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RPT-STMON-001

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Assessment of the Proposed INTEC CPP-666 Stack Monitoring Site for Compliance with ANSI/HPS N13.1-1999

JA Glissmeyer
JE Flaherty

February 2010

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This document was prepared for CH2M-WG Idaho, LLC as part of the Statement of Work for CPP-666 Exhaust Stack Testing (SOW-7515). The testing described in this document was further guided by the CPP-666 Air Sampling Test Plan (TP-STMON-001).

Pacific Northwest National Laboratory
Richland, Washington 99352

Completeness of Testing

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

Approved:

John A. Glissmeyer
Stack Monitoring Project Manager

4/27/2010
Date

Summary

This document reports on a series of tests to determine whether the proposed new location for air sampling probes in the CPP-666 heating, ventilation and air conditioning (HVAC) exhaust duct would meet the applicable regulatory criteria regarding the placement of an air sampling probe. Federal regulations[(a)] require that a sampling probe be located in the exhaust stack according to the criteria of the American National Standards Institute/Health Physical Society (ANSI/HPS) N13.1-1999, *Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stack and Ducts of Nuclear Facilities*. These criteria address the capability of the sampling probe to extract a sample that is representative of the effluent stream.

The in-place testing conducted for this project was part of the Service Agreement (No. CWI-724292) established between CH2M-WG Idaho (CWI) and Pacific Northwest National Laboratory (PNNL). The statement of work (SOW-7515) within this Service Agreement provides information regarding the scope, requirements, safety, and submittals.

The tests conducted by PNNL during October 2009 on the CPP-666 exhaust system are described within this report. The proposed sampling probe location is in the underground concrete duct between the building and the 50-m exhaust stack. The tests conducted on the duct indicate that the proposed air sampling probe location meets the criteria of the standard.

The series of tests consists of various measurements taken over a grid of points in the duct cross section at the proposed sampling-probe location. The results of the test series on the CPP-666 exhaust duct as it relates to the criteria from ANSI/HPS N13.1-1999 are summarized below.

1. Uniform Air Velocity—The gas momentum across the stack cross section where the sample is extracted should be well-mixed or uniform. The uniformity is expressed as the variability of the measurements about the mean, expressed as the coefficient of variance (COV). It is calculated as the standard deviation divided by the mean and expressed as a percentage—the lower the COV value, the more uniform the velocity. The acceptance criterion is that the COV of the air velocity must be ≤20% across the cross section of the duct. The results of the measurements at the proposed air sampling probe location ranged from 2.3 to 3.5%, which is well within the acceptance criterion.

2. Angular Flow—The purpose of this test is to determine whether the air velocity vector is aligned with the sampling nozzle. The average flow angle relative to the nozzle axis should not be more than 20°. The average measured values ranged from 1.4 to 2.1 degrees, so this criterion was met.

3. Uniform Concentration of Tracer Gases—A uniform contaminant concentration in the sampling plane enables the extraction of samples that represent the true concentration. This was first tested using a tracer gas injected into the airstream in a straight duct downstream of the fans and inside the building. The two acceptance criteria are that 1) the COV of the measured tracer-gas concentration is ≤ 20% across duct cross section and 2) at none of the measurement points did the concentration vary from

(a) Title 40 of the Code of Federal Regulations (CFR), Part 61, National Emissions Standards for Hazardous Air Pollutants (NESHAP), Subpart H, *National Emission Standard For Emissions of Radionuclides other than Radon from Department of Energy Facilities*.

the mean by >30%. Out of the eight runs performed, all of the results meet the acceptance criteria, and the maximum values observed were 12% COV and 18.8% maximum deviation.

4. Uniform Concentration of Tracer Particles—Uniformity in contaminant concentration at the sampling probe was further demonstrated using tracer particles large enough to exhibit inertial effects. Particles of 10-µm aerodynamic diameter were used. The acceptance criterion is that the COV of particle concentration is ≤20% across the sampling probe location. Initially, the particles were inappropriately injected directly into a bend in the ductwork, and those results showed borderline failures of 23.5% and 24.9% COV. The probe was then adjusted slightly to correctly inject into the centerline of the straight run of duct. After correcting the injection point, the results met the acceptance criterion and ranged from 12.3% to 16.4% COV.

Based on these tests, the location proposed for the new air sampling probe meets the requirements of the ANSI/HPS N13.1-1999 standard.

Acronyms

AD	aerodynamic diameter
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
CFR	Code of Federal Regulations
COV	coefficient of variance
CWI	CH2M-WG Idaho, LLC
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
FIO	for information only
HDI	"How Do I…?"
HPS	Health Physics Society
HVAC	heating, ventilation, and air conditioning
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
M&TE	materials and testing equipment
NESHAP	National Emissions Standards for Hazardous Air Pollutants
OPC	optical particle counter
PNNL	Pacific Northwest National Laboratory
QA	quality assurance
QAM	Quality Assurance Manual
QAP	Quality Assurance Plan
QARD	Quality Assurance Requirements and Descriptions
RH	remote-handled
RWDP	Remote Waste Disposition Project
SF_6	sulfur hexafluoride
SOW	statement of work
TI	test instruction

Acknowledgments

This work was supported by the American Recovery and Reinvestment Act under a Related Services Agreement with the U.S. Department of Energy (DOE) under Contract DE-AC05-76RL01830. Pacific Northwest National Laboratory is operated for DOE by Battelle.

Preparation and execution of this study involved a number of staff from both PNNL and CH2M-WG Idaho. We would like to particularly acknowledge the support of our quality engineer, Kirsten Meier, and administrative support from Andrea Boehler. Scientific staff members Victor Morris, Xiao-Ying Yu, Mikhail Pekour, and Jim Droppo provided technical and moral support throughout the process. Additionally, Carmen Arimescu, Roseanne Aaberg, and J. Matthew Barnett provided technical reviews. Wayne Cosby provided editorial support for this report. The team of support staff at CWI was also integral to the successful completion of the work conducted at the Idaho Nuclear Technology and Engineering Center. Facilities staff, as well as crafts and radiological support staff, were professional and a pleasure to work with. We appreciate the positive attitudes and willingness to be flexible during long work days.

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1.0 Introduction

The Idaho Nuclear Technology and Engineering Center (INTEC) was established in the 1950s to recover usable uranium in spent fuel from government reactors. Today, this facility's focus has turned to cleanup and the protection of the Snake River Plain Aquifer. Per state and federal requirements, remote-handled (RH) waste stored in INTEC facilities must be processed or re-packaged for final land disposal. The Remote Waste Disposition Project (RWDP) has been proposed to provide the Idaho National Laboratory (INL) with the capability to process RH waste for final disposal. This new capability under the RWDP will be located at the INTEC in building CPP-666. The existing stack monitoring system for this building was constructed according to outdated standards. Under the RWDP operations, it is anticipated that the potential dose associated with processing the waste will exceed the 0.1 millirem per year threshold limit given in Title 40 of the Code of Federal Regulations (CFR), Part 61, National Emissions Standards for Hazardous Air Pollutants (NESHAP), Subpart H, *National Emission Standard For Emissions of Radionuclides other than Radon from Department of Energy Facilities*. As a result, emissions monitoring must be conducted and must conform to the applicable federal regulations. The RWDP had determined that in-place testing was the preferred approach for identifying a sampling location in the CPP-666 heating, ventilation, and air conditioning (HVAC) ductwork that meets the applicable criteria.

The series of in-place tests performed by the Stack Sampling Project staff at Pacific Northwest National Laboratory (PNNL) assessed whether the particular proposed sampling location in the CPP-666 HVAC exhaust duct would meet the applicable regulatory criteria regarding the placement of an air sampling probe. The NESHAP requires that a sampling probe be located in the exhaust stack according to the criteria of the American National Standards Institute/Health Physical Society (ANSI/HPS) N13.1-1999, *Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stack and Ducts of Nuclear Facilities*.

The in-place testing conducted for this project was part of the Service Agreement (No. CWI-724292) established between CH2M-WG Idaho (CWI) and PNNL. The statement of work (SOW-7515) within this Service Agreement provides information regarding the scope, requirements, safety, and submittals.

The tests conducted by PNNL during October 2009 on the CPP-666 exhaust system are described within this report. The tests conducted on the stack indicate that the proposed air sampling location meets the criteria of the standard.

1.1 Qualification Criteria

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

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

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

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

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

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

Tests to determine if Criteria 1 through 4 are met were conducted on the CPP-666 exhaust duct, near the planned position of the sampling probes. The testing conducted, as well as the results of these tests, is described in subsequent sections of this report.

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

2.0 CPP-666 Duct Configuration

The CPP-666 exhaust duct system originates in the CPP-666 building and then travels below grade to the base of a 50-meter exhaust stack that is approximately 50 meters away from the CPP-666 building. Figure 2.1 is a photograph depicting the relative position of the exhaust stack compared to the CPP-666 building. Within the building, there are three fans available to power the exhaust air. Typically, only two of the fans are used at a time.

The relevant features of the duct are depicted in Figure 2.2. Within the building, the duct is a 78-inch (1.9-meter) circular duct. Just before the 90-degree vertical bend in the duct, there is a tee that was constructed as an alternate stack emission point. The leg of this tee carries no flow and terminates within the building. At the base of the building, the 78-inch circular duct makes another 90-degree bend and subsequently changes to a 72-inch high by 78-inch wide (1.8-m by 2.0-m) rectangular cross-section constructed of concrete. Under the roadway, the duct gradually changes to a 48-inch tall by 108-inch wide (1.2-m by 2.7-m) duct. The proposed stack monitoring location and the actual stack testing location was located in this section of duct. The nearest upstream change in cross-sectional shape is approximately 120 feet from the stack monitoring location. Downstream from the proposed stack monitoring location, the duct gradually changes again to a 108-inch tall by 48-inch wide (2.7-m by 1.2-m) cross-sectional shape. This is the shape that enters the base of the circular exhaust stack. For stack monitoring purposes, the two bends in the circular duct as well as the shape change from circular to square and then rectangular serve to aid in the mixing of any potential contaminants in the system.

Figure 2.3 is a photograph that depicts the interior surface of the duct as seen from one of the test ports. This photo is looking upstream (towards the building) from the test port.

Figure 2.1. Photograph of the CPP-666 Building and the Exhaust Stack

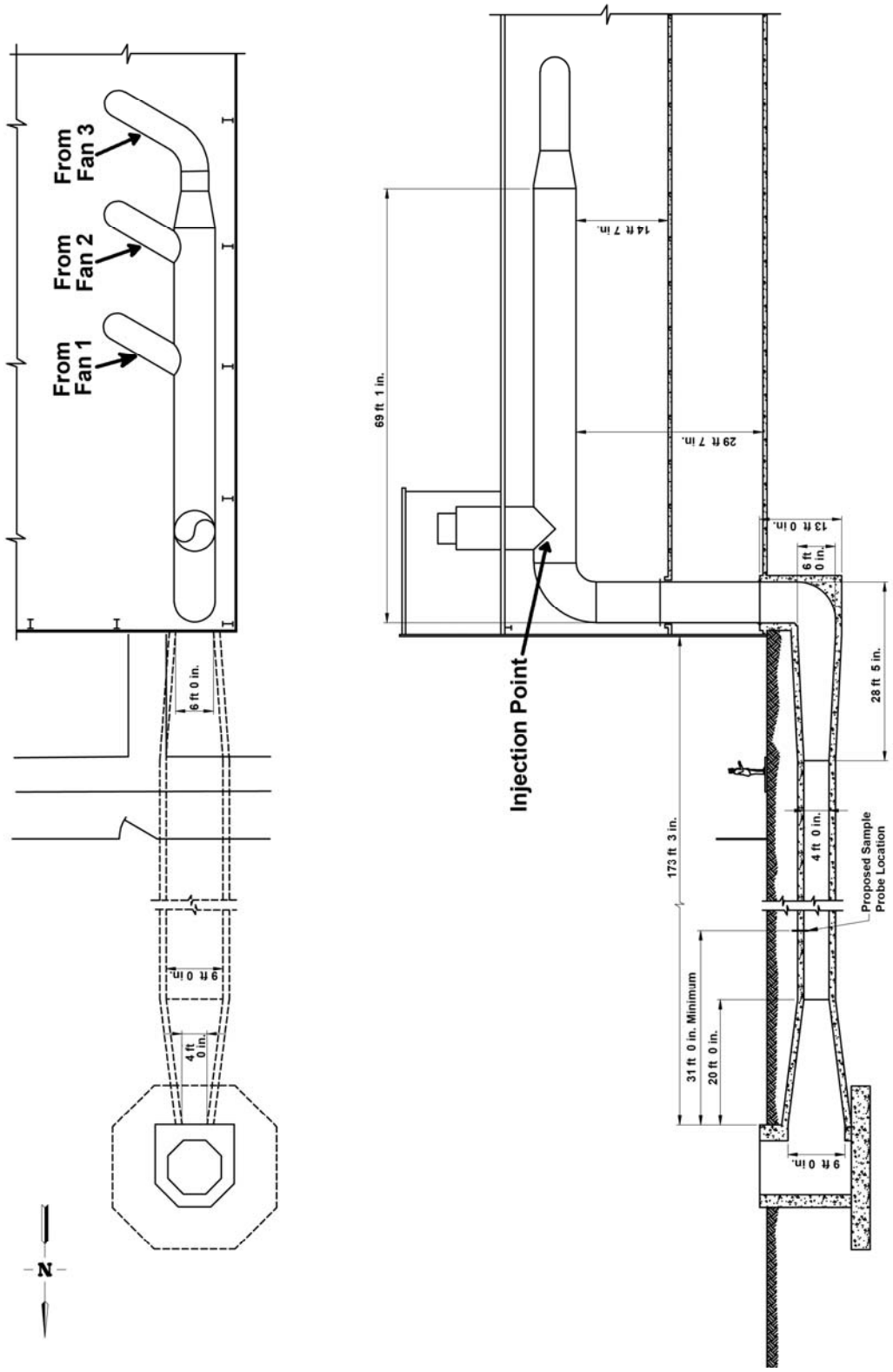

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Figure 2.2. Plan View and Side View of the Exhaust Duct System at CPP-666

(a)

(b)

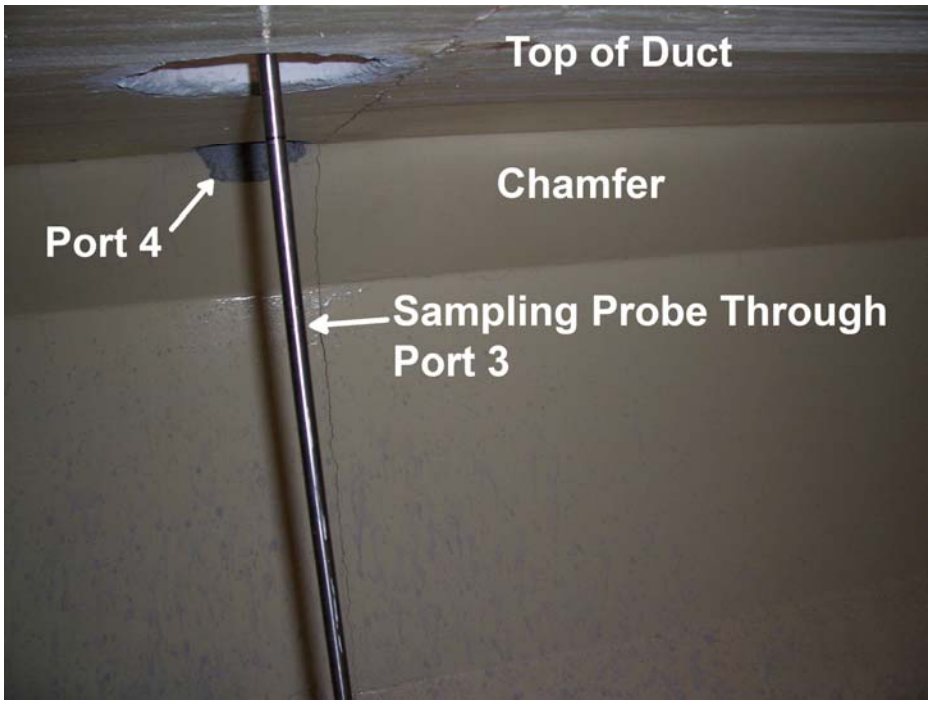


Figure 2.3. Photographs of the Duct Interior

(a) Looking Upstream from the Sampling Position
(b) Showing Test Ports and a Sampling Probe

3.0 Testing Methods

The testing methods were based on the requirements of ANSI/HPS N13.1-1999. A test plan, TP-STMON-001, *Testing the CPP-666 Stack Air Sampling Position*, was prepared by PNNL and approved by CWI. This plan referenced the use of PNNL procedures, which define how the test should be conducted in general. A test instruction (TI) was prepared for each test type as follows:

- TI-STMON-002, Determine Air Velocity Uniformity of CPP-666 Stack
- TI-STMON-003, Determine Flow Angle in CPP-666 Stack
- TI-STMON-004, Tests of Gas Tracer Mixing in CPP-666 Stack
- TI-STMON-005, Tests of Particle Tracer Mixing in CPP-666 Stack.

These contain specific instructions pertaining to the tests that are not addressed in the more generalized procedures. Such information includes the following:

- Layout of measurement points
- Location of tracer injection points
- List of equipment and instrumentation
- Safety requirements
- List of test runs
- Test description and measurement data sheets with hand entries
- Table of preliminary results.

Because the final data sheets and a description of the test methods are included in the report, the TIs are not included here. A summary of the stack testing methods used for each of the four test types is presented in this section.

3.1 Quality Assurance

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

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

The procedures necessary to implement the requirements are documented through PNNL's "How Do I…?" (HDI).[(a)]

The Stack Monitoring Project performs work in accordance with the *Stack Monitoring Project Quality Assurance Plan* (STMON-QA-001, QAP*)*. Work was performed to the quality requirements of NQA-1-1989 Part I, Basic and Supplementary Requirements, NQA-2a-1990, Part 2.7, and DOE/RW-0333P, Rev 13, *Quality Assurance Requirements and Descriptions (QARD)*. These quality requirements are implemented through the *Stack Monitoring Project Quality Assurance Manual* (STMON-QA-003, QAM).

Experiments that are not method-specific were performed in accordance with QA-STMON-1101 "Scientific Investigations" and QA-STMON-1201 "Calibration and Control of Measuring and Testing Equipment." Properly calibrated measuring and test equipment (M&TE) was used to acquire sufficient data to produce quality results.

The Stack Monitoring Project addresses internal verification and validation activities by conducting an Independent Technical Review of the final data report in accordance with the project's procedure QA-STMON-604. All data transcriptions and calculations are also independently reviewed in accordance with internal procedures for test instructions, spreadsheet calculations, and hand calculations. Project procedures QA-STMON-301, -1105, and –SCP2 describe these QA procedures. These reviews verify that the reported results are traceable, that inferences and conclusions are soundly based, and the reported work satisfies the Test Plan objectives. These review procedures are part of PNNL's Stack Monitoring Project, *Quality Assurance Manual*.

3.2 Stack Tests

The tests described in the following sub-sections were conducted under typical operating conditions for the HVAC system. Of the three fans that are installed in this system, typically fans number 2 and 3 are in operation (see Figure 2.2.). Several tests were conducted with Fans 1 and 2 operating as a check on the potential variability in test results for different fan operations. This was presumed to be the worst-case in terms of mixing because Fan 1 is the one furthest downstream in the system. A single fan case was not tested because there is no intent at the facility to operate with a single fan.

Measurements were made at specific locations within the duct for each of the four tests described in the following sub-sections. The number and distance between measurement points was based on the U.S. Environmental Protection Agency (EPA) procedure 40 CFR 60, Appendix A, Method 1, for rectangular ducts. During the planning phases of this work, the duct was described as a 48-inch-tall by 108-inch-wide rectangular duct. When the test ports were drilled into the duct, it was discovered that there were large chamfers in the corners of the duct. Figure 3.1 shows the cross section of the duct at the sampling location with the positions of the 12 measurement points indicated by the intersection of the dashed lines. Each of the four measurement ports were designated as Ports 1 through 4, with Port 1 located farthest west. At each port, the three measurement points were 8, 24, and 40 inches from the floor of the duct. The measurement point closest to the port was Point 1, while the point closest to the floor of the duct was Point 3.

(a) System for managing the delivery of laboratory-level policies, requirements, and procedures.

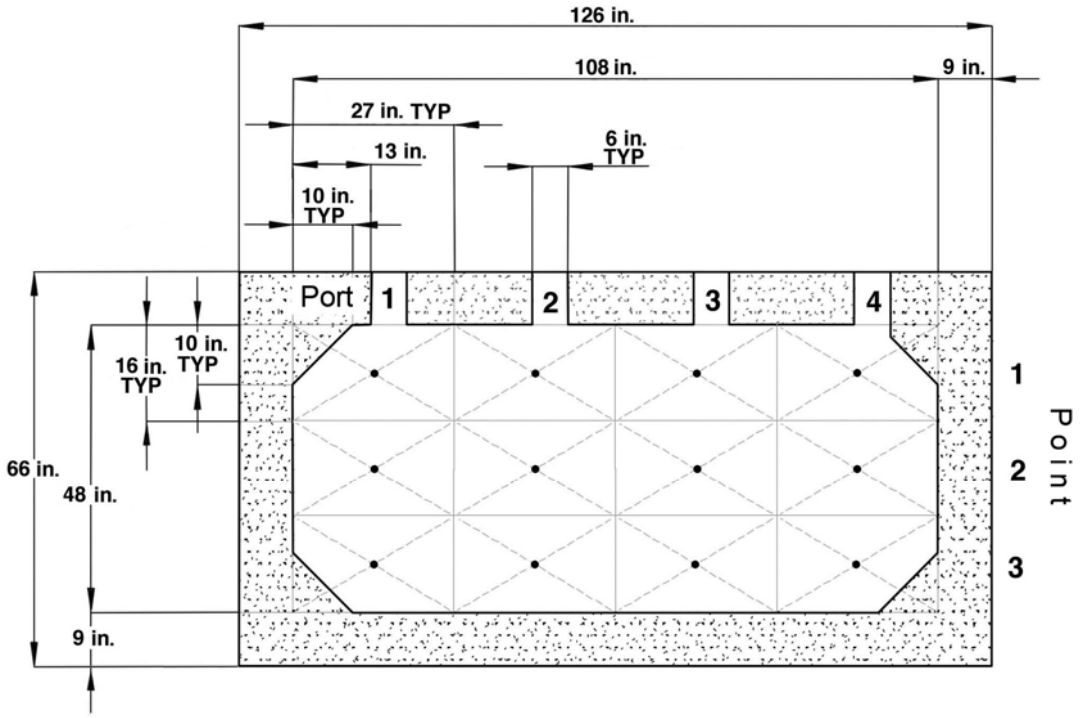


Figure 3.1. Cross-Section of the Duct at the Testing Location

3.2.1 Velocity Uniformity

The uniformity of air velocity at the stack monitoring location indicates that the momentum in the stack is well-mixed. The method used to conduct the velocity uniformity tests was based on 40 CFR 60, Appendix A, Method 1. The criterion for acceptance from the velocity uniformity test is that the COV should be less than 20%.

The air velocity was measured three times at each of the 12 grid points across the cross-section of the duct. The average of the three measurements was used to determine the mean and standard deviation of the velocity across the cross-sectional plane. The coefficient of variance (also known as the percent relative standard deviation) was calculated as 100 times the standard deviation divided by the mean.

Each air velocity measurement was made using an S-type pitot tube connected to a calibrated electronic manometer (GrayWolf, Zephyr II+, Shelton, CT) by flexible tubing. Duct air temperature measurements were made with a handheld thermal anemometer (TSI, Model 8360, Shoreview, MN). Figure 3.2 shows the equipment used for this test. In this test, the S-type pitot tube was positioned so that the normal vector to one of the two openings at the tip was pointing in the same direction as the axis of the duct. The procedure EMS-JAG-04 and the test instruction TI-STMON-002 were followed to conduct this test.

Figure 3.2. Equipment Used for the Velocity Uniformity Test

The panel on the left shows the S-type pitot tube connected to the electronic manometer. The upper panel on the right shows the tip of the S-type pitot tube, while the lower panel on the right is the thermal anemometer.

3.2.2 Flow Angle

The air velocity vector approaching the sample nozzle should be aligned with the axis of the nozzle within an acceptable deviation angle so that the sample extraction performance is not degraded. The test method is based on 40 CFR 60, Appendix A, Method 1, Section 11.4, "Verification of the Absence of Cyclonic Flow." The term "flow angle" refers to the angle between the velocity vector of the flow in the duct and the axis of the sampling nozzle. For the stack testing activities, the flow angle was measured at a grid of 12 points in a cross section of the duct near the location of the planned sampling probes (see Figure 3.1). The criterion for acceptance from the flow-angle test is that the average angle must be <20°.

The flow angle measurements were made using an S-type pitot tube (Dwyer Instruments, 160S-72, Michigan City, IN) attached by flexible tubing to a slant-tube manometer (Dwyer Instruments, 400-5) and an angle-indicating device attached to the sampling port as shown in Figure 3.3. For this test, the S-type pitot tube was rotated so that the planes of the two openings at the tip of the tube were parallel to the flow in the duct. The pitot tube is considered perpendicular to the flow in this position. The large metal plate in Figure 3.3 is the angle-indicating device. It has markings at every degree from -30 degrees to 30 degrees. When the pressures on both tubes of the S-type pitot tube were equal (as indicated by the manometer), the pitot tube was perpendicular to the flow. The procedure EMS-JAG-05 and the test instruction TI-STMON-003 were used to conduct this test.

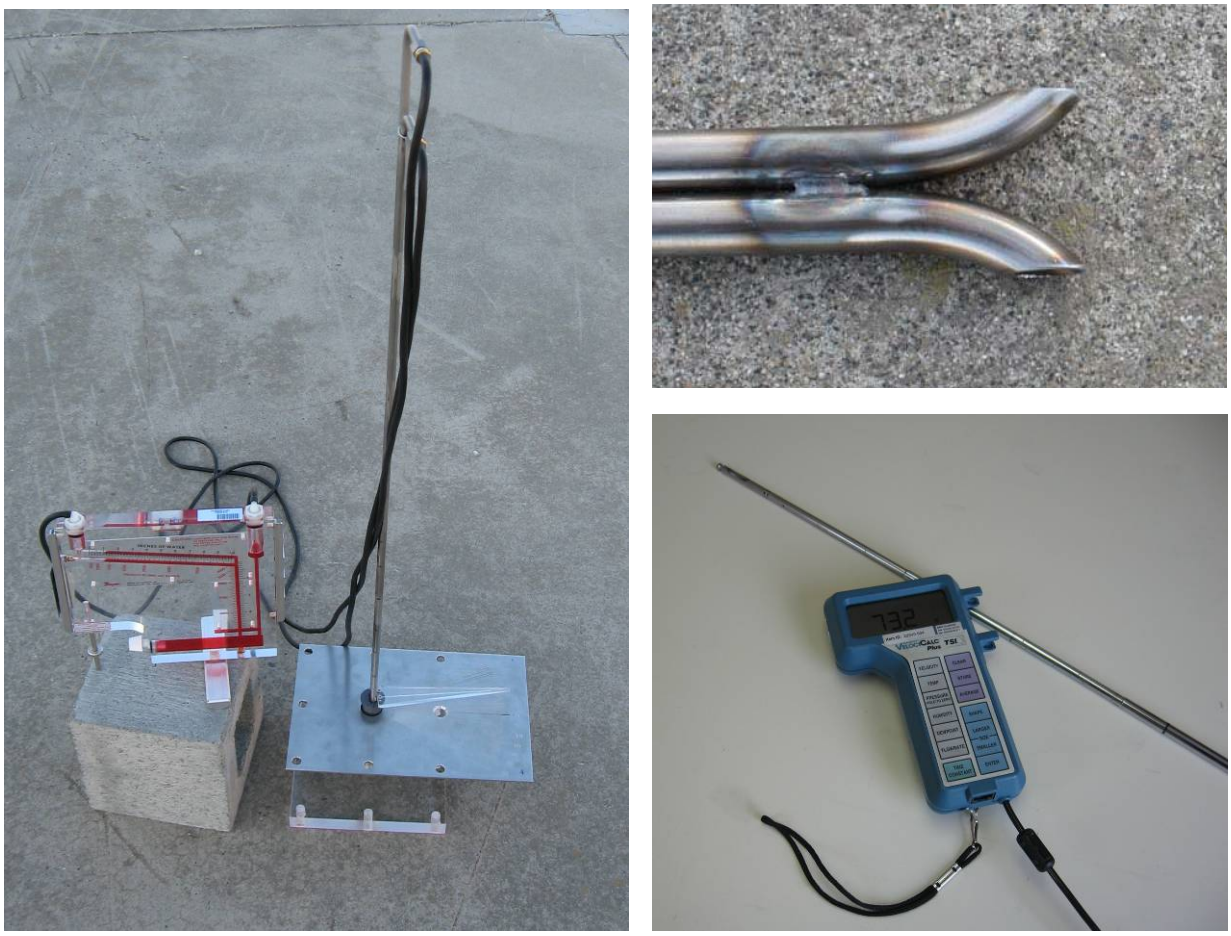


Figure 3.3. Equipment Used for the Flow Angle Test

The panel on the left shows the S-type pitot tube connected to the slant-tube manometer. The upper panel on the right shows the tip of the S-type pitot tube, while the lower panel on the right is the thermal anemometer.

3.2.3 Gaseous Tracer Uniformity

The gaseous contaminant concentration uniformity at the proposed monitoring location was demonstrated using the tracer gas sulfur hexafluoride (SF_6). A compressed gas cylinder and flow controller was used to deliver a constant stream of SF_6 into the duct. The gaseous tracer was injected into the duct air at a point downstream of the fans and upstream of the vertical bend in the duct (see Figure 2.2). Five different injection points were used, one per test run. Then the test with the worst COV was repeated. The five injection points were at the centerline, near the bottom of the duct, near the top of the duct, near the east side of the duct, and near the west side of the duct. Figure 3.4 shows the five injection locations at the duct cross-section with an injection probe located at one of the injection locations.

For each test run, the tracer concentration was measured three times at each of the 12 grid points across the proposed sampling location. The criterion for acceptance from the gaseous tracer test is that the COV should be less than or equal to 20%, and the concentration at any measurement point should not deviate from the mean by more than 30%.

A photoacoustic gas analyzer (Brüel & Kjær, Model 1302, Ballerup, Denmark) was used to measure tracer gas concentrations. The concentration variation is the important result for this test, so calibration bias is not important in the test results. However, the analyzer response was checked using calibration standards before conducting the test series to verify an adequate instrument response. The response was considered acceptable if the concentration from the instrument was within 10% of the calibration standard, or if the instrument response had a high level of precision. As a result of quality concerns raised by CWI, the PNNL-provided gas analyzer was operated simultaneously with a CWI-provided analyzer. The CWI instrument was recently calibrated by an ISO-9000 calibration laboratory and was considered to have a higher quality pedigree than the PNNL instrument, which was last calibrated by the manufacturer in January of 2007.

A simple probe was used to extract the sample and deliver it to the gas analyzer. A small pump drew air from within the stack through the probe. The gas analyzers then sampled the air from the sample line for analysis. Figure 3.5 shows the equipment set-up for this test. Each gas analyzer collected air samples from a separate tee in the main sample line. The procedure EMS-JAG-01 and the test instruction TI-STMON-004 were used to conduct this test.

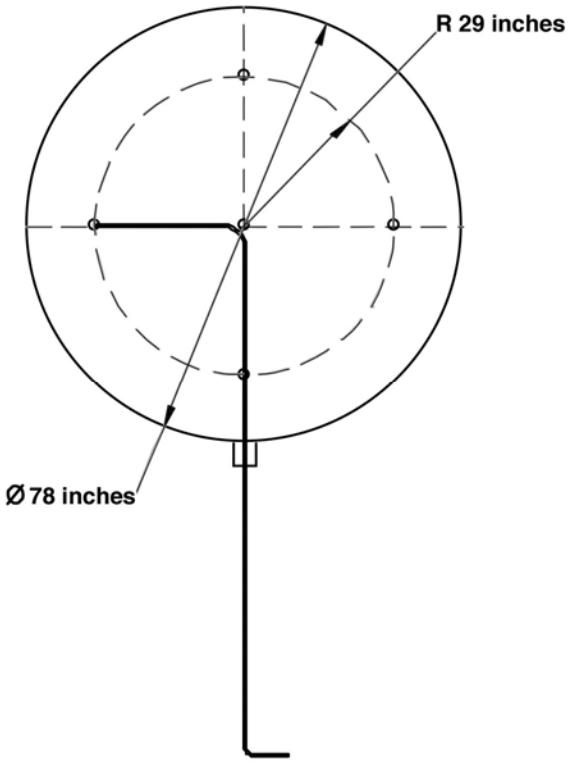


Figure 3.4. Cross-Section of the Duct Showing the Locations of the Five Gaseous Tracer Injection Points

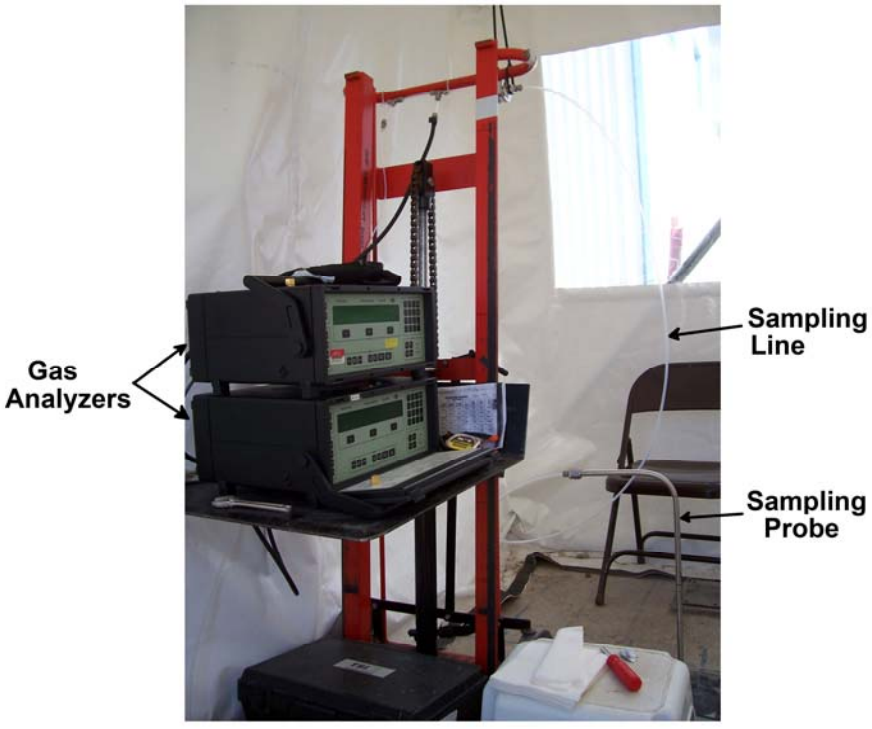


Figure 3.5. Equipment Used for the Gaseous Tracer Sampling

3.2.4 Particle Tracer Uniformity

The uniformity of the particulate contaminant concentration was demonstrated using polydisperse pump oil particles as a particle tracer. Vacuum pump oil was drawn into a compressed-air-driven spray nozzle housed in a plastic chamber. These aerosol particles were injected into the duct air at an injection point downstream of the fans and upstream of the vertical bend in the duct as shown in Figure 2.2. Figure 3.6 is a photograph that shows the equipment set-up for the aerosol injection. The plastic chamber is also referred-to as the aerosol generator. In the photo in Figure 3.6, two aerosol generators (located in the center, bottom of the photo) are connected by flexible tubing to a single injection probe. The aerosol was injected at the centerline of the circular duct, and this test was repeated to gain some sense of the variability of the results.

The initial aerosol injection used a probe with a 28-in.-long leg for injection along the longitudinal axis of the duct. However, the initial test results indicated that the COV was slightly out of compliance to the ANSI/HPS 13.1-1999. It was concluded that the leg of the probe was inappropriately injecting the particles directly into the 90° bend in the duct. Moving the injection point upstream in the system was expected to resolve this problem. However, there were several limitations to selecting and installing a new injection point. First and foremost, the injection point had to be downstream of the current stack monitoring system since it was possible that the aerosol could do damage to this system. Additionally, it was expected that anywhere from one to several days would be needed to design, install, and inspect a new injection port in the duct. Therefore, the quickest compromise was to shorten the leg of the injection probe by 26 inches to effectively move the injection point 26 inches upstream of the initial injection point.

The concentration of the particles is measured at the sampling grid points with a calibrated optical particle counter (OPC, Met-One Model A2408, Grants Pass, OR). A simple probe was used to extract the sample and deliver it to the OPC. Figure 3.7 shows the sampling set-up, with the simple probe connected to the optical particle counter. The OPC sorts the particles into six size channels. As mentioned in Section 1.1, the particles of interest have an AD of 10 μm. Therefore, only data in the 9- to 11-μm channel of the OPC were used. For the first two runs, the particle concentration was measured three times at each of the 12 grid points across the cross-section of the duct. The particle concentration was measured five times at each point for the other runs. The criterion for acceptance from the particle uniformity test is that the COV should be less than 20%. The procedure EMS-JAG-02 and the test instruction TI-STMON-005 were used to conduct this test.

(a)

(b)

Figure 3.6. Equipment Used for the Particle Injection

(a) View looking North showing the aerosol generators, ductwork and injection probe
(b) View looking West showing the duct configuration and aerosol injection probe

Figure 3.7. Equipment Used for the Particle Sampling

4.0 Stack Testing Results

This section summarizes the results of the stack testing activities.

4.1 Velocity Uniformity

Table 4.1 lists the results for the velocity uniformity tests performed on the CPP-666 duct. In addition to the typical operating condition, which uses Fans 2 and 3, a test with Fans 1 and 2 was also conducted. This was presumed to be the worst-case fan condition because Fan 1 is the one nearest to the proposed sampling location. In all cases, the results were well within the criterion of COV values less than 20%. The mean velocity at each of the 12 sampling locations for the first two velocity test is included in Figure 4.1 as an example. The completed data sheets from these three tests are available in Appendix A.

Table 4.1. Summary of Velocity Uniformity Tests

Fan Operating Configuration	Run No	cfm	% COV[(a)]
Fan 2 & 3	VT – 1	73,606	2.3
Fan 2 & 3	VT – 2	73,618	2.4
Fan 1 & 2	VT – 3	74,142	3.5

(a) COV must be ≤ 20%

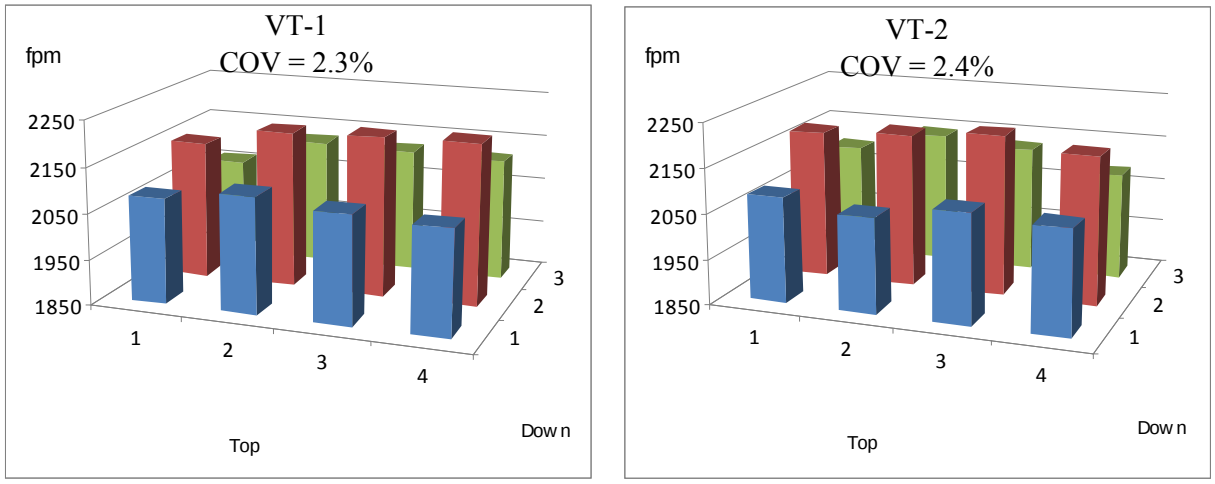


Figure 4.1. Mean Velocity Measurements at each of the 12 Sampling Locations

4.2 Flow Angle

Table 4.2 lists the results for the flow angle tests performed on the CPP-666 duct. In both cases, the results were well within the criterion of COV values less than 20%. The mean flow angle at each of the 12 sampling locations is included in Figure 4.2. The completed data sheets from these two tests are available in Appendix B.

Table 4.2. Summary of Flow Angle Tests

Fan Operating Configuration	Run No	Measured cfm	Mean Absolute Flow Angle[(a)]
Fan 2 & 3	FA – 1	~73,600	2.1
Fan 2 & 3	FA – 2	~73,600	1.4

(a) Mean absolute flow angle must be $\leq 20^{o}$.

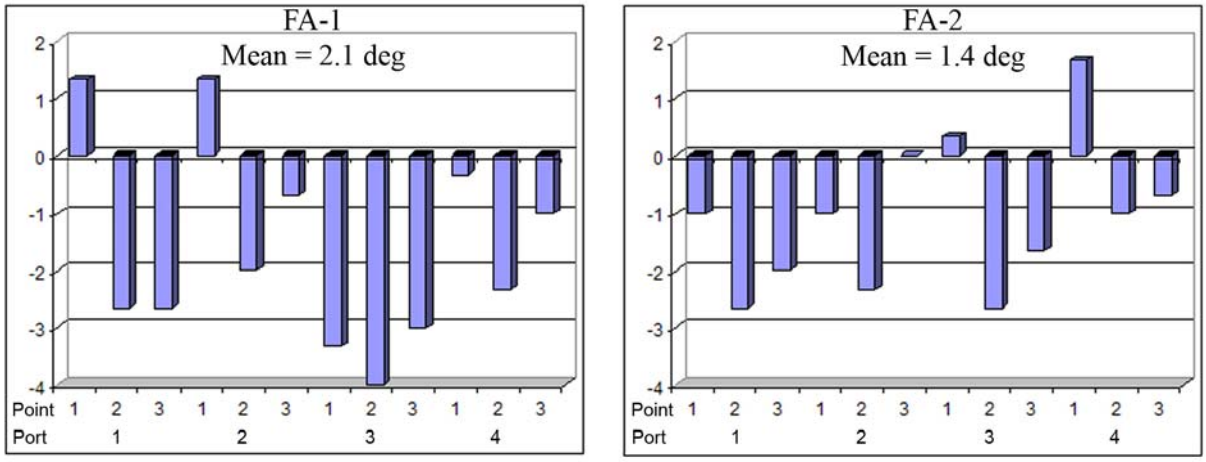


Figure 4.2. Mean Flow Angle Measurements at each of the 12 Sampling Locations

4.3 Gaseous Tracer Uniformity

During the gas tracer testing, the response of the gas analyzers was checked against calibration standards of appropriate concentrations. The two standards purchased for this project were found to contain concentration levels that were not in agreement with the requested concentrations. A non-conformance report was filed, and corrective actions were taken to replace the calibration standards. The gas analyzer response checks were conducted with the replacement calibration standards.

The calibration check is typically used to make certain that the instrument response is stable and that the concentration reported by the instrument is in agreement with the calibration standard. During the calibration checks conducted at INTEC with the replacement calibration standards, the concentration reported by both the PNNL and CWI gas analyzers were sometimes not within 10% of the concentration of the standards. After extensive checking of the system parameters and tubing connections, we determined that there was an effect due to ambient pressures that we did not fully understand. Since the differential concentration is important for these tests, and because both instrument responses were stable, we accepted the deviation in the measured concentration and proceeded with the tests. (The barometric pressure effect was confirmed when checks conducted in Richland, Washington, showed good agreement between the same replacement standards and the PNNL gas analyzer.)

Table 4.3 lists the results for the gaseous tracer uniformity tests performed on the CPP-666 duct. Both the result from the PNNL and the CWI gas analyzers are presented separately in the final two columns. A test with Fans 1 and 2 was also conducted in addition to the typical operating condition, which uses Fans 2 and 3. (The fan operating configuration of Fan 1 and Fan 2 is presumed to be the

worst-case fan condition since Fan 1 is the one furthest downstream in the system and nearest to the injection point.) The worst case injection point was at the west side of the duct, so this was repeated with Fans 2 and 3 as well as with Fans 1 and 2.

In all cases, the results were well within the criterion of COV values less than 20% and a maximum deviation of less than 30%. The mean SF_6 concentration at each of the 12 sampling locations for the cases with the lowest and highest COV values is included in Figure 4.3 as an example. The completed data sheets from these eight tests are available in Appendix C.

Table 4.3. Summary of Gas Tracer Uniformity Tests

Fan Operating Configuration	Injection Position	Run No	% Max Deviation[(a)] (PNNL / CWI)	% COV[(b)] (PNNL / CWI)
Fan 2 & 3	Center	GT – 1	2.7 / 7.0	1.8 / 3.7
Fan 2 & 3	Top	GT – 2	13.1 / --[(c)]	7.8 / --
Fan 2 & 3	Bottom	GT – 3	3.3 / 2.6	1.8 / 2.0
Fan 2 & 3	East	GT – 5	11.6 / 13.8	8.3 / 8.4
Fan 2 & 3	West	GT – 4	15.6 / 18.8	10.9 / 12.0
Fan 2 & 3	West	GT – 6	15.8 / 17.2	11.0 / 12.0
Fan 2 & 3	West	GT – 7	16.4 / 15.8	11.4 / 11.0
Fan 1 & 2	West	GT – 8	9.0 / 8.2	6.2 / 5.2

(a) Max deviation must be ≤ 30%.
(b) COV must be ≤ 20%.
(c) The CWI gas analyzer was inoperable during this run.

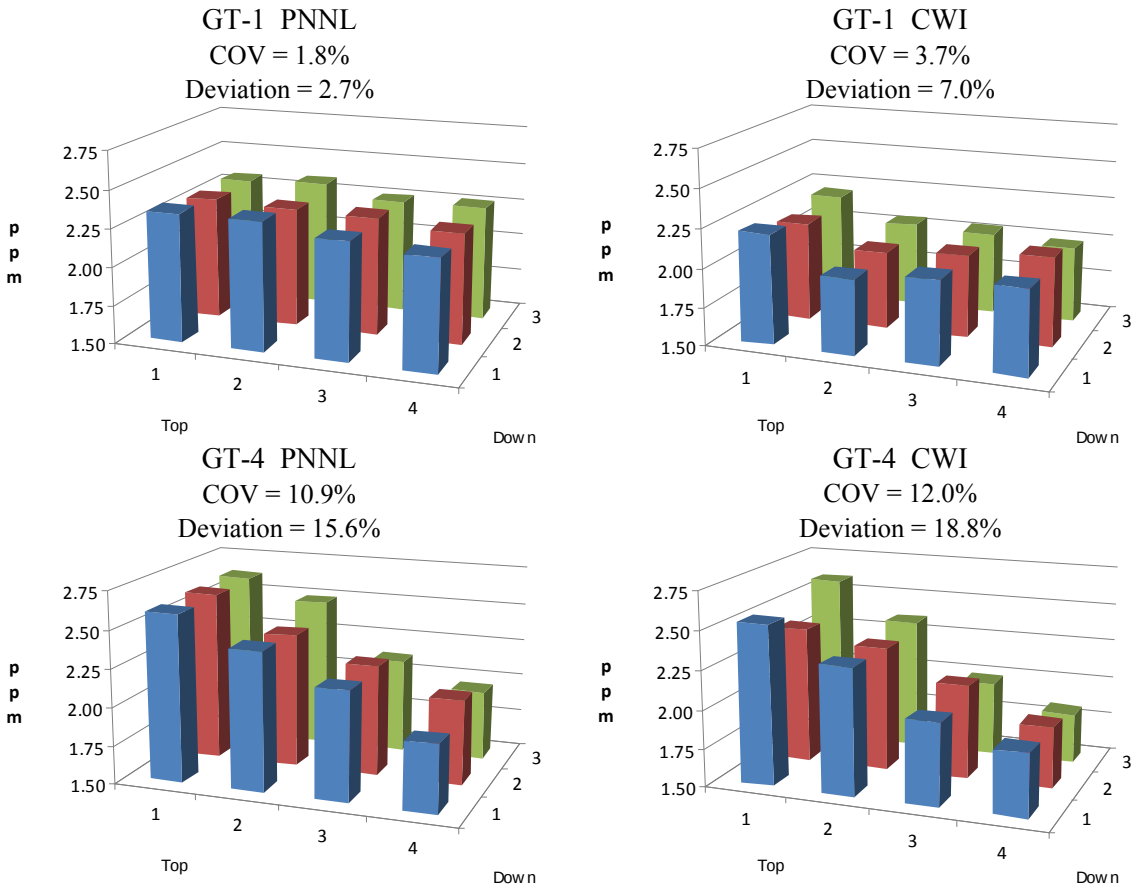


Figure 4.3. SF_6 Concentrations at the 12 Sampling Locations Using PNNL and CWI Instruments

4.4 Particle Tracer Uniformity

Table 4.4 lists the results for the particle tracer uniformity tests performed on the CPP-666 duct. A test with Fans 1 and 2 operating was also conducted in addition to the typical operating condition, which uses Fans 2 and 3.

During the first two runs, the particle concentration varied enough to fail the criterion. Measurements showed that the probe was inappropriately injecting the tracer particles directly into the 90° duct bend. As described in Section 3, the injection probe was therefore shortened to effectively move the injection position 26 inches upstream in the duct. Thereafter, the results were within the criterion of COV values less than 20%. The maximum deviation from the mean is also listed in Table 4.4 for information only. There is no acceptance criterion for this measure. The mean 9- to 11-µm particle concentration at each of the 12 sampling locations for two of the cases is included in Figure 4.4 as an example. The completed data sheets from these five tests are available in Appendix D.

Table 4.4. Summary of Particle Tracer Uniformity Tests

Fan Operating Configuration	Injection Position	Run No	% Max Deviation	% COV[(a)]
Fan 2 & 3	Center	PT – 1	37.8	24.9
Fan 2 & 3	Center	PT – 2	47.9	23.5
Fan 2 & 3	Center (shortened probe)	PT – 3	33.7	13.6
Fan 2 & 3	Center (shortened probe)	PT – 4	31.8	12.3
Fan 1 & 2	Center (shortened probe)	PT – 5	25.2	16.4

(a) COV must be ≤ 20%.

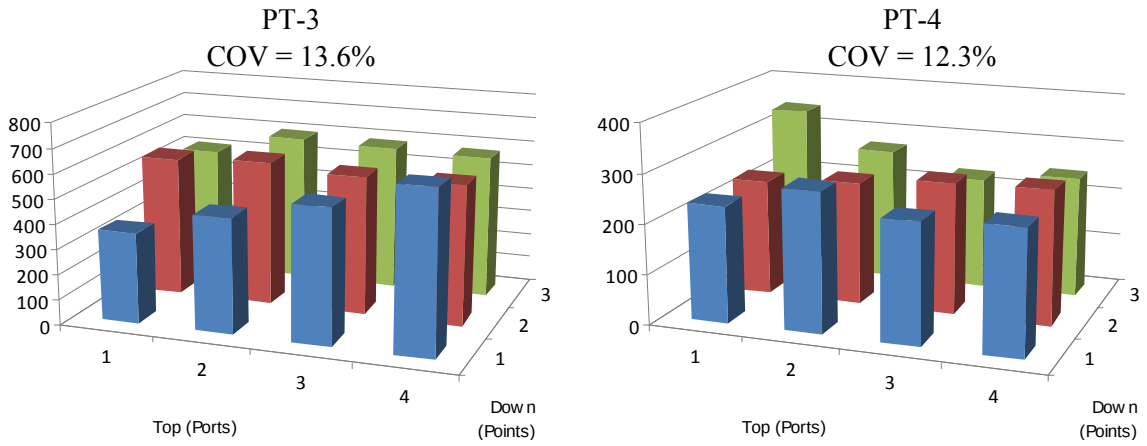


Figure 4.4. Particle Concentrations at the 12 Sampling Locations

5.0 References

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

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

American National Standards Institute (ANSI). 1999. *Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stacks and Ducts of Nuclear Facilities*. ANSI/HPS N13.1—1999, New York.

American Society of Mechanical Engineers (ASME). 2001. *Quality Assurance Requirements for Nuclear Facility Applications.* NQA-1-2000, New York.

Appendix A

Velocity Uniformity Data Sheets

Appendix A: Velocity Uniformity Data Sheets

VELOCITY TRAVERSE DATA FORM

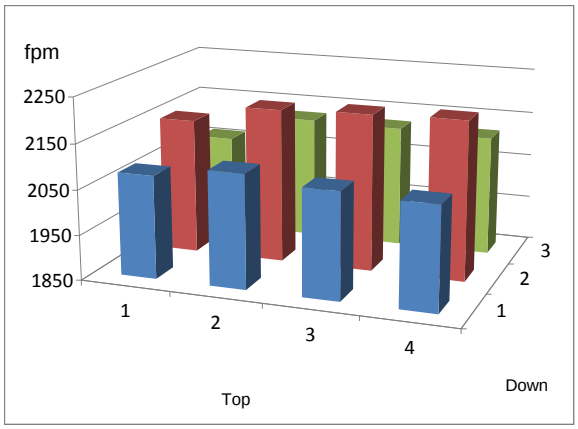
Site	**INTEC CPP-666**	Run No.	**VT-1**
Date	**10/8/09**	Fan Configuration	**Fan 2 & 3**
Duct Ht	48 in.	Testers	JAG, JEF
Duct Width	108 in.	Stack Temp	67.0 deg F
Chamfer H/W	10.0 in.	Start/End Time	1420 / 1545
Duct Area	34.61 sq ft	Pitot Correction:	0.84
Distance to disturbance	122 ft	Data Files:	NA
Velocity units	ft/min		

		Trial ---->	1	2	3	Mean
Port	Point	Depth, in.	Velocity			
1	1	8	2082	2095	2060	2079.0
1	2	24	2108	2172	2176	2152.1
1	3	40	2075	2080	2035	2063.3
2	1	8	2082	2113	2114	2103.1
2	2	24	2201	2186	2192	2192.7
2	3	40	2119	2129	2126	2124.9
3	1	8	2099	2071	2087	2086.0
3	2	24	2197	2202	2197	2198.8
3	3	40	2155	2101	2109	2121.6
4	1	8	2066	2050	2121	2079.0
4	2	24	2209	2197	2202	2202.8
4	3	40	2142	2072	2135	2116.5
		Averages ---------->	2128.0	2122.4	2129.5	2126.6

	fpm	% Dev. from mean		
Mean	2126.6		Flow (cfm)	73605.6
Min Point	2063.3	-3.0%	Std. Dev.	49.5
Max Point	2202.8	3.6%	COV as %	2.3

	Start	Finish	
Stack temp	66	68.5	F
Equipment temp	N/A	N/A	F
Ambient temp	65.3	63.5	F
Stack static	0.15	0.38	mbars
Ambient pressure	25.13	25.10	in Hg
Total Stack pressure	851.15	850.38	mbars
Ambient humidity	30%	32%	RH

Instuments Used:		**Cal Due**
Fisher Scientific	SN 90936818	9/29/2010
Zephyr II+	SN 80355	9/18/2010
TSI Velocicalc	SN 209060	7/14/2010
Dwyer Pitot Tube	PN 1605-72 A304	Cert. of Conf.



Notes: 25.1 in Hg = 341 in H2O

Entries made by:	John Glissmeyer	
Signature/date	*On File w/ Original*	10/8/2009

Technical Data Review performed by:	Rosanne L Aaberg	
Signature/date	11/6/2009	
	On File w/ Original	

VELOCITY TRAVERSE DATA FORM

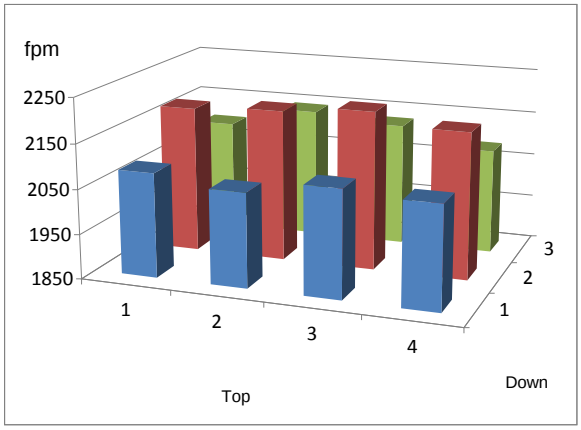
Site	**INTEC CPP-666**	Run No.	**VT-2**
Date	**10/8/09**	Fan Configuration	**Fan 2 & 3**
Duct Ht	48 in.	Testers	JAG, JEF
Duct Width	108 in.	Stack Temp	68.5 deg F
Chamfer H/W	10.0 in.	Start/End Time	1550 / 1655
Duct Area	34.61 sq ft	Pitot Correction:	0.84
Distance to disturbance	122 ft	Data Files:	NA
Velocity units	ft/min		

		Trial ---->	1	2	3	Mean
Port	Point	Depth, in.	Velocity			
1	1	8	2092	2090	2069	2083.8
1	2	24	2172	2181	2187	2179.8
1	3	40	2115	2065	2113	2097.8
2	1	8	2078	2068	2038	2061.4
2	2	24	2180	2198	2192	2190.2
2	3	40	2134	2160	2139	2144.0
3	1	8	2094	2081	2097	2090.8
3	2	24	2207	2201	2208	2205.3
3	3	40	2130	2108	2144	2127.2
4	1	8	2069	2097	2076	2080.4
4	2	24	2183	2184	2166	2177.8
4	3	40	2107	2104	2046	2085.7
		Averages ---------->	2130.1	2127.9	2123.0	2127.0

	fpm	% Dev. from mean		
Mean	2127.0		Flow (cfm)	73617.7
Min Point	2061.4	-3.1%	Std. Dev.	50.5
Max Point	2205.3	3.7%	COV as %	2.4

	Start	Finish	
Stack temp	68.5	68.5	F
Equipment temp	N/A	N/A	F
Ambient temp	63.5	63.5	F
Stack static	0.38	0.26	mbars
Ambient pressure	25.10	25.10	in Hg
Total Stack pressure	850.28	850.16	mbars
Ambient humidity	31%	33%	RH

Instuments Used:		**Cal Due**
Fisher Scientific	SN 90936818	9/29/2010
Zephyr II+	SN 80355	9/18/2010
TSI Velocicalc	SN 209060	7/14/2010
Dwyer Pitot Tube	PN 1605-72 A304	Cert. of Conf.



Notes:

Entries made by:	John Glissmeyer	
Signature/date	*On File w/ Original*	10/8/2009

Technical Data Review performed by:	Rosanne L Aaberg	
Signature/date	11/6/2009	
	On File w/ Original	

VELOCITY TRAVERSE DATA FORM

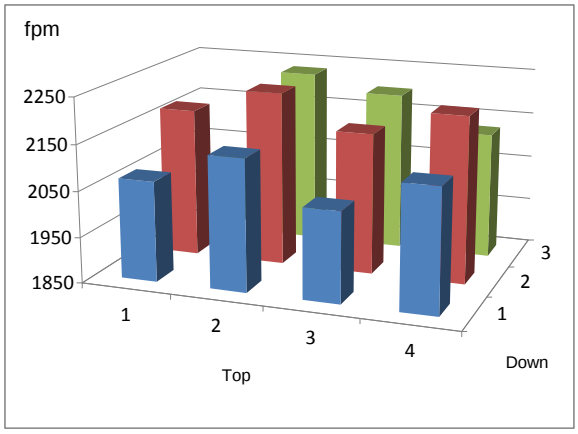
Site	**INTEC CPP-666**	Run No.	**VT-3**
Date	**10/17/09**	Fan Configuration	**Fan 1 & 2**
Duct Ht	48 in.	Testers	JAG, JEF
Duct Width	108 in.	Stack Temp	74.5 deg F
Chamfer H/W	10.0 in.	Start/End Time	1640 / 1740
Duct Area	34.61 sq ft	Pitot correction:	0.84
Distance to disturbance	122 ft	Data Files:	NA
Velocity units	ft/min		

		Trial ---->	1	2	3	Mean
Port	Point	Depth, in.	Velocity			
1	1	8	2066	2061	2077	2068.4
1	2	24	2175	2181	2172	2175.9
1	3	40	1976	2018	2013	2002.3
2	1	8	2097	2134	2180	2137.0
2	2	24	2233	2217	2240	2229.9
2	3	40	2227	2239	2233	2233.0
3	1	8	2012	2062	2066	2046.8
3	2	24	2146	2161	2165	2157.4
3	3	40	2194	2197	2207	2199.1
4	1	8	2108	2123	2123	2117.9
4	2	24	2218	2201	2218	2212.3
4	3	40	2129	2150	2097	2125.8
		Averages ---------->	2131.8	2145.3	2149.4	2142.1

	fpm	% Dev. from mean		
Mean	2142.1		Flow (cfm)	74141.8
Min Point	2002.3	-6.5%	Std. Dev.	74.1
Max Point	2233.0	4.2%	COV as %	3.5

	Start	Finish	
Stack temp	74	75	F
Equipment temp	N/A	N/A	F
Ambient temp	81	76	F
Stack static	0.20	0.20	in H2O
Ambient pressure	854.0	854.0	mbars
Total Stack pressure	854.5	854.5	mbars
Ambient humidity	29%	30%	RH

Instuments Used:		**Cal Due**
Fisher Scientific	SN 90936818	9/29/2010
Zephyr II+	SN 80355	9/18/2010
TSI Velocicalc	SN 209060	7/14/2010
Dwyer Pitot Tube	PN 1605-72 A304	Cert. of Conf.



Notes:

Entries made by:	John Glissmeyer	
Signature/date	*On File w/ Original*	10/17/2009

Technical Data Review performed by:	Rosanne L Aaberg
Signature/date	11/6/2009
	On File w/ Original

Appendix B

Flow Angle Data Sheets

Appendix B: Flow Angle Data Sheets

FLOW ANGLE DATA FORM

Site	**INTEC CPP-666**		Run No.	**FA-1**	
Date	10/9/2009		Fan configuration	**Fan 2 & 3**	
Testers	JAG, JEF		Fan Setting	**N/A**	
Duct Width	108	in	Stack Temp	66.5	deg F
Duct H	48.0	in	Start/End Time	0845 / 0935	
Chamfer H/W	10	in	Approx. air vel.	1860	sfpm point >> 2, 1
Duct Area	34.61	ft2	Units	degrees (clockwise > pos. nos.)	
Distance to disturbance	122	ft			

		Trial ---->	1	2	3	Mean
Port	Point	Depth, in.	degrees clockwise			
1	1	8	3	0	1	1.3
1	2	24	-3	-3	-2	-2.7
1	3	40	-3	-3	-2	-2.7
2	1	8	0	2	2	1.3
2	2	24	-2	-1	-3	-2.0
2	3	40	-1	-1	0	-0.7
3	1	8	-4	-3	-3	-3.3
3	2	24	-4	-4	-4	-4.0
3	3	40	-3	-3	-3	-3.0
4	1	8	0	-1	0	-0.3
4	2	24	-3	-2	-2	-2.3
4	3	40	-2	-1	0	-1.0
				Mean of absolute values:		2.1

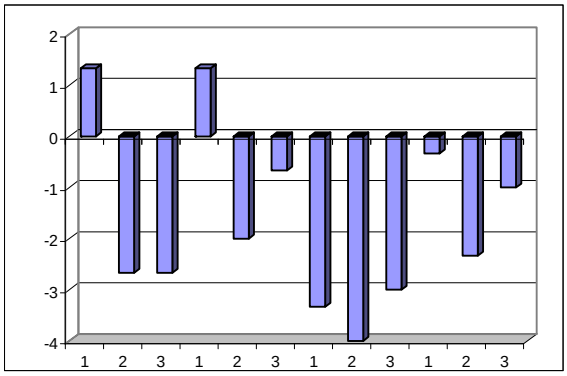
Instuments Used:		**Cal. Due**
S-type pitot	Dwyer 72-inch S-type Pitot #11	Cert. of conformance
TSI Velocicalc	SN 209060	7/14/2010
Angle indicator	Shop built	Cat. 3
Manometer	SN 24906	Cat. 1 8/25/10

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

Notes: Floor to top of acrylic cover plate equals 1.5 inches

Depth to velocity check point is

8 + 9 + 1.5 = 18.5 inches



Entries made by:	John Glissmeyer		Technical Data Review performed by:	Rosanne Aaberg	
Signature/date	*On File w/ Original*	10/9/2009	Signature/date	On file w/ original	*11/6/2009*

FLOW ANGLE DATA FORM

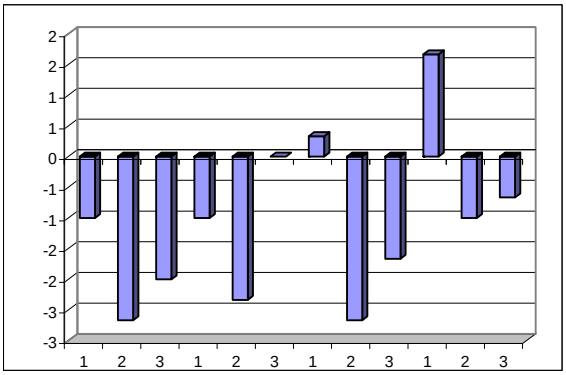
Site	**INTEC CPP-666**		Run No.	**FA-2**	
Date	10/9/2009		Fan configuration	**Fan 2 & 3**	
Testers	JAG, JEF		Fan Setting	**N/A**	
Duct Width	108	in	Stack Temp	66.4	deg F
Duct H	48.0	in	Start/End Time	0945 / 1020	
Chamfer H/W	10	in	Approx. air vel.	1740	sfpm point >> 2,1
Duct Area	34.61	ft2	Units	degrees (clockwise > pos. nos.)	
Distance to disturbance	122	ft			

		Trial ---->	1	2	3	Mean
Port	Point	Depth, in.	degrees clockwise			
1	1	8	-1	0	-2	-1.0
1	2	24	-3	-2	-3	-2.7
1	3	40	-2	-2	-2	-2.0
2	1	8	0	-1	-2	-1.0
2	2	24	-2	-2	-3	-2.3
2	3	40	-1	0	1	0.0
3	1	8	0	0	1	0.3
3	2	24	-2	-2	-4	-2.7
3	3	40	-2	-2	-1	-1.7
4	1	8	2	2	1	1.7
4	2	24	-1	-1	-1	-1.0
4	3	40	-1	-1	0	-0.7
				Mean of absolute values:		1.4

Instuments Used:		**Cal. Due**
S-type pitot	Dwyer 72-inch S-type Pitot #11	Cert. of conformance
TSI Velocicalc	SN 209060	7/14/2010
Angle indicator	Shop built	Cat. 3
Manometer	SN 24906	Cat. 1 8/25/10

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

Notes:



Entries made by:	John Glissmeyer		Technical Data Review performed by:	Rosanne Aaberg	
Signature/date	*On File w/ Original*	10/9/2009	Signature/date	On file w/ original *11/6/2009*	

Appendix C

Tracer Gas Uniformity Data Sheets

Appendix C: Tracer Gas Uniformity Data Sheets

TRACER GAS TRAVERSE DATA FORM

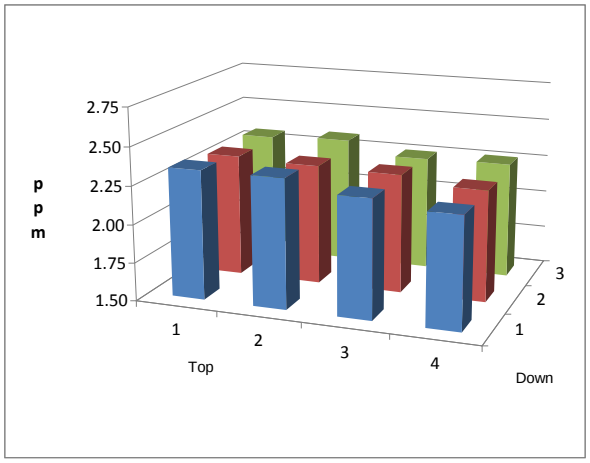
Site	**INTEC CPP-666**	Run No.	**GT-1-PNNL**
Date	10/16/2009	Fan Configuration	**Fans 2 & 3**
Stack Width	108 in.	Testers	**JAG & JEF**
Stack Ht	48 in.	Stack Temp	71.5 deg F
Stack X-Area	36.0 ft ^{2}	Start/End Time	1415 / 1530
Distance to disturbance	122 ft	Gas Analyzer Check:	N.A.
Measurement units	ppm SF6	Injection Point	**Center of duct in Rm 208 downstream of Tee**

			Trial ---->	1	2	3	Mean
	Port	Point	Depth, in.	ppm			
Start	1	1	8	2.31	2.34	2.39	2.347
	1	2	24	2.31	2.30	2.31	2.307
	1	3	40	2.26	2.42	2.27	2.317
	2	1	8	2.33	2.32	2.39	2.347
	2	2	24	2.28	2.30	2.29	2.290
	2	3	40	2.34	2.36	2.31	2.337
	3	1	8	2.28	2.28	2.26	2.273
	3	2	24	2.26	2.28	2.30	2.280
	3	3	40	2.27	2.26	2.23	2.253
	4	1	8	2.24	2.25	2.19	2.227
	4	2	24	2.24	2.20	2.25	2.230
	4	3	40	2.27	2.23	2.29	2.263
			Averages ---------->	2.283	2.295	2.290	2.289

	ppm	Dev. from mean		
Mean	2.29			
Min Point	2.23	-2.7%	Std. Dev.	0.04
Max Point	2.35	2.5%	COV as %	1.8

	Start	Finish	
Tracer tank pressure	200	200	psig
Injection flowmeter	4.0	4.0	lpm
Stack Temp	71	72	ºF
Center Pt. air vel.	1760	1760	fpm
Sampling flowmeter	7	6	lpm HiQ
Ambient pressure	861	861	mbar
Ambient humidity	32	28	RH
Ambient Temp	74	82	ºF
B&K vapor correction	Y	Y	Y/N
Back-Gd gas	7, 8, 11, 5	19, 18, 17, 16	ppb
No. Bk-Gd samples	4	4	n

Instruments Used:	**SN**	**Cal Due**
B&K 1302 Gas Analyzer	1788615	N.A.
Fisher Weather Station	90936818	9/29/2010
TSI VelociCalc	209060	7/14/2010
Omega FMA-2010-A flowmeter	27708	N.A.



Notes: Turned on SF6 at 1420.

Entries made by:	John Glissmeyer	10/16/2009
Signature/date	*Signature on file with original*	

Technical Data Review performed by:	Rosanne Aaberg	
Signature/date	*Signature on file with original*	11/6/2009

TRACER GAS TRAVERSE DATA FORM

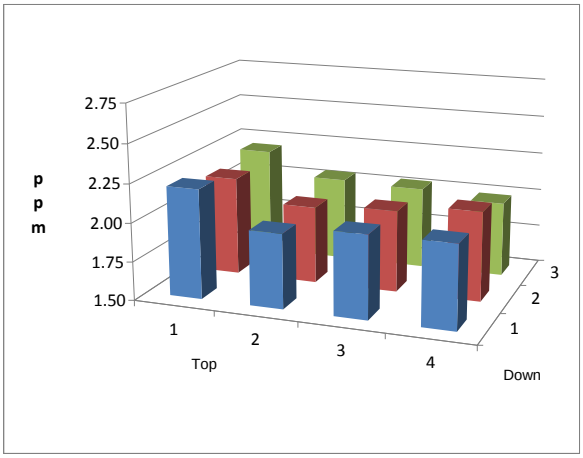
Site	**INTEC CPP-666**	Run No.	**GT-1-CWI**
Date	10/16/2009	Fan Configuration	**Fans 2 & 3**
Stack Width	108 in.	Testers	**JAG & JEF**
Stack Ht	48 in.	Stack Temp	71.5 deg F
Stack X-Area	36.0 ft^2	Start/End Time	1415 / 1530
Distance to disturbance	122 ft	Gas Analyzer Check:	N.A.
Measurement units	ppm SF6	Injection Point	**Center of duct in Rm 208 at Tee**

	Port	Point	Depth, in.	Trial ----> 1	2	3	Mean
				ppm			
	1	1	8	2.14	2.17	2.32	2.210
	1	2	24	2.16	2.19	2.07	2.140
4th	1	3	40	2.23	2.28	2.08	2.197
	2	1	8	2.01	1.96	1.98	1.983
	2	2	24	1.98	2.00	2.02	2.000
3rd	2	3	40	2.01	2.01	2.12	2.047
	3	1	8	2.05	2.03	2.03	2.037
	3	2	24	2.08	2.03	1.98	2.030
Start ^	3	3	40	2.15	1.98	1.97	2.033
	4	1	8	1.92	2.13	2.07	2.040
	4	2	24	1.95	2.08	2.21	2.080
2nd	4	3	40	1.99	1.95	2.02	1.987
		Averages ---------->		2.056	2.068	2.073	2.065

	ppm	Dev. from mean		
Mean	2.07			
Min Point	1.98	-4.0%	Std. Dev.	0.08
Max Point	2.21	7.0%	COV as %	3.7

	Start	Finish	
Tracer tank pressure	200	200	psig
Injection flowmeter	4.0	4.0	lpm
Stack Temp	71	72	ºF
Center Pt. air vel.	1760	1760	fpm
Sampling flowmeter	7	6	lpm HiQ
Ambient pressure	861	861	mbar
Ambient humidity	32	28	RH
Ambient Temp	74	82	ºF
B&K vapor correction	Y	Y	Y/N
Back-Gd gas	-72, -78, -76, -80	-62, -70, -71, -73	ppb
No. Bk-Gd samples	4	4	n

Instruments Used:	**SN**	**Cal Due**
B&K 1302 Gas Analyzer	CWI	N.A.
Fisher Weather Station	90936818	9/29/2010
TSI VelociCalc	209060	7/14/2010
Omega FMA-2010-A flowmeter	27708	N.A.



Notes: Turned on SF6 at 1420.

Entries made by:	John Glissmeyer	10/16/2009	Technical Data Review performed by:	Rosanne Aaberg	
Signature/date	*Signature on file with original*		Signature/date	*Signature on file with original*	11/6/2009

TRACER GAS TRAVERSE DATA FORM

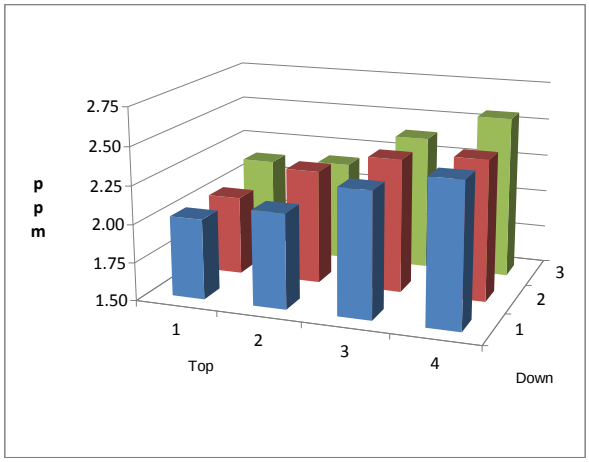
Site	**INTEC CPP-666**	Run No.	**GT-2-PNNL**
Date	10/16/2009	Fan Configuration	**Fans 2 & 3**
Stack Width	108 in.	Testers	**JAG & JEF**
Stack Ht	48 in.	Stack Temp	72.5 deg F
Stack X-Area	36.0 ft^2	Start/End Time	1540 / 1720
Distance to disturbance	122 ft	Gas Analyzer Check:	N.A.
Measurement units	ppm SF6	Injection Point	**Top of duct in Rm 208 at Tee**

	Port	Point	Depth, in.	Trial ----> 1	2	3	Mean
				ppm			
	1	1	8	2.06	1.89	2.13	2.027
	1	2	24	2.04	1.96	2.06	2.020
	1	3	40	2.17	2.23	2.01	2.137
	2	1	8	2.14	2.09	2.14	2.123
	2	2	24	2.21	2.23	2.31	2.250
	2	3	40	2.13	2.16	2.20	2.163
	3	1	8	2.33	2.29	2.34	2.320
	3	2	24	2.41	2.38	2.34	2.377
	3	3	40	2.42	2.42	2.33	2.390
Start	4	1	8	2.36	2.41	2.54	2.437
	4	2	24	2.39	2.46	2.42	2.423
	4	3	40	2.65	2.50	2.55	2.567
	Averages ---------->			2.276	2.252	2.281	2.269

	ppm	Dev. from mean		
Mean	2.27			
Min Point	2.02	-11.0%	Std. Dev.	0.18
Max Point	2.57	13.1%	COV as %	7.8

Instruments Used:	SN	Cal Due
B&K 1302 Gas Analyzer	1788615	N.A.
Fisher Weather Station	90936818	9/29/2010
TSI VelociCalc	209060	7/14/2010
Omega FMA-2010-A flowmeter	27708	N.A.

	Start	Finish	
Tracer tank pressure	200	200	psig
Injection flowmeter	4.0	4.0	lpm
Stack Temp	72	73	ºF
Center Pt. air vel.	1760	1710	fpm
Sampling flowmeter	7	7	lpm HiQ
Ambient pressure	861	860	mbar
Ambient humidity	28	25	RH
Ambient Temp	82	75	ºF
B&K vapor correction	Y	Y	Y/N
Back-Gd gas	19, 18, 17, 16	28, 24, 23, 23	ppb
No. Bk-Gd samples	4	4	n



Notes: CWI B&K 1302 started showing very low readings after backgrounds were completed an gas flow started. It was removed for a calibration check. Continued with the PNNL instrument.

Entries made by:	John Glissmeyer	10/16/2009	Technical Data Review performed by:	Rosanne Aaberg	
Signature/date	*Signature on file with original*		Signature/date	*Signature on file with original*	11/6/2009

TRACER GAS TRAVERSE DATA FORM

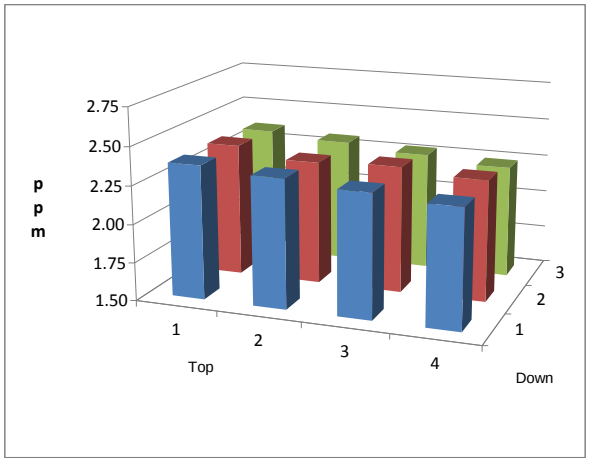
Site	**INTEC CPP-666**	Run No.	**GT-3-PNNL**
Date	10/17/2009	Fan Configuration	**Fans 2 & 3**
Stack Width	108 in.	Testers	**JAG & JEF**
Stack Ht	48 in.	Stack Temp	68 deg F
Stack X-Area	36.0 ft^2	Start/End Time	0840 / 1005
Distance to disturbance	122 ft	Gas Analyzer Check:	N.A.
Measurement units	ppm SF6	Injection Point	**bottom of duct in Rm 208 at Tee**

	Port	Point	Depth, in.	Trial ----> 1	2	3	Mean
				ppm			
Start	1	1	8	2.34	2.39	2.40	2.377
	1	2	24	2.33	2.41	2.39	2.377
	1	3	40	2.39	2.33	2.35	2.357
	2	1	8	2.31	2.31	2.41	2.343
	2	2	24	2.29	2.32	2.32	2.310
	2	3	40	2.39	2.26	2.31	2.320
	3	1	8	2.30	2.32	2.30	2.307
	3	2	24	2.35	2.29	2.35	2.330
	3	3	40	2.27	2.29	2.28	2.280
	4	1	8	2.35	2.28	2.19	2.273
	4	2	24	2.32	2.27	2.29	2.293
	4	3	40	2.28	2.27	2.17	2.240
	Averages ---------->			2.327	2.312	2.313	2.317

	ppm	Dev. from mean		
Mean	2.32			
Min Point	2.24	-3.3%	Std. Dev.	0.04
Max Point	2.38	2.6%	COV as %	1.8

Instruments Used:	SN	Cal Due
B&K 1302 Gas Analyzer	1788615	N.A.
Fisher Weather Station	90936818	9/29/2010
TSI VelociCalc	209060	7/14/2010
Omega FMA-2010-A flowmeter	27708	N.A.

	Start	Finish	
Tracer tank pressure	200	200	psig
Injection flowmeter	4.0	4.0	lpm
Stack Temp	68	68	ºF
Center Pt. air vel.	1790	1820	sfpm
Sampling flowmeter	8	5	lpm HiQ
Ambient pressure	860	860	mbar
Ambient humidity	35	43	RH
Ambient Temp	67	71	ºF
B&K vapor correction	N	N	Y/N
Back-Gd gas	36, 34, 32, 29	39, 37, 35, 34	ppb
No. Bk-Gd samples	4	4	n



Notes: Took initial readings with CWI instrument, and they read very poorly. Screen read: "Operational Error." Re-started instrument. OE = "Operating Error, Pump Error"
* Got real low readings during temperature drop. Loose fitting found in CWI sample line. Re-sampled ports 1 and 2.

Entries made by:	John Glissmeyer	10/17/2009	Technical Data Review performed by:	Rosanne Aaberg	
Signature/date			Signature/date	11/6/2009	
	Signature on file with original			*Signature on file with original*	

TRACER GAS TRAVERSE DATA FORM

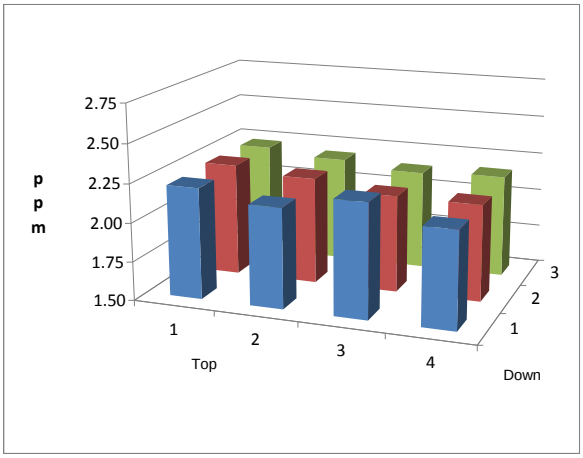
Site	**INTEC CPP-666**	Run No.	**GT-3-CWI**
Date	10/17/2009	Fan Configuration	**Fans 2 & 3**
Stack Width	108 in.	Testers	**JAG & JEF**
Stack Ht	48 in.	Stack Temp	68 deg F
Stack X-Area	36.0 ft^2	Start/End Time	0840 / 1005
Distance to disturbance	122 ft	Gas Analyzer Check:	N.A.
Measurement units	ppm SF6	Injection Point	**bottom of duct in Rm 208 at Tee**

			Trial ---->	1	2	3	Mean
	Port	Point	Depth, in.	ppm			
Start	1	1	8	2.30	2.17	2.18	2.217
	1	2	24	2.26	2.24	2.19	2.230
	1	3	40	2.20	2.20	2.28	2.227
	2	1	8	2.25	2.02	2.17	2.147
	2	2	24	2.17	2.18	2.22	2.190
	2	3	40	2.20	2.19	2.17	2.187
	3	1	8	2.26	2.31	2.13	2.233
	3	2	24	2.17	2.12	2.09	2.127
	3	3	40	2.25	2.12	2.06	2.143
	4	1	8	2.16	2.12	2.09	2.123
	4	2	24	2.11	2.05	2.21	2.123
	4	3	40	2.27	2.13	2.09	2.163
		Averages ---------->		2.217	2.154	2.157	2.176

	ppm	Dev. from mean		
Mean	2.18			
Min Point	2.12	-2.4%	Std. Dev.	0.04
Max Point	2.23	2.6%	COV as %	2.0

	Start	Finish	
Tracer tank pressure	200	200	psig
Injection flowmeter	4.0	4.0	lpm
Stack Temp	68	68	ºF
Center Pt. air vel.	1790	1820	fpm
Sampling flowmeter	8	5	lpm HiQ
Ambient pressure	860	860	mbar
Ambient humidity	35	43	RH
Ambient Temp	67	71	ºF
B&K vapor correction	N	N	Y/N
Back-Gd gas	-18, -18, -15, -8	-14, -14, -17, -17	ppb
No. Bk-Gd samples	4	4	n

Instruments Used:	**SN**	**Cal Due**
B&K 1302 Gas Analyzer	CWI	N.A.
Fisher Weather Station	90936818	9/29/2010
TSI VelociCalc	209060	7/14/2010
Omega FMA-2010-A flowmeter	27708	N.A.



Notes: Took initial readings with CWI instrument, and they read very poorly. Screen read: "Operational Error." Re-started instrument. OE = "Operating Error, Pump Error"

* Got real low readings during temperature drop. Loose fitting found in CWI sample line. Re-sampled ports 1 and 2.

Entries made by:	John Glissmeyer	10/17/2009	Technical Data Review performed by:	Rosanne Aaberg	
Signature/date	*Signature on file with original*		Signature/date	11/6/2009 *Signature on file with original*	

TRACER GAS TRAVERSE DATA FORM

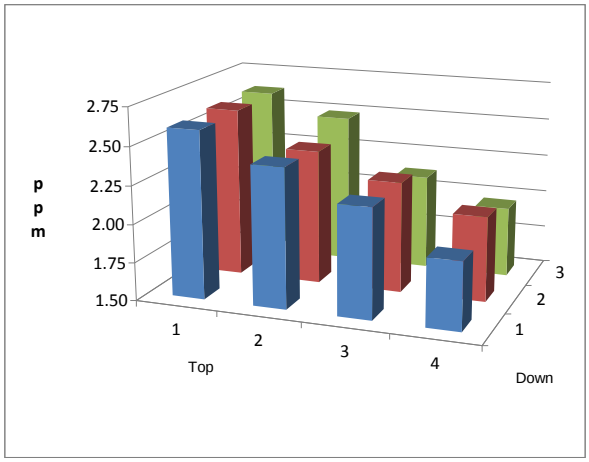
Site	**INTEC CPP-666**	Run No.	**GT-4-PNNL**
Date	10/17/2009	Fan Configuration	**Fans 2 & 3**
Stack Width	108 in.	Testers	**JAG & JEF**
Stack Ht	48 in.	Stack Temp	68 deg F
Stack X-Area	36.0 ft^2	Start/End Time	1010 / 1055
Distance to disturbance	122 ft	Gas Analyzer Check:	N.A.
Measurement units	ppm SF6	Injection Point	**west side of duct in Rm 208 at Tee**

	Port	Point	Depth, in.	Trial ----> 1	2	3	Mean
				ppm			
Start	1	1	8	2.61	2.61	2.58	2.600
	1	2	24	2.60	2.57	2.67	2.613
	1	3	40	2.58	2.60	2.69	2.623
	2	1	8	2.45	2.38	2.41	2.413
	2	2	24	2.37	2.41	2.37	2.383
	2	3	40	2.49	2.48	2.49	2.487
	3	1	8	2.18	2.18	2.29	2.217
	3	2	24	2.22	2.25	2.21	2.227
	3	3	40	2.13	2.04	2.20	2.123
	4	1	8	1.96	1.90	1.97	1.943
	4	2	24	2.05	1.95	2.17	2.057
	4	3	40	1.96	2.00	1.92	1.960
		Averages ---------->		2.300	2.281	2.331	2.304

	ppm	Dev. from mean		
Mean	2.30			
Min Point	1.94	-15.6%	Std. Dev.	0.25
Max Point	2.62	13.9%	COV as %	10.9

	Start	Finish	
Tracer tank pressure	200	200	psig
Injection flowmeter	4.0	4.0	lpm
Stack Temp	68	68	ºF
Center Pt. air vel.	1820	1810	sfpm
Sampling flowmeter	5	5	lpm HiQ
Ambient pressure	860	860	mbar
Ambient humidity	42	43	RH
Ambient Temp	71	72	ºF
B&K vapor correction	N	N	Y/N
Back-Gd gas	39, 37, 35, 34	49, 40, 34, 38	ppb
No. Bk-Gd samples	4	4	n

Instruments Used:	**SN**	**Cal Due**
B&K 1302 Gas Analyzer	1788615	N.A.
Fisher Weather Station	90936818	9/29/2010
TSI VelociCalc	209060	7/14/2010
Omega FMA-2010-A flowmeter	27708	N.A.



Notes:

Entries made by:	John Glissmeyer	10/17/2009
Signature/date	*Signature on file with original*	

Technical Data Review performed by:	Rosanne Aaberg	
Signature/date	*Signature on file with original*	11/6/2009

TRACER GAS TRAVERSE DATA FORM

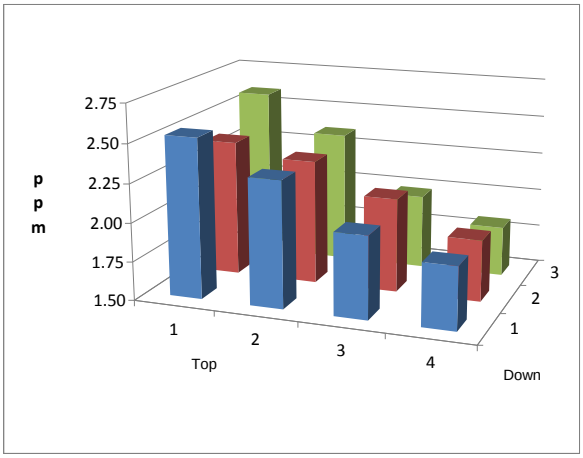
Site	**INTEC CPP-666**	Run No.	**GT-4-CWI**
Date	10/17/2009	Fan Configuration	**Fans 2 & 3**
Stack Width	108 in.	Testers	**JAG & JEF**
Stack Ht	48 in.	Stack Temp	68 deg F
Stack X-Area	36.0 ft^2	Start/End Time	1010 / 1055
Distance to disturbance	122 ft	Gas Analyzer Check:	N.A.
Measurement units	ppm SF6	Injection Point	**west side of duct in Rm 208 at Tee**

			Trial ---->	1	2	3	Mean
	Port	Point	Depth, in.	ppm			
Start	1	1	8	2.60	2.57	2.43	2.533
	1	2	24	2.46	2.21	2.47	2.380
	1	3	40	2.54	2.55	2.70	2.597
	2	1	8	2.41	2.22	2.32	2.317
	2	2	24	2.48	2.22	2.20	2.300
	2	3	40	2.35	2.38	2.33	2.353
	3	1	8	1.96	2.05	2.08	2.030
	3	2	24	2.12	2.04	2.16	2.107
	3	3	40	2.18	2.04	1.72	1.980
	4	1	8	1.90	1.88	1.93	1.903
	4	2	24	1.89	1.94	1.86	1.897
	4	3	40	1.88	1.70	1.89	1.823
		Averages ---------->		2.231	2.150	2.174	2.185

	ppm	Dev. from mean		
Mean	2.19			
Min Point	1.82	-16.6%	Std. Dev.	0.26
Max Point	2.60	18.8%	COV as %	12.0

Instruments Used:	SN	Cal Due
B&K 1302 Gas Analyzer	CWI	N.A.
Fisher Weather Station	90936818	9/29/2010
TSI VelociCalc	209060	7/14/2010
Omega FMA-2010-A flowmeter	27708	N.A.

	Start	Finish	
Tracer tank pressure	200	200	psig
Injection flowmeter	4.0	4.0	lpm
Stack Temp	68	68	ºF
Center Pt. air vel.	1820	1810	fpm
Sampling flowmeter	5	5	lpm HiQ
Ambient pressure	860	860	mbar
Ambient humidity	42	43	RH
Ambient Temp	71	72	ºF
B&K vapor correction	N	N	Y/N
Back-Gd gas	-14, -14, -17, -17	-15, 16, -23, -20	ppb
No. Bk-Gd samples	4	4	n



Notes:

Entries made by:	John Glissmeyer	10/17/2009	Technical Data Review performed by:	Rosanne Aaberg
Signature/date	*Signature on file with original*		Signature/date	11/6/2009 *Signature on file with original*

TRACER GAS TRAVERSE DATA FORM

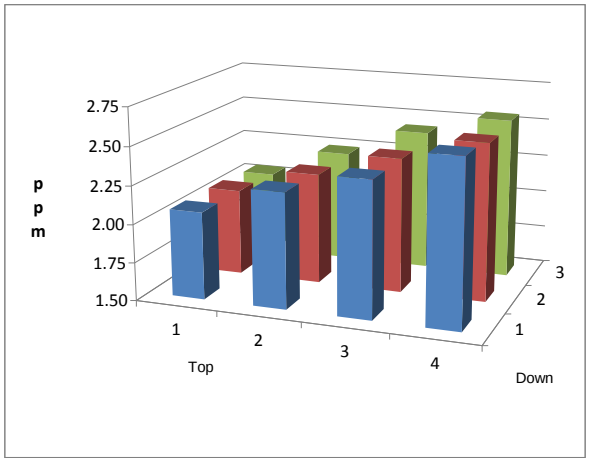
Site	**INTEC CPP-666**	Run No.	**GT-5-PNNL**
Date	10/17/2009	Fan Configuration	**Fans 2 & 3**
Stack Width	108 in.	Testers	**JAG & JEF**
Stack Ht	48 in.	Stack Temp	68.5 deg F
Stack X-Area	36.0 ft^2	Start/End Time	1055 / 1145
Distance to disturbance	122 ft	Gas Analyzer Check:	N.A.
Measurement units	ppm SF6	Injection Point	**east side of duct in Rm 208 at Tee**

	Port	Point	Depth, in.	Trial ----> 1	2	3	Mean
				ppm			
	1	1	8	2.11	2.00	2.11	2.073
	1	2	24	2.08	2.04	2.09	2.070
	1	3	40	1.91	2.05	2.18	2.047
	2	1	8	2.26	2.27	2.24	2.257
	2	2	24	2.24	2.22	2.23	2.230
	2	3	40	2.32	2.16	2.24	2.240
	3	1	8	2.42	2.35	2.39	2.387
	3	2	24	2.42	2.41	2.32	2.383
	3	3	40	2.42	2.37	2.50	2.430
Start	4	1	8	2.58	2.55	2.60	2.577
	4	2	24	2.53	2.51	2.55	2.530
	4	3	40	2.50	2.49	2.68	2.557
	Averages ---------->			2.316	2.285	2.344	2.315

	ppm	Dev. from mean		
Mean	2.32			
Min Point	2.05	-11.6%	Std. Dev.	0.19
Max Point	2.58	11.3%	COV as %	8.3

	Start	Finish	
Tracer tank pressure	200	200	psig
Injection flowmeter	4.0	4.0	lpm
Stack Temp	68	69	ºF
Center Pt. air vel.	1870	1790	sfpm
Sampling flowmeter	5	5	lpm HiQ
Ambient pressure	860	859	mbar
Ambient humidity	40	36	RH
Ambient Temp	72	72	ºF
B&K vapor correction	N	N	Y/N
Back-Gd gas	49, 40, 34, 38	38, 36, 35, 35	ppb
No. Bk-Gd samples	4	4	n

Instruments Used:	**SN**	**Cal Due**
B&K 1302 Gas Analyzer	1788615	N.A.
Fisher Weather Station	90936818	9/29/2010
TSI VelociCalc	209060	7/14/2010
Omega FMA-2010-A flowmeter	27708	N.A.



Notes:

Entries made by:	John Glissmeyer	10/17/2009
Signature/date	*Signature on file with original*	

Technical Data Review performed by:	Rosanne Aaberg	
Signature/date	*Signature on file with original*	11/6/2009

TRACER GAS TRAVERSE DATA FORM

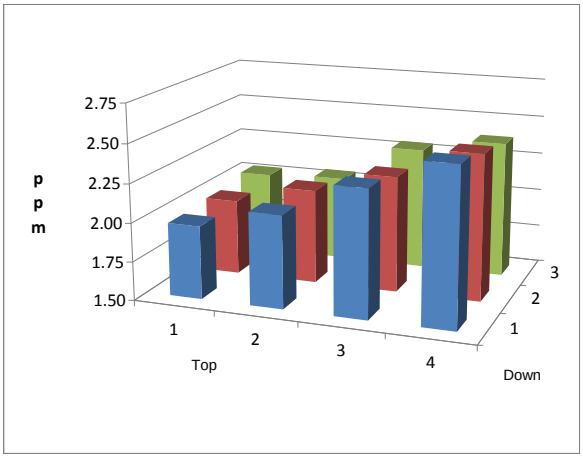
Site	**INTEC CPP-666**	Run No.	**GT-5-CWI**
Date	10/17/2009	Fan Configuration	**Fans 2 & 3**
Stack Width	108 in.	Testers	**JAG & JEF**
Stack Ht	48 in.	Stack Temp	68.5 deg F
Stack X-Area	36.0 ft^2	Start/End Time	1055 / 1145
Distance to disturbance	122 ft	Gas Analyzer Check:	N.A.
Measurement units	ppm SF6	Injection Point	**east side of duct in Rm 208 at Tee**

			Trial ---->	1	2	3	Mean
	Port	Point	Depth, in.	ppm			
	1	1	8	2.07	1.92	1.93	1.973
	1	2	24	2.05	2.10	1.82	1.990
	1	3	40	2.08	2.04	1.98	2.033
	2	1	8	2.12	2.14	2.04	2.100
	2	2	24	2.04	2.13	2.16	2.110
	2	3	40	2.15	2.05	1.96	2.053
	3	1	8	2.26	2.34	2.35	2.317
	3	2	24	2.29	2.26	2.20	2.250
	3	3	40	2.35	2.26	2.28	2.297
Start	4	1	8	2.48	2.44	2.61	2.510
	4	2	24	2.42	2.47	2.44	2.443
	4	3	40	2.38	2.56	2.21	2.383
		Averages ---------->		2.224	2.226	2.165	2.205

	ppm	Dev. from mean		
Mean	2.21			
Min Point	1.97	-10.5%	Std. Dev.	0.19
Max Point	2.51	13.8%	COV as %	8.4

	Start	Finish	
Tracer tank pressure	200	200	psig
Injection flowmeter	4.0	4.0	lpm
Stack Temp	68	69	ºF
Center Pt. air vel.	1870	1790	fpm
Sampling flowmeter	5	5	lpm HiQ
Ambient pressure	860	859	mbar
Ambient humidity	40	36	RH
Ambient Temp	72	72	ºF
B&K vapor correction	N	N	Y/N
Back-Gd gas	-15, 16, -23, -20	32, -17, -20, -16	ppb
No. Bk-Gd samples	4	4	n

Instruments Used:	**SN**	**Cal Due**
B&K 1302 Gas Analyzer	CWI	N.A.
Fisher Weather Station	90936818	9/29/2010
TSI VelociCalc	209060	7/14/2010
Omega FMA-2010-A flowmeter	27708	N.A.



Notes:

Entries made by:	John Glissmeyer	10/17/2009	Technical Data Review performed by:	Rosanne Aaberg
Signature/date	*Signature on file with original*		Signature/date	11/6/2009 *Signature on file with original*

TRACER GAS TRAVERSE DATA FORM

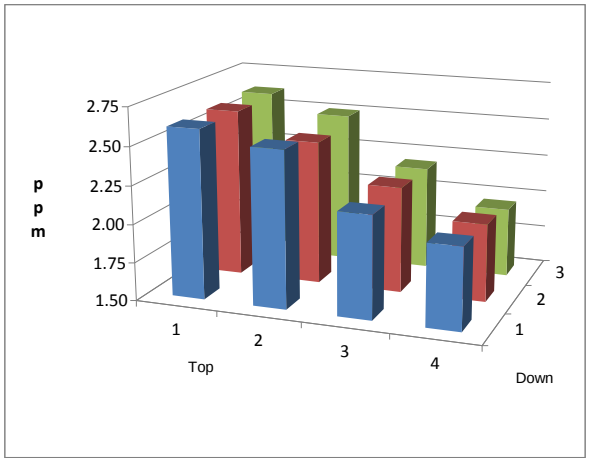
Site	**INTEC CPP-666**	Run No.	**GT-6-PNNL**
Date	10/17/2009	Fan Configuration	**Fans 2 & 3**
Stack Width	108 in.	Testers	**JAG & JEF**
Stack Ht	48 in.	Stack Temp	71 deg F
Stack X-Area	36.0 ft^2	Start/End Time	1315 / 1403
Distance to disturbance	122 ft	Gas Analyzer Check:	N.A.
Measurement units	ppm SF6	Injection Point	**west side of duct in Rm 208 at Tee**

	Port	Point	Trial ----> Depth, in.	1	2	3	Mean
				ppm			
Start	1	1	8	2.48	2.67	2.67	2.607
	1	2	24	2.71	2.60	2.51	2.607
	1	3	40	2.54	2.66	2.66	2.620
	2	1	8	2.61	2.53	2.43	2.523
	2	2	24	2.45	2.48	2.40	2.443
	2	3	40	2.66	2.55	2.30	2.503
	3	1	8	2.17	2.24	2.10	2.170
	3	2	24	2.27	2.26	2.05	2.193
	3	3	40	2.14	2.26	2.15	2.183
	4	1	8	2.07	2.02	2.01	2.033
	4	2	24	2.12	1.96	1.95	2.010
	4	3	40	1.84	2.03	1.99	1.953
		Averages ---------->		2.338	2.355	2.268	2.321

	ppm	Dev. from mean		
Mean	2.32			
Min Point	1.95	-15.8%	Std. Dev.	0.25
Max Point	2.62	12.9%	COV as %	11.0

Instruments Used:	SN	Cal Due
B&K 1302 Gas Analyzer	1788615	N.A.
Fisher Weather Station	90936818	9/29/2010
TSI VelociCalc	209060	7/14/2010
Omega FMA-2010-A flowmeter	27708	N.A.

	Start	Finish	
Tracer tank pressure	200	175	psig
Injection flowmeter	4.0	4.0	lpm
Stack Temp	71	71	ºF
Center Pt. air vel.	1740	1750	sfpm
Sampling flowmeter	6	5	lpm HiQ
Ambient pressure	858	857	mbar
Ambient humidity	33	32	RH
Ambient Temp	71	72	ºF
B&K vapor correction	N	N	Y/N
Back-Gd gas	32, 37, 32, 30	39, 39, 39, 35	ppb
No. Bk-Gd samples	4	4	n



Notes:

Entries made by:	John Glissmeyer	10/17/2009
Signature/date	*Signature on file with original*	

Technical Data Review performed by:	Rosanne Aaberg	
Signature/date	11/6/2009	
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TRACER GAS TRAVERSE DATA FORM

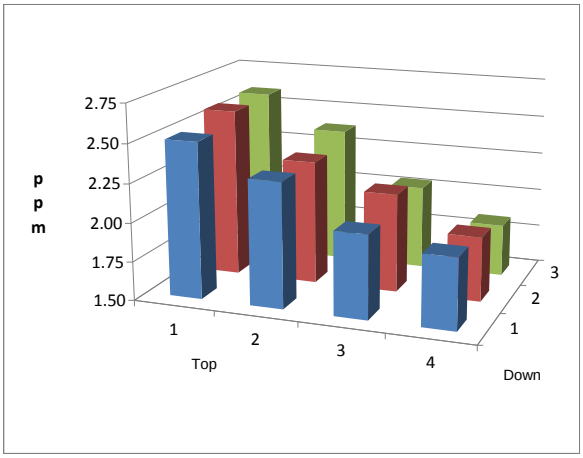
Site	**INTEC CPP-666**	Run No.	**GT-6-CWI**
Date	10/17/2009	Fan Configuration	**Fans 2 & 3**
Stack Width	108 in.	Testers	**JAG & JEF**
Stack Ht	48 in.	Stack Temp	71 deg F
Stack X-Area	36.0 ft^2	Start/End Time	1055 / 1145
Distance to disturbance	122 ft	Gas Analyzer Check:	N.A.
Measurement units	ppm SF6	Injection Point	**west side of duct in Rm 208 at Tee**

			Trial ---->	1	2	3	Mean
	Port	Point	Depth, in.	ppm			
Start	1	1	8	2.45	2.48	2.59	2.507
	1	2	24	2.56	2.63	2.57	2.587
	1	3	40	2.52	2.56	2.71	2.597
	2	1	8	2.35	2.25	2.32	2.307
	2	2	24	2.32	2.28	2.29	2.297
	2	3	40	2.56	2.28	2.30	2.380
	3	1	8	2.04	2.15	1.92	2.037
	3	2	24	2.28	2.10	2.03	2.137
	3	3	40	2.11	2.01	2.00	2.040
	4	1	8	1.96	1.72	2.19	1.957
	4	2	24	2.00	1.79	1.96	1.917
	4	3	40	1.96	1.70	1.85	1.837
		Averages ---------->		2.259	2.163	2.228	2.216

	ppm	Dev. from mean		
Mean	2.22			
Min Point	1.84	-17.1%	Std. Dev.	0.27
Max Point	2.60	17.2%	COV as %	12.0

Instruments Used:	SN	Cal Due
B&K 1302 Gas Analyzer	CWI	N.A.
Fisher Weather Station	90936818	9/29/2010
TSI VelociCalc	209060	7/14/2010
Omega FMA-2010-A flowmeter	27708	N.A.

	Start	Finish	
Tracer tank pressure	200	175	psig
Injection flowmeter	4.0	4.0	lpm
Stack Temp	71	71	ºF
Center Pt. air vel.	1740	1750	fpm
Sampling flowmeter	6	5	lpm HiQ
Ambient pressure	858	857	mbar
Ambient humidity	33	32	RH
Ambient Temp	71	72	ºF
B&K vapor correction	N	N	Y/N
Back-Gd gas	-27, -24, -20 -21	-14, -20, -21, -21	ppb
No. Bk-Gd samples	4	4	n



Notes:

Entries made by:	John Glissmeyer	10/17/2009	Technical Data Review performed by:	Rosanne Aaberg
Signature/date	*Signature on file with original*		Signature/date	11/6/2009 *Signature on file with original*

TRACER GAS TRAVERSE DATA FORM

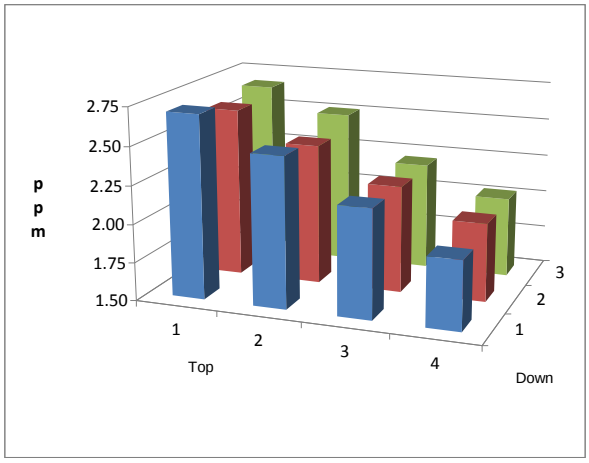
Site	**INTEC CPP-666**	Run No.	**GT-7-PNNL**
Date	10/17/2009	Fan Configuration	**Fans 2 & 3**
Stack Width	108 in.	Testers	**JAG & JEF**
Stack Ht	48 in.	Stack Temp	71.5 deg F
Stack X-Area	36.0 ft^2	Start/End Time	1403 / 1440
Distance to disturbance	122 ft	Gas Analyzer Check:	N.A.
Measurement units	ppm SF6	Injection Point	**west side of duct in Rm 208 at Tee**

	Port	Point	Depth, in.	Trial ----> 1	2	3	Mean
				ppm			
	1	1	8	2.70	2.73	2.67	2.700
	1	2	24	2.60	2.58	2.66	2.613
	1	3	40	2.64	2.62	2.74	2.667
	2	1	8	2.41	2.49	2.55	2.483
	2	2	24	2.40	2.46	2.40	2.420
	2	3	40	2.52	2.58	2.43	2.510
	3	1	8	2.23	2.20	2.20	2.210
	3	2	24	2.21	2.18	2.21	2.200
	3	3	40	2.22	2.22	2.18	2.207
Start	4	1	8	1.95	1.95	1.95	1.950
	4	2	24	2.08	1.98	1.98	2.013
	4	3	40	1.94	2.04	2.10	2.027
		Averages ---------->		2.325	2.336	2.339	2.333

	ppm	Dev. from mean		
Mean	2.33			
Min Point	1.95	-16.4%	Std. Dev.	0.27
Max Point	2.70	15.7%	COV as %	11.4

Instruments Used:	SN	Cal Due
B&K 1302 Gas Analyzer	1788615	N.A.
Fisher Weather Station	90936818	9/29/2010
TSI VelociCalc	209060	7/14/2010
Omega FMA-2010-A flowmeter	27708	N.A.

	Start	Finish	
Tracer tank pressure	175	175	psig
Injection flowmeter	4.0	4.0	lpm
Stack Temp	71	72	ºF
Center Pt. air vel.	1750	1720	sfpm
Sampling flowmeter	5	5	lpm HiQ
Ambient pressure	857	856	mbar
Ambient humidity	32	32	RH
Ambient Temp	72	74	ºF
B&K vapor correction	N	N	Y/N
Back-Gd gas	39, 39, 39, 35	36, 36, 36, 31	ppb
No. Bk-Gd samples	4	4	n



Notes:

Entries made by:	John Glissmeyer	10/17/2009
Signature/date	*Signature on file with original*	

Technical Data Review performed by:	Rosanne Aaberg	
Signature/date	11/6/2009	
	Signature on file with original	

TRACER GAS TRAVERSE DATA FORM

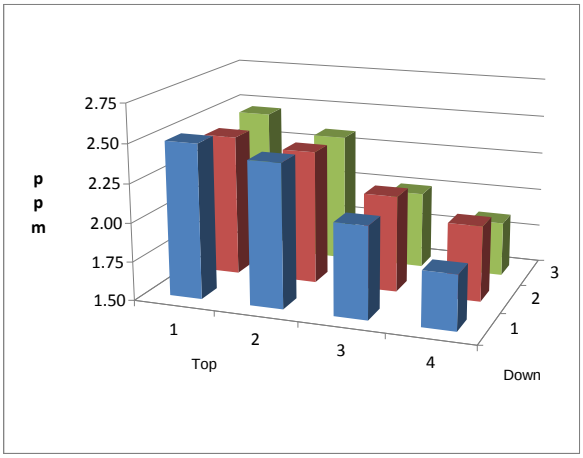
Site	**INTEC CPP-666**	Run No.	**GT-7-CWI**
Date	10/17/2009	Fan Configuration	**Fans 2 & 3**
Stack Width	108 in.	Testers	**JAG & JEF**
Stack Ht	48 in.	Stack Temp	71.5 deg F
Stack X-Area	36.0 ft^2	Start/End Time	1403 / 1440
Distance to disturbance	122 ft	Gas Analyzer Check:	N.A.
Measurement units	ppm SF6	Injection Point	**west side of duct in Rm 208 at Tee**

			Trial ---->	1	2	3	Mean
	Port	Point	Depth, in.	ppm			
	1	1	8	2.48	2.48	2.53	2.497
	1	2	24	2.34	2.38	2.53	2.417
	1	3	40	2.36	2.41	2.61	2.460
	2	1	8	2.41	2.45	2.41	2.423
	2	2	24	2.34	2.42	2.33	2.363
	2	3	40	2.30	2.23	2.49	2.340
	3	1	8	2.06	2.05	2.16	2.090
	3	2	24	2.16	2.08	2.13	2.123
	3	3	40	2.01	2.04	1.95	2.000
Start	4	1	8	1.80	1.89	1.87	1.853
	4	2	24	2.04	1.98	1.94	1.987
	4	3	40	1.81	1.95	1.80	1.853
		Averages ---------->		2.176	2.197	2.229	2.201

	ppm	Dev. from mean		
Mean	2.20			
Min Point	1.85	-15.8%	Std. Dev.	0.24
Max Point	2.50	13.5%	COV as %	11.0

	Start	Finish	
Tracer tank pressure	175	175	psig
Injection flowmeter	4.0	4.0	lpm
Stack Temp	71	72	ºF
Center Pt. air vel.	1750	1720	fpm
Sampling flowmeter	5	5	lpm HiQ
Ambient pressure	857	856	mbar
Ambient humidity	32	32	RH
Ambient Temp	72	74	ºF
B&K vapor correction	N	N	Y/N
Back-Gd gas	-14, -20, -21, -21	-19, -25, -25, -25	ppb
No. Bk-Gd samples	4	4	n

Instruments Used:	**SN**	**Cal Due**
B&K 1302 Gas Analyzer	CWI	N.A.
Fisher Weather Station	90936818	9/29/2010
TSI VelociCalc	209060	7/14/2010
Omega FMA-2010-A flowmeter	27708	N.A.



Notes:

Entries made by:	John Glissmeyer	10/17/2009	Technical Data Review performed by:	Rosanne Aaberg
Signature/date	*Signature on file with original*		Signature/date	11/6/2009 *Signature on file with original*

TRACER GAS TRAVERSE DATA FORM

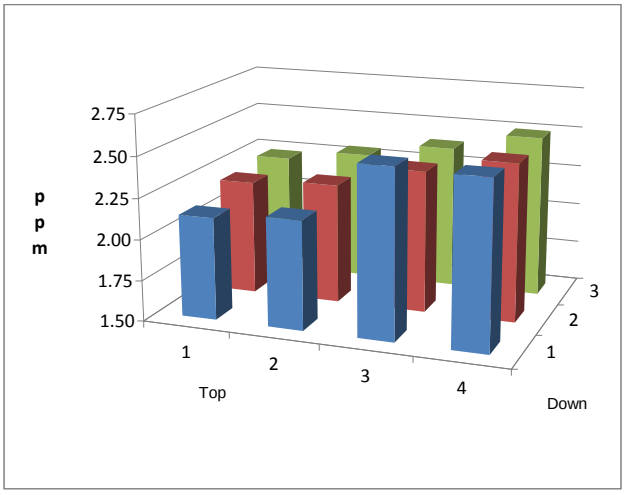
Site	**INTEC CPP-666**	Run No.	**GT-8-PNNL**
Date	10/17/2009	Fan Configuration	**Fans 1 & 2**
Stack Width	108 in.	Testers	**JAG & JEF**
Stack Ht	48 in.	Stack Temp	73 deg F
Stack X-Area	36.0 ft ^{2}	Start/End Time	1530 / 1630
Distance to disturbance	122 ft	Gas Analyzer Check:	N.A.
Measurement units	ppm SF6	Injection Point	**west side of duct in Rm 208 at Tee**

	Port	Point	Trial ----> Depth, in.	1	2	3	Mean
				ppm			
Start	1	1	8	2.04	2.18	2.16	2.127
	1	2	24	2.20	2.25	2.16	2.203
	1	3	40	2.29	2.20	2.21	2.233
	2	1	8	2.20	2.13	2.17	2.167
	2	2	24	2.23	2.24	2.24	2.237
	2	3	40	2.31	2.32	2.27	2.300
	3	1	8	2.65	2.48	2.46	2.530
	3	2	24	2.39	2.35	2.37	2.370
	3	3	40	2.40	2.37	2.39	2.387
	4	1	8	2.53	2.49	2.53	2.517
	4	2	24	2.53	2.40	2.47	2.467
	4	3	40	2.44	2.52	2.53	2.497
		Averages ---------->		2.351	2.328	2.330	2.336

	ppm	Dev. from mean		
Mean	2.34			
Min Point	2.13	-9.0%	Std. Dev.	0.14
Max Point	2.53	8.3%	COV as %	6.2

	Start	Finish	
Tracer tank pressure	175	175	psig
Injection flowmeter	4.0	4.0	lpm
Stack Temp	73	73	ºF
Center Pt. air vel.	1710	1780	sfpm
Sampling flowmeter	5	5	lpm HiQ
Ambient pressure	855	855	mbar
Ambient humidity	30	29	RH
Ambient Temp	78	80	ºF
B&K vapor correction	N	N	Y/N
Back-Gd gas	33, 29, 33, 31	37, 35, 33, 37	ppb
No. Bk-Gd samples	4	4	n

Instruments Used:	**SN**	**Cal Due**
B&K 1302 Gas Analyzer	1788615	N.A.
Fisher Weather Station	90936818	9/29/2010
TSI VelociCalc	209060	7/14/2010
Omega FMA-2010-A flowmeter	27708	N.A.



Notes:

Entries made by: John Glissmeyer 10/17/2009
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Signature on file with original

Technical Data Review performed by: Rosanne Aaberg
Signature/date 11/6/2009
Signature on file with original

TRACER GAS TRAVERSE DATA FORM

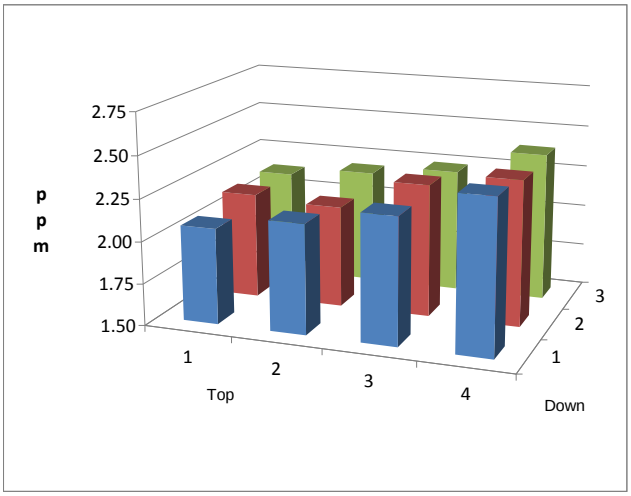
Site	**INTEC CPP-666**	Run No.	**GT-8-CWI**
Date	10/17/2009	Fan Configuration	**Fans 1 & 2**
Stack Width	108 in.	Testers	**JAG & JEF**
Stack Ht	48 in.	Stack Temp	73 deg F
Stack X-Area	36.0 ft ^{2}	Start/End Time	1530 / 1630
Distance to disturbance	122 ft	Gas Analyzer Check:	N.A.
Measurement units	ppm SF6	Injection Point	**west side of duct in Rm 208 at Tee**

	Port	Point	Depth, in.	Trial ----> 1	2	3	Mean
				ppm			
Start	1	1	8	2.05	2.08	2.08	2.070
	1	2	24	2.08	2.17	2.15	2.133
	1	3	40	2.17	2.07	2.16	2.133
	2	1	8	1.98	2.40	2.08	2.153
	2	2	24	2.18	2.02	2.12	2.107
	2	3	40	2.19	2.21	2.16	2.187
	3	1	8	2.19	2.12	2.44	2.250
	3	2	24	2.38	2.26	2.23	2.290
	3	3	40	2.20	2.27	2.25	2.240
	4	1	8	2.39	2.35	2.49	2.410
	4	2	24	2.48	2.27	2.35	2.367
	4	3	40	2.33	2.46	2.38	2.390
		Averages ---------->		2.218	2.223	2.241	2.228

	ppm	Dev. from mean		
Mean	2.23			
Min Point	2.07	-7.1%	Std. Dev.	0.12
Max Point	2.41	8.2%	COV as %	5.2

Instruments Used:	SN	Cal Due
B&K 1302 Gas Analyzer	CWI	N.A.
Fisher Weather Station	90936818	9/29/2010
TSI VelociCalc	209060	7/14/2010
Omega FMA-2010-A flowmeter	27708	N.A.

	Start	Finish	
Tracer tank pressure	175	175	psig
Injection flowmeter	4.0	4.0	lpm
Stack Temp	73	73	ºF
Center Pt. air vel.	1710	1780	fpm
Sampling flowmeter	5	5	lpm HiQ
Ambient pressure	855	855	mbar
Ambient humidity	30	29	RH
Ambient Temp	78	80	ºF
B&K vapor correction	N	N	Y/N
Back-Gd gas	-33, -29, -30, -32	-26, -27, -22, -28	ppb
No. Bk-Gd samples	4	4	n



Notes:

Entries made by:	John Glissmeyer	10/17/2009
Signature/date	*Signature on file with original*	
Technical Data Review performed by:	Rosanne Aaberg	
Signature/date	*Signature on file with original*	11/6/2009

Appendix D

Tracer Particle Uniformity Data Sheets

Appendix D: Tracer Particle Uniformity Data Sheets

PARTICLE TRACER TRAVERSE DATA FORM

Site	**INTEC CPP-666**	Run No.	**PT-1**
Date	10/10/2009	Fan configuration	**Fans 2 & 3**
Testers	JAG, JEF	Fan Setting	**N/A** **Hz**
Duct Width	108 in.	Stack Temp	65.25 deg F
Duct Height	48 in.	Start/End Time	1310 / 1510
Chamfer H/W	10.0 in	Oil Used	Edwards 19
Stack X-Area	4984.0 in.2	Injection Point	**Center of Room 208 duct, after bypass**
Distance to disturbance	122 ft	Measurement units	particles/ft3

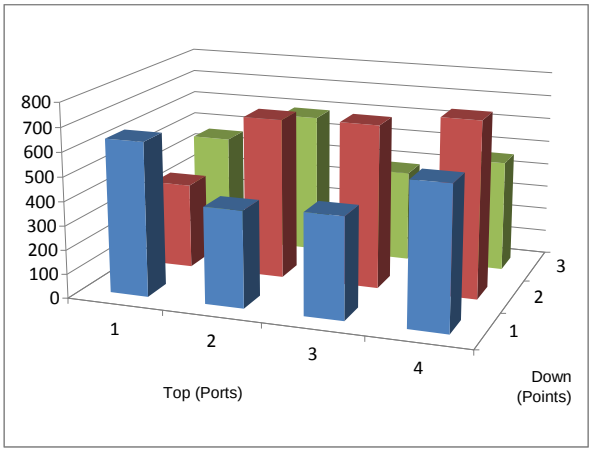
		Trial ---->	1	2	3	Mean
Port	Point	Depth, in.	particles/ft3			
1	1	8	682	581	653	638.7
1	2	24	337	367	365	356.3
1	3	40	472	471	442	461.7
2	1	8	420	399	380	399.7
2	2	24	713	644	654	670.3
2	3	40	642	580	550	590.7
3	1	8	408	431	419	419.3
3	2	24	740	638	662	680.0
3	3	40	358	441	346	381.7
4	1	8	585	556	619	586.7
4	2	24	702	715	780	732.3
4	3	40	470	425	490	461.7
		Averages ---------->	544.1	520.7	530.0	531.6

	pt/ft3	Dev. from mean		
Mean	531.6		Mean	531.6
Min Point	356.3	-33.0%	Std. Dev.	132.3
Max Point	732.3	37.8%	COV as %	24.9

Instuments Used:

		Cal. Due
TSI Velocicalc	SN 209060	7/14/2010
Met One A2408	SN 96258675	4/16/2010
Fisher Scientific	SN 90936818	9/29/2010

	Start	Finish	
Generator Inlet Press	7.8 / 8.8	8 / 9	psig
Stack Temp	65	65.5	F
Approx. air vel.	1750	1850	sfpm
Ambient pressure	25.16	25.1	inHg
Ambient humidity	25%	27%	RH
Ambient temp	64.4	60.8	F
Back-Gd aerosol	0, 0, 0, 0	0, 0, 1, 1	pt/ft3
No. Bk-Gd samples	4	4	
Compressor output	N/A	N/A	psig



Notes: Operating two aerosol generators connected with a tee. 1.5" hose has a #11 nozzle. 1.25" hose has a #9 nozzle. Both connected to a 1.5" probe. Readings taken consecutively at a point because of difficulty in moving and contamination surveys. At Port 2, Point 1, extra readings were taken after raising probe from Port 2, Point 3: 424, 472, 466. Started at Port 1 and moved to Port 4. At each port, started at Point 3 and moved to Point 1.

Entries made by:	John Glissmeyer		Technical Data Review performed by:	Rosanne Aaberg	
Signature/date	*On File w/ Original*	10/10/2009	Signature/date		11/6/2009
				Signature on file with original	

PARTICLE TRACER TRAVERSE DATA FORM

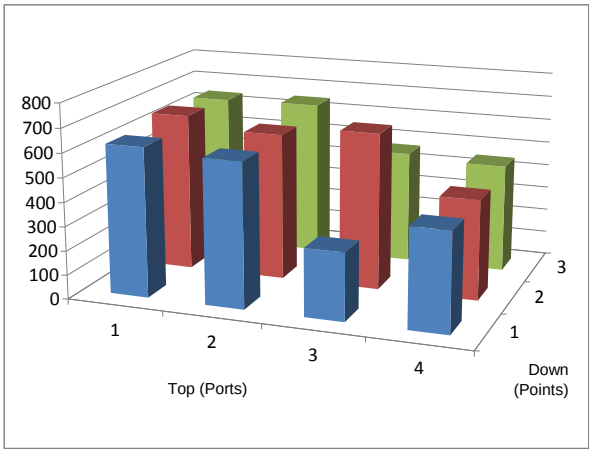
Site	**INTEC CPP-666**	Run No.	**PT-2**
Date	10/10/2009	Fan configuration	**Fans 2 & 3**
Testers	JAG, JEF	Fan Setting	**N/A** **Hz**
Duct Width	108 in.	Stack Temp	66.25 deg F
Duct Height	48 in.	Start/End Time	1515 / 1705
Chamfer H/W	10.0 in	Oil Used	Edwards 19
Stack X-Area	4984 in.2	Injection Point	**Center of Room 208 duct, after bypass**
Distance to disturbance	122 ft	Measurement units	particles/ft3

			Trial ---->	1	2	3	Mean
Port	Point	Depth, in.		particles/ft3			
1	1	8		657	552	651	620.0
1	2	24		652	677	644	657.7
1	3	40		630	651	646	642.3
2	1	8		579	615	603	599.0
2	2	24		592	623	616	610.3
2	3	40		629	631	686	648.7
3	1	8		291	279	270	280.0
3	2	24		637	648	662	649.0
3	3	40		473	477	456	468.7
4	1	8		420	420	389	409.7
4	2	24		408	410	428	415.3
4	3	40		459	442	450	450.3
			Averages ---------->	535.6	535.4	541.8	537.6

	pt/ft3	Dev. from mean		
Mean	537.6		Mean	537.6
Min Point	280.0	-47.9%	Std. Dev.	126.5
Max Point	657.7	22.3%	COV as %	23.5

	Start	Finish	
Generator Inlet Press	7.9 / 8.9	7.9 / 8.9	psig
Stack Temp	65.5	67	F
Approx. air vel.	1850	1810	sfpm
Ambient pressure	25.1	25.07	inHg
Ambient humidity	27%	28%	RH
Ambient temp	60.8	63.5	F
Back-Gd aerosol	0, 0, 1, 1	0, 0, 0, 0	pt/ft3
No. Bk-Gd samples	4	4	
Compressor output	N/A	N/A	psig

Instuments Used:		**Cal. Due**
TSI Velocicalc	SN 209060	7/14/2010
Met One A2408	SN 96258675	4/16/2010
Fisher Scientific	SN 90936818	9/29/2010



Notes: Operating two aerosol generators connected with a tee. 1.5" hose has a #11 nozzle. 1.25" hose has a #9 nozzle. Both connected to a 1.5" probe. Readings taken consecutively at a point because of difficulty in moving and contamination surveys.

Started at Port 4 and moved to Port 1. At each port, started at Point 3 and moved to Point 1.

Entries made by:	Julia Flaherty		Technical Data Review performed by:	Rosanne Aaberg	
Signature/date	*On File w/ Original*	10/10/2009	Signature/date	*Signature on file with original*	11/6/2009

PARTICLE TRACER TRAVERSE DATA FORM

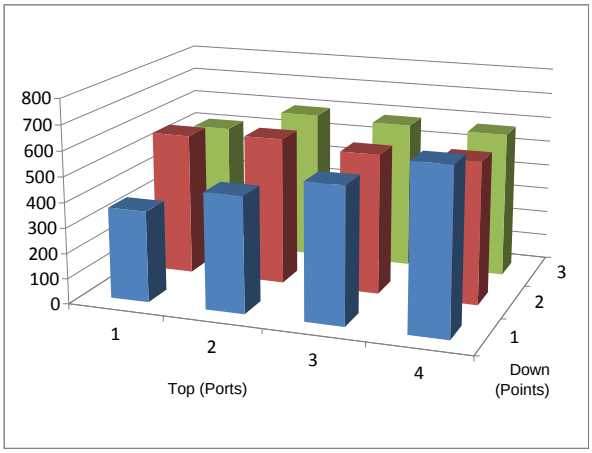
Site	**INTEC CPP-666**	Run No.	**PT-3**
Date	10/12/2009	Fan configuration	**Fans 2 & 3**
Testers	JAG, JEF	Fan Setting	**N/A** **Hz**
Duct Width	108 in.	Stack Temp	66 deg F
Duct Height	48 in.	Start/End Time	1505 / 1740
Chamfer H/W	10.0 in	Oil Used	Edwards 19
Stack X-Area	4984 in.2	Injection Point	**Center of Room 208 duct, at downstream edge of bypass**
Distance to disturbance	122 ft	Measurement units	particles/ft3

			Trial ---->	1	2	3	4	5	Mean
Port	Point	Depth, in.		particles/ft3					
1	1	8		358	353	347	384	367	361.8
1	2	24		541	576	576	612	523	565.6
1	3	40		508	480	494	531	531	508.8
2	1	8		459	467	485	458	432	460.2
2	2	24		577	532	600	612	603	584.8
2	3	40		537	638	584	601	622	596.4
3	1	8		518	529	534	571	538	538.0
3	2	24		504	499	550	605	627	557.0
3	3	40		644	554	576	591	560	585.0
4	1	8		604	669	623	710	639	649.0
4	2	24		623	565	558	534	537	563.4
4	3	40		622	567	568	559	577	578.6
			Averages ---------->	541.3	535.8	541.3	564.0	546.3	545.7

	pt/ft3	Dev. from mean		
Mean	545.7		Mean	545.7
Min Point	361.8	-33.7%	Std. Dev.	74.3
Max Point	649.0	18.9%	COV as %	13.6

	Start	Finish	
Generator Inlet Press	8 / 9	8 / 9	psig
Stack Temp	65	67	F
Approx. air vel.	1700	1700	sfpm
Ambient pressure	24.92	24.89	inHg
Ambient humidity	31%	33%	RH
Ambient temp	60.8	60.8	F
Back-Gd aerosol	0, 0, 0, 0	0, 0, 0, 0	pt/ft3
No. Bk-Gd samples	4	4	
Compressor output	N/A	N/A	psig

Instuments Used:		**Cal. Due**
TSI Velocicalc	SN 209060	7/14/2010
Met One A2408	SN 96258675	4/16/2010
Fisher Scientific	SN 90936818	9/29/2010



Notes: Shortened injection probe 26" so that the injection is 2.25" downstream of probe center. Operating two aerosol generators connected with a tee. One aerosol generator has a #11 nozzle and the other has a #9 nozzle. Both connected to 1.25" probe. Readings taken consecutively at a point due to difficulty in moving the probe. Started at Port 1 and moved to Port 4. At each port, started at Point 3 and moved to Point 1.

Entries made by:	Julia Flaherty		Technical Data Review performed by:	Rosanne Aaberg
Signature/date	*On File w/ Original*	10/12/2009	Signature/date	11/6/2009
				Signature on file with original

PARTICLE TRACER TRAVERSE DATA FORM

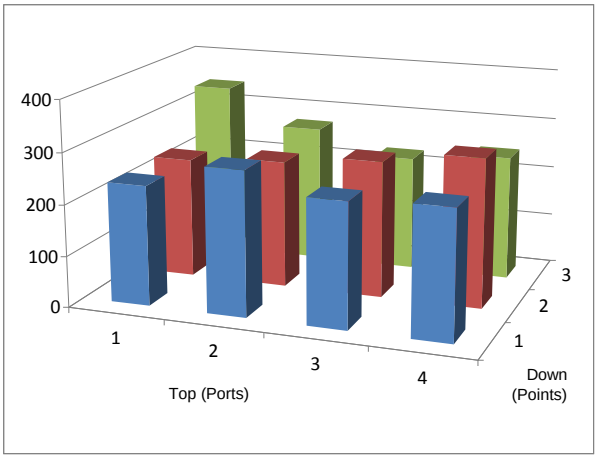
Site	**INTEC CPP-666**	Run No.	**PT-4**
Date	10/13/2009	Fan configuration	**Fans 2 & 3**
Testers	JAG, JEF	Fan Setting	**N/A** **Hz**
Duct Width	108 in.	Stack Temp	66.75 deg F
Duct Height	48 in.	Start/End Time	0850/1135
Chamfer H/W	10.0 in	Oil Used	Edwards 19
Stack X-Area	4984.0 in.2	Injection Point	**Center of Room 208 duct, at downstream edge of bypass**
Distance to disturbance	122 ft	Measurement units	particles/ft3

		Trial ---->	1	2	3	4	5	Mean
Port	Point	Depth, in.	particles/ft3					
1	1	8	216	238	232	247	240	234.6
1	2	24	233	241	242	247	221	236.8
1	3	40	335	359	351	318	351	342.8
2	1	8	306	279	301	279	247	282.4
2	2	24	241	259	241	249	257	249.4
2	3	40	266	272	255	290	275	271.6
3	1	8	245	229	254	249	239	243.2
3	2	24	289	259	291	270	229	267.6
3	3	40	214	207	224	239	249	226.6
4	1	8	242	217	236	290	271	251.2
4	2	24	290	287	291	292	298	291.6
4	3	40	232	251	238	253	251	245.0
		Averages ---------->	259.1	258.2	263.0	268.6	260.7	261.9

	pt/ft3	Dev. from mean		
Mean	261.9		Mean	261.9
Min Point	226.6	-13.5%	Std. Dev.	32.3
Max Point	342.8	30.9%	COV as %	12.3

	Start	Finish	
Generator Inlet Press	7.9/8.9	7.9/8.9	psig
Stack Temp	66	67.5	F
Approx. air vel.	1870	1770	sfpm
Ambient pressure	24.89	24.92	inHg
Ambient humidity	51%	44%	RH
Ambient temp	63	71	F
Back-Gd aerosol	0,0,0,0	0,0,0,0	pt/ft3
No. Bk-Gd samples	4	4	
Compressor output	N/A	N/A	psig

Instuments Used:		**Cal. Due**
TSI Velocicalc	SN 209060	7/14/2010
Met One A2408	SN 96258675	4/16/2010
Fisher Scientific	SN 90936818	9/29/2010



Notes: Shortened injection probe 26" so that the injection is 2.25" downstream of probe center. Operating two aerosol generators connected with a tee. One aerosol generator has a #11 nozzle and the other has a #9 nozzle. Both connected to 1.25" probe. Readings taken consecutively at a point due to difficulty in moving the probe. We started Port 4 in wrong order, point 1 instead of 3. No explanation for the initial drop in concentration.

Entries made by:	Julia Flaherty		Technical Data Review performed by:	Rosanne Aaberg	
Signature/date	*On File w/ Original*	10/12/2009	Signature/date	11/5/2009	
				Signature on file with original	

PARTICLE TRACER TRAVERSE DATA FORM

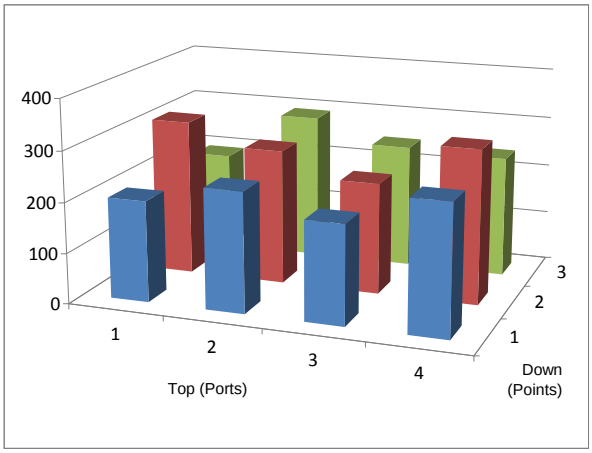
Site	**INTEC CPP-666**	Run No.	**PT-5**
Date	10/19/2009	Fan configuration	**Fans 1 & 2**
Testers	JAG, JEF	Fan Setting	**N/A** **Hz**
Duct Width	108 in.	Stack Temp	72.5 deg F
Duct Height	48 in.	Start/End Time	0940 / 1530
Chamfer H/W	10.0 in	Oil Used	Edwards 19
Stack X-Area	4984 in.2	Injection Point	**Center of Room 208 duct, at downstream edge of bypass**
Distance to disturbance	122 ft	Measurement units	particles/ft3

			Trial ---->	1	2	3	4	5	Mean
Port	Point	Depth, in.		particles/ft3					
1	1	8		214	171	190	190	238	200.6
1	2	24		363	348	296	286	258	310.2
1	3	40		201	182	217	186	189	195.0
2	1	8		199	220	235	244	295	238.6
2	2	24		264	257	303	267	250	268.2
2	3	40		294	278	280	317	293	292.4
3	1	8		192	212	207	179	195	197.0
3	2	24		256	217	205	226	200	220.8
3	3	40		241	240	224	257	271	246.6
4	1	8		277	269	242	279	221	257.6
4	2	24		298	307	272	298	353	305.6
4	3	40		256	201	249	273	221	240.0
			Averages ---------->	254.6	241.8	243.3	250.2	248.7	247.7

	pt/ft3	Dev. from mean		
Mean	247.7		Mean	247.7
Min Point	195.0	-21.3%	Std. Dev.	40.7
Max Point	310.2	25.2%	COV as %	16.4

	Start	Finish	
Generator Inlet Press	8, 9	8, 9	psig
Stack Temp	72	73	F
Approx. air vel.	1800	1780	sfpm
Ambient pressure	24.98	24.95	inHg
Ambient humidity	37%	44%	RH
Ambient temp	77	71	F
Back-Gd aerosol	0,0,0,0	0,0,0,0	pt/ft3
No. Bk-Gd samples	4	4	
Compressor output	N/A	N/A	psig

Instuments Used:		**Cal. Due**
TSI Velocicalc	SN 209060	7/14/2010
Met One A2408	SN 96258675	4/16/2010
Fisher Scientific	SN 90936818	9/29/2010



Notes: Shortened injection probe 26" so that the injection is 2.25" downstream of probe center. Operating two aerosol generators connected with a tee. One aerosol generator has a #11 nozzle and the other has a #9 nozzle. Both connected to 1.25" probe. Readings taken consecutively at a point due to difficulty in moving the probe. Started at Port 1 and ended at Port 4. At each port, started at Point 1. This was a very windy day and the CPP-666 flow probes witnessed that in jumpy readings.

Entries made by:	John Glissmeyer		Technical Data Review performed by:	Rosanne Aaberg
Signature/date	*On File w/ Original*	10/19/2009	Signature/date	11/5/2009
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