



**Energy Fuels Resources Corporation
Piñon Ridge Mill**

**Quality Assurance Audit Report for
Meteorological and Ambient Air Monitoring Network**

2nd Quarter 2009

Prepared by:



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1 Introduction

Inter-Mountain Laboratories – Air Science Division performed quality assurance audits on April 22, 2009. The audits included all (5) of the ambient air monitoring systems and the (2) meteorological monitoring systems at the Piñon Ridge Mill Site located approximately 15 miles from Naturita, Colorado. The Piñon Ridge Mill Site is operated by Energy Fuels Resources Corporation. This is a list of the monitoring sites and the associated equipment:

Site 1

- Meteorological Station – 10m Tower
 - Wind Speed
 - Wind Direction
 - Vertical Wind Speed
 - Temperature (2m & 10m)
 - Delta Temperature
 - Relative Humidity
 - Solar Radiation
 - Barometric Pressure
 - Precipitation
 - Evaporation
- PM₁₀ Sampler – Thermo FRM 2000 PM₁₀
- TSP Sampler – Tisch Hi-Vol 5170

Site 2

- Meteorological Station – 30m Tower
 - Wind Speed
 - Wind Direction
 - Vertical Wind Speed
 - Temperature (2m & 30m)
 - Delta Temperature
 - Relative Humidity
 - Solar Radiation
 - Barometric Pressure
- PM₁₀ Sampler – Thermo FRM 2000 PM₁₀
- TSP Sampler – Tisch Hi-Vol 5170

Site 3

- TSP Sampler – Tisch Hi-Vol 5170

Site 4

- TSP Sampler – Tisch Hi-Vol 5170

Site 5

- TSP Sampler – Tisch Hi-Vol 5170

1.1 Audit References

The audits were conducted in accordance with the following guideline documents:

- Ambient Monitoring Guidelines for the Prevention of Significant Deterioration (PSD), May 1987
- Environmental Protection Agency (EPA) Meteorological Monitoring Guidance for Regulatory Modeling Applications, February 2000 (MMGRMA) (EPA-454/R-99-005)
- Quality Assurance Handbook for Air Pollution Measurements Systems, Vol. I – A Field Guide to Environmental Quality Assurance, April 1994
- Quality Assurance Handbook for Air Pollution Measurements Systems, Vol. II – Ambient Air Quality Monitoring Program, December 2008
- Quality Assurance Handbook for Air Pollution Measurements Systems, Vol. IV – Meteorological Measurements, September 1989
- Quality Assurance Handbook for Air Pollution Measurement Systems, Vol. V, Meteorological Measurements, EPA 1995
- Ambient Air Monitoring Requirements for the Air Pollution Control Division of the Colorado Department of Public Health and Environment, Technical Services Program Air Pollution Control Division, April 2001
- U.S. Nuclear Regulatory Commission Regulatory Guide, Office of Standards Development, Regulatory Guide 4.14 – Radiological Effluent and Environmental Monitoring at Uranium Mills, Revision 1, April 1980
- U.S. Nuclear Regulatory Commission Regulatory Guide, Office of Nuclear Regulatory Research, Regulatory Guide 3.63 – Onsite Meteorological Measurement Program For Uranium Recovery Facilities – Data Acquisition and Reporting, March 1988.

2 Audit Methodology and Accuracy Goals

2.1 Meteorological Stations

2.1.1 Wind Speed

The wind speed was verified by rotating the sensor shaft using a DC-powered variable-speed motor equipped with an optical encoder output referenced to a crystal oscillator. A standard sensor speed was calculated based on the audit rotational speed and compared to the instantaneous logger reading. An R.M. Young Torque Disc was used to ensure bearing integrity of the wind speed sensor. All data were recorded on a standardized audit form.

2.1.2 Wind Direction

The wind direction sensor orientation was verified by using a Brunton precision magnetic compass. Instantaneous direction readings from the logger were compared to the standards and recorded on a standardized form.

2.1.3 Temperature

Proper operation of the temperature sensors was verified by placing the sensors and a precision NIST-traceable electronic thermometer in three equilibrated temperature baths (ice bath, warm bath, and ambient bath). Both reference thermometer and logger readings were recorded on a standardized form.

2.1.4 Delta Temperature

Proper operation of the temperature sensors was verified by placing the sensors and a precision NIST-traceable electronic thermometer in three equilibrated temperature baths (ice bath, warm bath, and ambient bath). Both reference thermometer and logger readings were recorded on a standardized form.

2.1.5 Relative Humidity

The relative humidity was checked by co-locating a reference sensor next to the station sensor. The reading was taken and the difference between the audit standard and the on-site data logger were compared to acceptance criteria.

2.1.6 Solar Radiation

The solar radiation was checked by co-locating a reference sensor next to the station sensor. The readings of covered and uncovered were taken and the differences between the audit standard and the on-site data logger were compared to acceptance criteria.

2.1.7 Barometric Pressure

The barometric pressure was checked by co-locating a reference sensor next to the station sensor. The reading was taken and the difference between the audit standard and the on-site data logger were compared to acceptance criteria.

2.1.8 Precipitation

The precipitation gauge was challenged three times using a lab quality burette and water. The volume of water required to cause the tipping bucket to activate was measured and volumes were recorded along with the calculated value for activation on a standardized form.

2.1.9 Evaporation

The evaporation pan was audit by recording the values from a yardstick measuring the depth of the pan and comparing the reading of the logger. All data were recorded on a standardized audit form.

2.2 Ambient Air Monitoring

2.2.1 PM₁₀ FRM Partisol Samplers

The PM₁₀ FRM Partisol Sampler audits included a verification of the flow, barometric pressure, ambient temperature, and filter temperature. The flow audit was completed by removing the inlet of the sampler and installing a Flow Transfer Standard (FTS) with an associated digital manometer. The calculated flow of the FTS and the sampler flow were compared to the acceptance criteria.

Proper operation of the temperature sensors (ambient and filter) in the sampler were verified by comparing the sensors and a precision NIST-traceable electronic thermometer. Both reference thermometer and sampler readings were recorded on a standardized form.

The barometric pressure was checked by co-locating a reference sensor next to the sampler. The reading was taken and the difference between the audit standard and the sampler was compared to acceptance criteria.

2.2.2 TSP Hi-Volume Samplers

Audits of the Hi-Volume Samplers were completed by finding the numerical relationship between the sampler output (volumetric flow rate) and its flow indicator (stagnation pressure ratio). The stagnation pressure is an area of low pressure underneath the filter caused by the resistance to airflow through the filter. The stagnation pressure ratio is a mathematical relationship of stagnation and ambient pressures. To find the numerical relationship to the multiple point (multi-point) calibration was completed on the sampler. The audit flow and design flow are compared to the acceptable criteria. The following equipment was required for the audit:

- 1) National Institute of Standards and Technology (NIST) traceable variable resistance transfer standard (calibration orifice) with faceplate.
- 2) Portable thermometer, capable of accurately measuring temperature over the range of 0 to 50 °C to the nearest ±1 °C and referenced to a NIST or American Society for Testing and Materials (ASTM) thermometer within ±2 °C at least annually.
- 3) Portable barometer, capable of accurately measuring ambient barometric pressure over the range of 500 to 800 millimeters of mercury (mm Hg) to the nearest millimeter of mercury, and referenced within ±5 mm Hg to a barometer of known accuracy at least annually.
- 4) Digital manometers (0 – 20" and 0 – 40") with tubing.

2.3 Audit Thresholds

2.3.1 Meteorological Monitoring Systems

Audit goals for the parameters measured by the meteorological monitoring systems are those specified in the US EPA *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV, Meteorological Measurements*, March 1995. Accuracy goals by parameter are shown below.

Table 2-1 – Meteorological Sensor Criteria

Sensor	Specifications
Wind Speed	±0.5 m/s
Wind Speed – Starting Threshold	< 0.5 gm-cm
Wind Direction	± 5.0 compass degrees
Vertical Wind Speed	±.2 m/s ± 5.0 percent of observed
Temperature	±0.5 °C
Delta Temperature	±0.1 °C
Relative Humidity	±5.0 %
Solar Radiation	±5.0 percent of observed
Barometric Pressure	±0.09 in Hg
Precipitation	±10 percent of observed

2.3.2 Ambient Monitoring Systems

Audit goals for the parameters measured by the ambient monitoring systems are those specified in the US EPA *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Ambient Air Quality Monitoring Program*, December 2008. Accuracy goals by parameter are shown below.

Table 2-2 – PM₁₀ Sampler Criteria

Sensor	Specifications
Ambient Temperature	±2.0 °C
Filter Temperature	±2.0 °C
Pressure	± 10 mm Hg
Flow Rate	±4.0 percent of observed (±0.67 lpm)
External Leak Check	<8.5 in Hg / 30 seconds
Internal Leak Check	<8.5 in Hg / 30 seconds

Table 2-3 – TSP Sampler Criteria

Sensor	Specifications
Audit Flow Difference	±6.0 percent
Design Flow Difference	±7.0 percent

3 Audit Results

Audit results for Site #1 – 5 can be found in Appendices A, B, and C.

4 Findings/Recommendations

The audits of the Ambient Air Monitoring equipment were within the specifications during the 2nd Quarter of 2009. The audits of the Meteorological Monitoring equipment were within the audit specifications at Site #1 and Site #2, including the evaporation pan. The quality assurance audits on the equipment at the Site #1, #2, #3, #4, and #5 were all within specifications. Results of the audits can be found in Appendix A, B, and C.

Appendix A

PM₁₀ Sampler Audits



Partisol FRM Single Point Verification

Network: Energy Fuels
Date: 4/22/2009
Time: 0834 MST
Verified by: R. Campbell
Streamline FTS ID: D000201
Streamline FTS cal. expires: 1/8/2010
Streamline FTS "m": 0.4118
Streamline FTS "b": -0.6502
Temp Standard ID: IML 0888
Press Standard ID: IML 0968
Manometer ID: IML 0949
Notes as found: Ok

Sampler ID: 1-2

As-Found Calibration Values

Parameter	Offset	Span
A/I	-0.0030	0.9993
Amb. Temp.	0.0072	
Filter Temp.	0.0066	
Pressure	-0.0364	
Flow	-0.0058	0.9656

Sensors Verification

Sensor	Indicated	ΔP	Actual	Difference	Specification
Amb. Temp.	16.70		16.28	0.42	$\pm 2^{\circ}\text{C}$
Filter Temp.	18.10		17.56	0.54	$\pm 2^{\circ}\text{C}$
Pressure	624.0		626.6	2.6	$\pm 10 \text{ mmHg}$
Flow	16.70	4.97	16.55	0.15	16.7 lpm $\pm 4\%$ ($\pm 0.67 \text{ lpm}$)

External Leak Check: Pass
 (<8.5"Hg/30 sec.)

Internal Leak Check: Pass
 (<8.5"Hg/30 sec.)

Notes:



Partisol FRM Single Point Verification

Network: Energy Fuels
Date: 4/22/2009
Time: 1210 MST
Verified by: W. Adler
Streamline FTS ID: D000201
Streamline FTS cal. expires: 1/8/2010
Streamline FTS "m": 0.4118
Streamline FTS "b": -0.6502
Temp Standard ID: IML 0888
Press Standard ID: IML 0968
Manometer ID: IML 0949
Notes as found: Ok

Sampler ID: 2-2

As-Found Calibration Values

Parameter	Offset	Span
A/I	-0.0020	0.9996
Amb. Temp.	-0.0003	
Filter Temp.	-0.0032	
Pressure	-0.0075	
Flow	-0.0115	0.9898

Sensors Verification

Sensor	Indicated	ΔP	Actual	Difference	Specification
Amb. Temp.	23.1		23.6	0.5	$\pm 2^{\circ}\text{C}$
Filter Temp.	25.3		25.5	0.2	$\pm 2^{\circ}\text{C}$
Pressure	619		623	4	$\pm 10 \text{ mmHg}$
Flow	16.70	4.89	16.67	0.03	16.7 lpm $\pm 4\%$ ($\pm 0.67 \text{ lpm}$)

External Leak Check: Pass
 (<8.5"Hg/30 sec.)

Internal Leak Check: Pass
 (<8.5"Hg/30 sec.)

Notes:

Appendix B

TSP Sampler Audits

Sampler Flow Rate Audit

Network: Energy Fuels Resources

Sampler ID: 1-1

AIRS Site ID: N/A

Sampler Audit Date: 4/22/2009

Orifice ID: B

Ambient Temperature (°C): 15.7

Ambient Temperature (°K): 288.9

Sampler Type: Tisch TE-5170-DV-BL

Audited By: Will Adler

Sampler Calibration Date: 4/16/2009

Orifice Calibration Date: 3/3/2009

Ambient Pressure ("Hg): 24.67

Ambient Pressure (mmHg): 627

Orifice Calibration: $Q_a = \{\text{SQRT} [\Delta P * (T_a / P_a)] - b\} * \{1/m\}$
where $m = 1.268$ and $b = -0.024$

Sampler Calibration: $Q_a = \{[P_1/P_a - b]*[\text{SQRT}(T_a)]\} * \{1/m\}$
where $m = 11.4459$ and $b = 0.1270$

Accuracy Flow Audit

Orifice		Sampler	
ΔP ("H ₂ O)	Qa (m ³ /min)	ΔP ("H ₂ O)	Qa (m ³ /min)
4.68	⇒ 1.1773	25.4	⇒ 1.1838

Sampler Qa percent difference from Orifice Qa: 0.6%

Design Flow Audit

Sampler with Orifice Removed

ΔP ("H ₂ O)	Qa (m ³ /min)
21.7	⇒ 1.2002

Corrected Sampler Qa: 1.1930 m³/min

Design Qa: 1.1300 m³/min

Corrected sampler Qa percent difference from design Qa: 5.6%

Audit performed according to EPA Quality Assurance Handbook for Air Pollution

Notes:

Sampler Flow Rate Audit

Network: Energy Fuels Resources

Sampler ID: 2-1

AIRS Site ID: N/A

Sampler Audit Date: 4/22/2009

Orifice ID: B

Ambient Temperature (°C): 26.7

Ambient Temperature (°K): 299.9

Sampler Type: Tisch TE-5170-DV-BL

Audited By: Renae Campbell

Sampler Calibration Date: 4/16/2009

Orifice Calibration Date: 3/3/2009

Ambient Pressure ("Hg): 24.57

Ambient Pressure (mmHg): 624

Orifice Calibration: $Q_a = \{\text{SQRT} [\Delta P * (T_a / P_a)] - b\} * \{1/m\}$
where $m = 1.268$ and $b = -0.024$

Sampler Calibration: $Q_a = \{[P_1/P_a - b]*[\text{SQRT}(T_a)]\} * \{1/m\}$
where $m = 10.3903$ and $b = 0.2213$

Accuracy Flow Audit

Orifice		Sampler	
ΔP ("H ₂ O)	Qa (m ³ /min)	ΔP ("H ₂ O)	Qa (m ³ /min)
4.47	⇒ 1.1747	25.3	⇒ 1.1718

Sampler Qa percent difference from Orifice Qa: -0.2%

Design Flow Audit

Sampler with Orifice Removed

ΔP ("H ₂ O)	Qa (m ³ /min)
21.7	⇒ 1.1895

Corrected Sampler Qa: 1.1919 m³/min

Design Qa: 1.1300 m³/min

Corrected sampler Qa percent difference from design Qa: 5.5%

Audit performed according to EPA Quality Assurance Handbook for Air Pollution

Notes:

Sampler Flow Rate Audit

Network: Energy Fuels Resources	Sampler Type: Tisch TE-5170-DV-BL
Sampler ID: 3-1	Audited By: Renae Campbell
AIRS Site ID: N/A	Sampler Calibration Date: 4/17/2009
Sampler Audit Date: 4/22/2009	Orifice Calibration Date: 3/3/2009
Orifice ID: B	Ambient Pressure ("Hg): 24.57
Ambient Temperature (°C): 23.8	Ambient Pressure (mmHg): 624
Ambient Temperature (°K): 297.0	

Orifice Calibration: $Q_a = \{\text{SQRT} [\Delta P * (T_a / P_a)] - b\} * \{1/m\}$
 where $m = 1.268$ and $b = -0.024$

Sampler Calibration: $Q_a = \{[P_1/P_a - b]*[\text{SQRT}(T_a)]\} * \{1/m\}$
 where $m = 12.0097$ and $b = 0.0877$

Accuracy Flow Audit

Orifice	Sampler
ΔP ("H ₂ O)	ΔP ("H ₂ O)
Qa (m ³ /min)	Qa (m ³ /min)
4.43 ⇒ 1.1639	25.0 ⇒ 1.2017

Sampler Qa percent difference from Orifice Qa: 3.2%

Design Flow Audit

Sampler with Orifice Removed	
ΔP ("H ₂ O)	Qa (m ³ /min)
21.7 ⇒	1.2159

Corrected Sampler Qa:	1.1770	m ³ /min
Design Qa:	1.1300	m ³ /min

Corrected sampler Qa percent difference from design Qa: 4.2%

Audit performed according to EPA Quality Assurance Handbook for Air Pollution

Notes:

Sampler Flow Rate Audit

Network: Energy Fuels Resources	Sampler Type: Tisch TE-5170-DV-BL
Sampler ID: 4-1	Audited By: Will Adler
AIRS Site ID: N/A	Sampler Calibration Date: 4/17/2009
Sampler Audit Date: 4/22/2009	Orifice Calibration Date: 3/3/2009
Orifice ID: B	Ambient Pressure ("Hg): 24.88
Ambient Temperature (°C): 19.9	Ambient Pressure (mmHg): 632
Ambient Temperature (°K): 293.1	

Orifice Calibration: $Q_a = \{\text{SQRT} [\Delta P * (T_a / P_a)] - b\} * \{1/m\}$
 where $m = 1.268$ and $b = -0.024$

Sampler Calibration: $Q_a = \{[P1/P_a - b]*[\text{SQRT}(T_a)]\} * \{1/m\}$
 where $m = 11.6708$ and $b = 0.1191$

Accuracy Flow Audit

Orifice	Sampler
ΔP ("H ₂ O)	ΔP ("H ₂ O)
Qa (m ³ /min)	Qa (m ³ /min)
4.64 ⇒ 1.1758	25.4 ⇒ 1.1819

Sampler Qa percent difference from Orifice Qa: 0.5%

Design Flow Audit

Sampler with Orifice Removed

ΔP ("H ₂ O)	Qa (m ³ /min)
21.9 ⇒	1.1970

Corrected Sampler Qa:	1.1910	m ³ /min
Design Qa:	1.1300	m ³ /min

Corrected sampler Qa percent difference from design Qa: 5.4%

Audit performed according to EPA Quality Assurance Handbook for Air Pollution

Notes:

Sampler Flow Rate Audit

Network: Energy Fuels Resources	Sampler Type: Tisch TE-5170-DV-BL
Sampler ID: 5-1	Audited By: Renae Campbell
AIRS Site ID: N/A	Sampler Calibration Date: 4/17/2009
Sampler Audit Date: 4/22/2009	Orifice Calibration Date: 3/3/2009
Orifice ID: B	Ambient Pressure ("Hg): 24.44
Ambient Temperature (°C): 23.9	Ambient Pressure (mmHg): 621
Ambient Temperature (°K): 297.1	

Orifice Calibration: $Q_a = \{\text{SQRT} [\Delta P * (T_a / P_a)] - b\} * \{1/m\}$
 where $m = 1.268$ and $b = -0.024$

Sampler Calibration: $Q_a = \{[P1/P_a - b]*[\text{SQRT}(T_a)]\} * \{1/m\}$
 where $m = 11.3823$ and $b = 0.1417$

Accuracy Flow Audit

Orifice	Sampler
ΔP ("H ₂ O)	ΔP ("H ₂ O)
Qa (m ³ /min)	Qa (m ³ /min)
4.49 ⇒ 1.1749	25.5 ⇒ 1.1837

Sampler Qa percent difference from Orifice Qa: 0.7%

Design Flow Audit

Sampler with Orifice Removed

ΔP ("H ₂ O)	Qa (m ³ /min)
21.8 ⇒	1.2004

Corrected Sampler Qa:	1.1920	m ³ /min
Design Qa:	1.1300	m ³ /min

Corrected sampler Qa percent difference from design Qa: 5.5%

Audit performed according to EPA Quality Assurance Handbook for Air Pollution

Notes:

Appendix C

Meteorological System Audits

METEOROLOGICAL STATION AUDIT SUMMARY

Met Station: EFRC - Site #1
 Audit Performed By: W.Adler, R. Campbell - IML Air Science

Audit Date: 22-Apr-09

Sensor	Mfr./Model	Serial Number	Reference Device	Serial/ID Number
Wind Speed 10m (WS):	RM Young Wind Monitor AQ	82346	quartz referenced drive motor	IML 0896
Wind Direction 10m (WD):	RM Young Wind Monitor AQ	82346	transit, compass	IML 0900
Temperature @ 2 Meters:	RM Young Platinum RTD Temp Probe	13638	digital thermistor	IML 0888
Temperature @ 10 Meters:	RM Young Platinum RTD Temp Probe	13639	digital thermistor	IML 0888
Relative Humidity (RH):	CSI CS 500	C2430074	digital hygrometer	IML 0891
Barometric Pressure (BP):	PTB 101B	C2430048	digital barometer	IML 0968
Solar Radiation:	LI-COR LI200SZ	PY57101	collocated LI200X	PY60636
Precipitation:	Met One 12" tipping bucket	G6356	lab grade burette	N/A
Data acquisition system:	CSI CR3000 datalogger	2397	N/A	N/A

Audit Results

		Reference	Reference	DAS Value	Difference	Specification
		RPM	m/s			
AQ WS 10 meters (cm/s)		0	0.00	0.00	0.00	below threshold
		300	1.54	1.54	0.00	0.56 (2)
		800	4.10	4.10	0.00	0.56 (2)
		3000	15.36	15.36	0.00	0.77 (2)
		8000	40.96	40.96	0.00	2.05 (2)
WS 10 m start torque (gm-cm)			Reference	DAS Value	Difference	Specification
			$\tau < 0.5$	N/A	N/A	1.0 (3)
WD 10 meters (degrees)			0.0	0.3	0.3	5.0 (2)
			90.0	90.4	0.4	5.0 (2)
			180.0	179.6	0.4	5.0 (2)
			270.0	270.1	0.1	5.0 (2)
		Reference	Reference	DAS Value	Difference	Specification
		RPM	cm/s			
Vertical WS 10 meters (cm/s) (Clockwise)		0	0.00	-0.29	0.29	below threshold
		200	100.00	100.27	0.27	25.00 (2)
	EPS:	600	300.00	295.70	4.30	35.00 (2)
		2000	1000.00	974.18	25.82	70.00 (2)
		5000	2500.00	2439.07	60.93	145.00 (2)
			0	0.00	-0.29	0.29
	CFT:	200	100.00	100.20	0.20	25.00 (2)
		600	300.00	299.38	0.62	35.00 (2)
		2000	1000.00	989.39	10.61	70.00 (2)
		5000	2500.00	2470.12	29.88	145.00 (2)
Vertical WS 10 meters (cm/s) (Counter-Clockwise)		0	0.00	-0.02	0.02	below threshold
		200	-100.00	-101.20	1.20	25.00 (2)
	EPS:	600	-300.00	-295.62	4.38	35.00 (2)
		2000	-1000.00	-985.30	14.70	70.00 (2)
		5000	-2500.00	-2441.30	58.70	145.00 (2)
			0	0.00	-0.29	0.29
	CFT:	200	-100.00	-101.30	1.30	25.00 (2)
		600	-300.00	-306.20	6.20	35.00 (2)
		2000	-1000.00	-999.10	0.90	70.00 (2)
		5000	-2500.00	-2496.20	3.80	145.00 (2)
WS 10 m start torque (gm-cm)			$\tau < 0.5$	N/A	N/A	1.0 (3)

		Reference (°C):	DAS Value	Difference	Specification		
Temp. (°C): 2 meter		0.00	-0.04	0.04	0.5	(2)	
		15.50	15.55	0.05	0.5	(2)	
		45.15	45.11	0.04	0.5	(2)	
Temp. (°C): 10 meter		0.00	0.04	0.04	0.5	(2)	
		15.50	15.53	0.03	0.5	(2)	
		45.15	45.14	0.01	0.5	(2)	
		Reference	DAS Value	Difference	Specification		
Relative Humidity (%)	Hourly Averages	43.9	40.0	3.9	5.0	(2)	
RH Sensor Temp (°C):	Hourly Averages	44.6	44.3	0.3			
Solar Radiation (W/m ²)	Hourly Averages	un-covered	485.65	484.14	1.5	24.3	(4)
		covered	0.00	0.13			
Barometric Pressure ("Hg)		24.68	24.66	0.02	0.09	(4)	
		DAS Value (in)	Reference (ml)	DAS Equivalent	Difference	Specification	
Precipitation (0.1" equiv.)		0.10	188.4	185.3	3.0	18.5	(2)
		0.10	184.2	185.3	1.1	18.5	(2)
		0.10	185.9	185.3	0.6	18.5	(2)
				Average Diff:	1.6	18.5	(2)
		2m sensor	10m sensor	ΔT - B	Specification		
Delta Temperature (°C):		-0.04	0.04	0.09	0.1	(2)	
		15.55	15.53	0.02	0.1	(2)	
		45.11	45.14	0.03	0.1	(2)	
BOLD difference values exceed performance specifications							
(1)= Performance specification listed in facilities' Quality Assurance Project Plan							
(2)= EPA Quality Assurance Manual for Air Pollution Measurement Systems, Vol. IV, 1989							
(3)= Manufacturer's Specifications							
(4)= EPA On-Site Meteorological Program Guidance for Regulatory Modeling Applications							
Notes, Recommendations							
Time Offline: 0625 MST							
Time Online: 0830 MST							

METEOROLOGICAL STATION AUDIT SUMMARY

Met Station: EFRC - Site #2
 Audit Performed By: W. Adler, R. Campbell - IML Air Science

Audit Date: 22-Apr-09

Sensor	Mfr./Model	Serial Number	Reference Device	Serial/ID Number
Wind Speed 30m (WS):	RM Young Wind Monitor AQ	82347	quartz referenced drive motor	IML 0896
Wind Direction 30m (WD):	RM Young Wind Monitor AQ	82347	transit, compass	IML 0900
Temperature @ 2 Meters:	RM Young Platinum RTD Temp Probe	13640	digital thermistor	IML 0888
Temperature @ 30 Meters:	RM Young Platinum RTD Temp Probe	13641	digital thermistor	IML 0888
Relative Humidity (RH):	CSI CS 500	C2730148	digital hygrometer	IML 0891
Barometric Pressure (BP):	PTB 101B	C2750056	digital barometer	IML 0968
Solar Radiation:	LI-COR LI200SZ	PY57102	collocated LI200X	PY60636
Data acquisition system:	CSI CR3000 datalogger	2421	N/A	N/A

Audit Results

	Reference		DAS Value	Difference	Specification		
	RPM	m/s					
AQ WS 30 meters (cm/s)	0	0.00	0.00	0.00	below threshold		
	300	1.54	1.54	0.00	0.56	(2)	
	800	4.10	4.10	0.00	0.56	(2)	
	3000	15.36	15.36	0.00	0.77	(2)	
	8000	40.96	40.96	0.00	2.05	(2)	
WS 30 m start torque (gm-cm)	Reference		DAS Value	Difference	Specification		
	$\tau < 0.5$		N/A	N/A	1.0	(3)	
WD 30 meters (degrees)	Reference		DAS Value	Difference	Specification		
	0.0		0.2	0.2	5.0	(2)	
	90.0		90.0	0.0	5.0	(2)	
	180.0		180.0	0.0	5.0	(2)	
		270.0	270.4	0.4	5.0	(2)	
Vertical WS 30 meters (cm/s) (Clockwise)	Reference		DAS Value	Difference	Specification		
	0		0.00	0.00	below threshold		
	EPS:	200	100.00	98.39	1.61	25.00	(2)
		600	300.00	288.75	11.25	35.00	(2)
		2000	1000.00	957.73	42.27	70.00	(2)
		5000	2500.00	2391.68	108.32	145.00	(2)
	CFT:	0	0.00	0.00	0.00	below threshold	
		200	100.00	100.41	0.41	25.00	(2)
		600	300.00	300.32	0.32	35.00	(2)
		2000	1000.00	992.20	7.80	70.00	(2)
	5000	2500.00	2479.65	20.35	145.00	(2)	
	Vertical WS 30 meters (cm/s) (Counter-Clockwise)	Reference		DAS Value	Difference	Specification	
		0		0.00	0.00	below threshold	
		EPS:	200	-100.00	-97.81	2.19	25.00
600			-300.00	-289.92	10.08	35.00	(2)
2000			-1000.00	-955.56	44.44	70.00	(2)
5000			-2500.00	-2391.10	108.90	145.00	(2)
CFT:		0	0.00	0.00	0.00	below threshold	
		200	-100.00	-100.60	0.60	25.00	(2)
		600	-300.00	-303.13	3.13	35.00	(2)
		2000	-1000.00	-996.29	3.71	70.00	(2)
5000		-2500.00	-2470.10	29.90	145.00	(2)	
WS 30 m start torque (gm-cm)		$\tau < 0.5$		N/A	N/A	1.0	(3)

		Reference (°C):	DAS Value	Difference	Specification		
Temp. (°C): 2 meter		1.38	1.37	0.01	0.5	(2)	
		18.53	18.59	0.06	0.5	(2)	
		34.92	34.86	0.06	0.5	(2)	
Temp. (°C): 30 meter		1.38	1.37	0.01	0.5	(2)	
		18.53	18.58	0.05	0.5	(2)	
		34.92	34.84	0.08	0.5	(2)	
		Reference	DAS Value	Difference	Specification		
Relative Humidity (%)	Hourly Averages	17.3	17.0	0.3	5.0	(2)	
RH Sensor Temp (°C):	Hourly Averages	75.1	69.8	5.3			
Solar Radiation (W/m ²)	Hourly Averages	un-covered	1020	1018	2.0	51.0	(4)
		covered	0.21	0.86			
Barometric Pressure ("Hg)		24.80	24.78	0.02	0.09	(4)	
		2m sensor	10m sensor	ΔT - B	Specification		
Delta Temperature (°C):		1.37	1.37	0.00	0.1	(2)	
		18.59	18.58	0.01	0.1	(2)	
		34.86	34.84	0.02	0.1	(2)	
BOLD difference values exceed performance specifications							
(1)= Performance specification listed in facilities' Quality Assurance Project Plan							
(2)= EPA Quality Assurance Manual for Air Pollution Measurement Systems, Vol. IV, 1989							
(3)= Manufacturer's Specifications							
(4)= EPA On-Site Meteorological Program Guidance for Regulatory Modeling Applications							
Notes, Recommendations							
Time Offline: 1047 MST							
Time Online:1335 MST							

Evaporation Pan Verification Sheet

Evap Span **9.4612**
Evap Offset **1.5018**

Empty Pan Logger Reading:

Verification Point	Yardstick Reading (in)*	Logger Reading	Percent Difference
1	7.25	7.64000	5.4%

Notes:

* Yard Stick Reading - taken at the pan outlet to the gauge

Offline: 0625 MST

Online: 0830 MST

Appendix D

Transfer Standard Certifications

Certificate of Accuracy

Transfer Standard Type: Electronic Thermometer Certificate No: T 050808. 03

Transfer standard, model/type: Cole Parmer Digi-Sense ThermoLogR Thermistor Thermometer
Serial number: 429725 IML 0888 Probe S/N: IML 429725
submitted by/owner: Inter-Mountain Laboratories, Inc.
Air Science Division
555 Absaraka Street
Sheridan, WY 82801

Was compared to:
NIST Traceable Hg-in-glass thermometers, serial numbers 2J3106, 2Y6027, 3L9452.
Miller & Weber Hg-in-glass thermometer sn 2J3106 and 2Y6027 are traceable to NIST Test No. 209621, Test Method ASTM E-77. 2J3106 is traceable through Standard No. 1S1262. 2Y6027 is traceable through Standard No. 9C8072. Miller & Weber Hg-in-glass thermometer sn 3L9452 is traceable to NIST Thermometer 40350, through Transfer Standards 3C4465 & 1Y9716.

Date: 05/08/08 Lab temperature: 69.8 °F
Barometric Pressure: 656.6 mmHG

Reference Standard (°C)	Transfer Standard (°C)	Difference from Reference (°C)	Transfer Standard Correction* (°C)
0.0	0.00	0.0	0.0
10.0	10.00	0.0	0.0
18.1	18.10	0.0	0.0
25.0	25.00	0.0	0.0
48.0	47.98	0.0	0.0

Adjusted Offset = - 0.08

Note:

If no sign is given on the correction, the true temperature is higher than the indicated temperature. If the sign is negative, the true temperature is lower than the indicated temperature.

Transfer Standard adjustments made? YES NO

Post-calibration measurements:

Reference Thermistor (°C)	Transfer Standard (°C)	Difference from Reference (°C)	Transfer Standard Correction* (°C)
See Offset and measurements above			

Reviewed: _____

Date: _____

5/8/08

Roger L. Sanders, PE

Chinook Engineering

a division of Inter-Mountain Laboratories, Inc.
555 Absaraka Street
Sheridan, Wyoming 82801 USA
(307) 672-7790
chinook@imlinc.com

Certificate of Accuracy

Transfer Standard Type: Barometric Pressure/Altimeter

Certificate No: B 102808. 01

Transfer standard model: Pretel AltiPlus A2
Serial number: 27604 IML 0968
submitted by/owner: Inter-Mountain Laboratories, Inc.
Air Science Division
555 Absaraka Street
Sheridan, WY 82801

Was compared to Precision Absolute Reference Barometer:
Model number: 355-AI0900 Serial number: 913930-M1
Certified accuracy of ± 0.007 "Hg
NIST traceable to Ruska Deadweight Tester SN 38342/C-85

Date: 10/28/08 Lab temperature 74.1 °F
Lab pressure 668.6 mm Hg

Reference barometer ("Hg)	Transfer Standard ("Hg)	Difference from Reference ("Hg)	Transfer Standard Correction* ("Hg)
24.00	24.00	0.00	0.00
25.00	25.00	0.00	0.00
26.00	26.00	0.00	0.00
26.33	26.33	0.00	0.00
27.50	27.50	0.00	0.00

Note:
If no sign is given on the correction, the true pressure is higher than the indicated pressure. If the sign is negative, the true pressure is lower than the indicated pressure.

Transfer Standard adjustments made? YES NO

Post-calibration measurements:

Reference barometer ("Hg)	Transfer Standard ("Hg)	Difference from Reference ("Hg)	Transfer Standard Correction* ("Hg)

Reviewed: R Sanders Date: 10/28/08

Roger L. Sanders, PE

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chinook@imlinc.com

Certificate of Accuracy

Transfer Standard Type: Electronic Hygrometer

Certificate No: H 120208. 02

Transfer standard, model/type: Dwyer Series 485 Digital Hygrometer

Serial number: IML 0891

submitted by/owner: Inter-Mountain Laboratories, Inc.

Air Science Division

555 Absaraka Street

Sheridan, WY 82801

Was compared to Saturated Salt Solution Standards using ASTM Method E 104 - 02, Standard Practice for Maintaining Constant Relative Humidity by Means of Aqueous Solutions, using Temperature Reference Standard Streamline™ Pro MultiCal™ System Remote Temperature Probe S/N T030301.

Date: 11/30/2008 - 12/02/2008

Lab temperature: 68 - 72 °F

Barometric Pressure: 653.8 - 663.7 mmHG

Lab %RH: 35 - 45%

Reference Salt Standard	Reference Temperature °C	Reference Standard (%RH)	Uncertainty	Transfer Standard (%RH)	Difference from Reference (%RH)	Transfer Standard Correction* (%RH)
Lithium Chloride	20.3	11.82	±0.72	12.4	0.6	-0.6
Potassium Acetate						
Magnesium Chloride	19.6	33.09	±0.21	34.3	1.2	-1.2
Magnesium Nitrate	20.1	54.35	±0.23	54.8	0.4	-0.4
Sodium Chloride	19.6	75.48	±0.20	77.3	1.8	-1.8

Temperature Reference Standard (°C)	Transfer Standard (°C)	Difference from Reference (°C)	Transfer Standard Correction* (°C)
20.3	20.6	0.3	-0.3
19.6	20.0	0.4	-0.4
20.1	20.0	-0.1	0.1
19.6	19.6	0.0	0.0

Reviewed:

R. Sanders

Date:

12/2/08

Roger L. Sanders, PE

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Certificate of Calibration

Streamline™ flow transfer standard (FTS) # D000201
 was calibrated against NIST traceable critical flow venturis
 S/Ns 10961, 10962, 10963, 18491, 30421 on: 1/8/2009

This calibration expires: **1/8/2010**

r10

The actual flow rate (Q_a) through the FTS is:

$$Q_a = \left[m \times \left(\sqrt{\frac{(\Delta P)(T_{amb})}{P_{amb}}} \right) \right] + b$$

$m = 0.4118$

$b = -0.6502$

Q_a = actual flow rate in liters/minute

ΔP = pressure reading from the manometer in "H₂O

T_{amb} = ambient temperature in Kelvins

P_{amb} = ambient pressure in atmospheres*

* 1 atmosphere = 760 mmHg, = 29.92"Hg, =101,325 Pa

Reviewed: *R JH*

Date: *1/8/09*

Quality Assurance Check

Primary Standard Q_{actual} (l/min)	Streamline FTS ΔP ("H ₂ O)	Streamline FTS $Q_{line\ fit}$ (l/min)	Absolute Difference (l/min)	% Difference* full scale
20.01	7.26	20.03	0.02	0.11%
17.50	5.59	17.49	0.00	-0.01%
14.99	4.15	14.99	0.01	0.03%
12.48	2.91	12.45	-0.03	-0.15%
9.98	1.91	9.95	-0.03	-0.13%
7.47	1.12	7.46	-0.01	-0.05%
4.98	0.55	5.02	0.04	0.20%

T_a (°C)= 23.7
 P_a (atm)= 0.855 $r = 1.0000$

*all points must be within ±2%

Chinook Engineering

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Streamline™ FTS, US Patent #5792966

CERTIFICATE OF CALIBRATION

Orifice Transfer Standard - **B**

IML Air Science Sheridan, WY

B orifice transfer standard was calibrated on the NIST traceable
Dresser rootsmeter serial # 9217756 on 3-Mar-09

Calibration expires 3-Mar-10

The reference flow rate (Q_r) through the orifice, in cubic meters per minute, is:

$$Q_r = A (\Delta P_o)^B \quad r = 0.9997$$

where: $A = 0.510$

$B = 0.490$

ΔP_o = pressure drop across orifice, in inches of water

The actual flow rate (Q_a) through the orifice, in cubic meters per minute, is:

$$Q_a = \frac{\left[\left(\sqrt{(\Delta P_o) \left(\frac{T_a}{P_a} \right)} \right) - b \right]}{m} \quad r = 0.9998$$

where: $m = 1.268$

$b = -0.024$

ΔP_o = pressure drop across orifice, inches of water

T_a = ambient temperature, Kelvin

P_a = ambient pressure, mm Hg

The flow rate through the orifice corrected to standard conditions (Q_{std}),
in cubic meters per minute, is:

$$Q_{std} = \frac{\left[\left(\sqrt{\Delta P_o \left(\frac{P_a}{T_a} \right) \left(\frac{298}{760} \right)} \right) - b \right]}{m} \quad r = 0.9998$$

where: $m = 2.025$

$b = -0.033$

ΔP_o = pressure drop across orifice, inches of water

T_a = ambient temperature, Kelvin

P_a = ambient pressure, mm Hg

SH

Reviewed

3/25/2009

Date



**ORIFICE TRANSFER STANDARD CALIBRATION
QUALITY ASSURANCE**

Orifice Transfer Standard# B

The following table is a comparison of measured flow rate versus the flow rate calculated from the new calibration equation. Quality Assurance guidelines require the difference at each point to be less than 2% for a valid calibration. A minimum of three measurement points are required within the operational flow rate interval (1.019 to 1.246 m³/min for PM10 samplers and 1.1 to 1.7 m³/min for TSP samplers).

Q _a measured	Q _a calculated	difference
0.919	0.914	-0.58%
1.046	1.053	0.61%
1.133	1.131	-0.13%
1.218	1.222	0.38%
1.313	1.312	-0.07%
1.374	1.371	-0.23%
1.447	1.447	-0.01%

References: 40 CFR 50, Appendix B, Reference Method for the Determination of Suspended Particulate Matter in the Atmosphere (High Volume Method); 40 CFR 50, Appendix J, Reference Method for the Determination of Particulate Matter as PM10 in the Atmosphere; and Quality Assurance Handbook for Air Pollution Measurement Systems: Volume II. Ambient Air Specific Methods, (EPA 600/4-77/027a, June 1992), Sections 2.2.2.5 and 2.11.2.2.1.

Data Input

Roots Meter SN:	629846					
DATE:	3-Mar-09	POINT	DELTA VOLUME m ³	TIME MIN	DELTA H roots mmHg	DELTA H orifice "H ₂ O
ORIFICE #:	B	1	3.3985	3.6713	4.3902	2.8500
TECH:	Cory Medill	2	3.3985	3.2192	5.8847	3.8000
TEMP (°C):	23.70	3	3.3985	2.9692	6.8188	4.4000
PRES("Hg):	25.83	4	3.3985	2.7567	8.0331	5.1500
CLIENT:	IML Air Science	5	3.3985	2.5508	9.3409	5.9500
LOCATION:	Sheridan, WY	6	3.3985	2.4348	10.1815	6.5000
		7	3.3985	2.3078	11.3958	7.2500

POINT	Actual Flow			POINT	Standard Flow		
	V _a m ³	Q _a m ³ /min	Y-AXIS		V _{std} m ³	Q _{std} m ³ /min	Y-AXIS
1	3.376	0.919	1.136	1	2.925	0.797	1.572
2	3.368	1.046	1.311	2	2.919	0.907	1.815
3	3.363	1.133	1.411	3	2.915	0.982	1.953
4	3.357	1.218	1.526	4	2.909	1.055	2.113
5	3.350	1.313	1.641	5	2.903	1.138	2.271
6	3.346	1.374	1.715	6	2.899	1.191	2.373
7	3.339	1.447	1.811	7	2.894	1.254	2.507



CERTIFICATE OF CALIBRATION

Test Unit

Model: 18802
Motor SN: IML 0896
Control Unit SN: CA03395
Range: 200-15000 RPM

Motor RPM	Indicated RPM					
	Clockwise Output Range			Counter Clockwise Output Range		
	Low	High	Average	Low	High	Average
600	600.0	600.1	600.0	600.0	600.0	600.0
1200	1199.9	1199.9	1199.9	1199.9	1200.1	1199.9
2400	2399.8	2399.8	2399.8	2399.8	2399.8	2399.8
4200	4199.7	4199.7	4199.7	4199.7	4199.7	4199.7
6000	5999.7	5999.7	5999.7	5998.7	5999.7	5999.5
8100	8099.6	8099.6	8099.6	8099.6	8099.6	8099.6
9900	9899.5	9899.5	9899.5	9899.5	9899.5	9899.5

The instrument above has been presented for inspection and test as shown

The indicated work was performed using standards traceable to the National Institute of Standards and Technologies (NIST)

Standard SN: 51892014
Technician: C. Medill
Date: 1/5/2009

THE BRUNTON COMPANY

Certificate Of Calibration

IML 0900

Equipment Owner:

Name: Inter-Mountain Labs

Address: 555 Absarokee

City, State, Zip: Sheridan Wyo 82801

Calibration traceable to the National Institute of Standards and Technology in accordance with Mil-STD-45662A has been accomplished on the instrument listed below by comparison with standards maintained by The Brunton Co. The accuracy and stability of all standards maintained by The Brunton Co. are traceable to national standards maintained by the National Institute of Standards and Technology in Washington, D.C. and Boulder, CO. Complete record of all work performed is maintained by The Brunton Co. and is available for inspection upon request.

This Unit has been calibrated to Lietz TM10E serial number 30937 traceable to N.B.S. no. 738 227675 this 29 Day of January 20 09

DESCRIPTION: Pocket transit

PURCHASE ORDER: 186512

ORDER NUMBER: 2015209

LOT NUMBER: 1718246

MODEL NUMBER: F-5008

SERIAL NUMBER: 5080800156

CALIBRATION DATE: 1-29-09

RECALIBRATION DUE DATE: 1-29-10

Signed: Edie Murrell
QUALITY CONTROL MANAGER

CERTIFICATE of CALIBRATION

for LI-COR SENSOR

Model Number: LI-200SZ

Serial Number: PY60636 Calibration Date: July 17, 2008

Output: 89.2 microamps per 1000 watts m⁻²

IMPORTANT: *Read the appropriate instruction manual before using this sensor.*

IMPORTANT: *It is recommended that sensors be recalibrated every two years.*

Calibration Technician: _____

Caron Deschane

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Biosciences

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