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# MACT Emissions Test Report

## University of Iowa
## Oakdale Renewable Energy Plant
## Hurst Boiler Exhaust Duct
## Coralville, Iowa
## November 4 and 5, 2014

## Report Submittal Date
## December 8, 2014

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## Project No. M144705

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Elmhurst, Illinois 60126
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# 1.0 EXECUTIVE SUMMARY

MOSTARDI PLATT conducted a MACT emissions test program for University of Iowa at the Oakdale Renewable Energy Plant in Coralville, Iowa on the Hurst Boiler Exhaust Duct on November 4 and 5, 2014. This report summarizes the results of the test program and test methods used.

The test location, test dates, and test parameters are summarized below.

| TEST INFORMATION | | |
|---|---|---|
| **Test Location** | **Test Dates** | **Test Parameters** |
| Hurst Boiler Exhaust Duct | November 4 and 5, 2014 | Filterable Particulate Matter (FPM), Nitrogen Oxides ($NO_x$), Carbon Monoxide (CO), Mercury (Hg), and Hydrogen Chloride (HCl) |

Selected results of the test program are summarized below. A complete summary of emission test results follows the narrative portion of this report.

| TEST RESULTS | | | | | |
|---|---|---|---|---|---|
| **Test Location** | **Date** | **Test Parameter** | **MACT Emission Limits** | **Permitted Emission Limits** | **Emission Rates** |
| Hurst Boiler Exhaust Duct | 11/4/14 | FPM | 0.03 lb/mmBtu | | 0.0018 lb/mmBtu |
| | | HCl | 0.022 lb/mmBtu | | 0.0003 lb/mmBtu |
| | 11/5/14 | Hg | 0.8 lb/TBtu | | 0.6284 lb/TBtu |
| | | $NO_X$ | | 4.13 lb/hr | 2.09 lb/hr |
| | | CO | 620 ppm @ 3% $O_2$ | | 8.1 ppm @ 3% $O_2$ |
| | | | | 4.13 lb/hr | 0.13 lb/hr |

A standard Fd-Factor of 9,240 dscf/mmBtu for wood was used to calculate emissions on lb/mmBtu and lb/TBtu basis. The unit tripped during the third run on November 5, 2014 and testing was not completed for $NO_X$, CO, and Hg. Values for the data collected are shown in the tables in Section 3.0 but were not included in the average emissions due to the lack of post-test calibrations for the gas constituents. Mostardi Platt was unable to calculate a valid Hg lb/mmBtu emissions value for Run 3. In addition, the Method 30B spiked trap concentrations were assumed from previous testing but were not within the proper range for Runs 1 and 2.

The Stationary Source Audit Sample Program audit sample was obtained and submitted for analysis to Maxxam Analytics. The results of that audit sample were compared to the assigned value by ERA and found to be acceptable. The audit sample results and evaluation are appended to this report.

Operating data as provided by the University of Iowa are included in Appendix A.

The identification of individuals associated with the test program is summarized below.


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| TEST PERSONNEL INFORMATION | | |
|---|---|---|
| **Location** | **Address** | **Contact** |
| Test Coordinator | The University of Iowa<br>Oakdale Renewable Energy Plant<br>Oakdale Campus<br>Coralvillle, Iowa 52319 | Mr. Mark Maxwell<br>Environmental Engineer<br>(319) 335-6185 (phone)<br>mark-maxwell@uiowa.edu |
| Testing Company Representative | Mostardi Platt<br>888 Industrial Drive<br>Elmhurst, Illinois 60126 | Mr. Daniel E. Tuider<br>Project Manager<br>(630) 993-2100 (phone)<br>dtuider@mp-mail.com |

The test crew consisted of Messrs. J. Keable, S. McGough, and D. Tuider of Mostardi Platt.

# 2.0 TEST METHODOLOGY

Emission testing was conducted following the methods specified in 40CFR60, Appendix A. Schematics of the test section diagrams and sampling trains used are included in Appendix B and C, respectively. Calculation nomenclature and example calculations are included in Appendix D. Appendix E includes laboratory sample analysis. Copies of reference method data sheets and field data sheets for each test run are included in Appendix F and G.

The following methodology was used during the test program:

## Method 1 Traverse Point Determination

Test measurement points were selected in accordance with Method 1. The characteristics of measurement location are summarized below.

| TEST POINT INFORMATION | | | | |
|---|---|---|---|---|
| **Location** | **Upstream Diameters** | **Downstream Diameters** | **Test Parameter** | **Number of Sampling Points** |
| Hurst Boiler Exhaust Duct | >0.5 | >2.0 | FPM, Volumetric Flow | 25 |
| | | | $NO_x$ and CO | 20 |
| | | | Hg | 3 |
| | | | HCl | 1 |

## Stratification Test for Gaseous Sampling

A 20 point gaseous stratification test was performed during Run 1 on November 5, 2014. All of the results were greater than 10 % difference and consequently 20 points were used for Runs 2 and 3 (partial run).

## Method 2 Volumetric Flow Rate Determination

Gas velocity was measured following Method 2, for purposes of calculating exhaust gas volumetric flow rate and emission rates on a lb/hr basis. An S-type pitot tube, differential pressure gauge, thermocouple and temperature readout were used to determine gas velocity at each sample point. All of the equipment used was calibrated in accordance with the specifications of the Method. Calibration data are presented in Appendix H.


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## Method 3A Oxygen ($O_2$)/Carbon Dioxide ($CO_2$) Determination

$CO_2$ and $O_2$ concentrations were measured to determine exhaust gas molecular weight in accordance with Method 3A. A Servomex analyzer was used to determine stack gas $O_2$ and $CO_2$ content and, by difference, nitrogen content. All of the equipment used was calibrated in accordance with the specifications of the Method. Calibration data are presented in Appendix H and copies of gas cylinder certifications are included in Appendix I.

## Method 4 Moisture Determination

USEPA Method 4 was utilized to determine water ($H_2O$) content of the exhaust gas. 100 milliliters (ml) of water were added to each of the first two impingers, the third impinger was left empty, and the fourth impinger was charged with approximately 200 grams of silica gel. The impingers were placed in an ice bath to maintain the sampled gas passed through the silica gel impinger outlet below 68°F in order to increase the accuracy of the sampled dry gas volume measurement. The water volumes of the impinger train were measured and the silica gel was weighed before and after each test run to determine the mass of moisture condensed.

Each sample was extracted through a heated stainless-steel probe and filter assembly at a constant sample rate of approximately 0.75 cubic feet per minute, which was maintained throughout the course of the test run. A minimum of 21 dry standard cubic feet (dscf) are sampled for, each moisture run. After each run, a leak check of the sampling train was performed at a vacuum greater than the sampling vacuum to determine if any leakage had occurred during sampling. Following the leak check, the impingers were removed from the ice bath, water levels were measured, and the silica gel weight was recorded.

All of the equipment used was calibrated in accordance with the specifications of the Method. Calibration data are presented in Appendix H.

## Method 7E Nitrogen Oxide ($NO_X$) Determination

Exhaust gas nitrogen oxide concentrations and emission rates were determined in accordance with Method 7E. A Thermo Scientific 42 Series nitrogen oxide analyzer was used to determine nitrogen oxide concentrations, in the manner specified in the Method.

Exhaust gas was delivered to the analyzer via a Teflon® sampling line, heated to a minimum temperature of 250°F. Excess moisture in the exhaust gas was removed using a refrigerated condenser. The entire system was calibrated in accordance with the Method, using certified calibration gases introduced at the probe, before and after each test run.

A list of calibration gases used and the results of all calibration and other required quality assurance checks can be found in Appendix H. Copies of gas cylinder certifications are included in Appendix I.

## Method 10 Carbon Monoxide (CO) Determination

Exhaust gas carbon monoxide concentrations and emission rates were determined in accordance with Method 10. A Thermo Scientific 48 Series carbon monoxide analyzer was used to determine carbon monoxide concentrations, in the manner specified in the Method.

Exhaust gas was delivered to the analyzer via a Teflon® sampling line, heated to a minimum temperature of 250°F. Excess moisture in the exhaust gas was removed using a refrigerated condenser. The entire system was calibrated in accordance with the Method, using certified calibration gases introduced at the probe, before and after each test run.


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A list of calibration gases used and the results of all calibration and other required quality assurance checks can be found in Appendix H. Copies of gas cylinder certifications are included in Appendix I.

## Method 5 Filterable Particulate Matter (FPM) Determination

Exhaust gas FPM concentrations and emission rates were determined in accordance with Method 5. An Environmental Supply Company sampling train was used to sample stack gas at an isokinetic rate, as specified in the Method. Particulate matter in the sample probe was recovered using an acetone wash. The probe wash and filter catch were analyzed by Mostardi Platt in accordance with the Method. Laboratory analysis data are included in Appendix D. All of the equipment used was calibrated in accordance with the specifications of the Method. Calibration data are presented in Appendix H.

## Method 26 Hydrogen Chloride (HCl) Determination

Exhaust gas Hydrogen Chloride (HCl) concentration and emission rates were determined in accordance with Method 26. An Environmental Supply Company, Inc. sampling train was used to collect the sample. A single-point sample was extracted from the gas stream and passed through dilute (0.1 N) sulfuric acid. In the dilute acid, the HCl dissolved and formed chloride (Cl) ions. The sample train consisted of a Teflon® filter placed on the outlet of a heated borosilicate glass probe liner and five impingers. The first two impingers contained the dilute sulfuric acid, the third and fourth impingers contained a 0.1 N sodium hydroxide (NaOH), and the fifth impinger contained silica gel to absorb any remaining moisture. A DI rinse was performed on each set of impingers, and samples were stored in nalgene sample containers for transport. The dilute sulfuric acid samples were then analyzed for HCl by Maxxam Analytics, Inc. All of the equipment used was calibrated in accordance with the specifications of the Method. Calibration data are presented in Appendix H.

## Mercury Determination by Method 30B (Sorbent Trap Method)

Paired trains were utilized using three test points.

Per Method 30B sampling, each sample was collected on the paired in-situ sorbent traps. A tube of silica was used to capture remaining moisture prior to the sample reaching the gas metering system.

The sample train used for this test program was designed by APEX, Inc. and meets all requirements for Method 30B sampling. Samples were analyzed onsite utilizing an Ohio Lumex, Inc. analyzer for total gaseous mercury. All of the equipment used was calibrated in accordance with the specifications of the Method. Calibration data are presented in Appendix H. Mercury quality assurance and control data are found in Appendix J.


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# 3.0 TEST RESULT SUMMARIES

**Client:** University of Iowa
**Facility:** Oakdale Renewable Energy Plant
**Test Location:** Hurst Boiler Exhaust Duct
**Test Method:** 5

| Source Condition | Normal | Normal | Normal | |
|---|---|---|---|---|
| Date | 11/4/14 | 11/4/14 | 11/4/14 | |
| Start Time | 8:35 | 11:30 | 14:15 | |
| End Time | 11:05 | 13:47 | 16:32 | |
| | Run 1 | Run 2 | Run 3 | Average |
| **Stack Conditions** | | | | |
| Average Gas Temperature, °F | 358.2 | 364.5 | 373.9 | 365.5 |
| Flue Gas Moisture, percent by volume | 13.2% | 14.9% | 14.7% | 14.3% |
| Average Flue Pressure, in. Hg | 29.64 | 29.64 | 29.64 | 29.64 |
| Gas Sample Volume, dscf | 77.462 | 78.437 | 75.223 | 77.041 |
| Average Gas Velocity, ft/sec | 11.274 | 11.466 | 11.107 | 11.282 |
| Gas Volumetric Flow Rate, acfm | 13,022 | 13,243 | 12,828 | 13,031 |
| Gas Volumetric Flow Rate, dscfm | 7,227 | 7,152 | 6,863 | 7,081 |
| Gas Volumetric Flow Rate, scfm | 8,325 | 8,402 | 8,047 | 8,258 |
| Average % $CO_2$ by volume, dry basis | 11.6 | 11.4 | 11.8 | 11.6 |
| Average % $O_2$ by volume, dry basis | 8.9 | 9.1 | 8.8 | 8.9 |
| Isokinetic Variance | 99.7 | 102.1 | 102.0 | 101.3 |
| Standard Fd Factor, dscf/mmBtu | 9,240.0 | 9,240.0 | 9,240.0 | 9,240.0 |
| **Filterable Particulate Matter (Method 5)** | | | | |
| grams collected | 0.0046 | 0.0047 | 0.0023 | 0.0039 |
| grains/acf | 0.0005 | 0.0005 | 0.0003 | 0.0004 |
| grains/dscf | 0.0009 | 0.0009 | 0.0005 | 0.0008 |
| lb/hr | 0.057 | 0.057 | 0.028 | 0.047 |
| lb/mmBtu (Standard Fd Factor) | 0.0021 | 0.0022 | 0.0011 | 0.0018 |

**HCl Test Results Summary**
**University of Iowa**
**Oakdale Renewable Energy Plant**
**Hurst Boiler Exhaust Duct**

| Run No. | Location | Date | Time | Meter Volume, dscf | $O_2$, % dry | HCl detected, mg* | HCl Concentration ppmvd | Fd Factor | HCl lbs/MMBtu |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Stack | 11/4/2014 | 8:55-9:55 | 4.17 | 8.90 | 0.053 | 0.30 | 9240.0 | 0.0005 |
| 2 | Stack | 11/4/2014 | 12:00-13:00 | 4.18 | 9.10 | 0.030 | 0.17 | 9240.0 | 0.0003 |
| 3 | Stack | 11/4/2014 | 14:43-15:43 | 4.13 | 8.80 | 0.030 | 0.17 | 9240.0 | 0.0003 |
| Average | | | | | | | 0.21 | 9240.0 | 0.0003 |

* Runs 2 and 3 were not detected and the detection limit used in the calculation


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## Method 30B (Sorbent Trap) Mercury Test Results Summary
## University of Iowa
## Oakdale Renewable Energy Plant
## Hurst Boiler Exhaust Duct

| Test No. | Date | Start Time | End Time | $V_m$ (standard L) | ng detected | ppb | $O_2$, % dry | ug/dscm | ug/wscm | lb/Tbtu (Fd Factor) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1A | 11/5/2014 | 11:35 | 12:45 | 137.576 | 85.60 | 0.07 | 11.20 | 0.62 | 0.56 | 0.7733 |
| 1B | | | | 135.462 | 78.90 | 0.07 | 11.20 | 0.58 | 0.52 | 0.7239 |
| Average | | | | | 82.25 | 0.07 | 11.20 | 0.60 | 0.54 | 0.7486 |
| 2A | 11/5/2014 | 13:25 | 14:35 | 136.702 | 59.20 | 0.05 | 11.00 | 0.43 | 0.39 | 0.5274 |
| 2B | | | | 132.931 | 53.40 | 0.05 | 11.00 | 0.40 | 0.36 | 0.4892 |
| Average | | | | | 56.30 | 0.05 | 11.00 | 0.42 | 0.37 | 0.5083 |
| 3A | 11/5/2014 | 15:13 | 16:05 | 116.988 | 28.90 | 0.03 | 10.40 | 0.25 | 0.22 | 0.2836 |
| 3B | | | | 96.283 | 25.60 | 0.03 | 10.40 | 0.27 | 0.24 | 0.3053 |
| Average | | | | | 27.25 | 0.03 | 10.40 | 0.26 | 0.23 | 0.2945 |
| | | | | | | | | | | |
| Overall Average* | | | | | 69.28 | 0.06 | 11.10 | 0.51 | 0.46 | 0.6284 |

*Unit tripped during Run 3 and was not included in the average

University of Iowa
Oakdale Renewable Energy Plant
Hurst Boiler Exhaust Duct
Gaseous Summary

| Test No. | Date | Start Time | End Time | $NO_x$, ppm (dry) | CO, ppm (dry) | $CO_2$, % (dry) | $O_2$, % (dry) | CO ppm (dry) @ 3% $O_2$ | Flowrate, DSCFM | Fd Factor, dscf/MMBtu | O2 based NOx lb/MMBtu | O2 based CO lb/MMBtu | $NO_x$ lb/hr | CO lb/hr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 11/05/14 | 11:35 | 13:01 | 45.8 | 3.0 | 9.3 | 11.2 | 5.5 | 6,514.0 | 9,240.0 | 0.109 | 0.004 | 2.14 | 0.09 |
| 2 | 11/05/14 | 13:25 | 14:48 | 43.9 | 5.9 | 9.6 | 11.0 | 10.7 | 6,479.0 | 9,240.0 | 0.102 | 0.008 | 2.04 | 0.17 |
| 3 | 11/05/14 | 15:13 | 16:01 | 44.4 | 9.2 | 10.1 | 10.4 | 15.7 | 6,601.0 | 9,240.0 | 0.098 | 0.012 | 2.10 | 0.26 |
| Average* | | | | 44.9 | 4.5 | 9.5 | 11.1 | 8.1 | 6,496.5 | 9,240.0 | 0.106 | 0.006 | 2.09 | 0.13 |

*Unit tripped during Run 3 and Run 3 is not included in the average


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# 4.0 CERTIFICATION

MOSTARDI PLATT is pleased to have been of service to University of Iowa. If you have any questions regarding this test report, please do not hesitate to contact us at 630-993-2100.

## CERTIFICATION

As project manager, I hereby certify that this test report represents a true and accurate summary of emissions test results and the methodologies employed to obtain those results, and the test program was performed in accordance with the methods specified in this test report.

MOSTARDI PLATT

_____ Project Manager
Daniel E. Tuider

_____ Quality Assurance
Jeffrey M. Crivlare


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# APPENDICES


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# Appendix A - Plant Operating Data


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| HURST 2014 Boiler MACT Testing | | | OAK_B#1_FT839 | |
|---|---|---|---|---|
| Run # | Start Time | End Time | Hurst Steam Load (KLbs/Hr) | Hurst Design Steam Capacity (Klbs/Hr) |
| FPM Runs | | | | |
| 1 | 11/4/14 8:35 | 11/4/14 11:05 | 13.44056426 | 20 |
| 2 | 11/4/14 11:30 | 11/4/14 13:47 | 13.25513696 | 20 |
| 3 | 11/4/14 14:15 | 11/4/14 16:32 | 13.17647585 | 20 |
| HCl Runs | | | | |
| 1 | 11/4/14 8:55 | 11/4/14 9:55 | 13.60085547 | 20 |
| 2 | 11/4/14 12:00 | 11/4/14 13:00 | 13.04965777 | 20 |
| 3 | 11/4/14 14:43 | 11/4/14 15:43 | 13.07267843 | 20 |
| Mercury Runs | | | | |
| 1 | 11/5/14 11:35 | 11/5/14 12:45 | 11.82363673 | 20 |
| 2 | 11/5/14 13:25 | 11/5/14 14:35 | 11.76296755 | 20 |
| 3 | 11/5/14 15:13 | 11/5/14 16:05 | 11.45545742 | 20 |
| CO and NOx Runs | | | | |
| 1 | 11/5/14 11:35 | 11/5/14 13:01 | 11.77905421 | 20 |
| 2 | 11/5/14 13:25 | 11/5/14 14:48 | 11.78580092 | 20 |
| 3 | 11/5/14 15:13 | 11/5/14 16:01 | 11.42337514 | 20 |


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# Appendix B - Test Section Diagrams


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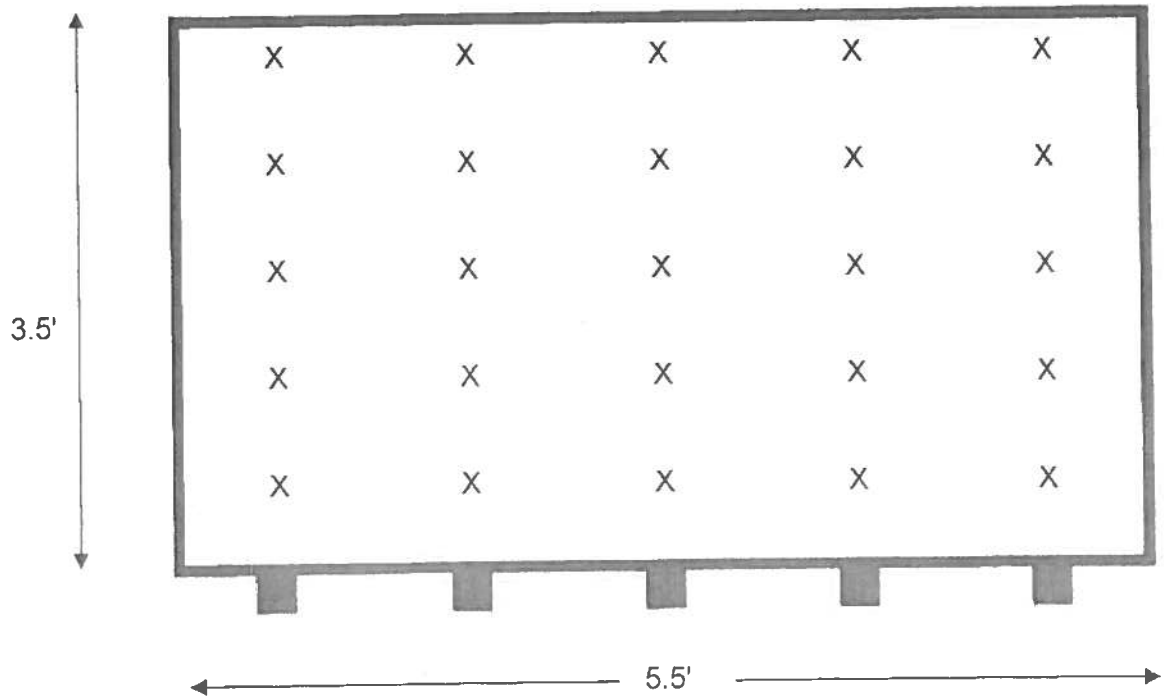
# EQUAL AREA TRAVERSE FOR RECTANGULAR DUCTS
## (FPM and Volumetric Flow Testing)




Job: The University of Iowa
Oakdale Renewable Energy Plant
Coralville, Iowa

Date: November 4 and 5, 2014

Area: 19.25 Square Feet

Test Location: Hurst Boiler Exhaust Duct

No. Test Ports: 5

Length: 5.5 Feet

Tests Points per Port: 5

Width: 3.5 Feet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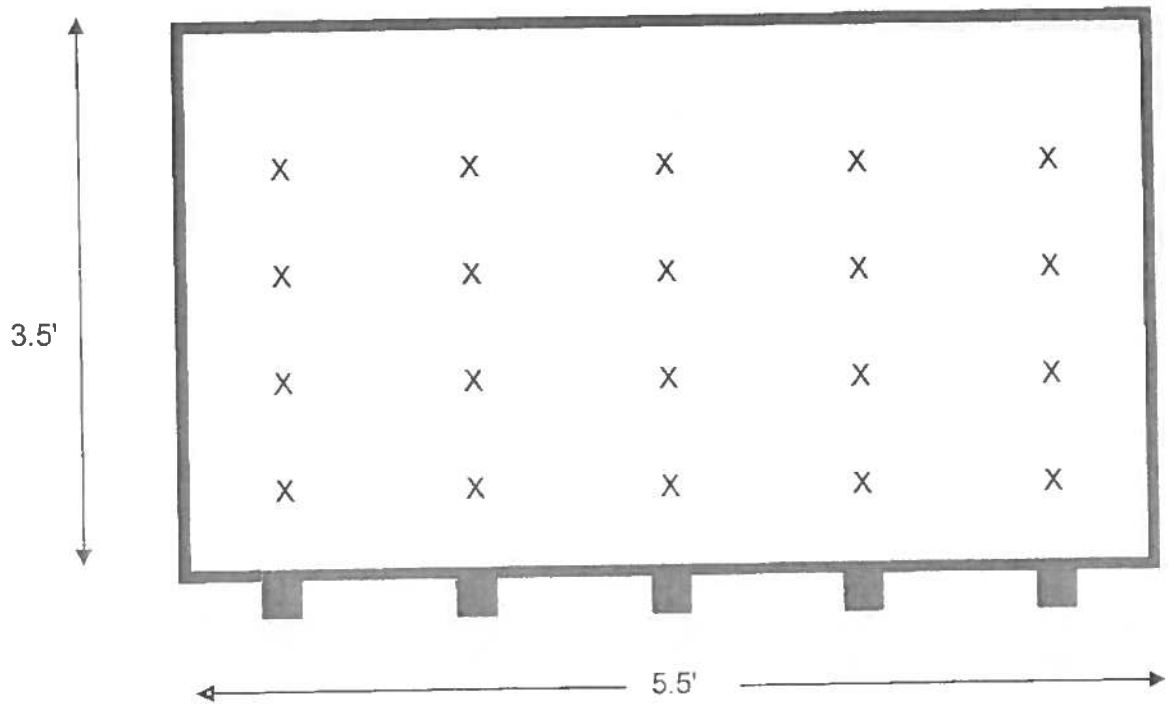
# EQUAL AREA TRAVERSE FOR RECTANGULAR DUCTS
## ($NO_X$ and CO Testing)




Job: The University of Iowa
Oakdale Renewable Energy Plant
Coralville, Iowa

Date: November 5, 2014

Area: 19.25 Square Feet

Test Location: Hurst Boiler Exhaust Duct

No. Test Ports: 5

Length: 5.5 Feet

Tests Points per Port: 4

Width: 3.5 Feet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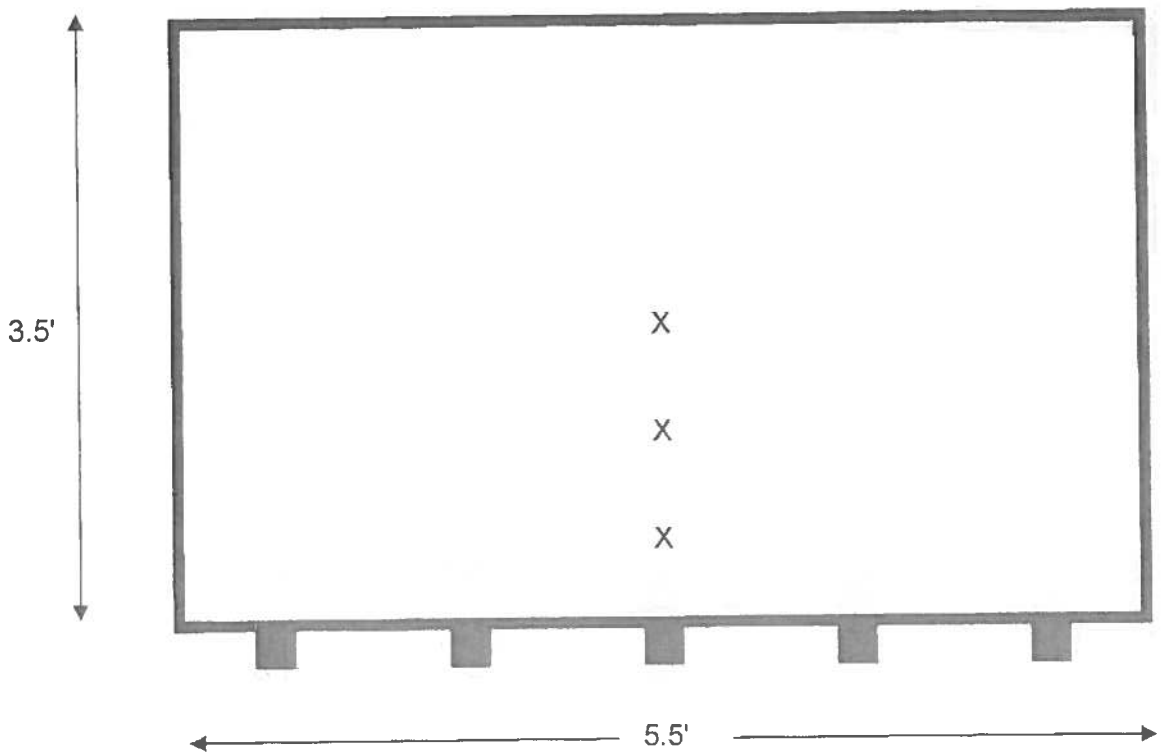
# EQUAL AREA TRAVERSE FOR RECTANGULAR DUCTS
## (Hg Testing)




| | | | |
|---|---|---|---|
| Job: | The University of Iowa<br>Oakdale Renewable Energy Plant<br>Coralville, Iowa | | |
| Date: | November 5, 2014 | Area: | 19.25 Square Feet |
| Test Location: | Hurst Boiler Exhaust Duct | No. Test Ports: | 3 |
| Length: | 5.5 Feet | Tests Points per Port: | 1 |
| Width: | 3.5 Feet | | |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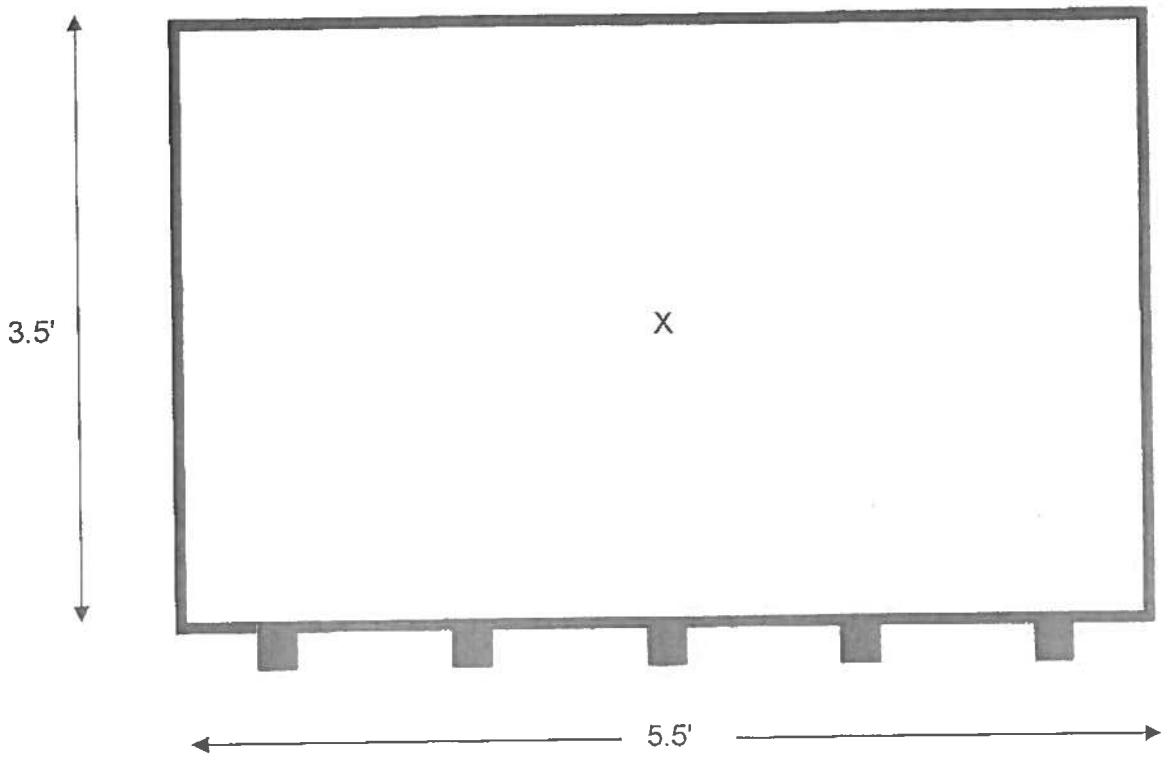
# EQUAL AREA TRAVERSE FOR RECTANGULAR DUCTS
## (HCl Testing)




Job: The University of Iowa
Oakdale Renewable Energy Plant
Coralville, Iowa

Date: November 4, 2014

Test Location: Hurst Boiler Exhaust Duct

Length: 5.5 Feet

Width: 3.5 Feet

Area: 19.25 Square Feet

No. Test Ports: 1

Tests Points per Port: 1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# Appendix C - Sample Train Diagrams


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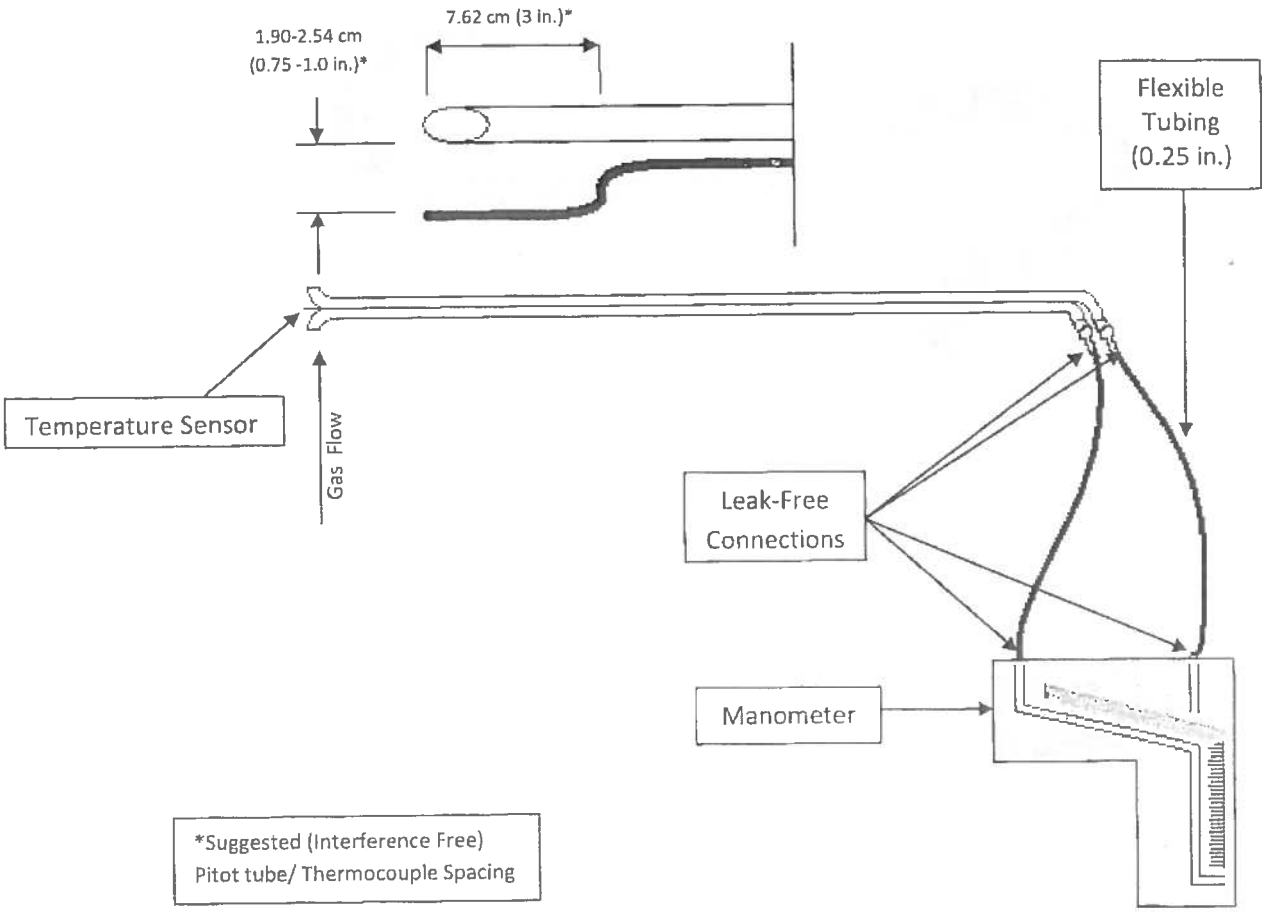
# USEPA Method 2- Type S Pitot Tube Manometer Assembly





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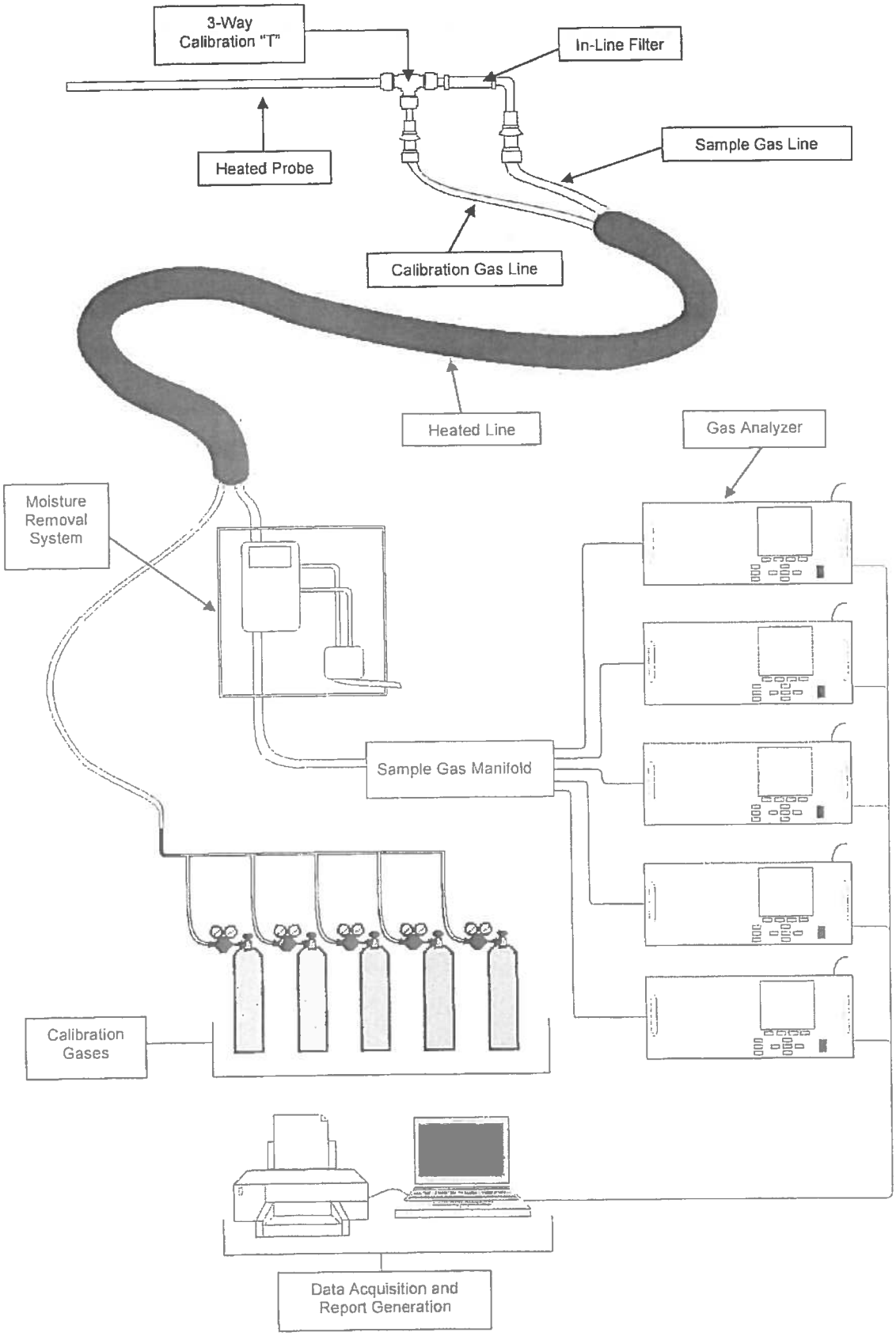
# USEPA Method 3A Extractive Gaseous Sampling Diagram





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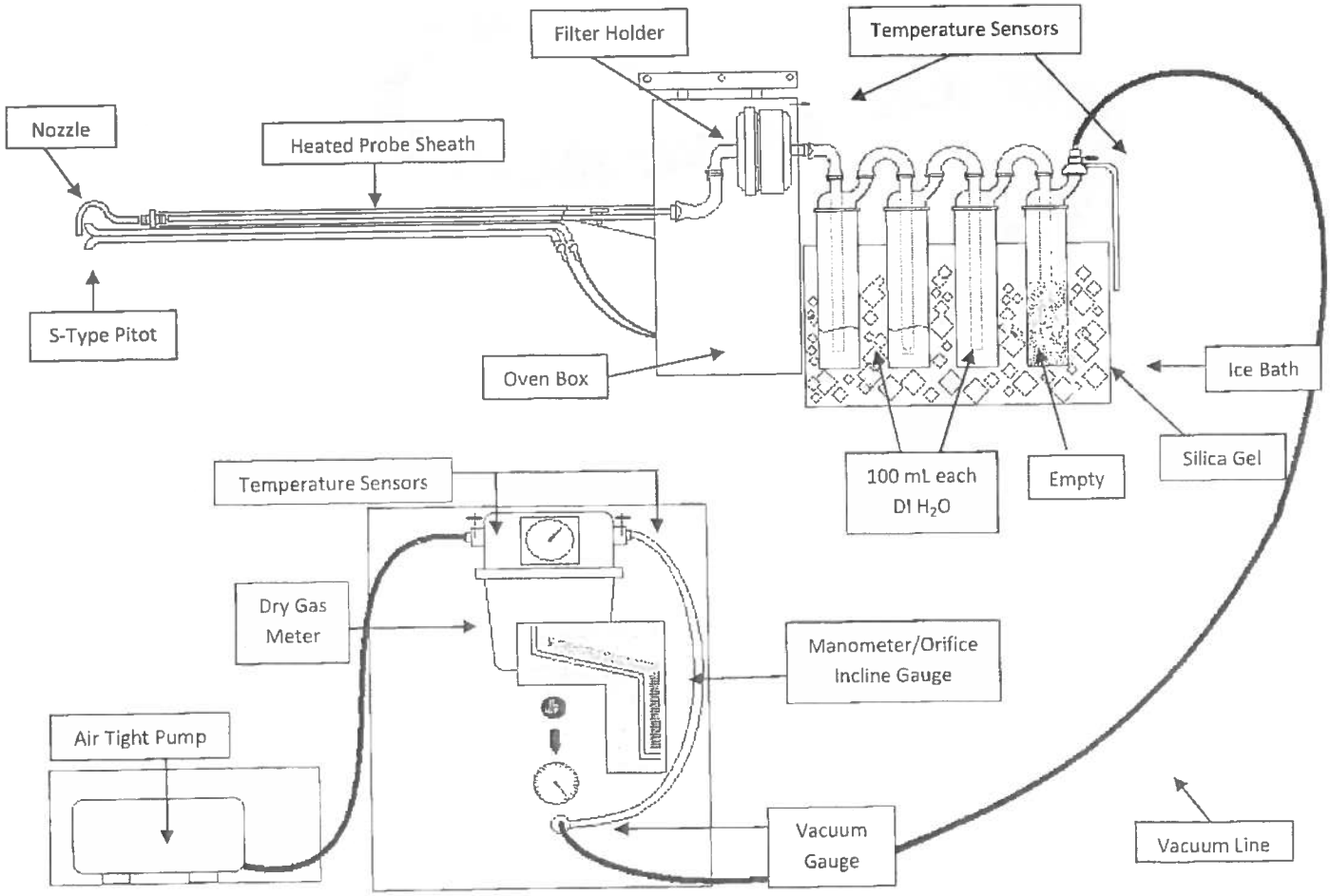
# USEPA Method 5- Particulate Matter Sample Train Diagram





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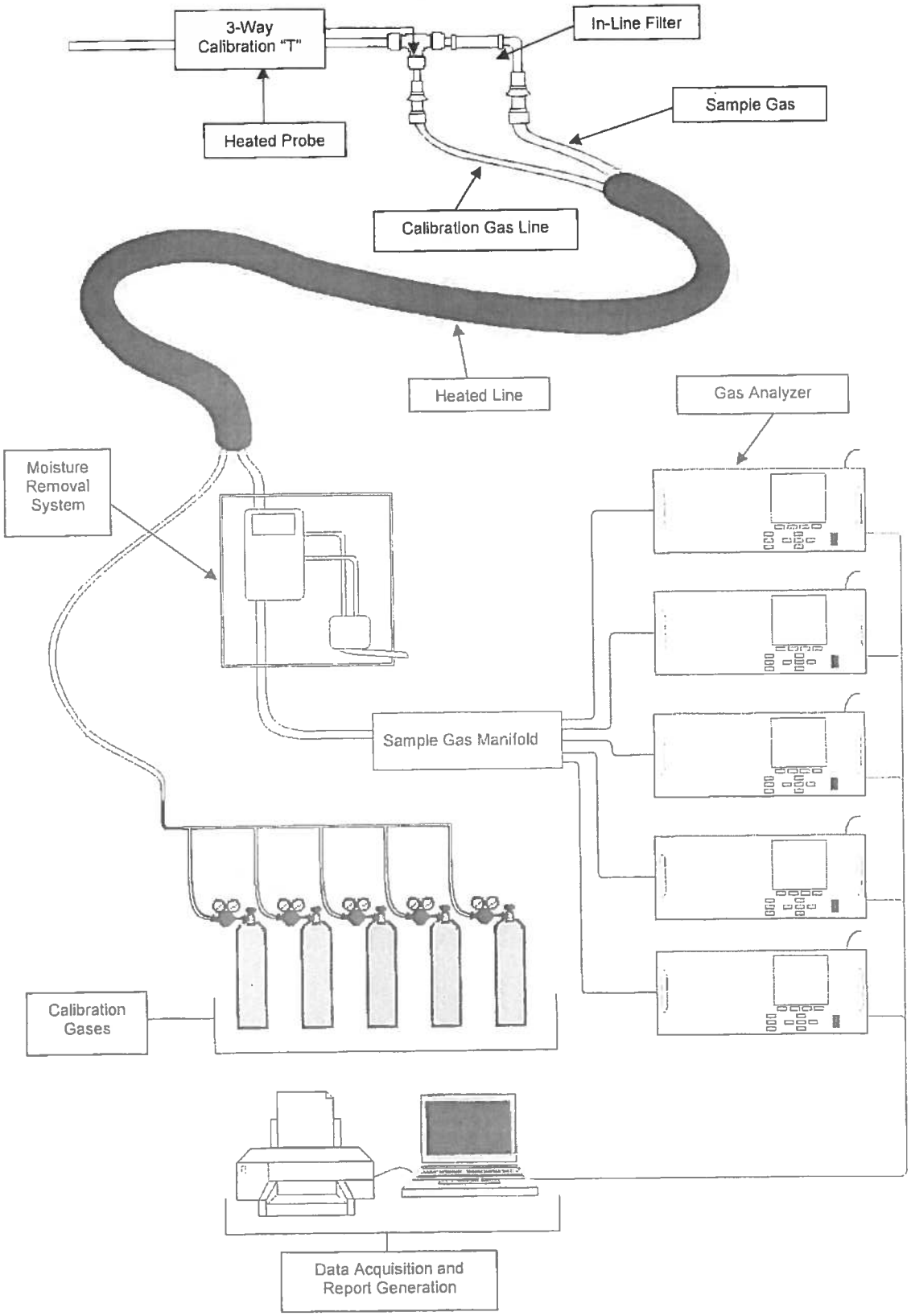
# USEPA Methods 3A, 7E and 10 Extractive Gaseous Sampling Diagram





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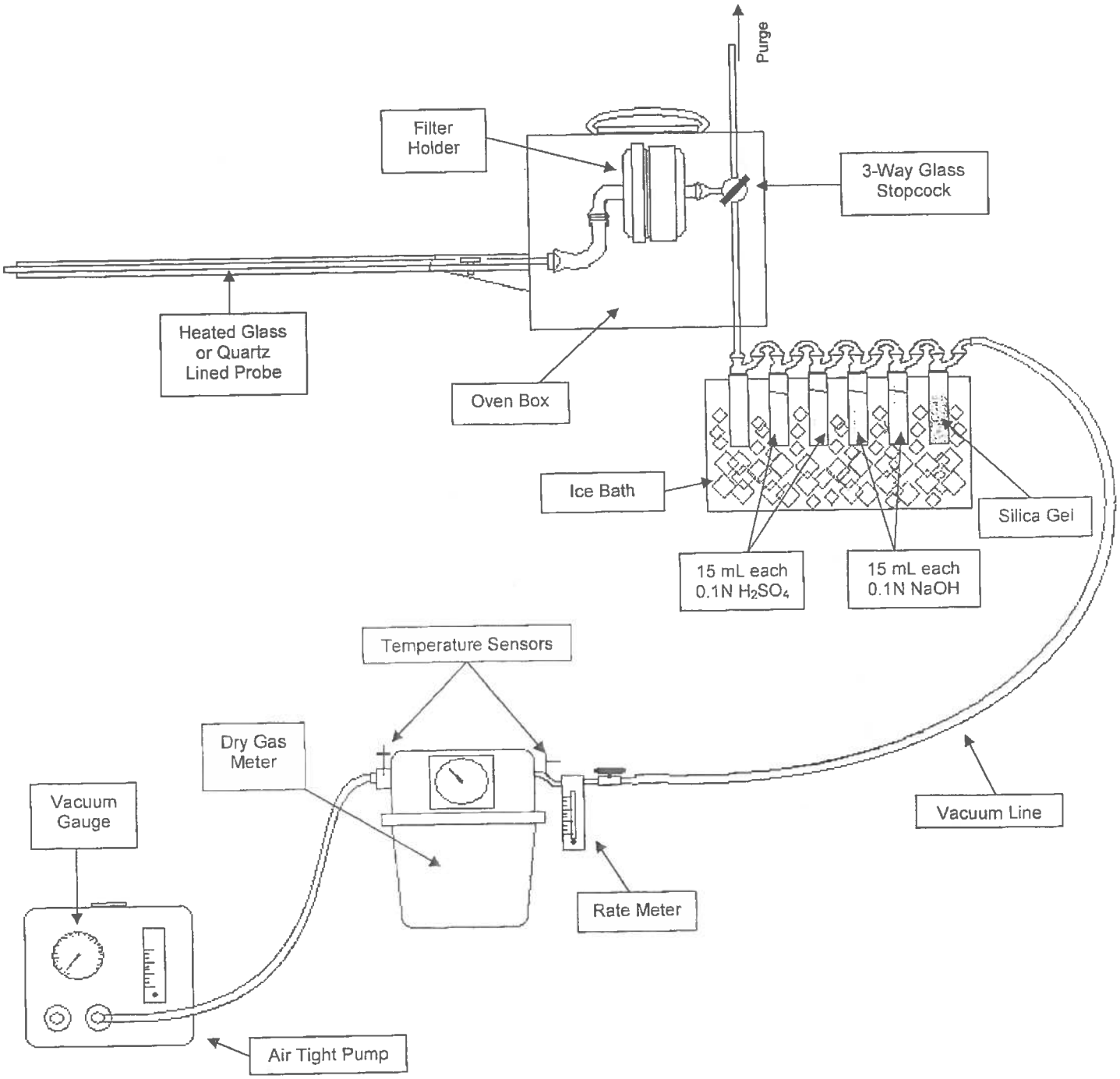
# USEPA Method 26 – Halogen Sample Train Diagram





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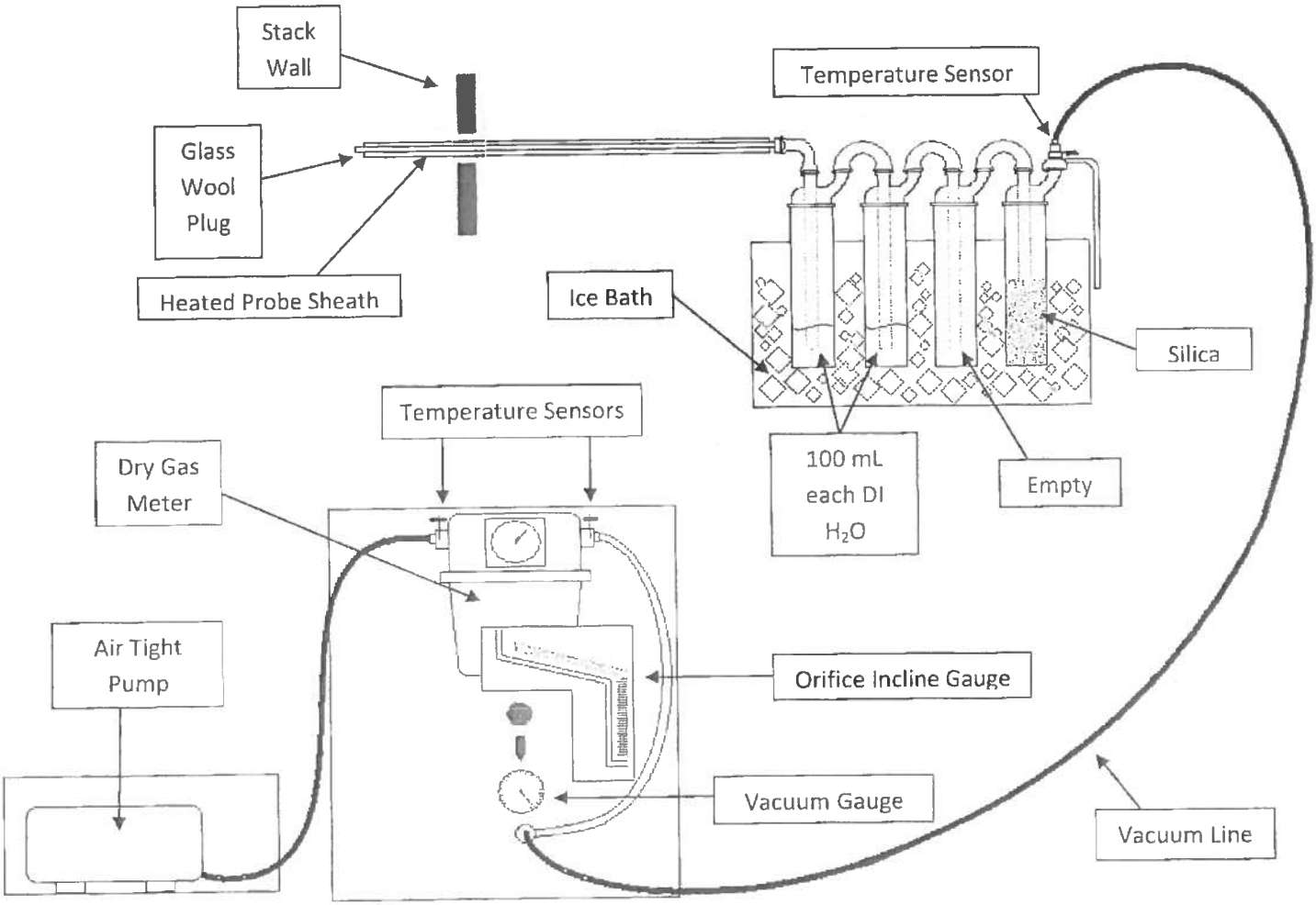
## USEPA Method 4- Moisture Content Sample Train Diagram





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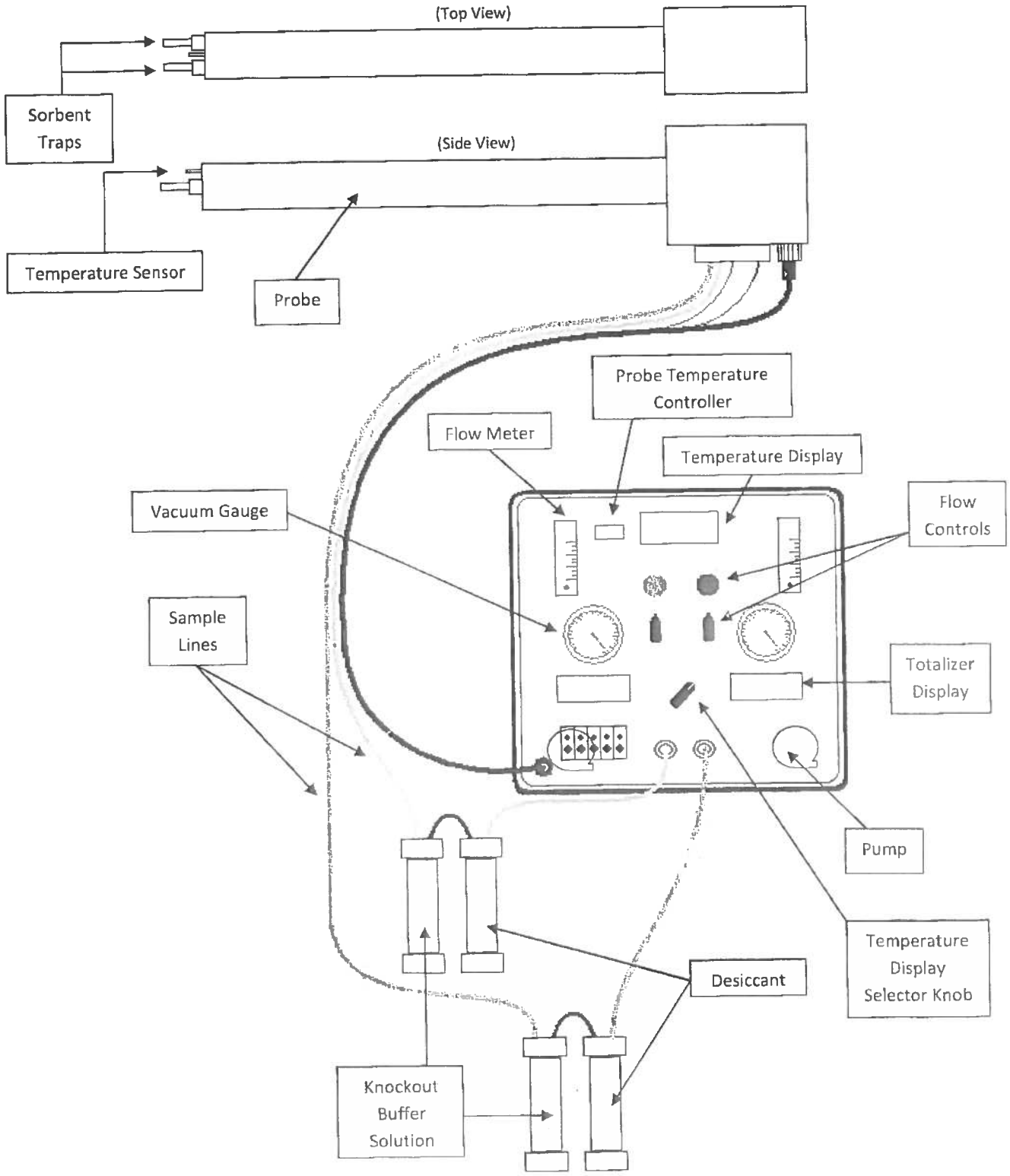
# USEPA Method 30B- Mercury Sorbent Trap Sampling Train





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# Appendix D - Calculation Nomenclature and Formulas


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| | |
|---|---|
| Client: | University of Iowa |
| Facility: | Oakdale Renewable Energy Plant |
| Test Location: | Hurst Boiler Exhaust Duct |
| Run: | 1 |
| Date: | 11/4/2014 |
| Method: | 5 |
| Source Condition: | Normal |

**Dry Molecular Weight**

$$Md = 0.44 \times (\%CO_2) + 0.32 \times (\%O_2) + 0.28 \times \%N_2$$

$\%CO_2 =$ 11.6 $\%O_2 =$ 8.9 $\%N_2 =$ 79.5

Md = 30.212

**Wet Molecular Weight**

$$Ms = Md \times (1-Bws) + (18.0 \times Bws)$$

Md = 30.212 Bws = 0.132

Ms = 28.601

**Meter Volume at Standard Conditions**

$$Vm(std) = 17.647 \times Y \times Vm \times \frac{(Pbar + DH/13.6)}{Tm}$$

Y = 1.001 Vm = 78.991 Pbar = 29.65

DH = 1.09 Tm = 535.5

Vm(std) = 77.462

**Volume of Water Vapor Condensed**

$$Vw(std) = 0.0471 \times (\text{net } H_2O \text{ gain})$$

Net $H_2O$ = 249.9

Vw(std) = 11.770

**Moisture Content**

$$Bws = \frac{Vwc(std)}{Vwc(std) + Vm(std)}$$

Vw(std) = 11.770 Vm(std) = 77.462

Bws = 0.132 0.148791709


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| | |
|---|---|
| Client: | University of Iowa |
| Facility: | Oakdale Renewable Energy Plant |
| Test Location: | Hurst Boiler Exhaust Duct |
| Run: | 1 |
| Date: | 11/4/2014 |
| Method: | 5 |
| Source Condition: | Normal |

Average Duct Velocity

$$Vs = 85.49 \times Cp \times \text{Sqrt DP (avg)} \times (Ts\ (avg) / (Ps \times Ms))^{1/2}$$

Cp = 0.840 Ts (avg) = 818.2 Sqrt DP (avg): 0.160
Ps = 29.64 Ms = 28.601

Vs = 11.274

Volumetric Flow Rate (Actual Basis)

$$Q = Vs \times A \times 60$$

Vs = 11.274 A = 19.250

Q = 13,022

Volumetric Flow Rate (Standard Basis)

$$Qstd = 17.647 \times Q \times \frac{Ps}{Ts\ (avg)}$$

Q = 13,022 Ps = 29.64 Ts (avg) = 818.2

Qstd = 8,325

Volumetric Flow Rate (Standard Dry Basis)

$$Qstd(dry) = Qstd \times (1-Bws)$$

Qstd = 8,325 Bws = 0.132

Qstd(dry) = 7,227

Isokinetic Variation:

$$\%ISO = \frac{0.0945 \times Ts \times Vm(std)}{Vs \times \theta \times An \times Ps \times (1-Bws)}$$

Ts = 818.2 Vm(std) = 77.462 Vs = 11.274
An = 0.0016558 θ = 125 Ps = 29.64
Bws = 0.132

%ISO = 99.7


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| | |
|---|---|
| Client: | University of Iowa |
| Facility: | Oakdale Renewable Energy Plant |
| Test Location: | Hurst Boiler Exhaust Duct |
| Run: | 1 |
| Date: | 11/4/2014 |
| Method: | 5 |
| Source Condition: | Normal |

**PM Concentration:**
This example represents the filterable fraction. For other fractions, use the obtained mn for that particulate fraction.

$$Co = \frac{m_n \times 15.43}{Vm(std)}$$

$m_n$ (g) = 0.0046 Vm(std) = 77.462

Co = 0.0009 gr/dscf

**PM Emission Rate:**

$$\text{Emission Rate lb/hr} = \frac{Co}{7{,}000} \times Qstd(dry) \times 60$$

Co = 0.0009 Qstd(dry) = 7,227

Emission Rate lb/hr = 0.057 lb/hr

$F_d$= 9,240.0 $O_2$%= 8.9

$$\text{Emission Rate lb/mmBtu } (F_d \text{ Factor}) = \frac{Co}{7{,}000} \times F_d \text{ (dscf/mmBtu)} \times \frac{20.9}{20.9 - O_2\%}$$

Emission Rate lb/mmBtu ($F_d$ Factor) = 0.0021


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**Client:** University of Iowa
**Facility:** Oakdale Renewable Energy Plant
**Test Location:** Hurst Boiler Exhaust Duct
**Run:** 1A
**Date:** 11/5/2014

**Mercury Meter Volume at Standard Conditions (Liters)**

Vm(std) = 17.647 x Y x Vm x $\frac{Pbar}{Tm}$

Y = 1.012 Vm = 140.532 Tm = 541.80 Pbar = 29.70

Vm(std) = 137.576

**Hg Concentration:**

ppb Hg = (total ng of Hg on trap/1X10^9) x (0.0022046226/Vm(std)*0.0353)*385X10^7/200.59*1000

Total ng Hg = 85.6 Vm(std) = 137.576

ppb Hg = 0.07

ug/dscm = (total ng of Hg on trap/1000)/Vm(std)/1000

ug/dscm = 0.62

ug/wscm = ug/dscm*(1-Bws)

ug/wscm = 0.56

**Hg Emission Rate:**

lb/TBtu (fd factor) = (total ng of Hg on trap/1000000000*0.0022046226/Vm(std)*0.035314667)*Fd Factor*(20.9/(20.9-%O2)*1000000

lb/TBtu (fd factor) = 0.773313


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# Volumetric Flow Rate Example Calculations

**Client:** University of Iowa
**Plant:** Oakdale Renewable Energy Center
**Location:** Hurst Boiler Exhaust Duct
**Run:** Normal Load, Run 1
**Date:** 11/05/14

## Moisture Content

$$Bws = \frac{e' - AP(t-t')}{P}$$

where: e' = saturated vapor pressure of water, in. Hg, at the wet bulb temperature, t'
A = $3.67 \times 10^{-4}(1+0.00064(t'-32))$
P = absolute pressure, in. Hg, in the duct
t = dry bulb temperature, °F
t' = wet bulb temperature, °F

**Bws = 0.100**

## Dry Molecular Weight

$Md = 0.44 \times (\%CO_2) + 0.32 \times (\%O_2) + 0.28 \times \%N_2$

$\%CO_2$ = 9.3 $\%O_2$ = 11.2 $\%N_2$ = 79.5

**Md = 29.94**

## Wet Molecular Weight

Ms = Md x (1-Bws) + (18.0 x Bws)

Md = 29.94 Bws = 0.100

**Ms = 28.74**

## Average Duct Velocity

$Vs = 85.49 \times Cp \times \text{Sqrt } \Delta P \text{ (avg)} \times (Ts \text{ (avg)}/(Ps \times Ms))^{1/2}$

Cp = 0.840 Ts (avg) = 827.8 Sqrt ΔP avg: 0.140
Ps = 29.69 Ms = 28.74

**Vs = 9.90**

## Volumetric Flow Rate

Q (Actual Basis)= Vs x A x 60

Vs = 9.90 A = 19.250

**Q = 11435 acfm**

$$Qs \text{ (Standard Basis)} = 17.647 \times Q \times \frac{Ps}{460 + Ts \text{ (avg)}}$$

Q = 11435 Ps = 29.69 Ts (avg) = 827.8

**Qs = 7238 scfm**

Qs (Standard Basis)= scfm x 60 min/hr

**Qs = 434278 scfh**


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## Volumetric Flow Nomenclature

$A$ = Cross-sectional area of stack or duct, $ft^2$

$B_{ws}$ = Water vapor in gas stream, proportion by volume

$C_p$ = Pitot tube coefficient, dimensionless

$M_d$ = Dry molecular weight of gas, lb/lb-mole

$M_s$ = Molecular weight of gas, wet basis, lb/lb-mole

$M_w$ = Molecular weight of water, 18.0 lb/lb-mole

$P_{bar}$ = Barometric pressure at testing site, in. Hg

$P_g$ = Static pressure of gas, in. Hg (in. $H_2O$/13.6)

$P_s$ = Absolute pressure of gas, in. Hg = $P_{bar} + P_g$

$P_{std}$ = Standard absolute pressure, 29.92 in. Hg

$Q_{acfm}$ = Actual volumetric gas flow rate, acfm

$Q_{sd}$ = Dry volumetric gas flow rate corrected to standard conditions, dscf/hr

$R$ = Ideal gas constant, 21.85 in. Hg-$ft^3$/°R-lb-mole

$T_s$ = Absolute gas temperature, °R

$T_{std}$ = Standard absolute temperature, 528°R

$v_s$ = Gas velocity, ft/sec

$V_{w(std)}$ = Volume of water vapor in gas sample, corrected to standard conditions, scf

$Y$ = Dry gas meter calibration factor

$\Delta p$ = Velocity head of gas, in. $H_2O$

$K_1$ = 17.647 °R/in. Hg

%EA = Percent excess air

$\%CO_2$ = Percent carbon dioxide by volume, dry basis

$\%O_2$ = Percent oxygen by volume, dry basis

$\%N_2$ = Percent nitrogen by volume, dry basis

0.264 = Ratio of $O_2$ to $N_2$ in air, v/v

0.28 = Molecular weight of $N_2$ or CO, divided by 100

0.32 = Molecular weight of $O_2$ divided by 100

0.44 = Molecular weight of $CO_2$ divided by 100

13.6 = Specific gravity of mercury (Hg)


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### Volumetric Air Flow Calculations

$$Vm\,(std) = 17.647 \times Vm \times \left[ \frac{(P_{bar} + (\frac{DH}{13.6}))}{(460 + Tm)} \right] \times Y$$

$$Vw\,(std) = 0.0471 \times Vlc$$

$$Bws = \left[ \frac{Vw\,(std)}{Vw\,(std) + Vm\,(std)} \right]$$

$$Md = (0.44 \times \%CO_2) + (0.32 \times \%O_2) + [0.28 \times (100 - \%CO_2 - \%O_2)]$$

$$Ms = Md \times (1 - Bws) + (18 \times Bws)$$

$$Vs = \sqrt{\frac{(Ts + 460)}{Ms \times Ps}} \times \sqrt{DP} \times Cp \times 85.49$$

$$Acfm = Vs \times Area\,(of\ stack\ or\ duct) \times 60$$

$$Scfm = Acfm \times 17.647 \times \left[ \frac{Ps}{(460 + Ts)} \right]$$

$$Scfh = Scfm \times 60 \frac{min}{hr}$$

acfm = actual cubic feet per minute
scfm = standard cubic feet per minute
scfh = standard cubic feet per hour

Cp = pitot tube correction factor
Ps = absolute flue gas pressure
Ms = molecular weight of gas (lb/lb mole)
Md = dry molecular weight of gas (lb/lb mole)
Bws = water vapor in gas stream proportion by volume


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### Particulate Nomenclature

$A$ = Cross-sectional area of stack or duct, square feet
$A_n$ = Cross-sectional area of nozzle, square feet
$B_{ws}$ = Water vapor in gas stream, by volume
$C_a$ = Acetone blank residue concentration, g/g
$C_{acf}$ = Concentration of particulate matter in gas stream at actual conditions, gr/acf
$C_p$ = Pitot tube coefficient
$C_s$ = Concentration of particulate matter in gas stream, dry basis, corrected to standard conditions, gr/dscf
IKV = Isokinetic sampling variance, must be 90.0 % ≤ IKV ≤ 110.0%
$M_d$ = Dry molecular weight of gas, lb/lb-mole
$M_s$ = Molecular weight of gas, wet basis, lb/lb-mole
$M_w$ = Molecular weight of water, 18.0 lb/lb-mole
$m_a$ = Mass of residue of acetone after evaporation, grams
$P_{bar}$ = Barometric pressure at testing site, inches mercury
$P_g$ = Static pressure of gas, inches mercury (inches water/13.6)
$P_s$ = Absolute pressure of gas, inches mercury = $P_{bar} + P_g$
$P_{std}$ = Standard absolute pressure, 29.92 inches mercury
$Q_{acfm}$ = Actual volumetric gas flow rate, acfm
$Q_{sd}$ = Dry volumetric gas flow rate corrected to standard conditions, dscfh
$R$ = Ideal gas constant, 21.85 inches mercury cubic foot/°R-lb-mole
$T_m$ = Dry gas meter temperature, °R
$T_s$ = Gas temperature, °R
$T_{std}$ = Absolute temperature, 528°R
$V_a$ = Volume of acetone blank, ml
$V_{aw}$ = Volume of acetone used in wash, ml
$W_a$ = Weight of residue in acetone wash, grams
$m_n$ = Total amount of particulate matter collected, grams
$V_{1c}$ = Total volume of liquid collected in impingers and silica gel, ml
$V_m$ = Volume of gas sample as measured by dry gas meter, dcf
$V_{m(std)}$ = Volume of gas sample measured by dry gas meter, corrected to standard conditions, dscf
$v_s$ = Gas velocity, ft/sec
$V_{w(std)}$ = Volume of water vapor in gas sample, corrected to standard conditions, scf
$Y$ = Dry gas meter calibration factor
$\Delta H$ = Average pressure differential across the orifice meter, inches water
$\Delta p$ = Velocity head of gas, inches water
$\rho_a$ = Density of acetone, 0.7855 g/ml (average)
$\rho_w$ = Density of water, 0.002201 lb/ml
$\theta$ = Total sampling time, minutes
$K_1$ = 17.647 °R/in. Hg
$K_2$ = 0.04707 $ft^3$/ml
$K_4$ = 0.09450/100 = 0.000945
$K_p$ = Pitot tube constant, $85.49 \frac{\text{ft}}{\text{sec}}\left[\frac{(\text{lb/lb-mole})(\text{in.Hg})}{(^\circ\text{R})(\text{in.H}_2\text{O})}\right]^{1/2}$
%EA = Percent excess air
$\%CO_2$ = Percent carbon dioxide by volume, dry basis
$\%O_2$ = Percent oxygen by volume, dry basis
%CO = Percent carbon monoxide by volume, dry basis
$\%N_2$ = Percent nitrogen by volume, dry basis
0.264 = Ratio of $O_2$ to $N_2$ in air, v/v
28 = Molecular weight of $N_2$ or CO
32 = Molecular weight of $O_2$
44 = Molecular weight of $CO_2$
13.6 = Specific gravity of mercury (Hg)


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### Particulates Calculation Formulas

1. $V_{w(std)} = V_{lc}\left(\frac{\rho_w}{M_w}\right)\left(\frac{RT_{std}}{P_{std}}\right) = K_2 V_{lc}$

2. $V_{m(std)} = V_m Y \left(\frac{T_{std}}{T_m}\right)\left(\frac{(P_{bar} + (\frac{\Delta H}{13.6}))}{P_{std}}\right) = K_1 V_m Y \frac{(P_{bar} + (\frac{\Delta H}{13.6}))}{T_m}$

3. $B_{ws} = \frac{V_{w(std)}}{(V_{m(std)} + V_{w(std)})}$

4. $M_d = 0.44(\%CO_2) + 0.32(\%O_2) + 0.28(\%N_2)$

5. $M_s = M_d(1 - B_{ws}) + 18.0(B_{ws})$

6. $C_a = \frac{m_a}{V_a \rho_a}$

7. $W_a = C_a V_{aw} \rho_a$

8. $C_{acf} = 15.43 K_i \left(\frac{m_n P_s}{V_{w(std)} + V_{m(std)}\ T_s}\right)$

9. $C_S = (15.43 \text{ grains/gram})\ (m_n / V_{m(std)})$

10. $v_s = K_p C_p \sqrt{\frac{\Delta P\ T_s}{P_s M_s}}$

11. $Q_{acfm} = v_s A(60_{sec/min})$

12. $Q_{sd} = (3600_{sec/hr})(1 - B_{ws})\ v_s \left(\frac{T_{std} P_s}{T_s P_{std}}\right) A$

13. E (emission rate, lbs/hr) $= Q_{std}(C_s/7000 \text{ grains/lb})$

14. $IKV = \frac{T_s V_{m(std)} P_{std}}{T_{std} v_s \theta A_n P_s 60(1 - B_{ws})} = K_4 \frac{T_s V_{m(std)}}{P_s v_s A_n \theta (1 - B_{ws})}$

15. $\%EA = \left(\frac{\%O_2 - (0.5\%CO)}{0.264\%N_2 - (\%O_2 - 0.5\%CO)}\right) \times 100$


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**Method 30B Determination of Vapor Phase Mercury Nomenclature**

B = Breakthrough (%).

Bws = Moisture content of sample gas as measured by Method 4, percent/100.

Ca = Concentration of Hg for the sample collection period, for sorbent trap "a" (µg/dscm).

Cb = Concentration of Hg for the sample collection period, for sorbent trap "b"(µg/dscm).

Cd = Hg concentration, dry basis (µg/dscm).

Crec = Concentration of spiked compound measured (µg/m3).

Cw = Hg concentration, wet basis (µg/m3).

m1 = Mass of Hg measured on sorbent trap section 1 (µg).

m2 = Mass of Hg measured on sorbent trap section 2 (µg).

mrecovered= Mass of spiked Hg recovered in Analytical Bias or Field Recovery Test (µg).

ms = Total mass of Hg measured on spiked trap in Field Recovery Test (µg).

mspiked = Mass of Hg spiked in Analytical Bias or Field Recovery Test (µg).

mu = Total mass of Hg measured on unspiked trap in Field Recovery Test (µg).

R = Percentage of spiked mass recovered (%).

RD = Relative deviation between the Hg concentrations from traps "a" and "b" (%).

vs = Volume of gas sampled, spiked trap in Field Recovery Test (dscm).

Vt = Total volume of dry gas metered during the collection period (dscm); for the purposes of this method, standard temperature and pressure are defined as 20° C and 760 mm Hg, respectively.

vu = Volume of gas sampled, unspiked trap in Field Recovery Test (dscm).


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## MOISTURE CALCULATIONS

$$V_{wc(std)} = \frac{(V_f - V_i)\,\rho_w\,R\,T_{std}}{P_{std}M_w} = 0.04707(V_f - V_i)$$

$$V_{wsg(std)} = \frac{(W_f - W_i)\,R\,T_{std}}{P_{std}\,M_w} = 0.04715\,(W_f - W_i)$$

$$V_{m(std)} = 17.64\;V_m\,Y\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m}$$

$$B_{ws} = \frac{V_{wc(std)} + V_{wsg(std)}}{V_{wc(std)} + V_{wsg(std)} + V_{m(std)}}$$

Where:

$B_{ws}$ = Water vapor in gas stream, proportion by volume
$M_w$ = Molecular weight of water, 18.015 lb/lb-mole
$P_{bar}$ = Barometric pressure at the testing site, in. Hg
$P_{std}$ = Standard absolute pressure, 29.92 in. Hg
R = Ideal gas constant, 0.048137 (in. Hg)($ft^3$)/(g-mole)(°R) = [21.8348(in. Hg)($ft^3$)/(lb-mole)(°R)]/453.592 g-mole/lb-mole
$T_m$ = Absolute average dry gas meter temperature, °R
$T_{std}$ = Standard absolute temperature, 528 °R
$V_f$ = Final volume of condenser water, ml
$V_i$ = Initial volume of condenser water, ml
$V_m$ = Dry gas volume measured by dry gas meter, dcf
$V_{m(std)}$ = Dry gas volume measured by dry gas meter, corrected to standard conditions, scf
$V_{wc(std)}$ = Volume of condensed water vapor, corrected to standard conditions, scf
$V_{wsg(std)}$ = Volume of water vapor collected in silica gel, corrected to standard conditions, scf
$W_f$ = Final weight of silica gel, g
$W_i$ = Initial weight of silica gel, g
Y = Dry gas meter calibration factor
$\Delta H$ = Average pressure exerted on dry gas meter outlet by gas sample bag, in. $H_2O$
$\rho_w$ = Density of water, 0.9982 g/ml
13.6 = Specific gravity of mercury (Hg)
17.64 = $T_{std}/P_{std}$
0.04707 = $ft^3$/ml 0.04715 = $ft^3$/g


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## Coal Emission Rate Calculations

A pollutant emission rate (E), expressed as pounds of pollutant per million Btu heat input from the fuel combusted can be calculated by several methods as follows:

A. $C = C_s/7000$ where, C = pollutant concentration, lb/dscf
$c_s$ = pollutant concentration, grains/dscf

B. If fuel flow is monitored and the fuel combusted during the test is sampled and analyzed for gross calorific value, then:

$$E = \frac{Q_{sd}C}{\text{fuel flow rate (lb/hr) GCV}} \times 10^6$$

where, E = lbs per million Btu
GCV = gross calorific value, Btu/lb
$Q_{sd}$ = dry volumetric gas flow at standard conditions, dscf/hr

C. If an integrated gas sample is taken during the test and analyzed for $\%CO_2$ or $\%O_2$, dry basis by volume, with an approved USEPA Method 3 or 3A gas analyzer, then

$$E = C F_c \frac{100}{(\%CO_2)} \text{ or, } E = C F \frac{20.9}{(20.9 - \%O_2)} \quad \text{where,}$$

$\%CO_2$ and $\%O_2$ are expressed as percent values:

$F_c$ = a factor representing a ratio of the volume of carbon dioxide generated to the calorific value of the fuel combusted, 1840 scf $CO_2$/million Btu for sub-bituminous or 1800 scf/million Btu for bituminous.
F = a factor representing a ratio of the volume of dry flue gases generated to the calorific value of the fuel combusted, 9820 dscf/million Btu for sub-bituminous or 9780 dscf/million Btu for bituminous.

D. If fuel sample increments are taken and composited during the test and an ultimate analysis is performed and the GCV is determined, then

$$F_c = \frac{321 \times 10^3 (\%C)}{GCV} \text{ where, } \%C = \text{carbon content by weight expressed as percent}$$

$$F = \frac{[3.64(\%H) + 1.53(\%C) + 0.57(\%S) + 0.14(\%N) - 0.46(\%O_2)]}{GCV} \times 10^6$$

1. H = Hydrogen, percent
2. C = Carbon, percent
3. S = Sulfur, percent
4. N = Nitrogen, percent
5. O = Oxygen, percent


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### Pollutant Concentration Correction to 3% Percent Oxygen

$$C_{adj} = C_d \frac{20.9 - 3\%}{20.9 - \%O_2}$$

where:

| | | |
|---|---|---|
| $C_{adj}$ | = | Pollutant concentration corrected to percent $O_2$ |
| 20.9- 3% | = | Percent $O_2$, the defined $O_2$ correction value, percent |
| 20.9 | = | Percent $O_2$ in air |
| $\%O_2$ | = | Measured $O_2$ concentration dry basis, percent |
| $C_d$ | = | Pollutant concentration measured, dry basis, ppm. |


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## ppm Conversion Calculations and Factors

**ppm to lbs/scf**

(ppm X) x (conversion factor X) = X lbs/scf

**lbs/scf to lbs/hr**

Dry ppm's with dry flow, and wet ppm's with wet flow.

(X lbs/scf) x (airflow scf/min) x (60 min/hr) = X lbs/hr

**lbs/scf to lbs/mmBtu**

Dry ppm's with dry diluent, and wet ppm's with wet diluent.

**$CO_2$** – (X lbs/scf) x ($F_c$) x ($100/CO_2$) = X lbs/mmBtu

**$O_2$** – (X lbs/scf) x ($F_d$) x ($20.9/(20.9-O_2)$) = X lbs/mmBtu

**Conversion Factors**

$NO_x$ – $1.19396 \times 10^{-7}$

$SO_2$ – $1.6625 \times 10^{-7}$

CO – $7.2664 \times 10^{-8}$

$CH_4$ – $4.1637 \times 10^{-8}$

$C_3H_8$ – $1.1419 \times 10^{-7}$


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## ppmv to lb/hr Conversion Calculations

1. $$ppm\ SO_2 \times 1.660 \times 10^{-7} = \frac{lbs/SO_2}{scf}$$

$$\frac{lbs\ SO_2}{scf} \times \frac{scf}{min} \times \frac{60\ min}{hr} = \frac{lbs\ SO_2}{hr}$$

2. $$ppm\ NO_x \times 1.194 \times 10^{-7} = \frac{lbs/NO_{x2}}{scf}$$

$$\frac{lbs\ NO_x}{scf} \times \frac{scf}{min} \times \frac{60\ min}{hr} = \frac{lbs\ NO_x}{hr}$$

3. $$ppm\ CO \times 7.266 \times 10^{-8} = \frac{lbs/CO}{scf}$$

$$\frac{lbs\ CO}{scf} \times \frac{scf}{min} \times \frac{60\ min}{hr} = \frac{lbs\ CO}{hr}$$

4. $$ppm\ C_3H_8 \times 1.142 \times 10^{-7} = \frac{lbsC_3H_8}{scf}$$

$$\frac{lbs\ C_3H_8}{scf} \times \frac{scf}{min} \times \frac{60\ min}{hr} = \frac{lbs\ C_3H_8}{hr}$$

5. $$ppm\ CH_4 \times 4.164 \times 10^{-8} = \frac{lbs/CH_4}{scf}$$

$$\frac{lbs\ CH_4}{scf} \times \frac{scf}{min} \times \frac{60\ min}{hr} = \frac{lbs\ CH_4}{hr}$$

6. $$ppm\ NMHC\ as\ C_3H_8 \times 9.3427 \times 10^{-8} = \frac{lbs\ C}{scf}$$

$$\frac{lbs\ C}{scf} \times \frac{lbsscf}{min} \times \frac{60\ min}{hr} = \frac{lbs\ C}{hr}$$


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## Calculations for Hydrogen Chloride by Method 26 or 26A

### Concentration

$$\frac{\text{lb HCl}}{\text{dscf}} = \frac{\mu\text{g HCl in sample}}{4.536 \times 10^8 \times \text{dscf}}$$

where:

$4.536 \times 10^8 = \mu g/lb$

dscf = Volume of gas sampled

$$\mu g/\text{lb HCl} = \mu g\ \text{Cl} \times \frac{36.453}{35.453}$$

### Parts Per Million

$$\text{ppm HCl} = \frac{\text{lb HCl}}{\text{dscf}} \div \frac{36.453}{385 \times 10^6}$$

where:

385 = Volume of 1 lb mole of gas at 68°F and 29.92 in. Hg

$10^6$ = Conversion of ppm v/v

### Emission Rate

lb HCl/dscf × dscfm × 60 min/hr = lb/hr HCl


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# Appendix E - Laboratory Data


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| | |
|---|---|
| **Client:** | **University of Iowa** |
| **Facility:** | **Oakdale Renewable Energy Plant** |
| **Project Number:** | **M144705** |
| **Test Location:** | **Hurst Boiler Exhaust Duct** |
| **Test Method:** | **5** |
| **Filterable Analysis Date:** | **11/10/2014** |

**Filter Drying Temp °F:** **Ambient-Des. 24 hrs**
**Analyst:** **JMG**

| Description | Sample Date | ID# | vol. (ml) | Initial Weight (grams) | Final Weight (grams) | Net Weight Gain (grams) |
|---|---|---|---|---|---|---|
| **Filterable Particulate** | | | | | | |
| Test No. 1 | 11/4/2014 | | | | | |
| Source Condition: Normal | | | | | | |
| M5 Filter | | 7670 | | 0.4489 | 0.4498 | 0.0009 |
| Acetone Wash (M5 Pans) | | 3675 | 40 ml | 5.2267 | 5.2305 | 0.0038 |
| Acetone Blank | | | | | | 0.0001 |
| Total Front Half Weight | | | | | | **0.0046** |
| **Filterable Particulate** | | | | | | |
| Test No. 2 | 11/4/2014 | | | | | |
| Source Condition: Normal | | | | | | |
| M5 Filter | | 7695 | | 0.4479 | 0.4491 | 0.0012 |
| Acetone Wash (M5 Pans) | | 3676 | 45 ml | 5.2241 | 5.2277 | 0.0036 |
| Acetone Blank | | | | | | 0.0001 |
| Total Front Half Weight | | | | | | **0.0047** |
| **Filterable Particulate** | | | | | | |
| Test No. 3 | 11/4/2014 | | | | | |
| Source Condition: Normal | | | | | | |
| M5 Filter | | 7669 | | 0.4520 | 0.4528 | 0.0008 |
| Acetone Wash (M5 Pans) | | 3677 | 40 ml | 5.2432 | 5.2448 | 0.0016 |
| Acetone Blank | | | | | | 0.0001 |
| Total Front Half Weight | | | | | | **0.0023** |
| **Reagent Blank Summary** | | | | | | |
| Acetone Wash (M5 Pans) | | 3678 | 100 ml | 5.2447 | 5.2449 | 0.0002 |


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## Chain-of-Custody Form

Project Number: M144705

Date Results Required:

Client: UNIVERSITY OF IOWA

TAT Required:

Plant/Test Location: OAKDALE/

Project Supervisor: DAN TUIDER

| Sample Number | Sample Date | Sample Point Identification | # of Conts | Sub Lab | Analysis Required | Volume, mls |
|---|---|---|---|---|---|---|
| 001 | 11/4/14 | HURST BOILER EXHAUST DUCT TEST 1 | 2 | | M5 | |
| 002 | 11/4/14 | HURST BOILER EXHAUST DUCT TEST 2 | 2 | | M5 | |
| 003 | 11/4/14 | HURST BOILER EXHAUST DUCT TEST 3 | 2 | | M5 | |
| 004 | 11/4/14 | HURST BOILER EXHAUST DUCT TEST 1 | 2 | | M26 | |
| 005 | 11/4/14 | HURST BOILER EXHAUST DUCT TEST 2 | 2 | | M26 | |
| 006 | 11/4/14 | HURST BOILER EXHAUST DUCT TEST 3 | 2 | | M26 | |
| 007 | 11/5/14 | HURST BOILER EXHAUST DUCT TEST 1 | 2 | | 30B | |
| 008 | 11/5/14 | HURST BOILER EXHAUST DUCT TEST 2 | 2 | | 30B | |
| 009 | 11/5/14 | HURST BOILER EXHAUST DUCT TEST 3 | 2 | | 30B | |
| 010 | 11/4/14 | H2SO4 REAGENT BLANK | 1 | | MRG | |
| 011 | 11/4/14 | NaOH REAGENT BLANK | 1 | | MRG | |
| 012 | 11/4/14 | ACETONE REAGENT BLANK | 1 | | M5 | |
| 013 | | | | | | |
| 014 | | | | | | |
| 015 | | | | | | |
| 016 | | | | | | |
| 017 | | | | | | |
| 018 | | | | | | |
| 019 | | | | | | |
| 020 | | | | | | |

| Delivered to Lab by: | Date/Time: | Received by: | Date/Time: | Processed by: | Date/Time: |
|---|---|---|---|---|---|
| DAN TUIDER | 11/6/14 1400 | [signature] | 11/6/14 | [signature] | 11/10/14 |

Laboratory Notes:

UNIT WENT DOWN DURING TEST 3 OF THE 30B ON 11/5/14.


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Maxxam

Your Project #: M144705
Site#: HURST BOILER
Site Location: UNIVERISTY OF IOWA
Your C.O.C. #: 004, 005, 001, 002, 003

**Attention:Data Reporting**

Mostardi Platt
888 Industrial Rd
Elmhurst, IL
USA 60126-1121

**Report Date: 2014/11/28**
Report #: R3237848
Version: 1 - Final

# CERTIFICATE OF ANALYSIS

**MAXXAM JOB #: B4L6336**
**Received: 2014/11/13, 15:30**

Sample Matrix: Stack Sampling Train
# Samples Received: 6

| Analyses | Quantity | Date Extracted | Date Analyzed | Laboratory Method | Reference |
|---|---|---|---|---|---|
| Anions in Water by Ion Chromatography (1) | 1 | N/A | 2014/11/27 | BRL SOP-00105 | EPA 300.0 m |
| Hydrogen Halides -Midget H2SO4 Imp | 5 | 2014/11/27 | 2014/11/27 | BRL SOP-00108 | EPA 26 m |
| Volume of Sulfuric Acid Impinger | 5 | N/A | 2014/11/27 | | |

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

(1) SCC/CAEAL

Encryption Key Clayton Johnson
28 Nov 2014 17:52:51 -05:00

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Clayton Johnson, Project Manager - Air Toxics, Source Evaluation
Email: CJohnson@maxxam.ca
Phone# (905)817-5769

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Maxxam Job #: B4L6336
Report Date: 2014/11/28

Mostardi Platt
Client Project #: M144705
Site Location: UNIVERISTY OF IOWA

## EPA M26 HYDROGEN HALIDES AND HALOGENS(M)

| Maxxam ID | | YM2026 | YM2027 | YM2028 | YM2028 | | | |
|---|---|---|---|---|---|---|---|---|
| Sampling Date | | 2014/11/04 | 2014/11/04 | 2014/11/04 | 2014/11/04 | | | |
| COC Number | | 004 | 005 | 001 | 001 | | | |
| | Units | H2SO4 REAGENT BLANK | DI REAGENT BLANK | TEST 1 H2SO4 IMPS | TEST 1 H2SO4 IMPS Lab-Dup | RDL | QC Batch | MDL |
| Sulfuric Acid Volume | ml | 100 | 125 | 37 | N/A | 1 | 3839753 | 1 |
| Hydrochloric Acid | ug | <30 | <30 | 53 | 53 | 30 | 3839781 | 6.0 |

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

| Maxxam ID | | YM2029 | YM2030 | | | |
|---|---|---|---|---|---|---|
| Sampling Date | | 2014/11/04 | 2014/11/04 | | | |
| COC Number | | 002 | 003 | | | |
| | Units | TEST 2 H2SO4 IMPS | TEST 3 H2SO4 IMPS | RDL | QC Batch | MDL |
| Sulfuric Acid Volume | ml | 44 | 49 | 1 | 3839753 | 1 |
| Hydrochloric Acid | ug | <30 | <30 | 30 | 3839781 | 6.0 |

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch



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Maxxam Job #: B4L6336
Report Date: 2014/11/28

Mostardi Platt
Client Project #: M144705
Site Location: UNIVERISTY OF IOWA

## RESULTS OF ANALYSES OF STACK SAMPLING TRAIN

| Maxxam ID | | YM2031 | | | |
|---|---|---|---|---|---|
| Sampling Date | | 2014/11/04 | | | |
| | Units | AUDIT-102814K-1440 | RDL | QC Batch | MDL |
| Chloride (Cl) | mg/L | 22 | 0.3 | 3839819 | 0.01 |

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch



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Maxxam Job #: B4L6336
Report Date: 2014/11/28

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Client Project #: M144705
Site Location: UNIVERISTY OF IOWA

## TEST SUMMARY

**Maxxam ID:** YM2026
**Sample ID:** H2SO4 REAGENT BLANK
**Matrix:** Stack Sampling Train

**Collected:** 2014/11/04
**Shipped:**
**Received:** 2014/11/13

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Hydrogen Halides -Midget H2SO4 Imp | IC/SPEC | 3839781 | 2014/11/27 | 2014/11/27 | Ann-Marie Stern |
| Volume of Sulfuric Acid Impinger | | 3839753 | N/A | 2014/11/27 | Frank Mo |

**Maxxam ID:** YM2027
**Sample ID:** DI REAGENT BLANK
**Matrix:** Stack Sampling Train

**Collected:** 2014/11/04
**Shipped:**
**Received:** 2014/11/13

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Hydrogen Halides -Midget H2SO4 Imp | IC/SPEC | 3839781 | 2014/11/27 | 2014/11/27 | Ann-Marie Stern |
| Volume of Sulfuric Acid Impinger | | 3839753 | N/A | 2014/11/27 | Frank Mo |

**Maxxam ID:** YM2028
**Sample ID:** TEST 1 H2SO4 IMPS
**Matrix:** Stack Sampling Train

**Collected:** 2014/11/04
**Shipped:**
**Received:** 2014/11/13

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Hydrogen Halides -Midget H2SO4 Imp | IC/SPEC | 3839781 | 2014/11/27 | 2014/11/27 | Ann-Marie Stern |
| Volume of Sulfuric Acid Impinger | | 3839753 | N/A | 2014/11/27 | Frank Mo |

**Maxxam ID:** YM2028 Dup
**Sample ID:** TEST 1 H2SO4 IMPS
**Matrix:** Stack Sampling Train

**Collected:** 2014/11/04
**Shipped:**
**Received:** 2014/11/13

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Hydrogen Halides -Midget H2SO4 imp | IC/SPEC | 3839781 | 2014/11/27 | 2014/11/27 | Ann-Marie Stern |

**Maxxam ID:** YM2029
**Sample ID:** TEST 2 H2SO4 IMPS
**Matrix:** Stack Sampling Train

**Collected:** 2014/11/04
**Shipped:**
**Received:** 2014/11/13

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Hydrogen Halides -Midget H2SO4 Imp | IC/SPEC | 3839781 | 2014/11/27 | 2014/11/27 | Ann-Marie Stern |
| Volume of Sulfuric Acid Impinger | | 3839753 | N/A | 2014/11/27 | Frank Mo |

**Maxxam ID:** YM2030
**Sample ID:** TEST 3 H2SO4 IMPS
**Matrix:** Stack Sampling Train

**Collected:** 2014/11/04
**Shipped:**
**Received:** 2014/11/13

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Hydrogen Halides -Midget H2SO4 Imp | IC/SPEC | 3839781 | 2014/11/27 | 2014/11/27 | Ann-Marie Stern |
| Volume of Sulfuric Acid Impinger | | 3839753 | N/A | 2014/11/27 | Frank Mo |



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Maxxam Job #: B4L6336
Report Date: 2014/11/28

Mostardi Platt
Client Project #: M144705
Site Location: UNIVERISTY OF IOWA

## TEST SUMMARY

**Maxxam ID:** YM2031
**Sample ID:** AUDIT-102814K-1440
**Matrix:** Stack Sampling Train

**Collected:** 2014/11/04
**Shipped:**
**Received:** 2014/11/13

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Anions in Water by Ion Chromatography | IC/EC | 3839819 | N/A | 2014/11/27 | Ann-Marie Stern |



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Client Project #: M144705
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## GENERAL COMMENTS

**Results relate only to the items tested.**



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Maxxam Job #: B4L6336
Report Date: 2014/11/28

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Client Project #: M144705
Site Location: UNIVERISTY OF IOWA

## QUALITY ASSURANCE REPORT

| QA/QC Batch | Init | QC Type | Parameter | Date Analyzed | Value | % Recovery | Units | QC Limits |
|---|---|---|---|---|---|---|---|---|
| 3839781 | A_S | Matrix Spike(YM2028) | Hydrochloric Acid | 2014/11/27 | | 96 | % | 80 - 120 |
| 3839781 | A_S | Spiked Blank | Hydrochloric Acid | 2014/11/27 | | 101 | % | 90 - 110 |
| 3839781 | A_S | Method Blank | Hydrochloric Acid | 2014/11/27 | <30 | | ug | |
| 3839781 | A_S | RPD - Sample/Sample Dup | Hydrochloric Acid | 2014/11/27 | NC | | % | 20 |

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (one or both samples < 5x RDL).



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Maxxam Job #: B4L6336
Report Date: 2014/11/28

Mostardi Platt
Client Project #: M144705
Site Location: UNIVERISTY OF IOWA

## VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Frank Mo, B.Sc., Inorganic Lab. Manager

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## Chain-of-Custody Form

| | |
|---|---|
| Project Number: M144705 | Date Results Required: |
| Client: University of Iowa | TAT Required: |
| Plant/Test Location: Hurst Boiler | Project Supervisor: DT |

| Sample Number | Sample Date | Sample Point Identification | Test Code | Sub Line | Analysis Required | Volume mL |
|---|---|---|---|---|---|---|
| 001 | 11/4/14 | Test 1-H2SO4 mpa | 1 | MAX | M26-HCl | [illegible] |
| 002 | 11/4/14 | Test 2-H2SO4 mpa | 1 | MAX | M26-HCl | [illegible] |
| 003 | 11/4/14 | Test 3-H2SO4 mpa | 1 | MAX | M26-HCl | [illegible] |
| 004 | 11/4/14 | H2SO4-Reagent Blank | 1 | MAX | M26-HCl | [illegible] |
| 005 | 11/4/14 | DI Reagent Blank | 1 | MAX | M26-HCl | [illegible] |
| 006 | | Audit Sample | | | | |
| 007 | | | | | | |
| 008 | | | | | | |
| 009 | | | | | | |
| 010 | | | | | | |
| 011 | | | | | | |
| 012 | | | | | | |
| 013 | | | | | | |
| 014 | | | | | | |
| 015 | | | | | | |
| 016 | | | | | | |
| 017 | | | | | | |
| 018 | | | | | | |
| 019 | | | | | | |
| 020 | | | | | | |

| Delivered to Lab by: | Date/Time: | Received by: | Date/Time: | Processed by: | Date/Time: |
|---|---|---|---|---|---|
| [illegible] | [illegible] | [illegible] | [illegible] | | |

Laboratory Notes



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ERA
A Waters Company

December 3, 2014

Jenna Ghanma
Mostardi Platt
888 Industrial Drive
Elmhurst, IL 60123

Enclosed is your final report for ERA's Stationary Source Audit Sample (SSAS) Program. Your final report includes an evaluation of all results submitted by your laboratory to ERA.

Data Evaluation Protocols: All analytes in ERA's SSAS Program have been evaluated comparing the reported result to the acceptance limits generated using the criteria contained in the TNI SSAS Table.

For any "Not Acceptable" results, please contact your state regulator for any corrective action requirements.

Thank you for your participation in ERA's SSAS Program. If you have any questions, please contact our Proficiency Testing Department at 1-800-372-0122.

Sincerely,

Kristina Sanchez
Quality Officer

cc: Project File Number 102814K

ERA
A Waters Company

| Recipient Type | Report Recipient | Contact |
|---|---|---|
| Agency | IA-DNR (SSAS)<br><br>7900 Hickman Road<br>Suite 1<br>Windsor Heights, IA 50324 USA | Dennis Thielen<br>dennis.thielen@dnr.iowa.gov<br>Phone: 515-281-4899 |
| Facility | University of Iowa - Oakdale Campus<br><br>2320 Crosspark Rd<br>Coralville, IA 52241 USA | Mark Maxwell<br>mark-maxwell@uiowa.edu<br>Phone: 319-335-6185 |
| Lab | Maxxam Analytics Inc<br><br>6740 Campobello Rd<br>Mississauga, ON L5N 2L8 Canada | Clayton Johnson<br>Project Manager - Source Evaluation<br>cjohnson@maxxam.ca<br>Phone: (905) 817-5769 |
| Tester | Mostardi Platt<br><br>888 Industrial Drive<br>Elmhurst, IL 60123 USA | Jenna Ghanma<br>jghanma@mp-mail.com<br>Phone: 630-993-2685 |


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# 102814K Laboratory Exception Report

A Waters Company

Clayton Johnson
Project Manager - Source Evaluation
Maxxam Analytics Inc
6740 Campobello Rd
Mississauga, ON L5N 2L8
(905) 817-5769

EPA ID: Not Reported
ERA Customer Number: M748564

## Evaluation Checks

There are no values reported with < where the assigned value was greater than 0.

## Not Acceptable Evaluations

There were no Not Acceptable evaluations for this study.



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ERA
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# Final Report Results For Laboratory
# Maxxam Analytics Inc



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ERA
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# SSAP Evaluation Report

Project Number: **102814K**

ERA Customer Number: **M748564**

Laboratory Name: **Maxxam Analytics Inc**

## Inorganic Results



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# 102814K Evaluation Final Complete Report

A Waters Company

Clayton Johnson
Project Manager - Source Evaluation
Maxxam Analytics Inc
6740 Campobello Rd
Mississauga, ON L5N 2L8
(905) 817-5769

EPA ID: **Not Reported**
ERA Customer Number: **M748564**

Project No. M144705
Hurst Boiler Exhaust Duct

| TNI Analyte Code | Analyte | Units | Reported Value | Assigned Value | Acceptance Limits | Performance Evaluation | Method Description | Analysis Date | Analyst Name |
|---|---|---|---|---|---|---|---|---|---|
| *SSAP Hydrogen Halides in Impinger Solution (cat# 1140-1) Study Dates: 10/28/14 - 12/03/14* | | | | | | | | | |
| 1770 | Hydrogen Chloride | mg/L | 22.1 | 22.8 | 20.5 - 25.1 | Acceptable | EPA 26A 2000 | 11/27/2014 | |
| 1775 | Hydrogen Fluoride | mg/L | | 33.0 | 29.7 - 36.3 | Not Reported | | | |



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Ohio Lumex Calibration and Results Summary
University of Iowa
Oakdale Renewable Energy Center
Hurst Boiler Exhaust Duct
November 5, 2014

| No | Description | M, mg | C, ng | Area | Maximum | Time |
|---|---|---|---|---|---|---|
| 19 | University of Iowa | 1 | | | | |
| 20 | Std__25 Ricca | 1 | 25 | 10700 | 1120 | 12:47:02 PM |
| 21 | Std__50 Ricca | 1 | 48 | 20400 | 2760 | 12:49:25 PM |
| 22 | Std__100 Ricca | 1 | 99 | 42100 | 4470 | 12:53:02 PM |
| 23 | Std__10 Ricca | 1 | 10 | 4390 | 482 | 12:58:23 PM |
| 24 | Std__5 Ricca | 1 | 5.2 | 2210 | 257 | 1:00:56 PM |
| 25 | Std__25 HP ICV | 1 | 24 | 10300 | 900 | 1:03:14 PM |
| 26 | Test 1A 210119 Section 1 | 1 | 84 | 35700 | 2590 | 1:07:30 PM |
| 27 | Test 1A 210119 Section 2 | 1 | 1.6 | 666 | 25 | 1:09:40 PM |
| | **Test 1A Total** | | **85.6** | | | |
| 28 | Std__250 Ricca | 1 | 250 | 106000 | 13600 | 1:11:53 PM |
| 29 | Test 1B 211390 Section 1 25ng Spike | 1 | 102 | 43300 | 2740 | 1:17:45 PM |
| 30 | Test 1B 211390 Section 2 25ng Spike | 1 | 1.9 | 811 | 24 | 1:20:17 PM |
| | **Test 1B Total** | | **78.9** | | | |
| 31 | Test 2A 012446 Section 1 | 1 | 55 | 23300 | 2120 | 1:23:29 PM |
| 32 | Test 2A 012446 Section 2 | 1 | 4.2 | 1770 | 14 | 1:29:55 PM |
| | **Test 2A Total** | | **59.2** | | | |
| 33 | Test 2B 201242 Section 1 25ng Spike | 1 | 76 | 32300 | 2340 | 1:33:55 PM |
| 34 | Test 2B 201242 Section 2 25ng Spike | 1 | 2.4 | 1010 | 10 | 1:38:01 PM |
| | **Test 2B Total** | | **53.4** | | | |
| 35 | Test 3A 210456 Section 1 | 1 | 28 | 11900 | 1070 | 1:40:47 PM |
| 36 | Test 3A 210456 Section 2 | 1 | 0.9 | 391 | 14 | 1:45:58 PM |
| | **Test 3A Total** | | **28.9** | | | |
| 37 | Std__25 Ricca | 1 | 24 | 10300 | 890 | 1:47:41 PM |
| 38 | Test 3B 211459 Section 1 25ng Spike | 1 | 49 | 21000 | 1280 | 1:50:06 PM |
| 39 | Test 3B 211459 Section 2 25ng Spike | 1 | 1.6 | 662 | 20 | 1:53:55 PM |
| | **Test 3B Total** | | **25.6** | | | |
| 40 | Void | 1 | 15 | 6540 | 693 | 1:56:54 PM |
| 41 | Std__25 Ricca | 1 | 23 | 9950 | 875 | 1:59:43 PM |
| 42 | | 1 | | | | |


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## Appendix F - Reference Method Test Data (Computerized Sheets)


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| | | | |
|---|---|---|---|
| **Client:** | University of Iowa | | |
| **Facility:** | Oakdale Renewable Energy Plant | | |
| **Test Location:** | Hurst Boiler Exhaust Duct | | |
| **Project #:** | M144705 | | |
| **Test Method:** | 5 | | |
| **Test Engineer:** | SMcG | | |
| **Test Technician:** | JHK | | |
| **lb/mmBtu Emissions by:** | Standard | | |
| **Type of Fuel Firing:** | Wood | | |
| | **R1** | **R2** | **R3** |
| **Standard Fuel Factor Fd, dscf/mmBtu:** | 9240.00 | 9240.00 | 9240.00 |
| **Temp ID:** | CM19 | CM19 | CM19 |
| **Meter ID:** | CM19 | CM19 | CM19 |
| **Pitot ID:** | 170 | 170 | 170 |
| **Nozzle Diameter (Inches):** | 0.551 | 0.551 | 0.551 |
| **Meter Calibration Factor (Y):** | 1.001 | 1.001 | 1.001 |
| **Meter Orifice Setting (Delta H):** | 1.512 | 1.512 | 1.512 |
| **Nozzle Kit ID Number and Material:** | Glass Misc | Glass Misc | Glass Misc |
| **Pitot Tube Coefficient:** | | 0.840 | |
| **Probe Length (Feet):** | | 4.0 | |
| **Probe Liner Material:** | | Glass | |
| **Sample Plane:** | | Horizontal | |
| **Port Length (Inches):** | | 6.00 | |
| **Port Size (Diameter, Inches):** | | 6.00 | |
| **Port Type:** | | Flange | |
| **Duct Shape:** | | Rectangular | |
| **Length (Feet):** | | 3.5 | |
| **Width (Feet):** | | 5.5 | |
| **Duct Area (Square Feet):** | | 19.250 | |
| **Equivalent Diameter Rectangular Duct (Feet):** | | 4.278 | |
| **Upstream Diameters:** | | >.5 | |
| **Downstream Diameters:** | | >2 | |
| **Number of Ports Sampled:** | | 5 | |
| **Number of Points per Port:** | | 5 | |
| **Minutes per Point:** | | 5.0 | |
| **Minutes per Reading:** | | 5.0 | |
| **Total Number of Traverse Points:** | | 25 | |
| **Test Length (Minutes):** | | 125 | |
| **Train Type:** | | Hot Box | |
| **Source Condition:** | | Normal | |
| **Servomex Serial Number:** | | | |
| **Moisture Balance ID:** | | | |
| **# of Runs** | | 3 | |


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## Run 1-Method 5

**Client:** University of Iowa
**Facility:** Oakdale Renewable Energy Plant
**Test Location:** Hurst Boiler Exhaust Duct
**Source Condition:** Normal

**Date:** 11/4/14
**Start Time:** 8:35
**End Time:** 11:05

### DRY GAS METER CONDITIONS

| | | |
|---|---|---|
| ΔH: | 1.09 | in. $H_2O$ |
| Meter Temperature, Tm: | 75.5 | °F |
| Sqrt ΔP: | 0.160 | in. $H_2O$ |
| Stack Temperature, Ts: | 358.2 | °F |
| Meter Volume, Vm: | 78.991 | $ft^3$ |
| Meter Volume, Vmstd: | 77.462 | dscf |
| Meter Volume, Vwstd: | 11.770 | wscf |
| Isokinetic Variance: | 99.7 | %I |
| Standard Fuel Factor Fd: | 9,240.0 | dscf/mmBtu |
| Test Length | 125.00 | in mins. |
| Nozzle Diameter | 0.551 | In inches |
| Barometric Pressure | 29.65 | in Hg |
| Calculated Fo: | 1.03 | |

### STACK CONDITIONS

| | | |
|---|---|---|
| Static Pressure | -0.10 | in. $H_2O$ |
| Flue Pressure (Ps): | 29.64 | in. Hg. abs. |
| Carbon Dioxide: | 11.60 | % |
| Oxygen: | 8.90 | % |
| Nitrogen: | 79.50 | % |
| Gas Weight dry, Md: | 30.212 | lb/lb mole |
| Gas Weight wet, Ms: | 28.601 | lb/lb mole |
| Excess Air: | 73.627 | % |
| Gas Velocity, Vs: | 11.274 | fps |
| Volumetric Flow: | 13,022 | acfm |
| Volumetric Flow: | 7,227 | dscfm |
| Volumetric Flow: | 8,325 | scfm |
| Fo Validity: | Pass | |

### MOISTURE DETERMINATION

| | | | | | |
|---|---|---|---|---|---|
| Initial Impinger Content: | 1973.9 | ml | Silica Initial Wt. | 833.7 | grams |
| Final Impinger Content: | 2194.9 | ml | Silica Final Wt. | 862.6 | grams |
| Impinger Difference: | 221.0 | ml | Silica Difference: | 28.9 | grams |

Total Water Gain: 249.9 Moisture, Bws: 0.132

| Port-Point No. | Clock Time | Velocity Head Δp in. H2O | Orifice ΔH in. H2O | Actual Meter Vol. $ft^3$ | Stack Temp °F | Meter Temp Inlet °F | Meter Temp Outlet °F | Sqrt. Δp | Collected Vol. $ft^3$ | Point Vel ft/sec |
|---|---|---|---|---|---|---|---|---|---|---|
| 1-1 | 8:35:00 | 0.02 | 0.82 | 48.115 | 356 | 72 | 71 | 0.141 | 2.788 | 9.977 |
| -2 | 8:40:00 | 0.01 | 0.41 | 50.903 | 359 | 72 | 71 | 0.100 | 1.964 | 7.055 |
| -3 | 8:45:00 | 0.02 | 0.82 | 52.867 | 356 | 72 | 71 | 0.141 | 2.767 | 9.977 |
| -4 | 8:50:00 | 0.02 | 0.82 | 55.634 | 357 | 74 | 72 | 0.141 | 2.783 | 9.977 |
| -5 | 8:55:00 | 0.01 | 0.41 | 58.417 | 353 | 74 | 72 | 0.100 | 1.986 | 7.055 |
| | 9:00:00 | | | 60.403 | | | | | | |
| 2-1 | 9:03.00 | 0.03 | 1.23 | 60.403 | 361 | 74 | 73 | 0.173 | 3.413 | 12.219 |
| -2 | 9:08:00 | 0.03 | 1.23 | 63.816 | 362 | 77 | 74 | 0.173 | 3.409 | 12.219 |
| -3 | 9:13:00 | 0.03 | 1.24 | 67.225 | 360 | 77 | 74 | 0.173 | 3.404 | 12.219 |
| -4 | 9:18:00 | 0.03 | 1.24 | 70.629 | 359 | 78 | 74 | 0.173 | 3.440 | 12.219 |
| -5 | 9:23.00 | 0.02 | 0.83 | 74.069 | 354 | 78 | 74 | 0.141 | 2.809 | 9.977 |
| | 9:28:00 | | | 76.878 | | | | | | |
| 3-1 | 9:40:00 | 0.04 | 1.64 | 76.878 | 364 | 77 | 75 | 0.200 | 3.947 | 14.110 |
| -2 | 9:45:00 | 0.04 | 1.65 | 80.825 | 363 | 78 | 75 | 0.200 | 3.926 | 14.110 |
| -3 | 9:50:00 | 0.04 | 1.65 | 84.751 | 362 | 78 | 75 | 0.200 | 3.967 | 14.110 |
| -4 | 9:55:00 | 0.03 | 1.24 | 88.718 | 360 | 78 | 75 | 0.173 | 3.427 | 12.219 |
| -5 | 10:00:00 | 0.03 | 1.25 | 92.145 | 352 | 79 | 75 | 0.173 | 3.443 | 12.219 |
| | 10:05:00 | | | 95.588 | | | | | | |
| 4-1 | 10:10:00 | 0.03 | 1.24 | 95.588 | 357 | 77 | 75 | 0.173 | 3.431 | 12.219 |
| -2 | 10:15:00 | 0.04 | 1.65 | 99.019 | 360 | 78 | 75 | 0.200 | 3.962 | 14.110 |
| -3 | 10:20:00 | 0.03 | 1.24 | 102.981 | 361 | 78 | 75 | 0.173 | 3.413 | 12.219 |
| -4 | 10:25:00 | 0.03 | 1.24 | 106.394 | 358 | 79 | 75 | 0.173 | 3.444 | 12.219 |
| -5 | 10:30:00 | 0.02 | 0.83 | 109.838 | 355 | 79 | 76 | 0.141 | 2.803 | 9.977 |
| | 10:35:00 | | | 112.641 | | | | | | |
| 5-1 | 10:40:00 | 0.03 | 1.24 | 112.641 | 360 | 77 | 76 | 0.173 | 3.433 | 12.219 |
| -2 | 10:45:00 | 0.03 | 1.24 | 116.074 | 360 | 78 | 76 | 0.173 | 3.433 | 12.219 |
| -3 | 10:50:00 | 0.02 | 0.83 | 119.507 | 357 | 78 | 76 | 0.141 | 2.805 | 9.977 |
| -4 | 10.55:00 | 0.02 | 0.83 | 122.312 | 356 | 79 | 76 | 0.141 | 2.812 | 9.977 |
| -5 | 11:00:00 | 0.01 | 0.42 | 125.124 | 354 | 79 | 76 | 0.100 | 1.982 | 7.055 |
| | 11:05:00 | | | 127.106 | | | | | | |
| Total | 2:05:00 | | | 78.991 | | 76.8 | 74.3 | | 78.991 | |
| Average | | | 1.09 | | 358.2 | 75.5 | | 0.160 | | |
| Min | | | 0.41 | | 352.0 | 71.0 | | 0.100 | | |
| Max | | | 1.65 | | 364.0 | 79.0 | | 0.200 | | |


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## Run 2-Method 5

**Client:** University of Iowa
**Facility:** Oakdale Renewable Energy Plant
**Test Location:** Hurst Boiler Exhaust Duct
**Source Condition:** Normal

**Date:** 11/4/14
**Start Time:** 11:30
**End Time:** 13:47

### DRY GAS METER CONDITIONS

| | | |
|---|---|---|
| ΔH: | 1.11 | In. $H_2O$ |
| Meter Temperature, Tm: | 74.8 | °F |
| Sqrt ΔP: | 0.161 | In. $H_2O$ |
| Stack Temperature, Ts: | 364.5 | °F |
| Meter Volume, Vm: | 79.876 | $ft^3$ |
| Meter Volume, Vmstd: | 78.437 | dscf |
| Meter Volume, Vwstd: | 13.711 | wscf |
| Isokinetic Variance: | 102.1 | %I |
| Standard Fuel Factor Fd: | 9,240.00 | dscf/mmBtu |
| Test Length | 125.00 | in mins. |
| Nozzle Diameter | 0.551 | in inches |
| Barometric Pressure | 29.65 | in Hg |
| Calculated Fo: | 1.04 | |

### STACK CONDITIONS

| | | |
|---|---|---|
| Static Pressure | -0.10 | In. $H_2O$ |
| Flue Pressure (Ps): | 29.64 | in. Hg. abs. |
| Carbon Dioxide: | 11.40 | % |
| Oxygen: | 9.10 | % |
| Nitrogen: | 79.5 | % |
| Gas Weight dry, Md: | 30.188 | lb/lb mole |
| Gas Weight wet, Ms: | 28.375 | lb/lb mole |
| Excess Air: | 76.548 | % |
| Gas Velocity, Vs: | 11.466 | fps |
| Volumetric Flow: | 13,243 | acfm |
| Volumetric Flow: | 7,152 | dscfm |
| Volumetric Flow: | 8,402 | scfm |
| Fo Validity: | Pass | |

### MOISTURE DETERMINATION

| | | | | | |
|---|---|---|---|---|---|
| Initial Impinger Content: | 2005.3 | ml | Silica Initial Wt. | 848.0 | grams |
| Final Impinger Content: | 2275.3 | ml | Silica Final Wt. | 869.1 | grams |
| Impinger Difference: | 270.0 | ml | Silica Difference: | 21.1 | grams |

Total Water Gain: 291.1 Moisture, Bws: 0.149

| Port-Point No. | Clock Time | Velocity Head Δp in. H2O | Orifice ΔH in. H2O | Actual Meter Vol. $ft^3$ | Stack Temp °F | Meter Temp Inlet °F | Meter Temp Outlet °F | Sqrt. Δp | Collected Vol. $ft^3$ | Point Vel ft/sec |
|---|---|---|---|---|---|---|---|---|---|---|
| 1-1 | 11:30:00 | 0.02 | 0.83 | 27.642 | 364 | 73 | 73 | 0.141 | 2.804 | 10.055 |
| -2 | 11:35:00 | 0.02 | 0.83 | 30.446 | 367 | 73 | 72 | 0.141 | 2.788 | 10.055 |
| -3 | 11:40:00 | 0.02 | 0.82 | 33.234 | 368 | 73 | 72 | 0.141 | 2.780 | 10.055 |
| -4 | 11:45:00 | 0.02 | 0.83 | 36.014 | 368 | 75 | 72 | 0.141 | 2.789 | 10.055 |
| -5 | 11:50:00 | 0.01 | 0.42 | 38.803 | 359 | 75 | 73 | 0.100 | 1.976 | 7.110 |
| | 11:55:00 | | | 40.779 | | | | | | |
| 2-1 | 11:58:00 | 0.03 | 1.24 | 40.779 | 367 | 75 | 73 | 0.173 | 3.431 | 12.315 |
| -2 | 12:03:00 | 0.04 | 1.65 | 44.210 | 368 | 75 | 73 | 0.200 | 3.948 | 14.220 |
| -3 | 12:08:00 | 0.03 | 1.24 | 48.158 | 366 | 77 | 73 | 0.173 | 3.422 | 12.315 |
| -4 | 12:13:00 | 0.03 | 1.25 | 51.580 | 365 | 77 | 73 | 0.173 | 3.434 | 12.315 |
| -5 | 12:18:00 | 0.02 | 0.84 | 55.014 | 361 | 77 | 73 | 0.141 | 2.807 | 10.055 |
| | 12:23:00 | | | 57.821 | | | | | | |
| 3-1 | 12:26:00 | 0.04 | 1.66 | 57.821 | 366 | 76 | 73 | 0.200 | 3.971 | 14.220 |
| -2 | 12:31:00 | 0.04 | 1.66 | 61.792 | 367 | 77 | 73 | 0.200 | 3.949 | 14.220 |
| -3 | 12:36:00 | 0.04 | 1.66 | 65.741 | 366 | 77 | 74 | 0.200 | 3.967 | 14.220 |
| -4 | 12:41:00 | 0.04 | 1.66 | 69.708 | 369 | 78 | 74 | 0.200 | 3.943 | 14.220 |
| -5 | 12:46:00 | 0.03 | 1.25 | 73.651 | 364 | 78 | 74 | 0.173 | 3.447 | 12.315 |
| | 12:51:00 | | | 77.098 | | | | | | |
| 4-1 | 12:54:00 | 0.03 | 1.24 | 77.098 | 368 | 77 | 74 | 0.173 | 3.420 | 12.315 |
| -2 | 12:59:00 | 0.03 | 1.24 | 80.518 | 370 | 77 | 74 | 0.173 | 3.441 | 12.315 |
| -3 | 13:04:00 | 0.03 | 1.24 | 83.959 | 372 | 77 | 74 | 0.173 | 3.423 | 12.315 |
| -4 | 13:09:00 | 0.03 | 1.24 | 87.382 | 369 | 77 | 74 | 0.173 | 3.416 | 12.315 |
| -5 | 13:14:00 | 0.02 | 0.83 | 90.798 | 363 | 77 | 74 | 0.141 | 2.813 | 10.055 |
| | 13:19:00 | | | 93.611 | | | | | | |
| 5-1 | 13:22:00 | 0.02 | 0.87 | 93.611 | 330 | 76 | 74 | 0.141 | 2.873 | 10.055 |
| -2 | 13:27:00 | 0.03 | 1.27 | 96.484 | 353 | 77 | 74 | 0.173 | 3.450 | 12.315 |
| -3 | 13:32:00 | 0.02 | 0.83 | 99.934 | 369 | 77 | 74 | 0.141 | 2.802 | 10.055 |
| -4 | 13:37:00 | 0.02 | 0.83 | 102.736 | 370 | 78 | 74 | 0.141 | 2.794 | 10.055 |
| -5 | 13:42:00 | 0.01 | 0.42 | 105.530 | 364 | 78 | 74 | 0.100 | 1.988 | 7.110 |
| | 13:47:00 | | | 107.518 | | | | | | |
| Total | 2:05.00 | | | 79.876 | | 76.3 | 73.4 | | 79.876 | |
| Average | | | 1.11 | | 364.5 | 74.8 | | 0.161 | | |
| Min | | | 0.42 | | 330.0 | 72.0 | | 0.100 | | |
| Max | | | 1.66 | | 372.0 | 78.0 | | 0.200 | | |


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## Run 3-Method 5

**Client:** University of Iowa
**Facility:** Oakdale Renewable Energy Plant
**Test Location:** Hurst Boiler Exhaust Duct
**Source Condition:** Normal

**Date:** 11/4/14
**Start Time:** 14:15
**End Time:** 16:32

### DRY GAS METER CONDITIONS

| | | |
|---|---|---|
| ΔH: | 1.03 | In. $H_2O$ |
| Meter Temperature, Tm: | 81.4 | °F |
| Sqrt ΔP: | 0.156 | In. $H_2O$ |
| Stack Temperature, Ts: | 373.9 | °F |
| Meter Volume, Vm: | 77.553 | $ft^3$ |
| Meter Volume, Vmstd: | 75.223 | dscf |
| Meter Volume, Vwstd: | 12.985 | wscf |
| Isokinetic Variance: | 102.0 | %I |
| Standard Fuel Factor Fd: | 9,240.00 | dscf/mmBtu |
| Test Length | 125.00 | in mins. |
| Nozzle Diameter | 0.551 | in inches |
| Barometric Pressure | 29.65 | in Hg |
| Calculated Fo: | 1.03 | |

### STACK CONDITIONS

| | | |
|---|---|---|
| Static Pressure | -0.10 | in. $H_2O$ |
| Flue Pressure (Ps): | 29.64 | in. Hg. abs. |
| Carbon Dioxide: | 11.80 | % |
| Oxygen: | 8.80 | % |
| Nitrogen: | 79.4 | % |
| Gas Weight dry, Md: | 30.240 | lb/lb mole |
| Gas Weight wet, Ms: | 28.438 | lb/lb mole |
| Excess Air: | 72.359 | % |
| Gas Velocity, Vs: | 11.107 | fps |
| Volumetric Flow: | 12,828 | acfm |
| Volumetric Flow: | 6,863 | dscfm |
| Volumetric Flow: | 8,047 | scfm |
| Fo Validity: | Pass | |

### MOISTURE DETERMINATION

| | | | | | |
|---|---|---|---|---|---|
| Initial Impinger Content: | 1932.6 | ml | Silica Initial Wt. | 852.7 | grams |
| Final Impinger Content: | 2189.6 | ml | Silica Final Wt. | 871.4 | grams |
| Impinger Difference: | 257.0 | ml | Silica Difference: | 18.7 | grams |

Total Water Gain: 275.7 Moisture, Bws: 0.147

| Port-Point No. | Clock Time | Velocity Head Δp in. H2O | Orifice ΔH in. H2O | Actual Meter Vol. $ft^3$ | Stack Temp °F | Meter Temp Inlet °F | Meter Temp Outlet °F | Sqrt. Δp | Collected Vol. $ft^3$ | Point Vel ft/sec |
|---|---|---|---|---|---|---|---|---|---|---|
| 1-1 | 14:15:00 | 0.02 | 0.82 | 8.548 | 377 | 77 | 77 | 0.141 | 2.799 | 10.101 |
| -2 | 14:20:00 | 0.02 | 0.82 | 11.347 | 378 | 80 | 77 | 0.141 | 2.802 | 10.101 |
| -3 | 14:25:00 | 0.02 | 0.82 | 14.149 | 379 | 82 | 78 | 0.141 | 2.803 | 10.101 |
| -4 | 14:30:00 | 0.02 | 0.83 | 16.952 | 379 | 83 | 78 | 0.141 | 2.804 | 10.101 |
| -5 | 14:35:00 | 0.01 | 0.42 | 19.756 | 372 | 83 | 78 | 0.100 | 1.992 | 7.142 |
| | 14:40:00 | | | 21.748 | | | | | | |
| 2-1 | 14:43:00 | 0.03 | 1.24 | 21.748 | 378 | 81 | 79 | 0.173 | 3.458 | 12.371 |
| -2 | 14:48:00 | 0.03 | 1.25 | 25.206 | 375 | 84 | 80 | 0.173 | 3.447 | 12.371 |
| -3 | 14:53:00 | 0.03 | 1.25 | 28.653 | 375 | 85 | 80 | 0.173 | 3.454 | 12.371 |
| -4 | 14:58:00 | 0.03 | 1.25 | 32.107 | 373 | 85 | 80 | 0.173 | 3.464 | 12.371 |
| -5 | 15:03:00 | 0.02 | 0.84 | 35.571 | 371 | 86 | 81 | 0.141 | 2.822 | 10.101 |
| | 15:08:00 | | | 38.393 | | | | | | |
| 3-1 | 15:11:00 | 0.03 | 1.26 | 38.393 | 371 | 86 | 81 | 0.173 | 3.491 | 12.371 |
| -2 | 15:16:00 | 0.04 | 1.67 | 41.884 | 372 | 85 | 81 | 0.200 | 3.998 | 14.285 |
| -3 | 15:21:00 | 0.04 | 1.67 | 45.882 | 374 | 85 | 81 | 0.200 | 3.996 | 14.285 |
| -4 | 15:26:00 | 0.03 | 1.25 | 49.878 | 375 | 85 | 81 | 0.173 | 3.460 | 12.371 |
| -5 | 15:31:00 | 0.02 | 0.84 | 53.338 | 370 | 84 | 81 | 0.141 | 2.828 | 10.101 |
| | 15:36:00 | | | 56.166 | | | | | | |
| 4-1 | 15:39:00 | 0.03 | 1.25 | 56.166 | 374 | 83 | 81 | 0.173 | 3.477 | 12.371 |
| -2 | 15:44:00 | 0.03 | 1.25 | 59.643 | 375 | 83 | 80 | 0.173 | 3.421 | 12.371 |
| -3 | 15:49:00 | 0.03 | 1.25 | 63.064 | 374 | 83 | 80 | 0.173 | 3.482 | 12.371 |
| -4 | 15:54:00 | 0.02 | 0.83 | 66.546 | 374 | 83 | 80 | 0.141 | 2.811 | 10.101 |
| -5 | 15:59:00 | 0.02 | 0.84 | 69.357 | 369 | 84 | 80 | 0.141 | 2.833 | 10.101 |
| | 16:04:00 | | | 72.190 | | | | | | |
| 5-1 | 16:07:00 | 0.02 | 0.83 | 72.190 | 374 | 82 | 80 | 0.141 | 2.823 | 10.101 |
| -2 | 16:12:00 | 0.03 | 1.25 | 75.013 | 375 | 82 | 80 | 0.173 | 3.459 | 12.371 |
| -3 | 16:17:00 | 0.02 | 0.83 | 78.472 | 373 | 82 | 79 | 0.141 | 2.812 | 10.101 |
| -4 | 16:22:00 | 0.02 | 0.83 | 81.284 | 372 | 82 | 79 | 0.141 | 2.819 | 10.101 |
| -5 | 16:27:00 | 0.01 | 0.42 | 84.103 | 368 | 82 | 79 | 0.100 | 1.998 | 7.142 |
| | 16:32:00 | | | 86.101 | | | | | | |
| Total | 2:05:00 | | | 77.553 | | 83.1 | 79.6 | | 77.553 | |
| Average | | | 1.03 | | 373.9 | 81.4 | | 0.156 | | |
| Min | | | 0.42 | | 368.0 | 77.0 | | 0.100 | | |
| Max | | | 1.67 | | 379.0 | 86.0 | | 0.200 | | |


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Client: University of Iowa
Facility: Oakdale Renewable Energy Center
Project #: M144705
Test Location: Hurst Boiler Exhaust Duct
Operating Condition: Normal
Date: 11/4/14
Run 1

| Time | CO2 % (dry) | O2 % (dry) |
|---|---|---|
| 8:35 | 11.97 | 8.60 |
| 8:36 | 12.74 | 7.78 |
| 8:37 | 12.34 | 8.28 |
| 8:38 | 11.76 | 8.86 |
| 8:39 | 11.32 | 9.24 |
| 8:40 | 10.97 | 9.55 |
| 8:41 | 10.84 | 9.66 |
| 8:42 | 11.04 | 9.46 |
| 8:43 | 11.22 | 9.29 |
| 8:44 | 11.39 | 9.20 |
| 8:45 | 11.28 | 9.24 |
| 8:46 | 11.37 | 9.17 |
| 8:47 | 11.63 | 8.95 |
| 8:48 | 11.66 | 8.87 |
| 8:49 | 11.77 | 8.78 |
| 8:50 | 12.09 | 8.50 |
| 8:51 | 12.33 | 8.26 |
| 8:52 | 12.25 | 8.37 |
| 8:53 | 11.92 | 8.66 |
| 8:54 | 11.90 | 8.69 |
| 8:55 | 11.74 | 8.82 |
| 8:56 | 12.01 | 8.54 |
| 8:57 | 11.93 | 8.64 |
| 8:58 | 12.01 | 8.58 |
| 8:59 | 12.48 | 8.10 |
| 9:00 | 12.32 | 8.25 |
| 9:01 | 12.57 | 8.11 |
| 9:02 | 11.68 | 8.91 |
| 9:03 | 11.04 | 9.49 |
| 9:04 | 11.39 | 9.19 |
| 9:05 | 11.34 | 9.18 |
| 9:06 | 11.52 | 9.06 |
| 9:07 | 11.52 | 9.07 |
| 9:08 | 11.27 | 9.24 |
| 9:09 | 11.41 | 9.17 |
| 9:10 | 11.51 | 9.04 |
| 9:11 | 11.78 | 8.77 |
| 9:12 | 11.93 | 8.64 |
| 9:13 | 11.92 | 8.66 |
| 9:14 | 11.82 | 8.73 |
| 9:15 | 11.65 | 8.93 |
| 9:16 | 11.44 | 9.11 |
| 9:17 | 11.68 | 8.75 |
| 9:18 | 11.70 | 8.91 |
| 9:19 | 11.45 | 9.14 |
| 9:20 | 11.19 | 9.30 |
| 9:21 | 11.39 | 9.17 |
| 9:22 | 11.86 | 8.69 |
| 9:23 | 12.19 | 8.32 |
| 9:24 | 11.54 | 9.05 |
| 9:25 | 11.10 | 9.46 |
| 9:26 | 10.72 | 9.78 |
| 9:27 | 10.76 | 9.74 |
| 9:28 | 10.78 | 9.79 |
| 9:29 | 10.94 | 9.61 |
| 9:30 | 11.23 | 9.32 |
| 9:31 | 11.35 | 9.18 |
| 9:32 | 11.77 | 8.82 |
| 9:33 | 11.93 | 8.68 |
| 9:34 | 11.77 | 8.82 |
| 9:35 | 11.65 | 8.92 |
| 9:36 | 11.62 | 8.96 |
| 9:37 | 11.57 | 8.97 |
| 9:38 | 11.75 | 8.81 |
| 9:39 | 11.79 | 8.79 |
| 9:40 | 11.97 | 8.65 |
| 9:41 | 11.79 | 8.76 |
| 9:42 | 11.68 | 8.92 |
| 9:43 | 11.66 | 8.90 |
| 9:44 | 11.69 | 8.90 |
| 9:45 | 11.73 | 8.86 |


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| | | |
|---|---|---|
| 9:46 | 11.78 | 8.85 |
| 9:47 | 12.12 | 8.40 |
| 9:48 | 12.45 | 8.18 |
| 9:49 | 11.79 | 8.83 |
| 9:50 | 11.11 | 9.44 |
| 9:51 | 11.15 | 9.38 |
| 9:52 | 11.23 | 9.32 |
| 9:53 | 11.62 | 8.99 |
| 9:54 | 11.54 | 9.03 |
| 9:55 | 11.71 | 8.89 |
| 9:56 | 11.65 | 8.95 |
| 9:57 | 11.60 | 8.97 |
| 9:58 | 11.76 | 8.84 |
| 9:59 | 11.71 | 8.88 |
| 10:00 | 11.84 | 8.76 |
| 10:01 | 11.38 | 9.15 |
| 10:02 | 11.78 | 8.83 |
| 10:03 | 11.33 | 9.22 |
| 10:04 | 11.32 | 9.26 |
| 10:05 | 11.36 | 9.22 |
| 10:06 | 11.23 | 9.32 |
| 10:07 | 11.43 | 9.12 |
| 10:08 | 11.54 | 9.09 |
| 10:09 | 11.56 | 9.01 |
| 10:10 | 11.77 | 8.83 |
| 10:11 | 11.80 | 8.73 |
| 10:12 | 12.38 | 8.30 |
| 10:13 | 11.78 | 8.84 |
| 10:14 | 11.45 | 9.14 |
| 10:15 | 11.20 | 9.39 |
| 10:16 | 11.40 | 9.16 |
| 10:17 | 11.47 | 9.14 |
| 10:18 | 11.54 | 9.04 |
| 10:19 | 11.62 | 8.97 |
| 10:20 | 11.62 | 8.94 |
| 10:21 | 11.72 | 8.89 |
| 10:22 | 11.41 | 9.16 |
| 10:23 | 11.54 | 9.03 |
| 10:24 | 11.65 | 8.93 |
| 10:25 | 11.62 | 8.96 |
| 10:26 | 11.77 | 8.83 |
| 10:27 | 11.94 | 8.63 |
| 10:28 | 11.90 | 8.72 |
| 10:29 | 11.91 | 8.69 |
| 10:30 | 11.76 | 8.83 |
| 10:31 | 11.61 | 8.99 |
| 10:32 | 11.23 | 9.30 |
| 10:33 | 11.88 | 8.74 |
| 10:34 | 11.92 | 8.68 |
| 10:35 | 12.13 | 8.47 |
| 10:36 | 12.69 | 7.90 |
| 10:37 | 11.95 | 8.69 |
| 10:38 | 11.45 | 9.17 |
| 10:39 | 11.05 | 9.51 |
| 10:40 | 11.01 | 9.52 |
| 10:41 | 11.21 | 9.34 |
| 10:42 | 11.33 | 9.26 |
| 10:43 | 11.29 | 9.30 |
| 10:44 | 11.21 | 9.34 |
| 10:45 | 11.20 | 9.41 |
| 10:46 | 11.26 | 9.29 |
| 10:47 | 11.36 | 9.15 |
| 10:48 | 11.52 | 9.06 |
| 10:49 | 11.66 | 8.93 |
| 10:50 | 11.73 | 8.83 |
| 10:51 | 11.77 | 8.84 |
| 10:52 | 11.55 | 8.99 |
| 10:53 | 11.79 | 8.79 |
| 10:54 | 11.90 | 8.71 |
| 10:55 | 11.84 | 8.74 |
| 10:56 | 11.87 | 8.74 |
| 10:57 | 11.97 | 8.64 |
| 10:58 | 12.08 | 8.54 |
| 10:59 | 12.13 | 8.51 |
| 11:00 | 12.46 | 8.11 |
| 11:01 | 12.51 | 8.16 |
| 11:02 | 11.98 | 8.68 |
| **Average** | **11.65** | **8.93** |
| **Min** | 10.72 | 7.78 |
| **Max** | 12.74 | 9.79 |


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**Client:** University of Iowa
**Facility:** Oakdale Renewable Energy Center
**Project #:** M144705
**Test Location:** Hurst Boiler Exhaust Duct
**Operating Condition:** Normal
**Date:** 11/4/14
**Run 2**

| Time | CO2 % (dry) | O2 % (dry) |
|---|---|---|
| 11:30 | 11.24 | 9.31 |
| 11:31 | 11.44 | 9.18 |
| 11:32 | 11.24 | 9.33 |
| 11:33 | 11.13 | 9.37 |
| 11:34 | 11.59 | 8.99 |
| 11:35 | 11.67 | 8.90 |
| 11:36 | 11.66 | 8.95 |
| 11:37 | 11.62 | 8.92 |
| 11:38 | 11.73 | 8.84 |
| 11:39 | 11.70 | 8.85 |
| 11:40 | 11.63 | 8.94 |
| 11:41 | 11.77 | 8.80 |
| 11:42 | 11.91 | 8.65 |
| 11:43 | 11.92 | 8.64 |
| 11:44 | 11.60 | 8.96 |
| 11:45 | 11.29 | 9.22 |
| 11:46 | 11.44 | 9.11 |
| 11:47 | 11.66 | 8.87 |
| 11:48 | 11.89 | 8.67 |
| 11:49 | 12.34 | 8.25 |
| 11:50 | 11.79 | 8.80 |
| 11:51 | 11.33 | 9.24 |
| 11:52 | 11.25 | 9.32 |
| 11:53 | 11.33 | 9.22 |
| 11:54 | 11.37 | 9.20 |
| 11:55 | 11.41 | 9.17 |
| 11:56 | 11.43 | 9.13 |
| 11:57 | 11.45 | 9.12 |
| 11:58 | 11.59 | 8.97 |
| 11:59 | 11.54 | 9.01 |
| 12:00 | 11.78 | 8.77 |
| 12:01 | 11.68 | 8.88 |
| 12:02 | 11.34 | 9.19 |
| 12:03 | 11.40 | 9.14 |
| 12:04 | 11.50 | 9.04 |
| 12:05 | 11.40 | 9.16 |
| 12:06 | 11.60 | 8.95 |
| 12:07 | 11.61 | 8.95 |
| 12:08 | 11.71 | 8.88 |
| 12:09 | 11.52 | 9.03 |
| 12:10 | 11.56 | 9.00 |
| 12:11 | 11.53 | 9.01 |
| 12:12 | 12.11 | 8.42 |
| 12:13 | 12.46 | 8.10 |
| 12:14 | 12.40 | 8.25 |
| 12:15 | 11.50 | 9.13 |
| 12:16 | 10.74 | 9.78 |
| 12:17 | 10.95 | 9.57 |
| 12:18 | 10.97 | 9.56 |
| 12:19 | 11.12 | 9.42 |
| 12:20 | 11.33 | 9.25 |
| 12:21 | 11.50 | 9.09 |
| 12:22 | 11.39 | 9.19 |
| 12:23 | 11.52 | 9.05 |
| 12:24 | 11.62 | 8.94 |
| 12:25 | 11.44 | 9.10 |
| 12:26 | 11.39 | 9.19 |
| 12:27 | 11.46 | 9.08 |
| 12:28 | 11.39 | 9.14 |
| 12:29 | 11.55 | 9.02 |
| 12:30 | 11.54 | 9.01 |
| 12:31 | 11.41 | 9.16 |
| 12:32 | 11.47 | 9.08 |
| 12:33 | 11.47 | 9.08 |
| 12.34 | 11.72 | 8.86 |
| 12:35 | 11.71 | 8.90 |


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| | | |
|---|---|---|
| 12:36 | 12.05 | 8.52 |
| 12:37 | 12.47 | 8.11 |
| 12:38 | 12.71 | 7.90 |
| 12:39 | 12.03 | 8.62 |
| 12:40 | 11.49 | 9.08 |
| 12:41 | 11.19 | 9.37 |
| 12:42 | 11.29 | 9.27 |
| 12:43 | 11.30 | 9.27 |
| 12:44 | 11.45 | 9.11 |
| 12:45 | 11.67 | 8.92 |
| 12:46 | 11.67 | 8.93 |
| 12:47 | 11.84 | 8.74 |
| 12:48 | 11.80 | 8.78 |
| 12:49 | 11.68 | 8.89 |
| 12:50 | 11.64 | 8.93 |
| 12:51 | 11.49 | 9.07 |
| 12:52 | 11.62 | 8.95 |
| 12:53 | 11.67 | 8.89 |
| 12:54 | 11.79 | 8.79 |
| 12:55 | 11.95 | 8.65 |
| 12:56 | 11.81 | 8.80 |
| 12:57 | 11.71 | 8.88 |
| 12:58 | 11.80 | 8.80 |
| 12:59 | 12.16 | 8.40 |
| 13:00 | 12.17 | 8.45 |
| 13:01 | 12.59 | 8.07 |
| 13:02 | 12.21 | 8.43 |
| 13:03 | 11.62 | 8.95 |
| 13:04 | 11.38 | 9.20 |
| 13:05 | 11.38 | 9.18 |
| 13:06 | 11.38 | 9.18 |
| 13:07 | 11.42 | 9.14 |
| 13:08 | 11.67 | 8.90 |
| 13:09 | 11.70 | 8.87 |
| 13:10 | 11.74 | 8.79 |
| 13:11 | 12.01 | 8.59 |
| 13:12 | 11.81 | 8.80 |
| 13:13 | 11.46 | 9.06 |
| 13:14 | 12.03 | 8.53 |
| 13:15 | 11.73 | 8.86 |
| 13:16 | 11.74 | 8.83 |
| 13:17 | 11.73 | 8.78 |
| 13:18 | 11.71 | 9.10 |
| 13:19 | 8.48 | 12.07 |
| 13:20 | 8.30 | 12.17 |
| 13:21 | 8.82 | 11.66 |
| 13:22 | 9.02 | 11.27 |
| 13:23 | 9.33 | 10.91 |
| 13:24 | 8.55 | 11.88 |
| 13:25 | 9.10 | 11.32 |
| 13:26 | 10.74 | 9.69 |
| 13:27 | 11.08 | 9.42 |
| 13:28 | 11.07 | 9.45 |
| 13:29 | 11.27 | 9.27 |
| 13:30 | 11.35 | 9.20 |
| 13:31 | 11.66 | 8.90 |
| 13:32 | 11.54 | 9.07 |
| 13:33 | 11.69 | 8.83 |
| 13:34 | 11.84 | 8.74 |
| 13:35 | 12.01 | 8.56 |
| 13:36 | 12.07 | 8.49 |
| 13:37 | 12.04 | 8.55 |
| 13:38 | 12.05 | 8.54 |
| 13:39 | 11.88 | 8.67 |
| 13:40 | 11.84 | 8.75 |
| 13:41 | 11.69 | 8.83 |
| 13:42 | 11.99 | 8.58 |
| 13:43 | 12.39 | 8.20 |
| 13:44 | 11.98 | 8.56 |
| 13:45 | 11.69 | 8.91 |
| 13:46 | 12.29 | 8.29 |
| 13:47 | 11.84 | 8.78 |
| **Average** | **11.50** | **9.06** |
| **Min** | 8.30 | 7.90 |
| **Max** | 12.71 | 12.17 |


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**Client:** University of Iowa
**Facility:** Oakdale Renewable Energy Center
**Project #:** M144705
**Test Location:** Hurst Boiler Exhaust Duct
**Operating Condition:** Normal
**Date:** 11/4/14
**Run 3**

| Time | CO2 % (dry) | O2 % (dry) |
|---|---|---|
| 14:15 | 11.54 | 8.98 |
| 14:16 | 11.73 | 8.83 |
| 14:17 | 11.76 | 8.82 |
| 14:18 | 11.85 | 8.70 |
| 14:19 | 11.91 | 8.66 |
| 14:20 | 11.90 | 8.66 |
| 14:21 | 12.04 | 8.54 |
| 14:22 | 11.83 | 8.73 |
| 14:23 | 11.96 | 8.60 |
| 14:24 | 11.83 | 8.73 |
| 14:25 | 11.79 | 8.73 |
| 14:26 | 11.76 | 8.78 |
| 14:27 | 11.79 | 8.75 |
| 14:28 | 11.76 | 8.76 |
| 14:29 | 11.66 | 8.87 |
| 14:30 | 11.68 | 8.87 |
| 14:31 | 11.57 | 8.93 |
| 14:32 | 11.53 | 8.96 |
| 14:33 | 11.81 | 8.70 |
| 14:34 | 11.76 | 8.78 |
| 14:35 | 12.69 | 7.85 |
| 14:36 | 11.98 | 8.59 |
| 14:37 | 11.50 | 9.03 |
| 14:38 | 11.37 | 9.12 |
| 14:39 | 11.34 | 9.19 |
| 14:40 | 11.29 | 9.22 |
| 14:41 | 11.31 | 9.18 |
| 14:42 | 11.68 | 8.87 |
| 14:43 | 11.82 | 8.78 |
| 14:44 | 11.86 | 8.72 |
| 14:45 | 11.95 | 8.64 |
| 14:46 | 12.10 | 8.50 |
| 14:47 | 12.16 | 8.45 |
| 14:48 | 12.03 | 8.53 |
| 14:49 | 11.85 | 8.75 |
| 14:50 | 11.77 | 8.79 |
| 14:51 | 11.72 | 8.82 |
| 14:52 | 11.84 | 8.73 |
| 14:53 | 11.78 | 8.79 |
| 14:54 | 11.69 | 8.88 |
| 14:55 | 11.52 | 9.03 |
| 14:56 | 11.57 | 8.98 |
| 14:57 | 11.68 | 8.87 |
| 14:58 | 11.74 | 8.83 |
| 14:59 | 12.60 | 7.94 |
| 15:00 | 12.54 | 8.01 |
| 15:01 | 11.84 | 8.77 |
| 15:02 | 11.22 | 9.32 |
| 15:03 | 11.18 | 9.32 |
| 15:04 | 11.18 | 9.34 |
| 15:05 | 11.27 | 9.27 |
| 15:06 | 11.44 | 9.10 |
| 15:07 | 11.49 | 9.06 |
| 15:08 | 11.76 | 8.83 |
| 15:09 | 11.89 | 8.68 |
| 15:10 | 11.97 | 8.60 |
| 15:11 | 11.89 | 8.70 |
| 15:12 | 11.98 | 8.60 |
| 15:13 | 12.00 | 8.56 |
| 15:14 | 12.10 | 8.49 |
| 15:15 | 12.07 | 8.51 |
| 15:16 | 12.11 | 8.46 |
| 15:17 | 12.08 | 8.52 |
| 15:18 | 11.97 | 8.62 |
| 15:19 | 12.09 | 8.50 |
| 15:20 | 11.99 | 8.59 |


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| | | |
|---|---|---|
| 15:21 | 11.69 | 8.92 |
| 15:22 | 11.81 | 8.93 |
| 15:23 | 11.63 | 8.93 |
| 15:24 | 11.87 | 8.72 |
| 15:25 | 12.14 | 8.41 |
| 15:26 | 12.44 | 8.19 |
| 15:27 | 11.98 | 8.65 |
| 15:28 | 11.66 | 8.91 |
| 15:29 | 11.53 | 9.05 |
| 15:30 | 11.45 | 9.11 |
| 15:31 | 11.53 | 9.04 |
| 15:32 | 11.58 | 8.99 |
| 15:33 | 11.70 | 8.87 |
| 15:34 | 11.74 | 8.84 |
| 15:35 | 11.80 | 8.79 |
| 15:36 | 11.81 | 8.76 |
| 15:37 | 11.92 | 8.68 |
| 15:38 | 11.92 | 8.67 |
| 15:39 | 11.92 | 8.66 |
| 15:40 | 11.90 | 8.69 |
| 15:41 | 11.98 | 8.61 |
| 15:42 | 11.73 | 8.86 |
| 15:43 | 11.67 | 8.89 |
| 15:44 | 11.79 | 8.80 |
| 15:45 | 11.81 | 8.78 |
| 15:46 | 11.79 | 8.79 |
| 15:47 | 11.71 | 8.86 |
| 15:48 | 11.79 | 8.80 |
| 15:49 | 11.67 | 8.87 |
| 15:50 | 12.34 | 8.23 |
| 15:51 | 12.05 | 8.58 |
| 15:52 | 11.67 | 8.92 |
| 15:53 | 11.69 | 8.90 |
| 15:54 | 11.66 | 8.92 |
| 15:55 | 11.72 | 8.86 |
| 15:56 | 11.61 | 8.96 |
| 15:57 | 11.67 | 8.92 |
| 15:58 | 11.78 | 8.81 |
| 15:59 | 11.67 | 8.89 |
| 16:00 | 11.74 | 8.81 |
| 16:01 | 11.85 | 8.74 |
| 16:02 | 12.03 | 8.53 |
| 16:03 | 11.92 | 8.68 |
| 16:04 | 11.85 | 8.73 |
| 16:05 | 11.99 | 8.59 |
| 16:06 | 11.98 | 8.62 |
| 16:07 | 11.94 | 8.65 |
| 16:08 | 11.88 | 8.72 |
| 16:09 | 11.92 | 8.68 |
| 16:10 | 11.95 | 8.64 |
| 16:11 | 11.87 | 8.73 |
| 16:12 | 11.87 | 8.71 |
| 16:13 | 11.87 | 8.73 |
| 16:14 | 11.91 | 8.69 |
| 16:15 | 12.39 | 8.15 |
| 16:16 | 12.13 | 8.52 |
| 16:17 | 11.83 | 8.78 |
| 16:18 | 11.79 | 8.81 |
| 16:19 | 11.65 | 8.94 |
| 16:20 | 11.59 | 9.00 |
| 16:21 | 11.67 | 8.90 |
| 16:22 | 11.60 | 8.97 |
| 16:23 | 11.75 | 8.82 |
| 16:24 | 11.77 | 8.81 |
| 16:25 | 11.84 | 8.74 |
| 16:26 | 11.93 | 8.62 |
| 16:27 | 12.02 | 8.57 |
| 16:28 | 12.15 | 8.42 |
| 16:29 | 12.16 | 8.44 |
| 16:30 | 12.18 | 8.43 |
| 16:31 | 12.12 | 8.48 |
| 16:32 | 11.94 | 8.65 |
| **Average** | **11.82** | **8.75** |
| **Min** | 11.18 | 7.85 |
| **Max** | 12.69 | 9.34 |


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## Method 30B (Sorbent Trap) Mercury Test Results Summary
## University of Iowa
## Oakdale Renewable Energy Plant
## Hurst Boiler Exhaust Duct

| Test No. | Date | Start Time | End Time | $V_m$ (standard L) | ng detected | ppb | $O_2$, % dry | ug/dscm | ug/wscm | lb/Tbtu (Fd Factor) | paired trap agreement, % difference |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1A | 11/5/2014 | 11:35 | 12:45 | 137.576 | 85.60 | 0.07 | 11.20 | 0.62 | 0.56 | 0.7733 | |
| 1B | | | | 135.462 | 78.90 | 0.07 | 11.20 | 0.58 | 0.52 | 0.7239 | |
| Average | | | | | 82.25 | 0.07 | 11.20 | 0.60 | 0.54 | 0.7486 | 3.30 |
| 2A | 11/5/2014 | 13:25 | 14:35 | 136.702 | 59.20 | 0.05 | 11.00 | 0.43 | 0.39 | 0.5274 | |
| 2B | | | | 132.931 | 53.40 | 0.05 | 11.00 | 0.40 | 0.36 | 0.4892 | |
| Average | | | | | 56.30 | 0.05 | 11.00 | 0.42 | 0.37 | 0.5083 | 3.75 |
| 3A | 11/5/2014 | 15:13 | 16:05 | 116.988 | 28.90 | 0.03 | 10.40 | 0.25 | 0.22 | 0.2836 | |
| 3B | | | | 96.283 | 25.60 | 0.03 | 10.40 | 0.27 | 0.24 | 0.3053 | |
| Average | | | | | 27.25 | 0.03 | 10.40 | 0.26 | 0.23 | 0.2945 | -3.68 |
| | | | | | | | | | | | |
| Overall Average* | | | | | 69.28 | 0.06 | 11.10 | 0.51 | 0.46 | 0.6284 | |

*Unit tripped during Run 3 and was not included in the average


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## METHOD 30B TEST RESULTS

| | | | |
|---|---|---|---|
| Project #: | M144705 | Location: | Hurst Boiler Exhaust Duct |
| Client: | University of Iowa | Condition: | Normal |
| Facility: | Oakdale Renewable Energy Plant | Data Taken By: | JHK |
| Fuel Type: | Wood | Fuel Factor: | 9240 |
| Hg Analyzer ID: | | Diluent: | O2 % |

Test Number: 1A Trap Number: OL210119 Start Time: 11:35 End Time: 12:45 Date: 11/5/2014

| | | | |
|---|---|---|---|
| Pressure, Barometric(Hg"): | 29.700 | Hg (ng) | 85.6 |
| Initial Volume (liters) | 0 | Water Vapor in Flue Gas (Bws): | 0.100 |
| Final Volume (liters) | 140.532 | Meter Volume (Standard liters) | 137.576 |
| Meter Temperature (°F) | 81.80 | Hg (ppb) | 0.07 |
| Meter Calibration (Y) | 1.012 | Hg (ug/dscm) | 0.62 |
| CO2 % | 9.30 | | |
| O2 % | 11.20 | Hg (lb/Tbtu), Fd Factor | 0.773313 |

Test Number: 2A Trap Number: OLC012446 Start Time: 13:25 End Time: 14:35 Date: 11/5/2014

| | | | |
|---|---|---|---|
| Pressure, Barometric(Hg"): | 29.700 | Hg (ng) | 59.2 |
| Initial Volume (liters) | 0 | Water Vapor in Flue Gas (Bws): | 0.104 |
| Final Volume (liters) | 140.464 | Meter Volume (Standard liters) | 136.702 |
| Meter Temperature (°F) | 85.00 | Hg (ppb) | 0.05 |
| Meter Calibration (Y) | 1.012 | Hg (ug/dscm) | 0.43 |
| CO2 % | 9.60 | | |
| O2 % | 11.00 | Hg (lb/Tbtu), Fd Factor | 0.527360 |

Test Number: 3A Trap Number: OL210456 Start Time: 15:13 End Time: 16:05 Date: 11/5/2014

| | | | |
|---|---|---|---|
| Pressure, Barometric(Hg"): | 29.700 | Hg (ng) | 28.9 |
| Initial Volume (liters) | 0 | Water Vapor in Flue Gas (Bws): | 0.100 |
| Final Volume (liters) | 101.459 | Meter Volume (Standard liters) | 116.988 |
| Meter Temperature (°F) | | Hg (ppb) | 0.03 |
| Meter Calibration (Y) | 1.012 | Hg (ug/dscm) | 0.25 |
| CO2 % | 10.10 | | |
| O2 % | 10.40 | Hg (lb/Tbtu), Fd Factor | 0.283639 |


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## METHOD 30B TEST RESULTS

| | | | |
|---|---|---|---|
| Project #: | M144705 | Location: | Hurst Boiler Exhaust Duct |
| Client: | University of Iowa | Condition: | Normal |
| Facility: | Oakdale Renewable Energy Plant | Data Taken By: | JHK |
| Fuel Type: | Wood | Fuel Factor: | 9240 |
| Hg Analyzer ID: | 0 | Diluent: | O2 % |

| Test Number: 1B | Trap Number: OL211390 | Start Time: 11:35 End Time: 12:45 | Date: 11/5/2014 |
|---|---|---|---|
| Pressure, Barometric(Hg"): | 29.700 | Hg (ng) | 78.9 |
| Initial Volume (liters) | 0 | Water Vapor in Flue Gas (Bws): | 0.100 |
| Final Volume (liters) | 142.173 | Meter Volume (Standard liters) | 135.462 |
| Meter Temperature (°F) | 82.93 | Hg (ppb) | 0.07 |
| Meter Calibration (Y) | 0.987 | Hg (ug/dscm) | 0.58 |
| CO2 % | 9.30 | | |
| O2 % | 11.20 | Hg (lb/Tbtu), Fd Factor | 0.723911 |
| | | Spiked Trap Run | Y |
| | | Spike Concentration | 25 |

| Test Number: 2B | Trap Number: OL201242 | Start Time: 13:25 End Time: 14:35 | Date: 11/5/2014 |
|---|---|---|---|
| Pressure, Barometric(Hg"): | 29.700 | Hg (ng) | 53.4 |
| Initial Volume (liters) | 0 | Water Vapor in Flue Gas (Bws): | 0.104 |
| Final Volume (liters) | 140.639 | Meter Volume (Standard liters) | 132.931 |
| Meter Temperature (°F) | 87.30 | Hg (ppb) | 0.05 |
| Meter Calibration (Y) | 0.987 | Hg (ug/dscm) | 0.40 |
| CO2 % | 9.60 | | |
| O2 % | 11.00 | Hg (lb/Tbtu), Fd Factor | 0.489191 |
| | | Spiked Trap Run | Y |
| | | Spike Concentration | 25 |

| Test Number: 3B | Trap Number: OL211459 | Start Time: 15:13 End Time: 16:05 | Date: 11/5/2014 |
|---|---|---|---|
| Pressure, Barometric(Hg"): | 29.700 | Hg (ng) | 25.6 |
| Initial Volume (liters) | 0 | Water Vapor in Flue Gas (Bws): | 0.100 |
| Final Volume (liters) | 101.61 | Meter Volume (Standard liters) | 96.283 |
| Meter Temperature (°F) | 87.00 | Hg (ppb) | 0.03 |
| Meter Calibration (Y) | 0.987 | Hg (ug/dscm) | 0.27 |
| CO2 % | 10.10 | | |
| O2 % | 10.40 | Hg (lb/Tbtu), Fd Factor | 0.305281 |
| | | Spiked Trap Run | Y |
| | | Spike Concentration | 25 |


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**Compliance Stratification Test Results Summary**
**University of Iowa**
**Oakdale Renewable Energy Plant**
**Hurst Boiler Exhaust Duct**
**November 5, 2014**

| | |
|---|---|
| **Number of Ports Sampled:** | 5 |
| **Number of Points per Port:** | 4 |
| **Total Number of Traverse Points:** | 20 |

| Port No. | Point No. | Point Marking, inches | Time | $O_2$% | Actual % Difference $O_2$% | $CO_2$% | Actual % Difference $CO_2$% | $NO_x$ ppm | Actual % Difference $NO_x$ ppm | CO ppm | Actual % Difference CO ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 11.25 | 11:37 | 9.21 | 19.19 | 11.34 | 23.53 | 64.0 | 42.79 | 0.9 | 64.71 |
| | 2 | 21.75 | 11:40 | 9.40 | 17.53 | 11.12 | 21.13 | 62.3 | 39.00 | 0.3 | 88.24 |
| | 3 | 32.25 | 11:43 | 10.06 | 11.74 | 10.40 | 13.29 | 51.3 | 14.46 | 2.1 | 17.65 |
| | 4 | 42.75 | 11:46 | 10.56 | 7.35 | 10.02 | 9.15 | 55.8 | 24.50 | 0.3 | 88.24 |
| 2 | 1 | 11.25 | 11:57 | 9.68 | 15.07 | 10.83 | 17.97 | 45.1 | 0.62 | 4.7 | 84.31 |
| | 2 | 21.75 | 12:00 | 11.01 | 3.40 | 9.57 | 4.25 | 46.3 | 3.30 | 5.0 | 96.08 |
| | 3 | 32.25 | 12:03 | 10.59 | 7.08 | 9.97 | 8.61 | 41.6 | 7.18 | 1.4 | 45.10 |
| | 4 | 42.75 | 12:06 | 12.70 | 11.43 | 7.85 | 14.49 | 33.5 | 25.26 | 3.5 | 37.25 |
| 3 | 1 | 11.25 | 12:15 | 9.69 | 14.98 | 10.79 | 17.54 | 66.0 | 47.26 | 1.1 | 56.86 |
| | 2 | 21.75 | 12:18 | 10.74 | 5.77 | 9.78 | 6.54 | 54.0 | 20.48 | 0.3 | 88.24 |
| | 3 | 32.25 | 12:21 | 13.53 | 18.71 | 7.16 | 22.00 | 33.1 | 26.15 | 1.6 | 37.25 |
| | 4 | 42.75 | 12:24 | 14.14 | 24.06 | 6.65 | 27.56 | 28.5 | 36.41 | 1.9 | 25.49 |
| 4 | 1 | 11.25 | 12:34 | 9.55 | 16.21 | 10.98 | 19.61 | 45.4 | 1.29 | 3.8 | 49.02 |
| | 2 | 21.75 | 12:37 | 9.95 | 12.70 | 10.63 | 15.80 | 47.1 | 5.09 | 6.1 | 139.22 |
| | 3 | 32.25 | 12:40 | 12.56 | 10.20 | 8.03 | 12.53 | 46.6 | 3.97 | 3.1 | 21.57 |
| | 4 | 42.75 | 12:43 | 13.43 | 17.83 | 7.27 | 20.81 | 40.5 | 9.64 | 0.7 | 72.55 |
| 5 | 1 | 11.25 | 12:52 | 13.66 | 19.85 | 7.04 | 23.31 | 31.8 | 29.05 | 3.5 | 37.25 |
| | 2 | 21.75 | 12:55 | 12.19 | 6.95 | 8.32 | 9.37 | 36.3 | 19.01 | 3.2 | 25.49 |
| | 3 | 32.25 | 12:58 | 12.55 | 10.11 | 8.03 | 12.53 | 34.5 | 23.03 | 3.9 | 52.94 |
| | 4 | 42.75 | 13:01 | 12.75 | 11.87 | 7.82 | 14.81 | 32.7 | 27.04 | 3.6 | 41.18 |
| Average | | | | 11.40 | | 9.18 | | 44.8 | | 2.6 | |


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**Client:** University of Iowa
**Facility:** Oakdale Renewable Energy Plant
**Project #:** M144705
**Test Location:** Hurst Boiler Exhaust Duct
**Operating Condition:** Normal
**Date:** 11/5/14

**Run 1**

| Time | NOx ppmvd | CO ppmvd | CO2 % (dry) | O2 % (dry) |
|---|---|---|---|---|
| 11:35 | 63.80 | 1.50 | 11.55 | 9.05 |
| 11:36 | 64.40 | 1.00 | 11.37 | 9.19 |
| 11:37 | 64.00 | 0.90 | 11.34 | 9.21 |
| 11:38 | 65.40 | 0.90 | 11.37 | 9.20 |
| 11:39 | 63.90 | 0.50 | 11.19 | 9.37 |
| 11:40 | 62.30 | 0.30 | 11.12 | 9.40 |
| 11:41 | 61.20 | 0.50 | 10.81 | 9.80 |
| 11:42 | 53.70 | 0.70 | 9.91 | 10.72 |
| 11:43 | 51.30 | 2.10 | 10.40 | 10.06 |
| 11:44 | 56.70 | 3.70 | 10.51 | 9.99 |
| 11:45 | 57.50 | 0.80 | 10.36 | 10.20 |
| 11:46 | 55.80 | 0.30 | 10.02 | 10.56 |
| 11:55 | 41.50 | 9.10 | 10.68 | 9.86 |
| 11:56 | 42.70 | 4.60 | 10.77 | 9.75 |
| 11:57 | 45.10 | 4.70 | 10.83 | 9.68 |
| 11:58 | 45.90 | 4.90 | 11.00 | 9.50 |
| 11:59 | 49.20 | 4.90 | 11.05 | 9.57 |
| 12:00 | 46.30 | 5.00 | 9.57 | 11.01 |
| 12:01 | 43.80 | 2.10 | 9.31 | 11.26 |
| 12:02 | 42.20 | 1.90 | 8.58 | 11.98 |
| 12:03 | 41.60 | 1.40 | 9.97 | 10.59 |
| 12:04 | 43.20 | 1.60 | 8.35 | 12.41 |
| 12:05 | 28.50 | 1.60 | 7.83 | 12.76 |
| 12:06 | 33.50 | 3.50 | 7.85 | 12.70 |
| 12:13 | 63.60 | 7.70 | 11.15 | 9.40 |
| 12:14 | 65.60 | 2.40 | 10.98 | 9.56 |
| 12:15 | 66.00 | 1.10 | 10.79 | 9.69 |
| 12:16 | 64.20 | 0.70 | 10.74 | 9.78 |
| 12:17 | 62.20 | 0.60 | 10.39 | 10.21 |
| 12:18 | 54.10 | 0.30 | 9.78 | 10.74 |
| 12:19 | 50.20 | 1.10 | 9.25 | 11.49 |
| 12:20 | 38.00 | 1.00 | 7.18 | 13.60 |
| 12:21 | 33.10 | 1.60 | 7.16 | 13.53 |
| 12:22 | 31.60 | 2.50 | 7.38 | 13.31 |
| 12:23 | 29.20 | 2.70 | 6.50 | 14.35 |
| 12:24 | 28.50 | 1.90 | 6.65 | 14.14 |
| 12:32 | 43.40 | 4.20 | 10.73 | 9.80 |
| 12:33 | 43.90 | 4.10 | 10.65 | 9.86 |
| 12:34 | 45.40 | 3.80 | 10.98 | 9.55 |
| 12:35 | 45.70 | 4.10 | 10.88 | 9.63 |
| 12:36 | 46.40 | 5.00 | 10.91 | 9.59 |
| 12:37 | 47.10 | 6.10 | 10.63 | 9.95 |
| 12:38 | 48.50 | 10.50 | 11.09 | 9.55 |
| 12:39 | 47.80 | 14.70 | 8.56 | 11.98 |
| 12:40 | 46.60 | 3.10 | 8.03 | 12.56 |
| 12:41 | 44.60 | 1.30 | 7.74 | 12.83 |
| 12:42 | 43.80 | 0.80 | 7.65 | 12.95 |
| 12:43 | 40.50 | 0.70 | 7.27 | 13.43 |
| 12:50 | 30.10 | 2.90 | 7.03 | 13.68 |
| 12:51 | 31.20 | 3.80 | 6.99 | 13.77 |
| 12:52 | 31.80 | 3.50 | 7.04 | 13.66 |
| 12:53 | 31.20 | 2.80 | 6.88 | 13.84 |
| 12:54 | 32.60 | 2.30 | 8.00 | 12.45 |
| 12:55 | 36.30 | 3.20 | 8.32 | 12.19 |
| 12:56 | 35.50 | 3.00 | 8.25 | 12.22 |
| 12:57 | 35.80 | 3.20 | 8.51 | 12.02 |
| 12:58 | 34.50 | 3.90 | 8.03 | 12.55 |
| 12:59 | 32.20 | 3.00 | 7.84 | 12.63 |
| 13:00 | 33.30 | 3.10 | 7.83 | 12.76 |
| 13:01 | 32.70 | 3.60 | 7.82 | 12.75 |
| **Average** | 45.80 | 3.00 | 9.36 | 11.23 |
| **Min** | 28.50 | 0.30 | 6.50 | 9.05 |
| **Max** | 66.00 | 14.70 | 11.55 | 14.35 |


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**Client:** University of Iowa
**Facility:** Oakdale Renewable Energy Plant
**Project #:** M144705
**Test Location:** Hurst Boiler Exhaust Duct
**Operating Condition:** Normal
**Date:** 11/5/14
**Run 2**

| Time | NOx ppmvd | CO ppmvd | CO2 % (dry) | O2 % (dry) |
|---|---|---|---|---|
| 13:25 | 26.50 | 3.20 | 6.51 | 14.30 |
| 13:26 | 24.90 | 4.80 | 6.73 | 14.02 |
| 13:27 | 24.60 | 4.80 | 6.60 | 14.16 |
| 13:28 | 25.50 | 4.70 | 6.63 | 14.14 |
| 13:29 | 27.00 | 4.40 | 7.25 | 13.38 |
| 13:30 | 29.40 | 3.70 | 7.39 | 13.20 |
| 13:31 | 30.20 | 5.00 | 7.29 | 13.40 |
| 13:32 | 32.60 | 7.60 | 9.22 | 11.12 |
| 13:33 | 42.10 | 22.00 | 10.19 | 10.27 |
| 13:34 | 50.60 | 11.10 | 10.52 | 9.96 |
| 13:35 | 53.50 | 4.80 | 9.94 | 10.63 |
| 13:36 | 51.40 | 3.10 | 9.48 | 11.00 |
| 13:43 | 47.10 | 2.10 | 10.19 | 10.31 |
| 13:44 | 45.60 | 3.30 | 10.26 | 10.24 |
| 13:45 | 45.10 | 5.70 | 10.45 | 10.06 |
| 13:46 | 44.90 | 5.40 | 10.62 | 9.84 |
| 13:47 | 45.00 | 8.00 | 10.00 | 10.63 |
| 13:48 | 41.60 | 6.30 | 9.21 | 11.29 |
| 13:49 | 41.70 | 3.00 | 8.27 | 12.40 |
| 13:50 | 35.90 | 1.50 | 7.47 | 13.18 |
| 13:51 | 36.50 | 1.10 | 7.41 | 13.20 |
| 13:52 | 33.10 | 1.00 | 5.98 | 14.92 |
| 13:53 | 25.70 | 0.60 | 5.33 | 15.53 |
| 13:54 | 25.80 | 0.60 | 5.23 | 15.63 |
| 14:01 | 41.40 | 12.20 | 10.27 | 10.24 |
| 14:02 | 41.10 | 9.50 | 10.23 | 10.27 |
| 14:03 | 40.60 | 9.40 | 10.47 | 10.03 |
| 14:04 | 40.00 | 12.00 | 10.24 | 10.30 |
| 14:05 | 38.30 | 13.60 | 10.17 | 10.30 |
| 14:06 | 39.80 | 15.30 | 10.78 | 9.71 |
| 14:07 | 42.00 | 14.50 | 10.55 | 10.05 |
| 14:08 | 39.60 | 9.80 | 9.82 | 10.69 |
| 14:09 | 37.20 | 7.80 | 9.12 | 11.41 |
| 14:10 | 35.80 | 5.30 | 8.61 | 12.02 |
| 14:11 | 32.50 | 5.00 | 8.60 | 11.87 |
| 14:12 | 35.40 | 7.10 | 8.58 | 11.83 |
| 14:19 | 49.90 | 4.60 | 11.04 | 9.46 |
| 14:20 | 50.40 | 4.20 | 11.00 | 9.47 |
| 14:21 | 52.50 | 3.10 | 11.24 | 9.27 |
| 14:22 | 53.00 | 4.00 | 11.20 | 9.30 |
| 14:23 | 54.50 | 3.40 | 11.09 | 9.39 |
| 14:24 | 56.10 | 3.40 | 10.92 | 9.56 |
| 14:25 | 56.30 | 2.80 | 10.88 | 9.67 |
| 14:26 | 52.70 | 5.80 | 10.37 | 10.04 |
| 14:27 | 58.10 | 15.40 | 10.77 | 9.72 |
| 14:28 | 62.30 | 7.80 | 10.54 | 9.95 |
| 14:29 | 64.10 | 3.80 | 10.33 | 10.12 |
| 14:30 | 64.70 | 1.70 | 10.22 | 10.33 |
| 14:37 | 52.80 | 1.60 | 11.07 | 9.39 |
| 14:38 | 50.90 | 2.20 | 11.14 | 9.36 |
| 14:39 | 49.80 | 3.20 | 11.14 | 9.39 |
| 14:40 | 48.70 | 3.10 | 11.14 | 9.36 |
| 14:41 | 47.50 | 3.90 | 11.14 | 9.34 |
| 14:42 | 47.20 | 5.40 | 11.16 | 9.37 |
| 14:43 | 46.00 | 9.00 | 10.75 | 10.04 |
| 14:44 | 43.80 | 5.90 | 10.85 | 9.34 |
| 14:45 | 46.10 | 6.60 | 11.30 | 9.21 |
| 14:46 | 49.10 | 5.60 | 10.82 | 9.76 |
| 14:47 | 52.70 | 4.20 | 11.15 | 9.43 |
| 14:48 | 51.60 | 3.40 | 9.76 | 10.68 |
| **Average** | 43.50 | 5.90 | 9.61 | 10.94 |
| **Min** | 24.60 | 0.60 | 5.23 | 9.21 |
| **Max** | 64.70 | 22.00 | 11.30 | 15.63 |


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**Client:** University of Iowa
**Facility:** Oakdale Renewable Energy Plant
**Project #:** M144705
**Test Location:** Hurst Boiler Exhaust Duct
**Operating Condition:** Normal
**Date:** 11/5/14

**Run 3**

| Time | NOx ppmvd | CO ppmvd | CO2 % (dry) | O2 % (dry) |
|---|---|---|---|---|
| 15:13 | 43.30 | 9.50 | 11.24 | 9.29 |
| 15:14 | 43.60 | 8.40 | 11.20 | 9.30 |
| 15:15 | 43.30 | 7.30 | 11.32 | 9.20 |
| 15:16 | 44.70 | 6.40 | 11.40 | 9.13 |
| 15:17 | 44.50 | 6.10 | 11.37 | 9.16 |
| 15:18 | 43.60 | 7.00 | 10.88 | 9.63 |
| 15:19 | 42.70 | 11.40 | 10.96 | 9.53 |
| 15:20 | 42.80 | 12.20 | 10.70 | 9.78 |
| 15:21 | 45.50 | 21.40 | 11.54 | 8.96 |
| 15:22 | 52.70 | 28.00 | 11.24 | 9.26 |
| 15:23 | 54.10 | 10.70 | 10.96 | 9.49 |
| 15:24 | 52.50 | 3.80 | 10.86 | 9.61 |
| 15:32 | 41.60 | 10.90 | 10.91 | 9.55 |
| 15:33 | 41.10 | 12.40 | 10.85 | 9.64 |
| 15:34 | 42.70 | 10.70 | 10.87 | 9.61 |
| 15:35 | 42.80 | 13.00 | 11.07 | 9.42 |
| 15:36 | 44.30 | 15.60 | 11.07 | 9.42 |
| 15:37 | 45.30 | 13.70 | 10.55 | 10.02 |
| 15:38 | 45.20 | 9.30 | 10.44 | 9.95 |
| 15:39 | 45.90 | 11.90 | 9.91 | 10.63 |
| 15:40 | 46.40 | 9.80 | 9.75 | 10.79 |
| 15:41 | 44.40 | 7.60 | 9.65 | 10.85 |
| 15:42 | 41.40 | 5.20 | 9.10 | 11.48 |
| 15:43 | 42.40 | 5.00 | 8.82 | 11.74 |
| 15:50 | 55.40 | 19.40 | 10.89 | 9.53 |
| 15:51 | 56.30 | 4.70 | 10.64 | 9.87 |
| 15:52 | 53.20 | 2.60 | 10.46 | 9.95 |
| 15:53 | 49.90 | 3.60 | 10.22 | 10.31 |
| 15:54 | 43.50 | 4.80 | 9.67 | 10.86 |
| 15:55 | 40.30 | 5.90 | 9.59 | 10.91 |
| 15:56 | 39.40 | 6.30 | 9.20 | 11.45 |
| 15:57 | 32.70 | 4.70 | 7.64 | 12.93 |
| 15:58 | 29.80 | 5.80 | 7.72 | 12.78 |
| 15:59 | 31.00 | 5.50 | 7.95 | 12.57 |
| 16:00 | 32.80 | 5.60 | 7.81 | 12.70 |
| 16:01 | 32.40 | 6.50 | 7.87 | 12.65 |
| Average | 43.70 | 9.20 | 10.18 | 10.33 |
| Min | 29.80 | 2.60 | 7.64 | 8.96 |
| Max | 56.30 | 28.00 | 11.54 | 12.93 |


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| | | |
|---|---|---|
| **Client:** | University of Iowa | |
| **Facility:** | Oakdale Renewable Energy Center | |
| **Test Location:** | Hurst Boiler Exhaust Duct | |
| **Project #:** | M144705 | |
| **Test Method:** | 2 | |
| **Test Engineer:** | SMcG | |
| **Test Technician:** | JHK | |
| **Type of Fuel Firing:** | Wood | |
| **Temp ID:** | CM19 | |
| **Meter ID:** | CM19 | |
| **Pitot ID:** | 91 | |
| **Pitot Type:** | S-Type | |
| **Pitot Tube Coefficient:** | 0.840 | |
| **Probe Length:** | 4.0 | **ft** |
| **Sample Plane:** | Horizontal | |
| **Port Length:** | 6.00 | **in.** |
| **Port Size (diameter):** | 6.00 | **in.** |
| **Port Type:** | Flange | |
| **Duct Shape:** | Rectangular | |
| **Length (traverse side of duct):** | 3.5 | **ft** |
| **Width:** | 5.5 | **ft** |
| **Location of Test Ports:** | Side of duct | |
| **Duct Area:** | 19.25 | **Sq. Ft.** |
| **Equivalent Diameter Rectangular Duct:** | 4.278 | |
| **Upstream Diameters:** | >0.5 | |
| **Downstream Diameters:** | >2.0 | |
| **Number of Ports Sampled:** | 5 | |
| **Number of Points per Port:** | 5 | |
| **Total Number of Traverse Points:** | 25 | |
| **Operating Level:** | Normal | |
| **Normal Load:** | (Normal) | |
| **Servomex Serial Number:** | | |
| **Moisture Balance ID:** | | |
| **Fluke ID:** | | |
| **Stack Liner Material:** | S | |
| **Default WAF:** | 0.995 | |
| **Calculated WAF:** | | |
| **Type of WAF Applied:** | N | |
| **Actual WAF Applied to all runs:** | | |


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# METHOD 2 VOLUMETRIC FLOW DATA

| | | | | |
|---|---|---|---|---|
| **Project Number:** | M144705 | **Operating Level:** | Normal | (Normal) |
| **Client:** | University of Iowa | **Run No.:** | 1 | |
| **Facility:** | Oakdale Renewable Energy Center | **Test Date:** | 11/5/2014 | |
| **Test Location:** | Hurst Boiler Exhaust Duct | **Start Time:** | 11:10 | |
| **Pitot ID:** | 91 | **End Time:** | 11:23 | |
| **Pitot Coefficient:** | 0.840 | **Test Engineer:** | SMcG | **Test Tech:** JHK |
| **Probe Length, Feet:** | 4 | **Port Length, Inches:** | 6 | |

| Port | Point | DP (in. $H_2O$) | Sqrt. DP | Temp (°F) | Velocity (V) |
|---|---|---|---|---|---|
| A | 1 | 0.02 | 0.1414 | 370.0 | 10.02 |
| A | 2 | 0.02 | 0.1414 | 370.0 | 10.02 |
| A | 3 | 0.02 | 0.1414 | 369.0 | 10.01 |
| A | 4 | 0.01 | 0.1000 | 368.0 | 7.07 |
| A | 5 | 0.01 | 0.1000 | 361.0 | 7.04 |
| B | 1 | 0.02 | 0.1414 | 371.0 | 10.02 |
| B | 2 | 0.02 | 0.1414 | 370.0 | 10.02 |
| B | 3 | 0.02 | 0.1414 | 370.0 | 10.02 |
| B | 4 | 0.01 | 0.1000 | 367.0 | 7.07 |
| B | 5 | 0.02 | 0.1414 | 363.0 | 9.97 |
| C | 1 | 0.04 | 0.2000 | 371.0 | 14.17 |
| C | 2 | 0.04 | 0.2000 | 371.0 | 14.17 |
| C | 3 | 0.03 | 0.1732 | 370.0 | 12.27 |
| C | 4 | 0.02 | 0.1414 | 368.0 | 10.00 |
| C | 5 | 0.02 | 0.1414 | 364.0 | 9.98 |

| Port | Point | DP (in. $H_2O$) | Sqrt. DP | Temp (°F) | Velocity (V) |
|---|---|---|---|---|---|
| D | 1 | 0.03 | 0.1732 | 370.0 | 12.27 |
| D | 2 | 0.03 | 0.1732 | 369.0 | 12.26 |
| D | 3 | 0.02 | 0.1414 | 369.0 | 10.01 |
| D | 4 | 0.02 | 0.1414 | 367.0 | 10.00 |
| D | 5 | 0.02 | 0.1414 | 364.0 | 9.98 |
| E | 1 | 0.02 | 0.1414 | 370.0 | 10.02 |
| E | 2 | 0.02 | 0.1414 | 369.0 | 10.01 |
| E | 3 | 0.01 | 0.1000 | 368.0 | 7.07 |
| E | 4 | 0.01 | 0.1000 | 366.0 | 7.06 |
| E | 5 | 0.01 | 0.1000 | 360.0 | 7.04 |

**Test Parameters**

| | | | |
|---|---|---|---|
| $P_{bar}$ - Barometric pressure, inches Hg | 29.70 | % $CO_2$ | 9.30 |
| $P_g$ - Stack Pressure, inches of $H_2O$ | -0.10 | % $O_2$ | 11.20 |
| $P_s$ - Absolute stack pressure, inches Hg | 29.69 | % $N_2$ | 79.50 |
| $t_s$ - Average stack temperature, °F | 367.8 | Md - dry basis lb/lb mole | 29.94 |
| Duct Shape: | Rectangular | Ms - wet basis lb/lb mole | 28.742 |
| Length, Feet | 3.5 | | |
| Width, Feet | 5.5 | | |
| | | **Bws - Moisture content fraction** | 0.100 |
| Cross Sectional Area of Stack, $Ft^2$ | 19.25 | Moisture determined by wb/db? | N |

**Method 2 Results**

| | | | |
|---|---|---|---|
| Average DP | 0.0204 | Q - ACFM | 11,435 |
| Average Sqrt DP | 0.1400 | Qsd - DSCFM | 6,514 |
| Average Velocity Vs (ft/sec) | 9.900 | Qs - SCFM | 7,238 |
| | | Qs - SCFH | 434,278 |


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## METHOD 2 VOLUMETRIC FLOW DATA

| | | | | | |
|---|---|---|---|---|---|
| **Project Number:** | M144705 | **Operating Level:** | Normal | (Normal) | |
| **Client:** | University of Iowa | **Run No.:** | 2 | | |
| **Facility:** | Oakdale Renewable Energy Center | **Test Date:** | 11/5/2014 | | |
| **Test Location:** | Hurst Boiler Exhaust Duct | **Start Time:** | 13:06 | | |
| **Pitot ID:** | 91 | **End Time:** | 13:17 | | |
| **Pitot Coefficient:** | 0.840 | **Test Engineer:** | SMcG | **Test Tech:** | JHK |
| **Probe Length, Feet:** | 4 | **Port Length, Inches:** | 6 | | |

| Port | Point | DP (in. $H_2O$) | Sqrt. DP | Temp (°F) | Velocity (V) |
|---|---|---|---|---|---|
| A | 1 | 0.02 | 0.1414 | 368.0 | 10.00 |
| A | 2 | 0.02 | 0.1414 | 369.0 | 10.01 |
| A | 3 | 0.01 | 0.1000 | 367.0 | 7.07 |
| A | 4 | 0.01 | 0.1000 | 367.0 | 7.07 |
| A | 5 | 0.01 | 0.1000 | 363.0 | 7.05 |
| B | 1 | 0.03 | 0.1732 | 369.0 | 12.26 |
| B | 2 | 0.02 | 0.1414 | 369.0 | 10.01 |
| B | 3 | 0.02 | 0.1414 | 368.0 | 10.00 |
| B | 4 | 0.01 | 0.1000 | 366.0 | 7.06 |
| B | 5 | 0.02 | 0.1414 | 363.0 | 9.97 |
| C | 1 | 0.04 | 0.2000 | 370.0 | 14.16 |
| C | 2 | 0.04 | 0.2000 | 371.0 | 14.17 |
| C | 3 | 0.03 | 0.1732 | 369.0 | 12.26 |
| C | 4 | 0.01 | 0.1000 | 368.0 | 7.07 |
| C | 5 | 0.03 | 0.1732 | 365.0 | 12.23 |

| Port | Point | DP (in. $H_2O$) | Sqrt. DP | Temp (°F) | Velocity (V) |
|---|---|---|---|---|---|
| D | 1 | 0.03 | 0.1732 | 368.0 | 12.25 |
| D | 2 | 0.03 | 0.1732 | 370.0 | 12.27 |
| D | 3 | 0.02 | 0.1414 | 369.0 | 10.01 |
| D | 4 | 0.02 | 0.1414 | 368.0 | 10.00 |
| D | 5 | 0.01 | 0.1000 | 366.0 | 7.06 |
| E | 1 | 0.02 | 0.1414 | 368.0 | 10.00 |
| E | 2 | 0.02 | 0.1414 | 369.0 | 10.01 |
| E | 3 | 0.02 | 0.1414 | 369.0 | 10.01 |
| E | 4 | 0.01 | 0.1000 | 367.0 | 7.07 |
| E | 5 | 0.01 | 0.1000 | 364.0 | 7.06 |

**Test Parameters**

| | | | |
|---|---|---|---|
| $P_{bar}$ - Barometric pressure, inches Hg | 29.70 | % $CO_2$ | 9.30 |
| $P_g$ - Stack Pressure, inches of $H_2O$ | -0.10 | % $O_2$ | 11.20 |
| $P_s$ - Absolute stack pressure, inches Hg | 29.69 | % $N_2$ | 79.50 |
| $t_s$ - Average stack temperature, °F | 367.6 | Md - dry basis lb/lb mole | 29.94 |
| Duct Shape: | Rectangular | Ms - wet basis lb/lb mole | 28.742 |
| Length, Feet | 3.5 | | |
| Width, Feet | 5.5 | | |
| | | **Bws - Moisture content fraction** | **0.100** |
| Cross Sectional Area of Stack, $Ft^2$ | 19.25 | Moisture determined by wb/db (Y or N) | N |

**Method 2 Results**

| | | | |
|---|---|---|---|
| Average DP | 0.0204 | Q - ACFM | 11,370 |
| Average Sqrt DP | 0.1392 | Qsd - DSCFM | 6,479 |
| Average Velocity Vs (ft/sec) | 9.844 | Qs - SCFM | 7,199 |
| | | Qs - SCFH | 431,939 |


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## METHOD 2 VOLUMETRIC FLOW DATA

| | | | | |
|---|---|---|---|---|
| **Project Number:** | M144705 | **Operating Level:** | Normal | (Normal) |
| **Client:** | University of Iowa | **Run No.:** | 3 | |
| **Facility:** | Oakdale Renewable Energy Center | **Test Date:** | 11/5/2014 | |
| **Test Location:** | Hurst Boiler Exhaust Duct | **Start Time:** | 15:01 | |
| **Pitot ID:** | 91 | **End Time:** | 15:13 | |
| **Pitot Coefficient:** | 0.840 | **Test Engineer:** | SMcG | **Test Tech:** JHK |
| **Probe Length, Feet:** | 4 | **Port Length, Inches:** | 6 | |

| Port | Point | DP (in. $H_2O$) | Sqrt. DP | Temp (°F) | Velocity (V) |
|---|---|---|---|---|---|
| A | 1 | 0.02 | 0.1414 | 375.0 | 10.04 |
| A | 2 | 0.02 | 0.1414 | 374.0 | 10.04 |
| A | 3 | 0.01 | 0.1000 | 371.0 | 7.09 |
| A | 4 | 0.01 | 0.1000 | 370.0 | 7.08 |
| A | 5 | 0.01 | 0.1000 | 364.0 | 7.06 |
| B | 1 | 0.03 | 0.1732 | 373.0 | 12.29 |
| B | 2 | 0.03 | 0.1732 | 373.0 | 12.29 |
| B | 3 | 0.02 | 0.1414 | 371.0 | 10.02 |
| B | 4 | 0.02 | 0.1414 | 369.0 | 10.01 |
| B | 5 | 0.02 | 0.1414 | 366.0 | 9.99 |
| C | 1 | 0.04 | 0.2000 | 374.0 | 14.20 |
| C | 2 | 0.04 | 0.2000 | 372.0 | 14.18 |
| C | 3 | 0.03 | 0.1732 | 371.0 | 12.27 |
| C | 4 | 0.02 | 0.1414 | 370.0 | 10.01 |
| C | 5 | 0.02 | 0.1414 | 367.0 | 10.00 |

| Port | Point | DP (in. $H_2O$) | Sqrt. DP | Temp (°F) | Velocity (V) |
|---|---|---|---|---|---|
| D | 1 | 0.03 | 0.1732 | 371.0 | 12.27 |
| D | 2 | 0.03 | 0.1732 | 371.0 | 12.27 |
| D | 3 | 0.02 | 0.1414 | 370.0 | 10.01 |
| D | 4 | 0.02 | 0.1414 | 368.0 | 10.00 |
| D | 5 | 0.01 | 0.1000 | 366.0 | 7.06 |
| E | 1 | 0.02 | 0.1414 | 371.0 | 10.02 |
| E | 2 | 0.02 | 0.1414 | 370.0 | 10.01 |
| E | 3 | 0.02 | 0.1414 | 369.0 | 10.01 |
| E | 4 | 0.01 | 0.1000 | 368.0 | 7.07 |
| E | 5 | 0.01 | 0.1000 | 365.0 | 7.06 |

**Test Parameters**

| | | | |
|---|---|---|---|
| $P_{bar}$ - Barometric pressure, inches Hg | 29.70 | % $CO_2$ | 9.60 |
| $P_g$ - Stack Pressure, inches of $H_2O$ | -0.10 | % $O_2$ | 11.20 |
| $P_s$ - Absolute stack pressure, inches Hg | 29.69 | % $N_2$ | 79.20 |
| $t_s$ - Average stack temperature, °F | 370.0 | Md - dry basis lb/lb mole | 29.98 |
| Duct Shape: | Rectangular | Ms - wet basis lb/lb mole | 28.750 |
| Length, Feet | 3.5 | | |
| Width, Feet | 5.5 | | |
| | | **Bws - Moisture content fraction** | 0.103 |
| Cross Sectional Area of Stack, $Ft^2$ | 19.25 | Moisture determined by wb/db (Y or N) | N |

**Method 2 Results**

| | | | |
|---|---|---|---|
| Average DP | 0.0212 | Q - ACFM | 11,656 |
| Average Sqrt DP | 0.1425 | Qsd - DSCFM | 6,601 |
| Average Velocity Vs (ft/sec) | 10.092 | Qs - SCFM | 7,359 |
| | | Qs - SCFH | 441,535 |


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# METHOD 4 MOISTURE DETERMINATION

| | | | | | |
|---|---|---|---|---|---|
| **Project Number:** | M144705 | **Run Number:** | 1 | | |
| **Client:** | University of Iowa | **Operating Level:** | Normal | (Normal) | |
| **Facility:** | Oakdale Renewable Energy Center | **Time:** | **Start-** 11:35 | **End-** 12:20 | |
| **Test Location:** | Hurst Boiler Exhaust Duct | **Test Engineer:** | SMcG | | |
| **Test Date:** | 11/5/2014 | **Test Tech:** | JHK | | |
| **Pressure, Barometric(Hg"):** | 29.70 | **Meter Calibration (Y):** | 1.001 | | |
| **Delta H:** | 1.512 | **Meter Delta H (dH):** | 1.512 | | |
| **Meter Initial Volume:** | 89.114 | **Initial Wt:** | 837.2 | | |
| **Meter Final Volume:** | 122.881 | **Final Wt:** | 853.1 | | |
| **Meter Temperature:** | 76.55 | **Initial Volume:** | 1928.6 | | |
| **Meter Volume dscf:** | 33.141 | **Final Volume:** | 1991.3 | | |
| | | **Water Vapor in Flue Gas (Bws):** | **0.100** | | |

| | | | | | |
|---|---|---|---|---|---|
| **Project Number:** | M144705 | **Run Number:** | 2 | | |
| **Client:** | University of Iowa | **Operating Level:** | Normal | (Normal) | |
| **Facility:** | Oakdale Renewable Energy Center | **Time:** | **Start-** 13:25 | **End-** 14:10 | |
| **Test Location:** | Hurst Boiler Exhaust Duct | **Test Engineer:** | SMcG | | |
| **Test Date:** | 11/5/2014 | **Test Tech:** | JHK | | |
| **Pressure, Barometric(Hg"):** | 29.70 | **Meter Calibration (Y):** | 1.001 | | |
| **Delta H:** | 1.512 | **Meter Delta H (dH):** | 1.512 | | |
| **Meter Initial Volume:** | 23.422 | **Initial Wt:** | 855.8 | | |
| **Meter Final Volume:** | 57.188 | **Final Wt:** | 863.3 | | |
| **Meter Temperature:** | 76.10 | **Initial Volume:** | 1980.0 | | |
| **Meter Volume dscf:** | 33.168 | **Final Volume:** | 2054.4 | | |
| | | **Water Vapor in Flue Gas (Bws):** | **0.104** | | |

| | | | | | |
|---|---|---|---|---|---|
| **Project Number:** | M144705 | **Run Number:** | 3 | | |
| **Client:** | University of Iowa | **Operating Level:** | Normal | (Normal) | |
| **Facility:** | Oakdale Renewable Energy Center | **Time:** | **Start-** 15:13 | **End-** 15:58 | |
| **Test Location:** | Hurst Boiler Exhaust Duct | **Test Engineer:** | SMcG | | |
| **Test Date:** | 11/5/2014 | **Test Tech:** | JHK | | |
| **Pressure, Barometric(Hg"):** | 29.70 | **Meter Calibration (Y):** | 1.001 | | |
| **Delta H:** | 1.512 | **Meter Delta H (dH):** | 1.512 | | |
| **Meter Initial Volume:** | 58.037 | **Initial Wt:** | 849.2 | | |
| **Meter Final Volume:** | 91.811 | **Final Wt:** | 856.9 | | |
| **Meter Temperature:** | 75.90 | **Initial Volume:** | 1965.0 | | |
| **Meter Volume dscf:** | 33.188 | **Final Volume:** | 2035.2 | | |
| | | **Water Vapor in Flue Gas (Bws):** | **0.100** | | |


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# Appendix G - Field Data Sheets


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# Isokinetic Sampling Cover Sheet

Test Engineer: SMcG
Test Technician: JHK

## Plant Information

Run Number: 1
Test Location: Hurst Boiler Exhaust Duct
Duct Shape: Circular or Rectangular
Flue Area: 19.250
Port Type: Flange
Test Method: 5/[illegible]

Date: 11/4/14
Client Name: University Iowa
Length: 3.5 Width: 5.5 or Diameter: 4.278 Equiv.
Upstream Diameters:
Port Length: 6"
Source Condition: Normal

Project Number: M144705
Plant Name: Oakdale
Downstream Diameters:
Port Diameter: 6"

## Meter and Probe Data

Meter ID: CM19
Pitot ID: 170
Nozzle Kit ID: Glass Misc.
Probe Length: 4'
Pre-Test Nozzle Leak Check: .00 @ 10 "Hg
Pre-Test Pitot Leak Check: ✓ @ 3.8 "$H_2O$

Meter Y Value: 1.001
Pitot Coefficient: .840
Nozzle Diameter: .551
Probe Liner: Glass

ΔH Value: 1.512
Train Type: Hot Box
Filter Number/Weight: 7670 / 0.4489
Thimble Number/Weight:
Post-Test Nozzle Leak Check: .00 @ 14 "Hg
Post-Test Pitot Leak Check: ✓ @ 3.6 "$H_2O$

## Traverse Data

Ports Sampled: 5
Total Points: 25

Points/Port: 5
Total Test Time: 125 min.

Min/Point: 5
Sample Plane: Horizontal or Vertical

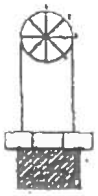
## Stack Parameters

Barometric Pressure: 29.65
$CO_2$ %: / / / Avg. 11.6
Imp and/or silica balance Model and S/N: 510-20
Initial Imp. Volume or Weight: 1973.9
Initial Silica Weight: 833.7

Static Pressure: -.1
$O_2$ %: / / / Avg. 8.9
Servomex Serial #: 4662-014401
Final Imp. Volume or Weight: 2194.9
Final Silica Weight: 862.6

Determined by: Method 3 or Method 3A
Imp. Volume or Weight Gain: 221.0
Silica Weight Gain: 28.9

Comments:

Post-Test Nozzle Verification:  1)____ 2)____ 3)____ 4)____

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# Isokinetic Sampling Field Data Sheet

| | | | | | |
|---|---|---|---|---|---|
| Project Number | M144705 | Date | 11-4-14 | Test Number | 1 |
| Client | University Iowa | Test Location | Hurst Boiler Exhaust Duct | Operator | SMCG Test Tech: JHK |
| Plant | Oakdale | Test Method | 5/[redacted] | Page Number | 1 of 1 |

| Port-Point #. | Time | (ΔP) | Orifice Setting (ΔH) | Meter Volume ($V_m$) $ft^3$, Actual | Square Root, ΔP | Meter Rate, Cubic Feet/ Min. | Theoretical Meter Volume, ($V_m$) $ft^3$, per point | Theoretical Meter Volume, ($V_m$) $ft^3$, total | Stack Temp, °F | Meter Temp Inlet, °F | Meter Temp Outlet, °F | Pump Vacuum, " Hg | Probe Temp. °F | Filter Temp. °F | Impinger Outlet Well Temp °F | CPM Filter Temp |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-1 | 8:35 | .02 | .82 | 48.115 | | | | | 356 | 72 | 71 | 5.5 | 250 | 248 | 65 | |
| 2 | 8:40 | .01 | .41 | 50.903 | | | | 50.891 | 359 | 72 | 71 | 4.0 | 252 | 250 | 62 | |
| 3 | 8:45 | .02 | .82 | 52.867 | | | | 52.850 | 356 | 72 | 71 | 5.5 | 251 | 250 | 60 | |
| 4 | 8:50 | .02 | .82 | 55.634 | | | | 55.626 | 357 | 74 | 72 | 5.5 | 251 | 250 | 61 | |
| 5 | 8:55 | .01 | .41 | 58.417 | | | | 58.409 | 353 | 74 | 72 | 4.0 | 250 | 252 | 61 | |
| | 9:00 | | | 60.403 | | | | 60.381 | | | | | | | | |
| 2-1 | 9:03 | .03 | 1.23 | 60.403 | | | | | 361 | 74 | 73 | 6.5 | 249 | 250 | 60 | |
| 2 | 9:08 | .03 | 1.23 | 63.816 | | | | 63.805 | 362 | 77 | 74 | 6.5 | 251 | 250 | 59 | |
| 3 | 9:13 | .03 | 1.24 | 67.225 | | | | 67.218 | 360 | 77 | 74 | 6.5 | 252 | 250 | 60 | |
| 4 | 9:18 | .03 | 1.24 | 70.629 | | | | 70.636 | 359 | 78 | 74 | 6.5 | 250 | 250 | 61 | |
| 5 | 9:23 | .02 | .83 | 74.069 | | | | 74.058 | 354 | 78 | 74 | 5.5 | 250 | 250 | 62 | |
| | 9:28 | | | 76.878 | | | | 76.861 | | | | | | | | |
| 3-1 | 9:40 | .04 | 1.64 | 76.878 | | | | | 364 | 77 | 75 | 7.5 | 252 | 249 | 60 | |
| 2 | 9:45 | .04 | 1.65 | 80.825 | | | | 80.818 | 363 | 78 | 75 | 7.5 | 251 | 250 | 61 | |
| 3 | 9:50 | .04 | 1.65 | 84.751 | | | | 84.764 | 362 | 78 | 75 | 7.5 | 250 | 250 | 61 | |
| 4 | 9:55 | .03 | 1.24 | 88.718 | | | | 88.712 | 360 | 78 | 76 | 6.5 | 250 | 250 | 62 | |
| 5 | 10:00 | .03 | 1.25 | 92.145 | | | | 92.136 | 352 | 79 | 75 | 6.5 | 251 | 250 | 62 | |
| | 10:05 | | | 95.588 | | | | 95.579 | | | | | | | | |
| 4-1 | 10:10 | .03 | 1.24 | 95.588 | | | | | 357 | 77 | 75 | 6.5 | 250 | 250 | 60 | |
| 2 | 10:15 | .04 | 1.65 | 99.019 | | | | 99.015 | 360 | 78 | 75 | 7.5 | 251 | 249 | 59 | |
| 3 | 10:20 | .03 | 1.24 | 102.981 | | | | 102.968 | 361 | 78 | 75 | 6.5 | 250 | 250 | 60 | |
| 4 | 10:25 | .03 | 1.24 | 106.394 | | | | 106.389 | 358 | 79 | 75 | 6.5 | 249 | 250 | 61 | |
| 5 | 10:30 | .02 | .83 | 109.838 | | | | 109.820 | 355 | 79 | 76 | 5.5 | 250 | 249 | 61 | |
| | 10:35 | | | 112.641 | | | | 112.629 | | | | | | | | |
| 5-1 | 10:40 | .03 | 1.24 | 112.641 | | | | | 360 | 77 | 76 | 6.5 | 250 | 250 | 61 | |
| 2 | 10:45 | .03 | 1.24 | 116.074 | | | | 116.065 | 360 | 78 | 76 | 6.5 | 250 | 250 | 61 | |
| 3 | 10:50 | .02 | .83 | 119.507 | | | | 119.491 | 357 | 78 | 76 | 5.5 | 249 | 250 | 62 | |
| 4 | 10:55 | .02 | .83 | 122.312 | | | | 122.294 | 356 | 79 | 76 | 5.5 | 250 | 250 | 62 | |
| 5 | 11:00 | .01 | .42 | 125.124 | | | | 125.102 | 354 | 79 | 76 | 4.0 | 249 | 250 | 63 | |
| | 11:05 | | | 127.106 | | | | 127.089 | | | | | | | | |

DS-005 M5 Isokinetic Field Data Sheet


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## IMPINGER WEIGHT SHEET

PLANT: UNIVERSITY OF IOWA

UNIT NO: HURST BOILER

LOCATION: EXHAUST DUCT

DATE: 11/4/14

TEST NO: 1

METHOD: 5

WEIGHED/MEASURED BY: DT

BALANCE ID: 510-10

| Circle One: | FINAL WEIGHT MLS / GRAMS | INITIAL WEIGHT MLS / GRAMS | IMPINGER GAIN | IMPINGER CONTENTS |
|---|---|---|---|---|
| IMPINGER 1 | 894.9 | 737.4 | | DI H2O |
| IMPINGER 2 | 780.5 | 735.3 | | DI H2O |
| IMPINGER 3 | 519.5 | 501.2 | | BLANK |
| IMPINGER 4 | 862.6 | 833.7 | 28.9 | SILICA |
| IMPINGER 5 | | | | |
| IMPINGER 6 | | | | |
| IMPINGER 7 | | | | |
| IMPINGER 8 | | | | |

| | FINAL TOTAL | INITIAL TOTAL | TOTAL IMPINGER GAIN |
|---|---|---|---|
| IMPINGERS | 2194.9 | 1973.9 | 221.0 |
| SILICA | 862.6 | 833.7 | 28.9 |

# Isokinetic Sampling Cover Sheet

Test Engineer: SMcG
Test Technician: JHK

## Plant Information

Run Number: 2
Test Location: Hurst Boiler Exhaust Duct
Duct Shape: Circular or Rectangular
Flue Area: 19.250
Port Type: Flange
Test Method: 5/~~[illegible]~~

Date: 11/4/14
Client Name: University Iowa
Length: 3.5 Width: 5.5 or Diameter: 4.278 Equiv.
Upstream Diameters:
Port Length: 6"
Source Condition: Normal

Project Number: M144705
Plant Name: Oakdale
Downstream Diameters:
Port Diameter: 6"

## Meter and Probe Data

Meter ID: CM19
Pitot ID: 170
Nozzle Kit ID: Glass Mix
Probe Length: 4'
Pre-Test Nozzle Leak Check: .00 @ 13 "Hg
Pre-Test Pitot Leak Check: ✓ @ 3.6 "$H_2O$

Meter Y Value: 1.001
Pitot Coefficient: .840
Nozzle Diameter: .551
Probe Liner: Glass
Post-Test Nozzle Leak Check: .00 @ 14 "Hg
Post-Test Pitot Leak Check: ✓ @ 3.4 "$H_2O$

ΔH Value: 1.512
Train Type: Hot Box
Filter Number/Weight: 7695 / 0.4479
Thimble Number/Weight:

## Traverse Data

Ports Sampled: 5
Total Points: 25

Points/Port: 5
Total Test Time: 125 min.

Min/Point: 5
Sample Plane: Horizontal or Vertical

## Stack Parameters

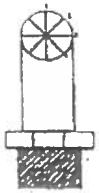
Barometric Pressure: 29.65
$CO_2$ %: / / / Avg. 11.4
Imp and/or silica balance Model and S/N:
Initial Imp. Volume or Weight: 2005.3
Initial Silica Weight: 848.0

Static Pressure: -.1
$O_2$ %: / / / Avg. 9.1
Final Imp. Volume or Weight: 2275.3
Final Silica Weight: 869.1

Determined by: Method 3 or Method 3A
Servomex Serial #: 4662-014001
Imp. Volume or Weight Gain: 270.0
Silica Weight Gain: 21.1

Comments:

Post-Test Nozzle Verification: 1)____ 2)____ 3)____ 4)____



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# Isokinetic Sampling Field Data Sheet

Project Number: M144705
Date: 11/4/14
Test Number: 2
Client: University Iowa
Test Location: Hurst Boiler Exhaust Duct
Operator: SMCG
Test Tech: JHK
Plant: Oakdale
Test Method: 5/~~[illegible]~~
Page Number: 1 of 1

| Port-Point #. | Time | (ΔP) | Orifice Setting (ΔH) | Meter Volume ($V_m$) $ft^3$, Actual | Square Root, ΔP | Meter Rate, Cubic Feet/ Min. | Theoretical Meter Volume, ($V_m$) $ft^3$, per point | Theoretical Meter Volume, ($V_m$) $ft^3$, total | Stack Temp, °F | Meter Temp Inlet, °F | Meter Temp Outlet, °F | Pump Vacuum, " Hg | Probe Temp. °F | Filter Temp. °F | Impinger Outlet Well Temp °F | CPM Filter Temp |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-1 | 11:30 | .02 | .83 | 27.642 | | | | | 364 | 73 | 73 | 4.0 | 251 | 251 | 59 | |
| 2 | 11:35 | .02 | .83 | 30.446 | | | | 30.433 | 367 | 73 | 72 | 4.0 | 250 | 250 | 55 | |
| 3 | 11:40 | .02 | .82 | 33.234 | | | | 33.216 | 368 | 73 | 72 | 4.0 | 250 | 250 | 55 | |
| 4 | 11:45 | .02 | .83 | 36.014 | | | | 35.998 | 368 | 75 | 72 | 4.0 | 250 | 250 | 57 | |
| 5 | 11:50 | .01 | .42 | 38.803 | | | | 38.785 | 359 | 75 | 73 | 3.0 | 250 | 250 | 57 | |
| | 11:55 | | | 40.779 | | | | 40.768 | | | | | | | | |
| 2-1 | 11:58 | .03 | 1.24 | 40.779 | | | | | 367 | 75 | 73 | 5.5 | 249 | 250 | 62 | |
| 2 | 12:03 | .04 | 1.65 | 44.210 | | | | 44.198 | 368 | 75 | 73 | 7.0 | 252 | 250 | 54 | |
| 3 | 12:08 | .03 | 1.24 | 48.158 | | | | 48.142 | 366 | 77 | 73 | 5.5 | 251 | 250 | 53 | |
| 4 | 12:13 | .03 | 1.25 | 51.580 | | | | 51.569 | 365 | 77 | 73 | 5.5 | 250 | 250 | 52 | |
| 5 | 12:18 | .02 | .84 | 55.014 | | | | 54.999 | 361 | 77 | 73 | 4.0 | 250 | 250 | 53 | |
| | 12:23 | | | 57.821 | | | | 57.805 | | | | | | | | |
| 3-1 | 12:26 | .04 | 1.66 | 57.821 | | | | | 366 | 76 | 73 | 7.0 | 249 | 250 | 55 | |
| 2 | 12:31 | .04 | 1.66 | 61.792 | | | | 61.774 | 367 | 77 | 73 | 7.0 | 252 | 250 | 53 | |
| 3 | 12:36 | .04 | 1.66 | 65.741 | | | | 65.729 | 366 | 77 | 74 | 7.0 | 250 | 250 | 52 | |
| 4 | 12:41 | .04 | 1.66 | 69.708 | | | | 69.690 | 369 | 78 | 74 | 7.0 | 250 | 250 | 53 | |
| 5 | 12:46 | .03 | 1.25 | 73.651 | | | | 73.647 | 364 | 78 | 74 | 5.5 | 250 | 250 | 54 | |
| | 12:51 | | | 77.098 | | | | 77.085 | | | | | | | | |
| 4-1 | 12:54 | .03 | 1.24 | 77.098 | | | | | 368 | 77 | 74 | 5.5 | 250 | 250 | 55 | |
| 2 | 12:59 | .03 | 1.24 | 80.518 | | | | 80.524 | 370 | 77 | 74 | 5.5 | 250 | 250 | 55 | |
| 3 | 13:04 | .03 | 1.24 | 83.959 | | | | 83.946 | 372 | 77 | 74 | 5.5 | 250 | 250 | 54 | |
| 4 | 13:09 | .03 | 1.24 | 87.382 | | | | 87.364 | 369 | 77 | 74 | 5.5 | 250 | 250 | 54 | |
| 5 | 13:14 | .02 | .83 | 90.798 | | | | 90.788 | 363 | 77 | 74 | 4.0 | 250 | 250 | 55 | |
| | 13:19 | | | 93.611 | | | | 93.594 | | | | | | | | |
| 5-1 | 13:22 | .02 | .87 | 93.611 | | | | | 330 | 76 | 74 | 4.0 | 250 | 250 | 57 | |
| 2 | 13:27 | .03 | 1.27 | 96.484 | | | | 96.472 | 353 | 77 | 74 | 5.5 | 250 | 250 | 56 | |
| 3 | 13:32 | .02 | .83 | 99.934 | | | | 99.930 | 369 | 77 | 74 | 4.0 | 249 | 250 | 56 | |
| 4 | 13:37 | .02 | .83 | 102.736 | | | | 102.725 | 370 | 78 | 74 | 4.0 | 250 | 250 | 57 | |
| 5 | 13:42 | .01 | .42 | 105.530 | | | | 105.522 | 364 | 78 | 74 | 3.0 | 249 | 250 | 58 | |
| | 13:47 | | | 107.518 | | | | 107.507 | | | | | | | | |

DS-005 M5 Isokinetic Field Data Sheet


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## IMPINGER WEIGHT SHEET

PLANT: UNIVERSITY OF IOWA

UNIT NO: HURST BOILER

LOCATION: EXHAUST DUCT

DATE: 11/4/14

TEST NO: 2

METHOD: 5

WEIGHED/MEASURED BY: DT

BALANCE ID: S10-10

| Circle One: | FINAL WEIGHT MLS / GRAMS | INITIAL WEIGHT MLS / GRAMS | IMPINGER GAIN | IMPINGER CONTENTS |
|---|---|---|---|---|
| IMPINGER 1 | 931.2 | 708.5 | | DI $H_2O$ |
| IMPINGER 2 | 721.6 | 682.5 | | DI $H_2O$ |
| IMPINGER 3 | 622.5 | 614.3 | | BLANK |
| IMPINGER 4 | 869.1 | 848.0 | | SILICA |
| IMPINGER 5 | | | | |
| IMPINGER 6 | | | | |
| IMPINGER 7 | | | | |
| IMPINGER 8 | | | | |

| | FINAL TOTAL | INITIAL TOTAL | TOTAL IMPINGER GAIN |
|---|---|---|---|
| IMPINGERS | 2275.3 | 2005.3 | 270 |
| SILICA | 869.1 | 848.0 | 21.1 |


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# Isokinetic Sampling Cover Sheet

Test Engineer: SMCG
Test Technician: JHK

## Plant Information

Run Number: 3
Test Location: Hurst Boiler Exhaust Duct
Duct Shape: Circular or Rectangular
Flue Area: 19.250
Port Type: Flange
Test Method: 5/~~[illegible]~~

Date: 11/4/14
Client Name: University Iowa
Length: 3.5 Width: 5.5 or Diameter: 4.278 Equiv.
Upstream Diameters:
Port Length: 6"
Source Condition: Normal

Project Number: M144705
Plant Name: Oakdale
Downstream Diameters:
Port Diameter: 6"

## Meter and Probe Data

Meter ID: CM19
Pitot ID: 170
Nozzle Kit ID: Glass Misc
Probe Length: 4'
Pre-Test Nozzle Leak Check: .00 @ 15 "Hg
Pre-Test Pitot Leak Check: ✓ @ 3.4 "$H_2O$

Meter Y Value: 1.001
Pitot Coefficient: .840
Nozzle Diameter: .551
Probe Liner: Glass

ΔH Value: 1.512
Train Type: Hot Box
Filter Number/Weight: 7669 / 0.4520
Thimble Number/Weight:
Post-Test Nozzle Leak Check: .00 @ 14 "Hg
Post-Test Pitot Leak Check: ✓ @ 3.4 "$H_2O$

## Traverse Data

Ports Sampled: 5
Total Points: 25

Points/Port: 5
Total Test Time: 125 min.

Min/Point: 5
Sample Plane: Horizontal or Vertical

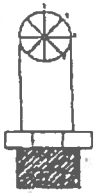
## Stack Parameters

Barometric Pressure: 29.65
$CO_2$ %: / / / Avg. 11.8
Imp and/or silica balance Model and S/N:
Initial Imp. Volume or Weight: 1932.6
Initial Silica Weight: 852.7

Static Pressure: -.1
$O_2$ %: / / / Avg. 8.8
Final Imp. Volume or Weight: 2189.6
Final Silica Weight: 871.4

Determined by: Method 3 or Method 3A
Servomex Serial #: 4622-014401
Imp. Volume or Weight Gain: 257.0
Silica Weight Gain: 18.7

Comments:

Post-Test Nozzle Verification:  1)____ 2)____ 3)____ 4)____

DS-004 Rev042809



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# Isokinetic Sampling Field Data Sheet

| | | | | | |
|---|---|---|---|---|---|
| Project Number | M144705 | Date | 11-4-14 | Test Number | 3 |
| Client | University Iowa | Test Location | Hurst Boiler Exhaust Duct | Operator: | SMCG Test Tech: JHK |
| Plant | Oakdale | Test Method | 5/[redacted] | Page Number: | 1 of 1 |

| Port-Point #. | Time | (ΔP) | Orifice Setting (ΔH) | Meter Volume ($V_m$) $ft^3$, Actual | Square Root, ΔP | Meter Rate, Cubic Feet/ Min. | Theoretical Meter Volume, ($V_m$) $ft^3$, per point | Theoretical Meter Volume, ($V_m$) $ft^3$, total | Stack Temp, °F | Meter Temp Inlet, °F | Meter Temp Outlet, °F | Pump Vacuum, " Hg | Probe Temp. °F | Filter Temp. °F | Impinger Outlet Well Temp °F | CPM Filter Temp |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-1 | 14:15 | .02 | .82 | 08.548 | | | | | 377 | 77 | 77 | 4.0 | 252 | 252 | 54 | |
| 2 | 14:20 | .02 | .82 | 11.347 | | | | 11.338 | 378 | 80 | 77 | 4.0 | 251 | 253 | 52 | |
| 3 | 14:25 | .02 | .82 | 14.149 | | | | 14.134 | 379 | 82 | 78 | 4.0 | 250 | 251 | 51 | |
| 4 | 14:30 | .02 | .83 | 16.952 | | | | 16.937 | 379 | 83 | 78 | 4.0 | 250 | 251 | 51 | |
| 5 | 14:35 | .01 | .42 | 19.756 | | | | 19.741 | 372 | 83 | 78 | 3.0 | 250 | 251 | 50 | |
| | 14:40 | | | 21.748 | | | | 21.733 | | | | | | | | |
| 2-1 | 14:43 | .03 | 1.24 | 21.748 | | | | | 378 | 81 | 79 | 5.5 | 249 | 251 | 58 | |
| 2 | 14:48 | .03 | 1.25 | 25.206 | | | | 25.182 | 375 | 84 | 80 | 5.5 | 253 | 253 | 50 | |
| 3 | 14:53 | .03 | 1.25 | 28.653 | | | | 28.635 | 375 | 85 | 80 | 5.5 | 250 | 252 | 50 | |
| 4 | 14:58 | .03 | 1.25 | 32.107 | | | | 32.091 | 373 | 85 | 80 | 5.5 | 249 | 251 | 51 | |
| 5 | 15:03 | .02 | .84 | 35.571 | | | | 35.552 | 371 | 86 | 81 | 4.0 | 250 | 250 | 51 | |
| | 15:08 | | | 38.393 | | | | 38.386 | | | | | | | | |
| 3-1 | 15:11 | .03 | 1.26 | 38.393 | | | | | 371 | 86 | 81 | 5.5 | 250 | 250 | 54 | |
| 2 | 15:16 | .04 | 1.67 | 41.854 | | | | 41.864 | 372 | 85 | 81 | 7.0 | 252 | 250 | 53 | |
| 3 | 15:21 | .04 | 1.67 | 45.882 | | | | 45.866 | 374 | 85 | 81 | 7.0 | 250 | 250 | 54 | |
| 4 | 15:26 | .03 | 1.25 | 49.878 | | | | 49.863 | 375 | 85 | 81 | 5.5 | 250 | 250 | 55 | |
| 5 | 15:31 | .02 | .84 | 53.338 | | | | 53.322 | 370 | 84 | 81 | 4.0 | 250 | 250 | 56 | |
| | 15:36 | | | 56.166 | | | | 56.153 | | | | | | | | |
| 4-1 | 15:39 | .03 | 1.25 | 56.166 | | | | | 374 | 83 | 81 | 5.5 | 252 | 250 | 54 | |
| 2 | 15:44 | .03 | 1.25 | 59.643 | | | | 59.621 | 375 | 83 | 80 | 5.5 | 251 | 250 | 53 | |
| 3 | 15:49 | .03 | 1.25 | 63.064 | | | | 63.071 | 374 | 83 | 80 | 5.5 | 250 | 250 | 53 | |
| 4 | 15:54 | .02 | .83 | 66.546 | | | | 66.523 | 374 | 83 | 80 | 4.0 | 249 | 250 | 54 | |
| 5 | 15:59 | .02 | .84 | 69.357 | | | | 69.341 | 369 | 84 | 80 | 4.0 | 250 | 250 | 55 | |
| | 16:04 | | | 72.190 | | | | 72.171 | | | | | | | | |
| 5-1 | 16:07 | .02 | .83 | 72.190 | | | | | 374 | 82 | 80 | 4.0 | 249 | 250 | 57 | |
| 2 | 16:12 | .03 | 1.25 | 75.013 | | | | 75.006 | 375 | 82 | 80 | 5.5 | 251 | 250 | 56 | |
| 3 | 16:17 | .02 | .83 | 78.472 | | | | 78.453 | 373 | 82 | 79 | 4.0 | 250 | 250 | 56 | |
| 4 | 16:22 | .02 | .83 | 81.284 | | | | 81.268 | 372 | 82 | 79 | 4.0 | 250 | 250 | 57 | |
| 5 | 16:27 | .01 | .42 | 84.103 | | | | 84.089 | 368 | 82 | 79 | 3.0 | 249 | 250 | 57 | |
| | 16:32 | | | 86.101 | | | | 86.081 | | | | | | | | |

DS-005 M5 Isokinetic Field Data Sheet


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## IMPINGER WEIGHT SHEET

PLANT: UNIVERSITY OF IOWA

UNIT NO: HURST BOILER

LOCATION: EXHAUST DUCT

DATE: 11/4/14

TEST NO: 3

METHOD: 5

WEIGHED/MEASURED BY: DT

BALANCE ID: 510-10

| Circle One: | FINAL WEIGHT MLS / GRAMS | INITIAL WEIGHT MLS / GRAMS | IMPINGER GAIN | IMPINGER CONTENTS |
|---|---|---|---|---|
| IMPINGER 1 | 932.8 | 713.4 | | DI H2O |
| IMPINGER 2 | 748.2 | 717.6 | | DI H2O |
| IMPINGER 3 | 508.6 | 501.6 | | BLANK |
| IMPINGER 4 | 871.4 | 852.7 | | SILICA |
| IMPINGER 5 | | | | |
| IMPINGER 6 | | | | |
| IMPINGER 7 | | | | |
| IMPINGER 8 | | | | |

| | FINAL TOTAL | INITIAL TOTAL | TOTAL IMPINGER GAIN |
|---|---|---|---|
| IMPINGERS | 2189.6 | 1932.6 | 257 |
| SILICA | 871.4 | 852.7 | 18.7 |


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M26

MULTI METHOD NON-ISOKINETIC FIELD DATA SHEET

Project Name/Number: University of Iowa Oakdale M144705 Date: 11-4-2014
Test Location: Hurst boiler exhaust duct Source Condition:
Test Method: 26 Meter ID: MM1 Pre-Calibration Date: 10-27-2014
Meter ΔH: N/A Meter Y: 0.998 Test Engineer: JHK

Test (Run) No. 1 Barometric Pressure ($P_{bar}$) 29.65 in. Hg
Static Pressure: -.1 Stack Temperature: (From Method Test Data)

Gas Sample Analysis
%$CO_2$ %$O_2$

| Clock Time 24 hour | Meter Volume ($V_m$) $ft^3$ or L (Circle One) | Meter Gage Pressure (ΔH) in. $H_2O$ | Meter ~~Inlet~~ Temp. ($t_m$) °F | Meter Outlet Temp. ($t_m$) °F | Impinger Outlet Temp °F | Meter Vacuum "Hg |
|---|---|---|---|---|---|---|
| 855 | 0.000 | 2.0 | 80 | | | 4 |
| 900 | 10.105 | | 80 | | | 4 |
| 905 | 20.239 | | 80 | | | 4 |
| 910 | 30.172 | | 80 | | | 4 |
| 915 | 40.163 | | 80 | | | 4 |
| 920 | 50.199 | | 80 | | | 4 |
| 925 | 60.076 | | 81 | | | 4 |
| 930 | 70.165 | | 81 | | | 3 |
| 935 | 80.206 | | 81 | | | 3 |
| 940 | 90.133 | | 81 | | | 3 |
| 945 | 100.153 | | 82 | | | 3 |
| 950 | 110.179 | | 82 | | | 3 |
| 955 | 122.293 | | 82 | | | 3 |
| | | | | | | |
| | | | | | | |
| Total Vol. in $ft^3$ ($V_m$)= | 4.319 | Multiply total volume collected in Liters by 0.035315 to convert to $ft^3$ | | | | |

Condensate
_____ mls ($V_f$)
- _____ mls ($V_i$)
= _____ mls gained

Silica Gel or Train
_____ grams ($W_f$)
- _____ grams ($W_i$)
= _____ grams gained

Average Meter Temperature: 80.77
(average of both inlet and outlet if applicable)

Comments:

Pre-Test Leak Check: 0 @ 10 "Hg
Post-Test Leak Check: 0 @ 10 "Hg

Test (Run) No. 2 Barometric Pressure ($P_{bar}$) 29.65 in. Hg
Static Pressure: -.1 Stack Temperature: (From Method Test Data)

Gas Sample Analysis
%$CO_2$ %$O_2$

| Clock Time 24 hour | Meter Volume ($V_m$) $ft^3$ or L (Circle One) | Meter Gage Pressure (ΔH) in. $H_2O$ | Meter ~~Inlet~~ Temp. ($t_m$) °F | Meter Outlet Temp. ($t_m$) °F | Impinger Outlet Temp °F | Meter Vacuum "Hg |
|---|---|---|---|---|---|---|
| 1200 | 0.000 | 2.0 | 78 | | | 2 |
| 1205 | 10.067 | | 78 | | | 2 |
| 1210 | 20.194 | | 78 | | | 2 |
| 1215 | 30.187 | | 78 | | | 2 |
| 1220 | 40.199 | | 79 | | | 2 |
| 1225 | 50.203 | | 79 | | | 2 |
| 1230 | 60.112 | | 79 | | | 2 |
| 1235 | 70.176 | | 79 | | | 2 |
| 1240 | 80.103 | | 79 | | | 2 |
| 1245 | 90.109 | | 79 | | | 2 |
| 1250 | 100.184 | | 79 | | | 2 |
| 1255 | 110.089 | | 79 | | | 2 |
| 1300 | 122.036 | | 79 | | | 2 |
| | | | | | | |
| | | | | | | |
| Total Vol. in $ft^3$ ($V_m$)= | 4.310 | Multiply total volume collected in Liters by 0.035315 to convert to $ft^3$ | | | | |

Condensate
_____ mls ($V_f$)
- _____ mls ($V_i$)
= _____ mls gained

Silica Gel or Train
_____ grams ($W_f$)
- _____ grams ($W_i$)
= _____ grams gained

Average Meter Temperature: 78.69
(average of both inlet and outlet if applicable)

Comments:

Pre-Test Leak Check: 0 @ 10 "Hg
Post-Test Leak Check: 0 @ 10 "Hg


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M26

MULTI METHOD NON-ISOKINETIC FIELD DATA SHEET

Project Name/Number: University of Iowa Oakdale M144705 Date: 11-4-2014
Test Location: Hurst boiler exhaust duct Source Condition:
Test Method: 26 Meter ID: MM1 Pre-Calibration Date: 10-27-2014
Meter ΔH: N/A Meter Y: 0.998 Test Engineer: JHK

Test (Run) No. 3 Barometric Pressure ($P_{bar}$) 29.65 in. Hg
Static Pressure: -.1 Stack Temperature: _____ (From Method _____ Test Data)

Gas Sample Analysis: _____ %$CO_2$ _____ %$O_2$

| Clock Time 24 hour | Meter Volume ($V_m$) ft³ or L (Circle One) | Meter Gage Pressure (ΔH) in. $H_2O$ | Meter ~~Inlet~~ Temp. ($t_m$) °F | Meter Outlet Temp. ($t_m$) °F | Impinger Outlet Temp °F | Meter Vacuum "Hg |
|---|---|---|---|---|---|---|
| 1443 | 0.000 | 2.0 | 85 | | | 2 |
| 1448 | 10.201 | | 85 | | | 2 |
| 1453 | 20.212 | | 85 | | | 2 |
| 1458 | 30.191 | | 86 | | | 2 |
| 1503 | 40.187 | | 86 | | | 2 |
| 1508 | 50.035 | | 86 | | | 2 |
| 1513 | 60.187 | | 86 | | | 2 |
| 1518 | 70.123 | | 87 | | | 2 |
| 1523 | 80.144 | | 87 | | | 2 |
| 1528 | 90.096 | | 87 | | | 2 |
| 1533 | 100.016 | | 87 | | | 2 |
| 1538 | 110.225 | | 87 | | | 2 |
| 1543 | 122.372 | | 87 | | | 2 |

Total Vol. in ft³ ($V_m$)= 4.321 Multiply total volume collected in Liters by 0.035315 to convert to ft³

Condensate: _____ mls ($V_f$) - _____ mls ($V_i$) = _____ mls gained

Silica Gel or Train: _____ grams ($W_f$) - _____ grams ($W_i$) = _____ grams gained

Average Meter Temperature: 86.23
(average of both inlet and outlet if applicable)

Comments:

Pre-Test Leak Check: 0 @ 10 "Hg
Post-Test Leak Check: _____ @ _____ "Hg

Test (Run) No. _____ Barometric Pressure ($P_{bar}$) _____ in. Hg
Static Pressure: _____ Stack Temperature: _____ (From Method _____ Test Data)

Gas Sample Analysis: _____ %$CO_2$ _____ %$O_2$

| Clock Time 24 hour | Meter Volume ($V_m$) ft³ or L (Circle One) | Meter Gage Pressure (ΔH) in. $H_2O$ | Meter Inlet Temp. ($t_m$) °F | Meter Outlet Temp. ($t_m$) °F | Impinger Outlet Temp °F | Meter Vacuum "Hg |
|---|---|---|---|---|---|---|
| | | | | | | |

Total Vol. in ft³ ($V_m$)= _____ Multiply total volume collected in Liters by 0.035315 to convert to ft³

Condensate: _____ mls ($V_f$) - _____ mls ($V_i$) = _____ mls gained

Silica Gel or Train: _____ grams ($W_f$) - _____ grams ($W_i$) = _____ grams gained

Average Meter Temperature: _____
(average of both inlet and outlet if applicable)

Comments:

Pre-Test Leak Check: _____ @ _____ "Hg
Post-Test Leak Check: _____ @ _____ "Hg


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# MERCURY SORBENT TRAP FIELD DATA SHEET

Project Name/Number: University Iowa / Oakdale / M144705
Sampling Location: Hurst Boiler Exhaust Duct
Run Number: 1
Date: 11-5-2014
Barometric Pressure: 29.70
Source Condition: Normal
Test Engineer: JHK
Dry Gas Meter No. MM5
Y = 1.012
Trap Number OL 210119

## Sample Train A

| Clock Time 24 hour | Stack Temp. °F | Sorbent Trap Temp. °F | Meter Temp. ($t_m$) °F | Meter Volume ($V_m$) liters | Meter Vacuum, Hg |
|---|---|---|---|---|---|
| 1135 | 368 | 360 | 80 | 0.000 | 12 |
| 1140 | 368 | 360 | 80 | 10.006 | 12 |
| 1145 | 368 | 360 | 80 | 20.145 | 12 |
| 1150 | 368 | 360 | 80 | 30.019 | 12 |
| 1155 | 368 | 362 | 81 | 40.023 | 12 |
| 1200 | 368 | 362 | 81 | 50.098 | 12 |
| 1205 | 369 | 362 | 81 | 60.064 | 12 |
| 1210 | 370 | 362 | 82 | 70.030 | 12 |
| 1215 | 370 | 364 | 82 | 80.198 | 13 |
| 1220 | 372 | 364 | 82 | 89.980 | 13 |
| 1225 | 374 | 367 | 83 | 100.012 | 13 |
| 1230 | 374 | 367 | 83 | 110.067 | 13 |
| 1235 | 377 | 370 | 84 | 120.111 | 14 |
| 1240 | 377 | 371 | 84 | 130.055 | 14 |
| ~~Total/Average~~ 1245 | 375 | 370 | 84 | 140.532 | |

(81.8)

Dry Gas Meter No. MM5B Y = 0.987 Trap Number OL 211390 Spike Value 25 ng

## Sample Train B

| Clock Time 24 hour | Stack Temp. °F | Sorbent Trap Temp. °F | Meter Temp. ($t_m$) °F | Meter Volume ($V_m$) liters | Meter Vacuum, Hg |
|---|---|---|---|---|---|
| 1135 | 368 | 360 | 81 | 0.000 | 13 |
| 1140 | 368 | 360 | 81 | 10.681 | 13 |
| 1145 | 368 | 360 | 81 | 20.790 | 13 |
| 1150 | 368 | 360 | 81 | 30.921 | 13 |
| 1155 | 368 | 362 | 82 | 40.996 | 14 |
| 1200 | 368 | 362 | 82 | 50.877 | 14 |
| 1205 | 369 | 362 | 82 | 61.172 | 14 |
| 1210 | 370 | 362 | 83 | 71.303 | 14 |
| 1215 | 370 | 364 | 83 | 81.514 | 15 |
| 1220 | 372 | 364 | 84 | 91.496 | 15 |
| 1225 | 374 | 367 | 84 | 101.424 | 15 |
| 1230 | 374 | 367 | 85 | 111.577 | 15 |
| 1235 | 377 | 370 | 85 | 121.678 | 15 |
| 1240 | 377 | 371 | 85 | 131.545 | 15 |
| ~~Total/Average~~ 1245 | 375 | 370 | 85 | 142.173 | |

(82.93)

Train A: Pre-Test Leak Check – Pass @ 25 ☐Hg
Post-Test Leak Check – Pass @ 25 ☐Hg

Train B: Pre-Test Leak Check – Pass @ 25 ☐Hg
Post-Test Leak Check – Pass @ 25 ☐Hg

| Average | | | | |
|---|---|---|---|---|
| | A | 371.07 | 364.07 | 81.80 |
| | B | 371.07 | 364.07 | 82.93 |

DS-021 Method 30B Hg Sorbent Trap


© Mostardi Platt

Trap ID

OL210119

OHIO LUMEX

# Sorbent Trap Chain of Custody

Plant/Source: _____ Test Location: HURST BOILER OUTLET DUCT

Boiler ID: _____ Trap (A) B (Circle One) Run 1

☒ **Unspiked** ☐ **Spiked At:** _____ QA/QC Signature (Trap Maker) _____

Certified Accuracy ± 10%, Traceable to NIST

Lot Number: U-187 QA/QC Signature (Spiker) _____

Spike Date: _____ Spike Time: _____

☐ High Flow ☐ Coil Pre-filter ☐ 240 mm
☐ Static Pre-filter ☐ AGS ☐ 300 mm
☐ Fluffy Pre-filter ☒ 185 mm ☐ 450 mm

Estimated Hg in Section 1: _____ ng

Sampled By: _____ Type of Trap: 30B

Test Start (Date/Time) _____ Leak Check Pass/Fail _____ Test End (Date/Time) _____ Leak Check Pass/Fail _____

| Date | Time | Duct Temp (°F or °C) | Sorbent Trap Temp (°F or °C) | Flow Rate (cc/min) | Dry Gas Meter Liters Initial | Dry Gas Meter Liters Final | Total Volume Pulled |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| Total/Average | | | | | | | |

Chain of Custody

Relinquished by Tech.: _____ Date: _____

Received by: _____ Date: _____

Relinquished by: _____ Date: _____

Received for Laboratory by: _____ Date: _____

**Make sure all of your sampling conditions prevent moisture condensation in the trap media. Moisture condensation is a major cause of breakthrough and spike loss in sorbent traps and should be prevented at all costs.**

For Analysis contact us:

Ohio Lumex Co., Inc. 9263 Ravenna Road Unit A-3, Twinsburg, OH 44087 USA

**Phone 330-405-0837 Fax 330-405-0847 US Toll Free: 888-876-2611**

Impregnated Activated Carbon – Refer to MSDS

Deactivated glass and glass wool

**Best Before: February 2016**


© Mostardi Platt

Trap ID

OL211390

OHIO LUMEX

# Sorbent Trap Chain of Custody

Plant/Source: _____ Test Location: HURST BOILER EXHAUST DUCT

Boiler ID: _____ Trap A (B) (Circle One) RUN (1)

☐ **Unspiked** ☒ **Spiked At:** 25ng QA/QC Signature (Trap Maker) [signature]

Certified Accuracy ± 10%, Traceable to NIST

Lot Number: S-262 QA/QC Signature (Spiker) [signature]

Spike Date: 4/25/2014 Spike Time: 0950

☐ High Flow ☐ Coil Pre-filter ☐ 240 mm
☐ Static Pre-filter ☐ AGS ☐ 300 mm
☐ Fluffy Pre-filter ☒ 185 mm ☐ 450 mm

Estimated Hg in Section 1: _____ ng

Sampled By: _____ Type of Trap: 30B

Test Start (Date/Time) _____ Leak Check Pass/Fail _____ Test End (Date/Time) _____ Leak Check Pass/Fail _____

| Date | Time | Duct Temp (°F or °C) | Sorbent Trap Temp (°F or °C) | Flow Rate (cc/min) | Dry Gas Meter Liters Initial | Dry Gas Meter Liters Final | Total Volume Pulled |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| Total/Average | | | | | | | |

## Chain of Custody

Relinquished by Tech.: _____ Date: _____

Received by: _____ Date: _____

Relinquished by: _____ Date: _____

Received for Laboratory by: _____ Date: _____

**Make sure all of your sampling conditions prevent moisture condensation in the trap media. Moisture condensation is a major cause of breakthrough and spike loss in sorbent traps and should be prevented at all costs.**

For Analysis contact us:
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**Phone 330-405-0837 Fax 330-405-0847 US Toll Free: 888-876-2611**

Impregnated Activated Carbon – Refer to MSDS

Deactivated glass and glass wool

**Best Before: April 2016**



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# MERCURY SORBENT TRAP FIELD DATA SHEET

Project Name/Number: University Iowa / Oakdale / M144705
Sampling Location: Hurst Boiler Exhaust Duct
Run Number: 2
Date: 11-5-2014
Barometric Pressure: 29.7
Source Condition: Normal
Test Engineer: JHK
Dry Gas Meter No. MM5 Y = 1.012
Trap Number OLC012446

## Sample Train A

| Clock Time 24 hour | Stack Temp. °F | Sorbent Trap Temp. °F | Meter Temp. ($t_m$) °F | Meter Volume ($V_m$) liters | Meter Vacuum, Hg |
|---|---|---|---|---|---|
| 1325 | 384 | 364 | 85 | 0.000 | 15 |
| 1330 | 384 | 364 | 85 | 10.227 | 15 |
| 1335 | 385 | 365 | 85 | 20.231 | 15 |
| 1340 | 385 | 365 | 85 | 30.202 | 15 |
| 1345 | 384 | 368 | 85 | 40.179 | 15 |
| 1350 | 385 | 370 | 85 | 50.032 | 15 |
| 1355 | 385 | 373 | 85 | 60.133 | 15 |
| 1400 | 385 | 375 | 85 | 70.072 | 15 |
| 1405 | 385 | 376 | 85 | 80.071 | 15 |
| 1410 | 385 | 377 | 85 | 90.110 | 15 |
| 1415 | 385 | 377 | 85 | 100.152 | 15 |
| 1420 | 385 | 378 | 85 | 110.178 | 15 |
| 1425 | 386 | 379 | 85 | 120.211 | 15 |
| 1430 | 386 | 379 | 85 | 130.133 | 15 |
| ~~Total/Average~~ 1435 | 388 | 379 | 85 | 140.464 | |

85

Dry Gas Meter No. MM5B Y = 0.987 Trap Number OL201242 Spike Value 25 ng

## Sample Train B

| Clock Time 24 hour | Stack Temp. °F | Sorbent Trap Temp. °F | Meter Temp. ($t_m$) °F | Meter Volume ($V_m$) liters | Meter Vacuum, Hg |
|---|---|---|---|---|---|
| 1325 | 384 | 364 | 87 | 0.000 | 13 |
| 1330 | 384 | 364 | 87 | 10.219 | 13 |
| 1335 | 385 | 365 | 87 | 20.163 | 13 |
| 1340 | 385 | 365 | 87 | 30.188 | 13 |
| 1345 | 384 | 368 | 87 | 40.040 | 13 |
| 1350 | 385 | 370 | 87 | 50.094 | 14 |
| 1355 | 385 | 372 | 87 | 60.063 | 14 |
| 1400 | 385 | 375 | 88 | 70.055 | 14 |
| 1405 | 385 | 376 | 87 | 80.132 | 14 |
| 1410 | 385 | 377 | 87 | 90.146 | 13 |
| 1415 | 385 | 377 | 87 | 100.158 | 13 |
| 1420 | 385 | 378 | 88 | 110.162 | 13 |
| 1425 | 386 | 379 | 88 | 120.209 | 13 |
| 1430 | 386 | 379 | 88 | 130.201 | 13 |
| ~~Total/Average~~ 1435 | 388 | 379 | 88 | 140.639 | |

87.3

Train A: Pre-Test Leak Check – Pass @ 25 ☐Hg
Post-Test Leak Check – Pass @ 25 ☐Hg
Train B: Pre-Test Leak Check – Pass @ 25 ☐Hg
Post-Test Leak Check – Pass @ 25 ☐Hg

DS-021 Method 30B Hg Sorbent Trap

| | | | | |
|---|---|---|---|---|
| Average | A | 385.13 | 372.60 | 85.0 |
| Total/Average | B | 385.13 | 372.60 | 87.33 |


© Mostardi Platt

Trap ID

OLC012446

OHIO LUMEX

Sorbent Trap Chain of Custody

Plant/Source: _____ Test Location: HURST BOILER EXHAUST DUCT

Boiler ID: _____ Trap (A) B (Circle One) RUN 2

☒ **Unspiked** ☐ **Spiked At:** _____ QA/QC Signature (Trap Maker) [signature]

Certified Accuracy ± 10%, Traceable to NIST

Lot Number: U-24C QA/QC Signature (Spiker) _____

Spike Date: _____ Spike Time: _____

☐ High Flow ☐ Coil Pre-filter ☐ 240 mm
☐ Static Pre-filter ☐ AGS ☐ 300 mm
☐ Fluffy Pre-filter ☒ 185 mm ☐ 450 mm

Estimated Hg in Section 1: _____ ng

Sampled By: _____ Type of Trap: 30B

Test Start (Date/Time) _____ Leak Check Pass/Fail _____ Test End (Date/Time) _____ Leak Check Pass/Fail _____

| Date | Time | Duct Temp (°F or °C) | Sorbent Trap Temp (°F or °C) | Flow Rate (cc/min) | Dry Gas Meter Liters Initial | Dry Gas Meter Liters Final | Total Volume Pulled |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| Total/Average | | | | | | | |

Chain of Custody

Relinquished by Tech.: _____ Date: _____

Received by: _____ Date: _____

Relinquished by: _____ Date: _____

Received for Laboratory by: _____ Date: _____

**Make sure all of your sampling conditions prevent moisture condensation in the trap media. Moisture condensation is a major cause of breakthrough and spike loss in sorbent traps and should be prevented at all costs.**

For Analysis contact us:
Ohio Lumex Co., Inc. 9263 Ravenna Road Unit A-3, Twinsburg, OH 44087 USA
**Phone 330-405-0837 Fax 330-405-0847 US Toll Free: 888-876-2611**

Impregnated Activated Carbon – Refer to MSDS
Deactivated glass and glass wool

**Best Before: July 2016**


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Trap ID

OL201242

OHIO LUMEX

# Sorbent Trap Chain of Custody

Plant/Source: _____ Test Location: HURST BOILER EXHAUST DUCT

Boiler ID: _____ Trap A (B) (Circle One) RUN (2)

☐ **Unspiked** ☒ **Spiked At:** 25ng QA/QC Signature (Trap Maker) [signature]

Certified Accuracy ± 10%, Traceable to NIST

Lot Number: S-265 QA/QC Signature (Spiker) [signature]

Spike Date: 4/25/2014 Spike Time: 1200

☐ High Flow ☐ Coil Pre-filter ☐ 240 mm
☐ Static Pre-filter ☐ AGS ☐ 300 mm
☐ Fluffy Pre-filter ☒ 185 mm ☐ 450 mm

Estimated Hg in Section 1: _____ ng

Sampled By: _____ Type of Trap: 30B

Test Start (Date/Time) _____ Leak Check Pass/Fail _____ Test End (Date/Time) _____ Leak Check Pass/Fail _____

| Date | Time | Duct Temp (°F or °C) | Sorbent Trap Temp (°F or °C) | Flow Rate (cc/min) | Dry Gas Meter Liters Initial | Dry Gas Meter Liters Final | Total Volume Pulled |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| Total/Average | | | | | | | |

Chain of Custody

Relinquished by Tech.: _____ Date: _____

Received by: _____ Date: _____

Relinquished by: _____ Date: _____

Received for Laboratory by: _____ Date: _____

**Make sure all of your sampling conditions prevent moisture condensation in the trap media. Moisture condensation is a major cause of breakthrough and spike loss in sorbent traps and should be prevented at all costs.**

For Analysis contact us:
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**Phone 330-405-0837 Fax 330-405-0847 US Toll Free: 888-876-2611**

Impregnated Activated Carbon – Refer to MSDS
Deactivated glass and glass wool

**Best Before: April 2016**


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# MERCURY SORBENT TRAP FIELD DATA SHEET

Project Name/Number: University Iowa / Oakdale / M144705 Run Number: 3
Sampling Location: Hurst Boiler Exhaust Duct Barometric Pressure: 29.70
Date: 11-5-2014 Test Engineer: JHK
Source Condition: Normal Trap Number: OL210456
Dry Gas Meter No. MM5 Y = 1.012

**Sample Train A**

| Clock Time 24 hour | Stack Temp. °F | Sorbent Trap Temp. °F | Meter Temp. ($t_m$) °F | Meter Volume ($V_m$) liters | Meter Vacuum, Hg |
|---|---|---|---|---|---|
| 1513 | 375 | 362 | 84 | 0.000 | 15 |
| 1518 | 375 | 362 | 84 | 11.551 | 15 |
| 1523 | 376 | 365 | 84 | 21.652 | 15 |
| 1528 | 376 | 365 | 84 | 31.543 | 15 |
| 1533 | 377 | 367 | 84 | 41.751 | 15 |
| 1538 | 379 | 368 | 84 | 51.715 | 15 |
| 1543 | 379 | 368 | 84 | 61.664 | 15 |
| 1548 | 379 | 369 | 84 | 71.606 | 15 |
| 1553 | 380 | 370 | 84 | 81.612 | 15 |
| 1558 | 380 | 371 | 84 | 91.619 | 15 |
| 1603 | 381 | 373 | 84 | 101.459 | 15 |
| 1608 | 381 | 373 | 84 | | 15 |
| 1613 | | | | | |
| 1618 | | | | | |
| Total/Average 1623 | | | | | |

Dry Gas Meter No. MM5B Y = 0.987 Trap Number OL211459 Spike Value 25 ng

**Sample Train B**

| Clock Time 24 hour | Stack Temp. °F | Sorbent Trap Temp. °F | Meter Temp. ($t_m$) °F | Meter Volume ($V_m$) liters | Meter Vacuum, Hg |
|---|---|---|---|---|---|
| 1513 | 375 | 362 | 87 | 0.000 | 14 |
| 1518 | 375 | 362 | 87 | 11.714 | 14 |
| 1523 | 376 | 365 | 87 | 21.789 | 14 |
| 1528 | 376 | 365 | 87 | 31.633 | 14 |
| 1533 | 377 | 367 | 87 | 41.697 | 14 |
| 1538 | 379 | 368 | 87 | 51.687 | 14 |
| 1543 | 379 | 368 | 87 | 61.599 | 14 |
| 1548 | 379 | 369 | 87 | 71.611 | 14 |
| 1553 | 380 | 370 | 87 | 81.501 | 14 |
| 1558 | 380 | 371 | 87 | 91.766 | 14 |
| 1603 | 381 | 373 | 87 | 101.810 | 14 |
| 1608 | 381 | 373 | 87 | | 14 |
| 1613 | | | | | 14 |
| 1618 | | | | | |
| Total/Average 1623 | | | | | |

Train A: Pre-Test Leak Check – Pass @ 25 ☐Hg
Post-Test Leak Check – Pass @ _____ ☐Hg

Train B: Pre-Test Leak Check – Pass @ _____ ☐Hg
Post-Test Leak Check – Pass @ _____ ☐Hg

DS-021 Method 30B Hg Sorbent Trap


© Mostardi Platt

Trap ID

OL210456

OHIO LUMEX

# Sorbent Trap Chain of Custody

Plant/Source: _____ Test Location: HURST BOILER EXHAUST OUT

Boiler ID: _____ Trap A B (Circle One) Test 3 NOT COMPLETED

☒ **Unspiked** ☐ **Spiked At:** _____ QA/QC Signature (Trap Maker) _____

Certified Accuracy ± 10%, Traceable to NIST

Lot Number: U-187 QA/QC Signature (Spiker) _____

Spike Date: _____ Spike Time: _____

☐ High Flow ☐ Coil Pre-filter ☐ 240 mm
☐ Static Pre-filter ☐ AGS ☐ 300 mm
☐ Fluffy Pre-filter ☒ 185 mm ☐ 450 mm

Estimated Hg in Section 1: _____ ng

Sampled By: _____ Type of Trap: 30B

Test Start (Date/Time) _____ Leak Check Pass/Fail _____ Test End (Date/Time) _____ Leak Check Pass/Fail _____

| Date | Time | Duct Temp (°F or °C) | Sorbent Trap Temp (°F or °C) | Flow Rate (cc/min) | Dry Gas Meter Liters Initial | Dry Gas Meter Liters Final | Total Volume Pulled |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| Total/Average | | | | | | | |

Chain of Custody

Relinquished by Tech.: _____ Date: _____

Received by: _____ Date: _____

Relinquished by: _____ Date: _____

Received for Laboratory by: _____ Date: _____

**Make sure all of your sampling conditions prevent moisture condensation in the trap media. Moisture condensation is a major cause of breakthrough and spike loss in sorbent traps and should be prevented at all costs.**

For Analysis contact us:
Ohio Lumex Co., Inc. 9263 Ravenna Road Unit A-3, Twinsburg, OH 44087 USA
**Phone 330-405-0837 Fax 330-405-0847 US Toll Free: 888-876-2611**

Impregnated Activated Carbon – Refer to MSDS
Deactivated glass and glass wool

**Best Before: February 2016**


© Mostardi Platt

Trap ID

OL211459

OHIO LUMEX

# Sorbent Trap Chain of Custody

Plant/Source: _____ Test Location: HURST BOILER EXHAUST DUCT

Boiler ID: _____ Trap A (B) (Circle One) Test 3 NOT COMPLETED

☐ **Unspiked** ☒ **Spiked At:** 25ng QA/QC Signature (Trap Maker) _____

Certified Accuracy ± 10%, Traceable to NIST

Lot Number: S-263 QA/QC Signature (Spiker) _____

Spike Date: 4/24/2014 Spike Time: 1600

☐ High Flow ☐ Coil Pre-filter ☐ 240 mm
☐ Static Pre-filter ☐ AGS ☐ 300 mm
☐ Fluffy Pre-filter ☒ 185 mm ☐ 450 mm

Estimated Hg in Section 1: _____ ng

Sampled By: _____ Type of Trap: 30B

Test Start (Date/Time) _____ Leak Check Pass/Fail _____ Test End (Date/Time) _____ Leak Check Pass/Fail _____

| Date | Time | Duct Temp (°F or °C) | Sorbent Trap Temp (°F or °C) | Flow Rate (cc/min) | Dry Gas Meter Liters Initial | Dry Gas Meter Liters Final | Total Volume Pulled |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| Total/Average | | | | | | | |

## Chain of Custody

Relinquished by Tech.: _____ Date: _____

Received by: _____ Date: _____

Relinquished by: _____ Date: _____

Received for Laboratory by: _____ Date: _____

**Make sure all of your sampling conditions prevent moisture condensation in the trap media. Moisture condensation is a major cause of breakthrough and spike loss in sorbent traps and should be prevented at all costs.**

For Analysis contact us:
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**Phone 330-405-0837 Fax 330-405-0847 US Toll Free: 888-876-2611**

Impregnated Activated Carbon – Refer to MSDS

Deactivated glass and glass wool

Best Before: April 2016


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# GAS TRAVERSE DATA

Project: M144705 UNIVERSITY OF IOWA

Location: HURST BOILER EXHAUST DUCT

Date: 11/05/14 Test No: 11 STRATIFICATION Time: 1135-1301

| Point No. | Time | $NO_x$ | $SO_2$ | CO | $CO_2$ | $O_2$ | |
|---|---|---|---|---|---|---|---|
| 1 - 1 | 1135-1137 | 64.0 | | 0.9 | 11.34 | 9.21 | 1137 |
| - 2 | 1138-1140 | 62.3 | | 0.3 | 11.12 | 9.40 | 1140 |
| - 3 | 1141-1143 | 51.3 | | 2.1 | 10.4 | 10.06 | 1143 |
| - 4 | 1144-1146 | 55.8 | | 0.3 | 10.02 | 10.56 | 1146 |
| | | | | | | | |
| | | | | | | | |
| 2 - 1 | 1155-1157 | 45.1 | | 4.7 | 10.83 | 9.68 | 1157 |
| - 2 | 1158-1200 | 46.3 | | 5.0 | 9.57 | 11.01 | 1200 |
| - 3 | 1201-1203 | 41.6 | | 1.4 | 9.97 | 10.59 | 1203 |
| - 4 | 1204-1206 | 33.5 | | 3.5 | 7.85 | 12.7 | 1206 |
| | | | | | | | |
| 3 - 1 | 1213-1215 | 66.0 | | 1.1 | 10.79 | 9.69 | 1215 |
| - 2 | 1216-1218 | 54.1 | | 0.3 | 9.78 | 10.14 | 1218 |
| - 3 | 1219-1221 | 33.1 | | 1.6 | 7.16 | 13.53 | 1221 |
| - 4 | 1222-1224 | 28.5 | | 1.9 | 6.65 | 14.14 | 1224 |
| | | | | | | | |
| | | | | | | | |
| 4 - 1 | 1232-1234 | 45.4 | | 3.8 | 10.98 | 9.55 | 1234 |
| - 2 | 1235-1237 | 47.1 | | 6.1 | 10.63 | 9.95 | 1237 |
| - 3 | 1238-1240 | 46.6 | | 3.1 | 8.03 | 12.56 | 1240 |
| - 4 | 1241-1243 | 40.5 | | 0.7 | 7.27 | 13.43 | 1243 |
| | | | | | | | |
| | | | | | | | |
| 5 - 1 | 1250-1252 | 31.8 | | 3.5 | 7.04 | 13.66 | 1252 |
| - 2 | 1253-1255 | 36.3 | | 3.2 | 8.32 | 12.19 | 1255 |
| - 3 | 1256-1258 | 34.5 | | 3.9 | 8.03 | 12.55 | 1258 |
| - 4 | 1259-1301 | 32.7 | | 3.6 | 7.82 | 12.75 | 1301 |

Data Taken By: DT/JHF


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# PART 60 GASEOUS FIELD DATA SHEET

Project Number: M144705
Client: UNIVERSITY OF IOWA
Test Location: HURST BOILER EXHAUST DUCT

Date: 11/5/14
Operator: DAN TUIGER
Fuel Factor: 9240

| | Time | | Reference Method Data | | | CO2% | Volumetric Flow Data | |
|---|---|---|---|---|---|---|---|---|
| Test | Start | End | $NO_X$ ppm | CO ppm | $O_2$ % | ~~Time~~ | scfh, RM Data | scfh, CEM Data |
| 1 | 1135 | 1301 | 45.8 | 3.0 | 11.23 | 9.36 | | |
| 2 | 1325 | 1448 | 43.5 | 5.9 | 10.94 | 9.61 | | |
| 3 | 1513 | | | | | | | |

| | Calibration Corrected RM Data | | | | CO2% | CEM Data | | |
|---|---|---|---|---|---|---|---|---|
| Test | $NO_X$ ppm | CO ppm | $O_2$ % | $NO_X$ lbs/MMBtu | ~~$NO_X$ ppm~~ | CO ppm | $O_2$ % | $NO_X$ lbs/MMBtu |
| 1 | 45.8 | 3.0 | 11.2 | | 9.3 | | | |
| 2 | 43.9 | 5.9 | 11.2 | | 9.6 | | | |
| 3 | | | | | | | | |


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# Volumetric Flow Rate Determination Field Data Sheet

Project Number: M144705
Client: Univ. Iowa / Oakdale
Test Location: Hurst Boiler Exhaust Duct
Source Condition: Normal
Test Engineer: SMcG

Date: 11-5-14
Test Number: (1) Pre-1
Start Time: 11:10
End Time: 11:23
Test Tech: JHK

Duct Diameter 4.278 ft
Flue Area 19.250 ft²
Port Length 6 "
$P_{bar}$ 29.7 "Hg
Static -.1 "$H_2O$
Static ____ "Hg
$P_s$ ____ "Hg

$CO_2$ % 9.3
$O_2$ % 11.2
$N_2$ % ____
Meter No. CM19

Upstream Disturbance, Diameters ____
Downstream Disturbance, Diameters ____
Pitot ID 091 Pitot Coefficient ($C_p$) .840
Wet Bulb Temp –
Dry Bulb Temp 367.8
$B_{ws}$ .100

Leak Checks
Pre ✓@ 3.5
Post ✓@ 3.7

| Port-Point # | ΔP | Temp. °F | $\sqrt{\Delta P}$ | Null Point Angle, Degrees | Port-Point # | ΔP | Temp. °F | $\sqrt{\Delta P}$ | Null Point Angle, Degrees |
|---|---|---|---|---|---|---|---|---|---|
| 1-1 | .02 | 370 | | | 4-1 | .03 | 370 | | |
| 2 | .02 | 370 | | | 2 | .03 | 369 | | |
| 3 | .02 | 369 | | | 3 | .02 | 369 | | |
| 4 | .01 | 368 | | | 4 | .02 | 367 | | |
| 5 | .01 | 361 | | | 5 | .02 | 364 | | |
| | | | | | | | | | |
| 2-1 | .02 | 371 | | | 5-1 | .02 | 370 | | |
| 2 | .02 | 370 | | | 2 | .02 | 369 | | |
| 3 | .02 | 370 | | | 3 | .01 | 368 | | |
| 4 | .01 | 367 | | | 4 | .01 | 366 | | |
| 5 | .02 | 363 | | | 5 | .01 | 360 | | |
| | | | | | | | | | |
| 3-1 | .04 | 371 | | | | | | | |
| 2 | .04 | 371 | | | | | | | |
| 3 | .03 | 370 | | | | | | | |
| 4 | .02 | 368 | | | | | | | |
| 5 | .02 | 364 | | | | | | | |
| Average | | | | | | | | | |

.44 x $CO_2$% + .32 x $O_2$% + .28 x $N_2$% = _____(Md)

(_____Md × _____1-Bws) + (18 ×_____Bws) = _____(Ms)

$$85.49 \times \_\_\_ Cp \times \sqrt{\frac{(\_\_\_\_\_)Ts\ °R}{\_\_\_ Ms \times \_\_\_ Ps}} \times \_\_\_ \sqrt{\Delta P} = \_\_\_ \text{ ft/sec } (Vs)$$

_____ Vs × _____ Flue Area × 60 = _____acfm

$$17.647 \times \_\_\_\_ \text{acfm} \times \frac{Ps}{Ts\ °R} = \_\_\_\_\_ \text{ scfm} \times 60 = \_\_\_\_\_ \text{ scfh}$$


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# Volumetric Flow Rate Determination Field Data Sheet

Project Number: M144705
Date: 11-5-14
Client: Univ. Iowa / Oakdale
Test Number: (2) Post-1 / Pre-2
Test Location: Hurst Boiler Exhaust Duct
Start Time: 13:06
Source Condition: Normal
End Time: 13:17
Test Engineer: SMCG
Test Tech: JHK

Duct Diameter 4.278 ft
Flue Area 19.250 ft²
Port Length 6 "
Upstream Disturbance, Diameters ____
Downstream Disturbance, Diameters ____
Pitot ID 091 Pitot Coefficient ($C_p$) .840

$P_{bar}$ 29.7 "Hg
Static -.1 "$H_2O$
Static ____ "Hg
$P_s$ ____ "Hg

$CO_2$ % 9.3
$O_2$ % 11.2
$N_2$ % ____
Meter No. CM19

Wet Bulb Temp ____
Dry Bulb Temp 367.6
$B_{ws}$ ____

Leak Checks
Pre ✓ @ 3.7
Post ✓ @ 3.8

| Port-Point # | ΔP | Temp. °F | $\sqrt{\Delta P}$ | Null Point Angle, Degrees | Port-Point # | ΔP | Temp. °F | $\sqrt{\Delta P}$ | Null Point Angle, Degrees |
|---|---|---|---|---|---|---|---|---|---|
| 1-1 | .02 | 368 | | | 4-1 | .03 | 368 | | |
| 2 | .02 | 369 | | | 2 | .03 | 370 | | |
| 3 | .01 | 367 | | | 3 | .02 | 369 | | |
| 4 | .01 | 367 | | | 4 | .02 | 368 | | |
| 5 | .01 | 363 | | | 5 | .01 | 366 | | |
| | | | | | | | | | |
| 2-1 | .03 | 369 | | | 5-1 | .02 | 368 | | |
| 2 | .02 | 369 | | | 2 | .02 | 369 | | |
| 3 | .02 | 368 | | | 3 | .02 | 369 | | |
| 4 | .01 | 366 | | | 4 | .01 | 367 | | |
| 5 | .02 | 363 | | | 5 | .01 | 364 | | |
| | | | | | | | | | |
| 3-1 | .04 | 370 | | | | | | | |
| 2 | .04 | 371 | | | | | | | |
| 3 | .03 | 369 | | | | | | | |
| 4 | .01 | 368 | | | | | | | |
| 5 | .03 | 365 | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| Average | | | | | | | | | |

.44 x $CO_2$% + .32 x $O_2$% + .28 x $N_2$% = _____(Md)

(_____Md × _____1-Bws) + (18 ×_____Bws) = _____(Ms)

$$85.49 \times \_\_\_\_ Cp \times \sqrt{\frac{(\_\_\_\_\_)Ts\ °R}{\_\_\_\_ Ms \times \_\_\_\_ Ps}} \times \_\_\_\_ \sqrt{\Delta P} = \_\_\_\_ \text{ ft/sec } (Vs)$$

_____ Vs × _____ Flue Area × 60 = _____acfm

$$17.647 \times \_\_\_\_ acfm \times \frac{Ps}{Ts\ °R} = \_\_\_\_\_ scfm \times 60 = \_\_\_\_\_ scfh$$

# Volumetric Flow Rate Determination Field Data Sheet

Project Number: M144705
Date: 11-5-14
Client: Univ. Iowa / Oakdale
Test Number: (3) Post-2 / Pre-3
Test Location: Hurst Boiler Exhaust Duct
Start Time: 15:01
Source Condition: Normal
End Time: 15:13
Test Engineer: SMcG
Test Tech: JHK

Duct Diameter 4.278 ft
Flue Area 19.250 ft²
Port Length 6 "
$P_{bar}$ 29.7 "Hg
Static -.1 "$H_2O$
Static _____ "Hg
$P_s$ _____ "Hg

$CO_2$ % 9.6
$O_2$ % 11.2
$N_2$ % _____
Meter No. CM19

Upstream Disturbance, Diameters _____
Downstream Disturbance, Diameters _____
Pitot ID 091 Pitot Coefficient ($C_p$) .840
Wet Bulb Temp _____
Dry Bulb Temp _____
$B_{ws}$ .104

Leak Checks
Pre ✓0.28
Post ✓0.37

| Port-Point # | ΔP | Temp. °F | $\sqrt{\Delta P}$ | Null Point Angle, Degrees | Port-Point # | ΔP | Temp. °F | $\sqrt{\Delta P}$ | Null Point Angle, Degrees |
|---|---|---|---|---|---|---|---|---|---|
| 1-1 | .02 | 375 | | | 4-1 | .03 | 371 | | |
| 2 | .02 | 374 | | | 2 | .03 | 371 | | |
| 3 | .01 | 371 | | | 3 | .02 | 370 | | |
| 4 | .01 | 370 | | | 4 | .02 | 368 | | |
| 5 | .01 | 364 | | | 5 | .01 | 366 | | |
| | | | | | | | | | |
| 2-1 | .03 | 373 | | | 5-1 | .02 | 371 | | |
| 2 | .03 | 373 | | | 2 | .02 | 370 | | |
| 3 | .02 | 371 | | | 3 | .02 | 369 | | |
| 4 | .02 | 369 | | | 4 | .01 | 368 | | |
| 5 | .02 | 366 | | | 5 | .01 | 365 | | |
| | | | | | | | | | |
| 3-1 | .04 | 374 | | | | | | | |
| 2 | .04 | 372 | | | | | | | |
| 3 | .03 | 371 | | | | | | | |
| 4 | .02 | 370 | | | | | | | |
| 5 | .02 | 367 | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| Average | | | | | | | | | |

.44 x $CO_2$% + .32 x $O_2$% + .28 x $N_2$% = _____(Md)

(_____Md × _____1-Bws) + (18 ×_____Bws) = _____(Ms)

$$85.49 \times \_\_\_Cp \times \sqrt{\frac{(\_\_\_\_\_)Ts\ °R}{\_\_\_Ms \times \_\_\_Ps}} \times \_\_\_ \sqrt{\Delta P} = \_\_\_ \text{ ft/sec } (Vs)$$

_____ Vs × _____ Flue Area × 60 = _____acfm

$$17.647 \times \_\_\_\_acfm \times \frac{Ps}{Ts\ °R} = \_\_\_\_\_ \text{ scfm} \times 60 = \_\_\_\_\_ \text{ scfh}$$


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# MOISTURE FIELD DATA SHEET

Project Name/Number: University Iowa/Oakdale/M144705 Date: 11-5-14
Test Location: Hurst Boiler Exhaust Duct Source Condition: Normal
Test Method: 4 Meter ID: CM19 Pre-Calibration Date:
Meter ΔH: 1.512 Meter Y: 1.001 Test Engineer: SMCG

Test (Run) No. 1 Barometric Pressure ($P_{bar}$) 29.7 in. Hg
Static Pressure: -.1 Stack Temperature: 367.8 (From Method ____ Test Data)

Gas Sample Analysis: 9.3 %$CO_2$ 11.2 %$O_2$

| Clock Time 24 hour | Meter Volume (Vm) ft3 or L (Circle One) | Meter Gage Pressure (ΔH) in. $H_2O$ | Meter Inlet Temp. ($t_m$) °F | Meter Outlet Temp. ($t_m$) °F | Impinger Outlet Temp °F | Meter Vacuum "Hg |
|---|---|---|---|---|---|---|
| 11:35 | 89.114 | 1.5 | 75 | 74 | 63 | 7.0 |
| 11:40 | 92.879 | | 74 | 74 | 55 | 7.0 |
| 11:45 | 96.609 | | 75 | 75 | 59 | 7.0 |
| 11:50 | 100.352 | | 76 | 75 | 60 | 7.0 |
| 11:55 | 104.106 | | 78 | 75 | 60 | 7.0 |
| 12:00 | 107.858 | | 79 | 76 | 61 | 7.0 |
| 12:05 | 111.629 | | 80 | 76 | 62 | 7.0 |
| 12:10 | 115.382 | | 80 | 76 | 62 | 7.0 |
| 12:15 | 119.130 | | 80 | 76 | 63 | 7.0 |
| 12:20 | 122.881 | | 81 | 76 | 63 | 7.0 |
| Total Vol. in ft3 (Vm)= | 33.767 | Multiply total volume collected in Liters by 0.035315 to convert to $ft^3$ | | | | |

Condensate: 1991.3/ ____ / ____ mls ($V_f$); -1928.6 ____ / ____ mls ($V_i$); = 62.7 mls gained

Silica Gel or Train: 853.1 grams ($W_f$); -837.2 grams ($W_i$); = 15.9 grams gained

Average Meter Temperature: 76.55
(average of both inlet and outlet if applicable)

BWS .100

Comments:

Pre-Test Leak Check: .00 @ 15 "Hg
Post-Test Leak Check: .00 @ 15 "Hg

Test (Run) No. 2 Barometric Pressure ($P_{bar}$) 29.7 in. Hg
Static Pressure: -.1 Stack Temperature: 367.6 (From Method ____ Test Data)

Gas Sample Analysis: 9.3 %$CO_2$ 11.2 %$O_2$

| Clock Time 24 hour | Meter Volume (Vm) ft3 or L (Circle One) | Meter Gage Pressure (ΔH) in. $H_2O$ | Meter Inlet Temp. ($t_m$) °F | Meter Outlet Temp. ($t_m$) °F | Impinger Outlet Temp °F | Meter Vacuum "Hg |
|---|---|---|---|---|---|---|
| 13:25 | 23.422 | 1.5 | 74 | 74 | 44 | 4.0 |
| 13:30 | 27.183 | | 74 | 75 | 44 | 4.0 |
| 13:35 | 30.937 | | 75 | 75 | 45 | 4.0 |
| 13:40 | 34.691 | | 76 | 75 | 45 | 4.0 |
| 13:45 | 38.443 | | 77 | 75 | 46 | 4.0 |
| 13:50 | 42.190 | | 78 | 75 | 47 | 4.0 |
| 13:55 | 45.936 | | 79 | 75 | 49 | 4.0 |
| 14:00 | 49.684 | | 80 | 75 | 49 | 4.0 |
| 14:05 | 53.441 | | 80 | 75 | 50 | 4.0 |
| 14:10 | 57.188 | | 80 | 75 | 51 | 4.0 |
| Total Vol. in $ft^3$ ($V_m$)= | 33.766 | Multiply total volume collected in Liters by 0.035315 to convert to $ft^3$ | | | | |

Condensate: 2054.4/ ____ / ____ mls ($V_f$); -1980.0 ____ / ____ mls ($V_i$); = 74.4 mls gained

Silica Gel or Train: 863.3 grams ($W_f$); -855.8 grams ($W_i$); = 7.5 grams gained

Average Meter Temperature: 76.10
(average of both inlet and outlet if applicable)

BWS .104

Comments:

Pre-Test Leak Check: .00 @ 14 "Hg
Post-Test Leak Check: .00 @ 16 "Hg


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# MOISTURE FIELD DATA SHEET

Project Name/Number: University Iowa/Oakdale/M144705 Date: 11-5-14
Test Location: Hurst Boiler Exhaust Duct Source Condition: Normal
Test Method: 4 Meter ID: CM19 Pre-Calibration Date:
Meter ΔH: 1.512 Meter Y: 1.001 Test Engineer: SMCG

Test (Run) No. 3 Barometric Pressure ($P_{bar}$) 29.7 in. Hg
Static Pressure: -.1 Stack Temperature: 370.0 (From Method ____ Test Data)

Gas Sample Analysis: 9.6 %$CO_2$ 11.2 %$O_2$

| Clock Time 24 hour | Meter Volume (Vm) ft3 or L (Circle One) | Meter Gage Pressure (ΔH) in. $H_2O$ | Meter Inlet Temp. ($t_m$) °F | Meter Outlet Temp. ($t_m$) °F | Impinger Outlet Temp °F | Meter Vacuum "Hg |
|---|---|---|---|---|---|---|
| 15:13 | 58.037 | 1.5 | 74 | 74 | 58 | 4.5 |
| 15:18 | 61.798 | | 75 | 74 | 53 | 4.5 |
| 15:23 | 65.549 | | 75 | 74 | 54 | 4.5 |
| 15:28 | 69.303 | | 76 | 75 | 54 | 4.5 |
| 15:33 | 73.050 | | 77 | 75 | 54 | 4.5 |
| 15:38 | 76.811 | | 78 | 75 | 55 | 4.5 |
| 15:43 | 80.547 | | 79 | 75 | 55 | 4.5 |
| 15:48 | 84.305 | | 79 | 75 | 56 | 4.5 |
| 15:53 | 88.052 | | 79 | 75 | 56 | 4.5 |
| 15:58 | 91.811 | | 79 | 75 | 56 | 4.5 |
| Total Vol. in ft3 (Vm)= | 33.774 | Multiply total volume collected in Liters by 0.035315 to convert to $ft^3$ | | | | |

Condensate: 2035.2 / ____ / ____ mls ($V_f$) − 1965.0 / ____ / ____ mls ($V_i$) = 70.2 mls gained

Silica Gel or Train: 856.9 grams ($W_f$) − 849.2 grams ($W_i$) = 7.7 grams gained

Average Meter Temperature: 75.9
(average of both inlet and outlet if applicable)

BWS .100

Comments:

Pre-Test Leak Check: .00 @ 13 "Hg
Post-Test Leak Check: .00 @ 13 "Hg

Test (Run) No. ____ Barometric Pressure ($P_{bar}$) ____ in. Hg
Static Pressure: ____ Stack Temperature: ____ (From Method ____ Test Data)

Gas Sample Analysis: ____ %$CO_2$ ____ %$O_2$

| Clock Time 24 hour | Meter Volume (Vm) ft3 or L (Circle One) | Meter Gage Pressure (ΔH) in. $H_2O$ | Meter Inlet Temp. ($t_m$) °F | Meter Outlet Temp. ($t_m$) °F | Impinger Outlet Temp °F | Meter Vacuum "Hg |
|---|---|---|---|---|---|---|
| Total Vol. in $ft^3$ ($V_m$)= | | Multiply total volume collected in Liters by 0.035315 to convert to $ft^3$ | | | | |

Condensate: ____ / ____ / ____ mls ($V_f$) − ____ / ____ / ____ mls ($V_i$) = ____ mls gained

Silica Gel or Train: ____ grams ($W_f$) − ____ grams ($W_i$) = ____ grams gained

Average Meter Temperature: ____
(average of both inlet and outlet if applicable)

Comments:

Pre-Test Leak Check: ____ @ ____ "Hg
Post-Test Leak Check: ____ @ ____ "Hg


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## IMPINGER WEIGHT SHEET

PLANT: UNIVERSITY OF IOWA

UNIT NO: HURST BOILER

LOCATION: EXHAUST DUCT

DATE: 11/5/14

TEST NO: 1

METHOD: 4

WEIGHED/MEASURED BY: DT

BALANCE ID: S10-10

| Circle One: | FINAL WEIGHT MLS / GRAMS | INITIAL WEIGHT MLS / GRAMS | IMPINGER GAIN | IMPINGER CONTENTS |
|---|---|---|---|---|
| IMPINGER 1 | 754.3 | 710.3 | | DI H2O |
| IMPINGER 2 | 704.3 | 715.7 | | DI H2O |
| IMPINGER 3 | 532.7 | 502.6 | | BLANK |
| IMPINGER 4 | 853.1 | 837.2 | 15.9 | SILICA |
| IMPINGER 5 | | | | |
| IMPINGER 6 | | | | |
| IMPINGER 7 | | | | |
| IMPINGER 8 | | | | |

| | FINAL TOTAL | INITIAL TOTAL | TOTAL IMPINGER GAIN |
|---|---|---|---|
| IMPINGERS | 1991.3 | 1928.6 | 62.7 |
| SILICA | 853.1 | 837.2 | 15.9 |


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## IMPINGER WEIGHT SHEET

PLANT: UNIVERSITY OF IOWA

UNIT NO: HURST BOILER

LOCATION: EXHAUST DUCT

DATE: 11/5/14

TEST NO: 2

METHOD: 4

WEIGHED/MEASURED BY: DT

BALANCE ID: S10-10

| Circle One: | FINAL WEIGHT MLS / GRAMS | INITIAL WEIGHT MLS / GRAMS | IMPINGER GAIN | IMPINGER CONTENTS |
|---|---|---|---|---|
| IMPINGER 1 | 759.2 | 699.5 | | DI H2O |
| IMPINGER 2 | 677.1 | 665.0 | | DI H2O |
| IMPINGER 3 | 618.1 | 615.5 | | BLANK |
| IMPINGER 4 | 863.3 | 855.8 | | SILICA |
| IMPINGER 5 | | | | |
| IMPINGER 6 | | | | |
| IMPINGER 7 | | | | |
| IMPINGER 8 | | | | |

| | FINAL TOTAL | INITIAL TOTAL | TOTAL IMPINGER GAIN |
|---|---|---|---|
| IMPINGERS | 2054.4 | ~~2831~~980.0 | 74.4 |
| SILICA | 863.3 | 855.8 | 7.5 |


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## IMPINGER WEIGHT SHEET

PLANT: UNIVERSITY OF IOWA

UNIT NO: HURST BOILER

LOCATION: EXHAUST DUCT

DATE: 11/5/14

TEST NO: 3

METHOD: 4

WEIGHED/MEASURED BY: DT

BALANCE ID: 510-10

| Circle One: | FINAL WEIGHT MLS / GRAMS | INITIAL WEIGHT MLS / GRAMS | IMPINGER GAIN | IMPINGER CONTENTS |
|---|---|---|---|---|
| IMPINGER 1 | 811.4 | 754.3 | | DI H2O |
| IMPINGER 2 | 715.3 | 704.3 | | DI H2O |
| IMPINGER 3 | 508.5 | 506.4 | | BLANK |
| IMPINGER 4 | 856.9 | 849.2 | | SILICA |
| IMPINGER 5 | | | | |
| IMPINGER 6 | | | | |
| IMPINGER 7 | | | | |
| IMPINGER 8 | | | | |

| | FINAL TOTAL | INITIAL TOTAL | TOTAL IMPINGER GAIN |
|---|---|---|---|
| IMPINGERS | 2035.2 | 1965 | 70.2 |
| SILICA | 856.9 | 849.2 | 7.7 |



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# Appendix H - Calibration Data


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# MOSTARDI PLATT

## Procedures for Calibration

### Dry Gas Meters

The test meters are calibrated according to Method 5, Section 5.3 and "Procedures for Calibrating and Using Dry Gas Volume Meters as Calibration Standards" by P.R. Westlin and R.T. Shigehara, March 10, 1978.

### Analytical Balance

The accuracy of the analytical balance is checked with Class S, Stainless Steel Type 303 weights manufactured by F. Hopken and Son, Jersey City, New Jersey.

### Temperature Sensing Devices

The potentiometer and thermocouples are calibrated utilizing a NBS traceable millivolt source.

### Nozzles

The nozzles are measured according to Method 5, Section 5.1.

### Pitot Tubes

The pitot tubes used during this test program are fabricated according to the specification described and illustrated in the Code of Federal Regulations, Title 40, Part 60, Appendix A, Methods 1 through 5 as published in the Federal Register, Volume 42, No. 160; hereafter referred to by the appropriate method number. The pitot tubes comply with the alignment specifications in Method 2, Section 4; and the pitot tube assemblies are in compliance with specifications in the same section.


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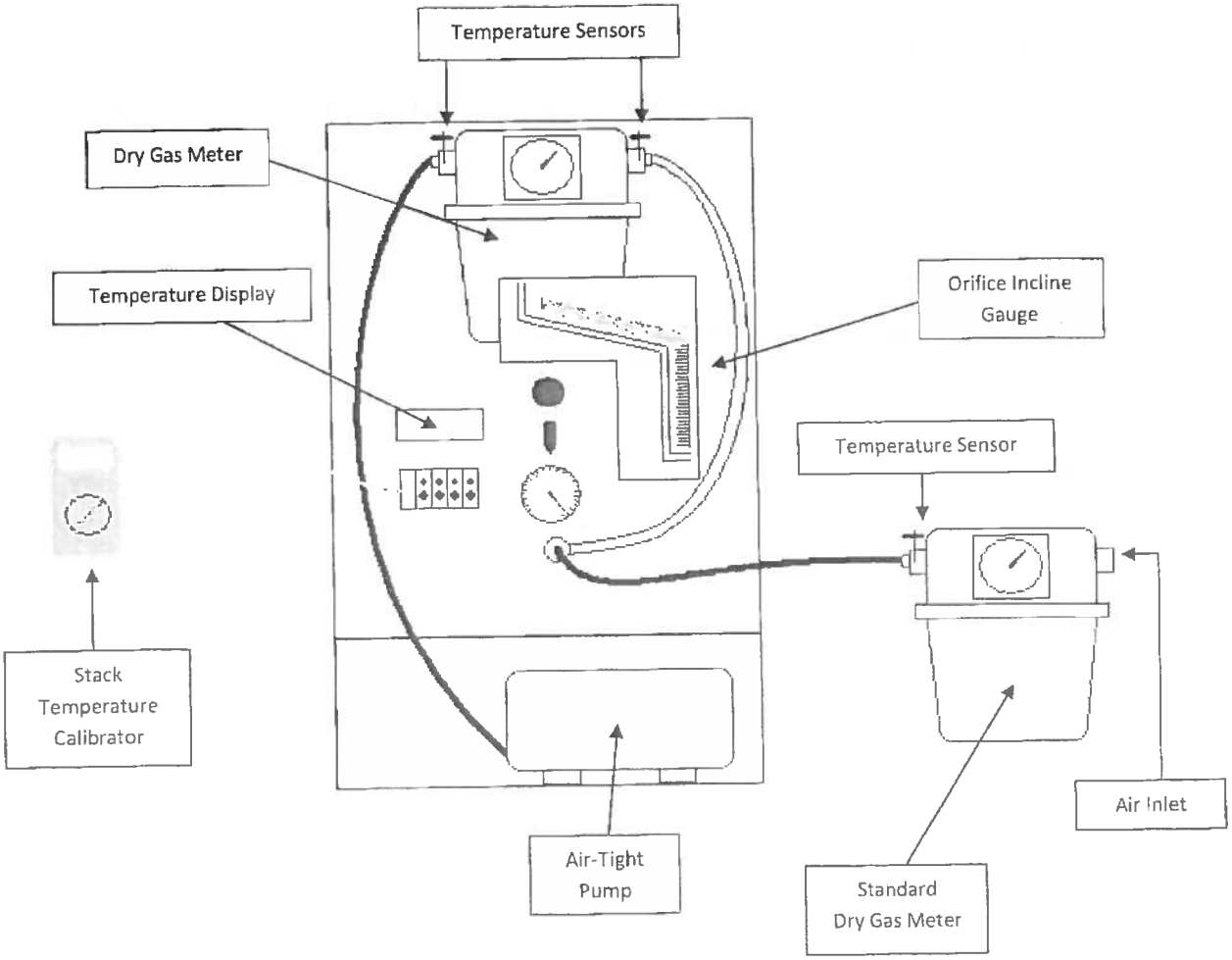
# Dry Gas Meter/Control Module Calibration Diagram





© Mostardi Platt

# METER CALIBRATION

| Meter Information | | | | | |
|---|---|---|---|---|---|
| Console Model | XC-260 | Dry Gas Meter Number | M5 A | Encoder Model | HEDS-9100-F00 |
| Gas Meter Model | SK25 | Totalizer Scale Factor (Initial) | 1.0000 | Totalizer Model | RED LION |
| | | Totalizer Scale Factor (Final) | 1.0123 | Temp Display Model | JENCO |

| Calibration Conditions | | | | | | | |
|---|---|---|---|---|---|---|---|
| WTM ID | 15340981 | Calibration Technician | AMH | | | Calibration Date | 27-Oct-14 |
| WTM Cal Factor | 1.0055 | Barometric Pressure | (Pb) | 738.03939 | mm Hg | | |

| Calibration Data | | | | | | | | | | | Results | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Run Time | | Dry Gas Meter | | Wet Test Meter | | Standardized Volumes | | | | Totalizer Gamma | Totalizer Gamma | Meter Gamma | | Corrected Flowrate |
| | Elapsed | | Gas Temp | Totalizer Display | Gas Volume | Gas Temp | Totalizer Initial SF | Totalizer Final SF | Dry Gas Meter | Wet Test Meter | Initial | Variation | DGM Display | Variation | |
| | (Θ) | | ($t_m$) | | ($V_w$) | ($t_w$) | ($V_{m(std)}$) | ($V_{m(std)}$) | ($V_{m(std)}$) | ($V_{w(std)}$) | (Y) | (ΔY) | (Y) | (ΔY) | ($Q_m$) |
| | min | | °C | liters | liters | °C | std liters | std liters | std liters | std liters | | | | | slm |
| Run 1 - Initial | 0.00 | | 17.778 | 0 | 2556.98 | 17.778 | | | | | | | | | |
| Final | 38.51 | | 19.444 | 117.016 | 2674.38 | 18.333 | | | | | | | | | |
| Total/Avg | 38.51 | | 18.611 | 117.016 | 117.4 | 18.0555 | 114.257 | 115.666 | | 115.482 | 1.011 | -0.002 | | | 3.02 |
| Run 2 - Initial | 0.00 | | 19.444 | 0 | 2674.38 | 18.333 | | | | | | | | | |
| Final | 30.00 | | 20.556 | 59.176 | 2734.05 | 18.889 | | | | | | | | | |
| Total/Avg | 30.00 | | 20 | 59.176 | 59.67 | 18.611 | 57.507 | 58.216 | | 58.584 | 1.019 | 0.006 | | | 1.96 |
| Run 3 - Initial | 0.00 | | 19.444 | 0 | 2734.05 | 18.889 | | | | | | | | | |
| Final | 30.00 | | 21.111 | 28.397 | 2762.37 | 18.889 | | | | | | | | | |
| Total/Avg | 30.00 | | 20.278 | 28.397 | 28.32 | 18.889 | 27.570 | 27.910 | | 27.778 | 1.008 | -0.005 | | | 0.93 |

1.012

**Average Meter Calibration Factor Y** **1.012**

Note: For Calibration Factor Y, the ratio of the reading of the calibration meter to the dry gas meter, acceptable tolerance of individual values from the average is +-0.02.



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# METER CALIBRATION

## Meter Information

| | | | | | |
|---|---|---|---|---|---|
| Console Model | XC-260 | Dry Gas Meter Number | M5 8 | Encoder Model | HEDS-9100-F00 |
| Gas Meter Model | SK25 | Totalizer Scale Factor (Initial) | 1.0000 | Totalizer Model | RED LION |
| | | Totalizer Scale Factor (Final) | 0.9870 | Temp Display Model | JENCO |

## Calibration Conditions

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| WTM ID | 15340981 | Calibration Technician | AMH | | | Calibration Date | 27-Oct-14 |
| WTM Cal Factor | 1.0055 | Barometric Pressure | (Pb) | 738.039395 | mm Hg | | |

## Calibration Data / Results

| | Run Time Elapsed (Θ) min | | Dry Gas Meter Gas Temp ($t_m$) °C | Dry Gas Meter Totalizer Display liters | Wet Test Meter Gas Volume ($V_w$) liters | Wet Test Meter Gas Temp ($t_w$) °C | Standardized Volumes Totalizer Initial SF ($V_{m(std)}$) std liters | Standardized Volumes Totalizer Final SF ($V_{m(std)}$) std liters | Standardized Volumes Dry Gas Meter ($V_{m(std)}$) std liters | Standardized Volumes Wet Test Meter ($V_{w(std)}$) std liters | Totalizer Gamma Initial (Y) | Totalizer Gamma Variation (ΔY) | Meter Gamma DGM Display (Y) | Meter Gamma Variation (ΔY) | Corrected Flowrate ($Q_m$) slm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Run 1 - Initial | 0.00 | | 21.111 | 0 | 2762.37 | 18.889 | | | | | | | | | |
| Final | 38.00 | | 21.111 | 118.781 | 2880.84 | 19.444 | | | | | | | | | |
| Total/Avg | 38.00 | | 21.111 | 118.781 | 118.47 | 19.1665 | 114.995 | 113.496 | | 116.092 | 1.010 | 0.023 | | | 3.07 |
| Run 2 - Initial | 0.00 | | 21.111 | 0 | 2880.84 | 19.444 | | | | | | | | | |
| Final | 30.22 | | 22.778 | 55.886 | 2935.95 | 20 | | | | | | | | | |
| Total/Avg | 30.22 | | 21.9445 | 55.886 | 55.11 | 19.722 | 53.952 | 53.248 | | 53.901 | 0.999 | 0.012 | | | 1.79 |
| Run 3 - Initial | 0.00 | | 22.778 | 0 | 2935.95 | 20 | | | | | | | | | |
| Final | 30.00 | | 22.778 | 27.886 | 2962.137 | 20.556 | | | | | | | | | |
| Total/Avg | 30.00 | | 22.778 | 27.886 | 26.187 | 20.278 | 26.845 | 26.495 | | 25.564 | 0.952 | -0.035 | | | 0.86 |
| | | | | | | | | | | 0.987 | | | | | |

**Average Meter Calibration Factor Y** **0.987**

Note: For Calibration Factor Y, the ratio of the reading of the calibration meter to the dry gas meter, acceptable tolerance of individual values from the average is +-0.02.



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## Stack Temperature Sensor Calibration

Meter Box # : M5 Name : AMH

Ambient Temperature : 64 °F Date : October 27, 2014

Calibrator Model # : CL23A

Serial # : T-249465

Date Of Certification : August 7, 2012

Primary Standards Directly Traceable National Institute of Standards and Technology (NIST)

| Reference Source Temperature (°F) | Test Thermometer Temperature (°F) | Temperature Difference % |
|---|---|---|
| 0 | 1 | 0.2 |
| 250 | 251 | 0.1 |
| 600 | 600 | 0.0 |
| 1200 | 1201 | 0.1 |

$$\frac{(\text{Ref. Temp., °F} + 460) - (\text{Test Therm. Temp., °F} + 460)}{\text{Ref. Temp., °F} + 460} * 100 <= 1.5\ \%$$


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# METER CALIBRATION

## Meter Information

| | | | | | |
|---|---|---|---|---|---|
| Console Model | XC-260 | Dry Gas Meter Number | M5 A | Encoder Model | HEDS-9100-F00 |
| Gas Meter Model | SK25 | Totalizer Scale Factor (Initial) | 1.0000 | Totalizer Model | RED LION |
| | | Totalizer Scale Factor (Final) | 0.9951 | Temp Display Model | JENCO |

## Calibration Conditions

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| WTM ID | 16745468 | Calibration Technician | SVD | | | Calibration Date | 7-Nov-14 |
| WTM Cal Factor | 1.0039 | Barometric Pressure | (Pb) | 749.21411 | mm Hg | | |

## Calibration Data / Results

| | Run Time Elapsed (Θ) min | | Dry Gas Meter Gas Temp ($t_m$) °C | Dry Gas Meter Totalizer Display liters | Wet Test Meter Gas Volume ($V_w$) liters | Wet Test Meter Gas Temp ($t_w$) °C | Standardized Volumes Totalizer Initial SF ($V_{m(std)}$) std liters | Standardized Volumes Totalizer Final SF ($V_{m(std)}$) std liters | Standardized Volumes Dry Gas Meter ($V_{m(std)}$) std liters | Standardized Volumes Wet Test Meter ($V_{w(std)}$) std liters | Totalizer Gamma Initial (Y) | Totalizer Gamma Variation (ΔY) | Meter Gamma DGM Display (Y) | Meter Gamma Variation (ΔY) | Corrected Flowrate ($Q_m$) slm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Run 1 - Initial | 0.00 | | 15.556 | 0 | 1539.62 | 15.556 | | | | | | | | | |
| Final | 38.51 | | 18.333 | 123.395 | 1663.08 | 18.333 | | | | | | | | | |
| Total/Avg | 38.51 | | 16.945 | 123.395 | 123.46 | 16.9445 | 123.013 | 122.414 | | 123.558 | 1.004 | 0.009 | | | 3.22 |
| Run 2 - Initial | 0.00 | | 18.333 | 0 | 1663.08 | 18.333 | | | | | | | | | |
| Final | 30.00 | | 18.333 | 62.586 | 1724.89 | 18.333 | | | | | | | | | |
| Total/Avg | 30.00 | | 18.333 | 62.586 | 61.81 | 18.333 | 62.095 | 61.792 | | 61.564 | 0.991 | -0.004 | | | 2.06 |
| Run 3 - Initial | 0.00 | | 18.333 | 0 | 1724.89 | 18.333 | | | | | | | | | |
| Final | 30.00 | | 18.333 | 28.732 | 1753.21 | 18.333 | | | | | | | | | |
| Total/Avg | 30.00 | | 18.333 | 28.732 | 28.32 | 18.333 | 28.507 | 28.368 | | 28.207 | 0.990 | -0.006 | | | 0.94 |

0.995

**Average Meter Calibration Factor Y** **0.995**

Note: For Calibration Factor Y, the ratio of the reading of the calibration meter to the dry gas meter, acceptable tolerance of individual values from the average is +-0.02.



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# METER CALIBRATION

**Meter Information**

| | | | | | |
|---|---|---|---|---|---|
| Console Model | XC-260 | Dry Gas Meter Number | M5 B | Encoder Model | HEDS-9100-F00 |
| Gas Meter Model | SK25 | Totalizer Scale Factor (Initial) | 1.0000 | Totalizer Model | RED LION |
| | | Totalizer Scale Factor (Final) | 0.9941 | Temp Display Model | JENCO |

**Calibration Conditions**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| WTM ID | 14159239 | Calibration Technician | SVD | | | Calibration Date | 7-Nov-14 |
| WTM Cal Factor | 1.0011 | Barometric Pressure | (Pb) | 749.214114 | mm Hg | | |

**Calibration Data**

| | Run Time Elapsed (Θ) min | | Dry Gas Meter Gas Temp ($t_m$) °C | Dry Gas Meter Totalizer Display liters | Wet Test Meter Gas Volume ($V_w$) liters | Wet Test Meter Gas Temp ($t_w$) °C | Standardized Volumes Totalizer Initial SF ($V_{m(std)}$) std liters | Standardized Volumes Totalizer Final SF ($V_{m(std)}$) std liters | Standardized Volumes Dry Gas Meter ($V_{m(std)}$) std liters | Standardized Volumes Wet Test Meter ($V_{w(std)}$) std liters | Totalizer Gamma Initial (Y) | Results: Totalizer Gamma Variation (ΔY) | Results: Meter Gamma DGM Display (Y) | Results: Meter Gamma Variation (ΔY) | Results: Corrected Flowrate ($Q_m$) slm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Run 1 - Initial | 0.00 | | 15.556 | 0 | 2561.71 | 15.556 | | | | | | | | | |
| Final | 38.00 | | 18.333 | 124.288 | 2686.50 | 18.333 | | | | | | | | | |
| Total/Avg | 38.00 | | 16.9445 | 124.288 | 124.79 | 16.9445 | 123.903 | 123.166 | | 124.540 | 1.005 | 0.011 | | | 3.28 |
| Run 2 - Initial | 0.00 | | 18.333 | 0 | 2686.5 | 18.333 | | | | | | | | | |
| Final | 30.22 | | 18.333 | 57.567 | 2743.22 | 18.333 | | | | | | | | | |
| Total/Avg | 30.22 | | 18.333 | 57.567 | 56.72 | 18.333 | 57.115 | 56.776 | | 56.337 | 0.986 | -0.008 | | | 1.87 |
| Run 3 - Initial | 0.00 | | 18.333 | 0 | 2743.22 | 18.333 | | | | | | | | | |
| Final | 30.00 | | 18.333 | 25.668 | 2768.62 | 18.333 | | | | | | | | | |
| Total/Avg | 30.00 | | 18.333 | 25.668 | 25.4 | 18.333 | 25.467 | 25.315 | | 25.228 | 0.991 | -0.003 | | | 0.84 |

0.994

**Average Meter Calibration Factor Y** **0.994**

Note: For Calibration Factor Y, the ratio of the reading of the calibration meter to the dry gas meter, acceptable tolerance of individual values from the average is +-0.02.



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## *Stack Temperature Sensor Calibration*

*Meter Box # :* *M5* *Name :* *SVD*

*Ambient Temperature :* *61* *° F* *Date :* *November 7, 2014*

*Calibrator Model # :* *CL23A*

*Serial # :* *T-249465*

*Date Of Certification :* *August 7, 2012*

*Primary Standards Directly Traceable National Institute of Standards and Technology (NIST)*

| Reference Source Temperature (° F) | Test Thermometer Temperature (° F) | Temperature Difference % |
|---|---|---|
| 0 | 1 | 0.2 |
| 250 | 251 | 0.1 |
| 600 | 599 | 0.1 |
| 1200 | 1201 | 0.1 |

$$\frac{(\text{Ref. Temp., °F} + 460) - (\text{Test Therm. Temp., °F} + 460)}{\text{Ref. Temp., °F} + 460} * 100 <= 1.5\ \%$$


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*Meter Box Calibration*

## Dry Gas Meter Calibration Data

| | | | |
|---|---|---|---|
| Dry Gas Meter No. | CM19 | Date: | October 29, 2014 |
| Standard Meter No. | 16745468 | Calibrated By: | KJC |
| Standard Meter (Y) | 1.0039 | Barometric Pressure: | 29.34 |

| Run Number | | Orifice Setting in $H_2O$ Chg (H) | Standard Meter Gas Volume vr | Dry Gas Meter Gas Volume vd | Standard Meter Temp. F° tr | Dry Gas Meter Inlet Temp. F° tdi | Dry Gas Meter Outlet Temp. F° tdo | Dry Gas Meter Avg. Temp. F° td | Time Min | Time Sec | Y | Chg (H) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Final | | | 103.922 | 22.713 | 60 | 62 | 61 | | | | | |
| Initial | | | 98.122 | 16.865 | 68 | 61 | 61 | | | | | |
| Difference | 1 | 0.20 | 5.800 | 5.848 | 64 | 62 | 61 | 61 | 20 | 33 | 0.986 | 1.428 |
| Final | | | 9.922 | 28.727 | 60 | 64 | 62 | | | | | |
| Initial | | | 4.233 | 23.008 | 59 | 62 | 61 | | | | | |
| Difference | 2 | 0.50 | 5.689 | 5.719 | 60 | 63 | 62 | 62 | 13 | 6 | 0.999 | 1.479 |
| Final | | | 16.925 | 35.741 | 60 | 65 | 63 | | | | | |
| Initial | | | 10.232 | 29.022 | 60 | 63 | 62 | | | | | |
| Difference | 3 | 0.70 | 6.693 | 6.719 | 60 | 64 | 63 | 63 | 13 | 2 | 1.001 | 1.481 |
| Final | | | 23.121 | 41.943 | 60 | 66 | 64 | | | | | |
| Initial | | | 17.214 | 36.028 | 60 | 65 | 64 | | | | | |
| Difference | 4 | 0.90 | 5.907 | 5.915 | 60 | 66 | 64 | 65 | 10 | 11 | 1.006 | 1.488 |
| Final | | | 28.908 | 47.730 | 60 | 67 | 64 | | | | | |
| Initial | | | 23.411 | 42.230 | 60 | 66 | 64 | | | | | |
| Difference | 5 | 1.20 | 5.497 | 5.500 | 60 | 67 | 64 | 65 | 8 | 25 | 1.007 | 1.564 |
| Final | | | 97.963 | 16.726 | 58 | 61 | 60 | | | | | |
| Initial | | | 92.221 | 11.034 | 58 | 60 | 59 | | | | | |
| Difference | 6 | 2.00 | 5.742 | 5.692 | 58 | 61 | 60 | 60 | 6 | 57 | 1.008 | 1.632 |
| | | | | | | | | | Average | | **1.001** | **1.512** |



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## *Stack Temperature Sensor Calibration*

*Meter Box # :* CM19 *Name :* KJC

*Ambient Temperature :* 63 °F *Date :* October 29, 2014

*Calibrator Model # :* CL23A

*Serial # :* T-249465

*Date Of Certification :* August 7, 2012

*Primary Standards Directly Traceable National Institute of Standards and Technology (NIST)*

| Reference Source Temperature (° F) | Test Thermometer Temperature (° F) | Temperature Difference % |
|---|---|---|
| 0 | 1 | 0.2 |
| 250 | 247 | 0.4 |
| 600 | 596 | 0.4 |
| 1200 | 1198 | 0.1 |

$$\frac{(\text{Ref. Temp., °F} + 460) - (\text{Test Therm. Temp., °F} + 460)}{\text{Ref. Temp., °F} + 460} * 100 <= 1.5\ \%$$


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*Meter Box Calibration*

## Dry Gas Meter Calibration Data

| | | | |
|---|---|---|---|
| Dry Gas Meter No. | CM19 | Date: | November 5, 2014 |
| Standard Meter No. | 4319699 | Calibrated By: | SVD |
| Standard Meter (Y) | 1.0053 | Barometric Pressure: | 29.50 |

| Run Number | | Orifice Setting in $H_2O$ Chg (H) | Standard Meter Gas Volume vr | Dry Gas Meter Gas Volume vd | Standard Meter Temp. F° tr | Dry Gas Meter Inlet Temp. F° tdi | Dry Gas Meter Outlet Temp. F° tdo | Dry Gas Meter Avg. Temp. F° td | Time Min | Time Sec | Y | Chg (H) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Final | | | 37.288 | 18.858 | 60 | 63 | 62 | | | | | |
| Initial | | | 26.306 | 7.743 | 58 | 61 | 60 | | | | | |
| Difference | 1 | 0.20 | 10.982 | 11.115 | 59 | 62 | 61 | 62 | 39 | 59 | 0.992 | 1.471 |
| Final | | | 42.529 | 24.144 | 60 | 65 | 62 | | | | | |
| Initial | | | 37.288 | 18.858 | 60 | 63 | 62 | | | | | |
| Difference | 2 | 0.50 | 5.241 | 5.286 | 60 | 64 | 62 | 63 | 12 | 13 | 0.996 | 1.508 |
| Final | | | 48.811 | 30.495 | 61 | 67 | 63 | | | | | |
| Initial | | | 42.529 | 24.144 | 60 | 65 | 62 | | | | | |
| Difference | 3 | 0.70 | 6.282 | 6.351 | 61 | 66 | 63 | 64 | 12 | 38 | 0.995 | 1.571 |
| Final | | | 53.974 | 35.728 | 60 | 68 | 64 | | | | | |
| Initial | | | 48.811 | 30.495 | 61 | 67 | 63 | | | | | |
| Difference | 4 | 0.90 | 5.163 | 5.233 | 61 | 68 | 64 | 66 | 9 | 11 | 0.994 | 1.576 |
| Final | | | 59.389 | 41.198 | 61 | 68 | 64 | | | | | |
| Initial | | | 53.974 | 35.728 | 60 | 68 | 64 | | | | | |
| Difference | 5 | 1.20 | 5.415 | 5.470 | 61 | 68 | 64 | 66 | 8 | 31 | 0.997 | 1.642 |
| Final | | | 26.306 | 7.743 | 58 | 61 | 60 | | | | | |
| Initial | | | 20.974 | 2.431 | 58 | 59 | 63 | | | | | |
| Difference | 6 | 2.00 | 5.332 | 5.312 | 58 | 60 | 62 | 61 | 6 | 20 | 1.004 | 1.561 |
| | | | | | | | | | Average | | **0.996** | **1.555** |



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## *Stack Temperature Sensor Calibration*

*Meter Box # :* CM19 *Name :* SVD

*Ambient Temperature :* 60 °F *Date :* November 5, 2014

*Calibrator Model # :* CL23A

*Serial # :* T-249465

*Date Of Certification :* August 7, 2012

*Primary Standards Directly Traceable National Institute of Standards and Technology (NIST)*

| Reference Source Temperature (°F) | Test Thermometer Temperature (°F) | Temperature Difference % |
|---|---|---|
| 0 | -2 | 0.4 |
| 250 | 247 | 0.4 |
| 600 | 596 | 0.4 |
| 1200 | 1198 | 0.1 |

$$\frac{(\text{Ref. Temp., °F} + 460) - (\text{Test Therm. Temp., °F} + 460)}{\text{Ref. Temp., °F} + 460} * 100 <= 1.5\ \%$$


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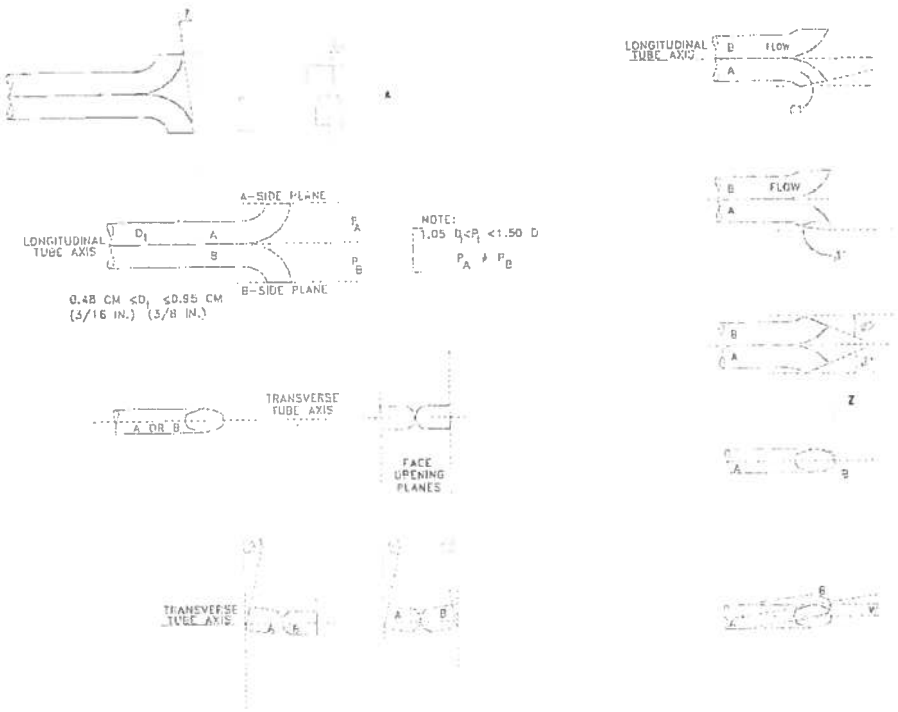
# S TYPE PITOT TUBE INSPECTION WORKSHEET

Pitot Tube No: 91 Date: 10/13/2014 Inspectors Name: TFN

Type of Probe: (circle one) M2 M5 M17 Probe Length: 4 ft.




Pitot tube assembly level? x yes ____ no

Pitot tube openings damaged? ____ yes (explain below) x no

$a_1$ = 1.5 ° (<10°), $a_2$ = 3.5 ° (<10°) z = A sin g = 0.034 (in.); (<0.125 in.)

$b_1$ = 1 ° (<5°), $b_2$ = 4 ° (<5°) w = A sin q = 0.025 (in.); (<0.03125 in.)

γ = 2 °, θ = 1.5 °, A = 0.973 (in.) $P_A$ = 0.487 (in.), $P_B$ = 0.487 (in.), $D_t$ = 0.375 (in.)

Calibration required? ____ yes x no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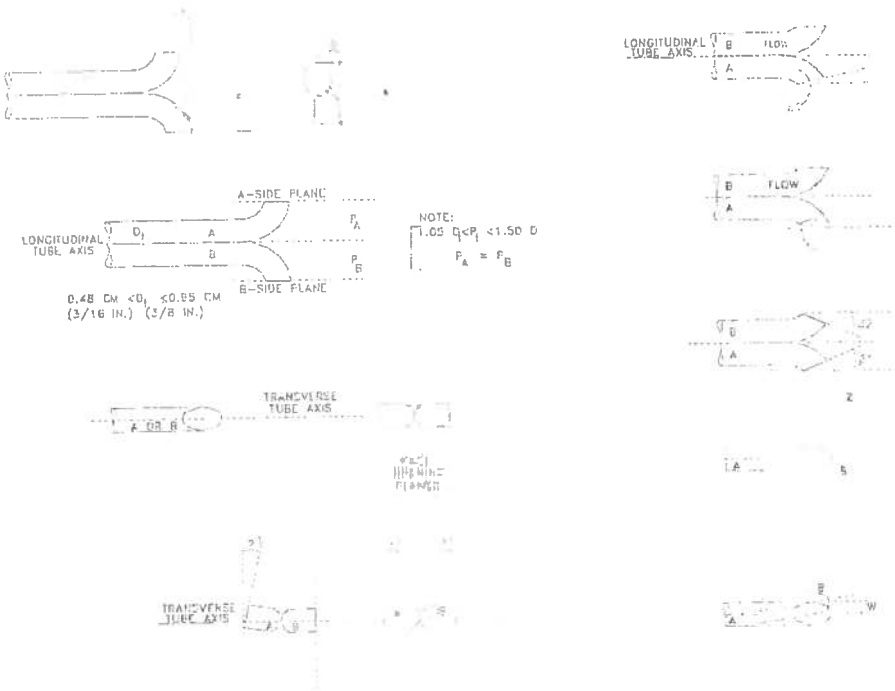
# S TYPE PITOT TUBE INSPECTION WORKSHEET

Pitot Tube No: 170 Date: 10/13/2014 Inspector's Name: TFN

Type of Probe: (circle one) M2 M5 M17 Probe Length: 4 ft.




Pitot tube assembly level? x yes ____ no

Pitot tube openings damaged? ____ yes (explain below) x no

$a_1$ = 2 ° (<10°), $a_2$ = 1.5 ° (<10°) z = A sin g = 0.020 (in.); (<0.125 in.)

$b_1$ = 2 ° (<5°), $b_2$ = 1.5 ° (<5°) w = A sin q = 0.020 (in.); (<0.03125 in.)

$\gamma$ = 1 °, $\theta$ = 1 °, A = 1.144 (in.) $P_A$ = 0.572 (in.), $P_B$ = 0.572 (in.), $D_t$ = 0.375 (in.)

Calibration required? ____ yes x no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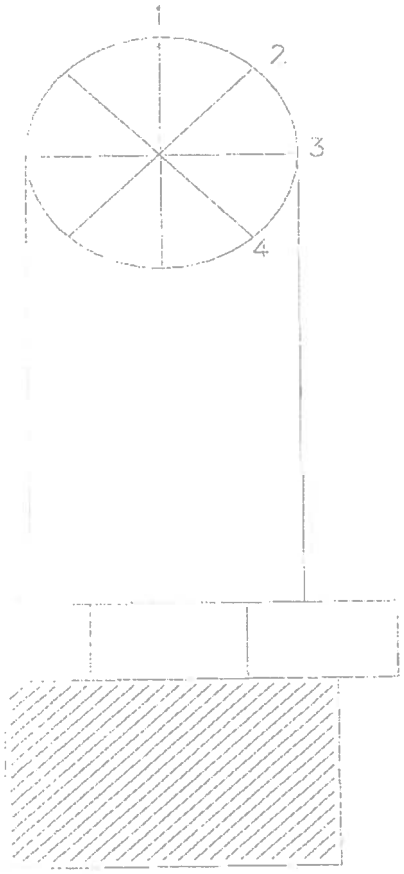
# Nozzle Calibration

Date: 5/30/2012

Nozzle ID No.: SG2

Analyst: RICHS




| | |
|---|---|
| 0.551 | 1 |
| 0.551 | 2 |
| 0.552 | 3 |
| 0.550 | 4 |

| Average |
|---|
| **0.551** |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WEIGHING SOLUTIONS INC.

SALES-SERVICE-RENTALS
3310-14 N. HARLEM AVENUE
CHICAGO, IL 60634

PHONE
773-836-2800
FAX
773-836-2891

## CALIBRATION REPORT

Company Name MOSTARDI PLATT
Date SEPTEMBER 4, 2013
Location LAB
Weight Set # E 554

Model # E 0640
Serial/ID # G 045112105123 8
Manufacturer OHAUS
Tolerance ± 0.05%

| | | Before Cal.: | After Cal.: |
|---|---|---|---|
| Capacity | 62 g | | |
| Readability | 0.1mg | | |
| Weight # 1 | 0.1mg | 0.0001 g | 0.0001 g |
| Weight # 2 | 1 g | 1.0000 g | 1.0000 g |
| Weight # 3 | 10 g | 10.0001 g | 10.0000 g |
| Weight # 4 | 20 g | 20.0002 g | 20.0000 g |
| Weight # 5 | 50 g | 50.0004 g | 50.0000 g |

| | Accept | Reject |
|---|---|---|
| Linearity | ✓ | |
| Cornerload | ✓ | |
| Repeatability | ✓ | |
| Hysteresis | ✓ | |

Comments Cleaned and adjusted calibration to N.I.S.T. specifications.

Technician

678
State Of IL Registration

STATE OF ILLINOIS
WEIGHING SOLUTIONS
NO. 1604
REGISTERED SCALE AGENCY


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# RLWS Mass Value CERTIFICATE

| | |
|---|---|
| Contractor: | **Weighing Solutions Inc**<br>PO Box 95<br>River Grove, IL 60171-0095 |
| Purchase Order #: | 1268 |
| Client: | **Weighing Solutions Inc** |
| Address: | 3310 N Harlem Ave |
| City & State: | Chicago, IL 60634 |
| Date Received: | 19 OCT 2012 |
| Date Calibrated: | 24 OCT 2012 |
| Temperature Range: | 21.41 to 21.72 °C |
| Pressure Range: | 727.3 to 727.6 mmHg |
| Relative Humidity Range: | 44 to 46 % |
| Air Density: | 1.1406 to 1.1419 mg/cm³ |
| Traceable Report #: | 1927133 |
| NIST Certificate #: | 681/280058-10, 822/278785-10 |
| Tested By: | 12 |
| Procedure: | Modified Substitution (WI05-0023) |
| Contractor Req Recall Date: | 2 Years |
| Primary Standard Calibration Date: | 02/11/11, 10/21/09 **Due:** 02/11/15, 10/21/13 |
| Description of Weights: | 100 g. Polished Weight, 50 g to 5 kg Satin Finish Weights & 5-10 kg Satin Finish Grip Handle Weights, ASTM Class "2", Set S/N 5661 |

Although there are two NIST numbers, one or both may apply.

| Nominal Value | Id. | Conventional Mass Corr. As Found (mg) | Conventional Mass Corr. As Left (mg) | Unc. K=2 (mg) | Tol. (mg) | Balance Used | Standard Set Used | Calibrated/due MM-DD-YY/MM-DD-YY | Assumed Density (g/cm³) |
|---|---|---|---|---|---|---|---|---|---|
| 50 g | | -0.118 | -0.118 | 0.026 | 0.25 | 1183Q | K594Q | 08-10-12/11-09-12 | 7.85 |
| 100 g | | -0.143 | -0.143 | 0.049 | 0.50 | 1183Q | K594Q | 08-10-12/11-09-12 | 7.84 |
| 100 g | . | -0.221 | -0.221 | 0.049 | 0.50 | 1183Q | K594Q | 08-10-12/11-09-12 | 8.00 |
| 200 g | | -0.020 | -0.020 | 0.059 | 1.0 | 619Q | K594Q | 08-10-12/11-09-12 | 7.84 |
| 300 g | | -1.257 | -1.257 | 0.086 | 1.5 | 619Q | K594Q | 08-10-12/11-09-12 | 7.84 |
| 400 g | | -1.326 | -1.326 | 0.098 | 1.5 | 619Q | K594Q | 08-10-12/11-09-12 | 7.84 |
| 1 kg | | -0.57 | -0.57 | 0.14 | 5.0 | 619Q | K594Q | 08-10-12/11-09-12 | 7.84 |
| 1 kg | .. | 0.90 | 0.90 | 0.14 | 5.0 | 619Q | K594Q | 08-10-12/11-09-12 | 7.85 |
| 3 kg | | -5.83 | -5.83 | 0.81 | 15 | 975Q | K594Q | 08-10-12/11-09-12 | 7.84 |
| 5000 g | | -0.8 | -0.8 | 1.1 | 25 | 975Q | K594Q | 08-10-12/11-09-12 | 7.84 |
| 10 kg | ... | 12.1 | 12.1 | 1.8 | 50 | 975Q | K594Q | 08-10-12/11-09-12 | 7.84 |
| 10 kg | ..... | 16.1 | 16.1 | 1.8 | 50 | 975Q | K594Q | 08-10-12/11-09-12 | 7.84 |

Check with your local state agency for certification of compliance on legal-for-trade items.

Prepared By:

RICE LAKE WEIGHING SYSTEMS

9001 REGISTERED

Page 1 of 1 Page

Dated 24 OCT 2012

Dan Demers Metrologist

230 West Coleman Street • Rice Lake, WI 54868 • USA
TEL: 715-234-9171 • FAX: 715-234-6967

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# RLWS Mass Value CERTIFICATE

**Contractor:** Weighing Solutions Inc
PO Box 95
River Grove, IL 60171-0095

**Purchase Order #:** 1268
**Client:** Weighing Solutions Inc
**Address:** 3310 N Harlem Ave

**City & State:** Chicago, IL 60634
**Date Received:** 19 OCT 2012
**Date Calibrated:** 23 OCT 2012 to 24 OCT 2012
**Temperature Range:** 21.00 to 21.79 °C
**Pressure Range:** 725.6 to 727.5 mmHg
**Relative Humidity Range:** 43 to 49 %
**Air Density:** 1.1381 to 1.1436 mg/cm³
**Traceable Report #:** 1927133A
**NIST Certificate #:** 681/280058-10, 822/278785-10
**Tested By:** 12
**Procedure:** Modified Substitution (WI05-0023)
**Contractor Req Recall Date:** 2 Years
**Primary Standard Calibration Date:** 02/11/11, 10/21/09 **Due:** 02/11/15, 10/21/13
**Description of Weights:** 1 mg to 100 g Polished Kit, ASTM Class "1", S/N E559
Although there are two NIST numbers, one or both may apply.

☒ Indicates As Found >= Tol

| Nominal Value | Id. | Conventional Mass Corr. As Found (mg) | Conventional Mass Corr. As Left (mg) | | Unc. K=2 (mg) | Tol. (mg) | Balance Used | Standard Set Used | Calibrated/due MM-DD-YY/MM-DD-YY | Assumed Density (g/cm³) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 mg | | 0.0057 | 0.0057 | | 0.0012 | 0.010 | 327Q | K594Q | 08-10-12/11-09-12 | 7.95 |
| 2 mg | | 0.0027 | 0.0027 | | 0.0013 | 0.010 | 327Q | K594Q | 08-10-12/11-09-12 | 7.95 |
| 2 mg | . | 0.0048 | 0.0048 | | 0.0013 | 0.010 | 327Q | K594Q | 08-10-12/11-09-12 | 7.95 |
| 5 mg | | 0.0041 | 0.0041 | | 0.0013 | 0.010 | 327Q | K594Q | 08-10-12/11-09-12 | 7.95 |
| 10 mg | | -0.0017 | -0.0017 | | 0.0018 | 0.010 | 327Q | K594Q | 08-10-12/11-09-12 | 7.95 |
| 20 mg | | -0.0018 | -0.0018 | | 0.0016 | 0.010 | 327Q | K594Q | 08-10-12/11-09-12 | 7.95 |
| 20 mg | . | -0.0022 | -0.0022 | | 0.0016 | 0.010 | 327Q | K594Q | 08-10-12/11-09-12 | 7.95 |
| 50 mg | | 0.0068 | 0.0068 | | 0.0019 | 0.010 | 327Q | K594Q | 08-10-12/11-09-12 | 7.95 |
| 100 mg | | -0.0056 | -0.0056 | | 0.0015 | 0.010 | 327Q | K594Q | 08-10-12/11-09-12 | 7.95 |
| 200 mg | | -0.0029 | -0.0029 | | 0.0015 | 0.010 | 327Q | K594Q | 08-10-12/11-09-12 | 7.95 |
| 200 mg | . | -0.0022 | -0.0022 | | 0.0015 | 0.010 | 327Q | K594Q | 08-10-12/11-09-12 | 7.95 |
| 500 mg | | -0.0072 | -0.0072 | | 0.0018 | 0.010 | 327Q | K594Q | 08-10-12/11-09-12 | 7.95 |
| 1 g | | -0.0225 | -0.0225 | | 0.0026 | 0.034 | 327Q | K594Q | 08-10-12/11-09-12 | 7.95 |
| 2 g | | 0.0134 | 0.0134 | | 0.0026 | 0.034 | 327Q | K594Q | 08-10-12/11-09-12 | 7.95 |
| 2 g | . | 0.0179 | 0.0179 | | 0.0026 | 0.034 | 327Q | K594Q | 08-10-12/11-09-12 | 7.95 |
| 5 g | | 0.0052 | 0.0052 | | 0.0052 | 0.034 | 327Q | K594Q | 08-10-12/11-09-12 | 7.95 |
| 10 g | | -0.038 | 0.000 | ☒ | 0.012 | 0.050 | 676Q | K594Q | 08-10-12/11-09-12 | 7.95 |
| 20 g | | 0.053 | 0.053 | | 0.012 | 0.074 | 676Q | K594Q | 08-10-12/11-09-12 | 7.95 |
| 20 g | . | -0.046 | -0.046 | | 0.012 | 0.074 | 676Q | K594Q | 08-10-12/11-09-12 | 7.95 |
| 50 g | | 0.034 | 0.034 | | 0.026 | 0.12 | 1183Q | K594Q | 08-10-12/11-09-12 | 7.95 |
| 100 g | | -0.289 | 0.142 | ☒ | 0.049 | 0.25 | 1183Q | K594Q | 08-10-12/11-09-12 | 7.95 |

Check with your local state agency for certification of compliance on legal-for-trade items.

Prepared By:

RICE LAKE WEIGHING SYSTEMS | 9001 REGISTERED

Page 1 of 1 Page

Dated 24 OCT 2012

Dan Demers Metrologist

230 West Coleman Street • Rice Lake, WI 54868 • USA
TEL: 715-234-9171 • FAX: 715-234-6967

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# State of Illinois

## Department of Agriculture

Registration Number: 1604

Expires: 02/28/2014

Bureau of Weights and Measures

Registered Service Company Certificate of Registration

This is to certify that the named company has met all requirements for registration with this office for weighing devices.

Bureau Chief
Bureau of Weights & Measures

Issued To:

WEIGHING SOLUTIONS, INC.
3310-14 N HARLEM AVE
CHICAGO, IL 60634



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# Registered Technician - Registration Cards

STATE OF ILLINOIS
DEPARTMENT OF AGRICULTURE
**Registered Technician:**
0678 LITTLE, JAMES M
**Registered Service Company:**
1604 WEIGHING SOLUTIONS, INC.
**Registered For:**
Scale
**Expires** February 28, 2014

**Registered Technician's Signature**

The Department of Agriculture requires that all persons selling, installing, servicing, repairing, or reconditioning weighing or measuring devices used in trade or commerce be registered.

This Technician has met all of the qual ifications of the State of Illinois and is currently registered with the Illinois Department of Agriculture in good standing.

**Bureau of Weights & Measures**
**Telephone (217) 785-8301**

IL406-1122 X021-486-0030


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| Pre/Post | Date | Time | Analyst | Ambient Temperature degrees F | Relative Humidity % | Barometric Pressure inches Hg | Calibration Standard 50.0000g | % Error | Calibration Standard 5.0000g | % Error | Calibration Standard 0.5000g | % Error |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pre | 11/10/2014 | 8:00 AM | JMG | 70 | 23.0 | 29.18 | 49.9997 g | 0.00 | 4.9999 g | 0.00 | 0.5001 g | -0.02 |
| Post | 11/10/2014 | 3:00 PM | JMG | 70 | 23.0 | 29.08 | 49.9998 g | 0.00 | 4.9999 g | 0.00 | 0.5001 g | -0.02 |
| Pre | 11/11/2014 | 8:00 AM | JMG | 71 | 23.0 | 29.00 | 49.9998 g | 0.00 | 5.0000 g | 0.00 | 0.5000 g | 0.00 |
| Post | 11/11/2014 | 3:00 PM | JMG | 71 | 23.0 | 29.00 | 49.9998 g | 0.00 | 5.0000 g | 0.00 | 0.5000 g | 0.00 |
| Pre | 11/12/2014 | 8:00 AM | JMG | 71 | 23.0 | 29.00 | 49.9998 g | 0.00 | 5.0000 g | 0.00 | 0.5000 g | 0.00 |
| Post | 11/12/2014 | 3:00 PM | JMG | 71 | 23.0 | 29.00 | 49.9998 g | 0.00 | 5.0000 g | 0.00 | 0.5000 g | 0.00 |
| Pre | 11/13/2014 | 8:00 AM | JMG | 71 | 23.0 | 29.00 | 49.9998 g | 0.00 | 5.0000 g | 0.00 | 0.5000 g | 0.00 |
| Post | 11/13/2014 | 3:00 PM | JMG | 71 | 23.0 | 29.00 | 49.9998 g | 0.00 | 5.0000 g | 0.00 | 0.5000 g | 0.00 |
| Pre | 11/14/2014 | | | | | | | | | | | |
| Post | 11/14/2014 | | | | | | | | | | | |
| Pre | 11/17/2014 | | | | | | | | | | | |
| Post | 11/17/2014 | | | | | | | | | | | |
| Pre | 11/18/2014 | 8:00 AM | JMG | 72 | 22.0 | 29.41 | 49.9998 g | 0.00 | 5.0000 g | 0.00 | 0.5000 g | 0.00 |
| Post | 11/18/2014 | 3:00 PM | JMG | 72 | 22.0 | 29.41 | 49.9999 g | 0.00 | 5.0001 g | 0.00 | 0.5000 g | 0.00 |
| Pre | 11/19/2014 | | | | | | | | | | | |
| Post | 11/19/2014 | | | | | | | | | | | |
| Pre | 11/20/2014 | 10:00 AM | JMG | 74 | 22.0 | 29.44 | 50.0000 g | 0.00 | 5.0000 g | 0.00 | 0.5000 g | 0.00 |
| Post | 11/20/2014 | 3:15 PM | JMG | 74 | 22.0 | 29.44 | 50.0000 g | 0.00 | 5.0000 g | 0.00 | 0.5000 g | 0.00 |
| Pre | 11/21/2014 | | | | | | | | | | | |
| Post | 11/21/2014 | | | | | | | | | | | |
| Pre | 11/24/2014 | 7:30 AM | JMG | 73 | 23.0 | 28.50 | 50.0002 g | 0.00 | 5.0001 g | 0.00 | 0.5000 g | 0.00 |
| Post | 11/24/2014 | 3:15 PM | JMG | 73 | 23.0 | 28.44 | 50.0002 g | 0.00 | 5.0001 g | 0.00 | 0.5000 g | 0.00 |
| Pre | 11/25/2014 | 8:00 AM | JMG | 73 | 22.0 | 29.38 | 50.0002 g | 0.00 | 5.0002 g | 0.00 | 0.5001 g | -0.02 |
| Post | 11/25/2014 | | | | | | | | | | | |
| Pre | 11/26/2014 | | | | | | | | | | | |
| Post | 11/26/2014 | | | | | | | | | | | |
| Pre | 11/27/2014 | | | | | | | | | | | |
| Post | 11/27/2014 | | | | | | | | | | | |
| Pre | 11/28/2014 | | | | | | | | | | | |
| Post | 11/28/2014 | | | | | | | | | | | |

Balance II OHAUS Model Explorer
S/N 1973



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# CALIBRATION SUMMARY

Project Number: M144705
Client: UNIVERSITY OF IOWA
Test Location: HURST BOILER EXHAUST DUCT
Make & Model: SERVOMEX SERVOPRO 1440

Date: 11/4/14
Operator: DAN TUIDER
Box Truck: 5
S/N: 01440D1/4662

| Type | Cal Level | Cylinder ID | Cylinder Value | Analyzer Response | Difference, % of Span | Cylinder Pressure (psi) | Cylinder Expiration Date |
|---|---|---|---|---|---|---|---|
| $CO_2$ % | Zero | — | 0.0 | 0.01 | -0.05 | — | — |
| | Mid | CC183734 | 9.968 | 9.98 | -0.06 | 1050 | 5/23/22 |
| | High | CC415912 | 19.47 | 19.47 | 0.0 | 900 | 10/4/21 |
| $O_2$ % | Zero | — | 0.0 | 0.06 | -0.27 | — | — |
| | Mid | CC455275 | 11.99 | 12.03 | -0.18 | 1950 | 9/22/12 |
| | High | CC94285 | 22.25 | 22.2 | 0.22 | 800 | 10/5/21 |

| $CO_2$% | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Run # | $C_{ma}$ | Pre Cal | Post Cal | Pre Zero | Post Zero | $C_o$ | $C_m$ | C | $C_{gas}$ |
| 1 | 9.968 | 10.03 | 10.01 | 0.01 | 0.02 | | | 11.65 | 11.6 |
| 2 | 9.968 | 10.01 | 10.03 | 0.02 | 0.01 | | | 11.50 | 11.4 |
| 3 | 9.968 | 10.03 | 10.00 | 0.01 | 0.01 | | | 11.82 | 11.8 |
| 4 | | | | | | | | | |
| 5 | | | | | | | | | |
| 6 | | | | | | | | | |

| $O_2$% | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Run # | $C_{ma}$ | Pre Cal | Post Cal | Pre Zero | Post Zero | $C_o$ | $C_m$ | C | $C_{gas}$ |
| 1 | 11.99 | 12.00 | 11.99 | 0.0 | 0.0 | | | 8.93 | 8.9 |
| 2 | 11.99 | 11.99 | 11.95 | 0.0 | -0.02 | | | 9.06 | 9.1 |
| 3 | 11.99 | 11.95 | 11.95 | -0.02 | -0.01 | | | 8.75 | 8.8 |
| 4 | | | | | | | | | |
| 5 | | | | | | | | | |
| 6 | | | | | | | | | |

$$C_{gas} = \frac{(C - C_o) \times C_{ma}}{(C_m - C_o)}$$

where:
$C_{gas}$ = Effluent gas concentration, dry basis, %
C = Average gas concentration indicated by gas analyzer, dry basis, %
$C_o$ = Average of initial and final system calibration bias check responses for the zero gas, %
$C_m$ = Average of initial and final system calibration bias check responses for the upscale calibration gas, %
$C_{ma}$ = Actual concentration of the upscale calibration gas, %

DS-029A


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| | | | |
|---|---|---|---|
| Client: | University of Iowa | Test Location: | Hurst Boiler Exhaust Duct |
| Facility: | Oakdale Renewable Energy Center | Date: | 11/4/14 |
| Project #: | M144705 | Operator: | DET |
| Operating Condition: | Normal | | |

| | | |
|---|---|---|
| Probe Length: | 4.0 | ft |
| Probe Type: | Extractive | |
| Sample Plane: | Horizontal | |
| Port Length: | 6.00 | in. |
| Port Size (diameter): | 6 | in. |
| Port Type: | Flange | |
| Duct Shape: | Rectangular | |
| Length (traverse side of duct): | 3.5 | ft |
| Width: | 5.5 | ft |
| Location of Test Ports: | | |
| Duct Area: | 19.25 | Sq. Ft. |
| Equivalent Diameter Rectangular Duct: | 4.278 | |
| Upstream Diameters: | >.5 | |
| Downstream Diameters: | >2 | |
| Number of Ports Sampled: | 5 | |
| Number of Points per Port: | 4 | |
| Total Number of Traverse Points: | 20 | |

Point Markings (including port length):

| Point # | inches |
|---|---|
| 1 | 13.01 |
| 2 | 27.00 |
| 3 | 40.99 |

| Type | Setting | Cylinder ID | Cylinder Value | Analyzer Response | Difference, % of Span | Expiration Date | Final Bottle Pressure, PSI |
|---|---|---|---|---|---|---|---|
| CO2 % (dry) | Zero | | 0 | 0.01 | -0.05% | | |
| | Mid | CC183734 | 9.968 | 9.98 | -0.06% | 5/23/2022 | 1050 |
| | High | CC415912 | 19.47 | 19.47 | 0.00% | 10/14/2021 | 900 |
| O2 % (dry) | Zero | | 0 | 0.06 | -0.27% | | |
| | Mid | CC455275 | 11.99 | 12.03 | -0.18% | 9/22/2022 | 1950 |
| | High | CC94285 | 22.25 | 22.20 | 0.22% | 10/15/2021 | 800 |

## Response Time Data

| Type | RM Analyzer Make/Model | RM Analyzer s/n | Analyzer Span | RM Gas Span |
|---|---|---|---|---|
| CO2 % (dry) | Servomex ServoPro 1440 | 4662-01440D1 | 20 | 19.47 |
| O2 % (dry) | Servomex ServoPro 1440 | 4662-01440D1 | 25 | 22 |
| | Start | | 95% Response | Time (min) |
| Upscale | 8:01:00 | | 8:03:00 | 2 |
| Downscale | 8:04:00 | | 8:06:00 | 2 |


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**Client:** University of Iowa
**Facility:** Oakdale Renewable Energy Center
**Fuel Type:** Wood
**Fuel Factor:** 9240
**Diluent:** O2 %

**Location:** Hurst Boiler Exhaust Duct
**Date:** 11/4/14
**Operator:** DET
**Project #:** M144705
**Fuel Factor: by** Standard

**CO2 % (dry) Correction Data**

| Run # | Cma | Precal | Postcal | Pre zero | Post zero | Co | Cm | C | Cgas | Span Bias | Span Drift | Zero Bias | Zero Drift |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 9.97 | 10.03 | 10.01 | 0.01 | 0.02 | 0.02 | 10.02 | 11.65 | 11.6 | -0.15 | -0.10 | -0.05 | 0.05 |
| 2 | 9.97 | 10.01 | 10.03 | 0.02 | 0.01 | 0.02 | 10.02 | 11.50 | 11.4 | -0.26 | 0.10 | 0.00 | -0.05 |
| 3 | 9.97 | 10.03 | 10.00 | 0.01 | 0.01 | 0.01 | 10.02 | 11.82 | 11.8 | -0.10 | -0.15 | 0.00 | 0.00 |

**O2 % (dry) Correction Data**

| Run # | Cma | Precal | Postcal | Pre zero | Post zero | Co | Cm | C | Cgas | Span Bias | Span Drift | Zero Bias | Zero Drift |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 11.99 | 12.00 | 11.99 | 0.00 | 0.00 | 0.00 | 12.00 | 8.93 | 8.9 | 0.18 | -0.04 | 0.27 | 0.00 |
| 2 | 11.99 | 11.99 | 11.95 | 0.00 | -0.02 | -0.01 | 11.97 | 9.06 | 9.1 | 0.36 | -0.18 | 0.36 | -0.09 |
| 3 | 11.99 | 11.95 | 11.95 | -0.02 | -0.01 | -0.02 | 11.95 | 8.75 | 8.8 | 0.36 | 0.00 | 0.31 | 0.04 |

**Calibration Corrected Data**

| Run # | Run Date | Start Time | End Time | CO2 % (dry) | O2 % (dry) |
|---|---|---|---|---|---|
| 1 | 11/4/14 | 8:35 | 11:02 | 11.6 | 8.9 |
| 2 | 11/4/14 | 11:30 | 13:47 | 11.4 | 9.1 |
| 3 | 11/4/14 | 14:15 | 16:32 | 11.8 | 8.8 |


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**Client:** University of Iowa
**Facility:** Oakdale Renewable Energy Center
**Project #:** M144705
**Test Location:** Hurst Boiler Exhaust Duct
**Operating Condition:** Normal
**Date:** 11/4/14

**Linearity Cal/Pre 1 Cal**

| Time | CO2 % (dry) | | O2 % (dry) | |
|---|---|---|---|---|
| 7:36 | 0.01 | | 22.20 | ih |
| 7:37 | 5.44 | | 14.16 | |
| 7:38 | 19.15 | | -0.41 | |
| 7:39 | 19.36 | | -0.16 | |
| 7:40 | 19.47 | ih | -0.05 | |
| 7:41 | 14.32 | | 3.94 | |
| 7:42 | 0.03 | | 12.25 | |
| 7:43 | 0.01 | | 12.03 | |
| 7:44 | 0.01 | iz | 12.03 | im |
| 7:45 | 7.99 | | 2.20 | |
| 7:46 | 9.98 | im | 0.06 | iz |
| 7:47 | 9.75 | | 1.45 | |
| 7:48 | 0.15 | | 20.61 | |
| 7:49 | 0.06 | | 20.65 | |
| 7:50 | 0.04 | | 11.18 | |
| 7:51 | 0.01 | | 0.02 | |
| 7:52 | 0.01 | | -0.02 | |
| 7:53 | 0.01 | | -0.02 | |
| 7:54 | 0.01 | | 0.09 | |
| 7:55 | 0.01 | | 0.03 | |
| 7:56 | 0.01 | | -0.04 | |
| 7:57 | 0.00 | | -0.04 | |
| 7:58 | 0.00 | | -0.04 | |
| 7:59 | 0.33 | | -0.06 | |
| 8:00 | 9.72 | | -0.14 | |
| 8:01 | 10.03 | m | 0.00 | z |
| 8:02 | 8.20 | | 2.90 | |
| 8:03 | 0.13 | | 11.80 | |
| 8:04 | 0.01 | z | 12.00 | m |


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**Client:** University of Iowa
**Facility:** Oakdale Renewable Energy Center
**Project #:** M144705

**Test Location:** Hurst Boiler Exhaust Duct
**Operating Condition:** Normal
**Date:** 11/4/14

**Post 1/Pre 2**

| Time | CO2 % (dry) | | O2 % (dry) | |
|---|---|---|---|---|
| 11:04 | 2.28 | | 11.42 | |
| 11:05 | 0.04 | | 11.98 | |
| 11:06 | 0.02 | z | 11.99 | m |
| 11:07 | 4.35 | | 5.81 | |
| 11:08 | 9.96 | | 0.04 | |
| 11:09 | 10.01 | m | 0.00 | z |

**Post 2/Pre 3**

| Time | CO2 % (dry) | | O2 % (dry) | |
|---|---|---|---|---|
| 13:59 | 0.01 | | 11.94 | |
| 14:00 | 0.01 | z | 11.95 | m |
| 14:01 | 7.15 | | 2.40 | |
| 14:02 | 10.00 | | 0.00 | |
| 14:03 | 10.03 | m | -0.02 | z |

**Post 3**

| Time | CO2 % (dry) | | O2 % (dry) | |
|---|---|---|---|---|
| 16:42 | 0.01 | | 11.93 | |
| 16:43 | 0.01 | z | 11.95 | m |
| 16:44 | 6.43 | | 3.28 | |
| 16:45 | 10.00 | m | -0.01 | z |
| 16:46 | 10.04 | | -0.03 | |


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## CALIBRATION SUMMARY

Project Number: M144705
Client: UNIVERSITY OF IOWA
Test Location: HURST BOILER EXHAUST DUCT

Date: 11/5/14
Operator: DAN TUIDER
Box Truck: 5

| Analyzer Type, S/N, and Span | Cal Level | Cylinder ID Serial Number | Expected Cal Value | Actual Response | Difference As % of Span | Cylinder Pressure (psi) | Cylinder Expiration Date |
|---|---|---|---|---|---|---|---|
| $NO_x$ | Zero | — | 0.0 | 0.2 | -0.22 | — | — |
| | Mid | CC422360 | 46.68 | 47.3 | -0.68 | 950 | 2/17/17 |
| | High | CC310556 | 90.78 | 91.2 | -0.46 | 700 | 6/12/22 |
| $SO_2$ | Zero | | | | | | |
| | Mid | | | | | | |
| | High | | | | | | |
| $CO_2$ | Zero | — | 0.0 | 0.0 | 0.0 | — | — |
| | Mid | CC183734 | 9.968 | 9.97 | -0.01 | 1000 | 5/23/22 |
| | High | CC415912 | 19.47 | 19.50 | -0.15 | 850 | 10/14/21 |
| $O_2$ | Zero | — | 0.0 | -0.01 | 0.04 | — | — |
| | Mid | CC455275 | 11.99 | 11.96 | 0.13 | 1900 | 9/22/22 |
| | High | CC94285 | 22.25 | 22.30 | -0.22 | 750 | 10/15/21 |
| CO | Zero | — | 0.0 | 0.0 | 0.0 | — | — |
| | Mid | XC013299B | 14.89 | 14.9 | -0.03 | 1400 | 12/3/20 |
| | High | SG9146478BAL | 30.63 | 30.5 | 0.42 | 1900 | 7/16/21 |


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| | | | |
|---|---|---|---|
| Client: | University of Iowa | Test Location: | Hurst Boiler Exhaust Duct |
| Facility: | Oakdale Renewable Energy Plant | Date: | 11/5/14 |
| Project #: | M144705 | Operator: | Dan Tulder |
| Operating Condition: | Normal | | |

| | | |
|---|---|---|
| Probe Length: | 4.0 | ft |
| Probe Type: | Extractive | |
| Sample Plane: | Horizontal | |
| Port Length: | 6.00 | in. |
| Port Size (diameter): | 6 | in. |
| Port Type: | Flange | |
| Duct Shape: | Rectangular | |
| Length (traverse side of duct): | 3.5 | ft |
| Width: | 5.5 | ft |
| Location of Test Ports: | Side of duct | |
| Duct Area: | 19.25 | Sq. Ft. |
| Equivalent Diameter Rectangular Duct: | 4.278 | |
| Upstream Diameters: | >.5 | |
| Downstream Diameters: | >2 | |
| Number of Ports Sampled: | 5 | |
| Number of Points per Port: | 4 | |
| Total Number of Traverse Points: | 20 | |

Point Markings (including port length):

| Point # | Inches |
|---|---|
| 1 | 13.01 |
| 2 | 27.00 |
| 3 | 40.99 |

| Type | Setting | Cylinder ID | Cylinder Value | Analyzer Response | Difference, % of Span | Expiration Date | Final Bottle Pressure, PSI |
|---|---|---|---|---|---|---|---|
| NOx ppmvd | Zero | | 0 | 0.20 | -0.22% | | |
| | Mid | CC422360 | 46.68 | 47.30 | -0.68% | 2/17/2017 | |
| | High | CC310556 | 90.78 | 91.20 | -0.46% | 6/12/2022 | |
| CO ppmvd | Zero | | 0 | 0.00 | 0.00% | | |
| | Mid | XC013299B | 14.89 | 14.90 | -0.03% | 12/3/2020 | |
| | High | SG9146479BAL | 30.63 | 30.50 | 0.42% | 7/16/2021 | |
| CO2 % (dry) | Zero | | 0 | 0.00 | 0.00% | | |
| | Mid | CC183734 | 9.968 | 9.97 | -0.01% | 5/23/2022 | |
| | High | CC415912 | 19.47 | 19.50 | -0.15% | 10/14/2021 | |
| O2 % (dry) | Zero | | 0 | -0.01 | 0.04% | | |
| | Mid | CC455275 | 11.99 | 11.96 | 0.13% | 9/22/2022 | |
| | High | CC94285 | 22.25 | 22.30 | -0.22% | 10/15/2021 | |

## Response Time Data

| Type | RM Analyzer Make/Model | RM Analyzer s/n | Analyzer Span | RM Gas Span |
|---|---|---|---|---|
| NOx ppmvd | TECO 42i-HL | 1023743809 | 500 | 90.78 |
| CO ppmvd | TECO 48i | 0603715217 | 1000 | 30.63 |
| CO2 % (dry) | Servomex ServoPro 1440 | 4662-01440D1 | 20 | 19.47 |
| O2 % (dry) | Servomex ServoPro 1440 | 4662-01440D1 | 25 | 22 |
| | Start | | 95% Response | Time (min) |
| Upscale | 11:15:00 | | 11:17:00 | 2 |
| Downscale | 11:21:00 | | 11:23:00 | 2 |


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**Client:** University of Iowa
**Facility:** Oakdale Renewable Energy Plant
**Fuel Type:** Wood
**Fuel Factor:** 9240
**Diluent:** O2 %

**Location:** Hurst Boiler Exhaust Duct
**Date:** 11/5/14
**Operator:** Dan Tuider
**Project #:** M144705
**Fuel Factor: by** Standard

**NOx ppmvd Correction Data**

| Run # | Cma | Precal | Postcal | Pre zero | Post zero | Co | Cm | C | Cgas | Span Bias | Span Drift | Zero Bias | Zero Drift |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 46.68 | 46.70 | 46.60 | 0.40 | 0.30 | 0.35 | 46.65 | 45.80 | 45.8 | 0.77 | -0.11 | -0.11 | -0.11 |
| 2 | 46.68 | 46.60 | 45.90 | 0.30 | 0.20 | 0.25 | 46.25 | 43.50 | 43.9 | 1.54 | -0.77 | 0.00 | -0.11 |
| 3 | 46.68 | 45.90 | | 0.20 | | 0.20 | 45.90 | 43.70 | 44.4 | | | | |

**CO ppmvd Correction Data**

| Run # | Cma | Precal | Postcal | Pre zero | Post zero | Co | Cm | C | Cgas | Span Bias | Span Drift | Zero Bias | Zero Drift |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 14.89 | 14.90 | 14.90 | 0.00 | 0.00 | 0.00 | 14.90 | 3.00 | 3.0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 14.89 | 14.90 | 14.90 | 0.00 | 0.00 | 0.00 | 14.90 | 5.90 | 5.9 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 14.89 | 14.90 | | 0.00 | | 0.00 | 14.90 | 9.20 | 9.2 | | | | |

**CO2 % (dry) Correction Data**

| Run # | Cma | Precal | Postcal | Pre zero | Post zero | Co | Cm | C | Cgas | Span Bias | Span Drift | Zero Bias | Zero Drift |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 9.97 | 10.00 | 10.00 | 0.01 | 0.05 | 0.03 | 10.00 | 9.36 | 9.3 | -0.15 | 0.00 | -0.26 | 0.21 |
| 2 | 9.97 | 10.00 | 10.01 | 0.05 | 0.03 | 0.04 | 10.01 | 9.61 | 9.6 | -0.21 | 0.05 | -0.15 | -0.10 |
| 3 | 9.97 | 10.01 | | 0.03 | | 0.03 | 10.01 | 10.18 | 10.1 | | | | |

**O2 % (dry) Correction Data**

| Run # | Cma | Precal | Postcal | Pre zero | Post zero | Co | Cm | C | Cgas | Span Bias | Span Drift | Zero Bias | Zero Drift |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 11.99 | 11.99 | 11.95 | 0.05 | 0.06 | 0.06 | 11.97 | 11.23 | 11.2 | 0.04 | -0.18 | -0.31 | 0.04 |
| 2 | 11.99 | 11.95 | 11.93 | 0.06 | 0.06 | 0.06 | 11.94 | 10.94 | 11.0 | 0.13 | -0.09 | -0.31 | 0.00 |
| 3 | 11.99 | 11.93 | | 0.06 | | 0.06 | 11.93 | 10.33 | 10.4 | | | | |

**Calibration Corrected Data**

| Run # | Run Date | Start Time | End Time | NOx ppmvd | CO2 % (dry) | O2 % (dry) | CO ppmvd |
|---|---|---|---|---|---|---|---|
| 1 | 11/5/14 | 11:35 | 13:01 | 45.8 | 9.3 | 11.2 | 3.0 |
| 2 | 11/5/14 | 13:25 | 14:48 | 43.9 | 9.6 | 11.0 | 5.9 |
| 3 | 11/5/14 | 15:13 | 16:01 | 44.4 | 10.1 | 10.4 | 9.2 |


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**Client:** University of Iowa
**Facility:** Oakdale Renewable Energy Plant
**Project #:** M144705
**Test Location:** Hurst Boiler Exhaust Duct
**Operating Condition:** Normal
**Date:** 11/5/14

**Linearity Cal/Pre 1 Cal**

| Time | NOx ppmvd | | CO ppmvd | | CO2 % (dry) | | O2 % (dry) | |
|---|---|---|---|---|---|---|---|---|
| 8:10 | 0.00 | | -0.10 | | 0.00 | | **22.30** | ih |
| 8:11 | 0.10 | | -0.10 | | 10.51 | | 9.02 | |
| 8:12 | 0.00 | | -0.10 | | 20.20 | | 0.00 | |
| 8:13 | 0.00 | | -0.10 | | 19.56 | | 0.00 | |
| 8:14 | 0.00 | | -0.20 | | 19.50 | | 0.00 | |
| 8:15 | 0.00 | | -0.10 | | **19.50** | ih | 0.00 | |
| 8:16 | 0.00 | | 0.70 | | 14.37 | | 0.09 | |
| 8:17 | 0.00 | | 394.80 | | 0.02 | | 0.14 | |
| 8:18 | 0.00 | | 827.00 | | 0.01 | | 0.14 | |
| 8:19 | 0.00 | | 836.10 | | 0.01 | | 0.15 | |
| 8:20 | 0.00 | | 896.70 | | 0.00 | | 0.15 | |
| 8:21 | 0.00 | | **967.90** | | 0.00 | | 0.14 | |
| 8:22 | 0.80 | | 938.90 | | 0.01 | | 0.13 | |
| 8:23 | 85.50 | | 211.60 | | 0.00 | | 0.01 | |
| 8:24 | 155.10 | | 1.50 | | 0.00 | | 0.01 | |
| 8:25 | 153.00 | | 1.40 | | 0.00 | | 0.00 | |
| 8:26 | **151.60** | | 1.40 | | 0.00 | | 0.00 | |
| 8:27 | 143.20 | | 8.70 | | 0.00 | | 0.09 | |
| 8:28 | 6.10 | | 353.40 | | 0.00 | | 0.11 | |
| 8:29 | 0.20 | | 473.80 | | 0.00 | | 0.05 | |
| 8:30 | 0.20 | | **484.80** | | 0.00 | | 0.03 | |
| 8:31 | 2.00 | | 478.00 | | 0.01 | | 0.19 | |
| 8:32 | 72.70 | | 141.10 | | 0.00 | | -0.04 | |
| 8:33 | 91.40 | | 1.50 | | 0.00 | | -0.04 | |
| 8:34 | **91.20** | lh | 1.40 | | 0.00 | | -0.04 | |
| 8:35 | 91.00 | | 1.00 | | 0.00 | | 0.50 | |
| 8:36 | 29.80 | | 1.40 | | 0.00 | | 11.91 | |
| 8:37 | 0.20 | | 0.20 | | 0.00 | | 11.95 | |
| 8:38 | **0.20** | iz | -0.10 | | 0.00 | | **11.96** | im |
| 8:39 | 0.10 | | -0.10 | | 4.75 | | 6.09 | |
| 8:40 | 0.00 | | -0.10 | | 9.66 | | 0.74 | |
| 8:41 | 0.10 | | -0.10 | | 9.97 | im | 0.00 | |
| 8:42 | 0.00 | | 2.30 | | 6.31 | | 0.05 | |
| 8:43 | 0.00 | | 41.00 | | 0.01 | | 0.00 | |
| 8:44 | 0.00 | | 37.50 | | 0.00 | | -0.01 | |
| 8:45 | 0.00 | | **30.50** | ih | 0.00 | | -0.01 | |
| 8:46 | 0.00 | | 29.70 | | 0.00 | | -0.01 | |
| 8:47 | 0.00 | | 29.70 | | 0.00 | | -0.01 | |
| 8:48 | 0.00 | | 29.60 | | 0.00 | | -0.01 | |
| 8:49 | 18.30 | | 24.50 | | 0.01 | | 0.07 | |
| 8:50 | 49.90 | | 1.80 | | 0.00 | | -0.02 | |
| 8:51 | 48.10 | | 0.00 | | 0.00 | | -0.02 | |
| 8:52 | 47.70 | | -0.10 | | 0.00 | | -0.02 | |
| 8:53 | 47.50 | | 0.00 | | 0.00 | | -0.01 | |
| 8:54 | **47.30** | im | **0.00** | iz | **0.00** | iz | **-0.01** | iz |
| 8:55 | 31.20 | | 2.00 | | 0.00 | | 0.04 | |
| 8:56 | 0.20 | | 13.70 | | 0.00 | | 0.04 | |
| 8:57 | 0.10 | | 14.90 | | 0.00 | | 0.04 | |
| 8:58 | 0.00 | | **14.90** | im | 0.00 | | 0.04 | |
| 11:10 | 0.50 | | 0.30 | | 9.99 | | 0.00 | |
| 11:11 | 0.40 | | 0.30 | | 10.00 | m | -0.01 | |
| 11:12 | 0.40 | | 0.30 | | 5.50 | | 6.05 | |
| 11:13 | 0.40 | | 0.40 | | 0.10 | | 11.88 | |
| 11:14 | 0.40 | z | 0.60 | | 0.04 | | 11.99 | m |
| 11:15 | 0.40 | | 0.60 | | 0.03 | | 10.75 | |
| 11:16 | 23.50 | | 0.60 | | 0.02 | | 0.20 | |
| 11:17 | 45.60 | | 0.50 | | 0.02 | | 0.06 | |
| 11:18 | 46.50 | | 0.60 | | 0.02 | | 0.05 | |
| 11:19 | 46.70 | | 0.40 | | 0.02 | | 0.05 | |
| 11:20 | 46.70 | | 0.00 | | 0.02 | | 0.05 | |
| 11:21 | 46.70 | m | 0.00 | z | 0.01 | z | 0.05 | z |
| 11:22 | 15.60 | | 7.40 | | 0.01 | | 0.04 | |
| 11:23 | 0.50 | | 14.70 | | 0.01 | | 0.04 | |
| 11:24 | 0.40 | | 14.90 | m | 0.01 | | 0.04 | |


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**Client:** University of Iowa
**Facility:** Oakdale Renewable Energy Plant
**Project #:** M144705

**Test Location:** Hurst Boiler Exhaust Duct
**Operating Condition:** Normal
**Date:** 11/5/14

**Post 1/Pre 2**

| Time | NOx ppmvd | | CO ppmvd | | CO2 % (dry) | | O2 % (dry) | |
|---|---|---|---|---|---|---|---|---|
| 13:06 | 2.60 | | 1.90 | | 0.08 | | 11.91 | |
| 13:07 | 0.30 | z | 0.00 | | 0.04 | | 11.95 | m |
| 13:08 | 0.30 | | 0.00 | | 1.50 | | 9.34 | |
| 13:09 | 0.20 | | 0.00 | | 9.86 | | 0.09 | |
| 13:10 | 0.20 | | 0.00 | | 10.00 | m | 0.00 | |
| 13:11 | 0.20 | | 0.00 | | 8.63 | | 0.01 | |
| 13:12 | 30.40 | | 0.00 | | 0.18 | | 0.06 | |
| 13:13 | 46.60 | m | 0.00 | z | 0.05 | z | 0.06 | z |
| 13:14 | 46.40 | | 0.00 | | 0.03 | | 0.06 | |
| 13:15 | 43.60 | | 0.70 | | 0.03 | | 0.06 | |
| 13:16 | 2.50 | | 11.90 | | 0.02 | | 0.05 | |
| 13:17 | 0.30 | | 14.90 | | 0.02 | | 0.05 | |
| 13:18 | 0.20 | | 14.90 | m | 0.02 | | 0.05 | |

**Post 2/Pre 3**

| Time | NOx ppmvd | | CO ppmvd | | CO2 % (dry) | | O2 % (dry) | |
|---|---|---|---|---|---|---|---|---|
| 14:54 | 0.30 | | 0.00 | | 0.03 | | 11.92 | |
| 14:55 | 0.20 | | 0.00 | | 0.03 | | 11.93 | |
| 14:56 | 0.20 | z | 0.00 | | 0.02 | | 11.93 | m |
| 14:57 | 0.20 | | 0.00 | | 2.99 | | 7.48 | |
| 14:58 | 0.20 | | 0.00 | | 9.93 | | 0.06 | |
| 14:59 | 0.20 | | 0.00 | | 10.01 | m | -0.01 | |
| 15:00 | 1.10 | | 0.00 | | 7.78 | | 0.01 | |
| 15:01 | 36.70 | | 0.00 | | 0.14 | | 0.06 | |
| 15:02 | 46.20 | | 0.00 | | 0.04 | | 0.06 | |
| 15:03 | 45.90 | m | 0.00 | z | 0.03 | z | 0.06 | z |
| 15:04 | 39.50 | | 0.90 | | 0.02 | | 0.06 | |
| 15:05 | 1.90 | | 12.20 | | 0.02 | | 0.06 | |
| 15:06 | 0.20 | | 14.90 | | 0.02 | | 0.06 | |
| 15:07 | 0.20 | | 14.90 | m | 0.02 | | 0.06 | |


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# NO2 to NO Converter Test

**Client:** University of Iowa
**Facility:** Oakdale Renewable Energy Plant
**Location:** Hurst Boiler Exhaust Duct
**Date:** 11/4/14
**Project #:** M144705

**Conv. Temp:** 632.4 °C
**Max:** 84.3 ppm
**Min:** 83.2 ppm
**% of Max:** 1.30 %

| Pre-Calibration | | | Test | | | Post-Calibration | | Cal |
|---|---|---|---|---|---|---|---|---|
| Time | $NO_x$ | Cal Flag | Time | $NO_x$ | | Time | $NO_x$ | Flag |
| 16:51 | 0.3 | z | 17:09 | 84.3 | Max | 17:45:00 | 0.2 | z |
| 16:52 | 4.8 | | 17:10 | 84.2 | | 17:46:00 | 5.1 | |
| 16:53 | 121.0 | | 17:11 | 84.2 | | 17:47:00 | 122.2 | |
| 16:54 | 154.1 | | 17:12 | 84.1 | | 17:48:00 | 108.2 | |
| 16:55 | 153.5 | | 17:13 | 84.1 | | 17:49:00 | 93.5 | |
| 16:56 | 153.4 | h | 17:14 | 83.9 | | 17:50:00 | 92.7 | m |
| 16:57 | 150.7 | | 17:15 | 84.0 | | | | |
| 16:58 | 96.8 | | 17:16 | 83.7 | | | | |
| 16:59 | 94.0 | | 17:17 | 83.9 | | | | |
| 17:00 | 93.5 | | 17:18 | 83.7 | | | | |
| 17:01 | 92.4 | | 17:19 | 83.6 | | | | |
| 17:02 | 91.8 | m | 17:20 | 83.6 | | | | |
| | | | 17:21 | 83.7 | | | | |
| | | | 17:22 | 84.1 | | | | |
| | | | 17:23 | 83.8 | | | | |
| | | | 17:24 | 84.0 | | | | |
| | | | 17:25 | 83.7 | | | | |
| | | | 17:26 | 83.9 | | | | |
| | | | 17:27 | 83.7 | | | | |
| | | | 17:28 | 83.8 | | | | |
| | | | 17:29 | 83.7 | | | | |
| | | | 17:30 | 83.6 | | | | |
| | | | 17:31 | 83.5 | | | | |
| | | | 17:32 | 83.3 | | | | |
| | | | 17:33 | 83.5 | | | | |
| | | | 17:34 | 83.2 | Min | | | |
| | | | 17:35 | 83.4 | | | | |
| | | | 17:36 | 83.3 | | | | |
| | | | 17:37 | 83.7 | | | | |
| | | | 17:38 | 83.4 | | | | |
| | | | 17:39 | 83.6 | | | | |

**PRE-CAL RESULT**

| | |
|---|---|
| zero | 0.3 |
| mid | 0.67% |
| high | 1.25% |

**POST-CAL RESULT**

| | |
|---|---|
| zero | 0.2 |
| mid | 1.27% |

| Type | | RM Analyzer Make/Model | RM Analyzer s/n | Analyzer Span | RM Gas Span | | |
|---|---|---|---|---|---|---|---|
| NOx ppmvd | | TECO 42i-HL | 1023743809 | 90.78 | 151.5 | | |
| Type | Setting | Cylinder ID | Cylinder Value | Analyzer Response | Difference, % of Span | Expiration Date | Final Bottle Pressure, PSI |
| NOx ppmvd | Zero | 0 | 0 | 0.30 | -0.20% | | 0 |
| | Mid | CC310556 | 90.78 | 91.80 | -0.67% | 6/12/2022 | 750 |
| | High | CC360686 | 151.5 | 153.40 | -1.25% | 5/16/2021 | 1350 |


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# Appendix I - Gas Cylinder Calibration Sheets


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# CERTIFICATE OF ANALYSIS
## Grade of Product: EPA Protocol

| | | | |
|---|---|---|---|
| Part Number: | E02NI99E15A0163 | Reference Number: | 54-124418926-2 |
| Cylinder Number: | CC422360 | Cylinder Volume: | 144.3 Cubic Feet |
| Laboratory: | ASG - Chicago - IL | Cylinder Pressure: | 2015 PSIG |
| PGVP Number: | B12014 | Valve Outlet: | 660 |
| Gas Code: | NO,BALN | Certification Date: | Feb 17, 2014 |

**Expiration Date: Feb 17, 2017**

Certification performed in accordance with "EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards (May 2012)" document EPA 600/R-12/531, using the assay procedures listed. Analytical Methodology does not require correction for analytical interference. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.

Do Not Use This Cylinder below 100 psig, i.e. 0.7 megapascals.

### ANALYTICAL RESULTS

| Component | Requested Concentration | Actual Concentration | Protocol Method | Total Relative Uncertainty | Assay Dates |
|---|---|---|---|---|---|
| NOX | 45.00 PPM | 46.68 PPM | G1 | +/- 1.0% NIST Traceable | 02/08/2014, 02/17/2014 |
| NITRIC OXIDE | 45.00 PPM | 46.63 PPM | G1 | +/- 1.0% NIST Traceable | 02/08/2014, 02/17/2014 |
| NITROGEN | Balance | | | | |

### CALIBRATION STANDARDS

| Type | Lot ID | Cylinder No | Concentration | Uncertainty | Expiration Date |
|---|---|---|---|---|---|
| NTRM | 13061056 | CC423751 | 99.86 PPM NITRIC OXIDE/NITROGEN | +/- 0.8% | Nov 19, 2019 |
| PRM | 12312 | 680179 | 10.01 PPM NITROGEN DIOXIDE/NITROGEN | +/- 2.0% | Oct 15, 2014 |
| GMIS | 124205889130 | CC323209 | 4.824 PPM NITROGEN DIOXIDE/NITROGEN | +/- 2.0% | Oct 25, 2015 |

The SRM, PRM or RGM noted above is only in reference to the GMIS used in the assay and not part of the analysis.

### ANALYTICAL EQUIPMENT

| Instrument/Make/Model | Analytical Principle | Last Multipoint Calibration |
|---|---|---|
| Nexus 470 AEP0000428 | FTIR | Jan 21, 2014 |
| Nexus 470 AEP0000428 | FTIR | Jan 21, 2014 |

**Triad Data Available Upon Request**

Notes:

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# CERTIFICATE OF ANALYSIS
## Grade of Product: EPA Protocol

| | | | |
|---|---|---|---|
| Part Number: | E02NI99E15A3576 | Reference Number: | 54-124439571-2 |
| Cylinder Number: | CC310556 | Cylinder Volume: | 144.3 Cubic Feet |
| Laboratory: | ASG - Chicago - IL | Cylinder Pressure: | 2015 PSIG |
| PGVP Number: | B12014 | Valve Outlet: | 660 |
| Gas Code: | NO,BALN | Certification Date: | Jun 12, 2014 |

**Expiration Date: Jun 12, 2022**

Certification performed in accordance with "EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards (May 2012)" document EPA 600/R-12/531, using the assay procedures listed. Analytical Methodology does not require correction for analytical interference. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.

Do Not Use This Cylinder below 100 psig, i.e. 0.7 megapascals.

### ANALYTICAL RESULTS

| Component | Requested Concentration | Actual Concentration | Protocol Method | Total Relative Uncertainty | Assay Dates |
|---|---|---|---|---|---|
| NOX | 90.00 PPM | 90.78 PPM | G1 | +/- 0.9% NIST Traceable | 06/05/2014, 06/12/2014 |
| NITRIC OXIDE | 90.00 PPM | 90.47 PPM | G1 | +/- 0.9% NIST Traceable | 06/05/2014, 06/12/2014 |
| NITROGEN | Balance | | | | |

### CALIBRATION STANDARDS

| Type | Lot ID | Cylinder No | Concentration | Uncertainty | Expiration Date |
|---|---|---|---|---|---|
| NTRM | 13061056 | CC423751 | 99.86 PPM NITRIC OXIDE/NITROGEN | +/- 0.8% | Nov 19, 2019 |
| PRM | 12312 | 680179 | 10.01 PPM NITROGEN DIOXIDE/NITROGEN | +/- 2.0% | Feb 14, 2012 |
| GMIS | 124206889102 | CC320508 | 4.979 PPM NITROGEN DIOXIDE/NITROGEN | +/- 2.0% | May 04, 2015 |

The SRM, PRM or RGM noted above is only in reference to the GMIS used in the assay and not part of the analysis.

### ANALYTICAL EQUIPMENT

| Instrument/Make/Model | Analytical Principle | Last Multipoint Calibration |
|---|---|---|
| Nexus 470 AEP0000428 | FTIR | May 28, 2014 |
| Nexus 470 AEP0000428 | FTIR | May 28, 2014 |

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# CERTIFICATE OF ANALYSIS
## Grade of Product: EPA Protocol

| | | | |
|---|---|---|---|
| Part Number: | E02NI99E15A0283 | Reference Number: | 54-124373811-3 |
| Cylinder Number: | CC360686 | Cylinder Volume: | 144.4 CF |
| Laboratory: | ASG - Chicago - IL | Cylinder Pressure: | 2015 PSIG |
| PGVP Number: | B12013 | Valve Outlet: | 660 |
| Gas Code: | NO,BALN | Certification Date: | May 16, 2013 |

**Expiration Date: May 16, 2021**

Certification performed in accordance with "EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards (May 2012)" document EPA 600/R-12/531, using the assay procedures listed. Analytical Methodology does not require correction for analytical interference. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.

Do Not Use This Cylinder below 100 psig, i.e. 0.7 megapascals.

### ANALYTICAL RESULTS

| Component | Requested Concentration | Actual Concentration | Protocol Method | Total Relative Uncertainty | Assay Dates |
|---|---|---|---|---|---|
| NOX | 150.0 PPM | 151.5 PPM | G1 | +/- 0.6% NIST Traceable | 05/09/2013, 05/16/2013 |
| NITRIC OXIDE | 150.0 PPM | 151.5 PPM | G1 | +/- 0.6% NIST Traceable | 05/09/2013, 05/16/2013 |
| NITROGEN | Balance | | | | |

### CALIBRATION STANDARDS

| Type | Lot ID | Cylinder No | Concentration | Uncertainty | Expiration Date |
|---|---|---|---|---|---|
| NO | 12061954 | CC367722 | 250.8 PPM NITRIC OXIDE/NITROGEN | +/- 0.5% | May 04, 2018 |
| NO2 | 124206889130 | CC323209 | 4.824 PPM NITROGEN DIOXIDE/NITROGEN | +/- 2.0% | Oct 25, 2015 |

### ANALYTICAL EQUIPMENT

| Instrument/Make/Model | Analytical Principle | Last Multipoint Calibration |
|---|---|---|
| Nexus 470 AEP0000428 | FTIR | May 01, 2013 |
| Nexus 470 AEP0000428 | FTIR | May 01, 2013 |

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# CERTIFICATE OF ANALYSIS
## Grade of Product: EPA Protocol

| | | | |
|---|---|---|---|
| Part Number: | E02NI99E15A1129 | Reference Number: | 54-124348254-5 |
| Cylinder Number: | XC013299B | Cylinder Volume: | 144.3 CF |
| Laboratory: | ASG - Chicago - IL | Cylinder Pressure: | 2015 PSIG |
| PGVP Number: | B12012 | Valve Outlet: | 350 |
| Gas Code: | APPVD | Analysis Date: | Dec 03, 2012 |

Expiration Date: Dec 03, 2020

Certification performed in accordance with "EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards (May 2012)" document EPA 600/R-12/531, using the assay procedures listed. Analytical Methodology does not require correction for analytical interference. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.

Do Not Use This Cylinder below 100 psig, i.e. 0.7 megapascals.

### ANALYTICAL RESULTS

| Component | Requested Concentration | Actual Concentration | Protocol Method | Total Relative Uncertainty |
|---|---|---|---|---|
| CARBON MONOXIDE | 15.00 PPM | 14.89 PPM | G1 | +/- 1% NIST Traceable |
| NITROGEN | Balance | | | |

### CALIBRATION STANDARDS

| Type | Lot ID | Cylinder No | Concentration | Expiration Date |
|---|---|---|---|---|
| NTRM/CO | 08060201 | CC255804 | 51.26 PPM CARBON MONOXIDE/NITROGEN | Jan 17, 2018 |

### ANALYTICAL EQUIPMENT

| Instrument/Make/Model | Analytical Principle | Last Multipoint Calibration |
|---|---|---|
| Nexus 470 AEP0000426 | FTIR | Nov 05, 2012 |

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# CERTIFICATE OF ANALYSIS
## Grade of Product: EPA Protocol

| | | | |
|---|---|---|---|
| Part Number: | E02NI99E15A0497 | Reference Number: | 54-124384692-1 |
| Cylinder Number: | SG9146479BAL | Cylinder Volume: | 144.3 CF |
| Laboratory: | ASG - Chicago - IL | Cylinder Pressure: | 2015 PSIG |
| PGVP Number: | B12013 | Valve Outlet: | 350 |
| Gas Code: | CO,BALN | Certification Date: | Jul 16, 2013 |

**Expiration Date: Jul 16, 2021**

Certification performed in accordance with "EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards (May 2012)" document EPA 600/R-12/531, using the assay procedures listed. Analytical Methodology does not require correction for analytical interference. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.

Do Not Use This Cylinder below 100 psig, i.e. 0.7 megapascals.

### ANALYTICAL RESULTS

| Component | Requested Concentration | Actual Concentration | Protocol Method | Total Relative Uncertainty | Assay Dates |
|---|---|---|---|---|---|
| CARBON MONOXIDE | 30.00 PPM | 30.63 PPM | G1 | +/- 1.0% NIST Traceable | 07/16/2013 |
| NITROGEN | Balance | | | | |

### CALIBRATION STANDARDS

| Type | Lot ID | Cylinder No | Concentration | Uncertainty | Expiration Date |
|---|---|---|---|---|---|
| CO | 12060505 | CC353897 | 49.53 PPM CARBON MONOXIDE/NITROGEN | +/- 0.6% | Dec 20, 2017 |

### ANALYTICAL EQUIPMENT

| Instrument/Make/Model | Analytical Principle | Last Multipoint Calibration |
|---|---|---|
| Nexus 470 AEP0000428 | FTIR | Jun 21, 2013 |

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# CERTIFICATE OF ANALYSIS
## Grade of Product: EPA Protocol

| | | | |
|---|---|---|---|
| Part Number: | E02NI90E15A0123 | Reference Number: | 54-124435717-5 |
| Cylinder Number: | CC183734 | Cylinder Volume: | 149.8 CF |
| Laboratory: | ASG - Chicago - IL | Cylinder Pressure: | 2015 PSIG |
| PGVP Number: | B12014 | Valve Outlet: | 580 |
| Gas Code: | CO2,BALN | Certification Date: | May 23, 2014 |

**Expiration Date: May 23, 2022**

Certification performed in accordance with "EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards (May 2012)" document EPA 600/R-12/531, using the assay procedures listed. Analytical Methodology does not require correction for analytical interference. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.

Do Not Use This Cylinder below 100 psig, i.e. 0.7 megapascals.

### ANALYTICAL RESULTS

| Component | Requested Concentration | Actual Concentration | Protocol Method | Total Relative Uncertainty | Assay Dates |
|---|---|---|---|---|---|
| CARBON DIOXIDE | 10.00 % | 9.968 % | G1 | +/- 0.7% NIST Traceable | 05/23/2014 |
| NITROGEN | Balance | | | | |

### CALIBRATION STANDARDS

| Type | Lot ID | Cylinder No | Concentration | Uncertainty | Expiration Date |
|---|---|---|---|---|---|
| NTRM | 97050816 | SG9167530BAL | 7.029 % CARBON DIOXIDE/NITROGEN | +/- 0.5% | May 01, 2016 |

### ANALYTICAL EQUIPMENT

| Instrument/Make/Model | Analytical Principle | Last Multipoint Calibration |
|---|---|---|
| CO2-1 HORIBA VIA-510 V1E3H7P5 | NDIR | May 23, 2014 |

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# CERTIFICATE OF ANALYSIS
## Grade of Product: EPA Protocol

| | | | |
|---|---|---|---|
| Part Number: | E02NI80E15ACMD7 | Reference Number: | 54-124399697-2 |
| Cylinder Number: | CC415912 | Cylinder Volume: | 156.5 CF |
| Laboratory: | ASG - Chicago - IL | Cylinder Pressure: | 2015 PSIG |
| PGVP Number: | B12013 | Valve Outlet: | 580 |
| Gas Code: | CO2,BALN | Certification Date: | Oct 14, 2013 |

**Expiration Date: Oct 14, 2021**

Certification performed in accordance with "EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards (May 2012)" document EPA 600/R-12/531, using the assay procedures listed. Analytical Methodology does not require correction for analytical interference. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.

Do Not Use This Cylinder below 100 psig, i.e. 0.7 megapascals

### ANALYTICAL RESULTS

| Component | Requested Concentration | Actual Concentration | Protocol Method | Total Relative Uncertainty | Assay Dates |
|---|---|---|---|---|---|
| CARBON DIOXIDE | 19.50 % | 19.47 % | G1 | +/- 0.8% NIST Traceable | 10/14/2013 |
| NITROGEN | Balance | | | | |

### CALIBRATION STANDARDS

| Type | Lot ID | Cylinder No | Concentration | Uncertainty | Expiration Date |
|---|---|---|---|---|---|
| CO2 | 06120405 | CC184974 | 19.66 % CARBON DIOXIDE/NITROGEN | +/- 0.5% | May 01, 2016 |

### ANALYTICAL EQUIPMENT

| Instrument/Make/Model | Analytical Principle | Last Multipoint Calibration |
|---|---|---|
| CO2-1 HORIBA VIA-510 V1E3H7P5 | NDIR | Oct 11, 2013 |

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# CERTIFICATE OF ANALYSIS

## Grade of Product: EPA Protocol

| | | | |
|---|---|---|---|
| Part Number: | E02NI88E15A3424 | Reference Number: | 54-124455443-1 |
| Cylinder Number: | CC455275 | Cylinder Volume: | 145.4 Cubic Feet |
| Laboratory: | ASG - Chicago - IL | Cylinder Pressure: | 2015 PSIG |
| PGVP Number: | B12014 | Valve Outlet: | 590 |
| Gas Code: | O2,BALN | Certification Date: | Sep 22, 2014 |

**Expiration Date: Sep 22, 2022**

Certification performed in accordance with "EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards (May 2012)" document EPA 600/R-12/531, using the assay procedures listed. Analytical Methodology does not require correction for analytical interference. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.

Do Not Use This Cylinder below 100 psig, i.e. 0.7 megapascals.

### ANALYTICAL RESULTS

| Component | Requested Concentration | Actual Concentration | Protocol Method | Total Relative Uncertainty | Assay Dates |
|---|---|---|---|---|---|
| OXYGEN | 12.00 % | 11.99 % | G1 | +/- 1% NIST Traceable | 09/22/2014 |
| NITROGEN | Balance | | | | |

### CALIBRATION STANDARDS

| Type | Lot ID | Cylinder No | Concentration | Uncertainty | Expiration Date |
|---|---|---|---|---|---|
| NTRM | 06120208 | CC195923 | 20.9 % OXYGEN/NITROGEN | +/- 0.4% | Dec 01, 2015 |

### ANALYTICAL EQUIPMENT

| Instrument/Make/Model | Analytical Principle | Last Multipoint Calibration |
|---|---|---|
| O2-1 HORIBA MPA-510 3VUYL9NR | Paramagnetic | Sep 17, 2014 |

Triad Data Available Upon Request

Signature on file

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# CERTIFICATE OF ANALYSIS
## Grade of Product: EPA Protocol

| | | | |
|---|---|---|---|
| Part Number: | E02NI78E15A0124 | Reference Number: | 54-124399697-1 |
| Cylinder Number: | CC94285 | Cylinder Volume: | 146.3 CF |
| Laboratory: | ASG - Chicago - IL | Cylinder Pressure: | 2015 PSIG |
| PGVP Number: | B12013 | Valve Outlet: | 590 |
| Gas Code: | O2,BALN | Certification Date: | Oct 15, 2013 |

**Expiration Date: Oct 15, 2021**

Certification performed in accordance with "EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards (May 2012)" document EPA 600/R-12/531, using the assay procedures listed. Analytical Methodology does not require correction for analytical interference. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.

Do Not Use This Cylinder below 100 psig, i.e. 0.7 megapascals.

### ANALYTICAL RESULTS

| Component | Requested Concentration | Actual Concentration | Protocol Method | Total Relative Uncertainty | Assay Dates |
|---|---|---|---|---|---|
| OXYGEN | 22.00 % | 22.25 % | G1 | +/- 1.0% NIST Traceable | 10/15/2013 |
| NITROGEN | Balance | | | | |

### CALIBRATION STANDARDS

| Type | Lot ID | Cylinder No | Concentration | Uncertainty | Expiration Date |
|---|---|---|---|---|---|
| NTRM/O2 | 06120211 | CC195925 | 20.90 % OXYGEN/NITROGEN | +/- 0.4% | Dec 01, 2015 |

### ANALYTICAL EQUIPMENT

| Instrument/Make/Model | Analytical Principle | Last Multipoint Calibration |
|---|---|---|
| O2-1 HORIBA MPA-510 3VUYL9NR | Paramagnetic | Sep 23, 2013 |

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# Appendix J - Mercury QA/QC Data


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**Spike Recovery Summary**
**Oakdale Renewable Energy Plant**
**Hurst Boiler Exhaust Duct**
**11/5/2014**

| Test Run | Start Time | End Time | Actual Concentration, ng | Expected Spike Concentration, ng | Sample Volume, standard liters | Recovery % |
|---|---|---|---|---|---|---|
| 1A | 11:35 | 12:45 | 85.6 | N/A | 137.576 | 78.46 |
| 1B | | | 103.9 | 25 | 135.462 | |
| 2A | 13:25 | 14:35 | 59.2 | N/A | 136.702 | 83.33 |
| 2B | | | 78.4 | 25 | 132.931 | |
| 3A | 15:13 | 16:05 | 28.9 | N/A | 116.988 | 107.26 |
| 3B | | | 50.6 | 25 | 96.283 | |
| | | | | | **Average Recovery %** | **89.69** |


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# Certificate of Analysis

**Product Description:**

| | | | |
|---|---|---|---|
| Name: | Mercury | Source Material: | Mercury Metal |
| Part Number: | **100033-1** | Material Purity: | 99.9998% |
| Lot Number: | **1309308** | Matrix: | 2% (v/v) $HNO_3$ |

**Certified Value:** 1000 µg/mL ± 6 µg/mL

The Certified value is based on gravimetric and volumetric preparation, and confirmed against SRM 3133 (lot number 061204) by inductively coupled plasma optical emission spectrometry (ICP-OES) using an internal laboratory-developed method. The uncertainty in the certified value is calculated for a 95% confidence interval and coverage factor *k* is about 2.

**Density:** 1.009 g/mL ± 0.002 g/mL @ 22.4°C

**Uncertified Values:**

**Trace Metal Impurity Scan:** The data reported are based upon a scan of this specific lot at 1000 µg/mL via ICP analysis. The values are reported in µg/L.

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ag | < | 10 | Cu | < | 0.1 | Li | < | 0.02 | Rb | < | 0.02 | Th | < | 0.02 |
| Al | < | 0.1 | Dy | < | 0.02 | Lu | < | 0.02 | Re | < | 0.02 | Ti | < | 0.02 |
| As | < | 0.05 | Er | < | 0.02 | Mg | < | 0.5 | Rh | < | 0.02 | Tl | < | 0.02 |
| Au | < | 0.02 | Eu | < | 0.02 | Mn | < | 0.1 | Ru | < | 0.02 | Tm | < | 0.02 |
| B | < | 1 | Fe | < | 1 | Mo | < | 0.1 | Sb | < | 0.02 | U | < | 0.1 |
| Ba | < | 0.02 | Ga | < | 0.02 | Na | < | 3 | Sc | < | 0.02 | V | < | 0.05 |
| Be | < | 0.02 | Gd | < | 0.02 | Nb | < | 0.02 | Se | < | 0.1 | W | < | 0.02 |
| Bi | < | 0.02 | Ge | < | 0.02 | Nd | < | 0.02 | Si | < | 10 | Y | < | 0.02 |
| Ca | < | 1 | Hf | < | 0.02 | Ni | < | 0.02 | Sm | < | 0.02 | Yb | < | 0.02 |
| Cd | < | 0.02 | Ho | < | 0.02 | Os | | na | Sn | < | 1 | Zn | < | 2 |
| Ce | < | 0.02 | In | < | 0.02 | Pb | < | 0.05 | Sr | < | 0.02 | Zr | < | 0.02 |
| Co | < | 0.05 | Ir | < | 0.02 | Pd | < | 0.02 | Ta | < | 0.02 | Hg | | M |
| Cr | < | 0.1 | K | < | 1 | Pr | < | 0.02 | Tb | < | 0.02 | | | |
| Cs | | na | La | < | 0.02 | Pt | < | 0.02 | Te | < | 0.02 | na - not analyzed | | |

**Preparation Information:**

The standard solution is prepared using high purity materials and assayed by analytical methods for conformity prior to use. This standard was prepared using the methods developed at NIST for SRM Spectrometric Standard Solutions under appropriate laboratory conditions.

Sub-boiling distilled high-purity acid has been used to place the materials in solution and to stabilize the standard. The matrix is as noted above in 18 megaohm deionized water.

Stability of this product is based upon rigorous short term and long term testing of the solution for the certified value. This testing includes, but is not limited to, the effect of temperature and packaging on the product.



**High-Purity Standards is certified to ISO 9001:2008 and accredited to ISO/IEC 17025:2005 and ISO Guide 34:2009.**


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**Intended Use:**

This Certified Reference Material (CRM) is intended for use as a calibration standard for the quantitative determination of mercury, calibration of instruments such as ICPOES, ICPMS, AAS and XRF, and validation of analytical methods. It also can be used in EPA, ASTM and other methods.

**Traceability Information:**

The traceability of this standard is maintained through an unbroken chain of comparisons to appropriate standards with suitable procedure and measurement uncertainties. The maintenance of the base and derived units of International System of Units (SI) with traceability of measurement results (contemporary metrology) to SI ensures their comparability over time as follows.

a. **Standard Weight and Analytical Balance**
The standard weights (NBS weights Inventory No 20231A) are calibrated every two years by South Carolina Metrology Laboratory that is a participant in "NIST Weights and Measures Measurement Assurance Program" with a certificate of measurement traceability to NIST primary standards.
The balances are calibrated yearly by the ISO 17025 accredited metrology service, and are verified weekly by an in-house method using standard weights.

b. **Volumetric Device**
The calibration of volumetric vessels is checked annually using the NBS 602 method.

c. **Thermometer**
The standard thermometers are calibrated every year by the ISO 17025 accredited metrology service. The thermometers used in-house are verified against the standard thermometers yearly.

d. **Calibration Standards:**
The Calibration Standard is directly traceable to SRM 3100 Series Spectrometric Standard Solutions.

**Packaging and Storage Conditions:**

The standard is packaged in a pre-cleaned polyethylene bottle. To maintain the integrity of this product, the solution should be kept tightly capped and stored under normal laboratory conditions.

**Refer to Material Safety Datasheet (MSDS) for hazardous information.**

**Expiration Information:**

The expiry date is guaranteed to be valid for eighteen months from the shipping date provided. For this reason, standards from the same lot may have different expiration dates.

**Preparation Date:** April 3, 2013

**Shipped Date:** November 21, 2013

**Expiration Date:** May 21, 2015

**Certificate Issue Date:** April 29, 2013

**Quality Information:**

ISO/IEC 17025:2005 Accreditation
Certificate Number AT-1529

Vanny T. Yib,
Inorganic Laboratory Manager

ISO Guide 34:2009 (RMP) Accreditation
Certificate Number AR-1436

Angel Sellers
Quality Manager

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**High-Purity Standards is certified to ISO 9001:2008 and accredited to ISO/IEC 17025:2005 and ISO Guide 34:2009.**

# RICCA CHEMICAL COMPANY

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## Certificate of Analysis

**Mercury ICP Standard, 1 mL = 1 mg Hg (1,000 ppm Hg)**
**Hg in 3% HNO3**
Lot Number: 4310B59 Product Number: PHG1KN Expiration Date: APR 2015 Manufacture Date: 10/25/2013

The certified value for this product is confirmed in independent testing by a second qualified chemist. The uncertainty associated with the certified value is ± 0.5% relative, which is the sum of the estimated errors due to the purity of the raw material, the volumetric preparation of the solution, and transpiration of the solution through the container wall.
The final solution concentration is confirmed by AA, ICP, or ICP-MS, and is traceable to NIST Standard Reference Material 3133. All trace level elements were determined by ICP or ICP-MS.
**This product number replaces 4801 as of 2007.**

**Contains:**

| Name | CAS# | Grade |
|---|---|---|
| Mercury, Hg | 7439-97-6 | High Purity |
| Nitric Acid, HNO3 | 7697-37-2 | Trace Metals |
| Water, Deionized, H2O | 7732-18-5 | ACS, ASTM D 1193 (Type I), EP, USP |

| Test Name | Assay Method | Specification | Result |
|---|---|---|---|
| Appearance | Clarity, Color, Odor | Clear, colorless, odorless | Passed Test |
| Assay at 20 °C (traceable to NIST SRM 999) | Titrimetric vs. Potassium Thiocyanate (Volhard's Indicator) | 1000 ± 5 ppm Hg | 1001 ppm Hg |

I=Spectral Interference N=Not Tested

### Trace Elements by ICP or ICP - MS

All values reported in mg/L (ppm)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Aluminum (Al) | 0.02003 | Gallium (Ga) | < 0.0006 | Osmium (Os) | < 0.003 | Tantalum (Ta) | 0.00152 |
| Antimony (Sb) | < 0.0001 | Germanium (Ge) | < 0.0003 | Palladium (Pd) | 0.09381 | Tellurium (Te) | 0.02324 |
| Arsenic (As) | < 0.0007 | Gold (Au) | N | Phosphorus (P) | < 0.02 | Terbium (Tb) | < 0.00003 |
| Barium (Ba) | 0.0021 | Hafnium (Hf) | < 0.001 | Platinum (Pt) | 0.00058 | Thallium (Tl) | 0.00512 |
| Beryllium (Be) | < 0.0001 | Holmium (Ho) | < 0.0001 | Potassium (K) | < 0.00002 | Thorium (Th) | < 0.0002 |
| Bismuth (Bi) | 0.00043 | Indium (In) | < 0.00003 | Praseodymium (Pr) | < 0.00003 | Thulium (Tm) | < 0.00002 |
| Boron (B) | < 0.00005 | Indium (Ir) | < 0.00007 | Rhenium (Re) | < 0.00003 | Tin (Sn) | < 0.0002 |
| Cadmium (Cd) | < 0.00007 | Iron (Fe) | < 0.001 | Rhodium (Rh) | < 0.00003 | Titanium (Ti) | < 0.001 |
| Calcium (Ca) | I | Lanthanum (La) | < 0.00004 | Rubidium (Rb) | < 0.00004 | Tungsten (W) | 0.02310 |
| Cerium (Ce) | < 0.00003 | Lead (Pb) | < 0.00003 | Ruthenium (Ru) | < 0.00007 | Uranium (U) | 0.00009 |
| Cesium (Cs) | < 0.00005 | Lithium (Li) | < 0.02936065 | Samarium (Sm) | < 0.002 | Vanadium (V) | 0.00007 |
| Chromium (Cr) | < 0.00006 | Lutetium (Lu) | < 0.0003 | Scandium (Sc) | < 0.00008 | Ytterbium (Yb) | < 0.001 |
| Cobalt (Co) | < 0.00002 | Magnesium (Mg) | 0.0032 | Selenium (Se) | < 0.004 | Yttrium (Y) | < 0.00009 |
| Copper (Cu) | < 0.00005 | Manganese (Mn) | < 0.00002 | Silicon (Si) | < 0.007 | Zinc (Zn) | < 0.0003 |
| Dysprosium (Dy) | < 0.0001 | Molybdenum (Mo) | 0.0076 | Silver (Ag) | 0.0029 | Zirconium (Zr) | < 0.002 |
| Erbium (Er) | < 0.00007 | Neodymium (Nd) | < 0.0002 | Sodium (Na) | < 0.02 | | |
| Europium (Eu) | < 0.00008 | Nickel (Ni) | < 0.0001 | Strontium (Sr) | < 0.00006 | | |
| Gadolinium (Gd) | < 0.0002 | Niobium (Nb) | 0.00125 | Sulfur (S) | N | | |

| Specification | Reference | Method Number |
|---|---|---|
| Mercury ICP Standard, 1 mL = 1 mg Hg (1,000 ppm Hg) Hg in 3% HNO3 | EPA | 200.7 |

Volumetric glassware complies with Class A tolerance requirements of ASTM E 288 and NIST Circular 434; it is calibrated before first use and recalibrated regularly in accordance with ASTM E 542 and NIST Procedure NBSIR 74-461. Balances are calibrated regularly with weights certified traceable to the NIST national mass standard. Thermometers and temperature probes are calibrated before first use and recalibrated regularly with a thermometer traceable to NIST standards. All products are prepared according to master documents that ensure manufacture according to validated methods. Batch records document raw material traceability and production and testing history for each lot manufactured.

Life (unopened container):


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| Part Number | Shelf Life |
|---|---|
| PHG1KN-100 | 18 months |
| PHG1KN-500 | 18 months |

Recommended Storage: 15°C - 30°C (59°F - 86°F)

LaNelle Ohlhausen
Quality Assurance

This Certificate of Analysis is designed to comply with ISO Guide 31 "Reference Materials – Contents of Certificates and Labels."

To determine manufacture site using lot number, visit http://www.riccachemical.com/Documents/lot.pdf.

Version. 5


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## Ohio Lumex - Analytical Bias Test
## 14-Feb-08

| Minimum Mass Sample Determination | | | | | |
|---|---|---|---|---|---|
| Test Run | Test Time | Fraction | Actual Concentration, ng | Expected Spike Concentration, ng | Recovery % |
| 1 | 15:31 | $Hg^0$ | 28 | 30 | 93.33 |
| 2 | 16:03 | $Hg^0$ | 28 | 30 | 93.33 |
| 3 | 16:46 | $Hg^0$ | 27 | 30 | 90.00 |
| 1 | 15:54 | $HgCl_2$ | 31 | 30 | 103.33 |
| 2 | 16:13 | $HgCl_2$ | 29 | 30 | 96.67 |
| 3 | 16:38 | $HgCl_2$ | 28 | 30 | 93.33 |

| Maximum Mass Sample Determination | | | | | |
|---|---|---|---|---|---|
| Test Run | Test Time | Fraction | Actual Concentration, ng | Expected Spike Concentration, ng | Recovery % |
| 1 | 18:49 | $Hg^0$ | 1950 | 1900 | 102.63 |
| 2 | 18:57 | $Hg^0$ | 1890 | 1900 | 99.47 |
| 3 | 19:11 | $Hg^0$ | 1780 | 1900 | 93.68 |
| 1 | 18:41 | $HgCl_2$ | 1910 | 1900 | 100.53 |
| 2 | 18:51 | $HgCl_2$ | 1810 | 1900 | 95.26 |
| 3 | 19:00 | $HgCl_2$ | 1860 | 1900 | 97.89 |


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END OF THE REPORT


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