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Generic Effluent Monitoring System Certification for Salt Well Portable Exhauster

J. A. Glissmeyer
A. D. Maughan

September 1997

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

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BATTELLE
for the
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Printed in the United States of America

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Summary

Tests were conducted to verify that the Generic Effluent Monitoring System (GEMS), as it is applied to the Salt Well Portable Exhauster, meets all applicable regulatory performance criteria for air sampling systems at nuclear facilities. These performance criteria address both the suitability of the air sampling probe location and the transport of the sample to the collection devices. The criteria covering air sampling probe location ensure that the contaminants in the stack are well mixed with the airflow at the probe location such that the extracted sample represents the whole. The sample transport criteria ensure that the sampled contaminants are quantitatively delivered to the collection device. The specific performance criteria are described in detail in the report. The tests demonstrated that the GEMS/Salt Well Exhauster system meets all applicable performance criteria.

Pacific Northwest National Laboratory conducted the testing using a mockup of the Salt Well Portable Exhauster stack at the Numatec Hanford Company's 305 Building. The stack/sampling system configuration tested was designed to provide airborne effluent control for the Salt Well pumping operation at some U.S. Department of Energy (DOE) radioactive waste storage tanks at the Hanford Site, Washington. The portable design of the exhauster allows it to be used in other applications and over a range of exhaust air flowrates (approximately 200 - 1100 cubic feet per minute). The unit includes a stack section containing the sampling probe and another stack section containing the airflow, temperature and humidity sensors. The GEMS design features a probe with a single shrouded sampling nozzle, a sample delivery line, and sample collection system. The collection system includes a filter holder to collect the sample of record and an in-line detector head and filter for monitoring beta radiation-emitting particles.

Unrelated to the performance criteria, it was found that the record sample filter holder exhibited symptoms of sample bypass around the particle collection filter. This filter holder should either be modified or replaced with a different type.

Acknowledgments

This work was supported by the U.S. Department of Energy under Contract DE-AC06-76RLO 1830, with project funding from the Safety Upgrades Office and the Salt Well Stabilization Program at Lockheed Martin Hanford Company (LMHC). The authors wish to acknowledge P. L. Gassman of PNNL and the staff of Numatec Hanford Company's 305 Building for their assistance in conducting the tests. Eric M. Veith (LMHC) was the project engineer for the Salt Well Portable Exhauster.

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1.0 Introduction

Tests were conducted to verify that the Generic Effluent Monitoring System (GEMS) as applied to the Salt Well portable exhauster stack meets the performance criteria developed for air sampling systems at nuclear facilities. The performance criteria address both the suitability of the air sampling extraction location and the transport of the sample to the collection devices. The contaminants in the stack must be well mixed with the airflow at the sampling probe location. This ensures that the extracted sample represents the whole. Also, the sample must be transported with minimal loss to the collection devices.

The stack/sampling system configuration tested was designed to provide airborne effluent control for the Salt Well pumping operation at some of the U.S. Department of Energy's radioactive waste storage tanks at the Hanford Site in Richland, Washington. The portable design of the exhauster allows it to be used in other applications and over a range of exhaust air flowrates. The unit includes a stack section containing the sampling probe and another stack section containing the airflow, temperature and humidity sensors. The GEMS design features a probe with a single shrouded sampling nozzle, a sample delivery line, and sample collection system. The collection system includes a filter holder to collect the sample of record and an in-line detector head and filter for monitoring beta radiation-emitting particles. The tests were conducted by the Pacific Northwest National Laboratory using a mockup of the Salt Well Exhauster stack located at Numatec Hanford Company's 305 Building.

The regulatory and research background that constitute the basis for the performance tests are discussed. The performance criteria and the GEMS/Salt Well Exhauster system are described. The test methods and results are presented followed by the conclusions. Finally, the detailed test procedures and data sheets are included in the appendices.

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 requires the use of isokinetic[(a)] sampling nozzles as described in ANSI N13.1-1969 (American National Standards Institute 1982). More recent research (Rodgers et al. 1996; Glissmeyer and Ligotke 1995) indicates poor performance for isokinetic nozzles relative to that of the shrouded

(a) Air samples are extracted from the bulk airflow through a probe having a round orifice that is aerodynamically designed. The opening is generally pointed directly into the airflow. The term isokinetic means that the air velocity through the probe orifice matches that of the approaching airstream. This theoretically ensures that the sample airstream has the same concentration of particles of all sizes per unit air volume as the bulk airstream. If the probe orifice air velocity is lower than that of the bulk airstream, it is operating "subisokinetically." In this case, particles with significant inertia will be present in the sample airstream in a concentration greater than in the bulk airstream.

nozzle. The U.S. Environmental Protection Agency (EPA) has approved a U.S. Department of Energy (DOE) alternative method petition that allows the use of a sampling probe with a single shrouded nozzle in applications that previously required a probe with several isokinetic nozzles[(a)]. This single-point sample-extraction approach is applicable where the potential contaminants in the effluent are of a uniform concentration at the sampling location. The alternative method is a significant departure from the ANSI N13.1-1969 approach in that the sampling system must meet specific performance criteria. The approach taken in the alternative method was incorporated in a functional requirements document (FRD) for air sampling systems (Glissmeyer et. al. 1994).

To meet the need for upgraded air sampling systems compliant with the FRD, a Generic Effluent Monitoring System (GEMS) was developed so the probe and instrumentation could be used at exhaust stacks of any size, with appropriate adaptation. The design features a single shrouded sampling nozzle, a short sample delivery line, and a sample collection system. The collection system includes a filter holder to collect the sample of record and an in-line detector head for monitoring beta and gamma radiation-emitting particles. It is the application of this system to the Salt Well portable exhauster stack that is the subject of this report.

1.2 Performance Criteria

Certifying the compliance of new air samplers with the requirements of the FRD consists of two phases. The first phase is to demonstrate contaminant mixing at the sample extraction location, and the second is to demonstrate delivery of the sample to the collection devices. If the stack flowrate is expected to vary by >25% from the mean, the battery of tests are conducted at the mean and extremes of flowrate.

The performance criteria are as follows:

1. Angular Flow - Sampling probe nozzles are generally aligned with the axis of the stack. If the air travels up the stack in cyclonic fashion, the air velocity vector may be approaching the nozzle at an angle severe enough to impair the extraction of particles. The acceptance criterion for the absence of angular or cyclonic flow is that the average air velocity angle shall not exceed 20 degrees relative to the long axis of the stack.

2 Air Velocity Uniformity - It is important that the gas momentum across the stack cross section where the sample is extracted be well mixed or uniform. 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 percent COV value, the more uniform the velocity. The acceptance criterion is that the COV of the air velocity be ≤ 20% across the center two-thirds of the area of the stack.

(a) U.S. Environmental Protection Agency. 1994. Letter from Mary Nichols to Raymond Pelletier (11/21/94). EPA, Washington.

3. Gaseous Tracer Concentration Uniformity - A uniform contaminant concentration in the sampling plane enables the extraction of samples that represent the true concentration. This is first tested using a tracer gas. The acceptance criteria are that a) the COV of the tracer gas concentration is ≤20% across the center two-thirds of the sampling plane, and b) at no point in the sampling plane does the concentration vary from the mean by >30%.

4. Particle Tracer Concentration Uniformity - Uniformity in contaminant concentration at the sampling plane is tested using tracer particles of 10-μ aerodynamic diameter[a] (AD). This particle size is large enough to exhibit inertial effects. The acceptance criterion requires that the COV of particle concentration is ≤20% across the center two-thirds of the sampling plane.

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

1.3 System Testing

The sampling location was tested using a mockup of the Salt Well Exhauster stack assembled at Numatec Hanford Company's 305 Building. Figure 1 shows the mockup. It consists of an upward-discharge fan, transition and flexible duct, an 83-in.-tall stack section made of 10-in. pipe, a transition, and a short section of 6-in. pipe. The inlet of the sampling nozzle is about 46 in. above the transition from the flexible duct.

The Salt Well Exhauster is designed for operation at a range of airflows depending on the number of waste tanks it is ventilating. Table 1 lists the typical airflows and resulting velocity in the 10-in. pipe section of the stack.

Figure 2 diagrams the GEMS unit sampling cabinet, which contains a sample flow splitter, a record sample filter holder, a beta/gamma particle continuous air monitor (CAM) filter holder and sensing head, flowmeters, and automated flowrate control valves. The vacuum pumps and control systems are located in other cabinets. Attached to the sampling cabinet is the shrouded sampling nozzle (Figure 3) and sample transport line. The shrouded sampling nozzle, coupled to a short transport system, was shown to be superior to systems using traditional isokinetic nozzles in tests by Glissmeyer and Ligotke (1995) and Rodgers et. al. (1996). The system was tested with two different shrouded nozzles, both designed to sample at 2 cfm. The two nozzles were designed to sample from air moving with a velocity of 2.5 - 8.5 m/s and 8.0 - 16.0 m/s, respectively. Figure 4 shows the sample flow splitter, which splits the total sample flow (2 scfm) into two equal parts.

(a) The aerodynamic diameter of a particle of arbitrary shape and density is the diameter of a spherical water droplet that has the same sedimentation velocity in quiescent air as the arbitrary particle. Particles with the same aerodynamic diameter will exhibit the same aerodynamic behavior even if they vary in shape and density.

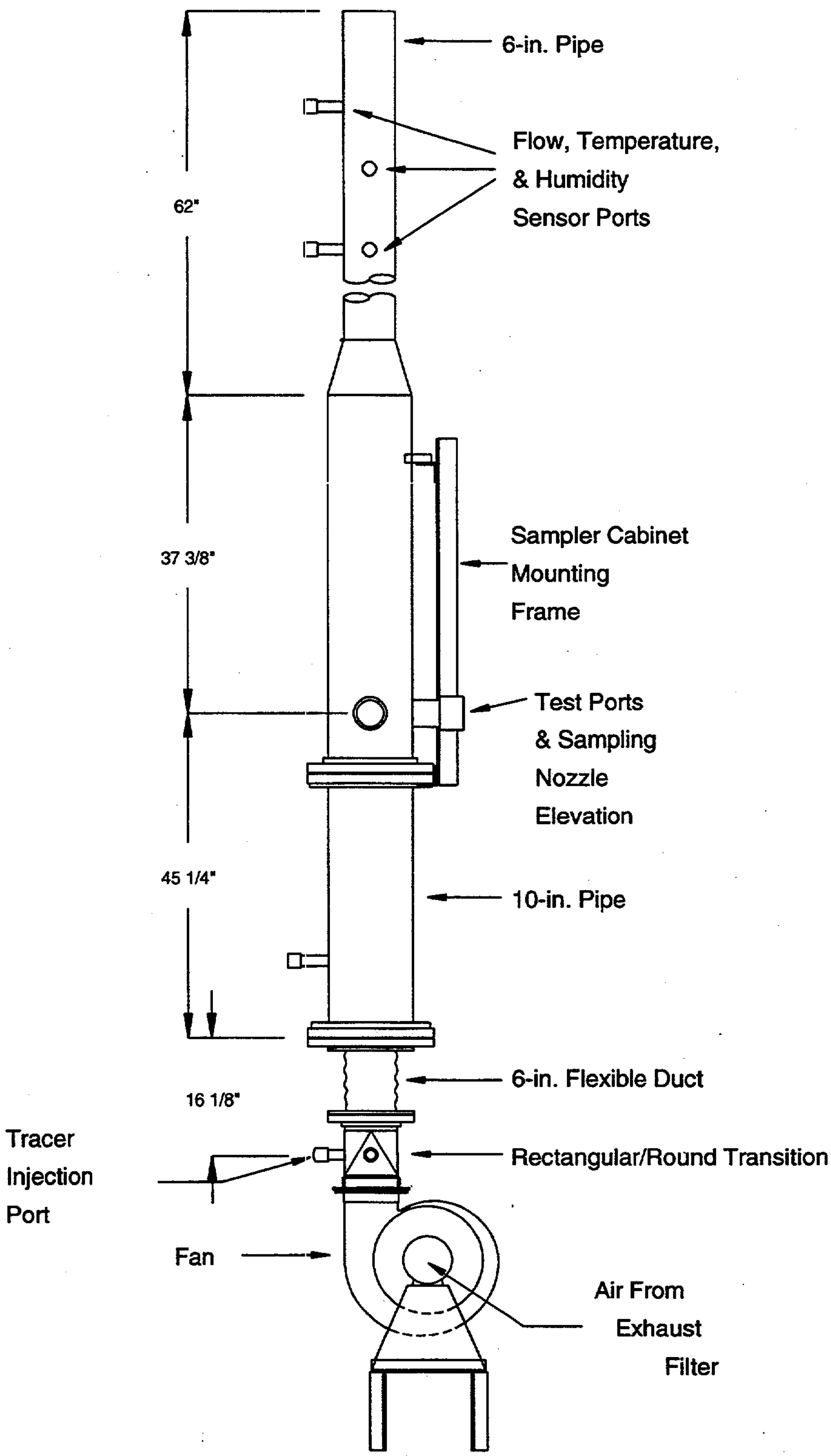

Figure 1. Mockup of Salt Well Exhauster Stack

Table 1. Expected Operating Flow Conditions for the Salt Well Exhauster

	cfm	ft/min	m/s
Low	250	482	2.45
Medium	500	964	4.90
High	1000	1929	9.80

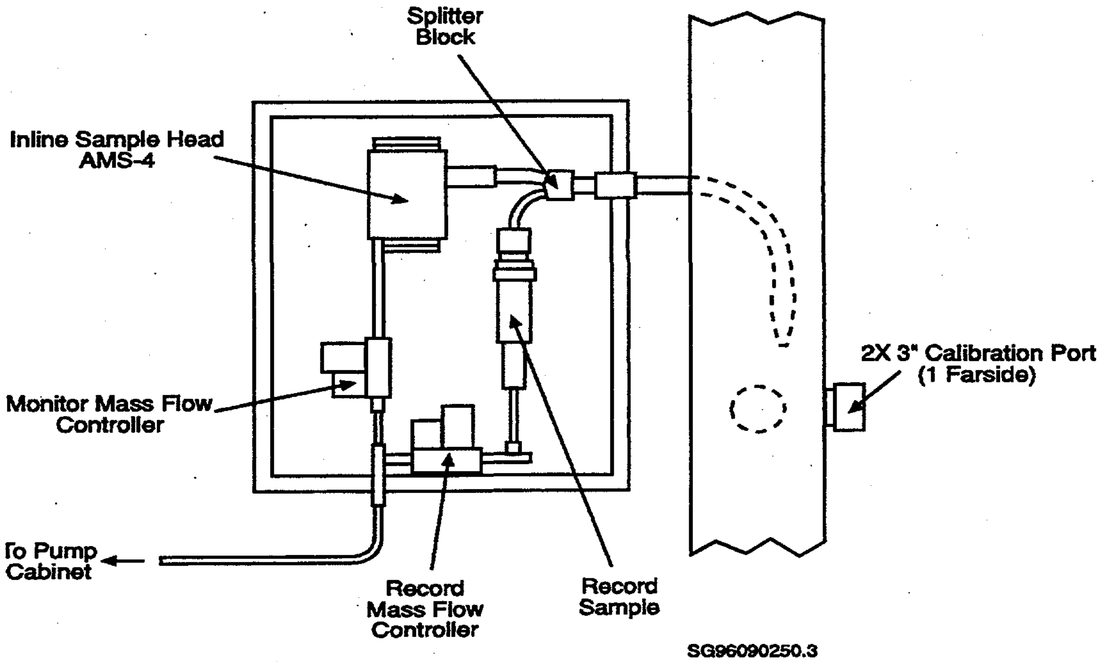

Figure 2. GEMS Sampling Cabinet

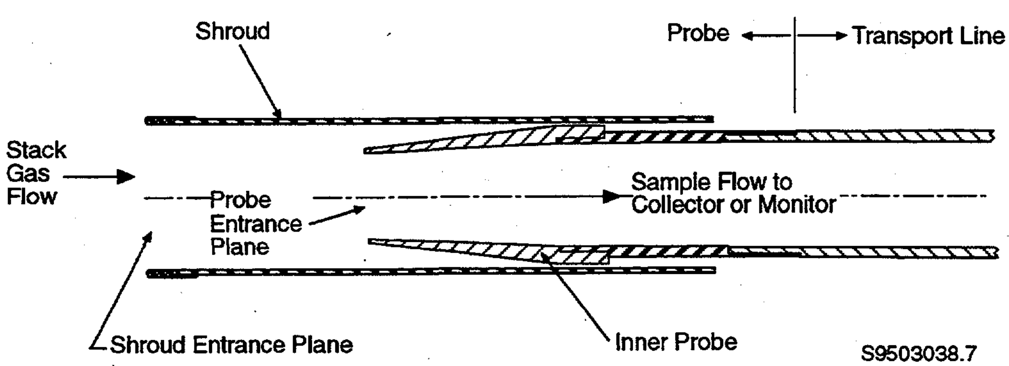

Figure 3. Configuration of Shrouded Nozzle

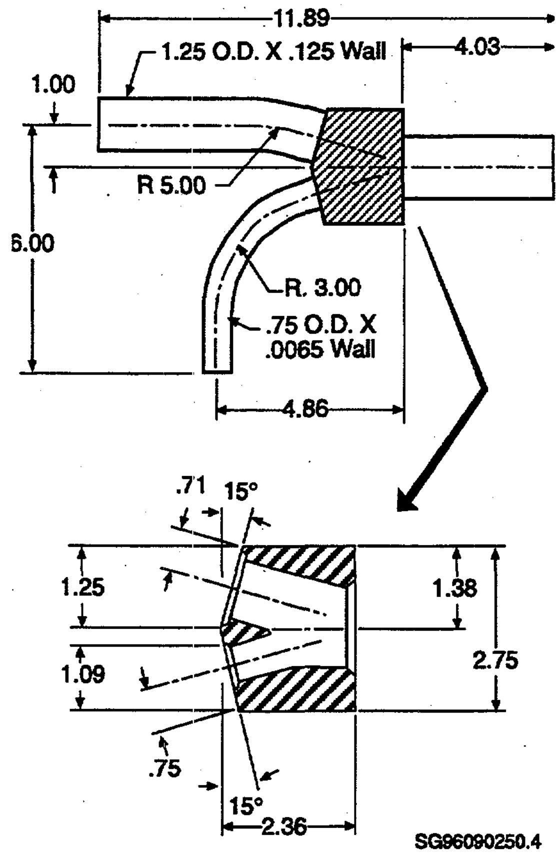

Figure 4. Diagram of Splitter Block

2.0 Certification Tests

The following subsections provide methods and results for the five certification tests. Tests were conducted to determine compliance with performance criteria covering angular flow, air velocity uniformity, gaseous tracer uniformity, particle tracer uniformity, and particle penetration.

2.1 Angular Flow

2.1.1 Method

The air velocity vector approaching the sample nozzle should be aligned with the axis of the nozzle within an acceptable angle so sample extraction performance is not degraded. The test method 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 average and extremes of flowrate in the existing stack using a type-S pitot tube, a slant tube manometer, and a protractor level attached to the pitot tube. The flow angle was measured at the elevation in the stack where the sampling nozzle would be located (test ports in Figure 1). The measurement grid was laid out in accordance with the EPA procedure. The pitot tube was rotated until a null differential pressure reading was obtained, and the angle of rotation was then recorded. Appendix A provides the detailed procedure.

2.1.2 Results

The average flow angles observed for the Salt Well stack are shown in Table 2. The acceptance criterion for the absence of substantial angular or cyclonic flow is that the average flow angle shall not exceed 20 degrees (relative to the long axis of the stack). This criterion was met in all flowrate cases. Data sheets for the tests are included in Appendix A.

Table 2. Mean Air Velocity Flow Angle Results

Fan Control Setting, Hz	Flow rate, cfm	Mean Flow Angle, degrees
16	306	5.4
24	491	4.5
48	1028	4.4

2.2 Air Velocity Uniformity

2.2.1 Method

The uniformity of air velocity in the cross section of the stack where the air sample is being extracted ensures that the air momentum in the stack is well mixed. To determine uniformity, air velocity was measured at the same points as those used for the angular flow test. The method used was based on 40 CFR 60, Appendix A, Method 1. The equipment included a standard Prandtl-type pitot tube and an electronic manometer. The procedure is detailed in Appendix B.

2.2.2 Results

The acceptance criterion is that the air velocity COV is ≤20% across the center two-thirds of the area of the stack. Table 3 summarizes the test results. Initial results showed unacceptable uniformity. Examination of the fan outlet and the flexible duct showed that their centerlines were out of alignment with the stack by nearly an inch. The misalignment was corrected, and the tests were repeated. The results then demonstrated uniformity, which met the acceptance criterion.

Figure 5 shows surface plots of velocity measurements before and after the alignment of the fan and flexible duct. (The data were normalized such that the maximum velocity measured is represented as 100% and the minimum as 0%. The only actual data are along the north-south and east-west axes. The remainder of the surface is interpolated.) The bottom view shows that before fan alignment, the

Table 3. Air Velocity Qualification Tests

	Before Fan Alignment			After Fan Alignment		
Fan Control Setting, Hz	Mean Velocity, m/s	Flow rate, cfm	COV	Mean Velocity, m/s	Flow rate, cfm	COV
12				2.09	213	10.9
16	3.34	340	32.8	3	306	10.4
21	4.64	473	28.9	4.19	428	11.3
24				4.81	491	8.7
42	9.7	990	29.1	8.81	899	8.7
48				10.07	1028	7.2
56				11.86	1210	8.8

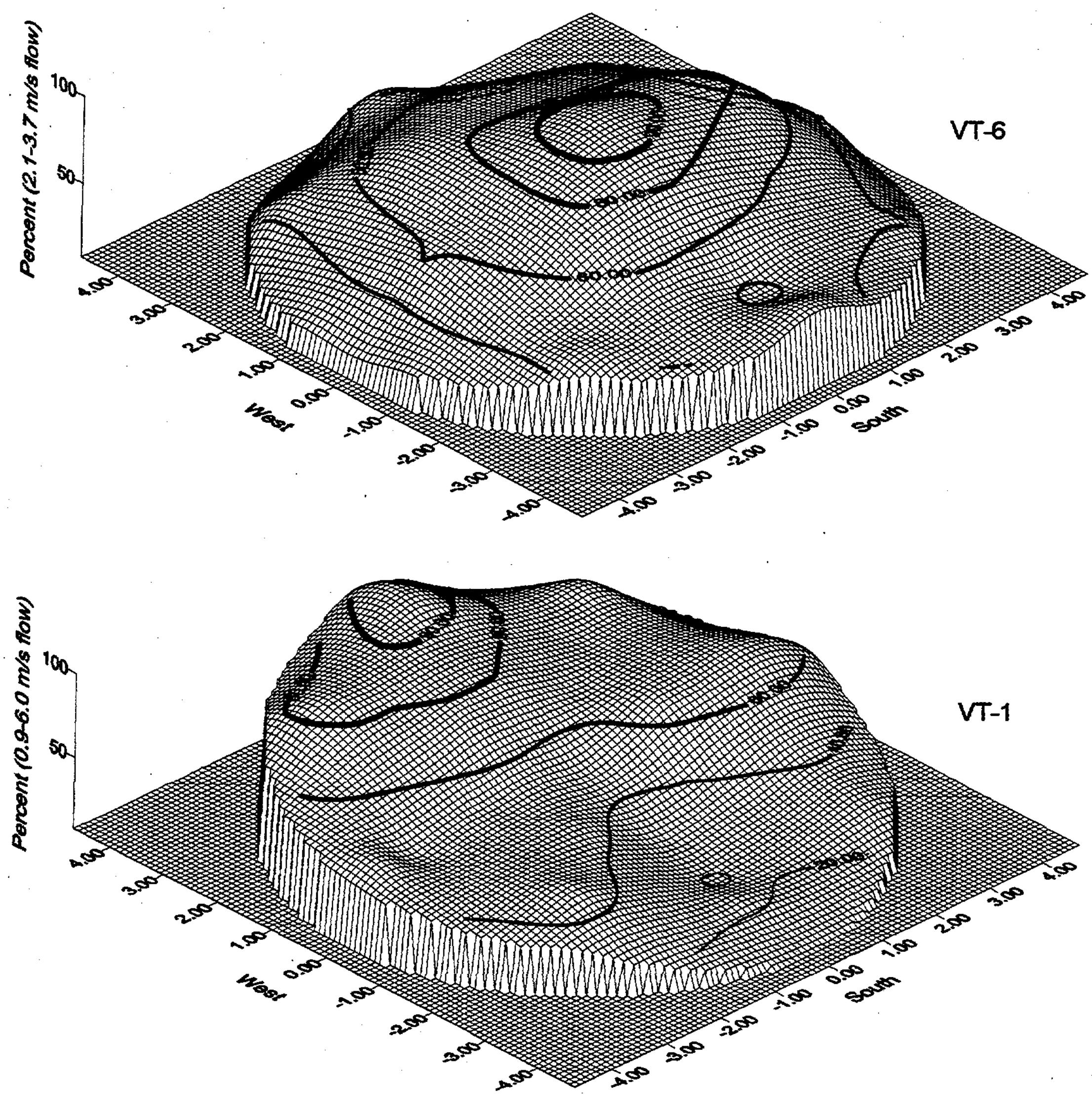

Figure 5. Before and After Fan Alignment. VT-1 at 340 cfm yields a COV of 32.8, VT6 at 306 cfm yields a COV of 10.4.

velocities covered a 6:1 range and the airflow was skewed to one side. The top view shows that, after alignment, the measured velocities only covered a 1.8:1 range, and the peak velocity was in the center. Data sheets for this test are included in Appendix B.

2.3 Gaseous Tracer Uniformity

2.3.1 Method

A uniform contaminant concentration at the sampling plane enables the extraction of samples that represent the true concentration. The concentration profile uniformity was demonstrated using sulfur hexafluoride as a tracer gas. The tracer gas was injected into the air upstream of the stack, and the concentration was measured at points in the sampling plane using a gas analyzer. The grid of measurement points was the same as that used for the velocity characterization tests described above. The gas analyzer used was a Bruel and Kjaer (Naerum, Denmark) Model 1302 calibrated for the tracer gas. The procedure is detailed in Appendix C.

2.3.2 Results

Table 4 summarizes test conditions and results. 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) no point in the sampling varies from the mean concentration by >30%. For two flowrates, measurements were made with the tracer gas injected at five different locations in the same plane between the fan and the flexible duct. The tracer was injected at points 1 in. from the wall on the north, south, east, and west sides of the rectangle/round transition. In these cases, the results ranged over 7 - 11% COV. Injections at the center of the rectangle/round transition were made twice, once by inserting the injection tube through the port on the north/south axis and again through the port on the east/west axis. The gas concentrations were more uniform with the centerpoint injections than with the wall injections. Additional tests were done at the extremes of the stack flowrate using only the west injection location. Repeatability was good and the acceptance criteria were met in all cases. Data sheets for individual test runs are included in Appendix C.

Figure 6 shows surface plots for the results obtained at 306 and 1210 cfm using the West injection point. The surface features are exaggerated because the data were normalized as a percentage of the data range. The range of data is only 1.5:1, so the surface is quite flat.

Table 4. Tracer Gas Mixing Results

Tracer Injection Position	% Coefficient of Variation at Flowrate Given			
	306 cfm	491 cfm	1028 cfm	1210 cfm
Center E/W		2.7	3.8	
Center N/S		2.1	2.6	
North		8.0	7.3	
South		9.0	8.6	
East		8.4	7.7	
West	10.8	10.1	9.6, 9.5	9.9

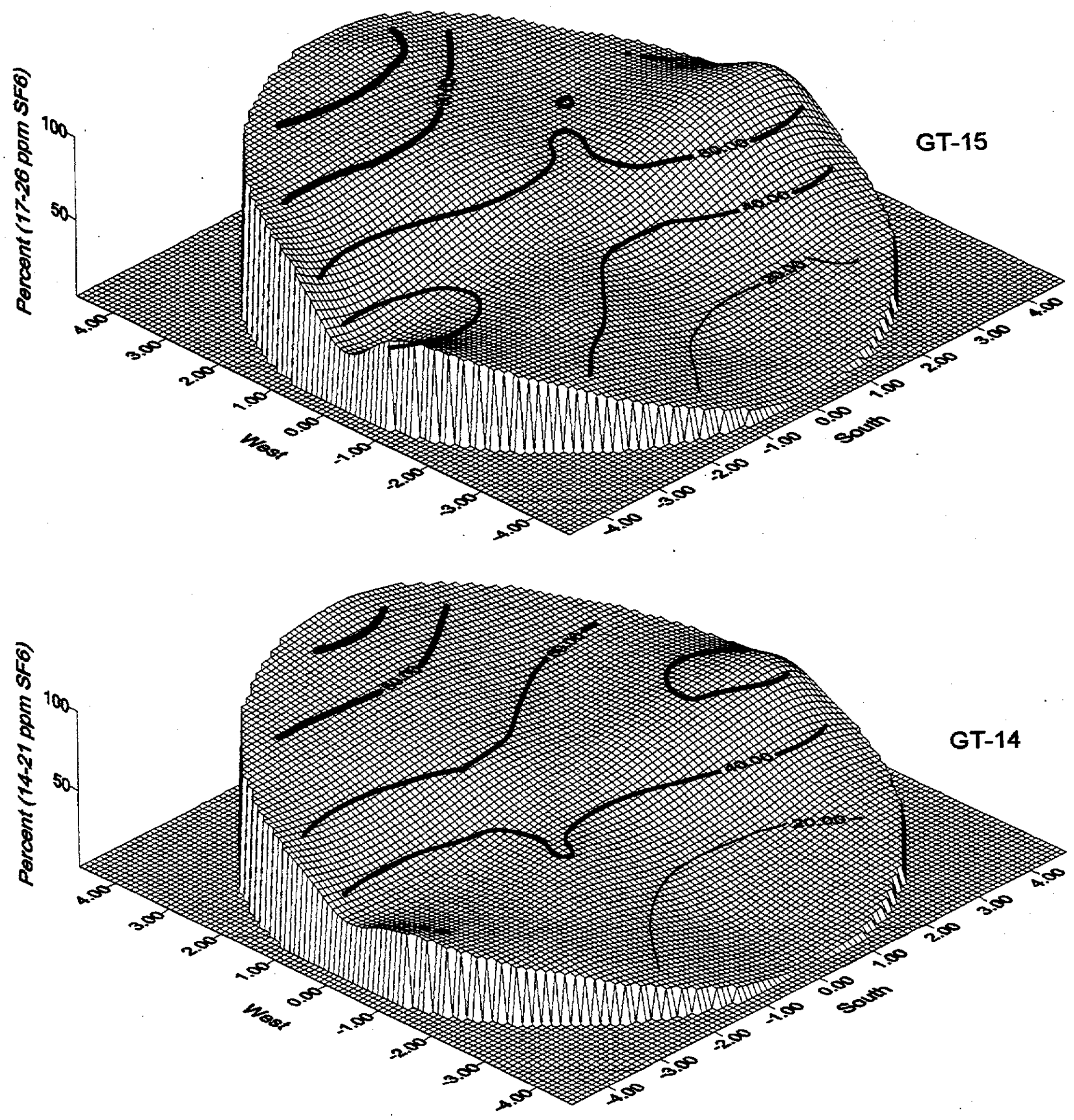

Figure 6. Tracer Gas Injected at West Location. GT-15 at ~300 cfm, GT-14 at ~1200 cfm.

2.4 Particle Tracer Uniformity

2.4.1 Method

The particle tracer uniformity test is conceptually similar to the gaseous tracer uniformity test. The gaseous tracer is replaced with a monodispersed aerosol of 10 μm AD particles, and the gas analyzer with optical particle counters (OPC). The acceptance criterion is that the COV of the tracer particle concentration be ≤20% across the center two-thirds of the sampling plane. The tracer particles may be introduced at only one location, the centerline of the stack or duct as far upstream as possible from the sampling location, but downstream of the filters, fans, or feeder ducts.

Monodisperse (single-sized) test aerosol particles of oleic acid tagged with a fluorescent dye (uranine) were created from methanol-based solutions using a vibrating orifice aerosol generator (VOAG). In the VOAG, the solution passes through a ~20-µm circular orifice to form a cylindrical jet. A piezoelectric crystal positioned on the orifice assembly oscillates at known frequency to cause the liquid jet to break into uniformly sized droplets. The droplets are dispersed from the orifice by flowing air to minimize droplet coagulation and maximize evaporation of the methanol.

The particle stream was injected at the centerline of the rectangle/round transition just above the fan. Particle concentration was measured at the stack using two OPCs (Met-One Model A2408, Grants Pass, OR). Each OPC had separate sampling probes designed to concurrently sample from the same elevation within the stack as used for the other tests. The probe of one OPC was set at a fixed location while the probe of the mobile OPC was moved to each traverse point in a random order. The fixed OPC recorded the particle concentration as a function of time in case the output of the VOAG varied. The traversing OPC and its probe was moved from point to point, first in one traverse direction and then the other. The layout of sampling points was the same as for the other tests, except that the size of the probe did not permit sampling as close to the inside of the stack wall. The detailed procedure is included in Appendix D.

2.4.2 Results

Particle concentration uniformity was measured at three different flowrates. Data sheets for each run are included in Appendix D. Table 5 summarizes the test results. The upper half of Table 5 shows the temperature range during the tests and the mean particle concentrations and standard deviations for each OPC and each traverse direction. The table shows that fewer particles arrive at the detector (OPC) when the flow is highest, i.e., they are diluted.

The standard deviations are much lower for the fixed OPC than for the mobile one. The standard deviation in the fixed OPC results is assumed to be caused by the variability in aerosol concentration over time and the variability in the response of the OPC. This would represent the minimum level of variability achievable using this test procedure without an independent determination of the actual contributions to the variability. It is assumed that the higher standard deviation in the randomized mobile OPC readings is caused by the concentration variation across the stack.

The percent COV for each test is listed in the bottom half of Table 5. The resulting percent COV for each normalization method and test also is listed. The results for each test are given with and without any normalization to account for variability in aerosol concentration with time. Both types of results satisfy the acceptance criterion. The third test (PT-3) has the highest COV, which may be due in part to counting errors associated with the lower particle concentration.

Table 5. Tracer Particle Mixing Results over the Center Two-Thirds of the Stack

Characteristic	Test PT-1	Test PT-2	Test PT-3
Each data point represents mean of:	Three 1-min counts	Three 1-min counts	Three 1-min counts
Ambient temperature during test, °F	72	72	72
Stack flowrate, cfm	491	213	1028
Mobile OPC			
North/south mean particles/ft^3	143	240	75
West/east mean particles/ft^3	119	199	81
North/south standard deviation	15	25	12
West/east standard deviation	18	26	18
Fixed OPC			
North/south mean particles/ft^3	146	390	95
West/east mean particles/ft^3	156	290	103
North/south standard deviation	7	18	11
West/east standard deviation	12	24	10
Overall Mobile OPC Percent COV per Normalization Method			
A. Mobile traverse readings adjusted by adding the amount needed to make the centerpoints equal their own average	13.7	15.7	19.9
B. Without normalization	16.6	14.7	19

Figures 7 and 8 show surface plots for each test. The results are again scaled so the extremes in the readings are represented as 0 and 100%. The largest range in readings was 2.55:1 in Test PT-3. Little similarity exists between the surface plots.

Figure 7 shows the surface plots for the velocity, gas, and particle mixing tests at approximately 500 cfm. In the case of the tracer gas traverse, the variability is greatly exaggerated because the range in readings was only 1.08:1.

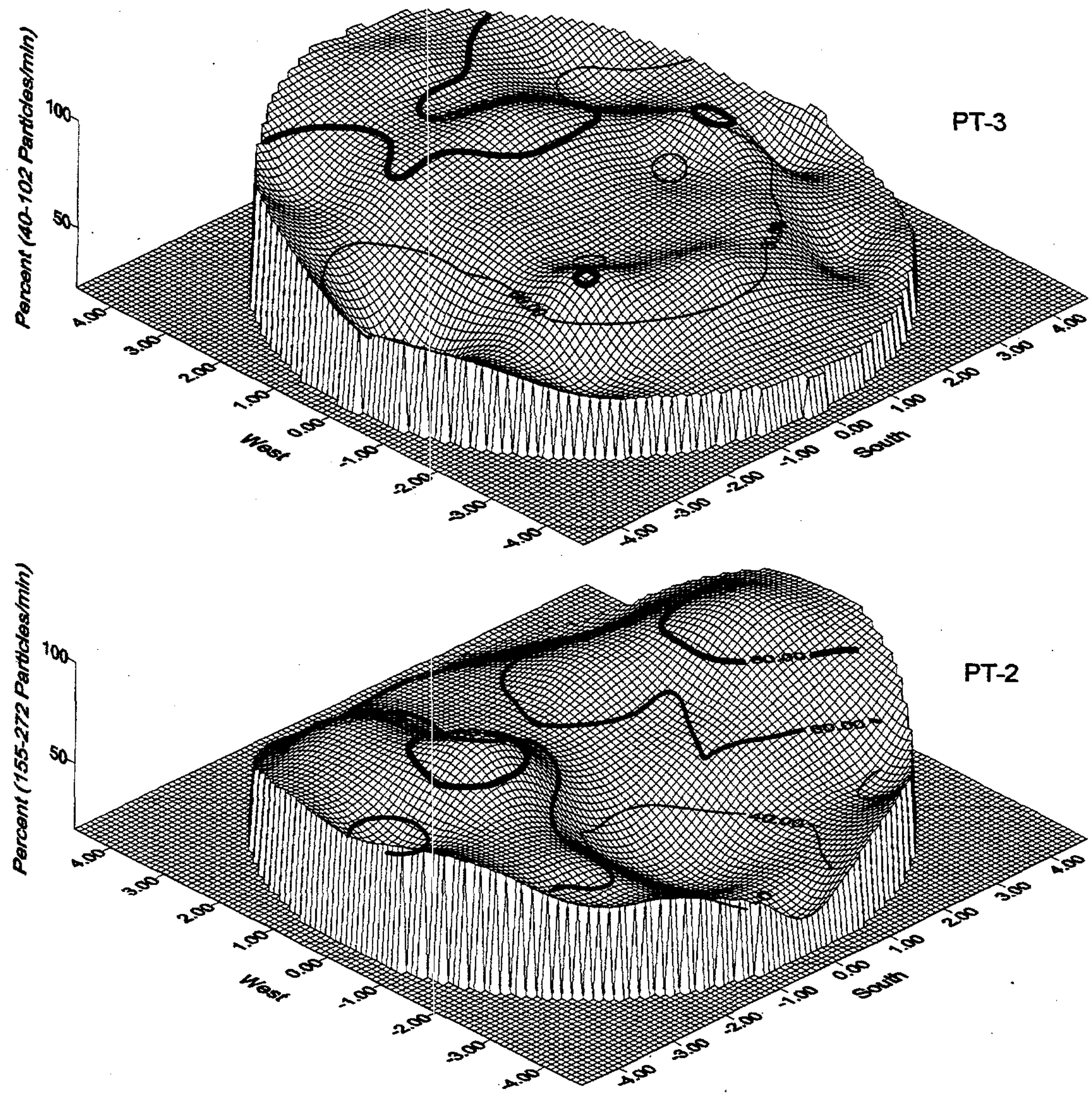

Figure 7. Tracer Particles Injected at Center Location. PT-2 flowrate at 213 cfm, and PT3 at 1028 cfm.

2.5 Particle Penetration

The FRD requires that the sample transport system deliver more than 50% of 10 μm AD particles from the stack to the sample collector. The desired nozzle characteristics are as follow:

- nozzle transmission ratio at 10 μ is 0.8 to 1.3
- nozzle aspiration ratio at 10 μ is 0.8 to 1.5.

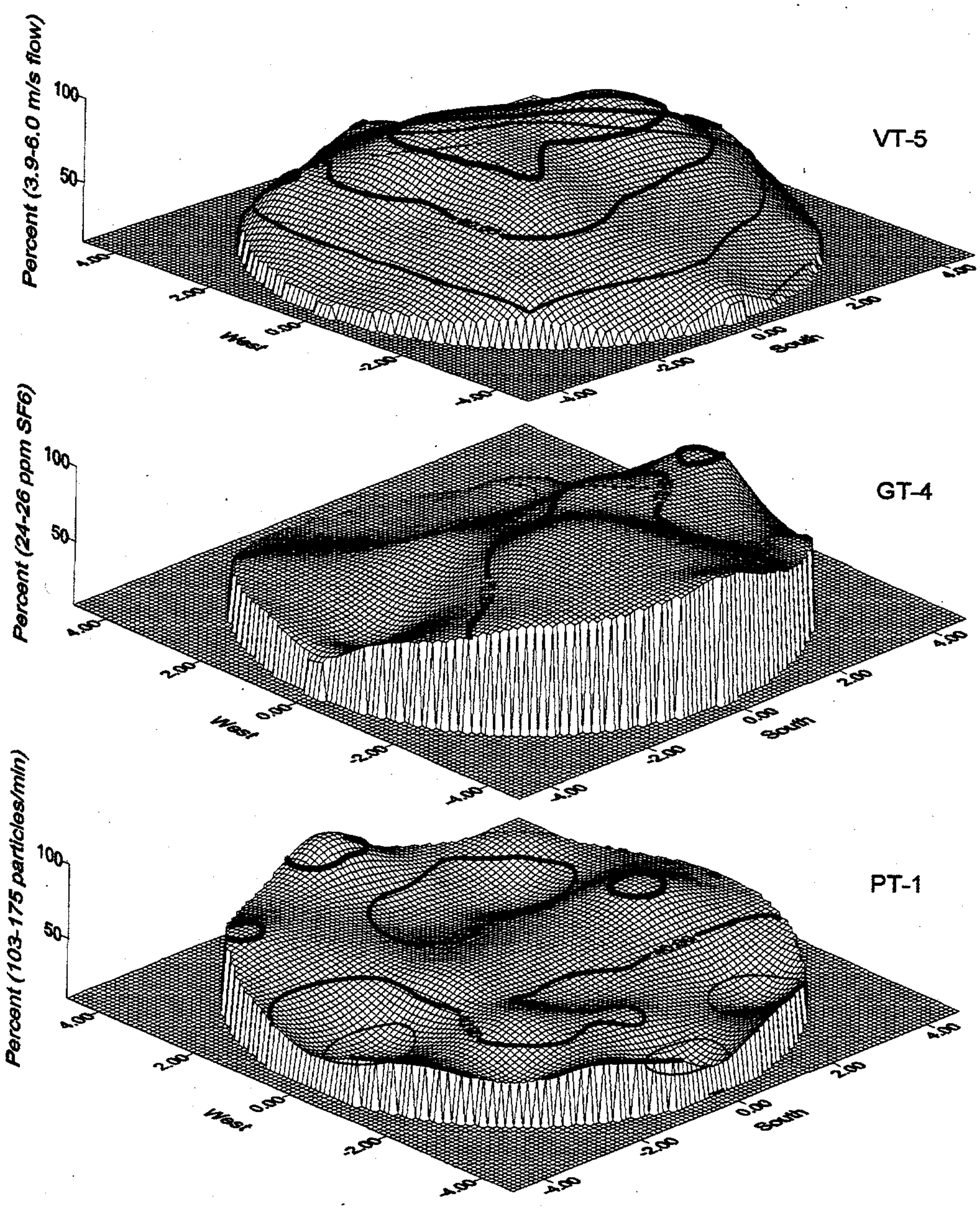

Figure 8. Comparison Among Velocity, Gas, and Particulate Tests all Run at Approximately 500 cfm

The nozzle characteristics are inherent in the design and were verified by the designers during wind tunnel tests (McFarland et al. 1989). The FRD requires that the particle transport be verified either experimentally or by using the DEPOSITION code (Riehl et al. 1996).

The manufacturer's analysis of particle penetration through the GEMS system is included in Appendix E. The analysis of the transport lines was performed using the DEPOSITION code. The analysis of the splitter was done by analogy to tests of a similar splitter reported by Glissmeyer and Ligotke (1995). The analysis showed that the penetration of 10 μm AD particles through the system, excluding the splitter, would be 66% at the low flow conditions and 94% at the high flow conditions. The worst case penetration through the splitter was estimated at 74%. Combined, the penetration should range from 49 to 70%. Because these tests were run on the first such unit received, the overall particle penetration was verified experimentally.

2.5.1 Method

A reference sampler, located in the stack at the same elevation as the shrouded nozzle, was used to measure the particle concentration in the stack. The reference sampler differed from the GEMS sampling system primarily by having a sharp-edged inlet nozzle followed immediately by a 47-mm glass fiber filter (Gelman Sciences Type A/E, Ann Arbor, MI). The flowrate through the reference sampler was adjusted so it operated isokinetically over the range of air flowrates. During each test, the reference sampler was moved through two or more positions to help ensure that the average concentration was measured. Identical glass fiber filters were installed in the record sample filter holder, in the beta CAM in-line head, as well as in the reference sampler. The flowrate through each of these was held at approximately 1 scfm.

The 10 μm AD test particles were injected along the centerline of the rectangle/round transition between the fan and the stack. The reference and the GEMS samplers were operated over the same time period. After each test, the internal components and nozzles of the systems were washed with methanol to remove the deposited particles. The sample filters were repeatedly leached in methanol to obtain the deposited uranine dye. The solutions were analyzed for fluorescent tracer content using a Perkin Elmer LS-50B Luminescence Spectrophotometer.

The first three tests were performed on the mockup stack as diagramed in Figure 1. Afterward, to accommodate related tests, the 10-in. pipe stack was replaced with a 10-in. sheet metal stack without the necked-down or tapered discharge at the top. (The inside diameter of the sheet metal stack was 10 in., up slightly from 9.75 in. for the pipe stack.) Two additional tests were then conducted, and additional velocity traverses were done to measure flowrates through the stack.

Electrical noise from the fan's motor speed controller interfered with the readings of the GEMS sample flowmeters, and, in some cases, the indicated flowrates varied significantly from the 1 scfm control point. Consequently, the GEMS flowmeters were calibrated under test conditions against the calibrated flowmeter used for the reference sampler, and the GEMS readings were adjusted accordingly.

2.5.2 Results

Table 6 summarizes results of the mass balance of particles collected by GEMS relative to the reference sampler. The unsatisfactory penetration results for the record sample and poor mass balance results for tests PEN-1 and PEN-3 are indicative of internal leakage or bypass found in the GEMS system. For example, the particle deposition pattern on the record sample filter (when viewed with a black light) was

Table 6. Collection of 10-μm AD Tracer Particles Relative to the Reference Sample

Characteristic	Run PEN-1	Run PEN-2	Run PEN-3	Run PEN-4	Run PEN-6
Stack flow, cfm	491	1028	213	894	232
Mean stack air velocity, m/s	4.81	10.07	2.09	8.34	2.34
% of Expected Mass at CAM					
Filter	53.9	119.6	59.3	81.7	55.2
Probe	5.6	18.1	5.3	9.2	0.5
Splitter	0.8	2.7	1.8	2.5	0.6
Filter holder	0.3	0.9	2.5	9.0	0.9
Unaccounted	39.5	-41.3	31.2	-2.5	37.9
% of Expected Mass at Record Sample					
Filter	46.3	76.1	46.2	92.6	65.7
Probe	5.5	13.2	6.4	8.7	0.5
Splitter	0.8	2.0	2.2	2.4	0.5
Filter holder	2.2	5.3	3.1	2.9	0.1
Unaccounted	45.2	3.5	42.2	-6.7	33.2

a thin arc stretching over one-third of the perimeter near the filter clamping ring. This record filter holder was found to leak significantly. It was temporarily repaired after test PEN-3, but the results were variable as shown for runs PEN-4 and PEN-6. Also, the deposition pattern on the filter paper was improved, but was still more pronounced around the clamping ring. This may indicate some remaining leakage. In contrast, the particle deposition patterns on the CAM and reference filters were much more uniform. The poor mass balance in some runs also could indicate an inadequate component washing procedure or sampling bias at the nozzles. Data sheets and analysis results for each run are included in Appendix F.

The first four runs were conducted with a shrouded nozzle designed for use with an air velocity of 8 - 16 m/s. In tests PEN-1 and PEN-4, the approach air velocity was in the 8 - 16 m/s range for which the nozzle was designed. The last run was conducted with a nozzle designed for a 2.5 - 8.5 m/s air velocity range. This low-velocity range nozzle would be used for applications where the Salt Well Exhauster was used at flowrates less than about 820 cfm.

The highest deposition in the splitter was 2.7% of the expected mass compared to 0.8% for the splitter tested by Glissmeyer and Ligotke (1995). This is considered acceptably low. Probe losses were in the 0.5 - 18% range compared with the less than 3% found in the wind tunnel tests by Glissmeyer and Ligotke (1995) for a similar configuration. The measured penetration exceeded the predicted penetration in three of the runs. Had the record sample filter holder not been leaky, the measured penetration probably would have been better in all cases.

3.0 Conclusions

The application of the GEMS to the Salt Well Portable Exhauster was shown to comply with the five performance criteria given in the FRD. These included: absence of cyclonic flow in the stack in the plane of the sample probe, uniformity of air velocity in the plane of the sample probe, uniformity of gaseous tracer concentration in the plane of the sample probe, uniformity of particulate tracer concentration in the plane of the sample probe, and penetration of the sample to the collectors. Initially, the system failed the velocity uniformity tests because the fan outlet was misaligned with the centerline of the stack base and the flexible duct section had excessive curvature. After realignment, this criterion was satisfied. The tests were conducted over the exhauster flow range of approximately 200 - 1100 ft^3/min. This then is the range for which the system is qualified.

Unrelated to the performance criteria, it was found that the record sample filter holder exhibited symptoms of sample bypass around the particle collection filter. This filter holder should either be modified or replaced with a different type.

These tests demonstrated the validity and benefit of the approach taken in the approved single point sampling alternative method. Before the alternative method, the standard EPA procedure for air sampling (40 CFR 60, Appendix A, Method 1) required a minimum of 8 straight stack diameters upstream of the sampling point and 2 straight stack diameters downstream. The ANSI N13.1 (1969) standard recommended that there be at least 10 and 5 straight stack diameters upstream and downstream of the sampling point. In this case, the sampling point was less than 5 stack diameters downstream of a significant flow disturbance, a point which would have been disallowed under the previously accepted requirements. However, it should be pointed out that a favorable result from performance testing may not always occur in instances of short straight upstream runs of duct or stack. In this case, the airstream mixing was enhanced by the turbulence from the abrupt change in internal diameter at the joint of the flexible duct and the stack.

4.0 References

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Appendix A

Angular Flow Test

Procedure for Angular Flow Test

February 6, 1997

Angular Flow Test

The acceptance criterion for the absence of angular or cyclonic flow is that the average flow angle shall not exceed 20° (relative to the long axis of the stack). The reason is so the air velocity vector approaching the sample nozzle is within an acceptable angle so sample extraction performance is not degraded. The test method is that of 40 CFR 60, Appendix A, Method 1, Section 2.4, "Verification of the Absence of Cyclonic Flow."

If the maximum and minimum stack flowrates differ by no more than a small percentage (assume less than 15%), then conduct this test at the average flowrate. If there is a greater range of stack flowrates, then conduct the test at the minimum and maximum conditions and optionally at the average. Perform two or three repetitions at each flowrate condition, two if it looks highly repeatable, three if not so repeatable. Fill out one of the attached data sheets for each flowrate. The top half of the sheet is for one traverse direction, the bottom half for the other direction. The climatological data are not needed to evaluate the results.

Equipment

Type-S pitot tube
Calibrated manometer or electronic manometer
Device for reading angle of pitot tube relative to long axis of the stack

The manometer should be checked to verify that it reads zero when the pressure differential across it is zero. It should also read non-zero when the pressure differential is non-zero (on the order of 0.01 in. of water or less).

Method

Select measurement points following Method 1 in 40 CFR 60, Appendix A as a guide to determine the minimum number of sample points. If a fluid-filled manometer is used, it must be leveled. Connect the manometer to the pitot tube. Position the pitot tube at each velocity measurement point, in succession, so that the face openings of the pitot tube are perpendicular to the stack cross sectional plane. In this position, it is at "0" reference. Note the differential pressure reading. If the reading is not zero at "0" reference, rotate the pitot tube (up to a 90° yaw angle) until a null reading is obtained. Record the rotation angle to the nearest degree. Assign the value of 0° to those points for which no rotation was required. If the average of the rotation angles at all traverse points is less than 20°, then the test criterion is satisfied.

ANGULAR FLOW TEST DATA FORM

Site	Saltwell Mockup @ 305	Run No.	AT-1
Date	3/4/97	Stack Temp	NA
Tester	Glissmeyer	Stack RH%	NA
Stack Dia.	9.75 in	Baro Press	NA
Stack X-Area	74.7 in2	Fan Setting	48 Hz, 1000 cfm
Elevation		Offset to index	
El. above disturbance	45.5 in.	Units	degrees clockwise

Traverse-->			E/W			S/N			
Trial --->			1	2	3	1	2	3	
Point	Depth, in.	cm							
1	0.20	0.52	8	10	9	9	9	9	
2	0.65	1.66	14	20	14	7	10	9	
3	1.15	2.92	11	15	11	7	7	8	
4	1.73	4.38	9	9	9	6	5	6	
5	2.44	6.19	6	6	5	4	4	5	
6	3.47	8.82	4	6	4	4	5	4	
7	6.28	15.95	2	4	3	4	3	4	
8	7.31	18.57	3	2	3	2	2	3	
9	8.02	20.38	2	2	2	2	2	1	
10	8.60	21.84	3	0	1	1	1	1	
11	9.10	23.11	0	1	0	1	1	0	
12	9.55	24.24	0	0	0	0	0	-1	
			west			north			All
Average of all data			5.2	6.3	5.1	3.9	4.1	4.1	4.8
w/o points by wall			5.4	6.5	5.2	3.8	4.0	4.1	4.8
Centerpoint			3	5	3	4	4	4	
Center 2/3 with centerpoint									All
Mean			4.8	5.4	4.6	3.8	3.7	4.0	4.4

Instuments Used:	Cal Exp. Date:
"S" pitot tube connected to slant tube manometer	NA

ANGULAR FLOW TEST DATA FORM

Site	Saltwell Mockup @ 305	Run No.	AT-2
Date	3/4/97	Stack Temp	NA
Tester	Glissmeyer	Stack RH%	NA
Stack Dia.	9.75 in	Baro Press	NA
Stack X-Area	74.7 in2	Fan Setting	24 Hz, 500 cfm
Elevation		Offset to index	
El. above disturbance	45.5 in.	Units	degrees clockwise

Traverse-->			E/W			S/N			
Trial --->			1	2	3	1	2	3	
Point	Depth, in.	cm							
1	0.20	0.52	6	9	10	5	7	10	
2	0.65	1.66	13	9	16	7	7	14	
3	1.15	2.92	17	13	12	0	10	11	
4	1.73	4.38	5	5	9	3	8	11	
5	2.44	6.19	9	9	4	3	7	6	
6	3.47	8.82	1	4	2	3	6	4	
7	6.28	15.95	4	1	4	2	5	4	
8	7.31	18.57	3	0	0	3	4	4	
9	8.02	20.38	0	4	0	3	3	3	
10	8.60	21.84	4	1	3	1	2	4	
11	9.10	23.11	0	0	0	1	1	3	
12	9.55	24.24	0	1	0	1	0	0	
			west			north			All
Average of all data			5.2	4.7	5.0	2.7	5.0	6.2	4.8
w/o points by wall			5.6	4.6	5.0	2.6	5.3	6.4	4.9
Centerpoint			2	4	1	4	5	5	
Center 2/3 with centerpoint									All
Mean			5.0	4.6	3.9	2.4	5.6	5.8	4.5

Instuments Used: | **Cal Exp. Date:**

Instruments Used	Cal Exp. Date
"S" pitot tube connected to slant tube manometer	NA

ANGULAR FLOW TEST DATA FORM

Site	Saltwell Mockup @ 305	Run No.	AT-3
Date	3/4 - 3/5/97	Stack Temp	NA
Tester	Glissmeyer	Stack RH%	NA
Stack Dia.	9.75 in	Baro Press	NA
Stack X-Area	74.7 in2	Fan Setting	16 Hz, 300 cfm
Elevation		Offset to index	
El. above disturbance	45.5 in.	Units	degrees clockwise

Traverse-->			E/W			S/N			
Trial ---->			1	2	3	1*	2*	3*	
Point	Depth, in.	cm							
1	0.20	0.52	14	16	11	6	5	9	
2	0.65	1.66	16	6	9	8	15	16	
3	1.15	2.92	16	6	9	8	7	12	
4	1.73	4.38	8	6	4	5	11	9	
5	2.44	6.19	7	7	4	3	4	9	
6	3.47	8.82	5	4	0	3	6	10	
7	6.28	15.95	7	3	0	3	7	8	
8	7.31	18.57	1	5	3	4	4	4	
9	8.02	20.38	0	2	2	1	6	5	
10	8.60	21.84	3	3	4	4	3	5	
11	9.10	23.11	3	0	0	1	2	4	
12	9.55	24.24	4	1	0	1	1	4	
			west			north			All
Average of all data			7.0	4.9	3.8	3.9	5.9	7.9	5.6
w/o points by wall			6.6	4.2	3.5	4.0	6.5	8.2	5.5
Centerpoint			11	8	0	4	10	7	
Center 2/3 with centerpoint									All
Mean			6.4	4.9	2.9	3.9	6.4	7.7	5.4

Instuments Used:	Cal Exp. Date:
"S" pitot tube connected to slant tube manometer	NA

* Data taken 3/5/97

Appendix B

Air Velocity Uniformity Test

Procedure to Calibrate Fan Controller and Conduct Velocity Traverses

February 6, 1997

Fan Controller Calibration

The purpose is to determine the fan speed controller frequency setting versus stack flowrate. The fan speed will be indicated by the frequency setting on the variable frequency controller. A calibration of approximate stack flow versus frequency will enable quicker execution of subsequent experiments. It is acknowledged that as the inlet filter loads, the calibration may change and may need to be repeated. A series of velocity traverses will be made at various frequency settings. Frequency settings can vary from 0 to 60 Hz.

1. Seal off all stack and duct openings, remove the top stack cover, and remove the inlet filter cover. Obtain a calibrated micro-manometer and pitot tube. Measure the stack inside diameter and the distance (offset) from the external index point at the traverse ports. Lay out the velocity traverse points per 40 CFR 60, Appendix A, Method 1 on a data sheet, and add a center point. Place a strip of masking tape along the barrel of the pitot tube, and mark each traverse point, including the offset to the index point. Attach fittings to the traverse port so that there will be a seal around the pitot tube barrel. Prepare an adequate number of copies of the data sheet. Call the weather station to get the barometric pressure and humidity for the location. Air temperature can be measured in the stack with a calibrated instrument during the velocity traverses.

2. At a frequency setting of 30, perform a full velocity traverse along both directions, repeating each traverse three times. Record the data, calculate the mean velocity, and determine a location where the velocity, measured is closest to the calculated mean. 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.

3. Measure the average velocity in the stack corresponding to settings on the fan controller. Space the fan controller settings at 5-Hz increments over the range of 5- to 60-Hz. Place the pitot tube at the location of the average velocity reading determined above. Record the velocity reading for each controller setting. Repeat three times. Calculate the average of the three readings at each controller setting. Plot the average reading versus controller frequency.

Velocity Traverse

Complete a velocity traverse following the method in Step 1 for each stack flowrate for which the angular flow, gas, and particle mixing tests will be conducted. From the plot of velocity versus controller frequency, select the frequency values corresponding to the test flowrates. At each flowrate, conduct a complete velocity traverse. Repeat three times. Change the controller setting between each traverse so the results will reflect the variability of the controller. Calculate the average velocity, omitting data from the center point and points closer to the wall than 0.5 in.

Calculate the coefficient of variance for the data from the above three velocity traverses. Omit the values for points closest to the wall, and include the center point. The acceptance criterion for the COV is ≤20% for the inner two-thirds of the stack diameter. The COV is 100 times the mean divided by the standard deviation.

VELOCITY TRAVERSE DATA FORM

Site	Salt Well Mockup @ 305	Run No.	VT-1
Date	2/20/97 - 2/21/97	Stack Temp	18.3 - 19 C
Tester	Glissmeyer	Stack RH%	NA
Stack Dia.	9.75 in.	Baro Press	1011.5 mbar, static 0.44 mbar
Stack X-Area	74.7 in2	Fan Setting	378 cfm, 16 Hz, 3.7 m/s
Elevation		Offset to index	
El. above disturbance	45.5 in	Center 2/3 from	0.89 to: 8.86
Units	m/s	Points in Center 2/3	3 to: 10

Traverse-->		E/W			S/N			
Trial --->		1	2*	3*	1	2	3	
Point	Depth	Velocity	Velocity	Velocity	Velocity	Velocity	Velocity	
1	0.20	1.8	2.4	2.2	1.5	0.9	1.3	
2	0.65	2.5	3.2	2.7	1.7	1.6	1.4	
3	1.15	3.2	3.5	3.1	1.9	1.8	1.7	
4	1.73	2.8	2.7	2.4	2.0	2.8	2.2	
5	2.44	2.9	2.8	3.0	1.5	2.5	2.1	
6	3.47	3.0	3.4	2.7	2.4	2.1	2.8	
7	6.28	3.2	4.2	4.3	4.6	4.5	4.9	
8	7.31	4.1	4.2	3.5	5.1	4.8	5.1	
9	8.02	3.9	4.3	4.0	5.9	5.3	5.6	
10	8.60	3.6	4.2	3.6	5.5	5.2	6.0	
11	9.10	3.3	3.0	3.7	4.9	5.4	5.1	
12	9.55	2.8	2.7	3.0	4.1	4.2	3.9	
		west			north			Avg.
Average of all data		3.1	3.4	3.2	3.4	3.4	3.5	3.34
w/o points by wall		3.3	3.6	3.3	3.6	3.6	3.7	3.49
Centerpoint	4.875	2.6	3.2	3.1	3.3	3.3	3.4	

Center 2/3 with centerpoint							Avg
Mean	3.3	3.6	3.3	3.6	3.6	3.8	3.51
Std. Dev.	0.510	0.635	0.608	1.715	1.375	1.658	1.154
COV %	15.7	17.6	18.4	47.9	38.3	44.1	32.8

Flow 340 cfm
Flow 578 m3/hr

* Data taken 2/21/97

Instuments Used: | **Cal Exp. Date:**

Solomat Zephyr S/N 12951472 Cal #521-28-09-001 | 2/7/98

VELOCITY TRAVERSE DATA FORM

Site	Salt Well Mockup @ 305	Run No.	VT-2
Date	2/21/97	Stack Temp	18.4 - 19.8 C
Tester	Glissmeyer	Stack RH%	NA
Stack Dia.	9.75 in.	Baro Press	1014 mbar, static 0.8 mbar
Stack X-Area	74.7 in2	Fan Setting	500 cfm, 4.9 m/s, 21 Hz
Elevation		Offset to index	
El. above disturbance	45.5 in	Center 2/3 from	0.89 to: 8.86
Units	m/s	Points in Center 2/3	3 to: 10

Traverse-->		W/E			N/S			
Trial --->		1	2	3	1	2	3	
Point	Depth	Velocity	Velocity	Velocity	Velocity	Velocity	Velocity	
1	0.20	3.8	3.4	3.3	1.7	1.7	2.0	
2	0.65	4.0	3.6	3.4	2.3	2.7	2.4	
3	1.15	4.2	3.9	4.8	2.6	2.7	2.9	
4	1.73	4.5	4.2	4.2	2.6	3.4	2.5	
5	2.44	4.7	3.6	4.2	3.8	2.6	2.9	
6	3.47	4.3	4.7	4.6	3.8	3.8	3.6	
7	6.28	4.6	5.1	5.5	5.6	6.3	5.6	
8	7.31	5.6	6.0	6.0	7.5	7.4	7.2	
9	8.02	5.6	6.2	5.9	7.6	7.1	7.0	
10	8.60	5.9	5.5	4.8	7.1	6.9	7.0	
11	9.10	4.7	4.5	4.9	7.2	6.6	6.2	
12	9.55	4.0	4.5	3.9	5.2	4.8	4.9	
		west			north			Avg.
Average of all data		4.7	4.6	4.6	4.8	4.7	4.5	4.64
w/o points by wall		4.8	4.7	4.8	5.0	5.0	4.7	4.84
Centerpoint	4.875	4.5	5.1	4.0	4.7	4.9	4.9	

Center 2/3 with centerpoint							Avg
Mean	4.9	4.9	4.9	5.0	5.0	4.8	4.92963
Std. Dev.	0.640	0.905	0.747	2.008	1.953	1.937	1.423
COV %	13.1	18.4	15.3	39.9	39.0	40.0	28.9

Flow 473 cfm
Flow 804 m3/hr

Instuments Used:	Cal Exp. Date:
Solomat Zephyr S/N 12951472 Cal #521-28-09-001	2/7/98

VELOCITY TRAVERSE DATA FORM

Site	Salt Well Mockup @ 305	Run No.	VT-3
Date	2/21/97	Stack Temp	18.4 - 19.8 C
Tester	Glissmeyer	Stack RH%	NA
Stack Dia.	9.75 in.	Baro Press	1014 mbar, static 3.4 mbar
Stack X-Area	74.7 in2	Fan Setting	1000 cfm, 9.8 m/s, 42 Hz
Elevation		Offset to index	
El. above disturbance	45.5 in	Center 2/3 from	0.89 to: 8.86
Units	m/s	Points in Center 2/3	3 to: 10

Traverse-->		W/E			N/S		
Trial --->		1	2	3	1	2	3
Point	Depth	Velocity	Velocity	Velocity	Velocity	Velocity	Velocity
1	0.20	8.0	6.4	7.0	4.1	4.4	5.0
2	0.65	7.8	7.1	7.9	5.1	4.2	5.6
3	1.15	8.2	8.4	8.2	6.2	4.7	5.6
4	1.73	9.5	8.4	8.4	4.3	6.4	6.0
5	2.44	7.9	8.2	8.5	6.1	7.1	7.1
6	3.47	9.5	9.0	9.3	8.0	7.1	6.9
7	6.28	12.3	12.4	10.6	12.0	13.5	13.1
8	7.31	12.1	12.8	11.3	14.4	14.7	13.4
9	8.02	11.2	12.9	11.7	14.6	14.9	15.8
10	8.60	11.4	12.0	12.0	14.8	14.8	14.2
11	9.10	10.1	10.2	10.5	15.2	14.3	13.7
12	9.55	7.9	8.7	9.3	12.1	10.9	11.2

	west			north			Avg.
Average of all data	9.7	9.7	9.6	9.7	9.8	9.8	9.70
w/o points by wall	10.0	10.1	9.8	10.1	10.2	10.1	10.06

Centerpoint	4.875	10.7	10.1	9.7	11.0	11.2	9.8

Center 2/3 with centerpoint							Avg
Mean	10.3	10.5	10.0	10.2	10.5	10.2	10.3
Std. Dev.	1.615	2.044	1.482	4.100	4.162	3.960	2.985
COV %	15.7	19.5	14.9	40.4	39.7	38.8	29.1

Flow 990 cfm
Flow 1682 m3/hr

Instuments Used:	**Cal Exp. Date:**
Solomat Zephyr S/N 12951472 Cal #521-28-09-001	2/7/98

VELOCITY TRAVERSE DATA FORM

Site	Salt Well Mockup @ 305	Run No.	VT-4
Date	2/26/97	Stack Temp	20.5 C
Tester	Glissmeyer	Stack RH%	NA
Stack Dia.	9.75 in.	Baro Press	1001.6, stack static 0.7 mbar
Stack X-Area	74.7 in2	Fan Setting	500 cfm, 4.9 m/s, 21 Hz
Elevation		Offset to index	
El. above disturbance	45.5 in	Center 2/3 from	0.89 to: 8.86
Units	m/s	Points in Center 2/3	3 to: 10

Measured after alignment of fan and stack centerlines.

Traverse-->		W/E			N/S			
Trial --->		1	2	3	1	2	3	
Point	Depth	Velocity	Velocity	Velocity	Velocity	Velocity	Velocity	
1	0.20	3	3.9	3	2.8	4.1	3.5	
2	0.65	3.7	3.4	4.1	3.5	4.2	3.6	
3	1.15	3.7	4.2	3.8	4	3.8	4.4	
4	1.73	3.8	4.9	3.9	4.1	4.4	3.3	
5	2.44	4.5	4.1	4.7	4.7	4.3	4.6	
6	3.47	4.9	5.5	4.7	5.2	5.4	4.8	
7	6.28	4.9	5.5	4.7	5.2	5.4	4.8	
8	7.31	4.4	5	5.4	4.9	4.3	4.8	
9	8.02	4.5	4.5	3.9	4.2	4.4	4.1	
10	8.60	4.4	4	3.8	4	4.4	4.2	
11	9.10	3.2	3.7	4	4.3	4.3	3.8	
12	9.55	3.7	3.1	3.1	3.6	3.6	3.3	
		west			north			Avg.
Average of all data		4.1	4.3	4.1	4.2	4.4	4.1	4.19
w/o points by wall		4.2	4.5	4.3	4.4	4.5	4.2	4.35
Centerpoint	4.875	4.6	5	4.9	4.9	4.9	4.7	

Center 2/3 with centerpoint							Avg
Mean	4.4	4.7	4.4	4.6	4.6	4.4	4.53
Std. Dev.	0.420	0.573	0.585	0.504	0.537	0.494	0.512
COV %	9.5	12.1	13.2	11.0	11.7	11.2	11.3

Flow 428 cfm
Flow 727 m3/hr

Instuments Used:	**Cal Exp. Date:**
Solomat Zephyr S/N 12951472 Cal #521-28-09-001	2/7/98

VELOCITY TRAVERSE DATA FORM

Site	Salt Well Mockup @ 305	Run No.	VT-5
Date	2/27/97	Stack Temp	21.1 C
Tester	Glissmeyer	Stack RH%	NA
Stack Dia.	9.75 in.	Baro Press	1002.4, stack 1 mbar
Stack X-Area	74.7 in2	Fan Setting	500 cfm, 4.9 m/s, 24 Hz
Elevation		Offset to index	
El. above disturbance	45.5 in	Center 2/3 from	0.89 to: 8.86
Units	m/s	Points in Center 2/3	3 to: 10

Measured after alignment of fan and stack centerlines.

Traverse-->		W/E			N/S			
Trial --->		1	2	3	1	2	3	
Point	Depth	Velocity	Velocity	Velocity	Velocity	Velocity	Velocity	
1	0.20	3.9	4.2	3.9	3.9	4.2	4.5	
2	0.65	4.2	4.5	4.1	4.5	5.5	4.5	
3	1.15	4.2	4.3	4.2	5.0	4.6	4.5	
4	1.73	4.5	4.3	5.2	4.6	5.7	4.5	
5	2.44	4.9	4.7	4.5	5.1	4.8	5.2	
6	3.47	5.1	5.3	5.4	5.4	5.1	5.3	
7	6.28	5.4	5.5	6.0	5.5	5.9	5.5	
8	7.31	5.5	5.2	5.4	5.2	5.4	5.2	
9	8.02	4.7	4.8	5.0	5.0	5.2	5.1	
10	8.60	5.0	4.9	5.1	5.1	5.0	5.6	
11	9.10	4.5	4.2	4.7	4.2	4.7	4.8	
12	9.55	4.3	4.1	4.2	4.0	4.3	3.9	
		west			north			Avg.
Average of all data		4.7	4.7	4.8	4.8	5.0	4.9	4.81
w/o points by wall		4.8	4.8	5.0	5.0	5.2	5.0	4.95
Centerpoint	4.875	5	5.3	5.5	6.2	4.9	5.6	
Center 2/3 with centerpoint								Avg
Mean		4.9	4.9	5.1	5.2	5.2	5.2	5.09
Std. Dev.		0.412	0.438	0.539	0.444	0.424	0.418	0.444
COV %		8.4	8.9	10.5	8.5	8.2	8.1	8.7

Flow 491 cfm
Flow 834 m3/hr

Instuments Used:	Cal Exp. Date:
Solomat Zephyr S/N 12951472 Cal #521-28-09-001	2/7/98

VELOCITY TRAVERSE DATA FORM

Site	Salt Well Mockup @ 305	Run No.	VT-6
Date	2/27/1997 & 2/28	Stack Temp	21.2 C - 16.7 C
Tester	Glissmeyer	Stack RH%	NA
Stack Dia.	9.75 in.	Baro Press	1002.4 - 1012.1, stack 0.4 mbar
Stack X-Area	74.7 in2	Fan Setting	16 Hz
Elevation		Offset to index	
El. above disturbance	45.5 in	Center 2/3 from	0.89 to: 8.86
Units	m/s	Points in Center 2/3	3 to: 10

Measured after alignment of fan and stack centerlines.

Traverse-->		W/E			N/S			
Trial --->		1	2	3	1	2*	3*	
Point	Depth	Velocity	Velocity	Velocity	Velocity	Velocity	Velocity	
1	0.20	2.4	2.2	2.3	2.8	3.2	2.7	
2	0.65	3.0	2.4	2.4	4.2	2.5	2.7	
3	1.15	2.6	2.7	2.9	3.0	2.8	3.1	
4	1.73	2.8	3.2	3.3	2.8	2.8	2.7	
5	2.44	3.3	3.1	3.0	2.9	3.1	3.2	
6	3.47	3.3	3.4	3.5	3.5	3.3	3.6	
7	6.28	3.3	3.7	3.5	3.1	3.3	3.6	
8	7.31	3.7	3.2	3.4	3.2	3.2	3.4	
9	8.02	3.3	3.2	2.9	3.3	2.9	3.0	
10	8.60	2.6	3.0	2.9	2.7	3.4	2.8	
11	9.10	3.0	2.7	3.0	2.9	3.3	3.0	
12	9.55	2.4	2.7	2.5	2.1	2.6	2.2	
		west			north			Avg.
Average of all data		3.0	3.0	3.0	3.0	3.0	3.0	3.00
w/o points by wall		3.1	3.1	3.1	3.2	3.1	3.1	3.09
Centerpoint	4.875	3.8	3.7	3.5	3.4	3.9	3.8	

Center 2/3 with centerpoint							Avg
Mean	3.2	3.2	3.2	3.1	3.2	3.2	3.20
Std. Dev.	0.437	0.321	0.280	0.274	0.348	0.381	0.332
COV %	13.7	9.9	8.7	8.8	10.9	11.7	10.4

Flow 306 cfm
Flow 519 m3/hr

Instuments Used:	Cal Exp. Date:
Solomat Zephyr S/N 12951472 Cal #521-28-09-001	2/7/98

* measured 2/28/97

VELOCITY TRAVERSE DATA FORM

Site	Salt Well Mockup @ 305	Run No.	VT-7
Date	2/27/97	Stack Temp	22.9 C
Tester	Glissmeyer	Stack RH%	NA
Stack Dia.	9.75 in.	Baro Press	1002.4, stack 3 mbar
Stack X-Area	74.7 in2	Fan Setting	42 Hz
Elevation		Offset to index	
El. above disturbance	45.5 in	Center 2/3 from	0.89 to: 8.86
Units	m/s	Points in Center 2/3	3 to: 10

Measured after alignment of fan and stack centerlines.

Traverse-->		W/E			N/S			
Trial --->		1	2	3	1	2	3	
Point	Depth	Velocity	Velocity	Velocity	Velocity	Velocity	Velocity	
1	0.20	7.5	6.9	6.9	8.3	7.6	7.8	
2	0.65	8.4	7.4	7.5	8.2	9.1	8.0	
3	1.15	8.1	8.3	8.3	8.8	7.6	9.0	
4	1.73	7.3	7.3	9.2	9.5	8.7	8.5	
5	2.44	9.4	9.7	9.5	9.6	9.8	8.5	
6	3.47	8.8	9.4	8.8	9.4	9.5	9.3	
7	6.28	10.4	9.7	10.1	10.0	10.0	9.8	
8	7.31	9.7	10.4	10.7	9.0	10.3	9.2	
9	8.02	9.9	9.8	11.2	9.3	10.3	9.3	
10	8.60	8.8	9.6	8.7	9.6	8.3	8.9	
11	9.10	7.9	8.5	7.9	9.6	8.9	8.5	
12	9.55	6.9	7.1	7.0	8.1	8.2	7.1	
		west			north			Avg.
Average of all data		8.6	8.7	8.8	9.1	9.0	8.7	8.81
w/o points by wall		8.9	9.0	9.2	9.3	9.3	8.9	9.09
Centerpoint	4.875	10.4	10.5	9.3	9.3	9.4	9.8	

Center 2/3 with centerpoint							Avg
Mean	9.2	9.4	9.5	9.4	9.3	9.1	9.33
Std. Dev.	1.049	1.013	0.960	0.352	0.938	0.477	0.814
COV %	11.4	10.8	10.1	3.7	10.1	5.2	8.7

Flow 899 cfm
Flow 1528 m3/hr

Instuments Used: **Cal Exp. Date:**

Solomat Zephyr S/N 12951472 Cal #521-28-09-001 — 2/7/98

VELOCITY TRAVERSE DATA FORM

Site	Salt Well Mockup @ 305	Run No.	VT-8
Date	2/28/97	Stack Temp	16.7 - 19.7 C
Tester	Glissmeyer	Stack RH%	NA
Stack Dia.	9.75 in.	Baro Press	1012.1, stack 4 mbar
Stack X-Area	74.7 in2	Fan Setting	48 Hz
Elevation		Offset to index	
El. above disturbance	45.5 in	Center 2/3 from	0.89 to: 8.86
Units	m/s	Points in Center 2/3	3 to: 10

Measured after alignment of fan and stack centerlines.

Traverse-->		W/E			N/S			
Trial --->		1	2	3	1	2	3	
Point	Depth	Velocity	Velocity	Velocity	Velocity	Velocity	Velocity	
1	0.20	8.9	8.0	9.1	8.5	9.5	9.0	
2	0.65	8.7	8.5	9.7	9.6	9.7	9.5	
3	1.15	9.2	9.0	9.6	9.7	9.4	9.9	
4	1.73	10.1	9.7	9.6	10.7	9.0	10.6	
5	2.44	10.0	10.9	10.2	9.4	11.0	10.4	
6	3.47	10.4	10.8	11.3	10.6	11.1	10.1	
7	6.28	11.7	11.9	11.2	11.3	11.4	10.9	
8	7.31	11.2	11.7	10.6	10.6	10.7	10.7	
9	8.02	11.0	11.4	11.3	10.3	10.8	10.5	
10	8.60	10.4	10.5	10.7	10.5	10.4	9.6	
11	9.10	10.4	10.0	9.8	9.6	9.8	9.6	
12	9.55	9.6	9.9	9.6	8.3	8.0	7.8	
		west			north			Avg.
Average of all data		10.1	10.2	10.2	9.9	10.1	9.9	10.07
w/o points by wall		10.3	10.4	10.4	10.2	10.3	10.2	10.32
Centerpoint	4.875	11.6	11.5	11.9	11.8	11.3	11.6	
Center 2/3 with centerpoint								Avg
Mean		10.6	10.8	10.7	10.5	10.6	10.5	10.62
Std. Dev.		0.820	0.963	0.798	0.730	0.838	0.587	0.767
COV %		7.7	8.9	7.4	6.9	7.9	5.6	7.2

Flow 1028 cfm
Flow 1746 m3/hr

Instuments Used: | **Cal Exp. Date:**

Solomat Zephyr S/N 12951472 Cal #521-28-09-001 | 2/7/98

VELOCITY TRAVERSE DATA FORM

Site	Salt Well Mockup @ 305	Run No.	VT-9
Date	4/2/97	Stack Temp	75 deg F (23.9 deg C)
Tester	Maughan	Stack RH%	21 % 200 Area station
Stack Dia.	9.75 in.	Baro Press	1014.5, static 5.4 mbar
Stack X-Area	74.7 in2	Fan Setting	56 Hz (approx <1200 cfm) *
Elevation		Offset to index	
El. above disturbance	45.5 in	Center 2/3 from	0.89 to: 8.86
Units	m/s	Points in Center 2/3	3 to: 10

Measured after alignment of fan and stack centerlines.

Traverse-->		W/E			N/S		
Trial --->		East 1	2	3	South 1	2	3
Point	Depth	Velocity	Velocity	Velocity	Velocity	Velocity	Velocity
1	0.20	10.9	9.8	9.9	7.8	10.9	8.1
2	0.65	11.9	10.6	11.4	10.2	11.1	11.3
3	1.15	10.0	11.7	11.6	9.7	10.8	9.7
4	1.73	12.0	11.2	11.7	10.3	12.4	12.2
5	2.44	11.8	12.1	11.9	13.1	12.5	12.8
6	3.47	12.3	13.1	12.8	12.9	12.0	13.2
7	6.28	14.0	13.9	13.7	14.3	13.7	13.4
8	7.31	12.8	13.6	13.6	13.0	13.0	12.4
9	8.02	12.2	13.2	14.4	12.2	11.9	12.7
10	8.60	12.7	12.8	12.8	11.9	13.1	11.9
11	9.10	11.4	11.6	11.9	11.5	12.0	12.8
12	9.55	10.2	9.6	10.8	9.6	9.7	11.7

	west			north			Avg.
Average of all data	11.9	11.9	12.2	11.4	11.9	11.9	11.86
w/o points by wall	12.1	12.4	12.6	11.9	12.3	12.2	12.25

Centerpoint	4.875	13.3	14.2	13.5	13.3	13.5	13.9

Center 2/3 with centerpoint							Avg
Mean	12.3	12.9	12.9	12.3	12.5	12.5	12.57
Std. Dev.	1.114	1.017	0.993	1.476	0.904	1.208	1.105
COV %	9.0	7.9	7.7	12.0	7.2	9.7	8.8

Flow 1210 cfm
Flow 2056 m3/hr

Instuments Used:	**Cal Exp. Date:**
Solomat Zephyr S/N 12951472 Cal #521-28-09-001	2/7/98

* Measurements made without the "hood" attached to the top of the stack.

Note: each of the above readings were averages of 55 to 62 separate readings.

Note: the desired probe angle (90-deg) from the vertical stack was not always perfectly maintained.

VELOCITY TRAVERSE DATA FORM

Site	Salt Well Mockup @ 305	Run No.	VT-10
Date	4/25/97	Stack Temp	72 F
Tester	Maughan	Stack RH%	NA
Stack Dia.	9.75 in.	Baro Press	1015, static 0.34 mbar
Stack X-Area	74.7 in2	Fan Setting	12 Hz
Elevation		Offset to index	
El. above disturbance	45.5 in	Center 2/3 from	0.89 to: 8.86
Units	m/s	Points in Center 2/3	3 to: 10

Measured after alignment of fan and stack centerlines.

Traverse-->		W/E			N/S			
Trial --->		East 1	2	3	South 1	2	3	
Point	Depth	Velocity	Velocity	Velocity	Velocity	Velocity	Velocity	
1	0.20	1.7	1.6	1.7	1.7	1.6	1.8	
2	0.65	2.0	1.8	1.8	2.3	1.9	1.9	
3	1.15	2.1	2.0	1.8	2.3	1.9	2.0	
4	1.73	2.0	2.1	2.0	2.4	2.1	2.2	
5	2.44	2.2	2.2	2.3	2.4	2.6	2.5	
6	3.47	2.3	2.4	2.2	2.2	2.4	2.4	
7	6.28	2.6	2.5	2.6	2.5	2.9	2.4	
8	7.31	2.3	2.3	2.2	2.2	2.0	2.3	
9	8.02	2.1	2.1	2.0	2.5	2.4	2.5	
10	8.60	1.9	2.3	2.1	2.0	2.5	2.2	
11	9.10	1.8	1.7	1.8	1.8	1.9	1.6	
12	9.55	1.2	1.6	1.4	1.9	1.5	1.8	
		west			north			Avg.
Average of all data		2.0	2.1	2.0	2.2	2.1	2.1	2.09
w/o points by wall		2.1	2.1	2.1	2.3	2.3	2.2	2.18
Centerpoint	4.875	2.3	2.6	2.7	2.4	2.9	2.8	

Center 2/3 with centerpoint							Avg
Mean	2.2	2.3	2.2	2.3	2.4	2.4	2.30
Std. Dev.	0.206	0.199	0.289	0.164	0.362	0.229	0.251
COV %	9.4	8.7	13.1	7.1	15.0	9.7	10.9

Flow 213 cfm
Flow 362 m3/hr

Instuments Used: **Cal Exp. Date:**

Solomat Zephyr S/N 12951472 Cal #521-28-09-001 2/7/98

* Measurements made without the "hood" attached to the top of the stack.

Note: each of the above readings were averages of 50 separate readings.

Note: the desired probe angle (90-deg) from the vertical stack was not always perfectly maintained.

VELOCITY TRAVERSE DATA FORM

Site	AP40/Saltwell	Run No.	**VT-11**
Date	5/9/1997 and 5/14/97	Stack Temp	72 F for both days
Tester	Glissmeyer	Stack RH%	NA
Stack Dia.	10 in.	Baro Press	1003 & 997.3, static 2.5 & 2.0 mbar
Stack X-Area	78.5 in2	Fan Setting	40 Hz
Elevation		Offset to index	
El. above disturbance	43 in	Center 2/3 from	0.92 to: 9.08
Units	m/s	Points in Center 2/3	3 to: 10

Measured after alignment of fan and stack centerlines.

Traverse-->		W/E			N/S			
Trial --->		East 1	2	3	South 1	2	3	
Point	Depth	Velocity	Velocity	Velocity	Velocity	Velocity	Velocity	
1	0.21	6.4	7.0	5.9	4.5	5.8	5.7	
2	0.67	6.1	8.0	7.4	6.4	7.1	7.4	
3	1.18	7.4	8.4	7.9	7.0	7.5	7.7	
4	1.77	8.3	8.6	8.0	7.1	8.5	9.8	
5	2.50	8.5	9.5	8.3	7.6	9.8	9.2	
6	3.56	8.7	10.7	9.2	8.4	9.7	10.6	
7	6.44	11.4	12.4	11.4	10.8	11.3	11.0	
8	7.50	10.4	10.6	10.0	10.8	8.9	9.2	
9	8.23	9.1	10.7	10.5	10.8	9.9	9.1	
10	8.82	8.8	8.9	9.8	9.0	8.7	9.6	
11	9.33	5.4	6.2	6.7	10.0	8.1	8.2	
12	9.79	3.5	3.0	2.8	7.7	5.5	6.1	
		west			north			Avg.
Average of all data		7.8	8.7	8.2	8.3	8.4	8.6	8.34
w/o points by wall		8.4	9.4	8.9	8.8	9.0	9.2	8.94
Centerpoint	4.875	11.4	10.7	11.2	9.9	11.3	10.6	

Center 2/3 with centerpoint							Avg
Mean	9.3	10.1	9.6	9.0	9.5	9.6	9.53
Std. Dev.	1.411	1.301	1.328	1.599	1.263	1.010	1.303
COV %	1.745	1.861	1.513	1.506	1.024	0.889	13.7

Flow 895 cfm
Flow 1521 m3/hr

Instuments Used:	**Cal Exp. Date:**
Solomat Zephyr S/N 12951472 Cal #521-28-09-001	2/7/98
* Measurements made with the "hood" attached to the top of the stack.	
Note: each of the above readings were averages of 40 separate readings.	
Traverse #1 was run on 5/9/97.	

VELOCITY TRAVERSE DATA FORM

Site	AP40/Saltwell	Run No.	VT-12
Date	5/9/1997 and 5/14/97	Stack Temp	72 F (both days)
Tester	Glissmeyer	Stack RH%	NA
Stack Dia.	10 in.	Baro Press	1003 & 997.3, static 2.5 & 2.0 mbar
Stack X-Area	78.5 in2	Fan Setting	50 Hz
Elevation		Offset to index	
El. above disturbance	43 in	Center 2/3 from	0.92 to: 9.08
Units	m/s	Points in Center 2/3	3 to: 10

Measured after alignment of fan and stack centerlines.

Traverse-->		W/E			N/S			
Trial --->		East 1	2	3	South 1	2	3	
Point	Depth	Velocity	Velocity	Velocity	Velocity	Velocity	Velocity	
1	0.21	7.6	8.7	8.3	7.6	7.9	6.9	
2	0.67	8.4	9.6	9.6	9.7	9.0	10.3	
3	1.18	9.2	10.7	9.6	9.1	10.5	11.1	
4	1.77	9.4	11.3	10.8	10.4	12.4	11.1	
5	2.50	10.9	11.1	11.2	11.4	12.3	12.1	
6	3.56	11.9	13.1	13.7	10.6	13.7	13.3	
7	6.44	13.6	14.2	13.4	11.9	13.7	14.4	
8	7.50	12.9	13.3	12.2	13.0	12.1	12.6	
9	8.23	12.6	12.9	11.3	12.4	12.0	11.2	
10	8.82	11.6	11.3	10.8	11.7	11.3	11.6	
11	9.33	8.4	8.5	9.0	11.5	10.4	9.8	
12	9.79	5.0	5.4	4.6	8.2	7.6	6.8	
		west			north			Avg.
Average of all data		10.1	10.8	10.4	10.6	11.1	10.9	10.66
w/o points by wall		10.9	11.6	11.2	10.9	11.4	11.3	11.20
Centerpoint	4.875	13.7	14.4	14.3	13.2	14	14	
Center 2/3 with centerpoint								Avg
Mean		11.8	12.5	11.9	11.5	12.4	12.4	12.08
Std. Dev.		11.4	12.0	11.6	1.320	1.173	1.273	1.394
COV %		10.9	11.2	10.8	11.5	9.4	10.3	11.5

Flow 1144 cfm
Flow 1945 m3/hr

Instuments Used: | **Cal Exp. Date:**

Solomat Zephyr S/N 12951472 Cal #521-28-09-001 | 2/7/98

* Measurements made with the "hood" attached to the top of the stack.

Note: each of the above readings were averages of 40 separate readings.

Traverse #1 was run on 5/9/97.

VELOCITY TRAVERSE DATA FORM

Site	AP40/Saltwell	Run No.	VT-13
Date	6/18/97	Stack Temp	20.9 C, 70 F
Tester	Glissmeyer	Stack RH%	NA
Stack Dia.	10 in.	Baro Press	999.96, stack 0.04, tot. 1000 mbar
Stack X-Area	78.5 in2	Fan Setting	12 Hz
Elevation		Offset to index	
El. above disturbance	43 in	Center 2/3 from	0.92 to: 9.08
Units	m/s	Points in Center 2/3	3 to: 10

Measured after alignment of fan and stack centerlines.

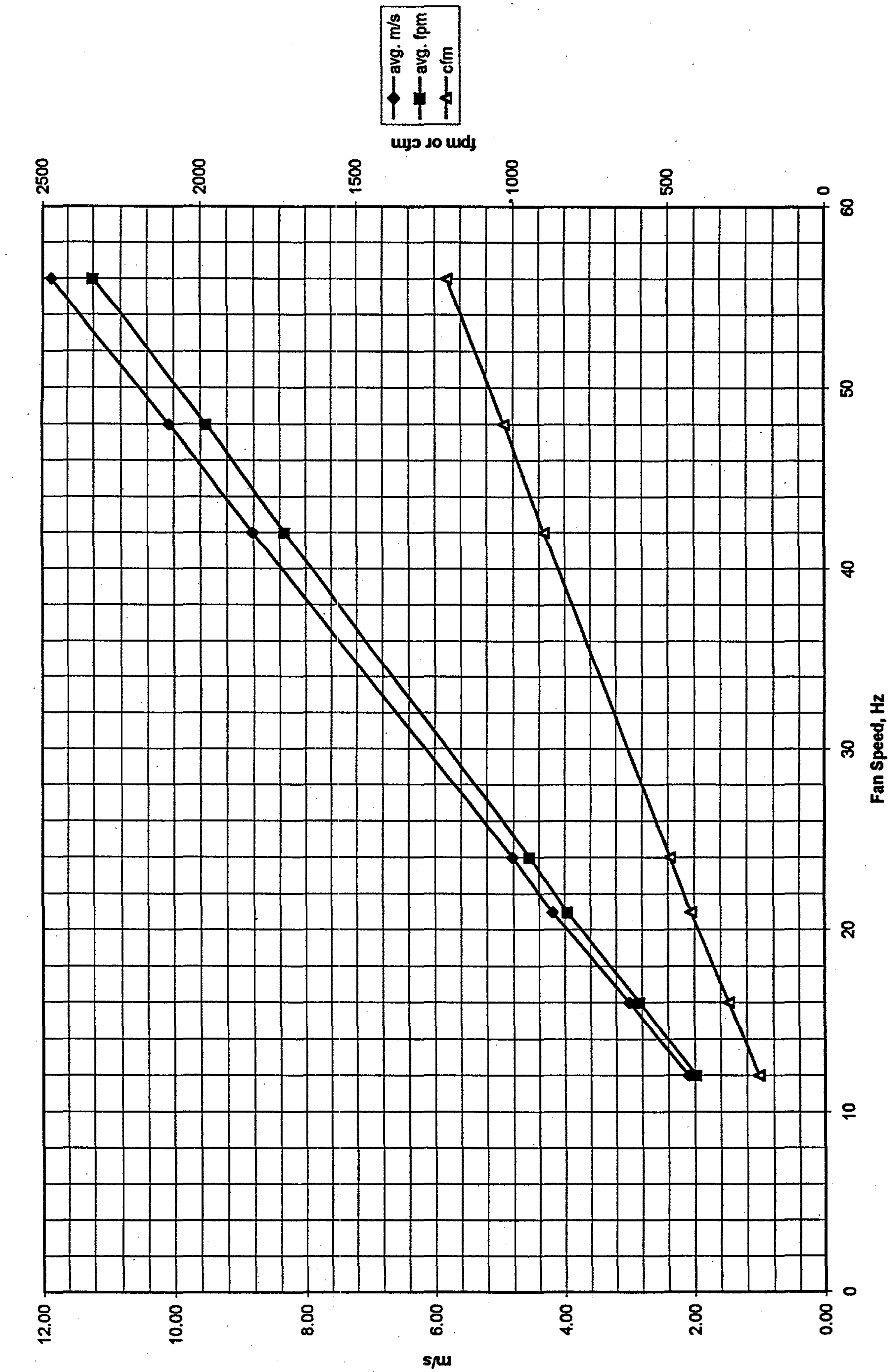
Traverse-->		W/E			N/S			
Trial --->		East 1	2	3	South 1	2	3	
Point	Depth	Velocity	Velocity	Velocity	Velocity	Velocity	Velocity	
1	0.21	1.0	1.6	1.7	1.4	1.1	0.8	
2	0.67	1.7	1.5	1.7	1.5	1.6	1.2	
3	1.18	2.1	1.5	2.1	1.7	1.7	1.9	
4	1.77	1.8	2.1	2.3	2.1	2.3	2.3	
5	2.50	2.2	1.7	2.3	2.2	2.6	2.3	
6	3.56	2.2	2.6	2.3	2.9	3.0	2.7	
7	6.44	2.9	2.8	2.9	3.3	2.9	3.2	
8	7.50	2.8	2.9	2.6	3.3	3.4	2.8	
9	8.23	2.8	2.4	2.1	2.7	2.7	2.8	
10	8.82	2.3	2.0	2.2	3.3	2.6	2.7	
11	9.33	1.8	1.5	1.4	2.7	2.4	2.8	
12	9.79	0.2	0.2	0.3	2.2	2.2	2.1	
		west			north			Avg.
Average of all data		2.0	1.9	2.0	2.4	2.4	2.3	2.17
w/o points by wall		2.3	2.1	2.2	2.5	2.5	2.4	2.34
Centerpoint	4.875	3.0	3.1	3.0	2.9	2.9	2.9	

Center 2/3 with centerpoint							Avg
Mean	2.5	2.3	2.4	2.7	2.7	2.6	2.54
Std. Dev.	2.4	2.3	2.3	0.588	0.479	0.390	0.469
COV %	2.2	2.0	2.0	21.7	17.9	14.9	18.5

Flow 232 cfm
Flow 395 m3/hr

Instuments Used:	**Cal Exp. Date:**
Solomat Zephyr S/N 12951472 Cal #521-28-09-001	2/7/98
* Measurements made with the "hood" attached to the top of the stack.	
Note: each of the above readings were averages of 40 separate readings.	

9.75 in. stack


avg. m/s
avg. fpm
cfm
fpm or cfm
2500
2000
1500
1000
500
0
m/s
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Fan Speed, Hz
0
10
20
30
40
50
60

Appendix C

Gaseous Tracer Uniformity Test

Procedure for Gas Concentration Uniformity Test

February 6, 1997

A uniform contaminant concentration at the sampling plane enables the extraction of samples that represent the true concentration. This will be tested first using a tracer gas. The acceptance criteria are that 1) the coefficient of variance (COV) of the tracer gas concentration is within ±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 more than 30%.

Equipment

Sulfur hexafluoride calibration gas (Matheson 100 ppmv in air)
Sulfur hexafluoride bulk gas (Matheson Instrument purity)
Gas analyzer calibrated for sulfur hexafluoride (Bruel and Kjaer Model 1302)
Gas regulator and flowmeter for metering sulfur hexafluoride
Sampling probe for intake to gas analyzer
Gas injection probe

Check Gas Analyzer

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 plotting the concentrations at the measurement points. The instrument's response should be checked against a calibration standard.

The calibration check equipment consists of the calibration standard sulfur hexafluoride gas, the gas regulator, valve, and a tee with one leg feeding the flowmeter and the other leg attached to the inlet of the Model 1302. Set the Model 1302's clock (part 4.4.2 in manual). Although the Model 1302 has a gas concentration display, it is convenient to record the data on a printer or computer. See the Manual Part 12 (especially Part 12.2.5) for connecting to a printer in data log mode.

Check the zero and calibration of the gas analyzer with the sulfur hexafluoride calibration gas using either the calibration procedure in the analyzer's manual (part 2.2.4 and 2.5) or using the Model 1302 in continuous measurement mode. To set up for continuous measurements, follow the manual procedures starting in Part 4.2. The measurements should be done using the SF_6 filter (Filter B) with (except in dry climates) water vapor correction. Set up the units of measurement as in Part 4.2.3. Enter the barometric pressure, standard temperature (that used by the calibration gas vendor), and the sampling tube length into the environmental setup (part 4.2.4). Set up a continuous monitoring task (4.2.5), and initiate monitoring (4.2.6). Monitor room conditions and record the data for several measurements. The SF_6 concentration in the room should be several orders of magnitude below the calibration gas content. The humidity should be close to ambient. Set the calibration gas flow just enough to excess a slight amount of the gas into the outdoor atmosphere (keep the float in the rotameter up while the analyzer is pulling its sample). The SF_6 reading should be within 10% of the calibration gas concentration, and the water content should be much lower than ambient.

Setup for Stack Measurements

Lay out the sampling points using the same method as for a velocity traverse (40 CFR 60, Appendix A, Method 1). Add a center point, which is not called for in the EPA method cited.

The injection equipment consists of a cylinder of pure sulfur hexafluoride gas, a gas regulator, flowmeter, valve, flexible tubing, and an injection probe (short length of ¼ in. stainless steel tubing with 90° bend at the gas exit end) attached to an injection port on the stack mockup. The connections must be made using fittings that will ensure that the connections cannot be inadvertently broken.

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 into the flow in 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, valve, and vacuum pump. The rotameter and vacuum pump should be sized for about a 2 - 3 lpm flow of air. 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, locate the gas analyzer and printer near the test port on the stack.

Mark the sampling probe so the inlet can be placed at each successive measurement point. Prepare a data sheet on which to enter gas concentration readings and other information relevant to the test.

Estimate the SF_6 injection rate so the average diluted concentration will be within the range of 10 - 100% of the concentration of the calibration gas according to the following equation:

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

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

$$\textit{rotameter reading} = k \times \textit{actual flowrate}$$

where k is 2.25 for SF_6. For example, for a stack flowrate of 955 cfm (27,046 lpm) and a target concentration of 35 ppmv, the injection flowrate should be about 0.95 lpm. For an injection flowrate of about 1 lpm SF_6, the rotameter reading will be about 2.25 lpm air.

Measurements

On the data record sheet, record the test conditions, including the injection point, fan control setting, starting pressure in the tracer gas tank, date, time, ambient temperature, pressure, and humidity. Also record the equipment used and names of the test operators. With the fan controller set as needed for the test conditions, verify the centerline air velocity at the sampling plane.

Start the sampling train and the analyzer to warm it up and achieve equilibrium. The probe can be in any position in the stack. Using the analyzer, record the background level of the tracer gas after the readings stabilize. Do not proceed with the test if the background exceeds 5% of the anticipated average concentration in the stack. Readings also can be made with and without water vapor correction. If the air is dry enough where the water vapor contribution is negligible, the balance of the readings can be done without the correction, thus reducing the time to make each run.

Position the injection probe as directed in the test conditions. Start the injection of the tracer gas at the desired flowrate. Observe the concentration readings in the stack. When they stabilize, adjust the injection rate if the readings are not within 50% of the target concentration. Then, successively position the analyzer's probe at each traverse point. Record at least two analyzer readings for each traverse point. Repeat the entire traverse.

At the end of the test, record a measurement of the ambient concentration of the tracer. Record the climatic conditions if they have changed. Also record the rotameter settings, the elapsed time since the start of injection, and the final pressure in the tracer gas tank.

After the conclusion of the test, calculate the COV of the tracer gas concentrations in the stack.

Potential Test Conditions

This test can be repeated using various tracer injection points to determine if the COV is sensitive to "streaming" at the point where contaminants can be released downstream of the final ventilation filters. The test should include the range of stack flowrates that are observed at the facility. For any given injection plane, five injection points should be used, including the centerline and within 20% of a diameter from the wall at four orthogonally spaced points. Initial tests can be performed at the average stack flowrate with tracer injection at the centerline of the duct.

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. This may result in a false indication of good mixing.

CAUTION

The American Conference of Governmental Industrial Hygienists (ACGIH) time weighted average limit for human exposure sulfur hexafluoride gas is 1000 ppm. It is colorless and odorless.

TRACER GAS TRAVERSE DATA FORM

Site	Salt well mockup @ 305	Run No.	GT-1
Date	Mar. 13, 1997	Injection point	Center
Tester	Glissmeyer, Maughan	Fan Setting	24 Hz for ~ 500 cfm
Stack Dia.	9.75 in.	Stack Temp	
tack X-Area	74.7 in.	Offset to index	
Elevation		Center 2/3 from	0.89 to: 8.86
El. above disturbance	45.5 inches	Points in Center 2/3	3 to: 10
Concentration units	ppm SF_6		

Traverse-->		E/W			S/N			
Trial --->		East 1	2	3	South 1	2	3	
Point	Depth, in.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	
1	0.21	24.3	23.9	23.6	25.6	26.3	25.4	
2		24.2	24.7	24.1	25.8	26.0	25.5	
3	1.18	24.9	24.5	24.5	25.6	25.7	25.8	
4	1.77	24.4	24.2	24.3	25.7	26.0	25.7	
5	2.50	24.9	24.8	24.8	26.2	26.2	26.0	
6	3.56	24.9	24.9	25.1	26.0	26.1	25.5	
7	6.44	26.1	26.3	26.5	25.8	25.9	25.5	
8	7.50	26.5	26.9	26.7	25.3	25.6	25.3	
9	8.23	26.6	26.6	26.1	25.4	25.5	24.9	
10	8.82	27.0	26.2	27.0	24.9	25.7	25.2	
11	9.33	26.9	26.8	26.9	24.6	25.3	25.1	
12	9.79	27.0	26.6	26.5	24.9	25.9	25.5	
		West			North			All
Average of all data		25.6	25.5	25.5	25.5	25.9	25.5	25.6
w/o points by wall		25.6	25.6	25.6	25.5	25.8	25.5	25.6
Centerpoint	0.50	26	25.6	25.6	25.9	25.8	25.8	

Center 2/3 with centerpoint							All
Mean	25.7	25.6	25.6	25.6	25.8	25.5	25.65
Std. Dev.	0.935	0.989	1.001	0.397	0.235	0.346	0.701
COV %	3.6	3.9	3.9	1.5	0.9	1.4	2.7

	Start	Finish	
Tracer tank pressure	~300	~300	psig
Ambient Temp	73	75	F
Injection flowmeter	0.18 (20)	0.18 (20)	lpm [glass ball in meter]
Sampling flowmeter	10	10	lpm
Ambient pressure	1014.4	1013.9	mbar
Ambient humidity	39%	36%	%RH
Wind @ 2 m	NA	NA	m/s
Wind direction	NA	NA	degrees
Centerline vel.			m/s

Gas analyzer checked on: 12 Mar. 97

Instuments Used:	Cal Exp. Date:
Solomat Zephyr #12951472	2/7/98
B & K Model 1302 #1765299, run with/without water correction	NA
Sierra Inc. Constant Flow Air Sampler	NA

TRACER GAS TRAVERSE DATA FORM

Site	Salt well mockup @ 305	Run No.	GT-2
Date	Mar. 3, 1997	Injection point	West
Tester	Maughan	Fan Setting	24 Hz for ~ 500 cfm
Stack Dia.	9.75 in.	Stack Temp	
tack X-Area	74.7 in.	Offset to index	
Elevation		Center 2/3 from	0.89 to: 8.86
El. above disturbance	45.5 inches	Points in Center 2/3	3 to: 10
Concentration units	ppm SF_6		

Traverse-->		E/W			S/N			
Trial ---->		East 1	2	3	South 1	2	3	
Point	Depth, in.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	
1	0.21	24.4	24.4	24.6	20.6	20.2	19.9	
2	0.67	23.8	25.0	24.4	20.9	19.5	21.1	
3	1.18	24.9	25.9	25.0	21.6	20.6	20.3	
4	1.77	24.5	24.7	24.2	21.7	21.0	21.2	
5	2.50	24.7	24.8	24.7	22.1	21.8	21.8	
6	3.56	25.3	24.5	24.6	22.8	23.3	23.7	
7	6.44	27.3	26.8	26.2	27.4	27.1	27.1	
8	7.50	27.6	27.5	27.0	28.6	27.1	28.3	
9	8.23	27.8	27.5	27.4	29.3	30.1	28.8	
10	8.82	27.5	28.0	27.8	29.3	29.6	30.1	
11	9.33	28.0	27.2	27.1	30.1	29.7	30.2	
12	9.79	28.4	26.8	27.7	29.4	29.8	30.1	
		West			North			All
Average of all data		26.2	26.1	25.9	25.3	25.0	25.2	25.6
w/o points by wall		26.1	26.2	25.8	25.4	25.0	25.3	25.6
Centerpoint	0.50	26.3	26.4	26.2	25.8	25.9	24.9	

Center 2/3 with centerpoint

						All
Mean	26.2	26.2	25.4	25.2		25.67
Std. Dev.	1.372	1.332	3.365	3.624		2.586
COV %	5.2	5.1	13.2	14.4		10.1

	Start	Finish		
Tracer tank pressure	~280	~280	psig	Gas analyzer checked on: 12 Mar. 97
Ambient Temp	65	72	F	[Garage door open at first, closed @ E/W, 2,2 pt.]
Injection flowmeter	0.18 (20)	0.18 (20)	lpm [glass ball in meter]	
Sampling flowmeter	10	10	lpm	
Ambient pressure	1014.8	1011.6	mbar	
Ambient humidity	59%	50%	%RH	
Wind @ 2 m	NA	NA	m/s	
Wind direction	NA	NA	degrees	
Centerline vel.			m/s	

Instuments Used:	Cal Exp. Date:
Solomat Zephyr #12951472	2/7/98
B & K Model 1302 #1765299, run with/without water correction	NA
Sierra Inc. Constant Flow Air Sampler	NA

TRACER GAS TRAVERSE DATA FORM

Site	Salt well mockup @ 305	Run No.	GT-3
Date	Mar. 14, 1997	Injection point	East
Tester	Maughan	Fan Setting	24 Hz for ~ 500 cfm
Stack Dia.	9.75 in.	Stack Temp	
tack X-Area	74.7 in.	Offset to index	
Elevation		Center 2/3 from	0.89 to: 8.86
El. above disturbance	45.5 inches	Points in Center 2/3	3 to: 10
Concentration units	ppm SF_6		

Traverse-->		E/W			S/N			
Trial --->		East 1	2	3	South 1	2	3	
Point	Depth, in.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	
1	0.21	26.6	25.9	26.6	30.1	29.6	28.9	
2	0.67	26.9	26.3	25.9	29.8	29.4	29.5	
3	1.18	26.6	26.4	26.9	29.3	29.1	29.0	
4	1.77	26.5	26.4	26.6	28.8	29.2	29.4	
5	2.50	26.6	26.4	26.4	28.7	28.4	28.6	
6	3.56	26.1	26.1	26.0	27.4	27.4	27.1	
7	6.44	25.1	25.3	24.3	25.8	24.0	23.8	
8	7.50	24.5	24.2	24.2	22.9	22.5	23.0	
9	8.23	24.7	24.2	24.8	22.3	22.5	22.2	
10	8.82	23.5	24.1	24.3	21.8	21.6	22.1	
11	9.33	25.8	24.2	25.0	22.1	21.4	21.9	
12	9.79	25.1	25.0	24.2	21.6	21.6	21.5	
		West			North			All
Average of all data		25.7	25.4	25.4	25.9	25.6	25.6	25.6
w/o points by wall		25.6	25.4	25.4	25.9	25.6	25.7	25.6
Centerpoint	0.50	26	25.6	25.8	25.8	25.8	26.1	

Center 2/3 with centerpoint

							All
Mean	25.5	25.4	25.5	25.9	25.6	25.7	25.60
Std. Dev.	1.108	1.007	1.083	2.933	3.044	2.984	2.140
COV %	4.3	4.0	4.2	11.3	11.9	11.6	8.4

	Start	Finish	
Tracer tank pressure	~280	~280	psig
Ambient Temp	70,72,73	66	F
Injection flowmeter	0.18 (20)	0.18 (20)	lpm [glass ball in meter]
Sampling flowmeter	10	10	lpm
Ambient pressure	1011.6		mbar
Ambient humidity	50%		%RH
Wind @ 2 m	NA	NA	m/s
Wind direction	NA	NA	degrees
Centerline vel.			m/s

Gas analyzer checked on: 12 Mar. 97

Instuments Used:	Cal Exp. Date:
Solomat Zephyr #12951472	2/7/98
B & K Model 1302 #1765299, run with/without water correction	NA
Sierra Inc. Constant Flow Air Sampler	NA

TRACER GAS TRAVERSE DATA FORM

Site	Salt well mockup @ 305	Run No.	GT-4
Date	Mar. 17, 1997	Injection point	Center in N/S
Tester	Maughan	Fan Setting	24 Hz for ~ 500 cfm
Stack Dia.	9.75 in.	Stack Temp	
tack X-Area	74.7 in.	Offset to index	
Elevation		Center 2/3 from	0.89 to: 8.86
El. above disturbance	45.5 inches	Points in Center 2/3	3 to: 10
Concentration units	ppm SF_6		

Traverse-->		E/W			S/N			
Trial --->		East 1	2	3	South 1	2	3	
Point	Depth, in.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	
1	0.21	24.1	24.4	23.9	25.9	25.9	25.4	
2	0.67	25.2	24.6	24.9	26.0	25.9	25.9	
3	1.18	25.2	24.7	24.2	25.8	25.4	25.6	
4	1.77	24.5	24.7	24.4	25.9	25.5	25.6	
5	2.50	24.8	24.9	24.7	26.0	25.8	25.5	
6	3.56	25.1	25.2	25.1	25.7	25.8	25.9	
7	6.44	25.6	25.5	25.8	25.1	25.0	24.6	
8	7.50	25.5	25.4	25.3	24.6	24.6	24.1	
9	8.23	25.6	25.3	25.3	24.5	24.3	24.2	
10	8.82	25.5	25.5	25.7	24.4	24.2	24.1	
11	9.33	25.2	25.4	25.5	24.4	24.2	24.5	
12	9.79	25.4	24.2	25.7	24.5	24.2	24.0	
		West			North			All
Average of all data		25.1	25.0	25.0	25.2	25.1	25.0	25.1
w/o points by wall		25.2	25.1	25.1	25.2	25.1	25.0	25.1
Centerpoint	0.50	25.3	25.2	25.4	25.4	25.2	25.2	

Center 2/3 with centerpoint							All
Mean	25.2	25.2	25.1	25.3	25.1	25.0	25.14
Std. Dev.	0.381	0.317	0.557	0.636	0.607	0.728	0.538
COV %	1.5	1.3	2.2	2.5	2.4	2.9	2.1

	Start	Finish	
Tracer tank pressure	300	300	psig
Ambient Temp	72	68	F
Injection flowmeter	0.18 (20)	0.18 (20)	lpm [glass ball in meter]
Sampling flowmeter	10	10	lpm
Ambient pressure	1016.3	1017.3	mbar
Ambient humidity	53%	47%	RH
Wind @ 2 m	NA	NA	m/s
Wind direction	NA	NA	degrees
Centerline vel.			m/s

Gas analyzer checked on: 12 Mar. 97

Instuments Used:	Cal Exp. Date:
Solomat Zephyr #12951472	2/7/98
B & K Model 1302 #1765299, run with/without water correction	NA
Sierra Inc. Constant Flow Air Sampler	NA

TRACER GAS TRAVERSE DATA FORM

Site	Salt well mockup @ 305	Run No.	GT-5
Date	Mar. 17, 1997	Injection point	North
Tester	Maughan	Fan Setting	24 Hz for ~ 500 cfm
Stack Dia.	9.75 in.	Stack Temp	
tack X-Area	74.7 in.	Offset to index	
Elevation		Center 2/3 from	0.89 to: 8.86
El. above disturbance	45.5 inches	Points in Center 2/3	3 to: 10
Concentration units	ppm SF_6		

Traverse-->		E/W			S/N			
Trial --->		East 1	2	3	South 1	2	3	
Point	Depth, in.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	
1	0.21	30.8	29.3	29.3	25.2	25.8	25.3	
2	0.67	29.8	28.8	29.4	25.1	25.5	24.5	
3	1.18	29.7	29.3	28.5	25.4	25.5	26.1	
4	1.77	29.3	28.1	28.6	25.6	25.9	25.8	
5	2.50	28.5	28.4	28.3	25.9	25.3	26.2	
6	3.56	27.4	27.8	27.2	25.6	26.3	25.7	
7	6.44	23.4	23.8	23.6	26.0	26.5	26.4	
8	7.50	22.9	22.7	22.7	26.3	26.2	26.2	
9	8.23	21.7	22.0	22.5	26.1	26.2	25.3	
10	8.82	21.8	21.9	21.9	26.6	25.5	25.9	
11	9.33	21.6	21.5	21.2	25.9	25.8	26.2	
12	9.79	21.6	22.0	21.6	26.2	25.7	25.4	
		West			North			All
Average of all data		25.7	25.5	25.4	25.8	25.9	25.8	25.7
w/o points by wall		25.6	25.4	25.4	25.9	25.9	25.8	25.7
Centerpoint	0.50	25.9	25.3	25.6	25.9	25.9	26	

Center 2/3 with centerpoint							All
Mean	25.6	25.5	25.4	25.9	25.9	26.0	25.72
Std. Dev.	3.241	2.976	2.800	0.374	0.415	0.328	2.054
COV %	12.6	11.7	11.0	1.4	1.6	1.3	8.0

	Start	Finish	
Tracer tank pressure	300	300	psig
Ambient Temp	68	74	F
Injection flowmeter	0.18 (20)	0.18 (20)	lpm [glass ball in meter]
Sampling flowmeter	10	10	lpm
Ambient pressure	1017.3	1018	mbar
Ambient humidity	47%	40%	RH
Wind @ 2 m	NA	NA	m/s
Wind direction	NA	NA	degrees
Centerline vel.			m/s

Gas analyzer checked on: 12 Mar. 97

Instuments Used:	**Cal Exp. Date:**
Solomat Zephyr #12951472	2/7/98
B & K Model 1302 #1765299, run with/without water correction	NA
Sierra Inc. Constant Flow Air Sampler	NA

TRACER GAS TRAVERSE DATA FORM

Site	Salt well mockup @ 305	Run No.	GT-6
Date	Mar. 17, 1997	Injection point	South
Tester	Maughan	Fan Setting	24 Hz for ~ 500 cfm
Stack Dia.	9.75 in.	Stack Temp	
tack X-Area	74.7 in.	Offset to index	
Elevation		Center 2/3 from	0.89 to: 8.86
El. above disturbance	45.5 inches	Points in Center 2/3	3 to: 10
Concentration units	ppm SF_6		

Traverse-->		E/W			S/N			
Trial --->		East 1	2	3	South 1	2	3	
Point	Depth, in.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	
1	0.21	21.3	21.5	20.6	26.8	24.6	26.0	
2	0.67	21.0	21.5	20.9	26.8	25.9	25.8	
3	1.18	21.0	21.6	21.6	26.0	25.4	25.8	
4	1.77	21.5	21.6	21.8	25.6	25.1	26.2	
5	2.50	22.1	22.3	22.4	25.7	26.0	25.7	
6	3.56	24.1	23.5	23.4	25.5	25.4	25.8	
7	6.44	25.4	27.2	27.0	24.8	24.2	24.6	
8	7.50	27.4	28.7	28.5	24.3	24.1	23.9	
9	8.23	28.7	28.9	29.2	23.5	24.1	24.2	
10	8.82	29.7	29.7	28.8	24.2	23.6	23.7	
11	9.33	29.6	30.0	29.8	23.8	23.6	24.3	
12	9.79	30.5	29.7	30.5	23.6	23.8	24.6	
		West			North			All
Average of all data		25.2	25.5	25.4	25.1	24.7	25.1	25.1
w/o points by wall		25.1	25.5	25.3	25.0	24.7	25.0	25.1
Centerpoint	0.50		25.1	25.3	24.6	24.8	25	
Center 2/3 with centerpoint								All
Mean		25.0	25.4	25.3	24.9	24.7	25.0	25.06
Std. Dev.		3.363	3.299	3.133	0.837	0.791	0.929	2.258
COV %		13.5	13.0	12.4	3.4	3.2	3.7	9.0

	Start	Finish	
Tracer tank pressure	300	300	psig
Ambient Temp	73	73	F
Injection flowmeter	0.18 (20)	0.18 (20)	lpm [glass ball in meter]
Sampling flowmeter	10	10	lpm
Ambient pressure	1018	1019	mbar
Ambient humidity	40%	71%	RH
Wind @ 2 m	NA	NA	m/s
Wind direction	NA	NA	degrees
Centerline vel.			m/s

Gas analyzer checked on: 12 Mar. 97

Instuments Used:	Cal Exp. Date:
Solomat Zephyr #12951472	2/7/98
B & K Model 1302 #1765299, run with/without water correction	NA
Sierra Inc. Constant Flow Air Sampler	NA

TRACER GAS TRAVERSE DATA FORM

Site	Salt well mockup @ 305	Run No.	GT-7
Date	Mar. 18, 1997	Injection point	South
Tester	Maughan	Fan Setting	48 Hz for ~ 1000 cfm
Stack Dia.	9.75 in.	Stack Temp	
tack X-Area	74.7 in.	Offset to index	
Elevation		Center 2/3 from	0.89 to: 8.86
El. above disturbance	45.5 inches	Points in Center 2/3	3 to: 10
Concentration units	ppm SF_6		

Traverse-->		E/W			S/N			
Trial --->		East 1	2	3	South 1	2	3	
Point	Depth, in.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	
1	0.21	10.4	10.2	10.5	12.7	12.5	12.7	
2	0.67	10.4	10.4	10.6	12.6	12.4	12.5	
3	1.18	10.8	10.7	10.9	12.9	12.7	12.5	
4	1.77	10.7	10.7	10.5	12.6	12.7	12.5	
5	2.50	10.9	11.0	10.9	12.5	12.5	12.6	
6	3.56	11.5	11.6	11.4	12.5	12.4	12.5	
7	6.44	13.1	13.3	13.2	12.2	11.8	12.0	
8	7.50	13.8	13.8	13.9	11.9	11.8	12.0	
9	8.23	14.2	14.2	14.5	12.1	12.0	12.0	
10	8.82	14.4	14.5	14.3	12.1	12.2	11.9	
11	9.33	14.4	14.7	14.5	12.0	11.8	12.1	
12	9.79	14.6	14.6	14.7	12.1	12.1	11.7	
		West			North			All
Average of all data		12.4	12.5	12.5	12.4	12.2	12.3	12.4
w/o points by wall		12.4	12.5	12.5	12.3	12.2	12.3	12.4
Centerpoint	0.50	12.3	12.5	12.3	12.3	12.2	12.2	

Center 2/3 with centerpoint							All
Mean	12.4	12.5	12.4	12.3	12.3	12.2	12.36
Std. Dev.	1.509	1.531	1.582	0.309	0.347	0.279	1.062
COV %	12.2	12.3	12.7	2.5	2.8	2.3	8.6

	Start	Finish	
Tracer tank pressure	300	300	psig
Ambient Temp	73	73	F
Injection flowmeter	0.18 (20)	0.18 (20)	lpm [glass ball in meter]
Sampling flowmeter	10	10	lpm
Ambient pressure	1019	1019.8	mbar
Ambient humidity	71%	57%	RH
Wind @ 2 m	NA	NA	m/s
Wind direction	NA	NA	degrees
Centerline vel.			m/s

Gas analyzer checked on: 12 Mar. 97

Instuments Used:	**Cal Exp. Date:**
Solomat Zephyr #12951472	2/7/98
B & K Model 1302 #1765299, run with/without water correction	NA
Sierra Inc. Constant Flow Air Sampler	NA

TRACER GAS TRAVERSE DATA FORM

Site	Salt well mockup @ 305	Run No.	GT-8
Date	Mar. 18-19, 1997	Injection point	Center on N/S
Tester	Maughan	Fan Setting	48 Hz for ~ 1000 cfm
Stack Dia.	9.75 in.	Stack Temp	
tack X-Area	74.7 in.	Offset to index	
Elevation		Center 2/3 from	0.89 to: 8.86
El. above disturbance	45.5 inches	Points in Center 2/3	3 to: 10
Concentration units	ppm SF_6		

Traverse-->		E/W			S/N			
Trial ---->		East 1	2	3	South 1	2	3	
Point	Depth, in.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	
1	0.21	12.0	11.9	11.8	12.3	12.2	11.9	
2	0.67	11.9	11.9	11.7	12.2	12.2	12.1	
3	1.18	11.8	12.0	11.9	12.2	12.2	12.0	
4	1.77	11.9	11.9	11.9	12.2	12.2	12.1	
5	2.50	12.0	12.0	12.0	12.4	12.3	12.1	
6	3.56	12.3	12.2	12.2	12.2	12.3	12.2	
7	6.44	12.6	12.7	12.6	12.1	12.4	12.3	
8	7.50	12.9	12.8	12.9	12.2	12.1	12.5	
9	8.23	12.9	12.8	12.9	12.4	12.3	12.0	
10	8.82	12.9	12.9	12.9	12.1	12.1	12.4	
11	9.33	13.1	12.9	13.0	12.3	12.2	12.2	
12	9.79	13.1	13.0	12.8	12.2	12.3	12.1	
		West			North			All
Average of all data		12.5	12.4	12.4	12.2	12.2	12.2	12.3
w/o points by wall		12.4	12.4	12.4	12.2	12.2	12.2	12.3
Centerpoint	0.50	12.5	12.5	12.4	12.3	12.4	12.3	

Center 2/3 with centerpoint							All
Mean	12.4	12.4	12.4	12.2	12.3	12.2	12.33
Std. Dev.	0.444	0.399	0.431	0.112	0.113	0.176	0.315
COV %	3.6	3.2	3.5	0.9	0.9	1.4	2.6

	Start	Finish	
Tracer tank pressure	300	300	psig
Ambient Temp	71	71	F
Injection flowmeter	0.18 (20)	0.18 (20)	lpm [glass ball in meter]
Sampling flowmeter	10	10	lpm
Ambient pressure	1019.8	1018.6	mbar
Ambient humidity	57%	81%	RH
Wind @ 2 m	NA	NA	m/s
Wind direction	NA	NA	degrees
Centerline vel.			m/s

Gas analyzer checked on: 12 Mar. 97

Instuments Used:	Cal Exp. Date:
Solomat Zephyr #12951472	2/7/98
B & K Model 1302 #1765299, run with/without water correction	NA
Sierra Inc. Constant Flow Air Sampler	NA

TRACER GAS TRAVERSE DATA FORM

Site	Salt well mockup @ 305	Run No.	GT-9
Date	Mar. 19, 1997	Injection point	North
Tester	Maughan	Fan Setting	48 Hz for ~ 1000 cfm
Stack Dia.	9.75 in.	Stack Temp	
tack X-Area	74.7 in.	Offset to index	
Elevation		Center 2/3 from	0.89 to: 8.86
El. above disturbance	45.5 inches	Points in Center 2/3	3 to: 10
Concentration units	ppm SF_6		

Traverse-->		E/W			S/N			
Trial --->		East 1	2	3	South 1	2	3	
Point	Depth, in.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	
1	0.21	14.4	14.6	14.3	13.1	13.1	12.8	
2	0.67	14.4	14.6	14.3	12.8	12.8	13.1	
3	1.18	14.4	14.4	14.2	13.0	13.0	13.1	
4	1.77	14.3	14.0	13.9	12.9	13.0	12.9	
5	2.50	14.0	14.1	13.9	12.8	13.0	13.0	
6	3.56	13.6	13.6	13.3	12.8	13.0	13.1	
7	6.44	12.1	12.0	11.9	12.9	13.0	12.8	
8	7.50	11.4	11.4	11.2	12.6	12.8	12.9	
9	8.23	11.1	11.0	11.2	12.7	12.6	12.7	
10	8.82	11.0	10.9	11.0	12.8	12.6	12.8	
11	9.33	11.0	10.9	10.8	12.8	12.4	12.4	
12	9.79	11.0	10.8	10.8	12.8	12.6	12.5	
		West			North			All
Average of all data		12.7	12.7	12.6	12.8	12.8	12.8	12.7
w/o points by wall		12.7	12.7	12.6	12.8	12.8	12.9	12.8
Centerpoint	0.50	12.8	12.9	12.7	12.9	13	13	

Center 2/3 with centerpoint							All
Mean	12.7	12.7	12.6	12.8	12.9	12.9	12.78
Std. Dev.	1.389	1.401	1.295	0.120	0.176	0.139	0.929
COV %	10.9	11.0	10.3	0.9	1.4	1.1	7.3

	Start	Finish	
Tracer tank pressure	300	300	psig
Ambient Temp	71	73	F
Injection flowmeter	0.18 (20)	0.18 (20)	lpm [glass ball in meter]
Sampling flowmeter	10	10	lpm
Ambient pressure	1019	1018.3	mbar
Ambient humidity	81%	69%	RH
Wind @ 2 m	NA	NA	m/s
Wind direction	NA	NA	degrees
Centerline vel.			m/s

Gas analyzer checked on: 12 Mar. 97

Instuments Used:	**Cal Exp. Date:**
Solomat Zephyr #12951472	2/7/98
B & K Model 1302 #1765299, run with/without water correction	NA
Sierra Inc. Constant Flow Air Sampler	NA

TRACER GAS TRAVERSE DATA FORM

Site	Salt well mockup @ 305	Run No.	GT-10
Date	Mar. 19, 1997	Injection point	East
Tester	Maughan	Fan Setting	48 Hz for ~ 1000 cfm
Stack Dia.	9.75 in.	Stack Temp	
tack X-Area	74.7 in.	Offset to index	
Elevation		Center 2/3 from	0.89 to: 8.86
El. above disturbance	45.5 inches	Points in Center 2/3	3 to: 10
Concentration units	ppm SF_6		

Traverse-->		E/W			S/N			
Trial --->		East 1	2	3	South 1	2	3	
Point	Depth, in.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	
1	0.21	12.7	12.9	12.9	14.4	14.4	14.6	
2	0.67	12.9	12.8	12.7	14.4	14.6	14.6	
3	1.18	12.9	13.1	12.9	14.5	14.3	14.7	
4	1.77	12.8	13.1	13.0	14.3	14.2	14.4	
5	2.50	12.8	12.9	12.8	13.9	14.0	14.0	
6	3.56	13.0	13.1	13.0	13.5	13.6	13.5	
7	6.44	12.6	12.5	12.4	12.0	12.0	12.2	
8	7.50	12.4	12.3	12.3	11.4	11.5	11.4	
9	8.23	12.4	12.2	12.4	11.2	11.2	11.0	
10	8.82	12.3	12.5	12.3	10.7	10.9	10.8	
11	9.33	12.3	12.4	12.4	10.8	10.8	10.9	
12	9.79	12.3	12.0	12.6	10.9	10.7	10.6	
		West			North			All
Average of all data		12.6	12.7	12.6	12.7	12.7	12.7	12.7
w/o points by wall		12.6	12.7	12.6	12.7	12.7	12.8	12.7
Centerpoint	0.50	12.8	12.6	12.9	12.6	12.7	12.8	

Center 2/3 with centerpoint							All
Mean	12.7	12.7	12.7	12.7	12.7	12.8	12.70
Std. Dev.	0.250	0.357	0.308	1.428	1.357	1.485	0.981
COV %	2.0	2.8	2.4	11.3	10.7	11.6	7.7

	Start	Finish	
Tracer tank pressure	300	300	psig
Ambient Temp	73	73	F
Injection flowmeter	0.18 (20)	0.18 (20)	lpm [glass ball in meter]
Sampling flowmeter	10	10	lpm
Ambient pressure	1018.3	1017.1	mbar
Ambient humidity	69%	54%	RH
Wind @ 2 m	NA	NA	m/s
Wind direction	NA	NA	degrees
Centerline vel.			m/s

Gas analyzer checked on: 12 Mar. 97

Instuments Used:	Cal Exp. Date:
Solomat Zephyr #12951472	2/7/98
B & K Model 1302 #1765299, run with/without water correction	NA
Sierra Inc. Constant Flow Air Sampler	NA

TRACER GAS TRAVERSE DATA FORM

Site	Salt well mockup @ 305	Run No.	GT-11	
Date	Mar. 19, 1997	Injection point	West	
Tester	Maughan	Fan Setting	48 Hz for ~ 1000 cfm	
Stack Dia.	9.75 in.	Stack Temp		
tack X-Area	74.7 in.	Offset to index		
Elevation		Center 2/3 from	0.89	to: 8.86
El. above disturbance	45.5 inches	Points in Center 2/3	3	to: 10
Concentration units	ppm SF_6			

Traverse-->		E/W			S/N			
Trial ---->		East 1	2	3	South 1	2	3	
Point	Depth, in.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	
1	0.21	11.7	11.8	11.8	10.4	9.9	10.2	
2	0.67	11.7	11.4	11.7	10.4	10.2	10.1	
3	1.18	11.7	11.6	11.7	10.6	10.2	10.1	
4	1.77	11.7	11.7	11.7	10.9	10.5	10.4	
5	2.50	11.8	11.8	11.7	11.0	10.6	10.7	
6	3.56	12.0	11.9	12.0	11.4	11.4	11.3	
7	6.44	12.9	12.8	12.8	13.5	13.4	13.1	
8	7.50	13.0	13.0	13.1	14.0	13.9	13.7	
9	8.23	13.5	13.2	13.2	14.2	14.2	14.1	
10	8.82	13.1	12.9	13.2	14.5	14.3	14.1	
11	9.33	13.2	13.2	13.2	14.2	14.4	14.5	
12	9.79	13.0	13.1	13.1	14.7	14.5	14.6	
		West			North			All
Average of all data		12.4	12.4	12.4	12.5	12.3	12.2	12.4
w/o points by wall		12.5	12.4	12.4	12.5	12.3	12.2	12.4
Centerpoint	0.50	12.2	12.3	12.4	12.3	12.2	12.3	
Center 2/3 with centerpoint								All
Mean		12.4	12.4	12.4	12.5	12.3	12.2	12.37
Std. Dev.		0.693	0.627	0.667	1.574	1.686	1.620	1.186
COV %		5.6	5.1	5.4	12.6	13.7	13.3	9.6

	Start	Finish	
Tracer tank pressure	300	300	psig
Ambient Temp	76	75	F
Injection flowmeter	0.18 (20)	0.18 (20)	lpm [glass ball in meter]
Sampling flowmeter	10	10	lpm
Ambient pressure	1017.1	1014.9	mbar
Ambient humidity	54%	49%	RH
Wind @ 2 m	NA	NA	m/s
Wind direction	NA	NA	degrees
Centerline vel.			m/s

Gas analyzer checked on: 12 Mar. 97

Instuments Used:	Cal Exp. Date:
Solomat Zephyr #12951472	2/7/98
B & K Model 1302 #1765299, run with/without water correction	NA
Sierra Inc. Constant Flow Air Sampler	NA

TRACER GAS TRAVERSE DATA FORM

Site	Salt well mockup @ 305	Run No.	GT-12
Date	Mar. 20, 1997	Injection point	Center on E/W
Tester	Maughan	Fan Setting	48 Hz for ~ 1000 cfm
Stack Dia.	9.75 in.	Stack Temp	
tack X-Area	74.7 in.	Offset to index	
Elevation		Center 2/3 from	0.89 to: 8.86
El. above disturbance	45.5 inches	Points in Center 2/3	3 to: 10
Concentration units	ppm SF_6		

Traverse-->		E/W			S/N			
Trial --->		East 1	2	3	South 1	2	3	
Point	Depth, in.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	
1	0.21	11.9	12.1	11.7	12.7	12.7	12.7	
2	0.67	11.5	12.0	11.9	12.7	12.6	12.8	
3	1.18	11.8	11.9	12.0	12.9	12.7	12.6	
4	1.77	11.9	12.1	12.0	12.7	12.7	12.8	
5	2.50	12.0	12.2	12.3	12.7	12.8	12.8	
6	3.56	12.3	12.5	12.4	13.0	12.9	13.0	
7	6.44	13.1	13.4	13.2	12.9	12.8	12.8	
8	7.50	13.3	13.6	13.6	12.8	12.8	12.8	
9	8.23	13.5	13.6	13.5	12.7	12.7	12.8	
10	8.82	13.6	13.7	13.7	12.8	12.9	12.8	
11	9.33	13.4	13.7	13.5	12.7	12.9	12.8	
12	9.79	13.6	13.7	13.6	12.9	12.9	12.7	
		West			North			All
Average of all data		12.7	12.9	12.8	12.8	12.8	12.8	12.8
w/o points by wall		12.6	12.9	12.8	12.8	12.8	12.8	12.8
Centerpoint	0.50	12.6	12.9	12.9	12.9	12.9	12.8	

Center 2/3 with centerpoint

							All
Mean	12.7	12.9	12.8	12.8	12.8	12.8	12.80
Std. Dev.	0.714	0.721	0.688	0.109	0.087	0.100	0.485
COV %	5.6	5.6	5.4	0.9	0.7	0.8	3.8

	Start	Finish	
Tracer tank pressure	300	300	psig
Ambient Temp	69	73	F
Injection flowmeter	0.18 (20)	0.18 (20)	lpm [glass ball in meter]
Sampling flowmeter	10	9	lpm
Ambient pressure	1019.8	1021	mbar
Ambient humidity	43%	34%	RH
Wind @ 2 m	NA	NA	m/s
Wind direction	NA	NA	degrees
Centerline vel.			m/s

Gas analyzer checked on: 12 Mar. 97

Instuments Used:	Cal Exp. Date:
Solomat Zephyr #12951472	2/7/98
B & K Model 1302 #1765299, run with/without water correction	NA
Sierra Inc. Constant Flow Air Sampler	NA

TRACER GAS TRAVERSE DATA FORM

Site	Salt well mockup @ 305	Run No.	GT-13
Date	Mar. 20, 1997	Injection point	West
Tester	Maughan	Fan Setting	48 Hz for ~ 1000 cfm
Stack Dia.	9.75 in.	Stack Temp	
tack X-Area	74.7 in.	Offset to index	
Elevation		Center 2/3 from	0.89 to: 8.86
El. above disturbance	45.5 inches	Points in Center 2/3	3 to: 10
Concentration units	ppm SF_6		

Traverse-->		E/W			S/N			
Trial --->		East 1	2	3	South 1	2	3	
Point	Depth, in.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	
1	0.21	19.3	19.2	19.2	16.9	17.1	16.5	
2	0.67	19.3	19.2	19.0	16.7	17.0	16.7	
3	1.18	18.9	19.2	19.5	16.8	16.5	17.1	
4	1.77	19.2	18.8	19.1	17.3	16.7	17.2	
5	2.50	19.3	19.3	19.5	18.0	17.6	17.6	
6	3.56	19.3	19.3	19.7	18.5	18.6	18.7	
7	6.44	21.2	21.0	21.2	21.7	21.4	21.4	
8	7.50	21.6	21.7	21.2	22.4	21.4	22.5	
9	8.23	21.9	21.7	21.9	23.0	23.1	23.3	
10	8.82	21.2	21.8	21.7	23.3	23.2	23.4	
11	9.33	22.1	22.1	21.6	23.9	23.9	24.0	
12	9.79	21.7	21.9	21.9	24.2	23.8	23.6	
		West			North			All
Average of all data		20.4	20.4	20.5	20.2	20.0	20.2	20.3
w/o points by wall		20.4	20.4	20.4	20.2	19.9	20.2	20.3
Centerpoint	0.50	20.2	20.3	20.7	20.0	20	19.9	

Center 2/3 with centerpoint							All
Mean	20.3	20.3	20.5	20.1	19.8	20.1	20.20
Std. Dev.	1.175	1.230	1.062	2.555	2.607	2.604	1.920
COV %	5.8	6.0	5.2	12.7	13.1	12.9	9.5

	Start	Finish	
Tracer tank pressure	300	300	psig
Ambient Temp	73	68	F
Injection flowmeter	0.36 (40)	0.36 (40)	lpm [glass ball in meter]
Sampling flowmeter	10	10	lpm
Ambient pressure	1021	1021	mbar
Ambient humidity	34%	34%	RH
Wind @ 2 m	NA	NA	m/s
Wind direction	NA	NA	degrees
Centerline vel.			m/s

Gas analyzer checked on: 12 Mar. 97

Instuments Used:	**Cal Exp. Date:**
Solomat Zephyr #12951472	2/7/98
B & K Model 1302 #1765299, run with/without water correction	NA
Sierra Inc. Constant Flow Air Sampler	NA

TRACER GAS TRAVERSE DATA FORM

Site	Salt well mockup @ 305	Run No.	GT-14
Date	Mar. 20, 1997	Injection point	West
Tester	Maughan	Fan Setting	56 Hz for ~ 1200 cfm
Stack Dia.	9.75 in.	Stack Temp	
tack X-Area	74.7 in.	Offset to index	
Elevation		Center 2/3 from	0.89 to: 8.86
El. above disturbance	45.5 inches	Points in Center 2/3	3 to: 10
Concentration units	ppm SF_6		

Traverse-->		E/W			S/N			
Trial --->		East 1	2	3	South 1	2	3	
Point	Depth, in.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	
1	0.21	16.2	16.7	16.4	14.0	13.9	13.9	
2	0.67	16.4	16.7	16.3	14.0	14.1	14.0	
3	1.18	16.4	16.6	16.3	14.2	14.2	14.3	
4	1.77	16.5	16.6	16.2	13.3	14.5	14.3	
5	2.50	16.3	16.6	16.5	14.3	15.0	14.7	
6	3.56	16.6	16.9	16.8	15.8	15.4	15.8	
7	6.44	17.9	17.9	18.0	18.1	17.9	18.3	
8	7.50	18.1	18.2	18.3	19.0	18.7	19.0	
9	8.23	18.5	18.2	18.3	19.6	19.4	19.5	
10	8.82	18.7	18.4	18.9	19.8	19.9	19.9	
11	9.33	18.5	18.1	19.1	20.4	20.0	20.4	
12	9.79	18.6	18.1	18.0	20.5	20.8	20.2	
		West			North			All
Average of all data		17.4	17.4	17.4	16.9	17.0	17.0	17.2
w/o points by wall		17.4	17.4	17.5	16.9	16.9	17.0	17.2
Centerpoint	0.50	17.1	17.6	17.2	16.9	16.7	17.2	
Center 2/3 with centerpoint								All
Mean		17.3	17.4	17.4	16.8	16.9	17.0	17.14
Std. Dev.		0.959	0.768	1.006	2.491	2.192	2.283	1.703
COV %		5.5	4.4	5.8	14.8	13.0	13.4	9.9

	Start	Finish	
Tracer tank pressure	300	300	psig
Ambient Temp	68	68	F
Injection flowmeter	0.36 (40)	0.36 (40)	lpm [glass ball in meter]
Sampling flowmeter	10	10	lpm
Ambient pressure	1021	1020.9	mbar
Ambient humidity	34%	29%	RH
Wind @ 2 m	NA	NA	m/s
Wind direction	NA	NA	degrees
Centerline vel.			m/s

Gas analyzer checked on: 12 Mar. 97

Instuments Used:	Cal Exp. Date:
Solomat Zephyr #12951472	2/7/98
B & K Model 1302 #1765299, run with/without water correction	NA
Sierra Inc. Constant Flow Air Sampler	NA

TRACER GAS TRAVERSE DATA FORM

Site	Salt well mockup @ 305	Run No.	GT-15
Date	Mar. 20, 1997	Injection point	West
Tester	Maughan	Fan Setting	16 Hz for ~ 300 cfm
Stack Dia.	9.75 in.	Stack Temp	
tack X-Area	74.7 in.	Offset to index	
Elevation		Center 2/3 from	0.89 to: 8.86
El. above disturbance	45.5 inches	Points in Center 2/3	3 to: 10
Concentration units	ppm SF_6		

Traverse-->		E/W			S/N			
Trial --->		East 1	2	3	South 1	2	3	
Point	Depth, in.	Conc.	Conc.	Conc.	Conc.	Conc.	Conc.	
1	0.21	19.0	19.8	20.2	17.1	17.8	17.4	
2	0.67	19.8	19.0	19.6	17.8	17.4	18.0	
3	1.18	19.6	19.3	19.5	18.4	19.2	18.1	
4	1.77	19.6	19.9	19.5	18.3	17.8	18.4	
5	2.50	19.6	20.3	20.5	19.3	19.3	19.2	
6	3.56	21.2	20.3	20.4	19.8	20.4	20.2	
7	6.44	22.4	22.5	22.4	23.6	24.2	23.3	
8	7.50	23.6	23.5	23.0	24.5	24.4	24.5	
9	8.23	23.4	23.9	23.5	24.8	25.1	25.4	
10	8.82	23.6	23.7	22.9	26.0	26.2	26.1	
11	9.33	24.2	24.0	24.0	25.8	24.4	25.7	
12	9.79	23.7	24.4	23.7	26.1	26.1	25.5	
		West			North			All
Average of all data		21.6	21.7	21.6	21.8	21.9	21.8	21.7
w/o points by wall		21.7	21.6	21.5	21.8	21.8	21.9	21.7
Centerpoint	0.50	21.3	21.5	21.2	22.0	22.0	21.7	
Center 2/3 with centerpoint								All
Mean		21.6	21.7	21.4	21.9	22.1	21.9	21.75
Std. Dev.		1.737	1.791	1.552	2.984	3.024	3.072	2.345
COV %		8.0	8.3	7.2	13.7	13.7	14.0	10.8

	Start	Finish	
Tracer tank pressure	300	300	psig
Ambient Temp	68	76	F
Injection flowmeter	0.09 (10)	0.08 (9)	lpm [glass ball in meter]
Sampling flowmeter	10	10	lpm
Ambient pressure	1020.9	1020.9	mbar
Ambient humidity	29%	29%	RH
Wind @ 2 m	NA	NA	m/s
Wind direction	NA	NA	degrees
Centerline vel.			m/s

Gas analyzer checked on: 12 Mar. 97

Instuments Used:	Cal Exp. Date:
Solomat Zephyr #12951472	2/7/98
B & K Model 1302 #1765299, run with/without water correction	NA
Sierra Inc. Constant Flow Air Sampler	NA

Appendix D

Particle Tracer Uniformity Test

Procedure for Particle Concentration Uniformity Test

February 7, 1997

A uniform contaminant concentration at the sampling plane (i.e., the plane of the sampling probe nozzle) enables the collection of samples that represent the true concentration. This uniformity is demonstrated by measuring the mixing or uniformity of air momentum and the gaseous and particulate contaminant concentrations. This procedure deals with the particle concentration uniformity test.

The general approach is to inject particles of a known size into the test stack just downstream of the fan. The concentration of the particles are then measured at several points in the cross section of the sampling plane using an optical particle counter (OPC). A simple sampling probe will extract an aliquot of the stack airflow for counting by the OPC. Because the generation rate for tracer particles may vary with time, a second OPC observes the particle concentration from a fixed point in the stack. The data from the traversing OPC can then be adjusted if there is a temporal trend observed with the fixed OPC. Several particle injection points and stack flowrates may be tested as additional parameters affecting the mixing determination. The coefficient of variance of the concentration readings at the individual points is calculated, and the result compared to the acceptance criterion for uniformity. The particle mixing is acceptable if the coefficient of variance (COV) of the tracer 10 μm aerodynamic diameter (AD) particles is less than 20% across the center two-thirds of the sampling plane.

Equipment

Vibrating orifice aerosol generator (VOAG) system (or other suitable aerosol generator)
Two optical particle counters (OPC)
Sampling probes for the particle counters
Particle injection probe
Aerosol feed solution (oleic acid in methanol)

Optical Particle Counter Setup

The absolute calibration of the OPC is not as important because the concentration data are used in a relative manner to calculate the COV and to plot the particle concentrations at the measurement points. The instrument's response may be checked against calibrated standard particles (e.g., polystyrene latex spheres from Duke Scientific) to address relative accuracy. Here, it is assumed sufficient to determine the precision with which the tracer particles of a known size are consistently counted in the same OPC particle size channel. This can be determined during testing or before. However, the favorable comparison of particles obtained by the OPC with those observed on a flurad-coated microscope slide will lend to acceptable test results.

The sampling probes for both OPCs should be identical and of a simple design. The elevation of the intake nozzle of the traversing unit should be the same as the sampling plane. The intake nozzle for the fixed unit may be located anywhere within the stack at an elevation near that of the sampling plane. The two probes should not interfere with each other, either physically or by causing flow disturbances for each other. The intake nozzles may be designed for subisokinetic operation because these optimize the collection of larger (10 μ) particles called for here. Mark the traversing OPC's sampling probe to aid in placing the inlet at each measurement point.

The aerodynamic characteristics of the probes for both OPCs should be the same and have similar line loss (penetration) values. A flexible tube probe could have changing shape, which would result in variable line loss problems during the tests. To keep the line loss fixed and comparable, the probes should be of a fixed and rigid configuration. The use of the traversing OPC is facilitated by mounting it on a sliding platform, allowing movement along the axis of the sampling port.

The settings for the parameters and operation of the OPCs and aerosol generator are detailed in other procedures. The OPC data can be recorded initially on either the internal paper tape or using the RS232 connection to a computer serial port.

VOAG Setup

The VOAG should be located as close as possible to the injection port. The equipment arrangement should approximate that shown in Figure D.1. The Krypton-85 aerosol charge neutralizer may be needed if the particles are to be transported more than a couple of meters. The neutralizer minimizes deposition caused by the static charge of the particles. The neutralizer should be located in a radiological control

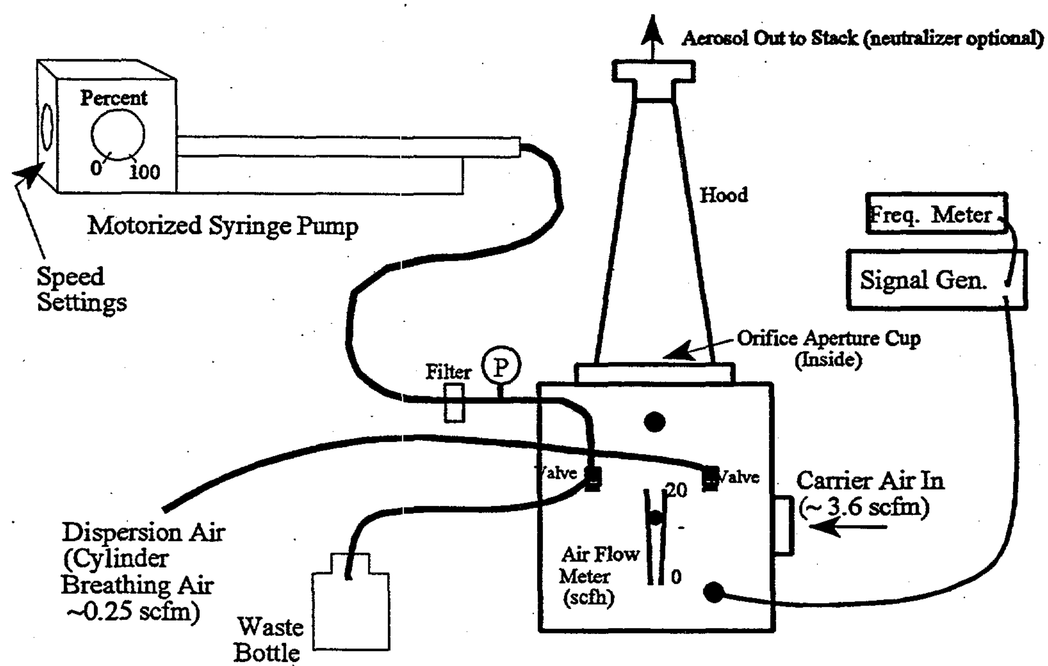


Figure D.1. Vibrating Orifice Aerosol Generator area. The syringe pump should be filled with an oleic acid and methanol solution, and the operational parameters configured for generating 10 µm AD particles.

Setup for Stack Measurements

Lay out the sampling points using the same method as for a velocity traverse (40 CFR 60, Appendix A, Method 1) with the addition of the center point. These can be the same points as those used for the gaseous tracer experiment. Points closer to the stack wall than one-half the width of the traversing OPC's sampling probe should be omitted.

Measurements

On the data record sheet, record the test conditions of injection point, fan control setting, date, time, and stack temperature. Also record the equipment used and the names of test operators. After the fan controller is set as needed for the test conditions, verify the centerline air velocity at the sampling plane using a pitot tube or other anemometer. At the end of the test, re-record any test parameters if they have changed.

Start the OPCs and make a series of measurements of the background level of aerosol in the stack after the readings stabilize. Do not proceed with the test if the background exceeds 5% of the anticipated average concentration in the stack when the VOAG is started.

Position the injection probe as directed for the test conditions. Start the injection of the tracer particles. Proceed quickly with the OPC traverses as the VOAG may have a limited operating time.

Potential Test Conditions

For any given injection plane, use a particle injection point at the duct centerline as a minimum. Where the tracer gas tests showed borderline acceptable mixing, suggested additional points would be within 20% of a diameter from the wall at four orthogonally spaced points. This test can be repeated using various tracer injection points to determine if the COV is sensitive to "streaming" at the point where contaminants can be released downstream of the final ventilation filters. Initial tests will be performed at the average stack flowrate as a minimum. The test plan may also include the extremes of stack flowrates that are observed at the facility.

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, which may result in a false indication of good mixing.

CAUTION

Observe appropriate precautions and procedures for using and handling the aerosol charge neutralizer and the aerosol feed solution.

PARTICLE TRAVERSE RESULTS SUMMARY

Site: Saltwell Mockup in 350
Testers: Maughan/Glissmeyer
Stack Dia. 9.75 in.
Stack X-Area 74.66 in2
Measurement elevation ___ in.
El. above disturbance 45.5 in.
Injection Point: centerline fan outlet

Run No. PT-1
Date 4/18/97
Particle Dp 10.5 micron
Particle AD 10 micron
Aerosol Solution 26
Fan Setting 24 Hz
Center 2/3 from 0.89 inches to: 8.86
Points in Center 2/3 3 to: 10

Each OPC data point includes: single one-minute count

	S/N Traverse				E/W Traverse				
Point	1	2	3	Avg.	1	2	3	Avg.	
2	155	154	113	140.7	127	139	143	136.3	
3	140	131	118	129.7	92	97	94	94.3	
4	116	138	119	124.3	106	87	81	91.3	
5	114	122	128	121.3	113	121	144	126.0	
6	144	167		155.5	112	115	110	112.3	
Center	134	163	159	152.0	145	131	112	129.3	
7	140	158	150	149.3	117	128	102	115.7	
8	184	149	160	164.3	110	114	116	113.3	
9	164	151	142	152.3	138	126	123	129.0	
10	129	136	161	142.0	171	173	147	163.7	
11	165	133	157	151.7	109	116	133	119.3	
Center 2/3									**Grand**
Mean	140.6	146.1	142.1	143.4	122.7	121.3	114.3	119.4	131.4
Std. Dev.	22.2	15.3	18.3	15.1	24.2	24.2	21.6	21.5	21.8
C.O.V	15.8	10.5	12.9	10.5	19.7	20.0	18.9	18.0	16.6
All Points									**Grand**
Mean	144.1	145.6	140.7	143.9	121.8	122.5	118.6	121.0	132.4
Std. Dev.	21.5	14.5	19.4	13.7	22.1	22.4	21.7	19.9	20.4
C.O.V	14.9	10.0	13.8	9.5	18.1	18.3	18.3	16.5	15.4

Adjusted so Centerpoints Equal

	S/N Traverse		E/W Traverse		
Point	Avg.	Adj.	Avg.	Adj.	
2	140.7	129.3	136.3	147.7	
3	129.7	118.3	94.3	105.7	
4	124.3	113.0	91.3	102.7	
5	121.3	110.0	126.0	137.3	
6	155.5	144.2	112.3	123.7	
Center	152.0	140.7	129.3	140.7	
7	149.3	138.0	115.7	127.0	
8	164.3	153.0	113.3	124.7	
9	152.3	141.0	129.0	140.3	
10	142.0	130.7	163.7	175.0	
11	151.7	140.3	119.3	130.7	
Center 2/3					**Grand**
Mean	143.4	132.1	119.4	130.8	131.4
Std. Dev.	15.1	15.1	21.5	21.5	18.0
C.O.V	10.5	11.4	18.0	16.5	13.7
All Points					**Grand**
Mean	143.9	132.6	121.0	132.3	132.4
Std. Dev.	13.7	13.7	19.9	19.9	16.7
C.O.V	9.5	10.4	16.5	15.1	12.6

PARTICLE TRAVERSE RESULTS SUMMARY

Site	Saltwell Mockup in 350	Run No.	PT-2
Testers:	Maughan/Glissmeyer	Date	4/22/97
Stack Dia.	9.75 in.	article Dp	10.5 micron
Stack X-Area	74.66 in2	Particle AD	10 micron
Measurement elevation	in.	Aerosol Solution	26
El. above disturbance	45.5 in.	Fan Setting	12 Hz
Injection Point: centerline fan outlet		Center 2/3 from	0.89 inches to: 8.86
		Points in Center 2/3	3 to: 10

Each OPC data point includes: single one-minute count

	S/N Traverse				E/W Traverse				
Point	1	2	3	Avg.	1	2	3	Avg.	
2	257	265	263	261.7	214	227	249	230.0	
3	217	236	204	219.0	153	168	153	158.0	
4	212	221	186	206.3	211	203	209	207.7	
5	250	268	247	255.0	203	162	179	181.3	
6	280	266	261	269.0	177	179	188	181.3	
Center	236	196	210	214.0	190	222	248	220.0	
7	216	217	221	218.0	225	229	221	225.0	
8	250	272	257	259.7	234	230	198	220.7	
9	239	269	297	268.3	190	233	252	225.0	
10	236	259	245	246.7	177	165	177	173.0	
11	258	249	272	259.7	170	153	161	161.3	
Center 2/3									**Grand**
Mean	237.3	244.9	236.4	239.6	195.6	199.0	202.8	199.1	219.3
Std. Dev.	21.4	28.1	34.3	25.1	25.5	30.5	33.1	25.8	32.3
C.O.V	9.0	11.5	14.5	10.5	13.0	15.3	16.3	12.9	14.7
All Points									**Grand**
Mean	241.0	247.1	242.1	243.4	194.9	197.4	203.2	198.5	220.9
Std. Dev.	20.8	25.8	33.2	24.0	24.9	32.1	35.6	27.7	34.2
C.O.V	8.6	10.5	13.7	9.9	12.8	16.3	17.5	14.0	15.5

Adjusted so Centerpoints Equal

	S/N Traverse		E/W Traverse		
Point	Avg.	Adj.	Avg.	Adj.	
2	261.7	264.7	230.0	227.0	
3	219.0	222.0	158.0	155.0	
4	206.3	209.3	207.7	204.7	
5	255.0	258.0	181.3	178.3	
6	269.0	272.0	181.3	178.3	
Center	214.0	217.0	220.0	217.0	
7	218.0	221.0	225.0	222.0	
8	259.7	262.7	220.7	217.7	
9	268.3	271.3	225.0	222.0	
10	246.7	249.7	173.0	170.0	
11	259.7	262.7	161.3	158.3	
Center 2/3					**Grand**
Mean	239.6	242.6	199.1	196.1	219.3
Std. Dev.	25.1	25.1	25.8	25.8	34.3
C.O.V	10.5	10.3	12.9	13.1	15.7
All Points					**Grand**
Mean	243.4	246.4	198.5	195.5	220.9
Std. Dev.	24.0	24.0	27.7	27.7	36.3
C.O.V	9.9	9.7	14.0	14.2	16.4

PARTICLE TRAVERSE RESULTS SUMMARY

Site: Saltwell Mockup in 305
Testers: Maughan/Glissmeyer
Stack Dia. 9.75 in.
Stack X-Area 74.66 in2
Measurement elevation ____ in.
El. above disturbance 45.5 in.
Injection Point: centerline fan outlet

Run No. PT-3
Date 4/24/97
article Dp 10.5 micron
Particle AD 10 micron
Aerosol Solution 26
Fan Setting 48 Hz
Center 2/3 from 0.89 inches to: 8.86
Points in Center 2/3 3 to: 10

Each OPC data point includes: single one-minute count

Point	S/N Traverse 1	2	3	Avg.	E/W Traverse 1	2	3	Avg.	
2	45	58	50	51.0	57	91	84	77.3	
3	51	59	66	58.7	87	109	79	91.7	
4	64	60	54	59.3	47	53	44	48.0	
5	73	77	87	79.0	87	92	65	81.3	
6	67	84	55	68.7	87	99	96	94.0	
Center	72	80	69	73.7	96	92	83	90.3	
7	80	101	87	89.3	64	89	91	81.3	
8	89	62	75	75.3	123	110	85	106.0	
9	87	101	91	93.0	47	73	64	61.3	
10	86	92	68	82.0	93	74	67	78.0	
11	87	97	96	93.3	85	109	105	99.7	
Center 2/3									**Grand**
Mean	74.3	79.6	72.4	75.4	81.2	87.9	74.9	81.3	78.4
Std. Dev.	12.5	16.6	13.7	12.0	24.6	18.5	16.3	17.6	14.9
C.O.V	16.9	20.9	18.9	15.9	30.3	21.0	21.8	21.6	19.0
All Points									**Grand**
Mean	72.8	79.2	72.5	74.8	79.4	90.1	78.5	82.6	78.7
Std. Dev.	15.0	17.3	16.0	14.4	23.2	17.7	17.2	16.8	15.7
C.O.V	20.6	21.8	22.0	19.2	29.3	19.6	22.0	20.3	20.0

Adjusted so Centerpoints Equal

Point	S/N Traverse Avg.	Adj.	E/W Traverse Avg.	Adj.	
2	51.0	59.3	77.3	69.0	
3	58.7	67.0	91.7	83.3	
4	59.3	67.7	48.0	39.7	
5	79.0	87.3	81.3	73.0	
6	68.7	77.0	94.0	85.7	
Center	73.7	82.0	90.3	82.0	
7	89.3	97.7	81.3	73.0	
8	75.3	83.7	106.0	97.7	
9	93.0	101.3	61.3	53.0	
10	82.0	90.3	78.0	69.7	
11	93.3	101.7	99.7	91.3	
Center 2/3					**Grand**
Mean	75.4	83.8	81.3	73.0	78.4
Std. Dev.	12.0	12.0	17.6	17.6	15.6
C.O.V	15.9	14.3	21.6	24.1	19.9
All Points					**Grand**
Mean	74.8	83.2	82.6	74.3	78.7
Std. Dev.	14.4	14.4	16.8	16.8	15.9
C.O.V	19.2	17.3	20.3	22.6	20.2

Appendix E

Particle Penetration Test

Procedure for Particle Penetration Test

February 7, 1997

It is necessary that the contaminant sample extracted from the stack be quantitatively delivered to the collection device. The deposition of particles in the sample transport tubing is a strong function of particle size for particles larger than 1 µm. An assessment of the particle size and activity distribution in the effluent stream upstream of the filtration devices will establish an upper bound size that may have a significant contribution to the effluent concentration. In the absence of such a determination, the default criterion of ≥50% penetration of 10 µm AD particles from the free stream in the stack to the collector is used. Acceptable assessment tools include the DEPOSITION code (Riehl et al. 1996) or experimental measurement. This procedure provides a method for the experimental measurement. This method is applicable after a demonstration of particle concentration uniformity in the sampling plane.

The general approach is to inject 10 µm AD particles into the test stack just downstream of the fan in the centerline of the duct. The airstream is simultaneously sampled with an in-stack air sampler and the subject system, and the results compared. Particles tagged with a fluorescent dye are used, and the samples are analyzed with a fluorimeter. Besides comparing the results of particles collected, the deposition of particles optionally may be measured if needed to explain the results.

Equipment

Vibrating orifice aerosol generator (VOAG) system (or other suitable aerosol generator)
Particle injection probe
Aerosol feed solution (fluorescent dye tagged oleic acid in methanol)
In-stack reference sampling system (IRSS)
The tested sampling system (TSS)
Optional optical particle counter (OPC) to confirm the quality of the particles generated
Optional sampling probe for the OPC

Tested Sampling System

The tested sampling system is installed and operated according to the system design and operating manuals with the possible exception that the sample filter be identical to that used in the IRSS. If the TSS contains a continuous air monitor (CAM), the CAM can be replaced with an in-line filter holder to remove the effects of particle deposition in the CAM from the test results. It is important to cross calibrate the flowmeters in both the IRSS and TSS to eliminate biasing the results based on separate flowmeter measurements.

In-Stack Reference Sampling System

The IRSS differs from the tested sampling system primarily by having a sharp-edged inlet nozzle followed within several centimeters by a 47-mm Gelman glass fiber filter. The sampling flowrate is adjusted so it is always operated isokinetically. Consequently, negligible sampling bias and internal losses are exhibited, and analysis of the filter will indicate a true measure of the relative aerosol concentration in the stack. The nozzle and filter holder are located in the stack. The balance of the sampling train consists of a mass flowmeter, valve, and vacuum pump.

The IRSS nozzle should be located in the stack far enough away from the TSS nozzle in order to avoid physical and aerodynamic interference. It also should be positioned at the same stack elevation as used in the other tests. Multiple IRSS's may be used and the results averaged, or the position of the IRSS may be changed during a run to obtain an average concentration of particles.

VOAG

The VOAG should be located as close as possible to the injection port. The Krypton-85 aerosol charge neutralizer may be needed if the particles are to be transported more than a couple of meters to minimize deposition caused by the static charge of the particles. The neutralizer should be located in a radiological material area. The syringe pump should be filled with the aerosol solution, and the operational parameters configured for generating 10 µm AD particles.

In the VOAG, the aerosol solution passes through an ~20-µm circular orifice to form a cylindrical jet. A piezoelectric crystal positioned on the orifice assembly is oscillated at known frequencies to cause the liquid jet to break up into uniformly sized droplets. As the methanol in the droplets evaporate, an air jet disperses the particles to avoid coagulation.

The final diameter of the monodisperse particles is calculated from the solute (oleic acid and uranine) concentration, the solution flow rate, and the frequency of oscillation. Particle size and quality are checked using one or both of two diagnostic methods (survey of particles deposited to a coated slide using a light microscope and measurement of optical particle size and particle size distribution using a clean room counter). Particle quality is determined as the ratio of doublet particles (formed when two particles collided and coagulated) to singlet particles. Final particle density (oleic acid and uranine) is calculated and used to determine the aerodynamic size of the monodisperse particles during each test. An optical particle counter may also be used to verify particle quality.

Measurements

On the data record sheet, record the test conditions of particle injection point, fan control setting, aerosol generator settings, aerosol solution, stack centerline velocity, date, time, TSS and IRSS sample flowrates, and stack temperature. Also record the equipment used and the names of the test operators.

At the end of the test, re-record any test parameters if they have changed. Position the injection probe as directed in the test conditions. Start the injection of the tracer particles.

Potential Test Conditions

If stack or sample flows are expected to vary by more than 25%, the test conditions should include the extremes (and optionally the average). This test should be repeated to estimate the precision of the measurements. A sample run includes one set of operating conditions. Precision can be quickly estimated by changing the collection filters three or more times during a sample run.

Sample Analysis

Samples are analyzed fluoroscopically to determine the relative number of particles collected on internal probe surfaces and on filters. The interior surfaces of the nozzles and probes are rinsed two or three times with 20- to 30-mL aliquots of methanol to remove deposited particles. (Ninety-nine percent of the dye usually is removed after three rinses.) In the case of filters, 4 to 5 mL of methanol is added to the filter in a beaker, and the filters are gently agitated for a few seconds. This procedure is repeated three to four times. The fluorescence of the resulting methanol solutions are then measured on a fluorometer typically between 15 and 60 min after the methanol is added. The readings are repeated three times consecutively and averaged. Because the filter media can cause a measurable background fluorescence, two blank filters should be included with every batch of filter samples. The total quantity of fluorescent dye in the filter samples, in units of fluorescence, is determined by correcting the average reading by the average quantity of fluorescence in the two blank filter solutions. Fluorometer scale factors of 1X, 10X, and 50X are used to increase the range of the instrument and are factors included in determining the quantity of fluorescent particulate matter in the samples. No blank correction is usually necessary for the internal nozzle and probe surfaces; however, the fluorometer is zeroed using blank methanol before analyzing all samples. The fluorometer zero is confirmed periodically during each batch of samples.

CAUTION

Observe appropriate precautions and procedures for using and handling the aerosol charge neutralizer, methanol, and aerosol feed solution as well as during laboratory analyses.

GEMS PENETRATION ANALYSES — Density 0.7914 — Fluorescence Analysis

PENetrate Sample ID	Run	Description	Sample Date	Analysis Date	Other	Vol.	Dilution 1 : xx	Order for Analyses	Peak Area	Gross Wt. (w/sample)	Tare	Liquid Sample Wt	Sample Vol	Spectra File
0		Alcohol Blank		28-May-97				0	-14.5					
1	2	IRRS filter sample	2-May-97	28-May-97	Clearly visible yellow center spot, ~1.5cm dia.		1:9.295	12	13356	26.7029	16.6733	10.0296	12.67	a-p1d001.sp
2	2	CAM-AMS filter sample	2-May-97	28-May-97	slight yellowed center w/ distinct outter edge		1:3.1271	7	17245	24.6625	16.4748	8.1877	10.35	a-p02001.sp
3	2	Record filter sample	2-May-97	28-May-97	difficult to see any yellow but w/ coloration at edge exposed by filter ring		1:9.9857	8	4405	25.2716	16.5141	8.7575	11.07	a-p3d001.sp
4	2	Splitter wash	2-May-97	28-May-97	clear liquid	1 3/4"		4	499	191.8281	123.4664	68.3617	86.38	a-p04001.sp
5	2	Record wipe (wash)	2-May-97	28-May-97				1	5950	24.3007	16.6364	7.6643	9.68	a-p05001.sp
6	2	IRRS Wash	2-May-97	28-May-97	clear liquid	3/4"		6	5685	146.4264	123.5027	22.9237	28.97	a-p06001.sp
7	2	CAM-AMS wash	2-May-97	28-May-97	clear liquid	3/4"		5	229	147.9467	123.6601	24.2866	30.69	a-p07001.sp
8	2	Shrouded Probe wash	2-May-97	28-May-97	clear liquid	1 3/8"		2	4333	176.2404	123.8383	52.4021	66.21	a-p08001.sp
9	1	CAM-AMS filter sample	1-May-97	28-May-97	~2 cm center yellowed spot w/ darker perimeter		1:10.8738	9	3716	27.6309	16.4534	11.1775	14.12	a-p9d001.sp
10	1	IRRS filter sample	1-May-97	28-May-97	filter had considerable debris w/ yellowed spot		1:118.932 1:6.3290	11	283 15704	27.7777	16.6104	11.1673	14.11	apd10001.sp ap10d001.sp

GEMS PENETRATION ANALYSES — Density 0.7914 — Fluorescence Analysis

PENetrate Sample ID	Run	Description	Sample Date	Analysis Date	Other	Vol.	Dilution 1 : xx	Order for Analyses	Peak Area	Gross Wt. (w/sample)	Tare	Liquid Sample Wt	Sample Vol	Spectra File
11	1	Record filter sample	1-May-97	28-May-97	difficult to see any yellow but w/ coloration at edge exposed by filter ring		1:9.342 1:94.381	10	3809 160	27.8436	16.7211	11.1225	14.05	a11d001.sp ad11d001.sp
12	3	Methanol blank	5-May-97		clear liquid	3/4"		1	-13	147.7900				
13	3	CAM-AMS blank filter	5-May-97					2	-2					
14	3	IRRS blank filter	5-May-97											
15	3	Sample splitter wash	5-May-97		clear liquid	11/16"		7	2245	144.6524	123.888	20.7644	26.24	
16	3	IRSS wash	5-May-97		clear liquid	3/8"		6	13152	129.319	123.711	5.608	7.09	
17	3	GEMs probe wash	5-May-97		clear liquid	9/16"		4	9052	138.8147	123.598	15.2167	19.23	
18	3	CAM wash	5-May-97		clear liquid	5/8"		5	1561	144.0869	123.6877	20.3992	25.78	
19	3	Record filter holder wash	5-May-97		clear liquid	11/16"		3	1568	144.5477	123.4257	21.122	26.69	
20	3	IRSS filter sample	5-May-97		slight yellowed center		1:11	10	8669			0	0.00	
21	3	CAM filter sample	5-May-97		light yellow center darker at circle perimeter		1:11 1:1000	9	9817 15			0	0.00	
22	3	Record filter sample	5-May-97		hardly detectable yellow, but yellowed edge		1:11 1:1000	8	6339 -10			0	0.00	
STD A			7-May-97											
STD B			7-May-97											
STD C			7-May-97											
23	4	IRSS Wash	9-May-97					7	7475	131.7669	122.8682	8.8987	11.24	pn23_001.sp
24	4	Probe Wash	9-May-97					4	2462	160.6825	123.419	37.2635	47.09	pn24_001.sp
25	4	Splitter wash	9-May-97					5	754	155.5694	122.1222	33.4472	42.26	pn27_001.sp
26	4	Record wash	9-May-97					3	462	156.2622	122.9461	33.3161	42.10	pn26_001.sp

GEMS PENETRATION ANALYSES — Density 0.7914 — Fluorescence Analysis

PENetrate Sample ID	Run	Description	Sample Date	Analysis Date	Other	Vol.	Dilution 1 : xx	Order for Analyses	Peak Area	Gross Wt. (w/sample)	Tare	Liquid Sample Wt	Sample Vol	Spectra File
27	4	CAM wash	9-May-97					6	1976	146.4142	123.5957	22.8185	28.83	p27a_001.sp
28	4	IRSS filter sample	9-May-97			~15	1:10 1:100	10	14636 590	26.8297	16.7809	10.0488	12.70	p28c_001.sp p28d_001.sp
29	4	Record filter sample	9-May-97			~9	1:10 1:100	9	8795 296	22.2865	16.7636	5.5229	6.98	p29c_001.sp p29d_001.sp
30	4	CAM filter sample	9-May-97		First syringe filter dissolved > milky soln. Refiltered w/ corr. type	~11		8	6036	23.5903	16.8366	6.7537	8.53	p30d_001.sp
31	4	IRSS Field Blank filter	5-May-97		Filter dissolved as above. Also PEN 14	~11		1	27.34	23.1836	16.7401	6.4435	8.14	pn31_001.sp
32	4	Blank methanol						2	-13					pn32_001.sp
33	5	Probe Wash	2-Jun-97	4-Jun-97	clear liquid			5	574	160.5833	123.594	36.9893	46.74	p33--001.sp
34	5	Record wash	2-Jun-97	4-Jun-97	clear liquid			3	65	160.4544	123.4367	37.0177	46.77	p34--001.sp
35	5	Ref (IRSS) wash	2-Jun-97	4-Jun-97	clear liquid			6	6585	129.5447	123.7122	5.8325	7.37	p35--001.sp
36	5	Record wash	2-Jun-97	4-Jun-97	fairly even color distr. across filter			-		25.6658	15.1632	10.5026	13.27	
37	5	CAM filter sample	2-Jun-97	4-Jun-97	Central spot w/ darker perimeter			-		25.5821	15.155	10.4271	13.18	
38	5	Ref (IRSS) filter	2-Jun-97	4-Jun-97	Central spot w/ out distinct edges			-		25.6923	15.1992	10.4931	13.26	
36D	5	dilution of Record f.					1:9.8055	9	14656		15.0733			p36D-001.sp
37D	5	dilution of CAM filter					1:9.8475	8	11793		15.1705			p37D-001.sp
38D	5	dilution of Ref. filter					1:8.809	7	11374		15.2492			p38D-001.sp
39	5	Splitter wash	2-Jun-97	4-Jun-97	clear liquid			4	554	168.809	123.8864	44.9226	56.76	p39--001.sp
40	5	Methanol blank	2-Jun-97	4-Jun-97	clear liquid			1	-6.9	-	123.8128			p40--001.sp

GEMS PENETRATION ANALYSES *Density* *0.7914* *Fluorescence Analysis*

PENetrate Sample ID	Run	Description	Sample Date	Analysis Date	Other	Vol.	Dilution 1 : xx	Order for Analyses	Peak Area	Gross Wt. (w/sample)	Tare	Liquid Sample Wt	Sample Vol	Spectra File
41	5	CAM wash	2-Jun-97	4-Jun-97	clear liquid			2	798	149.1897	123.6964	25.4933	32.21	p41--001.sp

Analyst		Method	Slit Abs	2.5 Emisson
Date	Method Description			
Notes:	C:\FLDM\Data\Paul\Export			
Notes:				

Penetration Test Results
Straight 10-inch stack

Run: PEN-1
Stack flow 500 cfm
Fan setting 24 Hz

pectral analysis date: 5/28/97
Stack sample date: 5/1/97
Solvent density: 0.7914 g/cc

Sample #	Reference filter 10	Ref nozzle wash 6	Combined Ref Total	CAM filter 9	Record filter 11	Probe wash 8	Splitter wash 4	CAM holder wash 7	Record holder wash 5	Combined GEMS Total	Unaccounted
Elapsed time, min	123			123	123						
Referenced Flowrate, lpm	35.5			26.1	26.6						
Air Vol L	4367		4367	3210	3272					6482.1	
Bottle gross wt., g	27.7777	146.4264		27.6309	27.8436	176.2404	191.8281	147.9467	24.3007		
Bottle Tare, g	16.6104	123.5027		16.4534	16.7211	123.8383	123.4664	123.6601	16.6364		
Liq vol in bottle, ml	14.11	28.97		14.12	14.05	66.21	86.38	30.69	9.68		
Dilution (1 to x.xxx)	6.3296	0.2351		10.8738	9.342	0.4120	0.4120	0.4120	0.4120		
Peak area	15704	5685		3716	3809	4333	499	229	5950		
Conc. in Liq., mg/ml	4.96E-04	1.80E-04		1.17E-04	1.20E-04	1.37E-04	1.58E-05	7.24E-06	1.88E-04		
Adj. for dilutn., mg/ml	3.14E-03	4.22E-05		1.28E-03	1.12E-03	5.64E-05	6.50E-06	2.98E-06	7.75E-05		
mg collected	4.43E-02	1.22E-03	4.55E-02	1.80E-02	1.58E-02	3.74E-03	5.61E-04	9.15E-05	7.50E-04	3.90E-02	
% collected, mg	97.3%	2.7%		46.3%	40.5%	9.6%	1.4%	0.2%	1.9%		
Measured air concentration, mg/L			1.04E-05	5.62E-06	4.83E-06					6.01E-06	
% of Reference Conc.				53.9%	46.3%						
Expected in GEMS, mg										0.067613	
% Total Expected				26.7%	23.4%	5.5%	0.8%	0.1%	1.1%	57.6%	42.4%
Expected on CAM, mg				3.35E-02							
% Total Expected				53.9%		5.6%	0.8%	0.3%		60.5%	39.5%
Expected on Record, mg					3.41E-02						
% Total Expected					46.3%	5.5%	0.8%		2.2%	54.8%	45.2%

Notes:
Perkin Elmer LS-50 B Luminescence Spectrophotomer
Spectral Range (nm) 500 - 720 of emission curve
Excitation band (nm) 493
Scan speed 120
Slit width 2.5
3.5 ml cuvette

Test done with high velocity range shrouded nozzle.
The shape of the inlet to the Record filter prevents washing the particles off.
The washes were done after Run PEN-2 and the amounts apportioned between the two runs by the ratio of sample volumes. The apportioning is accounted for in the dilution.

Cal. curve to convert area to mg/ml	
Slope	3.16E-08
Intercept	0.00E+00
CAM flow, lpm	29.149
Record flow, lpm	29.149
Reference flow, lpm	35.5

Penetration Test Results | Run: PEN-2 | pectral analysis date: 5/28/97
Straight 10-inch stack | Stack flow 1000 cfm | Stack sample date: 5/2/97
Fan setting 48 Hz | Solvent density: 0.7914 g/cc

Sample #	Reference filter 1	Ref nozzle wash 6	Combined Ref Total	CAM filter 2	Record filter 3	Probe wash 8	Splitter wash 4	CAM holder wash 7	Record holder wipe 5	Combined GEMS Total	
Elapsed time, min	196			196	196						
Referenced Flowrate, lpm	72.5			19.9	27.3						
Air Vol, L	14210		14210	3900	5351					9251.2	
Bottle gross wt., g	26.7029	146.4264		24.6625	25.2716	176.2404	191.8281	147.9467	24.3007		
Bottle Tare, g	16.6733	123.5027		16.4748	16.5141	123.8383	123.4664	123.6601	16.6364		
Liq vol in bottle, ml	12.67	28.97		10.35	11.07	66.21	86.38	30.69	9.68		
Dilution (1 to x.xxx)	9.295	0.7649		3.127	9.986	0.5880	0.5880	0.5880	0.5880		
Peak area	13356	5685		17245	4405	4333	499	229	5950		
Conc. in Liq., mg/ml	4.22E-04	1.80E-04		5.45E-04	1.39E-04	1.37E-04	1.58E-05	7.24E-06	1.88E-04		
Adj. for dilutn., mg/ml	3.92E-03	1.37E-04		1.70E-03	1.39E-03	8.05E-05	9.27E-06	4.26E-06	1.11E-04		
mg collected	4.97E-02	3.98E-03	5.37E-02	1.76E-02	1.54E-02	5.33E-03	8.01E-04	1.31E-04	1.07E-03	4.03E-02	
% collected, mg	92.6%	7.4%		43.7%	38.1%	13.2%	2.0%	0.3%	2.7%		
Measured air concentration, mg/L			3.78E-06	4.52E-06	2.87E-06					4.36E-06	
% of Reference Conc.				119.6%	76.1%						Unaccounted
Expected in GEMS, mg										0.034959	
% Total Expected				50.4%	44.0%	15.2%	2.3%	0.4%	3.1%	115.4%	-15.4%
Expected on CAM, mg				1.47E-02							
% Total Expected				119.6%		18.1%	2.7%	0.9%		141.3%	-41.3%
Expected on Record, mg					2.02E-02						
% Total Expected					76.1%	13.2%	2.0%		5.3%	96.5%	3.5%

Notes:

Perkin Elmer LS-50 B Luminescence Spectrophotomer
Spectral Range (nm) 500 - 720 of emission curve
Excitation band (nm) 493
Scan speed 120
Slit width 2.5
3.5 ml cuvette

Test done with high velocity range shrouded nozzle.
The washes were done after Run PEN-2 and the amounts apportioned between the two runs by the ratio of sample volumes. The apportioning is accounted for in the dilution.

Cal. curve to convert area to mg/ml	
Slope	3.16E-08
Intercept	0.00E+00
CAM flow, lpm	22.73433
Record flow, lpm	28.583
Reference flow, lpm	72.5

Penetration Test Results
Straight 10-inch stack

Run: PEN-3
Stack flow 213 cfm
Fan setting 12 Hz

Spectral analysis date: 5/7/97
Stack sample date: 5/5/97
Solvent density: 0.7914 g/cc

Sample #	Reference filter 20	Ref nozzle wash 16	Combined Ref Total	CAM filter 21	Record filter 22	Probe wash 17	Splitter wash 15	CAM holder wash 18	Record holder wash 19	Combined GEMS Total	Unaccounted
Elapsed time, min	72			72	72						
Referenced Flowrate, lpm	15.26			26.3	21.8						
Air Vol, L	1098.7		1098.7	1893.6	1569.6					3463.2	
Bottle gross wt., g		129.3190				138.8147	144.6524	144.0869	144.5477		
Bottle Tare, g		123.7110				123.5980	123.8800	123.6877	123.4257		
Liq vol in bottle, ml	9	7.09		9	9	19.23	26.25	25.78	26.69		
Dilution	11	1		11	11	1	1	1	1		
Peak area	8669	13152		9817	6339	9052	2245	1561	1568		
Conc. in Liq., mg/ml	2.7E-04	4.2E-04		3.1E-04	2.0E-04	2.9E-04	7.1E-05	4.9E-05	5.0E-05		
Adj. for dilutn., mg/ml	3.0E-03	4.2E-04		3.4E-03	2.2E-03	2.9E-04	7.1E-05	4.9E-05	5.0E-05		
mg collected	2.7E-02	2.9E-03	3.0E-02	3.1E-02	2.0E-02	5.5E-03	1.9E-03	1.3E-03	1.3E-03	6.0E-02	
% collected, mg	90.2%	9.8%		50.8%	32.8%	9.1%	3.1%	2.1%	2.2%		
Measured air concentration, mg/L			2.7E-05	1.6E-05	1.3E-05					1.7E-05	
% of Reference Conc.				59.3%	46.2%						
Expected in GEMS, mg										0.094766	
% Total Expected				32.4%	20.9%	5.8%	2.0%	1.3%	1.4%	63.8%	36.2%
Expected on CAM, mg				5.18E-02							
% Total Expected				59.3%		5.3%	1.8%	2.5%		68.8%	31.2%
Expected on Record, mg					4.30E-02						
% Total Expected					46.2%	6.4%	2.2%		3.1%	57.8%	42.2%

Notes:
Perkin Elmer LS-50 B Luminescence Spectrophotomer
Spectral Range (nm) 500 - 720 of emission curve
Excitation band (nm) 493
Scan speed 120
Slit width 2.5
3.5 ml cuvette

Test done with high velocity range shrouded nozzle.
The shape of the inlet to the Record filter prevents washing the partilces off.

Cal. curve to convert area to mg/ml	
Slope	3.16E-08
Intercept	0.00E+00
CAM flow, lpm	28.10
Record flow, lpm	23.32
Reference flow, lpm	15.26

Penetration Test Results — Straight 10-inch stack

Run: PEN-4
Stack flow 894 cfm
Fan setting 40 Hz

pectral analysis date: 5/9/97
Stack sample date: 5/8/97
Solvent density: 0.7914 g/cc

Sample #	Reference filter 28	Ref. nozzle wash 23	Combined Ref. Total	CAM filter 30	Record filter 29	Probe wash 24	Splitter wash 25	CAM holder wash 27	Record holder wash 26	Combined GEMS Total	Unaccounted
Elapsed time, min	233			233	233						
Referenced Flowrate, lpm	90			29.2	30.7						
Air Vol, L	20970		20970	6804	7153					13956.7	
Bottle gross wt., g	26.8297	131.7669		23.5903	22.2865	160.6825	155.5694	146.4142	156.2622		
Bottle Tare, g	16.7809	122.8682		16.8366	16.7636	123.4190	122.1222	123.5957	122.9461		
Liq vol in bottle, ml	12.70	11.24		8.53	6.98	47.09	42.26	28.83	42.10		
Dilution (1 to x.xx)	10	1		10	10	1	1	1	1		
Peak area	14636	7475		6036	8795	2462	754	1976	462		
Conc. in Liq., mg/ml	4.62E-04	2.36E-04		1.91E-04	2.78E-04	7.78E-05	2.38E-05	6.24E-05	1.46E-05		
Adj. for dilutn, mg/ml	4.62E-03	2.36E-04		1.91E-03	2.78E-03	7.78E-05	2.38E-05	6.24E-05	1.46E-05		
mg collected	5.87E-02	2.66E-03	6.14E-02	1.63E-02	1.94E-02	3.66E-03	1.01E-03	1.80E-03	6.15E-04	4.28E-02	
% collected, mg	95.7%	4.3%		38.1%	45.4%	8.6%	2.4%	4.2%	1.4%		
Measured air concentration, mg/L			2.93E-06	2.39E-06	2.71E-06					3.06E-06	
% of Reference Conc.				81.7%	92.6%						
Expected in GEMS, mg										0.040853	
% Total Expected				39.8%	47.5%	9.0%	2.5%	4.4%	1.5%	104.7%	-4.7%
Expected on CAM, mg				1.99E-02							
% Total Expected				81.7%		9.2%	2.5%	9.0%		102.5%	-2.5%
Expected on Record, mg					2.09E-02						
% Total Expected					92.6%	8.7%	2.4%		2.9%	106.7%	-6.7%

Notes:
Perkin Elmer LS-50 B Luminescence Spectrophotomer
Spectral Range (nm) 500 - 720 of emission curve
Excitation band (nm) 493
Scan speed 120
Slit width 2.5
3.5 ml cuvette

Test done with high velocity range shrouded nozzle.
The shape of the inlet to the Record filter prevents washing the partilces off.

Cal. curve to convert area to mg/ml	
Slope	3.16E-08
Intercept	0.00E+00
CAM flow, lpm	30.60
Record flow, lpm	30.22
Reference flow, lpm	90.03

Penetration Test Results　Run: PEN-6
Straight 10-inch stack　Stack flow 213 cfm
Fan setting 12 Hz

pectral analysis date: 6/4/97
Stack sample date: 6/2/97
Solvent Density: 0.7914 g/cc

Sample #	Reference filter 38	Ref nozzle wash 35	Combined Ref Total	CAM filter 37	Record filter 36	Probe wash 33	Splitter wash 39	CAM holder wash 41	Record holder wash 34	Combined GEMS Total	Unaccounted
Elapsed time, min	79			79	79						
Referenced Flowrate, lpm	15.04			30.3	31.7						
Air Vol, L	1188		1188	2394	2504					4898.0	
Bottle gross wt., g	25.6923	129.5447		25.5821	25.6658	160.5833	168.809	149.1897	160.4544		
Bottle Tare, g	15.1992	123.7120		15.1550	15.1632	123.5940	123.8860	123.6960	123.4370		
Liq vol in bottle, ml	13.26	7.37		13.18	13.27	46.74	56.76	32.21	46.77		
Dilution (1 to x.xx)	8.809	1		9.8475	9.8055	1	1	1	1		
Peak area	11374	6585		11793	14656	574	554	798	65		
Conc. in Liq., mg/ml	3.59E-04	2.08E-04		3.73E-04	4.63E-04	1.81E-05	1.75E-05	2.52E-05	2.05E-06		
Adj. for dilutn., mg/ml	3.17E-03	2.08E-04		3.67E-03	4.54E-03	1.81E-05	1.75E-05	2.52E-05	2.05E-06		
mg collected	4.20E-02	1.53E-03	4.35E-02	4.84E-02	6.03E-02	8.48E-04	9.94E-04	8.12E-04	9.61E-05	1.11E-01	
% collected, mg	96.5%	3.5%		43.4%	54.1%	0.8%	0.9%	0.7%	0.1%		
Measured air concentration, mg/L			3.66E-05	2.02E-05	2.41E-05					2.27E-05	
% of Reference Conc.				55.2%	65.7%						
Expected in GEMS, mg										0.179375	
% Total Expected				27.0%	33.6%	0.5%	0.6%	0.5%	0.1%	62.1%	37.9%
Expected on CAM, mg				8.77E-02							
% Total Expected				55.2%		0.5%	0.6%	0.9%		57.1%	42.9%
Expected on Record, mg					9.17E-02						
% Total Expected					65.7%	0.5%	0.5%		0.1%	66.8%	33.2%

Notes:
Perkin Elmer LS-50 B Luminescence Spectrophotomer
Spectral Range (nm) 500 - 720 of emission curve
Excitation band (nm) 493
Scan speed 120
Slit width 2.5
3.5 ml cuvette

Sample and Record filters ruptured during Run-5.
Test done with low velocity range shrouded nozzle.
The shape of the inlet to the Record filter prevents washing the partilces off.

Cal curve to convert area to mg/ml	
Slope	3.16E-08
Intercept	0.00E+00
CAM flow, lpm	31.53
Record flow, lpm	30.97
Reference flow, lpm	15.04

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