PNNL-13687

Pacific Northwest National Laboratory
Operated by Battelle for the U.S. Department of Energy

Qualification Tests for the Air Sampling System at the 296-Z-7 Stack

J. A. Glissmeyer
A. D. Maughan

October 2001

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RL01830

PACIFIC NORTHWEST NATIONAL LABORATORY
operated by
BATTELLE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC06-76RL01830

Printed in the United States of America

Available to DOE and DOE contractors from the
Office of Scientific and Technical Information,
P.O. Box 62, Oak Ridge, TN 37831-0062;
ph: (865) 576-8401
fax: (865) 576-5728
email: reports@adonis.osti.gov

Available to the public from the National Technical Information Service,
U.S. Department of Commerce, 5285 Port Royal Rd., Springfield, VA 22161
ph: (800) 553-6847
fax: (703) 605-6900
email: orders@ntis.fedworld.gov
online ordering: http://www.ntis.gov/ordering.htm

This document was printed on recycled paper.

(8/00)

PNNL-13687

Qualification Tests for the Air Sampling System at the 296-Z-7 Stack

J. A. Glissmeyer
A. D. Maughan

October 2001

Prepared for
the U.S. Department of Energy
under Contract DE-AC06-76RL01830

Pacific Northwest National Laboratory
Richland, Washington 99352

Summary

This report documents tests performed by Pacific Northwest National Laboratory to verify that the air monitoring system for the 296-Z-7 ventilation exhaust stack meets the applicable regulatory criteria regarding the placement of the air sampling probe, sample transport, and stack flow measurement accuracy. These criteria ensure that the contaminants in the stack are well mixed with the airflow at the location of the probe so that the collected sample represents the whole. The sequence of tests addresses the

- acceptability of the flow angle relative to the probe
- uniformity of air velocity and gaseous and particle tracers in the cross section of the stack
- delivery of the sample from the sampler nozzle to the collection filter.

The tests conducted on the air monitoring system demonstrated that the location for the air-sampling probe meets all performance criteria for air sampling systems at nuclear facilities. The performance criterion for particle transport was also met. All tests were successful, and all acceptance criteria were met.

The 296-Z-7 stack vents the process area and gloveboxes constructed in the Plutonium Stabilization and Handling (W-460) Project. The process area is housed in the 2736-ZB Building, adjacent to the Plutonium Finishing Plant in the 200 West Area of the Hanford Site.

Acknowledgments

This work was supported by the U.S. Department of Energy under Contract DE-AC06-76RL01830, with project funding from the Plutonium Stabilization and Handling Project (W-460) managed by Fluor Hanford, Inc. The authors wish to acknowledge the technical assistance of Johnny D. Dick and craft services of the Plutonium Finishing Plant, Fluor Hanford, Inc. for invaluable technical assistance.

Contents

Figures

Tables

1.0 Introduction

The Project W460 Plutonium Stabilization and Handling (296-Z-7) Stack is located adjacent to the 2736-ZB Building in the 200 West Area at the U.S. Department of Energy's (DOE) Hanford Site. The W460 Project is modifying the 2736-ZB Building to package stabilized special nuclear material into the weld (nested pair) stainless steel containers specified by the latest DOE standard. The equipment consists of areas to receive, sort, and repackage incoming materials contained in various existing container configurations, supplemental stabilization capacity (furnaces) to drive off unwanted moisture, quality control stations and placing repackaged, stabilized and quality checked material into a welded stainless steel inner container. All the forgoing equipment modules are contained within gloveboxes and reside inside room 642 of building 2736-ZB.

Emissions resulting from stabilization and packaging activities/work preformed within the gloveboxes and room 642 will be exhausted through the new stack (296-Z-7) after passing through two stages of high-efficiency particulate air (HEPA) filtration with a minimum efficiency of 99.95 percent for particles with a medium diameter of 0.3 micron. The stack/emission sampling will consist of a continuous record air sampler for particulate radionuclides, a flow monitor, and a continuous alpha monitor device with alarm functions.

This report documents tests that were conducted to verify that the air monitoring system at the 296-Z-7 ventilation exhaust stack meets the applicable regulatory criteria regarding the placement of the air-sampling probe, the transport of the sample to the collection device, and the accuracy of the stack flow measurement system. The performance criteria, test methods, results, and conclusions are discussed. The detailed test procedures and data sheets are included in the appendices. These tests were conducted by Pacific Northwest National Laboratory[1] staff.

Process offgas emission monitoring for radionuclides in DOE facilities is required under federal and state law. A notice of construction (NOC [DOE 2000]) was submitted to the Washington State Department of Health describing the process, the offgas treatment system, and the offgas radionuclide monitoring system. The NOC also describes the standards to which the offgas treatment and monitoring must adhere. The tests documented in this report are required to demonstrate the efficacy of the air monitoring system and demonstrate compliance with the standards given in the NOC.

1.1 Background

On December 15, 1989, 40 CFR 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities," came into effect. This regulation governs portions of the design and implementation of facility effluent air sampling. Further, 40 CFR 61, Subpart H requires the use of isokinetic sampling nozzles as described in American National Standards Institute (ANSI) N13.1-1969 (ANSI 1982). This standard has been replaced by ANSI/HPS

[1] Pacific Northwest National Laboratory is operated by Battelle for the U.S. Department of Energy.

N13.1-1999 (ANSI 1999), "Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stacks and Ducts of Nuclear Facilities," though this version has yet to be formally incorporated into the U.S. Environmental Protection Agency (EPA) regulation (40 CFR 61, Subpart H). In the interim, EPA has accepted the key features of the updated standard as an accepted alternative to the older version (Nichols[2]).

1.2 Performance Criteria

The ANSI/HPS N13.1-1999 performance criteria for sampling nozzle placement and particle transport are described as follows:

1. Angular Flow – 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 stack and sampling nozzle by more than 20°.

2. Uniform Air Velocity – 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 criterion is that the COV of the air velocity must be ≤20% across the center two-thirds of the area of the stack.

3. Uniform Concentration of Tracer Gases – 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. The fan is a good mixer, so injecting the tracer downstream of the fan provides worst-case results[3]. 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. Uniform Concentration of Tracer Particles – 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 criterion is that the COV of particle concentration is ≤20% across the center two-thirds of the sampling plane.

[2] Letter from M. D. Nichols (EPA, Assistant Administrator for Air Radiation) to R. F. Pelletier (DOE). 1994, Washington, D.C.

[3] Worst-case results are those that might be observed if the fan itself became contaminated and later released contaminants.

5. Sample Extraction and Transport System Performance – The criteria are that 1) nozzle transmission ratio for a 10-ìm AD particle is 0.8 to 1.3, 2) nozzle aspiration ratio for a 10-ìm AD particle is 0.8 to 1.5, and 3) the test particle penetration through transport system is ≥50% for 10-ìm AD particles.

1.3 Ventilation Exhaust Stack Description

The 296-Z-7 stack emissions are from the process glovebox offgas and the general ventilation air from room 642 of the 2736-ZB Building. The total exhaust air flow should normally be about 1550-1800 cfm. All exhaust air is filtered through two-stage, high-efficiency particulate air (HEPA) filters prior to discharge. The ventilation flow is powered by one of two fans located next to the 296-Z-7 stack.

The stack has an internal diameter of 15.25 inches and is about 50 feet tall. Figure 1.1 diagrams the stack, the duct leading to the stack, the location of the air monitoring probe, and the location of the test ports. The approximate number of stack diameters from the top of the stack breach to the sampling nozzle and the test ports is 12.4.

Figure 1.2 shows the interior of the air monitoring probe cabinet. Shown are the sample lines, record sample filter holder, the alpha continuous air monitor.

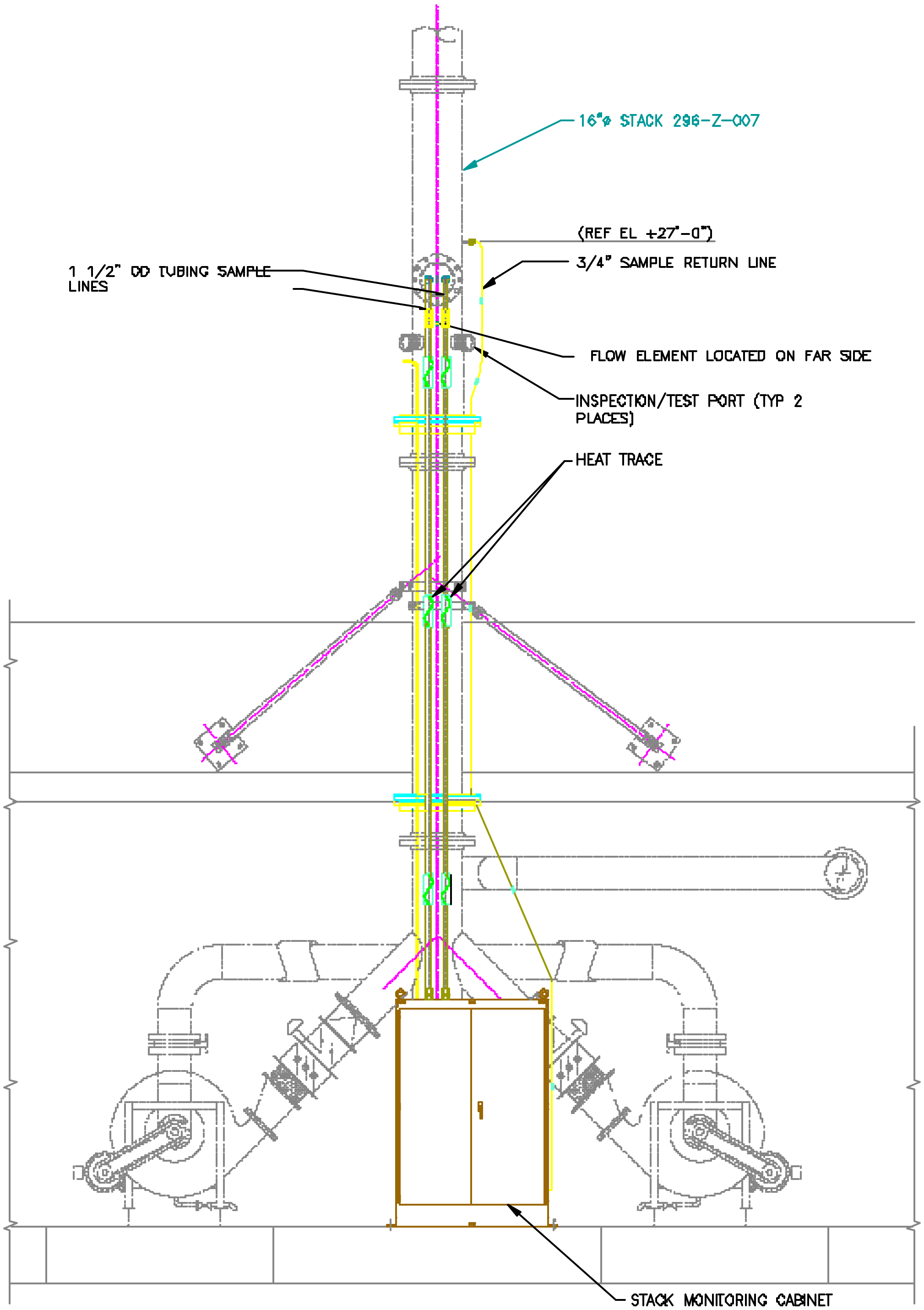


Figure 1.1. 296-Z-7 Ventilation Exhaust Stack

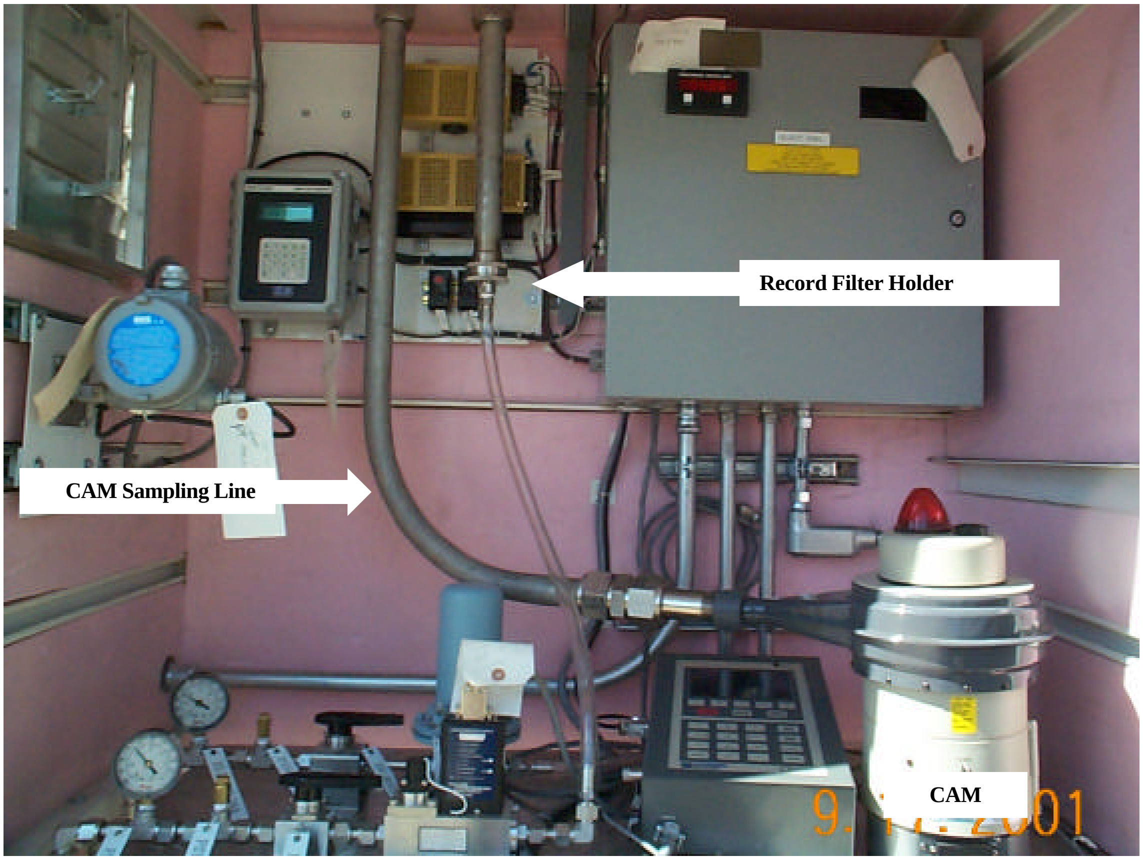


Figure 1.2. Interior of the Air Monitoring Cabinet

2.0 Qualification Tests

The qualification test methods and results are described in this chapter. Tests were conducted to determine compliance with performance criteria covering angular flow, air-velocity uniformity, gaseous-tracer uniformity, and particle-tracer uniformity. Particle penetration through the sampler piping was estimated using a model. A test of stack flow element accuracy will be conducted at a later time.

Measurements were made at the test ports shown in Figure 1.1 and at flowrates representing the expected emergency and normal stack flowrates of about 300 and 1550-1800 acfm. A temporary scaffold (Figure 2.1) was constructed to facilitate access to the test ports. All tests were performed with the South fan operating. Because of symmetry, the qualification results would be the same if the North fan were used instead.

Figure 2.1. Temporary Scaffold

2.1 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.

2.1.1 Method

The method to determine velocity uniformity is an adaptation of 40 CFR 60, Appendix A, Methods 1 and 2. The equipment included a standard Prandtl-type pitot tube and a calibrated electronic manometer as shown in Figure 2.2. The procedure is detailed in Appendix B. The grid of measurement points was

Figure 2.2. Equipment to Determine Velocity – Standard Pitot Tube, Level, and Electronic Manometer

laid out in accordance with the 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 north-east/south-west direction and also along the south-east/north-west direction.

To facilitate the performance of this and subsequent tests, it was first necessary to correlate fan speed control (a variable frequency drive) settings and the desired stack flowrates. Following the procedure in Appendix A, the first velocity uniformity measurement (Run VT-1) was made at the maximum setpoint 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 control setting. The results are plotted in Appendix A. Setpoints for the desired flowrates were estimated from the plot and used in the test runs (Runs VT-2 to VT-4) to measure velocity uniformity. Run VT-1 also provides a data point for velocity uniformity.

2.1.2 Results

The measured COV across the center two-thirds of the area of the stack are listed in Table 2.1 and meets the criterion that the air velocity COV be ≤20%. Figure 2.3 shows a bar graph of the mean velocity measured at each point for 278 acfm, which had the worst case uniformity (COV) result.

Table 2.1 Velocity Uniformity Results

278 acfm	9% COV
537 acfm	8% COV
1733 acfm	5% COV
2230 acfm	6% COV
COV = coefficient of variance.	

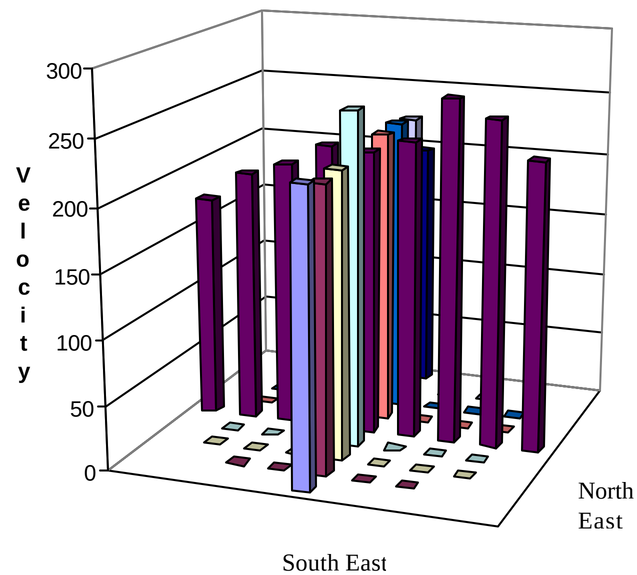


Figure 2.3. Velocity Uniformity at 278 acfm (COV 9%)

2.2 Angular Flow

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. Cyclonic flow must be absent so the contaminant concentration is nearly uniform across the stack.

2.2.1 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 normal flowrate in the 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 as shown in Figure 2.4. 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 C provides the detailed procedure.

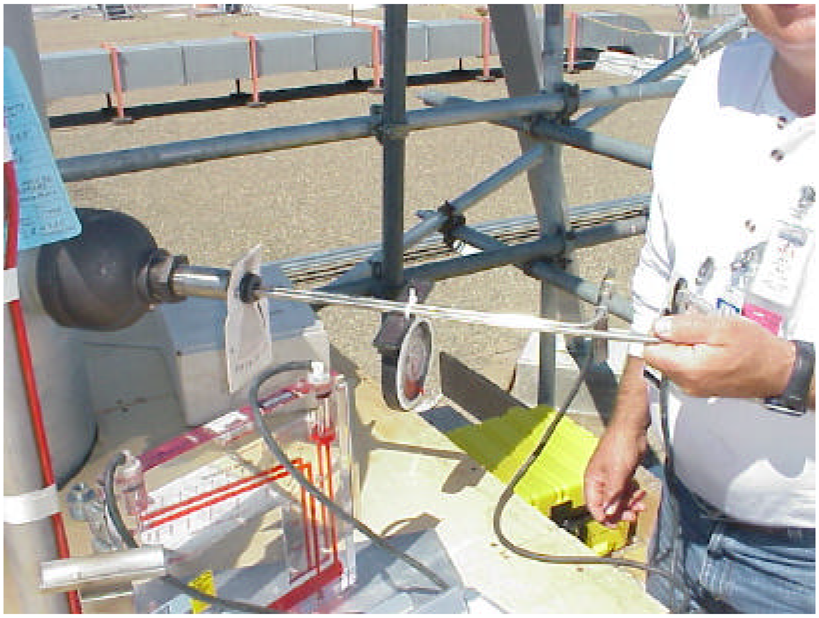


Figure 2.4. Equipment to Measure Flow Angle

2.2.2 Results

The resulting average flow angle was 8.8º at 278 acfm and 12.6º at 1733 acfm, meeting the <20° flow-angle acceptance criterion. The maximum values measured at any point were 31º near the south-east side of the stack at the higher flow, and 17º near the south-west side of the stack at the lower flow. Appendix A includes the data sheets, and plots of the results.

2.3 Uniformity of Tracer Gases

A uniform contaminant concentration at the sampling plane enables the extraction of samples that represent the true concentration. This was first tested using a tracer gas as described in Section 2.3.1.

2.3.1 Method

The concentration uniformity is first demonstrated with a tracer gas injected into the exhaust duct, downstream of the fan, between the dampers and the stack as shown if Figure 2.5. The concentration of the tracer gas is then measured near the sampling probe 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.

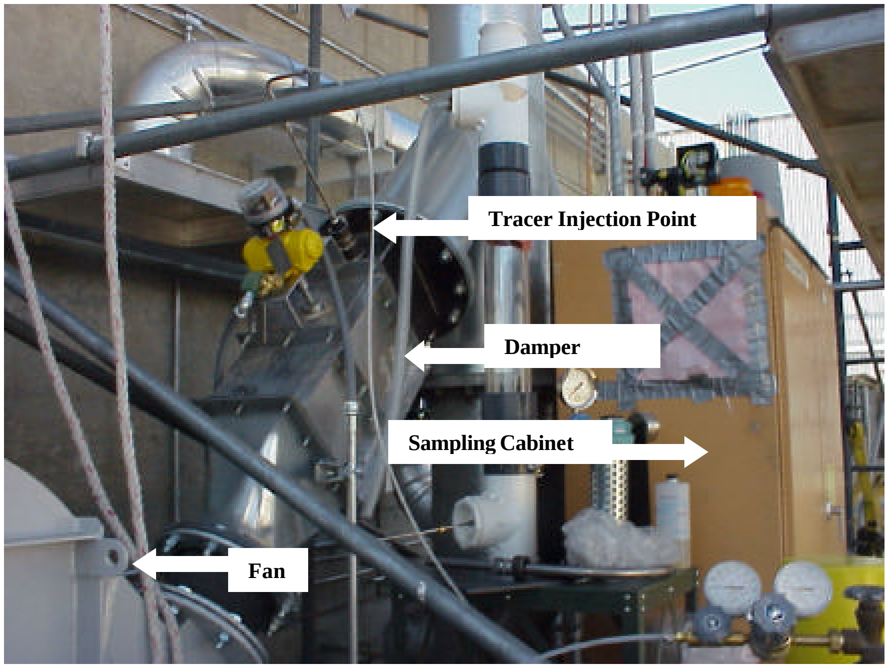


Figure 2.5. Tracer Gas Injection Location

In five successive tests at 1733 acfm, the sulfur hexafluoride[4] tracer was injected along the centerline of the duct and within 2.4 inches (approximately 25% of a hydraulic diameter) of each corner of the duct. The test with the top-east corner injection position was repeated because that appeared to have the worst case result. Finally, another test using this injection point was conducted at the lower, 278 acfm, flowrate to determine if there was a significant flowrate effect.

The gas samples are withdrawn from the stack through a simple probe and a gas analyzer shown in Figure 2.6. A Bruel and Kjaer (Naerum, Denmark) Model 1302 gas analyzer, calibrated for the tracer gas, is used for the measurements. The procedure is detailed in Appendix D.

2.3.2 Results

Table 2.2 summarizes the results of the individual test runs. The detailed data sheets are included in Appendix D. The acceptance criteria are that 1) the COV of the tracer gas concentration be ≤20% across the center two-thirds of the sampling plane and 2) at none of the measurement points does the average concentration differ from the mean concentration by >30%. The COV results ranged from 0.4% to 2.8% for the center two-thirds of the stack, and the largest deviation of any single-point concentration from the mean concentration in any one run ranged from 0.9 to 3.5%. The acceptance criteria were met in all cases and the tracer was well mixed with the airflow. The test at 278 acfm shows that there is no flowrate effect at the low-flow condition. Figure 2.7 is a plot of the worst case results.

[4] A tracer used for many purposes including building ventilation studies, tracing piping, and wind flow field measurements.

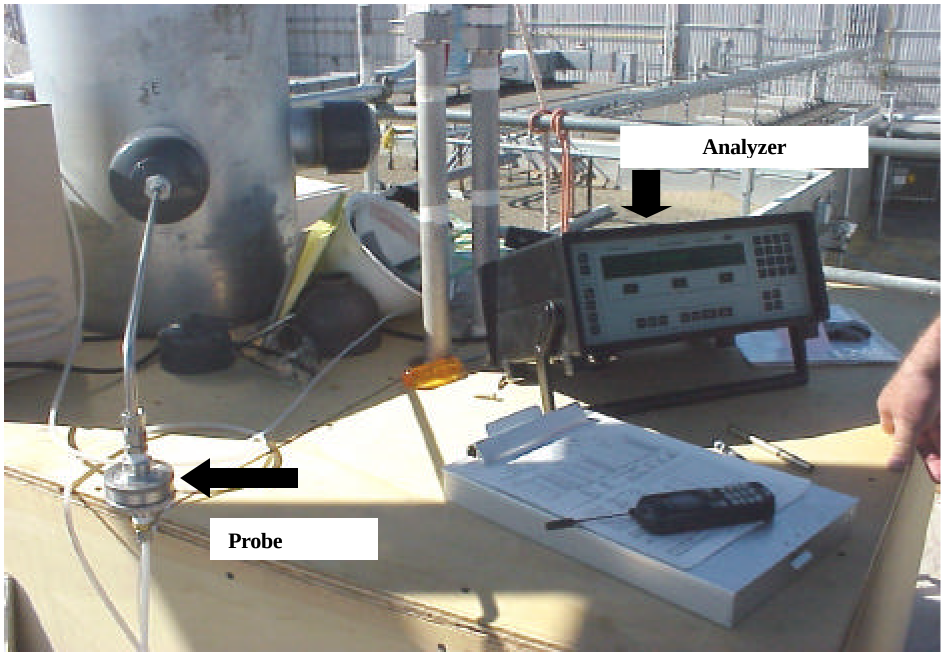


Figure 2.6. Tracer Gas Probe and Analyzer

2.4 Uniformity of Tracer Particles

The second demonstration of uniform contaminant concentration is made using tracer particles.

2.4.1 Method

The test method for uniformity of tracer particles is similar to the test for uniformity 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. The particles were made by spraying vacuum-pump oil through a nozzle mounted inside a chamber. Particles were then injected into the duct in a stream of compressed air as shown in Figure 2.8.

A simple probe was used to extract the sample from the stack and transport it to the optical particle counter[5] arranged as shown in Figure 2.9. The OPC sorts the number of particles into six size channels. Each concentration reading was the count of particles collected in one minute in the 9 to 11 ìm channel. 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 particle mixing is acceptable if the COV of the tracer particles of 10-ìm AD is less than 20% across the center two-thirds of the sampling plane. The detailed procedure is included in Appendix E.

[5] Optical Particle Counter (OPC), Met-One Model A2408, Grants Pass, Oregon.

Table 2.2. Tracer Gas Mixing Results

Runs/Configuration	Results	Criteria	Meets
2 with injection in top-east corner of duct, at 1733 acfm	2.8% and 0.4% COV 3.5% and 0.9% deviation from mean	COV ≤20% in center 2/3 of stack ≤30% maximum deviation from mean	Yes
1 with injection in top-west corner of duct, at 1733 acfm	1.0% COV, 2.1% deviation from mean		Yes
1 with injection in bottom-east corner of duct, at 1733 acfm	0.4% COV, 0.9% deviation from mean		Yes
1 with injection in bottom-west corner of duct, at 1733 acfm	0.7% COV, 1.4% deviation from mean		Yes
1 with injection in center of duct, at 1733 acfm	1.3% COV, 2.0% deviation from mean		Yes
1 with injection in top-east corner of duct, at 278 acfm	1.2% COV, 2.5% deviation from mean		Yes
COV = coefficient of variance.			

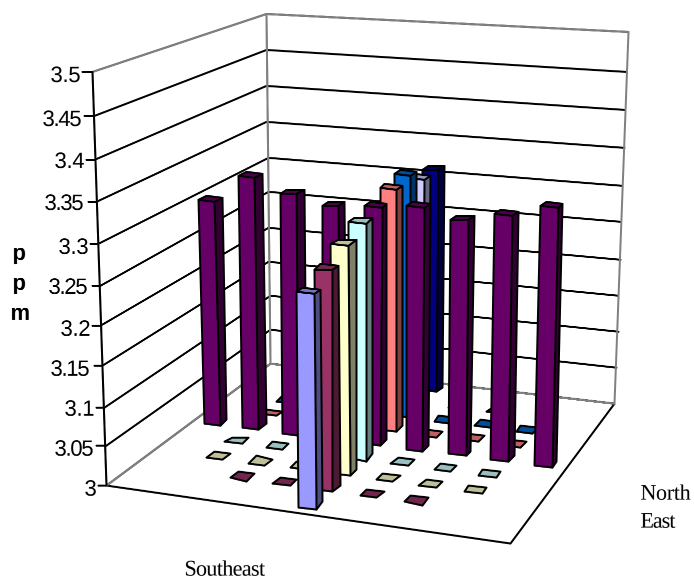


Figure 2.7. Worst Case Measurements of Gas Tracer Concentration (top-east injection, 1733 acfm, COV 2.8%)

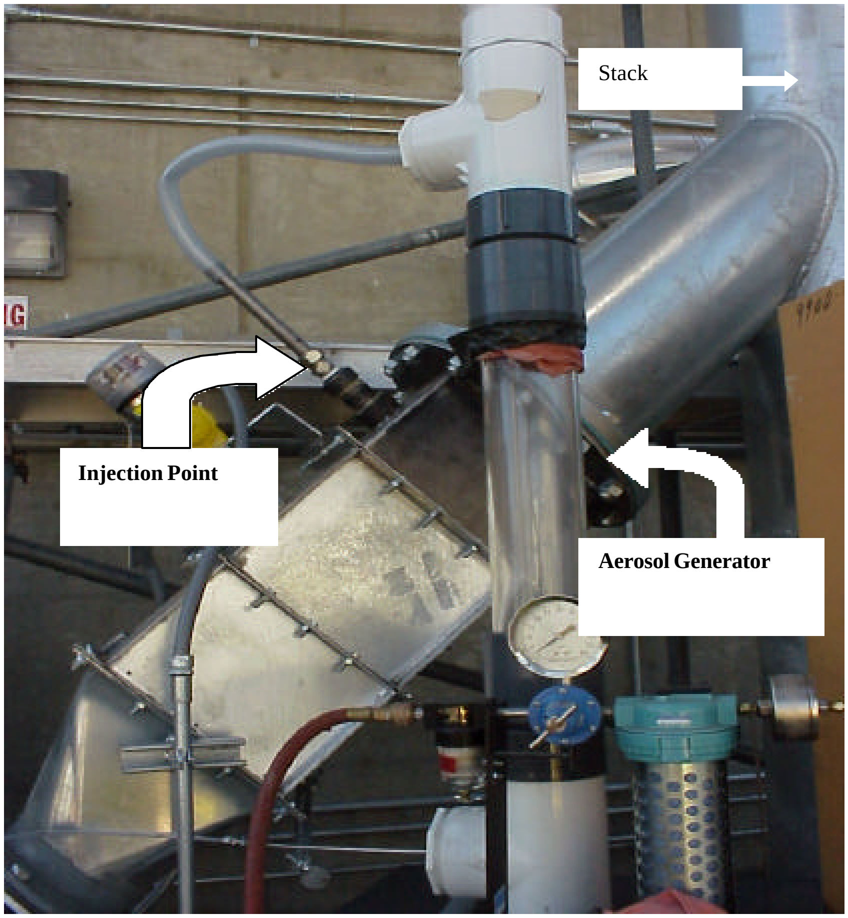


Figure 2.8 Particle Generator and Injection Point

2.4.2 Results

The uniformity of particle concentration was measured twice at 1733 acfm and once at 278 acfm. The results are summarized in Table 2.3 and the data sheets are included in Appendix E. The COV results labeled "raw" are 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 centerpoint 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. The improvement in uniformity observed in the raw data was caused by the particle generator output becoming more uniform over time. In all cases, the performance criterion was met. Figure 2.10 is a bar chart showing the normalized concentration data for the first test at 1733 acfm.

A comparison of Figures 2.3, 2.7, and 2.10 shows that the tracer gas is more uniform than the tracer particles and velocity. The higher COV for particles indicates that the particles mix slower, probably

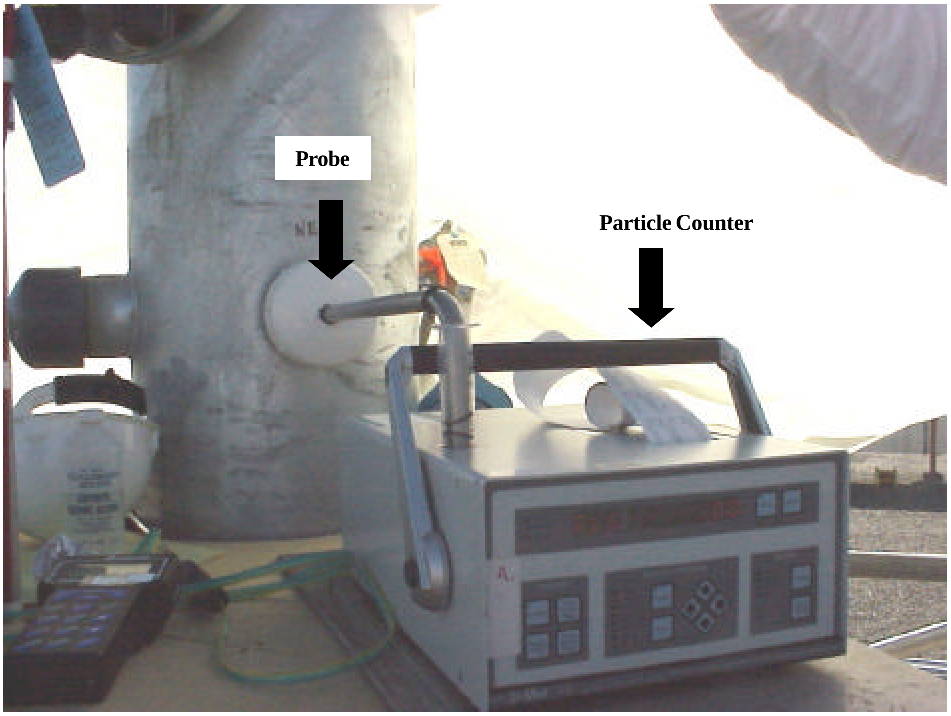


Figure 2.9. Optical Particle Counter and Probe Arrangement

Table 2.3 Particle Tracer Uniformity Results for the Center Two-Thirds of the Stack

Test	Runs/Configuration	Results	Criteria	Meets
Particle tracer uniformity, at test ports just below nozzles, with tracer injection in duct downstream of dampers on south side of stack. Time normalized results.	2 with center injection at 1733 acfm	Raw: 10.8% and 4.8% COV Normalized: 5.8% and 5.8% COV	COV ≤20% in center 2/3 of stack	Yes
	1 with center injection at 278 acfm	Raw: 4.1% COV Normalized: 3.0% COV		Yes

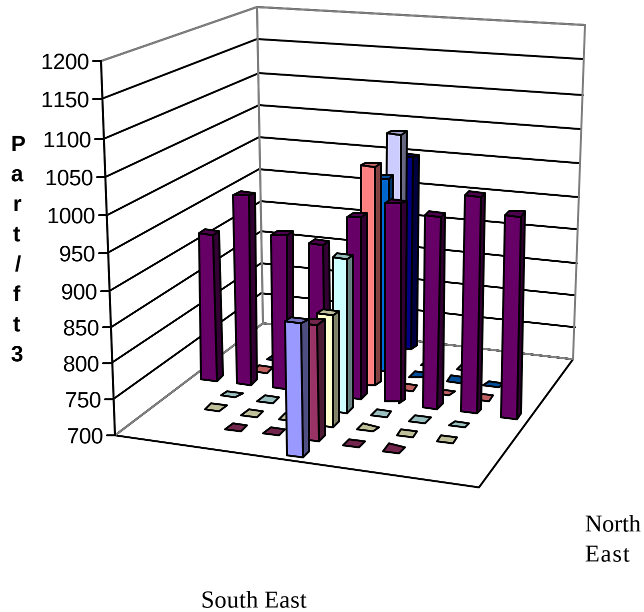


Figure 2.10. Plot of Tracer Particle Measurements from Run PT-1 (COV 5.8%)

because of their inertial and drag properties. The gas mixes very well with the air, so the concentration is quite uniform, even though the velocity is less uniform. This underscores the need for the separate tests, because the results of one test do not necessarily predict those of the others.

2.5 Sample Extraction and Transport System Performance

The acceptance criteria are: 1) nozzle transmission ratio for a 10 ìm AD particle is 0.8 to 1.3, 2) nozzle aspiration ratio for a 10 ìm AD particle is 0.8 to 1.5, and 3) the test particle penetration through transport system is ≥50% for 10 ìm AD particles. The nozzle characteristics are inherent in the design and were verified in wind-tunnel tests (McFarland et al. 1989; Glissmeyer and Ligotke 1995) and in the manufacturer's submittals. The overall particle transport is required to be verified experimentally or with the DEPOSITION 4.0 code (Riehl et al. 1996). The nozzle design factors are addressed in DEPOSITION 4.0; however, the results are combined into the overall transmission result for the nozzle and not stated separately.

Particle penetration through the sampling lines was assessed using the DEPOSITION 4.0 code. The code was verified against a benchmark test case. The sample transport elements modeled in the code include sampling nozzles, straight tubes at any angle to the horizontal plane, bends, and expansions and contractions in tube size. The code does not model splitters.

Figure 2.11 is a diagram of the segments of the sampler tubing. The characteristics and penetration results for the sampling system elements are listed in Table 2.4. The estimated overall particle penetration from the free stream to the splitter was 86%, which exceeds the acceptance criterion.

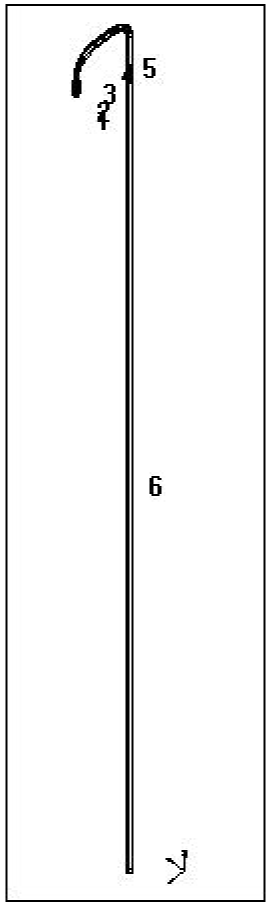


Figure 2.11. Diagram Labeling the Elements 1-6 (see Table 2.4) of the Sampling System Tubing

Table 2.4. DEPOSITION 4.0 Calculation Results

DEPOSITION 4.0. Mon Sep 17 14:36:00 2001					
Exit Stokes #		Exit Reynolds #		Total Penetration	
0.0086		2159		**85.7%**	
Element #	Element	Penetration	Stokes #	Reynolds #	Notes
1.	Probe	94.5%	0.0086	2159	Probe diameter: 18.3 mm, Shroud diameter: 53.8 mm, Velocity reduction ratio 3.31
2.	Tube	100.0%	0.0086	2159	Length: 0.051 m, At 90.000° from horizontal
3.	Bend	96.2%	0.0086	2159	Bend angle: 90.000°
4.	Tube	98.1%	0.0086	2159	Length: 0.178 m, At 0.000° from horizontal
5.	Bend	96.2%	0.0086	2159	Bend angle: 90.000°
6.	Tube	99.9%	0.0086	2159	Length: 6.02 m, At 90.000° from horizontal
Ambient temperature (deg.C): 25.0					
Ambient pressure (mm Hg): 745.0					
Flow rate (L/min): 56.6					
Free stream velocity (m/s): 7.0					
Particle diameter (μm): 10.0					
Note: Calculations were made with the best possible extrapolations of the model(s).					

3.0 Conclusions

The tests conducted on the W460 Plutonium Stabilization and Handling (296-Z-7 stack) air monitoring system demonstrated that the location for the air-sampling probe meets all performance criteria for air sampling systems at nuclear facilities. The performance criterion for particle transport also was met. Table 3.1 summarizes the conclusions for these tests.

With regard to the last row in the table, the compliance of the sampling nozzle with certain detailed acceptance criteria were not separately tested in connection with this installation. These two acceptance criteria for nozzles are that the transmission be in the 0.8 to 1.3 range and that the aspiration ratio be in the 0.8 to 1.5 range for 10-ìm-AD particles. The nozzle characteristics are inherent in the design and were verified previously in wind tunnel tests (McFarland et al. 1989; Glissmeyer and Ligotke 1995) and in the manufacturer's submittals. These factors are addressed in the modeling done with DEPOSITION 4.0; however, the results are combined into the overall transmission result for the nozzle and not stated separately. This study concludes that these criteria are met.

Table 3.1. Conclusions on Air Sampling System Tests

Test	Runs/Configuration	Results	Criteria	Meets
Flow angle, at test ports just below nozzles	1 at 278 acfm	8.8°	<20°	Yes
	1 at 1733 acfm	12.6°		Yes
Velocity uniformity at test ports just below nozzles	278 acfm	9% COV	COV ≤20%	Yes
	537 acfm	8% COV		Yes
	1733 acfm	5% COV		Yes
	2230 acfm	6% COV		Yes
Gas tracer uniformity, at test ports just below nozzles, with tracer injection in duct downstream of dampers on south side of stack. One test at reduced flow.	2 with injection in top-east corner of duct, at 1733 acfm	2.8% and 0.4% COV 3.5% and 0.9% deviation from mean	COV ≤20% in center 2/3 of stack ≤30% maximum deviation from mean	Yes
	1 with injection in top-west corner of duct, at 1733 acfm	1.0% COV, 2.1% deviation from mean		Yes
	1 with injection in bottom-east corner of duct, at 1733 acfm	0.4% COV, 0.9% deviation from mean		Yes
	1 with injection in bottom-west corner of duct, at 1733 acfm	0.7% COV, 1.4% deviation from mean		Yes
	1 with injection in center of duct, at 1733 acfm	1.3% COV, 2.0% deviation from mean		Yes
	1 with injection in top-east corner of duct, at 278 acfm	1.2% COV, 2.5% deviation from mean		Yes
Particle tracer uniformity, at test ports just below nozzles, with tracer injection in duct downstream of dampers on south side of stack. Time normalized results.	2 with center injection at 1733 acfm	5.8% and 5.8% COV	COV ≤20% in center 2/3 of stack	Yes
	1 with center injection at 278 acfm	3.0% COV		Yes
Particle penetration from free stream to filter	DEPOSITION 4.0 run	86% for 10 ìm AD particles	≥50% for 10 ìm AD particles	Yes

4.0 References

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

40 CFR 60, Appendix A, Method 2, as amended. U.S. Environmental Protection Agency. "Method 2 - Determination of Stack Gas Velocity and Volumetric Flow Rate." *Code of Federal Regulations*.

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

American National Standards Institute (ANSI). 1982. *Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities*. AANSI N13.1-1969, American National Standards Institute, New York.

American National Standards Institute (ANSI). 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, New York.

DEPOSITION 4.0 available for download at url:
http://wwwmengr.tamu.edu/Software/Deposition/deposition.html

DOE. 2000. *Radioactive Air Emissions Notice of Construction for Plutonium Finishing Plant Project W0460, "Plutonium Stabilization and Handling*." DOE/RL-2000-42, Rev. 2, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Glissmeyer, J. A., and M. W. Ligotke. 1995. *Generic Air Sampler Probe Tests*. PNL-10816, Pacific Northwest Laboratory, Richland, Washington.

McFarland, A. R., C. A. Ortiz, M. E. Moore, R. E. DeOtte, Jr., and A. Somasundaram. 1989. "A Shrouded Aerosol Sampling Probe." *Environ. Sci. Technol.* 23:1487-1492.

Riehl, J. R., V. R. Dileep, N. K. Anand, and A. R. McFarland. 1996. *DEPOSITION 4.0: An Illustrated User's Guide.* Aerosol Technology Laboratory Report 8838/7/96, Department of Mechanical Engineering, Texas A&M University, College Station, Texas.

Appendix A

Test to Calibrate Ventilation Flow Controller

Procedure
Test Instruction
Technical Review
Data Sheets

PNNL Operating Procedure	
Title: Test to Calibrate Ventilation Flow Controller	**Org. Code:** **D9T99** **Procedure No.:** **EMS-JAG-03** **Rev. No.:** **0**
Work Location: General	**Effective Date:** **November 18, 1998**
Author: John A. Glissmeyer	**Supersedes Date:**
Identified Hazards: ☐ Radiological ☐ Hazardous Materials ■ Physical Hazards ☐ Hazardous Environment ☐ Other:	**Identified Use Category:** ☐ Mandatory Use ☐ Continuous Use ■ Reference Use ☐ Information Use

Are One-Time Modifications Allowed? ■ Yes ☐ No

Person Signing	Signature	Date
Technical review: James L. Huckaby	J L Hy	11/20/98
Project Manager: John Glissmeyer	John Glissmeyer	11/19/98
Line Manager: James Droppo	J Droppo	11/20/98
Quality Engineer: Thomas G. Walker	Thomas G Walker	12/18/98

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 is used when needed to facilitate testing these characteristics. This procedure is a means to quickly correlate flow control device settings with the ventilation flowrate in a stack or duct. This correlation is determined prior to other tests of the stack monitoring system. This correlation makes it easier to set the flow control to achieve repeatable values of flowrate. Other procedures that may follow address flow angle, uniformity of gas velocity, 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 correlation between stack flow control settings and the measured stack flowrate. The tests are applicable to effluent stacks or ducts within the following constraints:

- The available range of adjustment in the ventilation flowrate of the system being tested or modeled.
- The operating limits of the air velocity measurement device used.

This procedure may need to be repeated if there are significant changes made in the ventilation system or loading of the ventilation filters.

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:

{tc \l3 "Equipment}

- Calibrated slant tube or electronic manometer,
- Pitot tube,
- Platform, ladders, or manlifts as needed to access the test ports,
- Fittings to limit leakage around the pitot tube in the test port and to stabilize the pitot tube so it can be positioned repeatedly.

6.0 Work Instructions for Setup, Measurements, and Data Reduction

Job specific instructions given in the test instruction, illustrated in Exhibit D, will provide specific details and operating parameters necessary to perform this procedure.

6.1 Preliminary Steps:

6.1.1 Verify that the interior dimensions of the stack or duct at the measurement location agree with those used in calculating the grid of measurement points given in the test instruction or data sheet. The measurement location should be approximately the same as the air sampling nozzle openings.

8/3/01
JWS

15.25 in. I.D.

> **Note.** The grid of velocity measurement points is calculated in accordance with 40 CFR 60, Appendix A, Method 1. A center point is also added.

6.1.2 Provide essential supplies at the sampling location. (pitot tube, manometer, connecting tubing, fittings to adapt pitot tube to the test ports, marking pens, data sheets, writing and pitot tube supporting platforms). 8/3/01 JAG

6.1.3 Verify that the flow control device is capable of the flow control settings given in the Test Instruction, particularly that setting to be used for the detailed velocity traverse. 8/3/01 JAG

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. 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. 8/3/01 JAG

6.1.5 Mark the pitot tube for each point in the measurement grid. Use a permanent marker so the inlet can be placed at each successive measurement point. 8/3/01 JAG

Numbered in reverse order by mistake. Reverse the numbering on spreadsheet 8/5/01 JAG

6.1.6 Obtain barometric, temperature, and relative humidity information for the flow measurement location. Air temperature can be measured in the stack with a calibrated instrument during the velocity traverses. 8/3/01 JAG

6.1.7 Attach the manometer to the pitot tube. Insert the pitot tube in the stack and seal the opening around the pitot tube. 8/3/01 JAG

6.2 Flow Measurement

6.2.1 Set the flow controller as instructed for the detailed velocity traverse. 8/3/01 JAG

6.2.2 Verify that the directional orientations and the numbered sample positions are consistent with the data sheet. 8/3/01 JAG

6.2.3 Measure and record, on the data sheet, the velocity or differential 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. 8/3/01

6.2.4 Repeat Step 6.2.3. Perform two or three repetitions of the measurements in each traverse direction, two if it is highly repeatable, three if not so repeatable. 8/3/01

6.2.5 Compare the results in Step 6.2.3 with those of 6.2.4. If the measurements are not highly reproducible, repeat again Step 6.2.3. 8/3/01

6.2.6 Calculate the average air velocity and identify the point(s) where the velocity most nearly equals the average. 8/4/01

6.3 Estimated Flow at Other Settings

6.3.1 Prepare a data sheet for recording average air velocity measured over the range of flow control settings. (See Exhibit B.) 8/4/01

6.3.2 Place the pitot tube at the point of average velocity as determined in Step 6.2.6. 8/4/01

6.3.3 Record the velocity reading for each flow controller setting specified in the Test Instruction. 8/4/01

6.3.4 Repeat Step 6.3.3 two times for a total of three replicate measurements at each flow setting. 8/4/01

6.3.5 Calculate the mean velocity and flowrate corresponding to each flow controller setting. 8/4/08

16 and 48 Hz
acfm 300 1800

6.3.6 Plot the mean velocity and flow versus flow controller setting as illustrated in Exhibit C. Calculate the equation of the line fitting the data. Didn't fit equation because of non-linearity. Interpolated between points 8/4/01 JAG

6.3.7 Review the datasheets for completeness. 8/4/01 JAG

6.3.8 Sign and date the datasheets attesting to their validity. 8/4/01 JAG

7.0 Exhibits/Attachments

Exhibit A – Illustration of Detailed Velocity Traverse Data Sheet

VELOCITY TRAVERSE DATA FORM

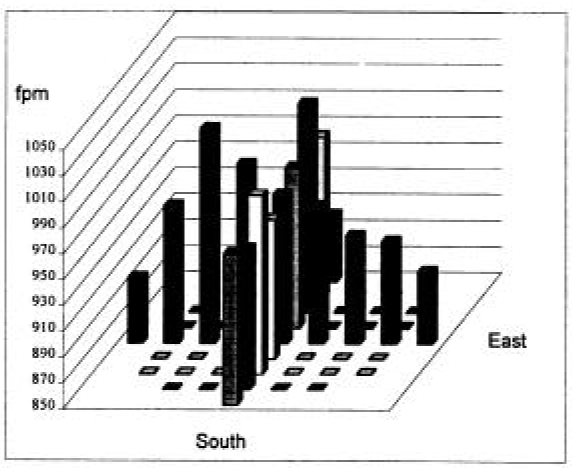
Site	W420 6" Model in 305 Building	Run No.	**VT6May5_1**
Date	May 5, 1998	Stack Temp	74 deg F
Tester	Maughan	Stack RH	39 %
Stack Dia.	6.328 in.	BP (sta. + static)	~~992 + 0.94~~ =~ 993 mbars
Stack X-Area	31.5 in.	Fan Setting	**20 Hz**
Elevation		Center 2/3 from	0.58 to: 5.75
El. above disturbance	49.25 in.	Points in Center 2/3	2 to: 7
Units	fpm		

Traverse-->		East				South			
Trial ---->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.								
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
		West				North			
Traverse Averages ---------->					946.70				966.00

				Center 2/3	E/W	S/N	All
Average of all data	956.35						
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 %	3.2	1.9	2.6

Flow 209 cfm

Flow 355 m3/hr



Notes:

Instuments Used:

Solomat Zephyr #12951472

Cal # 521-28-09-001, Expires 5/1/99

Signature signifying compliance with Procedure EMS-JAG-03

Signature/Date

Exhibit B – Illustration of Velocity vs. Flow Controller Setting Data Sheer

VELOCITY vs. FLOW CONTROL SETTING DATA FORM

Site	W420 6-inch Stack, Bldg. 305	Run No.	**VFMay6_1**
Date	5/6/98	Stack Temp	72 deg. F
Tester	D. Maughan	Stack RH%	44 % outdoor
Stack Dia.	6.375 inch	Baro Press	995 mbar, sta. 300A;
Stack X-Area	31.9 sq. in.		static 5 Hz 0.05 mbar
Elevation		Fan Setting	
El. above disturbance		Offset to index	

Reference point used from detailed velocity traverse: Pt. 5 on S>N Transect

Velocity Readings, units = fpm

Controller Hz	1	2	3	Mean	StDev	Flow, cfm	Static Pressure	Other Conditions
5	231	217	204	217.3	13.5	48	0.1	With inlet filter
10	470	459	453	460.7	8.6	102		
15	720	756	731	735.7	18.4	163		
20	978	973	1003	984.7	16.1	218		
25	1200	1204	1219	1207.7	10.0	268		
30	1481	1478	1517	1492.0	21.7	331	2.2	
35	1730	1731	1747	1736.0	9.5	385		
40	2014	2017	2022	2017.7	4.0	447		
45	2217	2232	2301	2250.0	44.8	498		
50	2461	2498	2495	2484.7	20.6	550		
55	2703	2706	2717	2708.7	7.4	600		
60	2988	3007	3103	3032.7	61.6	672	8.6	

Notes:

Each reading is the running average of approximately 40 points

The stack inlet filter, before the HEPA, has a moderate dust loading.

Instuments Used:

Solomat Zephyr Ser# 12951472, Cal# 521-28-09-001

Cal Exp. Date:

2/7/99

Signature signifying compliance with Procedure EMS-JAG-03

Signature/Date

Exhibit C – Plot of Flowrate vs. Controller Setting

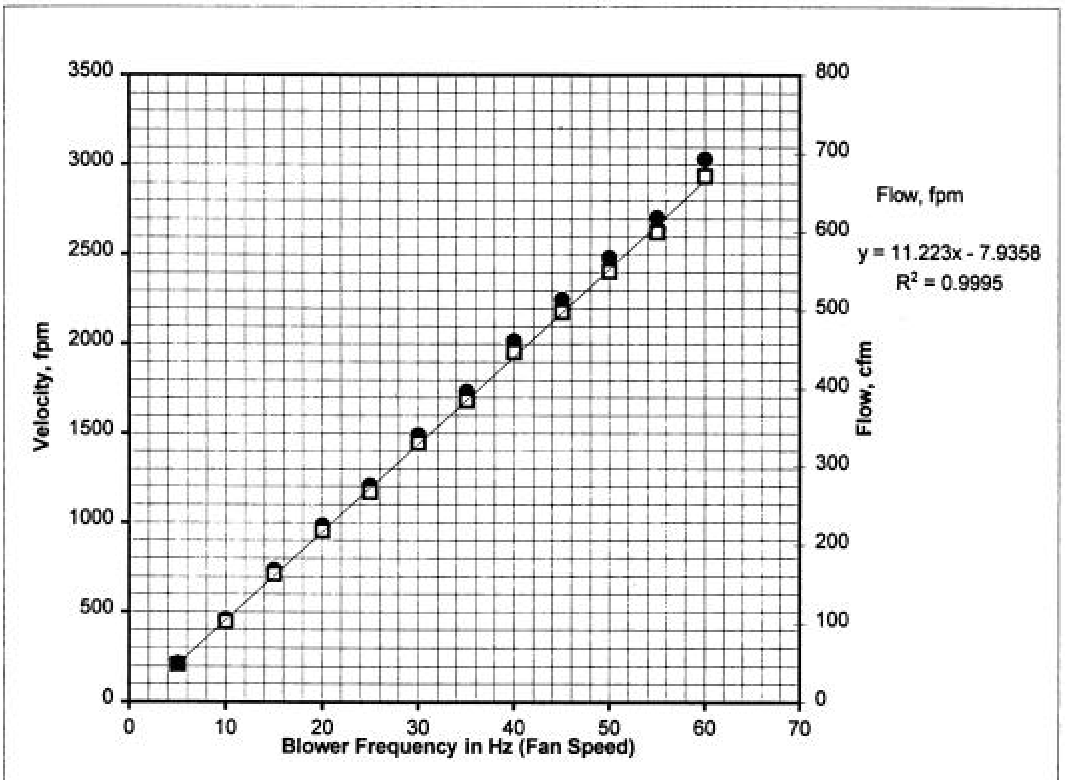


Exhibit D – Illustrative Test Instruction

Test Instruction		
Project: W420 6" Stack Calibration 28361	Date: August 19, 1998	Work Package: **K83017**
Tests: Calibration of Ventilation Flow Controller for W420 6" Full-Scale Model Stack		
Staff: David Maughan		
Reference Procedures: 1. Operating Manual for Solomat Zephyr 2. Procedure EMS-JAG-03 Test to Calibrate Ventilation Flow Controller, Rev. 0, Nov. 20, 1998		
Equipment: 1. W420 6" Full-Scale Model Stack, Fan and Fan Speed Controller located in 305 Bldg. 2. Solomat Zephyr and pitot tube		
Safety Considerations: Review and observe the applicable Numatec Job Hazard Analysis for the project		
Instructions: 1. Assemble the equipment for the flow controller calibration test at the ports at the elevation of the sampling probe 2. Layout the measurement points with the following distances 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 inches 3. Measure the velocity at each point with the flow controller set at 30 Hz. Repeat each measurement thrice. 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 on the controller over the 5 - 60 Hz range 7. Record and plot the data 6. Diagram mounting fixtures and retain assembly for subsequent tests		
Desired Completion Date:		
Approvals: ______________________ John Glissmeyer, project manager		____________ Date
Test completed by:		Date:

Test Instruction		
Project: **W460 Stack Sampler Qualification**	Date: **August 2, 2001**	Work Package: **F14752**
Tests: **Calibration of Ventilation Flow Controller for W460 Stack**		
Staff: David Maughan, John Glissmeyer, Dan Edwards		
Reference Procedures: 1. Operating Manual for Solomat Zephyr 2. Procedure EMS-JAG-03 Test to Calibrate Ventilation Flow Controller, Rev. 0, Nov. 18, 1998		
Equipment: 1. Stack, Fan and Fan Speed Controller. 2. Solomat Zephyr and pitot tube		
Safety Considerations: Review and observe the applicable Job Hazard Analysis for the project		
Instructions: 1. Assemble the equipment for the flow controller calibration test at the ports at the elevation of the sampling probe inlet nozzles 2. Measure the stack inside diameter and layout the measurement points for an 8 point traverse 3. Measure the velocity at each point with the flow controller set at ~~midrange~~ top of range 8/2/01 JAG. Repeat each measurement thrice. 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 on the controller over about 10 - 100 percent of the range 7. Record and plot the data 6. Diagram mounting fixtures and retain assembly for subsequent tests		
Desired Completion Date: 8/6/01		
Approvals: John Glissmeyer John Glissmeyer, project manager	8/2/01 Date	
Test completed by: John Glissmeyer	Date: 8/4/01	

Test Instruction		
Project: **W460 Stack Sampler Qualification**	Date: **August 2, 2001**	Work Package: **F14752**
Tests: **Calibration of Ventilation Flow Controller for W460 Stack**		
Staff: David Maughan, John Glissmeyer, Dan Edwards		
Reference Procedures: 1. Operating Manual for Solomat Zephyr 2. Procedure EMS-JAG-03 Test to Calibrate Ventilation Flow Controller, Rev. 0, Nov. 18, 1998		
Equipment: 1. Stack, Fan and Fan Speed Controller. 2. Solomat Zephyr and pitot tube		
Safety Considerations: Review and observe the applicable Job Hazard Analysis for the project		
Instructions: 1. Assemble the equipment for the flow controller calibration test at the ports at the elevation of the sampling probe inlet nozzles 2. Measure the stack inside diameter and layout the measurement points for an 8 point traverse JG 8/4/01 3. Measure the velocity at each point with the flow controller set at ~~midrange~~ did at max setting. Repeat each measurement thrice. 4. Record data on velocity data sheets → See VT-1 JG 8/4/01 5. Identify point of average velocity 6. Mount pitot tube at that point and measure velocity at 5 Hz increments on the controller over about 10 - 100 percent of the range 7. Record and plot the data 6. Diagram mounting fixtures and retain assembly for subsequent tests		
Desired Completion Date: 8/6/01		
Approvals: John Glissmeyer John Glissmeyer, project manager		8/2/01 Date
Test completed by: John Glissmeyer		Date: 8/4/01

VELOCITY vs. FREQUENCY DATA FORM

Site	W460	Run No.	VF-1	John Glissmeyer 8/4/01
Date	8/4/01	Stack Temp	83 F	
Tester	Glissmeyer	Stack RH%	36%	
Stack Dia.	15.25 in.	Baro Press	987.2 mbar	
Stack X-Area	182.7 in2	Fan Setting	Various	
Elevation	N.A.	Offset to index	N.A.	
El. above disturbance	189 inches			

Reference point used from velocity traverse VT-1: N.E. #4

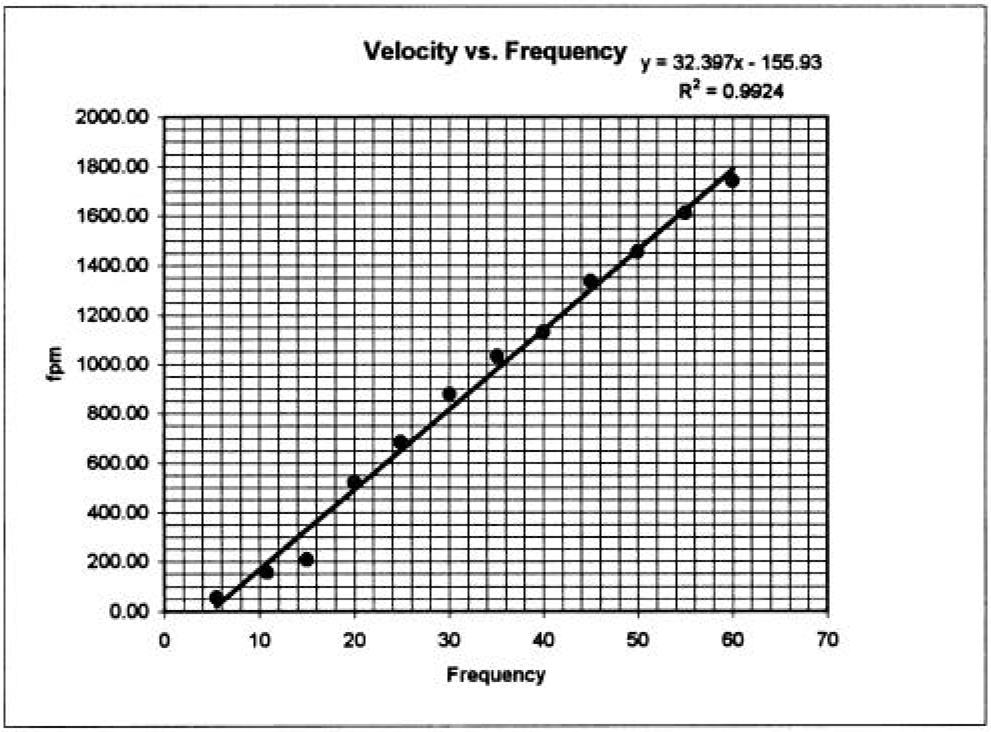
Velocity Readings, units = FPM

Hz	1	2	3	Mean	StDev	2 StDev
5.5	70	28	65	54.33	22.94	45.88
10.8	168	179	125	157.33	28.54	57.07
15	211	199	216	208.67	8.74	17.47
20	559	503	509	523.67	30.75	61.49
24.9	688	688	676	684.00	6.93	13.86
30.1	897	916	816	876.33	53.11	106.21
35.1	1074	960	1057	1030.33	61.50	123.00
40	1132	1130	1130	1130.67	1.15	2.31
45	1293	1354	1359	1335.33	36.75	73.49
50	1428	1493	1445	1455.33	33.71	67.42
55	1572	1606	1652	1610.00	40.15	80.30
60	1672	1778	1779	1743.00	61.49	122.98

Target cfm	Target fpm	Estmtd Hz
300	236	16
1800	1418	48

Instuments Used: Solomat Zephyr Ser# 12951472

Cal Exp. Date: 7/26/02



INDEPENDENT TECHNICAL REVIEW RECORD

PACIFIC NORTHWEST NATIONAL LABORATORIES INDEPENDENT TECHNICAL REVIEW RECORD	DOCUMENT NO.: Plot of Velocity Versus Fan Frequency, Run VF-1	Page 1 of __

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 call John Glissmeyer, 376-8552, cell 531-8006. Comments Due: 9/26/01

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

Organization/Department	Designated Reviewer: Tim Jarvis	Signature/Date
Multimedia Exposure Assessment Group		Timothy Jarvis 26SEP2001

CONCUR [X]	CONCUR, WITH COMMENTS [ ]	DO NOT CONCUR [ ]	NOT REVIEWED [ ]

Comt. No.	Comment and/ or Recommendation:	Resolution:
1	- TRANSCRIPTION CHECK - NO PROBLEMS NOTED	- NO RESPONSE REQUIRED
2	- CALCULATION CHECK - NO PROBLEMS NOTED	- NO RESPONSE REQUIRED
3	- FORMAT CHECK - NO PROBLEMS NOTED	- NO RESPONSE REQUIRED

Concur with Resolution	Date	Comments Resolved By	Date

Appendix B

Uniformity of Air Velocity

Procedure
Test Instruction
Technical Review
Data Sheets

PNNL Operating Procedure	
Title: Test to Determine Uniformity of Gas Velocity at the Elevation of a Sampler Probe	**Org. Code:** **D9T99** **Procedure No.:** **EMS-JAG-04** **Rev. No.:** **0**
Work Location: General	**Effective Date:** **November 24, 1998**
Author: John A. Glissmeyer	**Supersedes Date:**
Identified Hazards: ☐ Radiological ☐ Hazardous Materials ■ Physical Hazards ☐ Hazardous Environment ☐ Other:	**Identified Use Category:** ☐ Mandatory Use ☐ Continuous Use ■ Reference Use ☐ Information Use

Are One-Time Modifications Allowed? ■ Yes ☐ No

Person Signing	Signature	Date
Technical review: James L. Huckaby	J L Hy	11/24/98
Project Manager: John Glissmeyer	John Glissmeyer	11/24/98
Line Manager: James Droppo	JDroppo	11/24/98
Quality Engineer: Thomas G. Walker	Thomas G Walker	12/18/98

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 ± 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.

6.1 Preliminary Steps:

6.1.1 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. 8/3/01 JAG

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). 8/3/01 JAG

6.1.3 Verify that the ventilation flow control device is capable of the flow control settings given in the Test Instruction. 8/4/01 JAG

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. 8/4/01 JAG

> **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. 8/4/01 JAG

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. 8/4/01 JAG

6.1.7 Insert the velocity sensor in the stack or duct and seal the opening around it. 8/4/01 JAG

6.2 Velocity Uniformity Measurement

6.2.1 Set the flow controller per the test instruction. 8/4/01 JAG

6.2.2 Verify that the directional orientations and the numbered measurement positions are consistent with the data sheet. 8/4/01 JAG

6.2.3 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. 8/4/01 JAG

6.2.4 Repeat Step 6.2.3.

6.2.5 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. 8/4/01 JAG

6.2.6 Calculate the average air velocity for each measurement point. 8/4/01 JAG

6.2.7 Calculate the overall average velocity and flowrate for the stack or duct, omitting the center point. 8/6/01 JAG

6.2.8 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). 8/6/01 JAG

6.2.9 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. 8/6/01 JAG

6.2.10 Review the datasheets for completeness. 8/6/01 JAG

6.2.11 Sign and date the datasheets attesting to their validity. 8/6/01 JAG

7.0 Exhibits/Attachments

Exhibit A – Illustration of Detailed Velocity Traverse Data Sheet

VELOCITY TRAVERSE DATA FORM

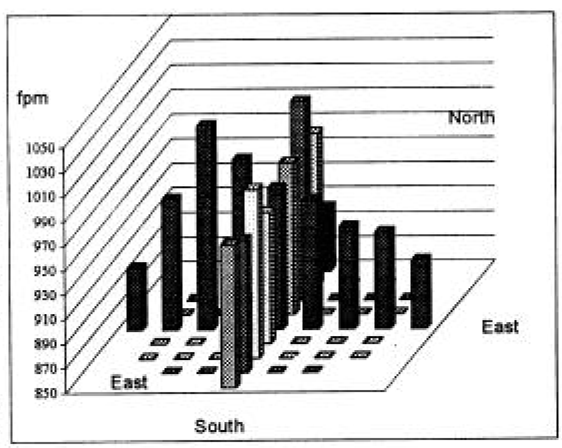
Site	W420 6" Model in 305 Building	Run No.	VT6May5_1
Date	May 5, 1998	Stack Temp	74 deg F
Tester	Maughan	Stack RH	39 %
Stack Dia.	6.328 in.	BP (sta. + static)	992 + 0.94 =~ 993 mbars
Stack X-Area	31.5 in.	Fan Setting	20 Hz
Elevation		Center 2/3 from	0.58 to: 5.75
El. above disturbance	49.25 in.	Points in Center 2/3	2 to: 7
Units	fpm		

Traverse-->		East				South			
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
			West				North		
Traverse Averages ---------->					946.70				966.00

Average of all data	956.35			Center 2/3	E/W	S/N	All
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 %	3.2	1.9	2.6

Flow 209 cfm

Flow 355 m3/hr



Notes:

Instuments Used:

Solomat Zephyr #12951472

Cal # 521-28-09-001, Expires 5/1/99

Signature signifying compliance with Procedure EMS-JAG-04

Signature/Date

Exhibit B – Illustrative Test Instruction

Test Instruction		
Project: W420 6" Stack Calibration 28361	Date: August 19, 1998	Work Package: **K83017**
Tests: Velocity Uniformity High Flow in W420 6" Full-Scale Model Stack		
Staff: David Maughan		
Reference Procedures: 1. Operating Manual for Solomat Zephyr 2. Test to Determine Uniformity of Gas Velocity at the Elevation of a Sampler Probe, Procedure EMS-JAG-04		
Equipment: 1. W420 6" Full-Scale Model Stack, Fan and Fan Speed Controller located in 305 Bldg. 2. Solomat Zephyr and pitot tube		
Safety Considerations: Review and observe the applicable Numatec Job Hazard Analysis for the project		
Instructions: 1. Assemble the equipment for the velocity uniformity test at the ports at the elevation of the sampling probe 2. Layout the measurement points with the following distances 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 inches.3. Measure the velocity at each point at the high (400 cfm) extreme of stack flow. Repeat each measurement twice. 4. Record data on velocity data sheets 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:

Test Instruction		
Project: W460 Stack Sampler Qualification	Date: **July 31, 2001**	Work Package: **F14752**

Tests: Velocity Uniformity at Nominal Flow in W460 Stack

Staff: John Glissmeyer, Dan Edwards, David Maughan

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

Equipment:
1. TSI VelociCalc or Solomat Zephyr and 24" standard pitot tube

Safety Considerations:
Observe the applicable Job Hazard Analysis for the project

Instructions:
1. Assemble the equipment for the velocity uniformity test at the ports at the elevation of the sampling probe
2. Mark the completion of each step on the field copy of the procedure. Mark-out those steps not applicable to this stack.
2. Layout the measurement points as listed on the data sheet. Use the same test ports as for flow angle test
3. Measure the velocity uniformity at the facility nominal stack flow (around 1,500 – 1,800 cfm). Stack flow can be estimated from preliminary manual traverses or an installed stack flowmeter
4. Record data on velocity data sheet
5. Diagram mounting fixtures and retain assembly for subsequent tests

Desired Completion Date: 8/4/2001

Approvals: John Glissmeyer
John Glissmeyer, project manager — 7/31/01 Date

Test completed by: John Glissmeyer Date: 8/4/01

INDEPENDENT TECHNICAL REVIEW RECORD

PACIFIC NORTHWEST NATIONAL LABORATORIES INDEPENDENT TECHNICAL REVIEW RECORD	DOCUMENT NO.: Calculation of Velocity Uniformity Characteristics for the W460 Stack, Runs VT-1 to VT-4. (Note VT-1 calibrates the ventilation flow controller)	Page 1 of 1

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 call John Glissmeyer, 376-8552, cell 531-8006. Comments Due: 8/ 20 /2001

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 (1st 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 grand mean and maximum deviation of mean for all measurement point.
5. Calculation of normalized velocity data (2 points) for plotting
6. Verify orientation of plotted bars

Organization/Department	Designated Reviewer: Tim Jarvis	Signature/~~Date~~
Multimedia Exposure Assessment Group		[signature] 16 Aug 2001

CONCUR [ ]	CONCUR, WITH COMMENTS [X]	DO NOT CONCUR [ ]	NOT REVIEWED [ ]

Comt. No.	Comment and/ or Recommendation:	Resolution:
1	VT-1, VT-2; TRANSCRIPTION CHECK (@100%) CALCULATION CHECK (@30%) AND EDITORIAL CHECK (@100%) NOTED NO ERRORS	– NO RESOLUTION REQUIRED
2	VT-3; TRANSCRIPTION CHECK (@100%) NOTED • TOTAL STACK PRESSURE – START; FIELD SHEET HAD VALUE '988.3'; COMPUTER SHEET HAS VALUE '988.4'. • AMBIENT HUMIDITY – START; FIELD SHEET HAS <u>NO</u> VALUE, COMPUTER SHEET HAS VALUE '36'. CALCULATION CHECK (@30%) AND EDITORIAL CHECK (@ 100%) NOTED NO ERRORS.	– Humidity value of 34% RH from HMS data inserted into VT-2 and VT-3 JAG 9/14/01 computer sheet changed to values shown on field data sheet for Tot. stack P., The ambient humidity value 36 is removed. (It was carried through from VT-2.) VT-3 was run between VT-2 (RH=34) and VT-4 (RH=28) so the RH was between these values.
3	NO ERRORS NOTED FOR TRANSCRIPTION CHECK (@100%), CALCULATION CHECK (@30%) AND EDITORIAL CHECK (@ 100%) FOR VT-4 AND VF-1	NO RESOLUTION REQUIRED

PACIFIC NORTHWEST NATIONAL LABORATORIES INDEPENDENT TECHNICAL REVIEW RECORD	DOCUMENT NO.: Calculation of Velocity Uniformity Characteristics for the W460 Stack, Runs VT-1 to VT-4	Page _ of _

Comt. No.	Comment and/ or Recommendation:	Resolution:
	Concur with Resolution Date 7 SEP 2001	Comments Resolved By Date 9/14/01

VELOCITY TRAVERSE DATA FORM

Site	W460 Stack	Run No.	VT-1
Date	8/3/01		
Tester	Glissmeyer	Fan Setting	**60 Hz**
Stack Dia.	15.25 in.	Stack Temp	100 deg F
Stack X-Area	182.7 in.2	Start/End Time	1430/1600
Elevation		Center 2/3 from	1.40 to: 13.85
Distance to disturbance	189 inches	Points in Center 2/3	2 to: 7
Velocity units	ft/min	Data Files:	NA

Traverse-->		NorthEast				SouthEast			
Trial --->		1	2	3	Mean	1	2	3	Mean
CorrectLabel	Depth, in.	Velocity				Velocity			
1	0.50	1543	1652	1656	1617.0	1598	1654	1723	1658.3
2	1.60	1791	1740	1726	1752.3	1618	1705	1694	1672.3
3	2.96	1751	1787	1816	1784.7	1698	1685	1733	1705.3
4	4.93	1804	1795	1828	1809.0	1706	1671	1681	1686.0
Center	7.63	1863	1825	1803	1830.3	1852	1793	1847	1830.7
5	10.32	1823	1768	1699	1763.3	1909	2003	1935	1949.0
6	12.29	1814	1789	1763	1788.7	2058	1973	1994	2008.3
7	13.65	1851	1702	1757	1770.0	1953	1940	1972	1955.0
8	14.75	1576	1374	1566	1505.3	1703	1752	1673	1709.3
Averages ---------->		1757.3	1714.7	1734.9	1735.6	1788.3	1797.3	1805.6	1797.1

All	ft/min	Dev. from mean	***Center 2/3***	NE	SE	All
Mean	1766.4		Mean	1785.5	1829.5	1807.5
Min Point	1505.3	-14.8%	Std. Dev.	27.1	143.0	101.5
Max Point	2008.3	13.7%	COV as %	1.5	7.8	6

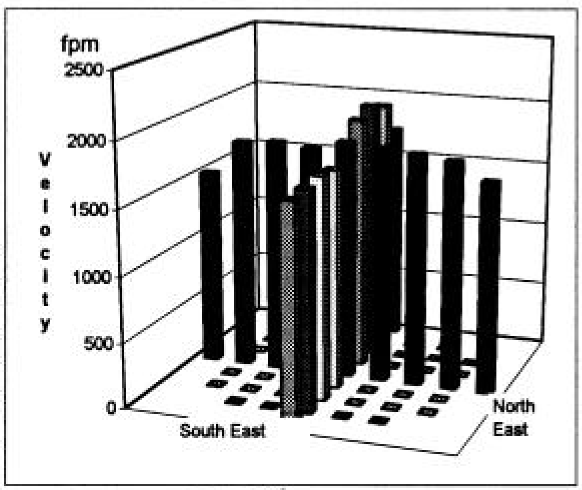
Approx Flo 2230 acfm

Instuments Used:

Pitot #5, 36-in. standard

Solmat Zephyr SN 12951472

	Start	Finish	
Stack temp	100	94	F
Equipment temp	87	83	F
Ambient temp	85	83	F
Stack static	1.7	2.40	mbars
Ambient pressure	983.4	983.4	mbars
Total Stack pressure	984.1	985.8	mbars
Ambient humidity	23	23	RH



Notes: Stack measures 15.25 inches diameter via both test ports.

Shrouded nozzles are installed

Point labelling and data order corrected from data sheet so consistent with remainder of tests, so first point is closest to test port, and has least depth.

Signature signifies compliance with Procedure EMS-JAG-4 Signature/date (on field data form)	Signature verifying data and calculations: 24SEP2001

W4608ptvel.xls VT-1 9/14/01

VELOCITY TRAVERSE DATA FORM

Site	W460 Stack	Run No.	VT-2			
Date	8/4/01					
Tester	Glissmeyer	Fan Setting	16.0 Hz			
Stack Dia.	15.25 in.	Stack Temp	82 deg F			
Stack X-Area	182.7 in.2	Start/End Time	1513/1550			
Elevation		Center 2/3 from	1.40	to:	13.85	
Distance to disturbance	189 inches	Points in Center 2/3	2	to:	7	
Velocity units	ft/min	Data Files:	NA			

Traverse-->		NorthEast				SouthEast			
Trial --->		1	2	3	Mean	1	2	3	Mean
CorrectLabel	Depth, in.	Velocity				Velocity			
1	0.50	441	392	432	421.7	382	342	285	336.3
2	1.60	481	471	466	472.7	421	410	432	421.0
3	2.96	505	466	481	484.0	387	359	359	368.3
4	4.93	502	400	406	436.0	377	398	372	382.3
Center	7.63	459	382	435	425.3	487	434	411	444.0
5	10.32	444	447	423	438.0	467	493	408	456.0
6	12.29	409	470	426	435.0	464	484	481	476.3
7	13.65	432	410	427	423.0	466	487	445	466.0
8	14.75	258	352	340	316.7	427	465	420	437.3
Averages ------>		436.8	421.1	426.2	428.0	430.9	430.2	401.4	420.9

All	ft/min	Dev. from mean	*Center 2/3*	NE	SE	All
Mean	424.4		Mean	444.9	430.6	437.7
Min Point	316.7	-25.4%	Std. Dev.	23.8	41.8	33.5
Max Point	484.0	14.0%	COV as %	5.3	9.7	8

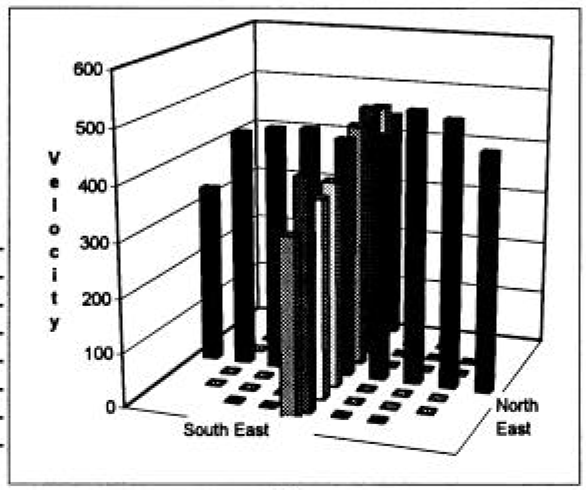
Approx Flo 537 acfm

Instuments Used:

Pitot #5, 36-in. standard

Solmat Zephyr SN 12951472 7/26/02 Cal due

	Start	Finish	
Stack temp	82	80	F
Equipment temp	82	82	F
Ambient temp	77	79	F
Stack static	0.079	0.095	mbars
Ambient pressure	987.2	987.2	mbars
Total Stack pressure	987.3	987.3	mbars
Ambient humidity	36	34	RH



Notes: Stack measures 15.25 inches diameter via both test ports.

Shrouded nozzles are installed

Corrected point labelling used.

Signature signifies compliance with Procedure EMS-JAG-4 Signature/date (on field data form)	Signature verifying data and calculations: Timothy J. [signature] 24SEP2001

W4608ptvel.xls VT-2 9/14/01

VELOCITY TRAVERSE DATA FORM

Site	W460 Stack	Run No.	VT-3
Date	8/4/01		
Tester	Glissmeyer	Fan Setting	48 Hz
Stack Dia.	15.25 in.	Stack Temp	80 deg F
Stack X-Area	182.7 in.2	Start/End Time	1550/1620
Elevation		Center 2/3 from	1.40 to: 13.85
Distance to disturbance	189 inches	Points in Center 2/3	2 to: 7
Velocity units	ft/min	Data Files:	NA

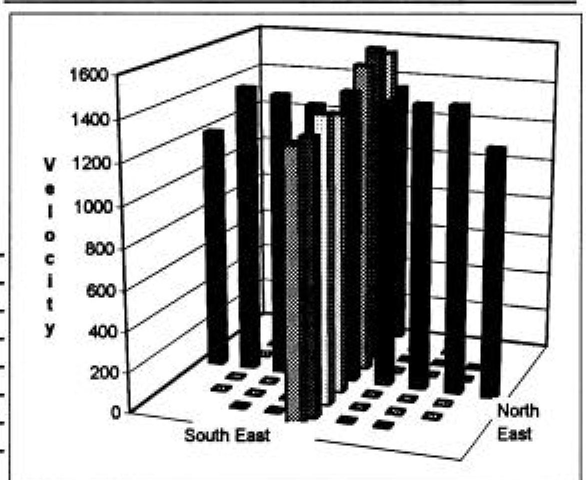
Traverse-->		NorthEast				SouthEast			
Trial --->		1	2	3	Mean	1	2	3	Mean
CorrectLabel	Depth, in.	Velocity				Velocity			
1	0.50	1251	1166	1239	1218.7	1289	1314	1246	1283.0
2	1.60	1486	1395	1353	1411.3	1271	1289	1285	1281.7
3	2.96	1391	1357	1462	1403.3	1337	1299	1418	1351.3
4	4.93	1428	1382	1415	1408.3	1321	1366	1273	1320.0
Center	7.63	1383	1467	1470	1440.0	1371	1404	1388	1387.7
5	10.32	1388	1357	1356	1367.0	1497	1483	1464	1481.3
6	12.29	1383	1372	1450	1401.7	1486	1514	1605	1535.0
7	13.65	1462	1435	1382	1426.3	1529	1415	1527	1490.3
8	14.75	1242	1208	1136	1195.3	1345	1279	1250	1291.3
Averages ----------->		1379.3	1348.8	1362.6	1363.6	1382.9	1373.7	1384.0	1380.2

All	ft/min	Dev. from mean	*Center 2/3*	NE	SE	All
Mean	1371.9		Mean	1408.3	1406.8	1407.5
Min Point	1195.3	-12.9%	Std. Dev.	22.8	96.3	67.2
Max Point	1535.0	11.9%	COV as %	1.6	6.8	5

Approx Flo 1733 acfm

Instuments Used:
Pitot #5, 36-in. standard
Solmat Zephyr SN 12951472 7/26/02 Cal due

	Start	Finish	
Stack temp	80	84	F
Equipment temp	82	83	F
Ambient temp	79	79	F
Stack static	1.196	1.379	mbars
Ambient pressure	987.2	987.2	mbars
Total Stack pressure	988.3	988.6	mbars
Ambient humidity	34	34	RH



Notes: Stack measures 15.25 inches diameter via both test ports.
Shrouded nozzles are installed

Signature signifies compliance with Procedure EMS-JAG-4 Signature/date (on field data form)

Signature verifying data and calculations: 24SEP2001

W4608ptvel.xls VT-3 9/14/01

VELOCITY TRAVERSE DATA FORM

Site	W460 Stack	Run No.	VT-4
Date	8/6/01		
Tester	Glissmeyer/Maughan	Fan Setting	9.1 Hz
Stack Dia.	15.25 in.	Stack Temp	87 deg F
Stack X-Area	182.7 in.2	Start/End Time	1430/1515
Elevation		Center 2/3 from	1.40 to: 13.85
Distance to disturbance	189 inches	Points in Center 2/3	2 to: 7
Velocity units	ft/min	Data Files:	NA

Traverse-->		NorthEast				SouthEast			
Trial --->		1	2	3	Mean	1	2	3	Mean
CorrectLabel	Depth, in.	Velocity				Velocity			
1	0.50	187	261	229	225.7	156	259	234	216.3
2	1.60	262	255	244	253.7	245	172	213	210.0
3	2.96	247	287	267	267.0	232	204	202	212.7
4	4.93	276	207	215	232.7	257	223	263	247.7
Center	7.63	242	214	210	222.0	223	204	207	211.3
5	10.32	221	225	228	224.7	223	233	198	218.0
6	12.29	242	195	186	207.7	209	226	225	220.0
7	13.65	239	167	186	197.3	201	234	216	217.0
8	14.75	185	154	186	175.0	150	212	198	186.7
Averages ———>		233.4	218.3	216.8	222.9	210.7	218.6	217.3	215.5

All	ft/min	Dev. from mean	***Center 2/3***	NE	SE	All
Mean	219.2		Mean	229.3	219.5	224.4
Min Point	175.0	-20.2%	Std. Dev.	24.5	12.9	19.5
Max Point	267.0	21.8%	COV as %	10.7	5.9	9

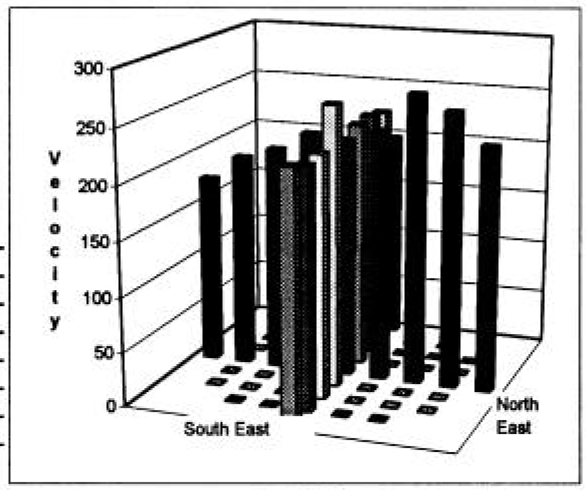
Approx Flo 278 acfm

Instuments Used:

Pitot #5, 36-in. standard

Solmat Zephyr SN 12951472 7/26/02 Cal due

	Start	Finish	
Stack temp	87	86	F
Equipment temp	93	90	F
Ambient temp	85	84	F
Stack static	0.065	0.021	mbars
Ambient pressure	990.3	990.3	mbars
Total Stack pressure	990.4	990.3	mbars
Ambient humidity	28	28	RH
Centerline Velocity w/solomat pitot	238	249	fpm



Notes: Stack measures 15.25 inches diameter via both test ports.

Shrouded nozzles are installed

Signature signifies compliance with Procedure EMS-JAG-4 Signature/date (on field data form)	Signature verifying data and calculations: 24 Sept 2001

W4608ptvel.xls VT-4 9/14/01

Appendix C

Angular Flow

Procedure
Test Instruction
Technical Review
Data Sheets

PNNL Operating Procedure	
Title: Test to Determine Flow Angle	**Org. Code:** D9T99 **Procedure No.:** EMS-JAG-05 **Rev. No.:** 0
Work Location: General	**Effective Date:** November 24, 1998
Author: John A. Glissmeyer	**Supersedes Date:**
Identified Hazards: ☐ Radiological ☐ Hazardous Materials ■ Physical Hazards ☐ Hazardous Environment ☐ Other:	**Identified Use Category:** ☐ Mandatory Use ☐ Continuous Use ■ Reference Use ☐ Information Use

Are One-Time Modifications Allowed? ■ Yes ☐ No

Person Signing	Signature	Date
Technical review: James L. Huckaby	[illegible]	12/31/98
Project Manager: John Glissmeyer	John Glissmeyer	1/4/99
Line Manager: James Droppo	[illegible]	1/5/99
Quality Engineer: Thomas G. Walker	Thomas G Walker	1/7/99

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 cross-sectional 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 ± 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.

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.

6.1 Preliminary Steps:

6.1.1 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. JWS 8/6/01

> 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). JWS 8/6/01

6.1.3 Verify that the ventilation flow control device is capable of the flow control settings given in the Test Instruction. JWS 8/6/01

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 "east-west". 8/6/01

6.1.5 Mark the Type-S pitot tube to indicate the insertion depth for each point in the measurement grid. 8/6/01

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.) 8/6/01

> **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. 8/6/01

> **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. 8/6/01

> **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.

6.1.9 Position the inclined manometer on a stable platform and level the device using the spirit level. 8/6/01 JAS

> **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. 8/6/01 JAS

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.) 8/6/01 JAS

6.1.12 Reconnect the flexible tubes to the pitot tube. 8/6/01 JAS

6.2 Angular Flow Measurements

6.2.1 Verify that the directional orientations and the numbered measurement positions are consistent with the data sheet. 8/6/01 JAS

6.2.2 Measure and record, on the data sheet, the angular reading at each measurement point in succession. If the readout device has an averaging feature, record the average of a series of several readings. 8/6/01 JAS

> **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.

6.2.3 Repeat Step 6.3.3. 8/6/01 JAG

6.2.4 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. 8/6/01 JAG

6.2.5 Calculate the absolute average air-flow angle for each measurement point. 8/7/01 JAG

6.2.6 Calculate the average absolute flow angle for all measurement points. 8/7/01 JAG

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

6.2.7 Review the datasheets for completeness. 8/7/01 JAG

6.2.8 Sign and date the datasheets attesting to their validity. 8/7/01 JAG

7.0 Exhibits/Attachments

Exhibit A – Illustrative Test Instruction

Test Instruction		
Project: W420 6" Stack Calibration 28361	Date: August 19, 1998	Work Package: **K83017**
Tests: Flow Angle at High Flow in W420 6" Full-Scale Model Stack		
Staff: David Maughan		
Reference Procedures: 1. Operating Manual for Solomat Zephyr 2. Test to Determine Flow Angle at the Elevation of a Sampler Probe, Procedure EMS-JAG-05		
Equipment: 1. W420 6" Full-Scale Model Stack, Fan and Fan Speed Controller located in 305 Bldg. 2. S-type Pitot Tube, slant tube or electronic manometer, and Protractor Level		
Safety Considerations: Review and observe the applicable Numatec Job Hazard Analysis for the project		
Instructions: 5. Assemble the equipment for the flow angle test at the ports at the elevation of the sampling probe. 2. Layout the measurement points with the following distances 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 inches.3. Measure the flow angle at each point at the high (400 cfm) extreme of stack flow. Repeat each measurement twice. 4. Record the data on flow angle data sheets. 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:	

Exhibit B – Illustration of Flow Angle Data Sheet

W420 296-C-5 FLOW ANGLE at High and Low Average Flow Rates

Site	Bldg. 305		Run No.	
Date	12/ /1998		Stack Temp	deg. F
Tester			Stack RH	percent
Stack Dia.	12	in	Baro Press	mbar
Stack X-Area	113.1	in2	Fan Setting	Hz
Elevation		ft	Fan input port	
El. above disturbance		in	Flowrate (pre- & post-)	and
Input air filtered?		Y or N	Approx. avg. Flowrate	cfm at centerline
			Units	degrees (clockwise > pos. nos.)

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			All
Absolute Average of all data:		0.0	0.0	0.0	0.0	0.0	0.0	0.0

Instuments Used:

Parallel-tube pitot with 90-deg. bends at sample ends, 24-inches in length.
Dwyer Instruments 0-5 inch inclined manometer with red guage oil
zero'd and leveled (with connecting tubes open to room atmosphere).
Angles made using Empire #36 circular protractor.

Cal Exp. Date: NA

Notes:

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

Signature signifies compliance with Procedure EMS-JAG-05

Signature/date

Test Instruction		
Project: W460 Stack Sampler Qualification	Date: July 31, 2001	Work Package: **F14752**
Tests: Flow Angle at Nominal Flow in W460 Stack		
Staff: John Glissmeyer, Dan Edwards, David Maughan		
Reference Procedures: 1. *Test to Determine Flow Angle at the Elevation of a Sampler Probe*, Procedure EMS-JAG-05		
Equipment: 1. Stack operating at nominal flow, test ports in round stack just upstream of sampling probe. One port on stack centerline on SOUTHEAST side of stack, the other on NORTHEAST side of stack. Test ports to have minimum 2 inch pipe short nipple and cap. 2. S-type Pitot Tube, slant tube or electronic manometer, connecting surgical or silicone tubing, clamp-on pointer and protractor, and protractor level, tape measure, Sharpie Pen, or pre-marked template 3. Adapter swivel fittings to interface pitot tube to test port		
Safety Considerations: Observe the applicable Job Hazard Analysis for the project		
Instructions: 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 this stack. 3. Assemble the equipment for the flow angle test at the test ports. The protractor level can be attached to the pitot tube for flow in the vertical direction. 4. Use the measurement points indicated on data sheet. (Marks may be made on the pitot tube using a Sharpie pen. The ink removes easily with drug store type isopropyl alcohol. Make allowance for the depth of the adapters and width of the pitot tube opening.) 5. Verify that stack flow is about the target flowrate. This can be determined from manual velocity readings or the output of the installed stack flowmeter. 6. Measure the flow angle at each point. Repeat each measurement three times. 7. Record the data on flow angle data sheets. 8. Diagram mounting fixtures and retain assembly for subsequent tests.		
Desired Completion Date: 8/3/01		
Approvals: John Glissmeyer John Glissmeyer		7/31/01 Date
Test completed by: John Glissmeyer	Date: 8/6/01	

INDEPENDENT TECHNICAL REVIEW RECORD

PACIFIC NORTHWEST NATIONAL LABORATORIES INDEPENDENT TECHNICAL REVIEW RECORD	DOCUMENT NO.: Calculation of Flow Angle for the W460 Stack, Runs FA-1 and FA-2	Page 1 of 1

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 call John Glissmeyer, 376-8552, cell 531- 8006. Comments Due: 8/ 20 /2001

Additional Information: (Scope of Review, etc) Please verify the following:

1. Transfer of field data to spreadsheet
2. Calculation of intermediate mean values of flow angle per traverse (one per port) and measurement point (1st and last points per port)
3. Calculation of overall mean absolute angle

Organization/Department	Designated Reviewer: Tim Jarvis	Signature/Date
Multimedia Exposure Assessment Group		[signature] 16 Aug 2001

CONCUR [ ]	CONCUR, WITH COMMENTS [X]	DO NOT CONCUR [ ]	NOT REVIEWED [ ]

Comt. No.	Comment and/ or Recommendation: BOTH FA-1 AND FA-2 RUNS	Resolution:
1	TRANSCRIPTION CHECK: NO TRANSCRIPTION ERRORS NOTED. 100% CHECK.	NO RESOLUTION REQUIRED
2	CALCULATION CHECK: NO CALCULATIONAL ERRORS NOTED. 30% CHECK.	NO RESOLUTION REQUIRED
3	EDITORIAL CHECK: THE NUMBERS LISTED UNDER: START 1730 FINISH 1630 NEED UNITS.	Added hours. JAG 9/17/01 Will add feet/min (fpm) to both numbers on computer data sheet. This stack center pt. reading is uncorrected relative to original stack flow calibration and is taken to show in an approximate way that the flow, test to test, and conditions are the same.

PACIFIC NORTHWEST NATIONAL LABORATORIES INDEPENDENT TECHNICAL REVIEW RECORD	DOCUMENT NO.: Calculation of Flow Angle for the W460 Stack, Runs FA-1 and FA-2		Page _ of _
Comt. No.	Comment and/ or Recommendation:	Resolution:	
Concur with Resolution	Date	Comments Resolved By	Date 9/14/01

FLOW ANGLE DATA FORM

Site	W460 Stack		Run No.	FA-1	
Date	8/6/01		Stack Temp	92	deg. F
Tester	Glissmeyer/Maughan		Stack RH	28	percent
Stack Dia.	15.25	in	Baro Press	990.3	mbar
Stack X-Area	182.7	in2	Fan Setting	48 Hz	
Elevation		ft	Fan input port	South	
Distance to disturbance	189	in	Stack flow		cfm
Input air filtered?	Y	Y or N	Units	degrees (clockwise > pos. nos.)	

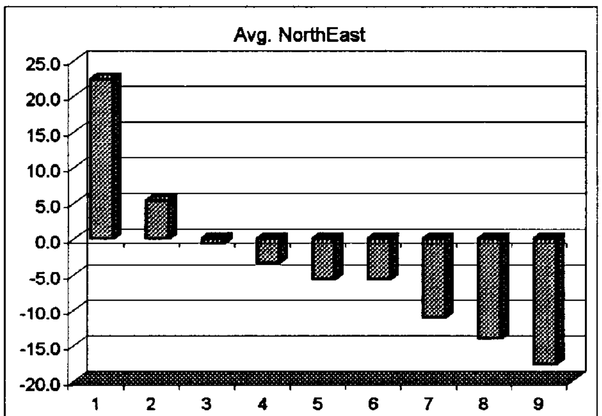
Traverse-->		NorthEast				SouthEast			
Trial --->		1	2	3		1	2	3	
Point	Depth, in.	deg. cw	deg. cw	deg. cw	Avg.	deg. cw	deg. cw	deg. cw	Avg.
1	0.50	24	21	22	22.3	29	31	32	30.7
2	1.60	2	6	8	5.3	31	30	30	30.3
3	2.96	-1	-1	0	-0.7	24	23	24	23.7
4	4.93	-1	0	-9	-3.3	16	18	20	18.0
Center	7.63	-8	-5	-4	-5.7	-2	-7	-6	-5.0
5	10.32	-7	-5	-5	-5.7	-9	-9	-10	-9.3
6	12.29	-12	-10	-11	-11.0	-9	-4	-6	-6.3
7	13.65	-14	-14	-14	-14.0	-9	-6	-8	-7.7
8	14.75	-19	-18	-16	-17.7	-10	-10	-10	-10.0
Mean of absolute values		9.8	8.9	9.9		15.4	15.3	16.2	
w/o points by wall:		6.4	5.9	7.3		14.3	13.9	14.9	
								all	12.6
								w/o wall pts	10.4

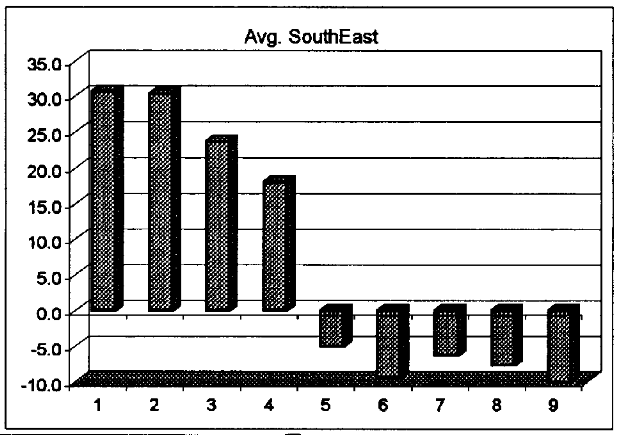
Instuments Used:

S-type pitot	Pitot-2
Stanley protractor level	Prot-1
Manometer	Man-1

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

Start 1630 hours
Finish 1730 hours
C.L. Vel 1415 fpm with Solomat Zephyr SN 12951472 ReCal due 7/26/02





Signature signifies compliance with Procedure EMS-JAG-05

Signature/date (on field data form)

Signature verifying data and calculations:

24 SEP 2001

FLOW ANGLE DATA FORM

Site	W460 Stack		Run No.	FA-2	
Date	8/6/01		Stack Temp	87	deg. F
Tester	Glissmeyer/Maughan		Stack RH	26	percent
Stack Dia.	15.25	in	Baro Press	989.3	mbar
Stack X-Area	182.7	in2	Fan Setting	9.1 Hz	
Elevation		ft	Fan input port	South	
Distance to disturbance	189	in	Stack flow		cfm
Input air filtered?	Y	Y or N	Units	degrees (clockwise > pos. nos.)	

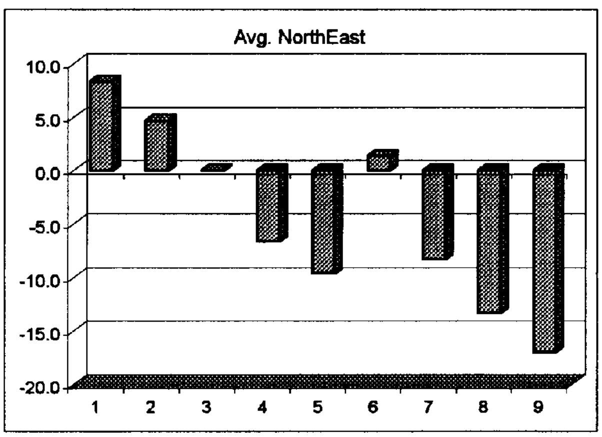
Traverse-->		NorthEast				SouthEast			
Trial --->		1	2	3		1	2	3	
Point	Depth, in.	deg. cw	deg. cw	deg. cw	Avg.	deg. cw	deg. cw	deg. cw	Avg.
1	0.50	1	9	15	8.3	14	4	14	10.7
2	1.60	7	-11	18	4.7	14	-3	12	7.7
3	2.96	3	-13	10	0.0	0	-9	9	0.0
4	4.93	-9	-7	-4	-6.7	-1	3	-4	-0.7
Center	7.63	-11	-9	-9	-9.7	-7	-7	-9	-7.7
5	10.32	6	-2	0	1.3	-10	-11	-8	-9.7
6	12.29	-1	-9	-15	-8.3	-5	-5	-6	-5.3
7	13.65	-9	-11	-20	-13.3	-11	-5	-10	-8.7
8	14.75	-15	-15	-21	-17.0	-14	-12	-7	-11.0
Mean of absolute values		6.9	9.6	12.4		8.4	6.6	8.8	
w/o points by wall:		6.6	8.9	10.9		6.9	6.1	8.3	
								all	8.8
								w/o wall pts	7.9

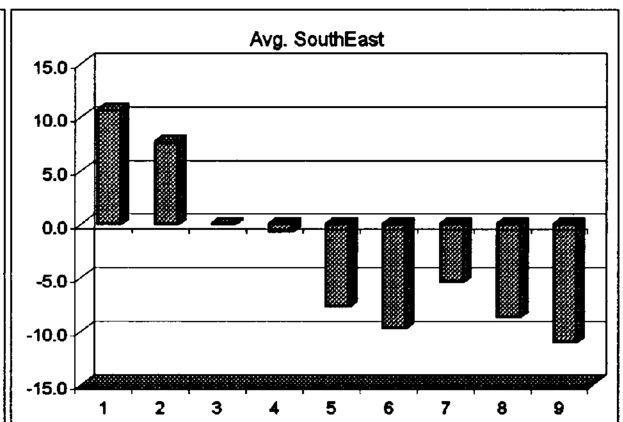
Instuments Used:

S-type pitot	Pitot-2
Stanley protractor level	Prot-1
Manometer	Solomat Zephyr
	SN 12951472 ReCal due 7/26/02

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

C.L. Vel 232 fpm with Solomat Zephyr





Signature signifies compliance with Procedure EMS-JAG-05

Signature/date (on field data form)

Signature verifying data and calculations:

24SEP2001

Appendix D

Uniformity of Tracer Gases

Procedure
Test Instruction
Technical Review
Data Sheets

PNNL Operating Procedure	
Title: Test to Determine Uniformity of a Tracer Gas at a Sampler Probe	**Org. Code:** D9T99 **Procedure No.:** EMS-JAG-01 **Rev. No.:** 1
Work Location: General	**Effective Date:** May 26, 2000
Author: John A. Glissmeyer	**Supersedes Date:** November 10, 1998
Identified Hazards: ☐ Radiological ☐ Hazardous Materials ■ Physical Hazards ☐ Hazardous Environment ☐ Other:	**Identified Use Category:** ☐ Mandatory Use ☐ Continuous Use ■ Reference Use ☐ Information Use
Are One-Time Modifications Allowed? ■ Yes ☐ No	

Person Signing	Signature	Date
Technical review: James L. Huckaby	J L H	5/23/00
Project Manager: John Glissmeyer	John Glissmeyer	5/22/00
Line Manager: James Droppo	J Droppo	6-12-00
Concurrence:		
Quality Engineer: Thomas G. Walker	Thomas G Walker	5/23/00

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.

- 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 time-weighted average limit for human exposure to sulfur hexafluoride gas is 1000 ppm (6,000 mg/m^3). 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 tracer-injection 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). 8/7/01 JOS

6.1.2 Fill in test information on data form. 8/7/01 JOS

6.1.3 Obtain barometric, temperature, and relative-humidity information for the gas analyzer. 8/7/01 JOS

6.1.4 Set up the gas analyzer system at the stack sampling port according to the illustrations in Exhibits A and B. 8/7/01 JOS

> **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 in line 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. 8/7/01 JG

6.2.2 Verify the stack centerline air velocity in the sampling plane using a velocity flow meter, and record value on data sheet. 8/7/01 JG

6.2.3 Turn-on the gas analyzer. 8/7/01 JG

6.2.4 Program the analyzer for: JG 8/7/01

- 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. 8/7/01 JG

> **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.

> **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 plan 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.

8/7/01 JAG

6.3.2 Record these readings in the logbook designated for the tests.

Recorded 5 readings out of about 10

8/7/01 JAG

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 90° 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{tc \l3 "Potential Test Conditions}**
> Injection plane – 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.

6.4.1 Position the injection probe, according to the test instruction found as Attachment A.

8/7/01 JAG

6.4.2 Start injection of the tracer gas and adjust for flow rate specified in the test instruction and note the time.

8/7/01 JAG

Note: Estimation of Sulfur Hexafluoride Injection Rate
Estimate the SF_6 injection rate so the average diluted concentration will be within the range of 10 to 100% of the concentration of the calibration check gas according to the following equation:

$$injection\ flowrate = stack\ flowrate \times \frac{target\ ppmv}{10^6}$$

The rotameter reading should be adjusted for the density of the SF_6. The air equivalent reading is

$$rotameter\ reading = k\ x\ actual\ flowrate$$

where k is 2.53 (the square-root of the density) for SF_6.

6.4.3 On the data sheet, label the columns of data according to the directions of the traverses. 8/7/01 JAG

6.4.4 Verify that the directional orientations and the numbered sample positions are consistent. 8/7/01 JAG

6.4.5 Position the sample probe at each measurement point in succession, and record the reading on the dataform. 8/7/01 JAG

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.

6.4.6 Perform two additional repetitions of Step 6.4.5. above 8/7/01 JAG

6.4.7 Switch the tests to the other direction and repeat Steps 6.4.5 and 6.4.6. 8/7/01 JAG

6.4.8 Check the data sheet for completeness. 8/7/01 JAG

6.4.9 Record the final 8/7/01
- 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. Continued for subsequent tests 8/7/01

6.4.11 Continue operation of the gas analyzer for several minutes to purge any remaining gas through the analyzer. Skip on intermediate tests 8/7/01

6.4.12 Measure the background tracer gas concentration and record the levels on the data sheet. 8/7/01

6.4.13 Record any climatic conditions that have changed on the data sheet. 8/7/01

6.4.14 Enter the centerline stack velocity flow on the data sheet. 8/7/01

6.4.15 Record any deviations from the above procedure on the data sheet. 8/7/01

6.4.16 Repeat steps 6.4.1 – 6.4.15 for each run as indicated in the Test Instruction. 8/8/01

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).

6.5.1 Review the raw data sheets for completeness. 8/8/01

6.5.2 Enter the data into the electronic data sheet. 8/8 - 8/7/01

6.5.3 Calculate the COV for the run. 8/8 - 8/7/01

> **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. 8/9/01

> **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. 8/9/01

> **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.

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. 8/1/01

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). 8/1/01

6.6.3 Program for a continuous monitoring task (4.2.5), and initiate monitoring (4.2.6). 8/1/01 JRS

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. 8/1/01 JRS

> **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. 8/1/01 JRS

> **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 SF_6 background concentrations will increase as the analyzer is checked. The SF_6 reading should be within 10% of the calibration-gas concentration, and the water content should be much lower than ambient.

6.6.6 Obtain baseline tracer (calibration gas) readings at the end of the calibration check. Record results on the data sheet. 8/1/01 JRS

> **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 connecting to a printer in data log mode.

7.0 Exhibits/Attachments

Exhibit A – Overview of Stack and Injection/Sampling Setups

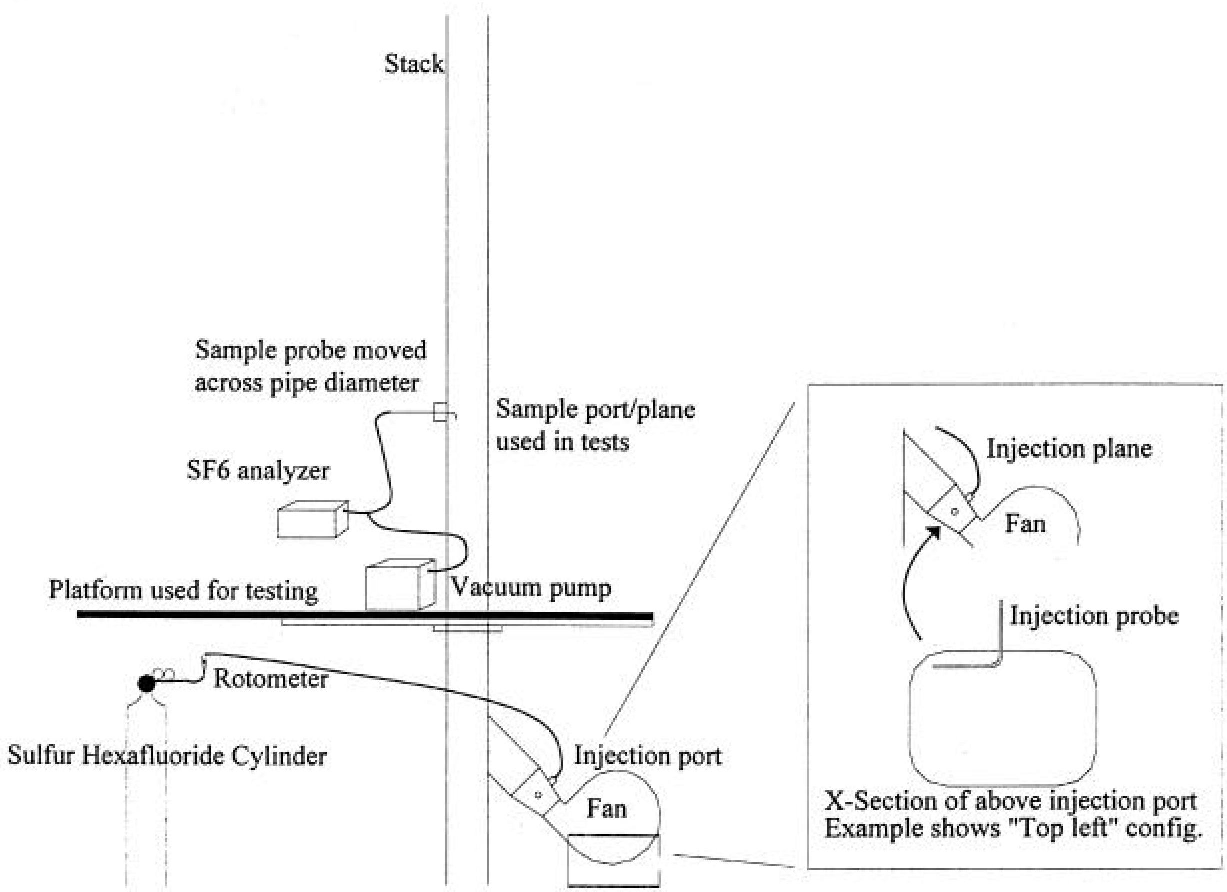

Stack
Sample probe moved
across pipe diameter
Sample port/plane
used in tests
SF6 analyzer
Platform used for testing
Vacuum pump
Rotometer
Sulfur Hexafluoride Cylinder
Injection port
Fan
Injection plane
Fan
Injection probe
X-Section of above injection port
Example shows "Top left" config.

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

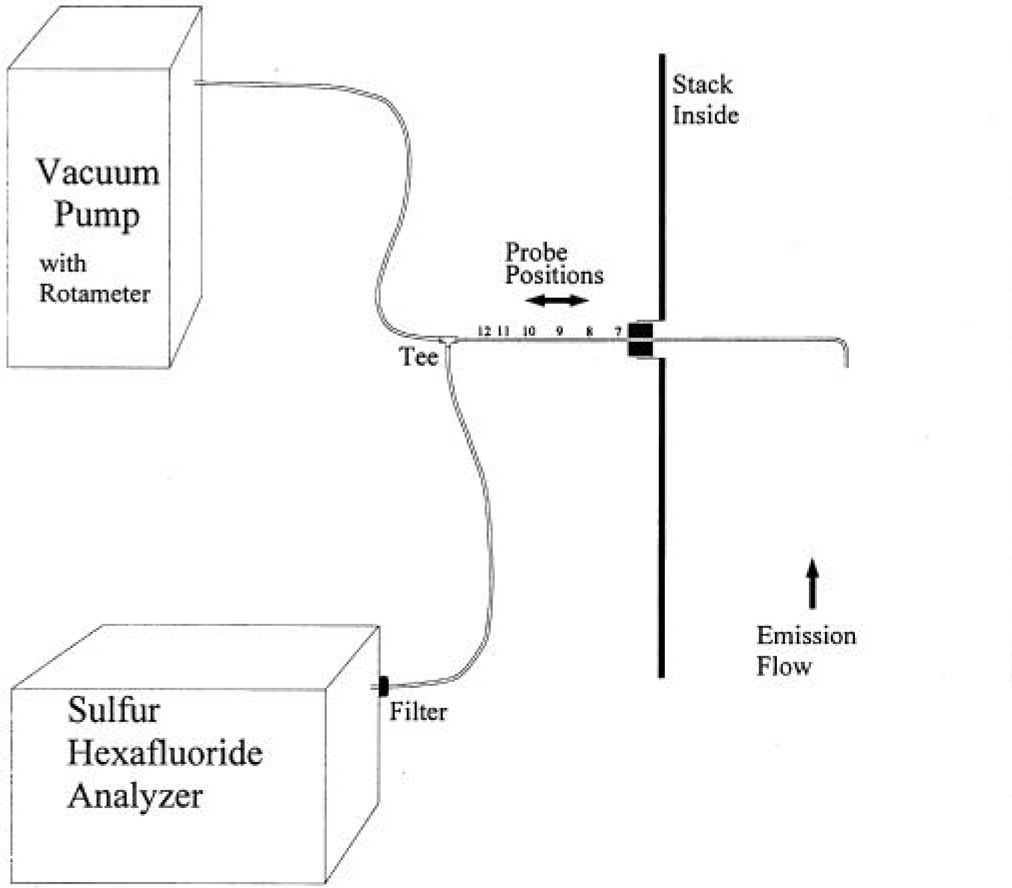


Exhibit C – Example EXCEL Data Sheet

TRACER GAS TRAVERSE DATA FORM

Site		Run No.			
Date		Injection point			
Tester		Fan Setting	Hz		
Stack Dia.	27.25 in.	Stack Temp	deg F		
Stack X-Area	583.2 in.	Start/End Time			
Elevation		Center 2/3 from	2.50	to:	24.75
El. above disturbance	in.	Points in Center 2/3	3	to:	10
Concentration units	ppm SF_6				

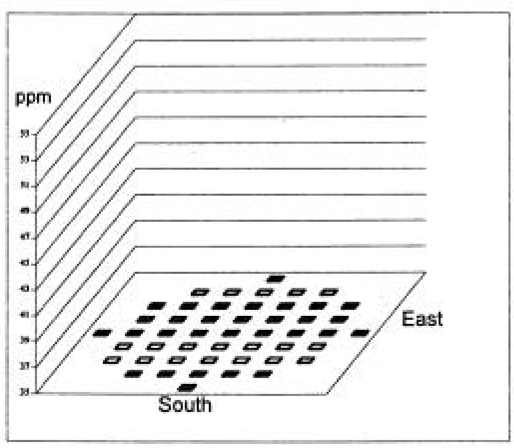
Traverse-->		East				South			
Trial --->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.
1	1.00								
2	1.83								
3	3.22								
4	4.82								
5	6.81								
6	9.70								
Center	13.63								
7	17.55								
8	20.44								
9	22.43								
10	24.03								
11	25.42								
12	26.25								
		West				North			
Traverse Averages ---------->									

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

	Start	Finish	
Tracer tank pressure			psig
Ambient Temp			F
Centerline vel.			fpm
Record stack flow			fpm
Injection flowmeter			lpm [glass ball in meter]
Sampling flowmeter			lpm Sierra
Ambient pressure			mm Hg
Ambient humidity			RH
B&K vapor correction			Y/N
Back-Gd gas level			ppm
No. Bk-Gd samples			n

Gas analyzer checked ____________________

Notes: ____________________



Notes: ____________________

Instuments Used:

Solomat Zephyr #12951472

B & K Model 1302 #1765299

Sierra Inc. Constant Flow Air Sampler

Signing/dating signifies compliance with sections 6.1.1-6.5.5 in the PNNL Procedure No. EMS-JAG-01 (11/10/98).

Signature/Date:

Attachment A – Illustrative Test Instruction.

Test Instruction

Project: Canister Storage Stack Qualification, 29303	Date: November 10, 1998	Work Package: K97052

Tests: Tracer Gas Uniformity of Full-Scale Stack

Staff: David Maughan, John Glissmeyer

Reference Procedures:

1. Procedure EMS-JAG-01, Rev. 0, Test to Determine Uniformity of a Tracer Gas at a Sampler Probe, Nov. 10, 1998
2. Operating Manual for Bruel and Kjaer Model 1302 Gas Analyzer

Equipment:

1. Canister Storage Stack and inspected work platforms
2. Sulfur hexafluoride gas (pure and calibration gas), regulator, control valve, rotameter, injection probe (¼ in. OD × 36 in. long stainless tubing), and tubing
3. Bruel and Kjaer Model 1302 Gas Analyzer, probe, vacuum pump, fittings

Safety Considerations:

Review and observe the applicable Duke Job Hazard Analysis for the project

Instructions:

1. Verify training on the procedure and verify that instrumentation is within calibration
2. Weigh the tracer cylinder before shipment to jobsite
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 of 9000 (2232 fpm)
7. Set the injection flowrate at about 0.76 lpm for a tracer concentration of ~ 3 ppm
8. Set the sampler flowrate at approximately 10 lpm
9. Conduct one or more tracer 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 should be at the fittings provided on the rectangular discharge of the fan. Left and right are from the point of view of the fan looking toward the stack)
10. Record data on copies of the attached data sheet
11. Repeat the test with the worst case result two additional times
12. Diagram mounting fixtures and retain assembly for any subsequent re-tests
13. Weigh the tracer gas cylinder after these tests

Desired Completion Date: 11/20/98

Approvals: ______________________________ ____________

John Glissmeyer, Project Manager   Date

Test completed by: Date:

Test Instruction

Project: W460 Stack Sampler Qualification	Date: July 26, 2001	Work Package: **14752**

Tests: Tracer Gas Uniformity of W460 Stack

Staff: John Glissmeyer, Dan Edwards, David Maughan

Reference Procedures:

1. Procedure EMS-JAG-01, Rev. 1, *Test to Determine Uniformity of a Tracer Gas at a Sampler Probe*, May 26, 2000
2. Operating Manual for Bruel and Kjaer Model 1302 Gas Analyzer

Equipment:

1. W460 Stack and inspected work platforms
2. Sulfur hexafluoride gas (pure and calibration gas), regulator, control valve, rotameter, injection probe, and tubing. Injection occurs in transition duct between damper and stack inlet. The near wall injection points are within 2.4 in. (25% of hydraulic diameter) of corner of transition duct wall (based on an 8 x 12 inch rectangle). That is within 2.3 inches along the 8 inch side and 4.3 inches along the 12 inch side. Size injection probe accordingly.
3. Bruel and Kjaer Model 1302 Gas Analyzer, probe, vacuum pump, fittings

Safety Considerations:

Observe the applicable Job Hazard Analysis for the project

Instructions:

1. Verify training on the procedure and verify that instrumentation is within calibration
2. Weigh the tracer cylinder before shipment to jobsite
3. Obtain climatic information from the Hanford Weather Service, phone 373-2716 or http://etd.pnl.gov:2080/HMS/lastob.htm
4. Mark the completion of each step on the field copy of the procedure. Mark-out those steps not applicable to this stack.
5. Install equipment as directed in the procedures
6. Mark sampling probe for the measurement points shown on the data sheet
7. Verify that stack flow is about 1500 cfm ± 200 cfm
8. Set the injection flowrate at about 0.05 lpm (reads about 0.13 lpm on an air rotameter when corrected for gas density) for a tracer concentration of ~ 1 ppm
9. Set the sampler flowrate at approximately 10 lpm
10. Conduct one or more tracer mixing tests at the following sets of conditions:

Stack Flow	Injection point at duct from fan to stack
Normal	Centerline and top-west, bottom-west, top-east, bottom-east corners.

(The injection plane should be at the fittings provided on the transition between the gravity damper and the inlet of the stack on the south side.)

11. Record data on copies of the attached data sheet
12. Repeat the test with the worst case result
12. Diagram mounting fixtures and retain assembly for any subsequent re-tests
13. Record the weight of the tracer gas cylinder after these tests

Desired Completion Date: 8/7/01

Approvals: John Glissmeyer   7/31/01
John Glissmeyer   Date

Test completed by: John Glissmeyer   Date: 8/8/01

INDEPENDENT TECHNICAL REVIEW RECORD

PACIFIC NORTHWEST NATIONAL LABORATORIES INDEPENDENT TECHNICAL REVIEW RECORD	DOCUMENT NO.: Calculation of Gas Tracer Uniformity Characteristics for the W460 Stack, Runs GT-1 to 7	Page 1 of 2

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 call John Glissmeyer, 376-8552, cell 531-8006. Comments Due: 8/ 20 /2001

Additional Information: (Scope of Review, etc) Please verify the following:

1. Transfer of field data to spreadsheet (all runs)
2. Calculation of intermediate mean concentration values per traverse (one per port) and measurement point (1st and last points per port) for the first and last runs.
3. Calculation of port and overall mean concentration, standard deviation, and %COV for the center 2/3 of stack area in first and last runs.
4. Calculation of grand mean and maximum deviation of mean for all measurement points in first and last runs.
5. Calculation of normalized concentration data (2 points) for plotting in the first and last runs.
6. Verify orientation of plotted bars in the first and last runs.
7. Verify consistency of equations in intermediate runs by inspection of spreadsheet in software form.

Organization/Department	Designated Reviewer: Tim Jarvis	Signature/Date
Multimedia Exposure Assessment Group		[signature] 16 Aug 2001

CONCUR [ ]	CONCUR, WITH COMMENTS [X]	DO NOT CONCUR [ ]	NOT REVIEWED [ ]

Comt. No.	Comment and/ or Recommendation:	Resolution:
1	GT-1 - TRANSCRIPTION CHECK (@100%) BOX VAPOR CORRECTION - FINISH - FIELD SHEET APPEARS TO HAVE VALUE 'N', COMPUTER SHEET HAS VALUE 'Y'! ORIGINAL FIELD SHEET NEEDS TO BE CHECKED. NO ERRORS NOTED IN CALCULATION CHECK (@30%) OR EDITORIAL CHECK (@ 100%).	1 - Changed both start and finished indications to N. Vapor correction was switched on, but water content was not being measured, so vapor correction was effectively OFF. This was corrected on the next run. It made no discernible difference because humidity was low.
2	GT-2, GT-3: NO ERRORS NOTED IN TRANSCRIPTION CHECK (@100%), CALCULATION CHECK (@ 30%) OR EDITORIAL CHECK (@100%)	- NO RESOLUTION REQUIRED

PACIFIC NORTHWEST	DOCUMENT NO.:	

NATIONAL LABORATORIES INDEPENDENT TECHNICAL REVIEW RECORD	Calculation of Gas Tracer Uniformity Characteristics for the W460 Stack, Runs GT-1 to 7	Page 2 of 2

Comt. No.	Comment and/ or Recommendation:	Resolution:
3	GT-4: TRANSCRIPTION CHECK (@ 100%) 'BACK-GD GAS LEVEL - FINISH - LAST ENTRY FIELD SHEET HAS VALUE '12'; COMPUTER SHEET HAS VALUE '1'. No. BK-GD SAMPLES - FINISH FIELD SHEET HAS VALUE '5'; COMPUTER SHEET HAS VALUE '6'. • NO ERRORS NOTED IN CALCULATION CHECK, OR EDITORIAL CHECK.	3. Reduced font size so all values shown. Six readings were recorded on field sheet.
4	GT-05, GT-06: NO ERRORS NOTED FOR TRANSCRIPTION CHECK (@ 100%) CALCULATION CHECK (@ 30%), OR EDITORIAL CHECK (@ 100%)	
5	GT-07: TRANSCRIPTION CHECK (@ 100%) • SAMPLE PORT TEMP - FINISH - FIELD SHEET HAS VALUE '86'. COMPUTER SHEET HAS VALUE '92'. • CENTER LINE VEL. - START; FIELD SHEET HAS NO VALUE. COMPUTER SHEET HAS VALUE '221'. • INJECTION FLOWMETER - START AND FINISH. FIELD SHEET HAS NO VALUES. COMPUTER SHEET HAS VALUES '4' AND '4', RESPECTIVELY. NO ERRORS NOTED FOR CALCULATION CHECK (@ 30%) OR EDITORIAL CHECK (@ 100%).	5- Corrected to 86 Corrected to N.A. Corrected to agree with field data sheet.
Concur with Resolution [signature] Date 7/31/01		Comments Resolved By [signature] Date 5/27/01

PACIFIC NORTHWEST NATIONAL LABORATORIES INDEPENDENT TECHNICAL REVIEW RECORD	DOCUMENT NO.: Calculation of Gas analyzer Calibration Check of 8/1/2001.	Page 1 of __

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 call John Glissmeyer, 376-8552, cell 531-8006. Comments Due: 9/ 18 /2001

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.

Organization/Department Multimedia Exposure Assessment Group	Designated Reviewer: Tim Jarvis	Signature/Date 21 SEP 2001

CONCUR [ ]	CONCUR, WITH COMMENTS [X]	DO NOT CONCUR [ ]	NOT REVIEWED [ ]

Comt. No.	Comment and/ or Recommendation:	Resolution:
1	TRANSCRIPTION VALIDATION -	
	- LEFT COLUMN TOP: "w/ STARTING Po" SHOULD BE "w/ STARTING Pof"	- Reformatted cells
	- SUGGEST CHANGING "END PRESS" TO "END PRESSURE"	- No RESPONSE REQUIRED
	- RIGHT COLUMN DATA ON CALIBRATION READINGS. FIELD SHEET HAS "5" ENTRIES FOR PPM COMPENSATING FOR WATER VAPOR. THE COMPUTER SHEET HAS "6" ENTRIES.	- Deleted extra entry
2	MATH VALIDATION - NO ERRORS DETECTED.	- No Response Required.

Sulfur hexafluoride Gas Calibration performed on B&K on 8/1/01 **by** John Glissmeyer

John Glissmeyer 8/1/01

Setup details: B&K sample inlet tube = 6 ft
997.5 mbar station pressure, analyzer corrects to 20 deg C

21 ppm SF_6 +/- 5% standard

Cylinder: FF18781 w/ starting P of 1200 psi

B&K Calibration readings: (ppm)	End press	1200 psi
22.4	Compensating for water vapor	
22.5		
22.5		
22.5		
22.5		
22.5	Not compensating for water vapor	
22.5		
22.5		
22.6		
22.5	= avg	

1.1 ppm SF_6 +/- 10% standard

Cylinder: FF18763 w/ starting P of 850
end P = 650

B&K Calibration readings: (ppm)	
1.13	Compensating for water vapor
1.13	
1.13	
1.13	
1.13	
1.13	Not compensating for water vapor
1.12	
1.13	
1.12	
1.13	= avg

Pre-Test Room background

0.0367	Not compensating for water vapor
0.038	
0.0145	Compensating for water vapor
0.0117	
0.0122	
0.0126	
0.0121	

TRACER GAS TRAVERSE DATA FORM

Site	W460 Stack	Run No.	GT-1
Date	8/7/01	Injection Point	Center
Tester	Maughan/Glissmeyer	Fan Setting	48 Hz
Stack Dia.	15.25 in.	Stack Temp	89 deg F
Stack X-Area	182.7 in.2	Start/End Time	1540/1640
Elevation	N.A.	Center 2/3 from	1.40 to: 13.85
Distance to disturbance	189 inches	Points in Center 2/3	2 to: 7
Measurement units	ppm SF6	Data Files:	W4608ptgas.xls

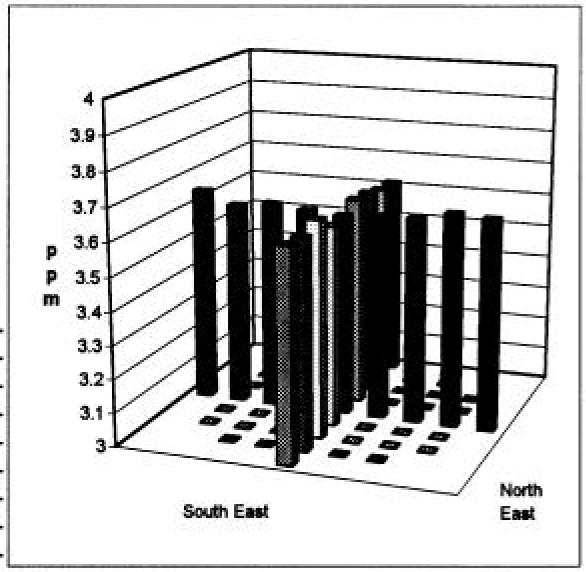
Traverse-->		NorthEast				SouthEast			
Trial --->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppm				ppm			
1	0.50	3.58	3.69	3.63	3.633	3.51	3.57	3.54	3.540
2	1.60	3.63	3.72	3.57	3.640	3.52	3.55	3.53	3.533
3	2.96	3.63	3.69	3.53	3.617	3.59	3.54	3.54	3.557
4	4.93	3.66	3.62	3.56	3.613	3.52	3.52	3.50	3.513
Center	7.63	3.66	3.61	3.55	3.607	3.50	3.53	3.52	3.517
5	10.32	3.64	3.68	3.52	3.613	3.56	3.55	3.51	3.540
6	12.29	3.65	3.69	3.53	3.623	3.52	3.56	3.53	3.537
7	13.65	3.66	3.67	3.50	3.610	3.51	3.54	3.52	3.523
8	14.75	3.73	3.68	3.53	3.647	3.55	3.49	3.52	3.520
Averages ----------->		3.65	3.67	3.55	3.623	3.531	3.539	3.523	3.531

All	ppm	Dev. from mean	*Center 2/3*	NE	SE	All
Mean	3.577		Mean	3.618	3.531	3.575
Min Point	3.513	-1.8%	Std. Dev.	0.011	0.015	0.046
Max Point	3.647	2.0%	COV as %	0.309	0.425	1.301

Avg. Conc. 3.579 ppm

Gas analyzer checked: 8/1/01

	Start	Finish	
Tracer tank pressure	280	280	psig
Sample Port Temp	89	89	F fpm
Centerline vel.	1414	1389.0	fpm
Injection flowmeter	5	5	black ball**
Stack flow	1733	1733	cfm
Sampling flowmeter	10	10	lpm Sierra
Ambient pressure	743.6	742.4	mm Hg
Ambient humidity	27.0	24.0	RH
B&K vapor correction	N	N	Y/N
Back-Gd gas level	15,9,12,13,8	16,29,20,19	ppb
No. Bk-Gd samples	5	4	n



Instuments Used:

B & K Model 1302 #1765299 User Cal Check

Sierra Inc. Constant Flow Air Sampler

Solomat Zephyr SN 14714 Cal due 7/26/02

Notes:

** The rotameter tube has both a steel and glass float.

The black ball is the glass float.

Signature signifies compliance with Procedure EMS-JAG-01 Signature/date (on field data form)	Signature verifying data and calculations: 21SEP2001

W4608ptgas.xls GT-1 9/14/01

TRACER GAS TRAVERSE DATA FORM

Site	W460 Stack	Run No.	GT-2		
Date	8/7/01	Injection Point	Bottom East		
Tester	Maughan/Glissmeyer	Fan Setting	48 Hz		
Stack Dia.	15.25 in.	Stack Temp	89 deg F		
Stack X-Area	182.7 in.2	Start/End Time	1650/1750		
Elevation	N.A.	Center 2/3 from	1.40	to:	13.85
Distance to disturbance	189 inches	Points in Center 2/3	2	to:	7
Measurement units	ppm SF6	Data Files:	W4608ptgas.xls		

Traverse-->		NorthEast				SouthEast			
Trial --->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppm				ppm			
1	0.50	3.11	3.09	3.14	3.113	3.11	3.17	3.13	3.137
2	1.60	3.22	3.10	3.14	3.153	3.12	3.08	3.17	3.123
3	2.96	3.11	3.11	3.12	3.113	3.14	3.15	3.14	3.143
4	4.93	3.10	3.13	3.15	3.127	3.15	3.11	3.10	3.120
Center	7.63	3.09	3.12	3.15	3.120	3.09	3.13	3.13	3.117
5	10.32	3.11	3.12	3.12	3.117	3.08	3.12	3.15	3.117
6	12.29	3.11	3.13	3.11	3.117	3.13	3.11	3.14	3.127
7	13.65	3.16	3.13	3.10	3.130	3.09	3.16	3.16	3.137
8	14.75	3.17	3.09	3.16	3.140	3.10	3.09	3.11	3.100
Averages --------->		3.13	3.11	3.13	3.126	3.112	3.124	3.137	3.124

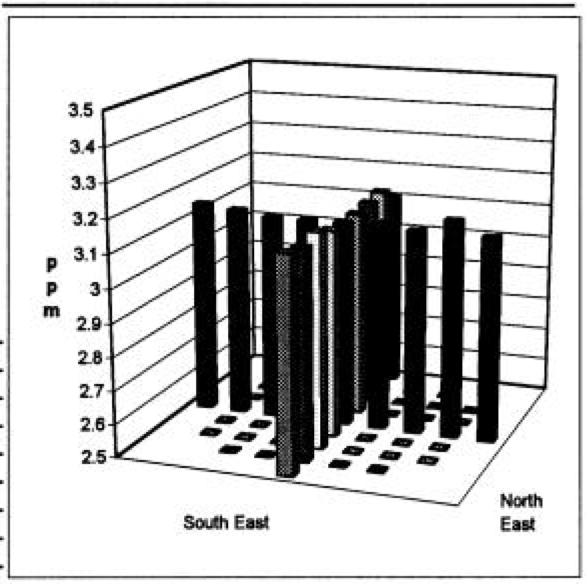
All	ppm	Dev. from mean	***Center 2/3***	NE	SE	All
Mean	3.125		Mean	3.125	3.126	3.126
Min Point	3.100	-0.8%	Std. Dev.	0.014	0.010	0.012
Max Point	3.153	0.9%	COV as %	0.439	0.328	**0.373**

Avg. Conc. 3.126 ppm

Gas analyzer checked: 8/1/01

	Start	Finish	
Tracer tank pressure	280	280	psig
Sample Port Temp	89	91	F
Centerline vel.	1389	1361.0	fpm
Injection flowmeter	5	5	black ball**
Stack flow	1733	1733	cfm
Sampling flowmeter	10	10	lpm Sierra
Ambient pressure	742.4	742.0	mm Hg
Ambient humidity	24.0	20.0	RH
B&K vapor correction	Y	Y	Y/N
Back-Gd gas level	16,29,20,19	20,18,12,23	ppb
No. Bk-Gd samples	4	4	n

fpm



Instuments Used:

B & K Model 1302 #1765299 User Cal Check

Sierra Inc. Constant Flow Air Sampler

Solomat Zephyr SN 14714 Cal due 7/26/02

Notes:

** The rotameter tube has both a steel and glass float.

The black ball is the glass float.

Signature signifies compliance with Procedure EMS-JAG-01 Signature/date (on field data form)	Signature verifying data and calculations: 24 SEP 2001

W4608ptgas.xls GT-2 9/14/01

TRACER GAS TRAVERSE DATA FORM

Site	W460 Stack	Run No.	GT-3
Date	8/7/01	Injection Point	**Bottom West**
Tester	Maughan/Glissmeyer	Fan Setting	**48** Hz
Stack Dia.	15.25 in.	Stack Temp	91 deg F
Stack X-Area	182.7 in.2	Start/End Time	1758/1855
Elevation	N.A.	Center 2/3 from	1.40 to: 13.85
Distance to disturbance	189 inches	Points in Center 2/3	2 to: 7
Measurement units	ppm SF6	Data Files:	W4608ptgas.xls

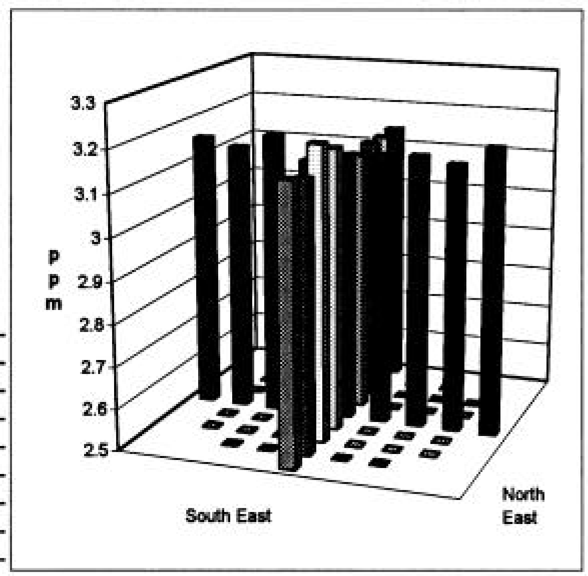
Traverse-->		NorthEast				SouthEast			
Trial --->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppm				ppm			
1	0.50	3.12	3.22	3.20	3.181	3.13	3.14	3.13	3.133
2	1.60	3.10	3.10	3.21	3.137	3.11	3.12	3.12	3.117
3	2.96	3.16	3.12	3.17	3.150	3.14	3.23	3.16	3.177
4	4.93	3.08	3.21	3.15	3.147	3.14	3.14	3.17	3.150
Center	7.63	3.14	3.14	3.14	3.140	3.12	3.10	3.13	3.117
5	10.32	3.10	3.16	3.10	3.120	3.10	3.09	3.11	3.100
6	12.29	3.10	3.17	3.25	3.173	3.11	3.13	3.09	3.111
7	13.65	3.09	3.17	3.16	3.140	3.08	3.12	3.13	3.110
8	14.75	3.18	3.08	3.21	3.157	3.09	3.12	3.13	3.113
Averages ---------->		3.12	3.15	3.18	3.149	3.113	3.133	3.130	3.125

All	ppm	Dev. from mean	***Center 2/3***	NE	SE	All
Mean	3.137		Mean	3.144	3.126	3.135
Min Point	3.100	-1.2%	Std. Dev.	0.016	0.027	0.023
Max Point	3.181	1.4%	COV as %	0.514	0.874	**0.749**

Avg. Conc. 3.138 ppm

Gas analyzer checked: 8/1/01

	Start	Finish	
Tracer tank pressure	280	250	psig
Sample Port Temp	91	89	F fpm
Centerline vel.	1361	1388.0	fpm
Injection flowmeter	5	4	black ball**
Stack flow	1733	1733	cfm
Sampling flowmeter	10	10	lpm Sierra
Ambient pressure	742.0	741.7	mm Hg
Ambient humidity	20.0	21.0	RH
B&K vapor correction	Y	y	Y/N
Back-Gd gas level	20,18,12,23	30,30,24,25	ppb
No. Bk-Gd samples	4	4	n



Instuments Used:

B & K Model 1302 #1765299 User Cal Check

Sierra Inc. Constant Flow Air Sampler

Solomat Zephyr SN 14714 Cal due 7/26/02

Notes:

** The rotameter tube has both a steel and glass float.

The black ball is the glass float.

Signature signifies compliance with Procedure EMS-JAG-01 Signature/date (on field data form)	Signature verifying data and calculations: 24SEP2001

W4608ptgas.xls GT-3 9/14/01

TRACER GAS TRAVERSE DATA FORM

Site	W460 Stack	Run No.	GT-4
Date	8/8/01	Injection Point	Top East
Tester	Maughan/Glissmeyer	Fan Setting	48 Hz
Stack Dia.	15.25 in.	Stack Temp	91 deg F
Stack X-Area	182.7 in.2	Start/End Time	1124/1227
Elevation	N.A.	Center 2/3 from	1.40 to: 13.85
Distance to disturbance	189 inches	Points in Center 2/3	2 to: 7
Measurement units	ppm SF6	Data Files:	W4608ptgas.xls

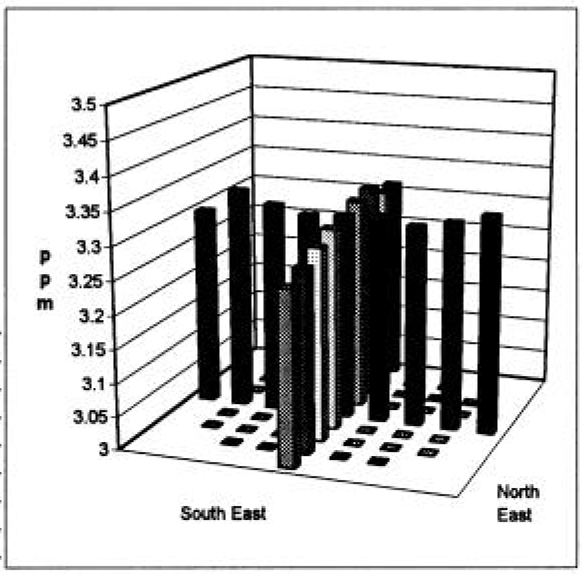
Traverse-->		NorthEast				SouthEast			
Trial --->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppm				ppm			
1	0.50	3.15	3.17	3.11	3.143	3.06	3.37	3.35	3.260
2	1.60	3.12	3.15	3.12	3.130	3.12	3.38	3.32	3.273
3	2.96	3.13	3.12	3.11	3.120	3.22	3.34	3.31	3.290
4	4.93	3.15	3.10	3.14	3.130	3.28	3.36	3.27	3.303
Center	7.63	3.10	3.15	3.13	3.127	3.29	3.35	3.29	3.310
5	10.32	3.12	3.14	3.11	3.123	3.31	3.38	3.27	3.320
6	12.29	3.11	3.16	3.13	3.133	3.30	3.42	3.26	3.327
7	13.65	3.14	3.16	3.15	3.150	3.30	3.40	3.23	3.310
8	14.75	3.12	3.11	3.12	3.117	3.31	3.37	3.25	3.310
Averages ----------->		3.13	3.14	3.12	3.130	3.243	3.374	3.283	3.300

All	ppm	Dev. from mean	***Center 2/3***	NE	SE	All
Mean	3.215		Mean	3.130	3.305	3.218
Min Point	3.117	-3.1%	Std. Dev.	0.010	0.018	0.092
Max Point	3.327	3.5%	COV as %	0.310	0.549	**2.844**

Avg. Conc. 3.215 ppm

Gas analyzer checked: 8/1/01

	Start	Finish	
Tracer tank pressure	250	250	psig
Sample Port Temp	91	92	F fpm
Centerline vel.	1377	1380.0	fpm
Injection flowmeter	5	5.5	black ball**
Stack flow	1733	1733	cfm
Sampling flowmeter	10	10	lpm Sierra
Ambient pressure	746.0	745.3	mm Hg
Ambient humidity	21.0	18.0	RH
B&K vapor correction	Y	Y	Y/N
Back-Gd gas level	17,10,13,16	43,34,27,27,28,12	ppb
No. Bk-Gd samples	4	6	n



Instuments Used:

B & K Model 1302 #1765299 User Cal Check

Sierra Inc. Constant Flow Air Sampler

Solomat Zephyr SN 14714 Cal due 7/26/02

Notes:

** The rotameter tube has both a steel and glass float.

The black ball is the glass float.

Signature signifies compliance with Procedure EMS-JAG-01 Signature/date (on field data form)	Signature verifying data and calculations: 24SEP2001

W4608ptgas.xls GT-4 9/14/01

TRACER GAS TRAVERSE DATA FORM

Site	W460 Stack	Run No.	GT-5
Date	8/8/01	Injection Point	Top West
Tester	Maughan/Glissmeyer	Fan Setting	48 Hz
Stack Dia.	15.25 in.	Stack Temp	92 deg F
Stack X-Area	182.7 in.2	Start/End Time	1240/1345
Elevation	N.A.	Center 2/3 from	1.40 to: 13.85
Distance to disturbance	189 inches	Points in Center 2/3	2 to: 7
Measurement units	ppm SF6	Data Files:	W4608ptgas.xls

Traverse-->		NorthEast				SouthEast			
Trial --->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppm				ppm			
1	0.50	3.81	3.85	3.82	3.827	3.99	3.88	3.90	3.923
2	1.60	3.86	3.82	3.76	3.813	3.98	3.87	3.86	3.903
3	2.96	3.83	3.80	3.76	3.797	3.93	3.90	3.90	3.910
4	4.93	3.82	3.84	3.80	3.820	3.92	3.86	3.83	3.870
Center	7.63	3.78	3.88	3.71	3.790	3.91	3.81	3.90	3.873
5	10.32	3.88	3.83	3.73	3.813	3.87	3.87	3.84	3.860
6	12.29	3.87	3.81	3.76	3.813	3.87	3.87	3.81	3.850
7	13.65	3.85	3.84	3.71	3.800	3.84	3.88	3.81	3.843
8	14.75	3.83	3.79	3.77	3.797	3.86	3.85	3.85	3.853
Averages ---------->		3.84	3.83	3.76	3.808	3.908	3.866	3.856	3.876

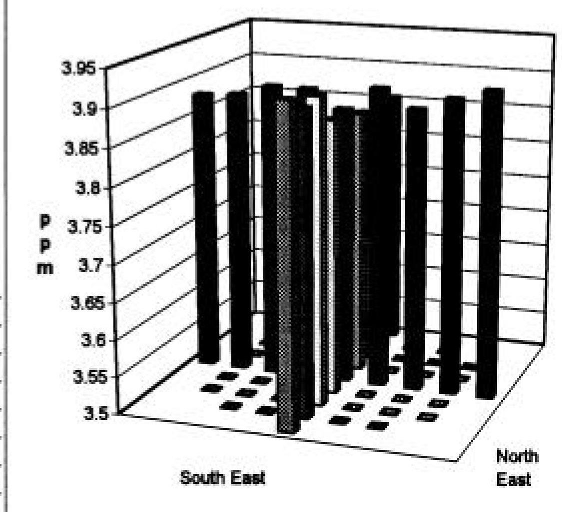
All	ppm	Dev. from mean	*Center 2/3*	NE	SE	All
Mean	3.842		Mean	3.807	3.873	3.840
Min Point	3.790	-1.4%	Std. Dev.	0.011	0.025	0.039
Max Point	3.923	2.1%	COV as %	0.290	0.656	**1.020**

Avg. Conc. 3.843 ppm

Gas analyzer checked: 8/1/01

	Start	Finish	
Tracer tank pressure	250	250	psig
Sample Port Temp	92	92	F
Centerline vel.	1380	1391.0	fpm
Injection flowmeter	10	7	black ball**
Stack flow	1733	1733	cfm
Sampling flowmeter	10	10	lpm Sierra
Ambient pressure	745.3	744.2	mm Hg
Ambient humidity	18.0	16.0	RH
B&K vapor correction	Y	Y	Y/N
Back-Gd gas level	27,27,28,12	39,24,24,20	ppb
No. Bk-Gd samples	4	4	n

fpm



Instuments Used:

B & K Model 1302 #1765299 User Cal Check

Sierra Inc. Constant Flow Air Sampler

Solomat Zephyr SN 14714 Cal due 7/26/02

Notes:

** The rotameter tube has both a steel and glass float.

The black ball is the glass float.

Signature signifies compliance with Procedure EMS-JAG-01 Signature/date (on field data form)	Signature verifying data and calculations 24SEP2001

W4608ptgas.xls GT-5 9/14/01

TRACER GAS TRAVERSE DATA FORM

Site	W460 Stack	Run No.	GT-6		
Date	8/8/01	Injection Point	Top East		
Tester	Maughan/Glissmeyer	Fan Setting	48 Hz		
Stack Dia.	15.25 in.	Stack Temp	92 deg F		
Stack X-Area	182.7 in.2	Start/End Time	1420/1530		
Elevation	N.A.	Center 2/3 from	1.40	to:	13.85
Distance to disturbance	189 inches	Points in Center 2/3	2	to:	7
Measurement units	ppm SF6	Data Files:	W4608ptgas.xls		

Traverse-->		NorthEast				SouthEast			
Trial --->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppm				ppm			
1	0.50	4.44	4.51	4.49	4.480	4.42	4.39	4.49	4.433
2	1.60	4.45	4.47	4.49	4.470	4.44	4.39	4.51	4.447
3	2.96	4.48	4.47	4.49	4.480	4.39	4.38	4.48	4.417
4	4.93	4.50	4.48	4.50	4.493	4.44	4.39	4.51	4.447
Center	7.63	4.51	4.43	4.43	4.457	4.46	4.41	4.50	4.457
5	10.32	4.49	4.44	4.43	4.453	4.46	4.39	4.52	4.457
6	12.29	4.48	4.44	4.43	4.450	4.42	4.43	4.51	4.453
7	13.65	4.51	4.42	4.46	4.463	4.42	4.41	4.47	4.433
8	14.75	4.51	4.48	4.44	4.477	4.41	4.50	4.49	4.467
Averages ----------->		4.49	4.46	4.46	4.469	4.429	4.410	4.498	4.446

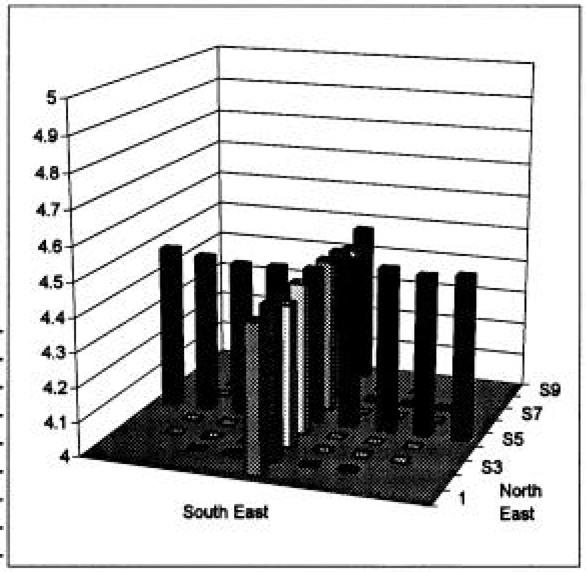
All	ppm	Dev. from mean	Center 2/3	NE	SE	All
Mean	4.457		Mean	4.467	4.444	4.455
Min Point	4.417	-0.9%	Std. Dev.	0.016	0.015	0.019
Max Point	4.493	0.8%	COV as %	0.350	0.329	**0.418**

Avg. Conc. 4.458 ppm

Gas analyzer checked: 8/1/01

	Start	Finish	
Tracer tank pressure	250	250	psig
Sample Port Temp	92	92	F
Centerline vel.	1391	1444.0	fpm
Injection flowmeter	10	10	black ball**
Stack flow	1733	1733	cfm
Sampling flowmeter	10	10 - 11	lpm Sierra
Ambient pressure	744.2	743.3	mm Hg
Ambient humidity	16.0	14.0	RH
B&K vapor correction	Y	Y	Y/N
Back-Gd gas level	39,24,24,20	48,39,33,34	ppb
No. Bk-Gd samples	4	4	n

fpm



Instuments Used:

B & K Model 1302 #1765299 User Cal Check

Sierra Inc. Constant Flow Air Sampler

Solomat Zephyr SN 14714 Cal due 7/26/02

Notes:

** The rotameter tube has both a steel and glass float.
The black ball is the glass float.

Signature signifies compliance with Procedure EMS-JAG-01
Signature/date (on field data form)

Signature verifying data and calculations: 24SEP2001

W4608ptgas.xls GT-6 9/14/01

TRACER GAS TRAVERSE DATA FORM

Site	W460 Stack	Run No.	GT-7
Date	8/8/01	Injection Point	Top East
Tester	Maughan/Glissmeyer	Fan Setting	9.1 Hz
Stack Dia.	15.25 in.	Stack Temp	92 deg F
Stack X-Area	182.7 in.2	Start/End Time	1545/1645
Elevation	N.A.	Center 2/3 from	1.40 to: 13.85
Distance to disturbance	189 inches	Points in Center 2/3	2 to: 7
Measurement units	ppm SF6	Data Files:	W4608ptgas.xls

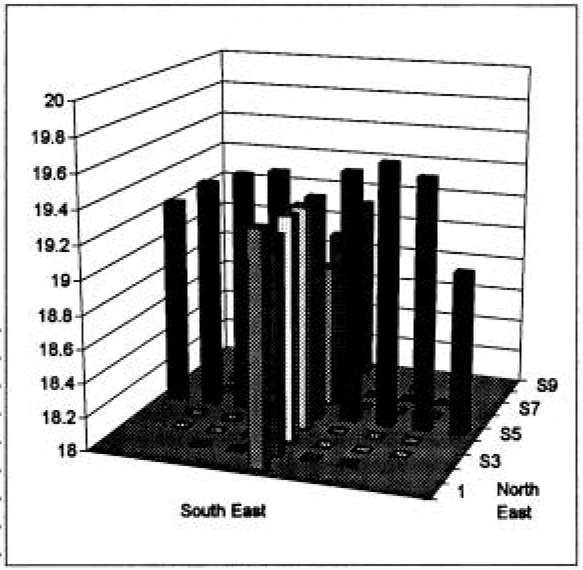
Traverse-->		NorthEast				SouthEast			
Trial --->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppm				ppm			
1	0.50	18.6	18.9	19.4	18.97	19.3	19.1	19.4	19.27
2	1.60	19.6	19.1	19.8	19.50	19.8	18.9	18.8	19.17
3	2.96	19.3	19.9	19.5	19.57	19.6	18.9	19.2	19.23
4	4.93	19.5	19.7	19.3	19.50	19.0	19.3	19.4	19.23
Center	7.63	18.9	19.2	19.9	19.33	19.1	19.4	19.2	19.23
5	10.32	19.5	19.3	19.6	19.47	18.4	18.8	19.1	18.77
6	12.29	19.6	19.2	19.5	19.43	19.1	18.7	18.9	18.90
7	13.65	19.0	19.6	19.5	19.37	19.6	18.8	19.3	19.23
8	14.75	19.4	19.1	19.2	19.23	18.5	19.3	19.2	19.00
Averages ---------->		19.27	19.33	19.52	19.374	19.16	19.02	19.17	19.115

All	ppm	Dev. from mean	*Center 2/3*	NE	SE	All
Mean	19.244		Mean	19.452	19.110	19.281
Min Point	18.767	-2.5%	Std. Dev.	0.081	0.194	0.228
Max Point	19.567	1.7%	COV as %	0.418	1.016	**1.184**

Avg. Conc. 19.240 ppm

Gas analyzer checked: 8/1/01

	Start	Finish	
Tracer tank pressure	250	250	psig
Sample Port Temp	92	86	F fpm
Centerline vel.	N.A.	221	fpm
Injection flowmeter	one unit above steel ball		black ball**
Stack flow	278	278	cfm
Sampling flowmeter	10	10-Jan	lpm Sierra
Ambient pressure	743.3	742.7	mm Hg
Ambient humidity	14.0	14.0	RH
B&K vapor correction	Y	Y	Y/N
Back-Gd gas level	48,39,33,34	27,24,12,13	ppb
No. Bk-Gd samples	4	4	n



Instuments Used:

B & K Model 1302 #1765299 User Cal Check

Sierra Inc. Constant Flow Air Sampler

Solomat Zephyr SN 14714 Cal due 7/26/02

Notes:

** The rotameter tube has both a steel and glass float.

The black ball is the glass float.

Signature signifies compliance with Procedure EMS-JAG-01 Signature/date (on field data form)	Signature verifying data and calculations: 24OCT2001

W4608ptgas.xls GT-7 9/14/01

Appendix E

Uniformity of Tracer Particles

Procedure
Test Instruction
Technical Review
Data Sheets

PNNL Operating Procedure	
Title: Test to Determine Uniformity of a Tracer Aerosol at a Sampler Probe	**Org. Code:** **~~D9T99~~ 77** **Procedure No.:** **EMS-JAG-02** **Rev. No.:** **1**
Work Location: General	**Effective Date:** **May 24, 2000**
Author: John A. Glissmeyer	**Supersedes Date:** **November 10, 1998**
Identified Hazards: ☐ Radiological ☐ Hazardous Materials ■ Physical Hazards ☐ Hazardous Environment ☐ Other:	**Identified Use Category:** ☐ Mandatory Use ☐ Continuous Use ■ Reference Use ☐ Information Use

Are One-Time Modifications Allowed? ■ Yes ☐ No

Person Signing	Signature	Date
Technical review: James L. Huckaby	J L Hy	8/31/00
Project Manager: John Glissmeyer	John Glissmeyer	8/31/00
Line Manager: James Droppo	[illegible]	8/31/00
Concurrence:		
Quality Engineer: Thomas G. Walker	Thomas G Walker	8/31/00

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.

- 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/m^3. 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/m^3 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:

{tc \l3 "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

- 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:

6.1.1 Provide essential supplies at the sampling location (particulate generation equipment, supply air and regulators, fittings and probe-port couplers, marking pens, data sheets, writing and probe-supporting platforms). 8/9/01 JAG

6.1.2 Fill in test information on dataform. 8/9/01 JAG
[DO NOT DELETE THIS ITEM; REQUIRED TEXT.]

6.1.3 Observe the current flow setting for the test stack and record on the data sheet. 8/9/01 JAG

6.1.4 Obtain barometric, temperature, and relative humidity information for the particle counter location. 8/9/01 JAG

6.1.5 Measure the stack centerline air velocity in the sampling plane using a velocity flow meter, and record value on data sheet. 8/9/01 JAG

6.1.6 Mark the sampling probe with a permanent marker so the inlet can be placed at each successive measurement point. 8/9/01 JAG

> **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
> **{tc \l3 "Potential Test Conditions}**

6.1.7 Couple the OPCs and probes to the stack sampling ports according to the illustration in Exhibit A. 8/9/01 JAG

Used mobile OPC only.

Note: The **sampling equipment** consists of stainless steel probes with ¾ outside diameter and thin-wall 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 optical particle counters.

8/9/01 JAG

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

8/9/01 JAG

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

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
- centerline flow velocity for the test stack.

8/9/01 JAG

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

8/9/01 JAG

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

8/9/01 JAG

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

8/9/01 JAG

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.

6.3.7 Perform two additional repetitions of Step 6.3.6. 8/9/01 JAG

6.3.8 Switch the tests to the other direction and repeat steps 6.3.6 and 6.3.7. 8/9/01 JAG

6.3.9 Check the data sheet for completeness. 8/9/01 JAG

6.3.10 Record the final 8/9/01 JAG

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

6.3.11 Shut off the air pressure to the aerosol generator. 8/9/01 JAG

6.3.12 Continue operation of the OPCs for several minutes to purge any remaining test aerosol from the stack. 8/9/01 JAG

6.3.13 Measure the centerline background particulate concentrations at the mobile monitor and record the levels on the data sheet. 8/9/01 JAG
After PT-3
PT-1, PT-2, PT-3 were done consecutively on the same day.

6.3.14 Record any climatic conditions that have changed on the data sheet. 8/9/01 JAG

6.3.15 Measure the final centerline stack velocity flow on the data sheet. 8/9/01 JAG

6.3.16 Record any deviations from the above procedure on the data sheet. 8/9/01 JAG

6.3.17 Repeat steps 6.3.1 to 6.3.16 for each run as indicated in the test instruction. 8/9/01 JAG

6.4 Data Recording and Calculations

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

6.4.1 Review the raw data sheets for completeness. 8/10/01 JAG

6.4.2 Enter the data into the electronic data sheet. 8/10/01 JAG

6.4.3 Calculate the COV for the run. 8/10/01 JAG

> **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. 8/10/01 JAG

> **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. 8/10/01 JAG

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

Exhibits/Attachments

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

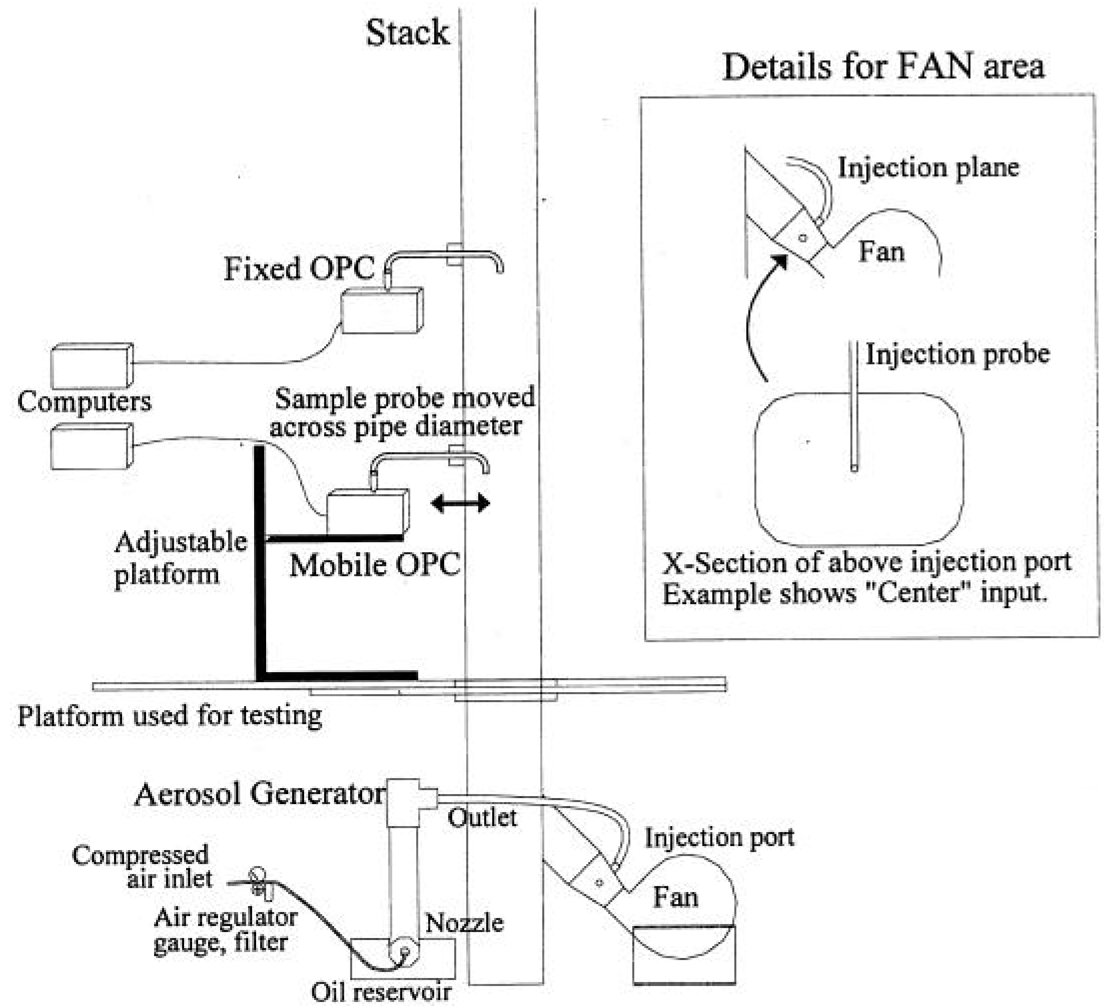


Exhibit B – Illustrative Data Collection Sheet

TRACER GAS TRAVERSE DATA FORM

Site ______________________ Run No. PT- ______________________

Date ______________________ Injection point ______________________

Tester ______________________ Fan Setting __________ Hz

Stack Dia. 28 in. Stack Temp __________ F

Stack X-Area 615.8 in. Center 2/3 from 2.57 to: 25.43

Elevation ______________________ Pts in Center 2/3 3 to: 10

Dirstance to disturbance ______ in. Data Files: ______________________

Conc. units Particles per minute Oil type ______________________

Traverse	Sampling	Aerosol notes:	Start	Finish	
1	4				
2	9	Record Stack flow			cfm
3	12	Ambient Temp			F
4	2	Dispersion air			psi
5	10	Carrier air			psi
6	13	Ambient pressure			mbars
C	1	Ambient humidity			RH
7	3	Stack centerline vel.			fpm
8	7	Back-Gd level (OPC-M)			cpm
9	8	Back-Gd level (OPC-F)			cpm
10	5	No. Bk-Gd samples			n
11	11	OPC-M flowrate			fpm
12	6	OPC-F flowrate			fpm

Traverse	N>S			E>W		
Order	F/M	F/M	F/M	F/M	F/M	F/M
C						
4						
7						
1						
10						
12						
8						
9						
2						
5						
11						
3						
6						

Instuments Used: Cal Exp. Date:

Solomat Zephyr #12951472 (stack center velocity)

OPC- A (M/F:)

OPC - B (M/F:)

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

Signature/Date:

Exhibit C – Illustrative Data Reporting Form

PARTICULATE TRAVERSE DATA REPORT FORM

Site		Run No.	PT-
Date		Injection point	
Tester		Fan Setting	Hz
Stack Dia.	27.25 in.	Stack Temp	F
Stack X-Area	583.2 in.	Center 2/3 from	2.50 to: 24.75
Elevation		Pts in Center 2/3	3 to: 10
Distance to disturbance	in.	Data Files:	
Conc. units	Particles per minute (cpm)	Oil	

Traverse-->		East				South			
Trial --->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.
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								
		West				North			
Traverse Averages ---------->									

Average of all data			
Maximum Positive Deviation	Max Point		
Maximum Negative Deviation	Min Point		

Center 2/3	E/W	S/N	All
Mean			
Std. Dev.			
COV %			

	Start	Finish	
Record stack flow			cfm
Ambient temp			F
Dispersion air			psi
Carrier air			psi
Ambient pressure			mbars
Ambient humidity			RH
Stack centerline vel.			fpm
Bk-Gd level (OPC-M)			cpm
Bk-Gd level (OPC-F)			cpm
No. Bk-Gd samples			n
OPC-M flowrate			fpm
OPC-F flowrate			fpm

Gas analyzer checked

Notes:

Instuments Used:

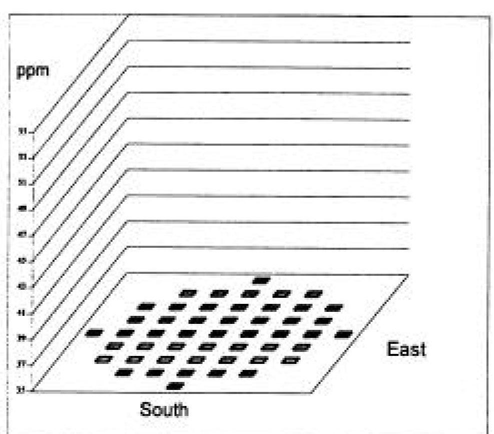
Solomat Zephyr #12951472

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:



Attachment A – Illustrative Test Instructions

Test Instruction

Project: Canister Storage Stack Qualification, 29303	Date: November 10, 1998	Work Package: K97052

Tests: Tracer Gas Uniformity of Full-Scale Stack

Staff: David Maughan, John Glissmeyer

Reference Procedures:

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 (OPC), Model A2408

Equipment:

1. Canister Storage Stack and inspected work platforms
2. Vacuum pump oil, oil mist generator, air lines, regulator, precision pressure gauge
3. Oil mist injection probe,.OPC sample probes, probe/stack couplers
4. OPCs with computers and links
5. Velocity measurement device

Safety Considerations:

Review and observe the applicable Duke Job Hazard Analysis for the project

Instructions:

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 times background for 10-micron particles.
8. Set the sampler flowrate at approximately 10 lpm
9. Conduct one or more tracer mixing tests at the following sets of conditions:

Stack Flow	Injection point at duct from fan to stack
Normal	Centerline

(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, Project Manager Date

Test completed by: Date:

Test Instruction

Project: W460 Stack Sampler Qualification	Date: **July 30, 2001**	Work Package: **F14752**

Tests: Tracer Particle Uniformity of W460 Stack

Staff: John Glissmeyer, Dan Edwards, David Maughan

Reference Procedures:

1. Procedure EMS-JAG-02, Rev. 1, *Test to Determine Uniformity of a Particulate Aerosol at a Sampler*, May 24, 2000
2. Operating Manual for Met-One Optical Particle Counter (OPC), Model A2408

Equipment:

1. W460 Stack and inspected work platforms, compressed air source
2. Vacuum pump oil, oil mist generator, air lines, regulator, precision pressure gauge
3. Oil mist injection probe, OPC sample probes, probe/stack couplers, 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 Analysis for the project

Instructions:

1. Verify training on the procedure and that instrumentation is within calibration
2. Obtain Fisherbrand 19 Mechanical Pump Fluid
1. Obtain climatic information from the Hanford Weather Service, phone 373-2716 or http://etd.pnl.gov:2080/HMS/lastob.htm
2. Mark the completion of each step on the field copy of the procedure. Mark-out those steps not applicable to this stack.
3. Install equipment as directed in the procedures. Only the mobile OPC will be used. The aerosol delivery line should be as vertical as possible to avoid oil accumulation.
4. Use a sliding platform for the OPC and clamp the probe so both the OPC and probe move together.
5. Mark sampling probe for the measurement points shown on the data sheet.
6. Verify that stack flow is about 1500 cfm ± 200 cfm
7. Initially set the injection system input psi at 5 and vary to obtain particle counts at the sampling ports that are about 10 times background for 10-micron particles.
8. Monitor the flowrate on the OPC.
9. Conduct tracer mixing tests at the following sets of conditions:

Stack Flow	Injection point at duct from fan to stack
Normal	Centerline

(The injection plane should be at the fittings provided on the transition between the gravity damper and the inlet of the stack on the south side.)

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: 8/8/01

Approvals: John Glissmeyer — 7/31/01
John Glissmeyer — Date

Test completed by: John Glissmeyer — Date: 8/9/01

INDEPENDENT TECHNICAL REVIEW RECORD

PACIFIC NORTHWEST NATIONAL LABORATORIES INDEPENDENT TECHNICAL REVIEW RECORD	DOCUMENT NO.: Calculation of Particle Tracer Uniformity Characteristics for the W460 Stack, Runs PT-1 to 3	Page 1 of 2

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 call John Glissmeyer, 376-8552, cell 531-8006. Comments Due: 8/ 20 /2001

Additional Information: (Scope of Review, etc) Please verify the following:

1. Transfer of field data to spreadsheet (all runs)
2. Calculation of intermediate mean concentration values per traverse (one per port) and measurement point (1st and last points per port) for one run.
3. Calculation of port and overall mean concentration, standard deviation, and %COV for the center 2/3 of stack for one run.
4. Calculation of grand mean and maximum deviation of mean for all measurement points in one run.
5. Calculation of normalized concentration data (2 points) for plotting in one run.
6. Verify orientation of plotted bars in one run.
7. Verify consistency of equations in runs by inspection of spreadsheet in software form.

Organization/Department	Designated Reviewer: Tim Jarvis	Signature/Date
Multimedia Exposure Assessment Group		[signature] 16 Aug 2001

CONCUR [ ]	CONCUR, WITH COMMENTS [X]	DO NOT CONCUR [ ]	NOT REVIEWED [ ]

Comt. No.	Comment and/ or Recommendation:	Resolution:
	PT-1	
1	– NO ERRORS NOTED IN TRANSCRIPTION CHECK (100%), CALCULATION CHECK (30%) OR EDITORIAL CHECK (100%)	– NO RESOLUTION REQUIRED.
	PT-2	
2	– TRANSCRIPTION CHECK (@ 100%) NOTED AMBIENT HUMIDITY – START VALUES FOR FIELD SHEET IS '14' AND FOR COMPUTER SHEET IS '22.0'. NO ERRORS NOTED FOR CALCULATION CHECK (@ 30%) OR EDITORIAL CHECK (@ 100%).	– Computer sheet changed to value shown on field sheet, i.e., 14. Significant figures on the computer sheet were adjusted.

PACIFIC NORTHWEST	DOCUMENT NO.:	

NATIONAL LABORATORIES INDEPENDENT TECHNICAL REVIEW RECORD	Calculation of Particle Tracer Uniformity Characteristics for the W460 Stack, Runs PT-1 to 3	Page 2 of 2

Comt. No.	Comment and/ or Recommendation:	Resolution:
3	PT-3 TRANSCRIPTION CHECK (@100%) PARTICLES/PT3 - REP 3 - POINT 4 SOUTHEAST. FIELD SHEET VALUE IS 2644, COMPUTER SHEET VALUE IS 2664. NO ERRORS NOTED FOR CALCULATION CHECK (@ 30%) or EDITORIAL CHECK (@ 100%).	transcription error changed on computer sheet to that of field data sheet (2644). also corrected the number of backgd. measurements taken.

Concur with Resolution [illegible signature] Date [illegible] Comments Resolved By [illegible signature] Date 9/14/01

PARTICLE TRACER TRAVERSE DATA FORM

Site	W460 Stack	Run No.	PT-1
Date	8/9/01		
Tester	Glissmeyer/Maughan	Fan Setting	48
Stack Dia.	15.25 in.	Stack Temp	93 deg F
Stack X-Area	182.7 in.2	Start/End Time	1228/1430
Elevation		Center 2/3 from	1.40 to: 13.85
Distance to disturbance	189 in.	Points in Center 2/3	2 to: 7
Measurement units	particles/ft3	Data Files:	W4608ptpart.xls

Traverse-->		NorthEast				SouthEast			
Trial --->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	particles/ft3				particles/ft3			
1	0.50	1058	990	903	983.7	771	701	759	743.7
2	1.60	1078	999	936	1004.3	733	700	750	727.7
3	2.96	1059	974	886	973.0	728	739	706	724.3
4	4.93	995	1000	961	985.3	737	791	801	776.3
Center	7.63	1017	927	940	961.3	783	867	790	813.3
5	10.32	894	971	890	918.3	843	906	838	862.3
6	12.29	950	907	920	925.7	808	879	824	837.0
7	13.65	1103	928	902	977.7	812	931	903	882.0
8	14.75	930	888	930	916.0	835	832	862	843.0
Averages ---------->		1009.3	953.8	918.7	960.6	783.3	816.2	803.7	801.1

All	pt/ft3	Dev. from mean	*Center 2/3*	NE	SE	All	Normlzd
Mean	880.8		Mean	963.7	803.3	883.48	956.56
Min Point	724.3	-17.8%	Std. Dev.	31.4	62.7	95.89	55.18
Max Point	1004.3	14.0%	COV as %	3.3	7.8	10.85	5.77

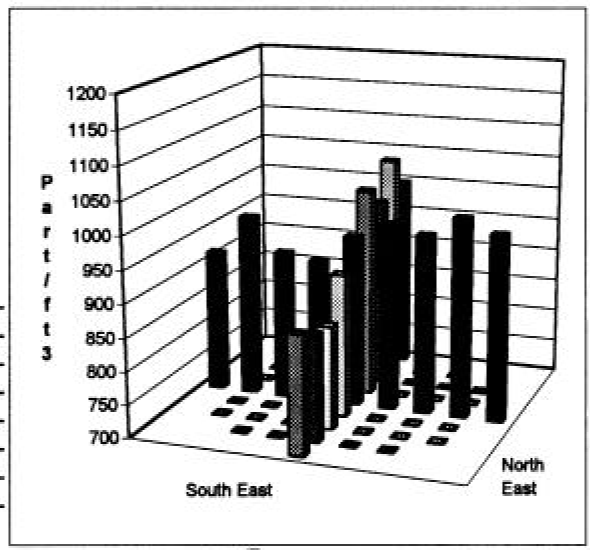
Avg Conc 880 pt/ft3

Instuments Used:

Solmat Zephyr SN 12951472 Cal due 7/26/01

OPC A (9/5/01) MetOne A2408-1 Serial No.96258674

	Start	Finish	
Generator Inlet Press	3	3	psig
Sample Port Temp	93	92	F
Centerline vel.	1424	1371	fpm
Stack flow	278	278	cfm
Ambient pressure	743.3	742.0	mm Hg
Ambient humidity	22	14	RH
Ambient temp		96	F
Back-Gd aerosol	26,17,13,16,6,6	see PT-3	pt/ft3
No. Bk-Gd samples	6		



Optical Particle Counters:(Cal due 9/5/01)

OPC A (9/5/01) MetOne A2408-1 Serial No.96258674

Oil Used: FisherBrand 19

Signature signifies compliance with Procedure EMS-JAG-02 Signature/date (on field data form)

Signature verifying data and calculations:

24SEP2001

W4608ptpart-Aug10.xls PT-1 9/14/01

PARTICLE TRACER TRAVERSE DATA FORM

Site	W460 Stack	Run No.	PT-2
Date	8/9/01		
Tester	Glissmeyer/Maughan	Fan Setting	48
Stack Dia.	15.25 in.	Stack Temp	92 deg F
Stack X-Area	182.7 in.2	Start/End Time	1436/1552
Elevation		Center 2/3 from	1.40 to: 13.85
Distance to disturbance	189 in.	Points in Center 2/3	2 to: 7
Measurement units	particles/ft3	Data Files:	W4608ptpart.xls

Traverse-->		NorthEast				SouthEast			
Trial --->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	particles/ft3				particles/ft3			
1	0.50	833	910	719	820.7	769	795	861	808.3
2	1.60	1097	850	743	896.7	778	766	831	791.7
3	2.96	814	853	756	807.7	833	823	775	810.3
4	4.93	873	771	781	808.3	787	816	771	791.3
Center	7.63	858	736	743	779.0	846	861	869	858.7
5	10.32	855	724	739	772.7	834	910	824	856.0
6	12.29	853	751	781	795.0	875	886	798	853.0
7	13.65	836	737	699	757.3	855	866	795	838.7
8	14.75	844	732	769	781.7	891	864	831	862.0
Averages ---------->		873.7	784.9	747.8	802.1	829.8	843.0	817.2	830.0

All	pt/ft3	Dev. from mean	*Center 2/3*	NE	SE	All	Normlzd
Mean	816.1		Mean	802.4	828.5	815.45	856.48
Min Point	757.3	-7.2%	Std. Dev.	45.6	30.1	39.51	49.25
Max Point	896.7	9.9%	COV as %	5.7	3.6	4.85	5.75

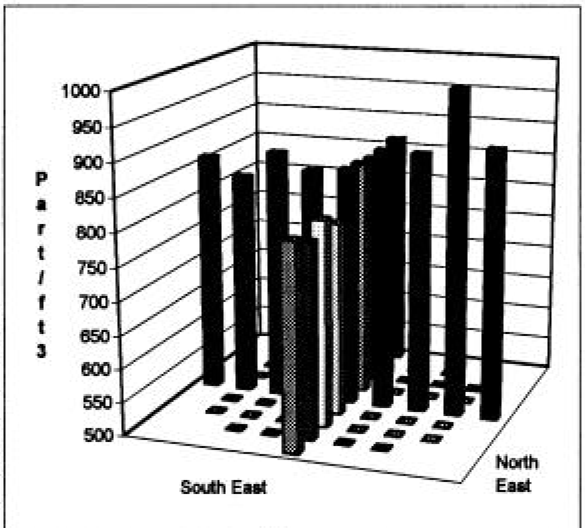
Avg Conc 816 pt/ft3

Instuments Used:

Solmat Zephyr SN 12951472 Cal due 7/26/01

OPC A (9/5/01) MetOne A2408-1 Serial No.96258674

	Start	Finish	
Generator Inlet Press	3	3	psig
Sample Port Temp	93	93	F
Centerline vel.	1424	1657	fpm
Stack flow	278	278	cfm
Ambient pressure	742.0	741.1	mm Hg
Ambient humidity	14	14	RH
Ambient temp	96	97	F
Back-Gd aerosol	recorded in PT1 and PT3		pt/ft3
No. Bk-Gd samples			



Optical Particle Counters:(Cal due 9/5/01)

OPC A (9/5/01) MetOne A2408-1 Serial No.96258674

Oil Used: FisherBrand 19

Signature signifies compliance with Procedure EMS-JAG-02 Signature/date (on field data form)

Signature verifying data and calculations: 24SEP2001

W4608ptpart-Aug10.xls PT-2 9/14/01

PARTICLE TRACER TRAVERSE DATA FORM

Site	W460 Stack	Run No.	PT-3
Date	8/9/01		
Tester	Glissmeyer/Maughan	Fan Setting	9.1
Stack Dia.	15.25 in.	Stack Temp	93 deg F
Stack X-Area	182.7 in.2	Start/End Time	1637/1757
Elevation		Center 2/3 from	1.40 to: 13.85
Distance to disturbance	189 in.	Points in Center 2/3	2 to: 7
Measurement units	particles/ft3	Data Files:	W4608ptpart.xls

Traverse-->		NorthEast				SouthEast			
Trial --->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	particles/ft3				particles/ft3			
1	0.50	3131	2861	2884	2958.7	3049	2813	2536	2799.3
2	1.60	3003	2828	2895	2908.7	2988	2778	2578	2781.3
3	2.96	2976	2839	2863	2892.7	2808	2767	2550	2708.3
4	4.93	2938	2912	2792	2880.7	2885	2900	2644	2809.7
Center	7.63	2865	2869	2903	2879.0	2802	2828	2744	2791.3
5	10.32	3056	2871	2798	2908.3	2889	2510	2471	2623.3
6	12.29	2894	2953	2702	2849.7	2809	2565	2407	2593.7
7	13.65	2939	2900	2724	2854.3	2777	2440	2614	2610.3
8	14.75	3034	2848	2684	2855.3	2789	2587	2589	2655.0
Averages ---------->		2981.8	2875.7	2805.0	2887.5	2866.2	2687.6	2570.3	2708.0

All	pt/ft3	Dev. from mean	*Center 2/3*	NE	SE	All	Normlzd
Mean	2797.8		Mean	2881.9	2702.6	2792.24	2834.68
Min Point	2593.7	-7.3%	Std. Dev.	23.6	93.3	113.72	83.26
Max Point	2958.7	5.8%	COV as %	0.8	3.5	4.07	2.94

Avg Conc 2793 pt/ft3

Instuments Used:

Solmat Zephyr SN 12951472 Cal due 7/26/01

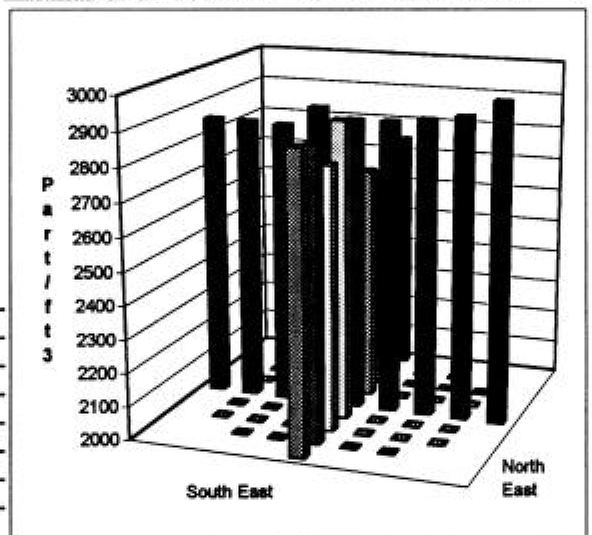
OPC A (9/5/01) MetOne A2408-1 Serial No.96258674

	Start	Finish	
Generator Inlet Press	2	2	psig
Sample Port Temp	90	87	F
Centerline vel.	253	172	fpm
Stack flow	278	278	cfm
Ambient pressure	741.1	740.4	mm Hg
Ambient humidity	14	14	RH
Ambient temp	97	98	F
Back-Gd aerosol	14,5,7,17,15,8,7,6,11		pt/ft3
No. Bk-Gd samples		9	

Optical Particle Counters:(Cal due 9/5/01)

OPC A (9/5/01) MetOne A2408-1 Serial No.96258674

Oil Used: FisherBrand 19



Signature signifies compliance with Procedure EMS-JAG-02 Signature/date (on field data form)	Signature verifying data and calculations: 24SEP2001

W4608ptpart-Aug10.xls PT-3 9/14/01

Appendix F

Calculation of Particle Penetration

Code Output
Configuration Sketch
Technical Review

DEPO 4 RUN 1 FOR NEW W460 STACK
34.7980 MM ID TUBE
JOHN GLISSMEYER
August 10, 2001

```
----------------------------------------------------------------
Deposition 4.0. Fri Aug 10 11:51:10 2001
----------------------------------------------------------------

 Exit     Exit       Total
 Stokes # Reynolds # Penetration
 -------- ---------- -----------
   0.0086       2159       85.7%

Element #  Element         Penetration  Stokes #  Reynolds #  Notes
---------- ----------      -----------  --------  ----------   -----
        1. Probe                 94.5%    0.0086        2159   Probe diameter:
0.00 mm, Shroud diameter: 2.00 mm, Velocity reduction ratio 0.000.
        2. Tube                 100.0%    0.0086        2159   Length: 0.051 m,
At 90.000 degrees from horizontal.
        3. Bend                  96.2%    0.0086        2159   Bend angle:
90.000 degrees.
        4. Tube                  98.1%    0.0086        2159   Length: 0.178 m,
At 0.000 degrees from horizontal.
        5. Bend                  96.2%    0.0086        2159   Bend angle:
90.000 degrees.
        6. Tube                  99.9%    0.0086        2159   Length: 6.020 m,
At 90.000 degrees from horizontal.

Ambient temperature (deg.C) :       25.0
Ambient pressure (mm Hg)    :      745.0
Flow rate (L/min)           :       56.6
Free stream velocity (m/s)   :        7.0
Particle diameter (µm)      :       10.0

---------
N O T E S
---------

<< Calculations were made with the best possible >>
<< extrapolations of the model(s).               >>
```

Benchmark Run
September 17, 2001
28.6 mm tube (see Appendix B of ANSI N13.1-1999)

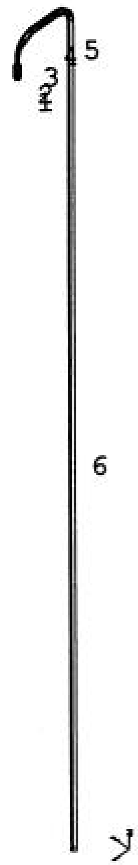
```
----------------------------------------------------------------
Deposition 4.0. Mon Sep 17 14:32:47 2001
----------------------------------------------------------------

 Exit     Exit       Total
 Stokes # Reynolds # Penetration
 -------- ---------- -----------
   0.0154       2680       77.3%

Element #  Element         Penetration  Stokes #  Reynolds #  Notes
```

```
---------- ----------      ----------- -------- ----------   -----
        1. Probe                 97.4%    0.0154        2680   Probe diameter:
0.00 mm, Shroud diameter: 2.00 mm, Velocity reduction ratio 0.000
        2. Tube                 100.0%    0.0154        2680   Length: 0.200 m,
At 90.000 degrees from horizontal.
        3. Bend                  93.3%    0.0154        2680   Bend angle:
90.000 degrees.
        4. Tube                  91.3%    0.0154        2680   Length: 1.000 m,
At 0.000 degrees from horizontal.
        5. Bend                  93.3%    0.0154        2680   Bend angle:
90.000 degrees.
        6. Tube                  99.9%    0.0154        2680   Length: 2.000 m,
At 90.000 degrees from horizontal.

Ambient temperature (deg.C) :       25.0
Ambient pressure (mm Hg)    :      760.0
Flow rate (L/min)           :       56.6
Free strem velocity (m/s)   :       10.0
Particle diameter (µm)      :       10.0

---------
N O T E S
---------

<< Calculations were made with the best possible >>
<< extrapolations of the model(s).               >>
```

Repeat of DEPO 4 RUN 1 FOR NEW W460 STACK
34.7980 MM ID TUBE
JOHN GLISSMEYER
September 17, 2001

```
-----------------------------------------------------------------
Deposition 4.0. Mon Sep 17 14:36:00 2001
-----------------------------------------------------------------

 Exit     Exit       Total
 Stokes # Reynolds # Penetration
 -------- ---------- -----------
   0.0086       2159       85.7%

Element #  Element          Penetration  Stokes #  Reynolds #  Notes
---------- ----------      ----------- -------- ----------   -----
        1. Probe                 94.5%    0.0086        2159   Probe diameter:
0.00 mm, Shroud diameter: 2.00 mm, Velocity reduction ratio 0.000.
        2. Tube                 100.0%    0.0086        2159   Length: 0.051 m,
At 90.000 degrees from horizontal.
        3. Bend                  96.2%    0.0086        2159   Bend angle:
90.000 degrees.
        4. Tube                  98.1%    0.0086        2159   Length: 0.178 m,
At 0.000 degrees from horizontal.
        5. Bend                  96.2%    0.0086        2159   Bend angle:
90.000 degrees.
        6. Tube                  99.9%    0.0086        2159   Length: 6.020 m,
At 90.000 degrees from horizontal.
```

```
Ambient temperature (deg.C) :        25.0
Ambient pressure (mm Hg)    :       745.0
Flow rate (L/min)           :        56.6
Free strem velocity (m/s)   :         7.0
Particle diameter (µm)      :        10.0

---------
N O T E S
---------

<< Calculations were made with the best possible >>
<< extrapolations of the model(s).               >>
```



F.4

INDEPENDENT TECHNICAL REVIEW RECORD

PACIFIC NORTHWEST NATIONAL LABORATORIES INDEPENDENT TECHNICAL REVIEW RECORD	DOCUMENT NO.: Calculation of Particle Penetration Through W460 Stack Sampler Tubing	Page 1 of __

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 call John Glissmeyer, 376-8552, cell 531-8006. Comments Due: 9/18/2001

Additional Information: (Scope of Review, etc) Please verify the following:

1. Transfer of dimensional data to input parameter table in report
2. Calculation of particle penetration using DEPOSITION 4.0 code, compare results against the report for benchmark and system configurations

Organization/Department	Designated Reviewer: Tim Jarvis	Signature/Date
Multimedia Exposure Assessment Group		24SEP2001

CONCUR [X]	CONCUR, WITH COMMENTS [ ]	DO NOT CONCUR [ ]	NOT REVIEWED [ ]

Comt. No.	Comment and/ or Recommendation:	Resolution:
1	TRANSCRIPTION CHECK - NO PROBLEMS NOTED.	NO RESOLUTION REQUIRED
2	CALCULATION CHECK. NO PROBLEMS NOTED	NO RESOLUTION REQUIRED
3	FORMAT CHECK. NO PROBLEMS NOTED.	NO RESOLUTION REQUIRED

Distribution

No. of
<u>Copies</u>

OFFSITE

8 **DOE Richland Operations Office**

G. Dragseth	A6-33
L. R. Fitch	T5-57
J. T. Lilly (2)	R3-56
B. B. Nelson-Maki	T5-54
C. D. Stuart	T4-50
Public Reading Room (2)	H2-53

No. of
<u>Copies</u>

9 **Pacific Northwest National Laboratory**

J. G. Droppo, Jr	K6-80
A. D. Maughan	K6-80
J. A. Glissmeyer (5)	K6-80
Hanford Technical Library (2)	P8-55