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PNNL-19262, Rev. 1
RPT-STMON-002, Rev. 1

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

Assessment of the 3430 Building Filtered Exhaust Stack Sampling Probe Location

JA Glissmeyer
JE Flaherty

July 2010

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Pacific Northwest National Laboratory
Richland, Washington 99352

Completeness of Testing

This report describes the results of work and testing specified by test plan TP-STMON-001. The work and any associated testing followed the quality assurance requirements outlined in the test specification/plan. The descriptions provided in this test report are an accurate account of both the conduct of the work and the data collected. Test plan results are reported. Also reported are any unusual or anomalous occurrences that are different from expected results. The test results and this report have been reviewed and verified.

Approved:

John A. Glissmeyer (signature) — 7/12/10

John A. Glissmeyer
Stack Monitoring Project Manager

Date

Summary

Pacific Northwest National Laboratory performed a demonstration to determine the acceptable location in which to place an air sampling probe for emissions monitoring for radionuclides in the exhaust air discharge from the new 3430 Building Filtered Exhaust Stack. The method was to adopt the results of a previously performed test series for a system of similar configuration, followed by a partial test on the actual system to verify the applicability of previously performed tests. The qualification criteria included 1) a uniform air velocity, 2) an average flow angle that does not deviate from the axis of the duct by more than 20°, 3) a uniform concentration of tracer gases, and 4) a uniform concentration of tracer particles.

Section 1 provides background information for the demonstration, and Section 2 describes the test strategy, including the criteria for the applicability of model results and the test matrix. Section 3 describes the flow -angle test and the velocity uniformity test, Section 4 provides the test results, and Section 5 provides the conclusions. Appendix A includes the test data sheets, and Appendix B gives applicable qualification results from the previously tested model stack.

The data from the previously tested and similarly designed stack was demonstrated to be applicable to the current design for the 3430 Building Filtered Exhaust Stack. The 3430 stack was tested in both January and May of 2010 to document the results of several changes that were made to the exhaust system after the January tests. The 3430 stack meets the qualification criteria given in the American National Standards Institute/Health Physics Society N13.1-1999 standard. Changes to the system configuration or operations outside of the bounds of this report (e.g., exhaust velocity increases, relocation of sample probe) will require retesting/reevaluation to determine compliancewith the requirements.

Acronyms

acfm	actual cubic feet per minute
AD	aerodynamic diameter
ANSI	American National Standards Institute
ASME	America Society of Mechanical Engineers
CFR	Code of Federal Regulations
COV	coefficient of variance
D	duct diameter
DIA	number of duct diameters, distance divided by duct diameter
DOE	U.S. Department of Energy
DV	product of duct diameter and mean air velocity
EPA	U.S. Environmental Protection Agency
FA	flow-angle test run
HDI	"How Do I…?"
HPS	Health Physics Society
NQA	Nuclear Quality Assurance
PNNL	Pacific Northwest National Laboratory
QA	quality assurance
R&D	research and development
scfm	standard cubic feet per minute
STMON	Stack Monitoring Project
VT	velocity uniformity test run

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1.0 Introduction

Pacific Northwest National Laboratory (PNNL) determined that emissions monitoring must be conducted for radionuclides in the exhaust air discharge from the new 3430 Building. The performance of the air monitoring system must conform to the applicable federal regulations (Title 40 of the Code of Federal Rgulations Part 61 [40 CFR 61], Subpart H). This regulation requires that a sampling probe be located in the 3430 Building Filtered Exhaust Stack according to the criteria of the ANSI/HPS[a] N13.1-1999, *Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stack and Ducts of Nuclear Facilities*. This standard requires that a series of tests be performed to demonstrate the acceptability of the location of the air sampling probe in the system. The test series includes measurement of the flow angle, velocity uniformity, gas tracer uniformity, and particle tracer uniformity as measured in the stack cross section at the sampling probe nozzle location.

A facility may choose to perform the demonstration using one of the following three approaches:

1. Perform the full test series on the actual exhaust system.
2. Perform the full test series on a scale model of the exhaust system, followed by a partial test of the actual exhaust system to verify the validity of the model results.
3. Adopt the results of a previously performed test series for a system of similar configuration, followed by a partial test of the actual system to verify the applicability of the previously performed tests.

The third approach was selected to to evaluate the acceptability of the location of the air sampling probe in 3430 Building filtered exhaust stack to monitor discharged air for radionuclides. Consequently, a limited series of tests was performed on the actual exhaust system using the criteria for qualifying the location of a stack air monitoring probe and the configuration of the 3430 Building filtered exhaust stack, as described below. Then the results were compared to those of the previously tested system.

This report describes the tests performed on the actual system and also presents the results from the previously tested system that serves as the basis for compliance with the standard as it relates to the sampling probe location.

The tests conducted by PNNL during January and May 2010 on the 3430 Building filtered air exhaust system are described in this report. The test results indicate that the proposed air sampling location meets the criteria of the standard.

1.1 Qualification Criteria

The qualification criteria for a stack air monitoring probe location are taken from ANSI/HPS N13.1-1999 and are paraphrased as follows:

1. <u>Uniform Air Velocity</u> – It is important that the gas velocity across the stack cross-section where the sample is extracted be fairly uniform. Consequently, the velocity is measured at several points in the stack at the position of the sampling nozzle. The uniformity is expressed as the variability of the

[a] American National Standards Institute delegates the writing, publication and maintenance of this standard to the Health Physics Society, McLean, Virginia.

measurements about the mean. This is expressed using the coefficient of variation (COV),[(a)] which is the standard deviation divided by the mean and expressed as a percentage. The lower the COV value, the more uniform the velocity. The acceptance criterion is that the COV of the air velocity must be ≤ 20% across the sampling plane.

2. Angular Flow – Sampling nozzles are typically aligned with the axis of the stack. If the air travels up the stack in cyclonic fashion, the air velocity vector approaching a sampling nozzle could be sufficiently misaligned with the nozzle to impair the extraction of particles. Consequently, the flow angle is measured in the duct at the proposed location of the sampling probe. The average air-velocity angle must not deviate from the axis of the duct by more than 20°.

3. Uniform Concentration of Tracer Gases – A uniform contaminant concentration in the sampling plane enables the extraction of samples that represent the true concentration within the duct. The uniformity of the concentration is first tested using a tracer gas to represent gaseous effluents. The fan is a good mixer, so injecting the tracer downstream of the fan provides worst-case results. The acceptance criteria are that 1) the COV of the measured tracer gas concentration is ≤ 20% across the sampling location and 2) at no point in the sampling location does the concentration vary from the mean by > 30%.

4. Uniform Concentration of Tracer Particles – The second set of tests addressing contaminant-concentration uniformity at the sampling position uses tracer particles large enough to exhibit inertial effects. Tracer particles of 10-µm (10^{-6} m) aerodynamic diameter (AD) are used by default unless it is known that larger contaminant particles will be present in the airstream. The acceptance criterion is that the COV of particle concentration is ≤ 20% across the sampling location.

It was determined that compliance with these criteria was already demonstrated for a similar stack configuration by testing a scale model as reported by Glissmeyer and Droppo (2007).

To be able to apply the results of the scale model tests, Section 5.2.2.2 of the ANSI/HPS N13.1-1999 standard defines additional criteria for applying the results as a substitute for the actual 3430 Building Filtered Exhaust Stack.

- The scale model and its sampling location must be geometrically similar to the actual 3430 Building Filtered Exhaust Stack.
- The product of the duct diameter and the mean velocity (DV) for the scale model must be within a factor of six of the DV for the actual 3430 Building Filtered Exhaust Stack.
- The Reynolds number for the actual and model stacks must be > 10,000.

The scale-model results are considered valid if the following are shown by testing on the actual stacks:

- The velocity profile in the actual 3430 Building Filtered Exhaust Stack meets the uniformity criterion.
- The velocity uniformity COV values for the actual and model stacks agree within 5% COV.
- The flow angle criterion (with a mean value less than or equal to 20°) is met.

(a) *Coefficient of variation* is considered "dated" terminology. The modern terminology is *percent relative standard deviation*. However, because the standard uses the older terminology, it will likewise be used here.

1.2 3430 Building Filtered Exhaust Stack Configuration

Figure 1.1 shows a crude plan view of the 3430 Building Filtered Exhaust Stack on the roof of the 3430 Building. Figure 1.2 shows the scale model stack (designated HV-C2) tested by Glissmeyer and Droppo (2007).

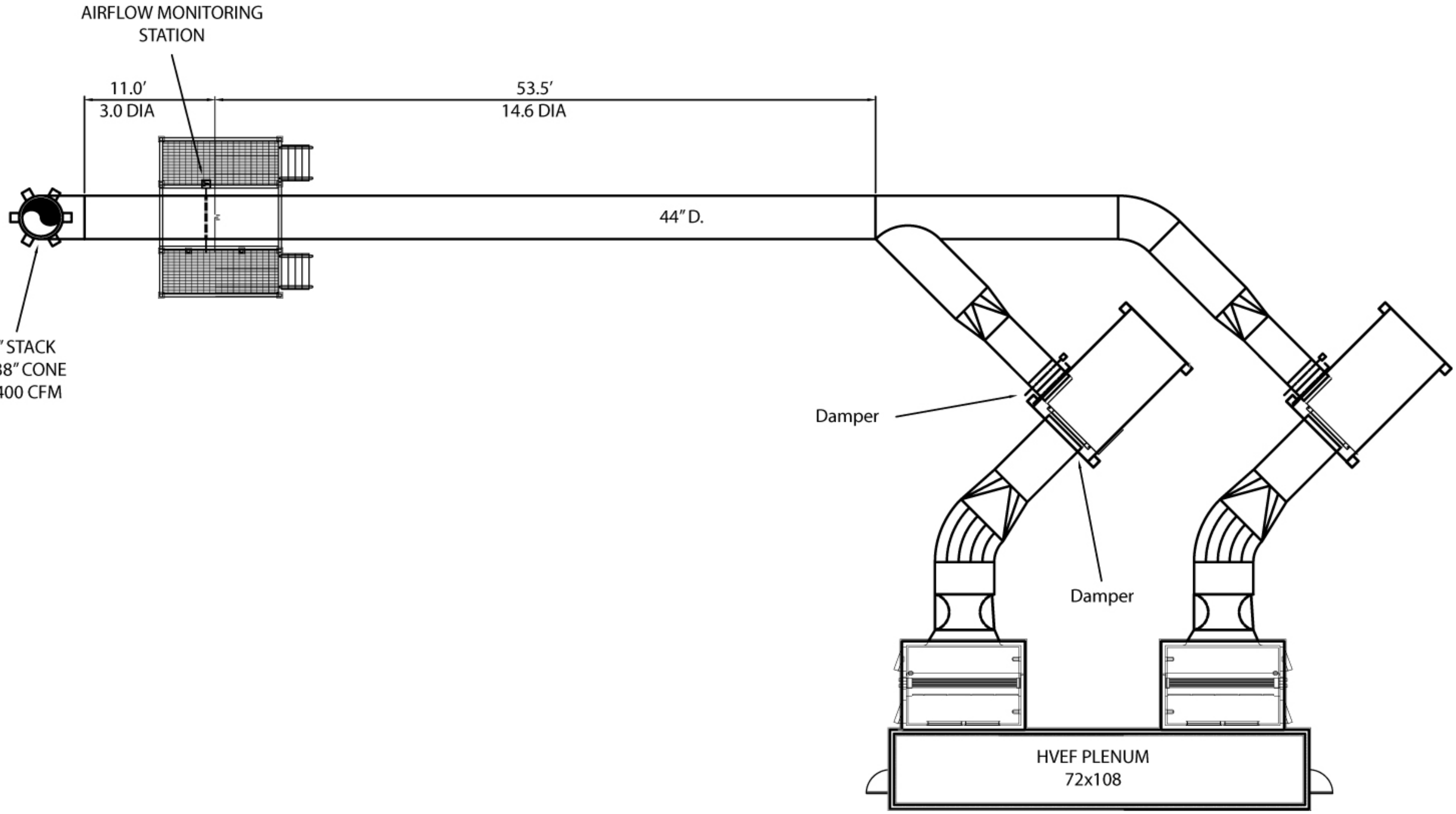

Figure 1.1. Plan View of 3430 Building Filtered Exhaust Stack

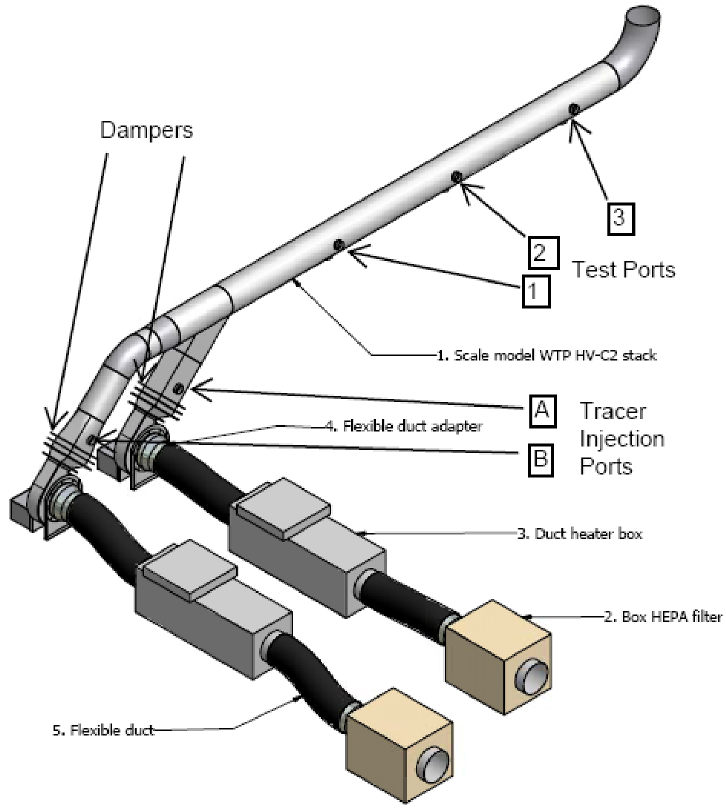

Figure 1.2. Scale Model Tested by Glissmeyer and Droppo (2007)

The difference between the two designs is that the model stack (except for the bend upwards at the discharge end) is rotated 90° around its long axis so that the air from the fans enters the straight section from the side rather than from the bottom. This should have no effect on the uniformity of tracers and the air velocity uniformity and flow angles. The model stack was tested with one and both fans operating, which covers the possible operating modes.

Table 1.1 lists key dimensional and flow parameters for both the model stack and the 3430 Building Filtered Exhaust Stack. During the first set of tests, which were conducted in January 2010, the discharge diameter was 38 in. However, after these tests were conducted, additional fume hoods were incorporated into the exhaust system. With the increased flow through the system, the stack exit cone was removed so the discharge diameter during the May 2010 testing was 44 in.

Table 1.1. Comparative Stack Dimensions

Operating Parameters	Model	3430 Building
Duct diameter at sampling probe	12 in.	43.75 in.
Number of duct diameters[a] from upstream duct junction to sampling probe or test ports	Port 1 – 4.45 Port 2—9.47 Port 3—14.5	14.6
Number of duct diameters from sampling probe or test ports to downstream bend	Port 3—2.25	3
Discharge diameter	12 in.	38 in. / 44 in.
Number of operating fans	1 and 2	2
Total available fans	2	2

(a) The number of duct diameter refers to the ratio of the linear distance (to some feature) to the stack duct diameter. It is used to compare the relative distance to duct features for stacks of different sizes.

2.0 Test Strategy

The criteria for the applicability of model results and the matrix of tests underlying the testing strategy are described in the following sections.

2.1 Criteria for Applicability of Model Results

The velocity uniformity test results from the model stack are a factor in the formulation of one of the criteria for the applicability of the model results to any other stack. Table 2.1 lists the results from the velocity uniformity tests performed on the model using Test Ports 2 and 3 for both one and two operating fans. The average velocity uniformity (% COV) results were 4.8% COV and 4.9% COV for one and two operating fans, respectively. The most applicable test results for comparison with the 3430 Building exhaust system are the scale model results from Test Port 3 when both fans were running. The average velocity uniformity for these conditions was 4.7% COV. Therefore, the acceptance range for velocity uniformity results for the 3430 Building Filtered Exhaust Stack is 0% COV to 9.7% COV [a]for the results from the HV-C2 scale model to be considered applicable.

Table 2.1. List of HV-C2 Velocity Uniformity Test Results with Dampers Installed (from Glissmeyer and Droppo 2007)

Test Port	Operating Fans	Run No.	Control Damper Setting (degrees)	Back Flow Damper Setting (degrees)	Flowrate cfm	Velocity fpm	% COV
2	A	VT-16	90	70	973	1239	3.6
2	B	VT-19	90	70	977	1244	6
3	A	VT-17	90	70	1002	1276	3.4
3	B	VT-18	90	70	959	1221	6
				Average	977.8	1245.0	4.8
2	A & B	VT-13	90	70	2094	2666	6.1
2	A & B	VT-23	90	70	2132	2715	5.1
2	A & B	VT-24	90	70	2126	2706	4.4
3	A & B	VT-14	90	70	2117	2696	4.4
3	A & B	VT-21	90	70	2136	2720	5.1
3	A & B	VT-22	90	70	2180	2775	4.5
				Average	2130.8	2713.0	4.9

Table 2.2 shows calculations of the acceptable range of the diameter × velocity criterion that also determines the applicability of the scale-model results to the actual stacks. The product of duct diameter times air velocity during both tests (DV=113,750 / DV=144,375) was within the acceptable factor of six of the scale model's DV product (32,556 × 6 = 195,336) for two operating fans. Table 2.2 also includes the Reynolds number for the scale tests and the building stack tests. In all cases, the Reynolds numbers are greater than 10,000, which is another criterion for applying the scale model results to the building stack

[a] 4.7% ±5.0% = 0% – 9.7% (considering only positive values).

Table 2.2. Calculation of Acceptable Ranges of Diameter × Velocity Products and Reynolds Number

Stack	Diameter (in)	Configuration	Mean. velocity (fpm)	Product DV, in × fpm	Maximum 6 × (D x V)	Reynolds Number
Model	12	One fan	1245	14,940	89,640	1.3E+05
Model	12	Two fans	2713	32,556	195,336	2.8E+05
3430-Jan	43.75	Two Fans	2600	113,750		9.8E+05
3430-May	43.75	Two Fans	3300	144,375		1.3E+06

2.2 Test Matrix

Table 2.3 lists the minimum matrix of tests needed for the 3430 Building Filtered Exhaust Stack. Also included in the list are the optional tests that may be required if the applicable criteria for velocity uniformity and diameter/velocity product were not met as presented above.

Table 2.3. Minimum Test Runs for 3430 Building Qualification

Test Configuration				Estimated Number of Test Runs			
Fans	#	Injection Port	Test Port	Flow Angle	Velocity	Gas Tracer (optional)[a]	Particle Tracer (optional)
Maximum flowrate	1	Junction	At Probe	2	2	7	2
Minimum flowrate	2	Junction	At Probe	1	1	1	1
Total				3	3	8	3
Grand Total				17			

(a) Five of the seven runs involve injecting the tracer gas in the four corners and center of the cross section at the injection location. The two additional runs are replicates of the test with the worst-case result.

3.0 Test Methods

The test methods for the flow angle and velocity uniformity are outlined below. Tracer tests are not currently planned. Figure 3.1 shows the layout of the duct in the location of the air sampling probe and the test ports used in the test.

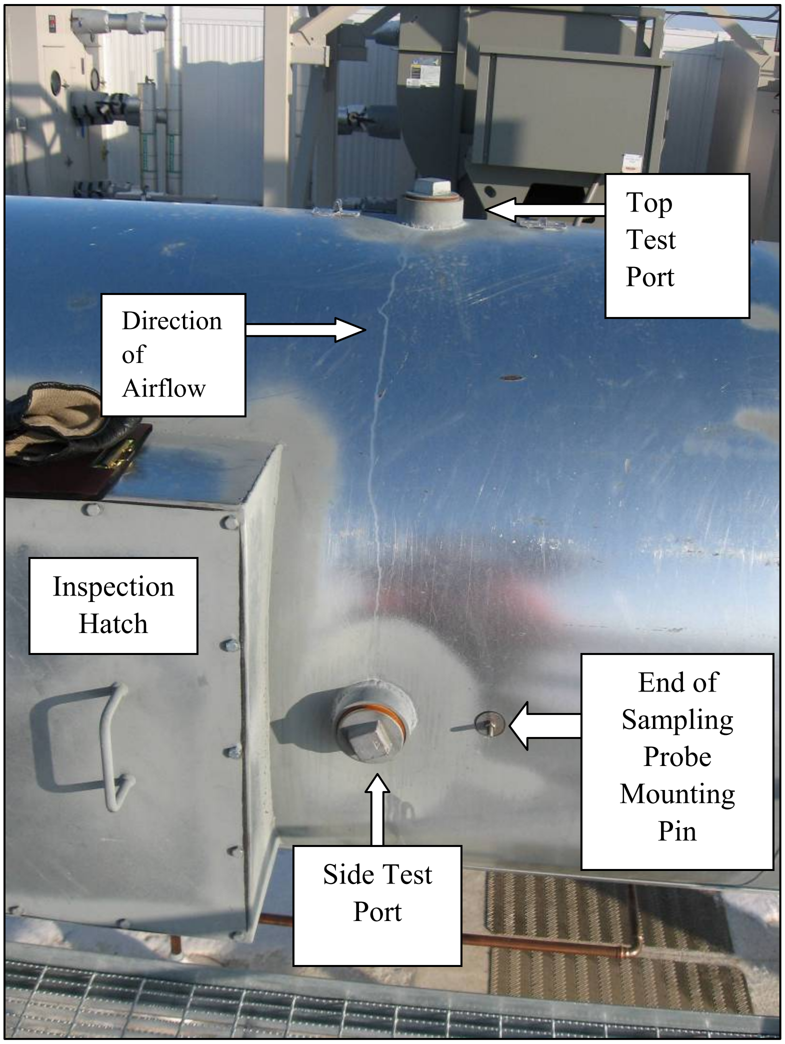

Figure 3.1. Layout of Test Ports and Other Duct Features

Figure 3.2 shows the inside of the duct looking downstream (with inspection hatch removed). A shrouded nozzle and flow sensor are part of the sample probe assembly.

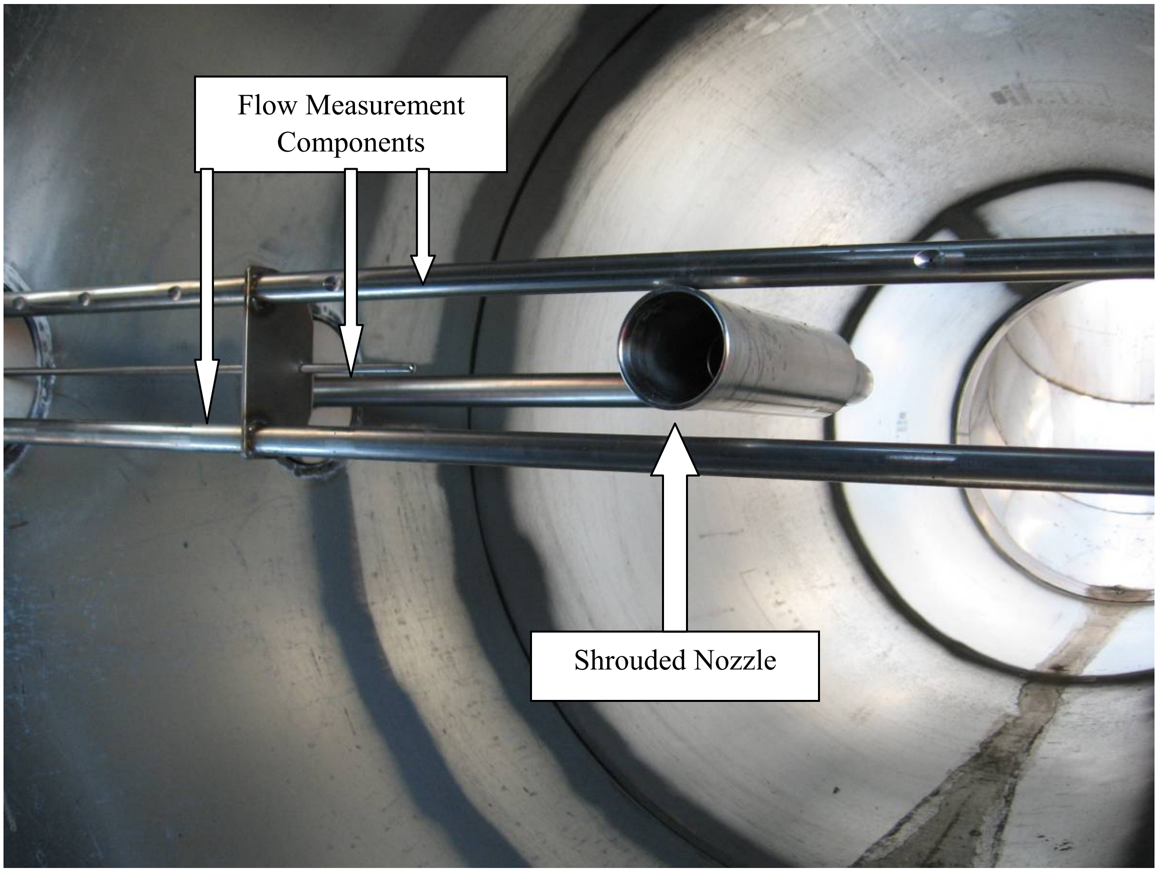

Figure 3.2. Sampling Probe Assembly

3.1 Flow Angle Test

The air-velocity vector approaching the sample nozzle should be aligned with the axis of the nozzle, within an acceptable angle, so sample extraction performance is not degraded (see Section 2). The test method is based on 40 CFR 60, Appendix A, Method 1, Section 11.4.

The "flow angle" is the average angle between the air velocity vector and the axis of the sampling nozzle. The flow angle was measured at a grid of points in a cross section of the 3430 Building Filtered Exhaust Stack at the test ports just a few inches upstream of the actual sampling probe. The grid is an array of points in an x-pattern in the cross section of the duct. One line of points is aligned in the same direction as the sampling probe assembly. The other line is perpendicular to the sample probe assembly. The number and distance between measurement points is based on the U.S. Environmental Protection Agency's (EPA's) method in 40 CFR 60, Appendix A, Method 1.

Measurements were made using a S-type Pitot tube (Dwyer Instruments, 160S-72, Michigan City, IN) attached by flexible tubing to a slant tube manometer (Dwyer Instruments, 400-S), and an angle-indicating device. PNNL operating procedure EMS-JAG-05, "Test to Determine Flow Angle," was used to determine the mean flow angle.

Figure 3.3 is a view looking upstream from the test ports toward the exhaust fans. The S-type Pitot tube is installed in the duct attached to an angle-indicating device threaded to the top test port. Figure 3.4 shows the slant-tube manometer.

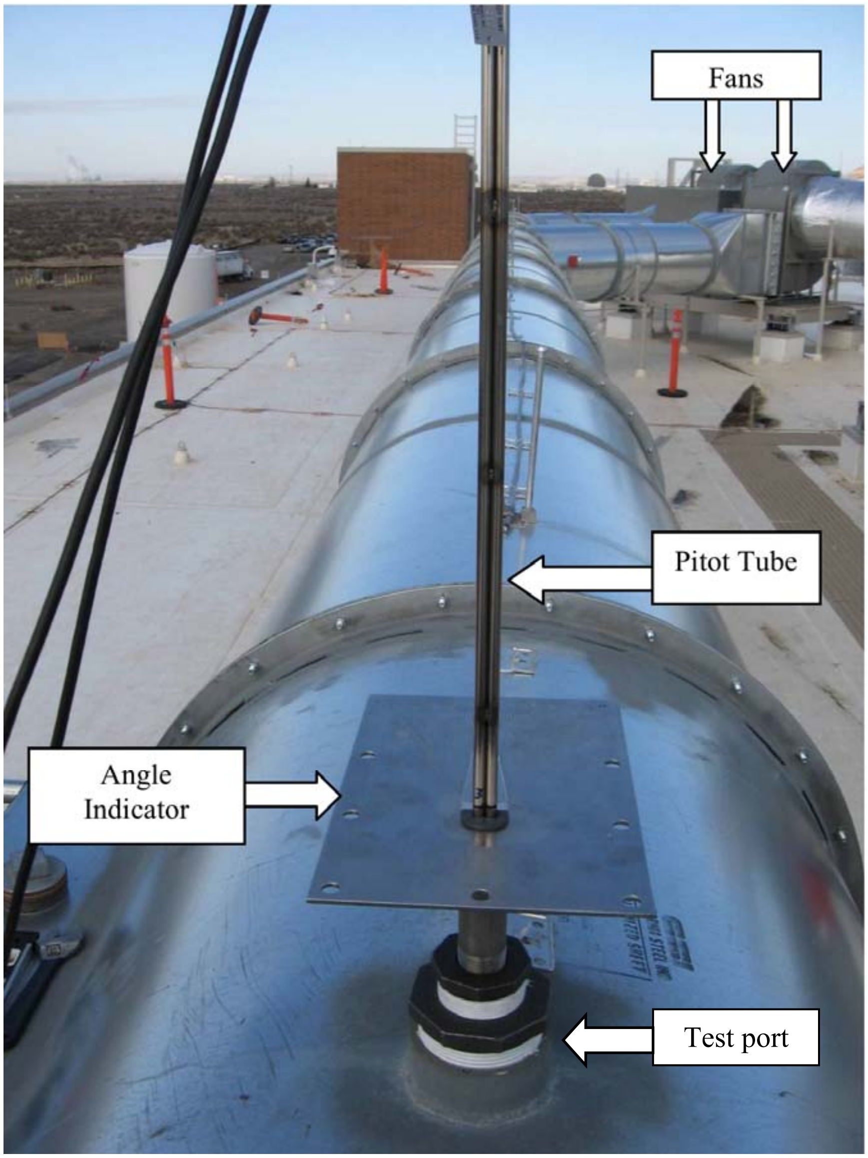

Figure 3.3. Flow Angle Indicator and Pitot Tube Installed

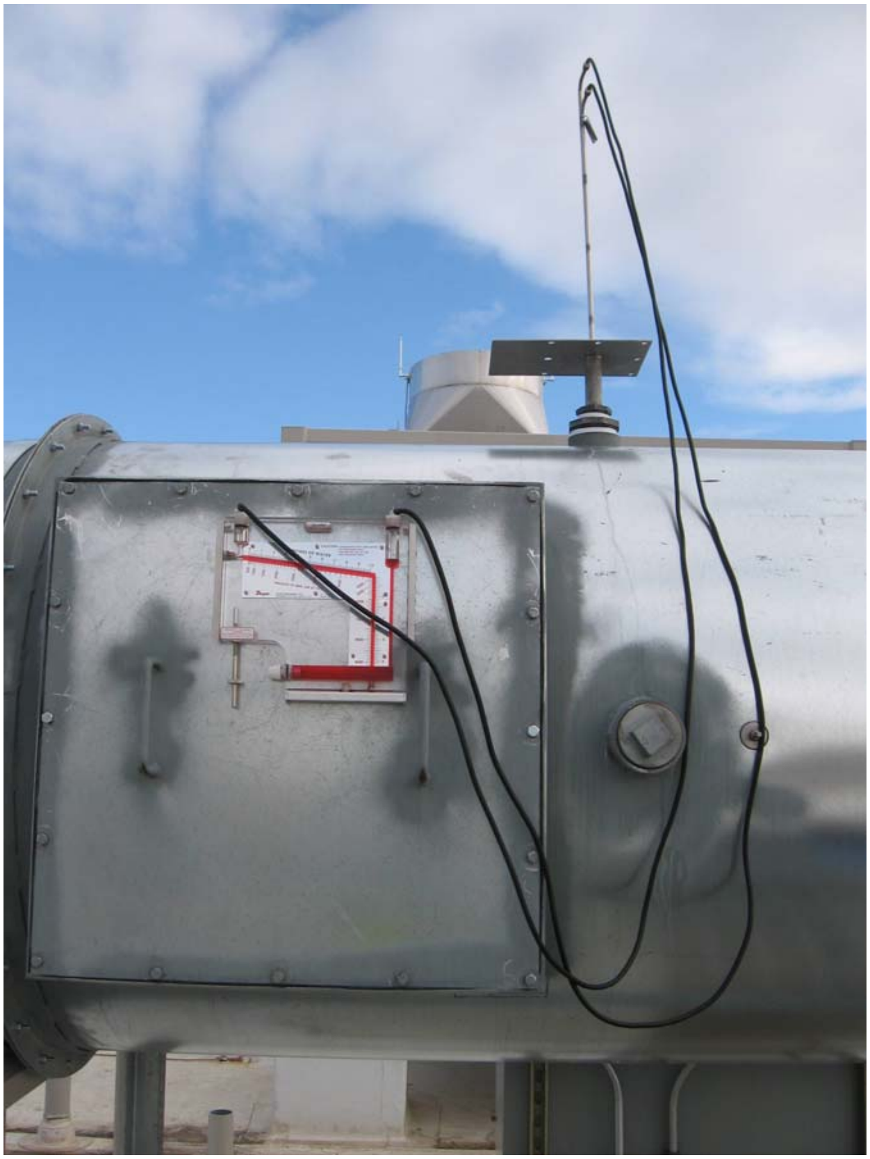

Figure 3.4. Slant Tube Manometer on Inspection Hatch Cover

3.2 Velocity Uniformity Test

To determine uniformity, air velocity is measured at the same grid of points used for the flow angle test. The method used is based on 40 CFR 60, Appendix A, Method 1.

The air velocity is measured three times at each grid point, and each measurement is recorded. The measurements at each grid point are averaged to determine the mean velocity at each grid point. The average values for each grid point in the center two thirds of the stack are used to calculate the mean and standard deviation of velocity for the sampling location. The % COV is calculated as 100 times the standard deviation divided by the mean. This value should be less than or equal to 9.7% for the scale model tests to apply to the stack.

The test equipment used included an S-type Pitot tube and a calibrated electronic manometer (GrayWolf, ZephyrII+, Shelton, CT) as shown in Figure 3.5. The Pitot tube is inserted in the duct as shown in Figure 3.4, except an electronic manometer is used in place of the slant-tube manometer. The electronic manometer indicates actual air velocity, assuming a Pitot tube correction factor of 1. Because the S-type Pitot tube has a correction factor of 0.84, the recorded values were corrected after the test. PNNL operating procedure EMS-JAG-04 "Test to Determine Uniformity of Air Velocity at a Sampler Probe," was used for this test.

Figure 3.5. Electronic Manometer Connected to Pitot Tube

3.3 Quality Assurance

The PNNL Quality Assurance (QA) Program is based upon the requirements as defined in the U.S. Department of Energy (DOE) Order 414.1C, Quality Assurance and 10 CFR 830, Energy/Nuclear Safety Management, Subpart A—Quality Assurance Requirements (a.k.a., the Quality Rule). PNNL has chosen to implement the following consensus standards in a graded approach:

- American Society of Mechanical Engineers (ASME) NQA-1-2000, *Quality Assurance Requirements for Nuclear Facility Applications, Part 1, Requirements for Quality Assurance Programs for Nuclear Facilities*.
- ASME NQA-1-2000, Part II, Subpart 2.7, *Quality Assurance Requirements for Computer Software for Nuclear Facility Applications*.
- ASME NQA-1-2000, Part IV, Subpart 4.2, *Graded Approach Application of Quality Assurance Requirements for Research and Development*.

The procedures necessary to implement the requirements are documented in PNNL's standards-based management system called "How Do I…?" (HDI).[a]

The Stack Monitoring Project (STMON) implements a National Quality Assurance (NQA)-1-2000 Quality Assurance Program, graded on the approach presented in NQA-1-2000, Part IV, Subpart 4.2. The STMON Quality Assurance Manual (QA-STMON-0002[b]) describes the technology life cycle stages under the STMON Quality Assurance Plan (QA-STMON-0001[c]). The technology life cycle includes the progression of technology development, commercialization, and retirement in process phases of basic and applied research and development (R&D), engineering, and production and operation until process completion. The life cycle is characterized by flexible and informal QA activities in basic research, which becomes more structured and formalized through the applied R&D stages:

- BASIC RESEARCH – Basic research consists of research tasks that are conducted to acquire and disseminate new scientific knowledge. During basic research, maximum flexibility is desired to allow the researcher the necessary latitude to conduct the research.
- APPLIED RESEARCH – Applied research consists of research tasks that acquire data and documentation necessary to make sure that results can be satisfactorily reproduced. The emphasis during this stage of a research task is on achieving adequate documentation and controls necessary to be able to reproduce results.
- DEVELOPMENTAL WORK – Developmental Work consists of research tasks moving toward technology commercialization. These tasks still require a degree of flexibility, and there is still a degree of uncertainty that exists in many cases. The role of quality on Developmental Work is to make sure that adequate controls to support movement into commercialization exist.
- RESEARCH AND DEVELOPMENT SUPPORT ACTIVITIES – Support activities are those that are conventional and secondary in nature to the advancement of knowledge or development of technology, but allow the primary purpose of the work to be accomplished in a credible manner. An example of a support activity is controlling and maintaining documents and records. The level of quality for these activities is the same as for developmental work.

The work described in this report has been completed under the QA technology level of Development Work. STMON addresses internal verification and validation activities by conducting an independent technical review of the final data report in accordance with STMON's procedure QA-STMON-601,[d] "Document Preparation and Change." This review verifies that the reported results are traceable, that inferences and conclusions are soundly based, and that the reported work satisfies the Test Plan objectives.

The tests were conducted according to an approved test plan and test instructions. Data transcription and calculations were independently reviewed.

(a) A system for managing the delivery of laboratory-level policies, requirements, and procedures.
(b) QA-STMON-0002, Rev. 0. January 2, 2010. "Pacific Northwest National Laboratory Stack Monitoring Project Quality Assurance Manual." Pacific Northwest National Laboratory, Richland, Washington.
(c) QA-STMON-0001, Rev. 0. January 2, 2010. "Pacific Northwest National Laboratory Stack Monitoring Project Quality Assurance Plan." Pacific Northwest National Laboratory, Richland, Washington.
(d) QA-STMON-0601, Rev. 0. January 2, 2010. "Document Preparation and Change." Pacific Northwest National Laboratory, Richland, Washington.

4.0 Test Results

Independent reviews were performed to verify the data transcription and calculations. The final data sheets are attached in Appendix A.

The duct diameters were field measured at the test ports and found to be 43.75 in. as listed in Table 4.1. The distance from the test ports to the nearest upstream disturbance (the junction of the ducts from the fans) was 53.5 ft[a]. Therefore, in terms of duct diameters (DIA = distance divided by the duct diameter), the tests were performed 14.7 DIA downstream of the duct junction. In comparison, the test ports in the model tested by Glissmeyer and Droppo (2007) were 4.45 DIA, 9.47 DIA, and 14.5 DIA for Test Ports 1, 2, and 3, respectively, downstream of the junction.

Table 4.1. Test Port Depth Measurements

Side of duct	Measurement Port	Measured Duct Depth, in.
Top	1	43.75
West Side	2	43.75

4.1 Velocity Uniformity Results

The measured air velocity % COV values are summarized in Table 4.2, which also lists the airflow calculated from the velocity measurements for each velocity uniformity test run (VT). VT-1 through VT-3 were conducted during January 2010, while VT-4 through VT-7 were conducted during May 2010. For the January tests, the average result was 3.5% COV, while the May test average was 3.6% COV with two fans running. These results are both well within the acceptance criterion derived in Section 2.1 (< 9.7 % COV) for verifying that the 3430 Building Filtered Exhaust Stack configuration is represented by the model tests of Glissmeyer and Droppo (2007).

[a] The data sheets from the January 2010 stack tests incorrectly report the distance to disturbance as 74.5 ft. This was the distance from the port to the far end of the duct junction, whereas the near end of the duct junction (the correct distance) was 53.5 ft.

Table 4.2. 3430 Building Filtered Exhaust Stack Velocity Uniformity Test Runs

	Fan Operating Configuration	Run Nos.	Measured Airflow, acfm	% COV
JAN	Maximum (2 Fans, Sashes Open)	VT-1	27,147	3.2
	Maximum (2 Fans, Sashes Open)	VT-2	26,961	3.5
	Minimum (2 Fans, Sashes Closed)	VT-3	17,712	3.7
MAY	Maximum (2 Fans, Sashes Open)	VT-4	34,252	3.8
	Maximum (2 Fans, Sashes Open)	VT-5	34,352	3.8
	Minimum (2 Fans, Sashes Closed)	VT-6	24,634	3.2
	Minimum (1 Fan, Sashes Closed)	VT-7	24,613	2.6

4.2 Flow Angle Results

The results for the flow angle test runs (FAs) are listed in Table 4.3. The airflow displayed in the air sampling cabinet, which is listed in units of standard cubic feet per minute (scfm), is included in this table as well. FA-1 through FA-3 were conducted during January 2010, while FA-4 through FA-7 were conducted during May 2010. For both the January and May tests, the average flow angle was 2.6°. This result is acceptable and well within the acceptance criterion of 20°.

Table 4.3. 3430 Building Filtered Exhaust Stack Flow Angle Test Runs

	Fan Operating Configuration	Run Nos.	Airflow Displayed in Sampling Cabinet ,scfm	Mean Absolute Flow Angle
JAN	Maximum (2 Fans, Sashes Open)	FA-1	27,400	2.8
	Maximum (2 Fans, Sashes Open)	FA-2	27,300	2.2
	Minimum (2 Fans, Sashes Closed)	FA-3	17,000	2.9
MAY	Maximum (2 Fans, Sashes Open)	FA-4	31,650	1.8
	Maximum (2 Fans, Sashes Open)	FA-5	31,250	2.6
	Minimum (2 Fans, Sashes Closed)	FA-6	23,150	2.9
	Minimum (1 Fan, Sashes Closed)	FA-7	23,300	3.0

5.0 Conclusions

Velocity uniformity tests were performed on the 3430 Building Filtered Exhaust Stack during both January and May 2010. Tests were conducted in May to ensure that modifications made to the exhaust system after the January testing did not negatively affect the validity of adopting the results of the previously conducted scale testing. Both tests showed acceptable agreement with the scale model tests performed previously (Glissmeyer and Droppo 2007), and the current location for the air sampling probe meets the qualification criteria given in ANSI/HPS-1999. The gas and particle tracer qualification results of the scale model apply equally to the full-sized stack. The results from Glissmeyer and Droppo (2007) are included in Appendix B of this report. The results for the flow angle test on the 3430 Building Filtered Exhaust Stack also show compliance with the flow-angle criterion.

6.0 References

10 CFR 830, Subpart A. 2008. "Quality Assurance Requirements." *Code of Federal Regulations*, U.S. Department of Energy.

40 CFR 60, Appendix A, Method 1. 2008. "Sample and Velocity Traverses for Stationary Sources." *Code of Federal Regulations,* U.S. Environmental Protection Agency.

40 CFR 61, Subpart H. 2002. "National Emission Standard For Emissions of Radionuclides Other Than Radon from Department of Energy Facilities." *Code of Federal Regulations,* U.S. Environmental Protection Agency.

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EMS-JAG-04, Rev. 2. *Test to Determine Uniformity of Air Velocity at a Sampler Probe*. Pacific Northwest National Laboratory, Richland, Washington.

EMS-JAG-05, Rev. 2. *Test to Determine Flow Angle*. Pacific Northwest National Laboratory, Richland, Washington.

Appendix A

Data Sheets

Appendix A: Data Sheets

FLOW ANGLE DATA FORM

FlowAngleRev0.xls — 4-Aug-06 Based on ---- CCP-WTPSP-178

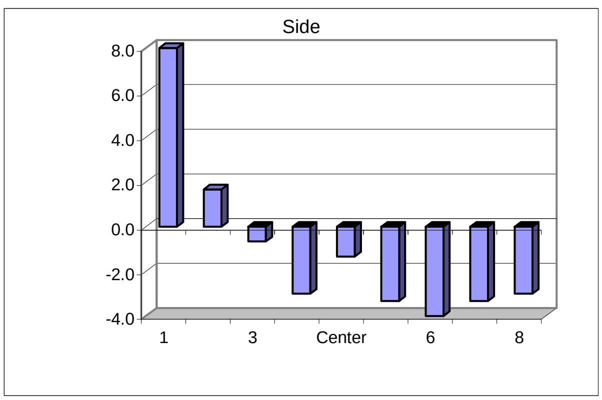
Site	**3430 Stack**	Run No.	**FA-1**
Date	1/6/2010	Fan Setting	**Maximum**
Tester	JAG/JEF	Fan configuration	**2 fans**
Stack Dia.	43.75 in	Approx. air vel.	2670 sfpm at side center
Stack X-Area	1503.3 in2	Units	degrees (clockwise > pos. nos.)
Elevation	N.A. ft	Port	1&2
Distance to disturbance	74.5 ft	Stack Temp	55 F
Start/End Time	1055/1140		

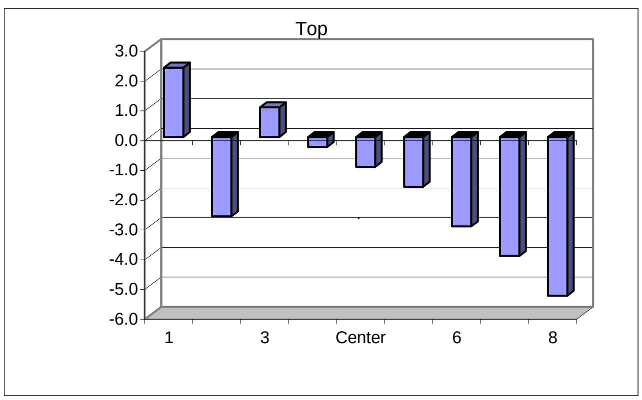
Order -->		1st				2nd			
Traverse-->		**Side**				**Top**			
Trial ---->		1	2	3		1	2	3	
Point	Depth, in.	deg. cw	deg. cw	deg. cw	Avg.	deg. cw	deg. cw	deg. cw	Avg.
1	1.40	8	8	8	8.0	2	3	2	2.3
2	4.58	0	0	5	1.7	-5	-2	-1	-2.7
3	8.46	-2	0	0	-0.7	1	1	1	1.0
4	14.09	-5	-4	0	-3.0	0	0	-1	-0.3
Center	21.81	-4	0	0	-1.3	-1	-1	-1	-1.0
5	29.53	-4	-1	-5	-3.3	-2	-1	-2	-1.7
6	35.16	-5	-3	-4	-4.0	-3	-3	-3	-3.0
7	39.04	-4	-3	-3	-3.3	-4	-4	-4	-4.0
8	42.23	-3	-4	-2	-3.0	-6	-5	-5	-5.3
Mean of absolute values of all data:					3.1				2.4
w/o points by wall:					2.5				2.0
								all	2.8
								w/o wall pts	2.2

Instuments Used:		**Cal. Due**
S-type pitot	Dwyer 72-inch S-type Pitot#11 160S-72-A30U	Cert. of conformance
Velocity sensor	TSI VELOCICALC 209060	7/14/2010
Angle indicator	Shop built	Cat. 3
Manometer	Dwyer 400-5, S36N	Cat. 3

Notes: Air sampler Masstron shows 27,400 scfm stack flow.
All hood sashes open

Note:
To assure similar hose connections between the manometer and pitot tube, rotating the pitot tube assembly clockwise drives the meniscus to the right (to higher pos. numbers).





Entries made by:	John Glissmeyer	Technical Data Review performed by:	J. Matthew Barnett
Signature/date	1/6/2010	Signature/date	1/18/2010
	signature on original		signature on original

FLOW ANGLE DATA FORM

FlowAngleRev0.xls | 4-Aug-06 Based on ---- CCP-WTPSP-178

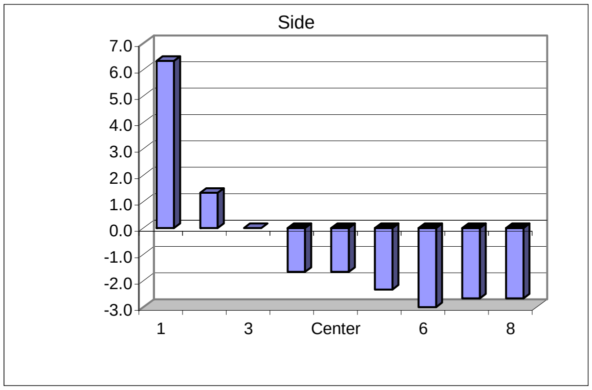
Site	**3430 Stack**	Run No.	**FA-2**
Date	1/6/2010	Fan Setting	**Maximum**
Tester	JAG/JEF	Fan configuration	**2 fans**
Stack Dia.	43.75 in	Approx. air vel.	2820 sfpm at side center
Stack X-Area	1503.3 in2	Units	degrees (clockwise > pos. nos.)
Elevation	N.A. ft	Port	1&2
Distance to disturbance	74.5 ft	Stack Temp	57 F
Start/End Time	1250/1318		

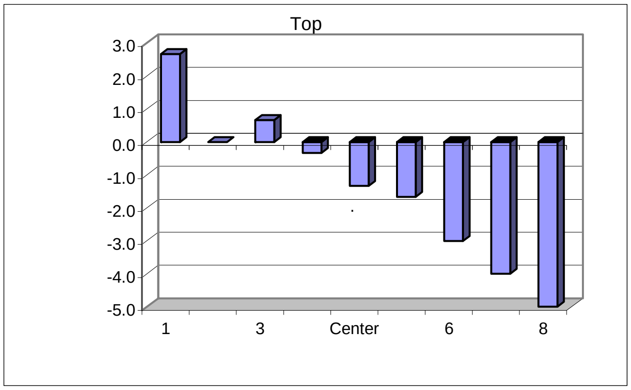
Order -->		2nd				1st			
Traverse-->		Side				Top			
Trial ---->		1	2	3		1	2	3	
Point	Depth, in.	deg. cw	deg. cw	deg. cw	Avg.	deg. cw	deg. cw	deg. cw	Avg.
1	1.40	8	5	6	6.3	2	4	2	2.7
2	4.58	4	0	0	1.3	0	0	0	0.0
3	8.46	1	0	-1	0.0	0	1	1	0.7
4	14.09	-1	-1	-3	-1.7	-1	0	0	-0.3
Center	21.81	-1	-2	-2	-1.7	-2	-1	-1	-1.3
5	29.53	-2	-2	-3	-2.3	-2	-2	-1	-1.7
6	35.16	-3	-3	-3	-3.0	-3	-3	-3	-3.0
7	39.04	-2	-3	-3	-2.7	-4	-4	-4	-4.0
8	42.23	-2	-3	-3	-2.7	-5	-5	-5	-5.0
Mean of absolute values of all data:					2.4				2.1
w/o points by wall:					1.8				1.6
								all	2.2
								w/o wall pts	1.7

Instuments Used:		**Cal. Due**
S-type pitot	Dwyer 72-inch S-type Pitot#11 160S-72-A30U	Cert. of conformance
Velocity sensor	TSI VELOCICALC 209060	7/14/2010
Angle indicator	Shop built	Cat. 3
Manometer	Dwyer 400-5, S36N	Cat. 3

Notes: Air sampler Masstron rads 27,300 scfm
All sashes open

Note:
To assure similar hose connections between the manometer and pitot tube, rotating the pitot tube assembly clockwise drives the meniscus to the right (to higher pos. numbers).





Entries made by:	John Glissmeyer	Technical Data Review performed by:	J. Matthew Barnett
Signature/date	1/6/2010	Signature/date	1/18/2010
	signature on original		signature on original

FLOW ANGLE DATA FORM

FlowAngleRev0.xls

4-Aug-06 Based on ---- CCP-WTPSP-178

Site	**3430 Stack**	Run No.	**FA-3**
Date	1/7/2010	Fan Setting	**Minimum, night setback**
Tester	JAG/DMT	Fan configuration	**1 & 2**
Stack Dia.	43.75 in	Approx. air vel.	1740 sfpm at side center
Stack X-Area	1503.3 in2	Units	degrees (clockwise > pos. nos.)
Elevation	N.A. ft	Port	1&2
Distance to disturbance	74.5 ft	Stack Temp	58 F
Start/End Time	1230/1325		

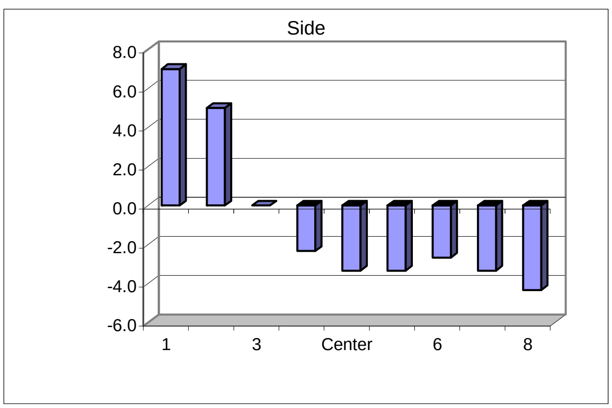
Order -->		1st				2nd			
Traverse-->		**Side**				**Top**			
Trial ---->		1	2	3		1	2	3	
Point	Depth, in.	deg. cw	deg. cw	deg. cw	Avg.	deg. cw	deg. cw	deg. cw	Avg.
1	1.40	8	7	6	7.0	2	0	-6	-1.3
2	4.58	4	5	6	5.0	-4	-4	-3	-3.7
3	8.46	-1	2	-1	0.0	-2	-3	1	-1.3
4	14.09	-2	-2	-3	-2.3	-3	-1	-1	-1.7
Center	21.81	-4	-3	-3	-3.3	-2	-2	-2	-2.0
5	29.53	-3	-3	-4	-3.3	0	-2	-2	-1.3
6	35.16	-2	-3	-3	-2.7	-3	-3	-3	-3.0
7	39.04	-3	-4	-3	-3.3	-2	-3	-3	-2.7
8	42.23	-4	-5	-4	-4.3	-5	-5	-3	-4.3
Mean of absolute values of all data:					3.5				2.4
w/o points by wall:					2.9				2.2

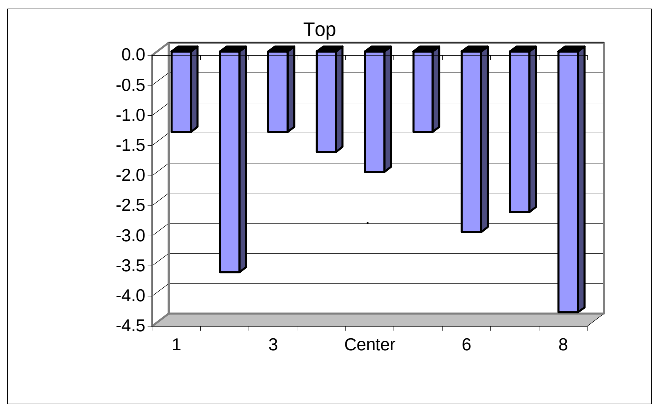
all	2.9
w/o wall pts	2.5

Instuments Used:		**Cal. Due**
S-type pitot	Dwyer 72-inch S-type Pitot#11 160S-72-A30U	Cert. of conformance
Velocity sensor	TSI VELOCICALC 209060	7/14/2010
Angle indicator	Shop built	Cat. 3
Manometer	Dwyer 400-5, S36N	Cat. 3

Notes: RAES Masstron reads 17,000 scfm and 1615 afpm

Note:
To assure similar hose connections between the manometer and pitot tube, rotating the pitot tube assembly clockwise drives the meniscus to the right (to higher pos. numbers).





Entries made by:	John Glissmeyer	Technical Data Review performed by:	J. Matthew Barnett
Signature/date	1/7/2010	Signature/date	1/18/2010
	signature on original		signature on original

VELOCITY TRAVERSE DATA FORM

Site	**3430 Bldg**	Run No.	**VT-1**
Date	**1/6/10**	Fan Configuration	**Fans 1&2**
Testers	JAG/JEF	Fan Setting	**Maximum**
Stack Dia.	43.75 in.	Stack Temp	57.8 deg F
Stack X-Area	1503.3 in.2	Start/End Time	1324/1509
Test Port	1&2	Center 2/3 from	4.01 to: 39.74
Distance to disturbance	74.5 ft	Points in Center 2/3	2 to: 7
Velocity units	ft/min	Pitot corr. Factor	0.84

Order -->		1st				2nd			
Traverse-->		Side				Top			
Trial ---->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	Velocity				Velocity			
1	1.40	2196	2024	2176	2131.9	2396	2342	2327	2354.8
2	4.58	2545	2511	2512	2522.8	2675	2672	2680	2675.7
3	8.46	2629	2633	2706	2655.8	2693	2794	2757	2747.9
4	14.09	2696	2733	2735	2721.3	2827	2839	2814	2826.9
Center	21.81	2733	2751	2761	2748.2	2809	2797	2790	2798.6
5	29.53	2770	2774	2748	2763.9	2810	2806	2796	2803.6
6	35.16	2754	2763	2724	2746.8	2778	2785	2780	2781.0
7	39.04	2604	2619	2600	2607.6	2667	2630	2551	2616.0
8	42.23	2285	2234	2291	2270.0	2386	2390	2367	2380.8
Averages ---------->		2579.0	2560.2	2583.6	2574.3	2671.1	2672.8	2651.2	2665.0

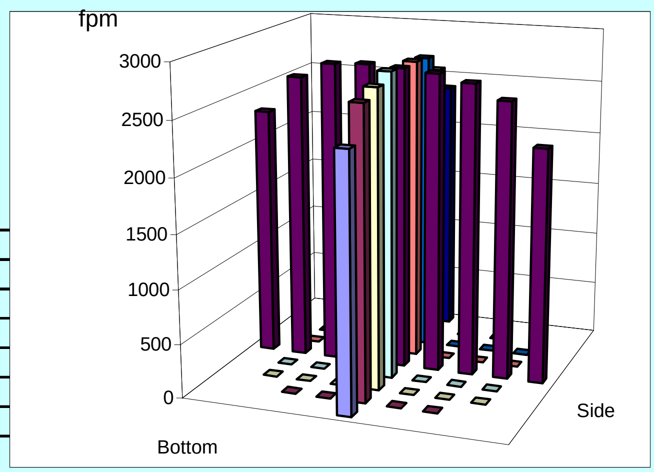
All	ft/min	Dev. from mean	***Center 2/3***	Side	Bottom	All
Mean	2619.6		Mean	2680.9	2750.0	2715.4
Min Point	2131.9	-18.6%	Std. Dev.	89.8	77.0	88.0
Max Point	2826.9	7.9%	COV as %	3.3	2.8	**3.2**

Flow w/o C-Pt 27147 acfm

Vel Avg w/o C-Pt 2600 fpm

	Start	Finish	
Stack temp	58.5	57	F
Equipment temp	N.A.	N.A.	F
Ambient temp	45	42	F
Stack static	0.10	0.10	mbars
Ambient pressure	1021	1022	mbars
Total Stack pressure	1021	1022	mbars
Ambient humidity	37%	42%	RH

Instuments Used:		Cal Due
Fisher Scientific	SN 90936818	9/29/2010
Zephyr II+	SN 80355	9/18/2010
TSI Velocicalc	SN 209060	7/14/2010
Dwyer Pitot Tube	160S-72-A30U	Cert. of Conf.



Notes:

Entries made by: John Glissmeyer	Technical Data Review performed by: J. Matthew Barnett
Signature/date 1/6/2010	Signature/date 1/18/2010
signature on original	signature on original

VELOCITY TRAVERSE DATA FORM

Site	**3430 Bldg**	Run No.	**VT-2**
Date	**1/6/10**	Fan Configuration	**Fans 1&2**
Testers	JAG/JEF	Fan Setting	**Maximum**
Stack Dia.	43.75 in.	Stack Temp	56.5 deg F
Stack X-Area	1503.3 in.2	Start/End Time	1525/1630
Test Port	1&2	Center 2/3 from	4.01 to: 39.74
Distance to disturbance	74.5 ft	Points in Center 2/3	2 to: 7
Velocity units	ft/min	Pitot corr. Factor	0.84

Order -->		2nd				1st			
Traverse-->		Side				Top			
Trial ---->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	Velocity				Velocity			
1	1.40	2119	2187	2147	2151.0	2347	2410	2345	2367.4
2	4.58	2411	2507	2477	2465.1	2676	2659	2696	2677.1
3	8.46	2553	2600	2607	2586.4	2755	2751	2710	2738.7
4	14.09	2717	2691	2689	2698.9	2822	2755	2734	2770.3
Center	21.81	2752	2737	2725	2737.8	2793	2789	2713	2765.0
5	29.53	2773	2706	2747	2741.8	2763	2790	2737	2763.0
6	35.16	2748	2726	2745	2739.8	2774	2766	2744	2761.4
7	39.04	2527	2596	2583	2568.7	2638	2629	2611	2625.8
8	42.23	2276	2298	2278	2284.2	2434	2373	2336	2381.1
Averages ---------->		2541.7	2560.9	2555.3	2552.6	2666.8	2657.9	2625.2	2650.0

All	ft/min	Dev. from mean	***Center 2/3***	Side	Bottom	All
Mean	2601.3		Mean	2648.4	2728.8	2688.6
Min Point	2151.0	-17.3%	Std. Dev.	109.1	55.7	93.1
Max Point	2770.3	6.5%	COV as %	4.1	2.0	**3.5**

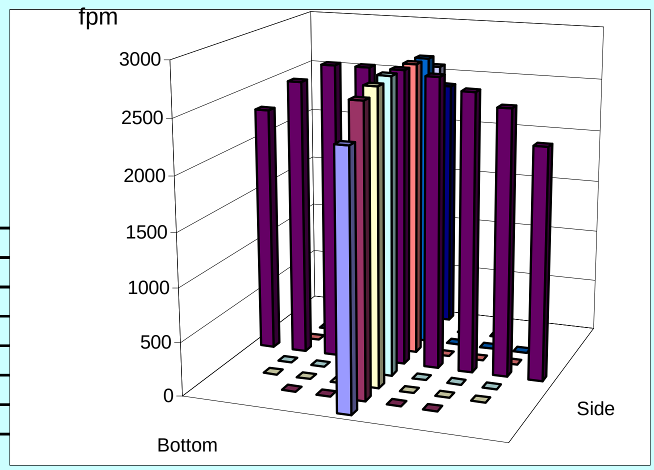
Flow w/o C-Pt 26961 acfm

Vel Avg w/o C-Pt 2583 fpm

	Start	Finish	
Stack temp	57	56	F
Equipment temp	N.A.	N.A.	F
Ambient temp	42	35	F
Stack static	0.10	0.10	mbars
Ambient pressure	1022	1021	mbars
Total Stack pressure	1022	1021	mbars
Ambient humidity	42%	54%	RH

Instuments Used:

		Cal Due
Fisher Scientific	SN 90936818	9/29/2010
Zephyr II+	SN 80355	9/18/2010
TSI Velocicalc	SN 209060	7/14/2010
Dwyer Pitot Tube	160S-72-A30U	Cert. of Conf.



Notes:

Entries made by: John Glissmeyer	Technical Data Review performed by: J. Matthew Barnett
Signature/date 1/6/2010	Signature/date 1/18/2010
signature on original	signature on original

VELOCITY TRAVERSE DATA FORM

Site	**3430 Bldg**	Run No.	**VT-3**
Date	**1/7/10**	Fan Configuration	**Fans 1&2**
Testers	JAG/DMT	Fan Setting	**Minimum**
Stack Dia.	43.75 in.	Stack Temp	60.0 deg F
Stack X-Area	1503.3 in.2	Start/End Time	1355/1550
Test Port	1&2	Center 2/3 from	4.01 to: 39.74
Distance to disturbance	74.5 ft	Points in Center 2/3	2 to: 7
Velocity units	ft/min	Pitot corr. Factor	0.84

Order -->		2nd				1st			
Traverse-->		Side				Top			
Trial ---->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	Velocity				Velocity			
1	1.40	1429	1389	1394	1403.9	1482	1564	1547	1531.0
2	4.58	1694	1685	1667	1682.2	1744	1774	1768	1762.0
3	8.46	1744	1754	1756	1751.4	1852	1850	1861	1854.4
4	14.09	1781	1758	1779	1772.7	1871	1891	1851	1871.0
Center	21.81	1802	1798	1798	1799.3	1837	1794	1797	1809.4
5	29.53	1812	1817	1803	1810.8	1809	1781	1793	1794.2
6	35.16	1798	1788	1804	1796.8	1713	1763	1740	1738.8
7	39.04	1636	1686	1643	1655.1	1659	1665	1672	1665.4
8	42.23	1525	1483	1523	1510.0	1538	1561	1538	1545.6
Averages ---------->		1691.1	1684.2	1685.4	1686.9	1722.7	1738.1	1729.8	1730.2

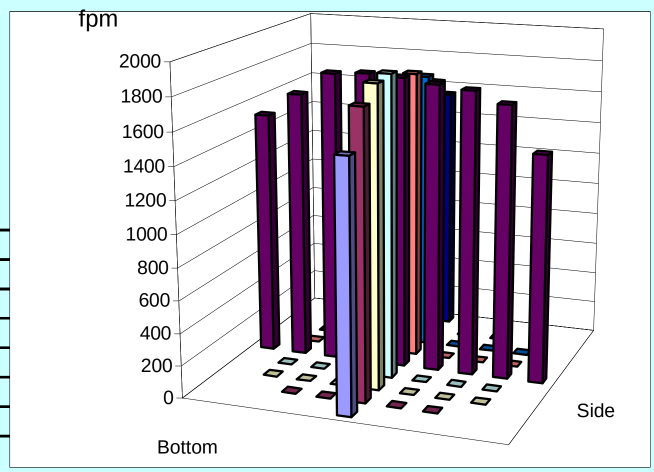
All	ft/min	Dev. from mean	***Center 2/3***	Side	Bottom	All
Mean	1708.6		Mean	1752.6	1785.0	1768.8
Min Point	1403.9	-17.8%	Std. Dev.	61.1	70.5	65.6
Max Point	1871.0	9.5%	COV as %	3.5	4.0	**3.7**

Flow w/o C-Pt 17712 acfm

Vel Avg w/o C-Pt 1697 fpm

	Start	Finish	
Stack temp	66	54	F
Equipment temp	N.A.	N.A.	F
Ambient temp	36	33	F
Stack static	0.10	0.10	mbars
Ambient pressure	1021	1020	mbars
Total Stack pressure	1021	1020	mbars
Ambient humidity	47%	52%	RH

Instuments Used:		Cal Due
Fisher Scientific	SN 90936818	9/29/2010
Zephyr II+	SN 80355	9/18/2010
TSI Velocicalc	SN 209060	7/14/2010
Dwyer Pitot Tube	160S-72-A30U	Cert. of Conf.



Notes:

RAES MASStron reads 17,300 scfm

Entries made by: John Glissmeyer	Technical Data Review performed by: J. Matthew Barnett
Signature/date 1/7/2010	Signature/date 1/18/2010
signature on original	signature on original

FLOW ANGLE DATA FORM

FlowAngleRev0.xls — 4-Aug-06 Based on ---- CCP-WTPSP-178

Site	**EP-3430-01-S**	Run No.	**FA-4**
Date	5/20/2010	Fan Setting	**Sashes Open**
Tester	JAG, JEF	Fan configuration	**2 Fans**
Stack Dia.	43.75 in	Approx. air vel.	3460 sfpm at point side center
Stack X-Area	1503.3 in2	Units	degrees (clockwise > pos. nos.)
Elevation	N.A. ft	Port	nearest to probe
Distance to disturbance	53.5 ft	Stack Temp	74 deg F
Start/End Time	1350 / 1435		

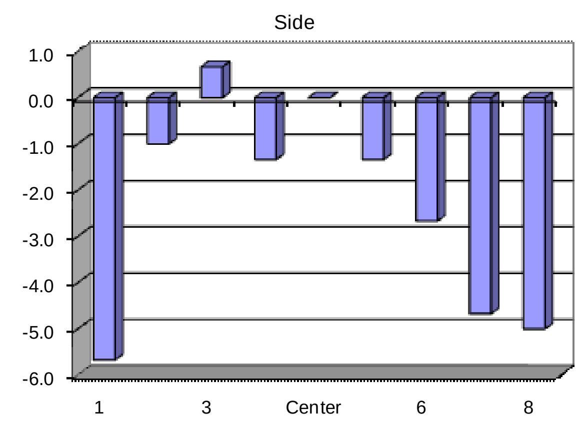
Order -->		1st				2nd			
Traverse-->		Side				Top			
Trial ---->		1	2	3		1	2	3	
Point	Depth, in.	deg. cw	deg. cw	deg. cw	Avg.	deg. cw	deg. cw	deg. cw	Avg.
1	1.40	-3	-7	-7	-5.7	3	3	-6	0.0
2	4.59	-1	0	-2	-1.0	-1	-1	0	-0.7
3	8.49	1	1	0	0.7	-1	1	3	1.0
4	14.13	-1	-1	-2	-1.3	0	1	2	1.0
Center	21.88	0	0	0	0.0	0	0	0	0.0
5	29.62	-2	-2	0	-1.3	-1	0	0	-0.3
6	35.26	-3	-3	-2	-2.7	-2	0	-1	-1.0
7	39.16	-8	-3	-3	-4.7	-4	-3	-2	-3.0
8	42.35	-7	-4	-4	-5.0	-3	-3	-3	-3.0
Mean of absolute values of all data:					2.5				1.1
w/o points by wall:					1.7				1.0
								all	1.8
								w/o wall pts	1.3

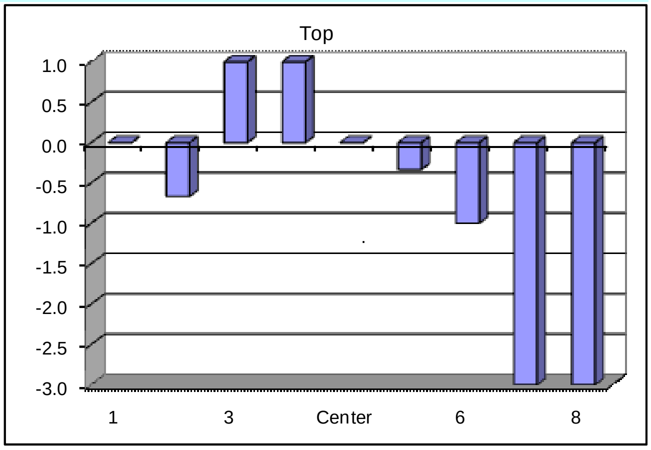
Instuments Used:			**Cal. Due**
S-type pitot	Dwyer 72-inch S-type Pitot#11		Cert. of conformance
Velocity sensor	TSI Velocicalc SN 305039		6/23/2010
Angle indicator	Shop built	Cat. 3	
Manometer	Dwyer 400-5, S36N	Cat. 3	

Notes: RAES reading, scfm

start	31,500
end	31,800

Note:
To assure similar hose connections between the manometer and pitot tube, rotating the pitot tube assembly clockwise drives the meniscus to the right (to higher pos. numbers).





Entries made by:	John Glissmeyer		Technical Data Review performed by:	Carmen Arimescu	
Signature/date	*On File w/ Original*	5/20/2010	Signature/date	*On File w/ Original*	6/24/2010

FLOW ANGLE DATA FORM

FlowAngleRev0.xls — 4-Aug-06 Based on ---- CCP-WTPSP-178

Site	**EP-3430-01-S**	Run No.	**FA-5**
Date	5/20/2010	Fan Setting	**Sashes Open**
Tester	JAG, JEF	Fan configuration	**2 Fans**
Stack Dia.	43.75 in	Approx. air vel.	3630 sfpm at point: side center
Stack X-Area	1503.3 in2	Units	degrees (clockwise > pos. nos.)
Elevation	N.A. ft	Port	nearest to probe
Distance to disturbance	53.5 ft	Stack Temp	74 deg F
Start/End Time	1435 / 1530		

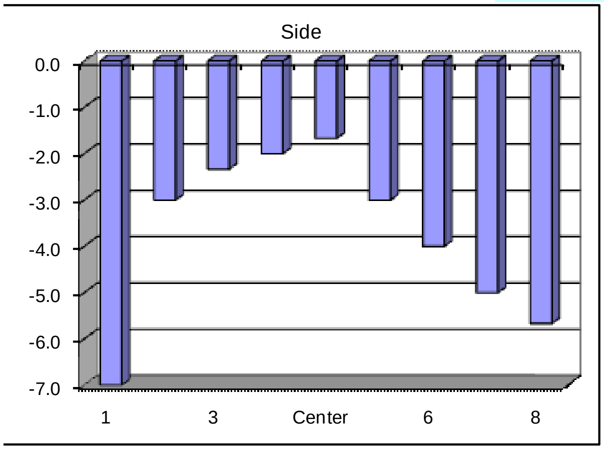
Order -->		2nd				1st			
Traverse-->		Side				Top			
Trial ---->		1	2	3		1	2	3	
Point	Depth, in.	deg. cw	deg. cw	deg. cw	Avg.	deg. cw	deg. cw	deg. cw	Avg.
1	1.40	-7	-8	-6	-7.0	2	5	4	3.7
2	4.59	0	-3	-6	-3.0	-2	1	-1	-0.7
3	8.49	-2	-2	-3	-2.3	-1	0	2	0.3
4	14.13	-3	-2	-1	-2.0	0	0	2	0.7
Center	21.88	-2	-1	-2	-1.7	0	0	0	0.0
5	29.62	-3	-3	-3	-3.0	0	-1	-1	-0.7
6	35.26	-4	-4	-4	-4.0	-1	-2	-1	-1.3
7	39.16	-5	-5	-5	-5.0	-3	-2	-2	-2.3
8	42.35	-6	-6	-5	-5.7	-2	-3	-3	-2.7
Mean of absolute values of all data:					3.7				1.4
w/o points by wall:					3.0				0.9
								all	2.6
								w/o wall pts	1.9

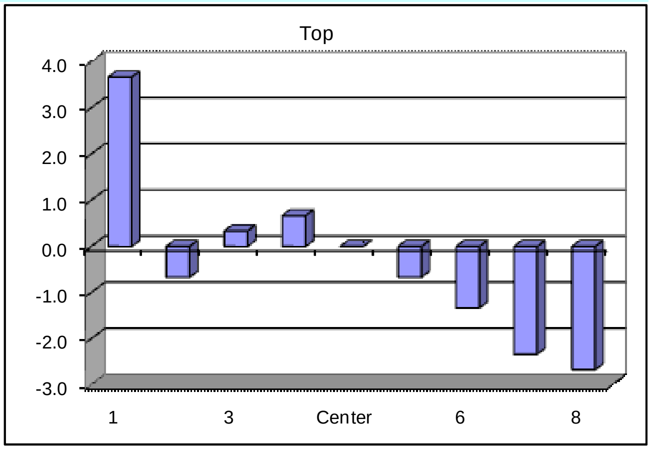
Instuments Used:		**Cal. Due**
S-type pitot	Dwyer 72-inch S-type Pitot#11	Cert. of conformance
Velocity sensor	TSI Velocicalc SN 305039	6/23/2010
Angle indicator	Shop built	Cat. 3
Manometer	Dwyer 400-5, S36N	Cat. 3

Notes: RAES reading, scfm

start	31,400
end	31,100

Note:
To assure similar hose connections between the manometer and pitot tube, rotating the pitot tube assembly clockwise drives the meniscus to the right (to higher pos. numbers).





Entries made by:	John Glissmeyer		Technical Data Review performed by:	Carmen Arimescu	
Signature/date	*On File w/ Original*	5/20/2010	Signature/date	*On File w/ Original*	6/24/2010

FLOW ANGLE DATA FORM

FlowAngleRev0.xls 4-Aug-06 Based on ---- CCP-WTPSP-178

Site	**EP-3430-01-S**	Run No.	**FA-6**
Date	5/20/2010	Fan Setting	**Sashes Open**
Tester	JAG, JEF	Fan configuration	**2 Fans**
Stack Dia.	43.75 in	Approx. air vel.	2700 sfpm at point side center
Stack X-Area	1503.3 in2	Units	degrees (clockwise > pos. nos.)
Elevation	N.A. ft	Port	nearest to probe
Distance to disturbance	53.5 ft	Stack Temp	74 deg F
Start/End Time	1555 / 1625		

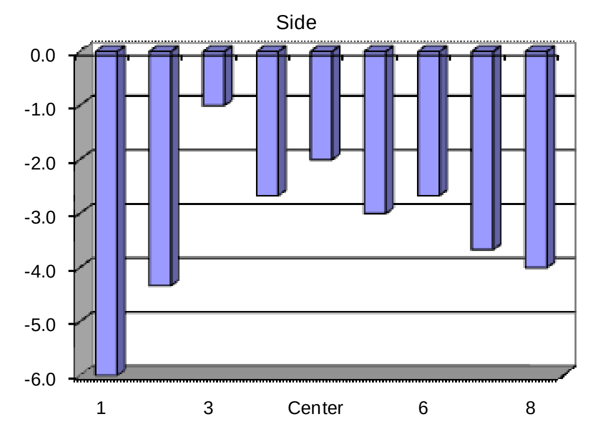
Order -->		1st				2nd			
Traverse-->		Side				Top			
Trial ---->		1	2	3		1	2	3	
Point	Depth, in.	deg. cw	deg. cw	deg. cw	Avg.	deg. cw	deg. cw	deg. cw	Avg.
1	1.40	-7	-5	-6	-6.0	7	-10	-10	-4.3
2	4.59	-5	-4	-4	-4.3	1	1	0	0.7
3	8.49	-1	-1	-1	-1.0	0	0	1	0.3
4	14.13	-4	-2	-2	-2.7	-2	-1	0	-1.0
Center	21.88	-3	-2	-1	-2.0	-2	-3	-1	-2.0
5	29.62	-3	-3	-3	-3.0	-2	-2	-1	-1.7
6	35.26	-2	-3	-3	-2.7	-3	-3	-4	-3.3
7	39.16	-4	-4	-3	-3.7	-4	-3	-6	-4.3
8	42.35	-3	-6	-3	-4.0	-5	-4	-4	-4.3
Mean of absolute values of all data:					3.3				2.4
w/o points by wall:					2.8				1.9
								all	2.9
								w/o wall pts	2.3

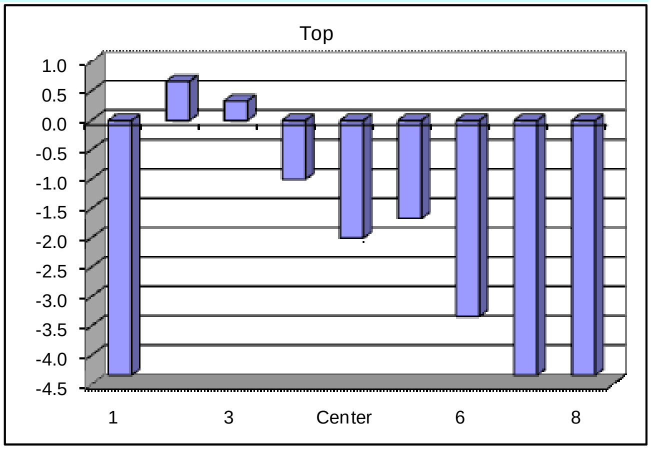
Instuments Used:			**Cal. Due**
S-type pitot	Dwyer 72-inch S-type Pitot#11		Cert. of conformance
Velocity sensor	TSI Velocicalc SN 305039		6/23/2010
Angle indicator	Shop built	Cat. 3	
Manometer	Dwyer 400-5, S36N	Cat. 3	

Notes: RAES reading, scfm

start	23,100
end	23,200

Note:
To assure similar hose connections between the manometer and pitot tube, rotating the pitot tube assembly clockwise drives the meniscus to the right (to higher pos. numbers).





Entries made by:	John Glissmeyer		Technical Data Review performed by:	Carmen Arimescu	
Signature/date	*On File w/ Original*	5/20/2010	Signature/date	*On File w/ Original*	6/24/2010

FLOW ANGLE DATA FORM

FlowAngleRev0.xls

4-Aug-06 Based on ---- CCP-WTPSP-178

Site	EP-3430-01-S		Run No.	FA-7
Date	5/21/2010		Fan Setting	Sashes Down
Tester	JAG, JEF		Fan configuration	Near Fan (#2)
Stack Dia.	43.75	in	Approx. air vel.	2390 sfpm at point : side center
Stack X-Area	1503.3	in2	Units	degrees (clockwise > pos. nos.)
Elevation	N.A.	ft	Port	nearest to probe
Distance to disturbance	53.5	ft	Stack Temp	71.5 deg F
Start/End Time	1148 / 1250			

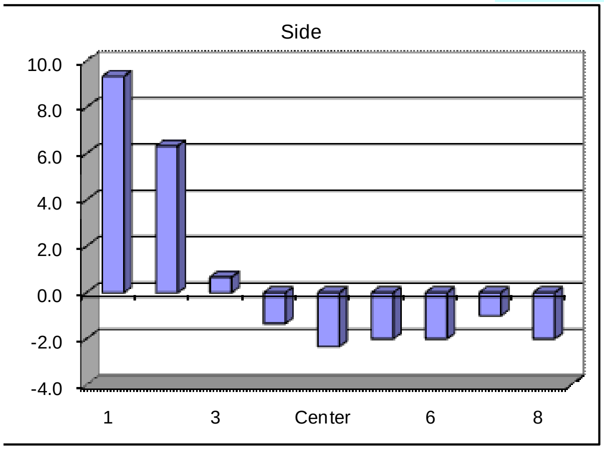
Order -->		2nd				1st			
Traverse-->		Side				Top			
Trial ---->		1	2	3		1	2	3	
Point	Depth, in.	deg. cw	deg. cw	deg. cw	Avg.	deg. cw	deg. cw	deg. cw	Avg.
1	1.40	12	7	9	9.3	-3	11	10	6.0
2	4.59	6	6	7	6.3	11	5	10	8.7
3	8.49	1	0	1	0.7	4	0	2	2.0
4	14.13	-1	-2	-1	-1.3	0	-3	1	-0.7
Center	21.88	-3	-2	-2	-2.3	0	-3	0	-1.0
5	29.62	-2	-2	-2	-2.0	-4	-2	0	-2.0
6	35.26	-2	-2	-2	-2.0	-4	-3	0	-2.3
7	39.16	-1	-1	-1	-1.0	-4	-4	0	-2.7
8	42.35	-2	-2	-2	-2.0	-3	-2	0	-1.7
Mean of absolute values of all data:					3.0				3.0
w/o points by wall:					2.2				2.8
								all	3.0
								w/o wall pts	2.5

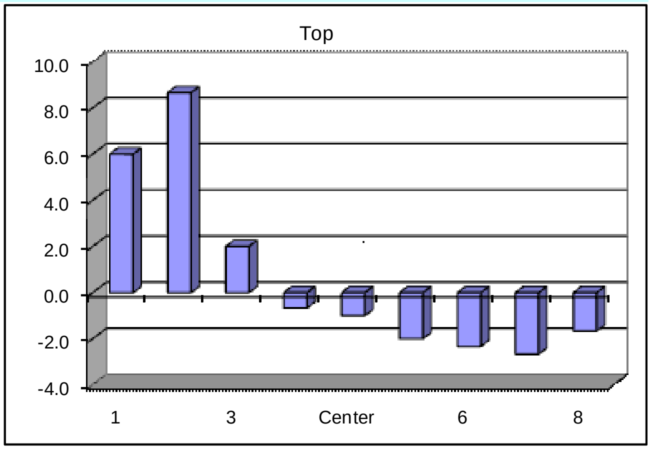
Instuments Used:		Cal. Due
S-type pitot	Dwyer 72-inch S-type Pitot#11	Cert. of conformance
Velocity sensor	TSI Velocicalc SN 305039	6/23/2010
Angle indicator	Shop built	Cat. 3
Manometer	Dwyer 400-5, S36N	Cat. 3

Notes: RAES reading, scfm

start	23,300
end	23,300

Note:
To assure similar hose connections between the manometer and pitot tube, rotating the pitot tube assembly clockwise drives the meniscus to the right (to higher pos. numbers).





Entries made by:	John Glissmeyer		Technical Data Review performed by:	Carmen Arimescu	
Signature/date	*On File w/ Original*	5/21/2010	Signature/date	*On File w/ Original*	6/24/2010

VELOCITY TRAVERSE DATA FORM

Site	**EP-3430-01-S**	Run No.	**VT-4**
Date	**5/20/10**	Fan Configuration	**2 Fans**
Testers	JAG, JEF	Fan Setting	**Sashes Open**
Stack Dia.	43.75 in.	Stack Temp	72.5 deg F
Stack X-Area	1503.3 in.2	Start/End Time	0915 / 1055
Test Port	nearest probe	Center 2/3 from	4.01 to: 39.74
Distance to disturbance	53.5 ft	Points in Center 2/3	2 to: 7
Velocity units	ft/min	Pitot Correction:	0.84

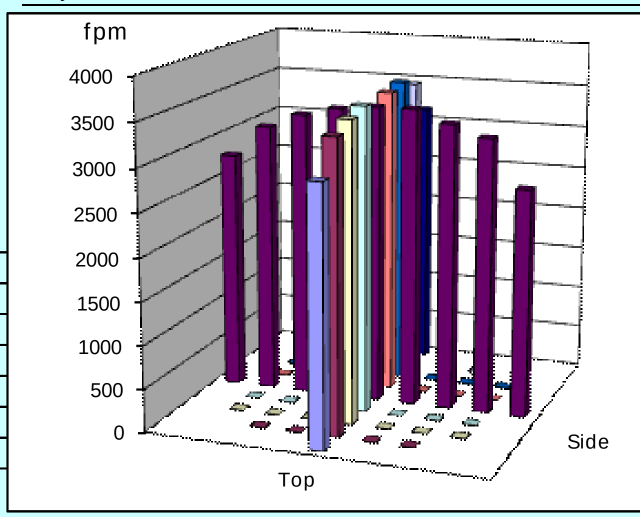
Order -->		1st				2nd			
Traverse-->		Side				Top			
Trial ---->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	Velocity				Velocity			
1	1.40	2725	2622	2612	2653.0	2990	2994	2955	2979.8
2	4.59	3196	3205	3194	3198.4	3387	3368	3354	3369.8
3	8.49	3310	3347	3337	3331.4	3479	3486	3461	3475.4
4	14.13	3465	3446	3503	3471.2	3562	3552	3531	3548.2
Center	21.88	3476	3468	3458	3467.2	3475	3457	3444	3458.6
5	29.62	3456	3409	3397	3420.5	3562	3556	3531	3549.6
6	35.26	3360	3317	3294	3323.9	3599	3600	3600	3600.0
7	39.16	3146	3154	3156	3152.0	3483	3506	3536	3508.1
8	42.35	2733	2787	2838	2785.7	3105	3142	3140	3129.0
Averages ---------->		3207.3	3195.0	3198.8	3200.4	3404.7	3406.7	3394.7	3402.0

All	ft/min	Dev. from mean	***Center 2/3***	Side	Top	All
Mean	3301.2		Mean	3337.8	3501.4	3419.6
Min Point	2653.0	-19.6%	Std. Dev.	126.2	75.4	131.1
Max Point	3600.0	9.1%	COV as %	3.8	2.2	**3.8**

Flow w/o C-Pt 34252 acfm
Vel Avg w/o C-Pt 3281 fpm

	Start	Finish	
Stack temp	72	73	F
Equipment temp	N.A.	N.A.	F
Ambient temp	55	58	F
Stack static	2.40	2.00	mbars
Ambient pressure	1001	997	mbars
Total Stack pressure	1003	999	mbars
Ambient humidity	48%	39%	RH

Instuments Used:		Cal Due
Fisher Scientific	SN 90936818	9/29/2010
Zephyr II+	SN 80355	9/18/2010
TSI Velocicalc	SN 305039	6/23/2010
Dwyer Pitot Tube	PN 1605-72 A304	Cert. of Conf.



Notes: Stack exit cone has been permanently removed.

RAES Reading, scfm	
Start	32,100
End	32,200

All 70 hoods open to 18-in. mark.

Entries made by:	Julia Flaherty		Technical Data Review performed by:	Carmen Arimescu	
Signature/date	*On File w/ Original*	5/20/2010	Signature/date	*On File w/ Original*	6/25/2010

VELOCITY TRAVERSE DATA FORM

Site	**EP-3430-01-S**	Run No.	**VT-5**
Date	**5/20/10**	Fan Configuration	**2 Fans**
Testers	JAG, JEF	Fan Setting	**Sashes Open**
Stack Dia.	43.75 in.	Stack Temp	73.5 deg F
Stack X-Area	1503.3 in.2	Start/End Time	1100 / 1220
Test Port	nearest probe	Center 2/3 from	4.01 to: 39.74
Distance to disturbance	53.5 ft	Points in Center 2/3	2 to: 7
Velocity units	ft/min	Pitot Correction:	0.84

Order -->		1st				2nd			
Traverse-->		Side				Top			
Trial ---->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	Velocity				Velocity			
1	1.40	2695	2713	2701	2702.8	2905	3020	2964	2962.7
2	4.59	3243	3224	3175	3214.1	3342	3375	3338	3351.9
3	8.49	3401	3336	3369	3368.7	3471	3481	3506	3486.0
4	14.13	3499	3527	3464	3496.9	3549	3535	3566	3549.8
Center	21.88	3494	3535	3476	3501.7	3465	3416	3460	3447.1
5	29.62	3360	3469	3457	3428.6	3552	3578	3577	3568.9
6	35.26	3302	3342	3335	3326.4	3573	3597	3600	3589.9
7	39.16	3179	3168	3106	3150.8	3496	3493	3503	3497.2
8	42.35	2816	2814	2780	2803.1	3163	3189	3102	3151.7
Averages ---------->		3221.0	3236.4	3206.9	3221.5	3390.6	3409.4	3401.7	3400.6

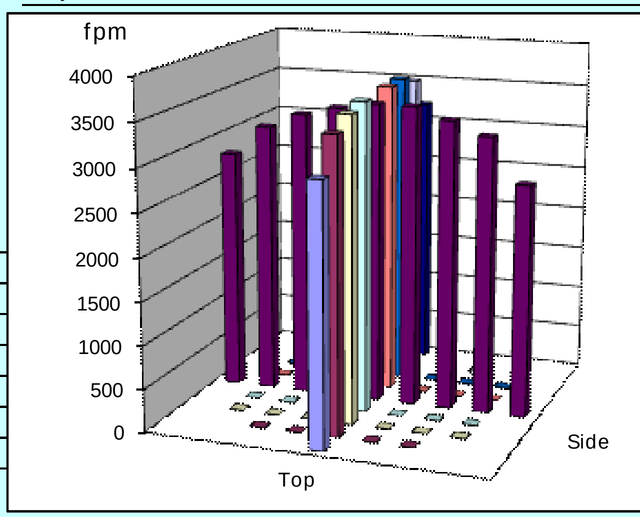
All	ft/min	Dev. from mean	***Center 2/3***	Side	Top	All
Mean	3311.0		Mean	3355.3	3498.7	3427.0
Min Point	2702.8	-18.4%	Std. Dev.	135.2	81.9	130.6
Max Point	3589.9	8.4%	COV as %	4.0	2.3	**3.8**

Flow w/o C-Pt 34352 acfm

Vel Avg w/o C-Pt 3291 fpm

	Start	Finish	
Stack temp	73	74	F
Equipment temp	N.A.	N.A.	F
Ambient temp	58	63	F
Stack static	2.00	1.60	mbars
Ambient pressure	997	995	mbars
Total Stack pressure	999	997	mbars
Ambient humidity	39%	34%	RH

Instuments Used:		Cal Due
Fisher Scientific	SN 90936818	9/29/2010
Zephyr II+	SN 80355	9/18/2010
TSI Velocicalc	SN 305039	6/23/2010
Dwyer Pitot Tube	PN 1605-72 A304	Cert. of Conf.



Notes: RAES, scfm

Start 32,200

End 32,200

Entries made by:	Julia Flaherty		Technical Data Review performed by:	Carmen Arimescu	
Signature/date	*On File w/ Original*	5/20/2010	Signature/date	*On File w/ Original*	6/25/2010

VELOCITY TRAVERSE DATA FORM

Site	**EP-3430-01-S**	Run No.	**VT-6**
Date	**5/21/10**	Fan Configuration	**2 Fans**
Testers	JAG, JEF	Fan Setting	**Sashes Closed**
Stack Dia.	43.75 in.	Stack Temp	62.5 deg F
Stack X-Area	1503.3 in.2	Start/End Time	0825 / 0950
Test Port	nearest probe	Center 2/3 from	4.01 to: 39.74
Distance to disturbance	53.5 ft	Points in Center 2/3	2 to: 7
Velocity units	ft/min	Pitot Corection:	0.84

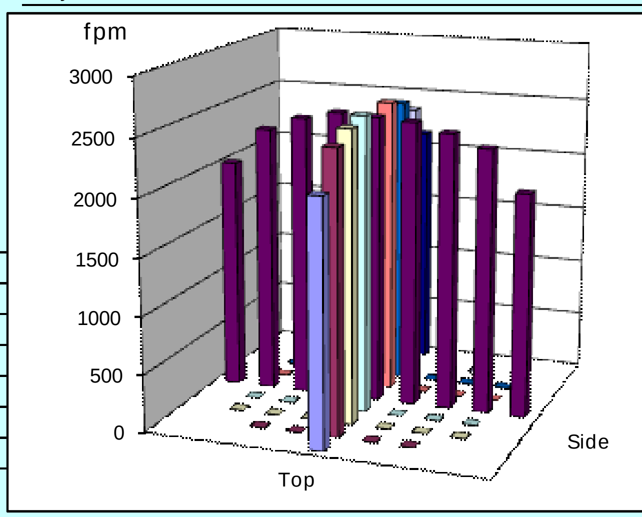
Order -->		2nd				1st			
Traverse-->		Side				Top			
Trial ---->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	Velocity				Velocity			
1	1.40	1960	1929	1980	1956.1	2094	2117	2130	2113.7
2	4.59	2336	2296	2298	2310.0	2439	2434	2428	2433.8
3	8.49	2420	2419	2414	2417.8	2495	2524	2546	2521.7
4	14.13	2491	2497	2486	2491.7	2568	2552	2596	2572.1
Center	21.88	2517	2513	2507	2512.7	2516	2474	2505	2498.2
5	29.62	2536	2525	2532	2530.9	2565	2565	2571	2567.0
6	35.26	2487	2460	2439	2462.0	2497	2502	2521	2506.8
7	39.16	2350	2341	2334	2341.9	2375	2391	2405	2390.1
8	42.35	2026	2009	2032	2022.4	2113	2133	2105	2117.1
Averages ---------->		2347.1	2332.2	2335.9	2338.4	2406.9	2410.1	2423.1	2413.4

All	ft/min	Dev. from mean	***Center 2/3***	Side	Top	All
Mean	2375.9		Mean	2438.2	2498.5	2468.3
Min Point	1956.1	-17.7%	Std. Dev.	85.3	66.7	80.0
Max Point	2572.1	8.3%	COV as %	3.5	2.7	**3.2**

Flow w/o C-Pt 24634 acfm
Vel Avg w/o C-Pt 2360 fpm

	Start	Finish	
Stack temp	60	65	F
Equipment temp	N.A.	N.A.	F
Ambient temp	63	60	F
Stack static	0.70	0.80	mbars
Ambient pressure	1008	1000	mbars
Total Stack pressure	1009	1001	mbars
Ambient humidity	34%	41%	RH

Instuments Used:		Cal Due
Fisher Scientific	SN 90936818	9/29/2010
Zephyr II+	SN 80355	9/18/2010
TSI Velocicalc	SN 305039	6/23/2010
Dwyer Pitot Tube	PN 1605-72 A304	Cert. of Conf.



Notes: RAES, scfm

Start 23,500

End 23,600

Matthew measured 53 ft 10 in from test ports to disturbance.

Entries made by:	John Glissmeyer		Technical Data Review performed by:	Carmen Arimescu	
Signature/date	*On File w/ Original*	5/21/2010	Signature/date	*On File w/ Original*	6/25/2010

VELOCITY TRAVERSE DATA FORM

Site	EP-3430-01-S	Run No.	VT-7
Date	5/21/10	Fan Configuration	1 Fan (#2 on - near fan)
Testers	JAG, JEF	Fan Setting	~60%, Sashes Closed
Stack Dia.	43.75 in.	Stack Temp	66.5 deg F
Stack X-Area	1503.3 in.2	Start/End Time	1025 / 1145
Test Port	nearest probe	Center 2/3 from	4.01 to: 39.74
Distance to disturbance	53.5 ft	Points in Center 2/3	2 to: 7
Velocity units	ft/min	Pitot Correction:	0.84

Order -->		1st				2nd			
Traverse-->		Side				Top			
Trial ---->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	Velocity				Velocity			
1	1.40	2002	1990	1966	1986.0	2087	2167	2126	2126.9
2	4.59	2309	2292	2329	2310.3	2381	2338	2365	2361.5
3	8.49	2410	2390	2381	2393.4	2437	2437	2426	2433.2
4	14.13	2463	2454	2442	2452.8	2528	2507	2508	2514.7
Center	21.88	2446	2496	2476	2472.7	2462	2497	2461	2473.5
5	29.62	2520	2502	2485	2502.1	2533	2556	2560	2549.7
6	35.26	2481	2429	2471	2460.6	2505	2524	2515	2514.7
7	39.16	2426	2421	2398	2415.0	2436	2448	2422	2435.2
8	42.35	2065	2113	2108	2095.5	2169	2195	2150	2171.1
Averages ---------->		2346.9	2342.9	2339.7	2343.2	2393.2	2407.7	2392.6	2397.8

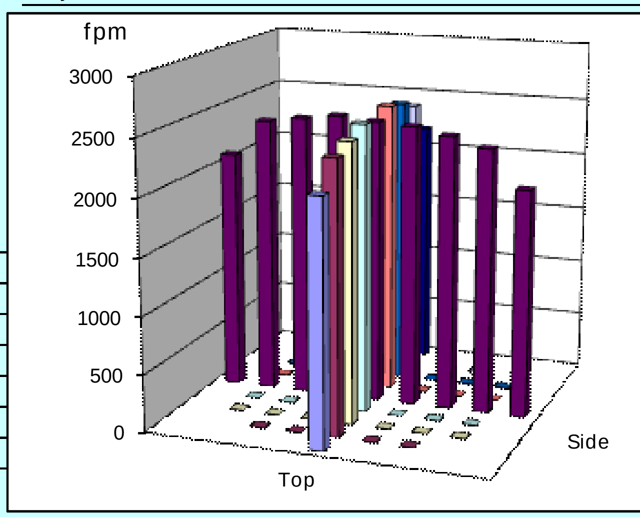
All	ft/min	Dev. from mean	***Center 2/3***	Side	Top	All
Mean	2370.5		Mean	2429.6	2468.9	2449.2
Min Point	1986.0	-16.2%	Std. Dev.	63.7	64.1	64.7
Max Point	2549.7	7.6%	COV as %	2.6	2.6	**2.6**

Flow w/o C-Pt 24613 acfm

Vel Avg w/o C-Pt 2358 fpm

	Start	Finish	
Stack temp	65	68	F
Equipment temp	N.A.	N.A.	F
Ambient temp	62	55	F
Stack static	0.60	0.80	mbars
Ambient pressure	1000	999	mbars
Total Stack pressure	1001	1000	mbars
Ambient humidity	38%	48%	RH

Instuments Used:		Cal Due
Fisher Scientific	SN 90936818	9/29/2010
Zephyr II+	SN 80355	9/18/2010
TSI Velocicalc	SN 305039	6/23/2010
Dwyer Pitot Tube	PN 1605-72 A304	Cert. of Conf.



Notes: RAES, scfm

Start	23,400
End	23,300

Entries made by:	John Glissmeyer		Technical Data Review performed by:	Carmen Arimescu	
Signature/date	*On File w/ Original*	5/21/2010	Signature/date	*On File w/ Original*	6/25/2010

Appendix B

Applicable Qualification Results from the Model Stack

Appendix B: Applicable Qualification Results from the Model Stack

These data are extracted from the report by Glissmeyer and Droppo (2007).

Table B.1 lists the gas-tracer uniformity tests conducted on the scale model with the dampers installed at the fan outlets. Only the data for Test Ports 2 and 3 are shown. The model test port 3 was about the same number of duct diameters to the nearest upstream disturbance, whereas the model test port 2 was about 5 duct diameters closer to the nearest upstream disturbance than the test ports on the 3430 Building Filtered Exhaust Stack.

The % COV was calculated for the measured gas concentration at the points in the center two-thirds area of the 3430 Building Filtered Exhaust Stack. The percent deviation from the mean concentration was also calculated for any point in the measurement grid.

Table B.1. Summarized Results of Gas-Tracer Uniformity Tests with Dampers

Injection Port		Operating Fans	Test Port	Run No.	Control Damper Setting (degrees)	Back Flow Damper Setting (degrees)	Center $^2/_3$% COV	% Deviation from Mean
B	Center	A & B	2	GT-49	45.0	45.0	1.7	4.4
B	Center	A & B	3	GT-48	45.0	45.0	1.3	2.6
A	Center	A	2	GT-38	90.0	70.0	1.3	2.6
A	Center	A	3	GT-37	90.0	70.0	2.3	5.3
A	Center	A & B	2	GT-27	90.0	70.0	7.2	13.8
A	Center	A & B	3	GT-34	90.0	70.0	3.2	7.9
B	Center	B	2	GT-46	90.0	70.0	1.1	1.9
B	Center	B	3	GT-47	90.0	70.0	1.7	2.9
B	Center	A & B	2	GT-52	90.0	70.0	6.3	12.3
B	Center	A & B	3	GT-54	90.0	70.0	3.9	9.1
A	Far Left	A & B	2	GT-28	90.0	70.0	5.2	9.8
A	Far Left	A & B	2	GT-31	90.0	70.0	4.5	13.1
A	Far Left	A & B	3	GT-32	90.0	70.0	3.2	6.6
A	Far Right	A & B	2	GT-29	90.0	70.0	10.0	28.3
A	Far Right	A & B	3	GT-33	90.0	70.0	2.8	5.8
A	Near Left	A & B	2	GT-51	90.0	70.0	2.0	4.5
A	Near Left	A & B	3	GT-36	90.0	70.0	2.9	5.5
A	Near Right	A & B	2	GT-30	90.0	70.0	5.7	9.6
A	Near Right	A & B	3	GT-35	90.0	70.0	3.5	7.9

Table B.2 lists the particle tracer uniformity results for the model stack. Data are shown for Test Ports 2 and 3. The test ports on the 3430 Building Filtered Exhaust Stack were about 5 duct diameters farther downstream of the duct junction than Test Port 2 on the model, and were at a similar relative position to test port 3 on the model. The last column shows the uniformity results for the combination of operating parameters tested.

Table B.2. Particle-Tracer Uniformity Tests with Dampers

Injection Port	Operating Fans	Test Port	Run No.	Control Damper Setting (degrees)	Back Flow Damper Setting (degrees)	Normalized % COV
A	A & B	2	PT-12	90	70	13.75
A	A & B	2	PT-21	90	70	7.41
A	A & B	3	PT-13	90	70	9.72
A	A & B	3	PT-20	90	70	8.12
A	A	2	PT-15	90	70	2.46
A	A	3	PT-14	90	70	3.73
B	B	2	PT-18	90	70	3.02
B	B	3	PT-19	90	70	3.61

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