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.
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/recorddisplay.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 in 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.

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

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 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°. (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 ($N_{\text{re}}$) 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 $N_{\text{re}}$ for the test to be performed. You must verify the assumed $N_{\text{re}}$ 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 $N_{\text{re}}$ 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 $\Delta H$.
Use Equation 11 to calculate the meter box orifice pressure drop ($\Delta H$) after you calculate the optimum sampling rate and confirm the $N_{\text{re}}$.

(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 $\Delta H$ 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 $Q_{\text{Nozzle}}$. 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 ($R_{\text{min}}$). Use Equation 17 to calculate the maximum nozzle/stack velocity ratio ($R_{\text{max}}$). Use the stack gas viscosity in this calculation.

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

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

8.5.4.4 Conversion of gas velocities to velocity pressure. Use Equation 22 to convert $v_{\text{min}}$ to minimum velocity pressure, $\Delta p_{\text{min}}$. Use Equation 23 to convert $v_{\text{max}}$ to maximum velocity pressure, $\Delta p_{\text{max}}$.

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 $\Delta p_{\text{min}}$ and $\Delta p_{\text{max}}$. 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 $\Delta p_{\text{min}}$ and $\Delta p_{\text{max}}$.

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 0.1 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). Here, N_p 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 PM2.5 cyclone cup and the reagent (and brush cleaning) rinses of the interior surface of the PM2.5 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.

\[ A = \text{Area of stack or duct at sampling location, square inches.} \]
\[ A_n = \text{Area of nozzle, square feet.} \]
\[ B_{ws} = \text{Moisture content of gas stream, fraction (e.g., 10 percent H}_2\text{O is B}_{ws} = 0.10).} \]
\[ C = \text{Cunningham correction factor for particle diameter, D}_p \text{ and calculated using the cyclone temperature of 780°R.} \]
\[ \%CO_2 = \text{Carbon dioxide content of gas stream, percent by volume.} \]
\[ Ca = \text{Acetone blank concentration, mg/mg.} \]
\[ C_{PM2.5} = \text{Conc. of filterable PM}_{2.5}, \text{ gr/DSCF.} \]
\[ C_p = \text{Pitot coefficient for the Pitot, dimensionless} \]
\[ C_p' = \text{Coefficient for the Pitot used in the preliminary traverse, dimensionless.} \]
\[ C_r = \text{Re-estimated Cunningham correction factor for particle diameter equivalent to the actual cut size diameter and calculated using the actual stack gas temperature, dimensionless.} \]
\[ C_{tf} = \text{Conc. of total filterable PM, gr/DSCF.} \]
\[ C_1 = -150.3162 \text{ (micropoise)} \]
\[ C_2 = 18.0614 \text{ (micropoise/K}^{0.5} \text{)} = 13.4622 \text{ (micropoise/R}^{0.5} \text{)} \]
\[ C_3 = 1.19183 \times 10^8 \text{ (micropoise/K}^2 \text{)} = 3.86153 \times 10^6 \text{ (micropoise/R}^2 \text{)} \]
\[ C_4 = 0.591123 \text{ (micropoise)} \]
\[ C_5 = 91.9723 \text{ (micropoise)} \]
\[ C_6 = 4.91705 \times 10^{-5} \text{ (micropoise/K}^2 \text{)} = 1.51761 \times 10^{-5} \text{ (micropoise/R}^2 \text{)} \]
\[ D = \text{Inner diameter of sampling nozzle, inches.} \]
\[ D_p = \text{Physical particle size, micrometers.} \]
\[ D_{50} = \text{Particle cut diameter, micrometers.} \]
\[ D_{50-1} = \text{Re-calculated particle cut diameters based on re-estimated C}_r \text{, micrometers.} \]
\[ D_{50LL} = \text{Cut diameter for cyclone I (not used for OTM-036) corresponding to the 2.25 micrometer cut diameter for PM}_{2.5} \text{ cyclone, micrometers.} \]
\[ D_{50N} = D_{50} \text{ value for PM}_{2.5} \text{ cyclone calculated during the Nth iterative step, micrometers.} \]
\[ D_{50(N+1)} = D_{50} \text{ value for PM}_{2.5} \text{ cyclone calculated during the N+1 iterative step, micrometers.} \]
\[ D_{50T} = \text{Cyclone I (not used for OTM-036) cut diameter corresponding to the middle of the overlap zone shown in Figure 7 of Section 17, micrometers.} \]
I = Percent isokinetic sampling, dimensionless.

\[ K_p = 85.49, \frac{\text{ft/sec}}{\text{pounds/mole} \cdot \text{°R}} \]

\( M_a \) = Mass of residue of acetone after evaporation, mg.
\( M_d \) = Molecular weight of dry gas, pounds/pound Mole.
\( \text{mg} \) = Milligram.
\( \text{mg/L} \) = 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.
\( N_{\text{tp}} \) = Number of iterative steps or total traverse points.
\( N_{\text{re}} \) = 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,
\[ \% O_{2,wet} = (1 - B_{ws}) \times \% O_{2,\text{dry}} \]

\( P_{\text{bar}} \) = 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)
\( Q_{\text{ST}} \) = Dry gas sampling rate through the sampling assembly, DSCFM.
\( Q_1 \) = Sampling rate for cyclone I to achieve specified \( D_{50} \). (Not used in OTM-036)
\( Q_{2.5} \) = Sampling rate for PM2.5 Cyclone to achieve specified \( D_{50} \).
\( Q_{\text{Nozzle}} \) = Actual air flow rate through the nozzle.
\( R_{\text{max}} \) = Nozzle/stack velocity ratio parameter, dimensionless.
\( R_{\text{min}} \) = 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.
\( v_{\text{max}} \) = Maximum gas velocity calculated from Equations 18 or 19, ft/sec.
\( v_{\text{min}} \) = 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.
$\Delta H = $ 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.)

$$[(\Delta p)^{0.5}]_{avg} = \text{Average of square roots of the velocity pressures measured during the preliminary traverse, inches W.C.}$$
$\Delta p_m = $ Observed velocity pressure using S-type Pitot tube in preliminary traverse, inches W.C.
$\Delta p_{avg} = $ Average velocity pressure, inches W.C.
$\Delta p_{max} = $ Maximum velocity pressure, inches W.C.
$\Delta p_{min} = $ Minimum velocity pressure, inches W.C.
$\Delta p_n = $ Velocity pressure measured at point n during the test run, inches W.C.
$\Delta p_1 = $ Velocity pressure measured at point 1, inches W.C.
$\gamma = $ Dry gas meter gamma value, dimensionless.
$\mu_c = $ Gas viscosity of gas stream in the PM$_{2.5}$ cyclone, micropoise.
$\mu_s = $ Gas viscosity of stack gas, micropoise.
$\theta = $ Total run time, min.
$\rho_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.

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).

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

\[
\mu_c = C_1 + C_2 \sqrt{T_c} + C_3 T_c^{-2} + C_4 (\%O_{2,wet}) - C_5 B_{ws} + C_6 B_{ws} T_c^2
\]  (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.

\[
C = 1 + 0.0057193 \left[ \frac{\mu_c}{P_s D_{50}} \right] \left[ \frac{T_c}{M_w} \right]^{0.5}
\]  (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:

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

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

For N_{re} greater than or equal to 3,162. Use the cyclone gas stream viscosity from Equation 3b in this calculation.
\[ Q_{2.5} = 0.007657 \left[ \frac{\mu_c}{\mu_c c_{0.6205}} \right] \left[ \frac{P_s M_w}{T_c} \right]^{-0.3795} \left[ \frac{1}{2.5} \right]^{1.241} \] (Eq. 9)

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

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

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

Meter Box Orifice Pressure Drop.

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

Equation 12 not used.

Velocity of Stack Gas.

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

Calculated Nozzle Diameter for Acceptable Sampling Rate.

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

Velocity of Gas in Nozzle.

\[ V_n = \left( \frac{Q_{\text{Nozzle}}}{60 \text{ min/sec}} \right) \frac{1}{A_n} \] (Eq. 15)

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

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

Maximum Nozzle/Stack Velocity Ratio Parameter. Use the stack gas viscosity from Equation 3a for this calculation.
\[ R_{max} = \left[ 0.4457 + \left( 0.5690 + \frac{0.2603\mu_s(Q_{Nozzle})^{0.5}}{v_n^{1.5}} \right)^{0.5} \right] \quad (Eq. 17) \]

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

\[ v_{min} = v_n (0.5) \quad (Eq. 18) \]

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

\[ V_{min} = v_n R_{min} \quad (Eq. 19) \]

Maximum Gas Velocity for \( R_{max} < 1.5 \).

\[ V_{max} = v_n R_{max} \quad (Eq. 20) \]

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

\[ V_{max} = v_n (1.5) \quad (Eq. 21) \]

Minimum Velocity Pressure.

\[ \Delta p_{min} = 1.3686\times10^{-4} \left[ \frac{P_s M_w}{T_s} \right] \left[ \frac{v_{min}}{C_p} \right]^2 \quad (Eq. 22) \]

Maximum Velocity Pressure.

\[ \Delta p_{max} = 1.3686\times10^{-4} \left[ \frac{P_s M_w}{T_s} \right] \left[ \frac{v_{max}}{C_p} \right]^2 \quad (Eq. 23) \]

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

\[ t_n = \left[ \frac{C_p\sqrt{\Delta p_n}}{C_p^{\frac{1}{2}}(\sqrt{\Delta p})_{avg}} \right] \left[ \frac{t_r}{N_{tp}} \right] \quad (Eq. 24) \]

Equations 25, 26, and 27 not used.

Dry Gas Volume Sampled at Standard Conditions.

\[ V_{ms} = \left[ \frac{528}{29.92} \right] \left[ (\gamma)(V_m) \right] \left[ \frac{P_{bar}}{13.6 T_m} \right] \quad (Eq. 28) \]
Sample Flow Rate at Standard Conditions.

\[
Q_{sST} = \frac{V_{ms}}{\theta}
\]  
(Eq. 29)

Volume of Water Vapor.

\[
V_{ws} = 0.04707 V_c
\]  
(Eq. 30)

Moisture Content of Gas Stream.

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

Sampling Rate.

\[
Q_{2.5} = \frac{29.92}{528} Q_{sST} \left[ \frac{1}{1 - B_{ws}} \right] \left[ \frac{T_c}{P_s} \right]
\]  
(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.

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

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

PM\(_{2.5}\) 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.

\[
C_r = 1 + 0.0057193 \left[ \frac{\mu_c}{P_s D_{50}} \right]^{0.5} \left[ \frac{T_c}{M_w} \right]
\]  
(Eq. 36)
Re-calculated Particle Cut Diameter for $N_{re} < 3,162$.

$$D_{50-1} = 0.0024302 \left[ \frac{\mu_c}{Q_{2.5}} \right]^{1.1791} \left[ \frac{1}{C_r} \right]^{0.5} \left[ \frac{T_c}{P_s M_w} \right]^{0.6790}$$  \hspace{1cm} \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.

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

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

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

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

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

Percent Isokinetic Sampling.

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

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

$$C_{tf} = \left[ \frac{7000}{453,592} \right] \left[ \frac{M_1+M_2+M_3+M_4+M_5}{V_{ms}} \right]$$  \hspace{1cm} \text{(Eq. 45)}

Equation 46 not used.

Concentration of Filterable PM$_{2.5}$.

$$C_{fPM2.5} = \left[ \frac{7000}{453,592} \right] \left[ \frac{M_1+M_2}{V_{ms}} \right]$$  \hspace{1cm} \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


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

<table>
<thead>
<tr>
<th>Particle Size Range</th>
<th>Concentration and% by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total collectable PM</td>
<td>0.015 grains per Dry Standard Cubic Foot, gr/DSCF</td>
</tr>
<tr>
<td>≤ 10 and &gt; that 2.5 micrometers</td>
<td>40% of total collectable PM</td>
</tr>
<tr>
<td>≤ 2.5 micrometers</td>
<td>20% of total collectable PM</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Cyclone</th>
<th>Minimum cut diameter</th>
<th>Maximum cut diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM_{2.5} Cyclone Also termed Cyclone IV</td>
<td>2.25 micrometers</td>
<td>2.75 micrometers</td>
</tr>
</tbody>
</table>

Table 3. Test Calculations

<table>
<thead>
<tr>
<th>If you are using…</th>
<th>To calculate..</th>
<th>Then use…</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preliminary Data</td>
<td>Dry gas molecular weight, M_{d}</td>
<td>Equation 1</td>
</tr>
<tr>
<td>Dry gas molecular weight (M_{d}) and preliminary moisture content of the gas stream</td>
<td>Wet gas molecular weight, M_{w}</td>
<td>Equation 2a</td>
</tr>
<tr>
<td>Stack gas temperature, oxygen and moisture content of the gas stream</td>
<td>Stack gas viscosity, ( \mu_{s} )</td>
<td>Equation 3a</td>
</tr>
<tr>
<td>Cyclone gas temperature</td>
<td>PM_{2.5} Cyclone viscosity ( \mu_{c} )</td>
<td>Equation 3b</td>
</tr>
<tr>
<td>Gas viscosity, ( \mu_{c} )</td>
<td>Cunningham correction factor^b, C</td>
<td>Equation 4</td>
</tr>
<tr>
<td>( D_{50} ) for PM_{2.5} cyclone and ( N_{e} &lt; 3162 )</td>
<td>Final sampling rate for the PM_{2.5} cyclone, ( Q_{2.5} )</td>
<td>Equation 8</td>
</tr>
</tbody>
</table>
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 9

Q$_{2.5}$ from Equation 29

Verify the assumed Reynolds number, N$_{re}$

Equation 10

---

Table 4. ΔH Values Based on Preliminary Traverse Data

<table>
<thead>
<tr>
<th>Stack Temperature (°R)</th>
<th>$T_s - 5^\circ$</th>
<th>$T_s$</th>
<th>$T_s + 5^\circ$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta H$, (inches W.C.)</td>
<td>a</td>
<td>a</td>
<td>a</td>
</tr>
</tbody>
</table>

$^a$ These values are to be filled in by the stack tester

---

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 5 is not used.

Table 6. Calculations for Recovery of PM$_{2.5}$

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

$^a$ 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

<table>
<thead>
<tr>
<th>Component</th>
<th>Designation</th>
<th>Precutter Nozzle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precutter Barrel Diameter</td>
<td>W</td>
<td>0.80</td>
</tr>
<tr>
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</tr>
<tr>
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<td>0.78</td>
</tr>
<tr>
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<tr>
<td>Nozzle Support Extension Orifice Diameter</td>
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</table>

0.06 Inches wall Thickness on Top

1.04 Inches

1.54 Inches

0.50 Inches

0.20 inches

0.78 inches

0.26 inches

0.04 inches

0.44 Inch separation to center Line of outlet tube

Droplet Reservoir, 0.50 inches high, 0.153 cubic inches

0.12 Wall thickness on sides

O-ring

Method 203A/Nozzle
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
Figure 7. PM$_{2.5}$ cyclone Dimensions
Figure 8. Acceptable Sampling Rate for the PM$_{2.5}$ Cyclone
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
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
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\textsubscript{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\textsubscript{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\textsubscript{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\textsubscript{2.5} particulate matter. These data are summarized in Table 1.

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<th>Run ID</th>
<th>Total Nozzle (mg)</th>
<th>Cyclone Inlet and Probe (mg)</th>
<th>Cyclone Outlet (mg)</th>
<th>Total Filter (mg)</th>
<th>Total, PM\textsubscript{2.5} (mg)</th>
<th>Total Catch (mg)</th>
<th>Nozzle Catch, % of Total</th>
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<td>1.8</td>
<td>8.5</td>
<td>Filter Tear</td>
<td>Filter Tear</td>
</tr>
</tbody>
</table>

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](image)

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](image)
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
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.
December 21, 2015

Ms. Cathe Kalisz, P.E.
Policy Advisor
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1220 L Street NW
Washington, DC 20005

Mr. Ashok K. Jain
Southern Regional Manager
National Council for Air and Stream Improvement (NCASI)
402 SW 140th Terrace
Newberry, FL 32669

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>
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<tr>
<th>Method 301 Validation Test Runs</th>
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<th>Total PM2.5 Catch Weights, mg</th>
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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

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<td>6.1</td>
<td>2.4</td>
<td>16.4</td>
<td>18.8</td>
<td>36.1</td>
<td>16.9</td>
<td>32.4</td>
</tr>
<tr>
<td>U2-2</td>
<td>3.3</td>
<td>1.1</td>
<td>16.3</td>
<td>17.4</td>
<td>28.5</td>
<td>11.6</td>
<td>19.0</td>
</tr>
<tr>
<td>S1-2</td>
<td>6.7</td>
<td>2.1</td>
<td>47.6</td>
<td>49.7</td>
<td>67.9</td>
<td>9.9</td>
<td>13.5</td>
</tr>
<tr>
<td>S2-2</td>
<td>6.6</td>
<td>1.1</td>
<td>48.0</td>
<td>49.1</td>
<td>67.2</td>
<td>9.8</td>
<td>13.4</td>
</tr>
<tr>
<td>U1-3</td>
<td>3.1</td>
<td>1.9</td>
<td>20.9</td>
<td>21.9</td>
<td>34.9</td>
<td>8.9</td>
<td>14.2</td>
</tr>
<tr>
<td>U2-3</td>
<td>1.5</td>
<td>0.7</td>
<td>21.7</td>
<td>22.4</td>
<td>31.3</td>
<td>4.8</td>
<td>6.7</td>
</tr>
<tr>
<td>S1-3</td>
<td>4.4</td>
<td>0.9</td>
<td>37.1</td>
<td>38.0</td>
<td>52</td>
<td>8.5</td>
<td>11.6</td>
</tr>
<tr>
<td>S2-3</td>
<td>2.2</td>
<td>1.1</td>
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<td>31.8</td>
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<td>4.6</td>
<td>6.9</td>
</tr>
<tr>
<td>U1-4</td>
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<td>32.9</td>
<td>7.0</td>
<td>10.0</td>
</tr>
<tr>
<td>U2-4</td>
<td>2.3</td>
<td>1.0</td>
<td>23.7</td>
<td>24.7</td>
<td>34.3</td>
<td>6.7</td>
<td>9.3</td>
</tr>
<tr>
<td>S1-4</td>
<td>0.6</td>
<td>0.6</td>
<td>26.9</td>
<td>27.5</td>
<td>35.1</td>
<td>1.7</td>
<td>2.2</td>
</tr>
<tr>
<td>S2-4</td>
<td>1.6</td>
<td>1.2</td>
<td>26.5</td>
<td>27.7</td>
<td>35.1</td>
<td>4.6</td>
<td>5.8</td>
</tr>
<tr>
<td>U1-5</td>
<td>2.9</td>
<td>0.7</td>
<td>14.7</td>
<td>15.4</td>
<td>27.9</td>
<td>10.4</td>
<td>18.8</td>
</tr>
<tr>
<td>U2-5</td>
<td>1.3</td>
<td>0.7</td>
<td>15.1</td>
<td>15.8</td>
<td>22.5</td>
<td>5.8</td>
<td>8.2</td>
</tr>
<tr>
<td>S1-5</td>
<td>8.9</td>
<td>0.9</td>
<td>55</td>
<td>55.9</td>
<td>75.6</td>
<td>11.8</td>
<td>15.9</td>
</tr>
<tr>
<td>S2-5</td>
<td>3.5</td>
<td>0.8</td>
<td>5.8</td>
<td>6.6</td>
<td>22.1</td>
<td>Filter Tear</td>
<td></td>
</tr>
<tr>
<td>U1-6</td>
<td>2.7</td>
<td>1.5</td>
<td>29.5</td>
<td>31</td>
<td>41</td>
<td>6.6</td>
<td>8.7</td>
</tr>
<tr>
<td>U2-6</td>
<td>3.2</td>
<td>1.8</td>
<td>30.1</td>
<td>31.9</td>
<td>41.6</td>
<td>7.7</td>
<td>10.0</td>
</tr>
<tr>
<td>S1-6</td>
<td>2.1</td>
<td>1.2</td>
<td>37.4</td>
<td>38.6</td>
<td>47.4</td>
<td>4.4</td>
<td>5.4</td>
</tr>
<tr>
<td>S2-6</td>
<td>2.2</td>
<td>0.6</td>
<td>1.2</td>
<td>1.8</td>
<td>8.5</td>
<td>Filter Tear</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Average</td>
<td>7.8</td>
<td>11.7</td>
</tr>
</tbody>
</table>

**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>
<thead>
<tr>
<th>Run</th>
<th>PM2.5 Cyclone 50% Cut Size (micrometers)</th>
<th>Run</th>
<th>PM10 Cyclone 50% Cut Size (micrometers)</th>
<th>PM2.5 Cyclone 50% Cut Size (micrometers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.35</td>
<td>2</td>
<td>10.73</td>
<td>2.26</td>
</tr>
<tr>
<td>3</td>
<td>2.96</td>
<td>4</td>
<td>10.80</td>
<td>2.29</td>
</tr>
<tr>
<td>5</td>
<td>2.70</td>
<td>6</td>
<td>10.84</td>
<td>2.30</td>
</tr>
<tr>
<td>7</td>
<td>2.72</td>
<td>8</td>
<td>10.82</td>
<td>2.29</td>
</tr>
<tr>
<td>9</td>
<td>2.67</td>
<td>10</td>
<td>10.92</td>
<td>2.36</td>
</tr>
<tr>
<td>11</td>
<td>2.72</td>
<td>12</td>
<td>10.87</td>
<td>2.31</td>
</tr>
<tr>
<td>Average</td>
<td>2.69</td>
<td>Average</td>
<td>10.83</td>
<td>2.30</td>
</tr>
</tbody>
</table>

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.

![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](image)

No significant difference in the PM2.5 fractions measured with sampling trains with and without a probe prior to the cyclone and filter.
Table 4. Comparison of Precutter Nozzle and Method 201A PM10 Cyclone Performance
December 2015 Test Program

<table>
<thead>
<tr>
<th>Run</th>
<th>Wet Stack Sampling Train Conditions</th>
<th>Precutter Nozzle (mass %)</th>
<th>&gt;PM2.5 Catch from Cyclone (mass %)</th>
<th>PM2.5 on Filter and in Rinses of the Cyclone Outlet Tube and Filter Holder Rinse (mass %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wet wall</td>
<td>20</td>
<td>41.8</td>
<td>38.2</td>
</tr>
<tr>
<td>3</td>
<td>Wet wall</td>
<td>7.4</td>
<td>58.5</td>
<td>34.0</td>
</tr>
<tr>
<td>5</td>
<td>Wet wall</td>
<td>20.8</td>
<td>49.1</td>
<td>30.1</td>
</tr>
<tr>
<td>7</td>
<td>Wet wall</td>
<td>33.3</td>
<td>42.1</td>
<td>24.6</td>
</tr>
<tr>
<td>9</td>
<td>Wet wall</td>
<td>19.5</td>
<td>39.8</td>
<td>40.6</td>
</tr>
<tr>
<td>11</td>
<td>Wet wall</td>
<td>19.0</td>
<td>50.4</td>
<td>30.6</td>
</tr>
<tr>
<td></td>
<td><strong>Average %</strong></td>
<td><strong>20.0</strong></td>
<td><strong>47.0</strong></td>
<td><strong>33.0</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Run</th>
<th>Method 201A Sampling Train Conditions</th>
<th>&gt;PM10 Catch from PM10 Cyclone (mass %)</th>
<th>&gt;PM2.5 and ≤ PM10 Catch from PM10 Cyclone Outlet (mass %)</th>
<th>PM2.5 on Filter, and in Rinses of the PM2.5 Cyclone Outlet Tube and Filter Holder Rinse (mass %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Dry</td>
<td>25.3</td>
<td>62.3</td>
<td>12.3</td>
</tr>
<tr>
<td>4</td>
<td>Dry</td>
<td>20.4</td>
<td>47.5</td>
<td>32.1</td>
</tr>
<tr>
<td>6</td>
<td>Dry</td>
<td>7.6</td>
<td>65.3</td>
<td>27.1</td>
</tr>
<tr>
<td>8</td>
<td>Dry</td>
<td>22.2</td>
<td>51.9</td>
<td>25.9</td>
</tr>
<tr>
<td>10</td>
<td>Dry</td>
<td>17.3</td>
<td>45.6</td>
<td>39.6</td>
</tr>
<tr>
<td>12</td>
<td>Dry</td>
<td>22.0</td>
<td>52.0</td>
<td>30.0</td>
</tr>
<tr>
<td></td>
<td><strong>Average, %</strong></td>
<td><strong>18.0</strong></td>
<td><strong>54.1</strong></td>
<td><strong>27.9</strong></td>
</tr>
</tbody>
</table>

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 penetrate 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>
<thead>
<tr>
<th>Test Conditions</th>
<th>Run 1</th>
<th>Run 5</th>
<th>Run 6</th>
<th>Run 2</th>
<th>Run 3</th>
<th>Run 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probe</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Wetted Precutter</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Delta H</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
</tr>
</tbody>
</table>

**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 (3/8\textsuperscript{th} 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>
<thead>
<tr>
<th>Probe Length, Feet</th>
<th>Residence Time (Seconds) at 0.35 ACFM</th>
<th>Residence Time (Seconds) at 0.60 ACFM</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>0.70</td>
<td>0.41</td>
</tr>
<tr>
<td>4</td>
<td>0.94</td>
<td>0.55</td>
</tr>
<tr>
<td>5</td>
<td>1.17</td>
<td>0.68</td>
</tr>
<tr>
<td>6</td>
<td>1.40</td>
<td>0.82</td>
</tr>
<tr>
<td>7</td>
<td>1.64</td>
<td>0.95</td>
</tr>
<tr>
<td>8</td>
<td>1.87</td>
<td>1.09</td>
</tr>
</tbody>
</table>

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
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. Precut 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 precut can be directly compared with the greater than PM10 size fraction recovered from the Method 201A PM10 cyclone.

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

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cc:

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Appendix B

West Stack Sampling System Development Report

September 16, 2013
TABLE OF CONTENTS

1. SUMMARY 1
   1.1 Purpose and Scope 1
   1.2 Conclusions 1
   1.3 Test Program Participants 3

2. WS2.5 SAMPLING SYSTEM DESIGN CHARACTERISTICS 5
   2.1 Performance Criteria 5
   2.2 Sampling Train 6
   2.3 Comparison of the WS2.5 Sampling Method and Other Test Methods 9

3. LABORATORY EVALUATION 11
   3.1 Initial Laboratory Tests 11
   3.2 Follow-up Laboratory Test Program 21

4. CATALYTIC CRACKER STACK TEST PROGRAM 27
   4.1 Test Methods 27
   4.2 Test Program 1, Scrubber-Controlled FCCU 32
   4.3 Test Program 2, ESP Controlled FCCU 36
   4.4 Test Program 3, Scrubber Controlled FCCU 46

5. COMPARISON OF FIELD TEST PROGRAMS 1, 2, AND 3 53
   5.1 Emission Comparisons 53
   5.2 Wet Stack Filterable PM2.5 Sampling System 54

REFERENCES 55

APPENDICES
Volume I, Data Sheets for Test Program 1
Volume II, Data Sheets for Test Program 2
Volume III, Data Sheets for Test Program 3
Volume IV, Data Sheets for Laboratory Analyses

FIGURES

Figure 2-1. Wet Stack PM2 Sampling System 7
Figure 2-2. Heated Filter Box with Cyclone and PM2.5 Filter 7
Figure 2-3. WS2.5 Heated Probe and Nozzle 8
Figure 2-4. Estimated Cut Size for the WS2.5 Sampling System 90 Degree Curved Nozzle 8
Figure 2-5. Required Sample Flow Rate for the PM2.5 Cyclone in the WS2.5 Sampling System 9
<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-1</td>
<td>WS2.5 Heated Probe, 90 Degree Curved Nozzle, Mixing/Evaporating Chamber, Nebulizer Exhaust, Heated Air Line, and Excess Test Gas Exhaust Line</td>
</tr>
<tr>
<td>3-2</td>
<td>WS2.5 Sampling Heated Probe, Heated Filter Box, Impinger Case and Meter</td>
</tr>
<tr>
<td>3-3</td>
<td>Simulated Wet Scrubber (Packed Bed)</td>
</tr>
<tr>
<td>3-4</td>
<td>Simulated Scrubber Stack and Port</td>
</tr>
<tr>
<td>3-5</td>
<td>Probe and Filter temperatures at High Droplet Loadings</td>
</tr>
<tr>
<td>3-6</td>
<td>Nephelometer PM$_{2.5}$ Concentration Data</td>
</tr>
<tr>
<td>3-7</td>
<td>Polydisperse Spheres, Wide Field View</td>
</tr>
<tr>
<td>3-8</td>
<td>Polydisperse Spheres, Close View</td>
</tr>
<tr>
<td>3-9</td>
<td>Nozzle Run 6, Close View</td>
</tr>
<tr>
<td>3-10</td>
<td>Probe Run 6, Wide View</td>
</tr>
<tr>
<td>3-11</td>
<td>Probe Run 6, Close View</td>
</tr>
<tr>
<td>3-12</td>
<td>Cyclone Cup, Run 6, Wide View</td>
</tr>
<tr>
<td>3-13</td>
<td>Cyclone Cup, Run 6, Wide View</td>
</tr>
<tr>
<td>3-14</td>
<td>Nebulizer and Heated Chamber</td>
</tr>
<tr>
<td>3-15</td>
<td>Heated Chamber and WS2.5 Sampling System Nozzle and Probe</td>
</tr>
<tr>
<td>3-16</td>
<td>WS2.5 Sampling System and Modified Method 17-Type Sampling System in the Heated Chamber with Microsphere Injection</td>
</tr>
<tr>
<td>3-17</td>
<td>Photomicrograph of 2.1 Micrometer Silica Spheres, 50 Micrometer Field of View</td>
</tr>
<tr>
<td>3-18</td>
<td>Photomicrograph of 2.1 Micrometer Silica Spheres, 300 Micrometer Field of View</td>
</tr>
<tr>
<td>3-19</td>
<td>Photomicrograph of 1.44 Micrometer Silica Spheres, 50 Micrometer Field of View</td>
</tr>
<tr>
<td>3-20</td>
<td>Photomicrograph of 1.44 Micrometer Silica Spheres, 300 Micrometer Field of View</td>
</tr>
<tr>
<td>3-21</td>
<td>Comparison of the Expected and Measured PM$_{2.5}$ Size Fractions</td>
</tr>
<tr>
<td>4-1</td>
<td>Method 202 Condensable Particulate Matter Sampling Train</td>
</tr>
<tr>
<td>4-2</td>
<td>WS2.5 Sampling Train Used In FCCU Tests</td>
</tr>
<tr>
<td>4-3</td>
<td>Field Test 1, FCCU Stack Sampling Ports</td>
</tr>
<tr>
<td>4-4</td>
<td>Field Test 2, FCCU Stack Sampling Ports</td>
</tr>
<tr>
<td>4-5</td>
<td>Stack Filter Sample, 1000X Magnification</td>
</tr>
<tr>
<td>4-6</td>
<td>Stack Filter Sample, 8640X Magnification</td>
</tr>
<tr>
<td>4-7</td>
<td>Probe and Nozzle Rinse</td>
</tr>
<tr>
<td>4-8</td>
<td>PM$_{2.5}$ Cyclone Cup and Front Half Rinse</td>
</tr>
<tr>
<td>4-9</td>
<td>PM$_{2.5}$ Filter Sample, Photomicrograph 1</td>
</tr>
<tr>
<td>4-10</td>
<td>PM$_{2.5}$ Filter Samples, Photomicrograph 2</td>
</tr>
<tr>
<td>4-11</td>
<td>Field Test 3, FCCU Stack Sampling Ports</td>
</tr>
</tbody>
</table>
TABLES

Table 3-1. Solids Partitioning in the WS2.5 Sampling System 18
Table 4-1. Field Test 1, Selected Operational Parameters 32
Table 4-2. Field Test 1, Summary of Results, WS2.5 Method / Method 202 34
Table 4-3. Field Test 1, Summary of Results, EPA Method 5B / Method 202 34
Table 4-4. Field Test 1, Quality Assurance Results WS2.5 /Method 202 35
Table 4-5. Field Test 1, Quality Assurance Results, EPA Method 5B / Method 202 35
Table 4-6. Field Test 2, Selected Operational Parameters 36
Table 4-7. Field Test 2, Summary of Results, WS2.5 Method / Method 202 39
Table 4-8. Field Test 2, Summary of Results, EPA Method 5B / Method 202 40
Table 4-9. Field Test 2, Quality Assurance Results WS2.5 Method / Method 202 40
Table 4-10. Field Test 2, Quality assurance Results EPA Method 5B / Method 202 42
Table 4-11. Field Test 3, Selected Operational Parameters 48
Table 4-12. Field Test 3, Summary of Results, EPA Method 5B/Method 202 50
Table 4-13. Filed Test 3, Summary of Results, WS2.5 / Method 202 50
Table 4-14. Filed Test 3, Captured Moisture Levels, WS2.5 and Method 5B Sampling Trains 51
Table 4-15. Field Test 3, Quality assurance Results WS2.5 / Method 202 52
Table 4-16. Field Test 3, Quality assurance Results EPA Method 5B / Method 202 53
Table 5-1. Combined Data, Test Programs 1, 2, and 3 54
Table 5-2. PM2.5 Test Results, Test Programs 1, 2, and 3 54
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.

---

$^1$ 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. The precutter is discussed in the Method 301 Validation Test Program Report dated May 28, 2013.

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 from 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.
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 high purity 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

![Probe and Nozzle Width is 3.5 inches](image)

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

![Graph showing droplet diameter vs. collection efficiency](image)
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](image)

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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$^6$ U.S. EPA. Federal Register, December 21, 2010
PM₁₀ (10 to 2.5 micrometers) and PM₂.₅ 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 PM₁₀ 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 PM₂.₅ size range. This assumption introduces a significant bias to higher-than-true PM₂.₅ 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 PM₂.₅ 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 PM₂.₅.

The WS2.5 sampling system uses rapid evaporation to allow for the formation of PM₂.₅ particles from droplets in the sample gas stream. The rapid evaporation also removes the droplets as inertial impaction targets for PM₂.₅ 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 PM₂.₅ particles to the surfaces of larger particles in the sample gas stream and the probe internal surfaces.

The WS2.5 removes the Method 201A PM₁₀ cyclone and moves the PM₂.₅ 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 PM₂.₅ 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, PM2.5 cyclone, and PM2.5 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 PM2.5 emissions caused by evaporative shattering of solids-containing droplets
4. Minimal bias to lower-than-true PM2.5 emissions caused by PM2.5 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](image)

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.
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).
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>
<thead>
<tr>
<th>Run</th>
<th>Weight Distribution, %</th>
<th>Particle Size Range, Micrometers</th>
<th>Particles Size, Mass Median Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nozzle</td>
<td>Probe</td>
<td>Cyclone</td>
</tr>
<tr>
<td>1</td>
<td>12.0</td>
<td>32.9</td>
<td>54.0</td>
</tr>
<tr>
<td>2</td>
<td>28.3</td>
<td>28.0</td>
<td>43.7</td>
</tr>
<tr>
<td>3</td>
<td>11.8</td>
<td>50.0</td>
<td>38.2</td>
</tr>
<tr>
<td>4†</td>
<td>0.5</td>
<td>53.1</td>
<td>46.4</td>
</tr>
</tbody>
</table>

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 PM2.5 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 PM2.5 cyclone are well above 20 micrometers.
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.
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.

![Photomicrograph of 2.1 Micrometer Silica Spheres, 50 Micrometer Field-of-View (Method 17 Sampling Train)](image-url)
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)
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.

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 ≥ 90% and ≤ 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.
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 $\geq$ 80% and $\leq$ 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 SO₂ 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>
<thead>
<tr>
<th>Run #</th>
<th>Date</th>
<th>Time</th>
<th>Coke Burned lbs/hr</th>
<th>Scrubber Oxygen, %</th>
<th>Scrubber Slurry, pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>API 2.5/202-1 &amp; M5B/202-1</td>
<td>8/5/09</td>
<td>1008-1318</td>
<td>35558</td>
<td>4.5</td>
<td>7.45</td>
</tr>
<tr>
<td>API 2.5/202-2 &amp; M5B/202-2</td>
<td>8/5/09</td>
<td>1419-1724</td>
<td>35835</td>
<td>4.2</td>
<td>7.40</td>
</tr>
<tr>
<td>API 2.5/202-3 &amp; M5B/202-3</td>
<td>8/6/09</td>
<td>0830-1200</td>
<td>34849</td>
<td>4.5</td>
<td>7.4</td>
</tr>
</tbody>
</table>

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.
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>
<thead>
<tr>
<th>Parameter</th>
<th>API 2.5/202-1</th>
<th>API 2.5/202-2</th>
<th>API 2.5/202-3</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test date</td>
<td>8/5/09</td>
<td>8/5/09</td>
<td>8/6/09</td>
<td>N/A</td>
</tr>
<tr>
<td>Test time</td>
<td>1008-1318</td>
<td>1419-1721</td>
<td>0830-1142</td>
<td>N/A</td>
</tr>
<tr>
<td>Flue gas flow, DSCFM</td>
<td>144,800</td>
<td>142,500</td>
<td>157,060</td>
<td>148,120</td>
</tr>
</tbody>
</table>

**Total filterable particulate matter emissions**
- Concentration, grains/DSCF: 0.005, 0.010, 0.003, 0.006
- Mass emission rate, lb/hr: 6.33, 11.7, 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, 0.007, 0.010
- Mass emission rate, lb/hr: 16.2, 18.4, 9.82, 13.0

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>5B/202-1</th>
<th>5B/202-2</th>
<th>5B/202-3</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test date</td>
<td>8/5/09</td>
<td>8/5/09</td>
<td>8/6/09</td>
<td>N/A</td>
</tr>
<tr>
<td>Test time</td>
<td>1008-1314</td>
<td>1419-1724</td>
<td>0830-1200</td>
<td>N/A</td>
</tr>
<tr>
<td>Flue gas flow, DSCFM</td>
<td>143,090</td>
<td>145,970</td>
<td>144,730</td>
<td>144,600</td>
</tr>
</tbody>
</table>

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

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Requirement</th>
<th>5B/202-1</th>
<th>5B/202-2</th>
<th>5B/202-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isokinetic rate, percent</td>
<td>90-110</td>
<td>100.8</td>
<td>102.9</td>
<td>99.7</td>
</tr>
<tr>
<td>Pre-test leak check, CFM</td>
<td>&lt;0.02</td>
<td>0.000 @ 15&quot;</td>
<td>0.000 @ 15&quot;</td>
<td>0.000 @ 12&quot;</td>
</tr>
<tr>
<td>Post-test leak check, CFM</td>
<td>&lt;0.02</td>
<td>0.000 @ 8&quot;</td>
<td>0.000 @ 8&quot;</td>
<td>0.000 @ 8&quot;</td>
</tr>
<tr>
<td>Probe Temperature, °F</td>
<td>320±25</td>
<td>305-315</td>
<td>306-319</td>
<td>298-324</td>
</tr>
<tr>
<td>CPM filter gas temp., °F</td>
<td>&lt;85°F</td>
<td>75 – 83</td>
<td>76 - 77</td>
<td>64 – 70</td>
</tr>
<tr>
<td>Measured Moisture, %</td>
<td>N/A</td>
<td>22.4</td>
<td>22.5</td>
<td>21.8</td>
</tr>
<tr>
<td>Saturation Moisture, %</td>
<td>N/A</td>
<td>22.3</td>
<td>22.3</td>
<td>21.4</td>
</tr>
</tbody>
</table>

Pre-test Pitot tube leak check
| Side A (Impact), in. H₂O              | 0.0 @ ≥3"   | 0.0 @ 4"   | 0.0 @ 6"   | 0.0 @ 6"   |
| Side B (Static), in. H₂O              | 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 the WS2.5 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>
<thead>
<tr>
<th>Table 4-6. Field Test 2, Selected Operational Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run #</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>API 2.5/202-1 &amp; M5B/202-1</td>
</tr>
<tr>
<td>API 2.5/202-3 &amp; M5B/202-3</td>
</tr>
<tr>
<td>API 2.5/202-4 &amp; M5B/202-4</td>
</tr>
</tbody>
</table>

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.
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>
<thead>
<tr>
<th>Table 4-7. Field Test 2, Summary of Results, WS2.5 Method / Method 202</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
</tr>
<tr>
<td>Test date</td>
</tr>
<tr>
<td>Test time</td>
</tr>
<tr>
<td>Flue gas flow, DSCFM</td>
</tr>
</tbody>
</table>

**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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>5B/202-1</th>
<th>5B/202-3</th>
<th>5B/202-4</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test date</td>
<td>2-24-2010</td>
<td>2-25-2010</td>
<td>2-25-2010</td>
<td>N/A</td>
</tr>
<tr>
<td>Test time</td>
<td>0958-1304</td>
<td>0743-1043</td>
<td>1135-1435</td>
<td>N/A</td>
</tr>
<tr>
<td>Flue gas flow, DSCFM</td>
<td>81,534</td>
<td>86,511</td>
<td>82,558</td>
<td>83,534</td>
</tr>
</tbody>
</table>

#### Total filterable particulate matter emissions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>5B/202-1</th>
<th>5B/202-3</th>
<th>5B/202-4</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentration, grains/DSCF</td>
<td>0.00253</td>
<td>0.00149</td>
<td>0.00224</td>
<td>0.00209</td>
</tr>
<tr>
<td>Mass emission rate, lb/hr</td>
<td>1.8</td>
<td>1.1</td>
<td>1.6</td>
<td>1.5</td>
</tr>
</tbody>
</table>

#### Condensable particulate matter emissions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>5B/202-1</th>
<th>5B/202-3</th>
<th>5B/202-4</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentration, grains/DSCF</td>
<td>0.03566</td>
<td>0.03484</td>
<td>0.038695</td>
<td>0.0364</td>
</tr>
<tr>
<td>Mass emission rate, lb/hr</td>
<td>24.9</td>
<td>25.8</td>
<td>27.4</td>
<td>26.0</td>
</tr>
</tbody>
</table>

#### Total particulate matter emissions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>5B/202-1</th>
<th>5B/202-3</th>
<th>5B/202-4</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentration, grains/DSCF</td>
<td>0.03819</td>
<td>0.03633</td>
<td>0.04092</td>
<td>0.03848</td>
</tr>
<tr>
<td>Mass emission rate, lb/hr</td>
<td>26.7</td>
<td>26.9</td>
<td>28.9</td>
<td>27.5</td>
</tr>
</tbody>
</table>

### Table 4-9. Field Test 2, Quality Assurance Results WS2.5 Method / Method 202

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Requirement</th>
<th>API 2.5/202-1</th>
<th>API 2.5/202-3</th>
<th>API 2.5/202-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isokinetic rate, %</td>
<td>80-120</td>
<td>117.4</td>
<td>103.4</td>
<td>114.1</td>
</tr>
<tr>
<td>Pre-test leak check, CFM</td>
<td>&lt;0.02</td>
<td>0.000 @ 15&quot;</td>
<td>0.000 @ 15&quot;</td>
<td>0.000 @ 15&quot;</td>
</tr>
<tr>
<td>Post-test leak check, CFM</td>
<td>&lt;0.02</td>
<td>0.000 @ 15&quot;</td>
<td>0.000 @ 15&quot;</td>
<td>0.000 @ 15&quot;</td>
</tr>
<tr>
<td>Particle cut size, micrometers</td>
<td>2.25-2.75</td>
<td>2.66</td>
<td>2.74</td>
<td>2.66</td>
</tr>
<tr>
<td>Probe Temperature, °F</td>
<td>320±25</td>
<td>311-424</td>
<td>387-423</td>
<td>362-424</td>
</tr>
<tr>
<td>Filter, Cyclone Temperature, °F</td>
<td>320±25</td>
<td>311-328</td>
<td>310-325</td>
<td>312-327</td>
</tr>
<tr>
<td>CPM filter gas temp., °F</td>
<td>&lt;85°F</td>
<td>&lt;61</td>
<td>&lt;58</td>
<td>N/A</td>
</tr>
<tr>
<td>Impinger exit temp., °F</td>
<td>&lt;68°F</td>
<td>&lt;60</td>
<td>&lt;58</td>
<td>&lt;62</td>
</tr>
<tr>
<td>Measured Moisture, %</td>
<td>N/A</td>
<td>16.6</td>
<td>No Data</td>
<td>13.2</td>
</tr>
<tr>
<td>Saturation Moisture, %</td>
<td>N/A</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Pre test Pitot tube leak checks¹</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: ¹No Pitot tubes were attached to the WS2.5 sampling probes.
### Table 4-10. Field Test 2, Quality Assurance Results EPA Method 5B / Method 202

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Requirement</th>
<th>5B/202-1</th>
<th>5B/202-3</th>
<th>5B/202-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isokinetic rate, %</td>
<td>90-110</td>
<td>98.5</td>
<td>98.5</td>
<td>97.9</td>
</tr>
<tr>
<td>Pre-test leak check, CFM</td>
<td>&lt;0.02</td>
<td>0.000 @ 13&quot;</td>
<td>0.000 @ 15&quot;</td>
<td>0.000 @ 12&quot;</td>
</tr>
<tr>
<td>Post-test leak check, CFM</td>
<td>&lt;0.02</td>
<td>0.000 @ 10&quot;</td>
<td>0.000 @ 8&quot;</td>
<td>0.000 @ 8&quot;</td>
</tr>
<tr>
<td>Probe Temperature, °F</td>
<td>320±25</td>
<td>327-333</td>
<td>324-330</td>
<td>302-332</td>
</tr>
<tr>
<td>Filter, Cyclone Temperature, °F</td>
<td>320±25</td>
<td>296-315</td>
<td>297-316</td>
<td>297-313</td>
</tr>
<tr>
<td>CPM filter gas temp., °F</td>
<td>&lt;85°F</td>
<td>&lt; 59</td>
<td>&lt; 63</td>
<td>&lt; 67</td>
</tr>
<tr>
<td>Impinger exit temp, °F</td>
<td>&lt;68°F</td>
<td>&lt; 53</td>
<td>&lt; 63</td>
<td>&lt; 64</td>
</tr>
<tr>
<td>Measured Moisture, %</td>
<td>N/A</td>
<td>12.3</td>
<td>12.7</td>
<td>12.9</td>
</tr>
<tr>
<td>Saturation Moisture, %</td>
<td>N/A</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Pre test Pitot tube leak check</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Side A (Impact), in. H₂O</td>
<td>0.0 @ ≥3&quot;</td>
<td>0.0 @ 3&quot;</td>
<td>0.0 @ 3&quot;</td>
<td>0.0 @ 3&quot;</td>
</tr>
<tr>
<td>Side B (Static), in. H₂O</td>
<td>0.0 @ ≥3&quot;</td>
<td>0.0 @ 3&quot;</td>
<td>0.0 @ 3&quot;</td>
<td>0.0 @ 3&quot;</td>
</tr>
<tr>
<td>Post-test Pitot tube leak check</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Side A (Impact), in. H₂O</td>
<td>0.0 @ ≥3&quot;</td>
<td>0.0 @ 3&quot;</td>
<td>0.0 @ 3&quot;</td>
<td>0.0 @ 3&quot;</td>
</tr>
<tr>
<td>Side B (Static), in. H₂O</td>
<td>0.0 @ ≥3&quot;</td>
<td>0.0 @ 3&quot;</td>
<td>0.0 @ 3&quot;</td>
<td>0.0 @ 3&quot;</td>
</tr>
</tbody>
</table>

### Scanning Electron Microscopy

In order to demonstrate that there was no PM$_{2.5}$ particle capture before the filter which 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 particle 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/cm³, 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).
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 in 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.
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](image)
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
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 SO₂ 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>
<thead>
<tr>
<th>Table 4-11. Field Test 3, Selected Operational Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run #</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>API 2.5/028-1 &amp; M5B/028-1</td>
</tr>
<tr>
<td>API 2.5/028-3 &amp; M5B/028-3</td>
</tr>
</tbody>
</table>

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.
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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>5B/202-1</th>
<th>5B/202-2</th>
<th>5B/202-3</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test time</td>
<td>0949-1354</td>
<td>1458-1807</td>
<td>2012-2318</td>
<td>NA</td>
</tr>
<tr>
<td>Flue gas flow, DSCFM</td>
<td>96,515</td>
<td>96,667</td>
<td>95,628</td>
<td>96,270</td>
</tr>
<tr>
<td><strong>Total filterable particulate matter emissions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grains/DSCF @ 7%O₂</td>
<td>0.0031</td>
<td>0.0023</td>
<td>0.0021</td>
<td>0.0025</td>
</tr>
<tr>
<td>Mass emission rate, lb/hr</td>
<td>3.32</td>
<td>2.41</td>
<td>2.18</td>
<td>2.64</td>
</tr>
<tr>
<td><strong>Condensable particulate matter emissions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grains/DSCF @ 7%O₂</td>
<td>0.0026</td>
<td>0.0018</td>
<td>0.0019</td>
<td>0.0021</td>
</tr>
<tr>
<td>Mass emission rate, lb/hr</td>
<td>2.79</td>
<td>1.94</td>
<td>2.03</td>
<td>2.25</td>
</tr>
<tr>
<td><strong>Total particulate matter emissions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grains/DSCF @ 7%O₂</td>
<td>0.0057</td>
<td>0.0041</td>
<td>0.0040</td>
<td>0.0046</td>
</tr>
<tr>
<td>Mass emission rate, lb/hr</td>
<td>6.11</td>
<td>4.35</td>
<td>4.22</td>
<td>4.89</td>
</tr>
</tbody>
</table>

Table 4-13 Field Test 3, Summary of Results, WS2.5 Method / Method 202

<table>
<thead>
<tr>
<th>Parameter</th>
<th>API 2.5/202-1</th>
<th>API 2.5/202-2</th>
<th>API 2.5/202-3</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test time</td>
<td>0949-1353</td>
<td>1458-1805</td>
<td>2012-2313</td>
<td>NA</td>
</tr>
<tr>
<td>Flue gas flow, DSCFM</td>
<td>97,190</td>
<td>96,594</td>
<td>96,455</td>
<td>96,746</td>
</tr>
<tr>
<td><strong>Total filterable particulate matter emissions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grains/DSCF @ 7%O₂</td>
<td>0.0043</td>
<td>0.0045</td>
<td>0.0053</td>
<td>0.0047</td>
</tr>
<tr>
<td>Mass emission rate, lb/hr</td>
<td>4.61</td>
<td>4.73</td>
<td>5.54</td>
<td>4.96</td>
</tr>
<tr>
<td><strong>Filterable PM₂.₅ particulate matter emissions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grains/DSCF @ 7%O₂</td>
<td>0.0025</td>
<td>0.0031</td>
<td>NA</td>
<td>0.0028</td>
</tr>
<tr>
<td>Mass emission rate, lb/hr</td>
<td>2.84</td>
<td>3.34</td>
<td>NA</td>
<td>3.09</td>
</tr>
<tr>
<td><strong>Condensable particulate matter emissions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grains/DSCF @ 7%O₂</td>
<td>0.0022</td>
<td>0.0051</td>
<td>0.0032</td>
<td>0.0035</td>
</tr>
<tr>
<td>Mass emission rate, lb/hr</td>
<td>2.41</td>
<td>5.44</td>
<td>3.35</td>
<td>3.73</td>
</tr>
<tr>
<td><strong>Total particulate matter emissions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grains/DSCF @ 7%O₂</td>
<td>0.0065</td>
<td>0.0096</td>
<td>0.0085</td>
<td>0.0082</td>
</tr>
<tr>
<td>Mass emission rate, lb/hr</td>
<td>7.03</td>
<td>10.16</td>
<td>8.88</td>
<td>8.69</td>
</tr>
</tbody>
</table>

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          |

1No Pitot tubes were attached to the WS2.5 sampling probes.
### Table 4-16. Field Test 3, Quality Assurance Results EPA Method 5B / Method 202

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Requirement</th>
<th>5B/202-1</th>
<th>5B/202-2</th>
<th>5B/202-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isokinetic rate, %</td>
<td>90-110</td>
<td>101.1</td>
<td>99.9</td>
<td>97.8</td>
</tr>
<tr>
<td>Sample volumes</td>
<td>&gt;50 DSCF</td>
<td>102.335</td>
<td>102.927</td>
<td>99.693</td>
</tr>
<tr>
<td>Filter temperature, °F</td>
<td>320±25</td>
<td>304-322</td>
<td>300-331</td>
<td>297-324</td>
</tr>
<tr>
<td>Pre-test leak check, CFM</td>
<td>&lt;0.02</td>
<td>0.000 @ 10&quot;</td>
<td>0.000 @ 8&quot;</td>
<td>0.000 @ 14&quot;</td>
</tr>
<tr>
<td>Post-test leak check, CFM</td>
<td>&lt;0.02</td>
<td>0.000 @ 10&quot;</td>
<td>0.000 @ 12&quot;</td>
<td>0.000 @ 3&quot;</td>
</tr>
<tr>
<td>Measured moisture Content, %</td>
<td>N/A</td>
<td>19.51</td>
<td>18.21</td>
<td>18.91</td>
</tr>
<tr>
<td>Saturation moisture Content, %</td>
<td>N/A</td>
<td>18.47</td>
<td>18.35</td>
<td>18.07</td>
</tr>
<tr>
<td>CPM filter gas temp., °F</td>
<td>&lt;85°F</td>
<td>49-67</td>
<td>54-61</td>
<td>49-55</td>
</tr>
<tr>
<td>Impinger exit temp, °F</td>
<td>&lt;68°F</td>
<td>48-59</td>
<td>54-61</td>
<td>44-52</td>
</tr>
<tr>
<td>Pre test Pitot tube leak check</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Side A (Impact), in. H₂O</td>
<td>0.0 @ ≥3&quot;</td>
<td>0.0 @ 3&quot;</td>
<td>0.0 @ 3&quot;</td>
<td>0.0 @ 3&quot;</td>
</tr>
<tr>
<td>Side B (Static), in. H₂O</td>
<td>0.0 @ ≥3&quot;</td>
<td>0.0 @ 3&quot;</td>
<td>0.0 @ 3&quot;</td>
<td>0.0 @ 3&quot;</td>
</tr>
<tr>
<td>Post-test Pitot tube leak check</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Side A (Impact), in. H₂O</td>
<td>0.0 @ ≥3&quot;</td>
<td>0.0 @ 3&quot;</td>
<td>0.0 @ 3&quot;</td>
<td>0.0 @ 3&quot;</td>
</tr>
<tr>
<td>Side B (Static), in. H₂O</td>
<td>0.0 @ ≥3&quot;</td>
<td>0.0 @ 3&quot;</td>
<td>0.0 @ 3&quot;</td>
<td>0.0 @ 3&quot;</td>
</tr>
</tbody>
</table>

The data sheets for Test Program 3 are provided as the appendix of this report.
5. COMPARISON OF FIELD TEST PROGRAMS 1, 2, AND 3

5.1 COMPARISON 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 SO2 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>
<thead>
<tr>
<th>Plant</th>
<th>Sampling System</th>
<th>Total Filterable Particulate Matter, lbs/hr</th>
<th>Condensable Particulate Matter, lbs/hr</th>
<th>Total Particulate Matter, lbs/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Method 5B/202</td>
<td>4.00</td>
<td>7.56</td>
<td>11.56</td>
</tr>
<tr>
<td></td>
<td>WS2.5/202</td>
<td>5.17</td>
<td>7.46</td>
<td>12.63</td>
</tr>
<tr>
<td>2</td>
<td>Method 5B/202</td>
<td>1.50</td>
<td>26.0</td>
<td>27.5</td>
</tr>
<tr>
<td></td>
<td>WS2.5/202</td>
<td>4.30</td>
<td>24.4</td>
<td>28.7</td>
</tr>
<tr>
<td>3</td>
<td>Method 5B/202</td>
<td>2.64</td>
<td>2.25</td>
<td>8.69</td>
</tr>
<tr>
<td></td>
<td>WS2.5/202</td>
<td>4.96</td>
<td>3.73</td>
<td></td>
</tr>
</tbody>
</table>

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>
<thead>
<tr>
<th>Plant</th>
<th>Filterable Particulate Matter, lbs/hour</th>
<th>Filterable PM$_{2.5}$ Particulate Matter, lbs/hour</th>
<th>PM$_{2.5}$ % of Total Filterable Particulate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.17</td>
<td>1.20</td>
<td>23.2</td>
</tr>
<tr>
<td>2</td>
<td>4.30</td>
<td>0.26</td>
<td>6.0</td>
</tr>
<tr>
<td>3</td>
<td>4.96</td>
<td>3.03</td>
<td>61.1</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td>30.1</td>
</tr>
</tbody>
</table>

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


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
<table>
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<tr>
<th>PARAMETER</th>
<th>NOMENCLATURE</th>
<th>API-2.5-1</th>
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**Cut Sizes**

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<td>25.2</td>
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**FILTERABLE PARTICULATE EMISSIONS**

| Grains/DSCF | 0.003098 | 0.003320 | 0.003297 |
| Pounds/Hour | 3.800    | 4.154    | 4.090    |

**CONDENSIBLE PARTICULATE EMISSIONS**

| Grains/DSCF | 0.005037 | 0.006508 | 0.006774 |
| Pounds/Hour | 6.178    | 8.143    | 8.403    |

**TOTAL PARTICULATE EMISSIONS**

| Grains/DSCF | 0.008135 | 0.009828 | 0.010071 |
| Pounds/Hour | 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

\[ V_{mstd} = \left[ 17.647 \frac{\ell}{\ell} V_m \left( \frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m + 460} \right) \right] \]

\[ V_{mstd} = \left[ 17.647 \ell \frac{0.9941 \ell}{81.662} \left( \frac{29.60 + \frac{0.55}{13.6}}{550} \right) \right] \]
\[ V_{mstd} = 77.205 \text{ ft}^3 \]

Volume of Water Sampled, SCF

\[ V_{wstd} = 0.04715 \text{ [Weight of Condensed Moisture]} \]
\[ V_{wstd} = 0.04715 \text{ [473.4]} \]
\[ V_{wstd} = 22.321 \text{ ft}^3 \]

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

\[ M_{d} = 1 - \%H_2O/100 \]

\[ M_{d} = 1 - [22.29/100] \quad \text{Must use saturation moisture for } M_{d} \text{ calculation.} \]

\[ M_{d} = 0.777 \]

Molecular Weight of Sample Gas, Dry

\[ M_{d} = 0.44[\%CO_2]+0.32[\%O_2]+0.28[100-\%O_2-\%CO_2] \]

\[ M_{d} = 0.44[14.9]+0.32[2.8]+0.28[100-2.8-14.9] \]

\[ M_{d} = 30.50 \text{ pounds/pound-mole} \]

Molecular Weight of Sample Gas, Actual Conditions

\[ M_{s} = [M_{d} \times M_{d}] + [0.18 \times \%H_2O] \]

\[ M_{s} = [30.50 \times 0.777] + [0.18 \times 22.29] \]

\[ M_{s} = 27.71 \text{ pounds/pound-mole} \]

Average Stack Gas Velocity, Feet/second

\[ v_s = K \frac{C_{p} \left(\sqrt{\Delta p}\right)_{av}}{P_s M_s} \left[ \frac{T_s + 460}{P_s M_s} \right] \]

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

\[ v_s = 34.21 \text{ feet/second} \]
\textbf{Wet Volumetric Flue Gas Flow Rate at Stack Conditions, Cubic Feet per Minute}

\[ Q_{aw} = 60 \times vs \times A \]

\[ Q_{aw} = 60 \times 34.21 \times 103.868907 \]

\[ Q_{aw} = 213,198 \text{ Actual Cubic Feet per Minute} \]

\textbf{Dry Volumetric Flue Gas Flow Rate at Standard Conditions, Cubic Feet per Minute}

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

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

\[ Q_{sd} = 143,073 \text{ Dry Standard Cubic Feet per Minute} \]

\textbf{Isokinetic Sampling Rate, Percent}

\[ I = \left( \frac{100}{(60)(vs)(\theta)(A\eta)(Ps)(Mf\ell)(528)} \right) \left( \frac{T_s}{(V_{mat})(29.92)} \right) \]

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

\[ I = 100.8 \% \]
Filterable Particulate Matter Concentration, Grains per Dry Standard Cubic Foot

\[
gr/DSCF = \left[ \frac{CatchWeight (mg/1000)}{V_{mstd}} \right] \cdot \left( \frac{7000}{453.592} \right)\\
gr/DSCF = \left[ 0.0155 \right] \cdot \left( \frac{7000}{453.592} \right)\\
gr/DSCF = 0.000310
\]

Filterable Particulate Matter Emission Rate, Pounds per hour

\[
lb/hr = \left( \frac{mg/1000}{453.592} \right) \times \left( \frac{Q_{sd}}{V_{mstd}} \right) \times 60\\
lb/hr = \left( \frac{0.0155}{453.592} \right) \times \left( \frac{143,090}{77.205} \right) \times 60\\
lb/hr = 3.80
\]
VOLUME I

Appendix C – Field Data
Combined Cyclone PM10 & PM2.5 Run Data Sheet

**IDENTIFICATION INFORMATION**

<table>
<thead>
<tr>
<th>Plant Name</th>
<th>City</th>
<th>State</th>
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**PRELIMINARY CHECKS AND DATA**

- 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.

- Pitot Tube Pretest Leak Check: N/A
- Pitot Tube Posttest Leak Check: N/A

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<th>Barometric Pressure, In., Hg</th>
<th>Static Pressure, In., W.C.</th>
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**ACTUAL MOISTURE & GAS COMPOSITION**

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<th>Water Recovered, grams</th>
<th>Moisture, %</th>
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**Sampling Information**

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**QA Checks**

- Fill Volume, ACFM: 2.047
- Total Volume, ACFM: 84.27

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**Combined Cyclone PM10 & PM2.5 Run Data Sheet**

### Identification Information
- **Plant Name:**
- **City:**
- **State:**
- **Source Number:** FCC
drubber
- **Sampling Location:** Slipk
- **Test Personnel:** TAB
- **Meterbox ID:** 70223
- **ΔH:** 1303
- **Gamma, γ:** 0.4422
- **Nozzle ID:** N/A
- **Nozzle Diameter:** 0.252
- **Orsat/Fyrite:** N/A

### Preliminary Checks and Data
- **Actual**
  - Full Train Pretest Leak Check, ACFTM: 0.200
  - Partial Train Posttest Leak Check, ACFTM: 0.600
- **Req'd**
  - < 0.02 or 4%
- **Vacuum**
  - 15

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

- **A**
  - Pilot Tube Pretest Leak Check: N/A
  - Pilot Tube Posttest Leak Check: N/A

- **B**
  - Barometric Pressure, In. Hg: 29.60
  - Static Pressure, In. W.C.: -0.15

### Actual Moisture & Gas Composition
- Water Recovered, grams
- Moisture, %
  - CO₂ %
  - O₂ %

### Sampling Information

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<th>Port</th>
<th>Point</th>
<th>Dwell Time, (Min.)</th>
<th>Elapsed Time, h.m.s</th>
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<th>Meter Temp. (°F)</th>
<th>Stack Temp., (°F)</th>
<th>Sample Train Vac. (In. Hg)</th>
<th>Impinger Exit Gas Temp., (°F)</th>
<th>3H (In. H₂O)</th>
<th>Probe Temp., (°F)</th>
<th>Filter / Cyclone Temp., (°F)</th>
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### QA Checks
- **Averages**
  - Run:
  - Total Volume, ACM:
  - % in H₂O
  - microns
## Combined Cyclone PM10 & PM2.5 Run Data Sheet

### Identification Information
- **Plant Name:**
- **City:**
- **State:**
- **Source Number:** FCCS
- **Sampling Location:**
- **Test Personnel:**
- **Meterbox ID:**
- **H @:**
- **Gamma:**
- **Nozzle ID:**
- **Nozzle Diameter:**
- **Orsat/Fyrite:**

### Preliminary Checks and Data
- **Actual**
  - Full Train Pretest Leak Check, ACFM: 0.000
  - Partial Train Posttest Leak Check, ACFM: 0.000

- **Reg'd**
  - Vacuum: < 0.02 or 4% 15

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

### Actual Moisture & Gas Composition
- **Water Recovered, grams**
- **Moisture, %**
- **CO₂ %**
- **O₂ %**
- **Md_run**
- **Mw_run**

### Sampling Information

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<th>Meter Temp. (°F)</th>
<th>Stack Temp. (°F)</th>
<th>Sample Train Vac. (Hg.)</th>
<th>Impinger Exit Gas Temp. (°F)</th>
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### QA Checks
- **Run ID:** 3
- **Condition:**

### Barometric Pressure, In. Hg.: 27.7

### Static Pressure, In. W.C.: 0.15

### Total Run Time: 1:43:58
### Total Volume, ACF: 946.568

### Averages

<table>
<thead>
<tr>
<th>in. H₂O</th>
<th>°F</th>
<th>°F</th>
</tr>
</thead>
<tbody>
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### in H₂O

### % microns
## Source Information

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<th>Plant Name</th>
<th>City, State</th>
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## Sampling Information

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## Moisture Data

### Impinger 1
- **Contents** -
  - Initial Weight, grams: 460.5
  - Final Weight, grams: 635.0
  - Condensed Water, grams: 174.5

### Impinger 2
- **Contents** -
  - Initial Weight, grams: 600.6
  - Final Weight, grams: 600.6
  - Condensed Water, grams: 0.0

### Impinger 3
- **Contents** -
  - Initial Weight, grams: 607.8
  - Final Weight, grams: 606.9
  - Condensed Water, grams: -0.5

### Impinger 4
- **Contents** -
  - Initial Weight, grams: 596.2
  - Final Weight, grams: 594.5
  - Condensed Water, grams: 0.8

### Silica Gel
- **Contents** -
  - Adsorbed Water, grams: 11.0
  - Initial Weight, grams: 855.5
  - Final Weight, grams: 866.5
  - Total Water, grams: 185.8

### pH
- 5.5

---

Vm(std) = Volume of gas sampled at standard conditions (dscf) = \( \gamma m \times \frac{Pm}{(D+H/13.6)} \)\((Tm+460)\)
Vwc(std) = volume of water vapor at standard conditions (scf) = 0.04715 * volume of water collected (gms)
Bws = Mole fraction of water vapor = \( \frac{Vwc(std)}{(Vm(std) + Vwc(std))} \)
Percent Moisture = 100 * Bws

### IDENTIFICATION INFORMATION

- **Plan:**
- **City, State:**

- **Test Location:** 3CE/SLB, STACK
- **Personnel:** D.E., J.B. R.J.

- **Date:** 3/21
- **Start:** 10:06
- **Stop:** 11:15

- **Meterbox ID:** 82012
- **Filter ID:** Tare

- **Gamma (Y):** 0.97
- **Ideal Nozzle:** 0.312
- **Nozzle Dia.:** 0.258
- **Nozzle ID:** 1.3
- **Pilot Tube ID:** 4.4

- **K Factor:** 1.76
- **K Factor:**
- **TC Readout ID:** 82012

### PRELIMINARY CHECKS AND DATA

- **Actual:** Pre Leak Check, ACFM
  - **Vacuum:** < 0.02
  - **CO:** 5

- **Post Leak Check, ACFM:**
  - **A:** Ve 4
  - **B:** Ve 5

- **Pilot Pre Leak Check:** Ve 4
- **Pilot Post Leak Check:** Ve 4

- **Static Pressure, In. Hg:** -0.15
- **Barometric Pressure, In. Hg:** 29.60

### ACTUAL MOISTURE & GAS COMPOSITION

- **Water Recovered, grams:** 473.4
- **CO2 %:** 1.9
- **Moisture, %:** 22.43
- **O2 %:** 2.8

### Sampling Information

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<tr>
<th>Port/Point</th>
<th>Elapsed Time</th>
<th>Volume Metered</th>
<th>∆P</th>
<th>Meter Temp</th>
<th>Stack Temp</th>
<th>∆H</th>
<th>Probe Temp</th>
<th>Filter Temp</th>
<th>Exit Temp</th>
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### Averages

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<tbody>
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<td>in. H2O</td>
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### Max / Min °F

| ISO | High | Total |
Air Control Techniques, P.C.
Isokinetic Sampling Train Field Data Sheet

**IDENTIFICATION INFORMATION**

| Plant | |
| City, State | |

**PRELIMINARY CHECKS AND DATA**

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**Static Pressure, In. H2O**

-0.15

**Barometric Pressure, In. Hg**

29.60

**ACTUAL MOISTURE & GAS COMPOSITION**

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<tr>
<th>Water Recovered, grams</th>
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**Sampling Information**

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<th>Meter Temp</th>
<th>Stack Temp</th>
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<th>Probe Temp</th>
<th>Filter Temp</th>
<th>Exit Temp &lt; 68°F</th>
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**Method 5B Probe and Filter Temp 320°F ± 10° F**

**OTM028 Filter Temp < 85° F**

**Averages**

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<th>Vm</th>
<th>Max / Min °F</th>
<th>ISO</th>
<th>High</th>
<th>Total</th>
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<tr>
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<td>°F</td>
<td>in. H2O</td>
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<th>Filter ID Tare</th>
<th>K Factor</th>
<th>Water Recovered, grams</th>
<th>CO2 %</th>
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## Preliminary Checks and Data

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<table>
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<th>Pre Leak Check, ACFM</th>
<th>Post Leak Check, ACFM</th>
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<table>
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<tr>
<th>Static Pressure, In. H2O</th>
<th>Barometric Pressure, In. Hg</th>
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## Actual MOISTURE & GAS COMPOSITION

<table>
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<tr>
<th>K Factor</th>
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<th>CO2 %</th>
<th>Moisture, %</th>
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## Sampling Information

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<th>Volume Metered</th>
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<th>Stack Temp</th>
<th>ΔH</th>
<th>Probe Temp</th>
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### Method 5B Probe and Filter Temp 320°F ± 10°F

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## Averages

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<th>Vmstd</th>
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|---------|----|---------|---|--------|---------|

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<th>High</th>
<th>Total</th>
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4/11/2016
### Method 4 - Air Control Techniques, P.C.

#### Source Information
- **Client**: APT
- **Job #**: 1436
- **Sampling Location**: FLCU Scrubber Stack

#### Sampling Information
- **Run Number**: M5B038-1, M5B038-2, M5B038-3
- **Filter Identification**: R05763, R05762, R05741
- **Sampling Date**: 8/15/09, 8/15/09, 8/16/09
- **Recovery Date**: **N/A**

#### Moisture Data

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<th>Contents -</th>
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<td>Condensed Water, grams</td>
<td>457.4</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Impinger 2</th>
<th>Contents -</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final Weight, grams</td>
<td>618.0</td>
</tr>
<tr>
<td>Initial Weight, grams</td>
<td>618.0</td>
</tr>
<tr>
<td>Condensed Water, grams</td>
<td>0.01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Impinger 3</th>
<th>Contents -</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final Weight, grams</td>
<td>620.1</td>
</tr>
<tr>
<td>Initial Weight, grams</td>
<td>619.8</td>
</tr>
<tr>
<td>Condensed Water, grams</td>
<td>0.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Impinger 4</th>
<th>Contents -</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final Weight, grams</td>
<td>610.3</td>
</tr>
<tr>
<td>Initial Weight, grams</td>
<td>610.9</td>
</tr>
<tr>
<td>Condensed Water, grams</td>
<td>-0.6</td>
</tr>
</tbody>
</table>

| 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 | 573.4 | 503.7 | 455.9 |
| **pH** | 5.5 | 5.0 | 6.5 |

---

\[ Vm(\text{std}) = \text{Volume of gas sampled at standard conditions (dscf)} = \gamma \times 17.64 \times Vm \times (P/\text{bar} + (D \times 13.6))/(Tm + 460) \]

\[ Vw(\text{std}) = \text{volume of water vapor at standard conditions (scf)} = 0.04715 \times \text{volume of water collected (gms)} \]

\[ Bws = \text{Mole fraction of water vapor} = Vw(\text{std}) / (Vm(\text{std}) + Vw(\text{std})) \]

Percent Moisture = 100 \times Bws
### Method 3 - Air Control Techniques, P.C.

### Identification Information
- Client: API
- Date: 8/5/69
- Job: 1436
- Process: 01
- Fuel Type(s):

### Run Data

#### m5/028-1
- Leak: √
- Sample Time | Time of Analysis | CO₂ | O₂ Reading | O₂, %
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1008</td>
<td>1330</td>
<td>14.9</td>
<td>17.7</td>
<td>2.8</td>
</tr>
<tr>
<td>↓</td>
<td>↓</td>
<td>14.9</td>
<td>17.7</td>
<td>2.8</td>
</tr>
<tr>
<td>1320</td>
<td>1345</td>
<td>14.9</td>
<td>17.7</td>
<td>2.8</td>
</tr>
</tbody>
</table>
- Average: 14.9 | 17.7 | 2.8 |
- Orsat ID: ACT-1
- Bag ID: 7
- \( F_0 = 1.215 \)

#### m5/028-2
- Leak: √
- Sample Time | Time of Analysis | CO₂ | O₂ Reading | O₂, %
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1419</td>
<td>1730</td>
<td>15.5</td>
<td>18.1</td>
<td>2.6</td>
</tr>
<tr>
<td>↓</td>
<td>↓</td>
<td>15.5</td>
<td>18.1</td>
<td>2.6</td>
</tr>
<tr>
<td>1723</td>
<td>1745</td>
<td>15.5</td>
<td>18.1</td>
<td>2.6</td>
</tr>
</tbody>
</table>
- Average: 15.5 | 18.1 | 2.6 |
- Orsat ID: ACT-1
- Bag ID: 16
- \( F_0 = 1.181 \)

#### m5/028-3
- Leak: √
- Sample Time | Time of Analysis | CO₂ | O₂ Reading | O₂, %
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0830</td>
<td>1215</td>
<td>15.4</td>
<td>18.0</td>
<td>2.6</td>
</tr>
<tr>
<td>↓</td>
<td>↓</td>
<td>15.4</td>
<td>18.0</td>
<td>2.6</td>
</tr>
<tr>
<td>1200</td>
<td>1210</td>
<td>15.4</td>
<td>18.0</td>
<td>2.6</td>
</tr>
</tbody>
</table>
- Average: 15.4 | 18.0 | 2.6 |
- Orsat ID: ACT-1
- Bag ID: 15
- \( F_0 = 1.188 \)

### Fuel Factor (\( F_0 \)) Calculations

\[
F_0 = \frac{20.9 - \%O_2}{\%CO_2}
\]

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>( F_0 ) Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal: Anthracite &amp; Lignite</td>
<td>1.016 - 1.130</td>
</tr>
<tr>
<td>Bituminous</td>
<td>1.083 - 1.230</td>
</tr>
<tr>
<td>Oil: Distillate</td>
<td>1.260 - 1.413</td>
</tr>
<tr>
<td>Residual</td>
<td>1.210 - 1.370</td>
</tr>
<tr>
<td>Gas: Natural</td>
<td>1.600 - 1.836</td>
</tr>
<tr>
<td>Propane</td>
<td>1.434 - 1.586</td>
</tr>
<tr>
<td>Butane</td>
<td>1.405 - 1.553</td>
</tr>
<tr>
<td>Wood</td>
<td>1.000 - 1.120</td>
</tr>
<tr>
<td>Wood Bark</td>
<td>1.003 - 1.130</td>
</tr>
</tbody>
</table>
VOLUME I

Appendix D – Calibration Data
# APEX INSTRUMENTS METHOD 5 PRE-TEST CONSOLE CALIBRATION

**USING CALIBRATED CRITICAL ORIFICES**

## 5-POINT ENGLISH UNITS

<table>
<thead>
<tr>
<th>Console Model Number</th>
<th>DGM Model Number</th>
<th>DGM Serial Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>702233</td>
<td>RW 110</td>
<td>1014753</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Calibration Conditions</th>
<th>Factors/Conversions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barometric Pressure</td>
<td>Std Temp</td>
</tr>
<tr>
<td>29.80 in Hg</td>
<td>528</td>
</tr>
<tr>
<td>Theoretical Critical Vacuum$^1$</td>
<td>Std Press</td>
</tr>
<tr>
<td>14.07 in Hg</td>
<td>29.92 in Hg</td>
</tr>
<tr>
<td>Calibration Technician</td>
<td>$K_1$</td>
</tr>
<tr>
<td>DLS</td>
<td>17.647</td>
</tr>
</tbody>
</table>

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

$^1$The Critical Orifice Coefficient, $K$, must be entered in English units, (ft$^4$*lbf)/ft. (lbm/min).

<table>
<thead>
<tr>
<th>Run Time</th>
<th>DGM Orifice</th>
<th>Volume Initial</th>
<th>Volume Final</th>
<th>Outlet Temp Initial</th>
<th>Outlet Temp Final</th>
<th>Serial Number</th>
<th>Coefficient</th>
<th>Actual Vacuum</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.0</td>
<td>0.26</td>
<td>127.050</td>
<td>133.448</td>
<td>68</td>
<td>70</td>
<td>FO 40</td>
<td>0.2387</td>
<td>66</td>
</tr>
<tr>
<td></td>
<td></td>
<td>cubic feet</td>
<td>cubic feet</td>
<td>$^\circ F$</td>
<td>$^\circ F$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.5</td>
<td>0.61</td>
<td>139.560</td>
<td>145.297</td>
<td>71</td>
<td>71</td>
<td>FO 48</td>
<td>0.3493</td>
<td>66</td>
</tr>
<tr>
<td></td>
<td></td>
<td>cubic feet</td>
<td>cubic feet</td>
<td>$^\circ F$</td>
<td>$^\circ F$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.5</td>
<td>1.10</td>
<td>139.560</td>
<td>145.297</td>
<td>71</td>
<td>71</td>
<td>FO 55</td>
<td>0.4592</td>
<td>66</td>
</tr>
<tr>
<td></td>
<td></td>
<td>cubic feet</td>
<td>cubic feet</td>
<td>$^\circ F$</td>
<td>$^\circ F$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.5</td>
<td>1.80</td>
<td>148.500</td>
<td>150.845</td>
<td>72</td>
<td>73</td>
<td>FO 63</td>
<td>0.5907</td>
<td>66</td>
</tr>
<tr>
<td></td>
<td></td>
<td>cubic feet</td>
<td>cubic feet</td>
<td>$^\circ F$</td>
<td>$^\circ F$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.5</td>
<td>3.40</td>
<td>153.820</td>
<td>159.860</td>
<td>73</td>
<td>73</td>
<td>FO 73</td>
<td>0.8085</td>
<td>68</td>
</tr>
</tbody>
</table>

## Standardized Data

<table>
<thead>
<tr>
<th>Dry Gas Meter</th>
<th>Critical Orifice</th>
<th>Calibration Factor</th>
<th>Flowrate</th>
<th>$\Delta H$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{(0.011)}$</td>
<td>$O_{(0.011)}$</td>
<td>$(V)_{(0.011)}$</td>
<td>$(O)_{(0.011)}$</td>
<td>$\Delta H$</td>
</tr>
<tr>
<td>cubic feet</td>
<td>cubic feet</td>
<td>cfm</td>
<td>cfm</td>
<td>in H2O</td>
</tr>
<tr>
<td>5.562</td>
<td>0.399</td>
<td>5.572</td>
<td>0.310</td>
<td>1.002</td>
</tr>
<tr>
<td>5.567</td>
<td>0.453</td>
<td>5.546</td>
<td>0.452</td>
<td>0.998</td>
</tr>
<tr>
<td>5.679</td>
<td>0.600</td>
<td>5.650</td>
<td>0.596</td>
<td>0.993</td>
</tr>
<tr>
<td>8.040</td>
<td>0.769</td>
<td>8.044</td>
<td>0.766</td>
<td>0.996</td>
</tr>
<tr>
<td>5.810</td>
<td>1.055</td>
<td>5.767</td>
<td>1.049</td>
<td>0.993</td>
</tr>
</tbody>
</table>

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.

Identify that the above Dry Gas Meter was calibrated in accordance with USEPA Methods, CFR Title 40, Part 60, Appendix A-3, Method 5, 18.2.3

Signature: [Signature]

Date: 2-11-09
# APEX INSTRUMENTS METHOD 5 POST-TEST CONSOLE CALIBRATION

## USING CALIBRATED CRITICAL ORIFICES

### 3-POINT ENGLISH UNITS

<table>
<thead>
<tr>
<th>Meter Console Information</th>
<th>Calibration Conditions</th>
<th>Factors/Conversions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Console Model Number</strong></td>
<td>Date 05/02/09</td>
<td>Std Temp 528°F</td>
</tr>
<tr>
<td><strong>Console Serial Number</strong></td>
<td></td>
<td>Std Press 29.92 in Hg</td>
</tr>
<tr>
<td><strong>DGM Model Number</strong></td>
<td></td>
<td>Kt 17.647 cfm/in Hg</td>
</tr>
<tr>
<td><strong>DGM Serial Number</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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, $K^*_t$, must be entered in English units, $(t^°F - R)(in.Hg)$.min.

<table>
<thead>
<tr>
<th>Run Time</th>
<th>DGM Orifice</th>
<th>Volume Elapsed</th>
<th>Volume Initial</th>
<th>Volume Final</th>
<th>Outlet Temp Initial</th>
<th>Outlet Temp Final</th>
<th>Serial Number</th>
<th>Coefficient</th>
<th>Amb Temp Initial</th>
<th>Amb Temp Final</th>
<th>Actual Vacuum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$P_{o,m}$</td>
<td>(V$_o$)</td>
<td>(V$_o$)</td>
<td>(V$_o$)</td>
<td>(T$_o$)</td>
<td>(T$_o$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>in H$_2$O</td>
<td>cubic feet</td>
<td>cubic feet</td>
<td>cubic feet</td>
<td>°F</td>
<td>°F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.0</td>
<td>1.80</td>
<td>208.730</td>
<td>215.222</td>
<td>81</td>
<td>76</td>
<td>76</td>
<td>FO 63</td>
<td>0.5907</td>
<td>76</td>
<td>76</td>
<td>18.00</td>
</tr>
<tr>
<td>7.0</td>
<td>1.80</td>
<td>215.222</td>
<td>220.693</td>
<td>81</td>
<td>76</td>
<td>76</td>
<td>FO 63</td>
<td>0.5907</td>
<td>76</td>
<td>76</td>
<td>18.00</td>
</tr>
<tr>
<td>7.0</td>
<td>1.80</td>
<td>220.693</td>
<td>226.187</td>
<td>81</td>
<td>76</td>
<td>76</td>
<td>FO 63</td>
<td>0.5907</td>
<td>76</td>
<td>76</td>
<td>18.00</td>
</tr>
</tbody>
</table>

### Results

<table>
<thead>
<tr>
<th>Dry Gas Meter</th>
<th>Critical Orifice</th>
<th>Calibration Factor</th>
<th>Flowrate</th>
<th>$\Delta H$ @ 0.75 SCFM</th>
<th>Variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>$(V_{actual})$</td>
<td>$(Q_{actual})$</td>
<td>$(Y)$</td>
<td>$(\Delta Y)$</td>
<td>$(\Delta H)_{actual}$</td>
<td>$(\Delta H)_{avg}$</td>
</tr>
<tr>
<td>cubic feet</td>
<td>cfm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.406</td>
<td>0.730</td>
<td>5.358</td>
<td>0.765</td>
<td>0.991</td>
<td>-0.003</td>
</tr>
<tr>
<td>5.377</td>
<td>0.768</td>
<td>5.358</td>
<td>0.765</td>
<td>0.996</td>
<td>0.003</td>
</tr>
<tr>
<td>5.395</td>
<td>0.771</td>
<td>5.358</td>
<td>0.765</td>
<td>0.993</td>
<td>0.000</td>
</tr>
<tr>
<td>Pretest Gamma</td>
<td>0.9952</td>
<td>% Deviation 0.3</td>
<td>Y Average</td>
<td></td>
<td>1.708</td>
</tr>
</tbody>
</table>

**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 $\pm$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, 162.3.

Signature: [Signature]

Date: 9-02-09
<table>
<thead>
<tr>
<th>Date</th>
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</tr>
</thead>
<tbody>
<tr>
<td>OTM-036</td>
<td></td>
</tr>
<tr>
<td>Page 151</td>
<td>Page 151</td>
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<tr>
<td>643</td>
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</table>

## Calibration Conditions

<table>
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<tbody>
<tr>
<td>OTM-036</td>
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<tr>
<td>Page 151</td>
<td>Page 151</td>
</tr>
<tr>
<td>643</td>
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</table>

### Calibration Data

<table>
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<th>Calibration Conditions</th>
<th>Calibration Conditions</th>
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<tbody>
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<td>Page 151</td>
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## Calibration Data

<table>
<thead>
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### Material Code

<table>
<thead>
<tr>
<th>Material Code</th>
<th>Material Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>523</td>
<td>RGR-1000</td>
</tr>
</tbody>
</table>

### Dry Gas Meter

<table>
<thead>
<tr>
<th>Dry Gas Meter</th>
<th>Dry Gas Meter</th>
</tr>
</thead>
<tbody>
<tr>
<td>RGR-1000</td>
<td>RGR-1000</td>
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### Calibration Data

<table>
<thead>
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<th>Calibration Conditions</th>
<th>Calibration Conditions</th>
<th>Calibration Conditions</th>
<th>Calibration Conditions</th>
<th>Calibration Conditions</th>
<th>Calibration Conditions</th>
<th>Calibration Conditions</th>
<th>Calibration Conditions</th>
<th>Calibration Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>4/11/2016</td>
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# APEX INSTRUMENTS METHOD 5 POST-TEST CONSOLE CALIBRATION

**USING CALIBRATED CRITICAL ORIFICES**

**3-POINT ENGLISH UNITS**

<table>
<thead>
<tr>
<th>Meter Console Information</th>
<th>Calibration Conditions</th>
<th>Factors/Conversions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Console Model Number</td>
<td>522</td>
<td>Std Temp</td>
</tr>
<tr>
<td>Console Serial Number</td>
<td>802012</td>
<td>59°F</td>
</tr>
<tr>
<td>DGM Model Number</td>
<td>RW110</td>
<td>Std Press</td>
</tr>
<tr>
<td>DGM Serial Number</td>
<td>084447</td>
<td>29.92 in Hg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kc</td>
</tr>
<tr>
<td></td>
<td></td>
<td>17.847 aHg/ft³</td>
</tr>
</tbody>
</table>

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

2The Critical Orifice Coefficient, Kc, must be entered in English units, (k3/3)*g*(Vc/KV/ft³).

<table>
<thead>
<tr>
<th>Run Time</th>
<th>DGM Orifice Initial</th>
<th>Volume Initial</th>
<th>Volume Final</th>
<th>Outlet Temp Initial</th>
<th>Outlet Temp Final</th>
<th>Serial Number</th>
<th>Coefficient</th>
<th>Amb Temp Final</th>
<th>Amb Temp Initial</th>
<th>Actual Vacuum</th>
</tr>
</thead>
<tbody>
<tr>
<td>(mil)</td>
<td>(in. H2O)</td>
<td>(ft³)</td>
<td>(ft³)</td>
<td>(°F)</td>
<td>(°F)</td>
<td>(Kc)</td>
<td>(deg F)</td>
<td>(°F)</td>
<td>(°F)</td>
<td>(in. Hg)</td>
</tr>
<tr>
<td>7.5</td>
<td>1.70</td>
<td>15.300</td>
<td>21.178</td>
<td>80</td>
<td>80</td>
<td>FO 63</td>
<td>0.5907</td>
<td>76</td>
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<td>1.70</td>
<td>21.178</td>
<td>27.034</td>
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<td>81</td>
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**Results**

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<thead>
<tr>
<th>Standardized Data</th>
<th>Critical Orifice</th>
<th>Calibration Factor</th>
<th>Dry Gas Meter</th>
</tr>
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<tbody>
<tr>
<td>(Vmax)</td>
<td>(Cmax)</td>
<td>(Y)</td>
<td>(V)</td>
</tr>
<tr>
<td>(cubic feet)</td>
<td>(cubic feet)</td>
<td>(mil)</td>
<td>(ft³)</td>
</tr>
<tr>
<td>5.787</td>
<td>0.772</td>
<td>0.772</td>
<td>0.765</td>
</tr>
<tr>
<td>5.760</td>
<td>0.766</td>
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<td>5.769</td>
<td>0.772</td>
<td>0.772</td>
<td>0.765</td>
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<tr>
<td>Pretest Gasmeter</td>
<td>0.9941</td>
<td>% Deviation</td>
<td>0.1</td>
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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 ±0.03.

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: [Signature]

Date: 9-03-09
### Type S Pitot Tube Inspection

**Air Control Techniques, P.C.**

#### Identification Information

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<tr>
<th>Client</th>
<th>IN HOUSE</th>
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<tbody>
<tr>
<td>Plant Name</td>
<td>NA</td>
</tr>
<tr>
<td>City</td>
<td>CARY</td>
</tr>
<tr>
<td>State</td>
<td>NC</td>
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<tr>
<td>Pitot ID</td>
<td>4A</td>
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</table>

#### Inspection Results

| Inspection Data | | |
|-----------------|--------------|
| Level and Perpendicular? | Yes |
| Obstruction? | No |
| Damaged? | No |
| $\alpha_1 (-10^\circ \leq \alpha_1 \leq +10^\circ)$ | 0 |
| $\alpha_2 (-10^\circ \leq \alpha_2 \leq +10^\circ)$ | 0 |
| $\beta_1 (-5^\circ \leq \beta_1 \leq +5^\circ)$ | 0 |
| $\beta_2 (-5^\circ \leq \beta_2 \leq +5^\circ)$ | 0 |
| $\gamma$ | 0 |
| $\theta$ | 0 |
| $z = A \tan \gamma$ ($\leq 0.125$ inches) | 0 |
| $w = A \tan \theta$ ($\leq 0.03125$ inches) | 0 |
| $D_1$ (3/16 inch $\leq D_1 \leq 3/8$ inch) | 0.375 |
| $A$ | 0.875 |
| $A/V D_1$ (1.05 $\leq PA/D_1 \leq 1.5$) | 1.17 |

#### Notes

- Additional inspection notes can be added in the provided section.

#### Pitot Coefficient

| Coefficient of 0.84 Assigned? | Yes |
| Inspection Personnel | DL5 |

**Form ACTPC PI-2**
### Stainless Steel Nozzle Calibration and Condition

**Air Control Techniques, P.C.**

<table>
<thead>
<tr>
<th>Nozzle Set ID</th>
<th>Nozzle ID</th>
<th>Average</th>
<th>Measurements</th>
<th>High-Low</th>
<th>Condition</th>
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<td>0.123</td>
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<td>0.122</td>
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<tr>
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<td>0.186</td>
<td>0.181</td>
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**OTM-036**

Page 155 of 643

4/11/2016
## Glass Nozzle Calibration and Inspection
### Air Control Techniques, P.C.

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VOLUME I

Appendix E – Analytical Data
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.

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SEE PAGE 2

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Received By (Signature & Printed Name) Date: 3/11/09
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Relinquished By: (Signature and Printed Name) Date: 8/11/09
Received By: (Signature & Printed Name) Date: 8/11/09
# REPORT SUMMARY

RFA#: 1436

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Sample Matrix & Components:

Dry Filters, Front 6 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: [Signature]

Date: 8/25/09

(J. Bruce Nemet, Lab QA Officer)
## PARTICULATE SAMPLING LABORATORY RESULTS

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<td>Date</td>
<td>init</td>
<td>init</td>
</tr>
<tr>
<td>08/23</td>
<td>BNL</td>
<td>3.9026</td>
<td>08/23</td>
<td>3.8869</td>
</tr>
<tr>
<td>Baggage Tare Wt., g.</td>
<td>3.5659</td>
<td>3.4920</td>
<td>3.5960</td>
<td></td>
</tr>
<tr>
<td>Filter Tare Wt., g.</td>
<td>RQ-5763</td>
<td>0.3836</td>
<td>RQ-5762</td>
<td>0.3868</td>
</tr>
<tr>
<td>FILTER SAMPLE Wt., g.</td>
<td>0.0110</td>
<td>0.0163</td>
<td>0.0161</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rinse Container</th>
<th>Date</th>
<th>init</th>
<th>Date</th>
<th>init</th>
<th>Date</th>
<th>init</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>init</td>
<td>Date</td>
<td>init</td>
<td>Date</td>
<td>init</td>
<td>Date</td>
</tr>
<tr>
<td>08/23</td>
<td>BNL</td>
<td>3.4926</td>
<td>08/23</td>
<td>3.5526</td>
<td>08/23</td>
<td>3.6093</td>
</tr>
<tr>
<td>08/22</td>
<td>BNL</td>
<td>3.5337</td>
<td>08/22</td>
<td>3.5635</td>
<td>08/22</td>
<td>3.5680</td>
</tr>
<tr>
<td>Rinse Wt., g.</td>
<td>(122 ml)</td>
<td>3.3931</td>
<td>(122 ml)</td>
<td>3.3616</td>
<td>(99 ml)</td>
<td>3.6592</td>
</tr>
<tr>
<td>RINSE SAMPLE Wt., g.</td>
<td>0.0051</td>
<td>0.0019</td>
<td>0.0009</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 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.

<table>
<thead>
<tr>
<th>Blank Beaker #</th>
<th>1011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final w., mg.</td>
<td>3.6991</td>
</tr>
<tr>
<td>Tare w., mg.</td>
<td>3.6881</td>
</tr>
<tr>
<td>Residual, mg.</td>
<td>1</td>
</tr>
<tr>
<td>Volume, ml.</td>
<td>210</td>
</tr>
<tr>
<td>Density, g/ml</td>
<td>785.0</td>
</tr>
<tr>
<td>Upper Limit, mg/ml</td>
<td>6.16-05</td>
</tr>
</tbody>
</table>

### Visual Inspection of Filters

<table>
<thead>
<tr>
<th>Run ID</th>
<th>M5B-026-1</th>
<th>M5B-026-2</th>
<th>M5B-026-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>BROWN</td>
<td>BROWN</td>
<td>BROWN</td>
</tr>
<tr>
<td>Texture</td>
<td>STAIN</td>
<td>STAIN</td>
<td>STAIN</td>
</tr>
<tr>
<td>Foreign Matter</td>
<td>NONE</td>
<td>NONE</td>
<td>NONE</td>
</tr>
<tr>
<td>Relative Comp.</td>
<td>MEDIUM</td>
<td>MEDIUM</td>
<td>MEDIUM</td>
</tr>
</tbody>
</table>

### Visual Inspection of Rinses

<table>
<thead>
<tr>
<th>Run ID</th>
<th>M5B-026-1</th>
<th>M5B-026-2</th>
<th>M5B-026-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>BROWN</td>
<td>BROWN</td>
<td>BROWN</td>
</tr>
<tr>
<td>Texture</td>
<td>FILM</td>
<td>FILM</td>
<td>FILM</td>
</tr>
<tr>
<td>Foreign Matter</td>
<td>NONE</td>
<td>NONE</td>
<td>NONE</td>
</tr>
<tr>
<td>Relative Comp.</td>
<td>HIGH</td>
<td>MEDIUM</td>
<td>LOW</td>
</tr>
</tbody>
</table>

Miscellaneous Notes & Comments:

**Printing Date:** 25-Aug-05  **Printing Time:** 04:24 PM
## REAGENT BLANK LABORATORY RESULTS (Version 04.28.92)

<table>
<thead>
<tr>
<th>Date</th>
<th>Date Code</th>
<th>Weight, g.</th>
</tr>
</thead>
<tbody>
<tr>
<td>09/22</td>
<td>BNL</td>
<td>3.694</td>
</tr>
<tr>
<td>09/20</td>
<td>BNL</td>
<td>3.699</td>
</tr>
<tr>
<td>210 ml</td>
<td></td>
<td>3.6991</td>
</tr>
<tr>
<td>SAMPLE WT., g.</td>
<td></td>
<td>0.0010</td>
</tr>
</tbody>
</table>

Run Number: ACETONE BLANK

Sample ID/Container #: 1011
## REPORT SUMMARY

**RFA#: 1436**

<table>
<thead>
<tr>
<th>METHOD</th>
<th>PARTICULATE (\leq 2.5 \mu m)</th>
<th>PARTICULATE (&gt;2.5\mu m)</th>
<th>PROBE &amp; NOZZLE RINSE</th>
<th>TOTAL FILTERABLE PARTICULATE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ACETONE BLANK</strong></td>
<td>1.0 mg (210 mL)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>API2.5-028-1</strong></td>
<td>3.7 mg</td>
<td>0.9 mg</td>
<td>5.4 mg</td>
<td>10.0 mg</td>
</tr>
<tr>
<td><strong>API2.5-028-2</strong></td>
<td>1.0 mg</td>
<td>1.1 mg</td>
<td>15.6 mg</td>
<td>17.7 mg</td>
</tr>
<tr>
<td><strong>API2.5-028-3</strong></td>
<td>0.9 mg</td>
<td>1.3 mg</td>
<td>3.8 mg</td>
<td>6.0 mg</td>
</tr>
</tbody>
</table>
Sample Matrix & Components:

Dry Filters, Acetone Rinses (Precutter/Cyclone and Front\^4 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: [Signature]

Date: 8/25/09

(From Bruce Nemet, Lab QA Officer)
### PARTICULATE SAMPLING LABORATORY RESULTS (OTM-027)

<table>
<thead>
<tr>
<th>Plant Name</th>
<th>RFA #</th>
<th>1436</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method: OTM-027</td>
<td>Filename:</td>
<td>ACT</td>
</tr>
<tr>
<td>Date Received: 08/11/09</td>
<td>Page 1 of 4</td>
<td>File Pathway: C:\JOBS\1436\ACT,W81</td>
</tr>
</tbody>
</table>

**Run Number:** AP2.5-028-1

<table>
<thead>
<tr>
<th>Filter Container</th>
<th>Date</th>
<th>Init</th>
<th>&lt; 2.5 um</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>08/23</td>
<td>BNL</td>
<td>3.6000</td>
</tr>
<tr>
<td>Baggie Tare Wt., g.</td>
<td>SF47-873</td>
<td>3.5735</td>
<td></td>
</tr>
<tr>
<td>Filter Tare Wt., g.</td>
<td>SF47-873</td>
<td>0.1139</td>
<td></td>
</tr>
<tr>
<td>FILTER SAMPLE WT., g.</td>
<td>SF47-873</td>
<td>0.0020</td>
<td></td>
</tr>
</tbody>
</table>

**Sample I.D.**

<table>
<thead>
<tr>
<th>Date</th>
<th>Init</th>
<th>&lt; 2.5 um</th>
<th>(&gt; 2.5 um)</th>
<th>(&lt; Probe &amp; Nozzle Rinse)</th>
</tr>
</thead>
<tbody>
<tr>
<td>08/23</td>
<td>BNL</td>
<td>3.7933</td>
<td>08/23</td>
<td>3.6769</td>
</tr>
<tr>
<td>08/20</td>
<td>BNL</td>
<td>3.7930</td>
<td>08/20</td>
<td>3.6770</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.7917</td>
<td>08/20</td>
<td>0.0017</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.6977</td>
<td>08/20</td>
<td>3.6199</td>
</tr>
<tr>
<td>Rinse Wt., g.</td>
<td>50 ml</td>
<td>0.9017</td>
<td>08/20</td>
<td>0.6566</td>
</tr>
</tbody>
</table>

| Filter Catch, mg. | 2.6 | NA | NA |
| Blank Residue, mg. | 0.2 | 0.3 | 1.2 |
| Net Rinse Catch, mg. | 1.1 | 0.9 | 5.4 |

FILTERABLE PARTICULATE, mg.

<table>
<thead>
<tr>
<th>Blank Beaker</th>
<th>1011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final wt., mg.</td>
<td>3.6091</td>
</tr>
<tr>
<td>Tare wt., mg.</td>
<td>3.6681</td>
</tr>
<tr>
<td>Residue, mg.</td>
<td>1.0</td>
</tr>
<tr>
<td>Volume, ml.</td>
<td>210</td>
</tr>
<tr>
<td>Density, mg/ml</td>
<td>785.0</td>
</tr>
<tr>
<td>Conc., mg/L</td>
<td>6.066E-05</td>
</tr>
<tr>
<td>Upper Limit, mg/L</td>
<td>1.000E-05</td>
</tr>
</tbody>
</table>

**Visual Inspection:**

<table>
<thead>
<tr>
<th>Run ID</th>
<th>In Black Filter</th>
<th>2.5 Rinse</th>
<th>2.5-10 Rinse</th>
<th>&gt;10 Rinse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color:</td>
<td>BROWN</td>
<td>WHITE</td>
<td>WHITE</td>
<td>BROWN</td>
</tr>
<tr>
<td>Texture:</td>
<td>STAIN</td>
<td>FILM</td>
<td>FILM</td>
<td>FILM</td>
</tr>
<tr>
<td>Foreign Matter:</td>
<td>NONE</td>
<td>NONE</td>
<td>NONE</td>
<td>NONE</td>
</tr>
<tr>
<td>Relative Comp:</td>
<td>MEDIUM</td>
<td>LOW</td>
<td>LOW</td>
<td>HIGH</td>
</tr>
</tbody>
</table>

**Legend:**

- @ = Final Weight
- F = Filter
- R = Rinse

**Printing Date:** 15-Aug-05  **Printing Time:** 02:03 PM

**OTM-036** Page 167 of 643  **4/11/2016**
**PARTICULATE SAMPLING LABORATORY RESULTS (OTM-027)**

<table>
<thead>
<tr>
<th>Run Number</th>
<th>AP2.5-028-2</th>
</tr>
</thead>
</table>

**Filler Container #**

<table>
<thead>
<tr>
<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Init</th>
</tr>
</thead>
<tbody>
<tr>
<td>08/23</td>
<td>BNL 3.7615</td>
<td>08/23</td>
<td>SF47-874 0.1142</td>
<td>NO</td>
<td></td>
</tr>
</tbody>
</table>

**Sample I.D.**

<table>
<thead>
<tr>
<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Init</th>
</tr>
</thead>
<tbody>
<tr>
<td>08/23</td>
<td>377 (≤2.5 µm)</td>
<td>08/23</td>
<td>1226 (&gt;3.5 µm)</td>
<td>08/23</td>
<td>1268 (Probe &amp; Nozzle Rinse)</td>
</tr>
</tbody>
</table>

**RINSE SAMPLE WT., g.**

<table>
<thead>
<tr>
<th>Date</th>
<th>Init</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>08/23</td>
<td>3.5059</td>
<td>08/23</td>
</tr>
<tr>
<td>08/20</td>
<td>3.5059</td>
<td>08/20</td>
</tr>
<tr>
<td>(400 ml)</td>
<td>3.3719</td>
<td>(350 ml)</td>
</tr>
</tbody>
</table>

**FILTERABLE PARTICULATE, mg.**

<table>
<thead>
<tr>
<th>Date</th>
<th>Init</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>08/23</td>
<td>1.0</td>
<td>08/23</td>
</tr>
<tr>
<td>08/20</td>
<td>0.1</td>
<td>08/20</td>
</tr>
<tr>
<td>(400 ml)</td>
<td>1.4</td>
<td>(350 ml)</td>
</tr>
</tbody>
</table>

**Miscellaneous Notes & Comments:**

**Legend:**

- Ø = Final Weight
- F = Filter
- R = Rinse

**Visual Inspection:**

<table>
<thead>
<tr>
<th>Run ID</th>
<th>In Stack Filter</th>
<th>2.5 Rinse</th>
<th>2.5-10 Rinse</th>
<th>&gt;10 Rinse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color: BROWN WHITE WHITE</td>
<td>WHITE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Texture: STAIN FILM FILM</td>
<td>FILM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foreign Matter: NONE NONE NONE</td>
<td>NONE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relative Comp: MEDIUM LOW LOW</td>
<td>MEDIUM</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Miscellaneous Notes & Comments:**

- **Adjusted Catch (Negative Results Reported As Zero)**
### PARTICULATE SAMPLING LABORATORY RESULTS (OTM-027)

**Filter Container #**

<table>
<thead>
<tr>
<th>Date</th>
<th>Init</th>
<th>Baggage Tam Wt, g.</th>
<th>Filter Tam Wt, g.</th>
<th>FILTER SAMPLE WT., g.</th>
</tr>
</thead>
<tbody>
<tr>
<td>08/23</td>
<td>BN</td>
<td>4.0251</td>
<td>3.9121</td>
<td>0.0002</td>
</tr>
</tbody>
</table>

**Sample I.D.**

<table>
<thead>
<tr>
<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1247</td>
<td>(&lt; 2.5 um)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1405</td>
<td>(&gt; 2.5 um)</td>
</tr>
</tbody>
</table>

**Tam Wt, g.**

<table>
<thead>
<tr>
<th>Date</th>
<th>Init</th>
<th>Tam Wt, g.</th>
<th>Rinse Wt, g.</th>
<th>Blank Residue, mg.</th>
<th>Blank Rinse, mg.</th>
<th>FILTERABLE PARTICULATE, mg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>08/23</td>
<td>BN</td>
<td>3.4052</td>
<td>08/23</td>
<td>3.5318</td>
<td>08/23</td>
<td>3.5005</td>
</tr>
<tr>
<td>08/20</td>
<td>BN</td>
<td>3.4053</td>
<td>08/20</td>
<td>3.5316</td>
<td>08/20</td>
<td>3.5004</td>
</tr>
<tr>
<td>( 40 ml)</td>
<td></td>
<td>3.5301 ( 50 ml)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RINSE SAMPLE WT., g.</td>
<td>0.0009</td>
<td>0.0015</td>
<td>0.0045</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Blank Beaker #**

<table>
<thead>
<tr>
<th>Blank Beaker #</th>
<th>1011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final wt, mg.</td>
<td>3.6891</td>
</tr>
</tbody>
</table>

**Visual Inspection:**

<table>
<thead>
<tr>
<th>Run ID</th>
<th>In Stack Filter</th>
<th>2.5 Rinse</th>
<th>2.5-10 Rinse</th>
<th>&gt;10 Rinse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>BROWN</td>
<td>BROWN</td>
<td>WHITE</td>
<td>BROWN</td>
</tr>
<tr>
<td>Texture</td>
<td>STAIN</td>
<td>FILM</td>
<td>FILM</td>
<td>FILM</td>
</tr>
<tr>
<td>Foreign Matter</td>
<td>NONE</td>
<td>NONE</td>
<td>NONE</td>
<td>NONE</td>
</tr>
<tr>
<td>Relative Comp.</td>
<td>LOW</td>
<td>LOW</td>
<td>LOW</td>
<td>MEDIUM</td>
</tr>
</tbody>
</table>

**Miscellaneous Notes & Comments:**

- **Legend:**
  - @ = Final Weight
  - P = Filter
  - R = Rinse

- **Printing Date:** 29-Aug-49
- **Printing Time:** 02:43 PM

---

**OTM-036**

**Page 169 of 643**

4/11/2016
<table>
<thead>
<tr>
<th>Date</th>
<th>Initial</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>08/23</td>
<td>BNL</td>
<td>3.8894</td>
</tr>
<tr>
<td>08/20</td>
<td>BNL @</td>
<td>3.8891</td>
</tr>
<tr>
<td></td>
<td>(m) 210</td>
<td></td>
</tr>
</tbody>
</table>

**Tare Wt., g.**

**SAMPLE WT., g.**

0.0070
# REPORT SUMMARY

RFA#: 1436

<table>
<thead>
<tr>
<th>OTM-028 SAMPLE ID</th>
<th>ORGANIC Condensible PM</th>
<th>INORGANIC Condensible PM</th>
<th>(NH₄)₂SO₄ Correction</th>
<th>FIELD BLANK Correction</th>
<th>TOTAL Condensible PM</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACETONE/MeCl₂ BLANK</td>
<td>0.3 mg (180 mL)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H₂O BLANK</td>
<td></td>
<td>0.9 mg (310 mL)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FIELD BLANK</td>
<td>0.5 mg</td>
<td>2.4 mg</td>
<td>0.17 mg</td>
<td>N/A</td>
<td>2.9 mg</td>
</tr>
<tr>
<td>M5B-028-1</td>
<td>0.6 mg</td>
<td>24.6 mg</td>
<td>1.02 mg</td>
<td>2.0 mg</td>
<td>23.2 mg</td>
</tr>
<tr>
<td>M5B-028-2</td>
<td>0.6 mg</td>
<td>33.9 mg</td>
<td>1.70 mg</td>
<td>2.0 mg</td>
<td>32.5 mg</td>
</tr>
<tr>
<td>M5B-028-3</td>
<td>0.4 mg</td>
<td>33.5 mg</td>
<td>1.70 mg</td>
<td>2.0 mg</td>
<td>31.9 mg</td>
</tr>
<tr>
<td>API2.5/028-1</td>
<td>0.7 mg</td>
<td>16.9 mg</td>
<td>1.02 mg</td>
<td>2.0 mg</td>
<td>15.6 mg</td>
</tr>
<tr>
<td>API2.5/028-2</td>
<td>0.6 mg</td>
<td>11.5 mg</td>
<td>0.51 mg</td>
<td>2.0 mg</td>
<td>10.1 mg</td>
</tr>
<tr>
<td>API2.5/028-3</td>
<td>0.6 mg</td>
<td>10.1 mg</td>
<td>0.51 mg</td>
<td>2.0 mg</td>
<td>8.7 mg</td>
</tr>
</tbody>
</table>

* A maximum of 2.0 mg were deducted from the Total Condensable Particulate Matter (CPM) for each run.
Sample Matrix & Components:

H₂O (dry) Impinger samples, Back° Acetone/Methylene Chloride Rinses, Back° 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 transferred to water and methylene chloride field containers, respectively.

The H₂O field samples were then extracted with methylene chloride using the Back° 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 H₂O samples were evaporated at 85°F (at ambient pressure) until completely dry. H₂O samples were then resuspended in 50 mL deionized water and titrated to neutral pH using 0.1 N NH₄OH, 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 condensable 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: [Signature]
Date: 08/11/09

(J. Bruce Nemet, Lab QA Officer)
## PARTICULATE SAMPLING LABORATORY RESULTS (EPA OTM-028)

<table>
<thead>
<tr>
<th>DI H2O Container #</th>
<th>Date</th>
<th>%t</th>
<th>Date</th>
<th>Date</th>
<th>Date</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2/20</td>
<td>1675</td>
<td>8/20</td>
<td>983</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9/23</td>
<td>1675</td>
<td>8/20</td>
<td>983</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9/22</td>
<td>1675</td>
<td>8/20</td>
<td>983</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tare Wt., g.</td>
<td>470</td>
<td>575</td>
<td>515</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAMPLE Wt., g.</td>
<td>0.0256</td>
<td>0.0256</td>
<td>0.0256</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acetone/MeCl2 Container #</td>
<td>Date</td>
<td>%t</td>
<td>Date</td>
<td>Date</td>
<td>Date</td>
<td>Date</td>
</tr>
<tr>
<td></td>
<td>1206</td>
<td>1494</td>
<td>1006</td>
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<tr>
<td>9/23</td>
<td>1494</td>
<td>1006</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9/22</td>
<td>1494</td>
<td>1006</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tare Wt., g.</td>
<td>350</td>
<td>140</td>
<td>145</td>
<td></td>
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</tr>
<tr>
<td>SAMPLE Wt., g.</td>
<td>0.0026</td>
<td>0.0026</td>
<td>0.0026</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 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 (V) of NH4OH added (N=0.1), ml | 0.00 | 1.00 | 1.00 |
| Correction for ammonia added, mg. | 1.02 | 1.70 | 1.70 |
| Adjusted Inorganic Fraction Catch, mg. | 24.6 | 23.9 | 23.5 |

*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 DI H2O

<table>
<thead>
<tr>
<th>Run ID</th>
<th>M5B-028-1</th>
<th>M5B-028-2</th>
<th>M5B-028-3</th>
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<tbody>
<tr>
<td>Color</td>
<td>BROWN</td>
<td>BROWN</td>
<td>BROWN</td>
</tr>
<tr>
<td>Texture</td>
<td>FILM</td>
<td>FILM</td>
<td>FILM</td>
</tr>
<tr>
<td>Foreign Matter</td>
<td>NONE</td>
<td>NONE</td>
<td>NONE</td>
</tr>
<tr>
<td>Relative Comp.</td>
<td>HIGH</td>
<td>HIGH</td>
<td>HIGH</td>
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</tbody>
</table>

#### Visual inspection of MeCl2

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<tr>
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<th>M5B-028-1</th>
<th>M5B-028-2</th>
<th>M5B-028-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>WHITE</td>
<td>WHITE</td>
<td>WHITE</td>
</tr>
<tr>
<td>Texture</td>
<td>FILM</td>
<td>FILM</td>
<td>FILM</td>
</tr>
<tr>
<td>Foreign Matter</td>
<td>NONE</td>
<td>NONE</td>
<td>NONE</td>
</tr>
<tr>
<td>Relative Comp.</td>
<td>LOW</td>
<td>LOW</td>
<td>LOW</td>
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</table>

**Printing Date:** 23-Aug-03  **Printing Time:** 02:31 PM
# PARTICULATE SAMPLING LABORATORY RESULTS (EPA OTM-028)

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<thead>
<tr>
<th>DI H2O Container #</th>
<th>Date</th>
<th>Init</th>
<th>1345</th>
<th>Date</th>
<th>1491</th>
<th>Date</th>
<th>973</th>
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</thead>
<tbody>
<tr>
<td>06/23</td>
<td>ENL</td>
<td>3.7570</td>
<td>06/23</td>
<td>3.3988</td>
<td>06/22</td>
<td>3.8503</td>
<td></td>
</tr>
<tr>
<td>06/22</td>
<td>2NL</td>
<td>3.7075</td>
<td>06/22</td>
<td>3.6809</td>
<td>06/22</td>
<td>3.8503</td>
<td></td>
</tr>
<tr>
<td>(285 ml)</td>
<td></td>
<td>3.7735</td>
<td>(245 ml)</td>
<td>3.5268</td>
<td>(155 ml)</td>
<td>3.8497</td>
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</tr>
<tr>
<td>SAMPLE WT, g.</td>
<td>0.0179</td>
<td>0.0120</td>
<td>0.0106</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Aetna/MelCr2 Container #</th>
<th>Date</th>
<th>Init</th>
<th>60</th>
<th>Date</th>
<th>1062</th>
<th>Date</th>
<th>166</th>
</tr>
</thead>
<tbody>
<tr>
<td>06/23</td>
<td>ENL</td>
<td>3.6437</td>
<td>08/23</td>
<td>3.4591</td>
<td>06/23</td>
<td>3.4127</td>
<td></td>
</tr>
<tr>
<td>06/22</td>
<td>2NL</td>
<td>3.8437</td>
<td>06/22</td>
<td>3.4500</td>
<td>06/22</td>
<td>3.4127</td>
<td></td>
</tr>
<tr>
<td>(160 ml)</td>
<td></td>
<td>3.9430</td>
<td>(125 ml)</td>
<td>3.4424</td>
<td>(135 ml)</td>
<td>3.4121</td>
<td></td>
</tr>
<tr>
<td>SAMPLE WT, g.</td>
<td>0.0007</td>
<td>0.0006</td>
<td>0.0006</td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Organic Fraction Catch, mg. 0.7
Organic (MelCr2/Acetone) Field Blank Correction, mg. 0.0
Organic Fraction Catch, mg. 0.7

Inorganic Fraction Catch, mg. 17.9
Inorganics (H2O) Field Blank Correction, mg. 0.0
Volume (ml) of WHCH added (NH4Cl), ml 0.60
Correction for ammonia added, mg 1.02
Adjusted Inorganic Fraction Catch, mg. 16.3

---

TOTAL OTM-028 CONDENSIBLE PARTICULATE, mg. 15.6 10.1 8.7

---

Miscellaneous Notes & Comments:

<table>
<thead>
<tr>
<th>Visual Inspection of H2O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run ID</td>
</tr>
<tr>
<td>Color</td>
</tr>
<tr>
<td>Texture</td>
</tr>
<tr>
<td>Foreign Matter</td>
</tr>
<tr>
<td>Relative Comp</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Visual Inspection of MelCr2</th>
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</thead>
<tbody>
<tr>
<td>Run ID</td>
</tr>
<tr>
<td>Color</td>
</tr>
<tr>
<td>Texture</td>
</tr>
<tr>
<td>Foreign Matter</td>
</tr>
<tr>
<td>Relative Comp</td>
</tr>
</tbody>
</table>
### DI H2O Container #

<table>
<thead>
<tr>
<th>Date</th>
<th>Initi</th>
<th>51</th>
</tr>
</thead>
<tbody>
<tr>
<td>09/23</td>
<td>BNL</td>
<td>3.3993</td>
</tr>
<tr>
<td>09/22</td>
<td>BNL</td>
<td>3.3994</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tam Wt., g.</th>
<th>Date</th>
<th>Tam Wt., g.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(355 ml)</td>
<td>3.3987</td>
<td>(ml) 0.0000</td>
</tr>
<tr>
<td>SAMPLE Wt., g.</td>
<td>0.0026</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

### Acetone/MeC12 Container #

<table>
<thead>
<tr>
<th>Date</th>
<th>Initi</th>
<th>824</th>
</tr>
</thead>
<tbody>
<tr>
<td>09/23</td>
<td>BNL</td>
<td>3.6154</td>
</tr>
<tr>
<td>09/22</td>
<td>BNL</td>
<td>3.5163</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tam Wt., g.</th>
<th>Date</th>
<th>Tam Wt., g.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(110 ml)</td>
<td>3.5163</td>
<td>(ml) 0.0000</td>
</tr>
<tr>
<td>SAMPLE Wt., g.</td>
<td>0.0005</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

- **Organic Fraction Catch, mg.** 0.5 0.0 0.0
- **Organic (MeC12/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 (Vi) 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:**

<table>
<thead>
<tr>
<th>Run ID</th>
<th>Color</th>
<th>Texture</th>
<th>Foreign Matter</th>
<th>Relative Comp</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIELD BLANK</td>
<td>WHITE</td>
<td>FILM</td>
<td>NONE</td>
<td>LOW</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Run ID</th>
<th>Color</th>
<th>Texture</th>
<th>Foreign Matter</th>
<th>Relative Comp</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIELD BLANK</td>
<td>WHITE</td>
<td>FILM</td>
<td>NONE</td>
<td>LOW</td>
</tr>
</tbody>
</table>
## REAGENT BLANK LABORATORY RESULTS (Version 04.28.92)

<table>
<thead>
<tr>
<th>Sample ID/Container #</th>
<th>Date</th>
<th>Unit</th>
<th>Date</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2177</td>
<td></td>
<td>2279</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tare Wt, g.</th>
<th>06/23</th>
<th>3.8229</th>
<th>06/23</th>
<th>3.5733</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>06/22</td>
<td>3.8231</td>
<td>06/22</td>
<td>3.5731</td>
</tr>
<tr>
<td>SAMPLE WT, g.</td>
<td>180 mL</td>
<td>3.8226</td>
<td>310 mL</td>
<td>3.5722</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.0003</td>
<td></td>
<td>0.0009</td>
</tr>
</tbody>
</table>

### Blank Beaker #

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final Wt, mg.</td>
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<td>3.8229</td>
</tr>
<tr>
<td>Tare Wt, mg.</td>
<td></td>
<td>3.8226</td>
</tr>
<tr>
<td>Residue, mg.</td>
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<td>0.000</td>
</tr>
<tr>
<td>Volume, mL</td>
<td></td>
<td>180</td>
</tr>
<tr>
<td>Density, mg/mL</td>
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<td>1315.0</td>
</tr>
<tr>
<td>Conc., mg/L</td>
<td></td>
<td>2.00E-05</td>
</tr>
<tr>
<td>Upper Limit, mg/L</td>
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<td>2.00E-05</td>
</tr>
</tbody>
</table>

OTM-036

Page 176 of 643

4/11/2016
**REPORT SUMMARY**

**RFA#:** 1436

<table>
<thead>
<tr>
<th>SAMPLE ID</th>
<th>Suspended Solids</th>
<th>Dissolved Solids</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRS-RUN 1</td>
<td>303.6 mg/L</td>
<td>1.2 %</td>
</tr>
<tr>
<td>SRS-RUN 2</td>
<td>322.3 mg/L</td>
<td>1.3 %</td>
</tr>
<tr>
<td>SRS-RUN 3</td>
<td>295.1 mg/L</td>
<td>1.3 %</td>
</tr>
</tbody>
</table>
## PARTICULATE SAMPLING LABORATORY RESULTS

<table>
<thead>
<tr>
<th>Run Number</th>
<th>SRS-Run 1</th>
<th>SRS-Run 2</th>
<th>SRS-Run 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Suspended Solids</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>init</td>
<td>Date</td>
<td>Date</td>
</tr>
<tr>
<td>08/24</td>
<td>JSC</td>
<td>08/24</td>
<td>08/24</td>
</tr>
<tr>
<td>Baggie Tare Wt. g.</td>
<td>3</td>
<td>4.0150</td>
<td>4.6837</td>
</tr>
<tr>
<td>Filter Tare Wt. g.</td>
<td>NJ-97</td>
<td>3.6977</td>
<td>3.4685</td>
</tr>
<tr>
<td>Suspended Solid Wt. g</td>
<td>Sample Volume</td>
<td>940 ml</td>
<td>940 ml</td>
</tr>
<tr>
<td></td>
<td>0.9198</td>
<td>0.9722</td>
<td>0.9172</td>
</tr>
<tr>
<td></td>
<td>0.2975</td>
<td>0.3630</td>
<td>0.2744</td>
</tr>
<tr>
<td><strong>Dissolved Solids</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>init</td>
<td>Date</td>
<td>Date</td>
</tr>
<tr>
<td>08/24</td>
<td>JSC</td>
<td>08/24</td>
<td>08/24</td>
</tr>
<tr>
<td>Baggie Tare Wt. g.</td>
<td>30 ml</td>
<td>3.4567</td>
<td>4.2141</td>
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<tr>
<td>Dissolved Solid Wt. g</td>
<td>50 ml</td>
<td>0.6860</td>
<td>0.6479</td>
</tr>
</tbody>
</table>

- Suspended Solids, mg/L: 383.6, 322.3, 295.1
- Dissolved Solids, % by v/v: 1.2, 1.3, 1.3

### Visual Inspection of Filters

<table>
<thead>
<tr>
<th>Run ID</th>
<th>SRS-Run 1</th>
<th>SRS-Run 2</th>
<th>SRS-Run 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color:</td>
<td>BROWN</td>
<td>BROWN</td>
<td>BROWN</td>
</tr>
<tr>
<td>Texture:</td>
<td>STAIN</td>
<td>STAIN</td>
<td>STAIN</td>
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<tr>
<td>Foreign Matter:</td>
<td>NONE</td>
<td>NONE</td>
<td>NONE</td>
</tr>
<tr>
<td>Relative Comp:</td>
<td>MEDIUM</td>
<td>MEDIUM</td>
<td>LOW</td>
</tr>
</tbody>
</table>

### Visual Inspection of Rinses

- **Legend:**
  - @ = Final Weight
  - F = Filter
  - R = Rinse
- Color: YELLOW, YELLOW, YELLOW
- Texture: FLAKES, FLAKES, FLAKES
- Foreign Matter: NONE, NONE, NONE
- Relative Comp: HIGH, HIGH, HIGH

Miscellaneous Notes & Comments:

- Picking Date: 29-Aug-09
- Picking Time: 09:30 AM
<table>
<thead>
<tr>
<th>Run #</th>
<th>Filter</th>
<th>Acetone Rinse</th>
<th>Nozzle Cyclone</th>
<th>MeCl₂</th>
<th>Toluene</th>
<th>Chloroform/Ether</th>
<th>DI H₂O Impinger</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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<td>SHS - Run 1</td>
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<td></td>
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<tr>
<td></td>
<td>NJ-67</td>
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<td>0.916K</td>
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<td>NJ-69</td>
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<td>0.9281</td>
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</tr>
</tbody>
</table>
# PARTICULATE WORKSHEET

**Client** ACT-  | **RFA #** 11360
---|---
**Analyst** VNL | **Method** 58/027/028
---|---
**Date** 8/11/09
---|---

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<th>NOZZLE CYCLONE</th>
<th>MEOSL TOLENE CHLOROFORM/ETHER</th>
<th>DI H2O IMPINGER</th>
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**Sample:**
- **TAR**
- **PM 10**
- **PM 2.5**
- **PM 1.0**
- **PM 0.5**
- **PM 0.1**

**Units:**
- **Cont.**
- **Vol.**
- **Vol.(mL)**

**Notes:**
- **≤ 2.5**
- **2.5 - 10**
- **> 10**
VOLUME I

Appendix F – Research Triangle Institute Report
Comment: Fiber sample 2.
APPENDIX II
Data Sheets for Test Program 2
VOLUME II
VOLUME II

Appendix A – Test Results
<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>NOMENCLATURE</th>
<th>PM10-2.5-1</th>
<th>PM10-2.5-3</th>
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<tr>
<td>Date</td>
<td></td>
<td>2-24-10</td>
<td>2/25/2010</td>
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<tr>
<td>Run Time</td>
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<td>180.00</td>
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<td>Barometric Pressure, inches Hg</td>
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<td>29.90</td>
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<td>Volume of Gas Sampled</td>
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<td>Dry Gas Meter Temperature</td>
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<td>Dry Mole Fraction</td>
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<td>Carbon Dioxide</td>
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<td>Oxygen</td>
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<td>PM2.5 Catch (Filter)</td>
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<tr>
<td>Condensable PM catch</td>
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### Total Particulate Emissions

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### PM$_{10}$ Emissions

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<td>Grains/DSCF at 7% O2</td>
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### PM$_{2.5}$ Emissions

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<td>Grains/DSCF at 7% O2</td>
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<tr>
<td>Pounds/Hour</td>
<td>0.239</td>
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### Condensable Particulate Emissions

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<td>Nozzle Diameter</td>
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<td>Pitot Tube Coefficient</td>
<td>Cₚ</td>
<td></td>
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<td>Meter Calibration Factor</td>
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<td>Barometric Pressure, inches Hg</td>
<td>Bₚ - in Hg</td>
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<td>Volume of Gas Sampled</td>
<td>Vₘ - cu. ft.</td>
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<td>Dry Gas Meter Temperature</td>
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<td>Volume of Water Vapor</td>
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<td>Oxygen</td>
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<td>Total Particulate Catch</td>
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<td>Probe and Nozzle</td>
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<td>Cyclone &amp; Cup Catch</td>
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<td>Date</td>
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<tr>
<td>Carbon Dioxide</td>
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<td>Volumetric Air Flow, Actual</td>
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<td>Qsd - DSCFM</td>
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<td>Isokinetic Sampling Rate</td>
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**FILTERABLE PARTICULATE EMISSIONS**

| Grains/DSCF                  | gr/DSCF      | 0.0025    | 0.0015    | 0.0022    |
| Grains/DSCF at 12% CO₂       | gr/DSCF@12% CO₂ | 0.0020    | 0.0012    | 0.0018    |
| Grains/DSCF at 7% O₂         | gr/DSCF@7% O₂  | 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% CO₂       | gr/DSCF@12% CO₂ | 0.0276    | 0.0279    | 0.0309    |
| Grains/DSCF at 7% O₂         | gr/DSCF@7% O₂  | 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

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

\[ V_{\text{mstd}} = 17.64 \gamma 0.9602 \left[ 103.762 \left( \frac{29.90 + 0.88}{13.6} \right) \right] \]

\[ V_{\text{mstd}} = 99.452 \text{ ft}^3 \]

Volume of Water Sampled, SCF

\[ V_{wstd} = 0.04715 \text{ [Weight of Condensed Moisture]} \]
\[ V_{wstd} = 0.04715 \text{ [296.3]} \]
\[ V_{wstd} = 13.971 \text{ ft}^3 \]

Fraction of Water Vapor in Sample Gas Stream

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

\[ \%H_2O = \left( \frac{13.971}{99.452 + 13.971} \right) \times 100 \]

\[ \%H_2O = 12.32 \]
**Dry Mole Fraction of Flue Gas**

\[ M_{fd} = 1 - \frac{H2O}{100} \]

\[ M_{fd} = 1 - \frac{12.32}{100} \]  
Must use saturation moisture for Mfd calculation.

\[ M_{fd} = 0.877 \]

**Molecular Weight of Sample Gas, Dry**

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

\[ M_d = 0.44[15.5] + 0.32[6] + 0.28[100-6-15.5] \]

\[ M_d = 30.72 \text{ pounds/pound-mole} \]

**Molecular Weight of Sample Gas, Actual Conditions**

\[ M_s = \left[ M_d \times M_{fd} \right] + [0.18 \times \%H_2O] \]

\[ M_s = \left[ 30.71 \times 0.877 \right] + [0.18 \times 12.32] \]

\[ M_s = 29.15 \text{ pounds/pound-mole} \]

**Average Stack Gas Velocity, Feet/second**

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

\[ \text{vs} = (85.49)(0.84)(\sqrt{0.2563}) \left[ \sqrt{\frac{884.3}{(29.94)(29.15)}} \right] \]

\[ \text{vs} = 36.60 \text{ feet/second} \]
Wet Volumetric Flue Gas Flow Rate at Stack Conditions, Cubic Feet per Minute

\[ Q_{sw} = 60 \times vs \times A \]
\[ Q_{sw} = 60 \times 36.60 \times 70.882 \]
\[ Q_{sw} = 155,652 \text{ Actual Cubic Feet per Minute} \]

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

\[ Q_{sd} = 60 \times Mfd \times vs \times A \times \left[ \frac{528}{ts + 460} \right] \left[ \frac{Ps}{29.92} \right] \]
\[ Q_{sd} = 60 \times 0.877 \times 36.60 \times 70.882 \left[ \frac{528}{884.3} \right] \left[ \frac{29.94}{29.92} \right] \]
\[ Q_{sd} = 81,534 \text{ Dry Standard Cubic Feet per Minute} \]

Isokinetic Sampling Rate, Percent

\[ I = \left( \frac{100 \left( T_s \right) \left( V_{mstd} \right) \left( 29.92 \right)}{\left( 60 \right) \left( vs \right) \left( \theta \right) \left( An \right) \left( P_s \right) \left( M_{std} \right) \left( 528 \right)} \right) \]
\[ I = \left( \frac{100 \left( 884.3 \right) \left( 99.452 \right) \left( 29.92 \right)}{\left( 60 \right) \left( 36.60 \right) \left( 180 \right) \left( 0.000488 \right) \left( 29.94 \right) \left( 0.877 \right) \left( 528 \right)} \right) \]
\[ I = 98.5 \% \]
Filterable Particulate Matter Concentration, Grains per Dry Standard Cubic Foot

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

\[
gr/DSCF = \left[ \frac{0.0163}{99.452} \right] \times \frac{7000}{453.592}
\]

\[
gr/DSCF = 0.0025
\]

Filterable Particulate Matter Emission Rate, Pounds per hour

\[
\text{lb/hr} = \left( \frac{\text{mg/1000}}{453.592} \right) \times \left( \frac{Q_{sd}}{V_{\text{mstd}}} \right) \times 60
\]

\[
\text{lb/hr} = \left( \frac{0.0163}{453.592} \right) \times \left( \frac{81,534}{99.452} \right) \times 60
\]

\[
\text{lb/hr} = 1.77
\]
VOLUME II

Appendix C – Field Data
### Combined Cyclone PM10 & PM2.5 Run Data Sheet

#### Identification Information

- **Plant Name:**
- **City:**
- **State:**

- **Source Number:** FCC 135
- **Sampling Location:** Stack
- **Test Personnel:** TTB

- **Meterbox ID:** 909033
- **ΔH:** 1.9070
- **Gamma, γ:** 1.0206
- **Nozzle ID:** SS-1
- **Nozzle Diameter:** 0.182
- **Orsat/Fyre:** FYR

#### Preliminary Checks and Data

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

- **Pitot Tube Pretest Leak Check:** NA
- **Pitot Tube Posttest Leak Check:** NA

- **Barometric Pressure, In.Hg:** 29.90
- **Static Pressure, In. W.C.:** 0.51

#### Actual Moisture & Gas Composition

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<th>Water Recovered, grams</th>
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#### Sampling Information

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<th>Dwell Time, Min.</th>
<th>Elapsed Time, h:m:s</th>
<th>Meter Volume (ft³)</th>
<th>Meter Temp. (°F)</th>
<th>Stack Temp. (°F)</th>
<th>Sample Train Vac. (in. Hg)</th>
<th>Impinger Exit Gas Temp. (°F)</th>
<th>pH (in. H₂O)</th>
<th>Target pH (in. H₂O)</th>
<th>% Iso</th>
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**Total Run Time:** 3:00:00  **Total Volume, ACF:** 58,523

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#### QA Checks

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<table>
<thead>
<tr>
<th>%</th>
<th>microns</th>
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</table>
# Combined Cyclone PM10 & PM2.5 Run Data Sheet

## Identification Information

- **Plant Name:**
- **City:**
- **State:**
- **Source Number:** FCC 135
- **Date:** 2/25/2010
- **Sampling Location:** Stack
- **Start:** 0741
- **Stop:** 1041
- **Test Personnel:** TTB
- **Meter ID:** 909033
- **Filter ID:**
- **Tare:**
- **ΔH @ γ:** 1.9070
- **Gamma, γ:** 1.0206
- **Nozzle ID:**
- **Nozzle Diameter:** 0.182
- **Orsat/Fyrite:** FYR

## Preliminary Checks and Data

- **Full Train Pretest Leak Check, ACFM:** Actual: 0, Reg'd: < 0.02 or 4%, Vacuum: 15
- **Partial Train Posttest Leak Check, ACFM:** Actual: 0, Reg'd: 0.020

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

- **Pilot Tube Pretest Leak Check:** A: 0, B: 0
- **Pilot Tube Posttest Leak Check:** A: 0, B: 0

- **Barometric Pressure, in. Hg.:** 29.90
- **Static Pressure, in. W.C.:** 0.68

## Actual Moisture & Gas Composition

<table>
<thead>
<tr>
<th>Water Recovered, grams</th>
<th>Moisture, %</th>
<th>CO₂ %</th>
<th>Md_run</th>
<th>O₂ %</th>
<th>Mw_run</th>
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## Sampling Information

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<th>Port</th>
<th>Point</th>
<th>Dwell Time (Min.)</th>
<th>Elapsed Time, hrs:min:s</th>
<th>Meter Volume (ft³)</th>
<th>9P (in. H₂O)</th>
<th>Meter Temp. (°F)</th>
<th>Stack Temp., (°F)</th>
<th>Sample Train Vac. (in. Hg)</th>
<th>Impinger Exit Gas Temp., (°F)</th>
<th>9H (in. H₂O)</th>
<th>Target 9H (in. H₂O)</th>
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Total Run Time: 3:00:00 | Total Volume, ACF: 987.448

Run: PM10-2.5-3

**Averages:**

- **Dwell Time:** 0.34 Min.
- **Elapsed Time:** 50.1 Min.
- **Meter Volume:** 430.8 ft³

**Run:**

- **PM₁₀:** 0.401 in. H₂O
- **PM₂.₅:** 103.4 in. H₂O
- **% Iso:** 11.49 %
- **Microns:** 2.74 μm
## Combined Cyclone PM10 & PM2.5 Run Data Sheet

### IDENTIFICATION INFORMATION
- **Plant Name:**
- **City:**
- **State:**
- **Source Number:** FCC 135
- **Sampling Location:** Stack
- **Test Personnel:** TTB
- **Filter ID:**
- **Tare:**
- **Meterbox ID:** 909033
- **ΔH:** 1.9070
- **Gamma:** 1.0206
- **Nozzle ID:**
- **Nozzle Diameter:** 0.182
- **Orsat/Fyrite:** FYR

### PRELIMINARY CHECKS AND DATA
- **Full Train Pretest Leak Check, ACFM:** 0.001 < 0.02 or 4%
- **Partial Train Posttest Leak Check, ACFM:** 0.020
- **Vacuum:** 10
- **Pilot Tube Pretest Leak Check:** A
- **Pilot Tube Posttest Leak Check:** B
- **Barometric Pressure, In., Hg.:** 29.90
- **Static Pressure, In. W.C.:** 0.68

### ACTUAL MOISTURE & GAS COMPOSITION
- **Water Recovered, grams:** 138
- **CO₂ %:**
- **O₂ %:** 2.7
- **Moisture, %:** 12.600
- **Md_run:** 29.94
- **Mw_run:** 28.81

### QA Checks

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<th>Port</th>
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### Sampling Information
- **Total Run Time:** 3:00:00
- **Total Volume, ACF:** 58,254
- **Averages:** 0.29, 59.4, 430.3

### Run
- **PM10-2.5-4**
- **Averages:** 0.422
- **% in H₂O:** 114.1
- **microns:** 11.29
- **2.66**
# Air Control Techniques, P.C.
## Isokinetic Sampling Train Field Data Sheet

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## ACTUAL MOISTURE & GAS COMPOSITION

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## Actual Moisture & Gas Composition

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## Sampling Information

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## Averages

| Vm | 104.949 | 0.252 | 78.5 | 425.5 | 0.913 |
| Vmm | 98.962 | in. H2O | °F | °F | in HSC |

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### Averages

| Vm   | 108.048  | 0.2904  | 59.9  | 430.8 | 1.016 |
| Vmstd| 105.5533 | in. H2O | °F    | °F    | in H2O |

### QA Checks

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Method 1 - Air Control Techniques, P.C.

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
Equivalent Diameter = 2D(W)/(D+W), Inches
N/A
Stack/duct Area, Square Inches
10240.6
Distance To Flow Disturbances
Upstream
612
Downstream
156
Diameters
5.36
1.37

Point Location Data

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Location of Points in Circular Stacks or Ducts

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Location of Points in Rectangular Stacks or Ducts

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**Combined Cyclone PM10 & PM2.5 Run Data Sheet**

### Identification Information
- **Plant Name:**
- **City:**
- **State:**
- **Source Number:**
- **Sampling Location:**
- **Test Personnel:**
- **Meterbox ID:**
- **ΔH @:**
- **Gamma, g:**
- **Nozzle ID:**
- **Nozzle Diameter:**
- **Orsat/Fyrite:**
- **Filter ID:**
- **Tare:**

### Preliminary Checks and Data
- **Full Train Pretest Leak Check, ACFM:**
  - **Actual:**
  - **Req'd:**
  - **Vacuum:**
- **Partial Train Posttest Leak Check, ACFM:**
  - **Actual:**
  - **Req'd:**
  - **Vacuum:**

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

- **Pilot Tube Pretest Leak Check:**
  - **A**
  - **B**
- **Pilot Tube Posttest Leak Check:**
  - **A**
  - **B**

- **Barometric Pressure, In.Hg.**
- **Static Pressure, In.W.C.**

### Actual Moisture & Gas Composition
- **Water Recovered, grams**
- **Moisture, %**
  - **CO₂ %**
  - **O₂ %**

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**Total Run Time:** 3:00
**Total Volume, ACF:** 883.033

**Averages**
- **in. H₂O**
- **°F**

**Percentage:**
- **%**

**Microns:**
### Combined Cyclone PM10 & PM2.5 Run Data Sheet

#### Identification Information
- **Plant Name**: [Redacted]
- **City**: [Redacted]
- **State**: [Redacted]
- **Source Number**: [Redacted]
- **Sampling Location**: [Redacted]
- **Test Personnel**: [Redacted]
- **Filter ID**: [Redacted]
- **Tare**: [Redacted]
- **Meterbox ID**: [Redacted]
- **ΔH @ 1.95kPa**: [Redacted]
- **Gamma, γ**: [Redacted]
- **Nozzle ID**: [Redacted]
- **Nozzle Diameter**: 0.182
- **Orsat/Fyrite**: [Redacted]

#### Preliminary Checks and Data
- **Actual ACFM**: [Redacted]
- **Vacuum**: [Redacted]
- **Partial Train Posttest Leak Check, ACFM**: [Redacted]
  - **Vacuum**: [Redacted]
- **Pilot Tube Pretest Leak Check**: N/A
- **Pilot Tube Posttest Leak Check**: N/A
- **Barometric Pressure, In., Hg.**: 29.4
- **Static Pressure, In. W.C.**: 0.9

#### Actual Moisture & Gas Composition
- **Water Recovered, grams**: [Redacted]
- **CO₂ %**: [Redacted]
- **O₂ %**: [Redacted]
- **Moisture, %**: [Redacted]
- **Md_run**: [Redacted]
- **Mw_run**: [Redacted]

### Sampling Information

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#### QA Checks

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<td>microns</td>
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**Combined Cyclone PM10 & PM2.5 Run Data Sheet**

### Identification/Information

| Plant Name: | 
| City: | 
| State: | 
| Source Number: | 
| Sampling Location: | 
| Test Personnel: | 
| Meterbox ID: | 
| Δ H @ 190°F | 
| Gamma, γ | 
| Nozzle ID | 
| Nozzle Diameter | 
| Orsat/Fyrite | 

### Preliminary/Checks and Data

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

- Pitot Tube Pretest Leak Check
  - A: N/A
  - B: N/A

- Pitot Tube Posttest Leak Check

Barometric Pressure, In.Hg. | 29.9 |
Static Pressure, In. W.C. | 0.68 |

### Actual Moisture & Gas Composition

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<td>O₂ %</td>
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### Sampling Information

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Total Run Time: 3:00:03
Total Volume, ACF: 197.448

### QA Checks

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| % | microns |
### Identification Information

- **Plant Name:**
- **City:**
- **State:**
- **Source Number:**
- **Sampling Location:**
- **Test Personnel:**
- **Filter ID**
- **Tare**
- **Meterbox ID**
- **ΔH** @
- **Gamma, %:**
- **Nozzle ID:**
- **Nozzle Diameter:**
- **Orsat/Fyrite**

---

### Preliminary Checks and Data

- **Full Train Pretest Leak Check, ACFM:** 0.001 < 0.02 or 4% ID
- **Partial Train Posttest Leak Check, ACFM:** 6.000

(Indicate if the sampling head is removed before the posttest leak check. Keep the cyclone head upright prior to recovery.) Do not leak check during port changes.

#### Pitot Tube Checks
- **Pitot Tube Pretest Leak Check:**
- **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:**
- **CO₂ %:**
- **Moisture, %:**
- **O₂ %:**
- **Md_run:**
- **Mw_run:**

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### Sampling Information

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<td>362</td>
<td>312</td>
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Total Run Time: 3.00
Total Volume, ACF: 161.94

---

### QA Checks

- **in. H₂O**
- **°F**
- **%**
- **microns**
### Method 4 - Air Control Techniques, P.C.

#### Source Information

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<tr>
<td>129.5</td>
<td>1715-1815</td>
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Vm(std) = Volume of gas sampled at standard conditions (dsf) = 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: 456
- State: 

### Sampling Location and Port Information

- Sampling Location:
- Measured Barometric, In. Hg: 29.9
- Duct/Stack Dia., In.: 114
- Pitot ID: B-88
- Pitot Coeff. (Cp): 0.84
- TC ID: 

### Measurement Data

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<tr>
<th>Date</th>
<th>Run Identification</th>
<th>Static Pressure, In. WC</th>
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<th>End Time</th>
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<table>
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<tr>
<td>Positive Side</td>
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<td>12</td>
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<td>415</td>
<td>12</td>
<td>0.24</td>
<td>426</td>
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</tbody>
</table>

Average

\[ V_s = 85.49 \times C_p \times (\bar{\Delta P} \text{ avg}) \times (460 + t_0) / (P_s \times M_s)^{0.5} \]
Method 2 - Air Control Techniques, P.C.

Identification Information

<table>
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Sampling Location and Port Information

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<td>Duct/Stack Dia., In.</td>
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<table>
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Measurement Data

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Pitot Leak Checks

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<table>
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Average

\[ V_s = 85.49 \cdot C_p \cdot (\Delta P \text{ avg}) \cdot (460 + t_s) / (P_s \cdot M_p)^{0.5} \]
**Identification Information**

- **Plant:**
- **City, State:**
- **Test Location:**
- **Personnel:**
- **Meterbox ID:**
- **Filter ID:**
- **Date:** 2/24/10
- **Start:** 9:58
- **Stop:** 10:04
- **Pre Leak Check, ACFM:**
- **Post Leak Check, ACFM:**
- **Pilot Pre Leak Check:**
- **Pilot Post Leak Check:**
- **Static Pressure, In. H2O:** 10.5
- **Barometric Pressure, In. Hg:** 29.9

**Actual Moisture & Gas Composition**

- **K Factor:** 1.3
- **Water Recovered, grams:**
- **CO2 %:** 15.5
- **O2 %:** 6.0

**Sampling Information**

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<th>Stack Temp</th>
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<th>Probe Temp</th>
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<th>Exit Temp</th>
<th>Aux Temp</th>
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**Averages**

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<th>°F</th>
<th>in. H2O</th>
<th>%</th>
<th>in. Hg</th>
<th>Cu. Ft.</th>
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"Stopped For 2.5 Train (N2 Problem) For 6 Minutes"
### IDENTIFICATION INFORMATION

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### PRELIMINARY CHECKS AND DATA

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<th>Post Leak Check, ACFM</th>
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<table>
<thead>
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### ACTUAL MOISTURE & GAS COMPOSITION

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

#### IDENTIFICATION INFORMATION
- **Plant**: [Blank]
- **City, State**: [Blank]
- **Test Location**: [Blank]
- **Personnel**: [Blank]
- **Start Time**: 8:48
- **Stop Time**: 10:43
- **Meterbox ID**: OTM-036
- **Gamma (Y)**: 0.9642
- **Ideal Nozzle**: 0.095
- **Nozzle Dia.**: 0.299
- **Nozzle ID**: 1-4
- **Pilot Tube ID**: 8A
- **K Factor**: 3.66
- **TC Readout ID**: OTM-036

#### PRELIMINARY CHECKS AND DATA
- **Pre Leak Check, ACFM**: 9000
- **Post Leak Check, ACFM**: 9000
- **Actual Rec'd Vacuum**: 9

#### ACTUAL MOISTURE & GAS COMPOSITION
- **Static Pressure, In. Hg**: 29.40
- **Barometric Pressure, In. Hg**: 29.40

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**OTM-036**
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4/11/2016
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**Max / Min °F**

**ISO**

**High**

**Total**
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**Purge**

|          | 1377-1427 | 1730-1830 | 1440-1240 | 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 (sof) = 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 SO2 smell**
VOLUME II

Appendix D – Calibration Data
# APEX INSTRUMENTS METHOD 5 PRE-TEST CONSOLE CALIBRATION

## USING CALIBRATED CRITICAL ORIFICES

### 5-POINT ENGLISH UNITS

<table>
<thead>
<tr>
<th>Meter Console Information</th>
<th>Calibration Conditions</th>
<th>Factors/Conversions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Console Model Number</strong></td>
<td>Date</td>
<td>Time</td>
</tr>
<tr>
<td><strong>Console Serial Number</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DGM Model Number</strong></td>
<td><strong>Barometric Pressure</strong></td>
<td>29.60</td>
</tr>
<tr>
<td><strong>DGM Serial Number</strong></td>
<td><strong>Theoretical Critical Vacuum</strong></td>
<td>13.97</td>
</tr>
<tr>
<td></td>
<td>Calibration Technician</td>
<td>DLS</td>
</tr>
</tbody>
</table>

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, \((\text{in}^2 \cdot \text{min}) / (\text{in} \cdot \text{Hg} \cdot \text{sec})\).

### Calibration Data

<table>
<thead>
<tr>
<th>Run Time</th>
<th>Elapsed</th>
<th>DGM Orifice</th>
<th>( \Delta H )</th>
<th>Volume Initial</th>
<th>Volume Final</th>
<th>Outlet Temp Initial</th>
<th>Outlet Temp Final</th>
<th>Serial Number</th>
<th>Coefficient</th>
<th>Ambient Temp Initial</th>
<th>Ambient Temp Final</th>
<th>Actual Vacuum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(( \theta ))</td>
<td>(( P_1 ))</td>
<td>(( V_{Initial} ))</td>
<td>(( V_{Final} ))</td>
<td>(( T_1 ))</td>
<td>(( T_2 ))</td>
<td>FO</td>
<td>( K' )</td>
<td>FO</td>
<td>66</td>
<td>66</td>
<td>23</td>
</tr>
<tr>
<td>16.0</td>
<td>0.26</td>
<td>301,230</td>
<td>307,074</td>
<td>71</td>
<td>72</td>
<td>FO 40</td>
<td>0.2387</td>
<td>66</td>
<td>66</td>
<td>23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.5</td>
<td>0.58</td>
<td>307,200</td>
<td>312,656</td>
<td>72</td>
<td>73</td>
<td>FO 48</td>
<td>0.3463</td>
<td>66</td>
<td>66</td>
<td>22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.5</td>
<td>1.00</td>
<td>313,040</td>
<td>319,004</td>
<td>73</td>
<td>73</td>
<td>FO 55</td>
<td>0.4592</td>
<td>66</td>
<td>66</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.5</td>
<td>1.65</td>
<td>318,310</td>
<td>325,386</td>
<td>73</td>
<td>73</td>
<td>FO 63</td>
<td>0.5907</td>
<td>66</td>
<td>66</td>
<td>18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.5</td>
<td>3.15</td>
<td>325,790</td>
<td>331,795</td>
<td>73</td>
<td>74</td>
<td>FO 73</td>
<td>0.8085</td>
<td>66</td>
<td>66</td>
<td>16</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Results

| Dry Gas Meter | Standardized Data | Critical Orifice | Calibration Factor | Flowrate | \( \Delta H \) (\%)
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>( (V_{Result}) )</td>
<td>( (Q_{Standard}) )</td>
<td>( (V_{init}) )</td>
<td>( (Q_{init}) )</td>
<td>( (% Variation) )</td>
<td>Value</td>
</tr>
<tr>
<td>cubic feet</td>
<td>cubic feet</td>
<td>cubic feet</td>
<td>cubic feet</td>
<td>(( % ))</td>
<td>(( % ))</td>
</tr>
<tr>
<td>5.747</td>
<td>0.319</td>
<td>5.545</td>
<td>0.308</td>
<td>0.9949</td>
<td>0.005</td>
</tr>
<tr>
<td>5.959</td>
<td>0.458</td>
<td>5.170</td>
<td>0.490</td>
<td>0.9646</td>
<td>0.004</td>
</tr>
<tr>
<td>5.959</td>
<td>0.617</td>
<td>5.920</td>
<td>0.593</td>
<td>0.9809</td>
<td>0.001</td>
</tr>
<tr>
<td>6.679</td>
<td>0.797</td>
<td>5.718</td>
<td>0.782</td>
<td>0.9563</td>
<td>-0.004</td>
</tr>
<tr>
<td>6.014</td>
<td>1.024</td>
<td>5.739</td>
<td>1.043</td>
<td>0.9542</td>
<td>-0.006</td>
</tr>
</tbody>
</table>

Note: For Calibration Factor \( V \), the ratio of the reading of the calibration meter to the dry gas meter, acceptable tolerance of individual values from the average is \( \pm 0.02 \).

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: [Signature]

Date: 1-28-10
### APEX INSTRUMENTS METHOD 5 PRE-TEST CONSOLE CALIBRATION

**USING CALIBRATED CRITICAL ORIFICES**

**5-POINT ENGLISH UNITS**

<table>
<thead>
<tr>
<th>Console Model Number</th>
<th>DW 110</th>
</tr>
</thead>
<tbody>
<tr>
<td>Console Serial Number</td>
<td>550033</td>
</tr>
<tr>
<td>DGM Model Number</td>
<td>RW 110</td>
</tr>
<tr>
<td>DGM Serial Number</td>
<td>320963</td>
</tr>
</tbody>
</table>

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, (ft³/min)(lbm)/in Hg/min.

### Calibration Data

<table>
<thead>
<tr>
<th>Run Time</th>
<th>Metering Console</th>
<th>Calibration Data</th>
<th>Critical Orifice</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DGM Orifice</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Volume Initial</td>
<td>Volume Final</td>
<td>Outlet Temp Initial</td>
</tr>
<tr>
<td></td>
<td>(in H2O)</td>
<td>(cubic feet)</td>
<td>°F</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18.5</td>
<td>0.34</td>
<td>007.140</td>
<td>618.801</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.5</td>
<td>0.71</td>
<td>612.900</td>
<td>618.490</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.5</td>
<td>1.20</td>
<td>618.830</td>
<td>624.231</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.5</td>
<td>1.05</td>
<td>624.340</td>
<td>630.014</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.5</td>
<td>3.60</td>
<td>630.150</td>
<td>635.817</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Results

#### Standardized Data

<table>
<thead>
<tr>
<th>Dry Gas Meter</th>
<th>Critical Orifice</th>
<th>Calibration Factor</th>
<th>Dry Gas Meter</th>
<th>AH (ft³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(V_gas)</td>
<td>(Q_rough)</td>
<td>(Q_red)</td>
<td>(Q_red)</td>
<td>(AH)</td>
</tr>
<tr>
<td>cubic feet</td>
<td>cubic feet</td>
<td>cubic feet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.590</td>
<td>0.302</td>
<td>5.727</td>
<td>0.310</td>
<td>1.024</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.0034</td>
</tr>
<tr>
<td>5.635</td>
<td>0.443</td>
<td>5.646</td>
<td>0.452</td>
<td>1.020</td>
</tr>
<tr>
<td>5.553</td>
<td>0.585</td>
<td>5.558</td>
<td>0.599</td>
<td>1.019</td>
</tr>
<tr>
<td>5.636</td>
<td>0.751</td>
<td>5.745</td>
<td>0.705</td>
<td>1.019</td>
</tr>
<tr>
<td>5.652</td>
<td>1.028</td>
<td>5.767</td>
<td>1.049</td>
<td>1.029</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.029</td>
</tr>
</tbody>
</table>

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, 16.23.

Signature: [Signature]

Date: 4/11/2016
# APEX INSTRUMENTS METHOD 5 POST-TEST CONSOLE CALIBRATION

**USING CALIBRATED CRITICAL ORIFICES**

**3-POINT ENGLISH UNITS**

<table>
<thead>
<tr>
<th>Motor Console Information</th>
<th>Factors/Conversions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Console Model Number</td>
<td>526</td>
</tr>
<tr>
<td>Console Serial Number</td>
<td>802012</td>
</tr>
<tr>
<td>DGM Model Number</td>
<td>RW 110</td>
</tr>
<tr>
<td>DGM Serial Number</td>
<td>954447</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Calibration Conditions</th>
<th>Std Temp</th>
<th>526</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>12/01/10</td>
<td></td>
</tr>
<tr>
<td>Barometric Pressure</td>
<td>29.70</td>
<td>in Hg</td>
</tr>
<tr>
<td>Theoretical Critical Vacuum</td>
<td>14.0</td>
<td>in Hg</td>
</tr>
<tr>
<td>Calibration Technician</td>
<td>DLS</td>
<td></td>
</tr>
</tbody>
</table>

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, (in²·in·min)/(ft³·min).

## Calibration Data

<table>
<thead>
<tr>
<th>Run Time</th>
<th>DGM Orifice</th>
<th>Volume Initial</th>
<th>Volume Final</th>
<th>Outlet Temp Initial</th>
<th>Outlet Temp Final</th>
<th>Serial Number</th>
<th>Coefficient</th>
<th>Ambient Temp Initial</th>
<th>Ambient Temp Final</th>
<th>Actual Vacuum</th>
</tr>
</thead>
<tbody>
<tr>
<td>(h)</td>
<td>(P&lt;sub&gt;i&lt;/sub&gt;)</td>
<td>(V&lt;sub&gt;in&lt;/sub&gt;)</td>
<td>(V&lt;sub&gt;out&lt;/sub&gt;)</td>
<td>(t&lt;sub&gt;i&lt;/sub&gt;)</td>
<td>(t&lt;sub&gt;out&lt;/sub&gt;)</td>
<td>(1000)</td>
<td>(K)</td>
<td>(t&lt;sub&gt;in&lt;/sub&gt;)</td>
<td>(t&lt;sub&gt;out&lt;/sub&gt;)</td>
<td>(in Hg)</td>
</tr>
<tr>
<td>min</td>
<td>in H&lt;sub&gt;2&lt;/sub&gt;O</td>
<td>cubic feet</td>
<td>cubic feet</td>
<td>°F</td>
<td>°F</td>
<td></td>
<td></td>
<td>°F</td>
<td>°F</td>
<td></td>
</tr>
<tr>
<td>9.0</td>
<td>0.98</td>
<td>815.843</td>
<td>815.843</td>
<td>74</td>
<td>74</td>
<td>55</td>
<td>0.4592</td>
<td>68</td>
<td>68</td>
<td>20.50</td>
</tr>
<tr>
<td>9.0</td>
<td>0.98</td>
<td>821.300</td>
<td>821.300</td>
<td>74</td>
<td>74</td>
<td>55</td>
<td>0.4592</td>
<td>68</td>
<td>68</td>
<td>20.50</td>
</tr>
<tr>
<td>9.0</td>
<td>0.98</td>
<td>821.300</td>
<td>821.301</td>
<td>75</td>
<td>75</td>
<td>55</td>
<td>0.4592</td>
<td>68</td>
<td>68</td>
<td>20.50</td>
</tr>
</tbody>
</table>

## Standardized Data

| Dry Gas Meter | Critical Orifice | Calibration Factor | Dry Gas Meter | AH @
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(Y&lt;sub&gt;in&lt;/sub&gt;)</td>
<td>(Y&lt;sub&gt;out&lt;/sub&gt;)</td>
<td>(Q&lt;sub&gt;in&lt;/sub&gt;)</td>
<td>(Q&lt;sub&gt;out&lt;/sub&gt;)</td>
<td>Value</td>
</tr>
<tr>
<td>cubic feet</td>
<td>cubic feet</td>
<td>cfm</td>
<td>cfm</td>
<td>(Y)</td>
</tr>
<tr>
<td>5.650</td>
<td>0.628</td>
<td>5.342</td>
<td>0.594</td>
<td>0.945</td>
</tr>
<tr>
<td>5.659</td>
<td>0.629</td>
<td>5.342</td>
<td>0.594</td>
<td>0.944</td>
</tr>
<tr>
<td>5.658</td>
<td>0.629</td>
<td>5.342</td>
<td>0.594</td>
<td>0.944</td>
</tr>
<tr>
<td>Pretest Gamma</td>
<td>0.9802</td>
<td>% Deviation</td>
<td>1.6</td>
<td>0.945</td>
</tr>
</tbody>
</table>

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 Method, CFR Title 40, Part 60, Appendix A-3, Method 5, 16.2.3

Signature: [Signature]

Date: 12-01-10
## APEX INSTRUMENTS METHOD 8 POST-TEST CONSOLE CALIBRATION
### USING CALIBRATED CRITICAL ORIFICES
#### 3-POINT ENGLISH UNITS

<table>
<thead>
<tr>
<th>Console Model Number</th>
<th>522</th>
</tr>
</thead>
<tbody>
<tr>
<td>Console Serial Number</td>
<td>909033</td>
</tr>
<tr>
<td>DGM Model Number</td>
<td>RW 110</td>
</tr>
<tr>
<td>DGM Serial Number</td>
<td>328933</td>
</tr>
</tbody>
</table>

**Calibration Conditions**
- Date: 12/22/10
- Barometric Pressure: 30.00 in Hg
- Theoretical Critical Vacuum: 14.2 in Hg
- Calibration Technician: DLS

### Calibration Data

<table>
<thead>
<tr>
<th>Run Time</th>
<th>DGM Orifice</th>
<th>Volume Initial</th>
<th>Volume Final</th>
<th>Outlet Temp Initial</th>
<th>Outlet Temp Final</th>
<th>Serial Number</th>
<th>Coefficient</th>
<th>Amb Temp Initial</th>
<th>Amb Temp Final</th>
<th>Actual Vacuum</th>
</tr>
</thead>
<tbody>
<tr>
<td>17.5 min</td>
<td>0.34</td>
<td>396.370</td>
<td>401.727</td>
<td>09</td>
<td>79</td>
<td>FO 40</td>
<td>0.2287</td>
<td>64</td>
<td>64</td>
<td>24.00</td>
</tr>
<tr>
<td>17.5 min</td>
<td>0.34</td>
<td>401.727</td>
<td>407.078</td>
<td>99</td>
<td>69</td>
<td>FO 40</td>
<td>0.2287</td>
<td>64</td>
<td>64</td>
<td>24.00</td>
</tr>
</tbody>
</table>

### Results

<table>
<thead>
<tr>
<th>Standardized Data</th>
<th>Critical Orifice</th>
<th>Calibration Factor</th>
<th>Dry Gas Meter</th>
<th>Flowrate</th>
<th>0.75 SCFH</th>
<th>Variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>(V)</td>
<td>(Q)</td>
<td>(Vout)</td>
<td>(Qout)</td>
<td>(C)</td>
<td>(V)</td>
<td>(C)</td>
</tr>
<tr>
<td>cubic feet</td>
<td>cfm</td>
<td>cubic feet</td>
<td>cfm</td>
<td>cm</td>
<td>in H2O</td>
<td>cm</td>
</tr>
<tr>
<td>6.301</td>
<td>0.306</td>
<td>6.475</td>
<td>0.313</td>
<td>1.021</td>
<td>0.000</td>
<td>0.313</td>
</tr>
<tr>
<td>6.305</td>
<td>0.306</td>
<td>6.475</td>
<td>0.313</td>
<td>1.022</td>
<td>0.001</td>
<td>0.313</td>
</tr>
<tr>
<td>6.306</td>
<td>0.307</td>
<td>6.475</td>
<td>0.313</td>
<td>1.020</td>
<td>-0.001</td>
<td>0.313</td>
</tr>
</tbody>
</table>

- Pretest Gamma: 1.0205
- % Deviation: 0.1
- Y Average: 1.959

**Note:** For Calibration Factor Y, the ratio of the reading of the calibration meter to the dry gas meter, indicates 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: [Signature]
Date: 12-02-10
Type S Pitot Tube Inspection
Air Control Techniques, P.C.

Identification Information

Client: JU HOUKE
Job: NA
Plant Name: NA
Process: NA
City: CARY
State: NC
Pitot ID: 88

Inspection Results

Inspection Data
Level and Perpendicular?  Yes
Obstruction? No
Damaged? No
\( \alpha_1 (-10^\circ \leq \alpha_1 \leq +10^\circ) \)
\( \alpha_2 (-10^\circ \leq \alpha_2 \leq +10^\circ) \)
\( \beta_1 (-5^\circ \leq \beta_1 \leq +5^\circ) \)
\( \beta_2 (-5^\circ \leq \beta_2 \leq +5^\circ) \)
\( \gamma \)
\( \theta \)
z = A \tan \gamma (\leq 0.125 \text{ inches})
w = A \tan \theta (\leq 0.03125 \text{ inches})
D1 (3/16 inch \leq D1 \leq 3/8 inch)
A
A/2D1 (1.05 \leq PA/D1 \leq 1.5)

Notes

Pitot Coefficient

Coefficient of 0.84 Assigned? Yes

Inspection Personnel: DLS

Form ACTPC PI-2
Type S Pitot Tube Inspection
Air Control Techniques, P.C.

Identification Information

Client: In House
Plant Name: NA
City: Cary
Pitot ID: [4]

Inspection Results

Inspection Data

<table>
<thead>
<tr>
<th>Level and Perpendicular?</th>
<th>Y &lt;= 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obstruction?</td>
<td>No</td>
</tr>
<tr>
<td>Damaged?</td>
<td>No</td>
</tr>
<tr>
<td>$\alpha_1 (-10^\circ \leq \alpha_1 \leq +10^\circ)$</td>
<td>1</td>
</tr>
<tr>
<td>$\alpha_2 (-10^\circ \leq \alpha_2 \leq +10^\circ)$</td>
<td>1</td>
</tr>
<tr>
<td>$\beta_1 (-5^\circ \leq \beta_1 \leq +5^\circ)$</td>
<td>1</td>
</tr>
<tr>
<td>$\beta_2 (-5^\circ \leq \beta_2 \leq +5^\circ)$</td>
<td>0</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>-1</td>
</tr>
<tr>
<td>$\theta$</td>
<td>-1</td>
</tr>
<tr>
<td>$z = A \tan \gamma (\leq 0.125\text{ inches})$</td>
<td>0.0164</td>
</tr>
<tr>
<td>$w = A \tan \theta (\leq 0.03125\text{ inches})$</td>
<td>0.0164</td>
</tr>
<tr>
<td>$D_1 (3/16\text{ inch} \leq D_1 \leq 3/8\text{ inch})$</td>
<td>0.375</td>
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<tr>
<td>$A = 0.9375$</td>
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<tr>
<td>$A/2D_1 (1.05 \leq PA/D_1 \leq 1.5)$</td>
<td>1.25</td>
</tr>
</tbody>
</table>

Notes

Pitot Coefficient

| Coefficient of 0.84 Assigned? | Yes |
| Inspection Personnel | DLS |

Form ACTPC PI-2

OTM-036
Page 228 of 643
4/11/2016
## Stainless Steel Nozzle Calibration and Condition

Air Control Techniques, P.C.

<table>
<thead>
<tr>
<th>Nozzle Set ID</th>
<th>Nozzle ID</th>
<th>Average</th>
<th>Measurements</th>
<th>High-Low</th>
<th>Condition</th>
<th>Date Inspected</th>
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<tbody>
<tr>
<td>ACT-N-1</td>
<td>1-1</td>
<td>0.123</td>
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<td>3/11/07</td>
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<td>ACT-N-1</td>
<td>1-3</td>
<td>0.238</td>
<td>0.238 0.238 0.238</td>
<td>0.000</td>
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<tr>
<td>ACT-N-1</td>
<td>1-4</td>
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<td>0.300 0.300 0.298</td>
<td>0.002</td>
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<td>ACT-N-1</td>
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<td>0.368 0.368 0.368</td>
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<td>ACT-N-1</td>
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<td>0.427 0.427 0.428</td>
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<tr>
<td>ACT-N-1</td>
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<td>0.492 0.491 0.480</td>
<td>0.002</td>
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<td>3/11/07</td>
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<table>
<thead>
<tr>
<th>Nozzle Set ID</th>
<th>Nozzle ID</th>
<th>Average</th>
<th>Measurements</th>
<th>High-Low</th>
<th>Condition</th>
<th>Date</th>
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<tbody>
<tr>
<td>ACT-N-2</td>
<td>2-1</td>
<td>0.128</td>
<td>0.128 0.127 0.128</td>
<td>0.001</td>
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<td>0.176 0.177 0.178</td>
<td>0.002</td>
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<td>3/11/07</td>
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<tr>
<td>ACT-N-2</td>
<td>2-3</td>
<td>0.240</td>
<td>0.240 0.240 0.240</td>
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<td>3/11/07</td>
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<tr>
<td>ACT-N-2</td>
<td>2-4</td>
<td>0.298</td>
<td>0.297 0.298 0.298</td>
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<td>0.373 0.374 0.373</td>
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<td>2-6</td>
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<td>ACT-N-2</td>
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<td>0.498 0.497 0.497</td>
<td>0.001</td>
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<td>3/11/07</td>
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<table>
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<tr>
<th>Nozzle Set ID</th>
<th>Nozzle ID</th>
<th>Average</th>
<th>Measurements</th>
<th>High-Low</th>
<th>Condition</th>
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<tr>
<td>ACT-N-3</td>
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<td>0.120</td>
<td>0.120 0.121 0.120</td>
<td>0.001</td>
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<td>0.188 0.189 0.189</td>
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<td>3/11/07</td>
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<td>3-3</td>
<td>0.240</td>
<td>0.240 0.239 0.240</td>
<td>0.001</td>
<td>OK</td>
<td>3/11/07</td>
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<td>ACT-N-3</td>
<td>3-4</td>
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<td>0.254 0.254 0.255</td>
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<tr>
<td>ACT-N-3</td>
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<td>0.365</td>
<td>0.366 0.365 0.365</td>
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<tr>
<td>ACT-N-3</td>
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<table>
<thead>
<tr>
<th>Nozzle Set ID</th>
<th>Nozzle ID</th>
<th>Average</th>
<th>Measurements</th>
<th>High-Low</th>
<th>Condition</th>
<th>Date</th>
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<td>ACT-N-4</td>
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<td>3/11/07</td>
</tr>
<tr>
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<td>0.248 0.248 0.248</td>
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<tr>
<td>ACT-N-4</td>
<td>4-5</td>
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<td>0.002</td>
<td>OK</td>
<td>3/11/07</td>
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</tbody>
</table>

Name: [Signature]

难免遗失

VOLUME II

Appendix E – Analytical Data
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

<table>
<thead>
<tr>
<th>Company</th>
<th>Contact</th>
<th>Phone Number</th>
<th>Fax Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Control Techniques</td>
<td>Tom Holder</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Street Address</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>301 E Durham Rd</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>City, State, Zip</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cary NC 27513</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Analyses

- EPA 0011/TO-5/5315
- HF (EPA 13B)
- EPA 26A (HCl/C1₂)
- VOC's (HPLC)

### Turnaround Time:

- 10 Days (Standard)
- 5 Days (1.5x)
- 3 Days (2x)
- 2 Days (2.5x)
- 24 Hours (3x)

### Sample ID / Run #

<table>
<thead>
<tr>
<th>Sample ID / Run #</th>
<th>Train/Run Component</th>
<th>Train/Run Component</th>
<th>Train/Run Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXAMPLE: SCRUBBER INLET-I</td>
<td>0.1 N H2SO4 (Imp 1-3)</td>
<td>0.1 N H2SO4 (Imp 4)</td>
<td>0.1 N NaOH (Imp 5-6)</td>
</tr>
<tr>
<td>API-2.5/028-1</td>
<td>Filter, Nozzle &amp; Probe Rinse, &gt;2.5 Rinse, ≤2.5 Rinse Imp Soln &amp; Rinse, Imp Acetone Rinse, Imp MeCl2 Rinse</td>
<td></td>
<td></td>
</tr>
<tr>
<td>API-2.5/028-3</td>
<td>CPM Filter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>API-2.5-4</td>
<td>Filter, Nozzle &amp; Probe Rinse, &gt;2.5 Rinse, ≤2.5 Rinse</td>
<td></td>
<td></td>
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</table>

### Chain of Custody:

<table>
<thead>
<tr>
<th>Relinquished by (Signature)</th>
<th>Date</th>
<th>Received by (Signature)</th>
<th>Date</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tom Holder</td>
<td>3/1/10</td>
<td>Jeff Cope</td>
<td>3/1/10</td>
<td></td>
</tr>
</tbody>
</table>

### Notes:

- WHITE: Report Copy
- CANARY: Client Copy
- PINK: Lab Copy

JPC Form No. 37449A
<table>
<thead>
<tr>
<th>Sample ID / Run #</th>
<th>Train/Run Component</th>
<th>Train/Run Component</th>
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<tbody>
<tr>
<td>M5B/028-1</td>
<td>Filter, Frnt &amp; Rinse, Imp Soln &amp; Rinse, Imp Acetone Rinse, Imp MeCl2 Rinse, CPM Filter</td>
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<td>M5B/028-3</td>
<td>n</td>
<td>n</td>
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<tr>
<td>M5B/028-4</td>
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<td>n</td>
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<td>028-FB</td>
<td>Imp Soln &amp; Rinse, Imp Acetone Rinse, Imp MeCl2 Rinse, CPM Filter</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Acetone Blank</td>
<td></td>
</tr>
<tr>
<td></td>
<td>H2O Blank</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MeCl2 Blank</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CPM Filter Blank</td>
<td></td>
</tr>
</tbody>
</table>

**Chain of Custody:**

<table>
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<th>Date</th>
<th>Received by (Signature)</th>
<th>Date</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tom Holder</td>
<td>3/1/10</td>
<td>Jennifer L. Coops</td>
<td>3/1/10</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
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### REPORT SUMMARY

**RFA #:** 1436 (LC)

<table>
<thead>
<tr>
<th>SAMPLE ID</th>
<th>TOTAL FILTERABLE PARTICULATE</th>
</tr>
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<tbody>
<tr>
<td>Acetone Blank</td>
<td>0.1 mg (in 200 mls)</td>
</tr>
<tr>
<td>5B/028-1</td>
<td>16.3 mg</td>
</tr>
<tr>
<td>5B/028-3</td>
<td>10.2 mg</td>
</tr>
<tr>
<td>5B/028-4</td>
<td>14.4 mg</td>
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</table>
## REPORT SUMMARY

**RFA #:** 1436 (LC)

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<tr>
<th>SAMPLE ID</th>
<th>Particulate ≤ 2.5 μm</th>
<th>Particulate &gt; 2.5 μm</th>
<th>Particulate Probe And Nozzle</th>
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<tr>
<td>Acetone Blank</td>
<td>1.2 mg</td>
<td>1.2 mg</td>
<td>1.2 mg (in 200 mls)</td>
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<td>API-2.5/028-1</td>
<td>1.0 mg</td>
<td>1.0 mg</td>
<td>16.8 mg</td>
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<td>API-2.5/028-3</td>
<td>0.9 mg</td>
<td>0.9 mg</td>
<td>12.9 mg</td>
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<td>API-2.5/028-4</td>
<td>0.9 mg</td>
<td>0.5 mg</td>
<td>11.4 mg</td>
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</table>
## REPORT SUMMARY

RFA#: 1436

<table>
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<tr>
<th>SAMPLE ID</th>
<th>ORGANIC Condensible</th>
<th>INORGANIC Condensible</th>
<th>FIELD BLANK Correction $^1$</th>
<th>TOTAL Condensible</th>
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<tr>
<td>H$_2$O BLANK</td>
<td>0.4 mg (250 mL)</td>
<td>0.6 mg (240 mL)</td>
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<tr>
<td>MECl$_2$ BLANK</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FIELD BLANK</td>
<td>0.8 mg</td>
<td>1.7 mg</td>
<td>N/A</td>
<td>2.5 mg</td>
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<tr>
<td>M5B/028-1</td>
<td>1.5 mg</td>
<td>230.3 mg</td>
<td>2.0 mg</td>
<td>229.8 mg</td>
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<tr>
<td>M5B/028-3</td>
<td>26.4 mg</td>
<td>213.9 mg</td>
<td>2.0 mg</td>
<td>238.3 mg</td>
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<td>M5B/028-4</td>
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<td>248.9 mg</td>
<td>2.0 mg</td>
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<td>API-2.5/028-1</td>
<td>2.7 mg</td>
<td>89.0 mg</td>
<td>2.0 mg</td>
<td>89.7 mg</td>
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<td>1.3 mg</td>
<td>83.0 mg</td>
<td>2.0 mg</td>
<td>82.3 mg</td>
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</table>

$^1$ 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)  

<table>
<thead>
<tr>
<th>Run Number</th>
<th>5B/026-1</th>
<th>5B/026-3</th>
<th>5B/026-4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Filter Container #</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>Init</td>
<td>Date</td>
<td></td>
</tr>
<tr>
<td>3/12/10</td>
<td>JSC</td>
<td>0.3678</td>
<td>3/12/10</td>
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<tr>
<td><strong>Baggie Tare Wt., g.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Filter Tare Wt., g.</strong></td>
<td>RQ-5171</td>
<td>0.3655</td>
<td>RQ-5173</td>
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<tr>
<td><strong>FILTER SAMPLE WT., g.</strong></td>
<td>0.0020</td>
<td>0.0045</td>
<td></td>
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<tr>
<td><strong>Front 1/4 Rinse Container #</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>Init</td>
<td>Date</td>
<td></td>
</tr>
<tr>
<td>2433</td>
<td></td>
<td>036</td>
<td></td>
</tr>
</tbody>
</table>

| Date | Init | Date | | Date | | Date | |
| 3/15/10 | JSC | 3.3586 | 3/15/10 | 3.6901 | 3/15/10 | 3.7588 |
| 3/12/10 | JSC | 3.3587 | 3/15/10 | 3.6900 | 3/15/10 | 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 | | | |

- **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  
**Method:** (EPA METHOD 5B (40 CFR. PART 60))  
**RFA #:** 1436 (LC)

<table>
<thead>
<tr>
<th>Run Number</th>
<th>Acetone Blank</th>
</tr>
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<tbody>
<tr>
<td>Sample ID/Container #</td>
<td>2272</td>
</tr>
<tr>
<td>Date</td>
<td>Init</td>
</tr>
<tr>
<td>3/15/10</td>
<td>JSC</td>
</tr>
<tr>
<td>3/12/10</td>
<td>JSC</td>
</tr>
<tr>
<td>Tare Wt., g.</td>
<td>(</td>
</tr>
<tr>
<td>SAMPLE WT., g.</td>
<td></td>
</tr>
</tbody>
</table>

**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/lmg** 638.9E-9  
**Upper Limit, mg.** 10.0E-5

**Legend:**  
F = Final Weight

**Notes & Comments:**
Analytical Narrative

RFA #: 1436 (LC)

Client: Air Control Techniques  
Analyst: JSC  
Analysis: (OTM 027)

Date Received: 3/1/10  
Date Analyzed: 3/11/10  
Analyte(s): PM 2.5 FILTERABLE PARTICULATE

Sample Matrix & Components:

Dry Filters, Front ½ 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-27)

<table>
<thead>
<tr>
<th>Run Number</th>
<th>API-2.5/938-I</th>
<th>API-2.5/938-3</th>
<th>API-2.5/938-4</th>
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</thead>
<tbody>
<tr>
<td><strong>Filter Container #1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>Int</td>
<td>Date</td>
<td>Date</td>
</tr>
<tr>
<td>3/13/10</td>
<td>JSC</td>
<td>0.1135</td>
<td>3/13/10</td>
</tr>
<tr>
<td>Baggage Tare Wt., g.</td>
<td>JSC</td>
<td>JSC</td>
<td>JSC</td>
</tr>
<tr>
<td>472-196</td>
<td>0.1135</td>
<td>472-196</td>
<td>0.1135</td>
</tr>
<tr>
<td>FILTER SAMPLE Wt. g.</td>
<td>0.0005</td>
<td>0.0005</td>
<td>0.0005</td>
</tr>
</tbody>
</table>

≤ 2.5 µm Rinse Container #1

<table>
<thead>
<tr>
<th>Date</th>
<th>Int</th>
<th>Date</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/13/10</td>
<td>JSC</td>
<td>3.4255</td>
<td>3/13/10</td>
</tr>
<tr>
<td>Rinse Wt. g.</td>
<td>(30 ml)</td>
<td>3.4255</td>
<td>3/13/10</td>
</tr>
<tr>
<td>Rinse Wt. g.</td>
<td>(10 ml)</td>
<td>3.0007</td>
<td>3/13/10</td>
</tr>
<tr>
<td>Rinse Wt. g.</td>
<td>(5 ml)</td>
<td>0.0004</td>
<td>3/13/10</td>
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</tbody>
</table>

> 2.5 µm Rinse Container #1

<table>
<thead>
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<th>Int</th>
<th>Date</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/12/10</td>
<td>JSC</td>
<td>3.3315</td>
<td>3/12/10</td>
</tr>
<tr>
<td>3/12/10</td>
<td>JSC</td>
<td>3.3344</td>
<td>3/12/10</td>
</tr>
<tr>
<td>Rinse Wt. g.</td>
<td>(30 ml)</td>
<td>3.3332</td>
<td>3/12/10</td>
</tr>
<tr>
<td>Rinse Wt. g.</td>
<td>(10 ml)</td>
<td>3.0953</td>
<td>3/12/10</td>
</tr>
<tr>
<td>Rinse Wt. g.</td>
<td>(5 ml)</td>
<td>0.0072</td>
<td>3/12/10</td>
</tr>
</tbody>
</table>

Pinba And Micra Rinse Container #1

<table>
<thead>
<tr>
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<th>Int</th>
<th>Date</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/12/10</td>
<td>JSC</td>
<td>5.7129</td>
<td>3/12/10</td>
</tr>
<tr>
<td>3/12/10</td>
<td>JSC</td>
<td>5.7120</td>
<td>3/12/10</td>
</tr>
<tr>
<td>Rinse Wt. g.</td>
<td>(150 ml)</td>
<td>5.6910</td>
<td>3/12/10</td>
</tr>
<tr>
<td>Rinse Wt. g.</td>
<td>(100 ml)</td>
<td>0.0119</td>
<td>3/12/10</td>
</tr>
</tbody>
</table>

**Filter Catch, mg.**

<table>
<thead>
<tr>
<th></th>
<th>0.5</th>
<th>0.6</th>
<th>0.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 2.5 µm Rinse Catch, mg.</td>
<td>0.7</td>
<td>0.4</td>
<td>0.6</td>
</tr>
<tr>
<td>Rinse Blank Readings, mg.</td>
<td>0.2</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Wet Rinse Catch, mg.</td>
<td>0.5</td>
<td>0.3</td>
<td>0.5</td>
</tr>
<tr>
<td>&gt; 2.5 µm Rinse Catch, mg.</td>
<td>1.2</td>
<td>1.1</td>
<td>0.6</td>
</tr>
<tr>
<td>Rinse Blank Readings, mg.</td>
<td>0.2</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Wet Rinse Catch, mg.</td>
<td>1.0</td>
<td>0.9</td>
<td>0.5</td>
</tr>
<tr>
<td>Proba And Micra Rinse Catch, mg.</td>
<td>17.9</td>
<td>13.7</td>
<td>12.3</td>
</tr>
<tr>
<td>Rinse Blank Readings, mg.</td>
<td>1.1</td>
<td>0.6</td>
<td>0.9</td>
</tr>
<tr>
<td>Wet Rinse Catch, mg.</td>
<td>16.8</td>
<td>12.5</td>
<td>11.4</td>
</tr>
<tr>
<td>FILTERABLE PARTICULATE, mg.</td>
<td>18.8</td>
<td>14.7</td>
<td>12.8</td>
</tr>
</tbody>
</table>

**Notes & Comments:**
### REAGENT BLANK LABORATORY RESULTS

**Client:** Air Control Techniques  
**Method:** (OTM 027)  
**RFA #:** 1436 (LC)

<table>
<thead>
<tr>
<th>Sample ID/Container #</th>
<th>Date</th>
<th>Init</th>
<th>2372</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/12/10</td>
<td>JSC</td>
<td>F</td>
<td>3.3431</td>
</tr>
<tr>
<td>3/12/10</td>
<td>JSC</td>
<td></td>
<td>3.3432</td>
</tr>
<tr>
<td>Tare Wt., g.</td>
<td>200</td>
<td>ml</td>
<td>3.3419</td>
</tr>
<tr>
<td>SAMPLE WT., g.</td>
<td></td>
<td></td>
<td>0.0012</td>
</tr>
</tbody>
</table>

**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/ml** 7.6E-6  
**Upper Limit, mg** 10.0E-6
Sample Matrix & Components:

H₂O (dry) Impinger samples, Backwash Acetone/MoCl₂ Rinses, Backwash 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 transferred to water and methylene chloride field containers, respectively.

The H₂O field samples were then extracted with methylene chloride and combined with the organic backwash 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 H₂O samples were evaporated at 85°F (at ambient pressure) until completely dry. H₂O samples were then resuspended in 50 mL deionized water and titrated to neutral pH using 0.1 N NH₄OH, 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.
<table>
<thead>
<tr>
<th>DI H2O Container #</th>
<th>Date</th>
<th>Init</th>
<th>1515</th>
<th>Date</th>
<th>2353</th>
<th>Date</th>
<th>625</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>03/09</td>
<td>BNL</td>
<td>@</td>
<td>3.6119</td>
<td>03/09</td>
<td>@</td>
<td>3.3825</td>
</tr>
<tr>
<td></td>
<td>03/09</td>
<td>BNL</td>
<td>@</td>
<td>3.6122</td>
<td>03/09</td>
<td>@</td>
<td>3.3626</td>
</tr>
<tr>
<td>Tare Wt., g.</td>
<td>( 410 ml)</td>
<td>3.5741</td>
<td>( 420 ml)</td>
<td>3.1630</td>
<td>( 380 ml)</td>
<td>3.5631</td>
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<tr>
<td>SAMPLE Wt., g.</td>
<td>0.2278</td>
<td>6.2196</td>
<td>0.2259</td>
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<td></td>
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<table>
<thead>
<tr>
<th>Acetone/Methanol Container #</th>
<th>Date</th>
<th>Init</th>
<th>443</th>
<th>Date</th>
<th>7381</th>
<th>Date</th>
<th>2251</th>
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<tbody>
<tr>
<td></td>
<td>03/09</td>
<td>BNL</td>
<td>@</td>
<td>3.6414</td>
<td>03/09</td>
<td>@</td>
<td>3.2656</td>
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<tr>
<td></td>
<td>03/09</td>
<td>BNL</td>
<td>@</td>
<td>3.6419</td>
<td>03/09</td>
<td>@</td>
<td>2.2656</td>
</tr>
<tr>
<td>Tare Wt., g.</td>
<td>( 250 ml)</td>
<td>3.6399</td>
<td>( 250 ml)</td>
<td>3.2692</td>
<td>( 250 ml)</td>
<td>3.4654</td>
<td></td>
</tr>
<tr>
<td>SAMPLE Wt., g.</td>
<td>0.0015</td>
<td>0.0264</td>
<td>0.0024</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

| Organic Fraction Catch, mg. | 1.5 | 20.4 | 2.4 |
| Organic (Methanol/Acetone) Field Blank Correction, mg. | 0.0 | 0.0 | 0.0 |
| Organic Fraction Catch, mg. | 1.5 | 20.4 | 2.4 |

| Inorganic Fraction Catch, mg. | 237.8 | 219.6 | 266.8 |
| Inorganic (H2O) Field Blank Correction, mg. | 0.0 | 0.0 | 0.0 |
| Inorganic Fraction Catch, mg. | 237.8 | 219.5 | 266.8 |
| Volume (V) of NH4OH added (VHCl 1), ml | 4.4000 | 3.3000 | 4.5000 |
| Correction for ammonia added, mg | 7.4912 | 5.6189 | 7.8239 |
| 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:
<table>
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<tr>
<th>DI H2O Container ii</th>
<th>Date</th>
<th>init</th>
<th>Date</th>
<th>Date</th>
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<tbody>
<tr>
<td></td>
<td>03/09</td>
<td>BNL</td>
<td>2422</td>
<td>03/09</td>
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<tr>
<td></td>
<td>03/09</td>
<td>BNL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tare Wt., g.</td>
<td>( 210 ml)</td>
<td>3.5139</td>
<td>( 210 ml)</td>
<td>3.4554</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.5140</td>
<td></td>
<td>3.4664</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.0000</td>
<td></td>
<td>0.0000</td>
</tr>
<tr>
<td>SAMPLE Wt., g.</td>
<td>0.0000</td>
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<td>0.0000</td>
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</table>

<table>
<thead>
<tr>
<th>Acetone/MeCI2 Container ii</th>
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<th>Date</th>
<th>Date</th>
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<td>03/09</td>
<td>BNL</td>
<td>2337</td>
<td>03/09</td>
</tr>
<tr>
<td></td>
<td>03/09</td>
<td>BNL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tare Wt., g.</td>
<td>( 210 ml)</td>
<td>3.4944</td>
<td>( 160 ml)</td>
<td>3.3275</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.4946</td>
<td></td>
<td>3.3273</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.0000</td>
<td></td>
<td>0.0000</td>
</tr>
<tr>
<td>SAMPLE Wt., g.</td>
<td>0.0000</td>
<td></td>
<td>0.0013</td>
<td>ERR</td>
</tr>
</tbody>
</table>

| Organic Fraction Catch, mg. | 2.7 | 1.3 | ERR |
| Organic (MeCI2/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 (VI) of NA/COH added (N=0.1), ml | 6.00 | 6.00 | 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:
### DI H2O Container #

<table>
<thead>
<tr>
<th>Date</th>
<th>Unit</th>
<th>Date</th>
<th>Unit</th>
<th>Date</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>03/09</td>
<td>BNL</td>
<td>3.5451</td>
<td>03/09</td>
<td>BNL</td>
<td>3.5453</td>
</tr>
<tr>
<td>03/09</td>
<td>(149 ml)</td>
<td>3.5422</td>
<td>0.0000</td>
<td>0.0000</td>
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<tr>
<td>SAMPLE WT., g.</td>
<td>0.0019</td>
<td>0.0000</td>
<td>0.0000</td>
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</table>

### Acetone/McC12 Container #

<table>
<thead>
<tr>
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<th>Unit</th>
<th>Date</th>
<th>Unit</th>
<th>Date</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>03/09</td>
<td>BNL</td>
<td>3.7225</td>
<td>03/09</td>
<td>BNL</td>
<td>3.7223</td>
</tr>
<tr>
<td>03/09</td>
<td>(230 ml)</td>
<td>3.7215</td>
<td>0.0000</td>
<td>0.0000</td>
<td></td>
</tr>
<tr>
<td>SAMPLE WT., g.</td>
<td>0.0028</td>
<td>0.0000</td>
<td>0.0000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Organic Fraction Catch, mg.** 0.8 0.0 0.0
- **Organic (McC12/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 (V) of NH4OH added (N=0.1), ml** 1.000 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.

<table>
<thead>
<tr>
<th>Date</th>
<th>Unit</th>
<th>Date</th>
<th>Unit</th>
<th>Date</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>
**REAGENT BLANK LABORATORY RESULTS (Version 04.28.92)**

<table>
<thead>
<tr>
<th>Plant Name: Air Control Techniques</th>
<th>RFA #: 1436</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method: OTM-028</td>
<td></td>
</tr>
<tr>
<td>Date Received: 03/01/10</td>
<td></td>
</tr>
<tr>
<td>Page: 4 of 4</td>
<td></td>
</tr>
<tr>
<td>File Path: C:\UCBST1438ACT.WB1</td>
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</table>

<table>
<thead>
<tr>
<th>Blank Type</th>
<th>Methylene</th>
<th>Chloroform/acetone</th>
<th>Water</th>
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<tbody>
<tr>
<td>Sample ID/Container #:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>init</td>
<td>2335</td>
<td>Date</td>
</tr>
<tr>
<td>03/09</td>
<td>3.3681</td>
<td>03/09</td>
<td>@</td>
</tr>
<tr>
<td>03/06</td>
<td>@</td>
<td>3.3680</td>
<td>03/09</td>
</tr>
<tr>
<td>Tare Wt., g.</td>
<td>(250 ml)</td>
<td>3.3976</td>
<td>(140 ml)</td>
</tr>
<tr>
<td>SAMPLE Wt., g.</td>
<td></td>
<td>0.0004</td>
<td></td>
</tr>
</tbody>
</table>

| Blank Beaker #: | 2335 | 487 |
| Final Wt., mg. | 3.3680 | 3.5400 |
| 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/ml | 1.217E-06 @ | 4.28E-06 @ |
| Upper Limit, mg/ml | 1.000E-05 | 1.000E-05 |

OTM-036

Page 247 of 643

4/11/2016
## M5/17 Particulate Bench Sheet

**Client:** ACT  
**Analyst:** JSC  
**RFA #:** 1436 (LC)  
**Method:** 5B  
**Date Received:** 3/11/10  
**Date Analyzed:** 3/11/10

<table>
<thead>
<tr>
<th>Run #</th>
<th>Baggie #</th>
<th>Filter #</th>
<th>Filter Tare</th>
<th>Baggie #</th>
<th>Acetone Rinse</th>
</tr>
</thead>
<tbody>
<tr>
<td>SB 629 - 1</td>
<td>PA-6171</td>
<td>0.3658</td>
<td>2433</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>-3</td>
<td>PA-6173</td>
<td>0.3623</td>
<td>936</td>
<td>150</td>
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<tr>
<td>-4</td>
<td>PA-6174</td>
<td>0.3650</td>
<td>2110</td>
<td>100</td>
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**Acetone Blank**  
*(in House)*

<table>
<thead>
<tr>
<th>Rinse Volume</th>
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<tr>
<td>200</td>
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## OTM 027 Particulate Bench Sheet

**Client:** ACT  
**Analyst:** JSC  
**RFA #:** 1436 (C)  
**Method:** 25/028  
**Date Received:** 3/1/10  
**Date Analyzed:** 3/11/10

<table>
<thead>
<tr>
<th>Run #</th>
<th>Filter</th>
<th>Baggage #</th>
<th>Filter #</th>
<th>Filter Tare</th>
<th>≤ 2.5μm Rinse</th>
<th>&gt;2.5μm ≤40μm Rinse</th>
<th>&gt;40μm Rinse</th>
</tr>
</thead>
<tbody>
<tr>
<td>API-25/028-1</td>
<td>O-196</td>
<td>Q-196</td>
<td>0.1130</td>
<td>2336</td>
<td>30</td>
<td>1236</td>
<td>30</td>
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<tr>
<td>-3</td>
<td>O-198</td>
<td>Q-198</td>
<td>0.1131</td>
<td>2332</td>
<td>10</td>
<td>2357</td>
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<tr>
<td>-4</td>
<td>O-199</td>
<td>Q-199</td>
<td>0.1163</td>
<td>2404</td>
<td>10</td>
<td>2426</td>
<td>10</td>
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**ACETONE BLANK**  
(in-house)  

<p>| | | |</p>
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<tr>
<td></td>
<td></td>
<td>2372</td>
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<tr>
<td></td>
<td></td>
<td>260</td>
</tr>
<tr>
<td>RUN #</td>
<td>FILTER</td>
<td>ACETONE RINSE</td>
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<td>------------</td>
<td>--------</td>
<td>--------------</td>
</tr>
<tr>
<td>MEG/628-1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-4</td>
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<tr>
<td>AFT-2.5/628-1</td>
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<td>078-FB</td>
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<td>Kg+ Blank</td>
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</table>
VOLUME II

Appendix F – Research Triangle Institute Report
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).

Sample 028-3 (filter sample).
Sample 1236.

Sample 1236.
Sample 2270.
Sample 2332.

Sample 2332.
Sample 2336.

Sample 2336.
Sample 2357.

Sample 2357.
Sample 2349.

Sample 2349.
Comment: 028-1 fibrous glass filter large particle
Comment: 1236 spheres
Comment: 2270 Agglomeration
APPENDIX III
Data Sheets for Test Program 3
VOLUME III
VOLUME III

Appendix A – Test Results
<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>NOMENCLATURE</th>
<th>PM10-2.5-1</th>
<th>PM10-2.5-2</th>
<th>PM10-2.5-3</th>
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</thead>
<tbody>
<tr>
<td>Sampling Location</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Run Time</td>
<td>Theta</td>
<td>180.00</td>
<td>178.83</td>
<td>175.19</td>
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<tr>
<td>Nozzle Diameter</td>
<td>inches</td>
<td>0.173</td>
<td>0.173</td>
<td>0.173</td>
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<tr>
<td>Pitot Tube Coefficient</td>
<td>C_p</td>
<td>0.84</td>
<td>0.84</td>
<td>0.84</td>
</tr>
<tr>
<td>Meter Calibration Factor</td>
<td>Y</td>
<td>0.9846</td>
<td>0.9846</td>
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<tr>
<td>Barometric Pressure, inches Hg</td>
<td>B_p - in Hg</td>
<td>29.60</td>
<td>29.60</td>
<td>29.60</td>
</tr>
<tr>
<td>Meter Box Pressure Differential</td>
<td>ΔH - in H2O</td>
<td>0.34</td>
<td>0.34</td>
<td>0.35</td>
</tr>
<tr>
<td>Volume of Gas Sampled</td>
<td>V_m - cu. ft.</td>
<td>61.702</td>
<td>60.828</td>
<td>60.253</td>
</tr>
<tr>
<td>Dry Gas Meter Temperature</td>
<td>T_m - °F</td>
<td>67.9</td>
<td>66.8</td>
<td>56.7</td>
</tr>
<tr>
<td>Volume of Gas Sampled, Dry</td>
<td>V_mstd - cu. ft.</td>
<td>42.066</td>
<td>41.368</td>
<td>41.955</td>
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<tr>
<td>Liquid Collected</td>
<td>ml</td>
<td>248.3</td>
<td>242.5</td>
<td>240.5</td>
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<tr>
<td>Volume of Water Vapor</td>
<td>V_wstd - cu. ft.</td>
<td>11.687</td>
<td>11.414</td>
<td>11.320</td>
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<td>Moisture Content</td>
<td>%H_2O</td>
<td>21.734</td>
<td>21.63</td>
<td>21.25</td>
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<tr>
<td>Saturation Moisture</td>
<td>%H_2O</td>
<td>18.4</td>
<td>18.4</td>
<td>18.4</td>
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<tr>
<td>Dry Mole Fraction</td>
<td>M_fd</td>
<td>0.816</td>
<td>0.816</td>
<td>0.816</td>
</tr>
<tr>
<td>Carbon Dioxide</td>
<td>%CO_2</td>
<td>14.8</td>
<td>14.6</td>
<td>14.5</td>
</tr>
<tr>
<td>Oxygen</td>
<td>%O_2</td>
<td>2.9</td>
<td>3.1</td>
<td>3.2</td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>%CO</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>Nitrogen</td>
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<td>82.3</td>
<td>82.3</td>
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<td>Fuel Factor</td>
<td>F_0</td>
<td>1.216</td>
<td>1.219</td>
<td>1.221</td>
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<tr>
<td>Gas Molecular Weight, Dry</td>
<td>M_d</td>
<td>30.484</td>
<td>30.46</td>
<td>30.45</td>
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<td>Gas Molecular Weight, Wet</td>
<td>M_s</td>
<td>28.183</td>
<td>28.164</td>
<td>28.154</td>
</tr>
<tr>
<td>Static Pressure</td>
<td>P_g - in H_2O</td>
<td>-0.40</td>
<td>-0.40</td>
<td>-0.40</td>
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<tr>
<td>Stack Pressure</td>
<td>P_s</td>
<td>29.47</td>
<td>29.47</td>
<td>29.47</td>
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<tr>
<td>Stack Temperature</td>
<td>T_s - °F</td>
<td>137.0</td>
<td>137.0</td>
<td>137.0</td>
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<tr>
<td>Average Velocity Head</td>
<td>ΔP - in H_2O</td>
<td>0.501</td>
<td>0.494</td>
<td>0.493</td>
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<tr>
<td>Gas Velocity</td>
<td>V_s - ft./sec.</td>
<td>43.08</td>
<td>42.81</td>
<td>42.75</td>
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<td>Stack Area</td>
<td>A_s - sq. ft.</td>
<td>52.918</td>
<td>52.918</td>
<td>52.918</td>
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<tr>
<td>Volumetric Air Flow, Actual</td>
<td>Q_a - ACFM</td>
<td>138,771</td>
<td>135,933</td>
<td>135,737</td>
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<td>Q_s - DSCFM</td>
<td>97,190</td>
<td>96,594</td>
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<tr>
<td>Total Filterable Particulate Catch</td>
<td>mg</td>
<td>15.1</td>
<td>15.3</td>
<td>18.2</td>
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<tr>
<td>Probe and Nozzle Rinse</td>
<td>mg</td>
<td>5.4</td>
<td>4.3</td>
<td>16.3</td>
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<td>Greater than 2.5 rinse</td>
<td>mg</td>
<td>0.4</td>
<td>0.2</td>
<td>0.4</td>
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<td>Less than 2.5 rinse</td>
<td>mg</td>
<td>0.4</td>
<td>0</td>
<td>0.4</td>
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<tr>
<td>PM2.5 Catch (Filter)</td>
<td>mg</td>
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<td>10.8</td>
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<tr>
<td>Total Condensable Particulate Catch</td>
<td>mg</td>
<td>7.9</td>
<td>17.6</td>
<td>11</td>
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<td>Organic Catch</td>
<td>mg</td>
<td>1.7</td>
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<td>Inorganic Catch</td>
<td>mg</td>
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<td>18.4</td>
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<td>Plant</td>
<td>City</td>
<td>State</td>
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<tr>
<td>--------</td>
<td>-------</td>
<td>--------</td>
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<tr>
<td><strong>Total Filterable Particulate Matter Emissions</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Grains/DSCF</td>
<td>gr/DSCF</td>
<td>0.0055</td>
<td>0.0057</td>
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<td>Grains/DSCF at 7% O₂</td>
<td>gr/DSCF@7%O₂</td>
<td>0.0043</td>
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<tr>
<td>Pounds/Hour</td>
<td>lb/hr</td>
<td>4.61</td>
<td>4.73</td>
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<td><strong>Filterable PM₂.₅ Particulate Matter Emissions</strong></td>
<td></td>
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<tr>
<td>Grains/DSCF</td>
<td>gr/DSCF</td>
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<td>0.00403</td>
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<td>Grains/DSCF at 7% O₂</td>
<td>gr/DSCF@7%O₂</td>
<td>0.00263</td>
<td>0.00315</td>
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<tr>
<td>Pounds/Hour</td>
<td>lb/hr</td>
<td>2.84</td>
<td>3.34</td>
<td>0.46</td>
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<tr>
<td><strong>Condensable Particulate Matter Emissions</strong></td>
<td></td>
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<tr>
<td>Grains/DSCF</td>
<td>gr/DSCF</td>
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<td>0.0066</td>
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<td>Grains/DSCF at 7% O₂</td>
<td>gr/DSCF@7%O₂</td>
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<td>0.0051</td>
<td>0.0032</td>
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<tr>
<td>Pounds/Hour</td>
<td>lb/hr</td>
<td>2.41</td>
<td>5.44</td>
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<td><strong>Total Particulate Matter Emissions</strong></td>
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<tr>
<td>Grains/DSCF</td>
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<td>Grains/DSCF at 7% O₂</td>
<td>gr/DSCF@7%O₂</td>
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<td>Pounds/Hour</td>
<td>lb/hr</td>
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<td>10.16</td>
<td>8.88</td>
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### Plant Name
City, State
Project # 1436 F
Test Location FCCU Stack

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<td>Date</td>
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</tr>
<tr>
<td>Run Time</td>
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<td>180</td>
<td>180</td>
<td>180</td>
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<tr>
<td>Nozzle Diameter</td>
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<td>0.24</td>
<td>0.24</td>
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<td>52.918</td>
<td>52.918</td>
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<td>0.84</td>
<td>0.84</td>
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<td>1.0475</td>
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<td>Bp - in Hg</td>
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<td>29.50</td>
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<tr>
<td>Static Pressure</td>
<td>Pg - in. H2O</td>
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<td>-0.40</td>
<td>-0.40</td>
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<td>Ps</td>
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<td>29.47</td>
<td>29.47</td>
<td></td>
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<tr>
<td>Meter Box Pressure Differential</td>
<td>Δ H - in. H2O</td>
<td>1.11</td>
<td>1.12</td>
<td>2.88</td>
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<tr>
<td>Average Velocity Head</td>
<td>Δ p - in. H2O</td>
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<td>0.4926</td>
<td>0.4801</td>
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<tr>
<td>Volume of Gas Sampled</td>
<td>Vm - cu. ft.</td>
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<td>98.926</td>
<td>93.813</td>
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<tr>
<td>Dry Gas Meter Temperature</td>
<td>Tm - °F</td>
<td>66.9</td>
<td>65.6</td>
<td>55.8</td>
<td></td>
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<tr>
<td>Stack Temperature</td>
<td>Ts - °F</td>
<td>137.1</td>
<td>136.8</td>
<td>136.3</td>
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</tr>
<tr>
<td>Liquid Collected</td>
<td>grams</td>
<td>526.1</td>
<td>485.9</td>
<td>493</td>
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</tr>
<tr>
<td>Carbon Dioxide</td>
<td>% CO₂</td>
<td>14.8</td>
<td>14.6</td>
<td>14.5</td>
<td></td>
</tr>
<tr>
<td>Oxygen</td>
<td>% O₂</td>
<td>2.9</td>
<td>3.1</td>
<td>3.2</td>
<td></td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>% CO</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Nitrogen</td>
<td>% N₂</td>
<td>82.3</td>
<td>82.3</td>
<td>82.3</td>
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<tr>
<td>Fuel Factor</td>
<td>Fo</td>
<td>1.216</td>
<td>1.219</td>
<td>1.221</td>
<td></td>
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<tr>
<td>Volume of Gas Sampled, Dry</td>
<td>Vm std - cu. ft.</td>
<td>102.335</td>
<td>102.927</td>
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<tr>
<td>Volume of Water Vapor</td>
<td>Vw std - cu. ft.</td>
<td>24.806</td>
<td>22.910</td>
<td>23.245</td>
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<tr>
<td>Moisture Content</td>
<td>% H₂O</td>
<td>18.51</td>
<td>18.21</td>
<td>18.91</td>
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<tr>
<td>Saturation Moisture</td>
<td>% H₂O</td>
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<td>18.35</td>
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<td>Dry Mole Fraction</td>
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<td>0.818</td>
<td>0.819</td>
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<tr>
<td>Gas Molecular Weight, Dry</td>
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<td>30.48</td>
<td>30.46</td>
<td>30.45</td>
<td></td>
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<tr>
<td>Gas Molecular Weight, Wet</td>
<td>Ms</td>
<td>28.18</td>
<td>28.19</td>
<td>28.20</td>
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<tr>
<td>Gas Velocity</td>
<td>vs - ft./sec.</td>
<td>42.80</td>
<td>42.72</td>
<td>42.15</td>
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<tr>
<td>Volumetric Air Flow, Actual</td>
<td>Qaw - ACFM</td>
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<td>135,628</td>
<td>133,819</td>
<td>135,118</td>
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<td>Volumetric Air Flow, Standard</td>
<td>Qsd - DSCFM</td>
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<td>96,667</td>
<td>95,628</td>
<td>96,270</td>
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<td>Isokinetic Sampling Rate</td>
<td>% l</td>
<td>100.9</td>
<td>99.6</td>
<td>97.6</td>
<td></td>
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</tbody>
</table>

### 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 | 26.6 | 19.4 | 17.2 |
| Filterable Particulate Catch     | mg | 26.6 | 19.4 | 17.2 |

### Condensable Particulate Emissions

| Condesible Particulate Catch     | mg | 22.4 | 15.6 | 16   |
| Grains/DSCF                      | gr/DSCF | 0.0040 | 0.0029 | 0.0027 | 0.0032 |
| Grains/DSCF at 12% CO₂           | gr/DSCF@12% CO₂ | 0.0033 | 0.0024 | 0.0022 | 0.0026 |
| Grains/DSCF at 7% O₂             | gr/DSCF@7% O₂ | 0.0031 | 0.0023 | 0.0021 | 0.0025 |
| Pounds/Hour                      | lb/hr | 3.32  | 2.41  | 2.18  | 2.64  |

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

\[
V_{\text{msld}} = \left[ 17.64 \right] V_m \left[ \frac{p_{\text{bar}} + \Delta H}{T_m + 460} \right]^{\frac{29.50 + 1.11}{13.6}}^{\frac{526.9}{98.61}}
\]

\[ V_{\text{msld}} = 102.335 \text{ ft}^3 \]

Volume of Water Sampled, SCF

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

\[ V_{\text{wstd}} = 0.04715 \text{ [526.1]} \]

\[ V_{\text{wstd}} = 24.806 \text{ ft}^3 \]

Fraction of Water Vapor in Sample Gas Stream

\[
\% H_2O = \left( \frac{V_{\text{wstd}}}{V_{\text{msld}} + V_{\text{wstd}}} \right) \times 100
\]

\[ \% H_2O = \left( \frac{24.806}{102.335 + 24.806} \right) \times 100 \]

\[ \% H_2O = 19.51\% \]
Dry Mole Fraction of Flue Gas

\[ M_{fd} = 1 - \frac{\%H2O}{100} \]

\[ M_{fd} = 1 - \frac{18.47}{100} \quad \text{Must use saturation moisture for Mfd calculation.} \]

\[ M_{fd} = 0.815 \]

Molecular Weight of Sample Gas, Dry

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

\[ M_d = 0.44[14.8] + 0.32[2.9] + 0.28[100-2.9-14.8] \]

\[ M_d = 30.48 \text{ pounds/pound-mole} \]

Molecular Weight of Sample Gas, Actual Conditions

\[ M_s = [M_d \times M_{fd}] + [0.18 \times \%H_2O] \]

\[ M_s = [30.48 \times 0.815] + [0.18 \times 18.47] \]

\[ M_s = 28.18 \text{ pounds/pound-mole} \]

Average Stack Gas Velocity, Feet/second

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

\[ vs = (85.49)(0.84)(\sqrt{0.4942})\left[ \sqrt{\frac{597.1}{(29.47)(28.18)}} \right] \]

\[ vs = 42.80 \text{ feet/second} \]
Wet Volumetric Flue Gas Flow Rate at Stack Conditions, Cubic Feet per Minute

\[ Q_{aw} = 60 \times v_s \times A \]
\[ Q_{aw} = 60 \times 42.80 \times 52.91756 \]
\[ Q_{aw} = 135,907 \text{ Actual Cubic Feet per Minute} \]

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

\[ Q_{sd} = 60 \times Mfd \times v_s \times A \times \left[ \frac{528}{ts + 460} \right] \left[ \frac{Ps}{29.92} \right] \]
\[ Q_{sd} = 60 \times 0.815 \times 42.80 \times 52.91756 \left[ \frac{528}{597.1} \right] \left[ \frac{29.47}{29.92} \right] \]
\[ Q_{sd} = 96,515 \text{ Dry Standard Cubic Feet per Minute} \]

Isokinetic Sampling Rate, Percent

\[ I = \left( \frac{100 \left( T_s \right) \left( V_{\text{std}} \right) \left( 29.92 \right)}{\left( 60 \right) \left( v_s \right) \left( \theta \right) \left( \text{An} \right) \left( P_s \right) \left( M_{\text{std}} \right) \left( 528 \right)} \right) \]
\[ I = \left( \frac{100 \left( 597.1 \right) \left( 102.335 \right) \left( 29.92 \right)}{\left( 60 \right) \left( 42.80 \right) \left( 180 \right) \left( 0.000309 \right) \left( 29.47 \right) \left( 0.815 \right) \left( 528 \right)} \right) \]
\[ I = 100.9 \% \]
Filterable Particulate Matter Concentration, Grains per Dry Standard Cubic Foot

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

\[
gr/DSCF = \left[ \frac{0.0266}{102.335} \right] \left[ \frac{7000}{453.592} \right]
\]

\[gr/DSCF = 0.0040\]

Filterable Particulate Matter Emission Rate, Pounds per hour

\[
lb/hr = \left( \frac{mg}{1000} \right) \times \left( \frac{Qsd}{V_{std}} \right) \times 60
\]

\[
lb/hr = \left( \frac{0.0266}{453.592} \right) \times \left( \frac{96,515}{102.335} \right) \times 60
\]

\[lb/hr = 3.32\]
VOLUME III

Appendix C – Field Data
# Combined Cyclone PM10 & PM2.5 Run Data Sheet

## Identification Information
- **Plant Name:**
- **City:**
- **State:**
- **Source Number:** FCC Scrubber
- **Sampling Location:** Stack
- **Test Personnel:** TTB
- **Meterbox ID:** 702233
- **ΔH @:** 1.6880
- **Gamma, γ:** 0.9846
- **Nozzle ID:** 1
- **Nozzle Diameter:** 0.173
- **Orsat/Fyre:** FYR

## Preliminary Checks and Data
<table>
<thead>
<tr>
<th>Actual</th>
<th>Reg'd</th>
<th>Vacuum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Train Pretest Leak Check, ACFM</td>
<td>0.001</td>
<td>&lt; 0.02 or 4%</td>
</tr>
<tr>
<td>Partial Train Posttest Leak Check, ACFM</td>
<td>0</td>
<td>0.020</td>
</tr>
</tbody>
</table>

(There is no cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during data changes.

- **Pitot Tube Pretest Leak Check**: NA
- **Pitot Tube Posttest Leak Check**: NA

- **Barometric Pressure, in. Hg.**: 29.50
- **Static Pressure, in. W.C.**: -0.40

## Actual Moisture & Gas Composition
<table>
<thead>
<tr>
<th>Water Recovered, grams</th>
<th>Moisture, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>248.3</td>
<td>18.500</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CO₂ %</th>
<th>Md_run</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.8</td>
<td>29.78</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>N₂ LPM</th>
<th>O₂ %</th>
<th>Mw_run</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.23</td>
<td>2.9</td>
<td>28.40</td>
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</tbody>
</table>

## Sampling Information

### QA Checks

<table>
<thead>
<tr>
<th>Target ΦH (in. H₂O)</th>
<th>% Iso</th>
<th>Run Cumulative microns</th>
<th>D₉₀%</th>
</tr>
</thead>
<tbody>
<tr>
<td>ΦH (in. H₂O)</td>
<td>PM₁₀</td>
<td>PM₂⁻⁵</td>
<td></td>
</tr>
<tr>
<td>0.336</td>
<td>92.3</td>
<td>9.09</td>
<td>2.15</td>
</tr>
<tr>
<td>0.337</td>
<td>73.0</td>
<td>9.72</td>
<td>2.40</td>
</tr>
<tr>
<td>0.337</td>
<td>88.7</td>
<td>9.63</td>
<td>2.36</td>
</tr>
<tr>
<td>0.337</td>
<td>88.6</td>
<td>9.53</td>
<td>2.32</td>
</tr>
<tr>
<td>0.342</td>
<td>79.7</td>
<td>9.62</td>
<td>2.36</td>
</tr>
<tr>
<td>0.345</td>
<td>89.3</td>
<td>9.66</td>
<td>2.38</td>
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<tr>
<td>0.345</td>
<td>71.3</td>
<td>9.76</td>
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<tr>
<td>0.346</td>
<td>76.4</td>
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<tr>
<td>0.346</td>
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<td>9.83</td>
<td>2.45</td>
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<tr>
<td>0.346</td>
<td>86.9</td>
<td>9.89</td>
<td>2.47</td>
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</tbody>
</table>

### Averages
- **Total Run Time:** 3:00:00
- **Total Volume, ACF:** 61,702
- **PM10:** 0.500619
- **PM2.5:** 0.340

<table>
<thead>
<tr>
<th>PM10</th>
<th>PM2.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>63.1</td>
<td>10.13</td>
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### Dwell Time

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<tr>
<th>Port</th>
<th>Point</th>
<th>Dwell Time, Min.</th>
<th>Elapsed Time, hrs:mins</th>
<th>Meter Volume (ft³)</th>
<th>ΦP (in. H₂O)</th>
<th>Meter Temp. (°F)</th>
<th>Stack Temp. (°F)</th>
<th>Sample Train Vac. (in. Hg)</th>
<th>Impinger Exit Gas Temp. (°F)</th>
<th>ΦH (in. H₂O)</th>
<th>Target ΦH (in. H₂O)</th>
<th>% Iso</th>
<th>Run Cumulative microns</th>
<th>D₉₀%</th>
</tr>
</thead>
<tbody>
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<td>A</td>
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<td>329.1</td>
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<td>58</td>
<td>137</td>
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<td>56</td>
<td>0.34</td>
<td>0.336</td>
<td>92.3</td>
<td>9.09</td>
<td>2.15</td>
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<tr>
<td></td>
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<td>14.99</td>
<td>15:26</td>
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<td>59</td>
<td>137</td>
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<td>49</td>
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<td>0.34</td>
<td>0.337</td>
<td>88.7</td>
<td>9.63</td>
<td>2.36</td>
</tr>
<tr>
<td></td>
<td>4</td>
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<td>45:25</td>
<td>345</td>
<td>0.54</td>
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<td>137</td>
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<td>0.337</td>
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<td>B</td>
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<td>137</td>
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<td>56</td>
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<td>0.346</td>
<td>78.5</td>
<td>9.83</td>
<td>2.45</td>
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<td>137</td>
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<td>76.1</td>
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<td>137</td>
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<td>78.5</td>
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<td>0.346</td>
<td>86.9</td>
<td>9.89</td>
<td>2.47</td>
</tr>
</tbody>
</table>

### Run Information
- **Total Run Time:** 3:00:00
- **Total Volume, ACF:** 61,702
- **PM10:** 0.500619
- **PM2.5:** 0.340
### Combined Cyclone PM10 & PM2.5 Run Data Sheet

#### IDENTIFICATION INFORMATION

<table>
<thead>
<tr>
<th>Plant Name</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>City</td>
<td></td>
</tr>
<tr>
<td>State</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source Number</th>
<th>FCC Scrubber</th>
<th>Sampling Location</th>
<th>Stack</th>
<th>Test Personnel</th>
<th>TTB</th>
</tr>
</thead>
</table>

| Date          | 5/27/2010    | Start             | 1458  | Stop           | 1805 |

| Meterbox ID   | 702233       | Filter ID         |       | Tare           |     |

| $\Delta H$ @ | 0.8680       | Gamma, $\gamma$  | 0.9846 | Nozzle ID       | 2   |

| Nozzle Diameter | 0.173 | Orsat/Fyrite | FYR |

#### PRELIMINARY CHECKS AND DATA

<table>
<thead>
<tr>
<th>Full Train Pretest Leak Check, ACFM</th>
<th>Actual</th>
<th>Req'd</th>
<th>Vacuum</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>&lt; 0.02 or 4%</td>
<td>15</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Partial Train Posttest Leak Check, ACFM</th>
<th>Actual</th>
<th>Req'd</th>
<th>Vacuum</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.020</td>
<td>8</td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Pilot Tube Pretest Leak Check</th>
<th>A/B</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/a</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pilot Tube Posttest Leak Check</th>
<th>A/B</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/a</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Barometric Pressure, in. Hg.</th>
<th>29.50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static Pressure, in. W.C.</td>
<td>-0.40</td>
</tr>
</tbody>
</table>

#### ACTUAL MOISTURE & GAS COMPOSITION

<table>
<thead>
<tr>
<th>Water Recovered, grams</th>
<th>CO$_2$ %</th>
<th>Moisture, %</th>
<th>Md_run</th>
<th>Mw_run</th>
</tr>
</thead>
<tbody>
<tr>
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#### Sampling Information

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<th>Elapsed Time, h:m:s</th>
<th>Meter Volume (ft$^3$)</th>
<th>$\varphi P$ (in. H$_2$O)</th>
<th>Meter Temp. (°F)</th>
<th>Stack Temp., (°F)</th>
<th>Sample Train Vac. (in. Hg)</th>
<th>Impinger Exit Temp., (°F)</th>
<th>$\varphi H$ (in. H$_2$O)</th>
<th>Target $\varphi H$ (in. H$_2$O)</th>
<th>% Iso</th>
<th>Run Cumulative micros</th>
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#### QA Checks

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<th>Dwell Time, (Min.)</th>
<th>Elapsed Time, h:m:s</th>
<th>Meter Volume (ft$^3$)</th>
<th>$\varphi P$ (in. H$_2$O)</th>
<th>Meter Temp. (°F)</th>
<th>Stack Temp., (°F)</th>
<th>Sample Train Vac. (in. Hg)</th>
<th>Impinger Exit Temp., (°F)</th>
<th>$\varphi H$ (in. H$_2$O)</th>
<th>Target $\varphi H$ (in. H$_2$O)</th>
<th>% Iso</th>
<th>Run Cumulative micros</th>
<th>$D_{95}$, microns</th>
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<table>
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<th>$D_{95}$, microns</th>
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<tbody>
<tr>
<td>in H$_2$O</td>
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<td>microns</td>
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<th>$D_{95}$, microns</th>
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# Combined Cyclone PM10 & PM2.5 Run Data Sheet

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<table>
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<th>Sampling Location</th>
<th>Test Personnel</th>
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<tr>
<td>5/27/2010</td>
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<table>
<thead>
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<tr>
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<table>
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<tr>
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<table>
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<th>Orsat/Fyre</th>
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## PRELIMINARY CHECKS AND DATA

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

<table>
<thead>
<tr>
<th>Pilot Tube Pretest Leak Check</th>
<th>Pilot Tube Posttest Leak Check</th>
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<tbody>
<tr>
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<table>
<thead>
<tr>
<th>Barometric Pressure, ln.Hg.</th>
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<table>
<thead>
<tr>
<th>Static Pressure, ln. W.C.</th>
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## ACTUAL MOISTURE & GAS COMPOSITION

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<th>Moisture, %</th>
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<table>
<thead>
<tr>
<th>CO₂ %</th>
<th>Md_run</th>
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<td>(ln.H₂O)</td>
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## Sampling Information

### Sampling Information

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<tr>
<th>Port</th>
<th>Point</th>
<th>Dwell Time, (Min.)</th>
<th>Elapsed Time, h:m:s</th>
<th>Meter Volume (ft³)</th>
<th>ΨP (ln.H₂O)</th>
<th>Meter Temp. (°F)</th>
<th>Stack Temp., (°F)</th>
<th>Sample Train Vac. (in. Hg)</th>
<th>Impinger Exit Gas Temp., (°F)</th>
<th>ΨH (ln.H₂O)</th>
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<p>|         | 101.9 | 9.97 | 2.50 |
| in H₂O  |       |      |      |
| %      |       |      |      |
| microns|       |      |      |</p>
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**Averages**

| Vm | 98.81 | 0.4942 | 66.9 | 137.1 | 1.106 |
| Vmstd | 102.3347 | in. H2O | °F | °F | in H2O |

**Run ISO**

102.0 %
### IDENTIFICATION INFORMATION

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<th>Stop</th>
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<th>Filter ID</th>
<th>Tare</th>
<th>Gamma (( \gamma ))</th>
<th>Ideal Nozzle</th>
<th>Nozzle Dia.</th>
<th>Nozzle ID</th>
<th>Probe ID</th>
<th>TC Readout ID</th>
<th>K Factor</th>
<th>Water Recovered, grams</th>
<th>CO2 %</th>
<th>Moisture, %</th>
<th>18.206</th>
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### PRELIMINARY CHECKS AND DATA

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### ACTUAL MOISTURE & GAS COMPOSITION

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<th>Water Recovered, grams</th>
<th>CO2 %</th>
<th>Moisture, %</th>
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### Sampling Information

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<th>Point</th>
<th>Time Per Pt, (Min.)</th>
<th>Elapsed Time (h:m:s)</th>
<th>Dry Gas Meter (cu.ft.)</th>
<th>( \Delta P )</th>
<th>Meter Temp</th>
<th>Stack Temp</th>
<th>( \Delta H )</th>
<th>Target ( \Delta H )</th>
<th>Run ISO % Pt</th>
<th>Cum</th>
<th>Lk Chk Readings During Run</th>
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### Averages

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<th>*F</th>
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<th>Lk Check Readings During Run</th>
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<td>Vm/std</td>
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### Moisture Data

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<td>Initial Weight, grams</td>
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<td>Condensed Water, grams</td>
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<td>Initial Weight, grams</td>
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<td>Condensed Water, grams</td>
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<table>
<thead>
<tr>
<th>Impinger 3</th>
<th>100 ml H₂O</th>
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<td>[Graph]</td>
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<td>Initial Weight, grams</td>
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<td>Condensed Water, grams</td>
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<table>
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<td>Initial Weight, grams</td>
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<td>Adsorbed Water, grams</td>
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### OTM 028 Data

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<td>1450-1550</td>
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</table>

Vm(std) = Volume of gas sampled at standard conditions (dscf) = \( \text{gamma} \times 17.64 \times \text{V/m} \times [\text{Pbar}+(D \text{H}/13.6)] / (\text{Tm}+460) \)

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
<table>
<thead>
<tr>
<th>Port/Point</th>
<th>Time</th>
<th>Volume Metered</th>
<th>( \Delta P )</th>
<th>Meter Temp</th>
<th>Stack Temp</th>
<th>( \Delta H )</th>
<th>Probe Temp</th>
<th>Filter Temp</th>
<th>Exit Temp</th>
<th>Aux Temp</th>
<th>Vac</th>
<th>Lk Checks</th>
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<tbody>
<tr>
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<tr>
<td>E2</td>
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### Averages

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Stop: 0.054
Target: 1134
### IDENTIFICATION INFORMATION

- **Plant:** 
- **City, State:** 

### PRELIMINARY CHECKS AND DATA

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<th>Rec'd Vacuum</th>
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| Static Pressure, In. H2O | -0.40 |
| Barometric Pressure, In. Hg | 29.5 |

### ACTUAL MOISTURE & GAS COMPOSITION

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<th>K Factor</th>
<th>Water Recovered, grams</th>
<th>Moisture, %</th>
<th>CO2 %</th>
<th>O2 %</th>
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### Sampling Information

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<th>Elapsed Time</th>
<th>Volume Metered</th>
<th>ΔP</th>
<th>Meter Temp</th>
<th>Stack Temp</th>
<th>ΔH</th>
<th>Probe Temp</th>
<th>Filter Temp</th>
<th>Exit Temp</th>
<th>Aux Temp</th>
<th>Vac</th>
<th>Lt Checks</th>
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### Averages

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OTM-036  
Page 300 of 643  
4/11/2016
### 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

<table>
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<tr>
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<th>M5B/028-2</th>
<th>M5B/028-3</th>
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#### 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 H₂O
  - 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, 816.7
- Adsorbed Water, grams: 25.0, 27.3, 21.2
- Total Water, grams: 526.1, 485.9, 493.0

#### OTM 028 Data

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<td>1900-2000</td>
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Vm(std) = Volume of gas sampled at standard conditions (dscf) = gamma*17.64*Vm*[Pbar+(D H/13.6)]/(Tm+480)

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
## Source Testing And Consulting Services
### Meter Box Calibration

**Calibration Date:** 5/19/2010  
**Meter Box:** 1130  
**Technician:** MPT

<table>
<thead>
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<th>Y Calibration</th>
<th>Delta H @ Cal.</th>
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### PART 1: Orifice Calibration

**Calibration Orifice Set:**  
**Critical Vacuum:** 13.9

**Barometric Pressure (in. Hg):** 29.900

#### Collected Data

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<th>Initial Meter Volume (cu ft)</th>
<th>Final Meter Volume (cu ft)</th>
<th>Init Meter Temp (F)</th>
<th>Final Meter Temp (F)</th>
<th>Init Amb Temp (F)</th>
<th>Final Amb Temp (F)</th>
<th>Run Time min/sec</th>
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#### Calculated Data

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**Average for All Runs:** 1.0475 1.8487
PART 2: Thermocouple Calibration

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<th>Meter Reading (F)</th>
<th>Error (F)</th>
<th>Allowable Error (F)</th>
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APEX INSTRUMENTS METHOD 5 POST-TEST CONSOLE CALIBRATION
USING CALIBRATED CRITICAL ORIFICES
3-POINT ENGLISH UNITS

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<th>Meter Console Information</th>
<th>Calibration Conditions</th>
<th>Factors/Conversions</th>
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<td>Date: 07/21/10</td>
<td>Std Temp: 526°F</td>
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<tr>
<td></td>
<td>Barometric Pressure: 29.85 in Hg</td>
<td>Std Press: 26.02 in Hg</td>
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<td>Console Serial Number</td>
<td>Theoretical Critical Vacuum: 14.1 in Hg</td>
<td>Ks: 17.847 cfm/in Hg</td>
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<td>DGM Model Number</td>
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<tr>
<td>DGM Serial Number</td>
<td>Calibration Technician: DLS</td>
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</table>

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

2The Critical Orifice Coefficient, K', must be entered in English units, (ft^3*ft/min)/(in.Hg*min).

<table>
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<th>Run Time</th>
<th>DGM Orifice</th>
<th>Volume</th>
<th>Volume</th>
<th>Outlet Temp</th>
<th>Outlet Temp</th>
<th>Serial</th>
<th>Coefficient</th>
<th>Amb Temp</th>
<th>Amb Temp</th>
<th>Actual Vacuum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(in)</td>
<td>Initial</td>
<td>Final</td>
<td>Initial</td>
<td>Final</td>
<td>Number</td>
<td>K'</td>
<td>Initial</td>
<td>Final</td>
<td></td>
</tr>
<tr>
<td>7.0</td>
<td>1.85</td>
<td>317.530</td>
<td>327.932</td>
<td>75</td>
<td>75</td>
<td>FO 63</td>
<td>0.5807</td>
<td>67</td>
<td>67</td>
<td>17.00</td>
</tr>
<tr>
<td>7.0</td>
<td>1.85</td>
<td>322.732</td>
<td>327.932</td>
<td>75</td>
<td>75</td>
<td>FO 63</td>
<td>0.5807</td>
<td>67</td>
<td>67</td>
<td>17.00</td>
</tr>
<tr>
<td>7.0</td>
<td>1.85</td>
<td>327.932</td>
<td>333.137</td>
<td>75</td>
<td>75</td>
<td>FO 63</td>
<td>0.5807</td>
<td>67</td>
<td>67</td>
<td>17.00</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Results</th>
<th>Standardized Data</th>
<th>Critical Orifice</th>
<th>Calibration Factor</th>
<th>Dry Gas Meter</th>
<th>Flowrate</th>
<th>ΔH @</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(V_actual)</td>
<td>(Q_actual)</td>
<td>(V_calculated)</td>
<td>(Q_calculated)</td>
<td>(V)</td>
<td>(Q)</td>
</tr>
<tr>
<td></td>
<td>cfm</td>
<td>cubic-feet</td>
<td>cfm</td>
<td>cfm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.145</td>
<td>0.735</td>
<td>5.377</td>
<td>0.768</td>
<td>1.045</td>
<td>0.000</td>
<td>0.768</td>
</tr>
<tr>
<td>5.143</td>
<td>0.735</td>
<td>5.377</td>
<td>0.768</td>
<td>1.045</td>
<td>0.000</td>
<td>0.768</td>
</tr>
<tr>
<td>5.148</td>
<td>0.735</td>
<td>5.377</td>
<td>0.768</td>
<td>1.044</td>
<td>-0.001</td>
<td>0.768</td>
</tr>
<tr>
<td>Pretzel Gamma</td>
<td>1.0475</td>
<td></td>
<td></td>
<td></td>
<td>0.2</td>
<td>1.045</td>
</tr>
</tbody>
</table>

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 Method 5, CFR Title 40, Part 60, Appendix A-3, Method 5, 16.2.3

Signature: [Signature]
Date: 7-21-10

1492-EIS-1130
# APEX INSTRUMENTS METHOD 5 PRE-TEST CONSOLE CALIBRATION

**USING CALIBRATED CRITICAL ORIFICES**

**5-POINT ENGLISH UNITS**

<table>
<thead>
<tr>
<th>Meter Console Information</th>
<th>Calibration Data</th>
<th>Factors/Conversions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Console Model Number</strong></td>
<td><strong>DGM Orifice</strong></td>
<td><strong>Std Temp</strong> 529°F</td>
</tr>
<tr>
<td>522</td>
<td><strong>Volume Initial</strong></td>
<td><strong>Std Press</strong> 29.92 in Hg</td>
</tr>
<tr>
<td><strong>Console Serial Number</strong></td>
<td><strong>Volume Final</strong></td>
<td><strong>K</strong> 17.047 or Hg</td>
</tr>
<tr>
<td>702233</td>
<td><strong>Outlet Temp Initial</strong></td>
<td><strong>in Hg</strong></td>
</tr>
<tr>
<td><strong>DGM Model Number</strong></td>
<td><strong>Outlet Temp Final</strong></td>
<td><strong>in Hg</strong></td>
</tr>
<tr>
<td>RW 110</td>
<td>29.80</td>
<td>14.07</td>
</tr>
<tr>
<td><strong>DGM Serial Number</strong></td>
<td><strong>in Hg</strong></td>
<td><strong>in Hg</strong></td>
</tr>
<tr>
<td>1014753</td>
<td><strong>Calibration Technician</strong></td>
<td><strong>DLS</strong></td>
</tr>
</tbody>
</table>

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, (ft²·in³/sec)·(in Hg)⁻¹

<table>
<thead>
<tr>
<th>Run Time</th>
<th>Metering Console</th>
<th>Calibration Data</th>
<th>Critical Orifice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run Time</td>
<td>DGM Orifice</td>
<td>Volume Initial</td>
<td>Volume Final</td>
</tr>
<tr>
<td>0.00625</td>
<td>0.27</td>
<td>244.300</td>
<td>249.717</td>
</tr>
<tr>
<td>0.0100</td>
<td>0.61</td>
<td>240.020</td>
<td>265.396</td>
</tr>
<tr>
<td>0.0200</td>
<td>1.10</td>
<td>265.500</td>
<td>260.082</td>
</tr>
<tr>
<td>0.0400</td>
<td>1.80</td>
<td>261.100</td>
<td>266.975</td>
</tr>
<tr>
<td>0.0500</td>
<td>3.40</td>
<td>267.200</td>
<td>273.066</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standardized Data</th>
<th>Dry Gas Meter</th>
<th>Calibration Factor</th>
<th>Flowrate</th>
<th>( \Delta H @ )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_{\text{cal}} )</td>
<td>( Q_{\text{std}} )</td>
<td>( V_{\text{cal}} )</td>
<td>( Q_{\text{std}} )</td>
<td>( Y )</td>
</tr>
<tr>
<td>cubic feet</td>
<td>cfm</td>
<td>cubic feet</td>
<td>cfm</td>
<td>cm³/sec</td>
</tr>
<tr>
<td>5.358</td>
<td>0.315</td>
<td>5.263</td>
<td>0.310</td>
<td>0.983</td>
</tr>
<tr>
<td>5.517</td>
<td>0.460</td>
<td>5.429</td>
<td>0.452</td>
<td>0.983</td>
</tr>
<tr>
<td>5.493</td>
<td>0.604</td>
<td>5.305</td>
<td>0.596</td>
<td>0.986</td>
</tr>
<tr>
<td>5.639</td>
<td>0.778</td>
<td>5.751</td>
<td>0.767</td>
<td>0.985</td>
</tr>
<tr>
<td>5.858</td>
<td>1.065</td>
<td>5.772</td>
<td>1.059</td>
<td>0.985</td>
</tr>
</tbody>
</table>

\( \Delta H @ \) Average = 0.0846 Y Average = 1.688

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 [Signature]

Date 2-01-10
# APEX INSTRUMENTS METHOD 5 POST-TEST CONSOLE CALIBRATION

**USING CALIBRATED CRITICAL ORIFICES**

**3-POINT ENGLISH UNITS**

<table>
<thead>
<tr>
<th>Meter Console Information</th>
<th>Calibration Conditions</th>
<th>Factors/Conversions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Console Model Number</strong></td>
<td>522</td>
<td>Std Temp: 529 °F</td>
</tr>
<tr>
<td><strong>Console Serial Number</strong></td>
<td>702233</td>
<td>Std Press: 29.92 in Hg</td>
</tr>
<tr>
<td><strong>DGM Model Number</strong></td>
<td>RW 110</td>
<td>K&lt;sub&gt;1&lt;/sub&gt;: 17.647 cubic ft/in Hg</td>
</tr>
<tr>
<td><strong>DGM Serial Number</strong></td>
<td>961167</td>
<td></td>
</tr>
</tbody>
</table>

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<sub>c</sub>, must be entered in English units, \((\text{ft}^3/\text{in.} \cdot \text{Hg} \cdot \text{min})^2\).

<table>
<thead>
<tr>
<th>Run Time</th>
<th>DGM Orifice (ft&lt;sub&gt;c&lt;/sub&gt;)</th>
<th>Volume Initial (cubic feet)</th>
<th>Volume Final (cubic feet)</th>
<th>Outlet Temp Initial (°F)</th>
<th>Outlet Temp Final (°F)</th>
<th>Serial Number</th>
<th>Coefficient (K&lt;sub&gt;c&lt;/sub&gt;)</th>
<th>Coefficient (Y&lt;sub&gt;0&lt;/sub&gt;)</th>
<th>Coefficient (Y&lt;sub&gt;2&lt;/sub&gt;)</th>
<th>Actual Vacuum (in Hg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.0</td>
<td>1.70</td>
<td>262.400</td>
<td>267.910</td>
<td>75</td>
<td>75</td>
<td>FD 63</td>
<td>0.5907</td>
<td>72</td>
<td>72</td>
<td>19.00</td>
</tr>
<tr>
<td>7.0</td>
<td>1.70</td>
<td>267.910</td>
<td>273.378</td>
<td>75</td>
<td>75</td>
<td>FD 63</td>
<td>0.5907</td>
<td>72</td>
<td>72</td>
<td>19.00</td>
</tr>
<tr>
<td>7.0</td>
<td>1.70</td>
<td>273.378</td>
<td>278.881</td>
<td>75</td>
<td>75</td>
<td>FD 63</td>
<td>0.5907</td>
<td>72</td>
<td>72</td>
<td>19.00</td>
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**Dry Gas Meter**

<table>
<thead>
<tr>
<th>Standardized Data</th>
<th>Critical Orifice</th>
<th>Calibration Factor</th>
<th>Flowrate</th>
<th>Dry Gas Meter</th>
<th>ΔH (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>((\bar{V}_{m}))</td>
<td>((\bar{C}_{m}))</td>
<td>((\bar{C}_{g}))</td>
<td>Value</td>
<td>Variation</td>
<td>Std &amp; Corr</td>
</tr>
<tr>
<td>cubic feet</td>
<td>cubic feet</td>
<td>cfm</td>
<td>Y</td>
<td>(ΔY)</td>
<td>((\Delta H))</td>
</tr>
<tr>
<td>5.421</td>
<td>0.774</td>
<td>5.324</td>
<td>0.761</td>
<td>0.682</td>
<td>-0.034</td>
</tr>
<tr>
<td>5.429</td>
<td>0.768</td>
<td>5.324</td>
<td>0.761</td>
<td>0.990</td>
<td>0.003</td>
</tr>
<tr>
<td>5.384</td>
<td>0.771</td>
<td>5.324</td>
<td>0.761</td>
<td>0.987</td>
<td>0.001</td>
</tr>
<tr>
<td>Pretest Gamma</td>
<td>0.965</td>
<td>0.965</td>
<td>Y Average</td>
<td>1.634</td>
<td>((\Delta H)) Average</td>
</tr>
</tbody>
</table>

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: [Signature]

Date: 10-20-10
**Type S Pitot Tube Inspection**

**Air Control Techniques, P.C.**

**Identification Information**

<table>
<thead>
<tr>
<th>Client</th>
<th>Job</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>In House</strong></td>
<td><strong>NA</strong></td>
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</tbody>
</table>

<table>
<thead>
<tr>
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<th>Process</th>
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</thead>
<tbody>
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<td><strong>NA</strong></td>
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</tbody>
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<table>
<thead>
<tr>
<th>City</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cary</strong></td>
<td><strong>NC</strong></td>
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</table>

**Pitot ID**

---

**Inspection Results**

**Inspection Data**

<table>
<thead>
<tr>
<th>Inspection Data</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level and Perpendicular?</td>
<td><strong>Yes</strong></td>
</tr>
<tr>
<td>Obstruction?</td>
<td><strong>10°</strong></td>
</tr>
<tr>
<td>Damaged?</td>
<td><strong>1°</strong></td>
</tr>
<tr>
<td>( \alpha_1 ) ((-10° \leq \alpha_1 \leq +10°))</td>
<td><strong>1°</strong></td>
</tr>
<tr>
<td>( \alpha_2 ) ((-10° \leq \alpha_2 \leq +10°))</td>
<td><strong>10°</strong></td>
</tr>
<tr>
<td>( \beta_1 ) ((-5° \leq \beta_1 \leq +5°))</td>
<td><strong>10°</strong></td>
</tr>
<tr>
<td>( \beta_2 ) ((-5° \leq \beta_2 \leq +5°))</td>
<td><strong>10°</strong></td>
</tr>
<tr>
<td>( \gamma )</td>
<td><strong>10°</strong></td>
</tr>
<tr>
<td>( \theta )</td>
<td><strong>10°</strong></td>
</tr>
<tr>
<td>( z = A \tan \gamma ) ((\leq 0.125 \text{ inches}))</td>
<td><strong>0.0164</strong></td>
</tr>
<tr>
<td>( w = A \tan \theta ) ((\leq 0.03125 \text{ inches}))</td>
<td><strong>0.0164</strong></td>
</tr>
<tr>
<td>( D_1 ) ((3/16 \text{ inch} \leq D_1 \leq 3/8 \text{ inch}))</td>
<td><strong>0.375</strong></td>
</tr>
<tr>
<td>( A )</td>
<td><strong>0.9375</strong></td>
</tr>
<tr>
<td>( A/D_1 ) ((1.05 \leq PA/D_1 \leq 1.5))</td>
<td><strong>1.25</strong></td>
</tr>
</tbody>
</table>

**Notes**

---

**Pitot Coefficient**

<table>
<thead>
<tr>
<th>Coefficient of 0.84 Assigned?</th>
<th><strong>Yes</strong></th>
</tr>
</thead>
</table>

**Inspection Personnel**

<table>
<thead>
<tr>
<th>DLS</th>
</tr>
</thead>
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Form ACTPC PI-2
### Stainless Steel Nozzle Calibration and Condition

**Air Control Techniques, P.C.**

<table>
<thead>
<tr>
<th>Nozzle Set ID</th>
<th>Nozzle ID</th>
<th>Average</th>
<th>Measurements</th>
<th>High-Low</th>
<th>Condition</th>
<th>Date Inspected</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACT-N-1</td>
<td>1-1</td>
<td>0.123</td>
<td>0.123</td>
<td>0.124</td>
<td>0.122</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td>1-2</td>
<td>0.180</td>
<td>0.180</td>
<td>0.180</td>
<td>0.181</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>1-3</td>
<td>0.238</td>
<td>0.238</td>
<td>0.238</td>
<td>0.238</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>1-4</td>
<td>0.299</td>
<td>0.300</td>
<td>0.300</td>
<td>0.298</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td>1-5</td>
<td>0.368</td>
<td>0.368</td>
<td>0.368</td>
<td>0.368</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>1-6</td>
<td>0.427</td>
<td>0.427</td>
<td>0.427</td>
<td>0.428</td>
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</tr>
<tr>
<td></td>
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<td>0.492</td>
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<td>0.490</td>
<td>0.002</td>
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</table>

<table>
<thead>
<tr>
<th>Nozzle Set ID</th>
<th>Nozzle ID</th>
<th>Average</th>
<th>Measurements</th>
<th>High-Low</th>
<th>Condition</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACT-N-2</td>
<td>2-1</td>
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<td>0.128</td>
<td>0.128</td>
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<tr>
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<td>0.177</td>
<td>0.178</td>
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</tr>
<tr>
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<td>2-3</td>
<td>0.240</td>
<td>0.240</td>
<td>0.240</td>
<td>0.240</td>
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</tr>
<tr>
<td></td>
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<td>0.297</td>
<td>0.298</td>
<td>0.298</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>2-5</td>
<td>0.373</td>
<td>0.373</td>
<td>0.374</td>
<td>0.373</td>
<td>0.001</td>
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<tr>
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<td>0.440</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td>2-7</td>
<td>0.497</td>
<td>0.498</td>
<td>0.497</td>
<td>0.497</td>
<td>0.001</td>
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</table>

<table>
<thead>
<tr>
<th>Nozzle Set ID</th>
<th>Nozzle ID</th>
<th>Average</th>
<th>Measurements</th>
<th>High-Low</th>
<th>Condition</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACT-N-3</td>
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<td>0.120</td>
<td>0.120</td>
<td>0.121</td>
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</tr>
<tr>
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<td>0.239</td>
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<tr>
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<td>0.996</td>
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<td>0.997</td>
<td>0.995</td>
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<td>3-7</td>
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<td>0.494</td>
<td>0.494</td>
<td>0.494</td>
<td>0.000</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Nozzle Set ID</th>
<th>Nozzle ID</th>
<th>Average</th>
<th>Measurements</th>
<th>High-Low</th>
<th>Condition</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACT-N-4</td>
<td>4-1</td>
<td>0.301</td>
<td>0.300</td>
<td>0.301</td>
<td>0.302</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td>4-2</td>
<td>0.178</td>
<td>0.178</td>
<td>0.178</td>
<td>0.177</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>4-3</td>
<td>0.299</td>
<td>0.299</td>
<td>0.299</td>
<td>0.299</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>4-4</td>
<td>0.248</td>
<td>0.248</td>
<td>0.248</td>
<td>0.248</td>
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<td>0.364</td>
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<td>0.364</td>
<td>0.363</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>4-6</td>
<td>0.497</td>
<td>0.496</td>
<td>0.497</td>
<td>0.497</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>4-7</td>
<td>0.498</td>
<td>0.497</td>
<td>0.498</td>
<td>0.496</td>
<td>0.002</td>
</tr>
</tbody>
</table>

Name: [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

**Company:** Air Control Techniques  
**Contact:** Tom Holder  
**Street Address:** 301 E. Durham Rd.  
**City, State, Zip:** Cary NC 27513  
**Phone Number:** 919 460 7811  
**Fax Number:** 919 460 7897  

<table>
<thead>
<tr>
<th>Sample ID / Run #</th>
<th>Train/Run Component</th>
<th>Train/Run Component</th>
<th>Train/Run Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXAMPLE: SCRUBBER INLET-1</td>
<td>0.1 N H2SO4 (Imp 1-3)</td>
<td>0.1 N H2SO4 (Imp 4)</td>
<td>0.1 N NaOH (Imp 5-6)</td>
</tr>
<tr>
<td>API-2.5/028-1,2,3</td>
<td>Keep Separate</td>
<td>Nozzle + Probe Rinse, &gt;2.5 Rinse, ≤2.5 Rinse,</td>
<td>Filter, Imp Soln, Imp Acetone, Imp MeCl2, CPM Filter</td>
</tr>
<tr>
<td>MSB/028-1,2,3</td>
<td>Filter, Frnt/Rinse, Imp Soln, Imp Acetone,</td>
<td>Imp MeCl2, CPM Filter</td>
<td></td>
</tr>
</tbody>
</table>

*May Not Analyze*

**Turnaround Time:**
- [x] 10 Days (Standard)
- ☐ 5 Days (1.5x)
- ☐ 3 Days (2x)
- ☐ 2 Days (2.5x)
- ☐ 24 Hours (3x)

**Analyses**
- [ ] EPA 0011/TO-5/8315 analytes:
- [ ] analytes:
- [ ] HF (EPA 13B)
- [ ] EPA 26A (HCl/Cl2)
  - analytes:
- [ ] VOCs (HPLC)
  - analytes:
- [ ] Amines list:
- [ ] Phenol (EPA TO-8)
- [ ] SOx (EPA 6/8)
  - analytes:
- [ ] Ammonia (CTM-027)
- [ ] NOx (EPA 7A/7D)
- [ ] Filt Particulate (EPA 5)
- [ ] Conden Part (EPA 202)
- [ ] EPA 29
  - metals:
- [ ] Ontario-Hydro (Hg)
- [ ] EPA 101A (hg)
- [ ] Other
  - list
REPORT SUMMARY

RFA #: 1436 F
Method: EPA M5

<table>
<thead>
<tr>
<th>SAMPLE ID</th>
<th>TOTAL FILTERABLE PARTICULATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetone Blank</td>
<td>0.4 mg (in 220 mls)</td>
</tr>
<tr>
<td>M5B/028-1</td>
<td>26.6 mg</td>
</tr>
<tr>
<td>M5B/028-2</td>
<td>19.4 mg</td>
</tr>
<tr>
<td>M5B/028-3</td>
<td>17.2 mg</td>
</tr>
</tbody>
</table>
# REPORT SUMMARY

**RFA #:** 1436 F

<table>
<thead>
<tr>
<th>SAMPLE ID</th>
<th>Particulate ≤ 2.5 μm</th>
<th>Particulate &gt; 2.5 μm</th>
<th>Particulate Nozzle and Probe Rinse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetone Blank</td>
<td>0.4 mg</td>
<td>0.4 mg</td>
<td>0.4 mg (in 220 mls)</td>
</tr>
<tr>
<td>API-2.5/028-1</td>
<td>9.3 mg</td>
<td>0.4 mg</td>
<td>5.4 mg</td>
</tr>
<tr>
<td>API-2.5/028-2</td>
<td>10.8 mg</td>
<td>0.2 mg</td>
<td>4.3 mg</td>
</tr>
<tr>
<td>API-2.5/028-3</td>
<td>1.5 mg</td>
<td>0.4 mg</td>
<td>16.3 mg</td>
</tr>
</tbody>
</table>
## REPORT SUMMARY

<table>
<thead>
<tr>
<th>SAMPLE ID</th>
<th>Organic CPM</th>
<th>Inorganic CPM</th>
<th>Total CPM$^1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetone/MeCl₂ Blank</td>
<td></td>
<td></td>
<td>0.2 mg (in 135 mL)</td>
</tr>
<tr>
<td>DI H₂O Blank</td>
<td></td>
<td></td>
<td>1.2 mg (in 160 mL)</td>
</tr>
<tr>
<td>Field Train Blank</td>
<td>0.5 mg</td>
<td>1.3 mg</td>
<td>1.8 mg</td>
</tr>
<tr>
<td>API-2.5/028-1</td>
<td>1.7 mg</td>
<td>8.0 mg</td>
<td>7.9 mg</td>
</tr>
<tr>
<td>API-2.5/028-2</td>
<td>1.0 mg</td>
<td>18.4 mg</td>
<td>17.6 mg</td>
</tr>
<tr>
<td>API-2.5/028-3</td>
<td>2.0 mg</td>
<td>10.8 mg</td>
<td>11.0 mg</td>
</tr>
<tr>
<td>M5B/028-1</td>
<td>2.9 mg</td>
<td>21.3 mg</td>
<td>22.4 mg</td>
</tr>
<tr>
<td>M5B/028-2</td>
<td>2.3 mg</td>
<td>15.1 mg</td>
<td>15.6 mg</td>
</tr>
<tr>
<td>M5B/028-3</td>
<td>2.3 mg</td>
<td>15.5 mg</td>
<td>16.0 mg</td>
</tr>
</tbody>
</table>

$^1$ Total Condensable Particulate Matter (CPM) results have been Field Blank corrected up to a maximum of 2.0 mg.
Analytical Narrative

Client: Air Control Techniques
Analyst: JSC
Analysis: EPA M5

RFA #: 1436 F
Date Received: 6/3/10
Date Analyzed: 6/8/10
Analyte(s): FILTERABLE PARTICULATE

Sample Matrix & Components:

Dry Filters, Front 1/2 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°F, 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°F, 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:

H₂O 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  
**Method:** EPA M5  
**RFA #:** 1436 F

<table>
<thead>
<tr>
<th>Run Number</th>
<th>M5B/029-1</th>
<th>M5B/029-2</th>
<th>M5B/029-3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Filter Container #</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>Init</td>
<td>Date</td>
<td>Date</td>
</tr>
<tr>
<td>6/10/10</td>
<td>JSC 0.3533</td>
<td>6/10/10</td>
<td>0.3477</td>
</tr>
<tr>
<td>Baggie Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Filter Tare Wt., g.</td>
<td>0.3370</td>
<td>0.3357</td>
<td>0.3362</td>
</tr>
<tr>
<td>FILTER SAMPLE WT., g.</td>
<td>0.0183</td>
<td>0.0120</td>
<td>0.0141</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Front 1/4 Rinse Container #</strong></th>
<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Date</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/10/10</td>
<td>JSC 3.4869</td>
<td>6/10/10</td>
<td>3.5498</td>
<td>8/10/10</td>
<td>3.5468</td>
</tr>
<tr>
<td>6/10/10</td>
<td>JSC 3.4873</td>
<td>6/10/10</td>
<td>3.5469</td>
<td>8/10/10</td>
<td>3.4460</td>
</tr>
<tr>
<td>6/10/10</td>
<td>JSC 3.4764</td>
<td>6/10/10</td>
<td>3.5422</td>
<td>8/10/10</td>
<td>3.4423</td>
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<tr>
<td>Rinse Wt., g.</td>
<td>(120 ml) 0.0105</td>
<td>(130 ml) 0.0076</td>
<td>(120 ml) 0.0033</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FILTER SAMPLE WT., g.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Filter Catch, mg.</strong></td>
<td>16.3</td>
<td>12.0</td>
<td>14.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rinse Catch, mg.</td>
<td>10.5</td>
<td>7.6</td>
<td>3.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rinse Blank Residue, mg.</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net Rinse Catch, mg.</td>
<td>19.3</td>
<td>7.4</td>
<td>3.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>FILTERABLE PARTICULATE, mg.</strong></td>
<td>25.6</td>
<td>19.4</td>
<td>17.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Legend:**  
F = Final Weight

**Notes & Comments:**
# REAGENT BLANK LABORATORY RESULTS

**Client:** Air Control Techniques  
**Method:** EPA M5  
**RFA #:** 1436 F

<table>
<thead>
<tr>
<th>Run Number</th>
<th>Acetone Blank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample ID/Container</td>
<td>2434</td>
</tr>
<tr>
<td>Date</td>
<td>pt</td>
</tr>
<tr>
<td>6/10/10</td>
<td>JSC</td>
</tr>
<tr>
<td>6/10/10</td>
<td>JSC</td>
</tr>
<tr>
<td>Tare Wt., g.</td>
<td>(</td>
</tr>
<tr>
<td>SAMPLE WT., g.</td>
<td>0.0004</td>
</tr>
</tbody>
</table>

| 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/lmg | 2.325-05 <.. |
| Upper Limit, mg. | 1.00E-05 |

**Legend:**  
F = Final Weight

**Notes & Comments:**
### PARTICULATE SAMPLING LABORATORY RESULTS

**Client:** Air Control Techniques  
**Method:** OTM-027  
**RFA R:** 1436 F

<table>
<thead>
<tr>
<th>Run Number</th>
<th>API-2,54/02-1</th>
<th>API-2,54/02-3</th>
<th>API-2,54/02-5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter Container</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>Int</td>
<td>Date</td>
<td>Date</td>
</tr>
<tr>
<td>6/9/10</td>
<td>JSC</td>
<td>0.1345</td>
<td>5/9/10</td>
</tr>
<tr>
<td>Bag filter WT, g</td>
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<td></td>
</tr>
<tr>
<td>FILTER SAMPLE WT, g</td>
<td>0.1396</td>
<td>0.1364</td>
<td>0.1170</td>
</tr>
<tr>
<td></td>
<td>6/9/10</td>
<td>JSC</td>
<td>0.0289</td>
</tr>
<tr>
<td>6.5 μm Rinse Container</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>Int</td>
<td>Date</td>
<td>Date</td>
</tr>
<tr>
<td>6/9/10</td>
<td>JSC</td>
<td>3.9252</td>
<td>0.0107</td>
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<tr>
<td>Rinse Wt, g</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Rinse Sample Wt, g</td>
<td>0.0904</td>
<td>0.0111</td>
<td>0.0044</td>
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<tr>
<td>&gt; 2.5 μm Rinse Container</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>Int</td>
<td>Date</td>
<td>Date</td>
</tr>
<tr>
<td>6/9/10</td>
<td>JSC</td>
<td>2.0766</td>
<td>6/9/10</td>
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<tr>
<td>Rinse Wt, g</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Rinse Sample Wt, g</td>
<td>3.9251</td>
<td>3.4597</td>
<td>3.0077</td>
</tr>
<tr>
<td>Nozzle and Probe Rinse Container</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>Int</td>
<td>Date</td>
<td>Date</td>
</tr>
<tr>
<td>6/9/10</td>
<td>JSC</td>
<td>3.8785</td>
<td>0.0986</td>
</tr>
<tr>
<td>Rinse Wt, g</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rinse Sample Wt, g</td>
<td>3.0069</td>
<td>3.5497</td>
<td>3.0046</td>
</tr>
<tr>
<td>Filter Catch, mg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.5 μm Rinse Catch, mg</td>
<td>0.4</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Rinse Blank Residue, mg</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>0.4</td>
<td>0.0</td>
<td>0.4</td>
</tr>
<tr>
<td>&gt; 2.5 μm Rinse Catch, mg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rinse Blank Residue, mg</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Rinse Blank Residue, mg</td>
<td>0.4</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>Net Rinse Catch, mg</td>
<td>5.4</td>
<td>4.3</td>
<td>16.3</td>
</tr>
<tr>
<td>FILTERABLE PARTICULATE, mg</td>
<td>15.1</td>
<td>15.3</td>
<td>16.2</td>
</tr>
</tbody>
</table>

**Notes & Comments:**
### REAGENT BLANK LABORATORY RESULTS

**Client:** Air Control Techniques  
**Method:** OTM 027  
**RFA #:** 1436 F

<table>
<thead>
<tr>
<th>Run Number</th>
<th>Acetone Blank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample ID/Container #</td>
<td>2434</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Initial</th>
<th>wt. g.</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/10/10</td>
<td>JSC</td>
<td>F</td>
</tr>
<tr>
<td>6/10/10</td>
<td>JSC</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tare Wt., g.</th>
<th>0.0004</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAMPLE WT., g.</td>
<td>3.4520</td>
</tr>
<tr>
<td>Volume, ml.</td>
<td>220</td>
</tr>
<tr>
<td>Density, mg/ml</td>
<td>785.0</td>
</tr>
<tr>
<td>Conc., mg/ml</td>
<td>2.32E-06 ✔</td>
</tr>
<tr>
<td>Upper Limit, mg</td>
<td>1.00E-05</td>
</tr>
</tbody>
</table>
### CONDENSIBLE PARTICULATE MATTER LABORATORY RESULTS

**Client:** Air Control Techniques, Inc.  
**Method:** OTM-028  
**RFA #:** 1436-F

<table>
<thead>
<tr>
<th>Run Number</th>
<th>API-2.5/028-1</th>
<th>API-2.5/028-2</th>
<th>API-2.5/028-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetone/MeCl₂ Container #</td>
<td>Date</td>
<td>init</td>
<td>Date</td>
</tr>
<tr>
<td>Tare Wt., g.</td>
<td>3.5474</td>
<td>3.7046</td>
<td>3.5891</td>
</tr>
<tr>
<td>RINSE SAMPLE WT., g.</td>
<td>0.0017</td>
<td>0.0010</td>
<td>0.0020</td>
</tr>
</tbody>
</table>

| DI H₂O Container # | Date | init | Date | Date | Date |
| Tare Wt., g. | 3.5700 | 3.8626 | 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 NH₂OH Added (N=0.1), ml**  
  0.70  
  1.10  
  1.20

- **Correction For NH₃ 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:**
## CONDENSIBLE PARTICULATE MATTER LABORATORY RESULTS

<table>
<thead>
<tr>
<th>Client: Air Control Techniques, Inc.</th>
<th>RFA #: 1436-F</th>
</tr>
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<tbody>
<tr>
<td>Method: OTM-028</td>
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<table>
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<td>MSB/028-1</td>
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<table>
<thead>
<tr>
<th>Acetone/MeCl₂ Container #</th>
<th>Date</th>
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<tbody>
<tr>
<td></td>
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<td>1591</td>
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<table>
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<tr>
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<th>F</th>
<th>Date</th>
<th>BNL</th>
<th>F</th>
<th>Date</th>
<th>F</th>
</tr>
</thead>
</table>

| Tare Wt., g.  | 3.6624 | 3.5945 | 3.4927 |
| RINSE SAMPLE WT., g. | 0.0029 | 0.0023 | 0.0023 |

**DI H₂O Container #**

<table>
<thead>
<tr>
<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Date</th>
<th>Date</th>
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<tr>
<td></td>
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<td></td>
<td>2277</td>
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<th>Date</th>
<th>BNL</th>
<th>F</th>
<th>Date</th>
<th>F</th>
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</table>

| Tare Wt., g.  | 3.4137 | 3.5775 | 3.8683 |
| RINSE SAMPLE WT., g. | 0.0295 | 0.0200 | 0.0213 |

**Organic CPM Mass, mg.**

|        | 2.9  | 2.3  | 2.3  |

**Inorganic CPM Mass, mg**

|        | 29.5 | 20.0 | 21.3 |

**Volume of NH₃·OH Added (N=0.1), ml**

|        | 4.80 | 2.90 | 3.40 |

**Correction For NH₃ 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.  
**Method:** OTM-028  
**RFA #:** 1436-F

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</tr>
<tr>
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<table>
<thead>
<tr>
<th>Date</th>
<th>BNL</th>
<th>BNL F</th>
<th>Tare Wt., g.</th>
<th>Rinse Sample WT., g.</th>
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</thead>
<tbody>
<tr>
<td>6/16/2010</td>
<td></td>
<td></td>
<td>3.6456</td>
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<tr>
<td>6/14/2010</td>
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<table>
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<th>BNL F</th>
<th>Tare Wt., g.</th>
<th>Rinse Sample WT., g.</th>
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<tr>
<td>Volume of NH₄OH Added (N=0.1), ml</td>
<td>0.10</td>
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<tr>
<td>Correction For NH₄ Added, mg</td>
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<tr>
<td>Adjusted Inorganic CPM Mass, mg</td>
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<tr>
<td>Total Field Train Blank CPM Mass, mg</td>
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**Notes & Comments:**
# FIELD REAGENT BLANK LABORATORY RESULTS

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<table>
<thead>
<tr>
<th>Tare Wt., g.</th>
<th>6/16/2010</th>
<th>3.5751</th>
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<th>3.6545</th>
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<td>#N/A</td>
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<td>SAMPLE Wt., g.</td>
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<td>3.6757</td>
<td>#N/A</td>
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<tr>
<td>(ml)</td>
<td>(135 ml)</td>
<td>(160 ml)</td>
<td>(160 ml)</td>
<td>3.6533</td>
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<table>
<thead>
<tr>
<th>Field Reagent Blank Mass, mg</th>
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Notes & Comments:
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<th>Acetone Rinse</th>
<th>Nozzle Cyclone</th>
<th>MeOH</th>
<th>Toluene</th>
<th>Chloroform/Ether</th>
<th>DI H2O</th>
<th>Impinger</th>
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<tr>
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<td>3.4</td>
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<td>Field Blank</td>
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<td>6.1</td>
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<tr>
<td>Fgt Blank</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td>1.0</td>
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</tbody>
</table>
# OTM 027 Particulate Bench Sheet

**Client:** ACT  
**Analyst:** JEC  
**RFA #:** 1436F  
**Method:** 027  
**Date Received:** 6/3/10  
**Date Analyzed:** 6/8/10  

<table>
<thead>
<tr>
<th>Run #</th>
<th>Filter #</th>
<th>Filter Tare</th>
<th>Baggie #</th>
<th>Volume</th>
<th>Baggie #</th>
<th>Volume</th>
<th>Baggie #</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>APE-25028-1</td>
<td>446-1201</td>
<td>0.1256</td>
<td>161</td>
<td>10</td>
<td>561</td>
<td>20</td>
<td>1488</td>
<td>230</td>
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<tr>
<td></td>
<td>446-1302</td>
<td>0.134</td>
<td>44</td>
<td>10</td>
<td>1040</td>
<td>20</td>
<td>1659</td>
<td>170</td>
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<tr>
<td></td>
<td>446-1303</td>
<td>0.128</td>
<td>1631</td>
<td>10</td>
<td>1373</td>
<td>10</td>
<td>1644</td>
<td>170</td>
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<tr>
<td>Acetone</td>
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<td></td>
<td></td>
<td></td>
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<td>2434</td>
<td>220</td>
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</table>
# M5/17 Particulate Bench Sheet

## Client: ACT

## Analyst: JSC

## RFA #: 1436 F

## Date Received: 6/13/10

## Method: SB

## Date Analyzed: 6/18/10

<table>
<thead>
<tr>
<th>Run #</th>
<th>Filter</th>
<th>Filter #</th>
<th>Filter Tare</th>
<th>Acetone Rinse</th>
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</thead>
<tbody>
<tr>
<td>M5B 1028 - 1</td>
<td>Baggie #</td>
<td>839-6573</td>
<td>0.3370</td>
<td>1375</td>
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<td>- 2</td>
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<td>839-6574</td>
<td>0.3357</td>
<td>1639</td>
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<td>- 3</td>
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<td>839-6575</td>
<td>0.3362</td>
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<tr>
<td>KB (Acetone)</td>
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<td>2434</td>
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</table>
APPENDIX IV
Data Sheets for Laboratory Analyses
VOLUME IV
VOLUME IV

Appendix A – Test Results
API Test Data

- 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

Percent of Total Catch

Aerodynamic Size and Material

- 1.44 Silica No Nozzle
- 1.44 Silica 12/1/11
- 2.2 Silica Oring Bias Nozzle Separate Rinse
- 2.16 Polmer
- 1.70 Red Oxide
### IDENTITY INFORMATION

<table>
<thead>
<tr>
<th>Plant Name</th>
<th>ACTPC Lab</th>
</tr>
</thead>
<tbody>
<tr>
<td>City</td>
<td>Cary</td>
</tr>
<tr>
<td>State</td>
<td>NC</td>
</tr>
<tr>
<td>Source Number</td>
<td>N/A</td>
</tr>
<tr>
<td>Sampling Location</td>
<td>Lab</td>
</tr>
<tr>
<td>Test Personnel</td>
<td>TTB PJJ</td>
</tr>
</tbody>
</table>

### PRELIMINARY CHECKS AND DATA

- 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.

| 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
- \(\text{CO}_2\) %: 0
- \(\text{O}_2\) %: 20.9

### Sampling Information

| Port | Point | Dwell Time (Min.) | Elapsed Time (h:m:s) | Meter Volume (ft\(^3\)) | \(\Delta P\) (in. H\(_2\)O) | Motor Temp. (\(^\circ\)F) | Stack Temp. (\(^\circ\)F) | Sample Train Vac. (in. Hg) | Impinger Exit Gas Temp. (\(^\circ\)F) | \(\Delta H\) (in. H\(_2\)O) | Target \(\Delta H\) (in. H\(_2\)O) | % Iso | Run Cumulative % | \(D_{10}\) & \(D_{50}\) |
|------|-------|-------------------|----------------------|-------------------------|---------------------------|--------------------------|--------------------------|-------------------------------|--------------------------------|-----------------------------|-----------------|-----------------|-----------------|
| A    | 1     | 10.00             | 0                    | 506.9                   | 0.265                     | 81                       | 327                      | 2                            | 67                            | 0.46                        | 0.563           | 198.3           | 9.82            |
|      | 2     | 10.00             | 10.00                | 511.39                  | 0.265                     | 81                       | 324                      | 2                            | 67                            | 0.46                        | 0.567           | 197.5           | 9.83            |
|      | 3     | 10.00             | 20.00                | 515.87                  | 0.265                     | 82                       | 324                      | 2                            | 64                            | 0.46                        | 0.568           | 194.1           | 9.88            |
|      | 4     | 10.00             | 30.00                | 520.28                  | 0.265                     | 83                       | 324                      | 2                            | 64                            | 0.46                        | 0.569           | 197.6           | 9.87            |
|      | 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

### QA Checks

<table>
<thead>
<tr>
<th></th>
<th>Target (\Delta H) (in. H(_2)O)</th>
<th>Water Recovered, grams</th>
<th>Moisture, %</th>
<th>(D_{10}) &amp; (D_{50})</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.563</td>
<td>7.65</td>
<td>2.000</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>0.567</td>
<td>0</td>
<td>28.64</td>
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</tr>
</tbody>
</table>

### Sampling Information

- Water Recovered, grams: 7.65
- \(\text{CO}_2\) %: 0
- \(\text{O}_2\) %: 20.9

### QA Checks

- Run Cumulative %: 194.0
- \(D_{10}\) & \(D_{50}\): 9.99, 2.26
## Combined Cyclone PM10 & PM2.5 Run Data Sheet

### IDENTIFICATION INFORMATION
- **Plant Name**: ACTPC Lab
- **City**: Cary
- **State**: NC

### PRELIMINARY CHECKS AND DATA
- Full Train Pretest Leak Check, ACFM: Actual < 0.02 or 4%, Vacuum 16
- Partial Train Posttest Leak Check, ACFM: Actual 0.020, Vacuum 6

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

### ACTUAL MOISTURE & GAS COMPOSITION
- **Water Recovered, grams**: 6.85
- **CO₂ %**: 0
- **O₂ %**: 20.9
- **Moisture, %**: 2.001
- **Md_run**: 28.84
- **Mw_run**: 28.62

### Sampling Information

<table>
<thead>
<tr>
<th>Port</th>
<th>Point</th>
<th>Dwell Time, (Min.)</th>
<th>Elapsed Time, (h:m:s)</th>
<th>Meter Volume (ft³)</th>
<th>ΔP (in. H₂O)</th>
<th>Meter Temp. (°F)</th>
<th>Stack Temp. (°F)</th>
<th>Sample Train Vac. (in. Hg)</th>
<th>Impinger Exit Temp. (°F)</th>
<th>ΔH (in. H₂O)</th>
<th>Target ΔH (in. H₂O)</th>
<th>% Iso</th>
<th>Run Cumulative microns</th>
</tr>
</thead>
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<tr>
<td>A</td>
<td>1</td>
<td>10.00</td>
<td>0</td>
<td>253.6</td>
<td>0.265</td>
<td>71</td>
<td>321</td>
<td>2</td>
<td>62</td>
<td>0.56</td>
<td>0.587</td>
<td>170.1</td>
<td>10.94</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>10.00</td>
<td>10.00</td>
<td>257.45</td>
<td>0.265</td>
<td>72</td>
<td>321</td>
<td>2</td>
<td>63</td>
<td>0.56</td>
<td>0.588</td>
<td>172.9</td>
<td>10.88</td>
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<td></td>
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<td>20.00</td>
<td>261.37</td>
<td>0.265</td>
<td>73</td>
<td>321</td>
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<td>64</td>
<td>0.56</td>
<td>0.590</td>
<td>175.6</td>
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<td>1.467</td>
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**Total Run Time**: 40:00
**Total Volume, ACF**: 15.722

### QA Checks

- **Run ID**: 1.5 um Nominal
- **Condition**: 2.2 um Aerodynamic

| Run | 1.5 um Nominal | 0.560 | 173.2 | 10.80 | 2.59 |
### Combined Cyclone PM10 & PM2.5 Run Data Sheet

#### IDENTIFICATION INFORMATION
- **Plant Name**: ACTPC Lab
- **City**: Cary
- **State**: NC
- **Source Number**: N/A
- **Sampling Location**: Lab
- **Test Personnel**: TTB PJJ
- **Meterbox ID**: 909083
- **ΔH**: 1.9070
- **Gamma, γ**: 1.0206
- **Nozzle Diameter**: 0.173
- **Orsat/Fyrite**: N/A

#### PRELIMINARY CHECKS AND DATA

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

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#### ACTUAL MOISTURE & GAS COMPOSITION

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#### QA Checks

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<td>D₉₀, μm</td>
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#### Sampling Information

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<th>Meter Temp. (°F)</th>
<th>Stack Temp., (°F)</th>
<th>Sample Train Vac. (in. Hg)</th>
<th>Impinger Exit Gas Temp., (°F)</th>
<th>ΔH (in. H₂O)</th>
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| Total Run Time | 40:00 |
| Total Volume, ACFM | 15.810 |

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#### Notes
- Run ID: 1.0 um Nominal
- Condition: 1.4 um Aerodynamic
### Combined Cyclone PM10 & PM2.5 Run Data Sheet

#### IDENTIFICATION INFORMATION

- **Plant Name:** ACTPC Lab
- **City:** Cary
- **State:** NC
- **Source Number:** N/A
- **Sampling Location:** Lab
- **Test Personnel:** TTB PJJ
- **Meterbox ID:** 909083
- **ΔH @ Γ:** 1.9070
- **Gamma, γ:** 1.0206
- **Nozzle Diameter:** 0.173
- **Oreast/Fyre:** N/A
- **Date:** 12/1/2010
- **Start:** 1400
- **Stop:** 1440

**Filter ID** | **Tare**
---|---

### PRELIMINARY CHECKS AND DATA

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

- Pitot Tube Pretest Leak Check: A 0, B 0
- Pitot Tube Posttest Leak Check: A 0, B 0

**Barometric Pressure, In., Hg.** 29.65
**Static Pressure, In., W.C.** 0.00

### ACTUAL MOISTURE & GAS COMPOSITION

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<td>Moisture, %</td>
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<td>Mw_run</td>
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### Sampling Information

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<th>Port</th>
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<th>Elapsed Time, h:m:s</th>
<th>Meter Volume (ft³)</th>
<th>ΔP (in. H₂O)</th>
<th>Meter Temp. (°F)</th>
<th>Stack Temp. (°F)</th>
<th>Sample Train Vac. (in. Hg)</th>
<th>Impinger Exit Gas Temp. (°F)</th>
<th>ΔH (in. H₂O)</th>
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**Total Run Time:** 40:00
**Total Volume, ACF:** 20,648

**Averages:**
- ΔP (in. H₂O): 0.265
- Meter Temp.: 73.8
- Stack Temp.: 149.8
- Material: 0.560

### QA Checks

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**Run:** 2.1 um Nominal
### Combined Cyclone PM10 & PM2.5 Run Data Sheet

#### IDENTIFICATION INFORMATION
- **Plant Name**: ACTPC Lab
- **City**: Cary
- **State**: NC
- **Source Number**: N/A
- **Sampling Location**: Lab
- **Test Personnel**: TTB PJJ
- **Meterbox ID**: 909083
- **ΔH @**: 1.9070
- **Gamma, γ**: 1.0206
- **Nozzle ID**: API
- **Nozzle Diameter**: 0.173
- **Orsat/Fyrite**: N/A

#### PRELIMINARY CHECKS AND DATA
- **Full Train Pretest Leak Check, ACFM**: 0 < 0.02 or 4%
- **Partial Train Posttest Leak Check, ACFM**: 0.018
- **Vacuum**: 15

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

- **Pitot Tube Pretest Leak Check**: A 0
- **Pitot Tube Posttest Leak Check**: B 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
- **CO₂ %**: 0
- **Md_run**: 28.84
- **O₂ %**: 20.9
- **Mw_run**: 28.62

#### Sampling Information

<table>
<thead>
<tr>
<th>Port</th>
<th>Point</th>
<th>Dwell Time, (Min.)</th>
<th>Elapsed Time, h:m:s</th>
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<th>ΔH (in. H₂O)</th>
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<td>10.90</td>
<td>2.45</td>
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<tr>
<td></td>
<td>Total Run Time</td>
<td>40:00</td>
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</tr>
<tr>
<td></td>
<td>Total Volume, ACF</td>
<td>11,300</td>
<td></td>
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</tr>
</tbody>
</table>

#### QA Checks
- **Mean**: 147.7
- **Median**: 10.90
- **Standard Deviation**: 2.45

### Run Information
- **Run**: 2.1 um Nominal
- **Condition**: 2.2 um Aerodynamic

---

**Run ID**: 2.1 um Nominal

**Condition**: 2.2 um Aerodynamic
# Combined Cyclone PM10 & PM2.5 Run Data Sheet

## Identification Information
- **Plant Name:** ACTPC Lab
- **City:** Cary
- **State:** NC
- **Source Number:** N/A
- **Sampling Location:** Lab
- **Test Personnel:** TTB PJJ
- **Meterbox ID:** 909083
- **Filter ID:**
- **Tare:**
- **ΔH:** 1.9070
- **ΔH @:** 1.0206
- **Nozzle Diameter:** 0.173
- **Orsat/Fyrite:** N/A

## Preliminary Checks and Data

<table>
<thead>
<tr>
<th>Preliminary Check</th>
<th>Actual</th>
<th>Req'd</th>
<th>Vacuum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Train Pretest Leak Check, ACFM</td>
<td>0</td>
<td>&lt; 0.02 or 4%</td>
<td>15</td>
</tr>
<tr>
<td>Partial Train Posttest Leak Check, ACFM</td>
<td>0</td>
<td>0.020</td>
<td>6</td>
</tr>
</tbody>
</table>

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

## Pilot Tube Pretest Leak Check

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

## Pilot Tube Posttest Leak Check

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

### Barometric Pressure, in. Hg.
- **29.65**

### Static Pressure, in. W.C.
- **0.00**

## Actual Moisture & Gas Composition

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Recovered, grams</td>
<td>6.83</td>
</tr>
<tr>
<td>CO₂ %</td>
<td>0</td>
</tr>
<tr>
<td>O₂ %</td>
<td>20.9</td>
</tr>
</tbody>
</table>

### Moisture, %
- **2.000**

### Md_run
- **28.84**

### Mw_run
- **28.62**

## Sampling Information

### QA Checks

<table>
<thead>
<tr>
<th>Port</th>
<th>Point</th>
<th>Dwell Time, (Min.)</th>
<th>Elapsed Time, h:m:s</th>
<th>Meter Volume (ft³)</th>
<th>ΔP</th>
<th>(in. H₂O)</th>
<th>Meter Temp, (°F)</th>
<th>Stack Temp, (°F)</th>
<th>Sample Train Vac. (in. Hg)</th>
<th>Impinger Exit Gas Temp, (°F)</th>
<th>ΔH (in. H₂O)</th>
<th>Target ΔH (in. H₂O)</th>
<th>% Δ</th>
<th>Run Cumulative D₉₅, Micros</th>
<th>PM₁₀</th>
<th>PM₂.₅</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>10.00</td>
<td>0</td>
<td>339</td>
<td>0.265</td>
<td>71</td>
<td>320</td>
<td>2</td>
<td>66</td>
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<td>0.589</td>
<td>174.8</td>
<td>0</td>
<td>10.73</td>
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<tr>
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<td>10.00</td>
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<td>321</td>
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<td>0.590</td>
<td>169.4</td>
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<tr>
<td></td>
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<td>0.00</td>
<td>40:00</td>
<td>354.659</td>
<td>0.265</td>
<td>71</td>
<td>321</td>
<td>5</td>
<td>65</td>
<td>0.56</td>
<td>1.467</td>
<td>0</td>
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<td>10.82</td>
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</table>

### B

<table>
<thead>
<tr>
<th>Port</th>
<th>Point</th>
<th>Dwell Time, (Min.)</th>
<th>Elapsed Time, h:m:s</th>
<th>Meter Volume (ft³)</th>
<th>ΔP</th>
<th>(in. H₂O)</th>
<th>Meter Temp, (°F)</th>
<th>Stack Temp, (°F)</th>
<th>Sample Train Vac. (in. Hg)</th>
<th>Impinger Exit Gas Temp, (°F)</th>
<th>ΔH (in. H₂O)</th>
<th>Target ΔH (in. H₂O)</th>
<th>% Δ</th>
<th>Run Cumulative D₉₅, Micros</th>
<th>PM₁₀</th>
<th>PM₂.₅</th>
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</thead>
<tbody>
<tr>
<td>6</td>
<td>1</td>
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<td>40:00</td>
<td>0.00</td>
<td>354.659</td>
<td>0.265</td>
<td>71</td>
<td>321</td>
<td>5</td>
<td>65</td>
<td>0.56</td>
<td>1.467</td>
<td>0</td>
<td>2</td>
<td>10.82</td>
<td>2.59</td>
</tr>
</tbody>
</table>

### Total Run Time
- **40:00**

### Total Volume, ACF
- **15.659**

## QA Checks

### Target ΔH (in. H₂O)
- **0.589**

### % Δ
- **172.7**

### Run Cumulative D₉₅, Micros
- **10.82**

### PM₁₀
- **2.59**

### PM₂.₅
- **2.59**

## Averages

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
<th>Unit</th>
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<tr>
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<td>0.265</td>
<td>in. H₂O</td>
</tr>
<tr>
<td>Meter Temp</td>
<td>71.5</td>
<td>°F</td>
</tr>
<tr>
<td>Stack Temp</td>
<td>320.5</td>
<td>°F</td>
</tr>
<tr>
<td>Impinger Exit</td>
<td>0.56</td>
<td>in. H₂O</td>
</tr>
</tbody>
</table>

### D₉₅, Micros
- **17.2**

### % Δ
- **10.82**

### PM₂.₅
- **2.59**
McFarland Equations

\[ P = \exp\left(\frac{4.61 + a_m \theta \text{Stk}}{1 + b_m \theta \text{Stk} + c_m \theta \text{Stk}^2 + d_m \theta^2 \text{Stk}}\right) \times \frac{1}{100\%} \]

1. \[ a_m = -0.9526 - 0.05686 \ R_o \]
2. \[ b_m = \frac{-0.297 - 0.0174 \ R_o}{1 - 0.07 \ R_o + 0.0171 \ R_o^2} \]
3. \[ c_m = -0.306 + \frac{1.895}{\sqrt{R_o}} - \frac{2.0}{R_o} \]
4. \[ d_m = \frac{0.131 - 0.0132 \ R_o + 0.000383 \ R_o^2}{1 - 0.129 \ R_o + 0.0136 \ R_o^2} \]

R₀ is the curvature ratio or the radius of the bend divided by the radius of the duct (R₀ = Rᵦ/a)

Pui and Brockmann Equations

\[ P = \exp[-(2)(0.706) \text{Stk} \theta] \]

\[ \text{Stk} = \tau U_0/a \]

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
- 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

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<thead>
<tr>
<th>Droplet Diameter</th>
<th>Stop Dist Pt</th>
<th>Pui-Brockmann Pt</th>
<th>McFarland Pt</th>
<th>Effy</th>
<th>Effy</th>
<th>Average</th>
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<tbody>
<tr>
<td>um</td>
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<tr>
<td>0</td>
<td>0.00E+00</td>
<td>0.00E+00</td>
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<tr>
<td>100</td>
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<td>1.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>
VOLUME IV

Appendix B – Field Data
### Combined Cyclone PM10 & PM2.5 Run Data Sheet

#### Identification Information
- **Plant Name**: API PM2.5 Lab Study
- **City**: Cary
- **State**: NC
- **Source Number**: IX3 Box
- **Sampling Location**: Lab
- **Test Personnel**: TTB PJJ
- **Meterbox ID**: 32012
- **Filter ID**: Tare
- **Meter ID**: N/A
- **Nozzle ID**: N/A
- **Nozzle Diameter**: N/A
- **Orsat/Fyrite**: N/A

#### Preliminary Checks and Data

<table>
<thead>
<tr>
<th></th>
<th>Actual</th>
<th>Req'd</th>
<th>Vacuum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Train Pretest Leak Check, ACFM</td>
<td>0.60%</td>
<td>&lt; 0.2 or 4%</td>
<td>15</td>
</tr>
<tr>
<td>Partial Train Posttest Leak Check, ACFM</td>
<td>0.00%</td>
<td></td>
<td>9</td>
</tr>
</tbody>
</table>

(Train only)

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

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pitot Tube Pretest Leak Check</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Pitot Tube Posttest Leak Check</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Barometric Pressure, in., Hg</td>
<td>29.65</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Static Pressure, in. W.C.</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>0.00</td>
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</tbody>
</table>

#### Actual Moisture & Gas Composition

<table>
<thead>
<tr>
<th></th>
<th>Moisture, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Recovered, grams</td>
<td>4%</td>
</tr>
<tr>
<td>CO₂ %</td>
<td>0</td>
</tr>
<tr>
<td>O₂ %</td>
<td>20.9</td>
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</tbody>
</table>

#### QA Checks

<table>
<thead>
<tr>
<th>Port</th>
<th>Point</th>
<th>Dwell Time, (Min.)</th>
<th>Elapsed Time, h:m:s</th>
<th>Meter Volume (ft³)</th>
<th>Meter Temp, (°F)</th>
<th>Set 310 Chamber Temp, (°F)</th>
<th>Sample Train Vac. (in. Hg)</th>
<th>Impinger Exit Gas Temp., (°F)</th>
<th>RH (in. H₂O)</th>
<th>Probe Temp, (°F)</th>
<th>Filter Cyclone Temp, (°F)</th>
<th>Notes</th>
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<tbody>
<tr>
<td>A-</td>
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<td>56.0</td>
<td>81</td>
<td>203</td>
<td>2</td>
<td>2</td>
<td>0.58</td>
<td>325</td>
<td>327</td>
<td>3mL</td>
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<tr>
<td></td>
<td>1</td>
<td>10.00</td>
<td>10</td>
<td>51.3</td>
<td>81</td>
<td>200</td>
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<td>0.73</td>
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<td>324</td>
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<td>322</td>
<td>324</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>10.00</td>
<td>30</td>
<td>520.28</td>
<td>82.2</td>
<td>200</td>
<td>2</td>
<td>2</td>
<td>0.53</td>
<td>323</td>
<td>324</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total Run Time: 2h 45min

Total Volume, ACF: 504.17 ft³

#### Sampling Information

<table>
<thead>
<tr>
<th>Port</th>
<th>Point</th>
<th>Dwell Time, (Min.)</th>
<th>Elapsed Time, h:m:s</th>
<th>Meter Volume (ft³)</th>
<th>Meter Temp, (°F)</th>
<th>Set 310 Chamber Temp, (°F)</th>
<th>Sample Train Vac. (in. Hg)</th>
<th>Impinger Exit Gas Temp., (°F)</th>
<th>RH (in. H₂O)</th>
<th>Probe Temp, (°F)</th>
<th>Filter Cyclone Temp, (°F)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Run Information

Run: 4/11/2016

Total Volume, ACF: 504.17 ft³

#### Notes

- Last 4 minutes dry

<table>
<thead>
<tr>
<th>Port</th>
<th>Point</th>
<th>Dwell Time, (Min.)</th>
<th>Elapsed Time, h:m:s</th>
<th>Meter Volume (ft³)</th>
<th>Meter Temp, (°F)</th>
<th>Set 310 Chamber Temp, (°F)</th>
<th>Sample Train Vac. (in. Hg)</th>
<th>Impinger Exit Gas Temp., (°F)</th>
<th>RH (in. H₂O)</th>
<th>Probe Temp, (°F)</th>
<th>Filter Cyclone Temp, (°F)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Identification Information

- **Plant Name**: API PM2.5 Lab Study
- **City**: Cary
- **State**: NC
- **Source Number**: IX3 Box
- **Sampling Location**: Lab
- **Test Personnel**: TTB PJJ
- **Meterbox ID**: 32012
- **Filter ID**: Tare
- **Meter ID**: N/A
- **Nozzle ID**: N/A
- **Nozzle Diameter**: N/A
- **Orsat/Fyrite**: N/A

### Preliminary Checks and Data

<table>
<thead>
<tr>
<th></th>
<th>Actual</th>
<th>Req'd</th>
<th>Vacuum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Train Pretest Leak Check, ACFM</td>
<td>0.60%</td>
<td>&lt; 0.2 or 4%</td>
<td>15</td>
</tr>
<tr>
<td>Partial Train Posttest Leak Check, ACFM</td>
<td>0.00%</td>
<td></td>
<td>9</td>
</tr>
</tbody>
</table>

(Train only)

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

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pitot Tube Pretest Leak Check</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Pitot Tube Posttest Leak Check</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Barometric Pressure, in., Hg</td>
<td>29.65</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Static Pressure, in. W.C.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.00</td>
</tr>
</tbody>
</table>

### Actual Moisture & Gas Composition

<table>
<thead>
<tr>
<th></th>
<th>Moisture, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Recovered, grams</td>
<td>4%</td>
</tr>
<tr>
<td>CO₂ %</td>
<td>0</td>
</tr>
<tr>
<td>O₂ %</td>
<td>20.9</td>
</tr>
</tbody>
</table>

### QA Checks

<table>
<thead>
<tr>
<th>Port</th>
<th>Point</th>
<th>Dwell Time, (Min.)</th>
<th>Elapsed Time, h:m:s</th>
<th>Meter Volume (ft³)</th>
<th>Meter Temp, (°F)</th>
<th>Set 310 Chamber Temp, (°F)</th>
<th>Sample Train Vac. (in. Hg)</th>
<th>Impinger Exit Gas Temp., (°F)</th>
<th>RH (in. H₂O)</th>
<th>Probe Temp, (°F)</th>
<th>Filter Cyclone Temp, (°F)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total Run Time: 2h 45min

Total Volume, ACF: 504.17 ft³

### Run Information

Run: 4/11/2016

Total Volume, ACF: 504.17 ft³

### Notes

- Last 4 minutes dry
### Combined Cyclone PM10 & PM2.5 Run Data Sheet

#### Preliminary Checks and Data

<table>
<thead>
<tr>
<th>Actual</th>
<th>Req'd</th>
<th>Vacuum</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>&lt; 0.02 or 4%</td>
<td>15</td>
</tr>
</tbody>
</table>

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

#### Actual Moisture & Gas Composition

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂ %</td>
<td>0</td>
</tr>
<tr>
<td>Moisture</td>
<td>%</td>
</tr>
<tr>
<td>O₂ %</td>
<td>20.9</td>
</tr>
</tbody>
</table>

#### Sampling Information

<table>
<thead>
<tr>
<th>Port</th>
<th>Point</th>
<th>Dwell Time (Min.)</th>
<th>Elapsed Time (h:m:s)</th>
<th>Meter Volume (ft³)</th>
<th>Meter Temp. (°F)</th>
<th>Impinger Temp. (°F)</th>
<th>Sample Train Vac. (in. Hg)</th>
<th>Immerger Exit Gas Temp. (°F)</th>
<th>Probe Temp. (°F)</th>
<th>Filter Cyclone Temp. (°F)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>i</td>
<td>10.00</td>
<td>0</td>
<td>N/A</td>
<td>71</td>
<td>692</td>
<td>2</td>
<td>62</td>
<td>68</td>
<td>320</td>
<td></td>
</tr>
<tr>
<td>i</td>
<td>10.00</td>
<td>10</td>
<td>N/A</td>
<td>72</td>
<td>640</td>
<td>2</td>
<td>63</td>
<td>683</td>
<td>327</td>
<td>327</td>
<td></td>
</tr>
<tr>
<td>i</td>
<td>10.00</td>
<td>20</td>
<td>N/A</td>
<td>72</td>
<td>625</td>
<td>2</td>
<td>64</td>
<td>694</td>
<td>353</td>
<td>351</td>
<td></td>
</tr>
<tr>
<td>i</td>
<td>10.00</td>
<td>30</td>
<td>N/A</td>
<td>72</td>
<td>625</td>
<td>2</td>
<td>65</td>
<td>694</td>
<td>353</td>
<td>351</td>
<td></td>
</tr>
</tbody>
</table>

#### QA Checks

- 3m1.64m (Normal)
- 3m1.64m (Normal)
- Chilled to 40m
- Rise to 60m
- Last 4 minutes
- DRY

#### Run

- Run Time
- Total Volume, ACF
- Averages in H₂O °F °F in H₂O % microns
**Combined Cyclone PM10 & PM2.5 Run Data Sheet**

**IDENTIFICATION INFORMATION**
- **Plant Name**: API PM2.5 Lab Study
- **City**: Cary
- **State**: NC
- **Source Number**: IX3 Box
- **Sampling Location**: Lab
- **Test Personnel**: TTB PJJ

**PRELIMINARY CHECKS AND DATA**
- **Run ID**: AFT 2.1 Nominal
- **Condition**: 3.4 µm Angstrom

<table>
<thead>
<tr>
<th>Check</th>
<th>Actual</th>
<th>Req'd</th>
<th>Vacuum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Train Pretest Leak Check, ACFM</td>
<td>0</td>
<td>&lt; 0.02 or 4%</td>
<td>15</td>
</tr>
<tr>
<td>Partial Train Posttest Leak Check, ACFM</td>
<td>0/100</td>
<td></td>
<td>5</td>
</tr>
</tbody>
</table>

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

- **Pitot Tube Pretest Leak Check**: N/A
- **Pitot Tube Posttest Leak Check**: N/A

**ACTUAL MOISTURE & GAS COMPOSITION**

<table>
<thead>
<tr>
<th>Component</th>
<th>Moisture, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td></td>
</tr>
<tr>
<td>CO₂ %</td>
<td></td>
</tr>
<tr>
<td>O₂ %</td>
<td></td>
</tr>
</tbody>
</table>

**Sampling Information**

<table>
<thead>
<tr>
<th>Port</th>
<th>Point</th>
<th>Dwell Time, (Min.)</th>
<th>Elapsed Time, h:m:s</th>
<th>Meter Volume (in. H₂O)</th>
<th>@P Temp (°F)</th>
<th>Meter Volume (in. H₂O)</th>
<th>Chamber Temp. (°F)</th>
<th>Sample Temp. (°F)</th>
<th>Impinger Temp. (°F)</th>
<th>Probe Temp. (°F)</th>
<th>Filter Temp. (°F)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>10.00</td>
<td>0</td>
<td>498.500</td>
<td>93</td>
<td>69</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>3m/s Dilute to 1m/s</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>10.00</td>
<td>10</td>
<td>710.58</td>
<td>73</td>
<td>49</td>
<td>182</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>10.00</td>
<td>20</td>
<td>356.77</td>
<td>74</td>
<td>52</td>
<td>165</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>49+ Rise w/ 6 ml/s</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>10.00</td>
<td>30</td>
<td>405.64</td>
<td>75</td>
<td>52</td>
<td>165</td>
<td>149</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>50</td>
</tr>
</tbody>
</table>

**QA Checks**

**Total Run Time**

**Total Volume, ACF**

Run: _______________________

**Averages**

<table>
<thead>
<tr>
<th>in. H₂O</th>
<th>°F</th>
<th>°F</th>
<th>%</th>
<th>microns</th>
</tr>
</thead>
</table>

- [Image of the document with handwritten notes]
Combined Cyclone PM10 & PM2.5 Run Data Sheet

IDENTIFICATION INFORMATION

Plant Name: API PM2.5 Lab Study
City: Cary
State: NC
Source Number: X3 Box
Sampling Location: Lab
Test Personnel: ITB PJJ

Meter ID: 1010032
Filter ID: Tare

ΔH @ D: 904
Gamma, γ: 1.074
Nozzle ID: 0.75
Orsat/Fyrite:

PRELIMINARY CHECKS AND DATA

Full Train Pretest Leak Check, ACFM
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.

Barometric Pressure, ln.Hg.: 29.65
Static Pressure, ln. W.C.: 0.00

Pilot Tube Pretest Leak Check
Pilot Tube Posttest Leak Check

ACTUAL MOISTURE & GAS COMPOSITION

Water Recovered, grams
CO₂ %
O₂ %
Moisture, %
Md_run
Mw_run

Sampling Information

<table>
<thead>
<tr>
<th>Port</th>
<th>Point</th>
<th>Dwell Time (Min.)</th>
<th>Elapsed Time (h:m:s)</th>
<th>Meter Volume (ft³)</th>
<th>ΨP (In. H₂O)</th>
<th>Meter Temp. (°F)</th>
<th>ΔH PS Chamber Temp. (°F)</th>
<th>Sample Train Vac. (In. Hg)</th>
<th>Impinger Exit Gas Temp. (°F)</th>
<th>ΨH (In. H₂O)</th>
<th>Probe Temp. (°F)</th>
<th>Filter Cyclone Temp. (°F)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-</td>
<td>1</td>
<td>10.00</td>
<td>0</td>
<td>366.40</td>
<td>N/A</td>
<td>68</td>
<td>152</td>
<td>2</td>
<td>64</td>
<td>0.02</td>
<td>49</td>
<td>150</td>
<td>SAME AS PREV. 60S</td>
</tr>
<tr>
<td>A-</td>
<td>1</td>
<td>10.00</td>
<td>10</td>
<td>360.38</td>
<td>N/A</td>
<td>68</td>
<td>145</td>
<td>2</td>
<td>60</td>
<td>0.52</td>
<td>49</td>
<td>149</td>
<td></td>
</tr>
<tr>
<td>A-</td>
<td>1</td>
<td>10.00</td>
<td>20</td>
<td>344.76</td>
<td>N/A</td>
<td>67</td>
<td>158</td>
<td>2</td>
<td>50</td>
<td>0.52</td>
<td>49</td>
<td>149</td>
<td></td>
</tr>
<tr>
<td>A-</td>
<td>1</td>
<td>10.00</td>
<td>30</td>
<td>341.49</td>
<td>N/A</td>
<td>70</td>
<td>155</td>
<td>2</td>
<td>53</td>
<td>0.08</td>
<td>45</td>
<td>152</td>
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</tr>
</tbody>
</table>

Total Run Time

Total Volume, ACF

Averages

Run

in H₂O  °F  °F

in H₂O % microns

Polymer Spheres Run #2

Run ID: A1 2.1 Nominal
Condition: 3.2 AECO
## Combined Cyclone PM10 & PM2.5 Run Data Sheet

### Identification Information
- **Plant Name**: API PM2.5 Lab Study
- **City**: Cary
- **State**: NC
- **Source Number**: X3 Box
- **Sampling Location**: Lab
- **Test Personnel**: TT8 PJJ
- **Meterbox ID**: 010183
- **Filter ID**: 89-41

### Preliminary Checks and Data
- **Full Train Pretest Leak Check, ACfm**: 0 < 0.02 or 4%
- **Partial Train Posttest Leak Check, ACfm**: 0.100
- **Barometric Pressure, in.Hg**: 29.65
- **Static Pressure, in. W.C.**: 0.00

### Actual Moisture & Gas Composition
- **Water Recovered, grams**
- **CO₂ %**
- **O₂ %**

### Sampling Information

<table>
<thead>
<tr>
<th>Port</th>
<th>Point</th>
<th>Dwell Time (Min.)</th>
<th>Elapsed Time, h:m:s</th>
<th>Meter Volume (ft³)</th>
<th>Measured Temp. (°F)</th>
<th>Measured Temp. Comp. Chamber Temp. (°F)</th>
<th>Sample Train Vac. (in. Hg)</th>
<th>Impinger Exit Gas Temp. (°F)</th>
<th>Measured Temp. (°F)</th>
<th>Probe Temp. (°F)</th>
<th>Filter Cyclone Temp. (°F)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-</td>
<td>1</td>
<td>10.00</td>
<td>0</td>
<td>357.000</td>
<td>N/A</td>
<td>233</td>
<td>2</td>
<td>320</td>
<td>0.52</td>
<td>320</td>
<td>320</td>
<td>Dry Impinger</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>10.00</td>
<td>10</td>
<td>349.965</td>
<td>N/A</td>
<td>248</td>
<td>4</td>
<td>320</td>
<td>320</td>
<td>320</td>
<td>320</td>
<td>Test 16% 2070</td>
</tr>
<tr>
<td></td>
<td>1</td>
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<td>20</td>
<td>416.696</td>
<td>N/A</td>
<td>278</td>
<td>5</td>
<td>320</td>
<td>320</td>
<td>320</td>
<td>320</td>
<td>Test 16% 2070</td>
</tr>
<tr>
<td></td>
<td>1</td>
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<td>30</td>
<td>342.813</td>
<td>N/A</td>
<td>316</td>
<td>6</td>
<td>320</td>
<td>320</td>
<td>320</td>
<td>320</td>
<td>Test 16% 2070</td>
</tr>
<tr>
<td></td>
<td>1</td>
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<td>40</td>
<td>354.663</td>
<td>N/A</td>
<td>316</td>
<td>6</td>
<td>320</td>
<td>320</td>
<td>320</td>
<td>320</td>
<td>Test 16% 2070</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total Run Time</th>
<th>Total Volume, ACfm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run</td>
<td></td>
</tr>
</tbody>
</table>

### QA Checks
- **Averages**
  - **in. H₂O**
  - **°F**
  - **°C**

### Red Oxide

- **Run ID**: API 0.8 (Nominal)
- **Condition**: N/A
VOLUME IV

Appendix C – Calibration Data
### APEX INSTRUMENTS METHOD 5 PRE-TEST CONSOLE CALIBRATION

**USING CALIBRATED CRITICAL ORIFICES**

**5-POINT ENGLISH UNITS**

<table>
<thead>
<tr>
<th>Meter Console Information</th>
<th>Calibration Conditions</th>
<th>Factors/Conversions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Console Model Number</strong></td>
<td>Date 02/01/10</td>
<td>Std Temp 528°F</td>
</tr>
<tr>
<td><strong>Console Serial Number</strong></td>
<td></td>
<td>Std Press 26.92 in Hg</td>
</tr>
<tr>
<td><strong>DGM Model Number</strong></td>
<td>Barometric Pressure 29.80 in Hg</td>
<td></td>
</tr>
<tr>
<td><strong>DGM Serial Number</strong></td>
<td>Theoretical Critical Vacuum 14.07 in Hg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Calibration Technician DLS</td>
<td></td>
</tr>
</tbody>
</table>

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

2The Critical Orifice Coefficient, K', must be entered in English units, (in Hg ft ^2)/(min ft ^3).

<table>
<thead>
<tr>
<th>Run Time</th>
<th>DGM Orifice ΔH</th>
<th>Volume Initial (V1)</th>
<th>Volume Final (V2)</th>
<th>Outlet Temp Initial (T1)</th>
<th>Outlet Temp Final (T2)</th>
<th>Serial Number K'</th>
<th>Amb Temp Initial (Tamb)</th>
<th>Amb Temp Final (Tamb)</th>
<th>Actual Vacuum</th>
</tr>
</thead>
<tbody>
<tr>
<td>18.5</td>
<td>0.34</td>
<td>607.140</td>
<td>612.801</td>
<td>73°F</td>
<td>73°F</td>
<td>FO 40</td>
<td>68°F</td>
<td>68°F</td>
<td>24</td>
</tr>
<tr>
<td>12.5</td>
<td>0.71</td>
<td>612.900</td>
<td>618.490</td>
<td>72°F</td>
<td>72°F</td>
<td>FO 48</td>
<td>68°F</td>
<td>68°F</td>
<td>22</td>
</tr>
<tr>
<td>5.5</td>
<td>1.20</td>
<td>618.800</td>
<td>624.231</td>
<td>72°F</td>
<td>72°F</td>
<td>FO 55</td>
<td>68°F</td>
<td>68°F</td>
<td>21</td>
</tr>
<tr>
<td>7.5</td>
<td>1.95</td>
<td>624.340</td>
<td>630.014</td>
<td>72°F</td>
<td>72°F</td>
<td>FO 63</td>
<td>68°F</td>
<td>68°F</td>
<td>19</td>
</tr>
<tr>
<td>5.5</td>
<td>3.60</td>
<td>630.160</td>
<td>635.817</td>
<td>72°F</td>
<td>72°F</td>
<td>FO 73</td>
<td>68°F</td>
<td>68°F</td>
<td>17</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standardized Data</th>
<th>Critical Orifice</th>
<th>Calibration Factor</th>
<th>Dry Gas Meter</th>
<th>Flowsrate</th>
<th>0.75 SCFM</th>
<th>Variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>(V&lt;sub&gt;meas&lt;/sub&gt;)</td>
<td>(Q&lt;sub&gt;meas&lt;/sub&gt;)</td>
<td>(V&lt;sub&gt;crit&lt;/sub&gt;)</td>
<td>(Q&lt;sub&gt;crit&lt;/sub&gt;)</td>
<td>(Y)</td>
<td>Variation</td>
<td>Std &amp; Cor</td>
</tr>
<tr>
<td>cubic feet</td>
<td>cfm</td>
<td>cubic feet</td>
<td>cfm</td>
<td></td>
<td></td>
<td>(Y)</td>
</tr>
<tr>
<td>5.590</td>
<td>0.302</td>
<td>5.727</td>
<td>0.310</td>
<td>1.024</td>
<td>0.004</td>
<td>0.310</td>
</tr>
<tr>
<td>5.595</td>
<td>0.443</td>
<td>5.646</td>
<td>0.452</td>
<td>1.020</td>
<td>0.001</td>
<td>0.452</td>
</tr>
<tr>
<td>5.593</td>
<td>0.585</td>
<td>5.658</td>
<td>0.596</td>
<td>1.019</td>
<td>-0.002</td>
<td>0.596</td>
</tr>
<tr>
<td>5.595</td>
<td>0.751</td>
<td>5.745</td>
<td>0.768</td>
<td>1.019</td>
<td>-0.001</td>
<td>0.768</td>
</tr>
<tr>
<td>5.652</td>
<td>1.028</td>
<td>5.757</td>
<td>1.049</td>
<td>1.020</td>
<td>0.000</td>
<td>1.049</td>
</tr>
</tbody>
</table>

The flowsrate is in cfm, the variation is in %, (AH@) is in in Hg, and the variation is in %.

**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 S, 16.2.3

Signature [Signature]

Date 2-01-10
### APEX INSTRUMENTS METHOD 5 PRE-TEST CONSOLE CALIBRATION
### USING CALIBRATED CRITICAL ORIFICES
#### 5-POINT ENGLISH UNITS

<table>
<thead>
<tr>
<th>Meter Console Information</th>
<th>Calibration Conditions</th>
<th>Factors/Conversions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Console Model Number</td>
<td>Date</td>
<td>Std Temp</td>
</tr>
<tr>
<td></td>
<td>Time</td>
<td>528</td>
</tr>
<tr>
<td>Console Serial Number</td>
<td>01/28/10</td>
<td>°R</td>
</tr>
<tr>
<td>DGIM Model Number</td>
<td>Barometric Pressure</td>
<td>Std Press</td>
</tr>
<tr>
<td></td>
<td>29.60</td>
<td>26.02</td>
</tr>
<tr>
<td>DGIM Serial Number</td>
<td>Theoretical Critical Vacuum</td>
<td>13.97</td>
</tr>
<tr>
<td></td>
<td>Calibration Technician</td>
<td>K_v</td>
</tr>
</tbody>
</table>

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

*The Critical Orifice Coefficient, K_v, must be entered in English units, (ft^3)(in.Hg)/(min)(sec)*

<table>
<thead>
<tr>
<th>Run Time</th>
<th>DGM Orifice</th>
<th>Volume Initial</th>
<th>Volume Final</th>
<th>Outlet Temp Initial</th>
<th>Outlet Temp Final</th>
<th>Serial Number</th>
<th>Coefficient</th>
<th>Outflow Temp Initial</th>
<th>Ambient Temp Initial</th>
<th>Actual Vacuum</th>
</tr>
</thead>
<tbody>
<tr>
<td>18.0</td>
<td>0.25</td>
<td>301,230</td>
<td>307,074</td>
<td>71</td>
<td>72</td>
<td>FO 40</td>
<td>0.2387</td>
<td>66</td>
<td>66</td>
<td>23</td>
</tr>
<tr>
<td>11.5</td>
<td>0.98</td>
<td>307,200</td>
<td>312,659</td>
<td>72</td>
<td>73</td>
<td>FO 48</td>
<td>0.3483</td>
<td>66</td>
<td>66</td>
<td>22</td>
</tr>
<tr>
<td>9.5</td>
<td>1.00</td>
<td>313,040</td>
<td>319,004</td>
<td>73</td>
<td>73</td>
<td>FO 55</td>
<td>0.4592</td>
<td>66</td>
<td>66</td>
<td>20</td>
</tr>
<tr>
<td>7.6</td>
<td>1.00</td>
<td>319,310</td>
<td>325,360</td>
<td>73</td>
<td>73</td>
<td>FO 60</td>
<td>0.5907</td>
<td>66</td>
<td>66</td>
<td>18</td>
</tr>
<tr>
<td>5.5</td>
<td>1.35</td>
<td>325,700</td>
<td>331,795</td>
<td>73</td>
<td>74</td>
<td>FO 73</td>
<td>0.6086</td>
<td>66</td>
<td>66</td>
<td>16</td>
</tr>
</tbody>
</table>

#### Results

<table>
<thead>
<tr>
<th>Standardized Data</th>
<th>Critical Orifice</th>
<th>Calibration Factor</th>
<th>Dry Gas Meter</th>
<th>Flowrate</th>
<th>AH (°R)</th>
<th>Variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>(V_{w,es})</td>
<td>(Q_{w,es})</td>
<td>(V_{w,es})</td>
<td>(Q_{w,es})</td>
<td>(%)</td>
<td>(%)</td>
<td>(°R)</td>
</tr>
<tr>
<td>cubic feet</td>
<td>cfm</td>
<td>cubic feet</td>
<td>cfm</td>
<td></td>
<td></td>
<td>cm</td>
</tr>
<tr>
<td>5.747</td>
<td>0.319</td>
<td>5.545</td>
<td>0.308</td>
<td>0.9049</td>
<td>0.005</td>
<td>0.308</td>
</tr>
<tr>
<td>6.350</td>
<td>0.496</td>
<td>5.170</td>
<td>0.480</td>
<td>0.9646</td>
<td>0.004</td>
<td>0.450</td>
</tr>
<tr>
<td>6.859</td>
<td>0.617</td>
<td>6.630</td>
<td>0.693</td>
<td>0.9809</td>
<td>0.001</td>
<td>0.593</td>
</tr>
<tr>
<td>5.979</td>
<td>0.797</td>
<td>5.718</td>
<td>0.762</td>
<td>0.9563</td>
<td>-0.004</td>
<td>0.762</td>
</tr>
<tr>
<td>6.014</td>
<td>1.094</td>
<td>5.739</td>
<td>1.043</td>
<td>0.9542</td>
<td>-0.005</td>
<td>1.043</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.9802</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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: [Signature]

Date: 1-28-10
APEX INSTRUMENTS METHOD 5 POST-TEST CONSOLE CALIBRATION
USING CALIBRATED CRITICAL ORIFICES
3-POINT ENGLISH UNITS

<table>
<thead>
<tr>
<th>Meter Console Information</th>
<th>Calibration Conditions</th>
<th>Factors/Conversions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Console Model Number</td>
<td>522</td>
<td>Std Temp 528</td>
</tr>
<tr>
<td>Console Serial Number</td>
<td>802012</td>
<td>°R</td>
</tr>
<tr>
<td>DGM Model Number</td>
<td>RW 110</td>
<td>Std Press 29.92</td>
</tr>
<tr>
<td>DGM Serial Number</td>
<td>964447</td>
<td>in Hg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kk 17.647</td>
</tr>
<tr>
<td></td>
<td></td>
<td>cFmin Hg</td>
</tr>
<tr>
<td>Calibration Technician</td>
<td>DLS</td>
<td></td>
</tr>
</tbody>
</table>

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

2The Critical Orifice Coefficient, Kk, must be entered in English units, (in^4/ft^2)/(in Hg)(min).

<table>
<thead>
<tr>
<th>Run Time</th>
<th>DGM Orifice</th>
<th>Volume</th>
<th>Outlet Temp</th>
<th>Serial Number</th>
<th>Coefficient</th>
<th>Ambient Temp</th>
<th>Actual Vacuum</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.0</td>
<td>0.98</td>
<td>808.800</td>
<td>815.543</td>
<td>FO 55</td>
<td>0.4592</td>
<td>68</td>
<td>68</td>
</tr>
<tr>
<td>9.0</td>
<td>0.98</td>
<td>815.543</td>
<td>821.300</td>
<td>FO 55</td>
<td>0.4592</td>
<td>68</td>
<td>68</td>
</tr>
<tr>
<td>9.0</td>
<td>0.98</td>
<td>821.300</td>
<td>827.081</td>
<td>FO 55</td>
<td>0.4592</td>
<td>68</td>
<td>68</td>
</tr>
</tbody>
</table>

Results

<table>
<thead>
<tr>
<th>Dry Gas Meter</th>
<th>Critical Orifice</th>
<th>Calibration Factor</th>
<th>Dry Gas Meter</th>
<th>Flowrate</th>
<th>DH (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(V_{obs})</td>
<td>(V_{corr})</td>
<td>(V_{corr})</td>
<td>(Q_{corr})</td>
<td>(Q_{corr})</td>
<td>(Q_{corr})</td>
</tr>
<tr>
<td>cFmin</td>
<td>cFmin</td>
<td>cFmin</td>
<td>cFmin</td>
<td>cFmin</td>
<td>cFmin</td>
</tr>
<tr>
<td>5.650</td>
<td>0.628</td>
<td>5.342</td>
<td>0.594</td>
<td>0.945</td>
<td>0.001</td>
</tr>
<tr>
<td>0.026</td>
<td>5.342</td>
<td>0.594</td>
<td>0.944</td>
<td>-0.001</td>
<td>0.594</td>
</tr>
<tr>
<td>5.658</td>
<td>0.026</td>
<td>5.342</td>
<td>0.594</td>
<td>0.944</td>
<td>0.000</td>
</tr>
<tr>
<td>Pretest Gamma</td>
<td>0.026</td>
<td>5.342</td>
<td>0.594</td>
<td>0.945</td>
<td>1.543</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Console Model Number</th>
<th>522</th>
</tr>
</thead>
<tbody>
<tr>
<td>Console Serial Number</td>
<td>902033</td>
</tr>
<tr>
<td>DGM Model Number</td>
<td>RW 110</td>
</tr>
<tr>
<td>DGM Serial Number</td>
<td>328693</td>
</tr>
<tr>
<td>Calibration Technician</td>
<td>DLS</td>
</tr>
</tbody>
</table>

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, \( \text{ft}^3 \text{psi}^{-1} \text{sec} \text{ft}^{-1} \text{in.} \text{Hg}^{-1} \text{min} \).

### Calibration Data

<table>
<thead>
<tr>
<th>Run Time</th>
<th>DGM Orifice</th>
<th>Volume Initial</th>
<th>Volume Final</th>
<th>Outlet Temp Initial</th>
<th>Outlet Temp Final</th>
<th>Serial Number</th>
<th>Coefficient</th>
<th>Ambient Temp Initial</th>
<th>Ambient Temp Final</th>
<th>Actual Vacuum</th>
</tr>
</thead>
<tbody>
<tr>
<td>(min)</td>
<td>(HA)</td>
<td>(V(I))</td>
<td>(V(F))</td>
<td>(T(I))</td>
<td>(T(F))</td>
<td></td>
<td>K'</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17.5</td>
<td>0.34</td>
<td>366.370</td>
<td>401.727</td>
<td>69</td>
<td>70</td>
<td>FO 40</td>
<td>0.2387</td>
<td>64</td>
<td>64</td>
<td>24.00</td>
</tr>
<tr>
<td>17.5</td>
<td>0.34</td>
<td>401.727</td>
<td>407.078</td>
<td>70</td>
<td>69</td>
<td>FO 40</td>
<td>0.2387</td>
<td>64</td>
<td>64</td>
<td>24.00</td>
</tr>
<tr>
<td>17.5</td>
<td>0.34</td>
<td>407.078</td>
<td>412.435</td>
<td>69</td>
<td>69</td>
<td>FO 40</td>
<td>0.2387</td>
<td>64</td>
<td>64</td>
<td>24.00</td>
</tr>
</tbody>
</table>

### Results

| Standardized Data | Critical Orifice | Calibration Factor | Average Flowrate | Change in Vacuum | Average
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{N}_{\text{actual}} )</td>
<td>( \text{Q}_{\text{actual}} )</td>
<td>( \text{N}_{\text{calibrated}} )</td>
<td>(Y)</td>
<td>(AY)</td>
<td>(\text{Q}_{\text{calibrated}})</td>
</tr>
<tr>
<td>\text{cubic feet}</td>
<td>\text{cubic feet}</td>
<td>\text{cubic feet}</td>
<td>\text{cm}</td>
<td>\text{cm}</td>
<td>\text{cubic feet}</td>
</tr>
<tr>
<td>5.361</td>
<td>0.306</td>
<td>5.475</td>
<td>0.313</td>
<td>1.021</td>
<td>0.000</td>
</tr>
<tr>
<td>5.355</td>
<td>0.306</td>
<td>5.475</td>
<td>0.313</td>
<td>1.022</td>
<td>0.001</td>
</tr>
<tr>
<td>5.366</td>
<td>0.307</td>
<td>5.475</td>
<td>0.313</td>
<td>1.020</td>
<td>-0.001</td>
</tr>
<tr>
<td>Pretest Gamma</td>
<td>1.0206</td>
<td>% Deviation</td>
<td>0.1</td>
<td>1.021</td>
<td>Y Average</td>
</tr>
</tbody>
</table>

### Note:
For Calibration Factor Y, the ratio of the reading of the calibration meter to the dry gas meter, accounted 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: [Signature]

Date: 12-02-10
VOLUME IV

Appendix D – Analytical Data
### Silica 1.44 Aerodynamic or 1.0 Nominal

<table>
<thead>
<tr>
<th>Date</th>
<th>Test Run</th>
<th>No Nozzle</th>
<th>Greater Than 2.5 Rinse</th>
<th>Less Than 2.5 Rinse</th>
<th>Filter Less Than 2.5</th>
<th>Run Cut Size, microns</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/28/2010</td>
<td></td>
<td>Probe Only</td>
<td></td>
<td></td>
<td></td>
<td>2.26</td>
</tr>
<tr>
<td>Final Wt.</td>
<td>3.5494</td>
<td>3.7292</td>
<td>4.0843</td>
<td>0.1299</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial Wt.</td>
<td>3.5358</td>
<td>3.7257</td>
<td>4.0812</td>
<td>0.1131</td>
<td></td>
<td>37.0</td>
</tr>
<tr>
<td>% of Total</td>
<td>37%</td>
<td>9%</td>
<td>8%</td>
<td>45%</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>

**For 1 micron spheres**
- Aerodynamic Diameter: 1.44
- Greater Than %: 46%
- Less Than %: 54%

### Silica 1.44 Aerodynamic or 1.0 Nominal

<table>
<thead>
<tr>
<th>Date</th>
<th>Test Run</th>
<th>Probe &amp; Nozzle Rinse</th>
<th>Front 1/2 Cyclone Greater Than 2.5 Rinse</th>
<th>Back 1/2 Cyclone Front 1/2 Filter Holder Less Than 2.5 Rinse</th>
<th>Filter Less Than 2.5</th>
<th>Run Cut Size, microns</th>
</tr>
</thead>
<tbody>
<tr>
<td>12/1/2010</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.57</td>
</tr>
<tr>
<td>Bag #</td>
<td>134</td>
<td>N/A</td>
<td>A12</td>
<td>Q238</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final Wt.</td>
<td>3.8676</td>
<td>3.5011</td>
<td>3.5382</td>
<td>0.1189</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial Wt.</td>
<td>3.8625</td>
<td>3.4926</td>
<td>3.5374</td>
<td>0.1106</td>
<td></td>
<td>22.7</td>
</tr>
<tr>
<td>% of Total</td>
<td>22%</td>
<td>37%</td>
<td>4%</td>
<td>37%</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>

**For 1 micron spheres**
- Aerodynamic Diameter: 1.44
- Greater Than %: 60%
- Less Than %: 40%

### Silica 2.2 Aerodynamic or 1.5 Nominal

<table>
<thead>
<tr>
<th>Date</th>
<th>Test Run</th>
<th>Nozzle Rinse</th>
<th>Probe Front 1/2 Cyclone Greater Than 2.5 Rinse</th>
<th>Back 1/2 Cyclone Front 1/2 Filter Holder Less Than 2.5 Rinse</th>
<th>Filter Less Than 2.5</th>
<th>Run Cut Size, microns</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/30/2010</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.59</td>
</tr>
<tr>
<td>Bag #</td>
<td>160</td>
<td>A38</td>
<td>N/A</td>
<td>Q237</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final Wt.</td>
<td>3.6629</td>
<td>3.3944</td>
<td>3.7736</td>
<td>0.117</td>
<td></td>
<td></td>
</tr>
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<td>58%</td>
<td>19%</td>
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<td>100%</td>
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O-ring was broken, tried to remove pieces from rinse, may be heavy.

**For 1.5 micron spheres**
- Aerodynamic Diameter: 2.16
- Greater Than %: 74%
- Less Than %: 26%
### Polymer 2.2 Aerodynamic or 2.1 Nominal RUN # 2

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<th>Cyclone Greater Than 2.5 Rinse</th>
<th>Back 1/2</th>
<th>Cyclone Front 1/2 Filter Less Than 2.5 Rinse</th>
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<th>Run Cut Size, microns</th>
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For 3.0 micron spheres
Aerodynamic Diameter: 2.18
Greater Than %: 96%
Less Than %: 4%

### 12/1/2010 Test Run

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For 3.0 micron spheres
Aerodynamic Diameter: 2.18
Greater Than %: 98%
Less Than %: 2%

### Red Oxide 1.7 Aerodynamic or 0.8 Nominal

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For 1.5 micron spheres
Aerodynamic Diameter: 1.70
Greater Than %: 73%
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

Sample 2B, 1.44 Micron Silica Microspheres
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)

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% of Aerosol Anticipated in PM2.5 Fraction: 0.33
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OTM-036

Page 370 of 643

4/11/2016
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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:
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October 15, 2012
TABLE OF CONTENTS

1. PROJECT PURPOSE AND BACKGROUND 1
   1.1 Limitations of Available Test Methods for Filterable PM$_{2.5}$ 1
   1.2 Purpose 1
   1.3 Description of the API Wet Stack Filterable PM$_{2.5}$ Sampling System 2
   1.4 API Test Method Performance Criteria 7
   1.5 EPA Review Comments and Data Requirements 10

2. TEST APPARATUS 11
   2.1 Method 301 Testing Requirements 11
   2.2 Validation Testing Apparatus 11

3. METHOD 301 BIAS AND PRECISION TESTS 13
   3.1 Bias Measurements 13
   3.2 Precision 16
   3.3 PM$_{2.5}$ Losses in the Nozzle and Probe 16
   3.4 Nozzle Droplet Performance 17

4. TEST METHODS 18
   4.1 Flue Gas Velocity and Volumetric Flow Rate Using EPA Method 2 18
   4.2 Flue Gas Moisture Content Using EPA Method 4 18
   4.3 Flue Gas Composition and Molecular Weight 18
   4.4 Filterable PM$_{2.5}$ Using the API Wet Stack Sampling Method 18

5. QUALITY ASSURANCE AND QUALITY CONTROL 20
   5.1 Analyte Spiking 20
   5.2 Emission Testing Equipment 20

6. PROGRAM SCHEDULE AND MANAGEMENT 22
   6.1 Test Program Schedule 22
   6.2 Test Program Management 226
TABLES

Table 3-1 Bias and Precision Test Matrix 14
Table 6-1 Proposed Project Schedule 22

FIGURES

Figure 1-1 API Wet Stack PM$_{2.5}$ Sampling System 3
Figure 1-2 Heated Filter Box with Cyclone and PM$_{2.5}$ Filter 3
Figure 1-3 Precutter Nozzle 4
Figure 1-4 Collection Efficiency of EPA-S.R.I. Cyclone IV and
API PM$_{2.5}$ Cyclone 6
Figure 1-5 Required Sample Flow Rate for the PM$_{2.5}$ Cyclone in the
API PM$_{2.5}$ Sampling System 7
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.

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 micro-meter-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.

---

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<sub>2.5</sub> Cyclone**—The PM<sub>2.5</sub> cyclone used in the API sampling train is identical to the PM<sub>2.5</sub> 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.
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.
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 $320^\circ F \pm 25^\circ F$ 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 scattering 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 5 for each of the quad sampling trains.
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</table>
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.

\[ d_i = \left( \frac{S_{1i} + S_{2i}}{2} \right) - \left( \frac{M_{1i} + M_{2i}}{2} \right) - CS \]  

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.

\[ SD_d = \sqrt{\frac{\sum_{i=1}^{n} (d_i - d_m)^2}{n - 1}} \]  

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).

\[ t = \frac{|d_m|}{SD_d \sqrt{n}} \]  

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.

\[
B_R = \frac{|B|}{|CS|} \times 100
\]

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.

\[
RSD = \left( \frac{SD_d}{S_M} \right) \times 100
\]

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\textsubscript{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\textsubscript{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.

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<td>November 15, 2011</td>
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<tr>
<td></td>
<td>Submit revised protocol based on tests at MDF Plant</td>
<td>October 15, 2012</td>
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<td>October 25, 2012</td>
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<tr>
<td>4</td>
<td>Complete laboratory analysis</td>
<td>November 15, 2012</td>
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<td>5</td>
<td>Submit final report</td>
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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
# TABLE OF CONTENTS

## 1. SUMMARY
- 1.1 Purpose and Scope ........................................... 1
- 1.2 Conclusions .................................................. 1
- 1.3 Test Program Participants ................................... 2

## 2. API SAMPLING SYSTEM DESIGN CHARACTERISTICS
- 2.1 Performance Criteria .......................................... 3
- 2.2 Basis of the Method ........................................... 5
- 2.3 Sampling Train ................................................ 7

## 3. METHOD 301 VALIDATION TESTS
- 3.1 Sampling Locations ........................................... 15
- 3.2 Method 301 Sampling Train ................................ 17
- 3.3 Method 301 Test Procedures ................................. 20
- 3.4 Method 301 Test Data ........................................ 20
- 3.5 Bias and Precision Calculations ............................. 26

## 4. REFERENCES ..................................................... 30

### FIGURES

- Figure 2-1. WS2.5 Wet Stack Filterable PM$_2.5$ Sampling Train ........ 8
- Figure 2-2. Heated Filter Box with Cyclone and PM$_{2.5}$ Filter ........ 9
- Figure 2-3. Precutter Nozzle ..................................... 10
- Figure 2-4. Precutter Method 201A Nozzles ....................... 11
- Figure 2-5. Nozzle Droplet Capture Efficiency ..................... 12
- Figure 2-6. Collection Efficiency of EPA-S.R.I. Cyclone IV and WS2.5 PM$_{2.5}$ Cyclone ........ 13
- Figure 2-7. Required Minimum and Maximum Sample Flow Rates for the PM$_{2.5}$ Cyclone in the WS2.5 Sampling System ........ 14
- Figure 3-1. Sampling Port Internal Diameter ....................... 15
- Figure 3-2. Sampling Platform .................................... 16
- Figure 3-3. Dual Sampling Train with Two Sets of Method 4 Impingers .... 16
- Figure 3-4. Dual Sampling Train During Method 301 Validation Tests .... 17
- Figure 3-5. Dual PM$_{2.5}$ Cyclone/Filter Assemblies in Dual Train Hot Box ... 18
- Figure 3-6. Dual Sampling Train with Two Method 4 Trains .......... 18
- Figure 3-7. Crack in Filter S2-5 ................................ 24
- Figure 3-8. Crack in Filter S2-6 ................................ 24
- Figure 3-9. Correlation of the Unspiked Sampling Trains ............. 28
TABLES

Table 2-1. Particle Sizes Formed During Droplet Evaporation 7
Table 3-1. Bias and Precision Test Matrix 21
Table 3-2. Moisture Concentration 22
Table 3-3. PM$_{2.5}$ Sampling Conditions 22
Table 3-4. Quad Train Sampling Data 23
Table 3-5. Sodium Chloride Spike Quantities 25
Table 3-6. Alternative 1, Runs 1 Through 4 27
Table 3-7. Alternative 2, Runs 1 Through 6 (5S-2 and 6S-2 Excluded) 27
Table 3-8. Precision Calculations 28
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 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.

---

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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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.

$^2$ 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 exceed 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 $8.2 \times 10^{-12}$ grams) during evaporation.

<table>
<thead>
<tr>
<th>Droplet Size, $\mu$m</th>
<th>Weight of Droplet, grams</th>
<th>0.1</th>
<th>0.2</th>
<th>0.5</th>
<th>1</th>
<th>1.5</th>
<th>2</th>
<th>5</th>
<th>10</th>
</tr>
</thead>
<tbody>
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<tr>
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<td>5.2E-13</td>
<td>1.0E-12</td>
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</tr>
<tr>
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<td>1.8E-12</td>
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<td>8.8E-12</td>
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<tr>
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<td>4.2E-12</td>
<td>8.4E-12</td>
<td>2.1E-11</td>
<td>4.2E-11</td>
<td>6.3E-11</td>
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<td>2.1E-10</td>
<td>4.2E-10</td>
</tr>
<tr>
<td>25</td>
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<td>8.2E-12</td>
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<td>1.3E-09</td>
<td>3.3E-09</td>
<td>6.5E-09</td>
</tr>
</tbody>
</table>

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](image-url)
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

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.

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 2-3. Precutter Nozzle
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\textsubscript{2.5} emissions to the extent that large droplets evaporate and shatter to form PM\textsubscript{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.
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.

![Dual Sampling Train During Method 301 Validation Tests](image)

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 320°F ± 25°F. The cyclones are shown in Figure 3-5.
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 $\geq 80\%$ and $\leq 120\%$
- 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 $\leq 2.5$ 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 $\leq 2.5$ 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 $\leq 2.5$ 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>
<thead>
<tr>
<th>Run</th>
<th>Method</th>
<th>Sampling Train</th>
<th>Spiking Condition</th>
<th>Run Duration</th>
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<td>1</td>
<td>WS2.5</td>
<td>1</td>
<td>Spiked</td>
<td>120</td>
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<tr>
<td></td>
<td>WS2.5</td>
<td>2</td>
<td>Spiked</td>
<td>120</td>
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<td>120</td>
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Table 3-2. Moisture Concentrations

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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

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<th>Train</th>
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<th>Isokinetics %</th>
<th>Train</th>
<th>Cut Size, Micrometers</th>
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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

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<th>Cyclone Inlet and Probe (&gt;2.5)</th>
<th>Cyclone Outlet (≤2.5)</th>
<th>Total Filter (≤2.5)</th>
<th>Total, PM$_{2.5}$</th>
<th>Total Catch, PM$_{2.5}$</th>
<th>Catch Weights, Milligrams (Acetone and water rinse catch weights combined)</th>
<th>Volume Sampled, DSCF</th>
<th>Concentrations, PM$_{2.5}$, gr/DSCF</th>
<th>Total PM, gr/DSCF</th>
<th>PM$_{2.5}$ Fraction %</th>
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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>
<thead>
<tr>
<th>Run</th>
<th>Total Sodium and Chloride, gr/DSCF</th>
<th>Average of Total Sodium and Chloride, gr/DSCF</th>
<th>Sodium Chloride Spike Quantity, gr/DSCF</th>
<th>Average Sodium Chloride Spike Quantity, gr/DSCF</th>
</tr>
</thead>
<tbody>
<tr>
<td>U1-1</td>
<td>0.00320</td>
<td>0.00312</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>U2-1</td>
<td>0.00305</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>S1-1</td>
<td>0.02048</td>
<td>N/A</td>
<td>0.0174</td>
<td>N/A</td>
</tr>
<tr>
<td>S2-1</td>
<td>0.02226</td>
<td>N/A</td>
<td>0.0191</td>
<td>0.0182</td>
</tr>
<tr>
<td>U1-2</td>
<td>0.00186</td>
<td>0.00176</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>U2-2</td>
<td>0.00165</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>S1-2</td>
<td>0.02766</td>
<td>N/A</td>
<td>0.0259</td>
<td>0.0229</td>
</tr>
<tr>
<td>S2-2</td>
<td>0.02155</td>
<td>N/A</td>
<td>0.0198</td>
<td>N/A</td>
</tr>
<tr>
<td>U1-3</td>
<td>0.00191</td>
<td>0.00192</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>U2-3</td>
<td>0.00193</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>S1-3</td>
<td>0.01257</td>
<td>N/A</td>
<td>0.0106</td>
<td>0.0083</td>
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<tr>
<td>S2-3</td>
<td>0.00784</td>
<td>N/A</td>
<td>0.0059</td>
<td>N/A</td>
</tr>
<tr>
<td>U1-4</td>
<td>0.00318</td>
<td>0.00287</td>
<td>N/A</td>
<td>N/A</td>
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<td>U2-4</td>
<td>0.00255</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<td>S1-4</td>
<td>0.00502</td>
<td>N/A</td>
<td>0.0021</td>
<td>0.0023</td>
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<td>S2-4</td>
<td>0.00536</td>
<td>N/A</td>
<td>0.0025</td>
<td>N/A</td>
</tr>
<tr>
<td>U1-5</td>
<td>0.00292</td>
<td>0.00279</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>U2-5</td>
<td>0.00267</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>S1-5</td>
<td>0.03040</td>
<td>N/A</td>
<td>0.0276</td>
<td>0.0163</td>
</tr>
<tr>
<td>S2-5</td>
<td>0.00769</td>
<td>N/A</td>
<td>0.0049</td>
<td>N/A</td>
</tr>
<tr>
<td>U1-6</td>
<td>0.00392</td>
<td>0.00384</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>U2-6</td>
<td>0.00376</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>S1-6</td>
<td>0.00717</td>
<td>N/A</td>
<td>0.0033</td>
<td>0.0003</td>
</tr>
<tr>
<td>S2-6</td>
<td>0.00118</td>
<td>N/A</td>
<td>-0.0027</td>
<td>N/A</td>
</tr>
</tbody>
</table>
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.

\[ d_i = \left( \frac{S_{1i} + S_{2i}}{2} \right) - \left( \frac{M_{1i} + M_{2i}}{2} \right) - CS \]

Equation 301-13

Where:
- \( d_i \) = Bias during run i
- \( S_{1i} \) = First measured value of the \( i \)th spiked sample (total PM
- \( S_{2i} \) = Second measured value of the \( i \)th spiked sample (total PM
- \( M_{1i} \) = First measured value of the \( i \)th unspiked sample (total PM
- \( M_{2i} \) = Second measured value of the \( i \)th unspiked sample (total PM
- \( CS \) = Analyte spike value (sodium chloride PM 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.

\[ SD_d = \sqrt{\frac{\sum_{i=1}^{n} (d_i - d_m)^2}{n - 1}} \]

Equation 301-2

Where:
- \( SD_d \) = The standard deviation of the differences, gr/DSCF
- \( d_i \) = 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 was calculated from the means of the paired sample differences, the standard deviation of the differences, and the number of paired samples (6).

\[ t = \frac{|d_m|}{\frac{SD_d}{\sqrt{n}}} \]

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>
<thead>
<tr>
<th>di</th>
<th>dm</th>
<th>(di-dm)²</th>
<th>SD</th>
<th>t_stat</th>
<th>Degrees of Freedom</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.00403</td>
<td>-0.00209</td>
<td>3.77 x 10⁻⁶</td>
<td>0.00188</td>
<td>-2.22</td>
<td>3</td>
</tr>
<tr>
<td>-0.00325</td>
<td>-0.00209</td>
<td>1.35 x 10⁻⁶</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-0.00113</td>
<td>-0.00209</td>
<td>9.22 x 10⁻⁷</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.000055</td>
<td>-0.00209</td>
<td>4.59 x 10⁻⁶</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-0.00323</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.00049</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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.
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>
<thead>
<tr>
<th>Alternative</th>
<th>SM</th>
<th>RSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0236</td>
<td>7.97</td>
</tr>
<tr>
<td>2</td>
<td>0.0241</td>
<td>7.92</td>
</tr>
</tbody>
</table>

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


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.

APPENDIX A

TEST RESULTS - DETAILED
### Sampling Location: East Scrubber Stack

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>NOMENCLATURE</th>
<th>U1-1</th>
<th>U1-2</th>
<th>U1-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td></td>
<td>10/23/2012</td>
<td>10/24/2012</td>
<td>10/24/2012</td>
</tr>
<tr>
<td>Run Time</td>
<td>Theta</td>
<td>117.64</td>
<td>81.96</td>
<td>93.17</td>
</tr>
<tr>
<td>Nozzle Diameter</td>
<td>inches</td>
<td>0.216</td>
<td>0.216</td>
<td>0.233</td>
</tr>
<tr>
<td>Pitot Tube Coefficient</td>
<td>Cp</td>
<td>0.84</td>
<td>0.84</td>
<td>0.84</td>
</tr>
<tr>
<td>Meter Calibration Factor</td>
<td>Y</td>
<td>0.9762</td>
<td>0.9762</td>
<td>0.9762</td>
</tr>
<tr>
<td>Barometric Pressure, inches Hg</td>
<td>Bp - in Hg</td>
<td>30.20</td>
<td>29.80</td>
<td>29.80</td>
</tr>
<tr>
<td>Meter Box Pressure Differential</td>
<td>ΔH - in. H2O</td>
<td>0.35</td>
<td>0.36</td>
<td>0.38</td>
</tr>
<tr>
<td>Volume of Gas Sampled</td>
<td>Vm - cu. ft.</td>
<td>37.135</td>
<td>26.062</td>
<td>30.418</td>
</tr>
<tr>
<td>Dry Gas Meter Temperature</td>
<td>Tm - °F</td>
<td>74.9</td>
<td>60.0</td>
<td>77.0</td>
</tr>
<tr>
<td>Volume of Gas Sampled, Dry</td>
<td>Vmstd - cu. ft.</td>
<td>36.148</td>
<td>25.752</td>
<td>29.107</td>
</tr>
<tr>
<td>Liquid Collected</td>
<td>ml</td>
<td>188.4</td>
<td>125.2</td>
<td>146.1</td>
</tr>
<tr>
<td>Volume of Water Vapor</td>
<td>Vwstd - cu. ft.</td>
<td>8.868</td>
<td>5.893</td>
<td>6.877</td>
</tr>
<tr>
<td>Moisture Content</td>
<td>%H₂O</td>
<td>19.700</td>
<td>18.62</td>
<td>19.11</td>
</tr>
<tr>
<td>Saturation Moisture</td>
<td>%H₂O</td>
<td>16.6</td>
<td>15.9</td>
<td>15.9</td>
</tr>
<tr>
<td>Dry Mole Fraction, In Cyclone</td>
<td>Mfd - C</td>
<td>0.803</td>
<td>0.814</td>
<td>0.809</td>
</tr>
<tr>
<td>Dry Mole Fraction</td>
<td>Mfd</td>
<td>0.834</td>
<td>0.841</td>
<td>0.841</td>
</tr>
<tr>
<td>Carbon Dioxide</td>
<td>%CO₂</td>
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<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Oxygen</td>
<td>%O₂</td>
<td>21</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>%CO</td>
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<td>0</td>
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<tr>
<td>Nitrogen</td>
<td>%N₂</td>
<td>78</td>
<td>78</td>
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<tr>
<td>Fuel Factor</td>
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<td>-0.100</td>
<td>-0.100</td>
</tr>
<tr>
<td>Gas Molecular Weight, Dry</td>
<td>Md</td>
<td>29.00</td>
<td>29.00</td>
<td>29.00</td>
</tr>
<tr>
<td>Gas Molecular Weight, Wet, In Cyclone</td>
<td>Ms - C</td>
<td>26.83</td>
<td>26.95</td>
<td>26.90</td>
</tr>
<tr>
<td>Gas Molecular Weight, Wet</td>
<td>Ms</td>
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<td>27.25</td>
<td>27.25</td>
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<tr>
<td>Static Pressure</td>
<td>Pg - in. H₂O</td>
<td>-0.08</td>
<td>-0.08</td>
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<td>Stack Pressure</td>
<td>Ps</td>
<td>30.19</td>
<td>29.79</td>
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<tr>
<td>Stack Temperature</td>
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<td>131.9</td>
<td>131.8</td>
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<tr>
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<td>313.7</td>
<td>316.4</td>
<td>319.8</td>
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<td>Average Velocity Head</td>
<td>Δp - in H₂O</td>
<td>0.177</td>
<td>0.147</td>
<td>0.158</td>
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<td>Gas Velocity</td>
<td>vs - ft./sec.</td>
<td>25.74</td>
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<td>24.35</td>
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<tr>
<td>Stack Area</td>
<td>As - sq. ft.</td>
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<td>70.882</td>
<td>70.882</td>
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<tr>
<td>Volumetric Air Flow, Actual</td>
<td>Qaw - ACFM</td>
<td>109,479</td>
<td>100,052</td>
<td>103,558</td>
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<td>Volumetric Air Flow, Standard</td>
<td>Qsd - DSCFM</td>
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<td>74,709</td>
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</tr>
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<td>Isokinetic Sampling Rate</td>
<td>%I</td>
<td>104.54</td>
<td>117.15</td>
<td>96.64</td>
</tr>
<tr>
<td>Total Filterable Particulate Catch</td>
<td>mg</td>
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<td>36.1</td>
<td>34.9</td>
</tr>
<tr>
<td>Greater than 2.5 rinse</td>
<td>mg</td>
<td>28.7</td>
<td>17.3</td>
<td>13.0</td>
</tr>
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<td>2.4</td>
<td>1.0</td>
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<tr>
<td>PM2.5 Catch (Filter)</td>
<td>mg</td>
<td>31.8</td>
<td>16.4</td>
<td>20.9</td>
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### Sampling Location

<table>
<thead>
<tr>
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<th>U1-2</th>
<th>U1-3</th>
<th>Average</th>
</tr>
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<tr>
<td><strong>Total Filterable Particulate Matter Emissions</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grains/DSCF</td>
<td>0.0268</td>
<td>0.0216</td>
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</tr>
<tr>
<td>Pounds/Hour</td>
<td>18.82</td>
<td>13.85</td>
<td>12.27</td>
<td>14.98</td>
</tr>
<tr>
<td><strong>Filterable PM$_{2.5}$ Particulate Matter Emissions</strong></td>
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</tr>
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<td>0.01248</td>
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<td>10.22</td>
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<td>7.70</td>
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</table>

### Cut Sizes

<table>
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<th>Value</th>
<th>Value</th>
<th>Value</th>
<th>Value</th>
</tr>
</thead>
<tbody>
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<td>Gas viscosity, (micropoise)</td>
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<td>228.66</td>
<td>229.16</td>
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<td>0.5702</td>
<td>0.5728</td>
</tr>
<tr>
<td>Reynold number, (dimensionless)</td>
<td>N$_{Re}$</td>
<td>2213.22</td>
<td>2228.06</td>
<td>2219.45</td>
</tr>
<tr>
<td>Cunningham correction factor</td>
<td>C</td>
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<td>1.0894</td>
<td>1.0894</td>
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<tr>
<td>PM$_{2.5}$ cut diameter, (microns)</td>
<td>D$<em>{50 N</em>{Re}&lt;3162}$ - PM$_{2.5}$</td>
<td>2.69</td>
<td>2.65</td>
<td>2.65</td>
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<tr>
<td></td>
<td>D$<em>{50 N</em>{Re}&gt;3162}$ - PM$_{2.5}$</td>
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<td>2.33</td>
<td>2.33</td>
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<tr>
<td>PARAMETER</td>
<td>NOMENCLATURE</td>
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<td>U2-2</td>
<td>U2-3</td>
</tr>
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<td>-----------------------------------------------</td>
<td>--------------</td>
<td>------------</td>
<td>------------</td>
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</tr>
<tr>
<td>Sampling Location</td>
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<td></td>
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<td>10/24/2012</td>
<td>10/24/2012</td>
</tr>
<tr>
<td>Run Time</td>
<td>Theta</td>
<td>117.64</td>
<td>81.96</td>
<td>93.17</td>
</tr>
<tr>
<td>Nozzle Diameter</td>
<td>inches</td>
<td>0.212</td>
<td>0.212</td>
<td>0.232</td>
</tr>
<tr>
<td>Pitot Tube Coefficient</td>
<td>Cp</td>
<td>0.84</td>
<td>0.84</td>
<td>0.84</td>
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<tr>
<td>Meter Calibration Factor</td>
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<td>0.9833</td>
<td>0.9833</td>
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<td>Barometric Pressure, inches Hg</td>
<td>Bp - in Hg</td>
<td>30.20</td>
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<tr>
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<td>ΔH - in. H2O</td>
<td>0.32</td>
<td>0.31</td>
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<tr>
<td>Volume of Gas Sampled</td>
<td>Vm - cu. ft.</td>
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<tr>
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<td>Tm - °F</td>
<td>79.3</td>
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<td>Volume of Gas Sampled, Dry</td>
<td>Vmstd - cu. ft</td>
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<td>Liquid Collected</td>
<td>ml</td>
<td>207.3</td>
<td>126.4</td>
<td>151.4</td>
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<tr>
<td>Volume of Water Vapor</td>
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<td>Carbon Monoxide</td>
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<td>Nitrogen</td>
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<td>Fuel Factor</td>
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<td>Gas Molecular Weight, Wet, In Cyclone</td>
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<td>Gas Molecular Weight, Wet</td>
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<td>Stack Temperature</td>
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<td>0.158</td>
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<td>vs - ft./sec.</td>
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<td>11.1</td>
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<td>mg</td>
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<td><strong>Total Filterable Particulate Matter Emissions</strong></td>
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<td>Grains/DSCF</td>
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<td><strong>Cut Sizes</strong></td>
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<td>Gas viscosity, (micropoise)</td>
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<td>S1-3</td>
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<td>10/23/2012</td>
<td>10/24/2012</td>
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</tr>
<tr>
<td>Run Time</td>
<td>Theta</td>
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<td>Volume of Gas Sampled</td>
<td>Vm - cu. ft.</td>
<td>41.451</td>
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<td>Dry Gas Meter Temperature</td>
<td>Tm - °F</td>
<td>81.3</td>
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<td>Volume of Gas Sampled, Dry</td>
<td>Vmstd - cu. ft.</td>
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<td>Volume of Water Vapor</td>
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<td>Moisture Content</td>
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<td>%H2O</td>
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<td>Mfd - C</td>
<td>0.800</td>
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<td>Carbon Dioxide</td>
<td>%CO2</td>
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<tr>
<td>Oxygen</td>
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<td>Carbon Monoxide</td>
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<td>-0.100</td>
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<td>Gas Molecular Weight, Dry</td>
<td>Md</td>
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<td>Gas Molecular Weight, Wet, In Cyclone</td>
<td>Ms - C</td>
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<td>-0.08</td>
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<tr>
<td>Stack Pressure</td>
<td>Ps</td>
<td>30.19</td>
<td>29.79</td>
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<td>Stack Temperature</td>
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<td>0.158</td>
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<tr>
<td>Gas Velocity</td>
<td>vs - ft./sec.</td>
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<td>Stack Area</td>
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<td>Volumetric Air Flow, Actual</td>
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### Total Filterable Particulate Matter Emissions

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<td>Pounds/Hour lb/hr</td>
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### Filterable PM$_{2.5}$ Particulate Matter Emissions

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<td>Pounds/Hour lb/hr</td>
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### Cut Sizes

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<td>Gas viscosity, (micropoise)</td>
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<td>Run Time</td>
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<td>Nozzle Diameter</td>
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<td>Meter Calibration Factor</td>
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<td>Barometric Pressure, inches Hg</td>
<td>Bp - in Hg</td>
<td>30.20</td>
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<td>Meter Box Pressure Differential</td>
<td>ΔH - in. H2O</td>
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<td>Volume of Gas Sampled</td>
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<td>Volume of Gas Sampled, Dry</td>
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<td>Liquid Collected</td>
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<td>147.1</td>
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<td>Volume of Water Vapor</td>
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<td>8.388</td>
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<td>6.924</td>
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<td>Moisture Content</td>
<td>%H₂O</td>
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<td>18.82</td>
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<td>Saturation Moisture</td>
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<td>18.1</td>
<td>16.3</td>
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<td>1.1</td>
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### Sampling Location: East Scrubber Stack

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<th>Total Filterable Particulate Matter Emissions</th>
<th>S2-1</th>
<th>S2-2</th>
<th>S2-3</th>
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<td>Grains/DSCF (gr/DSCF)</td>
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<td>Pounds/ Hour (lb/hr)</td>
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<th>Filterable PM$_{2.5}$ Particulate Matter Emissions</th>
<th>S2-1</th>
<th>S2-2</th>
<th>S2-3</th>
<th>Average</th>
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<td>Grains/DSCF (gr/DSCF)</td>
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### Cut Sizes

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<th>S2-3</th>
<th>Average</th>
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<td>Gas viscosity, (micropoise)</td>
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<td>Run Time</td>
<td>Theta</td>
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<td>Nozzle Diameter</td>
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<td>0.233</td>
<td>0.233</td>
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<td>Pitot Tube Coefficient</td>
<td>Cp</td>
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<td>0.84</td>
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<td>Carbon Monoxide</td>
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Sampling Location: East Scrubber Stack

OTM-036  Page 446 of 643  4/11/2016
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<td>27.612</td>
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<td>131.6</td>
<td>160.6</td>
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<td>Volume of Water Vapor</td>
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<td>1</td>
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### Sampling Location
East Scrubber Stack

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<th>U2-4</th>
<th>U2-5</th>
<th>U2-6</th>
<th>Average</th>
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<th>U2-5</th>
<th>U2-6</th>
<th>Average</th>
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### Cut Sizes

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<td>Run Time</td>
<td>Theta</td>
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<td>Nozzle Diameter</td>
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<td>Pitot Tube Coefficient</td>
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<td>Meter Calibration Factor</td>
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<td>Barometric Pressure, inches Hg</td>
<td>Bp - in Hg</td>
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<td>Meter Box Pressure Differential</td>
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<td>Volume of Gas Sampled</td>
<td>Vm - cu. ft.</td>
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<tr>
<td>Dry Gas Meter Temperature</td>
<td>Tm - °F</td>
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<tr>
<td>Liquid Collected</td>
<td>ml</td>
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<tr>
<td>Volume of Water Vapor</td>
<td>Vwstd - cu. ft.</td>
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<tr>
<td>Moisture Content</td>
<td>%H₂O</td>
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<td>Saturation Moisture</td>
<td>%H₂O</td>
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<tr>
<td>Dry Mole Fraction, In Cyclone</td>
<td>Mfd - C</td>
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<tr>
<td>Dry Mole Fraction, Final</td>
<td>Mfd</td>
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<tr>
<td>Carbon Dioxide</td>
<td>%CO₂</td>
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<td>Oxygen</td>
<td>%O₂</td>
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<td>Gas Velocity</td>
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<td>Volumetric Air Flow, Standard</td>
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<td>Isokinetic Sampling Rate</td>
<td>%I</td>
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<td>Total Filterable Particulate Catch</td>
<td>mg</td>
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<tr>
<td>Greater than 2.5 rinse</td>
<td>mg</td>
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<tr>
<td>Less than 2.5 rinse</td>
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<td>PM2.5 Catch (Filter)</td>
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### Total Filterable Particulate Matter Emissions

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### Filterable PM$_{2.5}$ Particulate Matter Emissions

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<th>S1-6</th>
<th>Average</th>
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### Cut Sizes

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### Sampling Location

**East Scrubber Stack**

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<td>Gas Velocity</td>
<td>vs - ft./sec.</td>
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<td>Stack Area</td>
<td>As - sq. ft.</td>
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<td>Volumetric Air Flow, Actual</td>
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<td>Qsd - DSCFM</td>
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<tr>
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<td>lb/hr</td>
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<td>S2-6</td>
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<td>PM$_{2.5}$ cut diameter, (microns)</td>
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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)

\[ \begin{align*}
U1-1 & = 0.00320 \text{ gr/DSCF} \\
U2-1 & = 0.00305 \text{ gr/DSCF} \\
S1-1 & = 0.02048 \text{ gr/DSCF} \\
S2-1 & = 0.02226 \text{ gr/DSCF} \\
\end{align*} \]

Average Unspiked Concentration = \( \frac{(0.00320 + 0.00305)}{2} = 0.00312 \text{ gr/DSCF} \)

Sodium and Chloride in Spike

\[ \begin{align*}
S1-1 & = 0.02048 - 0.00312 = 0.0174 \text{ gr/DSCF} \\
S2-1 & = 0.02226 - 0.00312 = 0.0191 \text{ gr/DSCF} \\
CS & = \frac{(0.0174 + 0.0191)}{2} = 0.0182 \text{ gr/DSCF} \\
\end{align*} \]

\[ d_i = \text{Bias during run 1 was calculated using Equation 301-13} \]

\[ d_i = \left( \frac{S_{1i} + S_{2i}}{2} \right) - \left( \frac{M_{1i} + M_{2i}}{2} \right) - CS \]

\[ \text{Equation 301-13} \]

Total \( PM_{2.5} \) (Table 3-4)

\[ \begin{align*}
S_{1i} & = 0.0303 \text{ gr/DSCF, First measured value of the S1-1 spiked sample} \\
S_{2i} & = 0.0273 \text{ gr/DSCF, Second measured value of the S2-1 spiked sample} \\
M_{1i} & = 0.0146 \text{ gr/DSCF, First measured value of the U1-1 unspiked sample} \\
M_{2i} & = 0.0146 \text{ gr/DSCF, Second measured value of the U2-1 unspiked sample} \\
CS & = 0.0182 \text{ gr/DSCF, spike value (sodium chloride PM}_{2.5} \text{ spike quantity)} \\
\end{align*} \]

\[ d_i = \left( \frac{0.0303 + 0.0273}{2} \right) - \left( \frac{0.0146 + 0.0146}{2} \right) - 0.0182 \]

\[ d_i = -0.00403 \]
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.

\[ SD_d = \sqrt{\frac{\sum_{i}^{n} (d_i - d_m)^2}{n - 1}} \]  

Equation 301-2

Where:
- \( SD_d \) = The standard deviation of the differences, milligrams/DNm³
- \( d_i \) = 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)

\[
\begin{align*}
  d_1 &= -0.00403 \\
  d_2 &= -0.00325 \\
  d_3 &= -0.00113 \\
  d_4 &= 0.000055 \\
  d_m &= -0.00209 \\
  (d_1 - d_m)^2 &= 3.77 \times 10^{-6} \\
  (d_2 - d_m)^2 &= 1.35 \times 10^{-6} \\
  (d_3 - d_m)^2 &= 9.22 \times 10^{-7} \\
  (d_4 - d_m)^2 &= 4.59 \times 10^{-6} \\
\end{align*}
\]

\[
\sum_{i}^{n} (d_i - d_m)^2 = (3.77 \times 10^{-6}) + (1.35 \times 10^{-6}) + (9.22 \times 10^{-7}) + (4.59 \times 10^{-6}) = 1.06e-5
\]

\[
SD_d = \sqrt{\frac{1.06e-5}{4-1}} = 0.00188
\]

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).

\[
t = \frac{0.00209}{0.00188} \frac{1}{\sqrt{4}} = -2.22
\]  

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.

\[
\text{RSD} = \left( \frac{SD_d}{S_M} \right) \times 100
\]

\[
S_M = 0.0236
\]

\[
\text{RSD} = \left( \frac{0.00188}{0.0236} \right) \times 100 = 7.97
\]
APPENDIX C

FIELD DATA
### Method 1 - Air Control Techniques, P.C.

#### Diameters

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<thead>
<tr>
<th>Velocity</th>
<th>Up</th>
<th>Down</th>
<th>Particulate</th>
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<td>&gt;7.00</td>
<td>&gt;1.75</td>
<td>12</td>
</tr>
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<td>1.25</td>
<td>20</td>
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<tr>
<td>16</td>
<td>2</td>
<td>0.5</td>
<td>24 or 25</td>
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</table>

Note: If more than 8 and 2 diameters and duct is greater than 12" and less than 24", use 8 or 9 points.

#### Location of Points in Circular Stacks or Ducts

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<th>Location</th>
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<th>Downstream</th>
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#### Location of Points in Rectangular Stacks or Ducts

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**Method 4 - Air Control Techniques, P.C.**

**Source Information**
- Client:  
- Plant Name:  
- City, State:  
- Sampling Location: Scrubber Stack  
- Job #: 1756  
- Process: Pulp/Paper  
- 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 H₂O |  
| 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 H₂O |  
| 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 | 860.1 |  
| 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*V_m*(Pbar+(D H/13.6))/(Tm+460)  
Vwv(std) = volume of water vapor at standard conditions (scf) = 0.04715 * volume of water collected (gms)  
Bws = Mole fraction of water vapor = Vwv(std) / (Vm(std) + Vwv(std))  
Percent Moisture = 100 * Bws
### Combined Cyclone PM10 & PM2.5 Run Data Sheet

#### IDENTIFICATION INFORMATION
- **Plant Name:**
- **City:**
- **State:** North Carolina
- **Source Number:** EAST
- **Sampling Location:** Scrubber Stack
- **Test Personnel:** TTB, JMA
- **Date Started:** 12/2
- **Date Stopped:** 14/10

#### PRELIMINARY CHECKS AND DATA
- **Full Train Pretest Leak Check, ACFM:** 0.004
- **Partial Train Posttest Leak Check, ACFM:** 0.001

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

- **Pitot Tube Pretest Leak Check:** 44
- **Pitot Tube Posttest Leak Check:** 37

- **Barometric Pressure, In., Hg.:** 30.2
- **Static Pressure, In. W.C.:** -0.08

#### ACTUAL MOISTURE & GAS COMPOSITION
- **Water Recovered, grams:** 204
- **CO₂ %:** 1.0
- **O₂ %:** 21.0
- **Moisture, %:** 20.04

#### Sampling Information

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<tr>
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<th>Dwell Time (Min.)</th>
<th>Elapsed Time (h:m:s)</th>
<th>Meter Volume (ft³)</th>
<th>VR (In. H₂O)</th>
<th>Meter Temp. (°F)</th>
<th>Stack Temp. (°F)</th>
<th>Cyclone Temp. (°F)</th>
<th>Impinger Exit Gas Temp. (°F)</th>
<th>Sample Train Vac. (in. Hg)</th>
<th>Probe Temp. (°F)</th>
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#### QA Checks
- **PM10 Microns:**
- **PM2.5 Microns:**
- **D₉₀, Microns:**

#### Run Details
- **Total Run Time:** 157.78
- **Total Volume, ACF:** 41.451
- **Run ID:** 51-1
- **Condition:**

#### Averages
- **in H₂O:** 177.47
- **°F:** 81.3
- **°F:** 133.9

#### Other Data
- **1.295:**
- **110.3:**
- **10.87:**
- **2.48:**
- **%:**
- **Microns:**
### IDENTIFICATION INFORMATION

- **Plant Name:**
- **City:**
- **State:** North Carolina
- **Source Number:**
- **Sampling Location:** Scrubber Stack
- **Test Personnel:** TTB, JMA
- **Meterbox ID:** 702233
- **\( \Delta H \):** 1.595
- **Gamma, \( \gamma \):** .9381
- **Nozzle ID:** X-7
- **Nozzle Diameter:** .215
- **Orsat/Fyrite:** FYR

### PRELIMINARY CHECKS AND DATA

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

- **Pitot Tube Pretest Leak Check:** A 29.5 B 30.2
- **Pitot Tube Posttest Leak Check:** 5 5
- **Barometric Pressure, In., Hg:** 30.2
- **Static Pressure, In. W.C.:** -.05

### ACTUAL MOISTURE & GAS COMPOSITION

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### Sampling Information

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<th>Meter Volume (ft³)</th>
<th>( \nu P ) (In. H₂O)</th>
<th>Meter Temp. (°F)</th>
<th>Stack Temp. (°F)</th>
<th>Cyclone Temp. (°F)</th>
<th>Impinger Exit Gas Temp. (°F)</th>
<th>Sample Train Vac. (in. Hg)</th>
<th>Probe Temp. (°F)</th>
<th>Run Cumulative PM₁₀ (microns)</th>
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**Total Run Time:** 1:21:58

**Total Volume, ACFM:** 307.79

### QA Checks

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</table>
## Combined Cyclone PM10 & PM2.5 Run Data Sheet

### Identification Information
- **Plant Name:**
- **City:**
- **State:** North Carolina
- **Source Number:**
- **Sampling Location:** Scrubber Stack
- **Test Personnel:** TTB, JMA
- **Meterbox ID:** 702233
- **ΔH:** 1.575
- **Gamma:** 0.9381
- **Nozzle ID:** 8
- **Nozzle Diameter:** 0.229
- **Orsat/Fyrite:** FYR

### Preliminary Checks and Data
- **Actual:**
- **Req’d:**
- **Vacuum:**
- **Full Train Pretest Leak Check, ACFM:** 1002 < 0.02 or 4%
- **Partial Train Posttest Leak Check, ACFM:** 0.01
- **Vacuum:** 15
- **Pitot Tube Pretest Leak Check:** 4
- **Pitot Tube Posttest Leak Check:** 4
- **Barometric Pressure, In., Hg:** 29.8
- **Static Pressure, In. W.C.:** -0.05

### Actual Moisture & Gas Composition
- **Water Recovered, grams:** 144.4
- **Moisture, %:** 19.063
- **CO₂ %:** 1
- **O₂ %:** 21
- **Md_run:** 28.20
- **Mw_run:** 27.27

### Sampling Information

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<th>Port</th>
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<th>Dwell Time, (Min.)</th>
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<th>Meter Temp. (°F)</th>
<th>Stack Temp. (°F)</th>
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### QA Checks
- **D50 μm:**

### Spike
- **Spike:** 441.916 μg
- **Σ:** 5414 μg

### Averages
- **in. H₂O:** 1.038
- **°F:** 10.91
- **in H₂O:** 2.65

### Run
- **Run:**
- **Averages:**
- **D50 μm:**

---

**Note:**
- Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery. Do not leak check during port changes.
## Method 4 - Air Control Techniques, P.C.

### Source Information
- **Client:**
- **Plant Name:**
- **City, State:**
- **Sampling Location:** Scrubber Stack
- **Job #:** 1756
- **Process:** Pulp/Paper
- **Personnel:**

### Sampling Information
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### Moisture Data

#### Impinger 1
- **Contents - 100ml H2O**
  - **Final Weight, grams:**
    - U1-1: 874.3
    - U1-2: 832.1
    - U1-3: 816.0
  - **Initial Weight, grams:**
    - U1-1: 732.4
    - U1-2: 732.6
    - U1-3: 728.5
  - **Condensed Water, grams:**
    - U1-1: 141.9
    - U1-2: 99.5
    - U1-3: 87.5

#### Impinger 2
- **Contents - 100ml H2O**
  - **Final Weight, grams:**
    - U1-1: 734.0
    - U1-2: 712.1
    - U1-3: 762.0
  - **Initial Weight, grams:**
    - U1-1: 602.5
    - U1-2: 695.1
    - U1-3: 712.1
  - **Condensed Water, grams:**
    - U1-1: 31.5
    - U1-2: 17.0
    - U1-3: 49.9

#### Impinger 3
- **Contents - Empty**
  - **Final Weight, grams:**
    - U1-1: 603.0
    - U1-2: 604.4
    - U1-3: 605.8
  - **Initial Weight, grams:**
    - U1-1: 600.3
    - U1-2: 603.0
    - U1-3: 604.4
  - **Condensed Water, grams:**
    - U1-1: 2.7
    - U1-2: 1.4
    - U1-3: 1.4

#### Silica Gel
- **Final Weight, grams:**
  - U1-1: 878.3
  - U1-2: 885.6
  - U1-3: 893.2
- **Initial Weight, grams:**
  - U1-1: 866.0
  - U1-2: 878.3
  - U1-3: 885.6
- **Adsorbed Water, grams:**
  - U1-1: 12.3
  - U1-2: 7.3
  - U1-3: 7.6
- **Total Water, grams:**
  - U1-1: 188.4
  - U1-2: 125.2
  - U1-3: 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
A/27/2012
## Combined Cyclone PM10 & PM2.5 Run Data Sheet

### Identification Information
- **Plant Name:**
- **City:**
- **State:**
- **Source Number:** EAST
- **Sampling Location:** Scrubber Stack
- **Test Personnel:** TTB, JMA
- **Meterbox ID:** 902073
- **Filter ID:**
- **Tare:**
- **ΔH:** 19.04
- **Gamma:** y
- **Nozzle ID:** 1.7
- **Nozzle Diameter:** 0.26
- **Orsat/Fyrite:**

### Preliminary Checks and Data
- **Actual:**
- **Reg'd:**
- **Vacuum:**

### ACTUAL MOISTURE & GAS COMPOSITION
- **Water Recovered, grams:**
- **CO₂ %:**
- **O₂ %:**
- **Moisture, %:**
- **Md_run:**
- **Mw_run:**

### Sampling Information

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<tr>
<th>Port</th>
<th>Point</th>
<th>Dwell Time, Min.</th>
<th>Elapsed Time, h:m:s</th>
<th>Meter Volume (ft³)</th>
<th>ϕP (In. H₂O)</th>
<th>Meter Temp. (°F)</th>
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### QA Checks
- **Run Cumulative PM₁₀:**
- **PM₂.₅:**
- **Averages:**
  - **Run:**
  - **in. H₂O:**
  - **°F:**
  - **%:**
  - **microns:**
### Combined Cyclone PM10 & PM2.5 Run Data Sheet

#### IDENTIFICATION INFORMATION

- **Plant Name:**
- **City:**
- **State:**
- **Source Number:** EAST
- **Sampling Location:** Scrubber Stack
- **Test Personnel:** TTB, JMA
- **Full Train Pretest Leak Check, ACFS:** 0.000
- **Partial Train Posttest Leak Check, ACFS:** 0.000

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

#### PRELIMINARY CHECKS AND DATA

<table>
<thead>
<tr>
<th>Pitot Tube Pretest Leak Check</th>
<th>Pitot Tube Posttest Leak Check</th>
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<tbody>
<tr>
<td>A</td>
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<tr>
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Barometric Pressure, In. Hg: 30.2
Static Pressure, In. W.C: 0.28

#### ACTUAL MOISTURE & GAS COMPOSITION

- **Water Recovered, grams:**
- **Carbon Dioxide, %:**
- **Oxygen, %:**
- **Moisture, %:**

#### Sampling Information

<table>
<thead>
<tr>
<th>Port</th>
<th>Point</th>
<th>Dwell Time, (Min.)</th>
<th>Elapsed Time, h:m:s</th>
<th>Meter Volume (ft³)</th>
<th>φP (in. H₂O)</th>
<th>Meter Temp. (°F)</th>
<th>Stack Temp. (°F)</th>
<th>Cyclone Temp. (°F)</th>
<th>Impinger Exit Gas Temp. (°F)</th>
<th>φH (in. H₂O)</th>
<th>Sample Train Vac. (in. Hg)</th>
<th>Probe Temp. (°F)</th>
<th>Run Cumulative D₅₀, µm</th>
<th>PM₁₀, µm</th>
<th>PM₂.₅, µm</th>
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#### QA Checks

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<th>Averages</th>
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<th>PM₁₀, µm</th>
<th>PM₂.₅, µm</th>
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<td></td>
<td>in H₂O</td>
<td>°F</td>
<td>in H₂O</td>
<td>%</td>
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Combined Cyclone PM10 & PM2.5 Run Data Sheet

### IDENTIFICATION INFORMATION
- **Plant Name:**
- **City:**
- **State:**
- **Source Number:** EAST
- **Sampling Location:** Scrubber Stack
- **Test Personnel:** TTB, JMA

### PRELIMINARY CHECKS AND DATA
- **Run ID:** U1-3
- **Condition:**
- **Full Train Pretest Leak Check, ACFM:** 0.000 < 0.02 or 4%
- **Partial Train Posttest Leak Check, ACFM:** 0.000
- **(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.**

### ACTUAL MOISTURE & GAS COMPOSITION
- **Water Recovered, grams:**
- **CO₂ %:** 1
- **O₂ %:** 21
- **Moisture, %:**
- **Md_run:**
- **Mw_run:**

### Sampling Information

<table>
<thead>
<tr>
<th>Port</th>
<th>Point</th>
<th>Dwell Time, (Min.)</th>
<th>Elapsed Time, h:m:s</th>
<th>Meter Volume (ft³)</th>
<th>ρP (In. H₂O)</th>
<th>Meter Temp., (°F)</th>
<th>Stack Temp., (°F)</th>
<th>Cyclone Exit Gas Temp., (°F)</th>
<th>ρH (In. H₂O)</th>
<th>Sample Train Vac. (in. Hg)</th>
<th>Probe Temp. (°F)</th>
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### QA Checks
- **Total Run Time:**
- **Total Volume, ACF:**
- **Run Averages:**
  - **in H₂O:**
  - **°F:**
  - **%:**
  - **microns:**
- **PM₁₀:**
- **PM₂.₅:**
### Source Information

| Client |  
| City, State |  
| Scrubber Stack |  
| Job # | 1756  
| Process Personnel | Pulp/Paper |

### Sampling Information

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<th>S1-6</th>
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<td>10/25/12</td>
<td>10/25/12</td>
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### Moisture Data

#### Impinger 1

<p>| Contents - 100ml H2O |</p>
<table>
<thead>
<tr>
<th>Final Weight, grams</th>
<th>830.7</th>
<th>757.1</th>
<th>741.7</th>
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<tr>
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<td>676.6</td>
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<tr>
<td>Condensed Water, grams</td>
<td>120.0</td>
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</table>

#### Impinger 2

| Contents - 100ml H2O |  
|----------------------|------|------|------|
| Final Weight, grams | 680.3 | 719.8 | 752.3 |
| Initial Weight, grams | 676.4 | 686.3 | 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 | 1.6 |

#### Silica Gel

<table>
<thead>
<tr>
<th>Final Weight, grams</th>
<th>877.1</th>
<th>882.2</th>
<th>890.4</th>
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</thead>
<tbody>
<tr>
<td>Initial Weight, grams</td>
<td>866.1</td>
<td>877.1</td>
<td>882.2</td>
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<td>Adsorbed Water, grams</td>
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<tr>
<td>Total Water, grams</td>
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Vm(std) = Volume of gas sampled at standard conditions (dscf) = \( \text{gamma} \times 17.64 \times \frac{\text{Vm} \times (P_{\text{bar}} + (D \times H/13.6))}{(Tm+460)} \)

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  
4/11/2012  
OTM-036  
Page 468 of 643
### Combined Cyclone PM10 & PM2.5 Run Data Sheet

#### Identification Information
- **Plant Name:**
- **City:**
- **State:**
- **Source Number:**
- **Sampling Location:** Scrubber Stack
- **Test Personnel:** TTB, JMA
- **Meterbox ID:** 202253
- **Δ H:** 0.1545
- **Gamma, γ:** 0.738
- **Nozzle ID:** A0B
- **Nozzle Diameter:** 2.29
- **Orsat/Fyrite:** EYR

#### Preliminary Checks and Data

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<th>Checks</th>
<th>Actual</th>
<th>Reg'd</th>
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</thead>
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<td>&lt; 0.02 or 4%</td>
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<td>Partial Train Posttest Leak Check, ACFM</td>
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</table>

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

<table>
<thead>
<tr>
<th>Port</th>
<th>Point</th>
<th>Dwell Time, (Min.)</th>
<th>Elapsed Time, h.m.s</th>
<th>Meter Volume (ft³)</th>
<th>φP (In. H₂O)</th>
<th>Meter Temp. (°F)</th>
<th>Stack Temp. (°F)</th>
<th>Cyclone Temp. (°F)</th>
<th>Impinger Exit Gas Temp. (°F)</th>
<th>9H (In. H₂O)</th>
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#### Sampling Information

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#### QA Checks

**Spike @ 310°:**

- 474.35 in H₂O

**Microns:**

- 6.39 in H₂O

- %

- microns
## Combined Cyclone PM10 & PM2.5 Run Data Sheet

### IDENTIFICATION INFORMATION

- **Plant Name:** [Blank]
- **City:** [Blank]
- **State:** [Blank]
- **Source Number:** [Blank]
- **Sampling Location:** Scrubber Stack
- **Test Personnel:** TTB, JMA
- **Date:** 06/12/12
- **Start:** 8:20
- **Stop:** 9:49

### Meterbox ID
- **ID:** 702.233
- **ΔH:** 1.595
- **Gamma:** 1.9381
- **Nozzle ID:** 8
- **Nozzle Diameter:** 0.229
- **Orsat/Fyrite:** FYR

### PRELIMINARY CHECKS AND DATA

- **Actual:** 0.003
- **Reg'd:** < 0.02 or 4%
- **Vacuum:** 15.0

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

- **Pitot Tube Pretest Leak Check:** 4
- **Pitot Tube Posttest Leak Check:** 4

### ACTUAL MOISTURE & GAS COMPOSITION

- **Water Recovered, grams:** [Blank]
- **CO₂ %:** 1
- **O₂ %:** 21

### Sampling Information

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<tr>
<th>Port</th>
<th>Point</th>
<th>Dwell Time (Min)</th>
<th>Elapsed Time, h:m:s</th>
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### QA Checks

- **Probe Temp, ºF:** [Blank]
- **Run Cumulative:** PM10, PM2.5
- **D_{90}, Microns:** [Blank]

### Total Run Time: 1:22:42

### Total Volume, ACF

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<th>microns</th>
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Spike @ 104.776 on 201.2, 0.55, 0.205.
## Combined Cyclone PM10 & PM2.5 Run Data Sheet

### Identification Information
- **Plant Name:**
- **City:**
- **State:**
- **Source Number:**
- **Sampling Location:** Scrubber Stack
- **Test Personnel:** TTB, JMA

### Preliminary Checks and Data
- **Full Train Pretest Leak Check, ACFM:** Actual: 0.04, Reg'd: < 0.02 or 4%, Vacuum: 15
- **Partial Train Posttest Leak Check, ACFM:** Actual: 11
- **(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.**
- **Pitot Tube Pretest Leak Check (A)**
- **Pitot Tube Posttest Leak Check (B)**
- **Barometric Pressure, In./Hg.:** 29.8
- **Static Pressure, In. W.C.:** -0.08

### Actual Moisture & Gas Composition
- **Water Recovered, grams:**
- **CO₂ %:** 1
- **Moisture, %:**
- **O₂ %:** 21
- **Md_run:**
- **Mw_run:**

### Sampling Information

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<th>Point</th>
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<th>Elapsed Time, h:m:s</th>
<th>Meter Volume (ft³)</th>
<th>Temp. (°H₂O)</th>
<th>Meter Temp. (°F)</th>
<th>Stack Temp. (°F)</th>
<th>Cyclone Temp. (°F)</th>
<th>Impinger Exit Gas Temp., (°F)</th>
<th>pH (in. H₂O)</th>
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**Total Run Time:** 1:38:16
**Total Volume, ACF:** 542.57

### QA Checks
- **Spike:** @ 320°
- **Averages:** in. H₂O, °F, °F
- **in H₂O:** 545.19

## Run Cumulative D₅₀, microns
**Method 4 - Air Control Techniques, P.C.**

**Source Information**
- Client: 
- Plant Name: 
- City, State: 
- Sampling Location: Scrubber Stack
- Job #: 1756
- Process Personnel: Pulp/Paper
- Date: 10/24/12

**Sampling Information**

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**Moisture Data**

**Impinger 1**
- Contents - 100ml H2O
  - Final Weight, grams: 857.1, 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 H2O
  - 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

\[ V_m(\text{std}) = \text{Volume of gas sampled at standard conditions (dscf)} = \text{gamma} \times 17.64 \times \frac{V_m \times [Pbar+(D \times H/13.6)]}{(T_m+460)} \]
\[ V_w(\text{std}) = \text{volume of water vapor at standard conditions (scf)} = 0.04715 \times \text{volume of water collected (gms)} \]
\[ B_{w,s} = \text{Mole fraction of water vapor} = \frac{V_w(\text{std})}{(V_m(\text{std}) + V_w(\text{std}))} \]
\[ \text{Percent Moisture} = 100 \times B_{w,s} \]

**Revision 1**

OTM-036 Page 472 of 643
## Combined Cyclone PM10 & PM2.5 Run Data Sheet

### IDENTIFICATION INFORMATION
- **Plant Name:**
- **City:**
- **State:**
- **Source Number:** EAST
- **Sampling Location:** Scrubber Stack
- **Test Personnel:** TTB, JMA
- **Meterbox ID:** 491033
- **Filter ID:**
- **Tare:**
- **ΔH:** 1.94
- **Gamma:** 0.9712
- **Nozzle ID:** I-8
- **Nozzle Diameter:** 0.316
- **Orsat/Fyrite:** FVR

### PRELIMINARY CHECKS AND DATA
- **Full Train Pretest Leak Check, ACFM:** 12200 < 0.02 or 4%
- **Partial Train Posttest Leak Check, ACFM:** 0.000
- **(Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.**
  - Pitot Tube Pretest Leak Check: A 4, B 3
  - Pitot Tube Posttest Leak Check: 4
- **Barometric Pressure, In., Hg.:** 19.8
- **Static Pressure, In. W.C.:** -0.08

### ACTUAL MOISTURE & GAS COMPOSITION
- **Water Recovered, grams:**
- **CO₂ %:** 1
- **O₂ %:** 21
- **Moisture, %:**
- **Md_run:**
- **Mw_run:**

### Sampling Information

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### QA Checks
- **D₅₀, %:**
- **PM₁₀:**
- **PM₂.₅:**

### Averages
- **Run:**
- **in. H₂O:**
- **°F:**
- **in H₂O:**
- **%:**
- **microns:**
# Combined Cyclone PM10 & PM2.5 Run Data Sheet

## Identification Information
- **Plant Name:**
- **City:**
- **State:**
- **Source Number:** EA51
- **Sampling Location:** Scrubber Stack
- **Test Personnel:** TTB, JMA
- **Meterbox ID:** 989233
- **ΔH:** 1.96
- **Gamma, γ:** 0.962
- **Nozzle ID:** 1-8
- **Nozzle Diameter:** 0.253
- **Orsat/Fyrite:** PRK

## Preliminary Checks and Data
- **Full Train Pretest Leak Check, ACFM:** 0.000 < 0.02 or 4%
- **Partial Train Posttest Leak Check, ACFM:** 0.000

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

**Pitot Tube Pretest Leak Check:**
- **A:** 5 
- **B:** 4

**Pitot Tube Posttest Leak Check:**
- **A:** 3
- **B:** 4

**Barometric Pressure, In., Hg:** 27.8
**Static Pressure, In. W.C.:** -0.08

## Actual Moisture & Gas Composition
- **Water Recovered, grams:**
- **CO₂ %:**
- **O₂ %:** 21

## Sampling Information

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<tr>
<th>Port</th>
<th>Point</th>
<th>Dwell Time (Min.)</th>
<th>Elapsed Time (h:mm:ss)</th>
<th>Meter Volume (ft³)</th>
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## QA Checks

- **Run ID:** 41-3
- **Condition:**

## Sampling Information Averages

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<th>°F</th>
<th>°F</th>
<th>in H₂O</th>
<th>%</th>
<th>microns</th>
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Total Run Time:
- **Total Volume, ACF:**
**Combined Cyclone PM10 & PM2.5 Run Data Sheet**

**Identification Information**
- Plant Name: 
- City: 
- State: 
- Source Number: EAST
- Sampling Location: Scrubber Stack
- Test Personnel: TTB, JMA
- Meterbox ID: 90039
- \( \Delta H @ \): 0.964
- Gamma, \( \gamma \): 0.932
- Nozzle ID: 8
- Nozzle Diameter: 0.339
- Orsat/Fyre: PVR

**Preliminary Checks and Data**
- Full Train Pretest Leak Check, ACFM: 0.000 < 0.02 or 4%
- Partial Train Posttest Leak Check, ACFM: 0.420
- (Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.
- Pitot Tube Pretest Leak Check: A
- Pitot Tube Posttest Leak Check: B
- 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**

<table>
<thead>
<tr>
<th>Port</th>
<th>Point</th>
<th>Dwell Time, (Min.)</th>
<th>Elapsed Time, h.m.s</th>
<th>Meter Volume (ft³)</th>
<th>( \phi P ) (In. H₂O)</th>
<th>Meter Temp., (°F)</th>
<th>Stack Temp., (°F)</th>
<th>Cyclone Temp., (°F)</th>
<th>Impinger Exit Gas Temp., (°F)</th>
<th>( \phi H ) (In. H₂O)</th>
<th>Sample Train Vac. (In. Hg)</th>
<th>Probe Temp. (°F)</th>
<th>Run Cumulative</th>
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<td>324</td>
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**QA Checks**
- Total Run Time: 
- Total Volume, ACF: 
- Averages: in. H₂O, °F, °F
- Run in H₂O, %, microns

Run ID: L11-6
Condition: 

**External Measurements**
- Barometric Pressure, In., Hg: 29.8
- Static Pressure, In., W.C.: -0.08

**Notes**
- Do not leak check during port changes.
### Method 4 - Air Control Techniques, P.C.

**Source Information**

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<tr>
<th>Client</th>
<th>Plant Name</th>
<th>City, State</th>
<th>Job #</th>
<th>Process Personnel</th>
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<td>Run Number</td>
</tr>
<tr>
<td>Filter Identification</td>
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<tr>
<td>Sampling Date</td>
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### Moisture Data

#### Impinger 1
- **Contents - 100ml H2O**
- **Final Weight, grams** | 887.5 | 828.0 | 839.5 |
- **Initial Weight, grams** | 722.3 | 712.5 | 706.7 |
- **Condensed Water, grams** | 165.2 | 115.5 | 134.4 |

#### Impinger 2
- **Contents - 100ml H2O**
- **Final Weight, grams** | 771.0 | 773.3 | 738.0 |
- **Initial Weight, grams** | 746.3 | 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

## Identification Information
- **Plant Name:**
- **City:**
- **State:**
- **Source Number:** EAST
- **Sampling Location:** Scrubber Stack
- **Test Personnel:** TTB, JMA
- **Meterbox ID:** 82212
- **ΔH:** 1.522
- **Gamma, γ:** 1.0262
- **Nozzle ID:** BlmK-7
- **Nozzle Diameter:** 0.209
- **Orsat/Fyrite:**

## Preliminary Checks and Data

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

<table>
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<th>Pitot Tube Pretest Leak Check</th>
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<td>Static Pressure, In. W.C.</td>
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## Actual Moisture & Gas Composition

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<td>CO₂ %</td>
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<tr>
<td>O₂ %</td>
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## Sampling Information

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<th>Port</th>
<th>Point</th>
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<th>Elapsed Time, h:m:s</th>
<th>Meter Volume (ft³)</th>
<th>θP (In. H₂O)</th>
<th>Meter Temp. (°F)</th>
<th>Stack Temp. (°F)</th>
<th>Cyclone Temp. (°F)</th>
<th>Impinger Exit Gas Temp., (°F)</th>
<th>θH (In. H₂O)</th>
<th>Sample Train Vac. (In. Hg)</th>
<th>Probe Temp. (°F)</th>
<th>Run Cumulative microns</th>
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Total Run Time: 1:57:38
Total Volume, ACF: 37,385

## QA Checks

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### Averages

- **θP (In. H₂O):** 0.20
- **Meter Temp. (°F):** 78.3
- **Stack Temp. (°F):** 133.9

### in H₂O

- **Averages:** 0.250
- **Run Cumulative microns:** 2.59
## Combined Cyclone PM10 & PM2.5 Run Data Sheet

### Identification Information

- **Plant Name:**
- **City:**
- **State:**
- **Source Number:**
- **Sampling Location:** Scrubber Stack
- **Test Personnel:** TTB, JMA
- **Meterbox ID:** 502012
- **ΔH @ A:** 1.522
- **ΔH @ B:** 1.0252
- **Nozzle ID:** 7
- **Nozzle Diameter:** 0.209
- **Orsat/Fyrite:**

### Preliminary Checks and Data

- **Full Train Pretest Leak Check, ACFM:** 0.001, Actual, < 0.02 or 4%, Reg'd, 15
- **Partial Train Posttest Leak Check, ACFM:** 0.01, Actual, 0.02, Reg'd, 7

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

- **Pitot Tube Pretest Leak Check A:** 5
- **Pitot Tube Posttest Leak Check B:** 5
- **Barometric Pressure, In., Hg.:** 29.8
- **Static Pressure, In., W.C.:** 1.05

### Actual Moisture & Gas Composition

- **Water Recovered, grams:**
- **CO₂ %:** 1
- **O₂ %:** 21

### QA Checks

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<th>Port</th>
<th>Point</th>
<th>Dwell Time, (Min.)</th>
<th>Elapsed Time, h:m:s</th>
<th>Meter Volume (ft³)</th>
<th>φP (in. H₂O)</th>
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<th>Stack Temp. (°F)</th>
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<td>2.80</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>8.88</td>
<td>1:15:05</td>
<td>211.84</td>
<td>.14</td>
<td>75</td>
<td>133</td>
<td>319</td>
<td>58</td>
<td>.27</td>
<td>6</td>
<td>3.35</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Total Run Time:** 1:21:58

**Total Volume, ACF:** 215.028

**Averages:**
- in. H₂O 67 131.9
- °F 131.9

**Spike:**
- .233 in H₂O

**%**

**microns**
## Combined Cyclone PM10 & PM2.5 Run Data Sheet

### Identification Information
- **Plant Name:**
- **City:**
- **State:**
- **Source Number:**
- **Sampling Location:** Scrubber Stack
- **Test Personnel:** TTB, JMA
- **Date:** 10/24/12
- **Start:** 12:40
- **Stop:** 14:13

### Preliminary Checks and Data

<table>
<thead>
<tr>
<th>Condition</th>
<th>Date</th>
<th>Run ID</th>
<th>Reg'd</th>
<th>Vacuum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10/24/12</td>
<td>52.3</td>
<td>&lt; 0.02 or 4%</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.02</td>
<td>8</td>
</tr>
</tbody>
</table>

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

- Pitot Tube Pretest Leak Check: 4
- Pitot Tube Posttest Leak Check: 4

### Actual Moisture & Gas Composition

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barometric Pressure, In., Hg.</td>
<td>29.8</td>
</tr>
<tr>
<td>Static Pressure, In., W.C.</td>
<td>-0.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Recovered, grams</td>
<td>142.1</td>
</tr>
<tr>
<td>Moisture, %</td>
<td>19.5</td>
</tr>
<tr>
<td>CO₂ %</td>
<td>1</td>
</tr>
<tr>
<td>O₂ %</td>
<td>2.1</td>
</tr>
<tr>
<td>Md_run</td>
<td>28.20</td>
</tr>
<tr>
<td>Mw_run</td>
<td>27.23</td>
</tr>
</tbody>
</table>

### Sampling Information

<table>
<thead>
<tr>
<th>Port</th>
<th>Point</th>
<th>Dwell Time, (Min.)</th>
<th>Elapsed Time, h:m:s</th>
<th>Meter Volume (ft³)</th>
<th>Sample Train Vac. (in. Hg)</th>
<th>Run Cumulative D₅₀, microns</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>1</td>
<td>10.48</td>
<td>0</td>
<td>214.1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>10.48</td>
<td>10:26</td>
<td>223.05</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>10.48</td>
<td>40:31</td>
<td>226.07</td>
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<td></td>
<td>1</td>
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<td>51:17</td>
<td>229.22</td>
<td>2</td>
<td></td>
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<tr>
<td></td>
<td>1</td>
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<td>41:42</td>
<td>232.39</td>
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<tr>
<td></td>
<td>1</td>
<td>10.48</td>
<td>42:01</td>
<td>235.57</td>
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<td></td>
<td>1</td>
<td>10.48</td>
<td>10:31</td>
<td>238.09</td>
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</tr>
<tr>
<td></td>
<td>1</td>
<td>10.48</td>
<td>11:28</td>
<td>241.66</td>
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<tr>
<td></td>
<td>1</td>
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<td>33:18</td>
<td>241.70</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>10.48</td>
<td>9</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>10.48</td>
<td>12.59</td>
<td>2</td>
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</tr>
</tbody>
</table>

**Total Run Time:** 1:58:40
**Total Volume, ACF:** 28.607
**Averages:**

- **in. H₂O:** 15775
- **°F:** 83.1

### QA Checks

<table>
<thead>
<tr>
<th>Port</th>
<th>Point</th>
<th>Spike</th>
<th>@ 315°</th>
<th>Run Cumulative D₅₀, microns</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>1</td>
<td>6 min</td>
<td>to 1 hr</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Run:**

- **in. H₂O:** 106.8
- **%:** 10.97
- **microns:** 2.68

**Spike:**

- **in H₂O:** 0.240
- **%:** 106.8
- **microns:** 10.97

**Spike:**

- **in H₂O:** 2.4977
- **%:** 106.8
- **microns:** 10.97
<table>
<thead>
<tr>
<th>Moisture Data</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Impinger 1</strong></td>
</tr>
<tr>
<td>Contents - 100ml H₂O</td>
</tr>
<tr>
<td>Final Weight, grams</td>
</tr>
<tr>
<td>Initial Weight, grams</td>
</tr>
<tr>
<td>Condensed Water, grams</td>
</tr>
<tr>
<td><strong>Impinger 2</strong></td>
</tr>
<tr>
<td>Contents - 100ml H₂O</td>
</tr>
<tr>
<td>Final Weight, grams</td>
</tr>
<tr>
<td>Initial Weight, grams</td>
</tr>
<tr>
<td>Condensed Water, grams</td>
</tr>
<tr>
<td><strong>Impinger 3</strong></td>
</tr>
<tr>
<td>Contents - Empty</td>
</tr>
<tr>
<td>Final Weight, grams</td>
</tr>
<tr>
<td>Initial Weight, grams</td>
</tr>
<tr>
<td>Condensed Water, grams</td>
</tr>
<tr>
<td><strong>Silica Gel</strong></td>
</tr>
<tr>
<td>Final Weight, grams</td>
</tr>
<tr>
<td>Initial Weight, grams</td>
</tr>
<tr>
<td>Adsorbed Water, grams</td>
</tr>
<tr>
<td>Total Water, grams</td>
</tr>
</tbody>
</table>

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 = Moie fraction of water vapor = Vwc(std) / (Vm(std) + Vwc(std))
Percent Moisture = 100 * Bws
Combined Cyclone PM10 & PM2.5 Run Data Sheet

**IDENTIFICATION INFORMATION**

<table>
<thead>
<tr>
<th>Plant Name</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>City</td>
<td></td>
</tr>
<tr>
<td>State</td>
<td></td>
</tr>
<tr>
<td>Source Number</td>
<td>EAST</td>
</tr>
<tr>
<td>Sampling Location</td>
<td>Scrubber Stack</td>
</tr>
<tr>
<td>Test Personnel</td>
<td>TTB, JMA</td>
</tr>
<tr>
<td>Meterbox ID</td>
<td>11077</td>
</tr>
<tr>
<td>Δ H @ 0°C</td>
<td>0.651</td>
</tr>
<tr>
<td>Gamma, γ</td>
<td>0.2883</td>
</tr>
<tr>
<td>Nozzle ID</td>
<td>7 A6D</td>
</tr>
<tr>
<td>Nozzle Diameter</td>
<td>0.212</td>
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<td>Orsat/Frye</td>
<td>FYR</td>
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</tbody>
</table>

**PRELIMINARY CHECKS AND DATA**

<table>
<thead>
<tr>
<th>Actual</th>
<th>Req'd</th>
<th>Vacuum</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.020</td>
<td>&lt; 0.02 or 4%</td>
<td>15</td>
</tr>
<tr>
<td>0.400</td>
<td>15</td>
<td></td>
</tr>
</tbody>
</table>

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

| Pitot Tube Pretest Leak Check | 4'/6' |
| Pitot Tube Posttest Leak Check | 4'/6' |

| Barometric Pressure, In., Hg | 30.2 |
| Static Pressure, In. W.C. | -0.08 |

**ACTUAL MOISTURE & GAS COMPOSITION**

<table>
<thead>
<tr>
<th>Water Recovered, grams</th>
<th>Moisture, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂ %</td>
<td>1</td>
</tr>
<tr>
<td>O₂ %</td>
<td>21</td>
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</table>

<table>
<thead>
<tr>
<th>Md_run</th>
<th>Mw_run</th>
</tr>
</thead>
</table>

**Sampling Information**

<table>
<thead>
<tr>
<th>Port</th>
<th>Time (Min)</th>
<th>Elapsed Time, h:m:s</th>
<th>Volume (ft³)</th>
<th>ΦP (In. H₂O)</th>
<th>Stack Temp. (°F)</th>
<th>Cyclone Temp. (°F)</th>
<th>Impinger Exit Gas Temp. (°F)</th>
<th>ΦH (In. H₂O)</th>
<th>Sample Train Vac. (In. Hg)</th>
<th>Probe Temp. (°F)</th>
<th>Run Cumulative PM₁₀</th>
<th>PM₂.₅</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-1</td>
<td>4.59</td>
<td>9:59</td>
<td>276.3</td>
<td>0.17</td>
<td>76</td>
<td>326</td>
<td>600</td>
<td>0.38</td>
<td>3</td>
<td>320</td>
<td>314</td>
<td></td>
</tr>
<tr>
<td>A-2</td>
<td>4.91</td>
<td>9:35</td>
<td>279.24</td>
<td>0.17</td>
<td>77</td>
<td>313</td>
<td>61</td>
<td>0.38</td>
<td>3</td>
<td>314</td>
<td>314</td>
<td></td>
</tr>
<tr>
<td>A-3</td>
<td>4.91</td>
<td>11:12</td>
<td>282.69</td>
<td>0.17</td>
<td>78</td>
<td>315</td>
<td>61</td>
<td>0.32</td>
<td>4</td>
<td>314</td>
<td>314</td>
<td></td>
</tr>
<tr>
<td>A-4</td>
<td>0.87</td>
<td>18:47</td>
<td>385.46</td>
<td>0.18</td>
<td>76</td>
<td>313</td>
<td>61</td>
<td>0.32</td>
<td>4</td>
<td>314</td>
<td>314</td>
<td></td>
</tr>
<tr>
<td>A-5</td>
<td>0.87</td>
<td>18:36</td>
<td>390.61</td>
<td>0.16</td>
<td>79</td>
<td>313</td>
<td>61</td>
<td>0.32</td>
<td>5</td>
<td>313</td>
<td>313</td>
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</tr>
<tr>
<td>A-6</td>
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<td>388.84</td>
<td>0.18</td>
<td>79</td>
<td>313</td>
<td>61</td>
<td>0.32</td>
<td>6</td>
<td>314</td>
<td>314</td>
<td></td>
</tr>
<tr>
<td>A-7</td>
<td>0.87</td>
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<td>0.18</td>
<td>80</td>
<td>314</td>
<td>61</td>
<td>0.32</td>
<td>6</td>
<td>314</td>
<td>314</td>
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</tr>
<tr>
<td>A-8</td>
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<td>18:01</td>
<td>304.87</td>
<td>0.18</td>
<td>81</td>
<td>312</td>
<td>57</td>
<td>0.32</td>
<td>9</td>
<td>313</td>
<td>313</td>
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<tr>
<td>A-9</td>
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<td>306.49</td>
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<td>82</td>
<td>313</td>
<td>57</td>
<td>0.32</td>
<td>10</td>
<td>313</td>
<td>313</td>
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</tbody>
</table>

**QA Checks**

<table>
<thead>
<tr>
<th>Run Cumulative</th>
<th>D₅₀, μm</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM₁₀</td>
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</tr>
<tr>
<td>PM₂.₅</td>
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</tbody>
</table>

**Run Information**

<table>
<thead>
<tr>
<th>Run</th>
<th>12-XX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>4/11/2016</td>
</tr>
</tbody>
</table>

**Total Run Time**

<table>
<thead>
<tr>
<th>Total Run Time</th>
<th>1:17:28</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Volume, ACF</td>
<td>315.378</td>
</tr>
</tbody>
</table>

**Averages**

<table>
<thead>
<tr>
<th>in. H₂O</th>
<th>°F</th>
<th>°F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>in H₂O</th>
<th>%</th>
<th>microns</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Combined Cyclone PM10 & PM2.5 Run Data Sheet**

### Identification Information
- **Plant Name**
- **City**
- **State**
- **Source Number** EAST
- **Sampling Location** Scrubber Stack
- **Test Personnel** TTB, JMA

### Preliminary Checks and Data
<table>
<thead>
<tr>
<th>Description</th>
<th>Actual</th>
<th>Req'd</th>
<th>Vacuum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Train Pretest Leak Check, ACFM</td>
<td>0.000</td>
<td>&lt; 0.02 or 4%</td>
<td>15</td>
</tr>
<tr>
<td>Partial Train Posttest Leak Check, ACFM</td>
<td>0.000</td>
<td></td>
<td>13</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Description</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pitot Tube Pretest Leak Check</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Pitot Tube Posttest Leak Check</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Barometric Pressure, In., Hg.</td>
<td>29.8</td>
<td></td>
</tr>
<tr>
<td>Static Pressure, In. W.C.</td>
<td>-0.14</td>
<td></td>
</tr>
</tbody>
</table>

### Actual Moisture & Gas Composition
- **Water Recovered, grams**
- **CO₂ %**
- **O₂ %**
- **Moisture, %**
- **Md_run**
- **Mw_run**

### Sampling Information
<table>
<thead>
<tr>
<th>Port</th>
<th>Point</th>
<th>Dwell Time, (Min.)</th>
<th>Elapsed Time, h:m:s</th>
<th>Meter Volume (ft³)</th>
<th>ΔP (In. H₂O)</th>
<th>Meter Temp. (°F)</th>
<th>Stack Temp. (°F)</th>
<th>Cyclone Temp. (°F)</th>
<th>Impinger Exit Gas Temp. (°F)</th>
<th>ΔH (In. H₂O)</th>
<th>Sample Train Vac. (in. Hg.)</th>
<th>Probe Temp. (°F)</th>
<th>Run Cumulative PM₁₀ (μg)</th>
<th>PM₂₅ (μg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
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<td>346.060</td>
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<td>313</td>
<td>313</td>
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<td>18:23</td>
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<td>0.15</td>
<td>56</td>
<td>60</td>
<td>131</td>
<td>314</td>
<td>46</td>
<td>0.31</td>
<td>3</td>
<td>315</td>
<td>315</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>9.19</td>
<td>27:35</td>
<td>314.91</td>
<td>0.15</td>
<td>60</td>
<td>60</td>
<td>132</td>
<td>313</td>
<td>44</td>
<td>0.31</td>
<td>3</td>
<td>315</td>
<td>315</td>
</tr>
<tr>
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<td>9.19</td>
<td>47:14</td>
<td>301.67</td>
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<td>60</td>
<td>132</td>
<td>313</td>
<td>44</td>
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<td>3</td>
<td>315</td>
<td>315</td>
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<tr>
<td></td>
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<td>9.04</td>
<td>46:49</td>
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<td>68</td>
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<td>316</td>
<td>47</td>
<td>0.31</td>
<td>4</td>
<td>320</td>
<td>320</td>
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<tr>
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<td>9.04</td>
<td>56:06</td>
<td>333.99</td>
<td>0.14</td>
<td>73</td>
<td>73</td>
<td>132</td>
<td>316</td>
<td>50</td>
<td>0.31</td>
<td>5</td>
<td>320</td>
<td>320</td>
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<tr>
<td></td>
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<td>4:04</td>
<td>10:34</td>
<td>355.89</td>
<td>0.15</td>
<td>76</td>
<td>76</td>
<td>133</td>
<td>317</td>
<td>52</td>
<td>0.31</td>
<td>5</td>
<td>320</td>
<td>320</td>
</tr>
</tbody>
</table>

| Total Run Time | 1:21:58 | 31.466 |

### QA Checks

<table>
<thead>
<tr>
<th>Run</th>
<th>Cumulative</th>
<th>PM₁₀</th>
<th>PM₂₅</th>
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### Averages

<table>
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<tr>
<th>Run</th>
<th>in. H₂O</th>
<th>°F</th>
<th>°F</th>
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</thead>
<tbody>
<tr>
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### Total Volume, ACF

<table>
<thead>
<tr>
<th>in H₂O</th>
<th>%</th>
<th>microns</th>
</tr>
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<tbody>
<tr>
<td></td>
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</tbody>
</table>
### Combined Cyclone PM10 & PM2.5 Run Data Sheet

#### Identification Information
- **Plant Name:**
- **City:**
- **State:**
- **Source Number:** EAST
- **Sampling Location:** Scrubber Stack
- **Test Personnel:** TTB, JMA
- **Meterbox ID:** 0671
- **Filter ID:**
- **Tare:**

#### Preliminary Checks and Data
- **Actual:** 0.000
- **Req'd:** < 0.02 or 4%
- **Vacuum:** 15" 16"

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

- **Pitot Tube Pretest Leak Check:** N/A
- **Pitot Tube Posttest Leak Check:** N/A

- **Barometric Pressure, In., Hg:** 29.8
- **Static Pressure, In., W.C.:** -0.08

#### Actual Moisture & Gas Composition
- **Water Recovered, grams:**
- **CO₂ %:**
- **O₂ %:**
- **Moisture, %**
- **Md_run**
- **Mw_run**

#### Sampling Information

<table>
<thead>
<tr>
<th>Port</th>
<th>Point</th>
<th>Dwell Time, (Min)</th>
<th>Elapsed Time, h:mn:s</th>
<th>Meter Volume (ft³)</th>
<th>ϑP (In. H₂O)</th>
<th>Meter Temp. (°F)</th>
<th>Stack Temp. (°F)</th>
<th>Cyclone Temp. (°F)</th>
<th>Impinger Exit Gas Temp. (°F)</th>
<th>ϑH (In. H₂O)</th>
<th>Sample Train Vac. (In. Hg)</th>
<th>Probe Temp. (°F)</th>
<th>Run Cumulative microns PM₁₀</th>
<th>PM₂.₅</th>
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<tbody>
<tr>
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<td>0</td>
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<td>0.16</td>
<td>72</td>
<td>16</td>
<td>320</td>
<td>55</td>
<td>0.31</td>
<td>3</td>
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<td></td>
<td>1</td>
<td>10:43</td>
<td>41:51</td>
<td>345.16</td>
<td>0.16</td>
<td>72</td>
<td>133</td>
<td>321</td>
<td>56</td>
<td>0.31</td>
<td>3</td>
<td>320</td>
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<td></td>
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<td></td>
<td>0</td>
<td>10:43</td>
<td>42:14</td>
<td>350.87</td>
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<td>320</td>
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<tr>
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<td>1:33:35</td>
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<tr>
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<td>321</td>
<td>60</td>
<td>0.31</td>
<td>6</td>
<td>320</td>
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<td></td>
</tr>
</tbody>
</table>

**Total Run Time:**
**Total Volume, ACF:**

**Run Averages:**
in. H₂O  °F  °F

**Run:**}

#### QA Checks

**D₅₀,µ:**

**PM₁₀:**

**PM₂.₅:**
### Method 4 - Air Control Techniques, P.C.

#### Source Information

<table>
<thead>
<tr>
<th>Client</th>
<th>Plant Name</th>
<th>City, State</th>
<th>Job #</th>
<th>Process Personnel</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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#### Sampling Information

<table>
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<th>Run Number</th>
<th>S2-4</th>
<th>S2-5</th>
<th>S2-6</th>
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<tbody>
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<td>Final Date</td>
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</tr>
<tr>
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<td>Sampling Date</td>
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<td>10/25/12</td>
<td>10/25/12</td>
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</tbody>
</table>

#### Moisture Data

<table>
<thead>
<tr>
<th>Impinger 1</th>
<th>Contents - 100ml H2O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final Weight, grams</td>
<td>853.8</td>
</tr>
<tr>
<td>Initial Weight, grams</td>
<td>720.6</td>
</tr>
<tr>
<td>Condensed Water, grams</td>
<td>133.2</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Impinger 2</th>
<th>Contents - 100ml H2O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final Weight, grams</td>
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<tr>
<td>Initial Weight, grams</td>
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</tr>
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<td>Condensed Water, grams</td>
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</table>

<table>
<thead>
<tr>
<th>Impinger 3</th>
<th>Contents - Empty</th>
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</thead>
<tbody>
<tr>
<td>Final Weight, grams</td>
<td>594.5</td>
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<td>Initial Weight, grams</td>
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<tr>
<td>Condensed Water, grams</td>
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<table>
<thead>
<tr>
<th>Silica Gel</th>
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<tbody>
<tr>
<td>Final Weight, grams</td>
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<tr>
<td>Initial Weight, grams</td>
<td>775.5</td>
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<td>Adsorbed Water, grams</td>
<td>6.5</td>
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<tr>
<td>Total Water, grams</td>
<td>143.7</td>
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</tbody>
</table>

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

#### Identification Information
- **Plant Name:**
- **City:**
- **State:**

- **Source Number:**
- **Sampling Location:** Scrubber Stack
- **Test Personnel:** TTB, JMA

- **Meterbox ID:** 5020/12
- **$\Delta H$ @ Gamma, y:** 152.2
- **Nozzle ID:** 8
- **Nozzle Diameter:** 0.224
- **Orsat/Frye:**

#### Preliminary Checks and Data
- **Full Train Pretest Leak Check, ACFM:** 0.02, < 0.02 or 4%
- **Partial Train Posttest Leak Check, ACFM:** 15

(Additional checks and data not shown here.)

#### ACTUAL MOISTURE & GAS COMPOSITION
- **Water Recovered, grams:**
- **$CO_2$ %:** 1
- **$O_2$ %:** 21
- **Moisture, %:**
- **Md_run:**
- **Mw_run:**

#### Sampling Information

<table>
<thead>
<tr>
<th>Port</th>
<th>Point</th>
<th>Dwell Time, (Min.)</th>
<th>Elapsed Time, h:m:s</th>
<th>Meter Volume (ft³)</th>
<th>$\theta P$ (In. H2O)</th>
<th>Meter Temp. (°F)</th>
<th>Stack Temp. (°F)</th>
<th>Cyclone Temp. (°F)</th>
<th>Impinger Exit Gas Temp. (°F)</th>
<th>$\theta H$ (In. H2O)</th>
<th>Sample Train Vac. (in. Hg)</th>
<th>Probe Temp. (°F)</th>
<th>Run Cumulative microns</th>
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</thead>
<tbody>
<tr>
<td>C</td>
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<td>PM$_{2.5}$</td>
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<td>9.31</td>
<td>27:35</td>
<td>258.379</td>
<td>.16</td>
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<td>101</td>
<td>317</td>
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<td>8</td>
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**Total Run Time:** 1:23:47

**Total Volume, ACF:**

#### QA Checks

<table>
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<tr>
<th>Spike</th>
<th>@ 319°F</th>
</tr>
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<tbody>
<tr>
<td>276.63</td>
<td>in H2O</td>
</tr>
</tbody>
</table>

**Averages:**

- in. H2O
- °F

**in H2O**

**%**

**microns**
## Combined Cyclone PM10 & PM2.5 Run Data Sheet

### Identification Information
- **Plant Name:** 
- **City:** 
- **State:** 
- **Source Number:** 
- **Sampling Location:** Scrubber Stack
- **Test Personnel:** TTB, JMA

### Preliminary Checks and Data

<table>
<thead>
<tr>
<th></th>
<th>Actual</th>
<th>Req'd</th>
<th>Vacuum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Train Pretest Leak Check, ACFM</td>
<td>0.004</td>
<td>&lt; 0.02 or 4%</td>
<td>15</td>
</tr>
<tr>
<td>Partial Train Posttest Leak Check, ACFM</td>
<td>0.001</td>
<td>0.02</td>
<td>6</td>
</tr>
</tbody>
</table>

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

- **Pitot Tube Pretest Leak Check**
  - A: 4
  - B: 4
- **Pitot Tube Posttest Leak Check**
  - A: 4
  - B: 4

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barometric Pressure, in. Hg</td>
<td>29.8</td>
<td>Static Pressure, in. W.C.</td>
</tr>
</tbody>
</table>

### Actual Moisture & Gas Composition

<table>
<thead>
<tr>
<th></th>
<th>Moisture, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Recovered, grams</td>
<td></td>
</tr>
<tr>
<td>CO₂ %</td>
<td></td>
</tr>
<tr>
<td>O₂ %</td>
<td></td>
</tr>
</tbody>
</table>

### Sampling Information

<table>
<thead>
<tr>
<th>Port</th>
<th>Point</th>
<th>Dwell Time, (Min.)</th>
<th>Elapsed Time, h.m:s</th>
<th>Meter Volume (ft³)</th>
<th>°P (ln. H₂O)</th>
<th>Meter Temp. (°F)</th>
<th>Stack Temp. (°F)</th>
<th>Cyclone Temp. (°F)</th>
<th>Impinger Exit Gas Temp. (°F)</th>
<th>φH (ln. H₂O)</th>
<th>Sample Train Vac. (in. Hg)</th>
<th>Probe Temp. (°F)</th>
<th>Run Cumulative microns Dφ50, PM₁₀</th>
<th>PM₂,₅</th>
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<tr>
<td>L</td>
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<td>60</td>
<td>.25</td>
<td>4</td>
<td>309</td>
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</table>

**Total Run Time:** 1:32:49  
**Total Volume, ACF:** 306.550

### QA Checks

- **Spike:** 308.584
- **Run:** 308.584

**Averages:** 
- **in. H₂O**
- **°F**
- **%**
- **microns**
Combined Cyclone PM10 & PM2.5 Run Data Sheet

**IDENTIFICATION INFORMATION**

<table>
<thead>
<tr>
<th>Plant Name</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>City</td>
<td></td>
</tr>
<tr>
<td>State</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Source Number</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling Location</td>
<td>Scrubber Stack</td>
</tr>
<tr>
<td>Test Personnel</td>
<td>TTB, JMA</td>
</tr>
</tbody>
</table>

| Meterbox ID | 902012 |
| Δ H @ (in. H₂O) | 1.522 |
| Gamma, γ | 1.0252 |

**Preliminary Checks and Data**

<table>
<thead>
<tr>
<th>Actual</th>
<th>Req'd</th>
<th>Vacuum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Train Pretest Leak Check, ACFM</td>
<td>0.004</td>
<td>&lt; 0.02 or 4%</td>
</tr>
<tr>
<td>Partial Train Posttest Leak Check, ACFM</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

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

- Pitot Tube Pretest Leak Check A: 4
- Pitot Tube Posttest Leak Check B: 4

| Barometric Pressure, In.Hg | 29.8 |
| Static Pressure, In. W.C. | -.08 |

**Actual Moisture & Gas Composition**

<table>
<thead>
<tr>
<th>Water Recovered, grams</th>
<th>CO₂</th>
<th>O₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture, %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Md_run</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mw_run</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Sampling Information**

<table>
<thead>
<tr>
<th>Port</th>
<th>Point</th>
<th>Dwell Time, (Min.)</th>
<th>Elapsed Time, h:m:s</th>
<th>Meter Volume (ft³)</th>
<th>δP (in. H₂O)</th>
<th>Meter Temp. (°F)</th>
<th>Stack Temp. (°F)</th>
<th>Cyclone Temp. (°F)</th>
<th>Impinger Exit Gas Temp., (°F)</th>
<th>δH (in. H₂O)</th>
<th>Sample Train Vac. (in. Hg)</th>
<th>Probe Temp. (°F)</th>
<th>Run Cumulative D₅₀,d, Microns</th>
<th>PM₁₀</th>
<th>PM₂.₅</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>L</td>
<td>10.88</td>
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<td>.16</td>
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| Total Run Time | 1:38:16 |
| Total Volume, ACF | 341.604 |

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**Method 4 - Air Control Techniques, P.C.**

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### Moisture Data

#### Impinger 1
- **Contents - 100ml H2O**
  - Final Weight, grams: 934.2, 924.5, 830.6
  - Initial Weight, grams: 697.7, 700.2, 662.4
  - Condensed Water, grams: 36.5, 124.3, 168.2

#### Impinger 2
- **Contents - 100ml H2O**
  - 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 \times 17.64 \times Vm \times (Pbar+(D 
H/13.6)) \times (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

**IDENTIFICATION INFORMATION**
- Plant Name: 
- City: 
- State: 
- Source Number: EAST
- Sampling Location: Scrubber Stack
- Test Personnel: TTB, JMA
- Meterbox ID: X177
- Filter ID: 
- Tare:
- \( \Delta H \): 1551
- Gamma, \( \gamma \): 0.3338
- Nozzle ID: 8
- Nozzle Diameter: 0.232
- Orsat/Fyrite: XVR

**PRELIMINARY CHECKS AND DATA**
- Full Train Pretest Leak Check, ACFM: 0.000 < 0.02 or 4% 15
- Partial Train Posttest Leak Check, ACFM: 0.000
- (Remove cyclone sampling head before posttest leak check. Keep cyclone head upright prior to recovery.) Do not leak check during port changes.
- Pitot Tube Pretest Leak Check: N/A
- Pitot Tube Posttest Leak Check: N/A
- Barometric Pressure, In., Hg: 29.8
- Static Pressure, In. W.C.: -0.08

**ACTUAL MOISTURE & GAS COMPOSITION**
- Water Recovered, grams: 
- \( \text{CO}_2 \) %: 1
- \( \text{O}_2 \) %: 21
- Moisture, %: 
- Md_run: 
- Mw_run: 

**Sampling Information**

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<th>Elapsed Time, h:mins</th>
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<th>Meter Temp. (°F)</th>
<th>Stack Temp. (°F)</th>
<th>Cyclone Temp. (°F)</th>
<th>Impinger Exit Gas Temp. (°F)</th>
<th>( \delta H ) (in. H₂O)</th>
<th>Sample Train Vac. (In. Hg)</th>
<th>Probe Temp. (°F)</th>
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**QA Checks**
- Run ID: U2-4
- Condition: 
- Total Run Time: 
- Total Volume, ACF: 

**Averages**

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<th>°F</th>
<th>°F</th>
<th>in H₂O</th>
<th>%</th>
<th>microns</th>
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**Notes:**
- Barometric pressure and static pressure readings are provided.
- Leak checks are conducted as per the specified guidelines.
- Sampling information includes detailed data on dwell times, elapsed times, meter volumes, and temperatures.
- Moisture and gas composition readings are documented.
- QA checks list the run IDs and conditions with cumulative micron values and other relevant data points.

---

**Additional Observation:**
- The data sheet provides a comprehensive overview of the testing and sampling procedures, ensuring consistent and accurate data collection.
- The inclusion of detailed readings facilitates the analysis of environmental conditions and emissions.
## Combined Cyclone PM10 & PM2.5 Run Data Sheet

### IDENTIFICATION INFORMATION
- **Plant Name**: [Blank]
- **City**: [Blank]
- **State**: [Blank]
- **Source Number**: East
- **Sampling Location**: Scrubber Stack
- **Test Personnel**: TTB, JMA
- **Meterbox ID**: 167
- **ΔH**: 1.67
- **Gamma, γ**: 0.4233
- **Nozzle ID**: X8
- **Nozzle Diameter**: 0.332
- **Orsat/Fyrite**: PV

### PRELIMINARY CHECKS AND DATA
- **Actual**: 0.000
- **Req'd**: < 0.02 or 4%
- **Vacuum**: 15

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

- **Pitot Tube Pretest Leak Check**: NA
- **Pitot Tube Posttest Leak Check**: NA

- **Barometric Pressure, In. Hg**: 29.8
- **Static Pressure, In. W.C.**: -0.08

### ACTUAL MOISTURE & GAS COMPOSITION
- **Water Recovered, grams**: [Blank]
- **CO₂ %**: [Blank]
- **O₂ %**: 21%
- **Moisture, %**: [Blank]
- **Md_run**: [Blank]
- **Mw_run**: [Blank]

### Sampling Information

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<th>Stack Temp (°F)</th>
<th>Cyclone Temp (°F)</th>
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**Total Run Time**: 1:23:42

**Total Volume, ACF**: [Blank]

**Averages**: [Blank]

### QA Checks
- **in. H₂O**: [Blank]
- **°F**: [Blank]
- **%**: [Blank]
- **microns**: [Blank]
# Combined Cyclone PM10 & PM2.5 Run Data Sheet

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<table>
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### Preliminary Checks and Data

- **Full Train Pretest Leak Check, ACFM**: 0.000, **< 0.02 or 4%**
- **Partial Train Posttest Leak Check, ACFM**: 0.020, 15

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

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

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### Actual Moisture & Gas Composition

- **Water Recovered, grams**: 
- **CO₂ %**: 
- **O₂ %**: 
- **Moisture, %**: 
- **Md_run**: 
- **Mw_run**: 

### Sampling Information

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### QA Checks

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<thead>
<tr>
<th>Run Cumulative</th>
<th>D₅₀, microns</th>
<th>PM₁₀</th>
<th>PM₂.5</th>
</tr>
</thead>
</table>

Total Run Time
Total Volume, ACF
Run
Averages

<table>
<thead>
<tr>
<th>in. H₂O</th>
<th>°F</th>
<th>°F</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>in H₂O</th>
<th>%</th>
<th>microns</th>
</tr>
</thead>
</table>
APPENDIX D

CALIBRATION DATA
### APEX INSTRUMENTS METHOD 5 PRE-TEST CONSOLE CALIBRATION

**USING CALIBRATED CRITICAL ORIFICES**

**5-POINT ENGLISH UNITS**

<table>
<thead>
<tr>
<th>Meter Console Information</th>
<th>Calibration Conditions</th>
<th>Factors/Conversions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Console Model Number</td>
<td>Date</td>
<td>Std Temp</td>
</tr>
<tr>
<td></td>
<td></td>
<td>528</td>
</tr>
<tr>
<td>Console Serial Number</td>
<td>Time</td>
<td>°R</td>
</tr>
<tr>
<td>702233</td>
<td>12/27/11</td>
<td></td>
</tr>
<tr>
<td>DGM Model Number</td>
<td>Barometric Pressure</td>
<td>Std Press</td>
</tr>
<tr>
<td>RW 110</td>
<td>29.60</td>
<td>29.92</td>
</tr>
<tr>
<td>DGM Serial Number</td>
<td>Theoretical Critical Vacuum</td>
<td>in Hg</td>
</tr>
<tr>
<td></td>
<td>13.97</td>
<td>13.97</td>
</tr>
<tr>
<td></td>
<td>Calibration Technician</td>
<td>Kt</td>
</tr>
<tr>
<td></td>
<td>DLS</td>
<td>17.647</td>
</tr>
</tbody>
</table>

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

The Critical Orifice Coefficient, K, must be entered in English units, (r^2+R^2)/(r Hg/ min).

<table>
<thead>
<tr>
<th>Run Time</th>
<th>DGM Orifice (P)</th>
<th>Volume Initial (V)</th>
<th>Volume Final (V)</th>
<th>Outlet Temp Initial (T)</th>
<th>Outlet Temp Final (T)</th>
<th>Serial Number</th>
<th>Coefficient (K)</th>
<th>Critical Orifice (K)</th>
<th>Actual Vacuum (in Hg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(in H₂O)</td>
<td>cubic feet</td>
<td>cubic feet</td>
<td>°F</td>
<td>°F</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17.0</td>
<td>0.25</td>
<td>351.760</td>
<td>357.759</td>
<td>69</td>
<td>69</td>
<td>FO 40</td>
<td>0.2387</td>
<td>67</td>
<td>23</td>
</tr>
<tr>
<td>12.5</td>
<td>0.58</td>
<td>357.670</td>
<td>363.273</td>
<td>69</td>
<td>69</td>
<td>FO 48</td>
<td>0.3483</td>
<td>67</td>
<td>22</td>
</tr>
<tr>
<td>8.5</td>
<td>1.05</td>
<td>363.860</td>
<td>369.286</td>
<td>69</td>
<td>69</td>
<td>FO 55</td>
<td>0.4592</td>
<td>67</td>
<td>20</td>
</tr>
<tr>
<td>7.0</td>
<td>1.65</td>
<td>369.500</td>
<td>375.244</td>
<td>69</td>
<td>69</td>
<td>FO 63</td>
<td>0.5907</td>
<td>67</td>
<td>18</td>
</tr>
<tr>
<td>5.5</td>
<td>3.15</td>
<td>375.530</td>
<td>381.665</td>
<td>69</td>
<td>69</td>
<td>FO 73</td>
<td>0.8085</td>
<td>67</td>
<td>16</td>
</tr>
</tbody>
</table>

### Results

<table>
<thead>
<tr>
<th>Standardized Data</th>
<th>Calibration Factor</th>
<th>Dry Gas Meter</th>
<th>Flowrate</th>
<th>Variation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Value (Y)</td>
<td>(Y)</td>
<td>0.9404</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td>(AY)</td>
<td>(Q_{actual})</td>
<td>0.9379</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Q_{actual})</td>
<td>0.9369</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Q_{actual})</td>
<td>0.9362</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Q_{actual})</td>
<td>0.9391</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.9381</td>
<td>Y Average</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Meter Console Information</th>
<th>Calibration Conditions</th>
<th>Factors/Conversions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Console Model Number</td>
<td>Date</td>
<td>Std Temp</td>
</tr>
<tr>
<td>Console Serial Number</td>
<td>Time</td>
<td>528 °R</td>
</tr>
<tr>
<td>DGM Model Number</td>
<td>11/06/12</td>
<td>Std Press</td>
</tr>
<tr>
<td>DGM Serial Number</td>
<td></td>
<td>29.92 in Hg</td>
</tr>
<tr>
<td></td>
<td>Barometric Pressure</td>
<td>K&lt;sub&gt;s&lt;/sub&gt;</td>
</tr>
<tr>
<td></td>
<td>29.8</td>
<td>17.647 cm Hg</td>
</tr>
<tr>
<td></td>
<td>Theoretical Critical Vacuum&lt;sup&gt;1&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>14.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Calibration Technician</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DLS</td>
<td></td>
</tr>
</tbody>
</table>

<sup>1</sup>For valid test results, the Actual Vacuum should be 1 to 2 in. Hg greater than the Theoretical Critical Vacuum shown above.

<sup>2</sup>The Critical Orifice Coefficient, K<sub>c</sub>, must be entered in English units, (ft<sup>2</sup>·°R<sup>1</sup>)/(in·Hg·min).

<table>
<thead>
<tr>
<th>Run Time</th>
<th>DGM Orifice (P&lt;sub&gt;o&lt;/sub&gt;)</th>
<th>Volume Initial (V&lt;sub&gt;oi&lt;/sub&gt;)</th>
<th>Volume Final (V&lt;sub&gt;of&lt;/sub&gt;)</th>
<th>Outlet Temp Initial (T&lt;sub&gt;oi&lt;/sub&gt;)</th>
<th>Outlet Temp Final (T&lt;sub&gt;of&lt;/sub&gt;)</th>
<th>Serial Number</th>
<th>Coefficient K&lt;sub&gt;c&lt;/sub&gt;</th>
<th>Amb Temp Initial (T&lt;sub&gt;ai&lt;/sub&gt;)</th>
<th>Amb Temp Final (T&lt;sub&gt;a&lt;/sub&gt;f)</th>
<th>Actual Vacuum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>in H&lt;sub&gt;2&lt;/sub&gt;O cubic feet cubic feet °F °F</td>
<td>FO 48 0.5907 68 68 19.00</td>
<td>FO 48 0.5907 68 68 19.00</td>
<td>FO 48 0.5907 68 68 19.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8.0 1.65</td>
<td>66.900</td>
<td>73.399</td>
<td>73 75</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8.0 1.65</td>
<td>73.399</td>
<td>79.922</td>
<td>75 75</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standardized Data</th>
<th>Critical Orifice</th>
<th>Dry Gas Meter</th>
<th>Flowrate</th>
<th>Variation</th>
<th>Dry Gas Meter</th>
<th>0.75 SCFM</th>
<th>Variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>(V&lt;sub&gt;oi&lt;/sub&gt;)</td>
<td>(Q&lt;sub&gt;oi&lt;/sub&gt;)</td>
<td>(V&lt;sub&gt;of&lt;/sub&gt;)</td>
<td>(Q&lt;sub&gt;of&lt;/sub&gt;)</td>
<td>Value</td>
<td>Variation</td>
<td>Std &amp; Corr</td>
<td>(Q&lt;sub&gt;0.75&lt;/sub&gt;)</td>
</tr>
<tr>
<td>cubic feet</td>
<td>cfm</td>
<td>cubic feet</td>
<td>cfm</td>
<td>(Y)</td>
<td>(ΔY)</td>
<td>in H&lt;sub&gt;2&lt;/sub&gt;O</td>
<td>(ΔH@)</td>
</tr>
<tr>
<td>6.426</td>
<td>0.803</td>
<td>6.129</td>
<td>0.766</td>
<td>0.954</td>
<td>0.000</td>
<td>0.766</td>
<td>1.571</td>
</tr>
<tr>
<td>6.438</td>
<td>0.805</td>
<td>6.129</td>
<td>0.766</td>
<td>0.952</td>
<td>-0.002</td>
<td>0.766</td>
<td>1.568</td>
</tr>
<tr>
<td>6.418</td>
<td>0.802</td>
<td>6.129</td>
<td>0.766</td>
<td>0.955</td>
<td>0.001</td>
<td>0.766</td>
<td>1.568</td>
</tr>
<tr>
<td>Pretest Gamma</td>
<td>0.9381</td>
<td>% Deviation</td>
<td>1.6</td>
<td>0.953</td>
<td>Y Average</td>
<td>1.569</td>
<td>(ΔH@) Average</td>
</tr>
</tbody>
</table>

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  TT B  Date  11/06/12
# APEX INSTRUMENTS METHOD 5 PRE-TEST CONSOLE CALIBRATION

**USING CALIBRATED CRITICAL ORIFICES**

**5-POINT ENGLISH UNITS**

<table>
<thead>
<tr>
<th>Meter Console Information</th>
<th>Calibration Conditions</th>
<th>Factors/Conversions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Console Model Number</strong></td>
<td><strong>Date</strong> 05/25/12</td>
<td><strong>Std Temp</strong> 528°F</td>
</tr>
<tr>
<td><strong>Console Serial Number</strong></td>
<td>Barometric Pressure 30.00 in Hg</td>
<td><strong>Std Press</strong> 29.92 in Hg</td>
</tr>
<tr>
<td><strong>DGM Model Number</strong></td>
<td>Theoretical Critical Vacuum 14.16 in Hg</td>
<td><strong>K_r</strong> 17.647 in/h in Hg</td>
</tr>
<tr>
<td><strong>DGM Serial Number</strong></td>
<td>Calibration Technician DLS</td>
<td></td>
</tr>
</tbody>
</table>

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·h·atm)/(in·Hg·min).

### Calibration Data

<table>
<thead>
<tr>
<th>Run Time</th>
<th>GDM Orifice psi</th>
<th>Volume Initial (V_i,1)</th>
<th>Volume Final (V_i,2)</th>
<th>Outlet Temp Initial (T_i) °F</th>
<th>Outlet Temp Final (T_f) °F</th>
<th>Serial Number</th>
<th>Critical Orifice (K')</th>
<th>Amb Temp Initial (T_i) °F</th>
<th>Amb Temp Final (T_f) °F</th>
<th>Actual Vacuum (H) in Hg</th>
</tr>
</thead>
<tbody>
<tr>
<td>17.5 min</td>
<td>0.35</td>
<td>312.399</td>
<td>317.974</td>
<td>70</td>
<td>71</td>
<td>FO 40</td>
<td>0.2387</td>
<td>67</td>
<td>67</td>
<td>24</td>
</tr>
<tr>
<td>12.0 min</td>
<td>0.715</td>
<td>318.200</td>
<td>323.788</td>
<td>71</td>
<td>71</td>
<td>FO 48</td>
<td>0.3483</td>
<td>67</td>
<td>67</td>
<td>22</td>
</tr>
<tr>
<td>9.0 min</td>
<td>1.20</td>
<td>323.900</td>
<td>329.432</td>
<td>71</td>
<td>71</td>
<td>FO 55</td>
<td>0.4592</td>
<td>67</td>
<td>67</td>
<td>21</td>
</tr>
<tr>
<td>7.0 min</td>
<td>1.95</td>
<td>329.700</td>
<td>335.282</td>
<td>71</td>
<td>71</td>
<td>FO 63</td>
<td>0.5907</td>
<td>67</td>
<td>67</td>
<td>19</td>
</tr>
<tr>
<td>5.5 min</td>
<td>3.56</td>
<td>335.900</td>
<td>341.842</td>
<td>71</td>
<td>71</td>
<td>FO 73</td>
<td>0.8085</td>
<td>67</td>
<td>67</td>
<td>17</td>
</tr>
</tbody>
</table>

### Standardized Data

<table>
<thead>
<tr>
<th>Dry Gas Meter (V_actual)</th>
<th>Critical Orifice (ΔH@)</th>
<th>Value (Y)</th>
<th>Variation (ΔY)</th>
<th>Calibration Factor</th>
<th>Flowrate (Q)</th>
<th>Std &amp; Corr (ΔH@)</th>
<th>Variation (ΔH@)</th>
</tr>
</thead>
<tbody>
<tr>
<td>cubic feet</td>
<td>in</td>
<td>cubic feet</td>
<td>in</td>
<td>5.568</td>
<td>0.318</td>
<td>5.495</td>
<td>0.312</td>
</tr>
<tr>
<td>5.581</td>
<td>0.465</td>
<td>5.462</td>
<td>0.455</td>
<td>0.9787</td>
<td>0.002</td>
<td>0.455</td>
<td>1.944</td>
</tr>
<tr>
<td>5.532</td>
<td>0.615</td>
<td>5.401</td>
<td>0.600</td>
<td>0.9763</td>
<td>0.000</td>
<td>0.600</td>
<td>1.881</td>
</tr>
<tr>
<td>5.553</td>
<td>0.793</td>
<td>5.404</td>
<td>0.772</td>
<td>0.9731</td>
<td>-0.003</td>
<td>0.772</td>
<td>1.854</td>
</tr>
<tr>
<td>5.976</td>
<td>1.087</td>
<td>5.811</td>
<td>1.057</td>
<td>0.9724</td>
<td>-0.004</td>
<td>1.057</td>
<td>1.816</td>
</tr>
</tbody>
</table>

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**

<table>
<thead>
<tr>
<th>Meter Console Information</th>
<th>Calibration Conditions</th>
<th>Factors/Conversions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Console Model Number</strong></td>
<td>Date: 11/07/12 Time: 13:30</td>
<td>Std Temp: 528 °R</td>
</tr>
<tr>
<td><strong>Console Serial Number</strong></td>
<td>Barometric Pressure: 30.00 in Hg</td>
<td>Std Press: 29.92 in Hg</td>
</tr>
<tr>
<td><strong>DGM Model Number</strong></td>
<td>Theoretical Critical Vacuum: 14.2 in Hg</td>
<td>K&lt;sub&gt;c&lt;/sub&gt;: 17.647 ± 0.001 in Hg</td>
</tr>
<tr>
<td><strong>DGM Serial Number</strong></td>
<td>Calibration Technician: DGG</td>
<td></td>
</tr>
</tbody>
</table>

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<sub>c</sub>, must be entered in English units, \( \frac{\mathrm{ft}^2}{\mathrm{lb} \cdot \mathrm{min}} \).

<table>
<thead>
<tr>
<th>Run Time</th>
<th>DGM Orifice ( \Delta H )</th>
<th>Volume Console Initial ( V_{in} )</th>
<th>Volume Console Final ( V_{out} )</th>
<th>Outlet Temp Initial ( T_{in} ) (°F)</th>
<th>Outlet Temp Final ( T_{out} ) (°F)</th>
<th>Serial Number</th>
<th>Critical Orifice ( K_c )</th>
<th>Amb Temp Initial ( T_{amb} ) (°F)</th>
<th>Amb Temp Final ( T_{amb} ) (°F)</th>
<th>Actual Vacuum ( T_{act} ) (in. Hg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20.0</td>
<td>0.35</td>
<td>743.800</td>
<td>750.072</td>
<td>60</td>
<td>61</td>
<td>FO40</td>
<td>0.2387</td>
<td>62</td>
<td>64</td>
<td>23.00</td>
</tr>
<tr>
<td>20.0</td>
<td>0.35</td>
<td>750.072</td>
<td>756.377</td>
<td>61</td>
<td>62</td>
<td>FO40</td>
<td>0.2387</td>
<td>64</td>
<td>64</td>
<td>22.00</td>
</tr>
<tr>
<td>20.0</td>
<td>0.35</td>
<td>756.377</td>
<td>762.726</td>
<td>63</td>
<td>65</td>
<td>FO40</td>
<td>0.2387</td>
<td>63</td>
<td>63</td>
<td>22.00</td>
</tr>
</tbody>
</table>

#### Results

<table>
<thead>
<tr>
<th>Dry Gas Meter</th>
<th>Critical Orifice</th>
<th>Calibration Factor</th>
<th>Dry Gas Meter</th>
<th>Flowrate</th>
<th>( \Delta H @ )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_{in,m} )</td>
<td>( Q_{in,m} )</td>
<td>( Q_{out,m} )</td>
<td>( \Delta H )</td>
<td>0.75 SCFM</td>
<td>Variation</td>
</tr>
<tr>
<td>cubic feet</td>
<td>cfm</td>
<td>cfm</td>
<td>( Y )</td>
<td>( \Delta Y )</td>
<td>( \Delta H )</td>
</tr>
<tr>
<td>6.385</td>
<td>0.319</td>
<td>6.263</td>
<td>0.313</td>
<td>0.9809</td>
<td>0.003</td>
</tr>
<tr>
<td>6.406</td>
<td>0.320</td>
<td>6.257</td>
<td>0.313</td>
<td>0.9768</td>
<td>-0.001</td>
</tr>
<tr>
<td>6.420</td>
<td>0.321</td>
<td>6.263</td>
<td>0.313</td>
<td>0.975</td>
<td>-0.002</td>
</tr>
<tr>
<td>Pretest Gamma</td>
<td>0.9752</td>
<td>% Deviation 0.1</td>
<td>0.976</td>
<td>Y Average</td>
<td>2.043</td>
</tr>
</tbody>
</table>

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: 11/07/12
### APEX INSTRUMENTS METHOD 5 PRE-TEST CONSOLE CALIBRATION
USING CALIBRATED CRITICAL ORIFICES

#### 5-POINT ENGLISH UNITS

<table>
<thead>
<tr>
<th>Meter Console Information</th>
<th>Calibration Conditions</th>
<th>Factors/Conversions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Console Model Number</strong></td>
<td>Date: 06/08/12</td>
<td>Std Temp: 528</td>
</tr>
<tr>
<td><strong>Console Serial Number</strong></td>
<td></td>
<td>Std Press: 29.92 in Hg</td>
</tr>
<tr>
<td><strong>DGM Model Number</strong></td>
<td>Barometric Pressure: 29.90 in Hg</td>
<td>K&lt;sub&gt;r&lt;/sub&gt;: 29.92</td>
</tr>
<tr>
<td><strong>DGM Serial Number</strong></td>
<td>Theoretical Critical Vacuum: 14.11 in Hg</td>
<td>Calibration Technician: DLS</td>
</tr>
</tbody>
</table>

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<sub>r</sub>, must be entered in English units, \((\text{ec}^{-0.62})(\text{in.Hg})^{-0.5})\).

#### Calibration Data

<table>
<thead>
<tr>
<th>Run Time (min)</th>
<th>DGM Orifice Pressure (P&lt;sub&gt;d&lt;/sub&gt;)</th>
<th>DGM Orifice</th>
<th>Volume Initial (V&lt;sub&gt;in&lt;/sub&gt;)</th>
<th>Volume Final (V&lt;sub&gt;fin&lt;/sub&gt;)</th>
<th>Outlet Temp Initial (T&lt;sub&gt;i&lt;/sub&gt;)</th>
<th>Outlet Temp Final (T&lt;sub&gt;f&lt;/sub&gt;)</th>
<th>Serial Number</th>
<th>Coefficient (K&lt;sub&gt;r&lt;/sub&gt;)</th>
<th>Actual Vacuum (in Hg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>17.5</td>
<td>0.25</td>
<td>182.600</td>
<td>187.934</td>
<td>77</td>
<td>77</td>
<td>FO 40</td>
<td>0.2387</td>
<td>72</td>
<td>23</td>
</tr>
<tr>
<td>13.0</td>
<td>0.55</td>
<td>188.140</td>
<td>193.946</td>
<td>77</td>
<td>78</td>
<td>FO 48</td>
<td>0.3483</td>
<td>72</td>
<td>22</td>
</tr>
<tr>
<td>11.0</td>
<td>0.99</td>
<td>194.050</td>
<td>200.507</td>
<td>78</td>
<td>78</td>
<td>FO 55</td>
<td>0.4592</td>
<td>72</td>
<td>20</td>
</tr>
<tr>
<td>7.5</td>
<td>1.65</td>
<td>201.800</td>
<td>207.542</td>
<td>78</td>
<td>78</td>
<td>FO 63</td>
<td>0.5907</td>
<td>72</td>
<td>18</td>
</tr>
<tr>
<td>5.5</td>
<td>3.10</td>
<td>207.720</td>
<td>213.452</td>
<td>78</td>
<td>78</td>
<td>FO 73</td>
<td>0.8085</td>
<td>72</td>
<td>17</td>
</tr>
</tbody>
</table>

#### Results

<table>
<thead>
<tr>
<th>Dry Gas Meter (V&lt;sub&gt;meas&lt;/sub&gt;)</th>
<th>Critical Orifice (Q&lt;sub&gt;meas&lt;/sub&gt;)</th>
<th>Calibration Factor (Y)</th>
<th>% Variation</th>
<th>Std &amp; Corr ((\Delta H))</th>
<th>Flowrate ((\Delta H))</th>
<th>Variation ((\Delta H))</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.244 cfm</td>
<td>0.300 cubic feet</td>
<td>1.0326</td>
<td>0.007</td>
<td>0.309</td>
<td>1.417</td>
<td>-0.105</td>
</tr>
<tr>
<td>5.707 cubic feet</td>
<td>0.439 cubic feet</td>
<td>1.0284</td>
<td>0.003</td>
<td>0.452</td>
<td>1.495</td>
<td>-0.027</td>
</tr>
<tr>
<td>6.348 cubic feet</td>
<td>0.577 cubic feet</td>
<td>1.0315</td>
<td>0.006</td>
<td>0.595</td>
<td>1.550</td>
<td>0.028</td>
</tr>
<tr>
<td>5.664 cubic feet</td>
<td>0.754 cubic feet</td>
<td>1.0157</td>
<td>-0.009</td>
<td>0.766</td>
<td>1.566</td>
<td>0.044</td>
</tr>
<tr>
<td>5.665 cubic feet</td>
<td>1.030 cubic feet</td>
<td>1.0176</td>
<td>-0.008</td>
<td>1.048</td>
<td>1.582</td>
<td>0.060</td>
</tr>
<tr>
<td>1.0252 cubic feet</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.522</td>
<td></td>
</tr>
</tbody>
</table>

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: 06/08/12
## APEX INSTRUMENTS METHOD 5 POST-TEST CONSOLE CALIBRATION

### USING CALIBRATED CRITICAL ORIFICES

#### 1-POINT ENGLISH UNITS

<table>
<thead>
<tr>
<th>Meter Console Information</th>
<th>Calibration Data</th>
<th>Factors/Conversions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Console Model Number</strong></td>
<td><strong>Date</strong></td>
<td><strong>Time</strong></td>
</tr>
<tr>
<td>522</td>
<td>10/26/12</td>
<td></td>
</tr>
<tr>
<td><strong>Console Serial Number</strong></td>
<td><strong>Barometric Pressure</strong></td>
<td>in Hg</td>
</tr>
<tr>
<td>802012</td>
<td>29.90</td>
<td>in Hg</td>
</tr>
<tr>
<td><strong>DGM Model Number</strong></td>
<td><strong>Theoretical Critical Vacuum</strong></td>
<td>in Hg</td>
</tr>
<tr>
<td>RW 110</td>
<td>14.1</td>
<td>in Hg</td>
</tr>
<tr>
<td><strong>DGM Serial Number</strong></td>
<td><strong>Calibration Technician</strong></td>
<td></td>
</tr>
<tr>
<td>964447</td>
<td>DR</td>
<td></td>
</tr>
</tbody>
</table>

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

2The Critical Orifice Coefficient, K', must be entered in English units, \((ft^2 \cdot \text{in.}\cdot \text{Hg} \cdot \text{min})\).

### Run Time

<table>
<thead>
<tr>
<th>Run Time</th>
<th>DGM Orifice</th>
<th>Volume Initial</th>
<th>Volume Final</th>
<th>Outlet Temp Initial</th>
<th>Outlet Temp Final</th>
<th>Serial Number</th>
<th>Coefficient</th>
<th>Amb Temp Initial</th>
<th>Actual Vacuum</th>
</tr>
</thead>
<tbody>
<tr>
<td>(min)</td>
<td>((P_o))</td>
<td>((V_o)) cubic feet</td>
<td>((V_f)) cubic feet</td>
<td>((T_o)) °F</td>
<td>((T_f)) °F</td>
<td>K' ((\text{in. Hg} \cdot \text{min}))</td>
<td>((T_{amb})) °F</td>
<td>((T_{amb} )) °F</td>
<td>in Hg</td>
</tr>
<tr>
<td>10.0</td>
<td>1.60</td>
<td>346.711</td>
<td>354.428</td>
<td>68</td>
<td>70</td>
<td>FO03</td>
<td>0.5907</td>
<td>70</td>
<td>71</td>
</tr>
<tr>
<td>10.0</td>
<td>1.60</td>
<td>354.428</td>
<td>362.204</td>
<td>70</td>
<td>72</td>
<td>FO03</td>
<td>0.5907</td>
<td>71</td>
<td>72</td>
</tr>
<tr>
<td>10.0</td>
<td>1.60</td>
<td>362.204</td>
<td>370.061</td>
<td>72</td>
<td>73</td>
<td>FO03</td>
<td>0.5907</td>
<td>73</td>
<td>73</td>
</tr>
</tbody>
</table>

### Results

#### Dry Gas Meter

<table>
<thead>
<tr>
<th>Standardized Data</th>
<th>Critical Orifice</th>
<th>Calibration Factor</th>
<th>Dry Gas Meter</th>
<th>(\Delta H ) @</th>
</tr>
</thead>
<tbody>
<tr>
<td>((V_{meas})) cubic feet</td>
<td>((Q_{meas})) cfm</td>
<td>((V_{critical})) cubic feet</td>
<td>((Q_{critical})) cfm</td>
<td>Value</td>
</tr>
<tr>
<td>7.728</td>
<td>7.76</td>
<td>0.9623</td>
<td>0.006</td>
<td>0.767</td>
</tr>
<tr>
<td>7.757</td>
<td>7.76</td>
<td>0.9876</td>
<td>0.001</td>
<td>0.766</td>
</tr>
<tr>
<td>7.816</td>
<td>7.66</td>
<td>0.9788</td>
<td>-0.007</td>
<td>0.765</td>
</tr>
<tr>
<td>Pretest Gamma</td>
<td>1.0252</td>
<td>3.8</td>
<td>0.9862</td>
<td>Y Average</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th><strong>Meter Console Information</strong></th>
<th><strong>Factors/Conversions</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Console Model Number: 522</td>
<td>Std Temp: 526</td>
</tr>
<tr>
<td>Console Serial Number: 11077</td>
<td>°R</td>
</tr>
<tr>
<td>DGM Model Number: RW 110</td>
<td>Std Press: 29.92</td>
</tr>
<tr>
<td>DGM Serial Number: 964447</td>
<td>in Hg</td>
</tr>
</tbody>
</table>

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, (m^-0.5°F)(in.Hg.min).

<table>
<thead>
<tr>
<th>Run Time Elapsed (min)</th>
<th>DGM Orifice Volume Initial (cubic feet)</th>
<th>DGM Orifice Volume Final (cubic feet)</th>
<th>Metering Console Volume Initial (cubic feet)</th>
<th>Volume Final (cubic feet)</th>
<th>Outlet Temp Initial (°F)</th>
<th>Outlet Temp Final (°F)</th>
<th>Serial Number</th>
<th>Coefficient</th>
<th>Ambient Temp Initial (°F)</th>
<th>Ambient Temp Final (°F)</th>
<th>Actual Vacuum (in Hg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>17.5</td>
<td>0.265</td>
<td>984.520</td>
<td>990.031</td>
<td></td>
<td>74</td>
<td>74</td>
<td>FO 40</td>
<td>0.2387</td>
<td>73</td>
<td>73</td>
<td>23</td>
</tr>
<tr>
<td>17.0</td>
<td>0.59</td>
<td>990.160</td>
<td>998.013</td>
<td></td>
<td>73</td>
<td>73</td>
<td>FO 48</td>
<td>0.3483</td>
<td>73</td>
<td>73</td>
<td>22</td>
</tr>
<tr>
<td>10.0</td>
<td>1.05</td>
<td>998.200</td>
<td>1004.320</td>
<td></td>
<td>74</td>
<td>75</td>
<td>FO 55</td>
<td>0.4592</td>
<td>73</td>
<td>73</td>
<td>20</td>
</tr>
<tr>
<td>7.0</td>
<td>1.75</td>
<td>1004.520</td>
<td>1010.038</td>
<td></td>
<td>75</td>
<td>75</td>
<td>FO 63</td>
<td>0.5907</td>
<td>73</td>
<td>73</td>
<td>19</td>
</tr>
<tr>
<td>5.5</td>
<td>3.25</td>
<td>1010.260</td>
<td>1016.187</td>
<td></td>
<td>75</td>
<td>75</td>
<td>FO 73</td>
<td>0.8085</td>
<td>73</td>
<td>73</td>
<td>16</td>
</tr>
</tbody>
</table>

### Results

<table>
<thead>
<tr>
<th>Standardized Data</th>
<th>Critical Orifice</th>
<th>Calibration Factor</th>
<th>Dry Gas Meter Flowrate (°F)</th>
<th>Dry Gas Meter Flowrate (in H2O)</th>
<th>ΔH @ Value</th>
<th>Variation</th>
<th>Std &amp; Corr</th>
<th>0.75 SCFM (ΔH@)</th>
<th>Variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>(V_{\text{meter}})</td>
<td>(Q_{\text{meter}})</td>
<td>(V_{\text{Orifice}})</td>
<td>(Q_{\text{Orifice}})</td>
<td>(\gamma)</td>
<td>(\Delta\gamma)</td>
<td>(\text{Std} &amp; \text{Corr})</td>
<td>(0.75 \text{ SCFM})</td>
<td>(\Delta H)</td>
<td>(\Delta H)</td>
</tr>
<tr>
<td>cubic feet</td>
<td>cfm</td>
<td>cubic feet</td>
<td>cfm</td>
<td>(0.9926)</td>
<td>0.010</td>
<td>0.306</td>
<td>1.560</td>
<td>-0.091</td>
<td></td>
</tr>
<tr>
<td>5.394</td>
<td>0.308</td>
<td>5.356</td>
<td>0.306</td>
<td>(0.9850)</td>
<td>0.002</td>
<td>0.447</td>
<td>1.637</td>
<td>-0.014</td>
<td></td>
</tr>
<tr>
<td>7.077</td>
<td>0.453</td>
<td>7.592</td>
<td>0.447</td>
<td>(0.9816)</td>
<td>-0.002</td>
<td>0.589</td>
<td>1.575</td>
<td>0.025</td>
<td></td>
</tr>
<tr>
<td>5.997</td>
<td>0.600</td>
<td>5.887</td>
<td>0.589</td>
<td>(0.9798)</td>
<td>-0.004</td>
<td>0.757</td>
<td>1.692</td>
<td>0.041</td>
<td></td>
</tr>
<tr>
<td>5.411</td>
<td>0.773</td>
<td>5.301</td>
<td>0.757</td>
<td>(0.9773)</td>
<td>-0.006</td>
<td>1.037</td>
<td>1.689</td>
<td>0.039</td>
<td></td>
</tr>
<tr>
<td>5.834</td>
<td>1.061</td>
<td>5.701</td>
<td>1.037</td>
<td>(0.9833)</td>
<td>Y Average</td>
<td>1.651</td>
<td>ΔH Average</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** For Calibration Factor \(\gamma\), 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:** [Signature]

**Date:** 06-01-12
## APEX INSTRUMENTS METHOD 5 POST-TEST CONSOLE CALIBRATION
USING CALIBRATED CRITICAL ORIFICES
3-POINT ENGLISH UNITS

<table>
<thead>
<tr>
<th>Meter Console Information</th>
<th>Calibration Conditions</th>
<th>Factors/Conversions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Console Model Number</td>
<td>522</td>
<td>Std Temp 528</td>
</tr>
<tr>
<td>Console Serial Number</td>
<td>11077</td>
<td>in Hg</td>
</tr>
<tr>
<td>DGM Model Number</td>
<td>RW 110</td>
<td>Std Press 29.92</td>
</tr>
<tr>
<td>DGM Serial Number</td>
<td>96447</td>
<td>in Hg</td>
</tr>
<tr>
<td>Calibration Technician</td>
<td>TEH</td>
<td>K, 17.647 cR/in Hg</td>
</tr>
</tbody>
</table>

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, (inhg^-1/2)(in.Hg-mn).

### Run Time Data

<table>
<thead>
<tr>
<th>Run Time</th>
<th>DGM Orifice</th>
<th>Volume Initial</th>
<th>Outlet Temp Initial</th>
<th>Outlet Temp Final</th>
<th>Serial Number</th>
<th>Coefficient</th>
<th>Amb Temp Initial</th>
<th>Amb Temp Final</th>
<th>Actual Vacuum</th>
</tr>
</thead>
<tbody>
<tr>
<td>17.0 min</td>
<td>0.26</td>
<td>468.702</td>
<td>65</td>
<td>66</td>
<td>FO40</td>
<td>0.2378</td>
<td>69</td>
<td>69</td>
<td>24.50</td>
</tr>
<tr>
<td>17.0 min</td>
<td>0.26</td>
<td>474.072</td>
<td>66</td>
<td>67</td>
<td>FO40</td>
<td>0.2378</td>
<td>69</td>
<td>69</td>
<td>24.50</td>
</tr>
<tr>
<td>17.0 min</td>
<td>0.26</td>
<td>479.444</td>
<td>67</td>
<td>68</td>
<td>FO40</td>
<td>0.2378</td>
<td>69</td>
<td>69</td>
<td>24.50</td>
</tr>
</tbody>
</table>

### Results

<table>
<thead>
<tr>
<th>Dry Gas Meter</th>
<th>Critical Orifice</th>
<th>Calibration Factor</th>
<th>Flowrate</th>
<th>ΔH @</th>
</tr>
</thead>
<tbody>
<tr>
<td>(V_{mold})</td>
<td>(Q_{mold})</td>
<td>(Q_{corr})</td>
<td>(Q_{corr})</td>
<td>(ΔH @ 0.75 SCFM)</td>
</tr>
<tr>
<td>cubic feet</td>
<td>cfm</td>
<td>cubic feet</td>
<td>cfm</td>
<td></td>
</tr>
<tr>
<td>5.306</td>
<td>0.312</td>
<td>5.167</td>
<td>0.304</td>
<td>0.974</td>
</tr>
<tr>
<td>5.297</td>
<td>0.312</td>
<td>5.167</td>
<td>0.304</td>
<td>0.976</td>
</tr>
<tr>
<td>5.297</td>
<td>0.312</td>
<td>5.167</td>
<td>0.304</td>
<td>0.976</td>
</tr>
</tbody>
</table>

Pretest Gamma: 0.9833, % Deviation: 0.8

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.

<table>
<thead>
<tr>
<th>Nozzle Set ID</th>
<th>Nozzle ID</th>
<th>Average</th>
<th>Measurements</th>
<th>Maximum Variance</th>
<th>Condition</th>
<th>Date Inspected</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>1</td>
<td>0.123</td>
<td>0.123 0.122  0.123</td>
<td>0.001</td>
<td>New</td>
<td>7/30/12</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>0.133</td>
<td>0.133 0.133  0.133</td>
<td>0.000</td>
<td>New</td>
<td>7/30/12</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>0.153</td>
<td>0.153 0.153  0.153</td>
<td>0.000</td>
<td>New</td>
<td>7/30/12</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>0.171</td>
<td>0.171 0.171  0.170</td>
<td>0.001</td>
<td>New</td>
<td>7/30/12</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>0.185</td>
<td>0.185 0.185  0.185</td>
<td>0.000</td>
<td>New</td>
<td>7/30/12</td>
</tr>
<tr>
<td></td>
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By: [Signature]

Date: 7/30/12
## Precutter Nozzle Calibration and Inspection
### Air Control Techniques, P.C.

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*By: [Signature]*

*Date: 10/18/12*
APPENDIX E

ANALYTICAL DATA

RESOLUTION ANALYTICS

TOTAL and PM$_{2.5}$ FILTERABLE PARTICULATE MATTER
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
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

**Reporting Address:** Please attach a separate sheet of paper if billing address is different than reporting address.

**Company:** Air Control Techniques, PC  
**Street Address:** 301 East Durham Rd  
**City, State, Zip:** Cary, NC 27513  
**Contact:** John Richards

**Phone Number:** (919) 460-7811  
**Fax Number:** (919) 460-7877

## Sample ID / Run #

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<tr>
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<th>Train/Run Component</th>
<th>Train/Run Component</th>
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<td>2.5 acetone Water Rinse</td>
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## Chain of Custody:

Relinquished by (Signature)  
Date: 10/3/12  
Received by (Signature)  
Date: 10/3/12


do not hallucinate. turn of:

## Turnaround Time:

- [ ] 10 Days (Standard)  
- [ ] 5 Days (1.5x)  
- [ ] 3 Days (2x)  
- [ ] 2 Days (2.5x)  
- [ ] 24 Hours (3x)

## Analyses

- [ ] EPA 0011/TO-5/8315 analytes:  
- [ ] EPA 26A (HCl/C12) analytes:  
- [ ] VOC's (HPLC) analytes:  
- [ ] Ammonia (CTM-027)  
- [ ] NOx (EPA 7A/7D)  
- [ ] Filt Particulate (EPA 5)  
- [ ] Conden Part (EPA 202)  
- [ ] EPA 29 metals:  
- [ ] Ontario-Hydro (Hg)  
- [ ] EPA 101A (hg)  
- [ ] Other list

WHITE: Report Copy  
CANARY: Client Copy  
PINK: Lab Copy

JPC Form No. 37449A

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
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<th>Train/Run Component</th>
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OTM-036 WHITE: Report Copy CAN: Answer: Client Copy PINK: Lab Copy 4/11/2016 JPC Form No. 37488A
## Report Summary

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<td>S1-4</td>
<td>0.1 mg</td>
</tr>
<tr>
<td>S2-4</td>
<td>0.5 mg</td>
</tr>
<tr>
<td>U1-5</td>
<td>0.3 mg</td>
</tr>
<tr>
<td>U2-5</td>
<td>0.7 mg</td>
</tr>
<tr>
<td>S1-5</td>
<td>0.9 mg</td>
</tr>
<tr>
<td>S2-5</td>
<td>0.5 mg</td>
</tr>
<tr>
<td>U1-6</td>
<td>0.8 mg</td>
</tr>
<tr>
<td>U2-6</td>
<td>1.4 mg</td>
</tr>
<tr>
<td>S1-6</td>
<td>0.5 mg</td>
</tr>
<tr>
<td>S2-6</td>
<td>0.5 mg</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Run Number</th>
<th>U1-1 ≤2.5μg Acetone</th>
<th>U2-1 ≤2.5μg Acetone</th>
<th>S1-1 ≤2.5μg Acetone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
<tr>
<td>Baggie Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Filter Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>FILTER SAMPLE Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Front % Rinse Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
<tr>
<td>11/12/12 JSC</td>
<td>3.1668</td>
<td>11/12/12 JSC F</td>
<td>3.1664</td>
</tr>
<tr>
<td>11/12/12 JSC F</td>
<td>3.1664</td>
<td>11/12/12 F</td>
<td>3.3213</td>
</tr>
<tr>
<td>Tare Wt., g</td>
<td>( 50 ml)</td>
<td>3.1668 ( 50 ml)</td>
<td>3.3222 ( 50 ml)</td>
</tr>
<tr>
<td>RINSE SAMPLE Wt., g.</td>
<td>0.0016</td>
<td>0.0011</td>
<td>0.0012</td>
</tr>
<tr>
<td>Filter Catch, mg.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Rinse Catch, mg.</td>
<td>1.6</td>
<td>1.1</td>
<td>1.2</td>
</tr>
<tr>
<td>Rinse Blank Residue, mg.</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Net Rinse Catch, mg.</td>
<td>1.4</td>
<td>0.9</td>
<td>1.0</td>
</tr>
<tr>
<td>FILTERABLE PARTICULATE, mg.</td>
<td>1.4</td>
<td>0.9</td>
<td>1.0</td>
</tr>
</tbody>
</table>

**Legend:**

F = Final Weight

**Notes & Comments:**
## PARTICULATE SAMPLING LABORATORY RESULTS

**Client:** Air Control Techniques  
**Method:** EPA M5  
**RFA #:** 1756

<table>
<thead>
<tr>
<th>Run Number</th>
<th>S2-1</th>
<th>U1-2</th>
<th>U2-2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≤2.5μg Acetone</td>
<td>≤2.5μg Acetone</td>
<td>≤2.5μg Acetone</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Filter Container #</th>
<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baggie Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td></td>
</tr>
<tr>
<td>Filter Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td></td>
</tr>
<tr>
<td>FILTER SAMPLE WT., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Front ½ Rinse Container #</th>
<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2566</td>
<td>2473</td>
<td>1536</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>11/12/12</th>
<th>JSC</th>
<th>F</th>
<th>11/12/12</th>
<th>JSC</th>
<th>F</th>
<th>11/12/12</th>
<th>JSC</th>
<th>F</th>
<th>11/12/12</th>
<th>JSC</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>S2-1</td>
<td>3.4847</td>
<td>3.4842</td>
<td>3.6007</td>
<td>3.6005</td>
<td>3.6465</td>
<td>3.6462</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U1-2</td>
<td>(60 ml)</td>
<td>(70 ml)</td>
<td>(50 ml)</td>
<td>(50 ml)</td>
<td>(50 ml)</td>
<td>(50 ml)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rinse Wt., g.</th>
<th>0.0016</th>
<th>0.0020</th>
<th>0.0009</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Filter Catch, mg.</th>
<th>#N/A</th>
<th>#N/A</th>
<th>#N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rinse Catch, mg.</td>
<td>1.6</td>
<td>2.0</td>
<td>0.9</td>
</tr>
<tr>
<td>Rinse Blank Residue, mg.</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Net Rinse Catch, mg.</td>
<td>1.4</td>
<td>1.8</td>
<td>0.7</td>
</tr>
<tr>
<td>FILTERABLE PARTICULATE, mg.</td>
<td>1.4</td>
<td>1.8</td>
<td>0.7</td>
</tr>
</tbody>
</table>

**Legend:**  
F = Final Weight

**Notes & Comments:**
### PARTICULATE SAMPLING LABORATORY RESULTS

**Client:** Air Control Techniques  
**Method:** EPA M5  
**RFA #:** 1756

<table>
<thead>
<tr>
<th>Run Number</th>
<th>S1-2</th>
<th>S2-2</th>
<th>U1-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
<tr>
<td>Baggie Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Filter Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>FILTER SAMPLE WT., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Front 1/4 Rinse Container #</td>
<td>1378</td>
<td>Date</td>
<td>2533</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>JSC</th>
<th>F</th>
<th>Date</th>
<th>JSC</th>
<th>F</th>
<th>Date</th>
<th>JSC</th>
<th>F</th>
<th>Date</th>
<th>JSC</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/12/12</td>
<td>3.4271</td>
<td>11/12/12</td>
<td>3.5627</td>
<td>11/12/12</td>
<td>3.5545</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11/12/12</td>
<td>3.4268</td>
<td>11/12/12</td>
<td>3.5623</td>
<td>11/12/12</td>
<td>3.5543</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11/12/12</td>
<td>3.4251</td>
<td>11/12/12</td>
<td>3.5514</td>
<td>11/12/12</td>
<td>3.5535</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50 ml</td>
<td>0.0017</td>
<td>30 ml</td>
<td>0.0009</td>
<td>30 ml</td>
<td>0.0006</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 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

<table>
<thead>
<tr>
<th>Run Number</th>
<th>U2-3  ≤2.5μg Acetone</th>
<th>S1-3  ≤2.5μg Acetone</th>
<th>S2-3  ≤2.5μg Acetone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
<tr>
<td>Baggie Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Filter Tare Wt., g.</td>
<td>#N/A ##</td>
<td>#N/A ##</td>
<td>#N/A #N/A</td>
</tr>
<tr>
<td>FILTER SAMPLE WT., g.</td>
<td>#N/A ##</td>
<td>#N/A ##</td>
<td>#N/A #N/A</td>
</tr>
<tr>
<td>Front ¾ Rinse Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>JSC</th>
<th>Tare Wt., g.</th>
<th>Rinse Sample WT., g.</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/12/12</td>
<td>JSC F</td>
<td>3.5064</td>
<td>3.4446</td>
</tr>
<tr>
<td>11/12/12</td>
<td>JSC F</td>
<td>3.5059</td>
<td>3.4443</td>
</tr>
<tr>
<td>11/12/12</td>
<td>JSC F</td>
<td>3.4433</td>
<td>3.4697</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>JSC</th>
<th>Tare Wt., g.</th>
<th>Rinse Sample WT., g.</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/12/12</td>
<td>JSC</td>
<td>3.5058</td>
<td>3.4439</td>
</tr>
<tr>
<td>11/12/12</td>
<td>JSC</td>
<td>3.0004</td>
<td>3.4688</td>
</tr>
</tbody>
</table>

| Filter Catch, mg. | #N/A | #N/A | #N/A |
| Rinse Catch, mg. | 0.4 | 0.3 | 0.8 |
| Rinse Blank Residue, mg. | 0.1 | 0.3 | 0.8 |
| Net Rinse Catch, mg. | 0.0 ** | 0.3 | 0.8 |

**FILTERABLE PARTICULATE, mg.**

| **FILTERABLE PARTICULATE, mg.** | 0.0 | 0.3 | 0.8 |

**Negative results adjusted to zero.**

---

**Legend:**

F = Final Weight

**Notes & Comments:**

---
# PARTICULATE SAMPLING LABORATORY RESULTS

<table>
<thead>
<tr>
<th>Run Number</th>
<th>U1-4 ≤2.5μg Acetone</th>
<th>U2-4 ≤2.5μg Acetone</th>
<th>S1-4 ≤2.5μg Acetone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
<tr>
<td><strong>Baggie Tare Wt., g.</strong></td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td><strong>Filter Tare Wt., g.</strong></td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td><strong>FILTER SAMPLE WT., g.</strong></td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td><strong>Front ½ Rinse Container #</strong></td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
<tr>
<td>11/12/12</td>
<td>JSC</td>
<td>3.6241</td>
<td>11/12/12</td>
</tr>
<tr>
<td>11/12/12</td>
<td>JSC</td>
<td>3.6236</td>
<td>11/12/12</td>
</tr>
<tr>
<td><strong>Tare Wt., g.</strong></td>
<td>(30 ml)</td>
<td>3.6228</td>
<td>(40 ml)</td>
</tr>
<tr>
<td><strong>RINSE SAMPLE WT., g.</strong></td>
<td>0.0008</td>
<td>0.0011</td>
<td>0.0002</td>
</tr>
</tbody>
</table>

| 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
Method: EPA M5

<table>
<thead>
<tr>
<th>Run Number</th>
<th>S2-4 ≤2.5 µg Acetone</th>
<th>U1-5 ≤2.5 µg Acetone</th>
<th>U2-5 ≤2.5 µg Acetone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
<tr>
<td>Baggie Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Filter Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>FILTER SAMPLE WT., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Front ½ Rinse Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
</tbody>
</table>

Tare Wt., g.

<table>
<thead>
<tr>
<th>11/12/12 JSC</th>
<th>3.5135</th>
<th>11/12/12 JSC F</th>
<th>3.5130</th>
<th>11/12/12 F</th>
<th>3.6354</th>
<th>11/12/12 F</th>
<th>3.6350</th>
<th>11/12/12 F</th>
<th>3.3895</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/12/12 (ml)</td>
<td>3.5124</td>
<td>50 ml</td>
<td>3.6345</td>
<td>40 ml</td>
<td>3.3890</td>
<td>3.3882</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RINSE SAMPLE WT., g.

| 0.0006 | 0.0005 | 0.0008 |

Filter Catch, mg.

<table>
<thead>
<tr>
<th>#N/A</th>
<th>#N/A</th>
<th>#N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rinse Catch, mg.</td>
<td>0.6</td>
<td>0.5</td>
</tr>
<tr>
<td>Rinse Blank Residue, mg.</td>
<td>0.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Net Rinse Catch, mg.</td>
<td>0.5</td>
<td>0.3</td>
</tr>
<tr>
<td>FILTERABLE PARTICULATE, mg.</td>
<td>0.5</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Legend: F = Final Weight

Notes & Comments:
# PARTICULATE SAMPLING LABORATORY RESULTS

**Client:** Air Control Techniques  
**Method:** EPA M5  
**RFA #:** 1756

<table>
<thead>
<tr>
<th>Run Number</th>
<th>S1-5 ≤2.5ug Acetone</th>
<th>S2-5 ≤2.5ug Acetone</th>
<th>U1-6 ≤2.5ug Acetone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
<tr>
<td>Baggie Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Filter Tare Wt., g.</td>
<td>#N/A</td>
<td></td>
<td>#N/A</td>
</tr>
<tr>
<td>FILTER SAMPLE WT. , g.</td>
<td>#N/A ##</td>
<td>#N/A ##</td>
<td>#N/A ##</td>
</tr>
<tr>
<td>Front ½ Rinse Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
<tr>
<td>11/12/12 JSC</td>
<td>3.6512</td>
<td>11/12/12</td>
<td>3.4338</td>
</tr>
<tr>
<td>11/12/12 JSC F</td>
<td>3.6508</td>
<td>11/12/12 F</td>
<td>3.4333</td>
</tr>
<tr>
<td>3.6498 (30 ml)</td>
<td>3.4327 (40 ml)</td>
<td>3.6127</td>
<td></td>
</tr>
<tr>
<td>Rinse Wt. g.</td>
<td>0.0010</td>
<td>0.0006</td>
<td>0.0009</td>
</tr>
<tr>
<td>RINSE SAMPLE WT. , g.</td>
<td>0.0010</td>
<td>0.0006</td>
<td>0.0009</td>
</tr>
</tbody>
</table>

| 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

<table>
<thead>
<tr>
<th>Client:</th>
<th>Air Control Techniques</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method:</td>
<td>EPA M5</td>
</tr>
<tr>
<td>RFA #:</td>
<td>1756</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Run Number</th>
<th>U2-6 ≤2.5μg Acetone</th>
<th>S1-6 ≤2.5μg Acetone</th>
<th>S2-6 ≤5μg Acetone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
<tr>
<td>Baggie Tare Wt., g.</td>
<td>#N/A</td>
<td></td>
<td>#N/A</td>
</tr>
<tr>
<td>Filter Tare Wt., g.</td>
<td>#N/A</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| FILTER SAMPLE WT., g. | #N/A #
| Front ¾ Rinse Container # | Date | Init | Date | 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 | 3.7232 | 11/12/12 | 3.4716 |
| 11/12/12 | F | 3.5516 | 11/12/12 | 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:**
# Report Summary

<table>
<thead>
<tr>
<th>SAMPLE ID</th>
<th>H₂O ≤2.5μg RINSE PARTICULATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>U1-1</td>
<td>0.9 mg</td>
</tr>
<tr>
<td>U2-1</td>
<td>2.0 mg</td>
</tr>
<tr>
<td>S1-1</td>
<td>0.3 mg</td>
</tr>
<tr>
<td>S2-1</td>
<td>1.4 mg</td>
</tr>
<tr>
<td>U1-2</td>
<td>0.6 mg</td>
</tr>
<tr>
<td>U2-2</td>
<td>0.4 mg</td>
</tr>
<tr>
<td>S1-2</td>
<td>0.6 mg</td>
</tr>
<tr>
<td>S2-2</td>
<td>0.3 mg</td>
</tr>
<tr>
<td>U1-3</td>
<td>0.3 mg</td>
</tr>
<tr>
<td>U2-3</td>
<td>0.7 mg</td>
</tr>
<tr>
<td>S1-3</td>
<td>0.6 mg</td>
</tr>
<tr>
<td>S2-3</td>
<td>0.3 mg</td>
</tr>
<tr>
<td>U1-4</td>
<td>0.0 mg</td>
</tr>
<tr>
<td>U2-4</td>
<td>0.0 mg</td>
</tr>
<tr>
<td>S1-4</td>
<td>0.5 mg</td>
</tr>
<tr>
<td>S2-4</td>
<td>0.7 mg</td>
</tr>
<tr>
<td>U1-5</td>
<td>0.4 mg</td>
</tr>
<tr>
<td>U2-5</td>
<td>0.0 mg</td>
</tr>
<tr>
<td>S1-5</td>
<td>0.0 mg</td>
</tr>
<tr>
<td>S2-5</td>
<td>0.3 mg</td>
</tr>
<tr>
<td>U1-6</td>
<td>0.7 mg</td>
</tr>
<tr>
<td>U2-6</td>
<td>0.4 mg</td>
</tr>
<tr>
<td>S1-6</td>
<td>0.7 mg</td>
</tr>
<tr>
<td>S2-6</td>
<td>0.1 mg</td>
</tr>
</tbody>
</table>
Analytical Narrative

Sample Matrix & Components:

Front ½ DI H₂O ≤2.5μg Rinses, DI H₂O Blank

Summary of Sample Prep:

The DI H₂O rinses were transferred to pre-tared teflon "baggies" in a low humidity environment. The DI H₂O 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

<table>
<thead>
<tr>
<th>Run Number</th>
<th>U1-1 ≤2.5µg H₂O</th>
<th>U2-1 ≤2.5µg H₂O</th>
<th>S1-1 ≤2.5µg H₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
<tr>
<td>Baggie Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Filter Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>FILTER SAMPLE WT., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Front 1/3 Rinse Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>11/8/12</th>
<th>JSC</th>
<th>3.4443</th>
<th>11/8/12</th>
<th>3.2687</th>
<th>11/8/12</th>
<th>3.5838</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tare Wt., g.</td>
<td>(50 ml)</td>
<td>3.4428</td>
<td>(60 ml)</td>
<td>3.2660</td>
<td>(70 ml)</td>
<td>3.5832</td>
</tr>
<tr>
<td>RINSE SAMPLE WT., g.</td>
<td>0.0070</td>
<td>0.0022</td>
<td>0.0005</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 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

<table>
<thead>
<tr>
<th>Client:</th>
<th>Air Control Techniques</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method:</td>
<td>EPA M5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Run Number</th>
<th>S2-1</th>
<th>U1-2</th>
<th>U2-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>S2-1</td>
<td>≤2.5µg H₂O</td>
<td>≥2.5µg H₂O</td>
<td>≥2.5µg H₂O</td>
</tr>
</tbody>
</table>

**Filter Container #**

<table>
<thead>
<tr>
<th>Date</th>
<th>Init</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Baggie Tare Wt., g.**

<table>
<thead>
<tr>
<th>Date</th>
<th>Init</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Filter Tare Wt., g.**

<table>
<thead>
<tr>
<th>Date</th>
<th>Init</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**FILTER SAMPLE WT., g.**

<table>
<thead>
<tr>
<th>Date</th>
<th>Init</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

**Front ½ Rinse Container #**

<table>
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<tr>
<th>Date</th>
<th>Init</th>
</tr>
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<tbody>
<tr>
<td>3121</td>
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</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Date</th>
<th>Init</th>
</tr>
</thead>
<tbody>
<tr>
<td>1404</td>
<td></td>
</tr>
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<table>
<thead>
<tr>
<th>Date</th>
<th>Init</th>
</tr>
</thead>
<tbody>
<tr>
<td>4147</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Init</th>
</tr>
</thead>
</table>

**Tare Wt., g.**

<table>
<thead>
<tr>
<th>Date</th>
<th>Init</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/8/12</td>
<td>(60 ml)</td>
</tr>
</tbody>
</table>

**RINSE SAMPLE WT., g.**

<table>
<thead>
<tr>
<th>Date</th>
<th>Init</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0016</td>
<td>0.0008</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Init</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Filter Catch, mg.**

<table>
<thead>
<tr>
<th>Date</th>
<th>Init</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Rinse Catch, mg.**

<table>
<thead>
<tr>
<th>Date</th>
<th>Init</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Rinse Blank Residue, mg.**

<table>
<thead>
<tr>
<th>Date</th>
<th>Init</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>0.6</td>
</tr>
</tbody>
</table>

**Net Rinse Catch, mg.**

<table>
<thead>
<tr>
<th>Date</th>
<th>Init</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.4</td>
<td>0.6</td>
</tr>
</tbody>
</table>

**FILTERABLE PARTICULATE, mg.**

<table>
<thead>
<tr>
<th>Date</th>
<th>Init</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.4</td>
<td>0.6</td>
</tr>
</tbody>
</table>

**Legend:**  
F = Final Weight

**Notes & Comments:**
# PARTICULATE SAMPLING LABORATORY RESULTS

<table>
<thead>
<tr>
<th>Run Number</th>
<th>S1-2 ≤2.5µg H₂O</th>
<th>S2-2 ≤2.5µg H₂O</th>
<th>U1-3 ≤2.5µg H₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
<tr>
<td>Baggie Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Filter Tare Wt., g.</td>
<td>#N/A #</td>
<td>#N/A #</td>
<td>#N/A #</td>
</tr>
<tr>
<td>FILTER SAMPLE WT., g.</td>
<td>#N/A #</td>
<td>#N/A #</td>
<td>#N/A #</td>
</tr>
<tr>
<td>Front 1/4 Rinse Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
</tbody>
</table>

| 11/8/12 (50 ml) | 3.7097 | 11/8/12 (60 ml) | 3.9009 | 11/8/12 (70 ml) | 3.6466 |
| RINSE SAMPLE WT., g. | 0.0007 | 0.0005 | 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**

<table>
<thead>
<tr>
<th>Run Number</th>
<th>U2-3</th>
<th>S1-3</th>
<th>S2-3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≤2.5µg H₂O</td>
<td>≤2.5µg H₂O</td>
<td>≤2.5µg H₂O</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Filter Container #</th>
<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Date</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beggie Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Filter Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>FILTER SAMPLE WT., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Front ½ Rinse Container #</th>
<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Date</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>52</td>
<td>52</td>
<td>2144</td>
<td>2144</td>
<td>1451</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>11/8/12</th>
<th>JSC</th>
<th>3.7268</th>
<th>11/8/12</th>
<th>3.7699</th>
<th>11/8/12</th>
<th>3.5051</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/8/12</td>
<td>JSC</td>
<td>3.7253</td>
<td>11/8/12</td>
<td>3.7694</td>
<td>11/8/12</td>
<td>3.5046</td>
</tr>
<tr>
<td>(50 ml)</td>
<td></td>
<td>3.7255</td>
<td>(60 ml)</td>
<td>3.7686</td>
<td>(60 ml)</td>
<td>3.5041</td>
</tr>
<tr>
<td>RINSE SAMPLE WT., g.</td>
<td>0.0008</td>
<td>0.0008</td>
<td>0.0005</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 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:** EFA M5  
**RFA #:** 1756

<table>
<thead>
<tr>
<th>Run Number</th>
<th>U1-4 ≤2.5µg H₂O</th>
<th>U2-4 ≤2.5µg H₂O</th>
<th>S1-4 ≤2.5µg H₂O</th>
</tr>
</thead>
</table>

Filter Container #

<table>
<thead>
<tr>
<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Init</th>
</tr>
</thead>
</table>

Baggie Tare Wt., g.

Filter Tare Wt., g.

FILTER SAMPLE WT., g.

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Front % Rinse Container #

<table>
<thead>
<tr>
<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Init</th>
</tr>
</thead>
</table>

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1191</td>
<td>1623</td>
<td>2174</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Tare Wt., g.

<table>
<thead>
<tr>
<th>11/8/12</th>
<th>JSC</th>
<th>3.8743</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/8/12</td>
<td>JSC</td>
<td>3.8738</td>
</tr>
</tbody>
</table>

### Rinse Sample WT., g.

<table>
<thead>
<tr>
<th>70 ml</th>
<th>70 ml</th>
<th>80 ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.8737</td>
<td>3.7390</td>
<td></td>
</tr>
<tr>
<td>0.0001</td>
<td>0.0001</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Filter Catch, mg.</th>
<th>#N/A</th>
<th>#N/A</th>
<th>#N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rinse Catch, mg.</td>
<td>0.1</td>
<td>0.1</td>
<td>0.7</td>
</tr>
<tr>
<td>Rinse Blank Residue, mg.</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Net Rinse Catch, mg.</td>
<td>0.0 **</td>
<td>0.0 **</td>
<td>0.5</td>
</tr>
</tbody>
</table>

**FILTERABLE PARTICULATE, mg.**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>0.0</td>
<td>0.5</td>
</tr>
</tbody>
</table>

**Legend:**  
F = Final Weight  
**Negative results adjusted to zero.**

**Notes & Comments:**
## PARTICULATE SAMPLING LABORATORY RESULTS

**Client:** Air Control Techniques  
**Method:** EPA M5  
**RFA #: 1756**

<table>
<thead>
<tr>
<th>Run Number</th>
<th>S2-4</th>
<th>U1-5</th>
<th>U2-5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≤2.5µg H₂O</td>
<td>≤2.5µg H₂O</td>
<td>≤2.5µg H₂O</td>
</tr>
</tbody>
</table>

### Filter Container #

<table>
<thead>
<tr>
<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Date</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Baggie Tare Wt., g.</th>
<th>#N/A</th>
<th>#N/A</th>
<th>#N/A</th>
<th>#N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter Tare Wt., g.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FILTER SAMPLE WT., g.</td>
<td>#N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Front ½ Rinse Container #

<table>
<thead>
<tr>
<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Date</th>
<th>Date</th>
</tr>
</thead>
</table>

### Rinse Result Summary

|-------|------|-------|---------|---------|---------|---------|-------|-------|---------|---------|---------|---------|

<table>
<thead>
<tr>
<th>Date</th>
<th>JSC</th>
<th>JSC F</th>
<th>11/8/12</th>
<th>11/8/12</th>
<th>11/8/12</th>
<th>11/8/12</th>
<th>0.00006</th>
<th>0.00006</th>
<th>0.00006</th>
<th>0.00006</th>
<th>0.00006</th>
<th>0.00006</th>
</tr>
</thead>
</table>

### Rinse Result Summary

- **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

---

**Legend:**  
F = Final Weight

**Notes & Comments:**
## PARTICULATE SAMPLING LABORATORY RESULTS

**Client:** Air Control Techniques  
**Method:** EPA M5  
**RFA #:** 1756

<table>
<thead>
<tr>
<th>Run Number</th>
<th>S1-5 ≤2.5μg H₂O</th>
<th>S2-5 ≤2.5μg H₂O</th>
<th>U1-6 ≤2.5μg H₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
<tr>
<td>Baggage Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
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<td>Filter Tare Wt., g.</td>
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<td>#N/A</td>
<td>#N/A</td>
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<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Front ½ Rinse Container #</td>
<td>Date</td>
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<td>Date</td>
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<table>
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<tbody>
<tr>
<td>11/8/12</td>
<td>60 ml</td>
<td>3.5299</td>
<td>60 ml</td>
<td>3.4894</td>
<td>60 ml</td>
<td>3.4893</td>
<td>60 ml</td>
<td>3.4888</td>
<td>60 ml</td>
<td>3.7835</td>
<td>3.7846</td>
<td>3.7844</td>
<td>3.7835</td>
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<tr>
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<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
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<td></td>
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<tr>
<td>Net Rinse Catch, mg.</td>
<td>0.0 **</td>
<td>0.3</td>
<td>0.7</td>
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<tr>
<td>FILTERABLE PARTICULATE, mg.</td>
<td>0.0</td>
<td>0.3</td>
<td>0.7</td>
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**Legend:**  
F = Final Weight  

**Notes & Comments:**
### PARTICULATE SAMPLING LABORATORY RESULTS

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<thead>
<tr>
<th>Client: Air Control Techniques</th>
<th>RFA #: 1756</th>
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<table>
<thead>
<tr>
<th>Run Number</th>
<th>U2-6 ≤2.5μg H₂O</th>
<th>S1-6 ≤2.5μg H₂O</th>
<th>S2-6 ≤2.5μg H₂O</th>
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<tr>
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<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
<tr>
<td>Baggie Tare Wt., g</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
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<tr>
<td>Filter Tare Wt., g</td>
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<td>#N/A</td>
<td>#N/A</td>
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<td>FILTER SAMPLE WT., g</td>
<td>#N/A</td>
<td>#N/A</td>
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<table>
<thead>
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<th>Init</th>
<th>Date</th>
<th>Date</th>
<th>Date</th>
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<tbody>
<tr>
<td>Tare Wt., g</td>
<td>(</td>
<td>ml</td>
<td>(</td>
<td>(</td>
<td>(</td>
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<td>(</td>
<td>(</td>
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<td>(</td>
<td>(</td>
<td>(</td>
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</tr>
<tr>
<td>(50 ml)</td>
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<td></td>
<td>3.4066</td>
<td>3.6299</td>
<td>3.6291</td>
<td>3.6291</td>
<td>3.6291</td>
<td>3.4078</td>
<td>3.4076</td>
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<tr>
<td>RINSE SAMPLE WT., g</td>
<td>0.0005</td>
<td>0.0008</td>
<td>0.0002</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

| 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:**
## Report Summary

<table>
<thead>
<tr>
<th>SAMPLE ID</th>
<th>TOTAL FILTER PARTICULATE CATCH</th>
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<tbody>
<tr>
<td>U1-1</td>
<td>31.8 mg</td>
</tr>
<tr>
<td>U2-1</td>
<td>33.1 mg</td>
</tr>
<tr>
<td>S1-1</td>
<td>73.9 mg</td>
</tr>
<tr>
<td>S2-1</td>
<td>64.4 mg</td>
</tr>
<tr>
<td>U1-2</td>
<td>16.4 mg</td>
</tr>
<tr>
<td>U2-2</td>
<td>16.3 mg</td>
</tr>
<tr>
<td>S1-2</td>
<td>47.6 mg</td>
</tr>
<tr>
<td>S2-2</td>
<td>48.0 mg</td>
</tr>
<tr>
<td>U1-3</td>
<td>20.9 mg</td>
</tr>
<tr>
<td>U2-3</td>
<td>21.7 mg</td>
</tr>
<tr>
<td>S1-3</td>
<td>37.1 mg</td>
</tr>
<tr>
<td>S2-3</td>
<td>30.7 mg</td>
</tr>
<tr>
<td>U1-4</td>
<td>22.3 mg</td>
</tr>
<tr>
<td>U2-4</td>
<td>23.7 mg</td>
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<tr>
<td>S1-4</td>
<td>26.9 mg</td>
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<tr>
<td>S2-4</td>
<td>26.5 mg</td>
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<tr>
<td>U1-5</td>
<td>14.7 mg</td>
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<td>U2-5</td>
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<tr>
<td>S1-5</td>
<td>55.0 mg</td>
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<td>S2-5</td>
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<td>U1-6</td>
<td>29.5 mg</td>
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<td>U2-6</td>
<td>30.1 mg</td>
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<tr>
<td>S1-6</td>
<td>37.4 mg</td>
</tr>
<tr>
<td>S2-6</td>
<td>1.2 mg</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Run Number</th>
<th>U1-1</th>
<th>U2-1</th>
<th>S1-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
<tr>
<td>Baggie Tare Wt., g.</td>
<td>11/6/12</td>
<td>JSC</td>
<td>0.1431</td>
</tr>
<tr>
<td>Filter Tare Wt., g.</td>
<td></td>
<td></td>
<td>0.0000</td>
</tr>
<tr>
<td>FILTER SAMPLE WT., g.</td>
<td></td>
<td></td>
<td>0.1113</td>
</tr>
<tr>
<td>Front ½ Rinse Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tare Wt., g.</th>
<th>Rinse Sample Wt., g.</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>ml #/A</td>
</tr>
<tr>
<td>Filter Catch, mg.</td>
<td>31.8</td>
</tr>
<tr>
<td>Rinse Catch, mg.</td>
<td>#/A</td>
</tr>
<tr>
<td>Rinse Blank Residue, mg.</td>
<td>#/A</td>
</tr>
<tr>
<td>Net Rinse Catch, mg.</td>
<td>#/A #</td>
</tr>
<tr>
<td>FILTERABLE PARTICULATE, mg.</td>
<td>31.8</td>
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</tbody>
</table>

**Legend:**  
F = Final Weight

**Notes & Comments:**
# PARTICULATE SAMPLING LABORATORY RESULTS

**Client:** Air Control Techniques  
**Method:** EPA M5  
**RFA #:** 1756

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<thead>
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<tr>
<td>Date</td>
<td>Date</td>
<td>Date</td>
<td>Date</td>
</tr>
<tr>
<td>11/6/12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Init</td>
<td></td>
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</tr>
<tr>
<td>JSC</td>
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<tr>
<td>Baggage Tare Wt., g.</td>
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<td>0.1332</td>
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<td>FILTER SAMPLE WT., g.</td>
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<tr>
<td>Front 1/6 Rinse Container #</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>Date</td>
<td>Date</td>
<td>Date</td>
</tr>
<tr>
<td>Tare Wt., g.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rinse Sample Wt., g.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
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</tr>
<tr>
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<td>#N/A ml</td>
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<td>#N/A ml</td>
<td>#N/A</td>
<td>#N/A</td>
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<tr>
<td>Filter Catch, mg.</td>
<td>64.4</td>
<td>16.4</td>
<td>16.3</td>
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<td>Rinse Catch, mg.</td>
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<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Rinse Blank Residue, mg.</td>
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</tr>
<tr>
<td>Net Rinse Catch, mg.</td>
<td>#N/A #</td>
<td>#N/A #</td>
<td>#N/A #</td>
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<td>64.4</td>
<td>16.4</td>
<td>16.3</td>
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</table>

**Legend:**  
F = Final Weight

**Notes & Comments:**
### PARTICULATE SAMPLING LABORATORY RESULTS

**Client:** Air Control Techniques  
**Method:** EPA M5  
**RFA #:** 1756

<table>
<thead>
<tr>
<th>Run Number</th>
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<th>U1-3 Filter</th>
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<td>Init</td>
<td>Date</td>
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<td>11/6/12</td>
<td>JSC</td>
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<td>11/6/12</td>
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<td>FILTER SAMPLE WT., g.</td>
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<table>
<thead>
<tr>
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<th>Date</th>
<th>Init</th>
<th>Date</th>
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</table>

<table>
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<tr>
<th>Tare Wt., g.</th>
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<th>#N/A</th>
<th>#N/A</th>
<th>#N/A</th>
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<tbody>
<tr>
<td>RINSE SAMPLE WT., g.</td>
<td>(ml)</td>
<td>#N/A</td>
<td>(ml)</td>
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<td>(ml)</td>
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<td>(ml)</td>
<td>#N/A</td>
<td></td>
</tr>
</tbody>
</table>

- Filter Catch, mg.  
- Rinse Catch, mg.  
- Rinse Blank Residue, mg.  
- Net Rinse Catch, mg.  

| 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

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</tr>
<tr>
<td>Date</td>
<td>11/6/12</td>
<td>11/6/12</td>
<td>11/6/12</td>
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<tr>
<td>Initial</td>
<td>JSC</td>
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**Front 1/4 Rinse Container #**

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<th>Initial</th>
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</table>

<table>
<thead>
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<th>(#N/A ml)</th>
<th>(#N/A ml)</th>
<th>(#N/A ml)</th>
<th>(#N/A ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rinse Sample WT., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
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<td>37.1</td>
<td>30.7</td>
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</tr>
<tr>
<td>Rinse Catch, mg.</td>
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<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Rinse Blank Residue, mg.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Net Rinse Catch, mg.</td>
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<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
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<td>FILTERABLE PARTICULATE, mg.</td>
<td>21.7</td>
<td>37.1</td>
<td>30.7</td>
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</table>

**Legend:**  
F = Final Weight

**Notes & Comments:**
## PARTICULATE SAMPLING LABORATORY RESULTS

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<thead>
<tr>
<th>Run Number</th>
<th>U1-4 Filter</th>
<th>U2-4 Filter</th>
<th>S1-4 Filter</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Filter Container #</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>Init</td>
<td>Date</td>
<td>Date</td>
</tr>
<tr>
<td>11/6/12</td>
<td>JSC</td>
<td>11/6/12</td>
<td>0.1383</td>
</tr>
<tr>
<td>Baggie Tare Wt., g.</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>Filter Tare Wt., g.</td>
<td>0.1160</td>
<td>0.1177</td>
<td>0.1158</td>
</tr>
<tr>
<td>FILTER SAMPLE WT., g.</td>
<td>0.0223</td>
<td>0.0237</td>
<td>0.0269</td>
</tr>
<tr>
<td><strong>Front ½ Rinse Container #</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>Init</td>
<td>Date</td>
<td>Date</td>
</tr>
</tbody>
</table>

| **Tare Wt., g.** | ( ) | ( ) | ( ) | ( ) |
| **RINSE SAMPLE WT., g.** | #N/A | #N/A | #N/A | #N/A |
| Filter Catch, mg. | 22.3 | 23.7 | 26.9 | |
| Rinse Catch, mg. | #N/A | #N/A | #N/A | #N/A |
| Rinse Blank Residue, mg. | #N/A | #N/A | #N/A | #N/A |
| Net Rinse Catch, mg. | #N/A | #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**  
**Method:** EPA M5  
**RFA #:** 1756

<table>
<thead>
<tr>
<th>Run Number</th>
<th>S2-4 Filter</th>
<th>U1-5 Filter</th>
<th>U2-5 Filter</th>
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</thead>
<tbody>
<tr>
<td><strong>Filter Container #</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Date</td>
<td>Init</td>
<td>Date</td>
<td>Date</td>
</tr>
<tr>
<td>11/6/12</td>
<td>JSC</td>
<td>0.1444</td>
<td>11/6/12</td>
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<tr>
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<td>0.0000</td>
<td>0.0000</td>
</tr>
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<td>Filter Tare Wt., g.</td>
<td>0.1179</td>
<td>0.1167</td>
<td>0.1172</td>
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<tr>
<td>FILTER SAMPLE WT., g.</td>
<td>0.0255</td>
<td>0.0147</td>
<td>0.0151</td>
</tr>
</tbody>
</table>

| Front ¼ Rinse Container # | | | |
| Date | Init | Date | Date | Date |

| **Tare Wt., g.** | **#N/A** | **#N/A** | **#N/A** | **#N/A** |
| RINSE SAMPLE WT., g. | ml | ml | ml | ml |

| 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

<table>
<thead>
<tr>
<th>Run Number</th>
<th>S1-5</th>
<th>S2-5</th>
<th>U1-6</th>
</tr>
</thead>
<tbody>
<tr>
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<td>1/6/12</td>
<td>Date</td>
<td>Date</td>
</tr>
<tr>
<td>Filter Container #</td>
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<td>0.1725</td>
<td>0.1215</td>
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<td>0.0000</td>
<td>0.0000</td>
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<td>0.0058</td>
<td>0.0295</td>
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<table>
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</thead>
</table>

<table>
<thead>
<tr>
<th>Tar Wt., g.</th>
<th>RINSE SAMPLE WT., g.</th>
<th>#/N/A ml</th>
<th>#/N/A ml</th>
<th>#/N/A ml</th>
<th>#/N/A ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter Catch, mg.</td>
<td>55.0</td>
<td>5.8</td>
<td>29.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rinse Catch, mg.</td>
<td>#/N/A</td>
<td>#/N/A</td>
<td>#/N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rinse Blank Residue, mg.</td>
<td>#/N/A</td>
<td>#/N/A</td>
<td>#/N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net Rinse Catch, mg.</td>
<td>#/N/A #/N/A</td>
<td>#/N/A #/N/A</td>
<td>#/N/A #/N/A #/N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FILTERABLE PARTICULATE, mg.</td>
<td>55.0</td>
<td>5.8</td>
<td>29.5</td>
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</tbody>
</table>

**Legend:**  
F = Final Weight

**Notes & Comments:**
# PARTICULATE SAMPLING LABORATORY RESULTS

**Client:** Air Control Techniques  
**Method:** EPA M5  
**RFA #:** 1756

<table>
<thead>
<tr>
<th>Run Number</th>
<th>U2-6 Filter</th>
<th>S1-6 Filter</th>
<th>S2-6 Filter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
<tr>
<td>11/6/12</td>
<td>JSC</td>
<td>0.1464</td>
<td>11/6/12</td>
</tr>
<tr>
<td>Baggio Tare Wt., g.</td>
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<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>Filter Tare Wt., g.</td>
<td>0.1163</td>
<td>0.1166</td>
<td>0.1166</td>
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<tr>
<td>FILTER SAMPLE WT., g.</td>
<td>0.0301</td>
<td>0.0374</td>
<td>0.0012</td>
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</table>

<table>
<thead>
<tr>
<th>Front ¾ Rinse Container #</th>
<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Date</th>
<th>Date</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Wt., g.</th>
<th>#N/A</th>
<th>#N/A</th>
<th>#N/A</th>
<th>#N/A</th>
<th>#N/A</th>
<th>#N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rinse Sample WT., g.</td>
<td>(</td>
<td>ml)</td>
<td>(</td>
<td>ml)</td>
<td>(</td>
<td>ml)</td>
</tr>
<tr>
<td>Filter Catch, mg.</td>
<td>30.1</td>
<td>37.4</td>
<td>1.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rinse Catch, mg.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rinse Blank Residue, mg.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net Rinse Catch, mg.</td>
<td>#N/A #N/A</td>
<td>#N/A #N/A</td>
<td>#N/A #N/A #N/A #N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FILTERABLE PARTICULATE, mg.</td>
<td>30.1</td>
<td>37.4</td>
<td>1.2</td>
<td></td>
<td></td>
<td></td>
</tr>
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</table>

**Legend:**  
F = Final Weight

**Notes & Comments:**

OTM-036  
Page 536 of 643  
4/11/2016
## Report Summary

<table>
<thead>
<tr>
<th>SAMPLE ID</th>
<th>ACETONE NOZZLE RINSE PARTICULATE</th>
</tr>
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<tbody>
<tr>
<td>Acetone Blank</td>
<td>0.7 mg (in 230 mls)</td>
</tr>
<tr>
<td>U1-1</td>
<td>0.4 mg</td>
</tr>
<tr>
<td>U2-1</td>
<td>0.1 mg</td>
</tr>
<tr>
<td>S1-1</td>
<td>0.6 mg</td>
</tr>
<tr>
<td>S2-1</td>
<td>2.0 mg</td>
</tr>
<tr>
<td>U1-2</td>
<td>2.9 mg</td>
</tr>
<tr>
<td>U2-2</td>
<td>1.5 mg</td>
</tr>
<tr>
<td>S1-2</td>
<td>1.5 mg</td>
</tr>
<tr>
<td>S2-2</td>
<td>0.2 mg</td>
</tr>
<tr>
<td>U1-3</td>
<td>1.0 mg</td>
</tr>
<tr>
<td>U2-3</td>
<td>0.5 mg</td>
</tr>
<tr>
<td>S1-3</td>
<td>1.3 mg</td>
</tr>
<tr>
<td>S2-3</td>
<td>1.1 mg</td>
</tr>
<tr>
<td>U1-4</td>
<td>0.7 mg</td>
</tr>
<tr>
<td>U2-4</td>
<td>1.0 mg</td>
</tr>
<tr>
<td>S1-4</td>
<td>0.3 mg</td>
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<tr>
<td>S2-4</td>
<td>1.1 mg</td>
</tr>
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<tr>
<td>S1-6</td>
<td>1.5 mg</td>
</tr>
<tr>
<td>S2-6</td>
<td>1.2 mg</td>
</tr>
</tbody>
</table>
Analytical Narrative

Sample Matrix & Components:

Front ¼ 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

<table>
<thead>
<tr>
<th>Run Number</th>
<th>U1-1 (Nozzle Acetone)</th>
<th>U2-1 (Nozzle Acetone)</th>
<th>S1-1 (Nozzle Acetone)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
<tr>
<td>Baggage Tare Wt., g.</td>
<td>#N/A</td>
<td></td>
<td>#N/A</td>
</tr>
<tr>
<td>Filter Tare Wt., g.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FILTER SAMPLE WT., g.</td>
<td>#N/A</td>
<td>#</td>
<td>#N/A</td>
</tr>
<tr>
<td>Front ½ Rinse Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
</tbody>
</table>

| 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 | 3.4904 |
| 11/12/12 | INF | 0.0000 | 11/12/12 | INF | 0.0000 | INF |

<table>
<thead>
<tr>
<th>Rinse Sample Wt., g.</th>
<th>50 ml</th>
<th>40 ml</th>
<th>70 ml</th>
<th>70 ml</th>
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</thead>
<tbody>
<tr>
<td>Filter Catch, mg.</td>
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<td></td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Rinse Catch, mg.</td>
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<td></td>
<td>0.2</td>
<td>#N/A</td>
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<tr>
<td>Rinse Blank Residue, mg.</td>
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<td></td>
<td>0.1</td>
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<tr>
<td>Net Rinse Catch, mg.</td>
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<tr>
<td>FILTERABLE PARTICULATE, mg.</td>
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<td></td>
<td>0.1</td>
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</table>

**Legend:**  
F = Final Weight

**Notes & Comments:**
# PARTICULATE SAMPLING LABORATORY RESULTS

Client: **Air Control Techniques**  
Method: EPA M5  
RFA #: **1756**

<table>
<thead>
<tr>
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<th>S2-1 Nozzle acetone</th>
<th>U1-2 Nozzle acetone</th>
<th>U2-2 Nozzle acetone</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
<tr>
<td>Baggie Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
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<tr>
<td>Filter Tare Wt., g.</td>
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<td>#N/A</td>
<td>#N/A #N/A</td>
</tr>
<tr>
<td>FILTER SAMPLE WT., g.</td>
<td>#N/A #N/A</td>
<td>#N/A #N/A</td>
<td>#N/A #N/A</td>
</tr>
<tr>
<td>Front ½ Rinse Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
<tr>
<td>1344</td>
<td>11</td>
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<th>11/12/12</th>
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<tbody>
<tr>
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<td>JSC F</td>
<td>3.5336</td>
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<tr>
<td>60 ml</td>
<td>3.5314</td>
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<tr>
<td>70 ml</td>
<td>0.0022</td>
<td>0.0037</td>
<td>0.0017</td>
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<table>
<thead>
<tr>
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<th>11/12/12</th>
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</thead>
<tbody>
<tr>
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<tr>
<td>Rinse Catch, mg.</td>
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<td>Rinse Blank Residue, mg.</td>
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<td>FILTERABLE PARTICULATE, mg.</td>
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**Legend:**  
*F = Final Weight*

Notes & Comments:
# PARTICULATE SAMPLING LABORATORY RESULTS

**Client:** Air Control Techniques  
**Method:** EPA M5  
**RFA #:** 1756

<table>
<thead>
<tr>
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<th>S2-2</th>
<th>U1-3</th>
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<tbody>
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<td></td>
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<td>Nozzle Acetone</td>
<td>Nozzle Acetone</td>
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**Filter Container #**

<table>
<thead>
<tr>
<th>Date</th>
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<th>Date</th>
<th>Date</th>
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**Baggie Tare Wt., g.**

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**Filter Tare Wt., g.**

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**FILTER SAMPLE WT., g.**

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<th>#N/A</th>
<th>#N/A</th>
<th>#N/A</th>
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</table>

**Front ¼ Rinse Container #**

<table>
<thead>
<tr>
<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Date</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Date</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>11/12/12</th>
<th>JSC</th>
<th>3.6910</th>
<th>11/12/12</th>
<th>3.4826</th>
<th>11/12/12</th>
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<tbody>
<tr>
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<td>11/12/12</td>
<td>3.4824</td>
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<td>(</td>
<td>3.6880</td>
<td>60 ml</td>
<td>3.4820</td>
<td>70 ml</td>
<td>3.7213</td>
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</tbody>
</table>

**RINSE SAMPLE WT., g.**

<p>| | | | |</p>
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</thead>
<tbody>
<tr>
<td></td>
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<td>0.0012</td>
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</table>

**Tare Wt., g.**

<table>
<thead>
<tr>
<th>Filter Catch, mg.</th>
<th>Rinse Catch, mg.</th>
<th>Rinse Blank Residue, mg.</th>
<th>Net Rinse Catch, mg.</th>
<th>FILTERABLE PARTICULATE, mg.</th>
</tr>
</thead>
<tbody>
<tr>
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</table>

**Legend:**  
F = Final Weight

**Notes & Comments:**
# PARTICULATE SAMPLING LABORATORY RESULTS

<table>
<thead>
<tr>
<th>Run Number</th>
<th>U2-3</th>
<th>S1-3</th>
<th>S2-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
<tr>
<td>Baggie Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Filter Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>FILTER SAMPLE WT., g.</td>
<td>#N/A ##</td>
<td>#N/A ##</td>
<td>#N/A</td>
</tr>
<tr>
<td>Front 1/2 Rinse Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
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<table>
<thead>
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<th>11/12/12</th>
<th>11/12/12</th>
<th>11/12/12</th>
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<tr>
<td>JSC</td>
<td>3.4192</td>
<td>3.4192</td>
<td>3.3836</td>
<td>3.3831</td>
<td>3.7314</td>
</tr>
<tr>
<td>F</td>
<td>3.4197</td>
<td>3.4192</td>
<td>3.3836</td>
<td>3.3831</td>
<td>3.7319</td>
</tr>
<tr>
<td>50 ml</td>
<td>3.4185</td>
<td>3.4185</td>
<td>3.3816</td>
<td>3.3816</td>
<td>3.7302</td>
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<tr>
<td>RINSE SAMPLE WT., g.</td>
<td>0.0007</td>
<td>0.0015</td>
<td>0.0007</td>
<td>0.0015</td>
<td>0.0012</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
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<th>S1-4</th>
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<tr>
<td></td>
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<td>Nozzle Acetone</td>
<td>Nozzle Acetone</td>
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</table>

<table>
<thead>
<tr>
<th>Filter Container #</th>
<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Date</th>
<th>Date</th>
</tr>
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<tbody>
<tr>
<td>Baggage Tare Wt., g.</td>
<td>#N/A</td>
<td></td>
<td>#N/A</td>
<td></td>
<td>#N/A</td>
</tr>
<tr>
<td>Filter Tare Wt., g.</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>FILTER SAMPLE WT., g.</td>
<td>#N/A #</td>
<td>#N/A #</td>
<td>#N/A #</td>
<td>#N/A #</td>
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<table>
<thead>
<tr>
<th>Front ½ Rinse Container #</th>
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<th>Init</th>
</tr>
</thead>
<tbody>
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<td></td>
<td>1486</td>
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<td>2551</td>
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<tr>
<td></td>
<td>2156</td>
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<table>
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<th>JSC</th>
<th>Date</th>
<th>Date</th>
<th>Date</th>
<th>Date</th>
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<tbody>
<tr>
<td>11/12/12</td>
<td>3.8415</td>
<td>11/12/12</td>
<td>3.5701</td>
<td>11/12/12</td>
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<tr>
<td>11/12/12</td>
<td>3.8412</td>
<td>11/12/12</td>
<td>3.5699</td>
<td>11/12/12</td>
<td>3.7362</td>
<td></td>
</tr>
</tbody>
</table>

Tare Wt., g.  
(40 ml)  
(50 ml)  
RINSE SAMPLE WT., g.  
0.0008  
0.0012  
0.0005

<table>
<thead>
<tr>
<th>Filter Catch, mg.</th>
<th>#N/A</th>
<th>#N/A</th>
<th>#N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rinse Catch, mg.</td>
<td>0.8</td>
<td>1.2</td>
<td>0.5</td>
</tr>
<tr>
<td>Rinse Blank Residue, mg.</td>
<td>0.1</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Net Rinse Catch, mg.</td>
<td>0.7</td>
<td>1.0</td>
<td>0.3</td>
</tr>
</tbody>
</table>

FILTERABLE PARTICULATE, mg.  
0.7  
1.0  
0.3

**Legend:**  
F = Final Weight

**Notes & Comments:**
### PARTICULATE SAMPLING LABORATORY RESULTS

<table>
<thead>
<tr>
<th>Client: Air Control Techniques</th>
<th>Method: EPA M5</th>
<th>RFA #: 1756</th>
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<table>
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<tr>
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<th>S2-4 Nozzle Acetone</th>
<th>U1-5 Nozzle Acetone</th>
<th>U2-5 Nozzle Acetone</th>
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<tr>
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<td>Init</td>
<td>Date</td>
</tr>
<tr>
<td>Baggie Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
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<td>#N/A ##</td>
<td>#N/A #/A</td>
</tr>
<tr>
<td>FILTER SAMPLE WT., g.</td>
<td>#N/A #/A</td>
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<table>
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<tr>
<th>Front ½ Rinse Container #</th>
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<th>Date</th>
<th>Date</th>
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<tr>
<td>2401</td>
<td>Date</td>
<td>1010</td>
<td>Date</td>
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<td>1259</td>
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<table>
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<th>JSC F</th>
<th>JSC F</th>
<th>JSC F</th>
<th>JSC F</th>
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<tbody>
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<td>11/12/12</td>
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<td>#</td>
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<td>3.4423</td>
<td>#</td>
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</tr>
<tr>
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<td>#</td>
<td></td>
</tr>
<tr>
<td>0.0012</td>
<td>#</td>
<td>#</td>
<td>#</td>
<td>#</td>
<td></td>
</tr>
<tr>
<td>0.0018</td>
<td>#</td>
<td>#</td>
<td>#</td>
<td>#</td>
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</tr>
<tr>
<td>0.002</td>
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<td></td>
<td></td>
<td></td>
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</table>

| 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

<table>
<thead>
<tr>
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<th>S1-5 Nozzle Acetone</th>
<th>S2-5 Nozzle Acetone</th>
<th>U1-5 Nozzle Acetone</th>
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<tbody>
<tr>
<td>Filter Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
<tr>
<td>Baggage Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Filter Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>FILTER SAMPLE WT., g.</td>
<td>#N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Front 1/2 Rinse Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
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<table>
<thead>
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<th>F</th>
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<td>11/12/12</td>
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<td></td>
<td>11/12/12</td>
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<td></td>
</tr>
<tr>
<td>(40 ml)</td>
<td>3.6470</td>
<td></td>
<td>(40 ml)</td>
<td>3.7287</td>
<td></td>
<td>(40 ml)</td>
<td>3.5956</td>
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<tr>
<td>RINSE SAMPLE WT., g.</td>
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| 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

<table>
<thead>
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<tbody>
<tr>
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<table>
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<th>Filter Container #</th>
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<th>Init</th>
<th>Date</th>
<th>Date</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baggie Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Filter Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FILTER SAMPLE WT., g.</td>
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<td>#N/A</td>
<td>#N/A</td>
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<table>
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<tr>
<th>Front ½ Rinse Container #</th>
<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Date</th>
<th>Date</th>
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<tbody>
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<td></td>
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<td>2162</td>
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<th>11/12/12</th>
<th>11/12/12</th>
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<table>
<thead>
<tr>
<th>Tare Wt., g.</th>
<th>Rinse Sample Wt., g.</th>
</tr>
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<tbody>
<tr>
<td>(60 ml)</td>
<td>0.0014</td>
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<tr>
<td>(50 ml)</td>
<td>0.0017</td>
</tr>
<tr>
<td>(40 ml)</td>
<td>0.0013</td>
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| 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:**
# Report Summary

<table>
<thead>
<tr>
<th>SAMPLE ID</th>
<th>H₂O NOZZLE RINSE PARTICULATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>DI H₂O Blank</td>
<td>0.6 mg (in 220 mls)</td>
</tr>
<tr>
<td>U1-1</td>
<td>4.6 mg</td>
</tr>
<tr>
<td>U2-1</td>
<td>1.9 mg</td>
</tr>
<tr>
<td>S1-1</td>
<td>7.8 mg</td>
</tr>
<tr>
<td>S2-1</td>
<td>6.8 mg</td>
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<tr>
<td>U1-2</td>
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<tr>
<td>U2-2</td>
<td>1.8 mg</td>
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<td>S1-2</td>
<td>5.2 mg</td>
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<tr>
<td>S2-2</td>
<td>6.4 mg</td>
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<tr>
<td>S1-4</td>
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</tr>
<tr>
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<td>0.6 mg</td>
</tr>
<tr>
<td>S2-6</td>
<td>1.0 mg</td>
</tr>
</tbody>
</table>
Analytical Narrative

Sample Matrix & Components:

Front ½ DI H₂O Nozzle Rinses, DI H₂O Blank

Summary of Sample Prep:

The DI H₂O rinses were transferred to pre-tared teflon "baggies" in a low humidity environment. The DI H₂O 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

<table>
<thead>
<tr>
<th>Run Number</th>
<th>U1-1</th>
<th>U2-1</th>
<th>S1-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nozzle H₂O</td>
<td>Nozzle H₂O</td>
<td>Nozzle H₂O</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Filter Container #</th>
<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Date</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baggie Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
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<td>Filter Tare Wt., g.</td>
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<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
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<td>FILTER SAMPLE Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Front % Rinse Container #</th>
<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Date</th>
<th>Date</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>11/6/12</th>
<th>JSC</th>
<th>3.4689</th>
<th>11/8/12</th>
<th>3.5295</th>
<th>11/8/12</th>
<th>3.5322</th>
</tr>
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<tbody>
<tr>
<td>11/7/12</td>
<td>JSC</td>
<td>3.4965</td>
<td>11/7/12 F</td>
<td>3.5291</td>
<td>11/7/12 F</td>
<td>3.5317</td>
</tr>
<tr>
<td>Tare Wt., g.</td>
<td>(110 ml)</td>
<td>3.4816</td>
<td>(90 ml)</td>
<td>3.5270</td>
<td>(100 ml)</td>
<td>3.5236</td>
</tr>
<tr>
<td>RINSE SAMPLE Wt., g.</td>
<td>0.0049</td>
<td>0.0021</td>
<td>0.0081</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Filter Catch, mg.</th>
<th>#N/A</th>
<th>#N/A</th>
<th>#N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rinse Catch, mg.</td>
<td>4.9</td>
<td>2.1</td>
<td>8.1</td>
</tr>
<tr>
<td>Rinse Blank Residue, mg.</td>
<td>0.3</td>
<td>0.2</td>
<td>0.3</td>
</tr>
<tr>
<td>Net Rinse Catch, mg.</td>
<td>4.6</td>
<td>1.9</td>
<td>7.8</td>
</tr>
<tr>
<td>FILTERABLE PARTICULATE, mg.</td>
<td>4.6</td>
<td>1.9</td>
<td>7.8</td>
</tr>
</tbody>
</table>

**Legend:**  
F = Final Weight

**Notes & Comments:**
### PARTICULATE SAMPLING LABORATORY RESULTS

**Client:** Air Control Techniques  
**Method:** EPA M5  
**RFA #:** 1756

<table>
<thead>
<tr>
<th>Run Number</th>
<th>S2-1</th>
<th>U1-2</th>
<th>U2-2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nozzle H₂O</td>
<td>Nozzle H₂O</td>
<td>Nozzle H₂O</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Filter Container #</th>
<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Date</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baggie Tare Wt., g.</td>
<td></td>
<td></td>
<td>#N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Filter Tare Wt., g.</td>
<td></td>
<td></td>
<td></td>
<td>#N/A</td>
<td></td>
</tr>
<tr>
<td>FILTER SAMPLE WT., g.</td>
<td></td>
<td></td>
<td>#N/A ##</td>
<td>#N/A ##</td>
<td>#N/A #N/A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Front % Rinse Container #</th>
<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Date</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>58</td>
<td></td>
<td>2437</td>
<td></td>
<td>2483</td>
</tr>
</tbody>
</table>

| Date     | JSC | 11/8/12 | 3.5416 | 11/8/12 | 3.4413 | 11/8/12 | 3.6311 |
| 11/7/12  | JSC F | 3.5412 | 3.4410 | 11/7/12 | 3.6307 |
| 100 ml   |      | 3.5341 | 70 ml   | 3.4376 | 120 ml  | 3.6286 |
| Rinse Wt., g. |      | 0.0077 | 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

<table>
<thead>
<tr>
<th>Run Number</th>
<th>S1-2</th>
<th>S2-2</th>
<th>U1-3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nozzle H₂O</td>
<td>Nozzle H₂O</td>
<td>Nozzle H₂O</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Filter Container #</th>
<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Date</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Baggage Tare Wt., g.</th>
<th>#N/A</th>
<th>#N/A</th>
<th>#N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter Tare Wt., g.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FILTER SAMPLE Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Front ½ Rinse Container #</th>
<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Date</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>11/7/12</th>
<th>JSC</th>
<th>3.5059</th>
<th>11/8/12</th>
<th>3.5835</th>
<th>11/8/12</th>
<th>3.4741</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/7/12</td>
<td>JSC</td>
<td>3.5055</td>
<td>11/7/12</td>
<td>3.5833</td>
<td>11/7/12</td>
<td>3.4740</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tara Wt., g.</th>
<th>100 ml</th>
<th>70 ml</th>
<th>120 ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>RINSE SAMPLE Wt., g.</td>
<td>0.0055</td>
<td>0.0066</td>
<td>0.0024</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Filter Catch, mg.</th>
<th>#N/A</th>
<th>#N/A</th>
<th>#N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rinse Catch, mg.</td>
<td>5.5</td>
<td>6.6</td>
<td>2.4</td>
</tr>
<tr>
<td>Rinse Blank Residue, mg.</td>
<td>0.3</td>
<td>0.2</td>
<td>0.3</td>
</tr>
<tr>
<td>Net Rinse Catch, mg.</td>
<td>5.2</td>
<td>6.4</td>
<td>2.1</td>
</tr>
</tbody>
</table>

| 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

<table>
<thead>
<tr>
<th>Run Number</th>
<th>U2-3</th>
<th>S1-3</th>
<th>S2-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nozzle H₂O</td>
<td>Nozzle H₂O</td>
<td>Nozzle H₂O</td>
<td></td>
</tr>
</tbody>
</table>

#### Filter Container 
- **Date** | **Init** | **Date** | **Date** |
- **Baggie Tare Wt., g.** | #N/A | #N/A | #N/A |
- **Filter Tare Wt., g.** | #N/A | #N/A | #N/A |
- **FILTER SAMPLE WT., g.** | #N/A #/ | #N/A #/ | #N/A #/ |

<table>
<thead>
<tr>
<th>Front 1/4 Rinse Container #</th>
<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2478</td>
<td></td>
<td>2305</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1567</td>
</tr>
</tbody>
</table>

| 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 |
| 3.5351 (90 ml) | 3.4808 (80 ml) | 3.6603 |

| Rinse Wt., g. | 0.0012 | 0.0033 | 0.0013 |
| RINSE SAMPLE WT., g. | |

| 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  
**Method:** EPA M5  
**RFA #:** 1756

<table>
<thead>
<tr>
<th>Run Number</th>
<th>U1-4</th>
<th>U2-4</th>
<th>S1-4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nozzle H₂O</td>
<td>Nozzle H₂O</td>
<td>Nozzle H₂O</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Filter Container #</th>
<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baggage Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td></td>
</tr>
<tr>
<td>Filter Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td></td>
</tr>
<tr>
<td>FILTER SAMPLE WT., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
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</table>

<table>
<thead>
<tr>
<th>Front % Rinse Container #</th>
<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1633</td>
<td></td>
<td>2419</td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td>2804</td>
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<table>
<thead>
<tr>
<th>Date</th>
<th>JSC</th>
<th>F</th>
<th>Date</th>
<th>JSC</th>
<th>F</th>
<th>Date</th>
<th>F</th>
<th>Date</th>
<th>F</th>
<th>Date</th>
<th>F</th>
<th>Date</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/7/12</td>
<td>3.5791</td>
<td>11/7/12</td>
<td>3.4917</td>
<td>11/7/12</td>
<td>3.8700</td>
<td>11/7/12</td>
<td>3.3420</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tare Wt., g.</td>
<td>( 90 ml)</td>
<td>3.5773</td>
<td>( 110 ml)</td>
<td>3.4901</td>
<td>( 60 ml)</td>
<td>3.8785</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RINSE SAMPLE WT., g.</td>
<td>0.0018</td>
<td>0.0016</td>
<td>0.0005</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 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:**

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OTM-036  
Page 553 of 643  
4/11/2016
**PARTICULATE SAMPLING LABORATORY RESULTS**

Client: **Air Control Techniques**  
Method: **EPA M5**  
RFA #: **1756**

<table>
<thead>
<tr>
<th>Run Number</th>
<th>S2-4 Nozzle H₂O</th>
<th>U1-5 Nozzle H₂O</th>
<th>U2-5 Nozzle H₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
<tr>
<td>Baggie Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Filter Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>FILTER SAMPLE WT., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Front ½ Rinse Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>JSC</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/8/12</td>
<td>3.6606</td>
<td></td>
</tr>
<tr>
<td>11/7/12</td>
<td>3.6606</td>
<td></td>
</tr>
<tr>
<td>Rinse Wt., g. (50 ml)</td>
<td>3.6600</td>
<td></td>
</tr>
<tr>
<td>RINSE SAMPLE WT., g.</td>
<td>0.0006</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>JSC</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/8/12</td>
<td>3.5809</td>
<td></td>
</tr>
<tr>
<td>11/7/12</td>
<td>3.5808</td>
<td></td>
</tr>
<tr>
<td>Tare Wt., g. (80 ml)</td>
<td>3.5794</td>
<td></td>
</tr>
<tr>
<td>RINSE SAMPLE WT., g.</td>
<td>0.0014</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>JSC</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/8/12</td>
<td>3.6042</td>
<td></td>
</tr>
<tr>
<td>11/7/12</td>
<td>3.6042</td>
<td></td>
</tr>
<tr>
<td>Rinse Wt., g. (60 ml)</td>
<td>3.6028</td>
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<tr>
<td>RINSE SAMPLE WT., g.</td>
<td>0.0014</td>
<td></td>
</tr>
</tbody>
</table>

| 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:**

---

OTM-036  
Page 554 of 643  
4/11/2016
# PARTICULATE SAMPLING LABORATORY RESULTS

<table>
<thead>
<tr>
<th>Run Number</th>
<th>S1-5 Nozzle H₂O</th>
<th>S2-5 Nozzle H₂O</th>
<th>U1-5 Nozzle H₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>Init</td>
<td>Date</td>
<td>Date</td>
</tr>
<tr>
<td>Baggie Tara Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Filter Tara Wt., g.</td>
<td>#N/A #1</td>
<td>#N/A #1</td>
<td>#N/A #1</td>
</tr>
<tr>
<td>FILTER SAMPLE WT., g.</td>
<td>#N/A #2</td>
<td>#N/A #2</td>
<td>#N/A #2</td>
</tr>
<tr>
<td>Front 1/16 Rinse Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>JSC</th>
<th>11/8/12</th>
<th>3.4705</th>
<th>11/8/12</th>
<th>3.6685</th>
<th>11/8/12</th>
<th>3.7768</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/7/12</td>
<td>JSC</td>
<td>F</td>
<td>3.4704</td>
<td>11/7/12</td>
<td>F</td>
<td>3.6682</td>
<td>11/7/12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tare Wt., g.</th>
<th>(90 ml)</th>
<th>3.4623</th>
<th>(80 ml)</th>
<th>3.6646</th>
<th>(70 ml)</th>
<th>3.7752</th>
</tr>
</thead>
<tbody>
<tr>
<td>RINSE SAMPLE WT., g.</td>
<td>0.0081</td>
<td>0.0036</td>
<td>0.0015</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 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

<table>
<thead>
<tr>
<th>Client: Air Control Techniques</th>
<th>Method: EPA M5</th>
<th>RFA #: 1756</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run Number</td>
<td>U2-6</td>
<td>S1-6</td>
</tr>
<tr>
<td></td>
<td>Nozzle H₂O</td>
<td>Nozzle H₂O</td>
</tr>
<tr>
<td>Filter Container #</td>
<td>Date</td>
<td>Init</td>
</tr>
<tr>
<td>Baggie Tare Wt., g.</td>
<td>#N/A</td>
<td></td>
</tr>
<tr>
<td>Filter Tare Wt., g.</td>
<td></td>
<td>#N/A</td>
</tr>
<tr>
<td>FILTER SAMPLE WT., g.</td>
<td>#N/A ##</td>
<td></td>
</tr>
<tr>
<td>Front ½ Rinse Container #</td>
<td>Date</td>
<td>Init</td>
</tr>
</tbody>
</table>

| Date | 11/8/12 | 11/7/12 | 11/8/12 | 11/7/12 | 11/8/12 | 11/7/12 | 11/8/12 | 11/7/12 | 11/8/12 | 11/7/12 |
| JSC  | 3.6810  | 3.6809  | 3.6904  | 3.6905  | 3.4845  | 3.4844  | 3.6895  | 3.4831  | 0.0022  | 0.0009  |
| F    | 3.6940  | 3.6905  | 3.6905  | 3.6905  | 0.0013  | 0.0013  | 0.0013  |

| Tare Wt., g.                  | 3.6877 (90 ml) | 3.6895 (100 ml) | 3.4831 (100 ml) |
| RINSE SAMPLE WT., g.         | 0.0022         | 0.0009           | 0.0013           |

| 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:
## Report Summary

<table>
<thead>
<tr>
<th>SAMPLE ID</th>
<th>ACETONE PROBE AND &gt;2.5μg RINSE PARTICULATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>U1-1</td>
<td>9.1 mg</td>
</tr>
<tr>
<td>U2-1</td>
<td>5.7 mg</td>
</tr>
<tr>
<td>S1-1</td>
<td>5.1 mg</td>
</tr>
<tr>
<td>S2-1</td>
<td>5.7 mg</td>
</tr>
<tr>
<td>U1-2</td>
<td>5.7 mg</td>
</tr>
<tr>
<td>U2-2</td>
<td>3.7 mg</td>
</tr>
<tr>
<td>S1-2</td>
<td>3.8 mg</td>
</tr>
<tr>
<td>S2-2</td>
<td>7.2 mg</td>
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<td>U1-3</td>
<td>4.5 mg</td>
</tr>
<tr>
<td>U2-3</td>
<td>4.2 mg</td>
</tr>
<tr>
<td>S1-3</td>
<td>3.7 mg</td>
</tr>
<tr>
<td>S2-3</td>
<td>11.3 mg</td>
</tr>
<tr>
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<td>S1-6</td>
<td>2.6 mg</td>
</tr>
<tr>
<td>S2-6</td>
<td>2.5 mg</td>
</tr>
</tbody>
</table>
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**  
Method: **EPA M5**  
RFA #: **1756**

<table>
<thead>
<tr>
<th>Run Number</th>
<th>U1-1</th>
<th>U2-1</th>
<th>S1-1</th>
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<tbody>
<tr>
<td></td>
<td>Probe and &gt;2.5 ug Acetone</td>
<td>Probe and &gt;2.5 ug Acetone</td>
<td>Probe and &gt;2.5 ug Acetone</td>
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</table>

<table>
<thead>
<tr>
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<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baggie Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td></td>
</tr>
<tr>
<td>Filter Tare Wt., g</td>
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<td>#N/A</td>
<td>#N/A</td>
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<td>FILTER SAMPLE WT., g</td>
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<td>#N/A</td>
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<table>
<thead>
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<th>Init</th>
<th>Date</th>
<th>Date</th>
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<table>
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<th>11/12/12</th>
<th>F</th>
<th>3.6456</th>
<th>11/12/12</th>
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<td>11/12/12</td>
<td>F</td>
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<td>Tare Wt., g</td>
<td>(100 ml)</td>
<td>3.5772</td>
<td>(100 ml)</td>
<td>3.6396</td>
<td>(100 ml)</td>
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<tr>
<td>RINSE SAMPLE WT., g</td>
<td>0.0094</td>
<td>0.0060</td>
<td>0.0054</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

| 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

<table>
<thead>
<tr>
<th>Client: Air Control Techniques</th>
<th>RFA #: 1756</th>
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<td>Method: EPA M5</td>
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<table>
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<tr>
<th>Run Number</th>
<th>S2-1</th>
<th>U1-2</th>
<th>U2-2</th>
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<tbody>
<tr>
<td>Probe and &gt;2.5ug Acetone</td>
<td>Probe and &gt;2.5ug Acetone</td>
<td>Probe and &gt;2.5ug Acetone</td>
<td></td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Filter Container #</th>
<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Date</th>
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</table>

<table>
<thead>
<tr>
<th>Baggage Tare Wt., g.</th>
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<th>#N/A</th>
<th>#N/A</th>
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<tr>
<td>Filter Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>FILTER SAMPLE WT., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Front % Rinse Container #</th>
<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Date</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>1/12/12</th>
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<th>3.6806</th>
<th>11/12/12</th>
<th>3.6092</th>
<th>11/12/12</th>
<th>3.6765</th>
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</thead>
<tbody>
<tr>
<td>11/12/12</td>
<td>JSC F</td>
<td>3.6801</td>
<td>11/12/12 F</td>
<td>3.6090</td>
<td>11/12/12 F</td>
<td>3.6762</td>
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<tr>
<td>Tare Wt., g.</td>
<td>( 110 ml)</td>
<td>3.6741</td>
<td>( 90 ml)</td>
<td>3.6030</td>
<td>( 80 ml)</td>
<td>3.6722</td>
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<tr>
<td>RINSE SAMPLE WT., g.</td>
<td>0.0060</td>
<td>0.0060</td>
<td>0.0040</td>
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<td></td>
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<table>
<thead>
<tr>
<th>Filter Catch, mg.</th>
<th>#N/A</th>
<th>#N/A</th>
<th>#N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rinse Catch, mg.</td>
<td>6.0</td>
<td>6.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Rinse Blank Residue, mg.</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>Net Rinse Catch, mg.</td>
<td>5.7</td>
<td>5.7</td>
<td>3.7</td>
</tr>
<tr>
<td>FILTERABLE PARTICULATE, mg.</td>
<td>5.7</td>
<td>5.7</td>
<td>3.7</td>
</tr>
</tbody>
</table>

### Legend:
- F = Final Weight

### Notes & Comments:
# PARTICULATE SAMPLING LABORATORY RESULTS

**Client:** Air Control Techniques  
**Method:** EPA M5  
**RFA #:** 1756

<table>
<thead>
<tr>
<th>Run Number</th>
<th>S1-2 Probe and &gt;2.5ug Acetone</th>
<th>S2-2 Probe and &gt;2.5ug Acetone</th>
<th>U1-3 Probe and &gt;2.5ug Acetone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
<tr>
<td>Baggie Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Filter Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>FILTER SAMPLE WT., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Front % Rinse Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
<tr>
<td>11/12/12 JSC</td>
<td>3.5221</td>
<td>11/12/12</td>
<td>3.6622</td>
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<tr>
<td>11/12/12 JSC F</td>
<td>3.5218</td>
<td>11/12/12 F</td>
<td>3.6620</td>
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<tr>
<td>Tare Wt., g.</td>
<td>( 120 ml)</td>
<td>3.5176</td>
<td>( 110 ml)</td>
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<tr>
<td>RINSE SAMPLE WT., g.</td>
<td>0.0042</td>
<td>0.0075</td>
<td>0.0048</td>
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<tr>
<td>Filter Catch, mg.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Rinse Catch, mg.</td>
<td>4.2</td>
<td>7.5</td>
<td>4.8</td>
</tr>
<tr>
<td>Rinse Blank Residue, mg.</td>
<td>0.4</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>Net Rinse Catch, mg.</td>
<td>3.8</td>
<td>7.2</td>
<td>4.5</td>
</tr>
<tr>
<td>FILTERABLE PARTICULATE, mg.</td>
<td>3.8</td>
<td>7.2</td>
<td>4.5</td>
</tr>
</tbody>
</table>

**Legend:**  
*F = Final Weight*

**Notes & Comments:**
# PARTICULATE SAMPLING LABORATORY RESULTS

<table>
<thead>
<tr>
<th>Run Number</th>
<th>U2-3</th>
<th>S1-3</th>
<th>S2-3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Probe and ≥2.5µg Acetone</td>
<td>Probe and ≥2.5µg Acetone</td>
<td>Probe and ≥2.5µg Acetone</td>
</tr>
<tr>
<td><strong>Filter Container #</strong></td>
<td><strong>Date</strong></td>
<td><strong>Init</strong></td>
<td><strong>Date</strong></td>
</tr>
<tr>
<td>Baggie Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Filter Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>FILTER SAMPLE WT., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Front % Rinse Container #</td>
<td><strong>Date</strong></td>
<td><strong>Init</strong></td>
<td><strong>Date</strong></td>
</tr>
<tr>
<td></td>
<td>1676</td>
<td>1441</td>
<td>2303</td>
</tr>
</tbody>
</table>

| 11/12/12 | JSC | 3.7053 | 11/12/12 | F | 3.5367 | 11/12/12 | F | 3.5451 |
| 11/12/12 | JSC F | 3.7060 | 11/12/12 | F | 3.5367 | 11/12/12 | F | 3.5448 |
| Tare Wt., g. | (90 ml) | 3.7065 | (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

<table>
<thead>
<tr>
<th>Run Number</th>
<th>U1-4 Probe and &gt;2.5ug Acetone</th>
<th>U2-4 Probe and &gt;2.5ug Acetone</th>
<th>S1-4 Probe and &gt;2.5ug Acetone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
<tr>
<td>Baggie Tare Wt., g</td>
<td>#N/A</td>
<td></td>
<td>#N/A</td>
</tr>
<tr>
<td>Filter Tare Wt., g</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FILTER SAMPLE WT., g</td>
<td>#N/A</td>
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<td>#N/A</td>
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<tr>
<td>Front % Rinse Container #</td>
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<table>
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<tr>
<th>Date</th>
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<th>3.7532</th>
<th>11/12/12</th>
<th>F</th>
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<td>3.7527</td>
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<tr>
<td></td>
<td>(70 ml)</td>
<td>3.7490</td>
<td>(80 ml)</td>
<td>3.5969</td>
<td>(70 ml)</td>
<td>3.7135</td>
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<tr>
<td>Rinse Sample WT., g</td>
<td>0.0037</td>
<td>0.0036</td>
<td>0.0024</td>
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</table>

- **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

<table>
<thead>
<tr>
<th>Run Number</th>
<th>S2-4 (Probe and &gt;2.5μg Acetone)</th>
<th>U1-5 (Probe and &gt;2.5μg Acetone)</th>
<th>U2-5 (Probe and &gt;2.5μg Acetone)</th>
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<tbody>
<tr>
<td>Filter Container #</td>
<td>Date Init</td>
<td>Date</td>
<td>Date</td>
</tr>
<tr>
<td>Baggie Tare Wt., g</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Filter Tare Wt., g</td>
<td>#N/A #</td>
<td>#N/A #</td>
<td>#N/A #</td>
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<tr>
<td>FILTER SAMPLE WT., g</td>
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<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Front ¼ Rinse Container #</td>
<td>Date Init</td>
<td>Date</td>
<td>Date</td>
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<table>
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<th>JSC F</th>
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<td>3.7477</td>
<td>3.7422</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Tare Wt., g</td>
<td>( 130 ml)</td>
<td>3.3863</td>
<td>( 120 ml</td>
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<td>( 100 ml</td>
<td>3.7477</td>
<td>3.7422</td>
<td></td>
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<td>RINSE SAMPLE WT., g</td>
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<table>
<thead>
<tr>
<th>Filter Catch, mg.</th>
<th>#N/A</th>
<th>#N/A</th>
<th>#N/A</th>
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<tbody>
<tr>
<td>Rinse Catch, mg.</td>
<td>3.1</td>
<td>4.8</td>
<td>2.2</td>
</tr>
<tr>
<td>Rinse Blank Residue, mg.</td>
<td>0.4</td>
<td>0.4</td>
<td>0.3</td>
</tr>
<tr>
<td>Net Rinse Catch, mg.</td>
<td>2.7</td>
<td>4.4</td>
<td>1.9</td>
</tr>
<tr>
<td>FILTERABLE PARTICULATE, mg.</td>
<td>2.7</td>
<td>4.4</td>
<td>1.9</td>
</tr>
</tbody>
</table>

**Legend:**  
F = Final Weight

**Notes & Comments:**
# PARTICULATE_SAMPLING_LABORATORY_RESULTS

<table>
<thead>
<tr>
<th>Run Number</th>
<th>S1-5</th>
<th>S2-5</th>
<th>U1-6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S1-5</td>
<td>S2-5</td>
<td>U1-6</td>
</tr>
<tr>
<td></td>
<td>Probe and &gt;2.5µg Acetone</td>
<td>Probe and &gt;2.5µg Acetone</td>
<td>Probe and &gt;2.5µg Acetone</td>
</tr>
<tr>
<td>Filter Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baggie Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Filter Tare Wt., g.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FILTER SAMPLE WT., g.</td>
<td>#N/A ##</td>
<td>#N/A ##</td>
<td>#N/A #N/A</td>
</tr>
<tr>
<td>Front ¼ Rinse Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
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<tr>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 11/12/12 | JSC | 3.6853 | 11/12/12 | 3.7981 | 11/12/12 | 3.5122 |
| 11/12/12 | JSC | 3.6581 | 11/12/12 | 3.7978 | 11/12/12 | 3.5120 |
| Tare Wt., g. | ( 70 ml) | 3.6829 | ( 110 ml) | 3.7942 | ( 70 ml) | 3.5080 |
| RINSE SAMPLE WT., g. | 0.0036 | 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  

<table>
<thead>
<tr>
<th>Run Number</th>
<th>U2-6 Probe and &gt;2.5μg Acetone</th>
<th>S1-6 Probe and &gt;2.5μg Acetone</th>
<th>S2-6 Probe and &gt;2.5μg Acetone</th>
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</thead>
<tbody>
<tr>
<td>Filter Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
<tr>
<td>Baggie Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Filter Tare Wt., g.</td>
<td>#N/A</td>
<td></td>
<td>#N/A ##</td>
</tr>
<tr>
<td>FILTER SAMPLE WT., g.</td>
<td>#N/A ##</td>
<td>#N/A #N/A</td>
<td>#N/A #N/A</td>
</tr>
<tr>
<td>Front ¼ Rinse Container #</td>
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<td>Init</td>
<td>Date</td>
</tr>
<tr>
<td>2454</td>
<td>1527</td>
<td>1401</td>
<td></td>
</tr>
</tbody>
</table>

| 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 | 3.4490 | 11/12/12 | 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:**
# Report Summary

<table>
<thead>
<tr>
<th>SAMPLE ID</th>
<th>H₂O PROBE AND &gt;2.5μg RINSE</th>
<th>PARTICULATE</th>
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<tbody>
<tr>
<td>U1-1</td>
<td>14.6 mg</td>
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</tr>
<tr>
<td>U2-1</td>
<td>9.3 mg</td>
<td></td>
</tr>
<tr>
<td>S1-1</td>
<td>12.4 mg</td>
<td></td>
</tr>
<tr>
<td>S2-1</td>
<td>9.2 mg</td>
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<tr>
<td>U1-2</td>
<td>5.5 mg</td>
<td></td>
</tr>
<tr>
<td>U2-2</td>
<td>4.1 mg</td>
<td></td>
</tr>
<tr>
<td>S1-2</td>
<td>7.7 mg</td>
<td></td>
</tr>
<tr>
<td>S2-2</td>
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<tr>
<td>U1-3</td>
<td>5.4 mg</td>
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</tr>
<tr>
<td>U2-3</td>
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<td></td>
</tr>
<tr>
<td>S1-3</td>
<td>5.9 mg</td>
<td></td>
</tr>
<tr>
<td>S2-3</td>
<td>2.8 mg</td>
<td></td>
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<tr>
<td>U1-4</td>
<td>4.1 mg</td>
<td></td>
</tr>
<tr>
<td>U2-4</td>
<td>4.0 mg</td>
<td></td>
</tr>
<tr>
<td>S1-4</td>
<td>4.8 mg</td>
<td></td>
</tr>
<tr>
<td>S2-4</td>
<td>3.1 mg</td>
<td></td>
</tr>
<tr>
<td>U1-5</td>
<td>5.2 mg</td>
<td></td>
</tr>
<tr>
<td>U2-5</td>
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</tr>
<tr>
<td>S1-5</td>
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<tr>
<td>S2-5</td>
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<tr>
<td>U1-6</td>
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<td></td>
</tr>
<tr>
<td>U2-6</td>
<td>2.1 mg</td>
<td></td>
</tr>
<tr>
<td>S1-6</td>
<td>4.1 mg</td>
<td></td>
</tr>
<tr>
<td>S2-6</td>
<td>2.2 mg</td>
<td></td>
</tr>
</tbody>
</table>
Analytical Narrative

Sample Matrix & Components:

Front ½ DI H₂O Probe and >2.5μg Rinses, DI H₂O Blank

Summary of Sample Prep:

The DI H₂O rinses were transferred to pre-tared teflon "baggies" in a low humidity environment. The DI H₂O 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

<table>
<thead>
<tr>
<th>Run Number</th>
<th>U1-1 Probe and &gt;2.5µg H₂O</th>
<th>U2-1 Probe and &gt;2.5µg H₂O</th>
<th>S1-1 Probe and &gt;2.5µg H₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
<tr>
<td>Baggie Tare Wt., g.</td>
<td>#N/A</td>
<td></td>
<td>#N/A</td>
</tr>
<tr>
<td>Filter Tare Wt., g.</td>
<td>#N/A</td>
<td></td>
<td>#N/A</td>
</tr>
<tr>
<td>FILTER SAMPLE WT., g.</td>
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<td>#</td>
<td>#N/A</td>
</tr>
<tr>
<td>Front % Rinse Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
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<tr>
<td>1267</td>
<td>772</td>
<td>1694</td>
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<table>
<thead>
<tr>
<th>Date</th>
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<th>JSC F</th>
<th>11/8/12</th>
<th>11/8/12</th>
<th>11/7/12</th>
<th>11/7/12</th>
<th>11/8/12</th>
<th>11/8/12</th>
<th>11/7/12</th>
<th>11/7/12</th>
<th>11/8/12</th>
<th>11/8/12</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/7/12</td>
<td>JSC F</td>
<td>3.9217</td>
<td>11/7/12</td>
<td>F</td>
<td>3.4941</td>
<td>11/7/12</td>
<td>F</td>
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<td>11/7/12</td>
<td>3.4941</td>
<td>11/7/12</td>
<td>3.7710</td>
</tr>
<tr>
<td>140 ml</td>
<td>3.9087</td>
<td>190 ml</td>
<td>3.4944</td>
<td>180 ml</td>
<td>3.7581</td>
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<td>3.7581</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>RINSE SAMPLE WT., g.</td>
<td>0.0150</td>
<td>0.0097</td>
<td>0.0129</td>
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<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

| 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

<table>
<thead>
<tr>
<th>Run Number</th>
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<th>U1-2</th>
<th>U2-2</th>
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<tbody>
<tr>
<td></td>
<td>Probe and &gt;2.5ug H₂O</td>
<td>Probe and &gt;2.5ug H₂O</td>
<td>Probe and &gt;2.5ug H₂O</td>
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</tbody>
</table>

<table>
<thead>
<tr>
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<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Date</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baggie Tare Wt., g.</td>
<td></td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Filter Tare Wt., g.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FILTER SAMPLE Wt., g.</td>
<td></td>
<td>#N/A ##</td>
<td>#N/A ##</td>
<td>#N/A #N/A</td>
<td>#N/A #N/A</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Front ¼ Rinse Container #</th>
<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Date</th>
<th>Date</th>
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<tbody>
<tr>
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<td>1534</td>
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<td>417</td>
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<table>
<thead>
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<th>F</th>
<th>Date</th>
<th>JSC</th>
<th>F</th>
<th>Date</th>
<th>JSC</th>
<th>F</th>
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</thead>
<tbody>
<tr>
<td>11/8/12</td>
<td>3.7231</td>
<td>11/8/12</td>
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<td>11/8/12</td>
<td>3.5227</td>
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<td></td>
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</tr>
<tr>
<td>11/7/12</td>
<td>3.7233</td>
<td>11/7/12</td>
<td>3.6239</td>
<td>11/7/12</td>
<td>3.5228</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tara Wt., g.</th>
<th>3.7135</th>
<th>3.6182</th>
<th>3.5183</th>
</tr>
</thead>
<tbody>
<tr>
<td>(160 ml)</td>
<td>90 ml</td>
<td>110 ml</td>
<td></td>
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</tbody>
</table>

| Rinse Sample Wt., g. | 0.0096 | 0.0057 | 0.0044 |

<table>
<thead>
<tr>
<th>Filter Catch, mg.</th>
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<th>#N/A</th>
<th>#N/A</th>
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</thead>
<tbody>
<tr>
<td>Rinse Catch, mg.</td>
<td>9.6</td>
<td>5.7</td>
<td>4.4</td>
</tr>
<tr>
<td>Rinse Blank Residue, mg.</td>
<td>0.4</td>
<td>0.2</td>
<td>0.3</td>
</tr>
<tr>
<td>Net Rinse Catch, mg.</td>
<td>9.2</td>
<td>5.5</td>
<td>4.1</td>
</tr>
</tbody>
</table>

| FILTERABLE PARTICULATE, mg. | 9.2 | 5.5 | 4.1 |

**Legend:**  
F = Final Weight

**Notes & Comments:**
# PARTICULATE SAMPLING LABORATORY RESULTS

<table>
<thead>
<tr>
<th>Run Number</th>
<th>S1-2</th>
<th>S2-2</th>
<th>U1-3</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Probe and &gt;2.5μg H₂O</td>
<td>Probe and &gt;2.5μg H₂O</td>
<td>Probe and &gt;2.5μg H₂O</td>
</tr>
<tr>
<td>Filter Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
<tr>
<td>Baggage Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Filter Tare Wt., g.</td>
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<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>FILTER SAMPLE Wt., g.</td>
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<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Front ¾ Rinse Container #</td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Init</th>
<th>Date</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/7/12</td>
<td>JSC</td>
<td>3.5345</td>
<td>11/7/12</td>
</tr>
<tr>
<td>Tare Wt., g.</td>
<td>( 170 ml)</td>
<td>3.5263</td>
<td>( 180 ml)</td>
</tr>
<tr>
<td>RINSE SAMPLE Wt., g.</td>
<td>0.0082</td>
<td>0.0048</td>
<td>0.0059</td>
</tr>
</tbody>
</table>

| 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

<table>
<thead>
<tr>
<th>Run Number</th>
<th>U2-3 Probe and &gt;2.5µg H₂O</th>
<th>S1-3 Probe and &gt;2.5µg H₂O</th>
<th>S2-3 Probe and &gt;2.5µg H₂O</th>
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</thead>
<tbody>
<tr>
<td><strong>Filter Container #</strong></td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
<tr>
<td>Baggie Tare Wt., g.</td>
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<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>Filter Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
<tr>
<td>FILTER SAMPLE WT., g.</td>
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<td>#N/A ##</td>
<td>#N/A #N/A</td>
</tr>
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<td>Date</td>
</tr>
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<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
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</tr>
<tr>
<td>11/7/12</td>
<td>3.3545</td>
<td>3.3547</td>
</tr>
<tr>
<td>Tare Wt., g. (110 ml)</td>
<td>3.5140</td>
<td>3.7040</td>
</tr>
<tr>
<td>RINSE SAMPLE WT., g.</td>
<td>0.0035</td>
<td>0.0063</td>
</tr>
<tr>
<td>Rinse Blank Residue, mg.</td>
<td>0.3</td>
<td>0.4</td>
</tr>
<tr>
<td>Net Rinse Catch, mg.</td>
<td>3.2</td>
<td>5.9</td>
</tr>
<tr>
<td>FILTERABLE PARTICULATE, mg.</td>
<td>3.2</td>
<td>5.9</td>
</tr>
</tbody>
</table>

**Legend:**  
F = Final Weight

**Notes & Comments:**
## PARTICULATE SAMPLING LABORATORY RESULTS

<table>
<thead>
<tr>
<th>Run Number</th>
<th>U1-4 Probe and &gt;2.5ug H₂O</th>
<th>U2-4 Probe and &gt;2.5ug H₂O</th>
<th>S1-4 Probe and &gt;2.5ug H₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Date</td>
<td>Init</td>
<td>Date</td>
</tr>
<tr>
<td>Baggie Tare Wt., g.</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
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<tr>
<td>Filter Tare Wt., g.</td>
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<td>#N/A ###</td>
<td>#N/A #N/A</td>
</tr>
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| 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

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<th>U1-5 Probe and &gt;2.5µg H₂O</th>
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| JSC | JSC F | F | F | F | F | |
| 150 ml | 170 ml | 150 ml |

| 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  
**Method:** EPA M5  
**RFA #:** 1756

### Run Number

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<th>S2-5</th>
<th>U1-6</th>
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### Weight Values

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<table>
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<tr>
<td>170 ml</td>
<td>3.5292</td>
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<tr>
<td>110 ml</td>
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| RINSE SAMPLE Wt., g. | 0.0092 | 0.0092 | 0.0038 |

### Filter Catch, mg.

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<th></th>
<th>#N/A</th>
<th>#N/A</th>
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</table>

### Rinse Catch, mg.

|        | 9.2  | 9.2  | 3.0  |

### 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

<table>
<thead>
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<th>Method: EPA M5</th>
<th>RFA #: 1756</th>
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<tbody>
<tr>
<td><strong>Run Number</strong></td>
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<td><strong>S1-6</strong> (Probe and &gt;2.5ug H₂O)</td>
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<td>Init</td>
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<tr>
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<tr>
<td>Filter Tara Wt., g.</td>
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<tr>
<td>Front ¼ Rinse Container #</td>
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<td>Init</td>
</tr>
<tr>
<td>2427</td>
<td>1221</td>
<td>183</td>
</tr>
</tbody>
</table>

| 11/7/12 JSC F | 3.3240 | 11/7/12 F | 3.3833 | 11/7/12 F | 3.6494 |
| Tara Wt., g. (100 ml) | 3.3216 | 140 ml | 3.3788 | 180 ml | 3.6467 |
| RINSE SAMPLE WT., g. | 0.0024 | 0.0045 | 0.0027 |

| 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  
**Method:** EPA M5  
**RFA #:** 1756

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<td>SAMPLE WT., g.</td>
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</table>

| 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  
**Method:** EPA M5  
**RFA #:** 1756

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| 11/12/12 | JSC | 3.5621 |
| 11/12/12 | JSC | 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:**
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## M5/17 Particulate Bench Sheet

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<th>Filter #</th>
<th>Filter Tare</th>
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## M5/17 Particulate Bench Sheet

**Client:** ACT  
**Analyst:** SC  
**RFA #:** 1756  
**Method:** 5  
**Date Received:** 10/31/12  
**Date Analyzed:** 11/14/12

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# M5/17 Particulate Bench Sheet

**Client:** ACT  
**Analyst:** JSC  
**RFA #:** 1756  
**Method:** 160.1, 160.2  
**Date Received:** 10/31/12  
**Date Analyzed:** 11/8/12

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**Report Summary**

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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 oven, 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

Miscellaneous Comments Regarding Sample Analysis: (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  
**Method:** EPA 160.1, 160.2  
**RFA #:** 1756

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</tr>
<tr>
<td>11/12/12</td>
<td>JSC</td>
<td>0.1255</td>
<td>11/12/12</td>
</tr>
<tr>
<td>11/12/12</td>
<td>JSC F</td>
<td>0.1253</td>
<td>11/12/12</td>
</tr>
<tr>
<td></td>
<td>Baggage Tare Wt., g.</td>
<td>0.0000</td>
<td>11/12/12</td>
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<tr>
<td></td>
<td>Filter Tare Wt., g.</td>
<td>0.1236</td>
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<tr>
<td></td>
<td>TSS SAMPLE WT., g.</td>
<td>0.0015</td>
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<table>
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<th>Filterable Container #</th>
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<th>Date</th>
<th>Date</th>
<th>1562</th>
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<tbody>
<tr>
<td>11/13/12</td>
<td>JSC</td>
<td>4.3059</td>
<td>11/13/12</td>
<td>F</td>
<td>4.3277</td>
</tr>
<tr>
<td>11/13/12</td>
<td>JSC F</td>
<td>4.3056</td>
<td>11/13/12</td>
<td>F</td>
<td>4.3279</td>
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<tr>
<td></td>
<td>Tare Wt. g.</td>
<td>3.5472</td>
<td>3.3181</td>
<td>3.4661</td>
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<tr>
<td></td>
<td>TDS SAMPLE WT., g.</td>
<td>0.7584</td>
<td>1.0696</td>
<td>0.9675</td>
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<tr>
<td>Volume of Sample Filtered, ml</td>
<td>170</td>
<td>235</td>
<td>235</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residue Non-filterable, mg/L</td>
<td>8.82</td>
<td>2.13</td>
<td>2.55</td>
<td></td>
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</tr>
<tr>
<td>Residue Filterable, mg/L</td>
<td>4461</td>
<td>4296</td>
<td>4117</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Legend:**  
F = Final Weight

**Notes & Comments:**
APPENDIX F

ANALYTICAL DATA

RESOLUTION ANALYTICS

ION CHROMATOGRAPHY – H₂O RINSES
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
Quality Assurance Officer

www.resolutionanalytics.com
2733 Lee Avenue • Sanford, NC 27332 • Phone: 919-774-5557 • Fax: 919-776-6785
## Report Summary

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>$Cl_2$ (mg)</th>
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</thead>
<tbody>
<tr>
<td>U1-1</td>
<td>0.491</td>
</tr>
<tr>
<td>U2-1</td>
<td>0.339</td>
</tr>
<tr>
<td>S1-1</td>
<td>3.13</td>
</tr>
<tr>
<td>S2-1</td>
<td>3.77</td>
</tr>
<tr>
<td>U1-2</td>
<td>0.211</td>
</tr>
<tr>
<td>U2-2</td>
<td>0.155</td>
</tr>
<tr>
<td>S1-2</td>
<td>1.73</td>
</tr>
<tr>
<td>S2-2</td>
<td>1.25</td>
</tr>
<tr>
<td>U1-3</td>
<td>0.222</td>
</tr>
<tr>
<td>U2-3</td>
<td>0.174</td>
</tr>
<tr>
<td>S1-3</td>
<td>1.75</td>
</tr>
<tr>
<td>S2-3</td>
<td>0.717</td>
</tr>
<tr>
<td>U1-4</td>
<td>0.572</td>
</tr>
<tr>
<td>U2-4</td>
<td>0.431</td>
</tr>
<tr>
<td>S1-4</td>
<td>0.952</td>
</tr>
<tr>
<td>S2-4</td>
<td>0.580</td>
</tr>
<tr>
<td>U1-5</td>
<td>0.994</td>
</tr>
<tr>
<td>U2-5</td>
<td>0.703</td>
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<td>S1-5</td>
<td>2.85</td>
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<td>S2-5</td>
<td>3.76</td>
</tr>
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<td>U1-6</td>
<td>0.520</td>
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<tr>
<td>U2-6</td>
<td>0.397</td>
</tr>
<tr>
<td>S1-6</td>
<td>0.735</td>
</tr>
<tr>
<td>S2-6</td>
<td>0.349</td>
</tr>
</tbody>
</table>

*EPA Audits are reported in mg/L CL-*
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 chromatography. See data for dilution factors used in analysis.

Summary of Instrumentation:
- Dionex ICS-2100 ion chromatograph
- IonPac AS20 4x250mm
- Eluent: 25mM KOH
- Suppressor current: 85 mA
- 25µl injection volume
- Flow rate: 1.25 ml/min
- Temp: 30°C

Limits Of Quantification:

<table>
<thead>
<tr>
<th></th>
<th>Limit of Detection</th>
<th>Limit of Quantitation</th>
<th>Analytical Uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cl₂</td>
<td>0.003 mg/L Cl₂</td>
<td>0.200 mg/L Cl₂</td>
<td>Cl₂ ± 0.4%</td>
</tr>
</tbody>
</table>

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
### Chloride Standard Calibration Curve

<table>
<thead>
<tr>
<th>Conc. (mg/L)</th>
<th>Standard Areas</th>
<th>Average % Diff.</th>
<th>% Deviation from Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.200</td>
<td>0.0410 0.0377</td>
<td>0.0394 4.19%</td>
<td>0.213 6.47%</td>
</tr>
<tr>
<td>4.00</td>
<td>1.0490 1.0471</td>
<td>1.0481 0.09%</td>
<td>3.98 -0.44%</td>
</tr>
<tr>
<td>20.0</td>
<td>5.4155 5.4074</td>
<td>5.4115 0.07%</td>
<td>20.0 0.03%</td>
</tr>
<tr>
<td>40.0</td>
<td>11.0753 10.9794</td>
<td>11.0274 0.43%</td>
<td>40.0 0.00%</td>
</tr>
</tbody>
</table>

### Internal Calibration Verification

<table>
<thead>
<tr>
<th>Inj. 1</th>
<th>Inj. 2</th>
<th>Average Area</th>
<th>% Dev.</th>
<th>Expected Cl⁻</th>
<th>Actual Cl⁻</th>
<th>% Diff.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0978</td>
<td>2.1110</td>
<td>2.0994</td>
<td>0.55%</td>
<td>8.00</td>
<td>7.88</td>
<td>-1.44%</td>
</tr>
</tbody>
</table>

### Field Samples

<table>
<thead>
<tr>
<th>SAMPLE ID</th>
<th>AREA</th>
<th>AREA</th>
<th>AVERAGE AREA</th>
<th>% Diff.</th>
<th>DILUTION FACTOR</th>
<th>CI⁻ (mg/L)</th>
<th>VOLUME (ml)</th>
<th>CATCH (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>U1-1</td>
<td>2.6152</td>
<td>2.6330</td>
<td>2.6241</td>
<td>0.34%</td>
<td>1</td>
<td>9.822</td>
<td>50</td>
<td>0.491</td>
</tr>
<tr>
<td>U2-1</td>
<td>1.8014</td>
<td>1.7980</td>
<td>1.7997</td>
<td>0.09%</td>
<td>1</td>
<td>6.775</td>
<td>50</td>
<td>0.339</td>
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<tr>
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<td>8.5609</td>
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<td>8.5741</td>
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<td>2</td>
<td>62.697</td>
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<td>3.13</td>
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<tr>
<td>S2-1</td>
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<td>10.4158</td>
<td>10.3751</td>
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<td>75.422</td>
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<tr>
<td>U1-2</td>
<td>1.1224</td>
<td>1.1020</td>
<td>1.1122</td>
<td>0.92%</td>
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<td>4.221</td>
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<td>3.103</td>
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<td>9.4934</td>
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<td>34.604</td>
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</tr>
<tr>
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<td>6.8047</td>
<td>6.7680</td>
<td>6.7864</td>
<td>0.27%</td>
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<td>24.964</td>
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<tr>
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<tr>
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<td>3.484</td>
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<tr>
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<td>19.880</td>
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<td>14.057</td>
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<td>6.984</td>
<td>50</td>
<td>0.349</td>
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</table>
Report Summary

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<tr>
<th>Sample ID</th>
<th>Cl₂ (mg)</th>
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<tbody>
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</tr>
<tr>
<td>U2-1</td>
<td>0.119</td>
</tr>
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<td>S1-1</td>
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<td>S2-1</td>
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</tr>
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<td>0.086</td>
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<td>2.77</td>
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<td>3.64</td>
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<td>S2-5</td>
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<td>S1-6</td>
<td>0.196</td>
</tr>
<tr>
<td>S2-6</td>
<td>0.107</td>
</tr>
</tbody>
</table>

* EPA Audits are reported in mg/L CL-
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 chromatography. See data for dilution factors used in analysis.

Summary of Instrumentation:

Dionex ICS-2100 ion chromatograph
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:

<table>
<thead>
<tr>
<th>Limit of Detection</th>
<th>Limit of Quantitation</th>
<th>Analytical Uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.003 mg/L Cl₂</td>
<td>0.200 mg/L Cl₂</td>
<td>Cl₂ ± 0.4%</td>
</tr>
</tbody>
</table>

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
# Chlorine Analytical Data Sheet

## Chloride Standard Calibration Curve

<table>
<thead>
<tr>
<th>Conc. (mg/L)</th>
<th>Standard Areas</th>
<th>Average Area</th>
<th>% Diff.</th>
<th>CI' (mg/L)</th>
<th>% Deviation from Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inj. 1</td>
<td>Inj. 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.200</td>
<td>0.0410</td>
<td>0.0377</td>
<td>0.0394</td>
<td>0.213</td>
<td>6.47%</td>
</tr>
<tr>
<td>4.00</td>
<td>1.0490</td>
<td>1.0471</td>
<td>1.0481</td>
<td>3.98</td>
<td>-0.44%</td>
</tr>
<tr>
<td>20.0</td>
<td>5.4155</td>
<td>5.4074</td>
<td>5.4115</td>
<td>20.0</td>
<td>0.03%</td>
</tr>
<tr>
<td>40.0</td>
<td>11.0753</td>
<td>10.9794</td>
<td>11.0274</td>
<td>40.0</td>
<td>0.00%</td>
</tr>
</tbody>
</table>

## Internal Calibration Verification

<table>
<thead>
<tr>
<th></th>
<th>Inj. 1</th>
<th>Inj. 2</th>
<th>Average Area</th>
<th>% Dev.</th>
<th>Expected CI' (mg/L)</th>
<th>Actual CI' (mg/L)</th>
<th>% Diff.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICV Standard</td>
<td>2.0448</td>
<td>2.0709</td>
<td>2.0579</td>
<td>0.63%</td>
<td>8.00</td>
<td>7.73</td>
<td>-3.38%</td>
</tr>
</tbody>
</table>

## Field Samples

<table>
<thead>
<tr>
<th>SAMPLE ID</th>
<th>Inj. 1 AREA</th>
<th>Inj. 2 AREA</th>
<th>AVERAGE AREA</th>
<th>% Diff.</th>
<th>DILUTION FACTOR ND</th>
<th>CI' (mg/L)</th>
<th>VOLUME ND (ml)</th>
<th>CI3 CATCH (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>U1-1</td>
<td>1.0119</td>
<td>1.0069</td>
<td>1.0094</td>
<td>0.25%</td>
<td>1</td>
<td>3.838</td>
<td>50</td>
<td>0.192</td>
</tr>
<tr>
<td>U2-1</td>
<td>0.6228</td>
<td>0.6180</td>
<td>0.6204</td>
<td>0.39%</td>
<td>1</td>
<td>2.387</td>
<td>50</td>
<td>0.119</td>
</tr>
<tr>
<td>S1-1</td>
<td>6.8923</td>
<td>6.9128</td>
<td>6.9026</td>
<td>0.15%</td>
<td>2</td>
<td>50.762</td>
<td>50</td>
<td>2.64</td>
</tr>
<tr>
<td>S2-1</td>
<td>8.8794</td>
<td>8.8771</td>
<td>8.8783</td>
<td>0.01%</td>
<td>2</td>
<td>64.855</td>
<td>50</td>
<td>3.24</td>
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<tr>
<td>U1-2</td>
<td>0.4102</td>
<td>0.4040</td>
<td>0.4071</td>
<td>0.76%</td>
<td>1</td>
<td>1.590</td>
<td>50</td>
<td>0.080</td>
</tr>
<tr>
<td>U2-2</td>
<td>0.4455</td>
<td>0.4412</td>
<td>0.4434</td>
<td>0.48%</td>
<td>1</td>
<td>1.726</td>
<td>50</td>
<td>0.086</td>
</tr>
<tr>
<td>S1-2</td>
<td>10.3786</td>
<td>10.3595</td>
<td>10.3691</td>
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<td>2</td>
<td>37.690</td>
<td>50</td>
<td>1.88</td>
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<tr>
<td>S2-2</td>
<td>7.5454</td>
<td>7.5515</td>
<td>7.5485</td>
<td>0.04%</td>
<td>2</td>
<td>55.388</td>
<td>50</td>
<td>2.77</td>
</tr>
<tr>
<td>U1-3</td>
<td>0.4116</td>
<td>0.4088</td>
<td>0.4102</td>
<td>0.34%</td>
<td>1</td>
<td>1.602</td>
<td>50</td>
<td>0.080</td>
</tr>
<tr>
<td>U2-3</td>
<td>0.2712</td>
<td>0.2689</td>
<td>0.2701</td>
<td>0.43%</td>
<td>1</td>
<td>1.077</td>
<td>50</td>
<td>0.054</td>
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<tr>
<td>S1-3</td>
<td>4.5374</td>
<td>4.5145</td>
<td>4.5260</td>
<td>0.25%</td>
<td>1</td>
<td>16.790</td>
<td>50</td>
<td>0.840</td>
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<tr>
<td>S2-3</td>
<td>1.9170</td>
<td>1.9321</td>
<td>1.9246</td>
<td>0.39%</td>
<td>1</td>
<td>7.238</td>
<td>50</td>
<td>0.362</td>
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<tr>
<td>U1-4</td>
<td>2.8131</td>
<td>2.8296</td>
<td>2.8214</td>
<td>0.29%</td>
<td>1</td>
<td>10.549</td>
<td>50</td>
<td>0.527</td>
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<td>U2-4</td>
<td>1.1198</td>
<td>1.1278</td>
<td>1.1238</td>
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<td>4.264</td>
<td>50</td>
<td>0.213</td>
</tr>
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<td>S1-4</td>
<td>0.6105</td>
<td>0.6116</td>
<td>0.6111</td>
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<td>2.352</td>
<td>50</td>
<td>0.118</td>
</tr>
<tr>
<td>S2-4</td>
<td>0.6742</td>
<td>0.6805</td>
<td>0.6774</td>
<td>0.47%</td>
<td>1</td>
<td>2.600</td>
<td>50</td>
<td>0.130</td>
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<tr>
<td>U1-5</td>
<td>0.7961</td>
<td>0.7984</td>
<td>0.7973</td>
<td>0.14%</td>
<td>1</td>
<td>3.048</td>
<td>50</td>
<td>0.152</td>
</tr>
<tr>
<td>U2-5</td>
<td>0.8606</td>
<td>0.8592</td>
<td>0.8599</td>
<td>0.08%</td>
<td>1</td>
<td>3.281</td>
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<td>10.0002</td>
<td>9.9969</td>
<td>9.9986</td>
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<td>72.773</td>
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<td>S2-5</td>
<td>7.2057</td>
<td>7.1703</td>
<td>7.1880</td>
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<td>1</td>
<td>26.404</td>
<td>50</td>
<td>1.32</td>
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<tr>
<td>U1-6</td>
<td>1.2302</td>
<td>1.2312</td>
<td>1.2307</td>
<td>0.04%</td>
<td>1</td>
<td>4.062</td>
<td>50</td>
<td>0.233</td>
</tr>
<tr>
<td>U2-6</td>
<td>2.2260</td>
<td>2.2213</td>
<td>2.2237</td>
<td>0.11%</td>
<td>1</td>
<td>8.344</td>
<td>50</td>
<td>0.417</td>
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<tr>
<td>S1-6</td>
<td>1.0277</td>
<td>1.0306</td>
<td>1.0293</td>
<td>0.16%</td>
<td>1</td>
<td>3.913</td>
<td>50</td>
<td>0.196</td>
</tr>
<tr>
<td>S2-6</td>
<td>0.5601</td>
<td>0.5632</td>
<td>0.5567</td>
<td>0.62%</td>
<td>1</td>
<td>2.149</td>
<td>50</td>
<td>0.107</td>
</tr>
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# Report Summary

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>CI₂</th>
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<tbody>
<tr>
<td>DI H₂O Blank</td>
<td>&lt; 0.011</td>
</tr>
<tr>
<td>U1-1</td>
<td>0.026</td>
</tr>
<tr>
<td>U2-1</td>
<td>0.019</td>
</tr>
<tr>
<td>S1-1</td>
<td>0.219</td>
</tr>
<tr>
<td>S2-1</td>
<td>0.486</td>
</tr>
<tr>
<td>U1-2</td>
<td>0.031</td>
</tr>
<tr>
<td>U2-2</td>
<td>0.025</td>
</tr>
<tr>
<td>S1-2</td>
<td>0.126</td>
</tr>
<tr>
<td>S2-2</td>
<td>0.120</td>
</tr>
<tr>
<td>U1-3</td>
<td>0.017</td>
</tr>
<tr>
<td>U2-3</td>
<td>0.023</td>
</tr>
<tr>
<td>S1-3</td>
<td>0.129</td>
</tr>
<tr>
<td>S2-3</td>
<td>0.191</td>
</tr>
<tr>
<td>U1-4</td>
<td>0.042</td>
</tr>
<tr>
<td>U2-4</td>
<td>0.030</td>
</tr>
<tr>
<td>S1-4</td>
<td>0.070</td>
</tr>
<tr>
<td>S2-4</td>
<td>0.046</td>
</tr>
<tr>
<td>U1-5</td>
<td>0.030</td>
</tr>
<tr>
<td>U2-5</td>
<td>0.030</td>
</tr>
<tr>
<td>S1-5</td>
<td>0.084</td>
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<td>S2-5</td>
<td>0.051</td>
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<tr>
<td>U1-6</td>
<td>0.028</td>
</tr>
<tr>
<td>U2-6</td>
<td>0.034</td>
</tr>
<tr>
<td>S1-6</td>
<td>0.026</td>
</tr>
<tr>
<td>S2-6</td>
<td>0.058</td>
</tr>
</tbody>
</table>

* EPA Audits are reported in mg/L CI⁻.
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 chromatography. See data for dilution factors used in analysis.

Summary of Instrumentation:

Dionex ICS-2100 ion chromatograph
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 Cl₂ 0.200 mg/L Cl₂ Cl₂ ± 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
# Chlorine Analytical Data Sheet

## Chloride Standard Calibration Curve

<table>
<thead>
<tr>
<th>Ci (mg/L)</th>
<th>Standard Areas</th>
<th>Average</th>
<th>% Diff.</th>
<th>Cl (mg/L)</th>
<th>% Deviation from Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.200</td>
<td>0.0410 0.0377</td>
<td>0.0394</td>
<td>4.19%</td>
<td>0.213</td>
<td>6.47%</td>
</tr>
<tr>
<td>4.00</td>
<td>1.0490 1.0471</td>
<td>1.0481</td>
<td>0.09%</td>
<td>3.98</td>
<td>-0.44%</td>
</tr>
<tr>
<td>20.0</td>
<td>5.4155 5.4074</td>
<td>5.4115</td>
<td>0.07%</td>
<td>20.0</td>
<td>0.03%</td>
</tr>
<tr>
<td>40.0</td>
<td>11.0753 10.9794</td>
<td>11.0274</td>
<td>0.43%</td>
<td>40.0</td>
<td>0.00%</td>
</tr>
</tbody>
</table>

## Internal Calibration Verification

<table>
<thead>
<tr>
<th>Inj. 1</th>
<th>Inj. 2</th>
<th>Average</th>
<th>Dev.</th>
<th>Expected Cl (mg/L)</th>
<th>Actual Cl (mg/L)</th>
<th>% Diff.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICV Standard</td>
<td>2.0965 2.0930</td>
<td>2.0963</td>
<td>0.16%</td>
<td>8.00</td>
<td>7.87</td>
<td>-1.59%</td>
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</tbody>
</table>

## Matrix Spike

<table>
<thead>
<tr>
<th>Sample I.D.</th>
<th>Inj. 1</th>
<th>Inj. 2</th>
<th>Average</th>
<th>Dev.</th>
<th>Spike Cl (mg/L)</th>
<th>Sample Cl (mg/L)</th>
<th>Calc.Cl (mg/L)</th>
<th>% Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>S2-6</td>
<td>5.5608 5.5448</td>
<td>5.5528</td>
<td>0.14%</td>
<td>20.5</td>
<td>1.17</td>
<td>20.6</td>
<td>99.7%</td>
<td></td>
</tr>
</tbody>
</table>

Note: 0.5 ml of the above sample was spiked with 0.5 ml of a 40.0 ppm chloride standard.

## Field Samples

### SAMPLE ID | Inj. 1 AREA | Inj. 2 AREA | AVERAGE AREA | % Diff. | DILUTION FACTOR | Cl (mg/L) | SAMPLE VOLUME (ml) | Ci CATCH (mg) |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Di H2O Blank</td>
<td>0.0026</td>
<td>0.0022</td>
<td>&lt; 0.0364</td>
<td>NA</td>
<td>1</td>
<td>&lt; 0.213</td>
<td>50</td>
<td>&lt; 0.011</td>
</tr>
<tr>
<td>U1-1</td>
<td>0.1194</td>
<td>0.1155</td>
<td>0.1190</td>
<td>0.38%</td>
<td>1</td>
<td>0.511</td>
<td>50</td>
<td>0.026</td>
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<tr>
<td>U2-1</td>
<td>0.0874</td>
<td>0.0854</td>
<td>0.0864</td>
<td>1.16%</td>
<td>1</td>
<td>0.389</td>
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<td>0.019</td>
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<tr>
<td>S1-1</td>
<td>1.1546</td>
<td>1.1545</td>
<td>1.1546</td>
<td>0.00%</td>
<td>1</td>
<td>4.379</td>
<td>50</td>
<td>0.219</td>
</tr>
<tr>
<td>S2-1</td>
<td>2.5888</td>
<td>2.6024</td>
<td>2.5956</td>
<td>0.26%</td>
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<td>9.717</td>
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</tr>
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<td>0.1516</td>
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<td>0.1502</td>
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<td>0.628</td>
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<td>0.1151</td>
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<td>2.524</td>
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<td>0.6251</td>
<td>0.04%</td>
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<td>2.405</td>
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<tr>
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<td>0.344</td>
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<tr>
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<td>0.1055</td>
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<td>0.461</td>
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<tr>
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<td>0.6787</td>
<td>0.6674</td>
<td>0.6721</td>
<td>0.69%</td>
<td>1</td>
<td>2.580</td>
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<tr>
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<td>1.0061</td>
<td>1.0069</td>
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<td>1</td>
<td>3.829</td>
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<td>0.839</td>
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<tr>
<td>U2-4</td>
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<td>0.1426</td>
<td>0.04%</td>
<td>1</td>
<td>0.600</td>
<td>50</td>
<td>0.030</td>
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<tr>
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<td>0.3568</td>
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<td>1</td>
<td>1.402</td>
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<td>0.2282</td>
<td>0.2286</td>
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<td>0.922</td>
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<td>0.1453</td>
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<td>0.608</td>
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<tr>
<td>U2-5</td>
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<td>0.1400</td>
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<td>1</td>
<td>0.590</td>
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<tr>
<td>S1-5</td>
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<td>0.4288</td>
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<td>1.671</td>
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<td>0.084</td>
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<td>S2-5</td>
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<td>0.2545</td>
<td>0.2541</td>
<td>0.16%</td>
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<td>1.018</td>
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<td>0.081</td>
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<td>U1-6</td>
<td>0.1309</td>
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<td>0.1322</td>
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<td>1</td>
<td>0.561</td>
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<td>0.028</td>
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<tr>
<td>U2-6</td>
<td>0.1610</td>
<td>0.1630</td>
<td>0.1620</td>
<td>0.62%</td>
<td>1</td>
<td>0.673</td>
<td>50</td>
<td>0.034</td>
</tr>
<tr>
<td>S1-6</td>
<td>0.1218</td>
<td>0.1229</td>
<td>0.1224</td>
<td>0.45%</td>
<td>1</td>
<td>0.524</td>
<td>50</td>
<td>0.026</td>
</tr>
<tr>
<td>S2-6</td>
<td>0.2946</td>
<td>0.2924</td>
<td>0.2935</td>
<td>0.05%</td>
<td>1</td>
<td>1.165</td>
<td>50</td>
<td>0.051</td>
</tr>
</tbody>
</table>

Client: Air Control Techniques
RFA #: 1756- ≤ 2.5 μm H2O Rinses
Analysis: EPA Method 26/26A
<table>
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<tr>
<th>SAMPLE ID</th>
<th>≤ 2.5 μm</th>
<th>Probe Rinse</th>
<th>Nozzle &amp; &gt; 2.5 μm</th>
</tr>
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<tbody>
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<td></td>
<td></td>
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</tr>
<tr>
<td>U1-1</td>
<td>0.038 mg</td>
<td>0.410 mg</td>
<td>0.228 mg</td>
</tr>
<tr>
<td>U2-1</td>
<td>0.069 mg</td>
<td>0.250 mg</td>
<td>0.135 mg</td>
</tr>
<tr>
<td>S1-1</td>
<td>0.177 mg</td>
<td>2.19 mg</td>
<td>1.79 mg</td>
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<td>0.345 mg</td>
<td>2.43 mg</td>
<td>2.19 mg</td>
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<td>U1-2</td>
<td>0.051 mg</td>
<td>0.152 mg</td>
<td>0.123 mg</td>
</tr>
<tr>
<td>U2-2</td>
<td>0.070 mg</td>
<td>0.160 mg</td>
<td>0.099 mg</td>
</tr>
<tr>
<td>S1-2</td>
<td>0.167 mg</td>
<td>1.10 mg</td>
<td>1.16 mg</td>
</tr>
<tr>
<td>S2-2</td>
<td>0.092 mg</td>
<td>0.751 mg</td>
<td>1.92 mg</td>
</tr>
<tr>
<td>U1-3</td>
<td>0.043 mg</td>
<td>0.243 mg</td>
<td>0.106 mg</td>
</tr>
<tr>
<td>U2-3</td>
<td>0.084 mg</td>
<td>0.156 mg</td>
<td>0.091 mg</td>
</tr>
<tr>
<td>S1-3</td>
<td>0.144 mg</td>
<td>1.04 mg</td>
<td>0.543 mg</td>
</tr>
<tr>
<td>S2-3</td>
<td>0.289 mg</td>
<td>0.455 mg</td>
<td>0.261 mg</td>
</tr>
<tr>
<td>U1-4</td>
<td>0.093 mg</td>
<td>0.428 mg</td>
<td>0.376 mg</td>
</tr>
<tr>
<td>U2-4</td>
<td>0.098 mg</td>
<td>0.296 mg</td>
<td>0.221 mg</td>
</tr>
<tr>
<td>S1-4</td>
<td>0.130 mg</td>
<td>0.679 mg</td>
<td>0.113 mg</td>
</tr>
<tr>
<td>S2-4</td>
<td>0.097 mg</td>
<td>0.394 mg</td>
<td>0.114 mg</td>
</tr>
<tr>
<td>U1-5</td>
<td>0.086 mg</td>
<td>0.672 mg</td>
<td>0.196 mg</td>
</tr>
<tr>
<td>U2-5</td>
<td>0.070 mg</td>
<td>0.478 mg</td>
<td>0.137 mg</td>
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<tr>
<td>S1-5</td>
<td>0.101 mg</td>
<td>1.82 mg</td>
<td>2.33 mg</td>
</tr>
<tr>
<td>S2-5</td>
<td>0.089 mg</td>
<td>2.43 mg</td>
<td>0.779 mg</td>
</tr>
<tr>
<td>U1-6</td>
<td>0.056 mg</td>
<td>0.369 mg</td>
<td>0.242 mg</td>
</tr>
<tr>
<td>U2-6</td>
<td>0.060 mg</td>
<td>0.278 mg</td>
<td>0.287 mg</td>
</tr>
<tr>
<td>S1-6</td>
<td>0.058 mg</td>
<td>0.463 mg</td>
<td>0.135 mg</td>
</tr>
<tr>
<td>S2-6</td>
<td>0.117 mg</td>
<td>0.238 mg</td>
<td>0.103 mg</td>
</tr>
</tbody>
</table>
Analytical Narrative

Client/Plant Name: Air Control Techniques  
Analyst: TCS  
Analysis Method: Ion Chromatography  

Date Rec'd in lab: 10/31/2012  
Date of Analysis: 11/16/2012  
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  
**File Pathway:** C:\JOBS\ACT\1756\LESS THAN 2PT5.WB1  
**Analyst:** TCS  
**Job Num.:** 1756  
**File:** Less Than 2pt5  
**Date:** 11/13/2012

## Sodium Standard Calibration Curve by Linear Regression

<table>
<thead>
<tr>
<th>Na Conc. (ppm)</th>
<th>Standard Areas</th>
<th>Average Area</th>
<th>% Diff.</th>
<th>Calculated Std Conc. (ppm)</th>
<th>% Deviation from Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.25</td>
<td>82326</td>
<td>79160</td>
<td>80743</td>
<td>1.96%</td>
<td>1.20</td>
</tr>
<tr>
<td>5.00</td>
<td>321662</td>
<td>314363</td>
<td>318013</td>
<td>1.15%</td>
<td>4.94</td>
</tr>
<tr>
<td>20.0</td>
<td>1289664</td>
<td>1287450</td>
<td>1288557</td>
<td>0.09%</td>
<td>20.2</td>
</tr>
<tr>
<td>40.0</td>
<td>2484038</td>
<td>2599314</td>
<td>2541676</td>
<td>2.27%</td>
<td>39.9</td>
</tr>
</tbody>
</table>

**Standard Curve**  
Slope: 63582  
Y-Int: 4170  
LoQ (ppm): 1.20

## Field Samples in: DI H2O

<table>
<thead>
<tr>
<th>SAMPLE ID</th>
<th>Inj. 1 AREA</th>
<th>Inj. 2 AREA</th>
<th>AVERAGE AREA</th>
<th>% Diff.</th>
<th>DILUTION FACTOR</th>
<th>SAMPLE VOLUME (ml)</th>
<th>Na CATCH (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DI H2O Blank</td>
<td>123389</td>
<td>118754</td>
<td>121072</td>
<td>1.91%</td>
<td>1</td>
<td>50</td>
<td>0.092</td>
</tr>
<tr>
<td>U1-1</td>
<td>170754</td>
<td>168523</td>
<td>169639</td>
<td>0.66%</td>
<td>1</td>
<td>50</td>
<td>0.038</td>
</tr>
<tr>
<td>U2-1</td>
<td>211511</td>
<td>205402</td>
<td>208457</td>
<td>1.47%</td>
<td>1</td>
<td>50</td>
<td>0.069</td>
</tr>
<tr>
<td>S1-1</td>
<td>330242</td>
<td>362538</td>
<td>346390</td>
<td>4.66%</td>
<td>1</td>
<td>50</td>
<td>0.177</td>
</tr>
<tr>
<td>S2-1</td>
<td>550299</td>
<td>568695</td>
<td>559812</td>
<td>1.59%</td>
<td>1</td>
<td>50</td>
<td>0.345</td>
</tr>
<tr>
<td>U1-2</td>
<td>184038</td>
<td>188148</td>
<td>186143</td>
<td>1.13%</td>
<td>1</td>
<td>50</td>
<td>0.051</td>
</tr>
<tr>
<td>U2-2</td>
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<td>212569</td>
<td>210539</td>
<td>0.96%</td>
<td>1</td>
<td>50</td>
<td>0.076</td>
</tr>
<tr>
<td>S1-2</td>
<td>326428</td>
<td>340424</td>
<td>333426</td>
<td>2.10%</td>
<td>1</td>
<td>50</td>
<td>0.167</td>
</tr>
<tr>
<td>S2-2</td>
<td>242288</td>
<td>234034</td>
<td>238161</td>
<td>1.73%</td>
<td>1</td>
<td>50</td>
<td>0.092</td>
</tr>
<tr>
<td>U1-3</td>
<td>175632</td>
<td>175925</td>
<td>175789</td>
<td>0.08%</td>
<td>1</td>
<td>50</td>
<td>0.043</td>
</tr>
<tr>
<td>U2-3</td>
<td>229711</td>
<td>225296</td>
<td>227504</td>
<td>0.97%</td>
<td>1</td>
<td>50</td>
<td>0.084</td>
</tr>
<tr>
<td>S1-3</td>
<td>310978</td>
<td>298554</td>
<td>304766</td>
<td>2.04%</td>
<td>1</td>
<td>50</td>
<td>0.144</td>
</tr>
<tr>
<td>S2-3</td>
<td>488551</td>
<td>487834</td>
<td>488193</td>
<td>0.07%</td>
<td>1</td>
<td>50</td>
<td>0.289</td>
</tr>
<tr>
<td>U1-4</td>
<td>235036</td>
<td>243173</td>
<td>239105</td>
<td>1.70%</td>
<td>1</td>
<td>50</td>
<td>0.093</td>
</tr>
<tr>
<td>U2-4</td>
<td>245956</td>
<td>246536</td>
<td>246246</td>
<td>0.12%</td>
<td>1</td>
<td>50</td>
<td>0.098</td>
</tr>
<tr>
<td>S1-4</td>
<td>283151</td>
<td>289788</td>
<td>286470</td>
<td>1.16%</td>
<td>1</td>
<td>50</td>
<td>0.130</td>
</tr>
<tr>
<td>S2-4</td>
<td>244510</td>
<td>245129</td>
<td>244820</td>
<td>0.13%</td>
<td>1</td>
<td>50</td>
<td>0.097</td>
</tr>
<tr>
<td>U1-5</td>
<td>225068</td>
<td>235874</td>
<td>230471</td>
<td>2.34%</td>
<td>1</td>
<td>50</td>
<td>0.086</td>
</tr>
<tr>
<td>U2-5</td>
<td>210579</td>
<td>210600</td>
<td>210590</td>
<td>0.00%</td>
<td>1</td>
<td>50</td>
<td>0.070</td>
</tr>
<tr>
<td>S1-5</td>
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<td>252470</td>
<td>249608</td>
<td>1.15%</td>
<td>1</td>
<td>50</td>
<td>0.101</td>
</tr>
<tr>
<td>S2-5</td>
<td>238541</td>
<td>229238</td>
<td>233890</td>
<td>1.99%</td>
<td>1</td>
<td>50</td>
<td>0.089</td>
</tr>
<tr>
<td>U1-6</td>
<td>191024</td>
<td>192810</td>
<td>191917</td>
<td>0.47%</td>
<td>1</td>
<td>50</td>
<td>0.056</td>
</tr>
<tr>
<td>U2-6</td>
<td>200439</td>
<td>195137</td>
<td>197788</td>
<td>1.34%</td>
<td>1</td>
<td>50</td>
<td>0.060</td>
</tr>
<tr>
<td>S1-6</td>
<td>192333</td>
<td>197442</td>
<td>194888</td>
<td>1.31%</td>
<td>1</td>
<td>50</td>
<td>0.058</td>
</tr>
<tr>
<td>S2-6</td>
<td>279710</td>
<td>259137</td>
<td>269424</td>
<td>3.82%</td>
<td>1</td>
<td>50</td>
<td>0.117</td>
</tr>
</tbody>
</table>

# **** AUDIT REPORT ****

<table>
<thead>
<tr>
<th>IN-HOUSE AUDIT</th>
<th>Inj. 1</th>
<th>Inj. 2</th>
<th>Average Area</th>
<th>% Dev.</th>
<th>Expected ppm Na</th>
<th>Calculated ppm Na</th>
<th>Percent Diff.</th>
</tr>
</thead>
<tbody>
<tr>
<td>258218</td>
<td>250310</td>
<td>254264</td>
<td>1.56%</td>
<td>4.00</td>
<td>3.93</td>
<td>-1.66%</td>
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</table>

## MATRIX SPIKE

<table>
<thead>
<tr>
<th>Sample I.D.</th>
<th>Inj. 1 AREA</th>
<th>Inj. 2 AREA</th>
<th>Average Area</th>
<th>% Dev.</th>
<th>Expected ppm Na</th>
<th>Calculated ppm Na</th>
<th>% Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>S2-6</td>
<td>694399</td>
<td>644739</td>
<td>669569</td>
<td>3.71%</td>
<td>10.0</td>
<td>9.34</td>
<td>93.4%</td>
</tr>
</tbody>
</table>

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  
**File Pathway:** C:\JOBS\ACT\1756\NOZZLE RINSE.WB1  
**Analyst:** TCS  
**Job Num.:** 1756  
**Date:** 11/16/2012

## Sodium Standard Calibration Curve by Linear Regression

<table>
<thead>
<tr>
<th>Na Conc. (ppm)</th>
<th>Standard Areas</th>
<th>Average Area</th>
<th>% Diff.</th>
<th>Calculated Std Conc. (ppm)</th>
<th>% Deviation from Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.25</td>
<td>82326</td>
<td>79160</td>
<td>80743</td>
<td>1.96%</td>
<td>1.20</td>
</tr>
<tr>
<td>5.00</td>
<td>321662</td>
<td>314363</td>
<td>318013</td>
<td>1.15%</td>
<td>4.94</td>
</tr>
<tr>
<td>20.0</td>
<td>1289664</td>
<td>1287450</td>
<td>1288557</td>
<td>0.09%</td>
<td>20.2</td>
</tr>
<tr>
<td>40.0</td>
<td>2484038</td>
<td>2599314</td>
<td>2541676</td>
<td>2.27%</td>
<td>39.9</td>
</tr>
</tbody>
</table>

**Standard Curve**  
Slope: 63582  
Y-Int: 4170  
LoQ (ppm): 1.20

## Field Samples in: DI H2O

<table>
<thead>
<tr>
<th>SAMPLE ID</th>
<th>Inj. 1 AREA</th>
<th>Inj. 2 AREA</th>
<th>AVERAGE AREA</th>
<th>% Diff.</th>
<th>DILUTION FACTOR</th>
<th>SAMPLE VOLUME (ml)</th>
<th>Na CATCH (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>U1-1</td>
<td>402197</td>
<td>418903</td>
<td>410550</td>
<td>2.03%</td>
<td>1</td>
<td>50</td>
<td>0.228</td>
</tr>
<tr>
<td>U2-1</td>
<td>289476</td>
<td>295398</td>
<td>292437</td>
<td>1.01%</td>
<td>1</td>
<td>50</td>
<td>0.135</td>
</tr>
<tr>
<td>S1-1</td>
<td>1208849</td>
<td>1187327</td>
<td>1198088</td>
<td>0.90%</td>
<td>2</td>
<td>50</td>
<td>1.79</td>
</tr>
<tr>
<td>S2-1</td>
<td>1459147</td>
<td>1452446</td>
<td>1455797</td>
<td>0.23%</td>
<td>2</td>
<td>50</td>
<td>2.19</td>
</tr>
<tr>
<td>U1-2</td>
<td>277674</td>
<td>278607</td>
<td>278141</td>
<td>0.17%</td>
<td>1</td>
<td>50</td>
<td>0.123</td>
</tr>
<tr>
<td>U2-2</td>
<td>240736</td>
<td>235491</td>
<td>247113</td>
<td>2.58%</td>
<td>1</td>
<td>50</td>
<td>0.099</td>
</tr>
<tr>
<td>S1-2</td>
<td>1605041</td>
<td>1575723</td>
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<td>1</td>
<td>50</td>
<td>1.16</td>
</tr>
<tr>
<td>S2-2</td>
<td>1291024</td>
<td>1271312</td>
<td>1281618</td>
<td>0.77%</td>
<td>2</td>
<td>50</td>
<td>1.92</td>
</tr>
<tr>
<td>U1-3</td>
<td>255094</td>
<td>256767</td>
<td>255931</td>
<td>0.33%</td>
<td>1</td>
<td>50</td>
<td>0.106</td>
</tr>
<tr>
<td>U2-3</td>
<td>240825</td>
<td>232794</td>
<td>236810</td>
<td>1.70%</td>
<td>1</td>
<td>50</td>
<td>0.091</td>
</tr>
<tr>
<td>S1-3</td>
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<td>0.81%</td>
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<td>50</td>
<td>0.543</td>
</tr>
<tr>
<td>S2-3</td>
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<td>453504</td>
<td>2.25%</td>
<td>1</td>
<td>50</td>
<td>0.261</td>
</tr>
<tr>
<td>U1-4</td>
<td>592272</td>
<td>606304</td>
<td>599288</td>
<td>1.17%</td>
<td>1</td>
<td>50</td>
<td>0.376</td>
</tr>
<tr>
<td>U2-4</td>
<td>398515</td>
<td>405544</td>
<td>402030</td>
<td>0.87%</td>
<td>1</td>
<td>50</td>
<td>0.221</td>
</tr>
<tr>
<td>S1-4</td>
<td>258265</td>
<td>272129</td>
<td>265197</td>
<td>2.61%</td>
<td>1</td>
<td>50</td>
<td>0.113</td>
</tr>
<tr>
<td>S2-4</td>
<td>269080</td>
<td>264253</td>
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<td>0.91%</td>
<td>1</td>
<td>50</td>
<td>0.114</td>
</tr>
<tr>
<td>U1-5</td>
<td>379571</td>
<td>362470</td>
<td>371021</td>
<td>2.30%</td>
<td>1</td>
<td>50</td>
<td>0.196</td>
</tr>
<tr>
<td>U2-5</td>
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<td>280204</td>
<td>294890</td>
<td>4.98%</td>
<td>1</td>
<td>50</td>
<td>0.137</td>
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<tr>
<td>S1-5</td>
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<td>1586342</td>
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<td>2.75%</td>
<td>2</td>
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<td>2.33</td>
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<td>0.75%</td>
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<td>0.242</td>
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<tr>
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<td>251636</td>
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<td>50</td>
<td>0.103</td>
</tr>
</tbody>
</table>

## AUDIT REPORT

<table>
<thead>
<tr>
<th>Inj. 1</th>
<th>Inj. 2</th>
<th>Average Area</th>
<th>% Dev.</th>
<th>Expected ppm Na</th>
<th>Calculated ppm Na</th>
<th>Percent Diff.</th>
</tr>
</thead>
<tbody>
<tr>
<td>IN-HOUSE AUDIT</td>
<td>264690</td>
<td>277021</td>
<td>270856</td>
<td>2.28%</td>
<td>4.00</td>
<td>4.19</td>
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</tbody>
</table>
### Sodium Analytical Data Sheet

**Client Name:** Air Control Techniques  
**File Pathway:** C:\JOBS\ACT\1756\PROBE RINSE.WB1  
**Job Num.:** 1756  
**Analyst:** TCS  
**Date:** 11/16/2012

#### Sodium Standard Calibration Curve by Linear Regression

<table>
<thead>
<tr>
<th>Na Conc. (ppm)</th>
<th>Standard Areas</th>
<th>Average Area</th>
<th>% Diff.</th>
<th>Calculated Std Conc. (ppm)</th>
<th>% Deviation from Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inj. 1</td>
<td>Inj. 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.25</td>
<td>82326</td>
<td>79160</td>
<td>80743</td>
<td>1.96%</td>
<td>1.20</td>
</tr>
<tr>
<td>5.00</td>
<td>321662</td>
<td>314363</td>
<td>318013</td>
<td>1.15%</td>
<td>4.94</td>
</tr>
<tr>
<td>20.0</td>
<td>1289664</td>
<td>1287450</td>
<td>1288557</td>
<td>0.09%</td>
<td>20.2</td>
</tr>
<tr>
<td>40.0</td>
<td>2484038</td>
<td>2599314</td>
<td>2541676</td>
<td>2.27%</td>
<td>39.9</td>
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</table>

**Standard Curve**  
**Slope:** 63582  
**Y-Int:** 4170  
**LoQ (ppm):** 1.20

#### Field Samples in: DI H2O

<table>
<thead>
<tr>
<th>SAMPLE ID</th>
<th>Inj. 1 AREA</th>
<th>Inj. 2 AREA</th>
<th>AVERAGE AREA</th>
<th>% Diff.</th>
<th>DILUTION FACTOR</th>
<th>SAMPLE VOLUME (ml)</th>
<th>Na CATCH (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>U1-1</td>
<td>635732</td>
<td>649882</td>
<td>642807</td>
<td>1.10%</td>
<td>1</td>
<td>50</td>
<td>0.410</td>
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<tr>
<td>U2-1</td>
<td>440803</td>
<td>438390</td>
<td>439597</td>
<td>0.27%</td>
<td>1</td>
<td>50</td>
<td>0.250</td>
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<td>1456907</td>
<td>1458386</td>
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<td>0.05%</td>
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<td>50</td>
<td>2.19</td>
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<td>1621980</td>
<td>1606328</td>
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<td>2</td>
<td>50</td>
<td>2.43</td>
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<td>U1-2</td>
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<td>302188</td>
<td>315075</td>
<td>4.09%</td>
<td>1</td>
<td>50</td>
<td>0.152</td>
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<tr>
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<td>326039</td>
<td>324046</td>
<td>0.62%</td>
<td>1</td>
<td>50</td>
<td>0.160</td>
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<td>1.10</td>
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<td>1073692</td>
<td>1076366</td>
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<td>50</td>
<td>0.751</td>
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<tr>
<td>U1-3</td>
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<td>428370</td>
<td>430368</td>
<td>0.42%</td>
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<td>50</td>
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<tr>
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<td>313869</td>
<td>324610</td>
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<td>1.68%</td>
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<td>50</td>
<td>0.156</td>
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<td>1444469</td>
<td>1449462</td>
<td>0.34%</td>
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<td>50</td>
<td>1.04</td>
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<td>707228</td>
<td>699997</td>
<td>1.03%</td>
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<td>50</td>
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<td>511524</td>
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<td>988400</td>
<td>984556</td>
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<td>50</td>
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<td>50</td>
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<td>975068</td>
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<td>726589</td>
<td>731730</td>
<td>729160</td>
<td>0.35%</td>
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<td>0.478</td>
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<td>1191704</td>
<td>1249003</td>
<td>1220354</td>
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<td>50</td>
<td>1.82</td>
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<tr>
<td>S2-5</td>
<td>1595293</td>
<td>1618303</td>
<td>1606798</td>
<td>0.72%</td>
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<td>50</td>
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<tr>
<td>U1-6</td>
<td>587330</td>
<td>593443</td>
<td>590387</td>
<td>0.52%</td>
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<td>50</td>
<td>0.369</td>
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<tr>
<td>U2-6</td>
<td>477372</td>
<td>472485</td>
<td>474929</td>
<td>0.51%</td>
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<td>50</td>
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<td>704465</td>
<td>716363</td>
<td>710414</td>
<td>0.84%</td>
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<td>50</td>
<td>0.463</td>
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<tr>
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<td>428205</td>
<td>419901</td>
<td>424053</td>
<td>0.98%</td>
<td>1</td>
<td>50</td>
<td>0.238</td>
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#### **** AUDIT REPORT ****

<table>
<thead>
<tr>
<th>Inj. 1</th>
<th>Inj. 2</th>
<th>Average Area</th>
<th>% Dev.</th>
<th>Expected ppm Na</th>
<th>Calculated ppm Na</th>
<th>Percent Diff.</th>
</tr>
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<tbody>
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<td></td>
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<td></td>
<td></td>
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</tr>
</tbody>
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**IN-HOUSE AUDIT**  
250310  
264690  
257500  
2.79%  
4.00  
3.98  
-0.39%
APPENDIX G

ANALYTICAL DATA

RESOLUTION ANALYTICS

CHLORIDES ON FILTERS
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
Quality Assurance Officer

www.resolutionanalytics.com
2733 Lee Avenue • Sanford, NC 27332 • Phone: 919-774-5557 • Fax: 919-776-6785
Report Summary

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>CI</th>
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<tbody>
<tr>
<td>U1-1</td>
<td>2.06</td>
</tr>
<tr>
<td>U2-1</td>
<td>2.43</td>
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<td>0.670</td>
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<td>20.9</td>
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<td>16.5</td>
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<tr>
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</tr>
<tr>
<td>S1-3</td>
<td>9.34</td>
</tr>
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<td>S2-3</td>
<td>6.61</td>
</tr>
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<td>1.05</td>
</tr>
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<td>U2-4</td>
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<td>S1-4</td>
<td>3.11</td>
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<td>S2-4</td>
<td>3.57</td>
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<tr>
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<td>U2-5</td>
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<td>S1-6</td>
<td>6.91</td>
</tr>
<tr>
<td>S2-6</td>
<td>0.898</td>
</tr>
</tbody>
</table>

* EPA Audits are reported in mg/L CL-
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 chromatography. See data for dilution factors used in analysis.

Summary of Instrumentation:

Dionex ICS-2100 ion chromatograph
IonPac AS20 4x250mm
Eluent: 25mM KOH
Suppressor current: 85 mA

25μl injection volume
Flow rate: 1.25 ml/min
Temp: 30° C

Limits Of Quantification:

<table>
<thead>
<tr>
<th>Limit of Detection</th>
<th>Limit of Quantitation</th>
<th>Analytical Uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.003 mg/L Cl₂</td>
<td>0.200 mg/L Cl₂</td>
<td>Cl₂ ± 0.4%</td>
</tr>
</tbody>
</table>

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
# Chloride Analytical Data Sheet

## Chloride Standard Calibration Curve

<table>
<thead>
<tr>
<th>Conc. (mg/L)</th>
<th>Standard Areas</th>
<th>Average Area</th>
<th>% Diff.</th>
<th>% Deviation from Actual</th>
<th>CI (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.200</td>
<td>0.0410</td>
<td>0.0394</td>
<td>4.19%</td>
<td>0.213</td>
<td>6.47%</td>
</tr>
<tr>
<td>4.00</td>
<td>1.0490</td>
<td>1.0481</td>
<td>0.09%</td>
<td>3.98</td>
<td>-0.44%</td>
</tr>
<tr>
<td>20.0</td>
<td>5.4155</td>
<td>5.4115</td>
<td>0.07%</td>
<td>20.0</td>
<td>0.03%</td>
</tr>
<tr>
<td>40.0</td>
<td>11.0753</td>
<td>11.0274</td>
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<td>40.0</td>
<td>0.00%</td>
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</tbody>
</table>

### Internal Calibration Verification

<table>
<thead>
<tr>
<th>Conc. (mg/L)</th>
<th>Standard Areas</th>
<th>Average Area</th>
<th>% Dev.</th>
<th>Expected CI (mg/L)</th>
<th>Actual CI (mg/L)</th>
<th>% Diff.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.200</td>
<td>0.0410</td>
<td>0.0394</td>
<td>4.19%</td>
<td>0.213</td>
<td>7.85</td>
<td>-1.81%</td>
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</tbody>
</table>

## Field Samples

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<tr>
<th>SAMPLE ID</th>
<th>AREA</th>
<th>INJ. 1</th>
<th>INJ. 2</th>
<th>AVERAGE</th>
<th>% DIFF.</th>
<th>DILUTION FACTOR</th>
<th>CI (mg/L)</th>
<th>SAMPLE VOLUME (ml)</th>
<th>CI CATCH (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>U1-1</td>
<td>7.0284</td>
<td>6.9898</td>
<td>7.0091</td>
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<td>4</td>
<td>103.053</td>
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<td>2.06</td>
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<tr>
<td>U2-1</td>
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<td>121.609</td>
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<td>1188.471</td>
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<tr>
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<td>100</td>
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<tr>
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<td>0.06%</td>
<td>4</td>
<td>131.826</td>
<td>20</td>
<td>2.64</td>
<td></td>
</tr>
<tr>
<td>U2-6</td>
<td>8.8674</td>
<td>8.8336</td>
<td>8.8505</td>
<td>0.19%</td>
<td>4</td>
<td>129.317</td>
<td>20</td>
<td>2.69</td>
<td></td>
</tr>
<tr>
<td>S1-6</td>
<td>9.4675</td>
<td>9.4699</td>
<td>9.4687</td>
<td>0.15%</td>
<td>10</td>
<td>345.704</td>
<td>20</td>
<td>6.91</td>
<td></td>
</tr>
<tr>
<td>S2-6</td>
<td>6.1035</td>
<td>6.0703</td>
<td>6.0869</td>
<td>0.27%</td>
<td>2</td>
<td>44.894</td>
<td>20</td>
<td>0.898</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX H

ANALYTICAL DATA

RESOLUTION ANALYTICS

SODIUM ON FILTERS
### REPORT SUMMARY

**RFA#:** 1756-Filters

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Sodium</th>
</tr>
</thead>
<tbody>
<tr>
<td>U1-1</td>
<td>4.06 mg</td>
</tr>
<tr>
<td>U2-1</td>
<td>4.14 mg</td>
</tr>
<tr>
<td>S1-1</td>
<td>17.0 mg</td>
</tr>
<tr>
<td>S2-1</td>
<td>17.5 mg</td>
</tr>
<tr>
<td>U1-2</td>
<td>1.63 mg</td>
</tr>
<tr>
<td>U2-2</td>
<td>1.40 mg</td>
</tr>
<tr>
<td>S1-2</td>
<td>17.0 mg</td>
</tr>
<tr>
<td>S2-2</td>
<td>11.8 mg</td>
</tr>
<tr>
<td>U1-3</td>
<td>1.89 mg</td>
</tr>
<tr>
<td>U2-3</td>
<td>2.09 mg</td>
</tr>
<tr>
<td>S1-3</td>
<td>9.72 mg</td>
</tr>
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<td>S2-3</td>
<td>5.54 mg</td>
</tr>
<tr>
<td>U1-4</td>
<td>2.32 mg</td>
</tr>
<tr>
<td>U2-4</td>
<td>2.13 mg</td>
</tr>
<tr>
<td>S1-4</td>
<td>3.41 mg</td>
</tr>
<tr>
<td>S2-4</td>
<td>4.15 mg</td>
</tr>
<tr>
<td>U1-5</td>
<td>1.63 mg</td>
</tr>
<tr>
<td>U2-5</td>
<td>1.70 mg</td>
</tr>
<tr>
<td>S1-5</td>
<td>16.6 mg</td>
</tr>
<tr>
<td>S2-5</td>
<td>2.36 mg</td>
</tr>
<tr>
<td>U1-6</td>
<td>3.93 mg</td>
</tr>
<tr>
<td>U2-6</td>
<td>3.75 mg</td>
</tr>
<tr>
<td>S1-6</td>
<td>5.99 mg</td>
</tr>
<tr>
<td>S2-6</td>
<td>0.550 mg</td>
</tr>
</tbody>
</table>
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 20 µl Inj.
Eluent: 5.7 mM HNO3 Flow Rate: 1.75 mls/min
Gain 0.4 µS/cm 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: [Signature]
Date: 11/30/2012
# Sodium Analytical Data Sheet

## Sodium Standard Calibration Curve by Linear Regression

<table>
<thead>
<tr>
<th>Na Conc. (ppm)</th>
<th>Standard Areas</th>
<th>Average Area</th>
<th>% Diff.</th>
<th>Calculated Std Conc. (ppm)</th>
<th>% Deviation from Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.25</td>
<td>82326</td>
<td>79160</td>
<td>80743</td>
<td>1.96%</td>
<td>1.20</td>
</tr>
<tr>
<td>5.00</td>
<td>321662</td>
<td>314363</td>
<td>318013</td>
<td>1.15%</td>
<td>4.94</td>
</tr>
<tr>
<td>20.0</td>
<td>1289664</td>
<td>1287450</td>
<td>1288557</td>
<td>0.09%</td>
<td>20.2</td>
</tr>
<tr>
<td>40.0</td>
<td>2484038</td>
<td>2599314</td>
<td>2541676</td>
<td>2.27%</td>
<td>39.9</td>
</tr>
</tbody>
</table>

**Standard Curve**

- Slope: 61582
- Y-Int: 4170
- LoQ (ppm): 1.20

## Field Samples in: DI H2O

<table>
<thead>
<tr>
<th>SAMPLE ID</th>
<th>Inj. 1 AREA</th>
<th>Inj. 2 AREA</th>
<th>AVERAGE AREA</th>
<th>% Diff.</th>
<th>DILUTION FACTOR</th>
<th>SAMPLE VOLUME (ml)</th>
<th>Na CATCH (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DI H2O Blank</td>
<td>123389</td>
<td>118754</td>
<td>121072</td>
<td>1.91%</td>
<td>1</td>
<td>20</td>
<td>0.037</td>
</tr>
<tr>
<td>U1-1</td>
<td>1622859</td>
<td>1643805</td>
<td>1633332</td>
<td>0.64%</td>
<td>8</td>
<td>20</td>
<td>4.06</td>
</tr>
<tr>
<td>U2-1</td>
<td>1645404</td>
<td>1679119</td>
<td>1662262</td>
<td>1.01%</td>
<td>8</td>
<td>20</td>
<td>4.14</td>
</tr>
<tr>
<td>S1-1</td>
<td>536512</td>
<td>556878</td>
<td>546695</td>
<td>1.86%</td>
<td>100</td>
<td>20</td>
<td>17.0</td>
</tr>
<tr>
<td>S2-1</td>
<td>570812</td>
<td>554541</td>
<td>562677</td>
<td>1.45%</td>
<td>100</td>
<td>20</td>
<td>17.5</td>
</tr>
<tr>
<td>U1-2</td>
<td>1337823</td>
<td>1326913</td>
<td>1332368</td>
<td>0.41%</td>
<td>4</td>
<td>20</td>
<td>1.63</td>
</tr>
<tr>
<td>U2-2</td>
<td>2289314</td>
<td>2301486</td>
<td>2295400</td>
<td>0.27%</td>
<td>2</td>
<td>20</td>
<td>1.40</td>
</tr>
<tr>
<td>S1-2</td>
<td>540383</td>
<td>550533</td>
<td>545458</td>
<td>0.93%</td>
<td>100</td>
<td>20</td>
<td>17.0</td>
</tr>
<tr>
<td>S2-2</td>
<td>391067</td>
<td>367524</td>
<td>379296</td>
<td>3.10%</td>
<td>100</td>
<td>20</td>
<td>11.8</td>
</tr>
<tr>
<td>U1-3</td>
<td>1521885</td>
<td>1544548</td>
<td>1533217</td>
<td>0.74%</td>
<td>4</td>
<td>20</td>
<td>1.89</td>
</tr>
<tr>
<td>U2-3</td>
<td>1686122</td>
<td>1703289</td>
<td>1694706</td>
<td>0.51%</td>
<td>4</td>
<td>20</td>
<td>2.09</td>
</tr>
<tr>
<td>S1-3</td>
<td>321512</td>
<td>307474</td>
<td>314493</td>
<td>2.23%</td>
<td>100</td>
<td>20</td>
<td>9.72</td>
</tr>
<tr>
<td>S2-3</td>
<td>1767171</td>
<td>1787564</td>
<td>1777368</td>
<td>0.57%</td>
<td>10</td>
<td>20</td>
<td>5.54</td>
</tr>
<tr>
<td>U1-4</td>
<td>1872000</td>
<td>1881530</td>
<td>1876765</td>
<td>0.25%</td>
<td>4</td>
<td>20</td>
<td>2.32</td>
</tr>
<tr>
<td>U2-4</td>
<td>1740608</td>
<td>1707732</td>
<td>1724170</td>
<td>0.95%</td>
<td>4</td>
<td>20</td>
<td>2.13</td>
</tr>
<tr>
<td>S1-4</td>
<td>1103217</td>
<td>1095680</td>
<td>1099449</td>
<td>0.34%</td>
<td>10</td>
<td>20</td>
<td>3.41</td>
</tr>
<tr>
<td>S2-4</td>
<td>1350970</td>
<td>1321154</td>
<td>1336062</td>
<td>1.12%</td>
<td>10</td>
<td>20</td>
<td>4.15</td>
</tr>
<tr>
<td>U1-5</td>
<td>1317554</td>
<td>1346082</td>
<td>1331818</td>
<td>1.07%</td>
<td>4</td>
<td>20</td>
<td>1.63</td>
</tr>
<tr>
<td>U2-5</td>
<td>1380066</td>
<td>1394043</td>
<td>1387055</td>
<td>0.50%</td>
<td>4</td>
<td>20</td>
<td>1.70</td>
</tr>
<tr>
<td>S1-5</td>
<td>531970</td>
<td>537281</td>
<td>534626</td>
<td>0.50%</td>
<td>100</td>
<td>20</td>
<td>16.6</td>
</tr>
<tr>
<td>S2-5</td>
<td>771837</td>
<td>763657</td>
<td>767747</td>
<td>0.53%</td>
<td>10</td>
<td>20</td>
<td>2.36</td>
</tr>
<tr>
<td>U1-6</td>
<td>1586442</td>
<td>1572047</td>
<td>1579245</td>
<td>0.46%</td>
<td>8</td>
<td>20</td>
<td>3.93</td>
</tr>
<tr>
<td>U2-6</td>
<td>1515010</td>
<td>1506695</td>
<td>1510853</td>
<td>0.28%</td>
<td>8</td>
<td>20</td>
<td>3.75</td>
</tr>
<tr>
<td>S1-6</td>
<td>1917174</td>
<td>1923842</td>
<td>1920508</td>
<td>0.17%</td>
<td>10</td>
<td>20</td>
<td>5.99</td>
</tr>
<tr>
<td>S2-6</td>
<td>935717</td>
<td>939775</td>
<td>937746</td>
<td>0.22%</td>
<td>2</td>
<td>20</td>
<td>0.550</td>
</tr>
</tbody>
</table>

### **** AUDIT REPORT ****

<table>
<thead>
<tr>
<th>Inj. 1</th>
<th>Inj. 2</th>
<th>Average Area</th>
<th>% Dev.</th>
<th>Expected ppm Na</th>
<th>Calculated ppm Na</th>
<th>Percent Diff.</th>
</tr>
</thead>
<tbody>
<tr>
<td>252038</td>
<td>250449</td>
<td>251244</td>
<td>0.32%</td>
<td>4.00</td>
<td>3.89</td>
<td>-2.85%</td>
</tr>
</tbody>
</table>

**IN-HOUSE AUDIT**
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](image)

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>
<thead>
<tr>
<th>Run</th>
<th>Sphere Size, Microspheres, Micrometers</th>
<th>Velocity, ft/sec</th>
<th>Gravimetric Analyses (Resolution Analytics)</th>
<th>Microscopy Particle Clustering Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>22</td>
<td>30</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>14</td>
<td>30</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>11</td>
<td>30</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>4</td>
<td>7</td>
<td>30</td>
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<td>5</td>
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<td>11</td>
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<td>16</td>
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<td>17</td>
<td>14</td>
<td>60</td>
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<td>18</td>
<td>14</td>
<td>60</td>
<td>Yes</td>
<td>Yes</td>
</tr>
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<td>19</td>
<td>14</td>
<td>90</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>20</td>
<td>14</td>
<td>90</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>21</td>
<td>14</td>
<td>90</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

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 milligrams 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](image-url)
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>
<thead>
<tr>
<th>Run</th>
<th>Microsphere Size, Micrometers</th>
<th>Velocity, feet/sec</th>
<th>Gravimetric Analyses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>30</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>30</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
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<td>4</td>
<td>8</td>
<td>30</td>
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</tr>
<tr>
<td>5</td>
<td>15</td>
<td>30</td>
<td>Yes</td>
</tr>
<tr>
<td>6</td>
<td>15</td>
<td>30</td>
<td>Yes</td>
</tr>
<tr>
<td>7</td>
<td>10</td>
<td>30</td>
<td>Yes</td>
</tr>
<tr>
<td>8</td>
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<td>30</td>
<td>Yes</td>
</tr>
<tr>
<td>9</td>
<td>20</td>
<td>30</td>
<td>Yes</td>
</tr>
<tr>
<td>10</td>
<td>6</td>
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<td>20</td>
<td>60</td>
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<td>90</td>
<td>Yes</td>
</tr>
<tr>
<td>18</td>
<td>20</td>
<td>90</td>
<td>Yes</td>
</tr>
</tbody>
</table>

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

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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
\[ d_a = d_e \sqrt[3]{\frac{\rho_p}{\rho_o \chi}} , \]  
\[ \text{where } d_e \text{ is the equivalent volume diameter (the diameter of a sphere with the same volume as the particle in question), } \rho_p \text{ is the density of the particle, } \rho_o \text{ is the density of water, and } \chi \text{ is the dynamic shape factor for the particle. If a droplet that contains soluble and insoluble materials evaporates to leave a residual solid particle, that residual particle will have a density that is the weighted average of the densities of its constituents.} \]

If the particle is spherical then \( \chi \) is unity, but as particles become increasingly non-spherical \( \chi \) 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

\[ d_e = d_d \left( \frac{\rho_o \cdot \text{TS}}{\rho_p} \right)^{1/3} , \]

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.

\[ d_a = d_d \left( \frac{\rho_p}{\rho_o} \right)^{1/6} \left( \frac{1}{\chi} \right)^{1/2} . \]

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.

**Mass Emission Rate** – 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.

**Droplet Size Distribution** – 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. 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. The importance of this factor increases rapidly as droplet diameter decreases. 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. 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 Wilber², by Reisman and Frisbie⁶, 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.

![Cumulative size distributions by mass for droplets from cooling towers](image)

**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\textsuperscript{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, 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.\footnote{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\footnote{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.

**Particle Classification** – 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 100°C 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.

**Condensable Particles** – 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.

<table>
<thead>
<tr>
<th>Task</th>
<th>Months After Project Begins</th>
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<tbody>
<tr>
<td></td>
<td>0</td>
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<tr>
<td>Develop Simulator</td>
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<tr>
<td>A  Produce Gas Stream</td>
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<tr>
<td>B  Produce Particles</td>
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<tr>
<td>Develop “Gold Standard”</td>
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<tr>
<td>A  Develop nozzle</td>
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<td>B  Develop size classifier</td>
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<tr>
<td>C  Develop filter system</td>
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<td>D  Condensable particles</td>
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<tr>
<td>E  Assemble and evaluate system</td>
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<tr>
<td>F  Field test system</td>
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<tr>
<td>Develop Continuous Monitor</td>
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<tr>
<td>A  Identify methods</td>
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<tr>
<td>B  Evaluate methods</td>
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<tr>
<td>C  Develop Prototype</td>
<td></td>
</tr>
<tr>
<td>D  Field test system</td>
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REFERENCES


2. Wilber, Karl, “Comprehensive Drift Measurements on a Circular Mechanical Draft Cooling Tower”, J Cooling tower Institute 7 (2) 34-47 (no year indicated)


