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Sampling Point Compliance Tests for 325 Building at Set-Back Flow Conditions

MY Ballinger JA Glissmeyer JM Barnett KP Recknagle ST Yokuda

May 2011



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Pacific Northwest National Laboratory Richland, Washington 99352

Summary

The stack sampling system at the 325 Building (Radiochemical Processing Laboratory [RPL]) was constructed to comply with the American National Standards Institute's (ANSI's) *Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities* (ANSI N13.1–1969). This standard provided prescriptive criteria for the location of radionuclide air-sampling systems. In 1999, the standard was revised (*Sampling and Monitoring Releases of Airborne Radioactive Substances From the Stacks and Ducts of Nuclear Facilities* [ANSI/Health Physics Society [HPS] 13.1–1999]) to provide performance-based criteria for the location of sampling systems.

Testing was conducted for the 325 Building stack to determine whether the sampling system would meet the updated criteria for uniform air velocity and contaminant concentration in the revised ANSI/HPS 13.1–1999 standard under normal operating conditions (Smith et al. 2010). Measurement results were within criteria for all tests. Additional testing and modeling was performed to determine whether the sampling system would meet criteria under set-back flow conditions. This included measurements taken from a scale model with one-third of the exhaust flow and computer modeling of the system with two-thirds of the exhaust flow.

This report documents the results of the set-back flow condition measurements and modeling. Tests performed included flow angularity, uniformity of velocity, gas concentration, and particle concentration across the duct at the sampling location. Results are within ANSI/HPS 13.1–1999 criteria for all tests. These tests are applicable for the 325 Building stack under set-back exhaust flow operating conditions (980–45,400 cubic feet per minute [cfm]) with one fan running. The modeling results show that criteria are met for all tests using a two-fan configuration exhaust (flow modeled at 104,000 cfm). Combined with the results from the earlier normal operating conditions, the ANSI/HPS 13.1–1999 criteria for all tests are met for all configurations: one, two, or three fans (normal).

Acronyms and Abbreviations

AD	aerodynamic diameter
ANSI	American National Standards Institute
CFD	computational fluid dynamics
CFR	Code of Federal Regulations
cfm	cubic feet per minute
COV	coefficient of variation
EPA	Environmental Protection Agency
ft	foot/feet
HPS	Health Physics Society
Hz	hertz
in	inch(es)
kg	kilogram(s)
L	liter(s)
mm	millimeter(s)
OPC	optical particle counter
PNNL	Pacific Northwest National Laboratory
RPL	Radiochemical Processing Laboratory (325 Building)

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1.0 Introduction

The stack sampling system at the 325 Building (Radiochemical Processing Laboratory [RPL]) was constructed to comply with the American National Standards Institute's (ANSI's) *Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities* (ANSI N13.1–1969). This standard provided prescriptive criteria for the location of radionuclide air-sampling systems. In 1999, the standard was revised (*Sampling and Monitoring Releases of Airborne Radioactive Substances From the Stacks and Ducts of Nuclear Facilities* [ANSI/Health Physics Society {HPS} 13.1–1999]) to provide performance-based criteria for the location of sampling systems. Testing was conducted for the 325 Building stack to determine whether the sampling system would meet the updated criteria for uniform air velocity and contaminant concentration in the revised ANSI/HPS 13.1–1999 standard.

The 325 Facility emission point exhausts air from all areas of the building where radioactive materials are handled. The exhaust stream passes through high-efficiency particulate air filters located just upstream of the exhaust fans. The stack (Figure 1.1) is 88 feet (ft) tall and 8 ft in diameter, with flows at approximately 140,000 cfm. The sampling system is located approximately 80 ft above the ground (see the platform in Figure 1.1).



Figure 1.1. The 325 Building Stack

Because of the difficulty in taking measurements at the elevated sampling location and to avoid possible disruptions to facility operations, a scale model was used for the tests. The scale model was fabricated on an outside concrete pad. Scaffolding was used as support for the stack section and to gain access to the sample ports. Four variable speed fans were connected to the scale model in a configuration geometrically similar to the actual stack. The 325 facility normally operates only three of the four fans and alternates the standby fan. Therefore, a similar arrangement was used in the first set of testing (Smith et al. 2010). Testing results from measurements taken in 2002 demonstrated that the sampling

location on the 325 Building met the criteria in the 1999 standard for a well mixed location under normal operating conditions.

Subsequent testing was conducted in 2004 to determine whether the stack sampling system at the 325 Building would meet the 1999 standard criteria for uniform air velocity and contaminant concentration if the exhaust air flow was reduced to one-third to reduce energy use. The same scale model was used for these reduced flow tests. Tests performed included flow angularity, uniformity of velocity, gas concentration, and particle concentration across the duct at the sampling location. Tests were conducted with the fan nearest to the stack operating and the fan farthest from the stack operating in order to test the two extremes of fan configuration. Results are within ANSI/HPS 13.1–1999 criteria for all tests. These tests are applicable for the 325 Building stack under reduced flow operating conditions (below 45,400 cfm) with any single fan running.

In addition to the scale model testing, a computational fluid dynamics (CFD) model was used to predict results for a two-fan configuration. Results from the fluid dynamics model were also within ANSI/HPS 13.1–1999 criteria for all tests and bridged the data between the one- and three-fan configurations tested using the scale model.

2.0 Test Information and Results

This section discusses testing of a scale model of the RPL final exhaust system to determine whether the sampling system location met the criteria in ANSI/HPS N13.1–1999 for a well mixed location. The approach, test methods, and results are provided.

2.1 Test Plan

The objective of these tests was to demonstrate whether the EP-325-01-S exhaust stack meets the applicable regulatory criteria regarding the placement of the air-sampling probe under reduced exhaust flow. This has already been demonstrated for the normal flow-rate with three operating fans (Ballinger et al. 2004, Smith et al. 2010). This retest demonstrates whether the criteria are still met if the system flow-rate is reduced from the normal value by a factor of three when only one fan is used. The tests were conducted by Pacific Northwest National Laboratory (PNNL) staff. The standard governing the performance of the tests, test methods, and acceptance criteria is ANSI/HPS N13.1–1999, *Sampling and Monitoring Releases of Airborne Radioactive Substances From the Stack and Ducts of Nuclear Facilities* (ANSI 1999). The test plan for this series is included in Appendix A.

2.2 Scale-Model Testing Criteria

The ANSI/HPS N13.1–1999 standard contains acceptance criteria for the use of a similarly designed stack, including a scale-model, as a substitute for the actual stack (Section 5.2.2.2 of ANSI/HPS N13.1–1999). The acceptance criteria are summarized as follows:

- 1. The scale model and its sampling location must be geometrically similar to the actual stack, with components influencing contaminant mixing and velocity profile proportional in the scale model proportional to those in the actual stack.
- 2. The scale model's mean velocity times hydraulic diameter must be within a factor of six of the actual stack. The stack diameter of the scale model must be at least 250 millimeters (mm) at the sampling location. The Reynolds number for the prototype and scale model stacks must be greater than 10,000.

The scale model results are considered valid if:

- 1. The velocity profile in the actual stack meets the uniformity criteria, and
- 2. The difference between velocity coefficients of variation (COVs) of the two systems is not more than 5% COV units.
- 3. The sampling location is placed at a geometrically similar location in the actual and scale model stacks.

A scale model was used for these tests because of the difficulty in taking measurements at the elevated sampling location and to avoid possible disruptions to operations in this nuclear facility. The scale model of the RPL final exhaust system was designed with consideration for the above criteria. The portion of the RPL exhaust system containing the final exhaust fans, downstream ducting, and stack was considered a sufficient segment to model velocity and contaminant mixing adequately. Several scales were considered that fit the criteria above, with a 1:5.33 scale selected based on convenient stack and duct size (the scale model was 18 ft high and 18 inches [in; 46 cm] in diameter), and similarity of stack

velocity. See the test plan in Appendix A for more detail on considerations for the scale model. Figure 2.1 shows a side view of the scale model after it was completed.



Figure 2.1. Side View of Scale Model of RPL Final Exhaust System

2.3 Uniformity of Air Velocity

The uniformity of air velocity in the stack cross section where the air sample is being extracted ensures that the air momentum in the stack is well mixed. The method used to demonstrate air velocity uniformity and the results obtained are detailed in the following sections.

2.3.1 Method

To facilitate the performance of this and subsequent tests, it was first necessary to correlate the fan speed controller (a variable frequency drive) with the stack flowrate. Following the procedure in Appendix B, a velocity uniformity measurement (Run VT-LOW1) was made at the midrange fan speed setting (30 hertz [Hz]) to identify a single measurement point that best represented the average velocity. The air velocity was then measured at that point as a function of fan speed setting. The results are plotted in Figure 2.2. The set point for the balance of the tests reported here (37.1 Hz) was estimated from the plot. The Run VT-LOW1 also provided a data point for velocity uniformity.



Figure 2.2. Air Velocity as a Function of Fan Speed

For this and most other tests, either the fan nearest to or farthest from the stack (Figure 2.3) was running. These configurations were used because they are expected to bracket the cases for stack mixing. Disturbances closer to the sampling port are expected to be more disruptive to uniform mixing than those further away; thus, the near fan configuration should provide the worst case for velocity uniformity.



Figure 2.3. Fan Configuration

The method to determine velocity uniformity is an adaptation of 40 Code of Federal Regulations (CFR) 60, Appendix A, Method 1. The equipment included a standard Prandtl-type pitot tube and a calibrated electronic manometer as shown in Figure 2.4. The procedure is detailed in Appendix C. The grid of measurement points was laid out in accordance with the U.S. Environmental Protection Agency (EPA) procedure for eight points on each of two linear traverses, arranged perpendicular to each other.

The center point was added for additional information over what is otherwise a long distance between points 4 and 5. Thus, there were 9 points along the northeast/southwest direction and also along the southeast/northwest direction.



Figure 2.4. Velocity Uniformity Measuring Equipment

2.3.2 Results

The acceptance criterion for uniformity of air velocity is that the COV of the air velocity must be \leq 20% across the center two-thirds of the area of the stack. The measured COVs for air velocity in the center two-thirds of the area of the scale model stack are listed in Table 2.1 and range from 1.6 to 9.4. The data sheets are included in Appendix C. All of the scale model test results for velocity uniformity meet the criterion that the air velocity COVs be \leq 20%. On the actual stack with one fan operating, the full-scale velocity uniformity COVs range from 3.9 to 10.7 (Recknagle et al. 2008). The scale model and the full scale results show good agreement. This agreement meets the acceptance criterion (±5% COV units) for validating the scale model results. Figure 2.5 shows a bar graph of the mean velocity measured at each point for Run VT-1, one of the scale model results.

	Fan Frequency	Stack Flow Rate		
Runs	Setting (Hz)	(cfm)	% COV	
Near Fan				
VT-LOW1	30	1100	9.4	
VT-1	37.1	1389	4.0	
VT-3	37.1	1421	3.4	
Far Fan				
VT-2	37.1	1334	1.6	
VT-4	37.1	1335	1.9	

Table 2.1. Scale Model Velocity Uniformity Results



Figure 2.5. Velocity Measurements over the Measurement Grid for Run VT-1

2.4 Angular Flow

The angular flow measurement in the stack cross section where the air sample is being extracted ensures that the flow angle is not more than 20° across the sampling plane. The method used to demonstrate the angular flow and the results obtained are presented below.

2.4.1 Method

The test method used was based on 40 CFR 60, Appendix A, Method 1, Section 2.4, "Verification of the Absence of Cyclonic Flow." This test was conducted at the scaled set-back flowrate in the model stack. Measurements were made using a type-S pitot tube, a slant tube or electronic manometer, and a protractor level attached to the pitot tube (Figure 2.6). The flow angle was measured at the elevation of the sampling nozzle and at the same points as those used for the velocity uniformity test. The pitot tube was rotated until a null differential pressure reading was obtained, and the angle of rotation was then recorded. Appendix D provides the detailed procedure.



Figure 2.6. Type-S Pitot Tube and Protractor Level used to Measure Angular Flow

2.4.2 Results

The acceptance criterion for angular flow is an average flow-angle of $< 20^{\circ}$ across the sampling plane. Measurements were made at the same grid points as for the velocity uniformity. The acceptance criterion ($\leq 20^{\circ}$) was met in all cases. The results range from 8.0 to 14.3°. Table 2.2 shows a summary of the angular flow testing results. The data sheets for the angular flow test are presented in Appendix D.

Table 2.2. Flow Angle Results					
Fan Frequency Mean Flow					
Runs	Setting, Hz	Angle			
	Far Fan				
FA-1	37.1	9.5			
Near Fan					
FA-2	37.1	14.3			
FA-3	37.1	8.0			

2.5 Uniformity of Tracer Gases

A uniform gas contaminant concentration at the sampling plane enables the extraction of samples that represent the true gas concentration within the stack. Testing for uniformity of tracer gases at the sampling plane was conducted on the scale model stack at the scaled set-back flowrate.

2.5.1 Method

The concentration uniformity is demonstrated with a tracer gas (sulfur hexafluoride) injected into the exhaust duct, in the same area as the discharge from the model heat recovery boxes for the near- and far-

fans. The concentration of the tracer gas is then measured at the sampling location using the same grid of points as used in the other tests. From the measurements, the COV and maximum deviation from the mean are calculated as measures of uniformity.

The gas samples are withdrawn from the stack through a simple probe and a gas analyzer (Figure 2.7). A Bruel and Kjaer (Naerum, Denmark) Model 1302 calibrated for the tracer gas, is used for the measurements. The procedure and data sheets are detailed in Appendix E.



Figure 2.7. Tracer Gas Probe and Analyzer

2.5.2 Results

The acceptance criteria for uniformity of tracer gases are:

- 1) the COV of the tracer gas concentration be $\leq 20\%$ across the center two-thirds of the sampling plane
- 2) the average concentration, for each measurement point, differ from the mean concentration by < 30%.

Table 2.3 lists the tests performed and their results. Five injection points were used at each injection location. Corner injections were made within 1 in (25% of a hydraulic diameter) of the walls at the corners of the duct (Figure 2.3). The worst case result was repeated as Run GT-11, where the uniformity results ranged from 1.6 to 5.5% COV. The absolute value of the maximum deviations from the means ranged from 2.6 to 12.6%. In all cases, the acceptance criteria were met. Figure 2.8 is a bar graph of the results of Run GT-1.

			Max %	
Run	Injection Point	% COV	Dev	
	Near Fan			
GT-1	Top-south	4.75	12.6	
GT-11	Top-south	5.48	-10.2	
GT-2	Top-north	2.49	-4.2	
GT-3	Center	3.54	6.3	
GT-4	Bottom south	3.75	-6.9	
GT-5	Bottom-north	3.88	8.1	
Far Fan				
GT-6	Top-south	1.63	-2.6	
GT-7	Top-north	1.82	3.4	
GT-8	Center	2.28	4.8	
GT-10	Bottom south	2.22	4.1	
GT-9	Bottom-north	2.50	-4.4	

Table 2.3. Summary of Gas Tracer Uniformity Results During Simulated Setback Condition





2.6 Uniformity of Tracer Particles

A uniform particulate contaminant concentration at the sampling plane enables the extraction of samples that represent the true particulate concentration within the stack. Testing for uniformity of tracer particles at the sampling plane was conducted on the scale model stack. The method for determining uniformity of tracer particles and the results of the tests are detailed in the following sections.

2.6.1 Method

The test method for uniformity of tracer particles is similar to that of tracer gases, with the tracer gas replaced by tracer particles. However, only the centerline injection position is required. The concentration of the tracer particles, in the size range of interest, was measured at the same test points used in the other tests. Spraying vacuum-pump oil through a nozzle mounted inside a chamber produced the particles measured by the testing. These particles were then injected into the duct entrained in a stream of compressed air as shown in Figure 2.9.



Figure 2.9. Typical Particle Generator Setup

A simple probe was used to extract the sample from the stack and transport it to the optical particle counter¹ (OPC) arranged as shown in Figure 2.10. The OPC sorts the number of particles into six size channels. Only the readings from the size channel that measures particles in the 9 to 11 μ m size range are used for statistical calculations. Each data point consists of the number of particles counted during a one-minute sampling period. Three readings were taken at each point and averaged. The COV of the average concentration readings at each point is calculated and the result compared to the acceptance criterion for uniformity. The detailed procedure and data sheets are included in Appendix F.

¹ Met-One Model A2408, Hach Analytics, Grants Pass, OR.



Figure 2.10. Optical Particle Counter and Probe Arrangement for a Particle Uniformity Test

2.6.2 Results

The acceptance criterion for uniformity of tracer particle is a COV less than 20% for tracer particles of the 10-µm range across the center two-thirds of the sampling plane.

The particle concentration uniformity is demonstrated with tracer particles injected into the exhaust duct, in the same area as the discharge from the model heat recovery boxes for the near- and far-fans. Tests were conducted at the simulated set-back flowrate. The results are summarized in Table 2.4 and the data sheets are included in Appendix F. The results show slightly more uniformity for the near fan configuration than for the far fan configuration. However, in all cases, the performance criterion was met. Figure 2.11 is a bar chart showing the normalized concentration data for the worst case test, PT-1.

		Un-normalized	Normalized		
	Injection Point	% COV	% COV		
Far Fan					
PT-1	Center	10.5	11.6		
PT-3	Center	10.5	7.4		
Near Fan					
PT-2	Center	8.5	8.3		

Table 2.4. Particle Tracer Uniformity Results for the Center Two-Thirds of the Stack



Figure 2.11. Bar Chart of PT-1 Results

The COV results are shown in Table 2.4 with and without any normalization with time. The results after normalization also are shown. The normalization method adjusts all of the concentration readings by the same amount so that the center point readings taken from the two traverse directions were equalized. The effect of normalization would be more pronounced in cases where there was a shift in concentration with time. All of the normalized data met compliance criteria.

3.0 Computational Fluid Dynamics Model

In previous modeling work, a three-dimensional CFD model was created and validated for flow simulations of the RPL effluent stack (Recknagle et al. 2008). The CFD model from this previous work included the ability to simulate the operation of both the scale-model and the full-scale final exhaust system with any number or combination of the four fans. For the present work, this model was exercised to simulate operation in each of the six permutations of two-fan operation, each fan operating at 52,000 cfm for a total of 104,000 cfm air flow. Results of these simulations were then analyzed to determine the effectiveness of each fan combination to meet the ANSI/HPS N13.1–1999 criteria for well-mixed flow at the stack sampling location.

3.1 Method

The STAR-CD² code was used to simulate the stack flow and analyze the simulation data to determine if the conditions at the sampling point would meet the criteria in ANSI/HPS N13.1–1999 for uniformity of air velocity, flow angularity, and uniformity of tracer gas and particles. In the calculations for the tests, STAR-CD solved the finite-volume Navier-Stokes (conservation of mass and momentum) and transport equations to obtain the steady-state flow field and species concentrations at each location within the system. For the sulfur hexafluoride tracer gas simulations, a Eulerian two-phase flow model was used in the calculations. A Lagrangian dispersed two-phase flow model was used for the aerosol (oil droplet) release simulations. The Lagrangian methodology includes models for droplet collision, breakup, drag, and turbulent dispersion of the dispersed phase (oil droplets). In all simulation cases, the generation and dissipation of turbulence was modeled using the κ - ϵ turbulence model for large Reynolds number flow (as implemented in the STAR-CD code). The κ - ϵ model is a widely tested and validated two-equation (partial differential equation) closure model for the turbulent transport terms in the time-averaged Navier-Stokes system of equations for fluid momentum transport. In the model equations, κ is the turbulence kinetic energy, and ε is the rate of dissipation of that energy. This turbulence model is considered suitable for the flow conditions present in such a duct. Additional details on the modeling approach can be obtained from Recknagle et al. (2008).

A three-dimensional model of the RPL final ventilation system was created to replicate the actual system geometry from the final exhaust fans to the stack exit (Figure 3.1). The view angle in the figure is slightly off vertical showing the horizontal orientation of the fan ducts and their perpendicular entry into the main duct (also horizontal), the 90° horizontal turn of the main duct, and the turn from horizontal to the vertically oriented exhaust stack. Fan 1 is located furthest from the stack and fan number increases with proximity of the stack.

A simulation was run for each of the 2-fan configurations: fans 1 & 2, 1 & 3, 1 & 4, 2 & 3, 2 & 4, and 3 & 4. Data from each of simulations was extracted to obtain flow velocity, flow angle, concentration of tracer gas, and concentration of particles at each traverse point at the elevation of the sampling system. The data was entered into spreadsheets to determine whether the ANSI/HPS N13.1–1999 criteria would be met. Data sheets and plots are included in Appendix H.

² The CFD program STAR-CD, Version 3.15, Methodology Volume, is copyrighted by the CD-adapco Group (CD-adapco, Seattle Office, 3150 Richards, Suite 204, Bellevue, WA 98005).



Figure 3.1. Three-Dimensional Model Geometry of the RPL Final Effluent Stack

3.2 Results

Detailed flow field results from the two-fan configuration case simulating operation with fans 1 and 2 are shown in Figure 3.2 and in Appendix H. The figure shows flow velocity vectors in which high velocity is red and low velocity is blue. Figure 3.2 shows the flow in a horizontal plane entering the duct through fans 1 and 2, passing the non-operating fans 3 and 4, turning the 90° bend in the horizontal duct, and entering the vertical stack. Air from fan 1 was directed toward the main duct via turning vanes and joined by air from fan 2 in the main duct.



Figure 3.2. Flow Velocity Vectors in a Horizontal Plane (2-Fan Configuration, 104,000 cfm)

The transition from the horizontal duct to the vertical stack set up a swirl in the stack flow that can be seen in Figure 3.2 by the low velocity (blue) zone within the stack. A closer view of the horizontal section through the stack in Figure 3.3 shows the circulation zone at upper right with relatively higher speed flow surrounding the zone. This swirl was present in each flow case and contributed to the mixing within the stack.



Figure 3.3. Detail of Flow Vectors in a Horizontal Plane

Results of each of the two-fan configuration simulations are shown in Table 3.1, along with criteria from ANSI/HPS N13.1–1999. As shown in the table, all criteria are met in each of the simulations.

	Velocity Uniformity	Cyclonic Flow	Gas Tracer Uniformity	Gas Tracer Uniformity (max deviation from	Aerosol Uniformity (COV %,
Two-Fan Configuration	(COV %)	(Angle °)	(COV %)	and % of mean)	normalized)
1, 2	5.75	11.4	6.83	13.8	6.72
1, 3	5.83	11.2	6.18	13.3	7.60
1, 4	5.84	12.4	9.29	23.2	10.4
2, 3	5.61	10.8	6.22	14.3	7.12
2, 4	6.00	11.5	8.80	20.3	10.8
3, 4	6.02	11.4	8.74	20.4	10.9
ANSI/HPS N13.1–1999 criteria	≤ 20	≤ 20	≤ 20	\leq 30	≤ 20

Table 3.1. Results from CFD Modeling of RPL Final Exhaust System

4.0 Conclusions

A scale model was designed following criteria in ANSI/HPS N13.1–1999 of the 325 Building RPL final exhaust system. The scale model was used to determine whether the stack sampling system would meet criteria in ANSI/HPS 13.1–1999 for sampling system location under reduced exhaust flow conditions. A summary of the tests, measurement results, and criteria are provided in Table 4.1 and demonstrate that the sampling location on the 325 Building main stack meets the criteria in ANSI/HPS N13.1–1999 for a well mixed location during the set-back flow condition when only one fan is in operation.

			CFD	
	Scale-Model	Full-Scale	Simulation	ANSI/HPS
	Measurement	Measurement	Results	N13.1-1999
Test	(1-fan)	(1-fan)	(2-fan)	Criteria
Velocity uniformity (COV %)	1.6 – 9.4	3.9 - 10.7	5.6 - 6.0	≤ 20
Cyclonic flow (angle °)	8.0 - 14.3		10.8 - 12.4	≤ 20
Gas tracer uniformity (COV %)	1.6 - 5.5		6.2 – 9.3	≤ 20
Gas tracer uniformity (maximum deviation from and % of the mean)	2.6 - 12.6		13.3 - 23.2	≤ 3 0
Aerosol uniformity (COV %, normalized)	8.3 – 11.6		6.7 – 10.9	≤ 20

Table 4.1. Summary of Test Results for Low Flow RPL Exhaust

With regard to acceptance of the scale model as a substitute for the actual stack, the model used was designed to be geometrically similar to the actual stack. Components influencing contaminant mixing and velocity profile in the scale model were proportional to those in the actual stack, and the sampling location in the scale model placed in a geometrically similar location as in the actual stack. The velocity profile in the actual stack meets the uniformity criteria, and the difference between velocity COVs of the two systems is not more than 5% COV units (Table 4.1). The scale model stack diameter of 18 inches is greater than the minimum of 250 mm (10 in).

The lowest flow used in the scale model testing was 1,100 cfm (Table 1.1) resulting in a Reynolds number of 91,000 which is well above the required minimum of 10,000. Reynolds number calculations are shown in Appendix G for the ranges of flows in the actual and scale model stacks under normal and reduced flow conditions. All Reynolds numbers are substantially above 10,000.

Finally, the scale model's mean velocity times hydraulic diameter must be within a factor of six of the actual stack. For the one fan configuration, the scale model's mean velocity times hydraulic diameter at the 37.1 Hz setting ranged from $930-1200 \text{ ft}^2/\text{min}$. Using a factor of six, this corresponds to stack flows of 980-45,400 cfm (calculations in Appendix G).

All combinations of two-fan configurations were evaluated using a three-dimensional CFD model. The CFD simulation results are shown in Table 4.1 and indicate that the stack sampling system also meets ANSI/HPS N13.1–1999 criteria for a well mixed location with any two fans operating.

The scale-model measurement tests cover the reduced operating range of flows less than 45,400 cfm using a one fan configuration. Earlier tests were conducted on normal flow conditions covering three fan configurations ranging from 129,000 to 186,300 cfm (Smith et al. 2010). The three-dimensional CFD simulations were performed to evaluate all two-fan configurations. All measurements and simulations results showed that the sampling system location in the RPL stack meets the ANSI/HPS N13.1–1999 criteria for flow angularity and uniformity of flow, tracer gas, and aerosol under one-, two-, or three-fan configurations and flow conditions.

5.0 References

ANSI—American National Standards Institute. 1969. *Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities*. ANSI N13.1–1969, American National Standards Institute, NY. February 19.

ANSI/HPS—American National Standards Institute/Health Physics Society. 1999. Sampling and Monitoring Releases of Airborne Radioactive Substances From the Stacks and Ducts of Nuclear Facilities. ANSI/HPS N13.1–1999, American National Standards Institute, NY.

Ballinger MY, JM Barnett, JA Glissmeyer, and DL Edwards. 2004. "Evaluation of Sampling Locations for Two Radionuclide Air-Sampling Systems Based on the Requirements of ANSI/HPS N13.1-1999." *Health Physics* 86(4):406-415.

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

Recknagle KP, ST Yokuda, MY Ballinger, and JM Barnett. 2008. "Scaled Tests and Modeling of Effluent Stack Sampling Location Mixing." *Health Physics* 96(2):164-174.

Smith BM, MY Ballinger, JA Glissmeyer, and JM Barnett. 2010. *Sampling Point Compliance Tests for the 325 Building Stack at Full Flow Condition*. PNNL-19998, Pacific Northwest National Laboratory, Richland, WA.

Appendix A

Test Plan for Qualifying the EP-325-01-S Stack Air Sampling Position for Set-Back Flow Condition

Test Plan for Qualifying the EP-325-01-S Stack Air Sampling Position for Set-Back Flow Condition August 10, 2004

This series of tests will demonstrate whether the EP-325-01-S exhaust stack meets the applicable regulatory criteria regarding the placement of the air-sampling probe. This has already been demonstrated for the normal flowrate with three operating fans. This re-test will demonstrate whether the criteria are still met if the system flowrate is reduced from the normal value by a factor of three when only one fan is used. This stack exhausts the filtered ventilation air from all areas of the 325 Building Radiochemical Processing Laboratory where radionuclides are handled, including hot cell, waste treatment and radiochemistry. The tests will be conducted by Pacific Northwest National Laboratory staff. The standard governing the performance of the tests, test methods, and acceptance criteria is ANSI/HPS N13.1-1999, Sampling and Monitoring Releases of Airborne Radioactive Substances From the Stack and Ducts of Nuclear Facilities.

Performance Criteria

The qualification criteria for the location of the air sampling probe are as follows (Table 4, ANSI/HPS N13.1-1999):

- 1. Flow Angle Sampling nozzles are usually aligned with the axis of the stack. If the air travels up the stack in cyclonic fashion, the air velocity vector approaching the nozzle could be misaligned with the sampling nozzles enough to impair the extraction of particles. Consequently, the flow angle is measured in the stack at the elevation of the sampling nozzle. The average air-velocity angle must not deviate from the axis of the sampling nozzle by more than 20°.
- 2. Air Velocity Uniformity It is important that the gas momentum across the stack cross section where the sample is extracted be well mixed or uniform. Consequently, the velocity is measured at several points in the stack at the elevation of the sampling nozzle. The uniformity is expressed as the variability of the measurements about the mean. This is expressed using the relative coefficient of variance (COV), 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 criteria is that the COV of the air velocity must be ≤20% across the center two-thirds of the area of the stack.
- 3. Gas Tracer Uniformity A uniform contaminant concentration in the sampling plane enables the extraction of samples that represent the true concentration. This 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 center two-thirds of the sampling plane and 2) at no point in the sampling plane does the concentration vary from the mean by >30%.
- 4. Particle Tracer Uniformity Uniformity in contaminant concentration at the sampling elevation is further demonstrated using tracer particles large enough to exhibit inertial effects. Particles of 10-μm aerodynamic diameter (AD) are used by default unless it is known that larger particles are present in the airstream. The acceptance criteria is that the COV of particle concentration is ≤20% across the center two-thirds of the sampling plane.

Scale Model Testing Criteria

Testing to satisfy Criteria 1 - 4 will be conducted on a scale model of the exhaust ductwork and stack, from the heat recovery coils to the elevation of the sampling probe. The ANSI/HPS N13.1-1999 standard sets acceptance criteria for the use of a scale model as a substitute for the actual stack.

- The scale model and its sampling location must be geometrically similar to the actual stack.
- The model's mean velocity x hydraulic diameter product will be within a factor of six of the actual stack.
- The Reynold's number for the prototype and model stacks must > 10,000.

The scale model results are considered valid if:

- The velocity profile in the actual stack meets the uniformity criteria, and
- The uniformity COV for the actual and model stacks agree within 5% COV.

Conduct of Tests

Compliance with each performance criteria is demonstrated through performing a specific test procedure. The four procedures to be used are briefly described below and in the order in which they are usually conducted. Specific Test Instructions will be issued prior to the conduct of a test.

The tracer tests result in the emission of tracer gas (sulfur hexafluoride) and tracer particles (vacuum pump oil mist) from the scale model. The estimate of emissions from these tests is given below.

The Job Hazard Analysis (if any) and MSDS's for the tracer compounds are to be reviewed by testing staff prior to the conduct of any test. These documents are also to be kept available at the test site.

1.0 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. The test method is based on 40 CFR 60, Appendix A, Method 1, Section 2.4, "Verification of the Absence of Cyclonic Flow."

This test is conducted on the scale model stack. The flow angle is measured at a grid of points in a cross section of the stack at the scaled elevation of the actual sampling probe. The grid is an array of points in an x-pattern. One line of points is aligned in the same direction as the existing sampling probe on the actual stack. The other line will be perpendicular to that. The number and distance between measurement points is based on the EPA procedure 40 CFR 60, Appendix A, Method 1.

Measurements are made using a type-S pitot tube, a slant tube or electronic manometer, and a protractor level or angle indicating device attached to the pitot tube. The procedure EMS-JAG-05 Test to Determine Flow Angle at the Elevation of a Sampler Probe provides the general procedure for the determination of mean flow angle. Instructions specific for this stack will be given in a test instruction.

2.0 Air Velocity Uniformity Test

The uniformity of air velocity where the air sample is being extracted ensures that the air momentum in the stack is well mixed. To determine uniformity, air velocity is measured at the same grid of points used for the angular flow test. The method used is based on 40 CFR 60, Appendix A, Method 1. The equipment includes a standard Prandtl-type or S-type pitot tube and a calibrated electronic manometer. Procedure EMS-JAG-04, Test to Determine Uniformity of Gas Velocity at the Elevation of a Sampler Probe, is used for this test. This test takes about 90 minutes. A test instruction will be issued specifically for this test.

3.0 Gas Tracer Uniformity Test

A uniform contaminant concentration in the sampling plane enables the extraction of samples that represent the true concentration. Procedure EMS-JAG-01, Test to Determine Uniformity of a Tracer Gas at a Sampler Probe, is used for this test. The gaseous contaminant concentration uniformity is demonstrated using a tracer gas (sulfur hexafluoride) injected into the ductwork at various positions. For each injection position, the tracer concentration is measured at the sampling plane at the same grid of measurement points as used for the above tests. The uniformity is expressed as the COV of the measured tracer concentrations.

Tracer gas concentration is measured with a Bruel and Kjaer (Naerum, Denmark) Model 1302 gas analyzer calibrated for the tracer gas. The absolute calibration of the analyzer is unimportant to the test results; however, the analyzer response is checked using calibration standards prior to the conduct of the test. If the indicated concentration is within 20% of the standard, the response is acceptable.

For the proposed reduced flow condition, any one of the available four fans would be used to maintain the reduced airflow. There is a heat recovery box between each fan and the final exhaust duct. The planned tracer gas injection locations are just downstream of the heat recovery boxes nearest and farthest from the stack. These should represent the best and worst case conditions. An optional location would be in the duct just upstream of the breach to the stack. The tracer is injected along the centerline of the duct and at four locations near the corners of the duct.

For the single operating fan configuration, the five tracer injection points will be used for each injection location. The test will be repeated for the injection point found to have the least favorable result. Other repeat runs may be made at the discretion of the test director after a review of the preliminary results. Therefore, there will be a minimum of 11 test runs. Each run takes about 90 minutes. A test instruction will be issued specifically for this test.

The usage and emission of the tracer gas, sulfur hexafluoride, is based on a stack flow of 1442 cfm, a desired concentration of 1 ppm, and 13 tests. The total emission would be about 0.30 kg for 13 tests, or about 0.022 kg/test.

4.0 Particle Tracer Uniformity Test

The test for uniformity of tracer particles is similar to the test for uniformity of tracer gases. The general approach is to inject particles of a range of sizes, including the size of interest, into the center of the airstream. The concentration of the particles of the size range of interest is then measured at several points in the cross section of the sampling plane using an optical particle counter (OPC, Met-One Model A2408, Grants Pass, Oregon). A simple probe is used to extract the sample and deliver it to the OPC. The measurement points are the same as used for the above tests. The OPC should be within calibration.

The particles are made by spraying vacuum-pump oil through a nozzle housed in a chamber. The chamber provides a controlled means for injecting the particles into the airflow through a probe. Compressed air and an injection probe are required for the operation of the chamber.

The tracer injection port is the same as for the gaseous tracer; however, only the centerline injection point is used. The layout of measurement points is the same as for all of the other tests, except where the size of the probe does not permit sampling as close to the inside of the stack wall.

The OPC's sort the number of particles into six size channels. Each concentration reading is the count of particles collected in the 9- to 11- μ m channel. The readings are recorded on a data sheet. Three readings are taken at each point and averaged. The coefficient of variance of the average concentration readings at all points is calculated and the result compared to the acceptance criteria for uniformity. The particle mixing is acceptable if the COV of the tracer particles of 10- μ m aerodynamic diameter (AD) is less than or equal to 20% across the center two-thirds of the sampling plane.

There will be a minimum of 5 test runs, one for each injection position (used for the gas tracer uniformity tests) and flowrate, and one repeat test. Each test run can require up to four hours. Procedure EMS-JAG-02, Test to Determine Uniformity of a Tracer Aerosol at a Sampler Probe, is used for this test. A test instruction will be issued specifically for this test.

The usage and emission of the tracer aerosol oil (Fisherbrand 19 vacuum pump oil) may be as about high as 50 g per test run. (The use rate has never actually been measured. In any demonstrations that we have done, it has always been less than 0.5 L total.) Three tests can be completed in an 8-hour period.

Fan Configuration

In the actual fan house, there are four electric fans, three of which are normally used at a time. The capacity of the electric fans are about 46,000 cfm each. With three fans operating, the exhaust airflow is about 138,000 cfm. With one fan running in the reduced flow condition, the exhaust airflow would be about 46,000 cfm. The fans are housed in a small building. Each fan discharge's upward and into a heat recovery box, where coils and heat transfer fluid recover heat from the exhaust airflow. Each heat recovery box discharges into the main plenum which connects to the stack. Figure 1 is a diagram of the scale model for this part of the ventilation system. The parameters for the scale model are given in Table 1. The 5.33:1 scale results in a convenient stack and duct size of 18 inches to represent the actual 8 feet. It also results in a velocity close to that of the actual system. (With three fans operating, the actual and model velocities would be 2755 and 2449 fpm respectively.) To remain within the scaling parameters (velocity times hydraulic diameter within a factor of six) the model flowrate of 1442 cfm corresponds to 46,157 cfm, or one-third the stack flowrate of 138,473 (the average of eleven separate stack flow measurements).

There are plans to upgrade the fan capacities to about 50,000 or 60,000 cfm each. That would be a flowrate around 50,000 - 240,000 cfm depending on the fan usage. The overall flowrate range is then 45,666 (based on the lowest 3-fan stack flowrate measured) - 240,000 cfm. The corresponding minimum scale model flowrates would then be 1427 - 7500 cfm.
Flow parameters in scale models (colored values are inputs)

John Glissmeyer 4/13/01

Fluid characteristics:		
Mol. Wt.	28.95	
Temperature	70	F
Pressure	1	atm
Gas Density	0.0748	lb/ft3
Viscosity	0.000176	g/cm-s

Range of Reynolds number for scale model:

Min	3.88E+05	1/6 prototype
Max	1.40E+07	6 X prototype

Range of DV for scale model:

Min	3.67E+03	1/6 prototype
Max	1.32E+05	6 X prototype
Prototype	2.20E+04	

Sheet protected for data entry, no password Want to keep velocity < Mach 0.3, or <19700 fpm

Prototype Stack characteristics:

Diam	8.00	ft
Flow	138473	cfm
X-area	50.265	sq. ft
Mean U	2755	ft/min
Reynolds	2.33E+06	

Range of Q/D for scale model:

Min	2.88E+03	1/6 prototype
Max	1.04E+05	6 X prototype
Prototype	1.73E+04	

		Scaled ft at 1:X					
	Prototype						
Section	ft	3.20	4.00	5.33	7.00	1.00	1.00
Round Duct Section	Stack						
Diam, ft	8.00	2.500	2.000	1.500	1.143	8.000	8.000
Area, ft2	50.3	4.91	3.1	1.8	1.0	50.3	50.3
Flow at min Q/D, cfm	138473	7212	5770	4327	3297	23079	23079
Vel fpm	2755	1469	1837	2449	3214	459	459
Re	2.3E+06	3.9E+05	3.9E+05	3.9E+05	3.9E+05	3.9E+05	3.9E+05
Ratio Re		6.00	6.00	6.00	6.00	6.00	6.00
Round Duct Section	Stack						
Diam, ft	8.00	2.50	2.00	1.50	1.14	8.00	8.00
Area, ft2	50.3	4.91	3.1	1.8	1.0	50.3	50.3
Flow at min Q/D, cfm	45666	2378	1903	1427	1087	7611	7611
Vel fpm	908	485	606	808	1060	151	151
Re	2.3E+06	1.3E+05	1.3E+05	1.3E+05	1.3E+05	1.3E+05	1.3E+05
Ratio Re		18.19	18.19	18.19	18.19	18.19	18.19
Round Duct Section	Stack						
Diam, ft	8.00	2.500	2.000	1.500	1.143	8.000	8.000
Area, ft2	50.3	4.91	3.1	1.8	1.0	50.3	50.3
Flow at min Q/D, cfm	240000	12500	10000	7500	5714	40000	40000
Vel fpm	4775	2546	3183	4244	5570	796	796
Re	2.3E+06	6.7E+05	6.7E+05	6.7E+05	6.7E+05	6.7E+05	6.7E+05
Ratio Re		3.46	3.46	3.46	3.46	3.46	3.46
Round Duct Section	Stack						
Diam, ft	8.00	2.500	2.000	1.500	1.143	8.000	8.000
Area, ft2	50.3	4.91	3.1	1.8	1.0	50.3	50.3
Flow at min Q/D, cfm	60000	3125	2500	1875	1429	10000	10000
Vel fpm	1194	637	796	1061	1393	199	199
Re	2.3E+06	1.7E+05	1.7E+05	1.7E+05	1.7E+05	1.7E+05	1.7E+05
Ratio Re		13.85	13.85	13.85	13.85	13.85	13.85

Test Runs

Table 2 lists the estimated number of runs of the individual tests that will be performed for the reduced flow configuration.

Table 2.	Minimum	Test Runs	to be	Performed	for the	Reduced	Flow	Configuration
								0

			Estimated num		
Configuration	Scaled Stack	Flow Angle	Air Velocity	Gas Tracer	Particle
	Flowrate				Tracer
Current Fans	1427	1	2	11	3

All measurements are planned to be conducted at the simulated sampling probe elevation of the stack. The probe centerline is about 55.94-ft (?) above the top stack breach. That should be 10.5 ft on the scale model.

The test strategy underlying Table 2 is outlined in Table 3.

Table 3.	Proposed	Test	Sequence
----------	----------	------	----------

Test	Run	Injection Points	Comments
	One Fan Co	onfiguration	
Flow Control Cal.	VT-1, VF-1	N.A.	VT-1 at 30 Hz on
			controller, VF-1 at 5-
			Hz increments
Velocity Uniformity	VT-2, VT-3, VT-4	N.A.	First two where fan
	and VT-5		closest to the stack is
			used. Second two
			where the farthest fan
			is used
Flow Angle	FA-1, FA-2, FA-3	N.A.	One run per condition
			plus one repeat
Gas Tracer	GT-1 to GT-5	With injection	1427 cfm
		downstream of Fan 4	
	GT-6 to GT-10	With injection	1427 cfm
		downstream of Fan 1	
	GT-11	Repeat of worst case	1427 cfm
		from above	
Particle Tracer	PT-1 to PT-3	Centerline after Fan 1	1427 cfm
		and 4 and repeat of	
		worst case	





PLAN - RPL STACK



Appendix B

Flow Calibration Procedure and Data

PACIFIC NORTHWEST DOCUMENT NO.: NATIONAL LABORATORIES Plot of Velocity Versus I INDEPENDENT TECHNICAL Model, Spreadsheet 04-3 REVIEW RECORD Plot of Velocity Versus I					ncy for 29 II.XLS	<u>1-Z-1</u>	Page <u>1</u> of <u>1</u>	
The refer return the please ca	The referenced document is submitted for your review. Instructions for completing this form are attached. Please return the completed form to: <u>John Glissmeyer</u> . If you have any questions, please call <u>John Glissmeyer</u> , <u>376-8552</u> , cell <u>531-8006</u> . Comments Due: <u>9/28/04</u>							
Addition 1. 2. 3.	 Additional Information: (Scope of Review, etc) Please verify the following: 1. Transfer of field data to spreadsheet 2. Calculation of intermediate mean velocity values per frequency setting 3. Calculation of parameters for fitted line, do not force intercept to zero 							
Org Enviro	wer:		X Dar	Signa m /	ture/Date Aciber 130/04			
CONCU	R[] CONCUR, WITH CO	OMMENTS [x]	DO NO	T CONCU	/ R[]	NOT R	EVIEWED[]	
Comt. No	Comment and/ or Recomment	ndation:		Resolutio	on:			
1.	O – There should be consisted instrument by serial number noted on VT-1	ency in identifying t or calibration barco	ihe ode,	1. Changed to serial number.				
2	O – Stack temp (top of page temperature, rather than aver	VT-1) is starting rage based on table.		2. Changed to calculate the average of starting and ending temperatures.				
3	E - Set number format for s shows as 0.0)	tack static pressure	(0.04	3. Done				
4	M - The units given on the tmust correspond to the valuegiven in inches of Hg on origmbars VT1. Barometric pre'Cal Data' are inches of H20Hg.	re table essure ed as sheet nes of	4. Chang on both c	ed ambier lata sheets	nt pressur s.	re entries to in. Hg		
5	E – Sheet "Cal Data": remo cells, far right column of vel Hz" and "45+" below.	from ated	5. Done					
6	al lists her	6. Chang	ged to 120) 5/8				
Concur w	with Resolution	Date 15 9/30/0	64	Commen John	ts Resolve	ed By	Date 9/30/04	

		VE	LOCITY T	RAVERSE	DATA FOR	M			
	Site	325 Model			Run No.	VT-LOW1			
	Date	8/19/2004		Fan Co	nfiguration	FAN 4 (nea	r stack)		
	Testers	JMB/GSH/	NYB/DDD	F	an Setting	30 HZ			
	Stack Dia.	18	in.	s	tack Temp	95.6	deg F		
St	ack X-Area	254.5	in.2	Star	/End Time	12:19PM - 2	2:20PM		
	Elevation	139.75		Cent	er 2/3 from	1.65	to:	16.35	
Distance to d	listurbance	120 5/8	inches	Points in	Center 2/3	2	to:	7	
Ve	locity units	<u>ft/min</u>			Data Files:	NA			
Traverse>			Ea	ast			No	rth	
<u> Trial></u>		1	2	3	Mean	1	2	3	Mean
CorrectLabel	Depth, in.		Velo	ocity			Velo	ocity	
1	0.58	633	709	665	669.0	595	620	561	592.0
2	1.89	693	688	681	687.3	668	679	647	664.7
3	3.49	690	708	718	705.3	708	704	673	695.0
4	5.81	/13	689	692	698.0	724		708	/11.0
Center	9.00	64/	6/5	64/	656.3	6/0	660	642	657.3
5	12.19	610	589	541	580.0	64/	616	624	629.0
6	14.51	591	586	521		543	602	570	5/1./
- /	17.11	540	542	500	547.7	530	610	552	500.0
	17.42	628.7	630.8	617.7	628.7	622.0	637.1	611 3	524.7
Averages		020.7	0000.0	017.7		022.0	007.1	011.0	023.0
			ft/min	Dev	from mean	Center 2/3	West	North	
		Mean	626.1	<u></u>	lonnioun	Mean	634.4	642 1	638.2
		Min Point	524.7		-16 2%	Std Dev	67.7	56.6	60.1
		Max Point	711.0		13.6%	COV as %	10.7	8.8	9.4
Flow	w/o C-Pt	1100	acfm		Instument	s Used:			
Vel Avo	w/o C-Pt	622	fpm		Solomat Ze	ephyr SN 129	95-1472		Cal 8/12/04
		Start	Finish						-
Stack temp		98	93.2	F					
Equipment	temp	87	88.7	F					
Ambient ter	np	87	92	F		and the second designed as a second			
Stack static		0.04	0.03	mbars	800-	Frank and the second se			
Ambient pre	essure	29.4	29.4	in Hg	V				
Total Stack	pressure	1013.1	1012.2	mbars	e 700-			hili I	
Ambient hu	midity	37%	31%	RH	I 600-				-
					0				-
					c 500				
Notes:	Wind ENE	<u>6 mph</u>			400				
					V 200				
					300				
					f 200				
					P 100				
					m		e .		
		_			0				West
						North		/	
Cian church	innifico es-	nlinnen witt		Signature		to and colour	otions		1
Brocodure s	Ignities con	npliance with	I	Signature v	eritying dat	a and carcul	ations;	IA	1. 31
Signature /d	ata VL	910		9/22/	NI	XiA	anne	L Hat	Jen Y JUL
Signature/d		m fle	ange	~ 4790	/	/ <i>v</i> >			
	V		\mathcal{O}			,			\bigcirc

VELOCITY vs. FREQUENCY DATA FORM

	Site	Site 325 Model			Run No. Cal 1			
	Date	8/19/2004			ck Temp	87.9	deg F	
	Tester	JMB/GSH/	MYB	Sta	ack RH%	3	1%	
	Stack Dia.	18	in.	Ba	aro Press	29.4	in Hg	•
Sta	ck X-Area	254.5	in2	Fan Conf	iguration	1 fan (near fan)	
	Elevation	N.A.		Start/E	Ind Time	14:50	- 15:30	
El. above dis	sturbance	120 5/8	inches	Reference	e point fro	m velocit	y test VT	North 5
Velocity Rea	idings, unit	s =	fpm					
					Target	Target		
					cfm	fpm		
					1350	764		
		fp	m		1450	821		
Hz	1	2	3	Mean	StDev	2 StDev	cfm	
5	32	0	22	_18.00	16.37	32.74	31.81]
10	150	138	_ 177	155.00	19.97	<u>39.9</u> 5	273.91	
15	320	266	_ 272	286.00	29.60	<u>59.1</u> 9	505.40]
20	420	406	400	408.67	10.26	20.53	722.17	
25	536	490	513	513.00	23.00	46.00	906.55	
30	_ 669	576	604	616.33	47.71	95.42	1089.15	
35	_ 797	736	795	776.00	34.66	69.31	<u>1371.</u> 31	
40	923	852	903	892.67	36.61	73.22	1577.47	
45	1004	1042	1009	1018.33	20.65	41.30	1799.54	
50	1117	_ 1150	1165	1144.00	<u>2</u> 4.56	<u>49.11</u>	2021.61	
55	1207	1233	1271	1237.00	32.19	64.37	2185.96	
60	1414	1361	1361	1378.67	30.60	61.20	2436.31	

Instuments Used: Zephyr-Selomat 12951472, S/N 14714 Cal Exp. Date: 8/12/2005



Signature verifying data and calculations: Signature signifies compliance with Jaber 1soloy Procedure EMS, JAG-3/ Danne Lt lissneye 14 Signature/date

	Test Instruction					
Project: 325 Stack Sampler Qualification	Project: 325 Stack Sampler Date: August 16, 2004 Work Package: F59676 Qualification					
Tests: Calibration of Ven	tilation Flow Controller for 3 Configuration	325 Model Stack, 1 Electric Fan				
Staff: John Glissmeyer, Dave	Douglas, Marcel Ballinger, Ma	atthew Barnett				
Reference Procedures: 1. Operating Manual for 2. Procedure EMS-JAG 18, 1998	Solomat Zephyr, or other mic -03 Test to Calibrate Ventilati	cromanometer used on Flow Controller, Rev. 0, Nov.				
Equipment: 1. Model Stack, Fans an 2. Solomat Zephyr, or o	 Equipment: 1. Model Stack, Fans and Fan Speed Controller. Fans will be in positions EF1, EF4. 2. Solomat Zephyr, or other micromanometer, and pitot tube 					
Safety Considerations: Review and observe the applicable Job Hazard Analysis for the project						
Instructions: 1						
 3. With one fan operatin velocity at each point 	g, set the flow controller set a Repeat each measurement th	t midrange (30 Hz) and measure the				
 4. Record data on velocity data sheets 5. Identify point of average velocity 6 Mount pitot tube at that point and measure velocity at 5 Hz increments from 5 to 60 						
 Hz. 7. Record and plot the data 8. Determine approximate setpoints for subsequent target test flowrate (1350 - 1450 cfm, 764 - 821 fpm) for one operating fan. (35-37 Hz) 6. Diagram mounting fixtures and retain assembly for subsequent tests (duct tord ports) 						
Desired Completion Date: 8/27/04						
Approvals: <u>Approvals:</u> <u>John Glissmeyer</u> , project manager <u>Date</u>						
Test completed by: MTSer	itt	Date: = / >0/01				

Appendix C

Velocity Uniformity Procedure and Data

INDEPENDENT TECHNICAL REVIEW RECORD

The referenced document is submitted for your review. Instructions for completing this form are attached. Please return the completed form to:John Glissmeyer If you have any questions, please callJohn Glissmeyer, 376-8552, cell 531-8006 Comments Due:9/28/04 Additional Information: (Scope of Review, etc.) Please verify the following: . 1. Transfer of field data to spreadsheet . . . 2. Calculation of ort and overall mean velocity, standard deviation, and %COV for the center 2/3 of stack area . . 3. Calculation of port and overall mean velocity, standard deviation, and %COV for the center 2/3 of stack area . . 4. Calculation of port and overall mean velocity data (2 points) for plotting . . . 6. Verify orientation of plotted bars Organization/Department Environmental Health Sciences Group Designated Reviewer: Roseanne Aaberg . . . Comcur [] CONCUR, WITH COMMENTS [x] DO NOT CONCUR [] NOT REVIEWED [] . 1 Ambient pressure units should be listed in inches of Hg rather than in mbars, all four sheets 2 E - Label on Velocity Traverse Data Form Table: Change "Correct Label" to "Point", all forms <	PA NATI INDE	PACIFIC NORTHWEST DOCUMENT NO.: NATIONAL LABORATORIES Calculation of Velocity U INDEPENDENT TECHNICAL Stack, Spreadsheet 04-32 REVIEW RECORD Calculation of Velocity U					for 325 M <u>ls</u>	odel	Page <u>1</u> of <u>1</u>
Additional Information: (Scope of Review, etc) Please verify the following: 1. Transfer of field data to spreadsheet 2. Calculation of intermediate mean velocity values per traverse (one per port) and measurement point (1 st and last points per port) 3. Calculation of port and overall mean velocity, standard deviation, and %COV for the center 2/3 of stack area 4. Calculation of port and overall mean velocity, standard deviation, and %COV for the center 2/3 of stack area 6. Calculation of port and overall mean velocity data (2 points) for plotting 6. Verify orientation of plotted bars Organization/Department Environmental Health Sciences Group Group Designated Reviewer: Roscanne Aaberg Signature/Date CONCUR [] CONCUR, WITH COMMENTS [x] DO NOT CONCUR [] NOT REVIEWED [] Comt. Comment and/ or Recommendation: Resolution: Resolution: 7 E - Label on Velocity Traverse Data Form Table: OK OK 2 E - Label on Velocity Traverse Data Form Table: OK OK 4 M - Change number format of stack static pressure to show two decimal place for stack temp, and bave stack static pressure to inches of Hg, VT-1 and VT-2. (Note that ambient pressure is in	The referenced document is submitted for your review. Instructions for completing this form are attached. Please return the completed form to: <u>John Glissmeyer</u> . If you have any questions, please call <u>John Glissmeyer, 376-8552, cell 531-8006</u> . Comments Due: <u>9/28/04</u>								
Organization/Department Environmental Health Sciences Group Designated Reviewer: Roseanne Aaberg Signature/Date Rown Address CONCUR [] CONCUR, WITH COMMENTS [x] DO NOT CONCUR [] NOT REVIEWED [] Comt. No. Comment and/ or Recommendation: No. Resolution: Resolution: 1 Ambient pressure units should be listed in inches of Hg rather than in mbars, all four sheets See Comment 4 below. 2 E - Label on Velocity Traverse Data Form Table: Change "Correct Label" to "Point", all forms OK 3 E - Change number format of stack static pressure to show two decimal paces, VT-1, VT-3, VT-4. Should have one decimal place for stack temp, VT-1 and VT-2. (Note that ambient pressure to inches of Hg, VT-1 and VT-2. (Note that ambient pressure to inches of Hg, VT-1 and VT-2. (Note that ambient pressure to inches of Hg, VT-1 and VT-2. (Note that ambient pressure to inches of Hg, VT-1 and VT-2. (Note that ambient pressure to inches of Hg, VT-1 and VT-2. (Note that ambient pressure to inches of Hg, VT-1 and VT-2. (Note that ambient pressure to inches of Hg, VT-1 and VT-2. (Note that ambient pressure to inches of Hg, VT-1 and VT-2. (Note that ambient pressure to inches of Hg, VT-1 and VT-2. (Note that ambient pressure to inches of Hg, VT-1 and VT-2. (Note that ambient pressure to inches of Hg, VT-1 and VT-2. (Note that ambient pressure to inches of Hg, VT-1 and VT-2. (Note that ambient pressure to inches of Hg, VT-1 and VT-2. (Note that ambient pressure to inches of Hg, VT-1 and VT-2. (Note that ambient pressure to inches of Hg, VT-1 and VT-2. (Note that ambient pressure order from the labels of the graphs. In the future, the confusion could be reduce	 Additional Information: (Scope of Review, etc) Please verify the following: Transfer of field data to spreadsheet Calculation of intermediate mean velocity values per traverse (one per port) and measurement point (1st and last points per port) Calculation of port and overall mean velocity, standard deviation, and %COV for the center 2/3 of stack area Calculation of grand mean and maximum deviation of mean for all measurement point. Calculation of normalized velocity data (2 points) for plotting Verify orientation of plotted bars 								
CONCUR [] CONCUR, WITH COMMENTS [x] DO NOT CONCUR [] NOT REVIEWED [] Comt. No. Comment and/ or Recommendation: Resolution: 1 Ambient pressure units should be listed in inches of Hg rather than in mbars, all four sheets See Comment 4 below. 2 E - Label on Velocity Traverse Data Form Table: Change "Correct Label" to "Point", all forms OK 3 E - Change number format of stack static pressure to show two decimal paces, VT-1, VT-3, VT-4. Should have one decimal place for stack temp, OK, but the temperature indicator actually shows tenths, but is accurate to about a half of a degree. 4 M - Change units on ambient pressure to imbars on VT-3 and VT-4.) OK 5 O - The labels of points (corresponding to depth) in the West series is represented in reverse order from the labels of the graphs. In the future, the confusion could be reduced by reversing the points charted in the graph (source M32:U32 of spreadsheet). OK	Organization/Department Designated Reviewer: Environmental Health Sciences Group						Ros	Signa	ture/Date
Comt. No. Comment and/ or Recommendation: Resolution: 1 Ambient pressure units should be listed in inches of Hg rather than in mbars, all four sheets See Comment 4 below. 2 E - Label on Velocity Traverse Data Form Table: Change "Correct Label" to "Point", all forms OK 3 E - Change number format of stack static pressure to show two decimal paces, VT-1, VT-3, VT-4. Should have one decimal place for stack temp, OK, but the temperature indicator actually shows tenths, but is accurate to about a half of a degree. 4 M - Change units on ambient pressure to inches of Hg, VT-1 and VT-2. (Note that ambient pressure is in mbars on VT-3 and VT-4.) OK 5 O - The labels of points (corresponding to depth) in the West series is represented in reverse order from the labels of the graphs. In the future, the confusion could be reduced by reversing the points charted in the graph (source M32:U32 of spreadsheet). OK	CONCU	ONCUR [] CONCUR, WITH COMMENTS [x] DO NO				OT CONCU	R[]	NOT R	EVIEWED []
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 3 E - Change number format of stack static pressure to show two decimal paces, VT-1, VT-3, VT-4. Should have one decimal place for stack temp, 4 M - Change units on ambient pressure to inches of Hg, VT-1 and VT-2. (Note that ambient pressure is in mbars on VT-3 and VT-4.) 5 O - The labels of points (corresponding to depth) in the West series is represented in reverse order from the labels of the graphs. In the future, the confusion could be reduced by reversing the points charted in the graph (source M32:U32 of spreadsheet). 	2	E - La	abel on Velocity Trave ge "Correct Label" to "	rse Data Form Table 'Point", all forms	e:	ок			
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Concur with Resolution Date Comments Resolved By Date	Concur A	vijh Res Ban	ne L Hab	Date 4/30/0	4	Commen	ts Resolv	ed By	Date 9/30/04

		١	/ELOCITY T	RAVERSE	DATA FORM	1			
	Site	325 Model			Run No.	<u>VT-1</u>			
	Date	8/20/2004		Fan C	configuration	Fan 4 (near	stack)		
	Testers	MYB/DDD/G	SH/JMB		Fan Setting	37.1 Hz			
	Stack Dia.	18	in.		Stack Temp	82.5	deg F		
S	tack X-Area	254.5	in.2	Sta	art/End Time	9:07AM - 10	:15AM		
	Elevation	139 3/4		. Cer	nter 2/3 from	1.65	to:	16.35	
Distance to	disturbance	120 5/8	inches	Points i	n Center 2/3	2	to:	7	
V	elocity units	<u>ft/min</u>			Data Files:	NA			
Trial>		1	2	ະວເ 	Mean	1	071	2	Moon
Boint	Donth in	'		<u></u>		├── ──'	2	<u>_</u>	iviean
<u></u>	0.58	797		903	802.2	712	701		724.2
	1.80	942	974	917	944.3	- 713		709	<u> </u>
2	2.40	861	955	926	950.7	022	003	/ 90	827.0
3	- 5.49	860	000	961	950.2	847	<u>810</u>	010	825.0
Conter	0.01	814	007	838	921.2	927	954	010	820.0
Genter	9.00	920	700	030	702.0	027	004	03/	039.3
	14.19		764	709	793.0	010		803	809.3
0	14.01	730	704	793	709.0	/9/	754		780.3
/	17.42	699		620	649.7	722		- 781	787.0
	17.42	801.3	700.4	797.2	702.0	700 0	700 4	774.0	700 4
Averages	/	001.5	790.4		193.0	799.9	/90.4	//4.9	/00.4
			ft/min		from moon	Contor 2/2		North	
		Mean	700.7	Dev		Moon	912.2	<u>1101111</u> 911 7	P11 0
		Min Doint	790.7 649.7		10.00/	Iviean	012.2	011.7	811.9
		Max Daint	040.7		-10.0%		43.2	20.2	32.4
Elo		1280	009.0		0.170			2.5	4.0
		796	form		mstuments	osea.			
VEIAV	y w/0 C-Ft	700 Start	Finish						
Stool: tomp			 						
Stack temp	mn	91	82						
Ambient tem	n	77	85			. Second	~~		
Stock statio	þ	0.02	00	mhoro	000	and the second			
Ambient prog		0.02	20.5		900-				
Ambient pres	sure		29.0	in. ⊓g	V 800-				
Ambient burn	ressure	<u> </u>	1014.0	mbars	e 700-				
Amplent num	liaity	51%	41%	RH	1 /00		4		
					o 600-				
					i 500		-		
Notes:	Wind SE 14	0; 7-9 mph, 1	013.7 mbar		- t 100				
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					_ 0				West
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Procedure El		010	- 	6.1.10		P	a. n. /	Haha	9/20/0
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	V		0			/		C	' /

	0.11	\ 	ELOCITY T	RAVERSE [l 			
	Site	325 Model			Run No.	VT-2			
	Date	8/20/2004		Fan C	onfiguration	Fan 1 (far fr	om stack)		
	Testers	MYB/DDD/G	SH/JMB		Fan Setting	<u>37.1 Hz</u>			
	Stack Dia.	18	in		Stack Temp	85.6	deg F		
Si	tack X-Area	254.5	in.2	Sta	rt/End Time	10:25 - 11:32	2		
	Elevation	139 3/4		Cen	ter 2/3 from	1.65	to:	16.35	
Distance to	disturbance	120 5/8	inches	Points ir	Deta Files	2	to:	<u> </u>	
V	elocity units	<u>ivmin</u>			Data Flies.				
Traverse>			W	est			No		
Trial>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.		Velo	 ocity			Velo	ocity	
1	0.58	742	745	694	727.0	750	660	696	702.0
2	1.89	791	786	762	779.7	753	760	726	746.3
3	3.49	767	775	780	774.0	769	769	736	758.0
4	5.81	772	788	760	773.3	734	786	797	772.3
Center	9.00	760	778	760	766.0	734	771	757	754.0
5	12.19	781	792	801	791.3	757	761	768	762.0
6	14.51	778	787	785	783.3	801	769	757	775.7
7	16.11	766	767	801	778.0	747	782	742	757.0
8	17.42	611	699	679	663.0	769	716	712	732.3
Averages	>	752.0	768.6	758.0	759.5	757.1	752.7	743.4	751.1
		All	<u>ft/min</u>	Dev.	from mean	Center 2/3	West	North	All
		Mean	755.3			Mean	778.0	760.8	769.4
		Min Point	663.0		-12.2%	Std. Dev.	8.1	10.3	12.6
		Max Point	791.3		4.8%	COV as %		1.4	1.6
Flov	ww/oC-Pt	1334	actm		Instuments	Used:			
VelAv	g w/o C-Pt	755	tpm		Solomat Ze	phyr #14/14			
		Start	Finish						
Stack temp		86	91						
Equipment te	emp	83	84			- Carlora	~		
Amplent temp	0	60	90	F mb ara		a constant of the second second	.		
Stack static		0.02	0.02		800-				
Ambient pres	sure	29.5	29.0	in. ng	V 700-				
Total Stack p	ressure	1014.0	210	mpars.	e		(
Amplent num	апу	41%	31%	ΙκΗ	• I 600- o c 500-				
Notes:	wind from S	SW 6-9 mph			t ⁴⁰⁰ y ₃₀₀				
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					p 200				·····
		_			m 100		~ ~	アレテェェ	;
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		_							West
						North	-		
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	Site	225 Madal	/ELOCITY T	RAVERSE		1 \/T 2			
	Site	325 Model		-		<u>VI-3</u>			
	Date	8/26/2004		Fan C	onfiguration	Near Fan (#	4)		
	lesters	JAG/GSH/JM	<u>NB</u>		Fan Setting	37.1 Hz			
	Stack Dia.		<u>in.</u>		Stack Temp	82.4	deg F		
S	tack X-Area	254.5	in.2	Sta	art/End Time	11:22			
	Elevation			Cer	nter 2/3 from	1.65	to:	16.35	
Distance to	disturbance		Inches	Points	n Center 2/3	2	to:	7	
V	elocity units	<u>tt/min</u>			Data Files:	<u>NA</u>			
Traverse>			W	est			No		
Trial>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.		Velo	ocity			Velo	city	
1	0.58	827	831	771	809.7	772	700	742	738.0
2	1.89	830	888	819	845.7	829	784	784	799.0
3	3.49	858	896	844	866.0	836	817	843	832.0
4	5.81	918	894	835	882.3	855	832	856	847.7
Center	9.00	851	821	827	833.0	841	856	828	841.7
5	12.19	800	837	781	806.0	821	839	801	820.3
6	14.51	859	798	740	799.0	821	851	804	825.3
7	16.11	803	793	766	787.3	785	811	803	799.7
8	17.42	751	633	671	685.0	694	784	697	725.0
Averages	>	833.0	821.2	783.8	812.7	806.0	808.2	795.3	803.2
		All	<u>ft/min</u>	Dev	from mean	Center 2/3	West	North	<u>All</u>
		Mean	807.9			Mean	831.3	823.7	827.5
		Min Point	685.0		-15.2%	Std. Dev.	35.7	19.0	27.7
		Max Point	882.3		9.2%	COV as %	4.3	2.3	3.4
Flov	w w/o C-Pt	1421	acfm		Instuments	Used:			
Vel Av	g w/o C-Pt	804	fpm		Solomat Ze	phyr SN 1295	5-1472		
		Start	Finish						
Stack temp		81	84	F					
Equipment te	mp	74	79	F					
Ambient tem	D	74	76	F		and a second second second		************	
Stack static		0.02	0.00	mbars	900-	~~~~			
Ambient pres	sure	1016.5	1016.5	mbars	V 900				
Total Stack p	ressure	1017.0	1017.0	mbars	V 800-				
Ambient hum	idity	43%	38%	RH	i 700-				
					o 600				-
					C				
Notes:					i 500				-
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					300				
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Procedure El	MS-04G-4	910	~	ob. I.		1		abo.	9/2/2
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	04-	\ 205 Madal	ELOCITY T	RAVERSE		1			
	Site	325 Model		Fan O	Run No.	VI-4			
	Date	8/20/2004		Fan C	onfiguration	Far Fan (#1)			
	l esters	JAG/GSH	·		Fan Setting	37.1 HZ			
,	Stack Dia.		in	Ct.	Stack Temp	12:21	deg F		
5	Lack A-Area	254.5	In.2	Sta	tor 0/2 from	13:21	401	46.05	
Distance to	Elevation		inchoo	Cer Deinte i	Ter 2/3 from			10.35	
Distance to	alaaitu unita	ft/min		Points in	Deta Files	Z	- 10.	<u> </u>	
v	elocity units				Data Flies.				
Traverse>							Nor		
Trial>		1	2	3	Mean	1 1	2	3	Mean
Point	Depth, in.		Velo	ocity			Velo	city	
1	0.58	739	719	743	733.7	682	604	717	667.7
2	1.89	751	782	782	771.7	767	763	789	773.0
3	3.49	768	779	813	786.7	810	788	772	790.0
4	5.81	716	789	782	762.3	807	764	791	787.3
Center	9.00	755	741	774	756.7	771	760	767	766.0
5	12.19	762	790	779	777.0	760	782	797	779.7
6	14.51	786	797	780	787.7	796	796	742	778.0
7	16.11	769	745	693	735.7	789	760	784	777.7
8	17.42	637	677	623	645.7	738	726	750	738.0
Averages	>	742.6	757.7	752.1	750.8	768.9	749.2	767.7	761.9
		All	<u>ft/min</u>	Dev	from mean	Center 2/3	West	<u>North</u>	<u>All</u>
		Mean	756.4			Mean	768.2	778.8	773.5
		Min Point	645.7		-14.6%	Std. Dev.	18.4	8.1	14.7
		Max Point	790.0		4.4%	COV as %	2.4	1.0	1.9
Flo	w w/o C-Pt	1335	acfm		Instuments	: Used:			
Vel Av	g w/o C-Pt	756	fpm		Solomat Ze	phyr SN 1295	-1472		
		Start	Finish						
Stack temp		85	89	F					
Equipment te	emp	79	80	F			~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~		
Ambient tem	р	80	80	F		and a state of the			
Stack static		0.01	-0.04	mbars	800-		í La		
Ambient pres	ssure	1016.4	1016.8	mbars	V 700-				
Total Stack p	ressure	1016.4	1016.8	mbars	e				
Ambient hum	hidity	28%	28%	RH	600				
					0				-
					i c 500				
Notes:					- t ⁴⁰⁰				
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					-	-	e I P		
					- ().			West
					-	North			
Signature sig	nifies comp	liance with		Signature v	erifying data	and calculation	ons:		
Procedure E	MS, dAG-4	01 .	•	-1 -		D.		11 1	11
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	,		\mathcal{O}					\bigcirc	/

04-325velocity.xls VT-4 9/30/2004

	Test Instruction					
Project: 325 Stack Sampler Qualification	Date: August 16, 2004	Work Package: F59676				
Tests: Velocity Unifo	rmity in 325 Model Stack, 1	Electric Fan Configuration				
Staff: John Glissmeyer, Dave	Douglas, Marcel Ballinger, Ma	atthew Barnett				
 Reference Procedures: 1. Operating Manual for air 2. Procedure EMS-JAG-04, a Sampler Probe 	 Reference Procedures: 1. Operating Manual for air velocity instrument used 2. Procedure EMS-JAG-04, Test to Determine Uniformity of Gas Velocity at the Elevation of a Sampler Probe 					
3. Model Stack, Fans and Fa	an Speed Controller. Fans wil	l be in positions EF1, EF4.				
Equipment: 1. TSI VelociCalc, Solo velocity measurement	Equipment: 1. TSI VelociCalc, Solomat Zephyr and 36" standard pitot tube, or other calibrated velocity measurement instrumentation					
Safety Considerations: Observe the applicable Job Hazard Analysis for the project						
 Instructions: Verify training on the procedure and that instrumentation is within calibration. Assemble the equipment at the ports at the 12.5 foot elevation above the ground. Use the same measurement points as for flow calibration test. Mark the completion of each step on the field copy of the procedure. Mark-out those steps not applicable to this stack. With one operating fan, set the fan controller to achieve the desired approximate flowrate (1350 - 1450 cfm) Record data on velocity data sheet 						
6. If target flowrate is not a	chieved, adjust fan controller a	nd rerun test.				
 Repeat this test with the other fan operating. Repeat this test again with either fan operating or with the configuration yielding the highest % COV from the first two tests. Diagram mounting fixtures and retain assembly for subsequent tests 						
Desired Completion Date: 08/27/04						
Approvals: <u>Alle Hersonney</u> <u>8/18/04</u> John Glissmeyer, test director Date						
Test completed by:	Test completed by: Hussian Date: 8/26/04					
		ξ <i>γ</i>				

PNNL Operating Procedure					
Title: Test to Determine Uniformity of Gas Velocity at the Elevation of a Sampler Probe	Org. Code: Procedure No.: Rev. No.:	D9T99 EMS-JAG-04 0			
Work Location: General	Effective Date:	November 24, 199	8		
Author: John A. Glissmeyer	Supersedes Date:				
Identified Hazards:	Identified Use Category:				
Are One-Time Modifications Allov	ved? Yes 💥 Ì	No			
Person Signing	Signa	nture	Date		
Technical review: James L. Huckaby					
Project Manager:					
John Glissmeyer					
Line Manager:					
James Droppo					
Quality Engineer:					
Thomas G. Walker					

PNNL Operating Procedure	Rev. No. 0 Org. Code: D9T99	Page 2 of 7 Procedure No.: EMS-JAG-04					
Title: Test to Determine U	Title: Test to Determine Uniformity of Gas Velocity at the Elevation of a Sampler Probe						

1.0 Purpose

The performance of new stack sampling systems must be shown to satisfy the requirements of 40 CFR 61, Subpart H, "National Emission standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities." This regulation governs portions of the design and implementation of effluent air sampling. The stack sampler performance is adequately characterized when potential contaminants in the effluent are of a uniform concentration at the sampling plane and line losses are within acceptable limits. (The sampling plane is the cross section of the stack or duct where the sampling nozzle inlet is located.) Uniformity of contaminant concentration is unlikely where the gas velocity throughout the sampling plane is significantly non-uniform. This procedure provides the means to determine the uniformity of gas velocity, and is performed prior to measurements of contaminant uniformity. This procedure is performed after the range of gas flow conditions are established. Other procedures that usually follow address flow angle, and uniformity of gas and aerosol contaminants.

2.0 Applicability

This procedure can be used in the field or on modeled stacks and ducts to determine the uniformity of air velocity throughout the sampling plane. The results also provide a detailed determination of the flowrate at the ventilation control settings used for the procedure. The tests are applicable within the following constraints:

- The operating limits of the air velocity measurement device used are observed.
- The air velocity sensor element does not occupy more than a few percent of the cross sectional area in the sampling plane.

This procedure may need to be repeated if there are changes made in the configuration of the ventilation system. If the system under test operates within a limited range of airflow that does not change more than $\pm 25\%$, then this procedure is usually conducted once at the middle of the range. If the flow may vary more, then the procedure is performed at least at the extremes of flow.

3.0 Prerequisites and Conditions

Conditions and concerns that must be satisfied prior to performing this procedure are listed below:

- The job-hazards analysis for the work area must be prepared and followed.
- Safety glasses, hard toed or substantial shoes may be required in the work areas.
- Scaffold user training may be required to access the sampling ports of the stack.
- The flow ventilation control device must be installed and means available for its adjustment.
- Air velocity measurement equipment must be within calibration.
- The test instruction must be read and understood.

4.0 Precautions and Limitations

Access to the test ports may require the use of ladders, scaffolding or manlifts, which may necessitate special training for sampling personnel and any observers. The training requirements will be indicated in the job hazard analysis.

5.0 Equipment Used for Measurements

The following are essential items of equipment:

- Air velocity measurement apparatus, which may consist of a calibrated slant tube or electronic manometer, pitot tube, or some other type of sensor;
- Platform, ladders, or manlifts as needed to access the test ports;
- Fittings to limit leakage around the velocity sensor and to stabilize the sensor so it can be repositioned repeatably.

Further details on specific equipment for the job are provided in the Test Instruction. The air velocity instrumentation may be either the types used in 40 CFR 60, Appendix A, Method 2, or other measurement device for discrete points, such as a rotating vane or thermal anemometer. The user must be aware that different devices may give readings in terms of different gas conditions.

6.0 Work Instructions for Setup, Measurements, and Data Reduction

Job specific instructions given in the Test Instruction, illustrated in Exhibit B, will provide details and operating parameters necessary to perform this procedure.

PNNL Operating Procedure Rev. No. 0 Org. Code: D9T99

Page 4 of 7 Procedure No.: EMS-JAG-04

Title: Test to Determine Uniformity of Gas Velocity at the Elevation of a Sampler Probe

WS 9 6.1 8 6.1.1

Preliminary Steps:

- 1.1 Verify that the interior dimensions of the stack or duct at the sampling plane agree with those used in calculating the grid of measurement points given in the test instruction or data sheet.
- 6.1.2 Provide essential supplies at the sampling location (velocity measuring instrumentation, fittings to adapt the sensor to the test ports, marking pens, data sheets, writing and sensor supporting platforms).
- **6.1.3** Verify that the ventilation flow control device is capable of the flow control settings given in the Test Instruction.
- ✓ 6.1.4 Prepare a data sheet for the detailed velocity traverse. See illustration in Exhibit A. Label the columns of traverse data by the direction of the traverse.

Note. For example, if the first reading is closest to the east port, and the last reading is closest to the west port, then label the traverse east-west. Also the first point is the one closest to the port.

Note. The grid of velocity measurement points is calculated in accordance with 40 CFR 60, Appendix A, Method 1. A centerpoint is included as a common reference and for graphical purposes. The layout design divides the area of the sampling plane so that each point represents approximately an equal-sized area

- **6.1.5** Mark the velocity sensor body to indicate the insertion depth for each point in the measurement grid.
- **6.1.6** Obtain barometric pressure, relative humidity, and stack or duct temperature and static pressure if needed to convert the velocity sensor readings to velocity units.
 - 6.1.7 Insert the velocity sensor in the stack or duct and seal the opening around it.

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	Olg. Code: D9199	Procedure No.: EMIS-JAG-04				
Title: Test to Determine Uniformity of Gas Velocity at the Elevation of a Sampler Probe						

6.2 Velocity Uniformity Measurement



Set the flow controller per the test instruction.

Verify that the directional orientations and the numbered measurement positions are consistent with the data sheet.



Measure and record, on the data sheet, the velocity or pressure reading at each measurement point in succession. If the readout device has an averaging feature, record the average of a series of several readings.



MB 6.2.6

6.2.7

Repeat Step 6.2.3.

Compare the results in Step 6.2.3 with those of 6.2.4. If the measurements are not highly reproducible, repeat Step 6.2.3 again.

Calculate the average air velocity for each measurement point.

Calculate the overall average velocity and flowrate for the stack or duct, omitting the center point.



Calculate the coefficient of variance (COV, 100 times the standard deviation divided by the mean) using the average velocity for all points in the inner two-thirds of the cross section area (including the centerpoint).

Compare the observed COV for each run to the acceptance criterion. The acceptance criterion for the COV is #20% for the inner two-thirds of the stack diameter.



.2.10 Review the datasheets for completeness.

6.2.11 Sign and date the datasheets attesting to their validity.

PNNL Operating Procedure	Rev. No. 0	Page 6 of 7			
	Org. Code: D9T99	Procedure No.: EMS-JAG-04			
Title: Test to Determine Uniformity of Gas Velocity at the Elevation of a Sampler Probe					

7.0 Exhibits/Attachments

Exhibit A – Illustration of Detailed Velocity Traverse Data Sheet

VELOCITY TRAVERSE DATA FORM

	Site	W420 6" Moo	lel in 305 f	Building	Run No.	VT6May5_1			
	Date	May 5, 1998		Š	tack Temp	74 d	eg F		
	Tester	Maughan			Stack RH	39 %			
	Stack Dia.	6.328 in.		BP (sta	a. + static)	992 + 0.94 =	~ 993 mbai	s	
S	tack X-Area	31.5 in.		F	an Setting	20 H	z		
	Elevation			Cente	er 2/3 from	0.58	to: 5.	75	
El. above	disturbance	49.25 in.		Points in	Center 2/3	2	to: 7		
	Units	fpm							
Traverse>	Г		Ea	st			South	1	
Trial>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.
1	0.50	892	884	932	902.7	970	980	950	966.7
2	0.66	909	· 935	933	925.7	955	961	960	958.7
3	1.23	948	912	930	930.0	979	1005	979	987.7
4	2.04	946	961	951	952.7	963	951	957	957.0
Center	3.16	955	970	960	961.7	978	955	961	964.7
5	4.28	970	990	994	984.7	975	967	978	973.3
6	5.10	1022	991	1024	1012.3	1055	1010	968	1011.0
7	5.66	971	944	944	953.0	969	960	992	973.7
8	5.83	917	890	886	897.7	920	873	911	901.3
			We	st			North	<u> </u>	
Traverse Av	erages	>		_	946.70				966.00
Average of a	all data		956.35			Center 2/3	E/W	S/N	A
Upper Limit	1.3 x mean		1243.26	Max Point	1012.33	Mean	960.00	975.14	967.57
Lower Limit	0.7 x mean		669.45	Min Point	897.67	Std. Dev.	30.363	18.967	25.559
						COV %		1.9	2.6
Flow	209	cfm			,				
Flow	355	m3/hr							_ [
					_///				
				fpm	[4		_
Notes:					୮				
				1050	////				_
				1030	////				-
				1010					- i
				990-	///				-
				970-//					
				950-					7
				930					
				910				-	
				910	∕∕┛ݐ			' - / I	East
			890-		╤┎╻┚┎				
Instuments Used:			850	_		-	/		
Solomat Zephyr #12951472				820.2					
Cal # 521-28-09-001, Expires 5/1/99						South			
Cinnatura	alanik ing comp	lice a with Broom	Juro EMS- U	AG-04					

Signature/Date

PNNL Operating Procedure	Rev. No. 0	Page 7 of 7					
	Org. Code: D9T99	Procedure No.: EMS-JAG-04					
Title: Test to Determine Uniformity of Gas Velocity at the Elevation of a Sampler Probe							

Exhibit B – Illustrative Test Instruction

	Test Instruction					
Project: W420 6" Stack	Date: August 19, 1998	Work Package: K83017				
Calibration 28361						
Tests: Velocity Un	iformity High Flow in W420	6" Full-Scale Model Stack				
Staff: David Maughan						
Reference Procedures:						
1. Operating Manual for So	lomat Zephyr					
2. Test to Determine Unifor	mity of Gas Velocity at the E	levation of a Sampler Probe,				
Procedure EMS-JAG-04						
Equipment:						
1. W420 6" Full-Scale Mod	el Stack, Fan and Fan Speed	Controller located in 305 Bldg.				
2. Solomat Zephyr and pito	2. Solomat Zephyr and pitot tube					
Safety Considerations:						
Review and observe the appl	icable Numatec Job Hazard A	nalysis for the project				
Instructions:						
1. Assemble the equipment	for the velocity uniformity tes	st at the ports at the elevation of the				
sampling probe						
2. Layout the measurement	points with the following dist	ances from the inside of the stack				
wall: 0.5, 0.66, 1.23, 2.04, 3.	16, 4.28, 5.10, 5.66, 5.83 inch	les.3. Measure the velocity at				
each point at the high (400 c	tm) extreme of stack flow. Re	epeat each measurement twice.				
4. Record data on velocity of	4. Record data on velocity data sheets					
5. Diagram mounting fixtur	5. Diagram mounting fixtures and retain assembly for subsequent tests					
Desired Completion Date: 12/5	/98					
Approvals:						
John Glissmeyer,	project manager	Date				
Test completed by:		Date:				

Appendix D

Flow Angle Procedure and Data

PA NATIO INDE	CIFIC ONAL PENDE REVIE	NORTHWEST LABORATORIES ENT TECHNICAL W RECORD	DOCUMENT N Calculation of H Spreadsheet 04-	DOCUMENT NO.: Calculation of Flow Angle for 325 Model Stack, Spreadsheet 04-325-8ptfloang.xls					_ of <u>_1</u>	
The refer return the please ca	The referenced document is submitted for your review. Instructions for completing this form are attached. Please return the completed form to: <u>John Glissmeyer</u> . If you have any questions, please call John Glissmeyer, 376-8552, cell 531-8006 . Comments Due: 9/28/04									
 Additional Information: (Scope of Review, etc) Please verify the following: Transfer of field data to spreadsheet Calculation of intermediate mean values of flow angle per traverse (one per port) and measurement point (1st and last points per port) Calculation of overall mean absolute angle 										
Org Enviro	Organization/Department Designated Reviewer: vironmental Health Sciences Group					Riðar	signa me L	uture/Date	. a/30/00	
CONCU	R[]	CONCUR, WITH C	OMMENTS [x]	DO NO	OT CONCU	R[]	NOT R	REVIEWED	[]	
Comt. No.	Comr	nent and/ or Recomme	ndation:	•	Resolution:					
1	O- Instruments are not identified specifically. Manometer has calibration due date; barcode would identify instrument.				Barcode inserted.					
Concur with Resolution Roanne LApple Date 7/30/04 Comments Resolved By Date 2/20/04										

FLOW ANGLE DATA FORM

Site	325 Model					
Date	8/20/2004					
Tester	Tester MYB/GSH/JMB					
Stack Dia.	18	in				
Stack X-Area	254.5	in2				
Elevation	121.5	in				
Distance to disturbance	75	in				
		_				

Run No. FA-1 Fan Setting 37.1 Hz Fan configuration Fan 1 (Far from stack) Approx. stack flow 1442 cfm Units degrees (clockwise > pos. nos.)

Traverse>	Γ		E	ast			N	orth	
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	0.58	-15	-8	-15	-12.7	-13	-14	-17	-14.7
2	1.89	-14	-7	-20	-13.7	-12	-13	-16	-13.7
3	3.49	-4	-8	-15	-9.0	-10	-10	-12	-10.7
4	5.81	-7	-7	-9	-7.7	-4	-8	-6	-6.0
Center	9.00	3	-1	-1	0.3	3	-5	4	0.7
5	12.19	6	5	1	4.0	7	5	7	6.3
6	14.51	7	9	12	9.3	11	10	11	10.7
7	16.11	9	. 12	10	10.3	12	12	12	12.0
8	17.42	10	12	9	10.3	14	16	15	15.0
Mean of abs	solute values	8.3	7.7	10.2		9.6	10.3	11.1	
w/o points by	wall:	7.1	7.0	9.7		8.4	9.0	9.7	
								all	9.5
Instuments	Used:			Notes:				w/o wall pts	8.5

Instuments Used:

NI	~	4,		-	•
14	υ	u	2	9	•

		to assure
S-type pitot	Pitot 2	between th
Stanley protractor level	Prot 2	the pitot tul
Manometer	Man-3 Barcode 18120	meniscus t

8/6/2005

similar hose connections ne manometer and pitot tube, rotating be assembly clockwise drives the to the right (to higher pos. numbers).

Manometer Cal. Due



FLOW ANGLE DATA FORM

325 Model					
Date 8/20/2004					
Tester MYB/GSH/JMB					
18	in				
254.5	in2				
121.5	in				
75	in				
	325 Model 8/20/2004 MYB/GSH/ 18 254.5 121.5 75	325 Model 8/20/2004 MYB/GSH/JMB 18 254.5 121.5 75			

Run No. FA-2 Fan Setting 37.1 Hz Fan configuration Fan 4 (near stack) Approx. stack flow 1442 cfm Units degrees (clockwise > pos. nos.)

Traverse>]		Ea	ast			N	orth	
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	0.58	-12	-10	-20	-14.0	-19	-21	-20	-20.0
2	1.89	-12	-10	-22	-14.7	-15	-15	-15	-15.0
3	3.49	-21	-22	-25	-22.7	-20	-16	13	-16.3
4	5.81	-15	-19	-18	-17.3	-9	-15	-8	-10.7
Center	9.00	-5	0	-8	-4.3	-8	-6	-4	-6.0
5	12.19	7	5	1	4.3	7	8	12	9.0
6	14.51	18	13	7	12.7	13	15	16	14.7
7	16.11	20	17	15	17.3	19	15	18	17.3
8	17.42	21	22	23	22.0	21	19	19	19.7
Mean of abs	olute values	14.6	13.1	15.4		14.6	14.4	13.9	
w/o points by	wall:	14.0	12.3	13.7		13.0	12.9	12.3	
								ali	14.3
Instuments l	Jsed:			Notes:				w/o wall pts	13.0

Instuments Used:

Ν	o	te	s	;

		to assure similar hose connections
S-type pitot	Pitot 2	between the manometer and pitot tube, rotating
Stanley protractor level	Prot 2	the pitot tube assembly clockwise drives the
Manometer	Man-3 Barcode 18120	meniscus to the right (to higher pos. numbers).

Manometer Cal. Due





FLOW ANGLE DATA FORM

Site	325 Model		Run No. FA-3
Date	8/26/2004		Fan Setting 37.1 Hz
Tester	GSH/JAG		Fan configuration Near
Stack Dia.	18	in	Approx. stack flow cfm
Stack X-Area	254.5	in2	Units degrees (clockwise = NEG. nos.)
Elevation	121.5	in	
Distance to disturbance	75	in	

Traverse>	Г		Ea	ast			N	orth	
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	0.58	-2	-4	-4	-3.3	-1	-2	-2	-1.7
2	1.89	-3	-4	-7	-4.7	-3	-4	-4	-3.7
3	3.49	-4	-7	-14	-8.3	-4	-5	-7	-5.3
4	5.81	-3	-6	-11	-6.7	-3	-4	-4	-3.7
Center	9.00	0	-3	-3	-2.0	0	1	0	0.3
5	12.19	4	4	6	4.7	7	8	6	7.0
6	14.51	13	13	12	12.7	13	15	13	13.7
7	16.11	18	14	18	16.7	12	16	15	14.3
8	17.42	22	20	18	20.0	15	16	15	15.3
Mean of abs	olute values	7.7	8.3	10.3		6.4	7.9	7.3	
w/o points by	wall:	6.4	7.3	10.1		6.0	7.6	7.0	
								all	8.0
Instuments I	Jsed:			Notes:				w/o wall pts	7.4

		to assure similar nose connections
S-type pitot	Pitot 2	between the manometer and pitot tube, rotating
Stanley protractor level	Prot 2	the pitot tube assembly clockwise drives the
Manometer	Man-3 Barcode 18120	meniscus to the right (to higher pos. numbers).

Manometer Cal. Due

e 8/6/2005



Test Instruction					
Project: 325 Stack Sampler Oualification	Date: August 16, 2004	Work Package: F59676			
Tests: Flow Angle at Nominal Flow in 325 Model Stack, 1 Electric Fan Configuration					
Staff: John Glissmeyer, Marcel Bal	linger, Matthew Barnett, Dave Doug	glas			
Reference Procedures:					
1. Test to Determine Flow A	ngle at the Elevation of a Sampler H	Probe, Procedure EMS-JAG-05			
Equipment:					
1. S-type Pitot Tube, sla	nt tube or electronic manomet	ter, connecting surgical or silicone			
tubing, clamp-on poin	nter and protractor, and protrac	ctor level, tape measure, Sharpie			
Pen, or pre-marked te	mplate				
2. Adapter swivel fitting	s to interface pitot tube to test	port			
3. Model Stack, Fans an	d Fan Speed Controller. Fans	will be in positions EF1, EF4.			
	1	1			
Safety Considerations:					
Observe the applicable Job H	lazard Analysis for the project				
nstructions:					
1. Verify training on the procedure and that instrumentation is within calibration.					
2. Mark the completion of each step on the field copy of the procedure. Mark-out those					
steps not applicable to	o this stack.				
3. Assemble the equipm	ent for the flow angle test at the	he test ports ~ 12.5 feet above the			
ground. The protract	or level can be attached to the	pitot tube for flow in the vertical			
direction.		•			
4. Use the same measure	ement points as for flow calibred	ration test.			
5 Repeat flow angle measurement for both fans, which will be operated one at a time.					
6. Verify that stack flow is about the target flow rate $(1350 - 1450 \text{ cfm})$. This can be					
determined from man	ual velocity readings the pred	letermined flow control setpoint of			
the output of the insta	and versely readings, the prec				
7 Measure the flow angle at each point. Repeat each measurement three times					
7. Measure the now angle at each point. Repeat each measurement three times.					
6. Record the data on now angle data sheets.					
9. Diagram mounting II.	xtures and retain assembly for	subsequent tests.			
Desired Completion Date: 8/27/04					
Approvals: Month for	549	8/2/04			
John Glissmeyer		Date			
Test completed by:	Date:	81-20104			

•

Title: Test to Determine Flow Angle	Org. Code: Procedure No.: Rev. No.:	D9T99 EMS-JAG-05 0	
Work Location: General	Effective Date:	November 24, 19	998
Author: John A. Glissmeyer	Supersedes Date:		
 Hazardous Materials Physical Hazards Hazardous Environment 	Continuous Use Reference Use		
X Other: Are One-Time Modifications Allow	ved? Yes 💥	No	
X Other: Are One-Time Modifications Allov Person Signing	ved? Yes X	No	Date
Other: Are One-Time Modifications Allow Person Signing Technical review: James L. Huckaby	ved? Yes X	No	Date
Other: Are One-Time Modifications Allow Person Signing Technical review: James L. Huckaby Project Manager:	ved? Yes & Sign	No ature	Date
 Other: Are One-Time Modifications Allow Person Signing Technical review: James L. Huckaby Project Manager: John Glissmeyer 	ved? Yes X Sign	No	Date
Xe One-Time Modifications Allow Person Signing Technical review: James L. Huckaby Project Manager: John Glissmeyer Line Manager:	ved? Yes X Sign	No	Date
 Conternation Modifications Allow Person Signing Technical review: James L. Huckaby Project Manager: John Glissmeyer Line Manager: James Droppo 	ved? Yes X	No	Date
Xe Other: Are One-Time Modifications Allow Person Signing Technical review: James L. Huckaby Project Manager: John Glissmeyer Line Manager: James Droppo Quality Engineer:	ved? Yes X Sign	No	Date

PNNL Operating Procedure	Rev. No. 0 Org. Code: D9T99	Page 2 of 9 Procedure No.: EMS-JAG-05			
Title: Test to Determine Flow Angle					

1.0 Purpose

The performance of new stack sampling systems must be shown to satisfy the requirements of 40 CFR 61, Subpart H, "National Emission standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities." This regulation governs portions of the design and implementation of effluent air sampling. The stack sampler performance is adequately characterized when potential contaminants in the effluent are of a uniform concentration at the sampling plane and line losses are within acceptable limits. (The sampling plane is the cross section of the stack or duct where the sampling nozzle inlet is located.) Uniformity of contaminant concentration is highly unlikely where the mean angle of the gas velocity throughout the cross section of the stack or duct is significantly non-zero. This condition would also mean that the air velocity approaches the sampling nozzle at an unacceptable angle, degrading the performance of the nozzle. This procedure provides the means to determine the mean flow angle, and is performed prior to measurements of contaminant uniformity. This procedure is performed after the range of gas flow conditions is established. Other associated procedures generally follow and address uniformity of flow and of gas and aerosol contaminants.

2.0 Applicability

This procedure can be used in the field or on modeled stacks and ducts to determine the angle of the air velocity relative to the axis of the duct or stack. The angle measured is the roll angle. This should be determined at the sampling plane. The tests are applicable within the following constraints:

- The operating limits of the air velocity measurement device used are observed.
- The air velocity sensor element does not occupy more than a few percent of the crosssectional area in the plane of the element.

This procedure may need to be repeated if there are changes made in the configuration of the ventilation system. If the system under test operates within a limited range of airflow that does not change more than $\pm 25\%$, this procedure is usually conducted once at the middle of the range. If the flow varies more, the procedure is performed at least at the extremes of flow.

3.0 Prerequisites and Conditions

Conditions and concerns that must be satisfied prior to performing this procedure are listed below:

- The job-hazards analysis for the work area must be prepared and followed.
- Safety glasses, hard toed or substantial shoes may be required in the work areas.
- Scaffold user training may be required to access the sampling ports of the stack.
- A ventilation flow control device must be installed and means available for its adjustment.
- Air velocity measurement equipment must be within calibration.
- The test instruction must be read and understood.

4.0 Precautions and Limitations

Access to the test ports may require the use of ladders, scaffolding or manlifts, which may necessitate special training for sampling personnel and any observers. The training requirements will be indicated in the job hazard analysis.

5.0 Equipment Used for Measurements

The following are essential items of equipment:

- A Type-S pitot tube with sufficient length to reach across the diameter of the test stack,
- Slant tube or calibrated electronic manometer to indicate when the differential pressure reading of the pitot tube is about zero,
- Device for measuring the pitot tube angle at traverse points (e.g., a protractor level with good angle resolution). (Note: A three dimensional velocity probe capable of measuring both pitch and yaw angles of gas flow is also acceptable provided that modifications in the method outlined below are made),
- Tape or template to mark insertion depths on the pitot tube,
- Velocity sensor to check the stack airflow,
- Means to obtain temperature and barometric pressure for any corrections needed for the current test conditions,
- Platform, ladders, or manlifts as needed to support equipment and to access the test ports,
- Fittings to limit leakage around the pitot tube and to stabilize the tube so that it can be positioned repeatedly in the test stack at the same location.
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|-------------------------------------|--|--|--|--|--|
| Title: Test to Determine Flow Angle | | | | | |

Further details on specific equipment for the job are provided in the Test Instruction. The test method is based on 40 CFR 60, Appendix A, Method 1, Section 2.4, "Verification of the Absence of Cyclonic Flow." The measurement instrumentation may be either the type used in Method 1, or another measurement device designed for measuring the angle of the velocity vector at discrete points. The user should be aware that different devices may give different readings.

6.0 Work Instructions for Setup, Measurements, and Data Reduction

Job specific instructions given in the Test Instruction, illustrated in Exhibit A, will provide details and operating parameters necessary to perform this procedure. Prior to determination of flow angles, measurements should be made to assess whether the stack velocity flow is within normal limits.



Preliminary Steps:

Verify that the interior dimensions of the stack or duct at the measurement locations agree with those used in calculating the grid of measurement points given in the test instruction or data sheet.

> **Note.** The grid of measurement points is calculated in accordance with 40 CFR 60, Appendix A, Method 1. A centerpoint is included as a common reference and for graphical purposes. The layout design divides the area of the sampling plane so that each point represents approximately an equal-sized area

- **6.1.2** Provide essential supplies at the sampling location. (S-Type pitot tube, manometer, tubing, fittings to adapt the sensor to the test ports, marking pens, data sheets, writing and sensor supporting platforms).
- **6.1.3** Verify that the ventilation flow control device is capable of the flow control settings given in the Test Instruction.

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- **6.1.4** Prepare a data sheet for the measurement traverse. See illustration in Exhibit B. Label the columns of traverse data by the direction of the traverse. For example, if the first reading is closest to the east port, and the last reading is closest to the west port, then label the traverse "eastwest".
- 6.1.5 Mark the Type-S pitot tube to indicate the insertion depth for each point in the measurement grid.
- 6.1.6 Set the stack flow control per the test instruction. (Use a velocity or flow sensor to verify that correct flow has been achieved.)

Note. Flow verification can be based on a single point velocity reading. The single point can be the same one determined in the stack flow controller calibration in Procedure EMS-JAG-03. The barometric pressure, relative humidity, stack temperature and static pressure values may be needed to convert the velocity sensor readings to velocity units.

6.1.7 Insert the Type-S pitot tube in the stack or duct, seal the opening around it, and check for smooth operation of the pitot tube.

Note. Good measurements are dependent upon making small repeatable rotations of the pitot tube in the available fittings.

6.1.8 Establish a convention for representing the angular direction of flow.

Note. If an inclined manometer is used, connect the flexible tubes between the connectors on the pitot tube and the manometer so that rotating the pitot tube assembly clockwise drives the meniscus to the right, i.e., to higher positive numbers.

Attach a circular protractor to the pitot tube near the tubing connectors. Generally the protractor hangs below the pitot tubes. When the parallel tubes are in horizontal position, the protractor should indicate zero degrees. If the tubing assembly is rotated clockwise, the resulting counter-clockwise movement of the angle indicator produces an angle that is read as a positive number. This is consistent with the convention for reading circular angles.

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MAK / CY 6.1.9

1.9 Position the inclined manometer on a stable platform and level the device using the spirit level.

Note: Movement on the test platform may affect the manometer level. It should be checked frequently. Adjustments can be made at any time when the pitot tube is moved to the next position, but not during readings at any single point.

- **6.1.10** Connect the flexible tubes to the inclined manometer but disconnect them from the pitot tube.
- **6.1.11** Increase or decrease the red oil level in the inclined portion of the manometer to zero the meniscus. (This is done using a finger-adjustable screw at the base of the manometer.)
- 6.1.12 Reconnect the flexible tubes to the pitot tube.

6.2 Angular Flow Measurements

6.2.1 Verify that the directional orientations and the numbered measurement positions are consistent with the data sheet.



Note: Each test relies on one repetition for each measurement point in each traverse direction, repeated three times. The repeats are made as three separate runs and not as three consecutive measurements at each point.

The readings may be erratic for some flow conditions and at some traverse positions. Care should be taken to approach these variable readings from both higher and lower angles to obtain the most accurate equilibrium reading.

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Repeat Step 6.3.3.

Compare the results in Step 6.3.4 with those of 6.3.3. If the measurements are not highly reproducible, repeat Step 6.3.3 again.

Calculate the absolute average air-flow angle for each measurement point.

Calculate the average absolute flow angle for all measurement points.

Note: The acceptance criterion is that the average flow angle not exceed 20 degrees.



916 6.2.5 8-2-04

M.6.2.6

Review the datasheets for completeness.

Sign and date the datasheets attesting to their validity.

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7.0 Exhibits/Attachments

Exhibit A – Illustrative Test Instruction

	Test Instruction						
Project: W420 6" Stack	Date: August 19, 1998	Work Package: K83017					
Calibration 28361							
Tests: Flow An	gle at High Flow in W420 6"	Full-Scale Model Stack					
Staff: David Maughan							
Reference Procedures:							
1. Operating Manual for So	lomat Zephyr						
2. Test to Determine Flow A	Angle at the Elevation of a Sar	npler Probe, Procedure EMS-JAG-					
05							
Equipment:		Dente 11 - 1					
1. W420 6" Full-Scale Mod	lel Stack, Fan and Fan Speed C	Controller located in 305 Bldg.					
2. S-type Pitot Tube, slant t	ube or electronic manometer,	and Protractor Level					
Safety Considerations:							
Review and observe the appl	icable Numatec Job Hazard A	nalysis for the project					
Instructions:							
5. Assemble the equipment	for the flow angle test at the p	orts at the elevation of the sampling					
probe.							
2. Layout the measurement	points with the following dist	ances from the inside of the stack					
wall: 0.5, 0.66, 1.23, 2.04, 3.	16, 4.28, 5.10, 5.66, 5.83 inch	es.3. Measure the flow angle at					
each point at the high (400 c	fm) extreme of stack flow. Re	epeat each measurement twice.					
4. Record the data on flow a	angle data sheets.						
5. Diagram mounting fixtur	es and retain assembly for sub	osequent tests					
Desired Completion Date: 12/5	5/98						
Approvals:							
John Glissmeyer,	project manager	Date					
Test completed by:		Date:					

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Title: Test to Determine Flow Angle						

Exhibit B - Illus tration of Flow Angle Data Sheet

	W420 296	6-C-5 FLO	W ANGLE	E at High ar	nd Low Av	verage Flo	w Rates	
	Site_	12/ /100	8	S	Kun No. tack Temp		deg E	
	Tester	12/ /100	0	Stack RH percent			percent	
	Stack Dia.	12	in	Baro Press			mbar	
St	ack X-Area	113.1	in2	F	an Setting		Hz	
_	Elevation		ft	Fai	n input port		. .	
El. above o	disturbance	in		Flowrate (pr	e-&post-)		and of most cont	
input	an nitereu?			Approx. av	J. Flowrate Units	degrees (c	cim at cento clockwise > r	os nos)
						409.000 (0		
Traverse>	> · [East			South		
Trial>		1	2	3	1	2	3	
Point	Depth, in.	deg. cw	deg. cw	deg. cw	deg. cw	deg. cw	deg. cw	
1	0.50							
2	0.80							
3	1.42							
4	2.12	_						
5	3.00		_					
6	4.27							
CenterPt.	6.00							
7	7.77							
8	9.00					_		
9	9.88							
10	10.58							
11	11.20							
12	11.50							
			West			North		<u>All</u>
Absolute Av all data:	verage of	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Instuments Used: Cal Exp. Date: Parallel-tube pitot with 90-deg. bends at sample ends, 24-inches in length. NA Dwyer Instruments 0-5 inch inclined manometer with red guage oil zero'd and leveled (with connecting tubes open to room atmosphere). NA Angles made using Empire #36 circular protractor. Notes: To secure similar been connecting between the manameter and pitet tube rotation								
the pitot tub	e assemble	clockwise	drives the m	ne manomet neniscus to th	e right (to h	ligher pos. I	numbers).	

Signature signifies compliance with Procedure EMS-JAG-05	
Signature/date	

Appendix E

Tracer Gas Uniformity Procedure and Data

INDEPENDENT TECHNICAL REVIEW RECORD

PA NATI INDE	CIFIC ONAL PENDI REVIE	NORTHWEST LABORATORIES ENT TECHNICAL W RECORD	DOCUMENT N <u>Calculation of (</u> <u>Characteristics</u> 04-325 Scalega	er Uniformity Model Stack, Spreadsheets Page <u>1</u> of <u>1</u>				
The refer return the please ca	enced d e comple ll <u>Jc</u>	locument is submitted for eted form to: <u>John G</u> ohn Gissmeyer, 376-85	or your review. Ins lissmeyer 52, cell 531-8006	tructions	for complet	ting this f	orm are a If you ha Due:	ttached. Please ave any questions, 0/28/04
Additiona 1. 2. 3. 4. 5. 6. 7.	al Inform Transfe Calcula and last Calcula area in f Calcula Calcula Calcula Verify c Verify c print sp	mation: (Scope of Rev r of field data to spread tion of intermediate me points per port) for the tion of port and overall first and last runs. tion of grand mean and tion of normalized conc prientation of plotted ba consistency of equations readsheet formulas and	iew, etc) Please ve sheet (all runs) an concentration va first and last runs. mean concentration maximum deviation centration data (2 po rs in the first and la s in intermediate run inspect and mark th	rify the fo alues per t an, standar n of mean pints) for st runs. ns by insp nem.)	ollowing: raverse (on d deviation for all mea plotting in t pection of sp	e per port , and %Co asurement the first a preadshee	t) and mean OV for th t points in nd last run t in softw	asurement point (1 st e center 2/3 of stack first and last runs. ns. vare form. (May
Org Enviror	on/Department al Health Sciences	Designated Review Rosanne Aaberg	wer:		Da	Signa Fam	ture/Date	
CONCUI	R[]	CONCUR, WITH CO	DMMENTS [x]	DO NO	T CONCU	, R[]	NOT R	EVIEWED []
Comt.	Comr	ment and/ or Recommer	ndation:		Resolutio	on:		
1	O- In table indica	jection flowmeter row i needs a footnote explai ates (black, plastic ball jated with the value giv	n temperature/press ning what "ball**" or steel ball), and th en in the table	sure ne units	Done, however the reading is just a percent of scale. We adjust the flow to get in the concentration range that we want			
 associated with the value given in the table. M - Ambient pressure with units of mbar, listed at the bottom of temperature/ pressure table of sheets GT-1 though GT-4 should be listed as Ambient temperature, with units °F, as on the original sheets. Sheets GT-5 through GT-11 originals list Ambient Pressure in this location; Ambient Temperature is listed under Notes. These sheets should be corrected to list the Ambient temperature, same as for GT-1 					Added th existed.	e ambien	t tempera	ture data where it
3	O – T each repres graph by rev M32:	The labels of points (cor of the East series plots (sented in reverse order is. In the future, the conversing the points chart U32 of spreadsheets).	responding to depth (GT-1 through GT1 from the labels on t infusion could be rea ed in the graph (sou	ОК				
Concur y	vith Res <u>Xann</u>	olution 21 Aaber	Date 9/30/04	,	Commen	ts Resolv	ed By	Date <u>29/38/04</u>

		TR	ACER GAS	TRAVERSE	DATA FOR	M				
Site 325 Model					Run No.	<u>GT-1</u>				
	Date	9/1/2004		Fan C	configuration	Near fan				
	Tester	JAG/GSH/JN	1 <u>B</u>		Fan Setting	37.1 Hz				
_	Stack Dia.	18	n		Stack Temp	85 0	leg F			
S	tack X-Area	254.5	n.2	Sta	art/End Time	1500/1630		40.05		
	Elevation	N.A.		Cer	hter $2/3$ from	1.65	to:	16.35		
Distance to	disturbance	120	ncnes	Points I	n Center 2/3		το:	1		
weasu	rement units	ppm SF6		IŊ	jection Point	10p South_				
			 Fa				No	orth		
Trial>		1	2	3	Mean	1	2	3	Mean	
Point	Depth in		2				 	<u>~</u>		
1	0.58	3,55	3.03	3.24	3.27	3.25	3.27	2.94	3.15	
2	1.89	3.91	3.26	3.09	3.42	3.10	2.80	3.05	2.98	
3	3.49	3.12	2.89	3.12	3.04	3.00	2.86	3.24	3.03	
4	5.81	3.28	3.01	2.97	3.09	3.02	3.01	2.84	2.96	
Center	9.00	2.84	2.93	3.14	2.97	3.00	3.01	2.85	2.95	
5	12.19	2.94	2.88	2.90	2.91	2.79	2.90	2.96	2.88	
6	14.51	2.76	2.87	2.86	2.83	2.94	3.24	2.95	3.04	
7	16.11	3.08	3.38	2.80	3.09	2.81	2.86	2.99	2.89	
8	17.42	3.33	2.98	3.02	3.11	2.97	3.09	3.10	3.05	
Averages	>	3.20	3.03	3.02	3.08	2.99	3.00	2.99	2.99	
		AII	ppm	<u>Dev</u>	<u>/. from mean</u>	<u>Center 2/3</u>	<u>East</u>	<u>North</u>	All	
		Mean	3.04			Mean	3.05	2.96	3.01	
		Min Point	2.83		-6.8%	Std. Dev.	0.19	0.06	0.14	
	o o (7	Max Point	3.42		12.6%	COV as %	6.21	2.14	4./5	
Avg. Conc.	3.047	ppm				er cneckea:				
		04-14	Ti-i-b		9/1/2004	19 mph quet	s to 25 mph			
Tresser topk n	roccuro	Start	Finish 375	nsia		To mpn, gust	<u>s to zo mpn</u>	·		
Sample Port	Temp	85	85	F	· · · · · · · · · · · · · · · · · · ·					
Centerline ve	16115	833	826.0	fpm						
Injection flow	meter	3	3	% bl. ball**				******		
Stack flow				cfm		C. T. M. W. M.				
Sampling flow	wmeter	10	9.5	lpm Sierra	3.5					
Ambient pres	sure	748.3	748.5	mm Hg	3					
Ambient hum	hidity	28.0	24.0	RH	J					
B&K vapor c	orrection	N	N	Y/N	2.5			· · ·		
		41/33/35/28/								
Back-Gd gas	level	29	35/34/25/28	ррь	P 2					
No. Bk-Gd sa	amples	5	4	n Les E	m			i	- 1	
Ambient tem	p.	81.0	83.0	aeg. F	1.5-					
	Used:	200			-					
B & K Model	1302 #1765	299 Air Sampler			- ']			▋▐▛▌᠃▋	•••	
Selomat Ze	phyr SN 12	95-1472	_		0.5				e /	
**Reading of	n black pla	stic hall float	in flowmet	er	-	5	- 1 P			
Note: At this point the duct is 18 v 18 inches										
The injection probe reaches 8-in off center so with the					-				East	
elevation adjusted accordingly, the injection is one-inch					-	North				
from both si	des of a co	rner. Also, t	he center in	njection	-					
point is 8-in	point is 8-in closer to the stack than the injection port.									
Signature sig	nifies comp	liance with		Signature v	erifying data	and calculati	ons:	1		
Procedure E	MS-JAG-01	1 an	-			Ĉ.	li.	ha a	1- laid	
Signature/da	ite XX	n Alu	press	9/30/04	/	panne	LHA	Ber 1	50/04	
	\mathcal{O}		1			1 0/20/000 4	,	O'	/ /	
	U 04-325 Scale gasunif.xls GT1 9/30/2004									

	TRACER GAS TRAVERSE DATA FORM								
	Site	325 Model			Run No.	GT-2			
	Date	9/2/2004		Fan C	Configuration	Near fan			
	Tester	JAG/GSH/JM	В		Fan Setting	37.1 Hz			
	Stack Dia.	18 ii	n		Stack Temp	82 0	deg F		
S	tack X-Area	254.5 ii	n.2	Sta	art/End Time	1347/1445			
	Elevation	N.A.		Cer	nter 2/3 from	1.65	to:	16.35	
Distance to	disturbance	120 ii	nches	Points i	in Center 2/3	2	to:	7	
Measu	rement units	ppm SF6		In	jection Point	Top North - 1	-in from wal	s at corner	
Traverse>			Ea	ast			Nor	th	
Trial>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.		рр	m			рр	m	
1	0.58	3.42	3.70	3.71	3.61	3.68	3.64	3.60	3.64
2	1.89	3.55	3.86	3.56	3.66	3.68	3.57	3.43	· 3.56
3	3.49	3.65	3.71	3.44	3.60	3.64	3.37	3.43	3.48
4	5.81	3.50	3.70	3,46	3.55	3.62	3.43	3.43	3.49
Center	9.00	3.56	3.63	3.66	3.62	3.64	3.33	3.19	3.39
5	12.19	3.65	3.79	3.48	3.64	3.63	3.55	3.34	3.51
6	14.51	3.61	3.49	3.38	3.49	3.54	3.32	3.33	3.40
7	16.11	3.66	3.63	3.42	3.57	3.54	3.35	3.36	3.42
	17.42	3.63	3.57	3.30	3.50	3.64	<u>3.51</u>	3.30	3.48
Averages	>	3.58	3.68	3.49	3.58	3.62	3.45	3.38	3.48
		All	ppm	Dev	 from mean 	<u>Center 2/3</u>	<u>East</u>	<u>North</u>	All
		Mean	3.53			Mean	3.59	3.46	3.53
		Min Point	3.39		-4.2%	Std. Dev.	0.06	0.06	0.09
		Max Point	3.66		3.5%	COV as %	1.56	1.86	2.49
Avg. Conc.	3.538	ppm			Gas analyz	er checked:			
					9/1/2004				
		Start	Finish		Wind WSW	18 mph, gust	s to 25 mph		
Tracer tank p	ressure	315	3/5	psig					
Sample Port	lemp	/9	85	F					
Centerline ve	el.	813	826.0	1pm				*****	
injection flow	meter	3	3	% DI. Dall**	1	and the second sec		-	
Stack flow			0.5		4-				
Sampling tio	vmeter	10	9.5	ipm Sierra					
Amplent pres	sure	29.50	/48.5	mm rig	3.5				
		28			3-				-
B&K vapor c	orrection	25/22/26/26/	IN 101201/2010	T/IN					
Back-Gd das	level	26/22/20/26/	21	ppb	2.5				
No Bk-Gd sa	amples	5	4	n	P D				-
Ambient tem	D.			dea. F	m 27				-
Instuments	Used:	L		3	1.5				
B & K Model	1302 #1765	299							
Sierra Inc. C	onstant Flov	Air Sampler			14				····
Solomat Zer	ohvr SN 12	95-1472			0.5				
**Reading on black plastic ball float in flowmeter									
Notes: At this point, the duct is 18 x 18 inches					- 0-				
The injection	n probe rea	ches 8-in off	center, so	with the	•				East
elevation adjusted accordingly, the injection is one-inch						North			
from both si	des of a co	rner. Also, th	ne center in	njection	•				
point is 8-in	point is 8-in closer to the stack than the injection port.								
Signature sid	nifies comp	liance with	<u> </u>	Signature v	erifying data	and calculation	ons:		
Procedure E	MS-JAG-01	1	0			\sum	/ /	11	ah L
Signature/da	te	n Alex	only	9/20/00	1	Nean	ne ht	TAPA	4BOROY
			1					1	· · · ·
✓ 04-325 Scale gasunif.xls GT2 9/30/2004 ()									

			ACER GAS	IRAVERSE	DATAFUR				
	Site	325 Model			Run No.	GT-3			
	Date	9/2/2004		Fan C	onfiguration	Near fan			
	Tester	JAG/GSH/JN	<u>ив</u>		Fan Setting	37.1 Hz			
	Stack Dia.	18	in		Stack Temp	87	dea F		
St	tack X-Area	254.5	in.2	Sta	rt/End Time	1445/1525			
0.	Elevation	NA		Cer	ter 2/3 from	1.65	to:	16 35	
Distance to	disturbance	120	nches	Points i	n Center 2/3	2	to:	7	
Distance to	ansurbance		licites	r onto i	action Point	Contor		<u> </u>	
Measur	ement units	ppm SF0			ection Folint	Center			
Turiuman									
Traverse>			Ea	ast	Maar		110	rtn	
	<u> </u>	1	2	3	Mean	1	2	3	Mean
Point	Depth, in.		pp	om		0.00	<u>pp</u>	m o sel	
1	0.58	3.54	3.36	3.67	3.52	3.66	3.70	3.52	3.63
2	1.89	3.49	3.26	3.39	3.38	3.50	3.70	3.35	3.52
3	3.49	3.36	3.72	3.10	3.39	3.70	3.97	3.41	3.69
4	5.81	3.28	3.30	3.53	3.37	3.67	3.38	3.99	3.68
Center	9.00	3.46	3.15	3.44	3.35	3.58	3.48	3.01	3.36
5	12.19	3.45	3.48	3.42	_3.45	4.08	3.21	3.01	3.43
6	14.51	3.37	3.14	3.45	3.32	3.61	3.38	3.59	3.53
7	16.11	3.79	3.45	3.46	3.57	3.55	3.27	3.92	3.58
8	17.42	3.50	3.29	3.70	3.50	3.16	3.42	3.20	3.26
Averages	>	3.47	3.35	3.46	3.43	3.61	3.50	3.44	3.52
-									
		All	ppm	Dev	from mean	Center 2/3	East	North	All
		Mean	3.47			Mean	3.40	3.54	3.47
		Min Point	3.26		-6.1%	Std. Dev.	0.08	0.12	0.12
		Max Point	3.69		6.3%	COV as %	2.41	3.47	3.54
Ava Conc	3 489	nom			Gas analyz	er checked:			
Avg. Conc.	0.400	ppm			9/1/2004				
		Start	Finish		0/ 1/200				
Tracor tank n	roccuro	315	315	nsia					
Tracer tank p	ressure	315	315	psig ⊏					
Tracer tank p Sample Port	oressure Temp	315 86	315 88 779.0	psig F					
Tracer tank p Sample Port Centerline ve	oressure Temp el.	315 86 830	315 88 779.0	psig F fpm					
Tracer tank p Sample Port Centerline ve Injection flow	oressure Temp el. meter	315 86 830 3	315 88 779.0 3	psig F fpm % bl. ball**			1		
Tracer tank p Sample Port Centerline ve Injection flow Stack flow	oressure Temp el. meter	315 86 830 3	315 88 779.0 3	psig F fpm % bl. ball** cfm	47				
Tracer tank p Sample Port Centerline ve Injection flow Stack flow Sampling flow	oressure Temp el. vmeter wmeter	315 86 830 3 10	315 88 779.0 3 10	psig F fpm % bl. ball** cfm Ipm Sierra	4-				
Tracer tank p Sample Port Centerline ve Injection flow Stack flow Sampling flow Ambient pres	oressure Temp el. meter wmeter ssure	315 86 830 3 10 29.54	315 88 779.0 3 10 29.5	psig F fpm % bl. ball** cfm Ipm Sierra mm Hg	3.5	ļ			
Tracer tank p Sample Port Centerline ve Injection flow Stack flow Sampling flow Ambient press Ambient hum	oressure Temp el. meter wmeter ssure nidity	315 86 830 3 10 29.54 27	315 88 779.0 3 10 29.5 24	psig F fpm % bl. ball** cfm Ipm Sierra mm Hg %RH	4	ł			
Tracer tank p Sample Port Centerline ve Injection flow Stack flow Sampling flow Ambient pres Ambient hum B&K vapor co	oressure Temp el. meter wmeter ssure nidity prrection	315 86 830 3 10 29.54 27 N	315 88 779.0 3 10 29.5 24 N	psig F fpm % bl. ball** cfm Ipm Sierra mm Hg %RH Y/N	4	ł			
Tracer tank p Sample Port Centerline ve Injection flow Stack flow Sampling flow Ambient pres Ambient hum B&K vapor co	oressure Temp el. meter wmeter ssure nidity orrection	315 86 830 3 10 29.54 27 N 29/21/23/21/ 21/23/21/	315 88 779.0 3 10 29.5 24 N 25/20/24/22/ 23	psig F fpm % bl. ball** cfm Ipm Sierra mm Hg %RH Y/N	4	ł			
Tracer tank p Sample Port Centerline ve Injection flow Stack flow Sampling flow Ambient pres Ambient hum B&K vapor co Back-Gd gas	oressure Temp el. meter wmeter ssure hidity orrection	315 86 830 3 10 29.54 27 N 29/21/23/21/ 21/23/21/ 21	315 88 779.0 3 10 29.5 24 N 25/20/24/22/ 23	psig F fpm % bl. ball** cfm Ipm Sierra mm Hg %RH Y/N	4 3.5 3 2.5 P				
Tracer tank p Sample Port Centerline ve Injection flow Stack flow Sampling flow Ambient pres Ambient hum B&K vapor co Back-Gd gas No. Bk-Gd sa	oressure Temp el. meter wmeter ssure nidity orrection	315 86 830 3 10 29.54 27 N 29/21/23/21/ 21 5	315 88 779.0 3 10 29.5 24 N 25/20/24/22/ 23 5	psig F fpm % bl. ball** cfm Ipm Sierra mm Hg %RH Y/N Ppb n	4 3.5 3 2.5 P P 2	I			
Tracer tank p Sample Port Centerline ve Injection flow Stack flow Sampling flow Ambient pres Ambient hum B&K vapor co Back-Gd gas No. Bk-Gd sa Ambient temp	ressure Temp el. meter wmeter ssure nidity orrection elevel amples p.	315 86 830 3 	315 88 779.0 3 10 29.5 24 N 25/20/24/22/ 23 5 76.0	psig F fpm % bl. ball*** cfm Ipm Sierra mm Hg %RH Y/N Ppb n deg. F	4 3.5 3 2.5 P P 2 m 1.5				
Tracer tank p Sample Port Centerline ve Injection flow Stack flow Sampling flow Ambient pres Ambient hum B&K vapor co Back-Gd gas No. Bk-Gd sa Ambient tem Instuments	vressure Temp el. vrmeter ssure hidity orrection elevel amples p. Used:	315 86 830 3 10 29.54 27 N 29/21/23/21/ 21 5 75.0	315 88 779.0 3 10 29.5 24 N 25/20/24/22/ 23 5 76.0	psig F fpm % bl. ball** cfm Ipm Sierra mm Hg %RH Y/N Y/N ppb n deg. F	4- 3.5- 3- 2.5- p 2- m 1.5-				
Tracer tank p Sample Port Centerline ve Injection flow Stack flow Sampling flow Ambient press Ambient hum B&K vapor co Back-Gd gas No. Bk-Gd sa Ambient tem Instuments B & K Model	vressure Temp el. vrmeter ssure nidity orrection elevel amples p. Used:	315 86 830 3 10 29.54 27 N 29/21/23/21/ 21 5 75.0	315 88 779.0 3 10 29.5 24 N 25/20/24/22/ 23 5 76.0	psig F fpm % bl. ball** cfm Ipm Sierra mm Hg %RH Y/N ppb n deg. F	4- 3.5- 3- 2.5- P 2- m 1.5- 1-				
Tracer tank p Sample Port Centerline ve Injection flow Stack flow Sampling flow Ambient pres Ambient pres Ambient hum B&K vapor co Back-Gd gas No. Bk-Gd sa Ambient tem Instuments B & K Model Sierra Inc. Co	vressure Temp al. meter sure hidity orrection amples p. <u>Used:</u> 1302 #1765 onstant Floo	315 86 830 3 10 29.54 27 N 29/21/23/21/ 21 5 75.0 299 V Air Sampler	315 88 779.0 3 10 29.5 24 N 25/20/24/22/ 23 5 76.0	psig F fpm % bl. ball** cfm Ipm Sierra mm Hg %RH Y/N ppb n deg. F	4 3.5 3 2.5 P 2 m 1.5				
Tracer tank p Sample Port Centerline ve Injection flow Stack flow Sampling flow Ambient pres Ambient pres Ambient hum B&K vapor co Back-Gd gas No. Bk-Gd gas No. Bk-Gd sa Ambient tem Instuments B & K Model Sierra Inc. Co	oressure Temp II. meter wmeter ssure hidity orrection level amples p. Used: 1302 #1765 onstant Flow phyr SN 12	315 86 830 3 10 29.54 27 N 29/21/23/21/ 21 5 75.0 29/21/23/21/ 21 5 75.0	315 88 779.0 3 10 29.5 24 N 25/20/24/22/ 23 5 76.0	psig F fpm % bl. ball** cfm Ipm Sierra mm Hg %RH Y/N Ppb n deg. F	4 3.5 3 2.5 p 2.5 m 1.5 1 0.5				
Tracer tank p Sample Port Centerline ve Injection flow Stack flow Sampling flow Ambient pres Ambient hum B&K vapor co Back-Gd gas No. Bk-Gd sa Ambient tem Instuments B & K Model Sierra Inc. Co Solomat Zej	oressure Temp el. meter wmeter ssure hidity orrection level amples p. <u>Used:</u> 1302 #1765 onstant Flov phyr SN 12 in black pla	315 86 830 3 10 29.54 27 N 29/21/23/21/ 21 5 75.0 299 V Air Sampler 95-1472 stic ball floa	315 88 779.0 3 10 29.5 24 N 25/20/24/22/ 23 5 76.0	psig F fpm % bl. ball** cfm Ipm Sierra mm Hg %RH Y/N ppb n deg. F	4 3.5 3 2.5 P 2 m 1.5 1 0.5 0				
Tracer tank p Sample Port Centerline ve Injection flow Stack flow Sampling flow Ambient press Ambient hum B&K vapor co Back-Gd gas No. Bk-Gd sa Ambient tem Instuments B & K Model Sierra Inc. Co Solomat Zeg **Reading o Notes:	ressure Temp I. meter wmeter sure hidity orrection level amples p. <u>Used:</u> 1302 #1765 onstant Flov phyr SN 12 n black pla At this poir	315 86 830 3 10 29.54 27 N 29/21/23/21/ 21 5 75.0 29/9 V Air Sampler 95-1472 stic ball float	315 88 779.0 3 10 29.5 24 N 25/20/24/22/ 23 5 76.0 	psig F fpm % bl. ball** cfm Ipm Sierra mm Hg %RH Y/N ppb n deg. F er	4 3.5 3 2.5 P P 2 m 1.5 1 0.5 0				
Tracer tank p Sample Port Centerline ve Injection flow Stack flow Sampling flow Ambient pres Ambient pres Ambient hum B&K vapor co Back-Gd gas No. Bk-Gd sa Ambient tem Instuments B & K Model Sierra Inc. C Solomat Zeg **Reading o Notes: The injection	ressure Temp el. meter wmeter sure hidity orrection level amples p. Used: 1302 #1765 onstant Flow phyr SN 12 in black pla At this poir n probe rea	315 86 830 3 10 29.54 27 N 29/21/23/21/ 21 5 75.0 29/21/23/21/ 21 5 75.0 29/9 V Air Sampler 95-1472 stic ball floa it, the duct is ches 8-in of	315 88 779.0 3 10 29.5 24 N 25/20/24/22/ 23 5 76.0 76.0	psig F fpm % bl. ball** cfm Ipm Sierra mm Hg %RH Y/N ppb n deg. F deg. F ches with the	4 3.5 3 2.5 P P 2 m 1.5 1 0.5 0				East
Tracer tank p Sample Port Centerline ve Injection flow Stack flow Sampling flow Ambient press Ambient press Ambient num B&K vapor co Back-Gd gas No. Bk-Gd sa Ambient tem Instuments B & K Model Sierra Inc. Co Solomat Zep ***Reading o Notes: The injection elevation ad	ressure Temp I. meter wmeter sure hidity orrection level amples p. Used: 1302 #1765 onstant Flow phyr SN 12 in black pla At this poir n probe rea ljusted acco	315 86 830 3 10 29.54 27 N 29/21/23/21/ 21 29/21/23/21/ 21 5 75.0 29/21/23/21/ 21 5 75.0 29/21/23/21/ 21 5 75.0 29/21/23/21/ 21 5 75.0 29/21/23/21/ 21 5 75.0 29/21/23/21/ 21 5 75.0 20/21/23/21/ 21 5 75.0	315 88 779.0 3 10 29.5 24 N 25/20/24/22/ 23 5 76.0 76.0 15 76.0 16 5 76.0 17 5 76.0 17 5 76.0 17 5 76.0 17 5 76.0 17 18 18 18 18 18 18 18 18 18 18 18 18 18	psig F fpm % bl. ball** cfm Ipm Sierra mm Hg %RH Y/N ppb n deg. F deg. F ches ches with the one-inch	4 3.5 3 2.5 P P 2 m 1.5 1 0.5 0	North			East
Tracer tank p Sample Port Centerline ve Injection flow Stack flow Sampling flow Ambient press Ambient press Ambient num B&K vapor co Back-Gd gas No. Bk-Gd gas No. Bk-Gd sa Ambient tem Instuments B & K Model Sierra Inc. Co Solomat Zep **Reading o Notes: The injection elevation ac from both si	ressure Temp al. meter wmeter sure hidity orrection level amples p. Used: 1302 #1765 onstant Flov phyr SN 12 in black pla At this poir n probe rea ljusted acco des of a co	315 86 830 3 10 29.54 27 N 29/21/23/21/ 21 5 75.0 29/21/23/21/ 21 5 75.0 29/21/23/21/ 21 5 75.0 29/21/23/21/ 21 5 75.0 29/21/23/21/ 21 5 75.0 29/21/23/21/ 21 5 75.0 29/21/23/21/ 21 5 75.0 20/21/23/21/ 21 5 75.0 20/21/23/21/ 21 5 75.0 20/21/23/21/ 21 5 75.0 20/21/23/21/ 21 5 7 5.0 7 5 5 7 5 7 5 5 5 7 5 5 7 5 5 7 5	315 88 779.0 3 10 29.5 24 N 25/20/24/22/ 23 5 76.0 76.0 5 76.0 5 76.0 16 5 76.0 17 5 76.0 10 29.5 24 8 18 18 18 18 18 18 18 18 18 18 18 18 1	psig F fpm % bl. ball** cfm Ipm Sierra mm Hg %RH Y/N ppb n deg. F deg. F ches ches with the one-inch njection	4 3.5 3 2.5 P P 2 m 1.5 1 0.5 0	North			East
Tracer tank p Sample Port Centerline ve Injection flow Stack flow Sampling flow Ambient press Ambient press Ambient press Back-Gd gas No. Bk-Gd gas Solomat Zeg **Reading o Notes: The injection elevation action from both si point is 8-in	ressure Temp al. meter sure nidity orrection apples p. <u>Used:</u> <u>1302 #1765</u> onstant Flov phyr SN 12 n black pla At this poir n probe rea des of a co closer to th	315 86 830 3 10 29.54 27 N 29/21/23/21/ 21 5 75.0 29/21/23/21/ 21 5 75.0 29/21/23/21/ 21 5 75.0 29/21/23/21/ 21 5 75.0 29/9 v Air Sampler 95-1472 stic ball floa it, the duct is ches 8-in of prdingly, the rner. Also, the	315 88 779.0 3 10 29.5 24 N 25/20/24/22/ 23 5 76.0 5 76.0 4 10 29.5 24 N 25/20/24/22/ 23 5 76.0 10 25/20/24/22/ 23 5 76.0 10 29.5 24 N 25/20/24/22/ 23 5 76.0 10 29.5 24 N 25/20/24/22/ 23 5 76.0 10 29.5 24 N 25/20/24/22/ 23 5 76.0 10 29.5 24 N 25/20/24/22/ 23 5 76.0 10 29.5 24 N 25/20/24/22/ 23 5 76.0 10 29.5 24 N 25/20/24/22/ 23 5 76.0 10 29.5 24 N 25/20/24/22/ 23 5 76.0 10 29.5 24 N 25/20/24/22/ 23 5 76.0 10 29.5 24 10 29.5 24 10 29.5 24 29.5 24 10 25/20/24/22/ 23 5 76.0 10 10 29.5 24 10 29.5 24 10 29.5 24 29.5 24 10 29.5 24 29.5 24 10 29.5 24 10 29.5 24 29.5 24 29.5 24 10 29.5 24 29.5 29.5 24 29.5 24 10 29.5 29.5 29.5 29.5 29.5 29.5 29.5 29.5	psig F fpm % bl. ball** cfm Ipm Sierra mm Hg %RH Y/N ppb n deg. F deg. F ches ches with the one-inch njection on port.	4 3.5 3 2.5 p p 2 m 1.5 1 0.5 0	North			East
Tracer tank p Sample Port Centerline ve Injection flow Stack flow Sampling flow Ambient pres Ambient pres Ambient pres Back-Gd gas No. Bk-Gd gas The injection elevation ac from both si point is 8-in Signature sig	ressure Temp al. meter sure sure bidity orrection level amples p. Used: 1302 #1765 onstant Flow phyr SN 12 in black pla At this poir n probe rea dijusted accord des of a co closer to th gnifies comp	315 86 830 3 10 29.54 27 N 29/21/23/21/ 21 5 75.0 29/21/23/21/ 21 5 75.0 29/21/23/21/ 21 5 75.0 29/21/23/21/ 21 5 75.0 29/21/23/21/ 21 5 75.0 29/21/23/21/ 21 5 75.0 29/21/23/21/ 21 5 75.0 29/21/23/21/ 21 5 75.0 20/21/23/21/ 21 5 75.0 20/21/23/21/ 21 5 75.0 20/21/23/21/ 21 5 75.0 20/21/23/21/ 21 5 75.0 20/21/23/21/ 21 5 75.0 20/21/23/21/ 21 5 75.0 20/21/23/21/ 21 5 75.0 20/21/23/21/ 21 5 75.0 20/21/23/21/ 21 5 75.0 20/21/23/21/ 21 5 75.0 20/21/23/21/ 21 5 75.0 20/21/23/21/ 21 5 75.0 20/21/23/21/ 21 5 75.0 20/21/23/21/ 21 5 75.0 20/21/23/21/ 21 7 5 7 5 7 5 7 5 7 5 7 5 7 5 7 5 7 5 7	315 88 779.0 3 10 29.5 24 N 25/20/24/22/ 23 5 76.0 5 76.0 4 t in flowmet s 18 x 18 in f center, so injection is the center in the injecti	psig F fpm % bl. ball** cfm Ipm Sierra mm Hg %RH Y/N ppb n deg. F deg. F ches ches with the one-inch njection on port. Signature v	4 3.5 3 2.5 P 2 m 1.5 1 0.5 0	North	ions:		East
Tracer tank p Sample Port Centerline ve Injection flow Stack flow Sampling flow Ambient press Ambient hum B&K vapor co Back-Gd gas No. Bk-Gd sa Ambient tem Instuments B & K Model Sierra Inc. Co Solomat Zep **Reading o Notes: The injection elevation ac from both si point is 8-in Signature sig Procedure E	ressure Temp I. meter wmeter sure hidity orrection level amples p. <u>Used:</u> <u>1302 #1765</u> onstant Flov phyr SN 12 n black pla At this poir n black pla At this poir n probe rea ljusted acco des of a co closer to th gnifies comp MS-0AG-V	315 86 830 3 10 29.54 27 N 29/21/23/21/ 21 5 75.0 299 V Air Sampler 95-1472 stic ball float it, the duct is ches 8-in of ordingly, the rner. Also, the stack than liance with	315 88 779.0 3 10 29.5 24 N 25/20/24/22/ 23 5 76.0 5 76.0 4 t in flowmet s 18 x 18 in f center, so injection is the center in the injection	psig F fpm % bl. ball** cfm Ipm Sierra mm Hg %RH Y/N ppb n deg. F deg. F ches with the one-inch njection on port. Signature v	4 3.5 3 2.5 P 2 m 1.5 1 0.5 0	North			East
Tracer tank p Sample Port Centerline ve Injection flow Stack flow Sampling flow Ambient press Ambient press Ambient num B&K vapor co Back-Gd gas No. Bk-Gd sa Ambient tem Instuments B & K Model Sierra Inc. C Solomat Zeg **Reading o Notes: The injection elevation act from both si point is 8-in Signature sig Procedure E Signature/da	ressure Temp el. meter wmeter sure hidity orrection level amples p. Used: 1302 #1765 onstant Flow phyr SN 12 in black pla At this poir n probe rea ljusted acco des of a co closer to th gnifies comp MS-0AG-04 te	315 86 830 3 10 29.54 27 N 29/21/23/21/ 21 5 75.0 29/21/23/21/ 21 5 75.0 29/21/23/21/ 21 5 75.0 29/21/23/21/ 21 5 75.0	315 88 779.0 3 10 29.5 24 N 25/20/24/22/ 23 5 76.0 76.0 10 10 29.5 24 N 25/20/24/22/ 23 5 76.0	psig F fpm % bl. ball** cfm Ipm Sierra mm Hg %RH Y/N ppb n deg. F deg. F <u>ches</u> with the one-inch njection on port. Signature v	4 3.5 3 2.5 P 2 m 1.5 1 0.5 0	North and calculati	ions:	Lein C	East
Tracer tank p Sample Port Centerline ve Injection flow Stack flow Sampling flow Ambient press Ambient num B&K vapor co Back-Gd gas No. Bk-Gd sa Ambient tem Instuments B & K Model Sierra Inc. Co Solomat Zep **Reading o Notes: The injection elevation ac from both si point is 8-in Signature sig Procedure E Signature/da	ressure Temp I. meter wmeter sure nidity orrection level amples p. Used: 1302 #1765 onstant Flow phyr SN 12 in black pla At this poir n probe rea ljusted acco des of a co closer to th gnifies comp MS-03G-04 te	315 86 830 3 10 29.54 27 N 29/21/23/21/ 21 29/21/23/21/ 21 5 75.0 29/21/23/21/ 21 5 75.0 29/21/23/21/ 21 5 75.0 29/21/23/21/ 21 5 75.0 29/21/23/21/ 21 5 75.0 29/21/23/21/ 21 5 75.0 29/21/23/21/ 21 5 75.0 29/21/23/21/ 21 5 75.0 20/21/23/21/ 21 5 75.0 20/21/23/21/ 21 5 75.0 20/21/23/21/ 21 5 75.0 20/21/23/21/ 21 5 75.0 20/21/23/21/ 21 5 75.0 20/21/23/21/ 21 5 75.0 20/21/23/21/ 21 5 75.0 20/21/23/21/ 21 5 75.0 20/21/23/21/ 21 5 75.0 20/21/23/21/ 21 5 75.0 20/21/23/21/ 21 5 75.0 20/21/23/21/ 21 5 75.0 20/21/23/21/ 21 7 5 7 5 7 5 7 5 7 5 7 5 7 5 7 5 7 5 7	315 88 779.0 3 10 29.5 24 N 25/20/24/22/ 23 5 76.0 76.0 5 76.0 10 29.5 24 N 25/20/24/22/ 23 5 76.0 10 29.5 24 N 25/20/24/22/ 23 5 76.0	psig F fpm % bl. ball** cfm Ipm Sierra mm Hg %RH Y/N ppb n deg. F deg. F ches with the one-inch njection on port. Signature v 9/28/09	4 3.5 3 2.5 P 2 m 1.5 1 0.5 0	North and calculati	ions:	ber (East

		TR	ACER GAS	TRAVERSE		RM			
	Site	325 Model			Run No.	GT-4			
	Date	9/2/2004		Fan C	configuration	Near fan			
	Tester	JAG/GSH/JM	В		Fan Setting	37.1 Hz			
	Stack Dia.	18 ii	n.		Stack Temp	84.5	deg F		
S	tack X-Area	254.5 ii	n.2	Sta	art/End Time	1525/1606			
	Elevation	N.A.		Cer	nter 2/3 from	1.65	to:	16.35	
Distance to	disturbance	120 ii	nches	Points i	n Center 2/3	2	to:	7	
Measu	rement units	ppm SF6		In	jection Point	Bottom Sout	h - 1-in from	corner walls	
Traverse>			Ea	ist			No	rth	
Trial>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.		pp	m			pp	m	
1	0.58	4.23	3.64	4.27	4.05	3.73	3.69	3.72	3.71
2	1.89	4.00	4.41	3.61	4.01	3.54	3.73	3.70	3.66
3	3.49	3.76	4.14	4.14	4.01	3.49	3.94	3.89	3.77
4	5.81	3.92	3.51	3.73	3.72	3.73	3.64	3.53	3.63
Center	9.00	3.97	4.15	3.60	3.91	3.89	4.05	4.23	4.06
5	12.19	3.63	4.10	4.41	4.05	3.81	3.95	3.96	3.91
6	14.51	4.22	3.93	3,98	4.04	3.77	4.17	3.78	3.91
7	16.11	3.91	3.97	4.01	3.96	3.56	3.96	4.00	3.84
8	17.42	4.09	3.58	4.22	3.96	3.67	4.08	4.48	4.08
Averages	>	3.97	3.94	4.00	3.97	3.69	3.91	3.92	3.84
					_				
		All	ppm	Dev	<u>. from mean</u>	Center 2/3	<u>East</u>	<u>North</u>	<u>All</u>
		Mean	3.90			Mean	3.96	3.82	3.89
		Min Point	3.63		-6.9%	Std. Dev.	0.12	0.15	0.15
		Max Point	4.08		4.4%	COV as %	2.92	3.92	3.75
Avg. Conc.	3.894	ppm			Gas analyz	er checked:			
			- ···		9/1/2004				
Tressertenk	reacture	Start	Finish 315	nsia					
Tracer tank p	Temp	315		psig E					
Sample Port	Temp	770	771.0	fnm					
Lencerine ve	motor	113	5	% bl ball**	}				
Stock flow	meter	5		ofm	1	and the second se			
Sack llow	umeter	10	10	Inm Sierra	4.5				
Ambient pres	SUITA	29.54	29.5	mm Ha	4				- 1
Ambient pres	nidity	20.04	25	%RH					
B&K vapor o	orrection	<u></u> N	N	Y/N	3.5		-		
Dar vapor c	onection	25/20/24/22/	20/25/20/17/	1713	3				
Back-Gd gas	level	23	22	ppb					
No. Bk-Gd sa	amples	5	5	n	P 2.5-				1
Ambient tem	р.	76.0	77.0	deg. F	m 2-				-
Instuments	Used:				15				
B & K Model	1302 #1765	5299			. 1.5				
Sierra Inc. C	onstant Flow	v Air Sampler			1-				
Solomat Ze	phyr SN 12	95-1472			0.5-			ア₽₽₽₽	
**Reading of	n black pla	stic ball float	in flowmet	er			7. 1 P		
Notes:	At this poir	nt, the duct is	18 x 18 in	ches					
The injectio	n probe rea	ches 8-in off	center, so	with the				/	East
elevation ac	justed acc	ordingly, the i	njection is	one-inch		North			
from both si	des of a co	rner. Also, t	ne center i	njection					
point is 8-in	closer to the	ne stack than	the injection	on port.					
Signature sig	nifies comp	liance with		Signature v	erifying data	and calculat	ions:	1 1	
Procedure E	MS-JAG-01	1 01.	<	/	1	KA	/	Haha	9/2/001
Signature/da	te HA	n Blis	men	9/3	184	1170	mme L	TUBEL	4 20/01
	0		1			/		()	
	-		- 04-3	25 Scale gas		+ 9/30/2004			

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	Site	325 Model			Run No	GT-5			
	Data	0/3/2004		Ean C	onfiguration	Near fan			
	Dale	9/3/2004		FairC					
	l ester	JAG/JIVIB			Fan Setting	37.1 HZ			
-	Stack Dia.		1	0	Stack Temp	84.8 0	beg F		
S	tack X-Area	254.5 1	n.2	Sta	art/End lime	1404/1504			
	Elevation	N.A.		Cer	nter 2/3 from	1.65	to: <u>1</u>	6.35	
Distance to	disturbance	<u> </u>	nches	Points i	n Center 2/3	2	to: <u>7</u>		
Measu	rement units	ppm SF6		Inj	jection Point	Bottom North	I - 1-in from c	orner walls	
Traverse>			Ea	ist			Nort	h	
Trial>		1	2	3	Mean	1	2	3	Mea
Point	Depth, in.		рр	m			ppn	n	
1	0.58	3.10	3.67	3.19	3.32	3.68	3.73	3.94	3.7
2	1.89	3.14	3.51	3.37	3.34	3.54	3.39	3.68	3.5
3	3.49	3.31	3.30	4.08	3.56	3.44	3.85	3.50	3.6
4	5.81	3.32	4.17	3.63	3.71	3.50	3.79	3.69	3.6
Center	9.00	3.66	4.02	3.96	3.88	3.73	3.52	3 38	3 5
5	12 19	4 17	3 69	3.62	3.83	3.58	3 23	3.54	34
6	14 51	3.42	3 /3	3 79	3 54	3.26	3 78	3.81	3.6
	16.14	3.42	2 47	3.10	2.52	3.42	3.70	3 /2	24
/	17.10	3.03	2.02	3.40	3.55	2.45	3.63	2.45	
0	17.42	3.92	3.02	3.02	3.52	3.45	3.59	3.60	3.0
Averages	>	3.52	3,59	3.64	3.58	3.51	3.63	3.05	3.60
		All	maa	Dev	, from mean	Center 2/3	East	North	
		Mean	3 59			Mean	3 63	3 57	3 (
		linean	0.00			Std Day	0.00	0.07	0.4
		Min Point	3 32		_7 5%		0 19	1111/	
		Min Point	3.32		-7.5%		0.19	1.00	0.
Avg. Conc.	3.575	Min Point Max Point ppm	3.32 3.88		-7.5% 8.1% Gas analyz	COV as % er checked:	0.19	1.89	3.8
Avg. Conc. Tracer tank n	3.575	Min Point Max Point ppm Start	3.32 3.88 Finish 330	psia	-7.5% 8.1% Gas analyz 9/1/2004	COV as % er checked:	0.19 5.19	<u>1.89</u>	3.8
Avg. Conc. Tracer tank p Sample Port	3.575 pressure Temp	Min Point Max Point ppm Start 310 84.9	3.32 3.88 Finish 330 84.7	psig F	-7.5% 8.1% Gas analyz 9/1/2004	er checked:	0.19 5.19	1.89	3.8
Avg. Conc. Tracer tank p Sample Port Centerline ve	3.575 pressure Temp	Min Point Max Point ppm Start 310 84.9 782	3.32 3.88 Finish 330 84.7 801.0	psig F form	-7.5% 8.1% Gas analyz 9/1/2004	er checked:	0.19 5.19	<u>1.89</u>	3.0
Avg. Conc. Tracer tank p Sample Port Centerline ve	3.575 pressure Temp el.	Min Point Max Point ppm Start 310 84.9 782	3.32 3.88 Finish 330 84.7 801.0	psig F fpm % bl. ball**	-7.5% 8.1% Gas analyz 9/1/2004	er checked:	0.19 5.19		3.8
Avg. Conc. Tracer tank p Sample Port Centerline ve Injection flow	3.575 pressure Temp el. meter	Min Point <u>Max Point</u> ppm Start 310 84.9 782 4 78	3.32 3.88 Finish 330 84.7 801.0 4 80	psig F fpm % bl. ball**	-7.5% 8.1% Gas analyz 9/1/2004	er checked:	0.19 5.19		3.8
Avg. Conc. Tracer tank p Sample Port Centerline ve Injection flow Ambient temp	3.575 pressure Temp el. meter p.	Min Point <u>Max Point</u> ppm Start 310 84.9 782 4 78 10	3.32 3.88 Finish 330 84.7 801.0 4 80	psig F fpm % bl. ball** deg. F	-7.5% 8.1% Gas analyz 9/1/2004	er checked:	0.19 5.19		3.8
Avg. Conc. Tracer tank p Sample Port Centerline ve Injection flow Ambient temp Sampling flow	3.575 pressure Temp el. meter p. wmeter	Min Point Max Point ppm Start 310 84.9 782 4 782 4 78 10 751 20	3.32 3.88 Finish 330 84.7 801.0 4 80 10	psig F fpm % bl. ball** deg. F Ipm Sierra	-7.5% 8.1% Gas analyz 9/1/2004	er checked:	0.19 5.19		3.1
Avg. Conc. Tracer tank p Sample Port Centerline ve Injection flow Ambient temp Sampling flow	3.575 pressure Temp el. meter p. wmeter ssure	Min Point Max Point ppm Start 310 84.9 782 4 782 4 78 10 751.20	3.32 3.88 Finish 330 84.7 801.0 4 80 10 750.5	psig F fpm % bl. ball** deg. F Ipm Sierra mm Hg	-7.5% 8.1% Gas analyz 9/1/2004	er checked:			3.8
Avg. Conc. Tracer tank p Sample Port Centerline ve Injection flow Ambient temp Sampling flow Ambient pres Ambient hum	3.575 pressure Temp el. meter p. wmeter ssure ssure	Min Point Max Point ppm Start 310 84.9 782 4 78 10 751.20 30	3.32 3.88 Finish 330 84.7 801.0 4 80 10 750.5 27	psig F fpm % bl. ball** deg. F Ipm Sierra mm Hg %RH	-7.5% 8.1% Gas analyz 9/1/2004 4.5 4.5 4.5	er checked:	0.19 5.19		3.8
Avg. Conc. Tracer tank p Sample Port Centerline ve Injection flow Ambient temp Sampling flow Ambient pres Ambient hum B&K vapor co	3.575 pressure Temp el. meter p. wmeter ssure nidity porrection	Min Point Max Point ppm Start 310 84.9 782 4 78 10 751.20 30 N	3.32 3.88 Finish 330 84.7 801.0 4 80 10 750.5 27 N	psig F fpm % bl. ball** deg. F Ipm Sierra mm Hg %RH Y/N	-7.5% 8.1% Gas analyz 9/1/2004 4.5 4.5	er checked:			3.8
Avg. Conc. Tracer tank p Sample Port Centerline ve Injection flow Ambient temp Sampling flow Ambient pres Ambient hum B&K vapor co	3.575 pressure Temp el. meter p. wmeter ssure nidity porrection	Min Point Max Point ppm Start 310 84.9 782 4 782 4 78 10 751.20 30 N 29/23/31/29/ 2 25/24	3.32 3.88 Finish 330 84.7 801.0 4 80 10 750.5 27 N 29/28/22/21/ 29/28/22/21/	psig F fpm % bl. ball** deg. F lpm Sierra mm Hg %RH Y/N	-7.5% 8.1% Gas analyz 9/1/2004 4.5 4 3.5 3	er checked:			3.8
Avg. Conc. Tracer tank p Sample Port Centerline ve Injection flow Ambient temp Sampling flov Ambient pres Ambient hum B&K vapor co Back-Gd gas	3.575 pressure Temp el. meter p. wmeter ssure hidity orrection	Min Point Max Point ppm Start 310 84.9 782 4 782 4 782 4 782 30 N 29/23/31/29/ 26/31	3.32 3.88 Finish 330 84.7 801.0 4 80 10 750.5 27 N 29/28/22/21/ 25	psig F fpm % bl. ball** deg. F lpm Sierra mm Hg %RH Y/N	-7.5% 8.1% Gas analyz 9/1/2004 4.5 4 3.5 3 P 2.5	er checked:			3.8
Avg. Conc. Tracer tank p Sample Port Centerline ve Injection flow Ambient temp Sampling flov Ambient pres Ambient hum B&K vapor co Back-Gd gas No. Bk-Gd sa	3.575 pressure Temp el. meter p. wmeter ssure hidity orrection a level amples	Min Point Max Point ppm Start 310 84.9 782 4 782 4 782 4 782 30 N 29/23/31/29/2 26/31 6	3.32 3.88 Finish 330 84.7 801.0 4 80 10 750.5 27 N 29/28/22/21/ 25 5	psig F fpm % bl. ball** deg. F lpm Sierra mm Hg %RH Y/N Y/N ppb n	-7.5% 8.1% Gas analyz 9/1/2004 4.5 4 3.5 3 P 2.5 P	er checked:			3.1
Avg. Conc. Tracer tank p Sample Port Centerline ve Injection flow Ambient temp Sampling flow Ambient pres Ambient hum B&K vapor co Back-Gd gas No. Bk-Gd sa Ambient pres	3.575 pressure Temp el. meter p. wmeter ssure hidity prrection amples ssure	Min Point Max Point ppm Start 310 84.9 782 4 782 4 78 10 751.20 30 N 29/23/31/29/2 26/31 6 1016.5	3.32 3.88 Finish 330 84.7 801.0 4 80 10 750.5 27 N 29/28/22/21/ 25 5 1015.6	psig F fpm % bl. ball** deg. F lpm Sierra mm Hg %RH Y/N Ppb n mbar	-7.5% 8.1% Gas analyz 9/1/2004 4.5 4 3.5 3 P 2.5 P m 2	er checked:	0.19 5.19		3.8
Avg. Conc. Tracer tank p Sample Port Centerline ve Injection flow Ambient temp Sampling flow Ambient pres Ambient hum B&K vapor co Back-Gd gas No. Bk-Gd sa Ambient pres	3.575 pressure Temp el. meter p. wmeter ssure hidity prrection level amples ssure Used:	Min Point Max Point ppm Start 310 84.9 782 4 782 4 78 10 751.20 30 N 29/23/31/29/2 26/31 6 1016.5	3.32 3.88 Finish 330 84.7 801.0 4 80 10 750.5 27 N 29/28/22/21/ 25 5 1015.6	psig F fpm % bl. ball** deg. F lpm Sierra mm Hg %RH Y/N Y/N ppb n mbar	-7.5% 8.1% Gas analyz 9/1/2004 4.5 4 3.5 4 3.5 7 9 2.5 p m 2 1.5	er checked:			3.8
Avg. Conc. Tracer tank p Sample Port Centerline ve Injection flow Ambient temp Sampling flow Ambient pres Ambient hum B&K vapor co Back-Gd gas No. Bk-Gd sa Ambient pres Instuments B & K Model	3.575 pressure Temp el. meter p. wmeter ssure hidity porrection level amples ssure Used: 1302 #1765	Min Point Max Point ppm Start 310 84.9 782 4 78 10 751.20 30 N 29/23/31/29/2 26/31 6 1016.5 5299	3.32 3.88 Finish 330 84.7 801.0 4 80 10 750.5 27 N 29/28/22/21/ 25 5 1015.6	psig F fpm % bl. ball** deg. F lpm Sierra mm Hg %RH Y/N ppb n mbar	-7.5% 8.1% Gas analyz 9/1/2004 4.5 4 3.5 3 p 2.5 p m 2 1.5	er checked:			
Avg. Conc. Tracer tank p Sample Port Centerline ve Injection flow Ambient temp Sampling flow Ambient press Ambient press Instuments B & K Model Sierra Inc. Co	3.575 pressure Temp el. meter p. wmeter ssure nidity orrection level amples ssure Used: 1302 #1765 onstant Flow	Min Point Max Point ppm Start 310 84.9 782 4 78 10 751.20 30 N 29/23/31/29/ 26/31 6 1016.5 5299 v Air Sampler	3.32 3.88 Finish 330 84.7 801.0 4 80 10 750.5 27 N 29/28/22/21/ 25 5 1015.6	psig F fpm % bl. ball** deg. F lpm Sierra mm Hg %RH Y/N ppb n mbar	-7.5% 8.1% Gas analyz 9/1/2004 4.5 4 3.5 3 p 2.5 p m 2 1.5 1	er checked:			
Avg. Conc. Tracer tank p Sample Port Centerline ve Injection flow Ambient temp Sampling flov Ambient pres Ambient pres Back-Gd gas No. Bk-Gd sa Ambient pres Instuments B & K Model Sierra Inc. Co Solomat Zej	3.575 pressure Temp el. meter p. wmeter ssure nidity orrection level amples ssure <u>Used:</u> 1302 #1765 onstant Flov phyr SN 12	Min Point Max Point ppm Start 310 84.9 782 4 78 10 751.20 30 N 29/23/31/29/ 26/31 6 1016.5 5299 v Air Sampler 95-1472	3.32 3.88 Finish 330 84.7 801.0 4 80 10 750.5 27 N 29/28/22/21/ 25 5 1015.6	psig F fpm % bl. ball** deg. F lpm Sierra mm Hg %RH Y/N ppb n mbar	-7.5% 8.1% Gas analyz 9/1/2004 4.5 4 3.5 3 p 2.5 p 2.5 p 2.5 p 2.5 p 1.5 1 0.5	er checked:			
Avg. Conc. Tracer tank p Sample Port Centerline ve Injection flow Ambient temp Sampling flow Ambient pres Ambient pres Back-Gd gas No. Bk-Gd sa Ambient pres Instuments B & K Model Sierra Inc. Co Solomat Zep	3.575 pressure Temp el. meter p. wmeter ssure hidity orrection level amples ssure Used: 1302 #1765 onstant Flow phyr SN 12 n black pla	Min Point Max Point ppm Start 310 84.9 782 4 78 10 751.20 30 N 29/23/31/29/2 26/31 6 1016.5 5299 v Air Sampler 95-1472 stic ball float	3.32 3.88 Finish 330 84.7 801.0 4 80 10 750.5 27 N 29/28/22/21/ 25 5 1015.6 	psig F fpm % bl. ball** deg. F lpm Sierra mm Hg %RH Y/N ppb n mbar mbar	-7.5% 8.1% Gas analyz 9/1/2004 4.5 4 3.5 3 P 2.5 P m 2- 1.5 1 0.5	er checked:			
Avg. Conc. Tracer tank p Sample Port Centerline ve Injection flow Ambient temp Sampling flow Ambient pres Ambient pres Back-Gd gas No. Bk-Gd sa Ambient pres Instuments B & K Model Sierra Inc. Co Solomat Zep **Reading o Notes:	3.575 pressure Temp el. meter p. wmeter ssure hidity prrection level amples ssure Used: 1302 #1765 onstant Flow phyr SN 12 m black pla At this poir	Min Point Max Point ppm Start 310 84.9 782 4 78 10 751.20 30 N 29/23/31/29/2 26/31 6 1016.5 5299 v Air Sampler 95-1472 stic ball float nt, the duct is	3.32 3.88 Finish 330 84.7 801.0 4 80 10 750.5 27 N 29/28/22/21/ 25 5 1015.6 5 1015.6 	psig F fpm % bl. ball** deg. F lpm Sierra mm Hg %RH Y/N ppb n mbar mbar	-7.5% 8.1% Gas analyz 9/1/2004 4.5 4 3.5 3 P 2.5 P m 2- 1.5 1- 0.5 0	er checked:			
Avg. Conc. Tracer tank p Sample Port Centerline ve Injection flow Ambient temp Sampling flow Ambient pres Ambient pres Mobient pres Instuments B & K Model Sierra Inc. Co Solomat Zep **Reading o Notes: The injection	3.575 pressure Temp el. meter p. wmeter ssure hidity prrection i level amples assure Used: 1302 #1765 onstant Flov phyr SN 12 in black pla At this poir	Min Point Max Point ppm Start 310 84.9 782 4 78 10 751.20 30 N 29/23/31/29/ 26/31 6 1016.5 3299 v Air Sampler 95-1472 stic ball float at, the duct is iches 8-in off	3.32 3.88 Finish 330 84.7 801.0 4 80 10 750.5 27 N 29/28/22/21/ 25 5 1015.6 5 1015.6 in flowmeto 18 x 18 inc center, so	psig F fpm % bl. ball** deg. F lpm Sierra mm Hg %RH Y/N ppb n mbar er ches with the	-7.5% 8.1% Gas analyz 9/1/2004 4.5 4 3.5 4 3.5 3 P 2.5 P m 2 1.5 1 0.5 0	er checked:			U. 3.8
Avg. Conc. Tracer tank p Sample Port Centerline ve Injection flow Ambient temp Sampling flow Ambient press Ambient hum B&K vapor co Back-Gd gas No. Bk-Gd sa Ambient press Instuments B & K Model Sierra Inc. Co Solomat Zep **Reading o Notes: The injection elevation ad	3.575 pressure Temp el. meter p. wmeter ssure hidity prrection i level amples ssure Used: 1302 #1765 onstant Flov phyr SN 12 n black pla At this poir n probe rea	Min Point Max Point ppm Start 310 84.9 782 4 78 10 751.20 30 N 29/23/31/29/ 26/31 6 1016.5 3299 v Air Sampler 95-1472 stic ball float at, the duct is iches 8-in off ordingly, the i	3.32 3.88 Finish 330 84.7 801.0 4 80 10 750.5 27 N 29/28/22/21/ 25 5 1015.6 5 1015.6 in flowmeter 18 x 18 inc center, so njection is	psig F fpm % bl. ball** deg. F lpm Sierra mm Hg %RH Y/N ppb n mbar er ches with the one-inch	-7.5% 8.1% Gas analyz 9/1/2004 4.5 4 3.5 3 P 2.5 P m 2 1.5 1 0.5 0	cov as % er checked:			East
Avg. Conc. Tracer tank p Sample Port Centerline ve Injection flow Ambient temp Sampling flow Ambient press Ambient num B&K vapor co Back-Gd gas No. Bk-Gd sa Ambient press Instuments B & K Model Sierra Inc. Co Solomat Zep **Reading o Notes: The injection elevation ad from both si	3.575 pressure Temp el. meter p. wmeter ssure hidity prection level amples assure Used: 1302 #1765 onstant Flow phyr SN 12 n black pla At this poir n probe rea ljusted accord	Min Point Max Point ppm Start 310 84.9 782 4 78 10 751.20 30 N 29/23/31/29/2 26/31 6 1016.5 3299 v Air Sampler 95-1472 stic ball float nt, the duct is iches 8-in off ordingly, the i rner, Also, th	3.32 3.88 Finish 330 84.7 801.0 4 80 10 750.5 27 N 29/28/22/21/ 25 5 1015.6 5 1015.6 in flowmeter 18 x 18 inc center, so njection is ne center in	psig F fpm % bl. ball** deg. F lpm Sierra mm Hg %RH Y/N ppb n mbar er ches with the one-inch njection	-7.5% 8.1% Gas analyz 9/1/2004 4.5 4 3.5 3 P 2.5 p m 2 1.5 1 0.5 0	cov as % er checked:			East
Avg. Conc. Tracer tank p Sample Port Centerline very Ambient temp Sampling flow Ambient press Ambient press Ambient press Instuments B & K Model Sierra Inc. Co Solomat Zep **Reading o Notes: The injection elevation ad from both si point is 8-in	3.575 pressure Temp el. meter p. wmeter ssure hidity prrection level amples ssure Used: 1302 #1765 onstant Flow phyr SN 12 n black pla At this poir n probe rea ljusted acco des of a co closer to th	Min Point Max Point ppm Start 310 84.9 782 4 78 10 751.20 30 N 29/23/31/29/2 26/31 6 1016.5 3299 v Air Sampler 95-1472 stic ball float nt, the duct is is ches 8-in off ordingly, the i rner. Also, the	3.32 3.88 Finish 330 84.7 801.0 4 80 10 750.5 27 N 29/28/22/21/ 25 5 1015.6 5 1015.6 in flowmeter 18 x 18 interference in the injection is ne center in	psig F fpm % bl. ball** deg. F lpm Sierra mm Hg %RH Y/N ppb n mbar er ches with the one-inch njection	-7.5% 8.1% Gas analyz 9/1/2004 4.5 4 3.5 3 P 2.5 P m 2 1.5 1 0.5 0	cov as % er checked:			East
Avg. Conc. Tracer tank p Sample Port Centerline very Injection flow Ambient temp Sampling flow Ambient press Ambient press Instuments B & K Model Sierra Inc. Co Solomat Zep **Reading o Notes: The injection elevation ad from both si point is 8-in Signature size	3.575 pressure Temp el. meter p. wmeter ssure idity prection level amples ssure Used: 1302 #1765 onstant Flow phyr SN 12 in black pla At this poir n probe read justed accord des of a cord closer to the unifies compared	Min Point Max Point ppm Start 310 84.9 782 4 78 10 751.20 30 N 29/23/31/29/ 26/31 6 1016.5 3299 v Air Sampler 95-1472 stic ball float at, the duct is is ches 8-in off ordingly, the i rner. Also, the stack than liance with	3.32 3.88 Finish 330 84.7 801.0 4 80 10 750.5 27 N 29/28/22/21/ 25 5 1015.6 in flowmeto 18 x 18 in center, so njection is ne center ir the injectio	psig F fpm % bl. ball** deg. F lpm Sierra mm Hg %RH Y/N ppb n mbar er ches with the one-inch njection on port.	-7.5% 8.1% Gas analyz 9/1/2004 4.5 4 3.5 3 P 2.5 P m 2 1.5 1 0.5 0	er checked:			U. 3.4
Avg. Conc. Tracer tank p Sample Port Centerline very Injection flow Ambient temp Sampling flow Ambient press Ambient press Instuments B & K Model Sierra Inc. Co Solomat Zep **Reading o Notes: The injection elevation ad from both si point is 8-in Signature sig Procedure E	3.575 pressure Temp el. meter p. wmeter ssure nidity orrection level amples ssure Used: 1302 #1765 onstant Flow phyr SN 12 in black pla At this poir n probe rea ijusted acco des of a co closer to th pnifies comp	Min Point Max Point ppm Start 310 84.9 782 4 78 10 751.20 30 N 29/23/31/29/ 26/31 6 1016.5 5299 v Air Sampler 95-1472 stic ball float at, the duct is iches 8-in off ordingly, the i irner. Also, the he stack than liance with	3.32 3.88 Finish 330 84.7 801.0 4 80 10 750.5 27 N 29/28/22/21/ 25 5 1015.6 in flowmete 18 x 18 ind center, so njection is ne center ir the injectio	psig F fpm % bl. ball** deg. F lpm Sierra mm Hg %RH Y/N ppb n mbar er ches with the one-inch njection on port. Signature ve	-7.5% 8.1% Gas analyz 9/1/2004 4.5 4 3.5 3 p 2.5 p m 2 1.5 1 0.5 0	er checked:	0.19 5.19		East
Avg. Conc. Tracer tank p Sample Port Centerline ve Injection flow Ambient temp Sampling flow Ambient press Ambient press Mobient press Instuments B & K Model Sierra Inc. Co Solomat Zep **Reading o Notes: The injection elevation ad from both si point is 8-in Signature sig Procedure E Signature/da	3.575 pressure Temp el. meter p. wmeter ssure idity prection level amples ssure Used: 1302 #1765 onstant Flov phyr SN 12 in black pla At this poir n probe read justed accord des of a cord closer to the phyr SN 22 millies comp MS-JAG-01 te	Min Point Max Point ppm Start 310 84.9 782 4 78 10 751.20 30 N 29/23/31/29/2 26/31 6 1016.5 3299 v Air Sampler 95-1472 stic ball float at, the duct is iches 8-in off ordingly, the i rner. Also, the he stack than liance with Also, athe also, a	3.32 3.88 Finish 330 84.7 801.0 4 80 10 750.5 27 N 29/28/22/21/ 25 5 1015.6 5 1015.6 5 1015.6 1015.6	psig F fpm % bl. ball** deg. F lpm Sierra mm Hg %RH Y/N ppb n mbar er ches with the one-inch njection on port. Signature ve	-7.5% 8.1% Gas analyz 9/1/2004 4.5 4 3.5 3 P 2.5 P 2.5 P 2 1.5 1 0.5 0	er checked:	0.19 5.19		East

		TR	ACER GAS	TRAVERSE	DATA FOR	M			
	Site	325 Model			Run No.	GT-6			
	Date	9/3/2004		, Fan C	onfiguration	Far fan			
	Tester	JAG/JMB			Fan Setting	<u>37.1 Hz</u>			
	Stack Dia.	18_i	n		Stack Temp	88.25	deg F		
S	tack X-Area	254.5 i	n.2	Sta	art/End Time	1504/1630			
	Elevation	N.A.		Cer	nter 2/3 from	1.65	to:	16.35	
Distance to	disturbance	<u> </u>	nches	Points i	n Center 2/3	2	to:	7	
Measu	rement units	ppm SF6		Inj	jection Point	Top South, 1	-inch from c	orner walls	
							No	rth	_
Trial>		1	2	331	Mean	· 1	2	3	Mean
Point	Denth in	·	2	<u>_</u>	Mean		2	<u>_</u>	Mean
1 0111	0.58	4 01	3.89	4 03	3 98	3.98	3.84	3 94	3.92
2	1.89	3.79	3.91	3.83	3.84	3.80	3.76	4.06	3.87
2	3 49	3.97	3.96	4 02	3.98	3.83	4 04	3.82	3.90
4	5.81	3.83	3.92	3.87	3.87	3.87	3.72	3.85	3.81
Center	9.00	3.93	3.73	4 01	3.89	3.85	4 13	3.91	3.96
5	12 19	3.74	4 06	4 16	3 99	3 77	4.05	4 09	3.97
6	14 51	3.99	3.88	3,89	3.92	3.82	3.79	3.90	3 84
7	16.11	3.95	3,99	3.97	3.97	3.89	4.00	4 14	4 01
8	17.42	3.75	3.80	3.99	3.85	3.92	3.95	3.75	3.87
Averages	>	3.88	3.90	3.97	3.92	3.86	3.92	3.94	3.91
		AII	ppm	<u>Dev</u>	<u>. from mean</u>	<u>Center 2/3</u>	East	North	All
		Mean	3.91			Mean	3.92	3.91	3.92
		Min Point	3.81		-2.6%	Std. Dev.	0.06	0.07	0.06
	0.040	Max Point	4.01		2.5%	COV as <u>%</u>	1.46	1.89[1.63
Avg. Conc.	3.912	ppm			Gas analyz	er checked:			
				-	9/1/2004				
Tuesententen		Start	Finish	-					
Tracer tank p	Tomm	330		psig -					
Sample Port	Temp	764	750.0	F fnm					
Unicotion flow	n. Imeter	704	139.0	1/111 0/ b1 ball**)				
Ambient tem	nielei	80	+ 80	deg E		CARRY NEWSFORD PROPERTY			
Sampling flor	y. Nmotor		9.5	lom Sierra	4.5				
Ambient pres		750.50	741.0	mm Ha	4				
Ambient pres	nidity	27	24	%RH					
B&K vapor o	orrection	N	<u>N</u>		3.5-				
Dart vapor co	onection	23/23/27/29/	31/25/28/31/	1713	3				
Back-Gd gas	level	28	32	ppb					
No. Bk-Gd sa	amples	5	5	n	P 2.5-				-
Ambient pres	sure	1015.6	1002.8	mbar	m 2-				
Instuments	Used:				15				
B & K Model	1302 #1765	299			1.5		B., 883		
Sierra Inc. Co	1				1 1	/ / /			· · · · · · · · · · · · · · · · · · ·
	onstant Flov	v Air Sampler			1				
Solomat Zej	phyr SN 12	95-1472			0.5-				
**Reading o	phyr SN 12 n black pla	v Air Sampler 95-1472 stic ball float	in flowmet	er	0.5		<u>я</u> Р		
**Reading o	phyr SN 12 n black pla At this poir	v Air Sampler 95-1472 stic ball float it, the duct is	in flowmet	er	0.5- 0				
**Reading o Notes: The injection	onstant Flov phyr SN 12 n black pla At this poir n probe rea	v Air Sampler 95-1472 stic ball float it, the duct is iches 5-in off	in flowmet 11 x 12 in center, so	er ches with the	0.5-				East
Solomat Zep **Reading o Notes: The injection elevation ad	onstant Flov phyr SN 12 n black pla At this poir n probe rea ljusted acc	v Air Sampler 95-1472 stic ball float it, the duct is ches 5-in off ordingly, the	in flowmet 11 x 12 in center, so injection is	er ches with the one-inch	0.5-0-2	North			East
Solomat Zep **Reading o Notes: The injection elevation ad from both si	nstant Flov phyr SN 12 n black pla At this poir n probe rea ljusted acc des of a co	v Air Sampler 95-1472 stic ball float it, the duct is iches 5-in off ordingly, the rner. Also, t	in flowmet 11 x 12 in center, so injection is he center i	er ches with the one-inch njection	0.5 0.5	North			East
Solomat Zep **Reading o Notes: The injection elevation ad from both si point is 5-in	n black pla n black pla At this poir n probe rea ljusted acc des of a co closer to th	v Air Sampler 95-1472 stic ball float it, the duct is ches 5-in off ordingly, the rner. Also, the stack than	in flowmet 11 x 12 in center, so injection is he center in the injection	er ches with the one-inch njection on port.	1 0.5 0	North			East
Solomat Zer **Reading o Notes: The injection elevation ad from both si point is 5-in Signature sig	onstant Flov phyr SN 12 n black pla At this poir n probe rea ljusted acco des of a co closer to th gnifies comp	v Air Sampler 95-1472 stic ball float it, the duct is ches 5-in off ordingly, the rner. Also, the stack than liance with	in flowmet 11 x 12 in center, so injection is he center in the injection	er ches with the one-inch njection on port. Signature ve	1 0.5 0-	North	ons:		East
Solomat Zep **Reading o Notes: The injection elevation ad from both si point is 5-in Signature sig Procedure E	hyr SN 12 n black pla At this poir n probe rea ljusted acco des of a co closer to th gnifies comp MS JAG-9	v Air Sampler 95-1472 stic ball float ht, the duct is ches 5-in off ordingly, the rner. Also, the stack than liance with	in flowmet 11 x 12 in center, so injection is he center in the injection	er ches with the one-inch njection on port. Signature ve	erifying data	North and calculation	ons:		East
Solomat Zej **Reading o Notes: The injection elevation ad from both si point is 5-in Signature sig Procedure El Signature/da	n black pla n black pla At this poir n probe rea ljusted acco des of a co closer to th gnifies comp MS IAG-0 te	v Air Sampler 95-1472 stic ball float it, the duct is iches 5-in off ordingly, the rner. Also, the stack than liance with	in flowmet 11 x 12 in center, so injection is he center in the injection muga	er ches with the one-inch njection on port. Signature ve	erifying data	North and calculation		aber	East 9/30/04
Solomat Zep **Reading o Notes: The injection elevation ad from both si point is 5-in Signature sig Procedure E Signature/da	n black pla n black pla At this poir n probe rea ljusted acco des of a co closer to th gnifies comp MS JAG-01 te	v Air Sampler 95-1472 stic ball float at, the duct is iches 5-in off ordingly, the rner. Also, the rner. Also, the liance with	in flowmet 11 x 12 in center, so injection is he center in the injection	er ches with the one-inch njection on port. Signature ve 7/30/04	erifying data	North		aber	East

	TRACER GAS TRA Site <u>325 Model</u>					RM			
	Site	325 Wodel			Run No.	<u>GI-7</u>			
		9/8/2004		Fan C		Fartan			
	i ester	JAG/JMB			Fan Setting	37.1 Hz			
0	Stack Dia.	18	n		Stack Temp	84	deg F		
5	tack X-Area	254.51	n.2	Sta	art/End Time	1130/1222		10.05	
Distance to	Elevation	N.A.	nahaa	Deinteri	nter 2/3 from	1.65	to:	16.35	
Distance to	disturbance	<u>120 </u>	ncnes	Points I	n Center 2/3	Tax Marth 4	to:	<u>/</u>	
weasur	rement units	<u>ppm 5+0</u>		IŊ	jection Point	1 op North, 1	-inch from c	orner walls	
Traverse>			Ea	ast			No	orth	
Trial>		1 1	2	3	Mean	1 1	2	3	Mean
Point	Depth, in.		pr	m			00		
1	0.58	3.33	3.32	3.58	3.41	3.36	3.35	3,40	3.37
2	1.89	3.27	3.32	3.24	3.28	3.38	3.25	3.33	3.32
3	3.49	3.23	3.43	3.41	3.36	3.48	3.39	3.31	3.39
4	5.81	3.26	3.36	3.59	3.40	3.51	3.19	3.21	3.30
Center	9.00	3.42	3.42	3.46	3.43	3.19	3.24	3.48	3.30
5	12.19	3.22	3.41	3.42	3.35	3.44	3.36	3.58	3.46
6	14.51	3.49	3.35	3.23	3.36	3.44	3.53	3.45	3.47
7	16.11	3.39	3.18	3.37	3.31	3.39	3.26	3.36	3.34
8	17.42	3.30	3.15	3.35	3.27	3.55	3.28	3.26	3.36
Averages	>	3.32	3.33	3.41	3.35	3.42	3.32	3.38	3.37
		All	ppm	Dev	<u>, from mean</u>	<u>Center 2/3</u>	East	North	All
		Mean	3.36			Mean	3.36	3.37	3.36
		Min Point	3.27		-2.8%	Std. Dev.	0.05	0.07	0.06
A	0.000	Max Point	3.47		3.4%	COV as %	1.56	2.16	1.82
Avg. Conc.	3,360	ppm			Gas analyz	er checked:			
		Ctort	Finich		9/1/2004				
Tracer tank n	ressure	315	<u>- Finish</u> 315	nsia .					
Sample Port	Temn	83	85	F					
Centerline ve	l	765	765.0	fom					
Injection flow	meter	3.5	3.5	% bl. ball**				and a state of the	
Ambient tem	D.	77	79	dea. F		and the second			
Sampling flov	vmeter	10	10	lpm Sierra	4		1		
Ambient pres	sure	748.30	748.3	mm Ha	35-				
Ambient hum	idity	38	35	%RH	0.0	- 53 - 53			
B&K vapor co	orrection	N							
			N	Y/N	3-				
		38/40/41/37/	N 38/37/36/35/	Y/N	3		1		
Back-Gd gas	level	38/40/41/37/ 40	N 38/37/36/35/ 35	Y/N ppb	3- 2.5-				
Back-Gd gas No. Bk-Gd sa	level Imples	38/40/41/37/ 40 5	N 38/37/36/35/ 35 5	Y/N ppb n	3 2.5 P P 2				
Back-Gd gas No. Bk-Gd sa Ambient pres	level Imples Isure	38/40/41/37/ 40 5 1012.9	N 38/37/36/35/ 35 5 1012.9	Y/N ppb n mbar	3- 2.5- P P 2- m				
Back-Gd gas No. Bk-Gd sa Ambient pres Instuments [level amples sure U sed:	38/40/41/37/ 40 5 1012.9	N 38/37/36/35/ 35 5 1012.9	Y/N ppb n mbar	3 2.5 P 2 m 1.5				
Back-Gd gas No. Bk-Gd sa Ambient pres Instuments <u>J</u> B & K Model	level Imples sure Used: 1302 #1765	38/40/41/37/ 40 5 1012.9 299	N 38/37/36/35/ 35 5 1012.9	Y/N ppb n mbar	3 2.5 P 2 m 1.5				
Back-Gd gas No. Bk-Gd sa Ambient pres Instuments I B & K Model Sierra Inc. Co	level imples sure U sed: 1302 #1765 onstant Flow	38/40/41/37/ 40 5 1012.9 299 / Air Sampler	N 38/37/36/35/ 35 5 1012.9	Y/N ppb n mbar	3 2.5- p 2- m 1.5- 1-				
Back-Gd gas No. Bk-Gd sa Ambient pres Instuments I B & K Model Sierra Inc. Co Solomat Zep	level imples sure Used: 1302 #1765 onstant Flow ohyr SN 12	38/40/41/37/ 40 5 1012.9 299 / Air Sampler 95-1472	N 38/37/36/35/ 35 5 1012.9	Y/N ppb n mbar	3 2.5 p 2 m 1.5 1- 0.5				
Back-Gd gas No. Bk-Gd sa Ambient pres Instuments I B & K Model Sierra Inc. Co Solomat Zep	level imples sure Used: 1302 #1765 onstant Flow ohyr SN 12 n black pla	38/40/41/37/ 40 5 1012.9 299 / Air Sampler 95-1472 stic ball float	N 38/37/36/35/ 35 5 1012.9	Y/N ppb mbar 	3 2.5 P 2 m 1.5 1- 0.5				
Back-Gd gas No. Bk-Gd sa Ambient pres Instuments I B & K Model Sierra Inc. Co Solomat Zep **Reading of Notes:	level imples sure Used: 1302 #1765 onstant Flow ohyr SN 129 n black plat At this poin	38/40/41/37/ 40 5 1012.9 299 / Air Sampler 95-1472 stic ball float t, the duct is	N 38/37/36/35/ 35 5 1012.9 in flowmet 11 x 12 in	Y/N ppb mbar er	3 2.5 P 2 m 1.5 1- 0.5	0,0			
Back-Gd gas No. Bk-Gd sa Ambient pres Instuments I B & K Model Sierra Inc. Co Solomat Zep **Reading of Notes: The injection	level amples sure Used: 1302 #1765 onstant Flow ohyr SN 129 n black plac At this poin o probe rea	38/40/41/37/ 40 5 1012.9 299 Air Sampler 95-1472 stic ball float t, the duct is ches 5-in off	N 38/37/36/35/ 35 5 1012.9 in flowmet 11 x 12 in center, so	Y/N ppb n mbar er ches with the	3 2.5 P 2 m 1.5 1.5 0.5				East
Back-Gd gas No. Bk-Gd sa Ambient pres Instuments I B & K Model Sierra Inc. Co Solomat Zep **Reading of Notes: The injection elevation ad	level imples sure Used: 1302 #1765 onstant Flow ohyr SN 120 n black plas At this poin probe rea justed acco	38/40/41/37/ 40 5 1012.9 299 Air Sampler 95-1472 stic ball float t, the duct is ches 5-in off ordingly, the i	N 38/37/36/35/ 35 1012.9 in flowmet 11 x 12 ind center, so njection is	Y/N ppb n mbar er ches with the one-inch	3 2.5 p 2 m 1.5 1 0.5	North			East
Back-Gd gas No. Bk-Gd sa Ambient pres Instuments I B & K Model Sierra Inc. Co Solomat Zep **Reading of Notes: The injection elevation ad from both sig	level sure Used: 1302 #1765 onstant Flow ohyr SN 129 n black plas At this poin n probe rea justed accordes of a co	38/40/41/37/ 40 5 1012.9 299 / Air Sampler 95-1472 stic ball float t, the duct is ches 5-in off ordingly, the i	N 38/37/36/35/ 35 5 1012.9 in flowmet 11 x 12 in center, so njection is ne center ir	Y/N ppb n mbar er ches with the one-inch ojection	3 2.5 P 2 m 1.5 1.5 0.5	North			East
Back-Gd gas No. Bk-Gd sa Ambient pres Instuments I B & K Model Sierra Inc. Co Solomat Zep **Reading of Notes: The injection elevation ad from both sig point is 5-in	level sure Used: 1302 #1765 onstant Flow ohyr SN 129 n black plat At this poin n probe rea justed acco closer to th	38/40/41/37/ 40 5 1012.9 299 / Air Sampler 95-1472 stic ball float t, the duct is ches 5-in off ordingly, the i rner. Also, the e stack than	N 38/37/36/35/ 35 1012.9 in flowmet 11 x 12 in center, so njection is the center in the injection	Y/N ppb n mbar er ches with the one-inch njection on port.	3 2.5 P 2 m 1.5 1- 0.5 0	North			East
Back-Gd gas No. Bk-Gd sa Ambient pres Instuments I B & K Model Sierra Inc. Co Solomat Zep **Reading of Notes: The injection elevation ad from both sic point is 5-in Signature sig	level sure Used: 1302 #1765 onstant Flow ohyr SN 129 n black pla At this point n probe rea justed accordes of a co closer to the nifies comp	38/40/41/37/ 40 5 1012.9 299 Air Sampler 95-1472 stic ball float t, the duct is ches 5-in off ordingly, the i rner. Also, the e stack than iance with	N 38/37/36/35/ 35 1012.9 in flowmet 11 x 12 in center, so njection is ne center ir the injectio	Y/N ppb n mbar er ches with the one-inch njection on port. Signature ve	3 2.5 P 2 m 1.5 1.5 0.5 0-2	North	ons:		East
Back-Gd gas No. Bk-Gd sa Ambient pres Instuments I B & K Model Sierra Inc. Co Solomat Zep **Reading of Notes: The injection elevation ad from both sic point is 5-in Signature sig Procedure EN	level sure Used: 1302 #1765 onstant Flow ohyr SN 129 n black plas At this poin n probe rea justed accordes of a co closer to th nifies comp MS JAG-01	38/40/41/37/ 40 5 1012.9 299 Air Sampler 95-1472 stic ball float t, the duct is ches 5-in off ordingly, the i rner. Also, th e stack than liance with	N 38/37/36/35/ 35 5 1012.9 in flowmete 11 x 12 ind center, so njection is ne center in the injectio	Y/N ppb n mbar er ches with the one-inch njection on port. Signature ve	3 2.5 P 2 m 1.5 1 0.5 0	North	ons:		East
Back-Gd gas No. Bk-Gd sa Ambient pres Instuments I B & K Model Sierra Inc. Co Solomat Zep **Reading of Notes: The injection elevation ad from both sic point is 5-in Signature sig Procedure Eff	level imples sure Used: 1302 #1765 onstant Flow ohyr SN 120 n black plat At this poin probe rea justed acco closer to the nifies comp WS JAG-07 te	38/40/41/37/ 40 5 1012.9 299 / Air Sampler 95-1472 stic ball float t, the duct is ches 5-in off ordingly, the i rner. Also, the e stack than liance with	N 38/37/36/35/ 35 5 1012.9 in flowmete 11 x 12 ind center, so njection is the center in the injectio	Y/N ppb n mbar er ches with the one-inch one-inch one-inch Signature ver 9/36/07	3 2.5 P 2 m 1.5 1 0.5 0	North and calculation	ons:	by 9	East
Back-Gd gas No. Bk-Gd sa Ambient pres Instuments I B & K Model Sierra Inc. Co Solomat Zep **Reading of Notes: The injection elevation ad from both sic point is 5-in Signature sig Procedure EN Signature/dat	level sure Used: 1302 #1765 onstant Flow ohyr SN 129 n black plas At this poin n probe rea justed accordes of a co closer to the nifies comp WS IAG-01 te	38/40/41/37/ 40 5 1012.9 299 / Air Sampler 95-1472 stic ball float t, the duct is ches 5-in off ordingly, the i rner. Also, the e stack than liance with	N 38/37/36/35/ 35 5 1012.9 in flowmet 11 x 12 in center, so njection is ne center in the injectio	Y/N ppb n mbar er ches with the one-inch jection Signature ve <u>9/36/07</u> 25 Scale gasu	3 2.5 P 2 m 1.5 1.5 0.5 0 erifying data	North and calculation	ons:	by 9	East

		TR	ACER GAS	TRAVERSE	DATA FOR	RM .			
	Site	325 Model			Run No.	GT_8			
	Date	9/8/2004		Fan C	onfiguration	Far fan			
	Tester	JAG/JMB			Fan Setting	37.1 Hz			
	Stack Dia.	18 ii	n	S	Stack Temp	87 0	deg F		
S	tack X-Area	254.5 ii	n.2	Sta	rt/End Time	1222/1302			
	Elevation	N.A.		Cen	ter 2/3 from	1.65	to:	16.35	
Distance to	disturbance	<u> </u>	nches	Points ir	Center 2/3	2	to:	7	
Measu	rement units	ppm SF6		Inj	ection Point	Center			
_						·			
Traverse>			Ea	ist	Мали		No	rth	Maan
Irial>	Danth in	1	2	<u> </u>	Mean		2	<u>3</u>	Mean
Point	Depth, In.	2 24	2 15	3 50	2 22	3 47	3 30	3 42	3 43
1	1.80	3.34	3 35	3.30	3.33	3.47	3.54	3 38	3.43
2	3 49	3.24	3 33	3.29	3.29	3.54	3 43	3.36	3.44
4	5.40	3 29	3.22	3 33	3.28	3 48	3 44	3 34	3 42
Center	9.00	3 25	3.25	3.21	3.24	3.45	3.44	3.36	3.42
5	12 19	3.30	3.22	3.41	3.31	3.60	3.42	3.36	3.46
6	14.51	3.27	3.25	3.30	3.27	3.54	3.33	3.26	3.38
7	16.11	3.33	3.41	3.31	3.35	3.55	3.25	3.48	3.43
8	17.42	3.34	3.47	3.32	3.38	3.59	3.50	3.52	3.54
Averages	>	3.29	3.29	3.34	3.31	3.52	3.42	3.39	3.44
-									
		All	ppm	Dev	from mean	<u>Center 2/3</u>	East	North	All
		Mean	3.38			Mean	3.30	3.43	3.36
		Min Point	3.24		-4.1%	Std. Dev.	0.04	0.03	0.08
		Max Point	3.54		4.8%	COV as %	1.20	0.89	2.28
Avg. Conc.	3.382	ppm			Gas analyz	er checked:			
				-	9/1/2004				
		Start	Finish						
Tracer tank p	ressure	315	370	psig					
Sample Port	Temp	85	89	F					
Centerline ve	el.	765	739.0	fpm					
Injection flow	meter	3.5	3.5	% bl. ball**					
Ambient tem	p.	79	80						
Sampling flow	wmeter		00	deg. F	4-				
Ambient pres		10	9.5	deg. F Ipm Sierra	4-				
	sure	748.30	9.5	deg. F Ipm Sierra mm Hg	4 3.5	H			
Amplent num	nidity	748.30 35	9.5 747.8 32	deg. F Ipm Sierra mm Hg %RH	4 3.5	Ħ			
B&K vapor c	nidity orrection	10 748.30 35 N	9.5 9.5 747.8 32 N	deg. F Ipm Sierra mm Hg %RH Y/N	4- 3.5- 3-	I			
B&K vapor co	nidity orrection	10 748.30 35 N 38/37/36/35/ 35	9.5 747.8 32 N 32/32/35/31/ 31	deg. F Ipm Sierra mm Hg %RH Y/N ppb	4	Ŧ	15		
Back-Gd gas	nidity orrection level	10 748.30 35 N 38/37/36/35/ 35	9.5 747.8 32 32/32/35/31/ 31 5	deg. F Ipm Sierra mm Hg %RH Y/N ppb n	4 3.5 3 2.5	Ŧ			
Back-Gd gas No. Bk-Gd sa	nidity orrection level amples ssure	10 748.30 35 N 38/37/36/35/ 35 5 1012.9	9.5 747.8 32 32/32/35/31/ 31 5 1012.2	deg. F Ipm Sierra mm Hg %RH Y/N ppb n mbar	4- 3.5- 3- 2.5- P P 2- m	ł			
Back-Gd gas No. Bk-Gd sa Ambient pres	nidity orrection alevel amples ssure Used:	10 748.30 35 N 38/37/36/35/ 35 5 1012.9	9.5 747.8 32 32/32/35/31/ 31 5 1012.2	deg. F Ipm Sierra mm Hg %RH Y/N ppb n mbar	4 3.5 3 2.5 P 2 m 1.5				
Back-Gd gas No. Bk-Gd sa Ambient pres Instuments B & K Model	nidity orrection apples ssure Used: 1302 #1765	10 748.30 35 N 38/37/36/35/ 35 5 1012.9	9.5 747.8 32 32/32/35/31/ 31 5 1012.2	deg. F Ipm Sierra mm Hg %RH Y/N Ppb n mbar	4 3.5 3 2.5 P P 2 m 1.5	Ī			
Back-Gd gas No. Bk-Gd sa Ambient pres Instuments B & K Model Sierra Inc. C	nidity orrection elevel amples ssure Used: 1302 #1765 onstant Floy	10 748.30 35 N 38/37/36/35/ 35 5 1012.9	9.5 9.5 747.8 32 32/32/35/31/ 31 5 1012.2	deg. F Ipm Sierra mm Hg %RH Y/N ppb n mbar	4 3.5 3 2.5 P 2 m 1.5				
Back-Gd gas Back-Gd gas No. Bk-Gd sa Ambient pres Instuments B & K Model Sierra Inc. C Solomat Zel	nidity orrection level amples ssure Used: 1302 #1765 onstant Flov phyr SN 12	10 748.30 35 N 38/37/36/35/ 35 5 1012.9 i299 v Air Sampler 95-1472	9.5 747.8 32 32/32/35/31/ 31 5 1012.2	deg. F Ipm Sierra mm Hg %RH Y/N ppb n mbar	4 3.5 3 2.5 P 2 m 1.5 1 0.5				
Back-Gd gas Back-Gd gas No. Bk-Gd sa Ambient pres Instuments B & K Model Sierra Inc. C Solomat Zej **Reading o	nidity orrection amples ssure <u>Used:</u> 1302 #1765 onstant Flov phyr SN 12 n black pla	10 748.30 35 N 38/37/36/35/ 35 5 1012.9 v Air Sampler 95-1472 stic ball float	9.5 747.8 32 32/32/35/31/ 31 5 1012.2 in flowmet	deg. F Ipm Sierra mm Hg %RH Y/N ppb n mbar mbar er	4 3.5 3 2.5 P 2 m 1.5 1 0.5				
Back-Gd gas Back-Gd gas No. Bk-Gd sa Ambient pres Instuments B & K Model Sierra Inc. C Solomat Zeg **Reading o Notes:	nidity orrection amples ssure Used: 1302 #1765 onstant Flov phyr SN 12 on black pla At this poir	10 748.30 35 N 38/37/36/35/ 35 5 1012.9 v Air Sampler 95-1472 stic ball float it, the duct is	9.5 9.5 747.8 32 N 32/32/35/31/ 31 5 1012.2 in flowmet 11 x 12 in	deg. F Ipm Sierra mm Hg %RH Y/N ppb n mbar er	4 3.5 3 2.5 P 2 m 1.5 1 0.5				
Back-Gd gas Back-Gd gas No. Bk-Gd sa Ambient pres Instuments B & K Model Sierra Inc. C Solomat Zeg **Reading o Notes: The injection	nidity orrection elevel amples ssure Used: 1302 #1765 onstant Flov phyr SN 12 on black pla At this poir n probe rea	10 748.30 35 N 38/37/36/35/ 35 5 1012.9 v Air Sampler 95-1472 stic ball float it, the duct is iches 5-in off	9.5 9.5 747.8 32 32/32/35/31/ 31 5 1012.2 in flowmet 11 x 12 in center, so	deg. F Ipm Sierra mm Hg %RH Y/N ppb n mbar er ches with the	4 3.5 3 2.5 P 2 m 1.5 1 0.5 0				East
Back-Gd gas Back-Gd gas No. Bk-Gd sa Ambient pres Instuments B & K Model Sierra Inc. C Solomat Zeg **Reading o Notes: The injection elevation ac	nidity orrection amples ssure Used: 1302 #1765 onstant Flov phyr SN 12 on black pla At this poir n probe rea ljusted acce	748.30 35 N 38/37/36/35/ 35 5 1012.9 v Air Sampler 95-1472 stic ball float t, the duct is ches 5-in off ordingly, the i	9.5 9.5 747.8 32 32/32/35/31/ 31 5 1012.2 in flowmet 11 x 12 in center, so njection is	deg. F Ipm Sierra mm Hg %RH Y/N ppb n mbar er ches with the one-inch	4 3.5 3 2.5 P 2 m 1.5 1 0.5 0	North			East
Back-Gd gas Back-Gd gas No. Bk-Gd sa Ambient pres Instuments B & K Model Sierra Inc. C Solomat Zej ***Reading o Notes: The injection elevation ac from both si	nidity orrection amples ssure Used: 1302 #1765 onstant Flov phyr SN 12 in black pla At this poir n probe rea ijusted acco des of a co	748.30 35 N 38/37/36/35/ 35 5 1012.9 v Air Sampler 95-1472 stic ball float t, the duct is ches 5-in off ordingly, the i rner. Also, th	9.5 9.5 747.8 32 32/32/35/31/ 31 5 1012.2 in flowmet 11 x 12 in center, so njection is ne center i	deg. F Ipm Sierra mm Hg %RH Y/N ppb n mbar er ches with the one-inch njection	4 3.5 3 2.5 P 2 m 2 1.5 1 0.5 0	North			East
Back-Gd gas Back-Gd gas No. Bk-Gd sa Ambient pres Instuments B & K Model Sierra Inc. C Solomat Zeg **Reading o Notes: The injection elevation ac from both si point is 5-in	nidity orrection level amples ssure Used: 1302 #1765 onstant Flov phyr SN 12 on black pla At this poir n probe rea ljusted acco des of a co closer to th	748.30 35 N 38/37/36/35/ 35 5 1012.9 v Air Sampler 95-1472 stic ball float it, the duct is iches 5-in off ordingly, the i rner. Also, the	9.5 9.5 747.8 32 32/32/35/31/ 31 5 1012.2 in flowmet 11 x 12 in center, so njection is ne center in the injectio	deg. F Ipm Sierra mm Hg %RH Y/N ppb n mbar er ches with the one-inch njection on port.	4 3.5 3 2.5 P 2 m 1.5 1 0.5 0	North			East
Back-Gd gas Back-Gd gas No. Bk-Gd sa Ambient pres Instuments B & K Model Sierra Inc. C Solomat Zee **Reading o Notes: The injection elevation ac from both si point is 5-in Signature sig	nidity orrection level amples ssure Used: 1302 #1765 onstant Flov phyr SN 12 on black pla At this poir n probe rea ijusted acco des of a co closer to th gnifies comp	748.30 35 N 38/37/36/35/ 35 5 1012.9 v Air Sampler 95-1472 stic ball float nt, the duct is iches 5-in off ordingly, the i rner. Also, the istack than liance with	9.5 9.5 747.8 32 N 32/32/35/31/ 31 5 1012.2 in flowmet 11 x 12 in center, so njection is ne center in the injection	deg. F Ipm Sierra mm Hg %RH Y/N ppb n mbar er ches with the one-inch njection on port. Signature ve	4 3.5 3 2.5 P 2 m 1.5 1 0.5 0	North			East
Ambient num B&K vapor co Back-Gd gas No. Bk-Gd sa Ambient pres Instuments B & K Model Sierra Inc. C Solomat Zeg **Reading o Notes: The injection elevation ac from both si point is 5-in Signature sig Procedure E	nidity orrection level amples sure Used: 1302 #1765 onstant Flov phyr SN 12 on black pla At this poir n probe rea ljusted acco closer to th gnifies comp MSQAG-01	748.30 35 N 38/37/36/35/ 35 5 1012.9 v Air Sampler 95-1472 stic ball float it, the duct is iches 5-in off ordingly, the i rner. Also, th ie stack than liance with	9.5 9.5 747.8 32 N 32/32/35/31/ 31 5 1012.2 in flowmet 11 x 12 in center, so njection is ne center ii the injectio	deg. F Ipm Sierra mm Hg %RH Y/N ppb n mbar er ches with the one-inch njection on port. Signature ve	4 3.5 3 2.5 p 2 m 1.5 1 0.5 0	North	ons:		East
Ambient num B&K vapor co Back-Gd gas No. Bk-Gd sa Ambient pres Instuments B & K Model Sierra Inc. Co Solomat Zeg **Reading o Notes: The injection elevation ac from both si point is 5-in Signature sig Procedure E Signature/da	nidity orrection level amples ssure Used: 1302 #1765 onstant Flov phyr SN 12 on black pla At this poir n probe rea ljusted acco des of a co closer to th gnifies comp MSDAG-01 te	748.30 35 N 38/37/36/35/ 35 5 1012.9 v Air Sampler 95-1472 stic ball float it, the duct is iches 5-in off ordingly, the i rner. Also, th ie stack than liance with	9.5 9.5 747.8 32 N 32/32/35/31/ 31 5 1012.2 in flowmet 11 x 12 in center, so njection is ne center in the injection	deg. F Ipm Sierra mm Hg %RH Y/N ppb n mbar er ches with the one-inch njection on port. Signature ve	4 3.5 3 2.5 9 2 m 1.5 1 0.5 0	North and calculation Roam		Habu	East
Ambient num B&K vapor co Back-Gd gas No. Bk-Gd sa Ambient pres Instuments B & K Model Sierra Inc. Cr Solomat Zej **Reading o Notes: The injection elevation ac from both si point is 5-in Signature sig Procedure E Signature/da	sure nidity orrection level amples ssure Used: 1302 #1765 onstant Flov phyr SN 12 in black pla At this poir n probe rea ljusted acco des of a co closer to th gnifies comp MS DAG-01 te	748.30 35 N 38/37/36/35/ 35 5 1012.9 v Air Sampler 95-1472 stic ball float it, the duct is iches 5-in off ordingly, the i rner. Also, th is stack than liance with	9.5 9.5 747.8 32 N 32/32/35/31/ 31 5 1012.2 in flowmet 11 x 12 in center, so njection is ne center in the injection	deg. F Ipm Sierra mm Hg %RH Y/N ppb n mbar er ches with the one-inch njection on port. Signature ve	4 3.5 3 2.5 P 2 m 1.5 1 0.5 0	North and calculation Reserved		Habu	East

	TRACER GAS TRAV Site <u>325 Model</u>					CT 9			
	Data	0/9/2004		Ean C	onfiguration	Ear fan			
	Dale	9/0/2004		Fall C		27 4 U-			
	Ctack Dia				Fan Setting	<u>37.1 HZ</u>			
0	Stack Dia.	054.5	n	Cta	Stack Temp	89.5 0	leg F		
S	tack X-Area	254.51	n.2	Sta		1302/1354	4	10.05	
	Elevation	N.A.		Cer	iter 2/3 from	1.65	το:	16.35	
Distance to	disturbance	120 1	nches	Points I	n Center 2/3	2	to:	/	
Measu	rement units	ppm SF6		In	jection Point	Bottom North			
Traverse>			Ea	ist			No	rth	
Trial>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.		pp	m			рр	m	
1	0.58	3.24	3.54	3.21	3.33	3.37	· 3.26	2.98	3.20
2	1.89	3.49	3.33	3.50	3.44	3.25	3.36	3.20	3.27
3	3.49	3.27	3.23	3.35	3.28	3.47	3.33	3.23	3.34
4	5.81	3.58	3.35	3.40	3.44	3.42	3.09	3.18	3.23
Center	9.00	3.28	3.26	3.46	3.33	3.61	3.41	3.33	3.45
5	12.19	3.70	3.36	3.13	3.40	3.72	3.12	3.17	3.34
6	14.51	3.46	3.38	3.34	3.39	3.76	3.34	3.32	3.47
7	16.11	3.27	3.27	3.22	3.25	3.64	3.36	3.41	3.47
. 8	17.42	3.36	3.27	3.42	3.35	3.43	3.23	3.35	3.34
Averages	>	3.41	3.33	3.34	3.36	3.52	3.28	3.24	3.35
_									
		All	ppm	Dev	. from mean	Center 2/3	East	North	All
		Mean	3.35			Mean	3.36	3.37	3.37
		Min Point	3.20		-4.4%	Std. Dev.	0.07	0.10	0.08
		Max Point	3.47		3.6%	COV as %	2.23	2.93	2.50
Ava. Conc.	3.347	ppm			Gas analyz	er checked:			
					9/1/2004				
		Start	Finish						
Tracer tank p	ressure	370	390	psig					
Sample Port	Temp	87	92	F					
Centerline ve	el.	739	764.0	fpm					1
Injection flow	motor								1
	meter	3.5	3.5	% bl. ball**					
Ambient tem	nieter D	3.5	3.5 83	% bl. ball** deg. F					
Ambient tem	p. wmeter	3.5 80 10	3.5 83	% bl. ball** deg. F Ipm Sierra	4				
Ambient temp Sampling flow	p. wmeter	3.5 80 10 747.80	3.5 83 10 747.4	% bl. ball** deg. F Ipm Sierra mm Hg	4				
Ambient tem Sampling flov Ambient pres	p. wmeter ssure	3.5 80 10 747.80 32	3.5 83 10 747.4 29	% bl. ball** deg. F Ipm Sierra mm Hg %RH	3.5	1			
Ambient temp Sampling flow Ambient pres Ambient hum B&K vapor c	p. wmeter ssure hidity	3.5 80 10 747.80 32 N	3.5 83 10 747.4 29 N	% bl. ball** deg. F Ipm Sierra mm Hg %RH Y/N	4	4			
Ambient temp Sampling flov Ambient pres Ambient hum B&K vapor co	p. wmeter ssure nidity orrection	3.5 80 10 747.80 32 N 32/32/35/31/	3.5 83 10 747.4 29 N 38/33/31/32/	% bl. ball** deg. F Ipm Sierra mm Hg %RH Y/N	4 3.5 3	I			
Ambient temp Sampling flov Ambient pres Ambient hum B&K vapor co Back-Gd gas	nieter p. wmeter ssure nidity orrection	3.5 80 10 747.80 32 N 32/32/35/31/ 31	3.5 83 10 747.4 29 N 38/33/31/32/ 30	% bl. ball** deg. F Ipm Sierra mm Hg %RH Y/N ppb	4 3.5 3 2.5	Ŧ			
Ambient temp Sampling flov Ambient pres Ambient hum B&K vapor co Back-Gd gas No. Bk-Gd sa	nneter p. wmeter ssure nidity orrection s level amples	3.5 80 10 747.80 32 N 32/32/35/31/ 31 5	3.5 83 10 747.4 29 N 38/33/31/32/ 30 5	% bl. ball** deg. F Ipm Sierra mm Hg %RH Y/N ppb n	4 3.5 3 2.5 P 2.5	I			
Ambient temp Sampling flov Ambient pres Ambient hum B&K vapor co Back-Gd gas No. Bk-Gd sa Ambient pres	p. wmeter ssure nidity orrection s level amples ssure	3.5 80 10 747.80 32 N 32/32/35/31/ 31 5 1012.2	3.5 83 10 747.4 29 N 38/33/31/32/ 30 5 1012	% bl. ball** deg. F Ipm Sierra mm Hg %RH Y/N ppb n mbar	4 3.5 3 2.5 P 2 m	ł			
Ambient tem Sampling flov Ambient pres Ambient hum B&K vapor co Back-Gd gas No. Bk-Gd sa Ambient pres Instuments	nneter p. wmeter ssure nidity orrection s level amples ssure Used:	3.5 80 10 747.80 32 N 32/32/35/31/ 31 5 1012.2	3.5 83 10 747.4 29 N 38/33/31/32/ 30 5 1012	% bl. ball** deg. F Ipm Sierra mm Hg %RH Y/N ppb n mbar	4 3.5 3 2.5 P 2.5 m 1.5	I			
Ambient tem Sampling flov Ambient pres Ambient hum B&K vapor co Back-Gd gas No. Bk-Gd sa Ambient pres Instuments B & K Model	p. wmeter ssure hidity orrection level amples ssure Used: 1302 #1765	3.5 80 10 747.80 32 82/32/35/31/ 31 5 1012.2	3.5 83 10 747.4 29 N 38/33/31/32/ 30 5 1012	% bl. ball** deg. F Ipm Sierra mm Hg %RH Y/N ppb n mbar	4 3.5 3 2.5 P 2 m 1.5				
Ambient tem Sampling flov Ambient pres Ambient hum B&K vapor co Back-Gd gas No. Bk-Gd sa Ambient pres Instuments B & K Model Sierra Inc. C	niteter p. wmeter ssure nidity orrection i level amples ssure Used: 1302 #1765 onstant Floy	3.5 80 10 747.80 32 N 32/32/35/31/ 31 5 1012.2 5299 v Air Sampler	3.5 83 10 747.4 29 N 38/33/31/32/ 30 5 1012	% bl. ball** deg. F Ipm Sierra mm Hg %RH Y/N Ppb n mbar	4 3.5 3 2.5 p 2.5 m 1.5				
Ambient tem Sampling flov Ambient pres Ambient hum B&K vapor co Back-Gd gas No. Bk-Gd sa Ambient pres Instuments B & K Model Sierra Inc. C Solomat Zei	p. wmeter ssure nidity orrection a level amples ssure Used: 1302 #1765 onstant Flov	3.5 80 10 747.80 32 N 32/32/35/31/ 31 5 1012.2 5299 v Air Sampler 95-1472	3.5 83 10 747.4 29 N 38/33/31/32/ 30 5 1012	% bl. ball** deg. F Ipm Sierra mm Hg %RH Y/N Ppb n mbar	4 3.5 3 2.5 p 2 m 1.5 1 0.5				
Ambient tem Sampling flov Ambient pres Ambient pres Ambient hum B&K vapor co Back-Gd gas No. Bk-Gd sa Ambient pres Instuments B & K Model Sierra Inc. C Solomat Ze	p. wmeter ssure nidity orrection amples ssure Used: 1302 #1765 onstant Flov phyr SN 12 on black pla	3.5 80 10 747.80 32 N 32/32/35/31/ 31 5 1012.2 5299 v Air Sampler 95-1472 stic ball float	3.5 83 10 747.4 29 N 38/33/31/32/ 30 5 1012 	% bl. ball** deg. F Ipm Sierra mm Hg %RH Y/N ppb n mbar mbar	4 3.5 3 2.5 p 2 m 1.5 1 0.5				
Ambient tem Sampling flov Ambient pres Ambient pres Ambient hum B&K vapor co Back-Gd gas No. Bk-Gd sa Ambient pres Instuments B & K Model Sierra Inc. C Solomat Zee **Reading o Notes:	p. wmeter ssure nidity orrection amples ssure Used: 1302 #1765 onstant Flow phyr SN 12 on black pla At this poir	3.5 80 10 747.80 32 N 32/32/35/31/ 31 5 1012.2 5299 v Air Sampler 95-1472 stic ball float	3.5 83 10 747.4 29 N 38/33/31/32/ 30 5 1012 in flowmet	% bl. ball** deg. F Ipm Sierra mm Hg %RH Y/N ppb n mbar er ches	4 3.5 3 2.5 P 2 m 1.5 1 0.5	0,0			
Ambient tem Sampling flov Ambient pres Ambient pres Ambient hum B&K vapor co Back-Gd gas No. Bk-Gd sa Ambient pres Instuments B & K Model Sierra Inc. C Solomat Ze **Reading o Notes: The injectio	p. wmeter ssure nidity orrection level amples ssure Used: 1302 #1765 onstant Flow phyr SN 12 on black pla At this poir	3.5 80 10 747.80 32 N 32/32/35/31/ 31 5 1012.2 5299 v Air Sampler 95-1472 stic ball float it, the duct is cches 5-in off	3.5 83 10 747.4 29 N 38/33/31/32/ 30 5 1012 in flowmet 11 x 12 in center, so	% bl. ball** deg. F Ipm Sierra mm Hg %RH Y/N ppb n mbar er ches with the	4 3.5 3 2.5 9 2.5 m 1.5 1 0.5 0				East
Ambient tem Sampling flov Ambient pres Ambient pres Ambient hum B&K vapor co Back-Gd gas No. Bk-Gd sa Ambient pres Instuments B & K Model Sierra Inc. C Solomat Ze **Reading o Notes: The injection ac	p. wmeter ssure hidity orrection apples ssure Used: 1302 #1765 onstant Flow phyr SN 12 on black pla At this poir n probe rea	3.5 80 10 747.80 32 82/32/35/31/ 31 5 1012.2 5299 v Air Sampler 95-1472 stic ball float at, the duct is aches 5-in off	3.5 83 10 747.4 29 N 38/33/31/32/ 30 5 1012 in flowmet 11 x 12 in center, so injection is	% bl. ball** deg. F Ipm Sierra mm Hg %RH Y/N ppb n mbar er ches with the one-inch	4 3.5 3 2.5 9 2 7 9 2 m 1.5 1 0.5 0	North			East
Ambient tem Sampling flov Ambient pres Ambient pres Ambient hum B&K vapor co Back-Gd gas No. Bk-Gd sa Ambient pres Instuments B & K Model Sierra Inc. C Solomat Zep **Reading o Notes: The injection ac from both si	p. wmeter ssure hidity orrection level amples ssure Used: 1302 #1765 onstant Flov phyr SN 12 on black pla At this poir n probe rea ijusted acco	3.5 80 10 747.80 32 N 32/32/35/31/ 31 5 1012.2 5299 v Air Sampler 95-1472 stic ball float t, the duct is iches 5-in off ordingly, the	3.5 83 10 747.4 29 N 38/33/31/32/ 30 5 1012 in flowmet 11 x 12 in center, so injection is	% bl. ball** deg. F Ipm Sierra mm Hg %RH Y/N ppb n mbar er ches with the one-inch piection	4 3.5 3 2.5 P 2 m 1.5 1 0.5 0	North			East
Ambient tem Sampling flov Ambient pres Ambient pres Ambient hum B&K vapor co Back-Gd gas No. Bk-Gd sa Ambient pres Instuments B & K Model Sierra Inc. C Solomat Zee **Reading o Notes: The injection elevation ac from both si point is 5-in	p. wmeter ssure nidity orrection a level amples ssure Used: 1302 #1765 onstant Flov phyr SN 12 on black pla At this poir n probe rea djusted accorded	3.5 80 10 747.80 32 N 32/32/35/31/ 31 5 1012.2 5299 v Air Sampler 95-1472 stic ball float at, the duct is icches 5-in off ordingly, the rner. Also, t	3.5 83 10 747.4 29 N 38/33/31/32/ 30 5 1012 in flowmet 11 x 12 in center, so injection is he center in	% bl. ball** deg. F Ipm Sierra mm Hg %RH Y/N ppb n mbar er ches with the one-inch njection	4 3.5 3 2.5 9 2 m 1.5 1 0.5 0	North			East
Ambient tem Sampling flov Ambient pres Ambient pres Ambient pres Back-Gd gas No. Bk-Gd sa Ambient pres Instuments B & K Model Sierra Inc. C Solomat Zee **Reading o Notes: The injectio elevation ac from both si point is 5-in	p. wmeter ssure nidity orrection amples ssure Used: 1302 #1765 onstant Flow phyr SN 12 on black pla At this poir n probe rea djusted acco closer to the phiftes composition	3.5 80 10 747.80 32 N 32/32/35/31/ 31 5 1012.2 5299 v Air Sampler 95-1472 stic ball float nt, the duct is inches 5-in off ordingly, the rner. Also, the rne stack than	3.5 83 10 747.4 29 N 38/33/31/32/ 30 5 1012 in flowmet 11 x 12 in center, so injection is he center in the injection	% bl. ball** deg. F Ipm Sierra mm Hg %RH Y/N ppb n mbar er ches with the one-inch njection on port.	4 3.5 3 2.5 p 2 m 1.5 1 0.5 0	North			East
Ambient tem Sampling flov Ambient pres Ambient pres Ambient pres Back-Gd gas No. Bk-Gd sa Ambient pres Instuments B & K Model Sierra Inc. C Solomat Zee **Reading o Notes: The injectio elevation ac from both si point is 5-in Signature sig	p. wmeter ssure nidity orrection level amples ssure Used: 1302 #1765 onstant Flow phyr SN 12 on black pla At this poir n probe rea ljusted acc closer to th gnifies comp	3.5 80 10 747.80 32 N 32/32/35/31/ 31 5 1012.2 5299 v Air Sampler 95-1472 stic ball float th, the duct is icches 5-in off ordingly, the inner. Also, the stack than	3.5 83 10 747.4 29 N 38/33/31/32/ 30 5 1012 in flowmet 11 x 12 in center, so injection is he center in the injection	% bl. ball** deg. F Ipm Sierra mm Hg %RH Y/N ppb n mbar er ches with the one-inch njection on port. Signature v	4 3.5 3 2.5 P P 2 m 1.5 1 0.5 0	North			East
Ambient tem Sampling flov Ambient pres Ambient pres Ambient pres Back-Gd gas No. Bk-Gd sa Ambient pres Instuments B & K Model Sierra Inc. C Solomat Zee **Reading o Notes: The injectio elevation ac from both si point is 5-in Signature sig Procedure E	p. wmeter ssure nidity orrection level amples ssure Used: 1302 #1765 onstant Flow phyr SN 12 on black pla At this poir n probe rea djusted acco closer to th gnifies comp MS-AG-0	3.5 80 10 747.80 32 N 32/32/35/31/ 31 5 1012.2 5299 v Air Sampler 95-1472 stic ball float th, the duct is iches 5-in off ordingly, the rner. Also, the stack than liance with	3.5 83 10 747.4 29 N 38/33/31/32/ 30 5 1012 in flowmet 11 x 12 in center, so injection is he center in the injection	% bl. ball** deg. F Ipm Sierra mm Hg %RH Y/N ppb n mbar er ches with the one-inch njection on port. Signature v	4 3.5 3 2.5 9 2 m 1.5 1 0.5 0 0	North		Je de la	East
Ambient tem Sampling flov Ambient pres Ambient pres Ambient pres Back-Gd gas No. Bk-Gd gas No. Bk-Gd gas No. Bk-Gd gas Instuments B & K Model Sierra Inc. C Solomat Zee **Reading of Notes: The injection elevation act from both si point is 5-in Signature sig Procedure E Signature/da	wmeter sure addity orrection apples sure Used: 1302 #1765 onstant Flow phyr SN 12 on black pla At this poir n probe rea djusted acco closer to the gnifies comp MS-AG-00 the Warm	3.5 80 10 747.80 32 N 32/32/35/31/ 31 5 1012.2 5299 v Air Sampler 95-1472 stic ball float at, the duct is icches 5-in off ordingly, the irner. Also, the indiance with	3.5 83 10 747.4 29 N 38/33/31/32/ 30 5 1012 in flowmet 1012 in flowmet 11 x 12 in center, so injection is he center in the injection	% bl. ball** deg. F Ipm Sierra mm Hg %RH Y/N ppb n mbar mbar er ches with the one-inch njection on port. Signature v	4 3.5 3 2.5 9 9 2 m 1.5 1 0.5 0 9 0 9	North And calculation Dame		Jer (East $\frac{2}{3c/c}$
Ambient tem Sampling flov Ambient pres Ambient pres Ambient hum B&K vapor co Back-Gd gas No. Bk-Gd sa Ambient pres Instuments B & K Model Sierra Inc. C Solomat Zep **Reading o Notes: The injection elevation ac from both si point is 5-in Signature sig Procedure E Signature/da	wmeter sure soure nidity orrection level amples soure Used: 1302 #1765 onstant Flov phyr SN 12 on black pla At this poir n probe rea ljusted acco closer to the gnifies comp MS-AG-00 the Manuary States MS-AG-00	3.5 80 10 747.80 32 N 32/32/35/31/ 31 5 1012.2 5299 v Air Sampler 95-1472 stic ball float tt, the duct is inches 5-in off ordingly, the rner. Also, the stack than liance with	3.5 83 10 747.4 29 N 38/33/31/32/ 30 5 1012 in flowmet 11 x 12 in center, so injection is he center in the injection	% bl. ball** deg. F Ipm Sierra mm Hg %RH Y/N ppb n mbar er ches with the one-inch njection on port. Signature v <u>9/30/8</u>	4 3.5 3 2.5 9 2 m 1.5 1 0.5 0 erifying data	North		le la companya de la comp companya de la companya d	East

	Site	325 Model	ACER GAS	TRAVERSE					
	Det-	0/0/0004		F 0	Run NO.	GI-IU			
	Date	9/8/2004		Fan C	onfiguration	Fartan			
	lester	JMB/JAG			Fan Setting	37.1 Hz			
-	Stack Dia.	18 11	<u>n. </u>		Stack Temp	92	deg F		
S	tack X-Area	254.5 ii	1.2	Sta	rt/End Time	1354/1434			
	Elevation	N.A.		Cen	iter 2/3 from	1.65	to: <u>1</u>	6.35	
Distance to	disturbance	e120_ii	nches	Points i	n Center 2/3	2	to: <u>7</u>		
Measu	rement units	ppm SF6		Inj	ection Point	Bottom Sout	h		
Traverse>			Ea	ast			Nor	th	
Trial>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.		pp				ppn	n	
1	0.58	3.42	3.29	3,44	3.38	3.36	3.58	3 43	3 46
2	1.89	3,30	3.33	3 38	3 34	3 17	3 29	3 47	3 31
- 3	3 49	3.51	3 46	3.51	3 49	3.55	3 43	3 28	3 42
4	5.81	3.30	3.54	3 32	3 39	3.51	3 75	3.33	3.53
Center	9.01	3.28	3 53	3.62	3.49	2.45	3.10	3.35	0.00
Center	9.00	3.20	2.45	3.02	3.40	3.45	3.40	3.40	3.42
5	12.19	3.31	3.45	3.52	3.43	3.41	3.64	3.63	3.56
6	14.51	3.27	3.47	3.23	3.32	3.55	3.43	3.29	3.42
7	16.11	3.33	3.60	3.35	3.43	3.28	3.50	3.27	3.35
8	17.42	3.45	3.43	3.38	3.42	3.52	3.47	3.33	3.44
Averages	>	3.35	3.46	3.42	3.41	3.42	3.50	3.38	3.43
		Δ!!			from mean	Contor 2/3	Fast	North	
		Moon	2 42	Dev		Moon	2 41	2.42	2 40
		Mean Min Doint	0.42		2.00/	Niean	3.41	3.43	3.42
		Min Point	3.31		-3.2%	Std. Dev.	0.07	0.09	0.08
		IMAX POINT	3.30		4 1 %		1.91	2.61	2.22
	0.440	indx i onit			4.170	001 40 /0			
Avg. Conc.	3.418	ppm		,	Gas analyz	er checked:			
Avg. Conc.	3.418	ppm Start	Finish		Gas analyz 9/1/2004	er checked:			
Avg. Conc. Fracer tank p	3.418 pressure	ppm Start 390	Finish 390	psig	Gas analyz 9/1/2004	er checked:			
Avg. Conc. Fracer tank p	3.418 pressure Temp	Start 92	Finish 390 92	psig F	Gas analyz 9/1/2004	er checked:			
Avg. Conc. Fracer tank p Sample Port	3.418 pressure Temp	Start 390 92 764.0	Finish 390 92 763 0	psig F form	Gas analyz 9/1/2004	er checked:			
Avg. Conc. Fracer tank p Sample Port Centerline ve	3.418 pressure Temp I. meter	Start 390 92 764.0	Finish 390 92 763.0 3.5	psig F fpm % bl ball**	Gas analyz 9/1/2004	er checked:			
Avg. Conc. Tracer tank p Sample Port Centerline ve njection flow	3.418 pressure Temp el. meter	Start 390 92 764.0 3.5	Finish 390 92 763.0 3.5	psig F fpm % bl. ball**	Gas analyz 9/1/2004	er checked:			
Avg. Conc. Tracer tank p Sample Port Centerline ve njection flow Ambient temp	3.418 pressure Temp I. meter p.	Start 390 92 764.0 3.5 83	Finish 390 92 763.0 3.5 85	psig F fpm % bl. ball** deg. F	Gas analyz 9/1/2004	er checked:			
Avg. Conc. Tracer tank p Sample Port Centerline ve njection flow Ambient temp Sampling flow	3.418 pressure Temp II. meter p. wmeter	Start 390 92 764.0 3.5 83 10 747.4	Finish 390 92 763.0 3.5 85 10	psig F fpm % bl. ball** deg. F Ipm Sierra	Gas analyz 9/1/2004	er checked:			
Avg. Conc. Tracer tank p Sample Port Centerline ve njection flow Ambient temp Sampling flow Ambient pres	3.418 pressure Temp I. meter o. wmeter sure	Start 390 92 764.0 3.5 83 10 747.4	Finish 390 92 763.0 3.5 85 10 747.1	psig F fpm % bl. ball** deg. F Ipm Sierra mm Hg	Gas analyz 9/1/2004 3.5	er checked:			
Avg. Conc. Tracer tank p Sample Port Centerline ve njection flow Ambient temp Sampling flov Ambient pres Ambient hum	3.418 pressure Temp el. meter o. wmeter ssure aidity	Start 390 92 764.0 3.5 83 10 747.4 29	Finish 390 92 763.0 3.5 85 10 747.1 27	psig F fpm % bl. ball** deg. F lpm Sierra mm Hg %RH	Gas analyz 9/1/2004	er checked:			
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Avg. Conc. Fracer tank p Sample Port Centerline ve njection flow Ambient temp Sampling flov Ambient pres Ambient hum 3&K vapor co	3.418 pressure Temp el. meter o. wmeter ssure sidity prrection	Start 390 92 764.0 3.5 83 10 747.4 29 N 38/33/31/32/	Finish 390 92 763.0 3.5 85 10 747.1 27 N 16/31/36/38/	psig F fpm % bl. ball** deg. F lpm Sierra mm Hg %RH Y/N	Gas analyz 9/1/2004 3.5 3	er checked:			
Avg. Conc. Tracer tank p Sample Port Centerline ve Injection flow Ambient temp Sampling flov Ambient pres Ambient hum 3&K vapor co 3ack-Gd gas	3.418 pressure Temp el. meter o. wmeter ssure aidity prrection	Start 390 92 764.0 3.5 83 10 747.4 29 N 38/33/31/32/	Finish 390 92 763.0 3.5 85 10 747.1 27 N 6/31/36/38/ 30	psig F fpm % bl. ball** deg. F Ipm Sierra mm Hg %RH Y/N ppb	Gas analyz 9/1/2004 3.5 3 2.5	er checked:			
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		TF	RACER GAS	TRAVERSE	E DATA FOR	RM			
	Site	325 Model			Run No.	GT-11			
	Date	9/8/2004		Fan C	Configuration	Near fan			
	Tester	JMB/JAG		•	Fan Setting	37.1 Hz			
	Stack Dia.	18	in.		Stack Temp	90 c	leg F		
S	tack X-Area	254.5	in.2	Sta	art/End Time	1505-1545			
	Elevation	N.A.		Cer	nter 2/3 from	1.65	to:	6.35	
Distance to	disturbance	e 120	inches	Points i	in Center 2/3	2	to: 7	/	
Measu	rement units	ppm SF6		In	jection Point	Top South	_		
					-				
Traverse>			Ea	ast			Nor	th	
Trial>		1	2	3	Mean	1 1	2	3	Mean
Point	Depth, in.		p	om			ppr	n	
1	0.58	3.32	3.80	3.32	3.48	3.02	2.65	3.62	3.10
2	1.89	4.00	3.45	3.44	3.63	3.03	3.37	3.58	3.33
3	3.49	3.76	3.42	3.47	3.55	3.21	3.31	3.49	3.34
4	5.81	3.62	3.18	3.78	3.53	3.47	3.50	3.35	3.44
Center	9.00	3.28	3.45	3.11	3.28	3.38	3.42	3.65	3.48
5	12.19	3.03	2.99	2.99	3.00	3.07	3.48	3 46	3 34
6	14 51	3.45	3.08	3.61	3 38	3 31	3.50	3.08	3 30
7	16 11	3.26	3.46	3 46	3 39	2.86	3 14	2.96	2 99
8	17 42	3 14	3 42	3 22	3 26	2.00	3.04	3 30	3.04
Averages	>	3 43	3 36	3 38	3 39	3.12	3 27	3 39	3 26
, weiliges			0.00	0.00		0.12	0.27	0.00	0.20
		ΔΙΙ	nnm	Dev	from mean	Center 2/3	Fast	North	All
		Mean	3.32	001	<u>. nom mean</u>	Mean	3 39	3 32	3 36
		Min Point	2 00		-10.2%	Std Dov	0.21	0.16	0.19
		May Point	2.99		-10.2 %		6.17	0.10 1 92	5.49
Ava Cono	2 2 1 8	DDD			9.270		0.17	4.02	5.40
Avg. Conc.	3.310	ppm				er checked.			
		0 1 - 1	F () (9/1/2004				
T		Start	Finish						
Tracer tank p	oressure	350	390	psig					
Sample Port	i emp	89	91	F					
Centerine ve) .	769.0	/68.0	ipm	}				
Injection flow	meter	3.5	3.5	% bl. ball**	1	and the second sec		**********************	
Ambient tem	p.	85	89	aeg. F	4	an and the second			
Sampling flow	wmeter	10	10	Ipm Sierra					
Ambient pres	sure	747.1	746.4	mm Hg	3.5-				
Ambient hum	nidity	27	27	%RH					
B&K vapor co	orrection	N	N	Y/N	3				
Deals O.I	lay of	46/31/36/38/	36/34/36/30/		2.5-				
Back-Gd gas	level	30	30	aqq	p				-
NO. BK-GO Sa	ampies	0	5	mhar	P 2-				
Ampient pres	sure	1012	1011	mpar	m 15				
Instuments	Used:				. 1.5				-
B & K Model	1302 #1765	299			1-			▐▛▋▖▋	
Sierra Inc. Co	onstant Flov	v Air Sampler		_		<u> </u>			_ /
Solomat Zep	onyr SN 12	95-1472			0.5-	1 8	5] II I'	ਾ ₽₽	
"Reading o	n black pla	stic ball float	in flowmet	er	. 0				7
Notes:									
									East
						North			
					.{				
Signature sig	Inifies comp	liance with		Signature ve	erifying data	and calculatio	ns:	.1	
Procedure E	MS-07,G-01	0 01.	~		1	K	/	11.1.	3/
Signature/da	te VL	n Ali	soment	n 9/3	30/04	1020	nn h	March	-1/30
	1		$\overline{\Lambda}$		/			7 7	TT^{c}
			(/04-3)	25 Scale gasu	nif.xls GT1	1 9/30/2004		,	()

Test Instruction								
Project: 325 Stack Qualification	k Sampler	Date: August 16, 2004	Work Package: F	59676				
Tests: Trac	er Gas Unif	ormity in 325 Model Stac	x, 1 Electric Fan (Configuration				
Staff: John Glissme	eyer, Dave Do	uglas, Marcel Ballinger, Mat	hew Barnett					
 Reference Procedures: 1. Procedure EM Probe, May 20 2. Operating Mat 	IS-JAG-01, R 6, 2000 nual for Bruel	ev. 1, Test to Determine Unij and Kjaer Model 1302 Gas	ormity of a Tracer G	as at a Sampler				
Equipment: 1. 325 Model Sta 2. Sulfur hexaflu probe, and tub are within 3 in Size injection 3. Bruel and Kia	ack and inspect oride gas (pur ping. Injection a. (25% of hydrogeneric probe according er Model 130	cted work platforms. Fans wi re and calibration gas), regula n occurs in ports along horizo fraulic diameter) for smaller ngly. 2 Gas Analyzer, probe, yacu	be in positions EFI tor, control valve, ro tal duct. The near uct section and 4in.	, EF4. otameter, injection wall injection points for 18" x 18" duct.				
Safety Considerations	:	2 000 1 mary 201, p1000, vada	in pump, numbs					
Observe the appl	icable Job H	azard Analysis for the pro	ect					
 Verify trainin Verify trainin Weigh the tra Obtain climat http://etd.pnl. Mark the com applicable to Install equipm Mark samplin With one fan Set the injecti lpm on an air glass ball). Set the sampl Record each n Diagram mou Conduct one of 	g on the proce cer cylinder b ic information gov:2080/HM apletion of eac this stack. nent as directe ag probe for th operating, ver ion flowrate a rotameter wh er flowrate at run's data on o anting fixtures or more tracer	edure and verify that instrume efore shipment to jobsite M_{i} from the Hanford Weather (S/lastob.htm) what he procedures he measurement points shown rify that stack flow is about 1 t about 0.07 lpm for a tracer en corrected for gas density, approximately 10 lpm. copies of the attached data sh and retain assembly for any mixing tests at the following	ntation is within cal A. no scale and ervice, phone 373-2 e procedure. Mark-o on the data sheet 50 - 1450 cfm. concentration of ~ 1 bout 7 on the rotam eet subsequent re-tests sets of conditions:	ibration Lable 2013 9/1/04 716 or out those steps not ppm (reads about 0.14 eter scale with the				
Downstream 1 of Fan	Injection Posi	tions	Possible Runs					
EF4 ON	Center, 1 inch	from each corner	GT1 - 5					
EF1 ON	Center, 1 inch	from each corner	GT 6 – 10					
Worst case	Repeat of wor	st case	GT 11					
Desired Completion D	Date: 08/27/04							
Approvals:	Glissmeyer,	test director	Date:					
	Her	may	9/8/04	1				

PNNL Operating Procedure	Rev. No. 1	Page 1 of 16
	Org. Code: D9T99	Procedure No.: EMS-JAG-01
Title: Test to Deter	mine Uniformity of a Tra	acer Gas at a Sampler Probe

PNNL Operating Procedure			
Title: Test to Determine Uniformity of a Tracer Gas at a Sampler Probe	Org. Code: Procedure No.: Rev. No.:	D9T99 EMS-JAG-01 1	
Work Location: General	Effective Date:	May 26, 2000	
Author: John A. Glissmeyer	Supersedes Date:	November 10, 1998	3
 Identified Hazards: □ Radiological □ Hazardous Materials Physical Hazards □ Hazardous Environment □ Other: Are One-Time Modifications Allow 	Identified Use Category □ Mandatory Use □ Continuous Use Reference Use □ Information Use wed? Yes	gory: No	
Person Signing	Signa	ture	Date
Technical review: James L. Huckaby Project Manager:			
John Glissmeyer			
James Droppo			
Concurrence:		<i>I</i>	
Quality Engineer: Thomas G. Walker			

PNNL Operating Procedure	Rev. No. 1 Org. Code: D9T99	Page 2 of 16 Procedure No.: EMS-IAG-01	
Title: Test to Determine Uniformity of a Tracer Gas at a Sampler Probe			

1.0 Purpose

The performance of new stack sampling systems must be shown to satisfy the requirements of 40 CFR 61, Subpart H, "National Emission standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities." This regulation governs portions of the design and implementation of effluent air sampling. The stack sampler performance is adequately characterized when potential contaminants in the effluent are of a uniform concentration at the sampling location (plane), and line losses are within acceptable limits. This procedure determines whether the concentration of gaseous contaminants is uniformly distributed in the area of the sampling probe. Other procedures address flow angle, uniformity of gas velocity, and uniformity of particulate contaminants. A contaminant concentration that is uniform at the sampling plane enables the extraction of samples that represent the true emission concentration.

The uniformity is expressed as the variability of the measurements about the mean. This is expressed using the relative coefficient of variance (COV), which is the standard deviation divided by the mean and expressed as a percentage. The lower the COV value, the more uniform the gas concentration. The acceptance criterion is that the COV of the measured gas concentrations be # 20% across the center two-thirds of the area of the stack. Furthermore, the average concentration measured at any point cannot differ from the mean of all points by more than 30%.

2.0 Applicability

This procedure can be used in the field or on modeled stacks to determine whether air-sampling probes can collect representative samples under normal operations. The tests are applicable to effluent stacks or ducts within the following constraints:

- The tracer gas tests are generally limited to stacks with flowrates greater than 50 cubic feet per minute range. The upper bound of flowrate is determined by the sensitivity of the gas analyzer, the background reading for the tracer gas, and the availability of the tracer.
- Environmental constraints the gas analyzer will require the use of a controlled temperature environment to maintain the equipment above 55 degrees Fahrenheit.

3.0 Prerequisites and Conditions

Conditions and concerns that must be satisfied before sampling are listed below:

- Safety glasses and hard toed or substantial shoes are required in the work areas.
- Properly constructed and inspected work platforms may be needed to access the test ports.
- Scaffold-user or fall protection training may be required in some instances to access the sampling ports of the stack.
- Alcohol may be used for equipment cleanup. A flammable equipment storage cabinet is required to flammable chemicals.

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- Familiarity with the use and operation of gas delivery systems and the ability to detect concentration build-ups of the gas is essential to avoid exceeding ACGIH concentration for the tracer gas.
- Knowledge of the setup, use of, and operation of flowmeters, gas analyzers, and computers is essential.
- A job-hazards analysis may be required in certain cases.

4.0 Precautions and Limitations

Caution: The American Conference of Governmental Industrial Hygienists (ACGIH) 8-hour timeweighted average limit for human exposure to sulfur hexafluoride gas is 1000 ppm (6,000 mg/m³). It is colorless and odorless.

During tests of stacks with high flow rates, sulfur hexafluoride will be injected at a high rate into the base of the stack to overcome the large dilution factor needed to detect the tracer at the sampling ports above. If a leak occurs in the gas delivery system, the potential is present for a buildup of SF_6 to occur that could approach the 1000-ppm level. The gas is five times as heavy as air, so it will accumulate in confined spaces and in low areas. Leak tests of the delivery system will be made at least daily to prevent such an occurrence.

Access to the test ports may require the use of scaffolding or manlifts, either of which will necessitate special training for sampling personnel and any observers. The training requirements will be indicated in the job hazard analysis. This will limit access to the sampling ports to trained personnel.

If the purpose of a given run is to investigate the sensitivity of the COV determination to the tracerinjection location, the test may be invalid if the ending ambient concentration is elevated above that at the start of the test. This would indicate poor dispersion away from the test site and recirculation of the tracer to the inlet of the fan if the stack exhaust point is in view of and is reasonably close to the fan inlet. This may result in a false indication of good mixing.

5.0 Equipment Used for Stack Measurements

Specific calibration check concentration levels, probe dimensions, measurement grids, flow rates, and other special requirements will be provided in the specific Test Instruction. Exhibit A provides a typical layout for the test setup. The following are essential items of equipment:

- Sulfur hexafluoride calibration check gas
- Sulfur hexafluoride bulk gas

- Bruel and Kjaer Model 1302 Gas analyzer
- Gas regulators and flowmeters
- Gas sampling probe
- Gas injection probe
- Vacuum pump (Sierra)
- Air velocity meter

The absolute calibration of the Model 1302 Gas Analyzer is not as important as its general response because the concentration data are used in a relative manner in calculating the COV and in plotting the concentrations at the measurement points. Consequently, the analyzer is Category 2 MTE (user calibrated) and will be checked against a calibrated gas mixture before and after the series of tests, and the instrument's response may be checked on a daily basis. Agreement within 10% of the calibration gas is acceptable.

6.0 Work Instructions for Setup, Measurements, and Data Reduction

The steps taken to setup, configure, and operate the stack fans and test equipment are listed. Based on previous field measurements, the steps are ordered to achieve maximum efficiency in the testing. In addition to these steps, test instructions, which are developed for each test series, provide specific details and operating parameters.

6.1 Preliminary Steps:

6.1.1 Provide essential supplies at the sampling location. (gas cylinders and regulators, fittings and probe-port couplers, marking pens, data sheets, writing, and probe-supporting platforms).

6.1.2 Fill in test information on data form.

- **6.1.3** Obtain barometric, temperature, and relative-humidity information for the gas analyzer.
- 6.1.4 Set up the gas analyzer system at the stack sampling port according to the illustrations in Exhibits A and B.

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Note: The **sampling equipment** consists of a stainless steel probe with enough length to reach across the inside diameter of the stack, allowing for fittings. The intake end should have a 90° bend so that the open end of the tube faces downward or into the flow within the stack). The outlet end of the probe should terminate in a tee. One leg of the tee connects by flexible tubing to a rotameter and vacuum pump. This leg should draw from 1- to 10-lpm flow of air, depending on the volumetric flow in the stack. The other leg of the tee connects via flexible tubing to a coarse inline filter (47-mm-diameter glass fiber filter) and then to the Model 1302 gas analyzer inlet. To minimize tubing length to the analyzer, locate the gas analyzer near the test port on the stack.

6.2 System Startup

6.2.1 If not already running, start the stack fan, adjust the flow to the velocity called for in the test instruction, and record on the data sheet.

- **6.2.2** Verify the stack centerline air velocity in the sampling plane using a velocity flow meter, and record value on data sheet.
- 6.2.3 Turn-on the gas analyzer.

6.2.4 Program the analyzer for:

- 60-second samples,
- continuous operation,
- the current barometric pressure,
- moisture compensation if needed.

Note: Gas analyzer readings can be made with or without water-vapor correction. If the air is sufficiently dry (< than about 60% relative humidity) where the water vapor contribution is negligible (< than about 14.5E+03 ppm), the balance of the readings can be made with water vapor compensation but without water vapor measurement to reduce sample times.

6.2.5 Set the sample probe to the center position.

Note: Mark the sampling probe with a permanent marker so the inlet can be placed at each successive measurement point. The layout for the sample points is given in the test instruction.

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Note: Sampling plane traverse points Use the grid of measurement points provided with the tests instruction and dataform. This is usually the same as used for the velocity uniformity test. A centerpoint, is included as a common reference and for graphical purposes. The layout design divides the area of the sampling plane so that each point represents approximately an equal-sized area.

6.3 Daily Tracer Gas Background Concentration Measurement

- **6.3.1** At the beginning of sampling each day and after the analyzer has stabilized (about 10 minutes), obtain at least six consecutive background readings. Do not proceed with the test if the background exceeds 5% of the anticipated average concentration in the stack.
- **6.3.2** Record these readings in the logbook designated for the tests.

6.4 Gas Injection and Sample Collection

The injection equipment consists of a pressurized cylinder of pure liquid sulfur hexafluoride that converts to gas when released. The setup is shown in the figure in Exhibit B and includes a gas regulator, valve, flowmeter (rotameter), flexible tubing, and a stainless steel injection probe with a 90E bend at the discharge end, which is secured at one of five positions. The connections and fittings should be checked to ensure that they are secure and leak free to prevent the loss of gas.

Note: Location of Tracer Gas Injection Points

<u>Injection plane</u> – The tests are repeated using five tracer gas injection points (at the centerpoint and at four orthogonally spaced points) within the injection plane. These four points are located near the corners if the duct cross section is rectangular. The distance from these four points to the corner or wall is less than 25% of the

duct's hydraulic diameter (HD), which is calculated by

$$HD = \frac{2HW}{H+W}$$

where H and W are the height and width of a rectangular duct (H and W are the same in a round duct). More specific dimensions are given in the Test Instruction.

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6.4.1	Position the injection probe, according to the test instruction found as Attachment A.				
6.4.2	Start injection of the the specified in the test in	Start injection of the tracer gas and adjust for flow rate specified in the test instruction and note the time.			
	Note: Estim Estimate the S the range of 10 to the followin	nation of Sulfur Hexafluor F_6 injection rate so the averable to 100% of the concentration of the concentration:	ide Injection Rate age diluted concentration will be within ion of the calibration check gas accordin		
		injection flowrate = stac	k flowrate × $\frac{target ppmv}{10^6}$		
	The rotameter equivalent read	reading should be adjusted ding is	for the density of the SF_6 . The air		
		rotamatar reading =	- by actual floringto		
		Totumeter reduing -	- k x actual flowraie		

- **6.4.3** On the data sheet, label the columns of data according to the directions of the traverses.
- **6.4.4** Verify that the directional orientations and the numbered sample positions are consistent.
- 6.4.5 Position the sample probe at each measurement point in succession, and record the reading on the dataform.

Note: Each test relies on one repetition for each measurement point in each traverse direction, repeated three times. The repeats are made as three separate runs and not as three consecutive measurements at each point.

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- 6.4.6 Perform two additional repetitions of Step 6.4.5. above
 - **6.4.7** Switch the tests to the other direction and repeat Steps 6.4.5 and 6.4.6.
 - 6.4.8 Check the data sheet for completeness.

6.4.9 Record the final

- Rotameter flow rate
- Time since the start of gas injection
- Pressure in the gas cylinder.
- 6.4.10 Shut down the delivery of tracer gas.
- **6.4.11** Continue operation of the gas analyzer for several minutes to purge any remaining gas through the analyzer.
- **6.4.12** Measure the background tracer gas concentration and record the levels on the data sheet.
- **6.4.13** Record any climatic conditions that have changed on the data sheet.
- 6.4.14 Enter the centerline stack velocity flow on the data sheet.
- 6.4.15 Record any deviations from the above procedure on the data sheet.
- **6.4.16** Repeat steps 6.4.1 6.4.15 for each run as indicated in the Test Instruction.

6.5 Data Recording and Calculations

Prepare the electronic data sheet on which to enter gas concentration readings and other information relevant to the test (see test instruction).

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- **6.5.1** Review the raw data sheets for completeness.
 - 6.5.2 Enter the data into the electronic data sheet.
 - 6.5.3 Calculate the COV for the run.

Note: The EXCEL datasheet shown in Appendix C is set up to calculate the COV for each tracer gas concentration traverse using the average concentration data from all points in the inner two-thirds of the cross section area of the plane (including the center point).

6.5.4 Compare the observed COV for each run to the acceptance criterion.

Note: The test is acceptable if the COV is within #20% for the inner two-thirds of the stack diameter and if no point differs from the mean by more than 30%. This is determined by inspecting the average concentration at each measurement point. The COV is 100 times the standard deviation divided by the mean.

6.5.5 Sign and date the data sheet attesting to its validity.

Note: A separate datasheet will be provided and signed-off for each test run.

6.6 Gas Analyzer Calibration Check Steps

Check the gas analyzer calibration by subjecting the analyzer to sulfur hexafluoride calibration gas. Refer to the analyzer's manual, parts 2 and 4.

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6.6.1	Set up the system for gas analysis with the regulator, the
	valve, flexible tubing, and a tee with one leg exhausting
	excess gas through a flowmeter and the other leg attached to
	the inlet of the Model 1302. Program the units of
	measurement as in Part 4.2.3. Enter the barometric pressure
	in mm Hg pressure, standard temperature (that used by the
	calibration gas vendor), and the sampling tube length into
	the environmental setup (Part 4.2.4). Record the
	information on the data sheet.

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- **6.6.2** Set the Model 1302's clock. Program the analyzer for water compensation, but not water measurement, at 1-minute continuous measurement mode (according to Part 4.4.2 in manual).
- **6.6.3** Program for a continuous monitoring task (4.2.5), and initiate monitoring (4.2.6).
- **6.6.4** Monitor room conditions, and record the data for several measurements by sampling zero air or room air for at least 5 minutes.

Note: If the test location has a buildup of the gas, a zero air cylinder or clean air supply will be needed. The SF_6 concentration in the room should be several orders of magnitude below the calibration-gas. These settings optimize the low detection capabilities of the acoustically-based detection system.

6.6.5 Sample calibration gases (from lowest available concentrations to highest) for at least five readings each or until no observable trend is found. Record the identification of the calibration gas used. Record data and results in the Logbook.

Note: Set the calibration gas flow rate high enough to ensure that the glass ball in the rotameter does not drop to zero during any of the observed steps of a sample cycle. As the calibration check continues, gas levels exhausted during the check will be released into the room, and the SF₆ background concentrations will increase as the analyzer is checked. The SF₆ reading should be within 10% of the calibration-gas concentration, and the water content should be much lower than ambient.

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(WS 6.6.6 Obtain baseline tracer (calibration gas) readings at the end of the calibration check. Record results on the data sheet. 9//01Note: The reading will generally be recorded from the display. It may be convenient to record the data on a pr be coupled to the analyzer. See the Manual Part 12 (esp necting to a printer in data log mode. Note: The reading will generally be recorded from the digital concentration display. It may be convenient to record the data on a printer or computer, which can be coupled to the analyzer. See the Manual Part 12 (especially Part 12.2.5) for con-

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7.0 Exhibits/Attachments

Exhibit A - Overview of Stack and Injection/Sampling Setups



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Exhibit B - Details for Stack Sampling Probe and Gas Analyzer Setup



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Exhibit C – Example EXCEL Data Sheet

		110				Z IVI			
	Site				Run No.				
	Date _			Inje	ection point				
	Tester_			I	an Setting	<u> </u>	z		
Stack Dia. 27.25 in		27.25 in.		Stack Temp		deg F			
S	tack X-Area	583.2 in.		Star	t/End Time				
	Elevation_			Cent	er 2/3 from	2.50	to:	2 <u>4.75</u>	
El. above disturbance		in.		Points in	Center 2/3	3	to: -	10	
Concen	tration units	ppm SF ₆			_				
Traverse:	>		Ea	ast			So	uth	
<u> Trial></u>		1	2	3	Mean	1	2	3	Mea
Point	Depth, in.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	Con
1	1.00								
2	1.83								
3	3.22								
4	4.82								
5	6.81								
6	9.70								
Center	13.63								
7	17.55								
8	20.44								
9	22.43								
10	24.03								
11	25.42								
12	26.25								
Traverse A	verages	>	W	est		Comton 2/2	No		
Traverse A Average of	verages f all data	>		est		Center 2/3 Mean	EAW	S/N	
Traverse A Average of Maximum I Maximum I	L verages f all data Positive Devia	ation		Max Point		<i>Center 2/3</i> Mean Std. Dev.	No	S/N	
Traverse A Average of Maximum I Maximum I	verages f all data Positive Devia Negative Dev	ation iation	W	Max Point Min Point		Center 2/3 Mean Std. Dev. COV %	No	S/N	
Traverse A Average of Maximum I Maximum I Tracer tan	L verages f all data Positive Devia Negative Dev	ation iation Start	Finish	Max Point Min Point		Center 2/3 Mean Std. Dev. COV %	EAW	S/N	
Traverse A Average of Maximum I <u>Maximum I</u> Tracer tanl Ambient T	verages f all data Positive Devia Negative Dev k pressure emp	ation iation Start	Finish	Max Point Min Point psig	Gas analyze	Center 2/3 Mean Std. Dev. COV %	No	S/N	
Traverse A Average of Maximum I Maximum I Tracer tan Ambient To Centerline	verages f all data Positive Devia Negative Dev k pressure emp vel.	ation iation Start	Finish	Max Point Min Point psig F (Gas analyze	Center 2/3 Mean Std. Dev. COV %	No	S/N	
Traverse A Average of Maximum I Maximum I Tracer tan Ambient To Centerline Record sta	verages f all data Positive Devia Negative Dev k pressure emp vel. vel.	ation iation	Finish	Max Point Min Point psig F (fpm fpm	Gas analyze	Center 2/3 Mean Std. Dev. COV %	No	S/N	
Traverse A Average of Maximum I Maximum I Tracer tan Ambient To Centerline Record sta	verages f all data Positive Devia Negative Dev k pressure emp vel. vel. vel. owmeter	ation iation Start	Finish	Max Point Min Point psig F (fpm fpm Ipm [glass ba	Gas analyze Notes: Ill in meter]	Center 2/3 Mean Std. Dev. COV %	No	S/N	
Traverse A Average of Maximum I Maximum I Tracer tan Ambient To Centerline Record sta Injection flo Sampling f	verages f all data Positive Devia Negative Dev k pressure emp vel. vel. vel. tok flow powmeter	ation iation Start	Finish	Max Point Min Point psig F (fpm fpm Ipm [glass ba Ipm Sierra	Gas analyze Notes: Il in meter]	Center 2/3 Mean Std. Dev. COV %	No	S/N	
Traverse A Average of Maximum I Maximum I Maximum I Maximum I Maximum I Ambient To Sampling f Ambient pi	Averages f all data Positive Devia Negative D	ation iation Start	Finish	Max Point Min Point psig F (fpm fpm [lpm [glass ba lpm Sierra mm Hg	Gas analyze Notes: Il in meter]	Center 2/3 Mean Std. Dev. COV %	No	S/N	
Traverse A Average of Maximum I Maximum I Maximum I Tracer tan Ambient To Centerline Record sta Injection flo Sampling f Ambient pi	Averages f all data Positive Devia Negative D	ation iation Start	Finish	Max Point Min Point psig F (fpm fpm [glass ba lpm [glass ba lpm Sierra mm Hg RH	Gas analyze Notes: Ill in meter]	Center 2/3 Mean Std. Dev. COV %	No	S/N	
Traverse A Average of Maximum I Maximum I Ambient To Centerline Record sta Injection flo Sampling f Ambient fu B&K vapor	Averages f all data Positive Devia Negative	ation iation Start	Finish	Max Point Min Point psig F (fpm fpm [glass ba lpm [glass ba lpm Sierra mm Hg RH Y/N	Gas analyze Notes: Ill in meter]	Center 2/3 Mean Std. Dev. COV %	No	S/N	
Traverse A Average of Maximum I Maximum I Ambient To Centerline Record sta Injection flo Sampling f Ambient fu B&K vapor Back-Gd g	Averages f all data Positive Devia Negative	ation iation Start	Finish	Max Point Min Point psig F (fpm fpm [glass ba lpm [glass ba lpm Sierra mm Hg RH Y/N ppm	Gas analyze Notes: Il in meter]	Center 2/3 Mean Std. Dev. COV %	No	S/N	
Traverse A Average of Maximum I Maximum I Ambient To Centerline Record sta Injection flo Sampling f Ambient hu B&K vapor Back-Gd g No. Bk-Gd	Averages f all data Positive Devia Negative	ation iation Start	Finish	Max Point Min Point psig F (fpm fpm [glass ba lpm [glass ba lpm Sierra mm Hg RH Y/N ppm n	Gas analyze Notes: Il in meter]	Center 2/3 Mean Std. Dev. COV %	No	S/N	
Traverse A Average of Maximum I Maximum I Ambient To Centerline Record sta Injection flo Sampling f Ambient hu B&K vapor Back-Gd g No. Bk-Gd	Averages	ation iation Start	Finish	Max Point Min Point psig F (fpm fpm (glass ba lpm Sierra mm Hg RH Y/N ppm n	Gas analyze Notes: Il in meter]	Center 2/3 Mean Std. Dev. COV %	EAW	S/N	
Traverse A Average of Maximum I Maximum I Ambient Tr Centerline Record sta Injection fit Sampling f Ambient pi Ambient hi B&K vapor Back-Gd g No. Bk-Gd	Averages	ation iation Start	Finish	Max Point Min Point psig F (fpm fpm (glass ba lpm Sierra mm Hg RH Y/N ppm n	Gas analyze Notes: Il in meter]	Center 2/3 Mean Std. Dev. COV %	EAW	S/N	
Traverse A Average of Maximum I Maximum I Ambient Tr Centerline Record sta Injection fit Sampling f Ambient pi Ambient pi B&K vapor Back-Gd g No. Bk-Gd	Averages	ation iationStart	Finish	Max Point Min Point psig F (fpm fpm H Ipm [glass ba Ipm Sierra mm Hg RH Y/N ppm n	Gas analyze Notes: Il in meter]	Center 2/3 Mean Std. Dev. COV % er checked	EAW	S/N	
Traverse A Average of Maximum I Maximum I Ambient To Centerline Record sta Injection fit Sampling f Ambient pi Ambient pi Back vapor Back-Gd g No. Bk-Gd Notes:	Averages	ation iation Start	Finish	Max Point Min Point psig F (f fpm f fpm f lpm [glass ba lpm Sierra mm Hg RH Y/N ppm n	Gas analyze Notes: Il in meter]	Center 2/3 Mean Std. Dev. COV %	EAW	S/N	
Traverse A Average of Maximum I Maximum I Maximum I Tracer tan Ambient To Centerline Record sta Injection fit Sampling f Ambient pi Ambient pi Ambient pi Back-Gd g No. Bk-Gd Notes: Instument Solomat Z	Averages	Ation iation Start	Finish	Max Point Min Point psig F (fpm fpm (glass ba lpm Sierra mm Hg RH Y/N ppm n	Gas analyze Notes: Il in meter]	Center 2/3 Mean Std. Dev. COV %	EAW		
Traverse A Average of Maximum I Maximum I Ambient To Centerline Record sta Injection flo Sampling f Ambient hu B&K vapor Back-Gd g No. Bk-Gd Notes: Instument Solomat Z B & K Mode	Averages	Ation iation Start 472 5299 w Air Samples	Finish	Max Point Min Point psig F (fpm fpm [glass ba lpm [glass ba lpm Sierra mm Hg RH Y/N ppm n	Gas analyze	Center 2/3 Mean Std. Dev. COV %			st
Traverse A Average of Maximum I Maximum I Ambient To Centerline Record sta Injection flo Sampling f Ambient hu B&K vapor Back-Gd g No. Bk-Gd Notes: Instument Solomat Z B & K Mog Sierra Inc.	Averages	ation iation Start	Finish	Max Point Min Point psig F (fpm fpm (glass ba lpm Sierra mm Hg RH Y/N ppm n	Gas analyze Notes: Il in meter]	Center 2/3 Mean Std. Dev. COV %		S/N	st
Traverse A Average of Maximum I Maximum I Ambient To Centerline Record sta Injection flo Sampling f Ambient hu B&K vapor Back-Gd g No. Bk-Gd Notes: Instument Solomat Z B & K Mod Sierra Inc.	Averages	ation iation Start Start 472 5299 w Air Sampler mpliance with s	Etions 6.1.	Max Point Min Point psig F (fpm fpm (glass ba lpm Sierra mm Hg RH Y/N ppm n	Gas analyze Notes: Il in meter]	Center 2/3 Mean Std. Dev. COV % er checked			st
Traverse A Average of Maximum I Maximum I Ambient To Centerline Record sta Injection flo Sampling f Ambient hu B&K vapor Back-Gd g No. Bk-Gd Notes: Instument Solomat Z B & K Mog Sierra Inc. Signing/da	Averages	ation iation Start 472 5299 w Air Sampler mpliance with s e No. EMS-JAG	Etions 6.1.	Max Point Min Point psig F (fpm fpm (glass ba lpm Sierra mm Hg RH Y/N ppm n	Gas analyze Notes: Il in meter]	Center 2/3 Mean Std. Dev. COV % er checked			st

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Attachment A – Illustrative Test Instruction.
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Title: Test to Determine Uniformity of a Tracer Gas at a Sampler Probe

Test Instruction								
Project: Canister Storage	Date: November 10, 1998	Work Package: K97052						
Stack Qualification, 29303								
Tests: Tracer Gas Uniformity of Full-Scale Stack								
Staff: David Maughan, John C	Blissmeyer							
Reference Procedures:								
1. Procedure EMS-JAG-01,	Rev. 0, Test to Determine Unif	formity of a Tracer Gas at a Sampler						
Probe, Nov. 10, 1998								
2. Operating Manual for Bru	el and Kjaer Model 1302 Gas A	Analyzer						
Equipment:	in an atop days of a static surger							
1. Canister Storage Stack and 2. Sulfur hexefluoride gas (pu	inspected work platforms	control value reterestor injection						
2. Summi nexanuonue gas (pu	ng stainless tubing) and tubing	, control valve, rotameter, injection						
3 Bruel and Kizer Model 13	02 Gas Analyzer probe vacuur	m numn fittings						
Safety Considerations:	02 Gas A Maryzer, probe, vacua	in pump, numgs						
Review and observe the au	oplicable Duke Job Hazard Ana	lysis for the project						
Instructions:								
1. Verify training on the prod	cedure and verify that instrume	ntation is within calibration						
2. Weigh the tracer cylinder	before shipment to jobsite							
3. Obtain climatic informati	on from the Hanford Weather S	Service, phone 373-2716 or						
http://etd.pnl.gov:2080/H	MS/lastob.htm							
4. Install equipment as direc	cted in the procedures							
5. Mark sampling probe for	the measurement points shown	on the data sheet						
6. Verify that stack flow is a	about the target flowrate of 900	0 (2232 fpm)						
8 Set the sampler flowrate	at approximately 10 lpm	oncentration of ~ 5 ppm						
9. Conduct one or more trac	er mixing tests at the following	sets of conditions:						
Stack Flow	Injection point at duct	from fan to stack						
Normal	Centerline, top left, top right,	bottom left, bottom right						
(The injection plane sl	hould be at the fittings provided	on the rectangular discharge of the						
fan. Left and right are	e from the point of view of the f	an looking toward the stack)						
10. Record data on copies of	une allached data sneel	times						
12. Diagram mounting fixtur	es and retain assembly for any	subsequent re-tests						
13. Weigh the tracer gas cylin	nder after these tests							
Desired Completion Date: 11/	20/98							
Approvals:								
John Glissmeyer	, Project Manager	Date						
Test completed by:		Date:						

INDEPENDENT TECHNICAL REVIEW RECORD

PA NATI INDE	CIFIC ONAL PENDI REVIE	NORTHWEST LABORATORIES ENT TECHNICAL W RECORD	DOCUMENT N Calculation of C Documented in B&Kcalcheck.x	VO.: Jas analyz Spreadsh Ils.	zer Calibration Checks neet 04-325-			Page <u>1</u> of <u>1</u>	
The referenced document is submitted for your review. Instructions for completing this form are attached. Please return the completed form to: <u>John Glissmeyer</u> . If you have any questions, please call <u>John Glissmeyer, 376-8552, cell 531-8006</u> . Comments Due: <u>9/28/04</u>									
 Additional Information: (Scope of Review, etc) Please verify the following: 1. Transfer of field data to spreadsheet. 2. Calculation of intermediate mean and standard deviation of concentration values per calibration gas mixture. 									
Org Enviro	ganizatio onmenta G	on/Department I Health Sciences Froup	Designated Review Rosanne Aaberg		Rea	Signa	iture/Date		
CONCUI	R[]	CONCUR, WITH CO	OMMENTS [X]	DO NO	T CONCU	/ IR[]	NOT R	REVIEWED []	
Comt. No.	Comr	nent and/ or Recommen	ndation:		Resolution:				
1	O – A sprea	Add standard deviation date (line 27), as per	of concentration val review instructions.	lues to	Done				
2	E – S appro 20.38 to sho	et number format for ca opriate number of decim ppm readings should b ow values of 21.0.	alibration readings t nal places. Column pe set to one decima	o the 1, l place	Done				
Concur v RDa	vith Res	olution v L-Haber	Date 9/30/00	/	Commen	nts Resolve	ed By	Date 9/30/04	

Sulfur hexafluoride Gas Calibration performed on B&K on	9/1/2004 by John Glissmeyer Geoff Hunsaker
Setup details: B&K sample inlet tube = 6 ft 996.7 mbar station pressure, analyzer corrects to 83 deg F ambient temp 32 percent RH	o 20 deg C
20.38 ppm SF ₆ +/- 5% standard	1.04 ppm SF ₆ +/- 10% standard
Cylinder:SV16208 w/ starting P of 1900 psi End press 1850 psi B&K Calibration readings: (ppm) 20.7 Compensating for water vapor 20.6 20.8 21.1 21.0 21.1 Not compensating for water vapor 21.0 21.0 21.0 21.0	Cylinder: SV14250 w/ starting P of 1700 ps end P = 1500 ps B&K Calibration readings: (ppm) 1.06 Compensating for water vapor 1.05 1.05 1.05 1.05 1.05 1.05 1.07 1.08 1.07 1.07 1.07 1.07 1.07 1.07 1.07 1.07 1.07 1.07 1.07 1.07
20.9 = avg 0.17 Std Dev Pre-Test Room background, ppb Not compensating for water vapor, monitoring task 2 Not recorded. All were <50 ppb. Compensating for water vapor, monitoring task 1	1.06 = avg 0.01 Std Dev
Not recorded. All were <50 ppb.	

Signature verifying data and calculations: Hissmeyer 9/38/04 Norum & Habe 9/30/04 Signature signifies compliance with Procedure EMS-JAG-01 Hessmeyer 9/35/04 When Signature/date (on field data form)

Appendix F

Particle Tracer Gas Uniformity Procedure and Data

INDEPENDENT TECHNICAL REVIEW RECORD

P/ NATI INDE	ACIFIC IONAL EPENDI REVIE	NORTHWEST LABORATORIES ENT TECHNICAL W RECORD	DOCUMENT N Calculation of F Characteristics 04-325 Scale 8	racer Unifor tack Model,	r <u>mity</u> , Spreadsł	neet	Page <u>1</u> of <u>2</u>		
The refe return th please ca	renced d e comple allJo	locument is submitted t eted form to: <u>John (</u> hn Glissmeyer, 375-42	for your review. Ins Glissmeyer 345, cell 531-8006	structions	for complet	ing this fo	orm are a If you h Due:	attached. Please ave any questions, 9/28/04	
Addition 1. 2. 3. 4. 5. 6. 7.	nal Inform Transfe Calcula and last Calcula for one Calcula Calcula Verify of Spreads	mation: (Scope of Re- r of field data to spread tion of intermediate me points per port) for on tion of port and overal run. tion of grand mean and tion of normalized con prientation of plotted b consistency of equation heet in equation form a	view, etc) Please ve Isheet (all runs) ean concentration va e of the runs. I mean concentration maximum deviation centration data (2 pe ars in one run. s in all runs by insp nd mark calculation	erify the for alues per to n, standar n of mear oints) for ection of to checked	ollowing: raverse (one d deviation, n for all mea plotting in c spreadsheet d.)	e per port and %CC surement one run. in softwa) and me DV for th points ir are form.	asurement point (1 st he center 2/3 of stack h one run. (May print	
Or Envir	ganizatio onmenta	on/Department I Health Sciences	Designated Review Rosanne Aaberg	wer:		Roza	Signa	iture/Date	33/0
CONCU	R[]	CONCUR, WITH C	OMMENTS [x]	DO NO	T CONCU	/ R[]	NOT R	REVIEWED []	
Comt. No.	Comr	nent and/ or Recomme	ndation:	-	Resolution:				
1	M -C Trial	orrection to particle co 3, Center, from 4094 t	ncentration table, Ea o 4084.	ast,	Corrected	d on PT-2	a		
2	E - C footn Conc data s would	Change the Note at the ote concerning column entration table. (Columnet.) Locating the foot to be helpful.	bottom of page PT-1 1 of the Particle an 1 is replaced by a note just below the t	l a to a forth able	Done				
3	M – T must	The units given on the the correspond to the value ed as mbar, when it is	emperature / pressu es listed; ambient pr	re table essure	Corrected	l to in. Hg	g.		
4	O - S an av numb	Stack Temperature at the erage of start and end there typed in PT-1a and	e top of page is give emperature in PT-2: PT-3	en as a; it is a	Replaced the average parameter	this cell ge of the r table.	with a for values re	rmula to calculate corded in the	
5	O – A is giv down	Ambient pressure on da en as 29.258 on origin to 29.25.	PT-2a ounded	Changed to 29.258 on PT-2 and PT-2a					
6	0-0	Compressor output unit	s listed as psi rather sheets	than	They all read psig now.			1	
7	O – T the E labels be rec (sour	The labels of points (co est series is represented of the graphs. In the duced by reversing the ce M32:U32 of spread	rresponding to deptil d in reverse order fro future, the confusior points charted in the sheet).	h) in om the n could e graph	ОК				

PA NATI INDE	CIFIC NORTHWEST ONAL LABORATORIES PENDENT TECHNICAL REVIEW RECORD	DOCUMENT NO.: Calculation of Particle Tr Characteristics for 291-Z 291z18ptpart.xls	acer Uniformity -1 Model, Spreadsheet	Page <u>2</u> of <u>2</u>
Comt. No.	Comment and/ or Recommend	lation:	Resolution:	
Concur v	gith Resolution Janne L. Har	Date 9/30/04	Comments Resolved By	Date 2/30/04

•

	Site	PAR 325 Model S		ER TRAVE	RSE DATA F				
	Date	9/16/2004		Fan o	configuration	Far Fan			
	Tester	JAG/MYB/J	мв		Fan Setting	37.1 Hz			
	Stack Dia.	18	18 in.		Stack Temp		deg F		
S	stack X-Area	254.5	254.5 in.2		art/End Time	2:18 PM/ 4:30 PM			
	Elevation	N.A.		Center 2/3 from		1.65	to:	16.35	
Distance to	disturbance	120	inches	Points i	n Center 2/3	2	to:	7	
Measu	rement units	particles/ft3		In	jection Point	Dwnstrm of	far fan, cent	erline	
Order>			2nd				1st		
Traverse>			Ea	ast			Nor	th	
Trial>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	0	partic	les/ft3			particl	es/ft3	
1	0.58	2579	2506	2538	2541.0	2524	2067	2059	2216.7
2	1.89	2694	2438	2278	2470.0	2440	1953	1799	2064.0
3	3.49	2616	2443	2133	2397.3	2402	2109	1931	2147.3
4	5.81	2528	2539	2309	2458.7	2068	1904	1923	1965.0
Center	9.00	2403	2568	2596	2522.3	2855	1928	2014	2265.7
5	12.19	2272	2550	2427	2416.3	3089	2513	2022	2541.3
6	14.51	24/3	2421	2692	2528.7	3024	2620	2063	2569.0
/	16.11	2265	2274	2298	2279.0	4035	2782	2126	2981.0
8	17.42	2409	2464	2010	2294.3	4183	3298	3443	3641.3
Averages	>	2471.0	2407.0	2304.0	<u>2434.2</u>	2957.8	2352.7	2153.3	2487.9
	<u></u>	nt/ft3	 Dev	from mean	Contor 2/2	East	North		Normizd
	An Mean	2461.1			Mean	2438.0	2261.0	2400 40	2534 19
	Min Point	1965.0		-20.2%	Std Dev	2430.9	355.0	2400.40	2004.19
	May Point	3641.3		48.0%		35	15.1	10.49	11 55
Avg Conc	2469	nt/ft3			Instruments	Used:	10.1	10.40	
Avg Conc	2400	pullo			TSI Velocity	Calc Plus	S/N 200060	C	alih 8/25/04
		Start	Finish			Galerius	0/11/200000		
Generator In	let Press	3-4	~3	nsia					
Stack Temp		80	80	F					
Centerline ve	el.	770	805.0	fom					
Ambient pres	ssure	29.37	29.34	inHa					
Ambient hum	nidity	34%	32%	RH		The second s	1-		
Ambient tem	D	74	73	F	4200-		· · · · · · · · · · · · · · · · · · ·		
	F		12,17,17,12,		3700-		-	1	······
Back-Gd aer	osol	3,12,3,4,3,4	19,20	pt/ft3	P				
No. Bk-Gd sa	amples	6	6		a 3200				
Compressor	output reg	110	115	psig	r 2700	4			
Optical Part	icle Counte	rs:			t 2200				
Met One A24	108	S/N 96258	<u> 675</u>	Cal 8/5/04	1 2200				
Pre-test sta	bility readin	gs: 2248, 2	160 <u>,</u> 2200, 2	2210,					
2091, 1980	, <u>1908, 203</u>	3, <u>2</u> 005			3 1200)			
					- 700				
Oil Used:	FisherBrand	19				-			
Probe has a	4.5-in throw	so is that mu	ch closer to	the	. 20				
stack than t	he port.								
					-	North	· · · ·	~ /	East
					-	North			
				0					
Signature sig	Inities compi	lance with		Signature ve		and calculatio	ons:	/	11
Procedure E	NISUAG-UZ	910.	-	h. lan	Ka	ne 1	Ha	ben y	1/3/14
Signature/da	ne phin	-/JULA	meyer ?	120104		h	- /		
	U		0	5 On als 0 at	tula DT (0/00/2000		\bigcirc	/
			04-32	o ocale-optpal	nt.xis PI-1	9/30/2004			

		PART	ICLE TRAC	ER TRAVE	RSE DATA I	ORM			
	Site	325 Model S	tack		Run No.	PT-1a			
	Date	9/16/2004		Fano	configuration	Far Fan			
	Tester	JAG/MYB/JM	IB		Fan Setting	37.1 Hz			
	Stack Dia.	18 i	n.		Stack Temp	80 d	eg F		
5	Stack X-Area	254.5 i	n.2	Sta	art/End Time	2:18 PM/ 4:30	PM		
Distance to	Elevation	N.A		Cer	nter 2/3 from	1.65	to:	16.35	
Distance to	o disturbance	120	nches	Points	n Center 2/3	2	to:	7	
Measu	irement units	particles/ft3		In	jection Point	Dwnstrm of f	ar fan, cen	terline	
Order>		<u>_</u>	<u>2na</u>			1	<u>st</u>		
Traverse>			Ea	IST			Nor	rth	
1 riai>	<u> </u>	11	2	3	Mean	1	2	3	Mean
Point	Depth, in.	0.570	particl	es/ft3			particle	es/ft3	
1	0.58	2579	2506	2538	2541.0	1834	2067	2059	1986.7
2	1.89	2694	2438	2278	2470.0	1877	1953	1799	1876.3
3	3.49	2616	2443	2133	2397.3	2069	2109	1931	2036.3
4	5.81	2528	2539	2309	2458.7	2048	1904	1923	1958.3
Center	9.00	2403	2568	2596	2522.3	2352	1928	2014	2098.0
5	12.19	2272	2550	2427	2416.3	2196	2513	2022	2243.7
6	14.51	2473	2421	2692	2528.7	2184	2620	2063	2289.0
7	16.11	2265	2274	2298	2279.0	3462	2782	2126	2790.0
8	17.42	2409	2464	2010	2294.3	2969	3298	3443	3236.7
Averages	>	2471.0	2467.0	2364.6	2434.2	2332.3	2352.7	2153.3	2279.4
	Concern th	at more time	was neede	ed to stabili	ze after star	ting up partic	le generato	Dr.	
	All	pt/ft3	Dev	from mean	Center 2/3	East	North	<u>All</u>	Normizd
	Mean	2356.8			Mean	2438.9	2184.5	2311.71	2532.63
	Min Point	1876.3		-20.4%	Std. Dev.	85.8	304.6	252.26	273.40
	Max Point	3236.7		37.3%	COV as %	3.5	13.9	10.91	10.79
Avg Conc	2363	pt/ft3			Instuments TSI Velocity	Used: Calc Plus S	/N 209060	Ca	alib 8/25/04
		Start	Finish						
Generator In	let Press	3-4	~3	psig					
Stack Temp		80	80	F					
Centerline ve	el.	770	805.0	fpm					
Ambient pres	ssure	29.37	29.34	inHg		- And a start of the			hand a second
Ambient hun	nidity	34%	32%	RH	4000				
Ambient tem	p	74	73	F	4200		1-	The second s	
		1	12,17,17,12		3700-	and the second			and the second second
Back-Gd aer	rosol	3,12,3,4,3,4 ,	19,20	pt/ft3	P 3200	· · ·			
No. Bk-Gd s	amples	6	6		a 3200	1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1			
Compressor	output reg	110	115	psig	r 2700-				
Optical Part	ticle Counte	rs:			t 2200	1. 1. A. A. A.		ilian a	
Met One A2	408	S/N 962586	75	Cal 8/5/04	1 5 4700				
Pre-test sta	bility readin	gs: 2248, 21	<u>60, 2200, 2</u>	210,	· · · · · ·				
2091, 1980	<u>, 1908, 203</u>	3, 2005			3 1200	1			
Oil Head	FigherDerry	10			. 700				
Droke has	A E in the	1 19	ab alaara ta	the	200		վեր		1
Probe has a	4.5-IN INFOW	so is that muc	in closer to		-			00	/
slack inan t	ne port.						and the second		
					•	North		and for	East
					•	North			
Signature sig	gnifies comp	liance with		Signature ve	erifying data	and calculation	ns:		/
Procedure E Signature/da	MS-JAG-02	n Glis	Amere	7 9/30	104	_ KPa	inne	L Hebe	3 9/30
		ŗ	/04-3	325 Scale-8pt	part.xls PT-	1a 9/30/2004	Ļ	1 () ' /

	Cite	PART		ER TRAVER		ORM			
	Site	325 Model S	otack	-	Run No.	P1-2			
	Date	9/1//2004		Fanc	configuration	Near Fan			
	Tester	JAG/MYB/JM	<u>ив</u>		Fan Setting	37.1 Hz			
	Stack Dia.	18	in		Stack Temp	66	deg F		
S	itack X-Area	254.5	in.2	Sta	art/End Time	10:50/13:20			
	Elevation	<u>N.A.</u>		Cer	nter 2/3 from	1.65	to:	16.35	
Distance to	disturbance	120	inches	Points i	n Center 2/3	2	to:	7	
Measu	rement units	<u>particles/ft3</u>		Inj	jection Point	Near Fan, C	enterline do	wnstream	
Order>			<u>1</u> st				2 <u>nd</u>		
Traverse>			Ea	ist			Nor	th	
Trial>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.		partic	es/ft3			particle	es/ft3	
1	0.58	4987	2769	2930	3562.0	2629	2880	3068	2859.0
2	1.89	4980	2677	3068	3575.0	2772	3186	2879	2945.7
3	3.49	3190	3812	2676	3226.0	2758	3355	3548	3220.3
4	5.81	3499	4058	2584	3380.3	2787	3185	4027	3333.0
Center	9.00	4049	4810	2839	3899.3	2560	2986	4222	3256.0
5	12.19	4318	3638	2564	3506.7	2658	2651	3828	3045.7
6	14.51	3785	4313	3182	3760.0	3913	2753	3528	3398.0
7	16.11	3673	4102	3688	3821.0	3755	2513	4860	3709.3
8	17.42	3103	3172	2725	3000.0	2951	2999	5331	3760.3
Averages		3953.8	3705.7	2917.3	3525.6	2975.9	2945.3	3921.2	3280.8
/ Weilageo	-	0000.0		201710	0020.0	207010		002112	0200.0
	Δ//	nt/ft3	Dev	from mean	Center 2/3	Fast	North	All	Normlzd
	Mean	3403.2	<u></u>	<u>. nom moun</u>	Mean	3595 5	3272.6	3434 02	3757 33
	Min Point	2859.0		-16.0%	Std Dev	245.4	248.8	290 60	311 44
	Max Deint	2009.0		-10.0%		240.4	240.0 7 eľ	230.00	9.20
Ava Cono	2201			14.070	Instuments	0.0	7.0	0.40	0.23
Avy Conc	3301	puito			TSL Valaaitu		S/N 200060	C	-116 9/25/04
		Otart	Tiniah			Calc Plus	3/14 209000		and 6/25/04
Concentration In		Start	FINISH						
Generator In	let Press	4	4	psig					
Stack Temp		61	71	F					
Centerline ve	el.	855	795.0	tpm					
Ambient pres	ssure	29.3	29.258	InHg					
Ambient hun	hidity	74%	53%	RH	4700-				· · · · · · · · · · · · · · · · · · ·
Ambient tem	p	58	66	F	4200				Constant Constant State
Back-Gd aer	osol	3,3,2,3,4,5	1,3,4,3,0,3	pt/ft3	D 3700				
No. Bk-Gd s	amples	6	6		P 3700				
Compressor	output reg	110	115	psig	a 3200				100 million (100 million)
Optical Part	icle Counter	rs:			- t 2700	1			
Met One A24	108	S/N 962586	675	Cal 8/5/04	- / 2200	1			
Wind 12 mpl	n steady				_ f				
Oil Used:	FisherBrand	19			_ t 1/00				· · · · ·
Probe has a	4.5-in throw	so is that mu	ch closer to	the	3 1200				
stack than t	he port.				70	0			1
It appears that	there was a c	lecline and the	n a recovery ir	ı	20	0			
concentration	durring the tes	t. See column	averages.		_			5	7
Consistency c	hecks: at East	1 after the Eas	t measuremen	ments:	_				East
4430/4487/46	61/4399/4338/	4602				North		1	
At North2: 369	9/3692/3805/	3727/3715/380	4/3918/3999						
At North7: 506	5/4957/5263/	5052							
Signature sig	gnifies compl	iance with		Signature v	erifying data	and calculation	ons:	/	
Procedure E	MS-JAG202	01			\cap		111	1 1	
Signature/da	ite	Sum	eyer 91	30/04	//>	ann	L Hal	Les 9	130/04
	//	/	1 1					01	
		L							
			04-32	5 Scale-8ptpa	rt.xls PT-2	9/30/2004			

		PAR	TICLE TRAC		RSE DATA F	ORM			
	Site	325 Model S	Stack		Run No.	PT-2a			
	Date	9/17/2004		Fan c	configuration	Near Fan			
	Tester	JAG/MYB/JM	<u>//B</u>		Fan Setting	37.1 Hz			
	Stack Dia.	18 in		Stack Temp		66	deg F		
S	tack X-Area	254.5	in.2	Sta	art/End Time	10:50/13:20			
	Elevation	<u>N</u> .A.		Cer	nter 2/3 from	1.65	to:	16.35	
Distance to	disturbance	120	inches	Points i	n Center 2/3	2	to:	7	
Measu	rement units	particles/ft3		Inj	jection Point	<u>Near Fan, C</u>	Near Fan, Centerline downstream		
Order>			1st				2nd		
Traverse>			Ea	ist			No	rth	
Trial>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.		partic	es/ft3			particl	es/ft3	
1	0.58	4987	2769	4527	4094.3	2629	2880		2859.0
2	1.89	4980	2677	3534	3730.3	2772	3186	2879	2945.7
3	3.49	3190	3812	4235	3745.7	2758	3355	3548	3220.3
4	5.81	3499	4058	4313	3956.7	2787	3185	4027	3333.0
Center	9.00	4049	4810	4084	4314.3	2560	2986	4222	3256.0
5	12.19	4318	3638	3973	3976.3	2658	2651	3828	3045.7
6	14.51	3785	4313	3856	3984.7	3913	2753	3528	3398.0
7	16.11	3673	4102	3532	3769.0	3755	2513	4860	3709.3
8	17.42	3103	3172	2589	2954.7	2951	2999	5331	3760.3
Averages	>	3953.8	3705.7	3849.2	3836.2	2975.9	2945.3	3921.2	3280.8
	All	<u>pt/ft3</u>	Dev	<u>. from mean</u>	<u>Center 2/3</u>	East	<u>North</u>	All	Normizd
	Mean	3558.5			Mean	3925.3	3272.6	3598.93	4130.79
	Min Point	2859.0		-19.7%	Std. Dev.	205.4	248.8	403.43	339.31
	Max Point	4314.3		21.2%	COV as %	5.2	7.6	11.21	8.21
Avg Conc	3530	pt/ft3			Instuments	s Used:			
					TSI Velocity	/ Calc Plus	S/N 209060	C;	alib 8/25/04
		Start	Finish				_		_
Generator In	let Press	4	4	psig					
Stack Temp		61	71	F					
Centerline ve	el.	855	795.0	fpm					
Ambient pres	ssure	29.3	29.258	inHg		and the second se			
Ambient hum	nidity	74%	53%	RH	5200-				and the second second second second
Ambient tem	р	58	66	F	4700				The second se
Back-Gd aer	osol	3,3,2,3,4,5	1,3,4,3,0,3	pt/ft3	p 4200				· · · · · · · · ·
No. Bk-Gd sa	amples	6	6		a 3700				
Compressor	output reg	110	115	psig	I 2000				
Optical Part	icle Counte	rs:		0 1 0/5/04	- t				
Met One A24	408	S/N 96258	575	Cal 8/5/04	. 1 2700				· · · ·
					f 2200				
					t 1700				
Wind 12 mpl	h steady				3 120	0-			
Oil Used:	FisherBrand	119			70	0			1 de la companya de l
Probe has a	4.5-in throw	so is that mu	ch closer to	the	_ 20	10			
stack than t	the port.				-				
					-	North		a second	East
					-	North			
				Olemetrum	a wife size and a fea				
Signature sig	gnifies comp	lance with		Signature v	eritying data		ons: /	Λ	~/ /
Procedure E		210		9/2.1.		Know	~/ ·	Habh	4/30/11
Signature/da	ale WZAA	1/Jus	and the second	·/ SO/09	/	n Inorocco in	concontration	The X	1-1-1
NUTE: COLU	nin o East re	placed with to		a taken atter	perceiving I	nanciease in	concentration		
			04 222	Scala_Antron	tyle DT 24	0/20/2004			
			04-523	ocale-optpat		3/30/2004			

		PAR	ORM						
	Site	325 Model S	Stack		Run No.	<u>PT-3</u>			
	Date	9/17/2004		Fan o	configuration	Far Fan			
	Tester	JAG/MYB/J	MB		Fan Setting	37.1 Hz			
	Stack Dia.	18	in		Stack Temp	70.5	deg F		
S	Stack X-Area	254.5	in.2	Sta	art/End Time	1415/1620			
	Elevation	<u>N.A</u>		Cer	nter 2/3 from	1.65	to:	16.35	
Distance to	disturbance	120	inches	Points i	n Center 2/3	2	to:	7	
Measu	rement units	particles/ft3		In	jection Point	Dwnstrm of	far fan, cen	terline	
Order>			2nd				1st		
Traverse>			Ēa	ast			No	rth	
<u> Trial></u>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.		partic	les/ft3			particl	es/ft3	
1	0.58	765	651	648	688.0	665	519	486	556.7
2	1.89	715	646	688	683.0	625	542	657	608.0
3	3.49	642	572	556	590.0	542	712	844	699.3
4	5.81	533	571	510	538.0	772	477	812	687.0
Center	9.00	472	563	657	564.0	767	521	836	708.0
5	12.19	651	533	548	577.3	757	557	808	707.3
6	14.51	632	600	500	577.3	769	559	778	702.0
7	16.11	549	617	491	552.3	739	556	762	685.7
8	17.42	518	541	375	478.0	818	766	778	787.3
Averages	>	608.6	588.2	552.6	583.1	717.1	578.8	751.2	682.4
	All	pt/ft3	Dev	from mean	Center 2/3	East	North	AII	Normizd
	Mean	632.7			Mean	583.1	685.3	634.24	708.68
	Min Point	478.0		-24.5%	Std. Dev.	47.3	35.2	66.47	52.82
	Max Point	787.3		24.4%	COV as %	8.1	5.1	10.48	7.45
Ava Conc		1///0							
Avg Conc 632 pt/ft3 Instuments Used:									
Avy Conc	632	pt/ft3			Instuments TSI Velocity	Used: Calc Plus	S/N 209060	Ca	alib 8/25/04
Avg conc	632	pt/ft3 Start	Finish		Instuments TSI Velocity	Used: Calc Plus	S/N 209060	Ca	alib 8/25/04
Generator In	632 let Press	Start	Finish 4	psig	Instuments TSI Velocity	Used: Calc Plus	S/N 209060	Ca	alib 8/25/04
Generator In Stack Temp	632 let Press	Start 3	Finish 4	psig F	Instuments TSI Velocity	Used: Calc Plus	S/N 209060	Ca	alib 8/25/04
Generator In Stack Temp Centerline ve	632 let Press	Start 3 72 800	Finish 4 69 785.0	psig F fpm	Instuments TSI Velocity	Used: Calc Plus	S/N 209060	Ca	alib 8/25/04
Generator In Stack Temp Centerline ve	632 let Press el.	Start 3 72 800 29,256	Finish 4 69 785.0 29.04	psig F fpm inHa	Instuments TSI Velocity	Used: Calc Plus	S/N 209060	Ca	alib 8/25/04
Generator In Stack Temp Centerline ve Ambient pres	632 let Press el. ssure hidity	pt/ft3 Start 3 72 800 29.256 53%	Finish 4 69 785.0 29.04 45%	psig F fpm inHg RH	Instuments TSI Velocity	Used: Calc Plus	S/N 209060	Ca	alib 8/25/04
Generator In Stack Temp Centerline ve Ambient pres Ambient hum	632 let Press el. ssure hidity p	pt/ft3 Start 3 72 800 29.256 53% 67	Finish 4 69 785.0 29.04 45% 67	psig F fpm inHg RH F	Instuments TSI Velocity 900	Used: Calc Plus	S/N 209060	<u>C</u> :	alib 8/25/04
Generator In Stack Temp Centerline ve Ambient pres Ambient hum Ambient tem	632 let Press el. ssure hidity p	pt/ft3 Start 3 72 800 29.256 53% 67 11.13.12.8.1	Finish 4 69 785.0 29.04 45% 67	psig F fpm inHg RH F	900	Used: Calc Plus	S/N 209060	Ca	alib 8/25/04
Generator In Stack Temp Centerline ve Ambient pres Ambient hum Ambient tem Back-Gd aer	632 let Press el. ssure hidity p osol	pt/ft3 Start 3 72 800 29.256 53% 67 11,13,12,8,1 4,9	Finish 4 69 785.0 29.04 45% 67 6,12,9,6,9,3	psig F fpm inHg RH F pt/ft3	900 800-	Used: Calc Plus	S/N 209060	Ca	alib 8/25/04
Generator In Stack Temp Centerline ve Ambient pres Ambient hum Ambient tem Back-Gd aer No. Bk-Gd sa	632 let Press el. ssure hidity p osol amples	pt/ft3 Start 3 72 800 29.256 53% 67 11,13,12,8,1 4,9 6	Finish 4 69 785.0 29.04 45% 67 6,12,9,6,9,3 6	psig F fpm inHg RH F pt/ft3	900 900 900 900 800 P a 700	Used: Calc Plus	S/N 209060	Ca	alib 8/25/04
Generator In Stack Temp Centerline ve Ambient pres Ambient hum Ambient tem Back-Gd aer No. Bk-Gd sa Compressor	632 let Press el. ssure nidity p rosol amples output reg	pt/ft3 Start 3 72 800 29.256 53% 67 11,13,12,8,1 4,9 6 110	Finish 4 69 785.0 29.04 45% 67 6,12,9,6,9,3 6 115	psig F fpm inHg RH F pt/ft3 psig	900 900 800- P a 700-	Used: Calc Plus	S/N 209060		alib 8/25/04
Generator In Stack Temp Centerline ve Ambient pres Ambient hum Ambient tem Back-Gd aer No. Bk-Gd sa Compressor Optical Part	632 let Press el. ssure hidity p osol amples output reg icle Counte	pt/ft3 Start 3 72 800 29.256 53% 67 11,13,12,8,1 4,9 6 110 rs:	Finish 4 69 785.0 29.04 45% 67 6,12,9,6,9,3 6 115	psig F fpm inHg RH F pt/ft3 psig	900 900 800- P a 700- r t 600-	Used: Calc Plus	S/N 209060		alib 8/25/04
Generator In Stack Temp Centerline ve Ambient pres Ambient hum Ambient tem Back-Gd aer No. Bk-Gd sa Compressor Optical Part Met One A24	632 let Press el. ssure hidity p osol amples output reg icle Counter	pt/ft3 Start 3 72 800 29.256 53% 67 11,13,12,8,1 4,9 6 110 rs: S/N 962586	Finish 4 69 785.0 29.04 45% 67 6,12,9,6,9,3 6 115 675	psig F fpm inHg RH F pt/ft3 psig Cal 8/5/04	900 900 800- P a 700- r t 600- / 500	Used: Calc Plus	S/N 209060		alib 8/25/04
Generator In Stack Temp Centerline ve Ambient pres Ambient hum Ambient tem Back-Gd aer No. Bk-Gd sa Compressor Optical Part <u>Met One A22</u> SW wind 10	632 let Press el. ssure hidity p osol amples output reg icle Counter 108 moh at start	pt/ft3 Start 3 72 800 29.256 53% 67 11,13,12,8,1 4,9 6 110 rs: S/N 962586	Finish 4 69 785.0 29.04 45% 67 6,12,9,6,9,3 6,12,9,6,9,3 6 115	psig F fpm inHg RH F pt/ft3 psig Cal 8/5/04	900 900 800- P a 700- r t 600- f 500-	Used: Calc Plus	S/N 209060		alib 8/25/04
Generator In Stack Temp Centerline ve Ambient pres Ambient hum Ambient tem Back-Gd aer No. Bk-Gd sa Compressor Optical Part <u>Met One A24</u> <u>SW wind 10</u> SE wind 12	632 let Press el. ssure nidity p osol amples output reg icle Counter 408 mph at start mph at enc	pt/ft3 Start 3 72 800 29.256 53% 67 11,13,12,8,1 4,9 6 110 rs: S/N 962586	Finish 4 69 785.0 29.04 45% 67 6,12,9,6,9,3 6 115 575	psig F fpm inHg RH F pt/ft3 psig Cal 8/5/04	900 900 800- P a 700- r t 600- f 500- t 400-	Used: Calc Plus	S/N 209060		alib 8/25/04
Generator In Stack Temp Centerline ve Ambient pres Ambient hum Ambient tem Back-Gd aer No. Bk-Gd sa Compressor Optical Part Met One A24 SW wind 10 SE wind 12	632 let Press el. ssure nidity p cosol amples output reg <u>icle Counter</u> 408 mph at start mph at enc	pt/ft3 Start 3 72 800 29.256 53% 67 11,13,12,8,1 4,9 6 110 rs: S/N 962586	Finish 4 69 785.0 29.04 45% 67 6,12,9,6,9,3 6 115 675	psig F fpm inHg RH F pt/ft3 psig Cal 8/5/04	900 900 800- P a 700- r t 600- f 500- t 400- 3	Used: Calc Plus	S/N 209060		alib 8/25/04
Generator In Stack Temp Centerline ve Ambient pres Ambient hum Ambient tem Back-Gd aer No. Bk-Gd sa Compressor Optical Part Met One A24 SW wind 10 SE wind 12	632 let Press el. ssure hidity p osol amples output reg icle Counter 408 mph at start mph at enco	pt/ft3 Start 3 72 800 29.256 53% 67 11,13,12,8,1 4,9 6 110 rs: S/N 962586 1 19	Finish 4 69 785.0 29.04 45% 67 6,12,9,6,9,3 6 115 675	psig F fpm inHg RH F pt/ft3 psig Cal 8/5/04	900 900 800- P a 700- r t 600- f 500- t 400- 3 300-	Used: Calc Plus	S/N 209060		alib 8/25/04
Generator In Stack Temp Centerline ve Ambient pres Ambient hum Ambient tem Back-Gd aer No. Bk-Gd sa Compressor Optical Part <u>Met One A24</u> SW wind 10 <u>SE wind 12</u> Oil Used: Probe has a	632 let Press el. ssure hidity p osol amples output reg icle Counter 408 mph at start mph at enco FisherBranc 4.5-in throw	pt/ft3 Start 3 72 800 29.256 53% 67 11,13,12,8,1 4,9 6 110 rs: S/N 962586 1 19 so is that mu	Finish 4 69 785.0 29.04 45% 67 6,12,9,6,9,3 6 115 575 575	psig F fpm inHg RH F pt/ft3 psig Cal 8/5/04	Instuments TSI Velocity 900 800- P a 700- r 600- f 500- t 400- 3 300- 200	Used: Calc Plus	S/N 209060		alib 8/25/04
Generator In Stack Temp Centerline ve Ambient pres Ambient hum Ambient tem Back-Gd aer No. Bk-Gd sa Compressor Optical Part Met One A22 SW wind 10 SE wind 12 Oil Used: Probe has a stack than f	632 let Press el. ssure hidity p osol amples output reg icle Counter 408 mph at start mph at start mph at enco FisherBranc 4.5-in throw	pt/ft3 Start 3 72 800 29.256 53% 67 11,13,12,8,1 4,9 6 110 rs: S/N 962586 1 19 so is that mu	Finish 4 69 785.0 29.04 45% 67 6,12,9,6,9,3 6 115 575 575	psig F fpm inHg RH F pt/ft3 psig Cal 8/5/04 the	Instuments TSI Velocity 900 800 P 700 r 600 / 500 t 400 3000 200	Used: Calc Plus	S/N 209060		alib 8/25/04
Generator In Stack Temp Centerline ve Ambient pres Ambient hum Ambient tem Back-Gd aer No. Bk-Gd sa Compressor Optical Part Met One A22 SW wind 10 SE wind 12 Oil Used: Probe has a stack than f	632 let Press el. ssure hidity p osol amples output reg icle Counter 408 mph at start mph at start FisherBranc 4.5-in throw the port.	pt/ft3 Start 3 72 800 29.256 53% 67 11,13,12,8,1 4,9 6 110 rs: S/N 962586 1 19 so is that mu ecked at N4	Finish 4 69 785.0 29.04 45% 67 6,12,9,6,9,3 6 115 575 ch closer to	psig F fpm inHg RH F pt/ft3 psig Cal 8/5/04	900 900 800- P a 700- r t 600- f 500- t 400- 3 300- 200	Used: Calc Plus	S/N 209060		alib 8/25/04
Generator In Stack Temp Centerline ve Ambient pres Ambient hum Ambient tem Back-Gd aer No. Bk-Gd sa Compressor Optical Part Met One A24 SW wind 10 SE wind 12 Oil Used: Probe has a stack than 1 Pretest con 718 672 64	632 let Press el. ssure hidity p osol amples output reg icle Counter 408 mph at start mph at start mph at start mph at enco 4.5-in throw the port. sistency ch 2 672 739	pt/ft3 Start 3 72 800 29.256 53% 67 11,13,12,8,1 4,9 6 110 rs: S/N 962586 1 119 so is that mu ecked at N4	Finish 4 69 785.0 29.04 45% 67 6,12,9,6,9,3 6 115 675 675 675 675	psig F fpm inHg RH F pt/ft3 psig Cal 8/5/04	900 900 800- P a 700- r t 600- f t 400- 3 300- 200	Used: Calc Plus	S/N 209060		East
Generator In Stack Temp Centerline ve Ambient pres Ambient hum Ambient tem Back-Gd aer No. Bk-Gd sa Compressor Optical Part Met One A24 SW wind 10 SE wind 12 Oil Used: Probe has a stack than t Pretest con 718, 672, 64	632 let Press el. ssure hidity p osol amples output reg icle Counter itole Counter ito	pt/ft3 Start 3 72 800 29.256 53% 67 11,13,12,8,1 4,9 6 110 rs: S/N 962586 1 119 so is that mu ecked at N4	Finish 4 69 785.0 29.04 45% 67 6,12,9,6,9,3 6 115 675 675 ch closer to point:	psig F fpm inHg RH F pt/ft3 psig Cal 8/5/04	P 300- r 600- r 600- r 600- r 600- r 300- 200- 300-	Used: Calc Plus	S/N 209060		East
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Generator In Stack Temp Centerline ve Ambient pres Ambient hum Ambient tem Back-Gd aer No. Bk-Gd sa Compressor Optical Part Met One A24 SW wind 10 SE wind 12 Oil Used: Probe has a stack than 1 Pretest con 718, 672, 64	632 let Press el. ssure hidity p osol amples output reg icle Counter 408 mph at start mph at start mph at start mph at enc 4.5-in throw the port. sistency ch 2, 672, 739	pt/ft3 Start 3 72 800 29.256 53% 67 11,13,12,8,1 4,9 6 110 rs: S/N 962586 1 19 so is that mu ecked at N4 jance with	Finish 4 69 785.0 29.04 45% 67 6,12,9,6,9,3 6 115 575 575 ch closer to point:	psig F fpm inHg RH F pt/ft3 psig Cal 8/5/04 the	900 900 800- P a 700- r 600- f 500- t 400- 3 300- 200 P 200	Used: Calc Plus	S/N 209060		East
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04-325 Scale-8ptpart.xls PT3 9/30/2004

Test Instruction								
Project: 325 Stack Sampler E Qualification	Date: August 16, 2004	Work Package: F59676						
Tests: Tracer Particle Uniformity in 325 Model Stack, 1 Electric Fan Configuration								
Staff: John Glissmeyer, Dave Do	ouglas, Marcel Ballinger, M	atthew Barnett						
Reference Procedures:								
1. Procedure EMS-JAG-02, Rev Samplar May 24, 2000	7. 1, Test to Determine Uniform	nity of a Particulate Aerosol at a						
2. Operating Manual for Met-O	ne Optical Particle Counter (O	PC), Model A2408						
Equipment:	ne optical i aldere counter (o							
1. 325 Model Stack and inspecte	ed work platforms. Fans will b	e in positions EF1, EF4,						
2. Vacuum pump oil, oil mist ge	nerator, air lines, regulator, pro	cision pressure gauge compressed air						
source								
3. Oil mist injection probe, OPC	c sample probes, probe/stack co	ouplers, tape measure, marking pen						
4. OPC with computer (optional) and link							
5. Velocity measurement device	(optional) for verifying stack	flow						
Safety Considerations:								
Observe the applicable Job Hazard	d Analysis for the project							
Instructions:		1.1 1 111 .1						
1. Verify training on the procedu	ire and that instrumentation is	within calibration						
2. Obtain climatic information if	rom the Hanford Weather Serv	ice, phone $3/3-2/16$ or						
2 Mark the completion of each s	vis/lasion.illin	andura Mark out these store not						
3. Mark the completion of each s	step on the field copy of the pro-	ocedure. Mark-out mose steps not						
4 Install equipment as directed i	n the procedures Only the m	bile OPC will be used. The serosol						
delivery line should be as vert	ical as possible to avoid oil ac	sumulation						
5 Use a sliding platform for the	OPC and clamp the probe so h	oth the OPC and probe move together						
6. Mark sampling probe for the r	neasurement points shown on	the data sheet.						
7. Verify that stack flow is about	t 1350 – 1450 cfm.							
8. Initially set the injection system	m input psi at 5 and vary to ob	tain particle counts at the sampling						
ports that are about 10 times b	ackground for 10-micron parti	cles.						
9. Monitor the flowrate on the O	PC. Record data on copies of t	he attached the data sheet. Diagram						
mounting fixtures and retain a	ssembly for any subsequent re	-tests						
10. Conduct one or more tracer m	ixing tests at the following sets	s of conditions:						
Downstream of Fan	Injection Positions	Possible Runs						
EF1	Center	PT 1						
EF4	Center	PT 2						
Worst case fan position from eith	er this Center	PT 3						
or gas tracer tests								
Desired Completion Date: 08/27/	/04							
Approvals:	Lanne	aliolari						
Inha Glissmever test	director	Date						
Test Completed by:		Date:						
Test completed by	Thomas	Date. 9/17/04						
	\mathcal{J}							

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PNNL Operating Procedure	Rev. No. 1	Page 1 of 15
	Org. Code: D9T99	Procedure No.: EMS-JAG-02
Title: Test to Determ	ine Uniformity of a Trac	cer Aerosol at a Sampler Probe

PNNL Operating Procedure		
Title: Test to Determine Uniformity of a Tracer Aerosol at a Sampler Probe	Org. Code: D9T99 Procedure No.: EMS-JAG-0 Rev. No.: 1)2
Work Location: General	Effective Date: May 24, 200	0
Author: John A. Glissmeyer	Supersedes Date: November 10	, 1998
Identified Hazards:	Identified Use Category:	
□ Radiological	□ Mandatory Use	
 Hazardous Materials Physical Hazards Hazardous Environment 	□ Continuous Use Reference Use □ Information Use	
\Box Other:		
Are One-Time Modifications Allow	ved? Yes □ No	
Person Signing	Signature	Date
Technical review:		
James L. Huckaby	·	
Project Manager:		
John Glissmeyer		
Line Manager:		
James Droppo		
Concurrence:		
Quality Engineer:		
Thomas G. Walker		

PNNL Operating Procedure	Rev. No. 1 Org. Code: D9T99	Page 2 of 15 Procedure No : EMS IAG 02
Title: Test to Determ	ine Uniformity of a Tr	acer Aerosol at a Sampler Probe

1.0 Purpose

The performance of new stack sampling systems must be shown to satisfy the requirements of 40 CFR 61, Subpart H, "National Emission standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities." This regulation governs portions of the design and implementation of effluent air sampling. The stack sampler performance is adequately characterized when potential contaminants in the effluent are of a uniform concentration at the sampling location (plane), and line losses are within acceptable limits. This procedure determines whether the concentration of aerosol particulate contaminants is uniformly distributed in the area of the sampling probe. Other procedures address flow angle, uniformity of gas velocity, and uniformity of gas contaminants. A contaminant concentration that is uniform at the sampling plane enables the extraction of samples that represent the true emission concentration.

The uniformity is expressed as the variability of the measurements about the mean. This is expressed using the relative coefficient of variance (COV), which is the standard deviation divided by the mean and expressed as a percentage. The lower the COV value, the more uniform the particle concentration. The acceptance criterion is that the COV of the measured particle concentrations be # 20% across the center two-thirds of the area of the stack.

2.0 Applicability

This procedure can be used in the field or on modeled stacks to determine whether air-sampling probes can collect representative samples under normal operations. The tests are applicable to effluent stacks or ducts within the following constraints:

- The aerosol particulate tests are generally limited to stacks with flowrates greater than 50 cubic feet per minute range. The upper bound of flowrate is determined by the output capacity of the aerosol generator, the background reading for particulate aerosols, and the operational detection range of the optical particle counters.
- Environmental constraints optical particle counters will require the use of a controlled temperature environment to maintain the equipment above 55 degrees Fahrenheit.

3.0 Prerequisites and Conditions

Conditions and concerns that must be satisfied before sampling are listed below:

- Safety glasses and hard toed or substantial shoes are required in work areas.
- Test ports for tracer injection and sampling.
- Properly constructed and inspected work platforms may be needed to access the test ports.
- Scaffold-user or fall protection training may be required to access the sampling ports of the stack.
- Alcohol may be used for equipment cleanup. A flammable equipment storage cabinet is required to hold chemicals. Material Safety Data Sheets must be provided.

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Title: Test to Determ	ine Uniformity of a Tra	cer Aerosol at a Sampler Probe

- Air pressure (up to about 75 psi) is used to aerosolize oil into fine particles. Knowledge of the use and operation of pressurized air-lines, and the careful observations of any buildup of oil mist outside of the generator is essential to prevent exceeding American Conference of Governmental Industrial Hygienists (ACGIH) levels listed below.
- Knowledge of the setup, use of, and operation of flowmeters, particle counters, and computers is essential.
- A job-hazards analysis may be required in certain cases.

4.0 Precautions and Limitations

Caution: The ACGIH 8-hour time-weighted average limit for human exposure to mineral oil mist is 5 mg/m³. It is odorless.

During tests of stacks with high flowrates, oil droplets will be injected into the base of the stack to overcome the large dilution factor needed to detect selected particles at the sampling ports above. The potential is present for a buildup of oil mist to occur outside of the aerosol generator that could approach the 5 mg/m³ caution level. The undiluted mist is heavier than air, so it may accumulate in confined spaces and in low areas if allowed to escape. Visual inspections of the delivery system will be made at least daily to prevent such an occurrence.

Access to the test ports may require the use of scaffolding or manlifts, either of which will necessitate special training for sampling personnel and any observers. The training requirements will be indicated in the job hazard analysis.

The test may be invalid if the ending ambient concentration of mist is elevated above that observed at the start of the test. This would indicate poor dispersion away from the test site caused by recirculation of the tracer to the inlet of the fan and will only occur if the stack exhaust point is in view of and is reasonably close to the fan inlet. This may result in a false indication of good mixing.

5.0 Equipment Used for Stack Measurements

Specific calibration check concentration levels, probe dimensions, measurement grids, flowrates, and other special requirements will be provided in the specific Test Instruction. Exhibit A provides a typical layout for the test setup. The following are essential items of equipment:

- Vacuum pump oil
- Oil mist generator
- · Compressed air, compressed air hoses, and precision air regulators
- Oil mist injection probe
- Aerosol sampling probes
- Mechanism for accurate placement of sampling probe

Title: Test to Determine Uniformity of a Tracer Aerosol at a Sampler Probe

- Optical particle counters
- Computers linked to particle counters
- Velocity flow measurement meter.

Two optical particle counters (OPCs) may be used simultaneously to count particles that are approximately in the10-micron size range. A mobile OPC is designated to make point-by-point measurements in the orthogonal traverses. An optional reference OPC may be used to note trends in aerosol generator output over time and to validate the mobile sampler results. The operation of the reference OPC, at some fixed position in the stack, may be contingent on whether a suitable port is available on the test stack.

The counters, rechecked annually for calibration by the manufacturer, are synchronized for time, sample mode, flow, and count range to monitor their field performance. The absolute calibration of the OPCs is not as important as the general response because the concentration data are used in a relative manner in calculating the COV and in plotting the concentrations at the measurement points.

The aerosol generator siphons oil from a reservoir and forces the air/oil mixture through a spray nozzle to produce polydisperse particles. Non-hazardous oil with a low vapor pressure (such as Fisherbrand 19 vacuum pump oil) should be used in the reservoir. The quantity of aerosol generated is controlled by the amount of compressed air pressure, which should be filtered and controlled by a precision regulator. The nozzle is mounted in a large diameter, clear-plastic pipe (4-inches diameter or larger) so the output level can be observed. The aerosol generator output should connect to an injection tube with an inside diameter of at least 0.5 inches to minimize collisions with the inner wall of the tubing. Optimal operation depends on uniformly "wetting" the inner surfaces of the generator and transfer tubes; thus, a warm up period of up to ½ hour is needed for a constant aerosol output.

6.0 Work instructions for Setup, Measurements, and Data Reduction

The steps taken to set up, configure, and operate the stack fans and test equipment are listed. Based on previous field measurements, the steps are ordered to achieve maximum efficiency in the testing. In addition to these steps, the test instruction illustrated in Attachment A will provide specific details and operating parameters.

6.1 **Preliminary Steps:**

My3 6 9/16/04

143 0. 9/16/04

6.1.1 / Provide essential supplies at the sampling location (particulate generation 9/15/04 Jack 115/04 Jack 9/16/04 equipment, supply air and regulators, fittings and probe-port couplers, marking pens, data sheets, writing and probe-supporting platforms).

6.1.2 ' Fill in test information on dataform.

6.1.3 Cobserve the current flow setting for the test stack and record on the data sheet.

6.1.4 [<] Obtain barometric, temperature, and relative humidity information for the particle counter location.

6.1.5 'Measure the stack centerline air velocity in the sampling plane using a velocity flow meter, and record value on data sheet.

 $9|_{6}|_{0}$ 6.1.6 Mark the sampling probe with a permanent marker so the inlet can be relevant. inlet can be placed at each successive measurement point.

> Note: Sampling plane traverse points. Use the grid of measurement points provided with the test's instruction and dataform. This is usually the same as used for the velocity uniformity test. A center point is included as a common reference and for graphical purposes. The layout design divides the area of the sampling plane so that each point represents approximately an equal-sized area

6.1.7 Couple the OPCs and probes to the stack sampling ports according to the illustration in Exhibit A.

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Note: The sampling equipment consists of stainless steel probes with ³/₄ outside diameter and thinwall tubing with sufficient length to reach across the inside diameter of the stack while allowing for fittings. The sampling probe should have gradual 90° bends to minimize the inertial impact of particles with inner walls at bends, and the open end of the tube should face downward or into the flow in the stack. The outlet end of the probe should terminate at the OPC inlet. Minimize tubing length to minimize particle losses.

The sampling probes for both OPCs should be similar and of a simple design. The elevation of the intake nozzle of the traversing unit should be approximately in the same as the sampling plane. The intake nozzle for the reference unit may be located anywhere within the stack at an elevation near that of the sampling plane; however, the two probes should not interfere with each other, either physically or by causing flow disturbances for each other. The intake nozzles may be of sub-isokinetic or of shrouded design to optimize the collection of 10-micron particles.

The aerodynamic characteristics of the probes for both OPCs should be the same so that they have similar line-loss (penetration) values. For optimal particle collection, the probes should be of a fixed and rigid configuration. The mobile OPC with its attached probe should be mounted together on a sliding platform to move as a unit along the axis of the sampling port.

6.1.8 Turn-on the mobile and reference- WYB optical particle counters.

MyB 9/16/04

Note: Ensure that internal air circulation fans in the OPCs are on and that the sample probes are tightly connected to and are directly above or apart from the OPC sample inlet openings. Also ensure that the sliding platform supporting the mobile sampler is aligned for easy, free movement at the correct height for its stack port.

6.1.9 'Program and synchronize the OPCs for

-MYB 9/16/04

- 60-second samples
- 9- to 11-micron particle counting
- the current time
- cumulative counting mode.

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6.2 **Daily Particulate Background Concentration Measurement**

6.2.1 < At the beginning of each sampling day before starting the

aerosol generator, obtain at least six consecutive

background readings for both mobile and reference OPCs.

6.2.2 MyB 1/16/04 6.2.2 Record these readings on the data sheet and in the logbook $\frac{9/5}{0}$ designated for the tests.

Start and run the aerosol generator for approximately 30 minutes to stabilize its output.

mup 9/16/04

6.2.3

6.3 **Particle Injection and Sample Collection**

The injection equipment includes an air regulator, a precision air pressure gauge, and other components described in Section 5. The ³/₄-inch (OD) (or larger) injection probe with a 90E bend (with an approximately 3-inch radius of turn) will inject aerosol particles in the direction of emission flow. The connections and fittings should be checked to ensure that they are secure and leak free.

> Note: Location of the Injection Point Injection plane -- The tests are repeated using the centerpoint as the aerosol release point.

Position the injection probe, according to the test 6.3.1 instruction.

myB 9/16/04 6.3.2 myB 9/16/04

Start injection of the aerosol and adjust the flowrate to the input capabilities of the OPCs.

> Note: Aerosol injection is not precisely controlled. At air pressure readings above about 10 psi for the specific PNNL generator used, a dense oil mist is created in the generator and is available for injection. However, if the back-pressure, caused by a high rate of airflow past the port in the stack, at the injection port is high, carrier air may be required to inject the aerosol into the base of the stack. Under these conditions, the overall aerosol output will be low (less than perhaps 200 particles measured at the counter).

> In contrast, if there is little back-pressure, most of the generated aerosol, minus that lost from interactions with internal generator system and line walls, becomes available for injection. Here the output will be high (hundreds to thousands of particles injected per minute).

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Note: The OPC draws air from the stack, via the sample probe, at a fixed rate (one cubic foot per minute). Within the OPC, the air stream with particles passes through a laser beam where the particles are counted and placed in six size categories. In the less than 0.5-micron category, several hundred thousand differential counts are typical; but in the 9- to 11-micron category, oil mists greater than about 3,000 cpm cause a sensor overload condition. Thus, at the OPC, the flow rate is fixed, and a ceiling exists on the measurement of particles. Essentially, there is no adjustment of particle counting capability at the OPC, and the aerosol generator becomes the controlling factor for particulate output.

6.3.3 Record the initial

- injection system dispersion pressure in psi
- flowrate for the mobile and reference OPC MYB
- centerline flow velocity for the test stack.

6.3.4 On the data sheet, label the columns of data according to the directions of the traverses.

Verify that the directional orientations and the numbered sample positions are consistent.

Position the OPC and sample probe at each measurement point in succession, and record the reading on the data form.

Note: In each test, the measurement at each point is the average of three readings. The repeats are made as three separate runs and not as three consecutive measurements at each point.

49/16/04

6.3.5 m 43 g/16/04

myB /16/04

6.3.6 my 13 g/16/04

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Perform two additional repetitions of Step 6.3.6.

Switch the tests to the other direction and repeat steps 6.3.6 and 6.3.7.

6.3.9

Check the data sheet for completeness.

6.3.10 Record the final

- injection system dispersion pressure in psi
- flowrate for the mobile and reference OPC MYB

 4^{4} 6.3.11 Shut off the air pressure to the aerosol generator.

4/14/04 9/16/04

6.3.12 Continue operation of the OPCs for several minutes to purge any remaining test aerosol from the stack

my B /11/04

6.3.13 Measure the centerline background particulate

concentrations at the mobile monitor and record the levels on the data sheet.

19/16/04

6.3.14 Record any climatic conditions that have changed on the data sheet.

114B 9/16/04

6.3.15 Measure the final centerline stack velocity flow on the data sheet.

myB 9/16/04

6.3.16 Record any deviations from the above procedure on the data sheet.

9/17/14

6.3.17 Repeat steps 6.3.1 to 6.3.16 for each run as indicated in the test instruction.

Data Recording and Calculations 6.4

Prepare the electronic data sheet on which to enter particle-count readings and other information relevant to the test (see test instruction).

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- $\psi_{q|1}^{\mu}$ 6.4.1 $\psi_{q|1}^{\mu}$ 6.4.2 Review the raw data sheets for completeness.
 - Enter the data into the electronic data sheet.

Calculate the COV for the run.

Note: The EXCEL datasheet shown as Attachment C is set up to calculate the COV for each particulate concentration traverse using the average concentration data from all points in the inner two-thirds of the cross section area of the plane (including the center point).

6.4.4

Compare the observed COV for each run to the acceptance criterion.

> Note: The test is acceptable if the COV is #20% for the inner two-thirds of the stack diameter, and if no point differs from the mean by more than 30%. This is determined by inspecting the average concentration at each measurement point. The COV is 100 times the standard deviation divided by the mean.

6.4.5

Sign and date the data sheet illustrated in Attachment C attesting to its validity.

Note: A separate datasheet will be provided and signed-off for each test.

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Exhibits/Attachments

Exhibit A - Overview of Stack and Injection Setup and Particle Counters



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Exhibit B - Illustrative Data Collection Sheet

			INVOLUCIA ONO IN				
	Site			Run No.	PT-		_
	Date			Injection point			
	Tester			Fan Setting		Hz	
	Stack Dia.	28	in.	Stack Temp		F	
S	Stack X-Area	615.8	in.	Center 2/3 from	2.57	to:	25.43
	Elevation			Pts in Center 2/3	3	to:	10
Dirsta	nce to disturba	nce	in	Data Files:			
	Conc. units	Particles per mi	nute	Oil type			
	Travaraa	Sompling	Acrossing				
	1 averse	Samping	Aerosol notes:		Start	Finish	
		4	Decord Stock flow	Г	Start	rinish	alm
	2	9	Ambient Temp	-			
	3	12	Ambient remp	-			F
	4	2	Dispersion air	ŀ			psi
	5	10		-			psi
	6	13	Ambient pressure	ŀ			mbars
		1	Ambient numidity				RH
		3	Stack centerline ve				tpm
	8	/	Back-Gd level (OP	C-M)			cpm
	9	8	Back-Gd level (OP	C-F)			cpm
	10	5	No. Bk-Gd sample	s			n
	11	11	OPC-M flowrate	-			fpm
	12	6	OPC-F flowrate				fpm
	Traverse	A 1 A 100	N>S			E>W	
	Order	F/M	F/M	F/M	F/M	F/M	F/M
			and the second se		a state of the second se	1	
	C I	Contraction and Contraction and Contraction and Contraction and Contraction and Contraction and Contractional Contra			AND ADDRESS OF ADDRESS ADDRES		
	С						
	C 4						
	C 4 7						
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	C						
	C 4 7 1 10						
	C 4 7 1 10						
	C 4 7 1 10 12						
	C 4 7 1 10 12 8						
	C 4 7 1 10 12 8 9						
	C 4 7 1 10 12 8 9						
	C 4 7 1 10 12 8 9 2						
	C 4 7 1 10 12 8 9 2 5						
	C 4 7 1 10 12 8 9 2 5 5						
	C 4 7 1 10 12 8 9 2 5 11						
	C 4 7 10 12 8 9 2 5 11 3						
	C 4 7 10 12 8 9 2 5 11 3 6						
Solo	C 4 7 10 12 8 9 2 5 11 3 6 Instuments mat Zephyr	s Used: #12951472 (stac	k center velocity)				Cal Exp. Date:
Solo	C 4 7 1 10 12 8 9 2 5 11 3 6 Instuments mat Zephyr 2- A (M/F:	s Used: #12951472 (stac)	k center velocity)				Cal Exp. Date:
Solo OPC OPC	C 4 7 1 10 12 8 9 2 5 11 3 6 Instuments mat Zephyr C- A (M/F: C- B (M/F:	s Used: #12951472 (stac)	k center velocity)				Cal Exp. Date:

Signature/Date:

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Exhibit C - Illus trative Data Reporting Form

PARTICULATE TRAVERSE DATA REPORT FORM



Average of all data		Center 2/3	E/W	S/N	All
Maximum Positive Deviation	Max Point	Mean			
Maximum Negative Deviation	Min Point	Std. Dev.			
		COV %			

Record stack flow Ambient temp Dispersion air Carrier air Ambient pressure Ambient humidity Stack centerline vel. Bk-Gd level (OPC-M) Bk-Gd level (OPC-F) No. Bk-Gd samples OPC-M flowrate OPC-F flowrate

Instuments Used: Solomat Zephyr #12951472 B & K Model 1302 #1765299 Sierra Inc. Constant Flow Air Sampler

Signing/dating signifies compliance with Sec. 6.1.1-6.4.5 in the PNNL Procedure No. EMS-JAG-02 (11/10/98).

Signature/Date:

Gas analyzer checked Notes:



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Attachment A - Illustrative Test Instructions

PNNL Operating Procedure	Rev. No. 1	Page 15 of 15			
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Title: Test to Determine Uniformity of a Tracer Aerosol at a Sampler Probe

Test Instruction										
Project: Canister Storage Date: November 10, 1998 Work Package: K97052										
Stack Qualification, 29303										
Tests: Tracer Gas Uniformity of Full-Scale Stack										
Staff: David Maughan, John Glissmeyer										
Reference Procedures:										
1. Procedure EMS-JAG-02, R	1. Procedure EMS-JAG-02, Rev. 0, Test to Determine Uniformity of a Particulate Aerosol at a									
Sampler, Nov. 10, 1998										
2. Operating Manual for Met-	One Optical Particle Counter (O	PC), Model A2408								
Equipment:										
1. Canister Storage Stack and	inspected work platforms									
2. Vacuum pump oil, oil mist	generator, air lines, regulator, pr	ecision pressure gauge								
3. Oil mist injection probe, Ol	PC sample probes, probe/stack co	ouplers								
4. OPCs with computers and 1										
Safety Considerations:										
Beview and observe the app	plicable Duke Job Hazard Analy	sis for the project								
Instructions:	<u></u>	F								
1. Verify training on the procedure and that instrumentation is within calibration										
2. Obtain Fisherbrand 19 Mechanical Pump Fluid										
3. Obtain climatic information from the Hanford Weather Service, phone 373-2716 or										
http://etd.pnl.gov:2080/HMS/lastob.htm										
4. Install equipment as directed in the procedures										
5. Mark sampling probe for the measurement points shown on the data sheet										
6. Verify that stack flow is about the target flowrate 9000 (2232 fpm)										
7. Initially set the injection system input psi at 5 and vary to obtain particle counts at the sampling										
ports that are about 10 time	es background for 10-micron part	icles.								
8. Set the sampler howrate at	mixing tests at the following set	ts of conditions:								
Stack Flow	Injection point at duct	from fan to stack								
Normal	Center	line								
(The injection plane should	(The injection plane should be at the fittings provided in the rectangular discharge of the fan)									
10. Record data on copies of the attached the data sheet										
11. Repeat the test										
12. Diagram mounting fixtures and retain assembly for any subsequent re-tests										
Desired Completion Date: 11/30/98										
Approvals:										
John Glissmeyer, I	John Glissmeyer, Project Manager Date									
Test completed by:		Date:								

Appendix G

Calculations for Scale Model Criteria

Calculations for Scale Model Criteria

Reynolds Number Calculations

Re = rho * V * D/ u

Where Re = Reynolds Number

D = hydraulic diameter = diameter for cylinders

rho = air density = 1.1769 kg/m3

u = air viscosity = 1.85E-05 Pa s

Density and viscosity of air at 300K from Fundamentals of Momentum, Heat, and Mass Transfer, Welty, Wicks, and Wilson 1976

V = velocity = Q/A in m/s

Q =stack flow rate m3/s

A = stack area = πr^2 in m

Configuration	ration Stack Flow Stack Flow Diameter Hydraulic		Hydraulic	Area	V	V	Re		
	cfm	m3/s	in	Diameter	Diameter	m2	ft/min	m/s	
				ft	m				
High Flow (Actual)	145,400	68.34	96	8.00	2.44	4.667	2894	14.6	2,275,629
Low Flow (Actual)	133,000	62.51	96	8.00	2.44	4.667	2647	13.4	2,081,559
High - 1 fan (Proposed)	48,467	22.78	96	8.00	2.44	4.667	965	4.9	758,543
Low - 1 fan (Proposed)	44,333	20.84	96	8.00	2.44	4.667	882	4.5	693,853
Scale Model - 3 fan	5,823	2.74	18	1.50	0.46	0.164	3297	16.7	486,052
Scale Model - 3 fan	4,391	2.06	18	1.50	0.46	0.164	2486	12.6	366,521
Scale Model - 1 fan	1,370	0.64	18	1.50	0.46	0.164	776	3.9	114,355
Scale Model - 1 fan	1,413	0.66	18	1.50	0.46	0.164	800	4.0	117,945
Scale Model - 1 fan	1,100	0.52	18	1.50	0.46	0.164	623	3.2	91,818

Flow range using scale model:

Test	Hz	Average	hydraulic	Velocity x diam	Six Times	One-Sixth	stack diam	Stack Vel fpm		Stack flow cfr	
		Velocity, fpm	diameter, ft	ft2/min			ft	High	Low	High	Low
VT-LOW1	30	622	1.5	933	5598	155.5	8	699.8	19.4	35155	977
VT-1	37.1	786	1.5	1179	7074	196.5	8	884.3	24.6	44425	1234
VT-3	37.1	804	1.5	1206	7236	201	8	904.5	25.1	45442	1262
VT-2	37.1	755	1.5	1132.5	6795	188.75	8	849.4	23.6	42673	1185
VT-4	37.1	756	1.5	1134	6804	189	8	850.5	23.6	42729	1187
						area (ft2)=	50.24				

Appendix H

Computational Fluid Dynamics Model Details
Computational Fluid Dynamics Model Details



Figure H.1. Detail of flow vectors entering the main duct via fans #1 and #2 (for configuration of fans 1 & 2 farthest from the stack operational).



Figure H.2. Detail of flow vectors in the 90° bend in the horizontal duct (for configuration of fans 1 & 2 farthest from the stack operational).

Results: Operation of Fans 1 and 2



Figure H.3. Simulated flow velocity vectors and tracer gas concentrations for the case with fans 1 and 2 in operation: a) flow velocity in fans and lower ductwork, b) flow velocity in stack, c) velocity distribution in the stack at the elevation of the sampling system, d) tracer gas concentrations in the lower ductwork; tracer gas injected downstream of the fan nearest the stack, e) tracer gas concentrations in the stack, f) tracer gas distribution in the stack at the elevation of the sampling system.



SF6 Concentration with 2-Fan Configuration 1, 2

Figure H.4. Simulated results for the 2-fan configuration 1,2: Concentrations of a) SF6 tracer gas, and b) oil droplets at the elevation of the sampling system.



Figure H.5. Simulated results for the 2-fan configuration 1, 2: Flow velocity distribution at the elevation of the sampling system.



Flow Angle with 2-Fan Configuration 1, 2

Figure H.6. Simulated results for the 2-fan configuration 1, 2: Cyclonic flow angle at the elevation of the sampling system.

Results: Operation of Fans 1 and 3



Figure H.7. Simulated flow velocity vectors and tracer gas concentrations for the case with fans 1 and 3 in operation: a) flow velocity in fans and lower ductwork, b) flow velocity in stack, c) velocity distribution in the stack at the elevation of the sampling system, d) tracer gas concentrations in the lower ductwork; tracer gas injected downstream of the fan nearest the stack, e) tracer gas concentrations in the stack, f) tracer gas distribution in the stack at the elevation of the sampling system.



Figure H.8. Simulated results for the 2-fan configuration 1, 3: Concentrations of a) SF6 tracer gas, and b) oil droplets at the elevation of the sampling system.



Figure H.9. Simulated results for the 2-fan configuration 1, 3: Flow velocity distribution at the elevation of the sampling system.



Flow Angle with 2-Fan Configuration 1, 3

Figure H.10. Simulated results for the 2-fan configuration 1, 3: Cyclonic flow angle at the elevation of the sampling system.

Results: Operation of Fans 1 and 4



Figure H.11. Simulated flow velocity vectors and tracer gas concentrations for the case with fans 1 and 4 in operation: a) flow velocity in fans and lower ductwork, b) flow velocity in stack, c) velocity distribution in the stack at the elevation of the sampling system, d) tracer gas concentrations in the lower ductwork; tracer gas injected downstream of the fan nearest the stack, e) tracer gas concentrations in the stack, f) tracer gas distribution in the stack at the elevation of the sampling system.



Figure H.12. Simulated results for the 2-fan configuration 1, 4: Concentrations of a) SF6 tracer gas, and b) oil droplets at the elevation of the sampling system.



Figure H.13. Simulated results for the 2-fan configuration 1, 4: Flow velocity distribution at the elevation of the sampling system.



Flow Angle with 2-Fan Configuration 1, 4

Figure H.14. Simulated results for the 2-fan configuration 1, 4: Cyclonic flow angle at the elevation of the sampling system.

Results: Operation of Fans 2 and 3



Figure H.15. Simulated flow velocity vectors and tracer gas concentrations for the case with fans 2 and 3 in operation: a) flow velocity in fans and lower ductwork, b) flow velocity in stack, c) velocity distribution in the stack at the elevation of the sampling system, d) tracer gas concentrations in the lower ductwork; tracer gas injected downstream of the fan nearest the stack, e) tracer gas concentrations in the stack, f) tracer gas distribution in the stack at the elevation of the sampling system.



SF6 Concentration with 2-Fan Configuration 2, 3

Figure H.16. Simulated results for the 2-fan configuration 2, 3: Concentrations of a) SF6 tracer gas, and b) oil droplets at the elevation of the sampling system.



Figure H.17. Simulated results for the 2-fan configuration 2, 3: Flow velocity distribution at the elevation of the sampling system.



Flow Angle with 2-Fan Configuration 2, 3

Figure H.18. Simulated results for the 2-fan configuration 2, 3: Cyclonic flow angle at the elevation of the sampling system.

Results: Operation of Fans 2 and 4



Figure H.19. Simulated flow velocity vectors and tracer gas concentrations for the case with fans 2 and 4 in operation: a) flow velocity in fans and lower ductwork, b) flow velocity in stack, c) velocity distribution in the stack at the elevation of the sampling system, d) tracer gas concentrations in the lower ductwork; tracer gas injected downstream of the fan nearest the stack, e) tracer gas concentrations in the stack, f) tracer gas distribution in the stack at the elevation of the sampling system.



SF6 Concentration with 2-Fan Configuration 2, 4

Figure H.20. Simulated results for the 2-fan configuration 2, 4: Concentrations of a) SF6 tracer gas, and b) oil droplets at the elevation of the sampling system.



Figure H.21. Simulated results for the 2-fan configuration 2, 4: Flow velocity distribution at the elevation of the sampling system.



Flow Angle with 2-Fan Configuration 2, 4

Figure H.22. Simulated results for the 2-fan configuration 2, 4: Cyclonic flow angle at the elevation of the sampling system.

Results: Operation of Fans 3 and 4



Figure H.23. Simulated flow velocity vectors and tracer gas concentrations for the case with fans 3 and 4 in operation: a) flow velocity in fans and lower ductwork, b) flow velocity in stack, c) velocity distribution in the stack at the elevation of the sampling system, d) tracer gas concentrations in the lower ductwork; tracer gas injected downstream of the fan nearest the stack, e) tracer gas concentrations in the stack, f) tracer gas distribution in the stack at the elevation of the sampling system.



SF6 Concentration with 2-Fan Configuration 3, 4

Figure H.24. Simulated results for the 2-fan configuration 3, 4: Concentrations of a) SF6 tracer gas, and b) oil droplets at the elevation of the sampling system.



Figure H.25. Simulated results for the 2-fan configuration 3, 4: Flow velocity distribution at the elevation of the sampling system.



Flow Angle with 2-Fan Configuration 3, 4

Figure H.26. Simulated results for the 2-fan configuration 3, 4: Cyclonic flow angle at the elevation of the sampling system.

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