinquished By: (Signature and Printed Name) Date: 8/11/09

Received By: (Signature & Printed Name Date: 8/11/09

RESOLUTION ANALYTICS, INC.
Specialists in High Performance Liquid Chromatography

REPORT SUMMARY

RFA#: 1436

SAMPLE ID	TOTAL FILTERABLE PARTICULATE
ACETONE BLANK	1.0 mg (210 mL)
M5B-028-1	15.5 mg
M5B-028-2	17.6 mg
M5B-028-3	16.5 mg

Analytical Narrative

RFA # 1436

Page 1 of 1

Client/Plant Name:	Air Control Techniques	**Date Rec'd in lab:**	08/11/09
Analyst:	BNL	**Date of Analysis:**	08/23/09
Analysis Method:	EPA Method 5B	**Analyte(s):**	Filterable Particulate

Sample Matrix & Components:

Dry Filters, Front½ Acetone Rinses and solvent blanks

Summary of Sample Prep:

The acetone rinses and pre-tared filters were transferred to pre-tared teflon "baggies" in a low humidity environment. Acetone rinses were then evaporated overnight. Rinses and filters were oven dried at 325°F for 6 hours then placed in a low humidity environment for 2 hours, after which time they were weighed daily every six hours until consecutive weights agreed within ±0.5 mg.

All weights were recorded to the nearest 0.1 mg. The total catch reported for each run is a sum of the filterable and condensible (organic and inorganic) catches. The solvent blank catch weights have been subtracted out of sample catches in proportion with their respective solvent volumes.

Summary of Instrumentation:

Denver Pinnacle Series model analytical balance

Analytical Detection Limit(s): 0.5 mg

Miscellaneous Comments Regarding Sample Analysis: (Note unusual catch weights, interferences, odd sample behavior, and steps taken to confirm unusual results. Also note any deviations from standard analytical procedures, together with justification and possible affect on results. Specify samples when applicable.)

See Data Sheets for individual sample descriptions.

Confirmation of Data Review:

QA Officer Signature J. Bruce Nemet Date 8/25/09

(J. Bruce Nemet , Lab QA Officer)

PARTICULATE SAMPLING LABORATORY RESULTS

Plant Name:
Method: 5B
Date Received: 08/11/09

Page 1 of 2

RFA # **1436**
Filename: ACT
File Pathway: C:\JOBS\1436\ACT.WB1

Run Number	M5B-028-1	M5B-028-2	M5B-028-3

	Date	Init		Date		Date	
Filter Container #			1451		62		780
	08/23	BNL	3.9006	08/23	3.8869	08/23	4.0113
Baggie Tare Wt., g.			3.5058		3.4820		3.5960
Filter Tare Wt., g.		RQ-5763	0.3838	RQ-5762	0.3886	RQ-5741	0.3992
FILTER SAMPLE WT., g.			0.0110		0.0163		0.0161

	Date	Init		Date		Date	
Rinse Container #			659		207		444
	08/23	BNL @	3.4982	08/23	3.5636	08/23	3.6063
	08/22	BNL @	3.4982	08/22 @	3.5635	08/22 @	3.6060
Tare Wt., g.	(120	ml)	3.4931	(120 ml)	3.5616	(90 ml)	3.6052
RINSE SAMPLE WT., g.			0.0051		0.0019		0.0008

Filter Catch, mg.	**11.0**	**16.3**	**16.1**
Rinse Catch, mg.	5.1	1.9	0.8
Rinse Blank Residue, mg.	0.6	0.6	0.4
Net Rinse Catch, mg.	**4.5**	**1.3**	**0.4**
FILTERABLE PARTICULATE, mg.	**15.5**	**17.6**	**16.5**

Blank Beaker #	1011
Final wt., mg.	3.6891
Tare wt., mg.	3.6881
Residue, mg.	1
Volume, ml.	210
Density, mg/ml	785.0
Conc., mg/mg	6.1E-06 <-
Upper Limit, mg/mg	1.0E-05

Visual Inspection of Filters

Run ID	M5B-028-1	M5B-028-2	M5B-028-3
Color:	BROWN	BROWN	BROWN
Texture:	STAIN	STAIN	STAIN
Foreign Matter:	NONE	NONE	NONE
Relative Comp:	MEDIUM	MEDIUM	MEDIUM

Visual Inspection of Rinses

Run ID	M5B-028-1	M5B-028-2	M5B-028-3
Color:	BROWN	BROWN	BROWN
Texture:	FILM	FILM	FILM
Foreign Matter:	NONE	NONE	NONE
Relative Comp:	HIGH	MEDIUM	LOW

Legend:
@ = Final Weight
F = Filter
R = Rinse

Miscellaneous Notes & Comments:

Printing Date: 23-Aug-09
Printing Time: 04:34 PM

REAGENT BLANK LABORATORY RESULTS (Version 04.28.92)

Plant Name:
Method: 5B
Date Received: 08/11/09
Page 2 of 2
RFA # **1436**
Filename: ACT
File Pathway: C:\JOBS\1436\ACT.WB1

Run Number ACETONE BLANK

	Date	Init			1011
Sample ID/Container #					
	08/23	BNL			3.6894
	08/20	BNL	@		3.6891
Tare Wt., g.		(	210	ml)	3.6881
SAMPLE WT., g.					0.0010

∾ REPORT SUMMARY ∾

RFA#: 1436

METHOD OTM-027 SAMPLE ID	*Particulate ≤2.5 µm*	*Particulate >2.5µm*	*Probe & Nozzle Rinse*	*Total Filterable Particulate*
ACETONE BLANK		1.0 mg (210 mL)		
API2.5-028-1	3.7 mg	0.9 mg	5.4 mg	10.0 mg
API2.5-028-2	1.0 mg	1.1 mg	15.6 mg	17.7 mg
API2.5-028-3	0.9 mg	1.3 mg	3.8 mg	6.0 mg

Analytical Narrative RFA # 1436 Page 1 of 1

Client/Plant Name: Air Control Techniques **Date Rec'd in lab:** 08/11/09

Analyst: BNL **Date of Analysis:** 08/23/09

Analysis Method: EPA OTM-027 **Analyte(s):** PM2.5 micron

Sample Matrix & Components:

Dry Filters, Acetone Rinses (Precutter/Cyclone and Front½ rinses weighed separately), Acetone Blank

Summary of Sample Prep:

The acetone rinses and pre-tared filters were transferred to pre-tared teflon "baggies" in a low humidity environment. The acetone rinses were evaporated overnight, then desiccated for 24 hours, after which time they were weighed daily every six hours until consecutive weights agreed within ±0.5 mg. The filters were oven dried at 105°C for 2 hours and weighed immediately afterwards. All weights were recorded to the nearest 0.1 mg and include filterable particulate catch only. The total catch reported for each run is a sum of the filter and rinse catches. The acetone blank catch has been subtracted out of sample rinse catches in proportion with their respective volumes.

Summary of Instrumentation:

Denver Pinnacle Series model analytical balance

Analytical Detection Limit(s): 0.5 mg

Miscellaneous Comments Regarding Sample Analysis: (Note unusual catch weights, interferences, odd sample behavior, and steps taken to confirm unusual results. Also note any deviations from standard analytical procedures, together with justification and possible affect on results. Specify samples when applicable.)

No modifications to EPA Method 5 analytical procedure were made.

See Data Sheets for individual sample descriptions.

Confirmation of Data Review:

QA Officer Signature J. Bruce Nemet Date 8/25/09

(J. Bruce Nemet, Lab QA Officer)

PARTICULATE SAMPLING LABORATORY RESULTS (OTM-027)

Plant Name.		RFA #	1436
Method:	OTM-027	Filename:	ACT
Date Received:	08/11/09 Page 1 of 4	File Pathway:	C:\JOBS\1436\ACT.WB1

Run Number API2.5-028-1

Filter Container #	Date	Init	730 (< = 2.5 um)
	08/23	BNL	3.6900
Baggie Tare Wt., g.			3.5735
Filter Tare Wt., g.		SF47-873	0.1139
FILTER SAMPLE WT., g.			0.0026
			NO

Sample I.D.	Date	Init		676 (< = 2.5 um)	Date		1469 (>2.5 um)	Date		11 (Probe & Nozzle Rinse)
	08/23	BNL		3.7933	08/23	@	3.6769	08/23		3.8268
	08/20	BNL	@	3.7930	08/20		3.6770	08/20	@	3.8264
Tare Wt., g.	(	50	ml)	3.7917	(60	ml)	3.6757 (	250	ml)	3.8198
RINSE SAMPLE WT., g.				0.0013			0.0012			0.0066

Filter Catch, mg.	2.6	NA	NA
Rinse Catch, mg.	1.3	1.2	6.6
Blank Residue, mg.	0.2	0.3	1.2
Net Rinse Catch, mg.	1.1	0.9	5.4
FILTERABLE PARTICULATE, mg.	3.7	0.9	5.4

Blank Beaker #	1011
Final wt., mg.	3.6891
Tare wt., mg.	3.6881
Residue, mg.	1.0
Volume, ml.	210
Density, mg/ml	785.0
Conc., mg/mg	6.066E-06 <--
Upper Limit, mg/mg	1.000E-05

Visual Inspection:

Run ID	In Stack Filter	2.5 Rinse	2.5-10 Rinse	>10 Rinse
Color:	BROWN	WHITE	WHITE	BROWN
Texture:	STAIN	FILM	FILM	FILM
Foreign Matter:	NONE	NONE	NONE	NONE
Relative Comp:	MEDIUM	LOW	LOW	HIGH

Miscellaneous Notes & Comments:

Legend:
@ = Final Weight
F = Filter
R = Rinse

Printing Date: 25-Aug-09 Printing Time: 03:43 PM

PARTICULATE SAMPLING LABORATORY RESULTS (OTM-027)

Plant Name:		RFA #	1436
Method:	OTM-027	Filename:	ACT
Date Received:	08/11/09	File Pathway:	C:\JOBS\1436\ACT.WB1

Page 2 of 4

Run Number API2.5-028-2

Filter Container #	Date	Init	1495 (< = 2.5 um)
	08/23	BNL	3.7615
Baggie Tare Wt., g.			3.6463
Filter Tare Wt., g.		SF47-874	0.1142
FILTER SAMPLE WT., g.			0.0010
			NO

Sample I.D.	Date	Init		377 (< = 2.5 um)	Date		1226 (>2.5 um)	Date		1268 (Probe & Nozzle Rinse)
	08/23	BNL	@	3.5059	08/23		3.3719	08/23	@	3.9399
	08/20	BNL	@	3.5059	08/20	@	3.3718	08/20	@	3.9399
Tare Wt., g.	(	40	ml)	3.5058	(60	ml)	3.3704 (	150	ml)	3.9236
RINSE SAMPLE WT., g.				0.0001			0.0014			0.0163

Filter Catch, mg.	1.0	NA	NA
Rinse Catch, mg.	0.1	1.4	16.3
Blank Residue, mg.	0.2	0.3	0.7
Net Rinse Catch, mg.	0.0 **	1.1	15.6
FILTERABLE PARTICULATE, mg.	1.0	1.1	15.6

Blank Beaker #	1011
Final wt., mg.	3.6891
Tare wt., mg.	3.6881
Residue, mg.	1.0
Volume, ml.	210
Density, mg/ml	785.0
Conc., mg/mg	6.066E-06 <–
Upper Limit, mg/mg	1.000E-05

** Adjusted Catch (Negative Results Reported As Zero)

Visual Inspection:

Run ID	In Stack Filter	2.5 Rinse	2.5-10 Rinse	>10 Rinse
Color:	BROWN	WHITE	WHITE	WHITE
Texture:	STAIN	FILM	FILM	FILM
Foreign Matter:	NONE	NONE	NONE	NONE
Relative Comp:	MEDIUM	LOW	LOW	MEDIUM

Miscellaneous Notes & Comments:

Legend: @ = Final Weight
F = Filter
R = Rinse

Printing Date: 25-Aug-09 Printing Time: 03:43 PM

PARTICULATE SAMPLING LABORATORY RESULTS (OTM-027)

Plant Name:			RFA #	1436
Method:	OTM-027		Filename:	ACT
Date Received:	08/11/09	Page 3 of 4	File Pathway:	C:\JOBS\1436\ACT.WB1
Run Number		API2.5-028-3		

Filter Container #	Date	Init	1247 (< = 2.5 um)
	08/23	BNL	4.0251
Baggie Tare Wt., g.			3.9121
Filter Tare Wt., g.		SF47-875	0.1128
FILTER SAMPLE WT., g.			0.0002 ND

Sample I.D.	Date	Init		1249 (< = 2.5 um)	Date		1405 (>2.5 um)	Date		863 (Probe & Nozzle Rinse)
	08/23	BNL	@	3.4062	08/23		3.5318	08/23		3.5005
	08/20	BNL		3.4063	08/20	@	3.5316	08/20	@	3.5004
Tare Wt., g.	(	40	ml)	3.4053	(50	ml)	3.5301 (	140	ml)	3.4959
RINSE SAMPLE WT., g.				0.0009			0.0015			0.0045

Filter Catch, mg.	0.2	NA	NA
Rinse Catch, mg.	0.9	1.5	4.5
Blank Residue, mg.	0.2	0.2	0.7
Net Rinse Catch, mg.	0.7	1.3	3.8
FILTERABLE PARTICULATE, mg.	0.9	1.3	3.8

Blank Beaker #	1011
Final wt., mg.	3.6891
Tare wt., mg.	3.6881
Residue, mg.	1.0
Volume, ml.	210
Density, mg/ml	785.0
Conc., mg/mg	6.066E-06 <—
Upper Limit, mg/mg	1.000E-05

Visual Inspection:

Run ID	In Stack Filter	2.5 Rinse	2.5-10 Rinse	>10 Rinse
Color:	BROWN	BROWN	WHITE	BROWN
Texture:	STAIN	FILM	FILM	FILM
Foreign Matter:	NONE	NONE	NONE	NONE
Relative Comp:	LOW	LOW	LOW	MEDIUM

Miscellaneous Notes & Comments:

Legend: @ = Final Weight
F = Filter
R = Rinse

Printing Date: 25-Aug-09 Printing Time: 03:43 PM

REAGENT BLANK LABORATORY RESULTS

Plant Name:		RFA #	**1436**
Method:	OTM-027	Filename:	ACT
Date Received:	08/11/09 Page 4 of 4	File Pathway:	C:\JOBS\1436\ACT.WB1

Run Number ACETONE BLANK

Container #	Date	Init		1011
	08/23	BNL		3.6894
	08/20	BNL	@	3.6891
Tare Wt., g.	(	210	ml)	3.6881
SAMPLE WT., g.				0.0010

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REPORT SUMMARY

RFA#: 1436

OTM-028 SAMPLE ID	**ORGANIC Condensible PM**	**INORGANIC Condensible PM**	**$(NH_4)_2SO_4$ *Correction***	**FIELD BLANK *Correction* ***	**TOTAL Condensible PM**
ACETONE/$MeCl_2$ BLANK	0.3 mg (180 mL)				
H_2O BLANK		0.9 mg (310 mL)			
FIELD BLANK	0.5 mg	2.4 mg	0.17 mg	N/A	2.9 mg
M5B-028-1	0.6 mg	24.6 mg	1.02 mg	2.0 mg	23.2 mg
M5B-028-2	0.6 mg	33.9 mg	1.70 mg	2.0 mg	32.5 mg
M5B-028-3	0.4 mg	33.5 mg	1.70 mg	2.0 mg	31.9 mg
API2.5/028-1	0.7 mg	16.9 mg	1.02 mg	2.0 mg	15.6 mg
API2.5/028-2	0.6 mg	11.5 mg	0.51 mg	2.0 mg	10.1 mg
API2.5/028-3	0.6 mg	10.1 mg	0.51 mg	2.0 mg	8.7 mg

* A maximum of 2.0 mg were deducted from the Total Condensable Particulate Matter (CPM) for each run.

Analytical Narrative

RFA # 1436

Page 1 of 1

Client/Plant Name: Air Control Techniques

Date Rec'd in lab: 08/11/09

Analyst: BNL

Date of Analysis: 08/23/09

Analysis Method: EPA OTM-028

Analyte(s): Condensible Particulate

Sample Matrix & Components:

H_2O (dry) Impinger samples, Back½ Acetone/Methylene Chloride Rinses, Back½ CPM Filter, and solvent blanks.

Summary of Sample Prep:

CPM Filter was extracted by sonication twice first with water, then by methylene chloride per OTM-028. Each aliquot following 2 minutes sonication was transfered to water and methylene chloride field containers, respectively.

The H_2O field samples were then extracted with methylene chloride using the Back½ rinse as the first extract. Methylene Chloride rinses were evaporated overnight at ambient temperature then desiccated for 24 hours, after which time they were weighed daily every six hours until consecutive weights agreed within ±0.5 mg. The H_2O samples were evaporated at 85°F (at ambient pressure) until completely dry. H_2O samples were then resuspended in 50 mL deionized water and titrated to neutral pH using 0.1 N NH_4OH, allowed to dry again then desiccated for 24 hours and finally weighed daily every six hours until consecutive weights agreed within ±0.5 mg.

All weights were recorded to the nearest 0.1 mg. The total catch reported for each run is a sum of the condensible organic and inorganic catches minus total field blank catch weight or 2.0 mg, whichever is less.

Summary of Instrumentation:

Denver model Pinnacle Series analytical balance

Analytical Detection Limit(s): 0.5 mg

Miscellaneous Comments Regarding Sample Analysis: (Note unusual catch weights, interferences, odd sample behavior, and steps taken to confirm unusual results. Also note any deviations from standard analytical procedures, together with justification and possible affect on results. Specify samples when applicable.)

1) See data sheets for individual sample descriptions.

Confirmation of Data Review:

QA Officer Signature J. Bruce Nemet Date 8/25/09

(J. Bruce Nemet, Lab QA Officer)

PARTICULATE SAMPLING LABORATORY RESULTS (EPA OTM-028)

Plant Name:			*RFA #*	***1436***
Method:	*OTM-028*		*Filename:*	*ACT*
Date Received:	*08/11/09*	*Page 1 of 4*	*File Pathway:*	*C:\JOBS\1436\ACT.WB1*

Run Number	M5B-028-1	M5B-028-2	M5B-028-3

DI H2O Container #	*Date*	*Init*		*2176*	*Date*		*1675*	*Date*		*963*
	08/23	*BNL*	*@*	*3.8085*	*08/23*		*3.6363*	*08/23*		*3.4134*
	08/22	*BNL*	*@*	*3.8085*	*08/22*	*@*	*3.6361*	*08/22*	*@*	*3.4133*
Tare Wt., g.		*(470*	*ml)*	*3.7829*	*(575*	*ml)*	*3.6005*	*(515*	*ml)*	*3.3781*
SAMPLE WT., g.				*0.0256*			*0.0356*			*0.0352*

Acetone/MeCl2 Container #	*Date*	*Init*		*1255*	*Date*		*1494*	*Date*		*1006*
	08/23	*BNL*		*3.8829*	*08/23*	*@*	*3.6800*	*08/23*		*3.9873*
	08/22	*BNL*	*@*	*3.8827*	*08/22*	*@*	*3.6800*	*08/22*	*@*	*3.9872*
Tare Wt., g.		*(160*	*ml)*	*3.8821*	*(140*	*ml)*	*3.6794*	*(145*	*ml)*	*3.9868*
SAMPLE WT., g.				*0.0006*			*0.0006*			*0.0004*

Organic Fraction Catch, mg.	*0.6*	*0.6*	*0.4*
Organic (MeCl2/Acetone) Field Blank Correction, mg.	*0.0*	*0.0*	*0.0*
Organic Fraction Catch, mg.	***0.6***	***0.6***	***0.4***
Inorganic Fraction Catch, mg.	*25.6*	*35.6*	*35.2*
Inorganic (H2O) Field Blank Correction, mg.	*0.0*	*0.0*	*0.0*
Inorganic Fraction Catch, mg.	*25.6*	*35.6*	*35.2*
Volume (Vt) of NH4OH added (N=0.1), ml	*0.60*	*1.00*	*1.00*
Correction for ammonia added, mg	*1.02*	*1.70*	*1.70*
Adjusted Inorganic Fraction Catch, mg.	***24.6***	***33.9***	***33.5***

**A maximum of 2 mg deducted for field blank correction per OTM-028*

TOTAL OTM-028 CONDENSIBLE PARTICULATE, mg.	**23.2**	**32.5**	**31.9**

Miscellaneous Notes & Comments:

Visual Inspection of H2O			
Run ID	M5B-028-1	M5B-028-2	M5B-028-3
Color:	BROWN	BROWN	BROWN
Texture:	FILM	FILM	FILM
Foreign Matter:	NONE	NONE	NONE
Relative Comp:	HIGH	HIGH	HIGH

Visual Inspection of MeCl2			
Run ID	M5B-028-1	M5B-028-2	M5B-028-3
Color:	WHITE	WHITE	WHITE
Texture:	FILM	FILM	FILM
Foreign Matter:	NONE	NONE	NONE
Relative Comp:	LOW	LOW	LOW

Printing Date: 23-Aug-09 Printing Time: 02:30 PM

PARTICULATE SAMPLING LABORATORY RESULTS (EPA OTM-028)

Plant Name:			*RFA #*	***1436***
Method:	*OTM-028*		*Filename:*	*ACT*
Date Received:	*08/11/09*	*Page 2 of 4*	*File Pathway:*	*C:\JOBS\1436\ACT.WB1*

Run Number	API2.5/028-1	API2.5/028-2	API2.5/028-3

	Date	Init		1345	Date		1491	Date		973
DI H2O Container #										
	08/23	*BNL*		*3.7916*	*08/23*	*@*	*3.2388*	*08/23*	*@*	*3.6603*
	08/22	*BNL*	*@*	*3.7915*	*08/22*		*3.2389*	*08/22*	*@*	*3.6603*
Tare Wt., g.	*(*	*285*	*ml)*	*3.7736*	*(245*	*ml)*	*3.2268*	*(165*	*ml)*	*3.6497*
SAMPLE WT., g.				*0.0179*			*0.0120*			*0.0106*

	Date	Init		60	Date		1062	Date		186
Acetone/MeCl2 Container #										
	08/23	*BNL*	*@*	*3.6437*	*08/23*		*3.4501*	*08/23*	*@*	*3.4127*
	08/22	*BNL*	*@*	*3.6437*	*08/22*	*@*	*3.4500*	*08/22*	*@*	*3.4127*
Tare Wt., g.	*(*	*160*	*ml)*	*3.6430*	*(125*	*ml)*	*3.4494*	*(135*	*ml)*	*3.4121*
SAMPLE WT., g.				*0.0007*			*0.0006*			*0.0006*

Organic Fraction Catch, mg.	*0.7*	*0.6*	*0.6*
Organic (MeCl2/Acetone) Field Blank Correction, mg.	*0.0*	*0.0*	*0.0*
Organic Fraction Catch, mg.	***0.7***	***0.6***	***0.6***
Inorganic Fraction Catch, mg.	*17.9*	*12.0*	*10.6*
Inorganic (H2O) Field Blank Correction, mg.	*0.0*	*0.0*	*0.0*
Inorganic Fraction Catch, mg.	*17.9*	*12.0*	*10.6*
Volume (Vt) of NH4OH added (N=0.1), ml	*0.60*	*0.30*	*0.30*
Correction for ammonia added, mg	*1.02*	*0.51*	*0.51*
Adjusted Inorganic Fraction Catch, mg.	*16.9*	***11.5***	***10.1***

TOTAL OTM-028 CONDENSIBLE PARTICULATE, mg.	**15.6**	**10.1**	**8.7**

Miscellaneous Notes & Comments:

Visual Inspection of H2O			
Run ID	API2.5/028-1	API2.5/028-2	API2.5/028-3
Color:	WHITE/YELLOW	WHITE/YELLOW	WHITE
Texture:	FILM	FILM	FILM
Foreign Matter:	NONE	NONE	NONE
Relative Comp:	MEDIUM	MEDIUM	MEDIUM

Visual Inspection of MeCl2			
Run ID	API2.5/028-1	API2.5/028-2	API2.5/028-3
Color:	WHITE	WHITE	WHITE
Texture:	FILM	FILM	FILM
Foreign Matter:	NONE	NONE	NONE
Relative Comp:	LOW	LOW	LOW

Printing Date: 23-Aug-09 Printing Time: 02:30 PM

PARTICULATE SAMPLING LABORATORY RESULTS (EPA OTM-028)

Plant Name:			RFA #	1436
Method:	OTM-028		Filename:	ACT
Date Received:	08/11/09	Page 3 of 4	File Pathway:	C:\JOBS\1436\ACT.WB1

Run Number FIELD BLANK

DI H2O Container #	Date	Init		51		Date			Date	
	08/23	BNL	@	3.3993						
	08/22	BNL		3.3994				0.0000		0.0000
Tare Wt., g.		(355	ml)	3.3967	(		ml)	0.0000	(ml)	0.0000
SAMPLE WT., g.				0.0026				0.0000		0.0000

Acetone/MeCl2 Container #	Date	Init		824		Date			Date	
	08/23	BNL		3.5154						
	08/22	BNL	@	3.5153				0.0000		0.0000
Tare Wt., g.		(110	ml)	3.5148	(		ml)	0.0000	(ml)	0.0000
SAMPLE WT., g.				0.0005				0.0000		0.0000

Organic Fraction Catch, mg.	0.5	0.0	0.0
Organic (MeCl2/Acetone) Field Blank Correction, mg.	0.0	0.0	0.0
Organic Fraction Catch, mg.	0.5	0.0	0.0
Inorganic Fraction Catch, mg.	2.6	0.0	0.0
Inorganic (H2O) Field Blank Correction, mg.	0.0	0.0	0.0
Inorganic Fraction Catch, mg.	2.6	0.0	0.0
Volume (Vt) of NH4OH added (N=0.1), ml	0.10	0.00	0.00
Correction for ammonia added, mg	0.17	0.00	0.00
Adjusted Inorganic Fraction Catch, mg.	2.4	0.0	0.0

TOTAL OTM-028 CONDENSIBLE PARTICULATE, mg.	**2.9**	**0.0**	**0.0**

Miscellaneous Notes & Comments:

Visual Inspection of H2O			
Run ID	FIELD BLANK	0	0
Color:	WHITE		
Texture:	FILM		
Foreign Matter:	NONE		
Relative Comp:	LOW		

Visual Inspection of MeCl2			
Run ID	FIELD BLANK	0	0
Color:	WHITE		
Texture:	FILM		
Foreign Matter:	NONE		
Relative Comp:	LOW		

Printing Date: 23-Aug-09 Printing Time: 02:30 PM

REAGENT BLANK LABORATORY RESULTS (Version 04.28.92)

Plant Name:			RFA #	1436
Method:	OTM-028		Filename:	ACT
Date Received:	08/11/09	Page 4 of 4	File Pathway:	C:\JOBS\1436\ACT.WB1

Blank Type				Methylene Chloride/Acetone				Water
Sample ID/Container #				2177				2279
	Date	Init			Date			
	08/23		@	3.8229	08/23			3.5733
	08/22			3.8231	08/22		@	3.5731
Tare Wt., g.	(	180	ml)	3.8226	(	310	ml)	3.5722
SAMPLE WT., g.				0.0003				0.0009

Blank Beaker #	2177	2279
Final wt., mg.	3.8229	3.5731
Tare wt., mg.	3.8226	3.5722
Residue, mg.	0.300	0.900
Volume, ml.	180	310
Density, mg/ml	1315.0	1000.0
Conc., mg/mg	1.267E-06 @	2.903E-06 @
Upper Limit,mg/mg	1.000E-05	1.000E-05

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REPORT SUMMARY

RFA#: 1436

SAMPLE ID	*Suspended Solids*	*Dissolved Solids*
SRS-RUN 1	303.6 mg/L	1.2 %
SRS-RUN 2	322.3 mg/L	1.3 %
SRS-RUN 3	295.1 mg/L	1.3 %

PARTICULATE SAMPLING LABORATORY RESULTS

Plant Name:	***AIR CONTROL TECHNIQUES***	*RFA #*	***1436***
Method:	*Suspended/Disolved Solids*	*Filename:*	*ACT*
Date Received:	*08/11/09*	*File Pathway:*	*C:\JOBS\1436\ACT.WB1*

Page 1 of 1

Run Number				*SRS-Run 1*			*SRS-Run 2*			*SRS-Run 3*
Suspended Solids	*Date*	*Init*		*3*	*Date*		*284*	*Date*		*919*
	08/24	*JSC*		*5.0160*	*08/24*		*4.6837*	*08/24*		*4.4511*
Baggie Tare Wt., g.		*3*		*3.8017*			*3.4685*			*3.2386*
Filter Tare Wt., g.		*NJ-67*		*0.9168*	*NJ-68*		*0.9122*	*NJ-69*		*0.9381*
Suspended Solid Wt., g.	*Sample Volume*	*980*	*ml*	*0.2975*	*940*	*ml*	*0.3030*	*930*	*ml*	*0.2744*
Dissolved Solids	*Date*	*Init*		*2300*	*Date*		*2282*	*Date*		*2314*
	08/24	*JSC*		*4.0376*	*08/24*		*4.2141*	*08/24*		*3.9980*
Baggie Tare Wt., g.	*(*	*50*	*ml)*	*3.4507*	*(50*	*ml)*	*3.5702*	*(50*	*ml)*	*3.3329*
Dissolved Solid Wt., g.				*0.5869*			*0.6439*			*0.6651*
Suspended Solids, mg/L				***303.6***			***322.3***			***295.1***
Dissolved Solids, % w/v				***1.2***			***1.3***			***1.3***

Visual Inspection of Filters			
Run ID	*SRS-Run 1*	*SRS-Run 2*	*SRS-Run 3*
Color:	*BROWN*	*BROWN*	*BROWN*
Texture:	*STAIN*	*STAIN*	*STAIN*
Foreign Matter:	*NONE*	*NONE*	*NONE*
Relative Comp:	*MEDIUM*	*MEDIUM*	*LOW*

Visual Inspection of Rinses			
Run ID	*SRS-Run 1*	*SRS-Run 2*	*SRS-Run 3*
Color:	*YELLOW*	*YELLOW*	*YELLOW*
Texture:	*FLAKES*	*FLAKES*	*FLAKES*
Foreign Matter:	*NONE*	*NONE*	*NONE*
Relative Comp:	*HIGH*	*HIGH*	*HIGH*

Legend:
@ = Final Weight
F = Filter
R = Rinse

Miscellaneous Notes & Comments:

Printing Date: 25-Aug-09 Printing Time: 09:33 AM

PARTICULATE WORKSHEET

CLIENT AMT- Solids RFA # 1436

ANALYST RNL METHOD N/A DATE 8/11/09

RUN #	FILTER			ACETONE RINSE		NOZZLE CYCLONE		MECL2____ TOLUENE____ CHLOROFORM/ETHER____		DI H2O IMPINGER	
	CONT.#	FILTER #	TARE WT.(G)	CONT.#	VOL.(ML)	CONT.#	VOL.(ML)	CONT.#	VOL.(ML)	CONT.#	VOL.(ML)
SRS- Run 1		NT-67	0.9160							2300	980
-2		NT-68	0.9122							2282	940
-3		NT-69	0.9381							2314	930

PARTICULATE WORKSHEET

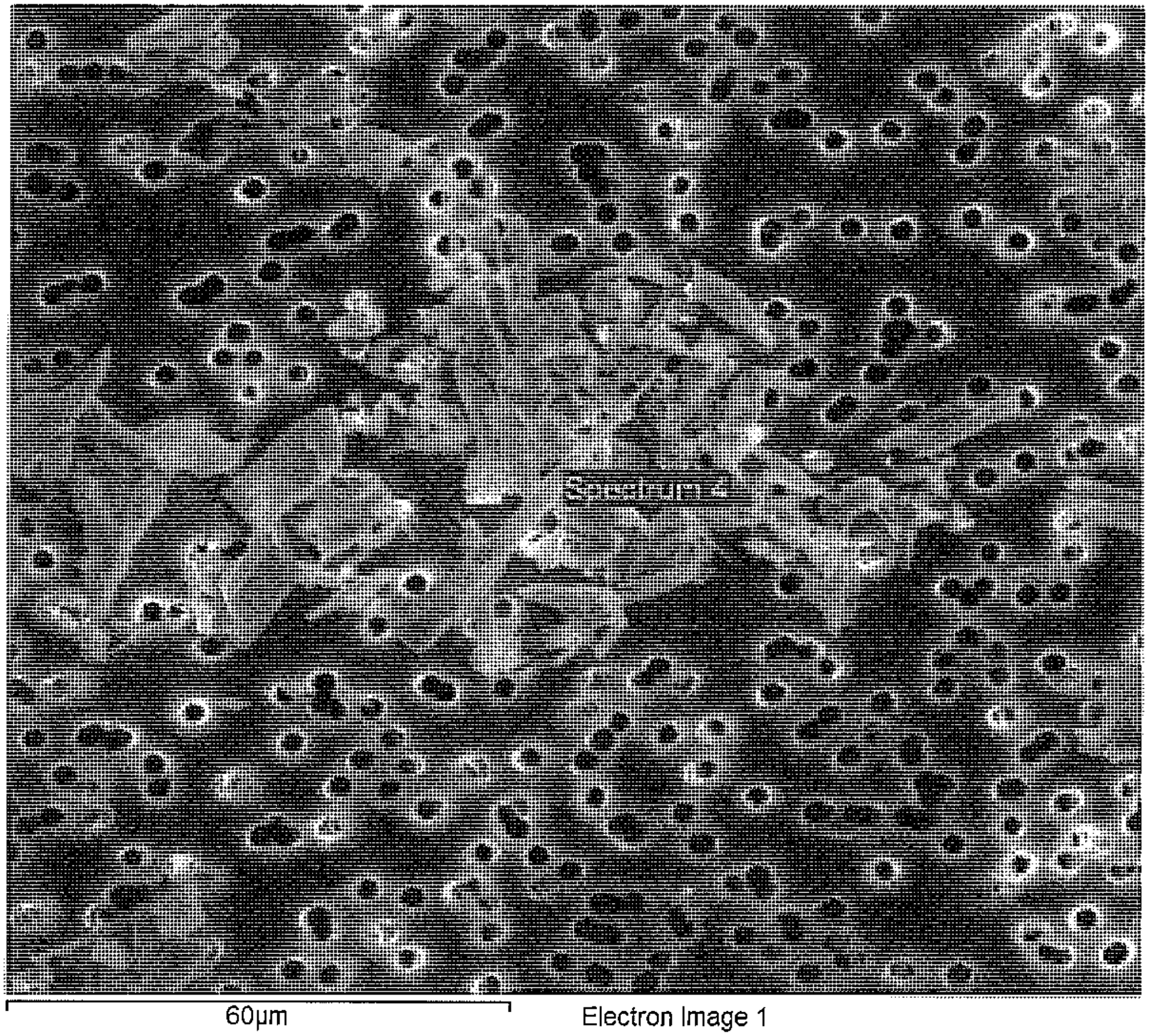
CLIENT ACT-
RFA # 1436
ANALYST BNL
METHOD 5B/027/028
DATE 8/11/09

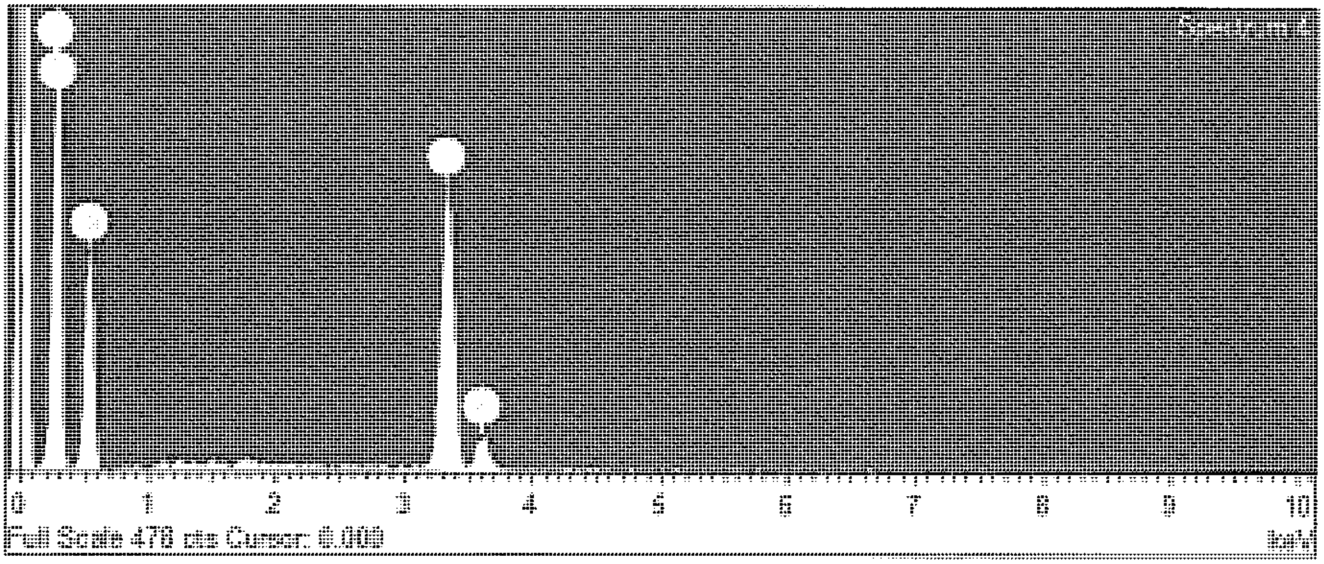
≤2.5 2.5-10

RUN #	FILTER			ACETONE RINSE		NOZZLE CYCLONE		MECL2___ TOLUENE___ CHLOROFORM/ETHER___		DI H2O IMPINGER	
	CONT.#	FILTER #	TARE WT.(G)	CONT.#	VOL.(ML)	CONT.#	VOL.(ML)	CONT.#	VOL.(ML)	CONT.#	VOL.(ML)
M5B-028-1	1451	RQ-5763	0.3838	659	120			1255	160	2176	470
-2	62	RQ-5762	0.3886	207	120			1494	140	1675	575
-3	780	RQ-5741	0.3992	444	90			10866	145	963	515
APM2.5-028-1	730	SF47-873	0.1139	676 11	50 250	1469	60	60	160	1345	285
-2	1495	SF47-874	0.1142	377 1268	40 150	1226	60	1862	125	1491	245
-3	1247	SF47-975	0.1128	1249 863	40 140	1405	50	186	135	973	165
Field Blank								824	110	51	355
Rgt Blank				1011	210			2177	180	2279	310

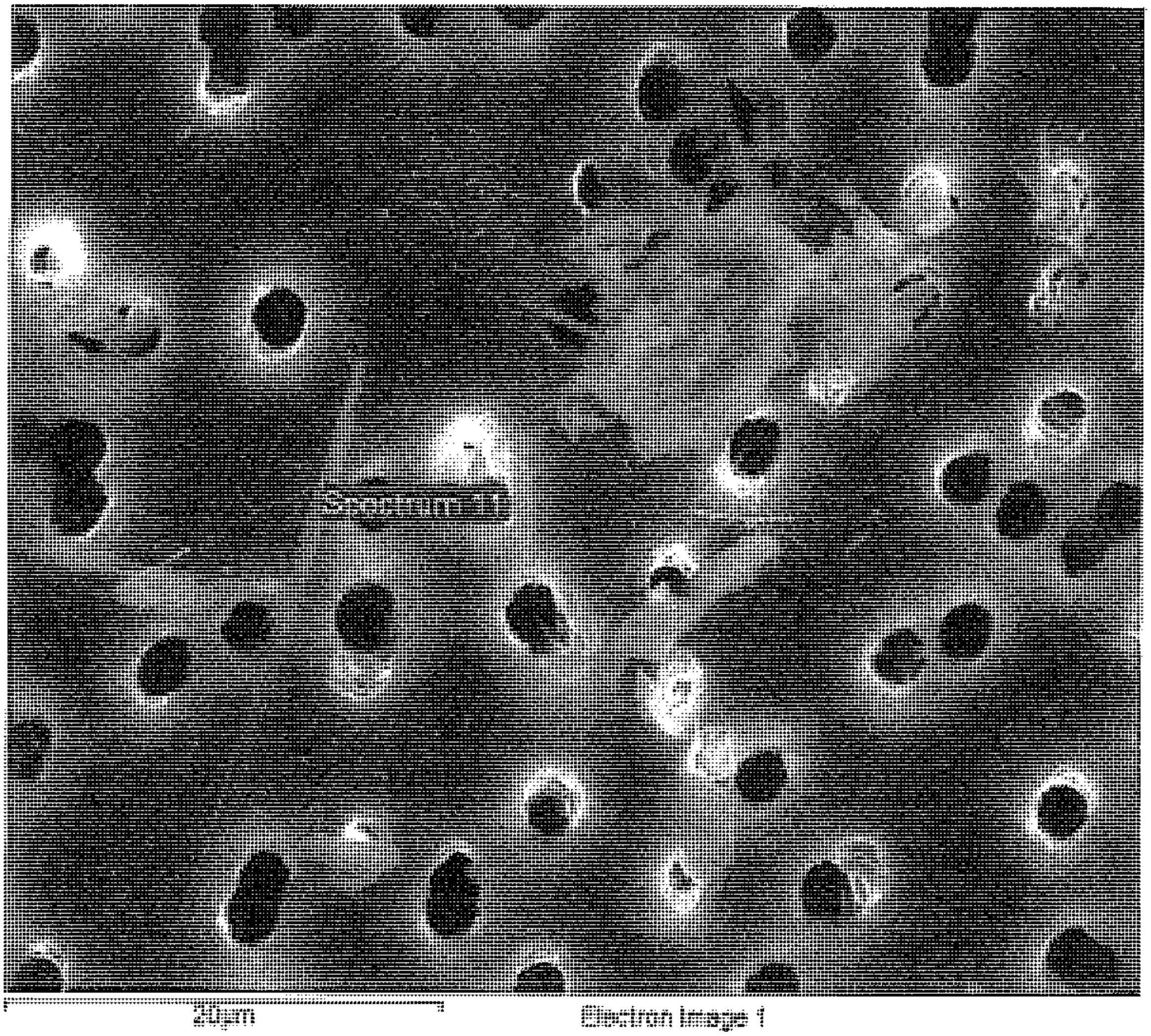
VOLUME I

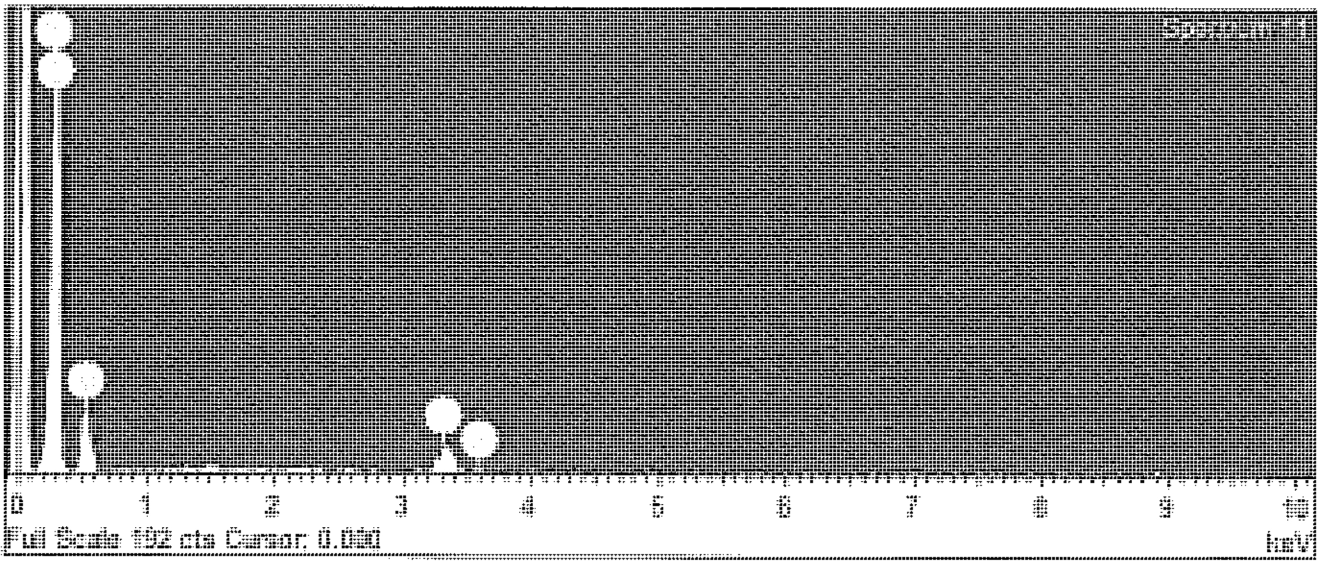
Appendix F – Research Triangle Institute Report





Comment: Particles and fibers sample 1.





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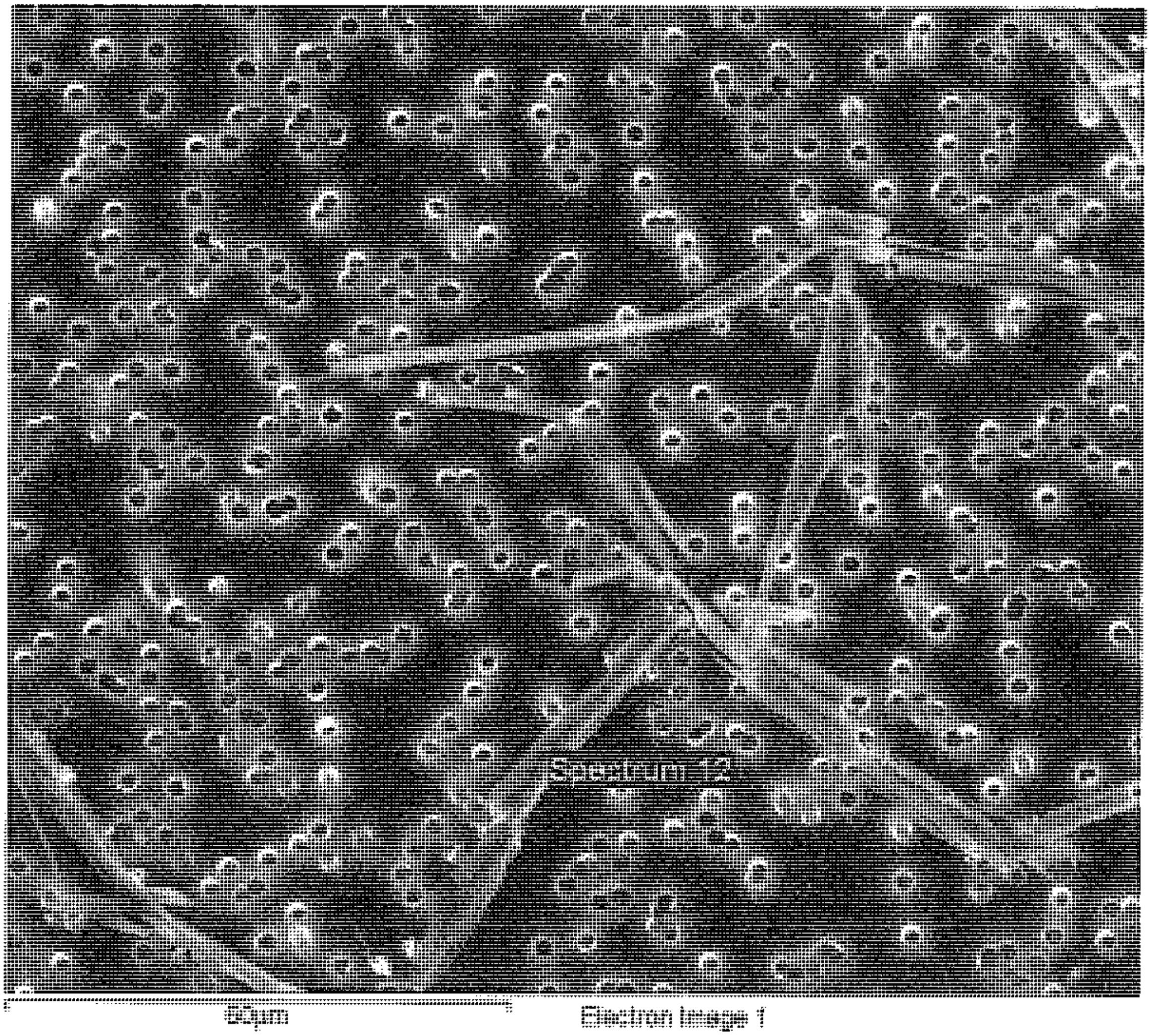
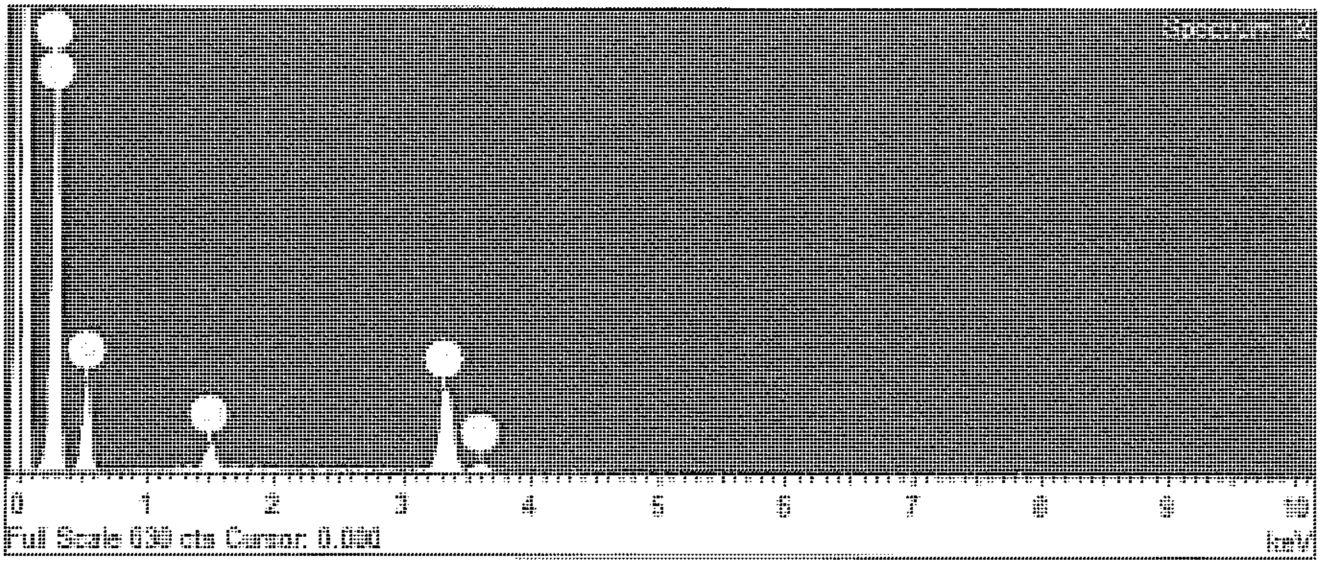
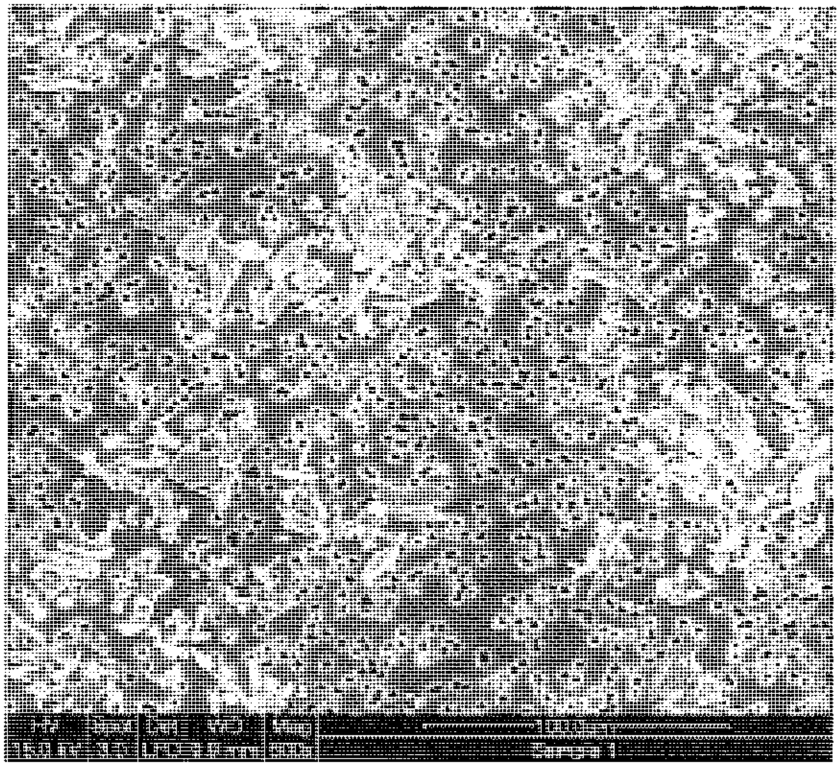
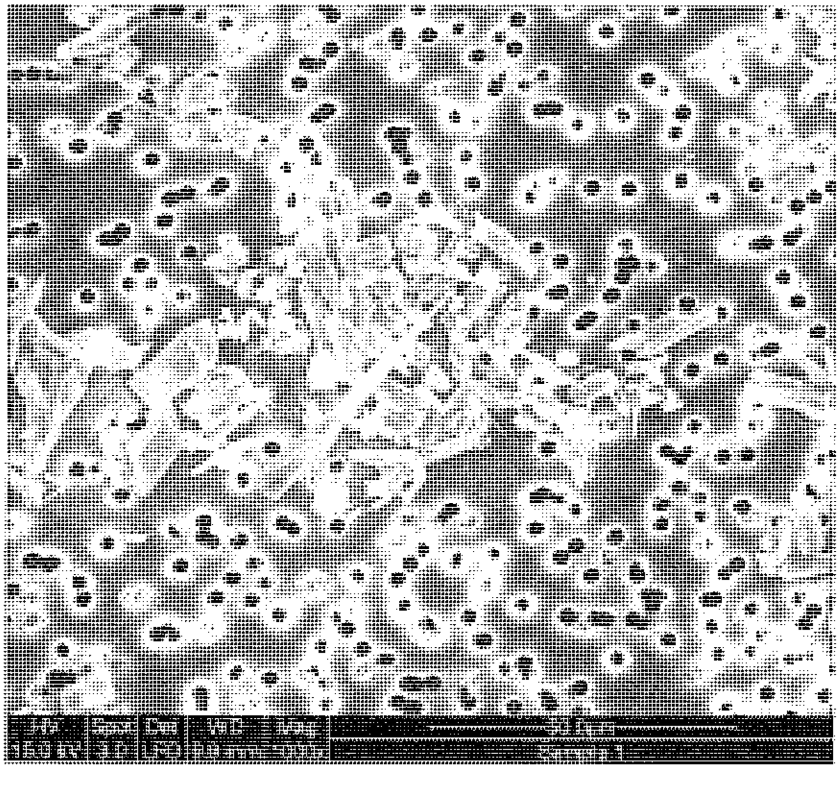
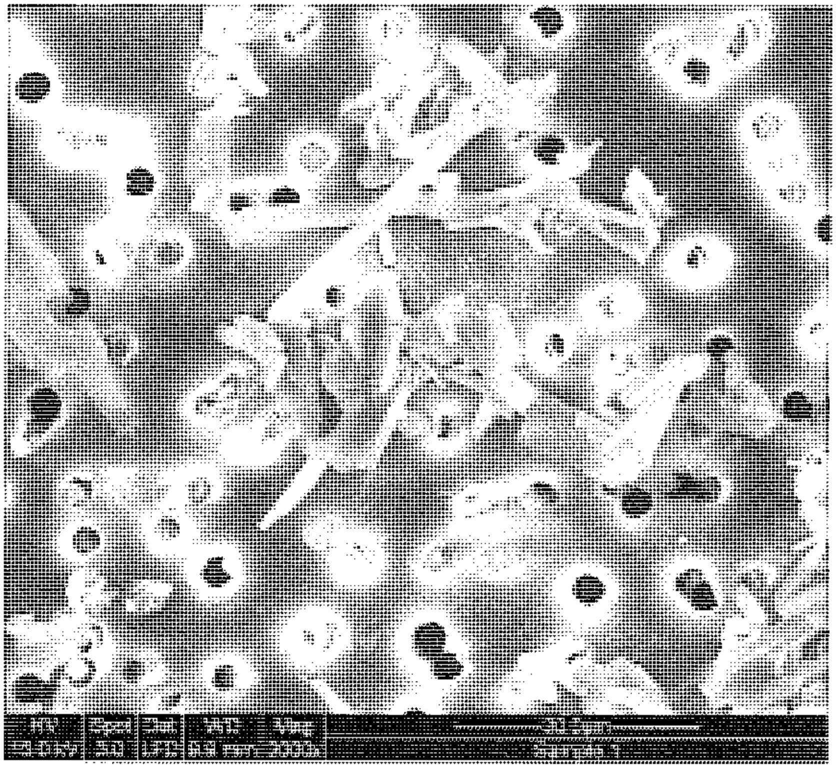


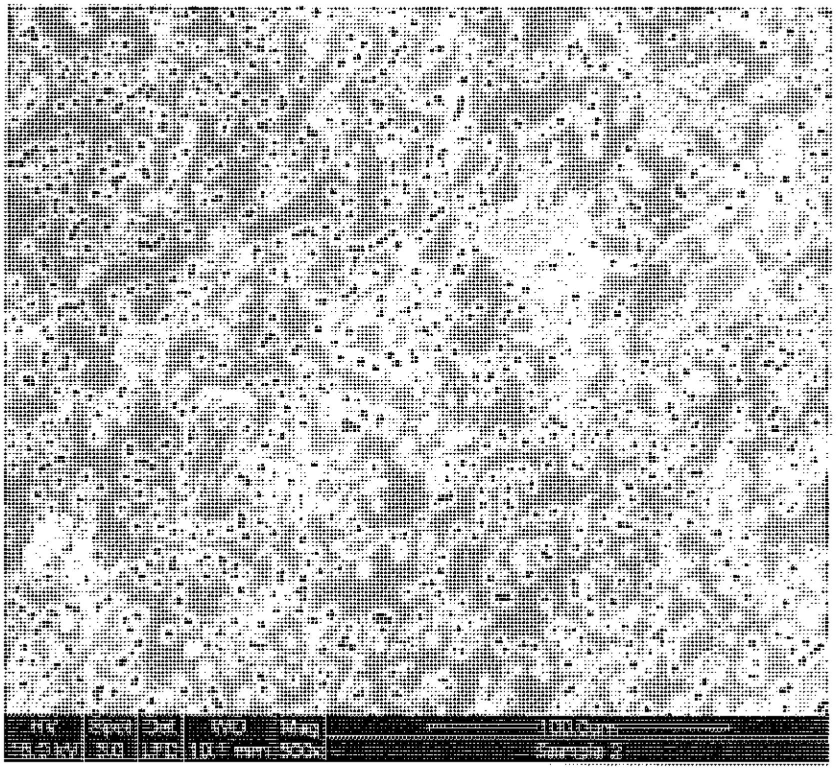


Comment: Fiber sample 3.






HV
Spot
Det
WD
Mag
LFD


HV
Spot
Det
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Mag
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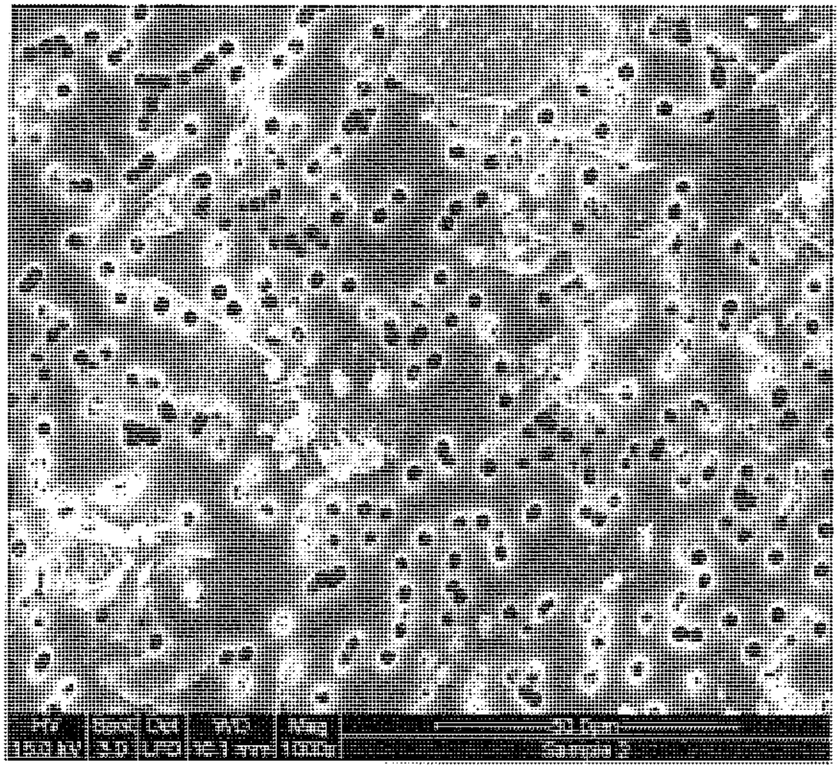
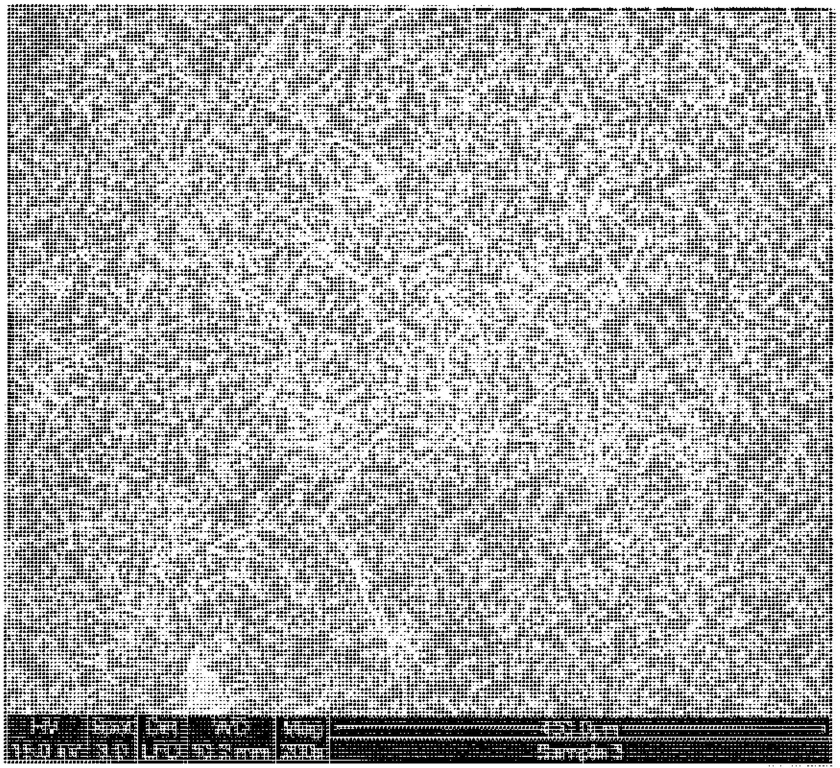
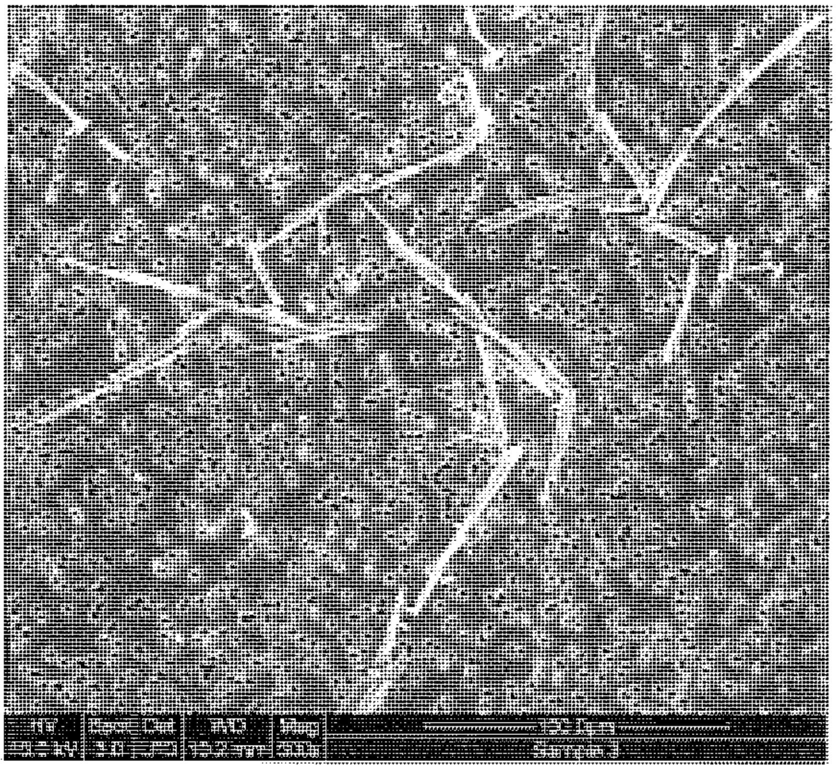
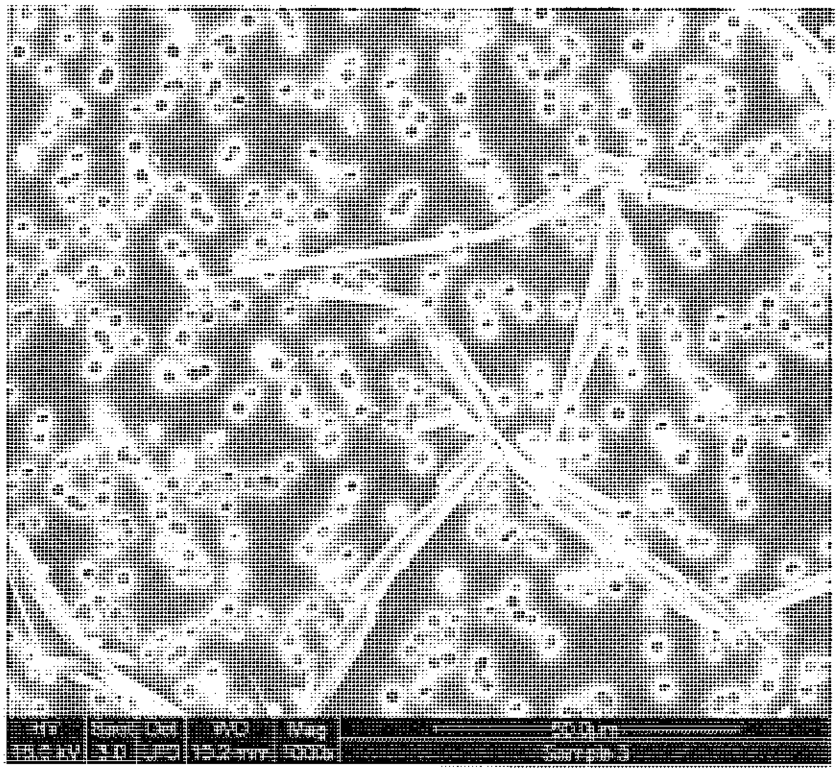

Mag
Sample 3


Mag
Sample 3


Sample 3


Sample 3

APPENDIX II
Data Sheets for Test Program 2

VOLUME II

VOLUME II

Appendix A – Test Results

Plant	
City	
State	
Sampling Location	Stack

PARAMETER	NOMENCLATURE	PM10-2.5-1	PM10-2.5-3
Sampling Location			
Date		2-24-10	2/25/2010
Run Time	Theta	180.00	180.00
Nozzle Diameter	inches	0.182	0.182
Pitot Tube Coefficient	Cp	0.84	0.84
Meter Calibration Factor	Y	1.0206	1.0206
Barometric Pressure, inches Hg	Bp - in Hg	29.90	29.90
Meter Box Pressure Differential	ΔH - in. H2O	0.40166667	0.400833333
Volume of Gas Sampled	Vm - cu. ft.	58.523	56.148
Dry Gas Meter Temperature	Tm - °F	59.9	50.1
Volume of Gas Sampled, Dry	Vmstd - cu. ft.	42.804	41.463
Liquid Collected	ml	181	0
Volume of Water Vapor	Vwstd - cu. ft.	8.520	0.000
Moisture Content	%H_20	16.600	0.00
Saturation Moisture	%H_20	100.0	100.0
Dry Mole Fraction	Mfd	0.834	1.000
Carbon Dioxide	%CO_2	15.5	15.5
Oxygen	%O_2	2.7	2.7
Carbon Monoxide	%CO	0	0
Nitrogen	%N_2	81.8	81.8
Fuel Factor	Fo	1.174	1.174
Gas Molecular Weight, Dry	Md	30.588	30.59
Gas Molecular Weight, Wet	Ms	28.498	30.588
Static Pressure	Pg - in. H_2O	0.51	0.68
Stack Pressure	Ps	29.94	29.95
Stack Temperature	Ts - °F	424.0	430.8
Average Velocity Head	Δp - in H_2O	0.25	0.34
Gas Velocity	vs - ft./sec.	36.55	41.29
Stack Area	As - sq. ft.	70.8821842	70.88218425
Volumetric Air Flow, Actual	Qaw - ACFM	155,439	175,609
Volumetric Air Flow, Standard	Qsd - DSCFM	77,475	104,188
Total Particulate Catch	mg	18.8	14.7
Probe and Nozzle	mg	16.8	12.9
Cyclone and Cup	mg	1.0	0.9
PM2.5 Catch (Filter)	mg	1.0	0.9
Condensable PM catch	mg	89.7	82.3

Plant			
City			
State			
Sampling Location	Stack		
		PM10-2.5-1	PM10-2.5-3
Total Particulate Emissions			
Grains/DSCF	gr/DSCF	0.006778	0.005471
Grains/DSCF at 7% O_2	gr/DSCF@7%O_2	0.005177	0.004179
Pounds/Hour	lb/hr	4.501	4.886
PM_{10} Emissions			
Grains/DSCF	gr/DSCF	0.000361	0.000335
Grains/DSCF at 7% O_2	gr/DSCF@7%O_2	0.000275	0.000256
Pounds/Hour	lb/hr	0.239	0.299
$PM_{2.5}$ Emissions			
Grains/DSCF	gr/DSCF	0.000361	0.000335
Grains/DSCF at 7% O_2	gr/DSCF@7%O_2	0.000275	0.000256
Pounds/Hour	lb/hr	0.239	0.299
Condensable Particulate Emissions			
Grains/DSCF	gr/DSCF	0.03236823	0.0306579
Grains/DSCF at 7% O_2	gr/DSCF@7%O_2	0.02472079	0.02341455
Pounds/Hour	lb/hr	21.495	27.379

Plant	
City	
State	
Sampling Location	Stack

PARAMETER	NOMENCLATURE	PM10-2.5-4
Sampling Location		
Date		2/25/2010
Run Time	Theta	180.00
Nozzle Diameter	inches	0.182
Pitot Tube Coefficient	Cp	0.84
Meter Calibration Factor	Y	1.0206
Barometric Pressure, inches Hg	Bp - in Hg	29.90
Meter Box Pressure Differential	ΔH - in. H2O	0.421666667
Volume of Gas Sampled	Vm - cu. ft.	58.254
Dry Gas Meter Temperature	Tm - °F	59.4
Volume of Gas Sampled, Dry	Vmstd - cu. ft.	42.586
Liquid Collected	ml	138
Volume of Water Vapor	Vwstd - cu. ft.	6.496
Moisture Content	%H_20	13.23
Saturation Moisture	%H_20	100.0
Dry Mole Fraction	Mfd	0.868
Carbon Dioxide	%CO_2	15.5
Oxygen	%O_2	2.7
Carbon Monoxide	%CO	0
Nitrogen	%N_2	81.8
Fuel Factor	Fo	1.174
Gas Molecular Weight, Dry	Md	30.59
Gas Molecular Weight, Wet	Ms	28.922
Static Pressure	Pg - in. H_2O	0.68
Stack Pressure	Ps	29.95
Stack Temperature	Ts - °F	430.3
Average Velocity Head	Δp - in H_2O	0.29
Gas Velocity	vs - ft./sec.	39.20
Stack Area	As - sq. ft.	70.88218425
Volumetric Air Flow, Actual	Qaw - ACFM	166,734
Volumetric Air Flow, Standard	Qsd - DSCFM	85,887
Total Particulate Catch	mg	12.8
Probe and Nozzle	mg	11.4
Cyclone & Cup Catch	mg	0.5
PM2.5 Catch Filter	mg	0.9

Plant		
City		
State		
Sampling Location	Stack	
		PM10-2.5-4
Total Particulate Emissions		
Grains/DSCF	gr/DSCF	0.004638
Grains/DSCF at 7% O_2	gr/DSCF@7%O_2	0.003543
Pounds/Hour	lb/hr	3.415
PM_{10} Emissions		
Grains/DSCF	gr/DSCF	0.000181
Grains/DSCF at 7% O_2	gr/DSCF@7%O_2	0.000138
Pounds/Hour	lb/hr	0.133
$PM_{2.5}$ Emissions		
Grains/DSCF	gr/DSCF	0.000326
Grains/DSCF at 7% O_2	gr/DSCF@7%O_2	0.000249
Pounds/Hour	lb/hr	0.240

Plant Name
City, State
Project # 1436
Test Location

PARAMETER	**NOMENCLATURE**	M5B/028-1	M5B/028-3	M5B/028-4
Date		2/24/2010	2/25/2010	2/25/2010
Run Time	θ	180	180	180
Nozzle Diameter	inches	0.299	0.299	0.298
Stack Area	As - sq. ft.	70.882	70.882	70.882
Pitot Tube Coefficient	Cp	0.84	0.84	0.84
Meter Calibration Factor	Y	0.9602	0.9602	0.9602
Barometric Pressure, inches Hg	Bp - in Hg	29.90	29.90	29.90
Static Pressure	Pg - in. H_2O	0.51	0.68	0.68
Stack Pressure	Ps	29.94	29.95	29.95
Meter Box Pressure Differential	Δ H - in. H_2O	0.88	1.02	0.93
Average Velocity Head	Δ p - in. H_2O	0.2563	0.2904	0.2655
Volume of Gas Sampled	Vm - cu. ft.	103.762	108.048	103.553
Dry Gas Meter Temperature	Tm - °F	69.8	59.9	68.8
Stack Temperature	Ts - °F	424.3	430.8	430.3
Liquid Collected	grams	296.3	324.7	312.8
Carbon Dioxide	% CO_2	15.5	15	15
Oxygen	% O_2	6	2.1	2.1
Carbon Monoxide	% CO	0	0	0
Nitrogen	% N_2	78.5	82.9	82.9
Fuel Factor	Fo	0.961	1.253	1.253
Volume of Gas Sampled, Dry	Vmstd - cu. ft.	99.452	105.553	99.451
Volume of Water Vapor	Vwstd - cu. ft.	13.971	15.310	14.749
Moisture Content	% H_20	12.32	12.67	12.91
Saturation Moisture	% H_20	100.00	100.00	100.00
Dry Mole Fraction	Mfd	0.877	0.873	0.871
Gas Molecular Weight, Dry	Md	30.72	30.48	30.48
Gas Molecular Weight, Wet	Ms	29.15	28.90	28.87
Gas Velocity	vs - ft./sec.	36.60	39.26	37.55
Volumetric Air Flow, Actual	Qaw - ACFM	155,652	166,964	159,683
Volumetric Air Flow, Standard	Qsd - DSCFM	81,534	86,512	82,558
Isokinetic Sampling Rate	% I	98.5	98.5	97.9
Filterable Particulate Catch	mg	16.3	10.2	14.4
Condesible Particulate Catch	mg	229.8	238.3	249.3
FILTERABLE PARTICULATE EMISSIONS				
Grains/DSCF	gr/DSCF	0.0025	0.0015	0.0022
Grains/DSCF at 12% CO_2	gr/DSCF@12% CO_2	0.0020	0.0012	0.0018
Grains/DSCF at 7% O_2	gr/DSCF@7% O_2	0.0024	0.0011	0.0017
Pounds/Hour	lb/hr	1.77	1.11	1.58
CONDENSABLE PARTICULATE EMISSIONS				
Grains/DSCF	gr/DSCF	0.0357	0.0348	0.0387
Grains/DSCF at 12% CO_2	gr/DSCF@12% CO_2	0.0276	0.0279	0.0309
Grains/DSCF at 7% O_2	gr/DSCF@7% O_2	0.0333	0.0258	0.0286
Pounds/Hour	lb/hr	24.92	25.84	27.38

VOLUME II

Appendix B – Example Calculations

EXAMPLE CALCULATIONS

Run Number: M5B/028-1

Stack Gas Temperature, °R

$$T_s = 460 + ts$$

$$T_s = 460 + 424.3 = 884.3$$

Volume of Dry Gas Sampled at Standard Conditions, Dry Standard Cubic Feet

$$V_{mstd} = [17.64][\gamma][V_m]\left[\frac{\left(P_{bar} + \frac{\Delta H}{13.6}\right)}{T_m + 460}\right]$$

$$V_{mstd} = [17.647][0.9602][103.762]\left[\frac{\left(29.90 + \frac{0.88}{13.6}\right)}{529.8}\right]$$

$$V_{mstd} = 99.452 \text{ ft}^3$$

Volume of Water Sampled, SCF

$$V_{wstd} = 0.04715 \text{ [Weight of Condensed Moisture]}$$

$$V_{wstd} = 0.04715 [296.3]$$

$$V_{wstd} = 13.971 \text{ ft}^3$$

Fraction of Water Vapor in Sample Gas Stream

$$\%H_2O = \left[\frac{V_{wstd}}{V_{mstd} + V_{wstd}}\right] \times 100$$

$$\%H_2O = \left[\frac{13.971}{99.452 + 13.971}\right] \times 100$$

$$\%H_2O = 12.32$$

Dry Mole Fraction of Flue Gas

$M_{fd} = 1\text{-}\%H2O/100$

$M_{fd} = 1\text{-}[12.32/100]$ Must use saturation moisture for Mfd calculation.

$M_{fd} = 0.877$

Molecular Weight of Sample Gas, Dry

$M_d = 0.44[\%CO_2]+0.32[\%O_2]+0.28[100\text{-}\%O_2\text{-}\%CO_2]$

$M_d = 0.44[15.5]+0.32[6]+0.28[100\text{-}6\text{-}15.5]$

$M_d = 30.72$ pounds/pound-mole

Molecular Weight of Sample Gas, Actual Conditions

$M_s = [M_d \text{ x } M_{fd}]+[0.18 \text{ x } \%H_2O]$

$M_s = [30.71 \text{ x } 0.877]+[0.18 \text{ x } 12.32]$

$M_s = 29.15$ pounds/pound-mole

Average Stack Gas Velocity, Feet/second

$$vs = K_p C_p \left(\sqrt{(\Delta p)}\right)_{avg} \left[\sqrt{\frac{T_s + 460}{P_s M_s}}\right]$$

$$vs = (85.49)(0.84)\left(\sqrt{0.2563}\right)\left[\sqrt{\frac{884.3}{(29.94)(29.15)}}\right]$$

vs = 36.60 feet/second

Wet Volumetric Flue Gas Flow Rate at Stack Conditions, Cubic Feet per Minute

$Q_{aw} = 60 \text{ x vs x A}$

$Q_{aw} = 60 \text{ x } 36.60 \text{ x } 70.882$

$Q_{aw} = 155{,}652$ Actual Cubic Feet per Minute

Dry Volumetric Flue Gas Flow Rate at Standard Conditions, Cubic Feet per Minute

$$Q_{sd} = 60 \times Mfd \times vs \times A \times \left[\frac{528}{ts + 460}\right]\left[\frac{Ps}{29.92}\right]$$

$$Q_{sd} = 60 \times 0.877 \times 36.60 \times 70.882\left[\frac{528}{884.3}\right]\left[\frac{29.94}{29.92}\right]$$

$Q_{sd} = 81{,}534$ Dry Standard Cubic Feet per Minute

Isokinetic Sampling Rate, Percent

$$I = \left(\frac{100\,(T_s)(V_{mstd})(29.92)}{(60)(vs)(\theta)(An)(P_s)(M_{fd})(528)}\right)$$

$$I = \left(\frac{100\,(884.3)(99.452)(29.92)}{(60)(36.60)(180)(0.000488)(29.94)(0.877)(528)}\right)$$

$I = 98.5\,\%$

Filterable Particulate Matter Concentration, Grains per Dry Standard Cubic Foot

$$\text{gr/DSCF} = \left[\frac{CatchWeight(mg/1000)}{V_{mstd}}\right]\left[\frac{7000}{453.592}\right]$$

$$\text{gr/DSCF} = \left[\frac{0.0163}{99.452}\right]\left[\frac{7000}{453.592}\right]$$

$$\text{gr/DSCF} = 0.0025$$

Filterable Particulate Matter Emission Rate, Pounds per hour

$$\text{lb/hr} = \left(\frac{mg/1000}{453.592}\right)\times\left(\frac{Qsd}{Vmstd}\right)\times 60$$

$$\text{lb/hr} = \left(\frac{0.0163}{453.592}\right)\times\left(\frac{81{,}534}{99.452}\right)\times 60$$

$$\text{lb/hr} = 1.77$$

VOLUME II

Appendix C – Field Data

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	PM10-2.5-1
Condition	Normal

IDENTIFICATION INFORMATION

Plant Name	
City	
State	

Source Number	FCC 135	Date	2-24-10
Sampling Location	Stack	Start	0958
Test Personnel	TTB	Stop	1302

Meterbox ID	909033
ΔH @	1.9070
Gamma, γ	1.0206
Nozzle ID	SS-1
Nozzle Diameter	0.182
Orsat/Fyrite	FYR

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0.001	< 0.02 or 4%	10
Partial Train Posttest Leak Check, ACFM		0.020	

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	NA	NA
Pitot Tube Posttest Leak Check	NA	NA

Barometric Pressure, In.,Hg.	29.90	Static Pressure, In. W.C.	0.51

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams	181	Moisture, %	12.312
CO_2 %	15.5	Md_run	29.86
O_2 %	2.7	Mw_run	28.81

Sampling Information											QA Checks			
Port	Point	Dwell Time, Min.	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Sample Train Vac. (in. Hg)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Target ΔH (in.H_2O)	% Iso	Run Cummulative D$_{50}$s, microns PM_{10}	$PM_{2.5}$
A	1	15.00	0	814.5	0.25	53	417	2	60	0.41	0.414	121.4	9.79	2.13
	2	15.00	15:00	819.63	0.25	57	422	2	55	0.41	0.417	117.2	9.90	2.17
	3	15.00	30:00	824.61	0.25	58	422	2	54	0.41	0.418	115.6	9.97	2.19
	4	15.00	45:00	829.53	0.25	59	423	2	58	0.38	0.419	111.2	10.08	2.23
	5	15.00	1:00:00	834.27	0.25	60	424	2	54	0.38	0.419	110.8	10.14	2.25
B	6	15.00	1:15:00	839	0.25	61	424	2	55	0.39	0.420	112.0	10.18	2.26
	1	15.00	1:30:00	843.79	0.25	61	426	2	54	0.39	0.420	111.9	10.20	2.27
	2	15.00	1:45:00	848.57	0.25	61	426	2	55	0.41	0.420	112.6	10.21	2.28
	3	15.00	2:00:00	853.38	0.25	61	426	2	56	0.41	0.420	114.5	10.21	2.28
	4	15.00	2:15:00	858.27	0.25	62	426	2	54	0.41	0.421	112.9	10.22	2.28
	5	15.00	2:30:00	863.1	0.25	63	426	2	51	0.41	0.422	115.9	10.21	2.27
	6	15.00	2:45:00	868.07	0.25	63	426	2	53	0.41	0.422	115.5	10.20	2.27
Total Run Time			3:00:00	873.023										
Total Volume, ACF				58.523										
				Averages	0.25	59.9	424			0.402		117.4	11.29	2.66
					in. H2O	°F	°F			in H2O		%	microns	

Run	PM10-2.5-1

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	PM10-2.5-3
Condition	

IDENTIFICATION INFORMATION

Plant Name	
City	
State	

Source Number	FCC 135	Date	2/25/2010
Sampling Location	Stack	Start	0741
Test Personnel	TTB	Stop	1041

Meterbox ID	909033
Δ H @	1.9070
Gamma, γ	1.0206
Nozzle ID	
Nozzle Diameter	0.182
Orsat/Fyrite	FYR

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM	0	0.020	

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	0	0
Pitot Tube Posttest Leak Check	0	0

Barometric Pressure, In.,Hg.	29.90	Static Pressure, In. W.C.	0.68

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams		Moisture, %	12.600
CO_2 %	15.5	Md_run	29.81
O_2 %	2.7	Mw_run	28.77

Sampling Information / QA Checks

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Sample Train Vac. (in. Hg)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Target ΔH (in.H_2O)	% Iso	Run Cummulative D_{50}s, microns PM_{10}	$PM_{2.5}$
A	1	15.00	0	931.3	0.34	46	429	2	46	0.41	0.427	104.9	10.18	2.28
	2	15.00	15:00	936.09	0.34	48	430	2	44	0.4	0.429	100.6	10.33	2.34
	3	15.00	30:00	940.7	0.34	48	430	2	45	0.4	0.429	101.9	10.35	2.34
	4	15.00	45:00	945.37	0.34	49	431	2	46	0.4	0.430	101.8	10.36	2.35
	5	15.00	1:00:00	950.04	0.34	50	431	2	47	0.4	0.431	102.0	10.36	2.35
B	6	15.00	1:15:00	954.73	0.34	50	431	2	47	0.4	0.431	102.2	10.36	2.35
	1	15.00	1:30:00	959.43	0.34	50	432	2	48	0.4	0.431	102.5	10.36	2.35
	2	15.00	1:45:00	964.14	0.34	50	432	2	50	0.4	0.431	102.5	10.36	2.35
	3	15.00	2:00:00	968.85	0.34	51	431	2	48	0.4	0.432	101.6	10.36	2.35
	4	15.00	2:15:00	973.53	0.34	52	431	2	51	0.4	0.433	101.6	10.37	2.35
	5	15.00	2:30:00	978.22	0.34	53	431	2	54	0.4	0.433	100.1	10.38	2.35
	6	15.00	2:45:00	982.85	0.34	54	431	2	58	0.4	0.434	99.2	10.40	2.36
Total Run Time			3:00:00	987.448										
Total Volume, ACF				56.148										
Averages					0.34	50.1	430.8			0.401		103.4	11.49	2.74
					in. H2O	°F	°F			in H2O		%	microns	

Run	PM10-2.5-3

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	PM10-2.5-4
Condition	

IDENTIFICATION INFORMATION

Plant Name	
City	
State	

Source Number	FCC 135	Date	2/25/2010
Sampling Location	Stack	Start	1135
Test Personnel	TTB	Stop	1435

		Filter ID	Tare
Meterbox ID	909033		
Δ H @	1.9070		
Gamma, γ	1.0206		
Nozzle ID			
Nozzle Diameter	0.182		
Orsat/Fyrite	FYR		

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0.001	< 0.02 or 4%	10
Partial Train Posttest Leak Check, ACFM	0	0.020	5

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	0	0
Pitot Tube Posttest Leak Check	0	0

Barometric Pressure, In.,Hg.	29.90	Static Pressure, In. W.C.	0.68

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams	138	Moisture, %	12.600
CO_2 %	15.5	Md_run	29.94
O_2 %	2.7	Mw_run	28.81

Sampling Information / *QA Checks*

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Sample Train Vac. (in. Hg)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Target ΔH (in.H_2O)	% Iso	Run Cummulative D$_{50}$s, microns PM$_{10}$	PM$_{2.5}$
A	1	15.00	0	987.7	0.29	55	430	2	50	0.4	0.437	109.8	11.66	2.86
	2	15.00	15:00	992.41	0.29	55	431	2	58	0.4	0.437	107.8	11.74	2.89
	3	15.00	30:00	997.03	0.29	57	430	2	57	0.42	0.439	111.5	11.67	2.86
	4	15.00	45:00	1001.83	0.29	58	430	2	59	0.42	0.440	112.2	11.63	2.84
	5	15.00	1:00:00	1006.67	0.29	60	430	2	57	0.42	0.442	109.0	11.64	2.85
B	6	15.00	1:15:00	1011.39	0.29	61	430	2	60	0.42	0.443	115.2	11.58	2.82
	1	15.00	1:30:00	1016.39	0.29	61	431	2	61	0.43	0.443	113.9	11.55	2.81
	2	15.00	1:45:00	1021.33	0.29	59	431	2	62	0.43	0.441	113.4	11.53	2.80
	3	15.00	2:00:00	1026.23	0.29	60	430	2	62	0.43	0.442	114.1	11.51	2.79
	4	15.00	2:15:00	1031.17	0.29	61	430	2	64	0.43	0.443	113.1	11.50	2.79
	5	15.00	2:30:00	1036.08	0.29	63	430	2	60	0.43	0.444	112.2	11.50	2.79
	6	15.00	2:45:00	1040.97	0.29	63	430	2	61	0.43	0.444	114.4	11.48	2.78
Total Run Time			3:00:00	1045.95										
Total Volume, ACF				58.254										
				Averages	0.29	59.4	430.3			0.422		114.1	11.29	2.66
					in. H2O	°F	°F			in H2O		%	microns	

Run	PM10-2.5-4

Air Control Techniques, P.C.
Isokinetic Sampling Train Field Data Sheet

Job # 1436

Run ID M5B/028-1
Condition

IDENTIFICATION INFORMATION

Plant
City, State

Test Location: FCC 135 Stack
Personnel: DLS, TTB
Date: 2/24/10
Start: 0958
Stop: 1304

Meterbox ID: 802012
ΔH@: 1.554
Gamma (Y): 0.9602
Ideal Nozzle: 0.361
Nozzle Dia.: 0.299
Nozzle ID: 1-4
Probe ID: 8A

Filter ID	Tare

K Factor: 3.35
TC Readout ID: 802012

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Pre Leak Check, ACFM	0	< 0.02 or 4%	13
Post Leak Check, ACFM	0	0.020	10

	A	B
Pitot Pre Leak Check		
Pitot Post Leak Check		

Static Pressure, In. H_2O: 0.51
Barometric Pressure, In. Hg: 29.90

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams: 296.3
Moisture, %: 12.317
CO_2 %: 15.5
O_2 %: 6

Sampling Information / *QA Checks*

Point	Time Per Pt, (Min.)	Elapsed Time (h:m:s)	Dry Gas Meter (cu.ft.)	ΔP	Meter Temp	Stack Temp	ΔH	Target Δ H	Run ISO % Pt	Run ISO % Cum	Lk Chck Readings During Run
1	15	0	501.457	0.25	57	421	0.84	0.839	100.1	100.1	LC 1
2	15	15:0	509.86	0.24	69	422	0.83	0.825	99.9	100.0	
3	15	30:0	518.27	0.22	70	422	0.76	0.757	99.6	99.9	
4	15	45:0	526.31	0.24	71	423	0.83	0.827	100.8	100.1	LC-2
5	15	1:00:0	534.82	0.24	72	424	0.83	0.828	100.3	100.2	
6	15	1:15:0	543.3	0.26	73	424	0.9	0.898	99.5	100.0	
7	15	1:30:0	552.07	0.28	71	426	0.96	0.961	98.9	99.9	LC-3
8	15	1:45:0	561.07	0.27	70	426	0.93	0.925	96.0	99.4	
9	15	2:00:0	569.63	0.26	69	426	0.89	0.889	95.7	98.9	
10	15	2:15:0	577.99	0.27	70	426	0.93	0.925	107.9	99.9	LC-4
11	15	2:30:0	587.61	0.27	72	426	0.93	0.929	96.6	99.6	
12	15	2:45:0	596.26	0.28	73	426	0.97	0.965	98.1	99.4	
13	15	3:00:0	605.219								LC-5
14	15	3:15:0									
15	15	3:30:0									
16	15	3:45:0									LC-6
17	15	4:00:0									
18	15	4:15:0									
19	15	4:30:0									LC-7
20	15	4:45:0									
21	15	5:00:0									
22	15	5:15:0									LC-8
23	15	5:30:0									
24	15	5:45:0									
25	15	6:00:0									
		6:15:0									

		Averages			
Vm	103.762	0.2563	69.8	424.3	0.883
Vmstd	99.4523	in. H_2O	°F	°F	in H_2O

Run ISO
98.5
%

Air Control Techniques, P.C.
Isokinetic Sampling Train Field Data Sheet

Job #	1436

Run ID	M5B/028-2
Condition	

IDENTIFICATION INFORMATION

Plant	
City, State	
Test Location	FCC 135 Stack
Personnel	DLS, TTB
Date	2/24/10
Start	1410
Stop	1710
Meterbox ID	802012
ΔH@	1.554
Gamma (Y)	0.9602
Ideal Nozzle	0.355
Nozzle Dia.	0.298
Nozzle ID	2-4
Probe ID	8B
K Factor	3.56
TC Readout ID	802012

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Pre Leak Check, ACFM	0	< 0.02 or 4%	14
Post Leak Check, ACFM	0	0.020	10

	A	B
Pitot Pre Leak Check		
Pitot Post Leak Check		

Static Pressure, In. H_2O	0.51
Barometric Pressure, In. Hg	29.90

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams	307.6	Moisture, %	12.782
CO_2 %	15	O_2 %	5.5

Sampling Information / QA Checks

Point	Time Per Pt, (Min.)	Elapsed Time (h:m:s)	Dry Gas Meter (cu.ft.)	ΔP	Meter Temp	Stack Temp	ΔH	Target Δ H	Run ISO % Pt	Run ISO % Cum	Lk Chck Readings During Run
1	15	0	606.041	0.28	71	425	1	0.998	100.9	100.9	LC 1
2	15	15:0	615.25	0.26	77	425	0.94	0.938	104.3	102.6	
3	15	30:0	624.53	0.26	78	425	0.94	0.940	97.4	100.9	
4	15	45:0	633.21	0.24	79	425	0.87	0.869	102.4	101.2	LC-2
5	15	1:00:0	642	0.25	81	425	0.91	0.909	100.0	101.0	
6	15	1:15:0	650.79	0.25	81	425	0.91	0.909	99.5	100.8	
7	15	1:30:0	659.54	0.24	81	426	0.87	0.872	99.1	100.5	LC-3
8	15	1:45:0	668.07	0.25	80	426	0.91	0.906	94.3	99.8	
9	15	2:00:0	676.34	0.26	79	426	0.94	0.941	96.9	99.4	
10	15	2:15:0	684.99	0.25	79	426	0.9	0.904	101.8	99.7	LC-4
11	15	2:30:0	693.9	0.25	78	426	0.9	0.903	97.6	99.5	
12	15	2:45:0	702.43	0.24	78	427	0.87	0.866	100.1	99.5	
13	15	3:00:0	710.99								LC-5
14	15	3:15:0									
15	15	3:30:0									
16	15	3:45:0									LC-6
17	15	4:00:0									
18	15	4:15:0									
19	15	4:30:0									LC-7
20	15	4:45:0									
21	15	5:00:0									
22	15	5:15:0									LC-8
23	15	5:30:0									
24	15	5:45:0									
25	15	6:00:0									
		6:15:0									

		Averages				
Vm	104.949	0.2524	78.5	425.6	0.913
Vmstd	98.9623	in. H_2O	°F	°F	in H_2O

Run ISO
99.8
%

Air Control Techniques, P.C.
Isokinetic Sampling Train Field Data Sheet

Job #	1436

Run ID	**M5B/028-3**
Condition	

IDENTIFICATION INFORMATION

Plant	
City, State	

Test Location	FCC 135 Stack	Date	2/25/10
Personnel	DLS, TTB	Start	0743
		Stop	1043

Meterbox ID	802012	Filter ID	Tare
ΔH@	1.554		
Gamma (Y)	0.9602		
Ideal Nozzle	0.356		
Nozzle Dia.	0.299		
Nozzle ID	1-4	K Factor	3.63
Probe ID	8A	TC Readout ID	802012

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Pre Leak Check, ACFM	0	< 0.02 or 4%	14
Post Leak Check, ACFM	0	0.020	9

	A	B
Pitot Pre Leak Check		
Pitot Post Leak Check		

Static Pressure, In. H_2O	0.68
Barometric Pressure, In. Hg	29.90

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams	324.7	Moisture, %	12.667
CO_2 %	15	O_2 %	2.1

Sampling Information / *QA Checks*

Point	Time Per Pt, (Min.)	Elapsed Time (h:m:s)	Dry Gas Meter (cu.ft.)	ΔP	Meter Temp	Stack Temp	ΔH	Target Δ H	Run ISO % Pt	Run ISO % Cum	Lk Chck Readings During Run
1	15	0	713.815	0.35	53	429	1.2	1.205	104.9	104.9	LC 1
2	15	15:0	724.17	0.3	54	430	1.05	1.035	98.2	101.7	
3	15	30:0	733.16	0.31	56	430	1.1	1.074	96.8	100.1	
4	15	45:0	742.2	0.29	58	431	1	1.007	99.9	100.0	LC-2
5	15	1:00:0	751.26	0.3	59	431	1.05	1.044	97.0	99.4	
6	15	1:15:0	760.22	0.29	60	431	1	1.011	98.5	99.3	
7	15	1:30:0	769.19	0.29	60	432	1	1.010	97.7	99.1	LC-3
8	15	1:45:0	778.08	0.28	61	432	0.99	0.977	100.0	99.2	
9	15	2:00:0	787.04	0.28	63	431	0.98	0.982	98.2	99.1	
10	15	2:15:0	795.88	0.27	64	431	0.95	0.949	96.7	98.8	LC-4
11	15	2:30:0	804.44	0.27	65	431	0.95	0.951	99.7	98.9	
12	15	2:45:0	813.28	0.26	66	431	0.92	0.917	98.4	98.9	
13	15	3:00:0	821.863								LC-5
14	15	3:15:0									
15	15	3:30:0									
16	15	3:45:0									LC-6
17	15	4:00:0									
18	15	4:15:0									
19	15	4:30:0									LC-7
20	15	4:45:0									
21	15	5:00:0									
22	15	5:15:0									LC-8
23	15	5:30:0									
24	15	5:45:0									
25	15	6:00:0									
		6:15:0									

		Averages			
Vm	108.048	0.2904	59.9	430.8	1.016
Vmstd	105.5533	in. H_2O	°F	°F	in H_2O

Run ISO
98.5
%

Method 1 - Air Control Techniques, P.C.

Date 2/24/10

Client	
Job #	
Plant Name	
State	
City	
Sampling Location	
No. of Ports Available	5
No. of Ports Used	2
Port Inside Diameter, Inches	3
Distance From Far Wall To Outside Of Port, Inches	129.0625
Nipple Length And/Or Wall Thickness, Inches	14.875
Depth Of Stack Or Duct, Inches	114.1875
Stack Or Duct Width (if rectangular), Inches	N/A
Equiv. Diameter = 2DW/(D+W), Inches	N/A
Stack/Duct Area, Square Inches (☐ x R^2 or L x W)	10240.6

	Upstream	Downstream
Distance to Flow Disturbances	612	156
Diameters	5.36	1.37

Note: If more than 8 and 2 diamteters and if duct dia. is less than 24" use 8 or 9 points.

	Diameters		
Velocity	UP	Down	Particulate
12	8	2	12
12	7	1.75	12
12	6	1.5	16
16	5	1.25	20
16	2	0.5	24 or 25

Point Location Data

Point	% of Duct Depth	Distance From Inside Wall	Distance From Outside of Port
1	4.4	5.024	19.899
2	14.6	16.671	31.546
3	29.6	33.800	48.675
4	70.4	80.388	95.263
5	85.4	97.516	112.391
6	95.6	109.163	124.038
7			
8			
9			
10	2.6	2.969	17.844
11	8.2	9.363	24.238
12	14.6	16.671	31.546
13	22.6	25.806	40.681
14	34.2	39.052	53.927
15	65.8	75.135	90.010
16	77.4	88.381	103.256
17	85.4	97.516	112.391
18	91.8	104.824	119.699
19	97.4	111.219	126.094
20			
21			
22			
23			
24			
25			

API Method

5B/202

Location of Points in Circular Stacks or Ducts

	4	6	8	10	12	14	16	18	20	22	24
1	6.7	4.4	3.2	2.6	2.1	1.8	1.6	1.4	1.3	1.1	1.1
2	25.0	14.6	10.6	8.2	6.7	5.7	4.9	4.4	3.9	3.5	3.2
3	75.0	29.6	19.4	14.6	11.8	9.9	8.5	7.5	6.7	6.0	5.5
4	93.3	70.4	32.3	22.6	17.7	14.6	12.5	10.9	9.7	8.7	7.9
5		85.4	67.7	34.2	25.0	20.1	16.9	14.6	12.9	11.6	10.5
6		95.6	80.6	65.8	35.6	26.9	22.0	18.8	16.5	14.6	13.2
7			89.5	77.4	64.4	36.6	28.3	23.6	20.4	18.0	16.1
8			96.8	85.4	75.0	63.4	37.5	29.6	25.0	21.8	19.4
9				91.8	82.3	73.1	62.5	38.2	30.6	26.2	23.0
10				97.4	88.2	79.9	71.7	61.8	38.8	31.5	27.2
11					93.3	85.4	78.0	70.4	61.2	39.3	32.3
12					97.9	90.1	83.1	76.4	69.4	60.7	39.8
13						94.3	87.6	81.2	75.0	68.5	60.2
14						98.2	91.5	85.4	79.6	73.8	67.7
15							95.1	89.1	83.5	78.2	72.8
16							98.4	92.5	87.1	82.0	77.0
17								95.6	90.3	85.4	80.6
18								98.6	93.3	88.4	83.9
19									96.1	91.3	86.8
20									98.7	94.0	89.5
21										96.5	92.1
22										98.9	94.5
23											96.8
24											98.9

Location of Points in Rectangular Stacks or Ducts

	2	3	4	5	6	7	8	9	10	11	12
1	25	16.7	12.5	10.0	8.3	7.1	6.3	5.6	5.0	4.5	4.2
2	75	50	37.5	30.0	25	21.4	18.8	16.7	15.0	13.6	12.5
3		83.3	62.5	50.0	41.7	35.7	31.3	27.8	25.0	22.7	20.8
4			87.5	70.0	58.3	50	43.8	28.9	35.0	31.8	29.2
5				90.0	75	64.3	56.3	50	45.0	40.9	37.5
6					91.7	78.6	68.8	61.1	55.0	50	45.8
7						92.9	81.3	72.2	65.0	59.1	54.2
8							93.8	83.3	75.0	68.2	62.5
9								94.4	85.0	77.3	70.8
10									95.0	86.4	79.2
11										95.5	87.5
12											95.8

0.0000-0.0625 - 0
0.0625-0.1875 - 1/8
0.1875-0.3125 - 1/4
0.3125-0.4375 - 3/8
0.4375-0.5625 - 1/2
0.5625-0.6875 - 5/8
0.6875-0.8125 - 3/4
0.8125-0.9375 - 7/8
0.9375-1.0000 - 1

'1 - 717 '3 - 325

T_2 = 413 T_4 = 365 @10:00

API

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	[illegible]-2.5-1
Condition	

IDENTIFICATION INFORMATION

Plant Name

City

State

Source Number

Sampling Location

Test Personnel TTB

Date 2/24/10

Start 0958

Stop 1302

Meterbox ID	909033
Δ H @	1.9070
Gamma, γ	1.0206
Nozzle ID	SS-1
Nozzle Diameter	0.182
Orsat/Fyrite	Fyrite

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0.001	< 0.02 or 4%	10
Partial Train Posttest Leak Check, ACFM	0.000		5

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	N/A	N/A
Pitot Tube Posttest Leak Check		

Barometric Pressure, In.,Hg. 29.4

Static Pressure, In. W.C. 0.51

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams		Moisture, %	
CO_2 %	15.5	Md_run	
O_2 %	~~0.0~~2.7	Mw_run	

Sampling Information / QA Checks

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Sample Train Vac. (In. Hg)	Impinger Exit Gas Temp., (°F)	ΔH (In. H_2O)	Probe Temp., (°F)	Filter / Cyclone Temp., (°F)	CPM Filter Temp., (°F)	Dilution Flow Rate, LPM
A	4	15	0	814.500	0.25	53	417	2	60	0.41	371	317	61	2.81
A	4	15	15	819.63	↓	57	422	2	55	0.41	424	316	60	2.81
A	4	15	30	824.61		58	422	2	54	0.41	420	311	59	2.81
A	4	15	45	829.53		59	423	2	58	0.38	418	328	61	2.81
A	4	15	1:00	834.27		60	424	2	54	0.38	418	323	60	2.81
A	4	15	1:15	839.00		61	424	2	55	0.39	418	327	60	2.81
A	4	15	1:30	843.79		61	426	2	54	0.39	418	323	60	2.81
A	4	15	1:45	848.57		61	426	2	55	0.4[illegible]	419	321	60	2.81
A	4	15	2:00	853.38		62	426	2	56	0.4[illegible]	419	320	60	2.80
A	4	15	2:15	858.27		62	426	2	54	0.41	419	322	60	2.81
A	4	15	2:30	863.10		63	426	2	51	0.41	419	313	58	2.81
A	4	15	2:45	868.07		63	426	2	53	0.41	420	311	60	2.82

Total Run Time 3:00 873.023

Total Volume, ACF

Averages						
	in. H2O	°F	°F	in H2O	%	microns

Run

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	API-2.52
Condition	

IDENTIFICATION INFORMATION

Plant Name
City
State

Source Number
Sampling Location
Test Personnel MS

Date 2/24/10
Start 1410
Stop 1710

Meterbox ID	989033
Δ H @	1.9070
Gamma, γ	1.0206
Nozzle ID	SS-2
Nozzle Diameter	0.182
Orsat/Fyrite	Fyrite

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0.002	< 0.02 or 4%	10
Partial Train Posttest Leak Check, ACFM	0.001		5

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	N/A	N/A
Pitot Tube Posttest Leak Check		

Barometric Pressure, In.,Hg. 29.9

Static Pressure, In. W.C. 0.51

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams		Moisture, %	
CO_2 %		Md_run	
O_2 %		Mw_run	

Sampling Information / QA Checks

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Sample Train Vac. (In. Hg)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Probe Temp., (°F)	Filter / Cyclone Temp., (°F)	CPM Filter Temp., (°F)	Dilution Flow Rate, LPM
A	4	0	0	874.118		66	425	2	61	0.38	~~333~~ 390	330	62	2.81
A	4	15	15	878.83		66	425	2	58	0.38	406	322	62	2.81
A	4	30	30	883.65		68	425	2	60	0.38	415	321	62	2.81
A	4	45	45	888.46		68	425	2	62	0.38	417	325	64	2.81
A	4	1:00	1:00	892.81		71	425	2	64	0.38	419	325	65	2.81
A	4	1:15	1:15	897.46		72	425	2	61	0.38	420	325	62	2.80
A	4	1:30	1:30	902.19		73	425	2	59	0.38	420	325	64	2.80
A	4	1:45	1:45	906.97		73	426	2	59	0.38	420	326	64	2.80
A	4	2:00	2:00	911.61		74	426	2	60	0.38	420	325	65	2.83
A	4	2:15	2:15	916.34		74	426	2	60	0.38	420	323	65	2.83
A	4	2:30	2:30	921.05		74	426	2	59	0.38	420	326	62	2.81
A	4	2:45	2:45	925.81	↓	75	426	2	59	0.38	420	330	63	2.81

Total Run Time 3:00 | 930.495

Total Volume, ACF

	ΔP	Meter Temp.	Stack Temp.	ΔH			
Averages							
	in. H2O	°F	°F	in H2O	%		microns

Run

1,= 702 13: [illegible] @ 750AM

T2= 397 T4: 168

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	RPI-2.5-3
Condition	

IDENTIFICATION INFORMATION

Plant Name:
City:
State:

Source Number:
Sampling Location:
Test Personnel: IID

Date: 2/25/16
Start: 0741
Stop: 1041

Meterbox ID	909033
ΔH @	1.9070
Gamma, γ	1.0206
Nozzle ID	SS-2
Nozzle Diameter	0.182
Orsat/Fyrite	Fyrite

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0.002	< 0.02 or 4%	10
Partial Train Posttest Leak Check, ACFM			

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	N/A	N/A
Pitot Tube Posttest Leak Check		

Barometric Pressure, In.,Hg.: 29.9
Static Pressure, In. W.C.: 0.68

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams		Moisture, %	
CO_2 %		Md_run	
O_2 %		Mw_run	

Sampling Information / QA Checks

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Sample Train Vac. (In. Hg)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Probe Temp., (°F)	Filter / Cyclone Temp., (°F)	CPM Filter Temp., (°F)	Dilution Flow Rate, LPM
A	4	15	0	931.300	0.34	46	429	2	46	0.41	387	310	54	2.81
A	4	15	15	936.09		48	430	2	44	0.40	421	317	51	2.80
A	4	15	30:01	940.70		48	430	2	45	0.4	423	320	52	2.82
A	4	15	45:01	945.37		49	431	2	46	0.4	423	323	53	2.82
A	4	15	1:00:01	950.04		50	431	2	47	0.4	423	324	53	2.81
A	4	15	1:15:01	954.73		50	431	2	47	0.4	423	323	52	2.81
A	4	15	1:30:01	959.43		50	432	2	48	0.4	423	321	51	2.80
A	4	15	1:45:01	964.14		50	432	2	50	0.4	423	324	53	2.82
A	4	15	2:00:01	968.85		51	431	2	48	0.4	423	325	54	2.82
A	4	15	2:15:02	973.53		52	431	2	51	0.4	423	324	56	2.80
A	4	15	2:30:02	978.22		53	431	2	54	0.4	423	325	57	2.81
A	4	15	2:45:02	982.85	↓	54	431	2	58	0.4	423	325	58	2.81

Total Run Time: 3:00:03 — 987.448
Total Volume, ACF:

	ΔP	Meter Temp.	Stack Temp.	ΔH	Filter / Cyclone	CPM Filter	Dilution Flow
Averages							
	in. H2O	°F	°F	in H2O	%	microns	

Run:

T1 = 430 T3 = 358
T2 = 424 T4 = 205 @1320

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	API-PM2.5-4
Condition	

IDENTIFICATION INFORMATION

Plant Name
City
State

Source Number
Sampling Location
Test Personnel

Date	2/25/10
Start	1135
Stop	1435

Meterbox ID	909033
Δ H @	1.9070
Gamma, γ	1.0206
Nozzle ID	SS-2
Nozzle Diameter	0.182
Orsat/Fyrite	Fyrite

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0.001	< 0.02 or 4%	10
Partial Train Posttest Leak Check, ACFM	0.000		5

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	N/A	N/A
Pitot Tube Posttest Leak Check		

Barometric Pressure, In.,Hg. 29.9
Static Pressure, In. W.C. 0.68

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams		Moisture, %	
CO_2 %		Md_run	
O_2 %		Mw_run	

Sampling Information / QA Checks

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Sample Train Vac. (in. Hg)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Probe Temp., (°F)	Filter / Cyclone Temp., (°F)	CPM Filter Temp., (°F)	Dilution Flow Rate, LPM
A	4	15	0	987.700	0.29	56	431	2	50	0.4	362	312	N/A	2.81
			15	992.41		55	431	2	58	0.4	406	327		2.80
			30	997.03		57	430	2	57	0.42	414	324		2.81
			45	1001.83		58	430	2	59	0.42	419	324		2.82
			1:00	1006.67		60	430	2	57	0.42	421	322		2.81
			1:15	1011.39		61	430	2	60	0.42	422	325		2.83
			1:30	1016.39		61	431	2	61	0.43	423	324		2.81
			1:45	1021.33		59	431	2	62	0.43	424	325		2.82
			2:00	1026.23		60	430	2	62	0.43	424	324		2.81
			2:15	1031.17		61	430	2	64	0.43	424	326		2.80
			2:30	1036.03		63	430	2	60	0.43	424	324		2.81
			2:45	1040.97		63	430	2	61	0.43	424	324		2.82

Total Run Time 3:00 | 1045.954
Total Volume, ACF

Averages						
	in. H2O	°F	°F	in H2O	%	microns

Run

Method 4 - Air Control Techniques, P.C.

Date 2/23/10

Source Information

Client
Plant Name
City, State
Sampling Location

Job # 1436
Process FCC
Personnel

Sampling Information

Run Number	API-1	API-2	API-3	API-4
Filter Identification	Q196	Q197	Q198	Q199
Sampling Date	2/24/10	2/24/10	2/25/10	2/25/10
Recovery Date	〃	〃	〃	〃

Moisture Data

pH	4	4	4	NA
Impinger 1 Contents -				
Final Weight, grams	462.8	457.9	457.2	742.8
Initial Weight, grams	339.1	340.6	339.5	635.0
Condensed Water, grams	123.7 ✓	117.3 ✓	117.7 ✓	107.8 ✓
Impinger 2 Contents -				
Final Weight, grams	597.7	634.1	597.4	509.2
Initial Weight, grams	598.2	635.0	598.6	494.5
Condensed Water, grams	-0.5 ✓	-0.9 ✓	-1.2 ✓	14.7 ✓
Impinger 3 Contents -				
Final Weight, grams	604.8	593.7	603.6	
Initial Weight, grams	605.4	594.6	604.3	
Condensed Water, grams	-0.6 ✓	-0.9 ✓	-0.7 ✓	
Impinger 4 Contents -				
Final Weight, grams				
Initial Weight, grams				
Condensed Water, grams				
Silica Gel -				
Final Weight, grams	842.3	902.9	856.0	817.0
Initial Weight, grams	831.0	891.9	842.3	801.5
Adsorbed Water, grams	11.3 ✓	11.0 ✓	13.7 ✓	15.5 ✓
Total Water, grams	133.9 ✓	126.5 ✓	129.5 ✓	138.0 ✓
Purge	1410-1510	1715-1815	1115-1215	NA

Vm(std) = Volume of gas sampled at standard conditions (dscf) = gamma*17.64*Vm*[Pbar+(D H/13.6)]/(Tm+460)
Vwc(std) = volume of water vapor at standard conditions (scf) = 0.04715 * volume of water collected (gms)
Bws = Mole fraction of water vapor = Vwc(std) / (Vm(std) + Vwc(std))
Percent Moisture = 100 * Bws

Method 2 - Air Control Techniques, P.C.

Identification Information

Client
City

Job 1456
State

Sampling Location and Port Information

Sampling Location
Measured Barometric, in. Hg 29.9
Duct/Stack Dia., In. 114

Pitot ID 8A, 8B
Pitot Coeff. (Cp) 0.84
TC ID

Measurement Data

Date	2-24-10	2-24-10	2-25-10
Run Identification	M2-1	M2-2	M2-3
Stactic Pressure, in. WC	+0.51	+0.63	+0.68
Start Time	0935	1720	0735
End Time	0945	1730	0740

Pitot Leak Checks

Positve Side	✓	✓	✓
Negative Side	✓	✓	✓

		Δp, in. WC	Temp. °F	Δp, in. WC	Temp. °F	Δp, in. WC	Temp. °F
A	1	0.26	417	0.25	427	0.34	425
	2	0.26	417	0.24	427	0.34	425
	3	0.26	417	0.24	428	0.34	426
	4	0.24	417	0.26	428	0.34	427
	5	0.26	417	0.26	428	0.34	427
	6	0.25	416	0.25	427	0.33	427
B	7	0.25	414	0.25	428		
	8	0.26	415	0.25	428		
	9	0.25	416	0.26	428		
	10	0.24	417	0.26	428		
	11	0.26	416	0.24	428		
	12	0.24	415	0.24	427		
	13						
	14						
	15						
	16						
	17						
	18						
	Average						

$V_s = 85.49 * C_p * ((\Delta P\ avg) * (460 + t_s) / (P_s * M_s))^{0.5}$

Method 2 - Air Control Techniques, P.C.

Identification Information

Client
City
Job 1436
State

Sampling Location and Port Information

Sampling Location		Pitot ID	8B
Measured Barometric, in. Hg	29.9	Pitot Coeff. (Cp)	0.84
Duct/Stack Dia., In.	114	TC ID	

Measurement Data

Date	2-25-10	Date		Date	
Run Identification	M2-4	Run Identification		Run Identification	
Stactic Pressure, in. WC	+0.68	Stactic Pressure, in. WC		Stactic Pressure, in. WC	
Start Time	1450	Start Time		Start Time	
End Time	1501	End Time		End Time	

Pitot Leak Checks

Positve Side	✓	Positve Side		Positve Side	
Negative Side	✓	Negative Side		Negative Side	

		Δp, in. WC	Temp. °F		Δp, in. WC	Temp. °F		Δp, in. WC	Temp. °F
B	1	0.28	430	1			1		
	2	0.29	430	2			2		
	3	0.29	431	3			3		
	4	0.28	430	4			4		
	5	0.28	430	5			5		
	6	0.28	430	6			6		
A	7	0.27	429	7			7		
	8	0.28	429	8			8		
	9	0.27	429	9			9		
	10	0.27	428	10			10		
	11	0.27	428	11			11		
	12	0.26	427	12			12		
	13			13			13		
	14			14			14		
	15			15			15		
	16			16			16		
	17			17			17		
	18			18			18		
	Average			Average			Average		

$V_s = 85.49 * C_p * ((\Delta P\ avg) * (460 + t_s) / (P_s * M_s))^{0.5}$

Air Control Techniques, P.C.
Isokinetic Sampling Train Field Data Sheet

Job # 1436

Run ID	M5B-1
Cond.	

IDENTIFICATION INFORMATION

Plant
City, State
Test Location
Personnel PJ, DLS, MB

Date 2.24.10
Start 0958
Stop 1304

Meterbox ID	802012
ΔH@	1.554
Gamma (Y)	0.9602
Ideal Nozzle	0.361
Nozzle Dia.	0.299
Nozzle ID	1-4
Pitot Tube ID	8A

Filter ID	Tare

K Factor 3.36
TC Readout ID 802012

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Pre Leak Check, ACFM	.000	< 0.02	13
Post Leak Check, ACFM	.000		10

	A	B
Pitot Pre Leak Check	✓	✓
Pitot Post Leak Check	✓	✓

Static Pressure, In. H_2O +0.51
Barometric Pressure, In. Hg 29.90

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams
Moisture, %
FYRITE CO2 % 15.5
O2 % 6.0

Sampling Information

CEM 2.7

Port/ Point	Elapsed Time	Volume Metered	ΔP	Meter Temp	Stack Temp	ΔH	Probe Temp	Filter Temp	Exit Temp	Aux Temp	Vac	Lk Chcks
B	0	501.457	0.25	57	421	0.84	328	297	48	56	2	LC 1
	15	509.86	0.24	69	422	0.83	323	296	50	59	2	
	30	518.27	0.22	70	422	0.76	329	311	50	58	2	
	45	526.31	0.24	71	423	0.83	333	317	53	61	2	LC-2
	60/0	534.82	0.24	72	424	0.83	332	314	48	58	2	
	15	543.30	0.26	73	424	0.90	331	315	49	57	2	
	30	552.07	0.28	71	426	0.96	330	297	50	57	2	LC-3
	45	561.07	0.27	70	426	0.93	330	295	50	57	2	
	120/0	569.63	0.26	69	426	0.89	326	302	50	59	2	
	15	577.99	0.27	70	426	0.93	328	296	47	51	2	LC-4
	30	~~587.~~ 586.61	0.28	72	426	0.93	327	302	48	51	2	
↓	45	596.26	0.28	73	426	0.97	327	305	48	51	2	
OFF	180	605.219										LC-5
												LC-6
												LC-7
												LC-8

		Averages				Max / Min °F			ISO	High	Total
Vm											
Vmstd		in. H_2O	°F	°F	in. H_2O				%	in. Hg	Cu. Ft.

STOPPED FOR 2.5 TRAIN (N^2 PROBLEM) FOR 6 MINUTES

Air Control Techniques, P.C.
Isokinetic Sampling Train Field Data Sheet

Job # 1436

Run ID M5B-2
Cond.

IDENTIFICATION INFORMATION

Plant
City, State

Test Location
Personnel PJ, DLS, TTB

Date 2-24-10
Start 1410
Stop 1710

Meterbox ID	802012
ΔH@	1.554
Gamma (Y)	0.9602
Ideal Nozzle	0.355
Nozzle Dia.	0.298
Nozzle ID	4-24
Pitot Tube ID	8B

Filter ID	Tare

K Factor 3.56
TC Readout ID 802012

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Pre Leak Check, ACFM	.000	< 0.02	14
Post Leak Check, ACFM			

	A	B
Pitot Pre Leak Check	✓	✓
Pitot Post Leak Check	✓	✓

Static Pressure, In. H_2O -0.51
Barometric Pressure, In. Hg 29.90

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams
Moisture, %
FYRITE CO2 % 15.0
O2 % 5.5

Sampling Information CEM

Port/ Point	Elapsed Time	Volume Metered	ΔP	Meter Temp	Stack Temp	ΔH	Probe Temp	Filter Temp	Exit Temp	Aux Temp	Vac	Lk Chcks
B	0	606.641	0.28	71	425	1.00	329	302	52	58	1	LC 1
	15	615.25	0.26	77	425	0.94	328	307	50	56	1	
	30	624.53	0.26	78	425	0.94	330	297	51	57	1	
	45	633.21	0.24	79	425	0.87	327	318	51	57	1	LC-2
	60/0	642.00	0.25	81	425	0.91	331	313	51	62	1	
	15	650.79	0.25	81	425	0.91	328	300	51	65	1	
	30	659.54	0.24	81	426	0.87	328	303	52	62	1	LC-3
	45	668.67	0.25	80	426	0.91	326	302	53	62	1	
	120/0	676.34	0.26	79	426	0.94	324	305	54	63	1	
	15	684.99	0.25	79	426	0.90	330	307	56	62	1	LC-4
	30	693.90	0.25	78	426	0.90	329	316	52	60	1	
	45	702.43	0.24	78	427	0.87	327	306	52	62	1	
	180	716.990										LC-5
												LC-6
												LC-7
												LC-8

		Averages				Max / Min °F			ISO	High	Total
Vm											
Vmstd		in. H_2O	°F	°F	in. H_2O				%	in. Hg	Cu. Ft.

Air Control Techniques, P.C.
Isokinetic Sampling Train Field Data Sheet

Job # 1438

Run ID M5B-3
Cond.

IDENTIFICATION INFORMATION

Plant
City, State

Test Location
Personnel PJ, DS, TB

Date 2-25-10
Start 0743
Stop 1043

Meterbox ID 802012
ΔH@ 1.554
Gamma (Y) 0.9662
Ideal Nozzle 0.355
Nozzle Dia. 0.299
Nozzle ID 1-4
Pitot Tube ID 8A

Filter ID	Tare

K Factor 3.66
TC Readout ID 802012

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Pre Leak Check, ACFM	.000	< 0.02	14
Post Leak Check, ACFM	.000		9

	A	B
Pitot Pre Leak Check	✓	✓
Pitot Post Leak Check	✓	✓

Static Pressure, In. H_2O +0.68
Barometric Pressure, In. Hg 29.90

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams
Moisture, %
CO2 %
O2 %

Sampling Information

Port/ Point	Elapsed Time	Volume Metered	ΔP	Meter Temp	Stack Temp	ΔH	Probe Temp	Filter Temp	Exit Temp	Aux Temp	Vac	Lk Chcks
B	0	713.815	0.35	53	429	1.20	300	308	45	52	3	LC 1
	15	724.17	0.30	54	430	1.05	318	310	46	52	3	
	30	733.16	0.31	56	430	1.10	311	308	47	54	3	
	45	742.20	0.29	58	431	1.00	308	312	48	55	3	LC-2
	60/0	751.26	0.30	59	431	1.05	307	307	50	54	3	
	15	760.22	0.29	60	432	1.00	296	299	54	58	3	
	30	769.19	0.29	60	432	1.00	297	304	56	60	3	LC-3
	45	778.08	0.28	61	432	0.99	296	304	51	55	3	
	120/0	787.04	0.28	63	431	0.98	296	298	52	56	3	
	15	795.88	0.27	64	431	0.95	299	302	56	58	3	LC-4
	30	804.44	0.27	65	431	0.95	304	297	58	61	3	
	45	813.28	0.26	66	431	0.92	312	305	66	63	3	
OFF	180	821.863										LC-5
												LC-6
												LC-7
												LC-8

		Averages				Max / Min °F			ISO	High	Total
Vm											
Vmstd		in. H_2O	°F	°F	in. H_2O				%	in. Hg	Cu. Ft.

Air Control Techniques, P.C.
Isokinetic Sampling Train Field Data Sheet

Job # 1436

Run ID MSB-4
Cond.

IDENTIFICATION INFORMATION

Plant
City, State

Test Location t
Personnel PJ, DLS, TTB
Date 2-25-10
Start 1135
Stop 1435

Meterbox ID 802012
ΔH@ 1.554
Gamma (Y) 0.9602
Ideal Nozzle 0.356
Nozzle Dia. 0.298
Nozzle ID 2-4
Pitot Tube ID 8B

Filter ID	Tare

K Factor 3.58
TC Readout ID 802012

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Pre Leak Check, ACFM	.000	< 0.02	12
Post Leak Check, ACFM			

	A	B
Pitot Pre Leak Check	✓	✓
Pitot Post Leak Check	✓	✓

Static Pressure, In. H_2O +0.68
Barometric Pressure, In. Hg 29.90

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams
Moisture, %
CO2 %
O2 %

Sampling Information

Port/ Point	Elapsed Time	Volume Metered	ΔP	Meter Temp	Stack Temp	ΔH	Probe Temp	Filter Temp	Exit Temp	Aux Temp	Vac	Lk Chcks
B	0	824.203	0.26	64	430	0.90	306	297	63	67	1	LC 1
	15	832.59	0.25	63	431	0.87	297	302	54	62	1	
	30	841.08	0.24	64	430	0.83	316	311	50	56	1	
	45	849.02	0.24	66	430	0.84	302	310	52	55	1	LC-2
	60/0	857.40	0.25	67	430	0.87	321	313	54	57	1	
	15	865.68	0.26	70	431	0.91	320	309	57	57	1	
	30	874.50	0.27	70	431	0.95	320	310	58	59	1	LC-3
	45	883.19	0.27	70	431	0.95	297	312	51	55	1	
	120/0	891.96	0.28	71	430	0.99	321	310	56	56	1	
	15	901.16	0.29	73	430	1.00	318	308	57	58	1	LC-4
	30	909.94	0.29	74	430	1.05	319	310	59	59	1	
	45	918.73	0.29	73	430	1.00	332	313	64	62	1	
OFF	180	927.756										LC-5
												LC-6
												LC-7
												LC-8

		Averages				Max / Min °F			ISO	High	Total
Vm											
Vmstd		in. H_2O	°F	°F	in. H_2O				%	in. Hg	Cu. Ft.

Method 4 - Air Control Techniques, P.C.

Date 2/23/10

Source Information

Client
Plant Name
City, State
Sampling Location

Job # 1436
Process FCC
Personnel

Sampling Information

Run Number	M5B-1	M5B-2	M5B-3	M5B-4
Filter Identification	RQ 6171	RQ 6172	RQ 6173	RQ 6174
Sampling Date	2/24/10	2/24/10	2/25/10	2/25/10
Recovery Date	"	"	"	"

Moisture Data

Impinger 1 Contents - pH	4	4	4	4
Final Weight, grams	666.1	661.7	692.8	624.9
Initial Weight, grams	396.5	373.8	396.0	340.1
Condensed Water, grams	269.6✓	287.9✓	296.8✓	284.8✓
Impinger 2 Contents -				
Final Weight, grams	619.1	616.9	612.5	617.0
Initial Weight, grams	612.2	617.4	612.5	615.7
Condensed Water, grams	6.9✓	-0.5✓	0.0✓	1.3✓
Impinger 3 Contents -				
Final Weight, grams	640.8	607.9	638.0	607.1
Initial Weight, grams	640.0	607.9	638.6	607.3
Condensed Water, grams	0.8✓	0.0✓	-0.6✓	-0.2✓
Impinger 4 Contents -				
Final Weight, grams				
Initial Weight, grams				
Condensed Water, grams				
Silica Gel -				
Final Weight, grams	856.1	875.5	863.6	855.8
Initial Weight, grams	837.1	855.3	835.1	828.9
Adsorbed Water, grams	19.0✓	20.2✓	28.5✓	26.9✓
Total Water, grams	296.3✓	307.6✓	324.7✓	312.8✓
Purge	1337-1437	1730-1830	1140-1240	1445-1545

Vm(std) = Volume of gas sampled at standard conditions (dscf) = gamma*17.64*Vm*[Pbar+(D H/13.6)]/(Tm+460)
Vwc(std) = volume of water vapor at standard conditions (scf) = 0.04715 * volume of water collected (gms)
Bws = Mole fraction of water vapor = Vwc(std) / (Vm(std) + Vwc(std))
Percent Moisture = 100 * Bws

Run 3 - cloudy after purge, sweet smell, others SO_2 smell

VOLUME II

Appendix D – Calibration Data

APEX INSTRUMENTS METHOD 5 PRE-TEST CONSOLE CALIBRATION
USING CALIBRATED CRITICAL ORIFICES
5-POINT ENGLISH UNITS

Meter Console Information	
Console Model Number	522
Console Serial Number	802012
DGM Model Number	RW 110
DGM Serial Number	964447

Calibration Conditions			
Date	Time	01/28/10	
Barometric Pressure		29.60	in Hg
Theoretical Critical Vacuum[1]		13.97	in Hg
Calibration Technician		DLS	

Factors/Conversions		
Std Temp	528	°R
Std Press	29.92	in Hg
K_1	17.647	oR/in Hg

[1]For valid test results, the Actual Vacuum should be 1 to 2 in. Hg greater than the Theoretical Critical Vacuum shown above.

[2]The Critical Orifice Coefficient, K', must be entered in English units, $(ft^3 * °R^{1/2})/(in.Hg*min)$.

Calibration Data										
Run Time	Metering Console					Critical Orifice				
Elapsed	DGM Orifice ΔH	Volume Initial	Volume Final	Outlet Temp Initial	Outlet Temp Final	Serial Number	Coefficient	Amb Temp Initial	Amb Temp Final	Actual Vacuum
(Θ)	(P_m)	(V_{mi})	(V_{mf})	(t_{mi})	(t_{mf})		K'	(t_{amb})	(t_{amb})	
min	in H_2O	cubic feet	cubic feet	°F	°F		see above2	°F	°F	in Hg
18.0	0.25	301.230	307.074	71	72	FO 40	0.2387	66	66	23
11.5	0.56	307.200	312.656	72	73	FO 48	0.3483	66	66	22
9.5	1.00	313.040	319.004	73	73	FO 55	0.4592	66	66	20
7.5	1.65	319.310	325.386	73	73	FO 63	0.5907	66	66	18
5.5	3.15	325.700	331.795	73	74	FO 73	0.8085	66	66	16

Results								
Standardized Data				Dry Gas Meter				
				Calibration Factor		Flowrate	ΔH @	
Dry Gas Meter		Critical Orifice		Value	Variation	Std & Corr	0.75 SCFM	Variation
$(V_{m(std)})$	$(Q_{m(std)})$	$(Vcr_{(std)})$	$(Q_{cr(std)})$	(Y)	(ΔY)	$(Q_{m(std)(corr)})$	(ΔH@)	(ΔΔH@)
cubic feet	cfm	cubic feet	cfm			cfm	in H2O	
5.747	0.319	5.545	0.308	0.9649	0.005	0.308	1.459	-0.095
5.359	0.466	5.170	0.450	0.9646	0.004	0.450	1.535	-0.020
5.859	0.617	5.630	0.593	0.9609	0.001	0.593	1.579	0.024
5.979	0.797	5.718	0.762	0.9563	-0.004	0.762	1.579	0.025
6.014	1.094	5.739	1.043	0.9542	-0.006	1.043	1.620	0.065
				0.9602	Y Average		1.554	ΔH@ Average

Note: For Calibration Factor Y, the ratio of the reading of the calibration meter to the dry gas meter, acceptable tolerance of individual values from the average is +-0.02.

I certify that the above Dry Gas Meter was calibrated in accordance with USEPA Methods, CFR Title 40, Part 60, Appendix A-3, Method 5, 16.2.3

Signature

Date 1-28-10

APEX INSTRUMENTS METHOD 5 PRE-TEST CONSOLE CALIBRATION
USING CALIBRATED CRITICAL ORIFICES
5-POINT ENGLISH UNITS

Meter Console Information	
Console Model Number	522
Console Serial Number	909033
DGM Model Number	RW 110
DGM Serial Number	328893

Calibration Conditions			
Date	Time	02/01/10	
Barometric Pressure		29.80	in Hg
Theoretical Critical Vacuum[1]		14.07	in Hg
Calibration Technician		DLS	

Factors/Conversions		
Std Temp	528	°R
Std Press	29.92	in Hg
K_1	17.647	oR/in Hg

[1]For valid test results, the Actual Vacuum should be 1 to 2 in. Hg greater than the Theoretical Critical Vacuum shown above.

[2]The Critical Orifice Coefficient, K', must be entered in English units, $(ft^3 * °R^{1/2})/(in.Hg*min)$.

Calibration Data

Run Time	Metering Console					Critical Orifice				
Elapsed	DGM Orifice ΔH	Volume Initial	Volume Final	Outlet Temp Initial	Outlet Temp Final	Serial Number	Coefficient	Amb Temp Initial	Amb Temp Final	Actual Vacuum
(Θ)	(P_m)	(V_{mi})	(V_{mf})	(t_{mi})	(t_{mf})		K'	(t_{amb})	(t_{amb})	
min	in H_2O	cubic feet	cubic feet	°F	°F		see above2	°F	°F	in Hg
18.5	0.34	607.140	612.801	73	73	FO 40	0.2387	68	68	24
12.5	0.71	612.900	618.490	72	72	FO 48	0.3483	68	68	22
9.5	1.20	618.630	624.231	72	72	FO 55	0.4592	68	68	21
7.5	1.95	624.340	630.014	72	72	FO 63	0.5907	68	68	19
5.5	3.60	630.150	635.817	72	72	FO 73	0.8085	68	68	17

Results

Standardized Data				Dry Gas Meter				
Dry Gas Meter		Critical Orifice		Calibration Factor		Flowrate	ΔH @	
				Value	Variation	Std & Corr	0.75 SCFM	Variation
$(V_{m(std)})$	$(Q_{m(std)})$	$(Vcr_{(std)})$	$(Q_{cr(std)})$	(Y)	(ΔY)	$(Q_{m(std)(corr)})$	(ΔH@)	(ΔΔH@)
cubic feet	cfm	cubic feet	cfm			cfm	in H2O	
5.590	0.302	5.727	0.310	1.024	0.004	0.310	1.974	0.067
5.535	0.443	5.646	0.452	1.020	-0.001	0.452	1.943	0.037
5.553	0.585	5.658	0.596	1.019	-0.002	0.596	1.894	-0.012
5.636	0.751	5.745	0.766	1.019	-0.001	0.766	1.867	-0.040
5.652	1.028	5.767	1.049	1.020	0.000	1.049	1.855	-0.052
				1.0206	Y Average		1.907	ΔH@ Average

Note: For Calibration Factor Y, the ratio of the reading of the calibration meter to the dry gas meter, acceptable tolerance of individual values from the average is +-0.02.

I certify that the above Dry Gas Meter was calibrated in accordance with USEPA Methods, CFR Title 40, Part 60, Appendix A-3, Method 5, 16.2.3

Signature

Date 2-01-10

APEX INSTRUMENTS METHOD 5 POST-TEST CONSOLE CALIBRATION
USING CALIBRATED CRITICAL ORIFICES
3-POINT ENGLISH UNITS

Meter Console Information	
Console Model Number	522
Console Serial Number	802012
DGM Model Number	RW 110
DGM Serial Number	964447

Calibration Conditions			
Date	Time	12/01/10	
Barometric Pressure		29.70	in Hg
Theoretical Critical Vacuum[1]		14.0	in Hg
Calibration Technician		DLS	

Factors/Conversions		
Std Temp	528	°R
Std Press	29.92	in Hg
K_1	17.647	oR/in Hg

[1] For valid test results, the Actual Vacuum should be 1 to 2 in. Hg greater than the Theoretical Critical Vacuum shown above.

[2] The Critical Orifice Coefficient, K', must be entered in English units, $(ft^3 {}^*{}^\circ R^{1/2})/(in.Hg^*min)$.

Calibration Data

Run Time	Metering Console					Critical Orifice				
Elapsed	DGM Orifice ΔH	Volume Initial	Volume Final	Outlet Temp Initial	Outlet Temp Final	Serial Number	Coefficient	Amb Temp Initial	Amb Temp Final	Actual Vacuum
(Θ)	(P_m)	(V_{mi})	(V_{mf})	(t_{mi})	(t_{mf})		K'	(t_{amb})	(t_{amb})	
min	in H_2O	cubic feet	cubic feet	°F	°F		see above2	°F	°F	in Hg
9.0	0.98	809.800	815.543	74	74	FO 55	0.4592	68	68	20.50
9.0	0.98	815.543	821.300	74	75	FO 55	0.4592	68	68	20.50
9.0	0.98	821.300	827.061	75	75	FO 55	0.4592	68	68	20.50

Results

Standardized Data				Dry Gas Meter				
Dry Gas Meter		Critical Orifice		Calibration Factor		Flowrate	ΔH @	
				Value	Variation	Std & Corr	0.75 SCFM	Variation
$(V_{m(std)})$	$(Q_{m(std)})$	$(Vcr_{(std)})$	$(Q_{cr(std)})$	(Y)	(ΔY)	$(Q_{m(std)(corr)})$	(ΔH@)	(ΔΔH@)
cubic feet	cfm	cubic feet	cfm			cfm	in H2O	
5.650	0.628	5.342	0.594	0.945	0.001	0.594	1.545	0.001
5.659	0.629	5.342	0.594	0.944	-0.001	0.594	1.543	0.000
5.658	0.629	5.342	0.594	0.944	0.000	0.594	1.542	-0.001
Pretest Gamma	0.9602	% Deviation	1.6	0.945	Y Average		1.543	ΔH@ Average

Note: For Calibration Factor Y, the ratio of the reading of the calibration meter to the dry gas meter, acceptable tolerance of individual values from the average is +-0.02.

I certify that the above Dry Gas Meter was calibrated in accordance with USEPA Methods, CFR Title 40, Part 60, Appendix A-3, Method 5, 16.2.3

Signature

Date 12-01-10

APEX INSTRUMENTS METHOD 5 POST-TEST CONSOLE CALIBRATION
USING CALIBRATED CRITICAL ORIFICES
3-POINT ENGLISH UNITS

Meter Console Information	
Console Model Number	522
Console Serial Number	909033
DGM Model Number	RW 110
DGM Serial Number	328893

Calibration Conditions			
Date	Time	12/02/10	
Barometric Pressure		30.00	in Hg
Theoretical Critical Vacuum[1]		14.2	in Hg
Calibration Technician		DLS	

Factors/Conversions		
Std Temp	528	°R
Std Press	29.92	in Hg
K_1	17.647	oR/in Hg

[1]For valid test results, the Actual Vacuum should be 1 to 2 in. Hg greater than the Theoretical Critical Vacuum shown above.

[2]The Critical Orifice Coefficient, K', must be entered in English units, $(ft^3 \cdot °R^{1/2})/(in.Hg \cdot min)$.

Calibration Data										
Run Time	Metering Console					Critical Orifice				
Elapsed	DGM Orifice ΔH	Volume Initial	Volume Final	Outlet Temp Initial	Outlet Temp Final	Serial Number	Coefficient	Amb Temp Initial	Amb Temp Final	Actual Vacuum
(Θ)	(P_m)	(V_{mi})	(V_{mf})	(t_{mi})	(t_{mf})		K'	(t_{amb})	(t_{amb})	
min	in H_2O	cubic feet	cubic feet	°F	°F		see above2	°F	°F	in Hg
17.5	0.34	396.370	401.727	69	70	FO 40	0.2387	64	64	24.00
17.5	0.34	401.727	407.078	70	69	FO 40	0.2387	64	64	24.00
17.5	0.34	407.078	412.435	69	69	FO 40	0.2387	64	64	24.00

Results								
Standardized Data				Dry Gas Meter				
Dry Gas Meter		Critical Orifice		Calibration Factor		Flowrate	ΔH @	
				Value	Variation	Std & Corr	0.75 SCFM	Variation
$(V_{m(std)})$	$(Q_{m(std)})$	$(Vcr_{(std)})$	$(Q_{cr(std)})$	(Y)	(ΔY)	$(Q_{m(std)(corr)})$	(ΔH@)	(ΔΔH@)
cubic feet	cfm	cubic feet	cfm			cfm	in H2O	
5.361	0.306	5.475	0.313	1.021	0.000	0.313	1.959	-0.001
5.355	0.306	5.475	0.313	1.022	0.001	0.313	1.959	-0.001
5.366	0.307	5.475	0.313	1.020	-0.001	0.313	1.961	0.001
Pretest Gamma	1.0206	% Deviation	0.1	1.021	Y Average		1.959	ΔH@ Average

Note: For Calibration Factor Y, the ratio of the reading of the calibration meter to the dry gas meter, acceptable tolerance of individual values from the average is +-0.02.

I certify that the above Dry Gas Meter was calibrated in accordance with USEPA Methods, CFR Title 40, Part 60, Appendix A-3, Method 5, 16.2.3

Signature

Date 12-02-10

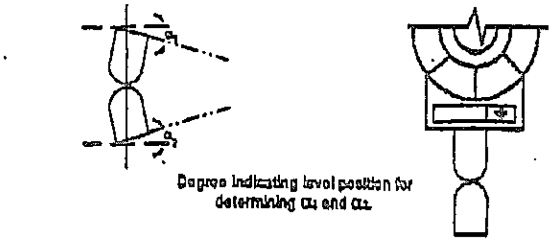
Type S Pitot Tube Inspection
Air Control Techniques, P.C.

Date 11-20-06

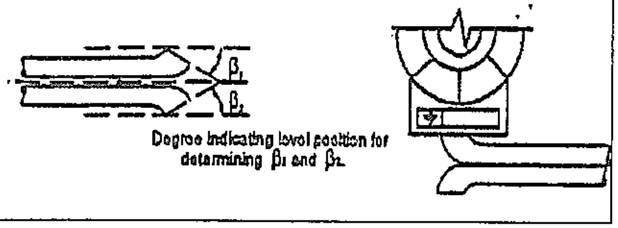
Identification Information

Client: IN HOUSE
Plant Name: NA
City: CARY
Job: NA
Process: NA
State: NC
Pitot ID: 8B

Inspection Results



Degree indicating level position for determining α_1 and α_2

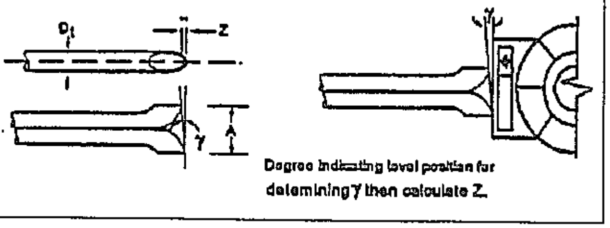


Degree indicating level position for determining β_1 and β_2

Inspection Data

Level and Perpendicular?	YES
Obstruction?	NO
Damaged?	NO
$\alpha1$ ($-10° \le \alpha1 \le +10°$)	1
$\alpha2$ ($-10° \le \alpha2 \le +10°$)	1
$\beta1$ ($-5° \le \beta1 \le +5°$)	-1
$\beta2$ ($-5° \le \beta2 \le +5°$)	0
γ	-1
θ	-1
z=A tan γ ($\le$0.125 inches)	0.0164
w=A tan θ ($\le$0.03125 inches)	0.0164
D1 (3/16 inch $\le$ D1 $\le$ 3/8 inch)	0.375
A	0.9375
A/2D1 (1.05 $\le$ PA/D1 $\le$ 1.5)	1.25

Degree indicating level position for determining θ



Degree indicating level position for determining γ then calculate Z.

Notes

Pitot Coefficient

Coefficient of 0.84 Assigned? YES
Inspection Personnel: DLS

Notes

Form ACTPC PI-2

Type S Pitot Tube Inspection
Air Control Techniques, P.C.

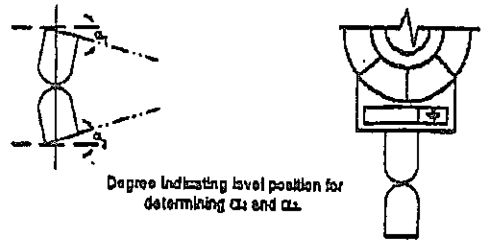
Date 5-28-02

Identification Information

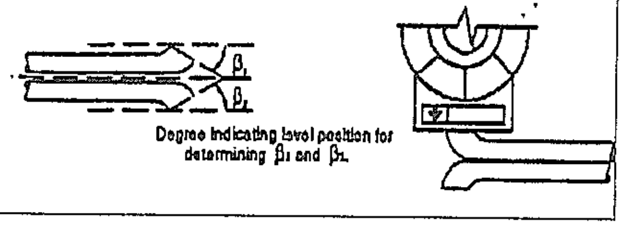
Client IN HOUSE
Plant Name NA
City CARY
Job NA
Process NA
State NC

Pitot ID 8A

Inspection Results



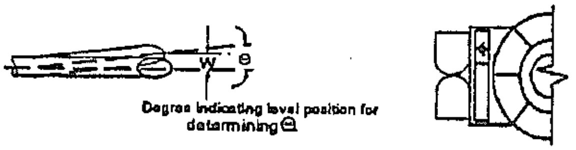
Degree indicating level position for determining α1 and α2.



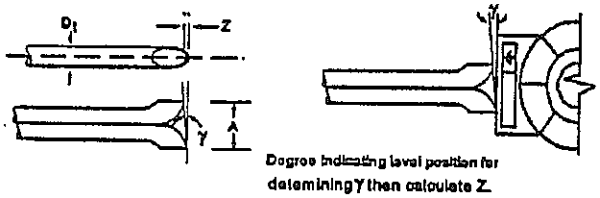
Degree indicating level position for determining β1 and β2.

Inspection Data

Level and Perpendicular?	YES
Obstruction?	NO
Damaged?	NO
α1 (-10° ≤ α1 ≤ + 10°)	1
α2 (-10° ≤ α2 ≤ + 10°)	1
β1 (-5° ≤ β1 ≤ + 5°)	-1
β2 (-5° ≤ β2 ≤ + 5°)	0
γ	-1
θ	-1
z=A tan γ (≤0.125 inches)	0.0164
w=A tan θ (≤0.03125 inches)	0.0164
D1 (3/16 inch ≤ D1 ≤ 3/8 inch)	0.375
A	0.9375
A/2D1 (1.05 ≤ PA/D1 ≤ 1.5)	1.25



Degree indicating level position for determining θ



Degree indicating level position for determining γ then calculate Z.

Notes

Pitot Coefficient

Coefficient of 0.84 Assigned? YES

Inspection Personnel DLS

Notes

Form ACTPC PI-2

Stainless Steel Nozzle Calibration and Condition
Air Control Techniques, P.C.

Nozzle Set ID	Nozzle ID	Average	Measurements			High-Low	Condition	Date Inspected
			1	2	3			
ACT-N-1	1-1	0.123	0.123	0.124	0.122	0.002	OK	3/11/07
ACT-N-1	1-2	0.180	0.180	0.180	0.181	0.001	OK	3/11/07
ACT-N-1	1-3	0.238	0.238	0.238	0.238	0.000	OK	3/11/07
ACT-N-1	1-4	0.299	0.300	0.300	0.298	0.002	OK	3/11/07
ACT-N-1	1-5	0.368	0.368	0.368	0.368	0.000	OK	3/11/07
ACT-N-1	1-6	0.427	0.427	0.427	0.428	0.001	OK	3/11/07
ACT-N-1	1-7	0.491	0.492	0.491	0.490	0.002	OK	3/11/07

Nozzle Set ID	Nozzle ID	Average	Measurements			High-Low	Condition	Date
			1	2	3			
ACT-N-2	2-1	0.128	0.128	0.127	0.128	0.001	OK	3/11/07
ACT-N-2	2-2	0.177	0.176	0.177	0.178	0.002	OK	3/11/07
ACT-N-2	2-3	0.240	0.240	0.240	0.240	0.000	OK	3/11/07
ACT-N-2	2-4	0.298	0.297	0.298	0.298	0.001	OK	3/11/07
ACT-N-2	2-5	0.373	0.373	0.374	0.373	0.001	OK	3/11/07
ACT-N-2	2-6	0.441	0.440	0.442	0.440	0.002	OK	3/11/07
ACT-N-2	2-7	0.497	0.498	0.497	0.497	0.001	OK	3/11/07

Nozzle Set ID	Nozzle ID	Average	Measurements			High-Low	Condition	Date
			1	2	3			
ACT-N-3	3-1	0.120	0.120	0.121	0.120	0.001	OK	3/11/07
ACT-N-3	3-2	0.189	0.188	0.189	0.189	0.001	OK	3/11/07
ACT-N-3	3-3	0.240	0.240	0.239	0.240	0.001	OK	3/11/07
ACT-N-3	3-4	0.254	0.254	0.254	0.255	0.001	OK	3/11/07
ACT-N-3	3-5	0.365	0.366	0.365	0.365	0.001	OK	3/11/07
ACT-N-3	3-6	0.996	0.996	0.997	0.995	0.002	OK	3/11/07
ACT-N-3	3-7	0.494	0.494	0.494	0.494	0.000	OK	3/11/07

Nozzle Set ID	Nozzle ID	Average	Measurements			High-Low	Condition	Date
			1	2	3			
ACT-N-4	4-1	0.301	0.300	0.301	0.302	0.002	OK	3/11/07
ACT-N-4	4-2	0.178	0.178	0.178	0.177	0.001	OK	3/11/07
ACT-N-4	4-3	0.299	0.299	0.299	0.299	0.000	OK	3/11/07
ACT-N-4	4-4	0.248	0.248	0.248	0.248	0.000	OK	3/11/07
ACT-N-4	4-5	0.364	0.364	0.364	0.363	0.001	OK	3/11/07
ACT-N-4	4-6	0.497	0.496	0.497	0.497	0.001	OK	3/11/07
ACT-N-4	4-7	0.498	0.497	0.498	0.499	0.002	OK	3/11/07

Name DANNY SPEER Signature

VOLUME II

Appendix E – Analytical Data

RESOLUTION ANALYTICS, INC.

Specialists in Air Emissions Analysis

ANALYTICAL REPORT

CLIENT: **AIR CONTROL TECHNIQUES, INC.**

PROJECT: 110027-1436 (LC)

ANALYTICAL SERVICES PROVIDED:

- FILTERABLE PARTICULATE
  (EPA METHOD 5B, PM 2.5)
- CONDENSIBLE PARTICULATE
  (EPA METHOD OTM-028)

Confirmation of Data Review:

To the best of my knowledge this analytical data has been checked thoroughly for completeness and the results presented are accurate, error-free, legible, and have been performed and validated in accordance with the approved method(s).

Date of Review: March 22, 2010

J. Bruce Nemet

Quality Assurance Officer

www.resolutionanalytics.com

2733 Lee Avenue • Sanford, NC 27332 • Phone: 919-774-5557 • Fax: 919-776-6785

Analysis Request / Chain of Custody

RESOLUTION ANALYTICS, INC.
Specialists in Air Emission Analysis
2733 Lee Avenue, Sanford, NC 27330
Phone (919) 774-5557 • Fax (919) 776-6785 • Email resolute@interpath.com

Reporting Address: [1] Please attach a separate sheet of paper if billing address is different than reporting address.	Phone Number	Fax Number
Company Air Control Techniques	Contact Tom Holder	
Street Address 301 E Durham Rd		
City, State, Zip Cary NC 27513	**Project:** 10027- 1436 (LC)	

Turnaround Time:
- ☑ 10 Days (Standard)
- ☐ 5 Days (1.5x)
- ☐ 3 Days (2x)
- ☐ 2 Days (2.5x)
- ☐ 24 Hours (3x)

Sample ID / Run #	Train/Run Component	Train/Run Component	Train/Run Component
EXAMPLE: SCRUBBER INLET-1	*0.1 N H2S04 (Imp 1-3)*	*0.1 N H2S04 (Imp 4)*	*0.1 N NaOH (Imp 5-6)*
API-2.5/028-1	Filter, Nozzle + Probe Rinse,	>2.5 Rinse,	≤2.5 Rinse
	Imp Soln + Rinse,	Imp Acetone Rinse,	Imp $MeCl_2$ Rinse
	CPM Filter		
API-2.5/028-3	"	"	"
API-2.5 - 4	Filter, Nozzle + Probe Rinse,	≥2.5 Rinse,	≤2.5 Rinse

Analyses
- ☐ EPA 0011/TO-5/8315
  - analytes: ________
  - analytes: ________
- ☐ HF (EPA 13B)
- ☐ EPA 26A (HC1/C1$_2$)
  - analytes: ________
- ☐ VOC's (HPLC)
  - analytes: ________
- ☐ Amines list: ________
- ☐ Phenol (EPA TO-8)
- ☐ SO$_X$ (EPA 6/8)
  - analytes: ________
- ☐ Ammonia (CTM-027)
- ☐ NO$_X$ (EPA 7A/7D)
- ☐ Filt Particulate (EPA 5)
- ☐ Conden Part (EPA 202)
- ☐ EPA 29
  - metals: ________
  - metals: ________
- ☐ Ontario-Hydro (Hg)
- ☐ EPA 101A (hg)
- ☐ Other
  - list ________

Chain of Custody:

Relinquished by (Signature)	Date	Received by (Signature)	Date	Comments
Tom Holder	3/1/10	Jeffrey S. Cooper	3/1/10	
Relinquished by (Signature)	Date	Received by (Signature)	Date	Comments

WHITE: Report Copy CANARY: Client Copy PINK: Lab Copy

JPC Form No. 37449A

Project: 10027-1436 (LC)

RESOLUTION ANALYTICS, INC.
Specialists in Air Emission Analysis

2733 Lee Avenue, Sanford, NC 27330
Phone (919) 774-5557 • Fax (919) 776-6785 • Email resolute@interpath.com

Sample ID / Run #	Train/Run Component	Train/Run Component	Train/Run Component
M5B/028-1	Filter, Frnt ½	Rinse, Imp Soln &	Rinse,
	Imp Acetone	Rinse, Imp MeCl2	Rinse, CPM Filter
M5B/028-3	"	"	"
M5B/028-4	"	"	"
028-FB	Imp Soln & Rinse,	Imp Acetone	Rinse, Imp MeCl2
	Rinse, CPM	Filter	
	Acetone Blank		
	H2O Blank		
	MeCl2 Blank		
	CPM Filter Blank		

Chain of Custody:

Relinquished by (Signature)	Date	Received by (Signature)	Date	Comments
Tom Holder	3/1/10	Jeffrey S. Coppley	3/1/10	
Relinquished by (Signature)	Date	Received by (Signature)	Date	Comments

RESOLUTION ANALYTICS, INC.

Specialists in Air Emissions Analysis

REPORT SUMMARY

RFA #: **1436 (LC)**

SAMPLE ID	TOTAL FILTERABLE PARTICULATE
Acetone Blank	0.1 mg (in 200 mls)
5B/028-1	16.3 mg
5B/028-3	10.2 mg
5B/028-4	14.4 mg

RESOLUTION ANALYTICS, INC.
Specialists in Air Emissions Analysis

REPORT SUMMARY

RFA #: 1436 (LC)

SAMPLE ID	Particulate ≤ 2.5 µm	Particulate > 2.5 µm	Particulate Probe And Nozzle
Acetone Blank	1.2 mg	1.2 mg	1.2 mg (in 200 mls)
API-2.5/028-1	1.0 mg	1.0 mg	16.8 mg
API-2.5/028-3	0.9 mg	0.9 mg	12.9 mg
API-2.5/028-4	0.9 mg	0.5 mg	11.4 mg

RESOLUTION ANALYTICS, INC.
Specialists in High Performance Liquid Chromatography

REPORT SUMMARY

RFA#: 1436

SAMPLE ID	ORGANIC Condensible	INORGANIC Condensible	FIELD BLANK *Correction* [1]	TOTAL Condensible
H_2O BLANK		0.6 mg (240 mL)		
$MeCl_2$ BLANK	0.4 mg (250 mL)			
FIELD BLANK	0.8 mg	1.7 mg	N/A	2.5 mg
M5B/028-1	1.5 mg	230.3 mg	2.0 mg	229.8 mg
M5B/028-3	26.4 mg	213.9 mg	2.0 mg	238.3 mg
M5B/028-4	2.4 mg	248.9 mg	2.0 mg	249.3 mg
API-2.5/028-1	2.7 mg	89.0 mg	2.0 mg	89.7 mg
API-2.5/028-3	1.3 mg	83.0 mg	2.0 mg	82.3 mg

[1] A maximum of 2.0 mg was deducted from the total condensible particulate matter (CPM) for each run.

Analytical Narrative

		RFA #:	1436 (LC)
Client:	Air Control Techniques	Date Received:	3/1/10
Analyst:	JSC	Date Analyzed:	3/11/10
Analysis:	(EPA METHOD 5B (40 CFR. PART 60)	Analyte(s):	FILTERABLE PARTICULATE

Sample Matrix & Components:

Dry Filters, Front½ Acetone Rinses, Acetone Blank

Summary of Sample Prep:

The acetone rinses were transferred to pre-tared teflon "baggies" in a low humidity environment. The acetone rinses were evaporated overnight then desiccated for 24 hours, after which time they were weighed daily every six hours until consecutive weights agreed within ±0.5 mg. The filters were baked 2 to 3 hours at 163° C, desiccated for 2 hours and weighed.

All weights were recorded to the nearest 0.1 mg and include filterable particulate catch only. The total catch reported for each run is a sum of the filter and rinse catches. The acetone blank catch has been subtracted from sample rinse catches in proportion with their respective volumes.

Summary of Instrumentation:

Denver model Pinnacle Series analytical balance

Analytical Detection Limit(s): 0.1 mg

Miscellaneous Comments Regarding Sample Analysis: (Note unusual catch weights, interferences, odd sample behavior, and steps taken to confirm unusual results. Also note any deviations from standard analytical procedures, together with justification and possible affect on results. Specify samples when applicable.)

No modifications to EPA Method 5 analytical procedure were made. See data sheets for individual sample descriptions.

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: (EPA METHOD 5B (40 CFR. PART 60))

RFA #: **1436 (LC)**

Run Number			5B/028-1		5B/028-3		5B/028-4
Filter Container #	Date	Init		Date		Date	
	3/12/10	JSC	0.3678	3/12/10	0.3668	3/12/10	0.3673
Baggie Tare Wt., g.			#N/A		#N/A		#N/A
Filter Tare Wt., g.		RQ-6171	0.3658	RQ-6173	0.3623	RQ-6174	0.3656
FILTER SAMPLE WT., g.			0.0020		0.0045		0.0017

Front ½ Rinse Container #				2433			936			2110
	Date	Init			Date			Date		
	3/15/10	JSC	F	3.3586	3/15/10		3.6901	3/15/10		3.7588
	3/12/10	JSC		3.3587	3/12/10	F	3.6900	3/12/10	F	3.7587
Tare Wt., g.	(	150	ml)	3.3442	(150	ml)	3.6842	(100	ml)	3.7460
RINSE SAMPLE WT., g.				0.0144			0.0058			0.0127

	5B/028-1	5B/028-3	5B/028-4
Filter Catch, mg.	**2.0**	4.5	**1.7**
Rinse Catch, mg.	14.4	5.8	12.7
Rinse Blank Residue, mg.	0.1	0.1	0.0
Net Rinse Catch, mg.	**14.3**	5.7	**12.7**
FILTERABLE PARTICULATE, mg.	**16.3**	**10.2**	**14.4**

Legend: F = Final Weight

Notes & Comments:

REAGENT BLANK LABORATORY RESULTS

Client: ***Air Control Techniques*** *RFA #:* ***1436 (LC)***
Method: (EPA METHOD 5B (40 CFR. PART 60))

Run Number				*Acetone Blank*
Sample ID/Container #				*2272*
	Date	*Init*		
	3/15/10	*JSC*		*3.4405*
	3/12/10	*JSC*	*F*	*3.4404*
Tare Wt., g.	*(*	*200*	*ml)*	*3.4403*
SAMPLE WT., g.				*0.0001*

Blank Beaker #	*2272*
Final wt., mg.	*3.4404*
Tare wt., mg.	*3.4403*
Residue, mg.	*0.1*
Volume, ml.	*200*
Density, mg/ml	*785.0*
Conc., mg/mg	*636.9E-9 <--*
Upper Limit, mg	*10.0E-6*

Legend: *F = Final Weight*

Notes & Comments:

N:Particulate Lab:Jobs:ACT:1436 (LC):M5B.xls

Analytical Narrative

		RFA #:	1436 (LC)
Client:	Air Control Techniques	Date Received:	3/1/10
Analyst:	JSC	Date Analyzed:	3/11/10
Analysis:	(OTM 027)	Analyte(s):	PM 2.5 FILTERABLE PARTICULATE

Sample Matrix & Components:

Dry Filters, Front½ Acetone Rinses, Acetone Blank (in house)

Summary of Sample Prep:

The acetone rinses were transferred to pre-tared teflon "baggies" in a low humidity environment. The acetone rinses were evaporated overnight then desiccated for 24 hours, after which time they were weighed daily every six hours until consecutive weights agreed within ±0.5 mg. The filters were baked 2 to 3 hours at 105° C, desiccated for 2 hours and weighed.

All weights were recorded to the nearest 0.1 mg and include filterable particulate catch only. The total catch reported for each run is a sum of the filter and rinse catches. The acetone blank catch has been subtracted from sample rinse catches in proportion with their respective volumes.

Summary of Instrumentation:

Denver model Pinnacle Series analytical balance

Analytical Detection Limit(s): 0.1 mg

Miscellaneous Comments Regarding Sample Analysis: (Note unusual catch weights, interferences, odd sample behavior, and steps taken to confirm unusual results. Also note any deviations from standard analytical procedures, together with justification and possible affect on results. Specify samples when applicable.)

No modifications to OTM 027 analytical procedure were made. See data sheets for individual sample descriptions.

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: (OTM 027)

RFA #: **1436 (LC)**

Run Number				API-2.5/028-1			API-2.5/028-3			API-2.5/028-4
Filter Container #										
	Date	Init			Date			Date		
	3/12/10	JSC		0.1135	3/12/10		0.1137	3/12/10		0.1167
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.		47Q-196		0.1130	47Q-198		0.1131	47Q-199		0.1163
FILTER SAMPLE WT., g.				0.0005			0.0006			0.0004
≤ 2.5 µm Rinse Container #				2336			2332			2404
	Date	Init			Date			Date		
	3/12/10	JSC	F	3.4368	3/12/10		3.4066	3/12/10		3.3235
	3/12/10	JSC	F	3.4368	3/12/10	F	3.4063	3/12/10	F	3.3232
Tare Wt., g.		(30	ml)	3.4361	(10	ml)	3.4059	(10	ml)	3.3226
RINSE SAMPLE WT., g.				0.0007			0.0004			0.0006
> 2.5 µm Rinse Container #				1236			2357			2426
	Date	Init			Date			Date		
	3/12/10	JSC		3.9336	3/12/10	F	3.0974	JSC		3.4201
	3/12/10	JSC	F	3.9334	3/12/10		3.0975	JSC	F	3.4198
Tare Wt., g.		(30	ml)	3.9322	(30	ml)	3.0963	(10	ml)	3.4192
RINSE SAMPLE WT., g.				0.0012			0.0011			0.0006
Probe And Nozzle Rinse Container #				2270			2439			2412
	Date	Init			Date			Date		
	3/12/10	JSC	F	3.7129	3/12/10		3.4285	3/12/10		3.5160
	3/12/10	JSC		3.7130	3/12/10	F	3.4284	3/12/10	F	3.5159
Tare Wt., g.		(180	ml)	3.6950	(130	ml)	3.4147	(150	ml)	3.5036
RINSE SAMPLE WT., g.				0.0179			0.0137			0.0123
Filter Catch, mg.				0.5			0.6			0.4
≤ 2.5 µm Rinse Catch, mg.				0.7			0.4			0.6
Rinse Blank Residue, mg.				0.2			0.1			0.1
Net Rinse Catch, mg.				0.5			0.3			0.5
> 2.5 µm Rinse Catch, mg.				1.2			1.1			0.6
Rinse Blank Residue, mg.				0.2			0.2			0.1
Net Rinse Catch, mg.				1.0			0.9			0.5
Probe And Nozzle Rinse Catch, mg.				17.9			13.7			12.3
Rinse Blank Residue, mg.				1.1			0.8			0.9
Net Rinse Catch, mg.				16.8			12.9			11.4
FILTERABLE PARTICULATE, mg.				18.8			14.7			12.8

Notes & Comments:

N:Particulate Lab:Jobs:ACT:1436 (LC):OTM 027 (2.5 & 10).xls

REAGENT BLANK LABORATORY RESULTS

Client: **Air Control Techniques**
Method: (OTM 027)

RFA #: **1436 (LC)**

Run Number				API-2.5/028-1
Sample ID/Container #				2372
	Date	Init		
	3/12/10	JSC	F	3.3431
	3/12/10	JSC		3.3432
Tare Wt., g.	(	200	ml)	3.3419
SAMPLE WT., g.				0.0012

Blank Beaker #	2372
Final wt., mg.	3.3431
Tare wt., mg.	3.3419
Residue, mg.	1.2
Volume, ml.	200
Density, mg/ml	785.0
Conc., mg/mg	7.6E-6 ✓
Upper Limit, mg.	10.0E-6

N:Particulate Lab:Jobs:ACT:1436 (LC):OTM 027 (2.5 & 10).xls

Analytical Narrative

RFA # 1436

Page 1 of 1

Client/Plant Name: AIR CONTROL TECHNIQUES

Date Rec'd in lab: 03/01/10

Analyst: BNL

Date of Analysis: 03/09/10

Analysis Method: EPA OTM-028

Analyte(s): Condensible Particulate

Sample Matrix & Components:

H_2O (dry) Impinger samples, Back½ Acetone/$MeCl_2$ Rinses, Back½ CPM Filter, Field Train Blank and Field Reagent Blanks.

Summary of Sample Prep:

CPM Filter was extracted by sonication twice first with water, then by methylene chloride per OTM-028. Each aliquot following 2 minutes sonication was transfered to water and methylene chloride field containers, respectively.

The H_2O field samples were then extracted with methylene chloride and combined with the organic back½ rinse. Methylene Chloride rinses were evaporated overnight at ambient temperature then desiccated for 24 hours, after which time they were weighed daily every six hours until consecutive weights agreed within ±0.5 mg. The H_2O samples were evaporated at 85°F (at ambient pressure) until completely dry. H_2O samples were then resuspended in 50 mL deionized water and titrated to neutral pH using 0.1 N NH_4OH, allowed to dry again then desiccated for 24 hours and finally weighed daily every six hours until consecutive weights agreed within ±0.5 mg.

All weights were recorded to the nearest 0.1 mg. The total catch reported for each run is a sum of the condensible organic and inorganic catches minus total field train blank catch weight or 2.0 mg, whichever is less.

Summary of Instrumentation:

Denver model Pinnacle Series analytical balance

Analytical Detection Limit(s): 0.5 mg

Miscellaneous Comments Regarding Sample Analysis: (Note unusual catch weights, interferences, odd sample behavior, and steps taken to confirm unusual results. Also note any deviations from standard analytical procedures, together with justification and possible affect on results. Specify samples when applicable.)

1) See data sheets for individual sample descriptions.

PARTICULATE SAMPLING LABORATORY RESULTS (EPA OTM-028)

Plant Name:	*AIR CONTROL TECHNIQUES*	*RFA #*	*1436*
Method:	*OTM-028*	*Filename:*	*ACT*
Date Received:	*03/01/10*	*Page 1 of 4*	
		File Pathway:	*C:\JOBS\1436\ACT.WB1*

Run Number				M5B/028-1			M5B/028-3			M5B/028-4
DI H2O Container #	*Date*	*Init*		*1515*	*Date*		*2353*	*Date*		*625*
	03/09	*BNL*	*@*	*3.8119*	*03/09*	*@*	*3.3825*	*03/09*	*@*	*3.8202*
	03/09	*BNL*		*3.8122*	*03/09*		*3.3828*	*03/09*		*3.8206*
Tare Wt., g.		*(410*	*ml)*	*3.5741*	*(420*	*ml)*	*3.1630*	*(380*	*ml)*	*3.5636*
SAMPLE WT., g.				*0.2378*			*0.2195*			*0.2566*
Acetone/MeCl2 Container #	*Date*	*Init*		*443*	*Date*		*2381*	*Date*		*2361*
	03/09	*BNL*	*@*	*3.6414*	*03/09*	*@*	*3.2856*	*03/09*	*@*	*3.4668*
	03/09	*BNL*		*3.6419*	*03/09*	*@*	*3.2856*	*03/09*		*3.4671*
Tare Wt., g.		*(250*	*ml)*	*3.6399*	*(250*	*ml)*	*3.2592*	*(250*	*ml)*	*3.4644*
SAMPLE WT., g.				*0.0015*			*0.0264*			*0.0024*

	M5B/028-1	M5B/028-3	M5B/028-4
Organic Fraction Catch, mg.	*1.5*	*26.4*	*2.4*
Organic (MeCl2/Acetone) Fiald Blank Correction, mg.	*0.0*	*0.0*	*0.0*
Organic Fraction Catch, mg.	***1.5***	***26.4***	***2.4***
Inorganic Fraction Catch, mg.	*237.8*	*219.5*	*256.6*
Inorganic (H2O) Field Blank Correction, mg.	*0.0*	*0.0*	*0.0*
Inorganic Fraction Catch, mg.	*237.8*	*219.5*	*256.6*
Volume (Vt) of NH4OH added (N=0.1), ml	*4.4000*	*3.3000*	*4.5000*
Correction for ammonia added, mg	*7.4932*	*5.6199*	*7.6635*
Adjusted Inorganic Fraction Catch, mg.	***230.3***	***213.9***	***248.9***

**A maximum of 2 mg deducted for field blank correction per OTM-028*

TOTAL OTM-028 CONDENSIBLE PARTICULATE, mg.	**229.8**	**238.3**	**249.3**

Miscellaneous Notes & Comments:

Printing Date 09-Mar-10 Printing Time: 03:08 PM

PARTICULATE SAMPLING LABORATORY RESULTS (EPA OTM-028)

Plant Name:	*AIR CONTROL TECHNIQUES*		*RFA #*	***1436***
Method:	*OTM-028*		*Filename:*	*ACT*
Date Received:	*03/01/10*	*Page 2 of 4*	*File Pathway:*	*C:\JOBS\1436\ACT.WB1*

Run Number	API-2.5/028-1	API-2.5/028-3

DI H2O Container #				*2422*			*2425*			
	Date	*Init*			*Date*			*Date*		
	03/09	*BNL*	*@*	*3.5139*	*03/09*	*@*	*3.4554*			
	03/09	*BNL*		*3.5140*	*03/09*	*@*	*3.4554*			*0.0000*
Tare Wt., g.		*(210*	*ml)*	*3.4249*	*(210*	*ml)*	*3.3724*	*(*	*ml)*	*0.0000*
SAMPLE WT., g.				*0.0890*			*0.0830*			*0.0000*

Acetone/MeCl2 Container #				*2387*			*2338*			
	Date	*Init*			*Date*			*Date*		
	03/09	*BNL*	*@*	*3.4044*	*03/09*		*3.3275*			
	03/09	*BNL*		*3.4046*	*03/09*	*@*	*3.3273*			
Tare Wt., g.		*(210*	*ml)*	*3.4017*	*(160*	*ml)*	*3.3260*	*(*	*ml)*	*0.0000*
SAMPLE WT., g.				*0.0027*			*0.0013*			*ERR*

Organic Fraction Catch, mg.	*2.7*	*1.3*	*ERR*
Organic (MeCl2/Acetone) Field Blank Correction, mg.	*0.0*	*0.0*	*0.0*
Organic Fraction Catch, mg.	*2.7*	*1.3*	*ERR*
Inorganic Fraction Catch, mg.	*89.0*	*83.0*	*0.0*
Inorganic (H2O) Field Blank Correction, mg.	*0.0*	*0.0*	*0.0*
Inorganic Fraction Catch, mg.	*89.0*	*83.0*	*0.0*
Volume (Vt) of NH4OH added (N=0.1), ml	*0.00*	*0.00*	*0.00*
Correction for ammonia added, mg	*0.00*	*0.00*	*0.00*
Adjusted Inorganic Fraction Catch, mg.	*89.0*	*83.0*	*0.0*

TOTAL OTM-028 CONDENSIBLE PARTICULATE, mg.	89.7	82.3	ERR

Miscellaneous Notes & Comments:

Printing Date 09-Mar-10 Printing Time 03:08 PM

PARTICULATE SAMPLING LABORATORY RESULTS (EPA OTM-028)

Plant Name:	*AIR CONTROL TECHNIQUES*	*RFA #*	*1436*
Method:	*OTM-028*	*Filename:*	*ACT*
Date Received:	*03/01/10* *Page 3 of 4*	*File Pathway:*	*C:\JOBS\1436\ACT.WB1*
Run Number	028-FB		

DI H2O Container #	*Date*	*Init*		*1489*	*Date*		*Date*	
	03/09	*BNL*	*@*	*3.5451*				
	03/09	*BNL*		*3.5453*		*0.0000*		*0.0000*
Tare Wt., g.		*(140*	*ml)*	*3.5432*	*(*	*ml) 0.0000*	*(*	*ml) 0.0000*
SAMPLE WT., g.				*0.0019*		*0.0000*		*0.0000*

Acetone/MeCl2 Container #	*Date*	*Init*		*2041*	*Date*		*Date*	
	03/09	*BNL*		*3.7225*				
	03/09	*BNL*	*@*	*3.7223*		*0.0000*		*0.0000*
Tare Wt., g.		*(230*	*ml)*	*3.7215*	*(*	*ml) 0.0000*	*(*	*ml) 0.0000*
SAMPLE WT., g.				*0.0008*		*0.0000*		*0.0000*

Organic Fraction Catch, mg.	*0.8*	*0.0*	*0.0*
Organic (MeCl2/Acetone) Field Blank Correction, mg.	*0.0*	*0.0*	*0.0*
Organic Fraction Catch, mg.	*0.8*	*0.0*	*0.0*
Inorganic Fraction Catch, mg.	*1.9*	*0.0*	*0.0*
Inorganic (H2O) Field Blank Correction, mg.	*0.0*	*0.0*	*0.0*
Inorganic Fraction Catch, mg.	*1.9*	*0.0*	*0.0*
Volume (Vt) of NH4OH added (N=0.1), ml	*0.1000*	*0.00*	*0.00*
Correction for ammonia added, mg	*0.1703*	*0.00*	*0.00*
Adjusted Inorganic Fraction Catch, mg.	*1.7*	*0.0*	*0.0*

TOTAL OTM-028 CONDENSIBLE PARTICULATE, mg.	**2.5**	**0.0**	**0.0**

Miscellaneous Notes & Comments:

Printing Date 09-Mar-10 Printing Time 03:08 PM

REAGENT BLANK LABORATORY RESULTS (Version 04.28.92)

Plant Name: **AIR CONTROL TECHNIQUES** RFA # **1436**
Method: OTM-028 Filename: ACT
Date Received: 03/01/10 Page 4 of 4 File Pathway: C:\JOBS\1436\ACT.WB1

Blank Type				Methylene Chloride/Acetone				Water
Sample ID/Container #				2335				487
	Date	Init				Date		
	03/09			3.3681		03/09	@	3.5406
	03/09		@	3.3680		03/09		3.5408
Tare Wt., g.	(	250	ml)	3.3676	(	140	ml)	3.5400
SAMPLE WT., g.				0.0004				0.0006

Blank Beaker #	2335	487
Final wt., mg.	3.3680	3.5406
Tare wt., mg.	3.3676	3.5400
Residue, mg.	0.400	0.600
Volume, ml.	250	140
Density, mg/ml	1315.0	1000.0
Conc., mg/mg	1.217E-06 @	4.286E-06 @
Upper Limit,mg/mg	1.000E-05	1.000E-05

M5/17 Particulate Bench Sheet

Client: ACT

Analyst: JSC

RFA #: 10027-1436 (LC)

Method: 5B

Date Received: 3/1/10

Date Analyzed: 3/11/10

Run #	Filter			Acetone Rinse	
	Baggie #	Filter #	Filter Tare	Baggie #	Rinse Volume
5B|029 - 1		RQ-6171	0.3658	2433	150
-3		RQ-6173	0.3623	936	150
-4		RQ-6174	0.3656	2110	100
ACETONE BLANK				2272	200
(IN HOUSE)					

OTM 027 Particulate Bench Sheet

Client: ACT
Analyst: JSC.
RFA #: 10027-1436 (LC)
Method: 2.5/028
Date Received: 3/1/10
Date Analyzed: 3/11/10

Run #	Filter			≤ 2.5µm Rinse		>2.5µm ~~≤10µm Rinse~~		PROBE + NOZZLE ~~≥10µm Rinse~~	
	Baggie #	Filter #	Filter Tare	Baggie #	Volume	Baggie #	Volume	Baggie #	Volume
API-25/028-1		Q-196	0.1130	2336	30	1236	30	2270	180
-3		Q-198	0.1131	2332	10	2357	30	2439	130
-4		Q-199	0.1163	2404	10	2426	10	2412	150
ACETONE BLANK (IN HOUSE)				2372	200				

PARTICULATE WORKSHEET

CLIENT ACT RFA # 1436 (1C)

ANALYST BNL METHOD OTM-028 DATE 3/1/10

RUN #	FILTER			ACETONE RINSE		NOZZLE CYCLONE		MECL2 ✓ TOLUENE ___ CHLOROFORM/ETHER ___		DI H2O IMPINGER		
	CONT.#	FILTER #	TARE WT.(G)	CONT.#	VOL.(ML)	CONT.#	VOL.(ML)	CONT.#	VOL.(ML)	CONT.#	VOL.(ML)	
M5B/028-1								443	250	1515	410	4.4
-3								2381	250	2353	420	3.3
-4								2361	250	625	380	4.5
APT-2.5/028-1								2387	210	2422	210	2.7
-3								2338	160	2425	210	3.0
028-FB								2041	230	1489	140	0.1
Rgt Blank								2335	250	487	140	

VOLUME II

Appendix F – Research Triangle Institute Report

RTI
INTERNATIONAL

TECHNICAL REPORT

Client:	**Air Control Techniques, P. C.**
RTI Project No.:	**0212441.003.003**
Date:	**May 25, 2010**
ACT P.O. No.:	**10035-1436**

Submitted by:

Owen S. Crankshaw
Research Triangle Institute
P.O. Box 12194
3040 Cornwallis Road
Research Triangle Park, NC 27709
(919) 541-7470

Submitted to:

John Richards
Air Control Techniques, P.C.
301 East Durham Road
Cary, NC 27513

INTRODUCTION

Two filter samples and six solid residue samples from Air Control Techniques were delivered to RTI on April 9, 2010. RTI was requested to provide an assessment of particle size utilizing scanning electron microscopy (SEM), to provide micrographs documenting the particle population, and to relate size to chemistry.

METHOD OF ANALYSIS

A representative portion of the filter was mounted on a conductive carbon pad on a standard SEM stub. The sample was coated with gold/palladium. The sample was examined in the SEM at 15 kV in high vacuum mode to examine the particles and to determine the relative size makeup and chemistry.

RESULTS OF ANALYSIS

Sample 028-1 (a fibrous glass filter) was composed of a homogenous population of partially agglomerated particles ranging from approximately 0.2 – 2 microns in size,. The particles are uniformly composed of aluminum, silicon, and oxygen. A few larger particles were present, including particles containing large amounts of sulfur, iron, and chromium.

Sample 028-3 (a fibrous glass filter) was composed of a homogenous population of partially agglomerated particles ranging from approximately 0.2 – 2 microns in size. The particles are uniformly composed of aluminum, silicon, and oxygen, with a small amount of sulfur detected. There were none of the larger sulfate particles detected by SEM.

Sample 1236 was composed of a fairly homogenous mat-like population of particles ranging from approximately 0.2 – 2 microns in size, with assorted irregular particles widely scattered throughout the main particle population. The primary particles are composed of aluminum, silicon, and oxygen. Larger particles (10-100 um) had more variation in composition, including sodium, calcium, and sulfur.

Sample 2270 was composed of a matted heterogenous mix of agglomerated particles and fragments ranging from approximately 0.2 – 20 microns in size, with some much larger platy particles present. The primary particles are composed of aluminum, silicon, chlorine, calcium, and oxygen. The platy particles and irregular larger particles were generally aluminum silicates also.

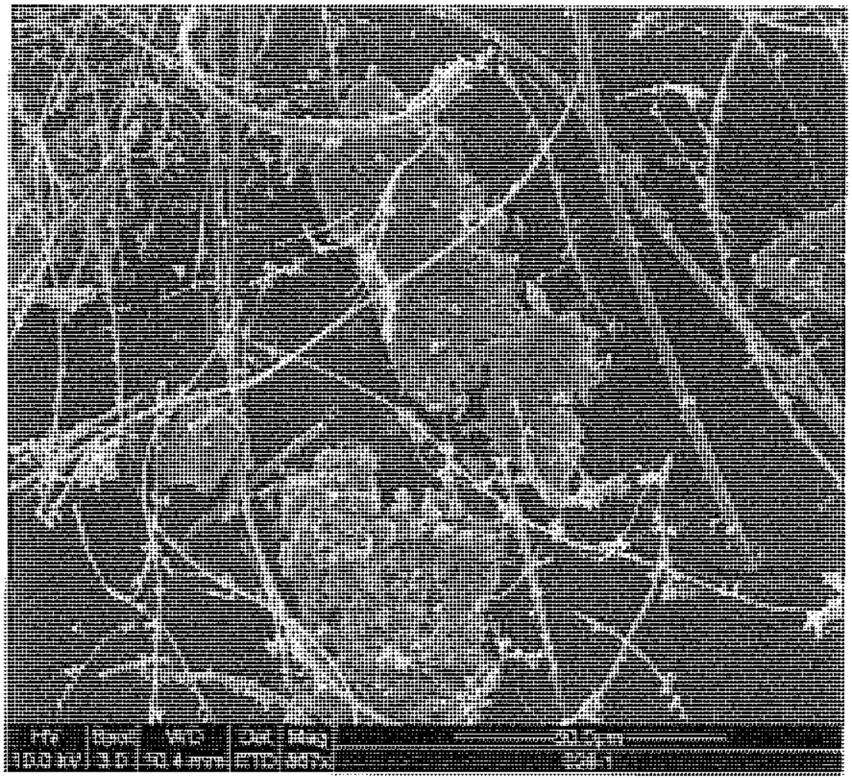
Sample 2332 was very lightly loaded, and was composed of a fairly homogenous population of agglomerated small particles ranging from approximately 0.2 – 2 microns in size, with assorted irregular particles widely scattered throughout the main particle population. The primary particles are composed of aluminum, silicon, and oxygen. Larger particles (5-100 um) had more variation in composition, including calcium-rich and sulfur-rich particles.

Sample 2336 was very lightly loaded, and was composed of a fairly homogenous population of agglomerated small particles ranging from approximately 0.2 – 2 microns in size, with assorted irregular particles widely scattered throughout the main particle population. The primary particles are composed of aluminum, silicon, sodium, chlorine, sulfur, magnesium, and oxygen. Larger particles (5-100 um) had more variation in composition, including organic, iron-rich, and sulfur-rich particles.

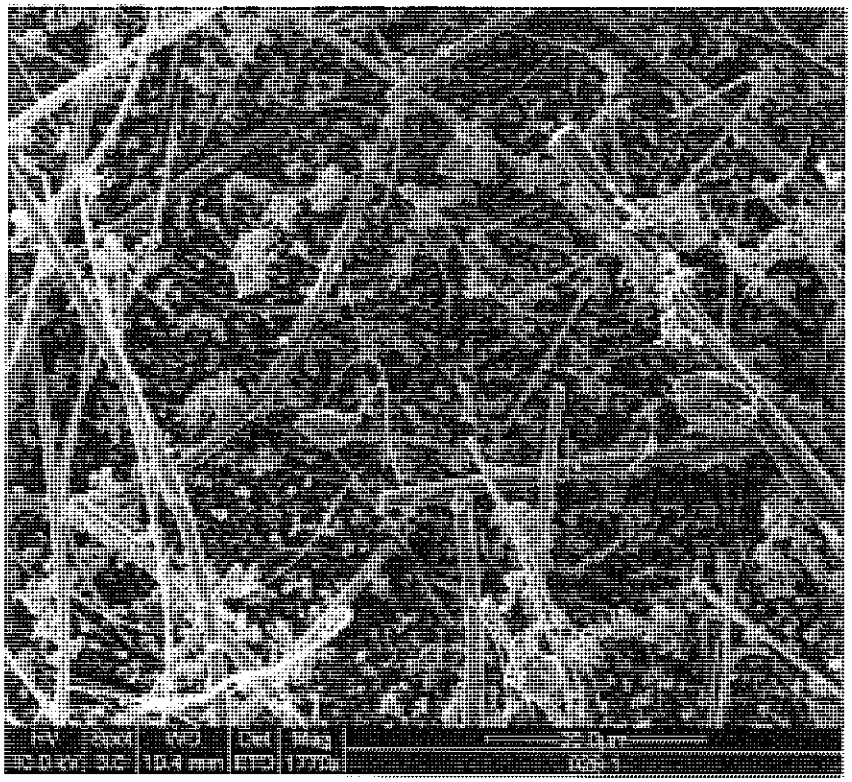
Sample 2357 was moderately loaded, and was composed of a mix of a homogenous population of particles ranging from approximately 0.2 – 2 microns in size and numerous fibrous glass fibers. There were a few assorted irregular particles widely scattered throughout the main particle/fiber population. The primary particles are composed of aluminum, silicon, and oxygen. Larger particles (5-100 um) had more variation in composition, including organic and calcium-rich particles.

Sample 2439 was composed of a fairly homogenous mat-like population of particles ranging from approximately 0.2 – 2 microns in size, with assorted irregular particles widely scattered throughout the main particle population. The primary particles are composed of chlorine and calcium. Larger particles (5-100 um) had more variation in composition, including a sulfur-rich and lanthanum-rich particle.

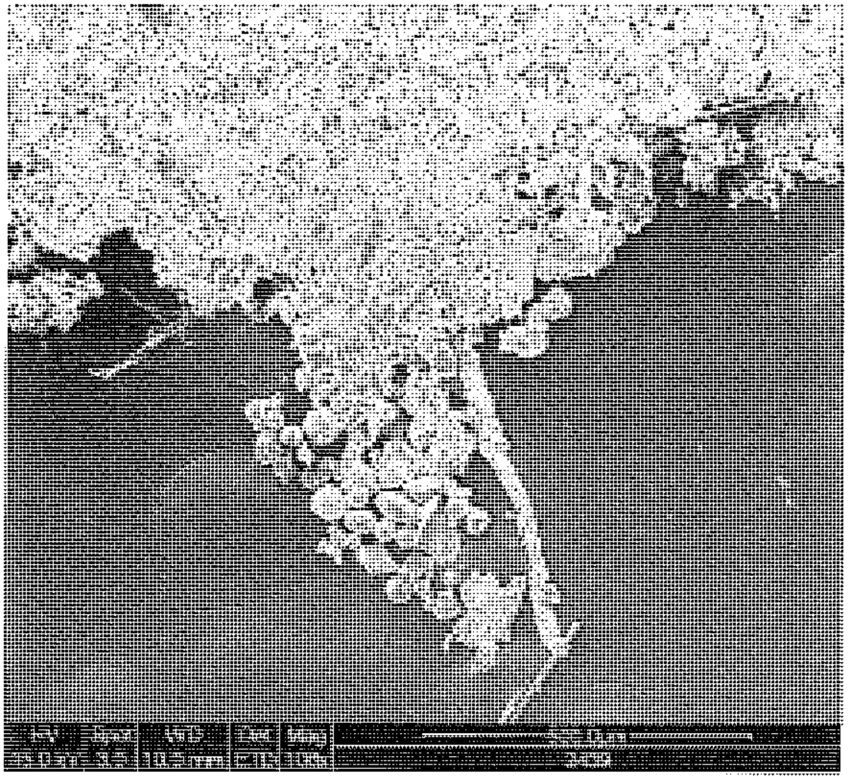
Micrographs and spectra of representative areas at various magnifications follow. Note that for many of the samples, there was a problem with the x-ray system that erroneously labeled several of the EDS images 1 mm. The correct image calibration for these samples can be found on the stand-alone SEM micrographs.



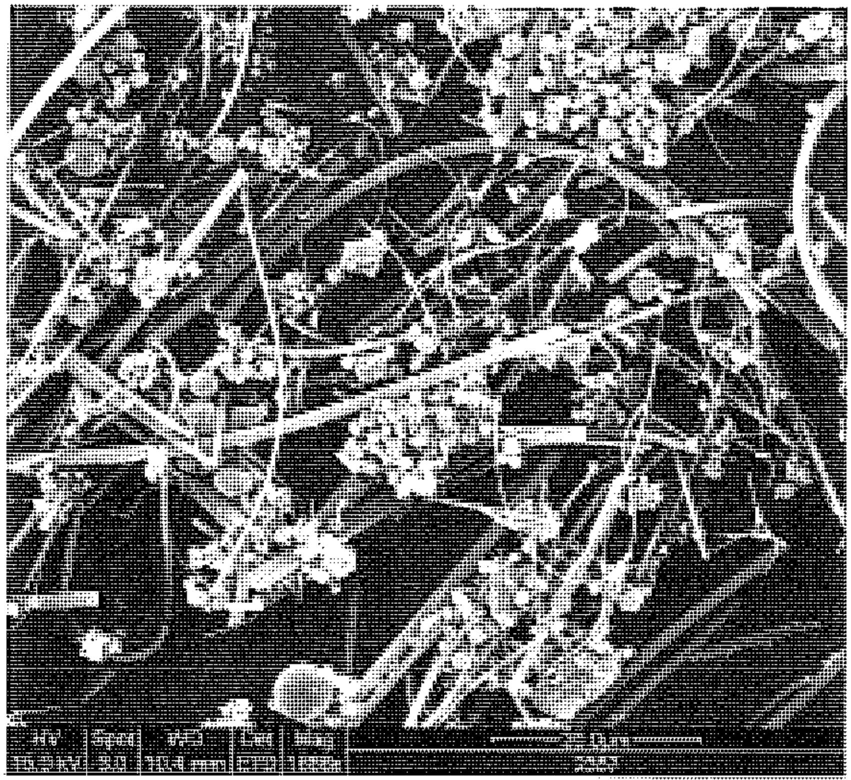
Sample 028-1 (filter sample).



Sample 028-1 (filter sample).



Sample 028-3 (filter sample).



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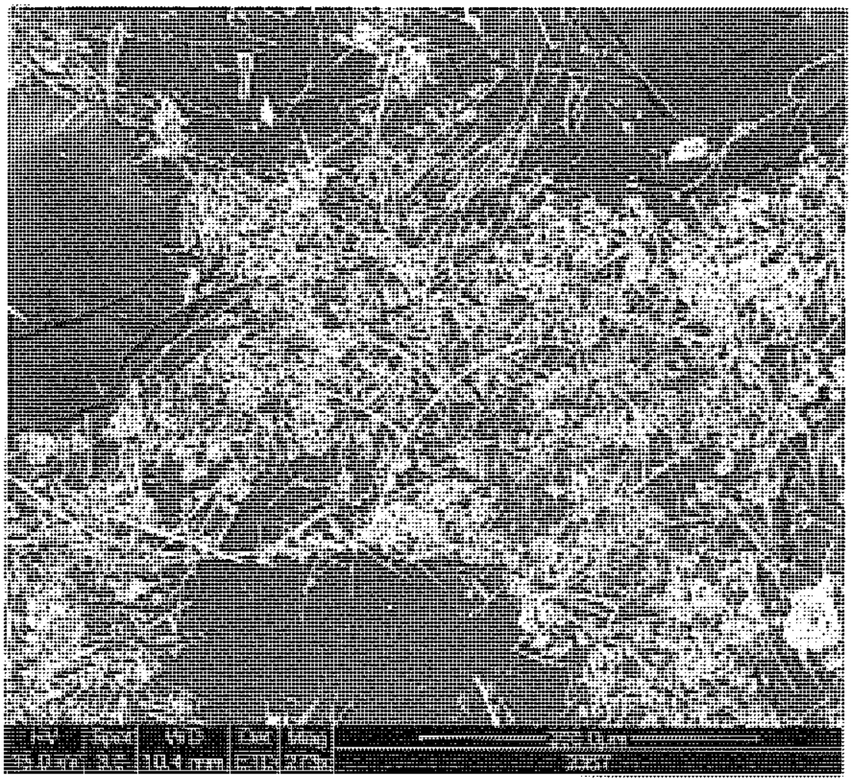

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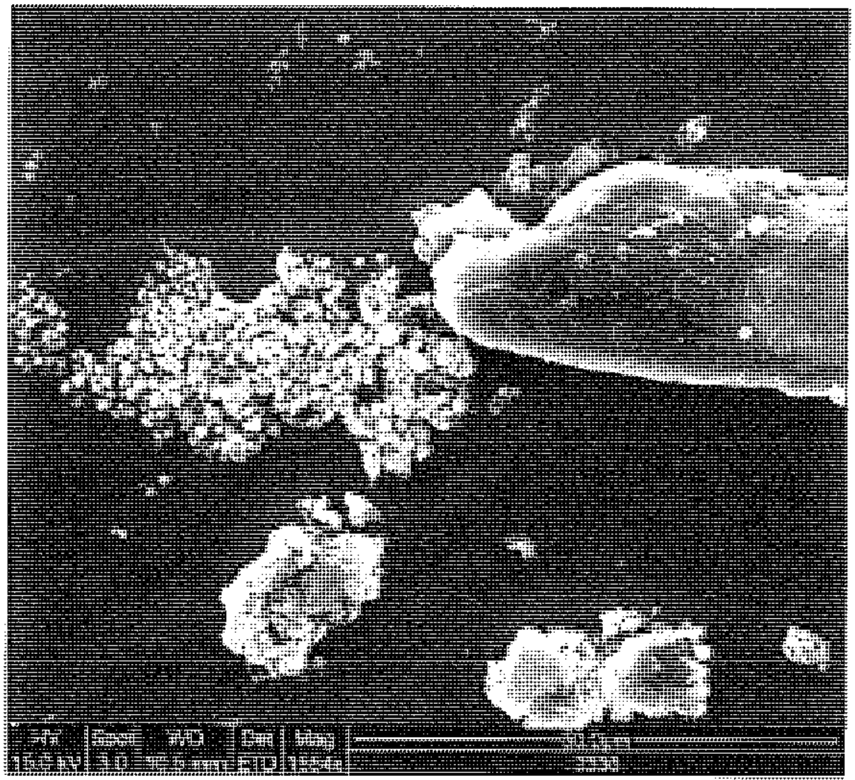

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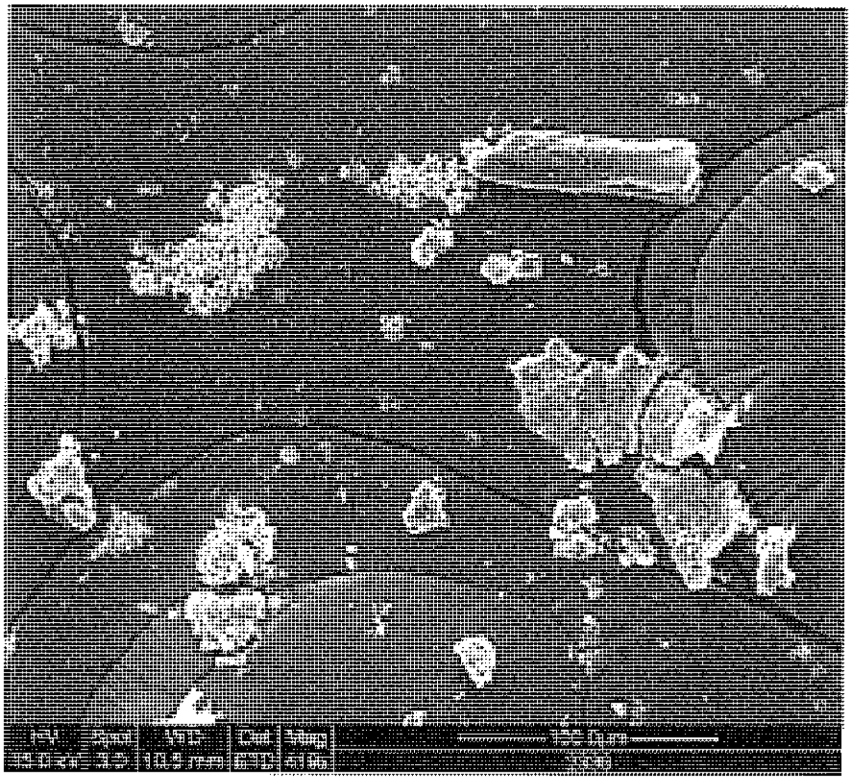

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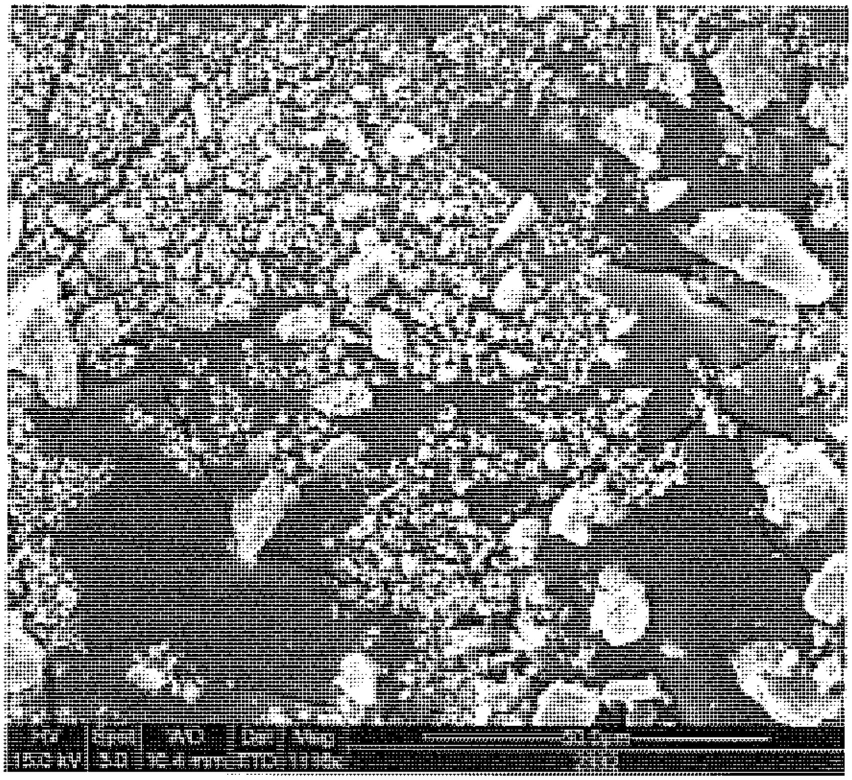

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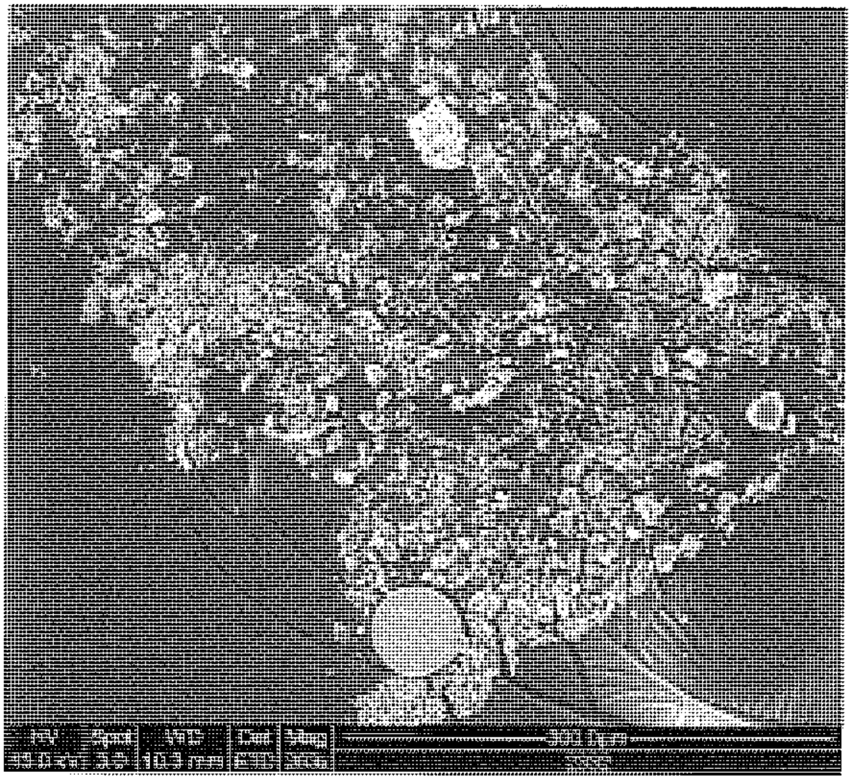

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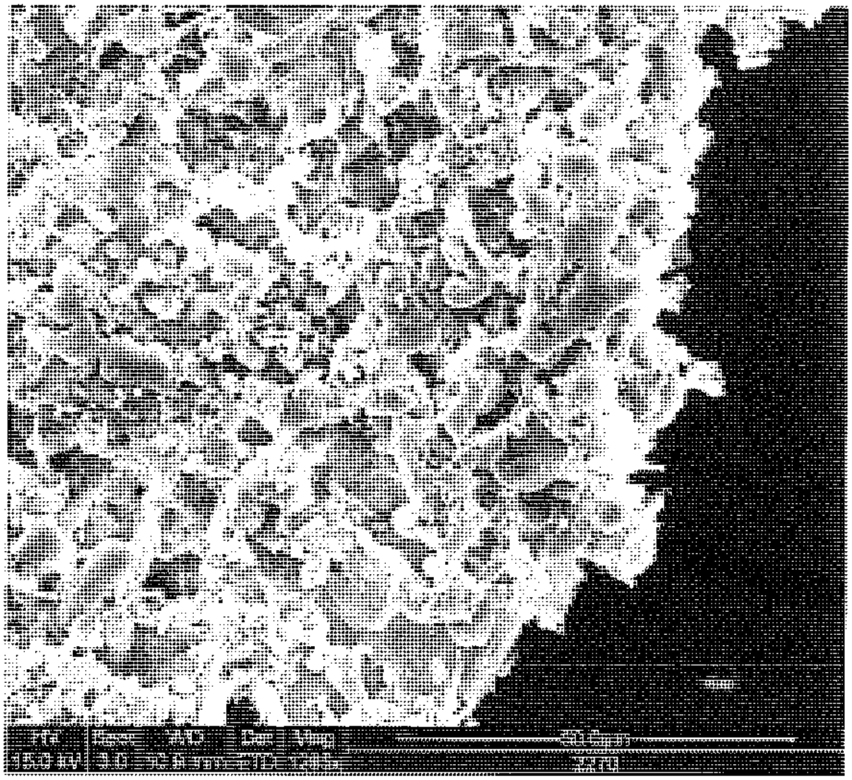

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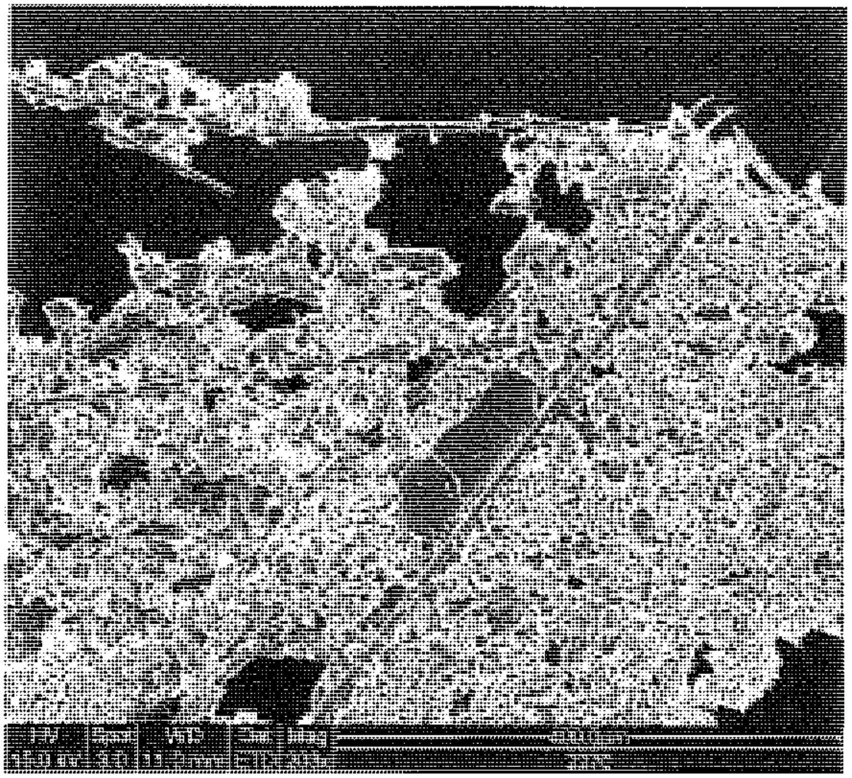

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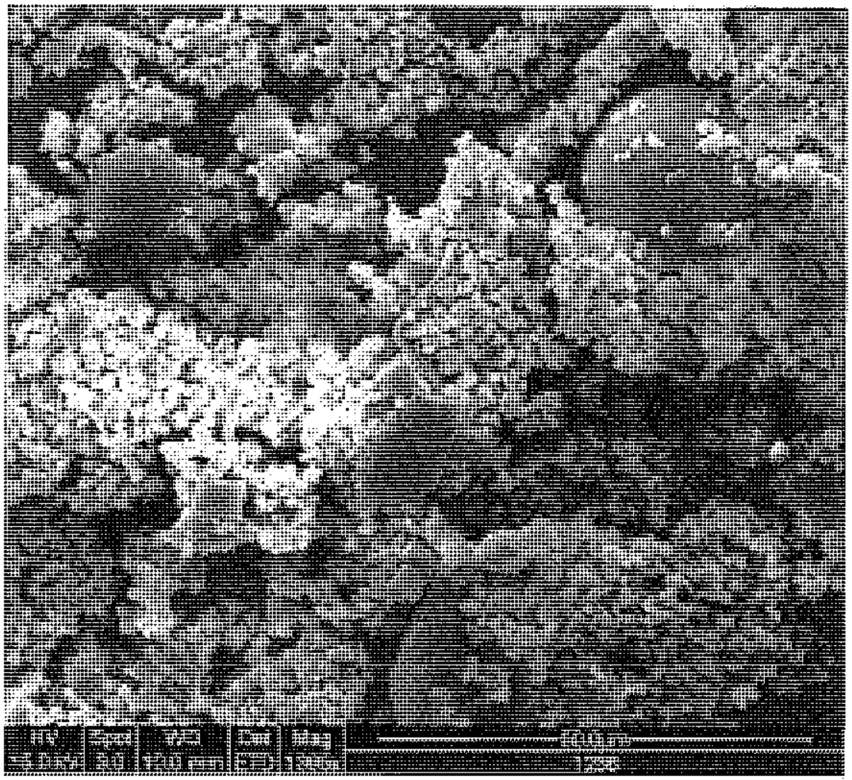

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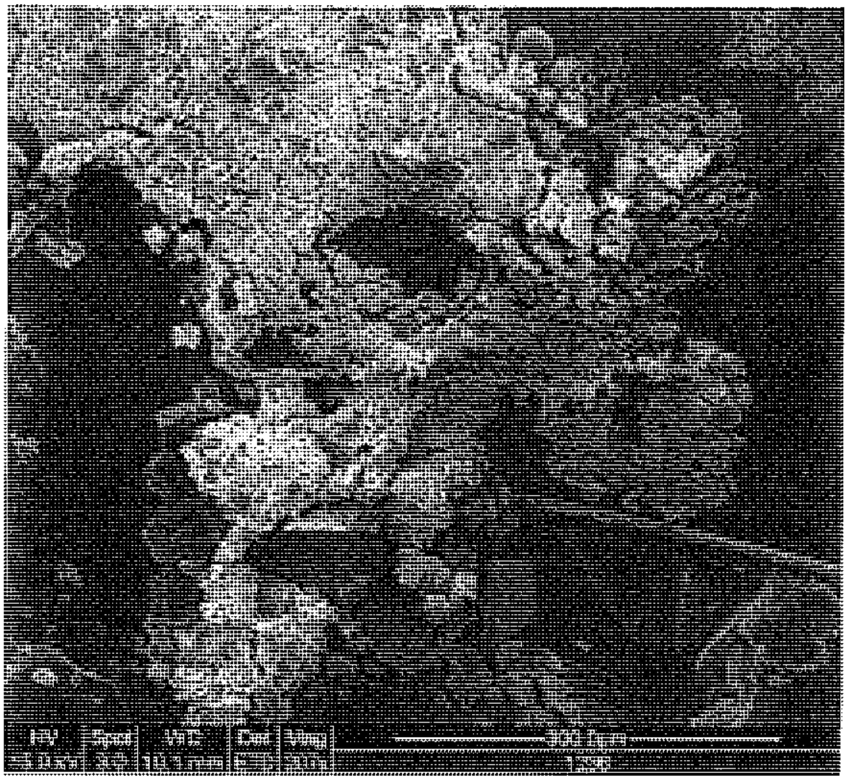

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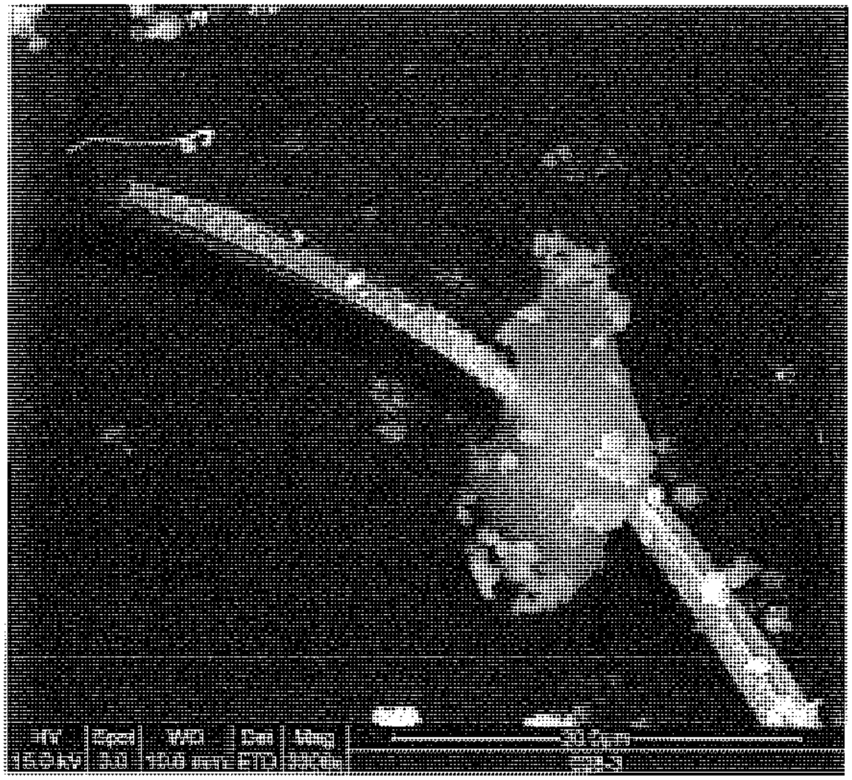

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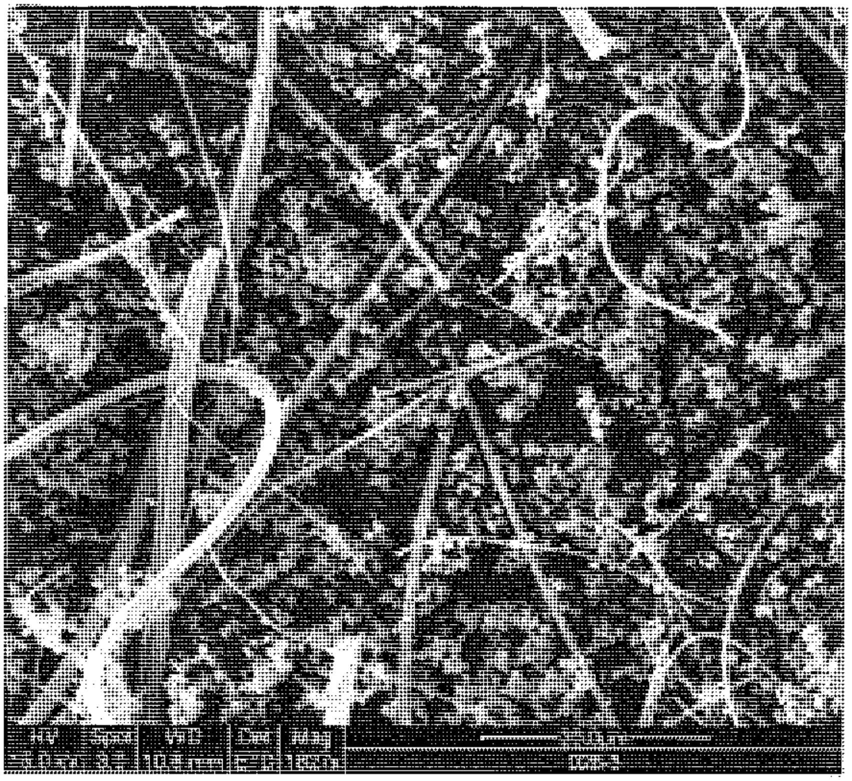

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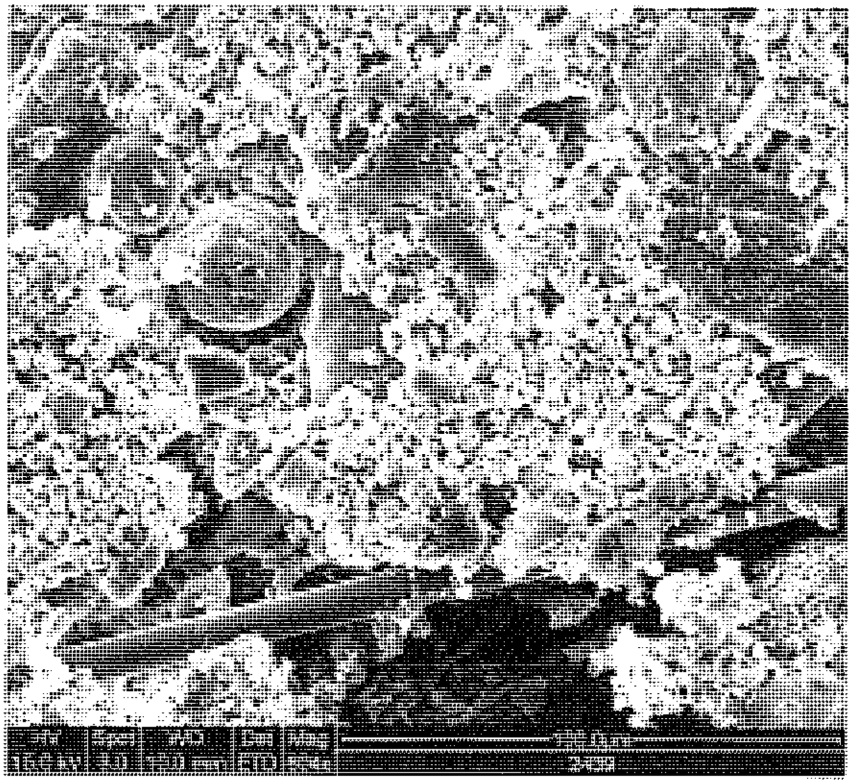

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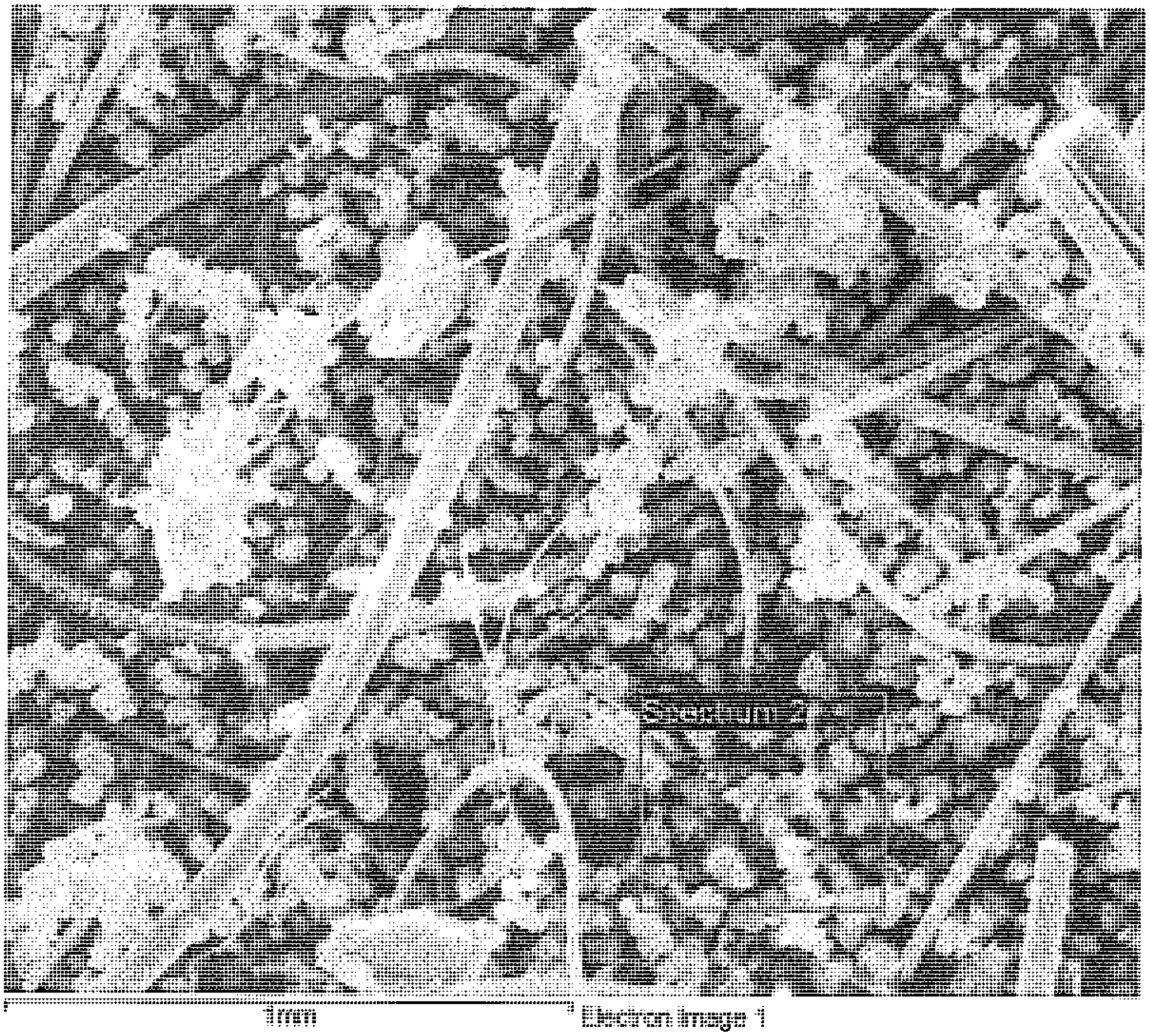
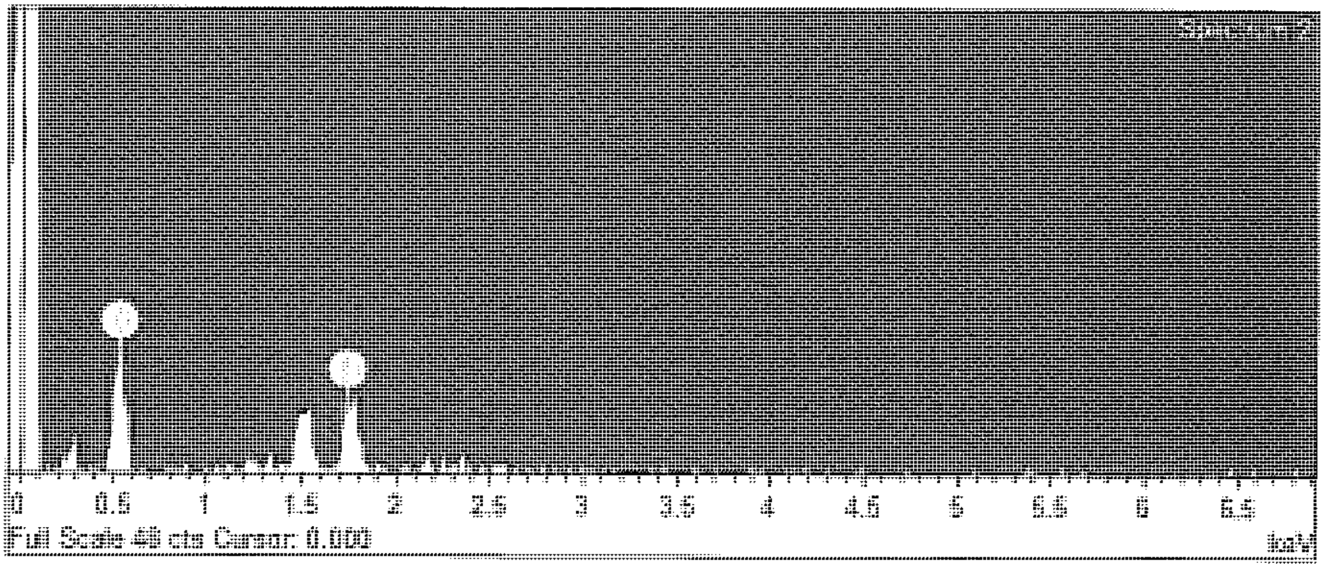
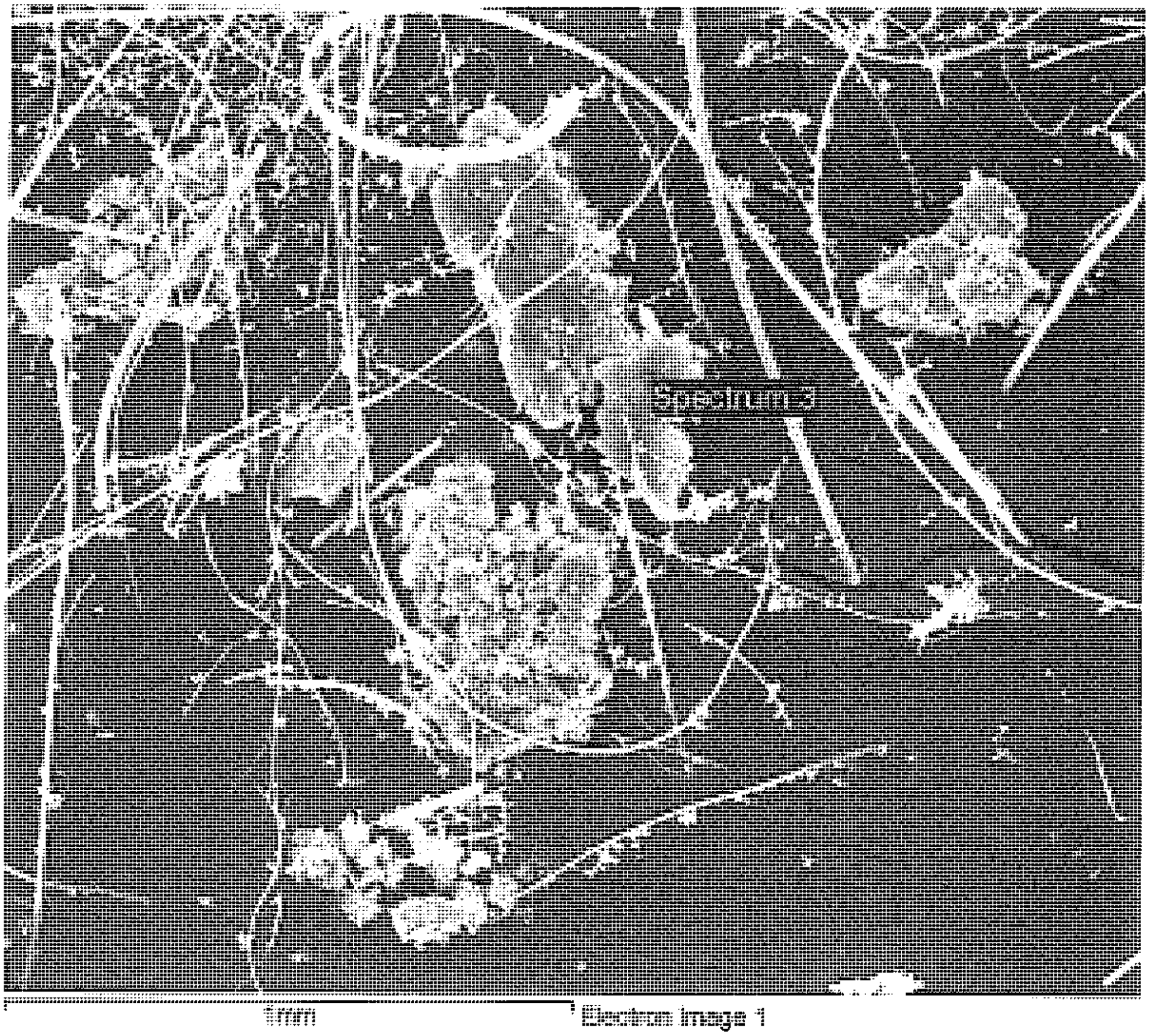
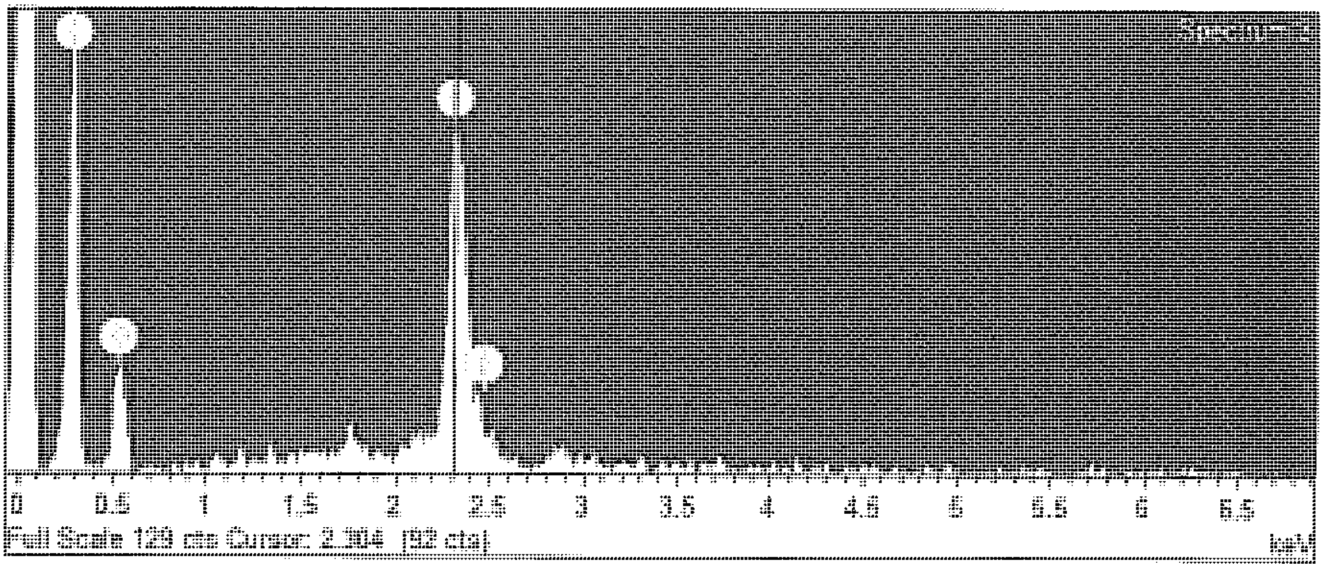




Comment: 028-1 fibrous glass filter

[illegible]





Comment: 028-1 fibrous glass filter large particle

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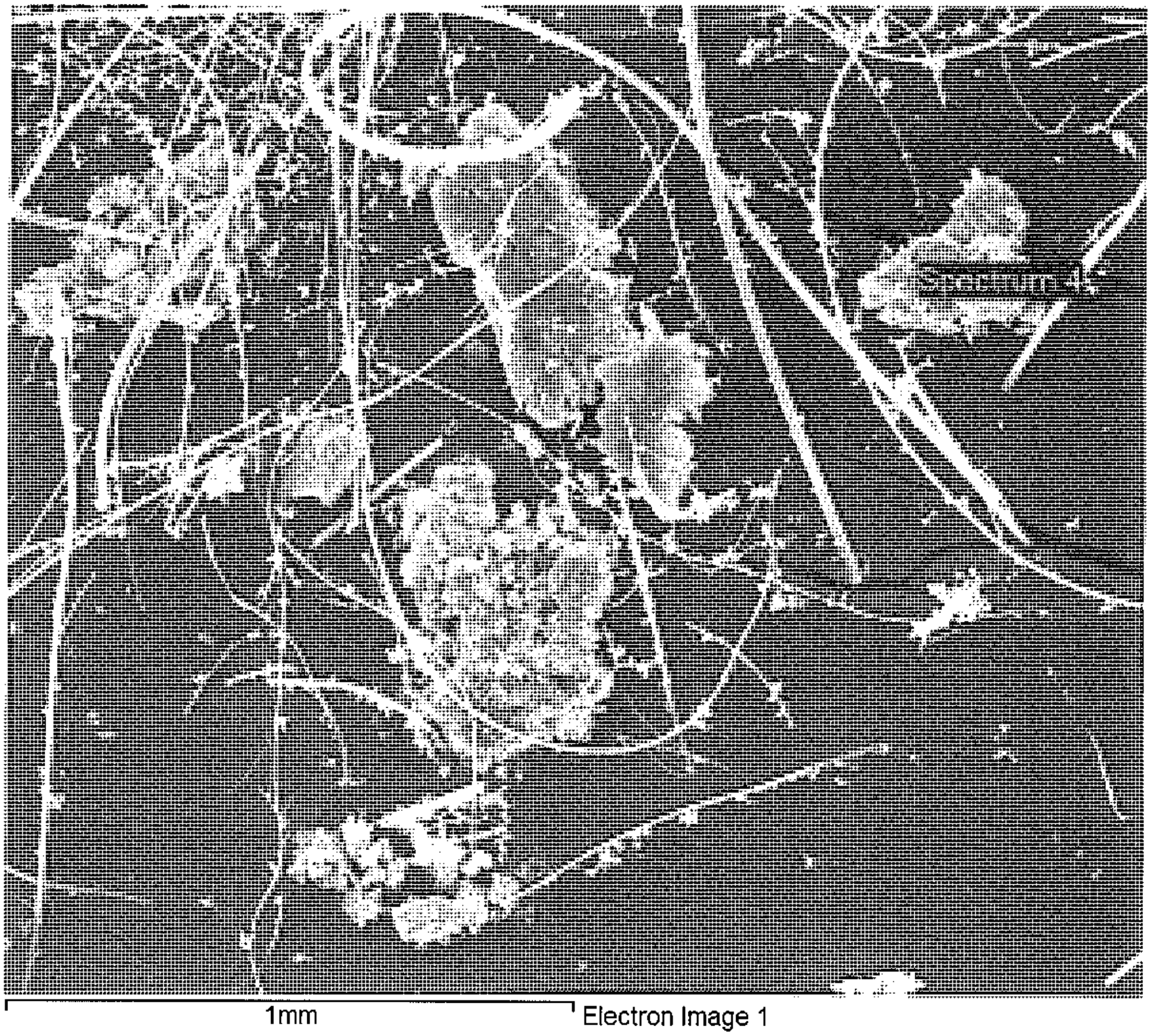
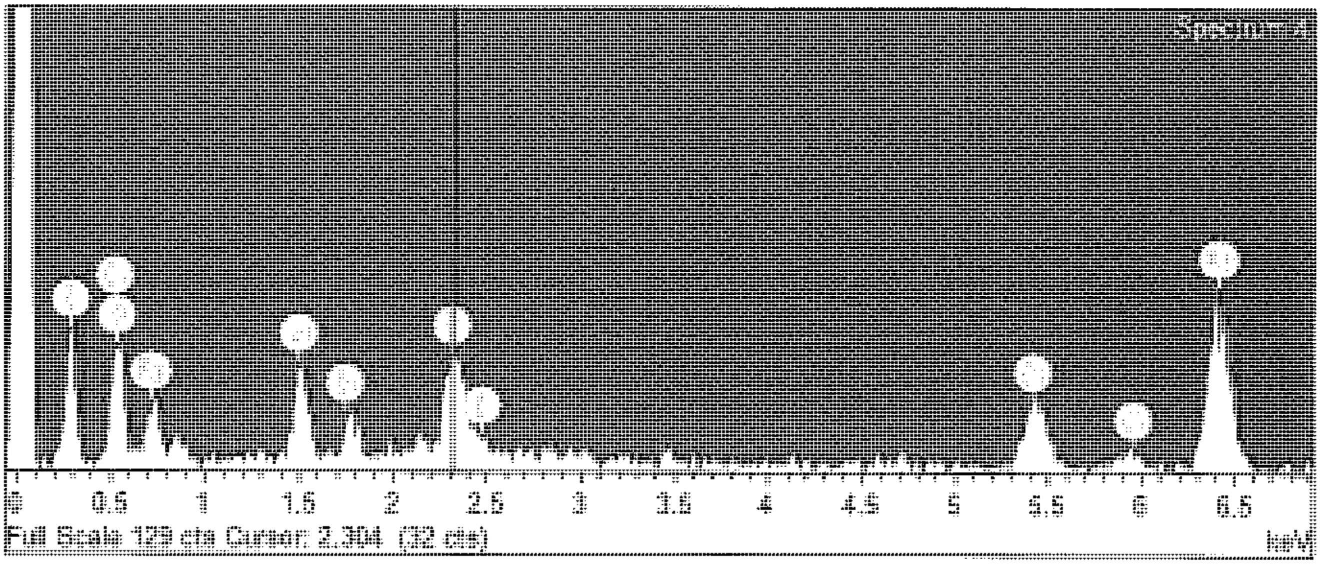


Electron Image 1



Comment: 028-1 fibrous glass filter large particle

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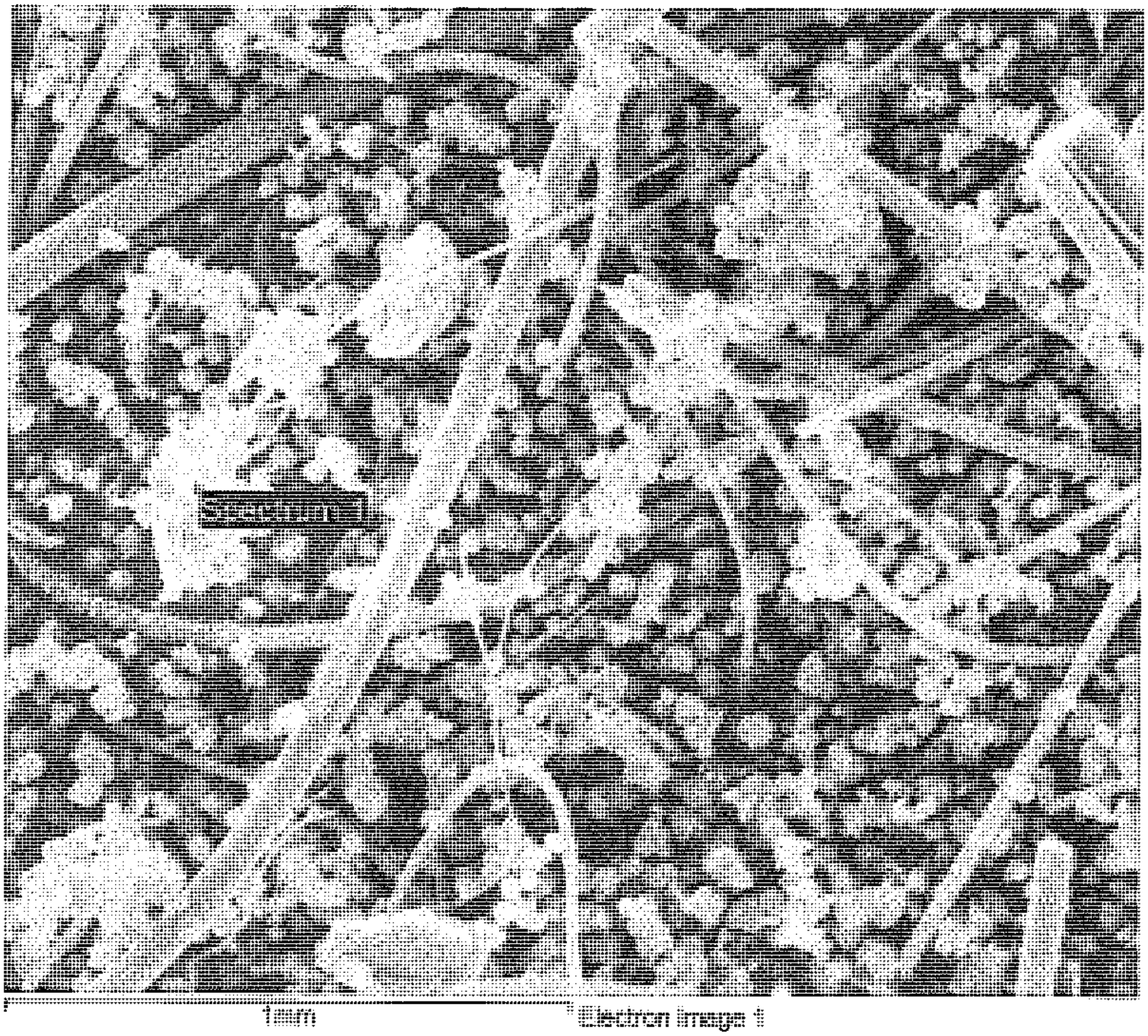
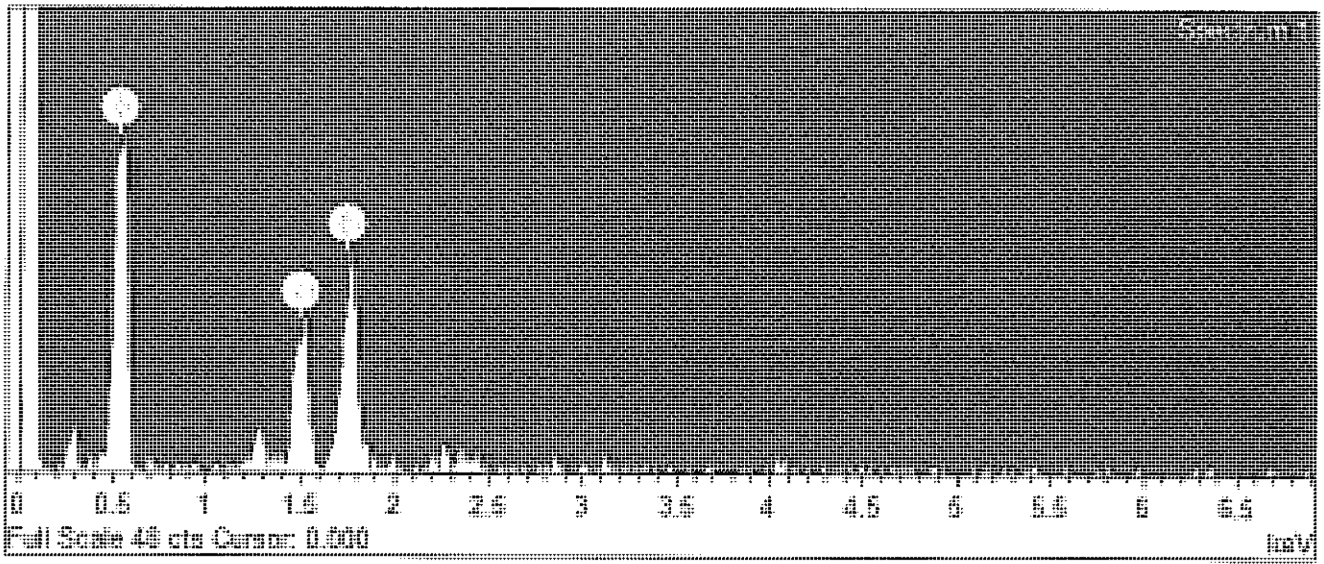
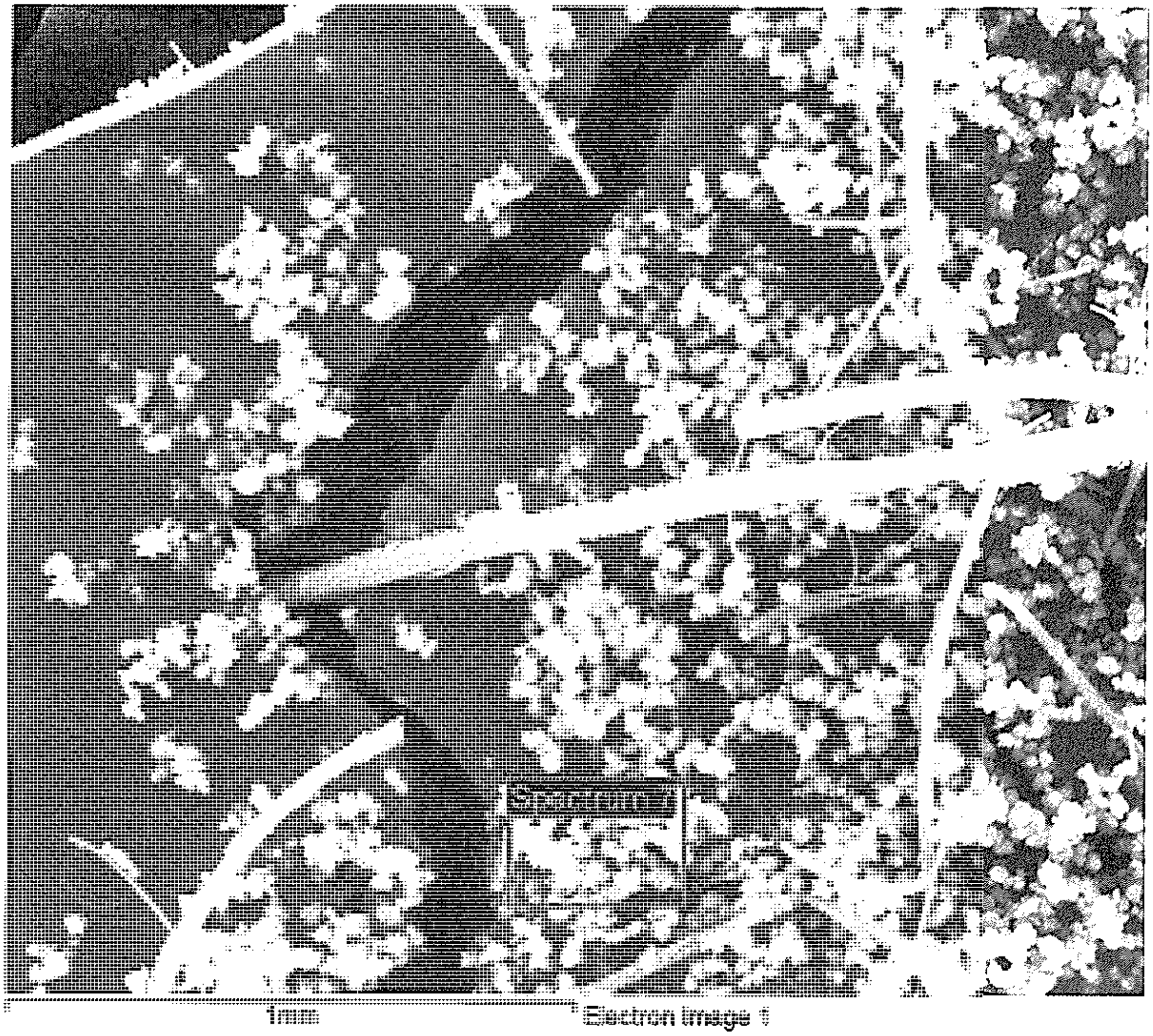
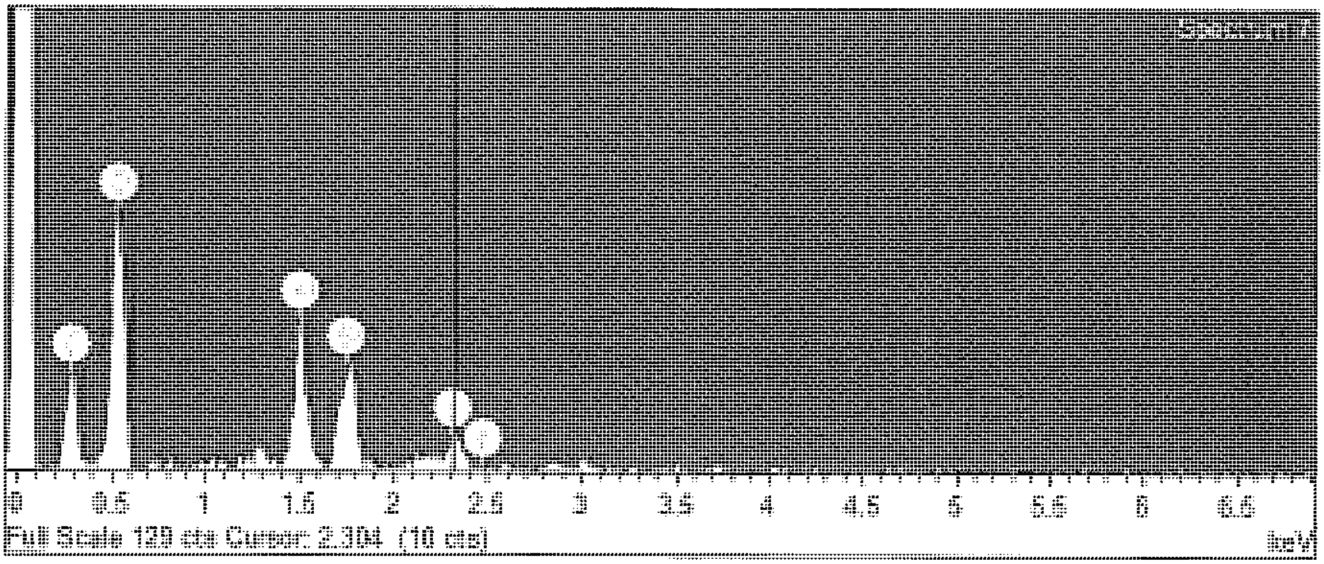




Comment: 028-1 fibrous glass filter





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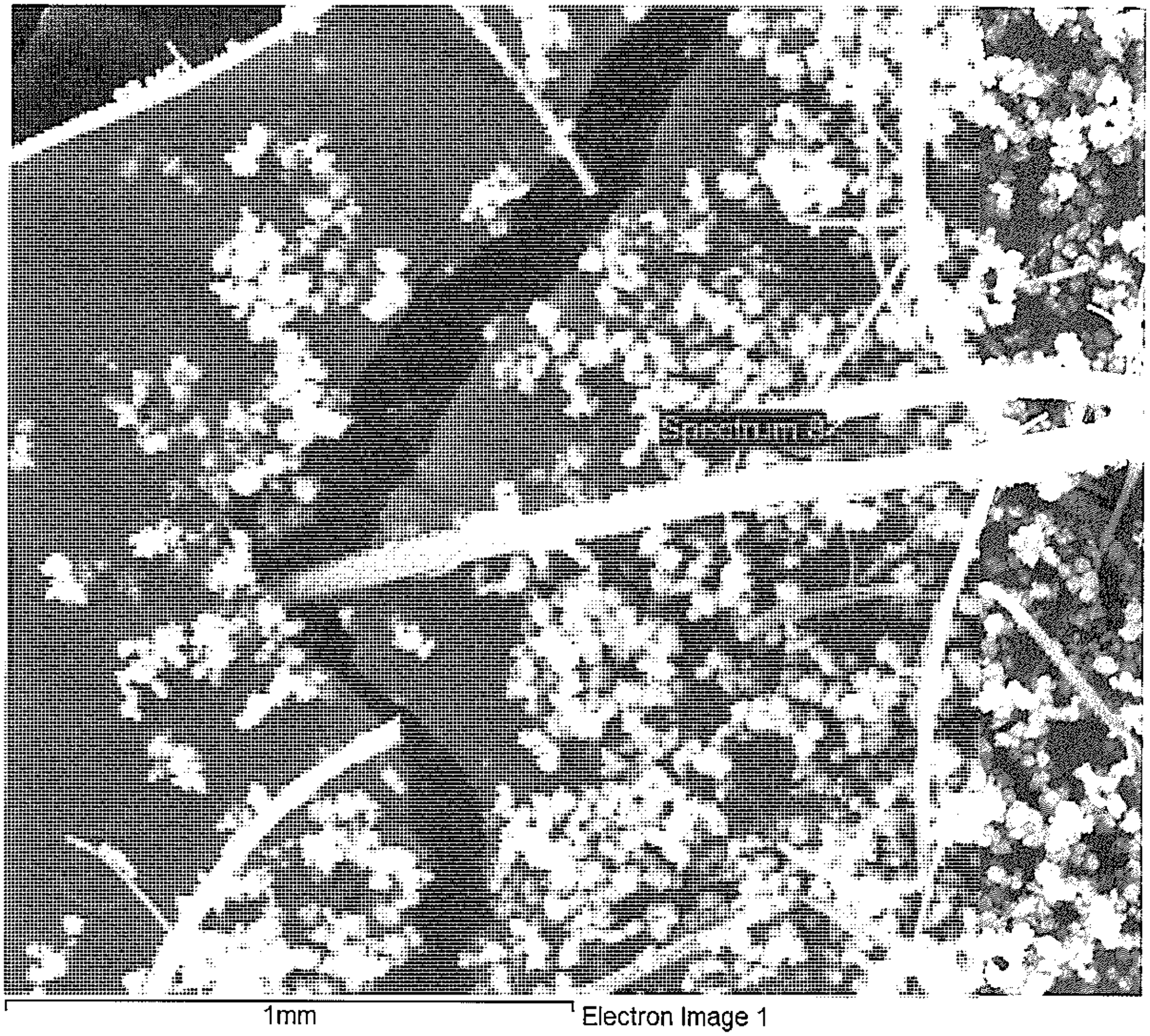

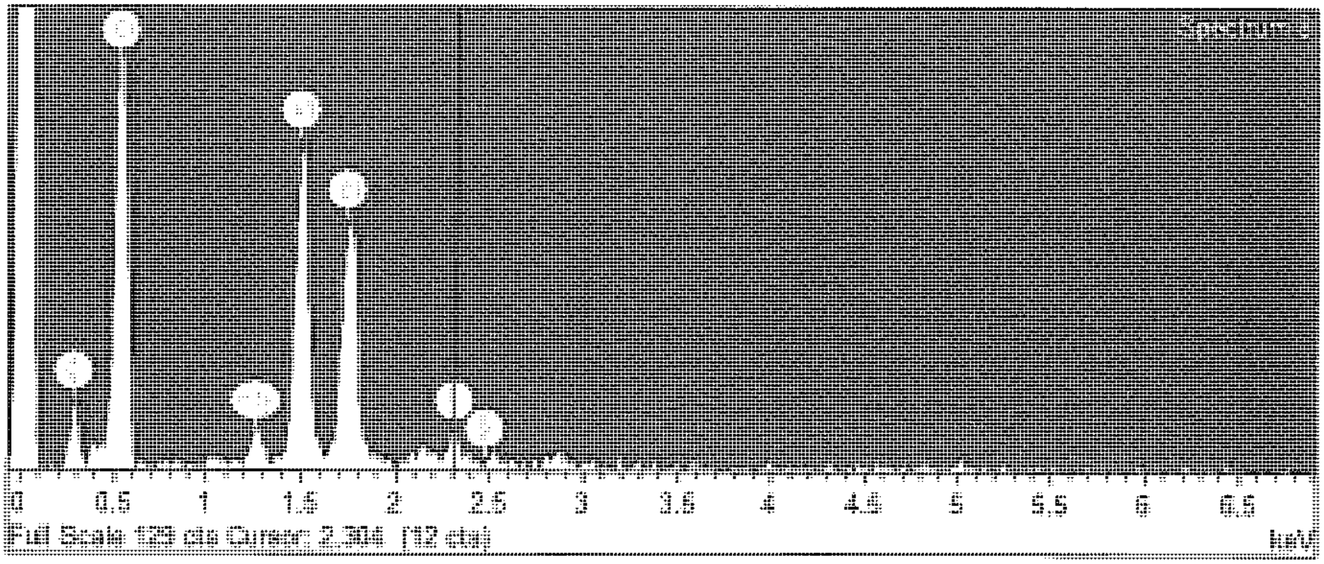

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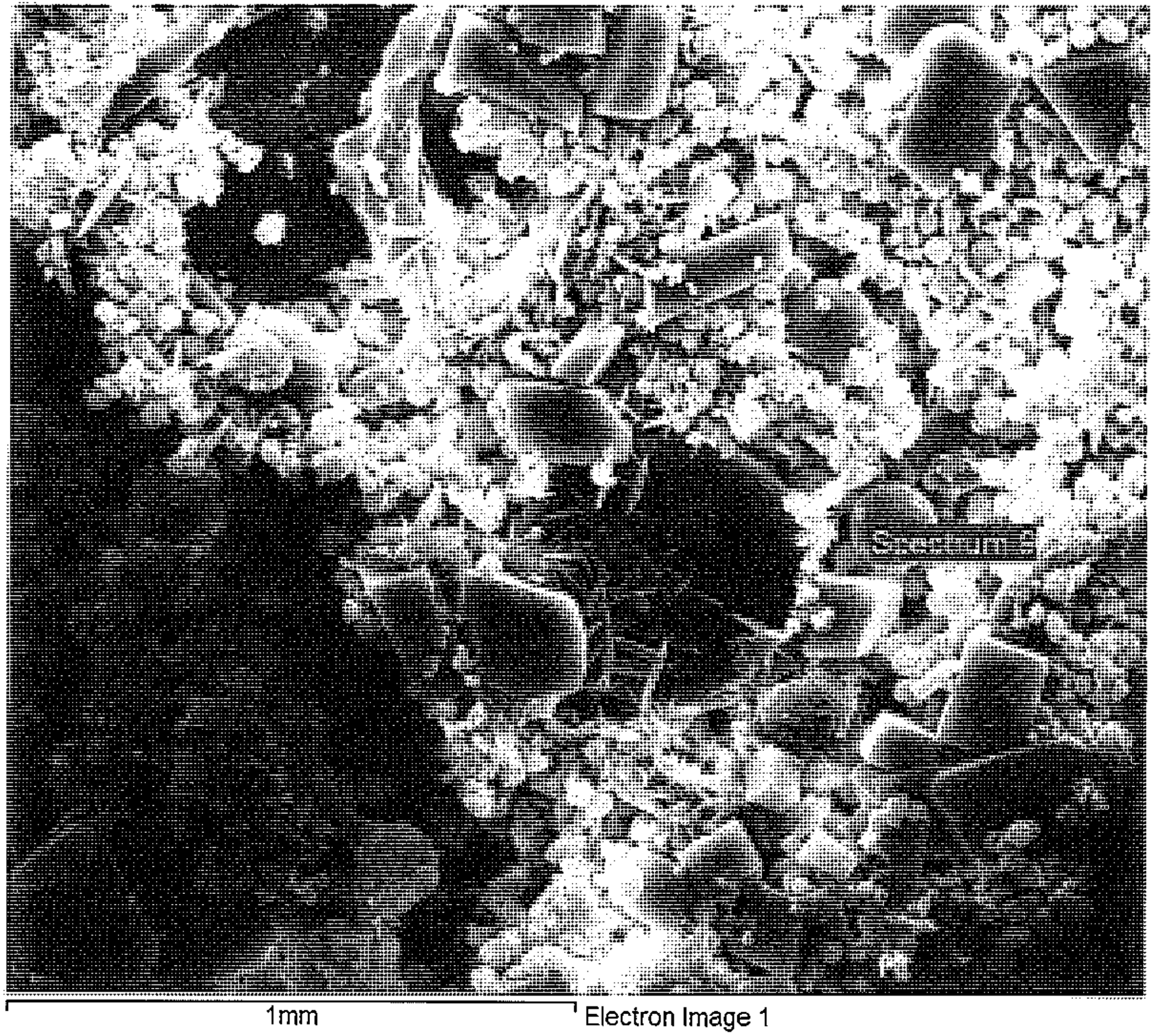
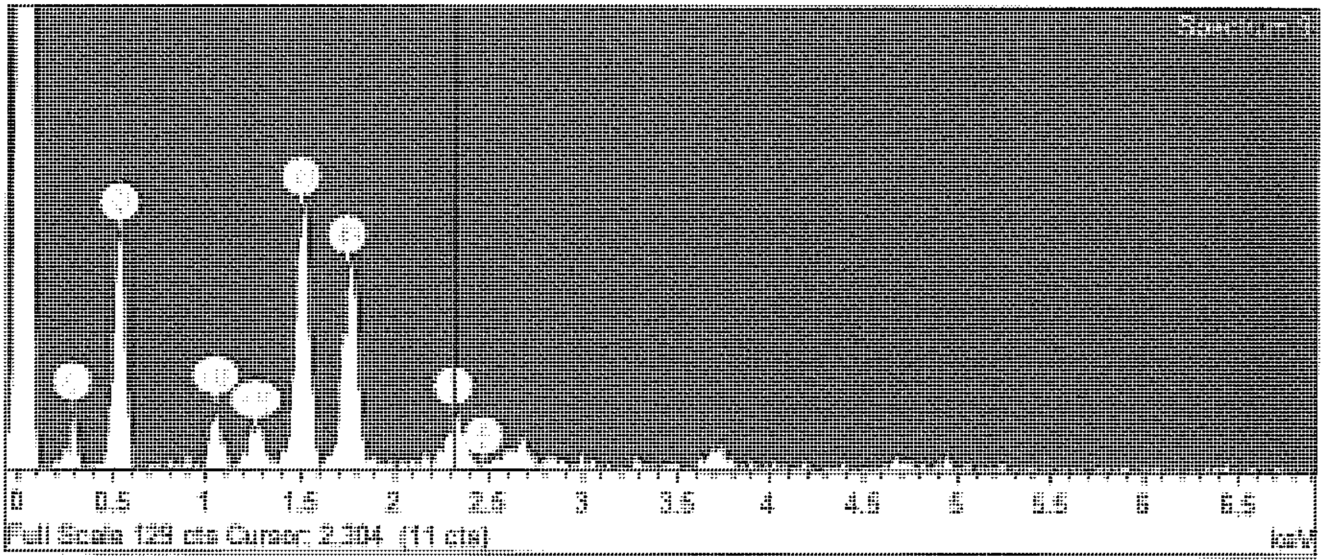
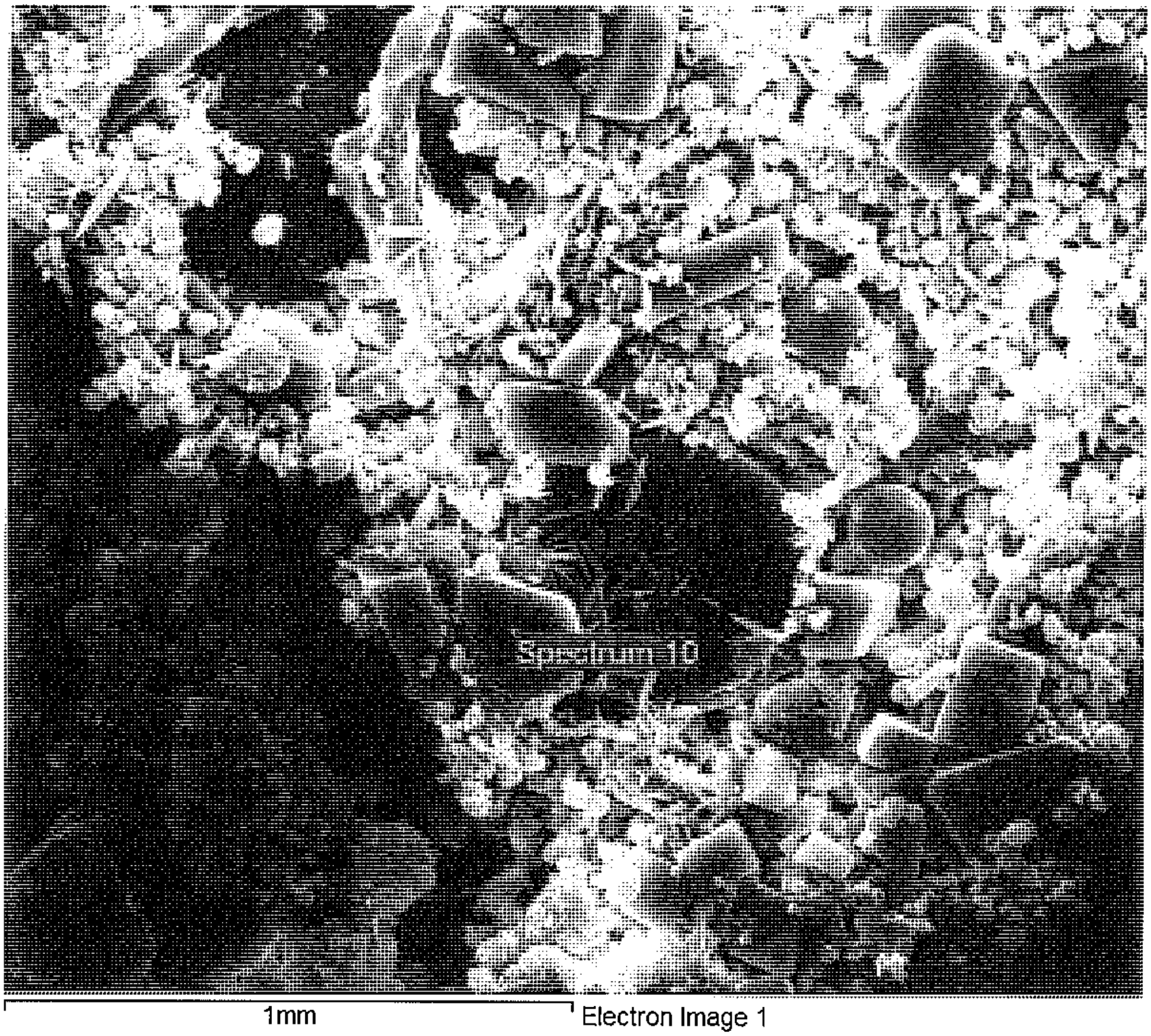
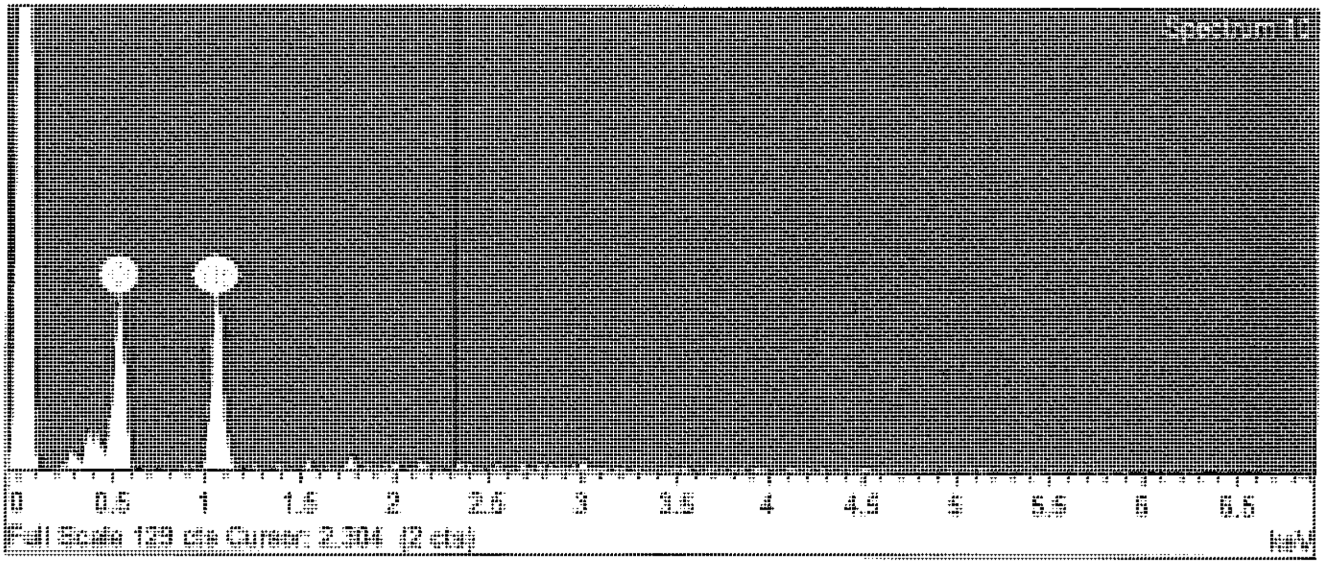


Electron Image 1

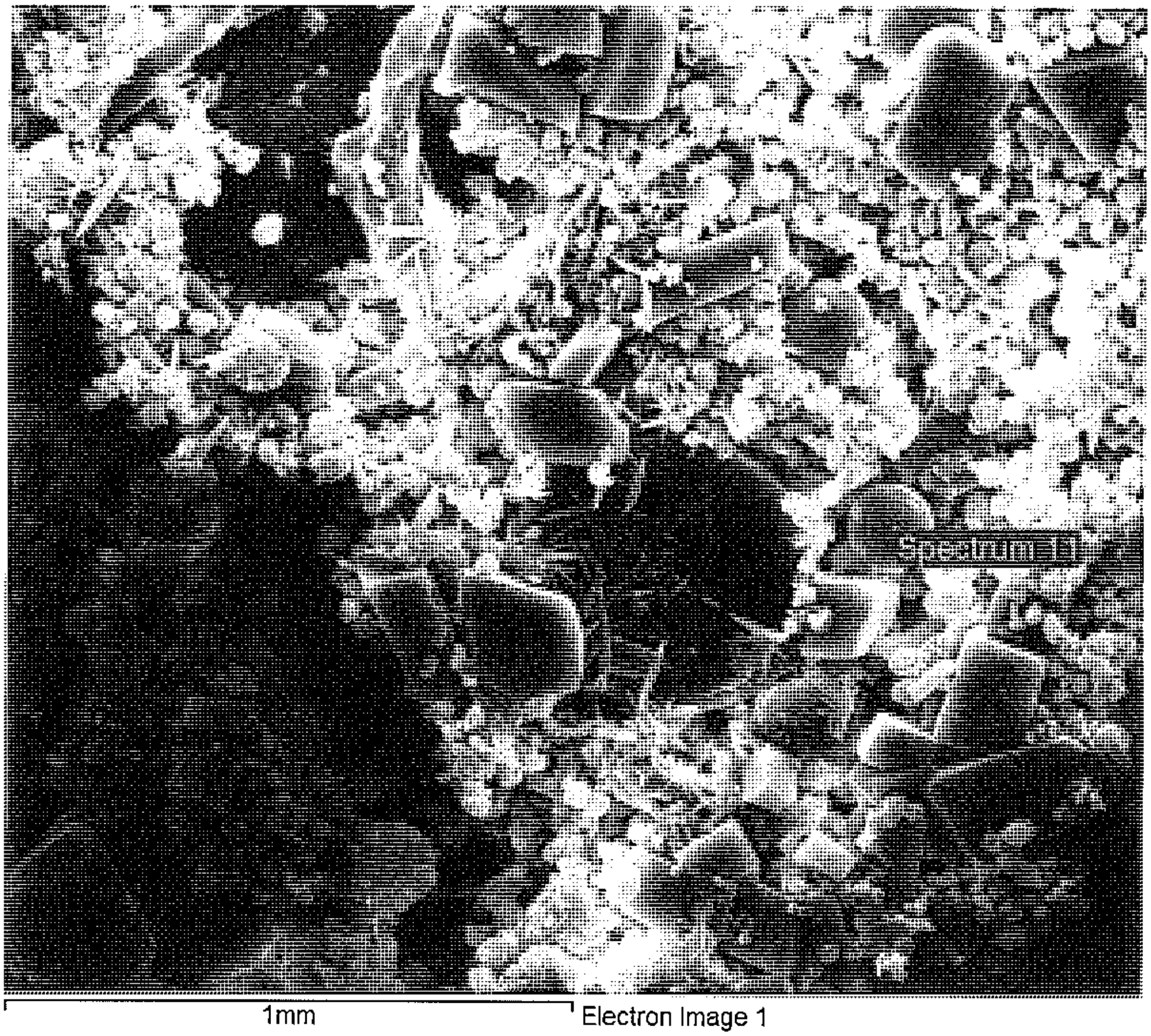


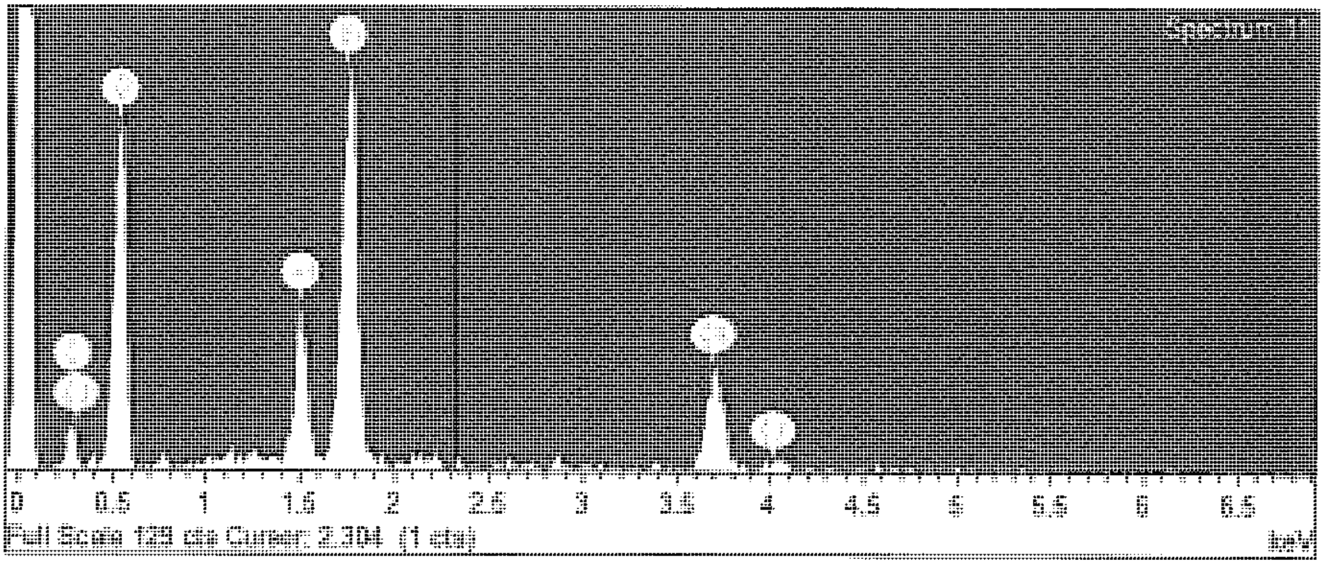
Comment: 1236 small particles



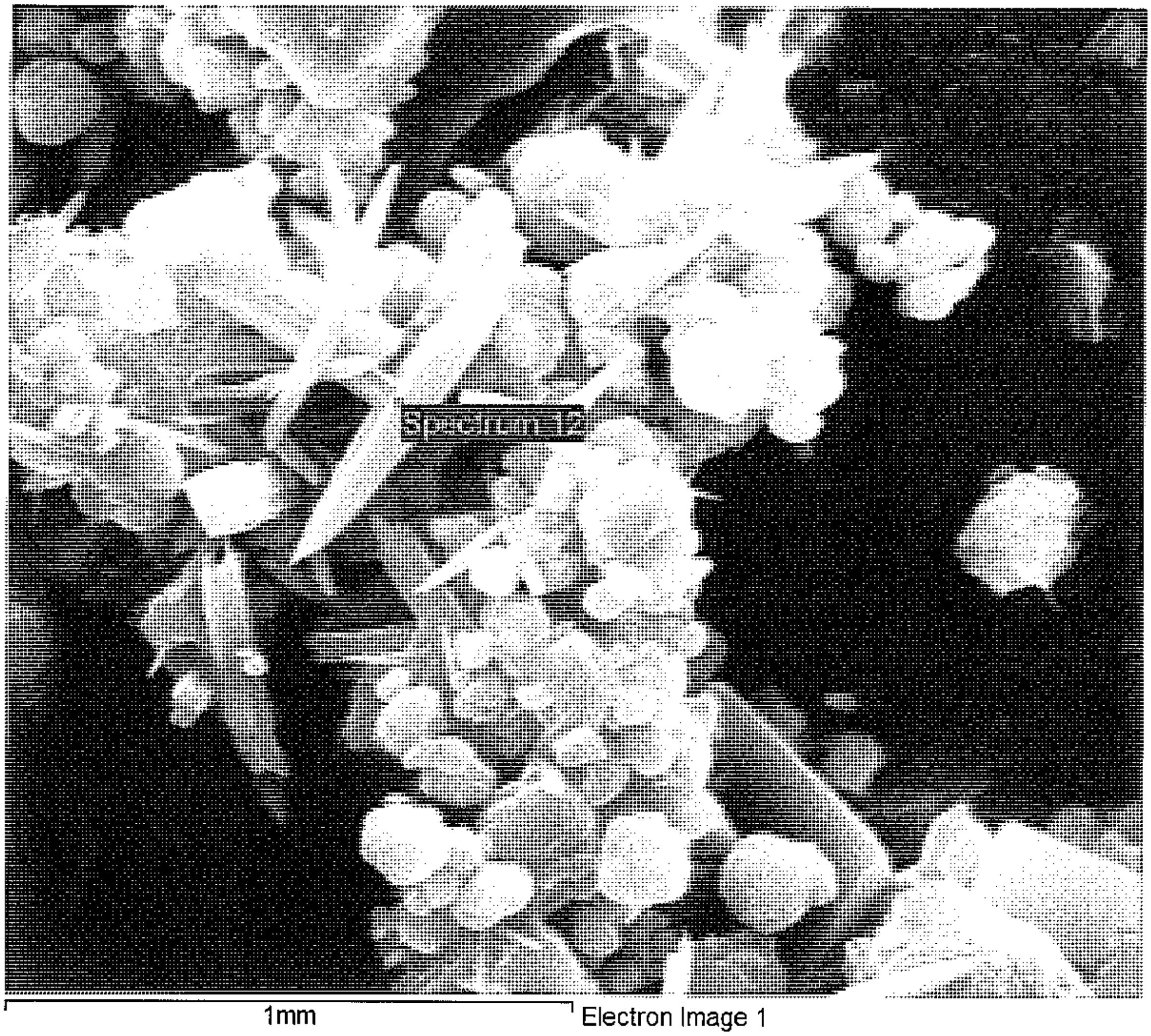


Comment: 1236 platy particles





Comment: 1236 spheres



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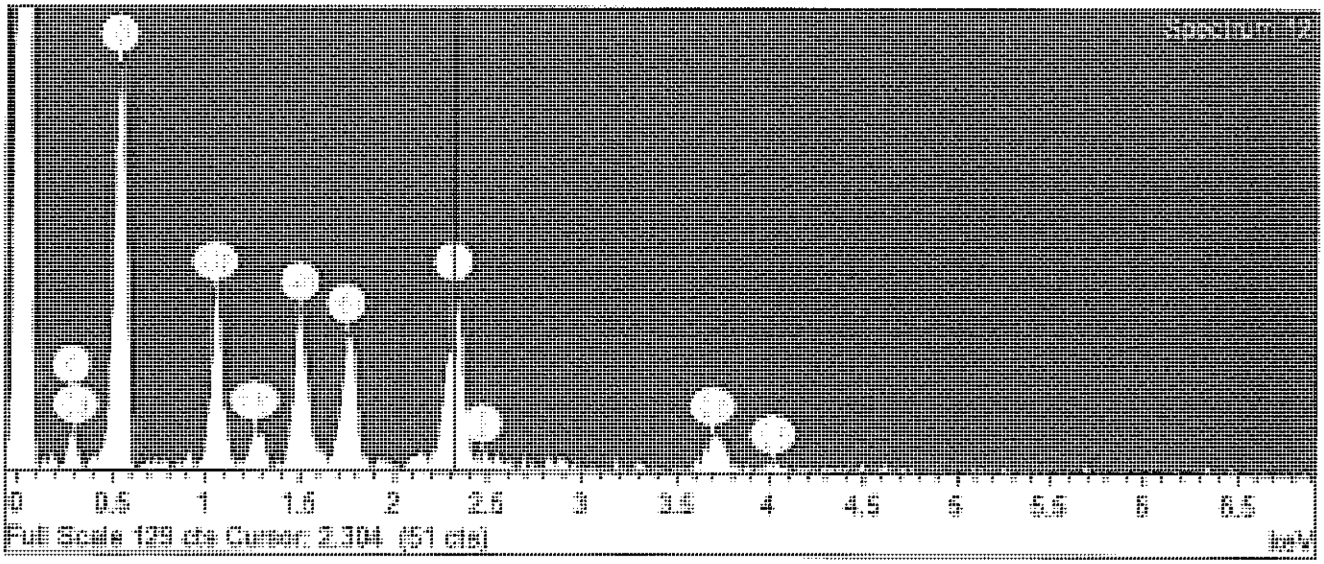
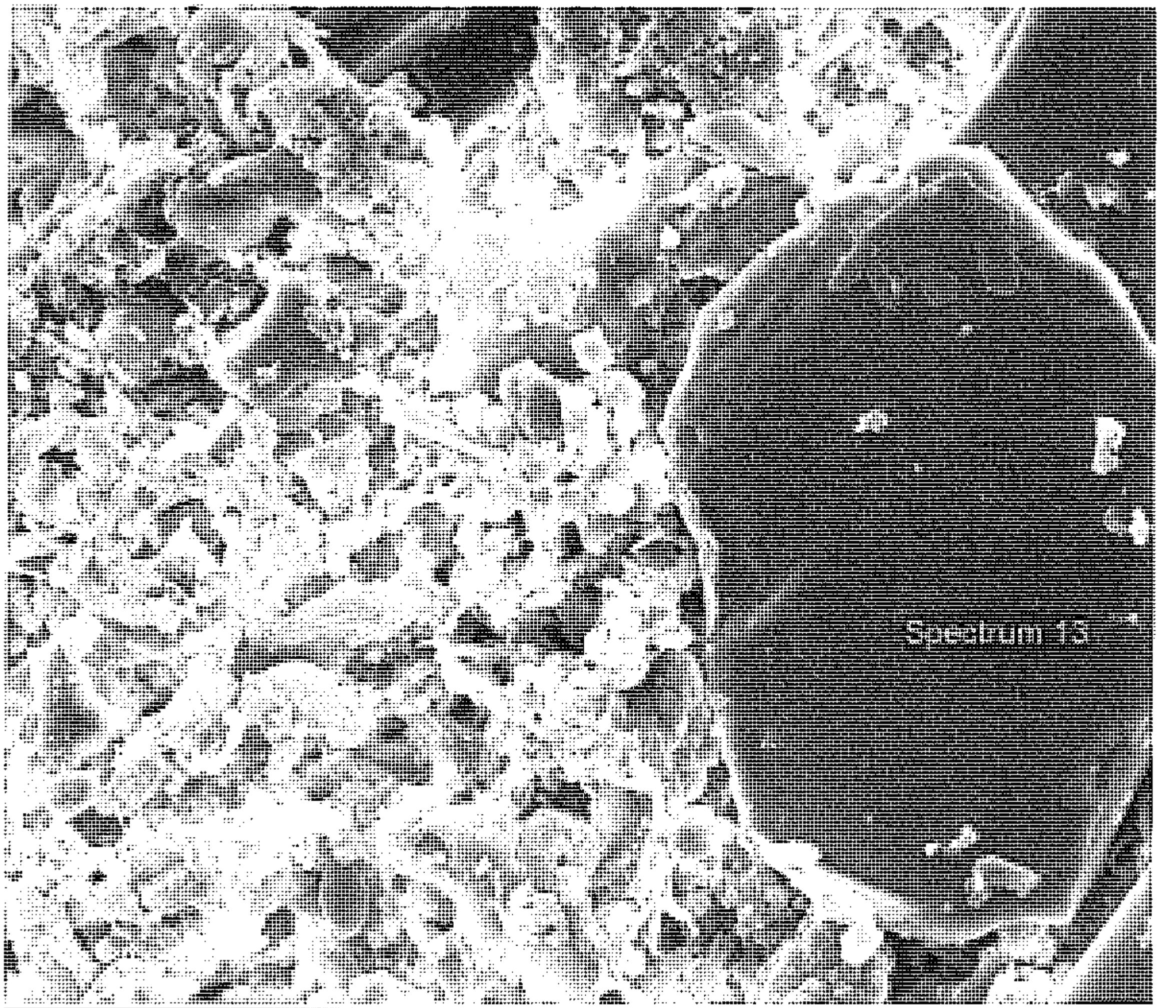
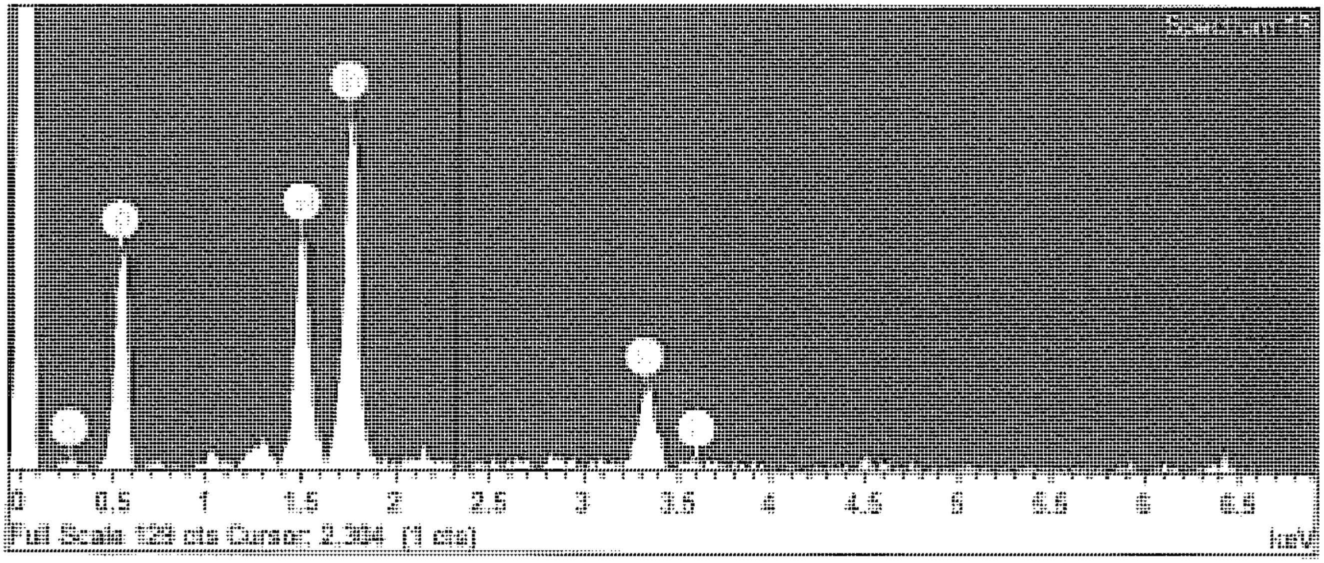


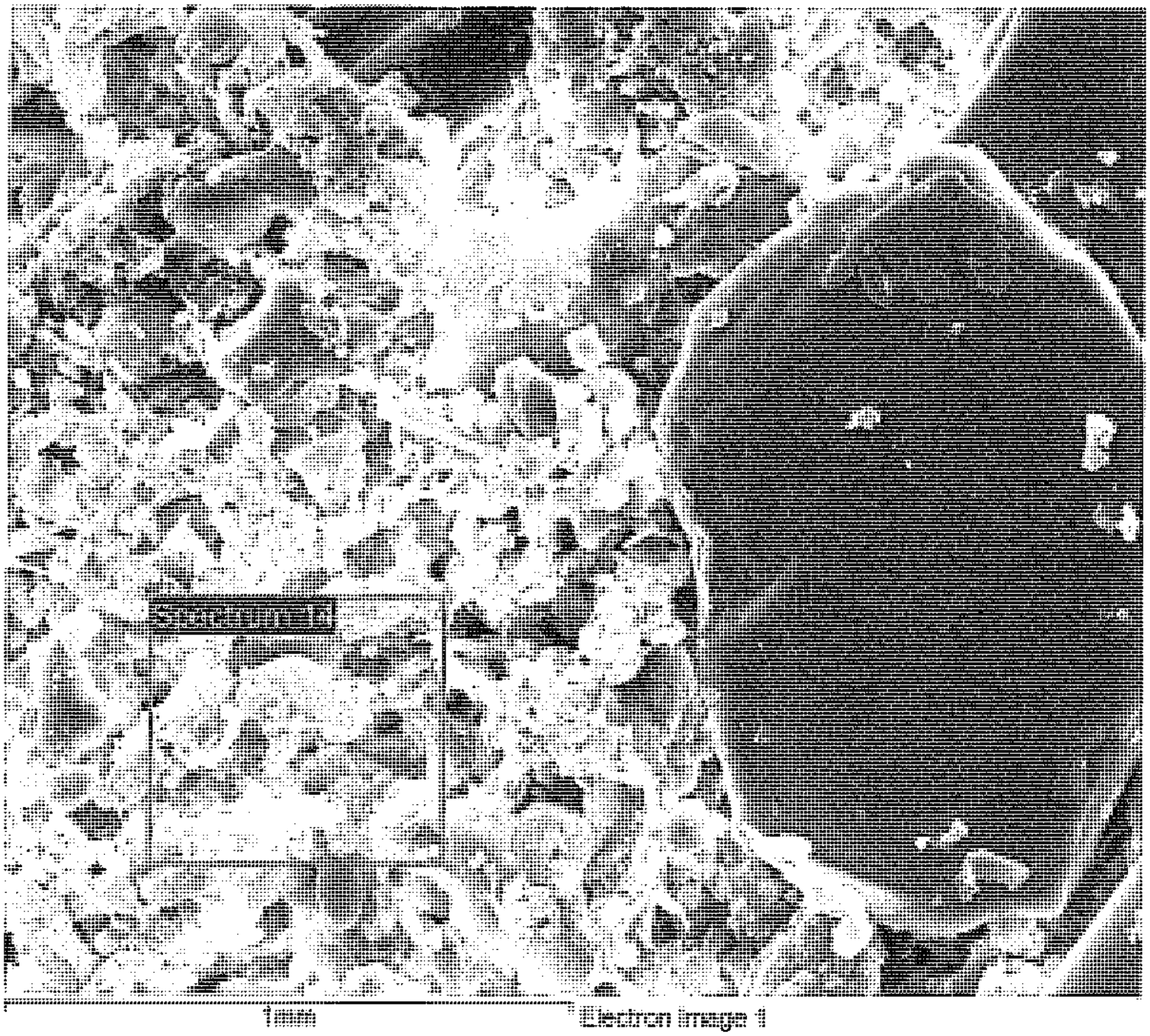
Comment: 1236 spicules

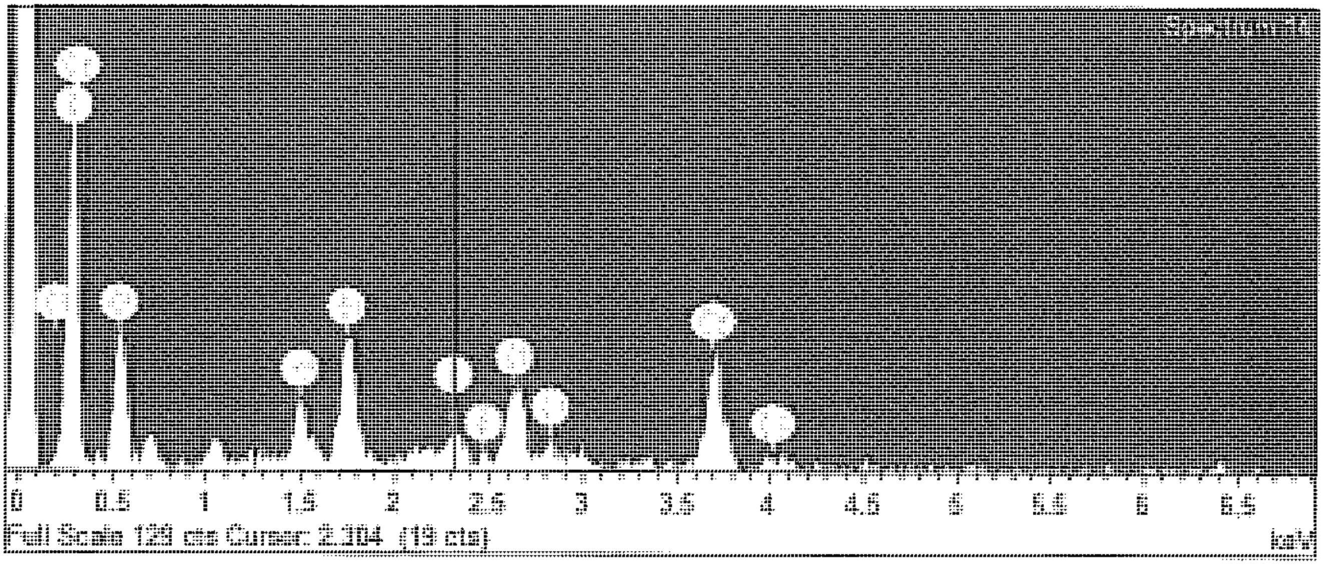


Electron Image 1



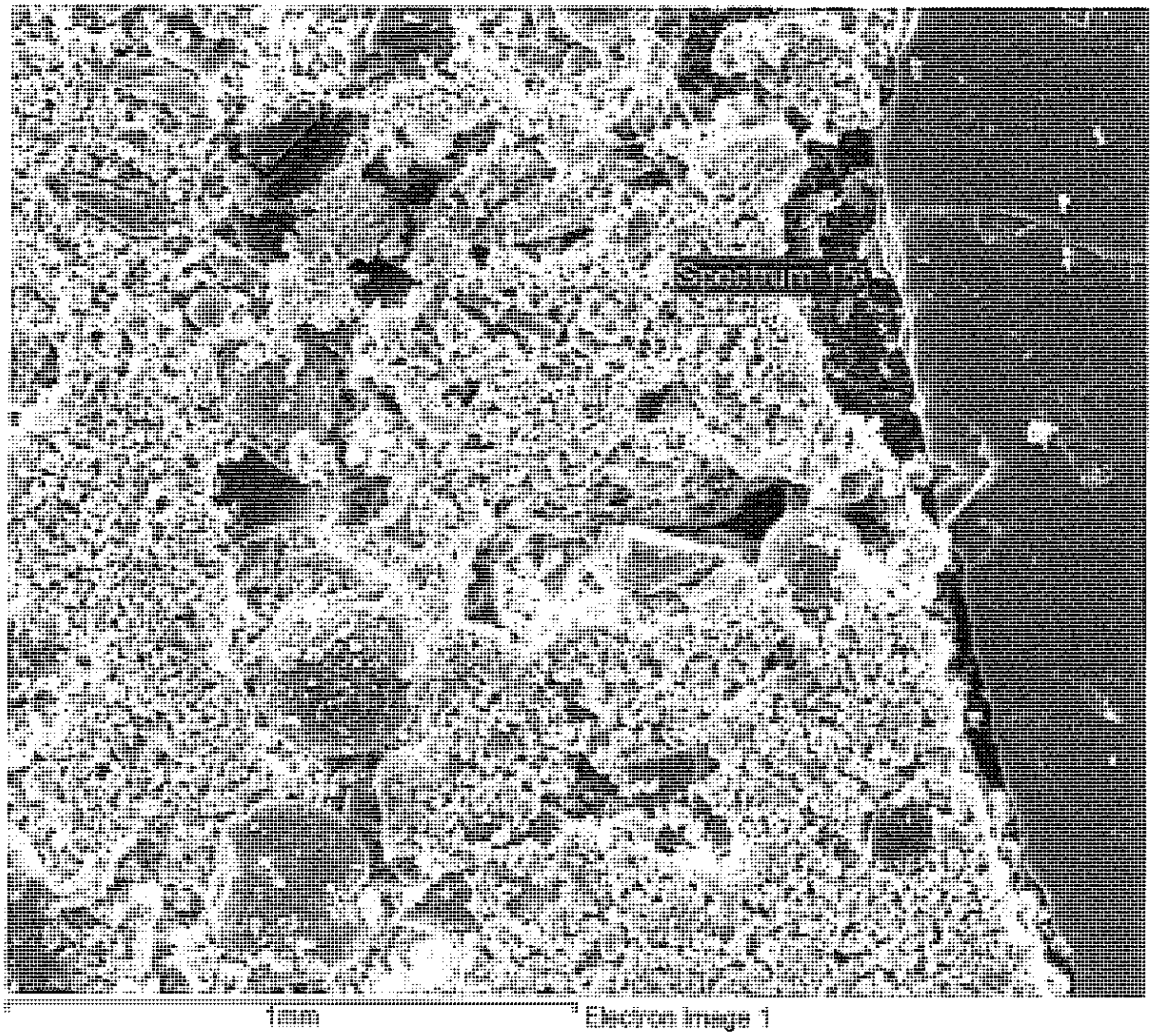
Comment: 2270 platy particle

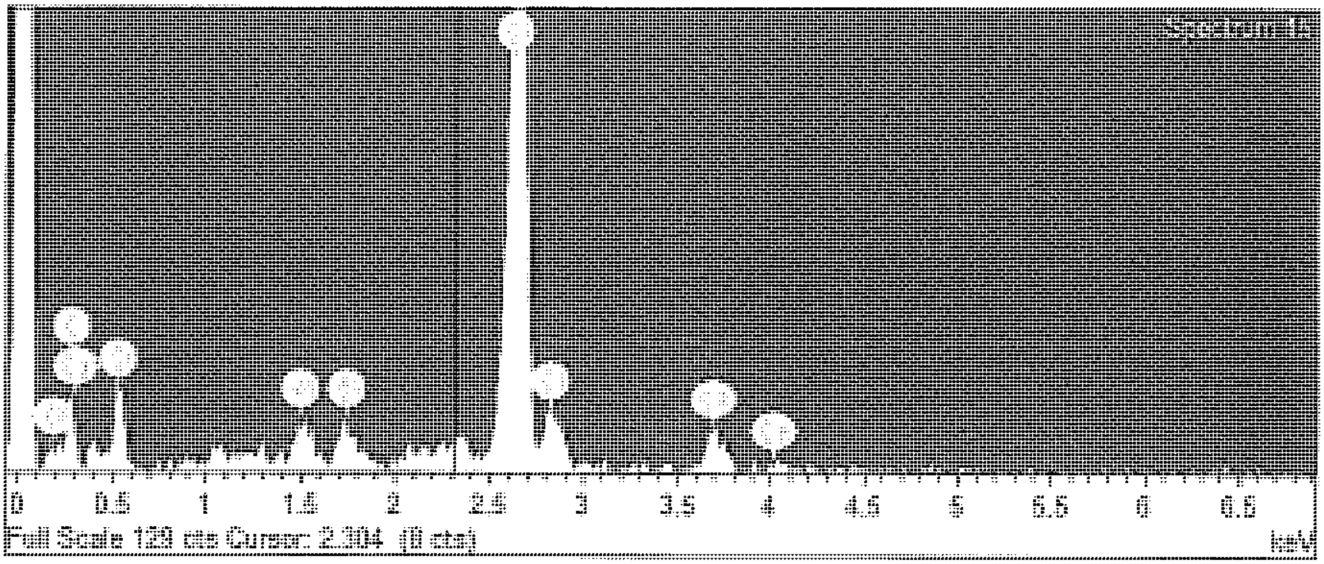




Comment: 2270 Agglomeration

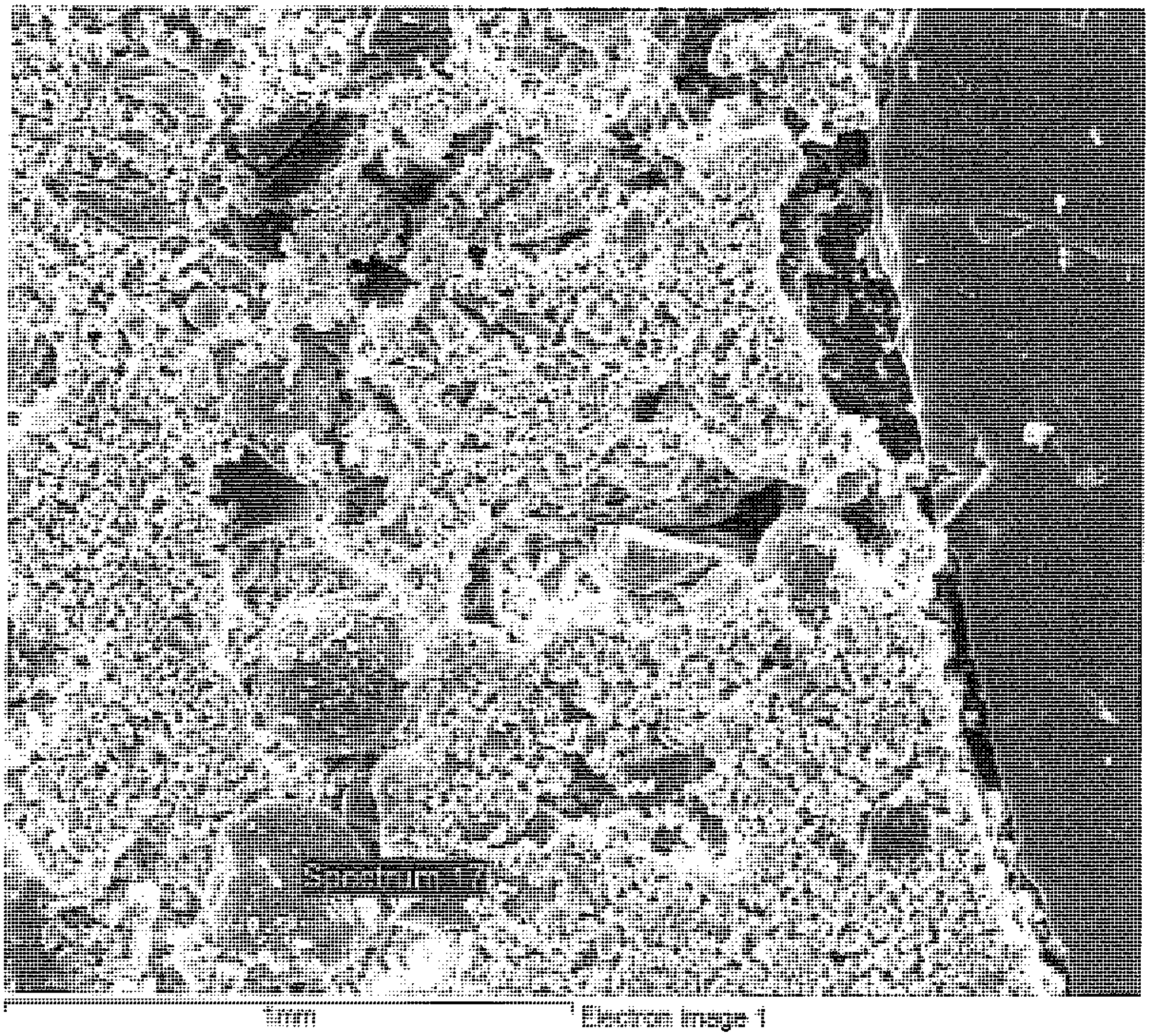
[illegible]

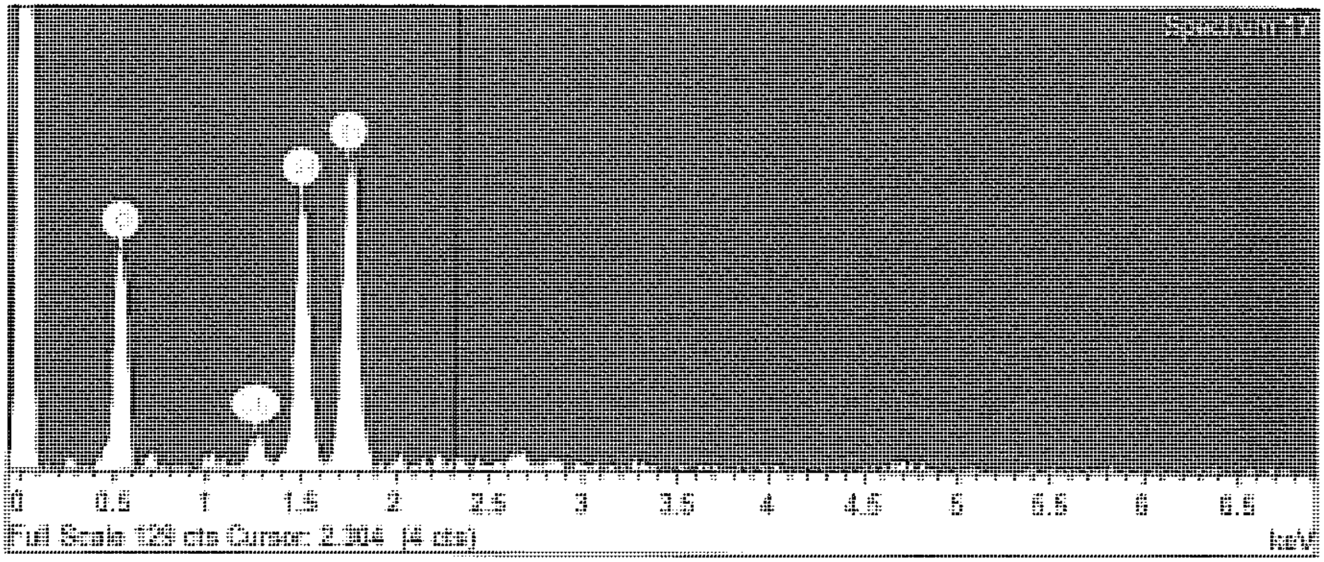




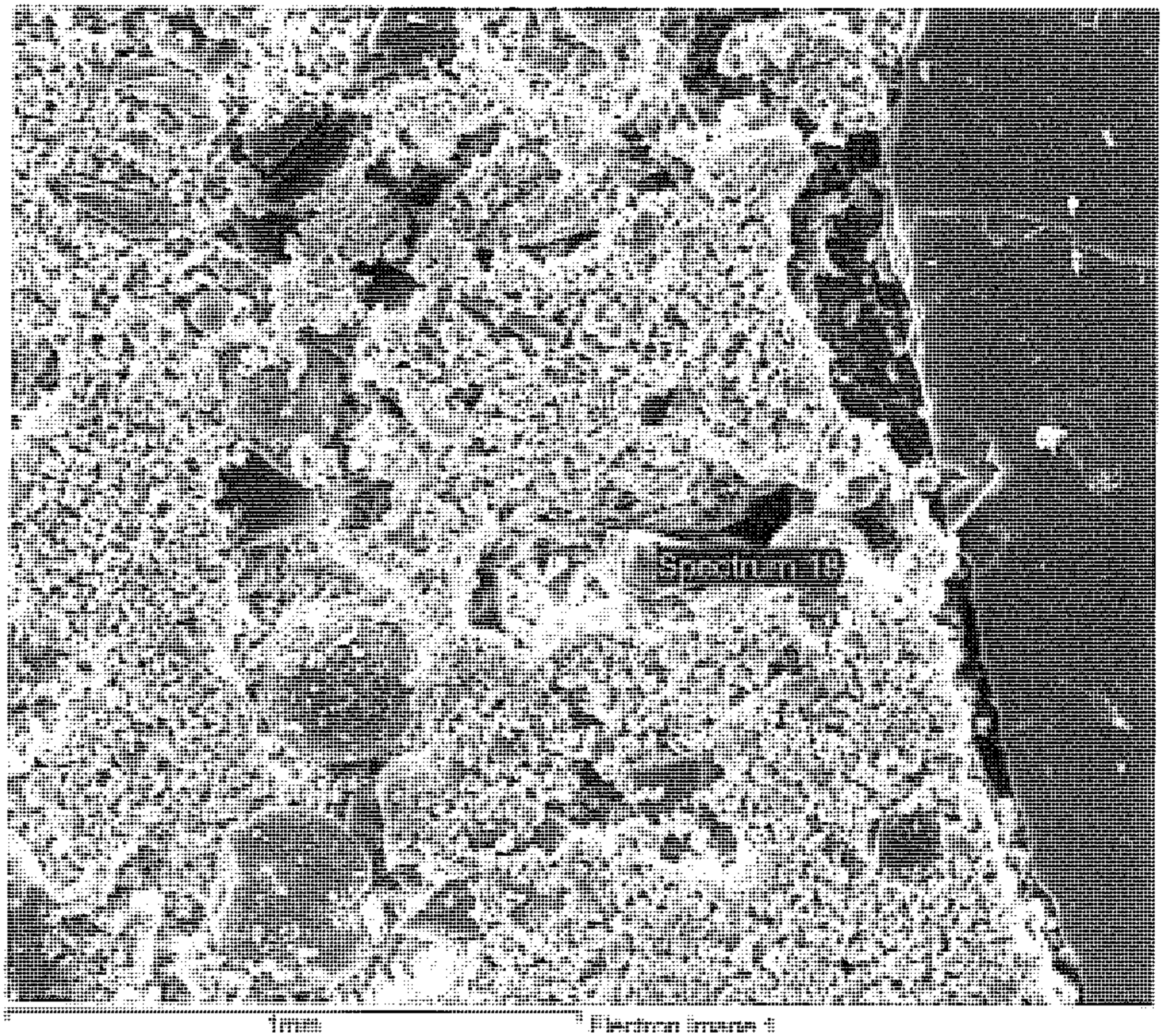
Comment: 2270 small particles

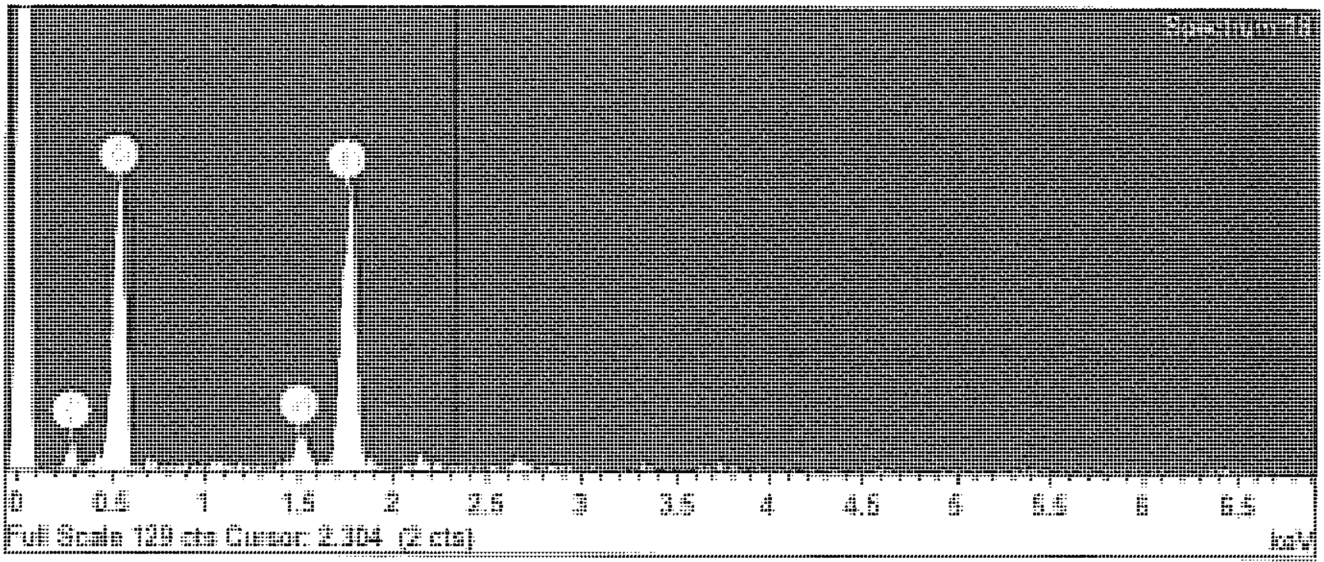
A21





Comment: 2270 large particle





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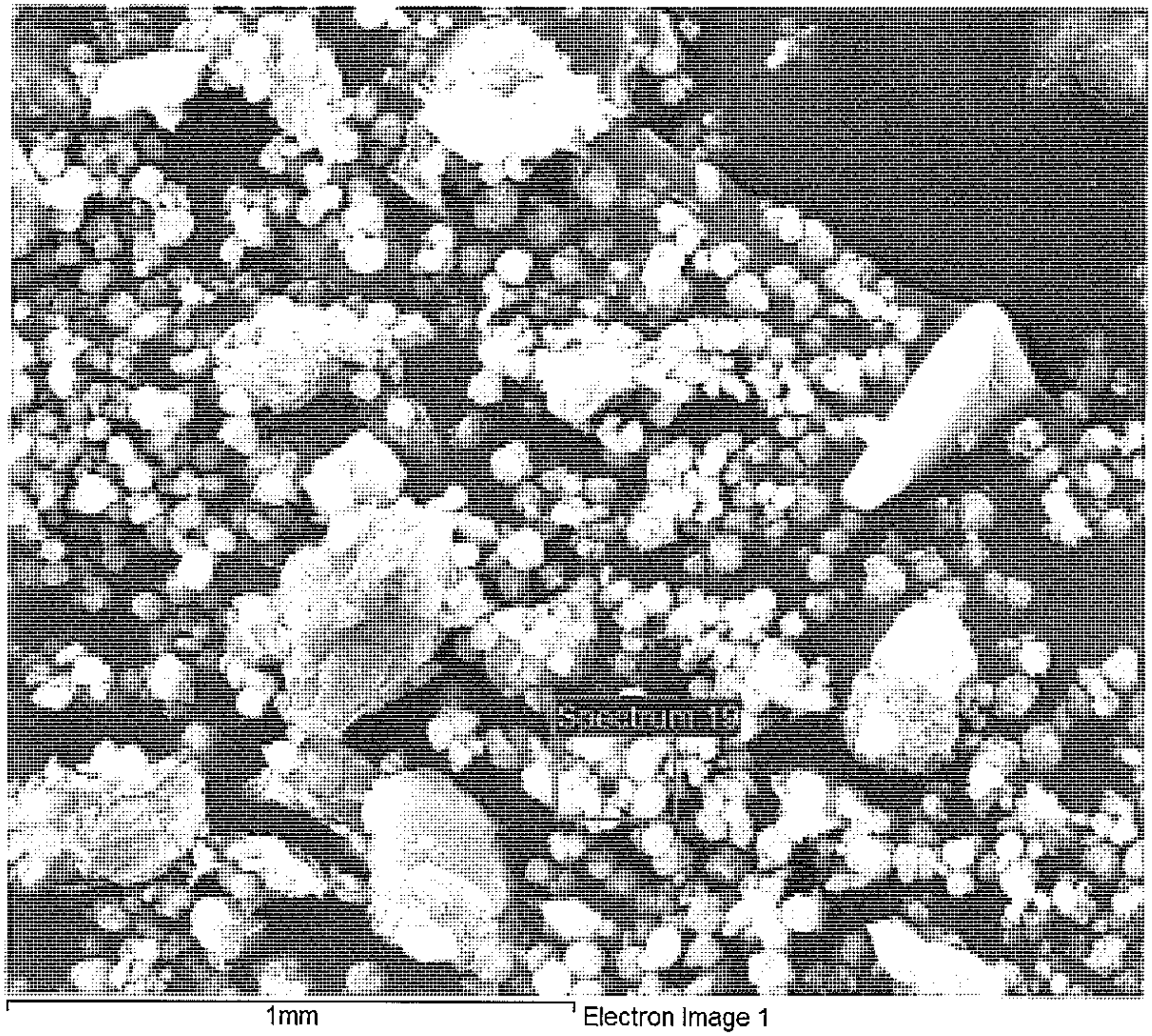
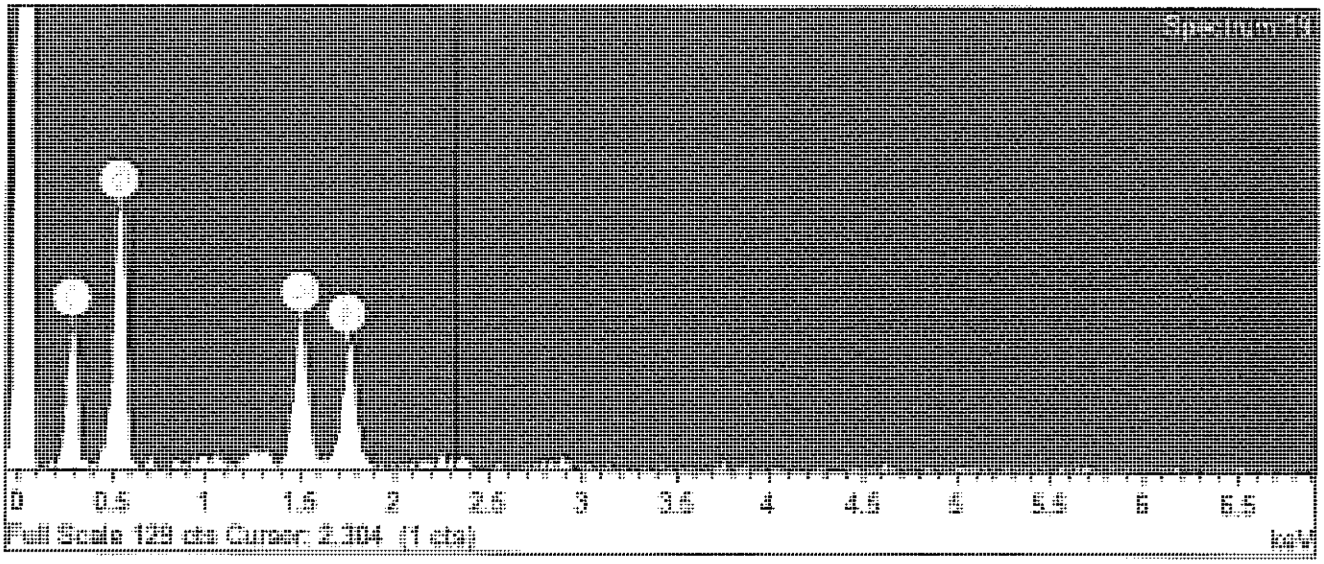
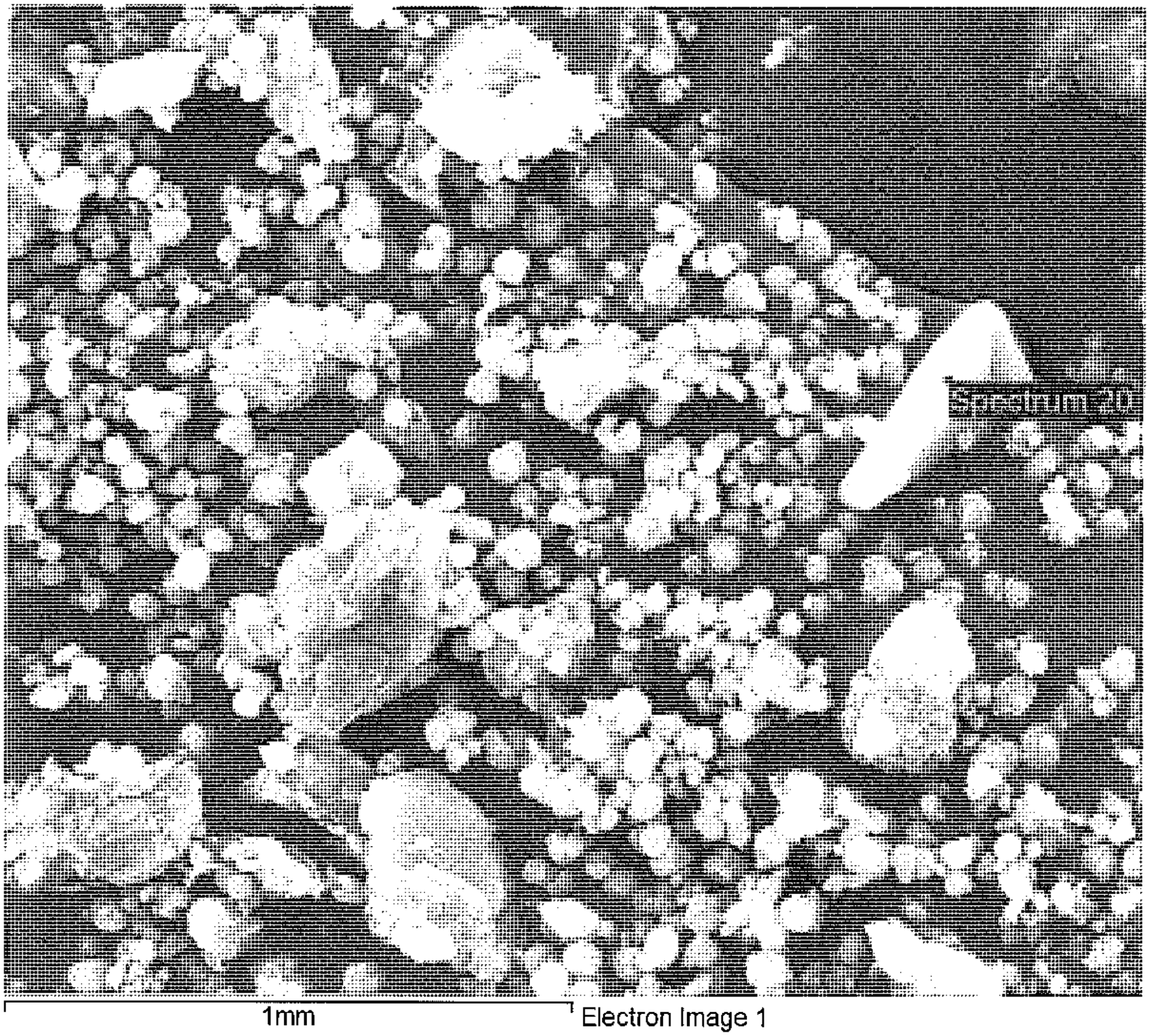
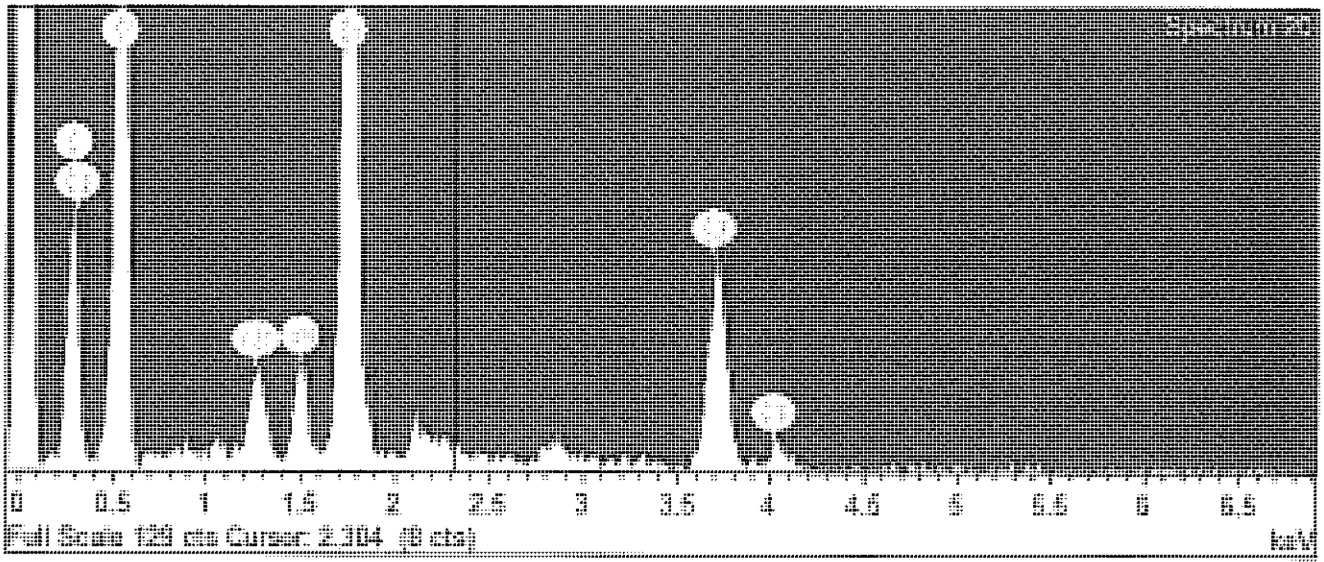


Electron Image 1



Comment: 2332 small particles





Comment: 2332 10 um particle

APPENDIX III
Data Sheets for Test Program 3

VOLUME III

VOLUME III

Appendix A – Test Results

Plant	
City	
State	
Sampling Location	Stack

PARAMETER	NOMENCLATURE	PM10-2.5-1	PM10-2.5-2	PM10-2.5-3
Sampling Location				
Date		5/27/2010	5/27/2010	5/27/2010
Run Time	Theta	180.00	178.83	175.19
Nozzle Diameter	inches	0.173	0.173	0.173
Pitot Tube Coefficient	Cp	0.84	0.84	0.84
Meter Calibration Factor	Y	0.9846	0.9846	0.9846
Barometric Pressure, inches Hg	Bp - in Hg	29.50	29.50	29.50
Meter Box Pressure Differential	ΔH - in. H2O	0.34	0.34	0.35
Volume of Gas Sampled	Vm - cu. ft.	61.702	60.828	60.253
Dry Gas Meter Temperature	Tm - °F	67.9	66.8	56.7
Volume of Gas Sampled, Dry	Vmstd - cu. ft.	42.086	41.368	41.955
Liquid Collected	ml	248.3	242.5	240.5
Volume of Water Vapor	Vwstd - cu. ft.	11.687	11.414	11.320
Moisture Content	%H_20	21.734	21.63	21.25
Saturation Moisture	%H_20	18.4	18.4	18.4
Dry Mole Fraction	Mfd	0.816	0.816	0.816
Carbon Dioxide	%CO_2	14.8	14.6	14.5
Oxygen	%O_2	2.9	3.1	3.2
Carbon Monoxide	%CO	0	0	0
Nitrogen	%N_2	82.3	82.3	82.3
Fuel Factor	Fo	1.216	1.219	1.221
Gas Molecular Weight, Dry	Md	30.484	30.46	30.45
Gas Molecular Weight, Wet	Ms	28.183	28.164	28.154
Static Pressure	Pg - in. H_2O	-0.40	-0.40	-0.40
Stack Pressure	Ps	29.47	29.47	29.47
Stack Temperature	Ts - °F	137.0	137.0	137.0
Average Velocity Head	Δp - in H_2O	0.501	0.494	0.493
Gas Velocity	vs - ft./sec.	43.08	42.81	42.75
Stack Area	As - sq. ft.	52.918	52.918	52.918
Volumetric Air Flow, Actual	Qaw - ACFM	136,771	135,933	135,737
Volumetric Air Flow, Standard	Qsd - DSCFM	97,190	96,594	96,455
Total Filterable Particulate Catch	mg	15.1	15.3	18.2
Probe and Nozzle Rinse	mg	5.4	4.3	16.3
Greater than 2.5 rinse	mg	0.4	0.2	0.4
Less than 2.5 rinse	mg	0.4	0	0.4
PM2.5 Catch (Filter)	mg	8.9	10.8	1.1
Total Condensable Particulate Catch	mg	7.9	17.6	11
Organic Catch	mg	1.7	1.0	2.0
Inorganic Catch	mg	8.0	18.4	10.8

Plant
City
State
Sampling Location Stack

		PM10-2.5-1	PM10-2.5-2	PM10-2.5-3	Average
Total Filterable Particulate Matter Emissions					
Grains/DSCF	gr/DSCF	0.0055	0.0057	0.0067	0.0060
Grains/DSCF at 7% O_2	gr/DSCF@7%O_2	0.0043	0.0045	0.0053	0.0047
Pounds/Hour	lb/hr	4.61	4.73	5.53	4.96
Filterable $PM_{2.5}$ Particulate Matter Emissions					
Grains/DSCF	gr/DSCF	0.00341	0.00403	0.00055	0.00266
Grains/DSCF at 7% O_2	gr/DSCF@7%O_2	0.00263	0.00315	0.00043	0.00207
Pounds/Hour	lb/hr	2.84	3.34	0.46	2.21
Condensable Particulate Matter Emissions					
Grains/DSCF	gr/DSCF	0.0029	0.0066	0.0040	0.0045
Grains/DSCF at 7% O_2	gr/DSCF@7%O_2	0.0022	0.0051	0.0032	0.0035
Pounds/Hour	lb/hr	2.41	5.44	3.35	3.73
Total Particulate Matter Emissions					
Grains/DSCF	gr/DSCF	0.0084	0.0123	0.0107	0.0105
Grains/DSCF at 7% O_2	gr/DSCF@7%O_2	0.0065	0.0096	0.0084	0.0082
Pounds/Hour	lb/hr	7.03	10.16	8.88	8.69

Plant Name
City, State
Project # 1436 F
Test Location FCCU Stack

PARAMETER	**NOMENCLATURE**	M5B-1	M5B-2	M5B-3	Averages
Date		5/27/2010	5/27/2010	5/27/2010	
Run Time	θ	180	180	180	
Nozzle Diameter	inches	0.238	0.24	0.24	
Stack Area	As - sq. ft.	52.918	52.918	52.918	
Pitot Tube Coefficient	Cp	0.84	0.84	0.84	
Meter Calibration Factor	Y	1.0475	1.0475	1.0475	
Barometric Pressure, inches Hg	Bp - in Hg	29.50	29.50	29.50	
Static Pressure	Pg - in. H_2O	-0.40	-0.40	-0.40	
Stack Pressure	Ps	29.47	29.47	29.47	
Meter Box Pressure Differential	Δ H - in. H_2O	1.11	1.12	2.88	
Average Velocity Head	Δ p - in. H_2O	0.4942	0.4926	0.4801	
Volume of Gas Sampled	Vm - cu. ft.	98.61	98.926	93.813	
Dry Gas Meter Temperature	Tm - °F	66.9	65.6	56.8	
Stack Temperature	Ts - °F	137.1	136.8	136.3	
Liquid Collected	grams	526.1	485.9	493	
Carbon Dioxide	% CO_2	14.8	14.6	14.5	
Oxygen	% O_2	2.9	3.1	3.2	
Carbon Monoxide	% CO	0	0	0	
Nitrogen	% N_2	82.3	82.3	82.3	
Fuel Factor	Fo	1.216	1.219	1.221	
Volume of Gas Sampled, Dry	Vmstd - cu. ft.	102.335	102.927	99.693	
Volume of Water Vapor	Vwstd - cu. ft.	24.806	22.910	23.245	
Moisture Content	% H_20	19.51	18.21	18.91	
Saturation Moisture	% H_20	18.47	18.35	18.07	
Dry Mole Fraction	Mfd	0.815	0.818	0.819	
Gas Molecular Weight, Dry	Md	30.48	30.46	30.45	
Gas Molecular Weight, Wet	Ms	28.18	28.19	28.20	
Gas Velocity	vs - ft./sec.	42.80	42.72	42.15	
Volumetric Air Flow, Actual	Qaw - ACFM	135,907	135,628	133,819	135,118
Volumetric Air Flow, Standard	Qsd - DSCFM	96,515	96,667	95,628	96,270
Isokinetic Sampling Rate	% I	100.9	99.6	97.6	
Filterable Particulate Catch					
Filter (FPM)	mg	16.3	12.0	14.1	
Rinse (FPM)	mg	10.3	7.4	3.1	
Reagent Blank	mg	0.2	0.0	0.0	
Field Blank	mg				
Filterable Particulate Catch	mg	26.6	19.4	17.2	
Grains/DSCF	gr/DSCF	0.0040	0.0029	0.0027	0.0032
Grains/DSCF at 12% CO_2	gr/DSCF@12% CO_2	0.0033	0.0024	0.0022	0.0026
Grains/DSCF at 7% O_2	gr/DSCF@7% O_2	0.0031	0.0023	0.0021	0.0025
Pounds/Hour	lb/hr	3.32	2.41	2.18	2.64
CONDENSABLE PARTICULATE EMISSIONS					
Condesible Particulate Catch	mg	22.4	15.6	16	
Grains/DSCF	gr/DSCF	0.0034	0.0023	0.0025	0.0027
Grains/DSCF at 12% CO_2	gr/DSCF@12% CO_2	0.0027	0.0019	0.0020	0.0022
Grains/DSCF at 7% O_2	gr/DSCF@7% O_2	0.0026	0.0018	0.0019	0.0021
Pounds/Hour	lb/hr	2.79	1.94	2.03	2.25

VOLUME III

Appendix B – Example Calculations

EXAMPLE CALCULATIONS

Run Number: 5B/028-1

Stack Gas Temperature, °R

$$T_s = 460 + ts$$

$$T_s = 460 + 137.1 = 597.1$$

Volume of Dry Gas Sampled at Standard Conditions, Dry Standard Cubic Feet

$$V_{mstd} = [17.64][\gamma][V_m\left[\frac{\left(P_{bar} + \frac{\Delta H}{13.6}\right)}{T_m + 460}\right]$$

$$V_{mstd} = [17.647][1.0475][98.61]\left[\frac{\left(29.50 + \frac{1.11}{13.6}\right)}{526.9}\right]$$

$$V_{mstd} = 102.335 \text{ ft}^3$$

Volume of Water Sampled, SCF

$$V_{wstd} = 0.04715 \text{ [Weight of Condensed Moisture]}$$

$$V_{wstd} = 0.04715\ [526.1]$$

$$V_{wstd} = 24.806 \text{ ft}^3$$

Fraction of Water Vapor in Sample Gas Stream

$$\%H_2O = \left[\frac{V_{wstd}}{V_{mstd} + V_{wstd}}\right] \times 100$$

$$\%H_2O = \left[\frac{24.806}{102.335 + 24.806}\right] \times 100$$

$$\%H_2O = 19.51\ \%$$

Dry Mole Fraction of Flue Gas

$M_{fd} = 1\text{-}\%H2O/100$

$M_{fd} = 1\text{-}[18.47/100]$ Must use saturation moisture for Mfd calculation.

$M_{fd} = 0.815$

Molecular Weight of Sample Gas, Dry

$M_d = 0.44[\%CO_2]+0.32[\%O_2]+0.28[100\text{-}\%O_2\text{-}\%CO_2]$

$M_d = 0.44[14.8]+0.32[2.9]+0.28[100\text{-}2.9\text{-}14.8]$

$M_d = 30.48$ pounds/pound-mole

Molecular Weight of Sample Gas, Actual Conditions

$M_s = [M_d \text{ x } M_{fd}]+[0.18 \text{ x } \%H_2O]$

$M_s = [30.48 \text{ x } 0.815]+[0.18 \text{ x } 18.47]$

$M_s = 28.18$ pounds/pound-mole

Average Stack Gas Velocity, Feet/second

$$vs = K_p C_p \left(\sqrt{(\Delta p)}\right)_{avg} \left[\sqrt{\frac{T_s + 460}{P_s M_s}}\right]$$

$$vs = (85.49)(0.84)\left(\sqrt{0.4942}\right)\left[\sqrt{\frac{597.1}{(29.47)(28.18)}}\right]$$

vs = 42.80 feet/second

Wet Volumetric Flue Gas Flow Rate at Stack Conditions, Cubic Feet per Minute

$Q_{aw} = 60 \text{ x vs x A}$

$Q_{aw} = 60 \text{ x } 42.80 \text{ x } 52.91756$

$Q_{aw} = 135.907$ Actual Cubic Feet per Minute

Dry Volumetric Flue Gas Flow Rate at Standard Conditions, Cubic Feet per Minute

$$Q_{sd} = 60 \times Mfd \times vs \times A \times \left[\frac{528}{ts + 460}\right]\left[\frac{Ps}{29.92}\right]$$

$$Q_{sd} = 60 \times 0.815 \times 42.80 \times 52.91756 \left[\frac{528}{597.1}\right]\left[\frac{29.47}{29.92}\right]$$

$Q_{sd} = 96,515$ Dry Standard Cubic Feet per Minute

Isokinetic Sampling Rate, Percent

$$I = \left(\frac{100\,(T_s)(V_{mstd})(29.92)}{(60)(vs)(\theta)(An)(P_s)(M_{fd})(528)}\right)$$

$$I = \left(\frac{100\,(597.1)(102.335)(29.92)}{(60)(42.80)(180)(0.000309)(29.47)(0.815)(528)}\right)$$

$I = 100.9\,\%$

Filterable Particulate Matter Concentration, Grains per Dry Standard Cubic Foot

$$\text{gr/DSCF} = \left[\frac{CatchWeight(mg/1000)}{V_{mstd}}\right]\left[\frac{7000}{453.592}\right]$$

$$\text{gr/DSCF} = \left[\frac{0.0266}{102.335}\right]\left[\frac{7000}{453.592}\right]$$

$$\text{gr/DSCF} = 0.0040$$

Filterable Particulate Matter Emission Rate, Pounds per hour

$$\text{lb/hr} = \left(\frac{mg/1000}{453.592}\right)\times\left(\frac{Qsd}{Vmstd}\right)\times 60$$

$$\text{lb/hr} = \left(\frac{0.0266}{453.592}\right)\times\left(\frac{96{,}515}{102.335}\right)\times 60$$

$$\text{lb/hr} = 3.32$$

VOLUME III

Appendix C – Field Data

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	PM10-2.5-1
Condition	Normal

IDENTIFICATION INFORMATION

Plant Name	
City	
State	

Source Number	FCC Scrubber	Date	5/27/2010
Sampling Location	Stack	Start	0949
Test Personnel	TTB	Stop	1353

Meterbox ID	702233
Δ H @	1.6880
Gamma, γ	0.9846
Nozzle ID	1
Nozzle Diameter	0.173
Orsat/Fyrite	FYR

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0.001	< 0.02 or 4%	10
Partial Train Posttest Leak Check, ACFM	0	0.020	10

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	NA	NA
Pitot Tube Posttest Leak Check	NA	NA

Barometric Pressure, In.,Hg.	29.50	Static Pressure, In. W.C.	-0.40

ACTUAL MOISTURE & GAS COMPOSITION

	Water Recovered, grams	248.3	Moisture, %	18.500
	CO_2 %	14.8	Md_run	29.78
N2 LPM 2.23	O_2 %	2.9	Mw_run	28.40

Sampling Information / *QA Checks*

Port	Point	Dwell Time, Min.	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Sample Train Vac. (in. Hg)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Target ΔH (in.H_2O)	% Iso	Run Cummulative D_{50}s, microns PM_{10}	$PM_{2.5}$
A	1	15.43	0	329.1	0.53	58	137	2	56	0.34	0.336	92.3	9.09	2.15
	2	14.99	15:26	334.95	0.5	59	137	2	49	0.34	0.337	73.0	9.72	2.40
	3	14.99	30:26	339.6	0.5	60	137	2	50	0.34	0.337	88.7	9.63	2.36
	4	15.58	45:25	345	0.54	60	137	2	52	0.34	0.337	88.6	9.53	2.32
	5	14.99	1:01:00	350.78	0.5	68	137	2	54	0.34	0.342	79.7	9.62	2.36
B	6	13.57	1:15:59	355.83	0.41	72	137	2	51	0.34	0.345	89.3	9.66	2.38
	1	15.72	1:29:33	360.491	0.55	72	137	2	53	0.34	0.345	71.3	9.76	2.42
	2	15.43	1:45:17	365.58	0.53	73	137	2	53	0.34	0.346	76.4	9.80	2.44
	3	15.14	2:00:43	370.78	0.51	73	137	2	56	0.34	0.346	78.5	9.83	2.45
	4	15.58	2:15:51	375.91	0.54	73	137	2	57	0.34	0.346	76.1	9.85	2.46
	5	14.99	2:31:26	381.18	0.5	73	137	2	58	0.34	0.346	78.5	9.87	2.46
	6	13.57	2:46:25	386.22	0.41	74	137	2	61	0.34	0.346	86.9	9.89	2.47
Total Run Time			3:00:00	390.802										
Total Volume, ACF				61.702										
				Averages	0.500619	67.9	137			0.340		83.1	10.13	2.57
Run	PM10-2.5-1				in. H2O	°F	°F			in H2O		%	microns	

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	PM10-2.5-2
Condition	

IDENTIFICATION INFORMATION

Plant Name	
City	
State	

Source Number	FCC Scrubber	Date	5/27/2010
Sampling Location	Stack	Start	1458
Test Personnel	TTB	Stop	1805

Meterbox ID	702233
Δ H @	1.6880
Gamma, γ	0.9846
Nozzle ID	2
Nozzle Diameter	0.173
Orsat/Fyrite	FYR

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM	0	0.020	8

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	N/a	
Pitot Tube Posttest Leak Check		

Barometric Pressure, In.,Hg.	29.50	Static Pressure, In. W.C.	-0.40

ACTUAL MOISTURE & GAS COMPOSITION

		Water Recovered, grams	242.5	Moisture, %	18.300
		CO_2 %	14.6	Md_run	29.69
N2 LPM	2.23	O_2 %	3.1	Mw_run	27.80

Sampling Information / QA Checks

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft³)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Sample Train Vac. (in. Hg)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Target ΔH (in.H_2O)	% Iso	Run Cummulative D_{50}s, microns PM_{10}	$PM_{2.5}$
A	1	15.43	0	391	0.53	70	137	2	56	0.34	0.345	79.6	9.88	2.46
	2	15.14	15:26	396.34	0.51	69	137	2	46	0.34	0.345	80.4	9.90	2.48
	3	14.99	30:34	401.53	0.5	69	137	2	46	0.34	0.345	80.3	9.93	2.49
	4	15.43	45:34	406.63	0.53	69	137	2	47	0.34	0.345	77.8	9.94	2.49
	5	14.84	1:01:00	411.87	0.49	69	137	2	47	0.34	0.345	83.1	9.93	2.49
B	6	13.74	1:15:51	417.01	0.42	69	137	2	49	0.34	0.345	85.6	9.95	2.50
	1	15.43	1:29:35	421.601	0.53	69	137	2	50	0.34	0.345	80.0	9.94	2.49
	2	14.99	1:45:00	426.95	0.5	66	137	2	45	0.34	0.343	80.1	9.95	2.49
	3	14.99	2:00:00	432.01	0.5	64	137	2	44	0.34	0.341	78.0	9.97	2.50
	4	15.58	2:15:00	436.95	0.54	63	137	2	45	0.34	0.341	76.9	9.97	2.50
	5	14.69	2:30:34	442.17	0.48	62	137	2	46	0.34	0.340	83.9	9.96	2.50
	6	13.57	2:45:15	447.19	0.41	62	137	2	46	0.34	0.340	90.8	9.95	2.50
Total Run Time			2:58:50	451.828										
Total Volume, ACF				60.828										
				Averages	0.494156	66.8	137			0.340		107.5	10.29	2.66
					in. H2O	°F	°F			in H2O		%	microns	

Run	PM10-2.5-2

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	PM10-2.5-3
Condition	

IDENTIFICATION INFORMATION

Plant Name	
City	
State	

Source Number	FCC Scrubber	Date	5/27/2010
Sampling Location	Stack	Start	2012
Test Personnel	TTB	Stop	2313

Meterbox ID	702233
Δ H @	1.6880
Gamma, γ	0.9846
Nozzle ID	3
Nozzle Diameter	0.173
Orsat/Fyrite	FYR

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM	0	0.020	8

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	0	0
Pitot Tube Posttest Leak Check	0	0

Barometric Pressure, In.,Hg.	29.50	Static Pressure, In. W.C.	-0.40

ACTUAL MOISTURE & GAS COMPOSITION

	Water Recovered, grams	240.5	Moisture, %	18.300
	CO_2 %	14.5	Md_run	29.71
N2 LPM 2.23	O_2 %	3.2	Mw_run	28.34

Sampling Information											QA Checks			
Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Sample Train Vac. (in. Hg)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Target ΔH (in.H_2O)	% Iso	Run Cummulative D_{50}s, microns PM_{10}	$PM_{2.5}$
A	1	15.00	0	453.1	0.52	55	137	1	52	0.35	0.345	81.9	9.85	2.45
	2	14.71	15:00	458.22	0.5	57	137	1	45	0.35	0.346	87.0	9.74	2.40
	3	15.00	29:42	463.42	0.52	57	137	1	45	0.35	0.346	80.3	9.81	2.43
	4	14.86	44:43	468.48	0.51	58	137	1	46	0.35	0.347	79.2	9.88	2.46
	5	14.41	59:34	473.41	0.48	58	137	1	50	0.35	0.347	83.1	9.90	2.47
B	6	13.32	1:13:58	478.26	0.41	58	137	1	52	0.35	0.347	89.6	9.91	2.48
	1	15.14	1:27:18	482.73	0.53	57	137	1	55	0.35	0.346	81.2	9.90	2.47
	2	14.86	1:42:26	487.92	0.51	56	137	1	59	0.35	0.346	81.9	9.90	2.47
	3	14.71	1:57:17	492.96	0.5	56	137	1	60	0.35	0.346	83.6	9.90	2.47
	4	15.14	2:12:00	497.99	0.53	56	137	1	53	0.35	0.346	85.9	9.86	2.45
	5	14.56	2:27:08	503.4	0.49	57	137	1	52	0.35	0.346	86.2	9.85	2.45
	6	13.48	2:41:43	508.47	0.42	55	137	1	53	0.35	0.345	98.5	9.81	2.43
Total Run Time			2:55:11	513.353										
Total Volume, ACF				60.253										
				Averages	0.492564	56.7	137			0.350		101.9	9.97	2.50
					in. H2O	°F	°F			in H2O		%	microns	

Run	PM10-2.5-3

Air Control Techniques, P.C.
Isokinetic Sampling Train Field Data Sheet

Job #	1436-F

Run ID	M5B-1
Condition	

IDENTIFICATION INFORMATION

Plant			
City, State			
Test Location	FCCU Stack	Date	5/27/10
Personnel	DLS,TTB,PJJ	Start	0949
		Stop	1354
Meterbox ID	1130	Filter ID	Tare
ΔH@	1.8487		
Gamma (Y)	1.0475		
Ideal Nozzle	0.282		
Nozzle Dia.	0.238		
Nozzle ID	1-3	K Factor	2.31
Probe ID	8B	TC Readout ID	

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Pre Leak Check, ACFM	0	< 0.02 or 4%	
Post Leak Check, ACFM	0	0.020	

	A	B
Pitot Pre Leak Check		
Pitot Post Leak Check		

Static Pressure, In. H_2O	-0.40
Barometric Pressure, In. Hg	29.50

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams	526.1	Moisture, %	19.510
CO_2 %	14.8	O_2 %	2.9

Sampling Information									QA Checks		
Point	Time Per Pt, (Min.)	Elapsed Time (h:m:s)	Dry Gas Meter (cu.ft.)	ΔP	Meter Temp	Stack Temp	ΔH	Target Δ H	Run ISO % Pt	Cum	Lk Chck Readings During Run
1	15	0	245.309	0.42	57	138	0.9	0.921	101.9	101.9	LC 1
2	15	15:0	252.78	0.49	58	137	1.05	1.080	97.6	99.7	
3	15	30:0	260.53	0.53	58	137	1.15	1.167	103.1	100.9	
4	15	45:0	269.04	0.5	64	137	1.1	1.114	107.5	102.6	LC-2
5	15	1:00:0	277.76	0.51	66	137	1.15	1.140	103.1	102.7	
6	15	1:15:0	286.24	0.53	68	137	1.2	1.190	107.5	103.5	
7	15	1:30:0	295.28	0.41	70	137	0.92	0.924	98.0	102.8	LC-3
8	15	1:45:0	302.56	0.48	72	137	1.1	1.086	98.4	102.2	
9	15	2:00:0	310.5	0.54	72	137	1.2	1.221	98.9	101.8	
10	15	2:15:0	318.96	0.5	72	137	1.15	1.131	104.9	102.2	LC-4
11	15	2:30:0	327.6	0.5	73	137	1.15	1.133	99.7	101.9	
12	15	2:45:0	335.82	0.53	73	137	1.2	1.201	95.4	101.4	
13	15	3:00:0	343.919								LC-5
14	15	3:15:0									
15	15	3:30:0									
16	15	3:45:0									LC-6
17	15	4:00:0									
18	15	4:15:0									
19	15	4:30:0									LC-7
20	15	4:45:0									
21	15	5:00:0									
22	15	5:15:0									LC-8
23	15	5:30:0									
24	15	5:45:0									
25	15	6:00:0									
		6:15:0									

		Averages			
Vm	98.61	0.4942	66.9	137.1	1.106
Vmstd	102.3347	in. H_2O	°F	°F	in H_2O

Run ISO
102.0
%

Air Control Techniques, P.C.
Isokinetic Sampling Train Field Data Sheet

Job #	1436-F

Run ID	**M5B-2**
Condition	

IDENTIFICATION INFORMATION

Plant			
City, State			
Test Location	FCCU Stack	Date	5/27/10
Personnel	DLS,TTB,PJJ	Start	1458
		Stop	1807
Meterbox ID	1130	Filter ID	Tare
ΔH@	1.8487		
Gamma (Y)	1.0475		
Ideal Nozzle	0.271		
Nozzle Dia.	0.240		
Nozzle ID	2-3	K Factor	2.27
Probe ID	8A	TC Readout ID	0

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Pre Leak Check, ACFM	0	< 0.02 or 4%	
Post Leak Check, ACFM	0	0.020	

	A	B
Pitot Pre Leak Check		
Pitot Post Leak Check		

Static Pressure, In. H_2O	-0.40
Barometric Pressure, In. Hg	29.50

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams	485.9	Moisture, %	18.206
CO_2 %	14.6	O_2 %	3.1

Sampling Information / QA Checks

Point	Time Per Pt, (Min.)	Elapsed Time (h:m:s)	Dry Gas Meter (cu.ft.)	ΔP	Meter Temp	Stack Temp	ΔH	Target Δ H	Run ISO % Pt	Run ISO % Cum	Lk Chck Readings During Run
1	15	0	354.599	0.41	68	137	0.94	0.935	101.3	101.3	LC 1
2	15	15:0	362.18	0.48	67	137	1.1	1.094	98.3	99.7	
3	15	30:0	370.12	0.51	66	137	1.1	1.159	100.3	99.9	
4	15	45:0	378.46	0.52	67	137	1.2	1.184	96.4	99.0	LC-2
5	15	1:00:0	386.56	0.5	67	137	1.15	1.138	98.6	98.9	
6	15	1:15:0	394.69	0.52	67	137	1.2	1.184	99.3	99.0	
7	15	1:30:0	403.04	0.42	66	137	0.96	0.954	100.6	99.2	LC-3
8	15	1:45:0	410.63	0.49	66	136	1.1	1.116	101.2	99.5	
9	15	2:00:0	418.88	0.53	64	137	1.2	1.200	93.6	98.8	
10	15	2:15:0	426.78	0.5	63	136	1.15	1.132	108.8	99.8	LC-4
11	15	2:30:0	435.69	0.51	63	137	1.15	1.153	116.9	101.4	
12	15	2:45:0	445.35	0.53	63	137	1.2	1.198	97.1	101.0	
13	15	3:00:0	453.525								LC-5
14	15	3:15:0									
15	15	3:30:0									
16	15	3:45:0									LC-6
17	15	4:00:0									
18	15	4:15:0									
19	15	4:30:0									LC-7
20	15	4:45:0									
21	15	5:00:0									
22	15	5:15:0									LC-8
23	15	5:30:0									
24	15	5:45:0									
25	15	6:00:0									
		6:15:0									

		Averages			
Vm	98.926	0.4926	65.6	136.8	1.121
Vmstd	102.9269	in. H_2O	°F	°F	in H_2O

Run ISO
99.6
%

Air Control Techniques, P.C.
Isokinetic Sampling Train Field Data Sheet

Job #	1436-F

Run ID	**M5B-3**
Condition	

IDENTIFICATION INFORMATION

Plant			
City, State			
Test Location	FCCU Stack	Date	5/27/10
Personnel	DLS,TTB,PJJ	Start	2012
		Stop	2318
Meterbox ID	1130	Filter ID	Tare
ΔH@	1.8487		
Gamma (Y)	1.0475		
Ideal Nozzle	0.269		
Nozzle Dia.	0.240		
Nozzle ID	1-3	K Factor	2.33
Probe ID	8B	TC Readout ID	0

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Pre Leak Check, ACFM	0	< 0.02 or 4%	
Post Leak Check, ACFM	0	0.020	

	A	B
Pitot Pre Leak Check		
Pitot Post Leak Check		

Static Pressure, In. H_2O	-0.40
Barometric Pressure, In. Hg	29.50

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams	493	Moisture, %	18.908
CO_2 %	14.5	O_2 %	3.2

Sampling Information									QA Checks		
Point	**Time Per Pt, (Min.)**	**Elapsed Time (h:m:s)**	**Dry Gas Meter (cu.ft.)**	**ΔP**	**Meter Temp**	**Stack Temp**	**ΔH**	**Target Δ H**	**Run ISO % Pt**	**Cum**	**Lk Chck Readings During Run**
1	15	0	454.012	0.43	57	137	23	0.985	99.8	99.8	LC 1
2	15	15:0	461.21	0.49	57	137	1.05	1.066	98.4	99.1	
3	15	30:0	469.2	0.51	57	136	1.1	1.172	95.4	97.8	
4	15	45:0	477.11	0.51	58	135	1.1	1.176	103.2	99.2	LC-2
5	15	1:00:0	485.69	0.48	58	136	1.05	1.105	89.6	97.3	
6	15	1:15:0	492.91	0.42	58	136	0.91	0.967	94.3	96.8	
7	15	1:30:0	500.02	0.49	57	135	1.05	1.128	98.9	97.1	LC-3
8	15	1:45:0	508.06	0.5	56	136	1.1	1.147	98.5	97.3	
9	15	2:00:0	516.13	0.52	56	137	1.1	1.190	93.3	96.9	
10	15	2:15:0	523.92	0.51	56	136	1.1	1.170	97.7	96.9	LC-4
11	15	2:30:0	532	0.5	56	137	1.1	1.145	98.7	97.1	
12	15	2:45:0	540.08	0.41	56	137	0.89	0.939	104.5	97.7	
13	15	3:00:0	547.825								LC-5
14	15	3:15:0									
15	15	3:30:0									
16	15	3:45:0									LC-6
17	15	4:00:0									
18	15	4:15:0									
19	15	4:30:0									LC-7
20	15	4:45:0									
21	15	5:00:0									
22	15	5:15:0									LC-8
23	15	5:30:0									
24	15	5:45:0									
25	15	6:00:0									
		6:15:0									

		Averages			
Vm	93.813	0.4801	56.8	136.3	2.879
Vmstd	99.6934	in. H_2O	°F	°F	in H_2O

Run ISO
98.4
%

Method 4/028 - Air Control Techniques, P.C.

Date 5/26/10

Source Information

Client	
Plant Name	
City, State	
Sampling Location	

Job #	1436 FD
Process	FCCU
Personnel	

Sampling Information

Run Number	API-2.5/028-1	API-2.5/028-2	API-2.5/028-3	
Filter Identification FPM	476-1301	476-1302	476-1303	
Filter Identification CPM	Teflon	Teflon	Teflon	
Sampling Date	5/27/10	5/27/10	5/27/10	

Moisture Data

Impinger 1
Contents - Empty

Final Weight, grams	562.2	571.3	565.3	
Initial Weight, grams	341.6	339.9	341.8	
Condensed Water, grams	220.6 ✓	231.4 ✓	223.5 ✓	

Impinger 2 - Empty
Contents -

Final Weight, grams	526.3	520.9	515.5	
Initial Weight, grams	514.8	520.9	517.0	
Condensed Water, grams	11.5 ✓	0.0 ✓	-1.5 ✓	

Impinger 3
Contents - 100 ml H_2O

Final Weight, grams				
Initial Weight, grams				
Condensed Water, grams				

Silica Gel -

Final Weight, grams	865.7	871.2	884.2	
Initial Weight, grams	849.5	860.1	865.7	
Adsorbed Water, grams	16.2 ✓	11.1 ✓	18.5 ✓	

Total Water, grams	248.3 ✓	242.5 ✓	240.5 ✓	

OTM 028 Data

Impinger Solution pH	5	5	5	
Purge	1450-1550	1900-2000	2330-0030	

Vm(std) = Volume of gas sampled at standard conditions (dscf) = gamma*17.64*Vm*[Pbar+(D H/13.6)]/(Tm+460)
Vwc(std) = volume of water vapor at standard conditions (scf) = 0.04715 * volume of water collected (gms)
Bws = Mole fraction of water vapor = Vwc(std) / (Vm(std) + Vwc(std))
Percent Moisture = 100 * Bws

Air Control Techniques, P.C.
Isokinetic Sampling Train Field Data Sheet

Job # 1436

Run ID	M5B-1
Cond.	

IDENTIFICATION INFORMATION

Plant
City, State:

Test Location
Personnel

Date 5/27/10
Start 0949
Stop 1354

Meterbox ID	1130	
ΔH@	~~1.810~~	1.8487
Gamma (Y)	~~1.008~~	1.0475
Ideal Nozzle	0.284	
Nozzle Dia.	0.238	
Nozzle ID	1-3	
Pitot Tube ID	8-B	

Filter ID	Tare

K Factor 2.31
TC Readout ID 1130

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Pre Leak Check, ACFM	0.00	< 0.02	10
Post Leak Check, ACFM	.000		10

	A	B
Pitot Pre Leak Check	✓	✓
Pitot Post Leak Check	✓	✓

Static Pressure, In. H_2O -0.4
Barometric Pressure, In. Hg 29.5

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams		Moisture, %	
CO_2 %		O_2 %	

Sampling Information

Port/ Point	Elapsed Time	Volume Metered	ΔP	Meter Temp	Stack Temp.	ΔH	Probe Temp	Filter Temp	Exit Temp	Aux Temp	Vac	Lk Chcks
E1	0:00	245.309	0.42	57	138	0.9	326	314	47	50	0.5	LC 1
E2	0:15	252.78	0.49	58	137	1.05	322	312	45	49	1.0	
E3	30	260.53	0.53	58	137	1.15	329	313	49	~~50~~	||	
E4	45	269.04	0.50	64	137	1.10	320	307	53	50	|	LC-2
E5	60/0	277.76	0.51	66	137	1.15	315	320	47	58	|	
E6	15	286.24	0.53	68	137	1.20	326	322	49	57	|	
S1	30	294.28	0.48	70	137	1.10	327	309	52	59	|	LC-3
S2	45	302.56	0.48	72	137	1.10	327	308	52	59	|	
S3	120/0	310.50	0.54	72	137	1.20	324	308	58	63	|	
S4	15	318.96	0.50	72	137	1.15	324	322	61	64	|	LC-4
S5	30	327.60	0.50	73	137	1.15	308	304	62	65	|	
S6	45	335.82	0.53	73	137	1.20	308	313	61	67	|	
OFF	180	343.919										LC-5
												LC-6
												LC-7
												LC-8

5:28
41

		Averages				Max / Min °F			ISO	High	Total
Vm											
Vmstd		in. H_2O	°F	°F	in. H_2O				%	in. Hg	Cu. Ft.

Stop 1034
RESTART 1134

Air Control Techniques, P.C.
Isokinetic Sampling Train Field Data Sheet

Job # 1436

Run ID MSB-2
Cond.

IDENTIFICATION INFORMATION

Plant [redacted]
City, State [redacted]

Test Location [redacted]
Personnel [redacted]

Date 5-27-10
Start 1458
Stop 1807

Meterbox ID	1130
ΔH@	1.8487
Gamma (Y)	1.0475
Ideal Nozzle	0.271
Nozzle Dia.	0.240
Nozzle ID	2-3
Pitot Tube ID	84

Filter ID	Tare

K Factor 228
TC Readout ID 1130

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Pre Leak Check, ACFM	.000	< 0.02	12
Post Leak Check, ACFM	.000		8

	A	B
Pitot Pre Leak Check	✓	✓
Pitot Post Leak Check	✓	✓

Static Pressure, In. H_2O -0.40
Barometric Pressure, In. Hg 29.5

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams
CO_2 %
Moisture, %
O_2 %

Sampling Information

Port/ Point	Elapsed Time	Volume Metered	ΔP	Meter Temp	Stack Temp	ΔH	Probe Temp	Filter Temp	Exit Temp	Aux Temp	Vac	Lk Chcks
1	0	354.599	0.41	68	137	0.94	329	320	55	61	1	LC 1
2	15	362.18	0.48	67	137	1.10	328	300	47	55	1	
3	30	370.12	0.51	66	137	1.10	331	305	47	56	1	
4	45	378.46	0.52	67	137	1.20	322	298	50	56	1	LC-2
5	60/0	386.56	0.50	67	137	1.15	312	313	55	58	1	
6	15	394.69	0.52	67	137	1.20	313	317	56	58	1	
1	30	403.04	0.42	66	137	0.96	313	319	55	59	1	LC-3
2	45	410.63	0.49	66	136	1.10	310	309	48	54	1	
3	120/0	428.88	0.53	64	137	1.20	314	311	56	54	1	
4	15	42678	0.50	63	136	1.15	316	313	53	55	1	LC-4
5	30	435.69	0.51	63	137	1.15	300	297	57	55	1	
6	45	445.35	0.53	63	137	1.20	301	324	59	57	1	
off	180	453525										LC-5
												LC-6
												LC-7
												LC-8

		Averages				Max / Min °F			ISO	High	Total
Vm											
Vmstd		in. H_2O	°F	°F	in. H_2O				%	in. Hg	Cu. Ft.

Air Control Techniques, P.C.
Isokinetic Sampling Train Field Data Sheet

Job #	1436

Run ID	MSB-3
Cond.	

IDENTIFICATION INFORMATION

Plant
City, State
Test Location
Personnel

Date 5-27-10
Start 2012
Stop 2318

Meterbox ID	[illegible]
ΔH@	[illegible]
Gamma (Y)	[illegible]
Ideal Nozzle	[illegible]
Nozzle Dia.	[illegible]
Nozzle ID	[illegible]
Pitot Tube ID	[illegible]

Filter ID	Tare

K Factor [illegible]
TC Readout ID [illegible]

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Pre Leak Check, ACFM	.000	< 0.02	14
Post Leak Check, ACFM	—		

	A	B
Pitot Pre Leak Check	✓	✓
Pitot Post Leak Check	✓	✓

Static Pressure, In. H_2O -0.40
Barometric Pressure, In. Hg 29.5

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams		Moisture, %	
CO_2 %		O_2 %	

Sampling Information

Port/ Point	Elapsed Time	Volume Metered	ΔP	Meter Temp	Stack Temp	ΔH	Probe Temp	Filter Temp	Exit Temp	Aux Temp	Vac	Lk Chcks
		[illegible]	0.43	57	[illegible]	[illegible]	[illegible]	293	45	50	1	LC 1
		[illegible]	[illegible]	57	135	[illegible]	[illegible]	[illegible]	41	49	1	
		[illegible]	0.51	57	136	[illegible]	[illegible]	[illegible]	[illegible]	49	1	
			0.41	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	49	1	LC-2
		[illegible]	0.43	[illegible]	[illegible]	1.05	270	301	48	51	1	
		[illegible]	0.43	58	136	[illegible]	319	302	44	49	1	
	30	[illegible]	0.44	57	135	[illegible]	320	301	45	51	1	LC-3
	45	[illegible]	[illegible]	56	[illegible]	1.10	324	303	46	52	1	
	120/0	51[illegible]	0.52	56	137	1.10	319	301	48	52	1	
	15	523.92	0.51	56	136	1.10	320	[illegible]	52	55	1	LC-4
	30	532.00	0.50	56	137	1.16	321	298	51	54	1	
6	45	540.08	0.41	56	137	0.89	321	299	50	54	1	
OFF	180	547.85										LC-5
												LC-6
												LC-7
												LC-8

		Averages				Max / Min °F			ISO	High	Total
Vm											
Vmstd		in. H_2O	°F	°F	in. H_2O				%	in. Hg	Cu. Ft.

Method 4/028 - Air Control Techniques, P.C.

Date 5/26/10

Source Information

Client
Plant Name
City, State
Sampling Location

Job # 1436 FD
Process FCCU
Personnel

Sampling Information

Run Number	M5B/028-1	M5B/028-2	M5B/028-3	
Filter Identification FPM	83Q-6573	83Q-6574	83Q-6575	
Filter Identification CPM	Teflon	Teflon	Teflon	
Sampling Date	5/27/10	5/27/10	5/27/10	

Moisture Data

Impinger 1
Contents - Empty

Final Weight, grams	894.1	853.9	872.5	
Initial Weight, grams	400.6	397.8	400.4	
Condensed Water, grams	493.5 ✓	456.1 ✓	472.1 ✓	

Impinger 2 - Empty
Contents -

Final Weight, grams	536.8	532.6	604.5	
Initial Weight, grams	532.5	530.9	603.4	
Condensed Water, grams	4.3 ✓	1.7 ✓	1.1 ✓	

Impinger 3
Contents - 100 ml H_2O

Final Weight, grams	606.2	594.2	603.4	
Initial Weight, grams	602.9	593.4	604.8	
Condensed Water, grams	3.3 ✓	0.8 ✓	-1.4 ✓	

Silica Gel -

Final Weight, grams	853.0	808.6	837.4	
Initial Weight, grams	828.0	781.3	816.2	
Adsorbed Water, grams	25.0 ✓	27.3 ✓	21.2 ✓	

Total Water, grams	526.1 ✓	485.9 ✓	493.0 ✓	

OTM 028 Data

Impinger Solution pH	5	4	4	
Purge	1450-1550	1900-2000	2330-0030	

Vm(std) = Volume of gas sampled at standard conditions (dscf) = gamma*17.64*Vm*[Pbar+(D H/13.6)]/(Tm+460)
Vwc(std) = volume of water vapor at standard conditions (scf) = 0.04715 * volume of water collected (gms)
Bws = Mole fraction of water vapor = Vwc(std) / (Vm(std) + Vwc(std))
Percent Moisture = 100 * Bws

VOLUME III

Appendix D – Calibration Data

Source Testing And Consulting Services
Meter Box Calibration

Calibration Date: 5/19/2010
Meter Box: 1130
Technician: MPT

Orifice ID	Y Calibration	Delta H @ Cal.	Vac
	pass	pass	pass
	pass	pass	pass
	pass	pass	pass
	pass	pass	pass
	pass	pass	pass

PART 1: Orifice Calibration

Calibration Orifice Set:
Critical Vacuum: 13.9
Barometric Pressure (in. Hg): 29.900

Collected Data

Orifice ID	Run #	Delta H	Initial Meter Volume (cu ft)	Final Meter Volume (cu ft)	Init Meter Temp (F)	Final Meter Temp (F)	Init Amb Temp (F)	Final Amb Temp (F)	Run Time min|sec		K Factor	Vac
	1	0.33	197.600	201.100	79.00	79.00	79.00	79.00	12	0	0.2396	22
	2	0.33	197.600	201.100	79.00	79.00	79.00	79.00	12	0	0.2396	22
	1	0.67	201.100	206.745	79.00	79.00	79.00	79.00	13	0	0.3486	20
	2	0.67	201.100	206.745	79.00	79.00	79.00	79.00	13	0	0.3486	20
	1	1.20	206.745	213.675	79.00	79.00	79.00	79.00	12	0	0.4591	17.5
	2	1.20	206.745	213.675	79.00	79.00	79.00	79.00	12	0	0.4591	17.5
	1	1.90	213.675	221.200	80.00	80.00	80.00	80.00	10	0	0.5923	16
	2	1.90	213.675	221.200	80.00	80.00	80.00	80.00	10	0	0.5923	16
	1	3.50	221.200	238.845	81.00	82.00	81.00	82.00	17	0	0.815	15
	2	3.50	221.200	238.845	81.00	82.00	81.00	82.00	17	0	0.815	15

Calculated Data

Orifice ID	Run #	Meter Volume (cu ft)	Meter Volume (std cu ft)	Corrected Meter Volume (std cu ft)	Ave Meter Temp (F)	Ave Amb Temp (F)	Y	Delta H @
	1	3.5	3.42769	3.70292	79	79	1.0803	1.9114
	2	3.5	3.42769	3.70292	79	79	1.0803	1.9114
	AVE						1.0803	1.9114
	1	5.645	5.53299	5.83643	79	79	1.0548	1.8364
	2	5.645	5.53299	5.83643	79	79	1.0548	1.8364
	AVE						1.0548	1.8364
	1	6.93	6.80133	7.09521	79	79	1.0432	1.9013
	2	6.93	6.80133	7.09521	79	79	1.0432	1.9013
	AVE						1.0432	1.9013
	1	7.525	7.38426	7.62107	80	80	1.0321	1.8148
	2	7.525	7.38426	7.62107	80	80	1.0321	1.8148
	AVE						1.0321	1.8148
	1	17.645	17.33465	17.80240	81.5	81.5	1.0270	1.7796
	2	17.645	17.33465	17.80240	81.5	81.5	1.0270	1.7796
	AVE						1.0270	1.7796
				Average for All Runs			1.0475	1.8487

Source Testing And Consulting Services
Meter Box Calibration

Calibration Date:
Meter Box:
Technician:

PART 2: Thermocouple Calibration

T/C Calibrator Make: T/C Calibrator Model:

Hg Thermometer Reading (F) :

Calibrator Output (F)	Meter Reading (F)	Error (F)	Allowable Error (F)	Result
0.0			9.24	
32.0			9.88	
70.0			10.64	
100.0			11.24	
200.0			13.24	
500.0			19.24	
1200.0			33.24	
1995.0			49.24	

APEX INSTRUMENTS METHOD 5 POST-TEST CONSOLE CALIBRATION
USING CALIBRATED CRITICAL ORIFICES
3-POINT ENGLISH UNITS

Meter Console Information	
Console Model Number	522
Console Serial Number	EIS 1130
DGM Model Number	
DGM Serial Number	

Calibration Conditions			
Date	Time	07/21/10	
Barometric Pressure		29.85	in Hg
Theoretical Critical Vacuum[1]		14.1	in Hg
Calibration Technician		DLS	

Factors/Conversions		
Std Temp	528	°R
Std Press	29.92	in Hg
K_1	17.647	oR/in Hg

[1] For valid test results, the Actual Vacuum should be 1 to 2 in. Hg greater than the Theoretical Critical Vacuum shown above.

[2] The Critical Orifice Coefficient, K', must be entered in English units, $(ft^3 \cdot °R^{1/2})/(in.Hg \cdot min)$.

Calibration Data										
Run Time	Metering Console					Critical Orifice				
Elapsed	DGM Orifice ΔH	Volume Initial	Volume Final	Outlet Temp Initial	Outlet Temp Final	Serial Number	Coefficient	Amb Temp Initial	Amb Temp Final	Actual Vacuum
(Θ)	(P_m)	(V_{mi})	(V_{mf})	(t_{mi})	(t_{mf})		K'	(t_{amb})	(t_{amb})	
min	in H_2O	cubic feet	cubic feet	°F	°F		see above2	°F	°F	in Hg
7.0	1.85	317.530	322.732	75	75	FO 63	0.5907	67	67	17.00
7.0	1.85	322.732	327.932	75	75	FO 63	0.5907	67	67	17.00
7.0	1.85	327.932	333.137	75	75	FO 63	0.5907	67	67	17.00

Results								
Standardized Data				Dry Gas Meter				
Dry Gas Meter		Critical Orifice		Calibration Factor		Flowrate	ΔH @	
				Value	Variation	Std & Corr	0.75 SCFM	Variation
$(V_{m(std)})$	$(Q_{m(std)})$	$(Vcr_{(std)})$	$(Q_{cr(std)})$	(Y)	(ΔY)	$(Q_{m(std)(corr)})$	(ΔH@)	(ΔΔH@)
cubic feet	cfm	cubic feet	cfm			cfm	in H2O	
5.145	0.735	5.377	0.768	1.045	0.000	0.768	1.754	0.000
5.143	0.735	5.377	0.768	1.045	0.000	0.768	1.754	0.000
5.148	0.735	5.377	0.768	1.044	-0.001	0.768	1.754	0.000
Pretest Gamma	1.0475	% Deviation	0.2	1.045	Y Average		1.754	ΔH@ Average

Note: For Calibration Factor Y, the ratio of the reading of the calibration meter to the dry gas meter, acceptable tolerance of individual values from the average is +-0.02.

I certify that the above Dry Gas Meter was calibrated in accordance with USEPA Methods, CFR Title 40, Part 60, Appendix A-3, Method 5, 16.2.3

Signature ____________ Date 7-21-10

APEX INSTRUMENTS METHOD 5 PRE-TEST CONSOLE CALIBRATION
USING CALIBRATED CRITICAL ORIFICES
5-POINT ENGLISH UNITS

Meter Console Information	
Console Model Number	522
Console Serial Number	702233
DGM Model Number	RW 110
DGM Serial Number	1014753

Calibration Conditions			
Date	Time	02/01/10	
Barometric Pressure		29.80	in Hg
Theoretical Critical Vacuum[1]		14.07	in Hg
Calibration Technician		DLS	

Factors/Conversions		
Std Temp	528	°R
Std Press	29.92	in Hg
K_1	17.647	oR/in Hg

[1]For valid test results, the Actual Vacuum should be 1 to 2 in. Hg greater than the Theoretical Critical Vacuum shown above.

[2]The Critical Orifice Coefficient, K', must be entered in English units, $(ft^3 \cdot {}^{\circ}R^{1/2})/(in.Hg \cdot min)$.

Calibration Data										
Run Time	Metering Console					Critical Orifice				
Elapsed	DGM Orifice ΔH	Volume Initial	Volume Final	Outlet Temp Initial	Outlet Temp Final	Serial Number	Coefficient	Amb Temp Initial	Amb Temp Final	Actual Vacuum
(Θ)	(P_m)	(V_{mi})	(V_{mf})	(t_{mi})	(t_{mf})		K'	(t_{amb})	(t_{amb})	
min	in H_2O	cubic feet	cubic feet	°F	°F		see above2	°F	°F	in Hg
17.0	0.27	244.300	249.717	72	72	FO 40	0.2387	67	67	23
12.0	0.61	249.820	255.388	72	71	FO 48	0.3483	67	67	21
9.0	1.10	255.500	260.982	71	72	FO 55	0.4592	67	67	20
7.5	1.80	261.100	266.975	72	71	FO 63	0.5907	67	67	18
5.5	3.40	267.200	273.066	71	71	FO 73	0.8085	67	67	17

Results									
Standardized Data				Dry Gas Meter					
				Calibration Factor		Flowrate	ΔH @		
Dry Gas Meter		Critical Orifice		Value	Variation	Std & Corr	0.75 SCFM	Variation
$(V_{m(std)})$	$(Q_{m(std)})$	$(Vcr_{(std)})$	$(Q_{cr(std)})$	(Y)	(ΔY)	$(Q_{m(std)(corr)})$	(ΔH@)	(ΔΔH@)
cubic feet	cfm	cubic feet	cfm			cfm	in H2O	
5.358	0.315	5.268	0.310	0.983	-0.002	0.310	1.567	-0.121
5.517	0.460	5.426	0.452	0.983	-0.001	0.452	1.667	-0.021
5.439	0.604	5.365	0.596	0.986	0.002	0.596	1.734	0.046
5.839	0.778	5.751	0.767	0.985	0.000	0.767	1.720	0.033
5.858	1.065	5.772	1.050	0.985	0.001	1.050	1.750	0.062
				0.9846	Y Average		1.688	ΔH@ Average

Note: For Calibration Factor Y, the ratio of the reading of the calibration meter to the dry gas meter, acceptable tolerance of individual values from the average is +-0.02.

I certify that the above Dry Gas Meter was calibrated in accordance with USEPA Methods, CFR Title 40, Part 60, Appendix A-3, Method 5, 16.2.3

Signature

Date 2-01-10

APEX INSTRUMENTS METHOD 5 POST-TEST CONSOLE CALIBRATION
USING CALIBRATED CRITICAL ORIFICES
3-POINT ENGLISH UNITS

Meter Console Information	
Console Model Number	522
Console Serial Number	702233
DGM Model Number	RW 110
DGM Serial Number	961167

Calibration Conditions			
Date	Time	10/20/10	
Barometric Pressure		29.7	in Hg
Theoretical Critical Vacuum[1]		14.0	in Hg
Calibration Technician		DLS	

Factors/Conversions		
Std Temp	528	°R
Std Press	29.92	in Hg
K_1	17.647	oR/in Hg

[1] For valid test results, the Actual Vacuum should be 1 to 2 in. Hg greater than the Theoretical Critical Vacuum shown above.

[2] The Critical Orifice Coefficient, K', must be entered in English units, $(ft^3 * °R^{1/2})/(in.Hg*min)$.

Calibration Data										
Run Time	Metering Console					Critical Orifice				
Elapsed	DGM Orifice ΔH	Volume Initial	Volume Final	Outlet Temp Initial	Outlet Temp Final	Serial Number	Coefficient	Amb Temp Initial	Amb Temp Final	Actual Vacuum
(Θ)	(P_m)	(V_{mi})	(V_{mf})	(t_{mi})	(t_{mf})		K'	(t_{amb})	(t_{amb})	
min	in H_2O	cubic feet	cubic feet	°F	°F		see above2	°F	°F	in Hg
7.0	1.70	262.400	267.910	75	75	FO 63	0.5907	72	72	19.00
7.0	1.70	267.910	273.378	75	75	FO 63	0.5907	72	72	19.00
7.0	1.70	273.378	278.861	75	75	FO 63	0.5907	72	72	19.00

Results								
Standardized Data				Dry Gas Meter				
Dry Gas Meter		Critical Orifice		Calibration Factor		Flowrate	ΔH @	
				Value	Variation	Std & Corr	0.75 SCFM	Variation
$(V_{m(std)})$	$(Q_{m(std)})$	$(Vcr_{(std)})$	$(Q_{cr(std)})$	(Y)	(ΔY)	$(Q_{m(std)(corr)})$	(ΔH@)	(ΔΔH@)
cubic feet	cfm	cubic feet	cfm			cfm	in H2O	
5.421	0.774	5.324	0.761	0.982	-0.004	0.761	1.634	0.000
5.379	0.768	5.324	0.761	0.990	0.003	0.761	1.634	0.000
5.394	0.771	5.324	0.761	0.987	0.001	0.761	1.634	0.000
Pretest Gamma	0.985	% Deviation	0.2	0.986	Y Average		1.634	ΔH@ Average

Note: For Calibration Factor Y, the ratio of the reading of the calibration meter to the dry gas meter, acceptable tolerance of individual values from the average is +-0.02.

I certify that the above Dry Gas Meter was calibrated in accordance with USEPA Methods, CFR Title 40, Part 60, Appendix A-3, Method 5, 16.2.3

Signature ____________ Date 10-20-10

Type S Pitot Tube Inspection
Air Control Techniques, P.C.

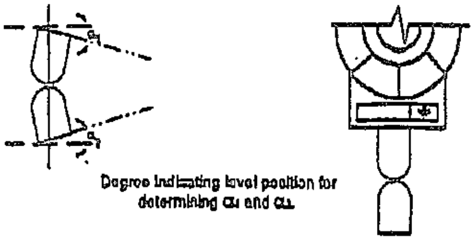
Date 5-28-02

Identification Information

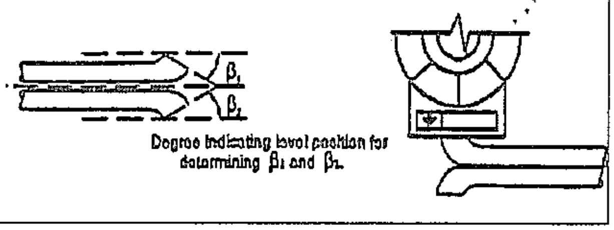
Client	IN HOUSE	Job	NA
Plant Name	NA	Process	NA
City	CARY	State	NC

Pitot ID 8A

Inspection Results



Degree indicating level position for determining α_1 and α_2.

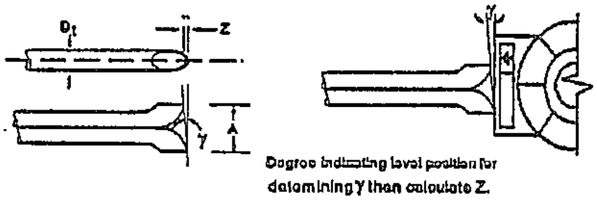


Degree indicating level position for determining β_1 and β_2.

Inspection Data

Level and Perpendicular?	YES
Obstruction?	NO
Damaged?	NO
α1 (-10° ≤ α1 ≤ + 10°)	1
α2 (-10° ≤ α2 ≤ + 10°)	1
β1 (-5° ≤ β1 ≤ + 5°)	-1
β2 (-5° ≤ β2 ≤ + 5°)	0
γ	-1
θ	-1
z=A tan γ (≤0.125 inches)	0.0164
w=A tan θ (≤0.03125 inches)	0.0164
D1 (3/16 inch ≤ D1 ≤ 3/8 inch)	0.375
A	0.9375
A/2D1 (1.05 ≤ PA/D1 ≤ 1.5)	1.25

Degree indicating level position for determining θ



Degree indicating level position for determining γ then calculate Z.

Notes

Pitot Coefficient

Coefficient of 0.84 Assigned? YES

Inspection Personnel DLS

Notes

Form ACTPC PI-2

Type S Pitot Tube Inspection
Air Control Techniques, P.C.

Date 11-20-06

Identification Information

Client IN HOUSE

Plant Name NA

City CARY

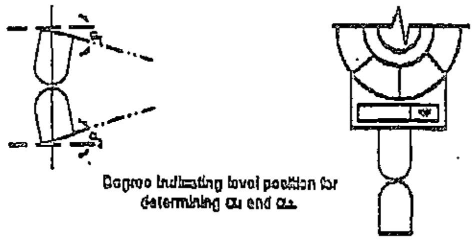
Job NA

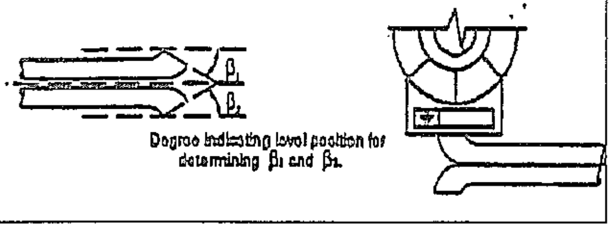
Process NA

State NC

Pitot ID 8B

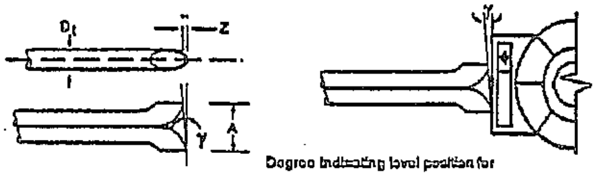
Inspection Results


Degree indicating level position for determining α_1 and α_2.



Degree indicating level position for determining β_1 and β_2.

Degree indicating level position for determining θ



Degree indicating level position for determining γ then calculate Z.

Inspection Data

Level and Perpendicular?	YES
Obstruction?	NO
Damaged?	NO
α1 (-10° ≤ α1 ≤ + 10°)	1
α2 (-10° ≤ α2 ≤ + 10°)	1
β1 (-5° ≤ β1 ≤ + 5°)	-1
β2 (-5° ≤ β2 ≤ + 5°)	0
γ	-1
θ	-1
z=A tan γ (≤0.125 inches)	0.0164
w=A tan θ (≤0.03125 inches)	0.0164
D1 (3/16 inch ≤ D1 ≤ 3/8 inch)	0.375
A	0.9375
A/2D1 (1.05 ≤ PA/D1 ≤ 1.5)	1.25

Notes

Pitot Coefficient

Coefficient of 0.84 Assigned? YES

Inspection Personnel DLS

Notes

Form ACTPC PI-2

Stainless Steel Nozzle Calibration and Condition
Air Control Techniques, P.C.

Nozzle Set ID	Nozzle ID	Average	Measurements			High-Low	Condition	Date Inspected
			1	2	3			
ACT-N-1	1-1	0.123	0.123	0.124	0.122	0.002	OK	3/11/07
ACT-N-1	1-2	0.180	0.180	0.180	0.181	0.001	OK	3/11/07
ACT-N-1	1-3	0.238	0.238	0.238	0.238	0.000	OK	3/11/07
ACT-N-1	1-4	0.299	0.300	0.300	0.298	0.002	OK	3/11/07
ACT-N-1	1-5	0.368	0.368	0.368	0.368	0.000	OK	3/11/07
ACT-N-1	1-6	0.427	0.427	0.427	0.428	0.001	OK	3/11/07
ACT-N-1	1-7	0.491	0.492	0.491	0.490	0.002	OK	3/11/07

Nozzle Set ID	Nozzle ID	Average	Measurements			High-Low	Condition	Date
			1	2	3			
ACT-N-2	2-1	0.128	0.128	0.127	0.128	0.001	OK	3/11/07
ACT-N-2	2-2	0.177	0.176	0.177	0.178	0.002	OK	3/11/07
ACT-N-2	2-3	0.240	0.240	0.240	0.240	0.000	OK	3/11/07
ACT-N-2	2-4	0.298	0.297	0.298	0.298	0.001	OK	3/11/07
ACT-N-2	2-5	0.373	0.373	0.374	0.373	0.001	OK	3/11/07
ACT-N-2	2-6	0.441	0.440	0.442	0.440	0.002	OK	3/11/07
ACT-N-2	2-7	0.497	0.498	0.497	0.497	0.001	OK	3/11/07

Nozzle Set ID	Nozzle ID	Average	Measurements			High-Low	Condition	Date
			1	2	3			
ACT-N-3	3-1	0.120	0.120	0.121	0.120	0.001	OK	3/11/07
ACT-N-3	3-2	0.189	0.188	0.189	0.189	0.001	OK	3/11/07
ACT-N-3	3-3	0.240	0.240	0.239	0.240	0.001	OK	3/11/07
ACT-N-3	3-4	0.254	0.254	0.254	0.255	0.001	OK	3/11/07
ACT-N-3	3-5	0.365	0.366	0.365	0.365	0.001	OK	3/11/07
ACT-N-3	3-6	0.996	0.996	0.997	0.995	0.002	OK	3/11/07
ACT-N-3	3-7	0.494	0.494	0.494	0.494	0.000	OK	3/11/07

Nozzle Set ID	Nozzle ID	Average	Measurements			High-Low	Condition	Date
			1	2	3			
ACT-N-4	4-1	0.301	0.300	0.301	0.302	0.002	OK	3/11/07
ACT-N-4	4-2	0.178	0.178	0.178	0.177	0.001	OK	3/11/07
ACT-N-4	4-3	0.299	0.299	0.299	0.299	0.000	OK	3/11/07
ACT-N-4	4-4	0.248	0.248	0.248	0.248	0.000	OK	3/11/07
ACT-N-4	4-5	0.364	0.364	0.364	0.363	0.001	OK	3/11/07
ACT-N-4	4-6	0.497	0.496	0.497	0.497	0.001	OK	3/11/07
ACT-N-4	4-7	0.498	0.497	0.498	0.499	0.002	OK	3/11/07

Name DANNY SPEER Signature

VOLUME III

Appendix E – Analytical Data

RESOLUTION ANALYTICS, INC.

Specialists in Air Emissions Analysis

ANALYTICAL REPORT

CLIENT:	**AIR CONTROL TECHNIQUES, INC.**
PROJECT:	1436 F

ANALYTICAL SERVICES PROVIDED:

- FILTERABLE & CONDENSIBLE PARTICULATE
  (EPA METHOD PM 2.5, 5B/028)

Confirmation of Data Review:

To the best of my knowledge this analytical data has been checked thoroughly for completeness and the results presented are accurate, error-free, legible, and have been performed and validated in accordance with the approved method(s).

Date of Review: June 17, 2010

J. Bruce Nemet
Quality Assurance Officer

www.resolutionanalytics.com
2733 Lee Avenue ◦ Sanford, NC 27332 ◦ Phone: 919-774-5557 ◦ Fax: 919-776-6785

Analysis Request / Chain of Custody

RESOLUTION ANALYTICS, INC.
Specialists in Air Emission Analysis
2733 Lee Avenue, Sanford, NC 27330
Phone (919) 774-5557 • Fax (919) 776-6785 • Email resolute@interpath.com

Reporting Address: [1] Please attach a separate sheet of paper if billing address is different than reporting address.	Phone Number 919 460 7811	Fax Number 919 460 7897
Company Air Control Techniques	Contact Tom Holder	
Street Address 301 E. Durham Rd.	PO # 10077 - 1436 F	
City, State, Zip Cary NC 27513	**Project:** 1436 F	

Turnaround Time:
- ☑ 10 Days (Standard)
- ☐ 5 Days (1.5x)
- ☐ 3 Days (2x)
- ☐ 2 Days (2.5x)
- ☐ 24 Hours (3x)

Sample ID / Run #	Train/Run Component	Train/Run Component	Train/Run Component
EXAMPLE: SCRUBBER INLET-1	*0.1 N H2S04 (Imp 1-3)*	*0.1 N H2S04 (Imp 4)*	*0.1 N NaOH (Imp 5-6)*
API-2.5/028-1,2 ③ *	Keep separate Nozzle + Probe Rinse,	>2.5 Rinse,	≤2.5 Rinse,
	Filter, Imp Soln,	Imp Acetone,	Imp MeCl2, CPM Filter
M5B/028-1,2,3	Filter, Frnt ½ Rinse,	Imp Soln,	Imp Acetone,
	Imp MeCl2,	CPM Filter	
* may Not analyze			

Analyses

- ☐ EPA 0011/TO-5/8315
  - analytes: ________
  - analytes: ________
- ☐ HF (EPA 13B)
- ☐ EPA 26A (HCl/Cl2)
  - analytes: ________
- ☐ VOC's (HPLC)
  - analytes: ________
- ☐ Amines list: ________
- ☐ Phenol (EPA TO-8)
- ☐ SO_x (EPA 6/8)
  - analytes: ________
- ☐ Ammonia (CTM-027)
- ☐ NO_x (EPA 7A/7D)
- ☐ Filt Particulate (EPA 5)
- ☐ Conden Part (EPA 202)
- ☐ EPA 29
  - metals: ________
  - metals: ________
- ☐ Ontario-Hydro (Hg)
- ☐ EPA 101A (hg)
- ☐ Other
  - list ________

Chain of Custody:

Relinquished by (Signature)	Date	Received by (Signature)	Date	Comments
Tom Holder	6/3/10			
Relinquished by (Signature)	Date	Received by (Signature)	Date	Comments
			6/3/10	

WHITE: Report Copy CANARY: Client Copy PINK: Lab Copy

JPC Form No. 37449A

RESOLUTION ANALYTICS, INC.
Specialists in Air Emissions Analysis

REPORT SUMMARY

RFA #: 1436 F

Method: EPA M5

SAMPLE ID	TOTAL FILTERABLE PARTICULATE
Acetone Blank	0.4 mg (in 220 mls)
M5B/028-1	26.6 mg
M5B/028-2	19.4 mg
M5B/028-3	17.2 mg

RESOLUTION ANALYTICS, INC.
Specialists in Air Emissions Analysis

REPORT SUMMARY

RFA #: **1436 F**

SAMPLE ID	**Particulate ≤ 2.5 µm**	**Particulate > 2.5 µm**	**Particulate Nozzle and Probe Rinse**
Acetone Blank	0.4 mg	0.4 mg	0.4 mg (in 220 mls)
API-2.5/028-1	9.3 mg	0.4 mg	5.4 mg
API-2.5/028-2	10.8 mg	0.2 mg	4.3 mg
API-2.5/028-3	1.5 mg	0.4 mg	16.3 mg

RESOLUTION ANALYTICS, INC.
Specialists in Air Emissions Analysis

REPORT SUMMARY

RFA #: **1436-F**

SAMPLE ID	Organic CPM	Inorganic CPM	Total CPM[1]
Acetone/$MeCl_2$ Blank			0.2 mg (in 135 mL)
DI H_2O Blank			1.2 mg (in 160 mL)
Field Train Blank	0.5 mg	1.3 mg	1.8 mg
API-2.5/028-1	1.7 mg	8.0 mg	7.9 mg
API-2.5/028-2	1.0 mg	18.4 mg	17.6 mg
API-2.5/028-3	2.0 mg	10.8 mg	11.0 mg
M5B/028-1	2.9 mg	21.3 mg	22.4 mg
M5B/028-2	2.3 mg	15.1 mg	15.6 mg
M5B/028-3	2.3 mg	15.5 mg	16.0 mg

---

[1] *Total Condensible Particulate Matter (CPM) results have been Field Blank corrected up to a maximum of 2.0 mg.*

Analytical Narrative

RFA #:	1436 F		
Client:	Air Control Techniques	Date Received:	6/3/10
Analyst:	JSC	Date Analyzed:	6/8/10
Analysis:	EPA M5	Analyte(s):	FILTERABLE PARTICULATE

Sample Matrix & Components:

Dry Filters, Front½ Acetone Rinses, Acetone Blank

Summary of Sample Prep:

The acetone rinses were transferred to pre-tared teflon "baggies" in a low humidity environment. The acetone rinses were evaporated, baked 6 hours @ 160° C, then desiccated for 24 hours, after which time they were weighed daily every six hours until consecutive weights agreed within ±0.5 mg. The filters were baked 6 hours at 160° C, desiccated for 2 hours and weighed.

All weights were recorded to the nearest 0.1 mg and include filterable particulate catch only. The total catch reported for each run is a sum of the filter and rinse catches. The acetone blank catch has been subtracted from sample rinse catches in proportion with their respective volumes.

Summary of Instrumentation:

Denver model Pinnacle Series analytical balance

Analytical Detection Limit(s): 0.1 mg

Miscellaneous Comments Regarding Sample Analysis: (Note unusual catch weights, interferences, odd sample behavior, and steps taken to confirm unusual results. Also note any deviations from standard analytical procedures, together with justification and possible affect on results. Specify samples when applicable.)

No modifications to EPA Method 5 analytical procedure were made. See data sheets for individual sample descriptions.

Analytical Narrative

RFA #: 1436 F

Client: Air Control Techniques
Date Received: 6/3/10
Analyst: JSC
Date Analyzed: 6/8/10
Analysis: OTM 027
Analyte(s): PM 2.5 FILTERABLE PARTICULATE

Sample Matrix & Components:

Dry Filters, Front½ Acetone Rinses, Acetone Blank

Summary of Sample Prep:

The acetone rinses and pre-tared filters were transferred to pre-tared teflon "baggies" in a low humidity environment. The acetone rinses were evaporated overnight then desiccated for 24 hours, after which time they were weighed daily every six hours until consecutive weights agreed within ±0.5 mg. The filters were baked 2 to 3 hours at 105° C, desiccated for 2 hours and weighed.

All weights were recorded to the nearest 0.1 mg and include filterable particulate catch only. The total catch reported for each run is a sum of the filter and rinse catches. The acetone blank catch has been subtracted from sample rinse catches in proportion with their respective volumes.

Summary of Instrumentation:

Denver model Pinnacle Series analytical balance

Analytical Detection Limit(s): 0.1 mg

Miscellaneous Comments Regarding Sample Analysis: **(Note unusual catch weights, interferences, odd sample behavior, and steps taken to confirm unusual results. Also note any deviations from standard analytical procedures, together with justification and possible affect on results. Specify samples when applicable.)**

No modifications to OTM 027 analytical procedure were made. See data sheets for individual sample descriptions.

Analytical Narrative		RFA #:	1436-F
Client:	Air Control Techniques, Inc.	Date Received:	6/3/2010
Analyst:	BNL	Date Analyzed:	6/17/2010
Analysis:	OTM-028	Analyte(s):	CONDENSIBLE PM

Sample Matrix & Components:

H_2O liquid impinger samples, organic impinger rinses, CPM filter, reagent blanks

Summary of Sample Prep:

The samples were received in the lab and logged in our custody records. They were then prepared and analyzed according to OTM 028.

Summary of Instrumentation:

Denver model Pinnacle Series analytical balance

Analytical Detection Limit(s): 0.1 mg

Miscellaneous Comments Regarding Sample Analysis: **(Note unusual catch weights, interferences, odd sample behavior, and steps taken to confirm unusual results. Also note any deviations from standard analytical procedures, together with justification and possible affect on results. Specify samples when applicable).**

No modifications to OTM 028 analytical procedure were made. See data sheets for individual sample notes and comments.

PARTICULATE SAMPLING LABORATORY RESULTS

Client: ***Air Control Techniques*** *RFA #:* ***1436 F***
Method: EPA M5

Run Number				*M5B/028-1*			*M5B/028-2*			*M5B/028-3*
Filter Container #										
	Date	*Init*			*Date*			*Date*		
	6/10/10	*JSC*		*0.3533*	*6/10/10*		*0.3477*	*6/10/10*		*0.3503*
Baggie Tare Wt., g.				*#N/A*			*#N/A*			*#N/A*
Filter Tare Wt., g.				*0.3370*			*0.3357*			*0.3362*
FILTER SAMPLE WT., g.				*0.0163*			*0.0120*			*0.0141*
Front ½ Rinse Container #				*1375*			*1639*			*1259*
	Date	*Init*			*Date*			*Date*		
	6/10/10	*JSC*	*F*	*3.4869*	*6/10/10*	*F*	*3.5498*	*6/10/10*	*F*	*3.4456*
	6/10/10	*JSC*		*3.4873*	*6/10/10*		*3.5499*	*6/10/10*		*3.4460*
Tare Wt., g.		*(120*	*ml)*	*3.4764*	*(130*	*ml)*	*3.5422*	*(120*	*ml)*	*3.4423*
RINSE SAMPLE WT., g.				*0.0105*			*0.0076*			*0.0033*
Filter Catch, mg.				***16.3***			***12.0***			***14.1***
Rinse Catch, mg.				*10.5*			*7.6*			*3.3*
Rinse Blank Residue, mg.				*0.2*			*0.2*			*0.2*
Net Rinse Catch, mg.				***10.3***			***7.4***			***3.1***
FILTERABLE PARTICULATE, mg.				***26.6***			***19.4***			***17.2***

Legend: *F = Final Weight*

Notes & Comments:

REAGENT BLANK LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1436 F**

Run Number				Acetone Blank
Sample ID/Container #				2434
	Date	Init		
	6/10/10	JSC	F	3.4524
	6/10/10	JSC		3.4527
Tare Wt., g.	(	220	ml)	3.4520
SAMPLE WT., g.				0.0004

Blank Beaker #	2434
Final wt., mg.	3.4524
Tare wt., mg.	3.4520
Residue, mg.	0.4
Volume, ml.	220
Density, mg/ml	785.0
Conc., mg/mg	2.32E-06 <--
Upper Limit, mg	1.00E-05

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: OTM 027

RFA #: **1436 F**

Run Number				API-2.5/028-1			API-2.5/028-2			API-2.5/028-3
Filter Container #										
	Date	Init			Date			Date		
	6/9/10	JSC		0.1345	6/9/10		0.1242	6/9/10		0.1139
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.				0.1256			0.1134			0.1128
FILTER SAMPLE WT., g.				0.0089			0.0108			0.0011
≤ 2.5 µm Rinse Container #				161			44			1631
	Date	Init			Date			Date		
	6/9/10	JSC	F	3.4057	6/9/10	F	3.8322	6/9/10	F	3.4950
	6/8/10	JSC		3.4059	6/8/10		3.8325	6/8/10		3.4954
Tare Wt., g.		(10	ml)	3.4053	(10	ml)	3.8322	(10	ml)	3.4946
RINSE SAMPLE WT., g.				0.0004			0.0000			0.0004
> 2.5 µm Rinse Container #				561			1040			1373
	Date	Init			Date			Date		
	6/9/10	JSC	F	3.5841	6/9/10	F	3.7085	6/9/10	F	3.5911
	6/8/10	JSC		3.5846	6/8/10		3.7090	6/8/10		3.5915
Tare Wt., g.		(20	ml)	3.5837	(20	ml)	3.7083	(10	ml)	3.5907
RINSE SAMPLE WT., g.				0.0004			0.0002			0.0004
Nozzle and Probe Rinse Container #				1488			1659			1644
	Date	Init			Date			Date		
	6/9/10	JSC	F	3.8782	6/9/10	F	3.5543	6/9/10		3.4372
	6/8/10	JSC		3.8783	6/8/10		3.5545	6/8/10	F	3.4370
Tare Wt., g.		(230	ml)	3.8724	(170	ml)	3.5497	(170	ml)	3.4204
RINSE SAMPLE WT., g.				0.0058			0.0046			0.0166
Filter Catch, mg.				8.9			10.8			1.1
≤ 2.5 µm Rinse Catch, mg.				0.4			0.0			0.4
Rinse Blank Residue, mg.				0.0			0.0			0.0
Net Rinse Catch, mg.				0.4			0.0			0.4
> 2.5 µm Rinse Catch, mg.				0.4			0.2			0.4
Rinse Blank Residue, mg.				0.0			0.0			0.0
Net Rinse Catch, mg.				0.4			0.2			0.4
Nozzle and Probe Rinse Catch, mg.				5.8			4.6			16.6
Rinse Blank Residue, mg.				0.4			0.3			0.3
Net Rinse Catch, mg.				5.4			4.3			16.3
FILTERABLE PARTICULATE, mg.				15.1			15.3			18.2

Notes & Comments:

REAGENT BLANK LABORATORY RESULTS

Client: **Air Control Techniques** RFA #: **1436 F**
Method: OTM 027

Run Number				Acetone Blank
Sample ID/Container #				2434
	Date	Init		
	6/10/10	JSC	F	3.4524
	6/10/10	JSC		3.4527
Tare Wt., g.	(	220	ml)	3.4520
SAMPLE WT., g.				0.0004

Blank Beaker #	2434
Final wt., mg.	3.4524
Tare wt., mg.	3.4520
Residue, mg.	0.4
Volume, ml.	220
Density, mg/ml	785.0
Conc., mg/mg	2.32E-06 ✓
Upper Limit, mg.	1.00E-05

CONDENSIBLE PARTICULATE MATTER LABORATORY RESULTS

Client: ***Air Control Techniques, Inc.*** *RFA #:* ***1436-F***
Method: *OTM-028*

Run Number			*API-2.5/028-1*			*API-2.5/028-2*			*API-2.5/028-3*
Acetone/MeCl$_2$ Container #			1379			610			1554
	Date	*Init*		*Date*			*Date*		
	6/16/2010	BNL F	3.5491	6/16/2010	F	3.7056	6/16/2010	F	3.5701
	6/14/2010	BNL F	3.5491	6/14/2010	F	3.7056	6/14/2010	F	3.5701
Tare Wt., g.			3.5474			3.7046			3.5681
RINSE SAMPLE WT., g.			0.0017			0.0010			0.0020

DI H$_2$O Container #			1479			2097			846
	Date	*Init*		*Date*			*Date*		
	6/17/2010	BNL F	3.5792	6/17/2010	F	3.6829	6/17/2010		3.5722
	6/16/2010	BNL F	3.5792	6/16/2010	F	3.6829	6/16/2010	F	3.5719
Tare Wt., g.			3.5700			3.6626			3.5591
RINSE SAMPLE WT., g.			0.0092			0.0203			0.0128

Organic CPM Mass, mg.	1.7	1.0	2.0
Inorganic CPM Mass, mg	9.2	20.3	12.8
Volume of NH$_4$OH Added (N=0.1), ml	0.70	1.10	1.20
Correction For NH$_3$ Added, mg	1.19	1.87	2.04
Adjusted Inorganic CPM Mass, mg	**8.0**	**18.4**	**10.8**
Total CPM Mass, mg	**7.9**	**17.6**	**11.0**

Notes & Comments:

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CONDENSIBLE PARTICULATE MATTER LABORATORY RESULTS

Client: **Air Control Techniques, Inc.**
Method: OTM-028
RFA #: **1436-F**

Run Number			M5B/028-1			M5B/028-2			M5B/028-3
Acetone/MeCl$_2$ Container #			235			1693			1591
	Date	Init		Date			Date		
	6/16/2010	BNL F	3.6653	6/16/2010	F	3.5968	6/16/2010	F	3.4950
	6/14/2010	BNL F	3.6653	6/14/2010	F	3.5968	6/14/2010		3.4951
Tare Wt., g.			3.6624			3.5945			3.4927
RINSE SAMPLE WT., g.			0.0029			0.0023			0.0023
DI H$_2$O Container #			1563			2277			1273
	Date	Init		Date			Date		
	6/17/2010	BNL	3.4433	6/17/2010		3.5976	6/17/2010	F	3.8896
	6/16/2010	BNL F	3.4432	6/16/2010	F	3.5975	6/16/2010	F	3.8896
Tare Wt., g.			3.4137			3.5775			3.8683
RINSE SAMPLE WT., g.			0.0295			0.0200			0.0213

	M5B/028-1	M5B/028-2	M5B/028-3
Organic CPM Mass, mg.	2.9	2.3	2.3
Inorganic CPM Mass, mg	29.5	20.0	21.3
Volume of NH$_4$OH Added (N=0.1), ml	4.80	2.90	3.40
Correction For NH$_3$ Added, mg	8.17	4.94	5.79
Adjusted Inorganic CPM Mass, mg	**21.3**	**15.1**	**15.5**
Total CPM Mass, mg	**22.4**	**15.6**	**16.0**

Notes & Comments:

FIELD TRAIN BLANK LABORATORY RESULTS

Client: **Air Control Techniques, Inc.** RFA #: **1436-F**
Method: OTM-028

Run Number Field Train Blank

Acetone/MeCl$_2$ Container # 1248

Date	Init		
6/16/2010	BNL		3.6456
6/14/2010	BNL	F	3.6454
Tare Wt., g.			3.6449
RINSE SAMPLE WT., g.			0.0005

DI H$_2$O Container # 2285

Date	Init		
6/17/2010	BNL	F	3.5791
6/16/2010	BNL		3.5792
Tare Wt., g.			3.5776
RINSE SAMPLE WT., g.			0.0015

Organic CPM Mass, mg.	0.5
Inorganic CPM Mass, mg	1.5
Volume of NH$_4$OH Added (N=0.1), ml	0.10
Correction For NH$_3$ Added, mg	0.17
Adjusted Inorganic CPM Mass, mg	1.3
Total Field Train Blank CPM Mass, mg	1.8

Notes & Comments:

D:\JOBS\ACT\1436\1436 06-10\OTM 028 DATA

FIELD REAGENT BLANK LABORATORY RESULTS

Client: ***Air Control Techniques, Inc.*** *RFA #:* ***1436-F***
Method: OTM-028

Run Number						*Acetone/MeCl$_2$*			*Di H_2O*
Container #						*2175*			*1579*
	Date	*Init*		*Date*			*Date*		
				6/16/2010		*3.6761*	*6/16/2010*	*F*	*3.6545*
		###		*6/14/2010*	*F*	*3.6759*	*6/14/2010*		*3.6547*
Tare Wt., g.	*(*	*ml)*	*#N/A*	*(135*	*ml)*	*3.6757*	*(160*	*ml)*	*3.6533*
SAMPLE WT., g.			*#N/A*			*0.0002*			*0.0012*
Field Reagent Blank Mass, mg			*#N/A*			*0.2*			*1.2*

Notes & Comments:

PARTICULATE WORKSHEET

CLIENT ACT RFA # 1436

ANALYST BNL METHOD OTM-028 DATE 6/3/10

RUN #	FILTER			ACETONE RINSE		NOZZLE CYCLONE		MECL2 ✓ TOLUENE___ CHLOROFORM/ETHER___		DI H2O IMPINGER		
	CONT.#	FILTER #	TARE WT.(G)	CONT.#	VOL.(ML)	CONT.#	VOL.(ML)	CONT.#	VOL.(ML)	CONT.#	VOL.(ML)	
API-2.5/028-1								1379		1479		0.7
-2								610		2097		1.1
-3								1554		846		1.2
M5B;028- 1								235		1563		4.8
-2								1693		2277		2.9
-3								1591		1273		3.4
Field Blank								1248		2285		0.1
Rgt Blank								2175	135	1579	160	

OTM 027 Particulate Bench Sheet

Client: ACT
Analyst: JSC

RFA #: 1436F
Method: 027

Date Received: 6/3/10
Date Analyzed: 6/8/10

Run #	Filter			≤ 2.5µm Rinse		>2.5µm ≤10µm Rinse		NOZZLE & PROBE ~~>10µm~~ Rinse	
	Baggie #	Filter #	Filter Tare	Baggie #	Volume	Baggie #	Volume	Baggie #	Volume
API-2.5/028 -1		476-1301	0.1256	161	10	561	20	1488	230
-2		476-1302	0.1134	44	10	1040	20	1659	170
-3		476-1303	0.1128	1631	10	1373	10	1644	170
RB (ACETONE)								2434	220

M5/17 Particulate Bench Sheet

Client: ACT
Analyst: JSC

RFA #: 1436 F
Method: 5B

Date Received: 6/3/10
Date Analyzed: 6/8/10

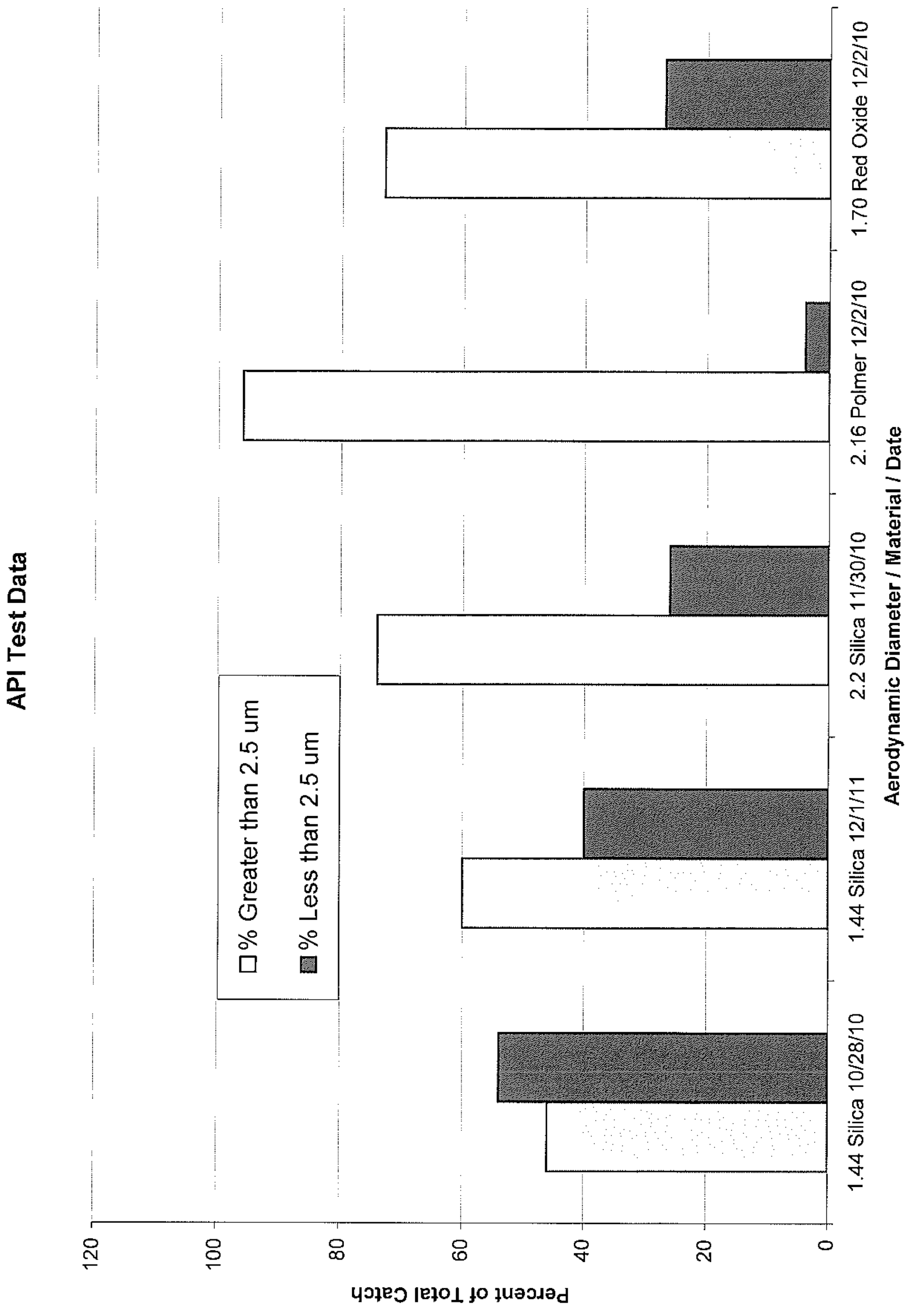
Run #	Filter			Acetone Rinse	
	Baggie #	Filter #	Filter Tare	Baggie #	Rinse Volume
M5B/028 - 1		830-6573	0.3370	1375	120
-2		830-6574	0.3357	1639	130
-3		830-6575	0.3362	1259	120
RB (ACETONE)				2434	220

APPENDIX IV
Data Sheets for Laboratory Analyses

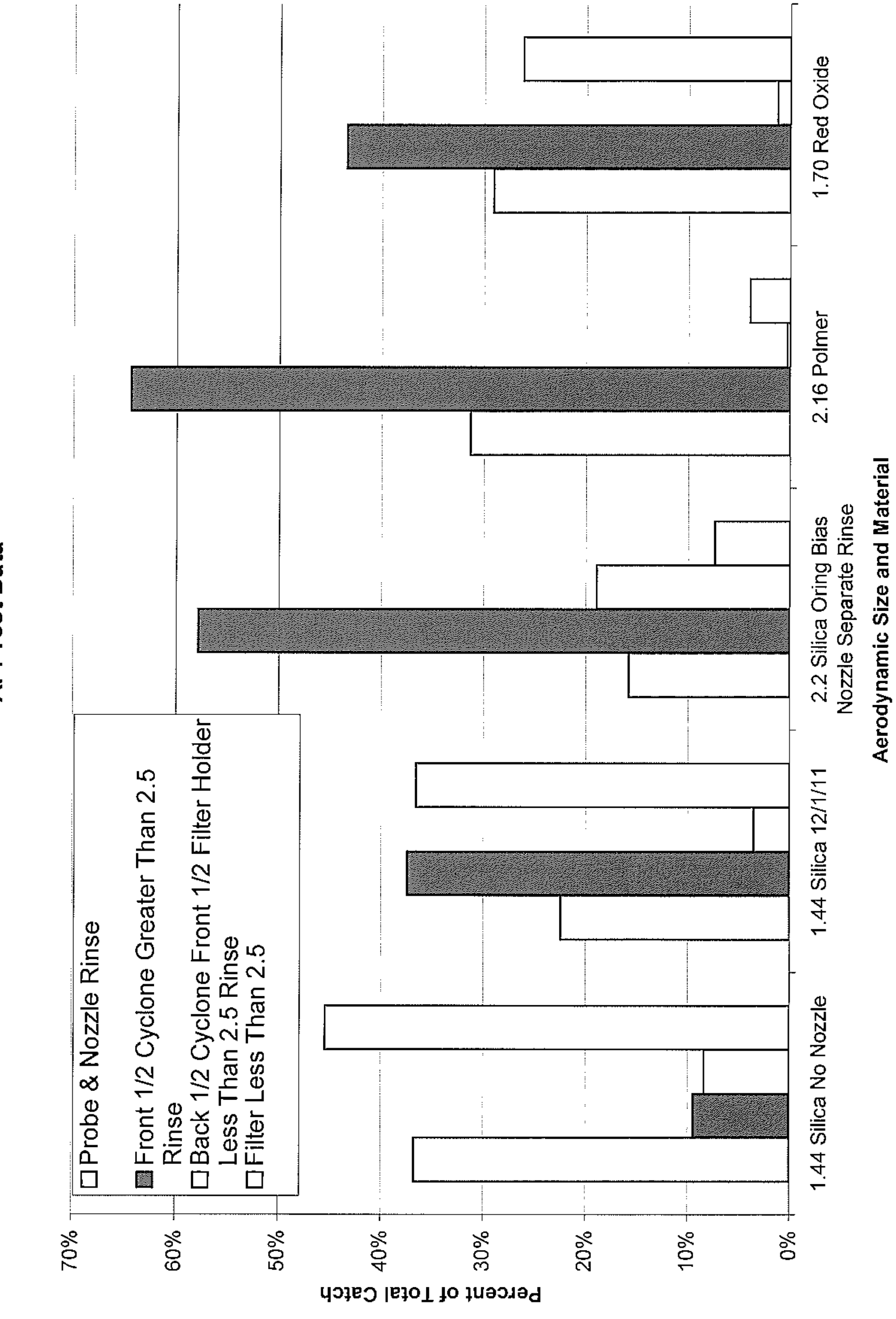
VOLUME IV

VOLUME IV

Appendix A – Test Results


API Test Data
□ % Greater than 2.5 um
▨ % Less than 2.5 um
Percent of Total Catch
0
20
40
60
80
100
120
1.44 Silica 10/28/10
1.44 Silica 12/1/11
2.2 Silica 11/30/10
2.16 Polmer 12/2/10
1.70 Red Oxide 12/2/10
Aerodynamic Diameter / Material / Date

API Test Data



Combined Cyclone PM10 & PM2.5 Run Data Sheet

Silica Spheres

Run ID	1.5 um Nominal
Condition	2.2 um Aerodynamic

IDENTIFICATION INFORMATION

Plant Name	ACTPC Lab
City	Cary
State	NC

Source Number	N/A	Date	10/28/2010
Sampling Location	Lab	Start	1155
Test Personnel	TTB PJJ	Stop	1235

Meterbox ID	802012
Δ H @	1.5540
Gamma, γ	0.9602
Nozzle ID	API
Nozzle Diameter	0.173
Orsat/Fyrite	N/A

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM	0	0.020	9

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	0	0
Pitot Tube Posttest Leak Check	0	0

Barometric Pressure, In.,Hg.	29.65	Static Pressure, In. W.C.	0.00

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams	7.65	Moisture, %	2.000
CO_2 %	0	Md_run	28.84
O_2 %	20.9	Mw_run	28.62

Sampling Information / *QA Checks*

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Sample Train Vac. (in. Hg)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Target ΔH (in.H_2O)	% Iso	Run Cummulative D_{50}s, microns PM_{10}	$PM_{2.5}$
A	1	10.00	0	506.9	0.265	81	327	2	67	0.46	0.563	198.3	9.82	2.20
	2	10.00	10:00	511.39	0.265	81	324	2	67	0.46	0.567	197.5	9.83	2.21
	3	10.00	20:00	515.87	0.265	82	324	2	64	0.46	0.568	194.1	9.88	2.23
	4	10.00	30:00	520.28	0.265	83	324	2	64	0.46	0.569	197.6	9.87	2.22
	5	0.00	40:00	524.779							1.401		9.87	2.22
B	6	0.00	40:00								1.401		9.87	2.22
	1	0.00	40:00								1.401		9.87	2.22
	2	0.00	40:00								1.401		9.87	2.22
	3	0.00	40:00								1.401		9.87	2.22
	4	0.00	40:00								1.401		9.87	2.22
	5	0.00	40:00								1.401		9.87	2.22
	6	0.00	40:00								1.401		9.87	2.22
Total Run Time			40:00											
Total Volume, ACF				17.879										
				Averages	0.265	81.8	324.8			0.460		194.0	9.99	2.26
					in. H2O	°F	°F			in H2O		%	microns	

Run	1.5 um Nominal

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Silica Spheres

Run ID	1.5 um Nominal
Condition	2.2 um Aerodynamic

IDENTIFICATION INFORMATION

Plant Name	ACTPC Lab
City	Cary
State	NC

Source Number	N/A	Date	11/30/2010
Sampling Location	Lab	Start	0240
Test Personnel	TTB PJJ	Stop	0320

Meterbox ID	909083
Δ H @	1.9070
Gamma, γ	1.0206
Nozzle ID	API
Nozzle Diameter	0.173
Orsat/Fyrite	N/A

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM	0	0.020	6

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	0	0
Pitot Tube Posttest Leak Check	0	0

Barometric Pressure, In.,Hg.	29.65	Static Pressure, In. W.C.	0.00

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams	6.85	Moisture, %	2.001
CO_2 %	0	Md_run	28.84
O_2 %	20.9	Mw_run	28.62

Sampling Information / *QA Checks*

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Sample Train Vac. (in. Hg)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Target ΔH (in.H_2O)	% Iso	Run Cummulative D_{50}s, microns PM_{10}	$PM_{2.5}$
A	1	10.00	0	253.6	0.265	71	321	2	62	0.56	0.587	170.1	10.94	2.64
	2	10.00	10:00	257.45	0.265	72	321	2	63	0.56	0.588	172.9	10.88	2.62
	3	10.00	20:00	261.37	0.265	73	321	2	64	0.56	0.590	175.6	10.81	2.59
	4	10.00	30:00	265.36	0.265	74	321	2	65	0.56	0.591		10.80	2.59
	5	0.00	40:00	269.322							1.467		10.80	2.59
B	6	0.00	40:00								1.467		10.80	2.59
	1	0.00	40:00								1.467		10.80	2.59
	2	0.00	40:00								1.467		10.80	2.59
	3	0.00	40:00								1.467		10.80	2.59
	4	0.00	40:00								1.467		10.80	2.59
	5	0.00	40:00								1.467		10.80	2.59
	6	0.00	40:00								1.467		10.80	2.59
Total Run Time			40:00											
Total Volume, ACF				15.722										
				Averages	0.265	72.5	321			0.560		173.2	10.80	2.59
					in. H2O	°F	°F			in H2O		%	microns	

Run	1.5 um Nominal

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Silica Spheres

Run ID	1.0 um Nominal
Condition	1.4 um Aerodynamic

IDENTIFICATION INFORMATION

Plant Name	ACTPC Lab
City	Cary
State	NC

Source Number	N/A	Date	12/1/2010
Sampling Location	Lab	Start	1013
Test Personnel	TTB PJJ	Stop	1053

Meterbox ID	909083
Δ H @	1.9070
Gamma, γ	1.0206
Nozzle ID	API
Nozzle Diameter	0.173
Orsat/Fyrite	N/A

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM	0	0.020	6

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	0	0
Pitot Tube Posttest Leak Check	0	0

Barometric Pressure, In.,Hg. 29.65 Static Pressure, In. W.C. 0.00

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams	6.89	Moisture, %	2.000
CO_2 %	0	Md_run	28.84
O_2 %	20.9	Mw_run	28.62

Sampling Information / QA Checks

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Sample Train Vac. (in. Hg)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Target ΔH (in.H_2O)	% Iso	Run Cummulative D_{50}s, microns PM_{10}	$PM_{2.5}$
A	1	10.00	0	269.6	0.265	71	321	2	65	0.56	0.587	172.7	10.82	2.59
	2	10.00	10:00	273.51	0.265	72	321	2	65	0.56	0.588	165.8	10.97	2.66
	3	10.00	20:00	277.27	0.265	72	320	2	64	0.56	0.590	175.4	10.88	2.62
	4	10.00	30:00	281.25	0.265	73	321	2	63	0.56	0.590	183.1	10.75	2.57
	5	0.00	40:00	285.41							1.467		10.75	2.57
B	6	0.00	40:00								1.467		10.75	2.57
	1	0.00	40:00								1.467		10.75	2.57
	2	0.00	40:00								1.467		10.75	2.57
	3	0.00	40:00								1.467		10.75	2.57
	4	0.00	40:00								1.467		10.75	2.57
	5	0.00	40:00								1.467		10.75	2.57
	6	0.00	40:00								1.467		10.75	2.57
Total Run Time			40:00											
Total Volume, ACF				15.810										
				Averages	0.265	72.0	320.8			0.560		174.3	10.75	2.57
					in. H2O	°F	°F			in H2O		%	microns	

Run	1.0 um Nominal

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Polymer Spheres

Run ID	2.1 um Nominal
Condition	2.2 um Aerodynamic

IDENTIFICATION INFORMATION

Plant Name	ACTPC Lab
City	Cary
State	NC

Source Number	N/A	Date	12/1/2010
Sampling Location	Lab	Start	1400
Test Personnel	TTB PJJ	Stop	1440

Meterbox ID	909083
Δ H @	1.9070
Gamma, γ	1.0206
Nozzle ID	API
Nozzle Diameter	0.173
Orsat/Fyrite	N/A

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM	0	0.020	5

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	0	0
Pitot Tube Posttest Leak Check	0	0

Barometric Pressure, In.,Hg.	29.65	Static Pressure, In. W.C.	0.00

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams	8.97	Moisture, %	2.000
CO_2 %	0	Md_run	28.84
O_2 %	20.9	Mw_run	28.62

Sampling Information / *QA Checks*

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Sample Train Vac. (in. Hg)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Target ΔH (in.H_2O)	% Iso	Run Cummulative D_{50}s, microns PM_{10}	$PM_{2.5}$
A	1	10.00	0	285.5	0.265	73	150	3	66	0.56	0.966	197.2	8.88	1.73
	2	10.00	10:00	290.57	0.265	73	150	3	62	0.56	0.966	202.3	8.80	1.70
	3	10.00	20:00	295.77	0.265	74	149	3	65	0.56	0.971	201.3	8.79	1.70
	4	10.00	30:00	300.96	0.265	75	150	3	65	0.56	0.970	201.1	8.78	1.69
	5	0.00	40:00	306.148							1.467		8.78	1.69
B	6	0.00	40:00								1.467		8.78	1.69
	1	0.00	40:00								1.467		8.78	1.69
	2	0.00	40:00								1.467		8.78	1.69
	3	0.00	40:00								1.467		8.78	1.69
	4	0.00	40:00								1.467		8.78	1.69
	5	0.00	40:00								1.467		8.78	1.69
	6	0.00	40:00								1.467		8.78	1.69
Total Run Time			40:00											
Total Volume, ACF				20.648										
				Averages	0.265	73.8	149.8			0.560		200.5	8.78	1.80
					in. H2O	°F	°F			in H2O		%	microns	

Run	2.1 um Nominal

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Polymer Spheres

Run ID	2.1 um Nominal
Condition	2.2 um Aerodynamic

IDENTIFICATION INFORMATION

Plant Name	ACTPC Lab
City	Cary
State	NC

Source Number	N/A	Date	12/2/2010
Sampling Location	Lab	Start	0930
Test Personnel	TTB PJJ	Stop	1010

Meterbox ID	909083
Δ H @	1.9070
Gamma, γ	1.0206
Nozzle ID	API
Nozzle Diameter	0.173
Orsat/Fyrite	N/A

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM	0	0.018	7

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	0	0
Pitot Tube Posttest Leak Check	0	0

Barometric Pressure, In.,Hg. 29.65 Static Pressure, In. W.C. 0.00

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams	4.96	Moisture, %	2.002
CO_2 %	0	Md_run	28.84
O_2 %	20.9	Mw_run	28.62

Sampling Information / *QA Checks*

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Sample Train Vac. (in. Hg)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Target ΔH (in.H_2O)	% Iso	Run Cummulative D_{50}s, microns PM_{10}	$PM_{2.5}$
A	1	10.00	0	306.6	0.265	68	150	2	64	0.52	0.957	148.4	10.87	2.43
	2	10.00	10:00	310.38	0.265	68	145	2	60	0.52	0.973	147.8	10.89	2.44
	3	10.00	20:00	314.16	0.265	69	150	2	56	0.52	0.959	146.6	10.92	2.45
	4	10.00	30:00	317.9	0.265	70	155	2	53	0.52	0.945		10.90	2.45
	5	0.00	40:00								1.467		10.90	2.45
B	6	0.00	40:00								1.467		10.90	2.45
	1	0.00	40:00								1.467		10.90	2.45
	2	0.00	40:00								1.467		10.90	2.45
	3	0.00	40:00								1.467		10.90	2.45
	4	0.00	40:00								1.467		10.90	2.45
	5	0.00	40:00								1.467		10.90	2.45
	6	0.00	40:00								1.467		10.90	2.45
Total Run Time			40:00											
Total Volume, ACF				11.300										
				Averages	0.265	68.8	150			0.520		147.7	10.90	2.45
					in. H2O	°F	°F			in H2O		%	microns	

Run	2.1 um Nominal

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Red Oxide

Run ID	0.8 um Nominal
Condition	1.7 um Aerodynamic

IDENTIFICATION INFORMATION

Plant Name	ACTPC Lab
City	Cary
State	NC

Source Number	N/A	Date	12/2/2010
Sampling Location	Lab	Start	1345
Test Personnel	TTB PJJ	Stop	1425

Meterbox ID	909083
Δ H @	1.9070
Gamma, γ	1.0206
Nozzle ID	API
Nozzle Diameter	0.173
Orsat/Fyrite	N/A

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM	0	0.020	6

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	0	0
Pitot Tube Posttest Leak Check	0	0

Barometric Pressure, In.,Hg.	29.65	Static Pressure, In. W.C.	0.00

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams	6.83	Moisture, %	2.000
CO_2 %	0	Md_run	28.84
O_2 %	20.9	Mw_run	28.62

Sampling Information / *QA Checks*

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Sample Train Vac. (in. Hg)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Target ΔH (in.H_2O)	% Iso	Run Cummulative microns PM_{10}	D_{50}s, $PM_{2.5}$
A	1	10.00	0	339	0.265	71	320	2	66	0.56	0.589	174.8	10.73	2.56
	2	10.00	10:00	342.96	0.265	71	320	4	61	0.56	0.589	170.4	10.82	2.59
	3	10.00	20:00	346.82	0.265	71	321	5	64	0.56	0.587	176.3	10.77	2.57
	4	10.00	30:00	350.81	0.265	73	321	5	65	0.56	0.590	169.4	10.82	2.59
	5	0.00	40:00	354.659							1.467		10.82	2.59
B	6	0.00	40:00								1.467		10.82	2.59
	1	0.00	40:00								1.467		10.82	2.59
	2	0.00	40:00								1.467		10.82	2.59
	3	0.00	40:00								1.467		10.82	2.59
	4	0.00	40:00								1.467		10.82	2.59
	5	0.00	40:00								1.467		10.82	2.59
	6	0.00	40:00								1.467		10.82	2.59
Total Run Time			40:00											
Total Volume, ACF				15.659										
				Averages	0.265	71.5	320.5			0.560		172.7	10.82	2.59
					in. H2O	°F	°F			in H2O		%	microns	

Run	0.8 um Nominal

McFarland Equations

$$P = \exp\left(\frac{4.61 + a_m\theta Stk}{1 + b_m\theta Stk + c_m\theta Stk^2 + d_m\theta^2 Stk}\right) x \frac{1}{100\%}$$

$$a_m = -0.9526 - 0.05686\ R_0$$

$$b_m = \frac{-0.297 - 0.0174\ R_0}{1 - 0.07\ R_0 + 0.0171\ R_0^{\ 2}}$$

$$c_m = -0.306 + \frac{1.895}{\sqrt{R_0}} - \frac{2.0}{R_0}$$

$$d_m = \frac{0.131 - 0.0132\ R_0 + 0.000383\ R_0^{\ 2}}{1 - 0.129\ R_0 + 0.0136\ R_0^{\ 2}}$$

Pui and Brockmann Equations

$$P = \exp[-(2)(0.706)\,Stk\,\theta]$$

$$Stk = \tau U_0/a$$

R_0 is the curvature ratio or the radius of the bend divided by the radius of the duct ($R_0 = R_b/a$)

Input Parameters

gas viscosity =	1.81E-05	kg/m s		
particle density =	1000	kg/m3		
tube velocity =	1	m/s		
stack velocity =	50	fps =	1.64	m/s

Bend Parameters

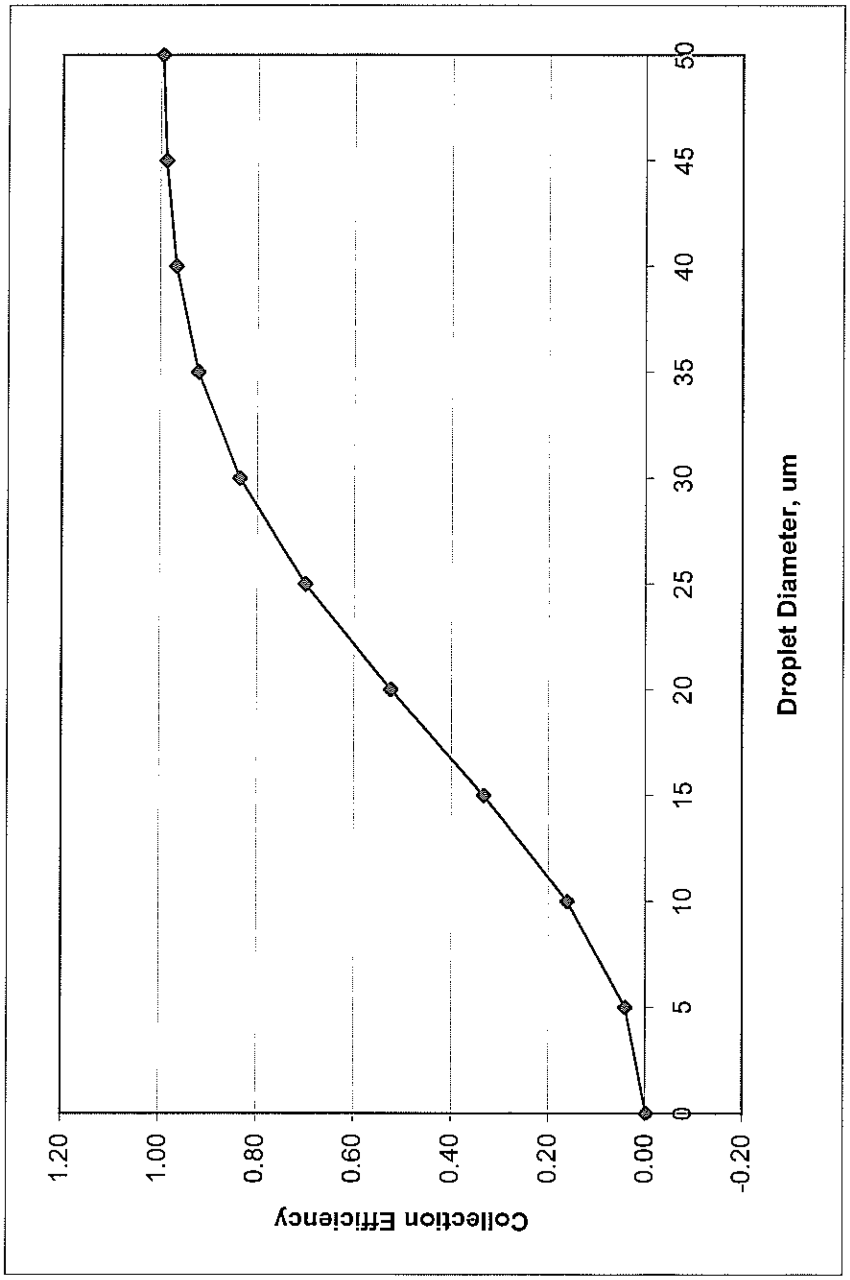
bend radius =	5	cm =	0.05	m	
tube radius =	0.35	cm =	0.0035	m	0.889 in
Theta =	90	degrees =	1.57	radians	
Ro =	14.29				

McFarland Parameters

am =	-1.764886
bm =	-0.156333
cm =	0.05537
dm =	0.010655

Calculated Data

Droplet Diameter			Stop Dist		Pui-Brockmann		McFarland		
um	m	tau	m	Stk	Pt	Eff'y	Pt	Eff'y	Average
0	0.000000	0.00E+00	0.00E+00	0.0	1.00	0.00	1.00	0.00	0.00
5	0.000005	7.67E-05	1.26E-04	0.0	0.95	0.05	0.97	0.03	0.04
10	0.000010	3.07E-04	5.04E-04	0.1	0.82	0.18	0.86	0.14	0.16
15	0.000015	6.91E-04	1.13E-03	0.2	0.65	0.35	0.69	0.31	0.33
20	0.000020	1.23E-03	2.01E-03	0.4	0.46	0.54	0.49	0.51	0.52
25	0.000025	1.92E-03	3.15E-03	0.5	0.30	0.70	0.30	0.70	0.70
30	0.000030	2.76E-03	4.53E-03	0.8	0.17	0.83	0.16	0.84	0.84
35	0.000035	3.76E-03	6.17E-03	1.1	0.09	0.91	0.07	0.93	0.92
40	0.000040	4.91E-03	8.06E-03	1.4	0.04	0.96	0.02	0.98	0.97
45	0.000045	6.22E-03	1.02E-02	1.8	0.02	0.98	0.01	0.99	0.99
50	0.000050	7.67E-03	1.26E-02	2.2	0.01	0.99	0.00	1.00	1.00
55	0.000055	9.28E-03	1.52E-02	2.7	0.00	1.00	0.00	1.00	1.00
60	0.000060	1.10E-02	1.81E-02	3.2	0.00	1.00	0.00	1.00	1.00
65	0.000065	1.30E-02	2.13E-02	3.7	0.00	1.00	0.00	1.00	1.00
70	0.000070	1.50E-02	2.47E-02	4.3	0.00	1.00	0.00	1.00	1.00
75	0.000075	1.73E-02	2.83E-02	4.9	0.00	1.00	0.00	1.00	1.00
80	0.000080	1.96E-02	3.22E-02	5.6	0.00	1.00	0.00	1.00	1.00
85	0.000085	2.22E-02	3.64E-02	6.3	0.00	1.00	0.00	1.00	1.00
90	0.000090	2.49E-02	4.08E-02	7.1	0.00	1.00	0.00	1.00	1.00
95	0.000095	2.77E-02	4.54E-02	7.9	0.00	1.00	0.00	1.00	1.00
100	0.000100	3.07E-02	5.04E-02	8.8	0.00	1.00	0.00	1.00	1.00


Collection Efficiency
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
0
5
10
15
20
25
30
35
40
45
50
Droplet Diameter, um

VOLUME IV

Appendix B – Field Data

Combined Cyclone PM10 & PM2.5 Run Data Sheet

No Nozzle

Silica Spheres

Run ID	API 1μm 3ml/diluted
Condition	to 30ml

IDENTIFICATION INFORMATION

Plant Name: API PM2.5 Lab Study
City: Cary
State: NC

Source Number: IX3 Box
Sampling Location: Lab
Test Personnel: TTB PJJ

Date: 10/28/15
Start: 1155
Stop: 1235

Meterbox ID: 80202
Δ H @: 1.554
Gamma, γ: 0.9600
Nozzle ID: N/A
Nozzle Diameter: N/A
Orsat/Fyrite: N/A

Filter ID	Tare
479236	

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0.002	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM	0.000		9

TRAIN ONLY

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	N/A	N/A
Pitot Tube Posttest Leak Check	N/A	N/A

Barometric Pressure, In.,Hg.: 29.65
Static Pressure, In. W.C.: 0.00

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams		Moisture, %	4%
CO_2 %	0	Md_run	
O_2 %	20.9	Mw_run	

Sampling Information

0.46

QA Checks

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Set 320 Chamber Temp., (°F)	Sample Train Vac. (in. Hg)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Probe Temp, (°F)	Filter Cyclone Temp, (°F)	Notes
A-	1	10.00	0	506.900	N/A	81	263	2	67	0.53	325	327	3ml 1μm
	1	10.00	10	511.39	N/A	81	261	2	67	0.53	323	324	diluted to 30ml
	1	10.00	20	515.87	N/A	82	260	2	64	0.53	322	324	
	1	10.00	30	520.28	N/A	83	260	2	64	0.53	323	324	Rinse w/ 6mls DI
			40	524.779									GRAD
													LAST 4 minutes DRY

Total Run Time:
Total Volume, ACF:

Averages							2.26 ~~1.37~~ ~~0.37~~
	in. H2O	°F	°F	in H2O	%		microns

Run:

3min ON POly
Mins 21-24

Silica Spheres

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	API 1.5μm Nominal
Condition	2.2μm Aero

IDENTIFICATION INFORMATION

Plant Name	API PM2.5 Lab Study
City	Cary
State	NC

Source Number	IX3 Box	Date	11/30/10
Sampling Location	Lab	Start	~~0240~~ 240
Test Personnel	TTB PJJ	Stop	~~0~~ 320

Meterbox ID	1919033
ΔH @	1.904
Gamma, γ	1.0266
Nozzle ID	API
Nozzle Diameter	0.173
Orsat/Fyrite	N/A

Filter ID	Tare
Q237	

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM	0.000		6

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	N/A	N/A
Pitot Tube Posttest Leak Check	N/A	N/A

Barometric Pressure, In.,Hg.	29.65	Static Pressure, In. W.C.	0.00

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams		Moisture, %	
CO_2 %	0	Md_run	
O_2 %	20.9	Mw_run	

Sampling Information

335 set **QA Checks**

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	set 320 Chamber Temp., (°F)	Sample Train Vac. (in. Hg)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Probe Temp, (°F)	Filter Cyclone Temp, (°F)	Notes
A-	1	10.00	0	253.600	N/A	71	242	2	62	0.56	325	321	3ml 1.6μm Nominal
	1	10.00	10	257.45	N/A	72	270	2	63	0.56	323	321	diluted to 30ml
	1	10.00	20	261.37	N/A	73	266	2	64	0.56	325	321	
	1	10.00	30	265.36	N/A	74	267	2	65	0.56	323	321	Rinse w/ 6ml's
			40	269.322									
													LAST 4 minutes
													DRY

Total Run Time	
Total Volume, ACF	

Averages							
							2.52
	in. H2O	°F	°F	in H2O	%		microns

Run	

3min Poly
Mins 10-13

Combined Cyclone PM10 & PM2.5 Run Data Sheet

SilicaSpheres

Run ID	API 1.0 µm Nominal/
Condition	1.4 µm Aero

IDENTIFICATION INFORMATION

Plant Name	API PM2.5 Lab Study
City	Cary
State	NC

Source Number	IX3 Box	Date	12/1/10
Sampling Location	Lab	Start	1013
Test Personnel	TTB PJJ	Stop	1053

Meterbox ID	909083
Δ H @	1.927
Gamma, γ	1.0206
Nozzle ID	API
Nozzle Diameter	3.173
Orsat/Fyrite	N/A

Filter ID	Tare
Q238	

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM	0.00		6

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	N/A	N/A
Pitot Tube Posttest Leak Check	N/A	N/A

Barometric Pressure, In.,Hg. 29.65
Static Pressure, In. W.C. 0.00

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams		Moisture, %	
CO_2 %		Md_run	
O_2 %		Mw_run	

Sampling Information / QA Checks

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Set 320 Chamber Temp., (°F)	Sample Train Vac. (in. Hg)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Probe Temp, (°F)	Filter Cyclone Temp, (°F)	Notes
A-	1	10.00	0	269.600	N/A	71	260	2	65	0.56	327	321	3ml 1.0 µm Nominal
	1	10.00	10	273.51	N/A	72	262	2	65	↓	327	321	diluted to 30ml
	1	10.00	20	277.27	N/A	72	261	2	64		327	320	
	1	10.00	30	381.25	N/A	73	263	2	63		327	321	Rinse w/6ml
			40	385.410									
													LAST 4 min dry

Total Run Time
Total Volume, ACF

Averages						
	in. H2O	°F	°F	in H2O	%	2.54 microns

Run

Poly 3mins
min 14-17

Polymer Spheres RUN #1

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	API 2.1 Nominal
Condition	2.2 μm Aero

IDENTIFICATION INFORMATION

Plant Name	API PM2.5 Lab Study
City	Cary
State	NC

Source Number	IX3 Box	Date	12/1/10
Sampling Location	Lab	Start	1400
Test Personnel	TTB PJJ	Stop	1440

Meterbox ID	909033
Δ H @	1.907
Gamma, γ	1.0226
Nozzle ID	
Nozzle Diameter	0.173
Orsat/Fyrite	—

Filter ID	Tare
Q237	

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM	0.000		5

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	N/A	N/A
Pitot Tube Posttest Leak Check	N/A	N/A

Barometric Pressure, In.,Hg.	29.65	Static Pressure, In. W.C.	0.00

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams		Moisture, %	
CO_2 %		Md_run	
O_2 %		Mw_run	

Sampling Information											QA Checks		
Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (in. H_2O)	Meter Temp. (°F)	SetAt 170 Chamber Temp., (°F)	Sample Train Vac. (in. Hg)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Probe Temp, (°F)	Filter Cyclone Temp, (°F)	Notes
A-	1	10.00	0	285.500	N/A	73	160	2	66	0.92	150	150	3mls Dilute to 30ml
	1	10.00	10	290.57	N/A	73	149	3	62		149	150	
	1	10.00	20	295.77	N/A	74	150	3	65		149	149	Rinse w/ 6mls
	1	10.00	30	300.96	N/A	75	152	3	65		149	150	
			40	306.148						↓			Last 4mins DRY

Total Run Time		
Total Volume, ACF		

Averages							1.80
	in. H2O	°F	°F	in H2O	%		microns

Run	

Polymer Spheres Run#2

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	API 2.1 Nominal
Condition	2.2 AE50

IDENTIFICATION INFORMATION

Plant Name	API PM2.5 Lab Study
City	Cary
State	NC

Source Number	IX3 Box	Date	12/2/10
Sampling Location	Lab	Start	930
Test Personnel	TTB PJJ	Stop	1010

Meterbox ID	98033
Δ H @	1.904
Gamma, γ	1.026
Nozzle ID	—
Nozzle Diameter	0.173
Orsat/Fyrite	—

Filter ID	Tare
Q246	

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM	0.000		10

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	N/A	N/A
Pitot Tube Posttest Leak Check	N/A	N/A

Barometric Pressure, In.,Hg.	29.65	Static Pressure, In. W.C.	0.00

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams		Moisture, %	
CO_2 %		Md_run	
O_2 %		Mw_run	

Sampling Information / QA Checks

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	SP 175 Chamber Temp., (°F)	Sample Train Vac. (in. Hg)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Probe Temp, (°F)	Filter Cyclone Temp, (°F)	Notes
A-	1	10.00	0	306.600	N/A	68	150	2	64	0.52	150	150	SAME AS PREVIOUS
	1	10.00	10	310.38	N/A	68	145	2	60	0.52	149	149	
	1	10.00	20	314.16	N/A	69	150	2	56	0.52	149	149	
	1	10.00	30	317.90	N/A	70	155	2	53	0.52	152	151	
			40	321.779									

Total Run Time	
Total Volume, ACF	

Averages							2.45
	in. H2O	°F	°F	in H2O	%		microns

Run	

Poly 3mins
15-17

RedOxide

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	API 0.8Nominal
Condition	1.7 AGO

IDENTIFICATION INFORMATION

Plant Name: API PM2.5 Lab Study
City: Cary
State: NC

Source Number: IX3 Box
Sampling Location: Lab
Test Personnel: TTB PJJ

Date: 12/2/10
Start: 1345
Stop: 1425

Meterbox ID: 79033
Δ H @: 1.907
Gamma, γ: 1.0206
Nozzle ID:
Nozzle Diameter: 0.173
Orsat/Fyrite:

Filter ID	Tare
Q241	

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM	0.000		6

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	N/A	N/A
Pitot Tube Posttest Leak Check	N/A	N/A

Barometric Pressure, In.,Hg. 29.65
Static Pressure, In. W.C. 0.00

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams		Moisture, %	
CO_2 %		Md_run	
O_2 %		Mw_run	

Sampling Information / QA Checks

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Set 320 Chamber Temp., (°F)	Sample Train Vac. (in. Hg)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Probe Temp, (°F)	Filter Cyclone Temp, (°F)	Notes
A-	1	10.00	0	339.000	N/A	71	283	2	66	0.56	320	320	Dry Impinges
	1	10.00	10	342.96	N/A	71	278	4	61	↓	323	320	Injection @ 20PSI
	1	10.00	20	346.82	N/A	71	276	5	64		323	321	↓
	1	10.00	30	350.81	N/A	73	276	6	65		324	321	PTO
			40	354.65									

Total Run Time
Total Volume, ACF

Averages: in. H2O; °F; °F; in H2O; %; 2.53 microns

Run

VOLUME IV

Appendix C – Calibration Data

APEX INSTRUMENTS METHOD 5 PRE-TEST CONSOLE CALIBRATION
USING CALIBRATED CRITICAL ORIFICES
5-POINT ENGLISH UNITS

Meter Console Information	
Console Model Number	522
Console Serial Number	909033
DGM Model Number	RW 110
DGM Serial Number	328893

Calibration Conditions			
Date	Time	02/01/10	
Barometric Pressure		29.80	in Hg
Theoretical Critical Vacuum[1]		14.07	in Hg
Calibration Technician		DLS	

Factors/Conversions		
Std Temp	528	°R
Std Press	29.92	in Hg
K_1	17.647	oR/in Hg

[1] For valid test results, the Actual Vacuum should be 1 to 2 in. Hg greater than the Theoretical Critical Vacuum shown above.

[2] The Critical Orifice Coefficient, K', must be entered in English units, $(ft^3 \cdot {}^\circ R^{1/2})/(in.Hg \cdot min)$.

Calibration Data										
Run Time	Metering Console					Critical Orifice				
Elapsed	DGM Orifice ΔH	Volume Initial	Volume Final	Outlet Temp Initial	Outlet Temp Final	Serial Number	Coefficient	Amb Temp Initial	Amb Temp Final	Actual Vacuum
(Θ)	(P_m)	(V_{mi})	(V_{mf})	(t_{mi})	(t_{mf})		K'	(t_{amb})	(t_{amb})	
min	in H_2O	cubic feet	cubic feet	°F	°F		see above2	°F	°F	in Hg
18.5	0.34	607.140	612.801	73	73	FO 40	0.2387	68	68	24
12.5	0.71	612.900	618.490	72	72	FO 48	0.3483	68	68	22
9.5	1.20	618.630	624.231	72	72	FO 55	0.4592	68	68	21
7.5	1.95	624.340	630.014	72	72	FO 63	0.5907	68	68	19
5.5	3.60	630.150	635.817	72	72	FO 73	0.8085	68	68	17

Results								
Standardized Data				Dry Gas Meter				
Dry Gas Meter		Critical Orifice		Calibration Factor		Flowrate	ΔH @	
				Value	Variation	Std & Corr	0.75 SCFM	Variation
$(V_{m(std)})$	$(Q_{m(std)})$	$(Vcr_{(std)})$	$(Q_{cr(std)})$	(Y)	(ΔY)	$(Q_{m(std)(corr)})$	(ΔH@)	(ΔΔH@)
cubic feet	cfm	cubic feet	cfm			cfm	in H2O	
5.590	0.302	5.727	0.310	1.024	0.004	0.310	1.974	0.067
5.535	0.443	5.646	0.452	1.020	-0.001	0.452	1.943	0.037
5.553	0.585	5.658	0.596	1.019	-0.002	0.596	1.894	-0.012
5.636	0.751	5.745	0.766	1.019	-0.001	0.766	1.867	-0.040
5.652	1.028	5.767	1.049	1.020	0.000	1.049	1.855	-0.052
				1.0206	Y Average		1.907	ΔH@ Average

Note: For Calibration Factor Y, the ratio of the reading of the calibration meter to the dry gas meter, acceptable tolerance of individual values from the average is +-0.02.

I certify that the above Dry Gas Meter was calibrated in accordance with USEPA Methods, CFR Title 40, Part 60, Appendix A-3, Method 5, 16.2.3

Signature ______________ Date 2-01-10

APEX INSTRUMENTS METHOD 5 PRE-TEST CONSOLE CALIBRATION
USING CALIBRATED CRITICAL ORIFICES
5-POINT ENGLISH UNITS

Meter Console Information	
Console Model Number	522
Console Serial Number	802012
DGM Model Number	RW 110
DGM Serial Number	964447

Calibration Conditions			
Date	Time	01/28/10	
Barometric Pressure		29.60	in Hg
Theoretical Critical Vacuum[1]		13.97	in Hg
Calibration Technician		DLS	

Factors/Conversions		
Std Temp	528	°R
Std Press	29.92	in Hg
K_1	17.647	oR/in Hg

[1] For valid test results, the Actual Vacuum should be 1 to 2 in. Hg greater than the Theoretical Critical Vacuum shown above.

[2] The Critical Orifice Coefficient, K', must be entered in English units, $(ft^3 \cdot {}^{\circ}R^{1/2})/(in.Hg \cdot min)$.

Calibration Data										
Run Time	Metering Console					Critical Orifice				
Elapsed	DGM Orifice ΔH	Volume Initial	Volume Final	Outlet Temp Initial	Outlet Temp Final	Serial Number	Coefficient	Amb Temp Initial	Amb Temp Final	Actual Vacuum
(Θ)	(P_m)	(V_{mi})	(V_{mf})	(t_{mi})	(t_{mf})		K'	(t_{amb})	(t_{amb})	
min	in H_2O	cubic feet	cubic feet	°F	°F		see above2	°F	°F	in Hg
18.0	0.25	301.230	307.074	71	72	FO 40	0.2387	66	66	23
11.5	0.56	307.200	312.656	72	73	FO 48	0.3483	66	66	22
9.5	1.00	313.040	319.004	73	73	FO 55	0.4592	66	66	20
7.5	1.65	319.310	325.386	73	73	FO 63	0.5907	66	66	18
5.5	3.15	325.700	331.795	73	74	FO 73	0.8085	66	66	16

Results								
Standardized Data				Dry Gas Meter				
Dry Gas Meter		Critical Orifice		Calibration Factor		Flowrate	ΔH @	
				Value	Variation	Std & Corr	0.75 SCFM	Variation
$(V_{m(std)})$	$(Q_{m(std)})$	$(Vcr_{(std)})$	$(Q_{cr(std)})$	(Y)	(ΔY)	$(Q_{m(std)(corr)})$	(ΔH@)	(ΔΔH@)
cubic feet	cfm	cubic feet	cfm			cfm	in H2O	
5.747	0.319	5.545	0.308	0.9649	0.005	0.308	1.459	-0.095
5.359	0.466	5.170	0.450	0.9646	0.004	0.450	1.535	-0.020
5.859	0.617	5.630	0.593	0.9609	0.001	0.593	1.579	0.024
5.979	0.797	5.718	0.762	0.9563	-0.004	0.762	1.579	0.025
6.014	1.094	5.739	1.043	0.9542	-0.006	1.043	1.620	0.065
				0.9602	Y Average		1.554	ΔH@ Average

Note: For Calibration Factor Y, the ratio of the reading of the calibration meter to the dry gas meter, acceptable tolerance of individual values from the average is +-0.02.

I certify that the above Dry Gas Meter was calibrated in accordance with USEPA Methods, CFR Title 40, Part 60, Appendix A-3, Method 5, 16.2.3

Signature

Date 1-28-10

APEX INSTRUMENTS METHOD 5 POST-TEST CONSOLE CALIBRATION
USING CALIBRATED CRITICAL ORIFICES
3-POINT ENGLISH UNITS

Meter Console Information	
Console Model Number	522
Console Serial Number	802012
DGM Model Number	RW 110
DGM Serial Number	964447

Calibration Conditions			
Date	Time	12/01/10	
Barometric Pressure		29.70	in Hg
Theoretical Critical Vacuum[1]		14.0	in Hg
Calibration Technician		DLS	

Factors/Conversions		
Std Temp	528	°R
Std Press	29.92	in Hg
K_1	17.647	oR/in Hg

[1] For valid test results, the Actual Vacuum should be 1 to 2 in. Hg greater than the Theoretical Critical Vacuum shown above.

[2] The Critical Orifice Coefficient, K', must be entered in English units, $(ft^3 \cdot {}^\circ R^{1/2})/(in.Hg \cdot min)$.

Calibration Data										
Run Time	Metering Console						Critical Orifice			
Elapsed	DGM Orifice ΔH	Volume Initial	Volume Final	Outlet Temp Initial	Outlet Temp Final	Serial Number	Coefficient	Amb Temp Initial	Amb Temp Final	Actual Vacuum
(Θ)	(P_m)	(V_{mi})	(V_{mf})	(t_{mi})	(t_{mf})		K'	(t_{amb})	(t_{amb})	
min	in H_2O	cubic feet	cubic feet	°F	°F		see above2	°F	°F	in Hg
9.0	0.98	809.800	815.543	74	74	FO 55	0.4592	68	68	20.50
9.0	0.98	815.543	821.300	74	75	FO 55	0.4592	68	68	20.50
9.0	0.98	821.300	827.061	75	75	FO 55	0.4592	68	68	20.50

Results									
Standardized Data				Dry Gas Meter					
				Calibration Factor		Flowrate	ΔH @		
Dry Gas Meter		Critical Orifice		Value	Variation	Std & Corr	0.75 SCFM	Variation	
$(V_{m(std)})$	$(Q_{m(std)})$	$(Vcr_{(std)})$	$(Q_{cr(std)})$	(Y)	(ΔY)	$(Q_{m(std)(corr)})$	(ΔH@)	(ΔΔH@)	
cubic feet	cfm	cubic feet	cfm			cfm	in H2O		
5.650	0.628	5.342	0.594	0.945	0.001	0.594	1.545	0.001	
5.659	0.629	5.342	0.594	0.944	-0.001	0.594	1.543	0.000	
5.658	0.629	5.342	0.594	0.944	0.000	0.594	1.542	-0.001	
Pretest Gamma	0.9602	% Deviation	1.6	0.945	Y Average		1.543	ΔH@ Average	

Note: For Calibration Factor Y, the ratio of the reading of the calibration meter to the dry gas meter, acceptable tolerance of individual values from the average is +-0.02.

I certify that the above Dry Gas Meter was calibrated in accordance with USEPA Methods, CFR Title 40, Part 60, Appendix A-3, Method 5, 16.2.3

Signature ____________ Date 12-01-10

APEX INSTRUMENTS METHOD 5 POST-TEST CONSOLE CALIBRATION
USING CALIBRATED CRITICAL ORIFICES
3-POINT ENGLISH UNITS

Meter Console Information	
Console Model Number	522
Console Serial Number	909033
DGM Model Number	RW 110
DGM Serial Number	328893

Calibration Conditions			
Date	Time	12/02/10	
Barometric Pressure		30.00	in Hg
Theoretical Critical Vacuum[1]		14.2	in Hg
Calibration Technician		DLS	

Factors/Conversions		
Std Temp	528	°R
Std Press	29.92	in Hg
K_1	17.647	oR/in Hg

[1] For valid test results, the Actual Vacuum should be 1 to 2 in. Hg greater than the Theoretical Critical Vacuum shown above.

[2] The Critical Orifice Coefficient, K', must be entered in English units, $(ft^3 \cdot °R^{1/2})/(in.Hg*min)$.

Calibration Data										
Run Time	Metering Console					Critical Orifice				
Elapsed	DGM Orifice ΔH	Volume Initial	Volume Final	Outlet Temp Initial	Outlet Temp Final	Serial Number	Coefficient	Amb Temp Initial	Amb Temp Final	Actual Vacuum
(Θ)	(P_m)	(V_{mi})	(V_{mf})	(t_{mi})	(t_{mf})		K'	(t_{amb})	(t_{amb})	
min	in H_2O	cubic feet	cubic feet	°F	°F		see above2	°F	°F	in Hg
17.5	0.34	396.370	401.727	69	70	FO 40	0.2387	64	64	24.00
17.5	0.34	401.727	407.078	70	69	FO 40	0.2387	64	64	24.00
17.5	0.34	407.078	412.435	69	69	FO 40	0.2387	64	64	24.00

Results									
Standardized Data				Dry Gas Meter					
Dry Gas Meter		Critical Orifice		Calibration Factor		Flowrate	ΔH @	
				Value	Variation	Std & Corr	0.75 SCFM	Variation
$(V_{m(std)})$	$(Q_{m(std)})$	$(Vcr_{(std)})$	$(Q_{cr(std)})$	(Y)	(ΔY)	$(Q_{m(std)(corr)})$	(ΔH@)	(ΔΔH@)
cubic feet	cfm	cubic feet	cfm			cfm	in H2O	
5.361	0.306	5.475	0.313	1.021	0.000	0.313	1.959	-0.001
5.355	0.306	5.475	0.313	1.022	0.001	0.313	1.959	-0.001
5.366	0.307	5.475	0.313	1.020	-0.001	0.313	1.961	0.001
Pretest Gamma	1.0206	% Deviation	0.1	1.021	Y Average		1.959	ΔH@ Average

Note: For Calibration Factor Y, the ratio of the reading of the calibration meter to the dry gas meter, acceptable tolerance of individual values from the average is +-0.02.

I certify that the above Dry Gas Meter was calibrated in accordance with USEPA Methods, CFR Title 40, Part 60, Appendix A-3, Method 5, 16.2.3

Signature ____________ Date 12-02-10

VOLUME IV

Appendix D – Analytical Data

Silica 1.44 Aerodynamic or 1.0 Nominal

10/28/2010 Test Run	No Nozzle Probe Only	Greater Than 2.5 Rinse	Less Than 2.5 Rinse	Filter Less Than 2.5	Run Cut Size, microns	
					2.26	
Final Wt.	3.5494	3.7292	4.0843	0.1299		
Initial Wt.	3.5358	3.7257	4.0812	0.1131		Total
	13.6	3.5	3.1	16.8		37.0
% of Total	37%	9%	8%	45%	100%	
	For 1 micron spheres				Greater Than %	46%
	Aerodynamic Diameter		1.44		Less Than %	54%

Silica 1.44 Aerodynamic or 1.0 Nominal

12/1/2010 Test Run	Probe & Nozzle Rinse	Front 1/2 Cyclone Greater Than 2.5 Rinse	Back 1/2 Cyclone Front 1/2 Filter Holder Less Than 2.5 Rinse	Filter Less Than 2.5	Run Cut Size, microns	
Bag #	134	N/A	A12	Q238	2.57	
Final Wt.	3.8676	3.5011	3.5382	0.1189		
Initial Wt.	3.8625	3.4926	3.5374	0.1106	Total	
	5.1	8.5	0.8	8.3	22.7	
% of Total	22%	37%	4%	37%	100%	
	For 1 micron spheres				Greater Than %	60%
	Aerodynamic Diameter		1.44		Less Than %	40%

Silica 2.2 Aerodynamic or 1.5 Nominal

11/30/2010 Test Run	Nozzle Rinse	Probe Front 1/2 Cyclone Greater Than 2.5 Rinse	Back 1/2 Cyclone Front 1/2 Filter Holder Less Than 2.5 Rinse	Filter Less Than 2.5	Run Cut Size, microns	
Bag #	160	A38	N/A	Q237	2.59	
Final Wt.	3.6629	3.3944	3.7736	0.117		
Initial Wt.	3.6614	3.3889	3.7718	0.1163	Total	
	1.5	5.5	1.8	0.7	9.5	
% of Total	16%	58%	19%	7%	100%	
	O-ring was broken tried to remove pieces from rinse, may be heavy.					
	For 1.5 micron spheres				Greater Than %	74%
	Aerodynamic Diameter		2.16		Less Than %	26%

Polymer 2.2 Aerodynamic or 2.1 Nominal RUN # 2

12/2/2010 Test Run	Probe & Nozzle Rinse	Front 1/2 Cyclone Greater Than 2.5 Rinse	Back 1/2 Cyclone Front 1/2 Filter Holder Less Than 2.5 Rinse	Filter Less Than 2.5	Run Cut Size, microns	
Bag #	A99	A8	33	Q240		
Final Wt.	3.531	3.6941	3.6993	0.1187	2.45	
Initial Wt.	3.4999	3.6301	3.699	0.1148	Total	
	31.1	64	0.3	3.9	99.3	
% of Total	31%	64%	0%	4%	100%	
	For 3.0 micron spheres				Greater Than %	96%
	Aerodynamic Diameter		2.18		Less Than %	4%

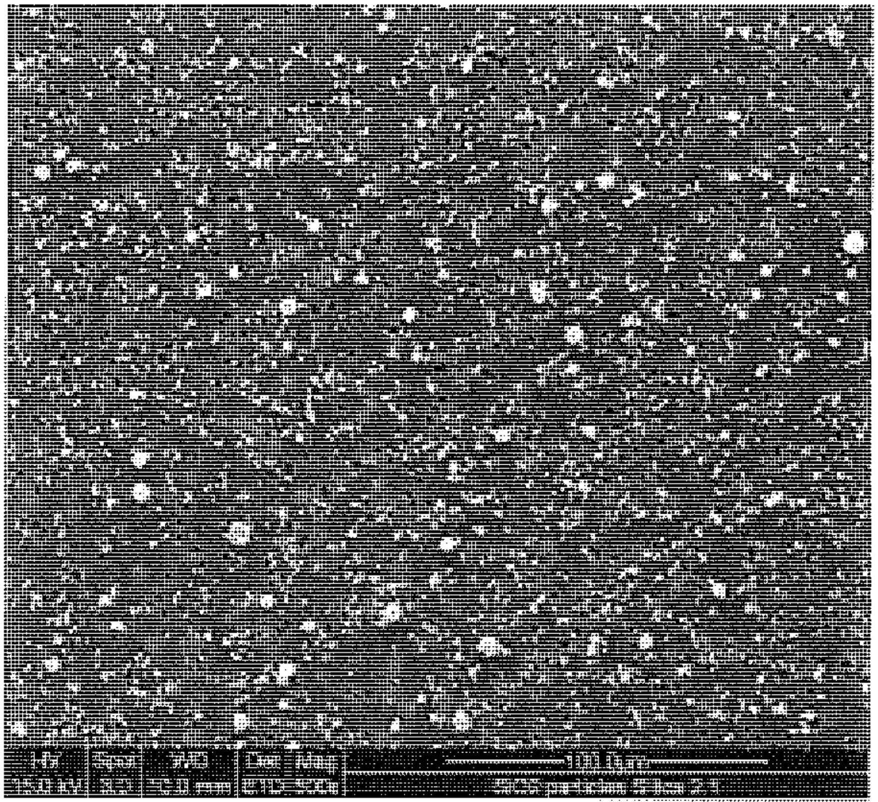
12/1/2010 Test Run	Probe & Nozzle Rinse	Front 1/2 Cyclone Greater Than 2.5 Rinse	Back 1/2 Cyclone Front 1/2 Filter Holder Less Than 2.5 Rinse	Filter Less Than 2.5	Run Cut Size, microns	
Bag #	8	N/A	A49	Q239	1.80	
Final Wt.	4.1326	3.5145	3.4935	0.1183	Run cut too Sharp	
Initial Wt.	4.0814	3.4364	3.4923	0.1171	Total	
	51.2	78.1	1.2	1.2	131.7	
% of Total	39%	59%	1%	1%	100%	
	For 3.0 micron spheres				Greater Than %	98%
	Aerodynamic Diameter		2.18		Less Than %	2%

Red Oxide 1.7 Aerodynamic or 0.8 Nominal

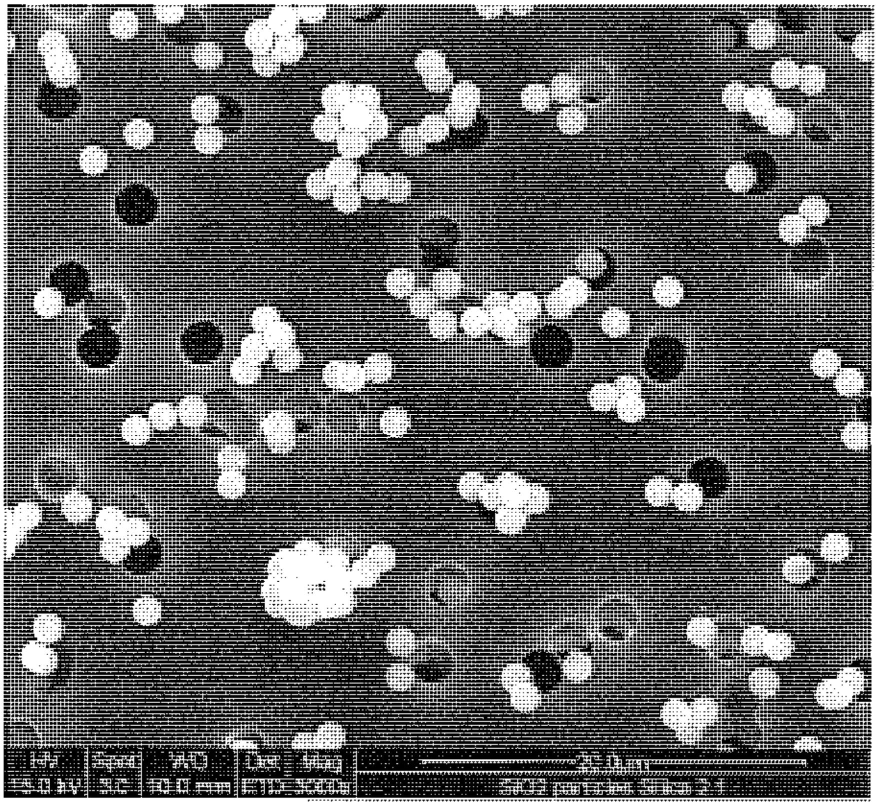
11/30/2010 Test Run	Probe & Nozzle Rinse	Front 1/2 Cyclone Greater Than 2.5 Rinse	Back 1/2 Cyclone Front 1/2 Filter Holder Less Than 2.5 Rinse	Filter Less Than 2.5	Run Cut Size, microns	
Bag #	49	45	A15	Q241	2.59	
Final Wt.	3.788	4.1082	3.6831	0.1663		
Initial Wt.	3.7267	4.0166	3.6804	0.1111	Total	
	61.3	91.6	2.7	55.2	210.8	
% of Total	29%	43%	1%	26%	100%	
	For 1.5 micron spheres				Greater Than %	73%
	Aerodynamic Diameter		1.70		Less Than %	27%

VOLUME IV

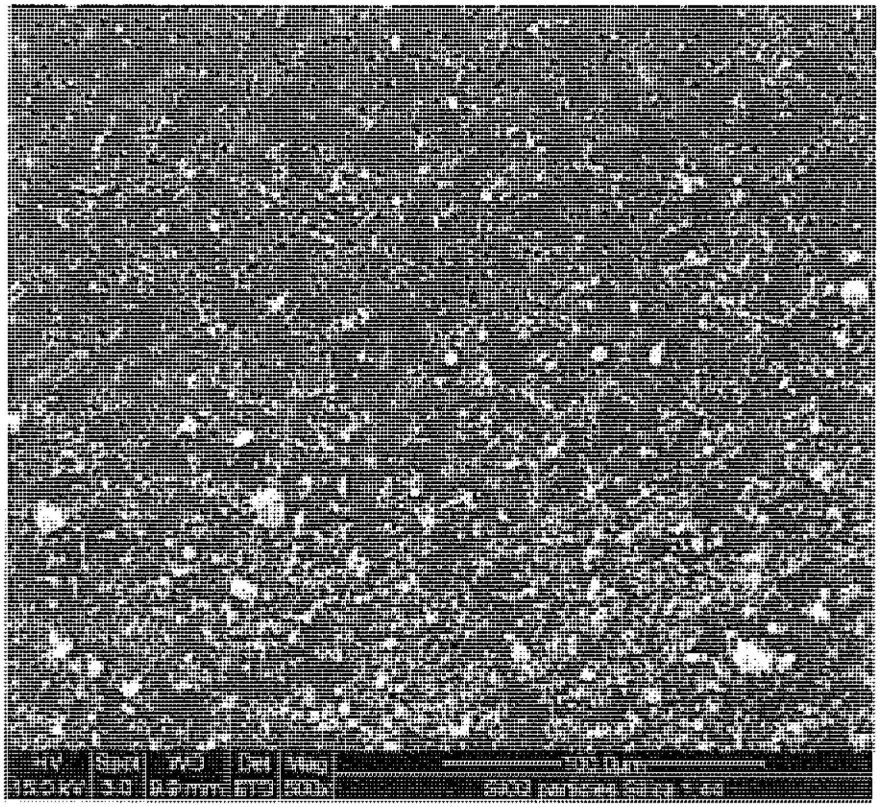
Appendix E – Research Triangle Institute Report



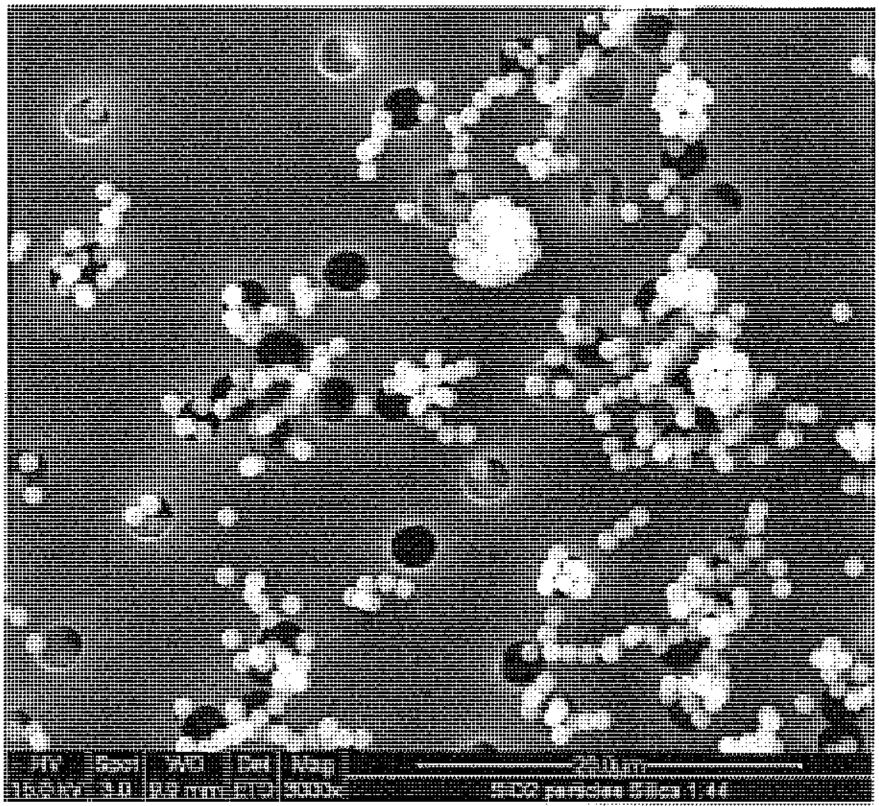
Sample 1A, 2.1 Micron Silica Microspheres



Sample 1B, 2.1 Micron Silica Microspheres



Sample 2A, 1.44 Micron Silica Microspheres



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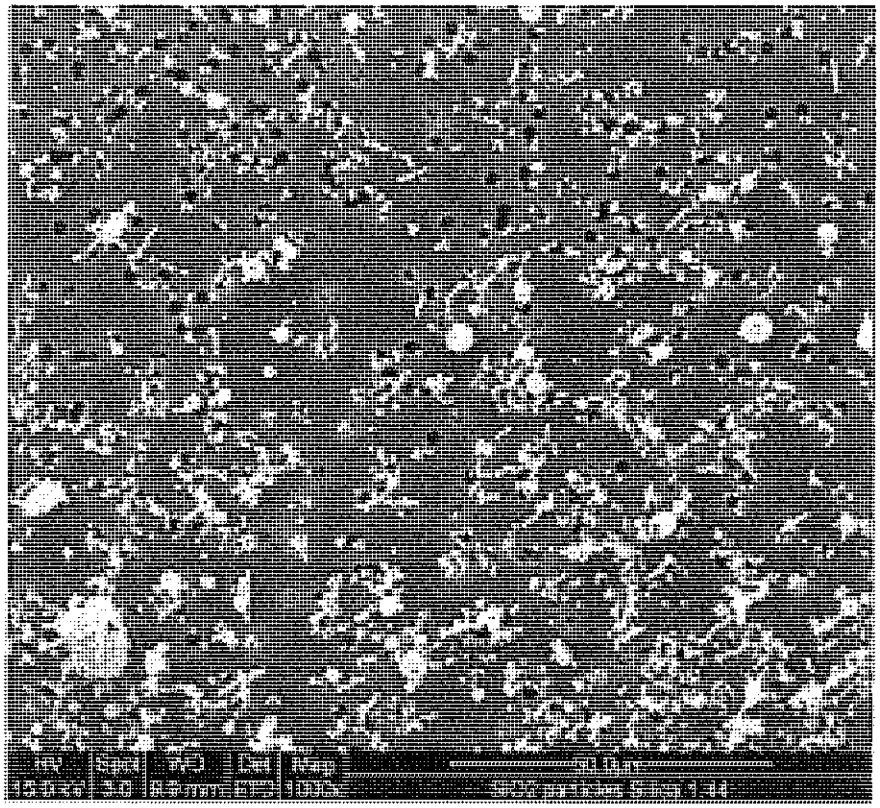
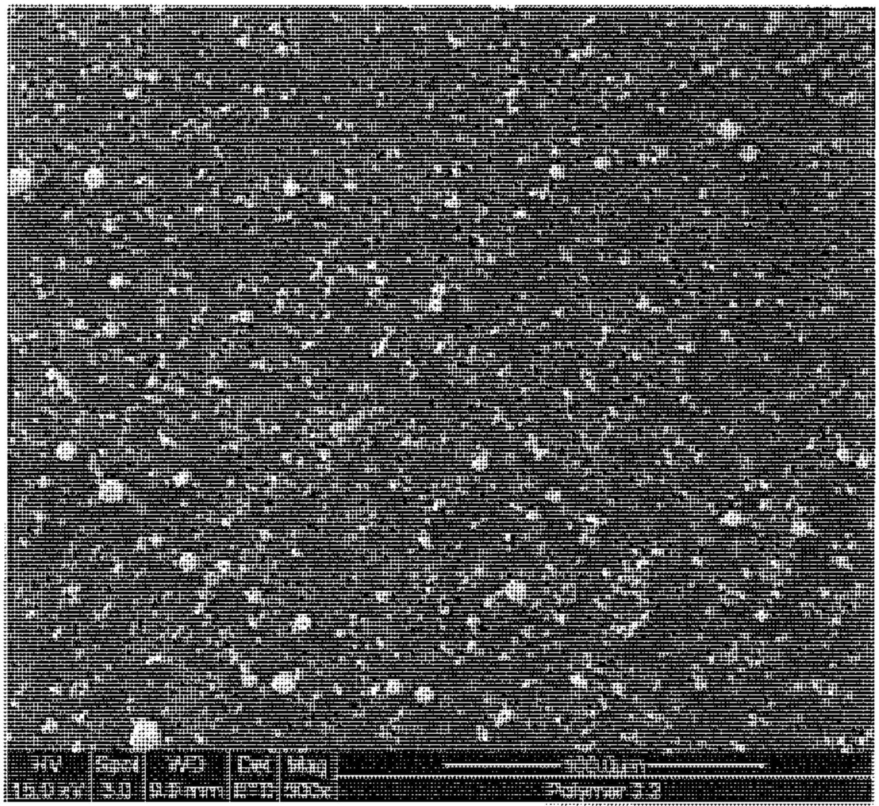
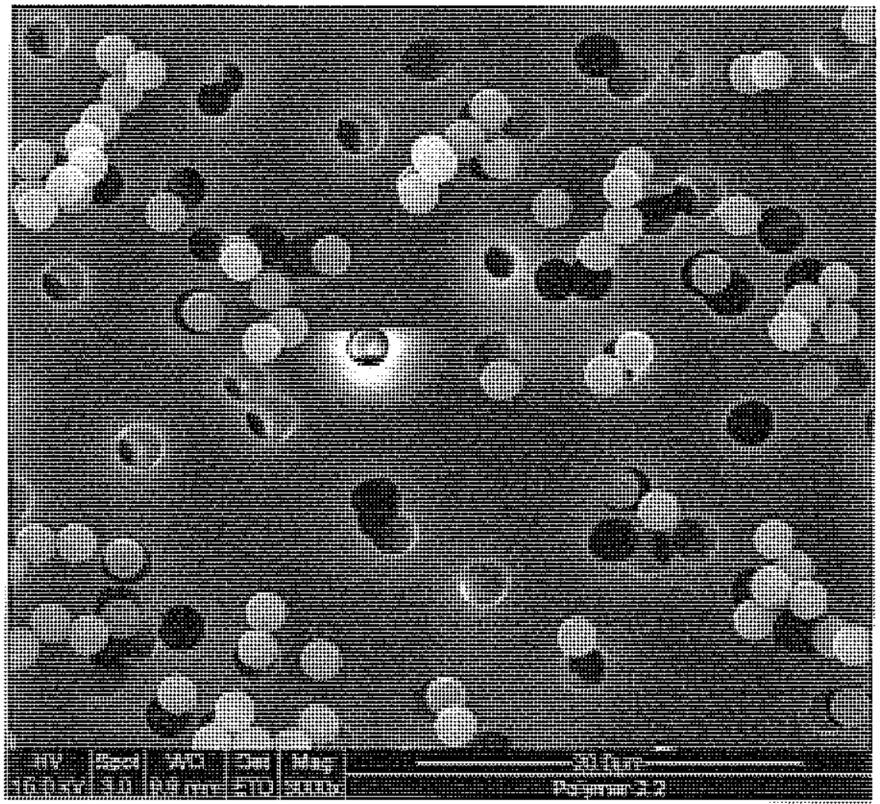


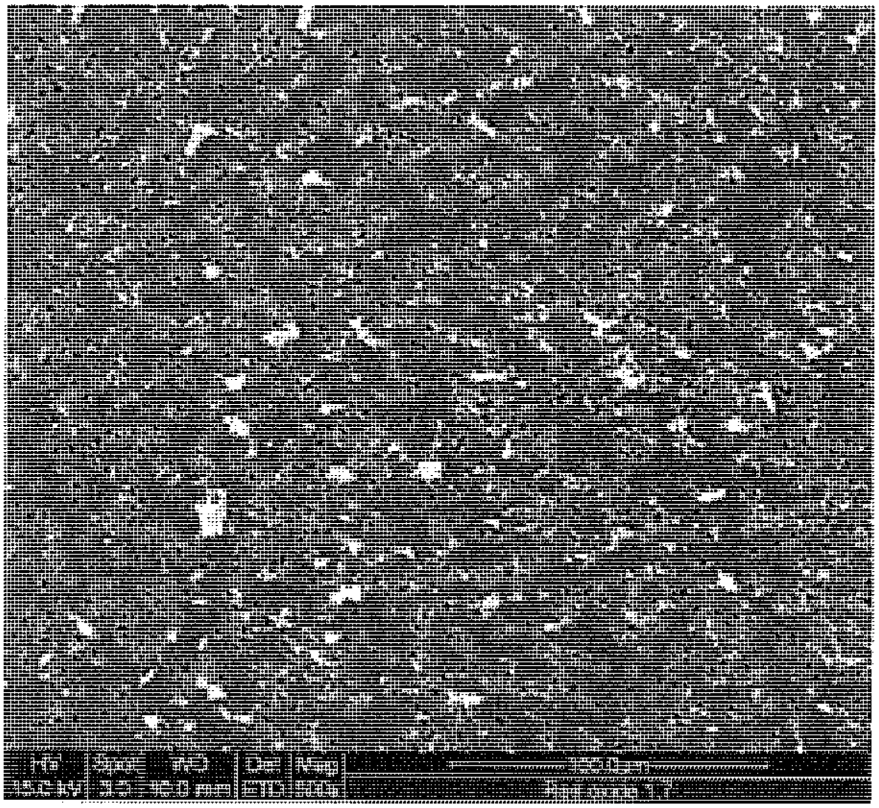
Sample 2C, 1.44 Micron Silica Microspheres



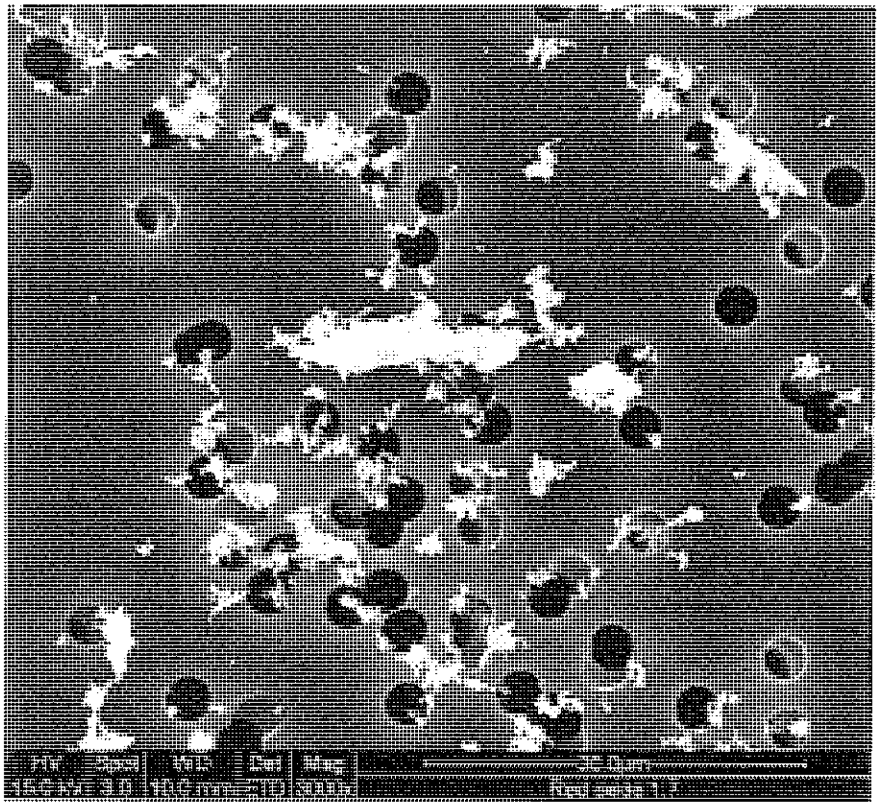
Sample 3A, 2.2 Micron Polymer Microspheres



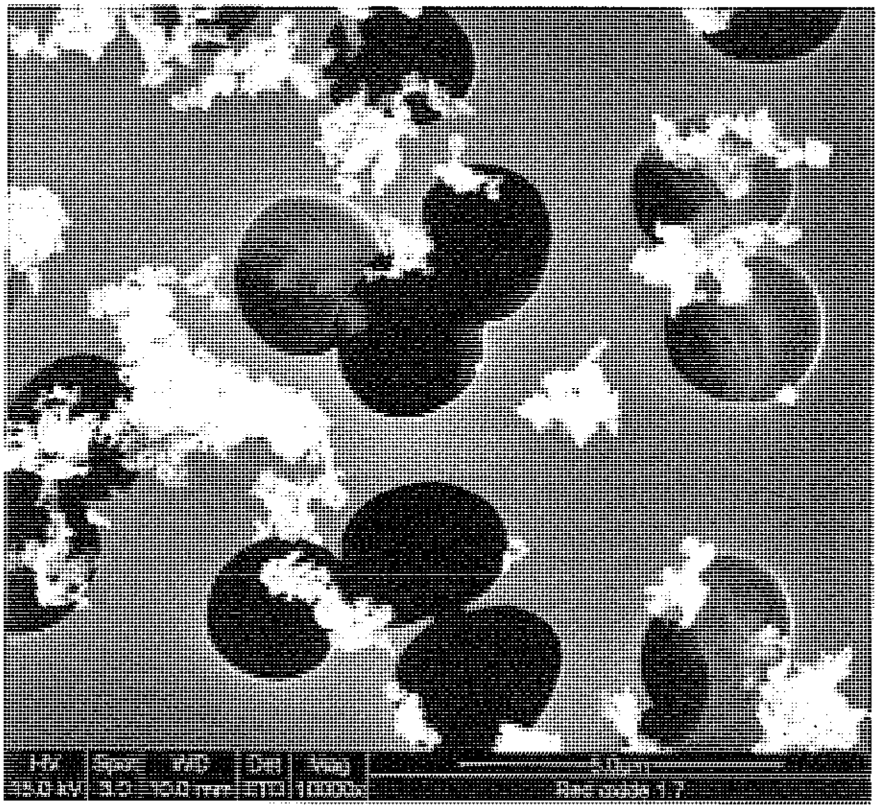
Sample 3B, 2.2 Micron Polymer Microspheres



Sample 4A, 1.7 Micron Red Oxide



Sample 4B, 1.7 Micron Red Oxide



Sample 4C, 1.7 Micron Red Oxide

Equivalent Aerodynamic Diameters of Sphere Clusters

Microsphere Sizes, in Micrometers, Aerodynamic

2.2 (Aerodynamic)

Silica Spheres

Number of Spheres	Mass	Equivalent Diameter
1	5.6	2.2
2	11.1	2.7
3	16.7	3.1
4	22.3	3.4
5	27.9	3.7
6	33.4	3.9
7	39.0	4.1
8	44.6	4.3
9	50.2	4.5
10	55.7	4.7
11	61.3	4.8
12	66.9	5.0
13	72.4	5.1
14	78.0	5.2
15	83.6	5.3
16	89.2	5.4

1.44 (Aerodynamic)

Silica Spheres

Number of Spheres	Mass	Equivalent Diameter
1	1.6	1.4
2	3.1	1.8
3	4.7	2.1
4	6.3	2.3
5	7.8	2.4
6	9.4	2.6
7	10.9	2.7
8	12.5	2.8
9	14.1	3.0
10	15.6	3.1
11	17.2	3.2
12	18.8	3.3
13	20.3	3.3
14	21.9	3.4
15	23.4	3.5
16	25.0	3.6

2.16 (Aerodynamic)

Polymer Spheres

Number of Spheres	Mass	Equivalent Diameter
1	5.3	2.1
2	10.5	2.7
3	15.8	3.1
4	21.1	3.4
5	26.4	3.6
6	31.6	3.9
7	36.9	4.1
8	42.2	4.3
9	47.5	4.4
10	52.7	4.6
11	58.0	4.7
12	63.3	4.9
13	68.6	5.0
14	73.8	5.1
15	79.1	5.2
16	84.4	5.4

1.7 (Aerodynamic)

Red Iron Oxide Particles

Number of Spheres	Mass	Equivalent Diameter
1	2.6	1.7
2	5.1	2.1
3	7.7	2.4
4	10.3	2.7
5	12.9	2.9
6	15.4	3.1
7	18.0	3.2
8	20.6	3.4
9	23.1	3.5
10	25.7	3.6
11	28.3	3.7
12	30.9	3.8
13	33.4	3.9
14	36.0	4.0
15	38.6	4.1
16	41.1	4.2

2.20 Silica Spheres

Number of Spheres in Cluster	Number of Clusters Counted	Total Number of Spheres	Equivalent Mass	Equivalent Diameter	Penetration Efficiency	Captured Spheres
1	214	214	5.57	2.18	70	149.8
2	59	118	11.14	2.74	32	37.76
3	32	96	16.72	3.14	15	14.4
4	22	88	22.29	3.45	10	8.8
5	8	40	27.86	3.71	7	2.8
6	5	30	33.43	3.94	5	1.5
7	1	7	39.01	4.15	4	0.28
8	2	16	44.58	4.34	4	0.64
9	2	18	50.15	4.51	3	0.54
10	3	30	55.72	4.67	3	0.9
11	0	0	61.30	4.82	2	0
12	1	12	66.87	4.96	2	0.24
Total Count	349	669				217.66
		% of Aerosol Anticipated in PM2.5 Fraction				0.33

1.44 Silica Microspheres

Number of Spheres in Cluster	Number of Clusters Counted	Total Number of Spheres	Equivalent Mass	Equivalent Diameter	Penetration Efficiency	Captured Spheres
1	156	156	1.56	1.43	97	151.32
2	71	142	3.13	1.80	92	130.64
3	69	207	4.69	2.06	80	165.6
4	34	136	6.25	2.27	65	88.4
5	32	160	7.81	2.44	52	83.2
6	24	144	9.38	2.59	48	69.12
7	23	161	10.94	2.73	31	49.91
8	15	120	12.50	2.85	22	26.4
9	14	126	14.06	2.96	17	21.42
10	10	100	15.63	3.07	15	15
11	12	132	17.19	3.17	12	15.84
12	18	216	18.75	3.26	10	21.6
16	17	272	25.00	3.58	6	16.32
		2072				854.77
		% of Aerosol Anticipated in PM2.5 Fraction				0.41

2.16 Polymer Microspheres

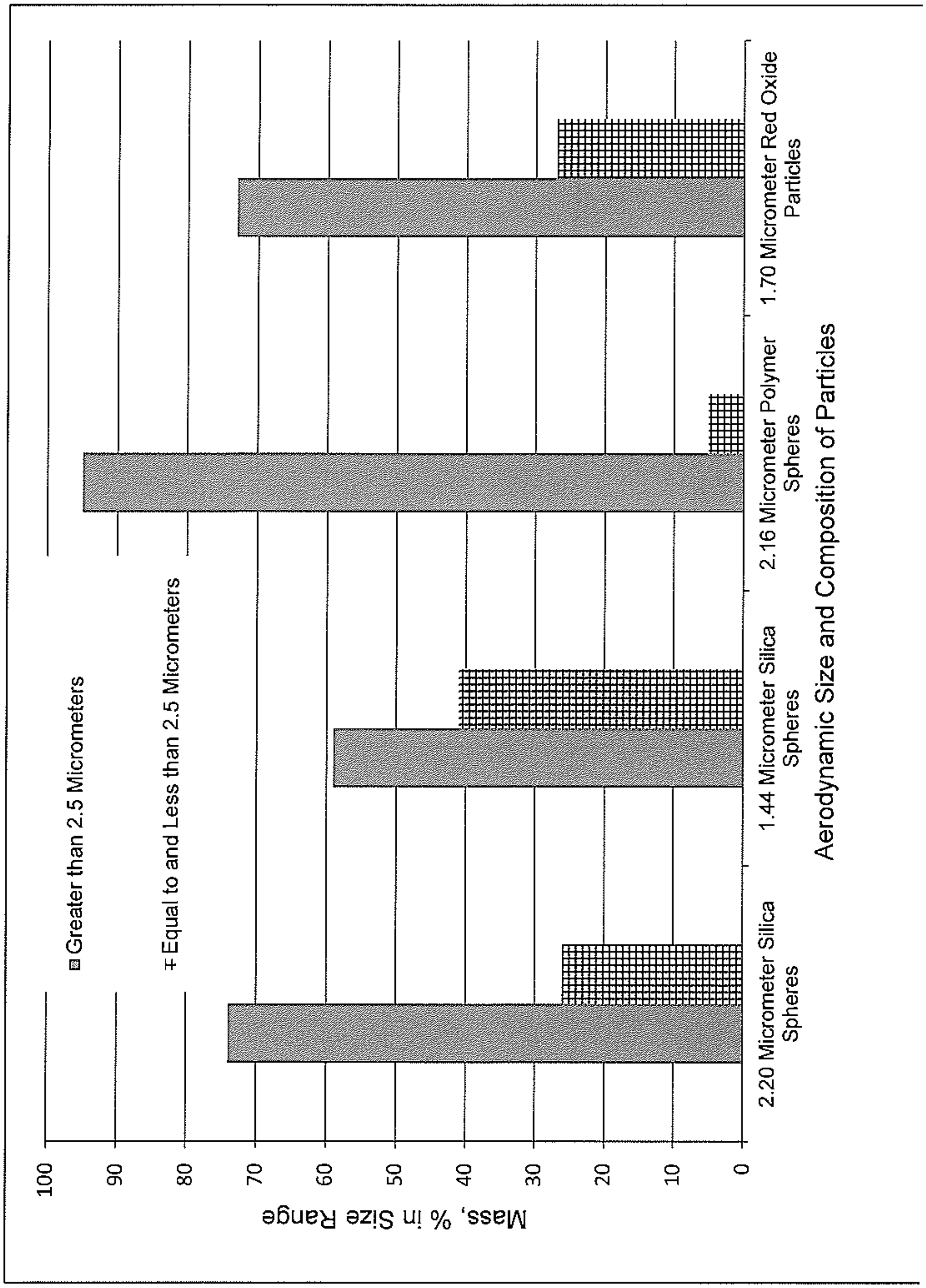
Number of Spheres in Cluster	Number of Clusters Counted	Total Number of Spheres	Equivalent Mass	Equivalent Diameter	Penetration Efficiency	Captured Spheres
1	44	44	5.27	2.14	70	30.8
2	18	36	10.55	2.69	32	11.52
3	11	33	15.82	3.08	15	4.95
4	7	28	21.10	3.39	10	2.8
5	6	30	26.37	3.65	7	2.1
6	5	30	31.64	3.87	5	1.5
7	7	35	36.92	4.07	4	1.4
8	3	24	42.19	4.26	4	0.96
9	1	9	47.47	4.43	3	0.27
10	1	10	52.74	4.58	3	0.3
11	2	22	58.01	4.73	2	0.44
12	1	12	63.29	4.87	2	0.24
16	0	0	84.38	5.00	2	0
		313				57.28
		% of Aerosol Anticipated in PM2.5 Fraction				0.18

1.70 Red Iron Oxide Particles

Group	Estimated Average Number of Particles in Cluster	Total Number of Clusters Counted	Total Number of Particles	Equivalent Mass	Equivalent Diameter	Penetration Efficiency	Particles in PM2.5 Catch
1	1	29	29	1.69	1.7	93	26.97
2	3	19	57	5.07	2.7	30	17.10
3	8	19	152	13.53	3.6	6	9.12
4	20	12	240	33.82	Large	0	0.00
			478.00	54.11			53.19
			% of Aerosol Anticipated in PM2.5 Fraction				0.11

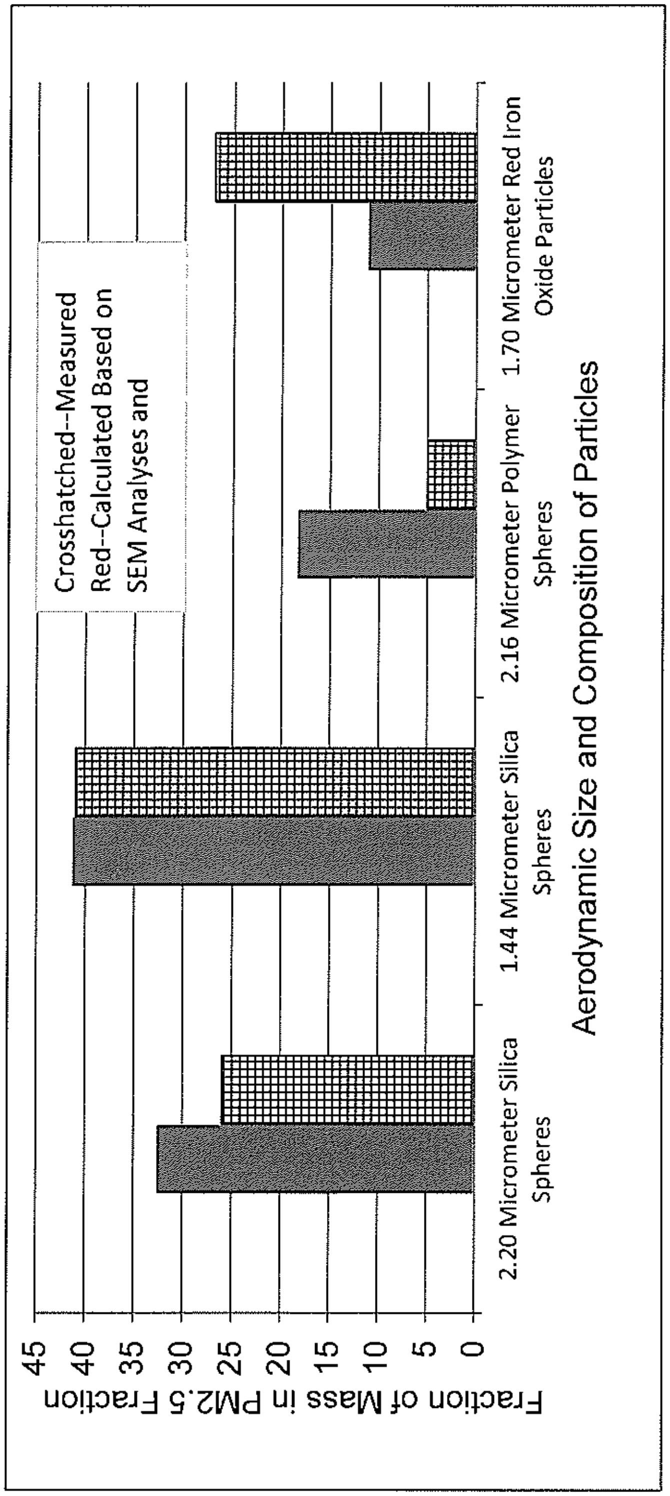
Lab Test Mass Recovery Values

Aerodynamic Diameter and Material	Greater than 2.5 Micrometers	Equal to and Less than 2.5 Micrometers
2.20 Micrometer Silica Spheres	74	26
1.44 Micrometer Silica Spheres	59	41
2.16 Micrometer Polymer Spheres	95	5
1.70 Micrometer Red Iron Oxide P	73	27


■ Greater than 2.5 Micrometers
▦ Equal to and Less than 2.5 Micrometers
Mass, % in Size Range
100
90
80
70
60
50
40
30
20
10
0
2.20 Micrometer Silica Spheres
1.44 Micrometer Silica Spheres
2.16 Micrometer Polymer Spheres
1.70 Micrometer Red Oxide Particles
Aerodynamic Size and Composition of Particles

Comparison of Estimated and Measured PM2.5 Fractions

Aerodynamic Diameter and Materi	Expected PM2.5 Mass Fraction	Measured PM2.5 Mass Fraction
2.20 Micrometer Silica Spheres	33	26
1.44 Micrometer Silica Spheres	41	41
2.16 Micrometer Polymer Spheres	18	5
1.70 Micrometer Red Iron Oxide P	11	27


Crosshatched--Measured
Red--Calculated Based on SEM Analyses and
Fraction of Mass in PM2.5 Fraction
45
40
35
30
25
20
15
10
5
0
2.20 Micrometer Silica Spheres
1.44 Micrometer Silica Spheres
2.16 Micrometer Polymer Spheres
1.70 Micrometer Red Iron Oxide Particles
Aerodynamic Size and Composition of Particles

Appendix C

Method 301 Test Protocol

October 15, 2012

API WET STACK FILTERABLE $PM_{2.5}$ TEST METHOD
METHOD 301 VALIDATION TEST PROGRAM PROTOCOL

Prepared for:

American Petroleum Institute
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Washington, D.C. 20005-4070

Prepared by:

Air Control Techniques, P.C.
301 E. Durham Road
Cary, North Carolina 27513

October 15, 2012

TABLE OF CONTENTS

Page Number

TABLES

FIGURES

1. PROJECT PURPOSE AND BACKGROUND

1.1 Limitations of Available Test Methods for Filterable $PM_{2.5}$

American Petroleum Institute (API) member companies will be required to measure and report $PM_{2.5}$ emissions from fluidized catalytic cracking units (FCCUs). The EPA reference methods designed to measure $PM_{2.5}$ emissions are Method 201A for filterable $PM_{2.5}$ and Method 202 for condensable $PM_{2.5}$. Method 201A cannot be used in saturated or droplet-laden gas streams because of (1) a potential bias to lower-than-true PM_{10} emissions caused by the sizes of the droplets entering the probe and (2) problems caused by large water droplets on the cyclone walls. EPA states the rationale for this limitation to Method 201A in the following statement posted on the EPA EMC website (www.epa.gov/ttn/EMC).

> Method 201A cannot be used to measure emissions from stacks that have entrained moisture droplets (e.g., a wet scrubber stack), since these stacks may have water droplets larger than the cut size for the PM_{10}-sizing device. To measure PM_{10} in stacks where water droplets are known to exist, EPA's Technical Information Document (TID-099-Methods 201 and 201A in Presence of Water Droplets) recommends use of Method 5 of Appendix A to 40 CFR part 60 (or a comparable method) and consideration of the particulate catch as PM_{10} emissions.
>
> U.S.EPA, www.epa.gov/ttn/EMC

Due to the limitations of Method 201A, regulatory agencies require FCCU operators to use Method 5B and to classify all of the particulate matter as $PM_{2.5}$. Field test data compiled previously using the API wet stack filterable $PM_{2.5}$ sampling system ("API test method") demonstrate that this assumption of 100% $PM_{2.5}$ in the stack gas streams introduces a bias to higher-than-true $PM_{2.5}$ emissions that can affect the accuracy of emission inventories and the effectiveness of control strategies.

1.2 Purpose

The American Petroleum Institute (API) would like to eliminate this bias to higher-than-true filterable $PM_{2.5}$ emissions by developing a filterable $PM_{2.5}$ test method designed for wet stacks serving FCCUs equipped with flue gas desulfurization systems (FGDs). Because there is nothing unique about the gas stream conditions in the wet, droplet-laden stacks of FCCUs, it is clear that this new test method could potentially be applicable to power plants, chemical plants, and other industrial sources operating wet scrubbers for sulfur dioxide and particulate matter control.

API has contracted with Air Control Techniques, P.C. to develop and evaluate the performance of the API test method. Air Control Techniques, P.C. has completed (1) initial laboratory testing, (2) field testing of the sampling system at three FCCUs, and (3) follow-up laboratory testing. Based, in part, on these already completed tests, EPA has agreed that the method may be promulgated as a reference method based on the results of the Method 301 Validation tests. The EPA letter is reproduced as Appendix A to this protocol. The purpose of the test program described in this protocol is to provide the Method 301 validation data required by EPA.

The basic objective of the API test method development project is to design a sampling system that can simultaneously capture solids-containing droplets and dry particles entrained in the effluent gas streams of wet scrubbers. EPA has requested 100% capture of droplets of 20 micrometers and 0% capture of droplets equal to or larger than 40 micrometer to adequately capture all droplets that could potentially evaporate to yield $PM_{2.5}$ particles in the atmosphere.

These EPA design criteria inherently include a conservative bias because most 20 micrometer-sized droplets released to the atmosphere will settle rapidly to the ground well before they can evaporate to dryness. In fact, the terminal settling velocities for these large droplets exceed 1.2 centimeters per second. Accordingly, some of the suspended and dissolved solids in these large droplets will be removed from the atmosphere by deposition on vegetation, adjacent surfaces, and the ground within several hundred feet from the stack.

The purpose of this project is to develop a sampling train that enhances the formation of dry particles from droplets equal to or less than 20 micrometers (aerodynamic diameter) by using rapid evaporation in the probe. The new sampling train must provide for high efficiency transport of the dry $PM_{2.5}$ particles to the $PM_{2.5}$ filter and must avoid premature capture in the sampling system.

1.3 Description of the API Wet Stack Filterable $PM_{2.5}$ Sampling System

Sampling Train Configuration—The proposed API wet stack sampling system is a simple modification of Method 201A as promulgated in December 2010. The in-stack PM_{10} and $PM_{2.5}$ cyclones on the Method 201A probe were replaced with a $PM_{2.5}$ cyclone and filter located in an out-of-stack heated box. The probe heaters used in Method 201A were enhanced to ensure complete and rapid droplet evaporation in the initial zone of the probe. The buttonhook nozzle of the Method 201A sampling system was replaced with a precutter nozzle having a 50% cut point of 30 micrometers (aerodynamic diameter) and a 100% capture efficiency for droplets equal to or less than 20 micrometers.

The API wet stack $PM_{2.5}$ sampling train shown in Figures 1-1 and 1-2 includes a nozzle, a heated probe, a heated $PM_{2.5}$ cyclone, and a heated 47mm non-reactive filter. An EPA Method 202 sampling train is used as the “back half” of this sampling train to measure the condensable $PM_{2.5}$ emissions along with the “front half” filterable $PM_{2.5}$ emissions.

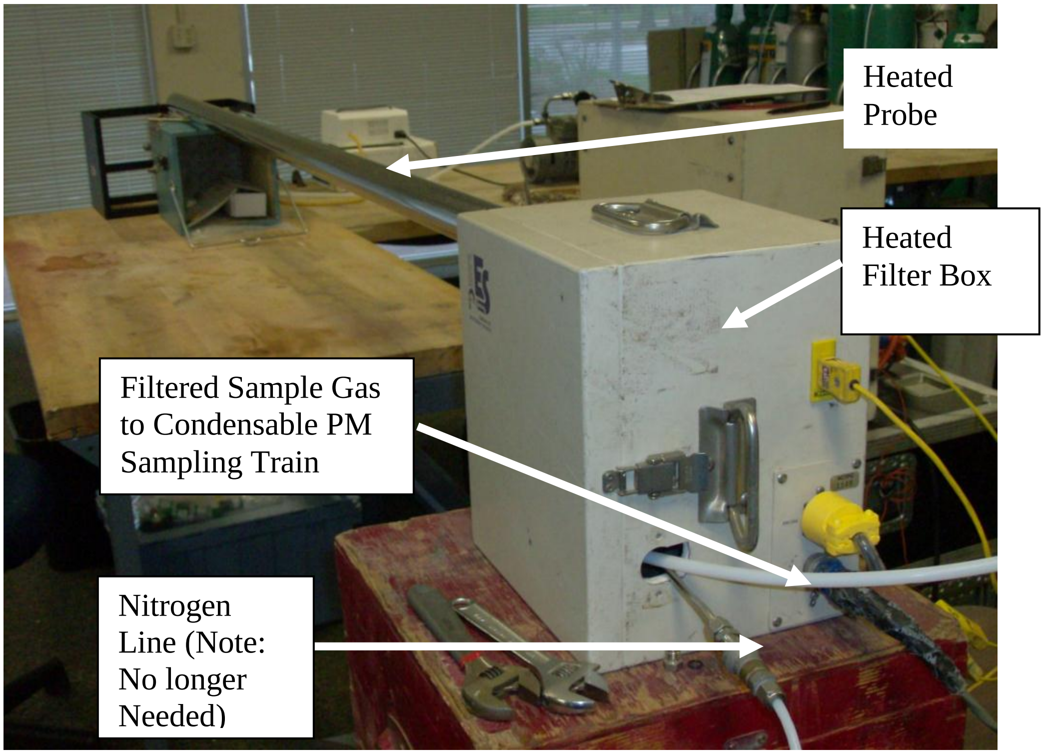

Figure 1-1. API Wet Stack $PM_{2.5}$ Sampling System

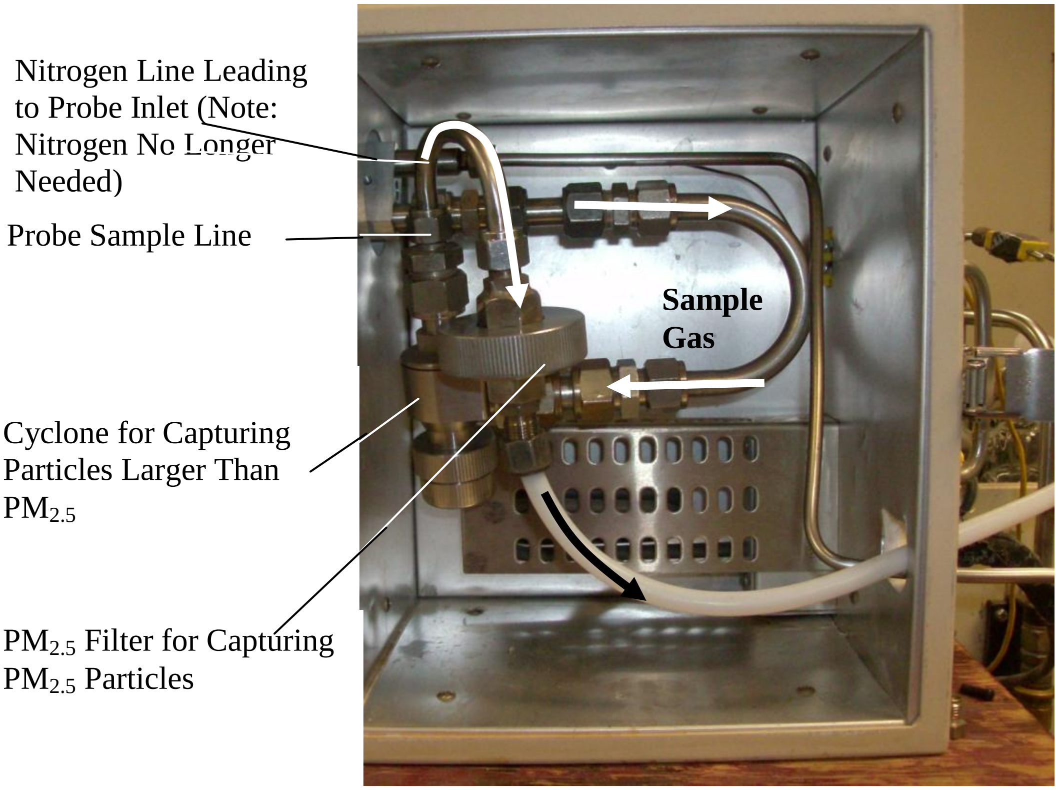

Figure 1-2. Heated Filter Box with Cyclone and $PM_{2.5}$ Filter

Originally, the API sampling system included a high-purity nitrogen injection line to the inlet of the probe to ensure proper droplet evaporation prior to the cyclone and filter. The field tests conducted in 2009 and 2010 demonstrated that the probe was capable of rapid and complete droplet evaporation. Accordingly, the nitrogen dilution line was not needed, even in gas streams with high droplet loadings. Accordingly, this part of the sampling system was eliminated to reduce the complexity in cyclone cut size and isokinetic sampling rate calculations conducted on a point-by-point basis during the emission tests.

Nozzle— A 90-degree nozzle was used for gas stream sampling in the laboratory tests and the field tests. During the stack tests at two FCCU wet scrubbers, the test crews observed liquid from droplets impacting on the exterior surface of the nozzle draining downward and being pulled into the nozzle with the sample gas stream. The droplets in the sample gas stream and the liquid pulled in from the exterior surface were pulled upward through the nozzle and into the probe. The capture of solids-containing liquid from the exterior surface of the nozzle resulted in a bias to higher-than-true measured total filterable particulate matter emissions.[1]

Air Control Techniques, P.C. has modified the nozzle to a precutter arrangement conceptually similar to the inertial droplet separator (IDS) nozzle being evaluated by EPA. A sketch of this precutter nozzle is shown in Figure 1-3.

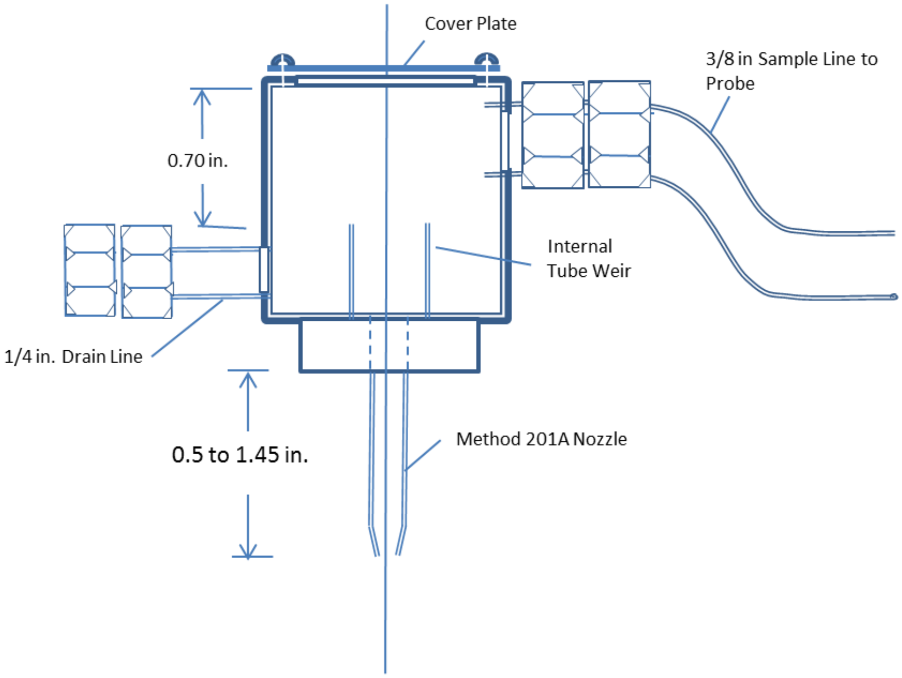

Figure 1-3. Precutter Nozzle

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[1] The measurement of total filterable particulate matter was a secondary objective of this method development program.

The gas stream is captured in a set of sampling nozzles identical to those used in Method 201A. The gas stream then enters a sampling tube where the velocity is set at approximately 15 feet per second when the overall sample flow rate is in the range of 0.55 ACFM—a typical sample flow rate for wet stacks having a gas stream temperature of 140°F.

The droplets in the sample gas stream turn 90 degrees to enter the probe. Droplets larger than 40 micrometers strike the interior wall of the precutter nozzle and are collected as a liquid at the bottom of the nozzle assembly. The liquid can be drained during port changes. If the reentrained liquid levels in the stack are extreme, the liquid collected in the precutter can be removed continuously using a peristaltic pump.

This precutter nozzle is designed to provide 100% capture of droplets having an aerodynamic diameter equal to or less than 20 micrometers, 50% capture of droplets of 30 micrometers, and 0% capture of droplets having an aerodynamic diameter equal to or greater than 40 micrometers. This satisfies EPA's method requirement stated in comments concerning previous versions of this protocol.

Probe—The probe used in the previous laboratory and field tests was a 1/2 inch (I.D.) stainless steel tube. As required by Method 5, a glass probe will be used instead. A conventional probe with supplemental heaters sufficient to maintain sample gas stream temperatures at 320°F ± 25°F will be used. A set of three thermocouples will be mounted inside the probe. These thermocouples will be monitored by a standard sampling console or a separate set of temperature readouts. Another thermocouple will monitor the filter box temperature.

$PM_{2.5}$ Cyclone—The $PM_{2.5}$ cyclone used in the API sampling train is identical to the $PM_{2.5}$ cyclone used in Method 201A. This cyclone is based on a unit termed "cyclone IV" in a five-cyclone sampling system originally developed jointly by Southern Research Institute (SRI) and the U.S. EPA. The performance curve for this cyclone at ambient temperature is illustrated in Figure 1-4.

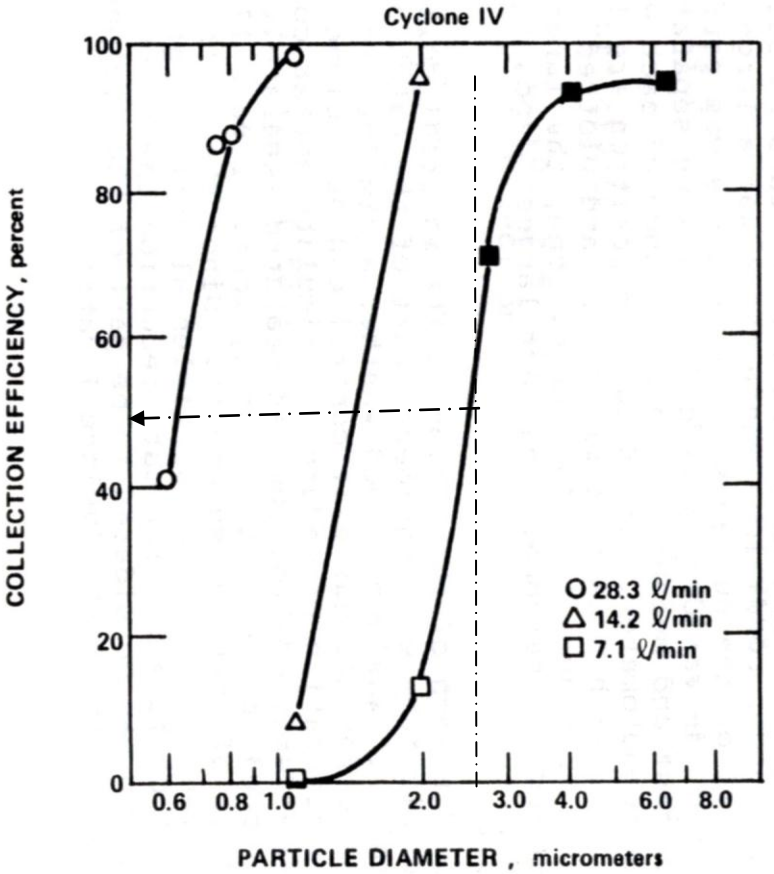

Figure 1-4. Collection Efficiency of EPA-S.R.I. Cyclone IV and API $PM_{2.5}$ Cyclone (Source: EPA-600/7/78-008, January 1978, page 25, dashed lines added)

This curve demonstrates that 50% of the particles that are exactly 2.5 micrometers (aerodynamic diameter) are captured in the cyclone. As indicated in the curve, the cyclone does not reach 100% capture efficiency for particles of at least 6 micrometers and perhaps even larger. Accordingly, some large particles can penetrate the cyclone, reach the $PM_{2.5}$ filter, and be counted as $PM_{2.5}$ particulate matter. Based on this curve, the $PM_{2.5}$ cyclone used in the API sampling system has a slight bias to higher-than-true particulate matter penetrating the $PM_{2.5}$ cyclone.

Sampling Rates—Sample gas flow in the API sampling system will be maintained within the $PM_{2.5}$ cyclone performance limits as shown in Figure 1-5 from Method 201A. The sample gas flow rate must be adjusted to maintain a 2.5 ± 0.25 micrometer cut size.

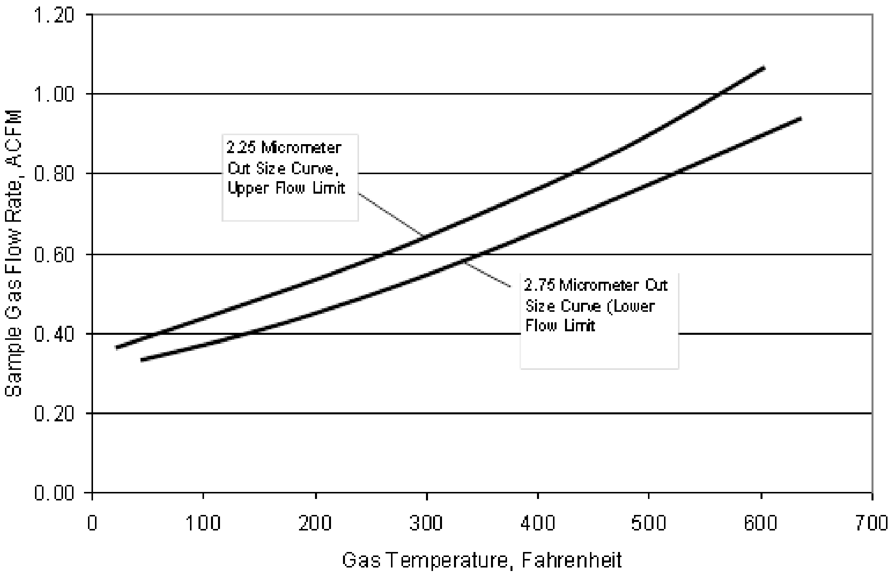

Figure 1-5. Required Sample Flow Rate for the $PM_{2.5}$ Cyclone in the API Sampling System

1.4 API Test Method Performance Criteria

API has adopted the following performance criteria in modifying the Method 201A sampling train to develop the API test method. Criteria 4, 5 and 6 are drawn partially from EPA's requirements.

1. Measurement of filterable $PM_{2.5}$ independently from condensable $PM_{2.5}$
2. Temperatures in the range of 320°F ± 25°F in the probe, $PM_{2.5}$ cyclone, and $PM_{2.5}$ filter, even when sampling gas streams with high droplet loadings
3. Isokinetic sampling rates in the range of 80% to 110%
4. Capture of 100% of the droplets and particles equal to or less than 20 micrometers and 0% of the droplets and particles equal to or greater than 40 micrometers
5. Bias of equal to or less than 10% to higher-than-true $PM_{2.5}$ emissions caused by evaporative shattering of solids-containing droplets and inadvertent capture of droplets impacting on the exterior surface of the nozzle
6. Bias of equal to or less than 10% to lower-than true $PM_{2.5}$ emissions caused by $PM_{2.5}$ particle losses in the sampling train from the nozzle through the $PM_{2.5}$ cyclone

Independent measurement of filterable and condensable $PM_{2.5}$ is needed to allow operators at refineries and other industrial sources to evaluate the possible emission control techniques to minimize $PM_{2.5}$ emissions. Filterable and condensable $PM_{2.5}$ particles form due to quite different mechanisms, and their emission rates are affected by entirely different process and air pollution control system operating parameters.

The temperature range of 320 ± 25°F is consistent with EPA Reference Method 5B, the test method used to measure total filterable particulate matter emissions. This temperature is necessary for the independent measurement of filterable and condensable $PM_{2.5}$. Most condensable vapor remains in the gas phase at 320 ± 25°F. This sampling system temperature ensures that the vapor phase materials pass through the $PM_{2.5}$ filter and are captured in the Method 202 impingers used as the back half of the overall sampling system.

An isokinetic sampling rate of 80% to 110% is needed to adequately capture droplets that can potentially evaporate to form $PM_{2.5}$ particles. While the isokinetic sampling rate is relatively unimportant for dry $PM_{2.5}$ particles and droplets, it is moderately important for particles and droplets larger than 10 micrometers.

A droplet capture efficiency of 100% of the droplets equal to or smaller than 20 micrometers in the nozzle is needed to ensure consistency with the EPA $PM_{2.5}$ continuous emission monitor that is presently under development.

Air Control Techniques, P.C. and API placed considerable emphasis on the practicality of the sampling equipment. Any manual test method for filterable $PM_{2.5}$ testing should include readily-available stack sampling equipment that can be purchased at reasonable cost. Testing organizations experienced with EPA Method 201A should be able to conduct the test method. To the maximum extent possible, the sample gas flow rates must be sufficient to provide accurately measurable particulate matter catch weights with run durations of equal to or less than 4 hours. Furthermore, the test method must be compatible with EPA Method 202 used as the “back half” of the overall sampling train.

Potential Biases—There are potential biases to both higher-than-true and lower-than-true emissions. A bias to higher-than-true $PM_{2.5}$ emissions can potentially be caused by Rayleigh shattering of rapidly evaporating droplets containing suspended and dissolved solids. (Hinds, Aerosol Technology, page 334) The $PM_{2.5}$ formation rate can significantly exceed the formation rate of $PM_{2.5}$ particles from droplets evaporating slowly in plumes and air masses. The API method development program has included an evaluation of the extent of $PM_{2.5}$ formation due to Rayleigh shattering in the probe of the sampling system.

A bias to lower than true $PM_{2.5}$ emissions can potentially be caused by (1) $PM_{2.5}$ particle inertial impaction into droplets in the sampling train, (2) Brownian diffusion of $PM_{2.5}$ particles to the nozzle and probe surfaces, and/or (3) electrostatic attraction of $PM_{2.5}$ particles with static charge to the nozzle and probe surfaces. This method development program is designed to evaluate the extent of $PM_{2.5}$ losses in the sampling system and to minimize these losses to the maximum extent possible.

Summary of Completed Laboratory and Field Tests—API and Air Control Techniques, P.C. have completed (1) an initial set of laboratory tests, (2) field tests at two wet scrubber-controlled FCCUs and one electrostatic precipitator-controlled FCCU, and (3) a follow-up laboratory test. The results of these test programs are summarized in a combined test report that provides much of the information requested by EPA in their April 8, 2011 letter to Air Control Techniques, P.C. (reproduced in Appendix A). The already compiled data and information from these test programs are summarized below with respect to each of the seven performance criteria discussed earlier.

Independent Measurement of Filterable and Condensable $PM_{2.5}$—The API wet stack sampling system is inherently capable of independently measuring filterable and condensable $PM_{2.5}$ emissions. During tests at the FCCUs, Air Control Techniques, P.C. simultaneously measured the condensable particulate matter emissions using a Method 5B/Method 202 sampling system and an API wet stack/Method 202 sampling system. There were no significant differences except for one of the tests when approximately 10% of the condensable particulate matter condensed at a cold spot in the relatively large wet stack probe. This probe has since been modified to eliminate the cold spot issue.

Ability to Maintain 320 ± 25°F Sample Gas Temperatures—During laboratory tests with droplet loadings exceeding 4.5 grams per cubic meter[2], the API wet stack probe remained within the specified temperature range. Tests at the two wet scrubber-controlled FCCUs also demonstrated the ability of the probe to maintain the design temperature range at droplet loadings exceeding 4.5 grams per actual cubic meter.

Isokinetic Sampling Rates—The API $PM_{2.5}$ sampling system can operate at sampling rates of 80% to 110%. The elimination of the nitrogen dilution line, which proved to be unnecessary, simplifies the field calculations needed to maintain isokinetic sampling rates. With the refined sampling train configuration, testing organizations capable of conducting Method 201A can also successfully conduct the wet stack test method.

Droplet and Particle Capture Efficiency of 100% for sizes equal to or less than 20 Micrometers—Tests using NIST traceable polydisperse microspheres will be conducted as part of the Method 301 validation tests to provide the data needed to determine the capture efficiency for droplets and particles equal to or below 20 micrometers. These polydisperse microspheres are in four distinct sizes of 5, 10, 20, and 50 micrometers. After accounting for the known density of these microspheres, the aerodynamic diameters are 7, 14, 28, and 70 micrometers. Samples recovered the precutter nozzle, probe, $PM_{2.5}$ cyclone, and $PM_{2.5}$ filter will be microscopically analyzed to determine the nozzle capture efficiency curve.

Minimal Positive Bias Due to Droplet Rayleigh Shattering—Laboratory test results indicate that droplet Rayleigh shattering causes a possible bias of less than 1% even when the droplet loadings and dissolved solids levels are extremely high.

Minimal Negative Bias Due to $PM_{2.5}$ Losses in the Nozzle and Probe—The field test program at the ESP controlled FCCUs and the follow-up laboratory tests using three types of NIST traceable monodisperse microspheres and SEM analyses demonstrated that $PM_{2.5}$ losses in the nozzle and probe are small. However, these tests did not accurately quantify the losses. The Method 301 validation tests addressed in this protocol will provide the additional data needed to demonstrate that $PM_{2.5}$ losses in the nozzle and probe are very small.

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[2] This droplet concentration is equivalent to a very high loading of 2 grains per SCF.

The field tests at the three FCCUs demonstrated that the API wet stack sampling system is as practical and easy to use as EPA Method 201A. All of the sampling equipment is readily available from a variety of the standard suppliers.

The need for the API wet stack sampling system was clearly demonstrated by the results of the tests at the FCCUs. The use of Method 5 or 5B total filterable particulate matter emissions data as a surrogate for filterable $PM_{2.5}$ emissions introduces a bias to higher-than-true filterable $PM_{2.5}$ emissions.

1.5 EPA Review Comments and Data Requirements

The U. S. EPA stated in its letter dated April 8, 2011 (Appendix A to this protocol) that, "…the method has the potential to be a promulgated method for measuring $PM_{2.5}$ at cat crackers with wet stacks." They went on to encourage API to seek broader support and testing of the method in other industries having sources with wet stacks.

EPA requested the following three categories of data to support promulgation of the method.

- Data demonstrating that the method satisfies the Method 301 accuracy and bias criteria
- Laboratory data showing that $PM_{2.5}$ is not retained in the front half of the sampling system
- Data demonstrating that the method captures a representative sample of the droplets having the potential to form $PM_{2.5}$ particulate matter

With respect to the Method 301 accuracy and bias criteria, EPA has requested an analyte spike in a droplet form to fully simulate the behavior of evaporating droplets captured in full scale systems. As part of the analyte spiking system, the droplets must be sized to equal to or less than 2.5 micrometers (aerodynamic).

EPA's requirement for data on $PM_{2.5}$ penetration through the front half of the sampling train has already been completed during the follow-up laboratory evaluation described above. The $PM_{2.5}$ droplet spiking tests conducted as part of the Method 301 validation tests will provide further confirmation of $PM_{2.5}$ loss of equal to or less than 10% of the total filterable $PM_{2.5}$ sample.

EPA has required that the sampling system capture 100% of the particles and droplets having an aerodynamic diameter of equal to or smaller than 20 micrometers.

2. TEST APPARATUS

2.1 Method 301 Testing Requirements

Method 301 establishes procedures to measure the systemic error (bias) and random error (precision) of proposed air emission test method. The bias must be within a range of plus or minus 10% (Section 8.0) of a reference standard. A correction factor is allowed to account for biases up to ±30 percent.

The random error of the test data at catch weights equivalent to the levels expected at a promulgated emission standard must have a relative standard difference of equal to or less than 20% (Section 10). The Method 301 validation tests must be conducted under conditions representative of actual stack conditions.

Section 6 of Method 301 includes three alternative techniques for bias and precision testing: (1) isotopic spiking, (2) comparison with a validated test method, and (3) analyte spiking. Only the third approach is applicable to the API test method.

The analyte spiking tests described in Method 301 involve six test runs using a set of four identical API sampling trains. The inlet nozzles for the sampling trains must be located within a 6 cm square area as specified in Section 6.4.2 of Method 301. During each of the six test runs, two of the sampling trains must be spiked, and two must be unspiked.

2.2 Validation Testing Apparatus

Dryer Stack—Air Control Techniques, P.C. will conduct the Method 301 validation tests at a stack serving a wet scrubber controlled dryer at a MDF plant. This sampling location is 1.9 stack diameters downstream and 3.7 diameters upstream of the nearest flow disturbances. We will use dual probes that are positioned at a single point within the stack. The sampling ports are each 4 inches inner diameter.

This system is representative of a large population of wet stacks in the petroleum and pulp and paper industries. The stack temperature ranges from 125°F to 135°F. Based on previous test data, the actual moisture levels are approximately 3% moisture above the calculated saturated levels. Accordingly, we anticipate a typical droplet loading in the stack gas stream. This source has condensed organic particulate matter that is believed to be primarily in the $PM_{2.5}$ size range. Two hour test runs should provide adequate $PM_{2.5}$ catch weights.

Analyte Spiking System—Air Control Techniques, P.C. will generate a $PM_{2.5}$ droplet analyte spike using an ammonium chloride droplet generator. Known quantities of hydrogen chloride, ammonium hydroxide, and deionized water will be placed in an evaporation chamber. The chamber will be heated to evaporate the hydrogen chloride, ammonium hydroxide, and water to form the ammonium chloride aerosol. The evaporated gas stream will be pulled through an impinger immersed in a water bath to decrease the temperature to approximately 120°F. Sufficient water will be added to ensure the growth of the ammonium chloride particles.

The ammonium chloride droplets are highly hygroscopic and will absorb water and grow larger. The ammonium chloride droplets will grow into the size range of 0.1 to 5 micrometers. The upper size of the droplets will be limited by the competition between condensation nuclei for moisture. The ammonium chloride–containing gas stream will pass through a standard $PM_{2.5}$ cyclone identical to the cyclones used in Method 201A to remove droplets larger than 2.5 micrometers.

By maintaining an analyte spike gas flow rate of 0.44 ACFM at 120°F (0.59 ACFM at 320°F), the 50% cut size of the $PM_{2.5}$ cyclone will be within 2.25 to 2.75 micrometers. The treated gas stream from the $PM_{2.5}$ cyclone outlet will be directed to the inlet of the API sampling train being spiked. The entire gas handling system will be maintained at approximately 120°F in the droplet generator to avoid water vapor condensation on the interior surfaces of the $PM_{2.5}$ cyclone and tubing handling the ammonium chloride.

The ammonium chloride-containing droplets will be injected into the inlet of the probe shown in Figure 1-3. From this injection point, the $PM_{2.5}$ particles will travel the entire length of the probe prior to reaching the $PM_{2.5}$ cyclone in the heated sampling box. The spike will be conducted in the middle of each test run. During spike injection, the API sampling systems will be operated at the same temperature range and sampling rate as the remainder of the test run. The duration of the spike will be set to provide a spike quantity of 50 milligrams in both trains. The probes used in the Method 301 tests will be three feet long.

3. METHOD 301 BIAS AND PRECISION TESTING

3.1 Bias Measurements

The API test method bias will be determined in accordance with the Method 301 procedures described in Section 12 of Method 301. A set of six tests will be conducted with quad API $PM_{2.5}$ sampling trains. Each sampling train will have a 90 degree curved nozzle for gas stream capture.

Prior to each test run, an S-type Pitot tube will be used to measure the gas velocity at the sampling location. A total of twelve traverse points will be used for the flow measurements. A Method 4 sampling train will also be used to measure the gas stream moisture content and droplet loadings. The operating conditions of the simulated stack will be adjusted if either measurement indicates operating conditions outside of the intended level. The stack gas velocity and moisture measurements will be repeated if any adjustments are made to the gas flow rate and/or droplet loadings.

The test matrix for the bias and precision tests is summarized in Table 3-1. The sampling time for each API $PM_{2.5}$ sampling train will be 120 minutes.

Prior to recovering the samples, the glass probe liner and the glass nozzle will be removed from the sampling train and photographed to document the presence or absence of dried solids. The API sampling trains will be recovered using deionized water to yield the following samples.

- Sample Jar 1 – Nozzle rinse
- Sample Jar 2 – Probe rinse
- Sample Jar 3 – $PM_{2.5}$ cyclone inlet and catch cup rinse
- Sample Jar 4 – $PM_{2.5}$ outlet tube and $PM_{2.5}$ front half filter holder rinse
- Sample Container 5 – $PM_{2.5}$ filter

The material in all four sample jars will be dried and weighed. The filter will be desiccated and weighed. Filterable $PM_{2.5}$ will be considered to be the sum of Sample Jar 4 and Sample Container 5for each of the quad sampling trains.

Table 3-1. Bias and Precision Test Matrix

Run	Method	Sampling Train	Spiking Condition	Run Duration
1	$PM_{2.5}$	1	Spiked	120
	$PM_{2.5}$	2	Spiked	120
	$PM_{2.5}$	3	Unspiked	120
	$PM_{2.5}$	4	Unspiked	120
	Moisture (Method 4)	1, 2, 3, 4	N/A	120
	Velocity (Method 2)	Pitot tube	N/A	120
2	$PM_{2.5}$	1	Spiked	120
	$PM_{2.5}$	2	Spiked	120
	$PM_{2.5}$	3	Unspiked	120
	$PM_{2.5}$	4	Unspiked	120
	Moisture (Method 4)	1, 2, 3, 4	N/A	120
	Velocity (Method 2)	Pitot tube	N/A	120
3	$PM_{2.5}$	1	Spiked	120
	$PM_{2.5}$	2	Spiked	120
	$PM_{2.5}$	3	Unspiked	120
	$PM_{2.5}$	4	Unspiked	120
	Moisture (Method 4)	1, 2, 3, 4	N/A	120
	Velocity (Method 2)	Pitot tube	N/A	120
4	$PM_{2.5}$	1	Spiked	120
	$PM_{2.5}$	2	Spiked	120
	$PM_{2.5}$	3	Unspiked	120
	$PM_{2.5}$	4	Unspiked	120
	Moisture (Method 4)	1, 2, 3, 4	N/A	120
	Velocity (Method 2)	Pitot tube	N/A	120
5	$PM_{2.5}$	1	Spiked	120
	$PM_{2.5}$	2	Spiked	120
	$PM_{2.5}$	3	Unspiked	120
	$PM_{2.5}$	4	Unspiked	120
	Moisture (Method 4)	1, 2, 3, 4	N/A	120
	Velocity (Method 2)	Pitot tube	N/A	120
6	$PM_{2.5}$	1	Spiked	120
	$PM_{2.5}$	2	Spiked	120
	$PM_{2.5}$	3	Unspiked	120
	$PM_{2.5}$	4	Unspiked	120
	Moisture (Method 4)	1, 2, 3, 4	N/A	120
	Velocity (Method 2)	Pitot tube	N/A	120

The first step in calculating the bias is to calculate the differences in the paired spiked sampling train test results in accordance with Method 301 Equation 301-13.

$$d_i = \left(\frac{S_{1i} + S_{2i}}{2}\right) - \left(\frac{M_{1i} + M_{2i}}{2}\right) - CS \qquad \text{Equation 301-13}$$

Where:

d_i = Bias during run i
S_{1i} = First measured value of the i^{th} spiked sample (total $PM_{2.5}$)
S_{2i} = Second measured value of the i^{th} spiked sample (total $PM_{2.5}$)
M_{1i} = First measured value of the i^{th} unspiked sample (total $PM_{2.5}$)
M_{2i} = Second measured value of the i^{th} unspiked sample (total $PM_{2.5}$)
CS = Analyte spike value (ammonium chloride $PM_{2.5}$ spike quantity)

The standard deviation of the differences in the means of the spiked sampling train tests will be calculated in accordance with Method 301 Equation 301-2.

$$\mathrm{SD}_{\mathrm{d}} = \sqrt{\frac{\sum_{\mathrm{i}}^{\mathrm{n}} \left(\mathrm{d}_{\mathrm{i}} - \mathrm{d}_{\mathrm{m}}\right)^2}{\mathrm{n} - 1}} \qquad \text{Equation 301-2}$$

Where:

SD_d = The standard deviation of the differences, milligrams/DNm^3
d_i = The differences in the results of the i^{th} sample
d_m = The mean of the paired sample differences
n = Total number of paired samples (6)

The t-statistic for the differences will be calculated from the means of the paired sample differences, the standard deviation of the differences, and the number of paired samples (6).

$$\mathrm{t} = \frac{\left|\mathrm{d}_{\mathrm{m}}\right|}{\frac{\mathrm{SD}_{\mathrm{d}}}{\sqrt{\mathrm{n}}}} \qquad \text{Equation 301-3}$$

Where:

t = t statistic
d_m = the mean of the paired sample differences
SD_d = The standard deviation of the differences, milligrams/DNm^3
n = Total number of paired samples (6)

The t-statistic will be compared with the critical value of the t-statistic to determine if the bias is significant at the 95 percent confidence interval. The two-sided confidence level critical value is 2.571 for the five degrees of freedom applicable to a set of six runs.

If the calculated t-value is less than the critical value, the bias will not be considered to be statistically significant, and the data will be acceptable. If the calculated t-value is greater than the critical value, the bias will be considered statistically significant, and the relative magnitude of the bias will be calculated in accordance with Equation 301-10 from Method 301. If the relative bias is less than or equal to 10 percent, the bias will be considered as acceptable in accordance with Method 301 Section 8.0.

$$B_R = \frac{|B|}{|CS|}100 \qquad \text{Equation 301-10}$$

Where:

B_R = Relative bias at the spike level, milligrams/DNm^3
CS = Mean spike level, milligrams/DNm^3
B = Bias calculated in Equation 301-13, milligrams/DNm^3

If the bias is less than or equal to 30 percent, a correction factor will be calculated to adjust the test results. If the bias exceeds 30 percent, the data will be considered unacceptable.

3.2 Precision

To evaluate the precision of the API sampling system, the relative standard deviation will be calculated in accordance with Equation 301-8.

$$\mathrm{RSD} = \left(\frac{\mathrm{SD_d}}{\mathrm{S_M}}\right)100 \qquad \text{Equation 301-8}$$

Where:

RSD = Relative standard deviation, %
SD_d = Standard deviation of the differences, milligrams/DNm^3
S_M = Mean of the twelve spiked test runs, milligrams/DNm^3

The API sampling system will meet the requirements of Method 301 Section 9.0 if the RSD is equal to or less than 20%

3.3 $PM_{2.5}$ Loss in the Sampling System

In addition to providing the $PM_{2.5}$ spike, the ammonium chloride analyte spike generator described in Section 2 of this protocol provides a direct means to evaluate the extent of $PM_{2.5}$ loss in the nozzle and probe of the API wet stack sampling train.

All five of the samples will be analyzed by ion chromatography to determine the ammonium and chloride levels. The combined total ammonium and chloride levels in sample jar 4 and sample container 5 from each test will be compared with the combined ammonium and chloride quantities in sample jars 1, 2, and 3. This will provide a measure of the loss of $PM_{2.5}$ droplets and particles in the sampling train. This value will be compared with the bias value measured as described in Section 3.1 of this protocol.

3.4 Nozzle Droplet Performance

The performance of the precutter nozzle used in the API test method will be evaluated based on microscopy analyses of nozzle rinses during tests will polydisperse NIST-traceable microspheres having four mixed monodisperse sizes of 7, 14, 28, and 70 micrometers.

4. TEST METHODS

4.1 Flue Gas Velocity and Volumetric Flow Rate Using EPA Method 2

The flue gas velocity and volumetric flow rates during the emission tests will be determined according to the procedures outlined in U.S. EPA Reference Method 2. Velocity measurements will be made using S-type Pitot tubes conforming to the geometric specifications outlined in Method 2. Velocity pressures will be measured with fluid manometers. Effluent gas temperatures will be measured with chromel-alumel thermocouples equipped with digital readouts. A cyclonic flow check will be performed prior to and following each of the six tests.

The flue gas velocity and volumetric gas flow rate tests will be conducted prior to each of the test runs summarized in Table 3-1.

4.2 Flue Gas Moisture Content Using EPA Method 4

The flue gas moisture content and droplet loadings during the Method 301 validation tests will be determined using Method 4 procedures. The impingers will be connected in series and contain water as listed in the method descriptions. The impingers will be contained in an ice bath to assure condensation of the flue gas moisture. Any moisture that is not condensed in the impingers is captured in the silica gel; therefore, all moisture can be weighed and entered into moisture content calculations.

The droplet loading will be calculated based on the percent of over-saturation of the gas stream measured using the Method 4 data.

4.3 Flue Gas Composition and Molecular Weight

The gas stream molecular weight will be determined based on the measured moisture level and ambient oxygen and carbon dioxide concentrations.

4.4 Filterable $PM_{2.5}$ Using the API Wet Stack Sampling System

Sampling System—The API $PM_{2.5}$ sampling system shown in Figures 1-2 and 1-2 includes a nozzle, heated probe, heated $PM_{2.5}$ cyclone, and heated 47mm filter. The probe will be a 1/2 inch (I.D.) glass tube extending 2 inches from the end of the heated probe. A set of three thermocouples will be mounted inside to the probe. The thermocouples will be monitored by a separate set of temperature readouts. Another thermocouple will monitor the filter box temperature.

Sample gas flow will be maintained within the $PM_{2.5}$ cyclone performance limits as shown in Figure 9 of Method 201A. The sample gas flow rate will be adjusted to maintain a 2.5 ± 0.25 micrometer cut size. A total sample flow rate of approximately 0.60 cubic feet per minute is anticipated.

The data quality objectives for the API sampling system tests include the following.

- Isokinetic sampling rates equal to or greater than 80% and equal to or less than 110%
- Stack gas sample volumes equal to or greater than 36 DSCF
- Pre-run leak check rates equal to or less than 0.02 DSCFM at 15 in. Hg (pre-run leak)
- Post-run leak check rates equal to or less than 0.02 DSCFM at maximum run vacuum (post-run leak check from outlet of cyclone)
- Sampling train exit temperatures equal to or less than 68°F
- Filter and probe temperature 320±25°F

Sample Recovery—The particulate matter captured in the API sampling trains will be divided into the following sample jars.

Sample Jar #1, Particulate Matter > 2.5 micrometers

- Solids in deionized water rinse of the sampling nozzle

Sample Jar #2, Particulate Matter > 2.5 micrometers

- Solids in deionized water rinse of the probe

Sample Jar #3, Particulate Matter >2.5 micrometers

- Solids in the deionized water rinse of the $PM_{2.5}$ cyclone cup
- Solids in the deionized water rinse of the $PM_{2.5}$ cyclone body

Sample Jar #4, Particulate Matter ≤ 2.5 micrometers

- Solids in inlet pipe to $PM_{2.5}$ filter
- Solids in inlet side of $PM_{2.5}$ filter housing

Sample Container #5, Particulate Matter ≤ 2.5 micrometers

- $PM_{2.5}$ filter

The total particulate matter is the sum of all the particulate matter recovered from the API cyclone sampling assembly (sample jars #1 through #4 and sample container #5). $PM_{2.5}$ particulate matter is the sum of the solids recovered from sample jar #4 and sample container #5.

Sample Analysis—EPA Method 5 analytical procedures will be used to analyze the filter and the deionized water rinses for particulate matter. The nozzle rinse, probe rinse, cyclone rinse, and filter will be sent to Resolution Analytics for gravimetric analyses and ion chromatography analyses for ammonium and chloride ions.

5. QUALITY ASSURANCE AND QUALITY CONTROL

5.1 Analyte Spiking

The concentration of ammonium chloride particulate matter generated by the analyte spiking system will be measured prior to the start of the bias and precision tests described in Section 3 of this protocol. A set of three mass concentration tests will be conducted using Method 5 test equipment operating at 120°F to avoid any disassociation of the captured ammonium chloride on the filter, in the probe, and in the front half of the filter holder.

The target mass concentration in 10 minutes is 20 milligrams. The HCl and/or NH_3 quantities will be adjusted as necessary to achieve 50 ± 5 milligrams with an analyte spike flow rate of 0.44 ACFM, a temperature of 120°F, and a sample flow duration of 10 minutes.

During these mass concentration tests, the quantity of water charged with the ammonium hydroxide and hydrogen chloride will be adjusted as needed to achieve adequate droplet sizes.

The analyte sample gas flow rate during spiking will be measured using the same meter box used to control sample gas flow during the test run. The meter box operating parameters monitored during spiking will include (1) vacuum, (2) dry gas meter box volumetric flow, (3) meter box temperature, (4) delta H, and (5) impinger exit temperature. With the exception of the operating temperature, the sampling system operating conditions during the spike will be essentially identical to those during the remainder of the test run. The sampling system temperatures will be maintained at or below 120°F to avoid disassociating the ammonium chloride particles. The same sampling run forms used for the test run will be used to monitor the spike.

5.2 Emission Testing Equipment

All testing will be conducted using QA/QC procedures established by the EPA for Methods 1, 2, 4, and 201A. Complete records concerning the QA/QC procedures will be prepared during the tests.

Leak Checks—Pretest and posttest leak checks will be conducted on each sampling train used in the tests. The leak checks will be conducted in accordance with Method 201A procedures. The $PM_{2.5}$ cyclone will be removed prior to the post-run leak check. The observed leak rates must be below 0.02 actual cubic feet per minute to be acceptable.

S-Type Pitot Tube Calibration and Use—The S-type Pitot tube used in this project will conform to EPA guidelines concerning construction and geometry. The Pitot tube will be calibrated in a wind tunnel.

The gas flow velocities at the sampling locations will be measured using EPA Methods 1A and 2. Each leg of the Pitot tube will be leak checked before and after each run. The yaw and the pitch axis of the Pitot tube will be maintained 90 degrees to the airflow. Checks for cyclonic flow will be completed before the start of the first test run.

No Pitot tubes will be attached to the four API sampling trains in the wet stack simulator. The Pitot tubes would increase the blockage factor for the sampling equipment.

Temperature Monitor Calibration—The thermocouples used in this project will be calibrated using the procedures described in Section 3.4.2 of EPA Publication No. 600/4-77-027b. Each temperature sensor will be calibrated at a minimum of three points over the anticipated range against NIST-traceable mercury in glass thermometers.

Dry Gas Meter Calibration—All dry gas meters will be fully calibrated to determine the volume correction factor prior to field use. Post-test calibration checks will be performed. Pre-and post-test calibrations must agree within ±5 percent. The calibration procedure is documented in Section 3.3.2 of EPA Publication No. 600/4-77-237b.

Moisture Scale Calibration—The scales used in the test program to determine flue gas moisture content will be calibrated using a standard set of weights.

Sample Recovery and Custody—The filters, impinger contents, and rinses will be recovered using standard EPA procedures specified in EPA Method 201A. All sampling equipment will be sealed to prevent contamination during transport to the recovery area.

All chemicals used for sampling train preparation and sample recovery will be American Chemical Society ACS, High Performance Liquid Chromatography (HPLC) or pesticide grade. Deionized water will meet or exceed the American Society for Testing Materials (ASTM) specifications for Type I reagent water.

All of the samples will be labeled immediately after recovery. The samples will be packed in numbered boxes and sealed. A chain of custody record and sample log will be maintained during the test program. The samples will be delivered to Resolution Analytics along with the appropriate chain of custody record forms.

Sample Identification—The test runs will be uniquely identified with designations that will follow each sample from collection through reporting. For example, the API wet stack test runs for the first Method 301 validation test run will be designated as M301-Train 1-Run 1, M301-Train 2-Run 1, M301-Train 3-Run 1, and M301-Train 4-Run 1.

6. PROJECT SCHEDULE AND MANAGEMENT

6.1 Test Program Schedule

The overall project will require 3 months. The project will be performed in accordance with the proposed schedule provided in Table 6-1.

Table 6-1. Proposed Project Schedule

Subtask #	Description of Subtask	Date
1	Submit protocol	November 15, 2011
	Submit revised protocol based on tests at MDF Plant	October 15, 2012
	Complete testing	October 25, 2012
4	Complete laboratory analysis	November 15, 2012
5	Submit final report	January 15, 2012

6.2 Test Program Management

The API Project Manager for this testing project is Cathe Kalisz. The Air Control Techniques, P.C. project manager is John Richards. Addresses and phone numbers of these individuals are provided below.

Cathe Kalisz
Director of Regulatory and Scientific Affairs
American Petroleum Institute
1220 L Street, NW Washington, DC 20005-4070
(202) 682-8472

John Richards, Ph.D., P.E.
Air Control Techniques, P.C.
301 E. Durham Road
Cary, North Carolina, 27513
(919) 460-7811

John Richards will be responsible for test program management and coordination with API and plant personnel. Tom Holder, David Goshaw, Tom Holder, and/or Jeff Aims will assist John Richards in test program implementation. Resolution Analytics will perform the API Sampling Method gravimetric and ion chromatography sample analyses.

Resolution Analytics, Inc.
Sanford, NC 27332
(919) 774-5557

Appendix D

Method 301 Test Report

September 16, 2013

WET STACK FILTERABLE $PM_{2.5}$ SAMPLING SYSTEM METHOD 301 VALIDATION TEST REPORT

Report Prepared for

American Petroleum Institute
Washington, D.C.

Report Prepared by

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Report Date
September 16, 2013

TABLE OF CONTENTS

FIGURES

TABLES

WET STACK FILTERABLE $PM_{2.5}$ SAMPLING SYSTEM METHOD 301 VALIDATION TEST REPORT

1. SUMMARY

1.1 PURPOSE AND SCOPE

The U.S. Environmental Protection Agency (EPA) and state regulatory agencies are now requesting that American Petroleum Institute (API) member companies provide $PM_{2.5}$ emissions data for sources such as fluid catalytic cracking units (FCCUs) equipped with flue gas desulfurization systems (FGDs). EPA is also requesting that Pulp and Paper Industry sources and other industry sources report $PM_{2.5}$ emissions data for sources controlled with wet scrubbers.

Droplets entrained in the effluent gas streams exiting the FGDs and wet scrubbers preclude the use of EPA Reference Method 201A[1] for the measurement of filterable $PM_{2.5}$. Current EPA guidance states that companies required to measure filterable $PM_{2.5}$ in saturated or droplet-laden stacks should use EPA Reference Method 5 or 5B and use the total filterable particulate matter as a surrogate for filterable $PM_{2.5}$. This Method 5-based approach is biased to higher-than-true emission rates of $PM_{2.5}$ because a portion of the material measured as total filterable particulate matter is larger than 2.5 micrometers. A filterable $PM_{2.5}$ test method suitable for use in moisture-saturated and droplet-laden stacks is needed to provide accurate filterable $PM_{2.5}$ emissions data to regulatory agencies.

API has contracted with Air Control Techniques, P.C. to design, fabricate, and test a filterable $PM_{2.5}$ sampling system for wet stack applications. The National Council of Air & Stream Improvement (NCASI) has contributed to this method development project. This method is intended to serve as a logical extension of EPA Methodx 201A and 5B. For the purposes of this report, this wet stack filterable $PM_{2.5}$ test method is termed "WS2.5."

Test programs at three FCCUs demonstrated that the WS2.5 sampling system can operate well in wet stacks of FGD-controlled catalytic crackers. The system can operate at conventional Method 201A isokinetic sampling rates of 100 ± 20% and at conventional Method 5B sampling temperatures of 320 ± 25°F even when the droplet loadings approach an especially high level of 0.40 grams per standard cubic meter. The results of these field tests, along with the laboratory studies conducted as part of the method development efforts, are discussed in the accompanying report "Wet Stack Filterable $PM_{2.5}$ Sampling System Method Development Report."

This report describes how the WS2.5 method was tested at a representative source and satisfied the EPA precision and bias requirements of Method 301.

1.2 CONCLUSIONS

The WS2.5 method is designed to provide an accurate means to measure filterable $PM_{2.5}$ particles in gas streams with entrained water droplets. The sampling system captures particles that are (1) suspended in water droplets, (2) present as dry particles in the stack gas stream, and (3) formed from dissolved solids during the in-probe evaporation of water droplets.

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[1] EPA Reference Method 201A was substantially revised and re-promulgated on December 21, 2010.

This wet stack filterable $PM_{2.5}$ sampling system consists of (1) a precutter nozzle, (2) a probe with heaters and sufficient heating capacity to maintain a temperature of 320 ± 25°F in droplet-laden gas streams, and (3) a heated sampling box at a temperature of 320 ± 25°F that includes a $PM_{2.5}$ cyclone and a $PM_{2.5}$ filter.

The WS2.5 sampling train operates with sample gas flow rates of approximately 0.55 to 0.65 ACFM. Run times vary from two to three hours in order to obtain sufficient $PM_{2.5}$ catch weights. Sample recovery and emission calculations parallel those specified in Method 201A. Quality assurance procedures for the WS2.5 sampling train are also similar to the procedures used in Method 201A.

API and NCASI are proposing that this modification of the EPA Method 201A sampling train be accepted for compliance testing based on satisfactory field tests and the successful method 301 validation tests.

Method 301 validation tests conducted on a wet scrubber controlled fiberboard dryer stack indicated that the precision of the new method was 7.9%, well within Method 301 requirements and that the bias was not statistically significant as defined in Method 301.

The new sampling method provides a practical, economical, and accurate means of measuring $PM_{2.5}$ emissions from wet stacks and should be adopted by the EPA as it has been shown to meet the requirements of Method 301.

1.3 TEST PROGRAM PARTICIPANTS

The API Project Manager for this testing project is Ms. Cathe Kalisz. The NACSI Project Manager is Mr. Lee Carlson. The Air Control Techniques, P.C. project manager is Mr. John Richards. Addresses and phone numbers of these individuals are provided below.

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Research Triangle Institute provided electron microscopy services for both the laboratory and field testing programs. The laboratory manager is Dr. Owen Crankshaw.

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2. WS2.5 SAMPLING SYSTEM DESIGN CHARACTERISTICS

2.1 PERFORMANCE CRITERIA

The following performance criteria were adopted in designing the wet stack filterable $PM_{2.5}$ sampling method:

1. Measurement of filterable $PM_{2.5}$ independently from condensable $PM_{2.5}$
2. Temperatures in the range of 320°F ± 25°F in the probe, $PM_{2.5}$ cyclone, and $PM_{2.5}$ filter, even when sampling gas streams with droplet loadings of 0.40 grams per cubic meter
3. Isokinetic sampling rates in the range of 100% ± 20%
4. Nozzle[2] capture efficiency of 100% for droplets larger than 20 micrometers
5. Less than 1% bias to higher-than-true $PM_{2.5}$ emissions caused by evaporative shattering of solids-containing droplets
6. Minimal bias to lower-than true $PM_{2.5}$ emissions caused by $PM_{2.5}$ particle losses in the nozzle or probe
7. Practical and economical stack sampling method that uses readily available commercial equipment

Independent measurement of filterable and condensable $PM_{2.5}$ is needed to allow refineries, paper industry sources, and other operators with saturated, droplet-laden stacks to evaluate control strategies to minimize $PM_{2.5}$ emissions. Filterable and condensable $PM_{2.5}$ particles form due to quite different mechanisms, and their emission rates are affected by entirely different process and air pollution control system operating parameters.

The temperature range of 320 ± 25°F is consistent with EPA Reference Method 5B, the test method used to measure total filterable particulate matter emissions. This temperature range is necessary for the independent measurement of filterable and condensable $PM_{2.5}$. Most condensable vapor remains in the gas phase at 320 ± 25°F. This sampling system temperature ensures that the vapor phase materials pass through the $PM_{2.5}$ filter and are captured in the Method 202 impingers used as the back half of the overall sampling system. The Method 202 sampling system also captures any organic particulate matter vaporized while the sample gas passes through the heated probe and filter box.

Operating a probe at 320 ± 25°F also favors rapid evaporation of droplets to dryness. This minimizes losses of the droplets to the walls.

An isokinetic sampling rate of 100% ± 20% is needed to ensure consistency with Method 201A. While the isokinetic sampling rate is relatively unimportant for dry $PM_{2.5}$ particles and droplets, it is moderately important for particles and droplets larger than 10 micrometers.

EPA has recently provided comments indicating that they will require a nozzle capture efficiency of 100% for droplets having an aerodynamic diameter equal to or larger than 20 micrometers. Thus, this design criterion was adopted.

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[2] Initially, a design criterion of 50% cut size of 20 micrometers. The 100% capture efficiency at 20 micrometers is based on EPA review comments.

An acceptable sampling method must not provide results that have either a significant positive or negative bias. A bias to higher-than-true $PM_{2.5}$ emissions can be caused by Rayleigh shattering of rapidly evaporating droplets containing suspended solids. Droplet shattering can result in a $PM_{2.5}$ formation rate that can significantly exceeds that of particles from droplets evaporating slowly in plumes or air masses.

A bias to lower than true $PM_{2.5}$ emissions can be caused by (1) $PM_{2.5}$ particle inertial impaction into droplets in the nozzle and probe, (2) Brownian diffusion of $PM_{2.5}$ particles to the nozzle and probe surfaces, and (3) electrostatic attraction of $PM_{2.5}$ particles to the nozzle and probe surfaces.

As shown in the accompanying method development report, the studies carried out in the laboratory show that this sampling system meets all of the performance criteria. In addition. the field tests at three FCCUs demonstrate that the method can be carried out with readily available stack sampling equipment that can be purchased at reasonable cost by testing organizations experienced with EPA Method 201A.

2.2 BASIS OF THE METHOD

Droplet Losses in the Probe—EPA guidance presently specifies Method 5 for use in droplet-laden gas streams. The sampling probes used in these tests operate at 248 ±25°F and can be as short as 3 feet. These sampling conditions are not necessarily well-suited for droplet evaporation. Nevertheless, Method 5 tests of droplet-laden stacks are not subject to filter wetting problems. This suggests that droplets in the size range typically present in wet scrubber stacks evaporate under these mild heating conditions and are collected as dry particles on the filter.

The wet stack filterable $PM_{2.5}$ sampling train has an equipment arrangement similar to Method 5. The filter and the cyclone upstream of the filter are enclosed in an external hot box. Droplet evaporation conditions are significantly enhanced by operating at 320 ± 25°F. Droplet evaporation is further accelerated by concentrating the probe heat at the inlet to maximize heat transfer to the gas stream. Droplet penetration to the cyclone and filter in the new sampling train is highly unlikely due to the more aggressive evaporation conditions in the probe.

$PM_{2.5}$ Particle Losses in the Probe—The gas velocities in a probe having a diameter of 1/2 inch have a transport velocity of only 7 feet per second when the sampling rate is 0.60 ACFM. This is an extremely low transport velocity that is unlikely to create conditions favorable for inertial impaction, even for particles having aerodynamic diameters well above 3 micrometers. At this velocity, the residence time for the sample gas stream in a probe of 8 feet is only 0.6 seconds. This is very little time for Brownian Diffusion. The low sample gas stream velocity in the probe also minimizes electrostatic charge buildup. Accordingly, there is little $PM_{2.5}$ loss due to electrostatic attraction. All of the physical forces that can contribute to capturing $PM_{2.5}$ particles in the probe are especially weak. Based on general aerosol physics considerations, the sampling system should have minimal bias to lower-than-true $PM_{2.5}$ emissions due to losses in the probe.

The general assessment of physical forces in the probe is supported by data concerning the relative differences in the rinse and filter catch weights observed in many Method 5 tests. When it is clear that most of the particulate matter is in the $PM_{2.5}$ size range, the filter usually has 80 to 99% of the total filterable particulate matter catch weight. When the particulate matter is composed primarily of large particles (e.g., clinker coolers), more than one-half of the filterable particulate matter catch weight is in the nozzle and probe rinse.

NCASI has provided information indicating that 87% of the filterable particulate matter was in the filter, and 13% was in the probe in a set of 91 tests of wet scrubbers in the Wood Products Industry. This distribution of solids in the sampling system is possible only because a large fraction of the particulate matter penetrates the probe. These data suggest that $PM_{2.5}$ losses in the nozzle and probe are extremely small. Air Control Techniques, P.C. has had a similar experience in a variety of emission tests of industrial sources.

These observations suggest that particles in the $PM_{2.5}$ size range are not captured significantly in the probe. Accordingly, placement of the $PM_{2.5}$ cyclones in a hot box external to the stack should be possible without experiencing much bias due to $PM_{2.5}$ losses in the probe.

The lack of particle capture in the probe obviously does not necessarily apply to suspended and dissolved solids in large droplets entering the probe. The large droplets can impact or settle due to gravity during transport through the probe.

To avoid this bias, it is important to rapidly evaporate the droplets or at least cause sufficient droplet evaporation to reduce the droplet size below the $PM_{2.5}$ size range. Rapid droplet evaporation can be achieved by using additional heaters in the initial part of the probe and by keeping the entire probe at 320 ± 25°F. With this approach, it should be possible to avoid losses of the $PM_{2.5}$ particulate matter that can potentially form as these droplets evaporate to dryness.

There are no data that suggest that all of the suspended and dissolved solids in droplets in the range of 5 to 50 micrometers convert to $PM_{2.5}$ particles upon evaporation in the atmosphere or in sampling train probes. The rapid evaporation needed to minimize droplet deposition in the probes can increase the fraction of $PM_{2.5}$ particles formed by Rayleigh shattering. This will create a bias to higher-than-true measured $PM_{2.5}$ emissions. This bias cannot be avoided due to the need to minimize droplet deposition in the probe.

Organic Particulate Matter Capture—Organic particulate matter in the gas stream being sampled will be vulnerable to vaporization. The extent of vaporization will be limited by the short residence time of the gas stream in the probe and filter box. A Method 202 sampling train after the filter box is needed to capture vaporized organic particulate matter.

Droplet Evaporation Rates—Droplets in the size range of 10 to 40 micrometers have droplet evaporation times of <0.1 to 1.2 seconds at ambient temperature. Several factors significantly increase the droplet evaporation rates in the WS2.5 sampling probe.

1. The droplets are evaporating in a gas stream that has an absolute temperature that is 42 to 52% higher than the atmosphere.
2. The droplets enter the evaporation zone at a liquid temperature of 130 to 180°F.
3. The solids content of the droplets is relatively low.

These factors reduce the droplet evaporation times substantially. Laboratory tests indicated that the droplets evaporate within the first foot of the probe inlet, even for the relatively large 40-micrometer sized droplets.

Particle Formation During Droplet Evaporation—The nozzle cut size was selected by EPA based on the size of the particle formed as the droplet evaporates to dryness. This particle size is directly related to the total suspended and dissolved solids content of the inlet droplet as indicated in Table 2-1. The shaded areas indicate combinations of droplet sizes and solids levels that can result in the formation of $PM_{2.5}$ particles (particle weight equal to or less than of 8.2 x 10^{-12} grams) during evaporation.

Table 2-1. Particle Sizes Formed During Droplet Evaporation

Droplet Size, µm	Weight of Droplet, grams	Mass of Particle at Various Solids Concentrations (Weight %) in Evaporation Droplets							
		0.1	0.2	0.5	1	1.5	2	5	10
5	6.5E-11	6.5E-14	1.3E-13	3.3E-13	6.5E-13	9.8E-13	1.3E-12	3.3E-12	6.5E-12
10	5.2E-10	5.2E-13	1.0E-12	2.6E-12	5.2E-12	7.9E-12	1.0E-11	2.6E-11	5.2E-11
15	1.8E-09	1.8E-12	3.5E-12	8.8E-12	1.8E-11	2.6E-11	3.5E-11	8.8E-11	1.8E-10
20	4.2E-09	4.2E-12	8.4E-12	2.1E-11	4.2E-11	6.3E-11	8.4E-11	2.1E-10	4.2E-10
25	8.2E-09	8.2E-12	1.6E-11	4.1E-11	8.2E-11	1.2E-10	1.6E-10	4.1E-10	8.2E-10
30	1.4E-08	1.4E-11	2.8E-11	7.1E-11	1.4E-10	2.1E-10	2.8E-10	7.1E-10	1.4E-09
40	3.3E-08	3.3E-11	6.7E-11	1.7E-10	3.3E-10	5.0E-10	6.7E-10	1.7E-09	3.3E-09
50	6.5E-08	6.5E-11	1.3E-10	3.3E-10	6.5E-10	9.8E-10	1.3E-09	3.3E-09	6.5E-09

This table indicates that droplets of 30 micrometers and above form particles larger than $PM_{2.5}$. Droplets larger than 15 micrometers form particles larger than $PM_{2.5}$ if the solids content of the evaporating droplets exceeds 0.5 weight percent—a very common range.

Considering that the solids content of reentrained droplets is usually in the range of 0.2 to 2 weight percent, the calculations summarized in Table 2-1 suggest that the WS2.5 wet stack sampling train should capture droplets equal to or less than 15 micrometers. A 50% cut size of 20 micrometers, as specified by EPA, provides for high efficiency capture of the 15-micrometer droplets.

2.3 SAMPLING TRAIN

The WS2.5 test method is a logical extension of EPA Method 201A, which uses two cyclones mounted in series and inserted into the gas stream. Particle separation into the Method 201A PM_{10} (10 to 2.5 micrometers) and $PM_{2.5}$ size fractions occurs at stack temperature. Method 201A cannot be used in saturated or droplet-laden gas streams because of (1) a potential bias to lower-than-true PM_{10} emissions because droplets may have larger sizes than the cut size of the collection device and (2) problems caused by water droplets on the cyclone walls. EPA states the rationale for this limitation to Method 201A in the following statement posted on the EPA EMC website (www.epa.gov/ttn/EMC).

> Method 201A cannot be used to measure emissions from stacks that have entrained moisture droplets (e.g., a wet scrubber stack), since these stacks may have water droplets larger than the cut size for the PM10-sizing device. To measure PM10 in stacks where water droplets are known to exist, EPA's Technical Information Document (TID-099-Methods 201 and 201A in Presence of Water Droplets) recommends use of Method 5 of Appendix A to 40 CFR part 60 (or a comparable method) and consideration of the particulate catch as PM10 emissions. U.S.EPA, www.epa.gov/ttn/EMC

Most regulatory agencies assume that all particulate matter captured in Methods 5 or 5B are in the $PM_{2.5}$ size range. This assumption introduces a significant bias to higher-than-true $PM_{2.5}$ emissions that adversely affects State Implementation Plan emission inventories and control strategies.

Sampling Train Configuration—The proposed WS2.5 wet stack sampling train is a simple modification of Method 201A as promulgated in December 2010. The in-stack PM_{10} and $PM_{2.5}$ cyclones on the Method 201A probe were replaced with a $PM_{2.5}$ cyclone and filter located in an out-of-stack heated box. The probe heaters used in Method 201A were enhanced to ensure complete and rapid droplet evaporation in the initial zone of the probe. The cyclone inlet nozzle of the Method 201A sampling system was replaced with a precutter nozzle having a 50% cut point of 27 to 45 micrometers (aerodynamic diameter) and a 100% capture efficiency for droplets equal to or less than 20 micrometers.

The WS2.5 sampling train shown in Figures 2-1 and 2-2 includes a nozzle, a heated probe, a heated $PM_{2.5}$ cyclone, and a heated 47mm non-reactive filter. An EPA Method 202 sampling train is used as the "back half" of this sampling train to measure the condensable $PM_{2.5}$ emissions along with the "front half" filterable $PM_{2.5}$ emissions.

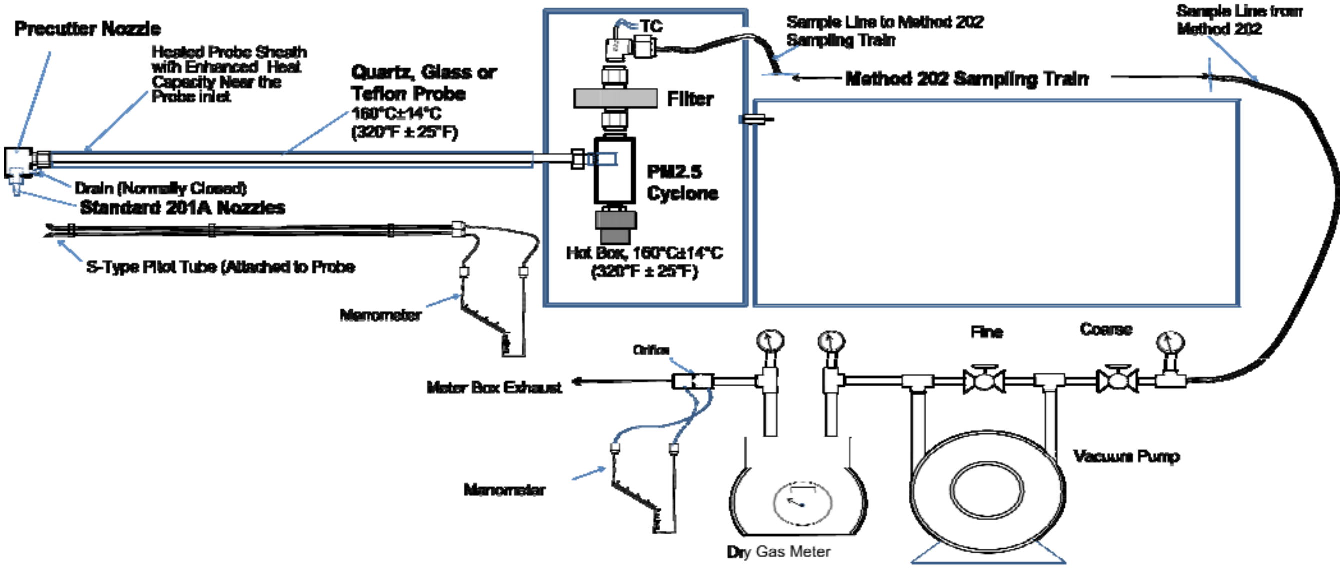

Figure 2-1. WS2.5 Wet Stack $PM_{2.5}$ Sampling Train

Figure 2-2. Heated Filter Box with $PM_{2.5}$ Cyclone and $PM_{2.5}$ Filter

Originally, the WS2.5 sampling system included a high-purity nitrogen injection line to the inlet of the probe to ensure proper droplet evaporation prior to the cyclone and filter. The field tests conducted in 2009 and 2010 demonstrated that the probe was capable of rapid and complete droplet evaporation. Accordingly, the nitrogen dilution line was not needed, even in gas streams with high droplet loadings. This part of the sampling system was eliminated to reduce the complexity in cyclone cut size and isokinetic sampling rate calculations conducted on a point-by-point basis during the emission tests.

Nozzle— A 90-degree nozzle was used for gas stream sampling in the laboratory tests and the field tests. During the stack tests at two FCCU wet scrubbers, the test crews observed liquid from droplets impacting on the exterior surface of the nozzle draining downward and being pulled into the nozzle with the sample gas stream. The droplets in the sample gas stream and the liquid pulled in from the exterior surface were pulled upward through the nozzle and into the probe. The capture of solids-containing liquid from the exterior surface of the nozzle resulted in a bias to higher-than-true measured total filterable particulate matter emissions.[3]

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[3] The measurement of total filterable particulate matter was a secondary objective of this method development program.

Air Control Techniques, P.C. modified the nozzle to a precutter arrangement conceptually similar to the inertial droplet separator (IDS) nozzle being evaluated by EPA. A sketch of this precutter nozzle is shown in Figure 2-3.

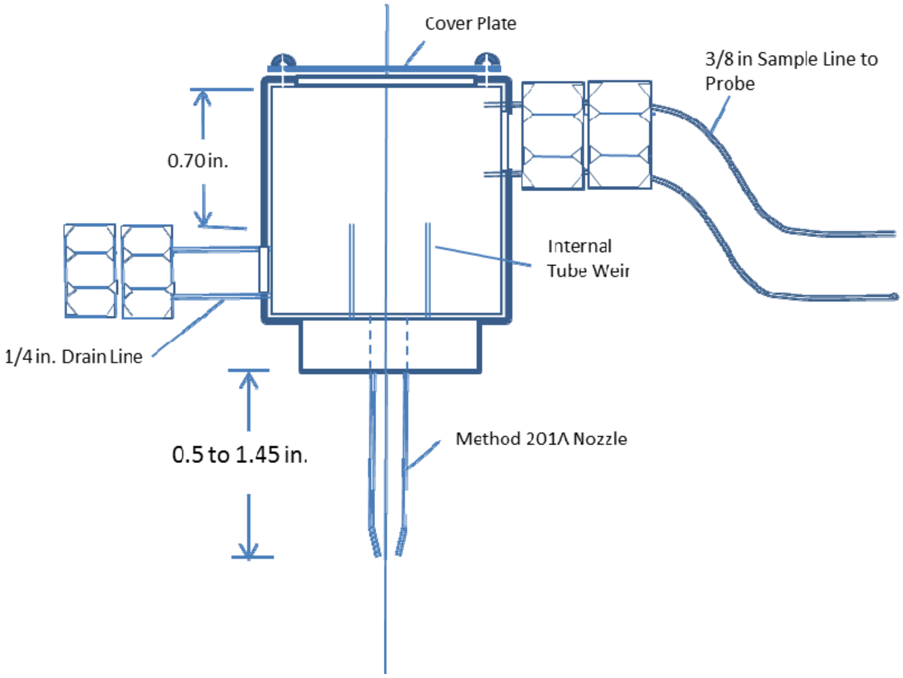

Figure 2-3. Precutter Nozzle

The gas stream is captured in a set of sampling nozzles identical to those used in Method 201A. The gas stream then enters a sampling tube where the velocity is set at approximately 15 feet per second when the overall sample flow rate is in the range of 0.55 ACFM—a typical sample flow rate for wet stacks having a gas stream temperature of 140°F.

The droplets in the sample gas stream turn 90 degrees to enter the probe. Droplets larger than 60 micrometers strike the interior wall of the precutter nozzle and are collected as a liquid at the bottom of the nozzle assembly. The liquid can be drained during port changes. If the reentrained liquid levels in the stack are extreme, the liquid collected in the precutter can be removed continuously using a peristaltic pump and the drain at the bottom of the nozzle chamber.

The precutter nozzle has a threaded fitting at the bottom that allows the use of a set of tapered nozzles (Figure 2-4) identical to those used in Method 201A. The fitting can be removed following the run to facilitate rinse recovery of solids

Figure 2-4. Precutter Method 201A Nozzles

The droplet capture efficiency of the precutter was evaluated using microspheres with physical sizes ranging from 5 to 50 micrometers. The aerodynamic diameters of the spheres were calculated based on the specific gravity of 2.1.

Prior to the capture efficiency tests, the precutter interior surfaces were coated with WD40 to minimize bounce of the rigid glass microspheres. A 47 mm filter was used immediately downstream of the nozzle. A sample of the polydisperse microspheres was pulled into the precutter through the nozzle at a flow rate of 0.55 ACFM. After several minutes of sampling, the sample flow was stopped, and the filter, precutter, and nozzle rinse was recovered. After desiccation, the samples were analyzed microscopically to determine the fraction of particles in each size range that penetrated the precutter to reach the filter.

The droplet capture efficiency curve is shown as the solid line in Figure 2-5. The data indicated a 50% cut efficiency between 27 and 45 micrometers. This is well above the 20 micrometer 50% cut size that was the design target. As indicated by the actual and design curves, the precutter has much lower droplet removal efficiency than intended. This creates a possible bias to higher-than-true $PM_{2.5}$ emissions to the extent that large droplets evaporate and shatter to form $PM_{2.5}$ particles.

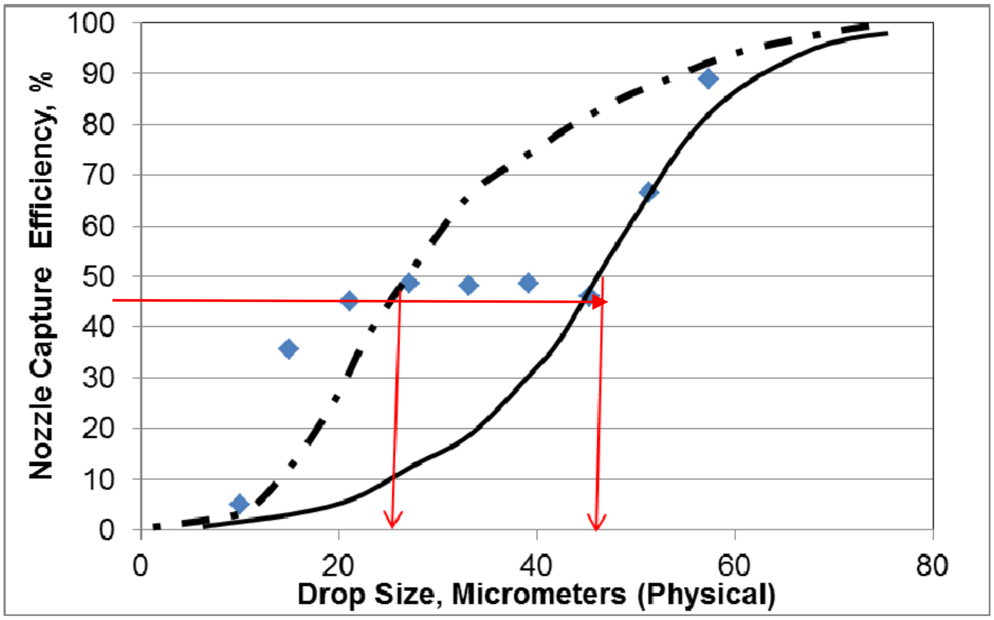

Figure 2-5. Nozzle Droplet Capture Efficiency

Probe—The probe used in the previous laboratory and field tests was a 1/2 inch (I.D.) stainless steel tube. A glass probe is now used instead. The probe is enclosed in a high temperature probe sheath, or a conventional probe with heaters sufficient to maintain sample gas stream temperatures at 320°F ±25°F. A set of thermocouples near the probe inlet monitors the probe temperature. Another thermocouple monitors the sample gas temperature exiting the filter.

$PM_{2.5}$ Cyclone—The $PM_{2.5}$ cyclone used in the WS2.5 sampling train is identical to the $PM_{2.5}$ cyclone used in Method 201A. This cyclone is based on a unit named "Cyclone IV" in a five-cyclone sampling system originally developed jointly by Southern Research Institute (SRI) and the U.S. EPA. The performance curve for this cyclone at ambient temperature is illustrated in Figure 2-6.

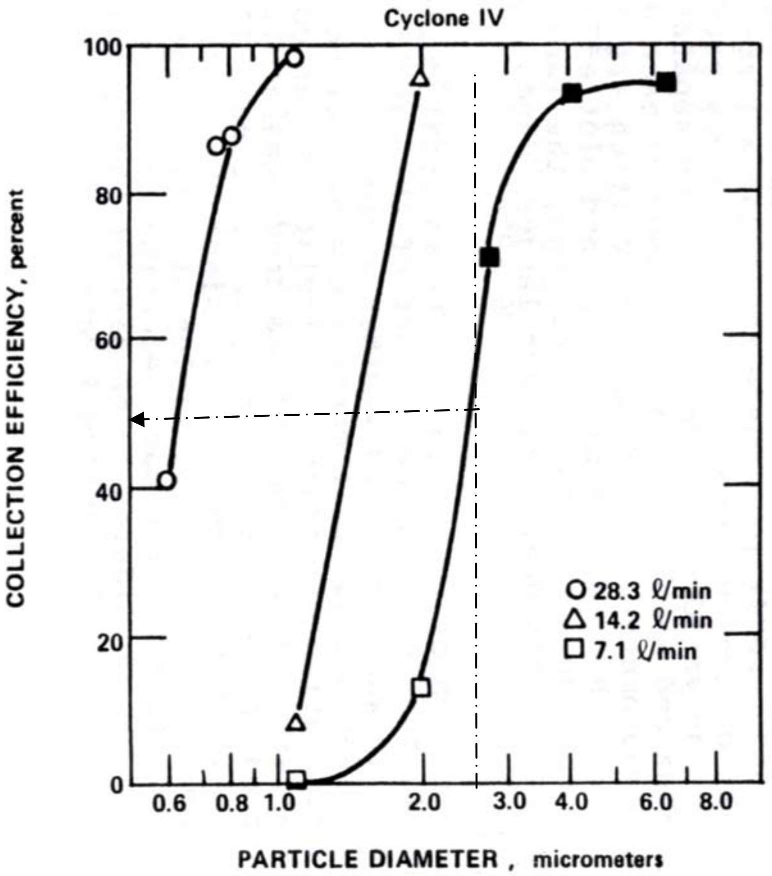

Figure 2-6. Collection Efficiency of EPA-S.R.I. Cyclone IV and WS2.5 Cyclone (Source: EPA-600/7/78-008, January 1978, page 25, dashed lines added)

This curve demonstrates that 50% of the particles that are exactly 2.5 micrometers (aerodynamic diameter) are captured in the cyclone. As indicated in the curve, the cyclone does not reach 100% capture efficiency for particles of at least 6 micrometers and perhaps even larger. Accordingly, some large particles can penetrate the cyclone, reach the $PM_{2.5}$ filter, and be counted as $PM_{2.5}$ particulate matter. Based on this curve, the $PM_{2.5}$ cyclone used in the WS2.5 sampling system has a slight bias to higher-than-true particulate matter penetrating the $PM_{2.5}$ cyclone.

Sampling Rates—Sample gas flow in the WS2.5 sampling system is maintained within the $PM_{2.5}$ cyclone performance limits as shown in Figure 2-7, which is based on Figure 10 of Method 201A. The sample gas flow rate must be adjusted to maintain a 2.5 ± 0.25 micrometer cut size.

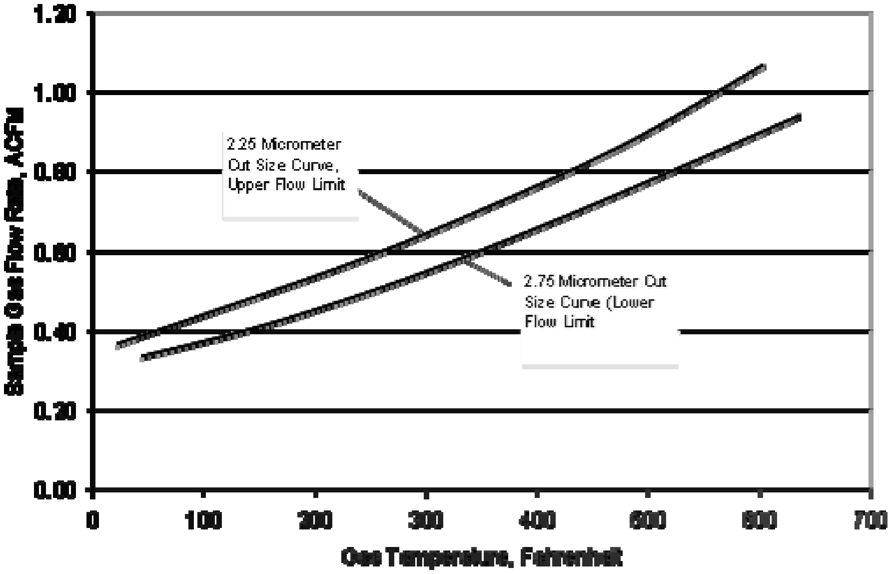

Figure 2-7. Required Minimum and Maximum Sample Flow Rates for the $PM_{2.5}$ Cyclone in the WS2.5 Sampling System

3. METHOD 301 VALIDATION TESTS

Air Control Techniques, P.C. has conducted Method 301 Validation Tests in accordance with the protocol submitted to the U.S. EPA on November 15, 2011 and revised on October 15, 2012. These tests were conducted at a Wood Products Industry facility located in North Carolina on October 21-23, 2012. This section presents a summary of the test location, spiking procedures, and test results. As indicated in this section, the WS2.5 sampling system satisfied the Method 301 bias and precision requirements.

3.1 SAMPLING LOCATIONS

Testing was performed at an exhaust stack serving a set of packed bed scrubbers. The stack had a diameter of 114 inches and four sampling ports located 90 degrees apart. The sampling ports were located 3.7 stack diameters downstream (35 feet) and 1.9 diameters upstream (18 feet) from flow disturbances. The upstream and downstream distances met EPA Method 1 specifications. During the Method 301 tests, two separate dual trains approached the middle of the stack using two ports located 180 degrees apart. As required by Method 301, the four sampling locations were located within one inch of each other at the sampling point.

The upstream flow disturbance was the converging section on top of the cylindrical packed bed scrubbers. The downstream flow disturbance was the stack discharge point. There were no stiffeners or other flow obstructions in the center of the stack.

The ports were slightly less than four inches I.D as indicated in Figure 3-1. The clearance for the dual sampling train with the attached nozzle and Pitot tube was extremely limited. The selection of nozzles was restricted due to the close clearances.

Figure 3-1. Sampling Port Internal Diameter

As indicated in Figure 3-2, the large sampling platform allowed the use of a jumper umbilical to one of the two sets of impingers needed for the dual trains. The second set of impingers remained on the grating (Figure 3-3), while the first set of impingers was attached to the hot box suspended on a rail.

Figure 3-2. Sampling Platform

Figure 3-3. Dual Sampling Train with Two Sets of Method 4 Impingers

Each of the dual sampling trains had a set of two $PM_{2.5}$ cyclones and filters. These cyclones were identical to those used in Method 201A. The $PM_{2.5}$ cyclones and filters were maintained at 320 ± 25°F in the filter box shown in Figure 3-4.

Figure 3-4. Dual Sampling Train During Method 301 Validation Tests

One of the two sampling trains in each of the dual trains was spiked with a sodium chloride aerosol following the test run. The spiking system consisted of a nebulizer and a $PM_{2.5}$ cyclone mounted in a heated box. The outlet of the cyclone containing droplets less than 2.5 micrometers in size entered the precutter nozzle positioned immediately adjacent to the analyte spiking system hot box. The nebulizer handled a salt solution of 8% by weight. The duration of the spike was established to provide sodium and chloride concentrations well in excess of the native salt and chloride levels in the source effluent gas stream.

3.2 METHOD 301 DUAL SAMPLING TRAIN

Method 301 requires the use of four identical sampling trains. Air Control Techniques, P.C. fabricated two dual trains, each having two sets of $PM_{2.5}$ cyclones and filters in a hot box designed to operate at 320F ± 25°F. The cyclones are shown in Figure 3-5.

Figure 3-5. Dual $PM_{2.5}$ Cyclone/Filter Assemblies in Dual Train Hot Box

The dual train had two separate Method 4 trains. One of the Method 4 trains was mounted in the conventional position behind the hot box. The second was placed on the platform grating as shown in Figure 3-6. A jumper line connected the outlet of the $PM_{2.5}$ filter to the inlet of the Method 4 sampling train.

Figure 3-6. Dual Sampling Train with Two Method 4 Trains

The data quality objectives for the WS2.5 wet stack sampling system tests included the following.

- Isokinetic sampling rates ≥80% and ≤ 120%
- Stack gas sample volumes equal to or greater than 36 DSCF
- Pre-run leak check rates equal to or less than 0.02 DSCFM at 5 psig (pre-run leak check of entire sampling train)
- Post-run leak check rates equal to or less than 0.02 DSCFM at maximum run vacuum (post-run leak check from outlet of the filter)
- Sampling train exit temperatures equal to or less than 68°F
- Filter and probe temperature equal to 320±25°F

The WS2.5 wet stack sampling system head was recovered using a nylon brush and ultra-pure acetone rinse. The particulate matter was divided into six separate sample jars and a filter container.

Sample Jar #1, Particulate Matter > 2.5 micrometers

- Solids in the acetone rinse of the sampling nozzle

Sample Jar #2, Particulate Matter > 2.5 micrometers

- Solids in the water rinse of the sampling nozzle

Sample Jar #3, Particulate Matter > 2.5 micrometers

- Solids in the acetone rise of the probe
- Solids in the acetone rinse of the $PM_{2.5}$ cyclone cup
- Solids in the acetone rinse of the $PM_{2.5}$ cyclone body

Sample Jar #4, Particulate Matter > 2.5 micrometers

* Solids in the water rise of the probe
* Solids in the water rinse of the $PM_{2.5}$ cyclone cup
* Solids in the water rinse of the $PM_{2.5}$ cyclone body

Sample Jar #5, Particulate Matter ≤2.5 micrometers

- Solids in the acetone rinse of the outlet tube of the cyclone body
- Solids in the acetone rinse of the inlet pipe to $PM_{2.5}$ filter
- Solids in the acetone rinse of the inlet side of $PM_{2.5}$ filter housing

Sample Jar #6, Particulate Matter ≤2.5 micrometers

- Solids in the water rinse of the outlet tube of the cyclone body
- Solids in the water rinse of the inlet pipe to $PM_{2.5}$ filter
- Solids in the water rinse of the inlet side of $PM_{2.5}$ filter housing

Filter, Container #7, Particulate Matter ≤ 2.5 micrometers

- $PM_{2.5}$ Filter

The total particulate matter is the sum of all the particulate matter recovered from the cyclone sampling assembly--sample jars #1 through #6 and the filter (sample #7). $PM_{2.5}$ particulate matter is the sum of the solids recovered from sample jars #5 and #6, and filter (sample #7).

EPA Method 5 analytical procedures were used to analyze the filter and the front half acetone rinses for particulate matter. Standard EPA procedures were used to recover the samples. Sample recovery was performed in a mobile lab at the facility. Each sampling train was sealed to prevent contamination during transport to and from the clean-up area.

3.3 METHOD 301 TEST PROCEDURES

The procedures described in Method 301 have been used to validate the WS2.5 method for $PM_{2.5}$ sampling in wet stacks. The bias and precision of the method has been determined by spiking two out of the four sampling trains with sodium chloride solutions and analyzing the results to calculate the precision and bias of the new method. The WS2.5 test method bias was determined in accordance with the Method 301 procedures described in Section 12 of Method 301.

The test matrix for the bias and precision tests is summarized in Table 3-1. The sampling time for each WS2.5 sampling train was adjusted to 90 minutes from the initially anticipated 120 minutes because the initial test demonstrated that there would be adequate catch weight, and the plant indicated that the process might not be available for portions of each day.

The WS2.5 sampling trains were recovered using deionized water and acetone because the emissions from the source include both inorganic and organic particulate matter.

The material in all of the sample jars was dried and weighed. The filter was desiccated and weighed.

3.4 METHOD 301 TEST DATA

The measured moisture concentrations in the various sampling trains are summarized in Table 3-2. The moisture levels ranged from approximately 1.5% to more than 5.5% over saturation calculated based on the gas temperature at the stack sampling point. The large differences between the calculated saturation moisture levels and the measured moisture levels demonstrate that there is a high concentration of entrained droplets in the stack.

Table 3-1. Bias and Precision Test Matrix

Run	Method	Sampling Train ,	Spiking Condition	Run Duration
1	WS2.5	1	Spiked	120
	WS2.5	2	Spiked	120
	WS2.5	3	Unspiked	120
	WS2.5	4	Unspiked	120
	Moisture (Method 4)	1, 2, 3, 4	N/A	120
	Velocity (Method 2)	Pitot tube	N/A	120
2	WS2.5	1	Spiked	90
	WS2.5	2	Spiked	90
	WS2.5	3	Unspiked	90
	WS2.5	4	Unspiked	90
	Moisture (Method 4)	1, 2, 3, 4	N/A	90
	Velocity (Method 2)	Pitot tube	N/A	90
3	WS2.5	1	Spiked	90
	WS2.5	2	Spiked	90
	WS2.5	3	Unspiked	90
	WS2.5	4	Unspiked	90
	Moisture (Method 4)	1, 2, 3, 4	N/A	90
	Velocity (Method 2)	Pitot tube	N/A	90
4	WS2.5	1	Spiked	90
	WS2.5	2	Spiked	90
	WS2.5	3	Unspiked	90
	WS2.5	4	Unspiked	90
	Moisture (Method 4)	1, 2, 3, 4	N/A	90
	Velocity (Method 2)	Pitot tube	N/A	90
5	WS2.5	1	Spiked	90
	WS2.5	2	Spiked	90
	WS2.5	3	Unspiked	90
	WS2.5	4	Unspiked	90
	Moisture (Method 4)	1, 2, 3, 4	N/A	90
	Velocity (Method 2)	Pitot tube	N/A	90
6	WS2.5	1	Spiked	90
	WS2.5	2	Spiked	90
	WS2.5	3	Unspiked	90
	WS2.5	4	Unspiked	90
	Moisture (Method 4)	1, 2, 3, 4	N/A	90
	Velocity (Method 2)	Pitot tube	N/A	90

Table 3-2. Moisture Concentrations							
Unspiked Trains				Spiked Trains			
Train	Saturation %	Measured %	Over-Saturation %	Train	Saturation %	Measured %	Over-Saturation %
U1-1	16.6	19.7	3.1	S1-1	16.6	20.0	3.4
U2-1	16.6	20.4	3.8	S2-1	16.6	18.1	1.5
U1-2	15.9	18.6	2.7	S1-2	15.9	19.6	3.7
U2-2	16.0	19.3	3.3	S2-2	15.9	18.8	2.9
U1-3	15.9	19.1	3.2	S1-3	15.9	19.1	3.2
U2-3	15.9	19.4	3.5	S2-3	15.9	19.6	3.7
U1-4	16.0	20.3	4.3	S1-4	16.2	20.2	4.0
U2-4	16.0	20.7	4.7	S2-4	16.2	20.6	4.4
U1-5	12.8	18.0	5.2	S1-5	12.8	18.1	5.3
U2-5	12.8	18.3	5.5	S2-5	12.8	18.0	5.2
U1-6	16.9	20.5	3.6	S1-6	16.9	19.8	2.9
U2-6	16.9	21.0	4.1	S2-6	16.9	20.0	3.1

The $PM_{2.5}$ cyclone cut sizes and the sampling train isokinetic rates are summarized in Table 3-3. The cut sizes remained within the 2.25 to 2.75 desired range for all of the runs. The isokinetic sampling rates ranged from 96.2 to 119.1%. All of the test runs were within the desired 80 to 120% range.

Table 3-3. $PM_{2.5}$ Sampling Conditions					
Unspiked Trains			Spiked Trains		
Train	Cut Size, Micrometers	Isokinetics %	Train	Cut Size, Micrometers	Isokinetics %
U1-1	2.69	104.5	S1-1	2.48	111.8
U2-1	2.49	114.1	S2-1	2.60	117.2
U1-2	2.65	117.2	S1-2	2.74	99.5
U2-2	2.73	117.5	S2-2	2.69	106.6
U1-3	2.65	96.6	S1-3	2.67	99.2
U2-3	2.58	99.1	S2-3	2.70	102.1
U1-4	2.58	96.2	S1-4	2.56	100.6
U2-4	2.48	99.9	S2-4	2.58	104.0
U1-5	2.48	107.1	S1-5	2.64	105.1
U2-5	2.45	108.5	S2-5	2.39	119.1
U1-6	2.49	99.6	S1-6	2.56	102.0
U2-6	2.43	101.9	S2-6	2.50	108.4

The results of the six quad train test runs are summarized in Table 3-4. More than one-half of the material captured was present on the filters. The quantities captured in the precutter nozzles were 10 to 15% of the total material. The $PM_{2.5}$ fraction of the total catch ranged from approximately 52 to 79% of the total.

Table 3-4. Quad Train Sampling Data

Run	Catch Weights, Milligrams (Acetone and water rinse catch weights combined)						Volume Sampled	Concentrations		$PM_{2.5}$ Fraction %
	Total Nozzle (>2.5)	Cyclone Inlet and Probe (>2.5)	Cyclone Outlet (≤2.5)	Total Filter (≤2.5)	Total, $PM_{2.5}$	Total Catch	DSCF	$PM_{2.5}$, gr/DSCF	Total PM, gr/DSCF	
U1-1	5.0	23.7	2.3	31.8	34.1	62.8	36.148	0.0146	0.0268	54.5
U2-1	2.0	15.0	2.9	33.1	36.0	53.0	38.005	0.0146	0.0215	67.9
S1-1	8.4	17.5	1.3	73.9	75.2	101.1	38.310	0.0303	0.0407	74.4
S2-1	8.8	14.9	2.8	64.4	67.2	90.9	37.972	0.0273	0.0369	73.9
U1-2	6.1	11.2	2.4	16.4	18.8	36.1	25.752	0.0113	0.0216	52.1
U2-2	3.3	7.8	1.1	16.3	17.4	28.5	24.878	0.0108	0.0177	61.1
S1-2	6.7	11.5	2.1	47.6	49.7	67.9	24.580	0.0312	0.0426	73.2
S2-2	6.6	11.5	1.1	48.0	49.1	67.2	25.210	0.0301	0.0411	73.2
U1-3	3.1	9.9	1.0	20.9	21.9	34.9	29.107	0.0116	0.0185	62.8
U2-3	1.5	7.4	0.7	21.7	22.4	31.3	29.600	0.0117	0.0163	71.7
S1-3	4.4	9.6	0.9	37.1	38.0	52.0	28.858	0.0203	0.0278	73.0
S2-3	2.2	14.1	1.1	30.7	31.8	48.1	28.411	0.0173	0.0261	66.3
U1-4	2.3	7.6	0.7	22.3	23.0	32.9	26.207	0.0135	0.0194	69.9
U2-4	2.3	7.3	1.0	23.7	24.7	34.3	26.956	0.0141	0.0196	71.9
S1-4	0.6	7.0	0.6	26.9	27.5	35.1	26.403	0.0161	0.0205	78.5
S2-4	1.6	5.8	1.2	26.5	27.7	35.1	26.123	0.0164	0.0207	79.2
U1-5	2.9	9.6	0.7	14.7	15.4	27.9	27.509	0.0086	0.0157	54.8
U2-5	1.3	5.4	0.7	15.1	15.8	22.5	27.612	0.0088	0.0126	69.8
S1-5	8.9	10.8	0.9	55.0	55.9	75.6	26.052	0.0331	0.0448	73.9
S2-5	3.5	12.0	0.8	5.8	6.6	22.1	28.267	0.0036	0.0121	29.9
U1-6	2.7	7.3	1.5	29.5	31.0	41.0	31.604	0.0151	0.0200	75.5
U2-6	3.2	6.5	1.8	30.1	31.9	41.6	32.042	0.0154	0.0200	77.0
S1-6	2.1	6.7	1.2	37.4	38.6	47.4	31.239	0.0191	0.0234	81.6
S2-6	2.2	4.5	0.6	1.2	1.8	8.7	31.780	0.0009	0.0042	20.7

During Runs S2-5 and S2-6, the $PM_{2.5}$ filters developed small cracks/tears that started at the edge and propagated approximately 1 centimeter into the filtering area. These cracks are shown in Figures 3-7 and 3-8. The photographs were taken after the filters were weighed and before the filters were processed for ion chromatography analyses.

The cracks/tears on the filters may have been due to a sharp edge in the sealing surface of the filter holder. This isolated issue is not related to any fundamental problem with the WS2.5 wet stack sampling train as indicated by the similarities in the greater than 2.5 material catch weights in the nozzle, probe, and cyclone inlet in the twenty-four sampling trains.

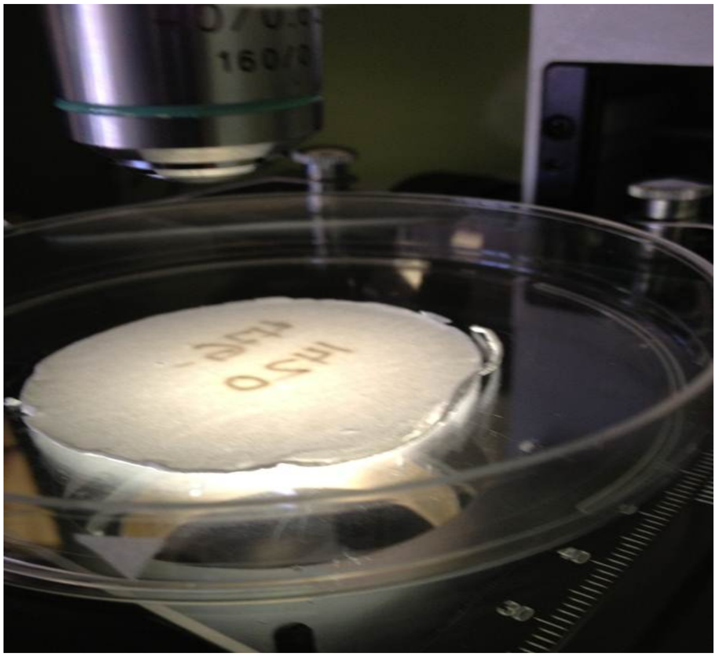

Figure 3-7. Crack in Filter S2-5

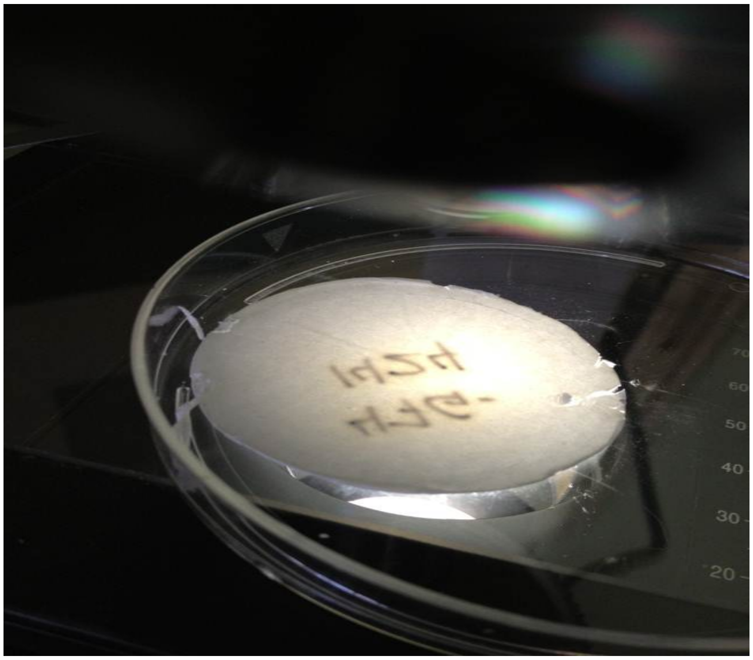

Figure 3-8. Crack in Filter S2-6

The total spike quantities were determined based on ion chromatography analyses of the sodium and chloride found in the water rinses of the nozzle, probe, and $PM_{2.5}$ cyclone (inlet and cup), $PM_{2.5}$ cyclone outlet, and filter. The native sodium and chloride levels were calculated as the average value of the total salt content in the two unspiked sampling trains in each run. The salt spike concentration was determined by subtracting the average sodium chloride level in the unspiked trains from the sodium and chloride levels in the two spiked sampling trains. This approach was needed because it was not possible to fully inject a pre-measured quantity of salt into the sampling train due to changes in the nebulizer performance as the level of saltwater in the reservoir decreased.

The performance of the nebulizer changed over the test series due to undetected build-up of salt deposits in portions of the nebulizer. The calculated spike quantities are listed in Table 3-5.

Table 3-5. Sodium Chloride Spike Quantities

Run	Total Sodium and Chloride, gr/DSCF	Average of Total Sodium and Chloride, gr/DSCF	Sodium Chloride Spike Quantity, gr/DSCF	Average Sodium Chloride Spike Quantity, gr/DSCF
U1-1	0.00320	0.00312	N/A	N/A
U2-1	0.00305		N/A	N/A
S1-1	0.02048	N/A	0.0174	0.0182
S2-1	0.02226	N/A	0.0191	
U1-2	0.00186	0.00176	N/A	N/A
U2-2	0.00165		N/A	N/A
S1-2	0.02766	N/A	0.0259	0.0229
S2-2	0.02155	N/A	0.0198	
U1-3	0.00191	0.00192	N/A	N/A
U2-3	0.00193		N/A	N/A
S1-3	0.01257	N/A	0.0106	0.0083
S2-3	0.00784	N/A	0.0059	
U1-4	0.00318	0.00287	N/A	N/A
U2-4	0.00255		N/A	N/A
S1-4	0.00502	N/A	0.0021	0.0023
S2-4	0.00536	N/A	0.0025	
U1-5	0.00292	0.00279	N/A	N/A
U2-5	0.00267		N/A	N/A
S1-5	0.03040	N/A	0.0276	0.0163
S2-5	0.00769	N/A	0.0049	
U1-6	0.00392	0.00384	N/A	N/A
U2-6	0.00376		N/A	N/A
S1-6	0.00717	N/A	0.0033	0.0003
S2-6	0.00118	N/A	-0.0027	

3.5 BIAS AND PRECISION CALCULATIONS

Bias—The bias of the WS2.5 wet stack test method was calculated using the following equations from Method 301. The first step in calculating the bias was to calculate the differences in the paired spiked sampling train test results in accordance with Method 301 Equation 301-13.

$$d_i = \left(\frac{S_{1i} + S_{2i}}{2}\right) - \left(\frac{M_{1i} + M_{2i}}{2}\right) - CS \qquad \text{Equation 301-13}$$

Where:

d_i = Bias during run i
S_{1i} = First measured value of the ith spiked sample (total $PM_{2.5}$)
S_{2i} = Second measured value of the ith spiked sample (total $PM_{2.5}$)
M_{1i} = First measured value of the ith unspiked sample (total $PM_{2.5}$)
M_{2i} = Second measured value of the ith unspiked sample (total $PM_{2.5}$)
CS = Analyte spike value (sodium chloride $PM_{2.5}$ spike quantity as calculated in Table 3-5)

The standard deviation of the differences in the means of the spiked sampling train tests was calculated in accordance with Method 301 Equation 301-2.

$$SD_d = \sqrt{\frac{\sum_{i}^{n} (d_i - d_m)^2}{n - 1}} \qquad \text{Equation 301-2}$$

Where:

SD_d = The standard deviation of the differences, gr/DSCF
d_i = The differences in the results of the ith sample
d_m = The mean of the paired sample differences
n = Total number of paired samples (6)

The t-statistic for the differences was calculated from the means of the paired sample differences, the standard deviation of the differences, and the number of paired samples (6).

$$t = \frac{|d_m|}{\frac{SD_d}{\sqrt{n}}} \qquad \text{Equation 301-3}$$

Where:

t = t statistic
d_m = The mean of the paired sample differences
SD_d = The standard deviation of the differences, gr/DSCF
n = Total number of paired samples (6)

Two alternative approaches were used in these calculations due to the problems with the filters in Runs S2-5 and S2-6 discussed earlier in this report. In the Alternative 1 approach, only the data from the first four test runs were included. In the Alternative 2 approach, the data included in the calculations consisted of all of the data from runs 1 through 4 and the unspiked tests in runs 5 and 6. The two spiked train runs with the torn filters were excluded in the Alternative 2 approach. The results of the Alternative 1 and Alternative 2 calculations are summarized in Tables 3-6 and 3-7.

Table 3-6. Alternative 1. Runs 1 Through 4

di	dm	$(di\text{-}dm)^2$	S_D	t_{stat}	Degrees of Freedom
-0.00403	-0.00209	3.77×10^{-6}	0.00188	-2.22	3
-0.00325	-0.00209	1.35×10^{-6}			
-0.00113	-0.00209	9.22×10^{-7}			
0.000055	-0.00209	4.59×10^{-6}			
-0.00323		Excluded			
0.00049		Excluded			

Table 3-7. Alternative 2. Runs 1 Through 6 (S2-5 and S2-6 Excluded)

Di	Dm	$(di\text{-}dm)^2$	S_D	t_{stat}	Degrees of Freedom
-0.00403	-0.00185	4.76×10^{-6}	0.00191	-2.37	5
-0.00325	-0.00185	1.96×10^{-6}			
-0.00113	-0.00185	5.20×10^{-7}			
0.000055	-0.00185	3.63×10^{-6}			
-0.00323	-0.00185	1.91×10^{-6}			
0.00049	-0.00185	5.46×10^{-6}			

The t-statistic was compared with the critical value of the t-statistic to determine if the bias is significant at the 95 percent confidence interval. The two-sided confidence level critical value is 2.571 for the five degrees of freedom applicable to a set of six runs. The results are not significant for either of the alternative approaches for evaluating the test data. Based on these results, the bias is not considered to be significant.

Precision—To evaluate the precision of the WS2.5 sampling system, the relative standard deviation was calculated in accordance with Equation 301-8.

$$RSD = \left(\frac{SD_d}{S_M} \right) 100 \qquad \text{Equation 301-8}$$

RSD = Relative standard deviation, %
SD_d = Standard deviation of the differences, gr/DSCF
S_M = Mean of the twelve spiked test runs, gr/DSCF

The WS2.5 sampling system will meet the requirements of Method 301 Section 9.0 if the RSD is equal to or less than 20%. The results of the calculations in accordance with Equation 301-8 are summarized in Table 3-8.

Table 3-8. Precision Calculations

Alternative	S_M	RSD
1	0.0236	7.97
2	0.0241	7.92

The results of the calculations indicate that the precision of the method is within the 20% requirement of Method 301. The precision of the method is also indicated by the good precision observed for the sampling results of the six sets of two unspiked sampling trains. As indicated in Figure 3-9, the correlation coefficient for this set of data was greater than 0.98.

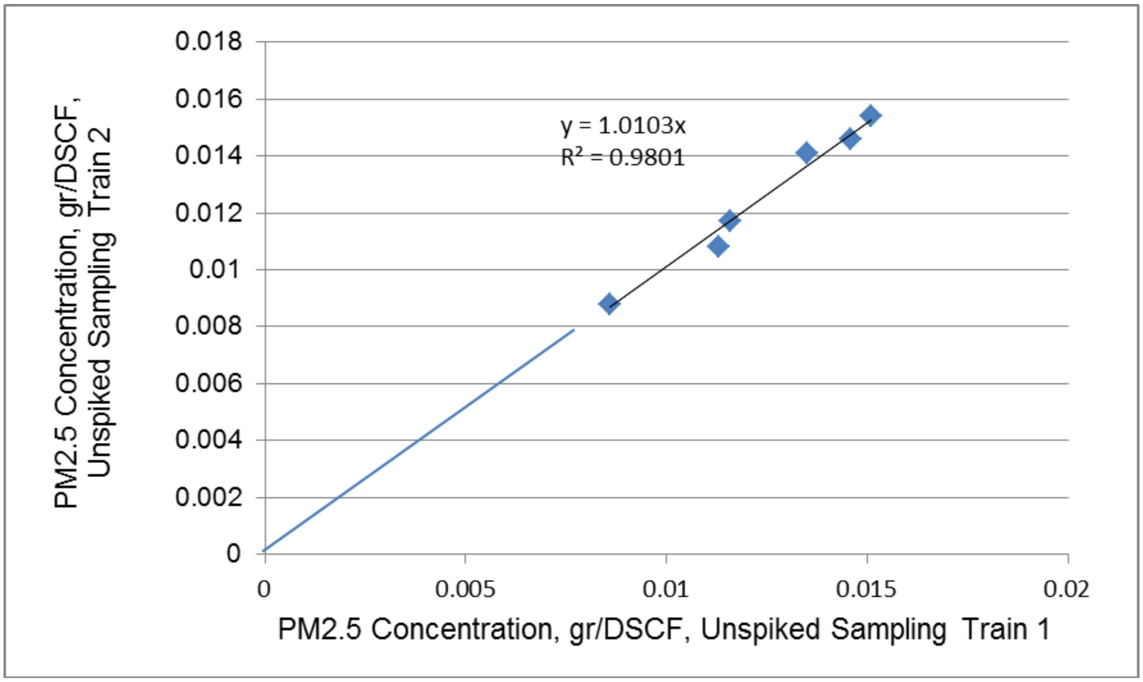

Figure 3-9. Correlation of the Unspiked Sampling Trains

The test results summarized in this report demonstrate that the WS2.5 method has met the bias and precision requirements of Method 301. API and NCASI recommend that EPA adopt the WS2.5 test method for measuring filterable $PM_{2.5}$ emissions in wet stacks.

5. REFERENCES

1. U.S. EPA, Method 201A - Method for Measurement of PM_{10} and $PM_{2.5}$ Emissions – Promulgated December 21, 2010.

2. U.S. EPA, Method 202 - Method for Measurement of Condensable Particulate Matter – Promulgated December 21, 2010.

3. Richards, J. "Test Protocol: PCA PM_{10}/$PM_{2.5}$ Emission Factor and Chemical Characterization Testing." Portland Cement Association Research Publication SP2081, July 1996.

4. Research Triangle Institute, Desert Research Institute, and Baldwin Environmental. "Quality Assurance Project Plat for Pre-field Laboratory Quality Assurance Evaluations of $PM_{2.5}$ Dilution Monitoring Device." February 17, 2009.

5. Smith. W. B. and R.R Wilson, Jr. "Development and Laboratory Evaluation of a Five-Stage Cyclone System." Southern Research Institute report to the U.S. EPA. EPA-600/7-78-008, January 1978.

APPENDIX A

TEST RESULTS - DETAILED

Sampling Location East Scrubber Stack

PARAMETER	NOMENCLATURE	U1-1	U1-2	U1-3
Sampling Location				
Date		10/23/2012	10/24/2012	10/24/2012
Run Time	Theta	117.64	81.96	93.17
Nozzle Diameter	inches	0.216	0.216	0.233
Pitot Tube Coefficient	Cp	0.84	0.84	0.84
Meter Calibration Factor	Y	0.9762	0.9762	0.9762
Barometric Pressure, inches Hg	Bp - in Hg	30.20	29.80	29.80
Meter Box Pressure Differential	ΔH - in. H2O	0.35	0.36	0.38
Volume of Gas Sampled	Vm - cu. ft.	37.135	26.062	30.418
Dry Gas Meter Temperature	Tm - °F	74.9	60.0	77.0
Volume of Gas Sampled, Dry	Vmstd - cu. ft.	36.148	25.752	29.107
Liquid Collected	ml	188.4	125.2	146.1
Volume of Water Vapor	Vwstd - cu. ft.	8.868	5.893	6.877
Moisture Content	%H_20	19.700	18.62	19.11
Saturation Moisture	%H_20	16.6	15.9	15.9
Dry Mole Fraction, In Cyclone	Mfd - C	0.803	0.814	0.809
Dry Mole Fraction	Mfd	0.834	0.841	0.841
Carbon Dioxide	%CO_2	1	1	1
Oxygen	%O_2	21	21	21
Carbon Monoxide	%CO	0	0	0
Nitrogen	%N_2	78	78	78
Fuel Factor	Fo	-0.100	-0.100	-0.100
Gas Molecular Weight, Dry	Md	29.00	29.00	29.00
Gas Molecular Weight, Wet, In Cyclone	Ms - C	26.83	26.95	26.90
Gas Molecular Weight, Wet	Ms	27.17	27.25	27.25
Static Pressure	Pg - in. H_2O	-0.08	-0.08	-0.08
Stack Pressure	Ps	30.19	29.79	29.79
Stack Temperature	Ts - °F	134.0	131.9	131.8
Cyclone Temperature	Tc - °F	313.7	316.4	319.8
Average Velocity Head	Δp - in H_2O	0.177	0.147	0.158
Gas Velocity	vs - ft./sec.	25.74	23.53	24.35
Stack Area	As - sq. ft.	70.882	70.882	70.882
Volumetric Air Flow, Actual	Qaw - ACFM	109,479	100,052	103,558
Volumetric Air Flow, Standard	Qsd - DSCFM	81,874	74,709	77,385
Isokinetic Sampling Rate	%I	104.54	117.15	96.64
Total Filterable Particulate Catch	mg	62.8	36.1	34.9
Greater than 2.5 rinse	mg	28.7	17.3	13.0
Less than 2.5 rinse	mg	2.3	2.4	1.0
PM2.5 Catch (Filter)	mg	31.8	16.4	20.9

Sampling Location East Scrubber Stack

		U1-1	U1-2	U1-3	Average
Total Filterable Particulate Matter Emissions					
Grains/DSCF	gr/DSCF	0.0268	0.0216	0.0185	0.0223
Pounds/Hour	lb/hr	18.82	13.85	12.27	14.98
Filterable $PM_{2.5}$ Particulate Matter Emissions					
Grains/DSCF	gr/DSCF	0.01456	0.01127	0.01161	0.01248
Pounds/Hour	lb/hr	10.22	7.21	7.70	8.38
Cut Sizes					
Gas viscosity, (micropoise)	μ	227.15	228.66	229.16	228.32
Gas sampling rate, ACFM	Qs	0.5556	0.5702	0.5728	0.5662
Renolds number, (dimensionless)	N_{re}	2213.22	2228.06	2219.45	2220.24
Cunningham correction factor	C	1.0859	1.0889	1.0894	1.0881
$PM_{2.5}$ cut diameter, (microns)	D_{50} N_{re}<3162 - $PM_{2.5}$	2.69	2.65	2.65	2.66
$PM_{2.5}$ cut diameter, (microns)	D_{50} N_{re}>3162 - $PM_{2.5}$	2.36	2.33	2.33	2.34

Sampling Location East Scrubber Stack

PARAMETER	NOMENCLATURE	U2-1	U2-2	U2-3
Sampling Location				
Date		10/23/2012	10/24/2012	10/24/2012
Run Time	Theta	117.64	81.96	93.17
Nozzle Diameter	inches	0.212	0.212	0.232
Pitot Tube Coefficient	Cp	0.84	0.84	0.84
Meter Calibration Factor	Y	0.9833	0.9833	0.9833
Barometric Pressure, inches Hg	Bp - in Hg	30.20	29.80	29.80
Meter Box Pressure Differential	ΔH - in. H2O	0.32	0.31	0.31
Volume of Gas Sampled	Vm - cu. ft.	39.078	25.265	30.938
Dry Gas Meter Temperature	Tm - °F	79.3	65.6	80.9
Volume of Gas Sampled, Dry	Vmstd - cu. ft.	38.005	24.878	29.600
Liquid Collected	ml	207.3	126.4	151.4
Volume of Water Vapor	Vwstd - cu. ft.	9.758	5.950	7.126
Moisture Content	%H_20	20.429	19.30	19.40
Saturation Moisture	%H_20	16.6	16.0	15.9
Dry Mole Fraction, In Cyclone	Mfd - C	0.796	0.807	0.806
Dry Mole Fraction	Mfd	0.834	0.840	0.841
Carbon Dioxide	%CO_2	1	1	1
Oxygen	%O_2	21	21	21
Carbon Monoxide	%CO	0	0	0
Nitrogen	%N_2	78	78	78
Fuel Factor	Fo	-0.100	-0.100	-0.100
Gas Molecular Weight, Dry	Md	29.00	29.00	29.00
Gas Molecular Weight, Wet, In Cyclone	Ms - C	26.75	26.88	26.87
Gas Molecular Weight, Wet	Ms	27.17	27.24	27.25
Static Pressure	Pg - in. H_2O	-0.08	-0.08	-0.08
Stack Pressure	Ps	30.19	29.79	29.79
Stack Temperature	Ts - °F	134.0	132.0	131.8
Cyclone Temperature	Tc - °F	313.7	316.4	319.8
Average Velocity Head	Δp - in H_2O	0.177	0.147	0.158
Gas Velocity	vs - ft./sec.	25.74	23.53	24.35
Stack Area	As - sq. ft.	70.882	70.882	70.882
Volumetric Air Flow, Actual	Qaw - ACFM	109,479	100,071	103,558
Volumetric Air Flow, Standard	Qsd - DSCFM	81,874	74,667	77,385
Isokinetic Sampling Rate	%I	114.1	117.5	99.1
Total Filterable Particulate Catch	mg	53.0	28.5	31.3
Greater than 2.5 rinse	mg	17.0	11.1	8.9
Less than 2.5 rinse	mg	2.9	1.1	0.7
PM2.5 Catch (Filter)	mg	33.1	16.3	21.7

Sampling Location East Scrubber Stack

		U2-1	U2-2	U2-3	Average
Total Filterable Particulate Matter Emissions					
Grains/DSCF	gr/DSCF	0.0215	0.0177	0.0163	0.0185
Pounds/Hour	lb/hr	15.10	11.31	10.82	12.41
Filterable $PM_{2.5}$ Particulate Matter Emissions					
Grains/DSCF	gr/DSCF	0.0146	0.0108	0.0117	0.0124
Pounds/Hour	lb/hr	10.26	6.91	7.75	8.30
Cut Sizes					
Gas viscosity, (micropoise)	μ	226.61	228.16	228.94	227.90
Gas sampling rate, ACFM	Qs	0.5895	0.5554	0.5846	0.577
Renolds number, (dimensionless)	N_{re}	2346.84	2169.21	2264.70	2260.2
Cunningham correction factor	C	1.093	1.086	1.092	1.090
$PM_{2.5}$ cut diameter, (microns)	D_{50} N_{re}<3162 - $PM_{2.5}$	2.49	2.73	2.58	2.60
$PM_{2.5}$ cut diameter, (microns)	D_{50} N_{re}>3162 - $PM_{2.5}$	2.24	2.38	2.29	2.31

Sampling Location Stack

PARAMETER	NOMENCLATURE	S1-1	S1-2	S1-3
Sampling Location				
Date		10/23/2012	10/24/2012	10/24/2012
Run Time	Theta	117.64	81.96	93.17
Nozzle Diameter	inches	0.215	0.229	0.229
Pitot Tube Coefficient	Cp	0.84	0.84	0.84
Meter Calibration Factor	Y	0.9381	0.9381	0.9381
Barometric Pressure, inches Hg	Bp - in Hg	30.20	29.80	29.80
Meter Box Pressure Differential	ΔH - in. H2O	0.295	0.240	0.273
Volume of Gas Sampled	Vm - cu. ft.	41.451	26.17	31.846
Dry Gas Meter Temperature	Tm - °F	81.3	65.6	84.8
Volume of Gas Sampled, Dry	Vmstd - cu. ft.	38.310	24.580	28.858
Liquid Collected	ml	204	127.4	144.4
Volume of Water Vapor	Vwstd - cu. ft.	9.602	5.997	6.797
Moisture Content	$\%H_20$	20.04	19.61	19.06
Saturation Moisture	$\%H_20$	16.59	15.94	15.89
Dry Mole Fraction, In Cyclone	Mfd - C	0.800	0.804	0.809
Dry Mole Fraction, Final	Mfd	0.834	0.841	0.841
Carbon Dioxide	$\%CO_2$	1	1	1
Oxygen	$\%O_2$	21	21	21
Carbon Monoxide	%CO	0	0	0
Nitrogen	$\%N_2$	78	78	78
Fuel Factor	Fo	-0.100	-0.100	-0.100
Gas Molecular Weight, Dry	Md	29.00	29.00	29.00
Gas Molecular Weight, Wet, In Cyclone	Ms - C	26.80	26.84	26.90
Gas Molecular Weight, Wet, Final	Ms	27.175	27.247	27.252
Static Pressure	Pg - in. H_2O	-0.08	-0.08	-0.08
Stack Pressure	Ps	30.19	29.79	29.79
Stack Temperature	Ts - °F	133.9	131.9	131.8
Cyclone Temperature	Tc - °F	309.3	305.7	314.7
Average Velocity Head	Δp - in H_2O	0.177	0.147	0.158
Gas Velocity	vs - ft./sec.	25.74	23.53	24.35
Stack Area	As - sq. ft.	70.882	70.882	70.882
Volumetric Air Flow, Actual	Qaw - ACFM	109,463	100,052	103,558
Volumetric Air Flow, Standard	Qsd - DSCFM	81,909	74,709	77,385
Isokinetic Sampling Rate	%I	111.78	99.48	99.19
Total Filterable Particulate Catch	mg	101.1	67.9	52.0
Greater than 2.5 rinse	mg	25.9	18.2	14.0
Less than 2.5 rinse	mg	1.3	2.1	0.9
PM2.5 Catch (Filter)	mg	73.9	47.6	37.1

Sampling Location	Stack	S1-1	S1-2	S1-3	Average
Total Filterable Particulate Matter Emissions					
Grains/DSCF	gr/DSCF	0.0407	0.0426	0.0278	0.0371
Pounds/Hour	lb/hr	28.59	27.30	18.45	24.78
Filterable $PM_{2.5}$ Particulate Matter Emissions					
Grains/DSCF	gr/DSCF	0.0303	0.0312	0.0203	0.0273
Pounds/Hour	lb/hr	21.27	19.98	13.48	18.24
Cut Sizes					
Gas viscosity, (micropoise)	μ	225.78	225.16	227.88	226.27
Gas sampling rate, ACFM	Qs	0.5881	0.5433	0.5638	0.565
Renolds number, (dimensionless)	N_{re}	2366.54	2177.47	2211.97	2251.99
Cunningham correction factor	C	1.092	1.084	1.088	1.088
$PM_{2.5}$ cut diameter, (microns)	D_{50} N_{re}<3162 - $PM_{2.5}$	2.48	2.74	2.67	2.63
$PM_{2.5}$ cut diameter, (microns)	D_{50} N_{re}>3162 - $PM_{2.5}$	2.24	2.39	2.35	2.33

Sampling Location East Scrubber Stack

PARAMETER	NOMENCLATURE	S2-1	S2-2	S2-3
Sampling Location				
Date		10/23/2012	10/24/2012	10/24/2012
Run Time	Theta	117.64	81.96	93.17
Nozzle Diameter	inches	0.209	0.224	0.224
Pitot Tube Coefficient	Cp	0.84	0.84	0.84
Meter Calibration Factor	Y	1.0252	1.0252	1.0252
Barometric Pressure, inches Hg	Bp - in Hg	30.20	29.80	29.80
Meter Box Pressure Differential	ΔH - in. H2O	0.25	0.23	0.24
Volume of Gas Sampled	Vm - cu. ft.	37.385	24.628	28.604
Dry Gas Meter Temperature	Tm - °F	78.3	67.0	83.1
Volume of Gas Sampled, Dry	Vmstd - cu. ft.	37.972	25.210	28.411
Liquid Collected	ml	178.2	124.2	147.1
Volume of Water Vapor	Vwstd - cu. ft.	8.388	5.846	6.924
Moisture Content	%H_20	18.09	18.82	19.60
Saturation Moisture	%H_20	16.59	15.94	15.89
Dry Mole Fraction, In Cyclone	Mfd - C	0.819	0.812	0.804
Dry Mole Fraction, Final	Mfd	0.834	0.841	0.841
Carbon Dioxide	%CO_2	1	1	1
Oxygen	%O_2	21	21	21
Carbon Monoxide	%CO	0	0	0
Nitrogen	%N_2	78	78	78
Fuel Factor	Fo	-0.100	-0.100	-0.100
Gas Molecular Weight, Dry	Md	29.00	29.00	29.00
Gas Molecular Weight, Wet, In Cyclone	Ms - C	27.01	26.93	26.84
Gas Molecular Weight, Wet	Ms	27.17	27.25	27.25
Static Pressure	Pg - in. H_2O	-0.08	-0.08	-0.08
Stack Pressure	Ps	30.19	29.79	29.79
Stack Temperature	Ts - °F	133.9	131.9	131.8
Cyclone Temperature	Tc - °F	309.3	305.7	314.7
Average Velocity Head	Δp - in H_2O	0.177	0.147	0.158
Gas Velocity	vs - ft./sec.	25.74	23.53	24.35
Stack Area	As - sq. ft.	70.882	70.882	70.882
Volumetric Air Flow, Actual	Qaw - ACFM	109,463	100,052	103,558
Volumetric Air Flow, Standard	Qsd - DSCFM	81,909	74,709	77,385
Isokinetic Sampling Rate	%I	117.2	106.6	102.1
Total Filterable Particulate Catch	mg	90.9	67.2	48.1
Greater than 2.5 rinse	mg	23.7	18.1	16.3
Less than 2.5 rinse	mg	2.8	1.1	1.1
PM2.5 Catch (Filter)	mg	64.4	48.0	30.7

Sampling Location East Scrubber Stack

		S2-1	S2-2	S2-3	Average
Total Filterable Particulate Matter Emissions					
Grains/DSCF	gr/DSCF	0.0369	0.0411	0.0261	0.0347
Pounds/Hour	lb/hr	25.94	26.34	17.33	23.20
Filterable $PM_{2.5}$ Particulate Matter Emissions					
Grains/DSCF	gr/DSCF	0.02731	0.03006	0.01727	0.02488
Pounds/Hour	lb/hr	19.17	19.25	11.46	16.63
Cut Sizes					
Gas viscosity, (micropoise)	μ	227.22	225.74	227.48	226.82
Gas sampling rate, ACFM	Qs	0.5690	0.5518	0.5588	0.56
Renolds number, (dimensionless)	N_{re}	2293.52	2212.98	2191.17	2232.56
Cunningham correction factor	C	1.0883	1.0859	1.0869	1.0870
$PM_{2.5}$ cut diameter, (microns)	D_{50} N_{re}<3162 - $PM_{2.5}$	2.60	2.69	2.70	2.66
$PM_{2.5}$ cut diameter, (microns)	D_{50} N_{re}>3162 - $PM_{2.5}$	2.31	2.37	2.36	2.35

Sampling Location East Scrubber Stack

PARAMETER	NOMENCLATURE	U1-4	U1-5	U1-6
Sampling Location				
Date		10/24/2012	10/25/2012	10/25/2012
Run Time	Theta	83.77	82.70	98.27
Nozzle Diameter	inches	0.233	0.233	0.233
Pitot Tube Coefficient	Cp	0.84	0.84	0.84
Meter Calibration Factor	Y	0.9762	0.9762	0.9762
Barometric Pressure, inches Hg	Bp - in Hg	29.80	29.80	29.80
Meter Box Pressure Differential	ΔH - in. H2O	0.38	0.4	0.39
Volume of Gas Sampled	Vm - cu. ft.	27.886	27.546	33.218
Dry Gas Meter Temperature	Tm - °F	86.8	54.6	80.1
Volume of Gas Sampled, Dry	Vmstd - cu. ft.	26.207	27.509	31.604
Liquid Collected	ml	142	128.3	173.4
Volume of Water Vapor	Vwstd - cu. ft.	6.684	6.039	8.162
Moisture Content	%H_20	20.322	18.00	20.53
Saturation Moisture	%H_20	16.0	12.8	16.9
Dry Mole Fraction, In Cyclone	Mfd - C	0.797	0.820	0.795
Dry Mole Fraction	Mfd	0.840	0.872	0.831
Carbon Dioxide	%CO_2	1	1	1
Oxygen	%O_2	21	21	21
Carbon Monoxide	%CO	0	0	0
Nitrogen	%N_2	78	78	78
Fuel Factor	Fo	-0.100	-0.100	-0.100
Gas Molecular Weight, Dry	Md	29.00	29.00	29.00
Gas Molecular Weight, Wet, In Cyclone	Ms - C	26.76	27.02	26.74
Gas Molecular Weight, Wet	Ms	27.236	27.595	27.141
Static Pressure	Pg - in. H_2O	-0.08	-0.08	-0.08
Stack Pressure	Ps	29.79	29.79	29.79
Stack Temperature	Ts - °F	132.1	123.7	134.1
Cyclone Temperature	Tc - °F	318.9	318.3	318.7
Average Velocity Head	Δp - in H_2O	0.160	0.135	0.161
Gas Velocity	vs - ft./sec.	24.54	22.24	24.70
Stack Area	As - sq. ft.	70.882	70.882	70.882
Volumetric Air Flow, Actual	Qaw - ACFM	104,353	94,584	105,060
Volumetric Air Flow, Standard	Qsd - DSCFM	77,805	74,318	77,260
Isokinetic Sampling Rate	%I	96.2	107.1	99.6
Total Filterable Particulate Catch	mg	32.9	27.9	41.0
Greater than 2.5 rinse	mg	9.9	12.5	10
Less than 2.5 rinse	mg	0.7	0.7	1.5
PM2.5 Catch (Filter)	mg	22.3	14.7	29.5

Sampling Location East Scrubber Stack

		U1-4	U1-5	U1-6	Average
Total Filterable Particulate Matter Emissions					
Grains/DSCF	gr/DSCF	0.0194	0.0157	0.0200	0.0183
Pounds/Hour	lb/hr	12.92	9.97	13.26	12.05
Filterable $PM_{2.5}$ Particulate Matter Emissions					
Grains/DSCF	gr/DSCF	0.01354	0.00864	0.01514	0.01244
Pounds/Hour	lb/hr	9.03	5.50	10.02	8.19
Cut Sizes					
Gas viscosity, (micropoise)	μ	228.03	229.61	227.82	228.49
Gas sampling rate, ACFM	Qs	0.5816	0.6005	0.5993	0.59
Renolds number, (dimensionless)	N_{re}	2256.21	2337.22	2325.64	2306.36
Cunningham correction factor	C	1.0915	1.0954	1.0948	1.0939
$PM_{2.5}$ cut diameter, (microns)	D_{50} $N_{re}<3162$ - $PM_{2.5}$	2.58	2.48	2.49	2.52
$PM_{2.5}$ cut diameter, (microns)	D_{50} $N_{re}>3162$ - $PM_{2.5}$	2.29	2.23	2.23	2.25

Sampling Location East Scrubber Stack

PARAMETER	NOMENCLATURE	U2-4	U2-5	U2-6
Sampling Location				
Date		10/24/2012	10/24/2012	10/25/2012
Run Time	Theta	83.77	82.70	98.27
Nozzle Diameter	inches	0.232	0.232	0.232
Pitot Tube Coefficient	Cp	0.84	0.84	0.84
Meter Calibration Factor	Y	0.9833	0.9833	0.9833
Barometric Pressure, inches Hg	Bp - in Hg	29.80	29.80	29.80
Meter Box Pressure Differential	ΔH - in. H2O	0.33	0.33	0.33
Volume of Gas Sampled	Vm - cu. ft.	28.451	27.673	33.509
Dry Gas Meter Temperature	Tm - °F	86.2	58.7	81.2
Volume of Gas Sampled, Dry	Vmstd - cu. ft.	26.956	27.612	32.042
Liquid Collected	ml	149.8	131.6	180.6
Volume of Water Vapor	Vwstd - cu. ft.	7.051	6.194	8.501
Moisture Content	%H_20	20.73	18.32	20.97
Saturation Moisture	%H_20	16.03	12.78	16.90
Dry Mole Fraction, In Cyclone	Mfd - C	0.793	0.817	0.790
Dry Mole Fraction	Mfd	0.840	0.872	0.831
Carbon Dioxide	%CO_2	1	1	1
Oxygen	%O_2	21	21	21
Carbon Monoxide	%CO	0	0	0
Nitrogen	%N_2	78	78	78
Fuel Factor	Fo	-0.100	-0.100	-0.100
Gas Molecular Weight, Dry	Md	29.00	29.00	29.00
Gas Molecular Weight, Wet, In Cyclone	Ms - C	26.72	26.98	26.69
Gas Molecular Weight, Wet	Ms	27.24	27.59	27.14
Static Pressure	Pg - in. H_2O	-0.08	-0.08	-0.08
Stack Pressure	Ps	29.79	29.79	29.79
Stack Temperature	Ts - °F	132.1	123.7	134.1
Cyclone Temperature	Tc - °F	319.2	318.3	318.8
Average Velocity Head	Δp - in H_2O	0.160	0.135	0.161
Gas Velocity	vs - ft./sec.	24.54	22.24	24.70
Stack Area	As - sq. ft.	70.882	70.882	70.882
Volumetric Air Flow, Actual	Qaw - ACFM	104,353	94,584	105,060
Volumetric Air Flow, Standard	Qsd - DSCFM	77,805	74,318	77,260
Isokinetic Sampling Rate	%I	99.9	108.5	101.9
Total Filterable Particulate Catch	mg	34.3	22.5	41.6
Greater than 2.5 rinse	mg	9.6	6.7	9.7
Less than 2.5 rinse	mg	1.0	0.7	1.8
PM2.5 Catch (Filter)	mg	23.7	15.1	30.1

Sampling Location East Scrubber Stack

		U2-4	U2-5	U2-6	Average
Total Filterable Particulate Matter Emissions					
Grains/DSCF	gr/DSCF	0.0196	0.0126	0.0200	0.0174
Pounds/Hour	lb/hr	13.10	8.01	13.27	11.46
Filterable $PM_{2.5}$ Particulate Matter Emissions					
Grains/DSCF	gr/DSCF	0.01414	0.00883	0.01536	0.01278
Pounds/Hour	lb/hr	9.43	5.63	10.17	8.41
Cut Sizes					
Gas viscosity, (micropoise)	μ	227.81	229.37	227.52	228.23
Gas sampling rate, ACFM	Qs	0.6016	0.6051	0.6111	0.61
Renolds number, (dimensionless)	N_{re}	2331.10	2354.53	2369.88	2351.84
Cunningham correction factor	C	1.0952	1.0965	1.0971	1.10
$PM_{2.5}$ cut diameter, (microns)	D_{50} N_{re}<3162 - $PM_{2.5}$	2.48	2.45	2.43	2.45
$PM_{2.5}$ cut diameter, (microns)	D_{50} N_{re}>3162 - $PM_{2.5}$	2.23	2.22	2.20	2.21

Sampling Location East Scrubber Stack

PARAMETER	NOMENCLATURE	S1-4	S1-5	S1-6
Sampling Location				
Date		10/24/2012	10/25/2012	10/25/2012
Run Time	Theta	83.77	82.70	98.27
Nozzle Diameter	inches	0.229	0.229	0.229
Pitot Tube Coefficient	Cp	0.84	0.84	0.84
Meter Calibration Factor	Y	0.9381	0.9381	0.9381
Barometric Pressure, inches Hg	Bp - in Hg	29.80	29.80	29.80
Meter Box Pressure Differential	ΔH - in. H2O	0.26	0.30	0.28
Volume of Gas Sampled	Vm - cu. ft.	29.554	27.476	34.571
Dry Gas Meter Temperature	Tm - °F	92.6	60.7	86.3
Volume of Gas Sampled, Dry	Vmstd - cu. ft.	26.403	26.052	31.239
Liquid Collected	ml	142.2	122.4	163.5
Volume of Water Vapor	Vwstd - cu. ft.	6.693	5.761	7.696
Moisture Content	%$H_2$0	20.224	18.11	19.77
Saturation Moisture	%$H_2$0	16.2	12.8	16.9
Dry Mole Fraction, In Cyclone	Mfd - C	0.798	0.819	0.802
Dry Mole Fraction, Final	Mfd	0.838	0.872	0.831
Carbon Dioxide	%CO_2	1	1	1
Oxygen	%O_2	21	21	21
Carbon Monoxide	%CO	0	0	0
Nitrogen	%N_2	78	78	78
Fuel Factor	Fo	-0.100	-0.100	-0.100
Gas Molecular Weight, Dry	Md	29.00	29.00	29.00
Gas Molecular Weight, Wet, In Cyclone	Ms - C	26.78	27.01	26.83
Gas Molecular Weight, Wet	Ms	27.221	27.590	27.141
Static Pressure	Pg - in. H_2O	-0.08	-0.08	-0.08
Stack Pressure	Ps	29.79	29.79	29.79
Stack Temperature	Ts - °F	132.4	123.8	134.1
Cyclone Temperature	Tc - °F	314.4	312.8	315.2
Average Velocity Head	Δp - in H_2O	0.160	0.135	0.161
Gas Velocity	vs - ft./sec.	24.55	22.24	24.70
Stack Area	As - sq. ft.	70.882	70.882	70.882
Volumetric Air Flow, Actual	Qaw - ACFM	104,413	94,601	105,060
Volumetric Air Flow, Standard	Qsd - DSCFM	77,673	74,283	77,260
Isokinetic Sampling Rate	%I	100.56	105.09	101.97
Total Filterable Particulate Catch	mg	35.1	75.6	47.4
Greater than 2.5 rinse	mg	7.6	19.7	8.8
Less than 2.5 rinse	mg	0.6	0.9	1.2
PM2.5 Catch (Filter)	mg	26.9	55.0	37.4

Sampling Location East Scrubber Stack

		S1-4	S1-5	S1-6	Average
Total Filterable Particulate Matter Emissions					
Grains/DSCF	gr/DSCF	0.0205	0.0448	0.0234	0.0296
Pounds/Hour	lb/hr	13.66	28.51	15.51	19.23
Filterable $PM_{2.5}$ Particulate Matter Emissions					
Grains/DSCF	gr/DSCF	0.01607	0.03311	0.01907	0.02275
Pounds/Hour	lb/hr	10.70	21.08	12.63	14.80
Cut Sizes					
Gas viscosity, (micropoise)	μ	226.959	228.098	227.498	227.52
Gas sampling rate, ACFM	Qs	0.5819	0.5654	0.5842	0.5772
Renolds number, (dimensionless)	N_{re}	2281.98	2230.05	2287.41	2266.48
Cunningham correction factor	C	1.092	1.089	1.092	1.0906
$PM_{2.5}$ cut diameter, (microns)	D_{50} N_{re}<3162 - $PM_{2.5}$	2.56	2.64	2.56	2.59
$PM_{2.5}$ cut diameter, (microns)	D_{50} N_{re}>3162 - $PM_{2.5}$	2.28	2.33	2.28	2.30

Sampling Location East Scrubber Stack

PARAMETER	NOMENCLATURE	S2-4	S2-5	S2-6
Sampling Location				
Date		10/24/2012	10/25/2012	10/25/2012
Run Time	Theta	83.77	82.70	98.27
Nozzle Diameter	inches	0.224	0.224	0.224
Pitot Tube Coefficient	Cp	0.84	0.84	0.84
Meter Calibration Factor	Y	1.0252	1.0252	1.0252
Barometric Pressure, inches Hg	Bp - in Hg	29.80	29.80	29.80
Meter Box Pressure Differential	ΔH - in. H2O	0.24	0.29	0.27
Volume of Gas Sampled	Vm - cu. ft.	26.763	27.355	32.104
Dry Gas Meter Temperature	Tm - °F	92.7	62.1	85.0
Volume of Gas Sampled, Dry	Vmstd - cu. ft.	26.123	28.267	31.780
Liquid Collected	ml	143.7	131.8	168.5
Volume of Water Vapor	Vwstd - cu. ft.	6.764	6.204	7.931
Moisture Content	%$H_2$0	20.567	18.00	19.97
Saturation Moisture	%$H_2$0	16.2	12.8	16.9
Dry Mole Fraction, In Cyclone	Mfd - C	0.794	0.820	0.800
Dry Mole Fraction	Mfd	0.838	0.872	0.831
Carbon Dioxide	%CO_2	1	1	1
Oxygen	%O_2	21	21	21
Carbon Monoxide	%CO	0	0	0
Nitrogen	%N_2	78	78	78
Fuel Factor	Fo	-0.100	-0.100	-0.100
Gas Molecular Weight, Dry	Md	29.00	29.00	29.00
Gas Molecular Weight, Wet, In Cyclone	Ms - C	26.74	27.02	26.80
Gas Molecular Weight, Wet, Final	Ms	27.22	27.59	27.14
Static Pressure	Pg - in. H_2O	-0.08	-0.08	-0.08
Stack Pressure	Ps	29.79	29.79	29.79
Stack Temperature	Ts - °F	132.4	123.7	134.1
Cyclone Temperature	Tc - °F	314.4	313.6	315.2
Average Velocity Head	Δp - in H_2O	0.160	0.135	0.161
Gas Velocity	vs - ft./sec.	24.55	22.24	24.70
Stack Area	As - sq. ft.	70.882	70.882	70.882
Volumetric Air Flow, Actual	Qaw - ACFM	104,413	94,584	105,060
Volumetric Air Flow, Standard	Qsd - DSCFM	77,673	74,318	77,260
Isokinetic Sampling Rate	%I	103.98	119.12	108.42
Total Filterable Particulate Catch	mg	35.1	22.1	8.7
Greater than 2.5 rinse	mg	7.4	15.5	6.9
Less than 2.5 rinse	mg	1.2	0.8	0.6
PM2.5 Catch (Filter)	mg	26.5	5.8	1.2

Sampling Location East Scrubber Stack

		S2-4	S2-5	S2-6	Average
Total Filterable Particulate Matter Emissions					
Grains/DSCF	gr/DSCF	0.0207	0.0121	0.0042	0.0123
Pounds/Hour	lb/hr	13.80	7.69	2.80	8.10
Filterable $PM_{2.5}$ Particulate Matter Emissions					
Grains/DSCF	gr/DSCF	0.01636	0.00360	0.00087	0.00695
Pounds/Hour	lb/hr	10.89	2.30	0.58	4.59
Cut Sizes					
Gas viscosity, (micropoise)	μ	226.70	228.38	227.35	227.48
Gas sampling rate, ACFM	Qs	0.5782	0.6132	0.5958	0.5958
Renolds number, (dimensionless)	N_{re}	2266.90	2414.40	2332.61	2337.97
Cunningham correction factor	C	1.091	1.098	1.094	1.094
$PM_{2.5}$ cut diameter, (microns)	D_{50} N_{re}<3162 - $PM_{2.5}$	2.58	2.39	2.50	2.49
$PM_{2.5}$ cut diameter, (microns)	D_{50} N_{re}>3162 - $PM_{2.5}$	2.29	2.18	2.24	2.24

APPENDIX B

EXAMPLE CALCULATIONS

Example Calculations, Method 301 Validation Test Program Results
Run 1, Alternative 1 Approach

Measured Sodium and Chloride Levels in Run 1 (Table 3-5)

U1-1 = 0.00320 gr/DSCF
U2-1 = 0.00305 gr/DSCF
S1-1 = 0.02048 gr/DSCF
S2-1 = 0.02226 gr/DSCF

Average Unspiked Concentration = (0.00320+0.00305)/2 = 0.00312 gr/DSCF

Sodium and Chloride in Spike
S1-1 = 0.02048 - 0.00312 = 0.0174 gr/DSCF
S2-1 = 0.02226 – 0.00312 = 0.0191 gr/DSCF
CS = (0.0174 + 0.0191)/2 = 0.0182 gr/DSCF

d_1 = Bias during run 1 was calculated using Equation 301-13

$$d_i = \left(\frac{S_{1i} + S_{2i}}{2}\right) - \left(\frac{M_{1i} + M_{2i}}{2}\right) - CS \qquad \text{Equation 301-13}$$

Total $PM_{2.5}$ (Table 3-4)
S_{1i} = 0.0303 gr/DSCF, First measured value of the S1-1 spiked sample
S_{2i} = 0.0273 gr/DSCF, Second measured value of the S2-1 spiked sample
M_{1i} = 0.0146 gr/DSCF, First measured value of the U1-1 unspiked sample
M_{2i} = 0.0146 gr/DSCF, Second measured value of the U2-1 unspiked sample

CS = 0.0182 gr/DSCF, spike value (sodium chloride $PM_{2.5}$ spike quantity)

$$d_i = \left(\frac{0.0303 + 0.0273}{2}\right) - \left(\frac{0.0146 + 0.0146}{2}\right) - 0.0182$$

$$d_i = -0.00403$$

The standard deviation of the differences in the means of the spiked sampling train tests was calculated in accordance with Method 301 Equation 301-2.

$$SD_d = \sqrt{\frac{\sum_{i}^{n}\left(d_i - d_m\right)^2}{n-1}} \qquad \text{Equation 301-2}$$

Where:

SD_d = The standard deviation of the differences, milligrams/DNm^3
d_i = The differences in the results of the ith sample
d_m = The mean of the paired sample differences
n = Total number of paired samples (6)

d_1 = -0.00403
d_2 = -0.00325
d_3 = -0.00113
d_4 = 0.000055

dm = -0.00209

$(d_1-d_m)^2$ = 3.77 e-6
$(d_2-d_m)^2$ = 1.35 e-6
$(d_3-d_m)^2$ = 9.22 e-7
$(d_4-d_m)^2$ = 4.59 e-6

$$\sum_{i}^{n}\left(d_i - d_m\right)^2 = (3.77e-6) + (1.35e-6) + (9.22e-7) + (4.59e-6) = 1.06e-5$$

$$SD_d = \sqrt{\frac{1.06e-5}{4-1}} = 0.00188$$

The t-statistic for the differences was calculated from the means of the paired sample differences, the standard deviation of the differences, and the number of paired samples (4).

$$t = \frac{\left|-0.00209\right|}{\frac{0.00188}{\sqrt{4}}} = -2.22 \qquad \text{Equation 301-3}$$

3 Degrees of Freedom

To evaluate the precision of the API/NCASI sampling system, the relative standard deviation was calculated in accordance with Equation 301-8.

$$\mathrm{RSD} = \left(\frac{\mathrm{SD}_d}{\mathrm{S}_M}\right)100 \qquad \text{Equation 301-8}$$

S_M = 0.0236

$$\mathrm{RSD} = \left(\frac{0.00188}{0.0236}\right)100 = 7.97$$

APPENDIX C

FIELD DATA

Method 1 - Air Control Techniques, P.C.

Date 10/23/2012

Client	[redacted]
Job #	1756
Plant Name	[redacted]
City, State	[redacted]
Sampling Location	East Scrubber Stack
No. of Ports Available	4
No. of Ports Used	1
Port Inside Diameter, Inches	4
Distance From Far Wall To Outside Of Port, Inches	120
Nipple Length And/Or Wall Thickness, Inches	6
Depth Of Stack Or Duct, Inches	114
Stack Or Duct Width (if rectangular), Inches	
Equiv. Diameter = 2DW/(D+W), Inches	
Stack/Duct Area, Square Feet (πR^2 or L x W)	70.882

	Upstream	Downstream
Distance to Flow Disturbances, feet	35	18
Diameters	3.7	1.9

Diameters			
Velocity	Up	Down	Particulate
12	>7.00	>1.75	12
12	6	1.5	16
16	5	1.25	20
16	2	0.5	24 or 25

Note: If more than 8 and 2 diameters and duct is greater than 12" and less than 24", use 8 or 9 points.

Point Location Data

Point	% of Duct Depth	Distance From Inside Wall	Distance From Outside of Port
1	4.4	5.016	11
2	14.6	16.644	22 5/8
3	29.6	33.744	39 6/8
4	70.4	80.256	86 2/8
5	85.4	97.356	103 3/8
6	95.6	108.984	115

0.0000 - 0.0625 - 0
0.0625 - 0.1875 - 1/8
0.1875 - 0.3125 - 1/4
0.3125 - 0.4375 - 3/8
0.4375 - 0.5625 - 1/2
0.5625 - 0.6875 - 5/8
0.6875 - 0.8125 - 3/4
0.8125 - 0.9375 - 7/8
0.9375 - 1.0000 - 1

Location of Points in Circular Stacks or Ducts

	4	6	8	10	12	14	16	18	20	22	24
1	6.7	4.4	3.2	2.6	2.1	1.8	1.6	1.4	1.3	1.1	1.1
2	25.0	14.6	10.5	8.2	6.7	5.7	4.9	4.4	3.9	3.5	3.2
3	75.0	29.6	19.4	14.6	11.8	9.9	8.5	7.5	6.7	6.0	5.5
4	93.3	70.4	32.3	22.6	17.7	14.6	12.5	10.9	9.7	8.7	7.9
5		85.4	67.7	34.2	25.0	20.1	16.9	14.6	12.9	1106	10.5
6		95.6	80.6	65.8	35.6	26.9	22.0	18.8	16.5	14.6	13.2
7			89.5	77.4	64.4	36.6	28.3	23.6	20.4	18.0	16.1
8			96.8	85.4	75.0	63.4	37.5	29.6	25.0	21.8	19.4
9				91.8	82.3	73.1	62.5	38.2	30.6	26.2	23
10				97.4	88.2	79.9	71.7	61.8	38.8	31.5	27.2
11					93.3	85.4	78.0	70.4	61.2	39.3	32.3
12					97.9	90.1	83.1	76.4	69.4	60.7	39.8
13						94.3	87.5	81.2	75	68.5	60.2
14						98.2	91.5	85.4	79.6	73.8	67.7
15							95.1	89.1	83.5	78.2	72.8
16							98.4	92.5	87.1	82.0	77
17								95.6	90.3	85.4	80.6
18								98.6	93.3	88.4	83.9
19									96.1	91.3	86.8
20									98.7	94.0	89.5
21										96.5	92.1
22										98.9	94.5
23											96.8
24											99.9

Location of Points in Rectangular Stacks or Ducts

	3	4	5	6	7	8	9	10	11	12
1	16.7	12.5	10.0	8.3	7.1	6.3	5.6	5.0	4.5	4.2
2	50	37.5	30.0	25	21.4	18.8	16.7	15.0	13.6	12.5
3	83.3	62.5	50.0	41.7	35.7	31.3	27.8	25.0	22.7	20.8
4		87.5	70.0	58.3	50	43.8	28.9	35.0	31.8	29.2
5			90.0	75	64.3	56.3	50	45.0	40.9	37.5
6				91.7	78.6	68.8	61.1	55.0	50	45.8
7					92.9	81.3	72.2	65.0	59.1	54.2
8						93.8	83.3	75.0	68.2	62.5
9							94.4	85.0	77.3	70.8
10								95.0	86.4	79.2
11									95.5	87.5
12										95.8

Method 4 - Air Control Techniques, P.C.

Date 10/23/12

Source Information

Client	[redacted]			
Plant Name	[redacted]		Job #	1756
City, State	[redacted]		Process	Pulp/Paper
Sampling Location	Scrubber Stack		Personnel	TEH

Sampling Information

Run Number	S1-1	S1-2	S1-3	
Filter Identification	476-1408	476-1406	476-1411	
Sampling Date	10/23/12	10/24/12	10/24/12	

Moisture Data

Impinger 1
Contents - 100ml H_2O

Final Weight, grams	892.0	847.7	857.4	
Initial Weight, grams	735.0	703.8	736.6	
Condensed Water, grams	157.0	143.9	120.8	

Impinger 2
Contents - 100ml H_2O

Final Weight, grams	731.0	667.6	670.4	
Initial Weight, grams	701.7	693.4	657.6	
Condensed Water, grams	29.3	-25.8	12.8	

Impinger 3
Contents - Empty

Final Weight, grams	614.5	618.8	612.0	
Initial Weight, grams	609.6	614.5	610.8	
Condensed Water, grams	4.9	4.3	1.2	

Silica Gel -

Final Weight, grams	851.4	856.5	866.1	
Initial Weight, grams	838.6	851.5	856.5	
Adsorbed Water, grams	12.8	5.0	9.6	

Total Water, grams	204.0	127.4	144.4	

Vm(std) = Volume of gas sampled at standard conditions (dscf) = gamma*17.64*Vm*[Pbar+(D H/13.6)]/(Tm+460)
Vwc(std) = volume of water vapor at standard conditions (scf) = 0.04715 * volume of water collected (gms)
Bws = Mole fraction of water vapor = Vwc(std) / (Vm(std) + Vwc(std))
Percent Moisture = 100 * Bws

Revision 1
4/27/2012

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	51-1
Condition	

IDENTIFICATION INFORMATION

Plant Name	
City	
State	North Carolina

Source Number	EAST	Date	10/23/12
Sampling Location	Scrubber Stack	Start	1212
Test Personnel	TTB, JMA	Stop	1410

Meterbox ID	702233
Δ H @	1.595
Gamma, γ	0.9381
Nozzle ID	X7
Nozzle Diameter	.215
Orsat/Fyrite	Fyr

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0.000	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM	.001	.02	14

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	4"✓	3"✓
Pitot Tube Posttest Leak Check		

Barometric Pressure, In.,Hg. 30.2

Static Pressure, In. W.C. -0.08

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams	204	Moisture, %	20.041
CO_2 %	1.0	Md_run	28.72
O_2 %	21.0	Mw_run	27.18

Sampling Information / QA Checks

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft³)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Cyclone Temp. (°F)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Sample Train Vac. (in. Hg)	Probe Temp. (°F)	Run Cummulative D_{50}s, microns PM_{10}	$PM_{2.5}$
C	1	9.59	0	335.4	.17	75	134	295	65	.33	1	325	10.39	2.43
	1	9.59	9.35	338.99	.17	77	134	297	65	.30	1	324	10.58	2.50
	1	9.59	19.12	342.42	.17	79	134	303	65	.25	2	320	10.86	2.61
	1	9.87	28:47	345.54	.18	79	134	307	65	.22	3	323	11.19	2.75
	1	9.87	38:39	348.44	.18	80	133	309	65	.27	4	322	11.15	2.74
	1	9.87	48:32	351.84 ~~362.42~~	.18	~~78~~ 83	134	313	65	.27	5	322	11.17	2.75
	1	9.87	58:24	355.14	.18	82	134	313	65	.27	6	322	11.17	2.75
	1	9.87	1:08:16	358.48	.18	83	134	316	65	.3	8	323	11.09	2.72
	1	9.87	1:18:09	362.05	.18	83	134	315	65	.3	9	322	11.04	2.70
	1	9.87	1:28:01	365.6	.18	84	134	314	65	.33	10	323	10.99	2.68
	1	9.87	1:37:53	369.21	.18	85	134	314	65	.35	12	322	10.91	2.64
		9.87	1:47:46	373.05	.18	86	134	316	65	.35	13	323	10.84	2.62

Total Run Time	1:57:38	376.85
Total Volume, ACF	41.451	

	ΔP	Meter Temp.	Stack Temp.	ΔH	Probe Temp.	PM_{10}	$PM_{2.5}$
Averages	.17747	81.3	133.9	.295	110.3	10.89	2.48
	in. H2O	°F	°F	in H2O	%	microns	

Run	

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	5/-2
Condition	

IDENTIFICATION INFORMATION

Plant Name	
City	
State	North Carolina

Source Number		Date	10/23/12
Sampling Location	Scrubber Stack	Start	835
Test Personnel	TTB, JMA	Stop	957

Meterbox ID	702233
ΔH @	1.595
Gamma, γ	.9381
Nozzle ID	X-7
Nozzle Diameter	.215
Orsat/Fyrite	FYR

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	.005	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM	.002	.02	7

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	5	5
Pitot Tube Posttest Leak Check	5	5

Barometric Pressure, In.,Hg.	~~30.2~~ 29.8	Static Pressure, In. W.C.	-.08

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams		Moisture, %	
CO_2 %	1	Md_run	
O_2 %	21	Mw_run	

Sampling Information / QA Checks

				Sampling Information							QA Checks			
													Run Cummulative D$_{50}$s, microns	
Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Cyclone Temp. (°F)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Sample Train Vac. (in. Hg)	Probe Temp. (°F)	PM_{10}	$PM_{2.5}$
C	1	9.19	0	381.8	.15	55	131	295	~~65~~ 55	.3	2	330	9.95	2.24
	1	9.19	9:11	385.178	.15	61	130	295	51	.23	2	329	10.63	2.49
	1	9.19	18:23	387.993	.15	62	131	295	53	.23	2	329	10.87	2.59
	1	9.19	27:35	390.828	.15	64	132	295	58	.23	3	327	10.95	2.62
	1	9.19	36:47	393.236	.15	66	132	299	61	.23	4	327	11.01	2.65
	1	9.04	45:58	396.621	.145	68	133	315	63	.21	5	328	11.13	2.70
	1	8.88	55:00	399.312	.14	70	132	319	65	.23	5	329	11.17	2.71
	1	9.19	1:03:54	402.08	.15	72	133	319	65	.25	6	330	11.16	2.71
	1	8.88	1:13:05	405.055	.14	72	133	319	65	.25	6	329		
			.	407.97										

Total Run Time	1:21:58
Total Volume, ACF	

Averages	.148104	~~67~~ 65.6	131.9		.240 ~~.233~~			
	in. H2O	°F	°F		in H2O	%		microns

spike
407.97
to
409.933

Run	

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	Sl-3
Condition	

IDENTIFICATION INFORMATION

Plant Name	
City	
State	North Carolina
Source Number	
Sampling Location	Scrubber Stack
Test Personnel	TTB, JMA
Date	10/24/12
Start	1240
Stop	1413
Meterbox ID	702233
Δ H @	1.595
Gamma, γ	.9381
Nozzle ID	8 AOD
Nozzle Diameter	.229
Orsat/Fyrite	FYR

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	.002	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM	.001	.02	9

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	4	4
Pitot Tube Posttest Leak Check	4	4

Barometric Pressure, In.,Hg. 29.8

Static Pressure, In. W.C. -.08

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams	144.4	Moisture, %	19.063
CO_2 %	1	Md_run	28.70
O_2 %	21	Mw_run	27.27

Sampling Information / QA Checks

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Cyclone Temp. (°F)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Sample Train Vac. (in. Hg)	Probe Temp. (°F)	Run Cummulative D_{50}s, microns PM_{10}	$PM_{2.5}$
C	1	10.43	0	410.1	.16	79	134	302	65	.36	2	324		
	1	10.43	10:26	414.282	.16	81	133	314	65	.25	3	323		
	1	10.43	20:51	417.789	.16	82	132	315	65	.25	3	323		
	1	10.43	31:17	421.013	.16	84	132	314	65	.25	4	324		
	1	10.43	41:42	424.453	.16	85	132	317	65	.27	5	325		
	1	10.43	52:08	427.98	.16	87	131	318	65	.27	6	324		
	1	10.09	1:02:33	431.547	.15	87	130	317	65	.27	6	325		
	1	10.09	1:12:39	435.03	.15	88	131	315	65	.27	7	325		
	1	10.43	1:22:45	438.47	.16	90	131	320	65	.27	8	325		
			1:33:10	441.946										

Total Run Time 1:33:10

Total Volume, ACF 31.846

	ΔP	Meter Temp.	Stack Temp.	ΔH	Probe Temp.	PM_{10}	$PM_{2.5}$
Averages	.15775	84.8	131.8	.273	103.2	10.91	2.65
	in. H2O	°F	°F	in H2O	%	microns	

Spike
441.946 @ 314°
to
444.17

Run

Method 4 - Air Control Techniques, P.C.

Date 10/22/12

Source Information

Client [redacted]
Plant Name [redacted]
City, State [redacted]
Sampling Location Scrubber Stack

Job # 1756
Process Pulp/Paper
Personnel TEH

Sampling Information

Run Number	U1-1	U1-2	U1-3	
Filter Identification	476-1397	476-1404	476-1409	
Sampling Date	1400 10/23/12	10/24/12	10/24/12	

Moisture Data

Impinger 1
Contents - 100ml H_2O

Final Weight, grams	874.3	832.1	816.0	
Initial Weight, grams	732.4	732.6	728.5	
Condensed Water, grams	141.9	99.5	87.5	

Impinger 2
Contents - 100ml H_2O

Final Weight, grams	734.0	712.1	762.0	
Initial Weight, grams	702.5	695.1	712.1	
Condensed Water, grams	31.5	17.0	49.9	

Impinger 3
Contents - Empty

Final Weight, grams	603.0	604.4	605.8	
Initial Weight, grams	600.3	603.0	604.4	
Condensed Water, grams	2.7	1.4	1.4	

Silica Gel -

Final Weight, grams	878.3	885.6	893.2	
Initial Weight, grams	866.0	878.3	885.6	
Adsorbed Water, grams	12.3	7.3	7.6	

Total Water, grams	188.4	125.2	146.1	

Vm(std) = Volume of gas sampled at standard conditions (dscf) = gamma*17.64*Vm*[Pbar+(D H/13.6)]/(Tm+460)
Vwc(std) = volume of water vapor at standard conditions (scf) = 0.04715 * volume of water collected (gms)
Bws = Mole fraction of water vapor = Vwc(std) / (Vm(std) + Vwc(std))
Percent Moisture = 100 * Bws

Revision 1
4/27/2012

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	UL-1
Condition	

IDENTIFICATION INFORMATION

Plant Name	
City	
State	
Source Number	EAST
Sampling Location	Scrubber Stack
Test Personnel	TTB, JMA
Date	10/23/12
Start	1212
Stop	1407
Meterbox ID	909033
ΔH @	1.904
Gamma, γ	0.9762
Nozzle ID	I-7
Nozzle Diameter	0.26
Orsat/Fyrite	Fyrite

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0.000	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM	0.000		5

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	N/A	N/A
Pitot Tube Posttest Leak Check	N/A	N/A

Barometric Pressure, In.,Hg. 30.2

Static Pressure, In. W.C. -0.08

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams		Moisture, %	
CO_2 %	~~2~~ 1	Md_run	
O_2 %	~~20~~ 21	Mw_run	

Sampling Information / QA Checks

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Cyclone Temp. (°F)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Sample Train Vac. (in. Hg)	Probe Temp. (°F)	Run Cummulative D$_{50}$s, microns PM$_{10}$	PM$_{2.5}$
A	1	9.59	0	829.100	0.17	69	134	320	60	~~0.37~~ 0.35	3	315		
	1	9.59	9:35	832.27	0.17	71	134	313	61	0.35	4	314		
	1	9.59	19:12	835.25	0.17	72	134	315	60	0.35	4	314		
	1	9.87	28:47	838.24	0.18	74	134	313	61	0.35	5	314		
	1	9.87	38:39	841.22	0.18	75	134	313	61	0.35	5	313		
	1	9.87	48:32	844.25	0.18	75	134	313	62	0.35	6	313		
	1	9.87	58:24	847.39	0.18	75	134	311	64	0.35	7	314		
	1	9:87	1:08:16	850.57	0.18	77	134	314	65	0.35	8	314		
	1	9.87	1:18:09	853.66	0.18	77	134	314	58	0.35+	9	312		
	1	9.87	1:28:01	856.36	0.18	78	134	312	50	0.35	10	313		
	1	9:87	1:37:53	859.71	0.18	79	134	313	46	0.35	11	313		
	1	9:87	1:47:46	863.01	0.18	79	134	313	48	0.35	11	312		

Total Run Time	1:57:38	866.235
Total Volume, ACF		

	ΔP	Meter Temp.	Stack Temp.	ΔH	Probe Temp.	PM$_{10}$	PM$_{2.5}$
Averages							
	in. H2O	°F	°F	in H2O	%	microns	

Run	

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	UI-2
Condition	

IDENTIFICATION INFORMATION

Plant Name
City
State

Source Number: EAST
Sampling Location: Scrubber Stack
Test Personnel: TTB, JMA

Date: 10/24/12
Start: 835
Stop: 957

Meterbox ID: 909033
ΔH @: 1.904
Gamma, γ: 0.9762
Nozzle ID: I-7
Nozzle Diameter: 0.216
Orsat/Fyrite: FyR

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0.002	< 0.02 or 4%	15"
Partial Train Posttest Leak Check, ACFM	0.000		12"

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	5" ✓	6" ✓
Pitot Tube Posttest Leak Check	4" ✓	3" ✓

Barometric Pressure, In.,Hg.: ~~30.2~~ 29.8
Static Pressure, In. W.C.: 0.08

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams		Moisture, %	
CO_2 %	1	Md_run	
O_2 %	21	Mw_run	

Sampling Information / QA Checks

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Cyclone Temp. (°F)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Sample Train Vac. (in. Hg)	Probe Temp. (°F)	Run Cummulative D$_{50}$s, microns PM$_{10}$	PM$_{2.5}$
A	1	9.19	0	866.588	0.15	53	131	320	52	0.36	3	313		
	1	9.19	9:11	869.83	0.15	52	130	314	47	0.36	3	315		
	1	9.19	18:23	872.75	0.15	55	131	314	49	0.36	3	315		
	1	9.19	27:35	875.61	0.15	57	132	313	49	0.36	3	315		
	1	9.19	36:47	878.43	0.15	58	132	315	49	0.36	4	312		
	1	9.04	45:58	881.28	0.145	62	133	318	52	0.36	5	320		
	1	8.88	55:00	884.15	0.14	65	132	319	53	0.36	6	321		
	1	9.19	1:03:54	886.79	0.15	68	133	317	57	0.36	6	320		
	1	8.88	1:13:05	889.45	0.14	70	133	318	62	0.36	7	320		
	1		1:21:58	892.862										
	1													
	1													

Total Run Time
Total Volume, ACF

Averages						
	in. H2O	°F	°F	in H2O	%	microns

Run

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	W-3
Condition	

IDENTIFICATION INFORMATION

Plant Name	[redacted]
City	
State	
Source Number	EAST
Sampling Location	Scrubber Stack
Test Personnel	TTB, JMA

Date	10/24/12
Start	1240
Stop	1413

Meterbox ID	909033
ΔH @	1.904
Gamma, γ	0.9762
Nozzle ID	I-8
Nozzle Diameter	~~0.216~~ 0.233
Orsat/Fyrite	FYR

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0.000	< 0.02 or 4%	15"
Partial Train Posttest Leak Check, ACFM	0.000		12"

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	4"w	5"w
Pitot Tube Posttest Leak Check	4"w	6"w

Barometric Pressure, In.,Hg. 29.8

Static Pressure, In. W.C. -0.08

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams		Moisture, %	
CO_2 %	1	Md_run	
O_2 %	21	Mw_run	

Sampling Information / QA Checks

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Cyclone Temp. (°F)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Sample Train Vac. (in. Hg)	Probe Temp. (°F)	Run Cummulative D50s, microns PM10	PM2.5
A	1	10:43	0	892.78	0.16	74	134	322	55	0.38	3	322		
	1	10:43	10:26	896.08	0.16	74	133	321	60	0.38	3	322		
	1	10:43	20:51	899.22	0.16	75	132	320	60	0.38	3	321		
	1	10:43	31:17	902.53	0.16	75	132	322	59	0.38	4	321		
	1	10:43	41:42	905.87	0.16	77	132	319	59	0.38	5	321		
	1	10:43	52:08	909.39	0.16	78	131	321	61	0.38	6	321		
	1	10:09	1:02:33	912.88	0.15	79	130	320	62	0.38	8	321		
	1	10:09	1:12:39	916.34	0.15	80	131	319	63	0.38	8	321		
	1	10:43	1:22:45	919.65	0.16	81	131	316	64	0.38	9	320		
			1:33:10	923.118										

Total Run Time

Total Volume, ACF

Averages: in. H2O | °F | °F | in H2O | % | microns

Run

Method 4 - Air Control Techniques, P.C.

Date 10/24/12

Source Information

Client			
Plant Name		Job #	1756
City, State		Process	Pulp/Paper
Sampling Location	Scrubber Stack	Personnel	

Sampling Information

Run Number	S1-4	S1-5	S1-6	
Filter Identification	476-1415	476-1419	476-1424	
Sampling Date	10/24/12	10/25/12	10/25/12	

Moisture Data

Impinger 1 Contents - 100ml H_2O				
Final Weight, grams	830.7	757.1	741.7	
Initial Weight, grams	710.7	682.9	676.6	
Condensed Water, grams	120.0	74.2	65.1	
Impinger 2 Contents - 100ml H_2O				
Final Weight, grams	680.3	719.8	752.3	
Initial Weight, grams	670.4	680.3	678.5	
Condensed Water, grams	9.9	39.5	73.8	
Impinger 3 Contents - Empty				
Final Weight, grams	613.3	619.9	627.6	
Initial Weight, grams	612.0	613.3	611.2	
Condensed Water, grams	1.3	3.6	16.4	
Silica Gel -				
Final Weight, grams	877.1	882.2	890.4	
Initial Weight, grams	866.1	877.1	882.2	
Adsorbed Water, grams	11.0	5.1	8.2	
Total Water, grams	142.2	122.4	163.5	

Vm(std) = Volume of gas sampled at standard conditions (dscf) = gamma*17.64*Vm*[Pbar+(D H/13.6)]/(Tm+460)

Vwc(std) = volume of water vapor at standard conditions (scf) = 0.04715 * volume of water collected (gms)

Bws = Mole fraction of water vapor = Vwc(std) / (Vm(std) + Vwc(std))

Percent Moisture = 100 * Bws

Revision 1
4/27/2012

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID: 51-4
Condition:

IDENTIFICATION INFORMATION

Plant Name:
City:
State:

Source Number:
Sampling Location: Scrubber Stack
Test Personnel: TTB, JMA

Date: 10/24/12
Start: 1600
Stop: 1724

Meterbox ID: 702233
ΔH @: 1.595
Gamma, γ: .9381
Nozzle ID: 8 AOD
Nozzle Diameter: .229
Orsat/Fyrite: FYR

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	.004	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM		.02	10

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	4	4
Pitot Tube Posttest Leak Check	4	4

Barometric Pressure, In.,Hg.: 29.8
Static Pressure, In. W.C.: -.08

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams:
CO_2 %: 1
O_2 %: 21
Moisture, %:
Md_run:
Mw_run:

Sampling Information / QA Checks

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft³)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Cyclone Temp. (°F)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Sample Train Vac. (in. Hg)	Probe Temp. (°F)	Run Cummulative D$_{50}$s, microns PM$_{10}$	PM$_{2.5}$
C	1	9.31	0	444.8	.16	86	132	295	55	.26	1	321		
	1	9.31	9:18	448.12	.16	89	132	305	60	.26	2	322		
	1	9.31	18.37	451.437	.16	92	131	314	62	.26	3	322		
	1	9.31	27:55	454.692	.16	93	131	317	62	.26	4	322		
	1	9.31	37:14	457.943	.16	93	131	318	62	.26	5	322		
	1	9.31	46:32	461.172	.16	94	131	320	63	.26	6	322		
	1	9.31	55:51	464.476	.16	95	133	320	63	.26	7	322		
	1	9.31	1:05:10	467.732	.16	95	135	321	63	.26	8	322		
	1	9.31	1:14:28	471.044	.16	96	136	320	64	.26	9	322		
			1:23:47	474.354										

Total Run Time: 1:23:47
Total Volume, ACF:

Spike @ 319°
474.354
to
476.392

Run		Averages	in. H2O	°F	°F		in H2O		%		microns

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	51-5
Condition	

IDENTIFICATION INFORMATION

Plant Name	[redacted]
City	[redacted]
State	[redacted]

Source Number		Date	10/25/12
Sampling Location	Scrubber Stack	Start	820
Test Personnel	TTB, JMA	Stop	949

Meterbox ID	702233
Δ H @	1.595
Gamma, γ	.9381
Nozzle ID	8
Nozzle Diameter	.229
Orsat/Fyrite	FYR

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	.003	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM	.001	.02	7

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	4	4
Pitot Tube Posttest Leak Check	4	4

Barometric Pressure, In.,Hg. 29.8

Static Pressure, In. W.C. -.08

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams		Moisture, %	
CO_2 %	1	Md_run	
O_2 %	21	Mw_run	

Sampling Information / QA Checks

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Cyclone Temp. (°F)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Sample Train Vac. (in. Hg)	Probe Temp. (°F)	Run Cummulative D_{50}s, microns PM_{10}	$PM_{2.5}$
C	1	2.07	0	476.7	.08	53	126	295	55	.3	1	337		
	1	6.29	7:04	479.225	.11	55	120	301	42	.3	1	337		
	1	8.29	15:22	482.133	.11	58	116	316	42	.3	2	331		
	1	9.68	23:40	485.136	.15	59	115	318	43	.31	3	330		
	1	10.0	33:20	488.486	.16	61	123	320	45	.29	4	331		
	~~1~~	~~9.68~~	~~1:03:20~~	~~497.57~~	~~.15~~	~~66~~	~~120~~	~~311~~	~~57~~	~~.29~~	~~5~~	~~332~~		
	1	10.0	43.20	491.856	.16	63	126	321	46	.29	4	330		
	1	10.0	53:20	495.255	.16	65	128	322	48	.29	5	331		
	1	9.68	1:03:20	497.57	.15	66	130	311	57	.29	5	330		
	1	9.68	1:13:01	500.867	.15	67	129	318	58	.29	6	331		
			1:22:42	504.176										

Total Run Time	1:22:42
Total Volume, ACF	

Spike @ ~~504.176~~ 504.85 to 507.205

Averages							
	in. H2O	°F	°F	in H2O	%	microns	

Run	

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	51-6
Condition	

IDENTIFICATION INFORMATION

Plant Name			
City			
State			

Source Number		Date	10/25/12
Sampling Location	Scrubber Stack	Start	1346
Test Personnel	TTB, JMA	Stop	1524

Meterbox ID	702233
∆ H @	1.595
Gamma, γ	.9381
Nozzle ID	8
Nozzle Diameter	.229
Orsat/Fyrite	FYR

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	.004	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM			11

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	4	4
Pitot Tube Posttest Leak Check	4	4

Barometric Pressure, In.,Hg. 29.8

Static Pressure, In. W.C. -.08

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams		Moisture, %	
CO_2 %	1	Md_run	
O_2 %	21	Mw_run	

Sampling Information											QA Checks		
Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	∆P (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Cyclone Temp. (°F)	Impinger Exit Gas Temp., (°F)	∆H (in. H_2O)	Sample Train Vac. (in. Hg)	Probe Temp. (°F)	Run Cummulative D_{50}s, microns PM_{10}	$PM_{2.5}$
C	1	10.88	0	508.0	.16	84	128	320	65	.28	1	300		
	1	11.22	10:53	511.576	.17	85	132	315	65	.28	3	318		
	1	10.88	22:06	515.977	.15	87	134	318	65	.28	5	318		
	1	10.54	32:59	519.908	.15	87	134	318	65	.28	6	318		
	1	10.88	43:31	523.675	.16	87	135	307	65	.28	7	318		
	1	11.22	54:24	527.392	.17	86	135	314	65	.28	8	318		
	1	10.88	1:05:37	531.3	.16	87	137	317	65	.28	9	318		
	1	10.88	1:16:30	535.182	.16	87	136	315	65	.28	10	318		
	1	10.88	1:27:23	538.95	.16	87	136	315	65	.28	10	317		
			1:38:16	542.571										

Total Run Time 1:38:16

Total Volume, ACF

Spike 542.571 to 545.19 @ 320°

Averages							
in. H2O	°F	°F	in H2O	%	microns		

Run	

Method 4 - Air Control Techniques, P.C.

Date 10/24/12

Source Information

Client	[redacted]		
Plant Name	[redacted]	Job #	1756
City, State	[redacted]	Process	Pulp/Paper
Sampling Location	Scrubber Stack	Personnel	

Sampling Information

Run Number	U1-4	U1-5	U1-6	
Filter Identification	476-1413	476-1417	476-1424	
Sampling Date	10/24/12	10/25/12	10/25/12	

Moisture Data

Impinger 1
Contents - 100ml H_2O

Final Weight, grams	851.1	843.6	861.3	
Initial Weight, grams	726.4	727.0	710.7	
Condensed Water, grams	124.7	116.6	150.6	

Impinger 2
Contents - 100ml H_2O

Final Weight, grams	717.7	724.6	738.6	
Initial Weight, grams	707.3	717.7	724.6	
Condensed Water, grams	10.4	6.9	14.0	

Impinger 3
Contents - Empty

Final Weight, grams	607.1	607.7	609.0	
Initial Weight, grams	605.8	607.1	607.7	
Condensed Water, grams	1.3	0.6	1.3	

Silica Gel -

Final Weight, grams	898.8	903.0	910.5	
Initial Weight, grams	893.2	898.8	903.0	
Adsorbed Water, grams	5.6	4.2	7.5	

Total Water, grams	142.0	128.3	173.4	

Vm(std) = Volume of gas sampled at standard conditions (dscf) = gamma*17.64*Vm*[Pbar+(D H/13.6)]/(Tm+460)
Vwc(std) = volume of water vapor at standard conditions (scf) = 0.04715 * volume of water collected (gms)
Bws = Mole fraction of water vapor = Vwc(std) / (Vm(std) + Vwc(std))
Percent Moisture = 100 * Bws

Revision 1
4/27/2012

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	UI-4
Condition	

IDENTIFICATION INFORMATION

Plant Name
City
State

Source Number	EAST	Date	10/24/12
Sampling Location	Scrubber Stack	Start	1600
Test Personnel	TTB, JMA	Stop	1724

Meterbox ID	909033	
ΔH @	1.904	
Gamma, γ	0.9762	
Nozzle ID	~~I-7~~	I-8
Nozzle Diameter	~~0.216~~	0.233
Orsat/Fyrite	FYR	

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0.000	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM	0.000		12

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	6" ✓	5" ✓
Pitot Tube Posttest Leak Check	4" ✓	3" ✓

Barometric Pressure, In.,Hg. 29.8

Static Pressure, In. W.C. -0.08

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams		Moisture, %	
CO_2 %	1	Md_run	
O_2 %	21	Mw_run	

Sampling Information / QA Checks

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Cyclone Temp. (°F)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Sample Train Vac. (in. Hg)	Probe Temp. (°F)	Run Cummulative D_{50}s, microns PM_{10}	$PM_{2.5}$
A	1	9.31	0	923.400	0.16	83	132	318	60	0.38	3	320		
	1	9.31	9:18	926.56	0.16	84	131	319	60	0.38	3	321		
	1	9.31	18:37	929.71	0.16	84	131	319	61	0.38	3	321		
	1	9.31	27:55	932.77	0.16	86	131	318	57	0.38	5	321		
	1	9.31	37:14	935.88	0.16	87	131	317	56	0.38	5	320		
	1	9.31	46:32	938.92	0.16	88	131	320	57	0.38	6	320		
	1	9.31	55:51	942.15	0.16	88	133	320	58	0.38	7	321		
	1	9.31	1:05:10	945.21	0.16	90	134	319	58	0.38	8	321		
	1	9.31	1:14:28	948.21	0.16	91	135	320	60	0.38	9	321		
			1:23:47	951.286										

Total Run Time

Total Volume, ACF

Averages	in. H2O	°F	°F	in H2O	%	microns

Run

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	41-5
Condition	

IDENTIFICATION INFORMATION

Plant Name	
City	
State	
Source Number	EA51
Sampling Location	Scrubber Stack
Test Personnel	TTB, JMA

Date	10/25/12
Start	0820
Stop	949

Meterbox ID	909033
ΔH @	1.904
Gamma, γ	0.9962
Nozzle ID	I-8
Nozzle Diameter	0.233
Orsat/Fyrite	FYR

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0.000	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM	0.000		15

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	5"✓	4"✓
Pitot Tube Posttest Leak Check	3"✓	5"✓

Barometric Pressure, In.,Hg. 29.8

Static Pressure, In. W.C. -0.08

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams		Moisture, %	
CO_2 %	1	Md_run	
O_2 %	21	Mw_run	

Sampling Information / QA Checks

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Cyclone Temp. (°F)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Sample Train Vac. (in. Hg)	Probe Temp. (°F)	Run Cummulative D50s, microns PM10	PM2.5
A	1	7.07	0	9.59.8	0.08	47	126	320	~~320~~ 44	0.4	3	322		
	2	8.29	7:04	954.21	0.11	49	120	316	37	0.4	3	321		
	3	8.29	15:22	956.77	0.11	50	116	318	38	0.4	3	321		
	4	9.68	23:40	959.37	0.15	52	115	317	39	0.4	3	322		
	5	10.00	33:20	962.31	0.16	54	123	319	41	0.4	4	322		
	6	10.00	43:20	965.85	0.16	56	126	320	41	0.4	5	322		
	7	10.00	53:20	969.11	0.16	58	128	320	41	0.4	6	322		
	8	9.68	103:20	972.61	0.15	61	130	317	42	0.4	7	321		
	9	9.68	1:13:01	976.00	0.15	64	129	318	43	0.4	8	321		
			1:22:42	979.346										

Total Run Time

Total Volume, ACF

Averages: in. H2O | °F | °F | in H2O | % | microns

Run

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID: UI-6
Condition:

IDENTIFICATION INFORMATION

Plant Name: [redacted]
City:
State:

Source Number: EAST
Sampling Location: Scrubber Stack
Test Personnel: TTB, JMA

Date: 10/25/12
Start: 1346
Stop: 1524

Meterbox ID: 909033
ΔH @: 1.904
Gamma, γ: 0.9762
Nozzle ID: I-8
Nozzle Diameter: 0.233
Orsat/Fyrite: FYR

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0.000	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM	0.200		15

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	~~NA~~ 5"	~~NA~~ 6"
Pitot Tube Posttest Leak Check	~~NA~~ 4"	~~NA~~ 4"

Barometric Pressure, In.,Hg. 29.8
Static Pressure, In. W.C. -0.08

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams:
CO_2 %:
O_2 %:
Moisture, %:
Md_run:
Mw_run:

Sampling Information / *QA Checks*

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Cyclone Temp. (°F)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Sample Train Vac. (in. Hg)	Probe Temp. (°F)	Run Cummulative D_{50}s, microns PM_{10}	$PM_{2.5}$
A	1	10.88	0	979.700	0.16	77	128	320	50	0.39	3	327		
	2	11.22	10:53	983.44	0.17	78	132	320	55	0.39	4	326		
	3	10.88	22:06	987.13	0.16	79	135	319	55	0.39	5	325		
	4	10.54	32:59	990.85	0.15	80	134	318	56	0.39	6	325		
	5	10.88	43:31	994.11	0.16	81	135	317	59	0.39	7	324		
	6	11.22	54:24	998.21	0.17	81	135	319	60	0.39	8	324		
	7	10.88	1:05:37	1002.01	0.16	81	137	317	61	0.39	9	324		
	8	10.88	1:16:30	1005.38	0.16	82	135	319	63	0.39	10	325		
	9	10.88	1:27:23	1009.32	0.16	82	136	319	64	0.39	11	324		
			1:38:16	1012.918										

Total Run Time:
Total Volume, ACF:

	ΔP	Meter Temp.	Stack Temp.	ΔH	Moisture	PM_{10}	$PM_{2.5}$
Averages							
	in. H2O	°F	°F	in H2O	%	microns	

Run:

Method 4 - Air Control Techniques, P.C.

Date 10/23/12

Source Information

Client	[redacted]		
Plant Name	[redacted]	Job #	1756
City, State	[redacted]	Process	Pulp/Paper
Sampling Location	Scrubber Stack	Personnel	

Sampling Information

Run Number	S2-1	S2-2	S2-3	
Filter Identification	476-1402	476-1407	476-1412	
Sampling Date	10/23/12	10/24/12	10/24/12	

Moisture Data

Impinger 1
Contents - 100ml H_2O

Final Weight, grams	887.5	828.0	839.5	
Initial Weight, grams	722.3	712.5	705.1	
Condensed Water, grams	165.2	115.5	134.4	

Impinger 2
Contents - 100ml H_2O

Final Weight, grams	771.0	773.3	738.0	
Initial Weight, grams	766.3	771.0	735.1	
Condensed Water, grams	4.7	2.3	2.9	

Impinger 3
Contents - Empty

Final Weight, grams	592.5	593.0	594.2	
Initial Weight, grams	591.8	592.5	592.8	
Condensed Water, grams	0.7	0.5	1.4	

Silica Gel -

Final Weight, grams	763.2	769.1	777.5	
Initial Weight, grams	755.6	763.2	769.1	
Adsorbed Water, grams	7.6	5.9	8.4	

Total Water, grams	178.2	124.2	147.1	

Vm(std) = Volume of gas sampled at standard conditions (dscf) = gamma*17.64*Vm*[Pbar+(D H/13.6)]/(Tm+460)
Vwc(std) = volume of water vapor at standard conditions (scf) = 0.04715 * volume of water collected (gms)
Bws = Mole fraction of water vapor = Vwc(std) / (Vm(std) + Vwc(std))
Percent Moisture = 100 * Bws

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	S2-1
Condition	

IDENTIFICATION INFORMATION

Plant Name
City
State

Source Number: EAST
Sampling Location: Scrubber Stack
Test Personnel: TTB, JMA

Date: 10/23/12
Start: 1212
Stop: 1410

Meterbox ID: 802012
Δ H @: 1.522
Gamma, γ: 1.0252
Nozzle ID: Blank-7
Nozzle Diameter: 0.209
Orsat/Fyrite: Fyr

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0.000	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM	.001	.02	10

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	N/A	N/A
Pitot Tube Posttest Leak Check	N/A	N/A

Barometric Pressure, In.,Hg.: 30.2
Static Pressure, In. W.C.: -0.08

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams	178.2	Moisture, %	18.093
CO_2 %	1.0	Md_run	28.72
O_2 %	21.0	Mw_run	27.33

Sampling Information / QA Checks

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Cyclone Temp. (°F)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Sample Train Vac. (in. Hg)	Probe Temp. (°F)	Run Cummulative D_{50}s, microns PM_{10}	$PM_{2.5}$
C	1	9.59	0	150.2	.17	75	134	295	60	.32	1	340	10.09	2.31
	1	9.59	9:35	153.65	.17	74	134	297	65	.28	1	340	10.35	2.41
	1	9.59	19:12	156.85	.17	75	134	303	65	.2	1	340	10.72	2.56
	1	9.87	28.47	159.67	.18	76	134	307	65	.2	1	340	11.03	2.69
	1	9.87	38:39	162.4	.18	77	133	309	65	.2	1	340	11.07	2.71
	1	9.87	48:32	165.42	.18	78	134	313	65	.2	2	340	11.00	2.68
	1	9.87	58:24	168.68	.18	79	134	313	65	.2	2	340	11.26	2.79
	1	9.87	1:08:16	171.1	.18	79	134	316	65	.25	4	340	11.21	2.77
	1	9.87	1:18:09	174.25	.18	80	134	315	65	.25	4	340	11.20	2.77
	1	9.87	1:28:01	177.3	.18	81	134	314	65	.3	6	340	11.09	2.72
	1	9.87	1:37:53	180.77	.18	82	134	314	65	.3	7	340	11.01	2.69
	1	9.67	1:47:46	[illegible]	.16	83	134	316	65	.3	8	340	10.96	2.67
	Total Run Time		1:57:38	187.59	↖ 184.21									
	Total Volume, ACF			37.385										
			Averages		.17747	78.3	133.9			.250		119.8	10.77	2.59
					in. H2O	°F	°F			in H2O		%	microns	

Run	

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	52-2
Condition	

IDENTIFICATION INFORMATION

Plant Name	[redacted]
City	
State	

Source Number		Date	10/24/12
Sampling Location	Scrubber Stack	Start	835
Test Personnel	TTB, JMA	Stop	957

Meterbox ID	802012
ΔH @	1.522
Gamma, γ	1.0252
Nozzle ID	7
Nozzle Diameter	.209
Orsat/Fyrite	FYR

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	.001	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM	.001	.02	7

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	5	5
Pitot Tube Posttest Leak Check	5	5

Barometric Pressure, In.,Hg.	29.8 30.2	Static Pressure, In. W.C.	-.08

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams		Moisture, %	
CO_2 %	1	Md_run	
O_2 %	21	Mw_run	

Sampling Information / QA Checks

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Cyclone Temp. (°F)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Sample Train Vac. (in. Hg)	Probe Temp. (°F)	Run Cummulative D50s, microns PM_{10}	$PM_{2.5}$
C	1	9.19	0	190.04	.15	57	131	295	65	.28	1	335	10.38	2.40
	1	9:19	9:11	193.411	.15	60	130	295	48	.23	1	336	10.78	2.58
	1	9.19	18:23	196.122	.15	61	131	295	48	.2	1	335	11.08	2.68
	1	9.19	27:35	198.668	.15	64	132	295	50	.2	2	336	11.23	2.74
	1	9.19	36:47	201.24	.15	68	132	299	53	.18	2	305	11.39	2.81
	1	9.04	45:58	203.706	.145	71	133	315	55	.2	3	331	11.45	2.83
	1	8.88	55:00	206.26	.14	73	132	319	56	.23	4	333	11.41	2.82
	1	9.19	1:03:54	208.965	.15	74	133	319	57	.26	5	333	11.35	2.80
	1	8.88	1:13:05	211.84	.14	75	133	319	58	.32	6	335		
				215.028										

Total Run Time	1:21:58
Total Volume, ACF	

	ΔP	Meter Temp.	Stack Temp.	ΔH			
Averages	.148104	67	131.9	.233			
	in. H2O	°F	°F	in H2O	%	microns	

spike
215.028
to
16.815

Run	

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	52-3
Condition	

IDENTIFICATION INFORMATION

Plant Name	
City	
State	
Source Number	
Sampling Location	Scrubber Stack
Test Personnel	TTB, JMA

Date	10/24/12
Start	1240
Stop	1413

Meterbox ID	802012
ΔH @	1.522
Gamma, γ	1.0252
Nozzle ID	8 - Blank
Nozzle Diameter	.224
Orsat/Fyrite	FYR

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	.004	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM	.002	.02	8

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	4	4
Pitot Tube Posttest Leak Check	4	4

Barometric Pressure, In.,Hg. 29.8

Static Pressure, In. W.C. -.08

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams	147.1	Moisture, %	19.595
CO_2 %	1	Md_run	28.70
O_2 %	21	Mw_run	27.23

Sampling Information / QA Checks

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Cyclone Temp. (°F)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Sample Train Vac. (in. Hg)	Probe Temp. (°F)	Run Cummulative microns PM_{10}	D_{50}s, $PM_{2.5}$
C	1	10.43	0	219.1	.16	79	134	302	65	.35	2	330		
	1	10.43	10:26	223.015	.16	80	133	314	62	.2	2	331		
	1	10.43	20:51	226.097	.16	81	132	315	65	.25	4	330		
	1	10.43	31:17	229.22	.16	82	132	314	64	.25	4	330		
	1	10.43	41:42	232.39	.16	84	132	317	64	.23	4	328		
	1	10.43	52:08	235.575	.16	84	131	318	63	.22	4	330		
	1	10.09	1:02:33	238.602	.15	85	130	317	64	.22	5	328		
	1	10.09	1:12:39	241.685	.15	86	131	315	65	.22	6	325		
	1	10.43	1:22:45	244.724	.16	87	131	320	64	.22	6	326		
			1:33:10	247.704										

Total Run Time 1:33:10

Total Volume, ACF 28.604

	ΔP	Meter Temp.	Stack Temp.	ΔH	Probe Temp.	PM_{10}	$PM_{2.5}$
Averages	.15775	83.1	131.8	.240	106.8	10.97	2.68
	in. H2O	°F	°F	in H2O	%	microns	

Spike 247.704 to 249.7 @ 319° 6 min 20 sec

Run	

Method 4 - Air Control Techniques, P.C.

Date 10/23/12

Source Information

Client	[redacted]		
Plant Name	[redacted]	Job #	1756
City, State	[redacted]	Process	Pulp/Paper
Sampling Location	Scrubber Stack	Personnel	TEH

Sampling Information

1410

Run Number	U2-1	U2-2	U2-3	
Filter Identification	476-1403	476-1405	476-[illegible]	
Sampling Date	10/23/12	10/24/12	10/24/12	

Moisture Data

Impinger 1
Contents - 100ml H_2O

Final Weight, grams	883.7	814.7	807.4	
Initial Weight, grams	711.4	695.9	691.2	
Condensed Water, grams	172.3	118.8	116.2	

Impinger 2
Contents - 100ml H_2O

Final Weight, grams	726.0	728.3	755.9	
Initial Weight, grams	701.5	726.0	728.3	
Condensed Water, grams	24.5	2.3	27.6	

Impinger 3
Contents - Empty

Final Weight, grams	605.6	605.8	606.5	
Initial Weight, grams	604.0	605.6	605.8	
Condensed Water, grams	1.6	0.2	0.7	

Silica Gel -

Final Weight, grams	903.0	908.1	915.0	
Initial Weight, grams	894.1	903.0	908.1	
Adsorbed Water, grams	8.9	5.1	6.9	

Total Water, grams	207.3	126.4	151.4	

Vm(std) = Volume of gas sampled at standard conditions (dscf) = gamma*17.64*Vm*[Pbar+(D H/13.6)]/(Tm+460)
Vwc(std) = volume of water vapor at standard conditions (scf) = 0.04715 * volume of water collected (gms)
Bws = Mole fraction of water vapor = Vwc(std) / (Vm(std) + Vwc(std))
Percent Moisture = 100 * Bws

Revision 1
4/27/2012

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	U2-~~2~~ 1
Condition	

IDENTIFICATION INFORMATION

Plant Name	
City	
State	

Source Number	EAST	Date	10/23/12
Sampling Location	Scrubber Stack	Start	1212
Test Personnel	TTB, JMA	Stop	1407

Meterbox ID	11077
ΔH @	1.651
Gamma, γ	0.9833
Nozzle ID	7 AOD
Nozzle Diameter	0.212
Orsat/Fyrite	FYR

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0.000	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM	0.000		15

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	4"✓	5"✓
Pitot Tube Posttest Leak Check	5"✓	6"L

Barometric Pressure, In.,Hg. 30.2

Static Pressure, In. W.C. -0.08

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams		Moisture, %	
CO_2 %	~~1~~ 1	Md_run	
O_2 %	~~20~~ 21	Mw_run	

Sampling Information

QA Checks

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Cyclone Temp. (°F)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Sample Train Vac. (in. Hg)	Probe Temp. (°F)	Run Cummulative microns PM10	D50s, PM2.5
A-1	1	9.59	0	276.3	0.17	76	134	320	60	~~0.32~~ .32	3	320		
A	1	9.59	9:35	279.54	0.17	77	134	313	64	0.32	3	314		
A	1	9.59	19:12	282.69	0.17	78	134	315	61	0.32	4	314		
A	1	9.87	28:47	285.95	0.18	78	134	313	61	0.32	4	314		
A	1	9.87	38:39	289.01	0.18	79	134	313	61	0.32	5	313		
A	1	9.87	48:32	292.31	0.18	79	134	313	61	0.32	5	313		
A	1	9.87	58:24	296.61	0.18	79	134	311	60	0.32	6	314		
A	1	9:87	1:08:16	298.84	0.18	80	134	314	61	0.32	7	314		
A	1	9:87	1:18:09	301.98	0.18	80	134	314	59	0.32	8	312		
A	1	9.87	1:28:01	304.87	0.18	81	134	312	57	0.32	9	313		
A	1	9.87	1:37:53	308.49	0.18	82	134	313	57	0.32	10	313		
A	1	9.87	1:47:46	312.17	0.18	82	134	313	57	0.32	10	312		

Total Run Time 1:57:38 315.378 315.378

Total Volume, ACF

Averages							
	in. H2O	°F	°F	in H2O	%	microns	

Run	

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	U2-2
Condition	

IDENTIFICATION INFORMATION

Plant Name			
City			
State			
Source Number	EAST	Date	10/24/12
Sampling Location	Scrubber Stack	Start	835
Test Personnel	TTB, JMA	Stop	957

Meterbox ID	11077
Δ H @	1.651
Gamma, γ	0.9833
Nozzle ID	7 A0D
Nozzle Diameter	0.212
Orsat/Fyrite	FYR

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0.000	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM	0.000		13

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	N/A	N/A
Pitot Tube Posttest Leak Check	N/A	N/A

Barometric Pressure, In.,Hg. ~~30.2~~ 29.8   Static Pressure, In. W.C. -0.18

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams		Moisture, %	
CO_2 %	1	Md_run	
O_2 %	21	Mw_run	

Sampling Information / QA Checks

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Cyclone Temp. (°F)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Sample Train Vac. (in. Hg)	Probe Temp. (°F)	Run Cummulative D50s, microns PM10	PM2.5
A	1	9.19	0	316.000	0.15	53	131	320	51	0.32	3	313		
	1	9.19	9:11	319.21	0.15	58	130	314	45	0.31	3	315		
	1	9.19	18:23	322.07	0.15	60	131	314	46	0.31	3	315		
	1	9.19	27:35	324.91	0.15	61	132	313	44	0.31	3	315		
	1	9.19	36:47	327.69	0.15	64	132	315	44	0.31	3	312		
	1	9.04	45:58	330.51	0.145	68	133	318	47	0.31	4	320		
	1	8.88	55:00	333.33	0.14	73	132	319	50	0.31	5	321		
	1	9.19	1:03:54	335.89	0.15	76	133	317	52	0.31	5	320		
	1	8.88	1:13:05	338.85	0.14	77	133	318	54	0.31	6	320		
	1		1:21:58	341.465										
	1													
	1													

Total Run Time		
Total Volume, ACF		

Averages							
	in. H2O	°F	°F	in H2O	%	microns	

Run	

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	U2-3
Condition	

IDENTIFICATION INFORMATION

Plant Name [redacted]
City
State

Source Number EAST
Sampling Location Scrubber Stack
Test Personnel TTB, JMA

Date 6/24/12
Start 1240
Stop 1413

Meterbox ID 1107
ΔH @ 1.651
Gamma, γ 0.9833
Nozzle ID X8
Nozzle Diameter 0.32 0.232
Orsat/Fyrite FYR

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0.000	< 0.02 or 4%	15"
Partial Train Posttest Leak Check, ACFM	0.000		10"

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	N/A	N/A
Pitot Tube Posttest Leak Check		

Barometric Pressure, In.,Hg. 29.8
Static Pressure, In. W.C. -0.08

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams		Moisture, %	
CO_2 %	1	Md_run	
O_2 %	21	Mw_run	

Sampling Information / QA Checks

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Cyclone Temp. (°F)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Sample Train Vac. (in. Hg)	Probe Temp. (°F)	Run Cummulative D_{50}s, microns PM_{10}	$PM_{2.5}$
A	-1	10:43	0	341.700	0.16	78	134	320	55	0.31	3	322		
	1	10:43	10:26	345.10	0.16	78	133	322	56	0.31	3	322		
	1	10:43	20:51	348.55	0.16	79	132	320	57	0.31	3	321		
	1	10:43	31:17	351.87	0.16	80	132	322	56	0.31	4	321		
	1	10:43	41:42	355.28	0.16	81	132	319	57	0.31	4	321		
	1	10:43	52:08	358.81	0.16	82	131	321	58	0.31	5	321		
	1	10:09	1:02:33	362.31	0.15	83	130	320	57	0.31	5	321		
	1	10:09	1:12:39	365.81	0.15	83	131	319	60	0.31	6	321		
	1	10:43	1:22:45	369.08	0.16	84	131	316	59	0.31	7	320		
			1:33:10	372.638										

Total Run Time
Total Volume, ACF

Averages						
	in. H2O	°F	°F	in H2O	%	microns

Run

Method 4 - Air Control Techniques, P.C.

Date

Source Information

Client	[redacted]		
Plant Name	[redacted]	Job #	1756
City, State	[redacted]	Process	Pulp/Paper
Sampling Location	Scrubber Stack	Personnel	

Sampling Information

Run Number	S2-4	S2-5	S2-6	
Filter Identification	476-1416	476-1420	476-	
Sampling Date	10/24/12	10/25/12	10/25/12	

Moisture Data

Impinger 1
Contents - 100ml H_2O

Final Weight, grams	853.8	825.8	806.8	
Initial Weight, grams	720.6	715.3	703.5	
Condensed Water, grams	133.2	110.5	103.3	

Impinger 2
Contents - 100ml H_2O

Final Weight, grams	741.7	750.4	804.7	
Initial Weight, grams	738.0	741.7	750.4	
Condensed Water, grams	3.7	8.7	54.3	

Impinger 3
Contents - Empty

Final Weight, grams	594.5	601.4	595.8 592.4	
Initial Weight, grams	594.2	593.7	~~601.4~~	
Condensed Water, grams	0.3	7.7	3.4	

Silica Gel -

Final Weight, grams	784.0	788.9	796.4	
Initial Weight, grams	777.5	784.0	788.9	
Adsorbed Water, grams	6.5	4.9	7.5	
Total Water, grams	143.7	131.8	168.5	

Vm(std) = Volume of gas sampled at standard conditions (dscf) = gamma*17.64*Vm*[Pbar+(D H/13.6)]/(Tm+460)
Vwc(std) = volume of water vapor at standard conditions (scf) = 0.04715 * volume of water collected (gms)
Bws = Mole fraction of water vapor = Vwc(std) / (Vm(std) + Vwc(std))
Percent Moisture = 100 * Bws

Revision 1
4/27/2012

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	52-4
Condition	

IDENTIFICATION INFORMATION

Plant Name [redacted]
City
State

Source Number		Date	10/24/12
Sampling Location	Scrubber Stack	Start	1600
Test Personnel	TTB, JMA	Stop	1724

Meterbox ID	502012
ΔH @	1.522
Gamma, γ	1.0252
Nozzle ID	8
Nozzle Diameter	.224
Orsat/Fyrite	FYR

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	.002	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM			10

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	4	4
Pitot Tube Posttest Leak Check	4	4

Barometric Pressure, In.,Hg. 29.8
Static Pressure, In. W.C. -.08

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams		Moisture, %	
CO_2 %	1	Md_run	
O_2 %	21	Mw_run	

Sampling Information / QA Checks

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Cyclone Temp. (°F)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Sample Train Vac. (in. Hg)	Probe Temp. (°F)	Run Cummulative D_{50}s, microns PM_{10}	$PM_{2.5}$
C	1	9.31	0	249.9	.16	88	132	295	60	.23	1	295		
	1	9.31	9:18	252.833	.16	89	132	305	60	.21	1	305		
	1	9.31	18.37	255.593	.16	90	131	314	61	.21	2	318		
	1	9.31	27.55	258.349	.16	92	131	317	62	.21	3	320		
	1	9.31	37:14	261.182	.16	93	131	318	62	.23	4	320		
	1	9.31	46:32	264.042	.16	94	131	320	62	.23	5	322		
	1	9.31	55:51	266.97	.16	95	133	320	63	.27	6	320		
	1	9.31	1:05:10	270.097	.16	96	135	321	63	.30	7	315		
	1	9.31	1:14:28	273.376	.16	97	136	320	64	.3	8	314		
			1:23:47	276.663										

Total Run Time 1:23:47
Total Volume, ACF

Spike
276.663
to
278.938
@ 319°

	Averages							
Run								
		in. H2O	°F	°F	in H2O	%	microns	

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	52-5
Condition	

IDENTIFICATION INFORMATION

Plant Name	
City	
State	
Source Number	
Sampling Location	Scrubber Stack
Test Personnel	TTB, JMA

Date	10/25/12
Start	820
Stop	949

Meterbox ID	802012
Δ H @	1.522
Gamma, γ	1.0252
Nozzle ID	8
Nozzle Diameter	.224
Orsat/Fyrite	FYR

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	.004	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM	.001	.02	6

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	4	4
Pitot Tube Posttest Leak Check	4	4

Barometric Pressure, In.,Hg. 29.8

Static Pressure, In. W.C. -.08

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams		Moisture, %	
CO_2 %		Md_run	
O_2 %		Mw_run	

Sampling Information / QA Checks

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft³)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Cyclone Temp. (°F)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Sample Train Vac. (in. Hg)	Probe Temp. (°F)	Run Cummulative D50s, microns PM10	PM2.5
C	1	7.07	0	279.2	.08	53	126	295	55	.31	1	300		
	1	8.29	7:04	281.546	.11	56	120	301	44	.31	1	307		
	1	8.29	15:22	284.37	.11	57	116	316	44	.31	1	307		
	1	9.68	23:40	287.206	.15	58	115	318	44	.3	1	310		
	1	10.0	33:20	290.38	.16	60	123	320	45	.28	1	308		
	1	10.0	43:20	293.603	.16	62	126	321	45	.27	2	310		
	1	10.0	53:20	296.942	.16	67	128	322	46	.27	3	309		
	1	9.68	1:07:20	300.272	.15	71	130	311	59	.27	4	310		
	1	9.68	1:13:01	303.528	.15	72	129	318	60	.25	4	309		
			1:22:42	306.535										

Total Run Time 1:22:42

Total Volume, ACF

Averages

	ΔP	Meter Temp.	Stack Temp.	ΔH	Probe Temp.	PM10	PM2.5
Averages							
	in. H2O	°F	°F	in H2O	%	microns	

Spike
306.535 @ 320°
to
308.584

Run	

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	52-6
Condition	

IDENTIFICATION INFORMATION

Plant Name
City
State

Source Number
Sampling Location Scrubber Stack
Test Personnel TTB, JMA

Date 10/25/12
Start 1346
Stop 1524

Meterbox ID 802012
Δ H @ 1.522
Gamma, γ 1.0252
Nozzle ID 8
Nozzle Diameter .224
Orsat/Fyrite FYR

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	.004	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM			5

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	4	4
Pitot Tube Posttest Leak Check	4	4

Barometric Pressure, In.,Hg. 29.8
Static Pressure, In. W.C. -.08

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams		Moisture, %	
CO_2 %	1	Md_run	
O_2 %	21	Mw_run	

Sampling Information / QA Checks

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Cyclone Temp. (°F)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Sample Train Vac. (in. Hg)	Probe Temp. (°F)	Run Cummulative D_{50}s, microns PM_{10}	$PM_{2.5}$
C	1	10.88	0	309.5	.16	83	128	320	65	.27	1	300		
	1	11.22	10:53	313.183	.17	83	132	315	65	.27	1	302		
	1	10.88	22:06	316.92	.16	84	135	313	62	.27	1	305		
	1	10.54	32:59	320.521	.15	85	134	318	62	.27	1	307		
	1	10.88	43:31	324.02	.16	86	135	307	63	.27	2	310		
	1	11.22	54:24	327.489	.17	85	135	314	64	.27	2	308		
	1	10.88	1:05:57	331.017	.16	86	137	317	64	.27	2	310		
	1	10.88	1:16:30	334.527	.16	86	135	318	65	.27	3	308		
	1	10.88	1:27:23	338.068	.16	87	136	315	65	.27	4	310		
			1:38:16	341.604										

Total Run Time
Total Volume, ACF

spike 341.604 to 342.7 @ 320°

Averages						
	in. H2O	°F	°F	in H2O	%	microns

Run

Method 4 - Air Control Techniques, P.C.

Date 10/24/12

Source Information

Client	[redacted]
Plant Name	[redacted]
City, State	[redacted]
Sampling Location	Scrubber Stack

Job #	1756
Process	Pulp/Paper
Personnel	TEH

Sampling Information

Run Number	U2-4	U2-5	U2-6	
Filter Identification	476-1414	476-1418	476-1422	
Sampling Date	10/24/12	10/25/12	10/25/12	

Moisture Data

Impinger 1
Contents - 100ml H_2O

Final Weight, grams	834.2	824.5	830.6	
Initial Weight, grams	697.7	700.2	662.4	
Condensed Water, grams	136.5	124.3	168.2	

Impinger 2
Contents - 100ml H_2O

Final Weight, grams	717.5	719.1	723.5	
Initial Weight, grams	713.5	717.5	719.1	
Condensed Water, grams	4.0	1.6	4.4	

Impinger 3
Contents - Empty

Final Weight, grams	607.0	607.5	607.5	
Initial Weight, grams	606.5	607.0	607.3	
Condensed Water, grams	0.5	0.5	0.2	

Silica Gel -

Final Weight, grams	923.8	929.0	936.8	
Initial Weight, grams	915.0	923.8	929.0	
Adsorbed Water, grams	8.8	5.2	7.8	

Total Water, grams	149.8	131.6	180.6	

Vm(std) = Volume of gas sampled at standard conditions (dscf) = gamma*17.64*Vm*[Pbar+(D H/13.6)]/(Tm+460)

Vwc(std) = volume of water vapor at standard conditions (scf) = 0.04715 * volume of water collected (gms)

Bws = Mole fraction of water vapor = Vwc(std) / (Vm(std) + Vwc(std))

Percent Moisture = 100 * Bws

Revision 1
4/27/2012

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	U2-4
Condition	

IDENTIFICATION INFORMATION

Plant Name:
City:
State:

Source Number: EAST
Sampling Location: Scrubber Stack
Test Personnel: TTB, JMA

Date: 10/24/12
Start: 1600
Stop: 1724

Meterbox ID: 1077
ΔH @: 1.651
Gamma, γ: 0.9833
Nozzle ID: ~~X8~~ X8
Nozzle Diameter: ~~0.212~~ 0.232
Orsat/Fyrite: FYR

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0.000	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM	0.000		10

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	N/A	N/A
Pitot Tube Posttest Leak Check		

Barometric Pressure, In.,Hg.: 29.8
Static Pressure, In. W.C.: -0.08

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams		Moisture, %	
CO_2 %	1	Md_run	
O_2 %	21	Mw_run	

Sampling Information											QA Checks			
Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Cyclone Temp. (°F)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Sample Train Vac. (in. Hg)	Probe Temp. (°F)	Run Cummulative D50s, microns PM10	PM2.5
A	1	9.31	0	374.300	0.16	85	132	318	60	0.33	3	320		
	1	9.31	9:18	~~380.59~~	0.16	85	131	319	60	0.33	3	321	377.42	
	1	9.31	18:37	380.59	0.16	85	131	319	61	0.33	3	321		
	1	9.31	27:55	383.66	0.16	86	131	318	64	0.33	~~3~~ 4	321		
	1	9.31	37:14	386.75	0.16	86	131	317	65	0.33	5	320		
	1	9.31	46:32	389.96	0.16	87	131	320	65	0.33	5	320		
	1	9.31	55:51	393.17	0.16	87	133	320	65	0.33	6	321		
	1	9.31	1:05:10	396.41	0.16	88	134	319	65	0.33	7	321		
	1	9.31	1:14:28	399.63	0.16	87	135	320	65	0.33	8	321	399.63	
			1:23:47	402.751										

Total Run Time:
Total Volume, ACF:

Averages						
in. H2O	°F	°F	in H2O	%	microns	

Run:

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	U2-5
Condition	

IDENTIFICATION INFORMATION

Plant Name	
City	
State	

Source Number	EAST	Date	10/25/12
Sampling Location	Scrubber Stack	Start	0820
Test Personnel	TTB, JMA	Stop	949

Meterbox ID	1077
Δ H @	1.651
Gamma, γ	0.9833
Nozzle ID	X8
Nozzle Diameter	0.232
Orsat/Fyrite	FYR

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0.000	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM	0.000		12

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	N/A	N/A
Pitot Tube Posttest Leak Check		

Barometric Pressure, In.,Hg. 29.8 Static Pressure, In. W.C. -0.08

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams		Moisture, %	
CO_2 %	1	Md_run	
O_2 %	21	Mw_run	

Sampling Information / QA Checks

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft³)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Cyclone Temp. (°F)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Sample Train Vac. (in. Hg)	Probe Temp. (°F)	Run Cummulative D50s, microns PM10	PM2.5
A	1	7:07	0	~~0.08~~ 403 3	0.08	52	126	320	~~320~~ 44	0.33	3	322	4033	
	2	8:29	7:04	405.75	0.11	54	120	316	41	0.33	3	321		
	3	8:29	15:22	408.47	0.11	55	116	318	42	0.33	3	321		
	4	9.68	23:40	411.11	0.15	56	115	317	42	0.33	3	322		
	5	10.00	33:20	414.01	0.16	58	123	319	44	0.33	3	322		
	6	10.00	43:20	417.58	0.16	60	126	320	45	0.33	4	322		
	7	9.68	53:20	420.77	0.16	62	128	320	45	0.33	5	322		
	8	9.68	103:20	424.28	0.15	65	130	314	45	0.33	5	321		
	9	9.68	1:13:01	427.62	0.15	71	129	318	48	0.33	6	321		
			1:22:42	430.973										

Total Run Time

Total Volume, ACF

Averages							
	in. H2O	°F	°F	in H2O	%	microns	

Run	

Combined Cyclone PM10 & PM2.5 Run Data Sheet

Run ID	U2-6
Condition	

IDENTIFICATION INFORMATION

Plant Name:
City:
State:

Source Number	EAST	Date	10/25/12
Sampling Location	Scrubber Stack	Start	1346
Test Personnel	TTB, JMA	Stop	1524

Meterbox ID	11071
ΔH @	1.651
Gamma, γ	0.9833
Nozzle ID	X8
Nozzle Diameter	0.232
Orsat/Fyrite	FYR

Filter ID	Tare

PRELIMINARY CHECKS AND DATA

	Actual	Req'd	Vacuum
Full Train Pretest Leak Check, ACFM	0.000	< 0.02 or 4%	15
Partial Train Posttest Leak Check, ACFM	0.000		15

(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.

	A	B
Pitot Tube Pretest Leak Check	N/A	N/A
Pitot Tube Posttest Leak Check		

Barometric Pressure, In.,Hg. 29.8
Static Pressure, In. W.C. -0.08

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams		Moisture, %	
CO_2 %		Md_run	
O_2 %		Mw_run	

Sampling Information / QA Checks

Port	Point	Dwell Time, (Min.)	Elapsed Time, h:m:s	Meter Volume (ft^3)	ΔP (In. H_2O)	Meter Temp. (°F)	Stack Temp., (°F)	Cyclone Temp. (°F)	Impinger Exit Gas Temp., (°F)	ΔH (in. H_2O)	Sample Train Vac. (in. Hg)	Probe Temp. (°F)	Run Cummulative D50s, microns PM_{10}	$PM_{2.5}$
A	1	10.88	0	431.300	0.16	79	128	320	65	0.33	3	327		
	2	11.22	10:53	435.06	0.17	85	132	320	55	0.33	3	326		
	3	10.88	22:06	438.79	0.16	78	135	319	53	0.33	4	325		
	4	10.54	32:59	442.48	0.15	81	134	319	55	0.33	5	325		
	5	10.88	43:31	445.77	0.16	82	135	317	58	0.33	6	324		
	6	11.22	54:24	449.87	0.17	81	135	319	60	0.33	7	324		
	7	10.88	1:05:37	453.76	0.16	81	137	317	60	0.33	8	324		
	8	10.88	1:16:30	457.16	0.16	81	135	319	62	0.33	9	325		
	9	10.88	1:27:23	461.19	0.16	82	136	319	63	0.33	9	324		
			1:38:16	464.809										

Total Run Time
Total Volume, ACF

Averages: in. H2O | °F | °F | in H2O | % | microns

Run

APPENDIX D

CALIBRATION DATA

APEX INSTRUMENTS METHOD 5 PRE-TEST CONSOLE CALIBRATION
USING CALIBRATED CRITICAL ORIFICES
5-POINT ENGLISH UNITS

Meter Console Information	
Console Model Number	522
Console Serial Number	702233
DGM Model Number	RW 110
DGM Serial Number	1014753

Calibration Conditions			
Date	**Time**	12/27/11	
Barometric Pressure		29.60	in Hg
Theoretical Critical Vacuum[1]		13.97	in Hg
Calibration Technician		DLS	

Factors/Conversions		
Std Temp	528	°R
Std Press	29.92	in Hg
K_1	17.647	oR/in Hg

[1]For valid test results, the Actual Vacuum should be 1 to 2 in. Hg greater than the Theoretical Critical Vacuum shown above.

[2]The Critical Orifice Coefficient, K', must be entered in English units, $(ft^3 \cdot {}^oR^{1/2})/(in.Hg \cdot min)$.

Calibration Data										
Run Time	**Metering Console**					**Critical Orifice**				
Elapsed	**DGM Orifice ΔH**	**Volume Initial**	**Volume Final**	**Outlet Temp Initial**	**Outlet Temp Final**	**Serial Number**	**Coefficient**	**Amb Temp Initial**	**Amb Temp Final**	**Actual Vacuum**
(Θ)	(P_m)	(V_{mi})	(V_{mf})	(t_{mi})	(t_{mf})		K'	(t_{amb})	(t_{amb})	
min	in H_2O	cubic feet	cubic feet	°F	°F		see above2	°F	°F	in Hg
17.0	0.25	351.760	357.391	69	69	FO 40	0.2387	67	67	23
12.5	0.58	357.670	363.723	69	69	FO 48	0.3483	67	67	22
8.5	1.05	363.860	369.286	69	69	FO 55	0.4592	67	67	20
7.0	1.65	369.500	375.244	69	69	FO 63	0.5907	67	67	18
5.5	3.15	375.530	381.665	69	69	FO 73	0.8085	67	67	16

Results								
Standardized Data				**Dry Gas Meter**				
				Calibration Factor		**Flowrate**	**ΔH @**	
Dry Gas Meter		**Critical Orifice**		**Value**	**Variation**	**Std & Corr**	**0.75 SCFM**	**Variation**
$(V_{m(std)})$	$(Q_{m(std)})$	$(Vcr_{(std)})$	$(Q_{cr(std)})$	(Y)	(ΔY)	$(Q_{m(std)(corr)})$	(ΔH@)	(ΔΔH@)
cubic feet	cfm	cubic feet	cfm			cfm	in H2O	
5.564	0.327	5.232	0.308	0.9404	0.002	0.308	1.469	-0.126
5.986	0.479	5.614	0.449	0.9379	0.000	0.449	1.603	0.008
5.372	0.632	5.033	0.592	0.9369	-0.001	0.592	1.674	0.078
5.695	0.814	5.332	0.762	0.9362	-0.002	0.762	1.594	-0.001
6.105	1.110	5.734	1.042	0.9391	0.001	1.042	1.637	0.041
				0.9381	Y Average		1.595	ΔH@ Average

Note: For Calibration Factor Y, the ratio of the reading of the calibration meter to the dry gas meter, acceptable tolerance of individual values from the average is +-0.02

I certify that the above Dry Gas Meter was calibrated in accordance with USEPA Methods, CFR Title 40, Part 60, Appendix A-3, Method 5, 16.2.3

Operator DLS

Date 12/27/2011

APEX INSTRUMENTS METHOD 5 POST-TEST CONSOLE CALIBRATION
USING CALIBRATED CRITICAL ORIFICES
3-POINT ENGLISH UNITS

Meter Console Information	
Console Model Number	522
Console Serial Number	702233
DGM Model Number	RW 110
DGM Serial Number	1014753

Calibration Conditions			
Date	Time	11/06/12	
Barometric Pressure		29.8	in Hg
Theoretical Critical Vacuum[1]		14.1	in Hg
Calibration Technician		DLS	

Factors/Conversions		
Std Temp	528	°R
Std Press	29.92	in Hg
K_1	17.647	oR/in Hg

[1] For valid test results, the Actual Vacuum should be 1 to 2 in. Hg greater than the Theoretical Critical Vacuum shown above.

[2] The Critical Orifice Coefficient, K', must be entered in English units, $(ft^3 * °R^{1/2})/(in.Hg*min)$.

Calibration Data

Run Time	Metering Console					Critical Orifice				
Elapsed	DGM Orifice ΔH	Volume Initial	Volume Final	Outlet Temp Initial	Outlet Temp Final	Serial Number	Coefficient	Amb Temp Initial	Amb Temp Final	Actual Vacuum
(Θ)	(P_m)	(V_{mi})	(V_{mf})	(t_{mi})	(t_{mf})		K'	(t_{amb})	(t_{amb})	
min	in H_2O	cubic feet	cubic feet	°F	°F		see above2	°F	°F	in Hg
8.0	1.65	66.900	73.399	73	75	FO 48	0.5907	68	68	19.00
8.0	1.65	73.399	79.922	75	75	FO 48	0.5907	68	68	19.00
8.0	1.65	79.922	86.425	75	75	FO 48	0.5907	68	68	19.00

Results

Standardized Data				Dry Gas Meter				
Dry Gas Meter		Critical Orifice		Calibration Factor		Flowrate	ΔH @	
				Value	Variation	Std & Corr	0.75 SCFM	Variation
$(V_{m(std)})$	$(Q_{m(std)})$	$(Vcr_{(std)})$	$(Q_{cr(std)})$	(Y)	(ΔY)	$(Q_{m(std)(corr)})$	(ΔH@)	(ΔΔH@)
cubic feet	cfm	cubic feet	cfm			cfm	in H2O	
6.426	0.803	6.129	0.766	0.954	0.000	0.766	1.571	0.002
6.438	0.805	6.129	0.766	0.952	-0.002	0.766	1.568	-0.001
6.418	0.802	6.129	0.766	0.955	0.001	0.766	1.568	-0.001
Pretest Gamma	0.9381	% Deviation	1.6	0.953	Y Average		1.569	ΔH@ Average

Note: For Calibration Factor Y, the ratio of the reading of the calibration meter to the dry gas meter, acceptable tolerance of individual values from the average is +-0.02.

I certify that the above Dry Gas Meter was calibrated in accordance with USEPA Methods, CFR Title 40, Part 60, Appendix A-3, Method 5, 16.2.3

Signature ______ TTB

Date ___11/6/12___

APEX INSTRUMENTS METHOD 5 PRE-TEST CONSOLE CALIBRATION
USING CALIBRATED CRITICAL ORIFICES
5-POINT ENGLISH UNITS

Meter Console Information	
Console Model Number	522
Console Serial Number	909033
DGM Model Number	RW 110
DGM Serial Number	961167

Calibration Conditions			
Date	**Time**	05/25/12	
Barometric Pressure		30.00	in Hg
Theoretical Critical Vacuum[1]		14.16	in Hg
Calibration Technician		DLS	

Factors/Conversions		
Std Temp	528	°R
Std Press	29.92	in Hg
K_1	17.647	oR/in Hg

[1]For valid test results, the Actual Vacuum should be 1 to 2 in. Hg greater than the Theoretical Critical Vacuum shown above.

[2]The Critical Orifice Coefficient, K', must be entered in English units, $(ft^3 \cdot {}^{\circ}R^{1/2})/(in.Hg \cdot min)$.

Calibration Data

Run Time	Metering Console					Critical Orifice				
Elapsed	DGM Orifice ΔH	Volume Initial	Volume Final	Outlet Temp Initial	Outlet Temp Final	Serial Number	Coefficient	Amb Temp Initial	Amb Temp Final	Actual Vacuum
(Θ)	(P_m)	(V_{mi})	(V_{mf})	(t_{mi})	(t_{mf})		K'	(t_{amb})	(t_{amb})	
min	in H_2O	cubic feet	cubic feet	°F	°F		see above2	°F	°F	in Hg
17.5	0.35	312.399	317.974	70	71	FO 40	0.2387	67	67	24
12.0	0.715	318.200	323.788	71	71	FO 48	0.3483	67	67	22
9.0	1.20	323.900	329.432	71	71	FO 55	0.4592	67	67	21
7.0	1.95	329.739	335.282	71	71	FO 63	0.5907	67	67	19
5.5	3.55	335.900	341.842	71	71	FO 73	0.8085	67	67	17

Results

Standardized Data				Dry Gas Meter				
Dry Gas Meter		Critical Orifice		Calibration Factor		Flowrate	ΔH @	
				Value	Variation	Std & Corr	0.75 SCFM	Variation
($V_{m(std)}$)	($Q_{m(std)}$)	($Vcr_{(std)}$)	($Q_{cr(std)}$)	(Y)	(ΔY)	($Q_{m(std)(corr)}$)	(ΔH@)	(ΔΔH@)
cubic feet	cfm	cubic feet	cfm			cfm	in H2O	
5.568	0.318	5.459	0.312	0.9803	0.004	0.312	2.024	0.120
5.581	0.465	5.462	0.455	0.9787	0.002	0.455	1.944	0.040
5.532	0.615	5.401	0.600	0.9763	0.000	0.600	1.881	-0.023
5.553	0.793	5.404	0.772	0.9731	-0.003	0.772	1.854	-0.050
5.976	1.087	5.811	1.057	0.9724	-0.004	1.057	1.816	-0.088
				0.9762	Y Average		1.904	ΔH@ Average

Note: For Calibration Factor Y, the ratio of the reading of the calibration meter to the dry gas meter, acceptable tolerance of individual values from the average is +-0.02.

I certify that the above Dry Gas Meter was calibrated in accordance with USEPA Methods, CFR Title 40, Part 60, Appendix A-3, Method 5, 16.2.3

Operator ______ DLS

Date ______ 5/25/2012

APEX INSTRUMENTS METHOD 5 POST-TEST CONSOLE CALIBRATION
USING CALIBRATED CRITICAL ORIFICES
3-POINT ENGLISH UNITS

Meter Console Information	
Console Model Number	522
Console Serial Number	909033
DGM Model Number	RW 110
DGM Serial Number	961167

Calibration Conditions			
Date	**Time**	11/07/12	13:30
Barometric Pressure		30.00	in Hg
Theoretical Critical Vacuum[1]		14.2	in Hg
Calibration Technician		DGG	

Factors/Conversions		
Std Temp	528	°R
Std Press	29.92	in Hg
K_1	17.647	oR/in Hg

[1]For valid test results, the Actual Vacuum should be 1 to 2 in. Hg greater than the Theoretical Critical Vacuum shown above.

[2]The Critical Orifice Coefficient, K', must be entered in English units, $(ft^3 \cdot °R^{1/2})/(in.Hg \cdot min)$.

Calibration Data										
Run Time	**Metering Console**					**Critical Orifice**				
Elapsed	**DGM Orifice ΔH**	**Volume Initial**	**Volume Final**	**Outlet Temp Initial**	**Outlet Temp Final**	**Serial Number**	**Coefficient**	**Amb Temp Initial**	**Amb Temp Final**	**Actual Vacuum**
(Θ)	(P_m)	(V_{mi})	(V_{mf})	(t_{mi})	(t_{mf})		K'	(t_{amb})	(t_{amb})	
min	in H_2O	cubic feet	cubic feet	°F	°F		see above2	°F	°F	in Hg
20.0	0.35	743.800	750.072	60	61	FO40	0.2387	62	64	23.00
20.0	0.35	750.072	756.377	61	62	FO40	0.2387	64	64	22.00
20.0	0.35	756.377	762.726	63	65	FO40	0.2387	63	63	22.00

Results								
Standardized Data				**Dry Gas Meter**				
Dry Gas Meter		**Critical Orifice**		**Calibration Factor**		**Flowrate**	**ΔH @**	
				Value	**Variation**	**Std & Corr**	**0.75 SCFM**	**Variation**
($V_{m(std)}$)	($Q_{m(std)}$)	($Vcr_{(std)}$)	($Q_{cr(std)}$)	(Y)	(ΔY)	($Q_{m(std)(corr)}$)	(ΔH@)	(ΔΔH@)
cubic feet	cfm	cubic feet	cfm			cfm	in H2O	
6.385	0.319	6.263	0.313	0.9809	0.003	0.313	2.047	0.005
6.406	0.320	6.257	0.313	0.9766	-0.001	0.313	2.047	0.005
6.420	0.321	6.263	0.313	0.975	-0.002	0.313	2.034	-0.009
Pretest Gamma	0.9762	**% Deviation**	0.1	0.978	Y Average		2.043	ΔH@ Average

Note: For Calibration Factor Y, the ratio of the reading of the calibration meter to the dry gas meter, acceptable tolerance of individual values from the average is +-0.02

I certify that the above Dry Gas Meter was calibrated in accordance with USEPA Methods, CFR Title 40, Part 60, Appendix A-3, Method 5, 16.2.3

Signature: TEH

Date: 11/7/12

APEX INSTRUMENTS METHOD 5 PRE-TEST CONSOLE CALIBRATION
USING CALIBRATED CRITICAL ORIFICES
5-POINT ENGLISH UNITS

Meter Console Information	
Console Model Number	522
Console Serial Number	802012
DGM Model Number	RW 110
DGM Serial Number	964447

Calibration Conditions			
Date	Time	06/08/12	
Barometric Pressure		29.90	in Hg
Theoretical Critical Vacuum[1]		14.11	in Hg
Calibration Technician		DLS	

Factors/Conversions		
Std Temp	528	°R
Std Press	29.92	in Hg
K_1	17.647	oR/in Hg

[1] For valid test results, the Actual Vacuum should be 1 to 2 in. Hg greater than the Theoretical Critical Vacuum shown above.

[2] The Critical Orifice Coefficient, K', must be entered in English units, $(ft^3 \cdot {}^\circ R^{1/2})/(in.Hg \cdot min)$.

Calibration Data

Run Time	Metering Console					Critical Orifice				
Elapsed	DGM Orifice ΔH	Volume Initial	Volume Final	Outlet Temp Initial	Outlet Temp Final	Serial Number	Coefficient	Amb Temp Initial	Amb Temp Final	Actual Vacuum
(Θ)	(P_m)	(V_{mi})	(V_{mf})	(t_{mi})	(t_{mf})		K'	(t_{amb})	(t_{amb})	
min	in H_2O	cubic feet	cubic feet	°F	°F		see above2	°F	°F	in Hg
17.5	0.25	182.600	187.934	77	77	FO 40	0.2387	72	72	23
13.0	0.55	188.140	193.946	77	78	FO 48	0.3483	72	72	22
11.0	0.99	194.050	200.507	78	78	FO 55	0.4592	72	72	20
7.5	1.65	201.800	207.542	78	78	FO 63	0.5907	72	72	18
5.5	3.10	207.720	213.452	78	78	FO 73	0.8085	72	72	17

Results

Standardized Data				Dry Gas Meter				
Dry Gas Meter		Critical Orifice		Calibration Factor		Flowrate	ΔH @	
				Value	Variation	Std & Corr	0.75 SCFM	Variation
$(V_{m(std)})$	$(Q_{m(std)})$	$(Vcr_{(std)})$	$(Q_{cr(std)})$	(Y)	(ΔY)	$(Q_{m(std)(corr)})$	(ΔH@)	(ΔΔH@)
cubic feet	cfm	cubic feet	cfm			cfm	in H2O	
5.244	0.300	5.415	0.309	1.0326	0.007	0.309	1.417	-0.105
5.707	0.439	5.870	0.452	1.0284	0.003	0.452	1.495	-0.027
6.348	0.577	6.548	0.595	1.0315	0.006	0.595	1.550	0.028
5.654	0.754	5.743	0.766	1.0157	-0.009	0.766	1.566	0.044
5.665	1.030	5.764	1.048	1.0176	-0.008	1.048	1.582	0.060
				1.0252	Y Average		1.522	ΔH@ Average

Note: For Calibration Factor Y, the ratio of the reading of the calibration meter to the dry gas meter, acceptable tolerance of individual values from the average is +-0.02

I certify that the above Dry Gas Meter was calibrated in accordance with USEPA Methods, CFR Title 40, Part 60, Appendix A-3, Method 5, 16.2.3

Signature: DLS

Date: 6/8/12

APEX INSTRUMENTS METHOD 5 POST-TEST CONSOLE CALIBRATION
USING CALIBRATED CRITICAL ORIFICES
3-POINT ENGLISH UNITS

Meter Console Information	
Console Model Number	522
Console Serial Number	802012
DGM Model Number	RW 110
DGM Serial Number	964447

Calibration Conditions			
Date	**Time**	10/26/12	
Barometric Pressure		29.90	in Hg
Theoretical Critical Vacuum[1]		14.1	in Hg
Calibration Technician		DR	

Factors/Conversions		
Std Temp	528	°R
Std Press	29.92	in Hg
K_1	17.647	oR/in Hg

[1]For valid test results, the Actual Vacuum should be 1 to 2 in. Hg greater than the Theoretical Critical Vacuum shown above.

[2]The Critical Orifice Coefficient, K', must be entered in English units, $(ft^3 * °R^{1/2})/(in.Hg*min)$.

Calibration Data

Run Time	Metering Console					Critical Orifice				
Elapsed	**DGM Orifice ΔH**	**Volume Initial**	**Volume Final**	**Outlet Temp Initial**	**Outlet Temp Final**	**Serial Number**	**Coefficient**	**Amb Temp Initial**	**Amb Temp Final**	**Actual Vacuum**
(Θ)	(P_m)	(V_{mi})	(V_{mf})	(t_{mi})	(t_{mf})		K'	(t_{amb})	(t_{amb})	
min	in H_2O	cubic feet	cubic feet	°F	°F		see above2	°F	°F	in Hg
10.0	1.60	346.711	354.428	68	70	FO63	0.5907	70	71	20.00
10.0	1.60	354.428	362.204	70	72	FO63	0.5907	71	72	20.00
10.0	1.60	362.204	370.061	72	73	FO63	0.5907	73	73	20.00

Results

Standardized Data				Dry Gas Meter				
				Calibration Factor		**Flowrate**	**ΔH @**	
Dry Gas Meter		**Critical Orifice**		**Value**	**Variation**	**Std & Corr**	**0.75 SCFM**	**Variation**
$(V_{m(std)})$	$(Q_{m(std)})$	$(Vcr_{(std)})$	$(Q_{cr(std)})$	(Y)	(ΔY)	$(Q_{m(std)(corr)})$	(ΔH@)	(ΔΔH@)
cubic feet	cfm	cubic feet	cfm			cfm	in H2O	
7.728	0.773	7.668	0.767	0.9923	0.006	0.767	1.540	0.002
7.757	0.776	7.661	0.766	0.9876	0.001	0.766	1.537	-0.001
7.816	0.782	7.650	0.765	0.9788	-0.007	0.765	1.537	-0.001
Pretest Gamma	1.0252	**% Deviation**	3.8	0.9862	Y Average		1.538	ΔH@ Average

Note: For Calibration Factor Y, the ratio of the reading of the calibration meter to the dry gas meter, acceptable tolerance of individual values from the average is +-0.02.

I certify that the above Dry Gas Meter was calibrated in accordance with USEPA Methods, CFR Title 40, Part 60, Appendix A-3, Method 5, 16.2.3

Signature ____________________ Date ____________________

APEX INSTRUMENTS METHOD 5 PRE-TEST CONSOLE CALIBRATION
USING CALIBRATED CRITICAL ORIFICES
5-POINT ENGLISH UNITS

Meter Console Information	
Console Model Number	522
Console Serial Number	11077
DGM Model Number	RW 110
DGM Serial Number	964447

Calibration Conditions			
Date	Time	06/01/12	
Barometric Pressure		29.60	in Hg
Theoretical Critical Vacuum[1]		13.97	in Hg
Calibration Technician		DLS	

Factors/Conversions		
Std Temp	528	°R
Std Press	29.92	in Hg
K_1	17.647	oR/in Hg

[1]For valid test results, the Actual Vacuum should be 1 to 2 in. Hg greater than the Theoretical Critical Vacuum shown above.

[2]The Critical Orifice Coefficient, K', must be entered in English units, $(ft^3 \cdot {}^\circ R^{1/2})/(in.Hg*min)$.

Calibration Data

Run Time	Metering Console					Critical Orifice				
Elapsed	DGM Orifice ΔH	Volume Initial	Volume Final	Outlet Temp Initial	Outlet Temp Final	Serial Number	Coefficient	Amb Temp Initial	Amb Temp Final	Actual Vacuum
(Θ)	(P_m)	(V_{mi})	(V_{mf})	(t_{mi})	(t_{mf})		K'	(t_{amb})	(t_{amb})	
min	in H_2O	cubic feet	cubic feet	°F	°F		see above2	°F	°F	in Hg
17.5	0.265	984.520	990.031	74	74	FO 40	0.2387	73	73	23
17.0	0.59	990.160	998.013	73	73	FO 48	0.3483	73	73	22
10.0	1.05	998.200	1004.320	74	75	FO 55	0.4592	73	73	20
7.0	1.75	1004.520	1010.038	75	75	FO 63	0.5907	73	73	19
5.5	3.25	1010.260	1016.187	75	75	FO 73	0.8085	73	73	16

Results

Standardized Data				Dry Gas Meter					
				Calibration Factor		Flowrate	ΔH @		
Dry Gas Meter		Critical Orifice		Value	Variation	Std & Corr	0.75 SCFM	Variation
$(V_{m(std)})$	$(Q_{m(std)})$	$(Vcr_{(std)})$	$(Q_{cr(std)})$	(Y)	(ΔY)	$(Q_{m(std)(corr)})$	(ΔH@)	(ΔΔH@)
cubic feet	cfm	cubic feet	cfm			cfm	in H2O	
5.394	0.308	5.356	0.306	0.9928	0.010	0.306	1.560	-0.091
7.707	0.453	7.592	0.447	0.9850	0.002	0.447	1.637	-0.014
5.997	0.600	5.887	0.589	0.9818	-0.002	0.589	1.675	0.025
5.411	0.773	5.301	0.757	0.9798	-0.004	0.757	1.692	0.041
5.834	1.061	5.701	1.037	0.9773	-0.006	1.037	1.689	0.039
				0.9833	Y Average		1.651	ΔH@ Average

Note: For Calibration Factor Y, the ratio of the reading of the calibration meter to the dry gas meter, acceptable tolerance of individual values from the average is +-0.02.

I certify that the above Dry Gas Meter was calibrated in accordance with USEPA Methods, CFR Title 40, Part 60, Appendix A-3, Method 5, 16.2.3

Signature ____________

Date 6-01-12

APEX INSTRUMENTS METHOD 5 POST-TEST CONSOLE CALIBRATION
USING CALIBRATED CRITICAL ORIFICES
3-POINT ENGLISH UNITS

Meter Console Information	
Console Model Number	522
Console Serial Number	11077
DGM Model Number	RW 110
DGM Serial Number	964447

Calibration Conditions			
Date	Time	11/07/12	0900
Barometric Pressure		29.40	in Hg
Theoretical Critical Vacuum[1]		13.9	in Hg
Calibration Technician		TEH	

Factors/Conversions		
Std Temp	528	°R
Std Press	29.92	in Hg
K_1	17.647	oR/in Hg

[1]For valid test results, the Actual Vacuum should be 1 to 2 in. Hg greater than the Theoretical Critical Vacuum shown above.

[2]The Critical Orifice Coefficient, K', must be entered in English units, $(ft^{3}*°R^{1/2})/(in.Hg*min)$.

Calibration Data										
Run Time	Metering Console					Critical Orifice				
Elapsed	DGM Orifice ΔH	Volume Initial	Volume Final	Outlet Temp Initial	Outlet Temp Final	Serial Number	Coefficient	Amb Temp Initial	Amb Temp Final	Actual Vacuum
(Θ)	(P_m)	(V_{mi})	(V_{mf})	(t_{mi})	(t_{mf})		K'	(t_{amb})	(t_{amb})	
min	in H_2O	cubic feet	cubic feet	°F	°F		see above2	°F	°F	in Hg
17.0	0.26	468.702	474.072	65	66	FO40	0.2378	69	69	24.50
17.0	0.26	474.072	479.444	66	67	FO40	0.2378	69	69	24.50
17.0	0.26	479.444	484.826	67	68	FO40	0.2378	69	69	24.50

Results								
Standardized Data				Dry Gas Meter				
				Calibration Factor		Flowrate	ΔH @	
Dry Gas Meter		Critical Orifice		Value	Variation	Std & Corr	0.75 SCFM	Variation
$(V_{m(std)})$	$(Q_{m(std)})$	$(Vcr_{(std)})$	$(Q_{cr(std)})$	(Y)	(ΔY)	$(Q_{m(std)(corr)})$	(ΔH@)	(ΔΔH@)
cubic feet	cfm	cubic feet	cfm			cfm	in H2O	
5.305	0.312	5.167	0.304	0.974	-0.001	0.304	1.566	0.003
5.297	0.312	5.167	0.304	0.976	0.000	0.304	1.563	0.000
5.297	0.312	5.167	0.304	0.976	0.001	0.304	1.560	-0.003
Pretest Gamma	0.9833	% Deviation	0.8	0.9750	Y Average		1.563	ΔH@ Average

Note: Acceptable tolerance of average Calibration Factor (Y) to pre-test calibration Y is +- 5 percent.

Note: For Calibration Factor Y, the ratio of the reading of the calibration meter to the dry gas meter, acceptable tolerance of individual values from the average is +-0.02.

I certify that the above Dry Gas Meter was calibrated in accordance with USEPA Methods, CFR Title 40, Part 60, Appendix A-3, Method 5, 16.2.3

Signature: TEH

Date: 11/7/12

Precutter Nozzle Calibration and Inspection
Air Control Techniques, P.C.

Nozzle Set ID	Nozzle ID	Average	Measurements			Maximum Variance	Condition	Date Inspected
			1	2	3			
I	1	0.123	0.123	0.122	0.123	0.001	New	7/30/12
I	2	0.133	0.133	0.133	0.133	0.000	New	7/30/12
I	3	0.153	0.153	0.153	0.153	0.000	New	7/30/12
I	4	0.171	0.171	0.171	0.170	0.001	New	7/30/12
I	5	0.185	0.185	0.185	0.185	0.000	New	7/30/12
I	6	0.201	0.201	0.200	0.201	0.001	New	7/30/12
I	7	0.216	0.217	0.216	0.215	0.002	New	7/30/12
I	8	0.233	0.234	0.233	0.232	0.002	New	7/30/12
I	9	0.251	0.252	0.252	0.250	0.002	New	7/30/12
I	10	0.273	0.273	0.272	0.273	0.001	New	7/30/12
I	11	0.295	0.294	0.296	0.296	0.002	New	7/30/12
I	12	0.320	0.320	0.320	0.320	0.000	New	7/30/12
X	1	0.122	0.122	0.122	0.121	0.001	New	7/30/12
X	2	0.132	0.132	0.132	0.132	0.000	New	7/30/12
X	3	0.153	0.153	0.152	0.153	0.001	New	7/30/12
X	4	0.170	0.171	0.170	0.170	0.001	New	7/30/12
X	5	0.184	0.185	0.184	0.184	0.001	New	7/30/12
X	6	0.200	0.200	0.200	0.200	0.000	New	7/30/12
X	7	0.215	0.215	0.215	0.216	0.001	New	7/30/12
X	8	0.232	0.232	0.232	0.232	0.000	New	7/30/12
X	9	0.250	0.250	0.249	0.250	0.001	New	7/30/12
X	10	0.271	0.271	0.270	0.271	0.001	New	7/30/12
X	11	0.297	0.298	0.296	0.296	0.002	New	7/30/12
X	12	0.320	0.320	0.319	0.320	0.001	New	7/30/12

By:

Date: 7/30/12

Precutter Nozzle Calibration and Inspection
Air Control Techniques, P.C.

Nozzle Set ID	Nozzle ID	Average	Measurements			Maximum Variance	Condition	Date Inspected
			1	2	3			
PM	1	0.123	0.122	0.123	0.124	0.002	New	10/18/12
2.5	2	0.133	0.134	0.133	0.133	0.001	New	10/18/12
BOX	3	0.153	0.153	0.153	0.154	0.001	New	10/18/12
AOD	4	0.173	0.173	0.174	0.172	0.002	New	10/18/12
PM	5	0.185	0.185	0.185	0.186	0.001	New	10/18/12
2.5	6	0.200	0.199	0.200	0.201	0.002	New	10/18/12
BOX	7	0.212	0.211	0.211	0.213	0.002	New	10/18/12
AOD	8	0.229	0.228	0.229	0.229	0.001	New	10/18/12
PM	9	0.249	0.248	0.249	0.250	0.002	New	10/18/12
2.5	10	0.268	0.268	0.268	0.267	0.001	New	10/18/12
BOX	11	0.293	0.292	0.294	0.293	0.002	New	10/18/12
AOD	12	0.317	0.317	0.318	0.317	0.001	New	10/18/12
								10/18/12
Ziplock	1	0.122	0.122	0.121	0.122	0.001	New	10/18/12
Bag	2	0.121	0.120	0.121	0.121	0.001	New	10/18/12
Ziplock	3	0.153	0.153	0.153	0.154	0.001	New	10/18/12
Bag	4	0.171	0.171	0.171	0.170	0.001	New	10/18/12
Ziplock	5	0.185	0.185	0.185	0.185	0.000	New	10/18/12
Bag	6	0.201	0.200	0.201	0.201	0.001	New	10/18/12
Ziplock	7	0.212	0.211	0.213	0.212	0.002	New	10/18/12
Bag	8	0.231	0.232	0.231	0.231	0.001	New	10/18/12
Ziplock	9	0.247	0.246	0.248	0.246	0.002	New	10/18/12
Bag	10	0.271	0.270	0.272	0.271	0.002	New	10/18/12
Ziplock	11	0.294	0.295	0.293	0.294	0.002	New	10/18/12
Bag	12	0.318	0.318	0.316	0.319	0.003	New	10/18/12
								10/18/12
PM2.5	1	0.122	0.122	0.122	0.121	0.001	New	10/18/12
Nozzle	2	0.134	0.134	0.132	0.135	0.003	New	10/18/12
BOX	3	0.147	0.140	0.148	0.154	0.014	Ruff	10/18/12
Blank	4	0.171	0.170	0.171	0.171	0.001	New	10/18/12
PM2.5	5	0.185	0.185	0.185	0.184	0.001	New	10/18/12
Nozzle	6	0.200	0.199	0.200	0.200	0.001	New	10/18/12
BOX	7	0.209	0.207	0.208	0.211	0.004	OK	10/18/12
Blank	8	0.224	0.221	0.224	0.226	0.005	Ruff	10/18/12
PM2.5	9	0.251	0.251	0.251	0.250	0.001	New	10/18/12
Nozzle	10	0.262	0.260	0.262	0.263	0.003	Ruff	10/18/12
BOX	11	0.296	0.295	0.296	0.297	0.002	New	10/18/12
Blank	12	0.319	0.320	0.318	0.318	0.002	New	10/18/12

By: ______________________

Date: 10/18/12

APPENDIX E

ANALYTICAL DATA

RESOLUTION ANALYTICS

TOTAL and $PM_{2.5}$ FILTERABLE PARTICULATE MATTER

RESOLUTION ANALYTICS, INC.
Specialists in Air Emissions Analysis

ANALYTICAL REPORT

CLIENT: **AIR CONTROL TECHNIQUES, INC.**

PROJECT: 1390-1756

ANALYTICAL SERVICES PROVIDED:

- PM 2.5 FILTERABLE PARTICULATE
  (EPA METHOD 201A)
- TOTAL SOLIDS
  (EPA METHOD 160-1/2)

Confirmation of Data Review:

To the best of my knowledge this analytical data has been checked thoroughly for completeness and the results presented are accurate, error-free, legible, and have been performed and validated in accordance with the approved method(s).

Date of Review: November 15, 2012

J. Bruce Nemet

J. Bruce Nemet
Quality Assurance Officer

www.resolutionanalytics.com
2733 Lee Avenue • Sanford, NC 27332 • Phone: 919-774-5557 • Fax: 919-776-6785

Analysis Request / Chain of Custody

RESOLUTION ANALYTICS, INC.
Specialists in Air Emission Analysis
2733 Lee Avenue, Sanford, NC 27330
Phone (919) 774-5557 • Fax (919) 776-6785 • Email resolute@interpath.com

Reporting Address: [1] Please attach a separate sheet of paper if billing address is different than reporting address.	Phone Number (919) 460-7811	Fax Number (919) 460-7897
Company Air Control Techniques, PC	Contact John Richards	
Street Address 301 East Durham Rd		
City, State, Zip Cary, NC 27513	**Project:** 1390-1756	

Turnaround Time:

- ☐ 10 Days (Standard)
- ☐ 5 Days (1.5x)
- ☐ 3 Days (2x)
- ☐ 2 Days (2.5x)
- ☐ 24 Hours (3x)

Sample ID / Run #	Train/Run Component	Train/Run Component	Train/Run Component
EXAMPLE: SCRUBBER INLET-1	*0.1 N H2S04 (Imp 1-3)*	*0.1 N H2S04 (Imp 4)*	*0.1 N NaOH (Imp 5-6)*
Water & Acetone	Blanks		(2Jars)
10-24-12 3:10PM WS water	WS water 10-24-12 430PM	3:15PM 10-25-12 WS water	Suspended & dissolved solids (3Jars)
S1-1 Filter, Nozzle acetone & Water Rinses, Probe acetone & water Rinse, ≤2.5 acetone & water Rinse			(6Jars + Petri)
S2-1 〃 〃	〃 〃	〃 〃	6Jars + Petri
U1-1 〃 〃	〃 〃	〃 〃	〃
U2-2 〃 〃	〃 〃	〃 〃	〃
S1-2 〃 〃	〃	〃 〃	〃

Analyses

- ☐ EPA 0011/TO-5/8315
  - analytes: ______
  - analytes: ______
- ☐ HF (EPA 13B)
- ☐ EPA 26A (HC1/C1$_2$)
  - analytes: ______
- ☐ VOC's (HPLC)
  - analytes: ______
- ☐ Amines list: ______
- ☐ Phenol (EPA TO-8)
- ☐ SO$_x$ (EPA 6/8)
  - analytes: ______
- ☐ Ammonia (CTM-027)
- ☐ NO$_x$ (EPA 7A/7D)
- ☐ Filt Particulate (EPA 5)
- ☐ Conden Part (EPA 202)
- ☐ EPA 29
  - metals: ______
  - metals: ______
- ☐ Ontario-Hydro (Hg)
- ☐ EPA 101A (hg)
- ☒ Other
  - list See Pg #2

Chain of Custody:

Relinquished by (Signature)	Date	Received by (Signature)	Date	Comments
	10/31/12		10/31/12	
Relinquished by (Signature)	Date	Received by (Signature)	Date	Comments

WHITE: Report Copy CANARY: Client Copy PINK: Lab Copy

JPC Form No. 37449A

Project: 1756 [redacted]

RESOLUTION ANALYTICS, INC.
Specialists in Air Emission Analysis

2733 Lee Avenue, Sanford, NC 27330
Phone (919) 774-5557 • Fax (919) 776-6785 • Email resolute@interpath.com

Sample ID / Run #	Train/Run Component	Train/Run Component	Train/Run Component
S2-2 Filter, Nozzle Acetone & H2O Rinse,	Probe Acetone &	≤2.5μ acetone & H2O Rinse	6 Jars + 1 Petri
U1-2	"		"
U2-2	" #1	"Gravimetric on	"
S1-3	"	all samples"	"
S2-3	" #2	IC on all H2O	"
U1-3	"	samples w/ gravimetric	"
U2-3	"	results above 1mg.	"
S1-4	"		"
S2-4	"		"
U1-4	"		"
U2-4	"		"
S1-5	"		"
S2-5	"		"
U1-5	"		"
U2-5	"		"
S1-6	"		"
S2-6	"		"
U1-6	"		"
U2-6	"		"

Chain of Custody:

Relinquished by (Signature)	Date	Received by (Signature)	Date	Comments
	10/31/12		10/31/12	
Relinquished by (Signature)	Date	Received by (Signature)	Date	Comments

RESOLUTION ANALYTICS, INC.
Specialists in Air Emissions Analysis

Client: Air Control Techniques
RFA #: 1756
Method: EPA M5

Report Summary

SAMPLE ID	ACETONE ≤2.5µg RINSE PARTICULATE
U1-1	1.4 mg
U2-1	0.9 mg
S1-1	1.0 mg
S2-1	1.4 mg
U1-2	1.8 mg
U2-2	0.7 mg
S1-2	1.5 mg
S2-2	0.8 mg
U1-3	0.7 mg
U2-3	0.0 mg
S1-3	0.3 mg
S2-3	0.8 mg
U1-4	0.7 mg
U2-4	1.0 mg
S1-4	0.1 mg
S2-4	0.5 mg
U1-5	0.3 mg
U2-5	0.7 mg
S1-5	0.9 mg
S2-5	0.5 mg
U1-6	0.8 mg
U2-6	1.4 mg
S1-6	0.5 mg
S2-6	0.5 mg

RESOLUTION ANALYTICS, INC.

Specialists in Air Emissions Analysis

Client:	Air Control Techniques
RFA #:	1756
Date Received:	10/31/12
Date Analyzed:	11/5/12
Analyst:	JSC
Analysis:	EPA M5
Analyte(s):	Filterable PM

Analytical Narrative

Sample Matrix & Components:

Front ½ Acetone ≤2.5µg Rinses, Acetone Blank

Summary of Sample Prep:

The acetone rinses were transferred to pre-tared teflon "baggies" in a low humidity environment. The acetone rinses were evaporated, then desiccated for 24 hours, after which time they were weighed daily every six hours until consecutive weights agreed within ±0.5 mg.

All weights were recorded to the nearest 0.1 mg and include filterable particulate catch only. The acetone blank catch has been subtracted from sample rinse catches in proportion with their respective volumes.

Summary of Instrumentation:

Denver model Pinnacle Series analytical balance

Analytical Detection Limit(s): 0.1 mg

Miscellaneous Comments Regarding Sample Analysis: (Note unusual catch weights, interferences, odd sample behavior, and steps taken to confirm unusual results. Also note any deviations from standard analytical procedures, together with justification and possible affect on results. Specify samples when applicable.)

No modifications to EPA Method 5 analytical procedure were made. See data sheets for individual sample descriptions.

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

Run Number		U1-1 ≤2.5μg Acetone		U2-1 ≤2.5μg Acetone		S1-1 ≤2.5μg Acetone
Filter Container #	Date | Init		Date		Date	
Baggie Tare Wt., g.		#N/A		#N/A		#N/A
Filter Tare Wt., g.						
FILTER SAMPLE WT., g.		#N/A #		#N/A #		#N/A #N/A
Front ½ Rinse Container #	Date | Init	760	Date	2631	Date	444
	11/12/12 JSC	3.1868	11/12/12	3.3214	11/12/12 F	3.6060
	11/12/12 JSC F	3.1864	11/12/12 F	3.3213	11/12/12	3.6062
Tare Wt., g.	(50 ml)	3.1848	(50 ml)	3.3202	(50 ml)	3.6048
RINSE SAMPLE WT., g.		0.0016		0.0011		0.0012
Filter Catch, mg.		**#N/A**		**#N/A**		**#N/A**
Rinse Catch, mg.		1.6		1.1		1.2
Rinse Blank Residue, mg.		0.2		0.2		0.2
Net Rinse Catch, mg.		**1.4**		**0.9**		**1.0**
FILTERABLE PARTICULATE, mg.		**1.4**		**0.9**		**1.0**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

Run Number				S2-1 ≤2.5µg Acetone			U1-2 ≤2.5µg Acetone			U2-2 ≤2.5µg Acetone
Filter Container #	Date	Init			Date			Date		
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A ##			#N/A ##			#N/A #N/A
Front ½ Rinse Container #	Date	Init		2566	Date		2473	Date		1536
	11/12/12	JSC		3.4847	11/12/12		3.6007	11/12/12		3.6465
	11/12/12	JSC	F	3.4842	11/12/12	F	3.6005	11/12/12	F	3.6462
Tare Wt., g.		(60	ml)	3.4826	(70	ml)	3.5985	(50	ml)	3.6453
RINSE SAMPLE WT., g.				0.0016			0.0020			0.0009

Filter Catch, mg.	**#N/A**	**#N/A**	**#N/A**
Rinse Catch, mg.	1.6	2.0	0.9
Rinse Blank Residue, mg.	0.2	0.2	0.2
Net Rinse Catch, mg.	**1.4**	**1.8**	**0.7**
FILTERABLE PARTICULATE, mg.	**1.4**	**1.8**	**0.7**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

Run Number				S1-2 ≤2.5μg Acetone			S2-2 ≤2.5μg Acetone			U1-3 ≤2.5μg Acetone
Filter Container #	Date	Init			Date			Date		
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A ##			#N/A ##			#N/A #N/A
Front ½ Rinse Container #	Date	Init		1378	Date		2533	Date		1667
	11/12/12	JSC		3.4271	11/12/12		3.5827	11/12/12		3.5545
	11/12/12	JSC	F	3.4268	11/12/12	F	3.5823	11/12/12	F	3.5543
Tare Wt., g.	(	50	ml)	3.4251	(30	ml)	3.5814	(30	ml)	3.5535
RINSE SAMPLE WT., g.				0.0017			0.0009			0.0008

	S1-2	S2-2	U1-3
Filter Catch, mg.	**#N/A**	**#N/A**	**#N/A**
Rinse Catch, mg.	1.7	0.9	0.8
Rinse Blank Residue, mg.	0.2	0.1	0.1
Net Rinse Catch, mg.	**1.5**	**0.8**	**0.7**
FILTERABLE PARTICULATE, mg.	**1.5**	**0.8**	**0.7**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

Run Number				U2-3 ≤2.5µg Acetone			S1-3 ≤2.5µg Acetone			S2-3 ≤2.5µg Acetone	
Filter Container #	Date	Init			Date			Date			
Baggie Tare Wt., g.				#N/A			#N/A			#N/A	
Filter Tare Wt., g.											
FILTER SAMPLE WT., g.				#N/A	##		#N/A	##		#N/A	#N/A
Front ½ Rinse Container #	Date	Init		1392	Date		2339	Date		2289	
	11/12/12	JSC		3.5064	11/12/12		3.4446	11/12/12		3.4701	
	11/12/12	JSC	F	3.5059	11/12/12	F	3.4443	11/12/12	F	3.4697	
Tare Wt., g.	(	40	ml)	3.5058	(30	ml)	3.4439	(40	ml)	3.4688	
RINSE SAMPLE WT., g.				0.0001			0.0004			0.0009	
Filter Catch, mg.				**#N/A**			**#N/A**			**#N/A**	
Rinse Catch, mg.				0.1			0.4			0.9	
Rinse Blank Residue, mg.				0.1			0.1			0.1	
Net Rinse Catch, mg.				**0.0** **			**0.3**			**0.8**	
FILTERABLE PARTICULATE, mg.				**0.0**			**0.3**			**0.8**	

**Negative results adjusted to zero.

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

	Date	Init			Date			Date		
Run Number				U1-4 ≤2.5µg Acetone			U2-4 ≤2.5µg Acetone			S1-4 ≤2.5µg Acetone
Filter Container #	Date	Init			Date			Date		
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A ##			#N/A ##			#N/A #N/A
Front ½ Rinse Container #	Date	Init		1231	Date		1387	Date		1585
	11/12/12	JSC		3.6241	11/12/12		3.6051	11/12/12		3.5883
	11/12/12	JSC	F	3.6236	11/12/12	F	3.6047	11/12/12	F	3.5881
Tare Wt., g.	(30		ml)	3.6228	(40	ml)	3.6036	(40	ml)	3.5879
RINSE SAMPLE WT., g.				0.0008			0.0011			0.0002
Filter Catch, mg.				**#N/A**			**#N/A**			**#N/A**
Rinse Catch, mg.				0.8			1.1			0.2
Rinse Blank Residue, mg.				0.1			0.1			0.1
Net Rinse Catch, mg.				**0.7**			**1.0**			**0.1**
FILTERABLE PARTICULATE, mg.				**0.7**			**1.0**			**0.1**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques** RFA #: **1756**
Method: EPA M5

Run Number				S2-4 ≤2.5µg Acetone			U1-5 ≤2.5µg Acetone			U2-5 ≤2.5µg Acetone
Filter Container #	Date	Init			Date			Date		
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A ##			#N/A ##			#N/A #N/A
Front ½ Rinse Container #				2574			548			2539
	Date	Init			Date			Date		
	11/12/12	JSC		3.5135	11/12/12		3.6354	11/12/12		3.3895
	11/12/12	JSC	F	3.5130	11/12/12	F	3.6350	11/12/12	F	3.3890
Tare Wt., g.	(	40	ml)	3.5124	(50	ml)	3.6345	(40	ml)	3.3882
RINSE SAMPLE WT., g.				0.0006			0.0005			0.0008
Filter Catch, mg.				**#N/A**			**#N/A**			**#N/A**
Rinse Catch, mg.				0.6			0.5			0.8
Rinse Blank Residue, mg.				0.1			0.2			0.1
Net Rinse Catch, mg.				**0.5**			**0.3**			**0.7**
FILTERABLE PARTICULATE, mg.				**0.5**			**0.3**			**0.7**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

Run Number		S1-5 ≤2.5µg Acetone		S2-5 ≤2.5µg Acetone		U1-6 ≤2.5µg Acetone
Filter Container #	Date | Init		Date		Date	
Baggie Tare Wt., g.		#N/A		#N/A		#N/A
Filter Tare Wt., g.						
FILTER SAMPLE WT., g.		#N/A ##		#N/A ##		#N/A #N/A
Front ½ Rinse Container #	Date | Init	1355	Date	1181	Date	2618
	11/12/12 JSC	3.6512	11/12/12	3.4338	11/12/12	3.6139
	11/12/12 JSC F	3.6508	11/12/12 F	3.4333	11/12/12 F	3.6136
Tare Wt., g.	(30 ml)	3.6498	(30 ml)	3.4327	(40 ml)	3.6127
RINSE SAMPLE WT., g.		0.0010		0.0006		0.0009
Filter Catch, mg.		**#N/A**		**#N/A**		**#N/A**
Rinse Catch, mg.		1.0		0.6		0.9
Rinse Blank Residue, mg.		0.1		0.1		0.1
Net Rinse Catch, mg.		**0.9**		**0.5**		**0.8**
FILTERABLE PARTICULATE, mg.		**0.9**		**0.5**		**0.8**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

Run Number			U2-6 ≤2.5µg Acetone		S1-6 ≤2.5µg Acetone		S2-6 ≤2.5µg Acetone
Filter Container #	Date	Init		Date		Date	
Baggie Tare Wt., g.			#N/A		#N/A		#N/A
Filter Tare Wt., g.							
FILTER SAMPLE WT., g.			#N/A ##		#N/A ##		#N/A #N/A
Front ½ Rinse Container #	Date	Init	2517	Date	1023	Date	234
	11/12/12	JSC	3.5534	11/12/12	3.7235	11/12/12	3.4721
	11/12/12	JSC F	3.5531	11/12/12 F	3.7232	11/12/12 F	3.4716
Tare Wt., g.		(40 ml)	3.5516	(30 ml)	3.7226	(40 ml)	3.4710
RINSE SAMPLE WT., g.			0.0015		0.0006		0.0006
Filter Catch, mg.			**#N/A**		**#N/A**		**#N/A**
Rinse Catch, mg.			1.5		0.6		0.6
Rinse Blank Residue, mg.			0.1		0.1		0.1
Net Rinse Catch, mg.			**1.4**		**0.5**		**0.5**
FILTERABLE PARTICULATE, mg.			**1.4**		**0.5**		**0.5**

Legend: F = Final Weight

Notes & Comments:

RESOLUTION ANALYTICS, INC.
Specialists in Air Emissions Analysis

Client: Air Control Techniques
RFA #: 1756
Method: EPA M5

Report Summary

SAMPLE ID	$H_2O \leq 2.5\mu g$ RINSE PARTICULATE
U1-1	0.9 mg
U2-1	2.0 mg
S1-1	0.3 mg
S2-1	1.4 mg
U1-2	0.6 mg
U2-2	0.4 mg
S1-2	0.6 mg
S2-2	0.3 mg
U1-3	0.3 mg
U2-3	0.7 mg
S1-3	0.6 mg
S2-3	0.3 mg
U1-4	0.0 mg
U2-4	0.0 mg
S1-4	0.5 mg
S2-4	0.7 mg
U1-5	0.4 mg
U2-5	0.0 mg
S1-5	0.0 mg
S2-5	0.3 mg
U1-6	0.7 mg
U2-6	0.4 mg
S1-6	0.7 mg
S2-6	0.1 mg

RESOLUTION ANALYTICS, INC.
Specialists in Air Emissions Analysis

Client:	Air Control Techniques
RFA #:	1756
Date Received:	10/31/12
Date Analyzed:	11/5/12
Analyst:	JSC
Analysis:	EPA M5
Analyte(s):	Filterable PM

Analytical Narrative

Sample Matrix & Components:

Front ½ DI H_2O ≤2.5μg Rinses, DI H_2O Blank

Summary of Sample Prep:

The DI H_2O rinses were transferred to pre-tared teflon "baggies" in a low humidity environment. The DI H_2O rinses were evaporated in an oven at 105° C, then desiccated for 24 hours, after which time they were weighed daily every six hours until consecutive weights agreed within ±0.5 mg.

All weights were recorded to the nearest 0.1 mg and include filterable particulate catch only. The DI H2O blank catch has been subtracted from sample rinse catches in proportion with their respective volumes.

Summary of Instrumentation:

Denver model Pinnacle Series analytical balance

Analytical Detection Limit(s): 0.1 mg

Miscellaneous Comments Regarding Sample Analysis: (Note unusual catch weights, interferences, odd sample behavior, and steps taken to confirm unusual results. Also note any deviations from standard analytical procedures, together with justification and possible affect on results. Specify samples when applicable.)

No modifications to EPA Method 5 analytical procedure were made. See data sheets for individual sample descriptions.

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

Run Number			U1-1 ≤2.5μg H_2O		U2-1 ≤2.5μg H_2O		S1-1 ≤2.5μg H_2O	
Filter Container #	Date	Init		Date		Date		
Baggie Tare Wt., g.			#N/A		#N/A		#N/A	
Filter Tare Wt., g.								
FILTER SAMPLE WT., g.			#N/A #		#N/A #		#N/A	#N/A
Front ½ Rinse Container #	Date	Init	230	Date	2042	Date	1256	
	11/8/12	JSC	3.4443	11/8/12	3.2687	11/8/12	3.5838	
	11/8/12	JSC F	3.4438	11/8/12 F	3.2682	11/8/12 F	3.5837	
Tare Wt., g.	(50 ml)		3.4428	(60 ml)	3.2660	(70 ml)	3.5832	
RINSE SAMPLE WT., g.			0.0010		0.0022		0.0005	
Filter Catch, mg.			**#N/A**		**#N/A**		**#N/A**	
Rinse Catch, mg.			1.0		2.2		0.5	
Rinse Blank Residue, mg.			0.1		0.2		0.2	
Net Rinse Catch, mg.			**0.9**		**2.0**		**0.3**	
FILTERABLE PARTICULATE, mg.			**0.9**		**2.0**		**0.3**	

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

Run Number		S2-1 ≤2.5μg H_2O		U1-2 ≤2.5μg H_2O		U2-2 ≤2.5μg H_2O
Filter Container #	Date | Init		Date		Date	
Baggie Tare Wt., g.		#N/A		#N/A		#N/A
Filter Tare Wt., g.						
FILTER SAMPLE WT., g.		#N/A ##		#N/A ##		#N/A #N/A
Front ½ Rinse Container #	Date | Init	3121	Date	1404	Date	4147
	11/8/12 JSC	3.8813	11/8/12	3.5088	11/8/12	3.5732
	11/8/12 JSC F	3.8811	11/8/12 F	3.5083	11/8/12 F	3.5729
Tare Wt., g.	(60 ml)	3.8795	(70 ml)	3.5075	(60 ml)	3.5723
RINSE SAMPLE WT., g.		0.0016		0.0008		0.0006
Filter Catch, mg.		**#N/A**		**#N/A**		**#N/A**
Rinse Catch, mg.		1.6		0.8		0.6
Rinse Blank Residue, mg.		0.2		0.2		0.2
Net Rinse Catch, mg.		**1.4**		**0.6**		**0.4**
FILTERABLE PARTICULATE, mg.		**1.4**		**0.6**		**0.4**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

Run Number				S1-2 ≤2.5μg H_2O			S2-2 ≤2.5μg H_2O			U1-3 ≤2.5μg H_2O
Filter Container #	Date	Init			Date			Date		
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A ##			#N/A ##			#N/A #N/A
Front ½ Rinse Container #	Date	Init		2147	Date		1293	Date		4143
	11/8/12	JSC		3.7102	11/8/12		3.9014	11/8/12		3.6470
	11/8/12	JSC	F	3.7097	11/8/12	F	3.9009	11/8/12	F	3.6466
Tare Wt., g.	(	50	ml)	3.7090	(60	ml)	3.9004	(70	ml)	3.6461
RINSE SAMPLE WT., g.				0.0007			0.0005			0.0005
Filter Catch, mg.				**#N/A**			**#N/A**			**#N/A**
Rinse Catch, mg.				0.7			0.5			0.5
Rinse Blank Residue, mg.				0.1			0.2			0.2
Net Rinse Catch, mg.				**0.6**			**0.3**			**0.3**
FILTERABLE PARTICULATE, mg.				**0.6**			**0.3**			**0.3**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

Run Number				U2-3 ≤2.5μg H_2O			S1-3 ≤2.5μg H_2O			S2-3 ≤2.5μg H_2O
Filter Container #	Date	Init			Date			Date		
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A ##			#N/A ##			#N/A #N/A
Front ½ Rinse Container #	Date	Init		52	Date		2144	Date		1451
	11/8/12	JSC		3.7268	11/8/12		3.7699	11/8/12		3.5051
	11/8/12	JSC	F	3.7263	11/8/12	F	3.7694	11/8/12	F	3.5046
Tare Wt., g.	(	50	ml)	3.7255	(60	ml)	3.7686	(60	ml)	3.5041
RINSE SAMPLE WT., g.				0.0008			0.0008			0.0005
Filter Catch, mg.				**#N/A**			**#N/A**			**#N/A**
Rinse Catch, mg.				0.8			0.8			0.5
Rinse Blank Residue, mg.				0.1			0.2			0.2
Net Rinse Catch, mg.				**0.7**			**0.6**			**0.3**
FILTERABLE PARTICULATE, mg.				**0.7**			**0.6**			**0.3**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

Run Number				U1-4 ≤2.5µg H_2O			U2-4 ≤2.5µg H_2O			S1-4 ≤2.5µg H_2O
Filter Container #	Date	Init			Date			Date		
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A ##			#N/A ##			#N/A #N/A
Front ½ Rinse Container #	Date	Init		1191	Date		1623	Date		2174
	11/8/12	JSC		3.8743	11/8/12		3.3725	11/8/12		3.7401
	11/8/12	JSC	F	3.8738	11/8/12	F	3.3721	11/8/12	F	3.7397
Tare Wt., g.		(70	ml)	3.8737	(70	ml)	3.3720	(80	ml)	3.7390
RINSE SAMPLE WT., g.				0.0001			0.0001			0.0007
Filter Catch, mg.				**#N/A**			**#N/A**			**#N/A**
Rinse Catch, mg.				0.1			0.1			0.7
Rinse Blank Residue, mg.				0.2			0.2			0.2
Net Rinse Catch, mg.				**0.0** **			**0.0** **			**0.5**
FILTERABLE PARTICULATE, mg.				**0.0**			**0.0**			**0.5**

**Negative results adjusted to zero.

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

Run Number				S2-4 ≤2.5µg H_2O			U1-5 ≤2.5µg H_2O			U2-5 ≤2.5µg H_2O
Filter Container #	Date	Init			Date			Date		
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A ##			#N/A ##			#N/A #N/A
Front ½ Rinse Container #	Date	Init		1409	Date		2359	Date		618
	11/8/12	JSC		3.4697	11/8/12		3.4310	11/8/12		3.3646
	11/8/12	JSC	F	3.4693	11/8/12	F	3.4306	11/8/12	F	3.3643
Tare Wt., g.		(50	ml)	3.4685 (	70	ml)	3.4300 (	70	ml)	3.3643
RINSE SAMPLE WT., g.				0.0008			0.0006			0.0000
Filter Catch, mg.				**#N/A**			**#N/A**			**#N/A**
Rinse Catch, mg.				0.8			0.6			0.0
Rinse Blank Residue, mg.				0.1			0.2			0.2
Net Rinse Catch, mg.				**0.7**			**0.4**			**0.0** **
FILTERABLE PARTICULATE, mg.				**0.7**			**0.4**			**0.0**

**Negative results adjusted to zero.

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

Run Number	Date	Init		S1-5 ≤2.5μg H_2O	Date		S2-5 ≤2.5μg H_2O	Date		U1-6 ≤2.5μg H_2O
Filter Container #										
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A ##			#N/A ##			#N/A #N/A
Front ½ Rinse Container #				1366			2145			4043
	11/8/12	JSC		3.5299	11/8/12		3.4894	11/8/12		3.7846
	11/8/12	JSC	F	3.5296	11/8/12	F	3.4893	11/8/12	F	3.7844
Tare Wt., g.	(	60	ml)	3.5296	(60	ml)	3.4888	(60	ml)	3.7835
RINSE SAMPLE WT., g.				0.0000			0.0005			0.0009

	S1-5	S2-5	U1-6
Filter Catch, mg.	**#N/A**	**#N/A**	**#N/A**
Rinse Catch, mg.	0.0	0.5	0.9
Rinse Blank Residue, mg.	0.2	0.2	0.2
Net Rinse Catch, mg.	**0.0** **	**0.3**	**0.7**
FILTERABLE PARTICULATE, mg.	**0.0**	**0.3**	**0.7**

**Negative results adjusted to zero.

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

Run Number				U2-6 ≤2.5μg H_2O			S1-6 ≤2.5μg H_2O			S2-6 ≤2.5μg H_2O
Filter Container #	Date	Init			Date			Date		
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A ##			#N/A ##			#N/A #N/A
Front ½ Rinse Container #	Date	Init		2405	Date		1129	Date		1428
	11/8/12	JSC		3.4072	11/9/12		3.6303	11/8/12		3.4078
	11/8/12	JSC	F	3.4071	11/8/12	F	3.6299	11/8/12	F	3.4076
Tare Wt., g.		(50	ml)	3.4066	(40	ml)	3.6291	(50	ml)	3.4074
RINSE SAMPLE WT., g.				0.0005			0.0008			0.0002
Filter Catch, mg.				**#N/A**			**#N/A**			**#N/A**
Rinse Catch, mg.				0.5			0.8			0.2
Rinse Blank Residue, mg.				0.1			0.1			0.1
Net Rinse Catch, mg.				**0.4**			**0.7**			**0.1**
FILTERABLE PARTICULATE, mg.				**0.4**			**0.7**			**0.1**

Legend: F = Final Weight

Notes & Comments:

Client: Air Control Techniques
RFA #: 1756
Method: EPA M5

Report Summary

SAMPLE ID	TOTAL FILTER PARTICULATE CATCH
U1-1	31.8 mg
U2-1	33.1 mg
S1-1	73.9 mg
S2-1	64.4 mg
U1-2	16.4 mg
U2-2	16.3 mg
S1-2	47.6 mg
S2-2	48.0 mg
U1-3	20.9 mg
U2-3	21.7 mg
S1-3	37.1 mg
S2-3	30.7 mg
U1-4	22.3 mg
U2-4	23.7 mg
S1-4	26.9 mg
S2-4	26.5 mg
U1-5	14.7 mg
U2-5	15.1 mg
S1-5	55.0 mg
S2-5	5.8 mg
U1-6	29.5 mg
U2-6	30.1 mg
S1-6	37.4 mg
S2-6	1.2 mg

RESOLUTION ANALYTICS, INC.

Specialists in Air Emissions Analysis

Client: Air Control Techniques
RFA #: 1756
Date Received: 10/31/12
Date Analyzed: 11/5/12
Analyst: JSC
Analysis: EPA M5
Analyte(s): Filterable PM

Analytical Narrative

Sample Matrix & Components:

Dry Filters

Summary of Sample Prep:

The filters were transferred to petri dishes in a low humidity environment. The filters were baked 2 to 3 hours at 105° C, cooled in a desiccator and weighed.

All weights were recorded to the nearest 0.1 mg and include filterable particulate catch only.

Summary of Instrumentation:

Denver model Pinnacle Series analytical balance

Analytical Detection Limit(s): 0.1 mg

Miscellaneous Comments Regarding Sample Analysis: (Note unusual catch weights, interferences, odd sample behavior, and steps taken to confirm unusual results. Also note any deviations from standard analytical procedures, together with justification and possible affect on results. Specify samples when applicable.)

No modifications to EPA Method 5 analytical procedure were made. See data sheets for individual sample descriptions.

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

Run Number			U1-1 Filter		U2-1 Filter		S1-1 Filter
Filter Container #	Date	Init		Date		Date	
	11/6/12	JSC	0.1431	11/6/12	0.1512	11/6/12	0.1914
Baggie Tare Wt., g.			0.0000		0.0000		0.0000
Filter Tare Wt., g.			0.1113		0.1181		0.1175
FILTER SAMPLE WT., g.			0.0318		0.0331		0.0739
Front ½ Rinse Container #	Date	Init		Date		Date	
Tare Wt., g.	(#N/A ml)		#N/A	(#N/A ml)	#N/A	(#N/A ml)	#N/A
RINSE SAMPLE WT., g.			#N/A		#N/A		#N/A
Filter Catch, mg.			**31.8**		**33.1**		**73.9**
Rinse Catch, mg.			#N/A		#N/A		#N/A
Rinse Blank Residue, mg.			#N/A		#N/A		#N/A
Net Rinse Catch, mg.			**#N/A #**		**#N/A #**		**#N/A #N/A**
FILTERABLE PARTICULATE, mg.			**31.8**		**33.1**		**73.9**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

Run Number			S2-1 Filter		U1-2 Filter		U2-2 Filter
Filter Container #	Date	Init		Date		Date	
	11/6/12	JSC	0.1811	11/6/12	0.1338	11/6/12	0.1332
Baggie Tare Wt., g.			0.0000		0.0000		0.0000
Filter Tare Wt., g.			0.1167		0.1174		0.1169
FILTER SAMPLE WT., g.			0.0644		0.0164		0.0163
Front ½ Rinse Container #	Date	Init		Date		Date	
Tare Wt., g.			(#N/A ml) #N/A		(### ml) #N/A		(## ml) #N/A
RINSE SAMPLE WT., g.			#N/A		#N/A		#N/A
Filter Catch, mg.			64.4		16.4		16.3
Rinse Catch, mg.			#N/A		#N/A		#N/A
Rinse Blank Residue, mg.			#N/A		#N/A		#N/A
Net Rinse Catch, mg.			**#N/A ##**		**#N/A ##**		**#N/A ####**
FILTERABLE PARTICULATE, mg.			**64.4**		**16.4**		**16.3**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques** RFA #: **1756**
Method: EPA M5

Run Number			S1-2 Filter		S2-2 Filter		U1-3 Filter
Filter Container #	Date	Init		Date		Date	
	11/6/12	JSC	0.1639	11/6/12	0.1652	11/6/12	0.1388
Baggie Tare Wt., g.			0.0000		0.0000		0.0000
Filter Tare Wt., g.			0.1163		0.1172		0.1179
FILTER SAMPLE WT., g.			0.0476		0.0480		0.0209
Front ½ Rinse Container #	Date	Init		Date		Date	
Tare Wt., g.		(#N/A ml)	#N/A	(### ml)	#N/A	(## ml)	#N/A
RINSE SAMPLE WT., g.			#N/A		#N/A		#N/A

	S1-2	S2-2	U1-3
Filter Catch, mg.	47.6	48.0	20.9
Rinse Catch, mg.	#N/A	#N/A	#N/A
Rinse Blank Residue, mg.	#N/A	#N/A	#N/A
Net Rinse Catch, mg.	#N/A ##	#N/A ##	#N/A ####
FILTERABLE PARTICULATE, mg.	47.6	48.0	20.9

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

Run Number			U2-3 Filter		S1-3 Filter		S2-3 Filter
Filter Container #	Date	Init		Date		Date	
	11/6/12	JSC	0.1375	11/6/12	0.1547	11/6/12	0.1471
Baggie Tare Wt., g.			0.0000		0.0000		0.0000
Filter Tare Wt., g.			0.1158		0.1176		0.1164
FILTER SAMPLE WT., g.			0.0217		0.0371		0.0307

Front ½ Rinse Container #	Date	Init		Date		Date	
Tare Wt., g.	(	#N/A ml)	#N/A	(	### ml) #N/A	(	## ml) #N/A
RINSE SAMPLE WT., g.			#N/A		#N/A		#N/A

Filter Catch, mg.	**21.7**	**37.1**	**30.7**
Rinse Catch, mg.	#N/A	#N/A	#N/A
Rinse Blank Residue, mg.	#N/A	#N/A	#N/A
Net Rinse Catch, mg.	**#N/A ##**	**#N/A ##**	**#N/A ####**
FILTERABLE PARTICULATE, mg.	**21.7**	**37.1**	**30.7**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques** RFA #: **1756**
Method: EPA M5

Run Number			U1-4 Filter		U2-4 Filter		S1-4 Filter
Filter Container #	Date	Init		Date		Date	
	11/6/12	JSC	0.1383	11/6/12	0.1408	11/6/12	0.1427
Baggie Tare Wt., g.			0.0000		0.0000		0.0000
Filter Tare Wt., g.			0.1160		0.1171		0.1158
FILTER SAMPLE WT., g.			0.0223		0.0237		0.0269

Front ½ Rinse Container #	Date	Init		Date		Date	

Tare Wt., g.	(#N/A ml)	#N/A	(### ml)	#N/A	(## ml)	#N/A
RINSE SAMPLE WT., g.		#N/A		#N/A		#N/A

Filter Catch, mg.	**22.3**	**23.7**	**26.9**
Rinse Catch, mg.	#N/A	#N/A	#N/A
Rinse Blank Residue, mg.	#N/A	#N/A	#N/A
Net Rinse Catch, mg.	**#N/A ##**	**#N/A ##**	**#N/A ####**
FILTERABLE PARTICULATE, mg.	**22.3**	**23.7**	**26.9**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques** RFA #: **1756**
Method: EPA M5

Run Number			S2-4 Filter		U1-5 Filter		U2-5 Filter
Filter Container #	Date	Init		Date		Date	
	11/6/12	JSC	0.1444	11/6/12	0.1314	11/6/12	0.1323
Baggie Tare Wt., g.			0.0000		0.0000		0.0000
Filter Tare Wt., g.			0.1179		0.1167		0.1172
FILTER SAMPLE WT., g.			0.0265		0.0147		0.0151

Front ½ Rinse Container #	Date	Init		Date		Date	

Tare Wt., g.	(#N/A ml)	#N/A	(### ml)	#N/A	(## ml)	#N/A
RINSE SAMPLE WT., g.		#N/A		#N/A		#N/A

Filter Catch, mg.	**26.5**	**14.7**	**15.1**
Rinse Catch, mg.	#N/A	#N/A	#N/A
Rinse Blank Residue, mg.	#N/A	#N/A	#N/A
Net Rinse Catch, mg.	**#N/A ##**	**#N/A ##**	**#N/A ####**
FILTERABLE PARTICULATE, mg.	**26.5**	**14.7**	**15.1**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

Run Number			S1-5 Filter		S2-5 Filter		U1-6 Filter
Filter Container #	Date	Init		Date		Date	
	11/6/12	JSC	0.1725	11/6/12	0.1215	11/6/12	0.1466
Baggie Tare Wt., g.			0.0000		0.0000		0.0000
Filter Tare Wt., g.			0.1175		0.1157		0.1171
FILTER SAMPLE WT., g.			0.0550		0.0058		0.0295
Front ½ Rinse Container #	Date	Init		Date		Date	
Tare Wt., g.		(#N/A ml)	#N/A	(### ml)	#N/A	(## ml)	#N/A
RINSE SAMPLE WT., g.			#N/A		#N/A		#N/A
Filter Catch, mg.			**55.0**		**5.8**		**29.5**
Rinse Catch, mg.			#N/A		#N/A		#N/A
Rinse Blank Residue, mg.			#N/A		#N/A		#N/A
Net Rinse Catch, mg.			**#N/A ##**		**#N/A ##**		**#N/A ####**
FILTERABLE PARTICULATE, mg.			**55.0**		**5.8**		**29.5**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

Run Number			U2-6 Filter		S1-6 Filter		S2-6 Filter
Filter Container #	Date	Init		Date		Date	
	11/6/12	JSC	0.1464	11/6/12	0.1542	11/6/12	0.1178
Baggie Tare Wt., g.			0.0000		0.0000		0.0000
Filter Tare Wt., g.			0.1163		0.1168		0.1166
FILTER SAMPLE WT., g.			0.0301		0.0374		0.0012
Front ½ Rinse Container #	Date	Init		Date		Date	
Tare Wt., g.		(#N/A ml)	#N/A	(### ml)	#N/A	(## ml)	#N/A
RINSE SAMPLE WT., g.			#N/A		#N/A		#N/A
Filter Catch, mg.			**30.1**		**37.4**		**1.2**
Rinse Catch, mg.			#N/A		#N/A		#N/A
Rinse Blank Residue, mg.			#N/A		#N/A		#N/A
Net Rinse Catch, mg.			**#N/A ##**		**#N/A ##**		**#N/A ####**
FILTERABLE PARTICULATE, mg.			**30.1**		**37.4**		**1.2**

Legend: F = Final Weight

Notes & Comments:

Client: Air Control Techniques
RFA #: 1756
Method: EPA M5

Report Summary

SAMPLE ID	ACETONE NOZZLE RINSE PARTICULATE
Acetone Blank	0.7 mg (in 230 mls)
U1-1	0.4 mg
U2-1	0.1 mg
S1-1	0.6 mg
S2-1	2.0 mg
U1-2	2.9 mg
U2-2	1.5 mg
S1-2	1.5 mg
S2-2	0.2 mg
U1-3	1.0 mg
U2-3	0.5 mg
S1-3	1.3 mg
S2-3	1.1 mg
U1-4	0.7 mg
U2-4	1.0 mg
S1-4	0.3 mg
S2-4	1.1 mg
U1-5	1.7 mg
U2-5	0.1 mg
S1-5	1.0 mg
S2-5	0.1 mg
U1-6	1.4 mg
U2-6	1.2 mg
S1-6	1.5 mg
S2-6	1.2 mg

RESOLUTION ANALYTICS, INC.
Specialists in Air Emissions Analysis

Client:	Air Control Techniques
RFA #:	1756
Date Received:	10/31/12
Date Analyzed:	11/5/12
Analyst:	JSC
Analysis:	EPA M5
Analyte(s):	Filterable PM

Analytical Narrative

Sample Matrix & Components:

Front ½ Acetone Nozzle Rinses, Acetone Blank

Summary of Sample Prep:

The acetone rinses were transferred to pre-tared teflon "baggies" in a low humidity environment. The acetone rinses were evaporated, then desiccated for 24 hours, after which time they were weighed daily every six hours until consecutive weights agreed within ±0.5 mg.

All weights were recorded to the nearest 0.1 mg and include filterable particulate catch only. The acetone blank catch has been subtracted from sample rinse catches in proportion with their respective volumes.

Summary of Instrumentation:

Denver model Pinnacle Series analytical balance

Analytical Detection Limit(s): 0.1 mg

Miscellaneous Comments Regarding Sample Analysis: (Note unusual catch weights, interferences, odd sample behavior, and steps taken to confirm unusual results. Also note any deviations from standard analytical procedures, together with justification and possible affect on results. Specify samples when applicable.)

No modifications to EPA Method 5 analytical procedure were made. See data sheets for individual sample descriptions.

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

Run Number				U1-1 Nozzle Acetone			U2-1 Nozzle Acetone			S1-1 Nozzle Acetone	
Filter Container #	Date	Init			Date			Date			
Baggie Tare Wt., g.				#N/A			#N/A			#N/A	
Filter Tare Wt., g.											
FILTER SAMPLE WT., g.				#N/A #			#N/A #			#N/A	#N/A
Front ½ Rinse Container #	Date	Init		2119	Date		1648	Date		1612	
	11/12/12	JSC		3.7915	11/12/12		3.4728	11/12/12		3.4809	
	11/12/12	JSC	F	3.7910	11/12/12	F	3.4723	11/12/12	F	3.4804	
Tare Wt., g.	(	50	ml)	3.7904	(40	ml)	3.4721	(70	ml)	3.4796	
RINSE SAMPLE WT., g.				0.0006			0.0002			0.0008	
Filter Catch, mg.				**#N/A**			**#N/A**			**#N/A**	
Rinse Catch, mg.				0.6			0.2			0.8	
Rinse Blank Residue, mg.				0.2			0.1			0.2	
Net Rinse Catch, mg.				**0.4**			**0.1**			**0.6**	
FILTERABLE PARTICULATE, mg.				**0.4**			**0.1**			**0.6**	

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

Run Number				S2-1 Nozzle Acetone			U1-2 Nozzle Acetone			U2-2 Nozzle Acetone
Filter Container #	Date	Init			Date			Date		
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A ##			#N/A ##			#N/A #N/A
Front ½ Rinse Container #	Date	Init		1344	Date		11	Date		1213
	11/12/12	JSC		3.5341	11/12/12		3.8233	11/12/12		3.7273
	11/12/12	JSC	F	3.5336	11/12/12	F	3.8229	11/12/12	F	3.7270
Tare Wt., g.	(	60	ml)	3.5314	(70	ml)	3.8198	(60	ml)	3.7253
RINSE SAMPLE WT., g.				0.0022			0.0031			0.0017
Filter Catch, mg.				**#N/A**			**#N/A**			**#N/A**
Rinse Catch, mg.				2.2			3.1			1.7
Rinse Blank Residue, mg.				0.2			0.2			0.2
Net Rinse Catch, mg.				**2.0**			**2.9**			**1.5**
FILTERABLE PARTICULATE, mg.				**2.0**			**2.9**			**1.5**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

Run Number				S1-2 Nozzle Acetone			S2-2 Nozzle Acetone			U1-3 Nozzle Acetone
Filter Container #	Date	Init			Date			Date		
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A ##			#N/A ##			#N/A #N/A
Front ½ Rinse Container #	Date	Init		63	Date		62	Date		1394
	11/12/12	JSC		3.6910	11/12/12		3.4826	11/12/12		3.7230
	11/12/12	JSC	F	3.6906	11/12/12	F	3.4824	11/12/12	F	3.7225
Tare Wt., g.	(	70	ml)	3.6889	(60	ml)	3.4820	(70	ml)	3.7213
RINSE SAMPLE WT., g.				0.0017			0.0004			0.0012
Filter Catch, mg.				**#N/A**			**#N/A**			**#N/A**
Rinse Catch, mg.				1.7			0.4			1.2
Rinse Blank Residue, mg.				0.2			0.2			0.2
Net Rinse Catch, mg.				**1.5**			**0.2**			**1.0**
FILTERABLE PARTICULATE, mg.				**1.5**			**0.2**			**1.0**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques** RFA #: **1756**
Method: EPA M5

Run Number				U2-3 Nozzle Acetone			S1-3 Nozzle Acetone			S2-3 Nozzle Acetone
Filter Container #	Date	Init			Date			Date		
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A ##			#N/A ##			#N/A #N/A
Front ½ Rinse Container #	Date	Init		255	Date		366	Date		1359
	11/12/12	JSC		3.4197	11/12/12		3.3836	11/12/12		3.7319
	11/12/12	JSC	F	3.4192	11/12/12	F	3.3831	11/12/12	F	3.7314
Tare Wt., g.	(	50	ml)	3.4185	(60	ml)	3.3816	(40	ml)	3.7302
RINSE SAMPLE WT., g.				0.0007			0.0015			0.0012
Filter Catch, mg.				**#N/A**			**#N/A**			**#N/A**
Rinse Catch, mg.				0.7			1.5			1.2
Rinse Blank Residue, mg.				0.2			0.2			0.1
Net Rinse Catch, mg.				**0.5**			**1.3**			**1.1**
FILTERABLE PARTICULATE, mg.				**0.5**			**1.3**			**1.1**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

Run Number				U1-4 Nozzle Acetone			U2-4 Nozzle Acetone			S1-4 Nozzle Acetone
Filter Container #	Date	Init			Date			Date		
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A ##			#N/A ##			#N/A #N/A
Front ½ Rinse Container #	Date	Init		1486	Date		2551	Date		2156
	11/12/12	JSC		3.8415	11/12/12		3.5701	11/12/12		3.7366
	11/12/12	JSC	F	3.8412	11/12/12	F	3.5699	11/12/12	F	3.7362
Tare Wt., g.	(	40	ml)	3.8404	(50	ml)	3.5687	(50	ml)	3.7357
RINSE SAMPLE WT., g.				0.0008			0.0012			0.0005
Filter Catch, mg.				**#N/A**			**#N/A**			**#N/A**
Rinse Catch, mg.				0.8			1.2			0.5
Rinse Blank Residue, mg.				0.1			0.2			0.2
Net Rinse Catch, mg.				**0.7**			**1.0**			**0.3**
FILTERABLE PARTICULATE, mg.				**0.7**			**1.0**			**0.3**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**

Method: EPA M5

RFA #: **1756**

Run Number				S2-4 Nozzle Acetone			U1-5 Nozzle Acetone			U2-5 Nozzle Acetone
Filter Container #	Date	Init			Date			Date		
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A ##			#N/A ##			#N/A #N/A
Front ½ Rinse Container #	Date	Init		2401	Date		1010	Date		1259
	11/12/12	JSC		3.3856	11/12/12		3.7172	11/12/12		3.4429
	11/12/12	JSC	F	3.3851	11/12/12	F	3.7169	11/12/12	F	3.4425
Tare Wt., g.	(	40	ml)	3.3839	(40	ml)	3.7151	(30	ml)	3.4423
RINSE SAMPLE WT., g.				0.0012			0.0018			0.0002
Filter Catch, mg.				**#N/A**			**#N/A**			**#N/A**
Rinse Catch, mg.				1.2			1.8			0.2
Rinse Blank Residue, mg.				0.1			0.1			0.1
Net Rinse Catch, mg.				**1.1**			**1.7**			**0.1**
FILTERABLE PARTICULATE, mg.				**1.1**			**1.7**			**0.1**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

Run Number	S1-5 Nozzle Acetone	S2-5 Nozzle Acetone	U1-6 Nozzle Acetone
Filter Container #			
Date | Init		Date	Date
Baggie Tare Wt., g.	#N/A	#N/A	#N/A
Filter Tare Wt., g.			
FILTER SAMPLE WT., g.	#N/A ##	#N/A ##	#N/A #N/A
Front ½ Rinse Container #	1340	1017	1478
Date | Init		Date	Date
	11/12/12 JSC F 3.6481 11/12/12 JSC 3.6482	11/12/12 3.7292 11/12/12 F 3.7289	11/12/12 3.5974 11/12/12 F 3.5971
Tare Wt., g.	(40 ml) 3.6470	(40 ml) 3.7287	(40 ml) 3.5956
RINSE SAMPLE WT., g.	0.0011	0.0002	0.0015

	S1-5	S2-5	U1-6
Filter Catch, mg.	**#N/A**	**#N/A**	**#N/A**
Rinse Catch, mg.	1.1	0.2	1.5
Rinse Blank Residue, mg.	0.1	0.1	0.1
Net Rinse Catch, mg.	**1.0**	**0.1**	**1.4**
FILTERABLE PARTICULATE, mg.	**1.0**	**0.1**	**1.4**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

Run Number				U2-6 Nozzle Acetone			S1-6 Nozzle Acetone			S2-6 Nozzle Acetone
Filter Container #	Date	Init			Date			Date		
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A ##			#N/A ##			#N/A #N/A
Front ½ Rinse Container #	Date	Init		113	Date		1399	Date		2162
	11/12/12	JSC		3.6415	11/12/12		3.5126	11/12/12		3.7144
	11/12/12	JSC	F	3.6411	11/12/12	F	3.5124	11/12/12	F	3.7143
Tare Wt., g.	(	60	ml)	3.6397	(50	ml)	3.5107	(40	ml)	3.7130
RINSE SAMPLE WT., g.				0.0014			0.0017			0.0013
Filter Catch, mg.				**#N/A**			**#N/A**			**#N/A**
Rinse Catch, mg.				1.4			1.7			1.3
Rinse Blank Residue, mg.				0.2			0.2			0.1
Net Rinse Catch, mg.				**1.2**			**1.5**			**1.2**
FILTERABLE PARTICULATE, mg.				**1.2**			**1.5**			**1.2**

Legend: F = Final Weight

Notes & Comments:

RESOLUTION ANALYTICS, INC.
Specialists in Air Emissions Analysis

Client: Air Control Techniques
RFA #: 1756
Method: EPA M5

Report Summary

SAMPLE ID	H_2O NOZZLE RINSE PARTICULATE
DI H_2O Blank	0.6 mg (in 220 mls)
U1-1	4.6 mg
U2-1	1.9 mg
S1-1	7.8 mg
S2-1	6.8 mg
U1-2	3.2 mg
U2-2	1.8 mg
S1-2	5.2 mg
S2-2	6.4 mg
U1-3	2.1 mg
U2-3	1.0 mg
S1-3	3.1 mg
S2-3	1.1 mg
U1-4	1.6 mg
U2-4	1.3 mg
S1-4	0.3 mg
S2-4	0.5 mg
U1-5	1.2 mg
U2-5	1.2 mg
S1-5	7.9 mg
S2-5	3.4 mg
U1-6	1.3 mg
U2-6	2.0 mg
S1-6	0.6 mg
S2-6	1.0 mg

RESOLUTION ANALYTICS, INC.
Specialists in Air Emissions Analysis

Client: Air Control Techniques
RFA #: 1756
Date Received: 10/31/12
Date Analyzed: 11/5/12
Analyst: JSC
Analysis: EPA M5
Analyte(s): Filterable PM

Analytical Narrative

Sample Matrix & Components:

Front ½ DI H_2O Nozzle Rinses, DI H_2O Blank

Summary of Sample Prep:

The DI H_2O rinses were transferred to pre-tared teflon "baggies" in a low humidity environment. The DI H_2O rinses were evaporated in an oven at 105° C, then desiccated for 24 hours, after which time they were weighed daily every six hours until consecutive weights agreed within ±0.5 mg.

All weights were recorded to the nearest 0.1 mg and include filterable particulate catch only. The DI H2O blank catch has been subtracted from sample rinse catches in proportion with their respective volumes.

Summary of Instrumentation:

Denver model Pinnacle Series analytical balance

Analytical Detection Limit(s): 0.1 mg

Miscellaneous Comments Regarding Sample Analysis: (Note unusual catch weights, interferences, odd sample behavior, and steps taken to confirm unusual results. Also note any deviations from standard analytical procedures, together with justification and possible affect on results. Specify samples when applicable.)

No modifications to EPA Method 5 analytical procedure were made. See data sheets for individual sample descriptions.

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

Run Number		U1-1 Nozzle H_2O		U2-1 Nozzle H_2O		S1-1 Nozzle H_2O
Filter Container #	Date | Init		Date		Date	
Baggie Tare Wt., g.		#N/A		#N/A		#N/A
Filter Tare Wt., g.						
FILTER SAMPLE WT., g.		#N/A #		#N/A #		#N/A #N/A
Front ½ Rinse Container #	Date | Init	1546	Date	1550	Date	2287
	11/8/12 JSC	3.4669	11/8/12	3.5295	11/8/12	3.5322
	11/7/12 JSC F	3.4665	11/7/12 F	3.5291	11/7/12 F	3.5317
Tare Wt., g.	(110 ml)	3.4616	(80 ml)	3.5270	(100 ml)	3.5236
RINSE SAMPLE WT., g.		0.0049		0.0021		0.0081

Filter Catch, mg.	**#N/A**	**#N/A**	**#N/A**
Rinse Catch, mg.	4.9	2.1	8.1
Rinse Blank Residue, mg.	0.3	0.2	0.3
Net Rinse Catch, mg.	**4.6**	**1.9**	**7.8**
FILTERABLE PARTICULATE, mg.	**4.6**	**1.9**	**7.8**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**　　RFA #: **1756**

Method: EPA M5

Run Number				S2-1 Nozzle H_2O			U1-2 Nozzle H_2O			U2-2 Nozzle H_2O
Filter Container #	Date	Init			Date			Date		
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A ##			#N/A ##			#N/A #N/A
Front ½ Rinse Container #	Date	Init		58	Date		2437	Date		2483
	11/8/12	JSC		3.5416	11/8/12		3.4413	11/8/12		3.6311
	11/7/12	JSC	F	3.5412	11/7/12	F	3.4410	11/7/12	F	3.6307
Tare Wt., g.		(100	ml)	3.5341	(70	ml)	3.4376	(120	ml)	3.6286
RINSE SAMPLE WT., g.				0.0071			0.0034			0.0021
Filter Catch, mg.				**#N/A**			**#N/A**			**#N/A**
Rinse Catch, mg.				7.1			3.4			2.1
Rinse Blank Residue, mg.				0.3			0.2			0.3
Net Rinse Catch, mg.				**6.8**			**3.2**			**1.8**
FILTERABLE PARTICULATE, mg.				**6.8**			**3.2**			**1.8**

Legend:　F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques** RFA #: **1756**
Method: EPA M5

Run Number				S1-2 Nozzle H_2O			S2-2 Nozzle H_2O			U1-3 Nozzle H_2O
Filter Container #	Date	Init			Date			Date		
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A ##			#N/A ##			#N/A #N/A
Front ½ Rinse Container #	Date	Init		2366	Date		2788	Date		2308
	11/7/12	JSC		3.5059	11/8/12		3.5835	11/8/12		3.4741
	11/7/12	JSC	F	3.5055	11/7/12	F	3.5833	11/7/12	F	3.4740
Tare Wt., g.		(100	ml)	3.5000	(70	ml)	3.5767	(120	ml)	3.4716
RINSE SAMPLE WT., g.				0.0055			0.0066			0.0024
Filter Catch, mg.				**#N/A**			**#N/A**			**#N/A**
Rinse Catch, mg.				5.5			6.6			2.4
Rinse Blank Residue, mg.				0.3			0.2			0.3
Net Rinse Catch, mg.				**5.2**			**6.4**			**2.1**
FILTERABLE PARTICULATE, mg.				**5.2**			**6.4**			**2.1**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

	Date	Init		U2-3 Nozzle H_2O	Date		S1-3 Nozzle H_2O	Date		S2-3 Nozzle H_2O
Run Number				U2-3 Nozzle H_2O			S1-3 Nozzle H_2O			S2-3 Nozzle H_2O
Filter Container #										
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A ##			#N/A ##			#N/A #N/A
Front ½ Rinse Container #				2478			2305			1567
	11/8/12	JSC		3.5368	11/8/12		3.4844	11/8/12		3.6618
	11/7/12	JSC	F	3.5363	11/7/12	F	3.4841	11/7/12	F	3.6616
Tare Wt., g.		(90	ml)	3.5351	(80	ml)	3.4808	(80	ml)	3.6603
RINSE SAMPLE WT., g.				0.0012			0.0033			0.0013
Filter Catch, mg.				**#N/A**			**#N/A**			**#N/A**
Rinse Catch, mg.				1.2			3.3			1.3
Rinse Blank Residue, mg.				0.2			0.2			0.2
Net Rinse Catch, mg.				**1.0**			**3.1**			**1.1**
FILTERABLE PARTICULATE, mg.				**1.0**			**3.1**			**1.1**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
RFA #: **1756**
Method: EPA M5

Run Number				U1-4 Nozzle H_2O			U2-4 Nozzle H_2O			S1-4 Nozzle H_2O
Filter Container #	Date	Init			Date			Date		
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A ##			#N/A ##			#N/A #N/A
Front ½ Rinse Container #	Date	Init		1633	Date		2419	Date		2804
	11/8/12	JSC		3.5794	11/8/12		3.4920	11/8/12		3.8793
	11/7/12	JSC	F	3.5791	11/7/12	F	3.4917	11/7/12	F	3.8790
Tare Wt., g.	(	90	ml)	3.5773	(110	ml)	3.4901	(60	ml)	3.8785
RINSE SAMPLE WT., g.				0.0018			0.0016			0.0005
Filter Catch, mg.				**#N/A**			**#N/A**			**#N/A**
Rinse Catch, mg.				1.8			1.6			0.5
Rinse Blank Residue, mg.				0.2			0.3			0.2
Net Rinse Catch, mg.				**1.6**			**1.3**			**0.3**
FILTERABLE PARTICULATE, mg.				**1.6**			**1.3**			**0.3**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

	Date	Init		S2-4 Nozzle H_2O	Date		U1-5 Nozzle H_2O	Date		U2-5 Nozzle H_2O
Run Number				S2-4 Nozzle H_2O			U1-5 Nozzle H_2O			U2-5 Nozzle H_2O
Filter Container #										
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A ##			#N/A ##			#N/A #N/A
Front ½ Rinse Container #				1094			1647			2519
	11/8/12	JSC	F	3.6606	11/8/12		3.5809	11/8/12	F	3.6042
	11/7/12	JSC	F	3.6606	11/7/12	F	3.5808	11/7/12	F	3.6042
Tare Wt., g.		(50	ml)	3.6600	(80	ml)	3.5794	(60	ml)	3.6028
RINSE SAMPLE WT., g.				0.0006			0.0014			0.0014
Filter Catch, mg.				**#N/A**			**#N/A**			**#N/A**
Rinse Catch, mg.				0.6			1.4			1.4
Rinse Blank Residue, mg.				0.1			0.2			0.2
Net Rinse Catch, mg.				**0.5**			**1.2**			**1.2**
FILTERABLE PARTICULATE, mg.				**0.5**			**1.2**			**1.2**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques** RFA #: **1756**
Method: EPA M5

Run Number				S1-5 Nozzle H_2O			S2-5 Nozzle H_2O			U1-6 Nozzle H_2O
Filter Container #	Date	Init			Date			Date		
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A ##			#N/A ##			#N/A #N/A
Front ½ Rinse Container #	Date	Init		481	Date		2058	Date		2825
	11/8/12	JSC		3.4705	11/8/12		3.6685	11/8/12		3.7768
	11/7/12	JSC	F	3.4704	11/7/12	F	3.6682	11/7/12	F	3.7767
Tare Wt., g.		(90	ml)	3.4623	(80	ml)	3.6646	(70	ml)	3.7752
RINSE SAMPLE WT., g.				0.0081			0.0036			0.0015
Filter Catch, mg.				**#N/A**			**#N/A**			**#N/A**
Rinse Catch, mg.				8.1			3.6			1.5
Rinse Blank Residue, mg.				0.2			0.2			0.2
Net Rinse Catch, mg.				**7.9**			**3.4**			**1.3**
FILTERABLE PARTICULATE, mg.				**7.9**			**3.4**			**1.3**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques** RFA #: **1756**
Method: EPA M5

Run Number				U2-6 Nozzle H_2O			S1-6 Nozzle H_2O			S2-6 Nozzle H_2O
Filter Container #	Date	Init			Date			Date		
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A ##			#N/A ##			#N/A #N/A
Front ½ Rinse Container #	Date	Init		1422	Date		362	Date		645
	11/8/12	JSC		3.6810	11/8/12	F	3.6904	11/8/12		3.4845
	11/7/12	JSC	F	3.6809	11/7/12		3.6905	11/7/12	F	3.4844
Tare Wt., g.	(	90	ml)	3.6787	(100	ml)	3.6895	(100	ml)	3.4831
RINSE SAMPLE WT., g.				0.0022			0.0009			0.0013

	U2-6	S1-6	S2-6
Filter Catch, mg.	**#N/A**	**#N/A**	**#N/A**
Rinse Catch, mg.	2.2	0.9	1.3
Rinse Blank Residue, mg.	0.2	0.3	0.3
Net Rinse Catch, mg.	**2.0**	**0.6**	**1.0**
FILTERABLE PARTICULATE, mg.	**2.0**	**0.6**	**1.0**

Legend: F = Final Weight

Notes & Comments:

RESOLUTION ANALYTICS, INC.
Specialists in Air Emissions Analysis

Client: Air Control Techniques
RFA #: 1756
Method: EPA M5

Report Summary

SAMPLE ID	ACETONE PROBE AND >2.5µg RINSE PARTICULATE
U1-1	9.1 mg
U2-1	5.7 mg
S1-1	5.1 mg
S2-1	5.7 mg
U1-2	5.7 mg
U2-2	3.7 mg
S1-2	3.8 mg
S2-2	7.2 mg
U1-3	4.5 mg
U2-3	4.2 mg
S1-3	3.7 mg
S2-3	11.3 mg
U1-4	3.5 mg
U2-4	3.3 mg
S1-4	2.2 mg
S2-4	2.7 mg
U1-5	4.4 mg
U2-5	1.9 mg
S1-5	2.1 mg
S2-5	3.3 mg
U1-6	3.8 mg
U2-6	4.4 mg
S1-6	2.6 mg
S2-6	2.5 mg

RESOLUTION ANALYTICS, INC.
Specialists in Air Emissions Analysis

Client: Air Control Techniques
RFA #: 1756
Date Received: 10/31/12
Date Analyzed: 11/5/12
Analyst: JSC
Analysis: EPA M5
Analyte(s): Filterable PM

Analytical Narrative

Sample Matrix & Components:

Front ½ Acetone Probe and >2.5µg Rinses, Acetone Blank

Summary of Sample Prep:

The acetone rinses were transferred to pre-tared teflon "baggies" in a low humidity environment. The acetone rinses were evaporated, then desiccated for 24 hours, after which time they were weighed daily every six hours until consecutive weights agreed within ±0.5 mg.

All weights were recorded to the nearest 0.1 mg and include filterable particulate catch only. The acetone blank catch has been subtracted from sample rinse catches in proportion with their respective volumes.

Summary of Instrumentation:

Denver model Pinnacle Series analytical balance

Analytical Detection Limit(s): 0.1 mg

Miscellaneous Comments Regarding Sample Analysis: **(Note unusual catch weights, interferences, odd sample behavior, and steps taken to confirm unusual results. Also note any deviations from standard analytical procedures, together with justification and possible affect on results. Specify samples when applicable.)**

No modifications to EPA Method 5 analytical procedure were made. See data sheets for individual sample descriptions.

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques** RFA #: **1756**
Method: EPA M5

Run Number				U1-1 Probe and >2.5μg Acetone			U2-1 Probe and >2.5μg Acetone			S1-1 Probe and >2.5μg Acetone	
Filter Container #	Date	Init			Date			Date			
Baggie Tare Wt., g.				#N/A			#N/A			#N/A	
Filter Tare Wt., g.											
FILTER SAMPLE WT., g.				#N/A #			#N/A #			#N/A	#N/A
Front ½ Rinse Container #	Date	Init		1471	Date		498	Date		2113	
	11/12/12	JSC		3.5869	11/12/12	F	3.6456	11/12/12		3.7102	
	11/12/12	JSC	F	3.5866	11/12/12	F	3.6456	11/12/12	F	3.7097	
Tare Wt., g.		(100	ml)	3.5772	(100	ml)	3.6396	(100	ml)	3.7043	
RINSE SAMPLE WT., g.				0.0094			0.0060			0.0054	
Filter Catch, mg.				**#N/A**			**#N/A**			**#N/A**	
Rinse Catch, mg.				9.4			6.0			5.4	
Rinse Blank Residue, mg.				0.3			0.3			0.3	
Net Rinse Catch, mg.				**9.1**			**5.7**			**5.1**	
FILTERABLE PARTICULATE, mg.				**9.1**			**5.7**			**5.1**	

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

Run Number				S2-1 Probe and >2.5μg Acetone			U1-2 Probe and >2.5μg Acetone			U2-2 Probe and >2.5μg Acetone
Filter Container #										
	Date	Init			Date			Date		
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A ##			#N/A ##			#N/A #N/A
Front ½ Rinse Container #				1619			1663			509
	Date	Init			Date			Date		
	11/12/12	JSC		3.6806	11/12/12		3.6092	11/12/12		3.6765
	11/12/12	JSC	F	3.6801	11/12/12	F	3.6090	11/12/12	F	3.6762
Tare Wt., g.	(	110	ml)	3.6741	(90	ml)	3.6030	(80	ml)	3.6722
RINSE SAMPLE WT., g.				0.0060			0.0060			0.0040
Filter Catch, mg.				**#N/A**			**#N/A**			**#N/A**
Rinse Catch, mg.				6.0			6.0			4.0
Rinse Blank Residue, mg.				0.3			0.3			0.3
Net Rinse Catch, mg.				**5.7**			**5.7**			**3.7**
FILTERABLE PARTICULATE, mg.				**5.7**			**5.7**			**3.7**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques** RFA #: **1756**
Method: EPA M5

Run Number				S1-2 Probe and >2.5µg Acetone			S2-2 Probe and >2.5µg Acetone			U1-3 Probe and >2.5µg Acetone
Filter Container #	Date	Init			Date			Date		
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A ##			#N/A ##			#N/A #N/A
Front ½ Rinse Container #	Date	Init		1649	Date		1601	Date		1489
	11/12/12	JSC		3.5221	11/12/12		3.6622	11/12/12		3.5483
	11/12/12	JSC	F	3.5218	11/12/12	F	3.6620	11/12/12	F	3.5480
Tare Wt., g.			(120 ml)	3.5176		(110 ml)	3.6545		(90 ml)	3.5432
RINSE SAMPLE WT., g.				0.0042			0.0075			0.0048
Filter Catch, mg.				**#N/A**			**#N/A**			**#N/A**
Rinse Catch, mg.				4.2			7.5			4.8
Rinse Blank Residue, mg.				0.4			0.3			0.3
Net Rinse Catch, mg.				**3.8**			**7.2**			**4.5**
FILTERABLE PARTICULATE, mg.				**3.8**			**7.2**			**4.5**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

	Date	Init		U2-3 Probe and >2.5µg Acetone	Date		S1-3 Probe and >2.5µg Acetone	Date		S2-3 Probe and >2.5µg Acetone
Run Number				U2-3			S1-3			S2-3
Filter Container #	Date	Init			Date			Date		
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A ##			#N/A ##			#N/A #N/A
Front ½ Rinse Container #	Date	Init		1676	Date		1441	Date		2303
	11/12/12	JSC		3.7053	11/12/12	F	3.5367	11/12/12		3.5451
	11/12/12	JSC	F	3.7050	11/12/12	F	3.5367	11/12/12	F	3.5448
Tare Wt., g.		(90 ml)		3.7005	(90 ml)		3.5327	(100 ml)		3.5332
RINSE SAMPLE WT., g.				0.0045			0.0040			0.0116
Filter Catch, mg.				**#N/A**			**#N/A**			**#N/A**
Rinse Catch, mg.				4.5			4.0			11.6
Rinse Blank Residue, mg.				0.3			0.3			0.3
Net Rinse Catch, mg.				**4.2**			**3.7**			**11.3**
FILTERABLE PARTICULATE, mg.				**4.2**			**3.7**			**11.3**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

Run Number			U1-4 Probe and >2.5µg Acetone			U2-4 Probe and >2.5µg Acetone			S1-4 Probe and >2.5µg Acetone	
Filter Container #	Date	Init		Date			Date			
Baggie Tare Wt., g.			#N/A			#N/A			#N/A	
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.			#N/A	##		#N/A	##		#N/A	#N/A
Front ½ Rinse Container #	Date	Init	2152	Date		1638	Date		654	
	11/12/12	JSC	3.7532	11/12/12	F	3.6005	11/12/12		3.7161	
	11/12/12	JSC F	3.7527	11/12/12		3.6008	11/12/12	F	3.7159	
Tare Wt., g.		(70 ml)	3.7490	(80 ml)		3.5969	(70 ml)		3.7135	
RINSE SAMPLE WT., g.			0.0037			0.0036			0.0024	
Filter Catch, mg.			**#N/A**			**#N/A**			**#N/A**	
Rinse Catch, mg.			3.7			3.6			2.4	
Rinse Blank Residue, mg.			0.2			0.3			0.2	
Net Rinse Catch, mg.			**3.5**			**3.3**			**2.2**	
FILTERABLE PARTICULATE, mg.			**3.5**			**3.3**			**2.2**	

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

Run Number				S2-4 Probe and >2.5µg Acetone			U1-5 Probe and >2.5µg Acetone			U2-5 Probe and >2.5µg Acetone
Filter Container #	Date	Init			Date			Date		
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A ##			#N/A ##			#N/A #N/A
Front ½ Rinse Container #	Date	Init		1116	Date		2155	Date		637
	11/12/12	JSC		3.3916	11/12/12		3.8702	11/12/12		3.7500
	11/12/12	JSC	F	3.3914	11/12/12	F	3.8701	11/12/12	F	3.7499
Tare Wt., g.	(	130	ml)	3.3883	(120	ml)	3.8653	(100	ml)	3.7477
RINSE SAMPLE WT., g.				0.0031			0.0048			0.0022
Filter Catch, mg.				**#N/A**			**#N/A**			**#N/A**
Rinse Catch, mg.				3.1			4.8			2.2
Rinse Blank Residue, mg.				0.4			0.4			0.3
Net Rinse Catch, mg.				**2.7**			**4.4**			**1.9**
FILTERABLE PARTICULATE, mg.				**2.7**			**4.4**			**1.9**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques** RFA #: **1756**
Method: EPA M5

Run Number	Date	Init		S1-5 Probe and >2.5µg Acetone	Date		S2-5 Probe and >2.5µg Acetone	Date		U1-6 Probe and >2.5µg Acetone
Filter Container #										
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A ##			#N/A ##			#N/A #N/A
Front ½ Rinse Container #				1617			414			2637
	11/12/12	JSC		3.6853	11/12/12		3.7981	11/12/12		3.5122
	11/12/12	JSC	F	3.6851	11/12/12	F	3.7978	11/12/12	F	3.5120
Tare Wt., g.	(	70	ml)	3.6828	(110	ml)	3.7942	(70	ml)	3.5080
RINSE SAMPLE WT., g.				0.0023			0.0036			0.0040
Filter Catch, mg.				**#N/A**			**#N/A**			**#N/A**
Rinse Catch, mg.				2.3			3.6			4.0
Rinse Blank Residue, mg.				0.2			0.3			0.2
Net Rinse Catch, mg.				**2.1**			**3.3**			**3.8**
FILTERABLE PARTICULATE, mg.				**2.1**			**3.3**			**3.8**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

Run Number				U2-6 Probe and >2.5µg Acetone			S1-6 Probe and >2.5µg Acetone			S2-6 Probe and >2.5µg Acetone
Filter Container #	Date	Init			Date			Date		
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A ##			#N/A ##			#N/A #N/A
Front ½ Rinse Container #	Date	Init		2464	Date		1527	Date		1401
	11/12/12	JSC		3.6718	11/12/12		3.4494	11/12/12		3.4495
	11/12/12	JSC	F	3.6716	11/12/12	F	3.4490	11/12/12	F	3.4490
Tare Wt., g.		(110	ml)	3.6669	(120	ml)	3.4460	(160	ml)	3.4460
RINSE SAMPLE WT., g.				0.0047			0.0030			0.0030

Filter Catch, mg.	**#N/A**	**#N/A**	**#N/A**
Rinse Catch, mg.	4.7	3.0	3.0
Rinse Blank Residue, mg.	0.3	0.4	0.5
Net Rinse Catch, mg.	**4.4**	**2.6**	**2.5**
FILTERABLE PARTICULATE, mg.	**4.4**	**2.6**	**2.5**

Legend: F = Final Weight

Notes & Comments:

RESOLUTION ANALYTICS, INC.
Specialists in Air Emissions Analysis

Client: Air Control Techniques
RFA #: 1756
Method: EPA M5

Report Summary

SAMPLE ID	H_2O PROBE AND >2.5µg RINSE PARTICULATE
U1-1	14.6 mg
U2-1	9.3 mg
S1-1	12.4 mg
S2-1	9.2 mg
U1-2	5.5 mg
U2-2	4.1 mg
S1-2	7.7 mg
S2-2	4.3 mg
U1-3	5.4 mg
U2-3	3.2 mg
S1-3	5.9 mg
S2-3	2.8 mg
U1-4	4.1 mg
U2-4	4.0 mg
S1-4	4.8 mg
S2-4	3.1 mg
U1-5	5.2 mg
U2-5	3.5 mg
S1-5	8.7 mg
S2-5	8.7 mg
U1-6	3.5 mg
U2-6	2.1 mg
S1-6	4.1 mg
S2-6	2.2 mg

RESOLUTION ANALYTICS, INC.
Specialists in Air Emissions Analysis

Client:	Air Control Techniques
RFA #:	1756
Date Received:	10/31/12
Date Analyzed:	11/5/12
Analyst:	JSC
Analysis:	EPA M5
Analyte(s):	Filterable PM

Analytical Narrative

Sample Matrix & Components:

Front ½ DI H_2O Probe and >2.5μg Rinses, DI H_2O Blank

Summary of Sample Prep:

The DI H_2O rinses were transferred to pre-tared teflon "baggies" in a low humidity environment. The DI H_2O rinses were evaporated in an oven at 105° C, then desiccated for 24 hours, after which time they were weighed daily every six hours until consecutive weights agreed within ±0.5 mg.

All weights were recorded to the nearest 0.1 mg and include filterable particulate catch only. The DI H2O blank catch has been subtracted from sample rinse catches in proportion with their respective volumes.

Summary of Instrumentation:

Denver model Pinnacle Series analytical balance

Analytical Detection Limit(s): 0.1 mg

Miscellaneous Comments Regarding Sample Analysis: **(Note unusual catch weights, interferences, odd sample behavior, and steps taken to confirm unusual results. Also note any deviations from standard analytical procedures, together with justification and possible affect on results. Specify samples when applicable.)**

No modifications to EPA Method 5 analytical procedure were made. See data sheets for individual sample descriptions.

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

Run Number				U1-1 Probe and >2.5μg H_2O			U2-1 Probe and >2.5μg H_2O			S1-1 Probe and >2.5μg H_2O
Filter Container #	Date	Init			Date			Date		
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A #			#N/A #			#N/A #N/A
Front ½ Rinse Container #	Date	Init		1267	Date		772	Date		1694
	11/8/12	JSC		3.9219	11/8/12		3.4943	11/8/12		3.7712
	11/7/12	JSC	F	3.9217	11/7/12	F	3.4941	11/7/12	F	3.7710
Tare Wt., g.	(	140	ml)	3.9067	(150	ml)	3.4844	(180	ml)	3.7581
RINSE SAMPLE WT., g.				0.0150			0.0097			0.0129
Filter Catch, mg.				**#N/A**			**#N/A**			**#N/A**
Rinse Catch, mg.				15.0			9.7			12.9
Rinse Blank Residue, mg.				0.4			0.4			0.5
Net Rinse Catch, mg.				**14.6**			**9.3**			**12.4**
FILTERABLE PARTICULATE, mg.				**14.6**			**9.3**			**12.4**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

Run Number				S2-1 Probe and >2.5µg H_2O			U1-2 Probe and >2.5µg H_2O			U2-2 Probe and >2.5µg H_2O
Filter Container #	Date	Init			Date			Date		
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A ##			#N/A ##			#N/A #N/A
Front ½ Rinse Container #	Date	Init		2157	Date		1534	Date		417
	11/8/12	JSC	F	3.7231	11/8/12	F	3.6239	11/8/12	F	3.5227
	11/7/12	JSC		3.7233	11/7/12	F	3.6239	11/7/12		3.5228
Tare Wt., g.	(	160	ml)	3.7135	(90	ml)	3.6182	(110	ml)	3.5183
RINSE SAMPLE WT., g.				0.0096			0.0057			0.0044

Filter Catch, mg.	**#N/A**	**#N/A**	**#N/A**
Rinse Catch, mg.	9.6	5.7	4.4
Rinse Blank Residue, mg.	0.4	0.2	0.3
Net Rinse Catch, mg.	**9.2**	**5.5**	**4.1**
FILTERABLE PARTICULATE, mg.	**9.2**	**5.5**	**4.1**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques** RFA #: **1756**
Method: EPA M5

Run Number				S1-2 Probe and >2.5µg H_2O			S2-2 Probe and >2.5µg H_2O			U1-3 Probe and >2.5µg H_2O
Filter Container #	Date	Init			Date			Date		
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A ##			#N/A ##			#N/A #N/A
Front ½ Rinse Container #	Date	Init		2645	Date		2154	Date		1379
	11/8/12	JSC		3.5346	11/8/12	F	3.7191	11/8/12	F	3.5533
	11/7/12	JSC	F	3.5345	11/7/12	F	3.7191	11/7/12		3.5535
Tare Wt., g.		(170	ml)	3.5263	(180	ml)	3.7143	(170	ml)	3.5474
RINSE SAMPLE WT., g.				0.0082			0.0048			0.0059
Filter Catch, mg.				**#N/A**			**#N/A**			**#N/A**
Rinse Catch, mg.				8.2			4.8			5.9
Rinse Blank Residue, mg.				0.5			0.5			0.5
Net Rinse Catch, mg.				**7.7**			**4.3**			**5.4**
FILTERABLE PARTICULATE, mg.				**7.7**			**4.3**			**5.4**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

Run Number				U2-3 Probe and >2.5μg H_2O			S1-3 Probe and >2.5μg H_2O			S2-3 Probe and >2.5μg H_2O
Filter Container #	Date	Init			Date			Date		
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A ##			#N/A ##			#N/A #N/A
Front ½ Rinse Container #	Date	Init		957	Date		704	Date		1235
	11/8/12	JSC	F	3.5175	11/8/12	F	3.7103	11/8/12	F	3.3545
	11/7/12	JSC		3.5176	11/7/12	F	3.7103	11/7/12		3.3547
Tare Wt., g.		(110 ml)		3.5140	(130 ml)		3.7040	(150 ml)		3.3513
RINSE SAMPLE WT., g.				0.0035			0.0063			0.0032
Filter Catch, mg.				**#N/A**			**#N/A**			**#N/A**
Rinse Catch, mg.				3.5			6.3			3.2
Rinse Blank Residue, mg.				0.3			0.4			0.4
Net Rinse Catch, mg.				**3.2**			**5.9**			**2.8**
FILTERABLE PARTICULATE, mg.				**3.2**			**5.9**			**2.8**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

Run Number	Date	Init		U1-4 Probe and >2.5μg H_2O	Date		U2-4 Probe and >2.5μg H_2O	Date		S1-4 Probe and >2.5μg H_2O
Filter Container #										
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A ##			#N/A ##			#N/A #N/A
Front ½ Rinse Container #				1684			1405			2211
	11/8/12	JSC		3.6461	11/8/12		3.5345	11/8/12		3.5818
	11/7/12	JSC	F	3.6460	11/7/12	F	3.5344	11/7/12	F	3.5816
Tare Wt., g.		(120	ml)	3.6416	(100	ml)	3.5301	(110	ml)	3.5765
RINSE SAMPLE WT., g.				0.0044			0.0043			0.0051

	U1-4	U2-4	S1-4
Filter Catch, mg.	**#N/A**	**#N/A**	**#N/A**
Rinse Catch, mg.	4.4	4.3	5.1
Rinse Blank Residue, mg.	0.3	0.3	0.3
Net Rinse Catch, mg.	**4.1**	**4.0**	**4.8**
FILTERABLE PARTICULATE, mg.	**4.1**	**4.0**	**4.8**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

Run Number				S2-4 Probe and >2.5μg H_2O			U1-5 Probe and >2.5μg H_2O			U2-5 Probe and >2.5μg H_2O
Filter Container #	Date	Init			Date			Date		
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A ##			#N/A ##			#N/A #N/A
Front ½ Rinse Container #	Date	Init		2377	Date		2559	Date		1089
	11/8/12	JSC		3.3595	11/8/12	F	3.5517	11/8/12		3.4709
	11/7/12	JSC	F	3.3594	11/7/12	F	3.5517	11/7/12	F	3.4707
Tare Wt., g.	(	150	ml)	3.3559	(170	ml)	3.5460	(150	ml)	3.4668
RINSE SAMPLE WT., g.				0.0035			0.0057			0.0039

Filter Catch, mg.	**#N/A**	**#N/A**	**#N/A**
Rinse Catch, mg.	3.5	5.7	3.9
Rinse Blank Residue, mg.	0.4	0.5	0.4
Net Rinse Catch, mg.	**3.1**	**5.2**	**3.5**
FILTERABLE PARTICULATE, mg.	**3.1**	**5.2**	**3.5**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques** RFA #: **1756**
Method: EPA M5

Run Number				S1-5 Probe and >2.5µg H_2O			S2-5 Probe and >2.5µg H_2O			U1-6 Probe and >2.5µg H_2O
Filter Container #										
	Date	Init			Date			Date		
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A ##			#N/A ##			#N/A #N/A
Front ½ Rinse Container #				696			2335			1531
	Date	Init			Date			Date		
	11/8/12	JSC		3.5385	11/8/12		3.3771	11/8/12	F	3.6765
	11/7/12	JSC	F	3.5384	11/7/12	F	3.3768	11/7/12	F	3.6765
Tare Wt., g.		(170	ml)	3.5292	(170	ml)	3.3676	(110	ml)	3.6727
RINSE SAMPLE WT., g.				0.0092			0.0092			0.0038
Filter Catch, mg.				**#N/A**			**#N/A**			**#N/A**
Rinse Catch, mg.				9.2			9.2			3.8
Rinse Blank Residue, mg.				0.5			0.5			0.3
Net Rinse Catch, mg.				**8.7**			**8.7**			**3.5**
FILTERABLE PARTICULATE, mg.				**8.7**			**8.7**			**3.5**

Legend: F = Final Weight

Notes & Comments:

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**
Method: EPA M5

RFA #: **1756**

Run Number				U2-6 Probe and >2.5μg H_2O			S1-6 Probe and >2.5μg H_2O			S2-6 Probe and >2.5μg H_2O
Filter Container #	Date	Init			Date			Date		
Baggie Tare Wt., g.				#N/A			#N/A			#N/A
Filter Tare Wt., g.										
FILTER SAMPLE WT., g.				#N/A ##			#N/A ##			#N/A #N/A
Front ½ Rinse Container #	Date	Init		2427	Date		1221	Date		183
	11/8/12	JSC		3.3245	11/8/12		3.3836	11/8/12	F	3.6494
	11/7/12	JSC	F	3.3240	11/7/12	F	3.3833	11/7/12	F	3.6494
Tare Wt., g.		(100	ml)	3.3216	(140	ml)	3.3788	(180	ml)	3.6467
RINSE SAMPLE WT., g.				0.0024			0.0045			0.0027

	U2-6	S1-6	S2-6
Filter Catch, mg.	**#N/A**	**#N/A**	**#N/A**
Rinse Catch, mg.	2.4	4.5	2.7
Rinse Blank Residue, mg.	0.3	0.4	0.5
Net Rinse Catch, mg.	**2.1**	**4.1**	**2.2**
FILTERABLE PARTICULATE, mg.	**2.1**	**4.1**	**2.2**

Legend: F = Final Weight

Notes & Comments:

REAGENT BLANK LABORATORY RESULTS

Client: **Air Control Techniques** RFA #: **1756**
Method: EPA M5

Run Number DI H2O Blank

	Date	Init		DI H2O Blank
Sample ID/Container #				2613
	11/8/12	JSC		3.5415
	11/7/12	JSC	F	3.5411
Tare Wt., g.	(	220	ml)	3.5405
SAMPLE WT., g.				0.0006

Blank Beaker #	2613
Final wt., mg.	3.5411
Tare wt., mg.	3.5405
Residue, mg.	0.6
Volume, ml.	220
Density, mg/ml	1000.0
Conc., mg/mg	2.73E-06 ✓
Upper Limit, mg	1.00E-05

Legend: F = Final Weight

Notes & Comments:

REAGENT BLANK LABORATORY RESULTS

Client: **Air Control Techniques** RFA #: **1756**
Method: EPA M5

Run Number				Acetone Blank
Sample ID/Container #				1460
	Date	Init		
	11/12/12	JSC		3.5621
	11/12/12	JSC	F	3.5619
Tare Wt., g.	(	230	ml)	3.5612
SAMPLE WT., g.				0.0007

Blank Beaker #	1460
Final wt., mg.	3.5619
Tare wt., mg.	3.5612
Residue, mg.	0.7
Volume, ml.	230
Density, mg/ml	785.0
Conc., mg/mg	3.88E-06 ✓
Upper Limit, mg	1.00E-05

Legend: F = Final Weight

Notes & Comments:

FILTERS ✓

M5/17 Particulate Bench Sheet

Client: ACT
Analyst: JSC

RFA #: 1756
Method: 5

Date Received: 10/31/12
Date Analyzed: 11/5/12

Run #	Filter			Acetone Rinse	
	Baggie #	Filter #	Filter Tare	Baggie #	Rinse Volume
U1 - 1		47G-1400	0.1113		
U2 - 1		-1403	0.1181		
S1 - 1		-1401	0.1175		
S2 - 1		-1402	0.1167		
U1 - 2		-1404	0.1174		
U2 - 2		-1405	0.1169		
S1 - 2		-1408	0.1163		
S2 - 2		-1407	0.1172		
U - 3		-1409	0.1179		
U2 - 3		-1410	0.1158		
S1 - 3		-1411	0.1176		
S2 - 3		-1412	0.1164		
U1 - 4		-1413	0.1160		
U2 - 4		-1414	0.1171		
S1 - 4		-1415	0.1158		
S2 - 4		-1416	0.1179		
U1 - 5		-1417	0.1167		
U2 - 5		-1418	0.1172		
S1 - 5		-1419	0.1175		
S2 - 5		-1420	0.1157		
U1 - 6		-1421	0.1171		
U2 - 6		-1422	0.1163		
S1 - 6		-1423	0.1168		
S2 - 6		-1424	0.1166		

NOZZLE ACETONES ✓

M5/17 Particulate Bench Sheet

Client: ACT
Analyst: JSC

RFA #: 1756
Method: 5

Date Received: ~~11/9/12~~ 10/31/12
Date Analyzed: 11/9/12

Run #	Filter			Acetone Rinse	
	Baggie #	Filter #	Filter Tare	Baggie #	Rinse Volume
U1-1				2119	50
U2-1				1648	40
S1-1				1612	70
S2-1				1344	60
U1-2				11	70
U2-2				1213	60
S-2				63	70
S2-2				62	60
U1-3				1394	70
U2-3				255	50
S1-3				366	60
S2-3				1359	40
U1-4				1486	40
U2-4				2551	50
S1-4				2156	50
S2-4				2401	~~50~~ 40
U1-5				1010	40
U2-5				1259	30
S1-5				1340	
S2-5				1017	40
U1-6				1478	40
U2-6				113	60
S1-6				1399	50
S2-6				2162	40

RB 1460 230

PROBE 70.2 ACETONES ✓

M5/17 Particulate Bench Sheet

Client: ACT
Analyst: JSC
RFA #: 1756 ~~11/9/12~~
Method: 5
Date Received: 10/31/12
Date Analyzed: 11/9/12

Run #	Filter			Acetone Rinse	
	Baggie #	Filter #	Filter Tare	Baggie #	Rinse Volume
U1-1				1471	100
U2-1				498	100
S1-1				2113	100
S2-1				1619	110
U1-2				1663	90
U2-2				509	80
S1-2				1649	120
S2-2				1601	110
U1-3				1489	90
U2-3				1676	90
S1-3				1441	90
S2-3				2303	100
U1-4				2152	70
U2-4				1638	80
S1-4				~~634~~ 654	70
S2-4				1116	130
U1-5				2155	120
U2-5				637	100
S1-5				1617	70
S2-5				414	110
U1-6				2637	70
U2-6				2464	110
S1-6				1527	120
S2-6				1401	160

≤ 2.5 ACETONES ✓

M5/17 Particulate Bench Sheet

Client: ACT
Analyst: JSC
RFA #: 1756
Method: 5
Date Received: 10/31/12
Date Analyzed: 11/9/12

Run #	Filter			Acetone Rinse	
	Baggie #	Filter #	Filter Tare	Baggie #	Rinse Volume
U1-1				760	50
U2-1				2631	50
S1-1				444	50
S2-1				2566	60
U1-2				2473	70
U2-2				1536	50
S1-2				1378	50
S2-2				2533	30
U1-3				1667	30
U2-3				1392	40
S1-3				2339	30
S2-3				2289	40
U1-4				1231	30
U2-4				1387	40
S1-4				1585	40
S2-4				2574	40
U1-5				548	50
U2-5				2539	40
S1-5				1355	30
S2-5				1181	30
U1-6				2618	40
U2-6				2517	40
S1-6				1023	30
S2-6				234	40

NOZZLE H_2O's ✓

M5/17 Particulate Bench Sheet

Client: ACT		RFA #: 1756	Date Received: 10/31/12
Analyst: JSC		Method: 5	Date Analyzed: 11/5/12

Run #	Filter			Acetone Rinse	
	Baggie #	Filter #	Filter Tare	Baggie #	Rinse Volume
U1-1				1546	110
U2-1				1550	80
S1-1				2287	160
S2-1				5058	100
U1-2				2437	70
U2-2				2483	120
S1-2				2366	100
S2-2				2788	70
U1-3				2308	120
U2-3				2478	90
S1-3				2305	80
S2-3				1567	80
U1-4				1633	90
U2-4				2419	110
S1-4				2804	60
S2-4				1094	50
U1-5				1647	80
U2-5				2519	60
S1-5				481	90
S2-5				2058	80
U1-6				2825	70
U2-6				1422	90
S1-6				362	100
S2-6				645	100

H_2O RB 2613 220

PROBE + > 2.5 H_2O

M5/17 Particulate Bench Sheet

Client: ACT
Analyst: JSC

RFA #: 1756
Method: 5

Date Received: 10/31/12
Date Analyzed: 11/5/12

Run #	Filter			Acetone Rinse	
	Baggie #	Filter #	Filter Tare	Baggie #	Rinse Volume
U1-1				1267	140
U2-1				772	150
S1-1				1694	180
S2-1				2157	160
U1-2				1534	90
U2-2				417	110
S1-2				2645	170
S2-2				2154	180
U1-3				1379	170
U2-3				957	110
S1-3				704	130
S2-3				1235	150
U1-4				1684	120
U2-4				1405	100
S1-4				2211	110
S2-4				2377	150
U1-5				2559	170
U2-5				1089	150
S1-5				696	170
S2-5				2335	170
U1-6				1531	110
U2-6				2427	100
S1-6				1221	140
S2-6				183	180

≤ 2.5 H_2O ✓

M5/17 Particulate Bench Sheet

Client: ACT
Analyst: JSC

RFA #: 1756
Method: 5

Date Received: 10/31/12
Date Analyzed: 11/6/12

Run #	Filter			H_2O ~~Acetone~~ Rinse	
	Baggie #	Filter #	Filter Tare	Baggie #	Rinse Volume
U1-1				230	50
U2-1				2042	60
S1-1				1256	70
2-				3121	60
U1-2				1404	70
U2-2				4147	60
S1-2				2147	50
S2-2				1293	60
U1-3				4143	
U2-3				52	50
S1-3				2144	60
S2-3				1451	60
U1-4				1191	70
U2-4				1623	70
S1-4				2174	80
S2-4				1409	50
U1-5				2359	70
U2-5				618	70
S1-5				1366	
S2-5				2145	60
U1-6				4043	60
U2-6				2405	50
S1-6				1129	40
S2-6				1428	50

M5/17 Particulate Bench Sheet

Client: ACT
Analyst: JBC

RFA #: 1756
Method: 160.1, 160.2

Date Received: 10/31/12
Date Analyzed: 11/8/12

Run #	Filter			H_2O ~~Acetone Rinse~~	
	Baggie #	Filter #	Filter Tare	Baggie #	Rinse Volume
10/24/12 3:10 PM WS WATER		47Q-1003	0.1238	788	170
10/24/12 4:30 PM WS WATER		47Q-1004	0.1235	2420	235
10/25/12 3:15 PM WS WATER		47Q-1005	0.1102	1562	235

RESOLUTION ANALYTICS, INC.
Specialists in Air Emissions Analysis

Client: Air Control Techniques
RFA #: 1756
Method: EPA 160.1, 160.2

Report Summary

SAMPLE ID	TOTAL NON-FILTERABLE RESIDUE	TOTAL FILTERABLE RESIDUE
10/24/12 3:10pm WS Water	8.82 mg/L	4461 mg/L
10/24/12 4:30pm WS Water	2.13 mg/L	4296 mg/L
10/25/12 3:15pm WS Water	2.55 mg/L	4117 mg/L

RESOLUTION ANALYTICS, INC.
Specialists in Air Emissions Analysis

Client: Air Control Techniques
RFA #: 1756
Date Received: 10/31/12
Date Analyzed: 11/8/12
Analyst: JSC
Analysis: EPA 160.1, 160.2
Analyte(s): Residue, Filterable And No

Analytical Narrative

Sample Matrix & Components:

Scrubber Effluent

Summary of Sample Prep:

All samples were volumed and filtered using a tared 47mm quartz filter. The filters were dried in an ov hour, cooled in a desiccator and weighed to constant weight. The waters were transferred to a tared we dried in an oven at 180° C, cooled in a desiccator, and weighed to constant weight. All weights were re 0.1 mg.

Summary of Instrumentation:

Denver model Pinnacle Series analytical balance

Analytical Detection Limit(s): 0.1 mg

<u>Miscellaneous Comments Regarding Sample Analysis:</u> (Note unusual catch weights, interferences, odd sam steps taken to confirm unusual results. Also note any deviations from standard analytical procedures, toget justification and possible affect on results. Specify samples when applicable.)

No modifications to EPA 160.1 and 160.2 analytical procedures were made. See data sheets for individ descriptions.

PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques** RFA #: **1756**
Method: EPA 160.1, 160.2

Run Number	10/24/12 3:10pm WS Water	10/24/12 4:30pm WS Water	10/25/12 3:15pm WS Water

	Date	Init			Date			Date		
Non-filterable Container #										
	11/12/12	JSC		0.1255	11/12/12		0.1242	11/12/12		0.1109
	11/12/12	JSC	F	0.1253	11/12/12	F	0.1240	11/12/12	F	0.1108
Baggie Tare Wt., g.				0.0000			0.0000			0.0000
Filter Tare Wt., g.				0.1238			0.1235			0.1102
TSS SAMPLE WT., g.				0.0015			0.0005			0.0006

	Date	Init			Date			Date		
Filterable Container #				788			2420			1562
	11/13/12	JSC		4.3059	11/13/12	F	4.3277	11/13/12	F	4.4336
	11/13/12	JSC	F	4.3056	11/13/12		4.3279	11/13/12		4.4337
Tare Wt., g.				3.5472			3.3181			3.4661
TDS SAMPLE WT., g.				0.7584			1.0096			0.9675

Volume of Sample Filtered, ml	170	235	235
Residue Non-filterable, mg/L	**8.82**	**2.13**	**2.55**
Residue Filterable, mg/L	**4461**	**4296**	**4117**

Legend: F = Final Weight

Notes & Comments:

N:Particulate Lab:Jobs:ACT:1756:October 31, 2012 1756 TDS and TSS.xlsx

APPENDIX F

ANALYTICAL DATA

RESOLUTION ANALYTICS

ION CHROMATOGRAPHY – H_2O RINSES

RESOLUTION ANALYTICS, INC.
Specialists in Air Emissions Analysis

ANALYTICAL REPORT

CLIENT: **AIR CONTROL TECHNIQUES, INC.**

PROJECT: 1756

ANALYTICAL SERVICES PROVIDED:

- IC SCAN OF H2O SAMPLE COMPONENTS
  (ION CHROMATOGRAPHY)

Confirmation of Data Review:

To the best of my knowledge this analytical data has been checked thoroughly for completeness and the results presented are accurate, error-free, legible, and have been performed and validated in accordance with the approved method(s).

Date of Review: November 20, 2012

J. Bruce Nemet

J. Bruce Nemet
Quality Assurance Officer

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RESOLUTION ANALYTICS, INC.
Specialists in Air Emissions Analysis

Client: Air Control Techniques
RFA #: 1756- Probe & > 2.5 µg H2O Rinses
Analysis: EPA Method 26/26A

Report Summary

Sample ID	Analyte(s) (mg) Cl_2
U1-1	0.491
U2-1	0.339
S1-1	3.13
S2-1	3.77
U1-2	0.211
U2-2	0.155
S1-2	1.73
S2-2	1.25
U1-3	0.222
U2-3	0.174
S1-3	1.75
S2-3	0.717
U1-4	0.572
U2-4	0.431
S1-4	0.952
S2-4	0.580
U1-5	0.994
U2-5	0.703
S1-5	2.85
S2-5	3.76
U1-6	0.520
U2-6	0.397
S1-6	0.735
S2-6	0.349

* EPA Audits are reported in mg/L CL-

RESOLUTION ANALYTICS, INC.
Specialists in Air Emissions Analysis

Client: Air Control Techniques
RFA #: 1756- Probe & > 2.5 µg H2O Rinses
Date Received: 10/31/2012
Date Analyzed: 11/14/2012
Analyst: TCS
Analysis: EPA Method 26/26A
Analyte(s): Hydrogen Halides and Halogens

Analytical Narrative

Sample Matrix & Components:

H2O probe rinses

Summary of Sample Prep:

Samples were resuspended in 50 ml DI H2O and sonicated for 15 minutes prior to analysis by ion chromatograghy. See data for dilution factors used in analysis.

Summary of Instrumentation:

Dionex ICS-2100 ion chromatogragh
IonPac AS20 4x250mm
Eluent: 25mM KOH
Suppressor current: 85 mA

25µl injection volume
Flow rate: 1.25 mls/min
Temp: 30° C

Limits Of Quantification:

Limit of Detection	Limit of Quantitation	Analytical Uncertainty
0.003 mg/L Cl_2	0.200 mg/L Cl_2	Cl_2 ± 0.4%

Summary Of QA Audit Sample Analysis:

See analytical data sheets for results of internal calibration verification standard results. All internal QC results within ±10 % limits.

Summary Sample Spike Analysis:

See Analytical data sheets for results of sample spike analyses. All spike results within 90% - 110% limits.

<u>Miscellaneous Comments Regarding Sample Analysis:</u> (Note unusual catch weights, interferences, odd sample behavior, and steps taken to confirm unusual results. Also note any deviations from standard analytical procedures, together with justification and possible affect on results. Specify samples when applicable.)

None

RESOLUTION ANALYTICS, INC.

Specialists in Air Emissions Analysis

Client: Air Control Techniques
RFA #: 1756- Probe & > 2.5 µg H2O Rinses
Analysis: EPA Method 26/26A

Chlorine Analytical Data Sheet

Chloride Standard Calibration Curve

Standard Manufacturer: AccuStandard
Lot ID: 211035184

m_2: 2.38E-04
m_1: 2.67E-01
b: -1.74E-02

R^2: 0.9999995

Cl$^-$ Conc. (mg/L)	Standard Areas Inj. 1	Inj. 2	Average Area	% Diff.	Cl$^-$ (mg/L)	% Deviation from Actual
0.200	0.0410	0.0377	0.0394	4.19%	0.213	6.47%
4.00	1.0490	1.0471	1.0481	0.09%	3.98	-0.44%
20.0	5.4155	5.4074	5.4115	0.07%	20.0	0.03%
40.0	11.0753	10.9794	11.0274	0.43%	40.0	0.00%

Internal Calibration Verification

Standard Manufacturer: AccuSpec
Lot ID: S110110006

	Inj. 1	Inj. 2	Average Area	% Dev.	Expected Cl$^-$ (mg/L)	Actual Cl$^-$ (mg/L)	% Diff.
ICV Standard	2.0878	2.1110	2.0994	0.55%	8.00	7.88	-1.44%

Field Samples

SAMPLE ID	Inj. 1 AREA	Inj. 2 AREA	ND	AVERAGE AREA	% Diff.	DILUTION FACTOR	ND	Cl$^-$ (mg/L)	SAMPLE VOLUME (ml)	ND	**Cl_2 CATCH (mg)**
U1-1	2.6152	2.6330		2.6241	0.34%	1		9.822	50		**0.491**
U2-1	1.8014	1.7980		1.7997	0.09%	1		6.775	50		**0.339**
S1-1	8.5609	8.5873		8.5741	0.15%	2		62.697	50		**3.13**
S2-1	10.3346	10.4156		10.3751	0.39%	2		75.422	50		**3.77**
U1-2	1.1224	1.1020		1.1122	0.92%	1		4.221	50		**0.211**
U2-2	0.8158	0.8085		0.8122	0.45%	1		3.103	50		**0.155**
S1-2	9.4904	9.4963		9.4934	0.03%	1		34.604	50		**1.73**
S2-2	6.8047	6.7680		6.7864	0.27%	1		24.964	50		**1.25**
U1-3	1.1808	1.1561		1.1685	1.06%	1		4.431	50		**0.222**
U2-3	0.9109	0.9178		0.9144	0.38%	1		3.484	50		**0.174**
S1-3	9.5737	9.6369		9.6053	0.33%	1		35.000	50		**1.75**
S2-3	3.8516	3.8583		3.8550	0.09%	1		14.341	50		**0.717**
U1-4	3.0677	3.0606		3.0642	0.12%	1		11.442	50		**0.572**
U2-4	2.2909	2.3082		2.2996	0.38%	1		8.624	50		**0.431**
S1-4	5.1308	5.1625		5.1467	0.31%	1		19.046	50		**0.952**
S2-4	3.1095	3.1068		3.1082	0.04%	1		11.604	50		**0.580**
U1-5	5.3524	5.4009		5.3767	0.45%	1		19.880	50		**0.994**
U2-5	3.7623	3.7920		3.7772	0.39%	1		14.057	50		**0.703**
S1-5	7.7882	7.7425		7.7654	0.29%	2		56.937	50		**2.85**
S2-5	10.3101	10.3667		10.3384	0.27%	2		75.164	50		**3.76**
U1-6	2.7742	2.7839		2.7791	0.17%	1		10.393	50		**0.520**
U2-6	2.1215	2.1078		2.1147	0.32%	1		7.941	50		**0.397**
S1-6	3.9730	3.9319		3.9525	0.52%	1		14.698	50		**0.735**
S2-6	1.8628	1.8495		1.8562	0.36%	1		6.984	50		**0.349**

RESOLUTION ANALYTICS, INC.
Specialists in Air Emissions Analysis

Client: Air Control Techniques
RFA #: 1756- Nozzle H2O Rinses
Analysis: EPA Method 26/26A

Report Summary

Sample ID	Analyte(s) (mg) Cl_2
U1-1	0.192
U2-1	0.119
S1-1	2.54
S2-1	3.24
U1-2	0.080
U2-2	0.086
S1-2	1.88
S2-2	2.77
U1-3	0.080
U2-3	0.054
S1-3	0.840
S2-3	0.362
U1-4	0.527
U2-4	0.213
S1-4	0.118
S2-4	0.130
U1-5	0.152
U2-5	0.164
S1-5	3.64
S2-5	1.32
U1-6	0.233
U2-6	0.417
S1-6	0.196
S2-6	0.107

* EPA Audits are reported in mg/L CL-

RESOLUTION ANALYTICS, INC.
Specialists in Air Emissions Analysis

Client: Air Control Techniques
RFA #: 1756- Nozzle H2O Rinses
Date Received: 10/31/2012
Date Analyzed: 11/15/2012
Analyst: TCS
Analysis: EPA Method 26/26A
Analyte(s): Hydrogen Halides and Halogens

Analytical Narrative

Sample Matrix & Components:

H2O nozzle rinses

Summary of Sample Prep:

Samples were resuspended in 50 ml DI H2O and sonicated for 15 minutes prior to analysis by ion chromatograghy. See data for dilution factors used in analysis.

Summary of Instrumentation:

Dionex ICS-2100 ion chromatogragh
IonPac AS20 4x250mm
Eluent: 25mM KOH
Suppressor current: 85 mA

25µl injection volume
Flow rate: 1.25 mls/min
Temp: 30° C

Limits Of Quantification:

Limit of Detection	Limit of Quantitation	Analytical Uncertainty
0.003 mg/L Cl_2	0.200 mg/L Cl_2	Cl_2 ± 0.4%

Summary Of QA Audit Sample Analysis:

See analytical data sheets for results of internal calibration verification standard results. All internal QC results within ±10 % limits.

Summary Sample Spike Analysis:

See Analytical data sheets for results of sample spike analyses. All spike results within 90% - 110% limits.

<u>Miscellaneous Comments Regarding Sample Analysis:</u> (Note unusual catch weights, interferences, odd sample behavior, and steps taken to confirm unusual results. Also note any deviations from standard analytical procedures, together with justification and possible affect on results. Specify samples when applicable.)

None

RESOLUTION ANALYTICS, INC.

Specialists in Air Emissions Analysis

Client: Air Control Techniques
RFA #: 1756- Nozzle H2O Rinses
Analysis: EPA Method 26/26A

Chlorine Analytical Data Sheet

Chloride Standard Calibration Curve

Standard Manufacturer: AccuStandard
Lot ID: 211035184

m_2: 2.38E-04
m_1: 2.67E-01
b: -1.74E-02

R^2: 0.9999995

Cl^- Conc. (mg/L)	Standard Areas Inj. 1	Standard Areas Inj. 2	Average Area	% Diff.	Cl^- (mg/L)	% Deviation from Actual
0.200	0.0410	0.0377	0.0394	4.19%	0.213	6.47%
4.00	1.0490	1.0471	1.0481	0.09%	3.98	-0.44%
20.0	5.4155	5.4074	5.4115	0.07%	20.0	0.03%
40.0	11.0753	10.9794	11.0274	0.43%	40.0	0.00%

Internal Calibration Verification

Standard Manufacturer: AccuSpec
Lot ID: S110110006

	Inj. 1	Inj. 2	Average Area	% Dev.	Expected Cl^- (mg/L)	Actual Cl^- (mg/L)	% Diff.
ICV Standard	2.0448	2.0709	2.0579	0.63%	8.00	7.73	-3.36%

Field Samples

SAMPLE ID	Inj. 1 AREA	Inj. 2 AREA	ND	AVERAGE AREA	% Diff.	DILUTION FACTOR	ND	Cl^- (mg/L)	SAMPLE VOLUME (ml)	ND	Cl_2 CATCH (mg)
U1-1	1.0119	1.0069		1.0094	0.25%	1		3.838	50		**0.192**
U2-1	0.6228	0.6180		0.6204	0.39%	1		2.387	50		**0.119**
S1-1	6.8923	6.9128		6.9026	0.15%	2		50.762	50		**2.54**
S2-1	8.8794	8.8771		8.8783	0.01%	2		64.855	50		**3.24**
U1-2	0.4102	0.4040		0.4071	0.76%	1		1.590	50		**0.080**
U2-2	0.4455	0.4412		0.4434	0.48%	1		1.726	50		**0.086**
S1-2	10.3786	10.3595		10.3691	0.09%	1		37.690	50		**1.88**
S2-2	7.5454	7.5515		7.5485	0.04%	2		55.388	50		**2.77**
U1-3	0.4116	0.4088		0.4102	0.34%	1		1.602	50		**0.080**
U2-3	0.2712	0.2689		0.2701	0.43%	1		1.077	50		**0.054**
S1-3	4.5374	4.5145		4.5260	0.25%	1		16.790	50		**0.840**
S2-3	1.9170	1.9321		1.9246	0.39%	1		7.238	50		**0.362**
U1-4	2.8131	2.8296		2.8214	0.29%	1		10.549	50		**0.527**
U2-4	1.1198	1.1278		1.1238	0.36%	1		4.264	50		**0.213**
S1-4	0.6105	0.6116		0.6111	0.09%	1		2.352	50		**0.118**
S2-4	0.6742	0.6805		0.6774	0.47%	1		2.600	50		**0.130**
U1-5	0.7961	0.7984		0.7973	0.14%	1		3.048	50		**0.152**
U2-5	0.8606	0.8592		0.8599	0.08%	1		3.281	50		**0.164**
S1-5	10.0002	9.9969		9.9986	0.02%	2		72.773	50		**3.64**
S2-5	7.2057	7.1703		7.1880	0.25%	1		26.404	50		**1.32**
U1-6	1.2302	1.2312		1.2307	0.04%	1		4.662	50		**0.233**
U2-6	2.2260	2.2213		2.2237	0.11%	1		8.344	50		**0.417**
S1-6	1.0277	1.0309		1.0293	0.16%	1		3.913	50		**0.196**
S2-6	0.5601	0.5532		0.5567	0.62%	1		2.149	50		**0.107**

Client: Air Control Techniques
RFA #: 1756- ≤ 2.5 µm H2O Rinses
Analysis: EPA Method 26/26A

Report Summary

Sample ID		**Analyte(s) (mg)** **Cl_2**
DI H_2O Blank	<	0.011
U1-1		0.026
U2-1		0.019
S1-1		0.219
S2-1		0.486
U1-2		0.031
U2-2		0.025
S1-2		0.126
S2-2		0.120
U1-3		0.017
U2-3		0.023
S1-3		0.129
S2-3		0.191
U1-4		0.042
U2-4		0.030
S1-4		0.070
S2-4		0.046
U1-5		0.030
U2-5		0.030
S1-5		0.084
S2-5		0.051
U1-6		0.028
U2-6		0.034
S1-6		0.026
S2-6		0.058

* EPA Audits are reported in mg/L CL-

RESOLUTION ANALYTICS, INC.
Specialists in Air Emissions Analysis

Client: Air Control Techniques
RFA #: 1756- ≤ 2.5 µm H2O Rinses
Date Received: 10/31/2012
Date Analyzed: 11/13/2012
Analyst: TCS
Analysis: EPA Method 26/26A
Analyte(s): Hydrogen Halides and Halogens

Analytical Narrative

Sample Matrix & Components:

H2O rinses

Summary of Sample Prep:

Samples were resuspended in 50 ml DI H2O and sonicated for 15 minutes prior to analysis by ion chromatograghy. See data for dilution factors used in analysis.

Summary of Instrumentation:

Dionex ICS-2100 ion chromatogragh
IonPac AS20 4x250mm
Eluent: 25mM KOH
Suppressor current: 85 mA

25µl injection volume
Flow rate: 1.25 mls/min
Temp: 30° C

Limits Of Quantification:

Limit of Detection	Limit of Quantitation	Analytical Uncertainty
0.003 mg/L Cl_2	0.200 mg/L Cl_2	Cl_2 ± 0.4%

Summary Of QA Audit Sample Analysis:

See analytical data sheets for results of internal calibration verification standard results. All internal QC results within ±10 % limits.

Summary Sample Spike Analysis:

See Analytical data sheets for results of sample spike analyses. All spike results within 90% - 110% limits.

Miscellaneous Comments Regarding Sample Analysis: **(Note unusual catch weights, interferences, odd sample behavior, and steps taken to confirm unusual results. Also note any deviations from standard analytical procedures, together with justification and possible affect on results. Specify samples when applicable.)**

None

RESOLUTION ANALYTICS, INC.
Specialists in Air Emissions Analysis

Client: Air Control Techniques
RFA #: 1756- ≤ 2.5 µm H2O Rinses
Analysis: EPA Method 26/26A

Chlorine Analytical Data Sheet

Chloride Standard Calibration Curve

Standard Manufacturer: AccuStandard
Lot ID: 211035184

m_2: 2.38E-04
m_1: 2.67E-01
b: -1.74E-02

R^2: 0.9999995

Cl^- Conc. (mg/L)	Standard Areas Inj. 1	Standard Areas Inj. 2	Average Area	% Diff.	Cl^- (mg/L)	% Deviation from Actual
0.200	0.0410	0.0377	0.0394	4.19%	0.213	6.47%
4.00	1.0490	1.0471	1.0481	0.09%	3.98	-0.44%
20.0	5.4155	5.4074	5.4115	0.07%	20.0	0.03%
40.0	11.0753	10.9794	11.0274	0.43%	40.0	0.00%

Internal Calibration Verification

Standard Manufacturer: AccuSpec
Lot ID: S110110006

	Inj. 1	Inj. 2	Average Area	% Dev.	Expected Cl^- (mg/L)	Actual Cl^- (mg/L)	% Diff.
ICV Standard	2.0995	2.0930	2.0963	0.16%	8.00	7.87	-1.59%

Matrix Spike

Sample I.D.	Inj. 1	Inj. 2	Average Area	% Dev.	Spike Cl^- (mg/L)	Sample Cl^- (mg/L)	Calc. Cl^- (mg/L)	% Recovery
S2-6	5.5608	5.5448	5.5528	0.14%	20.5	1.17	20.6	99.7%

Note: 0.5 mls of the above sample was spiked with
0.5 mls of a 40.0 ppm chloride standard.

Field Samples

SAMPLE ID	Inj. 1 AREA	Inj. 2 AREA	ND	AVERAGE AREA	% Diff.	DILUTION FACTOR	ND	Cl^- (mg/L)	SAMPLE VOLUME (ml)	ND	**Cl_2 CATCH (mg)**
DI H2O Blank	0.0026	0.0022	<	0.0394	NA	1	<	0.213	50	<	**0.011**
U1-1	0.1194	0.1185		0.1190	0.38%	1		0.511	50		**0.026**
U2-1	0.0874	0.0854		0.0864	1.16%	1		0.389	50		**0.019**
S1-1	1.1546	1.1545		1.1546	0.00%	1		4.379	50		**0.219**
S2-1	2.5888	2.6024		2.5956	0.26%	1		9.717	50		**0.486**
U1-2	0.1516	0.1487		0.1502	0.97%	1		0.628	50		**0.031**
U2-2	0.1159	0.1143		0.1151	0.70%	1		0.497	50		**0.025**
S1-2	0.6561	0.6579		0.6570	0.14%	1		2.524	50		**0.126**
S2-2	0.6253	0.6248		0.6251	0.04%	1		2.405	50		**0.120**
U1-3	0.0745	0.0742		0.0744	0.20%	1		0.344	50		**0.017**
U2-3	0.1046	0.1063		0.1055	0.81%	1		0.461	50		**0.023**
S1-3	0.6767	0.6674		0.6721	0.69%	1		2.580	50		**0.129**
S2-3	1.0076	1.0061		1.0069	0.07%	1		3.829	50		**0.191**
U1-4	0.2059	0.2067		0.2063	0.19%	1		0.839	50		**0.042**
U2-4	0.1425	0.1426		0.1426	0.04%	1		0.600	50		**0.030**
S1-4	0.3565	0.3570		0.3568	0.07%	1		1.402	50		**0.070**
S2-4	0.2290	0.2282		0.2286	0.17%	1		0.922	50		**0.046**
U1-5	0.1440	0.1453		0.1447	0.45%	1		0.608	50		**0.030**
U2-5	0.1397	0.1403		0.1400	0.21%	1		0.590	50		**0.030**
S1-5	0.4283	0.4293		0.4288	0.12%	1		1.671	50		**0.084**
S2-5	0.2537	0.2545		0.2541	0.16%	1		1.018	50		**0.051**
U1-6	0.1309	0.1335		0.1322	0.98%	1		0.561	50		**0.028**
U2-6	0.1610	0.1630		0.1620	0.62%	1		0.673	50		**0.034**
S1-6	0.1218	0.1229		0.1224	0.45%	1		0.524	50		**0.026**
S2-6	0.2946	0.2924		0.2935	[illegible]	1		1.165	50		**[illegible]**

RESOLUTION ANALYTICS, INC.
Specialists in High Performance Liquid Chromatography

REPORT SUMMARY

RFA#: 1756

SAMPLE ID	≤ 2.5 µm	Probe Rinse	Nozzle & > 2.5 µm
DI H2O BLANK	0.092 mg		
U1-1	0.038 mg	0.410 mg	0.228 mg
U2-1	0.069 mg	0.250 mg	0.135 mg
S1-1	0.177 mg	2.19 mg	1.79 mg
S2-1	0.345 mg	2.43 mg	2.19 mg
U1-2	0.051 mg	0.152 mg	0.123 mg
U2-2	0.070 mg	0.160 mg	0.099 mg
S1-2	0.167 mg	1.10 mg	1.16 mg
S2-2	0.092 mg	0.751 mg	1.92 mg
U1-3	0.043 mg	0.243 mg	0.106 mg
U2-3	0.084 mg	0.156 mg	0.091 mg
S1-3	0.144 mg	1.04 mg	0.543 mg
S2-3	0.289 mg	0.455 mg	0.261 mg
U1-4	0.093 mg	0.428 mg	0.376 mg
U2-4	0.098 mg	0.296 mg	0.221 mg
S1-4	0.130 mg	0.679 mg	0.113 mg
S2-4	0.097 mg	0.394 mg	0.114 mg
U1-5	0.086 mg	0.672 mg	0.196 mg
U2-5	0.070 mg	0.478 mg	0.137 mg
S1-5	0.101 mg	1.82 mg	2.33 mg
S2-5	0.089 mg	2.43 mg	0.779 mg
U1-6	0.056 mg	0.369 mg	0.242 mg
U2-6	0.060 mg	0.278 mg	0.287 mg
S1-6	0.058 mg	0.463 mg	0.135 mg
S2-6	0.117 mg	0.238 mg	0.103 mg

Analytical Narrative

RFA # 1756

Page 1 of 1

Client/Plant Name: Air Control Techniques

Date Rec'd in lab: 10/31/2012

Analyst: TCS

Date of Analysis: 11/16/2012

Analysis Method: Ion Chromatography

Analyte(s): Na

Sample Matrix & Components:

H2O rinse samples.

Summary of Sample Prep:

Samples were re-suspended in 50 ml of DI H2O and sonicated for 15 minutes prior to analysis by ion chromatography.

Summary of Instrumentation:

Shimadzu CDD-6A. Hamilton PRP-X200 250x4.1mm
Eluent: 5.7 mM HNO3
Gain 0.2 µS/cm

20 µl Inj.
Flow Rate: 1.75 mls/min
Temp: 40°C

Limit(s) of Quantification: 1.20 ppm Na

Summary of QA Audit Sample Analysis:

See Analytical Data Sheets for results of internal QC audit results. (All internal QC results were within ±10% limits.)

Summary of Sample Spike Analysis:

See Analytical Data Sheets for results of sample spike analyses. (All spike results were within 90-110% recovery limits.)

Miscellaneous Comments Regarding Sample Analysis: (Note unusual catch weights, interferences, odd sample behavior, and steps taken to confirm unusual results. Also note any deviations from standard analytical procedures, together with justification and possible affect on results. Specify samples when applicable.)

1. All samples were blank-corrected to account for background levels of sodium found in DI H2O.

Confirmation of Data Review:

To the best of my knowledge this analytical data has been checked thoroughly for completeness and the results presented are accurate, error-free, legible, and have been performed and validated in accordance with the approved method(s).

Lab QA Officer Signature ______________________ Date ____________

Sodium Analytical Data Sheet

Client Name:	**Air Control Techniques**	Job Num.	**1756**
File Pathway:	C:\JOBS\ACT\1756\LESS THAN 2PT5.WB1	File:	Less Than 2pt5
Analyst:	TCS	Date:	11/13/2012

Sodium Standard Calibration Curve by Linear Regression

Na Conc. (ppm)	Standard Areas Inj. 1	Standard Areas Inj. 2	Average Area	% Diff.		Calculated Std Conc. (ppm)	% Deviation from Actual
1.25	82326	79160	80743	1.96%		1.20	-3.65%
5.00	321662	314363	318013	1.15%		4.94	-1.28%
20.0	1289664	1287450	1288557	0.09%		20.2	1.00%
40.0	2484038	2599314	2541676	2.27%		39.9	-0.23%
Standard Curve		Slope:	63582	Y-Int:	4170	LoQ (ppm):	**1.20**

Field Samples in: DI H2O

SAMPLE ID	Inj. 1 AREA	Inj. 2 AREA	AVERAGE AREA	% Diff.	DILUTION FACTOR	SAMPLE VOLUME (ml)	Na CATCH (mg)
DI H2O Blank	123389	118754	121072	1.91%	1	50	**0.092**
U1-1	170754	168523	169639	0.66%	1	50	**0.038**
U2-1	211511	205402	208457	1.47%	1	50	**0.069**
S1-1	330242	362538	346390	4.66%	1	50	**0.177**
S2-1	550929	568695	559812	1.59%	1	50	**0.345**
U1-2	184038	188248	186143	1.13%	1	50	**0.051**
U2-2	208508	212569	210539	0.96%	1	50	**0.070**
S1-2	326428	340424	333426	2.10%	1	50	**0.167**
S2-2	242288	234034	238161	1.73%	1	50	**0.092**
U1-3	175652	175925	175789	0.08%	1	50	**0.043**
U2-3	229711	225296	227504	0.97%	1	50	**0.084**
S1-3	310978	298554	304766	2.04%	1	50	**0.144**
S2-3	488551	487834	488193	0.07%	1	50	**0.289**
U1-4	235036	243173	239105	1.70%	1	50	**0.093**
U2-4	245956	246536	246246	0.12%	1	50	**0.098**
S1-4	283151	289788	286470	1.16%	1	50	**0.130**
S2-4	244510	245129	244820	0.13%	1	50	**0.097**
U1-5	225068	235874	230471	2.34%	1	50	**0.086**
U2-5	210579	210600	210590	0.00%	1	50	**0.070**
S1-5	246745	252470	249608	1.15%	1	50	**0.101**
S2-5	238541	229238	233890	1.99%	1	50	**0.089**
U1-6	191024	192810	191917	0.47%	1	50	**0.056**
U2-6	200439	195137	197788	1.34%	1	50	**0.060**
S1-6	192333	197442	194888	1.31%	1	50	**0.058**
S2-6	279710	259137	269424	3.82%	1	50	**0.117**

******* AUDIT REPORT *******

	Inj. 1	Inj. 2	Average Area	% Dev.	Expected ppm Na	Calculated ppm Na	Percent Diff.
IN-HOUSE AUDIT	258218	250310	254264	1.56%	4.00	3.93	-1.66%

MATRIX SPIKE

Sample I.D.	Inj. 1	Inj. 2	Average Area	% Dev.	Expected ppm Na	Calculated ppm Na	% Recovery
S2-6	694399	644739	669569	3.71%	10.0	9.34	93.4%

Note: 0.50 mls of the above sample was spiked with
0.50 mls of a 20.0 ppm sodium standard.

Sodium Analytical Data Sheet

Client Name:	**Air Control Techniques**	Job Num.	**1756**
File Pathway:	C:\JOBS\ACT\1756\NOZZLE RINSE.WB1	File:	Nozzle Rinse
Analyst:	TCS	Date:	11/16/2012

Sodium Standard Calibration Curve by Linear Regression

Na Conc. (ppm)	Standard Areas Inj. 1	Inj. 2	Average Area	% Diff.	Calculated Std Conc. (ppm)	% Deviation from Actual
1.25	82326	79160	80743	1.96%	1.20	-3.65%
5.00	321662	314363	318013	1.15%	4.94	-1.28%
20.0	1289664	1287450	1288557	0.09%	20.2	1.00%
40.0	2484038	2599314	2541676	2.27%	39.9	-0.23%

Standard Curve — Slope: 63582 — Y-Int: 4170 — LoQ (ppm): **1.20**

Field Samples in: DI H2O

SAMPLE ID	Inj. 1 AREA	Inj. 2 AREA	AVERAGE AREA	% Diff.	DILUTION FACTOR	SAMPLE VOLUME (ml)	**Na CATCH (mg)**
U1-1	402197	418903	410550	2.03%	1	50	**0.228**
U2-1	289476	295398	292437	1.01%	1	50	**0.135**
S1-1	1208849	1187327	1198088	0.90%	2	50	**1.79**
S2-1	1459147	1452446	1455797	0.23%	2	50	**2.19**
U1-2	277674	278607	278141	0.17%	1	50	**0.123**
U2-2	240735	253491	247113	2.58%	1	50	**0.099**
S1-2	1605041	1575723	1590382	0.92%	1	50	**1.16**
S2-2	1291024	1271312	1281168	0.77%	2	50	**1.92**
U1-3	255094	256767	255931	0.33%	1	50	**0.106**
U2-3	240825	232794	236810	1.70%	1	50	**0.091**
S1-3	817816	804732	811274	0.81%	1	50	**0.543**
S2-3	463714	443294	453504	2.25%	1	50	**0.261**
U1-4	592272	606304	599288	1.17%	1	50	**0.376**
U2-4	398515	405544	402030	0.87%	1	50	**0.221**
S1-4	258265	272129	265197	2.61%	1	50	**0.113**
S2-4	269080	264253	266667	0.91%	1	50	**0.114**
U1-5	379571	362470	371021	2.30%	1	50	**0.196**
U2-5	309576	280204	294890	4.98%	1	50	**0.137**
S1-5	1501513	1586342	1543928	2.75%	2	50	**2.33**
S2-5	1119696	1102934	1111315	0.75%	1	50	**0.779**
U1-6	429669	428607	429138	0.12%	1	50	**0.242**
U2-6	478385	493982	486184	1.60%	1	50	**0.287**
S1-6	298996	286027	292512	2.22%	1	50	**0.135**
S2-6	256229	247083	251656	1.82%	1	50	**0.103**

******* AUDIT REPORT *******

	Inj. 1	Inj. 2	Average Area	% Dev.	Expected ppm Na	Calculated ppm Na	Percent Diff.
IN-HOUSE AUDIT	264690	277021	270856	2.28%	4.00	4.19	4.86%

Sodium Analytical Data Sheet

Client Name:	**Air Control Techniques**	Job Num.	**1756**
File Pathway:	C:\JOBS\ACT\1756\PROBE RINSE.WB1	File:	Probe Rinse
Analyst:	TCS	Date:	11/16/2012

Sodium Standard Calibration Curve by Linear Regression

Na Conc. (ppm)	Standard Areas Inj. 1	Standard Areas Inj. 2	Average Area	% Diff.		Calculated Std Conc. (ppm)	% Deviation from Actual
1.25	82326	79160	80743	1.96%		1.20	-3.65%
5.00	321662	314363	318013	1.15%		4.94	-1.28%
20.0	1289664	1287450	1288557	0.09%		20.2	1.00%
40.0	2484038	2599314	2541676	2.27%		39.9	-0.23%
Standard Curve		Slope:	63582	Y-Int:	4170	LoQ (ppm):	**1.20**

Field Samples in: DI H2O

SAMPLE ID	Inj. 1 AREA	Inj. 2 AREA	AVERAGE AREA	% Diff.	DILUTION FACTOR	SAMPLE VOLUME (ml)	Na CATCH (mg)
U1-1	635732	649882	642807	1.10%	1	50	**0.410**
U2-1	440803	438390	439597	0.27%	1	50	**0.250**
S1-1	1456907	1458386	1457647	0.05%	2	50	**2.19**
S2-1	1590676	1621980	1606328	0.97%	2	50	**2.43**
U1-2	327962	302188	315075	4.09%	1	50	**0.152**
U2-2	322053	326039	324046	0.62%	1	50	**0.160**
S1-2	1524564	1507841	1516203	0.55%	1	50	**1.10**
S2-2	1079039	1073692	1076366	0.25%	1	50	**0.751**
U1-3	432165	428570	430368	0.42%	1	50	**0.243**
U2-3	313869	324610	319240	1.68%	1	50	**0.156**
S1-3	1454454	1444469	1449462	0.34%	1	50	**1.04**
S2-3	692765	707228	699997	1.03%	1	50	**0.455**
U1-4	668949	662707	665828	0.47%	1	50	**0.428**
U2-4	483618	511524	497571	2.80%	1	50	**0.296**
S1-4	980712	988400	984556	0.39%	1	50	**0.679**
S2-4	622058	623469	622764	0.11%	1	50	**0.394**
U1-5	988669	961467	975068	1.39%	1	50	**0.672**
U2-5	726589	731730	729160	0.35%	1	50	**0.478**
S1-5	1191704	1249003	1220354	2.35%	2	50	**1.82**
S2-5	1595293	1618303	1606798	0.72%	2	50	**2.43**
U1-6	587330	593443	590387	0.52%	1	50	**0.369**
U2-6	477372	472485	474929	0.51%	1	50	**0.278**
S1-6	704465	716363	710414	0.84%	1	50	**0.463**
S2-6	428205	419901	424053	0.98%	1	50	**0.238**

***** **AUDIT REPORT** *****

	Inj. 1	Inj. 2	Average Area	% Dev.	Expected ppm Na	Calculated ppm Na	Percent Diff.
IN-HOUSE AUDIT	250310	264690	257500	2.79%	4.00	3.98	-0.39%

APPENDIX G

ANALYTICAL DATA

RESOLUTION ANALYTICS

CHLORIDES ON FILTERS

RESOLUTION ANALYTICS, INC.

Specialists in Air Emissions Analysis

ANALYTICAL REPORT

CLIENT:	**AIR CONTROL TECHNIQUES, INC.**
PROJECT:	1756

ANALYTICAL SERVICES PROVIDED:

- CL ON FILTERS
  (ION CHROMATOGRAPHY)

Confirmation of Data Review:

To the best of my knowledge this analytical data has been checked thoroughly for completeness and the results presented are accurate, error-free, legible, and have been performed and validated in accordance with the approved method(s).

Date of Review: November 29, 2012

J. Bruce Nemet

J. Bruce Nemet

Quality Assurance Officer

www.resolutionanalytics.com

2733 Lee Avenue • Sanford, NC 27332 • Phone: 919-774-5557 • Fax: 919-776-6785

Client: Air Control Techniques
RFA #: 1756- Filters
Analysis: EPA Method 26/26A

Report Summary

Sample ID	Analyte(s) (mg) Cl
U1-1	2.06
U2-1	2.43
S1-1	23.8
S2-1	24.8
U1-2	0.824
U2-2	0.670
S1-2	20.9
S2-2	16.5
U1-3	1.01
U2-3	1.03
S1-3	9.34
S2-3	6.61
U1-4	1.05
U2-4	0.940
S1-4	3.11
S2-4	3.57
U1-5	1.45
U2-5	1.49
S1-5	23.9
S2-5	3.30
U1-6	2.64
U2-6	2.59
S1-6	6.91
S2-6	0.898

* EPA Audits are reported in mg/L CL-

RESOLUTION ANALYTICS, INC.
Specialists in Air Emissions Analysis

Client: Air Control Techniques
RFA #: 1756- Filters
Date Received: 10/31/2012
Date Analyzed: 11/27/2012
Analyst: TCS
Analysis: EPA Method 26/26A
Analyte(s): Hydrogen Halides and Halogens

Analytical Narrative

Sample Matrix & Components:

Filters in DI H2O

Summary of Sample Prep:

Filters were desorbed in 20 ml DI H2O, sonicated for 15 minutes and homogenized prior to analysis by ion chromatograghy. See data for dilution factors used in analysis.

Summary of Instrumentation:

Dionex ICS-2100 ion chromatogragh	25µl injection volume
IonPac AS20 4x250mm	Flow rate: 1.25 mls/min
Eluent: 25mM KOH	Temp: 30° C
Suppressor current: 85 mA	

Limits Of Quantification:

Limit of Detection	Limit of Quantitation	Analytical Uncertainty
0.003 mg/L Cl_2	0.200 mg/L Cl_2	Cl_2 ± 0.4%

Summary Of QA Audit Sample Analysis:

See analytical data sheets for results of internal calibration verification standard results. All internal QC results within ±10 % limits.

Summary Sample Spike Analysis:

See Analytical data sheets for results of sample spike analyses. All spike results within 90% - 110% limits.

Miscellaneous Comments Regarding Sample Analysis: **(Note unusual catch weights, interferences, odd sample behavior, and steps taken to confirm unusual results. Also note any deviations from standard analytical procedures, together with justification and possible affect on results. Specify samples when applicable.)**

None

RESOLUTION ANALYTICS, INC.
Specialists in Air Emissions Analysis

Client: Air Control Techniques
RFA #: 1756- Filters
Analysis: EPA Method 26/26A

Chloride Analytical Data Sheet

Chloride Standard Calibration Curve

Standard Manufacturer: AccuStandard
Lot ID: 211035184

m_2: 2.38E-04
m_1: 2.67E-01
b: -1.74E-02

R^2: 0.9999995

Cl^- Conc. (mg/L)	Standard Areas Inj. 1	Standard Areas Inj. 2	Average Area	% Diff.	Cl^- (mg/L)	% Deviation from Actual
0.200	0.0410	0.0377	0.0394	4.19%	0.213	6.47%
4.00	1.0490	1.0471	1.0481	0.09%	3.98	-0.44%
20.0	5.4155	5.4074	5.4115	0.07%	20.0	0.03%
40.0	11.0753	10.9794	11.0274	0.43%	40.0	0.00%

Internal Calibration Verification

Standard Manufacturer: AccuSpec
Lot ID: S110110006

	Inj. 1	Inj. 2	Average Area	% Dev.	Expected Cl^- (mg/L)	Actual Cl^- (mg/L)	% Diff.
ICV Standard	2.0512	2.1315	2.0914	1.92%	8.00	7.85	-1.81%

Field Samples

SAMPLE ID	Inj. 1 AREA	Inj. 2 AREA	ND	AVERAGE AREA	% Diff.	DILUTION FACTOR	ND	Cl^- (mg/L)	SAMPLE VOLUME (ml)	ND	**Cl CATCH (mg)**
U1-1	7.0284	6.9898		7.0091	0.28%	4		103.053	20		**2.06**
U2-1	8.3274	8.2885		8.3080	0.23%	4		121.609	20		**2.43**
S1-1	3.1435	3.2258		3.1847	1.29%	100		1188.471	20		**23.8**
S2-1	3.3323	3.3261		3.3292	0.09%	100		1241.538	20		**24.8**
U1-2	5.5704	5.5799		5.5752	0.09%	2		41.197	20		**0.824**
U2-2	9.2121	9.1592		9.1857	0.29%	1		33.517	20		**0.670**
S1-2	2.7820	2.7995		2.7908	0.31%	100		1043.609	20		**20.9**
S2-2	2.2626	2.1230		2.1928	3.18%	100		823.000	20		**16.5**
U1-3	6.8634	6.8977		6.8806	0.25%	2		50.604	20		**1.01**
U2-3	7.0302	7.0240		7.0271	0.04%	2		51.655	20		**1.03**
S1-3	1.2331	1.2334		1.2333	0.01%	100		467.177	20		**9.34**
S2-3	9.0500	9.0500		9.0500	0.00%	10		330.363	20		**6.61**
U1-4	7.1999	7.0651		7.1325	0.94%	2		52.411	20		**1.05**
U2-4	6.3758	6.3794		6.3776	0.03%	2		46.989	20		**0.940**
S1-4	4.1894	4.1958		4.1926	0.08%	10		155.749	20		**3.11**
S2-4	4.8123	4.8156		4.8140	0.03%	10		178.380	20		**3.57**
U1-5	9.9336	10.0167		9.9752	0.42%	2		72.608	20		**1.45**
U2-5	10.2018	10.2177		10.2098	0.08%	2		74.259	20		**1.49**
S1-5	3.2369	3.1784		3.2077	0.91%	100		1196.918	20		**23.9**
S2-5	4.4614	4.4264		4.4439	0.39%	10		164.913	20		**3.30**
U1-6	9.0348	9.0204		9.0276	0.08%	4		131.828	20		**2.64**
U2-6	8.8674	8.8336		8.8505	0.19%	4		129.317	20		**2.59**
S1-6	9.4975	9.4699		9.4837	0.15%	10		345.704	20		**6.91**
S2-6	6.1035	6.0703		6.0869	0.27%	2		44.894	20		**0.898**

APPENDIX H

ANALYTICAL DATA

RESOLUTION ANALYTICS

SODIUM ON FILTERS

RESOLUTION ANALYTICS, INC.
Specialists in High Performance Liquid Chromatography

REPORT SUMMARY

RFA#: 1756-Filters

SAMPLE ID	Sodium
U1-1	4.06 mg
U2-1	4.14 mg
S1-1	17.0 mg
S2-1	17.5 mg
U1-2	1.63 mg
U2-2	1.40 mg
S1-2	17.0 mg
S2-2	11.8 mg
U1-3	1.89 mg
U2-3	2.09 mg
S1-3	9.72 mg
S2-3	5.54 mg
U1-4	2.32 mg
U2-4	2.13 mg
S1-4	3.41 mg
S2-4	4.15 mg
U1-5	1.63 mg
U2-5	1.70 mg
S1-5	16.6 mg
S2-5	2.36 mg
U1-6	3.93 mg
U2-6	3.75 mg
S1-6	5.99 mg
S2-6	0.550 mg

Analytical Narrative

RFA # 1756

Page 1 of 1

Client/Plant Name: Air Control Techniques

Date Rec'd in lab: 10/31/2012

Analyst: TCS

Date of Analysis: 11/29/2012

Analysis Method: Ion Chromatography

Analyte(s): Na

Sample Matrix & Components:

Filters in DI H2O.

Summary of Sample Prep:

Filters were desorbed in 20 ml of DI H2O, sonicated for 15 minutes and homogenized prior to analysis by ion chromatography.

Summary of Instrumentation:

Shimadzu CDD-6A. Hamilton PRP-X200 250x4.1mm

Eluent: 5.7 mM HNO3

Gain 0.4 µS/cm

20 µl Inj.

Flow Rate: 1.75 mls/min

Temp: 40°C

Limit(s) of Quantification: 1.20 ppm Na

Summary of QA Audit Sample Analysis:

See Analytical Data Sheets for results of internal QC audit results. (All internal QC results were within ±10% limits.)

Summary of Sample Spike Analysis:

See Analytical Data Sheets for results of sample spike analyses (All spike results were within 90-110% recovery limits.)

Miscellaneous Comments Regarding Sample Analysis: (Note unusual catch weights, interferences, odd sample behavior, and steps taken to confirm unusual results. Also note any deviations from standard analytical procedures, together with justification and possible affect on results. Specify samples when applicable.)

1. All samples were blank-corrected to account for background levels of sodium found in DI H2O.

Confirmation of Data Review:

To the best of my knowledge this analytical data has been checked thoroughly for completeness and the results presented are accurate, error-free, legible, and have been performed and validated in accordance with the approved method(s).

Lab QA Officer Signature J. Bruce Stewart

Date 11/30/2012

Sodium Analytical Data Sheet

Client Name:	**Air Control Techniques**	Job Num.	**1756**
File Pathway:	C:\JOBS\ACT\1756\FILTERS.WB1	File:	Filters
Analyst:	TCS	Date:	11/29/2012

Sodium Standard Calibration Curve by Linear Regression

Na Conc. (ppm)	Standard Areas Inj. 1	Standard Areas Inj. 2	Average Area	% Diff.	Calculated Std Conc. (ppm)	% Deviation from Actual
1.25	82326	79160	80743	1.96%	1.20	-3.65%
5.00	321662	314363	318013	1.15%	4.94	-1.28%
20.0	1289664	1287450	1288557	0.09%	20.2	1.00%
40.0	2484038	2599314	2541676	2.27%	39.9	-0.23%

Standard Curve Slope: 63582 Y-Int: 4170 LoQ (ppm): **1.20**

Field Samples in: DI H2O

SAMPLE ID	Inj. 1 AREA	Inj. 2 AREA	AVERAGE AREA	% Diff.	DILUTION FACTOR	SAMPLE VOLUME (ml)	**Na CATCH (mg)**
DI H2O Blank	123389	118754	121072	1.91%	1	20	**0.037**
U1-1	1622859	1643805	1633332	0.64%	8	20	**4.06**
U2-1	1645404	1679119	1662262	1.01%	8	20	**4.14**
S1-1	536512	556878	546695	1.86%	100	20	**17.0**
S2-1	570812	554541	562677	1.45%	100	20	**17.5**
U1-2	1337823	1326913	1332368	0.41%	4	20	**1.63**
U2-2	2289314	2301486	2295400	0.27%	2	20	**1.40**
S1-2	540383	550533	545458	0.93%	100	20	**17.0**
S2-2	391067	367524	379296	3.10%	100	20	**11.8**
U1-3	1521885	1544548	1533217	0.74%	4	20	**1.89**
U2-3	1686122	1703289	1694706	0.51%	4	20	**2.09**
S1-3	321512	307474	314493	2.23%	100	20	**9.72**
S2-3	1767171	1787564	1777368	0.57%	10	20	**5.54**
U1-4	1872000	1881530	1876765	0.25%	4	20	**2.32**
U2-4	1740608	1707732	1724170	0.95%	4	20	**2.13**
S1-4	1103217	1095680	1099449	0.34%	10	20	**3.41**
S2-4	1350970	1321154	1336062	1.12%	10	20	**4.15**
U1-5	1317554	1346082	1331818	1.07%	4	20	**1.63**
U2-5	1380066	1394043	1387055	0.50%	4	20	**1.70**
S1-5	531970	537281	534626	0.50%	100	20	**16.6**
S2-5	771837	763657	767747	0.53%	10	20	**2.36**
U1-6	1586442	1572047	1579245	0.46%	8	20	**3.93**
U2-6	1515010	1506695	1510853	0.28%	8	20	**3.75**
S1-6	1917174	1923842	1920508	0.17%	10	20	**5.99**
S2-6	935717	939775	937746	0.22%	2	20	**0.550**

***** AUDIT REPORT *****

	Inj. 1	Inj. 2	Average Area	% Dev.	Expected ppm Na	Calculated ppm Na	Percent Diff.
IN-HOUSE AUDIT	252038	250449	251244	0.32%	4.00	3.89	-2.85%

Appendix E

Precutter Nozzle Cut Size Test Protocol

May 12, 2014

Test Protocol

Precutter Nozzle Cut Size Filterable PM2.5 Wet Stack Test Method

Prepared for

American Petroleum Institute
1220 L Street NW
Washington, DC 20005

and

The National Council for Air & Stream Improvement
NCASI Southern Regional Center
402 SW 140th Terrace
Newberry, FL, 32669

Prepared by

Air Control Techniques, P.C.
301 E. Durham Road
Cary, NC 27513

May 12, 2014

Precutter Nozzle Testing Protocol
Filterable PM2.5 Wet Stack Test Method

This protocol summarizes a revised and expanded test program to evaluate a re-designed precutter nozzle for the filterable PM2.5 wet stack test method. This test program has been revised to address API, NCASI, and EPA review comments. The test program will be conducted after the present nozzle design is changed to increase the efficiency of droplet capture.

1. Purpose and Scope of the Nozzle Testing

Air Control Techniques, P.C. will redesign the nozzle to reduce the 50% cut size from the present range of 25 to 45 micrometer range to approximately 15 micrometers (aerodynamic). We will design for a 100% capture efficiency at or below 42 micrometers. As shown in Figure 1, the collection efficiency curve becomes asymptotic as it approaches 100%; accordingly, we will define the 100% capture efficiency size as the efficiency indicated by droplet penetration of less than or equal to 3% of the injected microspheres.

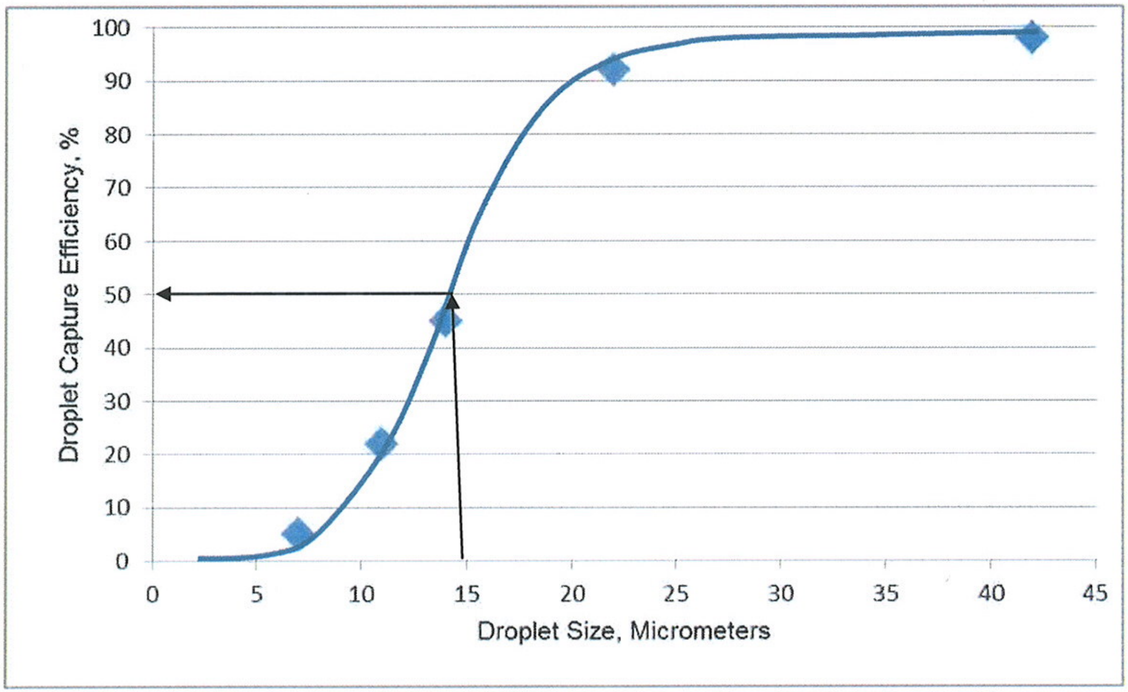

Figure 1. Target Capture Efficiency Versus Droplet Size Curve Using A Set of Five Monodisperse Microspheres

The nozzle orifice section diameter will be reduced to increase the velocity of droplets entering the main body of the precutter nozzle to achieve the lower cut size. The modified nozzle will be fabricated by Environmental Supply, Inc. in Durham North Carolina.

2. Precutter Nozzle Tests

The precutter nozzle tests have been divided into two parts: (1) runs 1 through 15 will evaluate the droplet capture efficiency versus droplet size curve at a simulated stack velocity of 30+3 feet per second, and (2) runs 16 through 21 will evaluate the change in the 50% cut size at simulated stack velocities of 60+6 and 90+9 feet per second. The 30+3 feet per second condition provides the worst case condition for achieving the EPA-specified 50% cut size at 15 micrometers. The higher stack velocities bracket the normal range of velocities in industrial wet scrubber stacks.

Droplet Capture Efficiency Curve at 30 Feet per Second—Air Control Techniques, P.C. will use NIST-traceable dry monodisperse spheres as standards in evaluating the performance of the modified nozzle. Borosilicate glass spheres with sizes of 7, 11, 14, and 22 micrometers (aerodynamic) and soda lime glass spheres of 42 micrometers (aerodynamic) will be purchased for the test program.

The spheres will be atomized in a small chamber that is heated to approximately 160°F to remove surface moisture and to minimize clustering. Particle charge neutralizers will be used in the chamber to minimize static charges that could contribute to clustering of the dispersed spheres.

The carrier gas stream from the mixing chamber will be cooled, if necessary, to approximately 140°F to 160°F to be consistent with typical scrubber stack temperatures. A portion of the carrier air stream will be directed into the sampling train nozzle tip. The nozzle sampling rate will be set at 0.50 to 0.60 ACFM depending on the temperature of the gas stream entering the nozzle.

The adequacy of dispersion of the monodisperse microspheres will be determined by drawing off a small sample gas stream after the mixing chamber and prior to gas stream entry to the nozzle. A particulate filter with polycarbonate filters will be used to obtain a sample of the dispersed microspheres. The sampling time will be less than 30 seconds to avoid build-up of microspheres, which could confound the evaluation of microsphere cluster formation. Photomicrographs of the filter samples during each test run will document the extent of cluster formation.

Prior to each test run, a thin layer of water generated by a fogging spray to simulate entrained droplets in a stack will be applied to the inside surfaces of the precutter nozzle to minimize microsphere bounce off the surface of the precutter. This coating is needed to adequately simulate the behavior of droplets in the nozzle.

Change in 50% Cut Size at 60 and 90 Feet per Second—These test runs will be conducted using only the 14-micrometer-sized microspheres. The tests will use procedures identical to those described for runs 1 through 15. The data from these six runs will be combined with the 14-micrometer microsphere tests included as runs 2, 7, and 12 (see test matrix) to evaluate the impact of the stack velocity on the droplet capture efficiency.

3. Test Matrix

The test program will consist of twenty-one separate test runs as summarized in Table 1. Following Run 5, the data will be summarized to determine if the modified nozzle has the desired 50% cut size at 15 micrometers and 90% capture efficiency at or below 42 micrometers. If not, the nozzle will be redesigned prior to Run 6.

Table 1. Test Matrix

Run	Sphere Size, Microspheres, Micrometers	Velocity, ft/sec	Gravimetric Analyses (Resolution Analytics)	Microscopy Particle Clustering Evaluation
1	22	30	Yes	Yes
2	14	30	Yes	Yes
3	11	30	Yes	Yes
4	7	30	Yes	Yes
5	42	30	Yes	Yes
6	22	30	Yes	Yes
7	14	30	Yes	Yes
8	11	30	Yes	Yes
9	7	30	Yes	Yes
10	42	30	Yes	Yes
11	22	30	Yes	Yes
12	14	30	Yes	Yes
13	11	30	Yes	Yes
14	7	30	Yes	Yes
15	42	30	Yes	Yes
16	14	60	Yes	Yes
17	14	60	Yes	Yes
18	14	60	Yes	Yes
19	14	90	Yes	Yes
20	14	90	Yes	Yes
21	14	90	Yes	Yes

4. Data Analysis

Following each test run, the nozzle assembly and the connecting tube between the precutter nozzle and the filter will be rinsed with acetone to determine the mass of microspheres captured in the nozzle. The front half of a 47mm filter holder and the filter will be recovered to determine the mass of microspheres that penetrated the nozzle assembly. All three samples from each test run will be dried and weighed by Resolution Analytics. The collection efficiency for the specific microsphere size will be determined based on the ratio of (1) the weight of the solids on the filter and the filter holder rinse and (2) the weight of the solids in the nozzle assembly rinse. Three test runs will be conducted for each size of monodisperse microspheres used.

The target catch weights during each of the runs will be a total of 20 to 50 milligrams of microspheres. Runs having catch weights lower than 3 millgrams of microspheres will be rejected and repeated. Rinses with less than 2 milligrams will be handled as zero values.

The precision of the three runs at each size range will be determined. An acceptable standard deviation of 3 runs would be approximately 20% of the efficiency value measured (i.e. 50% ±10% efficiency).

5. Report

A report summarizing the test results and the precutter nozzle design characteristics will be prepared following completion of the test matrix.

Appendix F

Precutter Nozzle Cut Size Test Report

April 19, 2015

Test Protocol

Precutter Nozzle Cut Size Filterable PM2.5 Wet Stack Test Method

Prepared for

American Petroleum Institute
1220 L Street NW
Washington, DC 20005

and

The National Council for Air & Stream Improvement
NCASI Southern Regional Center
402 SW 140th Terrace
Newberry, FL, 32669

Prepared by

Air Control Techniques, P.C.
301 E. Durham Road
Cary, NC 27513

May 12, 2014
Revised December 19, 2014

Precutter Nozzle Testing Protocol
Filterable PM2.5 Wet Stack Test Method

This protocol summarizes a modified test program to evaluate a re-designed precutter nozzle for the filterable PM2.5 wet stack test method. This test program has been revised to address testing issues identified during preliminary nozzle cut size tests and discussed during the December 18, 2014 meeting between EPA, API, NCASI, and Air Control Techniques, P.C. representatives.

1. Purpose and Scope of the Nozzle Testing

Air Control Techniques, P.C. has redesigned the nozzle to reduce the 50% cut size from the previously estimated range of 25 to 45 micrometer range to a range of 10 to 15 micrometers (aerodynamic).

As shown in Figure 1, the theoretical collection efficiency curve (solid black) becomes asymptotic as it approaches 100%. Preliminary tests using monodisperse microspheres indicated that the laboratory-measured capture efficiency for microspheres of 20 micrometers and larger is limited to the 80% to 90% range (dotted red line) due to bouncing of the rigid microspheres off of the interior surfaces of the precutter nozzle. Furthermore, the laboratory-measured capture efficiency curve approaches a minimum of approximately 20% for microspheres in the range of 2 to 8 micrometers due to clustering of the microspheres. Both microsphere-related issues affecting the laboratory tests are not relevant to droplets in wet stacks. Due to these limits, this laboratory test program will focus primarily on the 6 to 15 micrometer size range where both microsphere-related conditions are minimal.

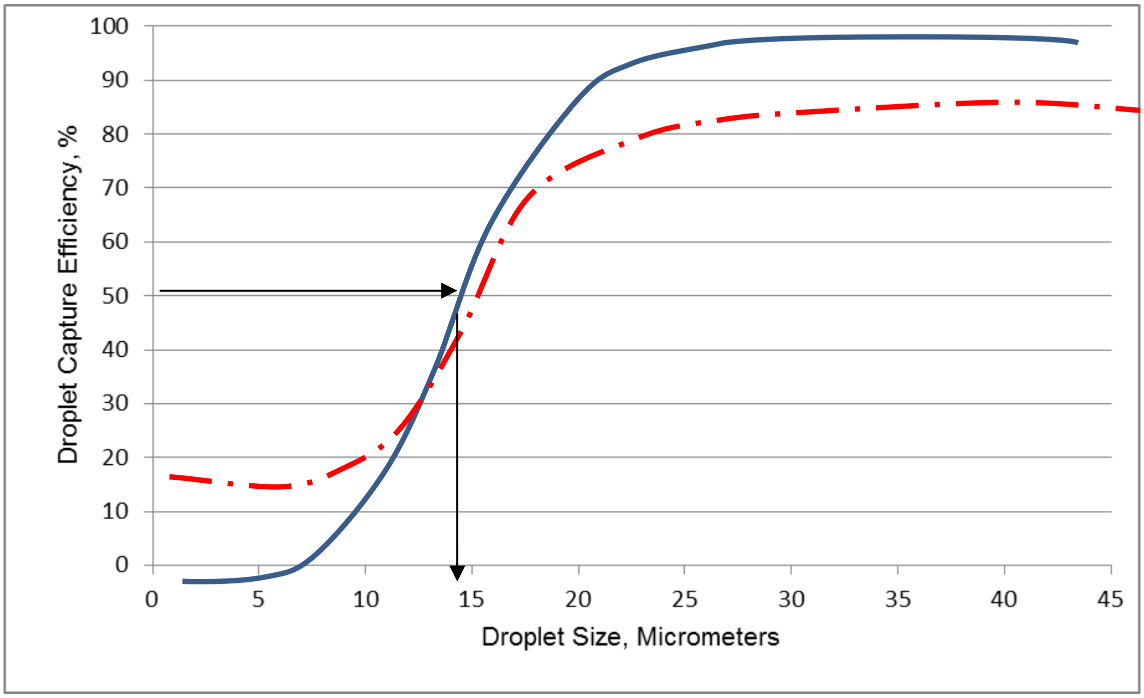

Figure 1. Target Capture Efficiency Versus Droplet Size Curve Using Monodisperse Microspheres

The nozzle orifice inlet barrel diameter has been modified to increase the velocity of droplets entering the main body of the precutter nozzle to achieve a 50% cut size between 10 and 15 micrometers. The modified nozzle has been fabricated by Environmental Supply, Inc. in Durham North Carolina.

2. Precutter Nozzle Tests

The precutter nozzle capture efficiency tests have been divided into three parts: (1) runs 1 through 9 will be at a simulated stack velocity of 30±6 feet per second, (2) runs 10 through 14 will be at a simulated stack velocities of 60±12 feet per second, and (3) runs 15 through 18 will be at simulated stack velocities of 90±18 feet per second. Table 1 summarizes the test matrix.

Table 1. Test Matrix

Run	Microsphere Size, Micrometers	Velocity, feet/sec	Gravimetric Analyses
1	6	30	Yes
2	6	30	Yes
3	6	30	Yes
4	8	30	Yes
5	15	30	Yes
6	15	30	Yes
7	10	30	Yes
8	12.6	30	Yes
9	20	30	Yes
10	6	60	Yes
11	8	60	Yes
12	15	60	Yes
13	12.6	60	Yes
14	20	60	Yes
15	6	90	Yes
16	8	90	Yes
17	12.6	90	Yes
18	20	90	Yes

The test program summarized in Table 1 will include eighteen separate runs using various sizes of monodisperse micrometers and three nozzle inlet velocities. In addition, a preliminary run will be made for the six, eight, and fifteen micrometer sized monodisperse microsphere size to evaluate the extent of clustering.

Droplet Capture Efficiency Curve at 30 Feet per Second—Air Control Techniques, P.C. will use NIST-traceable dry monodisperse spheres as standards in evaluating the performance of the modified nozzle. Microspheres with aerodynamic sizes of 6, 8, 10, 12.6, 15 and 20 micrometers will be used for the test program.

Liquid-suspended microspheres will be dispersed in a small chamber that is heated to 100°F to 130°F to remove surface moisture and to minimize clustering. The carrier air stream will be directed into the sampling train nozzle tip. The nozzle size will be selected to provide the appropriate inlet velocity specified in the test matrix.

Solid (borosilicate glass) microspheres will be dispersed in a small chamber using the sampling system inlet air stream. An impactor will be used after the dispersion chamber to remove clusters of microspheres. The carrier air stream will be directed into the sampling train nozzle tip. The nozzle size will be selected to provide the appropriate inlet velocity specified in the test matrix.

The adequacy of dispersion of the monodisperse microspheres will be determined by examining the filters during a set of preliminary test runs. A polycarbonate filter media will be used to obtain a sample of the dispersed microspheres. The sampling time will be less than 30 seconds to avoid build-up of microspheres, which could confound the evaluation of microsphere cluster formation. Photomicrographs of the filter samples from each preliminary test run will document the extent of cluster formation.

Prior to each test run, a thin layer of water will be applied to the inside surfaces of the precutter nozzle so that the behavior of the rigid microspheres simulates the behavior of water droplets striking the interior wall of the precutter.

Change in 50% Cut Size at 60 and 90 Feet per Second—The tests will use procedures identical to those described for runs 1 through 9. The nozzle will be changed to provide the appropriate inlet velocity.

3. Sample Analysis

Following each test run, the nozzle assembly and the connecting tube between the precutter nozzle and the filter will be rinsed with acetone to determine the mass of microspheres captured in the nozzle. The front half of a 47mm filter holder and the filter will be recovered to determine the mass of microspheres that penetrated the nozzle assembly. All three samples from each test run will be dried and weighed. The collection efficiency for the specific microsphere size will be determined based on the ratio of (1) the weight of the solids on the filter and the filter holder rinse and (2) the weight of the solids in the nozzle assembly rinse.

The target catch weights during each of the runs will be a total of 50 to 100 milligrams of microspheres. Runs having catch weights lower than 5 milligrams of microspheres will be rejected and repeated.

4. Report

A report summarizing the test results and the precutter nozzle design characteristics will be prepared following completion of the test matrix.

Appendix G

Leith, D. and Boundy, M. 2008. “Development of Plans for Monitoring Emissions of PM_1, $PM_{2.5}$ and PM_{10} from Stationary Sources with Wet Stacks,” U.S. Environmental Protection Agency, Research Triangle Park, NC 27709

DEVELOPMENT OF PLANS FOR MONITORING EMISSIONS OF PM1, PM2.5 AND PM10 FROM STATIONARY SOURCES WITH WET STACKS

prepared for:

Dr. Arthur S. Werner
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PO Box 12077
Research Triangle Park, NC 27709

prepared by:

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Department of Environmental Sciences and Engineering
University of North Carolina at Chapel Hill

29 February 2008

DEVELOPMENT OF PLANS FOR MONITORING EMISSIONS OF PM1, PM2.5 AND PM10 FROM STATIONARY SOURCES WITH WET STACKS

This report reviews and evaluates methods that might be used to monitor emissions of PM1, PM2.5 and PM10 from stationary sources whose exhaust gases contain water droplets. These droplets may contain both soluble and insoluble materials that become solid particles when the droplets are emitted to the atmosphere and evaporate. In addition to water droplets, the exhaust gas may contain solid particles unassociated with water droplets. Finally, the exhaust may also contain organic or inorganic compounds that condense to form particles when the gas cools. The specific mix of soluble and insoluble materials in water droplets, distinct solid particles, and condensable compounds will depend on the source of the exhaust gas and cannot be generalized.

The report contains three parts. The first describes a literature review, the second a statement of objectives for future research based on that review, and the third some recommendations for research to address the problems identified.

PART I – LITERATURE REVIEW

The review presented here is based on published and gray literature, much of which was supplied by Mr. Ron Myers at the U.S. EPA. In addition, we have discussed this issue with aerosol experts at other universities, at consulting firms, and elsewhere. Disagreement exists and some topics are controversial. The opinions presented here are those of the authors and are not intended to reflect a consensus.

Much of the literature that describes the emissions of particles from evaporated liquid droplets was developed to evaluate emissions from cooling towers. Some of this information concerns the percentage of liquid lost from these towers as droplets without regard to droplet size; a term called “drift” that is an important aspect of the performance guarantee given by cooling tower manufacturers. Methods to measure drift without regard to droplet size are not relevant to the present review and are not considered here.

The emission rate of PM1, PM2.5 and PM10 is defined as the mass rate at which particles smaller than 1 µm, 2.5 µm and 10 µm in aerodynamic diameter respectively, are released to the atmosphere after all droplets completely evaporate.

1. Aerodynamic Diameter

The definition of aerodynamic diameter is important here because this term is not always interpreted correctly in the literature reviewed. Aerodynamic diameter, d_a, is the diameter of a sphere with the density of water that has the same aerodynamic properties as the particle in question. The aerodynamic diameter of an irregularly shaped particle with known density is[1]

$$d_a = d_e \sqrt{\frac{\rho_p}{\rho_o \, \chi}} \quad , \tag{1}$$

where d_e is the equivalent volume diameter (the diameter of a sphere with the same volume as the particle in question), ρ_p is the density of the particle, ρ_o is the density of water, and χ is the dynamic shape factor for the particle. If a droplet that contains soluble and insoluble materials evaporates to leave a residual solid particle, that residual particle will have a density that is the weighted average of the densities of its constituents.

If the particle is spherical then χ is unity, but as particles become increasingly non-spherical χ becomes progressively larger. A residual particle that arises from a droplet that contains irregularly shaped, insoluble particles would tend to be irregular and have a shape factor greater than unity. A residual particle that arises from a droplet that contains soluble materials would tend to be spherical and have a shape factor closer to unity.

The equivalent volume diameter of the residual particle left after evaporation of a drop that contains both soluble and insoluble materials is

$$d_e = d_d \left(\frac{\rho_o \; TS}{\rho_p} \right)^{1/3} \quad , \tag{2}$$

where d_d is droplet diameter and TS is "total solids", defined as the mass fraction of both soluble and insoluble materials in the drop. Combination of equations (1) and (2) gives the relationship between droplet diameter and the aerodynamic diameter of the solid particle that results after the water in the droplet completely evaporates.

$$d_a = d_d \left(\frac{\rho_p}{\rho_o} \right)^{1/6} (TS)^{1/3} \left(\frac{1}{\chi} \right)^{1/2} \quad . \tag{3}$$

The importance of Eqs (1) through (3) will become more apparent as the discussion proceeds.

2. Methods to Measure PM1, PM2.5 and PM10

Two important methods have been described to measure particulate matter from wet gas streams. The first involves estimating the size distribution of emitted droplets and the TS in these droplets, then calculating the emission rate and size distribution of the residual solid particles that are generated *after the droplets evaporate in the atmosphere*. This method will be termed the "Droplet Distribution Method." The second method involves drying these droplets *as part of the sampling procedure*, and then measuring the emission rate of the resultant solid particles; this method will be termed the "Dried Particle Method."

2.1 Droplet Distribution Method

The procedure used with the Droplet Distribution Method is to calculate the aerodynamic diameter of the residual particle that results from each droplet emitted using Eq. (3), and then to add up the mass emissions for all such particles that are smaller than the aerodynamic diameter of concern.

The Droplet Distribution Method requires knowledge of:

(1) The mass emission rate of droplets to the atmosphere,

(2) The mass-based size distribution of these droplets,

(3) The concentration of TS in the droplets as a function of droplet size,

(4) The shape factor and density of residual solid particles as a function of particle size.

<u>Mass Emission Rate</u> – The mass emission rate of droplets to the atmosphere is, in the case of a cooling tower, the product of the mass flow of water through the tower and "drift". Although water flow through the tower can be determined relatively easily, drift is difficult to measure. Values of drift vary by orders of magnitude from installation to installation and depend on factors such as design of the entrainment separator, operating conditions, and state of repair.

<u>Droplet Size Distribution</u> – The mass-based size distribution of water droplets emitted to the atmosphere is difficult to measure because droplets can be tens to hundreds of micrometers in diameter. The inertia of such large droplets makes representative sampling difficult.

One method that has been used to measure droplet size distribution involves collecting droplets on sensitive paper.[2,3] A disk of this paper about 50 mm in diameter is held in the flowing gas stream and droplets collect on the disk by impaction. Each collected droplet produces a stain on the paper whose diameter is related to the original diameter of the droplet through a calibration. The sensitive paper method is a clever approach, but its use is not without problems. Because the method relies on impaction to collect droplets on the paper, and because impaction efficiency decreases strongly as droplet diameter decreases, a correction factor must be applied for droplets smaller than about 50 μm in diameter.[2] The importance of this factor increases rapidly as droplet diameter decreases.[4] Eq. (3) shows that if we are concerned primarily with residual solid particles whose aerodynamic diameters are smaller than 10 μm, for TS of about 10,000 ppm the parent droplets must be smaller than about 50 μm. Thus the importance of the correction factor would seem to increase, and the reliability for the sensitive paper method would seem to diminish for the very droplet sizes where accuracy is most important.

Another investigation of droplet size from cooling towers utilized simultaneous sampling through a forward-facing and a backward-facing nozzle.[5] The forward-facing nozzle should collect droplets of all sizes, whereas calculations suggest that the backward-facing nozzle should have a cut size (50% collection efficiency) of about 3.5 μm and collect relatively few particles larger than this size. At the same time, droplets larger than about 23 μm were collected on a static filter by impaction. This method requires sampling with forward and backward nozzles and with a static filter simultaneously to establish two points in the droplet size distribution curve: the fraction smaller than 3.5 μm and the fraction smaller than 23 μm in diameter.

Because droplet size distribution is difficult to measure accurately and requires substantial effort to obtain, it is tempting to use measurements at one facility to represent conditions at another. This approach, although expedient, comes with no assurance that measurements at one place will adequately represent another. Size distribution measurements made at different facilities can differ appreciably, a finding that is not reassuring if we wish to generalize results. Figure 1 shows cumulative size distributions by mass for droplets from cooling towers presented by Wilber[2], by Reisman and Frisbie[6], and by Entropy Environmentalists, Inc.[5] Substantial differences in these size distributions are apparent. For example, data in Figure 1 show that measurements of the mass median diameter (50% size) differ by over two orders of magnitude.

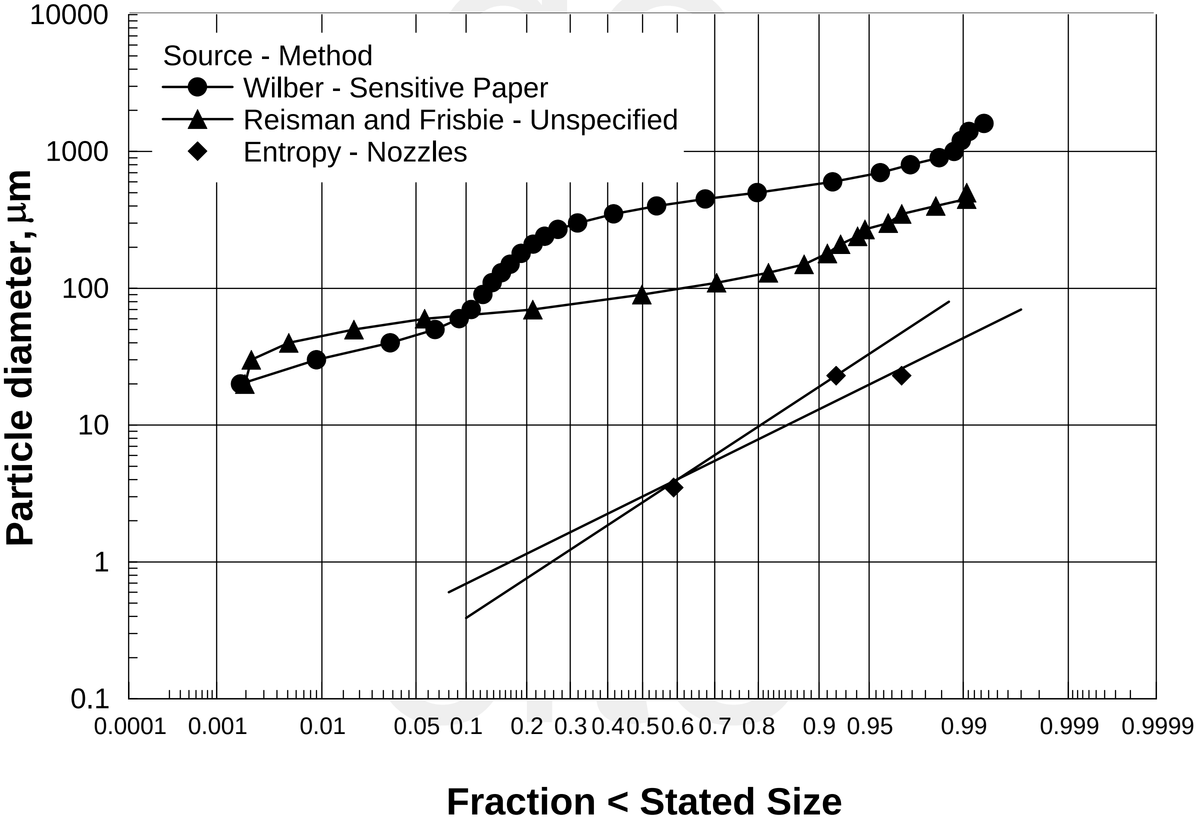


Figure 1. Cumulative size distributions by mass for droplets from cooling towers as reported in three studies.[2,5,6]

Solids Concentration – The TS concentration for droplets emitted from cooling towers might be assumed to be the same as the TS concentration in the raw process water. As droplets form they undoubtedly have the same TS as the process water; however, some droplet evaporation occurs in the tower and to the extent that it does, the droplets become enriched in TS. No method has been described to measure the TS in droplets at their point of release.

Shape Factor and Density of the Dried Solid Particles – Equation (3) shows that particle density and dynamic shape factor both affect the conversion from droplet diameter to aerodynamic diameter of the residual, dried solid. The effect of particle density is comparatively unimportant as it appears to the 1/6 power in the conversion; the effect of shape factor is more important as it appears to the 1/2 power. Although the effect of particle density has sometimes (but not always) been considered in calculations to determine particulate emissions, the more important effect of shape factor has not been considered.

Particulate emissions from scrubbers contain uncollected particles as well as insoluble particles in droplets. These particles are likely to have irregular shape so would have larger shape factors than particulate emissions from cooling towers that arise primarily from solids dissolved in water droplets.

Some authors have calculated emissions of PM10 using the Droplet Distribution Method without accounting for the difference between equivalent volume diameter and aerodynamic diameter as given in Eq. (1). For example, Reisman and Frisbie[6] determined the size distribution of emitted particles whose size was taken as the *equivalent volume* diameter rather than the *aerodynamic* diameter. Eq. (1) shows that if particle relative density is about 2.4 and shape factor is about 1.2, aerodynamic diameters are about 40% larger than the equivalent volume diameters presented in their work.

The Droplet Distribution Method focuses exclusively on TS, the dissolved and insoluble materials present in water droplets. This source seems likely to dominate particulate emissions from cooling towers. The Droplet Distribution Method does not include or consider the emission of particles unassociated with water droplets or the contribution of condensable materials, two sources that are unimportant for cooling towers but may be very important for industrial sources controlled by scrubbers. The Droplet Distribution Method will underestimate emissions to the extent that unassociated particles and condensable compounds are present.

In summary, the Droplet Distribution Method can provide useful estimates of particulate emissions from wet stacks, but only when certain conditions are met. These conditions include accurate knowledge of the droplet emission rate, droplet size distribution, and the concentration of TS in the droplets as a function of droplet size. Some of these data, particularly the droplet emission rate, the droplet size distribution and the TS concentration, are difficult to measure and may vary substantially from facility to facility. In addition, although somewhat less important, the density and shape factors of the residual solid particles must be known or estimated. The method does not address the contributions to PM1, PM2.5 and PM10 emissions that will occur if discrete solid particles or condensable materials are present. Because of these concerns, the Droplet Distribution Method does not seem to be a reliable way to determine PM1, PM2.5 and PM10 emissions accurately, except under unusual circumstances.

2.2 Dried Particle Method

With the Dried Particle Method, both droplets and individual particles not associated with droplets are sampled isokinetically from the wet gas stream. The sample is then immediately dried to evaporate all droplets. The residual, dry particles then pass through a heated size classification device that removes particles larger than a specified cut size such as 1, 2.5 and 10 μm. All particles that remain collect on a filter. After filtration, the sample gas can then be further processed to condense any inorganic or organic compounds present.

The Dried Particle Method requires:

(1) Isokinetic sampling of the exhaust gas stream,

(2) Representative sampling of the exhaust gas stream,

(3) An effective way to dry the gas stream immediately after sampling without losing droplets or particles to the wall of the sampling probe or drying chamber,

(4) A method to separate particles smaller than a specified size such as 1, 2.5 and 10 μm in aerodynamic diameter from the sample gas stream that operates properly even when sample flow changes to match isokinetic conditions,

(5) A method to analyze for condensable particles.

The Dried Particle Method can include discrete and condensable particles along with residual solids from dried water droplets. The chief disadvantage of the Dried Particle Method, and it is an important disadvantage, is that this method has not been widely used. Although at least one study has attempted to use some aspects of this method,[7] none has adequately addressed all aspects.

Isokinetic Sampling – If the velocity of the process gas matches the velocity of the gas that enters the sampling probe, then sampling is isokinetic. Departure from isokinetic sampling can cause appreciable errors in measured concentrations, errors that become larger as particle (or droplet) size increases. As shown in Figure 1, water droplets in a wet gas stream may be tens or even hundreds of micrometers in diameter. For water droplets this large, isokinetic sampling is critical. The dependence of sampling error on departure from isokinetic sampling is an important issue that needs full consideration. Gas velocities across the exhaust duct may vary from location to location and may swirl, particularly if the gas passes through a fan before sampling. Isokinetic sampling under these conditions presents a major challenge.

Representative Sampling – Droplet concentration and size distribution as well as the concentration of dissolved solids in the water droplets may vary with sampling location. As a result, to obtain results representative of the entire gas stream, multiple samples must be taken. This requirement leads to further complexity in the sampling plan.

The requirements for isokinetic and representative sampling for wet gas streams is even more important than for dry gas streams because droplets tend to be larger than the dry, solid particles emitted from dry industrial and combustion stacks. The error from anisokinetic sampling is relatively low for small particles, but increases as particle size increases.[1]

Drying the Sampled Gas Stream – For the Dried Particle Method to work, all droplets must rapidly and completely evaporate from the gas stream immediately downstream of the sampling nozzle. During this process the droplets must maintain their integrity; that is, they must not shatter or combine, because to do so would affect the sizes of the residual particles.

Israelson, Stich and Weast[7] used a heated probe for this purpose, and deserve full credit for developing this innovative method. Nevertheless, their results lead to some vexing questions for which answers are needed. They provide no information to establish conclusively that droplet evaporation in their heated probe is complete. Without complete evaporation of all droplets, the Dried Particle Method can give results that are seriously in error. Further, roughly half of the particles they sampled deposited on the inner walls of their heated probe. Particles that deposit on the probe walls do not reach the size-selective part of the sampling train so cannot be classified with regard to size.

<u>Particle Classification</u> – From the heated probe, the dried particles immediately pass to a heated size-classification device that removes particles larger than 1, 2.5 or 10 μm in aerodynamic diameter for measurement of PM1, PM2.5 or PM10, respectively. Although Israelson, Stich and Weast[7] used a heated cascade impactor for this purpose, a cyclone would be simpler and should be just as effective.

Ideally, the cyclone or impactor would be located directly after the droplet drier and at the inlet end of the sampling probe; however, placement there could make the sampling probe unwieldy. Placement at the outlet end of the sampling probe would solve that problem but raises the potential problem of particle collection in the probe itself.

Cut size, the aerodynamic particle diameter for which collector efficiency is 50%, depends on gas viscosity for both impactors and cyclones; therefore, gas temperature and gas makeup are both important. Either a cyclone or an impactor must be operated at a temperature at least as high as the heated probe to prevent condensation. If the sampled gas stream is close to 100C and saturated, much of the gas will be water vapor and have physical properties different from air.

In addition, cut size for both impactors and cyclones depends on gas flow. The dependence of cut size on flow is a problem here because sampling flow must be adjusted to the isokinetic value at each sampling point. A possible solution to this problem would be always to sample from the gas stream at a flow less than that required for the particle classification device, and to make up the difference in flow using clean makeup gas with appropriate temperature and physical properties.

Either an impactor or a cyclone could provide a cut diameter of 1, 2.5 or 10 μm. A filter immediately after the impactor or cyclone then collects the solid particles for gravimetric analysis. The filter is also heated to the temperature of the size classification device.

<u>Condensable Particles</u> – Following the filter, the gas stream might pass to an EPA CTM 039 sampling train that utilizes a dilution system to measure condensable aerosols. In this system, the hot stack gas is mixed with cool gas to lower its temperature, cause supersaturation of condensable compounds, and bring about their partitioning from the gas phase into the condensed phase. An EPA Method 202 sampling train could also be used, although this method is difficult to employ when sampling hot, saturated gas streams because a large amount of condensate is produced.

Israelson, Stich and Weast[7] used a Method 202 sampling train and found that an important portion of the total particle catch came from the impingers. They assumed that the particles that reached the impingers were too small to be caught by the upstream filter, but that explanation seems unlikely. Final filters used with impactors are very efficient even for the smallest particles. Another explanation is that the impingers collected particles of compounds that condense under ice-bath conditions. Such particles would be in the vapor phase at the hot filter, but would condense under the cold conditions of an ice bath. The implication of these findings is that the contribution of condensable particles can be important.

In summary, the Dried Particle Method requires considerable effort for isokinetic and representative sampling. The main disadvantages of this method are that a satisfactory heated probe, size classifying device, and final filter have yet to be developed. An important advantage is that unlike the Drop Distribution Method, the Dried Particle Method accounts for both unwetted and condensed particles.

2.3 Other Methods

Improvements might be made to the methods described above, or additional alternative methods might also be used. Some of these will be described here. All other methods also have problems, as will be described.

Possible Improvement to Sensitive Paper Method – A drawback of the sensitive paper method is that it relies on impaction to collect droplets on the paper surface. Because impaction efficiency decreases rapidly with decreasing droplet diameter, this method requires a correction factor that becomes increasingly important as droplet diameter becomes smaller.

A potential improvement to this method might be to sensitize and use a paper that is permeable to air flow. Sample would then be drawn through the sensitive paper at isokinetic velocity, eliminating the dependence of sampling efficiency on the impaction characteristics of the paper itself.

Interpretation of these results would still require knowledge of the TS value for each droplet analyzed, and these values seem likely to vary with droplet size. Droplets that are smaller because they have evaporated more could have higher TS than larger droplets. No easy method to determine how TS varies with droplet diameter seems apparent. In addition, this method would still not detect unwetted particles or account for condensed particles.

Light Extinction Method – Optical extinction of a light beam that shines across a droplet-laden gas is related to, among other parameters, the concentration of the droplets. With this procedure, a simple measurement of light extinction[1] might be used to determine the concentration of emitted droplets. Computed tomography coupled with light extinction can, in principle, account for spatial variations in droplet concentration and size distribution over a cross section of the gas stream.[8]

This method, although relatively simple and inexpensive to use, also relies on assumptions that are not readily verified. For example, the concentration calculation requires that TS values for the droplets be known – an assumption shared with the Droplet Distribution Method. The effect of multiple scattering would need to be addressed. The advantage of the Light Extinction Method over the Droplet Distribution Method is that the Light Extinction Method would seem to be a relatively easy way to measure drift. Development work would be necessary.

Heated Wire Method – A heated wire has been used to collect droplets to determine their size distribution and concentration. Droplets that collect on the wire alter its electrical resistance over a distance related to droplet diameter. After a brief period the droplet evaporates. A second-generation instrument developed using this principle was evaluated through laboratory and field tests.[9] The heated wire method is clever and holds promise. An important advantage of the heated wire method is that the development work has already been done.[10] Although the wires used as sensors are fragile and can become coated with particles, disposable sensors can be used.

A significant disadvantage is that the heated wire method, like the Droplet Distribution Method, does not account for unwetted particles or condensed particles. Further, use of the heated wire method to characterize PM1, PM2.5, or PM10 emissions requires knowledge of TS as a function of droplet diameter, information that is difficult to acquire. No instrument based on the heated wire method is commercially available.

In summary, the heated wire method seems most appropriate for measurements of drift from cooling towers where the emissions of primary concern are the droplets themselves. This method is less suited to measurements of particulate emissions.

3. Overall Evaluation

Monitoring the emission of PM1, PM2.5 and PM10 emissions from a wet gas stream is a challenging problem that has not been addressed successfully despite considerable effort. No consensus method to provide this information has emerged. The evaluation below is our best judgment of the approach that seems most likely to succeed, given the present state of our knowledge and the technical complexity of issues that must be overcome if the outcome is to be successful.

The Droplet Distribution Method relies on information that is difficult to obtain. Measurements of droplet emission rate, droplet size distribution, TS concentrations as a function of droplet size, and particle properties that include both density and shape factor as a function of particle size will require substantial effort and expense. These parameters are likely to vary from facility to facility with the result that assumptions for one facility based on measurements at another facility are suspect. The advantage of the Droplet Distribution Method is that this method has been used most widely, and as a consequence, it has gained some acceptance among facilities, consultants, and regulatory agencies.

The Dried Particle Method has methodological aspects superior to those of the Droplet Distribution Method. Whereas the Droplet Distribution Method relies on calculations to determine the size distribution of residual solid particles, and then requires further calculations to convert equivalent volume diameters into aerodynamic diameters, the Dried Particle Method measures directly the mass emission rate of particles with specified aerodynamic size. No conversions or calculations based on questionable assumptions are necessary. Further, the Dried Particle Method includes distinct, dry particles and condensable particles whereas the Droplet Distribution Method does not include particles from these sources. A disadvantage of the Dried Particle Method is that it has not been widely used so that many facilities, consultants, and regulatory agencies may not be familiar with it. A more significant disadvantage is that further development work will be necessary to address some important issues with method performance.

In our opinion, the methodological advantages of the Dried Particle Method outweigh its disadvantages. The work needed for this Method to become robust can help identify a research agenda.

PART II – PROBLEM STATEMENTS

This section of the report presents a succinct statement of objectives for future research related to monitoring PM emissions from wet gas streams and related to development of continuous emission monitors. These statements have been developed from gaps in our knowledge of how to monitor these emissions, identified from the literature search described above.

Problem 1 – Develop a wet stack simulator to produce in the laboratory the wet stack conditions found in industry.

Whatever method is developed to measure emissions from wet stacks, that method will need to be checked against conditions found in industry. The most efficient way to produce these conditions is in a laboratory with a wet stack simulator.

The simulator must be able to produce realistic concentrations of: (1) droplets containing representative dissolved and trapped TS; (2) residual particles that result from evaporation of droplets with a range of sizes and TS concentrations; (3) free particles unassociated with liquid droplets; and (4) particles that result from condensable compounds. The wet stack simulator must produce these concentrations at a range of conditions of temperature, moisture content, and gas composition representative of industry.

Problem 2 – Develop a “gold standard” for measuring emissions of PM1, PM2.5 and PM10 from wet gas streams.

A reliable and accepted method is needed to measure PM1, PM2.5 and PM10 emissions from wet gas streams. All methods used to date have limitations. Until a “gold standard” method is developed to satisfy this need, and until questions of its reliability are satisfied, questions about emissions from wet stacks will persist.

A “gold standard” method is needed both to determine accurately the emissions from processes that have wet stacks, and as a benchmark against which to judge alternative measurement methods.

Problem 3 – Evaluate the practicality and feasibility of continuously monitoring PM1, PM2.5 and PM10 emissions from wet gas streams.

Continuous monitors are particularly important for emissions trading. They are also useful to track emission excursions that can occur if process equipment malfunctions.

The “gold standard” method for measuring emissions may be impractical for use for continuous monitoring. Alternative methods more appropriate for continuous operation may be feasible and can be calibrated or validated using the “gold standard” method.

PART III – RECOMMENDATIONS

Here we present recommendations for research to address the problems identified in Part II above. Included are ideas related to the development of a “wet stack simulator”, the development of a “gold standard” for measurement of PM1, PM2.5 and PM10 from wet gas streams, and the development of continuous monitors for PM1, PM2.5 and PM10 from these streams. Also included is a timeline for conducting this work.

DEVELOPMENT OF A WET STACK SIMULATOR

The wet stack simulator must be able to produce a gas stream that adequately represents PM emissions and gas stream conditions, at a flow that is adequate to evaluate alternative sampling methods.

Task A – Design, Build, and Evaluate a Method to Produce a Representative Gas Stream.

The gas stream must be representative of the temperatures, moisture contents, and compositions found in industry, and at a flow that allows full-scale evaluation of particle sampling methods. Design specifications for these criteria need to be established. Alternative methods for producing a representative gas stream need to be considered, and the most feasible method selected.

One method to produce a saturated, hot gas stream is to add live steam to flowing gas. The ratio of steam to gas can control the temperature achieved. Particles can then be introduced to provide the required test conditions, see Task B.

Task B – Design, Build, and Evaluate a Method to Produce Representative Particles.

Particles and particle precursors should be added from three sources: (1) from droplets that contain TS in representative sizes and concentrations; (2) from unassociated, dry particles, and (3) from condensable compounds. These particles and particle precursors must be mixed with the gas stream. Provision should be made to introduce particles from each source both alone and in combination with each other.

DEVELOPMENT OF A “GOLD STANDARD” METHOD

For the reasons given above, we believe the Dried Particle Method is most appropriate for use as a “gold standard” method to measure PM emissions from wet stacks. We believe this method should be able to quantitate residual particles from dried liquid droplets, dry particles not associated with liquid droplets, and condensable particles. Below we list tasks related to development of a “gold standard” method based on the dried particle approach.

Task A – Design, Build and Evaluate a Heated Sampling Nozzle that will Evaporate All Water Drops Without Loss to Nozzle Walls.

This task is critical to effective development of the Dried Particle Method. The work involves determination of the minimum diameter for a sampling nozzle that can representatively collect “large” droplets, determination of the heat input necessary to evaporate all droplets, selection and design of a heat transfer method, and development of a method to assure that neither droplets nor residual particles deposit on the walls of the nozzle.

Small inlet nozzles may not be able to sample large water drops representatively. The relationship between nozzle size and droplet diameter, and the relationship between these parameters and flow required for isokinetic sampling under realistic conditions, should be investigated.

To minimize wall losses the use of a stream of sheath air near the nozzle walls should be investigated. The sheath air should help focus the droplets at the center of the gas stream. Sheath air is used for this purpose in the inlet nozzles for instruments such as the Aerodynamic Particle Sizer and the Aerosizer.

After design and fabrication, the heated sampling nozzle should be tested in the laboratory to assure that all sampled droplets evaporate completely, and to assure that no droplets or particles deposit on nozzle walls. A further goal of this work should be to establish that the method obtains a representative sample of the droplets in flowing gas. Iteration in design and testing will probably be necessary to meet these objectives.

Task B – Design, Build and Evaluate a Size Selective Classifier

The classifier will follow the drying nozzle and remove particles larger than a specified size in aerodynamic diameter. Three classifiers should be made: one to separate particles larger than 1 μm in aerodynamic diameter for PM1 measurements, one to separate particles larger than 2.5 μm in aerodynamic diameter for PM2.5 measurements, and one to separate particles larger than 10 μm in aerodynamic diameter for PM10 measurements. Operation could be at the temperature selected for the drying nozzle. Cyclones are simpler to operate than impactors, so initial efforts should probably focus on the development of cyclones for these purposes.

Work under this task includes both the design of suitable cyclones as well as the design of a system that will supply a fixed flow of gas to the cyclone to maintain its cut point even though sample flow varies to match isokinetic conditions. This flow maintenance system should be integrated with the design of the heated sampling nozzle and the sampling train for condensable particles.

Task C – Design, Build and Evaluate Filter System

This task is relatively straightforward compared to the previous two, but needs to be done. Included here is the need to identify appropriate filter media and a holder that will withstand the design temperatures and not shred the filters.

Task D – Investigate Methods to Sample Condensable Particles

This task is to evaluate alternative methods to sample condensable particles from the sample gas, and to select the method that seems most promising. A dilution-based method for sampling condensable particles, CTM 039, is currently in an advanced stage of development and should be given primary consideration although other methods should also be considered. The method selected must be appropriate for the sample gas flow to be used.

Task E – Assemble and Evaluate the Dried Particle Sampling System

Under this task, a complete prototype sampling system should be assembled and its performance evaluated under lab conditions. This laboratory work should be done for gas streams that carry known quantities of water droplets with known TS, in addition to discrete dry particles and condensable particles. Comparison should be made between the results from the method and known inputs. Again, some iteration in design and evaluation may be necessary.

Because the objective is to develop a “gold standard”, comprehensive laboratory tests to evaluate the system are necessary. These tests should cover the range of conditions reasonably expected under true, field conditions.

When this task is completed, a prototype system that is ready for evaluation under field conditions will be available.

Task F – Field Tests

Suitable sites must be selected, and permissions obtained to conduct the field tests. The goal of the field tests is to evaluate the practicality of the method under actual, field conditions.

DEVELOPMENT OF A METHOD FOR CONTINUOUS EMISSION MONITORING

A “gold standard” method developed along the lines described here is likely to require multi-point, isokinetic sampling. This methodology is accurate but is not readily compatible with continuous emission monitoring.

Alternative methods to monitor continuously can be developed, but are likely to rely on assumptions that are open to question. The work outlined below will investigate practical methods for continuously monitoring PM10. PM2.5, and PM1 emissions from wet stacks, and will identify and characterize the importance of the assumptions necessary for these methods to give reliable results. Once the “gold standard” method for monitoring emissions is developed, it can be used to validate the performance of continuous emission monitors in the field.

Task A – Identify and Characterize Methods for Continuous Emission Monitoring

Candidate methods range from the simple to the complex. One simple method involves the use of emission factors like those in AP-42 and used now. These factors are found by multiplying together a few terms that include factors such as TS of the process water and water flow rate. Instruments are already commercially available that can continuously monitor terms like TS and water flow rate, and the output from these instruments could feed into an emission factor to provide a continuous estimate of emissions that varies with process conditions. A more technically complex method less reliant on assumptions might involve use of the Light Extinction Method, perhaps coupled with computed tomography to provide continuous data for emissions over time.

Work under this task would evaluate candidate methods, list their input needs and the likelihood that these needs can be met, describe the work necessary to bring the most promising methods to fruition, and to estimate their inherent reliability.

Task B – Evaluate Candidate Methods for Continuous Emission Monitoring

With the information from Task A, the most promising approaches can be identified based on technical feasibility and on estimated complexity and cost. This task would involve consultation with colleagues at the U.S. EPA, at consulting firms, and with others who have knowledge and interest in this issue.

Completion of this task would result in identification of one or more approaches that seem promising.

Task C – Develop Prototype Continuous Emission Monitor

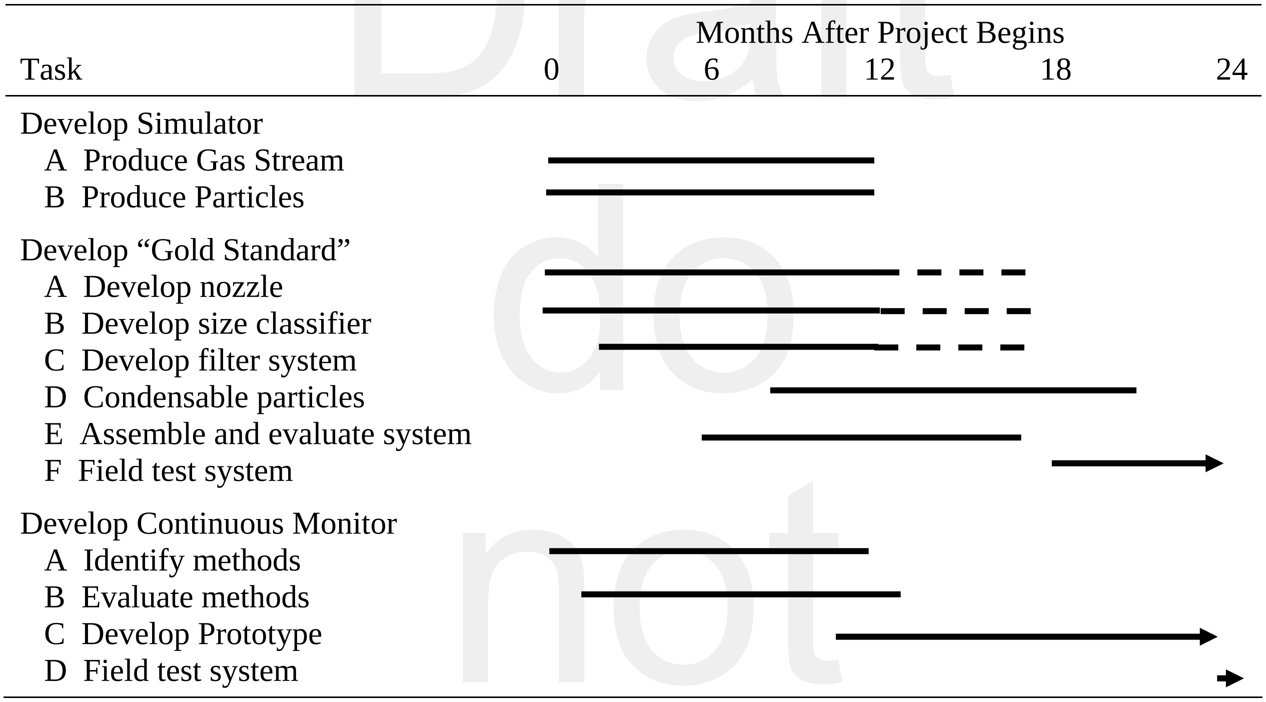
The promising approaches identified in Task B would be investigated further. Prototype systems would be built and evaluated under laboratory conditions.

Task D – Field Testing

The prototype continuous monitoring method would be evaluated at industrial sites. Comparisons between results from the continuous method and the “gold standard” method would be made. Calibration or redesign of the continuous monitoring method would be done as necessary.

TIMETABLE

Below is a timetable for accomplishing the tasks listed above.



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