ENVIRONMENTAL MANAGEMENT
BRIGHAM YOUNG UNIVERSITY
101 CHEMICALS MANAGEMENT BUILDING
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Document Date 1/9/2012
DAQ-2012-009834

UTAH DEPARTMENT OF
ENVIRONMENTAL QUALITY
JAN 17 2012
DIVISION OF AIR QUALITY

January 9, 2012

Amanda Smith, Executive Director
Department of Environmental Quality
195 North 1950 West
PO Box 144820
Salt Lake City, UT 84114-4820

Re: Brigham Young University NO_x Compliance Testing for Central Heating Plant Boiler #4 and Boiler #6 per Title V Operating Permit # 490 000 4002

Dear Ms. Smith,

Brigham Young University has recently completed the NOx compliance testing for the Central Heating Plant Boiler #4 and Boiler #6. Below is a table that summarizes the requirements for each boiler as set out in our Operating Permit and the results from our tests.

	Emission Limit	Achieved Emissions	Required Production Rate	Achieved Production Rate
Boiler #4	35.8 lbs/hour	15.1 lb/hr	52 MMBtu/hour	78.2 MMBtu/hour
Boiler #6	35.8 lbs/hour	18.6 lb/hr	60 MMBtu/hour	90.3 MMBtu/hour

Please find attached BYU's certification statement and the complete report provided to BYU by TETCO. Testing was performed December 6, 2011 and the report was submitted to EPA and the State within the 60 days allowed in the Operating Permit (due February 6, 2012).

Please contact Steven Zohner for questions or further information at 801-422-2804.

Respectfully,

Steven K Zohner

Steven K Zohner
Environmental Officer
Brigham Young University
112 CMB
Provo, UT 84602
Email: steven_zohner@byu.edu

State of Utah

GARY R. HERBERT
Governor

SPENCER J. COX
Lieutenant Governor

Department of
Environmental Quality

Amanda Smith
Executive Director

DIVISION OF AIR QUALITY
Bryce C. Bird
Director

10790

Title V Operating Permit

PERMIT NUMBER: 4900004002
DATE OF PERMIT: April 14, 2011
Date of Last Revision: June 3, 2014

This Operating Permit is issued to, and applies to the following:

Name of Permittee:

Brigham Young University
PO Box 20100
Provo, UT 84602

Permitted Location:

Brigham Young University: Main Campus
B-340 ASB
Provo, UT 84602

UTM coordinates: 445,000 m Easting, 4,455,200 m Northing
SIC code: 8221 (Colleges, Universities, & Professional Schools)

By:

_____
Bryce C. Bird, Director

Prepared By:

_____
Mr. William Andes

ENFORCEABLE DATES AND TIMELINES

The following dates or timeframes are referenced in
Section I: General Provisions of this permit.

Annual Certification Due:	September 30 and on that date of every calendar year that this permit is in force.
Renewal application due:	October 14, 2015
Permit expiration date:	April 14, 2016
Definition of "prompt":	written notification within 14 days.

ABSTRACT

Brigham Young University provides the full range of services normally found at a large university. As such, the following emission types are found on the campus and are covered in this permit: a central heating plant, other small boilers, a dry cleaning facility, a printing plant, paint spray booths, and emergency generators.

Two boilers located at the central heating plant are subject to 40 CFR 60 Subpart Db, Standards of Performance for Industrial-Commercial-Institutional Steam Generation Units. One boiler located at the central heating plant is subject to 40 CFR 60 Subpart Dc, Standards of Performance for Small Industrial-Commercial-Institutional Steam Generating Units. 40 CFR 63, Subpart JJJJJJ, National Emission Standards for Hazardous Air Pollutants for Industrial-Commercial-Institutional Boilers Area Sources applies. Certain emergency power generation engines are subject to 40 CFR 63, Subpart ZZZZ, National Emission Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines and 40 CFR 60, Subpart IIII, Standards of Performance for Stationary Compression Ignition Internal Combustion Engines. Also addressed are some emission activities that have no applicable requirements but are identified for information purposes. BYU is located in Provo, Utah which is a non-attainment area for PM_{10} and PM2.5. Provo is a maintenance area for CO. BYU is major for NO_x and SO_2; and an area source for HAPs.

OPERATING PERMIT HISTORY

Permit/Activity	Date Issued	Recorded Changes
Title V administrative amendment - enhanced AO (Project #OPP0107900008)	6/3/2014	Changes: Add and replace emergency engines and replace existing cyclonic dust collector at the Brewster carpentry shop with a bag house. Clarification of language of some conditions. Delete references to 40 CFR 63, Subpart KK as it no longer applies.
Title V administrative amendment - enhanced AO (Project #OPP0107900007)	10/02/2012	Changes: Add two emergency generators. Add requirements for 40 CFR 63, Subpart JJJJJJ. Correct typographical errors. Incorporate replacement dry cleaning facilities, clarify equipment for the boiler plant baghouse, and clarify pollution control at the Auxiliary Maintenance Building.
Title V renewal application (Project #OPP0107900006)	04/14/2011	Changes: VOC/HAP limits added. Redundant #2 Fuel oil limit deleted. Central Heating Plant- NG only requirement removed per AO change. SO_2 limits and testing for Boilers #2, #3, and #5 removed per AO change. Citations of NSPS requirements for boilers #1, #4, and #6 added. 10% opacity limit for boilers #1, #4, and #6 added per AO change. 10% opacity limit for Central Heating Plant Baghouse added per AO change. Deletion of Oxy-fuel condition for University service station. New usage conditions for emergency generators per AO modification. Removal of construction condition for emergency generators per AO modification. Snell Building Paint Booth added. Gas Fired Kiln added. Various conditions reorganized. Cyclonic dust collectors added.

		ROTC Bldg Boiler is no longer on site and has been removed from this permit. Cluff Bldg Boiler is no longer on site and has been removed from this permit. Ten percent annual capacity factor added for the Db boilers. Added requirements for Compression Ignition Internal Combustion Engines/ Removed reference to natural gas fired emergency generators Modified list of emergency generators based on AO modifications.
Title V administrative amendment by source (Project #OPP0107900003)	03/12/2002	Changes: Add three emergency generators rated at 1,500 kW each.
Title V reopening for cause by DAQ (Project #OPP0107900002)	08/26/1998	Changes: to update the inventory provision of the permit
Title V initial application (Project #OPP0107900001)	12/04/1997	

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This source is not subject to Title IV. This section is not applicable. 40

REVIEWER COMMENTS **41**

Issued under authority of Utah Code Ann. Section 19-2-104 and 19-2-109.1, and in accordance with Utah Administrative Code R307-415 Operating Permit Requirements.

All definitions, terms and abbreviations used in this permit conform to those used in Utah Administrative Code R307-101 and R307-415 (Rules), and 40 Code of Federal Regulations (CFR), except as otherwise defined in this permit. Unless noted otherwise, references cited in the permit conditions refer to the Rules.

Where a permit condition in Section I, General Provisions, partially recites or summarizes an applicable rule, the full text of the applicable portion of the rule shall govern interpretations of the requirements of the rule. In the case of a conflict between the Rules and the permit terms and conditions of Section II, Special Provisions, the permit terms and conditions of Section II shall govern except as noted in Provision I.M, Permit Shield.

SECTION I: GENERAL PROVISIONS

I.A **Federal Enforcement.**

All terms and conditions in this permit, including those provisions designed to limit the potential to emit, are enforceable by the EPA and citizens under the Clean Air Act of 1990 (CAA) except those terms and conditions that are specifically designated as "State Requirements". (R307-415-6b)

I.B **Permitted Activity(ies).**

Except as provided in R307-415-7b(1), the permittee may not operate except in compliance with this permit. (See also Provision I.E, Application Shield)

I.C **Duty to Comply.**

I.C.1 The permittee must comply with all conditions of the operating permit. Any permit noncompliance constitutes a violation of the Air Conservation Act and is grounds for any of the following: enforcement action; permit termination; revocation and reissuance; modification; or denial of a permit renewal application. (R307-415-6a(6)(a))

I.C.2 It shall not be a defense for a permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit. (R307-415-6a(6)(b))

I.C.3 The permittee shall furnish to the Director, within a reasonable time, any information that the Director may request in writing to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit or to determine compliance with this permit. Upon request, the permittee shall also furnish to the Director copies of records required to be kept by this permit or, for information claimed to be confidential, the permittee may furnish such records directly to the EPA along with a claim of confidentiality. (R307-415-6a(6)(e))

I.C.4 This permit may be modified, revoked, reopened, and reissued, or terminated for cause. The filing of a request by the permittee for a permit modification, revocation and reissuance, or termination, or of a notification of planned changes or anticipated noncompliance shall not stay any permit condition, except as provided under R307-415-7f(1) for minor permit modifications. (R307-415-6a(6)(c))

I.D **Permit Expiration and Renewal.**

I.D.1 This permit is issued for a fixed term of five years and expires on the date shown under "Enforceable Dates and Timelines" at the front of this permit. (R307-415-6a(2))

I.D.2 Application for renewal of this permit is due on or before the date shown under "Enforceable Dates and Timelines" at the front of this permit. An application may be submitted early for any reason. (R307-415-5a(1)(c))

I.D.3 An application for renewal submitted after the due date listed in I.D.2 above shall be accepted for processing, but shall not be considered a timely application and shall not relieve the permittee of any enforcement actions resulting from submitting a late application. (R307-415-5a(5))

I.D.4 Permit expiration terminates the permittee's right to operate unless a timely and complete renewal application is submitted consistent with R307-415-7b (see also Provision I.E, Application Shield) and R307-415-5a(1)(c) (see also Provision I.D.2). (R307-415-7c(2))

I.E **Application Shield.**

If the permittee submits a timely and complete application for renewal, the permittee's failure to have an operating permit will not be a violation of R307-415, until the Director takes final action on the permit renewal application. In such case, the terms and conditions of this permit shall remain in force until permit renewal or denial. This protection shall cease to apply if, subsequent to the completeness determination required pursuant to R307-415-7a(3), and as required by R307-415-5a(2), the applicant fails to submit by the deadline specified in writing by the Director any additional information identified as being needed to process the application. (R307-415-7b(2))

I.F **Severability.**

In the event of a challenge to any portion of this permit, or if any portion of this permit is held invalid, the remaining permit conditions remain valid and in force. (R307-415-6a(5))

I.G **Permit Fee.**

I.G.1 The permittee shall pay an annual emission fee to the Director consistent with R307-415-9. (R307-415-6a(7))

I.G.2 The emission fee shall be due on October 1 of each calendar year or 45 days after the source receives notice of the amount of the fee, whichever is later. (R307-415-9(4)(a))

I.H **No Property Rights.**

This permit does not convey any property rights of any sort, or any exclusive privilege. (R307-415-6a(6)(d))

I.I **Revision Exception.**

No permit revision shall be required, under any approved economic incentives, marketable permits, emissions trading and other similar programs or processes for changes that are provided for in this permit. (R307-415-6a(8))

I.J **Inspection and Entry.**

I.J.1 Upon presentation of credentials and other documents as may be required by law, the permittee shall allow the Director or an authorized representative to perform any of the following:

I.J.1.a Enter upon the permittee's premises where the source is located or emissions related activity is conducted, or where records are kept under the conditions of this permit. (R307-415-6c(2)(a))

I.J.1.b Have access to and copy, at reasonable times, any records that must be kept under the conditions of this permit. (R307-415-6c(2)(b))

I.J.1.c Inspect at reasonable times any facilities, equipment (including monitoring and air pollution control equipment), practice, or operation regulated or required under this permit. (R307-415-6c(2)(c))

I.J.1.d Sample or monitor at reasonable times substances or parameters for the purpose of assuring compliance with this permit or applicable requirements. (R307-415-6c(2)(d))

I.J.2 Any claims of confidentiality made on the information obtained during an inspection shall be made pursuant to Utah Code Ann. Section 19-1-306. (R307-415-6c(2)(e))

I.K **Certification.**

Any application form, report, or compliance certification submitted pursuant to this permit shall contain certification as to its truth, accuracy, and completeness, by a responsible official as defined in R307-415-3. This certification shall state that, based on information and belief formed after reasonable inquiry, the statements and information in the document are true, accurate, and complete. (R307-415-5d)

I.L **Compliance Certification.**

I.L.1 Permittee shall submit to the Director an annual compliance certification, certifying compliance with the terms and conditions contained in this permit, including emission limitations, standards, or work practices. This certification shall be submitted no later than the date shown under "Enforceable Dates and Timelines" at the front of this permit, and that date each year following until this permit expires. The certification shall include all the following (permittee may cross-reference this permit or previous reports): (R307-415-6c(5))

I.L.1.a The identification of each term or condition of this permit that is the basis of the certification;

I.L.1.b The identification of the methods or other means used by the permittee for determining the compliance status with each term and condition during the certification period. Such methods and other means shall include, at a minimum, the monitoring and related recordkeeping and reporting requirements in this permit. If necessary, the permittee also shall identify any other material information that must be included in the certification to comply with section 113(c)(2) of the Act, which prohibits knowingly making a false certification or omitting material information;

I.L.1.c The status of compliance with the terms and conditions of the permit for the period covered by the certification, including whether compliance during the period was continuous or intermittent. The certification shall be based on the method or means designated in Provision I.L.1.b. The certification shall identify each deviation and take it into account in the compliance certification. The certification shall also identify as possible exceptions to compliance any periods during which compliance is required and in which an excursion or exceedance as defined under 40 CFR Part 64 occurred; and

I.L.1.d Such other facts as the Director may require to determine the compliance status.

I.L.2 The permittee shall also submit all compliance certifications to the EPA, Region VIII, at the following address or to such other address as may be required by the Director: (R307-415-6c(5)(d))

Environmental Protection Agency, Region VIII
Office of Enforcement, Compliance and Environmental Justice
(mail code 8ENF)
1595 Wynkoop Street
Denver, CO 80202-1129

I.M **Permit Shield.**

I.M.1 Compliance with the provisions of this permit shall be deemed compliance with any applicable requirements as of the date of this permit, provided that:

I.M.1.a Such applicable requirements are included and are specifically identified in this permit, or (R307-415-6f(1)(a))

I.M.1.b Those requirements not applicable to the source are specifically identified and listed in this permit. (R307-415-6f(1)(b))

I.M.2 Nothing in this permit shall alter or affect any of the following:

I.M.2.a The emergency provisions of Utah Code Ann. Section 19-1-202 and Section 19-2-112, and the provisions of the CAA Section 303. (R307-415-6f(3)(a))

I.M.2.b The liability of the owner or operator of the source for any violation of applicable requirements under Utah Code Ann. Section 19-2-107(2)(g) and Section 19-2-110 prior to or at the time of issuance of this permit. (R307-415-6f(3)(b)

I.M.2.c The applicable requirements of the Acid Rain Program, consistent with the CAA Section 408(a). (R307-415-6f(3)(c))

I.M.2.d The ability of the Director to obtain information from the source under Utah Code Ann. Section 19-2-120, and the ability of the EPA to obtain information from the source under the CAA Section 114. (R307-415-6f(3)(d))

I.N **Emergency Provision.**

I.N.1 An "emergency" is any situation arising from sudden and reasonably unforeseeable events beyond the control of the source, including acts of God, which situation requires immediate corrective action to restore normal operation, and that causes the source to exceed a technology-based emission limitation under this permit, due to unavoidable increases in emissions attributable to the emergency. An emergency shall not include noncompliance to the extent caused by improperly designed equipment, lack of preventive maintenance, careless or improper operation, or operator error. (R307-415-6g(1))

I.N.2 An emergency constitutes an affirmative defense to an action brought for noncompliance with such technology-based emission limitations if the affirmative defense is demonstrated through properly signed, contemporaneous operating logs, or other relevant evidence that:

I.N.2.a An emergency occurred and the permittee can identify the causes of the emergency. (R307-415-6g(3)(a))

I.N.2.b The permitted facility was at the time being properly operated. (R307-415-6g(3)(b))

I.N.2.c During the period of the emergency the permittee took all reasonable steps to minimize levels of emissions that exceeded the emission standards, or other requirements in this permit. (R307-415-6g(3)(c))

I.N.2.d The permittee submitted notice of the emergency to the Director within two working days of the time when emission limitations were exceeded due to the emergency. This notice must contain a description of the emergency, any steps taken to mitigate emissions, and corrective actions taken. This notice fulfills the requirement of Provision I.S.2.c below. (R307-415-6g(3)(d))

I.N.3 In any enforcement proceeding, the permittee seeking to establish the occurrence of an emergency has the burden of proof. (R307-415-6g(4))

I.N.4 This emergency provision is in addition to any emergency or upset provision contained in any other section of this permit. (R307-415-6g(5))

I.O **Operational Flexibility.**

Operational flexibility is governed by R307-415-7d(1).

I.P **Off-permit Changes.**

Off-permit changes are governed by R307-415-7d(2).

I.Q **Administrative Permit Amendments.**

Administrative permit amendments are governed by R307-415-7e.

I.R **Permit Modifications.**

Permit modifications are governed by R307-415-7f.

I.S **Records and Reporting.**

I.S.1 Records.

I.S.1.a The records of all required monitoring data and support information shall be retained by the permittee for a period of at least five years from the date of the monitoring sample, measurement, report, or application. Support information includes all calibration and maintenance records, all original strip-charts or appropriate recordings for continuous monitoring instrumentation, and copies of all reports required by this permit. (R307-415-6a(3)(b)(ii))

I.S.1.b For all monitoring requirements described in Section II, Special Provisions, the source shall record the following information, where applicable: (R307-415-6a(3)(b)(i))

I.S.1.b.1 The date, place as defined in this permit, and time of sampling or measurement.

I.S.1.b.2 The date analyses were performed.

I.S.1.b.3 The company or entity that performed the analyses.

I.S.1.b.4 The analytical techniques or methods used.

I.S.1.b.5 The results of such analyses.

I.S.1.b.6 The operating conditions as existing at the time of sampling or measurement.

I.S.1.c Additional record keeping requirements, if any, are described in Section II, Special Provisions.

I.S.2 Reports.

I.S.2.a Monitoring reports shall be submitted to the Director every six months, or more frequently if specified in Section II. All instances of deviation from permit requirements shall be clearly identified in the reports. (R307-415-6a(3)(c)(i))

I.S.2.b All reports submitted pursuant to Provision I.S.2.a shall be certified by a responsible official in accordance with Provision I.K of this permit. (R307-415-6a(3)(c)(i)

I.S.2.c The Director shall be notified promptly of any deviations from permit requirements including those attributable to upset conditions as defined in this permit, the probable cause of such deviations, and any corrective actions or preventative measures taken. Prompt, as used in this condition, shall be defined as written notification within the number of days shown under "Enforceable Dates and Timelines" at the front of this permit. Deviations from permit requirements due to breakdowns shall be reported in accordance with the provisions of R307-107. (R307-415-6a(3)(c)(ii))

I.S.3 Notification Addresses.

I.S.3.a All reports, notifications, or other submissions required by this permit to be submitted to the Director are to be sent to the following address or to such other address as may be required by the Director:

Utah Division of Air Quality
P.O. Box 144820
Salt Lake City, UT 84114-4820
Phone: 801-536-4000

I.S.3.b All reports, notifications or other submissions required by this permit to be submitted to the EPA should be sent to one of the following addresses or to such other address as may be required by the Director:

For annual compliance certifications:

Environmental Protection Agency, Region VIII
Office of Enforcement, Compliance and Environmental Justice
(mail code 8ENF)
1595 Wynkoop Street
Denver, CO 80202-1129

For reports, notifications, or other correspondence related to permit modifications,

applications, etc.:

Environmental Protection Agency, Region VIII
Office of Partnerships null Assistance Air null Program (mail code 8P-AR)
1595 Wynkoop Street
Denver, CO 80202-1129
Phone: 303-312-6440

I.T **Reopening for Cause.**

I.T.1 A permit shall be reopened and revised under any of the following circumstances:

I.T.1.a New applicable requirements become applicable to the permittee and there is a remaining permit term of three or more years. No such reopening is required if the effective date of the requirement is later than the date on which this permit is due to expire, unless the terms and conditions of this permit have been extended pursuant to R307-415-7c(3), application shield. (R307-415-7g(1)(a))

I.T.1.b The Director or EPA determines that this permit contains a material mistake or that inaccurate statements were made in establishing the emissions standards or other terms or conditions of this permit. (R307-415-7g(1)(c))

I.T.1.c EPA or the Director determines that this permit must be revised or revoked to assure compliance with applicable requirements. (R307-415-7g(1)(d))

I.T.1.d Additional applicable requirements are to become effective before the renewal date of this permit and are in conflict with existing permit conditions. (R307-415-7g(1)(e))

I.T.2 Additional requirements, including excess emissions requirements, become applicable to a Title IV affected source under the Acid Rain Program. Upon approval by EPA, excess emissions offset plans shall be deemed to be incorporated into this permit. (R307-415-7g(1)(b))

I.T.3 Proceedings to reopen and issue a permit shall follow the same procedures as apply to initial permit issuance and shall affect only those parts of this permit for which cause to reopen exists. (R307-415-7g(2))

I.U **Inventory Requirements.**

An emission inventory shall be submitted in accordance with the procedures of R307-150, Emission Inventories. (R307-150)

I.V **Title IV and Other, More Stringent Requirements**

Where an applicable requirement is more stringent than an applicable requirement of regulations promulgated under Title IV of the Act, Acid Deposition Control, both provisions shall be incorporated into this permit. (R307-415-6a(1)(b))

SECTION II: SPECIAL PROVISIONS

II.A **Emission Unit(s) Permitted to Discharge Air Contaminants.**
(R307-415-4(3)(a) and R307-415-4(4))

II.A.1 **Permitted Source**
Source-wide

II.A.2 **Diesel Emergency Generators**
Diesel fired Compression Ignition Reciprocating Internal Combustion Engines (CI RICE) used only for emergency power generation. Location, horsepower, and date of manufacture are listed in Review Comments.

II.A.3 **ZZZZ/IIII Diesel Emergency Generators**
Emergency power generators used in the following buildings: Cannon Center, J. Ruben Clarke Law Building, Miller Park Baseball Fields, Ellsworth Building, Information Technology Building, Tanner Building, Broadcast Building 1, Broadcast Building 2, Clyde Engineering Building, Heritage Housing Complex 1 and 2, Marriott Center, Bean Life Science Museum, and Life Science Building. The respective horsepower and dates of manufacture are listed in Reviewer Comments.

II.A.4 **Central Heating Plant**
Boilers 1 - 6, inclusive, and a baghouse.

II.A.5 **Unit 1 - Boiler #1**
Natural Gas -fired boiler with fuel oil as an alternate fuel supply during natural gas curtailment. Rated at 64.0 MMBTU/hr. Subject to 40 CFR Part 60, Subpart Dc. Installed in 1991/1992.

II.A.6 **Units 2 & 3 - Boilers #2 & 3**
Two coal-fired boilers, each rated at 64.0 MMBtu, particulate emissions routed through Fabric Filter Baghouse. Installed in 1956 (pre NSPS).

II.A.7 **Units 4 & 6 - Boilers #4 & 6**
Natural Gas -fired boilers with fuel oil as an alternate fuel supply during natural gas curtailment. Subject to 40 CFR Part 60, Subpart Db. Rated at 192.0 MMBtu each. Installed in 1991/1992.

II.A.8 **Unit 5 - Boiler #5**
Coal-fired boiler, rated at 128.0 MMBtu, particulate emissions routed through Fabric Filter Baghouse. Installed in 1964 (pre NSPS).

II.A.9 **Central Heating Plant Baghouse**
Baghouse attached to exhaust of boilers 2, 3, & 5, inclusive. The baghouse controls emissions when boilers 2, 3, and 5 are fired on coal. This system includes one Fly Ash Baghouse and one Ash Silo Treatment System including a primary cyclone, a secondary cyclone, and a baghouse. Minimum Air Flow is 76,000 Actual Cubic Feet per Minute (ACFM).

II.A.10 **Unit 9 - Small Natural Gas Fired Boilers**
Natural gas fired only boilers less than 5 MMBTU/hr each. Located in various buildings.

II.A.11 **Unit 14 - Laundry Dry Cleaning Units**
Three dry cleaning units utilizing Iso-Paraffin Hydrocarbon (IPH) as solvent.

II.A.12 **Teaching Kilns**
Natural gas fired kilns located in the east side of Building #66 used for instruction. No unit specific applicable requirements.

II.A.13 **Four Paint Booths**

Booths located in the following buildings: Brewster Building, Auxiliary Maintenance Shop, Auto Shop, and Snell Building. Each paint booth shall be equipped with a paint arrestor particulate filter, or equivalent to control particulate emissions. All exhaust air from each of the paint booths shall be routed through its particulate control system before being exhausted to the atmosphere.

II.A.14 **Bio-Safety Laboratory**

HEPA filtering system controls emissions from the containment hood exhaust stack. No unit specific applicable requirements.

II.A.15 **Printing Equipment**

No unit specific applicable requirements.

II.A.16 **Misc. Fuel Tanks**

Four underground fuel oil storage tanks containing fuel oil only. Three 30,000 gallon tanks and one 20,000 gallon tank. No unit specific applicable requirements. (non NSPS tanks).

II.A.17 **Cyclonic Dust Collector**

A Cyclonic Dust Collector at the Snell Building. Installation date prior to November 29, 1969 (grandfathered).

II.A.18 **Laundry Boilers**

Two natural gas fired only boilers. Each rated at 8.4 MMBTU/hr.

II.A.19 **Portable Emergency Generators**

Diesel or propane fired emergency generators moved to locations as necessary. No unit specific applicable requirements.

II.A.20 **Coal Fired Boilers**

Boilers 2, 3, and 5 subject to 40 CFR 63, Subpart JJJJJJ.

II.A.21 **Baghouse Dust Collectors**

One baghouse dust collector on the Auxiliary Maintenance Building. Flow rate 188 acfm.

One baghouse dust collector on the Brewster Carpentry Shop. Flow rate is a maximum of 20,000 cfm (vented back inside of the building).

II.B Requirements and Limitations

The following emission limitations, standards, and operational limitations apply to the permitted facility as indicated:

II.B.1 Conditions on Permitted Source.

II.B.1.a **Condition:**

At all times, including periods of startup, shutdown, and malfunction, the permittee shall, to the extent practicable, maintain and operate any affected emission units, including associated air pollution control equipment, in a manner consistent with good air pollution control practice for minimizing emissions. Determination of whether acceptable operating and maintenance procedures are being used will be based on information available to the Director which may include, but is not limited to, monitoring results, opacity observations, review of operating and maintenance procedures, and inspection of the source. All maintenance performed on equipment authorized by DAQE-AN0107900015-13 shall be recorded. [Origin: DAQE-AN0107900015-13]. [40 CFR 60.11(d), R307-401-8(2)]

II.B.1.a.1 **Monitoring:**

Records required for this permit condition will serve as monitoring.

II.B.1.a.2 **Recordkeeping:**

Permittee shall document activities performed to assure proper operation and maintenance. Records shall be maintained in accordance with Provision I.S.1 of this permit.

II.B.1.a.3 **Reporting:**

There are no reporting requirements for this provision except those specified in Section I of this permit.

II.B.1.b **Condition:**

The permittee shall comply with the applicable requirements for servicing of motor vehicle air conditioners pursuant to 40 CFR 82, Subpart B - Servicing of Motor Vehicle Air Conditioners. [Origin: 40 CFR 82 Subpart B]. [40 CFR 82.30(b)]

II.B.1.b.1 **Monitoring:**

The permittee shall certify, in the annual compliance statement required in Section I of this permit, its compliance status with the requirements of 40 CFR 82, Subpart B.

II.B.1.b.2 **Recordkeeping:**

All records required in 40 CFR 82, Subpart B shall be maintained consistent with the requirements of Provision I.S.1 of this permit.

II.B.1.b.3 **Reporting:**

All reports required in 40 CFR 82, Subpart B shall be submitted as required. There are no additional reporting requirements except as outlined in Section I of this permit.

II.B.1.c **Condition:**

The permittee shall comply with the applicable requirements for recycling and emission reduction for class I and class II refrigerants pursuant to 40 CFR 82, Subpart F - Recycling and Emissions Reduction. [Origin: 40 CFR 82 Subpart F]. [40 CFR 82.150(b)]

II.B.1.c.1 **Monitoring:**

The permittee shall certify, in the annual compliance statement required in Section I of this permit, its compliance status with the requirements of 40 CFR 82, Subpart F.

II.B.1.c.2 **Recordkeeping:**

All records required in 40 CFR 82, Subpart F shall be maintained consistent with the requirements of Provision I.S.1 in of this permit.

II.B.1.c.3 **Reporting:**

All reports required in 40 CFR 82, Subpart F shall be submitted as required. There are no additional reporting requirements except as outlined in Section I of this permit.

II.B.1.d **Condition:**

The plant-wide emissions of VOCs and HAPs from the print booths, printing/publishing, dry cleaning and other campus-wide similar operations* shall not exceed:

16.00 tons per rolling 12-month period for VOCs generated from painting and printing/publishing activities
0.20 tons per rolling 12-month period for Xylene
0.33 tons per rolling 12-month period for Glycol Ethers
5.22 tons per rolling 12-month period for any combination of HAPs not listed above.

Any individual HAP shall comply with R307-410-5.

* "similar operations" includes painting of building interiors, paint applied to roads and parking lots, adhesives for putting down carpets, tiles, and other flooring. [Origin: DAQE-AN0107900015-13]. [R307-401-8(1)(a)(BACT)]

II.B.1.d.1 **Monitoring:**

Based on the first day of each month, a new 12-month total shall be calculated using data from the previous 12 months. Monthly calculations shall be made no later than 20 days after the end of each calendar month.

II.B.1.d.2 **Recordkeeping:**

VOC and HAP emissions shall be determined by maintaining a record of VOC and HAP emitting materials used each month. The records shall include the following data for each material used:

1. Name of the VOC or HAP emitting material, such as; paint, adhesive, solvent, thinner, reducers, chemical compounds, toxics, isocyanates, etc.

2. Density of each material used (pounds per gallon).

3. Percent by weight of VOC and HAP in each material used.

4. Gallons of each VOC and HAP emitting material used each month.

5. The amount of VOC and individual HAP emitted monthly by each material used, calculated by the following procedure:

VOC = (% VOC by Weight/100) x (Density lb/gal) x (Gal Consumed) x (1 ton/2000 lb)

HAP = (% HAP by Weight/100) x (Density lb/gal) x (Gal Consumed) x (1 ton/2000lb)

6. The total amount of VOC and HAP emitted monthly from all materials used.

7. The amount of VOC and HAP reclaimed for the month shall be similarly quantified and subtracted from the quantities calculated above, to provide the monthly total VOC and HAP emissions.

Records shall be maintained in accordance with Provision I.S.1 of this permit.

II.B.1.d.3 **Reporting:**

There are no reporting requirements for this provision except those specified in Section I of this permit.

II.B.1.e **Condition:**

The permittee shall notify the Director in writing when the installation of new equipment has been completed and is operational. To ensure proper credit when notifying the Director, send your correspondence to the Director, Attn: Compliance Section. If installation has not been completed within eighteen months from the approval date, the Director shall be notified in writing on the status of the installation. At that time, the Director shall require documentation of the continuous installation of the operation and may revoke the approval order in accordance with R307-401-18. [Origin: R307-401-18, DAQE-AN0107900015-13]. [R307-401-18, R307-401-8(1)(a)(BACT)]

II.B.1.e.1 **Monitoring:**

Records required for this permit condition will serve as monitoring.

II.B.1.e.2 **Recordkeeping:**

The permittee shall maintain a copy of each notification required by this permit condition in accordance with Provision I.S.1 of this permit.

II.B.1.e.3 **Reporting:**

There are no reporting requirements for this provision except those specified in Section I of this permit.

II.B.1.f **Condition:**

Any person who applies salt or abrasives such as crushed slag and sand to roads in PM_{10} and PM2.5 nonattainment and maintenance areas shall maintain records of the material applied. [Origin: R307-307]. [R307-307]

II.B.1.f.1 **Monitoring:**

Records required for this permit condition will serve as monitoring.

II.B.1.f.2 **Recordkeeping:**

Results of monitoring shall be maintained in accordance with Provision I.S.1 of this permit.

For Salt - the records shall include the quantity applied, the percent by weight of insoluble solids in the salt, and the percentage of the material that is sodium chloride (NaCl), magnesium chloride ($MgCl_2$), calcium chloride ($CaCl_2$), or potassium chloride(KCl)..

For abrasives such as sand or crushed slag - The records shall include the quantity applied and the percent by weight of fine material which passes the number 200 sieve in a standard gradation analysis.

All records shall be maintained for a period of at least two years, and the records shall be made available to the Director or his designated representative upon request.

II.B.1.f.3 **Reporting:**

There are no reporting requirements for this provision except those specified in Section I of this permit.

II.B.1.g **Condition:**

The sulfur content of any fuel oil or diesel burned shall be less than 0.0015 percent by weight. [Origin: DAQE-AN0107900015-13]. [R307-401-8(1)(a)(BACT)]

II.B.1.g.1 **Monitoring:**

Records required for this permit condition will serve as monitoring.

II.B.1.g.2 **Recordkeeping:**

For each delivery of oil, the permittee shall either:

A. Determine the fuel sulfur content expressed as weight percent in accordance with the methods of the American Society of Testing Materials (ASTM) Method D-4294-89 or approved equivalent;

B. Inspect the fuel sulfur content expressed as weight percent determined by the vendor using methods of the ASTM; or

C. Inspect documentation provided by the vendor that directly or indirectly demonstrates compliance with this provision.

II.B.1.g.3 **Reporting:**

There are no reporting requirements for this provision except those specified in Section I of this permit.

II.B.2 **Conditions on Diesel Emergency Generators**

II.B.2.a **Condition:**

Visible emissions shall be no greater than 20 percent opacity. [Origin: DAQE-AN0107900015-13]. [R307-401-8(1)(a)(BACT)]

II.B.2.a.1 **Monitoring:**

If an affected emission unit is operated during a calendar year, an opacity observation of the emission unit shall be performed in the calendar year that the emission unit was operated. The opacity observation can be conducted at any time during the calendar year. The opacity observation shall be conducted by an individual trained on the observation procedures of 40 CFR 60, Appendix A, Method 9, while the emission unit is operating. If visible emissions other than condensed water vapor are observed from the emission unit, an opacity determination of that emission unit shall be performed by a certified observer within 24 hours of the initial visual emission observation. The opacity determination shall be performed in accordance with 40 CFR 60, Appendix A, Method 9.

II.B.2.a.2 **Recordkeeping:**

The permittee shall keep a log which includes the location and description of each affected emission unit. For each calendar year for each affected emission unit, the log shall include either the date of the opacity observation and if visual emission other than condensed water vapor were observed or a note that the emission unit was not operated. Maintenance checks and readiness testing are operation. For each observed visual emission other than condensed water vapor the permittee shall record: date and time of visual emission observation, emission unit location and description, time and date of opacity determination, and percent opacity. The records required

by this provision and all data required by 40 CFR 60, Appendix A, Method 9 shall be maintained in accordance with Provision I.S.1 of this permit.

II.B.2.a.3 **Reporting:**

There are no reporting requirements for this provision except those specified in Section I of this permit.

II.B.2.b **Condition:**

Emergency generators shall be used for electricity producing operation only during the periods when electric power from the public utilities is interrupted, or for regular maintenance of the generators. Maintenance checks and readiness testing of each generator is limited to 100 hours per rolling 12-month period. The owner shall calculate a new 12 month total by the twentieth day of each month using data from the previous 12 months. [Origin: DAQE-AN0107900015-13]. [R307-401-8(1)(a)(BACT)]

II.B.2.b.1 **Monitoring:**

Records required for this permit condition will serve as monitoring.

II.B.2.b.2 **Recordkeeping:**

Records documenting the usage of each generator shall be kept in a log and shall show the date each generator was used, the duration in hours of each generator usage, the reason for each generator usage, and, if the usage is an emergency, indicate the nature of the emergency. The records of operation shall be kept on a weekly basis and shall be kept for all periods when the facility is in operation. Records shall be maintained in accordance with Provision I.S.1 of this permit.

II.B.2.b.3 **Reporting:**

There are no reporting requirements for this provision except those specified in Section I of this permit.

II.B.2.c **Condition:**

All RICE that are new, constructed, or reconstructed after June 12, 2006, shall comply with the requirements of 40 CFR 63.6590(c). [Origin: 40 CFR 63.6590]. [40 CFR 63 Subpart ZZZZ]

II.B.2.c.1 **Monitoring:**

The source shall demonstrate compliance by keeping records of engine manufacturer data.

II.B.2.c.2 **Recordkeeping:**

Results of monitoring shall be maintained in accordance with DAQE-0107900014-12 and Provision I.S.1 of this permit.

II.B.2.c.3 **Reporting:**

There are no reporting requirements for this provision except those specified in Section I of this permit.

II.B.3 **Conditions on ZZZZ/IIII Diesel Emergency Generators**

II.B.3.a **Condition:**

The permittee shall operate and maintain affected emission units that achieve the emission standards as required in 40 CFR 60.4205 over the entire life of the engine. The permittee shall do all of the following:
(1) Operate and maintain the stationary CI ICE and control device according to the manufacturer's emission-related written instructions;
(2) Change only those emission-related settings that are permitted by the manufacturer;
[Origin: 40 CFR 60 Subpart IIII]. [40 CFR 60.4206, 40 CFR 60.4211(a), 40 CFR 63 Subpart ZZZZ]

II.B.3.a.1 **Monitoring:**

The permittee shall document activities performed to assure proper operation and maintenance.

II.B.3.a.2 **Recordkeeping:**

Results of monitoring shall be maintained in accordance with Provision I.S.1 of this permit.

II.B.3.a.3 **Reporting:**

There are no reporting requirements for this provision except those specified in Section I of this permit.

II.B.3.b **Condition:**

The permittee of affected emission units with a displacement of less than 30 liters per cylinder shall purchase diesel fuel that meets the following per gallon standards of 40 CFR 80.510(b) for nonroad diesel fuel:
1. Sulfur content no greater than 15 ppm (0.0015 percent) by weight and
2. A minimum cetane index of 40 or a maximum aromatic content of 35 volume percent.
[Origin: 40 CFR 60 Subpart IIII]. [40 CFR 60.4207(b), 40 CFR 63 Subpart ZZZZ]

II.B.3.b.1 **Monitoring:**

Records to demonstrate compliances with this permit condition will serve as monitoring.

II.B.3.b.2 **Recordkeeping:**

For each fuel load received, the permittee shall maintain either fuel receipt records or other documentation showing fuel meets the specifications of 40 CFR 80.510(b). These records shall be maintained in accordance with Provision I.S.1 of this permit.

II.B.3.b.3 **Reporting:**

There are no reporting requirements for this provision except those specified in Section I of this permit.

II.B.3.c **Condition:**

Each emergency affected emission unit shall not exceed 100 hours of maintenance checks and readiness testing per year unless the permittee maintains records indicating that Federal, State, or local standards require maintenance and testing of affected emission units beyond 100hours per year. There is no time limit on the use of emergency stationary RICE in emergency situations. Emergency engines may operate up to 50 hours per year in non-emergency situations, but those 50 hours are counted towards the 100 hours per year provided for maintenance and testing. The 50 hours per year for non-emergency situations cannot be used for peak shaving or to generate income for a facility to supply power to an electric grid or otherwise supply non-emergency power as part of a financial arrangement with another entity. Any

operation other than emergency operation, maintenance and testing, and operation in non-emergency situations for 50 hours per year, as permitted in 40CFR 60.4211(f), is prohibited. [Origin: 40 CFR 40 CFR 60 Subpart IIII]. [40 CFR 60.4211(f), 40 CFR 63 Subpart ZZZZ]

II.B.3.c.1 **Monitoring:**

If an emergency affected emission unit does not meet the standards applicable to non-emergency engines, the permittee shall install a non-resettable hour meter prior to startup of the engine. [Origin: 40 CFR 60.4209(a)] Records required for this permit condition will serve as monitoring.

II.B.3.c.2 **Recordkeeping:**

Records of each affected emission unit shall be kept on a weekly basis in an operation and maintenance log. Records shall distinguish between maintenance-related hours and emergency use-related hours. If maintenance and testing beyond 100 hours per year are required by Federal, State, or local standards, records of these standards shall also be kept.

Starting with the model years in Table 5 of 40CFR 60 Subpart IIII, if an affected emission unit does not meet the standards applicable to non-emergency engines in the applicable model year, the permittee shall keep records of the operation of the engine in emergency and non-emergency service that are recorded through the non-resettable hour meter.The permittee must record the time of operation of the engine and the reason the engine was in operation during that time. (Origin: 40 CFR 60.4214(b))

Results of monitoring shall be maintained in accordance with Provision I.S.1 of this permit.

II.B.3.c.3 **Reporting:**

There are no reporting requirements for this provision except those specified in Section I of this permit.

II.B.3.d **Condition:**

For all affected emission units, except those that are modified, reconstructed, or removed from one existing location and reinstalled at a new location, the permittee shall comply with paragraphs (a) through (c).
(a) The permittee shall not install stationary CI RICE (excluding fire pump engines) that do not meet the applicable requirements for 2007 model year engines.
(b) The permittee shall not install stationary CI RICE (excluding fire pump engines) with a maximum engine power of less than 19 KW (25 HP) that do not meet the applicable requirements for 2008 model year engines.
(c) In addition to the requirements specified in 40 CFR 60.4201,4202, 4204, and 4205, it is prohibited to import stationary CI RICE with a displacement of less than 30 liters per cylinder that do not meet the applicable requirements specified in this section.[Origin: 40 CFR 60 Subpart IIII]. [40 CFR 60.4208, 40 CFR 63 Subpart ZZZZ]

II.B.3.d.1 **Monitoring:**

Records required for this permit condition will serve as monitoring.

II.B.3.d.2 **Recordkeeping:**

The permittee shall keep records of the install date of each affected emission unit and the applicable requirements (a, b, and/or c) for the emission unit. Records shall be maintained as described in Provision I.S.1 of this permit.

II.B.3.d.3 **Reporting:**

There are no reporting requirements for this provision except those specified in Section I of this permit.

II.B.3.e **Condition:**

Pre-2007 model year emergency affected emission units with a displacement of less than 10 liters per cylinder that are not fire pump engines shall comply with the emission standards in Table 1 of 40 CFR 60 Subpart IIII. Modified or reconstructed affected emission units with a displacement of less than 10 liters per cylinder that are not fire pump engines shall meet the emission standards in Table 1 of 40 CFR 60 Subpart IIII applicable to the model year, maximum engine power, and displacement of the modified or reconstructed engine. If the permittee conducts performance tests in-use on stationary CI ICE with a displacement of less than 30 liters per cylinder they shall meet the not-to-exceed (NTE) standards as indicated in 40 CFR 60.4212. [Origin: 40 CFR60 Subpart IIII]. [40 CFR 60.4205(a), 40 CFR 63 Subpart ZZZZ]

II.B.3.e.1 **Monitoring:**

The permittee shall demonstrate compliance according to one of the methods specified in paragraphs (1) through (5) of this section.
(1) Purchasing an engine certified according to 40 CFR part 89 or 40 CFR part 94, as applicable, for the same model year and maximum engine power. The engine must be installed and configured according to the manufacturer's specifications.
(2) Keeping records of performance test results for each pollutant for a test conducted on a similar engine. The test must have been conducted using the same methods specified in 40 CFR 60 Subpart IIII and these methods must have been followed correctly.
(3) Keeping records of engine manufacturer data indicating compliance with the standards.
(4) Keeping records of control device vendor data indicating compliance with the standards.
(5) Conducting an initial performance test to demonstrate compliance with the emission standards according to the requirements specified in 40 CFR 60.4212, as applicable.
(Origin: 40 CFR60.4211(b)).

II.B.3.e.2 **Recordkeeping:**

Results of monitoring shall be maintained in accordance with Provision I.S.1 of this permit.

II.B.3.e.3 **Reporting:**

There are no reporting requirements for this provision except those specified in Section I of this permit.

II.B.3.f **Condition:**

2007 model year and later emergency affected emission units with a displacement of less than 30 liters per cylinder that are not fire pump engines shall comply with the emission standards for new nonroad CI RICE in 40 CFR 60.4202, for all pollutants, for the same model year and maximum engine power for their 2007 model year and later emergency stationary CI RICE. [Origin: 40 CFR 60 Subpart IIII]. [40 CFR 60.4205(a), 40 CFR 63 Subpart ZZZZ]

II.B.3.f.1 **Monitoring:**

The permittee shall comply by purchasing an engine certified to the emission standards in 40 CFR 60.4205(b) for the same model year and maximum engine power. The engine must be installed, configured, operated, and maintained according to the manufacturer's emission-related specifications. (Origin: 40 CFR 60.4211(c)).

II.B.3.f.2 **Recordkeeping:**

Results of monitoring shall be maintained in accordance with Provision I.S.1 of this permit.

II.B.3.f.3 **Reporting:**

There are no reporting requirements for this provision except those specified in Section I of this permit.

II.B.4 **Conditions on the Central Heating Plant.**

II.B.4.a **Condition:**

The sulfur content of any coal or any mixture of coals burned shall not exceed either of the following:

1) 0.54 pounds of sulfur per million Btu heat input as determined by ASTM Method D-4239-85 or approved equivalent, and
2) 0.60 percent by weight as determined by ASTM Method D-4294-89 or approved equivalent. [Origin: DAQE-AN0107900015-13]. [R307-401-8(1)(a)(BACT)]

II.B.4.a.1 **Monitoring:**

To determine sulfur content of coal, the source shall:

1) At least monthly, the weight percent sulfur and the fuel heating value shall be obtained by submitting a coal sample to a laboratory acceptable to the Director, or
2) For each delivery of coal inspect the fuel sulfur content expressed as weight percent determined by the vendor using methods of the ASTM, or
3) For each delivery of coal, inspect documentation provided by the vendor that indirectly demonstrates compliance with this provision.

II.B.4.a.2 **Recordkeeping:**

Results of monitoring shall be maintained in accordance with Provision I.S.1 of this permit.

II.B.4.a.3 **Reporting:**

There are no reporting requirements for this provision except those specified in Section I of this permit.

II.B.4.b **Condition:**

Coal usage shall be no greater than 16,992 tons annually. Coal may be used as an emergency measure fuel during the annual period starting November 1 and ending February 28 (or February 29 in the case of leap year), with the approval of the Director, in the event both natural gas and fuel oil are unavailable. The remainder of the year coal may be fired at the discretion of the permittee. In addition, coal may be used during the winter months to perform stack testing as required by the DAQ. [Origin: DAQE-AN0107900015-13]. [R307-401-8(1)(a)(BACT)]

II.B.4.b.1 **Monitoring:**

No later than November 20 each year, the following calculations shall be performed to determine annual coal consumption. Each bucket of coal introduced into the boilers shall be weighed and totaled, giving the total annual coal consumption.

II.B.4.b.2 **Recordkeeping:**

Results of monitoring shall be maintained in accordance with Provision I.S.1 of this permit.

The following information shall be determined and maintained: The total amount of coal introduced into the boilers annually as of the end of the October along with the weight of each bucket introduced into the boilers.

II.B.4.b.3 **Reporting:**

In addition to the reporting requirements specified in Section I of this permit, the permittee shall notify the Director of coal usage as an emergency measure.

II.B.4.c **Condition:**

Fuel oil consumption for maintenance shall be no greater than 90,000 gallons per rolling 12-month period. [Origin: DAQE-AN0107900015-13]. [R307-401-8(1)(a)(BACT)]

II.B.4.c.1 **Monitoring:**

No later than the 20th day of each month, the following calculation shall be performed to determine the consumption for the month. The inventory amount at the beginning of the month shall be added to the total of all fuel oil receipts during the month. The inventory balance at the end of the month shall then be subtracted from this sum to determine the amount consumed during the month. The total consumption for the previous 12 month period shall be recorded each month.

II.B.4.c.2 **Recordkeeping:**

Results of monitoring shall be maintained in accordance with Provision I.S.1 of this permit.

II.B.4.c.3 **Reporting:**

There are no reporting requirements for this provision except those specified in Section I of this permit.

II.B.4.d **Condition:**

Natural gas consumption shall be no greater than 405 million standard cubic feet per rolling 12 month period. [Origin: DAQE-AN0107900015-13]. [R307-401-8(b)(a)(BACT)]

II.B.4.d.1 **Monitoring:**

No later than the 20th of each month, consumption of natural gas for the previous month shall be determined by examination of each gas supplier's billing records and/or meter readings, along with an operation log recording the consumption on a daily basis. The total consumption for the previous 12 month period shall be recorded each month.

II.B.4.d.2 **Recordkeeping:**

Results of monitoring shall be maintained in accordance with Provision I.S.1 of this permit.

II.B.4.d.3 **Reporting:**

There are no reporting requirements for this provision except those specified in Section I of this permit.

II.B.4.e **Condition:**

Fuel oil may be used for backup during natural gas curtailment (curtailment means the natural gas provider/supplier imposes a curtailment or interruption of service which is involuntary and beyond the control of the permittee). [Origin: DAQE-AN0107900015-3]. [R307-401-8(1)(a)(BACT)]

II.B.4.e.1 **Monitoring:**

Records required for this permit condition will serve as monitoring.

II.B.4.e.2 **Recordkeeping:**

Documentation to demonstrate the natural gas provider/supplier imposed a curtailment or interruption of service which is involuntary and beyond the control of the permittee shall be maintained in accordance with Provision I.S.1 of this permit. Records necessary to develop emissions estimates for the annual emission inventory shall be maintained in accordance with Provision I.S.1 of this permit.

II.B.4.e.3 **Reporting:**

In addition to the reporting requirements specified in Section I of this permit, the Director shall be notified within three business days of using fuel oil during a natural gas curtailment.

II.B.5 **Conditions on Central Heating Plant Dc Boiler #1.**

II.B.5.a **Condition:**

Emissions of NO_x shall be no greater than 9.55 lbs/hour and no greater than 95 ppmdv (using 7% excess oxygen). [Origin: DAQE-AN0107900015-13]. [R307-401-8(1)(a)(BACT)]

II.B.5.a.1 **Monitoring:**

Stack testing shall be performed as specified here:

(a) Frequency. If the boiler is operated for more than 100 hours per rolling 12 month period, the stack test shall be performed within 60 days of exceeding the 100 hours of operation. Supervisor monitoring and maintaining an operations log shall determine hours of operation.

(b) Notification. The Director shall be notified at least 30 days prior to conducting any required emission testing. A source test protocol shall be submitted to DAQ when the testing notification is submitted to the Director.

The source test protocol shall be approved by the Director prior to performing the test(s). The source test protocol shall outline the proposed test methodologies, stack to be tested, and procedures to be used. A pretest conference shall be held, if directed by the Director.

(c) Sample Location. The emission point shall be designed to conform to the requirements of 40 CFR 60, Appendix A, Method 1, or other EPA approved testing method as acceptable to the Director. An Occupational Safety and Health Administration (OSHA) or Mine Safety and Health Administration (MSHA) approved access shall be provided to the test location.

(d) Volumetric Flow Rate: The volumetric flow rate shall be measured using 40 CFR 60, Appendix A, Method 2 or other EPA approved testing method as acceptable to the Director.

(e) Nitrogen Oxides (NO_x): NO_x shall be measured using 40 CFR 60, Appendix A, Method 7, 7A, 7B, 7C, 7D, 7E, or other EPA approved testing method as acceptable to the Director.

(f) Calculations: To determine mass emission rates (lb/hr, etc.) the pollutant concentration as determined by the appropriate methods above shall be multiplied by the volumetric flow rate and any necessary conversion factors determined by the Director, to give the results in the specified units of the emission limitation.

(g) The production rate during all compliance testing shall be no less than 90% of the average production achieved in the previous three (3) years.

II.B.5.a.2 **Recordkeeping:**

Results of all stack testing shall be recorded and maintained in accordance with the associated test method and Provision I.S.1 of this permit.

II.B.5.a.3 **Reporting:**

Results of required stack testing shall be submitted to the Director within 60 days of completion of the testing. The submittal shall clearly identify results and indicate compliance status. The annual compliance certification required by Provision L in Section I of this permit shall use the most recent test results as a basis for stating compliance status for this limitation.

II.B.5.b **Condition:**

Visible emissions shall be no greater than 10 percent opacity when burning natural gas and no greater than 20% when burning fuel oil. [Origin: DAQE-AN0107900015-13]. [R307-401-8(1)(a)(BACT)]

II.B.5.b.1 **Monitoring:**

While burning natural gas, use of that fuel type shall be verified in lieu of monitoring via visible emissions observations. When fuel oil is burned the opacity will be measured by the opacity meter located on the Central Heating Plant stack.

II.B.5.b.2 **Recordkeeping:**

Records of fuel type used daily shall be maintained as described Provision I.S.1 of this permit. Results of opacity observations shall be recorded and maintained as described in Provision I.S.1 of this permit.

II.B.5.b.3 **Reporting:**

There are no reporting requirements for this provision except those specified in Section I of this permit.

II.B.5.c **Condition:**

The permittee shall burn natural gas as primary fuel and fuel oil as backup fuel. The source shall notify the Director within three business days of using fuel oil. [Origin: DAQE-AN0107900015-13]. [R307-401-8(1)(a)(BACT)]

II.B.5.c.1 **Monitoring:**

Records required for this permit condition will serve as monitoring.

II.B.5.c.2 **Recordkeeping:**

The daily operation log shall be maintained to document the type of fuel used. Documentation of natural gas curtailment shall be maintained. Records shall be maintained as described in Provision I.S.1 of this permit.

II.B.5.c.3 **Reporting:**

Notification as required in the condition is the only reporting provision except those specified in Section I of this permit.

II.B.5.d **Condition:**

The permittee shall keep daily records in the operation log of the amounts of each fuel combusted each day. [Origin: 40 CFR 60 Subpart Dc]. [40 CFR 60.48c(g)]

II.B.5.d.1 **Monitoring:**

Fuel consumption for each affected emission unit shall be determined by a fuel meter, or other method approved by the Director.

II.B.5.d.2 **Recordkeeping:**

Records of the amounts of each fuel combusted during each day for each affected unit shall be maintained as described in Provision I.S.1 of this permit.

II.B.5.d.3 **Reporting:**

There are no reporting requirements for this provision except those specified in Section I of this permit.

II.B.5.e **Condition:**

The permittee shall comply with all applicable requirements of 40 CFR 60 Subpart A. [Origin: 40 CFR 60 Subpart A]. [40 CFR 60 Subpart A]

II.B.5.e.1 **Monitoring:**

Records required for this permit condition will serve as monitoring.

II.B.5.e.2 **Recordkeeping:**

All applicable records and notifications required by 40 CFR 60 Subpart A shall be maintained in accordance with provision I.S.1 of this permit.

II.B.5.e.3 **Reporting:**

The permittee shall comply with the reporting requirements in Section I of this permit and any additional reporting and notification requirements of 40 CFR 60 Subpart A.

II.B.6 **Conditions on Central Heating Plant Coal Boilers #2 & #3.**

II.B.6.a **Condition:**

Emissions of NO_x shall be no greater than 37.4 lbs/hour or 331 ppmdv (using 7% excess oxygen) from each of boilers #2 and #3. [Origin: DAQE-AN0107900015-13]. [R307-401-8(1)(a)(BACT)]

II.B.6.a.1 **Monitoring:**

Stack testing shall be performed as specified here:

(a) Frequency. The source shall be tested every three years.

(b) Notification. The Director shall be notified at least 30 days prior to conducting any required emission testing. A source test protocol shall be submitted to DAQ when the testing notification is submitted to the Director.

The source test protocol shall be approved by the Director prior to performing the test(s). The source test protocol shall outline the proposed test methodologies, stack to be tested, and procedures to be used. A pretest conference shall be held, if directed by the Director.

(c) Sample Location. The emission point shall be designed to conform to the requirements of 40 CFR 60, Appendix A, Method 1, or other EPA approved testing method as acceptable to the Director. An Occupational Safety and Health Administration (OSHA) or Mine Safety and Health Administration (MSHA) approved access shall be provided to the test location.

(d) Volumetric Flow Rate: The volumetric flow rate shall be measured using 40 CFR 60, Appendix A, Method 2 or other EPA approved testing method as acceptable to the Director.

(e) Nitrogen Oxides (NO_x): NO_x shall be measured using 40 CFR 60, Appendix A, Method 7, 7A, 7B, 7C, 7D, 7E, or other EPA approved testing method as acceptable to the Director.

(f) Calculations: To determine mass emission rates (lb/hr, etc.) the pollutant concentration as determined by the appropriate methods above shall be multiplied by the volumetric flow rate and any necessary conversion factors determined by the Director, to give the results in the specified units of the emission limitation.

(g) The production rate during all compliance testing shall be no less than 90% of the average production achieved in the previous three (3) years.

II.B.6.a.2 **Recordkeeping:**

Results of all stack testing shall be recorded and maintained in accordance with the associated test method and Provision I.S.1 of this permit.

II.B.6.a.3 **Reporting:**

Results of required stack testing shall be submitted to the Director within 60 days of completion of the testing. The submittal shall clearly identify results and indicate compliance status. The annual compliance certification required by Provision L in Section I of this permit shall use the most recent test results as a basis for stating compliance status for this limitation.

II.B.7 **<u>Central Heating Plant Db Boilers #4 & #6.</u>**

II.B.7.a **Condition:**

Each boiler shall not exceed a 10 percent annual capacity factor (Annual capacity factor as defined in 40

CFR 60.41b). [Origin: DAQE-AN0107900015-13]. [R307-401-8(1)(a)(BACT)]

II.B.7.a.1 **Monitoring:**

The permittee shall calculate the annual capacity factor individually for distillate oil and natural gas for the reporting period.

The annual capacity factor is determined on a 12-month rolling average basis with a new annual capacity factor calculated at the end of each calendar month. (40 CFR Part 60.49b(d))

The combined annual capacity factor shall be calculated as A/P x 100

A = actual heat input from oil and natural gas during the calendar year.

P = potential heat input from 8,760 hours of operation during a calendar year at the maximum steady state design heat input capacity.

Potential heat input is calculated as:

P = (192 MMBtu/Hours) x (8,760 Hours/Year).

II.B.7.a.2 **Recordkeeping:**

Results of monitoring shall be maintained in accordance with Provision I.S.1 of this permit.

The following records shall be maintained for each operation day:

(1) Calendar date.

(2) The numbers of hours of operation.

(3) Hourly steam load.

(4) The amounts of each fuel combusted during each day.

(40 CFR Part 60.49b(p) and 40 CFR Part 60.49b(d)).

II.B.7.a.3 **Reporting:**

The permittee shall submit reports every six months containing:

(1) The annual capacity factor for the previous 12 months, and

(2) Results of any nitrogen oxides emissions test required during the reporting period, and

(3) The hours of operation during the reporting period, and

(4) The hours of operation since the last nitrogen oxides emissions test. (40 CFR Part 60.49b(q) and 40 CFR Part 60.49b(w)).

There are no other reporting requirements for this provision except those specified in Section I of this permit.

II.B.7.b **Condition:**

Emissions of NO_x shall be no greater than 38.5 lbs/hour and no greater than 127 ppmdv (using 7% excess oxygen) from each of boilers #4 and #6. [Origin: DAQE-AN0107900015-13]. [R307-401-8(1)(a)(BACT)]

II.B.7.b.1 **Monitoring:**

Stack testing shall be performed as specified here:

(a) Frequency. The source shall be tested every three years.

(b) Notification. The Director shall be notified at least 30 days prior to conducting any required emission testing. A source test protocol shall be submitted to DAQ when the testing notification is submitted to the Director.

The source test protocol shall be approved by the Director prior to performing the test(s). The source test protocol shall outline the proposed test methodologies, stack to be tested, and procedures to be used. A pretest conference shall be held, if directed by the Director.

(c) Sample Location. The emission point shall be designed to conform to the requirements of 40 CFR 60, Appendix A, Method 1, or other EPA approved testing method as acceptable to the Director. An Occupational Safety and Health Administration (OSHA) or Mine Safety and Health Administration (MSHA) approved access shall be provided to the test location.

(d) Volumetric Flow Rate: The volumetric flow rate shall be measured using 40 CFR 60, Appendix A, Method 2 or other EPA approved testing method as acceptable to the Director.

(e) Nitrogen Oxides (NO_x): NO_x shall be measured using 40 CFR 60, Appendix A, Method 7, 7A, 7B, 7C, 7D, 7E, or other EPA approved testing method as acceptable to the Director.

(f) Calculations: To determine mass emission rates (lb/hr, etc.) the pollutant concentration as determined by the appropriate methods above shall be multiplied by the volumetric flow rate and any necessary conversion factors determined by the Director, to give the results in the specified units of the emission limitation.

(g) The production rate during all compliance testing shall be no less than 90% of the average production achieved in the previous three (3) years.

II.B.7.b.2 **Recordkeeping:**

Results of all stack testing shall be recorded and maintained in accordance with the associated test method and Provision I.S.1 of this permit.

II.B.7.b.3 **Reporting:**

Results of required stack testing shall be submitted to the Director within 60 days of completion of the testing. The submittal shall clearly identify results and indicate compliance status. The annual compliance certification required by Provision L in Section I of this permit shall use the most recent test results as a basis for stating compliance status for this limitation.

II.B.7.c **Condition:**

Visible emissions shall be no greater than 10 percent opacity when burning natural gas and no greater than 20% opacity when burning fuel oil. [Origin: DAQE-AN0107900015-13]. [R307-401-8(1)(a)(BACT)]

II.B.7.c.1 **Monitoring:**

While burning natural gas, use of that fuel type shall be verified in lieu of monitoring via visible emissions observations. When fuel oil is burned then the opacity will be measured by the opacity meter located on the Central Heating Plant stack.

II.B.7.c.2 **Recordkeeping:**

Records of fuel type used daily shall be maintained as described in Provision I.S.1 of this permit. Results of opacity meter results shall be recorded and maintained as described in Provision I.S.1 of this permit.

II.B.7.c.3 **Reporting:**

There are no reporting requirements for this provision except those specified in Section I of this permit.

II.B.7.d **Condition:**

The permittee shall burn natural gas as primary fuel and fuel oil as backup fuel. The source shall notify the Director within three business days of using fuel oil. [Origin: DAQE-AN0107900015-13]. [R307-401-8(1)(a)(BACT)]

II.B.7.d.1 **Monitoring:**

Records required for this permit condition will serve as monitoring.

II.B.7.d.2 **Recordkeeping:**

Fuel receipts shall be maintained to document the type of fuel used. Documentation of natural gas curtailment shall be maintained. Records shall be maintained as described in Provision I.S.1 of this permit.

II.B.7.d.3 **Reporting:**

Notification as required in the condition is the only reporting provision except those specified in Section I of this permit.

II.B.7.e **Condition:**

The permittee shall keep daily records of the amounts of each fuel combusted each day. [Origin: 40 CFR 60 Subpart Db]. [40 CFR 60.49b(d)]

II.B.7.e.1 **Monitoring:**

Fuel consumption for each affected emission unit shall be determined by a fuel meter, or other method approved by the Director.

II.B.7.e.2 **Recordkeeping:**

Records of the amounts of each fuel combusted during each day for each affected unit shall be maintained as described in Provision I.S.1 of this permit.

II.B.7.e.3 **Reporting:**

There are no reporting requirements for this provision except those specified in Section I of this permit.

II.B.7.f **Condition:**

The permittee shall comply with all applicable requirements of 40 CFR 60 Subpart A. [Origin: 40 CFR 60 Subpart A]. [40 CFR 60 Subpart A]

II.B.7.f.1 **Monitoring:**

Records required for this permit condition will serve as monitoring.

II.B.7.f.2 **Recordkeeping:**

All applicable records and notifications required by 40 CFR 60 Subpart A shall be maintained in accordance with provision I.S.1 of this permit.

II.B.7.f.3 **Reporting:**

The permittee shall comply with the reporting requirements in Section I of this permit and any additional reporting and notification requirements of 40 CFR 60 Subpart A.

II.B.8 **Conditions on the Central Heating Plant Coal Boiler #5.**

II.B.8.a **Condition:**

Emissions of NO_x shall be no greater than 74.8 lbs/hour or 331 ppmdv (using 7% excess oxygen). [Origin: DAQE-AN0107900015-13]. [R307-401-8(1)(a)(BACT)]

II.B.8.a.1 **Monitoring:**

Stack testing shall be performed as specified here:

(a) Frequency. The source shall be tested every three years.

(b) Notification. The Director shall be notified at least 30 days prior to conducting any required emission testing. A source test protocol shall be submitted to DAQ when the testing notification is submitted to the Director.

The source test protocol shall be approved by the Director prior to performing the test(s). The source test protocol shall outline the proposed test methodologies, stack to be tested, and procedures to be used. A pretest conference shall be held, if directed by the Director.

(c) Sample Location. The emission point shall be designed to conform to the requirements of 40 CFR 60, Appendix A, Method 1, or other EPA approved testing method as acceptable to the Director. An Occupational Safety and Health Administration (OSHA) or Mine Safety and Health Administration (MSHA) approved access shall be provided to the test location.

(d) Volumetric Flow Rate: The volumetric flow rate shall be measured using 40 CFR 60,

Appendix A, Method 2 or other EPA approved testing method as acceptable to the Director.

(e) Nitrogen Oxides (NO_x): NO_x shall be measured using 40 CFR 60, Appendix A, Method 7, 7A, 7B, 7C, 7D, 7E, or other EPA approved testing method as acceptable to the Director.

(f) Calculations: To determine mass emission rates (lb/hr, etc.) the pollutant concentration as determined by the appropriate methods above shall be multiplied by the volumetric flow rate and any necessary conversion factors determined by the Director, to give the results in the specified units of the emission limitation.

(g) The production rate during all compliance testing shall be no less than 90% of the average production achieved in the previous three (3) years.

II.B.8.a.2 **Recordkeeping:**

Results of all stack testing shall be recorded and maintained in accordance with the associated test method and Provision I.S.1 of this permit.

II.B.8.a.3 **Reporting:**

Results of required stack testing shall be submitted to the Director within 60 days of completion of the testing. The submittal shall clearly identify results and indicate compliance status. The annual compliance certification required by Provision L in Section I of this permit shall use the most recent test results as a basis for stating compliance status for this limitation.

II.B.9 **Conditions on the Central Heating Plant Baghouse.**

II.B.9.a **Condition:**

Emissions of PM_{10} shall be no greater than 1.83 lbs/hour and 0.010 grains/dscf (using 68 degrees F & 29.92 in. Hg). [Origin: DAQE-AN0107900015-13]. [R307-401-8(1)(a)(BACT)]

II.B.9.a.1 **Monitoring:**

Stack testing shall be performed as specified here:

(a) Frequency. The source shall be tested every three years.

(b) Notification. The Director shall be notified at least 30 days prior to conducting any required emission testing. A source test protocol shall be submitted to DAQ when the testing notification is submitted to the Director.

The source test protocol shall be approved by the Director prior to performing the test(s). The source test protocol shall outline the proposed test methodologies, stack to be tested, and procedures to be used. A pretest conference shall be held, if directed by the Director.

(c) Sample Location. The emission point shall be designed to conform to the requirements of 40 CFR 60, Appendix A, Method 1, or other EPA approved testing method as acceptable to the Director. An Occupational Safety and Health Administration (OSHA) or Mine Safety and Health Administration (MSHA) approved access shall be provided to the test location.

(d) Volumetric Flow Rate: The volumetric flow rate shall be measured using 40 CFR 60, Appendix A, Method 2 or other EPA approved testing method as acceptable to the Director.

(e) PM_{10}: For stacks in which no liquid drops are present, the following methods shall be used: 40 CFR 51, Appendix M, Methods 201, 201a, or other EPA approved testing method as acceptable to the Director.

For stacks in which liquid drops are present, methods to eliminate the liquid drops should be explored. If no reasonable method to eliminate the drops exists, then the following methods shall be used: 40 CFR 60, Appendix A, Method 5, 5a, 5d, or 5e as appropriate, or other testing methods approved by the Director. The back half condensibles shall also be tested using the method specified by the Director. The portion of the front half of the catch considered PM_{10} shall be based on information in Appendix B of the fifth edition of the EPA document, AP-42, or other data acceptable to the Director.

The back half condensibles shall not be used for compliance demonstration but shall be used for inventory purposes.

(f) Calculations: To determine mass emission rates (lb/hr, etc.) the pollutant concentration as determined by the appropriate methods above shall be multiplied by the volumetric flow rate and any necessary conversion factors determined by the Director, to give the results in the specified units of the emission limitation.

(g) The production rate during all compliance testing shall be no less than 90% of the average production achieved in the previous three (3) years.

II.B.9.a.2 **Recordkeeping:**

Results of all stack testing shall be recorded and maintained in accordance with the associated test method and Provision I.S.1 of this permit.

II.B.9.a.3 **Reporting:**

Results of required stack testing shall be submitted to the Director within 60 days of completion of the testing. The submittal shall clearly identify results and indicate compliance status. The annual compliance certification required by Provision L in Section I of this permit shall use the most recent test results as a basis for stating compliance status for this limitation.

II.B.9.b **Condition:**

Visible emissions shall be no greater than 10 percent opacity. [Origin: DAQE-AN0107900015-13 and 40 CFR 63.11201(c)]. [40 CFR 63 Subpart JJJJJJ, R307-401-8(1)(a)(BACT)]

II.B.9.b.1 **Monitoring:**

The permittee shall calibrate, maintain and operate a continuous monitoring system for measuring the opacity of emissions discharged to the atmosphere in accordance with R307-170 and shall record the output of the system. The output shall be reviewed at least monthly for compliance with the opacity limit; compliance is to be based on the percent opacity averaged over six consecutive minutes. Effective March 12, 2014, monitoring shall also meet the requirements of 40 CFR 63, Subpart JJJJJJ.

II.B.9.b.2 **Recordkeeping:**

Results of the continuous opacity monitoring shall be recorded and maintained in accordance with Provision I.S.1 of this permit. Effective March 12, 2014, recordkeeping shall also meet the requirements of 40 CFR 63.11225.

II.B.9.b.3 **Reporting:**

There are no reporting requirements for this provision except those specified in Section I of this permit. Effective March 12, 2014, reporting shall also meet the requirements of 40 CFR 63.11225.

II.B.10 **Conditions on the Laundry Dry Cleaning Units.**

II.B.10.a **Condition:**

Dry cleaning equipment shall not exceed 55.6 gallons of iso-paraffin hydrocarbon (IPH) consumption per rolling 12-month period. At initial start-up, all dry cleaning equipment will be filled to a volume of up to 175 gallons total of IPH. This initial fill volume shall not be included in the rolling 12-month total. No other VOC or HAP emitting solvent shall be used for dry cleaning application. [Origin: DAQE-AN107900015-13]. [R307-401-8]

II.B.10.a.1 **Monitoring:**

Compliance with each limitation shall be determined on a rolling 12-month total. Based on the first day of each month, a new 12-month total shall be calculated using data from the previous 12 months. Monthly calculations shall be made no later than 20 days after the end of each calendar month. Consumption shall be determined by examination of each supplier's billing records and use of IPH each month.

II.B.10.a.2 **Recordkeeping:**

Records of consumption shall be kept for all periods when the dry cleaning system is in operation.

Records shall be maintained in accordance with Provision I.S.1 of this permit.

II.B.10.a.3 **Reporting:**

There are no reporting requirements for this provision except those specified in Section I of this permit.

II.B.11 **Conditions on Paint Booths.**

II.B.11.a **Condition:**

Visible emissions shall be no greater than 10 percent opacity. [Origin: DAQE-AN0107900015-13]. [R307-401-8(1)(a)(BACT)]

II.B.11.a.1 **Monitoring:**

In lieu of monitoring via visible emissions observations, the spray booth particulate capture system shall be maintained per the manufacturer's recommendations and inspected to demonstrate that functioning properly. Inspections shall consist of the following observations made at the specified frequencies:

A. Inspection for holes in the particulate filters - weekly
B Inspection of the particulate filters to determine proper installation within the support rack - weekly
C. Inspection of the exhaust fan to ensure that it is operating - whenever the spray booths begin operation.

II.B.11.a.2 **Recordkeeping:**

Results of maintenance and inspection shall be maintained in accordance with Provision I.S.1 of this permit.

II.B.11.a.3 **Reporting:**

There are no reporting requirements for this provision except those specified in Section I of this permit.

II.B.12 **Conditions on Cyclonic Dust Collector.**

II.B.12.a **Condition:**

Visible emissions shall be no greater than 20 percent opacity. [Origin: DAQE-AN0107900015-13]. [R307-305-3(1)]

II.B.12.a.1 **Monitoring:**

For each emissions unit operated during a semi annual period (i.e., January through June, July through December), a visual opacity survey shall be performed during the semi-annual period of operation. The opacity survey can be conducted anytime during the semi-annual period while the unit is operating. The opacity survey shall be conducted by an individual trained on the observation procedures of 40 CFR 60, Appendix A, Method 9. If visible emissions other than condensed water vapor are observed from the emission unit, an opacity determination of that emission unit shall be performed by a certified observer within 24 hours of the initial visual emission observation. The opacity determination shall be performed in accordance with 40 CFR 60, Appendix A, Method 9.

II.B.12.a.2 **Recordkeeping:**

Results of monitoring shall be maintained in accordance with Provision I.S.1 of this permit.

II.B.12.a.3 **Reporting:**

There are no reporting requirements for this provision except those specified in Section I of this permit.

II.B.13 **Conditions on Coal Fired Boilers.**

II.B.13.a **Condition:**

The source shall minimize the boiler's startup and shutdown periods following the manufacturer's recommended procedures. If manufacturer's recommended procedures are not available, the source shall follow recommended procedures for a unit of similar design for which manufacturer's recommended procedures are available. Compliance shall be maintained in accord with 40 CFR 63.11223. [Origin: 40 CFR 63.11196(a)(1), 40 CFR 63.11210(c), and 40 CFR 63.11223]. [40 CFR 63 Subpart JJJJJJ]

II.B.13.a.1 **Monitoring:**

Records required for this permit condition will serve as monitoring

II.B.13.a.2 **Recordkeeping:**

Record keeping shall be maintained in accord with 40 CFR 63.11225 and as described in Provision I.S.1 of this permit.

II.B.13.a.3 **Reporting:**

The permittee shall comply with the reporting requirements in Section I of this permit and reporting and notification requirements of 40 CFR 63.11225.

II.B.13.b **Condition:**

The source shall meet the requirements of Table 1. Initial compliance shall be demonstrated within 180 days of the effective date (September 17, 2014). [Origin: 40 CFR 63.11196(a)(2), 40 CFR 63.11201(a), and 40 CFR 63.11210(b)]. [40 CFR 63 Subpart JJJJJJ]

II.B.13.b.1 **Monitoring:**

Compliance with the mercury limit will be demonstrated by fuel analysis conducted according to 40 CFR 63.11213 and 40CFR 63, Subpart JJJJJJ, Table 5 using procedures in 40 CFR 63.11211(c). [Origin: 40 CFR 63.11205(b)] Frequency of fuel analysis shall be according to 40 CFR 63.11213, 40 CFR 63.11222(a)(3), and 40 CFR 63.11220(e).

Compliance with the CO limit shall be demonstrated by maintaining the oxygen level at or above the lowest 1-hour average oxygen level measured during the most recent CO performance stack test. Oxygen shall be monitored by a continuous emission monitor (CEM) in accord with 40 CFR 63.11205(c), 40 CFR 63.11221, 40 CFR 63.11222, and 40 CFR 63.11224. CO performance stack testing shall be in accord with 40 CFR 63.11212, 40 CFR 63.11220(a) & (d), and Table 3(7).

II.B.13.b.2 **Recordkeeping:**

Record keeping shall be maintained in accord with 40 CFR 63.11225 and as described in Provision I.S.1 of this permit.

II.B.13.b.3 **Reporting:**

The permittee shall comply with the reporting requirements in Section I of this permit and reporting and notification requirements of 40 CFR 63.11225.

II.B.13.c **Condition:**

The source shall complete a one time energy assessment performed by a qualified energy assessor meeting the criteria of 40 CFR 63, Subpart JJJJJJ, Table 2 (4). [Origin: 40 CFR 63.11196(a)(3)]. [40 CFR 63 Subpart JJJJJJ]

II.B.13.c.1 **Monitoring:**

Records required for this permit condition will serve as monitoring.

II.B.13.c.2 **Recordkeeping:**

Record keeping shall be maintained in accord with 40 CFR 63.11225 and as described in Provision I.S.1 of this permit.

II.B.13.c.3 **Reporting:**

The permittee shall comply with the reporting requirements in Section I of this permit and reporting and notification requirements of 40 CFR 63.11225.

II.B.14 **Baghouse Dust Collectors.**

II.B.14.a **Condition:**

Visible emissions shall be no greater than 10 percent opacity. [Origin: DAQE-AN0107900015-13]. [R307-305-3]

II.B.14.a.1 **Monitoring:**

An opacity survey shall be conducted anytime during the semi-annual period (i.e., January through June, July through December) while the unit is operating. The opacity survey shall be conducted by an individual trained on the observation procedures of 40 CFR 60, Appendix A, Method 9. If visible emissions other than condensed water vapor are observed from the emission unit, an opacity determination of that emission unit shall be performed by a certified observer within 24 hours of the initial visual emission observation. The opacity determination shall be performed in accordance with 40 CFR 60, Appendix A, Method 9.

II.B.14.a.2 **Recordkeeping:**

Results of monitoring shall be maintained in accordance with Provision I.S.1 of this permit.

II.B.14.a.3 **Reporting:**

There are no reporting requirements for this provision except those specified in Section I of this permit.

II.C **Emissions Trading**
(R307-415-6a(10))

Not applicable to this source.

II.D **Alternative Operating Scenarios**.
(R307-415-6a(9))

Not applicable to this source.

SECTION III: PERMIT SHIELD

A permit shield was not granted for any specific requirements.

SECTION IV: ACID RAIN PROVISIONS

IV.A **This source is not subject to Title IV. This section is not applicable.**

REVIEWER COMMENTS

This operating permit incorporates all applicable requirements contained in the following documents:

Incorporates	DAQE-AN107900015-13 dated July 31, 2013

1. Comment on an item originating in AO DAQE-AN0107900015-13 regarding Diesel Emergency Generators

   Locations for emergency engines, horsepower, and manufacture date: All are diesel fired compression ignition internal combustion engines.

   Auxiliary Maintenance Building (75hp - before 1982),
   Marriott Center (464 hp - 10/31/2013),
   Cougar Stadium (235 hp - 8/1981),
   Bean Life Science Museum (324hp - 9/13/2013),
   Crabtree Technology Building (167 hp, before 1985),
   Ernest L. Wilkinson Center (268 hp - 2/1996),
   Cannon Center (352 hp - 11/28/2006),
   Helaman Halls Telephone Node (75 hp - 11/29/1994),
   J. Ruben Clarke Law Building (145 hp - 7/9/2008),
   Smoot Administration Building (2 @ 335 hp each - 4/1990 and 4/1997),
   Brewster Building (67 hp - before 1993),
   Harman Continuing Education Building (201 hp - 6/23/1999),
   Chemicals Management Building (150 hp - before 1999),
   Miller Park Baseball Fields (26 hp - 9/27/2006),
   Kimball Tower (308 hp - 10/1978),
   Joseph F. Smith Building (450 hp - 7/9/2003),
   Wyview Telephone Node (67 hp - 11/29/1994),
   Wyview Park (67 hp - 3/31/1997),
   Brimhall Building (150 hp - before 1999),
   Conference Center (201 hp - 5/10/1995),
   Indoor Practice Facility (308 hp - 8/1988),
   Jesse Knight Building (380 hp - 10/2005),
   Ellsworth Building (99 hp - 9/27/2006),
   Information Technology Building (250 hp - 6/12/2008),
   Physical Plant Central Heating (650 hp - before 1989),
   Student Health Center (804 hp - before 1998),
   Benson Building (2 @ 1005 hp each - both in 1994),
   Talmage Building 3 @ 2220 hp each - 3/2002),
   Tanner Building (755 hp - 10/1/2007),
   Broadcast Building 1 (2922 hp - 11/5/2008),
   Broadcast Building 2 (2922 hp - 11/5/2008),
   Clyde Engineering BUilding (755 hp - 4/2011)
   Heritage Housing Complex 1 (1220 hp - 2/15/2011)
   Heritage Housing Complex 2 (1220 hp - 8/5/2013)
   Life Science Building (2220 hp - 11/15/2013). [Last updated May 14, 2014]

2. Comment on an item originating in AO DAQE-AN0107900015-13 regarding Diesel Emergency Generators

   Conversion Factor: Permittee asked that we include the standard conversion factor from kW to hp to avoid confusion. The conversion is: 1 hp = 0.746 kW [Last updated May 14, 2014]

3. Comment on an item originating in AO DAQE-AN0107900015-13 regarding Four Paint Booths
Other small paint booths: In addition to the four paint booths listed in the permit, there are small paint booths in the following buildings:
M.L. Bean Museum
Museum of Art
Harris Fine Arts Center
Fletcher Building
Brewster Building
Clyde Building
Stephen L. Richards Building
B-73, East of Snell Building
University Press Building
Wilkinson Building
Information Technology Building

Students build and paint scale models, stage props, and similar items in these areas as part of the educational experience. These small booths are considered environmentally insignificant and have no applicable requirements.
[Last updated May 14, 2014]

4. Comment on an item originating in AO DAQE-AN0107900015-13 regarding Unit 9 - Small Natural Gas Fired Boilers
Locations of boilers: Boilers <5 MMBTU/HR are in the following locations:

ROTC Building
University Press Building
Dairy Products Building
[Last updated May 14, 2014]

5. Comment on an item originating in 40 CFR 60.44b(k) regarding Units 4 & 6 - Boilers #4 & 6
NO_x monitoring**:** Conditions in the AO and operating permit require the source to meet 40 CFR 60.44b(j) for boiler 4 and 6. Therefore these two boilers are not required to meet the NO_x emission limits of 40 CFR 60, Subpart Db. The NO_x CEM of 40 CFR 60.46b(e) is not necessary. [Last updated May 14, 2014]

6. Comment on an item originating in AO DAQE-AN0107900015-13 regarding Four Paint Booths
Spray Booths: AO condition II.B.1.d has not been carried over into this permit. The requirement for equipping spray booths with particulate capture systems is not an emission or work practice limit. It is a construction specification and, therefore, is not carried over into this Operating Permit as a limit, but is included as part of the emissions unit description. The AO requirement for all air to pass through the particulate capture system will be met through filter system inspections included in the spray booth parametric opacity monitoring condition in this permit. [Last updated May 14, 2014]

7. Comment on an item originating in 40 CFR 64 regarding Permitted Source
Permitted Source, 40 CFR 64: BYU provided a CAM applicability evaluation. The Central Heating Plant coal fired boilers are subject to emission limitations and they do have a control device to achieve compliance with PM 10 requirements. Based upon the coal usage limitation in this permit and AP 42 factors for the coal fired boilers, the pre-control device emissions are 52.7 tons per year. There are no CAM requirements in this permit. [Last updated May 14, 2014]

8. Comment on an item originating in 40 CFR 63, Subpart ZZZZ regarding Diesel Emergency Generators
Stationary RICE: Existing stationary institutional emergency RICE located at an area

source of HAP do not have to meet the requirements of 40 CFR 63 subpart ZZZZ and subpart A. No initial notification is necessary. A new RICE located at an area source shall meet the requirements of 40 CFR 63, Subpart ZZZZ by meeting the requirements of 40 CFR 60, Subpart IIII. [Last updated May 14, 2014]

9. Comment on an item originating in AO DAQE-AN0107900015-13 regarding Printing Equipment
AO DAQE-AN0107900015-13 condition II.B.1.b.E: Visible emissions limit has not been carried over into the Title V Permit as there is no combustion or other process that can reasonably cause an opacity violation in the print shop. [Last updated May 14, 2014]

10. Comment on an item originating in AO DAQE-AN0107900015-13 regarding Laundry Boilers
Opacity limit: The two laundry boilers are only allowed to burn natural gas. For that reason, the 10% opacity limit in the AO was not carried over as a permit condition. [Last updated May 14, 2014]

11. Comment on an item originating in R307-415-3 regarding Permitted Source
Greenhouse Gases (GHGs): GHG applicability has been reviewed and evaluated in this permit action and there are no GHG requirements included in this permit. [Last updated May 14, 2014]

12. Comment on an item originating in AO DAQE-AN0107900015-13 regarding Permitted Source
Opacity limit: The AO indicates all other points not specifically listed are to have a 20% opacity limit. The only sources not specifically listed are the small boilers each less than 5.0 MMBTU/hr. These boilers are only fired by natural gas; therefore this limit was not carried over into this permit. [Last updated May 14, 2014]

13. Comment on an item originating in 40 CFR 60, Subpart K, Ka, Kb regarding Misc. Fuel Tanks
Fuel Oil Storage Tanks: The regulations do not apply due to vapor pressure and tank size. [Last updated May 14, 2014]

14. Comment on an item originating in AO DAQE-AN0107900015-13 regarding Permitted Source
Boilers: The source requested clarification that the boilers in this permit are high temperature water generators. [Last updated May 14, 2014]

DAQC-1237-12
Site ID 10790 (B4)

MEMORANDUM

To: **STACK TEST FILE – BRIGHAM YOUNG UNIVERSITY**

Through: Harold Burge, Major Source Compliance Section Manager HB

From: Rob Leishman, Environmental Scientist

Date: 10/19/2012

Subject:

Company:	Brigham Young University
Location:	BYU Physical Plant Department, 225 BRWB, Provo, Utah County, Utah
Contact:	Steven Zohner, 801-422-2804
Tester:	TETCO
Source:	Central Heating Plant Boilers #4 and #6
Airs #:	049-00004
Permit#	Title V operating permit 490004002 dated 4/14/2011
Action Code:	3A
Subject:	Review of Stack Test Report dated 1/9/2012

On 1/17/2012, DAQ received a test report for the Brigham Young University Central Heating Plant Boilers #4 and #6, in Provo, Utah. Testing was performed on 12/6/2011, to demonstrate compliance with the NO_X emission limits found in Title V operating permit dated 4/14/ 2011, Condition II.B.7.b. The DAQ-calculated test results are:

Source	Test Date	Pollutant	Result	Limit
Boiler #4	12/6/2011	NO_X	74 ppmdv @ 7% O_2 15.1 lb/hr	127 ppmdv @ 7% O_2 38.5 lb/hr
Boiler #6	12/6/2011	NO_X	81 ppmdv @ 7% O_2 18.6 lb/hr	127 ppmdv @ 7% O_2 38.5 lb/hr

DEVIATIONS: None noted.

CONCLUSION: The NO_X emissions were in compliance with the applicable limits at the time of testing.

RECOMMENDATION: No further action is necessary.

HPV: No compliance action is recommended.

Document Date 10/19/2012
DAQ-2012-009834

Division of Air Quality

Instrumental Reference Methods - Gaseous Measurements

Reference Methods 2, 3A, 6C, 7E, 10, & 19

Source Information

Company Name	**Brigham Young University**
Company Contact:	**Steven Zohner**
Contact Phone No.	**801-422-2804**
Stack Designation:	**Boiler #4 Central Heat Plant**

CO2 Interferece w/CO
☐ Yes

Wet CEM
☐ Yes

Correct For O2

Test & Review Dates

Test Date:	**12/6/2011**	High Flow Test Date:	1/0/1900
Review Date:	10/19/2012	Mid Flow Test Date:	1/0/1900
Observer:	Rob Leishman	Low Flow Test Date:	1/0/1900
Reviewer:	**ROB LEISHMAN**		

	Emission Limits			Emission Rates		
	SO_2	NO_X	CO	SO2	NOX	CO
lbs/MMBtu						
lbs/hr		35.8			15.101	
ppm		127.0			74.270	
Percent						
%O2 Correction as a whole #		**7.00**				

Test Information

Stack I.D. inches	As ft^2	Y	Dl H @	Cp	Pbar	Pq (static)	fuel flow rate (Btu/hr)	Heat Input (Btu/hr.)
136.00	100.88	1.0040	1.649	0.84	25.60	-0.34		

Round

Heat Input

Contractor Information

Contact:	Dean Kitchen
Contracting Company:	TETCO
Address:	90 E. Main, Lehi, Ut. 84043-2142
Phone No.:	801-768-0973
Project No.:	

☐ F factor used

Diluent
- ○ O2
- ○ CO2

Method 19 - F factors for Coal, Oil, and Gas

		Fd scf/MMBtu	Fw scf/MMBtu	Fc scf/MMBtu
COAL	Anthracite 2	○ 10100	○ 10540	○ 1970
	Bituminous	○ 9780	○ 10640	○ 1800
	Lignite	○ 9860	○ 11950	○ 1910
OIL		○ 9190	○ 320	○ 1420
GAS	Natural	○ 8710	○ 10610	○ 1040
	Propan	○ 8710	○ 10200	○ 1190
	Butane	○ 8710	○ 10390	○ 1250

Tabs Are Sh

BYU Boiler #4 1-9-12

Division of Air Quality

NSPS Relative Accuracy Performance Specification Test - CEMS C

Brigham Young University

Boiler #4 Central Heat Plant

lbs/MMBTU
- O2
- CO2
- Clear

Average Emission

Dry	SO_2	NO_X	CO
lbs/Mbtu			
lbs/hr		15.10	
ppm		74.27	
ppm corrected for %O2			

Average % concentration

CO_2	O_2
6.20	10.40

Run 1

Dry	SO_2	NO_X	CO	CO_2	O_2	Enter O2 or CO2 / O2
Atomic Weight	64	46	28			
lbs/MMBtu (O2)						E=Cd x Fd x (20.9/(20.9-%O2d))
lbs/MMBtu (CO2)						E=Cd x Fc x (100 / % CO2d)
lbs/cu.ft		6.701E-06				
lbs/hr		15.101		6.20	10.40	C For Cal Drift
ppm corrected for %O		74.27		6.20	10.40	Raw Value

Run 2

Dry	SO_2	NO_X	CO	CO_2	O_2	
Atomic Weight	64	46	28			
lbs/MMBtu (O2)						E=Cd x Fd x (20.9/(20.9-%O2d))
lbs/MMBtu (CO2)						E=Cd x Fc x (100 / % CO2d)
lbs/cu.ft		6.749E-06				
lbs/hr		15.20875		6.20	10.40	C For Cal Drift
ppm corrected for %O		74.80		6.20	10.40	Raw Value

Run 3

Dry	SO_2	NO_X	CO	CO_2	O_2	
Atomic Weight	64	46	28			
lbs/MMBtu (O2)						E=Cd x Fd x (20.9/(20.9-%O2d))
lbs/MMBtu (CO2)						E=Cd x Fc x (100 / % CO2d)
lbs/cu.ft		6.653E-06				
lbs/hr		14.993409		6.20	10.40	C For Cal Drift
ppm corrected for %O		73.74		6.20	10.40	Raw Value

Run 4

Dry	SO_2	NO_X	CO	CO_2	O_2	
Atomic Weight	64	46	28			
lbs/MMBtu (O2)						E=Cd x Fd x (20.9/(20.9-%O2d))
lbs/MMBtu (CO2)						E=Cd x Fc x (100 / % CO2d)
lbs/cu.ft						
lbs/hr						C For Cal Drift
ppm corrected for %O				0.00	0.00	Raw Value

Calibration Error Test

Test Date December 6, 2011			O_2				
		CS - Cal. Span	20.90				
		Units	%				
Cylinder No.	**Expiration Date**	**Cal. Gas**	**C_V- Certified Concentration**	**C_{Dir} or C_S - Measured Concentration**	Difference	**ACE** Eq. 7E-1 Analyzer Cal. Error	**Status**
		Low-level	0.00	0.00	0.00	0.00%	Passed Cal.
		Mid-level	10.00	10.00	0.00	0.00%	Passed Cal.
		High-level	20.90	20.90	0.00	0.00%	Passed Cal.
			% of Span	**Sec. 8.2.1 Cal Gas Verification**			
0 to 20% of CS - Cal. Span		Low-Level	0.00%				
40 to 60% of Cal. Span		Mid-level	47.85%				
100% of Cal. Span		High-level	100.00%				

Test Date December 6, 2011			CO_2				
		CS - Cal. Span	10.00				
		Units	%				
Cylinder No.	**Expiration Date**	**Cal. Gas**	**C_V- Certified Concentration**	**C_{Dir} or C_S - Measured Concentration**	Difference	**ACE** Eq. 7E-1 Analyzer Cal. Error	**Status**
		Low-level	0.00	0.00	0.00	0.000%	Passed Cal.
		Mid-level	5.00	5.00	0.00	0.000%	Passed Cal.
		High-level	10.00	10.00	0.00	0.000%	Passed Cal.
			% of Span	**Sec. 8.2.1 Cal Gas Verification**			
0 to 20% of Cal. Span		Low-Level	0.00%				
40 to 60% of Cal. Span		Mid-level	50.00%				
100% of Cal. Span		High-level	100.00%				

Test Date			SO2				
		CS - Cal. Span					
		Units	ppm				
Cylinder No.	**Expiration Date**	**Cal. Gas**	**C_V- Certified Concentration**	**C_{Dir} or C_S - Measured Concentration**	Difference	**ACE** Eq. 7E-1 Analyzer Cal. Error	**Status**
		Low-level					
		Mid-level					
		High-level					
			% of Span	**Sec. 8.2.1 Cal Gas Verification**			
0 to 20% of Cal. Span		Low-Level					
40 to 60% of Cal. Span		Mid-level					
100% of Cal. Span		High-level					

Test Date December 6, 2011			NOx				
		CS - Cal. Span	88.90				
		Units	ppm				
Cylinder No.	**Expiration Date**	**Cal. Gas**	**C_V- Certified Concentration**	**C_{Dir} or C_S - Measured Concentration**	Difference	**ACE** Eq. 7E-1 Analyzer Cal. Error	**Status**
		Low-level	0.00	0.00	0.00	0.000%	Passed Cal.
		Mid-level	43.70	43.90	0.20	0.225%	Passed Cal.
		High-level	88.90	88.30	0.60	0.675%	Passed Cal.
			% of Span	**Sec. 8.2.1 Cal Gas Verification**			
0 to 20% of Cal. Span		Low-Level	0.00%				
40 to 60% of Cal. Span		Mid-level	49.16%				
100% of Cal. Span		High-level	100.00%				

Test Date			CO				
		CS - Cal. Span					
		Units	ppm				
Cylinder No.	**Expiration Date**	**Cal. Gas**	**C_V- Certified Concentration**	**C_{Dir} or C_S - Measured Concentration**	Difference	**ACE** Eq. 7E-1 Analyzer Cal. Error	**Status**
		Low-level					
		Mid-level					
		High-level					
			% of Span	**Sec. 8.2.1 Cal Gas Verification**			
0 to 20% of Cal. Span		Low-Level					
40 to 60% of Cal. Span		Mid-level					
100% of Cal. Span		High-level					

Division of Air Quality Stack Test Review of

Brigham Young University

Boiler #4 Central Heat Plant

	SO_2	NO_X	CO	CO_2	O_2
CS Calibration Span		88.90		10.00	20.90
Units	ppm	ppm	ppm	%	%
CV - Cylinder Value:	SO_2	NO_X	CO	CO_2	O_2
Low-Level		**0.00**		**0.00**	**0.00**
Mid-Level		**43.70**		**5.00**	**10.00**
High-Level		**88.90**		**10.00**	**20.90**
0 to 20% of Cal. Span		**0.00%**		**0.00%**	**0.00%**
40 to 60% of Cal. Span		**49.2%**		**50.0%**	**47.8%**
100% of Cal. Span		**100.0%**		**100.0%**	**100.0%**

☐ CO Calibration Gas

Unprotectec

Cdir - Enter Actual Up-scale Cylinder Value Used To Correct Emission Concentration.

C_{Dir} C_{MA}		**43.70**		**5.00**	**10.00**

Calibration Error Test

Cs - Measured Concentration	SO_2	NO_X	CO	CO_2	O_2
Low-Level		**0.00**		**0.00**	**0.00**
Mid-Level		**43.90**		**5.00**	**10.00**
High-Level		**88.30**		**10.00**	**20.90**

Enter Up-scale Analyzer Response to be used during testing.

ACE Eq. 7E-1		**43.90**		**5.00**	**10.00**

NOTE
These cells sc appropriate (after the Cm entered.

If this scan is the Cma and gas value.

Low-Level		0.00%		0.00%	0.00%
ppmdv Difference		0		0	0
Status		**Passed Cal.**		**Passed Cal.**	**Passed Cal.**
Mid-Level		0.22%		0.00%	0.00%
ppmdv Difference		0.2		0	0
Status		**Passed Cal.**		**Passed Cal.**	**Passed Cal.**
High-Level		0.67%		0.00%	0.00%
ppmdv Difference		0.6		0	0
Status		**Passed Cal.**		**Passed Cal.**	**Passed Cal.**

☐ Failed Cal Error Dialog

Pre-Test Sampling System Bias

Initial Values	SO_2	NO_X	CO	CO_2	O_2
C_O - Low-Level		**0.10**		**0.00**	**0.00**
SBi - Zero Bias	TRUE	0.11%	TRUE	0.00%	0.00%
Difference	TRUE	0.1	TRUE	0	0
Pass or Failed Invalid Run		**Passed Cal.**		**Passed Cal.**	**Passed Cal.**
C_M - Up-scale Gas		**43.90**		**5.00**	**10.00**
SBi - Up-Scale Bias	TRUE	0.00%	TRUE	0.00%	0.00%
Difference	TRUE	0.00	TRUE	0.00	0.00
Pass or Failed Invalid Run	**TRUE**	**Passed Cal.**	**TRUE**	**Passed Cal.**	**Passed Cal.**

System Bias.
± 5% of Span

☐ Failed Bias Dialog

Raw Test Data

Test Date: 12/6/2011

	SO_2	NO_X	CO	CO_2	O_2
		56.4		**6.2**	**10.4**
	0.0%	**63.4%**	**0.0%**	**62.0%**	**49.8%**

Time	**Start**	**Stop**
SO_2		0:21
NO_X	0:00	0:21
CO	0:00	0:21
CO_2/O_2	0:00	0:21

Post-Test System Bias 7E-2 SB=(Cs - Cdir)/CS x 100

Final Values	SO_2	NO_X	CO	CO_2	O_2
C_O - Low-Level		-0.10		0.00	0.00
SBi - Zero Bias	TRUE	0.11%	TRUE	0.00%	0.00%
Difference	**TRUE**	**0.1**	**TRUE**	**0.0**	**0.0**
Pass or Invalid Run		**Passed Cal.**		**Passed Cal.**	**Passed Cal.**
C_M - Up-scale Gas		44.00		5.00	10.00
SBi - Up-Scale Bias	TRUE	0.11%	TRUE	0.00%	0.00%
Difference	TRUE	0.1	TRUE	0.0	0.0
Pass or Invalid Run		**Passed Cal.**		**Passed Cal.**	**Passed Cal.**

System Bias.
± 5% of Span

☑ Failed Bias Dialog

Calibration Drift % of Span - D=ABS(SBf - SBi)

Low-Level Drift	TRUE	0.00%	TRUE	0.00%	0.00%
Difference	TRUE	0.2	TRUE	0.0	0.0
Pass or Re-Calibrate		**Pass**		**Pass**	**Pass**
Up-scale Gas Drift	TRUE	0.11%	TRUE	0.00%	0.00%
Difference	**TRUE**	**0.1**	**TRUE**	**0.0**	**0.0**
Pass or Re-Calibrate		**Pass**		**Pass**	**Pass**

Drift
3% of Span

☐ Failed Drift Dialog

Division of Air Quality Stack Test Review of

Brigham Young University

Boiler #4 Central Heat Plant — **Flow & Moisture**

As ft^2	Pbar	Pq (static)	Ps	Avg Ts F	$CO2 - F_{CO2}$	O2	N2+C	Md	Ms
100.88	25.60	-0.34	25.58	321	6.20	10.40	83.40	29.41	28.25

Y	Cp	Vm cf	Vlc	A_{VG} Tm F	Vm std	Vw std	Bws	S Bws	7.3321
1.0040	0.84	50.844	99.00	99	41.220	4.660	0.1016	0.9990	0.999

AvgSqrtDlp	Vs	scfm wet	acfm	Qsd dscfh	Heat Input Btu/hr
0.1600	11.9	41,805	72,307	2.254E+6	

Load - Megawatts

Low	Mid	High

#1 - Times

Date

Point No.	dl "p"	sqrt dl "p"	ts F	tm F (in)	tm F (out)	Cp *3D Probe*	Final Vf	Initial Vi	
1	0.035	0.19	312	85	85		786.4	708.4	78
2	0.028	0.17	319	83	84		646.2	635.6	10.6
3	0.025	0.16	320	84	88		516.2	513.7	2.5
4	0.030	0.17	320	86	94		912.1	904.2	7.9
5	0.017	0.13	318	89	98				0
6	0.015	0.12	317	92	98				
7	0.013	0.11	316	93	102				
8	0.015	0.12	319	95	105				
9	0.023	0.15	316	98	108				
10	0.028	0.17	324	99	110				
11	0.022	0.15	324	101	112				
12	0.023	0.15	325	103	111				
13	0.035	0.19	319	103	111				
14	0.040	0.20	327	104	113				
15	0.037	0.19	327	105	115				
16	0.035	0.19	327	106	116				
17									
18									
19									
20									
21									
22									
23									
24									

Division of Air Quality Stack Test Review of
Brigham Young University

	SO_2	NO_X	CO	CO_2	O_2	*Boiler #4 Central Heat Plant*
CS Calibration Span		88.90		10.00	20.90	
Units	ppm	ppm	ppm	%	%	
CV - Cylinder Value:	SO_2	NO_X	CO	CO_2	O_2	
Low-Level		**0.00**		**0.00**	**0.00**	
Mid-Level		**43.70**		**5.00**	**10.00**	
High-Level		**88.90**		**10.00**	**20.90**	
0 to 20% of Cal. Span		**0.00%**		**0.00%**	**0.00%**	
40 to 60% of Cal. Span		**49.2%**		**50.0%**	**47.8%**	
100% of Cal. Span		**100.0%**		**100.0%**	**100.0%**	

Cdir - Enter Actual Up-scale Cylinder Value Used To Correct Emission Concentration.

C_{MA}		43.70		5.00	10.00

Calibration Error Test

Measured Concentration	SO_2	NO_X	CO	CO_2	O_2
Low-Level		**0.00**		**0.00**	**0.00**
Mid-Level		**43.90**		**5.00**	**10.00**
High-Level		**88.30**		**10.00**	**20.90**

Enter Up-scale Analyzer Response to be used during testing.

ACE Eq. 7E-1		43.90		5.00	10.00
Low-Level		0.00%		0.00%	0.00%
ppmdv Difference		0		0	0
Status		**Passed Cal.**		**Passed Cal.**	**Passed Cal.**
Mid-Level		0.22%		0.00%	0.00%
ppmdv Difference		0.2		0	0
Status		**Passed Cal.**		**Passed Cal.**	**Passed Cal.**
High-Level		0.67%		0.00%	0.00%
ppmdv Difference		0.6		0	0
Status		**Passed Cal.**		**Passed Cal.**	**Passed Cal.**

☐ Failed Cal Error Dialog

Pre-Test Sampling System Bias

Initial Values	SO_2	NO_X	CO	CO_2	O_2
C_O - Low-Level		-0.10		0.00	0.00
SBi - Zero Bias	TRUE	0.11%	TRUE	0.00%	0.00%
Difference	TRUE	0.1	TRUE	0	0
Pass or Invalid Run		Passed Cal.		Passed Cal.	Passed Cal.
C_M - Up-scale Gas		44.00		5.00	10.00
SBi - Up-Scale Bias	TRUE	0.11%	TRUE	0.00%	0.00%
Difference	TRUE	0.1	TRUE	0	0
Pass or Invalid Run	TRUE	Passed Cal.	TRUE	Passed Cal.	Passed Cal.

System Bias.
± 5% of Span

☐ Failed Bias Dialog

Raw Test Data

Test Date: 12/6/2011

	SO_2	NO_X	CO	CO_2	O_2
		57.0		**6.2**	**10.4**
	0.0%	**64.1%**	**0.0%**	**62.0%**	**49.8%**

Time	**Start**	**Stop**
SO_2		0:21
NO_X	0:00	0:21
CO	0:00	0:21
CO_2/O_2	0:00	0:21

Post-Test System Bias 7E-2 SB=(Cs - Cdir)/CS x 100

Final Values	SO_2	NO_X	CO	CO_2	O_2
C_O - Low-Level		-0.10		0.00	0.00
SBi - Zero Bias	TRUE	0.11%	TRUE	0.00%	0.00%
Difference	**TRUE**	**0.1**	**TRUE**	**0.0**	**0.0**
Pass or Invalid Run		Passed Cal.		Passed Cal.	Passed Cal.
C_M - Up-scale Gas		44.10		5.00	10.00
SBi - Up-Scale Bias	TRUE	0.22%	TRUE	0.00%	0.00%
Difference	TRUE	0.2	TRUE	0.0	0.0
Pass or Invalid Run		Passed Cal.		Passed Cal.	Passed Cal.

System Bias.
± 5% of Span

☐ Failed Bias Dialog

Calibration Drift % of Span - D=ABS(SBf - SBi)

Low-Level Drift	TRUE	0.00%	TRUE	0.00%	0.00%
Difference	TRUE	0.0	TRUE	0.0	0.0
Pass or Re-Calibrate		Pass		Pass	Pass
Up-scale Gas Drift	TRUE	0.11%	TRUE	0.00%	0.00%
Difference	**TRUE**	**0.1**	**TRUE**	**0.0**	**0.0**
Pass or Re-Calibrate		Pass		Pass	Pass

Response Spec.
3% of Span

☐ Failed Drift Dialog

Division of Air Quality Stack Test Review of
Brigham Young University

Boiler #4 Central Heat Pl — **Flow & Moisture**

As ft^2	Pbar	Pq (static)	Ps	Avg Ts F	CO2 - F_{CO2}	O2	N2+C	Md	Ms
100.88	25.60	-0.34	25.58	321	6.20	10.40	83.40	29.41	28.25

Y	Cp	Vm cf	Vlc	A_{VG} Tm F	Vm std	Vw std	Bws	S Bws	7.3321
1.0040	0.84	50.844	99.00	99	41.220	4.660	0.1016	0.9990	0.999

AvgSqrtDlp	Vs	scfm wet	acfm	Qsd dscfh	Heat Input Btu/hr
0.1600	11.9	41,805	72,307	2.254E+6	

#1 - Times
Date

Load - Megawatts		
Low	Mid	High

Point No.	dl "p"	sqrt dl "p"	ts F	tm F (in)	tm F (out)	Cp *3D Probe*	Final Vf	Initial Vi	
1	0.035	0.19	312	85	85		786.4	708.4	78
2	0.028	0.17	319	83	84		646.2	635.6	10.6
3	0.025	0.16	320	84	88		516.2	513.7	2.5
4	0.030	0.17	320	86	94		912.1	904.2	7.9
5	0.017	0.13	318	89	98				0
6	0.015	0.12	317	92	98				
7	0.013	0.11	316	93	102				
8	0.015	0.12	319	95	105				
9	0.023	0.15	316	98	108				
10	0.028	0.17	324	99	110				
11	0.022	0.15	324	101	112				
12	0.023	0.15	325	103	111				
13	0.035	0.19	319	103	111				
14	0.040	0.20	327	104	113				
15	0.037	0.19	327	105	115				
16	0.035	0.19	327	106	116				
17									
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24									

Division of Air Quality Stack Test Review of
Brigham Young University

Boiler #4 Central Heat Plant

	SO_2	NO_X	CO	CO_2	O_2
CS Calibration Span		88.90		10.00	20.90
Units	ppm	ppm	ppm	%	%
CV - Cylinder Value:	SO_2	NO_X	CO	CO_2	O_2
Low-Level		**0.00**		**0.00**	**0.00**
Mid-Level		**43.70**		**5.00**	**10.00**
High-Level		**88.90**		**10.00**	**20.90**
0 to 20% of Cal. Span		**0.00%**		**0.00%**	**0.00%**
40 to 60% of Cal. Span		**49.2%**		**50.0%**	**47.8%**
100% of Cal. Span		**100.0%**		**100.0%**	**100.0%**

Cdir - Enter Actual Up-scale Cylinder Value Used To Correct Emission Concentration.

C_{MA}		43.70		5.00	10.00

Calibration Error Test

Measured Concentration	SO_2	NO_X	CO	CO_2	O_2
Low-Level		**0.00**		**0.00**	**0.00**
Mid-Level		**43.90**		**5.00**	**10.00**
High-Level		**88.30**		**10.00**	**20.90**

Enter Up-scale Analyzer Response to be used during testing.

ACE Eq. 7E-1		43.90		5.00	10.00
Low-Level		0.00%		0.00%	0.00%
ppmv Difference		0		0	0
Status		**Passed Cal.**		**Passed Cal.**	**Passed Cal.**
Mid-Level		0.22%		0.00%	0.00%
ppmv Difference		0.2		0	0
Status		**Passed Cal.**		**Passed Cal.**	**Passed Cal.**
High-Level		0.67%		0.00%	0.00%
ppmv Difference		0.6		0	0
Status		**Passed Cal.**		**Passed Cal.**	**Passed Cal.**

☐ Failed Cal Error Dialog

Pre-Test Sampling System Bias

Initial Values	SO_2	NO_X	CO	CO_2	O_2
C_O - Low-Level		-0.10		0.00	0.00
SBi - Zero Bias	TRUE	0.11%	TRUE	0.00%	0.00%
Difference	TRUE	0.1	TRUE	0	0
Pass or Invalid Run		**Passed Cal.**		**Passed Cal.**	**Passed Cal.**
C_M - Up-scale Gas		44.10		5.00	10.00
SBi - Up-Scale Bias	TRUE	0.22%	TRUE	0.00%	0.00%
Difference	TRUE	0.2	TRUE	0	0
Pass or Invalid Run	**TRUE**	**Passed Cal.**	**TRUE**	**Passed Cal.**	**Passed Cal.**

System Bias. ± 5% of Span

☐ Failed Bias Dialog

Raw Test Data

Test Date: 12/6/2011

	SO_2	NO_X	CO	CO_2	O_2
		56.2		**6.2**	**10.4**
	0.0%	**63.2%**	**0.0%**	**62.0%**	**49.8%**

Time	**Start**	**Stop**
SO_2		0:21
NO_X	0:00	0:21
CO	0:00	0:21
CO_2/O_2	0:00	0:21

Post-Test System Bias 7E-2 SB=(Cs - Cdir)/CS x 100

Final Values	SO_2	NO_X	CO	CO_2	O_2
C_O - Low-Level		-0.10		0.00	0.00
SBi - Zero Bias	TRUE	0.11%	TRUE	0.00%	0.00%
Difference	**TRUE**	**0.1**	**TRUE**	**0.0**	**0.0**
Pass or Invalid Run		**Passed Cal.**		**Passed Cal.**	**Passed Cal.**
C_M - Up-scale Gas		44.10		5.00	10.00
SBi - Up-Scale Bias	TRUE	0.22%	TRUE	0.00%	0.00%
Difference	TRUE	0.2	TRUE	0.0	0.0
Pass or Invalid Run		**Passed Cal.**		**Passed Cal.**	**Passed Cal.**

System Bias. ± 5% of Span

☐ Failed Bias Dialog

Calibration Drift % of Span - D=ABS(SBf - SBi)

Low-Level Drift	TRUE	0.00%	TRUE	0.00%	0.00%
Difference	TRUE	0.0	TRUE	0.0	0.0
Pass or Re-Calibrate		**Pass**		**Pass**	**Pass**
Up-scale Gas Drift	TRUE	0.00%	TRUE	0.00%	0.00%
Difference	**TRUE**	**0.0**	**TRUE**	**0.0**	**0.0**
Pass or Re-Calibrate		**Pass**		**Pass**	**Pass**

Response Spec. **3% of Span**

☐ Failed Drift Dialog

Division of Air Quality Stack Test Review of
Brigham Young University

Boiler #4 Central Heat Pl — **Flow & Moisture**

As ft^2	Pbar	Pq (static)	Ps	Avg Ts F	CO2 - F_{CO2}	O2	N2+C	Md	Ms
100.88	25.60	-0.34	25.58	321	6.20	10.40	83.40	29.41	28.25

Y	Cp	Vm cf	Vlc	A_{VG} Tm F	Vm std	Vw std	Bws	S Bws	7.3321
1.0040	0.84	50.844	99.00	99	41.220	4.660	0.1016	0.9990	0.999

AvgSqrtDlp	Vs	scfm wet	acfm	Qsd dscfh	Heat Input Btu/hr
0.1600	11.9	41,805	72,307	2.254E+6	

#1 - Times
Date

Load - Megawatts		
Low	Mid	High

Point No.	dl "p"	sqrt dl "p"	ts F	tm F (in)	tm F (out)	Cp *3D Probe*	Final Vf	Initial Vi	
1	0.035	0.19	312	85	85		786.4	708.4	78
2	0.028	0.17	319	83	84		646.2	635.6	10.6
3	0.025	0.16	320	84	88		516.2	513.7	2.5
4	0.030	0.17	320	86	94		912.1	904.2	7.9
5	0.017	0.13	318	89	98				0
6	0.015	0.12	317	92	98				
7	0.013	0.11	316	93	102				
8	0.015	0.12	319	95	105				
9	0.023	0.15	316	98	108				
10	0.028	0.17	324	99	110				
11	0.022	0.15	324	101	112				
12	0.023	0.15	325	103	111				
13	0.035	0.19	319	103	111				
14	0.040	0.20	327	104	113				
15	0.037	0.19	327	105	115				
16	0.035	0.19	327	106	116				
17									
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23									
24									

Division of Air Quality

Instrumental Reference Methods - Gaseous Measurements

Reference Methods 2, 3A, 6C, 7E, 10, & 19

Source Information

Company Name	**Brigham Young University**
Company Contact:	**Steven Zohner**
Contact Phone No.	**801-422-2804**
Stack Designation:	**Boiler #6 Central Heat Plant**

CO2 Interferece w/CO: ☐ Yes

Wet CEM: ☐ Yes

Correct For O2

Test & Review Dates

Test Date:	**12/6/2011**	High Flow Test Date:	1/0/1900
Review Date:	10/19/2012	Mid Flow Test Date:	1/0/1900
Observer:	Rob Leishman	Low Flow Test Date:	1/0/1900
Reviewer:	**ROB LEISHMAN**		

	Emission Limits			Emission Rates		
	SO_2	NO_X	CO	SO2	NOX	CO
lbs/MMBtu						
lbs/hr		35.8			18.647	
ppm		127.0			80.563	
Percent						
%O2 Correction as a whole #		**7.00**				

Test Information

Stack I.D. inches	As ft^2	Y	Dl H @	Cp	Pbar	Pq (static)	fuel flow rate (Btu/hr)	Heat Input (Btu/hr.)
136.00	100.88	1.0040	1.649	0.84	25.60	-0.34		

Round

Heat Input

Contractor Information

Contact:	Dean Kitchen
Contracting Company:	TETCO
Address:	90 E. Main, Lehi, Ut. 84043-2142
Phone No.:	801-768-0973
Project No.:	

☐ F factor used

Diluent

- ○ O2
- ○ CO2

Method 19 - F factors for Coal, Oil, and Gas

		Fd scf/MMBtu	Fw scf/MMBtu	Fc scf/MMBtu
COAL	Anthracite 2	○ 10100	○ 10540	○ 1970
	Bituminous	○ 9780	○ 10640	○ 1800
	Lignite	○ 9860	○ 11950	○ 1910
OIL		○ 9190	○ 320	○ 1420
GAS	Natural	○ 8710	○ 10610	○ 1040
	Propan	○ 8710	○ 10200	○ 1190
	Butane	○ 8710	○ 10390	○ 1250

Tabs Are Sh

BYU Boiler #6 1-9-12

Division of Air Quality

NSPS Relative Accuracy Performance Specification Test - CEMS C

Brigham Young University

Boiler #6 Central Heat Plant

lbs/MMBTU
- O2
- CO2
- Clear

Average Emission

Dry	SO_2	NO_X	CO
lbs/Mbtu			
lbs/hr		18.647	
ppm		80.56	
ppm corrected for %O2			

Average % concentration

CO_2	O_2
7.40	8.00

Run 1

Dry	SO_2	NO_X	CO	CO_2	O_2	Enter O2 or CO2 / O2
Atomic Weight	64	46	28			
lbs/MMBtu (O2)						E=Cd x Fd x (20.9/(20.9-%O2d))
lbs/MMBtu (CO2)						E=Cd x Fc x (100 / % CO2d)
lbs/cu.ft		8.768E-06				
lbs/hr		18.307		7.40	8.00	C For Cal Drift
ppm corrected for %O		79.09		7.40	8.00	Raw Value

Run 2

Dry	SO_2	NO_X	CO	CO_2	O_2	
Atomic Weight	64	46	28			
lbs/MMBtu (O2)						E=Cd x Fd x (20.9/(20.9-%O2d))
lbs/MMBtu (CO2)						E=Cd x Fc x (100 / % CO2d)
lbs/cu.ft		8.947E-06				
lbs/hr		18.68063		7.40	8.00	C For Cal Drift
ppm corrected for %O		80.71		7.40	8.00	Raw Value

Run 3

Dry	SO_2	NO_X	CO	CO_2	O_2	
Atomic Weight	64	46	28			
lbs/MMBtu (O2)						E=Cd x Fd x (20.9/(20.9-%O2d))
lbs/MMBtu (CO2)						E=Cd x Fc x (100 / % CO2d)
lbs/cu.ft		9.078E-06				
lbs/hr		18.954979		7.40	8.00	C For Cal Drift
ppm corrected for %O		81.89		7.40	8.00	Raw Value

Run 4

Dry	SO_2	NO_X	CO	CO_2	O_2	
Atomic Weight	64	46	28			
lbs/MMBtu (O2)						E=Cd x Fd x (20.9/(20.9-%O2d))
lbs/MMBtu (CO2)						E=Cd x Fc x (100 / % CO2d)
lbs/cu.ft						
lbs/hr						C For Cal Drift
ppm corrected for %O				0.00	0.00	Raw Value

Calibration Error Test

Test Date December 6, 2011			O_2				
		CS - Cal. Span	20.90				
		Units	%				
Cylinder No.	**Expiration Date**	**Cal. Gas**	**C_V- Certified Concentration**	**C_{Dir} or C_S - Measured Concentration**	Difference	**ACE** Eq. 7E-1 Analyzer Cal. Error	**Status**
		Low-level	0.00	0.00	0.00	0.00%	Passed Cal.
		Mid-level	10.00	10.00	0.00	0.00%	Passed Cal.
		High-level	20.90	20.90	0.00	0.00%	Passed Cal.
			% of Span	**Sec. 8.2.1 Cal Gas Verification**			
0 to 20% of CS - Cal. Span		Low-Level	0.00%				
40 to 60% of Cal. Span		Mid-level	47.85%				
100% of Cal. Span		High-level	100.00%				

Test Date December 6, 2011			CO_2				
		CS - Cal. Span	10.00				
		Units	%				
Cylinder No.	**Expiration Date**	**Cal. Gas**	**C_V- Certified Concentration**	**C_{Dir} or C_S - Measured Concentration**	Difference	**ACE** Eq. 7E-1 Analyzer Cal. Error	**Status**
		Low-level	0.00	0.00	0.00	0.000%	Passed Cal.
		Mid-level	5.00	5.00	0.00	0.000%	Passed Cal.
		High-level	10.00	10.00	0.00	0.000%	Passed Cal.
			% of Span	**Sec. 8.2.1 Cal Gas Verification**			
0 to 20% of Cal. Span		Low-Level	0.00%				
40 to 60% of Cal. Span		Mid-level	50.00%				
100% of Cal. Span		High-level	100.00%				

Test Date			SO2				
		CS - Cal. Span					
		Units	ppm				
Cylinder No.	**Expiration Date**	**Cal. Gas**	**C_V- Certified Concentration**	**C_{Dir} or C_S - Measured Concentration**	Difference	**ACE** Eq. 7E-1 Analyzer Cal. Error	**Status**
		Low-level					
		Mid-level					
		High-level					
			% of Span	**Sec. 8.2.1 Cal Gas Verification**			
0 to 20% of Cal. Span		Low-Level					
40 to 60% of Cal. Span		Mid-level					
100% of Cal. Span		High-level					

Test Date December 6, 2011			NOx				
		CS - Cal. Span	88.90				
		Units	ppm				
Cylinder No.	**Expiration Date**	**Cal. Gas**	**C_V- Certified Concentration**	**C_{Dir} or C_S - Measured Concentration**	Difference	**ACE** Eq. 7E-1 Analyzer Cal. Error	**Status**
		Low-level	0.00	0.00	0.00	0.000%	Passed Cal.
		Mid-level	43.70	43.70	0.00	0.000%	Passed Cal.
		High-level	88.90	88.90	0.00	0.000%	Passed Cal.
			% of Span	**Sec. 8.2.1 Cal Gas Verification**			
0 to 20% of Cal. Span		Low-Level	0.00%				
40 to 60% of Cal. Span		Mid-level	49.16%				
100% of Cal. Span		High-level	100.00%				

Test Date			CO				
		CS - Cal. Span					
		Units	ppm				
Cylinder No.	**Expiration Date**	**Cal. Gas**	**C_V- Certified Concentration**	**C_{Dir} or C_S - Measured Concentration**	Difference	**ACE** Eq. 7E-1 Analyzer Cal. Error	**Status**
		Low-level					
		Mid-level					
		High-level					
			% of Span	**Sec. 8.2.1 Cal Gas Verification**			
0 to 20% of Cal. Span		Low-Level					
40 to 60% of Cal. Span		Mid-level					
100% of Cal. Span		High-level					

Division of Air Quality Stack Test Review of

Brigham Young University

Boiler #6 Central Heat Plant

☐ CO Calibration Gas

Unprotectec

	SO_2	NO_X	CO	CO_2	O_2
CS Calibration Span		88.90		10.00	20.90
Units	ppm	ppm	ppm	%	%
CV - Cylinder Value:	SO_2	NO_X	CO	CO_2	O_2
Low-Level		**0.00**		**0.00**	**0.00**
Mid-Level		**43.70**		**5.00**	**10.00**
High-Level		**88.90**		**10.00**	**20.90**
0 to 20% of Cal. Span		**0.00%**		**0.00%**	**0.00%**
40 to 60% of Cal. Span		**49.2%**		**50.0%**	**47.8%**
100% of Cal. Span		**100.0%**		**100.0%**	**100.0%**

Cdir - Enter Actual Up-scale Cylinder Value Used To Correct Emission Concentration.

C_{Dir} C_{MA}		**43.70**		**5.00**	**10.00**

Calibration Error Test

Cs - Measured Concentration	SO_2	NO_X	CO	CO_2	O_2
Low-Level		**0.00**		**0.00**	**0.00**
Mid-Level		**43.70**		**5.00**	**10.00**
High-Level		**88.90**		**10.00**	**20.90**

Enter Up-scale Analyzer Response to be used during testing.

ACE Eq. 7E-1		**43.70**		**5.00**	**10.00**

NOTE
These cells sc appropriate (after the Cm entered.

If this scan is the Cma and gas value.

Low-Level		0.00%		0.00%	0.00%
ppmdv Difference		0		0	0
Status		**Passed Cal.**		**Passed Cal.**	**Passed Cal.**
Mid-Level		0.00%		0.00%	0.00%
ppmdv Difference		0		0	0
Status		**Passed Cal.**		**Passed Cal.**	**Passed Cal.**
High-Level		0.00%		0.00%	0.00%
ppmdv Difference		0		0	0
Status		**Passed Cal.**		**Passed Cal.**	**Passed Cal.**

☐ Failed Cal Error Dialog

Pre-Test Sampling System Bias

Initial Values	SO_2	NO_X	CO	CO_2	O_2
C_O - Low-Level		**0.10**		**0.00**	**0.00**
SBi - Zero Bias	TRUE	0.11%	TRUE	0.00%	0.00%
Difference	TRUE	0.1	TRUE	0	0
Pass or Failed Invalid Run		**Passed Cal.**		**Passed Cal.**	**Passed Cal.**
C_M - Up-scale Gas		**43.60**		**5.00**	**10.00**
SBi - Up-Scale Bias	TRUE	0.11%	TRUE	0.00%	0.00%
Difference	TRUE	0.10	TRUE	0.00	0.00
Pass or Failed Invalid Run	**TRUE**	**Passed Cal.**	**TRUE**	**Passed Cal.**	**Passed Cal.**

System Bias.
± 5% of Span

☐ Failed Bias Dialog

Raw Test Data

Test Date: 12/6/2011

	SO_2	NO_X	CO	CO_2	O_2
		73.0		**7.4**	**8.0**
	0.0%	**82.1%**	**0.0%**	**74.0%**	**38.3%**

Time	**Start**	**Stop**
SO_2		0:21
NO_X	0:00	0:21
CO	0:00	0:21
CO_2/O_2	0:00	0:21

Post-Test System Bias 7E-2 SB=(Cs - Cdir)/CS x 100

Final Values	SO_2	NO_X	CO	CO_2	O_2
C_O - Low-Level		0.20		0.00	0.00
SBi - Zero Bias	TRUE	0.22%	TRUE	0.00%	0.00%
Difference	**TRUE**	**0.2**	**TRUE**	**0.0**	**0.0**
Pass or Invalid Run		**Passed Cal.**		**Passed Cal.**	**Passed Cal.**
C_M - Up-scale Gas		43.40		5.00	10.00
SBi - Up-Scale Bias	TRUE	0.34%	TRUE	0.00%	0.00%
Difference	TRUE	0.3	TRUE	0.0	0.0
Pass or Invalid Run		**Passed Cal.**		**Passed Cal.**	**Passed Cal.**

System Bias.
± 5% of Span

☑ Failed Bias Dialog

Calibration Drift % of Span - D=ABS(SBf - SBi)

Low-Level Drift	TRUE	0.11%	TRUE	0.00%	0.00%
Difference	TRUE	0.1	TRUE	0.0	0.0
Pass or Re-Calibrate		**Pass**		**Pass**	**Pass**
Up-scale Gas Drift	TRUE	0.22%	TRUE	0.00%	0.00%
Difference	**TRUE**	**0.2**	**TRUE**	**0.0**	**0.0**
Pass or Re-Calibrate		**Pass**		**Pass**	**Pass**

Drift
3% of Span

☐ Failed Drift Dialog

Division of Air Quality Stack Test Review of
Brigham Young University

Boiler #6 Central Heat Plant — **Flow & Moisture**

As ft^2	Pbar	Pq (static)	Ps	Avg Ts F	CO2 - F_{CO2}	O2	N2+C	Md	Ms
100.88	25.60	-0.34	25.58	307	7.40	8.00	84.60	29.50	28.04

Y	Cp	Vm cf	Vlc	A_{VG} Tm F	Vm std	Vw std	Bws	S Bws	5.9893
1.0040	0.84	48.950	126.10	85	40.710	5.936	0.1272	0.9990	0.999

AvgSqrtDlp	Vs	scfm wet	acfm	Qsd dscfh	Heat Input Btu/hr
0.1507	11.2	39,873	67,740	2.088E+6	

#1 - Times
Date

Load - Megawatts		
Low	Mid	High

Point No.	dl "p"	sqrt dl "p"	ts F	tm F (in)	tm F (out)	Cp *3D Probe*	Final Vf	Initial Vi	
1	0.020	0.14	306	64	65		816.2	713.8	102.4
2	0.018	0.13	305	64	67		623.2	609.7	13.5
3	0.020	0.14	305	66	72		533	529.6	3.4
4	0.020	0.14	308	68	77		877.3	870.5	6.8
5	0.015	0.12	304	73	82				0
6	0.017	0.13	304	76	85				
7	0.015	0.12	305	79	85				
8	0.014	0.12	305	81	90				
9	**0.085**	0.29	304	85	93				
10	0.035	0.19	309	86	96				
11	0.025	0.16	310	89	100				
12	0.016	0.13	308	91	100				
13	0.022	0.15	308	93	100				
14	0.025	0.16	309	94	102				
15	0.022	0.15	309	95	105				
16	0.020	0.14	309	96	106				
17									
18									
19									
20									
21									
22									
23									
24									

Division of Air Quality Stack Test Review of
Brigham Young University

	SO_2	NO_X	CO	CO_2	O_2	*Boiler #6 Central Heat Plant*
CS Calibration Span		88.90		10.00	20.90	
Units	ppm	ppm	ppm	%	%	
CV - Cylinder Value:	SO_2	NO_X	CO	CO_2	O_2	
Low-Level		**0.00**		**0.00**	**0.00**	
Mid-Level		**43.70**		**5.00**	**10.00**	
High-Level		**88.90**		**10.00**	**20.90**	
0 to 20% of Cal. Span		**0.00%**		**0.00%**	**0.00%**	
40 to 60% of Cal. Span		**49.2%**		**50.0%**	**47.8%**	
100% of Cal. Span		**100.0%**		**100.0%**	**100.0%**	

Cdir - Enter Actual Up-scale Cylinder Value Used To Correct Emission Concentration.

C_{MA}		43.70		5.00	10.00

Calibration Error Test

Measured Concentration	SO_2	NO_X	CO	CO_2	O_2
Low-Level		**0.00**		**0.00**	**0.00**
Mid-Level		**43.70**		**5.00**	**10.00**
High-Level		**88.90**		**10.00**	**20.90**

Enter Up-scale Analyzer Response to be used during testing.

ACE Eq. 7E-1		43.70		5.00	10.00
Low-Level		0.00%		0.00%	0.00%
ppmdv Difference		0		0	0
Status		**Passed Cal.**		**Passed Cal.**	**Passed Cal.**
Mid-Level		0.00%		0.00%	0.00%
ppmdv Difference		0		0	0
Status		**Passed Cal.**		**Passed Cal.**	**Passed Cal.**
High-Level		0.00%		0.00%	0.00%
ppmdv Difference		0		0	0
Status		**Passed Cal.**		**Passed Cal.**	**Passed Cal.**

☐ Failed Cal Error Dialog

Pre-Test Sampling System Bias

Initial Values	SO_2	NO_X	CO	CO_2	O_2
C_O - Low-Level		0.20		0.00	0.00
SBi - Zero Bias	TRUE	0.22%	TRUE	0.00%	0.00%
Difference	TRUE	0.2	TRUE	0	0
Pass or Invalid Run		**Passed Cal.**		**Passed Cal.**	**Passed Cal.**
C_M - Up-scale Gas		43.40		5.00	10.00
SBi - Up-Scale Bias	TRUE	0.34%	TRUE	0.00%	0.00%
Difference	TRUE	0.3	TRUE	0	0
Pass or Invalid Run	**TRUE**	**Passed Cal.**	**TRUE**	**Passed Cal.**	**Passed Cal.**

System Bias. ± 5% of Span

☐ Failed Bias Dialog

Raw Test Data

Test Date: 12/6/2011

	SO_2	NO_X	CO	CO_2	O_2
		74.6		**7.4**	**8.0**
	0.0%	**83.9%**	**0.0%**	**74.0%**	**38.3%**

Time	**Start**	**Stop**
SO_2		0:21
NO_X	0:00	0:21
CO	0:00	0:21
CO_2/O_2	0:00	0:21

Post-Test System Bias 7E-2 SB=(Cs - Cdir)/CS x 100

Final Values	SO_2	NO_X	CO	CO_2	O_2
C_O - Low-Level		0.20		0.00	0.00
SBi - Zero Bias	TRUE	0.22%	TRUE	0.00%	0.00%
Difference	**TRUE**	**0.2**	**TRUE**	**0.0**	**0.0**
Pass or Invalid Run		**Passed Cal.**		**Passed Cal.**	**Passed Cal.**
C_M - Up-scale Gas		43.80		5.00	10.00
SBi - Up-Scale Bias	TRUE	0.11%	TRUE	0.00%	0.00%
Difference	TRUE	0.1	TRUE	0.0	0.0
Pass or Invalid Run		**Passed Cal.**		**Passed Cal.**	**Passed Cal.**

System Bias. ± 5% of Span

☐ Failed Bias Dialog

Calibration Drift % of Span - D=ABS(SBf - SBi)

Low-Level Drift	TRUE	0.00%	TRUE	0.00%	0.00%
Difference	TRUE	0.0	TRUE	0.0	0.0
Pass or Re-Calibrate		**Pass**		**Pass**	**Pass**
Up-scale Gas Drift	TRUE	0.22%	TRUE	0.00%	0.00%
Difference	**TRUE**	**0.4**	**TRUE**	**0.0**	**0.0**
Pass or Re-Calibrate		**Pass**		**Pass**	**Pass**

Response Spec. **3% of Span**

☐ Failed Drift Dialog

Division of Air Quality Stack Test Review of
Brigham Young University

Boiler #6 Central Heat Pl — **Flow & Moisture**

As ft^2	Pbar	Pq (static)	Ps	Avg Ts F	CO2 - F_{CO2}	O2	N2+C	Md	Ms
100.88	25.60	-0.34	25.58	307	7.40	8.00	84.60	29.50	28.04

Y	Cp	Vm cf	Vlc	A_{VG} Tm F	Vm std	Vw std	Bws	S Bws	5.9893
1.0040	0.84	48.950	126.10	85	40.710	5.936	0.1272	0.9990	0.999

AvgSqrtDlp	Vs	scfm wet	acfm	Qsd dscfh	Heat Input Btu/hr
0.1507	11.2	39,873	67,740	2.088E+6	

#1 - Times
Date

Load - Megawatts		
Low	Mid	High

Point No.	dl "p"	sqrt dl "p"	ts F	tm F (in)	tm F (out)	Cp *3D Probe*	Final Vf	Initial Vi	
1	0.020	0.14	306	64	65		816.2	713.8	102.4
2	0.018	0.13	305	64	67		623.2	609.7	13.5
3	0.020	0.14	305	66	72		533	529.6	3.4
4	0.020	0.14	308	68	77		877.3	870.5	6.8
5	0.015	0.12	304	73	82				0
6	0.017	0.13	304	76	85				
7	0.015	0.12	305	79	85				
8	0.014	0.12	305	81	90				
9	**0.085**	0.29	304	85	93				
10	0.035	0.19	309	86	96				
11	0.025	0.16	310	89	100				
12	0.016	0.13	308	91	100				
13	0.022	0.15	308	93	100				
14	0.025	0.16	309	94	102				
15	0.022	0.15	309	95	105				
16	0.020	0.14	309	96	106				
17									
18									
19									
20									
21									
22									
23									
24									

Division of Air Quality Stack Test Review of
Brigham Young University

Boiler #6 Central Heat Plant

	SO_2	NO_X	CO	CO_2	O_2
CS Calibration Span		88.90		10.00	20.90
Units	ppm	ppm	ppm	%	%
CV - Cylinder Value:	SO_2	NO_X	CO	CO_2	O_2
Low-Level		**0.00**		**0.00**	**0.00**
Mid-Level		**43.70**		**5.00**	**10.00**
High-Level		**88.90**		**10.00**	**20.90**
0 to 20% of Cal. Span		**0.00%**		**0.00%**	**0.00%**
40 to 60% of Cal. Span		**49.2%**		**50.0%**	**47.8%**
100% of Cal. Span		**100.0%**		**100.0%**	**100.0%**

Cdir - Enter Actual Up-scale Cylinder Value Used To Correct Emission Concentration.

C_{MA}		43.70		5.00	10.00

Calibration Error Test

Measured Concentration	SO_2	NO_X	CO	CO_2	O_2
Low-Level		**0.00**		**0.00**	**0.00**
Mid-Level		**43.70**		**5.00**	**10.00**
High-Level		**88.90**		**10.00**	**20.90**

Enter Up-scale Analyzer Response to be used during testing.

ACE Eq. 7E-1		43.70		5.00	10.00
Low-Level		0.00%		0.00%	0.00%
ppmv Difference		0		0	0
Status		**Passed Cal.**		**Passed Cal.**	**Passed Cal.**
Mid-Level		0.00%		0.00%	0.00%
ppmv Difference		0		0	0
Status		**Passed Cal.**		**Passed Cal.**	**Passed Cal.**
High-Level		0.00%		0.00%	0.00%
ppmv Difference		0		0	0
Status		**Passed Cal.**		**Passed Cal.**	**Passed Cal.**

☐ Failed Cal Error Dialog

Pre-Test Sampling System Bias

Initial Values	SO_2	NO_X	CO	CO_2	O_2
C_O - Low-Level		0.20		0.00	0.00
SBi - Zero Bias	TRUE	0.22%	TRUE	0.00%	0.00%
Difference	TRUE	0.2	TRUE	0	0
Pass or Invalid Run		**Passed Cal.**		**Passed Cal.**	**Passed Cal.**
C_M - Up-scale Gas		43.80		5.00	10.00
SBi - Up-Scale Bias	TRUE	0.11%	TRUE	0.00%	0.00%
Difference	TRUE	0.1	TRUE	0	0
Pass or Invalid Run	**TRUE**	**Passed Cal.**	**TRUE**	**Passed Cal.**	**Passed Cal.**

System Bias.
± 5% of Span

☐ Failed Bias Dialog

Raw Test Data

Test Date: 12/6/2011

	SO_2	NO_X	CO	CO_2	O_2
		76.1		**7.4**	**8.0**
	0.0%	**85.6%**	**0.0%**	**74.0%**	**38.3%**

Time	**Start**	**Stop**
SO_2		0:21
NO_X	0:00	0:21
CO	0:00	0:21
CO_2/O_2	0:00	0:21

Post-Test System Bias 7E-2 SB=(Cs - Cdir)/CS x 100

Final Values	SO_2	NO_X	CO	CO_2	O_2
C_O - Low-Level		0.20		0.00	0.00
SBi - Zero Bias	TRUE	0.22%	TRUE	0.00%	0.00%
Difference	**TRUE**	**0.2**	**TRUE**	**0.0**	**0.0**
Pass or Invalid Run		**Passed Cal.**		**Passed Cal.**	**Passed Cal.**
C_M - Up-scale Gas		43.90		5.00	10.00
SBi - Up-Scale Bias	TRUE	0.22%	TRUE	0.00%	0.00%
Difference	TRUE	0.2	TRUE	0.0	0.0
Pass or Invalid Run		**Passed Cal.**		**Passed Cal.**	**Passed Cal.**

System Bias.
± 5% of Span

☐ Failed Bias Dialog

Calibration Drift % of Span - D=ABS(SBf - SBi)

Low-Level Drift	TRUE	0.00%	TRUE	0.00%	0.00%
Difference	TRUE	0.0	TRUE	0.0	0.0
Pass or Re-Calibrate		**Pass**		**Pass**	**Pass**
Up-scale Gas Drift	TRUE	0.11%	TRUE	0.00%	0.00%
Difference	**TRUE**	**0.1**	**TRUE**	**0.0**	**0.0**
Pass or Re-Calibrate		**Pass**		**Pass**	**Pass**

Response Spec.
3% of Span

☐ Failed Drift Dialog

Division of Air Quality Stack Test Review of
Brigham Young University

Boiler #6 Central Heat Pl — **Flow & Moisture**

As ft^2	Pbar	Pq (static)	Ps	Avg Ts F	CO2 - F_{CO2}	O2	N2+C	Md	Ms
100.88	25.60	-0.34	25.58	307	7.40	8.00	84.60	29.50	28.04

Y	Cp	Vm cf	Vlc	A_{VG} Tm F	Vm std	Vw std	Bws	S Bws	5.9893
1.0040	0.84	48.950	126.10	85	40.710	5.936	0.1272	0.9990	0.999

AvgSqrtDlp	Vs	scfm wet	acfm	Qsd dscfh	Heat Input Btu/hr
0.1507	11.2	39,873	67,740	2.088E+6	

#1 - Times
Date

Load - Megawatts		
Low	Mid	High

Point No.	dl "p"	sqrt dl "p"	ts F	tm F (in)	tm F (out)	Cp *3D Probe*	Final Vf	Initial Vi	
1	0.020	0.14	306	64	65		816.2	713.8	102.4
2	0.018	0.13	305	64	67		623.2	609.7	13.5
3	0.020	0.14	305	66	72		533	529.6	3.4
4	0.020	0.14	308	68	77		877.3	870.5	6.8
5	0.015	0.12	304	73	82				0
6	0.017	0.13	304	76	85				
7	0.015	0.12	305	79	85				
8	0.014	0.12	305	81	90				
9	**0.085**	0.29	304	85	93				
10	0.035	0.19	309	86	96				
11	0.025	0.16	310	89	100				
12	0.016	0.13	308	91	100				
13	0.022	0.15	308	93	100				
14	0.025	0.16	309	94	102				
15	0.022	0.15	309	95	105				
16	0.020	0.14	309	96	106				
17									
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23									
24									

ENVIRONMENTAL MANAGEMENT
BRIGHAM YOUNG UNIVERSITY
101 CHEMICALS MANAGEMENT BUILDING
PROVO, UTAH 84602-7800
(801) 422-6156 / FAX: (866) 475-0880

September 15, 2014

UTAH DEPARTMENT OF
ENVIRONMENTAL QUALITY

SEP 22 2014

DIVISION OF AIR QUALITY

Bryce C. Bird, Director
Division of Air Quality
195 North 1950 West
Salt Lake City, UT 84114-4820

Re: Brigham Young University Coal Units #2, #3, #5 NOx and Baghouse PM-10 Stack Test Results per Title V Operating Permit #490 000 4002 (SKZ-139-2014)

Dear Mr. Bird,

Attached is the report for Brigham Young University's stack testing of the coal fired units #2, #3, #5 for NOx and the Baghouse for PM-10. Testing was performed on August 19 - 21, 2014 by TETCO. All NOx tests were below the required permit limit. The PM-10 from the baghouse was also less than the permitted limit.

Table 1. Summary of Test Results From August 19-21, 2014 Stack Testing

Source	Pollutant	Measured Emissions ppm@ 7% O_2	Measured Emissions lb/hr	Emission Limits ppm@ 7% O_2	Emission Limits lb/hr	*Production Rate MMBtu/hr test	*Production Rate MMBtu/hr limit
Unit 2	NOx	207	11.4	331	37.4	40.5	4.3
Unit 3	NOx	218	21.9	331	37.4	42.6	4.3
Unit 5	NOx	242	25.6	331	74.8	41.4	34.5
Baghouse	PM-10	--	0.53	--	1.83	41.4	34.5

*Production rate during testing was above the required 90% of the three year average.

The certification for the stack testing is attached. Please contact Steven Zohner for questions or further information at 801-422-2804 (Steven_zohner@byu.edu).

Respectfully,

Steven K Zohner

Steven K Zohner, Environmental Compliance Officer
Brigham Young University
112 Chemical Management Building
Provo, UT 84602

Document Date 9/15/2014

DAQ-2014-015282

Re: Brigham Young University Coal Units #2, #3, #5 NOx and Baghouse PM-10 Stack Test Results per Title V Operating Permit #490 000 4002 (SKZ-139-2014)

Compliance Certification prepared for Title V permit # 490 000 400 2 issued to Brigham Young University on April 14, 2011 and revised June 3, 2014, in accordance with stipulation I.L

Certification

In accordance with Operating Permit provision I.K and UAC R307-415-5d, and based on information and belief formed after reasonable inquiry, I certify that the statements and information in this document are true, accurate, and complete.

Steven K Zohner

Signature of Person Preparing Report

Date: Sept 15, 2014

Steven K. Zohner
Environmental Compliance Officer
Brigham Young University

Brian Evans

Signature of Responsible Official

Date: 17 Sept 2014

Brian K. Evans
Chief Financial Officer and Administrative Vice President
Brigham Young University

PM_{10} PARTICULATE MATTER AND NO_x COMPLIANCE TEST CONDUCTED AT BRIGHAM YOUNG UNIVERSITY CENTRAL HEATING PLANT BAGHOUSE

BOILER #2
BOILER #3
BOILER #5

August 19-21, 2014

by:

TETCO
391 East 620 South
American Fork, Utah 84003

Prepared for:

Brigham Young University
Physical Plant Department
203 Brewster Building
Provo, UT 84602

Date of report:

September 9, 2014

CERTIFICATION OF REPORT INTEGRITY

Technical Emissions Testing Company (TETCO) certifies that this report represents the truth as well as can be derived by the methods employed. Every effort was made to obtain accurate and representative data and to comply with procedures set forth in the Federal Register.

Paul Kitchen

Reviewer: Paul R Kitchen

Date: 9/8/14

Dean A. Kitchen

Reviewer: Dean A Kitchen

Date: 9-8-14

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- B: Raw Field Data
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INTRODUCTION

Test Purpose

This test was performed to demonstrate compliance with the facility's Title V Operating Permit, Permit Number 4900004002. Testing measured the PM_{10} emissions from the Baghouse and NO_x emissions from the coal fired boilers. Emissions are calculated in grains per dry standard cubic foot, parts per million (ppm), and pounds per hour where applicable.

Test Location and Type of Process

The baghouse is located at the Brigham Young University Central Heating Plant in Provo, Utah. The baghouse serves as the dust collector for boilers (hot water heaters) #2, 3 and 5. These units operate on coal and are used to provide heating and cooling for the university. A process schematic representation is give in Figure 1 in Appendix D.

Test Dates

The baghouse PM_{10} emissions were measured August 19, 2014 while Boiler 5 was operating. NO_x emissions from Boiler #5 were also measured during the PM_{10} test.

NO_x emissions from Boilers #2 and 3 were measured August 20th and 21th respectfully.

Pollutants Tested and Methods Applied

The PM_{10} test on Boiler 5 was a gravimetric determination of PM_{10} particulate in accordance with EPA Methods 201A and 202. Method 202 is not for compliance but for inventory purposes only.

All NO_x measurements were taken according to EPA Method 7E. NO_x concentration levels from Boiler 5 were measured simultaneously with Method 201A; Method 201A supplied the flow rate data for the NO_x emission rate calculations. NO_x concentration levels from Boilers 2 and 3 were measured simultaneously with a Method 4 test on each respective boiler.

Test Participants

Test Facility	Paul Greenwood Clifford Alleman	
TETCO	Dean Kitchen Mike McNamara	Doug Olsen Kawai McNamara
State Agency	None	

Discussion of Errors or Irregularities

None.

Quality Assurance

Testing procedures and sample recovery techniques were according to those outlined in the Federal Register and the *Quality Assurance Handbook for Air Pollution Measurement Systems.*

SUMMARY OF RESULTS

Emission Results

Table I presents the results of the compliance test.

TABLE I Measured and Allowable PM_{10} and NO_x Emissions

Source	Test Method	Pollutant	Measured Emissions			Emission Limits		
			ppm @ 7% O2	gr/dscf	lb/hr	ppm @ 7% O2	gr/dscf	lb/hr
Boiler 2	3A, 4, 7E	NO_x	207	-	11.45	331	-	37.4
Boiler 3	3A, 4, 7E	NO_x	218	-	21.88	331	-	37.4
Boiler 5	3A, 4, 7E	NO_x	242	-	25.60	331	-	74.8
	201A	PM_{10} [1]	-	0.0023	0.53	-	0.010	1.83
	202	CPM	-	0.0091	2.12	-	-	-

1 The PM_{10} emission limit is a baghouse limit and not a specific boiler limit. The boiler with the greatest capacity, Boiler 5, was operating during the PM_{10} test.

Process Data

The process was operated according to standard procedures. Production data is included in Appendix D.

The average production rate recorded during testing on Boiler #2 was 40.50 mmBtu/hr. The average rate for Boiler #3 was 42.64 mmBtu/hr, and the average rate was 41.37 mmBtu/hr for Boiler #5. All production values were taken from control room integrator readings recorded before and after each test run except for run 1 on Boiler #3. The integrator was not working during run 1 on Boiler #3; therefore, the average from recorded instantaneous values were used as the production levels.

Description of Collected Samples

The PM_{10} filters were white is appearance at the conclusion of each test. Each front wash also appeared clear.

Cyclone Cut Rate and Isokinetics

The Federal Register specifies that acceptable tests for PM_{10} using EPA Method 201A shall not exceed $\pm 1\mu$ of the 10μ cut-point and either the measured pressure drop (ΔP's) shall not exceed the calculated ΔP maximum or ΔP minimum, or that one ΔP may exceed the ΔP maximum or minimum if the isokinetics remain within ±20% of 100%. These criteria were met during the Method 201A test on Boiler #5 and are shown in Table II.

TABLE II Cyclone Cut Rate and Isokinetics

Run #	Cyclone Cut Rate	% Isokinetics	#pts < ΔP_{min} or > ΔP_{max}
1	10.0	114	0
2	10.0	111	0
3	9.9	109	0

Gaseous Analyzer Performance Criteria

The NO_x, CO_2, and O_2 analyzers met all bias and calibration checks criteria as specified in the Federal Register. These values are found on the gas analyzer field data sheet in Appendix B.

SOURCE OPERATION

Sampling Port Location

The stack inside diameter is 136 inches. Port location is depicted in Figure 1. The ports are located 4.06 diameters (46 feet) downstream from the last disturbance and 5.03 diameters (57 feet) upstream from the next disturbance. There are four ports with inside diameters of six inches.

Sampling Point Location

Table III shows the distance of each sampling point from the inside wall. Each point is marked and identified with a glass tape wrapping and numbered. These points are determined by measuring the distance from the inside wall and adding the reference (port) measurement.

Table III Sampling Point Location

	Distance (inches) from Inside Wall	
Sample Point	Method 201A	Method 4
1	5.98	4.35
2	19.86	14.28
3	40.26	26.38
4		43.93

Sampling Train Description

To determine the actual emission rates for these sources, 40 CFR 60 Appendix A Methods 1-4, 7E, and 40 CFR 51 Appendix M Methods 201A and 202 were followed. The sampling trains was made of inert materials, (i.e., Teflon, stainless steel, glass, etc.) to prevent sampled gas and any interference.

The stack analyzer used to conduct Methods 1-4, 201A, and 202 is constructed to meet the specifications outlined in the CFR. The temperature sensors are K-type thermocouples. Heater, vacuum and pitot line connections are designed to be interchangeable with all units used by the tester. The probe liner was of borosilicate glass or Teflon. Sampling train sketches of Methods 4 and 201A/202 are found in Appendix E.

Sample boxes were prepared for testing by following the prescribed procedure outlined in Method 4 or 202.

The NO_x analyzer was an Horiba Instruments Model CLA-510SS, chemiluminescence unit. EPA Protocol 1 gases were used as the span and mid-range for the NO_x analyzer during all tests; their concentrations were 128 and 228 ppm. Dry nitrogen was used as the zero gas for the machine.

The CO_2/O_2 analyzer was a CAI Model ZRE unit. EPA Protocol 1 gases were used as the span and mid-range for the analyzer during all tests. The CO_2 concentrations were 20.70 and 10.10 percent and the O_2 concentrations were 20.90 and 10.00 percent. Dry nitrogen was used as the zero gas for the machine.

The sampling train for Method 7E is constructed with a heated stainless steel sampling probe about 7 feet long. The sample line between the sampling probe and gas conditioner was heated Teflon. Both were maintained above 220 degrees Fahrenheit. The sample conditioner uses Peltier plates to remove moisture. Sample lines and bias lines from the gas conditioner to the analyzer were Teflon. A sketch of the sampling train for this method appears as Figure 4 in Appendix E.

Sampling and Analytical Procedures

All sampling and analytical procedures employed were as specified in 40 CFR 60 Appendix A and 40 CFR 51 Appendix M.

Quality Assurance

All equipment set-up, sampling procedures, sample recovery and equipment calibrations were carried out according to the procedures specified in 40 CFR 60, 40 CFR 51 and the *Quality Assurance Handbook for Air Pollution Measurement Systems.*

APPENDIX

A: Complete Results and Sample Calculations
B: Raw Field Data
C: Laboratory Data and Chain of Custody
D: Raw Production Data
E: Calibration Procedures and Results
F: Related Correspondence

APPENDIX A

Table IV, Complete Results, Boiler #2
Table V, Complete Results, Boiler #3
Table VI, Complete Results, Boiler #5
Nomenclature
Sample Equations

COMPLETE RESULTS

Symbol	Description	Dimensions	Run #1	Run #2	Run #3	
Date	Date					
Begin	Time Test Began					
End	Time Test Ended					
Pb_m	Meter Barometric Pressure	In. Hg. Abs				
ΔH	Orifice Pressure Drop	In. H_2O				
Y	Meter Calibration Y Factor	dimensionless				
Vm	Volume Gas Sampled--Meter Conditions	cf				
T_m	Avg Meter Temperature	°F				
$\sqrt{\Delta P}$	Sq Root Velocity Head	Root In. H_2O				
Wt_{wc}	Weight Water Collected	Grams				
T_t	Duration of Test	Minutes				
C_p	Pitot Tube Coefficient	Dimensionless				
CO_2	Volume % Carbon Dioxide	Percent				
O_2	Volume % Oxygen	Percent				
N_2 & CO	Volume % Nitrogen and Carbon Monoxide	Percent				
Vm_{std}	Volume Gas Sampled (Standard)	dscf				
Vw	Volume Water Vapor	scf				
Bw_s	Fraction H_2O in Stack Gas	Fraction				
X_d	Fraction of Dry Gas	Fraction				
M_d	Molecular Wt. Dry Gas	lb/lbmol				
M_s	Molecular Wt. Stack Gas	lb/lbmol				
						AVG
T_s	Avg Stack Temperature	°F				
A_s	Stack Cross Sectional Area	Sq. Ft.				
P_G	Stack Static Pressure	In. H_2O				
Pb_p	Sample Port Barometric Pressure	In. Hg. Abs				
P_s	Stack Pressure	In. Hg. Abs				
Q_s	Stack Gas Volumetric Flow Rate (Std)	dscfm				
Q_a	Stack Gas Volumetric Flow Rate (Actual)	cfm				
V_s	Velocity of Stack Gas	fpm				
C_{NOx}	Concentration of NO_x	ppmdv				
C_{NOx}	Concentration of NO_x (@ 7% O_2)	ppmdv				
ER_{NOx}	Emission Rate of NO_x	lb / hr				

COMPLETE RESULTS

Symbol	Description	Dimensions	Run #1	Run #2	Run #3	
Date	Date					
Begin	Time Test Began					
End	Time Test Ended					
Pb_m	Meter Barometric Pressure	In. Hg. Abs				
ΔH	Orifice Pressure Drop	In. H_2O				
Y	Meter Calibration Y Factor	dimensionless				
Vm	Volume Gas Sampled--Meter Conditions	cf				
T_m	Avg Meter Temperature	°F				
$\sqrt{\Delta P}$	Sq Root Velocity Head	Root In. H_2O				
Wt_{wc}	Weight Water Collected	Grams				
T_t	Duration of Test	Minutes				
C_p	Pitot Tube Coefficient	Dimensionless				
CO_2	Volume % Carbon Dioxide	Percent				
O_2	Volume % Oxygen	Percent				
N_2 & CO	Volume % Nitrogen and Carbon Monoxide	Percent				
Vm_{std}	Volume Gas Sampled (Standard)	dscf				
Vw	Volume Water Vapor	scf				
Bw_s	Fraction H_2O in Stack Gas	Fraction				
X_d	Fraction of Dry Gas	Fraction				
M_d	Molecular Wt. Dry Gas	lb/lbmol				
M_s	Molecular Wt. Stack Gas	lb/lbmol				
						AVG
T_s	Avg Stack Temperature	°F				
A_s	Stack Cross Sectional Area	Sq. Ft.				
P_G	Stack Static Pressure	In. H_2O				
Pb_p	Sample Port Barometric Pressure	In. Hg. Abs				
P_s	Stack Pressure	In. Hg. Abs				
Q_s	Stack Gas Volumetric Flow Rate (Std)	dscfm				
Q_a	Stack Gas Volumetric Flow Rate (Actual)	cfm				
V_s	Velocity of Stack Gas	fpm				
C_{NOx}	Concentration of NO_x	ppmdv				
C_{NOx}	Concentration of NO_x (@ 7% O_2)	ppmdv				
ER_{NOx}	Emission Rate of NO_x	lb / hr				

COMPLETE RESULTS

Symbol	Description	Dimensions	Run #1	Run #2	Run #3	
Date	Date					
Filter #						
Begin	Time Test Began					
End	Time Test Ended					
Pb_m	Meter Barometric Pressure	In. Hg. Abs				
ΔH	Orifice Pressure Drop	In. H_2O				
Y	Meter Calibration Y Factor	dimensionless				
Vm	Volume Gas Sampled--Meter Conditions	cf				
T_m	Avg Meter Temperature	°F				
Ahead	Ave. Area Blocked by Sample Train	in^2				
A_s	Stack Cross Sectional Area	in^2				
b_f	Probe Blockage Factor for PM2.5					
$\sqrt{\Delta p_{s2}}$	Sq Root Velocity Pressure Corrected for bf	Root In. H_2O				
$\sqrt{\Delta P_{measured}}$	Sq Root Velocity Head (as measured)	Root In. H_2O				
$\sqrt{\Delta P}$	Sq Root Velocity Head (adj. for blockage if necessary)	Root In. H_2O				
Wt_{wc}	Weight Water Collected	Grams				
T_t	Duration of Test	Minutes				
C_p	Pitot Tube Coefficient	Dimensionless				
D_n	Nozzle Diameter	Inches				
CO_2	Volume % Carbon Dioxide	Percent				
O_2	Volume % Oxygen	Percent				
N_2 & CO	Volume % Nitrogen and Carbon Monoxide	Percent				
Vm_{std}	Volume Gas Sampled (Standard)	dscf				
Vw	Volume Water Vapor	scf				
Bw_s	Fraction H_2O in Stack Gas	Fraction				
X_d	Fraction of Dry Gas	Fraction				
M_d	Molecular Wt. Dry Gas	lb/lbmol				
M_s	Molecular Wt. Stack Gas	lb/lbmol				
%I	Percent Isokinetic	Percent				
u	Gas stream Viscosity	micropoise				
QsST	Dry Gas Sample Rate	dscfm				
QsCyc	Sampling Rate					
Nre	**Reynolds Number**					
D_{50}	PM10 Cut Point	microns				
Cr	Re-estimated Cunningham Correction Factor	Dimensionless				
Z	Ratio of D50 / D50-1 **($0.99 \leq Z \leq 1.01$)**	Dimensionless				
						AVG
T_s	Avg Stack Temperature	°F				
A_s	Stack Cross Sectional Area	Sq. Ft.				
P_G	Stack Static Pressure	In. H_2O				
Pb_p	Sample Port Barometric Pressure	In. Hg. Abs				
P_s	Stack Pressure	In. Hg. Abs				
Q_s	Stack Gas Volumetric Flow Rate (Std) Measured	dscfm				
Q_a	Stack Gas Volumetric Flow Rate (Actual) Measured	cfm				
V_s	Velocity of Stack Gas Measured	fpm				
$M_{PM10.0}$	Mass of PM10.0 Particulate	milligrams				
$M>_{PM10.0}$	Mass of >PM10.0 Particulate	milligrams				
M_{cpm}	Mass of Condensibles	milligrams				
$C_{PM10.0}$	Concentration of PM10.0 Particulate	gr / dscf				
$C>_{PM10.0}$	Concentration of >PM10.0 Particulate	gr / dscf				
C_{cpm}	Concentration of Condensibles	gr / dscf				
C_{NOx}	Concentration of NO_x	ppmdv				
C_{NOx}	Concentration of NO_x (@ 7% O_2)	ppmdv				
ER_{PM10}	Emission Rate of PM_{10} Particulate	lb / mmBtu				
$ER_{PM10.0}$	Emission Rate of PM10.0 Particulate	lb / hr				
$ER>_{PM10.0}$	Emission Rate of >PM10.0 Particulate	lb / hr				
ER_{cpm}	Emission Rate of Condensibles	lb / hr				
ER_{NOx}	Emission Rate of NO_x	lb / hr				

Method 201A/202 and Gases Nomeclature

$\%I$ = percent isokinetic, percent

A_s = stack cross-sectional area (ft^3)

$AS\Delta P$ = see $\sqrt{\Delta P}$

Btu = unit heat value (British thermal unit)

B_{ws} = fraction of water in stack gas

C_{cpm} = concentration of condensibles (grain/dscf)

C_{cors} = concentration of coarse particulate (gr/dscf)

CO_2 = percent carbon dioxide in the stack gas

C_p = pitot tube coefficient (0.84)

C_{PM10} = concentration of PM_{10} particulate (gr/dscf)

C_{gas} = concentration (ppm dry basis) of sampled gas using Method 6C, 7E, or 10 corrected for bias checks. Species symbol replaces *gas*.

$C_{gas\ (corr)}$ = actual gas concentration corrected to desired percent O_2

$C_{gas\ (lb/dscf)}$ = gas concentration converted to lb/dscf

D_{eq} = equivalent stack diameter (inches)

D_s = stack diameter (feet)

ΔH = orifice pressure drop (inches H_2O)

$\Delta H_@$ = orifice pressure (inches H_2O)

ΔH_d = orifice pressure head (inches H_2O) needed for cyclone flow rate

D_n = nozzle diameter (inches)

ΔP = stack flow pressure differential (inches H_2O)

Dp_{50} = 50% effective cutoff diameter of particle (μ)

EA = percent excess air

ER_{cpm} = emission rate of condensibles (lb/hr)

ER_{cors} = emission rate of coarse particulate (lb/hr)

ER_{gas} = emission rate of a gas (lb/hr), species symbol replaces "*gas*"

$ER_{(mmBtu)}$ = emission rate per mmBtu of fuel from Method 19

ER_{PM10} = emission rate of PM_{10} particulate (lb/hr)

ER_X = emission rate of compound which replaces x

F_d = Dry basis "F" factor from Method 19, Table 19-2

L = length of rectangular stack (inches)

mBtu = thousand Btu

M_{cpm} = mass of condensibles (milligrams)

M_{cors} = mass of coarse particulate (milligrams)

M_d = molecular weight of stack gas, dry basis (lb/lb-mol)

mmBtu = million Btu

M_{PM10} = mass of PM_{10} particulate (milligrams)

M_s = molecular weight of stack gas, wet basis (lb/lb-mol)

M_{wgas} = molecular weight of gas species (lb/lb-mol)

μ_s = gas viscosity (micropoise)

N_2 = percent nitrogen in the stack gas

O_2 = percent oxygen in the stack gas

$\sqrt{\Delta P}$ = average of the square roots of ΔP (may also be referred to as $AS\Delta P$)

Method 201A/202 and Gases Nomeclature

$\sqrt{\Delta P_1}$ = square root of ΔP at point 1 of the current test, Method 201A

$\sqrt{\Delta P_1'}$ = square root of ΔP at point 1 of the previous traverse, Method 201A

$\sqrt{\Delta P'_{ave}}$ = ave. of square roots of ΔP from the previous traverse

Pb_m = absolute barometric pressure at the dry gas meter (inches Hg)

Pb_p = absolute barometric pressure at the sample location (inches Hg)

P_G = stack static pressure (inches H_2O)

P_s = absolute stack pressure (inches Hg)

P_{std} = absolute pressure at standard conditions (29.92 inches Hg.)

pts = number of traverse points during the test (minimum of 6, maximum of 12)

θ = time of test (minutes)

θ_1 = sample time (duration in minutes) at first sample point for Method 201A

θ_n = sample time (duration in minutes) at sample point "n" for Method 201A

θ_{test} = target test time for Method 201A (minutes)

Q_a = stack gas volumetric flow rate (acfm)

Q_s = stack gas volumetric flow rate (dscfm)

Q_{sc} = actual gas flow rate through the cyclone (acfm)

Q_{sc}' = predicted actual gas flow rate through the cyclone (acfm)

Q_W = wet stack gas std. volumetric flow (ft^3/min, wscfm)

R = gas constant (21.85 inches Hg*ft^3/(lbmol*R))

R_{max} = multiplier for V_n

R_{min} = multiplier for V_n

T_m = meter temperature (^oF)

T_s = stack temperature (^oF)

T_{std} = absolute temperature at standard conditions (528^oR)

Tt = see θ

Vm = sample volume (ft^3) at meter conditions

Vm_{std} = volume standard (dscf), sample volume adjusted to 68^oF and 29.92 inches Hg.

V_{max} = maximum allowed nozzle velocity (fps)

V_{min} = minimum allowed nozzle velocity (fps)

V_n = target nozzle velocity (fps)

V_s = velocity of stack gas (fpm)

V_w = volume water vapor (scf) at 68^oF and 29.92 inches Hg.

W = width of rectangular stack (inches)

Wt_{wc} = weight of the condensed water collected (grams)

X_d = fraction of dry gas

Y = meter calibration Y-factor (dimensionless)

Method 201A/202 and Gases Sample Equations

$$\%I = Vm_{std} \cdot (T_s + 460) \cdot 1039 / (\theta \cdot V_s \cdot P_s \cdot X_d \cdot D_n^2)$$

$$A_s = (Ds^2 / 4) \cdot \pi$$

$$B_{ws} = V_w / (Vm_{std} + V_w)$$

$$C_{cpm} = M_{cpm} \cdot 0.01543 / Vm_{std}$$

$$C_{cors} = M_{cors} \cdot 0.01543 / Vm_{std}$$

$$C_{PM10} = M_{PM10} \cdot 0.01543 / Vm_{std}$$

$$C_{gas\ (corr)} = C_{gas} \cdot (20.9 - \text{desired } \%O_2) / (20.9 - \text{actual } \%O_2)$$

$$C_{gas\ (lb/dscf)} = C_{gas\ (ppm)} \cdot \text{Conversion factor from Method 19, Table 19-1)}$$

$$D_{eq} = 2 \cdot L \cdot W / (L + W)$$

$$\Delta H_d = [Q_{sc}' \cdot X_d \cdot P_s / (T_s + 460)]^2 \cdot [(T_m + 460) \cdot M_d \cdot 1.083 \cdot \Delta H_@ / Pb_m]$$

$$Dp_{50} = 0.15625 \cdot [(T_s + 460) / (M_s \cdot P_s)]^{0.2091} \cdot (\mu_s / Q_{sc})^{0.7091}$$

$$\Delta P_{max} = 1.3686 \cdot 10^{-4} \cdot P_s \cdot M_s \cdot V_{max}^2 / [(T_s + 460) \cdot C_p^2]$$

$$\Delta P_{min} = 1.3686 \cdot 10^{-4} \cdot P_s \cdot M_s \cdot V_{min}^2 / [(T_s + 460) \cdot C_p^2]$$

$$EA = (\%O_2 - 0.5\ \%CO) / [0.264\ \%N_2 - (\%O_2 - 0.5\ \%CO)]$$

$$ER_{cpm} = C_{cpm} \cdot Q_s \cdot 0.00857$$

$$ER_{cors} = C_{cors} \cdot Q_s \cdot 0.00857$$

$$ER_{gas} = P_{std} \cdot Q_s \cdot M_{wgas} \cdot C_{gas} \cdot 60 / (R \cdot T_{std} \cdot 10^6)$$

$$ER_{gas} = C_{gas(lb/dscf)} \cdot Qs \cdot 60$$

(Either ER_{gas} equation gives equivalent lb/hr values to 3 sig. figures)

$$ER_{(mmBtu)} = C_{gas(lb/dscf)} \cdot F_d \cdot (20.9/(20.9 - \%O_2)\text{, Method 19 Equation 19-1}$$

$$ER_{PM10} = C_{PM10} \cdot Q_s \cdot 0.00857$$

$$M_d = CO_2 \cdot 0.44 + O_2 \cdot 0.32 + N_2 \cdot 0.28$$

$$M_s = (M_d \cdot X_d) + (18 \cdot B_{ws})$$

$$\mu_s = [51.05 + 0.207 \cdot (T_s + 460) + 3.24 \cdot 10^{-5} \cdot (T_s + 460)^2 + 0.53147 \cdot \%O_2 - 74.143 \cdot B_{ws}]$$

$$P_s = Pb_p + (P_G / 13.6)$$

$$\theta_1 = (\sqrt{\Delta P_1'} / \sqrt{\Delta P'_{ave}}) \cdot (\theta_{test} / pts)$$

$$\theta_n = \theta_1 \cdot \sqrt{\Delta P_n} / \sqrt{\Delta P_1}$$

$$Q_a = V_s \cdot A_s$$

$$Q_s = Qa \cdot Xd \cdot Ps \cdot T_{std} / [(Ts + 460) \cdot P_{std}]$$

$$Q_{sc} = [(T_s + 460) \cdot P_{std} / (T_{std} \cdot P_s)] \cdot [(Vm_{std} + V_w) / \theta]$$

$$Q_{sc}' = \mu_s \cdot 0.002837 \cdot [(T_s + 460) / (M_s \cdot P_s)]^{0.2949}$$

$$Q_W = Q_s / X_d$$

$$R_{max} = 0.4457 + \sqrt{[0.5690 + (0.2603 \cdot \sqrt{Q_{sc}'} \cdot \mu_s / V_n^{1.5})]}$$

$$R_{min} = 0.2457 + \sqrt{[0.3072 - (0.2603 \cdot \sqrt{Q_{sc}'} \cdot \mu_s / V_n^{1.5})]}$$

$$V_{max} = V_n \cdot R_{max}$$

$$V_{min} = V_n \cdot R_{min}$$

$$Vm_{std} = Vm \cdot Y \cdot T_{std} \cdot (Pb_m + \Delta H / 13.6) / [P_{std} \cdot (T_m + 460)]$$

$$V_n = 3.056 \cdot Q_{sc}' / Dn^2$$

$$V_s = 85.49 \cdot 60 \cdot Cp \cdot \sqrt{\Delta P} \cdot \sqrt{[(T_s + 460) / (P_s \cdot M_s)]}$$

$$V_w = Wt_{wc} \cdot 0.04715$$

$$X_d = 1 - B_{ws}$$

APPENDIX B

Stack

Method 201A Preliminary Traverse and Sampling Point Location Data
Method 4 Preliminary Traverse and Sampling Point Location Data
Stratification Check

Boiler #2

Method 4 Field Data
Gas Analyzer Field Sheets and Data Logger Printout

Boiler #3

Method 4 Field Data
Gas Analyzer Field Sheets and Data Logger Printout

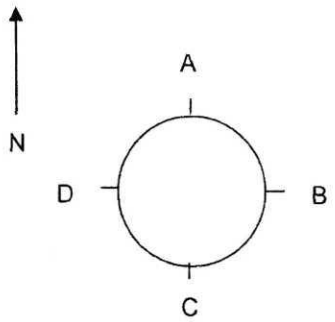
Boiler #5

PM_{10} Particulate Field Data
Gas Analyzer Field Sheets and Data Logger Printout

Stack

Prelim 6 pts

Method 201A



Stack Dia. 136 Reference: 16.5

Ports are 46.5' Upstream from next disturbance

Ports are 54.5' Downstream from last disturbance

Facility Brigham Young University Central Heating Plant

Stack Identification Baghouse Exhaust, Boiler # 5

Date 8/19/14

Barometric Pressure

Pb_m 25.30 in Hg Pb_p 25.22 in Hg

Static Pressure (P_G) -.15 in H_2O

Estimated Moisture (Bw_s) 5 %

Sample Height from Ground 80 feet

Comments:

Time: 6:09

Traverse Point	Percent Diameter	Distance From: ID	Distance From: Reference	Ports A	B	C	D	E	F
1	4.4	5.98	22.48	229 .005	233 .012	235 .020	230 .007		
2	14.6	19.86	36.36	232 .007	237 .015	237 .023	231 .015		
3	29.6	40.26	56.76	236 .008	237 .010	239 .020	234 .015		
Gas Analyzer Probe									
1	16.7	22.71	39.21						
2	50.0	68.00	84.50						
3	83.3	113.29	129.79						

Averages:

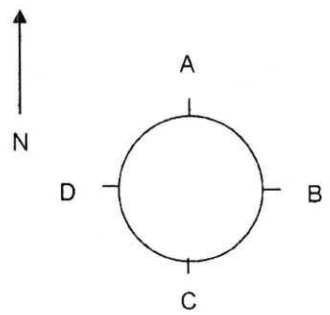
T_S 234.2 ∠ Flow

ΔP .013 √ΔP .1116

KEY => T_S ∠ Flow ΔP

Prelim 8 pts

Method 4



Stack Dia. 136 Reference: 16.5

Ports are 46.5' Upstream from next disturbance

Ports are 54.5' Downstream from last disturbance

Facility Brigham Young University Central Heating Plant

Stack Identification Baghouse Exhaust, Boiler # 3, 2

Date 8/20/14

Barometric Pressure

Pb_m 25.30 in Hg Pb_p 25.22 in Hg

Static Pressure (P_G) -.17 in H_2O

Estimated Moisture (Bw_s) 6 %

Sample Height from Ground 80 feet

Comments:

Time:

Traverse Point	Percent Diameter	Distance From: ID	Distance From: Reference	Ports A	B	C	D	E	F
1	3.2	4.35	20.85						
2	10.5	14.28	30.78						
3	19.4	26.38	42.88						
4	32.3	43.93	60.43						
Gas Analyzer Probe									
1	16.7	22.71	39.21						
2	50.0	68.00	84.50						
3	83.3	113.29	129.79						

Averages:

T_S _____ ∠ Flow _____

ΔP _____ √ΔP _____

KEY => T_S ∠ Flow ΔP

STRATIFICATION CHECK FIELD SHEET

Facility BYU **Source** Baghouse (Boiler #5)

Operator D Kitchen **Date** 8/18/14

	Point 1		Point 2		Point 3	
	Time	O2 %	Time	O2 %	Time	O2 %
Ave		**13.65**		**13.60**		**13.55**
3 Pt. Mean		**13.60**		**13.60**		**13.60**
% Diff From Mean		**0.4**		**0.0**		**0.4**

- The three sample points were on the east/west traverse line.

- If the % diff from mean is less than 5%, one sample point may be used. Use the sample point that gave the value closest to the mean value.
- If the % diff from mean is between 5% and 10%, use three sample points at 16.7, 50.0, and 83.3 % of diam.
- If the % diff from mean is greater than 10%, sample 12 points chosen according to EPA Method 1.

Boiler 2

M4 Field Data Sheet

Filter NA TETCO Sample Box B

Page 1 of 1 Run # 3

Plant: BYU Central Heating Plant

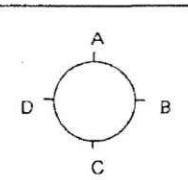
Date: Aug 21 2014

Location: Baghouse Exhaust, Boiler # 2

Operator: KY

	Traverse Point	Time Clock	Time Min (θ)	DGM (ft³)	ΔP (in H₂O)	ΔH (in H₂O) Desired	ΔH (in H₂O) Actual	Vacuum (in Hg)	Temperatures (°F) Stack (T_s)	Probe	Oven	CPM Filter	Effluent	DGM Temp (T_m) Out	In
P	1	13:34	0	4.902	.006	1.0	1.0	3	260	235			66	71	72
	2		4	7.525	.006		1.0	3	262	234			65	71	73
	3		8	10.146	.005		1.0	3	265	240			64	71	75
	4		12	12.779	.005		1.0	3	265	243			64	71	76
A	1	13:51	16	15.400	.004		1.0	3	262	251			63	72	76
	2		20	18.039	.005		1.0	3	261	247			63	72	76
	3		24	20.671	.005		1.0	3	263	250			64	72	77
	4		28	23.302	.006		1.0	3	263	256			63	72	78
C	1	14:09	32	25.937	.005		1.0	3	262	248			62	73	76
	2		36	28.565	.005		1.0	3	260	240			62	73	77
	3		40	31.200	.004		1.0	3	249	241			62	73	78
	4		44	33.834	.007		1.0	3	264	235			61	73	78
B	1	14:47	48	36.459	.007		1.0	3	261	247			63	73	77
	2		52	39.083	.006		1.0	3	262	255			61	73	78
	3		56	41.709	.006		1.0	3	263	258			60	73	78
	4		60	44.338	.005	1.0	1.0	3	265	255			60	74	79
		14:43	64	46.969											

Total	~~42.067~~ 42.067	1.1761	1.000	4198	2381	
Average		.0735		262.38	74.4	



Stack Diameter 136" Port Reference 16.5"

Ports are 57' Upstream from next disturbance

Ports are 46' Downstream from last disturbance

Assumed Moisture 6 %

Probe 516 Cp 0.84

Nozzle Calibration 1025

Avg D_n M4 inches

Gas Bag Auto

Console 4

Y-Factor 1.000

$\Delta H_@$ 1.455 in H_2O

Barometric Pressures

Pb_m 25.35 in Hg

Pb_p 25.27 in Hg

P_G (-0.18) in H_2O

Leak Check	Pre	Post
ft³/min	0.009	0.005
vac in Hg	22	18

Pitot Rate	0.0	0.0
In H_2O	.25	.25

Water Collected 30.7 g

Time Sampled 64 min

Review

K = @T_m

K = @T_m

Comments:

2101

Facility DTO

Operator R. Kitchen

GAS ANALYZER FIELD DATA

Source Boiler 2

Date 8-21-14

Response Time :60

Run			Gas Species	Rate	Initial Bias		Final Bias		Analyzer Avg	Corrected Avg
1	Begin	1047	NOx	600	0	126	0	128	86	87
	End	1156	CO		1	133	1	135	79.0	79.7
	Port Change		CO_2		0.01	10.05	0.02	10.05	5.40	5.35
			O_2		0.19	9.89	0.02	9.90	14.74	14.95

Run			Gas Species	Rate	Initial Bias		Final Bias		Analyzer Avg	Corrected Avg
2	Begin	1211	NOx	600	0	128	0	128	88	88
	End	1319	CO		1	135	1	135	~~76.2~~ 77.2	76.9
	Port Change		CO_2		0.07	10.05	0.09	10.09	5.02	4.94
			O_2		0.02	9.90	-0.04	9.96	15.21	15.32

Run			Gas Species	Rate	Initial Bias		Final Bias		Analyzer Avg	Corrected Avg
3	Begin	1334	NOx	600	0	128	0	128	85	85
	End	1443	CO		1	135	1	134	59.0	59.1
	Port Change		CO_2		0.09	10.09	0.12	9.94	5.10	5.09
			O_2		-0.04	9.96	-0.04	10.15	15.08	14.98

Run			Gas Species	Rate	Initial Bias		Final Bias		Analyzer Avg	Corrected Avg
	Begin									
	End									
	Port Change									

Gas Species	Calibration Gases				Calibration Error				Calibration Error			
NOx	0	128	228		1	126	229					
CO	0	136	222		1	136	223					
CO_2	0.00	10.10	20.70		0.04	10.13	20.50					
O_2	0.00	10.00	20.90		0.08	10.05	21.15					

Comments: All values are either ppmdv or mole percents. Corrected averages are analyzer averages corrected using equation 6C-1 unless otherwise indicated.

Eq. 7E-5: $C_{gas} = (C_{avg} - C_0) * [C_{ma} / (C_m - C_0)]$. Rate is sample flow rate in cc/min and is set within analyzer manufacturer specs.

M4 Field Data Sheet

Filter NA TETCO Sample Box A

Page 1 of 1 Run # 2

Plant: BYU Central Heating Plant

Date: Aug 21 2014

Location: Baghouse Exhaust, Boiler # 2

Operator: [illegible]

	Traverse Point	Time Clock	Time Min (θ)	DGM (ft³)	ΔP (in H₂O)	ΔH (in H₂O) Desired	ΔH (in H₂O) Actual	Vacuum (in Hg)	Temperatures (°F) Stack (T_s)	Probe	Oven	CPM Filter	Effluent	DGM Temp (T_m) Out	In
D	1	12:11	0	62.000	.005	1.0	1.0	3	261	255			65	70	71
	2		4	64.638	.005		1.0	3	260	253			64	70	73
	3		8	67.244	.004		1.0	3	267	260			64	71	75
	4		12	69.872	.007		1.0	3	268	254			64	71	77
A	1	12:29	16	72.518	.006		1.0	3	265	240			64	72	76
	2		20	75.151	.006		1.0	3	262	230			64	72	76
	3		24	77.797	.005		1.0	3	265	240			63	72	77
	4		28	80.434	.005		1.0	3	265	248			62	72	77
C	1	12:46	32	83.065	.006		1.0	3	262	252			63	72	76
	2		36	85.698	.005		1.0	3	263	248			62	72	77
	3		40	88.341	.005		1.0	3	266	248			61	72	77
	4		44	90.982	.004		1.0	3	265	246			61	72	77
B	1	13:03	48	93.614	.006		1.0	3	264	249			62	72	76
	2		52	96.242	.005		1.0	3	262	246			61	72	76
	3		56	98.872	.006		1.0	3	266	241			61	72	77
	4		60	101.501	.006	1.0	1.0	3	267	246			61	73	77
		13:19	64	104.130											
Total				42.130	1.1699		1.000		4228					7362	
Average					.0731				264.3					73.8	

Stack Diameter 136" Port Reference 16.5"

Ports are 57' Upstream from next disturbance

Ports are 46' Downstream from last disturbance

Assumed Moisture 6 %

Probe 516 Cp 0.84

1023 Nozzle Calibration — — — —

Avg D_n NA inches

Gas Bag Analyzer

Console 4

1767 Y-Factor 1.000

$\Delta H_@$ 1.495 in H_2O

Barometric Pressures

Pb_m 23.35 in Hg

Pb_p 25.27 in Hg

P_G −(0.18) in H_2O

Leak Check	Pre	Post
ft³/min	0.008	0.006
vac in Hg	22	18

Pitot Rate		
	0.0	0.0
In H_2O	.25	.25

Water Collected 29.4 g

Time Sampled 64 min

Review [illegible]

K = @T_m

K = @T_m

Comments:

2113

M4 Field Data Sheet

Filter NA TETCO Sample Box C

Page 1 of 1 Run # 1

Plant: BYU Central Heating Plant

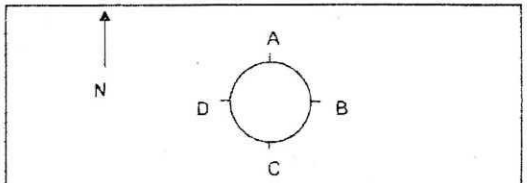
Date: Aug 21 2014

Location: Baghouse Exhaust, Boiler # 2

Operator: [illegible]

	Traverse Point	Time Clock	Time Min (θ)	DGM (ft³)	ΔP (in H₂O)	ΔH (in H₂O) Desired	ΔH (in H₂O) Actual	Vacuum (in Hg)	Temperatures (°F) Stack (T_s)	Probe	Oven	CPM Filter	Effluent	DGM Temp (T_m) Out	In
D	1	10:47	0	19.400	.005	1.0	1.0	4	263	235			65	66	67
	2		4	22.001	.006		1.0	4	262	234			63	67	68
	3		8	24.622	.005		1.0	4	266	247			61	67	70
	4		12	27.238	.005		1.0	4	267	253			60	67	71
A	1	11:04	16	29.830	.004		1.0	4	261	263			61	68	72
	2		20	32.441	.004		1.0	4	261	262			60	68	72
	3		24	35.045	.005		1.0	4	265	259			60	68	73
	4		28	37.649	.004		1.0	4	265	243			61	69	74
C	1	11:23	32	40.256	.005		1.0	4	262	250			63	69	73
	2		36	42.219	.006		1.0	4	261	235			63	69	74
	3		40	45.475	.005		1.0	4	266	235			63	69	75
	4		44	48.084	.004		1.0	4	266	236			62	69	76
B	1	11:46	48	50.692	.004		1.0	4	263	241			63	70	74
	2		52	53.303	.005		1.0	4	260	253			64	70	75
	3		56	55.915	.006		1.0	4	267	254			64	70	76
	4		60	58.537	.006	1.0	1.0	4	266	255			64	71	76
		11:56	64	61.153											
Total				41.753 ✓	1.1210 ✓				4223 ✓					.2263 ✓	
Average					~~.0700~~ .0701		1.000 ✓		263.94					70.7	

Comments:



Stack Diameter 136" Port Reference 16.5"

Ports are 57' Upstream from next disturbance

Ports are 46' Downstream from last disturbance

Assumed Moisture 6 %

Probe 516 Cp 0.84

Nozzle Calibration 964

Avg D_n M4 inches

Gas Bag Aug 1.20

Console 4

Y-Factor 1.000 1681

$\Delta H_@$ 1.495 in H_2O

Barometric Pressures

Pb_m 25.35 in Hg

Pb_p 25.27 in Hg

P_G (0.18) in H_2O

Leak Check	Pre	Post
ft³/min	0.009	0.005
vac in Hg	22	18

Pitot Rate		
in H_2O	~~5.0~~ .25	.25

Water Collected 29.1 g

Time Sampled 64 min

Review [illegible]

K = @T_m

K = @T_m

Brigham Young University Central Heating Plant, Boiler 2 (8/21/14)

Run 1				Run 2				Run 3			
Time	NO_x ppm	CO_2 %	O_2 %	Time	NO_x ppm	CO_2 %	O_2 %	Time	NO_x ppm	CO_2 %	O_2 %

Run 1				Run 2				Run 3			
Time	NO_x ppm	CO_2 %	O_2 %	Time	NO_x ppm	CO_2 %	O_2 %	Time	NO_x ppm	CO_2 %	O_2 %

Raw Avg				Raw Avg				Raw Avg			
Span				Span				Span			
Gas Val				Gas Val				Gas Val			
$Zero_i$				$Zero_i$				$Zero_i$			
$Zero_f$				$Zero_f$				$Zero_f$			
$Span_i$				$Span_i$				$Span_i$			
$Span_f$				$Span_f$				$Span_f$			
Corr.				Corr.				Corr.			

Calibration				Calibration				Calibration			
Span				Span				Span			
Zero Cal Gas											
Mid Cal Gas											
High Cal Gas											
Zero Resp											
Mid Cal Resp											
High Cal Resp											

Ana. Cal. Error (ACE)				ACE				ACE			
Zero Cal Error											
Mid Cal Error											
High Cal Error											

System Bias (zero, SB)				SB				SB			
Sys Zero Cal Bias Initial											
Sys Zero Cal Bias Final											
System Zero Drift											

System Bias (upscale, SB)				SB				SB			
System Cal Bias Initial											
System Cal Bias Final											
System Cal Drift											

$$C_{Gas} = (C_{avg} - C_0) \cdot [C_{ma} / (C_m - C_0)] \qquad \text{Eq. 7E-5}$$

$$C_0 = (C_{0i} + C_{0f}) / 2$$

$$C_m = (C_{mi} + C_{mf}) / 2$$

$$ACE = (C_{Dir} - C_v) \cdot 100\% / CS \qquad \text{Eq. 7E-1}$$

$$SB = (C_s - C_{Dir}) \cdot 100\% / CS \qquad \text{Eq. 7E-2}$$

$$\text{Drift (D)} = ABS(SB_{final} - Sb_{initial}) \qquad \text{Eq. 7E-4}$$

Brigham Young University Central Heating Plant, Boiler 3

Run 1				Run 2				Run 3			
Time	NO_x ppm	CO_2 %	O_2 %	Time	NO_x ppm	CO_2 %	O_2 %	Time	NO_x ppm	CO_2 %	O_2 %

Facility BYU

Operator D. Kitchen

GAS ANALYZER FIELD DATA

Source Boilers

Date 8/20/19

Response Time :60

Run 1			Gas Species	Rate	Initial Bias		Final Bias		Analyzer Avg	Corrected Avg
	Begin	7:43								
	End	8:56	NOx	600	0	127	0	125	98	99
	Port Change		CO		0.7	43.6	0.0	43.2	30.5	30.9
			CO_2		0.00	10.09	0.00	9.90	5.84	5.91
			O_2		0.10	9.91	0.35	9.85	14.20	14.47

Run 2			Gas Species	Rate	Initial Bias		Final Bias		Analyzer Avg	Corrected Avg
	Begin	920								
	End	1031	NOx	600	0	125	0	125	100	102
	Port Change		CO		0.0	43.2	0.5	43.3	30.5	31.0
			CO_2		0.00	9.90	0.00	10.11	5.80	5.86
			O_2		0.35	9.85	0.15	10.08	14.24	14.40

Run 3			Gas Species	Rate	Initial Bias		Final Bias		Analyzer Avg	Corrected Avg
	Begin	1050								
	End	1207	NOx	600	0	125	0	124	99	102
	Port Change		CO		0.5	43.3	0.7	43.6	33.2	33.6
			CO_2		0.00	10.11	~~10.09~~ 0.00	10.09	5.53	5.53
			O_2		0.15	10.08	0.12	10.02	14.51	14.50

Run			Gas Species	Rate	Initial Bias		Final Bias		Analyzer Avg	Corrected Avg
	Begin									
	End									
	Port Change									

Gas Species	Calibration Gases				Calibration Error				Calibration Error			
NOx	0	128	228		0	127	231					
CO	0.0	44.1	89.9		0.2	44.2	90.7					
CO_2	0.00	10.10	20.70		0.01	10.12	20.41					
O_2	0.00	10.00	20.90		0.02	10.03	21.00					

Comments: All values are either ppmdv or mole percents. Corrected averages are analyzer averages corrected using equation 6C-1 unless otherwise indicated.

Eq. 7E-5: $C_{gas} = (C_{avg} - C_0) * [C_{ma} / (C_m - C_0)]$. Rate is sample flow rate in cc/min and is set within analyzer manufacturer specs.

M4 Field Data Sheet

Filter NA TETCO Sample Box B

Page 1 of 1 Run # 3

Plant: BYU Central Heating Plant

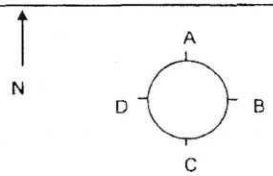
Date: Aug 20, 2014

Location: Baghouse Exhaust, Boiler # 3

Operator: Paul R Kitchen

Traverse Point	Time Clock	Time Min (θ)	DGM (ft³)	ΔP (in H₂O)	ΔH (in H₂O) Desired	ΔH (in H₂O) Actual	Vacuum (in Hg)	Temperatures (°F) Stack (T_s)	Probe	Oven	CPM Filter	Effluent	DGM Temp (T_m) Out	In
C 1	10:50	0	176.253	.012	1.0	1.0	3.0	258	228			65	68	69
2		4	178.865	.018	1.0	1.0	3.0	266	236			63	68	70
3		8	181.474	.02	1.0	1.0	3.0	270	250			62	69	73
4		12	184.092	.015	1.0	1.0	3.0	270	255			62	69	74
B 1	11:14	16	186.699	.006	1.0	1.0	3.0	260	271			64	70	71
2		20	189.317	.013	1.0	1.0	3.0	263	268			62	70	72
3		24	191.942	.013	1.0	1.0	3.0	266	266			55	70	74
4		28	194.566	.015	1.0	1.0	3.0	267	252			51	71	76
A 1	11:33	32	197.187	.006	1.0	1.0	3.0	248	244			51	72	76
2		36	199.816	.005	1.0	1.0	3.0	255	248			48	72	76
3		40	202.439	.007	1.0	1.0	3.0	265	248			47	72	77
4		44	205.063	.005	1.0	1.0	3.0	266	256			46	73	78
D 1	11:51	48	207.683	.01	1.0	1.0	3.0	256	253			50	74	77
2		52	210.306	.015	1.0	1.0	3.0	267	249			46	74	78
3		56	212.932	.018	1.0	1.0	3.0	267	240			46	74	79
4		60	215.558	.02	1.0	1.0	3.0	268	242			45	75	79
	12:07	64	218.181											
Total			41.928 ✓	√ 1.7362				4212					2340	
Average				√ .1085 ✓		1.0 ✓		263.3 ✓					73.1 ✓	

Comments



Stack Diameter 136" Port Reference 16.5"

Ports are 57' Upstream from next disturbance

Ports are 46' Downstream from last disturbance

Assumed Moisture 6 %

Probe 60-G1 Cp 0.84

Nozzle Calibration

— — — —

Avg D_n NA inches

Gas Bag ANALYZER

Console 4

Y-Factor 1.000

$\Delta H_@$ 1.495 in H_2O

Barometric Pressures

Pb_m 25.30 in Hg

Pb_p 25.22 in Hg

P_G -.17 in H_2O

Leak Check:	Pre	Post
ft³/min	0.002	0.001
vac in Hg	24.0	7.0

Pitot Rate	0.00	0.00
In H_2O	.25	.25

Water Collected 40.4 g

Time Sampled 64 min

Review PRK

K = @T_m

K = @T_m

M4 Field Data Sheet

Filter NA TETCO Sample Box A

Page 1 of 1 Run # 2

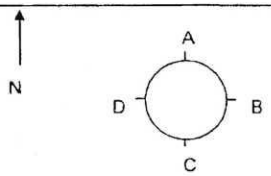
Plant: BYU Central Heating Plant

Date: Aug 20, 2014

Location: Baghouse Exhaust, Boiler #3

Operator: Paul R Kitchen

	Traverse Point	Time Clock	Time Min (0)	DGM (ft³)	ΔP (in H₂O)	ΔH (in H₂O) Desired	ΔH (in H₂O) Actual	Vacuum (in Hg)	Temperatures (°F) Stack (T_s)	Probe	Oven	CPM Filter	Effluent	DGM Temp (T_m) Out	In
D	1	9:20	0	133.633	.012	1.0	1.0	3.0	257	226			58	69	69
	2		4	136.254	.016	1.0	1.0	3.0	262	236			55	68	70
	3		8	138.875	.025	1.0	1.0	3.0	267	255			54	68	72
	4		12	141.491	.022	1.0	1.0	3.0	267	261			54	68	73
A	1	9:37	16	144.106	.009	1.0	1.0	3.0	256	244			54	70	74
	2		20	146.723	.01	1.0	1.0	3.0	264	245			53	70	74
	3		24	149.334	.01	1.0	1.0	3.0	265	244			52	71	76
	4		28	151.945	.01	1.0	1.0	3.0	265	242			52	71	77
B	1	9:56	32	154.567	.012	1.0	1.0	3.0	257	248			54	71	74
	2		36	157.188	.014	1.0	1.0	3.0	262	246			53	71	74
	3		40	159.809	.016	1.0	1.0	3.0	266	245			53	70	75
	4		44	162.430	.015	1.0	1.0	3.0	268	242			53	70	75
C	1	10:15	48	165.049	.015	1.0	1.0	3.0	254	271			57	70	72
	2		52	167.648	.025	1.0	1.0	3.0	261	270			55	69	72
	3		56	170.262	.025	1.0	1.0	3.0	269	267			54	69	73
	4		60	172.884	.02	1.0	1.0	3.0	270	258			55	69	74
		10:31	64	175.496											
Total				41.863 ✓	√ 1.9943				4210					2288	
Average					√ .1246 ✓		1.0 ✓		263.1					71.5 ✓	



Stack Diameter 136" Port Reference 16.5"

Ports are 57' Upstream from next disturbance

Ports are 46' Downstream from last disturbance

Assumed Moisture 6 %

Probe 60G-1 Cp 0.84

Nozzle Calibration

— — — —

Avg D_n NA inches

Gas Bag Analyzer

Console 4

Y-Factor 1.000

$\Delta H_@$ 1.495 in H_2O

Barometric Pressures

Pb_m 25.30 in Hg

Pb_p 25.22 in Hg

P_G -.17 in H_2O

Leak Check:	Pre	Post
ft³/min	0.002	0.001
vac in Hg	24.0	6.0

Pitot Rate	0.00	0.00
In H_2O	.25	.25

Water Collected 38.4 g

Time Sampled 64 min

Review PRK

K = @T_m

K = @T_m

Comments:

M4 Field Data Sheet

Filter NA TETCO Sample Box C

Page 1 of 1 Run # 1

Plant: BYU Central Heating Plant

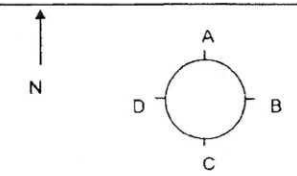
Date: Aug 20, 2012

Location: Baghouse Exhaust, Boiler # 3

Operator: Paul R Kitchen

	Traverse Point	Time Clock	Time Min (θ)	DGM (ft³)	ΔP (in H₂O)	ΔH (in H₂O) Desired	ΔH (in H₂O) Actual	Vacuum (in Hg)	Temperatures (°F) Stack (T_s)	Probe	Oven	CPM Filter	Effluent	DGM Temp (T_m) Out	In
C	1	7:43	0	91.042	.02	1.0	1.0	4.0	258	267			51	70	70
	2		4	93.662	.022	1.0	1.0	4.0	260	262			44	69	71
	3		8	96.279	.03	1.0	1.0	4.0	263	250			44	70	73
	4		12	98.907	.022	1.0	1.0	4.0	265	242			42	71	75
B	1	8:04	16	101.532	.01	1.0	1.0	4.0	254	269			52	71	73
	2		20	104.143	.013	1.0	1.0	4.0	258	271			45	70	73
	3		24	106.767	.015	1.0	1.0	4.0	263	264			45	70	74
	4		28	109.385	.015	1.0	1.0	4.0	264	257			45	70	75
A	1	8:22	32	112.003	.008	1.0	1.0	4.0	248	249			47	70	74
	2		36	114.624	.01	1.0	1.0	4.0	261	260			46	70	74
	3		40	117.240	.01	1.0	1.0	4.0	259	272			46	70	74
	4		44	119.856	.012	1.0	1.0	4.0	265	267			46	70	75
D	1	8:40	48	122.463	.015	1.0	1.0	4.0	258	254			50	69	73
	2		52	125.068	.02	1.0	1.0	4.0	264	240			47	69	73
	3		56	127.679	.022	1.0	1.0	4.0	266	250			47	69	74
	4		60	130.284	.02	1.0	1.0	4.0	266	249			48	70	75
		8:56	64	132.896											
Total				41.854 ✓	√ 2.0229				4172					2294	
Average					√ .1264 ✓		1.0 ✓		260.8 ✓					71.7 ✓	

Comments:



Stack Diameter 136" Port Reference 16.5"

Ports are 57' Upstream from next disturbance

Ports are 46' Downstream from last disturbance

Assumed Moisture 6 %

Probe 60G-1 Cp 0.84

Nozzle Calibration

— — — —

Avg D_n NA inches

Gas Bag Analyzer

Console 4

Y-Factor 1.000

$\Delta H_@$ 1.495 in H_2O

Barometric Pressures

Pb_m 25.30 in Hg

Pb_p 25.22 in Hg

P_G -.17 in H_2O

Leak Check:	Pre	Post
ft³/min	0.005	0.001
vac in Hg	24.0	7.0

Pitot Rate	0.00	0.00
In H_2O	.25	.25

Water Collected 436.9 g

Time Sampled 64 min

Review PRK

K = @T_m

K = @T_m

Boiler 3

Boiler 5

Run 1				Run 2				Run 3			
Time	NO_x ppm	CO_2 %	O_2 %	Time	NO_x ppm	CO_2 %	O_2 %	Time	NO_x ppm	CO_2 %	O_2 %

Raw Avg				Raw Avg				Raw Avg			
Span				Span				Span			
Gas Val				Gas Val				Gas Val			
$Zero_i$				$Zero_i$				$Zero_i$			
$Zero_f$				$Zero_f$				$Zero_f$			
$Span_i$				$Span_i$				$Span_i$			
$Span_f$				$Span_f$				$Span_f$			
Corr.				Corr.				Corr.			

Calibration				Calibration				Calibration			
Span				Span				Span			
Zero Cal Gas											
Mid Cal Gas											
High Cal Gas											
Zero Resp											
Mid Cal Resp											
High Cal Resp											

Ana. Cal. Error (ACE)				ACE				ACE			
Zero Cal Error											
Mid Cal Error											
High Cal Error											

System Bias (zero, SB)				SB				SB			
Sys Zero Cal Bias Initial											
Sys Zero Cal Bias Final											
System Zero Drift											

System Bias (upscale, SB)				SB				SB			
System Cal Bias Initial											
System Cal Bias Final											
System Cal Drift											

$C_{Gas} = (C_{avg} - C_0) \cdot [C_{ma} / (C_m - C_0)]$ Eq. 7E-5

$C_0 = (C_{0i} + C_{0f}) / 2$

$C_m = (C_{mi} + C_{mf}) / 2$

$ACE = (C_{Dir} - C_v) \cdot 100\% / CS$ Eq. 7E-1

$SB = (C_s - C_{Dir}) \cdot 100\% / CS$ Eq. 7E-2

$Drift\ (D) = ABS(SB_{final} - Sb_{initial})$ Eq. 7E-4

Run 1				Run 2				Run 3			
Time	NO_x ppm	CO_2 %	O_2 %	Time	NO_x ppm	CO_2 %	O_2 %	Time	NO_x ppm	CO_2 %	O_2 %

Raw Avg				Raw Avg				Raw Avg			
Span				Span				Span			
Gas Val				Gas Val				Gas Val			
$Zero_i$				$Zero_i$				$Zero_i$			
$Zero_f$				$Zero_f$				$Zero_f$			
$Span_i$				$Span_i$				$Span_i$			
$Span_f$				$Span_f$				$Span_f$			
Corr.				Corr.				Corr.			
Calibration				**Calibration**				**Calibration**			
Span				Span				Span			
Zero Cal Gas											
Mid Cal Gas											
High Cal Gas											
Zero Resp											
Mid Cal Resp											
High Cal Resp											
Ana. Cal. Error (ACE)				**ACE**				**ACE**			
Zero Cal Error											
Mid Cal Error											
High Cal Error											
System Bias (zero, SB)				**SB**				**SB**			
Sys Zero Cal Bias Initial											
Sys Zero Cal Bias Final											
System Zero Drift											
System Bias (upscale, SB)				**SB**				**SB**			
System Cal Bias Initial											
System Cal Bias Final											
System Cal Drift											

$C_{Gas} = (C_{avg} - C_0) \cdot [C_{ma} / (C_m - C_0)]$ Eq. 7E-5

$C_0 = (C_{0i} + C_{0f}) / 2$

$C_m = (C_{mi} + C_{mf}) / 2$

$ACE = (C_{Dir} - C_v) \cdot 100\% / CS$ Eq. 7E-1

$SB = (C_s - C_{Dir}) \cdot 100\% / CS$ Eq. 7E-2

$Drift\ (D) = ABS(SB_{final} - Sb_{initial})$ Eq. 7E-4

Brigham Yount University Central Heating Plant, Boiler 5, 8/19/14

Run 1				Run 2				Run 3			
Time	NO_x ppm	CO_2 %	O_2 %	Time	NO_x ppm	CO_2 %	O_2 %	Time	NO_x ppm	CO_2 %	O_2 %

201A/202 Field Data Sheet

TETCO

Filter 1278 Sample Box A

Page 1 of 1 Run # 1

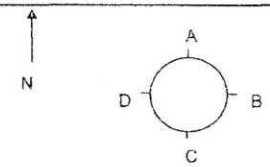
Plant: BYU Central Heating Plant

Date: Aug 19, 2014

Location: Baghouse Exhaust, Boiler # 5

Operator: Paul R Kitchen

Traverse Point	Time Clock	Time Min (θ)	DGM (ft³)	ΔP (in H₂O)	ΔH (in H₂O) Desired	ΔH (in H₂O) Actual	Vacuum (in Hg)	Temperatures (°F) Stack (T_s)	Probe	Oven	CPM Filter	Effluent	DGM Temp (T_m) Out	In
A 1	8:25	0	990.718	.006	.43	.43	3.0	240	259	X	68	66	68	68
2		4.25	992.555	.007	.43	.43	3.0	240	264	X	69	60	68	68
3		8.75	994.512	.009	.43	.43	3.0	243	257	X	70	58	68	69
D 1	8:43	13.75	996.692	.006	.43	.43	3.0	237	259	X	70	60	69	69
2		18.0	998.553	.017	.43	.43	3.0	243	261	X	70	57	69	70
3		25.0	1001.591	.019	.43	.43	3.0	246	235	X	72	55	69	71
C 1	9:05	32.5	1004.839	.015	.43	.43	3.0	239	264	X	72	59	70	71
2		39.0	1007.668	.025	.43	.43	3.0	242	244	X	73	57	70	72
3		47.5	1011.377	.022	.43	.43	3.0	246	250	X	75	56	71	73
B 1	9:31	55.5	1014.873	.010	.43	.43	3.0	236	268	X	74	60	71	72
2		60.75	1017.154	.012	.43	.43	3.0	244	261	X	75	59	71	72
3		66.75	1019.759	.015	.43	.43	3.0	244	250	X	73	59	71	74
OK	~~9:40~~ 9:49	73.25	1022.610											
Total			31.892 ✓	√ 1.36626				2900					1684	
Average				√ .1136 ✓		.43 ✓		241.7 ✓					70.2	



Stack Diameter 136" Port Reference 16.5"

Ports are 57' Upstream from next disturbance

Ports are 46' Downstream from last disturbance

Assumed Moisture 6 %

Probe 51G Cp (prelim) .764

Nozzle Calibration Cp (Act) .764

.474 .474 .475 .475

Avg D_n .4745 inches

Gas Bag Analyzer

Console 4

Y-Factor 1.000

$\Delta H_@$ 1.495 in H_2O

Barometric Pressures

Pb_m 25.30 in Hg

Pb_p 25.22 in Hg

P_G -.15 in H_2O

Leak Check:	Pre	Post
ft³/min	0.012	0.002
vac in Hg	24.0	12.0

Pitot Rate:		
	0.00	0.00
in H_2O	.25	.25

Water Collected 70.9 g

Time Sampled 73.25 min

Review PRK

Time Constant 53.667

Est Run Time t_r 72

Comments:

Δp min .004

Δp max .033

To determine dwell time at each pt, multiply the dwell time constant by the square root of the current sample point Δp.

201A/202 Field Data Sheet

TETCO

Filter 1279 Sample Box B

Page 1 of 1 Run # 2

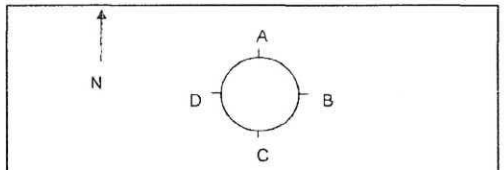
Plant: BYU Central Heating Plant

Date: Aug 19, 2014

Location: Baghouse Exhaust, Boiler # 5

Operator: Paul R Kitchen

	Traverse Point	Time Clock	Time Min (θ)	DGM (ft³)	ΔP (in H₂O)	ΔH (in H₂O) Desired	ΔH (in H₂O) Actual	Vacuum (in Hg)	Temperatures (°F) Stack (T_s)	Probe	Oven	CPM Filter	Effluent	DGM Temp (T_m) Out	In
B	1	10:38	0	25.010	.010	.43	.43	3.0	240	228	X	66	64	71	71
	2		5.25	27.318	.012	.43	.43	3.0	241	240	X	66	59	71	72
	3		11.0	29.831	.013	.43	.43	3.0	244	248	X	66	57	72	75
C	1	10:57	17.0	32.455	.020	.43	.43	3.0	244	247	X	67	58	74	76
	2		24.5	35.749	.020	.43	.43	3.0	245	247	X	68	57	75	77
	3		32.0	39.044	.018	.43	.43	3.0	246	240	X	68	57	76	78
D	1	11:22	39.0	42.110	.006	.43	.43	3.0	236	232	X	67	60	76	77
	2		43.0	43.866	.020	.43	.43	3.0	243	245	X	67	59	76	78
	3		50.5	47.158	.020	.43	.43	3.0	247	245	X	68	58	76	78
A	1	11:43	58.0	50.449	.009	.43	.43	3.0	237	263	X	68	61	74	75
	2		63.0	52.642	.010	.43	.43	3.0	240	259	X	71	59	74	75
	3		68.25	54.943	.012	.43	.43	3.0	244	257	X	73	59	73	75
		11:59	74.0	57.453											
Total				32.443 ✓	√ 1.4053				2907					1795	
Average					√ .1171 ✓		.43 ✓		242.3 ✓					74.8 ✓	



Stack Diameter 136" Port Reference 16.5"

Ports are 57' Upstream from next disturbance

Ports are 46' Downstream from last disturbance

Assumed Moisture 6 %

Probe 51G Cp (prelim) .744

Nozzle Calibration Cp (Act) .764

.474 .474 .475 .475

Avg D_n .4745 inches

Gas Bag Analyzer

Console 4

Y-Factor 1.000

$\Delta H_@$ 1.495 in H_2O

Barometric Pressures

Pb_m 25.30 in Hg

Pb_p 25.22 in Hg

P_G -.15 in H_2O

Leak Check:	Pre	Post
ft³/min	0.011	0.006
vac in Hg	24.0	7.0
Pitot Rate	0.00	0.00
in H_2O	.025	.25

Water Collected 32.8 g

Time Sampled 74.0 min

Review PRK

Time Constant 52.827

Est Run Time t_r 72

Comments

Δp min 0.004

Δp max 0.033

To determine dwell time at each pt, multiply the dwell time constant by the square root of the current sample point Δp.

201A/202 Field Data Sheet

TETCO

Filter 1286 Sample Box C

 Run # 3

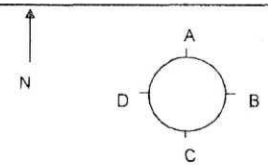
Plant: BYU Central Heating Plant

Date: Aug 19, 2014

Location: Baghouse Exhaust, Boiler # ~~4~~ 5

Operator: Paul R Kitchen

Traverse Point		Time Clock	Time Min (θ)	DGM (ft^3)	ΔP (in H_2O)	ΔH (in H_2O) Desired	ΔH (in H_2O) Actual	Vacuum (in Hg)	Temperatures (°F) Stack (T_s)	Probe	Oven	CPM Filter	Effluent	DGM Temp (T_m) Out	In
A	1	12:43	0	58.152	.009	.43	.43	3.0	243	241	X	69	66	69	69
	2		4.75	60.227	.010	.43	.43	3.0	243	256	X	67	64	69	69
	3		10.0	62.515	.010	.43	.43	3.0	244	261	X	66	63	69	71
D	1	13:00	15.25	64.798	.010	.43	.43	3.0	239	267	X	68	65	70	71
	2		20.5	67.074	.018	.43	.43	3.0	243	264	X	68	64	70	71
	3		27.5	70.126	.020	.43	.43	3.0	247	263	X	70	64	70	73
C	1	13:23	34.75	73.274	.015	.43	.43	3.0	237	243	X	68	51	70	72
	2		41.0	75.993	.025	.43	.43	3.0	240	234	X	68	51	70	72
	3		49.0	79.468	.022	.43	.43	3.0	248	242	X	69	51	71	73
B	1	13:48	56.5	82.725	.010	.43	.43	3.0	237	232	X	69	55	71	73
	2		61.75	85.006	.013	.43	.43	3.0	243	244	X	70	55	71	73
	3		67.5	87.507	.015	.43	.43	3.0	246	248	X	71	56	72	74
		14:05	73.75	90.225											
Total				32.073 ✓	√ 1.4359				2910					1703	
Average					√ .1197 ✓		.43 ✓		242.5 ✓					71.0	



Stack Diameter 136" Port Reference 16.5"

Ports are 57' Upstream from next disturbance

Ports are 46' Downstream from last disturbance

Assumed Moisture 6 %

Probe 51G Cp (prelim) .764

Nozzle Calibration Cp (Act) .764

.474 .474 .475 .475

Avg D_n .4745 inches

Gas Bag Analyzer

Console 4

Y-Factor 1.000

$\Delta H_@$ 1.495 in H_2O

Barometric Pressures

Pb_m 25.30 in Hg

Pb_p 25.22 in Hg

P_G -.15 in H_2O

Leak Check	Pre	Post
ft^3/min	0.012	0.009
vac in Hg	24.0	7.0

Pitot Rate		
	0.00	0.00
In H_2O	.25	.25

Water Collected 357 g

Time Sampled 73.75 min

Review PRK

Time Constant 51.261

Est Run Time t_r 72

Comments:

Δp min 0.004

Δp max 0.033

To determine dwell time at each pt, multiply the dwell time constant by the square root of the current sample point Δp.

Facility B70 Central Heating Plant GAS ANALYZER FIELD DATA Date 8-19-14

Operator D. Kitchen Source Boiler #5 Response Time 170

Run 1			Gas Species	Rate	Initial Bias		Final Bias		Analyzer Avg	Corrected Avg
	Begin	825								
	End	949	NO_x	600	0	127	0	127	130	131
	Port Change	~904	CO		0.4	22.0/45.0	0.3	21.9	19.9	19.5
		~930	CO_2		0.00	10.01	0.05	10.00	6.74	6.80
			O_2		0.07	9.95	0.04	10.03	13.47	13.50

Run 2			Gas Species	Rate	Initial Bias		Final Bias		Analyzer Avg	Corrected Avg
	Begin	1028								
	End	1159	NO_x	600	0	127	0	127	132	133
	Port Change	~1056	CO		0.3	21.9	0.0	21.3	21.4	21.4
		~1121	CO_2		0.05	10.00	0.02	10.13	6.74	6.76
			O_2		0.04	10.03	0.05	9.95	13.18	13.21

Run 3			Gas Species	Rate	Initial Bias		Final Bias		Analyzer Avg	Corrected Avg
	1243 Begin	~~1443~~								
	End	1405	NO_x	600	0	127	1	128	131	132
	Port Change	~1322	CO		0.0	21.3	0.5	21.7	19.1	19.1
			CO_2		0.02	10.13	0.00	10.18	6.69	6.65
			O_2		0.05	9.95	0.06	10.03	13.26	13.29

Run			Gas Species	Rate	Initial Bias		Final Bias		Analyzer Avg	Corrected Avg
	Begin									
	End									
	Port Change									

Gas Species	Calibration Gases				Calibration Error				Calibration Error			
NO_x	0	~~216~~ 128	228		0	126	229					
CO	0.0	21.6	44.1	44.9	0.1	21.9	~~45.1~~ 44.8	90.4				
CO_2	0.00	10.10	20.70		0.00	10.14	20.52					
O_2	0.00	10.00	20.90		0.06	10.11	20.92					

Comments: All values are either ppmdv or mole percents. Corrected averages are analyzer averages corrected using equation ~~6C-1~~ 7E-5 unless otherwise indicated.

Eq. 7E-5: $C_{gas} = (C_{avg} - C_0) * [C_{ma} / (C_m - C_0)]$. Rate is sample flow rate in cc/min and is set within analyzer manufacturer specs.

APPENDIX C

Sample Recovery
Gas Analysis Data (Analyzer)
Particulate Analysis
Method 202 Analysis
Chain of Custody

Method 5-4

Facility: BYU

Date: 8-21-14

Stack Identification: Boiler 2

IMPINGERS

Run: 1

Sample Box: C

Filter Number:

	Impinger Number 1	2	3	4	5	6
Initial Volume of liquid (H_2O) in impingers, (ml)	100	100	—	Silica Gel		
Final (g)	697.0	628.8	606.7	901.4		
Initial (g)	680.0	622.2	605.4	893.2		
Net (g)	17.0	6.6	1.3	8.2		

PM Filter Description

Total (g) 29.1

IMPINGERS

Run: 2

Sample Box: A

Filter Number:

	Impinger Number 1	2	3	4	5	6
Initial Volume of liquid (H_2O) in impingers, (ml)	100	100	—	Silica Gel		
Final (g)	746.9	*739.6	626.4	893.7		
Initial (g)	739.0	*731.5	621.9	884.8		
Net (g)	7.9	8.1	4.5	8.9		

PM Filter Description

Total (g) 29.4

IMPINGERS

Run: 3

Sample Box: D

Filter Number:

	Impinger Number 1	2	3	4	5	6
Initial Volume of liquid (H_2O) in impingers, (ml)	100	100	—	Silica Gel		
Final (g)	685.4	704.8	548.9	936.2		
Initial (g)	670.1	699.1	547.6	927.8		
Net (g)	15.3	5.7	1.3	8.4		

PM Filter Description

Total (g) 30.7

* 2nd imp. Final 739.6
Run 2 Initial 731.5

M202 Impinger Field Sheet

Facility: BYU Central Heating Plant — Date: 8-19-14

Stack Identification: Baghouse (Boiler 5) — Method: 201A

IMPINGERS

Run: 1 — Sample Box: A

Filter Number: 1278

Impinger Number	Dry 1	Dry 2	Cold 3	Cold 4	5	6
Initial Volume of liquid (H_2O) in impingers, (ml)			100	SG		
Final (g)	370.6	625.4	725.7	917.9		
Initial (g)	363.6	621.9	714.6	908.6		
Net (g)	7.0	3.5	11.1	9.3		
	weigh & analyse		weigh and discard			

Total (g): 30.9

Initials: DK PRK

pm filter description: small amount of gray PM visible

RINSES	H_2O	Acetone	Hexane

Purge start 1005

Purge end 1100

ml H_2O added 60 ml

IMPINGERS

Run: 2 — Sample Box: B

Filter Number: 1279

Impinger Number	Dry 1	Dry 2	Cold 3	Cold 4	5	6
Initial Volume of liquid (H_2O) in impingers, (ml)			100	SG		
Final (g)	376.7	594.9	723.1	875.0		
Initial (g)	360.5	591.4	715.5	864.5		
Net (g)	16.2	3.5	7.6	10.5		
	weigh & analyse		weigh and discard			

Total (g): 32.8

Initials: DK PRK

pm filter description: very light gray coloring

RINSES	H_2O	Acetone	Hexane

Purge start 1220

Purge end 1320

ml H_2O added ~~70~~ 60 ml

IMPINGERS

Run: 3 — Sample Box: C

Filter Number: 1286

Impinger Number	Dry 1	Dry 2	Cold 3	Cold 4	5	6
Initial Volume of liquid (H_2O) in impingers, (ml)			100	SG		
Final (g)	373.5	540.9	644.6	939.0		
Initial (g)	358.5	538.1	636.6	929.1		
Net (g)	15.0	2.8	8.0	9.9		
	weigh & analyse		weigh and discard			

Total (g): 35.7

Initials: DK PRK

pm filter description:

RINSES	H_2O	Acetone	Hexane

Purge start 1425

Purge end 1525

ml H_2O added 60

Method 4

Facility: BYU

Date: 8-20-14

Stack Identification: Boiler 3

IMPINGERS

Run: 1

Sample Box: C

	Impinger Number					
	1	2	3	4	5	6
	Initial Volume of liquid (H_2O) in impingers, (ml)					
	100	100	—	Silica Gel		
	1	2	3	4	5	6
Final (g)	680.0	677.2	605.4	893.2		
Initial (g)	654.6	615.8	602.3	884.2		
Net (g)	25.4	6.4	3.1	9.0		

Total (g) 43.9

IMPINGERS

Run: 2

Sample Box: A

	Impinger Number					
	1	2	3	4	5	6
	Initial Volume of liquid (H_2O) in impingers, (ml)					
	100	100	—	Silica Gel		
	1	2	3	4	5	6
Final (g)	739.0	~~725.5~~ 731.5	621.9	884.8		
Initial (g)	722.8	~~674.~~	616.0	874.5		
Net (g)	16.2	6.0	5.9	10.3		

Total (g) 38.4

IMPINGERS

Run: 3

Sample Box: B

	Impinger Number					
	1	2	3	4	5	6
	Initial Volume of liquid (H_2O) in impingers, (ml)					
	100	100	—	Silica Gel		
	1	2	3	4	5	6
Final (g)	670.1	699.1	542.6	927.8		
Initial (g)	644.5	696.2	542.3	917.1		
Net (g)	25.6	2.8	1.3	10.7		

Total (g) 40.4

IMPINGERS

Run: _____

Sample Box: _____

	Impinger Number					
	1	2	3	4	5	6
	Initial Volume of liquid (H_2O) in impingers, (ml)					
	100	100	—	Silica Gel		
	1	2	3	4	5	6
Final (g)						
Initial (g)						
Net (g)						

Total (g) _____

Facility: BYU | Date: 8/19/14

Stack Identification: Baghouse (Boiler 5) | Run: 1

Filter Number: 1278 | Sample Box: A

Blanks & Rinses

Blanks			Rinses		
Acetone (CH_3COCH_3)	0.0001	g/100ml	$Acetone_F$ (CH_3COCH_3)	70	ml
			$Acetone_C$ (CH_3COCH_3)	85	ml

Filter

$Final_1$:	0.2146	g	Date: 8/30/14	Time:	14:00
$Final_2$:	0.2147	g	Date: 9/1/14	Time:	15:00
$Final_{AVG}$:	0.2147	g			
Filter Preweight:	0.2124	g			
Net	0.0023	g			
Net	**2.3**	**mg**			

CRITERIA		
Process	Weight	Time
Final	Pass	Pass

PM_{10} Wash

$Final_1$:	49.1083	g	Date: 8/30/14	Time:	14:00
$Final_2$:	49.1085	g	Date: 9/1/14	Time:	15:00
$Final_{AVG}$:	49.1084	g			
$Initial_1$:	49.1058	g	Date: 12/11/13	Time:	8:00
$Initial_2$:	49.1058	g	Date: 12/11/13	Time:	14:00
$Initial_{AVG}$:	49.1058	g			
Gross:	0.0026	g			
Beaker Number: 75	Blank:	0.0001	g		
Net	0.0025	g			
Net	**2.5**	**mg**			

CRITERIA		
Process	Weight	Time
Final	Pass	Pass
Initial	Pass	Pass

Coarse Wash

$Final_1$:	49.4042	g	Date: 8/30/14	Time:	14:00
$Final_2$:	49.4044	g	Date: 9/1/14	Time:	15:00
$Final_{AVG}$:	49.4043	g			
$Initial_1$:	49.3950	g	Date: 12/11/13	Time:	8:00
$Initial_2$:	49.3947	g	Date: 12/11/13	Time:	14:00
$Initial_{AVG}$:	49.3949	g			
Gross:	0.0094	g			
Beaker Number: 76	Blank:	0.0001	g		
Net	0.0093	g			
Net	**9.3**	**mg**			

CRITERIA		
Process	Weight	Time
Final	Pass	Pass
Initial	Pass	Pass

RESULTS

	PM_{10}			Coarse		
Filter	2.3	mg				
Wash	2.5	mg		Wash	9.3	mg
Total	**4.8**	**mg**		**Total**	**9.3**	**mg**

Comments: Criteria: 1) Weights are ± 0.5 mg of each other, or within 1% of the net weight. 2) There shall be at least 6 hrs between weighings.

Lab Technician: DK Date: 9-5-14

Lab Technician: PRK Date: 9-8-14

Facility: BYU | Date: 8/19/14

Stack Identification: Baghouse (Boiler 5) | Run: 2

Filter Number: 1279 | Sample Box: B

Blanks & Rinses

Blanks			Rinses		
Acetone (CH_3COCH_3)	0.0001	g/100ml	$Acetone_F$ (CH_3COCH_3)	80	ml
			$Acetone_C$ (CH_3COCH_3)	80	ml

Filter

$Final_1$:	0.2133	g	Date: 8/30/14	Time:	14:00
$Final_2$:	0.2134	g	Date: 9/1/14	Time:	15:00
$Final_{AVG}$:	0.2134	g			
Filter Preweight:	0.2115	g			
Net	0.0019	g			
Net	**1.9**	**mg**			

CRITERIA		
Process	Weight	Time
Final	Pass	Pass

PM_{10} Wash

$Final_1$:	49.3076	g	Date: 8/30/14	Time:	14:00
$Final_2$:	49.3074	g	Date: 9/1/14	Time:	15:00
$Final_{AVG}$:	49.3075	g			
$Initial_1$:	49.3061	g	Date: 12/11/13	Time:	8:00
$Initial_2$:	49.3058	g	Date: 12/11/13	Time:	14:00
$Initial_{AVG}$:	49.3060	g			
Gross:	0.0015	g			
Beaker Number: 77	Blank:	0.0001	g		
Net	0.0014	g			
Net	**1.4**	**mg**			

CRITERIA		
Process	Weight	Time
Final	Pass	Pass
Initial	Pass	Pass

Coarse Wash

$Final_1$:	49.8157	g	Date: 8/30/14	Time:	14:00
$Final_2$:	49.8159	g	Date: 9/1/14	Time:	15:00
$Final_{AVG}$:	49.8158	g			
$Initial_1$:	49.8120	g	Date: 12/11/13	Time:	8:00
$Initial_2$:	49.8120	g	Date: 12/11/13	Time:	14:00
$Initial_{AVG}$:	49.8120	g			
Gross:	0.0038	g			
Beaker Number: 78	Blank:	0.0001	g		
Net	0.0037	g			
Net	**3.7**	**mg**			

CRITERIA		
Process	Weight	Time
Final	Pass	Pass
Initial	Pass	Pass

RESULTS

	PM_{10}		Coarse	
Filter	1.9	mg		
Wash	1.4	mg	Wash 3.7	mg
Total	**3.3**	**mg**	**Total 3.7**	**mg**

Comments: Criteria: 1) Weights are ± 0.5 mg of each other, or within 1% of the net weight. 2) There shall be at least 6 hrs between weighings.

Lab Technician: DA Date: 9-8-14

Lab Technician: PRK Date: 9-8-14

Facility: BYU | Date: 8/19/14

Stack Identification: Baghouse (Boiler 5) | Run: 3

Filter Number: 1286 | Sample Box: C

Blanks & Rinses

Blanks			Rinses		
Acetone (CH_3COCH_3)	0.0001	g/100ml	$Acetone_F$ (CH_3COCH_3)	70	ml
			$Acetone_C$ (CH_3COCH_3)	75	ml

Filter

$Final_1$:	0.2115	g	Date: 8/30/14	Time: 14:00	
$Final_2$:	0.2118	g	Date: 9/1/14	Time: 15:00	
$Final_{AVG}$:	0.2117	g			
Filter Preweight:	0.2093	g			
Net	0.0024	g			
Net	**2.4**	**mg**			

CRITERIA		
Process	Weight	Time
Final	Pass	Pass

PM_{10} Wash

$Final_1$:	49.9372	g	Date: 8/30/14	Time: 14:00	
$Final_2$:	49.9374	g	Date: 9/1/14	Time: 15:00	
$Final_{AVG}$:	49.9373	g			
$Initial_1$:	49.9355	g	Date: 12/11/13	Time: 8:00	
$Initial_2$:	49.9359	g	Date: 12/11/13	Time: 14:00	
$Initial_{AVG}$:	49.9357	g			
Gross:	0.0016	g			
Blank:	0.0001	g			
Net	0.0015	g			
Net	**1.5**	**mg**			

Beaker Number: 79

CRITERIA		
Process	Weight	Time
Final	Pass	Pass
Initial	Pass	Pass

Coarse Wash

$Final_1$:	49.9898	g	Date: 8/30/14	Time: 14:00	
$Final_2$:	49.9898	g	Date: 9/1/14	Time: 15:00	
$Final_{AVG}$:	49.9898	g			
$Initial_1$:	49.9870	g	Date: 12/11/13	Time: 8:00	
$Initial_2$:	49.9870	g	Date: 12/11/13	Time: 14:00	
$Initial_{AVG}$:	49.9870	g			
Gross:	0.0028	g			
Blank:	0.0001	g			
Net	0.0027	g			
Net	**2.7**	**mg**			

Beaker Number: 80

CRITERIA		
Process	Weight	Time
Final	Pass	Pass
Initial	Pass	Pass

RESULTS

	PM_{10}			Coarse	
Filter	2.4	mg			
Wash	1.5	mg	Wash	2.7	mg
Total	3.9	**mg**	**Total**	**2.7**	**mg**

Comments: Criteria: 1) Weights are ± 0.5 mg of each other, or within 1% of the net weight. 2) There shall be at least 6 hrs between weighings.

Lab Technician: DK Date: 9-5-14

Lab Technician: PRK Date: 9-8-14

Method 202 Laboratory Form

Facilty: BYU

Stack Identification: Baghouse (Boiler 5)

Test Date(s): 8/19/14

Sample Description/ID #	Run 1				Run 2				Run 3			
Inorganic CPM												
Beaker/tin #	150	Date	Time	Rel. Hum %	151	Date	Time	Rel. Hum %	152	Date	Time	Rel. Hum %
Final Weight (1), g	2.2391	8/30/14	14:00	< 1	2.2480	8/30/14	14:00	< 1	2.2264	8/30/14	14:00	< 1
Final Weight (2), g	2.2389	9/1/14	15:00	< 1	2.2479	9/1/14	15:00	< 1	2.2260	9/1/14	15:00	< 1
Ave. Final Weight, g	**2.2390**				**2.2480**				**2.2262**			
Initial Weight (1), g	2.2286	1/21/14	8:00	< 1	2.2369	1/21/14	8:00	< 1	2.2153	1/21/14	8:00	< 1
Initial Weight (2), g	2.2284	1/23/14	9:00	< 1	2.2367	1/23/14	9:00	< 1	2.2151	1/23/14	9:00	< 1
Ave. Initial Weight, g	**2.2285**				**2.2368**				**2.2152**			
m_r: Initial Inorganic Wt, mg	**10.50**				**11.15**				**11.00**			
H_2O added in Extractions, ml	60	pH	pH		60	pH	pH		60	pH	pH	
Reconstituted H_2O Volume, ml		Start	End			Start	End			Start	End	
N: Normality of NH_4OH												
V_t: Volume of NH_4OH, ml												
m_c: Mass of NH_4 Added, mg												
m_i (or m_{ib}): Final Inorganic Wt, mg	**10.50**				**11.15**				**11.00**			
Organic CPM												
Beaker/tin #	153	Date	Time	Rel. Hum %	154	Date	Time	Rel. Hum %	155	Date	Time	Rel. Hum %
Final Weight (1), g	2.2212	8/30/14	14:00	< 1	2.2285	8/30/14	14:00	< 1	2.2422	8/30/14	14:00	< 1
Final Weight (2), g	2.2210	9/1/14	15:00	< 1	2.2283	9/1/14	15:00	< 1	2.2421	9/1/14	15:00	< 1
Ave. Final Weight, g	**2.2211**				**2.2284**				**2.2422**			
Initial Weight (1), g	2.2134	1/21/14	8:00	< 1	2.2215	1/21/14	8:00	< 1	2.2361	1/21/14	8:00	< 1
Initial Weight (2), g	2.2130	1/23/14	9:00	< 1	2.2211	1/23/14	9:00	< 1	2.2357	1/23/14	9:00	< 1
Ave. Initial Weight, g	**2.2132**				**2.2213**				**2.2359**			
m_o (or m_{ob}): Net Organic Wt, mg	**7.90**				**7.10**				**6.25**			
m_{cpm} : Gross CPM, mg	**18.4**				**18.3**				**17.2**			
m_{cpm} : Blank CPM, mg	**2.0**				**2.0**				**2.0**			
m_{cpm} : Net CPM, mg	**16.4**				**16.3**				**15.2**			

pH Meter: Oakton pHTestr BNC, Electrode Model: 35801-00

	pH	Date	Time
Fisher pH Buffer (3/13) 4.00			
Fisher pH Buffer (2/13) 7.00			

Form Date: 7/6/11

Method 202 Field Reagent Blank Form

Facilty: BYU

Stack Identification: Baghouse (Boiler 5)

Test Date(s): 8/19/14

Blank Description/ID #	Water	Ricca ACS			Acetone	Fisher ACS			Hexane	Fisher Optima		
Lot #		4309B01				134324				136425		
Beaker/tin #	160	Date	Time	Rel. Hum %	161	Date	Time	Rel. Hum %	162	Date	Time	Rel. Hum %
Final Weight (1), g	2.2211	8/30/14	14:00	< 1	2.2245	8/30/14	14:00	< 1	2.2062	8/30/14	14:00	< 1
Final Weight (2), g	2.2210	9/1/14	15:00	< 1	2.2245	9/1/14	15:00	< 1	2.2058	9/1/14	15:00	< 1
Ave. Final Weight, g	**2.2211**				**2.2245**				**2.2060**			
Initial Weight (1), g	2.2210	1/21/14	8:00	< 1	2.2245	1/21/14	8:00	< 1	2.2062	1/21/14	8:00	< 1
Initial Weight (2), g	2.2206	1/22/14	9:00	< 1	2.2241	1/22/14	9:00	< 1	2.2058	1/22/14	9:00	< 1
Ave. Initial Weight, g	**2.2208**				**2.2243**				**2.2060**			
Blank Residual Mass, mg	**0.25**	Water			**0.20**	Acetone			**0.00**	Hexane		
Blank Volume, ml	225				225				225			
Max Blank Residulal Mass, mg	0.23				0.23				0.23			

Method 202 Laboratory Form

Facilty: BYU

Stack Identification: Baghouse (Boiler 5) Test Date(s): 8/19/14

Sample Description/ID #	Recovery Blank				Proof Blank			
Inorganic CPM								
Beaker/tin #	156	Date	Time	Rel. Hum %	157	Date	Time	Rel. Hum %
Final Weight (1), g	2.2136	8/30/14	14:00	< 1	2.2166	8/30/14	14:00	< 1
Final Weight (2), g	2.2140	9/1/14	15:00	< 1	2.2169	9/1/14	15:00	< 1
Ave. Final Weight, g	**2.2138**				**2.2168**			
Initial Weight (1), g	2.2132	1/21/14	8:00	< 1	2.2161	1/21/14	8:00	< 1
Initial Weight (2), g	2.2128	1/22/14	9:00	< 1	2.2157	1/22/14	9:00	< 1
Ave. Initial Weight, g	**2.2130**				**2.2159**			
m_r: Initial Inorganic Wt, mg	**0.80**				**0.85**			
H_2O added in Extractions, ml	60	pH	pH		60	pH	pH	
Reconstituted H_2O Volume, ml		Start	End			Start	End	
N: Normality of NH_4OH								
V_t: Volume of NH_4OH, ml								
m_c: Mass of NH_4 Added, mg								
m_i (or m_{ib}): Final Inorganic Wt, mg	**0.80**				**0.85**			
Organic CPM								
Beaker/tin #	158	Date	Time	Rel. Hum %	159	Date	Time	Rel. Hum %
Final Weight (1), g	2.2362	6/30/11	13:30	< 1	2.2302	6/30/11	13:30	< 1
Final Weight (2), g	2.2360	6/1/31	12:00	< 1	2.2304	6/1/31	12:00	< 1
Ave. Final Weight, g	**2.2361**				**2.2303**			
Initial Weight (1), g	2.2351	1/21/14	8:00	< 1	2.2294	1/21/14	8:00	< 1
Initial Weight (2), g	2.2348	1/22/14	9:00	< 1	2.2291	1/22/14	9:00	< 1
Ave. Initial Weight, g	**2.2350**				**2.2293**			
m_o (or m_{ob}): Net Organic Wt, mg	**1.15**				**1.05**			
m_{cpm} (or m_{fb}): Total CPM, mg	**2.0**				**1.9**			

pH Meter: Oakton pHTestr BNC, Electrode Model: 35801-00

	pH	Date	Time
Fisher pH Buffer (3/13) 4.00			
Fisher pH Buffer (2/13) 7.00			

Form Date: 7/6/11

Method 202 Laboratory Reagent Blank Form

Blank Description/ID #	Water	RICCA Reagent			Acetone	Fisher ACS			Hexane	Fisher OPTIMA		
Lot #		Lot 4206722				Lot 135783				Lot 135608		
Beaker/tin #	129	Date	Time	Rel. Hum %	130	Date	Time	Rel. Hum %	131	Date	Time	Rel. Hum %
Final Weight (1), g	2.2506	7/17/14	7:00	< 1	2.2282	7/17/14	7:00	< 1	2.2304	7/17/14	7:00	< 1
Final Weight (2), g	2.2504	7/17/14	13:00	< 1	2.2281	7/17/14	13:00	< 1	2.2300	7/17/14	13:00	< 1
Ave. Final Weight, g	**2.2505**				**2.2282**				**2.2302**			
Initial Weight (1), g	2.2505	1/21/14	8:00	< 1	2.2281	1/21/14	8:00	< 1	2.2302	1/21/14	8:00	< 1
Initial Weight (2), g	2.2507	1/23/14	9:00	< 1	2.2278	1/23/14	9:00	< 1	2.2298	1/23/14	9:00	< 1
Ave. Initial Weight, g	**2.2506**				**2.2280**				**2.2300**			
Blank Residual Mass, mg	**0.00**	Water			**0.20**	Acetone			**0.20**	Hexane		
Blank Volume, ml	200				200				200			
Max Blank Residulal Mass, mg	0.20				0.20				0.20			

TETCO **Stack Emission Analysis**
Accurate • Reliable • Qualified

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Chain of Custody

Sample Identification		Method of Analysis	Recovery Date	Sample Description
1278	Filter	EPA Method 201A Gravimetric	8-19-14	Filter
	Fine	EPA Method 201A Gravimetric		Fine Catch Acetone Wash
	Coarse	EPA Method 201A Gravimetric		Coarse Catch Acetone Wash
	H_2O	EPA Method 202 Gravimetric		Impinger Catch and H_2O Rinse
	Organic	EPA Method 202 Gravimetric		Acetone/Hexane Rinse
1279	Filter	EPA Method 201A Gravimetric		Filter
	Fine	EPA Method 201A Gravimetric		Fine Catch Acetone Wash
	Coarse	EPA Method 201A Gravimetric		Coarse Catch Acetone Wash
	H_2O	EPA Method 202 Gravimetric		Impinger Catch and H_2O Rinse
	Organic	EPA Method 202 Gravimetric		Acetone/Hexane Rinse
1280	Filter	EPA Method 201A Gravimetric		Filter
	Fine	EPA Method 201A Gravimetric		Fine Catch Acetone Wash
	Coarse	EPA Method 201A Gravimetric		Coarse Catch Acetone Wash
	H_2O	EPA Method 202 Gravimetric		Impinger Catch and H_2O Rinse
	Organic	EPA Method 202 Gravimetric		Acetone/Hexane Rinse

Sampled By:	Paul Kitchen	8-19-14
Recovered By:	D. Kitchen	8-19-14
Relinquished By:		
Received By:		
Relinquished By:		
Received By:		
Analyzed By:	D. Olsen	8-20-14

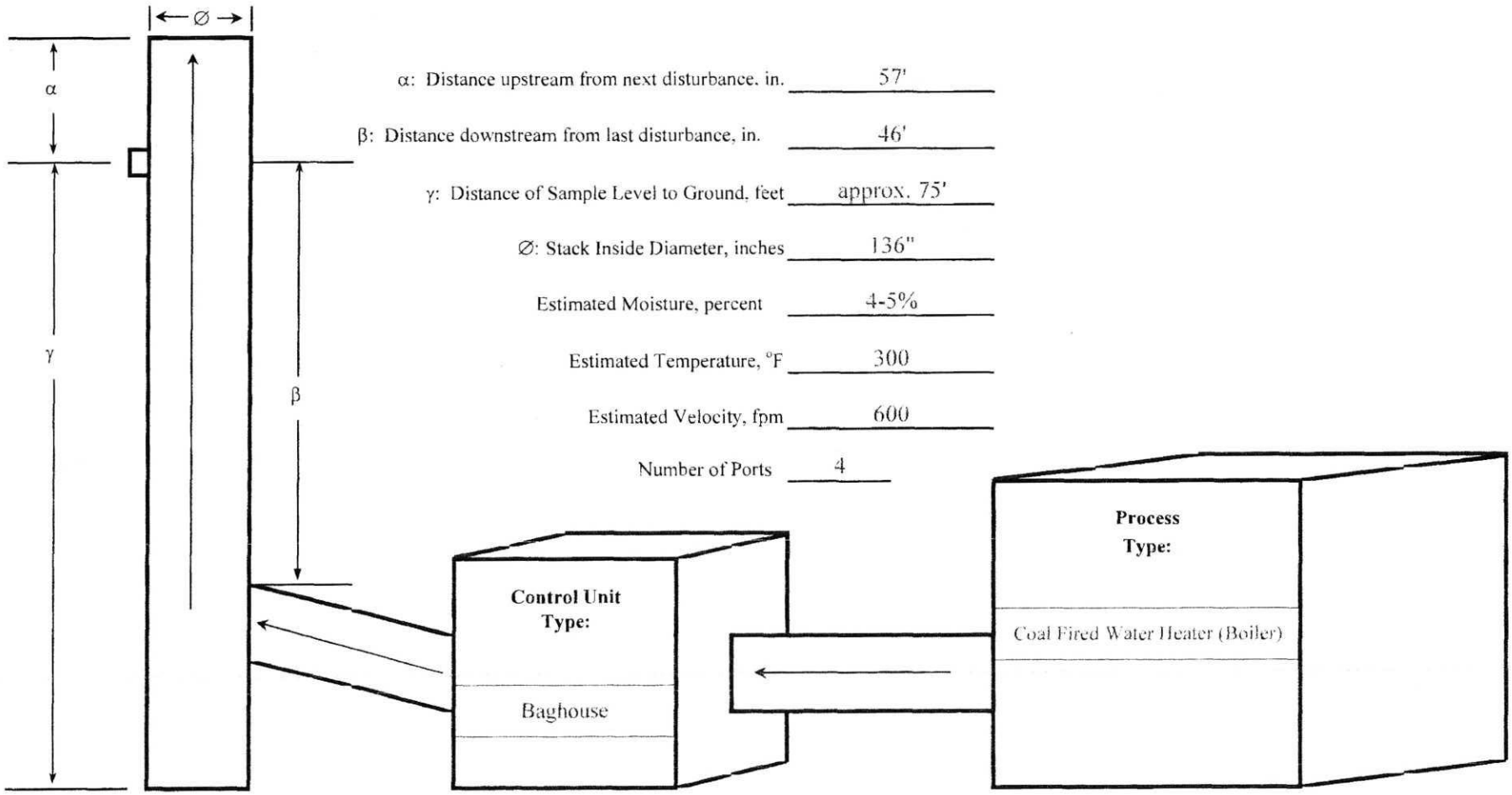
Unless otherwise indicated, all samples remain in the Custody of TETCO.

APPENDIX D

Figure 1 Schematic of Facility
Raw Production and Control Equipment Data

Facility: BYU Central Heating Plant

Stack Identification: Main Stack



α: Distance upstream from next disturbance, in. 57'

β: Distance downstream from last disturbance, in. 46'

γ: Distance of Sample Level to Ground, feet approx. 75'

∅: Stack Inside Diameter, inches 136"

Estimated Moisture, percent 4-5%

Estimated Temperature, °F 300

Estimated Velocity, fpm 600

Number of Ports 4

Figure 1. Facility Schematic Representation

Brigham Young University

Central Heating Plant Baghouse

Boiler # 2

Test Run #	Test Time	Integrator Reading mmBtu	Instantaneous Rate mmBtu/hr	Coal Scale Integrator lbs
1157	Start 1047	842.82	38.6	6103
	End ~~1057~~	868.03	39.72	6106
		net 45.21 38.75 mmBtu/hr		net
	Start 1210	876.92	38.29	6107
	End 1320	925.24	38.90	6109
		net 48.32 41.42 mmBtu/hr		net
1443	Start 1333	929.68	38.50	6110
	End ~~1443~~	978.60	38.59	612
		net 48.92 41.94 mmBtu/hr		net
	Start			
	End			
		net		net

Notes: Ave 40.50 mmBtu/hr

Brigham Young University

Central Heating Plant Baghouse

Boiler # 3 **Date:** 8-20-14

Test Run #	Test Time	Integrator Reading mmBtu	Instantaneous Rate mmBtu/hr	Coal Scale Integrator lbs
	Start 741	—	42.05	6022
	End 857		42.84	6025
		net	42.96	net
	Start 918	39.05	42.14	6025
	End 1032	93.40	41.36	6028
		net 54.35 44.87 mmBtu/hr		net
	Start 1047	103.13	~~41~~ 42.18	6029
	End ~~1012~~ 08	159.09	38.93	6032
		net 55.96 41.452 mmBtu/hr		net
	Start			
	End			
		net		net

Notes: ~~coal Btu~~ value Ave 42.64 mm Btu/hr

~~Efficiency~~

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Customer BYU CHP Page ____ Of ____
Job No. ____ Date 8/20/14 Made By SWB

Boiler #3 Run #1
Start Time 7:43

Min	mmBTU$_I$
0	43.15
15	41.87
30	42.47
45	42.23
60	42.26

Ave 42.296

Run #2 Start Time 9:20

0	42.14
15	41.29
30	42.01
45	41.93
60	41.80

Run #3 Start Time 10:50

0	42.17
15	40.14
30	38.93
45	39.15
60	38.91

S-019

Brigham Young University

Central Heating Plant Baghouse

Boiler # 5 **Date:** 8-19-14

Test Run #	Test Time	Integrator Reading mmBtu	Instantaneous Rate mmBtu/hr	Coal Scale Integrator lbs
	Start 819	8204.84	44.32	1852
	End 9950	8266.50	44.11	1856
	~~40.65~~	net 61.66 40.65/hr	ave 44.22	net 4
	Start 1034	8294.20	44.82	1857
	End 1200	8356.53	44.15	1861
		net 61.83 43.14/hr	ave 44.49	net 4
	Start 1239	8384.44	44.69	1863
	End 1406	8442.92	45.15	1866
		net 58.48 40.33/hr	ave 44.92	net 3
	Start			
	End			
		net		net

Notes: coal Btu value

Efficiency

APPENDIX E

Calibration of the console dry gas meter(s), pitot tubes, nozzles diameters, and temperature sensors were carried out in accordance with the procedures outlined in the Quality Assurance Handbook. The appropriate calibration data are presented in the following pages. The nozzle calibrations are recorded on the first page of the field data sheets.

Figure 2. Schematic Representation of Method 4 Sampling Train
Figure 3. Schematic Representation of Method 201A/202 Sampling Train
Figure 4. Schematic Representation of Gaseous Analyzer Sampling Train

Meter Box Calibration Data and Calculations Forms
Post-test Dry Gas Meter Calibration Data Forms
Type S Pitot Tube Inspection Data
Sample Box Temperature Sensor Calibration
Filter Balance Calibration
Calibration Gas Certifications
NO_x Converter Efficiency Check

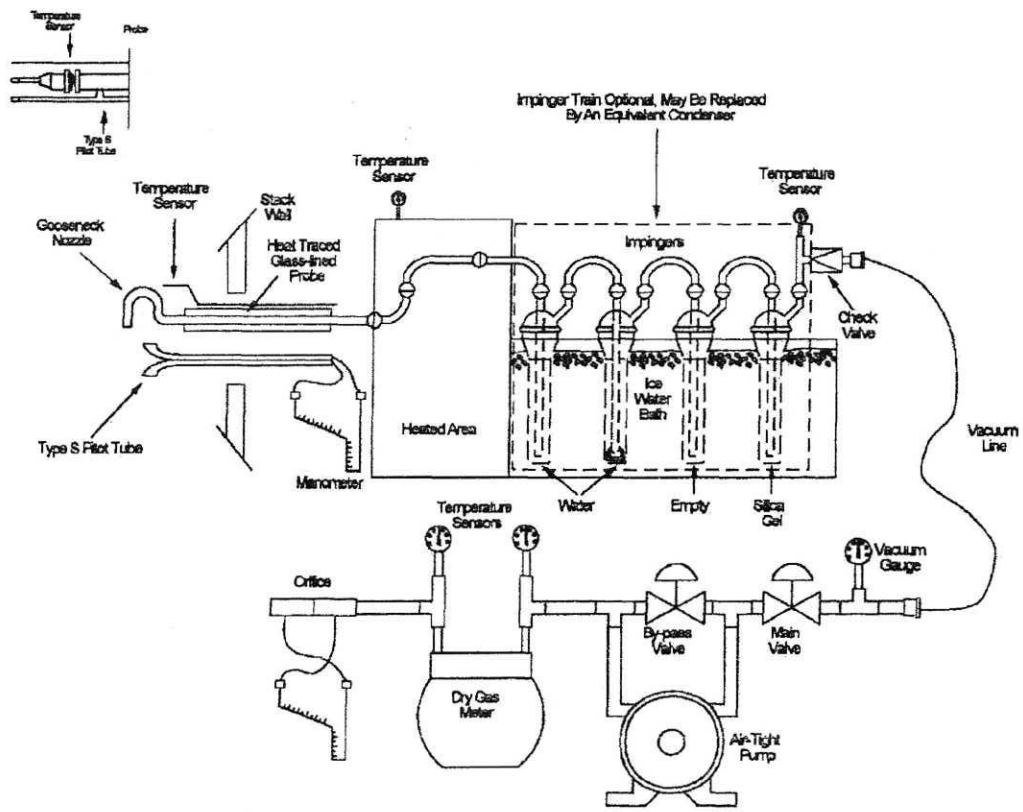


Figure 2. Schematic of Method 4 Sampling Train

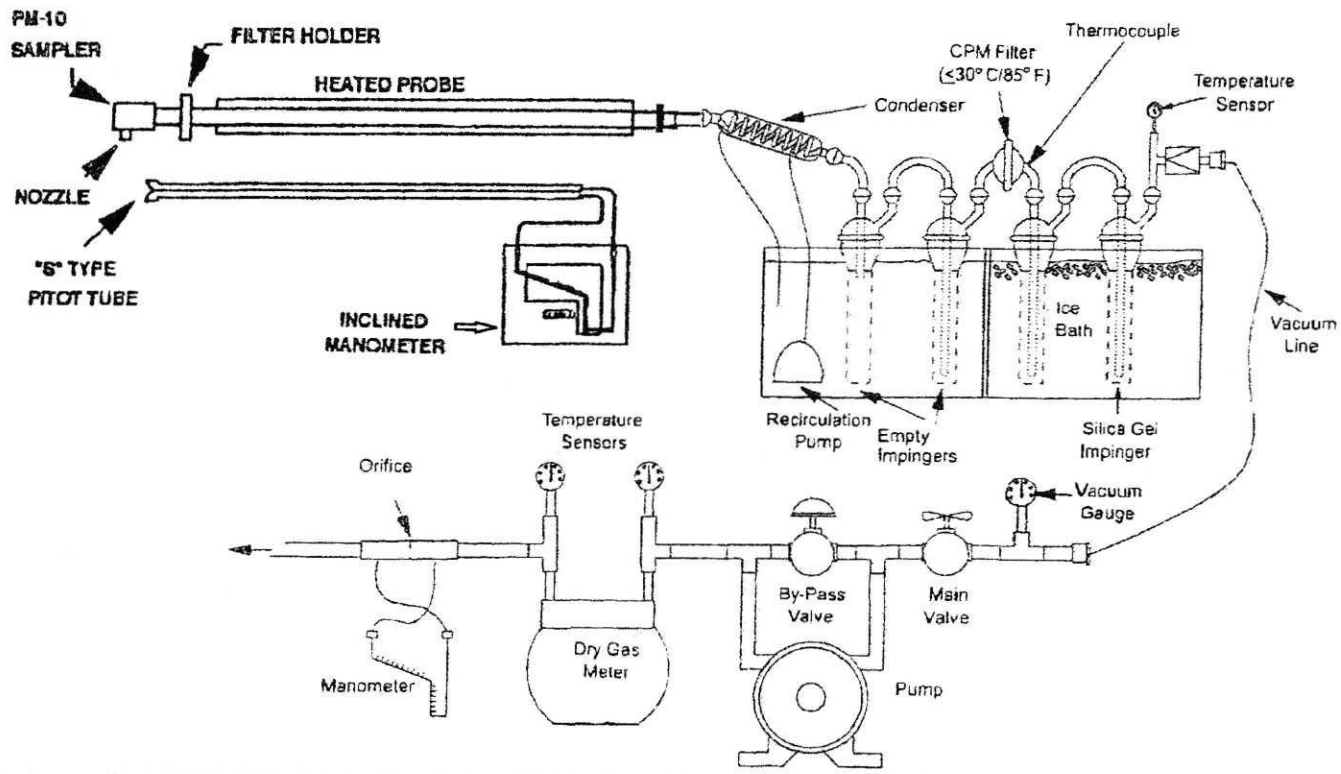


Figure 3. Schematic of Method 201A/202 Sampling Train

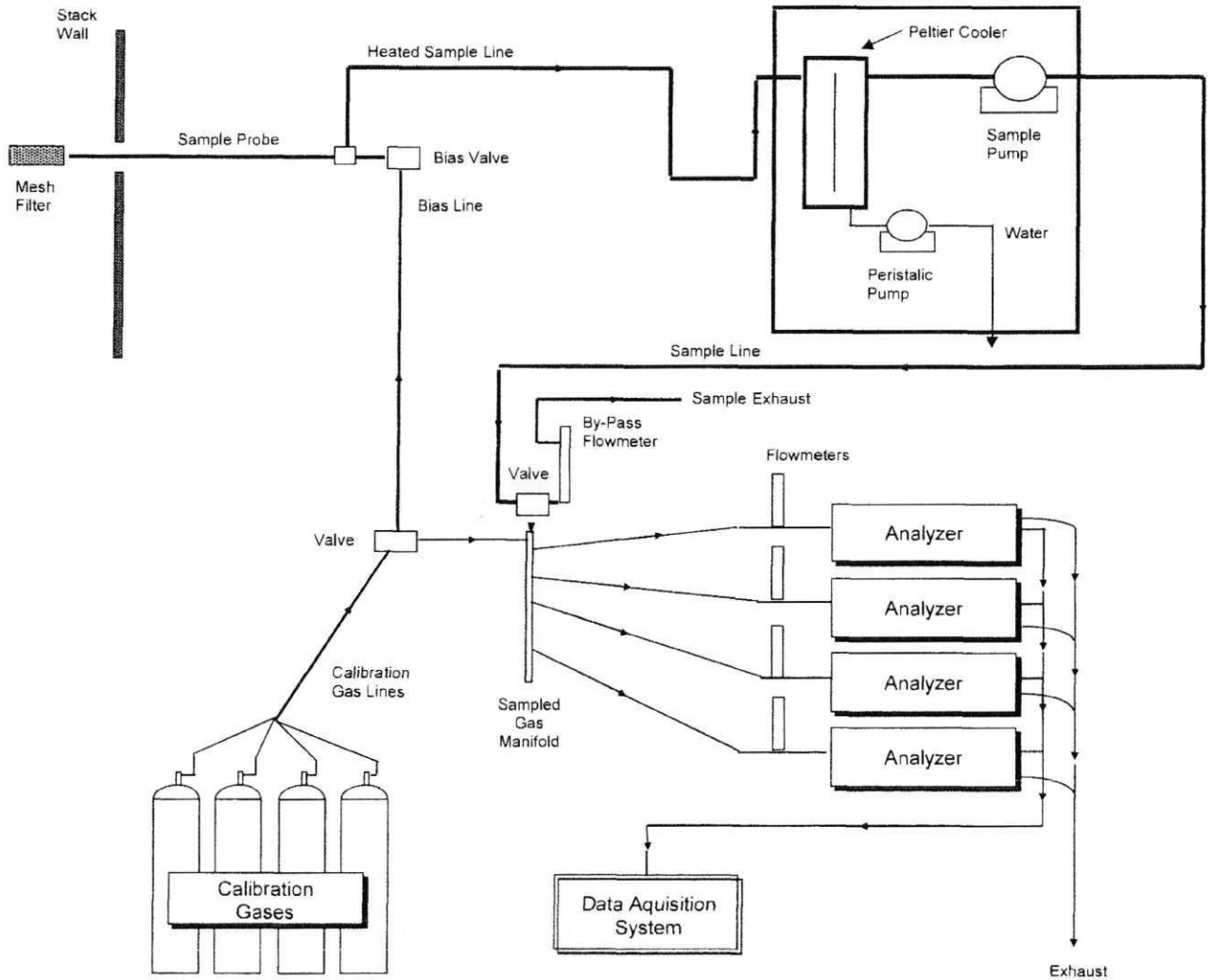


Figure 4. Schematic of Gas Analyzer Sampling Train.

METHOD 5 DRY GAS METER CALIBRATION USING CRITICAL ORIFICES

1) Select three critical orifices to calibrate the dry gas meter which bracket the expected operating range.
2) Record barometric pressure before and after calibration procedure.
3) Run at tested vacuum (from Orifice Calibration Report), for a period of time necessary to achieve a minimum total volume of 5 cubic feet.
4) Record data and information in the GREEN cells. YELLOW cells are calculated.

Quality - Service - Reliability

2014 Pre-Calibration

DATE: 12/6/2013
METER PART #: Console 4
METER SERIAL #: 27863
CRITICAL ORIFICE SET SERIAL #: 14535
BAROMETRIC PRESSURE (in Hg): INITIAL 25.45 | FINAL 25.25 | AVG (P_{bar}) 25.35
EQUIPMENT ID #: Console #4

IF Y VARIATION EXCEEDS 2.00%, ORIFICE SHOULD BE RECALIBRATED

ORIFICE #	RUN #	K' FACTOR (AVG)	TESTED VACUUM (in Hg)	DGM READINGS (FT^3) INITIAL	DGM READINGS (FT^3) FINAL	DGM READINGS (FT^3) NET (V_m)	TEMPERATURES °F AMBIENT	DGM INLET INITIAL	DGM INLET FINAL	DGM OUTLET INITIAL	DGM OUTLET FINAL	DGM AVG	ELAPSED TIME (MIN) θ	DGM ΔH (in H_2O)	(1) V_m (STD)	(2) V_{cr} (STD)	(3) Y	Y VARIATION (%)	$\Delta H_@$
30	1	0.8137	13	261.525	268.512	6.987	69	75	75	77	80	76.75	6.50	2.60	5.8683	5.8312	0.994		1.526
	2	0.8137	13	268.512	275.475	6.963	69	76	75	76	80	76.75	6.50	2.60	5.8481	5.8312	0.997		1.526
	3	0.8137	13	275.475	281.878	6.403	69	72	77	75	82	76.50	6.00	2.60	5.3803	5.3826	1.000		1.527
																AVG =	0.997	-0.28	
19	1	0.5317	13	300.021	306.251	6.230	69	67	68	68	69	68.00	9.00	1.10	5.2963	5.2758	0.996		1.531
	2	0.5317	13	306.251	312.128	5.877	69	68	69	68	71	69.00	8.50	1.10	4.9867	4.9827	0.999		1.528
	3	0.5317	13	312.128	318.340	6.212	69	68	71	67	70	69.00	9.00	1.10	5.2710	5.2758	1.001		1.528
																AVG =	0.999	-0.11	
12	1	0.3307	13	242.840	248.398	5.558	69	65	54	69	70	67.00	13.00	0.40	4.7244	4.7397	1.003		1.439
	2	0.3307	13	248.398	254.428	6.030	69	69	70	69	71	69.75	14.00	0.40	5.0989	5.1043	1.001		1.431
	3	0.3307	13	254.428	260.240	5.812	69	69	71	75	76	72.75	13.50	0.40	4.8869	4.9220	1.007		1.423
																AVG =	1.004	0.40	

USING THE CRITICAL ORIFICES AS CALIBRATION STANDARDS:
The following equations are used to calculate the standard volumes of air passed through the DGM, V_m (std), and the critical orifice, V_{cr} (std), and the DGM calibration factor, Y. These equations are automatically calculated in the spreadsheet above.

AVERAGE DRY GAS METER CALIBRATION FACTOR, Y = 1.000

AVERAGE $\Delta H_@$ = 1.495

(1) $$Vm_{(std)} = K_1 * Vm * \frac{Pbar + (\Delta H / 13.6)}{Tm}$$

= Net volume of gas sample passed through DGM, corrected to standard conditions
K_1 = 17.64 °R/in. Hg (English), 0.3858 °K/mm Hg (Metric)
T_m = Absolute DGM avg. temperature (°R - English, °K - Metric)

(2) $$Vcr_{(std)} = K' * \frac{Pbar * \Theta}{\sqrt{Tamb}}$$

= Volume of gas sample passed through the critical orifice, corrected to standard conditions
T_{amb} = Absolute ambient temperature (°R - English, °K - Metric)
K' = Average K' factor from Critical Orifice Calibration

(3) $$Y = \frac{Vcr_{(std)}}{Vm_{(std)}}$$

= DGM calibration factor

$$\Delta H_@ = \left(\frac{0.75\,\theta}{V_{cr}(std)}\right)^2 \Delta H \left(\frac{V_m(std)}{V_m}\right)$$

Temperature Sensors

	Reference °F	In °F	Out °F
Ice Bath	33	33	33
Ambient Air	62	62	62
Boiling Water	202	203	203

METHOD 5 DRY GAS METER CALIBRATION USING CRITICAL ORIFICES

1) Select three critical orifices to calibrate the dry gas meter which bracket the expected operating range.
2) Record barometric pressure before and after calibration procedure.
3) Run at tested vacuum (from Orifice Calibration Report), for a period of time necessary to achieve a minimum total volume of 5 cubic feet.
4) Record data and information in the GREEN cells. YELLOW cells are calculated.

Quality - Service - Reliability

BYU

DATE:	8/22/2014	METER SERIAL #:	27863	BAROMETRIC PRESSURE (in Hg):	INITIAL 25.45	FINAL 25.45	AVG (P_{bar}) 25.45
METER PART #:	Console 4	CRITICAL ORIFICE SET SERIAL #:	1453S	EQUIPMENT ID #:	Console #4		

IF Y VARIATION EXCEEDS 2.00%, ORIFICE SHOULD BE RECALIBRATED

ORIFICE #	RUN #	K' FACTOR (AVG)	TESTED VACUUM (in Hg)	DGM READINGS (FT^3) INITIAL	DGM READINGS (FT^3) FINAL	DGM READINGS (FT^3) NET (V_m)	TEMPERATURES °F AMBIENT	DGM INLET INITIAL	DGM INLET FINAL	DGM OUTLET INITIAL	DGM OUTLET FINAL	DGM AVG	ELAPSED TIME (MIN) θ	DGM ΔH (in H_2O)	(1) V_m (STD)	(2) V_{cr} (STD)	(3) Y	Y VARIATION (%)	$\Delta H_@$
12	1	0.3307	12	50.50	55.560	5.060	76	76	78	78	80	78	11.86	0.40	4.2297	4.3127	1.020		1.422
	2	0.3307	12	55.560	60.602	5.042	76	78	80	80	83	80.25	11.80	0.40	4.1971	4.2909	1.022		1.416
	3	0.3307	12	60.602	65.613	5.011	77	80	82	83	85	82.50	11.67	0.40	4.1539	4.2397	1.021		1.413
																AVG =	1.021	0.60	
19	1	0.5317	12	65.90	70.937	5.037	78	81	81	85	87	83.50	7.21	1.10	4.1762	4.2075	1.007		1.506
	2	0.5317	12	70.937	75.956	5.019	78	81	82	87	88	84.50	7.18	1.10	4.1537	4.190	1.009		1.504
	3	0.5317	12	75.956	81.015	5.059	78	82	82	87	88	84.75	7.24	1.10	4.1848	4.2250	1.010		1.503
																AVG =	1.009	-0.60	
	1					.0						0.00							
	2					.0						0.00							
	3					.0						0.00							
																AVG =			

USING THE CRITICAL ORIFICES AS CALIBRATION STANDARDS:
The following equations are used to calculate the standard volumes of air passed through the DGM, V_m (std), and the critical orifice, V_{cr} (std), and the DGM calibration factor, Y. These equations are automatically calculated in the spreadsheet above.

AVERAGE DRY GAS METER CALIBRATION FACTOR, Y = 1.015

AVERAGE $\Delta H_@$ = 1.461

(1) $$Vm_{(std)} = K_1 * Vm * \frac{Pbar + (\Delta H / 13.6)}{Tm}$$

= Net volume of gas sample passed through DGM, corrected to standard conditions
K_1 = 17.64 °R/in. Hg (English), 0.3858 °K/mm Hg (Metric)
T_m = Absolute DGM avg. temperature (°R - English, °K - Metric)

(2) $$Vcr_{(std)} = K' * \frac{Pbar * \Theta}{\sqrt{Tamb}}$$

= Volume of gas sample passed through the critical orifice, corrected to standard conditions
T_{amb} = Absolute ambient temperature (°R - English, °K - Metric)
K' = Average K' factor from Critical Orifice Calibration

(3) $$Y = \frac{Vcr_{(std)}}{Vm_{(std)}}$$

= DGM calibration factor

$$\Delta H_@ = \left(\frac{0.750}{V_{cr}(std)}\right)^2 \Delta H \left(\frac{V_m(std)}{V_m}\right)$$

Temperature Sensors

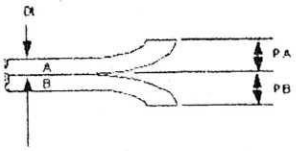
	Reference °F	In °F	Out °F
Ice Bath	32	33	33
Ambient Air	76	77	77
Boiling Water	204	203	203

Type S Pitot Tube Inspection Data

Date: 12/12/13

Pitot Tube Identification: 51-G

Technician: M. McNamara



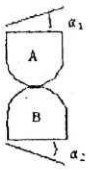
Dt= .375 in

Is $P_A = P_B$? Yes

Is $1.05 \cdot D_t \le D_t \le 1.50 \cdot D_t$? Yes

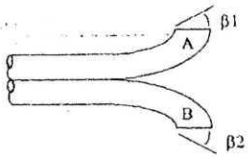
P_A = .468 in.

P_B = .468 in.



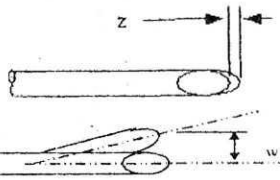
$\alpha_1 < 10°$ α_1 = 1 °

$\alpha_2 < 10°$ α_2 = 0 °

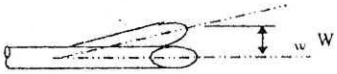


$\beta_1 < 5°$ β_1 = 2 °

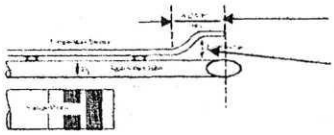
$\beta_2 < 5°$ β_2 = 2 °



$Z \le 0.125$ in. Z = .008 in.

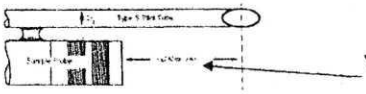


$W \le 0.03125$ in. W = .004 in.



W > 3 inches W = 7 in.

Z > 3/4 inch Z = 1 in.



$Y \ge 3$ inches Y = 3.5 in.

The pitot tube meets the specifications for a calibration factor of 0.84? Yes

Temperature Sensor Calibration

Reference:

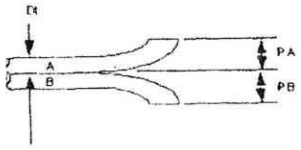
	Temperature Source (Medium)	Temperature Reference (°F)	Temperature Sensor (°F)	Temperature Difference (°F)
Probe	AIR	69	69	0
	Continuity			Yes
	Heat Check 248		Yes	250
Stack	AIR	69	69	0
	ICE WATER	33	32	1
	BOIL WATER	203	204	1
	SILICONE OIL			

Type S Pitot Tube Inspection Data

Date: 12-20-13

Pitot Tube Identification: 60-G-1

Technician: K. McNamara



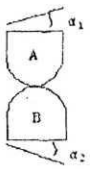
Dt= .375 in.

Is $P_A = P_B$? Yes

Is $1.05 \cdot D_t \le D_t \le 1.50 \cdot D_t$? Yes

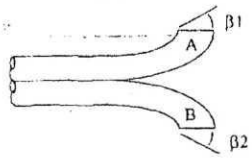
P_A = .455 in.

P_B = .455 in.



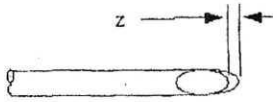
$\alpha_1 < 10°$ α_1 = 1 °

$\alpha_2 < 10°$ α_2 = 1 °

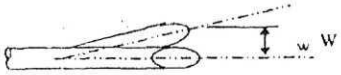


$\beta_1 < 5°$ β_1 = 0 °

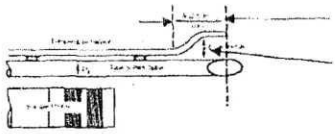
$\beta_2 < 5°$ β_2 = 1 °



$Z \le 0.125$ in. Z = .033 in.

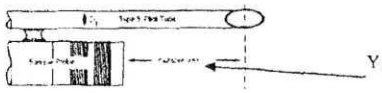


$W \le 0.03125$ in. W = .030 in.



W > 3 inches W = 6 1/2 in.

Z > 3/4 inch Z = 3 1/2 in.



Y ≥ 3 inches Y = Yes in.

The pitot tube meets the specifications for a calibration factor of 0.84? Y

Temperature Sensor Calibration

Reference:

	Temperature Source (Medium)	Temperature Reference (°F)	Temperature Sensor (°F)	Temperature Difference (°F)
Probe	AIR	69	69	0
	Continuity	—		Yes
	Heat Check 248	—	Yes	250
Stack	AIR	69	69	0
	ICE WATER	33	33	0
	BOIL WATER	204	204	0
	SILICONE OIL			

Environmental Supply Company, Inc.

Quality Source Sampling Systems & Accessories

Wind Tunnel Pitot Calibration

S-type Pitot ID:	**P-785**	Date:	**23-Feb-14**
Standard Pitot ID:	**RE2-20**	Personnel:	**BR**
Cp(std):	**0.99**	Cp(actual):	**0.764**
Part Number:		P_{bar}(in Hg):	**29.54**
Test Velocity (fps):	**50**	T(°F):	**56**
Wind Tunnel Location:	**Wake Forest, NC**	Tunnel Size:	**30" x 36"**

A-SIDE

ΔP_{std} (in. H_2O)	ΔP_s (in. H_2O)	Cp(s)	Deviation*
0.467	**0.773**	**0.769**	0.002
0.450	**0.770**	**0.757**	-0.001
0.460	**0.767**	**0.767**	0.000
	AVERAGE	**0.764**	0.001
		Std deviation	0.002

NOTES:

1. **Pitot calibrated with an Environmental Supply Co. PM10 cyclone.**
2. **C_p is only valid when used with PM10 cyclone.**
3. **C_p is only valid with 1" spacing from PM10 cyclone.**

$$Cp(s) = Cp(std)\sqrt{\frac{\Delta P(std)}{\Delta P(s)}}$$

*Deviation = {Cp(s) - *AVG* Cp(s)} {must be <0.010}

Standard deviation of the deviations must be less than 0.02 for both sides.

Pitot tube S/N P-785 was calibrated in accordance with the CFR 40, Part 60 Appendix A, Method 2, Section 10.

David Hen

Signature

2/23/14

Date

708 E. Club Blvd., Durham, North Carolina 27704 www.environsupply.com 919-956-9688 FAX: 919-682-0333

TETCO

Sample Box Temperature Sensor Calibration

Date: 12/13/13 Calibrator: Dean Kitchen Reference: Omega CL3512A

Unit ID	Thermocouple Location	Temperature Source (Medium)	Temperature Reference (°F)	Temperature Sensor (°F)	Temperature Difference (°F)
A	Oven	Water	32	34	2
		Water	204	203	-1
	Oven (4)	Water	33	34	1
		Water	204	202	-2
	Impinger Out	Water	33	34	1
		Water	204	203	-1
B	Oven	Water	33	33	0
		Water	204	202	-2
	Oven (4)	Water	33	34	1
		Water	203	203	0
	Impinger Out	Water	32	33	1
		Water	204	202	-2
C	Oven	Water	32	33	1
		Water	204	203	-1
	Oven (4)	Water	33	34	1
		Water	204	204	0
	Impinger Out	Water	33	33	0
		Water	203	202	-1
D	Oven	Water	33	34	1
		Water	203	203	0
	Oven (4)	Water	33	34	1
		Water	204	204	0
	Impinger Out	Water	33	33	0
		Water	204	202	-2
E	Oven	Water	33	34	1
		Water	203	202	-1
	Oven (4)	Water	33	33	0
		Water	204	203	-1
	Impinger Out	Water	33	34	1
		Water	204	203	-1
F	Oven	Water	33	34	1
		Water	204	202	-2
	Oven (4)	Water	33	34	1
		Water	204	202	-2
	Impinger Out	Water	33	33	0
		Water	203	202	-1
	Impinger Out G	Water	33	34	1
		Water	204	203	-1
	Impinger Out H	Water	33	34	1
		Water	204	202	-2
	Impinger Out I	Water	33	33	0
		Water	204	202	-2
	Impinger Out J	Water	33	34	1
		Water	203	202	-1

TETCO
Annual Balance Calibration Check

Date 12/19/13

Balance Denver Instruments, Model A-250, SN B045284

Weights Used Dener Instruments Weight Set,
SN 98-115146

Certified Weight grams	Measured Weight grams	Difference grams
0.1000	0.0999	0.0001
0.5000	0.5000	0.0000
1.0000	0.9999	0.0001
10.0000	9.9999	0.0001
50.0000	50.0001	-0.0001
100.0000	100.0001	-0.0001
120.0000	120.0000	0.0000
150.0000	150.0001	-0.0001

Technician Dean Kitchen

LIQUID TECHNOLOGY CORPORATION

"INDUSTRY LEADER IN SPECIALTY GASES"

Certificate of Analysis

- EPA PROTOCOL GAS -

* Extended Certificate *

Customer	TETCO (American Fork, UT)
Date	November 11, 2011
Delivery Receipt	DR-39358
Gas Standard	125 ppm NO, 125 ppm Carbon Monoxide/Nitrogen
Final Analysis Date	November 09, 2011
Expiration Date	November 09, 2019

DO NOT USE BELOW 150 psig

Analytical Data:
EPA Protocol, Section No. 2.2, Procedure G-1.

Reported Concentrations
Nitric Oxide: 127 ppm +/- 1.2 ppm
Carbon Monoxide: 136 ppm +/- 1.3 ppm
Nitrogen: Balance
Total NOx: 128 ppm
** Total NOx for Reference Use Only **

Reference Standards

SRM/GMIS	GMIS/GMIS	GMIS/GMIS
Cylinder Number:	EB-0027194/CC-56577	EB-0015851/CC-185111
Concentration:	96.25 ppm NO/249.21 ppm NO	105.98 ppm CO/257.47 ppm CO
Expiration Date:	04/25/13 - 01/03/13	10/21/12 - 10/22/12

Certification Instrumentation

Component:	Nitric Oxide	Carbon Monoxide
Make/Model:	Horiba - CLA 510	Horiba - VIA 510
Serial Number:	43331870031	UUBKWXYV
Principal of Measurement:	Chemiluminescence	NDIR
Last Calibration:	November 05, 2011	November 05, 2011

Cylinder Data

Cylinder Number:	CC-311364	Cylinder Volume:	130 Cubic Feet
Cylinder Outlet:	CGA 660	Cylinder Pressure:	1850 psig, 70°F
Expiration Date:	November 09, 2019		

Analytical Uncertainty and NIST Traceability are in compliance with EPA-600/R-12/531.

Certified by: David Scott

* Extended shelf life established January 22, 2013

PGVP Vendor ID: E12013

"UNMATCHED EXCELLENCE"

2048 APEX COURT APOPKA, FLORIDA 32703 ~ PHONE (407)-292-2990 FAX (407) 292-3313
WWW.LIQUIDTECHCORP.COM

LIQUID TECHNOLOGY CORPORATION

"INDUSTRY LEADER IN SPECIALTY GASES"

Certificate of Analysis

- EPA PROTOCOL GAS -

* Extended Certificate *

Customer	TETCO (American Fork, UT)
Date	August 09, 2012
Delivery Receipt	DR-43423
Gas Standard	230 ppm NO, 230 ppm Carbon Monoxide/Nitrogen
Final Analysis Date	August 05, 2012
Expiration Date	August 05, 2020

DO NOT USE BELOW 150 psig

Analytical Data:
EPA Protocol, Section No. 2.2, Procedure G-1.

Reported Concentrations
Nitric Oxide: 227 ppm +/- 2.2 ppm
Carbon Monoxide: 232 ppm +/- 2.3 ppm
Nitrogen: Balance
Total NOx: 228 ppm
** Total NOx for Reference Use Only **

Reference Standards

SRM/GMIS:	GMIS	GMIS
Cylinder Number:	CC-120933	CC-128982
Concentration:	262.83 ppm NO	257.47 ppm CO
Expiration Date:	01/13/14	10/20/12

Certification Instrumentation

Component:	Nitric Oxide	Carbon Monoxide
Make/Model:	Thermo 42i-LS	Horiba - VIA 510
Serial Number:	1033445889	UUBKWXYV
Principal of Measurement:	Chemiluminescence	NDIR
Last Calibration:	July 28, 2012	July 28, 2012

Cylinder Data

Cylinder Number:	EB-0024550	Cylinder Volume:	93 Cubic Feet
Cylinder Outlet:	CGA 660	Cylinder Pressure:	1325 psig, 70°F
Expiration Date:	August 05, 2020		

Analytical Uncertainty and NIST Traceability are in compliance with EPA-600/R-12/531.

Certified by: David Scott

PGVP Vendor ID: E12013

Original Data: 224 ppm NO, 224 ppm NOX, 238 ppm CO/Nitrogen (August 06, 2010)

* Extended shelf life established January 22, 2013

"UNMATCHED EXCELLENCE"

2048 APEX COURT APOPKA, FLORIDA 32703 ~ PHONE (407)-292-2990 FAX (407)-292-3313
WWW.LIQUIDTECHCORP.COM

AIR LIQUIDE Air Liquide America Specialty Gases LLC Scott

RATA CLASS

Dual-Analyzed Calibration Standard

500 WEAVER PARK RD, LONGMONT, CO 80501 Phone: 888-253-1635 Fax: 303-772-7673

CERTIFICATE OF ACCURACY: Interference Free™ Multi-Component EPA Protocol Gas

Assay Laboratory - PGVP Vendor ID: A42013

AIR LIQUIDE AMERICA SPECIALTY GASES LLC
500 WEAVER PARK RD
LONGMONT, CO 80501

P.O. No.: EPAS FOR STOCK
Document # : 49967938-009

Customer
ALA-CYL-SALT LAKE CITY (LOC 84427)

TRANSFER ACCOUNT- FILL LO
1676 SOUTH 700 WEST
SALT LAKE CITY UT 84104
US

ANALYTICAL INFORMATION Gas Type : CO2,O2,BALN

This certification was performed according to EPA Traceability Protocol For Assay & Certification of Gaseous Calibration Standards; Procedure G-1; September, 1997.

Cylinder Number: CC160837 **Certification Date:** 08Apr2013 **Exp. Date:** 09Apr2021
Cylinder Pressure*:** 2015 PSIG **Batch No:** LGM0084283

COMPONENT	CERTIFIED CONCENTRATION (Moles)		ACCURACY**	TRACEABILITY
CARBON DIOXIDE	10.1	%	+/- 1%	Direct NIST and VSL
OXYGEN	10.0	%	+/- 1%	
NITROGEN		BALANCE		

*** Do not use when cylinder pressure is below 150 psig.
** Analytical accuracy is based on the requirements of EPA Protocol Procedure G1, September 1997.

REFERENCE STANDARD

TYPE/SRM NO.	EXPIRATION DATE	CYLINDER NUMBER	CONCENTRATION	COMPONENT
NTRM 1675	05Jan2018	K015237	13.94 %	CARBON DIOXIDE
NTRM 2658	01Feb2016	K012175	10.03 %	OXYGEN

INSTRUMENTATION

INSTRUMENT/MODEL/SERIAL#	DATE LAST CALIBRATED	ANALYTICAL PRINCIPLE
FTIR/0929062	28Mar2013	FTIR
OXYMAT/6E/W5-951	11Mar2013	PARAMAGNETIC

ANALYZER READINGS

(Z = Zero Gas R = Reference Gas T = Test Gas r = Correlation Coefficient)

First Triad Analysis | Second Triad Analysis | Calibration Curve

CARBON DIOXIDE
Date: 05Apr2013 Response Unit:%
Z1 = 0.00114 R1 = 13.93662 T1 = 10.11691
R2 = 13.95509 Z2 = 0.00116 T2 = 10.11974
Z3 = 0.00448 T3 = 10.12244 R3 = 13.96093
Avg. Concentration: 10.11 %

Concentration = A + Bx + Cx2 + Dx3 + Ex4
r = 9.99997E-1
Constants: A = 0.00000E+0
B = 6.43498E-1 C = 4.66200E-3
D = 4.00000E-6 E = 0.00000E+0

OXYGEN
Date: 08Apr2013 Response Unit:VOLTS
Z1 = 0.00000 R1 = 10.04000 T1 = 10.03000
R2 = 10.03000 Z2 = 0.00000 T2 = 10.04000
Z3 = 0.00000 T3 = 10.03000 R3 = 10.03000
Avg. Concentration: 10.03 %

Concentration = A + Bx + Cx2 + Dx3 + Ex4
r = 0.999999
Constants A = 0.01274156
B = 0.999165608 C =
D = E =

APPROVED BY: _____
ADAM HANLEY

Download as...

500 WEAVER PARK RD, LONGMONT, CO 80501 Phone: 888-253-1635 Fax: 303-772-7673

RATA CLASS

Dual-Analyzed Calibration Standard

CERTIFICATE OF ACCURACY: Interference Free™ Multi-Component EPA Protocol Gas

Assay Laboratory - PGVP Vendor ID: A42010
AIR LIQUIDE AMERICA SPECIALTY GASES LLC
500 WEAVER PARK RD
LONGMONT, CO 80501

P.O. No.: TETCO ORDER
Document # : 38976952-003

Customer
ALA-CYL-SALT LAKE CITY (LOC 84427)

TRANSFER ACCOUNT- FILL LO
1676 SOUTH 700 WEST
SALT LAKE CITY UT 84104
US

ANALYTICAL INFORMATION Gas Type : CO2,O2,BALN

This certification was performed according to EPA Traceability Protocol For Assay & Certification of Gaseous Calibration Standards; Procedure G-1; September, 1997.

Cylinder Number: ALM007855
Cylinder Pressure*:** 2012 PSIG

Certification Date: 11Oct2010

Exp. Date: 12Oct2018
Batch No: LGM0008588

COMPONENT	CERTIFIED CONCENTRATION (Moles)	ACCURACY**	TRACEABILITY
CARBON DIOXIDE	20.7 %	+/- 1%	Direct NIST and VSL
OXYGEN	20.9 %	+/- 1%	
NITROGEN	BALANCE		

*** Do not use when cylinder pressure is below 150 psig.
** Analytical accuracy is based on the requirements of EPA Protocol Procedure G1, September 1997.

REFERENCE STANDARD

TYPE/SRM NO.	EXPIRATION DATE	CYLINDER NUMBER	CONCENTRATION	COMPONENT
NTRM 1800	01Mar2013	K015614	17.87 %	CARBON DIOXIDE
NTRM 2658	01Feb2016	K012175	10.03 %	OXYGEN

INSTRUMENTATION

INSTRUMENT/MODEL/SERIAL#	DATE LAST CALIBRATED	ANALYTICAL PRINCIPLE
FTIR//0929062	20Sep2010	FTIR
OXYMAT/6E/W5-951	01Oct2010	PARAMAGNETIC

ANALYZER READINGS

(Z=Zero Gas R=Reference Gas T=Test Gas r=Correlation Coefficient)

First Triad Analysis
CARBON DIOXIDE
Date: 08Oct2010 Response Unit: %
Z1=-0.00235 R1=17.87370 T1=20.67730
R2=17.87993 Z2=-0.00205 T2=20.69064
Z3=-0.00156 T3=20.69579 R3=17.88453
Avg. Concentration: 20.68 %
OXYGEN
Date: 11Oct2010 Response Unit: VOLTS
Z1=0.00000 R1=10.05000 T1=20.95000
R2=10.06000 Z2=0.00000 T2=20.97000
Z3=0.00000 T3=20.97000 R3=10.06000
Avg. Concentration: 20.92 %

Second Triad Analysis

Calibration Curve

Concentration=A+Bx+Cx2+Dx3+Ex4
r=9.99997E-1
Constants: A=0.00000E+0
B=5.83306E-1 C=4.44600E-3
D=0.00000E+0 E=0.00000E+0

Concentration=A+Bx+Cx2+Dx3+Ex4
r=0.999999
Constants: A=-0.01473945
B=1.000704376 C=
D= E=

QUALITY ASSURANCE

APPROVED BY: JAMES KRAUS
(signature on file)

AIR LIQUIDE Air Liquide America Specialty Gases LLC Scott

Shipped From:
500 WEAVER PARK RD
LONGMONT CO 80501
Phone: 888-253-1635 Fax: 303-772-7673

CERTIFICATE OF ANALYSIS

ASH GROVE CEMENT

HIGHWAY 132
6 MI E OF
LEAMINGTON UT 84638
US

DOCUMENT#:54258998 -005
PO#: 28358
ITEM #: 7501-30AL
DATE: 11Mar2014

CYLINDER #: CC217454
FILL PRESSURE: 2000 PSIG

PURE MATERIAL: NITROGEN CAS# 7727-37-9

GRADE: ACID RAIN CEM 0

PURITY: 99.9995%

IMPURITY	MAXIMUM CONCENTRATIONS	ACTUAL CONCENTRATIONS
SOX	0.1 PPM	< 0.1 PPM
NOX	0.1 PPM	< 0.1 PPM
CO	0.5 PPM	< 0.5 PPM
CO2	1 PPM	< 1 PPM
THC	0.1 PPM	< 0.1 PPM
H2O	2 PPM	< 2 PPM
O2	0.5 PPM	< 0.5 PPM

CGA 580

LOT # : LGM0114665

THIS CERTIFICATION DOES NOT EXPIRE PER EPA 600/R-12/531.

ANALYST: _____
BRANDON BUSSERT

NO_x Converter Efficiency Test

6:13	27.4
6:14	27.5
6:15	27.4
6:16	27.4
6:17	27.4
6:18	27.4
6:19	27.4
6:20	27.5
6:21	27.4
6:22	27.4
6:23	27.4
6:24	27.4
6:25	27.2
6:26	27.2
6:27	27.3
6:28	27.3
6:29	27.3
6:30	27.3
6:31	27.3
6:32	27.3
6:33	27.4
6:34	27.4
6:35	27.4
6:36	27.3
6:37	27.3
6:38	27.3
6:39	27.3
6:40	27.3
6:41	27.3
6:42	**27.3**

Concentration of Certified Gas used			ppmdv NO_x
Diluted with air at approx 1:1			
Instrument Span			ppmdv
	NO_{xPeak}	27.5	
	NO_{xFinal}		
(Eq. 7E-9)	Eff_{NO2}		%
Average Reading			ppmdv

40 CFR 60 Appendix A-4, Method 7E, Section 16.2.2

Fill a Tedlar bag approximately half full with either ambient air, pure oxygen, or an oxygen standard gas with at least 19.5 percent by volume oxygen content. Fill the remainder of the bag with mid-level NO in nitrogen calibration gas...

Immediately attach the bag to the inlet of the NO_x analyzer (or external converter if used) Measure the NO_x concentration for a period of 30 minutes. If the NO_x concentration drops more than 2 percent absolute from the peak value observed, then the NO_2 converter has failed to meet the criteria of this test. Take corrective action. The highest NO_x value observed is considered to be NO_{xPeak}. The final NO_x value observed is considered to be NO_{xFinal}.

APPENDIX F

The testing protocol and other correspondence related to the tests are included here.

State of Utah

GARY R. HERBERT
Governor

SPENCER J. COX
Lieutenant Governor

Department of
Environmental Quality

Amanda Smith
Executive Director

DIVISION OF AIR QUALITY
Bryce C. Bird
Director

COPY

August 6, 2014

DAQC-894-14
Site ID 10790 (B4)

Paul Greenwood
Brigham Young University
Physical Plant Department
225 BRWB
Provo, UT 84602

Dear Mr. Greenwood:

Re: Brigham Young University – Central Heating Plant Boilers #2, #3 and #5 - Protocol Review and Test Date Confirmation – Utah County

The testing protocols for the Brigham Young University Central Heating Plant Boilers #2, #3 and #5 received July 18, 2014, have been reviewed and found acceptable. The agreed upon test dates are August 18-23, 2014.

Acceptance of a protocol does not relieve the owner/operator and the testing contractor from strict adherence to all applicable EPA methods, Utah Division of Air Quality (DAQ) policies, Utah Air Quality Rules (UAQR), and methods approved by the Executive Secretary. Any deviation from EPA methods, DAQ policies, UAQR, and methods approved by the Executive Secretary must be addressed separately and express written consent given prior to commencement of testing.

The DAQ requires that all test reports include a statement signed by a responsible official certifying that:

A. Testing was conducted while the source was operating at the rate and/or conditions specified in the applicable approval order, operating permit, or federal regulation.

B. During testing, the source combusted fuels, used raw materials, and maintained process conditions representative of normal operations, and operated under such other relevant conditions specified by the Executive Secretary.

C. Based on information and belief formed after reasonable inquiry, the statements and information contained in the report are true, accurate, and complete.

COPY

If you have any questions, call me at (801) 536-4408 or e-mail me at rsirrine@utah.gov.

Sincerely,

Robert Sirrine

Robert Sirrine, Environmental Scientist
Division of Air Quality

RS:lk

cc: Utah County Health Department
TETCO

PM_{10} and NO_x COMPLIANCE EMISSION TESTING PROTOCOL
BRIGHAM YOUNG UNIVERSITY, PROVO, UTAH
CENTRAL HEATING PLANT BAGHOUSE
BOILERS #2, #3, AND #5

Project Organization and Responsibility

The following personnel and the testing contractor are presently anticipated to be involved in the testing program. Utah Department of Environmental Quality, Division of Air Quality (DAQ) may have their own personnel or contractor to observe all phases of the test project.

Company	Contacts
Brigham Young University Physical Plant Department 225 BRWB Provo, UT 84602	Paul Greenwood, (801) 422-5438 Assistant Director, Utilities, Engineering and Maintenance
Test Contractor TETCO 391 East 620 South American Fork, UT 84003	Dean A. Kitchen (801) 492-9106 Paul Kitchen

During these tests only Brigham Young University (BYU) personnel listed above or assigned personnel from the operation are authorized to answer or obtain answers to pertinent questions on the process conditions or the test protocol.

Test Schedule

It is planned to complete this test project the week of August 18, 2014. The testing crew will arrive, set up and take preliminary velocity, and cyclonic measurements on the 18th. One boiler will be tested per day with a planned starting date of August 19, 2014. A pretest meeting may be held at the request of BYU or DAQ.

Project Description

This test project will be conducted to comply with the requirements of BYU's Title V Operating Permit, Permit No. 4900004002, which requires testing the baghouse exhaust for PM_{10} emissions and Boilers #2, #3, and #5 for NO_x emissions every three years. The baghouse was last tested for PM_{10} emissions in 2012 and the boilers for NO_x emissions in 2013. BYU is advancing the test schedule to couple the testing with a boiler CO MACT test and to set the PM_{10} and NO_x testing on the same schedule.

PM_{10} particulate testing will be conducted using EPA Methods 201A and 202.

NO_x testing will be conducted according to EPA Methods 4 and 7E. It is planned to complete a separate Method 4 test for each NO_x test. NO_x testing may run concurrent with the PM_{10} testing on the baghouse; the exhaust flow rate measured during the PM_{10} test may be used to calculate NO_x lb/hr values.

The testing procedures will include accumulating process and production data.

Test Procedures

Methods 1-4, 7E, 201A, and 202

Three test runs of at least one hour each will be conducted for the PM_{10} test. Stack testing will be EPA Methods 1-4 as specified in 40 CFR 60 Appendix A and EPA Methods 201A and 202 as specified in 40 CFR 51 Appendix M. Method 202 is not for compliance but for informational purposes only.

Three NO_x tests runs will be conducted on each unit for NO_x emissions. Each test run will be at least one hour in duration. Testing will be EPA Methods 1-4 and 7E as specified in 40 CFR 60, Appendix A.

Additional procedures for the Method 4 and/or Method 201A tests are as follows:

1. Boilers #2, #3, and #5 have a common exhaust stack with an inside diameter of 136 inches. The sample ports are located 46 feet downstream and 57 feet upstream from any flow disturbance and conform to EPA Method 1. Sample points will be selected according to EPA Method 1.

2. EPA Method 2 will be used to determine the gas stream velocity. Type "S" pitot tubes will be used with a C_p factor of 0.84. Dual inclined/vertical manometers with graduations of 0.01 inches of water will be used. If the flows are below 0.05 inches of water a more sensitive manometer will be used. The graduation marks on it are .005 inches of water. Direction of gas flow will be checked for gas cyclonics prior to testing

3. EPA Method 3A will be used to determine the gas stream dry molecular weight. It is planned to use a CAI model ZRE dual gas unit to measure the CO_2 and O_2 levels. The CO_2 is measured with an NDIR and the O_2 with an electrochemical cell. The CO_2/O_2 measurements will run concurrent with the NO_x measurements.

4. EPA Method 4 will be followed to determine the gas stream moisture content.

5. Target sample time for Method 201A will be sufficient to ensure that the actual sample time will be at least 60 minutes.

Each Method 4 test will be of sufficient time to sample at least 21 dscf.

The duration of each Method 7E test run will be at least 60 minutes.

6. Probe liners will be borosilicate glass or Teflon for the PM_{10} testing and stainless steel for Method 4 sampling.

7. The glass fiber filters for the PM_{10} tests will meet the requirements of the method.

8. The barometric pressure will be measured with a barometer which is periodically checked against a mercury barometer. The barometer will be checked prior to testing to assure an accurate barometric pressure.

9. All current calibration data is submitted with this protocol, except nozzle calibration which will be done at the test site. Nozzle calibration will be included on the first page of each set of run sheets for each respective test run. Any calibration that is not current will be re-calibrated prior to the test dates.

10. Any necessary preparation and clean-up by the contractor will be performed in the contractor's sampling trailer. The laboratory work and analysis will be done by the contractor as soon as possible after the test project at 391 East 620 South, American Fork, Utah.

11. Verbal results will be reported to BYU. The written reports will submitted within 30 days following completion of the tests.

12. If plant maintenance or operating problems arise during the test, the test may be stopped. This determination will be made by the Brigham Young University representatives or operating personnel in consultation with agency representatives.

Gaseous Analyzer Measurements

The following procedures will be followed for the Method 3A and 7E tests:

1. A gaseous analyzer will be used to measure the NO_x concentration during the emissions test project. It is planned to run the NO_x machine on the 0-250 ppm range. EPA Protocol 1 gases will be used as calibration standards with dry nitrogen as a zero gas.

2. As previously noted, a gaseous analyzer will be used to measure the CO_2 and O_2 levels during the emissions test project. The CO_2 analyzer will run on the 0-10 percent range and the O_2 analyzer the 0-25 percent range. EPA Protocol 1 gases would be used as calibration standards with dry nitrogen as a zero gas.

3. The gas analyzer sampling train will consist of the following: an in-stack glass fiber filter, heated stainless steel probe, Teflon heated sampling line to the water removal system, water removal system, Teflon transport lines, gas manifold, and out of stack Teflon filter after the gas manifold but prior to analyzers. The sampling train is built such that the sampled gas only comes in contact with inert materials, i.e., Teflon, stainless steel, and glass.

4. The number of sample points for the Methods 3Aand 7E sampling train will be determined according to the results of a stratification check as per Method 7E, section 8.1.2.

5. The NO_x converter efficience check will be completed according to Method 7E, section 16.2.2.

6. Bias checks, calibration drift, zero drift and calibration error will follow the specified guidelines of EPA Methods 3A and 7E. Interference responses were determined in the factory and no alterations have been done, therefore, factory specifications are satisfactory.

7. A data logger will be used to record measured concentrations. Gas analyzer data during port changes will not be considered valid data.

Test Area

The test area shall include the Heating Plant control room, main floor, and stack areas, and the area around the contractors testing trailer.

Process Data

Process parameters are available via computer in the Heating Plant control room. Pertinent process parameters will be made available to DAQ personnel and included in the test report.

Quality Assurance

All testing and analysis in these compliance tests will be conducted according to Methods 3A, 4, 7E, 201A and 202 and appropriate sections of the EPA *Quality Assurance Handbook for Air Pollution Measurement Systems Volume III.*

Reporting

Complete copies of raw data, calculations and summary of test will be included in reports. All process and production data will be recorded and retained for inspection and copying by DAQ and

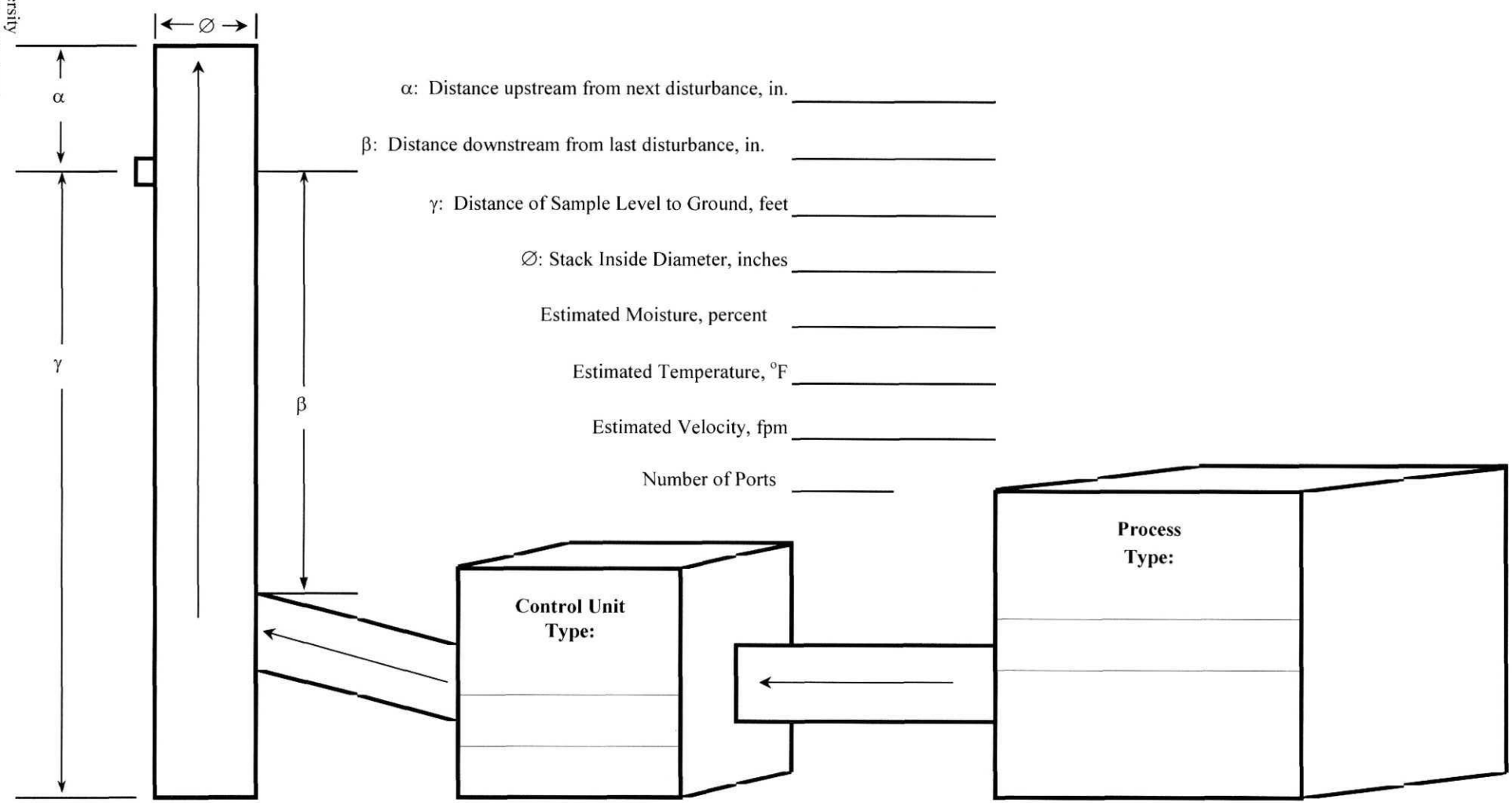
EPA. The contractor will furnish copies of the test report to Paul Greenwood, Assistant Director, Utilities, Engineering and Maintenance.

Appendix A

Facility Schematic

Facility: _____

Stack Identification: _____



α: Distance upstream from next disturbance, in. _____

β: Distance downstream from last disturbance, in. _____

γ: Distance of Sample Level to Ground, feet _____

∅: Stack Inside Diameter, inches _____

Estimated Moisture, percent _____

Estimated Temperature, °F _____

Estimated Velocity, fpm _____

Number of Ports _____

Appendix B

Calibration Data

METHOD 5 DRY GAS METER CALIBRATION USING CRITICAL ORIFICES

1) Select three critical orifices to calibrate the dry gas meter which bracket the expected operating range.
2) Record barometric pressure before and after calibration procedure.
3) Run at tested vacuum (from Orifice Calibration Report), for a period of time necessary to achieve a minimum total volume of 5 cubic feet.
4) Record data and information in the cells, YELLOW cells are calculated.

ENVIRONMENTAL SUPPLY COMPANY

Facility **New Calibration 2014**

					INITIAL	FINAL	AVG (P_{bar})
DATE:	12/20/2013	METER SERIAL #:	1522588	BAROMETRIC PRESSURE (in Hg):	25.55	25.55	25.55
METER PART #:	Console 3	CRITICAL ORIFICE SET SERIAL #:	1453S	EQUIPMENT ID #:	Console #3		

IF Y VARIATION EXCEEDS 2.00%, ORIFICE SHOULD BE RECALIBRATED

ORIFICE #	RUN #	K' FACTOR (AVG)	TESTED VACUUM (in Hg)	DGM READINGS (FT^3) INITIAL	DGM READINGS (FT^3) FINAL	DGM READINGS (FT^3) NET (V_m)	TEMPERATURES °F AMBIENT	DGM INLET INITIAL	DGM INLET FINAL	DGM OUTLET INITIAL	DGM OUTLET FINAL	DGM AVG	ELAPSED TIME (MIN) θ	DGM ΔH (in H_2O)	(1) V_m (STD)	(2) V_{cr} (STD)	(3) Y	Y VARIATION (%)	$\Delta H_@$
30	1	0.8137	13	309.703	315.060	5.357	75	77	79	77	79	78	5.00	2.90	4.5278	4.4955	0.993		1.706
	2	0.8137	13	315.060	320.956	5.896	75	79	81	79	82	80.25	5.50	2.90	4.9626	4.9450	0.996		1.699
	3	0.8137	13	320.956	326.293	5.337	75	82	83	82	82	82.25	5.00	2.90	4.4755	4.4955	1.004		1.692
																AVG =	0.998	-0.39	
19	1	0.5317	13	65.801	74.063	8.262	75	70	71	71	72	71.00	12.00	1.20	7.0409	7.050	1.001		1.667
	2	0.5317	13	74.063	81.662	7.599	75	71	72	72	72	71.75	11.00	1.20	6.4668	6.4625	0.999		1.664
	3	0.5317	13	286.80	292.304	5.504	75	72	73	72	73	72.50	8.00	1.20	4.6773	4.70	1.005		1.662
																AVG =	1.002	0.00	
12	1	0.3307	13	292.50	298.092	5.592	75	74	74	74	74	74.00	13.00	0.45	4.7286	4.7503	1.005		1.603
	2	0.3307	13	298.092	303.676	5.584	75	74	75	74	75	74.50	13.00	0.45	4.7174	4.7503	1.007		1.602
	3	0.3307	13	303.676	309.260	5.584	75	75	73	74	74	74.00	13.00	0.45	4.7218	4.7503	1.006		1.603
																AVG =	1.006	0.40	

USING THE CRITICAL ORIFICES AS CALIBRATION STANDARDS:
The following equations are used to calculate the standard volumes of air passed through the DGM, V_m (std), and the critical orifice, V_{cr} (std), and the DGM calibration factor, Y. These equations are automatically calculated in the spreadsheet above.

AVERAGE DRY GAS METER CALIBRATION FACTOR, Y = 1.002

AVERAGE $\Delta H_@$ = 1.655

(1) $$Vm_{(std)} = K_1 * Vm * \frac{Pbar + (\Delta H / 13.6)}{Tm}$$

= Net volume of gas sample passed through DGM, corrected to standard conditions
K_1 = 17.64 °R/in. Hg (English), 0.3858 °K/mm Hg (Metric)
T_m = Absolute DGM avg. temperature (°R - English, °K - Metric)

(2) $$Vcr_{(std)} = K' * \frac{Pbar * \Theta}{\sqrt{Tamb}}$$

= Volume of gas sample passed through the critical orifice, corrected to standard conditions
T_{amb} = Absolute ambient temperature (°R - English, °K - Metric)
K' = Average K' factor from Critical Orifice Calibration

(3) $$Y = \frac{Vcr_{(std)}}{Vm_{(std)}}$$

= DGM calibration factor

$$\Delta H_@ = \left(\frac{0.75\,\theta}{V_{cr}(std)}\right)^2 \Delta H \left(\frac{V_m(std)}{V_m}\right)$$

Temperature Sensors

Reference °F	In °F	Out °F
33	34	34
67	68	68
202	203	203

METHOD 5 DRY GAS METER CALIBRATION USING CRITICAL ORIFICES

Quality - Service - Reliability

1) Select three critical orifices to calibrate the dry gas meter which bracket the expected operating range.
2) Record barometric pressure before and after calibration procedure.
3) Run at tested vacuum (from Orifice Calibration Report), for a period of time necessary to achieve a minimum total volume of 5 cubic feet.
4) Record data and information in the cells, YELLOW cells are calculated.

2014 Pre-Calibration

DATE: 12/6/2013 | METER SERIAL #: 27863 | BAROMETRIC PRESSURE (in Hg): INITIAL 25.45, FINAL 25.25, AVG (P_{bar}) 25.35

METER PART #: Console 4 | CRITICAL ORIFICE SET SERIAL #: 1453S | EQUIPMENT ID #: **Console #4**

IF Y VARIATION EXCEEDS 2.00%, ORIFICE SHOULD BE RECALIBRATED

ORIFICE #	RUN #	K' FACTOR (AVG)	TESTED VACUUM (in Hg)	DGM READINGS (FT^3) INITIAL	DGM READINGS (FT^3) FINAL	NET (V_m)	TEMPERATURES °F AMBIENT	DGM INLET INITIAL	DGM INLET FINAL	DGM OUTLET INITIAL	DGM OUTLET FINAL	DGM AVG	ELAPSED TIME (MIN) θ	DGM ΔH (in H_2O)	(1) V_m (STD)	(2) V_{cr} (STD)	(3) Y	Y VARIATION (%)	$\Delta H_@$
30	1	0.8137	13	261.525	268.512	6.987	69	75	75	77	80	76.75	6.50	2.60	5.8683	5.8312	0.994		1.526
	2	0.8137	13	268.512	275.475	6.963	69	76	75	76	80	76.75	6.50	2.60	5.8481	5.8312	0.997		1.526
	3	0.8137	13	275.475	281.878	6.403	69	72	77	75	82	76.50	6.00	2.60	5.3803	5.3826	1.000		1.527
																AVG =	0.997	-0.28	
19	1	0.5317	13	300.021	306.251	6.230	69	67	68	68	69	68.00	9.00	1.10	5.2963	5.2758	0.996		1.531
	2	0.5317	13	306.251	312.128	5.877	69	68	69	68	71	69.00	8.50	1.10	4.9867	4.9827	0.999		1.528
	3	0.5317	13	312.128	318.340	6.212	69	68	71	67	70	69.00	9.00	1.10	5.2710	5.2758	1.001		1.528
																AVG =	0.999	-0.11	
12	1	0.3307	13	242.840	248.398	5.558	69	65	64	69	70	67.00	13.00	0.40	4.7244	4.7397	1.003		1.439
	2	0.3307	13	248.398	254.428	6.030	69	69	70	69	71	69.75	14.00	0.40	5.0989	5.1043	1.001		1.431
	3	0.3307	13	254.428	260.240	5.812	69	69	71	75	76	72.75	13.50	0.40	4.8869	4.9220	1.007		1.423
																AVG =	1.004	0.40	

USING THE CRITICAL ORIFICES AS CALIBRATION STANDARDS:
The following equations are used to calculate the standard volumes of air passed through the DGM, V_m (std), and the critical orifice, V_{cr} (std), and the DGM calibration factor, Y. These equations are automatically calculated in the spreadsheet above.

AVERAGE DRY GAS METER CALIBRATION FACTOR, Y = 1.000

AVERAGE $\Delta H_@$ = 1.495

(1) $$Vm_{(std)} = K_1 * Vm * \frac{Pbar + (\Delta H / 13.6)}{Tm}$$

= Net volume of gas sample passed through DGM, corrected to standard conditions
K_1 = 17.64 °R/in. Hg (English), 0.3858 °K/mm Hg (Metric)
T_m = Absolute DGM avg. temperature (°R - English, °K - Metric)

(2) $$Vcr_{(std)} = K' * \frac{Pbar * \Theta}{\sqrt{Tamb}}$$

= Volume of gas sample passed through the critical orifice, corrected to standard conditions
T_{amb} = Absolute ambient temperature (°R - English, °K - Metric)
K' = Average K' factor from Critical Orifice Calibration

(3) $$Y = \frac{Vcr_{(std)}}{Vm_{(std)}}$$

= DGM calibration factor

$$\Delta H_@ = \left(\frac{0.75\,\theta}{V_{cr}(std)}\right)^2 \Delta H \left(\frac{V_m(std)}{V_m}\right)$$

Temperature Sensors

	Reference °F	In °F	Out °F
Ice Bath	33	33	33
Ambient Air	62	62	62
Boiling Water	202	203	203

METHOD 5 DRY GAS METER CALIBRATION USING CRITICAL ORIFICES

Quality - Service - Reliability

1) Select three critical orifices to calibrate the dry gas meter which bracket the expected operating range.
2) Record barometric pressure before and after calibration procedure.
3) Run at tested vacuum (from Orifice Calibration Report), for a period of time necessary to achieve a minimum total volume of 5 cubic feet.
4) Record data and information in the cells, YELLOW cells are calculated.

2014 Pre-Calibration

DATE: 12/3/2013 | METER SERIAL #: 68092 | BAROMETRIC PRESSURE (in Hg): INITIAL 25.05, FINAL 25.05, AVG (P_{bar}) 25.05

METER PART #: Console 5 | CRITICAL ORIFICE SET SERIAL #: 1453S | EQUIPMENT ID #: Console #5

IF Y VARIATION EXCEEDS 2.00%, ORIFICE SHOULD BE RECALIBRATED

ORIFICE #	RUN #	K' FACTOR (AVG)	TESTED VACUUM (in Hg)	DGM READINGS (FT^3) INITIAL	DGM READINGS (FT^3) FINAL	DGM READINGS (FT^3) NET (V_m)	TEMPERATURES °F AMBIENT	DGM INLET INITIAL	DGM INLET FINAL	DGM OUTLET INITIAL	DGM OUTLET FINAL	DGM AVG	ELAPSED TIME (MIN) θ	DGM ΔH (in H_2O)	(1) V_m (STD)	(2) V_{cr} (STD)	(3) Y	Y VARIATION (%)	$\Delta H_@$
30	1	0.8137	13	201.341	207.873	6.532	65	82	86	83	87	84.50	6.00	2.60	5.3445	5.3391	0.999		1.511
	2	0.8137	13	207.873	213.329	5.456	65	83	87	82	89	85.25	5.00	2.60	4.4579	4.4493	0.998		1.509
	3	0.8137	13	213.329	218.790	5.461	65	82	89	83	93	86.75	5.00	2.60	4.4498	4.4493	1.000		1.505
																AVG =	0.999	-0.14	
19	1	0.5317	13	166.0190	171.673	5.654	65	80	82	80	84	81.50	8.00	1.11	4.6315	4.6517	1.004		1.513
	2	0.5317	13	171.673	177.364	5.691	65	80	84	84	86	83.50	8.00	1.11	4.6447	4.6517	1.002		1.507
	3	0.5317	13	177.364	182.725	5.361	65	84	86	93	94	89.25	7.50	1.11	4.3295	4.3610	1.007		1.491
																AVG =	1.004	0.40	
12	1	0.3307	14	184.250	189.510	5.260	65	70	70	75	77	73.00	12.00	0.40	4.3684	4.3398	0.993		1.429
	2	0.3307	14	189.510	194.784	5.274	65	74	75	80	82	77.75	12.00	0.40	4.3414	4.3398	1.000		1.416
	3	0.3307	14	194.784	200.112	5.328	65	80	82	85	88	83.75	12.00	0.40	4.3374	4.3398	1.001		1.400
																AVG =	0.998	-0.25	

USING THE CRITICAL ORIFICES AS CALIBRATION STANDARDS:
The following equations are used to calculate the standard volumes of air passed through the DGM, V_m (std), and the critical orifice, V_{cr} (std), and the DGM calibration factor, Y. These equations are automatically calculated in the spreadsheet above.

AVERAGE DRY GAS METER CALIBRATION FACTOR, Y = **1.000**

AVERAGE $\Delta H_@$ = **1.476**

(1) $$Vm_{(std)} = K_1 * Vm * \frac{Pbar + (\Delta H / 13.6)}{Tm}$$

= Net volume of gas sample passed through DGM, corrected to standard conditions
K_1 = 17.64 °R/in. Hg (English), 0.3858 °K/mm Hg (Metric)
T_m = Absolute DGM avg. temperature (°R - English, °K - Metric)

(2) $$Vcr_{(std)} = K' * \frac{Pbar * \Theta}{\sqrt{Tamb}}$$

= Volume of gas sample passed through the critical orifice, corrected to standard conditions
T_{amb} = Absolute ambient temperature (°R - English, °K - Metric)
K' = Average K' factor from Critical Orifice Calibration

(3) $$Y = \frac{Vcr_{(std)}}{Vm_{(std)}}$$

= DGM calibration factor

$$\Delta H_@ = \left(\frac{0.75\,\theta}{V_{cr}(std)}\right)^2 \Delta H \left(\frac{V_m(std)}{V_m}\right)$$

Temperature Sensors

Reference °F	In °F	Out °F
32	33	32
72	73	73
203	202	202

Pre 2014 5 console

METHOD 5 DRY GAS METER CALIBRATION USING CRITICAL ORIFICES

Quality - Service - Reliability

1) Select three critical orifices to calibrate the dry gas meter which bracket the expected operating range.
2) Record barometric pressure before and after calibration procedure.
3) Run at tested vacuum (from Orifice Calibration Report), for a period of time necessary to achieve a minimum total volume of 5 cubic feet.
4) Record data and information in the cells, YELLOW cells are calculated.

2014 Pre-Calibration

DATE: 12/11/2013 | METER SERIAL #: 26144 | BAROMETRIC PRESSURE (in Hg): INITIAL 25.80, FINAL 25.80, AVG (P_{bar}) 25.40

METER PART #: Console 6 | CRITICAL ORIFICE SET SERIAL #: 1453S | EQUIPMENT ID #: **Console #6**

IF Y VARIATION EXCEEDS 2.00%, ORIFICE SHOULD BE RECALIBRATED

ORIFICE #	RUN #	K' FACTOR (AVG)	TESTED VACUUM (in Hg)	DGM READINGS (FT^3) INITIAL	DGM READINGS (FT^3) FINAL	DGM READINGS (FT^3) NET (V_m)	TEMPERATURES °F AMBIENT	DGM INLET INITIAL	DGM INLET FINAL	DGM OUTLET INITIAL	DGM OUTLET FINAL	DGM AVG	ELAPSED TIME (MIN) θ	DGM ΔH (in H_2O)	(1) V_m (STD)	(2) V_{cr} (STD)	(3) Y	Y VARIATION (%)	$\Delta H_@$
30	1	0.8137	12	728.375	737.588	9.213	71	74	81	75	86	79	8.50	2.90	7.7273	7.6260	0.987		1.700
	2	0.8137	12	737.588	750.681	13.093	71	75	86	80	92	83.25	12.00	2.90	10.8956	10.7661	0.988		1.686
	3	0.8137	12	750.681	768.774	18.093	71	80	92	80	90	85.5	16.50	2.90	14.9943	14.8034	0.987		1.680
																AVG =	0.987	0.02	
19	1	0.5317	12	707.497	714.208	6.711	71	73	73	73	79	74.50	9.50	1.20	5.6485	5.5693	0.986		1.653
	2	0.5317	12	714.208	720.235	6.027	71	73	79	74	81	76.75	8.50	1.20	5.0515	4.9831	0.986		1.646
	3	0.5317	12	720.235	728.375	8.140	71	74	81	74	81	77.50	11.50	1.20	6.8129	6.7418	0.990		1.644
																AVG =	0.987	0.01	
12	1	0.3307	12	689.425	694.924	5.499	71	73	75	75	80	75.75	12.50	0.43	4.6073	4.5578	0.989		1.524
	2	0.3307	12	694.924	701.978	7.054	71	75	80	73	76	76.00	16.00	0.43	5.9074	5.8340	0.988		1.524
	3	0.3307	12	701.978	707.497	5.519	71	73	76	72	78	74.75	12.50	0.43	4.6327	4.5578	0.984		1.527
																AVG =	0.987	-0.03	

USING THE CRITICAL ORIFICES AS CALIBRATION STANDARDS:
The following equations are used to calculate the standard volumes of air passed through the DGM, V_m (std), and the critical orifice, V_{cr} (std), and the DGM calibration factor, Y. These equations are automatically calculated in the spreadsheet above.

AVERAGE DRY GAS METER CALIBRATION FACTOR, Y = 0.987

AVERAGE $\Delta H_@$ = 1.620

(1) $$Vm_{(std)} = K_1 * Vm * \frac{Pbar + (\Delta H / 13.6)}{Tm}$$

= Net volume of gas sample passed through DGM, corrected to standard conditions
K_1 = 17.64 °R/in. Hg (English), 0.3858 °K/mm Hg (Metric)
T_m = Absolute DGM avg. temperature (°R - English, °K - Metric)

(2) $$Vcr_{(std)} = K' * \frac{Pbar * \Theta}{\sqrt{Tamb}}$$

= Volume of gas sample passed through the critical orifice, corrected to standard conditions
T_{amb} = Absolute ambient temperature (°R - English, °K - Metric)
K' = Average K' factor from Critical Orifice Calibration

(3) $$Y = \frac{Vcr_{(std)}}{Vm_{(std)}}$$

= DGM calibration factor

$$\Delta H_@ = \left(\frac{0.75\,\theta}{V_{cr}(std)}\right)^2 \Delta H \left(\frac{V_m(std)}{V_m}\right)$$

Temperature Sensors

Reference °F	In °F	Out °F
33	33	33
68	67	68
202	202	202

METHOD 5 DRY GAS METER CALIBRATION USING CRITICAL ORIFICES

Quality - Service - Reliability

ENVIRONMENTAL SUPPLY COMPANY

2014 Pre-Calibration Console 7

1) Select three critical orifices to calibrate the dry gas meter which bracket the expected operating range.
2) Record barometric pressure before and after calibration procedure.
3) Run at tested vacuum (from Orifice Calibration Report), for a period of time necessary to achieve a minimum total volume of 5 cubic feet.
4) Record data and information in the cells, YELLOW cells are calculated.

DATE: 12/11/2013 | METER SERIAL #: 68092 | BAROMETRIC PRESSURE (in Hg): INITIAL 25.80, FINAL 25.80, AVG (P_{bar}) 25.80

METER PART #: Console 7 | CRITICAL ORIFICE SET SERIAL #: 1453S | EQUIPMENT ID #: Console #7

IF Y VARIATION EXCEEDS 2.00%, ORIFICE SHOULD BE RECALIBRATED

ORIFICE #	RUN #	K' FACTOR (AVG)	TESTED VACUUM (in Hg)	DGM READINGS (FT^3) INITIAL	DGM READINGS (FT^3) FINAL	DGM READINGS (FT^3) NET (V_m)	TEMPERATURES °F AMBIENT	DGM INLET INITIAL	DGM INLET FINAL	DGM OUTLET INITIAL	DGM OUTLET FINAL	DGM AVG	ELAPSED TIME (MIN) θ	DGM ΔH (in H_2O)	(1) V_m (STD)	(2) V_{cr} (STD)	(3) Y	Y VARIATION (%)	$\Delta H_@$
30	1	0.8137	13	449.035	454.600	5.565	60	75	78	76	81	77.5	5.00	3.20	4.7577	4.6045	0.968		1.815
	2	0.8137	13	454.600	460.702	6.102	60	76	81	80	85	80.5	5.50	3.20	5.1878	5.0649	0.976		1.805
	3	0.8137	13	460.702	466.825	6.123	60	81	90	86	91	87	5.50	3.20	5.1438	5.0649	0.985		1.783
																AVG =	0.976	-1.15	
19	1	0.5317	13	870.880	876.522	5.642	60	74	78	74	80	76.50	8.00	1.25	4.8059	4.8140	1.002		1.654
	2	0.5317	13	876.522	882.542	6.020	60	74	80	78	80	78.00	8.50	1.25	5.1136	5.1149	1.000		1.649
	3	0.5317	13	882.542	888.232	5.690	60	78	80	80	82	80.00	8.00	1.25	4.8154	4.8140	1.000		1.643
																AVG =	1.001	1.31	
12	1	0.3307	13	411.400	416.80	5.40	60	75	76	75	80	76.50	12.00	0.47	4.5896	4.4912	0.979		1.604
	2	0.3307	13	416.80	422.214	5.414	60	76	78	80	85	79.75	12.00	0.47	4.5738	4.4912	0.982		1.594
	3	0.3307	13	422.214	428.017	5.803	60	78	78	85	89	82.50	13.00	0.47	4.8775	4.8655	0.998		1.586
																AVG =	0.986	-0.16	

USING THE CRITICAL ORIFICES AS CALIBRATION STANDARDS:
The following equations are used to calculate the standard volumes of air passed through the DGM, V_m (std), and the critical orifice, V_{cr} (std), and the DGM calibration factor, Y. These equations are automatically calculated in the spreadsheet above.

AVERAGE DRY GAS METER CALIBRATION FACTOR, Y = **0.988**

AVERAGE $\Delta H_@$ = **1.682**

(1) $$Vm_{(std)} = K_1 * Vm * \frac{Pbar + (\Delta H / 13.6)}{Tm}$$

= Net volume of gas sample passed through DGM, corrected to standard conditions
K_1 = 17.64 °R/in. Hg (English), 0.3858 °K/mm Hg (Metric)
T_m = Absolute DGM avg. temperature (°R - English, °K - Metric)

(2) $$Vcr_{(std)} = K' * \frac{Pbar * \Theta}{\sqrt{Tamb}}$$

= Volume of gas sample passed through the critical orifice, corrected to standard conditions
T_{amb} = Absolute ambient temperature (°R - English, °K - Metric)
K' = Average K' factor from Critical Orifice Calibration

(3) $$Y = \frac{Vcr_{(std)}}{Vm_{(std)}}$$

= DGM calibration factor

$$\Delta H_@ = \left(\frac{0.75\,\theta}{V_{cr}(std)}\right)^2 \Delta H \left(\frac{V_m(std)}{V_m}\right)$$

Temperature Sensors

Reference °F	In °F	Out °F
32	33	33
72	73	73
201	202	203

METHOD 5 DRY GAS METER CALIBRATION USING CRITICAL ORIFICES

Quality - Service - Reliability

ENVIRONMENTAL SUPPLY COMPANY

2014 Pre-Calibration Console 8

1) Select three critical orifices to calibrate the dry gas meter which bracket the expected operating range.
2) Record barometric pressure before and after calibration procedure.
3) Run at tested vacuum (from Orifice Calibration Report), for a period of time necessary to achieve a minimum total volume of 5 cubic feet.
4) Record data and information in the cells, YELLOW cells are calculated.

DATE: 1/9/2014 | METER SERIAL #: 1297-3245 | BAROMETRIC PRESSURE (in Hg): INITIAL 25.35, FINAL 25.35, AVG (P_{bar}) 25.35

METER PART #: Console 8 | CRITICAL ORIFICE SET SERIAL #: 1453S | EQUIPMENT ID #: Console 8

IF Y VARIATION EXCEEDS 2.00%, ORIFICE SHOULD BE RECALIBRATED

ORIFICE #	RUN #	K' FACTOR (AVG)	TESTED VACUUM (in Hg)	DGM READINGS (FT^3) INITIAL	DGM READINGS (FT^3) FINAL	DGM READINGS (FT^3) NET (V_m)	TEMPERATURES °F AMBIENT	DGM INLET INITIAL	DGM INLET FINAL	DGM OUTLET INITIAL	DGM OUTLET FINAL	DGM AVG	ELAPSED TIME (MIN) θ	DGM ΔH (in H_2O)	(1) V_m (STD)	(2) V_{cr} (STD)	(3) Y	Y VARIATION (%)	$\Delta H_@$
30	1	0.8137	13	600.004	605.840	5.836	70	74	74	66	67	70.25	5.50	3.00	4.9674	4.9294	0.992		1.788
	2	0.8137	13	605.840	611.144	5.304	70	74	75	67	68	71	5.00	3.00	4.5082	4.4813	0.994		1.786
	3	0.8137	13	611.144	616.462	5.318	70	75	75	68	68	71.5	5.00	3.00	4.5158	4.4813	0.992		1.784
																AVG =	0.993	-1.04	
19	1	0.5317	13	617.447	622.924	5.477	71	75	75	68	69	71.75	8.00	1.20	4.6246	4.6807	1.012		1.665
	2	0.5317	13	622.924	628.427	5.503	71	75	77	69	69	72.50	8.00	1.20	4.640	4.6807	1.009		1.663
	3	0.5317	13	628.427	634.285	5.858	71	77	77	69	71	73.50	8.50	1.20	4.9301	4.9733	1.009		1.659
																AVG =	1.010	0.65	
12	1	0.3307	13	635.210	641.635	6.425	75	75	76	71	71	73.25	15.00	0.45	5.3981	5.4382	1.007		1.618
	2	0.3307	13	641.635	646.782	5.147	75	76	77	71	71	73.75	12.00	0.45	4.3203	4.3505	1.007		1.616
	3	0.3307	13	646.782	651.930	5.148	75	77	77	71	71	74.00	12.00	0.45	4.3191	4.3505	1.007		1.616
																AVG =	1.007	0.39	

USING THE CRITICAL ORIFICES AS CALIBRATION STANDARDS:
The following equations are used to calculate the standard volumes of air passed through the DGM, V_m (std), and the critical orifice, V_{cr} (std), and the DGM calibration factor, Y. These equations are automatically calculated in the spreadsheet above.

AVERAGE DRY GAS METER CALIBRATION FACTOR, Y = **1.003**

AVERAGE $\Delta H_@$ = **1.688**

(1) $$Vm_{(std)} = K_1 * Vm * \frac{Pbar + (\Delta H / 13.6)}{Tm}$$

= Net volume of gas sample passed through DGM, corrected to standard conditions
K_1 = 17.64 °R/in. Hg (English), 0.3858 °K/mm Hg (Metric)
T_m = Absolute DGM avg. temperature (°R - English, °K - Metric)

(2) $$Vcr_{(std)} = K' * \frac{Pbar * \Theta}{\sqrt{Tamb}}$$

= Volume of gas sample passed through the critical orifice, corrected to standard conditions
T_{amb} = Absolute ambient temperature (°R - English, °K - Metric)
K' = Average K' factor from Critical Orifice Calibration

(3) $$Y = \frac{Vcr_{(std)}}{Vm_{(std)}}$$

= DGM calibration factor

$$\Delta H_@ = \left(\frac{0.75\,\theta}{V_{cr}(std)}\right)^2 \Delta H \left(\frac{V_m(std)}{V_m}\right)$$

Temperature Sensors

	Reference °F	In °F	Out °F
Ice Bath	33	33	33
Ambient Air	71	72	72
Boiling Water	202	201	202

Console 8 Pre-test 2013

METHOD 5 DRY GAS METER CALIBRATION USING CRITICAL ORIFICES

Quality - Service - Reliability

ENVIRONMENTAL SUPPLY COMPANY

2014 Pre-Calibration Console 9

1) Select three critical orifices to calibrate the dry gas meter which bracket the expected operating range.
2) Record barometric pressure before and after calibration procedure.
3) Run at tested vacuum (from Orifice Calibration Report), for a period of time necessary to achieve a minimum total volume of 5 cubic feet.
4) Record data and information in the cells, YELLOW cells are calculated.

DATE: 1/8/2014
METER PART #: Console 9
METER SERIAL #: 1297-3245
CRITICAL ORIFICE SET SERIAL #: 1453S
BAROMETRIC PRESSURE (in Hg): INITIAL 25.45 | FINAL 25.45 | AVG (P_{bar}) 25.45
EQUIPMENT ID #: Console 9

IF Y VARIATION EXCEEDS 2.00%, ORIFICE SHOULD BE RECALIBRATED

ORIFICE #	RUN #	K' FACTOR (AVG)	TESTED VACUUM (in Hg)	DGM READINGS (FT^3) INITIAL	DGM READINGS (FT^3) FINAL	DGM READINGS (FT^3) NET (V_m)	TEMPERATURES °F AMBIENT	DGM INLET INITIAL	DGM INLET FINAL	DGM OUTLET INITIAL	DGM OUTLET FINAL	DGM AVG	ELAPSED TIME (MIN) θ	DGM ΔH (in H_2O)	(1) V_m (STD)	(2) V_{cr} (STD)	(3) Y	Y VARIATION (%)	$\Delta H_@$
30	1	0.8137	12	88.612	94.007	5.395	65	78	79	75	75	76.75	5.00	3.00	4.5541	4.5203	0.993		1.743
	2	0.8137	12	94.007	99.387	5.380	65	79	79	75	75	77.00	5.00	3.00	4.5393	4.5203	0.996		1.742
	3	0.8137	12	99.387	104.803	5.416	65	79	80	75	75	77.25	5.00	3.00	4.5676	4.5203	0.990		1.741
																AVG =	0.993	-0.96	
19	1	0.5317	12	105.106	110.310	5.204	70	75	76	69	71	72.75	7.50	1.20	4.4031	4.4097	1.001		1.652
	2	0.5317	12	110.310	115.878	5.568	70	76	78	71	71	74.00	8.00	1.20	4.70	4.7036	1.001		1.648
	3	0.5317	12	115.878	121.084	5.206	70	78	80	71	71	75.00	7.50	1.20	4.3862	4.4097	1.005		1.645
																AVG =	1.003	0.02	
12	1	0.3307	12	121.205	126.327	5.122	72	76	76	71	72	73.75	12.00	0.44	4.3161	4.380	1.015		1.565
	2	0.3307	12	126.327	131.458	5.131	72	76	76	72	72	74.00	12.00	0.44	4.3217	4.380	1.013		1.565
	3	0.3307	12	131.458	137.053	5.595	72	76	76	72	72	74.00	13.00	0.44	4.7125	4.7450	1.007		1.565
																AVG =	1.012	0.94	

USING THE CRITICAL ORIFICES AS CALIBRATION STANDARDS:
The following equations are used to calculate the standard volumes of air passed through the DGM, V_m (std), and the critical orifice, V_{cr} (std), and the DGM calibration factor, Y. These equations are automatically calculated in the spreadsheet above.

AVERAGE DRY GAS METER CALIBRATION FACTOR, Y = **1.002**

AVERAGE $\Delta H_@$ = **1.652**

(1) $$Vm_{(std)} = K_1 * Vm * \frac{Pbar + (\Delta H / 13.6)}{Tm}$$

= Net volume of gas sample passed through DGM, corrected to standard conditions
K_1 = 17.64 °R/in. Hg (English), 0.3858 °K/mm Hg (Metric)
T_m = Absolute DGM avg. temperature (°R - English, °K - Metric)

(2) $$Vcr_{(std)} = K' * \frac{Pbar * \Theta}{\sqrt{Tamb}}$$

= Volume of gas sample passed through the critical orifice, corrected to standard conditions
T_{amb} = Absolute ambient temperature (°R - English, °K - Metric)
K' = Average K' factor from Critical Orifice Calibration

(3) $$Y = \frac{Vcr_{(std)}}{Vm_{(std)}}$$

= DGM calibration factor

$$\Delta H_@ = \left(\frac{0.75\,\theta}{V_{cr}(std)}\right)^2 \Delta H \left(\frac{V_m(std)}{V_m}\right)$$

Temperature Sensors

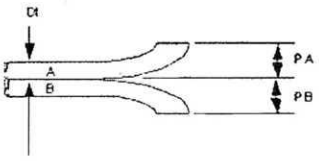
Reference °F	In °F	Out °F
32	33	33
72	73	73
201	202	203

Type S Pitot Tube Inspection Data

Date: 12-20-13

Pitot Tube Identification: 60-G-3

Technician: K. McNamara



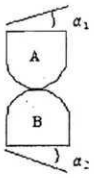
Dt= .375 in.

Is $P_A = P_B$? Yes

Is $1.05 \cdot D_t \le D_t \le 1.50 \cdot D_t$? Yes

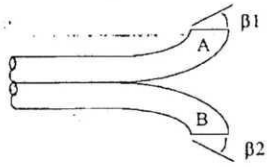
P_A = .65 in.

P_B = .65 in.



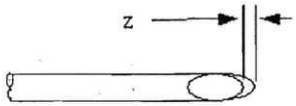
$\alpha_1 < 10°$ α_1 = 1 °

$\alpha_2 < 10°$ α_2 = 1 °

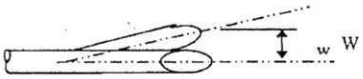


$\beta_1 < 5°$ β_1 = 0 °

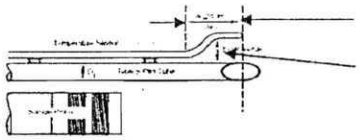
$\beta_2 < 5°$ β_2 = 0 °



$Z \le 0.125$ in. Z = .015 in.

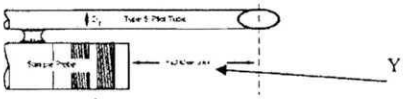


$W \le 0.03125$ in. W = .020 in.



W > 3 inches W = 8 in.

Z > 3/4 inch Z = 1 in.



Y ≥ 3 inches Y = 4 1/2 in.

The pitot tube meets the specifications for a calibration factor of 0.84? Yes

Temperature Sensor Calibration

Reference:

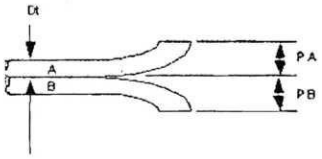
	Temperature Source (Medium)	Temperature Reference (°F)	Temperature Sensor (°F)	Temperature Difference (°F)
Probe	AIR	70	70	0
	Continuity	—	—	Yes
	Heat Check 248	—	—	255
Stack	AIR	70	70	0
	ICE WATER	32	32	0
	BOIL WATER	204	204	0
	SILICONE OIL			

Type S Pitot Tube Inspection Data

Date: 12-20-13

Pitot Tube Identification: 60-61-2

Technician: K. McNamara



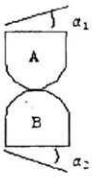
Dt= .375 in.

Is $P_A = P_B$? Yes

Is $1.05 \cdot D_t \le D_t \le 1.50 \cdot D_t$? Yes

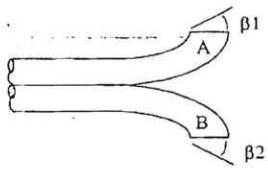
P_A = .470 in.

P_B = .470 in.



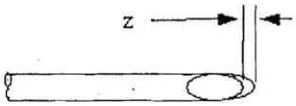
$\alpha_1 < 10°$ α_1 = 2 °

$\alpha_2 < 10°$ α_2 = 2 °

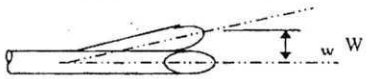


$\beta_1 < 5°$ β_1 = 1 °

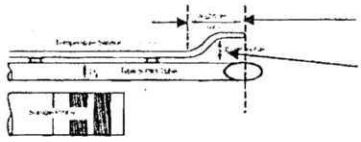
$\beta_2 < 5°$ β_2 = 0 °



$Z \le 0.125$ in. Z = .016 in.

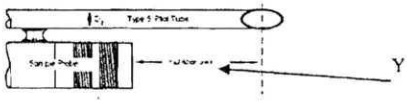


$W \le 0.03125$ in. W = .016 in.



W > 3 inches W = 6½ in.

Z > 3/4 inch Z = 1 in.



Y ≥ 3 inches Y = 3½ in.

The pitot tube meets the specifications for a calibration factor of 0.84? Yes

Temperature Sensor Calibration

Reference: _____

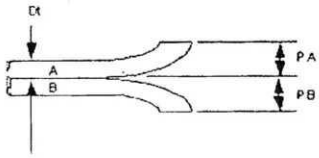
	Temperature Source (Medium)	Temperature Reference (°F)	Temperature Sensor (°F)	Temperature Difference (°F)
Probe	AIR	70	69	1
	Continuity			Yes
	Heat Check 248			250
Stack	AIR	70	69	1
	ICE WATER	33	35	2
	BOIL WATER	203	203	0
	SILICONE OIL			

Type S Pitot Tube Inspection Data

Date: 12-20-13

Pitot Tube Identification: 60-G-1

Technician: K. McNamara



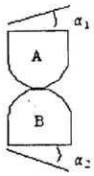
Dt= .375 in.

Is $P_A = P_B$? Yes

Is $1.05 \cdot D_t \le D_t \le 1.50 \cdot D_t$? Yes

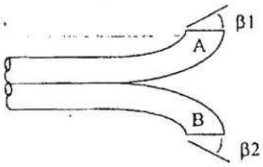
P_A = .455 in.

P_B = .455 in.



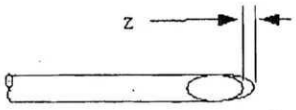
$\alpha_1 < 10°$ α_1 = 1 °

$\alpha_2 < 10°$ α_2 = 1 °

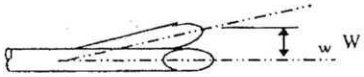


$\beta_1 < 5°$ β_1 = 0 °

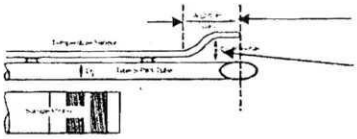
$\beta_2 < 5°$ β_2 = 1 °



$Z \le 0.125$ in. Z = .033 in.

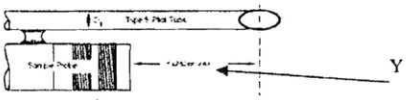


$W \le 0.03125$ in. W = .030 in.



W > 3 inches W = 6 ½ in.

Z > 3/4 inch Z = 3 ½ in.



Y ≥ 3 inches Y = Yes in.

The pitot tube meets the specifications for a calibration factor of 0.84? Y

Temperature Sensor Calibration

Reference: _____

	Temperature Source (Medium)	Temperature Reference (°F)	Temperature Sensor (°F)	Temperature Difference (°F)
Probe	AIR	69	69	0
	Continuity			Yes
	Heat Check 248		Yes	250
Stack	AIR	69	69	0
	ICE WATER	33	33	0
	BOIL WATER	204	204	0
	SILICONE OIL			

Date: 12/13/13 Calibrator: Dean Kitchen Reference: Omega CL3512A

Unit ID	Thermocouple Location	Temperature Source (Medium)	Temperature Reference (°F)	Temperature Sensor (°F)	Temperature Difference (°F)
A	Oven	Water	32	34	2
		Water	204	203	-1
	Oven (4)	Water	33	34	1
		Water	204	202	-2
	Impinger Out	Water	33	34	1
		Water	204	203	-1
B	Oven	Water	33	33	0
		Water	204	202	-2
	Oven (4)	Water	33	34	1
		Water	203	203	0
	Impinger Out	Water	32	33	1
		Water	204	202	-2
C	Oven	Water	32	33	1
		Water	204	203	-1
	Oven (4)	Water	33	34	1
		Water	204	204	0
	Impinger Out	Water	33	33	0
		Water	203	202	-1
D	Oven	Water	33	34	1
		Water	203	203	0
	Oven (4)	Water	33	34	1
		Water	204	204	0
	Impinger Out	Water	33	33	0
		Water	204	202	-2
E	Oven	Water	33	34	1
		Water	203	202	-1
	Oven (4)	Water	33	33	0
		Water	204	203	-1
	Impinger Out	Water	33	34	1
		Water	204	203	-1
F	Oven	Water	33	34	1
		Water	204	202	-2
	Oven (4)	Water	33	34	1
		Water	204	202	-2
	Impinger Out	Water	33	33	0
		Water	203	202	-1
	Impinger Out G	Water	33	34	1
		Water	204	203	-1
	Impinger Out H	Water	33	34	1
		Water	204	202	-2
	Impinger Out I	Water	33	33	0
		Water	204	202	-2
	Impinger Out J	Water	33	34	1
		Water	203	202	-1

TETCO
Annual Balance Calibration Check

Date 12/19/13

Balance Denver Instruments, Model A-250, SN B045284

Weights Used Dener Instruments Weight Set,
SN 98-115146

Certified Weight grams	Measured Weight grams	Difference grams
0.1000	0.0999	0.0001
0.5000	0.5000	0.0000
1.0000	0.9999	0.0001
10.0000	9.9999	0.0001
50.0000	50.0001	-0.0001
100.0000	100.0001	-0.0001
120.0000	120.0000	0.0000
150.0000	150.0001	-0.0001

Technician Dean Kitchen

LIQUID TECHNOLOGY CORPORATION

"INDUSTRY LEADER IN SPECIALTY GASES"

Certificate of Analysis

- EPA PROTOCOL GAS -

Customer	TETCO (American Fork, UT)
Date	April 24, 2014
Delivery Receipt	DR-51261
Gas Standard	450 ppm NO, 450 ppm Carbon Monoxide/Nitrogen
Final Analysis Date	April 23, 2014
Expiration Date	April 23, 2022

DO NOT USE BELOW 100 psig

Analytical Data:
EPA Protocol, Section No. 2.2, Procedure G-1.

Reported Concentrations
Nitric Oxide: 436 ppm +/- 1.0 ppm
Carbon Monoxide: 466 ppm +/- 1.0 ppm
Nitrogen: Balance
Total NOx: 437 ppm
** Total NOx for Reference Use Only **

Reference Standards

SRM/GMIS	GMIS/GMIS	GMIS/GMIS
Cylinder Number:	CC-231418/EB-0032976	CC-185111/EB-0024193
Concentration:	248.04 ppm NO/496.21 ppm NO	257.47 ppm CO/509.31 ppm CO
Expiration Date:	01/09/21 - 01/09/21	12/07/20 - 12/06/20

Certification Instrumentation

Component:	Nitric Oxide	Carbon Monoxide
Make/Model:	Nicolet 6700	Nicolet 6700
Serial Number:	APW1100563	APW1100563
Principal of Measurement:	FTIR	FTIR
Last Calibration:	April 10, 2014	April 03, 2014

Cylinder Data

Cylinder Number:	CC-251821	Cylinder Volume:	136 Cubic Feet
Cylinder Outlet:	CGA 660	Cylinder Pressure:	1950 psig, 70°F
Expiration Date:	April 23, 2022		

Analytical Uncertainty and NIST Traceability are in compliance with EPA-600/R-12/531.

Certified by: Cole Dylewski

Cole Dylewski

PGVP Vendor ID: E12014

"UNMATCHED EXCELLENCE"
2048 APEX COURT APOPKA, FLORIDA 32703 ~ PHONE (407)-292-2990 FAX (407)-292-3313
WWW.LIQUIDTECHCORP.COM
APOPKA, FL • HOUSTON, TX

LIQUID TECHNOLOGY CORPORATION

"INDUSTRY LEADER IN SPECIALTY GASES"

Certificate of Analysis

- EPA PROTOCOL GAS -

* Extended Certificate *

Customer	TETCO (American Fork, UT)
Date	August 09, 2012
Delivery Receipt	DR-43423
Gas Standard	230 ppm NO, 230 ppm Carbon Monoxide/Nitrogen
Final Analysis Date	August 05, 2012
Expiration Date	August 05, 2020

DO NOT USE BELOW 150 psig

Analytical Data:
EPA Protocol, Section No. 2.2, Procedure G-1.

Reported Concentrations
Nitric Oxide: 227 ppm +/- 2.2 ppm
Carbon Monoxide: 232 ppm +/- 2.3 ppm
Nitrogen: Balance
Total NOx: 228 ppm
** Total NOx for Reference Use Only **

Reference Standards

SRM/GMIS:	GMIS	GMIS
Cylinder Number:	CC-120933	CC-128982
Concentration:	262.83 ppm NO	257.47 ppm CO
Expiration Date:	01/13/14	10/20/12

Certification Instrumentation

Component:	Nitric Oxide	Carbon Monoxide
Make/Model:	Thermo 42i-LS	Horiba - VIA 510
Serial Number:	1033445889	UUBKWXYV
Principal of Measurement:	Chemiluminescence	NDIR
Last Calibration:	July 28, 2012	July 28, 2012

Cylinder Data

Cylinder Number:	EB-0024550	Cylinder Volume:	93 Cubic Feet
Cylinder Outlet:	CGA 660	Cylinder Pressure:	1325 psig, 70°F
Expiration Date:	August 05, 2020		

Analytical Uncertainty and NIST Traceability are in compliance with EPA-600/R-12/531.

Certified by: David Scott

PGVP Vendor ID: E12013

Original Data: 224 ppm NO, 224 ppm NOX, 238 ppm CO/Nitrogen (August 06, 2010)

* Extended shelf life established January 22, 2013

"UNMATCHED EXCELLENCE"

2048 APEX COURT APOPKA, FLORIDA 32703 ~ PHONE (407)-292-2990 FAX (407)-292-3313
WWW.LIQUIDTECHCORP.COM

LIQUID TECHNOLOGY CORPORATION

"INDUSTRY LEADER IN SPECIALTY GASES"

Certificate of Analysis

- EPA PROTOCOL GAS -

* Extended Certificate *

Customer	TETCO (American Fork, UT)
Date	November 11, 2011
Delivery Receipt	DR-39358
Gas Standard	125 ppm NO, 125 ppm Carbon Monoxide/Nitrogen
Final Analysis Date	November 09, 2011
Expiration Date	November 09, 2019

DO NOT USE BELOW 150 psig

Analytical Data:
EPA Protocol, Section No. 2.2, Procedure G-1.

Reported Concentrations
Nitric Oxide: 127 ppm +/- 1.2 ppm
Carbon Monoxide: 136 ppm +/- 1.3 ppm
Nitrogen: Balance
Total NOx: 128 ppm
** Total NOx for Reference Use Only **

Reference Standards

SRM/GMIS	GMIS/GMIS	GMIS/GMIS
Cylinder Number:	EB-0027194/CC-56577	EB-0015851/CC-185111
Concentration:	96.25 ppm NO/249.21 ppm NO	105.98 ppm CO/257.47 ppm CO
Expiration Date:	04/25/13 - 01/03/13	10/21/12 - 10/22/12

Certification Instrumentation

Component:	Nitric Oxide	Carbon Monoxide
Make/Model:	Horiba - CLA 510	Horiba - VIA 510
Serial Number:	43331870031	UUBKWXYV
Principal of Measurement:	Chemiluminescence	NDIR
Last Calibration:	November 05, 2011	November 05, 2011

Cylinder Data

Cylinder Number:	CC-311364	Cylinder Volume:	130 Cubic Feet
Cylinder Outlet:	CGA 660	Cylinder Pressure:	1850 psig, 70°F
Expiration Date:	November 09, 2019		

Analytical Uncertainty and NIST Traceability are in compliance with EPA-600/R-12/531.

Certified by: David Scott

* Extended shelf life established January 22, 2013

PGVP Vendor ID: E12013

"UNMATCHED EXCELLENCE"

2048 APEX COURT APOPKA, FLORIDA 32703 ~ PHONE (407)-292-2990 FAX (407)-292-3313
WWW.LIQUIDTECHCORP.COM

500 WEAVER PARK RD, LONGMONT, CO 80501 Phone: 888-253-1635 Fax: 303-772-7673

RATA CLASS

Dual-Analyzed Calibration Standard

CERTIFICATE OF ACCURACY: Interference Free™ Multi-Component EPA Protocol Gas

Assay Laboratory - PGVP Vendor ID: A42010
AIR LIQUIDE AMERICA SPECIALTY GASES LLC
500 WEAVER PARK RD
LONGMONT, CO 80501

P.O. No.: TETCO ORDER
Document # : 38976952-003

Customer
ALA-CYL-SALT LAKE CITY (LOC 84427)

TRANSFER ACCOUNT- FILL LO
1676 SOUTH 700 WEST
SALT LAKE CITY UT 84104
US

ANALYTICAL INFORMATION Gas Type : CO2,O2,BALN

This certification was performed according to EPA Traceability Protocol For Assay & Certification of Gaseous Calibration Standards; Procedure G-1; September, 1997.

Cylinder Number: ALM007855
Cylinder Pressure*:** 2012 PSIG

Certification Date: 11Oct2010

Exp. Date: 12Oct2018
Batch No: LGM0008588

COMPONENT	CERTIFIED CONCENTRATION (Moles)	ACCURACY**	TRACEABILITY
CARBON DIOXIDE	20.7 %	+/- 1%	Direct NIST and VSL
OXYGEN	20.9 %	+/- 1%	
NITROGEN	BALANCE		

*** Do not use when cylinder pressure is below 150 psig.
** Analytical accuracy is based on the requirements of EPA Protocol Procedure G1, September 1997.

REFERENCE STANDARD

TYPE/SRM NO.	EXPIRATION DATE	CYLINDER NUMBER	CONCENTRATION	COMPONENT
NTRM 1800	01Mar2013	K015614	17.87 %	CARBON DIOXIDE
NTRM 2658	01Feb2016	K012175	10.03 %	OXYGEN

INSTRUMENTATION

INSTRUMENT/MODEL/SERIAL#	DATE LAST CALIBRATED	ANALYTICAL PRINCIPLE
FTIR//0929062	20Sep2010	FTIR
OXYMAT/6E/W5-951	01Oct2010	PARAMAGNETIC

ANALYZER READINGS

(Z=Zero Gas R=Reference Gas T=Test Gas r=Correlation Coefficient)

First Triad Analysis
CARBON DIOXIDE
Date: 08Oct2010 Response Unit: %
Z1=-0.00235 R1=17.87370 T1=20.67730
R2=17.87993 Z2=-0.00205 T2=20.69064
Z3=-0.00156 T3=20.69579 R3=17.88453
Avg. Concentration: 20.68 %
OXYGEN
Date: 11Oct2010 Response Unit: VOLTS
Z1=0.00000 R1=10.05000 T1=20.95000
R2=10.06000 Z2=0.00000 T2=20.97000
Z3=0.00000 T3=20.97000 R3=10.06000
Avg. Concentration: 20.92 %

Second Triad Analysis

Calibration Curve

Concentration=A+Bx+Cx2+Dx3+Ex4
r=9.99997E-1
Constants: A=0.00000E+0
B=5.83306E-1 C=4.44600E-3
D=0.00000E+0 E=0.00000E+0

Concentration=A+Bx+Cx2+Dx3+Ex4
r=0.999999
Constants: A=-0.01473945
B=1.000704376 C=
D= E=

QUALITY ASSURANCE

APPROVED BY: JAMES KRAUS
(signature on file)

RATA CLASS

Dual-Analyzed Calibration Standard

500 WEAVER PARK RD, LONGMONT, CO 80501 Phone: 888-253-1635 Fax: 303-772-7670

CERTIFICATE OF ACCURACY: Interference Free™ Multi-Component EPA Protocol Gas

Assay Laboratory - PGVP Vendor ID: A42013

AIR LIQUIDE AMERICA SPECIALTY GASES LLC
500 WEAVER PARK RD
LONGMONT, CO 80501

P.O. No.: EPAS FOR STOCK
Document # : 49967938-009

Customer
ALA-CYL-SALT LAKE CITY (LOC 84427)

TRANSFER ACCOUNT- FILL LO
1676 SOUTH 700 WEST
SALT LAKE CITY UT 84104
US

ANALYTICAL INFORMATION Gas Type : CO2,O2,BALN

This certification was performed according to EPA Traceability Protocol For Assay & Certification of Gaseous Calibration Standards; Procedure G-1, September, 1997.

Cylinder Number: CC160837 **Certification Date:** 08Apr2013 **Exp. Date:** 09Apr2021
Cylinder Pressure*:** 2015 PSIG **Batch No:** LGM0084283

COMPONENT	CERTIFIED CONCENTRATION (Moles)		ACCURACY**	TRACEABILITY
CARBON DIOXIDE	10.1	%	+/- 1%	Direct NIST and VSL
OXYGEN	10.0	%	+/- 1%	
NITROGEN		BALANCE		

*** Do not use when cylinder pressure is below 150 psig.
** Analytical accuracy is based on the requirements of EPA Protocol Procedure G1, September 1997.

REFERENCE STANDARD

TYPE/SRM NO.	EXPIRATION DATE	CYLINDER NUMBER	CONCENTRATION	COMPONENT
NTRM 1675	05Jan2018	K015237	13.94 %	CARBON DIOXIDE
NTRM 2658	01Feb2016	K012175	10.03 %	OXYGEN

INSTRUMENTATION

INSTRUMENT/MODEL/SERIAL#	DATE LAST CALIBRATED	ANALYTICAL PRINCIPLE
FTIR 0929062	28Mar2013	FTIR
OXYMAT/6E/W5-951	11Mar2013	PARAMAGNETIC

ANALYZER READINGS

(Z = Zero Gas R = Reference Gas T = Test Gas r = Correlation Coefficient)

First Triad Analysis	Second Triad Analysis	Calibration Curve
CARBON DIOXIDE		
Date: 05Apr2013 Response Unit: %		Concentration = A + Bx + Cx2 + Dx3 + Ex4
Z1 = 0.00114 R1 = 13.93862 T1 = 10.11691		r = 9.99997E-1
R2 = 13.95509 Z2 = 0.00116 T2 = 10.11974		Constants: A = 0.00000E + 0
Z3 = 0.00448 T3 = 10.12244 R3 = 13.96093		B = 6.43498E-1 C = 4.66200E-3
Avg. Concentration: 10.11 %		D = 4.00000E-6 E = 0.00000E + 0
OXYGEN		
Date: 08Apr2013 Response Unit: VOLTS		Concentration = A + Bx + Cx2 + Dx3 + Ex4
Z1 = 0.00000 R1 = 10.04000 T1 = 10.03000		r = 0.999999
R2 = 10.03000 Z2 = 0.00000 T2 = 10.04000		Constants: A = 0.01274156
Z3 = 0.00000 T3 = 10.03000 R3 = 10.03000		B = 0.999165608 C =
Avg. Concentration: 10.03 %		D =

APPROVED BY: ADAM HANLEY

AIR LIQUIDE Air Liquide America Specialty Gases LLC Scott

RATA CLASS

Guaranteed +/- 1% Accuracy

500 WEAVER PARK RD, LONGMONT, CO 80501 Phone: 888-253-1635 Fax: 303-772-7673

CERTIFICATE OF ACCURACY: EPA Protocol Gas

Assay Laboratory - PGVP Vendor ID: A42013
AIR LIQUIDE AMERICA SPECIALTY GASES LLC
500 WEAVER PARK RD
LONGMONT, CO 80501

P.O. No.: EPA STOCK
Document # : 51864865-012

Customer
ALA-CYL-SALT LAKE CITY (LOC 84427)
TRANSFER ACCOUNT- FILL LO
1676 SOUTH 700 WEST
SALT LAKE CITY UT 84104
US

ANALYTICAL INFORMATION Gas Type : CO2,BALN

This certification was performed according to EPA Traceability Protocol For Assay & Certification of Gaseous Calibration Standards; Procedure G-1. EPA/600/R-12/531; May 2012. Do not use this standard if pressure is less than 100 psig.

Cylinder Number: ALM024496 **Certification Date:** 09Sep2013 **Exp. Date:** 10Sep2021
Cylinder Pressure: 2000 PSIG **Batch No:** LGM0097735

COMPONENT	CERTIFIED CONCENTRATION (Moles)	ACCURACY (ABSOLUTE / RELATIVE)
CARBON DIOXIDE	5.06 %	0.04 % / 0.8 %
NITROGEN	BALANCE	

TRACEABILITY

REFERENCE STANDARD

COMPONENT	CONCENTRATION	UNCERTAINTY	CYLINDER	TYPE/SRM SAMPLE	EXP. DATE
CARBON DIOXIDE	4.9540 %	0.0250 %	K014222	NTRM 2000	25Nov2017

ANALYTICAL METHOD

1st Analysis: 09Sep2013

COMPONENT	INSTRUMENT	ANALYTICAL/PRINCIPLE	CALIBRATED	CONCENTRATION
CARBON DIOXIDE	MKS ONLINE/2030/0929062	FTIR	28Aug2013	5.064 %

APPROVED BY: JON WITZAK

ENVIRONMENTAL MANAGEMENT
BRIGHAM YOUNG UNIVERSITY
101 CHEMICALS MANAGEMENT BUILDING
PROVO, UTAH 84602-7800
(801) 422-6156 / FAX: (866) 475-0880

Document Date 1/9/2012
DAQ-2012-009834

UTAH DEPARTMENT OF
ENVIRONMENTAL QUALITY
JAN 17 2012
DIVISION OF AIR QUALITY

January 9, 2012

Amanda Smith, Executive Director
Department of Environmental Quality
195 North 1950 West
PO Box 144820
Salt Lake City, UT 84114-4820

Re: Brigham Young University NO_x Compliance Testing for Central Heating Plant Boiler #4 and Boiler #6 per Title V Operating Permit # 490 000 4002

Dear Ms. Smith,

Brigham Young University has recently completed the NOx compliance testing for the Central Heating Plant Boiler #4 and Boiler #6. Below is a table that summarizes the requirements for each boiler as set out in our Operating Permit and the results from our tests.

	Emission Limit	Achieved Emissions	Required Production Rate	Achieved Production Rate
Boiler #4	35.8 lbs/hour	15.1 lb/hr	52 MMBtu/hour	78.2 MMBtu/hour
Boiler #6	35.8 lbs/hour	18.6 lb/hr	60 MMBtu/hour	90.3 MMBtu/hour

Please find attached BYU's certification statement and the complete report provided to BYU by TETCO. Testing was performed December 6, 2011 and the report was submitted to EPA and the State within the 60 days allowed in the Operating Permit (due February 6, 2012).

Please contact Steven Zohner for questions or further information at 801-422-2804.

Respectfully,

Steven K Zohner

Steven K Zohner
Environmental Officer
Brigham Young University
112 CMB
Provo, UT 84602
Email: steven_zohner@byu.edu

Certification

In accordance with Operating Permit provision I.K and UAC R307-415-5d, and based on information and belief formed after reasonable inquiry, I certify that the statements and information in this document are true, accurate, and complete.

Brian K. Evans

Signature of Responsible Official

Date: 9 Jan 2012

Brian K. Evans
Chief Financial Officer and Administrative Vice President
Brigham Young University

NO_X COMPLIANCE TEST CONDUCTED AT BRIGHAM YOUNG UNIVERSITY CENTRAL HEATING PLANT BOILER #4 AND BOILER #6

DECEMBER 6, 2011

by:

TETCO
391 East 620 South
American Fork, Utah 84003
Phone (801) 492-9106
Fax (801) 492-9107

UTAH DEPARTMENT OF
ENVIRONMENTAL QUALITY

JAN 17 2012

DIVISION OF AIR QUALITY

Prepared for:

Brigham Young University
Physical Plant Department
237 Brewster Building
Provo UT 84602

Date of report:
December 14, 2011

CERTIFICATION OF REPORT INTEGRITY

Technical Emissions Testing Company (TETCO) certifies that this report represents the truth as well as can be derived by the methods employed. Every effort was made to obtain accurate and representative data and to comply with procedures set forth in the Federal Register.

Dean A. Kitchen

Reviewer: _____

Date: 12-13-11

Doug Olsen

Reviewer: _____

Date: 12/13/11

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- Test Dates 1
- Pollutants Tested and Methods Applied 1
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- Quality Assurance 2

Summary of Results
- Emission Results 3
- Process Data 3
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INTRODUCTION

Test Purpose

This test was conducted to determine the NO_x emissions from Boilers No. 4 and 6 while fired with natural gas. These emissions are expressed in ppm at 7 percent oxygen and pounds per hour. These results are used to determine compliance with the Title V Permit for the facility.

Test Location, Type of Process

The tests were conducted at the Brigham Young University Central Heating Plant. The plant provides heating and cooling for the university.

A schematic representation of the baghouse exhaust stack is given as Figure 1 in Appendix D.

Test Dates

Three test runs were completed on both Boiler 4 and Boiler 6 December 6, 2011.

Pollutant Tested and Methods Applied

The tests were for NO_x emissions in accordance with EPA Methods 4 and 7E.

Test Participants

Test Facility	Paul Greenwood Clifford Alleman	
TETCO	Dean Kitchen Joseph Kitchen	Doug Olsen Kawai McNamara
State Agency	None	

Deviations from EPA Methods

None.

Quality Assurance

Testing procedures and sample recovery techniques were in accordance to those outlined in the Federal Register and the *Quality Assurance Handbook for Air Pollution Measurement Systems*.

SUMMARY OF RESULTS

Emission Results

Table I presents the compliance test results. Tables III-V in Appendix A have more detailed test data.

TABLE I Measured NO_x Emissions

Run #	Boiler 4		Boiler 6	
	ppm (@ 7% O_2)	lb/hr	ppm (@ 7% O_2)	lb/hr
1	74	15.1	79	18.3
2	75	15.2	81	18.7
3	74	15.0	82	18.9
Ave	**74**	**15.1**	**81**	**18.6**

Process Data

The process was operated according to standard procedures. All pertinent process data was available for recording by agency personnel. Btu totalizer readings were recorded before and after each test run. These values are found in Appendix D.

Allowable Emissions

The allowable NO_x concentration limit for each boiler is 127 ppm (corrected to 7 percent O_2).
The allowable NO_x emission rate for each boiler is 38.5 lb/hr.

Discussion of Errors or Irregularities

None.

Gaseous Analyzer Performance Criteria

The NO_x analyzer met all bias and calibration checks criteria as specified in the Federal Register. These values are found on the gas analyzer field data sheet in Appendix B.

SOURCE OPERATION

Sampling Port Location

The stack inside diameter is 136.0 inches. The six inch diameter ports are located 3.9 diameters (44 feet) downstream from the last disturbance and 4.9 diameters (56 feet) upstream from the next disturbance. All ports have an inside diameters of six inches. Port location is depicted in Figure 1 in the Appendix.

Sampling Point Location

Table II shows the distance of each sampling point for Method 4 from the inside wall. Each point is marked and identified with a glass tape wrapping and numbered. These points are determined by measuring the distance from the inside wall and adding the reference (port) measurement.

Table II. Sample Point Location

Sample Point #	Point Location from Inside Wall (inches)
1	4.35
2	14.28
3	26.38
4	43.93

Sampling Train Description

To determine the actual emission rates for these stacks, 40 CFR Part 60 Appendix A Methods 1-4 and 7E were followed.

All sampling trains were made of inert materials, (i.e., Teflon, Stainless Steel, glass, etc.) to prevent interference of the sampled gas and particulate.

The stack analyzer used to conduct Methods 1-4, is constructed to meet the specifications outlined in the CFR. The temperature sensors are K-type thermocouples. Heater, vacuum and pitot line connections have been designed to be interchangeable with all units used by the tester.

The probe liner was made of 316 stainless steel. A sketch of the sampling train is found as Figure 2 in the Appendix.

Sample boxes were prepared for testing by following the prescribed procedure outlined in Method 4.

The NO_x analyzer was an Horiba Instruments Model CLA-510SS, chemiluminescence unit. This was set on a 0-100 ppm range and spanned at 88.9 ppm for all tests. EPA Protocol 1 gases were used as the span and mid-range for the NO_x analyzer during all tests; their concentrations were 43.7 and 88.9 ppm. Dry nitrogen was used as the zero gas for the machine.

The gaseous analyzer sampling train is constructed with a heated stainless steel sampling probe about 8 feet long. The sample line between the sampling probe and gas conditioner was heated Teflon. Both were maintained above 220 degrees Fahrenheit. The sample conditioner uses permeation tubes to remove moisture. Sample lines and bias lines from the gas conditioner to the analyzer were Teflon. A sketch of the sampling train for this method appears in Figure 3 in the Appendix.

Sampling and Analytical Procedures

All sampling and analytical test procedures employed were as specified in 40 CFR 60.

Quality Assurance

All equipment set-up, sampling procedures, sample recovery and equipment calibrations were carried out according to the procedures specified in 40 CFR 60 and the *Quality Assurance Handbook for Air Pollution Measurement Systems*.

APPENDIX A

Table III, Complete Results, Boiler 4
Table IV, Complete Results, Boiler 6
Nomenclature
Sample Equations

TABLE III
COMPLETE RESULTS
BRIGHAM YOUNG UNIVERSITY
BOILER # 4

Symbol	Description	Dimensions				
Run #			1	2	3	
Date			12/6/11	12/6/11	12/6/11	
Begin	Time Test Began		9:49	10:22	10:55	
End	Time Test Ended		10:16	10:49	11:27	
Pb_m	Barometric Pressure	In. Hg Abs	25.60	25.60	25.60	
dH	Orifice Pressure Drop	In. H_2O	1.000	1.000	1.000	
Y	Meter Calibration Y Factor		1.004	1.004	1.004	
V_m	Volume Gas Sampled-- Meter Conditions	cf	50.844	50.844	50.844	
T_m	Ave. Meter Temperature	°F	99.3	99.3	99.3	
dPsqrt	Sq. Root Velocity Head	Root In. H_2O	0.1600	0.1600	0.1600	
Wt_{wc}	Weight Water Collected	Grams	99.0	99.0	99.0	
Tt	Duration of Test	Minutes	80	80	80	
C_p	Pitot Tube Coefficient		0.84	0.84	0.84	
CO_2	Volume % Carbon Dioxide	Percent	6.20	6.20	6.20	
O_2	Volume % Oxygen	Percent	10.40	10.40	10.40	
N_2&CO	Volume % Nitrogen and Carbon Monoxide	Percent	83.40	83.40	83.40	
Vm_{std}	Volume Gas Sampled (Standard)	dscf	41.355	41.355	41.355	
V_w	Volume Water Vapor	scf	4.668	4.668	4.668	
B_{wo}	Fraction H_2O in Stack Gas	Fraction	0.101	0.101	0.101	
X_d	Fraction of Dry Gas	Fraction	0.899	0.899	0.899	
M_d	Molecular Wt. Dry Gas	lb/lbmol	29.41	29.41	29.41	
M_s	Molecular Wt. Stack Gas	lb/lbmol	28.25	28.25	28.25	
T_s	Ave. Stack Temperature	°F	320.6	320.6	320.6	**320.6**
A_s	Stack Cross-Sectional Area	Sq. ft	100.880	100.880	100.880	
P_g	Stack Static Pressure	In. H_2O	-0.34	-0.34	-0.34	
Pb_p	Barometric Pressure at Sample Point	In. Hg	25.53	25.53	25.53	
P_s	Stack Pressure	In. Hg Abs	25.505	25.505	25.505	
Q_s	Stack Gas Volumetric Flow Rate (Std)	dscfm	3.75E+04	3.75E+04	3.75E+04	**3.75E+04**
Q_a	Stack Gas Volumetric Flow Rate (Actual)	cfm	7.24E+04	7.24E+04	7.24E+04	**7.24E+04**
V_s	Velocity of Stack Gas	fpm	7.18E+02	7.18E+02	7.18E+02	**7.18E+02**
C_{NOx}	Average NO_x Gas Concentration	ppm	56.1	56.5	55.6	**56.1**
C_{NOx}	Average NO_x Gas Concentration (@ 7% O2)	ppm	74.3	74.8	73.6	**74.2**
ER_{NOx}	Emission Rate of NO_x	lb/hr	15.09	15.20	14.95	**15.08**

TABLE IV
COMPLETE RESULTS
BRIGHAM YOUNG UNIVERSITY
BOILER # 6

Symbol	Description	Dimensions				
Run #			1	2	3	
Date			12/6/11	12/6/11	12/6/11	
Begin	Time Test Began		6:17	7:02	7:40	
End	Time Test Ended		6:46	7:32	8:13	
Pb_m	Barometric Pressure	In. Hg Abs	25.60	25.60	25.60	
dH	Orifice Pressure Drop	In. H_2O	1.000	1.000	1.000	
Y	Meter Calibration Y Factor		1.004	1.004	1.004	
V_m	Volume Gas Sampled-- Meter Conditions	cf	48.950	48.950	48.950	
T_m	Ave. Meter Temperature	°F	85.2	85.2	85.2	
dPsqrt	Sq. Root Velocity Head	Root In. H_2O	0.1507	0.1507	0.1507	
Wt_{wc}	Weight Water Collected	Grams	126.1	126.1	126.1	
Tt	Duration of Test	Minutes	80	80	80	
C_p	Pitot Tube Coefficient		0.84	0.84	0.84	
CO_2	Volume % Carbon Dioxide	Percent	7.40	7.40	7.40	
O_2	Volume % Oxygen	Percent	8.00	8.00	8.00	
N_2&CO	Volume % Nitrogen and Carbon Monoxide	Percent	84.60	84.60	84.60	
Vm_{std}	Volume Gas Sampled (Standard)	dscf	40.840	40.840	40.840	
V_w	Volume Water Vapor	scf	5.946	5.946	5.946	
B_{wo}	Fraction H_2O in Stack Gas	Fraction	0.127	0.127	0.127	
X_d	Fraction of Dry Gas	Fraction	0.873	0.873	0.873	
M_d	Molecular Wt. Dry Gas	lb/lbmol	29.50	29.50	29.50	
M_s	Molecular Wt. Stack Gas	lb/lbmol	28.04	28.04	28.04	
T_s	Ave. Stack Temperature	°F	306.8	306.8	306.8	**306.8**
A_s	Stack Cross-Sectional Area	Sq. ft	100.880	100.880	100.880	
P_g	Stack Static Pressure	In. H_2O	-0.36	-0.36	-0.36	
Pb_p	Barometric Pressure at Sample Point	In. Hg	25.53	25.53	25.53	
P_s	Stack Pressure	In. Hg Abs	25.504	25.504	25.504	
Q_s	Stack Gas Volumetric Flow Rate (Std)	dscfm	3.48E+04	3.48E+04	3.48E+04	**3.48E+04**
Q_a	Stack Gas Volumetric Flow Rate (Actual)	cfm	6.78E+04	6.78E+04	6.78E+04	**6.78E+04**
V_s	Velocity of Stack Gas	fpm	6.72E+02	6.72E+02	6.72E+02	**6.72E+02**
C_{NOx}	Average NO_x Gas Concentration	ppm	73.4	74.9	76.0	**74.8**
C_{NOx}	Average NO_x Gas Concentration (@ 7% O2)	ppm	79.1	80.7	81.9	**80.6**
ER_{NOx}	Emission Rate of NO_x	lb/hr	18.30	18.66	18.94	**18.64**

A_s = stack cross-sectional area (ft^3)
$AS\Delta P$ = see $\sqrt{\Delta P}$
Btu = unit heat value (British thermal unit)
B_{ws} = fraction of water in stack gas
C_0 = average of initial and final system zero gas calibration bias checks (ppm, percent)
C_m = average of initial and final system upscale gas calibration bias checks (ppm, percent)
C_{ma} = actual concentration of upscale calibration gas
CO_2 = percent carbon dioxide in the stack gas
C_p = pitot tube coefficient (0.84)
$C_{X\ (act)}$ = actual concentration of sampled gas using method 6C, 7E, and 10. corrected for bias checks (may be expressed as ppmdv, lb/dscf, etc.) species symbol replaces x.
$C_{X\ (avg)}$ = raw average gas concentration prior to bias correction (ppmdv, lb/dscf, etc.)
$C_{X\ (avg)}$ = species symbol replaces x.
$C_{X\ (corr)}$ = actual gas concentration corrected to required percent O_2
D_{eq} = Equivlent diameter for rectangular stack
ΔH = orifice pressure drop (inches H_2O)
$\Delta H_@$ = orifice pressure (inches H_2O)
ΔP = stack flow pressure differential (inches H_2O)
D_s = diameter of the stack (feet)
EA = percent excess air
ER_{gas} = emission rate of a gas (lb/hr)
ER_{mmBtu} = emission rate per mmBtu or ton of fuel etc.
ER_X = emission rate of compound which replaces x
mBtu = thousand Btu
M_d = molecular weight of stack gas, dry basis (lb/lb-mol)
mmBtu = million Btu
M_s = molecular weight of stack gas, wet basis (g/gmol)
M_{wx} = molecular weight of gas species (g/gmol)
N_2 = percent nitrogen in the stack gas
O_2 = percent oxygen in the stack gas
$\sqrt{\Delta P}$ = average of the square roots of ΔP (may also be referred to as $AS\Delta P$)
Pb_m = absolute barometric pressure at the dry gas meter (inches Hg)
Pb_p = absolute barometric pressure at the sample location (inches Hg)
P_G = stack static pressure (inches H_2O)
P_s = absolute stack pressure (inches Hg)
P_{std} = absolute pressure at standard conditions (29.92 inches Hg.)
θ = time of test (minutes)
Q_a = stack gas volumetric flow rate (acfm)
Q_s = stack gas volumetric flow rate (dscfm)
Q_W = wet stack gas std. volumetric flow (ft^3/min, wscfm)
R = gas constant (8.31451 J/gmol-^oK)
T_s = stack temperature (^oF)
T_{std} = absolute temperature at standard conditions (528^oR)
Tt = see θ
Vm = sample volume (ft^3) at meter conditions

Vm_{std} = volume standard (dscf), sample volume adjusted to 68°F and 29.92 inches Hg.

V_s = velocity of stack gas (fpm)

V_{wc} = volume water vapor (scf) at 68°F and 29.92 inches Hg.

Wt_{wc} = weight of the condensed water collected (grams)

X_{CO} = subscript referring to carbon monoxide, CO

X_d = fraction of dry gas

X_{H2S} = subscript referring to hydrogen sulfide, H_2S

X_{NOx} = subscript referring to oxides of nitrogen, NO_x

X_{SO2} = subscript referring to sulfur dioxide, SO_2

Y = meter calibration Y-factor (dimensionless)

$$A_s = (Ds^2 / 4) \cdot \pi$$

$$B_{ws} = V_w / (Vm_{std} + V_w)$$

$$C_{X\,(act)} = (C_{X\,(avg)} - C_0) \cdot C_{ma} / (C_m - C_0)$$

$$C_{X\,(corr)} = C_{X\,(avg)} \cdot (20.9 - \text{desired } \%O_2) / (20.9 - \text{actual } \%O_2)$$

$$C_{X\,(mass)} = M_w \cdot C_{X\,(ppm)} \cdot P_{std} / (R \cdot T_{std} \cdot 10^6)$$

$$D_{eq} = 2 \cdot L \cdot W / (L + W)$$

$$EA = (\%O_2 - 0.5\ \%CO) / [0.264\ \%N_2 - (\%O_2 - 0.5\ \%CO)]$$

$$ER_{gas} = P_{std} \cdot Q_s \cdot M_{wx} \cdot C_{X\,(act)} \cdot 60 / (R \cdot T_{std} \cdot 10^6)$$

$$ER_{mmBtu} = ER_X / (\text{mmBtu / hr})$$

$$M_d = CO_2 \cdot 0.44 + O_2 \cdot 0.32 + N_2 \cdot 0.28$$

$$M_s = (M_d \cdot X_d) + (18 \cdot B_{ws})$$

$$P_s = Pb_p + (P_G / 13.6)$$

$$Q_a = V_s \cdot A_s$$

$$Q_s = Qa \cdot Xd \cdot Ps \cdot T_{std} / [(Ts + 460) \cdot P_{std}]$$

$$Q_W = Q_s / X_d$$

$$Vm_{std} = Vm \cdot Y \cdot T_{std} \cdot (Pb_m + \Delta H / 13.6) / [P_{std} \cdot (T_m + 460)]$$

$$V_s = 85.49 \cdot 60 \cdot Cp \cdot \sqrt{\Delta P} \cdot \sqrt{[(T_s + 460) / (P_s \cdot M_s)]}$$

$$V_{wc} = Wt_{wc} \cdot 0.04715$$

$$X_d = 1 - B_{ws}$$

APPENDIX B

Preliminary Traverse and Sampling Point Location Data

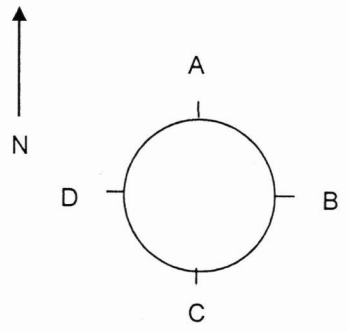
Boiler #4

- Method 4 Field Data
- Gas Analyzer Field Sheets and Data Logger Printout
- Stratification Check Field Sheet

Boiler 6

- Method 4 Field Data
- Gas Analyzer Field Sheets and Data Logger Printout
- Stratification Check Field Sheet

Prelim 8 pts



Stack Dia. 136 Reference: 16.5

Ports are 46.5' Upstream from next disturbance

Ports are 54.5' Downstream from last disturbance

Facility Brigham Young University Central Heating Plant

Stack Identification Baghouse Exhaust, Boiler # 4 & 6

Date 12-5-11

Barometric Pressure

Pb_m _____ in Hg Pb_p _____ in Hg

Static Pressure (P_G) _____ in H_2O

Estimated Moisture (Bw_s) _____ %

Sample Height from Ground _____ feet

Comments:

Time:

Traverse Point	Percent Diameter	Distance From: ID	Distance From: Reference	Ports A	B	C	D	E	F
1	3.2	4.35	20.85	9	8	7	10		
2	10.5	14.28	30.78	5	5	5	6		
3	19.4	26.38	42.88	4	3	4	4		
4	32.3	43.93	60.43	8	8	7	5		
Gas Analyzer Probe									
1	16.7	22.71	39.21						
2	50.0	68.00	84.50						
3	83.3	113.29	129.79						

Averages:

T_S _____ ∠ Flow _____

ΔP _____ √ΔP _____

KEY => T_S ∠ Flow ΔP

Boiler 4

M4 Field Data Sheet

TETCO

Filter NA Sample Box E

Page 1 of 1 Run # 1

Plant: BYU Central Heating Plant

Date: 12/6/11

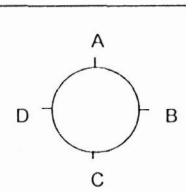
Location: Baghouse Exhaust, Boiler # 4

Operator: [illegible]

Traverse Point	Time Clock	Time Min (θ)	DGM (ft³)	ΔP (in H₂O)	ΔH (in H₂O) Desired	ΔH (in H₂O) Actual	Vacuum (in Hg)	Temperatures (°F) Stack (T_s)	Probe	Probe Out	Filter	Effluent	DGM Temp (T_m) Out	In
1	9:49	0	472.205	.035	1.0	1.0	2	312	260			34	85	85
2		5	475.298	.028		1.0	2	319	262			34	83	84
3		10	478.467	.025		1.0	2	320	261			36	84	88
4		15	481.616	.030		1.0	2	320	260			38	86	94
1	10:11	20	484.823	.017		1.0	2	318	249			41	89	98
2	*	25	487.958	.015		1.0	2	317	236			40	92	98
3		30	491.112	.013		1.0	2	316	235			40	93	102
4		35	494.280	.015		1.0	2	319	240			40	95	105
1	10:39	40	497.450	.023		1.0	2	316	235			40	98	108
2		45	500.626	.028		1.0	2	324	235			40	99	110
3	**	50	503.807	.022		1.0	2	324	241			41	101	112
4		55	507.004	.023		1.0	2	325	251			47	103	111
1	1107	60	510.206	.035		1.0	2	319	255			43	103	111
2		65	513.404	.040		1.0	2	327	252			40	104	113
3		70	516.610	.037		1.0	2	327	252			40	105	115
4		75	519.822	.035	1.0	1.0	2	327	249			40	106	116
	11:27	80	523.049											
Total			50.844	2.5606				5130					3176	
Average				.1600		1.000		320.63					99.25	

1066

2089



Stack Diameter 136" Port Reference 16.5"

Ports are 46.5' Upstream from next disturbance

Ports are 54.5' Downstream from last disturbance

Assumed Moisture 6 %

Probe 65A Cp 0.84

Nozzle Calibration NA

Avg D_n NA inches

Gas Bag F-05

Console 3

Y-Factor 1.004

$\Delta H_@$ 1.649 in H_2O

Barometric Pressures

Pb_m 25.60 in Hg

Pb_p 25.53 in Hg

P_G -0.34 in H_2O

Leak Check	Pre	Post
ft³/min	0.008	0.003
vac in Hg	23	14

Pitot Rate		
	0.0	0.0
In H_2O	.23	0.23

Water Collected 99.0 g

Time Sampled 80 min

Review [illegible]

K @T_m

K @T_m

Comments

* stopped At 10:16 For Bias check
started 10:22

* stopped At 10:49 For Bias check
started 10:55

3505
1906

Facility BYU Cental Heating Plant

GAS ANALYZER FIELD DATA

Date 12-6-11

Operator D. Kitchen

Source Main Stack Exhaust, Boiler # 4

Response Time :50

			Gas Species	Rate	Initial Bias		Final Bias		Analyzer Avg	Corrected Avg
Run 1	Begin	9:49								
	End	10:16	NO_x	600	0.1	43.9	-0.1	44.0	56.4	56.1
	Port Change									

			Gas Species	Rate	Initial Bias		Final Bias		Analyzer Avg	Corrected Avg
Run 2	Begin	1022								
	End	1044	NO_x	600	-0.1	44.0	-0.1	44.1	57.0	56.5
	Port Change									

			Gas Species	Rate	Initial Bias		Final Bias		Analyzer Avg	Corrected Avg
Run 3	Begin	1055								
	End	1127	NO_x	600	-0.1	44.1	0.0	44.2	56.2	55.6
	Port Change									

			Gas Species	Rate	Initial Bias		Final Bias		Analyzer Avg	Corrected Avg
Run	Begin									
	End		NO_x							
	Port Change									

Gas Species	Calibration Gases				Calibration Error				Calibration Error			
NO_x	0.0	43.7	88.9	125.0	0.0	43.9	88.3					

Comments: All values are either ppmdv or mole percents. Corrected averages are analyzer averages corrected using equation 7E-5 unless otherwise indicated.

Eq. 7E-5: $C_{gas} = (C_{avg} - C_0) * [C_{ma} / (C_m - C_0)]$. Rate is sample flow rate in cc/min and is set within analyzer manufacturer specs.

Brigham Young University, Boiler #4, 12/6/11

Run 1		Run 2		Run 3	
Time	NO_x ppm	Time	NO_x ppm	Time	NO_x ppm
9:49	57.0	10:22	56.0	10:55	56.6
9:50	57.0	10:23	56.2	10:56	57.0
9:51	56.7	10:24	56.1	10:57	56.8
9:52	56.5	10:25	56.2	10:58	56.7
9:53	56.3	10:26	56.3	10:59	56.6
9:54	56.2	10:27	56.0	11:00	56.6
9:55	56.3	10:28	56.1	11:01	56.4
9:56	56.2	10:29	56.5	11:02	56.5
9:57	56.4	10:30	56.3	11:03	56.4
9:58	56.6	10:31	56.5	11:04	56.6
9:59	56.4	10:32	56.6	11:05	56.4
10:00	56.5	10:33	56.9	11:06	56.4
10:01	56.6	10:34	57.0	11:07	56.2
10:02	56.5	10:35	57.3	11:08	56.0
10:03	56.3	10:36	57.3	11:09	55.8
10:04	56.4	10:37	57.6	11:10	55.7
10:05	56.3	10:38	57.4	11:11	55.5
10:06	56.3	10:39	57.6	11:12	55.6
10:07	56.3	10:40	57.5	11:13	55.7
10:08	56.4	10:41	57.4	11:14	56.0
10:09	56.2	10:42	57.5	11:15	55.7
10:10	56.4	10:43	57.7	11:16	55.8
10:11	56.4	10:44	57.9	11:17	56.0
10:12	56.2	10:45	57.6	11:18	55.8
10:13	56.6	10:46	57.7	11:19	55.8
10:14	56.4	10:47	57.6	11:20	56.1
10:15	56.3	10:48	57.5	11:21	56.4
10:16	56.3	10:49	57.4	11:22	56.3
				11:23	56.3
				11:24	56.3
				11:25	56.2
				11:26	56.1
				11:27	55.9

Raw Avg	56.4	**Raw Avg**	57.0	**Raw Avg**	56.2	
Span	88.9	**Span**	88.9	**Span**	88.9	
Gas Val	43.7	**Gas Val**	43.7	**Gas Val**	43.7	
$Zero_i$	0.1	**$Zero_i$**	-0.1	**$Zero_i$**	-0.1	
$Zero_f$	-0.1	**$Zero_f$**	-0.1	**$Zero_f$**	0.0	
$Span_i$	43.9	**$Span_i$**	44.0	**$Span_i$**	44.1	
$Span_f$	44.0	**$Span_f$**	44.1	**$Span_f$**	44.2	
Corr.	56.1	**Corr.**	56.5	**Corr.**	55.6	
Calibration		**Calibration**		**Calibration**		
Span	88.9	Span	88.9	Span	88.9	
Zero Cal Gas	0.0		0.0		0.0	
Mid Cal Gas	43.7		43.7		43.7	
High Cal Gas	88.9		88.9		88.9	
Zero Resp	0.0		0.0		0.0	
Mid Cal Resp	43.9		43.9		43.9	
High Cal Resp	88.3		88.3		88.3	Limits
Ana. Cal. Error (ACE)		**ACE**		**ACE**		
Zero Cal Error	0.00%		0.00%		0.00%	2.0%
Mid Cal Error	0.22%		0.22%		0.22%	2.0%
High Cal Error	-0.67%		-0.67%		-0.67%	2.0%
System Bias (zero, SB)		**SB**		**SB**		
Sys Zero Cal Bias Initial	0.11%		-0.11%		-0.11%	5.0%
Sys Zero Cal Bias Final	-0.11%		-0.11%		0.00%	5.0%
System Zero Drift (D)	0.22%		0.00%		0.11%	3.0%
System Bias (upscale, SB)		**SB**		**SB**		
System Cal Bias Initial	-49.94%		-49.83%		-49.72%	5.0%
System Cal Bias Final	-49.83%		-49.72%		-49.61%	5.0%
System Cal Drift (D)	0.11%		0.11%		0.11%	3.0%

$$C_{Gas} = (C_{avg} - C_0) \cdot [C_{ma} / (C_m - C_0)]$$ Eq. 7E-5

$$C_0 = (C_{0i} + C_{0f}) / 2$$

$$C_m = (C_{mi} + C_{mf}) / 2$$

$$ACE = (C_{Dir} - C_v) \cdot 100\% / CS$$ Eq. 7E-1

$$SB = (C_s - C_{Dir}) \cdot 100\% / CS$$ Eq. 7E-2

$$Drift\ (D) = ABS(SB_{final} - Sb_{initial})$$ Eq. 7E-4

STRATIFICATION CHECK FIELD SHEET

Facility BYU Heating Plant **Source** Main Stack, Boiler 4

Operator D Kitchen **Date** 12/6/11

Point 1		Point 2		Point 3	
Time	**NOx ppm**	**Time**	**NOx ppm**	**Time**	**NOx ppm**
9:22	56.5	9:27	55.6	9:32	55.9
9:23	56.6	9:28	55.3	9:33	56.1
9:24	56.1	9:29	55.6	9:34	56.2
9:25	55.7	9:30	55.6	9:35	56.2
9:26	55.8	9:31	55.6	9:36	56.2
Ave	**56.0**		**55.5**		**56.2**
3 Pt. Mean	**55.9**		**55.9**		**55.9**
% Diff From Mean	**0.2**		**0.7**		**0.5**

- The three sample points were on the east/west traverse line.

- If the % diff from mean is less than 5%, one sample point may be used. Use the sample point that gave the value closest to the mean value.
- If the % diff from mean is between 5% and 10%, use three sample points at 16.7, 50.0, and 83.3 % of diam.
- If the % diff from mean is greater than 10%, sample 12 points chosed according to EPA Method 1.

Boiler 6

M4 Field Data Sheet

TETCO

Filter NA Sample Box D

Page 1 of 1 Run # 1

Plant: BYU Central Heating Plant

Date: 12/6/11

Location: Baghouse Exhaust, Boiler # 6

Operator: [illegible]

Traverse Point	Time Clock	Time Min (θ)	DGM (ft³)	ΔP (in H₂O)	ΔH (in H₂O) Desired	ΔH (in H₂O) Actual	Vacuum (in Hg)	Temperatures (°F) Stack (T_s)	Probe	Probe Out	Filter	Effluent	DGM Temp (T_m) Out	In
D 1	6:17	0	422.153	.020	1.0	1.0	2	306	253			32	64	65
2		5	425.518	.018	1.0	1.0	2	305	265			37	64	67
3		10	428.544	.020	1.0	1.0	2	305	253			40	66	72
4		15	431.568	.020	1.0	1.0	2	308	250			41	68	77
C 1	6:41	20	434.606	.015	1.0	1.0	2	304	241			38	73	82
2	*	25	437.630	.017	1.0	1.0	2	304	245			40	76	85
3		30	440.675	.015	1.0	1.0	2	305	250			38	79	85
4		35	443.741	.014	1.0	1.0	2	305	240			39	81	90
B 1	7:22	40	446.798	.085	1.0	1.0	2	304	240			35	85	93
2		45	449.864	.035	1.0	1.0	2	309	243			39	86	96
3	**	50	452.943	.025	1.0	1.0	2	310	233			40	89	100
4		55	456.010	.016	1.0	1.0	2	310	247			40	91	100
A 1	7:53	60	459.033	.022	1.0	1.0	2	308	247			38	93	100
2		65	462.158	.025	1.0	1.0	2	308	263			42	94	102
3		70	465.240	.022	1.0	1.0	2	309	258			43	95	105
4		75	468.321	.020	1.0	1.0	2	309	255			44	96	106
	8:13	80	471.403											
Total			48.450	2.4115				4909					2725	
Average				.1507		1.000		306.81					85.2	

Stack Diameter 136" Port Reference 16.5"

Ports are 46.5' Upstream from next disturbance

Ports are 54.5' Downstream from last disturbance

Assumed Moisture 6 %

Probe 65A Cp 0.84

Nozzle Calibration NA

Avg D_n NA inches

Gas Bag E-05

Console 3

Y-Factor 1.004

$\Delta H_@$ 1.64 in H_2O

Barometric Pressures

Pb_m 25.60 in Hg

Pb_p 25.53 in Hg

P_G -.36 in H_2O

Leak Check:	Pre	Post
ft³/min	0.009	0.003
vac in Hg	23	13
Pitot Rate	0.0	0.0
In H_2O	0.22	23

Water Collected 126.1 g

Time Sampled 80 min

Review [illegible]

K = @T_m

K = @T_m

Comments:

* stopped At 6:46 For Bump check
start 7:02

** stopped At 7:32 For Bump check
start 7:40

3365
1832

18.64 lb/hr

80.6 ppm @ 7% O2

Facility BYU Cental Heating Plant

GAS ANALYZER FIELD DATA

Date 12 6 - 11

Operator D. Kitchen

Source Main Stack Exhaust, Boiler # 6

Response Time :50

			Gas Species	Rate	Initial Bias		Final Bias		Analyzer Avg	Corrected Avg
Run 1	Begin	6:17								
	End	6:46	NO_x	600	0.1	43.6	0.2	43.4	72.0	73.4
	Port Change									

			Gas Species	Rate	Initial Bias		Final Bias		Analyzer Avg	Corrected Avg
Run 2	Begin	702								
	End	7:32	NO_x	600	0.2	43.4	0.2	43.8	74.6	74.9
	Port Change									

			Gas Species	Rate	Initial Bias		Final Bias		Analyzer Avg	Corrected Avg
Run 3	Begin	740								
	End	813	NO_x	600	0.2	43.8	0.2	43.9	76.1	76.0
	Port Change									

			Gas Species	Rate	Initial Bias		Final Bias		Analyzer Avg	Corrected Avg
Run	Begin									
	End		NO_x							
	Port Change									

Gas Species	Calibration Gases				Calibration Error				Calibration Error			
NO_x	0.0	43.7	88.9	125.0	0.1	43.9	88.6					

Comments: All values are either ppmdv or mole percents. Corrected averages are analyzer averages corrected using equation 7E-5 unless otherwise indicated.

Eq. 7E-5: $C_{gas} = (C_{avg} - C_0) * [C_{ma} / (C_m - C_0)]$. Rate is sample flow rate in cc/min and is set within analyzer manufacturer specs.

Brigham Young University, Boiler # 6, 12/6/11

Run 1		Run 2		Run 3	
Time	NO_x ppm	Time	NO_x ppm	Time	NO_x ppm
6:17	71.4	7:02	74.7	7:40	77.1
6:18	71.8	7:03	74.6	7:41	76.8
6:19	72.2	7:04	74.3	7:42	76.1
6:20	72.6	7:05	74.2	7:43	75.8
6:21	72.6	7:06	73.8	7:44	75.5
6:22	72.6	7:07	73.7	7:45	75.5
6:23	72.5	7:08	73.9	7:46	75.6
6:24	72.6	7:09	74.0	7:47	75.8
6:25	72.7	7:10	74.4	7:48	76.1
6:26	72.6	7:11	74.2	7:49	76.4
6:27	72.6	7:12	73.8	7:50	76.5
6:28	72.7	7:13	73.6	7:51	76.7
6:29	72.9	7:14	73.4	7:52	76.4
6:30	73.4	7:15	73.7	7:53	76.4
6:31	73.9	7:16	73.7	7:54	75.8
6:32	74.6	7:17	73.4	7:55	75.4
6:33	74.9	7:18	73.3	7:56	74.8
6:34	74.7	7:19	73.4	7:57	74.3
6:35	74.6	7:20	73.3	7:58	76.9
6:36	74.7	7:21	73.3	7:59	76.6
6:37	74.6	7:22	72.9	8:00	77.6
6:38	74.4	7:23	76.1	8:01	77.9
6:39	74.1	7:24	76.7	8:02	76.7
6:40	73.3	7:25	75.8	8:03	77.6
6:41	72.8	7:26	75.7	8:04	77.7
6:42	72.4	7:27	75.9	8:05	77.5
6:43	72.0	7:28	75.9	8:06	77.2
6:44	71.5	7:29	76.0	8:07	76.0
6:45	71.3	7:30	76.4	8:08	74.9
6:46	71.2	7:31	76.9	8:09	75.7
		7:32	77.1	8:10	74.3
				8:11	74.2
				8:12	74.4
				8:13	75.6

Raw Avg	73.0	Raw Avg	74.6	Raw Avg	76.1		
Span	88.9	Span	88.9	Span	88.9		
Gas Val	43.7	Gas Val	43.7	Gas Val	43.7		
$Zero_i$	0.1	$Zero_i$	0.2	$Zero_i$	0.2		
$Zero_f$	0.2	$Zero_f$	0.2	$Zero_f$	0.2		
$Span_i$	43.6	$Span_i$	43.4	$Span_i$	43.8		
$Span_f$	43.4	$Span_f$	43.8	$Span_f$	43.9		
Corr.	73.4	Corr.	74.9	Corr.	76.0		
Calibration		Calibration		Calibration			
Span	88.9	Span	88.9	Span	88.9		
Zero Cal Gas	0.0		0.0		0.0		
Mid Cal Gas	43.7		43.7		43.7		
High Cal Gas	88.9		88.9		88.9		
Zero Resp	0.1		0.1		0.1		
Mid Cal Resp	43.9		43.9		43.9		
High Cal Resp	88.6		88.6		88.6		Limits
Ana. Cal. Error (ACE)		ACE		ACE			
Zero Cal Error	0.11%		0.11%		0.11%		2.0%
Mid Cal Error	0.22%		0.22%		0.22%		2.0%
High Cal Error	-0.34%		-0.34%		-0.34%		2.0%
System Bias (zero, SB)		SB		SB			
Sys Zero Cal Bias Initial	0.00%		0.11%		0.11%		5.0%
Sys Zero Cal Bias Final	0.11%		0.11%		0.11%		5.0%
System Zero Drift (D)	0.11%		0.00%		0.00%		3.0%
System Bias (upscale, SB)		SB		SB			
System Cal Bias Initial	-50.62%		-50.84%		-50.39%		5.0%
System Cal Bias Final	-50.84%		-50.39%		-50.28%		5.0%
System Cal Drift (D)	0.22%		0.45%		0.11%		3.0%

$$C_{Gas} = (C_{avg} - C_0) \cdot [C_{ma} / (C_m - C_0)] \qquad \text{Eq. 7E-5}$$

$$C_0 = (C_{0i} + C_{0f}) / 2$$

$$C_m = (C_{mi} + C_{mf}) / 2$$

$$ACE = (C_{Dir} - C_v) \cdot 100\% / CS \qquad \text{Eq. 7E-1}$$

$$SB = (C_s - C_{Dir}) \cdot 100\% / CS \qquad \text{Eq. 7E-2}$$

$$\text{Drift (D)} = ABS(SB_{final} - Sb_{initial}) \qquad \text{Eq. 7E-4}$$

STRATIFICATION CHECK FIELD SHEET

Facility BYU Heating Plant **Source** Main Stack, Boiler 6

Operator D Kitchen **Date** 12/6/11

Point 1		Point 2		Point 3	
Time	**NOx ppm**	**Time**	**NOx ppm**	**Time**	**NOx ppm**
5:55	70.7	6:00	71.4	6:05	73.9
5:56	70.9	6:01	71.1	6:06	73.2
5:57	71.4	6:02	70.4	6:07	73.9
5:58	71.8	6:03	70.1	6:08	73.2
5:59	72.2	6:04	70.1	6:09	71.9

Ave	**71.6**	**70.4**	**73.1**
3 Pt. Mean	**71.7**	**71.7**	**71.7**
% Diff From Mean	**0.2**	**1.7**	**1.9**

- The three sample points were on the east/west traverse line.

- If the % diff from mean is less than 5%, one sample point may be used. Use the sample point that gave the value closest to the mean value.
- If the % diff from mean is between 5% and 10%, use three sample points at 16.7, 50.0, and 83.3 % of diam.
- If the % diff from mean is greater than 10%, sample 12 points chosed according to EPA Method 1.

APPENDIX C

Sample Recovery
Gas Analysis Data (ORSAT)

Method 4

Facility: BYU Heating Plant
Stack Identification: Boilers 6 & 4

Date: 12-6-11

IMPINGERS

Run: 1 Sample Box: D

Boiler 6

	Impinger Number 1	2	3	4	5	6
Initial Volume of liquid (H_2O) in impingers, (ml)	100	100	—	Silica Gel		
Final (g)	816.2	623.2	533.0	877.3		
Initial (g)	713.8	609.7	529.6	870.5		
Net (g)	102.4	12.5	3.4	6.8		

Total (g) ~~2.4~~ 126.1

IMPINGERS

Run: 2 Sample Box: E

Boiler 4

	Impinger Number 1	2	3	4	5	6
Initial Volume of liquid (H_2O) in impingers, (ml)	100	100	—	Silica Gel		
Final (g)	786.4	646.2	516.2	912.1		
Initial (g)	708.4	635.6	513.7	904.2		
Net (g)	78.0	10.6	2.5	7.9		

Total (g) 99.0

IMPINGERS

Run: _____ Sample Box: _____

	Impinger Number 1	2	3	4	5	6
Initial Volume of liquid (H_2O) in impingers, (ml)	100	100	—	Silica Gel		
Final (g)						
Initial (g)						
Net (g)						

Total (g) _____

IMPINGERS

Run: _____ Sample Box: _____

	Impinger Number 1	2	3	4	5	6
Initial Volume of liquid (H_2O) in impingers, (ml)	100	100	—	Silica Gel		
Final (g)						
Initial (g)						
Net (g)						

Total (g) _____

Plant 1740 Heating Plant Location Boiler 4 & C

Analytical Method Orsat

Boiler C

Date 12-6-11
Test No. 1
Gas Bag No. E-05
Ambient Temp 68
Operator OAK

Gas	RUN 1 Actual Reading	RUN 1 Net	RUN 2 Actual Reading	RUN 2 Net	RUN 3 Actual Reading	RUN 3 Net	Average Net Volume
CO_2	7.4	7.4	7.4	7.4	7.4	7.4	7.40
O_2 (Net is Actual O_2 Reading Minus Actual CO_2 Reading).	15.4	8.0	15.4	8.0	15.4	8.0	8.0
N_2 (Net is 100 Minus Actual O_2 Reading).							

Boiler 4

Date 12-6-11
Test No. 1
Gas Bag No. E-05
Ambient Temp 68
Operator OAK

Gas	RUN 1 Actual Reading	RUN 1 Net	RUN 2 Actual Reading	RUN 2 Net	RUN 3 Actual Reading	RUN 3 Net	Average Net Volume
CO_2	6.2	6.2	6.2	6.2	6.2	6.2	6.20
O_2 (Net is Actual O_2 Reading Minus Actual CO_2 Reading).	16.6	10.4	16.6	10.4	16.6	10.4	10.4
N_2 (Net is 100 Minus Actual O_2 Reading).							

Date
Test No.
Gas Bag No.
Ambient Temp
Operator

Gas	RUN 1 Actual Reading	RUN 1 Net	RUN 2 Actual Reading	RUN 2 Net	RUN 3 Actual Reading	RUN 3 Net	Average Net Volume
CO_2							
O_2 (Net is Actual O_2 Reading Minus Actual CO_2 Reading).							
N_2 (Net is 100 Minus Actual O_2 Reading).							

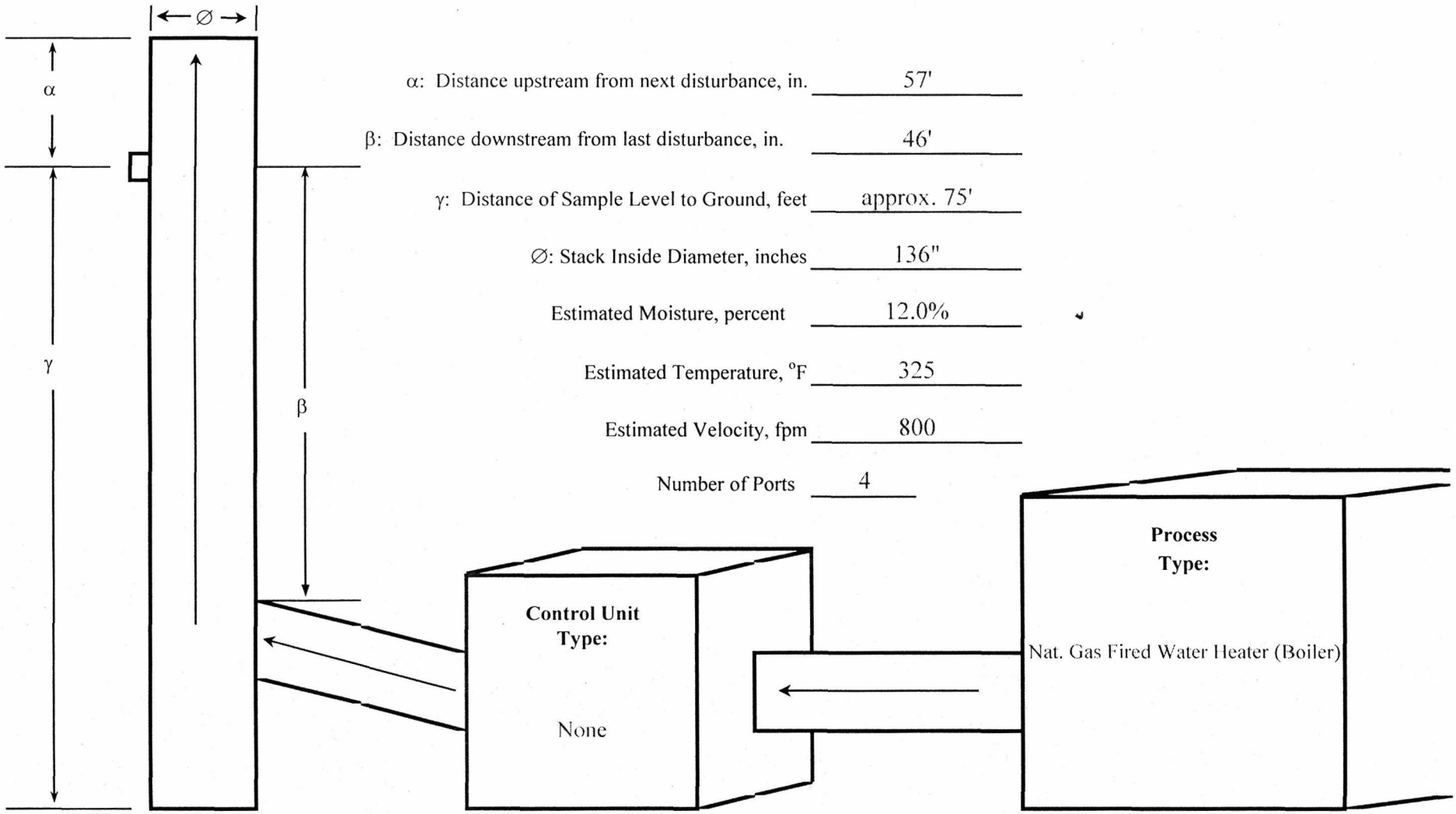
†O_2 was determined using a gas analyzer
CO is not measured, as it has the same molecular weight as N_2

APPENDIX D

Figure 1. Facility Schematic Representation
Raw Production

Facility: BYU Central Heating Plant

Stack Identification: Main Stack, Natural Gas



α: Distance upstream from next disturbance, in. 57'

β: Distance downstream from last disturbance, in. 46'

γ: Distance of Sample Level to Ground, feet approx. 75'

∅: Stack Inside Diameter, inches 136"

Estimated Moisture, percent 12.0%

Estimated Temperature, °F 325

Estimated Velocity, fpm 800

Number of Ports 4

Figure 1. Facility Schematic Representation

Brigham Young University

Central Heating Plant Baghouse

Boiler # 4 12-6-11

Test Run #	Test Time	Gas Flow Rate MCF	Instantaneous Rate mmBtu/hr	Integrator mmBtu
	Start 924	15284.98	74.5	529 132.50
	End 1019	15367.20	75.0	529205.50
		net		net 72.00
				⇒ 78.55 mmBtu/hr
	Start 1019	15367.20	75.0	529205.50
	End 1052	15417.73	75.1	529249.00
		net	~~75~~	net 43.5
				79.09 mmBtu/hr
	Start 1052	15417.73	75.0	529249.00
	End 1130	15479.87	72.9	529297.75
		net		net 48.75
				76.97 mmBtu/hr
	Start			
	End			
		net		net

Notes: average for all 3 test runs 78.2 mmBtu/hr

Brigham Young University

Central Heating Plant Baghouse

Boiler # 6 12-6-11

Test Run #	Test Time	Gas Flow Rate MCF	Instantaneous Rate mmBtu/hr	Integrator mmBtu
	Start 6:13	671576.13	81.6	705458.10
	End 6:51	671626.13	82.47	705515.81
		net		net 57.71
				=> 91.12 mmBtu/hr
	Start 700	671639.56	82.0	705529.13
	End 736	671687.81	84.93	705582.81
		net		net 57.68
				=> 89.47 mmBtu/hr
	Start 736	671687.81	84.93	705582.81
	End 816	671741.31	85.70	705642.94
		net		net 60.13 mmBtu
				=> 90.20 mmBtu/hr
	Start			
	End			
		net		net

Notes: Avg = 90.3 mmBtu/hr

APPENDIX E

Calibration of the console dry gas meter(s), pitot tubes, nozzles diameters, and temperature sensors were carried out in accordance with the procedures outlined in the Quality Assurance Handbook. The appropriate calibration data are presented in the following pages.

Figure 2. Schematic of Method 4 Sampling Train
Figure 3. Schematic of Gaseous Analyzer Sampling Train
Meter Box Calibration Data and Calculations Forms
Post-test Dry Gas Meter Calibration Data Forms
Type S Pitot Tube Inspection Data
Sample Box Temperature Sensor Calibration
Gas Calibration Gas Certification
NO_x Converter Efficiency Test

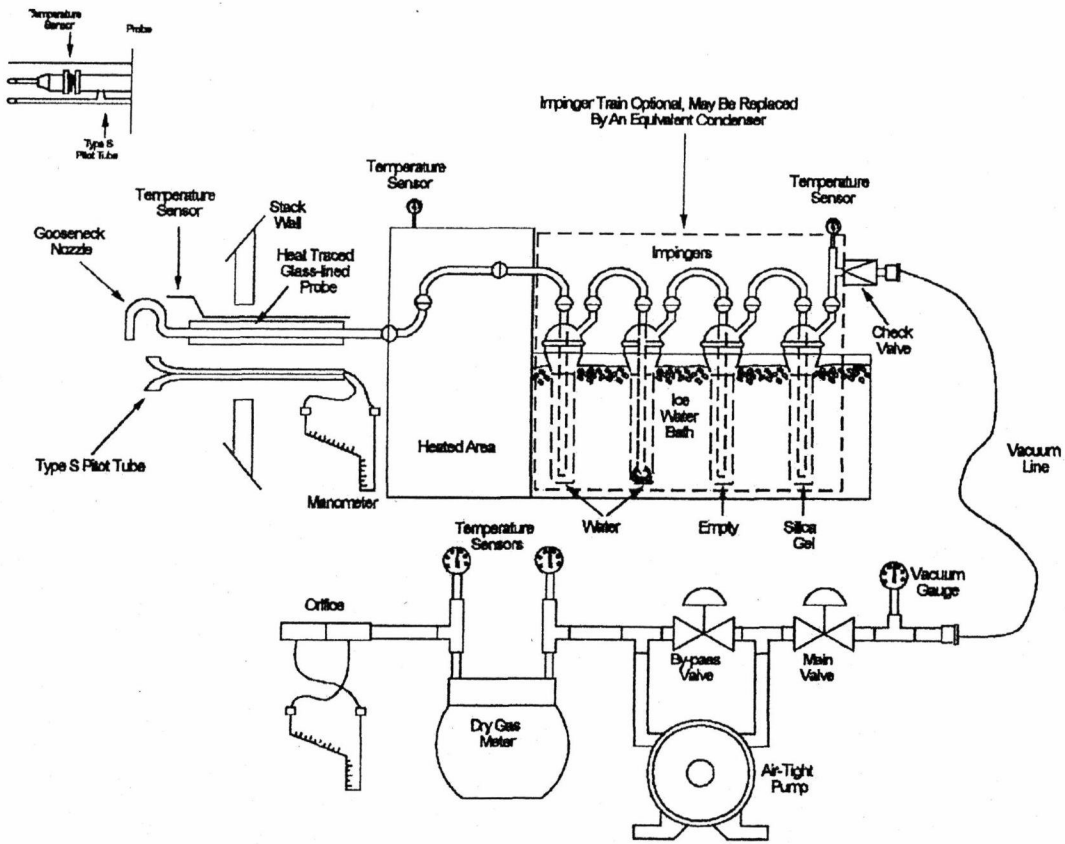


Figure 2. Schematic of Method 4 Sampling Train

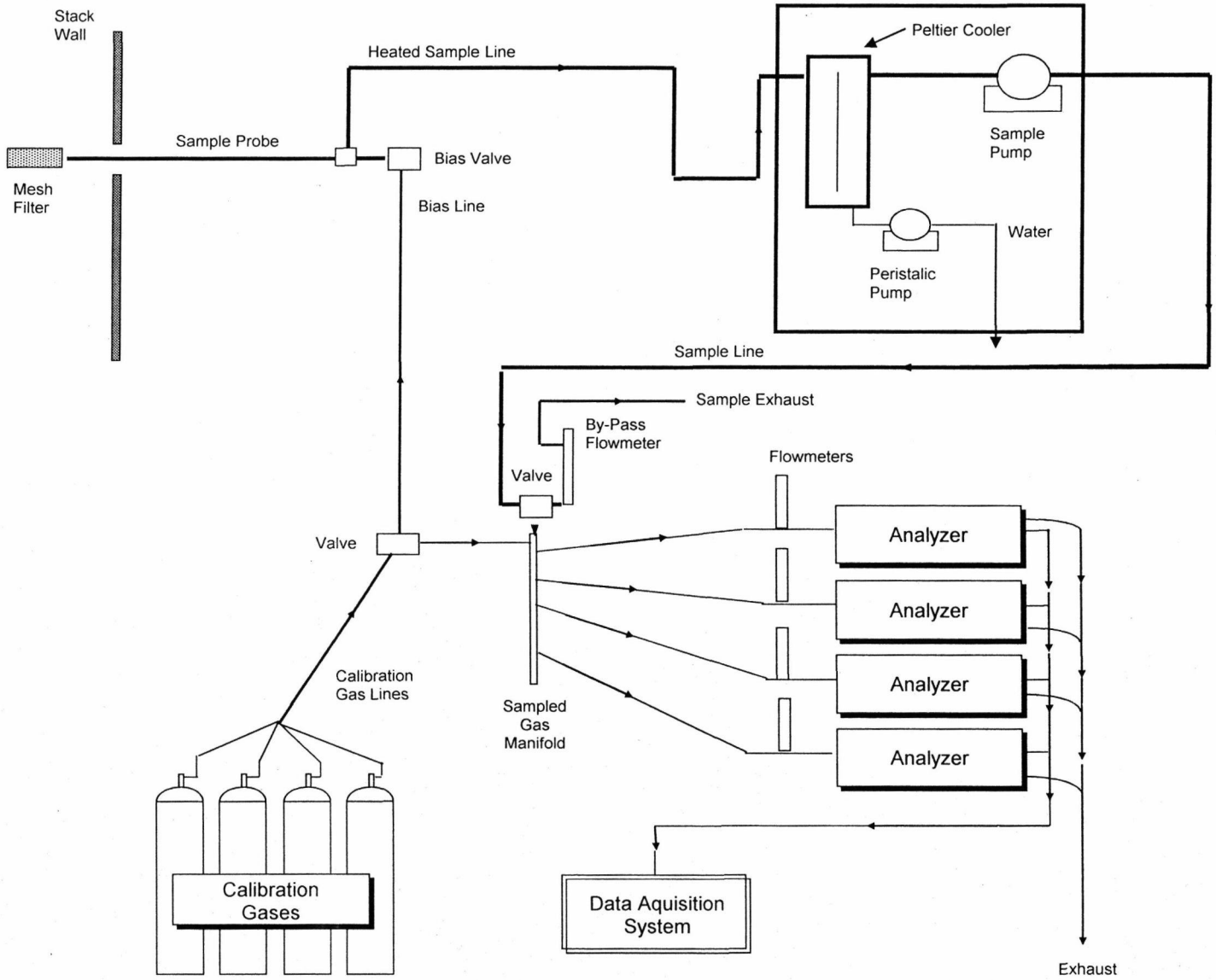


Figure 3. Schematic of Gas Analyzer Sampling Train.

METHOD 5 DRY GAS METER CALIBRATION USING CRITICAL ORIFICES

1) Select three critical orifices to calibrate the dry gas meter which bracket the expected operating range.
2) Record barometric pressure before and after calibration procedure.
3) Run at tested vacuum (from Orifice Calibration Report), for a period of time necessary to achieve a minimum total volume of 5 cubic feet.
4) Record data and information in the GREEN cells, YELLOW cells are calculated.

Facility **New Calibration 2011**

DATE: 12/15/2010
METER PART #: Console 3
METER SERIAL #: 1522588
CRITICAL ORIFICE SET SERIAL #: 1453S
BAROMETRIC PRESSURE (in Hg): INITIAL 25.30 | FINAL 25.30 | AVG (P_{bar}) 25.3
EQUIPMENT ID #: Console #3

IF Y VARIATION EXCEEDS 2.00%, ORIFICE SHOULD BE RECALIBRATED

ORIFICE #	RUN #	K' FACTOR (AVG)	TESTED VACUUM (in Hg)	DGM READINGS (FT^3) INITIAL	DGM READINGS (FT^3) FINAL	DGM READINGS (FT^3) NET (V_m)	TEMPERATURES °F AMBIENT	DGM INLET INITIAL	DGM INLET FINAL	DGM OUTLET INITIAL	DGM OUTLET FINAL	DGM AVG	ELAPSED TIME (MIN) θ	DGM ΔH (in H_2O)	(1) V_m (STD)	(2) V_{cr} (STD)	(3) Y	Y VARIATION (%)	$\Delta H_@$
30	1	0.8137	13	896.006	901.301	5.295	74	74	76	70	70	72.5	5.00	2.90	4.4778	4.4556	0.995		1.737
	2	0.8137	13	901.301	906.609	5.308	74	76	79	70	72	74.25	5.00	2.90	4.4741	4.4556	0.996		1.731
	3	0.8137	13	906.609	911.936	5.327	74	79	80	72	73	76.00	5.00	2.90	4.4754	4.4556	0.996		1.726
																AVG =	0.996	-0.89	
19	1	0.5317	13	912.40	917.596	5.196	74	79	80	75	82	79.00	7.50	1.20	4.3198	4.3672	1.011		1.655
	2	0.5317	13	917.596	922.809	5.213	74	80	82	74	77	78.25	7.50	1.20	4.340	4.3672	1.006		1.657
	3	0.5317	13	922.809	928.018	5.209	74	82	83	77	78	80.00	7.50	1.20	4.3226	4.3672	1.010		1.652
																AVG =	1.009	0.48	
12	1	0.3307	13	928.304	933.524	5.220	74	82	83	78	79	80.50	12.00	0.44	4.3182	4.3460	1.006		1.561
	2	0.3307	13	933.524	938.841	5.317	74	81	83	79	80	80.75	12.25	0.44	4.3964	4.4366	1.009		1.560
	3	0.3307	13	938.841	944.055	5.214	74	83	84	80	80	81.75	12.00	0.44	4.3032	4.3460	1.010		1.557
																AVG =	1.009	0.41	

USING THE CRITICAL ORIFICES AS CALIBRATION STANDARDS:
The following equations are used to calculate the standard volumes of air passed through the DGM, V_m (std), and the critical orifice, V_{cr} (std), and the DGM calibration factor, Y. These equations are automatically calculated in the spreadsheet above.

AVERAGE DRY GAS METER CALIBRATION FACTOR, Y = **1.004**

AVERAGE $\Delta H_@$ = **1.649**

(1) $$Vm_{(std)} = K_1 * Vm * \frac{Pbar + (\Delta H / 13.6)}{Tm}$$

= Net volume of gas sample passed through DGM, corrected to standard conditions
K_1 = 17.64 °R/in. Hg (English), 0.3858 °K/mm Hg (Metric)
T_m = Absolute DGM avg. temperature (°R - English, °K - Metric)

(2) $$Vcr_{(std)} = K' * \frac{Pbar * \Theta}{\sqrt{Tamb}}$$

= Volume of gas sample passed through the critical orifice, corrected to standard conditions
T_{amb} = Absolute ambient temperature (°R - English, °K - Metric)
K' = Average K' factor from Critical Orifice Calibration

(3) $$Y = \frac{Vcr_{(std)}}{Vm_{(std)}}$$

= DGM calibration factor

$$\Delta H_@ = \left(\frac{0.75\,\theta}{V_{cr}(std)}\right)^2 \Delta H \left(\frac{V_m(std)}{V_m}\right)$$

Temperature Sensors

Reference °F	In °F	Out °F
34	34	35
67	67	67
202	202	204

METHOD 5 DRY GAS METER CALIBRATION USING CRITICAL ORIFICES

1) Select three critical orifices to calibrate the dry gas meter which bracket the expected operating range.
2) Record barometric pressure before and after calibration procedure.
3) Run at tested vacuum (from Orifice Calibration Report), for a period of time necessary to achieve a minimum total volume of 5 cubic feet.
4) Record data and information in the **GREEN** cells, YELLOW cells are calculated.

Quality - Service - Reliability

Facility **BYU**

							INITIAL	FINAL	AVG (P_{bar})
DATE:	12/7/2011	METER SERIAL #:	1522588	BAROMETRIC PRESSURE (in Hg):			25.65	25.65	25.65
METER PART #:	Console 3	CRITICAL ORIFICE SET SERIAL #:	1453S	EQUIPMENT ID #:	Console #3				

IF Y VARIATION EXCEEDS 2.00%, ORIFICE SHOULD BE RECALIBRATED

ORIFICE #	RUN #	K' FACTOR (AVG)	TESTED VACUUM (in Hg)	DGM READINGS (FT^3) INITIAL	DGM READINGS (FT^3) FINAL	DGM READINGS (FT^3) NET (V_m)	TEMPERATURES °F AMBIENT	DGM INLET INITIAL	DGM INLET FINAL	DGM OUTLET INITIAL	DGM OUTLET FINAL	DGM AVG	ELAPSED TIME (MIN) θ	DGM ΔH (in H_2O)	(1) V_m (STD)	(2) V_{cr} (STD)	(3) Y	Y VARIATION (%)	$\Delta H_@$
19	1	0.5317	15	531.008	536.195	5.187	78	77	79	80	82	79.5	7.50	1.20	4.3677	4.4111	1.010		1.643
	2	0.5317	15	536.195	541.558	5.363	78	79	82	82	85	82	7.75	1.20	4.4950	4.5582	1.014		1.636
	3	0.5317	15	541.558	547.10	5.542	78	82	83	85	88	84.50	8.00	1.20	4.6237	4.7052	1.018		1.628
																AVG =	1.014	0.00	
	1					.0						0.00							
	2					.0						0.00							
	3					.0						0.00							
																AVG =			
	1					.0						0.00							
	2					.0						0.00							
	3					.0						0.00							
																AVG =			

USING THE CRITICAL ORIFICES AS CALIBRATION STANDARDS:
The following equations are used to calculate the standard volumes of air passed through the DGM, V_m (std), and the critical orifice, V_{cr} (std), and the DGM calibration factor, Y. These equations are automatically calculated in the spreadsheet above.

AVERAGE DRY GAS METER CALIBRATION FACTOR, Y = **1.014**

AVERAGE $\Delta H_@$ = **1.636**

(1) $$Vm_{(std)} = K_1 * Vm * \frac{Pbar + (\Delta H / 13.6)}{Tm}$$

= Net volume of gas sample passed through DGM, corrected to standard conditions
K_1 = 17.64 °R/in. Hg (English), 0.3858 °K/mm Hg (Metric)
T_m = Absolute DGM avg. temperature (°R - English, °K - Metric)

(2) $$Vcr_{(std)} = K' * \frac{Pbar * \Theta}{\sqrt{Tamb}}$$

= Volume of gas sample passed through the critical orifice, corrected to standard conditions
T_{amb} = Absolute ambient temperature (°R - English, °K - Metric)
K' = Average K' factor from Critical Orifice Calibration

(3) $$Y = \frac{Vcr_{(std)}}{Vm_{(std)}}$$

= DGM calibration factor

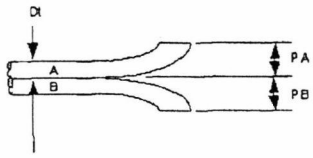
$$\Delta H_@ = \left(\frac{0.75\,\theta}{V_{cr}(std)}\right)^2 \Delta H \left(\frac{V_m(std)}{V_m}\right)$$

Type S Pitot Tube Inspection Data

Date: 12-20-10

Pitot Tube Identification: 65 A

Technician: K. McNamara



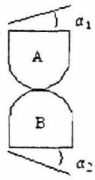
Dt= .250 in.

Is $P_A = P_B$? Yes

Is $1.05 \cdot D_t \le D_t \le 1.50 \cdot D_t$? Yes

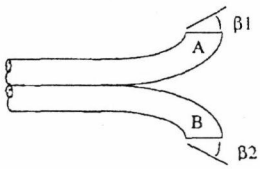
P_A = .368 in.

P_B = .368 in.



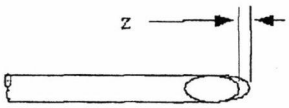
$\alpha_1 < 10°$ α_1 = 1 °

$\alpha_2 < 10°$ α_2 = 1 °

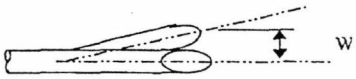


$\beta_1 < 5°$ β_1 = 0 °

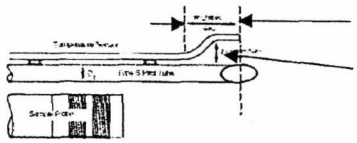
$\beta_2 < 5°$ β_2 = 0 °



$Z \le 0.125$ in. Z = .003 in.

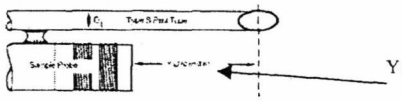


$W \le 0.03125$ in. W = .013 in.



W > 3 inches W = 6 in.

Z > 3/4 inch Z = 1 in.



Y ≥ 3 inches Y = 4 in.

The pitot tube meets the specifications for a calibration factor of 0.84? Yes

Temperature Sensor Calibration

Reference: _____

	Temperature Source (Medium)	Temperature Reference (°F)	Temperature Sensor (°F)	Temperature Difference (°F)
Probe	AIR	68	68	0
	Continuity	—	—	Yes
	Heat Check 248	—	Yes	250
Stack	AIR	66	68	0
	ICE WATER	32	32	0
	BOIL WATER	205	204	1
	SILICONE OIL			

TETCO

Sample Box Temperature Sensor Calibration

Date: 12/29/10 Calibrator: Mike McNamara Reference: Omega CL3512A

Unit ID	Thermocouple Location	Temperature Source (Medium)	Temperature Reference (°F)	Temperature Sensor (°F)	Temp. Diff. or Result (°F), P/F
A	Oven	Water	34	34	0
		Water	203	203	0
	Probe Out	Water	34	33	1
		Water	203	204	-1
	Impinger Out	Water	34	36	-2
		Water	203	203	0
B	Oven	Water	32	34	-2
		Water	203	204	-1
	Probe Out	Water	32	33	-1
		Water	202	204	-2
	Impinger Out	Water	31	31	0
		Water	203	205	-2
C	Oven	Water	34	36	-2
		Water	204	205	-1
	Probe Out	Water	34	36	-2
		Water	203	205	-2
	Impinger Out	Water	34	36	-2
		Water	203	201	2
D	Oven	Water	33	33	0
		Water	203	203	0
	Probe Out	Water	33	33	0
		Water	202	203	-1
	Impinger Out	Water	33	33	0
		Water	203	201	2
E	Oven	Water	33	34	-1
		Water	203	203	0
	Probe Out	Water	33	34	-1
		Water	203	204	-1
	Impinger Out	Water	33	33	0
		Water	203	204	-1
F	Oven	Water	33	33	0
		Water	203	202	1
	Probe Out	Water	33	33	0
		Water	203	201	2
	Impinger Out	Water	33	34	-1
		Water	203	201	2
	Impinger Out G	Water	33	34	-1
		Water	203	202	1
	Impinger Out H	Water	33	35	-2
		Water	203	202	1
	Impinger Out I	Water	33	33	0
		Water	203	204	-1
	Impinger Out J	Water	33	33	0
		Water	203	204	-1

LIQUID TECHNOLOGY CORPORATION

"INDUSTRY LEADER IN SPECIALTY GASES"

Certificate of Analysis

- EPA PROTOCOL GAS -

Customer	TETCO (American Fork, UT)
Date	July 13, 2010
Delivery Receipt	DR-29974
Gas Standard	45.0 ppm NO, 45.0 ppm Carbon Monoxide/Nitrogen
Final Analysis Date	July 08, 2010
Expiration Date	July 08, 2012

DO NOT USE BELOW 150 psig

Analytical Data:
EPA Protocol, Section No. 2.2, Procedure G-1.

Reported Concentrations:

Nitric Oxide: 43.7 ppm +/- 0.43 ppm

Carbon Monoxide: 46.3 ppm +/- 0.46 ppm

Nitrogen: Balance

Total NOx: 43.9 ppm

** Total NOx for Reference Use Only **

Reference Standards

SRM/GMIS	GMIS	GMIS/GMIS
Cylinder Number:	EB-0021453	CC-125604/CC-233168
Concentration:	48.68 ppm NO	25.5 ppm CO/50.67 ppm CO
Expiration Date:	05/05/12	02/27/12 - 02/12/12

Certification Instrumentation

Component:	Nitric Oxide	Carbon Monoxide
Make/Model:	Horiba - CLA 510	Nicolet-NEXUS 470
Serial Number:	43331870031	AEP99000154
Principal of Measurement:	Chemiluminescence	FTIR
Last Calibration:	June 14, 2010	July 07, 2010

Cylinder Data

Cylinder Number:	CC-310793	Cylinder Volume:	140 Cubic Feet
Cylinder Outlet:	CGA 660	Cylinder Pressure:	2000 psig, 70°F
Expiration Date:	July 08, 2012		

Analytical Uncertainty and NIST Traceability are in compliance with EPA-600/R-97/121.

Certified by:

Adam Strickland

"UNMATCHED EXCELLENCE"

2564 PEMBERTON DRIVE APOPKA, FLORIDA 32703 ~ PHONE (407)-292-2990 FAX (407)-292-3313
WWW.LIQUIDTECHCORP.COM

LIQUID TECHNOLOGY CORPORATION

"INDUSTRY LEADER IN SPECIALTY GASES"

Certificate of Analysis

- EPA PROTOCOL GAS -

Customer	TETCO (American Fork, UT)
Date	August 06, 2010
Delivery Receipt	DR-30291
Gas Standard	90.0 ppm NO, 90.0 ppm Carbon Monoxide/Nitrogen
Final Analysis Date	August 06, 2010
Expiration Date	August 06, 2012

DO NOT USE BELOW 150 psig

Analytical Data:
EPA Protocol, Section No. 2.2, Procedure G-1.

Reported Concentrations:

Nitric Oxide: 88.9 ppm +/- 0.88 ppm

Carbon Monoxide: 91.9 ppm +/- 0.91 ppm

Nitrogen: Balance

Total NOx: 88.9 ppm

** Total NOx for Reference Use Only **

Reference Standards

SRM/GMIS	GMIS	GMIS/GMIS
Cylinder Number:	EB-0021453	CC-233168/CC-231409
Concentration:	48.68 ppm NO	50.67 ppm CO/102.53 ppm CO
Expiration Date:	05/05/12	02/12/12 - 07/14/11

Certification Instrumentation

Component:	Nitric Oxide	Carbon Monoxide
Make/Model:	Horiba - CLA 510	Nicolet-NEXUS 470
Serial Number:	43331870031	AEP99000154
Principal of Measurement:	Chemiluminescence	FTIR
Last Calibration:	July 19, 2010	July 07, 2010

Cylinder Data

Cylinder Number:	EB-0024198	Cylinder Volume:	140 Cubic Feet
Cylinder Outlet:	CGA 660	Cylinder Pressure:	2000 psig, 70°F
Expiration Date:	August 06, 2012		

Analytical Uncertainty and NIST Traceability are in compliance with EPA-600/R-97/121.

Certified by:

Adam Strickland

"UNMATCHED EXCELLENCE"

2564 PEMBERTON DRIVE APOPKA, FLORIDA 32703 ~ PHONE (407)-292-2990 FAX (407)-292-3313
WWW.LIQUIDTECHCORP.COM

Scott Specialty Gases
www.scottgas.com

Shipped From: 8832 DICE ROAD
SANTA FE SPRINGS CA 90670-2516
Phone: 800-323-2212 Fax: 562-464-5262

C E R T I F I C A T E O F A N A L Y S I S

ALA-CYL-SALT LAKE CITY (LOC 84427)
TRANSFER ACCOUNT- FILL LO
1676 SOUTH 700 WEST
SALT LAKE CITY UT 84104
US

DOCUMENT#:43025901 -002
PO#: PURES
ITEM #: P841-30AL
DATE: 31Aug2011

CYLINDER #: CC236971
FILL PRESSURE: 02000 PSIG

PURE MATERIAL: NITROGEN CAS# 7727-37-9

GRADE: ACID RAIN CEM 0

PURITY: 99.9995%

IMPURITY	MAXIMUM CONCENTRATIONS	ACTUAL CONCENTRATIONS
SO2	0.1 PPM	<0.1 PPM
NOX	0.1 PPM	<0.1 PPM
CO	0.5 PPM	<0.5 PPM
CO2	1 PPM	<0.5 PPM
THC	0.1 PPM	<0.1 PPM
H2O	2 PPM	1.9 PPM
O2	0.5 PPM	0.4 PPM

QC BATCH : SBO0042184

ANALYST: _____
JMU

NO_x Converter Efficiency Test

Date	Time	Output
12/6/11	5:01	34.0
12/6/11	5:02	34.0
12/6/11	5:03	34.0
12/6/11	5:04	34.0
12/6/11	5:05	34.0
12/6/11	5:06	33.9
12/6/11	5:07	33.9
12/6/11	5:08	34.0
12/6/11	5:09	33.9
12/6/11	5:10	33.8
12/6/11	5:11	33.9
12/6/11	5:12	33.8
12/6/11	5:13	33.9
12/6/11	5:14	33.9
12/6/11	5:15	33.8
12/6/11	5:16	33.8
12/6/11	5:17	33.8
12/6/11	5:18	33.8
12/6/11	5:19	33.8
12/6/11	5:20	33.8
12/6/11	5:21	33.8
12/6/11	5:22	33.8
12/6/11	5:23	33.8
12/6/11	5:24	33.8
12/6/11	5:25	33.9
12/6/11	5:26	33.9
12/6/11	5:27	33.9
12/6/11	5:28	33.9
12/6/11	5:29	33.9
12/6/11	5:30	**33.9**
		END

	Concentration of Certified Gas used	**88.9**	ppmdv NO_x
	Diluted with air at approx 1:1		
	Instrument Span	**88.9**	ppmdv
	NO_{xPeak}	34.0	
	NO_{xFinal}	**33.9**	
(Eq. 7E-9)	Eff_{NO2}	**0.4**	%
	Average Reading	**33.9**	ppmdv

40 CFR 60 Appendix A-4, Method 7E, Section 16.2.2

Fill a Tedlar bag approximately half full with either ambient air, pure oxygen, or an oxygen standard gas with at least 19.5 percent by volume oxygen content. Fill the remainder of the bag with mid-level NO in nitrogen calibration gas...

Immediately attach the bag to the inlet of the NO_x analyzer (or external converter if used)... Measure the NO_x concentration for a period of 30 minutes. If the NO_x concentration drops more than 2 percent absolute from the peak value observed, then the NO_2 converter has failed to meet the criteria of this test. Take corrective action. The highest NO_x value observed is considered to be NO_{xPeak}. The final NO_x value observed is considered to be NO_{xFinal}.

APPENDIX F

The testing protocol and other correspondence related to the tests are included here.

State of Utah

GARY R. HERBERT
Governor

GREG BELL
Lieutenant Governor

Department of
Environmental Quality

Amanda Smith
Executive Director

DIVISION OF AIR QUALITY
Bryce C. Bird
Director

COPY

November 15, 2011

DAQC-1265-11
Site ID 10790 (B4)

Paul Greenwood
Brigham Young University
Physical Plant Department
225 BRWB
Provo, UT 84602

Dear Mr. Greenwood:

Re: Brigham Young University – Central Heating Plant Boilers #4 and #6 - Protocol Review and Test Date Confirmation – Utah County

The testing protocol for the Brigham Young University Central Heating Plant Boilers #4 and #6 dated October 27, 2011, has been reviewed and found acceptable. The agreed upon test date is December 6-7, 2011.

Acceptance of a protocol does not relieve the owner/operator and the testing contractor from strict adherence to all applicable EPA methods, Utah Division of Air Quality (DAQ) policies, Utah Air Quality Rules (UAQR), and methods approved by the Executive Secretary. Any deviation from EPA methods, DAQ policies, UAQR, and methods approved by the Executive Secretary must be addressed separately and express written consent given prior to commencement of testing.

The DAQ requires that all test reports include a statement signed by a responsible official certifying that:

A. Testing was conducted while the source was operating at the rate and/or conditions specified in the applicable approval order, operating permit, or federal regulation.

B. During testing, the source combusted fuels, used raw materials, and maintained process conditions representative of normal operations, and operated under such other relevant conditions specified by the Executive Secretary.

C. Based on information and belief formed after reasonable inquiry, the statements and information contained in the report are true, accurate, and complete.

If you have any questions, call me at (801) 536-4438 or e-mail me at rleishman@utah.gov.

Sincerely,

Rob Leishman, Environmental Scientist
Division of Air Quality

RL:lk

cc: Utah County Health Department
TETCO

NO_X COMPLIANCE EMISSION TESTING PROTOCOL
BRIGHAM YOUNG UNIVERSITY, PROVO, UTAH
CENTRAL HEATING PLANT BAGHOUSE
BOILERS #4 AND #6

Project Organization and Responsibility

The following personnel and the testing contractor are presently anticipated to be involved in the testing program. Utah Department of Environmental Quality, Division of Air Quality (DAQ) may have their own personnel or contractor to observe all phases including the process.

Company	**Contacts**
Brigham Young University Physical Plant Department 225 BRWB Provo, UT 84602	Paul Greenwood (801) 422-5438 Assistant Director, Utilities, Engineering and Maintenance
Test Contractor TETCO 391 East 620 South American Fork, UT 84003	Dean A. Kitchen (801) 492-9106 Paul Kitchen

During these tests only Brigham Young University (BYU) personnel listed above or assigned personnel from the operation are authorized to answer or obtain answers to pertinent questions on the process conditions or the test protocol.

Test Schedule

It is planned to complete this test project December 6-7, 2011. The testing crew will arrive, set up and take preliminary measurements December 5th. Testing will begin the morning of December 6th. A pretest meeting may be held at the request of BYU or DAQ.

Project Description

This test project will be conducted to comply with the requirements of BYU's Title V Operating Permit, Permit No. 4900004002, which requires testing Boilers #4 and #6 for NO_x emissions every three years. Testing will be performed according to EPA Methods 1-4, and 7E and will include accumulating process and production data.

Test Procedures

Three tests runs will be conducted on each unit for NO_x emissions. Testing will be EPA Methods 1-4 and 7E as specified in 40 CFR 60, Appendix A. One Method 4 test may span up to three Method 7E tests. Specific test procedures are as follows:

EPA Methods 1-4

1. Boilers #4 and #6 have a common exhaust stack with an inside diameter of 136 inches. The sample ports are located 46 feet downstream and 57 feet upstream from any flow disturbance and conform to EPA Method 1. Sample points will be selected according to EPA Method 1 for a non-particulate traverse.

2. EPA Method 2 will be used to determine gas stream velocity. Type "S" pitot tubes will be used with a C_p factor of 0.84. Dual inclined/vertical manometers with graduations in 0.01 inches of water will be used. If flows are below 0.05 inches of water a more sensitive manometer will be used. The graduations marks on int are 0.005 inches of water. Direction of gas flow will be checked for cyclonics prior to testing.

3. A barometer will be used to measure the barometric pressure. It is periodically checked against a mercury barometer. Prior to testing it will be checked to assure an accurate barometric pressure.

4. EPA Method 3 will be used to determine the gas stream dry molecular weight. An integrated flue gas sample will be taken from the exhaust line after the dry gas meter orifice during each run and analyzed at the completion of the test with an Orsat to determine the molecular weight of the effluent gas stream.

5. The Method 4 test run time will be sufficient to sample at least 21 dscf as required by Method 4.

6. The probe liners will be 316 stainless steel.

7. Preparation and clean-up by the contractor will be performed in the contractor's testing trailer. Laboratory work and analysis will be performed by the testing contractor as soon as possible after all tests have been completed.

8. If plant maintenance or operating problems arise during the test, the test may be stopped. This determination will be made by the Brigham Young University representatives or operating personnel in consultation with agency representatives.

9. Current calibration data is submitted in Appendix A of this protocol. Any equipment calibration that fall past due prior to the test date will be recalibrated prior to use.

Gaseous Analyzer Measurements

The following procedures will be used fo the Method 7E tests:

1. A gaseous analyzer will be used to measure the NO_x concentrations during the emissions test project. It is planned to run the NO_x machine on the 0-250 ppm range. EPA Protocol 1 gases will be used as calibration standards with dry nitrogen as a zero gas.

2. A gaseous analyzer may be used to measure the O_2 concentrations in place of an Orsat analysis during the emissions test project. If operated, the O_2 analyzer would be run on the 0-10 percent range. EPA Protocol 1 gases would be used as calibration standards with dry nitrogen as a zero gas.

3. The gas analyzer sampling train will consist of the following: an in-stack glass fiber filter, heated stainless steel probe, Teflon heated sampling line to the water removal system, water removal system, Teflon transport lines, gas manifold, and out of stack Teflon filter after the gas manifold but prior to analyzers. The sampling train is built such that the sampled gas only comes in contact with inert materials, i.e., Teflon, stainless steel, and glass.

4. The number of sample points for the Method 7E sampling train will be determined according to the results of a stratification check as per Method 7E, section 8.1.2.

5 The NO_x converter efficiency check will be completed according to Method 7E, section 16.2.2.

6. Bias checks, calibration drift, zero drift and calibration error will follow the specified guidelines of EPA Method 7E. Interference responses were determined in the factory and no alterations have been done, therefore, factory specifications are satisfactory.

7. A data logger will be used to record measured concentrations. Gas analyzer data during port changes will not be considered valid data.

Test Area

The test area shall include the Heating Plant control room, main floor, and stack areas, and the area around the contractors testing trailer.

Process Data

process parameters will be made available to DAQ personnel and included in the test report.

Quality Assurance

All testing and analysis in these tests will be conducted according to Methods 4 and 7E as specified in this protocol, and appropriate sections of the *EPA Quality Assurance Handbook for Air Pollution Measurement Systems Vol. III.*

Reporting

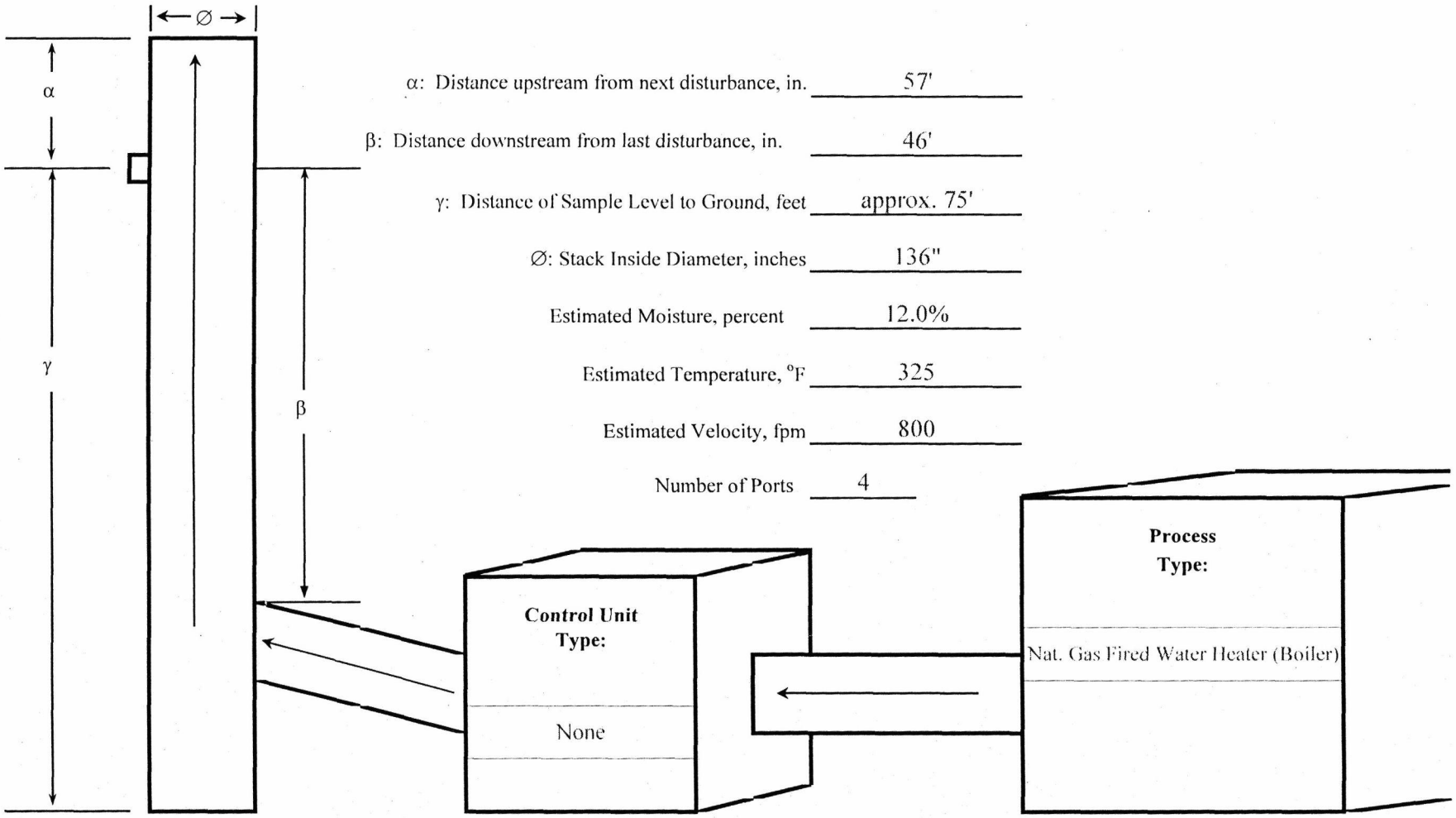
Complete copies of raw data, calculations and summary of test will be included in reports. All process and production data will be recorded and retained for inspection and copying by DAQ. The contractor will furnish copies of the test report to Paul Greenwood, Assistant Director, Utilities, Engineering and Maintenance.

Appendix A

lity Schematic

Facility: BYU Central Heating Plant

Stack Identification: Main Stack, Natural Gas



α: Distance upstream from next disturbance, in.	57'
β: Distance downstream from last disturbance, in.	46'
γ: Distance of Sample Level to Ground, feet	approx. 75'
Ø: Stack Inside Diameter, inches	136"
Estimated Moisture, percent	12.0%
Estimated Temperature, °F	325
Estimated Velocity, fpm	800
Number of Ports	4

Figure 1. Facility Schematic Representation

Appendix B

Calibration Data

METHOD 5 DRY GAS METER CALIBRATION USING CRITICAL ORIFICES

ES Quality - Service - Reliability

ENVIRONMENTAL SUPPLY COMPANY

1) Select three critical orifices to calibrate the dry gas meter which bracket the expected operating range.
2) Record barometric pressure before and after calibration procedure.
3) Run at tested vacuum (from Orifice Calibration Report), for a period of time necessary to achieve a minimum total volume of 5 cubic feet.
4) Record data and information in the GREEN cells, YELLOW cells are calculated.

Facility: **New Calibration 2011**

DATE: 12/15/2010

METER PART #: Console 3

METER SERIAL #: 1522588

CRITICAL ORIFICE SET SERIAL #: 1453S

BAROMETRIC PRESSURE (in Hg): INITIAL 25.30 | FINAL 25.30 | AVG (P_{bar}) 25.3

EQUIPMENT ID #: Console #3

IF Y VARIATION EXCEEDS 2.00%, ORIFICE SHOULD BE RECALIBRATED

ORIFICE #	RUN #	K' FACTOR (AVG)	TESTED VACUUM (in Hg)	DGM READINGS (FT^3) INITIAL	DGM READINGS (FT^3) FINAL	DGM READINGS (FT^3) NET (V_m)	TEMPERATURES °F AMBIENT	DGM INLET INITIAL	DGM INLET FINAL	DGM OUTLET INITIAL	DGM OUTLET FINAL	DGM AVG	ELAPSED TIME (MIN) θ	DGM ΔH (in H_2O)	(1) V_m (STD)	(2) V_{cr} (STD)	(3) Y	Y VARIATION (%)	$\Delta H_@$
30	1	0.8137	13	896.006	901.301	5.295	74	74	76	70	70	72.5	5.00	2.90	4.4778	4.4556	0.995		1.737
	2	0.8137	13	901.301	906.609	5.308	74	76	79	70	72	74.25	5.00	2.90	4.4741	4.4556	0.996		1.731
	3	0.8137	13	906.609	911.936	5.327	74	79	80	72	73	76.00	5.00	2.90	4.4754	4.4556	0.996		1.726
																AVG =	0.996	-0.89	
19	1	0.5317	13	912.40	917.596	5.196	74	79	80	75	82	79.00	7.50	1.20	4.3198	4.3672	1.011		1.655
	2	0.5317	13	917.596	922.809	5.213	74	80	82	74	77	78.25	7.50	1.20	4.340	4.3672	1.006		1.657
	3	0.5317	13	922.809	928.018	5.209	74	82	83	77	78	80.00	7.50	1.20	4.3226	4.3672	1.010		1.652
																AVG =	1.009	0.48	
12	1	0.3307	13	928.304	933.524	5.220	74	82	83	78	79	80.50	12.00	0.44	4.3182	4.3460	1.006		1.561
	2	0.3307	13	933.524	938.841	5.317	74	81	83	79	80	80.75	12.25	0.44	4.3964	4.4366	1.009		1.560
	3	0.3307	13	938.841	944.055	5.214	74	83	84	80	80	81.75	12.00	0.44	4.3032	4.3460	1.010		1.557
																AVG =	1.009	0.41	

USING THE CRITICAL ORIFICES AS CALIBRATION STANDARDS:
The following equations are used to calculate the standard volumes of air passed through the DGM, V_m (std), and the critical orifice, V_{cr} (std), and the DGM calibration factor, Y. These equations are automatically calculated in the spreadsheet above.

AVERAGE DRY GAS METER CALIBRATION FACTOR, Y = **1.004**

AVERAGE $\Delta H_@$ = **1.649**

(1) $$Vm_{(std)} = K_1 * Vm * \frac{Pbar + (\Delta H / 13.6)}{Tm}$$

= Net volume of gas sample passed through DGM, corrected to standard conditions
K_1 = 17.64 °R/in. Hg (English), 0.3858 °K/mm Hg (Metric)
T_m = Absolute DGM avg. temperature (°R - English, °K - Metric)

(2) $$Vcr_{(std)} = K' * \frac{Pbar * \Theta}{\sqrt{Tamb}}$$

= Volume of gas sample passed through the critical orifice, corrected to standard conditions
T_{amb} = Absolute ambient temperature (°R - English, °K - Metric)
K' = Average K' factor from Critical Orifice Calibration

(3) $$Y = \frac{Vcr_{(std)}}{Vm_{(std)}}$$

= DGM calibration factor

$$\Delta H_@ = \left(\frac{0.75\,\theta}{V_{cr}(std)}\right)^2 \Delta H \left(\frac{V_m(std)}{V_m}\right)$$

Temperature Sensors (4-28-08)

Reference °F	In °F	Out °F
34	34	35
67	67	67
202	202	204

METHOD 5 DRY GAS METER CALIBRATION USING CRITICAL ORIFICES

Quality - Service - Reliability

1) Select three critical orifices to calibrate the dry gas meter which bracket the expected operating range.
2) Record barometric pressure before and after calibration procedure.
3) Run at tested vacuum (from Orifice Calibration Report), for a period of time necessary to achieve a minimum total volume of 5 cubic feet.
4) Record data and information in the GREEN cells, YELLOW cells are calculated.

2011 Pre-Calibration

DATE: 12/15/2010
METER PART #: Console 4
METER SERIAL #: 27863
CRITICAL ORIFICE SET SERIAL #: 1453S
EQUIPMENT ID #: Console #4

	INITIAL	FINAL	AVG (P_{bar})
BAROMETRIC PRESSURE (in Hg):	25.25	25.25	25.25

IF Y VARIATION EXCEEDS 2.00%, ORIFICE SHOULD BE RECALIBRATED

ORIFICE #	RUN #	K' FACTOR (AVG)	TESTED VACUUM (in Hg)	DGM READINGS (FT^3) INITIAL	DGM READINGS (FT^3) FINAL	DGM READINGS (FT^3) NET (V_m)	TEMPERATURES °F AMBIENT	DGM INLET INITIAL	DGM INLET FINAL	DGM OUTLET INITIAL	DGM OUTLET FINAL	DGM AVG	ELAPSED TIME (MIN) θ	DGM ΔH (in H_2O)	(1) V_m (STD)	(2) V_{cr} (STD)	(3) Y	Y VARIATION (%)	$\Delta H_@$
30	1	0.8137	13	949.501	954.735	5.234	72	68	73	66	68	68.75	5.00	2.60	4.4450	4.4552	1.002		1.564
	2	0.8137	13	954.735	960.015	5.280	72	73	76	68	70	71.75	5.00	2.60	4.4588	4.4552	0.999		1.556
	3	0.8137	13	960.015	965.317	5.302	72	76	80	70	70	74.00	5.00	2.60	4.4585	4.4552	0.999		1.549
																AVG =	1.000	-0.32	
19	1	0.5317	13	966.902	972.124	5.222	72	82	86	72	76	79.00	7.50	1.12	4.3318	4.3668	1.008		1.542
	2	0.5317	13	972.124	977.544	5.420	72	86	88	76	80	82.50	7.75	1.12	4.4671	4.5123	1.010		1.532
	3	0.5317	13	977.544	982.827	5.283	72	88	90	80	83	85.25	7.50	1.12	4.3322	4.3668	1.008		1.524
																AVG =	1.009	0.52	
12	1	0.3307	13	983.4500	988.857	5.407	72	88	89	83	87	86.75	12.25	0.42	4.4127	4.4361	1.005		1.470
	2	0.3307	13	988.857	994.191	5.334	72	89	92	87	89	89.25	12.00	0.42	4.3333	4.3456	1.003		1.464
	3	0.3307	13	994.191	999.697	5.506	72	92	93	90	92	91.75	12.25	0.42	4.4528	4.4361	0.996		1.457
																AVG =	1.001	-0.20	

USING THE CRITICAL ORIFICES AS CALIBRATION STANDARDS:
The following equations are used to calculate the standard volumes of air passed through the DGM, V_m (std), and the critical orifice, V_{cr} (std), and the DGM calibration factor, Y. These equations are automatically calculated in the spreadsheet above.

AVERAGE DRY GAS METER CALIBRATION FACTOR, Y = **1.003**

AVERAGE $\Delta H_@$ = **1.517**

(1) $$Vm_{(std)} = K_1 * Vm * \frac{Pbar + (\Delta H / 13.6)}{Tm}$$

= Net volume of gas sample passed through DGM, corrected to standard conditions
K_1 = 17.64 °R/in. Hg (English), 0.3858 °K/mm Hg (Metric)
T_m = Absolute DGM avg. temperature (°R - English, °K - Metric)

(2) $$Vcr_{(std)} = K' * \frac{Pbar * \Theta}{\sqrt{Tamb}}$$

= Volume of gas sample passed through the critical orifice, corrected to standard conditions
T_{amb} = Absolute ambient temperature (°R - English, °K - Metric)
K' = Average K' factor from Critical Orifice Calibration

(3) $$Y = \frac{Vcr_{(std)}}{Vm_{(std)}}$$

= DGM calibration factor

$$\Delta H_@ = \left(\frac{0.75\,\theta}{V_{cr}(std)}\right)^2 \Delta H \left(\frac{V_m(std)}{V_m}\right)$$

Temperature Sensors

Reference °F	In °F	Out °F
33	34	34
67	67	67
201	203	202

METHOD 5 DRY GAS METER CALIBRATION USING CRITICAL ORIFICES

Quality - Service - Reliability

1) Select three critical orifices to calibrate the dry gas meter which bracket the expected operating range.
2) Record barometric pressure before and after calibration procedure.
3) Run at tested vacuum (from Orifice Calibration Report), for a period of time necessary to achieve a minimum total volume of 5 cubic feet.
4) Record data and information in the GREEN cells, YELLOW cells are calculated.

2011 Pre-Calibration

DATE: 12/20/2010
METER PART #: Console 5
METER SERIAL #: 68092
CRITICAL ORIFICE SET SERIAL #: 1453S
BAROMETRIC PRESSURE (in Hg): INITIAL 25.10 | FINAL 25.10 | AVG (P_{bar}) 25.10
EQUIPMENT ID #: Console #5

IF Y VARIATION EXCEEDS 2.00%, ORIFICE SHOULD BE RECALIBRATED

ORIFICE #	RUN #	K' FACTOR (AVG)	TESTED VACUUM (in Hg)	DGM READINGS (FT^3) INITIAL	DGM READINGS (FT^3) FINAL	DGM READINGS (FT^3) NET (V_m)	TEMPERATURES °F AMBIENT	DGM INLET INITIAL	DGM INLET FINAL	DGM OUTLET INITIAL	DGM OUTLET FINAL	DGM AVG	ELAPSED TIME (MIN) θ	DGM ΔH (in H_2O)	(1) V_m (STD)	(2) V_{cr} (STD)	(3) Y	Y VARIATION (%)	$\Delta H_@$
30	1	0.8137	12	155.004	161.521	6.517	74	82	83	89	93	86.75	6.00	2.55	5.320	5.3045	0.997		1.498
	2	0.8137	12	161.521	168.043	6.522	74	83	83	93	96	88.75	6.00	2.55	5.3046	5.3045	1.000		1.493
	3	0.8137	12	168.043	174.568	6.525	74	83	83	96	99	90.25	6.00	2.55	5.2926	5.3045	1.002		1.489
																AVG =	1.000	-0.09	
19	1	0.5317	13	136.700	142.672	5.972	74	81	80	84	86	82.75	8.50	1.11	4.8905	4.9104	1.004		1.532
	2	0.5317	13	142.672	148.297	5.625	74	80	81	86	88	83.75	8.00	1.11	4.5978	4.6215	1.005		1.529
	3	0.5317	13	148.297	153.926	5.629	74	81	82	88	89	85.00	8.00	1.11	4.5905	4.6215	1.007		1.526
																AVG =	1.005	0.47	
12	1	0.3307	13	116.20	125.809	9.609	74	76	78	77	80	77.75	22.00	0.40	7.9255	7.9047	0.997		1.437
	2	0.3307	13	125.809	131.075	5.266	74	78	80	80	81	79.75	12.00	0.40	4.3273	4.3117	0.996		1.432
	3	0.3307	13	131.075	136.357	5.282	74	80	81	81	84	81.50	12.00	0.40	4.3264	4.3117	0.997		1.428
																AVG =	0.997	-0.38	

USING THE CRITICAL ORIFICES AS CALIBRATION STANDARDS:
The following equations are used to calculate the standard volumes of air passed through the DGM, V_m (std), and the critical orifice, V_{cr} (std), and the DGM calibration factor, Y. These equations are automatically calculated in the spreadsheet above.

AVERAGE DRY GAS METER CALIBRATION FACTOR, Y = **1.001**

AVERAGE $\Delta H_@$ = **1.485**

(1) $$Vm_{(std)} = K_1 * Vm * \frac{Pbar + (\Delta H / 13.6)}{Tm}$$

= Net volume of gas sample passed through DGM, corrected to standard conditions
K_1 = 17.64 °R/in. Hg (English), 0.3858 °K/mm Hg (Metric)
T_m = Absolute DGM avg. temperature (°R - English, °K - Metric)

(2) $$Vcr_{(std)} = K' * \frac{Pbar * \Theta}{\sqrt{Tamb}}$$

= Volume of gas sample passed through the critical orifice, corrected to standard conditions
T_{amb} = Absolute ambient temperature (°R - English, °K - Metric)
K' = Average K' factor from Critical Orifice Calibration

(3) $$Y = \frac{Vcr_{(std)}}{Vm_{(std)}}$$

= DGM calibration factor

$$\Delta H_@ = \left(\frac{0.75\,\theta}{V_{cr}(std)}\right)^2 \Delta H \left(\frac{V_m(std)}{V_m}\right)$$

Temperature Sensors

Reference °F	In °F	Out °F
32	32	32
72	73	73
203	201	202

[redacted]METE[redacted]5 DR[redacted]AS M[redacted]R CALIBRATION USING CRITICAL ORIFICES

Quality - Service - Reliability

1) Select three critical orifices to calibrate the dry gas meter which bracket the expected operating range.
2) Record barometric pressure before and after calibration procedure.
3) Run at tested vacuum (from Orifice Calibration Report), for a period of time necessary to achieve a minimum total volume of 5 cubic feet.
4) Record data and information in the GREEN cells, YELLOW cells are calculated.

2011 Pre-Calibration

DATE: 12/14/2010 | METER SERIAL #: 26144 | BAROMETRIC PRESSURE (in Hg): INITIAL 25.20, FINAL 25.20, AVG (P_{bar}) 25.20

METER PART #: Console 6 | CRITICAL ORIFICE SET SERIAL #: 1453S | EQUIPMENT ID #: **Console #6**

IF Y VARIATION EXCEEDS 2.00%, ORIFICE SHOULD BE RECALIBRATED

ORIFICE #	RUN #	K' FACTOR (AVG)	TESTED VACUUM (in Hg)	DGM READINGS (FT^3) INITIAL	DGM READINGS (FT^3) FINAL	DGM READINGS (FT^3) NET (V_m)	TEMPERATURES °F AMBIENT	DGM INLET INITIAL	DGM INLET FINAL	DGM OUTLET INITIAL	DGM OUTLET FINAL	DGM AVG	ELAPSED TIME (MIN) θ	DGM ΔH (in H_2O)	(1) V_m (STD)	(2) V_{cr} (STD)	(3) Y	Y VARIATION (%)	$\Delta H_@$
30	1	0.8137	13	443.725	449.104	5.379	71	73	79	73	73	74.5	5.00	3.00	4.5153	4.4506	0.986		1.788
	2	0.8137	13	449.104	454.492	5.388	71	79	82	73	73	76.75	5.00	3.00	4.5039	4.4506	0.988		1.780
	3	0.8137	13	454.492	459.885	5.393	71	82	85	73	74	78.5	5.00	3.00	4.4934	4.4506	0.990		1.775
																AVG =	0.988	-0.51	
19	1	0.5317	12	460.802	466.60	5.798	72	78	80	75	75	77.00	8.25	1.20	4.8192	4.7939	0.995		1.662
	2	0.5317	12	466.60	471.872	5.272	72	80	81	75	75	77.75	7.50	1.20	4.3759	4.3581	0.996		1.659
	3	0.5317	12	471.872	477.157	5.285	72	81	81	75	76	78.25	7.50	1.20	4.3826	4.3581	0.994		1.658
																AVG =	0.995	0.19	
12	1	0.3307	12	477.70	482.955	5.255	72	78	79	76	77	77.50	12.00	0.43	4.3540	4.3370	0.996		1.534
	2	0.3307	12	482.955	488.227	5.272	72	79	82	77	78	79.00	12.00	0.43	4.3559	4.3370	0.996		1.530
	3	0.3307	12	488.227	493.613	5.386	72	82	82	78	80	80.50	12.25	0.43	4.4378	4.4273	0.998		1.526
																AVG =	0.996	0.33	

USING THE CRITICAL ORIFICES AS CALIBRATION STANDARDS:
The following equations are used to calculate the standard volumes of air passed through the DGM, V_m (std), and the critical orifice, V_{cr} (std), and the DGM calibration factor, Y. These equations are automatically calculated in the spreadsheet above.

AVERAGE DRY GAS METER CALIBRATION FACTOR, Y = 0.993

AVERAGE $\Delta H_@$ = 1.657

(1) $$Vm_{(std)} = K_1 * Vm * \frac{Pbar + (\Delta H / 13.6)}{Tm}$$

= Net volume of gas sample passed through DGM, corrected to standard conditions
K_1 = 17.64 °R/in. Hg (English), 0.3858 °K/mm Hg (Metric)
T_m = Absolute DGM avg. temperature (°R - English, °K - Metric)

(2) $$Vcr_{(std)} = K' * \frac{Pbar * \Theta}{\sqrt{Tamb}}$$

= Volume of gas sample passed through the critical orifice, corrected to standard conditions
T_{amb} = Absolute ambient temperature (°R - English, °K - Metric)
K' = Average K' factor from Critical Orifice Calibration

(3) $$Y = \frac{Vcr_{(std)}}{Vm_{(std)}}$$

= DGM calibration factor

$$\Delta H_@ = \left(\frac{0.75\,\theta}{V_{cr}(std)}\right)^2 \Delta H \left(\frac{V_m(std)}{V_m}\right)$$

Temperature Sensors

Reference °F	In °F	Out °F
33	33	34
68	67	67
202	202	202

1) Select three critical orifices to calibrate the dry gas meter which bracket the expected operating range.
2) Record barometric pressure before and after calibration procedure.
3) Run at tested vacuum (from Orifice Calibration Report), for a period of time necessary to achieve a minimum total volume of 5 cubic feet.
4) Record data and information in the GREEN cells, YELLOW cells are calculated.

2010 Pre-Calibration Console 7

DATE: 12/16/2010
METER PART #: Console 7
METER SERIAL #: 68092
CRITICAL ORIFICE SET SERIAL #: 1453S
BAROMETRIC PRESSURE (in Hg): INITIAL 25.45 | FINAL 25.45 | AVG (P_{bar}) 25.45
EQUIPMENT ID #: Console #7

IF Y VARIATION EXCEEDS 2.00%, ORIFICE SHOULD BE RECALIBRATED

ORIFICE #	RUN #	K' FACTOR (AVG)	TESTED VACUUM (in Hg)	DGM READINGS (FT^3) INITIAL	DGM READINGS (FT^3) FINAL	NET (V_m)	TEMPERATURES °F AMBIENT	DGM INLET INITIAL	DGM INLET FINAL	DGM OUTLET INITIAL	DGM OUTLET FINAL	DGM AVG	ELAPSED TIME (MIN) θ	DGM ΔH (in H_2O)	(1) V_m (STD)	(2) V_{cr} (STD)	(3) Y	Y VARIATION (%)	$\Delta H_@$
30	1	0.8137	12	3.7040	12.435	8.731	75	88	89	89	89	88.75	8.00	3.10	7.2110	7.1646	0.994		1.796
	2	0.8137	12	12.435	19.003	6.568	75	89	89	89	91	89.5	6.00	3.10	5.4171	5.3734	0.992		1.793
	3	0.8137	12	19.003	24.463	5.460	75	89	89	92	93	90.75	5.00	3.10	4.4931	4.4779	0.997		1.789
																AVG =	0.994	-0.38	
19	1	0.5317	12	968.901	974.579	5.678	75	80	81	84	86	82.75	8.00	1.15	4.7149	4.6816	0.993		1.569
	2	0.5317	12	974.579	980.960	6.381	75	81	82	86	88	84.25	9.00	1.15	5.2840	5.2668	0.997		1.564
	3	0.5317	12	980.960	986.636	5.676	75	82	83	88	89	85.50	8.00	1.15	4.6894	4.6816	0.998		1.561
																AVG =	0.996	-0.18	
12	1	0.3307	12	986.900	992.147	5.247	75	82	83	85	86	84.00	12.00	0.47	4.3385	4.3677	1.007		1.650
	2	0.3307	12	992.147	997.419	5.272	75	83	84	86	86	84.75	12.00	0.47	4.3531	4.3677	1.003		1.648
	3	0.3307	12	997.419	1,002.711	5.292	75	84	84	86	86	85.00	12.00	0.47	4.3676	4.3677	1.000		1.647
																AVG =	1.003	0.56	

USING THE CRITICAL ORIFICES AS CALIBRATION STANDARDS:
The following equations are used to calculate the standard volumes of air passed through the DGM, V_m (std), and the critical orifice, V_{cr} (std), and the DGM calibration factor, Y. These equations are automatically calculated in the spreadsheet above.

AVERAGE DRY GAS METER CALIBRATION FACTOR, Y = **0.998**

AVERAGE $\Delta H_@$ = **1.668**

(1) $$Vm_{(std)} = K_1 * Vm * \frac{Pbar + (\Delta H / 13.6)}{Tm}$$

= Net volume of gas sample passed through DGM, corrected to standard conditions
K_1 = 17.64 °R/in. Hg (English), 0.3858 °K/mm Hg (Metric)
T_m = Absolute DGM avg. temperature (°R - English, °K - Metric)

(2) $$Vcr_{(std)} = K' * \frac{Pbar * \Theta}{\sqrt{Tamb}}$$

= Volume of gas sample passed through the critical orifice, corrected to standard conditions
T_{amb} = Absolute ambient temperature (°R - English, °K - Metric)
K' = Average K' factor from Critical Orifice Calibration

(3) $$Y = \frac{Vcr_{(std)}}{Vm_{(std)}}$$

= DGM calibration factor

$$\Delta H_@ = \left(\frac{0.75\,\theta}{V_{cr}(std)}\right)^2 \Delta H \left(\frac{V_m(std)}{V_m}\right)$$

Temperature Sensors

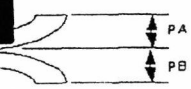
Reference °F	In °F	Out °F
32	33	33
72	73	73
120	120	121

Type S Pitot Tube Inspection Data

-20-10

Pitot Tube Identification: 69

Technician: K McNamara



Dt= .250 in.

Is $P_A = P_B$? Yes

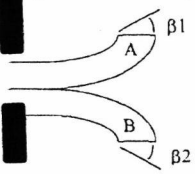
Is $1.05 \cdot D_t \le D_t \le 1.50 \cdot D_t$? Yes

P_A = .321 in.

P_B = .321 in.

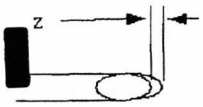
$\alpha_1 < 10°$ α_1 = 1 °

$\alpha_2 < 10°$ α_2 = 1 °

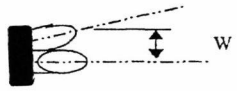


$\beta_1 < 5°$ β_1 = 1 °

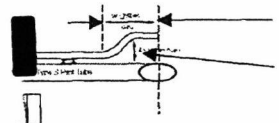
$\beta_2 < 5°$ β_2 = 1 °



$Z \le 0.125$ in. Z = .001 in.

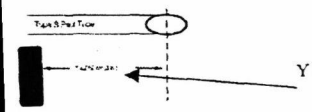


$W \le 0.03125$ in. W = .022 in.



W > 3 inches W = 3 in.

Z > 3/4 inch Z = 1 in.



$Y \ge 3$ inches Y = 4 1/4 in.

pitot tube meets the specifications for a calibration factor of 0.84? Yes

Temperature Sensor Calibration

Reference

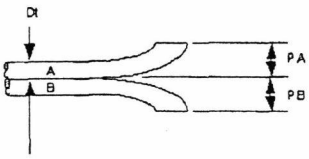
	Temperature Source (Medium)	Temperature Reference (°F)	Temperature Sensor (°F)	Temperature Difference (°F)
Probe	AIR	68	68	0
	Continuity	—	—	Yes
	Heat Check 248	—	Yes	1.50
Stack	AIR	68	66	0
	ICE WATER	32	32	0
	BOIL WATER	204	205	1
	SILICONE OIL			

Type S Pitot Tube Inspection Data

Date: 12-20-10

Pitot Tube Identification: 65 A

Technician: K. McNamara



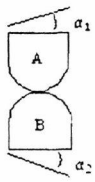
Dt= .250 in.

Is $P_A = P_B$? Yes

Is $1.05 \cdot D_t \le D_t \le 1.50 \cdot D_t$? Yes

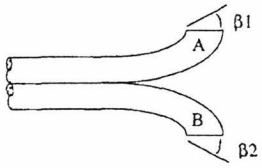
P_A = .368 in.

P_B = .368 in.



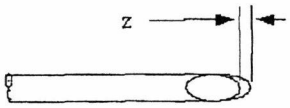
$\alpha_1 < 10°$ α_1 = 1 °

$\alpha_2 < 10°$ α_2 = 1 °

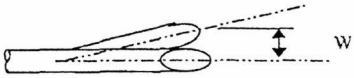


$\beta_1 < 5°$ β_1 = 0 °

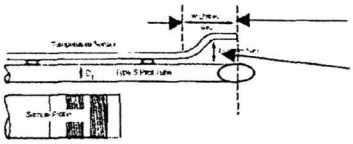
$\beta_2 < 5°$ β_2 = 0 °



Z ≤ 0.125 in. Z = .003 in.

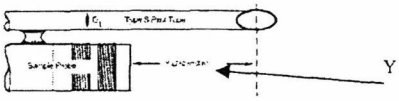


W ≤ 0.03125 in. W = .013 in.



W > 3 inches W = 6 in.

Z > 3/4 inch Z = 1 in.



Y ≥ 3 inches Y = 4 in.

The pitot tube meets the specifications for a calibration factor of 0.84? Yes

Temperature Sensor Calibration

Reference: _____

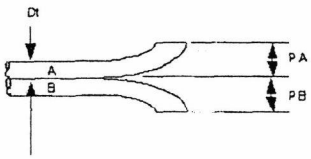
	Temperature Source (Medium)	Temperature Reference (°F)	Temperature Sensor (°F)	Temperature Difference (°F)
Probe	AIR	68	68	0
	Continuity	—	—	Yes
	Heat Check 248	—	Yes	250
Stack	AIR	66	66	0
	ICE WATER	32	32	0
	BOIL WATER	205	204	1
	SILICONE OIL			

Type S Pitot Tube Inspection Data

Date: 12-20-10

Pitot Tube Identification: 60-G-2

Technician: K McNamara



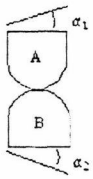
Dt= .375 in.

Is $P_A = P_B$? yes

Is $1.05 \cdot D_t \le D_t \le 1.50 \cdot D_t$? yes

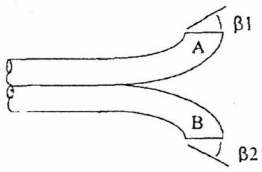
P_A = .478 in.

P_B = .472 in.



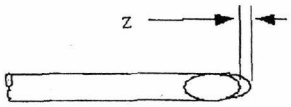
$\alpha_1 < 10°$ α_1 = 0 °

$\alpha_2 < 10°$ α_2 = 2 °

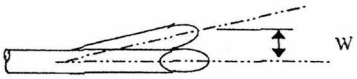


$\beta_1 < 5°$ β_1 = 2 °

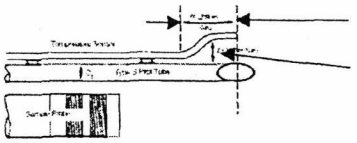
$\beta_2 < 5°$ β_2 = 2 °



$Z \le 0.125$ in. Z = .066 in.

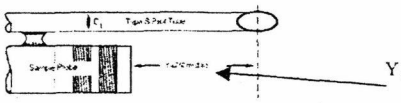


$W \le 0.03125$ in. W = .008 in.



W > 3 inches W = 4 4/8 in.

Z > 3/4 inch Z = ___ in.



$Y \ge 3$ inches Y = 3 9/16 in.

The pitot tube meets the specifications for a calibration factor of 0.84? Yes

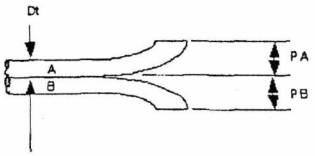
Temperature Sensor Calibration				
Reference:				
	Temperature Source (Medium)	Temperature Reference (°F)	Temperature Sensor (°F)	Temperature Difference (°F)
Probe	AIR	67	67	0
	Continuity	→	→	yes
	Heat Check 248	→	Yes	250
Stack	AIR	67	67	0
	ICE WATER	32	32	0
	BOIL WATER	204	204	0
	SILICONE OIL			

Type S Pitot Tube Inspection Data

Date: 12-20-10

Pitot Tube Identification: 60-G-1

Technician: K. McNamara



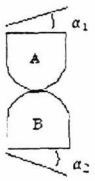
Dt= .375 in.

Is $P_A = P_B$? Yes

Is $1.05 \cdot D_t \le D_t \le 1.50 \cdot D_t$? Yes

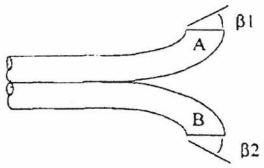
P_A = .454 in.

P_B = .454 in.



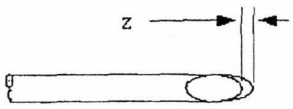
$\alpha_1 < 10°$ α_1 = 2 °

$\alpha_2 < 10°$ α_2 = 1 °

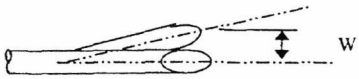


$\beta_1 < 5°$ β_1 = 1 °

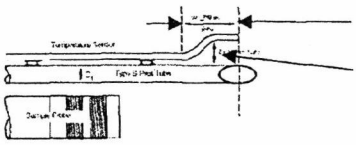
$\beta_2 < 5°$ β_2 = 2 °



Z ≤ 0.125 in. Z = .033 in.

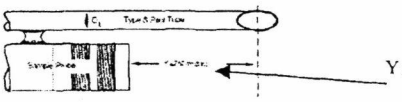


W ≤ 0.03125 in. W = .030 in.



W > 3 inches W = 4 in.

Z > 3/4 inch Z = 1 1/4 in.



Y ≥ 3 inches Y = 3 1/16 in.

The pitot tube meets the specifications for a calibration factor of 0.84? Yes

Temperature Sensor Calibration

Reference

	Temperature Source (Medium)	Temperature Reference (°F)	Temperature Sensor (°F)	Temperature Difference (°F)
Probe	AIR	68	68	0
	Continuity			Yes
	Heat Check 248		Yes	250
Stack	AIR	68	68	0
	ICE WATER	32	32	0
	BOIL WATER	204	204	0
	SILICONE OIL			

TETCO

Sample Box Temperature Sensor Calibration

Date: 12/29/10 Calibrator: Mike McNamara Reference: Omega CL3512A

Unit ID	Thermocouple Location	Temperature Source (Medium)	Temperature Reference (°F)	Temperature Sensor (°F)	Temp. Diff. or Result (°F), P/F
A	Oven	Water	34	34	0
		Water	203	203	0
	Probe Out	Water	34	33	1
		Water	203	204	-1
	Impinger Out	Water	34	36	-2
		Water	203	203	0
B	Oven	Water	32	34	-2
		Water	203	204	-1
	Probe Out	Water	32	33	-1
		Water	202	204	-2
	Impinger Out	Water	31	31	0
		Water	203	205	-2
C	Oven	Water	34	36	-2
		Water	204	205	-1
	Probe Out	Water	34	36	-2
		Water	203	205	-2
	Impinger Out	Water	34	36	-2
		Water	203	201	2
D	Oven	Water	33	33	0
		Water	203	203	0
	Probe Out	Water	33	33	0
		Water	202	203	-1
	Impinger Out	Water	33	33	0
		Water	203	201	2
E	Oven	Water	33	34	-1
		Water	203	203	0
	Probe Out	Water	33	34	-1
		Water	203	204	-1
	Impinger Out	Water	33	33	0
		Water	203	204	-1
F	Oven	Water	33	33	0
		Water	203	202	1
	Probe Out	Water	33	33	0
		Water	203	201	2
	Impinger Out	Water	33	34	-1
		Water	203	201	2
	Impinger Out G	Water	33	34	-1
		Water	203	202	1
	Impinger Out H	Water	33	35	-2
		Water	203	202	1
	Impinger Out I	Water	33	33	0
		Water	203	204	-1
	Impinger Out J	Water	33	33	0
		Water	203	204	-1

Since **Heusser Neweigh** 1906

Certificate of Balance Calibration

Company Name: Tetco
Address: 391 East 620 South
City/State/Zip: American Fork, Utah 84003

Next Calibration Due: **December, 2011**
Reference Weights Cal ID.: 74

Certificate No.: 2105
Calibration Date: 2010, December 13
Metrologist: Rebecca
Order Number: None

Manufacturer:	Model	Serial Number	Identification No.	Location	Nominal Mass	Indication
Ohaus	EP214	1122121229	None	Lab	1	1.0000
					200	199.9999

Comments:

Pertinent Information:
The artifact described herein has been calibrated using standards traceable to NIST. This is to certify the data reported herein is true and correct as of the date calibrated. The procedure used to calibrate the artifact meets the requirements and guidelines of the Heusser Neweigh Quality Assurance Program (Revision 2006-1) and the purchase requisition referenced herein, if any.

Authorized Signature: Rebecca Lewis

© Heusser Neweigh

Heusser Neweigh, LLC 832 Elgin Ave, Salt Lake City, UT 84106 801.486.0995 Fax 801.486.0995
This certificate may only be reproduced, in full, for internal use, by the customer to whom it is issued.

Rev. 061210

LIQUID TECHNOLOGY CORPORATION

"INDUSTRY LEADER IN SPECIALTY GASES"

Certificate of Analysis

- EPA PROTOCOL GAS -

Customer	TETCO (American Fork, UT)
Date	August 06, 2010
Delivery Receipt	DR-30291
Gas Standard	230 ppm NO, 230 ppm Carbon Monoxide/Nitrogen
Final Analysis Date	August 06, 2010
Expiration Date	August 06, 2012

DO NOT USE BELOW 150 psig

Analytical Data:

EPA Protocol, Section No. 2.2, Procedure G-1.

Reported Concentrations:

Nitric Oxide: 224 ppm +/- 2.2 ppm

Carbon Monoxide: 238 ppm +/- 2.3 ppm

Nitrogen: Balance

Total NOx: 224 ppm

** Total NOx for Reference Use Only **

Reference Standards

SRM/GMIS	GMIS/GMIS	GMIS/GMIS
Cylinder Number:	EB-0021691/CC-231368	CC-231409/CC-251549
Concentration:	167.13 ppm NO/253.03 ppm NO	102.53 ppm CO/267.38 ppm CO
Expiration Date:	05/03/12 - 07/16/12	07/14/11 - 11/01/11

Certification Instrumentation

Component:	Nitric Oxide	Carbon Monoxide
Make/Model:	Horiba - CLA 510	Nicolet-NEXUS 470
Serial Number:	43331870031	AEP99000154
Principal of Measurement:	Chemiluminescence	FTIR
Last Calibration:	July 19, 2010	July 07, 2010

Cylinder Data

Cylinder Number:	EB-0024550	Cylinder Volume:	140 Cubic Feet
Cylinder Outlet:	CGA 660	Cylinder Pressure:	2000 psig, 70°F
Expiration Date:	August 06, 2012		

Analytical Uncertainty and NIST Traceability are in compliance with EPA-600/R-97/121.

Certified by:

Adam Strickland

"UNMATCHED EXCELLENCE"

2564 PEMBERTON DRIVE APOPKA, FLORIDA 32703 ~ PHONE (407)-292-2990 FAX (407)-292-3313
WWW.LIQUIDTECHCORP.COM

Tetco # 35857580 12-31-09

AIR LIQUIDE Air Liquide America Specialty Gases LLC SCOTT™

RATA CLASS

Dual-Analyzed Calibration Standard

500 WEAVER PARK RD, LONGMONT, CO 80501 Phone: 888-253-1635 Fax: 303-772-7673

CERTIFICATE OF ACCURACY: Interference Free™ Multi-Component EPA Protocol Gas

Assay Laboratory

AIR LIQUIDE AMERICA SPECIALTY GASES LLC
500 WEAVER PARK RD
LONGMONT, CO 80501

P.O. No.: CODE & GO
Project No.: 08-83014-001

Customer

AIR LIQUIDE

TIM DALL
1676 SOUTH 700 WEST
SALT LAKE CITY UT 84104

ANALYTICAL INFORMATION

This certification was performed according to EPA Traceability Protocol For Assay & Certification of Gaseous Calibration Standards; Procedure G-1; September, 1997.

Cylinder Number: CC160789 **Certification Date:** 18Dec2009 **Exp. Date:** 18Dec2011
Cylinder Pressure*:** 1790 PSIG

COMPONENT	CERTIFIED CONCENTRATION (Moles)		ACCURACY**	TRACEABILITY
CARBON MONOXIDE	125	PPM	+/- 1%	Direct NIST and VSL
NITRIC OXIDE	125	PPM	+/- 1%	Direct NIST and VSL
NITROGEN - OXYGEN FREE		BALANCE		
TOTAL OXIDES OF NITROGEN	126.	PPM		Reference Value Only

*** Do not use when cylinder pressure is below 150 psig.
** Analytical accuracy is based on the requirements of EPA Protocol Procedure G1, September 1997.

REFERENCE STANDARD

TYPE/SRM NO.	EXPIRATION DATE	CYLINDER NUMBER	CONCENTRATION	COMPONENT
NTRM 1679	02Oct2010	KAL003131	101.0 PPM	CARBON MONOXIDE
NTRM 1684	15Oct2012	KAL004441	95.84 PPM	NITRIC OXIDE

INSTRUMENTATION

INSTRUMENT/MODEL/SERIAL#	DATE LAST CALIBRATED	ANALYTICAL PRINCIPLE
FTIR//1602651	10Dec2009	FTIR
FTIR//1602651	18Dec2009	FTIR

ANALYZER READINGS

(Z = Zero Gas R = Reference Gas T = Test Gas r = Correlation Coefficient)

CARBON MONOXIDE

First Triad Analysis

Date: 11Dec2009 Response Unit:PPM
Z1 = -0.00431 R1 = 100.7202 T1 = 124.3617
R2 = 100.8627 Z2 = 0.00425 T2 = 124.3715
Z3 = 0.03896 T3 = 124.6940 R3 = 100.9075
Avg. Concentration: 124.7 PPM

Second Triad Analysis

Date: 18Dec2009 Response Unit: PPM
Z1 = 0.02878 R1 = 100.4126 T1 = 123.9028
R2 = 100.4969 Z2 = 0.08344 T2 = 124.0817
Z3 = 0.15508 T3 = 124.3246 R3 = 100.6124
Avg. Concentration: 124.7 PPM

Calibration Curve

Concentration = A + Bx + Cx2 + Dx3 + Ex4
r = 1.00000E+0
Constants: A = 0.00000E+0
B = 8.29063E-1 C = 2.03000E-4
D = 0.00000E+0 E = 0.00000E+0

NITRIC OXIDE

First Triad Analysis

Date: 11Dec2009 Response Unit:PPM
Z1 = 0.01140 R1 = 96.18092 T1 = 125.1052
R2 = 96.20254 Z2 = 0.06020 T2 = 125.4558
Z3 = 0.19435 T3 = 125.5703 R3 = 96.46936
Avg. Concentration: 124.8 PPM

Second Triad Analysis

Date: 18Dec2009 Response Unit: PPM
Z1 = -0.17718 R1 = 95.16692 T1 = 123.8376
R2 = 95.77498 Z2 = -0.03225 T2 = 124.6951
Z3 = 0.03054 T3 = 124.7973 R3 = 96.23327
Avg. Concentration: 124.6 PPM

Calibration Curve

Concentration = A + Bx + Cx2 + Dx3 + Ex4
r = 9.99995E-1
Constants: A = 0.00000E+0
B = 9.51582E-1 C = 1.92000E-4
D = 0.00000E+0 E = 0.00000E+0

APPROVED BY: JW
Jon Witzak

State of Utah

GARY R. HERBERT
Governor

GREG BELL
Lieutenant Governor

Department of
Environmental Quality

Amanda Smith
Executive Director

DIVISION OF AIR QUALITY
Bryce C. Bird
Director

DAQE-AN107900015-13

July 31, 2013

Brian Evans
Brigham Young University
PO Box 20100
Provo, UT 84602

Dear Mr. Evans:

Re: Approval Order: Install Four (4) Additional Emergency Generators, Remove Dry Cleaning Equipment Requirements, and Replacement of Dust Collector
Project Number: N10790-0015

The attached document is the Approval Order for the above-referenced project. Future correspondence on this Approval Order should include the engineer's name as well as the DAQE number as shown on the upper right-hand corner of this letter. The project engineer for this action is Camron Harry, who may be reached at (801) 536-4232.

Sincerely,

Bryce C. Bird
Director

BCB:CAH:sa

cc: Mike Owens
Utah County Health Department

195 North 1950 West • Salt Lake City, UT
Mailing Address: P.O. Box 144820 • Salt Lake City, UT 84114-4820
Telephone (801) 536-4000 • Fax (801) 536-4099 • T.D.D. (801) 536-4414
www.deq.utah.gov
Printed on 100% recycled paper

STATE OF UTAH

Department of Environmental Quality

Division of Air Quality

APPROVAL ORDER: Install Four (4) Additional Emergency Generators, Remove Dry Cleaning Equipment Requirements, and Replacement of Dust Collector

Prepared By: Camron Harry, Engineer
Phone: (801) 536-4232
Email: caharry@utah.gov

APPROVAL ORDER NUMBER

DAQE-AN107900015-13

Date: July 31, 2013

Brigham Young University
Main Campus
Source Contact:
Steven Zohner
Phone: (801) 422-2804
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Bryce C. Bird
Director

Abstract

Brigham Young University (BYU) has requested to modify their current AO DAQE-AN107900014-12 to install four (4) diesel fired emergency generators (a 324 hp generator at the Bean Life Science Museum, a 464 hp generator at the Marriott Center, a 1,220 hp generator at the Heritage Halls housing complex, and a 2,220 hp generator at the new Life Science Building). BYU is also proposing to remove the applicability reference to 40 CFR 63 Subpart KK and the reference to percholoroethylene dry cleaning equipment that has been removed. And finally BYU is proposing to replace the existing cyclonic dust collector at the Brewster carpentry shop with a baghouse.

The main campus of BYU is located in Provo, Utah County. Utah County is a nonattainment area of the NAAQS for PM_{10} and $PM_{2.5}$. Provo is a maintenance area for CO. NSPS, 40 CFR 60 Subparts A, Db, Dc & IIII apply to this source. MACT, 40 CFR 63 Subparts A, JJJJJJ, & ZZZZ apply to this source. Title V of the 1990 Clean Air Act applies to this source.

Emissions will increase with this modification, in tons per year, as follows: NO_x + 1.61, CO + 0.17, PM_{10} - 0.02, $PM_{2.5}$ (subset of PM_{10}) - 0.02, SO_2 + 0.50, VOC + 0.06, total HAPs + 0.05, and CO_2e + 224.

The potential to emit totals, in tons per year, are as follows: NO_x = 113.72, CO = 36.28, PM_{10} = 13.06, $PM_{2.5}$ (subset of PM_{10}) = 13.06, SO_2 = 215.12, VOC = 16.11, total HAPs = 9.53, and CO_2e = 81,493.

The project has been evaluated and found to be consistent with the requirements of the Utah Administrative Code Rule 307 (UAC R307). A public comment period was held in accordance with UAC R307-401-7 and no comments were received. This air quality AO authorizes the project with the following conditions, and failure to comply with any of the conditions may constitute a violation of this order. This AO is issued to, and applies to the following:

Name of Permittee:	**Permitted Location:**
Brigham Young University PO Box 20100 Provo, UT 84602	Main Campus B-340 ASB Brigham Young University Provo, UT 84602

UTM coordinates: 445,000 m Easting, 4,455,200 m Northing, UTM Zone 12
SIC code: 8221 (Colleges, Universities, & Professional Schools)

Section I: GENERAL PROVISIONS

I.1 All records referenced in this AO or in other applicable rules, which are required to be kept by the owner/operator, shall be made available to the Director or Director's representative upon request, and the records shall include the five-year period prior to the date of the request. Unless otherwise specified in this AO or in other applicable state and federal rules, records shall be kept for a minimum of five (5) years. [R307-415-6a]

I.2 All definitions, terms, abbreviations, and references used in this AO conform to those used in the UAC R307 and 40 CFR. Unless noted otherwise, references cited in these AO conditions refer to those rules. [R307-101]

I.3 The limits set forth in this AO shall not be exceeded without prior approval. [R307-401]

I.4 Modifications to the equipment or processes approved by this AO that could affect the emissions covered by this AO must be reviewed and approved. [R307-401-1]

I.5 At all times, including periods of startup, shutdown, and malfunction, owners and operators shall, to the extent practicable, maintain and operate any equipment approved under this AO including associated air pollution control equipment in a manner consistent with good air pollution control practice for minimizing emissions. Determination of whether acceptable operating and maintenance procedures are being used will be based on information available to the Director which may include, but is not limited to, monitoring results, opacity observations, review of operating and maintenance procedures, and inspection of the source. All maintenance performed on equipment authorized by this AO shall be recorded. [R307-401-4]

I.6 The owner/operator shall comply with UAC R307-107. General Requirements: Breakdowns. [R307-107]

I.7 The owner/operator shall comply with UAC R307-150 Series. Inventories, Testing and Monitoring. [R307-150]

Section II: SPECIAL PROVISIONS

II.A The approved installations shall consist of the following equipment:

II.A.1 **Main Campus**

BYU Main Campus

II.A.2 **Portable Emergency Generators**

Diesel-fired and propane-fired emergency generators that are moved to various locations on campus as needed.

This equipment is listed for informational purposes only.

II.A.3 **Diesel-Fired Emergency Generators <200 Hp**

Location	Maximum engine Hp rating
Miller Park Baseball Fields	26
Brewster Building	67
Wyview Telephone Node	67
Wyview Park	67
Auxiliary Maintenance Building	75
Helaman Halls Telephone Node	75
Ellsworth Building	99
J. Reuben Clarke Law Building	145
Brimhall Building	150
Chemicals Management Building	150
Crabtree Technology Building	167

II.A.4 **Diesel-Fired Emergency Generators 200-600 Hp**

Location	Maximum engine Hp rating
Bean Life Science Museum	324
Conference Center	201
Harman Continuing Education Building	201
Cougar Stadium	235
Information Technology Building	250
Wilkinson Center	268
Indoor Practice Facility	308
Kimball Tower	308
Smoot Administration Building (1)	335
Smoot Administration Building (2)	335
Cannon Center	352
Jesse Knight Building	380
Joseph F. Smith Building	450
Marriott Center	464

II.A.5 **Diesel-Fired Emergency Generators >600 Hp**

Location	Maximum engine Hp rating
Physical Plant Central Heating	650
Tanner Building	755
Clyde Engineering Building	755
Student Health Center	804
Benson Building (1)	1005
Benson Building (2)	1005
Heritage Hall Complex (1)	1220
Heritage Hall Complex (2)	1220
Talmage Building (1)	2220
Talmage Building (2)	2220
Talmage Building (3)	2220
Life Science Building	2220
Broadcast Building (1)	2922
Broadcast Building (2)	2922

II.A.6 **Two (2) Boilers**

Fuel Type:	Natural gas
Heat Input Capacity:	8.4 MMBTU/hr (each)
Location	Laundry facility

II.A.7 **One (1) Boiler (Unit #1)**

Fuel Type:	Natural Gas with Fuel Oil as a backup fuel
Heat Input Capacity:	64.0 MMBTU/hr
NSPS:	Subpart Dc
Location:	Central Heating Plant

II.A.8 **Two (2) Boilers (Unit #2 & Unit #3)**

Fuel Type:	Coal
Heat Input Capacity:	64.0 MMBTU/hr (each)
Exhaust:	Main stack via the Fabric Filter Baghouse
NSPS:	These boilers were installed and operating prior to the applicability date of 40 CFR 60 Subpart Dc. They are not subject to the provisions of these NSPS requirements.
Location:	Central Heating Plant

II.A.9 **Two (2) Boilers (Unit #4 & Unit #6)**

Fuel Type:	Natural Gas with Fuel Oil as a backup fuel
Heat Input Capacity:	192.0 MMBTU/hr (each)
NSPS:	Subpart Db
Location:	Central Heating Plant

II.A.10 **One (1) Boiler (Unit #5)**

Fuel Type:	Coal
Heat Input Capacity:	128,000,000 BTU/hr
Exhaust:	Main stack via the Fabric Filter Baghouse
NSPS:	These boilers were installed and operating prior to the applicability date of 40 CFR 60 Subpart Db. They are not subject to the provisions of these NSPS requirements.
Location:	Central Heating Plant

II.A.11 **Boilers**

Fuel Type:	Natural Gas
Heat Input Capacity:	Each less than 5.0 MMBTU/hr
Location:	Various buildings

This equipment is listed for informational purposes only.

II.A.12 **Central Heating Plant Baghouse**

The Central Heating Plant includes Boilers 1-6. The baghouse controls emissions when boilers 2, 3 and 5 are fired on coal. This system includes the following:

One (1) Fly Ash Baghouse (treats fly ash directly from the boilers)

One (1) Ash Silo Treatment System including a primary cyclone, a secondary cyclone, and a baghouse (treats post Fly Ash Baghouse effluent and bottom ash directly from the boilers)

II.A.13 **Dry Cleaning Equipment**

Three (3) Dry Cleaning Units utilizing Iso-Paraffin Hydrocarbon (IPH) as solvent

II.A.14 **Teaching Kilns**

Fuel Type:	Natural Gas
Location:	East of Building #66

II.A.15 **Four (4) Paint Booths**

Locations:	Brewster Building Auxiliary Maintenance Shop Auto Shop Snell Building
Associated Controls:	Particulate arrestor filters

II.A.16 **Small Paint Booths**

Paint booths using spray cans for minor painting/teaching listed for information purposes only. The paint booths are located at several locations at the BYU Campus. B73- East of Snell Building, Brewster Building, Clyde Building, Fletcher Building, Harris Fine Arts Center, Monte L Bean Building, Stephen L Richards Building, University Press Building, Wilkinson Building Student Center, Museum of Art, IT Building.

These paint booths are listed for informational purposes only.

II.A.17 **Bio-Safety Laboratory**

Associated Controls:	HEPA filtering system controls emissions from the containment hood exhaust stack.

This equipment is listed for informational purposes only.

II.A.18 **Printing Equipment**

II.A.19 **Four (4) Fuel Storage Tanks**

Location:	Central Heating Plant
Capacity:	30,000 gallons each (three tanks)
Fuel Type:	Fuel oil

Location:	Broadcast Building
Capacity:	20,000 gallons (one tank)
Fuel Type:	Fuel oil

This equipment is listed for informational purposes only.

II.A.20 **One (1) Cyclonic Dust Collector**

A Cyclonic Dust Collector located at the Snell Building. This dust collector was installed prior to November 29, 1969 and is not required to be permitted.

II.A.21 **Two (2) Baghouse Dust Collectors**

Location:	Auxiliary Maintenance Building
Flow Rate:	188 acfm (vented to the atmosphere)
Installed:	1992

Location:	Brewster Carpentry Shop
Flow Rate:	Max of 20,000 cfm (vented back inside of the building)
Permitted:	2013

II.B Requirements and Limitations

II.B.1 **Limitations and Test Procedures**

II.B.1.a BYU shall notify the Director in writing when the installation of the new equipment has been completed and is operational. The new equipment includes the following: 324 hp (Bean Life Science Museum), 464 hp (Marriott Center), 1220 hp (Heritage Halls Housing complex), and 2,220 hp (Life Science Building) diesel fired emergency generators and the baghouse at the Brewster carpentry shop. To ensure proper credit when notifying the Director, send your correspondence to the Director, attn: Compliance Section.

If construction and/or installation has not been completed within 18 months from the date of this AO, the Director shall be notified in writing on the status of the construction and/or installation. At that time, the Director shall require documentation of the continuous construction and/or installation of the operation and may revoke the AO

[R307-401-18]

II.B.1.b Visible emissions from the following emission points shall not exceed the following values:

A. All natural gas fueled boilers equal to or greater than 5.0 MMBTU/hr - 10% opacity

B. All paint booth exhaust stacks - 10% opacity

C. All baghouse exhaust stacks - 10% opacity

D. All cyclonic separator exhaust stacks - 20% opacity

E. All print shop equipment exhaust stacks - 10% opacity

F. All diesel engines - 20% opacity

G. All other points - 20% opacity

Opacity observations of emissions from stationary sources shall be conducted according to 40 CFR 60, Appendix A, Method 9.

For sources that are subject to NSPS, opacity shall be determined by conducting observations in accordance with 40 CFR 60.11(b) and 40 CFR 60, Appendix A, Method 9.

[R307-305-3]

II.B.1.c Emergency generators shall be used for electricity producing operation only during the periods when electric power from the public utility is interrupted, or for regular maintenance of the generators. Records documenting the usage of each generator shall be kept in a log; and they shall show the date each generator was used, the duration in hours of each generator usage, and the reason for each generator usage.

BYU may operate emergency generators for the purpose of maintenance checks and readiness testing. Maintenance checks and readiness testing of such units is limited to 100 hours per rolling 12-month period per engine.

To determine compliance with a rolling 12-month total, no later than 20 days after the end of each month, a new 12-month total shall be calculated using data from the previous 12 months. Monthly calculations shall be made no later than 20 days after the end of each calendar month. Hours of operation shall be determined by supervisor monitoring and maintaining an operations log which shall include time of day of operation. The records of operation shall be kept on a weekly basis and shall be kept for all periods when the facility is in operation.

[R307-401]

II.B.1.d The paint booth locations at the Brewster Building, Auxiliary Maintenance Shop, Auto Shop, and Snell Building shall be equipped with a paint arrestor particulate filter, or equivalent to control particulate emissions. All exhaust air from each of the paint booths shall be routed through its particulate control system before being exhausted to the atmosphere. [R307-401]

II.B.2 **Central Heating Plant**

II.B.2.a The following consumption limits shall not be exceeded:

A. 16,992 tons of coal consumed annually.

B. 405 million scf of natural gas consumed per rolling 12-month period.

C. 90,000 gallons of fuel oil with a sulfur content < 0.0015% by weight consumed for maintenance.

D. 10 percent annual capacity factor* for natural gas and fuel oil for each boiler defined as Unit #4 and Unit #6 in Condition II.A.9 above.

*Annual capacity factor as defined in 40 CFR 60.41b.

Compliance with each limitation shall be determined on a rolling 12-month total. Based on the first day of each month, a new 12-month total shall be calculated using data from the previous 12 months. Monthly calculations shall be made no later than 20 days after the end of each calendar month. Records of coal, fuel oil, or natural gas consumption shall be kept for all periods when the Central Heating Plant is in operation. Consumption of natural gas, fuel oils, and coal for other boilers shall be determined by examination of each fuel supplier's billing records along with operations logs showing which day(s) each type of fuel was used. The records of consumption shall be kept on a daily basis. Supervisor monitoring and maintaining an operations log shall determine hours of operation of the emergency boiler and generators.

[R307-401]

II.B.2.b Emissions to the atmosphere at all times from the indicated emission point(s) shall not exceed the following rates and concentrations:

Central Heating Plant	Pollutant	lb/hr	ppmdv (7% O_2 dry)
Boiler #1	NO_x	9.55	95
Boiler #2	NO_x	37.4	331
Boiler #3	NO_x	37.4	331
Boiler #4	NO_x	38.5	127
Boiler #5	NO_x	74.8	331
Boiler #6	NO_x	38.5	127

Central Heating Plant	Pollutant	lb/hr	grains/dscf (68ºF, 29.92 in Hg)
Central Heating Plant Baghouse (Unit #8)	PM_{10}	1.83	0.010

Stack testing to show compliance with the emission limitations stated in the above condition shall be performed as specified below:

A.

Central Heating Plant Emission Point	Pollutant	Testing Status	Test Frequency
Boiler #1	NO_x	*	@
Boiler #2	NO_x	*	#
Boiler #3	NO_x	*	#
Boiler #4	NO_x	*	#
Boiler #5	NO_x	*	#
Boiler #6	NO_x	*	#
Baghouse	PM_{10}	*	#

B. Testing Status

* The initial testing has already been performed.

\# The test shall be performed at least every 3 years based on the date of the last stack test.

@ If Boiler #1 is operated for more than 100 hours per rolling 12-month period, the stack test shall be performed within 60 days of exceeding 100 hours of operations.

C. Notification

The Director shall be notified at least 30 days prior to conducting any required emission testing. A source test protocol shall be submitted to DAQ when the testing notification is submitted to the Director.

D. Sample Location

The emission point shall be designed to conform to the requirements of 40 CFR 60, Appendix A, Method 1, or other EPA-approved testing method, as acceptable to the Director. An Occupational Safety and Health Administration (OSHA) or Mine Safety and Health Administration (MSHA) approved access shall be provided to the test location.

E. Volumetric Flow Rate

40 CFR 60, Appendix A, Method 2 or other EPA-approved testing method, as acceptable to the Director.

F. PM_{10}

For stacks in which no liquid drops are present, the following methods shall be used: 40 CFR 51, Appendix M, Methods 201, 201a, or other EPA-approved testing method, as acceptable to the Director.

For stacks in which liquid drops are present, methods to eliminate the liquid drops should be explored. If no reasonable method to eliminate the drops exists, then the following methods shall be used: 40 CFR 60, Appendix A, Method 5, 5a, 5d, or 5e as appropriate, or other testing methods approved by the Director. The back half condensibles shall also be tested using the method specified by the Director. The portion of the front half of the catch considered PM_{10} shall be based on information in Appendix B of the fifth edition of the EPA document, AP-42, or other data acceptable to the Director.

The back half condensibles shall not be used for compliance demonstration but shall be used for inventory purposes.

G. NO_x

40 CFR 60, Appendix A, Method 7, 7A, 7B, 7C, 7D, 7E, or other EPA-approved testing method, as acceptable to the Director.

H. Calculations

To determine mass emission rates (lb/hr, etc.) the pollutant concentration as determined by the appropriate methods above shall be multiplied by the volumetric flow rate and any necessary conversion factors determined by the Director, to give the results in the specified units of the emission limitation.

I. Existing Source Operation

For an existing source/emission point, the production rate during all compliance testing shall be no less than 90% of the average production achieved in the previous three years.

The source test protocol shall be approved by the Director prior to performing the test(s). The source test protocol shall outline the proposed test methodologies, stack to be tested, and procedures to be used. A pretest conference shall be held, if directed by the Director.

[R307-401]

II.B.3 **Fuels**

II.B.3.a BYU shall use natural gas as a primary fuel and fuel oil with a sulfur content not to exceed 0.0015% by weight as a backup fuel in Boiler #1, Boiler #4, and Boiler #6.

Fuel oil may be used as an alternate fuel supply during natural gas curtailment. If any other fuel is to be used, an AO shall be required.

[R307-401]

II.B.3.b BYU shall use only natural gas as fuel in the two laundry facility 8.4 MMBTU/hr boilers. [R307-401]

II.B.3.c BYU shall use coal as fuel in Boiler #2, Boiler #3, and Boiler #5. [R307-401]

II.B.3.d BYU shall use natural gas as a fuel in the East Building #66 teaching kilns. [R307-401]

II.B.3.e BYU shall notify the Director within three business days of using fuel oil during a natural gas curtailment.

Coal may only be used as an emergency measure fuel during the annual period starting November 1 and ending February 28 (or February 29 in the case of leap years), with the approval of the Director, in the event both natural gas and fuel oil are unavailable. In addition, coal may be used during these winter months to perform stack testing as required by the DAQ.

[R307-401]

II.B.3.f The sulfur content of any coal or any mixture of coals burned shall not exceed either of the following:

A. 0.54 pounds of sulfur per million BTU heat input as determined by ASTM Method D-4239-85, or approved equivalent.

B. 0.60% by weight as determined by ASTM Method D-4239-85, or approved equivalent.

For the sulfur content of coal, BYU shall either:

C. Determine the weight percent sulfur and the fuel heating value by submitting a coal sample to a laboratory, acceptable to the Director, on no less than a monthly basis; or

D. For each delivery of coal, inspect the fuel sulfur content expressed as weight % determined by the vendor using methods of the ASTM; or

E. For each delivery of coal, inspect documentation provided by the vendor that indirectly demonstrates compliance with this provision.

[R307-401-8]

II.B.3.g The sulfur content of any fuel oil or diesel burned shall not exceed 0.0015 percent by weight for fuel oils or diesel consumed in all equipment. For each delivery of oil, BYU shall either:

A. Determine the fuel sulfur content expressed as weight % in accordance with the methods of the American Society for Testing Materials (ASTM) Method D-4294-89 or approved equivalent;

B. Inspect the fuel sulfur content expressed as weight % determined by the vendor using methods of the ASTM; or

C. Inspect documentation provided by the vendor that indirectly demonstrates compliance with this provision.

[R307-401-8]

II.B.4 **Dry Cleaning Equipment**

II.B.4.a Dry cleaning equipment shall not exceed 55.6 gallons of iso-paraffin hydrocarbon (IPH) consumption per rolling 12-month period. At initial start-up, all dry cleaning equipment will be filled to a volume of up to 175 gallons total of IPH. This initial fill volume shall not be included in the rolling 12-month total. No other VOC or HAP emitting solvent shall be used for dry cleaning application.

Compliance with each limitation shall be determined on a rolling 12-month total. Based on the first day of each month, a new 12-month total shall be calculated using data from the previous 12 months. Monthly calculations shall be made no later than 20 days after the end of each calendar month. Consumption shall be determined by examination of each supplier's billing records and use of IPH each month. Records of consumption shall be kept for all periods when the dry cleaning system is in operation.

[R307-401]

II.B.5 **VOC and HAP Limitations**

II.B.5.a The plant-wide emissions of VOCs and HAPs from the paint booths, printing/publishing, dry cleaning, and other campus-wide similar* operations shall not exceed:

16.00 tons per rolling 12-month period for VOCs generated from painting and printing/publishing activities
0.20 tons per rolling 12-month period for Xylene
0.33 tons per rolling 12-month period for Glycol Ethers
5.22 tons per rolling 12-month period for any combination of HAPs not listed above

Any individual HAP shall comply with UAC R307-410-5.

* "Similar Operations" includes painting of building interiors, paint applied to roads and parking lots, adhesives for putting down carpets, tiles and other flooring.

Compliance with each limitation shall be determined on a rolling 12-month total. Based on the twentieth day of each month, a new 12-month total shall be calculated using data from the previous 12 months.

The VOC and HAP emissions shall be determined by maintaining a record of VOC and HAP emitting materials used each month. The record shall include the following data for each material used:

A. Name of the VOC and HAPs emitting material, such as: paint, adhesive, solvent, thinner, reducers, chemical compounds, toxics, isocyanates, etc.

B. Density of each material used (pounds per gallon)

C. Percent by weight of all VOC and HAP in each material used

D. Gallons of each VOC and HAP emitting material used

E. The amount of VOC and HAP emitted monthly by each material used shall be calculated by the following procedure:

VOC = (% VOC by Weight/100) x [Density (lb/gal)] x Gal Consumed x 1 ton/2000 lb

HAP = (% HAP by Weight/100) x [Density (lb/gal)] x Gal Consumed x 1 ton/2000 lb

F. The amount of VOC or HAP emitted monthly from all materials used

G. The amount of VOCs or HAPs reclaimed for the month shall be similarly quantified and subtracted from the quantities calculated above to provide the monthly total VOC or HAP emissions.

[R307-401]

Section III: APPLICABLE FEDERAL REQUIREMENTS

In addition to the requirements of this AO, all applicable provisions of the following federal programs have been found to apply to this installation. This AO in no way releases the owner or operator from any liability for compliance with all other applicable federal, state, and local regulations including UAC R307.

NSPS (Part 60), A: General Provisions
NSPS (Part 60), Db: Standards of Performance for Industrial-Commercial-Institutional Steam Generating Units
NSPS (Part 60), Dc: Standards of Performance for Small Industrial-Commercial-Institutional Steam Generating Units
NSPS (Part 60), IIII: Standards of Performance for Stationary Compression Ignition Internal Combustion Engines
MACT (Part 63), A: General Provisions

MACT (Part 63), ZZZZ: National Emissions Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines
MACT (Part 63), JJJJJJ: National Emission Standards for Hazardous Air Pollutants for Industrial, Commercial, and Institutional Boilers Area Sources
Title V (Part 70) major source

PERMIT HISTORY

This AO is based on the following documents:

Replaces	DAQE-AN107900014-12 dated June 19, 2012
Is Derived From	Notice of Intent dated November 26, 2012
Is Derived From	Additional Information dated April 25, 2013
Is Derived From	Additional Information dated May 22, 2013

ADMINISTRATIVE CODING

The following information is for UDAQ internal classification use only:

Utah County
CDS A
MACT (Part 63), Nonattainment or Maintenance Area, Title V (Part 70) major source, PM_{10} SIP / Maint Plan, NSPS (Part 60)

ACRONYMS

The following lists commonly used acronyms and associated translations as they apply to this document:

40 CFR	Title 40 of the Code of Federal Regulations
AO	Approval Order
BACT	Best Available Control Technology
CAA	Clean Air Act
CAAA	Clean Air Act Amendments
CDS	Classification Data System (used by EPA to classify sources by size/type)
CEM	Continuous emissions monitor
CEMS	Continuous emissions monitoring system
CFR	Code of Federal Regulations
CMS	Continuous monitoring system
CO	Carbon monoxide
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent - 40 CFR Part 98, Subpart A, Table A-1
COM	Continuous opacity monitor
DAQ	Division of Air Quality (typically interchangeable with UDAQ)
DAQE	This is a document tracking code for internal UDAQ use
EPA	Environmental Protection Agency
FDCP	Fugitive dust control plan
GHG	Greenhouse Gas(es) - 40 CFR 52.21 (b)(49)(i)
GWP	Global Warming Potential - 40 CFR Part 86.1818-12(a)
HAP or HAPs	Hazardous air pollutant(s)
ITA	Intent to Approve
LB/HR	Pounds per hour
MACT	Maximum Achievable Control Technology
MMBTU	Million British Thermal Units
NAA	Nonattainment Area
NAAQS	National Ambient Air Quality Standards
NESHAP	National Emission Standards for Hazardous Air Pollutants
NOI	Notice of Intent
NO_x	Oxides of nitrogen
NSPS	New Source Performance Standard
NSR	New Source Review
PM_{10}	Particulate matter less than 10 microns in size
$PM_{2.5}$	Particulate matter less than 2.5 microns in size
PSD	Prevention of Significant Deterioration
PTE	Potential to Emit
R307	Rules Series 307
R307-401	Rules Series 307 - Section 401
SO_2	Sulfur dioxide
Title IV	Title IV of the Clean Air Act
Title V	Title V of the Clean Air Act
TPY	Tons per year
UAC	Utah Administrative Code
UDAQ	Utah Division of Air Quality (typically interchangeable with DAQ)
VOC	Volatile organic compounds

Certification

In accordance with Operating Permit provision I.K and UAC R307-415-5d, and based on information and belief formed after reasonable inquiry, I certify that the statements and information in this document are true, accurate, and complete.

Brian K. Evans

Signature of Responsible Official

Date: 9 Jan 2012

Brian K. Evans
Chief Financial Officer and Administrative Vice President
Brigham Young University

NO_X COMPLIANCE TEST CONDUCTED AT BRIGHAM YOUNG UNIVERSITY CENTRAL HEATING PLANT BOILER #4 AND BOILER #6

DECEMBER 6, 2011

by:

TETCO
391 East 620 South
American Fork, Utah 84003
Phone (801) 492-9106
Fax (801) 492-9107

UTAH DEPARTMENT OF
ENVIRONMENTAL QUALITY

JAN 17 2012

DIVISION OF AIR QUALITY

Prepared for:

Brigham Young University
Physical Plant Department
237 Brewster Building
Provo UT 84602

Date of report:
December 14, 2011

CERTIFICATION OF REPORT INTEGRITY

Technical Emissions Testing Company (TETCO) certifies that this report represents the truth as well as can be derived by the methods employed. Every effort was made to obtain accurate and representative data and to comply with procedures set forth in the Federal Register.

Dean A. Kitchen

Reviewer: _____

Date: 12-13-11

Doug Olsen

Reviewer: _____

Date: 12/13/11

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INTRODUCTION

Test Purpose

This test was conducted to determine the NO_x emissions from Boilers No. 4 and 6 while fired with natural gas. These emissions are expressed in ppm at 7 percent oxygen and pounds per hour. These results are used to determine compliance with the Title V Permit for the facility.

Test Location, Type of Process

The tests were conducted at the Brigham Young University Central Heating Plant. The plant provides heating and cooling for the university.

A schematic representation of the baghouse exhaust stack is given as Figure 1 in Appendix D.

Test Dates

Three test runs were completed on both Boiler 4 and Boiler 6 December 6, 2011.

Pollutant Tested and Methods Applied

The tests were for NO_x emissions in accordance with EPA Methods 4 and 7E.

Test Participants

Test Facility	Paul Greenwood Clifford Alleman	
TETCO	Dean Kitchen Joseph Kitchen	Doug Olsen Kawai McNamara
State Agency	None	

Deviations from EPA Methods

None.

Quality Assurance

Testing procedures and sample recovery techniques were in accordance to those outlined in the Federal Register and the *Quality Assurance Handbook for Air Pollution Measurement Systems*.

SUMMARY OF RESULTS

Emission Results

Table I presents the compliance test results. Tables III-V in Appendix A have more detailed test data.

TABLE I Measured NO_x Emissions

Run #	Boiler 4		Boiler 6	
	ppm (@ 7% O_2)	lb/hr	ppm (@ 7% O_2)	lb/hr
1	74	15.1	79	18.3
2	75	15.2	81	18.7
3	74	15.0	82	18.9
Ave	**74**	**15.1**	**81**	**18.6**

Process Data

The process was operated according to standard procedures. All pertinent process data was available for recording by agency personnel. Btu totalizer readings were recorded before and after each test run. These values are found in Appendix D.

Allowable Emissions

The allowable NO_x concentration limit for each boiler is 127 ppm (corrected to 7 percent O_2).
The allowable NO_x emission rate for each boiler is 38.5 lb/hr.

Discussion of Errors or Irregularities

None.

Gaseous Analyzer Performance Criteria

The NO_x analyzer met all bias and calibration checks criteria as specified in the Federal Register. These values are found on the gas analyzer field data sheet in Appendix B.

SOURCE OPERATION

Sampling Port Location

The stack inside diameter is 136.0 inches. The six inch diameter ports are located 3.9 diameters (44 feet) downstream from the last disturbance and 4.9 diameters (56 feet) upstream from the next disturbance. All ports have an inside diameters of six inches. Port location is depicted in Figure 1 in the Appendix.

Sampling Point Location

Table II shows the distance of each sampling point for Method 4 from the inside wall. Each point is marked and identified with a glass tape wrapping and numbered. These points are determined by measuring the distance from the inside wall and adding the reference (port) measurement.

Table II. Sample Point Location

Sample Point #	Point Location from Inside Wall (inches)
1	4.35
2	14.28
3	26.38
4	43.93

Sampling Train Description

To determine the actual emission rates for these stacks, 40 CFR Part 60 Appendix A Methods 1-4 and 7E were followed.

All sampling trains were made of inert materials, (i.e., Teflon, Stainless Steel, glass, etc.) to prevent interference of the sampled gas and particulate.

The stack analyzer used to conduct Methods 1-4, is constructed to meet the specifications outlined in the CFR. The temperature sensors are K-type thermocouples. Heater, vacuum and pitot line connections have been designed to be interchangeable with all units used by the tester.

The probe liner was made of 316 stainless steel. A sketch of the sampling train is found as Figure 2 in the Appendix.

Sample boxes were prepared for testing by following the prescribed procedure outlined in Method 4.

The NO_x analyzer was an Horiba Instruments Model CLA-510SS, chemiluminescence unit. This was set on a 0-100 ppm range and spanned at 88.9 ppm for all tests. EPA Protocol 1 gases were used as the span and mid-range for the NO_x analyzer during all tests; their concentrations were 43.7 and 88.9 ppm. Dry nitrogen was used as the zero gas for the machine.

The gaseous analyzer sampling train is constructed with a heated stainless steel sampling probe about 8 feet long. The sample line between the sampling probe and gas conditioner was heated Teflon. Both were maintained above 220 degrees Fahrenheit. The sample conditioner uses permeation tubes to remove moisture. Sample lines and bias lines from the gas conditioner to the analyzer were Teflon. A sketch of the sampling train for this method appears in Figure 3 in the Appendix.

Sampling and Analytical Procedures

All sampling and analytical test procedures employed were as specified in 40 CFR 60.

Quality Assurance

All equipment set-up, sampling procedures, sample recovery and equipment calibrations were carried out according to the procedures specified in 40 CFR 60 and the *Quality Assurance Handbook for Air Pollution Measurement Systems*.

APPENDIX A

Table III, Complete Results, Boiler 4
Table IV, Complete Results, Boiler 6
Nomenclature
Sample Equations

TABLE III
COMPLETE RESULTS
BRIGHAM YOUNG UNIVERSITY
BOILER # 4

Symbol	Description	Dimensions				
Run #			1	2	3	
Date			12/6/11	12/6/11	12/6/11	
Begin	Time Test Began		9:49	10:22	10:55	
End	Time Test Ended		10:16	10:49	11:27	
Pb_m	Barometric Pressure	In. Hg Abs	25.60	25.60	25.60	
dH	Orifice Pressure Drop	In. H_2O	1.000	1.000	1.000	
Y	Meter Calibration Y Factor		1.004	1.004	1.004	
V_m	Volume Gas Sampled-- Meter Conditions	cf	50.844	50.844	50.844	
T_m	Ave. Meter Temperature	°F	99.3	99.3	99.3	
dPsqrt	Sq. Root Velocity Head	Root In. H_2O	0.1600	0.1600	0.1600	
Wt_{wc}	Weight Water Collected	Grams	99.0	99.0	99.0	
Tt	Duration of Test	Minutes	80	80	80	
C_p	Pitot Tube Coefficient		0.84	0.84	0.84	
CO_2	Volume % Carbon Dioxide	Percent	6.20	6.20	6.20	
O_2	Volume % Oxygen	Percent	10.40	10.40	10.40	
N_2&CO	Volume % Nitrogen and Carbon Monoxide	Percent	83.40	83.40	83.40	
Vm_{std}	Volume Gas Sampled (Standard)	dscf	41.355	41.355	41.355	
V_w	Volume Water Vapor	scf	4.668	4.668	4.668	
B_{wo}	Fraction H_2O in Stack Gas	Fraction	0.101	0.101	0.101	
X_d	Fraction of Dry Gas	Fraction	0.899	0.899	0.899	
M_d	Molecular Wt. Dry Gas	lb/lbmol	29.41	29.41	29.41	
M_s	Molecular Wt. Stack Gas	lb/lbmol	28.25	28.25	28.25	
T_s	Ave. Stack Temperature	°F	320.6	320.6	320.6	**320.6**
A_s	Stack Cross-Sectional Area	Sq. ft	100.880	100.880	100.880	
P_g	Stack Static Pressure	In. H_2O	-0.34	-0.34	-0.34	
Pb_p	Barometric Pressure at Sample Point	In. Hg	25.53	25.53	25.53	
P_s	Stack Pressure	In. Hg Abs	25.505	25.505	25.505	
Q_s	Stack Gas Volumetric Flow Rate (Std)	dscfm	3.75E+04	3.75E+04	3.75E+04	**3.75E+04**
Q_a	Stack Gas Volumetric Flow Rate (Actual)	cfm	7.24E+04	7.24E+04	7.24E+04	**7.24E+04**
V_s	Velocity of Stack Gas	fpm	7.18E+02	7.18E+02	7.18E+02	**7.18E+02**
C_{NOx}	Average NO_x Gas Concentration	ppm	56.1	56.5	55.6	**56.1**
C_{NOx}	Average NO_x Gas Concentration (@ 7% O2)	ppm	74.3	74.8	73.6	**74.2**
ER_{NOx}	Emission Rate of NO_x	lb/hr	15.09	15.20	14.95	**15.08**

TABLE IV
COMPLETE RESULTS
BRIGHAM YOUNG UNIVERSITY
BOILER # 6

Symbol	Description	Dimensions				
Run #			1	2	3	
Date			12/6/11	12/6/11	12/6/11	
Begin	Time Test Began		6:17	7:02	7:40	
End	Time Test Ended		6:46	7:32	8:13	
Pb_m	Barometric Pressure	In. Hg Abs	25.60	25.60	25.60	
dH	Orifice Pressure Drop	In. H_2O	1.000	1.000	1.000	
Y	Meter Calibration Y Factor		1.004	1.004	1.004	
V_m	Volume Gas Sampled-- Meter Conditions	cf	48.950	48.950	48.950	
T_m	Ave. Meter Temperature	°F	85.2	85.2	85.2	
dPsqrt	Sq. Root Velocity Head	Root In. H_2O	0.1507	0.1507	0.1507	
Wt_{wc}	Weight Water Collected	Grams	126.1	126.1	126.1	
Tt	Duration of Test	Minutes	80	80	80	
C_p	Pitot Tube Coefficient		0.84	0.84	0.84	
CO_2	Volume % Carbon Dioxide	Percent	7.40	7.40	7.40	
O_2	Volume % Oxygen	Percent	8.00	8.00	8.00	
N_2&CO	Volume % Nitrogen and Carbon Monoxide	Percent	84.60	84.60	84.60	
Vm_{std}	Volume Gas Sampled (Standard)	dscf	40.840	40.840	40.840	
V_w	Volume Water Vapor	scf	5.946	5.946	5.946	
B_{wo}	Fraction H_2O in Stack Gas	Fraction	0.127	0.127	0.127	
X_d	Fraction of Dry Gas	Fraction	0.873	0.873	0.873	
M_d	Molecular Wt. Dry Gas	lb/lbmol	29.50	29.50	29.50	
M_s	Molecular Wt. Stack Gas	lb/lbmol	28.04	28.04	28.04	
T_s	Ave. Stack Temperature	°F	306.8	306.8	306.8	**306.8**
A_s	Stack Cross-Sectional Area	Sq. ft	100.880	100.880	100.880	
P_g	Stack Static Pressure	In. H_2O	-0.36	-0.36	-0.36	
Pb_p	Barometric Pressure at Sample Point	In. Hg	25.53	25.53	25.53	
P_s	Stack Pressure	In. Hg Abs	25.504	25.504	25.504	
Q_s	Stack Gas Volumetric Flow Rate (Std)	dscfm	3.48E+04	3.48E+04	3.48E+04	**3.48E+04**
Q_a	Stack Gas Volumetric Flow Rate (Actual)	cfm	6.78E+04	6.78E+04	6.78E+04	**6.78E+04**
V_s	Velocity of Stack Gas	fpm	6.72E+02	6.72E+02	6.72E+02	**6.72E+02**
C_{NOx}	Average NO_x Gas Concentration	ppm	73.4	74.9	76.0	**74.8**
C_{NOx}	Average NO_x Gas Concentration (@ 7% O2)	ppm	79.1	80.7	81.9	**80.6**
ER_{NOx}	Emission Rate of NO_x	lb/hr	18.30	18.66	18.94	**18.64**

A_s = stack cross-sectional area (ft^3)
$AS\Delta P$ = see $\sqrt{\Delta P}$
Btu = unit heat value (British thermal unit)
B_{ws} = fraction of water in stack gas
C_0 = average of initial and final system zero gas calibration bias checks (ppm, percent)
C_m = average of initial and final system upscale gas calibration bias checks (ppm, percent)
C_{ma} = actual concentration of upscale calibration gas
CO_2 = percent carbon dioxide in the stack gas
C_p = pitot tube coefficient (0.84)
$C_{X\ (act)}$ = actual concentration of sampled gas using method 6C, 7E, and 10. corrected for bias checks (may be expressed as ppmdv, lb/dscf, etc.) species symbol replaces x.
$C_{X\ (avg)}$ = raw average gas concentration prior to bias correction (ppmdv, lb/dscf, etc.)
$C_{X\ (avg)}$ = species symbol replaces x.
$C_{X\ (corr)}$ = actual gas concentration corrected to required percent O_2
D_{eq} = Equivlent diameter for rectangular stack
ΔH = orifice pressure drop (inches H_2O)
$\Delta H_@$ = orifice pressure (inches H_2O)
ΔP = stack flow pressure differential (inches H_2O)
D_s = diameter of the stack (feet)
EA = percent excess air
ER_{gas} = emission rate of a gas (lb/hr)
ER_{mmBtu} = emission rate per mmBtu or ton of fuel etc.
ER_X = emission rate of compound which replaces x
mBtu = thousand Btu
M_d = molecular weight of stack gas, dry basis (lb/lb-mol)
mmBtu = million Btu
M_s = molecular weight of stack gas, wet basis (g/gmol)
M_{wx} = molecular weight of gas species (g/gmol)
N_2 = percent nitrogen in the stack gas
O_2 = percent oxygen in the stack gas
$\sqrt{\Delta P}$ = average of the square roots of ΔP (may also be referred to as $AS\Delta P$)
Pb_m = absolute barometric pressure at the dry gas meter (inches Hg)
Pb_p = absolute barometric pressure at the sample location (inches Hg)
P_G = stack static pressure (inches H_2O)
P_s = absolute stack pressure (inches Hg)
P_{std} = absolute pressure at standard conditions (29.92 inches Hg.)
θ = time of test (minutes)
Q_a = stack gas volumetric flow rate (acfm)
Q_s = stack gas volumetric flow rate (dscfm)
Q_W = wet stack gas std. volumetric flow (ft^3/min, wscfm)
R = gas constant (8.31451 J/gmol-^oK)
T_s = stack temperature (^oF)
T_{std} = absolute temperature at standard conditions (528^oR)
Tt = see θ
Vm = sample volume (ft^3) at meter conditions

Vm_{std} = volume standard (dscf), sample volume adjusted to 68°F and 29.92 inches Hg.

V_s = velocity of stack gas (fpm)

V_{wc} = volume water vapor (scf) at 68°F and 29.92 inches Hg.

Wt_{wc} = weight of the condensed water collected (grams)

X_{CO} = subscript referring to carbon monoxide, CO

X_d = fraction of dry gas

X_{H2S} = subscript referring to hydrogen sulfide, H_2S

X_{NOx} = subscript referring to oxides of nitrogen, NO_x

X_{SO2} = subscript referring to sulfur dioxide, SO_2

Y = meter calibration Y-factor (dimensionless)

$$A_s = (Ds^2 / 4) \cdot \pi$$

$$B_{ws} = V_w / (Vm_{std} + V_w)$$

$$C_{X\,(act)} = (C_{X\,(avg)} - C_0) \cdot C_{ma} / (C_m - C_0)$$

$$C_{X\,(corr)} = C_{X\,(avg)} \cdot (20.9 - \text{desired } \%O_2) / (20.9 - \text{actual } \%O_2)$$

$$C_{X\,(mass)} = M_w \cdot C_{X\,(ppm)} \cdot P_{std} / (R \cdot T_{std} \cdot 10^6)$$

$$D_{eq} = 2 \cdot L \cdot W / (L + W)$$

$$EA = (\%O_2 - 0.5\ \%CO) / [0.264\ \%N_2 - (\%O_2 - 0.5\ \%CO)]$$

$$ER_{gas} = P_{std} \cdot Q_s \cdot M_{wx} \cdot C_{X\,(act)} \cdot 60 / (R \cdot T_{std} \cdot 10^6)$$

$$ER_{mmBtu} = ER_X / (\text{mmBtu / hr})$$

$$M_d = CO_2 \cdot 0.44 + O_2 \cdot 0.32 + N_2 \cdot 0.28$$

$$M_s = (M_d \cdot X_d) + (18 \cdot B_{ws})$$

$$P_s = Pb_p + (P_G / 13.6)$$

$$Q_a = V_s \cdot A_s$$

$$Q_s = Qa \cdot Xd \cdot Ps \cdot T_{std} / [(Ts + 460) \cdot P_{std}]$$

$$Q_W = Q_s / X_d$$

$$Vm_{std} = Vm \cdot Y \cdot T_{std} \cdot (Pb_m + \Delta H / 13.6) / [P_{std} \cdot (T_m + 460)]$$

$$V_s = 85.49 \cdot 60 \cdot Cp \cdot \sqrt{\Delta P} \cdot \sqrt{[(T_s + 460) / (P_s \cdot M_s)]}$$

$$V_{wc} = Wt_{wc} \cdot 0.04715$$

$$X_d = 1 - B_{ws}$$

APPENDIX B

Preliminary Traverse and Sampling Point Location Data

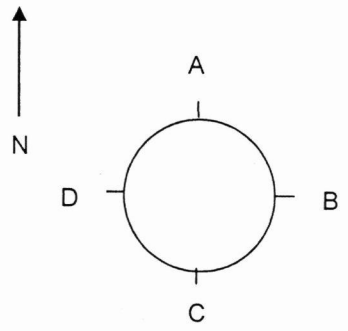
Boiler #4

- Method 4 Field Data
- Gas Analyzer Field Sheets and Data Logger Printout
- Stratification Check Field Sheet

Boiler 6

- Method 4 Field Data
- Gas Analyzer Field Sheets and Data Logger Printout
- Stratification Check Field Sheet

Prelim 8 pts



Stack Dia. 136 Reference: 16.5

Ports are 46.5' Upstream from next disturbance

Ports are 54.5' Downstream from last disturbance

Facility Brigham Young University Central Heating Plant

Stack Identification Baghouse Exhaust, Boiler # 4 & 6

Date 12-5-11

Barometric Pressure

Pb_m _____ in Hg Pb_p _____ in Hg

Static Pressure (P_G) _____ in H_2O

Estimated Moisture (Bw_s) _____ %

Sample Height from Ground _____ feet

Comments:

Time:

Traverse Point	Percent Diameter	Distance From: ID	Distance From: Reference	Ports A	B	C	D	E	F
1	3.2	4.35	20.85	9	8	7	10		
2	10.5	14.28	30.78	5	5	5	6		
3	19.4	26.38	42.88	4	3	4	4		
4	32.3	43.93	60.43	8	8	7	5		
Gas Analyzer Probe									
1	16.7	22.71	39.21						
2	50.0	68.00	84.50						
3	83.3	113.29	129.79						

Averages:

T_S _____ ∠ Flow _____

ΔP _____ √ΔP _____

KEY => T_S ∠ Flow ΔP

Boiler 4

M4 Field Data Sheet

TETCO

Filter NA Sample Box E

Page 1 of 1 Run # 1

Plant: BYU Central Heating Plant

Date: 12/6/11

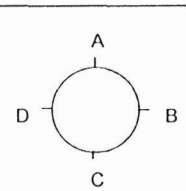
Location: Baghouse Exhaust, Boiler # 4

Operator: [illegible]

Traverse Point	Time Clock	Time Min (θ)	DGM (ft³)	ΔP (in H₂O)	ΔH (in H₂O) Desired	ΔH (in H₂O) Actual	Vacuum (in Hg)	Temperatures (°F) Stack (T_s)	Probe	Probe Out	Filter	Effluent	DGM Temp (T_m) Out	In
1	9:49	0	472.205	.035	1.0	1.0	2	312	260			34	85	85
2		5	475.298	.028		1.0	2	319	262			34	83	84
3		10	478.467	.025		1.0	2	320	261			36	84	88
4		15	481.616	.030		1.0	2	320	260			38	86	94
1	10:11	20	484.823	.017		1.0	2	318	249			41	89	98
2	*	25	487.958	.015		1.0	2	317	236			40	92	98
3		30	491.112	.013		1.0	2	316	235			40	93	102
4		35	494.280	.015		1.0	2	319	240			40	95	105
1	10:39	40	497.450	.023		1.0	2	316	235			40	98	108
2		45	500.626	.028		1.0	2	324	235			40	99	110
3	**	50	503.807	.022		1.0	2	324	241			41	101	112
4		55	507.004	.023		1.0	2	325	251			47	103	111
1	1107	60	510.206	.035		1.0	2	319	255			43	103	111
2		65	513.404	.040		1.0	2	327	252			40	104	113
3		70	516.610	.037		1.0	2	327	252			40	105	115
4		75	519.822	.035	1.0	1.0	2	327	249			40	106	116
	11:27	80	523.049											
Total			50.844	2.5606				5130					3176	
Average				.1600		1.000		320.63					99.25	

1066

2089



Stack Diameter 136" Port Reference 16.5"

Ports are 46.5' Upstream from next disturbance

Ports are 54.5' Downstream from last disturbance

Assumed Moisture 6 %

Probe 65A Cp 0.84

Nozzle Calibration NA

Avg D_n NA inches

Gas Bag F-05

Console 3

Y-Factor 1.004

$\Delta H_@$ 1.649 in H_2O

Barometric Pressures

Pb_m 25.60 in Hg

Pb_p 25.53 in Hg

P_G -0.34 in H_2O

Leak Check	Pre	Post
ft³/min	0.008	0.003
vac in Hg	23	14

Pitot Rate		
	0.0	0.0
In H_2O	.23	0.23

Water Collected 99.0 g

Time Sampled 80 min

Review [illegible]

K @T_m

K @T_m

Comments

* stopped At 10:16 For Bias check
started 10:22

* stopped At 10:49 For Bias check
started 10:55

3505
1906

Facility BYU Cental Heating Plant

GAS ANALYZER FIELD DATA

Date 12-6-11

Operator D. Kitchen

Source Main Stack Exhaust, Boiler # 4

Response Time :50

			Gas Species	Rate	Initial Bias		Final Bias		Analyzer Avg	Corrected Avg
Run 1	Begin	9:49								
	End	10:16	NO_x	600	0.1	43.9	-0.1	44.0	56.4	56.1
	Port Change									

			Gas Species	Rate	Initial Bias		Final Bias		Analyzer Avg	Corrected Avg
Run 2	Begin	1022								
	End	1044	NO_x	600	-0.1	44.0	-0.1	44.1	57.0	56.5
	Port Change									

			Gas Species	Rate	Initial Bias		Final Bias		Analyzer Avg	Corrected Avg
Run 3	Begin	1055								
	End	1127	NO_x	600	-0.1	44.1	0.0	44.2	56.2	55.6
	Port Change									

			Gas Species	Rate	Initial Bias		Final Bias		Analyzer Avg	Corrected Avg
Run	Begin									
	End		NO_x							
	Port Change									

Gas Species	Calibration Gases				Calibration Error				Calibration Error			
NO_x	0.0	43.7	88.9	125.0	0.0	43.9	88.3					

Comments: All values are either ppmdv or mole percents. Corrected averages are analyzer averages corrected using equation 7E-5 unless otherwise indicated.

Eq. 7E-5: $C_{gas} = (C_{avg} - C_0) * [C_{ma} / (C_m - C_0)]$. Rate is sample flow rate in cc/min and is set within analyzer manufacturer specs.

Brigham Young University, Boiler #4, 12/6/11

Run 1		Run 2		Run 3	
Time	NO_x ppm	Time	NO_x ppm	Time	NO_x ppm
9:49	57.0	10:22	56.0	10:55	56.6
9:50	57.0	10:23	56.2	10:56	57.0
9:51	56.7	10:24	56.1	10:57	56.8
9:52	56.5	10:25	56.2	10:58	56.7
9:53	56.3	10:26	56.3	10:59	56.6
9:54	56.2	10:27	56.0	11:00	56.6
9:55	56.3	10:28	56.1	11:01	56.4
9:56	56.2	10:29	56.5	11:02	56.5
9:57	56.4	10:30	56.3	11:03	56.4
9:58	56.6	10:31	56.5	11:04	56.6
9:59	56.4	10:32	56.6	11:05	56.4
10:00	56.5	10:33	56.9	11:06	56.4
10:01	56.6	10:34	57.0	11:07	56.2
10:02	56.5	10:35	57.3	11:08	56.0
10:03	56.3	10:36	57.3	11:09	55.8
10:04	56.4	10:37	57.6	11:10	55.7
10:05	56.3	10:38	57.4	11:11	55.5
10:06	56.3	10:39	57.6	11:12	55.6
10:07	56.3	10:40	57.5	11:13	55.7
10:08	56.4	10:41	57.4	11:14	56.0
10:09	56.2	10:42	57.5	11:15	55.7
10:10	56.4	10:43	57.7	11:16	55.8
10:11	56.4	10:44	57.9	11:17	56.0
10:12	56.2	10:45	57.6	11:18	55.8
10:13	56.6	10:46	57.7	11:19	55.8
10:14	56.4	10:47	57.6	11:20	56.1
10:15	56.3	10:48	57.5	11:21	56.4
10:16	56.3	10:49	57.4	11:22	56.3
				11:23	56.3
				11:24	56.3
				11:25	56.2
				11:26	56.1
				11:27	55.9

Raw Avg	56.4	**Raw Avg**	57.0	**Raw Avg**	56.2	
Span	88.9	**Span**	88.9	**Span**	88.9	
Gas Val	43.7	**Gas Val**	43.7	**Gas Val**	43.7	
$Zero_i$	0.1	**$Zero_i$**	-0.1	**$Zero_i$**	-0.1	
$Zero_f$	-0.1	**$Zero_f$**	-0.1	**$Zero_f$**	0.0	
$Span_i$	43.9	**$Span_i$**	44.0	**$Span_i$**	44.1	
$Span_f$	44.0	**$Span_f$**	44.1	**$Span_f$**	44.2	
Corr.	56.1	**Corr.**	56.5	**Corr.**	55.6	
Calibration		**Calibration**		**Calibration**		
Span	88.9	Span	88.9	Span	88.9	
Zero Cal Gas	0.0		0.0		0.0	
Mid Cal Gas	43.7		43.7		43.7	
High Cal Gas	88.9		88.9		88.9	
Zero Resp	0.0		0.0		0.0	
Mid Cal Resp	43.9		43.9		43.9	
High Cal Resp	88.3		88.3		88.3	Limits
Ana. Cal. Error (ACE)		**ACE**		**ACE**		
Zero Cal Error	0.00%		0.00%		0.00%	2.0%
Mid Cal Error	0.22%		0.22%		0.22%	2.0%
High Cal Error	-0.67%		-0.67%		-0.67%	2.0%
System Bias (zero, SB)		**SB**		**SB**		
Sys Zero Cal Bias Initial	0.11%		-0.11%		-0.11%	5.0%
Sys Zero Cal Bias Final	-0.11%		-0.11%		0.00%	5.0%
System Zero Drift (D)	0.22%		0.00%		0.11%	3.0%
System Bias (upscale, SB)		**SB**		**SB**		
System Cal Bias Initial	-49.94%		-49.83%		-49.72%	5.0%
System Cal Bias Final	-49.83%		-49.72%		-49.61%	5.0%
System Cal Drift (D)	0.11%		0.11%		0.11%	3.0%

$$C_{Gas} = (C_{avg} - C_0) \cdot [C_{ma} / (C_m - C_0)]$$ Eq. 7E-5

$$C_0 = (C_{0i} + C_{0f}) / 2$$

$$C_m = (C_{mi} + C_{mf}) / 2$$

$$ACE = (C_{Dir} - C_v) \cdot 100\% / CS$$ Eq. 7E-1

$$SB = (C_s - C_{Dir}) \cdot 100\% / CS$$ Eq. 7E-2

$$Drift\ (D) = ABS(SB_{final} - Sb_{initial})$$ Eq. 7E-4

STRATIFICATION CHECK FIELD SHEET

Facility BYU Heating Plant **Source** Main Stack, Boiler 4

Operator D Kitchen **Date** 12/6/11

Point 1		Point 2		Point 3	
Time	**NOx ppm**	**Time**	**NOx ppm**	**Time**	**NOx ppm**
9:22	56.5	9:27	55.6	9:32	55.9
9:23	56.6	9:28	55.3	9:33	56.1
9:24	56.1	9:29	55.6	9:34	56.2
9:25	55.7	9:30	55.6	9:35	56.2
9:26	55.8	9:31	55.6	9:36	56.2
Ave	**56.0**		**55.5**		**56.2**
3 Pt. Mean	**55.9**		**55.9**		**55.9**
% Diff From Mean	**0.2**		**0.7**		**0.5**

- The three sample points were on the east/west traverse line.

- If the % diff from mean is less than 5%, one sample point may be used. Use the sample point that gave the value closest to the mean value.
- If the % diff from mean is between 5% and 10%, use three sample points at 16.7, 50.0, and 83.3 % of diam.
- If the % diff from mean is greater than 10%, sample 12 points chosed according to EPA Method 1.

Boiler 6

M4 Field Data Sheet

TETCO

Filter NA Sample Box D

Page 1 of 1 Run # 1

Plant: BYU Central Heating Plant

Date: 12/6/11

Location: Baghouse Exhaust, Boiler # 6

Operator: [illegible]

Traverse Point	Time Clock	Time Min (θ)	DGM (ft³)	ΔP (in H₂O)	ΔH (in H₂O) Desired	ΔH (in H₂O) Actual	Vacuum (in Hg)	Temperatures (°F) Stack (T_s)	Probe	Probe Out	Filter	Effluent	DGM Temp (T_m) Out	In
D 1	6:17	0	422.153	.020	1.0	1.0	2	306	253			32	64	65
2		5	425.518	.018	1.0	1.0	2	305	265			37	64	67
3		10	428.544	.020	1.0	1.0	2	305	253			40	66	72
4		15	431.568	.020	1.0	1.0	2	308	250			41	68	77
C 1	6:41	20	434.606	.015	1.0	1.0	2	304	241			38	73	82
2	*	25	437.630	.017	1.0	1.0	2	304	245			40	76	85
3		30	440.675	.015	1.0	1.0	2	305	250			38	79	85
4		35	443.741	.014	1.0	1.0	2	305	240			39	81	90
B 1	7:22	40	446.798	.085	1.0	1.0	2	304	240			35	85	93
2		45	449.864	.035	1.0	1.0	2	309	243			39	86	96
3	**	50	452.943	.025	1.0	1.0	2	310	233			40	89	100
4		55	456.010	.016	1.0	1.0	2	310	247			40	91	100
A 1	7:53	60	459.033	.022	1.0	1.0	2	308	247			38	93	100
2		65	462.158	.025	1.0	1.0	2	308	263			42	94	102
3		70	465.240	.022	1.0	1.0	2	309	258			43	95	105
4		75	468.321	.020	1.0	1.0	2	309	255			44	96	106
	8:13	80	471.403											
Total			48.450	2.4115				4909					2725	
Average				.1507		1.000		306.81					85.2	

Stack Diameter 136" Port Reference 16.5"

Ports are 46.5' Upstream from next disturbance

Ports are 54.5' Downstream from last disturbance

Assumed Moisture 6 %

Probe 65A Cp 0.84

Nozzle Calibration NA

Avg D_n NA inches

Gas Bag E-05

Console 3

Y-Factor 1.004

$\Delta H_@$ 1.64 in H_2O

Barometric Pressures

Pb_m 25.60 in Hg

Pb_p 25.53 in Hg

P_G -.36 in H_2O

Leak Check:	Pre	Post
ft³/min	0.009	0.003
vac in Hg	23	13
Pitot Rate	0.0	0.0
In H_2O	0.22	23

Water Collected 126.1 g

Time Sampled 80 min

Review [illegible]

K = @T_m

K = @T_m

Comments:

* stopped At 6:46 For Bump check
start 7:02

** stopped At 7:32 For Bump check
start 7:40

3365
1832

18.64 lb/hr

80.6 ppm @ 7% O2

Facility BYU Cental Heating Plant

GAS ANALYZER FIELD DATA

Date 12 6 - 11

Operator D. Kitchen

Source Main Stack Exhaust, Boiler # 6

Response Time :50

			Gas Species	Rate	Initial Bias		Final Bias		Analyzer Avg	Corrected Avg
Run 1	Begin	6:17								
	End	6:46	NO_x	600	0.1	43.6	0.2	43.4	72.0	73.4
	Port Change									

			Gas Species	Rate	Initial Bias		Final Bias		Analyzer Avg	Corrected Avg
Run 2	Begin	702								
	End	7:32	NO_x	600	0.2	43.4	0.2	43.8	74.6	74.9
	Port Change									

			Gas Species	Rate	Initial Bias		Final Bias		Analyzer Avg	Corrected Avg
Run 3	Begin	740								
	End	813	NO_x	600	0.2	43.8	0.2	43.9	76.1	76.0
	Port Change									

			Gas Species	Rate	Initial Bias		Final Bias		Analyzer Avg	Corrected Avg
Run	Begin									
	End		NO_x							
	Port Change									

Gas Species	Calibration Gases				Calibration Error				Calibration Error			
NO_x	0.0	43.7	88.9	125.0	0.1	43.9	88.6					

Comments: All values are either ppmdv or mole percents. Corrected averages are analyzer averages corrected using equation 7E-5 unless otherwise indicated.

Eq. 7E-5: $C_{gas} = (C_{avg} - C_0) * [C_{ma} / (C_m - C_0)]$. Rate is sample flow rate in cc/min and is set within analyzer manufacturer specs.

Brigham Young University, Boiler # 6, 12/6/11

Run 1		Run 2		Run 3	
Time	NO_x ppm	Time	NO_x ppm	Time	NO_x ppm
6:17	71.4	7:02	74.7	7:40	77.1
6:18	71.8	7:03	74.6	7:41	76.8
6:19	72.2	7:04	74.3	7:42	76.1
6:20	72.6	7:05	74.2	7:43	75.8
6:21	72.6	7:06	73.8	7:44	75.5
6:22	72.6	7:07	73.7	7:45	75.5
6:23	72.5	7:08	73.9	7:46	75.6
6:24	72.6	7:09	74.0	7:47	75.8
6:25	72.7	7:10	74.4	7:48	76.1
6:26	72.6	7:11	74.2	7:49	76.4
6:27	72.6	7:12	73.8	7:50	76.5
6:28	72.7	7:13	73.6	7:51	76.7
6:29	72.9	7:14	73.4	7:52	76.4
6:30	73.4	7:15	73.7	7:53	76.4
6:31	73.9	7:16	73.7	7:54	75.8
6:32	74.6	7:17	73.4	7:55	75.4
6:33	74.9	7:18	73.3	7:56	74.8
6:34	74.7	7:19	73.4	7:57	74.3
6:35	74.6	7:20	73.3	7:58	76.9
6:36	74.7	7:21	73.3	7:59	76.6
6:37	74.6	7:22	72.9	8:00	77.6
6:38	74.4	7:23	76.1	8:01	77.9
6:39	74.1	7:24	76.7	8:02	76.7
6:40	73.3	7:25	75.8	8:03	77.6
6:41	72.8	7:26	75.7	8:04	77.7
6:42	72.4	7:27	75.9	8:05	77.5
6:43	72.0	7:28	75.9	8:06	77.2
6:44	71.5	7:29	76.0	8:07	76.0
6:45	71.3	7:30	76.4	8:08	74.9
6:46	71.2	7:31	76.9	8:09	75.7
		7:32	77.1	8:10	74.3
				8:11	74.2
				8:12	74.4
				8:13	75.6

Raw Avg	73.0	Raw Avg	74.6	Raw Avg	76.1		
Span	88.9	Span	88.9	Span	88.9		
Gas Val	43.7	Gas Val	43.7	Gas Val	43.7		
$Zero_i$	0.1	$Zero_i$	0.2	$Zero_i$	0.2		
$Zero_f$	0.2	$Zero_f$	0.2	$Zero_f$	0.2		
$Span_i$	43.6	$Span_i$	43.4	$Span_i$	43.8		
$Span_f$	43.4	$Span_f$	43.8	$Span_f$	43.9		
Corr.	73.4	Corr.	74.9	Corr.	76.0		
Calibration		Calibration		Calibration			
Span	88.9	Span	88.9	Span	88.9		
Zero Cal Gas	0.0		0.0		0.0		
Mid Cal Gas	43.7		43.7		43.7		
High Cal Gas	88.9		88.9		88.9		
Zero Resp	0.1		0.1		0.1		
Mid Cal Resp	43.9		43.9		43.9		
High Cal Resp	88.6		88.6		88.6		Limits
Ana. Cal. Error (ACE)		ACE		ACE			
Zero Cal Error	0.11%		0.11%		0.11%		2.0%
Mid Cal Error	0.22%		0.22%		0.22%		2.0%
High Cal Error	-0.34%		-0.34%		-0.34%		2.0%
System Bias (zero, SB)		SB		SB			
Sys Zero Cal Bias Initial	0.00%		0.11%		0.11%		5.0%
Sys Zero Cal Bias Final	0.11%		0.11%		0.11%		5.0%
System Zero Drift (D)	0.11%		0.00%		0.00%		3.0%
System Bias (upscale, SB)		SB		SB			
System Cal Bias Initial	-50.62%		-50.84%		-50.39%		5.0%
System Cal Bias Final	-50.84%		-50.39%		-50.28%		5.0%
System Cal Drift (D)	0.22%		0.45%		0.11%		3.0%

$$C_{Gas} = (C_{avg} - C_0) \cdot [C_{ma} / (C_m - C_0)] \qquad \text{Eq. 7E-5}$$

$$C_0 = (C_{0i} + C_{0f}) / 2$$

$$C_m = (C_{mi} + C_{mf}) / 2$$

$$ACE = (C_{Dir} - C_v) \cdot 100\% / CS \qquad \text{Eq. 7E-1}$$

$$SB = (C_s - C_{Dir}) \cdot 100\% / CS \qquad \text{Eq. 7E-2}$$

$$\text{Drift (D)} = ABS(SB_{final} - Sb_{initial}) \qquad \text{Eq. 7E-4}$$

STRATIFICATION CHECK FIELD SHEET

Facility BYU Heating Plant **Source** Main Stack, Boiler 6

Operator D Kitchen **Date** 12/6/11

Point 1		Point 2		Point 3	
Time	**NOx ppm**	**Time**	**NOx ppm**	**Time**	**NOx ppm**
5:55	70.7	6:00	71.4	6:05	73.9
5:56	70.9	6:01	71.1	6:06	73.2
5:57	71.4	6:02	70.4	6:07	73.9
5:58	71.8	6:03	70.1	6:08	73.2
5:59	72.2	6:04	70.1	6:09	71.9

Ave	**71.6**	**70.4**	**73.1**
3 Pt. Mean	**71.7**	**71.7**	**71.7**
% Diff From Mean	**0.2**	**1.7**	**1.9**

- The three sample points were on the east/west traverse line.

- If the % diff from mean is less than 5%, one sample point may be used. Use the sample point that gave the value closest to the mean value.
- If the % diff from mean is between 5% and 10%, use three sample points at 16.7, 50.0, and 83.3 % of diam.
- If the % diff from mean is greater than 10%, sample 12 points chosed according to EPA Method 1.

APPENDIX C

Sample Recovery
Gas Analysis Data (ORSAT)

Method 4

Facility: BYU Heating Plant
Stack Identification: Boilers 6 & 4

Date: 12-6-11

IMPINGERS

Run: 1 Sample Box: D

Boiler 6

	Impinger Number 1	2	3	4	5	6
Initial Volume of liquid (H_2O) in impingers, (ml)	100	100	—	Silica Gel		
Final (g)	816.2	623.2	533.0	877.3		
Initial (g)	713.8	609.7	529.6	870.5		
Net (g)	102.4	12.5	3.4	6.8		

Total (g) ~~2.4~~ 126.1

IMPINGERS

Run: 2 Sample Box: E

Boiler 4

	Impinger Number 1	2	3	4	5	6
Initial Volume of liquid (H_2O) in impingers, (ml)	100	100	—	Silica Gel		
Final (g)	786.4	646.2	516.2	912.1		
Initial (g)	708.4	635.6	513.7	904.2		
Net (g)	78.0	10.6	2.5	7.9		

Total (g) 99.0

IMPINGERS

Run: _____ Sample Box: _____

	Impinger Number 1	2	3	4	5	6
Initial Volume of liquid (H_2O) in impingers, (ml)	100	100	—	Silica Gel		
Final (g)						
Initial (g)						
Net (g)						

Total (g) _____

IMPINGERS

Run: _____ Sample Box: _____

	Impinger Number 1	2	3	4	5	6
Initial Volume of liquid (H_2O) in impingers, (ml)	100	100	—	Silica Gel		
Final (g)						
Initial (g)						
Net (g)						

Total (g) _____

Plant 1740 Heating Plant Location Boiler 4 & C

Analytical Method Orsat

Boiler C

Date 12-6-11
Test No. 1
Gas Bag No. E-05
Ambient Temp 68
Operator OAK

Gas	RUN 1 Actual Reading	RUN 1 Net	RUN 2 Actual Reading	RUN 2 Net	RUN 3 Actual Reading	RUN 3 Net	Average Net Volume
CO_2	7.4	7.4	7.4	7.4	7.4	7.4	7.40
O_2 (Net is Actual O_2 Reading Minus Actual CO_2 Reading).	15.4	8.0	15.4	8.0	15.4	8.0	8.0
N_2 (Net is 100 Minus Actual O_2 Reading).							

Boiler 4

Date 12-6-11
Test No. 1
Gas Bag No. E-05
Ambient Temp 68
Operator OAK

Gas	RUN 1 Actual Reading	RUN 1 Net	RUN 2 Actual Reading	RUN 2 Net	RUN 3 Actual Reading	RUN 3 Net	Average Net Volume
CO_2	6.2	6.2	6.2	6.2	6.2	6.2	6.20
O_2 (Net is Actual O_2 Reading Minus Actual CO_2 Reading).	16.6	10.4	16.6	10.4	16.6	10.4	10.4
N_2 (Net is 100 Minus Actual O_2 Reading).							

Date
Test No.
Gas Bag No.
Ambient Temp
Operator

Gas	RUN 1 Actual Reading	RUN 1 Net	RUN 2 Actual Reading	RUN 2 Net	RUN 3 Actual Reading	RUN 3 Net	Average Net Volume
CO_2							
O_2 (Net is Actual O_2 Reading Minus Actual CO_2 Reading).							
N_2 (Net is 100 Minus Actual O_2 Reading).							

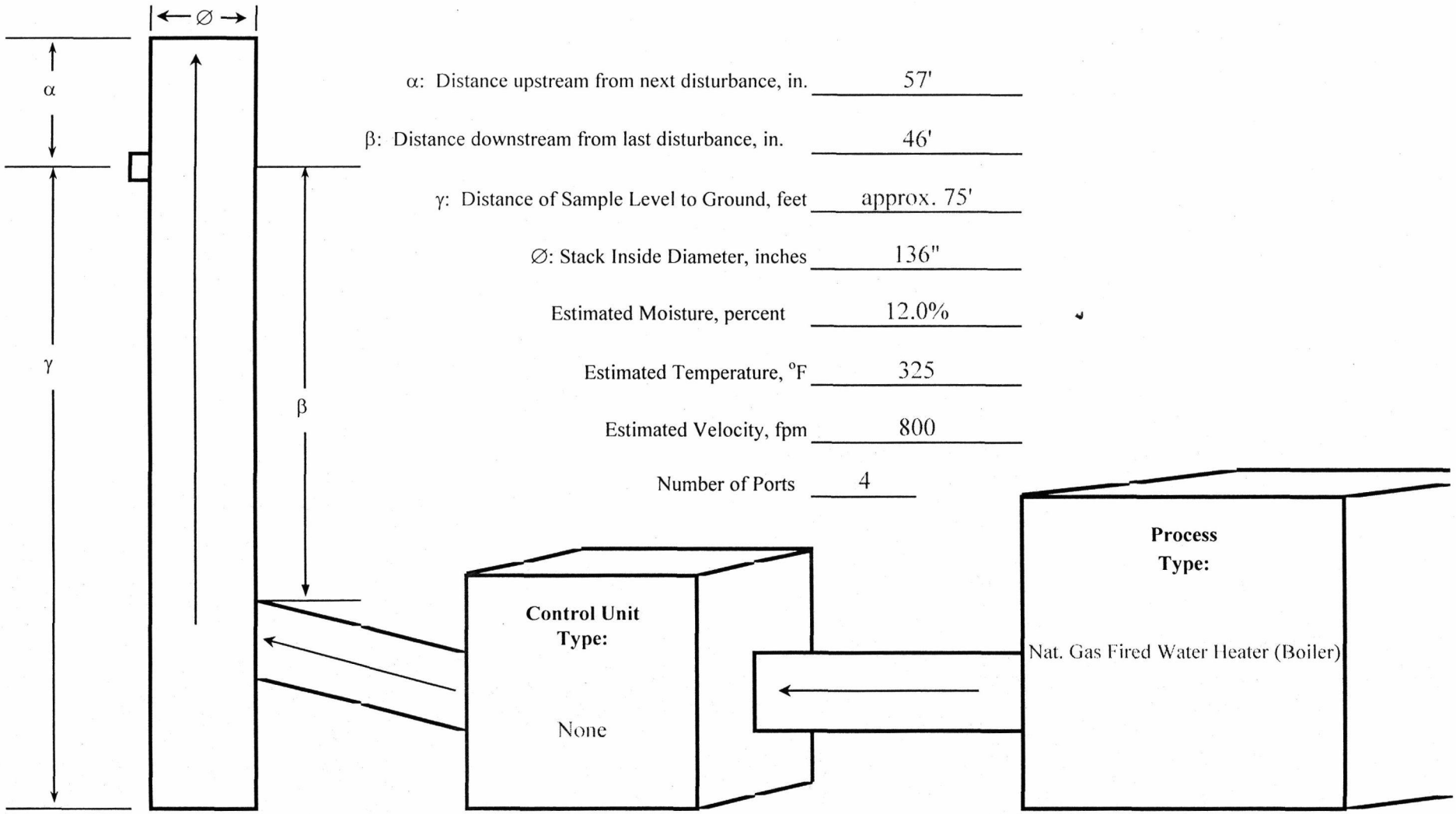
†O_2 was determined using a gas analyzer
CO is not measured, as it has the same molecular weight as N_2

APPENDIX D

Figure 1. Facility Schematic Representation
Raw Production

Facility: BYU Central Heating Plant

Stack Identification: Main Stack, Natural Gas



α: Distance upstream from next disturbance, in. 57'

β: Distance downstream from last disturbance, in. 46'

γ: Distance of Sample Level to Ground, feet approx. 75'

∅: Stack Inside Diameter, inches 136"

Estimated Moisture, percent 12.0%

Estimated Temperature, °F 325

Estimated Velocity, fpm 800

Number of Ports 4

Figure 1. Facility Schematic Representation

Brigham Young University

Central Heating Plant Baghouse

Boiler # 4 12-6-11

Test Run #	Test Time	Gas Flow Rate MCF	Instantaneous Rate mmBtu/hr	Integrator mmBtu
	Start 924	15284.98	74.5	529 132.50
	End 1019	15367.20	75.0	529205.50
		net		net 72.00
				⇒ 78.55 mmBtu/hr
	Start 1019	15367.20	75.0	529205.50
	End 1052	15417.73	75.1	529249.00
		net	~~75~~	net 43.5
				79.09 mmBtu/hr
	Start 1052	15417.73	75.0	529249.00
	End 1130	15479.87	72.9	529297.75
		net		net 48.75
				76.97 mmBtu/hr
	Start			
	End			
		net		net

Notes: average for all 3 test runs 78.2 mmBtu/hr

Brigham Young University

Central Heating Plant Baghouse

Boiler # 6 12-6-11

Test Run #	Test Time	Gas Flow Rate MCF	Instantaneous Rate mmBtu/hr	Integrator mmBtu
	Start 6:13	671576.13	81.6	705458.10
	End 6:51	671626.13	82.47	705515.81
		net		net 57.71
				=> 91.12 mmBtu/hr
	Start 700	671639.56	82.0	705529.13
	End 736	671687.81	84.93	705582.81
		net		net 57.68
				=> 89.47 mmBtu/hr
	Start 736	671687.81	84.93	705582.81
	End 816	671741.31	85.70	705642.94
		net		net 60.13 mmBtu
				=> 90.20 mmBtu/hr
	Start			
	End			
		net		net

Notes: Avg = 90.3 mmBtu/hr

APPENDIX E

Calibration of the console dry gas meter(s), pitot tubes, nozzles diameters, and temperature sensors were carried out in accordance with the procedures outlined in the Quality Assurance Handbook. The appropriate calibration data are presented in the following pages.

Figure 2. Schematic of Method 4 Sampling Train
Figure 3. Schematic of Gaseous Analyzer Sampling Train
Meter Box Calibration Data and Calculations Forms
Post-test Dry Gas Meter Calibration Data Forms
Type S Pitot Tube Inspection Data
Sample Box Temperature Sensor Calibration
Gas Calibration Gas Certification
NO_x Converter Efficiency Test

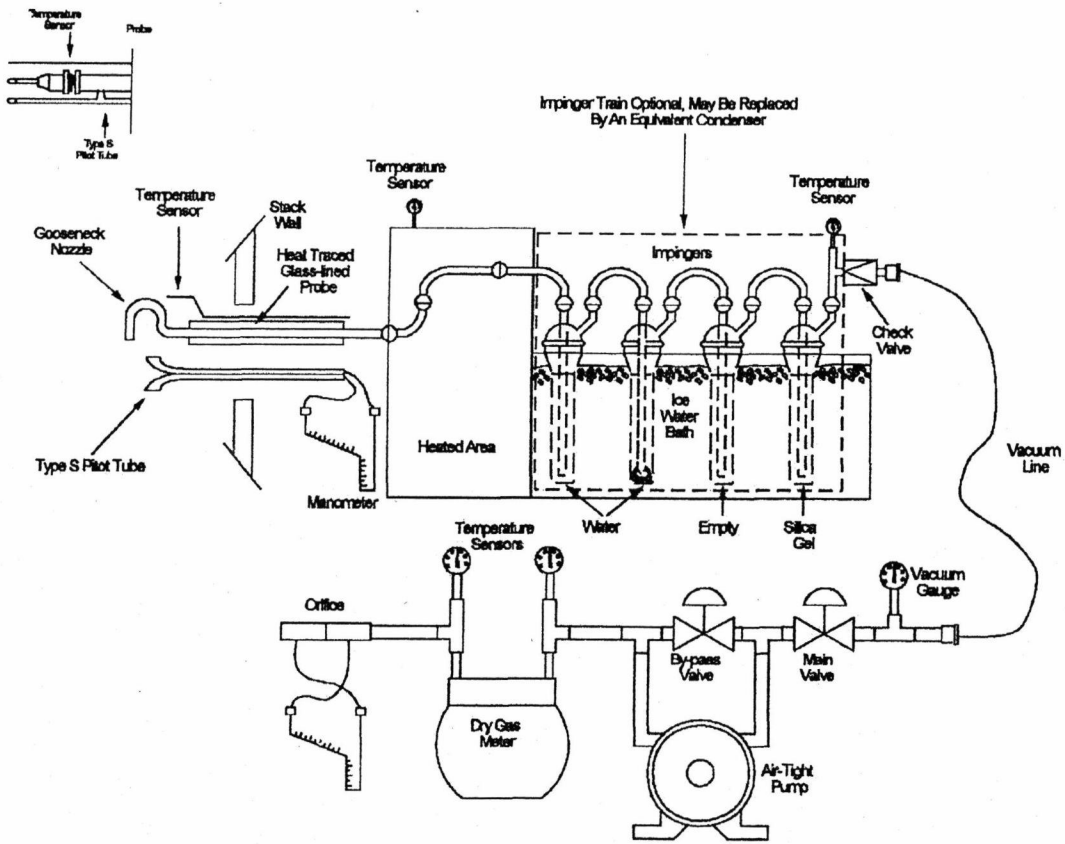


Figure 2. Schematic of Method 4 Sampling Train

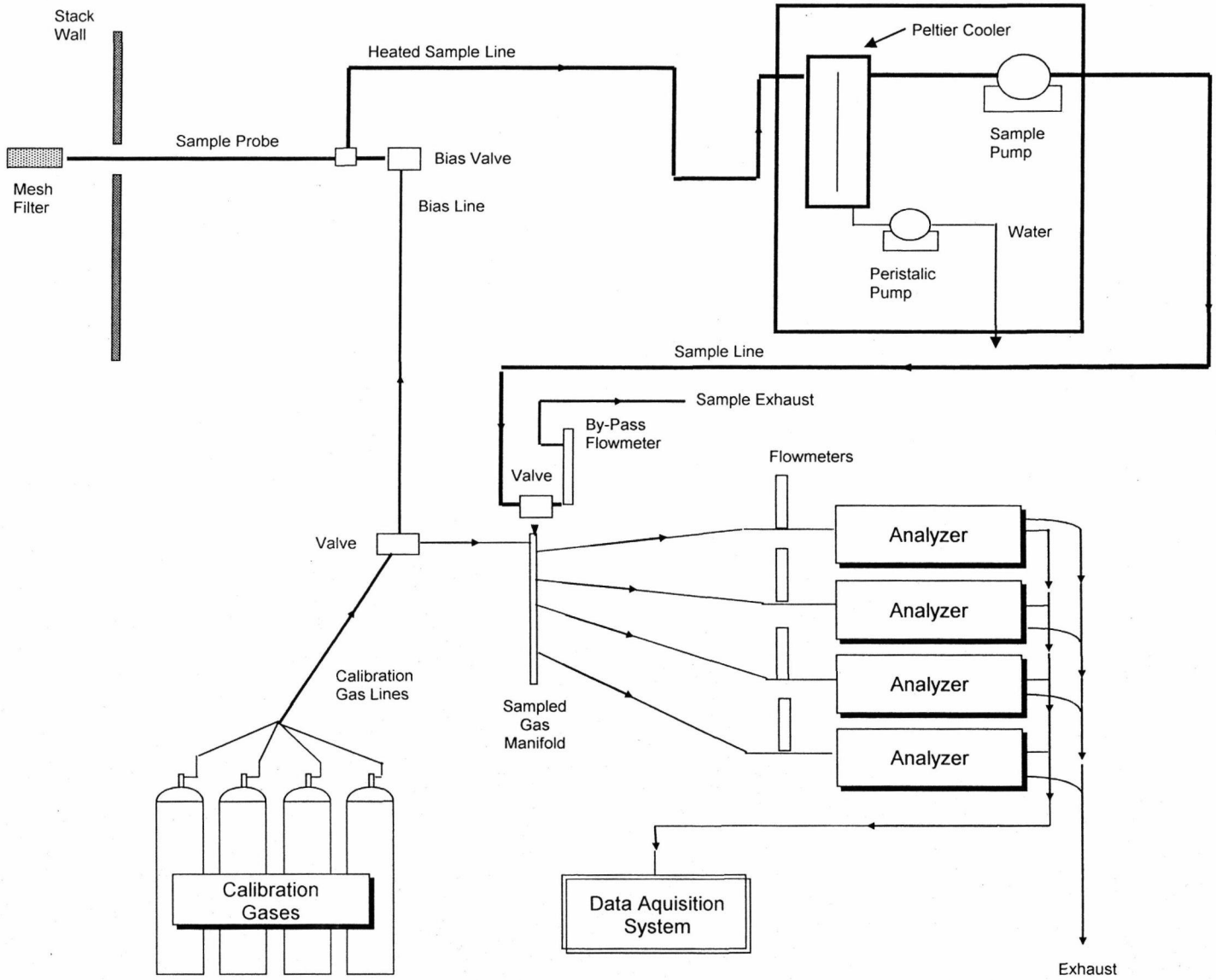


Figure 3. Schematic of Gas Analyzer Sampling Train.

METHOD 5 DRY GAS METER CALIBRATION USING CRITICAL ORIFICES

1) Select three critical orifices to calibrate the dry gas meter which bracket the expected operating range.
2) Record barometric pressure before and after calibration procedure.
3) Run at tested vacuum (from Orifice Calibration Report), for a period of time necessary to achieve a minimum total volume of 5 cubic feet.
4) Record data and information in the GREEN cells, YELLOW cells are calculated.

Facility **New Calibration 2011**

DATE: 12/15/2010
METER PART #: Console 3
METER SERIAL #: 1522588
CRITICAL ORIFICE SET SERIAL #: 1453S
BAROMETRIC PRESSURE (in Hg): INITIAL 25.30 | FINAL 25.30 | AVG (P_{bar}) 25.3
EQUIPMENT ID #: Console #3

IF Y VARIATION EXCEEDS 2.00%, ORIFICE SHOULD BE RECALIBRATED

ORIFICE #	RUN #	K' FACTOR (AVG)	TESTED VACUUM (in Hg)	DGM READINGS (FT^3) INITIAL	DGM READINGS (FT^3) FINAL	DGM READINGS (FT^3) NET (V_m)	TEMPERATURES °F AMBIENT	DGM INLET INITIAL	DGM INLET FINAL	DGM OUTLET INITIAL	DGM OUTLET FINAL	DGM AVG	ELAPSED TIME (MIN) θ	DGM ΔH (in H_2O)	(1) V_m (STD)	(2) V_{cr} (STD)	(3) Y	Y VARIATION (%)	$\Delta H_@$
30	1	0.8137	13	896.006	901.301	5.295	74	74	76	70	70	72.5	5.00	2.90	4.4778	4.4556	0.995		1.737
	2	0.8137	13	901.301	906.609	5.308	74	76	79	70	72	74.25	5.00	2.90	4.4741	4.4556	0.996		1.731
	3	0.8137	13	906.609	911.936	5.327	74	79	80	72	73	76.00	5.00	2.90	4.4754	4.4556	0.996		1.726
																AVG =	0.996	-0.89	
19	1	0.5317	13	912.40	917.596	5.196	74	79	80	75	82	79.00	7.50	1.20	4.3198	4.3672	1.011		1.655
	2	0.5317	13	917.596	922.809	5.213	74	80	82	74	77	78.25	7.50	1.20	4.340	4.3672	1.006		1.657
	3	0.5317	13	922.809	928.018	5.209	74	82	83	77	78	80.00	7.50	1.20	4.3226	4.3672	1.010		1.652
																AVG =	1.009	0.48	
12	1	0.3307	13	928.304	933.524	5.220	74	82	83	78	79	80.50	12.00	0.44	4.3182	4.3460	1.006		1.561
	2	0.3307	13	933.524	938.841	5.317	74	81	83	79	80	80.75	12.25	0.44	4.3964	4.4366	1.009		1.560
	3	0.3307	13	938.841	944.055	5.214	74	83	84	80	80	81.75	12.00	0.44	4.3032	4.3460	1.010		1.557
																AVG =	1.009	0.41	

USING THE CRITICAL ORIFICES AS CALIBRATION STANDARDS:
The following equations are used to calculate the standard volumes of air passed through the DGM, V_m (std), and the critical orifice, V_{cr} (std), and the DGM calibration factor, Y. These equations are automatically calculated in the spreadsheet above.

AVERAGE DRY GAS METER CALIBRATION FACTOR, Y = **1.004**

AVERAGE $\Delta H_@$ = **1.649**

(1) $$Vm_{(std)} = K_1 * Vm * \frac{Pbar + (\Delta H / 13.6)}{Tm}$$

= Net volume of gas sample passed through DGM, corrected to standard conditions
K_1 = 17.64 °R/in. Hg (English), 0.3858 °K/mm Hg (Metric)
T_m = Absolute DGM avg. temperature (°R - English, °K - Metric)

(2) $$Vcr_{(std)} = K' * \frac{Pbar * \Theta}{\sqrt{Tamb}}$$

= Volume of gas sample passed through the critical orifice, corrected to standard conditions
T_{amb} = Absolute ambient temperature (°R - English, °K - Metric)
K' = Average K' factor from Critical Orifice Calibration

(3) $$Y = \frac{Vcr_{(std)}}{Vm_{(std)}}$$

= DGM calibration factor

$$\Delta H_@ = \left(\frac{0.75\,\theta}{V_{cr}(std)}\right)^2 \Delta H \left(\frac{V_m(std)}{V_m}\right)$$

Temperature Sensors

Reference °F	In °F	Out °F
34	34	35
67	67	67
202	202	204

METHOD 5 DRY GAS METER CALIBRATION USING CRITICAL ORIFICES

1) Select three critical orifices to calibrate the dry gas meter which bracket the expected operating range.
2) Record barometric pressure before and after calibration procedure.
3) Run at tested vacuum (from Orifice Calibration Report), for a period of time necessary to achieve a minimum total volume of 5 cubic feet.
4) Record data and information in the **GREEN** cells, YELLOW cells are calculated.

Quality - Service - Reliability

Facility **BYU**

							INITIAL	FINAL	AVG (P_{bar})
DATE:	12/7/2011	METER SERIAL #:	1522588	BAROMETRIC PRESSURE (in Hg):			25.65	25.65	25.65
METER PART #:	Console 3	CRITICAL ORIFICE SET SERIAL #:	1453S	EQUIPMENT ID #:	Console #3				

IF Y VARIATION EXCEEDS 2.00%, ORIFICE SHOULD BE RECALIBRATED

ORIFICE #	RUN #	K' FACTOR (AVG)	TESTED VACUUM (in Hg)	DGM READINGS (FT^3) INITIAL	DGM READINGS (FT^3) FINAL	DGM READINGS (FT^3) NET (V_m)	TEMPERATURES °F AMBIENT	DGM INLET INITIAL	DGM INLET FINAL	DGM OUTLET INITIAL	DGM OUTLET FINAL	DGM AVG	ELAPSED TIME (MIN) θ	DGM ΔH (in H_2O)	(1) V_m (STD)	(2) V_{cr} (STD)	(3) Y	Y VARIATION (%)	$\Delta H_@$
19	1	0.5317	15	531.008	536.195	5.187	78	77	79	80	82	79.5	7.50	1.20	4.3677	4.4111	1.010		1.643
	2	0.5317	15	536.195	541.558	5.363	78	79	82	82	85	82	7.75	1.20	4.4950	4.5582	1.014		1.636
	3	0.5317	15	541.558	547.10	5.542	78	82	83	85	88	84.50	8.00	1.20	4.6237	4.7052	1.018		1.628
																AVG =	1.014	0.00	
	1					.0						0.00							
	2					.0						0.00							
	3					.0						0.00							
																AVG =			
	1					.0						0.00							
	2					.0						0.00							
	3					.0						0.00							
																AVG =			

USING THE CRITICAL ORIFICES AS CALIBRATION STANDARDS:
The following equations are used to calculate the standard volumes of air passed through the DGM, V_m (std), and the critical orifice, V_{cr} (std), and the DGM calibration factor, Y. These equations are automatically calculated in the spreadsheet above.

AVERAGE DRY GAS METER CALIBRATION FACTOR, Y = **1.014**

AVERAGE $\Delta H_@$ = **1.636**

(1) $$Vm_{(std)} = K_1 * Vm * \frac{Pbar + (\Delta H / 13.6)}{Tm}$$

= Net volume of gas sample passed through DGM, corrected to standard conditions
K_1 = 17.64 °R/in. Hg (English), 0.3858 °K/mm Hg (Metric)
T_m = Absolute DGM avg. temperature (°R - English, °K - Metric)

(2) $$Vcr_{(std)} = K' * \frac{Pbar * \Theta}{\sqrt{Tamb}}$$

= Volume of gas sample passed through the critical orifice, corrected to standard conditions
T_{amb} = Absolute ambient temperature (°R - English, °K - Metric)
K' = Average K' factor from Critical Orifice Calibration

(3) $$Y = \frac{Vcr_{(std)}}{Vm_{(std)}}$$

= DGM calibration factor

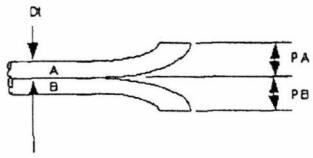
$$\Delta H_@ = \left(\frac{0.75\,\theta}{V_{cr}(std)}\right)^2 \Delta H \left(\frac{V_m(std)}{V_m}\right)$$

Type S Pitot Tube Inspection Data

Date: 12-20-10

Pitot Tube Identification: 65 A

Technician: K. McNamara



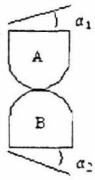
Dt= .250 in.

Is $P_A = P_B$? Yes

Is $1.05 \cdot D_t \le D_t \le 1.50 \cdot D_t$? Yes

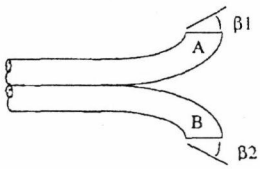
P_A = .368 in.

P_B = .368 in.



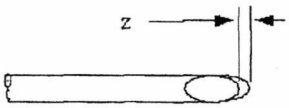
$\alpha_1 < 10°$ α_1 = 1 °

$\alpha_2 < 10°$ α_2 = 1 °

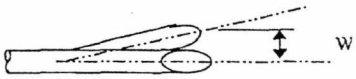


$\beta_1 < 5°$ β_1 = 0 °

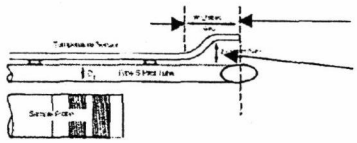
$\beta_2 < 5°$ β_2 = 0 °



$Z \le 0.125$ in. Z = .003 in.

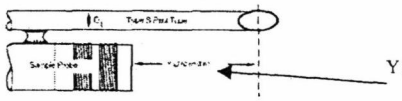


$W \le 0.03125$ in. W = .013 in.



W > 3 inches W = 6 in.

Z > 3/4 inch Z = 1 in.



Y ≥ 3 inches Y = 4 in.

The pitot tube meets the specifications for a calibration factor of 0.84? Yes

Temperature Sensor Calibration

Reference: _____

	Temperature Source (Medium)	Temperature Reference (°F)	Temperature Sensor (°F)	Temperature Difference (°F)
Probe	AIR	68	68	0
	Continuity	—	—	Yes
	Heat Check 248	—	Yes	250
Stack	AIR	66	68	0
	ICE WATER	32	32	0
	BOIL WATER	205	204	1
	SILICONE OIL			

TETCO

Sample Box Temperature Sensor Calibration

Date: 12/29/10 Calibrator: Mike McNamara Reference: Omega CL3512A

Unit ID	Thermocouple Location	Temperature Source (Medium)	Temperature Reference (°F)	Temperature Sensor (°F)	Temp. Diff. or Result (°F), P/F
A	Oven	Water	34	34	0
		Water	203	203	0
	Probe Out	Water	34	33	1
		Water	203	204	-1
	Impinger Out	Water	34	36	-2
		Water	203	203	0
B	Oven	Water	32	34	-2
		Water	203	204	-1
	Probe Out	Water	32	33	-1
		Water	202	204	-2
	Impinger Out	Water	31	31	0
		Water	203	205	-2
C	Oven	Water	34	36	-2
		Water	204	205	-1
	Probe Out	Water	34	36	-2
		Water	203	205	-2
	Impinger Out	Water	34	36	-2
		Water	203	201	2
D	Oven	Water	33	33	0
		Water	203	203	0
	Probe Out	Water	33	33	0
		Water	202	203	-1
	Impinger Out	Water	33	33	0
		Water	203	201	2
E	Oven	Water	33	34	-1
		Water	203	203	0
	Probe Out	Water	33	34	-1
		Water	203	204	-1
	Impinger Out	Water	33	33	0
		Water	203	204	-1
F	Oven	Water	33	33	0
		Water	203	202	1
	Probe Out	Water	33	33	0
		Water	203	201	2
	Impinger Out	Water	33	34	-1
		Water	203	201	2
	Impinger Out G	Water	33	34	-1
		Water	203	202	1
	Impinger Out H	Water	33	35	-2
		Water	203	202	1
	Impinger Out I	Water	33	33	0
		Water	203	204	-1
	Impinger Out J	Water	33	33	0
		Water	203	204	-1

LIQUID TECHNOLOGY CORPORATION

"INDUSTRY LEADER IN SPECIALTY GASES"

Certificate of Analysis

- EPA PROTOCOL GAS -

Customer	TETCO (American Fork, UT)
Date	July 13, 2010
Delivery Receipt	DR-29974
Gas Standard	45.0 ppm NO, 45.0 ppm Carbon Monoxide/Nitrogen
Final Analysis Date	July 08, 2010
Expiration Date	July 08, 2012

DO NOT USE BELOW 150 psig

Analytical Data:
EPA Protocol, Section No. 2.2, Procedure G-1.

Reported Concentrations:

Nitric Oxide: 43.7 ppm +/- 0.43 ppm

Carbon Monoxide: 46.3 ppm +/- 0.46 ppm

Nitrogen: Balance

Total NOx: 43.9 ppm

** Total NOx for Reference Use Only **

Reference Standards

SRM/GMIS	GMIS	GMIS/GMIS
Cylinder Number:	EB-0021453	CC-125604/CC-233168
Concentration:	48.68 ppm NO	25.5 ppm CO/50.67 ppm CO
Expiration Date:	05/05/12	02/27/12 - 02/12/12

Certification Instrumentation

Component:	Nitric Oxide	Carbon Monoxide
Make/Model:	Horiba - CLA 510	Nicolet-NEXUS 470
Serial Number:	43331870031	AEP99000154
Principal of Measurement:	Chemiluminescence	FTIR
Last Calibration:	June 14, 2010	July 07, 2010

Cylinder Data

Cylinder Number:	CC-310793	Cylinder Volume:	140 Cubic Feet
Cylinder Outlet:	CGA 660	Cylinder Pressure:	2000 psig, 70°F
Expiration Date:	July 08, 2012		

Analytical Uncertainty and NIST Traceability are in compliance with EPA-600/R-97/121.

Certified by:

Adam Strickland

"UNMATCHED EXCELLENCE"

2564 PEMBERTON DRIVE APOPKA, FLORIDA 32703 ~ PHONE (407)-292-2990 FAX (407)-292-3313
WWW.LIQUIDTECHCORP.COM

LIQUID TECHNOLOGY CORPORATION

"INDUSTRY LEADER IN SPECIALTY GASES"

Certificate of Analysis

- EPA PROTOCOL GAS -

Customer	TETCO (American Fork, UT)
Date	August 06, 2010
Delivery Receipt	DR-30291
Gas Standard	90.0 ppm NO, 90.0 ppm Carbon Monoxide/Nitrogen
Final Analysis Date	August 06, 2010
Expiration Date	August 06, 2012

DO NOT USE BELOW 150 psig

Analytical Data:
EPA Protocol, Section No. 2.2, Procedure G-1.

Reported Concentrations:

Nitric Oxide: 88.9 ppm +/- 0.88 ppm

Carbon Monoxide: 91.9 ppm +/- 0.91 ppm

Nitrogen: Balance

Total NOx: 88.9 ppm

** Total NOx for Reference Use Only **

Reference Standards

SRM/GMIS	GMIS	GMIS/GMIS
Cylinder Number:	EB-0021453	CC-233168/CC-231409
Concentration:	48.68 ppm NO	50.67 ppm CO/102.53 ppm CO
Expiration Date:	05/05/12	02/12/12 - 07/14/11

Certification Instrumentation

Component:	Nitric Oxide	Carbon Monoxide
Make/Model:	Horiba - CLA 510	Nicolet-NEXUS 470
Serial Number:	43331870031	AEP99000154
Principal of Measurement:	Chemiluminescence	FTIR
Last Calibration:	July 19, 2010	July 07, 2010

Cylinder Data

Cylinder Number:	EB-0024198	Cylinder Volume:	140 Cubic Feet
Cylinder Outlet:	CGA 660	Cylinder Pressure:	2000 psig, 70°F
Expiration Date:	August 06, 2012		

Analytical Uncertainty and NIST Traceability are in compliance with EPA-600/R-97/121.

Certified by:

Adam Strickland

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WWW.LIQUIDTECHCORP.COM

Scott Specialty Gases
www.scottgas.com

Shipped From: 8832 DICE ROAD
SANTA FE SPRINGS CA 90670-2516
Phone: 800-323-2212 Fax: 562-464-5262

C E R T I F I C A T E O F A N A L Y S I S

ALA-CYL-SALT LAKE CITY (LOC 84427)
TRANSFER ACCOUNT- FILL LO
1676 SOUTH 700 WEST
SALT LAKE CITY UT 84104
US

DOCUMENT#:43025901 -002
PO#: PURES
ITEM #: P841-30AL
DATE: 31Aug2011

CYLINDER #: CC236971
FILL PRESSURE: 02000 PSIG

PURE MATERIAL: NITROGEN CAS# 7727-37-9

GRADE: ACID RAIN CEM 0

PURITY: 99.9995%

IMPURITY	MAXIMUM CONCENTRATIONS	ACTUAL CONCENTRATIONS
SO2	0.1 PPM	<0.1 PPM
NOX	0.1 PPM	<0.1 PPM
CO	0.5 PPM	<0.5 PPM
CO2	1 PPM	<0.5 PPM
THC	0.1 PPM	<0.1 PPM
H2O	2 PPM	1.9 PPM
O2	0.5 PPM	0.4 PPM

QC BATCH : SBO0042184

ANALYST: _____
JMU

NO_x Converter Efficiency Test

Date	Time	Output
12/6/11	5:01	34.0
12/6/11	5:02	34.0
12/6/11	5:03	34.0
12/6/11	5:04	34.0
12/6/11	5:05	34.0
12/6/11	5:06	33.9
12/6/11	5:07	33.9
12/6/11	5:08	34.0
12/6/11	5:09	33.9
12/6/11	5:10	33.8
12/6/11	5:11	33.9
12/6/11	5:12	33.8
12/6/11	5:13	33.9
12/6/11	5:14	33.9
12/6/11	5:15	33.8
12/6/11	5:16	33.8
12/6/11	5:17	33.8
12/6/11	5:18	33.8
12/6/11	5:19	33.8
12/6/11	5:20	33.8
12/6/11	5:21	33.8
12/6/11	5:22	33.8
12/6/11	5:23	33.8
12/6/11	5:24	33.8
12/6/11	5:25	33.9
12/6/11	5:26	33.9
12/6/11	5:27	33.9
12/6/11	5:28	33.9
12/6/11	5:29	33.9
12/6/11	5:30	**33.9**
		END

	Concentration of Certified Gas used	**88.9**	ppmdv NO_x
	Diluted with air at approx 1:1		
	Instrument Span	**88.9**	ppmdv
	NO_{xPeak}	34.0	
	NO_{xFinal}	**33.9**	
(Eq. 7E-9)	Eff_{NO2}	**0.4**	%
	Average Reading	**33.9**	ppmdv

40 CFR 60 Appendix A-4, Method 7E, Section 16.2.2

Fill a Tedlar bag approximately half full with either ambient air, pure oxygen, or an oxygen standard gas with at least 19.5 percent by volume oxygen content. Fill the remainder of the bag with mid-level NO in nitrogen calibration gas...

Immediately attach the bag to the inlet of the NO_x analyzer (or external converter if used)... Measure the NO_x concentration for a period of 30 minutes. If the NO_x concentration drops more than 2 percent absolute from the peak value observed, then the NO_2 converter has failed to meet the criteria of this test. Take corrective action. The highest NO_x value observed is considered to be NO_{xPeak}. The final NO_x value observed is considered to be NO_{xFinal}.

APPENDIX F

The testing protocol and other correspondence related to the tests are included here.

State of Utah

GARY R. HERBERT
Governor

GREG BELL
Lieutenant Governor

Department of
Environmental Quality

Amanda Smith
Executive Director

DIVISION OF AIR QUALITY
Bryce C. Bird
Director

COPY

November 15, 2011

DAQC-1265-11
Site ID 10790 (B4)

Paul Greenwood
Brigham Young University
Physical Plant Department
225 BRWB
Provo, UT 84602

Dear Mr. Greenwood:

Re: Brigham Young University – Central Heating Plant Boilers #4 and #6 - Protocol Review and Test Date Confirmation – Utah County

The testing protocol for the Brigham Young University Central Heating Plant Boilers #4 and #6 dated October 27, 2011, has been reviewed and found acceptable. The agreed upon test date is December 6-7, 2011.

Acceptance of a protocol does not relieve the owner/operator and the testing contractor from strict adherence to all applicable EPA methods, Utah Division of Air Quality (DAQ) policies, Utah Air Quality Rules (UAQR), and methods approved by the Executive Secretary. Any deviation from EPA methods, DAQ policies, UAQR, and methods approved by the Executive Secretary must be addressed separately and express written consent given prior to commencement of testing.

The DAQ requires that all test reports include a statement signed by a responsible official certifying that:

A. Testing was conducted while the source was operating at the rate and/or conditions specified in the applicable approval order, operating permit, or federal regulation.

B. During testing, the source combusted fuels, used raw materials, and maintained process conditions representative of normal operations, and operated under such other relevant conditions specified by the Executive Secretary.

C. Based on information and belief formed after reasonable inquiry, the statements and information contained in the report are true, accurate, and complete.

If you have any questions, call me at (801) 536-4438 or e-mail me at rleishman@utah.gov.

Sincerely,

Rob Leishman, Environmental Scientist
Division of Air Quality

RL:lk

cc: Utah County Health Department
TETCO

NO_X COMPLIANCE EMISSION TESTING PROTOCOL
BRIGHAM YOUNG UNIVERSITY, PROVO, UTAH
CENTRAL HEATING PLANT BAGHOUSE
BOILERS #4 AND #6

Project Organization and Responsibility

The following personnel and the testing contractor are presently anticipated to be involved in the testing program. Utah Department of Environmental Quality, Division of Air Quality (DAQ) may have their own personnel or contractor to observe all phases including the process.

Company	**Contacts**
Brigham Young University Physical Plant Department 225 BRWB Provo, UT 84602	Paul Greenwood (801) 422-5438 Assistant Director, Utilities, Engineering and Maintenance
Test Contractor TETCO 391 East 620 South American Fork, UT 84003	Dean A. Kitchen (801) 492-9106 Paul Kitchen

During these tests only Brigham Young University (BYU) personnel listed above or assigned personnel from the operation are authorized to answer or obtain answers to pertinent questions on the process conditions or the test protocol.

Test Schedule

It is planned to complete this test project December 6-7, 2011. The testing crew will arrive, set up and take preliminary measurements December 5th. Testing will begin the morning of December 6th. A pretest meeting may be held at the request of BYU or DAQ.

Project Description

This test project will be conducted to comply with the requirements of BYU's Title V Operating Permit, Permit No. 4900004002, which requires testing Boilers #4 and #6 for NO_x emissions every three years. Testing will be performed according to EPA Methods 1-4, and 7E and will include accumulating process and production data.

Test Procedures

Three tests runs will be conducted on each unit for NO_x emissions. Testing will be EPA Methods 1-4 and 7E as specified in 40 CFR 60, Appendix A. One Method 4 test may span up to three Method 7E tests. Specific test procedures are as follows:

EPA Methods 1-4

1. Boilers #4 and #6 have a common exhaust stack with an inside diameter of 136 inches. The sample ports are located 46 feet downstream and 57 feet upstream from any flow disturbance and conform to EPA Method 1. Sample points will be selected according to EPA Method 1 for a non-particulate traverse.

2. EPA Method 2 will be used to determine gas stream velocity. Type "S" pitot tubes will be used with a C_p factor of 0.84. Dual inclined/vertical manometers with graduations in 0.01 inches of water will be used. If flows are below 0.05 inches of water a more sensitive manometer will be used. The graduations marks on int are 0.005 inches of water. Direction of gas flow will be checked for cyclonics prior to testing.

3. A barometer will be used to measure the barometric pressure. It is periodically checked against a mercury barometer. Prior to testing it will be checked to assure an accurate barometric pressure.

4. EPA Method 3 will be used to determine the gas stream dry molecular weight. An integrated flue gas sample will be taken from the exhaust line after the dry gas meter orifice during each run and analyzed at the completion of the test with an Orsat to determine the molecular weight of the effluent gas stream.

5. The Method 4 test run time will be sufficient to sample at least 21 dscf as required by Method 4.

6. The probe liners will be 316 stainless steel.

7. Preparation and clean-up by the contractor will be performed in the contractor's testing trailer. Laboratory work and analysis will be performed by the testing contractor as soon as possible after all tests have been completed.

8. If plant maintenance or operating problems arise during the test, the test may be stopped. This determination will be made by the Brigham Young University representatives or operating personnel in consultation with agency representatives.

9. Current calibration data is submitted in Appendix A of this protocol. Any equipment calibration that fall past due prior to the test date will be recalibrated prior to use.

Gaseous Analyzer Measurements

The following procedures will be used fo the Method 7E tests:

1. A gaseous analyzer will be used to measure the NO_x concentrations during the emissions test project. It is planned to run the NO_x machine on the 0-250 ppm range. EPA Protocol 1 gases will be used as calibration standards with dry nitrogen as a zero gas.

2. A gaseous analyzer may be used to measure the O_2 concentrations in place of an Orsat analysis during the emissions test project. If operated, the O_2 analyzer would be run on the 0-10 percent range. EPA Protocol 1 gases would be used as calibration standards with dry nitrogen as a zero gas.

3. The gas analyzer sampling train will consist of the following: an in-stack glass fiber filter, heated stainless steel probe, Teflon heated sampling line to the water removal system, water removal system, Teflon transport lines, gas manifold, and out of stack Teflon filter after the gas manifold but prior to analyzers. The sampling train is built such that the sampled gas only comes in contact with inert materials, i.e., Teflon, stainless steel, and glass.

4. The number of sample points for the Method 7E sampling train will be determined according to the results of a stratification check as per Method 7E, section 8.1.2.

5 The NO_x converter efficiency check will be completed according to Method 7E, section 16.2.2.

6. Bias checks, calibration drift, zero drift and calibration error will follow the specified guidelines of EPA Method 7E. Interference responses were determined in the factory and no alterations have been done, therefore, factory specifications are satisfactory.

7. A data logger will be used to record measured concentrations. Gas analyzer data during port changes will not be considered valid data.

Test Area

The test area shall include the Heating Plant control room, main floor, and stack areas, and the area around the contractors testing trailer.

Process Data

process parameters will be made available to DAQ personnel and included in the test report.

Quality Assurance

All testing and analysis in these tests will be conducted according to Methods 4 and 7E as specified in this protocol, and appropriate sections of the *EPA Quality Assurance Handbook for Air Pollution Measurement Systems Vol. III.*

Reporting

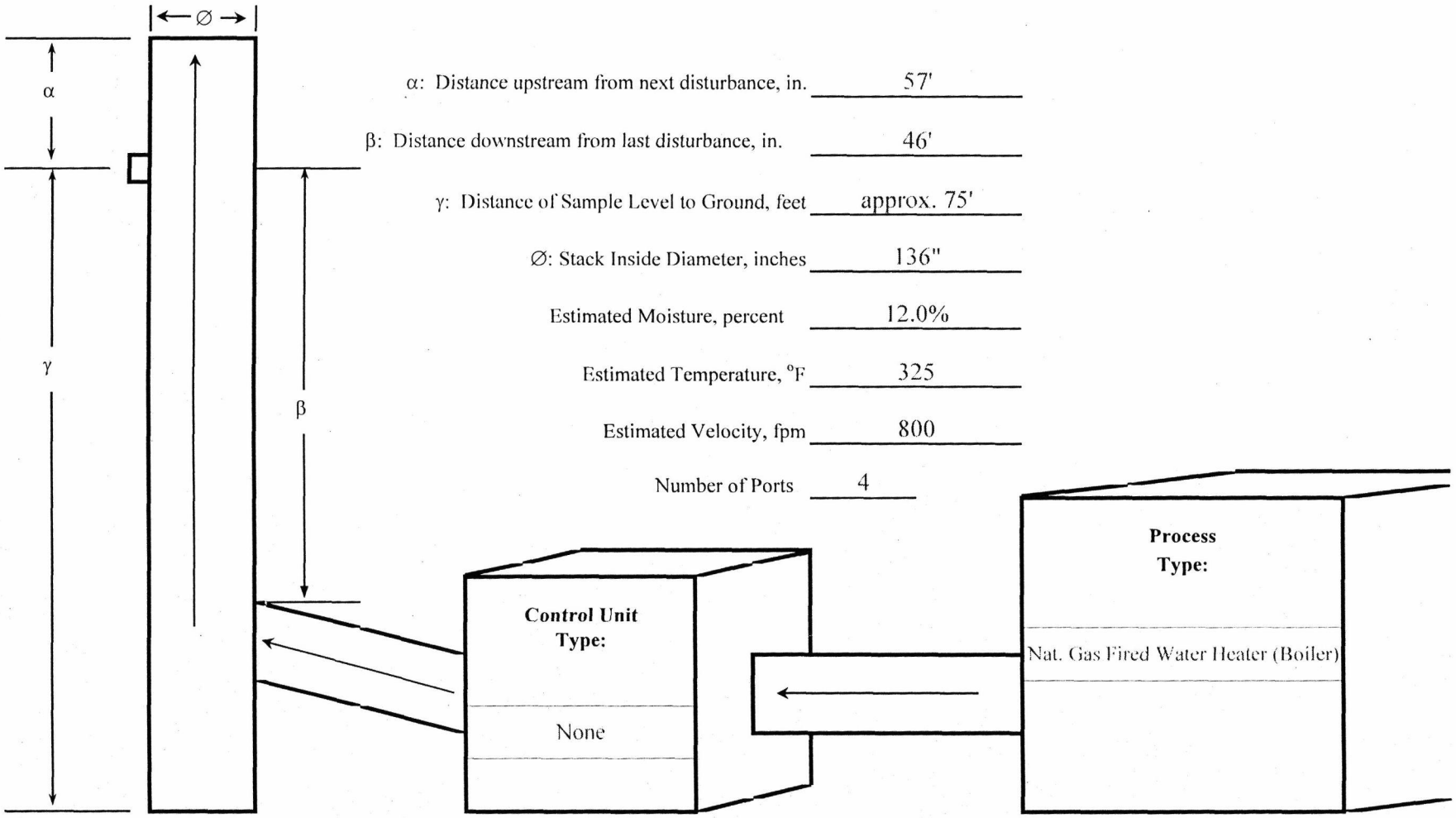
Complete copies of raw data, calculations and summary of test will be included in reports. All process and production data will be recorded and retained for inspection and copying by DAQ. The contractor will furnish copies of the test report to Paul Greenwood, Assistant Director, Utilities, Engineering and Maintenance.

Appendix A

lity Schematic

Facility: BYU Central Heating Plant

Stack Identification: Main Stack, Natural Gas



α: Distance upstream from next disturbance, in.	57'
β: Distance downstream from last disturbance, in.	46'
γ: Distance of Sample Level to Ground, feet	approx. 75'
Ø: Stack Inside Diameter, inches	136"
Estimated Moisture, percent	12.0%
Estimated Temperature, °F	325
Estimated Velocity, fpm	800
Number of Ports	4

Figure 1. Facility Schematic Representation

Appendix B

Calibration Data

METHOD 5 DRY GAS METER CALIBRATION USING CRITICAL ORIFICES

ES Quality - Service - Reliability

ENVIRONMENTAL SUPPLY COMPANY

1) Select three critical orifices to calibrate the dry gas meter which bracket the expected operating range.
2) Record barometric pressure before and after calibration procedure.
3) Run at tested vacuum (from Orifice Calibration Report), for a period of time necessary to achieve a minimum total volume of 5 cubic feet.
4) Record data and information in the GREEN cells, YELLOW cells are calculated.

Facility: **New Calibration 2011**

DATE: 12/15/2010

METER PART #: Console 3

METER SERIAL #: 1522588

CRITICAL ORIFICE SET SERIAL #: 1453S

BAROMETRIC PRESSURE (in Hg): INITIAL 25.30 | FINAL 25.30 | AVG (P_{bar}) 25.3

EQUIPMENT ID #: Console #3

IF Y VARIATION EXCEEDS 2.00%, ORIFICE SHOULD BE RECALIBRATED

ORIFICE #	RUN #	K' FACTOR (AVG)	TESTED VACUUM (in Hg)	DGM READINGS (FT^3) INITIAL	DGM READINGS (FT^3) FINAL	DGM READINGS (FT^3) NET (V_m)	TEMPERATURES °F AMBIENT	DGM INLET INITIAL	DGM INLET FINAL	DGM OUTLET INITIAL	DGM OUTLET FINAL	DGM AVG	ELAPSED TIME (MIN) θ	DGM ΔH (in H_2O)	(1) V_m (STD)	(2) V_{cr} (STD)	(3) Y	Y VARIATION (%)	$\Delta H_@$
30	1	0.8137	13	896.006	901.301	5.295	74	74	76	70	70	72.5	5.00	2.90	4.4778	4.4556	0.995		1.737
	2	0.8137	13	901.301	906.609	5.308	74	76	79	70	72	74.25	5.00	2.90	4.4741	4.4556	0.996		1.731
	3	0.8137	13	906.609	911.936	5.327	74	79	80	72	73	76.00	5.00	2.90	4.4754	4.4556	0.996		1.726
																AVG =	0.996	-0.89	
19	1	0.5317	13	912.40	917.596	5.196	74	79	80	75	82	79.00	7.50	1.20	4.3198	4.3672	1.011		1.655
	2	0.5317	13	917.596	922.809	5.213	74	80	82	74	77	78.25	7.50	1.20	4.340	4.3672	1.006		1.657
	3	0.5317	13	922.809	928.018	5.209	74	82	83	77	78	80.00	7.50	1.20	4.3226	4.3672	1.010		1.652
																AVG =	1.009	0.48	
12	1	0.3307	13	928.304	933.524	5.220	74	82	83	78	79	80.50	12.00	0.44	4.3182	4.3460	1.006		1.561
	2	0.3307	13	933.524	938.841	5.317	74	81	83	79	80	80.75	12.25	0.44	4.3964	4.4366	1.009		1.560
	3	0.3307	13	938.841	944.055	5.214	74	83	84	80	80	81.75	12.00	0.44	4.3032	4.3460	1.010		1.557
																AVG =	1.009	0.41	

USING THE CRITICAL ORIFICES AS CALIBRATION STANDARDS:
The following equations are used to calculate the standard volumes of air passed through the DGM, V_m (std), and the critical orifice, V_{cr} (std), and the DGM calibration factor, Y. These equations are automatically calculated in the spreadsheet above.

AVERAGE DRY GAS METER CALIBRATION FACTOR, Y = **1.004**

AVERAGE $\Delta H_@$ = **1.649**

(1) $$Vm_{(std)} = K_1 * Vm * \frac{Pbar + (\Delta H / 13.6)}{Tm}$$

= Net volume of gas sample passed through DGM, corrected to standard conditions
K_1 = 17.64 °R/in. Hg (English), 0.3858 °K/mm Hg (Metric)
T_m = Absolute DGM avg. temperature (°R - English, °K - Metric)

(2) $$Vcr_{(std)} = K' * \frac{Pbar * \Theta}{\sqrt{Tamb}}$$

= Volume of gas sample passed through the critical orifice, corrected to standard conditions
T_{amb} = Absolute ambient temperature (°R - English, °K - Metric)
K' = Average K' factor from Critical Orifice Calibration

(3) $$Y = \frac{Vcr_{(std)}}{Vm_{(std)}}$$

= DGM calibration factor

$$\Delta H_@ = \left(\frac{0.75\,\theta}{V_{cr}(std)}\right)^2 \Delta H \left(\frac{V_m(std)}{V_m}\right)$$

Temperature Sensors (4-28-08)

Reference °F	In °F	Out °F
34	34	35
67	67	67
202	202	204

METHOD 5 DRY GAS METER CALIBRATION USING CRITICAL ORIFICES

Quality - Service - Reliability

1) Select three critical orifices to calibrate the dry gas meter which bracket the expected operating range.
2) Record barometric pressure before and after calibration procedure.
3) Run at tested vacuum (from Orifice Calibration Report), for a period of time necessary to achieve a minimum total volume of 5 cubic feet.
4) Record data and information in the GREEN cells, YELLOW cells are calculated.

2011 Pre-Calibration

DATE: 12/15/2010
METER PART #: Console 4
METER SERIAL #: 27863
CRITICAL ORIFICE SET SERIAL #: 1453S
EQUIPMENT ID #: Console #4

	INITIAL	FINAL	AVG (P_{bar})
BAROMETRIC PRESSURE (in Hg):	25.25	25.25	25.25

IF Y VARIATION EXCEEDS 2.00%, ORIFICE SHOULD BE RECALIBRATED

ORIFICE #	RUN #	K' FACTOR (AVG)	TESTED VACUUM (in Hg)	DGM READINGS (FT^3) INITIAL	DGM READINGS (FT^3) FINAL	DGM READINGS (FT^3) NET (V_m)	TEMPERATURES °F AMBIENT	DGM INLET INITIAL	DGM INLET FINAL	DGM OUTLET INITIAL	DGM OUTLET FINAL	DGM AVG	ELAPSED TIME (MIN) θ	DGM ΔH (in H_2O)	(1) V_m (STD)	(2) V_{cr} (STD)	(3) Y	Y VARIATION (%)	$\Delta H_@$
30	1	0.8137	13	949.501	954.735	5.234	72	68	73	66	68	68.75	5.00	2.60	4.4450	4.4552	1.002		1.564
	2	0.8137	13	954.735	960.015	5.280	72	73	76	68	70	71.75	5.00	2.60	4.4588	4.4552	0.999		1.556
	3	0.8137	13	960.015	965.317	5.302	72	76	80	70	70	74.00	5.00	2.60	4.4585	4.4552	0.999		1.549
																AVG =	1.000	-0.32	
19	1	0.5317	13	966.902	972.124	5.222	72	82	86	72	76	79.00	7.50	1.12	4.3318	4.3668	1.008		1.542
	2	0.5317	13	972.124	977.544	5.420	72	86	88	76	80	82.50	7.75	1.12	4.4671	4.5123	1.010		1.532
	3	0.5317	13	977.544	982.827	5.283	72	88	90	80	83	85.25	7.50	1.12	4.3322	4.3668	1.008		1.524
																AVG =	1.009	0.52	
12	1	0.3307	13	983.4500	988.857	5.407	72	88	89	83	87	86.75	12.25	0.42	4.4127	4.4361	1.005		1.470
	2	0.3307	13	988.857	994.191	5.334	72	89	92	87	89	89.25	12.00	0.42	4.3333	4.3456	1.003		1.464
	3	0.3307	13	994.191	999.697	5.506	72	92	93	90	92	91.75	12.25	0.42	4.4528	4.4361	0.996		1.457
																AVG =	1.001	-0.20	

USING THE CRITICAL ORIFICES AS CALIBRATION STANDARDS:
The following equations are used to calculate the standard volumes of air passed through the DGM, V_m (std), and the critical orifice, V_{cr} (std), and the DGM calibration factor, Y. These equations are automatically calculated in the spreadsheet above.

AVERAGE DRY GAS METER CALIBRATION FACTOR, Y = **1.003**

AVERAGE $\Delta H_@$ = **1.517**

(1) $$Vm_{(std)} = K_1 * Vm * \frac{Pbar + (\Delta H / 13.6)}{Tm}$$

= Net volume of gas sample passed through DGM, corrected to standard conditions
K_1 = 17.64 °R/in. Hg (English), 0.3858 °K/mm Hg (Metric)
T_m = Absolute DGM avg. temperature (°R - English, °K - Metric)

(2) $$Vcr_{(std)} = K' * \frac{Pbar * \Theta}{\sqrt{Tamb}}$$

= Volume of gas sample passed through the critical orifice, corrected to standard conditions
T_{amb} = Absolute ambient temperature (°R - English, °K - Metric)
K' = Average K' factor from Critical Orifice Calibration

(3) $$Y = \frac{Vcr_{(std)}}{Vm_{(std)}}$$

= DGM calibration factor

$$\Delta H_@ = \left(\frac{0.75\,\theta}{V_{cr}(std)}\right)^2 \Delta H \left(\frac{V_m(std)}{V_m}\right)$$

Temperature Sensors

Reference °F	In °F	Out °F
33	34	34
67	67	67
201	203	202

METHOD 5 DRY GAS METER CALIBRATION USING CRITICAL ORIFICES

Quality - Service - Reliability

1) Select three critical orifices to calibrate the dry gas meter which bracket the expected operating range.
2) Record barometric pressure before and after calibration procedure.
3) Run at tested vacuum (from Orifice Calibration Report), for a period of time necessary to achieve a minimum total volume of 5 cubic feet.
4) Record data and information in the GREEN cells, YELLOW cells are calculated.

2011 Pre-Calibration

DATE: 12/20/2010
METER PART #: Console 5
METER SERIAL #: 68092
CRITICAL ORIFICE SET SERIAL #: 1453S
BAROMETRIC PRESSURE (in Hg): INITIAL 25.10 | FINAL 25.10 | AVG (P_{bar}) 25.10
EQUIPMENT ID #: Console #5

IF Y VARIATION EXCEEDS 2.00%, ORIFICE SHOULD BE RECALIBRATED

ORIFICE #	RUN #	K' FACTOR (AVG)	TESTED VACUUM (in Hg)	DGM READINGS (FT^3) INITIAL	DGM READINGS (FT^3) FINAL	DGM READINGS (FT^3) NET (V_m)	TEMPERATURES °F AMBIENT	DGM INLET INITIAL	DGM INLET FINAL	DGM OUTLET INITIAL	DGM OUTLET FINAL	DGM AVG	ELAPSED TIME (MIN) θ	DGM ΔH (in H_2O)	(1) V_m (STD)	(2) V_{cr} (STD)	(3) Y	Y VARIATION (%)	$\Delta H_@$
30	1	0.8137	12	155.004	161.521	6.517	74	82	83	89	93	86.75	6.00	2.55	5.320	5.3045	0.997		1.498
	2	0.8137	12	161.521	168.043	6.522	74	83	83	93	96	88.75	6.00	2.55	5.3046	5.3045	1.000		1.493
	3	0.8137	12	168.043	174.568	6.525	74	83	83	96	99	90.25	6.00	2.55	5.2926	5.3045	1.002		1.489
																AVG =	1.000	-0.09	
19	1	0.5317	13	136.700	142.672	5.972	74	81	80	84	86	82.75	8.50	1.11	4.8905	4.9104	1.004		1.532
	2	0.5317	13	142.672	148.297	5.625	74	80	81	86	88	83.75	8.00	1.11	4.5978	4.6215	1.005		1.529
	3	0.5317	13	148.297	153.926	5.629	74	81	82	88	89	85.00	8.00	1.11	4.5905	4.6215	1.007		1.526
																AVG =	1.005	0.47	
12	1	0.3307	13	116.20	125.809	9.609	74	76	78	77	80	77.75	22.00	0.40	7.9255	7.9047	0.997		1.437
	2	0.3307	13	125.809	131.075	5.266	74	78	80	80	81	79.75	12.00	0.40	4.3273	4.3117	0.996		1.432
	3	0.3307	13	131.075	136.357	5.282	74	80	81	81	84	81.50	12.00	0.40	4.3264	4.3117	0.997		1.428
																AVG =	0.997	-0.38	

USING THE CRITICAL ORIFICES AS CALIBRATION STANDARDS:
The following equations are used to calculate the standard volumes of air passed through the DGM, V_m (std), and the critical orifice, V_{cr} (std), and the DGM calibration factor, Y. These equations are automatically calculated in the spreadsheet above.

AVERAGE DRY GAS METER CALIBRATION FACTOR, Y = **1.001**

AVERAGE $\Delta H_@$ = **1.485**

(1) $$Vm_{(std)} = K_1 * Vm * \frac{Pbar + (\Delta H / 13.6)}{Tm}$$

= Net volume of gas sample passed through DGM, corrected to standard conditions
K_1 = 17.64 °R/in. Hg (English), 0.3858 °K/mm Hg (Metric)
T_m = Absolute DGM avg. temperature (°R - English, °K - Metric)

(2) $$Vcr_{(std)} = K' * \frac{Pbar * \Theta}{\sqrt{Tamb}}$$

= Volume of gas sample passed through the critical orifice, corrected to standard conditions
T_{amb} = Absolute ambient temperature (°R - English, °K - Metric)
K' = Average K' factor from Critical Orifice Calibration

(3) $$Y = \frac{Vcr_{(std)}}{Vm_{(std)}}$$

= DGM calibration factor

$$\Delta H_@ = \left(\frac{0.75\,\theta}{V_{cr}(std)}\right)^2 \Delta H \left(\frac{V_m(std)}{V_m}\right)$$

Temperature Sensors

Reference °F	In °F	Out °F
32	32	32
72	73	73
203	201	202

[redacted]METE[redacted]5 DR[redacted]AS M[redacted]R CALIBRATION USING CRITICAL ORIFICES

Quality - Service - Reliability

1) Select three critical orifices to calibrate the dry gas meter which bracket the expected operating range.
2) Record barometric pressure before and after calibration procedure.
3) Run at tested vacuum (from Orifice Calibration Report), for a period of time necessary to achieve a minimum total volume of 5 cubic feet.
4) Record data and information in the GREEN cells, YELLOW cells are calculated.

2011 Pre-Calibration

DATE: 12/14/2010 | METER SERIAL #: 26144 | BAROMETRIC PRESSURE (in Hg): INITIAL 25.20, FINAL 25.20, AVG (P_{bar}) 25.20

METER PART #: Console 6 | CRITICAL ORIFICE SET SERIAL #: 1453S | EQUIPMENT ID #: **Console #6**

IF Y VARIATION EXCEEDS 2.00%, ORIFICE SHOULD BE RECALIBRATED

ORIFICE #	RUN #	K' FACTOR (AVG)	TESTED VACUUM (in Hg)	DGM READINGS (FT^3) INITIAL	DGM READINGS (FT^3) FINAL	DGM READINGS (FT^3) NET (V_m)	TEMPERATURES °F AMBIENT	DGM INLET INITIAL	DGM INLET FINAL	DGM OUTLET INITIAL	DGM OUTLET FINAL	DGM AVG	ELAPSED TIME (MIN) θ	DGM ΔH (in H_2O)	(1) V_m (STD)	(2) V_{cr} (STD)	(3) Y	Y VARIATION (%)	$\Delta H_@$
30	1	0.8137	13	443.725	449.104	5.379	71	73	79	73	73	74.5	5.00	3.00	4.5153	4.4506	0.986		1.788
	2	0.8137	13	449.104	454.492	5.388	71	79	82	73	73	76.75	5.00	3.00	4.5039	4.4506	0.988		1.780
	3	0.8137	13	454.492	459.885	5.393	71	82	85	73	74	78.5	5.00	3.00	4.4934	4.4506	0.990		1.775
																AVG =	0.988	-0.51	
19	1	0.5317	12	460.802	466.60	5.798	72	78	80	75	75	77.00	8.25	1.20	4.8192	4.7939	0.995		1.662
	2	0.5317	12	466.60	471.872	5.272	72	80	81	75	75	77.75	7.50	1.20	4.3759	4.3581	0.996		1.659
	3	0.5317	12	471.872	477.157	5.285	72	81	81	75	76	78.25	7.50	1.20	4.3826	4.3581	0.994		1.658
																AVG =	0.995	0.19	
12	1	0.3307	12	477.70	482.955	5.255	72	78	79	76	77	77.50	12.00	0.43	4.3540	4.3370	0.996		1.534
	2	0.3307	12	482.955	488.227	5.272	72	79	82	77	78	79.00	12.00	0.43	4.3559	4.3370	0.996		1.530
	3	0.3307	12	488.227	493.613	5.386	72	82	82	78	80	80.50	12.25	0.43	4.4378	4.4273	0.998		1.526
																AVG =	0.996	0.33	

USING THE CRITICAL ORIFICES AS CALIBRATION STANDARDS:
The following equations are used to calculate the standard volumes of air passed through the DGM, V_m (std), and the critical orifice, V_{cr} (std), and the DGM calibration factor, Y. These equations are automatically calculated in the spreadsheet above.

AVERAGE DRY GAS METER CALIBRATION FACTOR, Y = 0.993

AVERAGE $\Delta H_@$ = 1.657

(1) $$Vm_{(std)} = K_1 * Vm * \frac{Pbar + (\Delta H / 13.6)}{Tm}$$

= Net volume of gas sample passed through DGM, corrected to standard conditions
K_1 = 17.64 °R/in. Hg (English), 0.3858 °K/mm Hg (Metric)
T_m = Absolute DGM avg. temperature (°R - English, °K - Metric)

(2) $$Vcr_{(std)} = K' * \frac{Pbar * \Theta}{\sqrt{Tamb}}$$

= Volume of gas sample passed through the critical orifice, corrected to standard conditions
T_{amb} = Absolute ambient temperature (°R - English, °K - Metric)
K' = Average K' factor from Critical Orifice Calibration

(3) $$Y = \frac{Vcr_{(std)}}{Vm_{(std)}}$$

= DGM calibration factor

$$\Delta H_@ = \left(\frac{0.75\,\theta}{V_{cr}(std)}\right)^2 \Delta H \left(\frac{V_m(std)}{V_m}\right)$$

Temperature Sensors

Reference °F	In °F	Out °F
33	33	34
68	67	67
202	202	202

1) Select three critical orifices to calibrate the dry gas meter which bracket the expected operating range.
2) Record barometric pressure before and after calibration procedure.
3) Run at tested vacuum (from Orifice Calibration Report), for a period of time necessary to achieve a minimum total volume of 5 cubic feet.
4) Record data and information in the GREEN cells, YELLOW cells are calculated.

2010 Pre-Calibration Console 7

DATE: 12/16/2010
METER PART #: Console 7
METER SERIAL #: 68092
CRITICAL ORIFICE SET SERIAL #: 1453S
BAROMETRIC PRESSURE (in Hg): INITIAL 25.45 | FINAL 25.45 | AVG (P_{bar}) 25.45
EQUIPMENT ID #: Console #7

IF Y VARIATION EXCEEDS 2.00%, ORIFICE SHOULD BE RECALIBRATED

ORIFICE #	RUN #	K' FACTOR (AVG)	TESTED VACUUM (in Hg)	DGM READINGS (FT^3) INITIAL	DGM READINGS (FT^3) FINAL	NET (V_m)	TEMPERATURES °F AMBIENT	DGM INLET INITIAL	DGM INLET FINAL	DGM OUTLET INITIAL	DGM OUTLET FINAL	DGM AVG	ELAPSED TIME (MIN) θ	DGM ΔH (in H_2O)	(1) V_m (STD)	(2) V_{cr} (STD)	(3) Y	Y VARIATION (%)	$\Delta H_@$
30	1	0.8137	12	3.7040	12.435	8.731	75	88	89	89	89	88.75	8.00	3.10	7.2110	7.1646	0.994		1.796
	2	0.8137	12	12.435	19.003	6.568	75	89	89	89	91	89.5	6.00	3.10	5.4171	5.3734	0.992		1.793
	3	0.8137	12	19.003	24.463	5.460	75	89	89	92	93	90.75	5.00	3.10	4.4931	4.4779	0.997		1.789
																AVG =	0.994	-0.38	
19	1	0.5317	12	968.901	974.579	5.678	75	80	81	84	86	82.75	8.00	1.15	4.7149	4.6816	0.993		1.569
	2	0.5317	12	974.579	980.960	6.381	75	81	82	86	88	84.25	9.00	1.15	5.2840	5.2668	0.997		1.564
	3	0.5317	12	980.960	986.636	5.676	75	82	83	88	89	85.50	8.00	1.15	4.6894	4.6816	0.998		1.561
																AVG =	0.996	-0.18	
12	1	0.3307	12	986.900	992.147	5.247	75	82	83	85	86	84.00	12.00	0.47	4.3385	4.3677	1.007		1.650
	2	0.3307	12	992.147	997.419	5.272	75	83	84	86	86	84.75	12.00	0.47	4.3531	4.3677	1.003		1.648
	3	0.3307	12	997.419	1,002.711	5.292	75	84	84	86	86	85.00	12.00	0.47	4.3676	4.3677	1.000		1.647
																AVG =	1.003	0.56	

USING THE CRITICAL ORIFICES AS CALIBRATION STANDARDS:
The following equations are used to calculate the standard volumes of air passed through the DGM, V_m (std), and the critical orifice, V_{cr} (std), and the DGM calibration factor, Y. These equations are automatically calculated in the spreadsheet above.

AVERAGE DRY GAS METER CALIBRATION FACTOR, Y = **0.998**

AVERAGE $\Delta H_@$ = **1.668**

(1) $$Vm_{(std)} = K_1 * Vm * \frac{Pbar + (\Delta H / 13.6)}{Tm}$$

= Net volume of gas sample passed through DGM, corrected to standard conditions
K_1 = 17.64 °R/in. Hg (English), 0.3858 °K/mm Hg (Metric)
T_m = Absolute DGM avg. temperature (°R - English, °K - Metric)

(2) $$Vcr_{(std)} = K' * \frac{Pbar * \Theta}{\sqrt{Tamb}}$$

= Volume of gas sample passed through the critical orifice, corrected to standard conditions
T_{amb} = Absolute ambient temperature (°R - English, °K - Metric)
K' = Average K' factor from Critical Orifice Calibration

(3) $$Y = \frac{Vcr_{(std)}}{Vm_{(std)}}$$

= DGM calibration factor

$$\Delta H_@ = \left(\frac{0.75\,\theta}{V_{cr}(std)}\right)^2 \Delta H \left(\frac{V_m(std)}{V_m}\right)$$

Temperature Sensors

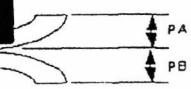
Reference °F	In °F	Out °F
32	33	33
72	73	73
120	120	121

Type S Pitot Tube Inspection Data

-20-10

Pitot Tube Identification: 69

Technician: K McNamara



Dt= .250 in.

Is $P_A = P_B$? Yes

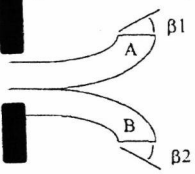
Is $1.05 \cdot D_t \le D_t \le 1.50 \cdot D_t$? Yes

P_A = .321 in.

P_B = .321 in.

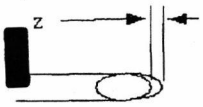
$\alpha_1 < 10°$ α_1 = 1 °

$\alpha_2 < 10°$ α_2 = 1 °

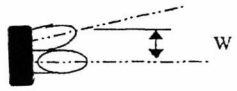


$\beta_1 < 5°$ β_1 = 1 °

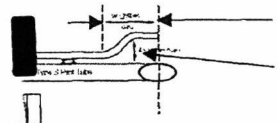
$\beta_2 < 5°$ β_2 = 1 °



$Z \le 0.125$ in. Z = .001 in.

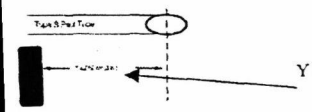


$W \le 0.03125$ in. W = .022 in.



W > 3 inches W = 3 in.

Z > 3/4 inch Z = 1 in.



$Y \ge 3$ inches Y = 4 1/4 in.

pitot tube meets the specifications for a calibration factor of 0.84? Yes

Temperature Sensor Calibration

Reference

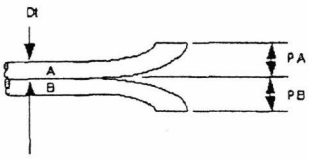
	Temperature Source (Medium)	Temperature Reference (°F)	Temperature Sensor (°F)	Temperature Difference (°F)
Probe	AIR	68	68	0
	Continuity	—	—	Yes
	Heat Check 248	—	Yes	1.50
Stack	AIR	68	66	0
	ICE WATER	32	32	0
	BOIL WATER	204	205	1
	SILICONE OIL			

Type S Pitot Tube Inspection Data

Date: 12-20-10

Pitot Tube Identification: 65 A

Technician: K. McNamara



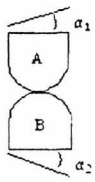
Dt= .250 in.

Is $P_A = P_B$? Yes

Is $1.05 \cdot D_t \le D_t \le 1.50 \cdot D_t$? Yes

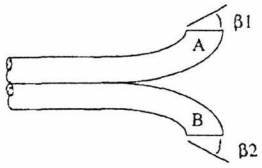
P_A = .368 in.

P_B = .368 in.



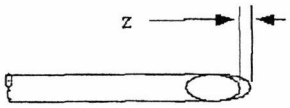
$\alpha_1 < 10°$ α_1 = 1 °

$\alpha_2 < 10°$ α_2 = 1 °

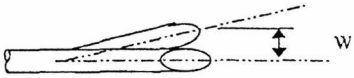


$\beta_1 < 5°$ β_1 = 0 °

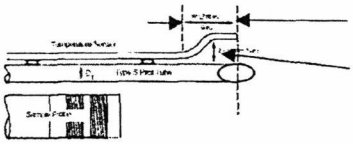
$\beta_2 < 5°$ β_2 = 0 °



Z ≤ 0.125 in. Z = .003 in.

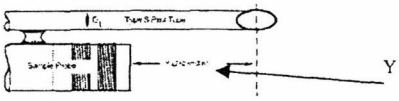


W ≤ 0.03125 in. W = .013 in.



W > 3 inches W = 6 in.

Z > 3/4 inch Z = 1 in.



Y ≥ 3 inches Y = 4 in.

The pitot tube meets the specifications for a calibration factor of 0.84? Yes

Temperature Sensor Calibration

Reference: _____

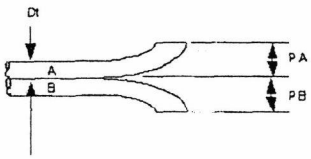
	Temperature Source (Medium)	Temperature Reference (°F)	Temperature Sensor (°F)	Temperature Difference (°F)
Probe	AIR	68	68	0
	Continuity	—	—	Yes
	Heat Check 248	—	Yes	250
Stack	AIR	66	66	0
	ICE WATER	32	32	0
	BOIL WATER	205	204	1
	SILICONE OIL			

Type S Pitot Tube Inspection Data

Date: 12-20-10

Pitot Tube Identification: 60-G-2

Technician: K McNamara



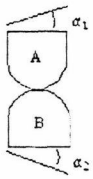
Dt= .375 in.

Is $P_A = P_B$? yes

Is $1.05 \cdot D_t \le D_t \le 1.50 \cdot D_t$? yes

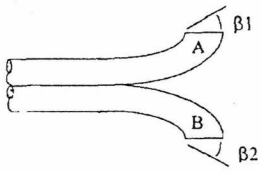
P_A = .478 in.

P_B = .472 in.



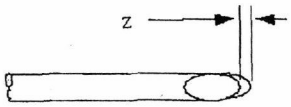
$\alpha_1 < 10°$ α_1 = 0 °

$\alpha_2 < 10°$ α_2 = 2 °

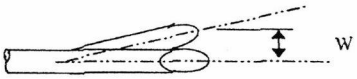


$\beta_1 < 5°$ β_1 = 2 °

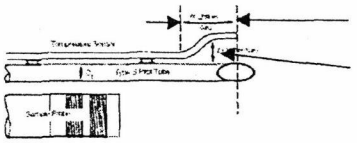
$\beta_2 < 5°$ β_2 = 2 °



$Z \le 0.125$ in. Z = .066 in.

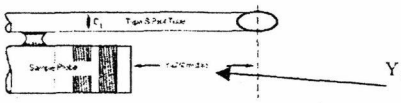


$W \le 0.03125$ in. W = .008 in.



W > 3 inches W = 4 4/8 in.

Z > 3/4 inch Z = ___ in.



$Y \ge 3$ inches Y = 3 9/16 in.

The pitot tube meets the specifications for a calibration factor of 0.84? Yes

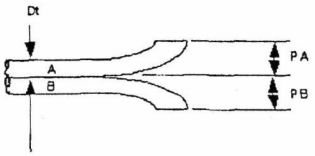
Temperature Sensor Calibration				
Reference:				
	Temperature Source (Medium)	Temperature Reference (°F)	Temperature Sensor (°F)	Temperature Difference (°F)
Probe	AIR	67	67	0
	Continuity	→	→	yes
	Heat Check 248	→	Yes	250
Stack	AIR	67	67	0
	ICE WATER	32	32	0
	BOIL WATER	204	204	0
	SILICONE OIL			

Type S Pitot Tube Inspection Data

Date: 12-20-10

Pitot Tube Identification: 60-G-1

Technician: K. McNamara



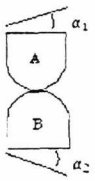
Dt= .375 in.

Is $P_A = P_B$? Yes

Is $1.05 \cdot D_t \le D_t \le 1.50 \cdot D_t$? Yes

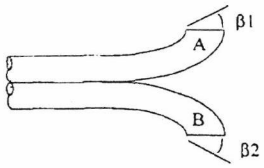
P_A = .454 in.

P_B = .454 in.



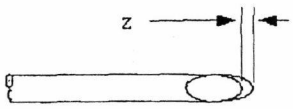
$\alpha_1 < 10°$ α_1 = 2 °

$\alpha_2 < 10°$ α_2 = 1 °

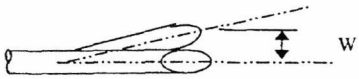


$\beta_1 < 5°$ β_1 = 1 °

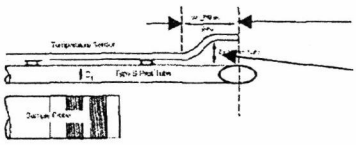
$\beta_2 < 5°$ β_2 = 2 °



Z ≤ 0.125 in. Z = .033 in.

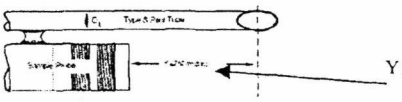


W ≤ 0.03125 in. W = .030 in.



W > 3 inches W = 4 in.

Z > 3/4 inch Z = 1 1/4 in.



Y ≥ 3 inches Y = 3 1/16 in.

The pitot tube meets the specifications for a calibration factor of 0.84? Yes

Temperature Sensor Calibration

Reference

	Temperature Source (Medium)	Temperature Reference (°F)	Temperature Sensor (°F)	Temperature Difference (°F)
Probe	AIR	68	68	0
	Continuity			Yes
	Heat Check 248		Yes	250
Stack	AIR	68	68	0
	ICE WATER	32	32	0
	BOIL WATER	204	204	0
	SILICONE OIL			

TETCO

Sample Box Temperature Sensor Calibration

Date: 12/29/10 Calibrator: Mike McNamara Reference: Omega CL3512A

Unit ID	Thermocouple Location	Temperature Source (Medium)	Temperature Reference (°F)	Temperature Sensor (°F)	Temp. Diff. or Result (°F), P/F
A	Oven	Water	34	34	0
		Water	203	203	0
	Probe Out	Water	34	33	1
		Water	203	204	-1
	Impinger Out	Water	34	36	-2
		Water	203	203	0
B	Oven	Water	32	34	-2
		Water	203	204	-1
	Probe Out	Water	32	33	-1
		Water	202	204	-2
	Impinger Out	Water	31	31	0
		Water	203	205	-2
C	Oven	Water	34	36	-2
		Water	204	205	-1
	Probe Out	Water	34	36	-2
		Water	203	205	-2
	Impinger Out	Water	34	36	-2
		Water	203	201	2
D	Oven	Water	33	33	0
		Water	203	203	0
	Probe Out	Water	33	33	0
		Water	202	203	-1
	Impinger Out	Water	33	33	0
		Water	203	201	2
E	Oven	Water	33	34	-1
		Water	203	203	0
	Probe Out	Water	33	34	-1
		Water	203	204	-1
	Impinger Out	Water	33	33	0
		Water	203	204	-1
F	Oven	Water	33	33	0
		Water	203	202	1
	Probe Out	Water	33	33	0
		Water	203	201	2
	Impinger Out	Water	33	34	-1
		Water	203	201	2
	Impinger Out G	Water	33	34	-1
		Water	203	202	1
	Impinger Out H	Water	33	35	-2
		Water	203	202	1
	Impinger Out I	Water	33	33	0
		Water	203	204	-1
	Impinger Out J	Water	33	33	0
		Water	203	204	-1

Since **Heusser Neweigh** 1906

Certificate of Balance Calibration

Company Name: Tetco
Address: 391 East 620 South
City/State/Zip: American Fork, Utah 84003

Next Calibration Due: **December, 2011**
Reference Weights Cal ID.: 74

Certificate No.: 2105
Calibration Date: 2010, December 13
Metrologist: Rebecca
Order Number: None

Manufacturer:	Model	Serial Number	Identification No.	Location	Nominal Mass	Indication
Ohaus	EP214	1122121229	None	Lab	1	1.0000
					200	199.9999

Comments:

Pertinent Information:
The artifact described herein has been calibrated using standards traceable to NIST. This is to certify the data reported herein is true and correct as of the date calibrated. The procedure used to calibrate the artifact meets the requirements and guidelines of the Heusser Neweigh Quality Assurance Program (Revision 2006-1) and the purchase requisition referenced herein, if any.

Authorized Signature: Rebecca Lewis

© Heusser Neweigh

Heusser Neweigh, LLC 832 Elgin Ave, Salt Lake City, UT 84106 801.486.0995 Fax 801.486.0995
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Rev. 061210

LIQUID TECHNOLOGY CORPORATION

"INDUSTRY LEADER IN SPECIALTY GASES"

Certificate of Analysis

- EPA PROTOCOL GAS -

Customer	TETCO (American Fork, UT)
Date	August 06, 2010
Delivery Receipt	DR-30291
Gas Standard	230 ppm NO, 230 ppm Carbon Monoxide/Nitrogen
Final Analysis Date	August 06, 2010
Expiration Date	August 06, 2012

DO NOT USE BELOW 150 psig

Analytical Data:

EPA Protocol, Section No. 2.2, Procedure G-1.

Reported Concentrations:

Nitric Oxide: 224 ppm +/- 2.2 ppm

Carbon Monoxide: 238 ppm +/- 2.3 ppm

Nitrogen: Balance

Total NOx: 224 ppm

** Total NOx for Reference Use Only **

Reference Standards

SRM/GMIS	GMIS/GMIS	GMIS/GMIS
Cylinder Number:	EB-0021691/CC-231368	CC-231409/CC-251549
Concentration:	167.13 ppm NO/253.03 ppm NO	102.53 ppm CO/267.38 ppm CO
Expiration Date:	05/03/12 - 07/16/12	07/14/11 - 11/01/11

Certification Instrumentation

Component:	Nitric Oxide	Carbon Monoxide
Make/Model:	Horiba - CLA 510	Nicolet-NEXUS 470
Serial Number:	43331870031	AEP99000154
Principal of Measurement:	Chemiluminescence	FTIR
Last Calibration:	July 19, 2010	July 07, 2010

Cylinder Data

Cylinder Number:	EB-0024550	Cylinder Volume:	140 Cubic Feet
Cylinder Outlet:	CGA 660	Cylinder Pressure:	2000 psig, 70°F
Expiration Date:	August 06, 2012		

Analytical Uncertainty and NIST Traceability are in compliance with EPA-600/R-97/121.

Certified by:

Adam Strickland

"UNMATCHED EXCELLENCE"

2564 PEMBERTON DRIVE APOPKA, FLORIDA 32703 ~ PHONE (407)-292-2990 FAX (407)-292-3313
WWW.LIQUIDTECHCORP.COM

Tetco # 35857580 12-31-09

AIR LIQUIDE Air Liquide America Specialty Gases LLC SCOTT™

RATA CLASS

Dual-Analyzed Calibration Standard

500 WEAVER PARK RD, LONGMONT, CO 80501 Phone: 888-253-1635 Fax: 303-772-7673

CERTIFICATE OF ACCURACY: Interference Free™ Multi-Component EPA Protocol Gas

Assay Laboratory

AIR LIQUIDE AMERICA SPECIALTY GASES LLC
500 WEAVER PARK RD
LONGMONT, CO 80501

P.O. No.: CODE & GO
Project No.: 08-83014-001

Customer

AIR LIQUIDE

TIM DALL
1676 SOUTH 700 WEST
SALT LAKE CITY UT 84104

ANALYTICAL INFORMATION

This certification was performed according to EPA Traceability Protocol For Assay & Certification of Gaseous Calibration Standards; Procedure G-1; September, 1997.

Cylinder Number: CC160789 **Certification Date:** 18Dec2009 **Exp. Date:** 18Dec2011
Cylinder Pressure*:** 1790 PSIG

COMPONENT	CERTIFIED CONCENTRATION (Moles)		ACCURACY**	TRACEABILITY
CARBON MONOXIDE	125	PPM	+/- 1%	Direct NIST and VSL
NITRIC OXIDE	125	PPM	+/- 1%	Direct NIST and VSL
NITROGEN - OXYGEN FREE		BALANCE		
TOTAL OXIDES OF NITROGEN	126.	PPM		Reference Value Only

*** Do not use when cylinder pressure is below 150 psig.
** Analytical accuracy is based on the requirements of EPA Protocol Procedure G1, September 1997.

REFERENCE STANDARD

TYPE/SRM NO.	EXPIRATION DATE	CYLINDER NUMBER	CONCENTRATION	COMPONENT
NTRM 1679	02Oct2010	KAL003131	101.0 PPM	CARBON MONOXIDE
NTRM 1684	15Oct2012	KAL004441	95.84 PPM	NITRIC OXIDE

INSTRUMENTATION

INSTRUMENT/MODEL/SERIAL#	DATE LAST CALIBRATED	ANALYTICAL PRINCIPLE
FTIR//1602651	10Dec2009	FTIR
FTIR//1602651	18Dec2009	FTIR

ANALYZER READINGS

(Z = Zero Gas R = Reference Gas T = Test Gas r = Correlation Coefficient)

CARBON MONOXIDE

First Triad Analysis

Date: 11Dec2009 Response Unit:PPM
Z1 = -0.00431 R1 = 100.7202 T1 = 124.3617
R2 = 100.8627 Z2 = 0.00425 T2 = 124.3715
Z3 = 0.03896 T3 = 124.6940 R3 = 100.9075
Avg. Concentration: 124.7 PPM

Second Triad Analysis

Date: 18Dec2009 Response Unit: PPM
Z1 = 0.02878 R1 = 100.4126 T1 = 123.9028
R2 = 100.4969 Z2 = 0.08344 T2 = 124.0817
Z3 = 0.15508 T3 = 124.3246 R3 = 100.6124
Avg. Concentration: 124.7 PPM

Calibration Curve

Concentration = A + Bx + Cx2 + Dx3 + Ex4
r = 1.00000E+0
Constants: A = 0.00000E+0
B = 8.29063E-1 C = 2.03000E-4
D = 0.00000E+0 E = 0.00000E+0

NITRIC OXIDE

First Triad Analysis

Date: 11Dec2009 Response Unit:PPM
Z1 = 0.01140 R1 = 96.18092 T1 = 125.1052
R2 = 96.20254 Z2 = 0.06020 T2 = 125.4558
Z3 = 0.19435 T3 = 125.5703 R3 = 96.46936
Avg. Concentration: 124.8 PPM

Second Triad Analysis

Date: 18Dec2009 Response Unit: PPM
Z1 = -0.17718 R1 = 95.16692 T1 = 123.8376
R2 = 95.77498 Z2 = -0.03225 T2 = 124.6951
Z3 = 0.03054 T3 = 124.7973 R3 = 96.23327
Avg. Concentration: 124.6 PPM

Calibration Curve

Concentration = A + Bx + Cx2 + Dx3 + Ex4
r = 9.99995E-1
Constants: A = 0.00000E+0
B = 9.51582E-1 C = 1.92000E-4
D = 0.00000E+0 E = 0.00000E+0

APPROVED BY: JW
Jon Witzak