PNNL-22167
WTP-RPT-227 Rev 0

U.S. DEPARTMENT OF ENERGY

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

Assessment of Waste Treatment Plant LAB C3V (LB-S1) Stack Sampling Probe Location for Compliance with ANSI/HPS N13.1-1999

JA Glissmeyer
JGH Geeting

February 2013

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Test Specification:	N/A
Work Authorization:	WA# 009
Statement of Work	BNI 24590-QL-SRA-W000-00101 Rev. 2
Test Plan:	TP-WTPSP-094, Rev 0
Test Exceptions:	N/A
Test Scoping Statement(s):	N/A
QA Technology Level:	Developmental Research

Prepared for
the U.S. Department of Energy
under Contract DE-AC05-76RL01830 and
Memorandum of Agreement (MOA):24590-QL-HC9-WA49-00001

Pacific Northwest National Laboratory
Richland, Washington 99352

Completeness of Testing

This report describes the results of work and testing specified by Test Plan TP-WTPSP-094. 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 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:

D E Kurath
Dean E. Kurath
Program Manager

2/14/13
Date

Summary

This report documents a series of tests used to assess the proposed air sampling location in the Hanford Tank Waste Treatment and Immobilization Plant (WTP) LAB C3V (LB-S1) exhaust stack with respect to the applicable criteria regarding the placement of an air sampling probe. Federal regulations[(a)] require that an air sampling probe be located in the exhaust stack in accordance with the criteria of American National Standards Institute/Health Physics 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 represents the effluent stream.

Testing was performed on a scale model of the stack as part of the River Protection Project—Waste Treatment Plant Support Program under Contract No. DE-AC05-76RL01830 according to a statement of work issued by Bechtel National Inc. (BNI 24590-QL-SRA-W000-00101 Rev. 2, *N13.1-1999 Stack Monitor Scale Model Testing and Qualification*) and Work Authorization 09 of Memorandum of Agreement 24590-QL-HC9-WA49-00001, and modified by Subcontract Change Notices 123 and 126. The internal Pacific Northwest National Laboratory (PNNL) project for this task is 53024, *Work for Hanford Contractors Stack Monitoring*. The testing described in this document was further guided by the Test Plan, *Air Sampling Probe Location Tests for Waste Treatment Plant LAB C3V (LB-S1) Air Exhaust System* (TP-WTPSP-094).

Tests consisted of various measurements taken over a grid of points in the duct cross-section at the designed sampling probe location. The ANSI/HPS N13.1-1999 criteria and the corresponding results of the test series on the scale model 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. Uniformity is defined as the variability of the measurements about the mean and expressed as the percent coefficient of variation (%COV). The %COV is calculated as the standard deviation divided by the mean and expressed as a percentage; thus, the lower the %COV value, the more uniform the velocity. The qualification criterion is that the %COV of the air velocity must be ≤20 across the center two-thirds of the cross-section of the duct where the sampling probe is to be located.
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 exceed 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. The two qualification criteria are that 1) the %COV of the measured tracer gas concentration is ≤20 across the center two-thirds of the duct cross-section, and 2) the gas concentration at any of the measurement points does not deviate from the overall mean concentration of all of the measurement points by >30 percent.

(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*.

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 qualification criterion is that the %COV of particle concentration is ≤20 for the measurement points in the center two-thirds of the duct at the sampling probe location.

The results of the tests for the LB-S1 model are summarized in Table S.1. The criteria for sampling probe locations given in ANSI/HPS N13.1-1999 were met in all cases. These criteria address the capability of the sampling probe to extract a sample that represents the effluent stream. Based on these scale model tests, the WTP prototypic sampling point, located 10.3 duct diameters downstream of the last 90 degree elbow, meets the air sampling probe requirements of the ANSI/HPS N13.1-1999 standard. [Note: The pipe fitting for the test port is 10.6 duct diameters from the last elbow, but the sampler turns 90° and extends down the stack 19.4". These tests were conducted at the distance of the sampling plane rather than the pipe fitting.] Additional velocity uniformity and flow angle tests on the actual stacks will be necessary during cold startup to confirm the validity of the modeled results. Guidance on those tests is provided in the conclusion of this report.

Table S.1. Summary of Results for the LB-S1 Scale Model Stack

	Acceptance Criteria	Units	LB-S1
Velocity Uniformity	≤20	%COV	3.1–7.6
Flow Angle	≤20	Degrees	3.5–6.9
Gas Tracer Uniformity	≤20	%COV	1.0–7.3
	≤30	Maximum % Deviation from Mean	2.0–14.9
Particle Tracer Uniformity	≤20	%COV	7.3–14.1

Quality Assurance

The PNNL quality assurance (QA) program is based on the requirements defined in the U.S. Department of Energy Order 414.1D, *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 I, "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), which is a system for managing the delivery of laboratory-level policies, requirements, and procedures.

The Waste Treatment Plant Support Program (WTPSP) implements an NQA-1-2000 QA program, using a graded approach presented in NQA-1-2000, Part IV, Subpart 4.2. The WTPSP Quality Assurance manual (QA-WTPSP-0002) describes the technology life cycle stages under the WTPSP QA plan (QA-WTPSP-0001). The technology life cycle includes the progression of technology development, commercialization, and retirement in process phases of basic and applied research and development (R&D), engineering and production, and operation until process completion. The life cycle is characterized by flexible and informal QA activities in basic research, which becomes more structured and formalized through the applied R&D stages. The work described in this report has been completed under the QA Technology level of Developmental Work as the data will be used for applying for air discharge permits.

- DEVELOPMENTAL WORK—Developmental work consists of research tasks moving toward technology commercialization. These tasks still require a degree of flexibility, and there is still a degree of uncertainty that exists in many cases. The role of quality on developmental work is to make sure that adequate controls exist to support movement into commercialization.

WTPSP addresses internal verification and validation activities by conducting an Independent Technical Review of the final data report in accordance with WTPSP's procedure QA-WTPSP-0601, *Document Preparation and Change*. This review verifies that the reported results are traceable, that inferences and conclusions are soundly based, and the reported work satisfies the test plan objectives. Appendix B lists the reviewed test plan, test instructions (TIs), and calculation packages used for the tests documented in this report.

Acknowledgments

Preparing, executing, and post-processing scale model measurements involved a number of Pacific Northwest National Laboratory staff. We would like to particularly acknowledge the support of our quality engineer, Kirsten Meier, and the administrative support from Chrissy Charron and Mona Champion. We would also like to express our appreciation to scientific staff members Ernest Antonio, Julia Flaherty, Carmen Arimescu, Mikhail Pekour, and Xiao-Ying Yu who conducted measurements under a variety of weather conditions. Additionally, Gary Josephson provided the technical review. Michael Parker provided editorial support for this report.

Pacific Northwest National Laboratory is operated for the U.S. Department of Energy by Battelle under Contract DE-AC05-76RL01830.

Acronyms

%COV	percent coefficient of variation
acfm	actual cubic feet per minute
afpm	actual feet per minute
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
BNI	Bechtel National, Inc.
CCP	computer-assisted calculation package
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
DV	hydraulic diameter × mean velocity
EPA	U.S. Environmental Protection Agency
HDI	"How Do I…?"
HEPA	high-efficiency particulate air (filter)
HPS	Health Physics Society
LB-S1	LAB C3V ventilation system emission unit
NESHAP	National Emissions Standards for Hazardous Air Pollutants
OPC	optical particle counter
PNNL	Pacific Northwest National Laboratory
QA	quality assurance
scfm	standard cubic feet per minute
SF_6	sulfur hexafluoride
sfpm	standard feet per minute
TI	test instruction
WTP	Hanford Tank Waste Treatment and Immobilization Plant
WTPSP	Waste Treatment Plant Support Program

Contents

Figures

Tables

1.0 Introduction

The purpose of these scale model tests is to document the extent to which the current Bechtel National, Inc. (BNI) design for the LAB C3V (LB-S1) air exhaust stack in the Hanford Tank Waste Treatment and Immobilization Plant (WTP) meets the applicable regulatory guidance. 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* requires that a sampling probe be located in the exhaust stack according to the criteria of the American National Standards Institute/Health Physics Society (ANSI/HPS) N13.1-1999, *Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stack and Ducts of Nuclear Facilities*[(a)]. The capability of the sampling probe locations to meet this standard has been demonstrated with a series of tests on scale models as described in the standard. The resulting data will be used by BNI as input to the air discharge permitting process before WTP cold commissioning.

This work is performed as part of the River Protection Project—Waste Treatment Plant Support Program under Contract No. DE-AC05-76RL01830 according to the statement of work issued by BNI (BNI 24590-QL-SRA-W000-00101, *N13.1-1999 Stack Monitor Scale Model Testing and Qualification*, Revision 2) and Work Authorization 09 of Memorandum of Agreement 24590-QL-HC9-WA49-00001 and modified by Subcontract Change Notices 123 and 126. The internal Pacific Northwest National Laboratory (PNNL) project for this task is 53024, *Work for Hanford Contractors Stack Monitoring*.

PNNL personnel conducted the scale model tests in 2012. No BNI personnel were directly involved in the tests. BNI WTP point of contact and facility engineers provided the most current engineering input to support PNNL's tests. BNI retains responsibility for the technical design of the stack discharge and air monitoring systems.

1.1 Qualification Criteria

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

1. Uniform Air Velocity—It is important to have fairly uniform gas velocity across the stack cross-section where the sample is extracted. Consequently, the velocity is measured at several discrete points in the duct cross-section at the proposed location of the sampling nozzle. Uniformity is defined as the variability of the measurements about the mean and expressed using the percent coefficient of variation (%COV).[(b)] The %COV is calculated as the standard deviation divided by the mean and expressed as a percentage; thus, the lower the %COV value, the more uniform the velocity. The qualification criterion is that the %COV of the air velocity must be ≤20 in the center two-thirds of the duct cross-section where the sampling probe is to be located.
2. Angular Flow—Sampling nozzles are typically aligned with the axis of the stack. If air travels through the stack in cyclonic fashion, the air velocity vector approaching a sampling nozzle could be

(a) Health Physics Society, McLean, VA 22101. The standard has been reaffirmed in 2011 and is identical to the 1999 version. The regulations have not been updated yet, so the 1999 version is still referenced.

(b) *Coefficient of variation* is considered dated terminology. The modern equivalent is *percent relative standard deviation*. Older terminology is used here for consistency with the standard.

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 of the flow angle measurements (made at the same grid of points as the velocity measurements) should not exceed 20° relative to the sampling nozzle axis.

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 with 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 qualification criteria are that 1) the %COV of the measured tracer gas concentration is ≤20 across the center two-thirds of the duct cross-section at the sampling location, and 2) the concentrations at all the measurement points do not deviate from the mean by >30 percent.
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 with an aerodynamic diameter of 10 μm are used by default unless it is known that larger contaminant particles will be present in the airstream. The qualification criterion is that the %COV of particle concentration is ≤20 across the center two-thirds of the duct at the sampling location.

Tests to determine if all criteria were met were conducted on a scale model of the LB-S1 stack. Conducting tests on a scale model of the exhaust system allows for the designed air sampling location to be qualified before cold commissioning and, in the case that testing results are not satisfactory, for design compensations to be made. Tracer concentration, velocity, and flow angle measurements were made using the same grid of points and duct cross-section. The ANSI/HPS N13.1-1999 standard sets additional qualification criteria for the use of a scale model as a substitute for the actual stack, including the following:

- the scale model and its sampling location must be geometrically similar to the actual stack
- the product of the hydraulic diameter and the mean velocity (DV value) for the scale model must be within a factor of six of the DV value for the actual stack
- the Reynolds number for the actual and model stacks must be >10,000.

The scale model results are considered valid if it is further shown that:

- the velocity profile in the actual stack meets the uniformity criterion (%COV ≤20)
- the velocity uniformity COV values for the actual and model stacks agree within 5 %COV
- the flow angle criterion (with a mean value ≤20°) is met.

Subsequent sections of this report provide descriptions and results of scale model testing. Tests to determine the validity of the scale model testing will be included in cold startup testing of the actual WTP stack under a separate test plan.

2.0 LAB C3V (LB-S1) Stack

2.1 Stack Geometry

Figure 2.1 provides the layout for the LB-S1 stack design. Figure 2.2 and Figure 2.3 provide photos of the scale model used for testing. Air was drawn in through four high efficiency particulate air (HEPA) filters to a common plenum. Duct heaters were installed between the common plenum and the fans to facilitate cold-weather testing.[(a)] Two fans were connected to duct A, B, or C. At each fan outlet a damper was installed to simulate the flow turbulence of the backdraft damper in WTP BNI design documents. In all cases, two fans were used and the unused inlet was blanked off. It should be noted that the test system upstream of the backdraft dampers was not to scale.

The test system was to scale from the backdraft dampers to the end of the stack. Some of the scaled design dimensions are provided in Figure 2.1. Test Port 1 represents the planned location for operational stack sampling according to current WTP BNI designs (10.3 duct diameters from the last pipe elbow to the sampling plane). All injection ports are located downstream of the fans and are therefore considered conservative in terms of mixing. Injection Port 2 is the WTP-based prototypic injection port and was used for most of the scaled testing. Injection Port 1 was an optional injection location located further upstream in case mixing proved inadequate from the WTP prototypic location. Mixing proved satisfactory for all cases. Only one particle tracer test used Injection Port 1. Injection Ports A, B, and C are additional optional injection locations located immediately downstream of the fans and were not used for this testing.

The scaling ratio of the actual dimensions to the scale model dimensions is 5:1. The scale model was constructed with a duct diameter of 12 in. for convenience and to maintain the ability to re-use duct sections for subsequent stack designs. Table 2.1 lists the diameter of the actual stack with the scaling factor for the 12-in. scale model diameter. The calculations of the key scale model dimensions were performed in spreadsheets and verified and validated in accordance with the Waste Treatment Plant Support Program (WTPSP's) procedure QA-WTPSP-0304, *Calculations*. ANSI/HPS N13.1-1999, Clause 5.2.2.2, requires that the models be geometrically similar to the actual stacks. Acceptable deviations in key dimensions of the scale model arising from scaling and fabrication errors are within ±5 percent for cross-sectional dimensions and 25 percent of a duct diameter in overall length between the sampling point and the flow disturbances. These deviations have less impact on the test results than the normal standard deviation of repeat tests. However, to minimize the deviations due to construction, the construction specification called for a tolerance of ± $^1/_8$ in. per 10 ft parallel to the direction of flow and ± $^1/_8$ in. for cross-sectional dimensions. The key scale model dimension for the as-built scale models were measured and recorded by testing staff.

(a) The air temperature in the operating WTP air exhaust stacks does not need to be simulated because it has negligible effect on the turbulence produced by the geometries of the systems. However, the air temperature during particle tracer uniformity testing was maintained above 55°F so that the optical particle counters and gas analyzer would provide reliable data.

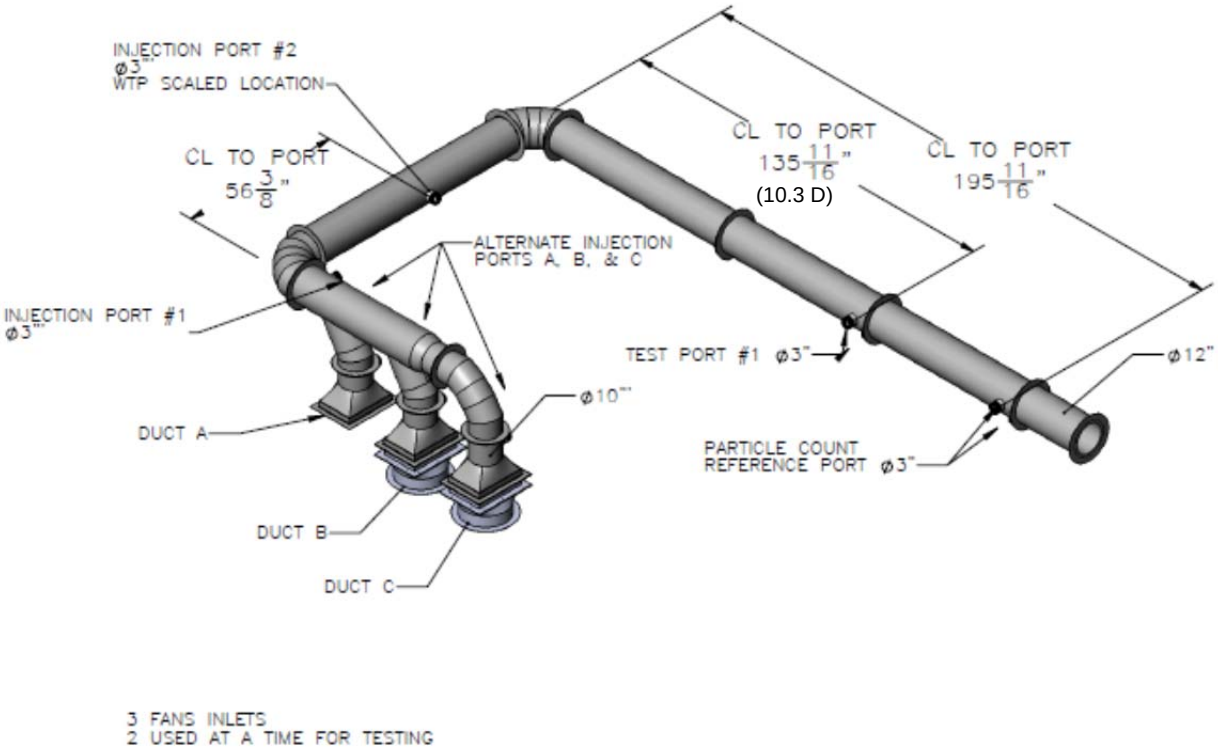


Figure 2.1. Layout of the LB-S1 Test System

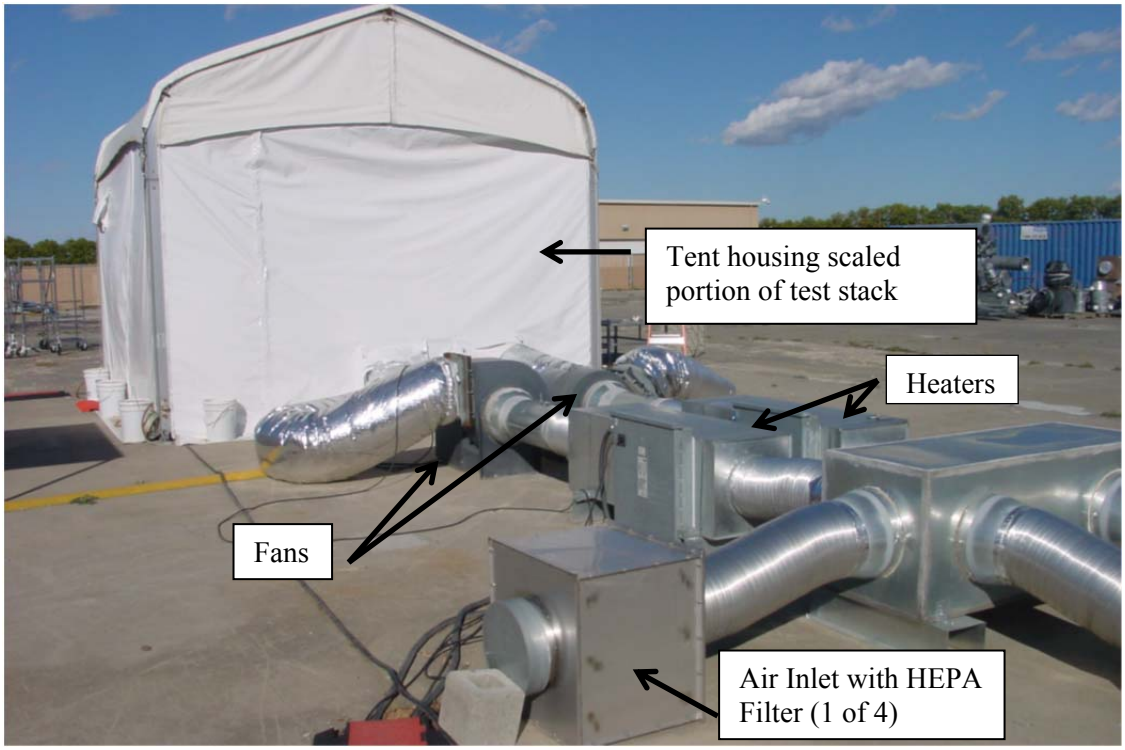


Figure 2.2. Photo of Outdoor (not-to-scale) Portion of the LB-S1 Test System

Figure 2.3. Photo of Air Inlet to the Scaled Portion of the LB-S1 Test System (configuration shown with fans connected to Ducts A and B with Duct C blanked off)

Table 2.1. Scaling Factor for 12-in. Diameter Scale Model Stack

	Actual Stack Diameter	Scaling Factor
LB-S1	60 in.	5

2.2 Stack Flows

Tests of scale model stacks were conducted at flow rates that bracket the range of expected normal and accident flow rates and operating configurations. Various combinations of flow rates and operating configurations were tested. BNI provided normal, minimum, and maximum flow rates for each of the three systems tested in this group. Maximum flow rates are approximately 120 percent of the normal flow rates, whereas minimum flow rates are approximately 83 percent of normal.

Additional considerations come from Clause 5.2.2.2 of the ANSI/HPS N13.1-1999 standard. The standard requires that the scale model's DV value be within a factor of six of the actual stack. For stacks with a circular cross-section, this is equivalent to requiring that the ratio of flow rate to stack diameter be within a factor of six of the actual stack. In addition, the standard requires that the Reynolds number for the prototype and model stacks both exceed 10,000.

Three fans are available for the LB-S1 exhaust system, which exhausts air from the C3 ventilation system in the laboratory facility. Two fans will be operated at a time and one will be on standby. The maximum, normal, and minimum flow rates in the LB-S1 exhaust system are expected to be 84,900, 73,350, and 62,750 standard cubic feet per minute (scfm), respectively. At the design temperatures (maximum, normal, and minimum) and pressures the target actual flows to be scaled for modeling are 88,800, 74,150, and 61,600 actual cubic feet per minute (acfm), respectively. Each fan is equipped with an adjustable-speed drive to compensate for filter loading and pressure variations.

Table 2.2 lists the range of design flow conditions for the actual stack, including the air flow (in acfm), air velocity (in actual feet per minute [afpm]) and the Reynolds number. The table also lists the corresponding model operating parameters needed for the scale model's hydraulic diameter × mean velocity (DV) value to be within a factor of 6 (i.e., $^1/_6$) of the actual stacks. The conditions prescribed for these scale model tests fulfill the criterion of a Reynolds number >10,000.

Table 2.2. Summary of Flow Parameters for the Actual and Scale Model Stacks

	Air Flow (acfm)		Air Velocity (afpm)		Reynolds Number	
Fan(s)–Flow	Actual Stack	Scale Model Minimum	Actual Stack	Scale Model Minimum	Actual Stack	Scale Model Minimum
Dual fan – Max flow	88,800	2960	4580	3816	2.1E+06	3.6E+05
Dual fan – Normal flow	74,150	2472	3824	3187	1.9E+06	3.2E+05
Dual fan – Min flow	61,600	2053	3177	2647	1.7E+06	2.2E+05

Table 2.3 lists the DV values for the actual and scale model stacks for the operating conditions given in Table 2.2. It also lists the scale model DV when the air velocity in the model stack matches that of the actual stack, which is our preferred operating condition for the model if the fan capacity will accommodate it.

Table 2.3. Summary of DV Values for the Actual and Scale Model Stacks

	DV (ft^2/min)		
Fan(s)—Flow	Predicted for Actual Stack	Scale Model Minimum	Scale Model Maximum
LB-S1			
Dual fans—Max flow	22,900	3816	4580
Dual fans—Normal flow	19,120	3187	3824
Dual fans—Min flow	15,885	2647	3177

3.0 Testing Methods

The testing methods were based on the requirements of ANSI/HPS N13.1-1999, Clauses 5.2 and 5.3. A test plan, TP-WTPSP-094, *Air Sampling Probe Location Tests for Waste Treatment Plant LAB C3V (LB-S1) Air Exhaust System,* was prepared by PNNL and approved by BNI. This plan referenced the use of PNNL procedures, which define, in general, how tests should be conducted. A test instruction (TI) was prepared for each test type and each scale model stack. These TIs contain specific instructions pertaining to the tests that are not addressed in the general 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 this report, the TIs are not included. This project's quality assurance (QA) program is described in Section 3.1 of this report. A summary of the methods used for each test type is presented in Section 3.2.

3.1 Quality Assurance

The PNNL QA program is based on the requirements defined in the U.S. Department of Energy (DOE) Order 414.1D, *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 I, "Requirements for Quality Assurance Programs for Nuclear Facilities" (ASME 2001)
- ASME NQA-1-2000, Part II, Subpart 2.7, *Quality Assurance Requirements for Computer Software for Nuclear Facility Applications* (ASME 2001)
- ASME NQA-1-2000, Part IV, Subpart 4.2, *Graded Approach Application of Quality Assurance Requirements for Research and Development* (ASME 2001).

The procedures necessary to implement the requirements are documented through PNNL's "How Do I…?" (HDI), which is a system for managing the delivery of laboratory-level policies, requirements, and procedures.

The WTPSP implements an NQA-1-2000 QA program using the graded approach presented in NQA-1-2000, Part IV, Subpart 4.2. The WTPSP QA manual (QA-WTPSP-0002) describes the technology life cycle stages under the WTPSP QA plan (QA-WTPSP-0001). The technology life cycle includes the progression of technology development, commercialization, and retirement in process phases of basic and applied research and development (R&D), engineering and production, and operation until

process completion. The life cycle is characterized by flexible and informal QA activities in basic research, which become more structured and formalized through the applied R&D stages.

- Basic Research—Basic research consists of research tasks conducted to acquire and disseminate new scientific knowledge. During basic research, maximum flexibility is desired to allow the researcher the necessary latitude to conduct the research.
- Applied Research—Applied research consists of research tasks that acquire data and documentation necessary to confirm satisfactory reproducibility of results. The emphasis during this stage is on achieving adequate documentation and controls necessary to achieve reproducible results.
- Developmental Work—Developmental work consists of research tasks moving toward technology commercialization. These tasks still require a degree of flexibility because, in many cases, a degree of uncertainty still exists. The role of quality on developmental work is to make sure that adequate controls exist to support movement into commercialization.
- R&D Support Activities—Support activities are conventional and secondary activities that support the advancement of knowledge or development of technology, but allow the primary purpose of the work to be accomplished in a credible manner. An example of a support activity is controlling and maintaining documents and records. The level of quality for these activities is the same as for developmental work.

The work described in this report has been completed as Developmental Work. WTPSP addresses internal verification and validation activities by conducting an independent technical review of the final data report in accordance with WTPSP procedure QA-WTPSP-0601, *Document Preparation and Change*. This review verifies that the reported results are traceable, that inferences and conclusions are soundly based, and that the reported work satisfies the test plan objectives. Appendix B lists the reviewed test plan, TIs, and calculation packages used for the tests documented in this report.

3.2 Stack Tests

The qualification tests described in the following sections were conducted under flow conditions between approximately 83 and 120 percent of the normal design flow condition listed in Table 2.2. The test matrix included with TP-WTPSP-094 described the minimum number of tests required for the LB-S1 stack.

Before conducting the tests to determine whether the qualification criteria described in Section 1.1 were met, two additional measurement sets were made. First, the major features of the stack were measured, including the longitudinal distances from the fan ducts to the bends, reducers, and ports and the duct diameter at each port. The second set of preliminary measurements determined the fan frequency drive settings needed to achieve the desired flow rates. For these measurements, the location within the duct cross-section with velocity measurements closest to the mean velocity was determined at Test Port 1. Next, velocities were measured at this location in 5-Hz fan frequency increments. By developing a frequency vs. velocity relationship for the scale model stack, the frequency setting needed to achieve the targeted flow conditions was determined.

Measurements were made at specific locations within the duct for each of the four qualification criteria tests. The number and distance between measurement points was based on U.S. Environmental

Protection Agency (EPA) procedure 40 CFR 60, Appendix A, Method 1, for circular stacks. For 12- to 24-in. duct diameters, eight traverse points are required at the relative positions shown in Figure 3.1. Measurements were also taken at the center point. In lieu of using two measurement points nearest to the walls at 3.2 percent of the duct diameter from the duct walls, the minimum distance from the wall was set to 0.5 in., as prescribed by EPA Method 1. The measurement point closest to the port was labeled Point 1 and the point farthest from the port was labeled Point 8.

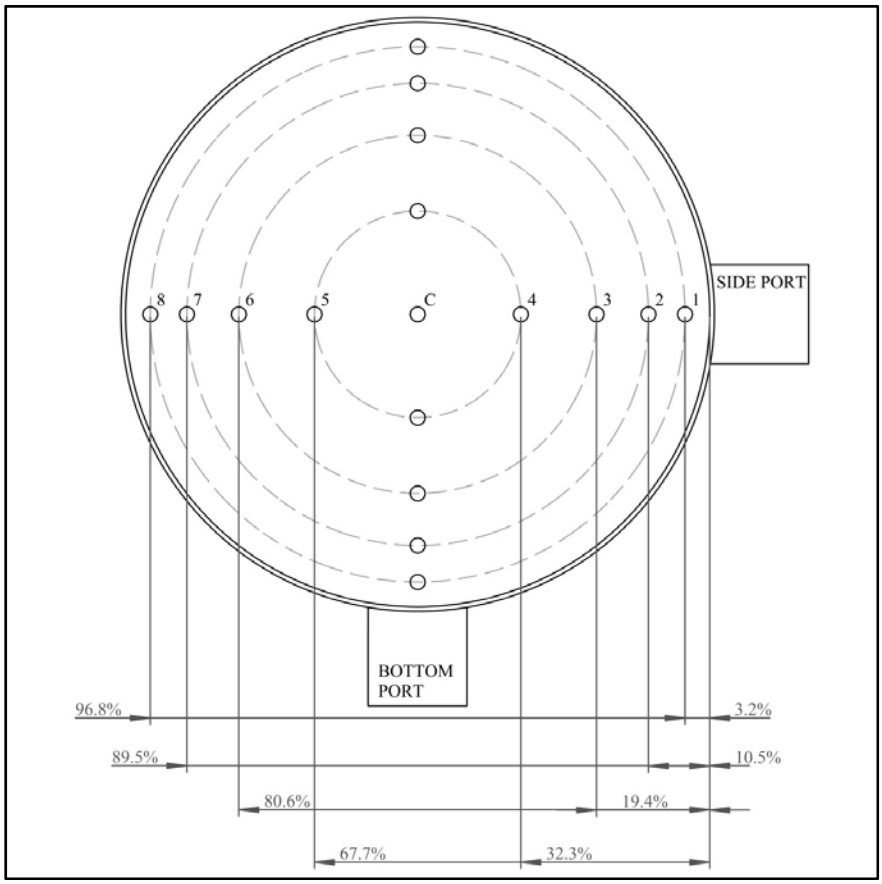


Figure 3.1. Cross-Section of the Duct at the Testing Ports With Measurement Points

3.2.1 Velocity Uniformity

The uniformity of air velocity at the stack monitoring location indicates whether the momentum in the stack is evenly distributed. The method used to conduct the velocity uniformity tests was based on 40 CFR 60, Appendix A, Method 1. The criterion for qualification from the velocity uniformity test is that the %COV should be less than 20 in the center two-thirds of the duct (i.e., Points 2-7).

For each run, three air velocity readings were obtained at each measurement point. The measured velocity was the average of the three readings. The measured velocity for each point was used to determine the mean and standard deviation of the velocity across the cross-sectional plane. The %COV was calculated as the standard deviation divided by the mean expressed as a percentage.

Air velocity and duct air temperature measurements were made using a handheld thermal anemometer. The thermal anemometer compensates for temperature and barometric pressure to report velocity in standard feet per minute. Figure 3.2 shows the thermal anemometer (TSI, Model 9535, Shoreview, Minnesota) used for this test. Testing was conducted in accordance with EMS-JAG-04 and TI-WTPSP-098.

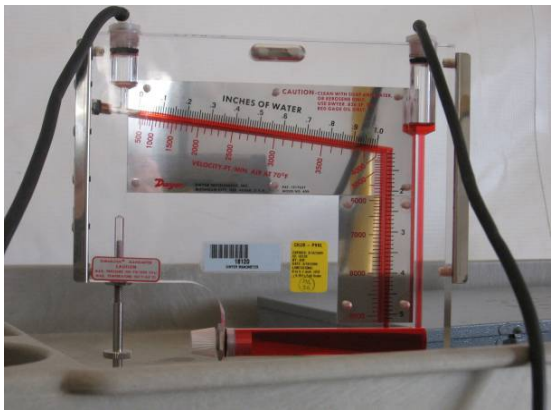
(a) (b)

Figure 3.2. Thermal Anemometer Used for the Velocity Uniformity Test: (a) Thermal Anemometer Device, and (b) Close-Up of Thermal Anemometer Probe Tip

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 range 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 testing activities, the flow angle was measured at a grid of nine points across two axes in a cross-section of the duct (see Figure 3.3). The qualification criterion for the flow angle test is that the average angle should not exceed 20°.

(a)



(b)

(c)

Figure 3.3. Equipment Used for the Flow Angle Test Included (a) an S-Type Pitot Tube Inserted in a Measurement Port With the Protractor Plate, and (b) a Slant-Tube Manometer; (c) Shows the Openings at the Tip of the S-Type Pitot Tube

Flow angles were measured using an S-type Pitot tube (Dwyer Instruments, 160S-36, Michigan City, Indiana) attached by flexible tubing to a slant-tube manometer (Dwyer Instruments, 400-5) and a protractor plate attached to the sampling port as shown in Figure 3.3. For this test, the 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 protractor plate (metal plate and pointer in Figure 3.3a) indicates angles using 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 measured flow angle for each point is the average of the three readings. These measured values were used to calculate the mean absolute value of the flow angle across the duct. Testing was conducted in accordance with EMS-JAG-05 and TI-WTPSP-099.

3.2.3 Gaseous Tracer Uniformity

The gaseous contaminant concentration uniformity was demonstrated using the tracer gas sulfur hexafluoride (SF_6). A compressed gas cylinder and a flow controller were used to deliver a constant stream of SF_6 into the duct. For this testing the gaseous tracer was injected into the duct through Injection Point 2 (WTP prototypic location) downstream of the fans. Figure 3.4 shows the injection locations with an injection probe positioned in the port. For separate test runs, the injection probe was positioned at one of five different locations in the duct cross-section as illustrated in Figure 3.4. For some tests, only the centerline position was used. The remaining four injection locations were within a specified distance of the duct wall. For a nominally 12-in. diameter duct, the four wall injection locations are within 2.4 in. of the wall.

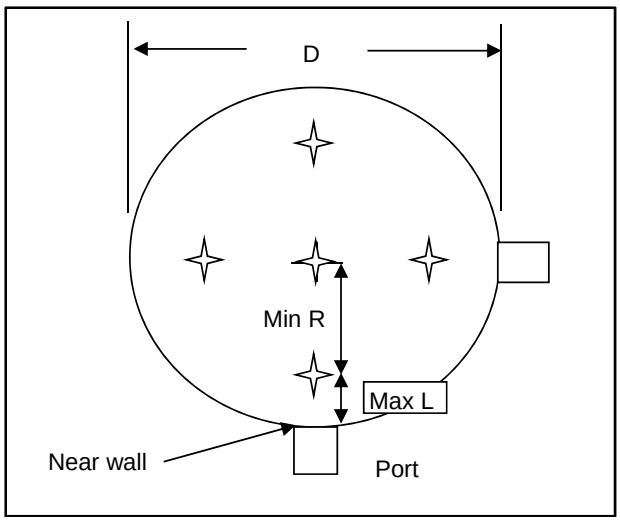


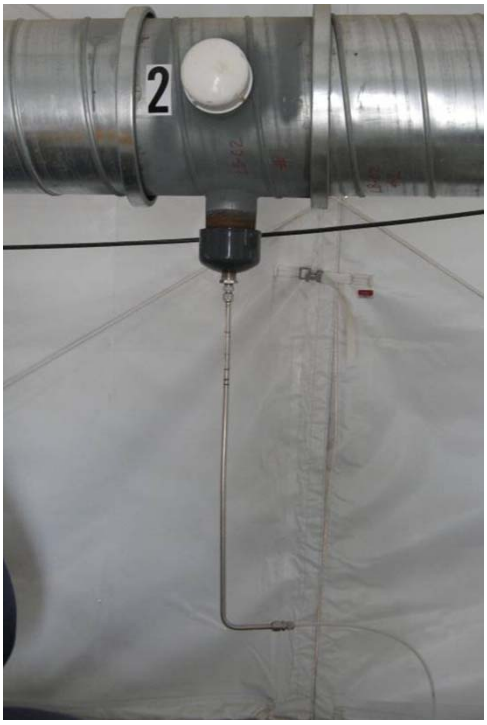
Figure 3.4. Illustration of Five Injection Points in a Circular Duct. Note: Max L is the maximum distance from the wall, which is 20 percent of the radius. Therefore, Min R, the minimum radius from the duct center, is 80 percent of the hydraulic radius. In the case of a round duct, the hydraulic diameter is equal to the physical diameter (D).

For each test run, the tracer concentration was read three times at each measurement point. The measured concentration for each point is the average of the three readings. These measured concentrations were used to calculate the overall mean, standard deviation, and %COV. These calculations were also performed just for the measurement points in the center two-thirds of the duct. The qualification criteria for the gaseous tracer test are that 1) the %COV should be ≤20 within the center two-thirds of the duct, and 2) the concentration at any measurement point should not deviate from the overall mean by more than 30 percent.

A photoacoustic gas analyzer (Brüel & Kjær, Model 1302, Ballerup, Denmark) was used to measure tracer gas concentrations. Because concentration variation is the important result for this test, calibration bias is not important. However, the analyzer response was checked against calibration standards before testing, on a weekly basis during testing, and after all tests were completed to verify adequate instrument response. The response was considered acceptable if the concentration from the instrument was within 10 percent of the calibration standard.

A simple probe was used to extract samples and deliver them to the gas analyzer. A small pump drew air from within the stack through the probe. The gas analyzer samples the air from the sample line for analysis.

Figure 3.6 shows the equipment setup for this test. Testing was conducted in accordance with EMS-JAG-01 and TI-WTPSP-100.



(a)

(b)

(c)

Figure 3.5. Equipment Used for the Gaseous Tracer Sampling: (a) example showing sampling probe installed in a port, (b) gas analyzer, and (c) sampling pump

3.2.4 Particle Tracer Uniformity

Particulate contaminant concentration uniformity was tested using polydisperse pump oil particles as a particle tracer. Vacuum pump oil was drawn into a spray nozzle (driven by compressed air) housed in a plastic chamber. The aerosol particles were injected into Injection Port 2 (downstream of the fans) as shown in Figure 3.6. Collectively, the plastic chamber and spray nozzle assembly are referred to as the aerosol generator. The aerosol was injected at the centerline of the duct. Some test runs were replicated to determine reproducibility.

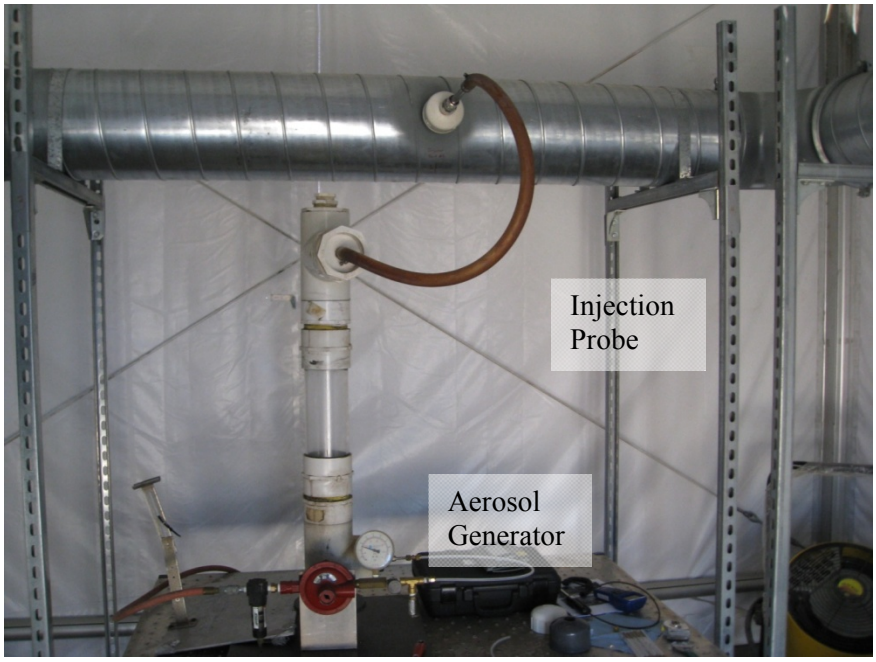


Figure 3.6. Equipment Used for Particle Injection

The concentration of the particles was measured at the sampling grid points with a calibrated optical particle counter (OPC, Hach, Met-One Model 3415, Loveland, Colorado). A simple probe was used to extract the sample and deliver it to the OPC. Figure 3.7a and b show the sampling setup with the sample probe connected to an OPC at the Particle Count Reference Port and Test Port 1, respectively. Figure 3.8 shows the sampling probe used. For the LB-S1 testing only the L-shaped probe was used. The OPC sorts the particles into eight size channels. As mentioned in Section 1.1, the particles of interest have an aerodynamic diameter of 10 μm. Therefore, only data in the 9- to 11-μm channel of the OPC were used.

The particle concentration was measured three times at each of the measurement points across the cross-section of the duct. The measured concentration for each point is the average of the three readings. From these measurements, the overall mean standard deviation and %COV were calculated for all of the points and also just for those within the center two-thirds of the duct. The qualification criterion for the particle tracer test is that the %COV should be ≤20 within the center two-thirds of the duct. Testing was conducted in accordance with EMS-JAG-02 and TI-WTPSP-101.

(a) (b)

Figure 3.7. Particle Counters Used for the Particle Sampling: (a) Reference Measurement Installed in Particle Count Reference Port, and (b) Sample Measurement Installed at Test Port 1

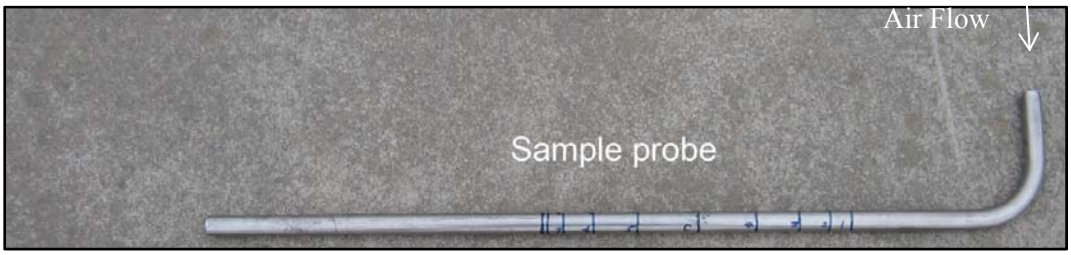


Figure 3.8. Sampling Probe Used for Particle Sampling

4.0 Stack Testing Results

This section summarizes the results of the stack testing activities for LB-S1. The primary, reportable results are the data and data calculations used to confirm that the requirements of the ANSI/HPS N13.1-1999 standard have been met. Independent reviews were performed to verify the data transcription and calculations. Calculations were performed using Microsoft Excel and documented in computer-assisted calculation packages (CCPs) in accordance with WTPSP procedures. The final data sheets are included in Appendix A. Tables summarizing test results are presented in the following sections.

4.1 LB-S1 Velocity Uniformity

Test results used to determine the fan frequency setting for the LB-S1 model are included in Appendix A.1. Table 4.1 lists the results for the velocity uniformity tests performed on the model LB-S1 stack (VT-1 through VT-20). In all cases the results were well within the criterion of %COV values ≤20. The mean velocity during testing ranged from 2573 to 4319 afpm (with corresponding flow rates of 2007 to 3375 scfm). The completed data sheets from these tests are included in Appendix A.2.

Table 4.1 also lists the targeted velocity range. The lower bound of the range meets both the Reynolds number and DV value criteria and the upper bound of the range corresponds to expected velocities in the stack under normal, maximum, and minimum flow conditions. The mean velocity tested was approximately 1 percent lower than the targeted range for fans AB, minimum flow conditions (i.e., VT-9 through VT-12). All other maximum, normal, and minimum flow conditions tested were within the targeted velocity range. The broader velocity range tested for fans AB met the %COV criteria. Further, the targeted velocity range was met with fans AC and BC, which also met the %COV criteria. The data, in totality, indicate the acceptability of the Test Port 1 location based on the velocity uniformity criteria.

The radial orientation of the test port in the actual LB-S1 stack had not been finalized as of this testing. To evaluate possible impacts due to changes in test port orientation, Runs V-19 and V-20 were conducted with the test port rotated 45°, which is the maximum possible angular deviation from the baseline. Table 4.1 indicates that V-19 and V-20 were in line with other measurements and well within 20 %COV. Therefore, changes in test port orientation are not expected to impact %COV and should not alter the conclusions of this report.

Table 4.2 summarizes the velocity uniformity %COV results as a function of operating fan and flow condition. In general, the %COV decreased with decreasing flow rate for all fan configurations, which is consistent with results for other stack configurations reported by Glissmeyer (2011). The %COV for fans AC are comparatively high for all flow conditions. This is likely an artifact of higher wind speeds during this testing (VT-13 through VT-15 were carried out in the same afternoon with wind speeds approaching the limit for testing). Nevertheless the %COV values are far below the qualification criterion of 20, regardless of any possible impacts due to wind speed. Results indicate that Test Port 1 is an acceptable location based on the %COV criterion.

Table 4.1. Summary of LB-S1 Velocity Uniformity Tests

Operating Fan(s)	Flow Condition	Run No.	Targeted Velocity (afpm)	Mean Velocity (afpm)	%COV
AB	Maximum (~120%)	VT-1	3816-4580	4274	5.9
		VT-2	3816-4580	4319	7.6
		VT-3	3816-4580	4154	5.2
		VT-4	3816-4580	4220	5.6
		VT-19[(a)]	3816-4580	4247	4.0
		VT-20[(a)]	3816-4580	4232	4.3
	Normal (100%)	VT-5	3187-3824	3596	3.9
		VT-6	3187-3824	3612	3.4
		VT-7	3187-3824	3585	4.2
		VT-8	3187-3824	3566	4.2
	Minimum (~83%)	VT-9	2647-3177	2573	3.5
		VT-10	2647-3177	2614	3.3
		VT-11	2647-3177	2614	3.3
		VT-12	2647-3177	2616	3.1
AC	Maximum (~120%)	VT-13	3816-4580	4210	7.2
		VT-14	3816-4580	4146	7.4
	Minimum (~83%)	VT-15	2647-3177	2939	6.4
BC	Maximum (~120%)	VT-16	3816-4580	4071	3.4
		VT-17	3816-4580	4221	4.0
	Minimum (~83%)	VT-18	2647-3177	2934	3.4

Similar test conditions are alternately shaded and unshaded.
(a) Test Port 1 was rotated 45 degrees.

Table 4.2. LB-S1 Velocity Uniformity (%COV) as a Function of Operating Fans and Nominal Flow Rate

Flow Rate Regime	Fan AB	Fan AC	Fan BC
Max (~120%)	6.1	7.3	3.7
Normal (100%)	3.9	--	--
Min (~83%)	3.3	6.4	3.4

Entries for a specific combination of flow regime and operating fans are average results from multiple tests when available; otherwise, the entries are the results from single tests. Although averaging is not the traditional statistical way to combine %COV values, it suffices for data summary purposes.

4.2 LB-S1 Flow Angle

Table 4.3 lists the results for the flow angle tests performed on the model LB-S1 stack. Results for all tests were well within the criterion of mean flow angle values ≤20°. Overall, mean absolute flow angle ranged between 3 and 7°. Individual mean flow angle measurements from specific locations were more

variable ranging between -14 and +19°. Each measurement point was measured three times with an average standard deviation of 1.7°. The standard deviation is an indication of the precision in the flow angle measurement as well as the actual variability within the stack at a particular point. Run FA-10 had the highest uncertainty in individual measurements with a standard deviation of 4.6°, almost 3 times the average. Winds during this test approached 18 mph. FA-10 conditions were repeated (with lighter wind conditions) in FA-11 and FA-12 and the standard deviation at each measurement point decreased to near the average (1.9 and 1.7°, respectively).

Table 4.3. Summary of LB-S1 Flow Angle Tests

Operating Fans	Flow Regime	Run No.	Approximate Air Velocity (sfpm)	Mean Absolute Flow Angle **(°)**
AB	Maximum (~120%)	FA-1	4407	5.2
		FA-2	4573	5.2
		FA-10[(a)]	4273	4.7
		FA-11[(a)]	4324	3.5
		FA-12[(a)]	4257	4.2
	Normal (100%)	FA-3	3789	5.9
		FA-4	3820	6.6
	Minimum (~83%)	FA-5	3140	5.7
		FA-6	2931	6.8
AC	Maximum (~120%)	FA-7	4361	6.9
		FA-8	4468	6.4
BC	Maximum (~120%)	FA-9	4455	6.0

Similar test conditions are alternately shaded and unshaded.
(a) Test Port 1 was rotated 45 degrees.

The radial orientation of the test port in the actual LB-S1 stack had not been finalized as of this testing. To evaluate possible impacts due to changes in test port orientation, FA-10, FA-11, and FA-12 were conducted with the test port rotated 45°, which is the maximum possible angular deviation from the baseline. Table 4.3 indicates that the flow angles were in line with other measurements and well within the qualification criterion of ≤20°. Therefore, changes in test port orientation are not expected to impact flow angle and should not alter the conclusions of this report.

Table 4.4 summarizes the flow angle results at the flow regimes tested for each of the three fan configurations. Results indicate that the Test Port 1 is an acceptable location based on the flow angle criterion. The completed data sheets from these tests are available in Appendix A.3.

Table 4.4. LB-S1 Mean Flow Angle (°) at Three Flow Regimes as a Function of Operating Fan

Flow Rate Regime	Fan AB	Fan AC	Fan BC
Max (~120%)	4.6	6.7	6.0
Normal (100%)	6.3	--	--
Min (~83%)	6.3	--	--

Entries for a specific combination of flow regime and fans are average results from multiple tests when available; otherwise, the entries are the results from single tests.

4.3 LB-S1 Gaseous Tracer Uniformity

Table 4.5 lists the results for the gaseous tracer uniformity tests performed on the model LB-S1 stack for Test Port 1 and the tracer injection at Injection Port 2. In all cases, the tracer was well mixed, with results well within the criteria of %COV values ≤20 and absolute values of maximum deviation ≤30 percent. The %COV values ranged from 1.0 to 7.3. The absolute value of the maximum deviation from the mean ranged from 2.0 to 14.9 percent. The completed data sheets from these tests are available in Appendix A.4.

Table 4.5. Summary of LB-S1 Gas Tracer Uniformity Tests

Fans	Injection Port	Test Port	Injections Position	Run Nos.	Target Avg. (fpm)	Approximate Air Velocity (afpm)	% COV	Abs % Max Deviation from Mean
AB Max	2	1	Center	GT-13	3816-4580	4368	2.2	4.3
			Far	GT-14		4379	3.7	7.4
			Near	GT-15		4376	3.8	6.3
			Bottom	GT-16		4384	5	8.4
			Top	GT-17		4166	5	11.1
AB Normal	2	1	Top	GT-18	3187-3824	3686	4.8	11.5
			Center	GT-19		3670	3	5.5
			Far	GT-20		3644	3.8	7.7
			Near	GT-21		3681	5.2	10.9
			Bottom	GT-22		3691	5.3	9.3
AB Min	2	1	Bottom	GT-23	2647-3177	2859	7.3	14.9
			Center	GT-24		2924	2.5	5.5
			Center	GT-25		2952	3.6	6.1
			Far	GT-26		2964	4.6	8.8
			Near	GT-27		2923	3.5	11.9
			Top	GT-28		2915	3.6	10.9
AC Max	2	1	Center	GT-7	3816-4580	4491	1.0	2.0
			Far	GT-8		4358	1.7	4
			Near	GT-9		4523	1.8	4.4
			Bottom	GT-10		4486	2.9	6.5
			Top	GT-11		4477	1.4	2.9
AC Min	2	1	Center	GT-12	2647-3177	3058	1.6	3.5
BC Max	2	1	Center	GT-1	3816-4580	4386	3.4	7
			Far	GT-2		4398	5.2	12.4
			Near	GT-3		4324	3.6	10
			Bottom	GT-5		4246	6.4	13.4
			Top	GT-4		4332	5.4	9.9
BC Min	2	1	Center	GT-6	2647-3177	3005	3.5	9.9
AB Min repeats	2	1	Bottom	GT-29	2647-3177	2952	5.9	14.2
			Bottom	GT-30		2933	4.6	11.6
AB Min 45 deg offset	2	1	Bottom	GT-31	2647-3177	2904	4.1	11.6
			Bottom	GT-32		2903	5.3	9.1

Figure 4.1 and 4.2 show gas tracer %COV and %maximum deviation from mean, respectively, plotted as a function of operating fans and gas injection location. The plots have similar trends and indicate a correlation between the criteria. Regardless of operating fan, the center injection point had the

least %COV indicating best mixing from a center injection location. Off-center injection points had higher %COV with the bottom injection point having the highest. Fan speed did not significantly impact these trends. Regardless of tracer gas injection location, the gas tracer %COV results were all well below the limit of 20 %COV and the percent absolute value of the deviation from the mean was well below the limit of 30 percent. Results indicate that the Test Port 1 is an acceptable location based on the criterion for gaseous tracers.

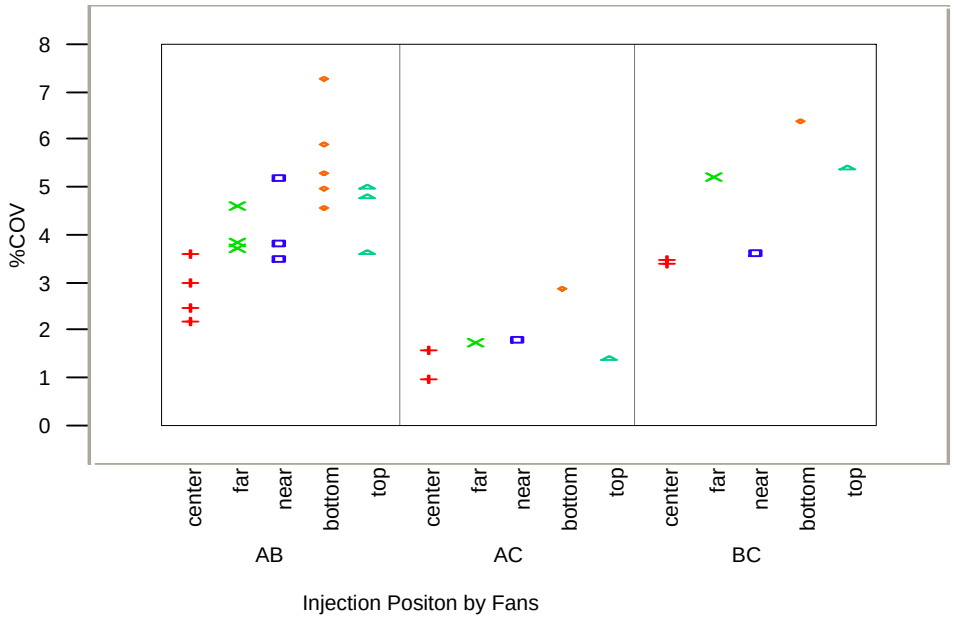


Figure 4.1. Gas Tracer %COV Displayed as a Function of Injection Location and Operating Fans

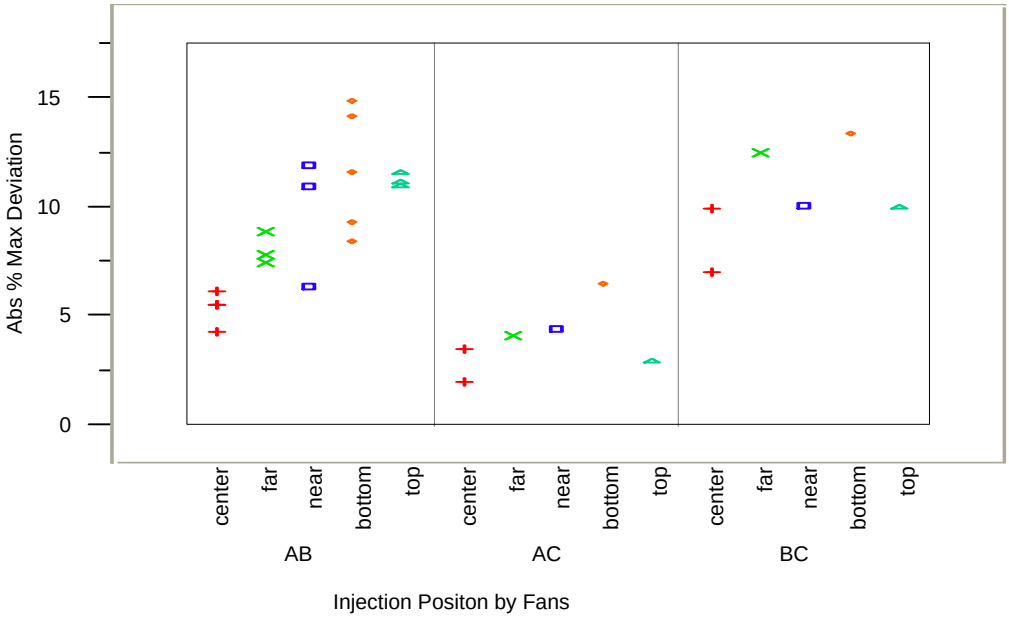


Figure 4.2. Absolute Value of the Maximum Deviation Displayed as a Function of Injection Location and Operating Fans

4.4 LB-S1 Particle Tracer Uniformity

Table 4.6 lists the results for the particle tracer uniformity tests performed on the scale model LB-S1 stack. Tests were conducted with two fans running simultaneously. The completed data sheets from these tests are available in Appendix A.5.

Table 4.6. Summary of LB-S1 Particle Tracer Uniformity Tests

Operating Fans	Injection Port & Location	Test Port	Flow Condition	Run No.	Approximate Air Velocity (sfpm)	%COV	Normalized %COV
AB	2 Center	1	Max	PT-3	4399	12.4	11.1
		1	Max	PT-4	4477	7.8	9.2
		1	Max	PT-5	4469	13.9	10.1
		1	Norm	PT-6	3633	17.6	7.3
		1	Min	PT-7	3089	13.8	11.4
AC	2 Center	1	Max	PT-2	4392	11.3	10.2
BC	2 Center	1	Max	PT-1	4364	13.8	14.1
	1 Center	1	Max	PT-8	4564	19.2	9.7

Similar test conditions are alternately shaded and unshaded.

Previous testing has shown that particle concentration measurements were usually higher through the bottom port (Glissmeyer et al 2011, 2012). Troubleshooting was unsuccessful in determining a consistent cause for this behavior. However, to mitigate errors, the concentration bias encountered between the two traverse directions at the measurement ports was removed by adjusting the data from the traverse with the lower concentration upward by a factor to match the concentrations at the center of the duct (the common point between the two traverses). These results were then termed "normalized." Figure 4.3 provides an example of variability in the aerosol production and a systematic bias between the bottom and side port measurements. The result of normalization is also illustrated in Figure 4.3 for PT-8 with side traverse data adjusted up by a factor of 1.4.

Table 4.6 shows the %COV values both with and without normalization. The %COV values ranged from 7.8 to 19.2. Although data normalization was not necessary to meet the criteria, the normalized data better match the reference data and the bottom data. This suggests that there is a sampling bias introduced when sampling through the side. Because there is no reason to suspect an actual bias in the horizontal versus vertical traverse, the normalized data are believed to better represent the actual variability and are the reported test results. Normalized %COV ranged from 7.3 to 14.1. In all cases, the results were within the criteria of %COV values ≤20. Results indicate that the Test Port 1 is an acceptable location based on the criterion for particle tracers.

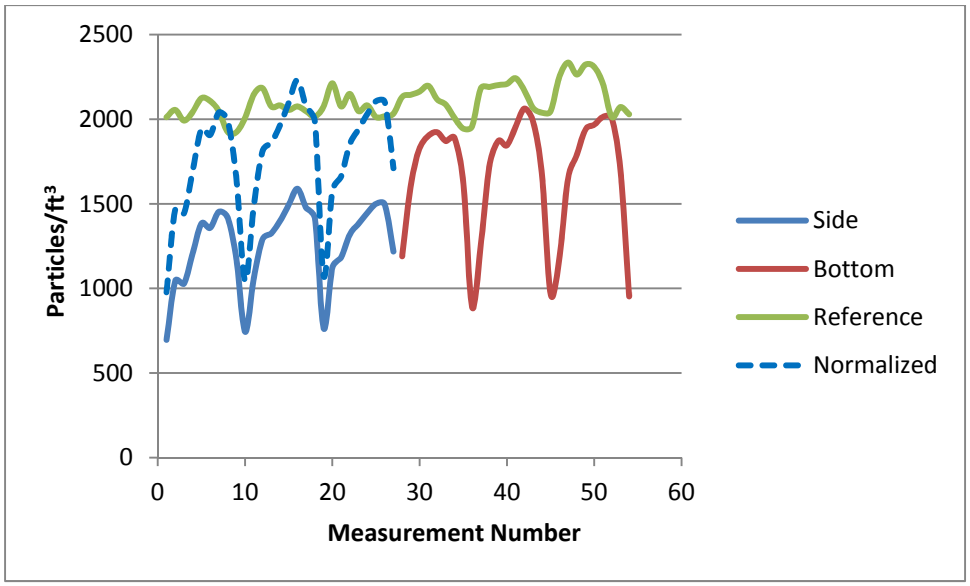


Figure 4.3. Measurement and Reference Particle Test Data from PT-8 on the LB-S1 Stack. The side and bottom lines represent measurement traverses from the side and bottom of Test Port 1, while the reference line represents the concentration at the center point of the Reference Port. This plot is an example of variability in the aerosol production and a systematic bias between the bottom and side port measurements. Normalized data are shown with dotted line. The data collected from the side port have been adjusted up by a factor of 1.4.

5.0 Conclusions

The results of the tests for the LB-S1 model are summarized in Table 5.1. The criteria for sampling probe locations given in ANSI/HPS N13.1-1999 were met in all cases. These criteria address the capability of the sampling probe to extract a sample that represents the effluent stream. Based on these scale model tests, WTP's proposed sampling location for LB-S1 simulated by Test Port 1 meets the air sampling probe requirements of the ANSI/HPS N13.1-1999 standard.

Table 5.1. Summary of Results for the LB-S1 Scale Model Stack

	Acceptance Criteria	Units	LB-S1
Velocity Uniformity	≤20	%COV	3.1–7.6
Flow Angle	≤20	Degrees	3.5–6.9
Gas Tracer Uniformity	≤20	%COV	1.0–7.3
	≤30	Maximum % Deviation from Mean	2.0–14.9
Particle Tracer Uniformity	≤20	%COV	7.3–14.1

The radial orientation of Test Port 1 had not been finalized in the actual LB-S1 stack as of this testing. Velocity uniformity and flow angle tests were conducted with the test port rotated 45°, which is the maximum possible angular deviation from the baseline. Results from these tests were in line with other measurements. Therefore, any change in test port radial orientation in the actual stack should not change the conclusions of this qualification testing.

According to the ANSI standard, velocity uniformity and flow angle tests on the actual stacks will be necessary during cold startup to confirm the validity of the scale model results in representing the actual stacks. Specifically the standard requires that the velocity uniformity test results for the actual stacks must be within 5 %COV of the range of results listed above for the scale model so that scale model results can be said to be representative of the stack. For example, if the actual LB-S1 stack sampling probe is located in a position corresponding to Test Port 1, the measured velocity uniformity %COV should be between 0.0 and 12.6 %COV (non-negative value for 3.1 – 5 = 0.0 and 7.6 + 5 = 12.6). The velocity uniformity test results summarized in Table 5.1 cover a range of flow conditions which are expected to bracket the conditions of the actual stack. For cold startup tests, the DV value and Reynolds number should meet the criteria listed in Section 1 (i.e., DV within a factor of six and Reynolds number >10,000). The velocity uniformity acceptance range would be constructed using the scale model results that correspond to the probe location and fan operating conditions present during the test on the actual stack.

6.0 References

10 CFR 830, Subpart A. "Quality Assurance Requirements," *Code of Federal Regulations,* U.S. Department of Energy, January 10, 2001.

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, NY.

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

DOE Order 414.1D. "Quality Assurance." U.S. Department of Energy, April 25, 2011.

Glissmeyer JA, JE Flaherty, and GF Piepel. 2011. *Assessment of the Group 5-6 (LB-C2, LB-S2, LV-S1) Stack Sampling Probe Locations for Compliance with ANSI/HPS N13.1-1999*. PNNL-20154, WTP-RPT-209, Pacific Northwest National Laboratory, Richland, Washington.

Glissmeyer JA, JE Flaherty, and EJ Antonio. 2012. *Assessment of the Group 3-4 (HV-S1, HV-S2, IHLW-S1) Stack Sampling Probe Locations for Compliance with ANSI/HPS N13.1-1999.* PNNL-21998, WTP-RPT-224, Pacific Northwest National Laboratory, Richland, Washington.

Appendix A

LB-S1 Data Sheets

Appendix A.1: LB-S1 Calibration of Ventilation Flow Controller Data Sheets

VELOCITY TRAVERSE DATA FORM

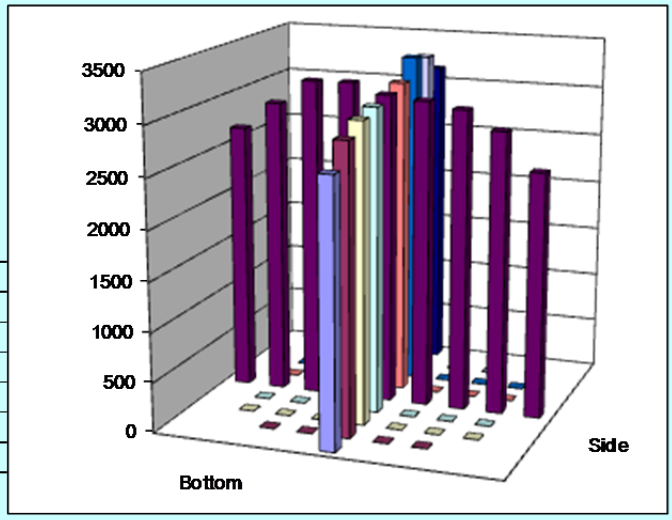
Site	LB-S1 Model	Run No.	FC-1
Date	10/11/12	Fan Configuration	AB
Testers	JEF, CA	Fan Setting	32.1 Hz
Stack Dia.	11.8906 in.	Stack Temp	76.9 deg F
Stack X-Area	111.0 in.2	Start/End Time	15:40 / 16:20
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Velocity units	std. ft/min	Data Files:	NA

Order -->		2nd				1st			
Traverse-->		Side				Bottom			
Trial -->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	Velocity				Velocity			
1	0.50	2089	2581	2708	2459.3	2454	2423	2458	2445.0
2	1.25	2756	2817	2930	2834.3	2690	2663	2637	2663.3
3	2.31	2937	3037	3077	3017.0	2785	2762	2761	2769.3
4	3.84	3056	3085	3091	3077.3	2823	2825	2819	2822.3
Center	5.95	3095	3146	3099	3113.3	2859	2865	2880	2868.0
5	8.05	3196	3207	3234	3212.3	2909	2932	2915	2918.7
6	9.58	3289	3084	3243	3205.3	3255	3083	2957	3098.3
7	10.64	3273	2441	3166	2960.0	3174	3029	2953	3052.0
8	11.39	3004	2011	3036	2683.7	2877	2940	2852	2889.7
Averages -->		2966.1	2823.2	3064.9	2951.4	2869.6	2835.8	2803.6	2836.3

All	ft/min	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	2893.9		Mean	3060.0	2884.6	2972.3
Min Point	2445.0	-15.5%	Std. Dev.	135.6	153.4	166.2
Max Point	3212.3	11.0%	COV as %	4.4	5.3	5.6

Flow w/o C-Pt	2222 scfm	Instuments Used:	Cal Due
Vel Avg w/o C-Pt	2882 sfpm	TSI VelociCalc S/N T95351203001	01/12/13
		Fisher Scientific S/N 90936818	12/7/2012

	Start	Finish	
Stack temp	77.7	76.1	F
Equipment temp	N/A	N/A	F
Ambient temp	75.2	75.2	F
Stack static	N/A	N/A	mbars
Ambient pressure	29.56	29.53	in Hg
Total Stack pressure	N/A	N/A	mbars
Ambient humidity	26%	27%	RH



Notes: Bottom 8 is the sweet spot.

CA 10/11/12

Entries made by:	Carmen Arimescu	10/11/2012	Technical Data Review performed by:		
Signature/date			Signature/date	GBJ	10/18/2012

VELOCITY TRAVERSE DATA FORM

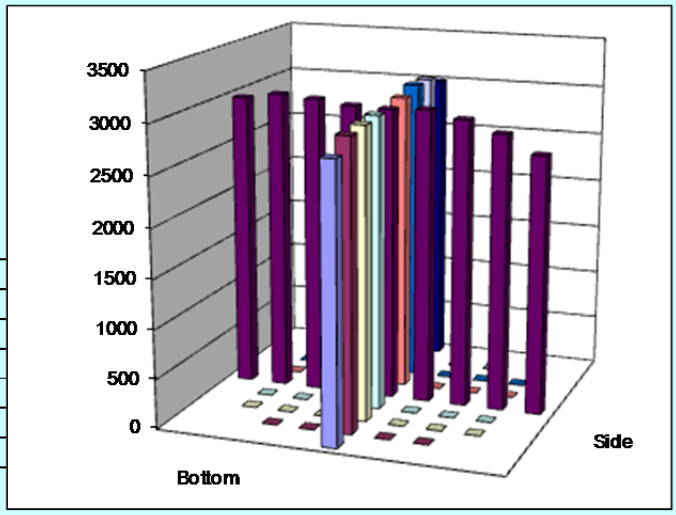
Site	LB-S1 Model	Run No.	FC-2
Date	10/15/12	Fan Configuration	AC
Testers	EA, CA	Fan Setting	32.1 Hz
Stack Dia.	11.8906 in.	Stack Temp	73.0 deg F
Stack X-Area	111.0 in.2	Start/End Time	11:15/11:45
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Velocity units	std. ft/min	Data Files:	NA

Order -->		2nd				1st			
Traverse-->		Side				Bottom			
Trial -->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	Velocity				Velocity			
1	0.50	2564	2619	2657	2613.3	2749	2766	2744	2753.0
2	1.25	2759	2735	2892	2795.3	2896	2862	2909	2889.0
3	2.31	2877	2861	2994	2910.7	2922	2921	2911	2918.0
4	3.84	2911	2940	3099	2983.3	2976	2910	2926	2937.3
Center	5.95	2881	2923	3084	2962.7	2955	2910	2916	2927.0
5	8.05	2958	2920	3048	2975.3	2985	2980	2962	2975.7
6	9.58	2991	2988	3075	3018.0	3046	3056	3025	3042.3
7	10.64	3026	3046	3057	3043.0	3026	3036	3046	3036.0
8	11.39	2970	2992	2993	2985.0	2952	2963	2959	2958.0
Averages ---------->		2881.9	2891.6	2988.8	2920.7	2945.2	2933.8	2933.1	2937.4

All	ft/min	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	2929.1		Mean	2955.5	2960.8	2958.1
Min Point	2613.3	-10.8%	Std. Dev.	82.1	59.4	68.9
Max Point	3043.0	3.9%	COV as %	2.8	2.0	2.3

Flow w/o C-Pt	2257 scfm	Instuments Used:	Cal Due
Vel Avg w/o C-Pt	2927 sfpm	TSI VelociCalc S/N T95351203001	01/12/13
		Fisher Scientific S/N 90936818	12/7/2012

	Start	Finish	
Stack temp	72	74	F
Equipment temp	N/A	N/A	F
Ambient temp	70.7	73.4	F
Stack static	N/A	N/A	mbars
Ambient pressure	29.56	29.56	in Hg
Total Stack pressure	N/A	N/A	mbars
Ambient humidity	40%	46%	RH



Notes: Center is the sweet spot.

CA 10/15/12

Entries made by:	Carmen Arimescu	10/15/2012	Technical Data Review performed by:
Signature/date			Signature/date GBJ 10/18/2012

VELOCITY TRAVERSE DATA FORM

Site	LB-S1 Model	Run No.	FC-3
Date	10/16/12	Fan Configuration	BC
Testers	EA, CA	Fan Setting	32 Hz
Stack Dia.	11.8906 in.	Stack Temp	64.5 deg F
Stack X-Area	111.0 in.2	Start/End Time	930/954
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Velocity units	std. ft/min	Data Files:	NA

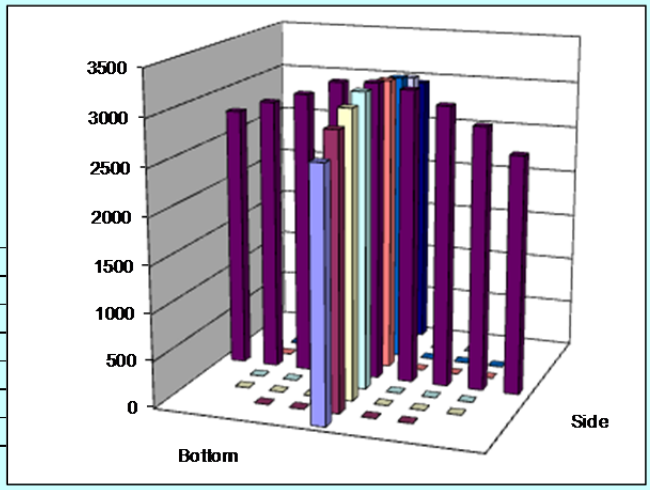
Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial -->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	Velocity				Velocity			
1	0.50	2550	2554	2516	**2540.0**	2553	2536	2559	**2549.3**
2	1.25	2871	2781	2779	**2810.3**	2732	2790	2828	**2783.3**
3	2.31	3171	2917	2901	**2996.3**	2903	2903	2948	**2918.0**
4	3.84	3350	3030	3029	**3136.3**	3005	2967	3065	**3012.3**
Center	5.95	3379	3109	3072	**3186.7**	3003	3018	3089	**3036.7**
5	8.05	3440	3062	3016	**3172.7**	2987	3005	3011	**3001.0**
6	9.58	3012	3052	3000	**3021.3**	2963	2934	3004	**2967.0**
7	10.64	2934	2912	2891	**2912.3**	2905	2921	2908	**2911.3**
8	11.39	2803	2800	2758	**2787.0**	2803	2763	2823	**2796.3**
Averages ---->		**3056.7**	**2913.0**	**2884.7**	**2951.4**	**2872.7**	**2870.8**	**2915.0**	**2886.1**

All	ft/min	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	2918.8		Mean	3033.7	2947.1	2990.4
Min Point	2540.0	-13.0%	Std. Dev.	141.1	86.1	121.0
Max Point	3186.7	9.2%	COV as %	4.7	2.9	4.0

Flow w/o C-Pt	2232	scfm	
Vel Avg w/o C-Pt	2895	sfpm	

Instuments Used:	Cal Due
TSI VelociCalc S/N T95351203001	01/12/13
Fisher Scientific S/N 90936818	12/7/2012

	Start	Finish	
Stack temp	65	64	F
Equipment temp	N/A	N/A	F
Ambient temp	67	65.3	F
Stack static	N/A	N/A	mbars
Ambient pressure	29.47		in Hg
Total Stack pressure	N/A	N/A	mbars
Ambient humidity	34%	36%	RH



Notes:

CA 10/16/12

Entries made by:	Carmen Arimescu	10/16/2012	Technical Data Review performed by:		
Signature/date			Signature/date	gbj	10/18/2012

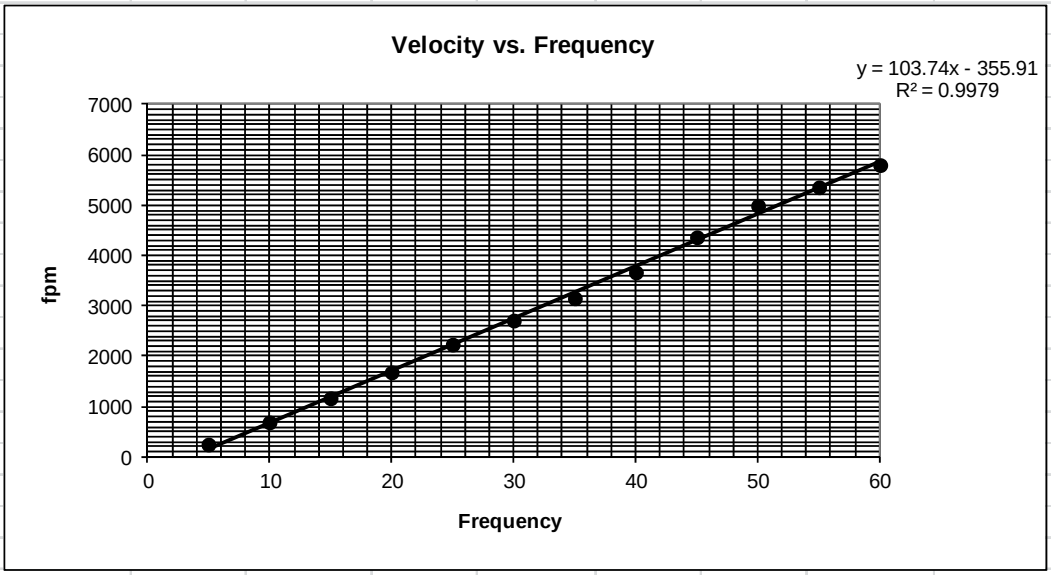
VELOCITY vs. FREQUENCY DATA FORM

Site	**LB-S1 model**		Run No.	**VF-1**	
Date	10/11/2012		Stack Temp	75.3	
Tester	CA,JEF		Ambient RH%	29%	
Stack Dia.	11.8906	in.	Ambient Press	29.53	in Hg
Stack X-Area	111.0	in2	Fan Configuration	AB	
Test Port	1		Start/End Time	1647/1810	
Dist. from disturbance	123.5	inches	Reference point from velocity test VC :		Bottom 8
Velocity Readings, units =		fpm			

Target cfm	Target fpm	Estmtd Hz	
2960	3816	40.2	max
2472	3187	34.2	normal
2053	2647	28.9	min

	fpm						
Hz	1	2	3	Mean	StDev	2 StDev	cfm
5	248	263	253	254.7	7.6	15.3	196.4
10	694	725	700	706.3	16.4	32.9	544.7
15	1137	1183	1168	1162.7	23.5	46.9	896.6
20	1656	1682	1681	1673.0	14.7	29.5	1290.1
25	2356	2181	2188	2241.7	99.1	198.2	1728.6
30	2693	2750	2754	2732.3	34.1	68.2	2107.0
35	3146	3199	3142	3162.3	31.8	63.6	2438.6
40	3736	3605	3684	3675.0	66.0	131.9	2834.0
45	4770	4157	4230	4385.7	334.8	669.7	3382.0
50	5136	5060	4814	5003.3	168.3	336.6	3858.3
55	5615	5271	5249	5378.3	205.3	410.5	4147.5
60	5867	5854	5711	5810.7	86.6	173.1	4480.9

Instuments Used:	**Cal Exp. Date:**
TSI VelociCalc S/N T95351203001	01/12/13
Fisher Scientific S/N 90936818	12/7/2012



Entries made by:	Carmen Arimescu	Technical Data Review performed by:	
Signature/date	10/11/2012	Signature/date GBJ	10/18/2012

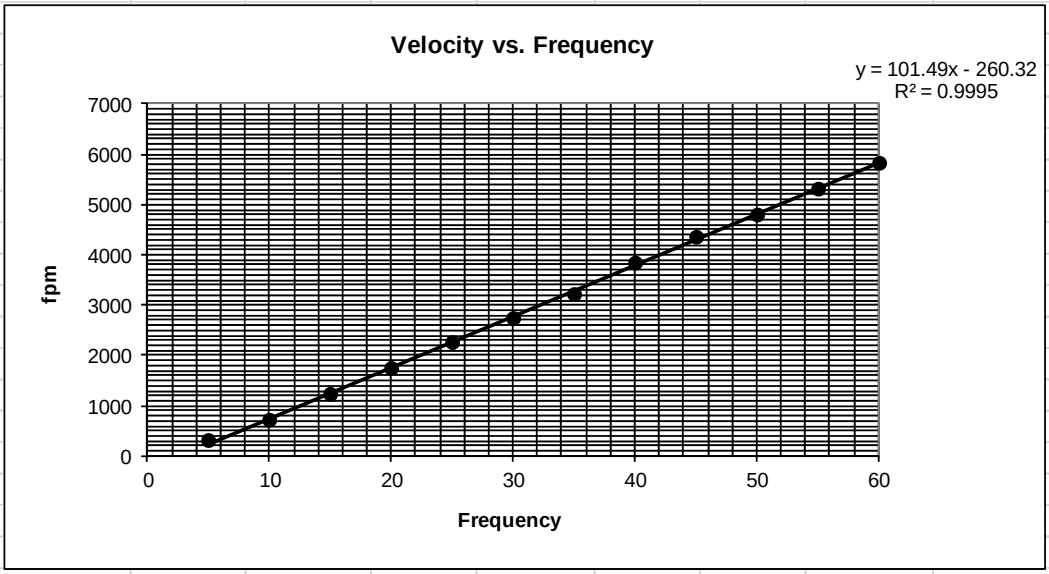
VELOCITY vs. FREQUENCY DATA FORM

Site	LB-S1 model		Run No.	VF-2	
Date	10/15/2012		Stack Temp	77	
Tester	CA, XY		Ambient RH%	38%	
Stack Dia.	11.8906	in.	Ambient Press	29.53	in Hg
Stack X-Area	111.0	in2	Fan Configuration	AC	
Test Port	1		Start/End Time	1:00/209	
Dist. from disturbance	123.5	inches	Reference point from velocity test VC :		Bottom Cente
Velocity Readings, units =		fpm			

Target cfm	Target fpm	Estmtd Hz	
2960	3816	40.2	max
2472	3187	34.0	normal
2053	2647	28.6	min

	fpm						
Hz	1	2	3	Mean	StDev	2 StDev	cfm
5	346	308	335	329.7	19.6	39.1	254.2
10	736	772	735	747.7	21.1	42.2	576.6
15	1242	1238	1220	1233.3	11.7	23.4	951.1
20	1737	1726	1762	1741.7	18.4	36.9	1343.1
25	2276	2261	2236	2257.7	20.2	40.4	1741.0
30	2725	2746	2777	2749.3	26.2	52.3	2120.1
35	3273	3175	3243	3230.3	50.2	100.4	2491.0
40	3779	3790	3939	3836.0	89.4	178.7	2958.1
45	4426	4299	4343	4356.0	64.5	129.0	3359.1
50	4869	4800	4803	4824.0	39.0	78.0	3720.0
55	5323	5304	5294	5307.0	14.7	29.5	4092.5
60	5902	5796	5840	5846.0	53.3	106.5	4508.1

Instuments Used:	**Cal Exp. Date:**
TSI VelociCalc S/N T95351203001	01/12/13
Fisher Scientific S/N 90936818	12/7/2012



Entries made by:	Carmen Arimescu	Technical Data Review performed by:	
Signature/date	10/15/2012	Signature/date GBJ	10/18/2012

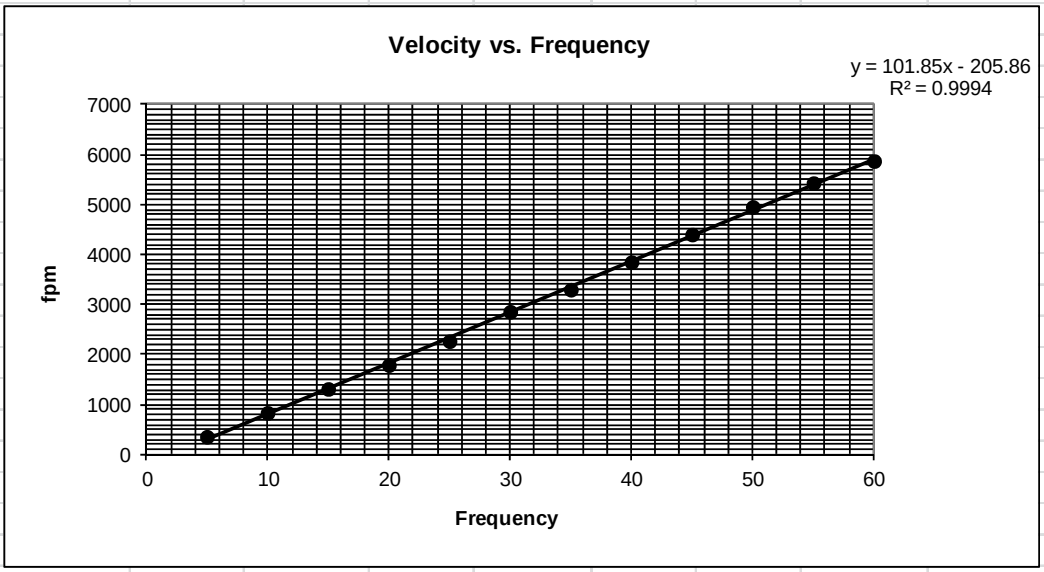
VELOCITY vs. FREQUENCY DATA FORM

Site	**LB-S1 model**	Run No.	**VF-3**		
Date	10/16/2012	Stack Temp	67		
Tester	EA, CA	Ambient RH%	35%		
Stack Dia.	11.8906 in.	Ambient Press	29.47	in Hg	
Stack X-Area	111.0 in2	Fan Configuration	BC		
Test Port	1	Start/End Time	1000/1045		
Dist. from disturbance	123.5 inches	Reference point from velocity test VC :		Bttom 7	
Velocity Readings, units =	fpm				

	Target cfm	Target fpm	Estmtd Hz	
	2960	3816	39.5	max
	2472	3187	33.3	normal
	2053	2647	28.0	min

	fpm						
Hz	1	2	3	Mean	StDev	2 StDev	cfm
5	324	362	391	359.0	33.6	67.2	276.8
10	851	839	825	838.3	13.0	26.0	646.5
15	1385	1271	1274	1310.0	65.0	129.9	1010.2
20	1860	1697	1807	1788.0	83.1	166.3	1378.8
25	2373	2233	2234	2280.0	80.5	161.1	1758.2
30	2934	2845	2782	2853.7	76.4	152.7	2200.6
35	3441	3194	3292	3309.0	124.4	248.7	2551.7
40	3969	3832	3791	3864.0	93.2	186.4	2979.7
45	4508	4343	4353	4401.3	92.5	185.0	3394.1
50	5055	4868	4971	4964.7	93.7	187.3	3828.5
55	5473	5412	5372	5419.0	50.9	101.7	4178.8
60	5881	5815	5899	5865.0	44.2	88.5	4522.8

Instuments Used:	**Cal Exp. Date:**
TSI VelociCalc S/N T95351203001	01/12/13
Fisher Scientific S/N 90936818	12/7/2012



Entries made by: Carmen Arimescu	Technical Data Review performed by:
Signature/date 10/16/2012	Signature/date GBJ 10/18/12

Appendix A.2: LB-S1 Velocity Uniformity Data Sheets

VELOCITY TRAVERSE DATA FORM

Site	LB-S1 Model	Run No.	VT-1
Date	10/12/2012	Fan Configuration	AB
Testers	XY, CA	Fan Setting	44 Hz
Stack Dia.	11.8906 in.	Stack Temp	63 deg F
Stack X-Area	111.0 in.2	Start/End Time	920AM/1006
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Velocity units	std. ft/min	Data Files:	NA

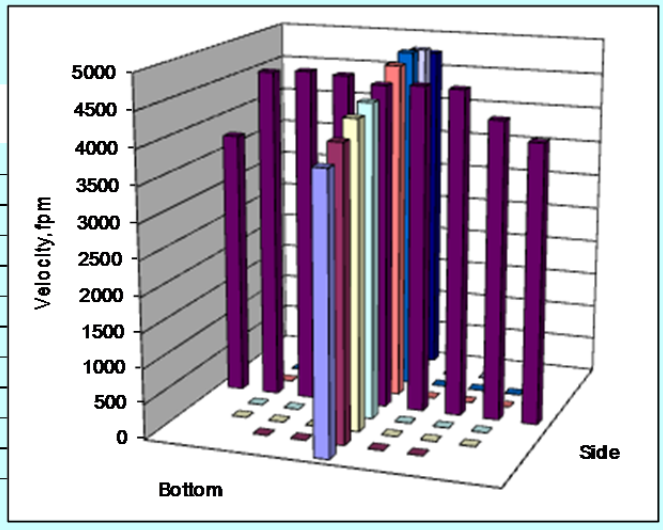
Order -->		2nd				1st			
Traverse-->		Side				Bottom			
Trial -->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	Velocity				Velocity			
1	0.50	3972	3858	4062	**3964.0**	3694	3700	3640	**3678.0**
2	1.25	4353	4206	4134	**4231.0**	3854	3903	3916	**3891.0**
3	2.31	4811	4637	4394	**4614.0**	4082	4116	4065	**4087.7**
4	3.64	4397	4737	4748	**4627.3**	4165	4199	4226	**4196.7**
Center	5.95	4695	4658	4468	**4607.0**	4309	4376	4311	**4332.0**
5	8.05	4793	4740	4587	**4706.7**	4477	4447	4591	**4505.0**
6	9.58	4547	4791	4863	**4733.7**	4645	4598	4562	**4601.7**
7	10.64	4556	4738	4788	**4694.0**	4521	4573	4598	**4564.0**
8	11.39	3001	3853	4405	**3753.0**	4544	4340	4463	**4449.0**
Averages ---------->		**4347.2**	**4468.7**	**4494.3**	**4436.7**	**4254.6**	**4250.2**	**4263.6**	**4256.1**

All	std.ft/min	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	4346.4		Mean	4602.0	4311.1	4456.5
Min Point	3678.0	-15.4%	Std. Dev.	170.9	266.4	262.7
Max Point	4733.7	8.9%	COV as %	3.7	6.2	5.9

Flow w/o C-Pt	3340 scfm
Vel Avg w/o C-Pt	4331 sfpm

Instuments Used:	Cal Due
Fisher Scientific Barometer SN 90936818	12/7/2012
TSI VelociCalc SN T95351203001	1/17/2013

	Start	Finish	
Stack temp	64.1	61.4	F
Ambient temp	61.7	61.7	F
Ambient pressure	29.44	29.44	in Hg
Ambient humidity	43%	43%	RH



Notes: Bottom #8 4464 fpm

CA 10/12/12

Entries made by:	Carmen Arimescu	10/12/12
Signature/date		

Technical Data Review performed by:		
Signature/date	gbj	10/22/2012

VELOCITY TRAVERSE DATA FORM

Site	LB-S1 Model	Run No.	VT-2
Date	10/12/2012	Fan Configuration	AB
Testers	XY, CA	Fan Setting	44 Hz
Stack Dia.	11.8906 in.	Stack Temp	63 deg F
Stack X-Area	111.0 in.2	Start/End Time	1006/1036
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Velocity units	std. ft/min	Data Files:	NA

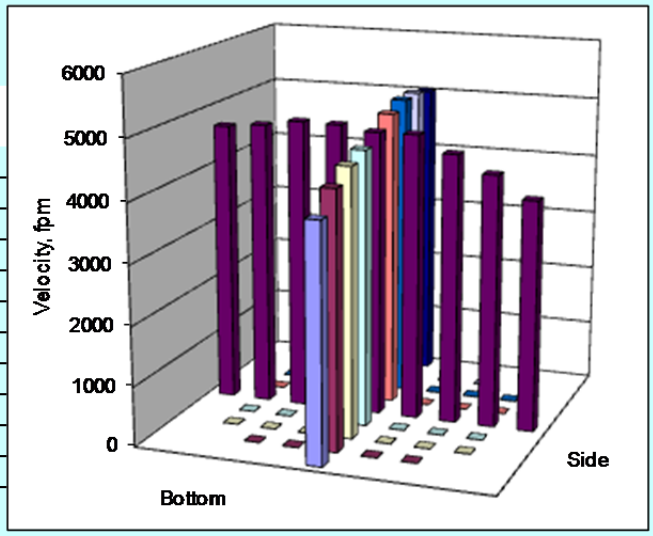
Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial -->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	Velocity				Velocity			
1	0.50	3888	3882	3814	**3861.3**	3577	3456	3503	**3512.0**
2	1.25	4285	4151	4250	**4228.7**	3813	3833	3806	**3817.3**
3	2.31	4572	4434	4537	**4514.3**	4029	3994	3994	**4005.7**
4	3.64	4889	4690	4787	**4788.7**	4095	4133	4123	**4117.0**
Center	5.95	4808	4776	4765	**4783.0**	4227	4243	4313	**4261.0**
5	8.05	4792	4899	4897	**4862.7**	4300	4470	4504	**4424.7**
6	9.58	4890	4839	4893	**4874.0**	4410	4597	4595	**4534.0**
7	10.64	4868	4850	4591	**4769.7**	4437	4509	4676	**4540.7**
8	11.39	4729	4667	4728	**4708.0**	4367	4508	4541	**4472.0**
Averages ---------->		**4635.7**	**4576.4**	**4584.7**	**4598.9**	**4139.4**	**4193.7**	**4228.3**	**4187.1**

All	std ft/min	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	4393.0		Mean	4688.7	4242.9	4465.8
Min Point	3512.0	-20.1%	Std. Dev.	235.3	276.9	338.3
Max Point	4874.0	10.9%	COV as %	5.0	6.5	7.6

Flow w/o C-Pt	3375 scfm
Vel Avg w/o C-Pt	4377 sfpm

Instuments Used:	Cal Due
Fisher Scientific Barometer SN 90936818	12/7/2012
TSI VelociCalc SN T95351203001	1/17/2013

	Start	Finish	
Stack temp	61.4	64.2	F
Ambient temp	61.7	63.5	F
Ambient pressure	29.44	29.47	in Hg
Ambient humidity	43%	43%	RH



Notes: Bottom #8 4261 fpm

CA 10/12/12

Entries made by: Carmen Arimescu 10/12/12
Signature/date

Technical Data Review performed by:
Signature/date gbj 10/22/2012

VELOCITY TRAVERSE DATA FORM

Site	LB-S1 Model	Run No.	VT-3
Date	10/12/2012	Fan Configuration	AB
Testers	XY, CA	Fan Setting	44 Hz
Stack Dia.	11.8906 in.	Stack Temp	64 deg F
Stack X-Area	111.0 in.2	Start/End Time	1036/1059
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Velocity units	std. ft/min	Data Files:	NA

Order —>		2nd				1st			
Traverse—>		Side				Bottom			
Trial —>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	Velocity				Velocity			
1	0.50	3726	3853	3806	3795.0	3491	3540	3565	3532.0
2	1.25	4035	4042	4046	4041.0	3805	3808	3849	3820.7
3	2.31	4254	4279	4243	4258.7	4008	3996	4064	4022.7
4	3.64	4323	4353	4301	4325.7	4154	4217	4261	4210.7
Center	5.95	4328	4371	4216	4305.0	4342	4330	4416	4362.7
5	8.05	4222	4261	4178	4220.3	4537	4543	4558	4546.0
6	9.58	4264	4200	4183	4215.7	4639	4624	4665	4642.7
7	10.64	4331	4177	4234	4247.3	4659	4626	4364	4549.7
8	11.39	4166	4170	4172	4169.3	4570	4680	4645	4631.7
Averages ——>		4183.2	4189.6	4153.2	4175.3	4245.0	4262.7	4265.2	4257.6

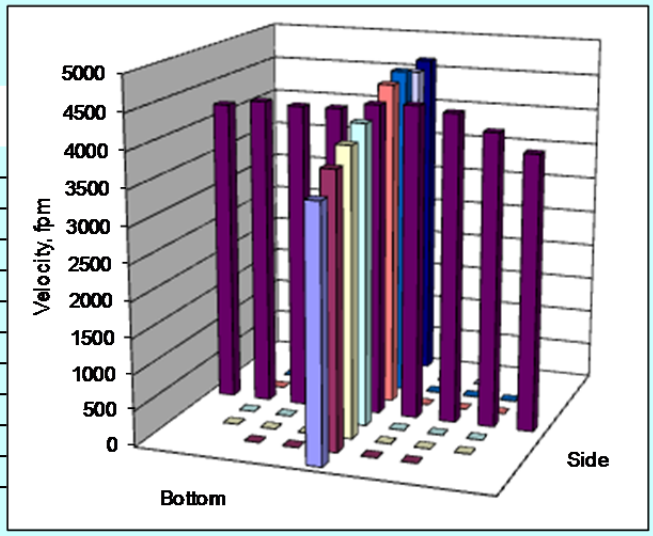
All	std ft/min	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	4216.5		Mean	4230.5	4307.9	4269.2
Min Point	3532.0	-16.2%	Std. Dev.	93.0	305.1	220.4
Max Point	4642.7	10.1%	COV as %	2.2	7.1	5.2

Flow w/o C-Pt 3240 scfm

Vel Avg w/o C-Pt 4202 sfpm

	Start	Finish	
Stack temp	64.2	64.2	F
Ambient temp	63.5	63.5	F
Ambient pressure	29.44	29.47	in Hg
Ambient humidity	38%	37%	RH

Instuments Used:	Cal Due
Fisher Scientific Barometer SN 90936818	12/7/2012
TSI VelociCalc SN T95351203001	1/17/2013



Notes: Bottom 8 4535 fpm

CA 10/12/12

Entries made by: Carmen Arimescu 10/12/12
Signature/date

Technical Data Review performed by:
Signature/date gbj 10/22/2012

VELOCITY TRAVERSE DATA FORM

Site	LB-S1 Model	Run No.	VT-4
Date	10/12/2012	Fan Configuration	AB
Testers	XY, CA	Fan Setting	44 Hz
Stack Dia.	11.8906 in.	Stack Temp	65 deg F
Stack X-Area	111.0 in.2	Start/End Time	1100/1135
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Velocity units	std. ft/min	Data Files:	NA

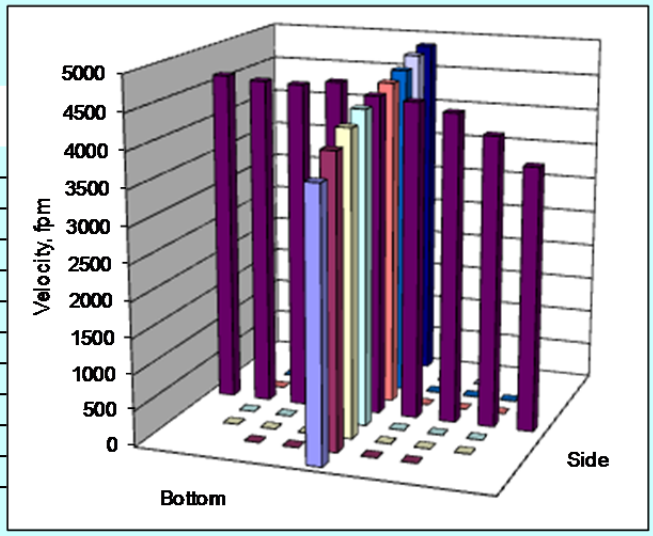
Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial -->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	Velocity				Velocity			
1	0.50	3698	3647	3666	**3670.3**	3587	3495	3547	**3543.0**
2	1.25	4002	4082	4060	**4048.0**	3790	3857	3823	**3823.3**
3	2.31	4341	4336	4280	**4319.0**	4032	3995	3989	**4005.3**
4	3.64	4509	4534	4259	**4434.0**	4112	4177	4141	**4143.3**
Center	5.95	4498	4681	4260	**4479.7**	4270	4197	4192	**4219.7**
5	8.05	4628	4850	4426	**4634.7**	4291	4333	4285	**4303.0**
6	9.58	4680	4506	4519	**4568.3**	4471	4329	4356	**4385.3**
7	10.64	4723	4401	4634	**4586.0**	4621	4404	4497	**4507.3**
8	11.39	4681	4664	4548	**4631.0**	4594	4595	4500	**4563.0**
Averages ---------->		**4417.8**	**4411.2**	**4294.7**	**4374.6**	**4196.4**	**4153.6**	**4147.8**	**4165.9**

All	std ft/min	Dev. from mean	***Center 2/3***	Side	Bottom	All
Mean	4270.2		Mean	4438.5	4198.2	4318.4
Min Point	3543.0	-17.0%	Std. Dev.	202.3	231.9	243.5
Max Point	4634.7	8.5%	COV as %	4.6	5.5	5.6

Flow w/o C-Pt	3285 scfm
Vel Avg w/o C-Pt	4260 sfpm

Instuments Used:	Cal Due
Fisher Scientific Barometer SN 90936818	12/7/2012
TSI VelociCalc SN T95351203001	1/17/2013

	Start	Finish	
Stack temp	65.0	65.0	F
Ambient temp	63.5	63.5	F
Ambient pressure	29.47	29.47	in Hg
Ambient humidity	37%	39%	RH



Notes: Bottom #8 4304 fpm

XYY 10/12/12

Entries made by: Xiao-Ying Yu 10/12/12	Technical Data Review performed by:
Signature/date	Signature/date gbj 10/22/2012

VELOCITY TRAVERSE DATA FORM

Site	LB-S1 Model	Run No.	VT-5
Date	10/12/2012	Fan Configuration	AB
Testers	XY, CA	Fan Setting	39 Hz
Stack Dia.	11.8906 in.	Stack Temp	66 deg F
Stack X-Area	111.0 in.2	Start/End Time	1221/1246
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Velocity units	std. ft/min	Data Files:	NA

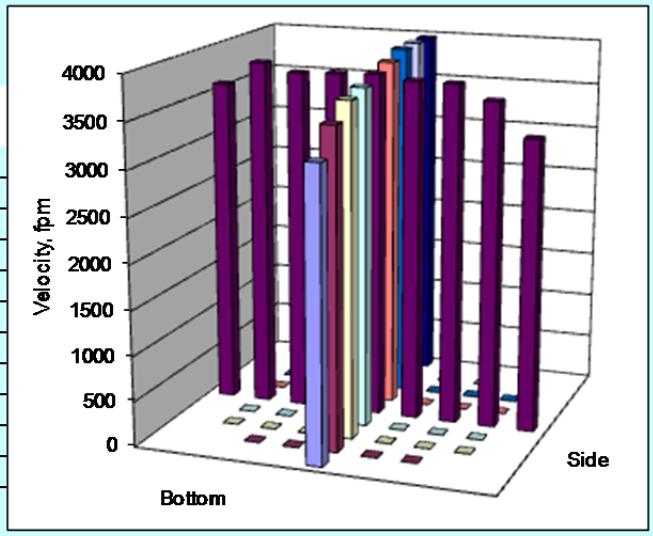
Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial -->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	Velocity				Velocity			
1	0.50	3444	3181	3078	3234.3	3048	3072	3066	3062.0
2	1.25	3552	3541	3728	3607.0	3356	3329	3350	3345.0
3	2.31	3742	3704	3849	3765.0	3541	3475	3526	3514.0
4	3.64	3698	3902	3711	3770.3	3587	3579	3542	3569.3
Center	5.95	3680	3883	3892	3818.3	3614	3669	3630	3637.7
5	8.05	3764	3826	3820	3803.3	3695	3696	3705	3698.7
6	9.58	3758	3887	3705	3783.3	3775	3804	3741	3773.3
7	10.64	3736	3947	3930	3871.0	3709	3872	3762	3781.0
8	11.39	3757	3465	3612	3611.3	3823	3809	3703	3778.3
Averages ---------->		3681.2	3704.0	3702.8	3696.0	3572.0	3589.4	3558.3	3573.3

All	std ft/min	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	3634.6		Mean	3774.0	3617.0	3695.5
Min Point	3062.0	-15.8%	Std. Dev.	82.0	155.6	144.6
Max Point	3871.0	6.5%	COV as %	2.2	4.3	3.9

Flow w/o C-Pt	2794 scfm
Vel Avg w/o C-Pt	3623 sfpm

Instuments Used:	Cal Due
Fisher Scientific Barometer SN 90936818	12/7/2012
TSI VelociCalc SN T95351203001	1/17/2013

	Start	Finish	
Stack temp	65.5	66.8	F
Ambient temp	65.3	65.3	F
Ambient pressure	29.50	29.50	in Hg
Ambient humidity	36%	36%	RH



Notes: Bottom 8 3828fpm

XYY 10/12/12

Entries made by: Xiao-Ying Yu 10/12/12	Technical Data Review performed by:
Signature/date	Signature/date gbj 10/22/2012

VELOCITY TRAVERSE DATA FORM

Site	LB-S1 Model	Run No.	VT-6
Date	10/12/2012	Fan Configuration	AB
Testers	XY, CA	Fan Setting	39 Hz
Stack Dia.	11.8906 in.	Stack Temp	67 deg F
Stack X-Area	111.0 in.2	Start/End Time	1247/116
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Velocity units	std. ft/min	Data Files:	NA

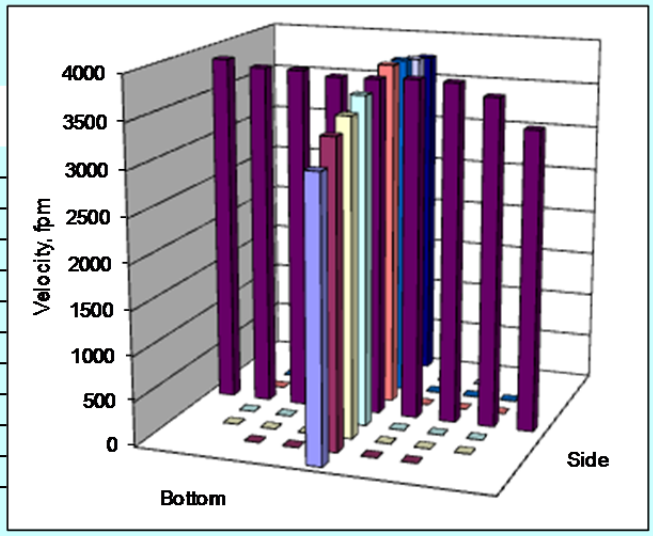
Order -->		2nd				1st			
Traverse-->		Side				Bottom			
Trial -->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	Velocity				Velocity			
1	0.50	3316	3239	3236	**3263.7**	3222	2978	3171	**3123.7**
2	1.25	3538	3707	3479	**3574.7**	3410	3384	3378	**3390.7**
3	2.31	3701	3719	3683	**3701.0**	3540	3521	3511	**3524.0**
4	3.64	3718	3673	3745	**3712.0**	3651	3644	3701	**3665.3**
Center	5.95	3675	3707	3689	**3690.3**	3748	3709	3846	**3767.7**
5	8.05	3649	3695	3712	**3685.3**	3849	3815	3887	**3850.3**
6	9.58	3712	3660	3825	**3732.3**	3790	3832	3893	**3838.3**
7	10.64	3746	3628	3836	**3736.7**	3781	3753	3829	**3787.7**
8	11.39	3811	3842	3764	**3805.7**	3751	3758	3717	**3742.0**
Averages ---------->		**3651.8**	**3652.2**	**3663.2**	**3655.7**	**3638.0**	**3599.3**	**3659.2**	**3632.2**

All	std. ft/min	Dev. from mean	***Center 2/3***	Side	Bottom	All
Mean	3644.0		Mean	3690.3	3689.1	3689.7
Min Point	3123.7	-14.3%	Std. Dev.	54.6	173.7	123.7
Max Point	3850.3	5.7%	COV as %	1.5	4.7	3.4

Flow w/o C-Pt	2802 scfm
Vel Avg w/o C-Pt	3633 sfpm

Instuments Used:	Cal Due
Fisher Scientific Barometer SN 90936818	12/7/2012
TSI VelociCalc SN T95351203001	1/17/2013

	Start	Finish	
Stack temp	66.8	66.4	F
Ambient temp	65.3	65.5	F
Ambient pressure	29.50	29.50	in Hg
Ambient humidity	36%	37%	RH



Notes: Bottom 8 is 3770 fpm

XYY 10/12/12

Entries made by: Carmen Arimescu 10/12/12	Technical Data Review performed by:
Signature/date	Signature/date gbj 10/22/2012

VELOCITY TRAVERSE DATA FORM

Site	LB-S1 Model	Run No.	VT-7
Date	10/12/2012	Fan Configuration	AB
Testers	CA, XY	Fan Setting	39 Hz
Stack Dia.	11.8906 in.	Stack Temp	67 deg F
Stack X-Area	111.0 in.2	Start/End Time	117/140
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Velocity units	std. ft/min	Data Files:	NA

Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial -->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	Velocity				Velocity			
1	0.50	3345	3355	3194	3298.0	2906	2986	2940	2944.0
2	1.25	3554	3492	3537	3527.7	3290	3301	3262	3284.3
3	2.31	3664	3659	3689	3670.7	3464	3457	3464	3461.7
4	3.64	3734	3734	3766	3744.7	3551	3560	3586	3565.7
Center	5.95	3773	3660	3710	3714.3	3632	3636	3659	3642.3
5	8.05	3892	3693	3695	3760.0	3703	3694	3739	3712.0
6	9.58	3900	3850	3793	3847.7	3756	3770	3735	3753.7
7	10.64	3869	3647	3862	3792.7	3739	3818	3726	3761.0
8	11.39	3747	3752	3984	3827.7	3654	3722	3818	3731.3
Averages ---------->		3719.8	3649.1	3692.2	3687.0	3521.7	3549.3	3547.7	3539.6

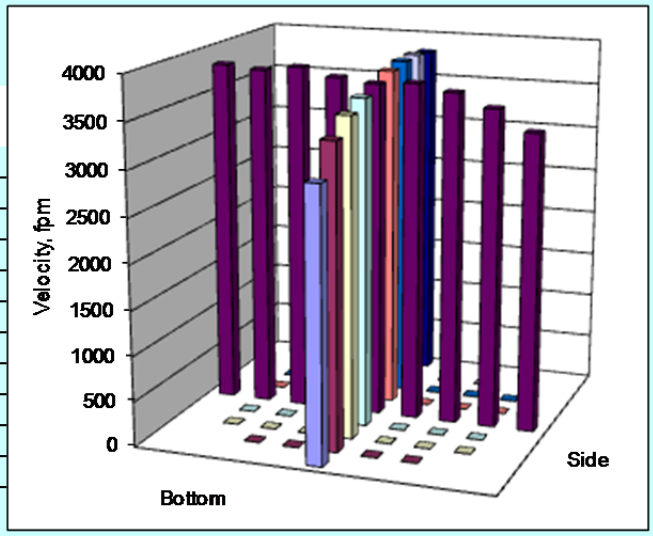
All	std. ft/min	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	3613.3		Mean	3722.5	3597.2	3659.9
Min Point	2944.0	-18.5%	Std. Dev.	102.6	175.0	152.4
Max Point	3847.7	6.5%	COV as %	2.8	4.9	4.2

Flow w/o C-Pt 2780 scfm

Vel Avg w/o C-Pt 3605 sfpm

Instuments Used:	Cal Due
Fisher Scientific Barometer SN 90936818	12/7/2012
TSI VelociCalc SN T95351203001	1/17/2013

	Start	Finish	
Stack temp	66.4	67.6	F
Ambient temp	65.3	64.4	F
Ambient pressure	29.47	29.47	in Hg
Ambient humidity	37%	40%	RH



Notes: Bottom 8 is 3671 fpm

Rain started while testing was going on.

XYY 10/12/12

Entries made by: Xiao-Ying Yu 10/12/12

Signature/date

Technical Data Review performed by:

Signature/date gbj 10/22/2012

VELOCITY TRAVERSE DATA FORM

Site	LB-S1 Model	Run No.	VT-8
Date	10/12/2012	Fan Configuration	AB
Testers	XY, CA	Fan Setting	39 Hz
Stack Dia.	11.8906 in.	Stack Temp	69 deg F
Stack X-Area	111.0 in.2	Start/End Time	145/230
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Velocity units	std. ft/min	Data Files:	NA

Order —>		2nd				1st			
Traverse—>		Side				Bottom			
Trial —>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	Velocity				Velocity			
1	0.50	3184	3144	3167	**3165.0**	3030	2946	2994	**2990.0**
2	1.25	3488	3474	3449	**3470.3**	3280	3344	3280	**3301.3**
3	2.31	3714	3663	3638	**3671.7**	3472	3478	3459	**3469.7**
4	3.64	3991	3794	3754	**3846.3**	3573	3596	3542	**3570.3**
Center	5.95	3903	3853	3825	**3860.3**	3621	3626	3625	**3624.0**
5	8.05	3587	3693	3827	**3702.3**	3669	3691	3688	**3682.7**
6	9.58	3714	3647	3684	**3681.7**	3721	3744	3695	**3720.0**
7	10.64	3793	3757	3717	**3755.7**	3682	3731	3715	**3709.3**
8	11.39	3758	3802	3708	**3756.0**	3674	3688	3646	**3669.3**
Averages ——>		**3681.3**	**3647.4**	**3641.0**	**3656.6**	**3524.7**	**3538.2**	**3516.0**	**3526.3**

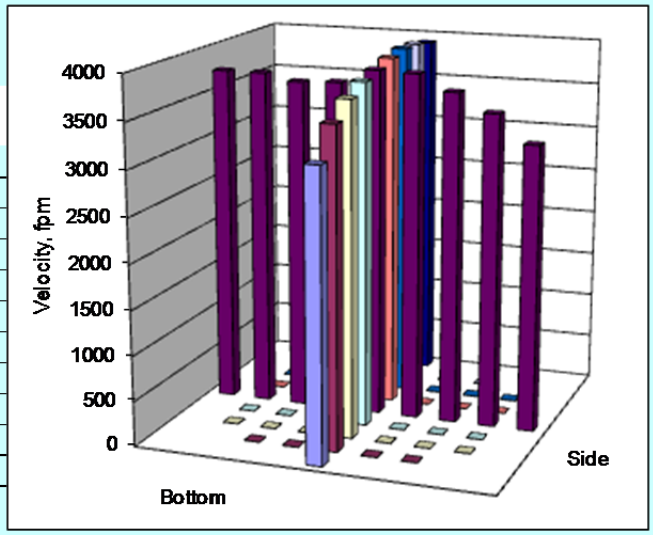
All	std. ft/min	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	3591.4		Mean	3712.6	3582.5	3647.5
Min Point	2990.0	-16.7%	Std. Dev.	131.0	152.0	152.2
Max Point	3860.3	7.5%	COV as %	3.5	4.2	**4.2**

Flow w/o C-Pt 2755 scfm

Vel Avg w/o C-Pt 3573 sfpm

Instuments Used:	Cal Due
Fisher Scientific Barometer SN 90936818	12/7/2012
TSI VelociCalc SN T95351203001	1/17/2013

	Start	Finish	
Stack temp	67.7	69.4	F
Ambient temp	65.3	68.0	F
Ambient pressure	29.50	29.47	in Hg
Ambient humidity	39%	36%	RH



Notes: Bottom #8 3652 fpm

XYY 10/12/12

Entries made by: Carmen Arimescu 10/12/12
Signature/date

Technical Data Review performed by:
Signature/date gbj 10/22/2012

VELOCITY TRAVERSE DATA FORM

Site	LB-S1 Model	Run No.	VT-9
Date	10/15/2012	Fan Configuration	AB
Testers	EA, CA	Fan Setting	28.9 Hz
Stack Dia.	11.8906 in.	Stack Temp	64 deg F
Stack X-Area	111.0 in.2	Start/End Time	9:00/923
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Velocity units	std. ft/min	Data Files:	NA

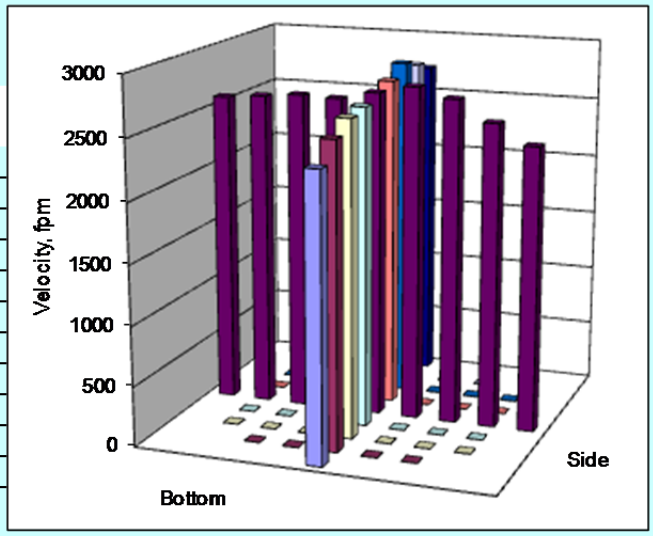
Order -->		2nd				1st			
Traverse-->		Side				Bottom			
Trial -->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	Velocity				Velocity			
1	0.50	2416	2377	2303	**2365.3**	2283	2318	2296	**2299.0**
2	1.25	2375	2585	2628	**2529.3**	2422	2464	2484	**2456.7**
3	2.31	2684	2646	2777	**2702.3**	2577	2546	2546	**2556.3**
4	3.64	2757	2737	2850	**2781.3**	2580	2577	2604	**2587.0**
Center	5.95	2712	2708	2723	**2714.3**	2661	2655	2615	**2643.7**
5	8.05	2622	2672	2645	**2646.3**	2694	2679	2681	**2684.7**
6	9.58	2668	2630	2674	**2657.3**	2774	2746	2817	**2779.0**
7	10.64	2664	2614	2609	**2629.0**	2767	2694	2693	**2718.0**
8	11.39	2622	2592	2589	**2601.0**	2630	2627	2678	**2645.0**
Averages ---------->		**2613.3**	**2617.9**	**2644.2**	**2625.1**	**2598.7**	**2589.6**	**2601.6**	**2596.6**

All	std. ft/min	Dev. from mean	***Center 2/3***	Side	Bottom	All
Mean	2610.9		Mean	2665.7	2632.2	2649.0
Min Point	2299.0	-11.9%	Std. Dev.	79.0	108.3	92.7
Max Point	2781.3	6.5%	COV as %	3.0	4.1	3.5

Flow w/o C-Pt	2007 scfm
Vel Avg w/o C-Pt	2602 sfpm

Instuments Used:	Cal Due
Fisher Scientific Barometer SN 90936818	12/7/2012
TSI VelociCalc SN T95351203001	1/17/2013

	Start	Finish	
Stack temp	61.6	66.1	F
Ambient temp	65.3	65.3	F
Ambient pressure	29.56	29.59	in Hg
Ambient humidity	63%	62%	RH



Notes: Bottom 8 2664 fpm

CA 10/15/12

Entries made by: Carmen Arimescu 10/15/12
Signature/date

Technical Data Review performed by:
Signature/date gbj 10/22/2012

VELOCITY TRAVERSE DATA FORM

Site	LB-S1 Model	Run No.	VT-10
Date	10/15/2012	Fan Configuration	AB
Testers	EA, CA	Fan Setting	28.9 Hz
Stack Dia.	11.8906 in.	Stack Temp	68 deg F
Stack X-Area	111.0 in.2	Start/End Time	9:30/950
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Velocity units	std. ft/min	Data Files:	NA

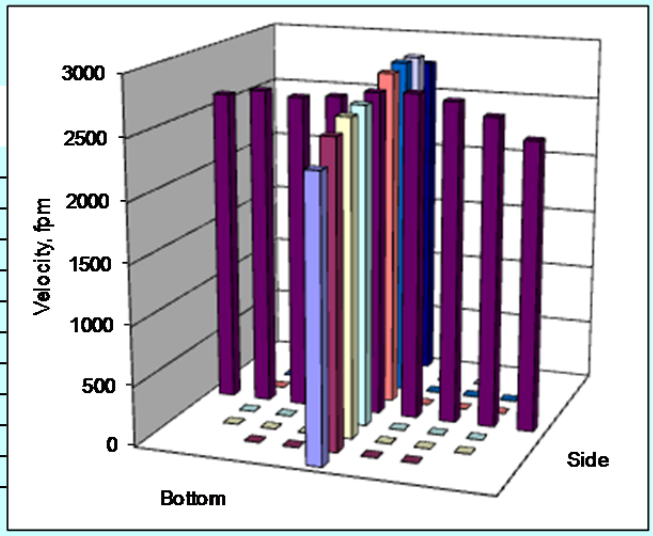
Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial -->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	Velocity				Velocity			
1	0.50	2430	2444	2363	**2412.3**	2254	2291	2336	**2293.7**
2	1.25	2606	2567	2565	**2579.3**	2535	2441	2476	**2484.0**
3	2.31	2724	2662	2665	**2683.7**	2518	2576	2625	**2573.0**
4	3.64	2792	2728	2667	**2729.0**	2607	2604	2616	**2609.0**
Center	5.95	2772	2702	2680	**2718.0**	2654	2664	2642	**2653.3**
5	8.05	2665	2633	2690	**2662.7**	2766	2757	2739	**2754.0**
6	9.58	2623	2652	2638	**2637.7**	2772	2793	2804	**2789.7**
7	10.64	2685	2695	2642	**2674.0**	2828	2763	2770	**2787.0**
8	11.39	2599	2680	2585	**2621.3**	2706	2641	2718	**2688.3**
Averages ---------->		**2655.1**	**2640.3**	**2610.6**	**2635.3**	**2626.7**	**2614.4**	**2636.2**	**2625.8**

All	std. ft/min	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	2630.6		Mean	2669.2	2664.3	2666.7
Min Point	2293.7	-12.8%	Std. Dev.	50.5	117.5	86.9
Max Point	2789.7	6.0%	COV as %	1.9	4.4	3.3

Flow w/o C-Pt	2023 acfm
Vel Avg w/o C-Pt	2624 fpm

Instuments Used:	Cal Due
Fisher Scientific Barometer SN 90936818	12/7/2012
TSI VelociCalc SN T95351203001	1/17/2013

	Start	Finish	
Stack temp	67	68.0	F
Ambient temp	66.2	67.0	F
Ambient pressure	29.59	29.59	in Hg
Ambient humidity	62%	59%	RH



Notes: Bottom #8 2663 fpm

CA 10/15/12

Entries made by: Carmen Arimescu 10/15/12
Signature/date

Technical Data Review performed by:
Signature/date gbj 10/22/2012

VELOCITY TRAVERSE DATA FORM

Site	LB-S1 Model	Run No.	VT-11
Date	10/15/2012	Fan Configuration	AB
Testers	EA, CA	Fan Setting	28.9 Hz
Stack Dia.	11.8906 in.	Stack Temp	69 deg F
Stack X-Area	111.0 in.2	Start/End Time	9:55/1020
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Velocity units	std. ft/min	Data Files:	NA

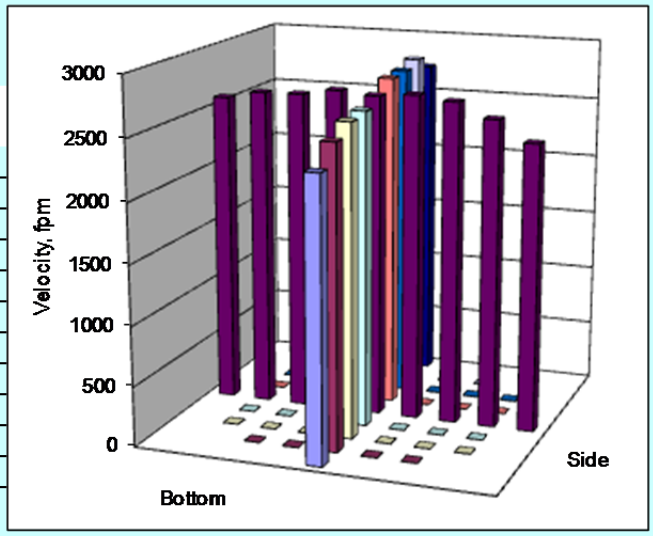
Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial -->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	Velocity				Velocity			
1	0.50	2419	2366	2380	**2388.3**	2276	2311	2320	**2302.3**
2	1.25	2574	2500	2606	**2560.0**	2483	2484	2448	**2471.7**
3	2.31	2682	2645	2715	**2680.7**	2580	2575	2542	**2565.7**
4	3.64	2702	2702	2741	**2715.0**	2562	2590	2623	**2591.7**
Center	5.95	2714	2679	2671	**2688.0**	2609	2689	2667	**2655.0**
5	8.05	2691	2794	2657	**2714.0**	2713	2780	2739	**2744.0**
6	9.58	2665	2662	2663	**2663.3**	2780	2750	2734	**2754.7**
7	10.64	2621	2717	2632	**2656.7**	2775	2843	2788	**2802.0**
8	11.39	2527	2680	2581	**2596.0**	2717	2678	2686	**2693.7**
Averages ---------->		**2621.7**	**2638.3**	**2627.3**	**2629.1**	**2610.6**	**2633.3**	**2616.3**	**2620.1**

All	std. ft/min	Dev. from mean	***Center 2/3***	Side	Bottom	All
Mean	2624.6		Mean	2668.2	2655.0	2661.6
Min Point	2302.3	-12.3%	Std. Dev.	52.8	119.1	88.7
Max Point	2802.0	6.8%	COV as %	2.0	4.5	3.3

Flow w/o C-Pt	2019 scfm
Vel Avg w/o C-Pt	2619 sfpm

Instuments Used:	Cal Due
Fisher Scientific Barometer SN 90936818	12/7/2012
TSI VelociCalc SN T95351203001	1/17/2013

	Start	Finish	
Stack temp	68	69	F
Ambient temp	67.0	68.9	F
Ambient pressure	29.59	29.56	in Hg
Ambient humidity	58%	56%	RH



Notes: Bottom #8 2692 fpm

CA 10/15/12

Entries made by: Carmen Arimescu 10/15/12	Technical Data Review performed by:
Signature/date	Signature/date gbj 10/22/2012

VELOCITY TRAVERSE DATA FORM

Site	LB-S1 Model	Run No.	VT-12
Date	10/15/2012	Fan Configuration	AB
Testers	EA, CA	Fan Setting	28.9 Hz
Stack Dia.	11.8906 in.	Stack Temp	70 deg F
Stack X-Area	111.0 in.2	Start/End Time	1025/1045
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Velocity units	std. ft/min	Data Files:	NA

Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial -->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	Velocity				Velocity			
1	0.50	2396	2344	2473	**2404.3**	2286	2228	2239	**2251.0**
2	1.25	2528	2582	2560	**2556.7**	2443	2499	2515	**2485.7**
3	2.31	2710	2695	2648	**2684.3**	2610	2554	2551	**2571.7**
4	3.64	2698	2677	2802	**2725.7**	2639	2608	2627	**2624.7**
Center	5.95	2718	2685	2650	**2684.3**	2623	2722	2645	**2663.3**
5	8.05	2669	2646	2628	**2647.7**	2710	2732	2692	**2711.3**
6	9.58	2698	2659	2691	**2682.7**	2829	2748	2729	**2768.7**
7	10.64	2722	2612	2631	**2655.0**	2848	2772	2774	**2798.0**
8	11.39	2549	2589	2609	**2582.3**	2723	2683	2711	**2705.7**
Averages ---------->		**2632.0**	**2609.9**	**2632.4**	**2624.8**	**2634.6**	**2616.2**	**2609.2**	**2620.0**

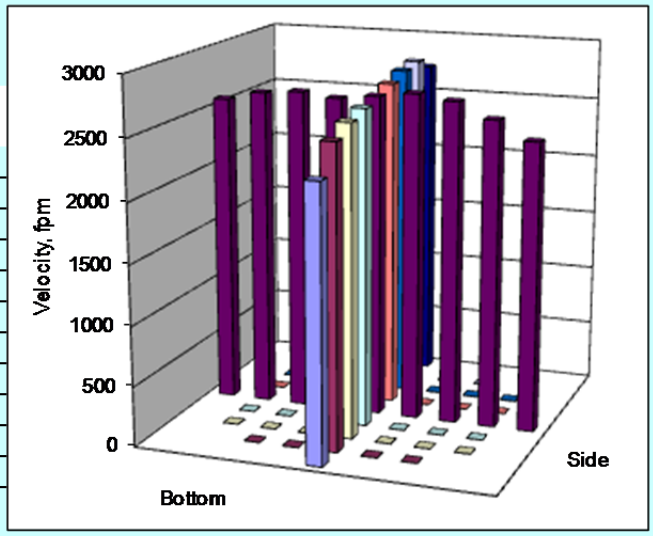
All	std. ft/min	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	2622.4		Mean	2662.3	2660.5	2661.4
Min Point	2251.0	-14.2%	Std. Dev.	53.0	110.3	83.1
Max Point	2798.0	6.7%	COV as %	2.0	4.1	3.1

Flow w/o C-Pt: **2017 scfm**

Vel Avg w/o C-Pt: **2616 sfpm**

Instuments Used:	Cal Due
Fisher Scientific Barometer SN 90936818	12/7/2012
TSI VelociCalc SN T95351203001	1/17/2013

	Start	Finish	
Stack temp	69	70.6	F
Ambient temp	68.9	69.8	F
Ambient pressure	29.56	29.56	in Hg
Ambient humidity	56%	54%	RH



Notes: Bottom #8 2796 fpm

CA 10/15/12

Entries made by: Carmen Arimescu 10/15/12
Signature/date

Technical Data Review performed by:
Signature/date gbj 10/22/2012

VELOCITY TRAVERSE DATA FORM

Site	LB-S1 Model	Run No.	VT-13
Date	10/15/2012	Fan Configuration	AC
Testers	XY, CA	Fan Setting	42 Hz
Stack Dia.	11.8906 in.	Stack Temp	74 deg F
Stack X-Area	111.0 in.2	Start/End Time	235/257
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Velocity units	std. ft/min	Data Files:	NA

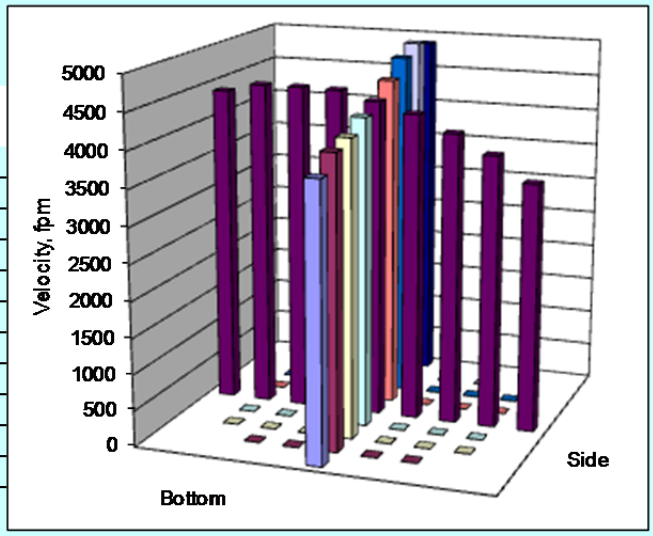
Order —>		2nd				1st			
Traverse—>		Side				Bottom			
Trial —>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	Velocity				Velocity			
1	0.50	3406	3518	3398	**3440.7**	3521	3585	3617	**3574.3**
2	1.25	3867	3853	3626	**3782.0**	3748	3784	3820	**3784.0**
3	2.31	4157	4109	3852	**4039.3**	3835	3866	3888	**3863.0**
4	3.64	4388	4280	4127	**4265.0**	4028	4082	3951	**4020.3**
Center	5.95	4475	4437	4303	**4405.0**	4125	4108	4154	**4129.0**
5	8.05	4605	4564	4408	**4525.7**	4331	4339	4270	**4313.3**
6	9.58	4501	4517	4588	**4535.3**	4536	4577	4464	**4525.7**
7	10.64	4610	4311	4680	**4533.7**	4648	4681	4612	**4647.0**
8	11.39	4410	4333	4511	**4418.0**	4609	4563	4549	**4573.7**
Averages ——>		**4268.8**	**4213.6**	**4165.9**	**4216.1**	**4153.4**	**4176.1**	**4147.2**	**4158.9**

All	std. ft/min	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	4187.5		Mean	4298.0	4183.2	4240.6
Min Point	3440.7	-17.8%	Std. Dev.	291.4	326.8	303.3
Max Point	4647.0	11.0%	COV as %	6.8	7.8	7.2

Flow w/o C-Pt	3221 scfm
Vel Avg w/o C-Pt	4178 sfpm

Instuments Used:	Cal Due
Fisher Scientific Barometer SN 90936818	12/7/2012
TSI VelociCalc SN T95351203001	1/17/2013

	Start	Finish	
Stack temp	74.5	73.9	F
Ambient temp	74.3	72.5	F
Ambient pressure	29.50	29.50	in Hg
Ambient humidity	42%	42%	RH



Notes: Bottom #8 4525 fpm
Fairly big wind.

CA 10/15/12

Entries made by: Carmen Arimescu 10/15/12
Signature/date

Technical Data Review performed by:
Signature/date gbj 10/22/2012

VELOCITY TRAVERSE DATA FORM

Site	LB-S1 Model	Run No.	VT-14
Date	10/15/2012	Fan Configuration	AC
Testers	XY, CA	Fan Setting	42 Hz
Stack Dia.	11.8906 in.	Stack Temp	74 deg F
Stack X-Area	111.0 in.2	Start/End Time	300/315
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Velocity units	std. ft/min	Data Files:	NA

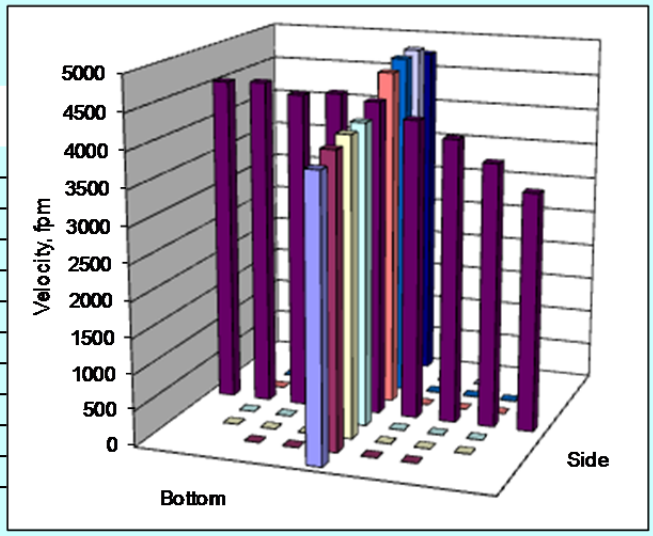
Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial -->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	Velocity				Velocity			
1	0.50	3331	3318	3309	3319.3	3613	3622	3598	3611.0
2	1.25	3660	3637	3740	3679.0	3709	3760	3766	3745.0
3	2.31	3796	3983	4121	3966.7	3815	3813	3860	3829.3
4	3.64	4031	4128	4401	4186.7	3895	3865	3883	3881.0
Center	5.95	4299	4415	4490	4401.3	4177	3986	3983	4048.7
5	8.05	4475	4599	4368	4480.7	4509	4195	4290	4331.3
6	9.58	4696	4497	4091	4428.0	4571	4384	4349	4434.7
7	10.64	4630	4513	4558	4567.0	4473	4473	4481	4475.7
8	11.39	4562	4598	4481	4547.0	4454	4307	4301	4354.0
Averages ---------->		4164.4	4187.6	4173.2	4175.1	4135.1	4045.0	4056.8	4079.0

All	std. ft/min	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	4127.0		Mean	4244.2	4106.5	4175.4
Min Point	3319.3	-19.6%	Std. Dev.	321.0	304.5	309.0
Max Point	4567.0	10.7%	COV as %	7.6	7.4	7.4

Flow w/o C-Pt	3173 scfm
Vel Avg w/o C-Pt	4115 sfpm

Instuments Used:	Cal Due
Fisher Scientific Barometer SN 90936818	12/7/2012
TSI VelociCalc SN T95351203001	1/17/2013

	Start	Finish	
Stack temp	73.9	73.6	F
Ambient temp	72.5	71.5	F
Ambient pressure	29.50	29.47	in Hg
Ambient humidity	43%	45%	RH



Notes:

CA 10/15/12

Entries made by: Carmen Arimescu 10/15/12	Technical Data Review performed by:
Signature/date	Signature/date gbj 10/22/2012

VELOCITY TRAVERSE DATA FORM

Site	LB-S1 Model	Run No.	VT-15
Date	10/15/2012	Fan Configuration	AC
Testers	XY, GBG, CA	Fan Setting	32 Hz
Stack Dia.	11.8906 in.	Stack Temp	72 deg F
Stack X-Area	111.0 in.2	Start/End Time	325/343
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Velocity units	std. ft/min	Data Files:	NA

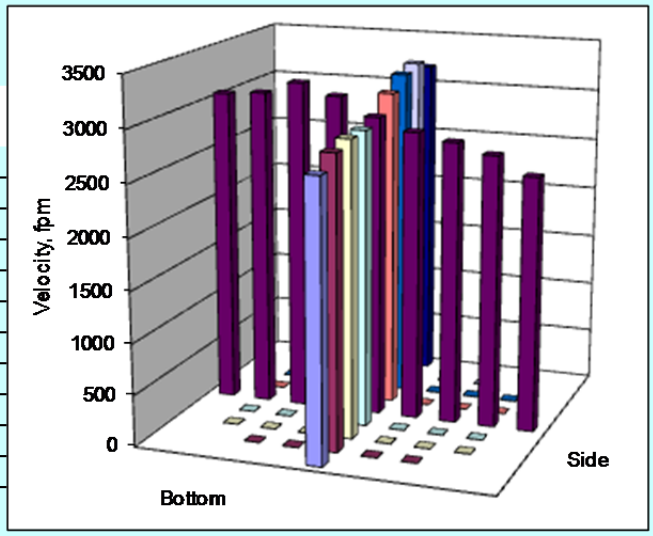
Order —>		2nd				1st			
Traverse—>		Side				Bottom			
Trial —>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	Velocity				Velocity			
1	0.50	2576	2406	2440	**2474.0**	2673	2646	2651	**2656.7**
2	1.25	2639	2644	2666	**2649.7**	2800	2780	2761	**2780.3**
3	2.31	2757	2725	2753	**2745.0**	2838	2836	2820	**2831.3**
4	3.64	2872	2805	2770	**2815.7**	2855	2836	2825	**2838.7**
Center	5.95	2942	3000	2859	**2933.7**	2940	2809	2921	**2890.0**
5	8.05	3238	3164	2927	**3109.7**	3059	3044	3048	**3050.3**
6	9.58	3360	3228	3062	**3216.7**	3188	3186	3135	**3169.7**
7	10.64	3232	3004	3052	**3096.0**	3281	3193	3192	**3222.0**
8	11.39	3132	3025	3045	**3067.3**	3110	3141	3140	**3130.3**
Averages ——>		**2972.0**	**2889.0**	**2841.6**	**2900.9**	**2971.6**	**2941.2**	**2943.7**	**2952.1**

All	std. ft/min	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	2926.5		Mean	2938.0	2968.9	2953.5
Min Point	2474.0	-15.5%	Std. Dev.	211.1	177.3	188.0
Max Point	3222.0	10.1%	COV as %	7.2	6.0	6.4

Flow w/o C-Pt	2258 scfm
Vel Avg w/o C-Pt	2928 sfpm

Instuments Used:	Cal Due
Fisher Scientific Barometer SN 90936818	12/7/2012
TSI VelociCalc SN T95351203001	1/17/2013

	Start	Finish	
Stack temp	72.4	71.1	F
Ambient temp	71.6	72	F
Ambient pressure	29.47	29.47	in Hg
Ambient humidity	46%	48%	RH



Notes: Bottom #8 3113 fpm.

CA 10/15/12

Entries made by: Carmen Arimescu 10/15/12	Technical Data Review performed by:
Signature/date	Signature/date gbj 10/22/2012

VELOCITY TRAVERSE DATA FORM

Site	LB-S1 Model	Run No.	VT-16
Date	10/17/12	Fan Configuration	BC
Testers	CA, JEF	Fan Setting	43.0 Hz
Stack Dia.	11.8906 in.	Stack Temp	51 deg F
Stack X-Area	111.0 in.2	Start/End Time	8:32 / 8:52
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Velocity units	std. ft/min	Data Files:	NA

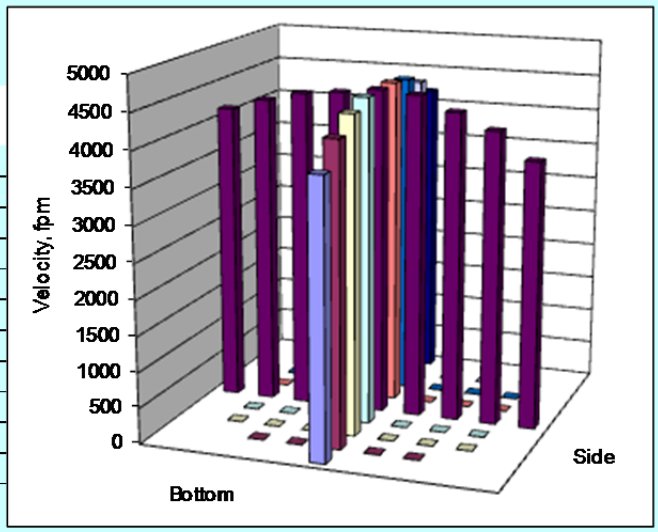
Order -->		2nd				1st			
Traverse-->		Side				Bottom			
Trial -->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	Velocity				Velocity			
1	0.50	3833	3550	3823	3735.3	3691	3733	3698	3707.3
2	1.25	4140	4071	4115	4108.7	4080	4048	4008	4045.3
3	2.31	4342	4321	4310	4324.3	4300	4280	4206	4262.0
4	3.64	4439	4600	4536	4525.0	4348	4439	4357	4381.3
Center	5.95	4570	4582	4545	4565.7	4437	4380	4353	4390.0
5	8.05	4477	4554	4464	4498.3	4460	4370	4361	4397.0
6	9.58	4498	4470	4385	4451.0	4388	4304	4382	4358.0
7	10.64	4246	4466	4261	4324.3	4251	4219	4243	4237.7
8	11.39	4170	4179	4155	4168.0	4098	4002	3979	4026.3
Averages ---------->		4301.7	4310.3	4288.2	4300.1	4228.1	4197.2	4176.3	4200.6

All	std. ft/min	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	4250.3		Mean	4399.6	4295.9	4347.8
Min Point	3707.3	-12.8%	Std. Dev.	159.0	127.5	148.5
Max Point	4565.7	7.4%	COV as %	3.6	3.0	3.4

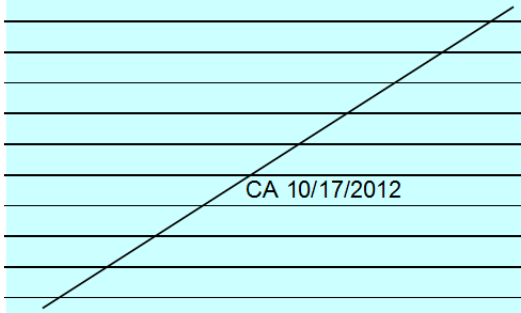
Flow w/o C-Pt	3256 scfm
Vel Avg w/o C-Pt	4222 sfpm

Instuments Used:	Cal Due
Fisher Scientific Barometer SN 90936818	12/7/2012
TSI VelociCalc SN T95351203001	1/17/2013

	Start	Finish	
Stack temp	51.0	51.0	F
Ambient temp	59.9	53.6	F
Ambient pressure	29.88	29.91	in Hg
Ambient humidity	33%	39%	RH



Notes: Bottom 7 = 4300 fpm



Entries made by:	Carmen Arimescu	Technical Data Review performed by:	
Signature/date	10/17/2012	Signature/date gbj	10/22/2012

VELOCITY TRAVERSE DATA FORM

Site	LB-S1 Model	Run No.	VT-17
Date	10/17/12	Fan Configuration	BC
Testers	CA, JEF	Fan Setting	43.0 Hz
Stack Dia.	11.8906 in.	Stack Temp	53 deg F
Stack X-Area	111.0 in.2	Start/End Time	8:52 / 9:20
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Velocity units	std. ft/min	Data Files:	NA

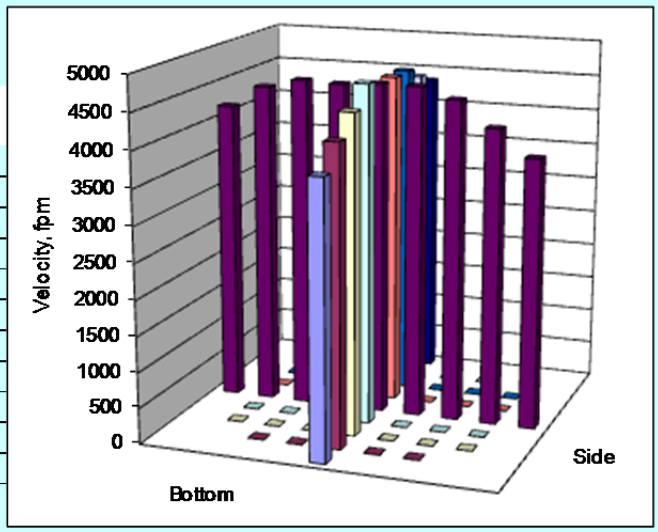
Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial -->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	Velocity				Velocity			
1	0.50	3433	4008	3882	3774.3	3778	3840	3688	3768.7
2	1.25	4179	4148	4092	4139.7	4000	4209	4100	4103.0
3	2.31	4580	4474	4420	4491.3	4414	4371	4364	4383.0
4	3.64	4782	4623	4523	4642.7	4584	4804	4599	4662.3
Center	5.95	4605	4815	4517	4645.7	4577	4567	4578	4574.0
5	8.05	4722	4644	4461	4609.0	4610	4587	4533	4576.7
6	9.58	4636	4752	4503	4630.3	4842	4586	4312	4580.0
7	10.64	4544	4324	4653	4507.0	4673	4305	4280	4419.3
8	11.39	4389	4075	4151	4205.0	4426	4254	4148	4276.0
Averages ---------->		4430.0	4429.2	4355.8	4405.0	4433.8	4391.4	4289.1	4371.4

All	std. ft/min	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	4388.2		Mean	4523.7	4471.2	4497.4
Min Point	3768.7	-14.1%	Std. Dev.	181.0	189.8	180.2
Max Point	4662.3	6.2%	COV as %	4.0	4.2	4.0

Flow w/o C-Pt	3363 scfm
Vel Avg w/o C-Pt	4361 sfpm

Instuments Used:	Cal Due
Fisher Scientific Barometer SN 90936818	12/7/2012
TSI VelociCalc SN T95351203001	1/17/2013

	Start	Finish	
Stack temp	51.0	54.0	F
Ambient temp	53.6	54.5	F
Ambient pressure	29.91	29.91	in Hg
Ambient humidity	39%	42%	RH



Notes:

JEF 10/17/12

Entries made by:	Julia Flaherty	Technical Data Review performed by:	
Signature/date	10/17/2012	Signature/date gbj	10/22/2012

VELOCITY TRAVERSE DATA FORM

Site	LB-S1 Model	Run No.	VT-18
Date	10/17/12	Fan Configuration	BC
Testers	JEF, CA	Fan Setting	32.0 Hz
Stack Dia.	11.8906 in.	Stack Temp	57 deg F
Stack X-Area	111.0 in.2	Start/End Time	945/1000
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Velocity units	std. ft/min	Data Files:	NA

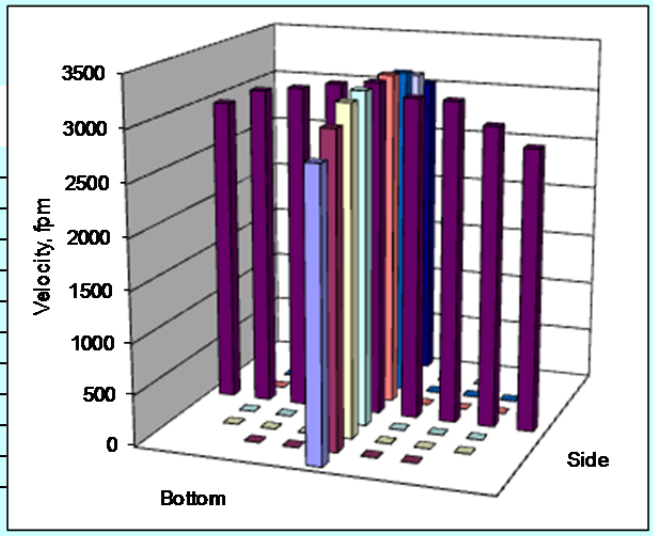
Order -->		2nd				1st			
Traverse-->		Side				Bottom			
Trial -->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	Velocity				Velocity			
1	0.50	2717	2837	2673	**2742.3**	2741	2639	2607	**2662.3**
2	1.25	2952	2881	2937	**2923.3**	2898	2865	2891	**2884.7**
3	2.31	3158	3170	3076	**3134.7**	3034	3052	3039	**3041.7**
4	3.64	3199	3147	3071	**3139.0**	3090	3066	3094	**3083.3**
Center	5.95	3250	3192	3348	**3263.3**	3062	3126	3101	**3096.3**
5	8.05	3212	3145	3321	**3226.0**	3097	3106	3119	**3107.3**
6	9.58	3139	3179	3176	**3164.7**	3088	3048	3073	**3069.7**
7	10.64	3062	3166	3129	**3119.0**	2986	2976	3023	**2995.0**
8	11.39	2954	2864	3098	**2972.0**	2852	2868	2854	**2858.0**
Averages ---------->		**3071.4**	**3064.6**	**3092.1**	**3076.0**	**2983.1**	**2971.8**	**2977.9**	**2977.6**

All	std. ft/min	Dev. from mean	***Center 2/3***	Side	Bottom	All
Mean	3026.8		Mean	3138.6	3039.7	3089.1
Min Point	2662.3	-12.0%	Std. Dev.	108.5	78.1	104.3
Max Point	3263.3	7.8%	COV as %	3.5	2.6	3.4

Flow w/o C-Pt	2319 scfm
Vel Avg w/o C-Pt	3008 sfpm

Instuments Used:	Cal Due
Fisher Scientific Barometer SN 90936818	12/7/2012
TSI VelociCalc SN T95351203001	1/17/2013

	Start	Finish	
Stack temp	57.0	57.0	F
Ambient temp	56.3	57.2	F
Ambient pressure	29.91	29.91	in Hg
Ambient humidity	41%	39%	RH



Notes: Bottom #7 3087

Ca 10/17/12

Entries made by:	Carmen Arimescu
Signature/date	10/17/2012
Technical Data Review performed by:	
Signature/date	

VELOCITY TRAVERSE DATA FORM

Site	LB-S1 Model	Run No.	VT-19
Date	11/7/12	Fan Configuration	AB
Testers	XY,CA	Fan Setting	45.0 Hz
Stack Dia.	11.8906 in.	Stack Temp	61 deg F
Stack X-Area	111.0 in.2	Start/End Time	930/1030
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Velocity units	std. ft/min	Data Files:	NA

Order -->		2nd				1st			
Traverse-->		Side				Bottom			
Trial -->		1	2	3	Mean	1	2		Mean
Point	Depth, in.	Velocity				Velocity			
1	0.50	3829	3451	3472	**3584.0**	3781	3881	3771	**3811.0**
2	1.25	4035	3989	3988	**4004.0**	4244	4212	4205	**4220.3**
3	2.32	4323	4298	4242	**4287.7**	4634	4471	4472	**4525.7**
4	3.86	4511	4407	4463	**4460.3**	4418	4622	4648	**4562.7**
Center	5.97	4622	4543	4475	**4546.7**	4624	4619	4686	**4643.0**
5	8.08	4711	4532	4509	**4584.0**	4541	4606	4669	**4605.3**
6	9.62	4702	4501	4525	**4576.0**	4512	4559	4543	**4538.0**
7	10.68	4563	4401	4441	**4468.3**	4402	4402	4335	**4379.7**
8	11.44	4386	4327	4295	**4336.0**	4187	4118	4202	**4169.0**
Averages ---------->		**4409.1**	**34.0**	**4267.8**	**4316.3**	**4371.4**	**4387.8**	**4392.3**	**4383.9**

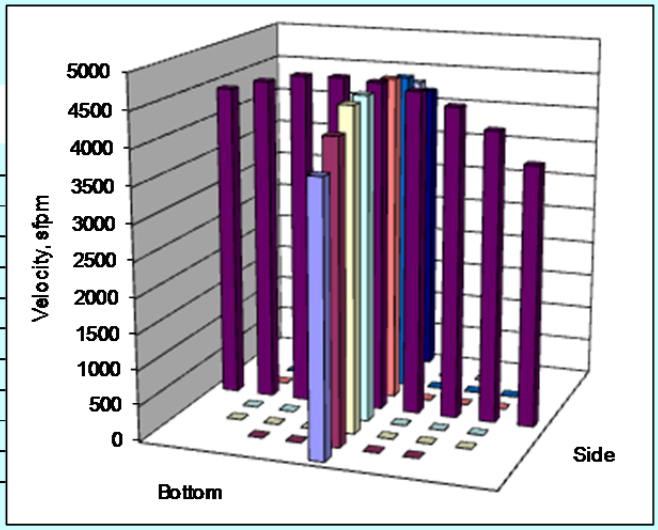
All	std. ft/min	Dev. from mean
Mean	4350.1	
Min Point	3584.0	-17.6%
Max Point	4643.0	6.7%

Center 2/3	Side	Bottom	All
Mean	4418.1	4496.4	4457.3
Std. Dev.	208.9	147.3	178.3
COV as %	4.7	3.3	**4.0**

Flow w/o C-Pt	3331 scfm
Vel Avg w/o C-Pt	4320 sfpm

Instuments Used:	Cal Due
Fisher Scientific Barometer SN 90936818	12/7/2012
TSI VelociCalc SN T95351203001	1/17/2013

	Start	Finish	
Stack temp	59.2	62.2	F
Ambient temp	64.4	67.1	F
Ambient pressure	29.71	29.71	in Hg
Ambient humidity	35%	32%	RH



Notes: 45 degree turn XY 11/7/12

bottom 8 4467 fpm

XY 11/7/12

Entries made by:	Carmen Arimescu	Technical Data Review performed by:	
Signature/date	Signature on file with original 11/7/2012	Signature/date	gbj 11/15/2012

VELOCITY TRAVERSE DATA FORM

Site	LB-S1 Model	Run No.	VT-20
Date	11/7/12	Fan Configuration	AB
Testers	XY,CA	Fan Setting	45.0 Hz
Stack Dia.	11.8906 in.	Stack Temp	62 deg F
Stack X-Area	111.0 in.2	Start/End Time	1030/1100
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Velocity units	s ft/min	Data Files:	NA

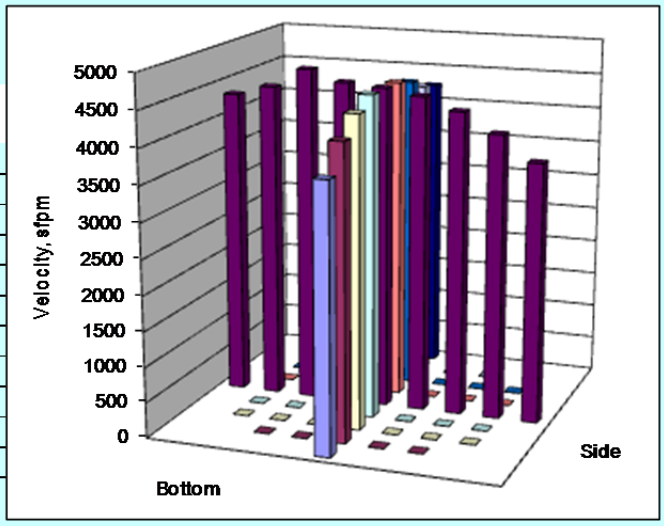
Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial -->		1	2	3	Mean	1	2		Mean
Point	Depth, in.	Velocity				Velocity			
1	0.50	3842	3498	3571	**3637.0**	4012	3519	3730	**3753.7**
2	1.25	4012	3917	4034	**3987.7**	4249	4094	4086	**4143.0**
3	2.32	4268	4247	4264	**4259.7**	4460	4413	4337	**4403.3**
4	3.86	4393	4425	4475	**4431.0**	4590	4604	4496	**4563.3**
Center	5.97	4476	4495	4572	**4514.3**	4590	4608	4492	**4563.3**
5	8.08	4533	4515	4620	**4556.0**	4584	4508	4553	**4548.3**
6	9.62	4503	4983	4643	**4709.7**	4513	4418	4475	**4468.7**
7	10.68	4460	4404	4442	**4435.3**	4304	4258	4379	**4313.7**
8	11.44	4316	4267	4310	**4297.7**	4321	4158	4254	**4244.3**
Averages ---------->		**4311.4**	**34.0**	**4325.7**	**4314.3**	**4402.6**	**4286.7**	**4311.3**	**4333.5**

All	s ft/min	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	4323.9		Mean	4413.4	4429.1	4421.2
Min Point	3637.0	-15.9%	Std. Dev.	232.4	156.9	190.6
Max Point	4709.7	8.9%	COV as %	5.3	3.5	4.3

Flow w/o C-Pt	3314 scfm
Vel Avg w/o C-Pt	4297 sfpm

Instuments Used:	Cal Due
Fisher Scientific Barometer SN 90936818	12/7/2012
TSI VelociCalc SN T95351203001	1/17/2013

	Start	Finish	
Stack temp	62.2	61.6	F
Ambient temp	67.1	69.8	F
Ambient pressure	29.71	29.71	in Hg
Ambient humidity	32%	32%	RH



Notes: Repeat of VT-19 at max velocity
XYY 11/7/12
bottom 8 4254 fpm

XY 11/7/12

Entries made by:	Carmen Arimescu	Technical Data Review performed by:	
Signature/date	Signature on file with original 11/7/2012	Signature/date	gbj 11/15/2012

Appendix A.3: LB-S1 Flow Angle Data Sheets

FLOW ANGLE DATA FORM

LB-S1_FlowAngle.xls

Site	LB-S1	Run No.	FA-1
Date	10/23/2012	Fan Setting	42.5 Hz
Tester	MSP, CA	Fan configuration	AB
Stack Dia.	11.8906 in	Approx. air vel.	4407 fpm at point >>
Stack X-Area	111.0 in2	Units	degrees (clockwise > pos. nos.)
Elevation	N.A. ft	Port	1
Distance to disturbance	123 in	Stack Temp	48
Start/End Time	900/1030		

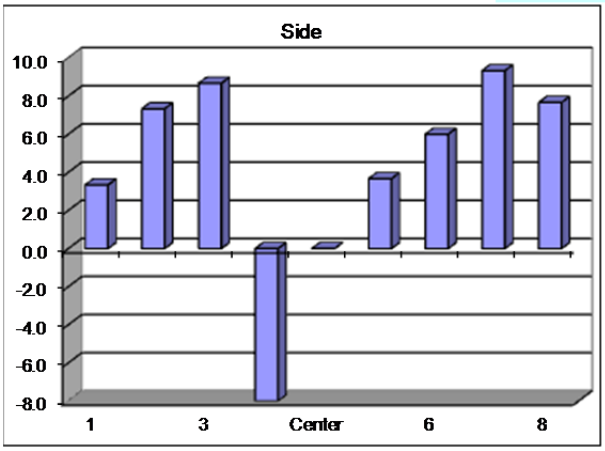
Order -->		2nd				1st			
Traverse-->		Side				Bottom			
Trial -->		1	2	3		1	2	3	
Point	Depth, in.	deg. cw	deg. cw	deg. cw	Avg.	deg. cw	deg. cw	deg. cw	Avg.
1	0.50	1	3	6	3.3	-9	-5	-4	-6.0
2	1.25	7	8	7	7.3	5	3	5	4.3
3	2.32	8	8	10	8.7	6	3	6	5.0
4	3.86	-9	-7	-8	-8.0	1	-9	-9	-5.7
Center	5.97	-1	1	0	0.0	-2	-1	2	-0.3
5	8.08	3	4	4	3.7	2	1	0	1.0
6	9.62	6	5	7	6.0	3	5	3	3.7
7	10.68	8	10	10	9.3	8	8	6	7.3
8	11.44	1	9	13	7.7	6	7	7	6.7
Mean of absolute values:					6.0				4.4
" "w/o points by wall:					6.1				3.9
								Grand mean ABS	5.2
								" "w/o wall pts	5.0

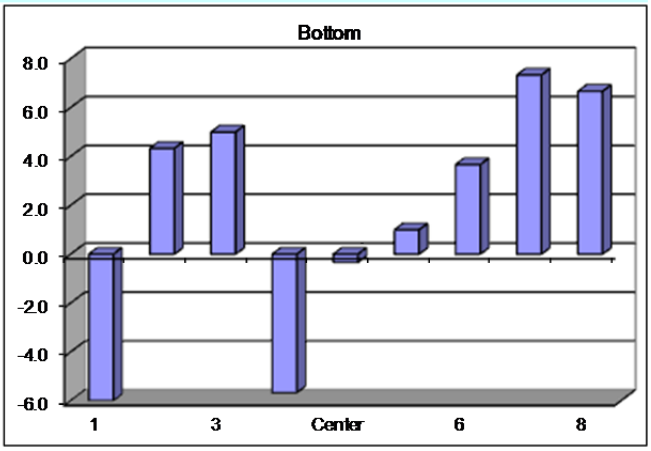
Instuments Used:			Cal. Due	
S-type pitot	Dwyer 24-inch S-type Pitot#10		Cert. of conformance	
Velocity sensor	TSI Velocicalc SN#T95351203001		17-Dec-12	
Angle indicator	Shop built		Cat. 3	
Manometer	Dwyer 400-5, S36N	MAN-5	Cat. 3	12/13/2012

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:

CA 10/23/12





Entries made by:	Carmen Arimescu	10/23/2012	Technical Data Review performed by:		
Signature/date	*On File w/ Original*		Signature/date	GBJ	11/16/2012

FLOW ANGLE DATA FORM

LB-S1_FlowAngle.xls

Site	LB-S1		Run No.	FA-2	
Date	10/23/2012		Fan Setting	42.5	Hz
Tester	MSP, CA		Fan configuration	AB	
Stack Dia.	11.8906	in	Approx. air vel.	4573	fpm at point >>
Stack X-Area	111.0	in2	Units	degrees (clockwise > pos. nos.)	
Elevation	N.A.	ft	Port	1	
Distance to disturbance	123	in	Stack Temp	55.2	
Start/End Time	1035/1107				

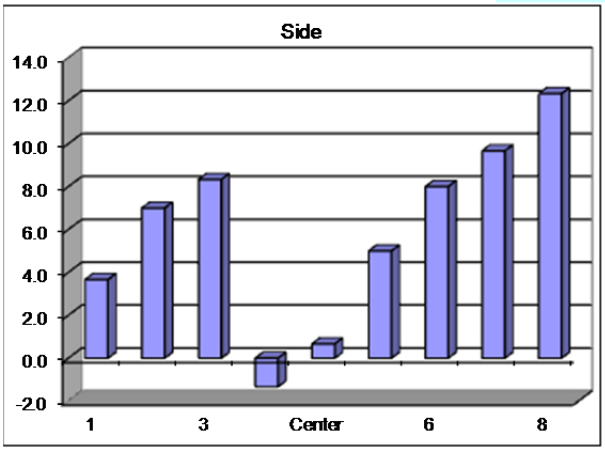
Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial -->		1	2	3		1	2	3	
Point	Depth, in.	deg. cw	deg. cw	deg. cw	Avg.	deg. cw	deg. cw	deg. cw	Avg.
1	0.50	4	4	3	3.7	-3	-6	1	-2.7
2	1.25	6	7	8	7.0	2	1	3	2.0
3	2.32	7	8	10	8.3	-2	2	2	0.7
4	3.86	-2	1	-3	-1.3	-14	-15	-13	-14.0
Center	5.97	-1	1	2	0.7	-8	-9	-6	-7.7
5	8.08	4	5	6	5.0	-4	-4	5	-1.0
6	9.62	8	8	8	8.0	-1	-1	-1	-1.0
7	10.68	10	11	8	9.7	3	5	3	3.7
8	11.44	11	13	13	12.3	7	7	3	5.7
Mean of absolute values:					6.2				4.3
" "w/o points by wall:					5.7				4.3
								Grand mean ABS	5.2
								" "w/o wall pts	5.0

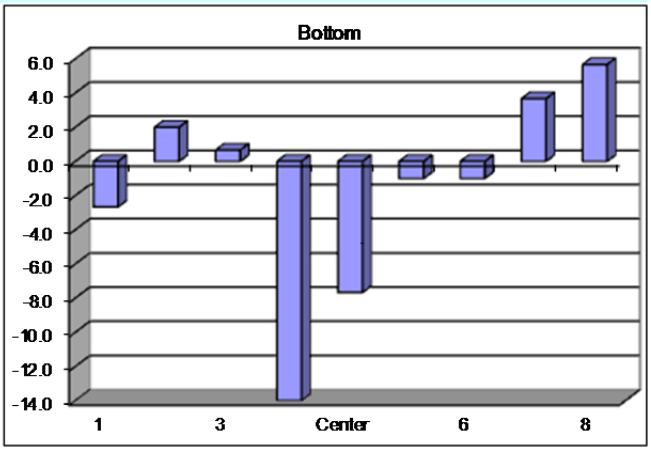
Instruments Used:			Cal. Due	
S-type pitot	Dwyer 24-inch S-type Pitot#10		Cert. of conformance	
Velocity sensor	TSI Velocicalc SN#T95351203001		17-Dec-12	
Angle indicator	Shop built		Cat. 3	
Manometer	Dwyer 400-5, S36N	MAN-5	Cat. 3	12/13/2012

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:

CA 12/23/12





Entries made by:	Carmen Arimescu	10/23/2012	Technical Data Review performed by:	
Signature/date	*On File w/ Original*		Signature/date	gbj 11/16/2012

FLOW ANGLE DATA FORM

LB-S1_FlowAngle.xls

Site	LB-S1		Run No.	FA-3	
Date	10/23/2012		Fan Setting	39	Hz
Tester	MSP, CA		Fan configuration	AB	
Stack Dia.	11.8906	in	Approx. air vel.	3789	fpm at point >>
Stack X-Area	111.0	in2	Units	degrees (clockwise > pos. nos.)	
Elevation	N.A.	ft	Port	1	
Distance to disturbance	123	in	Stack Temp	54.2	
Start/End Time	1110/1150				

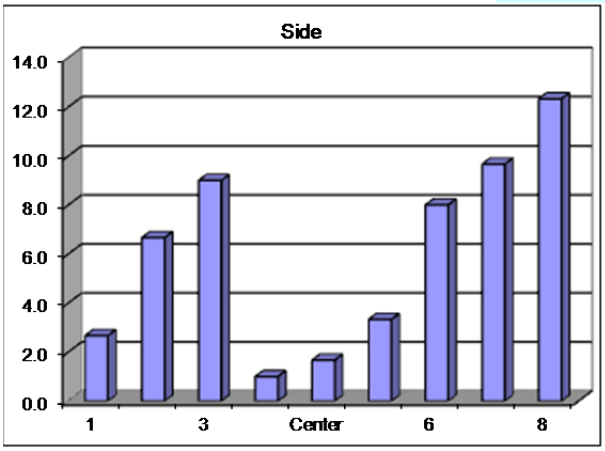
Order -->		2nd				1st			
Traverse-->		Side				Bottom			
Trial -->		1	2	3		1	2	3	
Point	Depth, in.	deg. cw	deg. cw	deg. cw	Avg.	deg. cw	deg. cw	deg. cw	Avg.
1	0.50	3	3	2	2.7	-6	-6	5	-2.3
2	1.25	10	8	2	6.7	8	8	9	8.3
3	2.32	11	9	7	9.0	7	7	8	7.3
4	3.86	1	-1	3	1.0	-1	2	0	0.3
Center	5.97	2	1	2	1.7	1	2	1	1.3
5	8.08	3	3	4	3.3	4	5	6	5.0
6	9.62	9	7	8	8.0	7	7	7	7.0
7	10.68	10	10	9	9.7	9	9	10	9.3
8	11.44	12	13	12	12.3	11	10	10	10.3
Mean of absolute values:					6.0				5.7
" "w/o points by wall:					5.6				5.5
								Grand mean ABS	5.9
								" "w/o wall pts	5.6

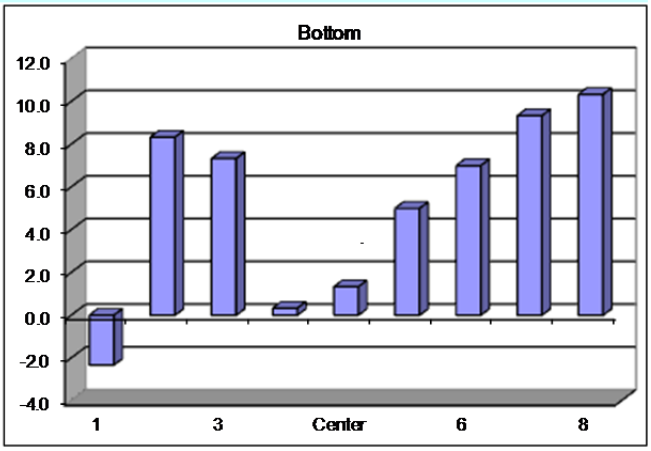
Instuments Used:			Cal. Due	
S-type pitot	Dwyer 24-inch S-type Pitot#10		Cert. of conformance	
Velocity sensor	TSI Velocicalc SN#T95351203001		17-Dec-12	
Angle indicator	Shop built		Cat. 3	
Manometer	Dwyer 400-5, S36N	MAN-5	Cat. 3	12/13/2012

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:

CA 12/23/12





Entries made by:	Carmen Arimescu	10/23/2012	Technical Data Review performed by:		
Signature/date	*On File w/ Original*		Signature/date	gbj	11/16/2012

FLOW ANGLE DATA FORM

LB-S1_FlowAngle.xls

Site	LB-S1	Run No.	FA-4
Date	10/23/2012	Fan Setting	39 Hz
Tester	MSP, CA	Fan configuration	AB
Stack Dia.	11.8906 in	Approx. air vel.	3820 fpm at point >>
Stack X-Area	111.0 in2	Units	degrees (clockwise > pos. nos.)
Elevation	N.A. ft	Port	1
Distance to disturbance	123.5 in	Stack Temp	57.2
Start/End Time	1200/1230		

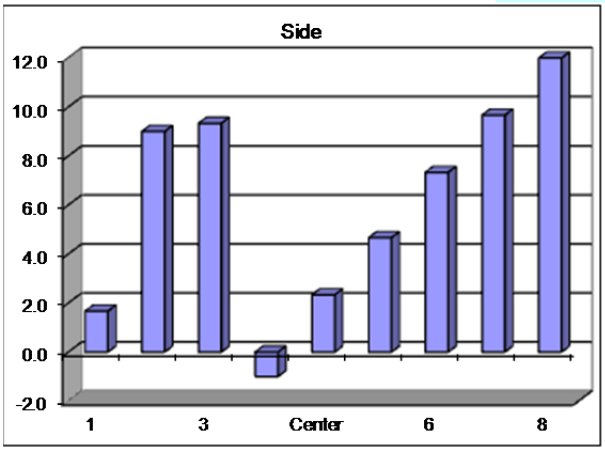
Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial -->		1	2	3		1	2	3	
Point	Depth, in.	deg. cw	deg. cw	deg. cw	Avg.	deg. cw	deg. cw	deg. cw	Avg.
1	0.50	5	-1	1	1.7	-7	-4	-4	-5.0
2	1.25	9	9	9	9.0	9	8	6	7.7
3	2.32	9	10	9	9.3	7	9	8	8.0
4	3.86	-4	2	-1	-1.0	1	3	1	1.7
Center	5.97	1	3	3	2.3	1	5	0	2.0
5	8.08	6	4	4	4.7	7	6	4	5.7
6	9.62	5	10	7	7.3	9	8	9	8.7
7	10.68	9	10	10	9.7	10	10	12	10.7
8	11.44	12	11	13	12.0	12	12	13	12.3
Mean of absolute values:					6.3				6.9
" "w/o points by wall:					6.2				6.3
								Grand mean ABS	6.6
								" "w/o wall pts	6.3

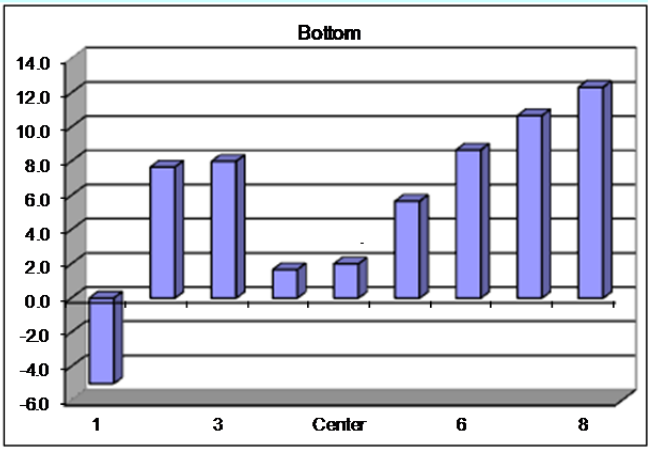
Instruments Used:			Cal. Due	
S-type pitot	Dwyer 24-inch S-type Pitot#10		Cert. of conformance	
Velocity sensor	TSI Velocicalc SN#T95351203001		17-Dec-12	
Angle indicator	Shop built		Cat. 3	
Manometer	Dwyer 400-5, S36N	MAN-5	Cat. 3	12/13/2012

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:

CA 12/23/12





Entries made by:	Carmen Arimescu	10/23/2012	Technical Data Review performed by:		
Signature/date	*On File w/ Original*		Signature/date	gbj	11/16/2012

FLOW ANGLE DATA FORM

LB-S1_FlowAngle.xls

Site	LB-S1		Run No.	FA-5	
Date	10/23/2012		Fan Setting	31	Hz
Tester	MSP, CA		Fan configuration	AB	
Stack Dia.	11.8906	in	Approx. air vel.	3140	fpm at point >>
Stack X-Area	111.0	in2	Units	degrees (clockwise > pos. nos.)	
Elevation	N.A.	ft	Port	1	
Distance to disturbance	123.5	in	Stack Temp	54.4	
Start/End Time	1205/110				

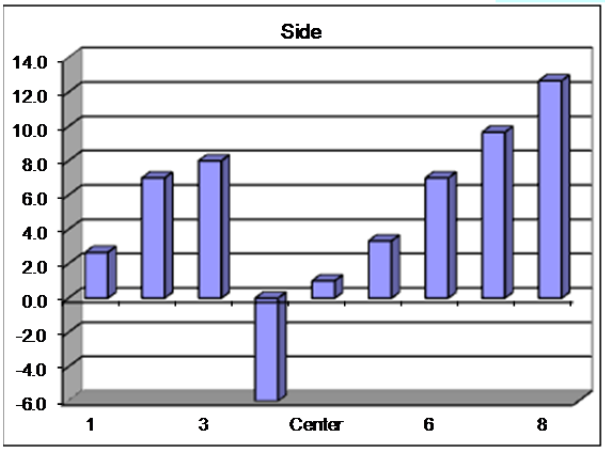
Order -->		2nd				1st			
Traverse-->		Side				Bottom			
Trial -->		1	2	3		1	2	3	
Point	Depth, in.	deg. cw	deg. cw	deg. cw	Avg.	deg. cw	deg. cw	deg. cw	Avg.
1	0.50	2	3	3	2.7	-8	6	-8	-3.3
2	1.25	6	8	7	7.0	7	6	7	6.7
3	2.32	9	7	8	8.0	5	5	6	5.3
4	3.86	-6	-6	-6	-6.0	-8	-3	-5	-5.3
Center	5.97	1	1	1	1.0	-2	1	0	-0.3
5	8.08	4	3	3	3.3	1	1	4	2.0
6	9.62	8	6	7	7.0	4	5	7	5.3
7	10.68	10	9	10	9.7	6	5	11	7.3
8	11.44	13	11	14	12.7	10	9	10	9.7
Mean of absolute values:					6.4				5.0
" "w/o points by wall:					6.0				4.6
								Grand mean ABS	5.7
								" "w/o wall pts	5.3

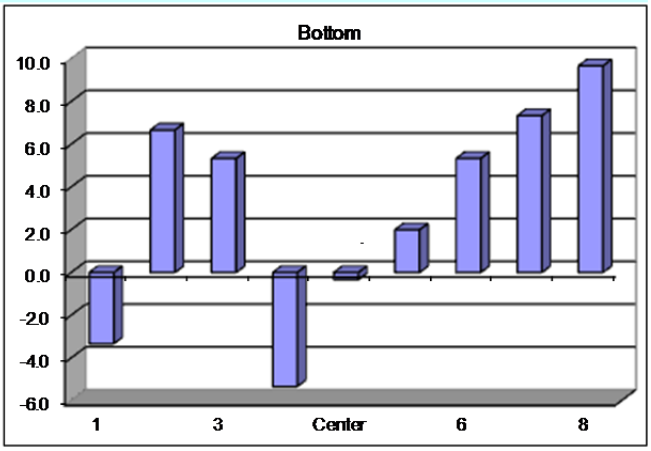
Instruments Used:			Cal. Due	
S-type pitot	Dwyer 24-inch S-type Pitot#10		Cert. of conformance	
Velocity sensor	TSI Velocicalc SN#T95351203001		17-Dec-12	
Angle indicator	Shop built		Cat. 3	
Manometer	Dwyer 400-5, S36N	MAN-5	Cat. 3	12/13/2012

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:

CA 12/23/12





Entries made by:	Carmen Arimescu	10/23/2012	Technical Data Review performed by:	
Signature/date	*On File w/ Original*		Signature/date	gbj 11/16/2012

FLOW ANGLE DATA FORM

LB-S1_FlowAngle.xls

Site	LB-S1	Run No.	FA-6
Date	10/23/2012	Fan Setting	31 Hz
Tester	MSP, GBJ	Fan configuration	AB
Stack Dia.	11.8906 in	Approx. air vel.	2931 fpm at point >>
Stack X-Area	111.0 in2	Units	degrees (clockwise > pos. nos.)
Elevation	N.A. ft	Port	1
Distance to disturbance	123.5 in	Stack Temp	55.1
Start/End Time	115/1340		

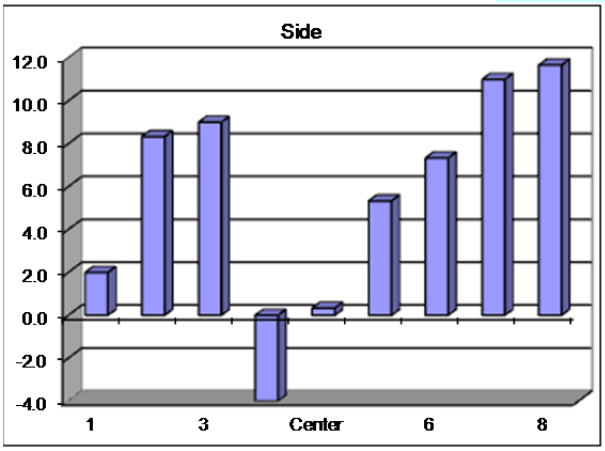
Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial -->		1	2	3		1	2	3	
Point	Depth, in.	deg. cw	deg. cw	deg. cw	Avg.	deg. cw	deg. cw	deg. cw	Avg.
1	0.50	1	2	3	2.0	-4	-7	-7	-6.0
2	1.25	7	8	10	8.3	9	8	7	8.0
3	2.32	7	10	10	9.0	7	6	5	6.0
4	3.86	-5	-6	-1	-4.0	-6	-4	-6	-5.3
Center	5.97	-1	1	1	0.3	3	3	1	2.3
5	8.08	6	4	6	5.3	6	6	6	6.0
6	9.62	7	7	8	7.3	8	9	7	8.0
7	10.68	10	11	12	11.0	12	10	9	10.3
8	11.44	12	12	11	11.7	13	11	11	11.7
Mean of absolute values:					6.6				7.1
" "w/o points by wall:					6.5				6.6
								Grand mean ABS	6.8
								" "w/o wall pts	6.5

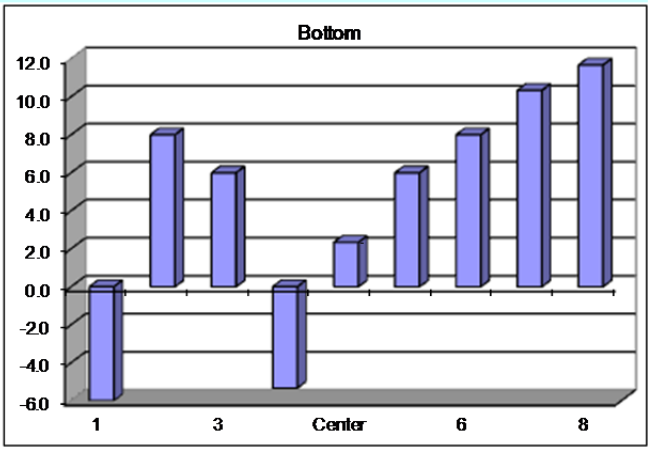
Instruments Used:			Cal. Due	
S-type pitot	Dwyer 24-inch S-type Pitot#10		Cert. of conformance	
Velocity sensor	TSI Velocicalc SN#T95351203001		17-Dec-12	
Angle indicator	Shop built		Cat. 3	
Manometer	Dwyer 400-5, S36N	MAN-5	Cat. 3	12/13/2012

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:

GBJ 12/23/12





Entries made by:	Gary Josephson	10/23/2012	Technical Data Review performed by:
Signature/date	*On File w/ Original*		Signature/date CA 11/17/2012

FLOW ANGLE DATA FORM

LB-S1_FlowAngle.xls

Site	LB-S1		Run No.	FA-7	
Date	10/23/2012		Fan Setting	42	Hz
Tester	MSP, CA		Fan configuration	AC	
Stack Dia.	11.8906	in	Approx. air vel.	4361	fpm at point >>
Stack X-Area	111.0	in2	Units	degrees (clockwise > pos. nos.)	
Elevation	N.A.	ft	Port	1	
Distance to disturbance	123.5	in	Stack Temp	57.7	
Start/End Time	1415/1440				

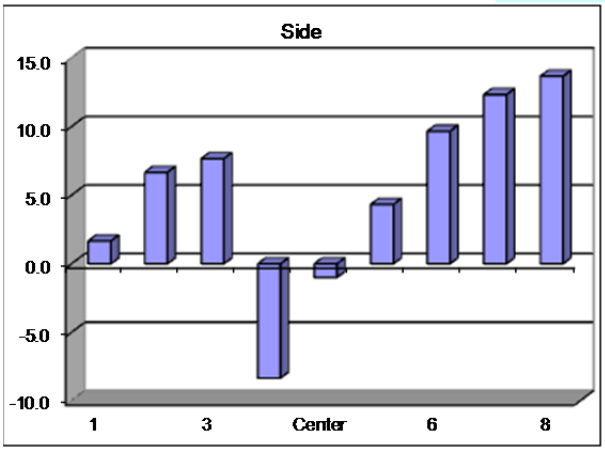
Order -->		2nd				1st			
Traverse-->		Side				Bottom			
Trial -->		1	2	3		1	2	3	
Point	Depth, in.	deg. cw	deg. cw	deg. cw	Avg.	deg. cw	deg. cw	deg. cw	Avg.
1	0.50	2	1	2	1.7	-11	-10	-11	-10.7
2	1.25	6	7	7	6.7	3	6	2	3.7
3	2.32	8	8	7	7.7	4	5	4	4.3
4	3.86	-8	-7	-10	-8.3	-4	-3	-2	-3.0
Center	5.97	-1	-1	-1	-1.0	-1	2	-1	0.0
5	8.08	5	4	4	4.3	6	6	5	5.7
6	9.62	10	11	8	9.7	8	9	10	9.0
7	10.68	10	13	14	12.3	10	10	12	10.7
8	11.44	13	14	14	13.7	12	15	9	12.0
Mean of absolute values:					7.3				6.6
" "w/o points by wall:					7.1				5.2
								Grand mean ABS	6.9
								" "w/o wall pts	6.2

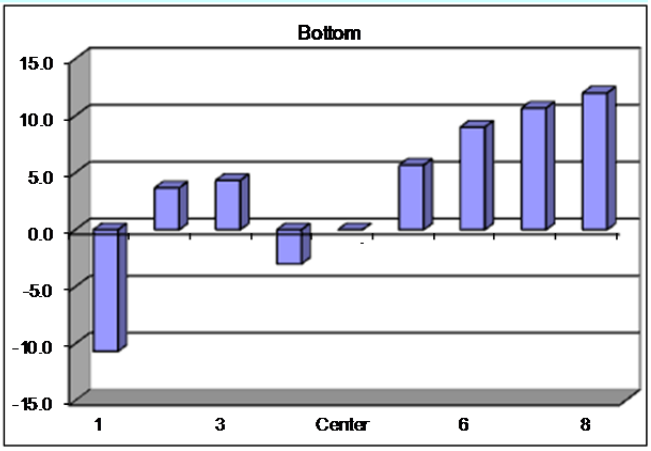
Instruments Used:			Cal. Due	
S-type pitot	Dwyer 24-inch S-type Pitot#10		Cert. of conformance	
Velocity sensor	TSI Velocicalc SN#T95351203001		17-Dec-12	
Angle indicator	Shop built		Cat. 3	
Manometer	Dwyer 400-5, S36N	MAN-5	Cat. 3	12/13/2012

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:

GBJ 12/23/12





Entries made by:	Gary Josephson	10/23/2012	Technical Data Review performed by:
Signature/date	*On File w/ Original*		Signature/date CA 11/17/2012

FLOW ANGLE DATA FORM

LB-S1_FlowAngle.xls

Site	10/23/2012		Run No.	FA-8	
Date	10/23/2012		Fan Setting	42	Hz
Tester	MSP, GBJ		Fan configuration	AC	
Stack Dia.	11.8906	in	Approx. air vel.	4468	fpm at point >>
Stack X-Area	111.0	in2	Units	degrees (clockwise > pos. nos.)	
Elevation	N.A.	ft	Port	1	
Distance to disturbance	123.5	in	Stack Temp	54.1	
Start/End Time	1445/1530				

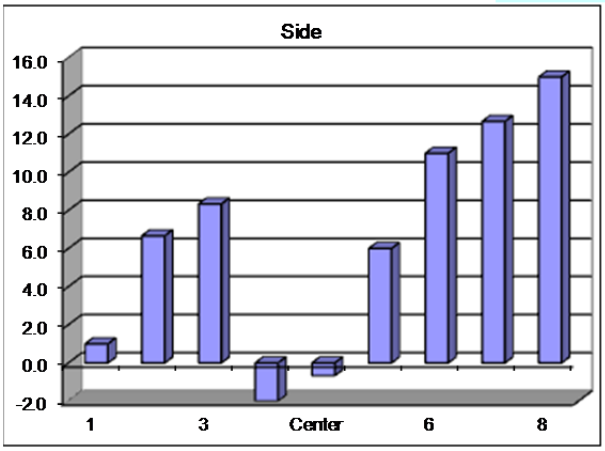
Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial -->		1	2	3		1	2	3	
Point	Depth, in.	deg. cw	deg. cw	deg. cw	Avg.	deg. cw	deg. cw	deg. cw	Avg.
1	0.50	-1	3	1	1.0	-15	-15	-13	-14.3
2	1.25	7	6	7	6.7	3	4	4	3.7
3	2.32	9	7	9	8.3	3	4	1	2.7
4	3.86	1	-1	-6	-2.0	-2	-1	-3	-2.0
Center	5.97	0	-1	-1	-0.7	-1	-3	-1	-1.7
5	8.08	9	5	4	6.0	3	2	4	3.0
6	9.62	12	10	11	11.0	6	5	5	5.3
7	10.68	13	12	13	12.7	6	7	9	7.3
8	11.44	16	14	15	15.0	9	13	11	11.0
Mean of absolute values:					7.0				5.7
" "w/o points by wall:					6.8				3.7
								Grand mean ABS	6.4
								" "w/o wall pts	5.2

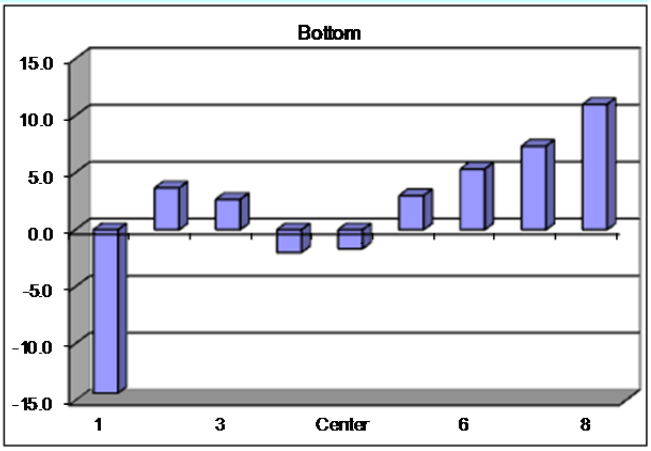
Instuments Used:			Cal. Due	
S-type pitot	Dwyer 24-inch S-type Pitot#10		Cert. of conformance	
Velocity sensor	TSI Velocicalc SN#T95351203001		17-Dec-12	
Angle indicator	Shop built		Cat. 3	
Manometer	Dwyer 400-5, S36N	MAN-5	Cat. 3	12/13/2012

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:

GBJ 12/23/12





Entries made by:	Gary Josephson	10/23/2012	Technical Data Review performed by:	
Signature/date	*On File w/ Original*		Signature/date	CA 11/17/2012

FLOW ANGLE DATA FORM

LB-S1_FlowAngle.xls

Site	LB-S1	Run No.	FA-9
Date	10/23/2012	Fan Setting	45 Hz
Tester	MSP, CA	Fan configuration	BC
Stack Dia.	11.8906 in	Approx. air vel.	4455 fpm at point >>
Stack X-Area	111.0 in2	Units	degrees (clockwise > pos. nos.)
Elevation	N.A ft	Port	1
Distance to disturbance	123.5 in	Stack Temp	59.5
Start/End Time	1555/1630		

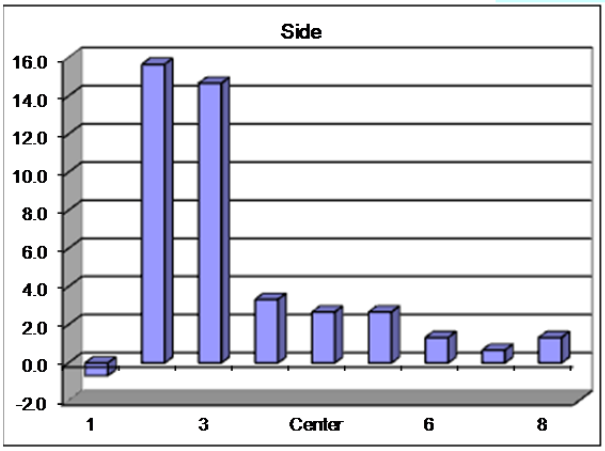
Order -->		2nd				1st			
Traverse-->		Side				Bottom			
Trial -->		1	2	3		1	2	3	
Point	Depth, in.	deg. cw	deg. cw	deg. cw	Avg.	deg. cw	deg. cw	deg. cw	Avg.
1	0.50	9	-6	-5	-0.7	7	12	7	8.7
2	1.25	16	16	15	15.7	18	19	20	19.0
3	2.32	16	14	14	14.7	15	17	18	16.7
4	3.86	3	4	3	3.3	5	1	5	3.7
Center	5.97	3	3	2	2.7	3	4	2	3.0
5	8.08	4	1	3	2.7	2	5	4	3.7
6	9.62	1	1	2	1.3	1	4	3	2.7
7	10.68	0	0	2	0.7	5	5	3	4.3
8	11.44	1	2	1	1.3	2	5	4	3.7
Mean of absolute values:					4.8				7.3
" "w/o points by wall:					5.9				7.6
								Grand mean ABS	6.0
								" "w/o wall pts	6.7

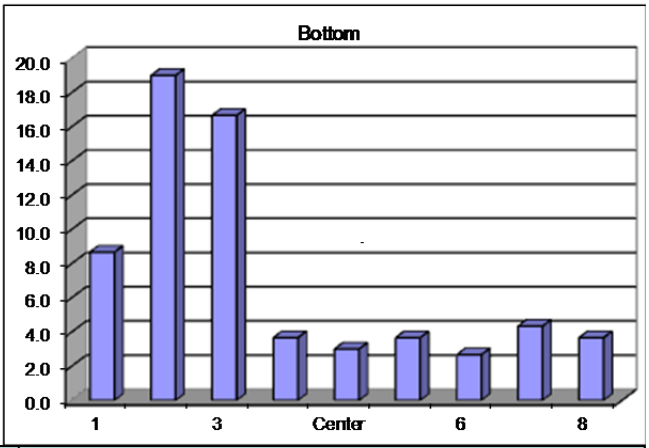
Instruments Used:			Cal. Due	
S-type pitot	Dwyer 24-inch S-type Pitot#10		Cert. of conformance	
Velocity sensor	TSI Velocicalc SN#T95351203001		17-Dec-12	
Angle indicator	Shop built		Cat. 3	
Manometer	Dwyer 400-5, S36N	MAN-5	Cat. 3	12/13/2012

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:

CA 10/23/12





Entries made by:	Carmen Arimescu	10/23/2012
Signature/date	*On File w/ Original*	

Technical Data Review performed by:		
Signature/date	gbj	11/16/2012

FLOW ANGLE DATA FORM

LB-S1_FlowAngle.xls

Site	LB-S1		Run No.	FA-10	
Date	11/7/2012		Fan Setting	45	Hz
Tester	XY, MSP		Fan configuration	AB	
Stack Dia.	11.8906	in	Approx. air vel.	4273	fpm at point >> Bottom 8
Stack X-Area	111.0	in2	Units	degrees (clockwise > pos. nos.)	
Elevation	N.A.	ft	Port	1	
Distance to disturbance	123.5	in	Stack Temp	62.1	
Start/End Time	1100/1200				

Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial -->		1	2	3		1	2	3	
Point	Depth, in.	deg. cw	deg. cw	deg. cw	Avg.	deg. cw	deg. cw	deg. cw	Avg.
1	0.50	-2	-11	-9	**-7.3**	0	9	-7	**0.7**
2	1.25	1	-16	-22	**-12.3**	5	-13	-12	**-6.7**
3	2.32	0	-14	-18	**-10.7**	6	-10	-9	**-4.3**
4	3.86	-1	-3	-6	**-3.3**	3	-1	-2	**0.0**
Center	5.97	-1	-11	-8	**-6.7**	-1	-1	-1	**-1.0**
5	8.08	-2	-13	-4	**-6.3**	-2	-2	-2	**-2.0**
6	9.62	-13	-4	-4	**-7.0**	-3	-2	-1	**-2.0**
7	10.68	-6	-3	-4	**-4.3**	-1	-2	-3	**-2.0**
8	11.44	-9	-3	-5	**-5.7**	-3	0	-2	**-1.7**
Mean of absolute values:					**7.1**				**2.3**
" "w/o points by wall:					**7.2**				**2.6**
								Grand mean ABS	**4.7**
								" "w/o wall pts	**4.9**

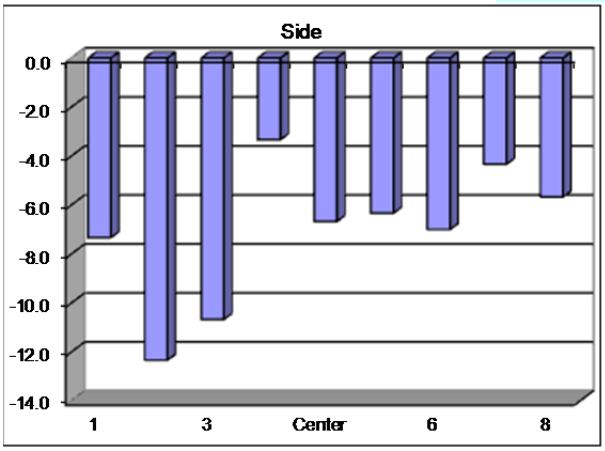
Instuments Used:			Cal. Due	
S-type pitot	Dwyer 24-inch S-type Pitot#10		Cert. of conformance	
Velocity sensor	TSI Velocicalc SN#T95351203001		17-Dec-12	
Angle indicator	Shop built		Cat. 3	
Manometer	Dwyer 400-5, S36N	MAN5	Cat. 3	12/13/2012

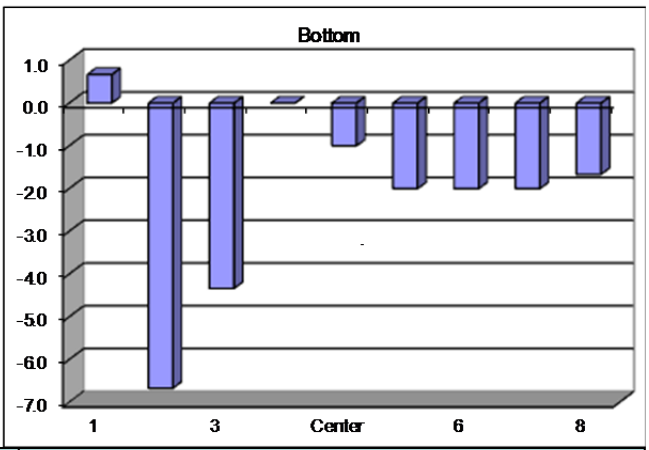
Note:
To assure similar hose connections between the manometer and pitot tube, rotating the pitot tube assembly clockwise drives the meniscus to the right (to higher pos. numbers).

Notes: Wind is 18 mph. The wind may interfere with measurements, will try a next time. XYY 11/7/12

XYY 11/7/12

Note: by time matching this test was determined to be conducted with test ports rotated 45 deg from horizontal/vertical. --gbj 12/15/12





Entries made by:	Xiao-Ying Yu	11/7/2012	Technical Data Review performed by:	
Signature/date	*On File w/ Original*		Signature/date	gbj 11/16/2012

FLOW ANGLE DATA FORM

LB-S1_FlowAngle.xls

Site	LB-S1		Run No.	FA-11	
Date	11/8/2012		Fan Setting	45	Hz
Tester	MSP, XY		Fan configuration	AB	
Stack Dia.	11.8906	in	Approx. air vel.	4324	fpm at point >> Bottom 8
Stack X-Area	111.0	in2	Units	degrees (clockwise > pos. nos.)	
Elevation	N.A.	ft	Port	1	
Distance to disturbance	123.5	in	Stack Temp	45.0 F	
Start/End Time	9:30/10:10				

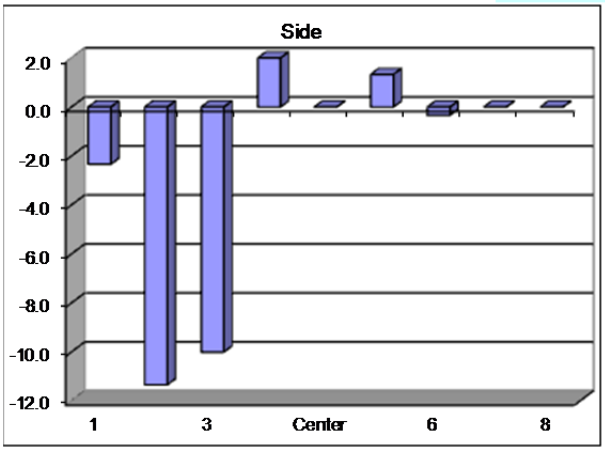
Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial --->		1	2	3		1	2	3	
Point	Depth, in.	deg. cw	deg. cw	deg. cw	Avg.	deg. cw	deg. cw	deg. cw	Avg.
1	0.50	-7	-6	6	**-2.3**	3	3	10	**5.3**
2	1.25	-13	-12	-9	**-11.3**	-10	-13	-11	**-11.3**
3	2.32	-10	-10	-10	**-10.0**	-12	-11	-14	**-12.3**
4	3.86	3	1	2	**2.0**	-1	1	-2	**-0.7**
Center	5.97	1	0	-1	**0.0**	-3	-1	-4	**-2.7**
5	8.08	3	1	0	**1.3**	1	1	1	**1.0**
6	9.62	2	-1	-2	**-0.3**	-2	-2	0	**-1.3**
7	10.68	1	2	-3	**0.0**	-1	2	1	**0.7**
8	11.44	1	1	-2	**0.0**	-2	1	1	**0.0**
Mean of absolute values:					**3.0**				**3.9**
" "w/o points by wall:					**3.6**				**4.3**
								Grand mean ABS	**3.5**
								" "w/o wall pts	**3.9**

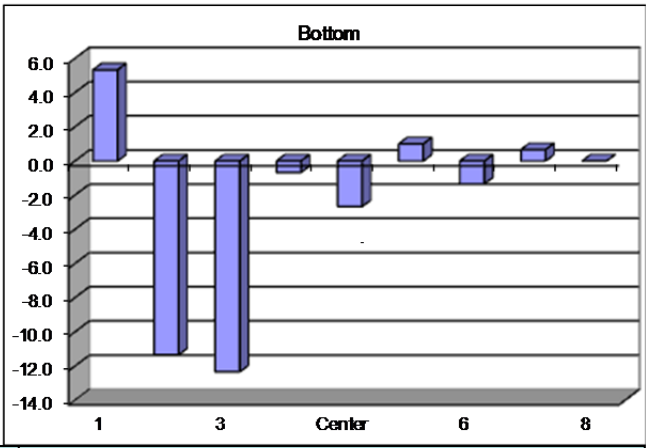
Instruments Used:			**Cal. Due**	
S-type pitot	Dwyer 24-inch S-type Pitot#10		Cert. of conformance	
Velocity sensor	TSI Velocicalc SN#T95351203001		17-Dec-12	
Angle indicator	Shop built		Cat. 3	
Manometer	Dwyer 400-5, S36N	MAN5	Cat. 3	12/13/2012

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: Ambient temperature 59.9F, Rh 34%. Less wind than yesterday.
XYY 11/8/12

XYY 11/8/12





Entries made by:	Xiao-Ying Yu	11/8/2012	Technical Data Review performed by:	
Signature/date	*On File w/ Original*		Signature/date	gbj 11/16/2012

FLOW ANGLE DATA FORM

LB-S1_FlowAngle.xls

Site	LB-S1		Run No.	FA-12	
Date	11/8/2012		Fan Setting	45	Hz
Tester	MSP, XY		Fan configuration	AB	
Stack Dia.	11.8906	in	Approx. air vel.	4257	fpm at point >> Bottom 8
Stack X-Area	111.0	in2	Units	degrees (clockwise > pos. nos.)	
Elevation	N.A.	ft	Port	1	
Distance to disturbance	123.5	in	Stack Temp	53.0 F	
Start/End Time	10:10/10:45				

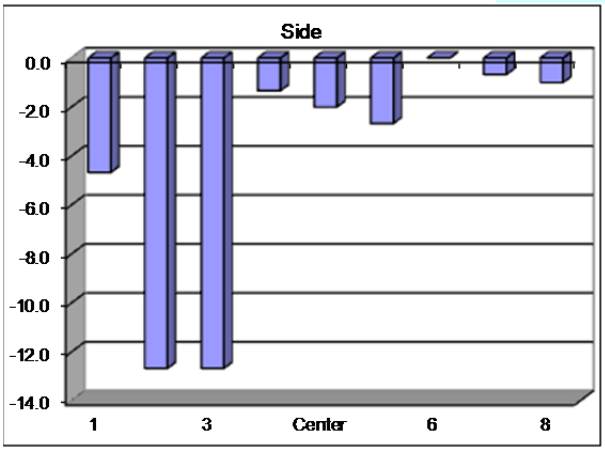
Order -->		2nd				1st			
Traverse-->		Side				Bottom			
Trial -->		1	2	3		1	2	3	
Point	Depth, in.	deg. cw	deg. cw	deg. cw	Avg.	deg. cw	deg. cw	deg. cw	Avg.
1	0.50	-8	6	-12	-4.7	11	12	8	10.3
2	1.25	-11	-14	-13	-12.7	-10	-8	-13	-10.3
3	2.32	-13	-13	-12	-12.7	-10	-9	-11	-10.0
4	3.86	-2	-1	-1	-1.3	-3	5	4	2.0
Center	5.97	-3	-2	-1	-2.0	1	2	1	1.3
5	8.08	-2	-4	-2	-2.7	1	1	0	0.7
6	9.62	-1	0	1	0.0	0	1	1	0.7
7	10.68	-1	-1	0	-0.7	2	1	1	1.3
8	11.44	0	0	-3	-1.0	1	0	2	1.0
Mean of absolute values:					4.2				4.2
" "w/o points by wall:					4.6				3.8
								Grand mean ABS	4.2
								" "w/o wall pts	4.2

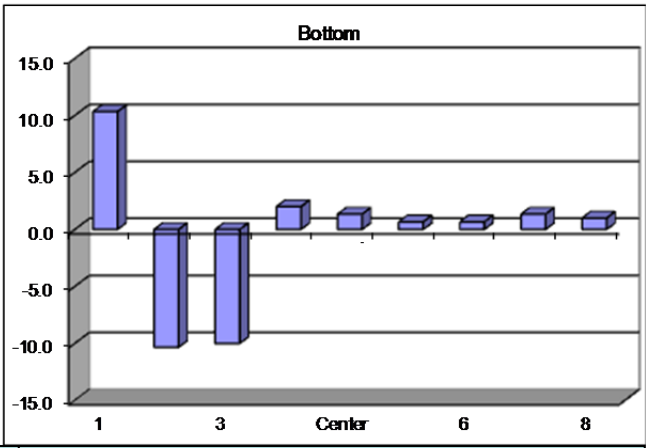
Instuments Used:			Cal. Due	
S-type pitot	Dwyer 24-inch S-type Pitot#10		Cert. of conformance	
Velocity sensor	TSI Velocicalc SN#T95351203001		17-Dec-12	
Angle indicator	Shop built		Cat. 3	
Manometer	Dwyer 400-5, S36N	MAN5	Cat. 3	12/13/2012

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: Ambient temperature is 59.0 F, and RH is 34%. Light wi XYY 11/8/12

XYY 11/8/12





Entries made by:	Xiao-Ying Yu	11/8/2012	Technical Data Review performed by:	
Signature/date	*On File w/ Original*		Signature/date	gbj 11/16/2012

Appendix A.4: LB-S1 Tracer Gas Uniformity Data Sheets

Rev. 0

TRACER GAS TRAVERSE DATA FORM

31-Jul-06

Site	LB-S1 Model	Run No.	GT-1
Date	10/25/2012	Fan Configuration	BC
Testers	MSP,CA, XY	Fan Setting	43 Hz
Stack Dia.	11.89 in.	Stack Temp	49.75 deg F
Stack X-Area	111.0 in.^{2}	Start/End Time	930/1130
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Measurement units	ppb SF6	Injection Point	Port 2 Center

Order -->		2nd				1st			
Traverse-->		Side				Bottom			
Trial —>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppb				ppb			
1	0.50	631	614	639	628.0	596	605	594	598.3
2	1.24	658	631	644	644.3	587	600	592	593.0
3	2.29	632	629	644	635.0	597	611	602	603.3
4	3.82	627	626	642	631.7	596	613	591	600.0
Center	5.91	624	607	607	612.7	627	608	610	615.0
5	8.00	602	581	596	593.0	592	610	603	601.7
6	9.52	575	565	590	576.7	609	606	615	610.0
7	10.57	576	565	570	570.3	604	619	605	609.3
8	11.31	558	558	571	562.3	604	591	617	604.0
Averages ———>		609.2	597.3	611.4	606.0	601.3	607.0	603.2	603.9

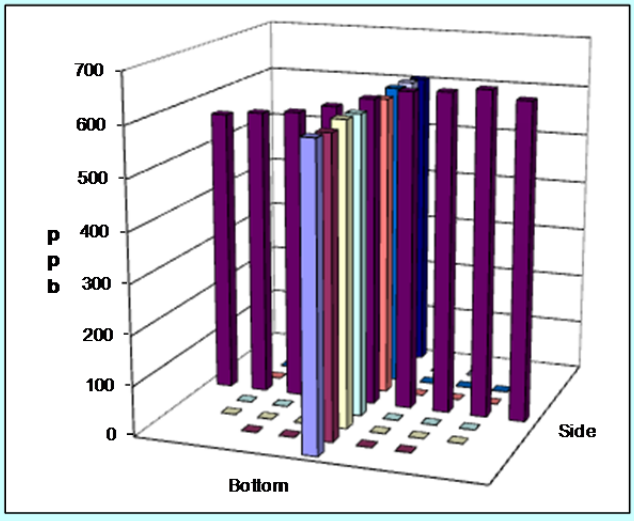
All	ppb	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	604.93		Mean	609.10	604.62	606.86
Min Point	562.33	-7.0%	Std. Dev.	29.58	7.37	20.84
Max Point	644.33	6.5%	COV as %	4.9	1.2	3.4

Avg. Conc. 603.813 ppb

Instruments Used:

B&K 1302 Gas Analyzer	SN	1788615	Cat2 M&TE
TSI VelociCalc	SN T95351203001		12/17/2012
Fisher Scientific	SN 90936818		12/7/2012

	Start	Finish	
Tracer tank pressure	20	100	psig
Injection flowmeter	50	50	sccm
Stack Temp	46.7	52.8	°F
Mean stack velocity	4572	4548	fpm
Sampling flowmeter	5	5	lpm
Ambient pressure	1016	1017	mbar
Ambient humidity	43%	23%	RH
Ambient Temp	59.0	70.7	°F
B&K vapor correction	Y	Y	Y/N
Back-Gd gas			ppb
	5,3,4,3,5	9,5,6,10,7	
No. Bk-Gd samples	5	5	n



Gas analyzer checked: 10/24/2012 XY10/25/12

Notes: Mean velocity = Bottom7

CA 10/25/12

Entries made by:	Carmen Arimescu	10/25/2012	Technical Data Review performed by:
Signature/date	Signature on file with original		Signature/date gbj 11/20/2012

Rev. 0

TRACER GAS TRAVERSE DATA FORM

31-Jul-06

Site	LB-S1 Model	Run No.	GT-2
Date	10/25/2012	Fan Configuration	BC
Testers	XY, CA	Fan Setting	43 Hz
Stack Dia.	11.89 in.	Stack Temp	54.5 deg F
Stack X-Area	111.0 in.^{2}	Start/End Time	1140/1300
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Measurement units	ppb SF6	Injection Point	Port 2 Far

Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial —>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppb				ppb			
1	0.50	566	581	564	570.3	607	622	577	602.0
2	1.24	572	592	552	572.0	627	642	629	632.7
3	2.29	566	561	568	565.0	623	598	643	621.3
4	3.82	563	564	583	570.0	599	587	614	600.0
Center	5.91	596	580	595	590.3	593	596	585	591.3
5	8.00	534	617	618	589.7	591	619	606	605.3
6	9.52	655	663	660	659.3	597	611	624	610.7
7	10.57	654	696	655	668.3	607	609	649	621.7
8	11.31	696	701	663	686.7	692	615	626	644.3
Averages ———>		600.2	617.2	606.4	608.0	615.1	611.0	617.0	614.4

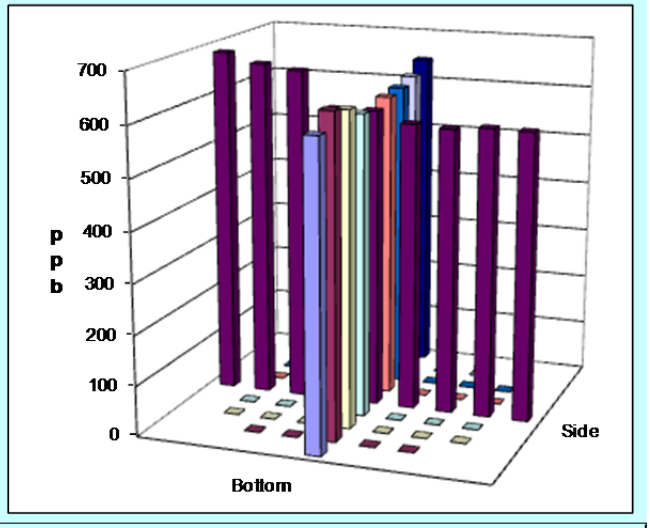
All	ppb	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	611.17		Mean	602.10	611.86	606.98
Min Point	565.00	-7.6%	Std. Dev.	43.34	14.29	31.41
Max Point	686.67	12.4%	COV as %	7.2	2.3	5.2

Avg. Conc. 613.708 ppb

Instruments Used:

B&K 1302 Gas Analyzer	SN	1788615	Cat2 M&TE
TSI VelociCalc	SN T95351203001		12/17/2012
Fisher Scientific	SN 90936818		12/7/2012

	Start	Finish	
Tracer tank pressure	100	100	psig
Injection flowmeter	50	50	sccm
Stack Temp	52.6	56.4	°F
Mean stack velocity	4552	4509	fpm
Sampling flowmeter	5	5	lpm
Ambient pressure	1017	1017	mbar
Ambient humidity	23%	42%	RH
Ambient Temp	70.7	56.3	°F
B&K vapor correction	Y	Y	Y/N
Back-Gd gas			ppb
	9,5,6,10,7	10,7,8,9,5	
No. Bk-Gd samples	5	5	n



Gas analyzer checked: 10/24/2012 CA 10/25/12

Notes: Mean velocity = Bottom7

CA 10/25/12

Entries made by:	Carmen Arimescu	10/25/2012	Technical Data Review performed by:
Signature/date	Signature on file with original		Signature/date gbj 11/21/2012

Rev. 0

TRACER GAS TRAVERSE DATA FORM

31-Jul-06

Site	LB-S1 Model	Run No.	GT-3
Date	10/26/2012	Fan Configuration	BC
Testers	MSP, CA	Fan Setting	43 Hz
Stack Dia.	11.89 in.	Stack Temp	45.9 deg F
Stack X-Area	111.0 in.^{2}	Start/End Time	900/1100
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Measurement units	ppb SF6	Injection Point	Port 2 Near

Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial —>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppb				ppb			
1	0.50	590	576	593	**586.3**	569	597	592	**586.0**
2	1.24	604	612	611	**609.0**	590	621	598	**603.0**
3	2.29	613	595	604	**604.0**	590	584	583	**585.7**
4	3.82	588	608	604	**600.0**	591	604	603	**599.3**
Center	5.91	612	586	561	**586.3**	610	607	600	**605.7**
5	8.00	599	575	574	**582.7**	587	603	597	**595.7**
6	9.52	550	568	560	**559.3**	588	566	567	**573.7**
7	10.57	512	536	551	**533.0**	569	593	571	**577.7**
8	11.31	539	506	525	**523.3**	554	560	557	**557.0**
Averages ———>		**578.6**	**573.6**	**575.9**	**576.0**	**583.1**	**592.8**	**585.3**	**587.1**

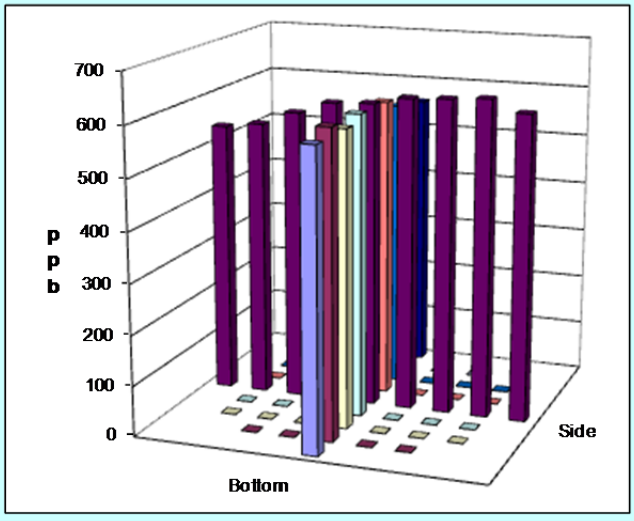
All	ppb	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	581.54		Mean	582.05	591.52	586.79
Min Point	523.33	-10.0%	Std. Dev.	27.30	12.62	21.01
Max Point	609.00	4.7%	COV as %	4.7	2.1	**3.6**

Avg. Conc. 579.729 ppb

Instruments Used:

B&K 1302 Gas Analyzer	SN	1788615	Cat2 M&TE
TSI VelociCalc	SN T95351203001		12/17/2012
Fisher Scientific	SN 90936818		12/7/2012

	Start	Finish	
Tracer tank pressure	100	100	psig
Injection flowmeter	50	50	sccm
Stack Temp	45.1	46.7	°F
Mean stack velocity	4500	4566	fpm
Sampling flowmeter	5	5	lpm
Ambient pressure	1012	1011	mbar
Ambient humidity	46%	40%	RH
Ambient Temp	53.6	58.1	°F
B&K vapor correction	Y	Y	Y/N
Back-Gd gas			ppb
	11,15,8,12,6	9,7,5,5,8	
No. Bk-Gd samples	5	5	n



Gas analyzer checked: 10/24/2012 CA 10/26/12

Notes: Mean velocity = Bottom7

CA 10/26/12

Entries made by:	Carmen Arimescu	10/26/2012	Technical Data Review performed by:
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Rev. 0

TRACER GAS TRAVERSE DATA FORM

31-Jul-06

Site	LB-S1 Model	Run No.	GT-4
Date	10/26/2012	Fan Configuration	BC
Testers	MSP, CA	Fan Setting	43 Hz
Stack Dia.	11.89 in.	Stack Temp	46.5 deg F
Stack X-Area	111.0 in.^{2}	Start/End Time	1105/1215
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Measurement units	ppb SF6	Injection Point	Port 2 Center Top

Order -->		2nd				1st			
Traverse-->		Side				Bottom			
Trial —>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppb				ppb			
1	0.50	648	641	646	645.0	617	626	615	619.3
2	1.24	632	667	654	651.0	609	609	602	606.7
3	2.29	619	630	648	632.3	617	611	641	623.0
4	3.82	613	609	637	619.7	600	593	620	604.3
Center	5.91	606	614	595	605.0	602	613	605	606.7
5	8.00	566	573	565	568.0	574	594	593	587.0
6	9.52	546	546	552	548.0	587	566	569	574.0
7	10.57	543	544	525	537.3	583	577	577	579.0
8	11.31	533	541	534	536.0	569	557	560	562.0
Averages ———>		589.6	596.1	595.1	593.6	595.3	594.0	598.0	595.8

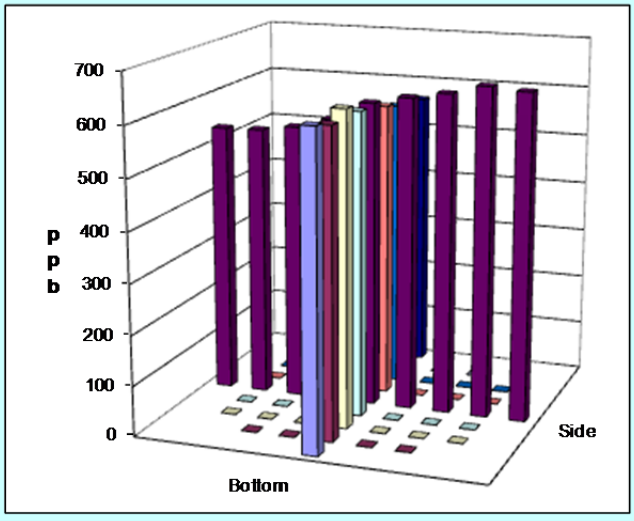
All	ppb	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	594.69		Mean	594.48	597.24	595.86
Min Point	536.00	-9.9%	Std. Dev.	43.78	17.65	32.10
Max Point	651.00	9.5%	COV as %	7.4	3.0	5.4

Avg. Conc. 593.292 ppb

Instruments Used:

B&K 1302 Gas Analyzer	SN	1788615	Cat2 M&TE
TSI VelociCalc	SN T95351203001		12/17/2012
Fisher Scientific	SN 90936818		12/7/2012

	Start	Finish	
Tracer tank pressure	100	100	psig
Injection flowmeter	50	50	sccm
Stack Temp	46.7	46.3	°F
Mean stack velocity	4566	4501	fpm
Sampling flowmeter	5	5	lpm
Ambient pressure	1011	1011	mbar
Ambient humidity	39%	38%	RH
Ambient Temp	58.1	58.1	°F
B&K vapor correction	Y	Y	Y/N
Back-Gd gas	6,9,3,5,7	5,4,5,5,1	ppb
No. Bk-Gd samples	5	5	n



Gas analyzer checked: 10/24/2012 CA 10/26/12

Notes: Mean velocity = Bottom7

CA 10/26/12

Entries made by:	Carmen Arimescu	10/26/2012	Technical Data Review performed by:
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Rev. 0

TRACER GAS TRAVERSE DATA FORM

31-Jul-06

Site	LB-S1 Model	Run No.	GT-5
Date	10/26/2012	Fan Configuration	BC
Testers	MSP, CA	Fan Setting	43 Hz
Stack Dia.	11.89 in.	Stack Temp	46.65 deg F
Stack X-Area	111.0 in.^{2}	Start/End Time	1230/1445
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Measurement units	ppb SF6	Injection Point	Port 2 center Bottom

Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial —>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppb				ppb			
1	0.50	527	526	518	523.7	584	547	572	567.7
2	1.24	592	523	567	560.7	556	578	580	571.3
3	2.29	515	577	597	563.0	546	576	583	568.3
4	3.82	596	573	546	571.7	580	590	561	577.0
Center	5.91	603	601	611	605.0	646	573	608	609.0
5	8.00	636	651	641	642.7	581	614	583	592.7
6	9.52	607	647	708	654.0	655	659	644	652.7
7	10.57	635	673	672	660.0	680	655	615	650.0
8	11.31	675	693	681	683.0	623	627	631	627.0
Averages ———>		598.4	607.1	615.7	607.1	605.7	602.1	597.4	601.7

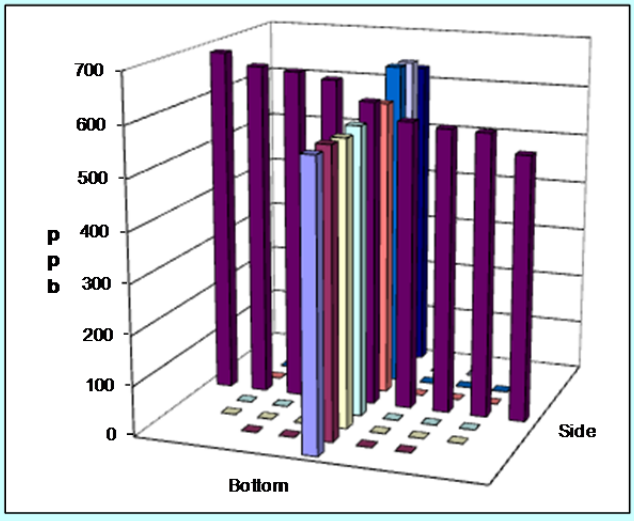
All	ppb	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	604.41		Mean	608.14	603.00	605.57
Min Point	523.67	-13.4%	Std. Dev.	44.00	35.82	38.64
Max Point	683.00	13.0%	COV as %	7.2	5.9	6.4

Avg. Conc. 604.083 ppb

Instruments Used:

B&K 1302 Gas Analyzer	SN	1788615	Cat2 M&TE
TSI VelociCalc	SN T95351203001		12/17/2012
Fisher Scientific	SN 90936818		12/7/2012

	Start	Finish	
Tracer tank pressure	100	100	psig
Injection flowmeter	50	50	sccm
Stack Temp	47	46.3	°F
Mean stack velocity	4412	4472	fpm
Sampling flowmeter	5	5	lpm
Ambient pressure	1010	1011	mbar
Ambient humidity	40%	39%	RH
Ambient Temp	50	60.8	°F
B&K vapor correction	Y	Y	Y/N
Back-Gd gas	2,6,3,0,3	5,7,8,3,2	ppb
No. Bk-Gd samples	5	5	n



Gas analyzer checked: 10/24/2012 CA 10/26/12

Notes: Mean velocity = Bottom7

CA 10/26/12

Entries made by:	Carmen Arimescu	10/26/2012	Technical Data Review performed by:
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Rev. 0

TRACER GAS TRAVERSE DATA FORM

31-Jul-06

Site	LB-S1 Model	Run No.	GT-6
Date	10/29/2012	Fan Configuration	BC
Testers	EA, CA	Fan Setting	32 Hz
Stack Dia.	11.89 in.	Stack Temp	68.65 deg F
Stack X-Area	111.0 in.^{2}	Start/End Time	1000/1150
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Measurement units	ppb SF6	Injection Point	Port 2 Center

Order -->		2nd				1st			
Traverse-->		Side				Bottom			
Trial —>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppb				ppb			
1	0.50	928	949	918	931.7	848	830	829	835.7
2	1.24	801	932	897	876.7	832	842	806	826.7
3	2.29	870	879	886	878.3	807	832	805	814.7
4	3.82	879	870	880	876.3	827	840	844	837.0
Center	5.91	832	846	862	846.7	838	865	856	853.0
5	8.00	807	795	830	810.7	832	860	865	852.3
6	9.52	813	802	802	805.7	841	833	833	835.7
7	10.57	814	782	782	792.7	897	875	874	882.0
8	11.31	801	812	830	814.3	872	891	889	884.0
Averages ———>		838.3	851.9	854.1	848.1	843.8	852.0	844.6	846.8

All	ppb	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	847.44		Mean	841.00	843.05	842.02
Min Point	792.67	-6.5%	Std. Dev.	37.53	21.86	29.53
Max Point	931.67	9.9%	COV as %	4.5	2.6	3.5

Avg. Conc. 847.146 ppb

Instruments Used:

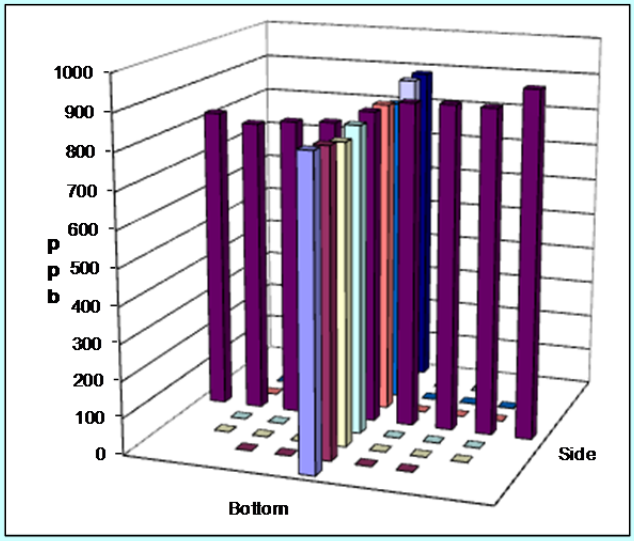
B&K 1302 Gas Analyzer	SN	1788615	Cat2 M&TE
TSI VelociCalc	SN T95351203001		12/17/2012
Fisher Scientific	SN 90936818		12/7/2012

	Start	Finish	
Tracer tank pressure	100	100	psig
Injection flowmeter	50	50	sccm
Stack Temp	65	72.3	°F
Mean stack velocity	3023	3009	fpm
Sampling flowmeter	5	5	lpm
Ambient pressure	998	1001	mbar
Ambient humidity	69%	44%	RH
Ambient Temp	64.4	71.6	°F
B&K vapor correction	Y	Y	Y/N
Back-Gd gas	1,-0.1,-2,-3,-5	9,6,5,5,-1	ppb
No. Bk-Gd samples	5	5	n

Gas analyzer checked: 10/24/2012 CA 10/29/12

Notes: Mean velocity = Bottom7

CA 10/29/12



Entries made by:	Carmen Arimescu	10/29/2012	Technical Data Review performed by:
Signature/date	Signature on file with original		Signature/date gbj 11/27/2012

Rev. 0

TRACER GAS TRAVERSE DATA FORM

31-Jul-06

Site	LB-S1 Model	Run No.	GT-7
Date	10/30/2012	Fan Configuration	AC
Testers	CA, XY	Fan Setting	43 Hz
Stack Dia.	11.89 in.	Stack Temp	60.1 deg F
Stack X-Area	111.0 in.^{2}	Start/End Time	940/1110
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Measurement units	ppb SF6	Injection Point	Port 2 Center

Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial —>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppb				ppb			
1	0.50	591	627	641	**619.7**	644	626	629	**633.0**
2	1.24	632	626	627	**628.3**	635	604	611	**616.7**
3	2.29	630	624	613	**622.3**	639	611	640	**630.0**
4	3.82	609	621	620	**616.7**	611	615	613	**613.0**
Center	5.91	603	612	631	**615.3**	615	610	615	**613.3**
5	8.00	652	616	628	**632.0**	621	615	625	**620.3**
6	9.52	638	624	625	**629.0**	604	622	621	**615.7**
7	10.57	622	618	622	**620.7**	616	609	629	**618.0**
8	11.31	612	616	620	**616.0**	611	618	619	**616.0**
Averages ———>		**621.0**	**620.4**	**625.2**	**622.2**	**621.8**	**614.4**	**622.4**	**619.6**

All	ppb	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	620.89		Mean	623.48	618.14	620.81
Min Point	613.00	-1.3%	Std. Dev.	6.44	5.82	6.51
Max Point	633.00	2.0%	COV as %	1.0	0.9	1.0

Avg. Conc. 621.708 ppb

Instruments Used:

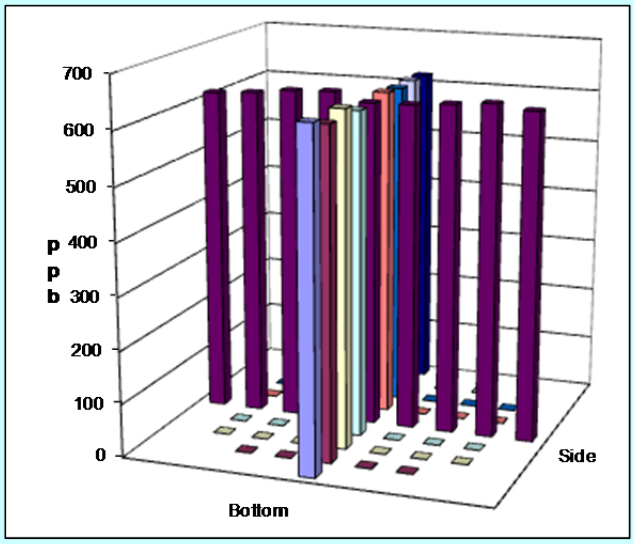
B&K 1302 Gas Analyzer	SN 1788615	Cat2 M&TE
TSI VelociCalc	SN T95351203001	12/17/2012
Fisher Scientific	SN 90936818	12/7/2012

	Start	Finish	
Tracer tank pressure	100	100	psig
Injection flowmeter	50	50	sccm
Stack Temp	59	61.2	°F
Mean stack velocity	4468	4540	fpm
Sampling flowmeter	5	5	lpm
Ambient pressure	1001	1000	mbar
Ambient humidity	44%	50%	RH
Ambient Temp	69.8	67.1	°F
B&K vapor correction	Y	Y	Y/N
Back-Gd gas	8,3,1,1,0	-2,-2,-5,-3,-2	ppb
No. Bk-Gd samples	5	5	n

Gas analyzer checked: 10/24/2012 CA 10/30/12

Notes: Mean velocity = Center

CA 10/30/12



Entries made by:	Carmen Arimescu	Technical Data Review performed by:	
Signature/date	Signature on file with original 10/30/2012	Signature/date	gbj 11/27/2012

Rev. 0

TRACER GAS TRAVERSE DATA FORM

31-Jul-06

Site	LB-S1 Model	Run No.	GT-8
Date	10/30/2012	Fan Configuration	AC
Testers	XY, CA, MSP	Fan Setting	43 Hz
Stack Dia.	11.89 in.	Stack Temp	62.45 deg F
Stack X-Area	111.0 in.^{2}	Start/End Time	1115/1217
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Measurement units	ppb SF6	Injection Point	Port 2 Far

Order -->		2nd				1st			
Traverse-->		Side				Bottom			
Trial —>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppb				ppb			
1	0.50	619	662	595	625.3	606	608	619	611.0
2	1.24	633	634	668	645.0	628	656	630	638.0
3	2.29	639	670	652	653.7	609	620	619	616.0
4	3.82	608	640	646	631.3	628	628	636	630.7
Center	5.91	618	646	653	639.0	633	615	613	620.3
5	8.00	625	621	631	625.7	639	617	642	632.7
6	9.52	621	617	632	623.3	623	618	626	622.3
7	10.57	618	627	617	620.7	638	643	634	638.3
8	11.31	634	618	607	619.7	646	635	595	625.3
Averages ———>		623.9	637.2	633.4	631.5	627.8	626.7	623.8	626.1

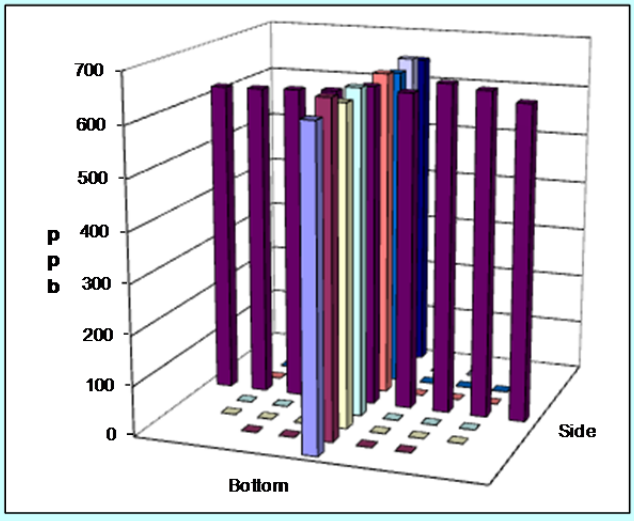
All	ppb	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	628.80		Mean	634.10	628.33	631.21
Min Point	611.00	-2.8%	Std. Dev.	12.25	8.85	10.69
Max Point	653.67	4.0%	COV as %	1.9	1.4	1.7

Avg. Conc. 628.688 ppb

Instruments Used:

B&K 1302 Gas Analyzer	SN	1788615	Cat2 M&TE
TSI VelociCalc	SN T95351203001		12/17/2012
Fisher Scientific	SN 90936818		12/7/2012

	Start	Finish	
Tracer tank pressure	100	100	psig
Injection flowmeter	50	50	sccm
Stack Temp	60.7	64.2	°F
Mean stack velocity	4534	4309	fpm
Sampling flowmeter	5	5	lpm
Ambient pressure	1000	1000	mbar
Ambient humidity	48%	40%	RH
Ambient Temp	68.0	72.5	°F
B&K vapor correction	Y	Y	Y/N
Back-Gd gas	-1,-2,4,-4,-6	3,1,6,4,4	ppb
No. Bk-Gd samples	5	5	n



Gas analyzer checked: 10/24/2012 CA 10/30/12

Notes: Mean velocity = Center

CA 10/30/12

Entries made by:	Carmen Arimescu	Technical Data Review performed by:	
Signature/date	Signature on file with original 10/30/2012	Signature/date	gbj 11/27/2012

Rev. 0

TRACER GAS TRAVERSE DATA FORM

31-Jul-06

Site	LB-S1 Model	Run No.	GT-9
Date	10/30/2012	Fan Configuration	AC
Testers	XY, MSP, CA	Fan Setting	43 Hz
Stack Dia.	11.89 in.	Stack Temp	64.35 deg F
Stack X-Area	111.0 in.^{2}	Start/End Time	1218/127
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Measurement units	ppb SF6	Injection Point	Port 2 Near

Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial —>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppb				ppb			
1	0.50	615	627	654	**632.0**	636	659	645	**646.7**
2	1.24	593	599	625	**605.7**	653	625	642	**640.0**
3	2.29	622	630	633	**628.3**	641	632	675	**649.3**
4	3.82	621	606	626	**617.7**	649	622	653	**641.3**
Center	5.91	637	633	639	**636.3**	646	641	636	**641.0**
5	8.00	634	647	636	**639.0**	640	639	637	**638.7**
6	9.52	647	629	648	**641.3**	627	624	628	**626.3**
7	10.57	638	642	641	**640.3**	603	646	650	**633.0**
8	11.31	641	628	620	**629.7**	640	625	600	**621.7**
Averages ———>		**627.6**	**626.8**	**635.8**	**630.0**	**637.2**	**634.8**	**640.7**	**637.6**

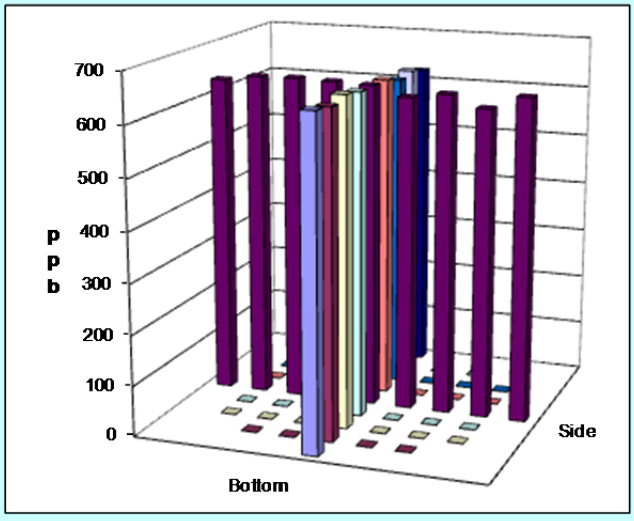
All	ppb	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	633.80		Mean	629.81	638.52	634.17
Min Point	605.67	-4.4%	Std. Dev.	13.56	7.21	11.37
Max Point	649.33	2.5%	COV as %	2.2	1.1	1.8

Avg. Conc. 633.188 ppb

Instruments Used:

B&K 1302 Gas Analyzer	SN	1788615	Cat2 M&TE
TSI VelociCalc	SN T95351203001		12/17/2012
Fisher Scientific	SN 90936818		12/7/2012

	Start	Finish	
Tracer tank pressure	100	100	psig
Injection flowmeter	50	50	sccm
Stack Temp	64.5	64.2	°F
Mean stack velocity	4502	4493	fpm
Sampling flowmeter	5	5	lpm
Ambient pressure	1000	1000	mbar
Ambient humidity	40%	41%	RH
Ambient Temp	72.5	73.4	°F
B&K vapor correction	Y	Y	Y/N
Back-Gd gas	-5,2,-5,-3,5	5,3,5,5,-5	ppb
No. Bk-Gd samples	5	5	n



Gas analyzer checked: 10/24/2012 CA 10/30/12

Notes: Mean velocity = Center

CA 10/30/12

Entries made by:	Carmen Arimescu	Technical Data Review performed by:	
Signature/date	Signature on file with original 10/30/2012	Signature/date	gbj 11/27/2012

Rev. 0

TRACER GAS TRAVERSE DATA FORM

31-Jul-06

Site	LB-S1 Model	Run No.	GT-10
Date	10/30/2012	Fan Configuration	AC
Testers	MSP, CA	Fan Setting	43 Hz
Stack Dia.	11.89 in.	Stack Temp	64.35 deg F
Stack X-Area	111.0 in.^{2}	Start/End Time	1331/1430
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Measurement units	ppb SF6	Injection Point	Port 2 Bottom

Order -->		2nd				1st			
Traverse-->		Side				Bottom			
Trial —>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppb				ppb			
1	0.50	645	644	639	**642.7**	620	587	615	**607.3**
2	1.24	639	630	619	**629.3**	618	629	599	**615.3**
3	2.29	657	660	629	**648.7**	615	644	633	**630.7**
4	3.82	682	637	639	**652.7**	660	625	644	**643.0**
Center	5.91	578	644	616	**612.7**	662	704	634	**666.7**
5	8.00	636	621	641	**632.7**	627	643	648	**639.3**
6	9.52	619	600	650	**623.0**	625	625	614	**621.3**
7	10.57	633	625	640	**632.7**	681	653	695	**676.3**
8	11.31	621	616	646	**627.7**	630	626	631	**629.0**
Averages ———>		**634.4**	**630.8**	**635.4**	**633.6**	**637.6**	**637.3**	**634.8**	**636.6**

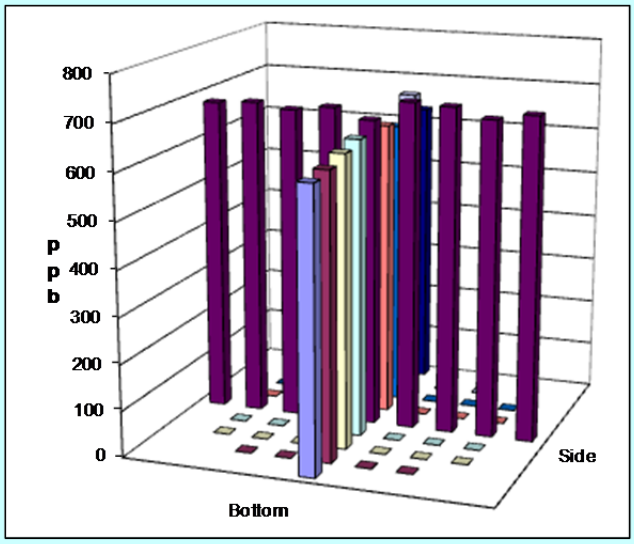
All	ppb	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	635.06		Mean	633.10	641.81	637.45
Min Point	607.33	-4.4%	Std. Dev.	13.90	22.59	18.58
Max Point	676.33	6.5%	COV as %	2.2	3.5	2.9

Avg. Conc. 634.479 ppb

Instruments Used:

B&K 1302 Gas Analyzer	SN 1788615	Cat2 M&TE
TSI VelociCalc	SN T95351203001	12/17/2012
Fisher Scientific	SN 90936818	12/7/2012

	Start	Finish	
Tracer tank pressure	100	100	psig
Injection flowmeter	50	50	sccm
Stack Temp	64.2	64.5	°F
Mean stack velocity	4493	4483	fpm
Sampling flowmeter	5	5	lpm
Ambient pressure	1000	999	mbar
Ambient humidity	40%	56%	RH
Ambient Temp	74.3	65.3	°F
B&K vapor correction	Y	Y	Y/N
Back-Gd gas	2,4,-1,-2,-1	-5, -3, -4, -7, -13	ppb
No. Bk-Gd samples	5	5	n



Gas analyzer checked: 10/24/2012 CA 10/30/12

Notes: Mean velocity = Center

CA 10/30/12

Entries made by:	Carmen Arimescu	Technical Data Review performed by:	
Signature/date	Signature on file with original 10/30/2012	Signature/date	gbj 11/27/2012

Rev. 0

TRACER GAS TRAVERSE DATA FORM

31-Jul-06

Site	LB-S1 Model	Run No.	GT-11
Date	10/30/2012	Fan Configuration	AC
Testers	MSP, CA	Fan Setting	43 Hz
Stack Dia.	11.89 in.	Stack Temp	63.35 deg F
Stack X-Area	111.0 in.^{2}	Start/End Time	1500/1620
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Measurement units	ppb SF6	Injection Point	Port 2 Top

Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial —>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppb				ppb			
1	0.50	633	606	618	**619.0**	593	623	637	**617.7**
2	1.24	656	657	633	**648.7**	625	640	613	**626.0**
3	2.29	634	646	642	**640.7**	638	617	644	**633.0**
4	3.82	639	646	636	**640.3**	632	623	623	**626.0**
Center	5.91	633	627	629	**629.7**	642	641	622	**635.0**
5	8.00	628	623	628	**626.3**	610	621	608	**613.0**
6	9.52	615	636	634	**628.3**	625	642	643	**636.7**
7	10.57	649	625	634	**636.0**	637	617	630	**628.0**
8	11.31	631	649	633	**637.7**	618	653	607	**626.0**
Averages ———>		**635.3**	**635.0**	**631.9**	**634.1**	**624.4**	**630.8**	**625.2**	**626.8**

All	ppb	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	630.44		Mean	635.71	628.24	631.98
Min Point	613.00	-2.8%	Std. Dev.	8.09	7.98	8.64
Max Point	648.67	2.9%	COV as %	1.3	1.3	1.4

Avg. Conc. 630.208 ppb

Instruments Used:

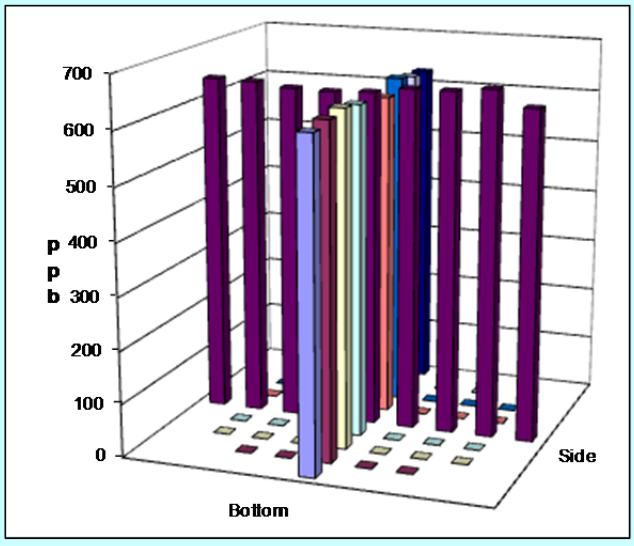
B&K 1302 Gas Analyzer	SN	1788615	Cat2 M&TE
TSI VelociCalc	SN T95351203001		12/17/2012
Fisher Scientific	SN 90936818		12/7/2012

	Start	Finish	
Tracer tank pressure	100	100	psig
Injection flowmeter	50	50	sccm
Stack Temp	64.5	62.2	°F
Mean stack velocity	4483	4505	fpm
Sampling flowmeter	5	5	lpm
Ambient pressure	999	999	mbar
Ambient humidity	47%	66%	RH
Ambient Temp	71.6	64.4	°F
B&K vapor correction	Y	Y	Y/N
Back-Gd gas	6,-5,-1,1,-5	1,-6,-10,-10, -5	ppb
No. Bk-Gd samples	5	5	n

Gas analyzer checked: 10/24/2012 CA 10/30/12

Notes: Mean velocity = Center

CA 10/30/12



Entries made by:	Carmen Arimescu	Technical Data Review performed by:	
Signature/date	Signature on file with original 10/30/2012	Signature/date	gbj 11/27/2012

Rev. 0

TRACER GAS TRAVERSE DATA FORM

31-Jul-06

Site	LB-S1 Model	Run No.	GT-12
Date	10/31/2012	Fan Configuration	AC
Testers	XY, CA	Fan Setting	31 Hz
Stack Dia.	11.89 in.	Stack Temp	62.1 deg F
Stack X-Area	111.0 in.^{2}	Start/End Time	1030/1200
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Measurement units	ppb SF6	Injection Point	Port 2 Center

Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial —>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppb				ppb			
1	0.50	873	874	894	880.3	931	876	932	913.0
2	1.24	893	885	864	880.7	908	907	900	905.0
3	2.29	862	853	864	859.7	914	860	920	898.0
4	3.82	861	871	889	873.7	924	883	916	907.7
Center	5.91	859	877	868	868.0	881	923	873	892.3
5	8.00	875	847	896	872.7	905	847	864	872.0
6	9.52	841	894	872	869.0	909	885	873	889.0
7	10.57	901	870	868	879.7	882	891	875	882.7
8	11.31	877	827	909	871.0	879	857	855	863.7
Averages ———>		871.3	866.4	880.4	872.7	903.7	881.0	889.8	891.5

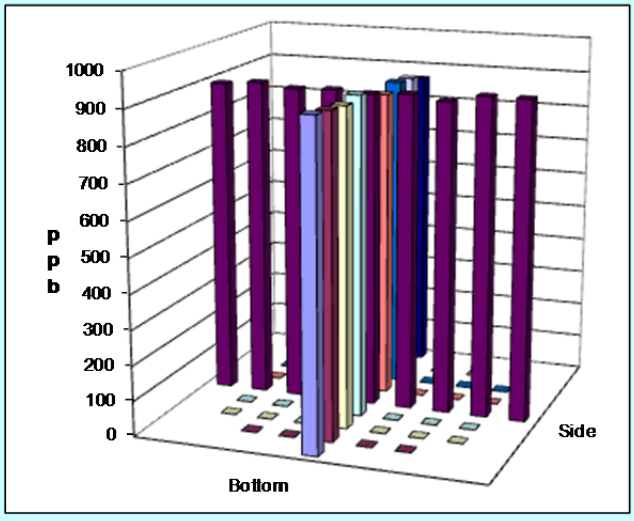
All	ppb	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	882.11		Mean	871.90	892.38	882.14
Min Point	859.67	-2.5%	Std. Dev.	7.24	12.55	14.48
Max Point	913.00	3.5%	COV as %	0.8	1.4	1.6

Avg. Conc. 882.354 ppb

Instruments Used:

B&K 1302 Gas Analyzer	SN	1788615	Cat2 M&TE
TSI VelociCalc	SN T95351203001		12/17/2012
Fisher Scientific	SN 90936818		12/7/2012

	Start	Finish	
Tracer tank pressure	100	100	psig
Injection flowmeter	50	50	sccm
Stack Temp	62.2	62	°F
Mean stack velocity	3100	3109	fpm
Sampling flowmeter	5	5	lpm
Ambient pressure	995	995	mbar
Ambient humidity	49%	44%	RH
Ambient Temp	69.8	71.6	°F
B&K vapor correction	Y	Y	Y/N
Back-Gd gas	-8,-6,10,-9,-7	8,4,2,0,0	ppb
No. Bk-Gd samples	5	5	n



Gas analyzer checked: 10/31/2012 CA 10/31/12

Notes: Mean velocity = Center

CA 10/31/12

Entries made by:	Carmen Arimescu	Technical Data Review performed by:	
Signature/date	Signature on file with original 10/31/2012	Signature/date	gbj 11/27/2012

Rev. 0

TRACER GAS TRAVERSE DATA FORM

31-Jul-06

Site	LB-S1 Model	Run No.	GT-13
Date	10/31/2012	Fan Configuration	AB
Testers	XY, CA,MSP	Fan Setting	44 Hz
Stack Dia.	11.89 in.	Stack Temp	59.35 deg F
Stack X-Area	111.0 in.^{2}	Start/End Time	1205/1320
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Measurement units	ppb SF6	Injection Point	Port 2 Center

Order -->		2nd				1st			
Traverse-->		Side				Bottom			
Trial —>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppb				ppb			
1	0.50	589	615	565	589.7	592	574	590	585.3
2	1.24	585	605	579	589.7	596	590	584	590.0
3	2.29	605	591	612	602.7	610	636	573	606.3
4	3.82	604	630	603	612.3	617	617	628	620.7
Center	5.91	618	635	639	630.7	613	606	602	607.0
5	8.00	606	624	624	618.0	618	617	613	616.0
6	9.52	587	612	616	605.0	625	608	647	626.7
7	10.57	631	650	621	634.0	603	623	637	621.0
8	11.31	629	621	642	630.7	620	636	614	623.3
Averages ———>		606.0	620.3	611.2	612.5	610.4	611.9	609.8	610.7

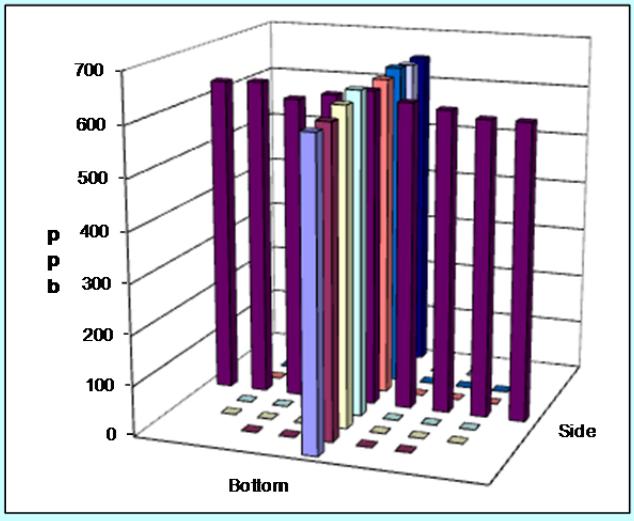
All	ppb	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	611.61		Mean	613.19	612.52	612.86
Min Point	585.33	-4.3%	Std. Dev.	15.78	12.43	13.65
Max Point	634.00	3.7%	COV as %	2.6	2.0	2.2

Avg. Conc. 610.708 ppb

Instruments Used:

B&K 1302 Gas Analyzer	SN	1788615	Cat2 M&TE
TSI VelociCalc	SN T95351203001		12/17/2012
Fisher Scientific	SN 90936818		12/7/2012

	Start	Finish	
Tracer tank pressure	100	100	psig
Injection flowmeter	50	50	sccm
Stack Temp	58	60.7	°F
Mean stack velocity	4453	4462	fpm
Sampling flowmeter	5	5	lpm
Ambient pressure	994	993	mbar
Ambient humidity	44%	42%	RH
Ambient Temp	73.4	74.3	°F
B&K vapor correction	Y	Y	Y/N
Back-Gd gas	-4, -5, -8, -9, -2	8,9,3,2,1	ppb
No. Bk-Gd samples	5	5	n



Gas analyzer checked: 10/31/2012 XYY 10/31/12

Notes: Mean Velocity at Bottom 8

XYY 10/31/12

Entries made by:	Carmen Arimescu	Technical Data Review performed by:	
Signature/date	Signature on file with original 10/31/2012	Signature/date	gbj 11/27/2012

Rev. 0

TRACER GAS TRAVERSE DATA FORM

31-Jul-06

Site	LB-S1 Model	Run No.	GT-14
Date	10/31/2012	Fan Configuration	AB
Testers	MSP, CA	Fan Setting	44 Hz
Stack Dia.	11.89 in.	Stack Temp	60.7 deg F
Stack X-Area	111.0 in.^{2}	Start/End Time	1329/1434
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Measurement units	ppb SF6	Injection Point	Port 2 Far

Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial —>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppb				ppb			
1	0.50	560	569	601	576.7	629	643	653	641.7
2	1.24	613	608	569	596.7	660	656	624	646.7
3	2.29	608	585	573	588.7	646	656	617	639.7
4	3.82	592	575	596	587.7	599	606	616	607.0
Center	5.91	585	587	600	590.7	611	606	615	610.7
5	8.00	624	637	599	620.0	585	590	598	591.0
6	9.52	633	605	628	622.0	581	608	595	594.7
7	10.57	654	650	667	657.0	594	629	599	607.3
8	11.31	648	617	659	641.3	592	616	576	594.7
Averages ———>		613.0	603.7	610.2	609.0	610.8	623.3	610.3	614.8

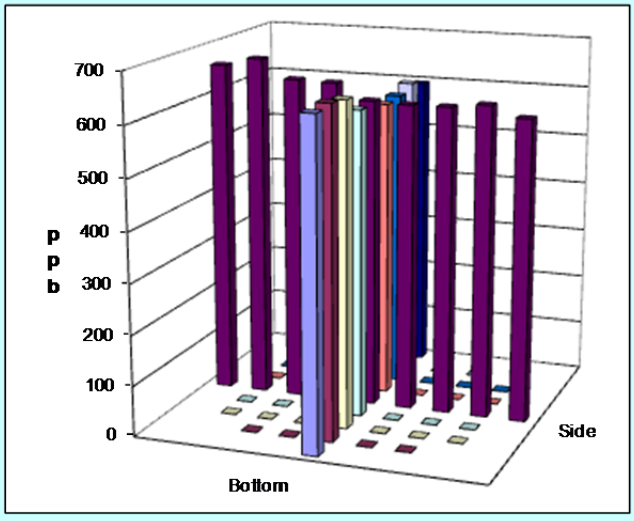
All	ppb	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	611.89		Mean	608.95	613.86	611.40
Min Point	576.67	-5.8%	Std. Dev.	25.66	21.34	22.82
Max Point	657.00	7.4%	COV as %	4.2	3.5	3.7

Avg. Conc. 613.292 ppb

Instruments Used:

B&K 1302 Gas Analyzer	SN	1788615	Cat2 M&TE
TSI VelociCalc	SN T95351203001		12/17/2012
Fisher Scientific	SN 90936818		12/7/2012

	Start	Finish	
Tracer tank pressure	100	100	psig
Injection flowmeter	50	50	sccm
Stack Temp	60.7	60.7	°F
Mean stack velocity	4462	4456	fpm
Sampling flowmeter	5	5	lpm
Ambient pressure	993	992	mbar
Ambient humidity	42%	42%	RH
Ambient Temp	74.3	75.2	°F
B&K vapor correction	Y	Y	Y/N
Back-Gd gas	0,-1,1,-7,-4	6,1,2,4,-1	ppb
No. Bk-Gd samples	5	5	n



Gas analyzer checked: 10/31/2012 CA 10/31/12

Notes: Mean Velocity at Bottom 8

CA 10/31/12

Entries made by:	Carmen Arimescu	Technical Data Review performed by:	
Signature/date	Signature on file with original 10/31/2012	Signature/date	gbj 11/27/2012

Rev. 0

TRACER GAS TRAVERSE DATA FORM

31-Jul-06

Site	LB-S1 Model	Run No.	GT-15
Date	10/31/2012	Fan Configuration	AB
Testers	MSP, CA	Fan Setting	44 Hz
Stack Dia.	11.89 in.	Stack Temp	60.7 deg F
Stack X-Area	111.0 in.^{2}	Start/End Time	1436/1546
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Measurement units	ppb SF6	Injection Point	Port 2 Near

Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial —>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppb				ppb			
1	0.50	636	657	610	**634.3**	591	620	593	**601.3**
2	1.24	665	635	653	**651.0**	570	587	599	**585.3**
3	2.29	627	640	622	**629.7**	593	583	623	**599.7**
4	3.82	626	646	649	**640.3**	605	608	620	**611.0**
Center	5.91	634	614	641	**629.7**	636	626	607	**623.0**
5	8.00	611	596	583	**596.7**	612	624	623	**619.7**
6	9.52	569	578	587	**578.0**	653	625	625	**634.3**
7	10.57	585	570	583	**579.3**	609	590	651	**616.7**
8	11.31	578	590	557	**575.0**	653	615	644	**637.3**
Averages ———>		**614.6**	**614.0**	**609.4**	**612.7**	**613.6**	**608.7**	**620.6**	**614.3**

All	ppb	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	613.46		Mean	614.95	612.81	613.88
Min Point	575.00	-6.3%	Std. Dev.	29.85	16.12	23.07
Max Point	651.00	6.1%	COV as %	4.9	2.6	**3.8**

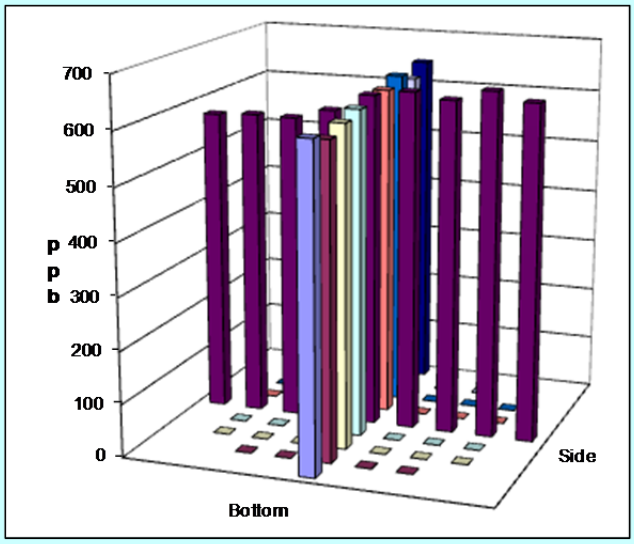
Avg. Conc. 611.854 ppb

Instruments Used:

B&K 1302 Gas Analyzer	SN	1788615	Cat2 M&TE
TSI VelociCalc	SN T95351203001		12/17/2012
Fisher Scientific	SN 90936818		12/7/2012

	Start	Finish	
Tracer tank pressure	100	100	psig
Injection flowmeter	50	50	sccm
Stack Temp	60.7	60.7	°F
Mean stack velocity	4456	4453	fpm
Sampling flowmeter	5	5	lpm
Ambient pressure	992	993	mbar
Ambient humidity	43%	46%	RH
Ambient Temp	74.3	72.5	°F
B&K vapor correction	Y	Y	Y/N
Back-Gd gas	-1, -6, -7, -2, -4	9,0,0,4,-2	ppb
No. Bk-Gd samples	5	5	n

Gas analyzer checked: 10/31/2012 CA 10/31/12



Notes: Mean Velocity at Bottom 8

CA 10/31/12

Entries made by:	Carmen Arimescu	Technical Data Review performed by:	
Signature/date	Signature on file with original 10/31/2012	Signature/date	gbj 11/27/2012

Rev. 0

TRACER GAS TRAVERSE DATA FORM

31-Jul-06

Site	LB-S1 Model	Run No.	GT-16
Date	10/31/2012	Fan Configuration	AB
Testers	MSP, CA	Fan Setting	44 Hz
Stack Dia.	11.89 in.	Stack Temp	59.85 deg F
Stack X-Area	111.0 in.^{2}	Start/End Time	1548/1703
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Measurement units	ppb SF6	Injection Point	Port 2 Bottom

Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial —>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppb				ppb			
1	0.50	576	572	584	577.3	675	602	619	632.0
2	1.24	581	525	577	561.0	626	615	674	638.3
3	2.29	583	565	591	579.7	614	611	642	622.3
4	3.82	588	600	559	582.3	601	585	599	595.0
Center	5.91	592	602	612	602.0	586	579	630	598.3
5	8.00	669	629	645	647.7	571	593	593	585.7
6	9.52	632	707	617	652.0	604	634	653	630.3
7	10.57	649	629	709	662.3	591	574	650	605.0
8	11.31	684	684	615	661.0	609	598	566	591.0
Averages ———>		617.1	612.6	612.1	613.9	608.6	599.0	625.1	610.9

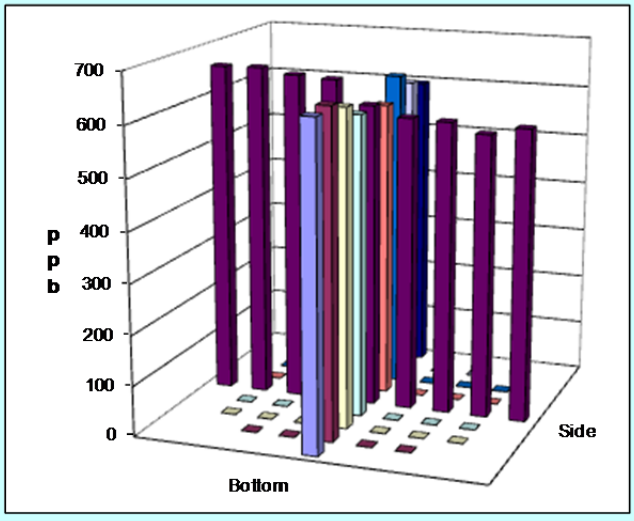
All	ppb	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	612.41		Mean	612.43	610.71	611.57
Min Point	561.00	-8.4%	Std. Dev.	40.89	19.76	30.86
Max Point	662.33	8.2%	COV as %	6.7	3.2	5.0

Avg. Conc. 613.938 ppb

Instruments Used:

B&K 1302 Gas Analyzer	SN	1788615	Cat2 M&TE
TSI VelociCalc	SN T95351203001		12/17/2012
Fisher Scientific	SN 90936818		12/7/2012

	Start	Finish	
Tracer tank pressure	100	100	psig
Injection flowmeter	50	50	sccm
Stack Temp	60.7	59	°F
Mean stack velocity	4453	4487	fpm
Sampling flowmeter	5	5	lpm
Ambient pressure	993	994	mbar
Ambient humidity	45%	44%	RH
Ambient Temp	73.4	73.4	°F
B&K vapor correction	Y	Y	Y/N
Back-Gd gas	8,2,-4,-4,-6	1,1,-3,-5,-5	ppb
No. Bk-Gd samples	5	5	n



Gas analyzer checked: 10/31/2012 CA 10/31/12

Notes: Mean Velocity at Bottom 8

CA 10/31/12

Entries made by:	Carmen Arimescu	Technical Data Review performed by:	
Signature/date	Signature on file with original 10/31/2012	Signature/date	gbj 11/27/2012

Rev. 0

TRACER GAS TRAVERSE DATA FORM

31-Jul-06

Site	LB-S1 Model	Run No.	GT-17
Date	11/1/2012	Fan Configuration	AB
Testers	JEF, CA	Fan Setting	44 Hz
Stack Dia.	11.89 in.	Stack Temp	56.65 deg F
Stack X-Area	111.0 in.^{2}	Start/End Time	900/1009
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Measurement units	ppb SF6	Injection Point	Port 2 Top

Order -->		2nd				1st			
Traverse-->		Side				Bottom			
Trial —>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppb				ppb			
1	0.50	616	610	599	608.3	657	659	658	658.0
2	1.24	613	605	601	606.3	642	637	640	639.7
3	2.29	610	598	603	603.7	650	640	635	641.7
4	3.82	631	593	606	610.0	648	626	629	634.3
Center	5.91	598	597	614	603.0	583	612	620	605.0
5	8.00	595	606	598	599.7	565	600	572	579.0
6	9.52	604	627	634	621.7	530	566	571	555.7
7	10.57	632	624	631	629.0	534	543	539	538.7
8	11.31	627	635	606	622.7	546	558	551	551.7
Averages ———>		614.0	610.6	610.2	611.6	595.0	604.6	601.7	600.4

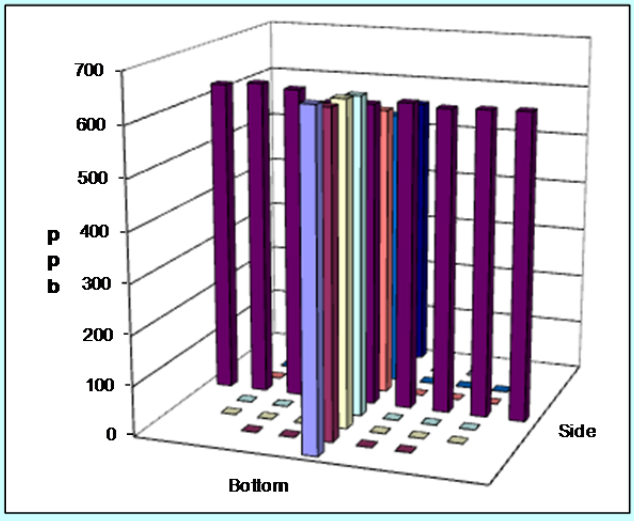
All	ppb	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	606.00		Mean	610.48	599.14	604.81
Min Point	538.67	-11.1%	Std. Dev.	10.84	42.18	30.17
Max Point	658.00	8.6%	COV as %	1.8	7.0	5.0

Avg. Conc. 606.250 ppb

Instruments Used:

B&K 1302 Gas Analyzer	SN	1788615	Cat2 M&TE
TSI VelociCalc	SN T95351203001		12/17/2012
Fisher Scientific	SN 90936818		12/7/2012

	Start	Finish	
Tracer tank pressure	100	100	psig
Injection flowmeter	50	50	sccm
Stack Temp	55	58.3	°F
Mean stack velocity	4257	4290	fpm
Sampling flowmeter	5	5	lpm
Ambient pressure	997	998	mbar
Ambient humidity	61%	50%	RH
Ambient Temp	63.5	64.4	°F
B&K vapor correction	Y	Y	Y/N
Back-Gd gas	-11,-9,-9,-8, -6	6, -2, 0, 0.8, -3	ppb
No. Bk-Gd samples	5	5	n



Gas analyzer checked: 10/31/2012

Notes: Mean Velocity at Bottom 8

CA 11/1/12

Entries made by:	Carmen Arimescu	Technical Data Review performed by:	
Signature/date	Signature on file with original 11/1/2012	Signature/date	gbj 11/27/2012

Rev. 0

TRACER GAS TRAVERSE DATA FORM

31-Jul-06

Site	LB-S1 Model	Run No.	GT-18
Date	11/1/2012	Fan Configuration	AB
Testers	JEF, CA	Fan Setting	39 Hz
Stack Dia.	11.89 in.	Stack Temp	57.9 deg F
Stack X-Area	111.0 in.^{2}	Start/End Time	1020/1128
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Measurement units	ppb SF6	Injection Point	Port 2 Top

Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial —>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppb				ppb			
1	0.50	740	722	750	737.3	685	683	686	684.7
2	1.24	762	724	739	741.7	704	690	673	689.0
3	2.29	744	749	744	745.7	680	685	690	685.0
4	3.82	742	704	743	729.7	691	694	682	689.0
Center	5.91	696	697	702	698.3	695	694	697	695.3
5	8.00	676	696	688	686.7	687	715	712	704.7
6	9.52	636	645	637	639.3	684	693	715	697.3
7	10.57	633	620	654	635.7	696	692	718	702.0
8	11.31	620	586	629	611.7	702	709	697	702.7
Averages ———>		694.3	682.6	698.4	691.8	691.6	695.0	696.7	694.4

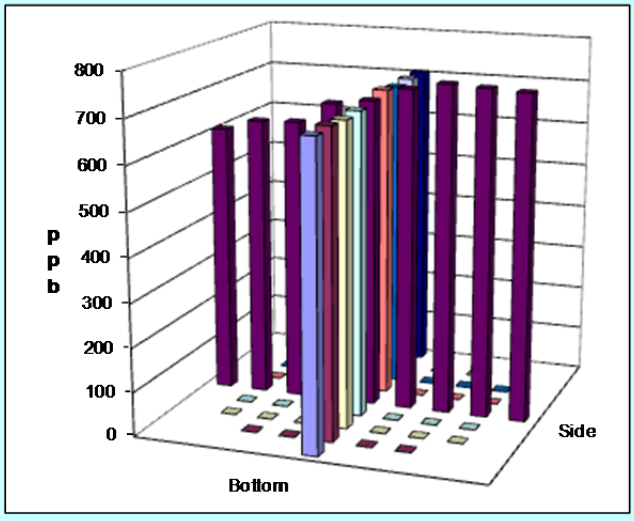
All	ppb	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	693.09		Mean	696.71	694.62	695.67
Min Point	611.67	-11.7%	Std. Dev.	45.87	7.29	31.57
Max Point	745.67	7.6%	COV as %	6.6	1.0	4.5

Avg. Conc. 692.625 ppb

Instruments Used:

B&K 1302 Gas Analyzer	SN	1788615	Cat2 M&TE
TSI VelociCalc	SN T95351203001		12/17/2012
Fisher Scientific	SN 90936818		12/7/2012

	Start	Finish	
Tracer tank pressure	100	100	psig
Injection flowmeter	50	50	sccm
Stack Temp	57.8	58	°F
Mean stack velocity	3747	3798	fpm
Sampling flowmeter	5	5	lpm
Ambient pressure	998	999	mbar
Ambient humidity	56%	48%	RH
Ambient Temp	62.6	65.3	°F
B&K vapor correction	Y	Y	Y/N
Back-Gd gas			ppb
	6,-2,0,0.8,-3	7,0,2,-3,0	
No. Bk-Gd samples	5	5	n



Gas analyzer checked: 10/31/2012

Notes: Mean Velocity at Bottom 8

CA 11/1/12

Entries made by:	Carmen Arimescu	Technical Data Review performed by:	
Signature/date	Signature on file with original 11/1/2012	Signature/date	gbj 11/27/2012

Rev. 0

TRACER GAS TRAVERSE DATA FORM

31-Jul-06

Site	LB-S1 Model	Run No.	GT-19
Date	11/1/2012	Fan Configuration	AB
Testers	JEF, CA	Fan Setting	39 Hz
Stack Dia.	11.89 in.	Stack Temp	57.25 deg F
Stack X-Area	111.0 in.^{2}	Start/End Time	1130/1236
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Measurement units	ppb SF6	Injection Point	Port 2 Center

Order -->		2nd				1st			
Traverse-->		Side				Bottom			
Trial —>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppb				ppb			
1	0.50	643	682	636	653.7	675	649	663	662.3
2	1.24	668	647	658	657.7	638	667	649	651.3
3	2.29	689	654	665	669.3	678	692	699	689.7
4	3.82	665	644	677	662.0	668	653	661	660.7
Center	5.91	685	666	668	673.0	681	691	681	684.3
5	8.00	698	693	666	685.7	688	680	695	687.7
6	9.52	701	684	700	695.0	690	698	691	693.0
7	10.57	727	722	709	719.3	730	694	725	716.3
8	11.31	734	701	688	707.7	694	716	702	704.0
Averages ———>		690.0	677.0	674.1	680.4	682.4	682.2	685.1	683.3

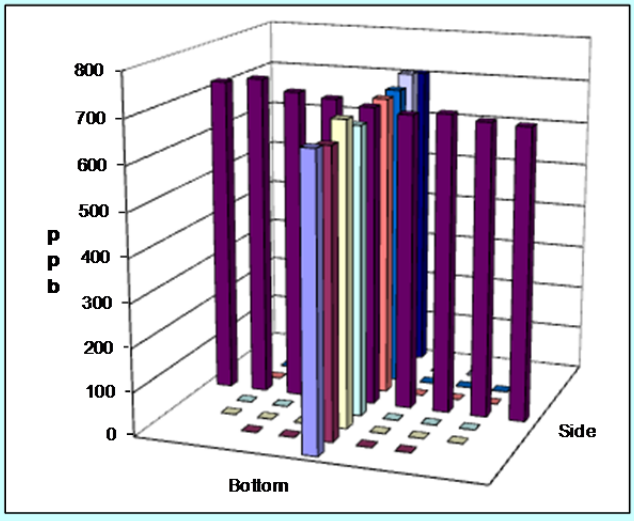
All	ppb	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	681.81		Mean	680.29	683.29	681.79
Min Point	651.33	-4.5%	Std. Dev.	21.56	21.53	20.76
Max Point	719.33	5.5%	COV as %	3.2	3.2	3.0

Avg. Conc. 682.208 ppb

Instruments Used:

B&K 1302 Gas Analyzer	SN	1788615	Cat2 M&TE
TSI VelociCalc	SN T95351203001		12/17/2012
Fisher Scientific	SN 90936818		12/7/2012

	Start	Finish	
Tracer tank pressure	100	100	psig
Injection flowmeter	50	50	sccm
Stack Temp	58	56.5	°F
Mean stack velocity	3798	3722	fpm
Sampling flowmeter	5	5	lpm
Ambient pressure	999	999	mbar
Ambient humidity	43%	42%	RH
Ambient Temp	67.1	71.6	°F
B&K vapor correction	Y	Y	Y/N
Back-Gd gas	-1,1, -1, 0.6,0.8	6,2,4,2,-8	ppb
No. Bk-Gd samples	5	5	n



Gas analyzer checked: 10/31/2012

Notes: Mean Velocity at Bottom 8

CA 11/1/12

Entries made by:	Carmen Arimescu	Technical Data Review performed by:	
Signature/date	Signature on file with original 11/1/2012	Signature/date	gbj 11/27/2012

Rev. 0

TRACER GAS TRAVERSE DATA FORM

31-Jul-06

Site	LB-S1 Model	Run No.	GT-20
Date	11/1/2012	Fan Configuration	AB
Testers	MSP, CA	Fan Setting	39 Hz
Stack Dia.	11.89 in.	Stack Temp	57.5 deg F
Stack X-Area	111.0 in.^{2}	Start/End Time	1240/1350
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Measurement units	ppb SF6	Injection Point	Port 2 Far

Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial —>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppb				ppb			
1	0.50	646	628	639	637.7	727	702	660	696.3
2	1.24	620	676	663	653.0	711	699	712	707.3
3	2.29	676	662	658	665.3	695	730	728	717.7
4	3.82	661	663	661	661.7	684	704	697	695.0
Center	5.91	685	677	671	677.7	661	693	706	686.7
5	8.00	725	726	696	715.7	681	660	676	672.3
6	9.52	749	708	712	723.0	674	671	654	666.3
7	10.57	728	720	767	738.3	679	672	701	684.0
8	11.31	739	737	751	742.3	668	716	710	698.0
Averages ———>		692.1	688.6	690.9	690.5	686.7	694.1	693.8	691.5

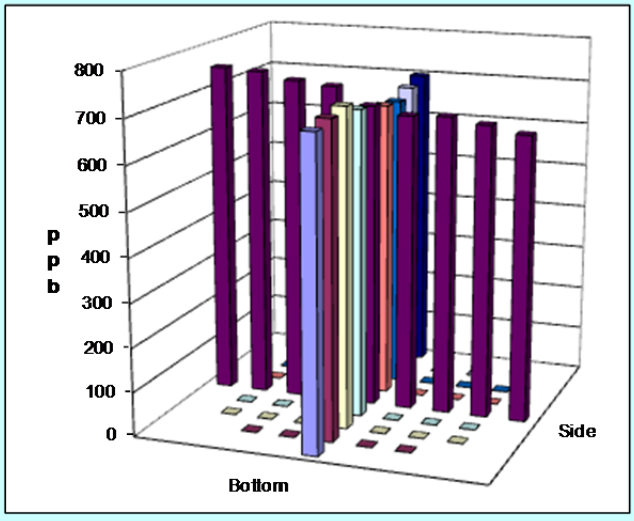
All	ppb	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	691.02		Mean	690.67	689.90	690.29
Min Point	637.67	-7.7%	Std. Dev.	34.19	18.30	26.35
Max Point	742.33	7.4%	COV as %	5.0	2.7	3.8

Avg. Conc. 692.125 ppb

Instruments Used:

B&K 1302 Gas Analyzer	SN	1788615	Cat2 M&TE
TSI VelociCalc	SN T95351203001		12/17/2012
Fisher Scientific	SN 90936818		12/7/2012

	Start	Finish	
Tracer tank pressure	100	100	psig
Injection flowmeter	50	50	sccm
Stack Temp	56.5	58.5	°F
Mean stack velocity	3722	3741	fpm
Sampling flowmeter	5	5	lpm
Ambient pressure	999	999	mbar
Ambient humidity	41%	36%	RH
Ambient Temp	71.6	75.2	°F
B&K vapor correction	Y	Y	Y/N
Back-Gd gas	-2,-2,0,-4,-4	10,7,5,5,2	ppb
No. Bk-Gd samples	5	5	n



Gas analyzer checked: 10/31/2012

Notes: Mean Velocity at Bottom 8

CA 11/1/12

Entries made by:	Carmen Arimescu	Technical Data Review performed by:	
Signature/date	Signature on file with original 11/1/2012	Signature/date	gbj 11/27/2012

Rev. 0

TRACER GAS TRAVERSE DATA FORM

31-Jul-06

Site	LB-S1 Model	Run No.	GT-21
Date	11/1/2012	Fan Configuration	AB
Testers	MSP, CA	Fan Setting	39 Hz
Stack Dia.	11.89 in.	Stack Temp	59.15 deg F
Stack X-Area	111.0 in.^{2}	Start/End Time	1355/1500
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Measurement units	ppb SF6	Injection Point	Port 2 Near

Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial —>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppb				ppb			
1	0.50	762	703	718	727.7	718	723	722	721.0
2	1.24	711	735	693	713.0	689	735	750	724.7
3	2.29	746	705	730	727.0	704	713	694	703.7
4	3.82	712	747	725	728.0	734	722	716	724.0
Center	5.91	730	704	687	707.0	686	676	698	686.7
5	8.00	673	657	636	655.3	642	628	674	648.0
6	9.52	646	639	654	646.3	657	634	656	649.0
7	10.57	626	656	651	644.3	637	628	675	646.7
8	11.31	623	613	586	607.3	609	587	644	613.3
Averages ———>		692.1	684.3	675.6	684.0	675.1	671.8	692.1	679.7

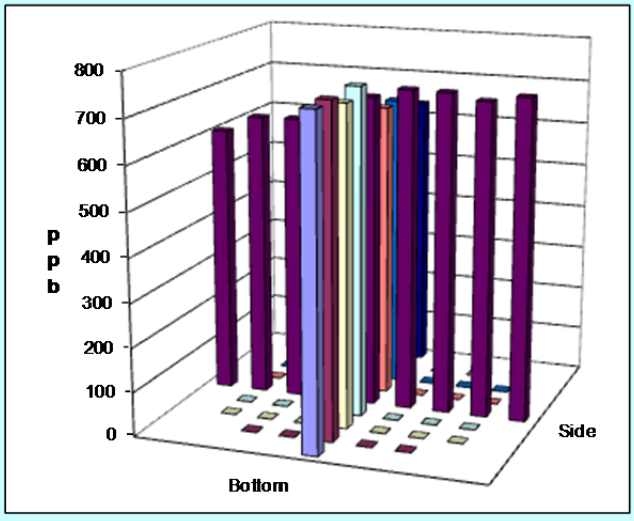
All	ppb	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	681.83		Mean	688.71	683.24	685.98
Min Point	607.33	-10.9%	Std. Dev.	38.33	35.49	35.60
Max Point	728.00	6.8%	COV as %	5.6	5.2	5.2

Avg. Conc. 679.958 ppb

Instruments Used:

B&K 1302 Gas Analyzer	SN	1788615	Cat2 M&TE
TSI VelociCalc	SN T95351203001		12/17/2012
Fisher Scientific	SN 90936818		12/7/2012

	Start	Finish	
Tracer tank pressure	100	100	psig
Injection flowmeter	50	50	sccm
Stack Temp	58.5	59.8	°F
Mean stack velocity	3741	3774	fpm
Sampling flowmeter	5	5	lpm
Ambient pressure	999	1000	mbar
Ambient humidity	36%	55%	RH
Ambient Temp	75.2	64.4	°F
B&K vapor correction	Y	Y	Y/N
Back-Gd gas			ppb
	-1,2,1,-2,-2	9,3,3,14,8	
No. Bk-Gd samples	5	5	n



Gas analyzer checked: 10/31/2012

Notes: Mean Velocity at Bottom 8

CA 11/1/12

Entries made by:	Carmen Arimescu	Technical Data Review performed by:	
Signature/date	Signature on file with original 11/1/2012	Signature/date	gbj 11/27/2012

Rev. 0

TRACER GAS TRAVERSE DATA FORM

31-Jul-06

Site	LB-S1 Model	Run No.	GT-22
Date	11/1/2012	Fan Configuration	AB
Testers	MSP, CA	Fan Setting	39 Hz
Stack Dia.	11.89 in.	Stack Temp	60.85 deg F
Stack X-Area	111.0 in.^{2}	Start/End Time	1505/1610
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Measurement units	ppb SF6	Injection Point	Port 2 Bottom

Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial —>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppb				ppb			
1	0.50	648	617	660	**641.7**	726	685	692	**701.0**
2	1.24	649	627	628	**634.7**	678	673	726	**692.3**
3	2.29	661	642	615	**639.3**	696	695	701	**697.3**
4	3.82	669	655	640	**654.7**	694	648	689	**677.0**
Center	5.91	697	703	713	**704.3**	677	678	682	**679.0**
5	8.00	757	705	671	**711.0**	698	691	703	**697.3**
6	9.52	753	731	747	**743.7**	737	735	725	**732.3**
7	10.57	771	774	738	**761.0**	661	736	670	**689.0**
8	11.31	866	754	643	**754.3**	726	665	760	**717.0**
Averages ———>		**719.0**	**689.8**	**672.8**	**693.9**	**699.2**	**689.6**	**705.3**	**698.0**

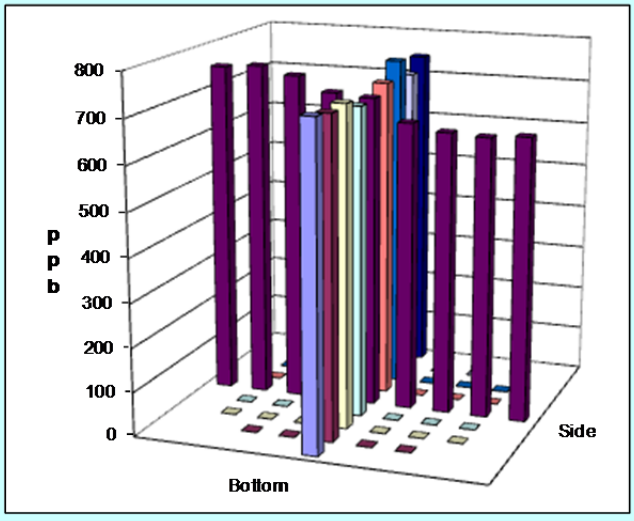
All	ppb	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	695.94		Mean	692.67	694.90	693.79
Min Point	634.67	-8.8%	Std. Dev.	50.65	18.38	36.63
Max Point	761.00	9.3%	COV as %	7.3	2.6	5.3

Avg. Conc. 696.479 ppb

Instruments Used:

B&K 1302 Gas Analyzer	SN	1788615	Cat2 M&TE
TSI VelociCalc	SN T95351203001		12/17/2012
Fisher Scientific	SN 90936818		12/7/2012

	Start	Finish	
Tracer tank pressure	100	100	psig
Injection flowmeter	50	50	sccm
Stack Temp	59.8	61.9	°F
Mean stack velocity	3774	3737	fpm
Sampling flowmeter	5	5	lpm
Ambient pressure	1000	1000	mbar
Ambient humidity	50%	41%	RH
Ambient Temp	67.1	71.6	°F
B&K vapor correction	Y	Y	Y/N
Back-Gd gas	7,2,3,-3,-1	9,-3,5,0,2	ppb
No. Bk-Gd samples	5	5	n



Gas analyzer checked: 10/31/2012

Notes: Mean Velocity at Bottom 8

CA 11/1/12

Entries made by:	Carmen Arimescu	Technical Data Review performed by:	
Signature/date	Signature on file with original 11/1/2012	Signature/date	gbj 11/27/2012

Rev. 0

TRACER GAS TRAVERSE DATA FORM

31-Jul-06

Site	LB-S1 Model	Run No.	GT-23
Date	11/2/2012	Fan Configuration	AB
Testers	MSP, CA	Fan Setting	30 Hz
Stack Dia.	11.89 in.	Stack Temp	53.05 deg F
Stack X-Area	111.0 in.^{2}	Start/End Time	900/1030
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Measurement units	ppb SF6	Injection Point	Port 2 Bottom

Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial —>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppb				ppb			
1	0.50	764	765	777	768.7	928	921	878	909.0
2	1.24	768	801	816	795.0	885	1030	911	942.0
3	2.29	853	835	867	851.7	863	864	877	868.0
4	3.82	865	868	812	848.3	898	849	887	878.0
Center	5.91	899	978	814	897.0	885	893	877	885.0
5	8.00	931	984	931	948.7	942	915	843	900.0
6	9.52	976	1030	1080	1028.7	932	872	865	889.7
7	10.57	1003	1040	1060	1034.3	974	857	972	934.3
8	11.31	1004	992	1060	1018.7	879	826	880	861.7
Averages ———>		895.9	921.4	913.0	910.1	909.6	891.9	887.8	896.4

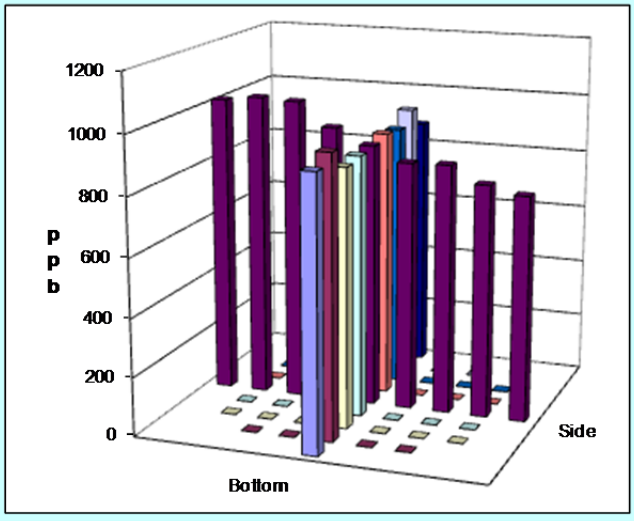
All	ppb	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	903.26		Mean	914.81	899.57	907.19
Min Point	768.67	-14.9%	Std. Dev.	92.62	28.23	66.26
Max Point	1034.33	14.5%	COV as %	10.1	3.1	7.3

Avg. Conc. 904.792 ppb

Instruments Used:

B&K 1302 Gas Analyzer	SN	1788615	Cat2 M&TE
TSI VelociCalc	SN T95351203001		12/17/2012
Fisher Scientific	SN 90936818		12/7/2012

	Start	Finish	
Tracer tank pressure	100	100	psig
Injection flowmeter	50	50	sccm
Stack Temp	50.7	55.4	°F
Mean stack velocity	2921	2985	fpm
Sampling flowmeter	5	5	lpm
Ambient pressure	1006	1006	mbar
Ambient humidity	57%	45%	RH
Ambient Temp	61.7	68.9	°F
B&K vapor correction	Y	Y	Y/N
Back-Gd gas	-3, -5, -7, -6, -6	1,1,4,-3,1	ppb
No. Bk-Gd samples	5	5	n



Gas analyzer checked: 10/31/2012

Notes: Mean Velocity at Bottom 8

CA 11/2/12

Entries made by:	Carmen Arimescu	Technical Data Review performed by:	
Signature/date	Signature on file with original 11/2/2012	Signature/date	gbj 11/27/2012

Rev. 0

TRACER GAS TRAVERSE DATA FORM

31-Jul-06

Site	LB-S1 Model	Run No.	GT-24
Date	11/2/2012	Fan Configuration	AB
Testers	MSP, CA	Fan Setting	30 Hz
Stack Dia.	11.89 in.	Stack Temp	57.95 deg F
Stack X-Area	111.0 in.^{2}	Start/End Time	1033/1140
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Measurement units	ppb SF6	Injection Point	Port 2 Center

Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial —>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppb				ppb			
1	0.50	885	899	864	882.7	856	868	898	874.0
2	1.24	893	904	891	896.0	884	847	851	860.7
3	2.29	881	935	915	910.3	895	861	856	870.7
4	3.82	883	902	915	900.0	891	882	896	889.7
Center	5.91	869	913	900	894.0	880	917	907	901.3
5	8.00	903	887	919	903.0	927	933	911	923.7
6	9.52	858	906	857	873.7	913	917	920	916.7
7	10.57	939	892	911	914.0	913	948	968	943.0
8	11.31	865	863	864	864.0	945	931	965	947.0
Averages ———>		886.2	900.1	892.9	893.1	900.4	900.4	908.0	903.0

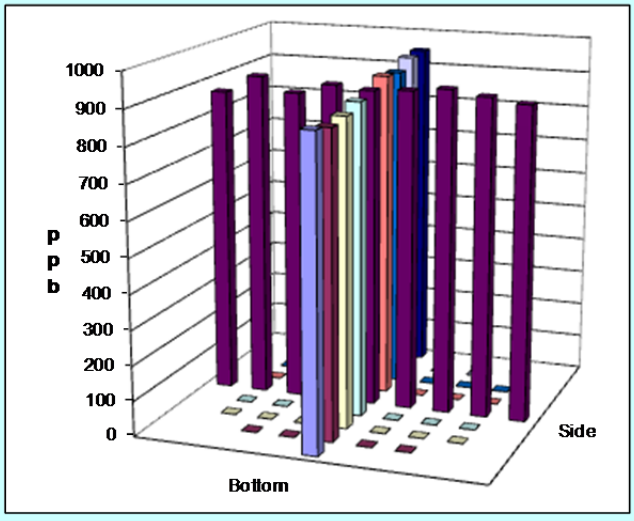
All	ppb	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	898.02		Mean	898.71	900.81	899.76
Min Point	860.67	-4.2%	Std. Dev.	13.20	29.43	21.94
Max Point	947.00	5.5%	COV as %	1.5	3.3	2.4

Avg. Conc. 898.063 ppb

Instruments Used:

B&K 1302 Gas Analyzer	SN	1788615	Cat2 M&TE
TSI VelociCalc	SN T95351203001		12/17/2012
Fisher Scientific	SN 90936818		12/7/2012

	Start	Finish	
Tracer tank pressure	100	100	psig
Injection flowmeter	50	50	sccm
Stack Temp	55.4	60.5	°F
Mean stack velocity	2985	2998	fpm
Sampling flowmeter	5	5	lpm
Ambient pressure	1006	1007	mbar
Ambient humidity	44%	39%	RH
Ambient Temp	67.1	71.6	°F
B&K vapor correction	Y	Y	Y/N
Back-Gd gas	-7, -6, -8, -6, -5	6,5,4,3,1	ppb
No. Bk-Gd samples	5	5	n



Gas analyzer checked: 10/31/2012

Notes: Mean Velocity at Bottom 8

CA 11/2/12

Entries made by:	Carmen Arimescu	Technical Data Review performed by:	
Signature/date	Signature on file with original 11/2/2012	Signature/date	gbj 11/28/2012

Rev. 0

TRACER GAS TRAVERSE DATA FORM

31-Jul-06

Site	LB-S1 Model	Run No.	GT-25
Date	11/2/2012	Fan Configuration	AB
Testers	MSP, CA	Fan Setting	30 Hz
Stack Dia.	11.89 in.	Stack Temp	62 deg F
Stack X-Area	111.0 in.^{2}	Start/End Time	1145/1310
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Measurement units	ppb SF6	Injection Point	Port 2 Center

Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial —>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppb				ppb			
1	0.50	910	999	934	947.7	892	857	851	866.7
2	1.24	925	953	951	943.0	834	907	843	861.3
3	2.29	909	948	954	937.0	866	865	885	872.0
4	3.82	965	953	917	945.0	898	894	886	892.7
Center	5.91	919	922	947	929.3	913	911	915	913.0
5	8.00	905	914	882	900.3	890	912	877	893.0
6	9.52	866	857	874	865.7	896	963	924	927.7
7	10.57	851	839	856	848.7	890	931	941	920.7
8	11.31	813	911	889	871.0	969	887	952	936.0
Averages ———>		895.9	921.8	911.6	909.7	894.2	903.0	897.1	898.1

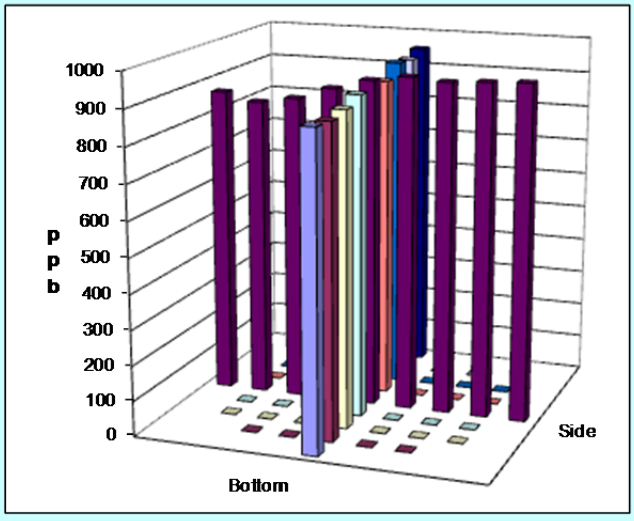
All	ppb	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	903.93		Mean	909.86	897.19	903.52
Min Point	848.67	-6.1%	Std. Dev.	39.24	24.79	32.21
Max Point	947.67	4.8%	COV as %	4.3	2.8	3.6

Avg. Conc. 901.771 ppb

Instruments Used:

B&K 1302 Gas Analyzer	SN	1788615	Cat2 M&TE
TSI VelociCalc	SN T95351203001		12/17/2012
Fisher Scientific	SN 90936818		12/7/2012

	Start	Finish	
Tracer tank pressure	100	100	psig
Injection flowmeter	50	50	sccm
Stack Temp	60.5	63.5	°F
Mean stack velocity	2998	2997	fpm
Sampling flowmeter	5	5	lpm
Ambient pressure	1007	1007	mbar
Ambient humidity	38%	35%	RH
Ambient Temp	71.6	75.2	°F
B&K vapor correction	Y	Y	Y/N
Back-Gd gas			ppb
	0,-2,2,-2,-1	9,6,7,5,0,1	
No. Bk-Gd samples	5	5	n



Gas analyzer checked: 10/31/2012

Notes: Mean Velocity at Bottom 8

CA 11/2/12

Entries made by:	Carmen Arimescu	Technical Data Review performed by:	
Signature/date	Signature on file with original 11/2/2012	Signature/date	gbj 11/28/2012

Rev. 0

TRACER GAS TRAVERSE DATA FORM

31-Jul-06

Site	LB-S1 Model	Run No.	GT-26
Date	11/5/2012	Fan Configuration	AB
Testers	EA, CA	Fan Setting	30 Hz
Stack Dia.	11.89 in.	Stack Temp	67.5 deg F
Stack X-Area	111.0 in.^{2}	Start/End Time	930/1040
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Measurement units	ppb SF6	Injection Point	Port 2 Far

Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial —>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppb				ppb			
1	0.50	837	867	859	854.3	945	945	964	951.3
2	1.24	851	831	837	839.7	960	885	966	937.0
3	2.29	866	875	861	867.3	895	987	974	952.0
4	3.82	882	854	899	878.3	888	883	900	890.3
Center	5.91	852	856	858	855.3	912	875	906	897.7
5	8.00	923	918	888	909.7	854	847	859	853.3
6	9.52	929	934	920	927.7	892	892	839	874.3
7	10.57	984	970	984	979.3	837	888	892	872.3
8	11.31	963	944	1001	969.3	904	915	842	887.0
Averages ———>		898.6	894.3	900.8	897.9	898.6	901.9	904.7	901.7

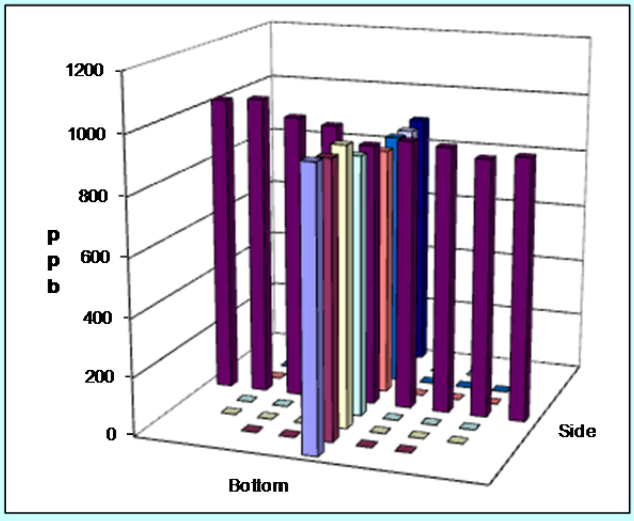
All	ppb	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	899.80		Mean	893.90	896.71	895.31
Min Point	839.67	-6.7%	Std. Dev.	48.42	35.82	40.94
Max Point	979.33	8.8%	COV as %	5.4	4.0	4.6

Avg. Conc. 902.708 ppb

Instruments Used:

B&K 1302 Gas Analyzer	SN 1788615	Cat2 M&TE
TSI VelociCalc	SN T95351203001	12/17/2012
Fisher Scientific	SN 90936818	12/7/2012

	Start	Finish	
Tracer tank pressure	100	100	psig
Injection flowmeter	50	50	sccm
Stack Temp	66	69	°F
Mean stack velocity	3005	2952	fpm
Sampling flowmeter	5	5	lpm
Ambient pressure	1011	1012	mbar
Ambient humidity	50%	17%	RH
Ambient Temp	68.0	74	°F
B&K vapor correction	Y	Y	Y/N
Back-Gd gas	-3,-5,-8,-8,-10	10,10,0.3,2,0.7	ppb
No. Bk-Gd samples	5	5	n



Gas analyzer checked: 10/31/2012

Notes: Mean Velocity at Bottom 8

CA 11/5/12

Entries made by:	Carmen Arimescu	Technical Data Review performed by:
Signature/date	Signature on file with original 11/5/2012	Signature/date

Rev. 0

TRACER GAS TRAVERSE DATA FORM

31-Jul-06

Site	LB-S1 Model	Run No.	GT-27
Date	11/5/2012	Fan Configuration	AB
Testers	EA, CA	Fan Setting	30 Hz
Stack Dia.	11.89 in.	Stack Temp	69.25 deg F
Stack X-Area	111.0 $in.^2$	Start/End Time	1045/1155
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Measurement units	ppb SF6	Injection Point	Port 2 Near

Order -->		2nd				1st			
Traverse-->		Side				Bottom			
Trial —>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppb				ppb			
1	0.50	975	937	985	965.7	863	890	903	885.3
2	1.24	942	973	953	956.0	856	900	924	893.3
3	2.29	976	915	968	953.0	919	925	922	922.0
4	3.82	959	964	965	962.7	906	907	938	917.0
Center	5.91	928	955	956	946.3	963	962	968	964.3
5	8.00	900	911	926	912.3	973	957	975	968.3
6	9.52	909	853	902	888.0	950	950	929	943.0
7	10.57	815	867	904	862.0	939	958	951	949.3
8	11.31	805	824		814.5	902	932	986	940.0
Averages ———>		912.1	911.0	944.9	917.8	919.0	931.2	944.0	931.4

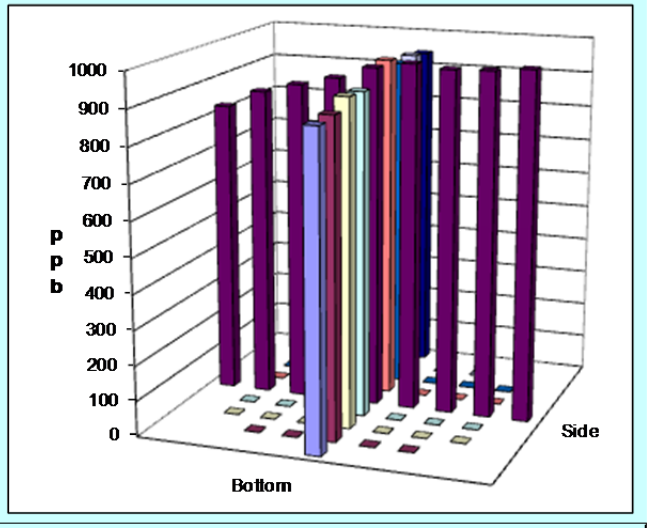
All	ppb	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	924.62		Mean	925.76	936.76	931.26
Min Point	814.50	-11.9%	Std. Dev.	38.97	27.23	32.80
Max Point	968.33	4.7%	COV as %	4.2	2.9	3.5

Avg. Conc. 920.781 ppb

Instruments Used:

B&K 1302 Gas Analyzer	SN	1788615	Cat2 M&TE
TSI VelociCalc	SN T95351203001		12/17/2012
Fisher Scientific	SN 90936818		12/7/2012

	Start	Finish	
Tracer tank pressure	100	100	psig
Injection flowmeter	50	50	sccm
Stack Temp	69	69.5	°F
Mean stack velocity	2952	2902	fpm
Sampling flowmeter	5	5	lpm
Ambient pressure	1012	1012	mbar
Ambient humidity	24%	40%	RH
Ambient Temp	73.4	70.7	°F
B&K vapor correction	Y	Y	Y/N
Back-Gd gas	-8 ,-6, -2, -7, -5	9, 6, 6, 3, 2	ppb
No. Bk-Gd samples	5	5	n



Gas analyzer checked: 10/31/2012

Notes: Mean Velocity at Bottom 8

CA 11/5/12

Entries made by:	Carmen Arimescu	Technical Data Review performed by:	
Signature/date	Signature on file with original 11/5/2012	Signature/date	gbj 11/28/2012

Rev. 0

TRACER GAS TRAVERSE DATA FORM

31-Jul-06

Site	LB-S1 Model	Run No.	GT-28
Date	11/5/2012	Fan Configuration	AB
Testers	MSP,CA	Fan Setting	30 Hz
Stack Dia.	11.89 in.	Stack Temp	70.05 deg F
Stack X-Area	111.0 in.^{2}	Start/End Time	1200/1310
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Measurement units	ppb SF6	Injection Point	Port 2 Top

Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial —>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppb				ppb			
1	0.50	938	996	998	977.3	864	883	898	881.7
2	1.24	925	1010	955	963.3	942	899	915	918.7
3	2.29	998	970	982	983.3	925	906	930	920.3
4	3.82	948	989	949	962.0	905	909	921	911.7
Center	5.91	951	931	953	945.0	919	906	951	925.3
5	8.00	884	910	927	907.0	938	924	916	926.0
6	9.52	875	860	874	869.7	938	959	924	940.3
7	10.57	850	858	888	865.3	966	916	939	940.3
8	11.31	821	817	827	821.7	923	915	959	932.3
Averages ———>		910.0	926.8	928.1	921.6	924.4	913.0	928.1	921.9

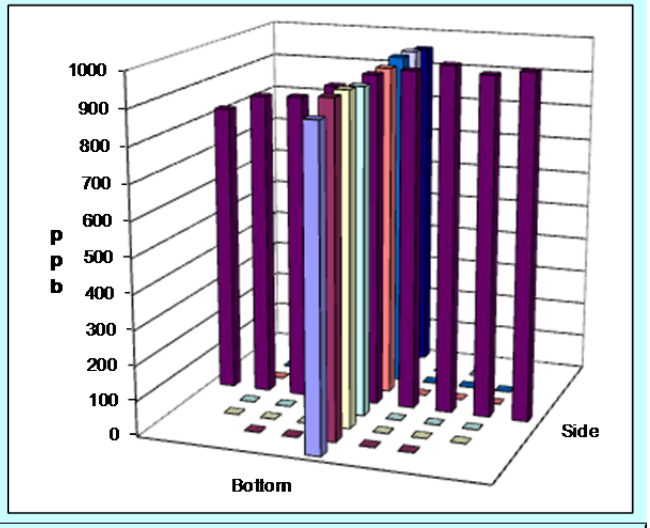
All	ppb	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	921.74		Mean	927.95	926.10	927.02
Min Point	821.67	-10.9%	Std. Dev.	47.48	10.82	33.10
Max Point	983.33	6.7%	COV as %	5.1	1.2	3.6

Avg. Conc. 920.063 ppb

Instruments Used:

B&K 1302 Gas Analyzer	SN	1788615	Cat2 M&TE
TSI VelociCalc	SN T95351203001		12/17/2012
Fisher Scientific	SN 90936818		12/7/2012

	Start	Finish	
Tracer tank pressure	100	100	psig
Injection flowmeter	50	50	sccm
Stack Temp	69.8	70.3	°F
Mean stack velocity	2931	2899	fpm
Sampling flowmeter	5	5	lpm
Ambient pressure	1012	1012	mbar
Ambient humidity	45%	43%	RH
Ambient Temp	69.8	69.8	°F
B&K vapor correction	Y	Y	Y/N
Back-Gd gas	-4,-5,-2,-3,-6	10,6,5,0,-3	ppb
No. Bk-Gd samples	5	5	n



Gas analyzer checked: 10/31/2012

Notes: Mean Velocity at Bottom 8

CA 11/5/12

Entries made by:	Carmen Arimescu	Technical Data Review performed by:	
Signature/date	Signature on file with original 11/5/2012	Signature/date	gbj 11/28/2012

Rev. 0

TRACER GAS TRAVERSE DATA FORM

31-Jul-06

Site	LB-S1 Model	Run No.	GT-29
Date	11/5/2012	Fan Configuration	AB
Testers	MSP,CA	Fan Setting	30 Hz
Stack Dia.	11.89 in.	Stack Temp	69.75 deg F
Stack X-Area	111.0 in.^{2}	Start/End Time	1325/1435
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Measurement units	ppb SF6	Injection Point	Port 2 Bottom

Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial —>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppb				ppb			
1	0.50	846	851	831	842.7	944	919	909	924.0
2	1.24	812	814	756	794.0	982	982	908	957.3
3	2.29	908	861	876	881.7	967	903	898	922.7
4	3.82	863	961	859	894.3	1000	893	900	931.0
Center	5.91	952	946	827	908.3	912	945	940	932.3
5	8.00	906	983	968	952.3	849	950	925	908.0
6	9.52	927	989	966	960.7	924	935	910	923.0
7	10.57	1020	1040	1080	1046.7	958	929	920	935.7
8	11.31	1020	1090	1020	1043.3	849	959	864	890.7
Averages ———>		917.1	948.3	909.2	924.9	931.7	935.0	908.2	925.0

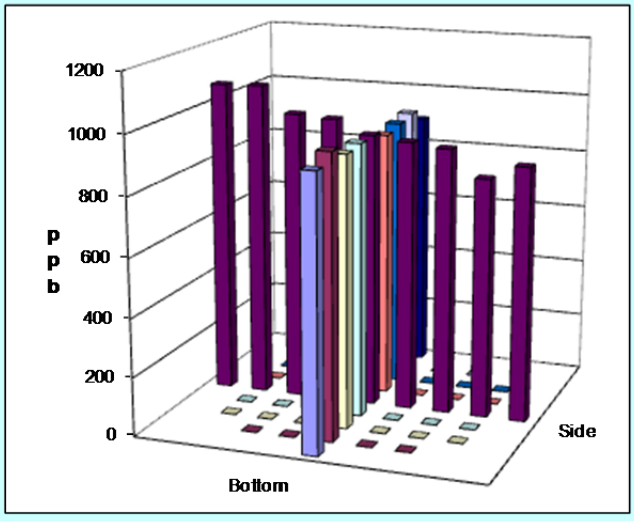
All	ppb	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	924.93		Mean	919.71	930.00	924.86
Min Point	794.00	-14.2%	Std. Dev.	78.40	15.12	54.51
Max Point	1046.67	13.2%	COV as %	8.5	1.6	5.9

Avg. Conc. 925.500 ppb

Instruments Used:

B&K 1302 Gas Analyzer	SN	1788615	Cat2 M&TE
TSI VelociCalc	SN T95351203001		12/17/2012
Fisher Scientific	SN 90936818		12/7/2012

	Start	Finish	
Tracer tank pressure	100	100	psig
Injection flowmeter	50	50	sccm
Stack Temp	70	69.5	°F
Mean stack velocity	2950	2956	fpm
Sampling flowmeter	5	5	lpm
Ambient pressure	1012	1011	mbar
Ambient humidity	43%	41%	RH
Ambient Temp	68.9	68.9	°F
B&K vapor correction	Y	Y	Y/N
Back-Gd gas			ppb
	3,2,0,-2,-1	4,6,8,5,3	
No. Bk-Gd samples	5	5	n



Gas analyzer checked: 10/31/2012

Notes: Mean Velocity at Bottom 8

CA 11/5/12

Entries made by:	Carmen Arimescu	Technical Data Review performed by:	
Signature/date	Signature on file with original 11/5/2012	Signature/date	gbj 11/28/2012

Rev. 0

TRACER GAS TRAVERSE DATA FORM

31-Jul-06

Site	LB-S1 Model	Run No.	GT-30
Date	11/5/2012	Fan Configuration	AB
Testers	MSP,CA	Fan Setting	30 Hz
Stack Dia.	11.89 in.	Stack Temp	68.45 deg F
Stack X-Area	111.0 in.^{2}	Start/End Time	1440/
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Measurement units	ppb SF6	Injection Point	Port 2 Bottom

Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial —>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppb				ppb			
1	0.50	818	818	864	833.3	938	988	861	929.0
2	1.24	840	915	830	861.7	889	902	881	890.7
3	2.29	876	815	888	859.7	845	850	901	865.3
4	3.82	921	877	859	885.7	858	891	897	882.0
Center	5.91	868	893	871	877.3	848	955	911	904.7
5	8.00	895	944	962	933.7	888	898	822	869.3
6	9.52	979	916	920	938.3	837	855	871	854.3
7	10.57	987	1020	993	1000.0	878	844	839	853.7
8	11.31	1010	964	1030	1001.3	937	868	922	909.0
Averages ———>		910.4	906.9	913.0	910.1	879.8	894.6	878.3	884.2

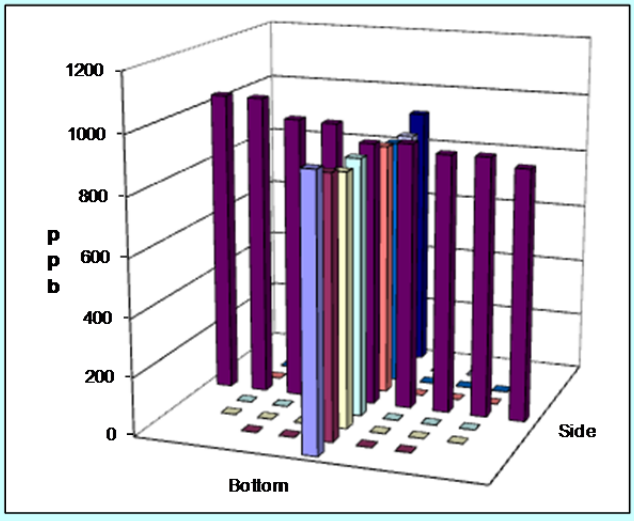
All	ppb	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	897.17		Mean	908.05	874.29	891.17
Min Point	833.33	-7.1%	Std. Dev.	51.58	19.06	41.26
Max Point	1001.33	11.6%	COV as %	5.7	2.2	4.6

Avg. Conc. 897.938 ppb

Instruments Used:

B&K 1302 Gas Analyzer	SN	1788615	Cat2 M&TE
TSI VelociCalc	SN T95351203001		12/17/2012
Fisher Scientific	SN 90936818		12/7/2012

	Start	Finish	
Tracer tank pressure	100	100	psig
Injection flowmeter	50	50	sccm
Stack Temp	69.5	67.4	°F
Mean stack velocity	2956	2928	fpm
Sampling flowmeter	5	5	lpm
Ambient pressure	1011	1011	mbar
Ambient humidity	41%	41%	RH
Ambient Temp	68.0	67	°F
B&K vapor correction	Y	Y	Y/N
Back-Gd gas	2,5,2,2,-2	9,6,7,5,3	ppb
No. Bk-Gd samples	5	5	n



Gas analyzer checked: 10/31/2012

Notes: Mean Velocity at Bottom 8

CA 11/5/12

Entries made by:	Carmen Arimescu	Technical Data Review performed by:	
Signature/date	Signature on file with original 11/5/2012	Signature/date	gbj 11/28/2012

Rev. 0

TRACER GAS TRAVERSE DATA FORM

31-Jul-06

Site	LB-S1 Model	Run No.	GT-31
Date	11/6/2012	Fan Configuration	AB
Testers	MSP,CA	Fan Setting	32 Hz
Stack Dia.	11.89 in.	Stack Temp	59.05 deg F
Stack X-Area	111.0 in.^{2}	Start/End Time	940/1140
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Measurement units	ppb SF6	Injection Point	Port 2 Bottom

Order -->		1st				2nd			
Traverse-->		Side				Bottom			
Trial —>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppb				ppb			
1	0.50	761	788	716	755.0	913	683	791	795.7
2	1.24	768	827	727	774.0	757	769	792	772.7
3	2.29	745	745	752	747.3	848	779	841	822.7
4	3.82	778	823	681	760.7	873	797	690	786.7
Center	5.91	811	709	771	763.7	747	777	799	774.3
5	8.00	854	786	838	826.0	770	870	780	806.7
6	9.52	875	806	778	819.7	749	812	811	790.7
7	10.57	791	873	908	857.3	751	729	786	755.3
8	11.31	845	875	935	885.0	683	850	798	777.0
Averages ———>		803.1	803.6	789.6	798.7	787.9	785.1	787.6	786.9

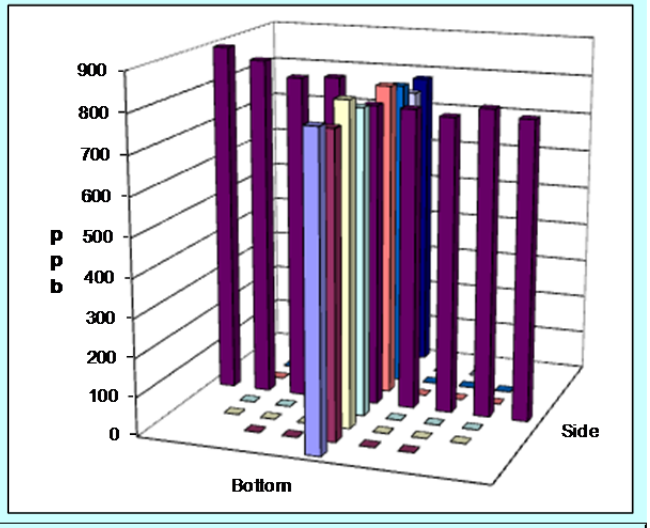
All	ppb	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	792.80		Mean	792.67	787.00	789.83
Min Point	747.33	-5.7%	Std. Dev.	41.41	22.51	32.16
Max Point	885.00	11.6%	COV as %	5.2	2.9	4.1

Avg. Conc. 795.771 ppb

Instruments Used:

B&K 1302 Gas Analyzer	SN	1765299	Cat2 M&TE
TSI VelociCalc	SN T95351203001		12/17/2012
Fisher Scientific	SN 90936818		12/7/2012

	Start	Finish	
Tracer tank pressure	100	100	psig
Injection flowmeter	50	50	sccm
Stack Temp	57.1	61	°F
Mean stack velocity	2997	2934	fpm
Sampling flowmeter	5	5	lpm
Ambient pressure	1006	1005	mbar
Ambient humidity	37%	39%	RH
Ambient Temp	67.1	67.1	°F
B&K vapor correction	Y	Y	Y/N
Back-Gd gas	6,7,6,6,5	10, 6, 10,11,8	ppb
No. Bk-Gd samples	5	5	n



Gas analyzer checked: 11/6/2012

Notes: 45 degree turn
Mean velocity = bottom 8

CA 11/6//12

Entries made by:	Carmen Arimescu	Technical Data Review performed by:	
Signature/date	Signature on file with original 11/6/2012	Signature/date	gbj 11/28/2012

Rev. 0

TRACER GAS TRAVERSE DATA FORM

31-Jul-06

Site	LB-S1 Model	Run No.	GT-32
Date	11/6/2012	Fan Configuration	AB
Testers	MSP,CA, JEF	Fan Setting	32 Hz
Stack Dia.	11.89 in.	Stack Temp	63.15 deg F
Stack X-Area	111.0 in.^{2}	Start/End Time	1145 /
Test Port	1	Center 2/3 from	1.09 to: 10.80
Distance to disturbance	123.5 inches	Points in Center 2/3	2 to: 7
Measurement units	ppb SF6	Injection Point	Port 2 Bottom

Order -->		2nd				1st			
Traverse-->		Side				Bottom			
Trial —>		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	ppb				ppb			
1	0.50	740	792	741	**757.7**	848	871	866	**861.7**
2	1.24	738	777	750	**755.0**	896	906	837	**879.7**
3	2.29	812	814	764	**796.7**	900	805	878	**861.0**
4	3.82	801	789	784	**791.3**	859	842	799	**833.3**
Center	5.91	828	808	806	**814.0**	789	773	823	**795.0**
5	8.00	841	840	849	**843.3**	775	798	838	**803.7**
6	9.52	872	888	914	**891.3**	783	776	712	**757.0**
7	10.57	883	831	859	**857.7**	825	754	756	**778.3**
8	11.31	783	923	863	**856.3**	825	781	719	**775.0**
Averages ———>		**810.9**	**829.1**	**814.4**	**818.1**	**833.3**	**811.8**	**803.1**	**816.1**

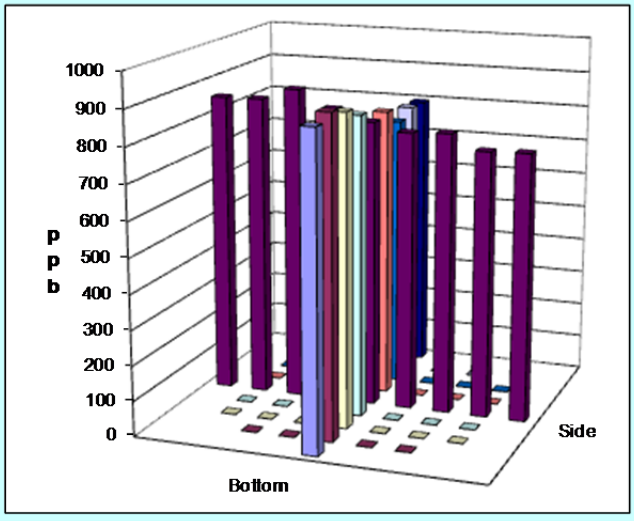
All	ppb	Dev. from mean	*Center 2/3*	Side	Bottom	All
Mean	817.11		Mean	821.33	815.43	818.38
Min Point	755.00	-7.6%	Std. Dev.	45.95	44.48	43.55
Max Point	891.33	9.1%	COV as %	5.6	5.5	5.3

Avg. Conc. 818.688 ppb

Instruments Used:

B&K 1302 Gas Analyzer	SN	1765299	Cat2 M&TE
TSI VelociCalc	SN T95351203001		12/17/2012
Fisher Scientific	SN 90936818		12/7/2012

	Start	Finish	
Tracer tank pressure	100	100	psig
Injection flowmeter	50	50	sccm
Stack Temp	61	65.3	°F
Mean stack velocity	2934	2948	fpm
Sampling flowmeter	5	5	lpm
Ambient pressure	1004	1002	mbar
Ambient humidity	42%	32%	RH
Ambient Temp	65.3	74.3	°F
B&K vapor correction	Y	Y	Y/N
Back-Gd gas			ppb
	2, 5, 9, 6, 5	9,8,7,3,7	
No. Bk-Gd samples	5	5	n



Gas analyzer checked: 11/6/2012

Notes: 45 degree turn
Mean velocity = bottom 8

CA 11/6/12

Entries made by:	Carmen Arimescu	Technical Data Review performed by:	
Signature/date	Signature on file with original 11/6/2012	Signature/date	gbj 11/28/2012

Appendix A.5: LB-S1 Tracer Particle Uniformity Data Sheets

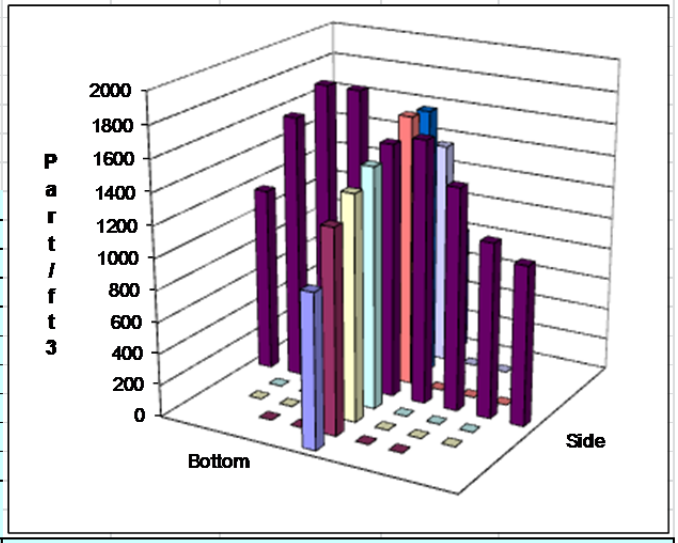
Rev. 0		PARTICLE TRACER TRAVERSE DATA FORM							
3 Aug. 2006	Site	LB-S1 Model			Run No.	PT-1			
	Date	10/17/2012			Fan configuration	BC			
	Tester	CA,JEF, EA			Fan Setting	43		Hz	
	Stack Dia.	11.8906 in.			Stack Temp	65.4 deg F			
	Stack X-Area	111.0 in.2			Start/End Time	1220/1400			
	Test Port	1			Center 2/3 from	1.09	to:	10.80	
Distance to disturbance		123.5 inches			Points in Center 2/3	2	to:	7	
Measurement units		particles/ft3			Injection Point	Port 2 Center			
	Order --->	2nd				1st			
	Traverse-->	Side				Bottom			
	Trial --->	1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	particles/ft3				particles/ft3			
1	0.50	1046	687	980	904.3	915	1022	977	971.3
2	1.24	1108	763	1107	992.7	1313	1256	1291	1286.7
3	2.29	1336	1138	1309	1261.0	1471	1365	1429	1421.7
4	3.82	1595	1458	1411	1488.0	1539	1510	1515	1521.3
Center	5.91	1705	1035	1562	1434.0	1579	1627	1584	1596.7
5	8.00	1804	1777	1514	1698.3	1659	1711	1759	1709.7
6	9.52	1812	1636	1651	1699.7	1622	1754	1691	1689.0
7	10.57	1494	1569	1420	1494.3	1367	1437	1431	1411.7
8	11.31	1129	1054	959	1047.3	765	770	818	784.3
Averages ---->		1447.7	1235.2	1323.7	1335.5	1358.9	1383.6	1388.3	1376.9

All	pt/ft3	Dev. from mean	*Center 2/3*	Side	Bottom	All	Normlzd
Mean	1356.2		Mean	1438.3	1519.5	1478.9	1560.48
Min Point	784.3	-42.2%	Std. Dev.	248.9	156.1	204.0	220.21
Max Point	1709.7	26.1%	COV as %	17.3	10.3	13.8	14.11

Avg Conc 1336 pt/ft3

	Start	Finish	
Generator Inlet Press	2.6	2.6	psig
Stack Temp	64	66.8	F
Centerline vel.	4404	4323	fpm
Ambient pressure	29.94	29.91	inHg
Ambient humidity	32%	31%	RH
Ambient temp	64.4	65.3	F
Back-Gd aerosol	1,1,5,5	5,3,7,3	pt/ft3
No. Bk-Gd samples	4	4	
Compressor output	18	23	psig

Instruments Used:		Cal. Due
TSI VelociCalc	T95351203001	12/17/2012
Fisher Scientific	90936818	12/7/2012
Met One OPC	1011529010	2/1/2013
Met One OPC	1011529009	1/9/2013



Notes:

CA 10/17/12

Oil Used: Edwards 19

Ref. Probe Location: Ref port downstream of Port 1

Probe Type / Configuration: L-Shaped Probe

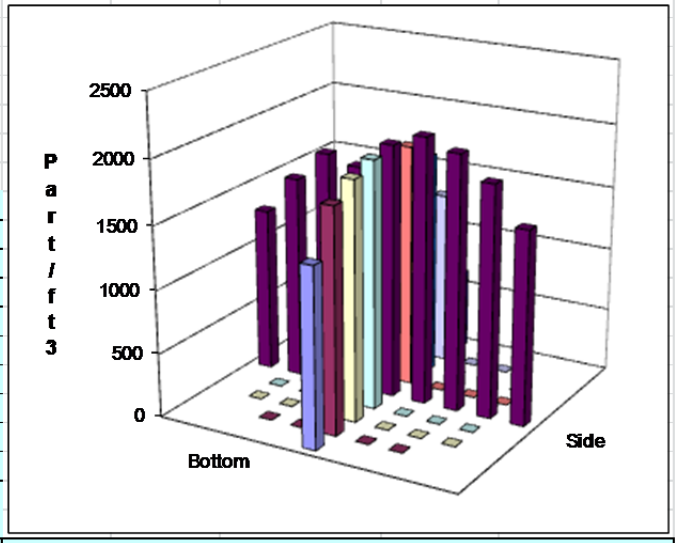
Entries made by:	Carmen Arimescu	10/17/2012	Technical Data Review performed by:		
Signature/date	*On File w/ Original*		Signature/date	gbj	11/19/2012

Rev. 0		PARTICLE TRACER TRAVERSE DATA FORM							
3 Aug. 2006	Site	LB-S1 Model			Run No.	PT-2			
	Date	10/17/2012			Fan configuration	AC			
	Tester	CA,EA			Fan Setting	43		Hz	
	Stack Dia.	11.8906 in.			Stack Temp	64 deg F			
	Stack X-Area	111.0 in.2			Start/End Time	1445/1630			
	Test Port	1			Center 2/3 from	1.09	to:	10.80	
Distance to disturbance		123.5 inches			Points in Center 2/3	2	to:	7	
Measurement units		particles/ft3			Injection Point	Port 2 center			
	Order --->	1st				2nd			
	Traverse-->	Side				Bottom			
	Trial --->	1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	particles/ft3				particles/ft3			
1	0.50	1528	1583	1476	1529.0	1335	1368	1274	1325.7
2	1.24	1768	1852	1862	1827.3	1608	1692	1673	1657.7
3	2.29	1880	2040	2110	2010.0	1838	1680	1783	1767.0
4	3.82	1909	2164	2204	2092.3	1821	1783	1895	1833.0
Center	5.91	1833	2045	2096	1991.3	1845	1842	1921	1869.3
5	8.00	1579	1861	1899	1779.7	1797	1726	1839	1787.3
6	9.52	1946	1853	1717	1838.7	1608	1633	1697	1646.0
7	10.57	1809	1545	1437	1597.0	1276	1253	1309	1279.3
8	11.31	1327	1057	1498	1294.0	592	554	616	587.3
Averages ---->		1731.0	1777.8	1811.0	1773.3	1524.4	1503.4	1556.3	1528.1

	All	pt/ft3	Dev. from mean	*Center 2/3*	Side	Bottom	All	Normlzd
	Mean	1650.7		Mean	1876.6	1691.4	1784.0	1839.19
	Min Point	587.3	-64.4%	Std. Dev.	167.8	199.8	201.7	188.20
	Max Point	2092.3	26.8%	COV as %	8.9	11.8	11.3	10.23
Avg Conc	1616	pt/ft3		Instuments Used:				Cal. Due

	Start	Finish	
Generator Inlet Press	2.6	2.6	psig
Stack Temp	68	60	F
Centerline vel.	4284	4499	fpm
Ambient pressure	29.91	29.91	inHg
Ambient humidity	33%	34%	RH
Ambient temp	61.7	59.9	F
Back-Gd aerosol	4,5,8,3	1,1,4,4	pt/ft3
No. Bk-Gd samples	4	4	
Compressor output	22	18	psig

TSI VelociCalc	T95351203001	12/17/2012
Fisher Scientific	90936818	12/7/2013
Met One OPC	1011529010	2/1/2013
Met One OPC	1011529009	1/9/2013



Notes:

CA 10/17/12

Oil Used: Edwards 19

Ref. Probe Location: Ref port downstream of Port 1

Probe Type / Configuration: L-Shaped Probe

Entries made by:	Carmen Arimescu	10/17/2012
Signature/date	*On File w/ Original*	

Technical Data Review performed by:		
Signature/date	gbj	11/19/2012

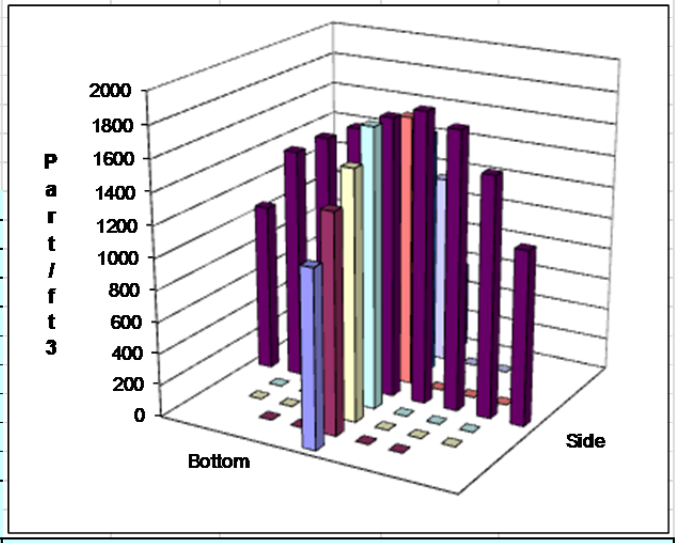
Rev. 0		PARTICLE TRACER TRAVERSE DATA FORM							
3 Aug. 2006	Site	LB-S1 Model			Run No.	PT-3			
	Date	10/11812			Fan configuration	AB			
	Tester	CA, EA			Fan Setting	43		Hz	
	Stack Dia.	11.8906 in.			Stack Temp	54.75 deg F			
	Stack X-Area	111.0 in.2			Start/End Time	943/1130			
	Test Port	1			Center 2/3 from	1.09	to:	10.80	
Distance to disturbance		123.5 inches			Points in Center 2/3	2	to:	7	
Measurement units		particles/ft3			Injection Point	Port 2 center			
Order --->		2nd				1st			
Traverse-->		Side				Bottom			
Trial --->		1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	particles/ft3				particles/ft3			
1	0.50	866	1127	812	935.0	1086	1191	1075	1117.3
2	1.24	1244	1420	1197	1287.0	1390	1407	1343	1380.0
3	2.29	1675	1478	1316	1489.7	1518	1676	1521	1571.7
4	3.82	1678	1481	1505	1554.7	1710	1830	1739	1759.7
Center	5.91	1608	1455	1424	1495.7	1775	1815	1684	1758.0
5	8.00	1412	1371	1453	1412.0	1724	1670	1722	1705.3
6	9.52	1362	1337	1303	1334.0	1579	1520	1523	1540.7
7	10.57	1175	1282	1245	1234.0	1256	1157	1182	1198.3
8	11.31	543	1249	911	901.0	509	568	559	545.3
Averages ---->		1284.8	1355.6	1240.7	1293.7	1394.1	1426.0	1372.0	1397.4

	All	pt/ft3	Dev. from mean	*Center 2/3*	Side	Bottom	All	Normlzd
	Mean	1345.5		Mean	1401.0	1559.1	1480.0	1602.91
	Min Point	545.3	-59.5%	Std. Dev.	119.7	209.7	183.4	177.48
	Max Point	1759.7	30.8%	COV as %	8.5	13.5	12.4	11.07

Avg Conc 1310 pt/ft3

	Start	Finish	
Generator Inlet Press	2.6	2.6	psig
Stack Temp	51.1	58.4	F
Centerline vel.	4502	4296	fpm
Ambient pressure	29.85	29.85	inHg
Ambient humidity	45%	42%	RH
Ambient temp	53.6	56.3	F
Back-Gd aerosol	2,2,6,0	3,2,4,3	pt/ft3
No. Bk-Gd samples	4	4	
Compressor output	19	22	psig

Instruments Used:		Cal. Due
TSI VelociCalc	T95351203001	12/17/2012
Fisher Scientific	90936818	12/7/2012
Met One OPC	1011529010	2/1/2013
Met One OPC	1011529009	1/9/2013



Notes:

CA 10/18/12

Oil Used: Edwards 19

Ref. Probe Location: Ref port downstream of Port 1

Probe Type / Configuration: L-Shaped Probe

Entries made by:	Carmen Arimescu	10/18/2012	Technical Data Review performed by:		
Signature/date	*On File w/ Original*		Signature/date	gbj	11/19/2012

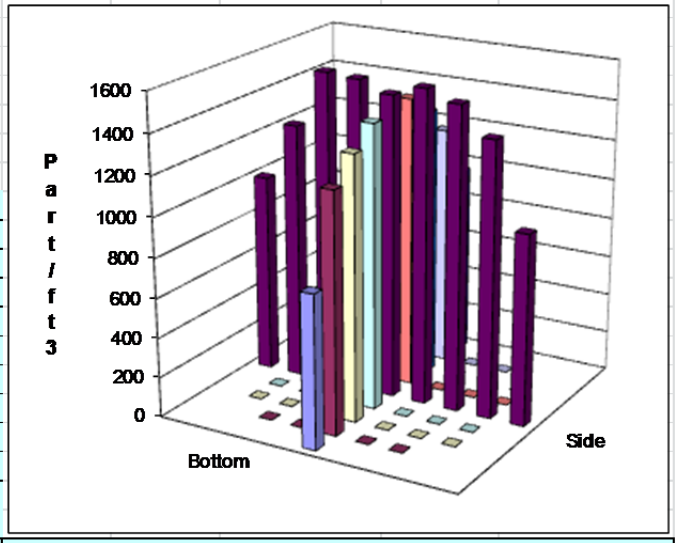
Rev. 0		PARTICLE TRACER TRAVERSE DATA FORM							
3 Aug. 2006	Site	LB-S1 Model			Run No.	PT-4			
	Date	10/18/2012			Fan configuration	AB			
	Tester	CA, XY			Fan Setting	42		Hz	
	Stack Dia.	11.8906 in.			Stack Temp	62.65 deg F			
	Stack X-Area	111.0 in.2			Start/End Time	1135/1320			
	Test Port	1			Center 2/3 from	1.09	to:	10.80	
Distance to disturbance		123.5 inches			Points in Center 2/3	2	to:	7	
Measurement units		particles/ft3			Injection Point	Port 2 center			
	Order --->	1st				2nd			
	Traverse-->	Side				Bottom			
	Trial --->	1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	particles/ft3				particles/ft3			
1	0.50	913	886	813	870.7	702	950	653	768.3
2	1.24	1366	1168	1225	1253.0	1152	1307	1154	1204.3
3	2.29	1453	1325	1363	1380.3	1205	1435	1334	1324.7
4	3.82	1410	1432	1437	1426.3	1331	1531	1407	1423.0
Center	5.91	1337	1406	1386	1376.3	1372	1633	1540	1515.0
5	8.00	1480	1451	1339	1423.3	1235	1610	1519	1454.7
6	9.52	1385	1515	1401	1433.7	1094	1479	1467	1346.7
7	10.57	1008	1375	1135	1172.7	975	1320	1334	1209.7
8	11.31	839	990	897	908.7	957	929	980	955.3
Averages ---->		1243.4	1283.1	1221.8	1249.4	1113.7	1354.9	1265.3	1244.6

All	pt/ft3	Dev. from mean	*Center 2/3*	Side	Bottom	All	Normlzd
Mean	1247.0		Mean	1352.2	1354.0	1353.1	1421.24
Min Point	768.3	-38.4%	Std. Dev.	100.5	119.0	105.8	130.60
Max Point	1515.0	21.5%	COV as %	7.4	8.8	7.8	9.19

Avg Conc 1222 pt/ft3

	Start	Finish	
Generator Inlet Press	2.6	2.6	psig
Stack Temp	59.8	65.5	F
Centerline vel.	4523	4431	fpm
Ambient pressure	29.83	29.8	inHg
Ambient humidity	38%	27%	RH
Ambient temp	59	73.4	F
Back-Gd aerosol	0,0,3,1	1,4,3,2	pt/ft3
No. Bk-Gd samples	4	4	
Compressor output	22	23	psig

Instruments Used:		Cal. Due
TSI VelociCalc	T95351203001	12/17/2012
Fisher Scientific	90936818	12/7/2012
Met One OPC	1011529010	2/1/2013
Met One OPC	1011529009	1/9/2013



Notes: Fan frequency was reduced from 43Hz to 42Hz
so the velocity would be around 4500fpm.
At 43Hz the velocity was around 5000fpm.

Ca 10/18/12

Oil Used: Edwards 19
Ref. Probe Location: Ref port downstream of Port 1
Probe Type / Configuration: L-Shaped Probe

Entries made by:	Carmen Arimescu	10/18/2012	Technical Data Review performed by:		
Signature/date	*On File w/ Original*		Signature/date	gbj	11/19/2012

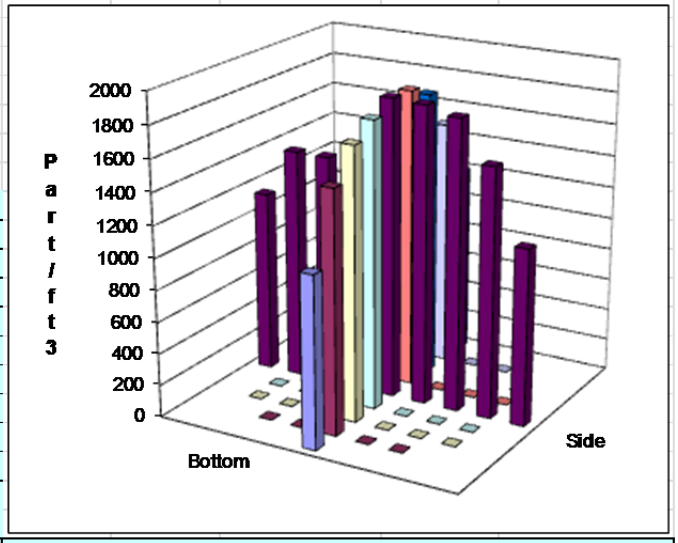
Rev. 0		PARTICLE TRACER TRAVERSE DATA FORM							
3 Aug. 2006	Site	LB-S1 Model			Run No.	PT-5			
	Date	10/18/2012			Fan configuration	AB			
	Tester	CA, XY			Fan Setting	42		Hz	
	Stack Dia.	11.8906 in.			Stack Temp	66.75 deg F			
	Stack X-Area	111.0 in.2			Start/End Time	1325/1530			
	Test Port	1			Center 2/3 from	1.09	to:	10.80	
Distance to disturbance		123.5 inches			Points in Center 2/3	2	to:	7	
Measurement units		particles/ft3			Injection Point	Port 2 center			
	Order --->	2nd				1st			
	Traverse-->	Side				Bottom			
	Trial --->	1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	particles/ft3				particles/ft3			
1	0.50	880	995	994	956.3	964	1020	1240	1074.7
2	1.24	1216	1417	1417	1350.0	1419	1505	1623	1515.7
3	2.29	1592	1527	1589	1569.3	1652	1714	1757	1707.7
4	3.82	1591	1553	1682	1608.7	1619	1876	1905	1800.0
Center	5.91	1693	1523	1640	1618.7	1680	1927	2021	1876.0
5	8.00	1408	1136	1430	1324.7	1665	1898	2039	1867.3
6	9.52	1067	1337	1348	1250.7	1683	1837	1857	1792.3
7	10.57	1187	1329	1236	1250.7	1354	1671	1619	1548.0
8	11.31	827	1077	1057	987.0	1113	1251	1205	1189.7
Averages ---->		1273.4	1321.6	1377.0	1324.0	1461.0	1633.2	1696.2	1596.8

	All	pt/ft3	Dev. from mean	*Center 2/3*	Side	Bottom	All	Normlzd
	Mean	1460.4		Mean	1424.7	1729.6	1577.1	1690.36
	Min Point	956.3	-34.5%	Std. Dev.	167.6	146.4	218.8	170.17
	Max Point	1876.0	28.5%	COV as %	11.8	8.5	13.9	10.07

Avg Conc 1425 pt/ft3

	Start	Finish	
Generator Inlet Press	2.6	2.6	psig
Stack Temp	65.5	68	F
Centerline vel.	4387	4550	fpm
Ambient pressure	29.8	29.77	inHg
Ambient humidity	25%	33%	RH
Ambient temp	77	65.3	F
Back-Gd aerosol	1,1,2,3	2,3,5,4	pt/ft3
No. Bk-Gd samples	4	4	
Compressor output	23	22	psig

Instruments Used:		Cal. Due
TSI VelociCalc	T95351203001	12/17/2012
Fisher Scientific	90936818	12/7/2012
Met One OPC	1011529010	2/1/2013
Met One OPC	1011529009	1/9/2013



Notes: Particle number concentration went up in the middle of testing,repeated one traverse.

CA 10/18/12

Oil Used: Edwards 19

Ref. Probe Location: Ref port downstream of Port 1

Probe Type / Configuration: L-Shaped Probe

Entries made by:	Carmen Arimescu	10/18/2012	Technical Data Review performed by:		
Signature/date	*On File w/ Original*		Signature/date	gbj	11/19/2012

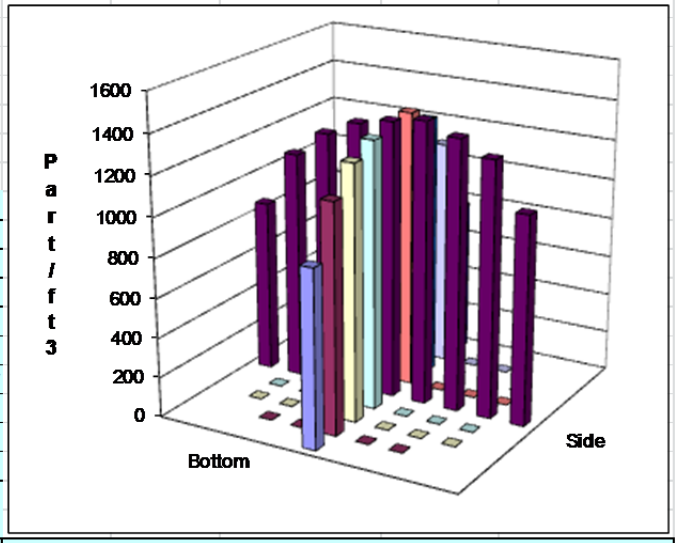
Rev. 0		PARTICLE TRACER TRAVERSE DATA FORM							
3 Aug. 2006	Site	LB-S1 Model			Run No.	PT-6			
	Date	10/22/2012			Fan configuration	AB			
	Tester	EA, CA			Fan Setting	36		Hz	
	Stack Dia.	11.8906	in.		Stack Temp	48.55	deg F		
	Stack X-Area	111.0	in.2		Start/End Time	941/1150			
	Test Port	1			Center 2/3 from	1.09	to:	10.80	
Distance to disturbance		123.5	inches		Points in Center 2/3	2	to:	7	
Measurement units		particles/ft3			Injection Point	Port 2 center			
	Order --->	1st				2nd			
	Traverse-->	Side				Bottom			
	Trial --->	1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	particles/ft3				particles/ft3			
1	0.50	732	775	751	752.7	895	912	870	892.3
2	1.24	875	971	914	920.0	1150	1152	1149	1150.3
3	2.29	999	958	962	973.0	1171	1312	1362	1281.7
4	3.82	997	1043	1001	1013.7	1263	1401	1369	1344.3
Center	5.91	987	987	1007	993.7	1367	1417	1379	1387.7
5	8.00	928	967	1011	968.7	1324	1462	1375	1387.0
6	9.52	934	862	946	914.0	1213	1326	1387	1308.7
7	10.57	802	811	849	820.7	1081	1143	1191	1138.3
8	11.31	644	562	655	620.3	736	731	848	771.7
Averages ---->		877.6	881.8	899.6	886.3	1133.3	1206.2	1214.4	1184.7

All	pt/ft3	Dev. from mean	*Center 2/3*	Side	Bottom	All	Normlzd
Mean	1035.5		Mean	943.4	1285.4	1114.4	1301.44
Min Point	620.3	-40.1%	Std. Dev.	65.1	103.8	196.0	95.24
Max Point	1387.7	34.0%	COV as %	6.9	8.1	17.6	7.32

Avg Conc 1016 pt/ft3

	Start	Finish	
Generator Inlet Press	2.6	2.6	psig
Stack Temp	48.9	48.2	F
Centerline vel.	3719	3546	fpm
Ambient pressure	29.29	29.26	inHg
Ambient humidity	50%	36%	RH
Ambient temp	47.3	62.6	F
Back-Gd aerosol	2,1,1,1	5,3,4,1	pt/ft3
No. Bk-Gd samples	4	4	
Compressor output	19	22	psig

Instruments Used:		Cal. Due
TSI VelociCalc	T95351203001	12/17/2012
Fisher Scientific	90936818	12/7/2012
Met One OPC	1011529010	2/1/2013
Met One OPC	1011529009	1/9/2013



Notes: Finish temp and pressure were measured inside of the tend because was raining .

CA 10/22/12

Oil Used: Edwards 19

Ref. Probe Location: Ref port downstream of Port 1

Probe Type / Configuration: L-Shaped Probe

Entries made by:	Carmen Arimescu	10/22/2012	Technical Data Review performed by:		
Signature/date	*On File w/ Original*		Signature/date	gbj	11/19/2012

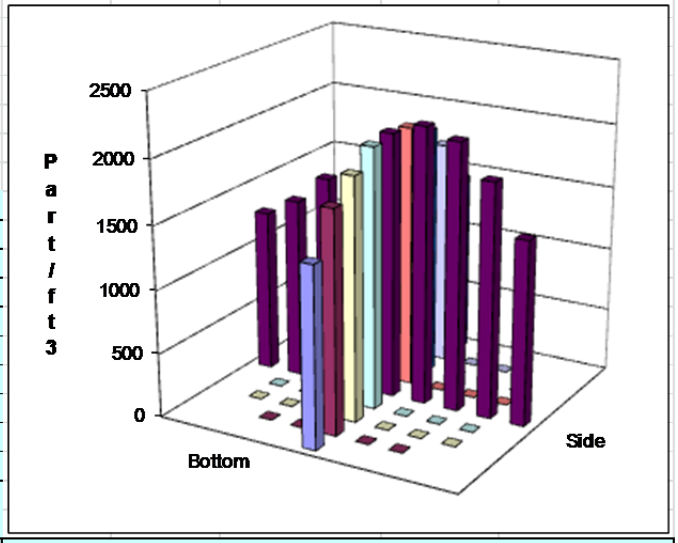
Rev. 0		PARTICLE TRACER TRAVERSE DATA FORM							
3 Aug. 2006	Site	LB-S1 Model			Run No.	PT-7			
	Date	10/22/2012			Fan configuration	AB			
	Tester	CA,XY			Fan Setting	31		Hz	
	Stack Dia.	11.8906	in.		Stack Temp	48.15	deg F		
	Stack X-Area	111.0	in.2		Start/End Time	1200/1400			
	Test Port	1			Center 2/3 from	1.09	to:	10.80	
	Distance to disturbance	123.5	inches		Points in Center 2/3	2	to:	7	
	Measurement units	particles/ft3			Injection Point	Port 2 center			
	Order --->	2nd				1st			
	Traverse-->	Side				Bottom			
	Trial --->	1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	particles/ft3				particles/ft3			
1	0.50	1131	1392	1337	1286.7	1438	1412	1409	1419.7
2	1.24	1578	1669	1657	1634.7	1778	1713	1748	1746.3
3	2.29	1897	1820	1870	1862.3	1880	1900	1946	1908.7
4	3.82	1998	1883	1903	1928.0	2051	2072	2027	2050.0
Center	5.91	1873	1825	1835	1844.3	1957	2127	2149	2077.7
5	8.00	1582	1435	1503	1506.7	2048	2118	1987	2051.0
6	9.52	1498	1457	1415	1456.7	1912	1923	2046	1960.3
7	10.57	1365	1239	1169	1257.7	1744	1754	1815	1771.0
8	11.31	1159	1131	1109	1133.0	1386	1462	1437	1428.3
Averages ---->		1564.6	1539.0	1533.1	1545.6	1799.3	1831.2	1840.4	1823.7

	All	pt/ft3	Dev. from mean	*Center 2/3*	Side	Bottom	All	Normlzd
	Mean	1684.6		Mean	1641.5	1937.9	1789.7	1893.50
	Min Point	1133.0	-32.7%	Std. Dev.	248.9	135.9	246.5	216.63
	Max Point	2077.7	23.3%	COV as %	15.2	7.0	13.8	11.44

Avg Conc 1650 pt/ft3

	Start	Finish	
Generator Inlet Press	2.6	2.6	psig
Stack Temp	49	47.3	F
Centerline vel.	3064	3113	fpm
Ambient pressure	29.26	29.23	inHg
Ambient humidity	41%	41%	RH
Ambient temp	59	66.2	F
Back-Gd aerosol	0,1,0,3	5,1,1,0	pt/ft3
No. Bk-Gd samples	4	4	
Compressor output	22	22	psig

Instruments Used:		Cal. Due
TSI VelociCalc	T95351203001	12/17/2012
Fisher Scientific	90936818	12/7/2012
Met One OPC	1011529010	2/1/2013
Met One OPC	1011529009	1/9/2013



Notes:

CA 10/22/12

Oil Used: Edwards 19

Ref. Probe Location: Ref port downstream of Port 1

Probe Type / Configuration: L-Shaped Probe

Entries made by:	Carmen Arimescu	10/22/2012	Technical Data Review performed by:		
Signature/date	*On File w/ Original*		Signature/date	gbj	11/19/2012

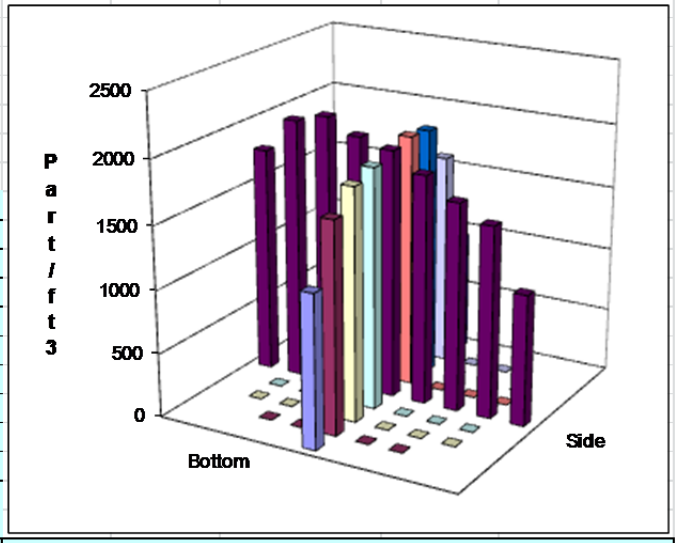
Rev. 0		PARTICLE TRACER TRAVERSE DATA FORM							
3 Aug. 2006	Site	LB-S1 Model			Run No.	PT-8			
	Date	10/24/2012			Fan configuration	Bottom			
	Tester	XY,CA			Fan Setting	45		Hz	
	Stack Dia.	11.8906 in.			Stack Temp	46.2 deg F			
	Stack X-Area	111.0 in.2			Start/End Time	930/1200			
	Test Port	1			Center 2/3 from	1.09	to:	10.80	
Distance to disturbance		123.5 inches			Points in Center 2/3	2	to:	7	
Measurement units		particles/ft3			Injection Point	Port 1 center			
	Order --->	1st				2nd			
	Traverse-->	Side				Bottom			
	Trial --->	1	2	3	Mean	1	2	3	Mean
Point	Depth, in.	particles/ft3				particles/ft3			
1	0.50	696	744	765	735.0	1190	1253	1174	1205.7
2	1.24	1045	1059	1122	1075.3	1613	1726	1652	1663.7
3	2.29	1028	1290	1183	1167.0	1829	1871	1788	1829.3
4	3.82	1207	1325	1319	1283.7	1901	1846	1940	1895.7
Center	5.91	1383	1398	1382	1387.7	1923	1956	1967	1948.7
5	8.00	1358	1493	1446	1432.3	1871	2063	2014	1982.7
6	9.52	1453	1589	1500	1514.0	1889	1986	2008	1961.0
7	10.57	1419	1476	1497	1464.0	1628	1679	1702	1669.7
8	11.31	1176	1414	1218	1269.3	891	968	953	937.3
Averages ---->		1196.1	1309.8	1270.2	1258.7	1637.2	1705.3	1688.7	1677.1

	All	pt/ft3	Dev. from mean	*Center 2/3*	Side	Bottom	All	Normlzd
	Mean	1467.9		Mean	1332.0	1850.1	1591.0	1860.30
	Min Point	735.0	-49.9%	Std. Dev.	162.9	135.0	304.8	180.75
	Max Point	1982.7	35.1%	COV as %	12.2	7.3	19.2	9.72

Avg Conc 1443 pt/ft3

	Start	Finish	
Generator Inlet Press	4	4	psig
Stack Temp	45.6	46.8	F
Centerline vel.	4564	4564	fpm
Ambient pressure	29.56	29.65	inHg
Ambient humidity	42%	70%	RH
Ambient temp	58.1	50.9	F
Back-Gd aerosol	0,1,2,0	0,1,0,3	pt/ft3
No. Bk-Gd samples	4	4	
Compressor output	19	22	psig

Instruments Used:		Cal. Due
TSI VelociCalc	T95351203001	12/17/2012
Fisher Scientific	90936818	12/7/2012
Met One OPC	1011529010	2/1/2013
Met One OPC	1011529009	1/9/2013



Notes:

CA 10/24/12

Oil Used: Edwards 19

Ref. Probe Location: Ref port downstream of Port 1

Probe Type / Configuration: L-Shaped Probe

Entries made by:	Carmen Arimescu	10/24/2012	Technical Data Review performed by:		
Signature/date	*On File w/ Original*		Signature/date	gbj	11/19/2012

Appendix B

Document List

Appendix B: Document List

Project Plan	PP-WTPSP-045 Rev. 1	Air Sampling Probe Location Tests for Waste Treatment Plant HV-S1, HV-S2, IHLW-S1 (Group 3-4), and LAB C3V (LB-S1) Air Exhaust Systems
Test Plan	TP-WTPSP-094	Air Sampling Probe Location Tests for Waste Treatment Plant LAB C3V (LB-S1) Air Exhaust System
Test Instructions	TI-WTPSP-096	Measurements of LB-S1 Scale Model
	TI-WTPSP-097	Calibration of Ventilation Flow Controller for LB-S1 Scale Model Stack
	TI-WTPSP-098	Velocity Uniformity Measurements of LB-S1 Scale Model
	TI-WTPSP-099	Determine Flow Angle in LB-S1 Scale Model Stack
	TI-WTPSP-100	Tests of Gas Tracer Mixing in LB-S1 Scale Model Stack
	TI-WTPSP-101	Tests of Particle Tracer Mixing in LB-S1 Scale Model Stack
Calculation Packages	CCP-WTPSP-1120	LAB C3V (LB-S1) Scale Model Flowrate Calculations
	CCP-WTPSP-1294	Scale Model Exhauster Dimensions LAB C3V (LB-S1)
	CCP-WTPSP-1298	Calibration of Ventilation Flow Controller for LB-S1 Scale Model
	CCP-WTPSP-1299	Determine Air Velocity Uniformity of LB-S1 Scale Model Stack
	CCP-WTPSP-1300	Determine Flow Angle in LB-S1 Scale Model Stack
	CCP-WTPSP-1175	Gas Tracer Mixing in LAB C3V (LB-S1) Scale Model Stack
	CCP-WTPSP-1174	Determine Particle Tracer Uniformity of LAB C3V (LB-S1) Scale Model Exhausters

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