# A.19 BAGHOUSE FOR PM CONTROL – FACILITY V

# INTRODUCTION

The examples in section A.19 were developed based on data collected during an EPA study of particulate matter (PM) continuous emissions monitoring systems (CEMS). Data were collected over a period of several months for three PM CEMS installed on a coal-fired boiler. Higher than normal PM concentrations were generated during testing by installing a baghouse bypass line and adjusting a butterfly valve on that line. Examples A.19a and A.19b present two approaches to the use of PM CEMS for CAM using data from one of the PM CEMS evaluated. The first example uses the procedures of draft Performance Specification 11 to calibrate the PM CEMS over an extended range of PM concentrations. This approach provides a reasonable assurance of compliance over the extended operating range, establishes the indicator level near the high end of the demonstrated operating range, and allows the source flexibility to operate within the extended range without an excursion.

The second example uses a limited amount of test data collected in the normal operating range to calibrate the PM CEMS. During normal operation there is a large margin of compliance with the emissions limit. However, the indicator range is based on a smaller data set collected over a smaller range of operation. Consequently, the indicator level where an excursion occurs is established at a lower value, near the normal operating range. This approach results in less flexibility but lower emissions testing costs because testing is only performed at normal operating conditions.

Details on the PM CEMS evaluation are contained in the report series, "Evaluation of Particulate Matter (PM) Continuous Emission Monitoring Systems (CEMS)," Volumes 1-5, prepared by Midwest Research Institute for the U. S. Environmental Protection Agency's Emissions Measurement Center. The EPA contact is Mr. Dan Bivins at (919) 541-5244, or bivins.dan@epa.gov.

# EXAMPLE COMPLIANCE ASSURANCE MONITORING: BAGHOUSE FOR PM CONTROL – FACILITY V

## I. Background

### A. Emissions Unit

| | |
|---|---|
| Description: | 375 mmBtu/hr coal-fired boilers |
| Identification: | Boilers 1 and 2 |
| Facility: | Facility V<br>Anytown, USA |

### B. Applicable Regulation, Emissions Limit, and Monitoring Requirements

| | |
|---|---|
| Regulation: | 40 CFR 60, Subpart Da<br>Permit |
| Emissions Limits:<br>PM: | <br>0.02 lb/mmBtu |
| Monitoring Requirements: | A baghouse inspection and maintenance program is performed and a PM continuous emissions monitoring system (CEMS) is used as an additional indicator of compliance with the PM limit. [Note: A COMS is used to assure compliance with the opacity limit and $NO_x$ and $SO_2$ CEMS are used to assure compliance with the $NO_x$ and $SO_2$ limits, but that monitoring is not addressed here.] |

### C. Control Technology:

Both boilers have a pulse jet fabric filter to control particulate emissions from the boiler and the lime slurry spray dryer (used for flue gas desulfurization) that follows each boiler. The boilers exhaust to a common stack.

## II. Monitoring Approach

The key elements of the monitoring approach for PM are presented in Table A.19a-1. The selected performance indicators are the signal from a PM CEMS and a baghouse inspection and maintenance program.

TABLE A.19a-1. MONITORING APPROACH

| | Indicator No. 1 | Indicator No. 2 |
|---|---|---|
| I. Indicator | PM concentration. | Bag condition. |
| Measurement Approach | A light scattering device is installed at a representative location downstream of the baghouse. | The inspection and maintenance program includes a semi-annual internal inspection of the baghouse and analysis of representative bag samples and bi-annual bag replacement. |
| II. Indicator Range | An excursion is defined as an hourly average PM concentration greater than 13 mg/acm. Excursions trigger an inspection, corrective action, and a reporting requirement. | An excursion is defined as failure to perform the semi-annual inspection and bi-annual bag replacement. Excursions trigger an inspection, corrective action, and a reporting requirement. |
| III. Performance Criteria<br>A. Data Representativeness | The light scattering instrument is located where a representative sample can be obtained in the baghouse exhaust. The amount of light reflected back at the optical sensor is proportional to the amount of particulate present in the exhaust. A field test was performed to correlate the monitor's response to PM concentration measured by Method 17. | Baghouse inspected visually for deterioration and bag samples taken to determine bag condition and remaining bag life. |
| B. Verification of Operational Status | Initial correlation test conducted August 1999. | NA |
| C. QA/QC Practices and Criteria | Daily drift checks, quarterly absolute calibration audit (ACA), and annual response calibration audit (RCA). Daily zero/span drift cannot exceed 4 percent of the upscale value for 5 consecutive days or more than 8 percent of the upscale value in any one day. The ACA involves challenging the PM CEMS with an audit standard at three operating levels, per Performance Specification (PS) 11. The RCA involves gathering simultaneous CEMS response and manual Reference Method data over a range of operating conditions, per PS 11. | Trained personnel perform inspections and maintenance. |
| D. Monitoring Frequency | Continuous. | Varies. |

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(TABLE A.19a-1. Continued)

| | Indicator No. 1 | Indicator No. 2 |
|---|---|---|
| Data Collection Procedures | The data acquisition system (DAS) collects a data point every second. The 1-second data are reduced to a 1-minute, a 15-minute, and then a 1-hour average PM emissions rate. The 1-hour average data are archived for at least 5 years. | Results of inspections and maintenance activities performed are recorded in baghouse maintenance log. |
| Averaging period | One hour. | NA |

MONITORING APPROACH JUSTIFICATION

I. Background

Two 375 mmBtu/hr traveling-grate, stoker-fired boilers are operated at this facility. Each boiler is rated at a nominal steam flow of 275,000 pounds per hour at 950°F and 1,540 psig. The boilers are fired with bituminous coal that averages 13,000 Btu per pound. The boilers were constructed in 1990 and are subject to 40 CFR 60, Subpart Da.

The boilers include mechanical separators in the boiler back-pass section for cinder collection and re-injection into the furnace area. A separate dust collector is located after the air heater section for heavy fly ash collection. The ash from the traveling grate is collected at the front of the boiler for removal to the ash storage silos.

Each boiler is equipped with a dry flue gas desulfurization (FGD) system for $SO_2$ control and a pulse jet fabric filter for PM control. The FGD uses a motor-driven atomizer to spray a lime slurry mixture into the gas path to neutralize acid mists from the boiler gas. The particulate from the slurry injection and the fine fly ash from the combustion process are collected in the baghouse. The FGD is designed to reduce the average sulfur dioxide concentration by at least 90 percent. The baghouse is designed to collect at least 99 percent of the total particulate in the boiler gas. Exhaust from both baghouses is routed to a common stack that exhausts to the atmosphere.

II. Rationale for Selection of Performance Indicators

The performance indicators selected are the signal from a PM CEMS and baghouse inspections. The PM CEMS is a light-scattering device that detects particulate matter in the baghouse exhaust by reading the back-scattered light from a collimated, near-infrared (IR) light emitting diode (LED). Because this instrument measures in the near-IR range, the sensitivity to changes in particle size is minimal and the response to particles in the 0.1 to 10 µm range is nearly constant. Preventive maintenance is performed on the baghouse to ensure it continues to operate properly and that the bags are in good condition.

III. Rationale for Selection of Indicator Ranges

The unit's PM limit is 0.02 lb/mmBtu, which corresponds to approximately 17 mg/acm. For the light scattering device signal, an excursion is defined as a PM concentration of greater than 13 mg/acm. At this level, the upper tolerance interval is just below the emissions limit and the unit still has a small margin of compliance. Therefore, corrective action will be initiated when the PM CEMS shows the unit is at approximately 75 percent of the emissions limit. Figure A.19a-1 shows a typical day's worth of data while operating at peak load. The PM monitor's signal is normally 2 to 4 mg/acm.

A total of 12 Method 17 test runs performed with paired sampling trains at varying PM concentrations were used to develop the relationship between the PM concentration in the baghouse exhaust and the monitor signal. Emissions, boiler load, opacity, and PM CEMS data from the test program are presented in Table A.19a-2. A baghouse bypass line and butterfly valve were installed for the purpose of generating higher than normal PM concentrations to calibrate the PM CEMS. Figure A.19a-2 shows the correlation curve developed during the initial testing, with the upper and lower confidence and tolerance limits calculated per draft Performance Specification 11. The relationship is a linear equation with an $R^2$ of 0.96. The confidence interval is the interval within which one would predict the calibration relationship lies with 95 percent confidence. The tolerance interval is the interval within which 75 percent of the data are expected to lie with 95 percent confidence.

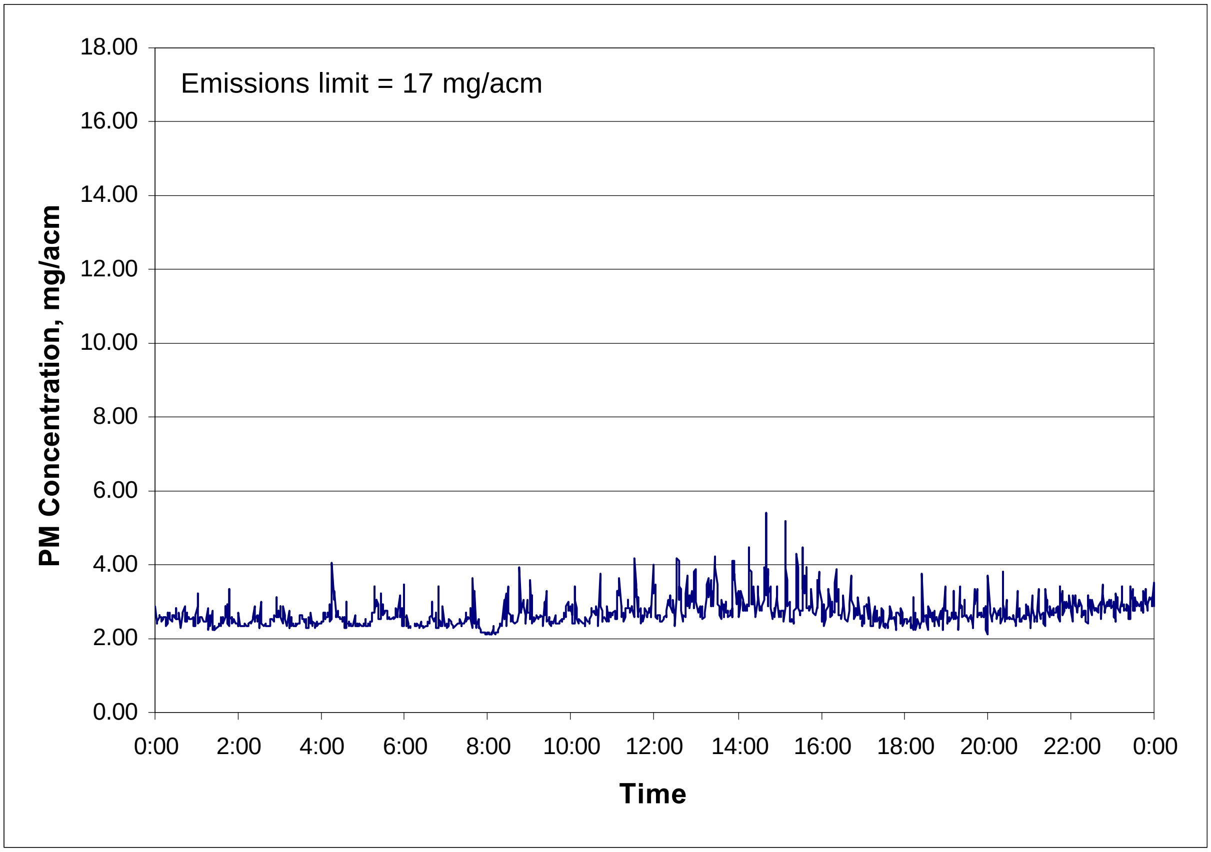


Figure A.19a-1. Light scattering monitor data for a typical day.

TABLE A.19a-2. PM CEMS INITIAL CORRELATION TEST DATA

| Parameter | Test Run | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Steam flow, 1,000 lb/hr | 271 | 281 | 283 | 282 | 280 | 284 | 281 | 281 | 281 | 285 | 268 | 281 |
| Method 17 result, mg/acm[1] | 11.6 | 13.9 | 14.5 | 3.03 | 2.68 | 3.20 | 16.3 | 10.5 | 9.42 | 15.4 | 8.76 | 18.7 |
| PM CEMS response, mA | 9.60 | 10.0 | 10.5 | 5.87 | 5.78 | 6.00 | 12.0 | 9.45 | 8.97 | 13.2 | 9.57 | 14.5 |
| Opacity, % | 3.72 | 4.51 | 5.27 | 3.71 | 3.54 | 3.92 | 4.01 | 4.22 | 4.14 | 4.25 | 4.11 | 5.39 |

[1]The Method 17 result is the average of sampling train A and sampling train B.

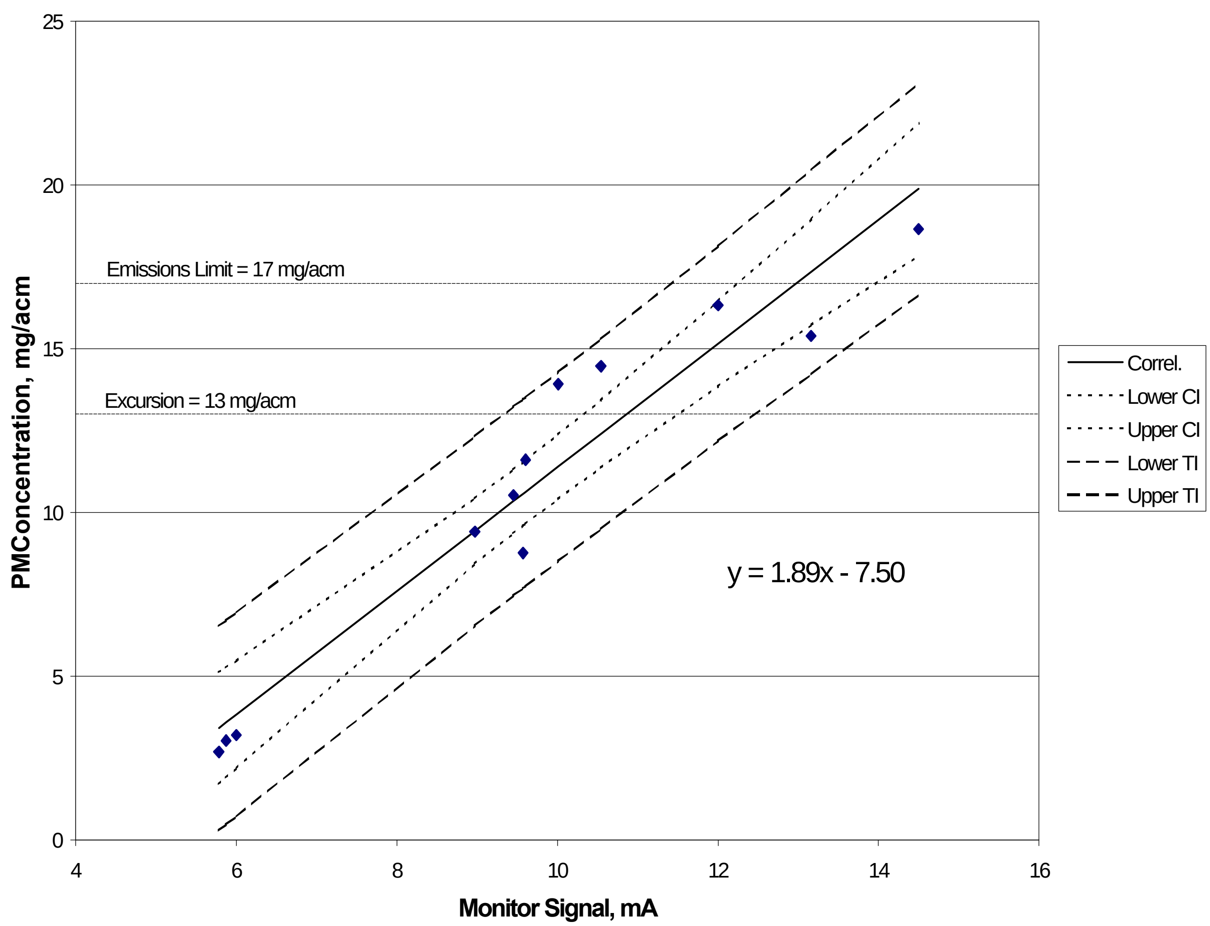


Figure A.19a-2. PM CEMS Correlation Curve.

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EXAMPLE COMPLIANCE ASSURANCE MONITORING:
BAGHOUSE FOR PM CONTROL – FACILITY V

## I. Background

### A. Emissions Unit

| | |
|---|---|
| Description: | 375 mmBtu/hr coal-fired boilers |
| Identification: | Boilers 1 and 2 |
| Facility: | Facility V<br>Anytown, USA |

### B. Applicable Regulation, Emissions Limit, and Monitoring Requirements

| | |
|---|---|
| Regulation: | 40 CFR 60, Subpart Da<br>Permit |
| Emissions Limits:<br>PM: | <br>0.02 lb/mmBtu |
| Monitoring Requirements: | A baghouse inspection and maintenance program is performed and a PM continuous emissions monitoring system (CEMS) is used as an additional indicator of compliance with the PM limit. [Note: A COMS is used to assure compliance with the opacity limit and $NO_x$ and $SO_2$ CEMS are used to assure compliance with the $NO_x$ and $SO_2$ limits, but that monitoring is not addressed here.] |

### C. Control Technology:

Both boilers have a pulse jet fabric filter to control particulate emissions from the boiler and the lime slurry spray dryer (used for flue gas desulfurization) that follows each boiler. The boilers exhaust to a common stack.

## II. Monitoring Approach

The key elements of the monitoring approach for PM are presented in Table A.19b-1. The selected performance indicators are the signal from a PM CEMS and a baghouse inspection and maintenance program.

TABLE A.19b-1. MONITORING APPROACH

| | Indicator No. 1 | Indicator No. 2 |
|---|---|---|
| I. Indicator | PM CEMS response. | Bag condition. |
| Measurement Approach | A light scattering type PM CEMS is installed at a representative location downstream of the baghouse. | The inspection and maintenance program includes a semi-annual internal inspection of the baghouse and analysis of representative bag samples and bi-annual bag replacement. |
| II. Indicator Range | An excursion is defined as an hourly average PM CEMS response greater than 7.5 mA. Excursions trigger an inspection, corrective action, and a reporting requirement. | An excursion is defined as failure to perform the semi-annual inspection and bi-annual bag replacement. Excursions trigger an inspection, corrective action, and a reporting requirement. |
| III. Performance Criteria<br>A. Data Representativeness | The PM CEMS is located where a representative sample can be obtained in the baghouse exhaust. An increase in the PM CEMS signal indicates an increase in the PM concentration. A field test was performed to compare the PM CEMS response to PM concentration measured by Method 17. | Baghouse inspected visually for deterioration and bag samples taken to determine bag condition and remaining bag life. |
| B. Verification of Operational Status | Initial verification test consisting of 3 test runs. | NA |
| C. QA/QC Practices and Criteria | Daily drift checks and quarterly absolute calibration audit (ACA). Daily zero/upscale drift cannot exceed 4 percent of the upscale value for 5 consecutive days or more than 8 percent of the upscale value in any one day. The ACA involves challenging the PM CEMS with an audit standard at three operating levels, per PS 11. | Trained personnel perform inspections and maintenance. |
| D. Monitoring Frequency | Continuous. | Varies. |
| Data Collection Procedures | The data acquisition system (DAS) collects a data point every 5 seconds. Those 5-second data are reduced to a 1-minute, a 15-minute, and then a 1-hour average PM CEMS response. The 1-hour average data are archived for at least 5 years. | Results of inspections and maintenance activities performed are recorded in baghouse maintenance log. |
| Averaging period | One hour. | NA |

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# MONITORING APPROACH JUSTIFICATION

## I. Background

Two 375 mmBtu/hr traveling-stoker grate, coal-fired boilers are operated at this facility. Each boiler is rated at a nominal steam flow of 275,000 pounds per hour at 950°F and 1,540 psig. The boilers are fired with bituminous coal that averages 13,000 Btu per pound. The boilers were constructed in 1990 and are subject to 40 CFR 60, Subpart Da.

The boilers include mechanical separators in the boiler back-pass section for cinder collection and re-injection into the furnace area. A separate dust collector is located after the air heater section for heavy fly ash collection. The ash from the traveling grate is collected at the front of the boiler for removal to the ash storage silos.

Each boiler is equipped with a dry flue gas desulfurization (FGD) system for $SO_2$ control and a pulse jet fabric filter for PM control. The FGD uses a motor-driven atomizer to spray a lime slurry mixture into the gas path to neutralize acid mists from the boiler gas. The particulate from the slurry injection and the fine fly ash from the combustion process are collected in the baghouse. The FGD is designed to reduce the average sulfur dioxide concentration by at least 90 percent. The baghouse is designed to collect at least 99 percent of the total particulate in the boiler gas. Exhaust from both baghouses is routed to a common stack that exhausts to the atmosphere.

## II. Rationale for Selection of Performance Indicators

The performance indicators selected are the signal from a PM CEMS and baghouse inspections. The PM CEMS is a light-scattering device that detects particulate matter in the baghouse exhaust by reading the back-scattered light from a collimated, near-infrared (IR) light emitting diode (LED). Because this instrument measures in the near-IR range, its sensitivity to changes in particle size is minimized and its response to particles in the 0.1 to 10 µm range is nearly constant. Preventive maintenance is performed on the baghouse to ensure it continues to operate properly and that the bags are in good condition.

## III. Rationale for Selection of Indicator Ranges

The boiler's PM limit is 0.02 lb/mmBtu, which corresponds to approximately 17 mg/acm. Three Reference Method (Method 17) test runs performed with paired sampling trains were conducted while operating the boiler at full load. These test data were used to develop the relationship between the PM concentration in the baghouse exhaust and the PM CEMS signal. Emissions, load, and PM CEMS data from the test program are presented in Table A.19b-2. Figure A.19b-1 shows a graphical representation of the PM CEMS response versus particulate concentration for the 3 test runs and the indicator range developed based on that data. The linear correlation was forced through the zero point (4 mA). The data showed that when the PM CEMS readings were at or below 6 mA, the PM concentration was less than 3.5 mg/acm, well below the PM limit (see Figure A.19b-1). Figure A.19b-2 shows a typical day's worth of

TABLE A.19b-2. PM CEMS RESPONSE VALIDATION TEST DATA

| Parameter | Test Run 1 | Test Run 2 | Test Run 3 |
|---|---|---|---|
| Steam flow, 1,000 lb/hr | 282 | 280 | 284 |
| Method 17 result, mg/acm[1] | 3.03 | 2.68 | 3.20 |
| PM CEMS response, mA | 5.87 | 5.78 | 6.00 |

[1]The Method 17 result is the average of sampling train A and sampling train B.

15-minute average PM CEMS data while operating at peak load. The PM monitor's signal normally is less than 6 mA. Based on the limited test data available and the source's low variability and large margin of compliance, the upper limit of the indicator range was set at 125 percent of the highest measured value. Therefore, for the PM CEMS, an excursion is defined as an hourly average PM CEMS response greater than 7.5 mA (corresponds to a predicted PM concentration of 5.53 mg/acm, about one-third of the PM limit).

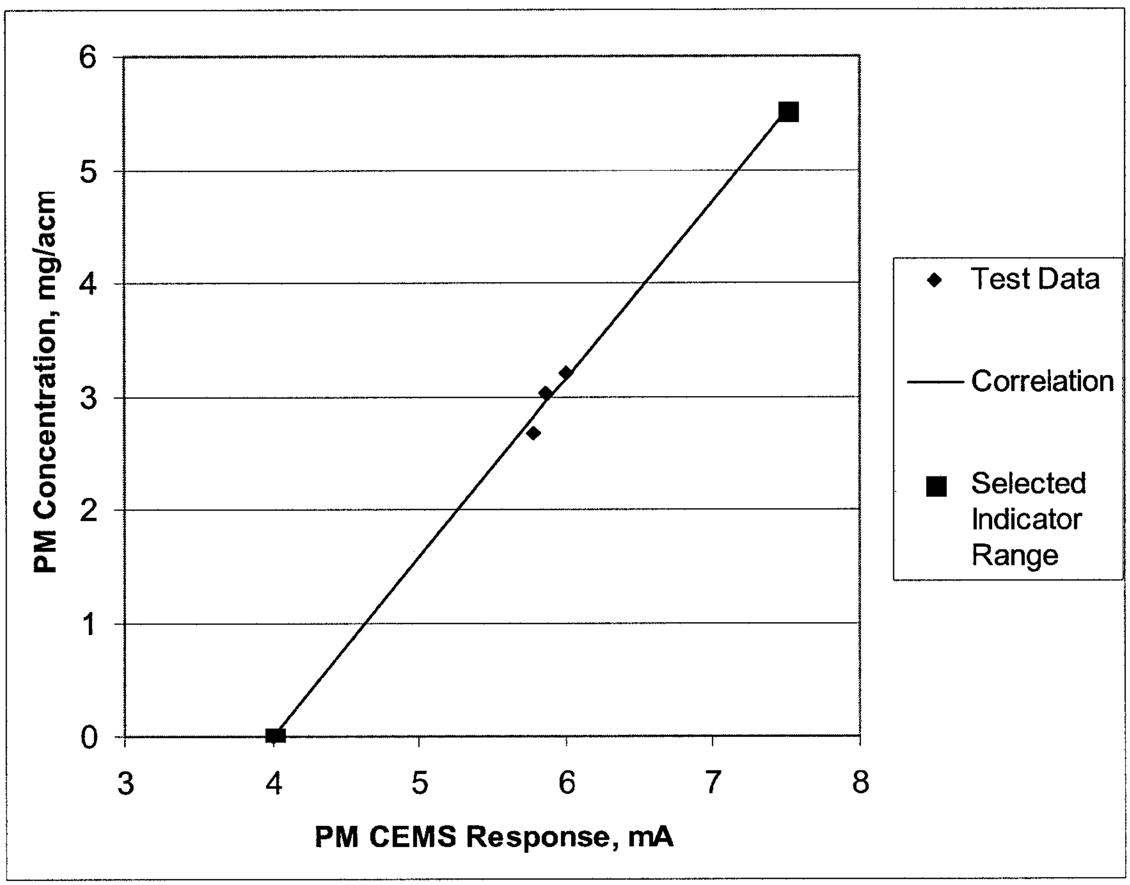


Figure A.19b-1. PM CEMS Calibration Curve and Indicator Range.

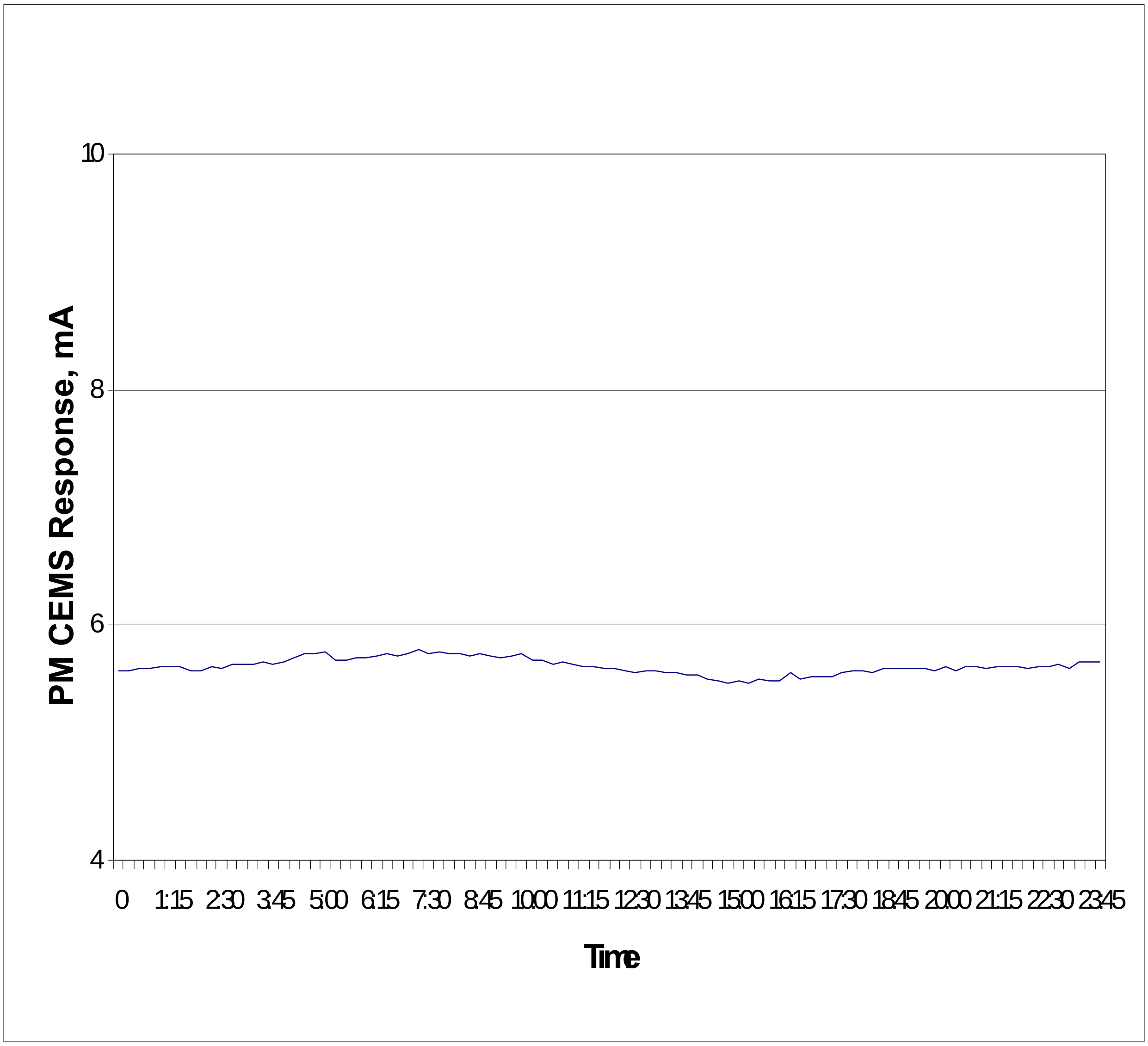


Figure A.19b-2. Typical daily output from PM CEMS (15-minute averages).

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# A.20 SCRUBBER FOR $SO_2$ CONTROL – FACILITY W

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# EXAMPLE COMPLIANCE ASSURANCE MONITORING
# SCRUBBER FOR $SO_2$ CONTROL – FACILITY W

## I. Background

### A. Emissions Unit

| | |
|---|---|
| Description: | Pulp Mill Blow Cyclone Vent |
| Identification: | PU2 - EP003 |
| Facility: | Facility W<br>Anytown, USA |

### B. Applicable Regulation, Emission Limit, and Monitoring Requirements

| | |
|---|---|
| Regulation: | State regulation and permit |
| Emission Limits: | |
| $SO_2$: | 94 percent control |
| Monitoring Requirements: | Scrubber liquid pH, liquid flow |

### C. Control Technology:

Wet scrubber to remove $SO_2$ from the digester system blow cyclone gases.

## II. Monitoring Approach

The key elements of the monitoring approach are presented in Table A.20-1. The selected performance indicators are the scrubber liquid pH and the scrubber liquid flow.

TABLE A.20-1. MONITORING APPROACH

| | Indicator No. 1 | Indicator No. 2 |
|---|---|---|
| I. Indicator | Scrubber liquid pH. | Scrubber liquid flow. |
| Measurement Approach | The scrubber liquid pH is measured using a pH sensor. | The scrubber liquid flow is measured using a magnetic flow tube element. |
| II. Indicator Range | An excursion is defined as an hourly scrubber pH value less than 9.0. An excursion shall trigger an inspection, corrective action as necessary, and a reporting requirement. | An excursion is defined as an hourly scrubber liquid flow value less than 175 gpm. An excursion shall trigger an inspection, corrective action as necessary, and a reporting requirement. |
| III. Performance Criteria<br>A. Data Representativeness | The scrubber liquid pH sensor is located in the scrubber liquid recirculation line. | The scrubber liquid flow rate sensor is located on the scrubber liquid recirculation line. |
| B. Verification of Operational Status | Calibration of the pH sensor conducted by comparison with laboratory measurements of the scrubber recirculation fluid. | Factory calibration of the magnetic flow tube element before installation. Check the unit when installed to verify correct electrical output. |
| C. QA/QC Practices and Criteria | Monitoring equipment and process downtime is recorded in a log. The pH meter is checked for accuracy (±0.2 pH units) monthly. The pH sensor is calibrated annually according to the quality assurance plan, which takes into account the manufacturer's specifications for equipment accuracy. | Monitoring equipment and process downtime is recorded in a log. The flow sensor is calibrated annually according to the quality assurance plan, which takes into account the manufacturer's specifications for equipment accuracy. |
| D. Monitoring Frequency | The scrubber liquid pH is measured continuously. | The scrubber liquid flow is measured continuously. |
| Data Collection Procedures | The operator records scrubber liquid pH once per hour on the scrubber operating log. | The operator records scrubber liquid flow once per hour on the scrubber operating log. |
| Averaging period | None. The pH is recorded once per hour. | None. The liquid flow rate is recorded once per hour. |

MONITORING APPROACH JUSTIFICATION

I. Background

The pollutant specific emissions unit is a wet scrubber that is used to remove residual $SO_2$ from the digester system blow cyclone gases. The vapor flows out of the top of the blow cyclone into the bottom of the wet scrubber. The scrubbing liquid is a weak sodium carbonate ($Na_2CO_3$) solution. This liquid enters the top of the scrubber through a distribution header to ensure the scrubber packing is uniformly wetted. The liquid flow rate is approximately 200 gallons per minute. The gas flows through the packed column and through a mesh pad mist eliminator to remove entrained sodium carbonate solution and then exits through the top of the scrubber to the atmosphere. The scrubber is constructed of a fiber-reinforced plastic (FRP) material that has chemical resistance properties suitable for this application.

An overflow nozzle in the scrubber maintains the liquid level at the bottom of the scrubber. A small amount of fresh sodium carbonate solution is added to the recirculation flow as the solution is discharged; the discharged solution is returned to the sulfur burner absorption tower as an input in the production of cooking liquor used to digest wood chips in the pulping process.

II. Rationale for Selection of Performance Indicators

To ensure compliance with the applicable emissions limit, a minimum scrubbing liquid flow rate must be supplied to the scrubber to absorb a given amount of $SO_2$ in the gas stream, given the size of the tower and height of the packed bed. The liquid to gas (L/G) ratio is a key operating parameter of the scrubber. If the L/G ratio decreases below the minimum, sufficient mass transfer of the pollutant from the gas phase to the liquid phase will not occur. The minimum liquid flow required to maintain the proper L/G ratio at the maximum gas flow and vapor loading through the scrubber can be determined. Maintaining this minimum liquid flow, even during periods of reduced gas flow, will ensure that the required L/G ratio is achieved at all times.

As the pH of the scrubbing liquid decreases, the concentration gradient between the liquid and gas decreases, and less $SO_2$ is absorbed. The chemical equation that describes the primary scrubbing action is as follows:

$$SO_2 + Na_2CO_3 \rightarrow Na_2SO_3 + CO_2$$

It is important to maintain a minimum pH of the scrubbing liquid to drive this equation.

III. Rationale for Selection of Indicator Ranges

Since the wet scrubber is a new installation at this facility, indicator ranges for the scrubber liquid pH and flow rate have been developed based on the manufacturer's design and operating guidelines, the chemistry of the reaction products, and previous experience operating this scrubber on a similar application at another facility. The selected range for scrubber liquid pH is greater than 9.0, to ensure the reaction favors creation of the sodium sulfite ($Na_2SO_3$) compound. This compound is subsequently utilized in the pulping process as an active cooking chemical. An excursion occurs and is documented if an hourly value is less than 9.0. The selected indicator range for scrubber liquid flow is greater than 175 gallons per minute. If an hourly value is less than 175 gallons per minute, an excursion occurs and is documented. Hourly readings are sufficient to ensure proper operation of the control device as operating experience with this scrubber has shown that the pH and flow do not vary appreciably over the course of a day (see Figure 1). In addition, since this unit is not a large CAM source (post-control emissions are less than the major source threshold), continuous monitoring is not required.

After data on these parameters are collected for 6 months and the operators have become familiar with the new scrubber system, a performance test will be conducted to verify that the removal efficiency standard can be met while operating within the selected indicator ranges. The performance test will be conducted at conditions that are representative of the operating conditions that prevailed during the previous 6-month period. The indicator ranges will be re-evaluated at that time.

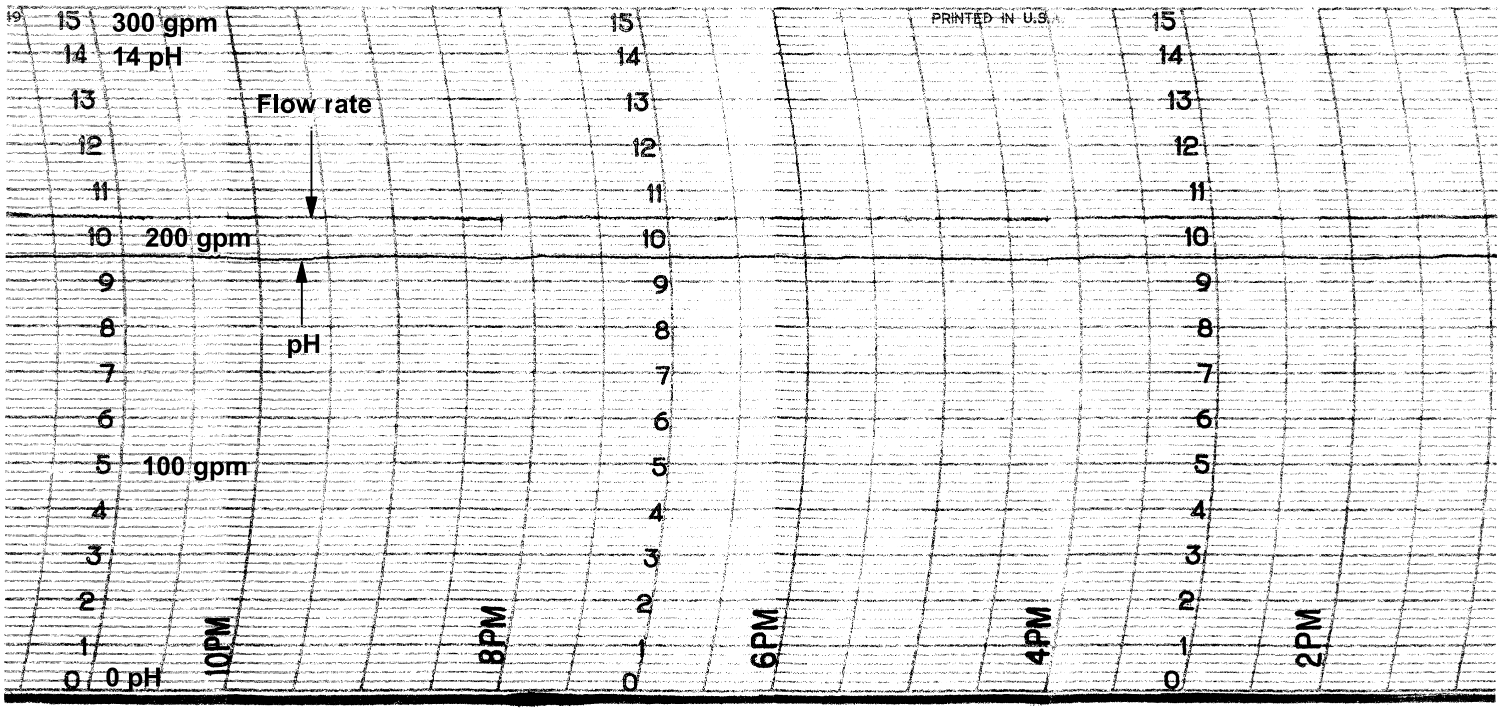


Figure 1. Typical scrubber flow rate and pH.

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# A.24 CARBON ADSORBER FOR VOC CONTROL--FACILITY EE

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# EXAMPLE COMPLIANCE ASSURANCE MONITORING
# CARBON ADSORBER FOR VOC CONTROL: FACILITY EE

## I. Background

### A. Emissions Unit

| | |
|---|---|
| Description: | Loading Rack |
| Identification: | LR-1 |
| APCD ID: | VRU-1 |
| Facility: | Facility EE<br>Anytown, USA |

### B. Applicable Regulation, Emission Limit, and Monitoring Requirements

| | |
|---|---|
| Regulation: | Permit, State regulation |
| Emission Limits: | |
| VOC: | 45 mg/liter of product loaded |
| Monitoring Requirements: | Monitor vacuum profile during carbon bed regeneration cycle, monitor for APCD bypass, test the carbon periodically, and conduct an inspection and maintenance program and a leak detection and repair program. |

### C. Control Technology: Carbon adsorber.

## II. Monitoring Approach

The key elements of the monitoring approach are presented in Table A.24-1. The amount of time the regenerating carbon bed remains at or below -27 inches of Hg is monitored to ensure the bed has been fully regenerated. An inspection and maintenance program, including annual testing of the carbon activity, is conducted to verify proper operation of the vapor recovery unit (VRU). Periodic leak checks of the vapor recovery unit also are conducted and the carbon adsorber bypass valve is monitored to ensure bypass of the control device is not occurring.

**Note:** Facility EE also monitors parameters related to the vapor tightness of connections and tank trucks and other parameters of the vapor recovery system, but this example focuses on the monitoring performed on the carbon adsorber.

TABLE A.24-1. MONITORING APPROACH

| | Indicator No. 1 | Indicator No. 2 | Indicator No. 3 |
|---|---|---|---|
| I. Indicator | Regeneration cycle vacuum. Specifically, the time the regenerating carbon bed remains at or below -27 inches Hg. | Documentation of inspection and maintenance program and annual carbon testing. | Equipment leaks. |
| Measurement Approach | Pressure transmitter. | Proper VRU operation is verified by performing periodic inspections and maintenance. Daily checks include verification of gasoline flow, purge air flow, cycle time, valve timing, and operating temperatures. Annual checks include carbon testing and pump and motor maintenance. | Monthly leak check of vapor recovery system. |
| II. Indicator Range | An excursion occurs when the regenerating carbon bed remains at or below -27 inches Hg for less than 2.5 minutes. When an excursion occurs, the loading rack will be shut down via an automated interlock system. An excursion will trigger an investigation, corrective action, and a reporting requirement. | An excursion occurs if the inspection or annual carbon test is not performed or documented or if corrective action is not initiated within 24 hours to correct any problems identified during the inspection of the unit or carbon testing. An excursion will trigger an investigation, corrective action, and a reporting requirement. | An excursion is defined as detection of a leak greater than or equal to 10,000 ppm (as methane) during normal loading operations. An excursion will trigger an investigation, corrective action, and a reporting requirement. Leaks will be repaired within 15 days. |
| III. Performance Criteria A. Data Representativeness | The pressure during the regeneration cycle is measured in the vacuum pump suction line. The minimum accuracy of the pressure transmitter is ±1.0 percent. | VRU operation verified visually by trained personnel using documented inspection and maintenance procedures. Representative carbon sample obtained from both beds. | A handheld monitor is used to check for leaks in the vapor collection system during loading operations. |
| B. Verification of Operational Status | NA | NA | NA |
| C. QA/QC Practices and Criteria | Pressure transmitter is calibrated annually. | Personnel are trained on inspection and maintenance procedures and proper frequencies. | Follow procedures in 40 CFR 60, Appendix A, Method 21. |
| D. Monitoring Frequency | Continuously during each regeneration cycle. | Varies. Carbon testing performed annually. | Monthly. |

(TABLE A.24-1. Continued.)

| | Indicator No. 1 | Indicator No. 2 | Indicator No. 3 |
|---|---|---|---|
| Data Collection Procedures | The data acquisition system (DAS) records the pressure profile during each regeneration cycle. Periods when the interlock system shuts down the loading rack also are recorded. | Results of inspections and any maintenance necessary are recorded in VRU operating log. Results of carbon testing are maintained onsite. | Records of inspections, leaks found, leaks repaired. |
| Averaging period | None. | None. | None. |
| APCD Bypass Monitoring: | The pressure in the VRU vapor line is monitored with a pressure transmitter to ensure bypass of the control device is not occurring. If the pressure in the VRU vapor line exceeds 18 inches of water, the safety relief valve opens and bypass occurs. All instances of control device bypass are recorded. | | |

MONITORING APPROACH JUSTIFICATION

## I. Background

The pollutant specific emissions unit (PSEU) is a vacuum regenerative carbon adsorber used to reduce VOC emissions from the loading of petroleum products (heating oil, diesel fuel, and gasoline). (Note: This facility is not a major source of HAP emissions and is not subject to 40 CFR 63, Subpart R, "National Emission Standards for Gasoline Distribution Facilities" or 40 CFR 60, Subpart XX, "Standards of Performance for Bulk Gasoline Terminals.")

The carbon adsorber has two identical beds, one adsorbing while the other is desorbing on a 15-minute cycle. Carbon bed regeneration is accomplished with a combination of high vacuum and purge air stripping which removes previously adsorbed gasoline vapor from the carbon and restores the carbon's ability to adsorb vapor during the next cycle. The vacuum pump extracts concentrated gasoline vapor from the carbon bed and discharges into a separator. Non-condensed gasoline vapor plus gasoline condensate flow from the separator to an absorber column which functions as the recovery device for the system. In the absorber, the hydrocarbon vapor flows up through the absorber packing where it is liquefied and subsequently recovered by absorption. Gasoline product from a storage tank is used as the absorbent fluid. The recovered product is returned along with the circulating gasoline back to the product storage tank A small stream of air and residual vapor exits the top of the absorber column and is recycled to the on-stream carbon bed where the residual hydrocarbon vapor is re-adsorbed.

## II. Rationale for Selection of Performance Indicators

The carbon adsorber system was custom-designed specifically for this installation based on the maximum expected loading and types of products loaded. The carbon beds and vacuum pump were sized appropriately. The vacuum profile during regeneration is an important variable in the performance of the VRU. If the carbon bed is overloaded, the time to achieve certain vacuum levels will be longer, and the bed will not be fully regenerated during the 15-minute cycle. Monitoring of the vacuum profile during regeneration, coupled with regular inspection and maintenance activities (including, daily verification of proper valve timing, cycle time, gasoline flow, and purge air flow) and annual testing of a carbon sample from each bed, serves to verify that the VRU is operating properly and provide a reasonable assurance of compliance.

A monthly leak inspection program is performed to ensure that the vapors released during loading are captured and conveyed to the VRU. A handheld monitor is used to detect leaks in the vapor collection system. The VRU's relief valve in the VRU vapor line also is monitored to ensure the control device is not bypassed. Bypass occurs when the pressure in the vapor line exceeds the safe limit.

## III. Rationale for Selection of Indicator Ranges

An engineering analysis was performed based on the worst case loading conditions expected. That analysis shows that if the regenerating carbon bed stays at or below -27 in Hg for at least 2.5 minutes the bed will be properly regenerated and will have the capacity to meet the VOC emissions limit under worst case loading conditions. Therefore, an excursion occurs when the regenerating bed does not stay at or below -27 in. Hg for at least 2.5 minutes. The expected vacuum profile during heavy loading is presented in Table A.24-2. All excursions will be documented and reported. An interlock system is used to shut down loading operations when an excursion occurs. Typical operating data show that the beds stay at or below -27 in. Hg for more than 5 minutes of the regeneration cycle, as shown in Table A.24-3.

The most recent performance test showed emissions of 3.8 mg/liter of gasoline loaded, less than 10 percent of the VOC limit. The unit's efficiency was calculated as 99.99 percent. The exhaust concentration equivalent of 45 mg/L loaded calculated at the time of the performance test was approximately 33,100 ppmv VOC. Table A.24-4 shows exhaust VOC concentration data for both beds collected over a period of several weeks using a portable VOC analyzer. The data show the carbon adsorber operated well under the VOC emission limit.

TABLE A.24-2. WORST-CASE MODELED VACUUM PROFILE (HEAVIEST LOADING)

| Minute | Inches Hg Vacuum |
|---|---|
| 1 | 14.0 |
| 2 | 19.6 |
| 3 | 22.3 |
| 4 | 24.3 |
| 5 | 25.0 |
| 6 | 25.3 |
| 7 | 25.6 |
| 8 | 26.0 |
| 9 | 26.2 |
| 10 | 26.5 |
| 11 | 26.8 |
| 12 | 27.0 |
| 13 | 27.3 |
| 13:30 | 27.5 |
| 14-15 | At 13:30, the bed is re-pressurized. |

TABLE A.24-3. TYPICAL VACUUM PROFILE DURING REGENERATION CYCLE

| Bed 1 | | Bed 2 | |
|---|---|---|---|
| Minute | Inches Hg Vacuum | Minute | Inches Hg Vacuum |
| 1 | 12.5 | 1 | 10 |
| 2 | 20.5 | 2 | 18 |
| 3 | 24 | 3 | 23 |
| 4 | 25 | 4 | 26 |
| 5 | 26 | 5 | 27.5 |
| 6 | 26.5 | 6 | 27.6 |
| 7 | 26.8 | 7 | 27.6 |
| 8 | 27 | 8 | 27.7 |
| 9 | 27.1 | 9 | 27.8 |
| 10 | 27.1 | 10 | 27.8 |
| 11 | 27.2 | 11 | 27.9 |
| 12 | 27.3 | 12 | 27.9 |
| 13 | 27.4 | 13 | 28 |
| 14 | At 13:30, the bed is re-pressurized. | 14 | At 13:30, the bed is re-pressurized. |
| 15 | | 15 | |

TABLE A.24-4. SAMPLE WEEKLY EXHAUST VOC CONCENTRATION DATA

| Week | Bed 1 (ppmv) | Bed 2 (ppmv) |
|---|---|---|
| 1 | 6,000 | 6,500 |
| 2 | 4,800 | 5,200 |
| 3 | 7,900 | 5,100 |
| 4 | 8,450 | 6,240 |
| 5 | 9,000 | 6,450 |
| 6 | 9,500 | 11,000 |
| 7 | 9,110 | 7,500 |
| 8 | 10,000 | 8,000 |
| 9 | 12,000 | 9,500 |
| 10 | 8,000 | 6,500 |

For the second indicator, an inspection and maintenance program is conducted, following documented procedures. This program is performed by terminal operators and contracted maintenance personnel. The results of all inspections and any maintenance performed are recorded in the VRU operating log. An excursion is defined as failure to conduct or document the required inspections or maintenance activities or failure to initiate corrective action within 24 hours to correct any problems identified during the inspection. All excursions will be documented and reported.

For the third indicator, an excursion is defined as detection of a leak greater than or equal to 10,000 ppm (as methane) during normal loading operations. If a leak is detected, corrective action will be initiated, and the leak will be repaired within 15 days. All excursions will be documented and reported. Control device bypass also is monitored. Bypass occurs when the pressure in the VRU vapor line exceeds 18 inches of water and the safety relief valve opens. All instances of control device bypass are recorded.

(Note: If an additional level of confidence in the monitoring approach were desired [e.g., if the unit had a small margin of compliance with the VOC limit], one option would be to require periodic [e.g., quarterly] testing at the carbon bed outlet with a portable VOC analyzer in lieu of the annual carbon testing.)

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# A.25 ELECTROSTATIC PRECIPITATOR (ESP) FOR PM CONTROL--FACILITY FF

EXAMPLE COMPLIANCE ASSURANCE MONITORING
ELECTROSTATIC PRECIPITATOR (ESP) FOR PM CONTROL: FACILITY FF

# I. Background

## A. Emissions Unit

| | |
|---|---|
| Description: | Coal-fired boilers |
| Identification: | B001, B002, B003 |
| APCD ID: | ESP1, ESP2, ESP3 |
| Facility: | Facility FF<br>Anytown, USA |

## B. Applicable Regulation, Emissions Limit, and Monitoring Requirements

| | |
|---|---|
| Regulation: | Permit, State regulation |
| Emissions Limits:<br>PM: | 0.137 lb/mmBtu |
| Current monitoring requirements: | None. |

## C. Control Technology: Electrostatic precipitator.

# II. Monitoring Approach

The key elements of the monitoring approach, including the indicators to be monitored, indicator ranges, and performance criteria are presented in Table A.25-1. Secondary voltage and current are monitored in each field and the power input to each ESP is determined.

TABLE A.25-1. MONITORING APPROACH

| | |
|---|---|
| I. Indicator | ESP secondary voltage and current are measured for each field to determine the power to each ESP. |
| Measurement Approach | The secondary voltage is measured using a voltmeter and the secondary current is measured using an ammeter. The total power (P) input to the ESP is the sum of the products of the secondary voltage (V) and current (I) in each field. ($P = V_1I_1 + V_2I_2$) |
| II. Indicator Range | An excursion is defined as an ESP power input less than 15 kW. Excursions trigger an inspection, corrective action, and a reporting requirement. |
| III. Performance Criteria<br>A. Data Representativeness | The voltage and current are measured using the instrumentation the manufacturer provided with the ESP. |
| B. Verification of Operational Status | NA |
| C. QA/QC Practices and Criteria | Confirm the meters read zero when the unit is not operating. |
| D. Monitoring Frequency | The secondary voltage and current are measured continuously and used to calculate the power input every 15 minutes. |
| Data Collection Procedures | The hourly average power input is calculated and recorded. |
| Averaging period | 1 hour. |

## MONITORING APPROACH JUSTIFICATION

### I. Background

The pollutant-specific emissions units are three 2-field ESP's controlling three coal-fired boilers. Boiler Nos. 1 and 3 are rated at 120,000 pounds of steam per hour and Boiler No. 2 is rated at 50,000 pounds of steam per hour. The three boilers are not subject to any New Source Performance Standards (NSPS). Boiler No. 1 typically operates from December through February, Boiler No. 2 typically operates from March through November, and Boiler No. 3 typically operates from December through March. The boilers normally are not operated at full capacity, but all emissions test have been performed at or near full load. These units are not "large" CAM sources (their post-control PM emissions are less than 100 tons per year) so continuous monitoring is not required.

### II. Rationale for Selection of Performance Indicators

In an ESP, electric fields are established by applying a direct-current voltage across a pair of electrodes, a discharge electrode and a collection electrode. Particulate matter suspended in the gas stream is electrically charged by passing through the electric field around each discharge electrode (the negatively charged electrode). The negatively charged particles then migrate toward the positively charged collection electrodes. The particulate matter is separated from the gas stream by retention on the collection electrode. Particulate is removed from the collection plates by shaking or rapping the plates.

As a general rule, ESP performance improves as total power input increases. This relationship is true when particulate matter and gas stream properties (such as PM concentration, size distribution, resistivity, and gas flow rate) remain stable and all equipment components (such as rappers, plates, wires, hoppers, and transformer-rectifiers) operate satisfactorily. In an ESP with many fields, the power distribution also plays a key role in the performance of the ESP. In this case, however, measurement of total power input is acceptable because the ESP has only two fields.

The secondary voltage drops when a malfunction, such as grounded electrodes, occurs in the ESP. When the secondary voltage drops, less particulate is charged and collected. Also, the secondary voltage can remain high but fail to perform its function if the collection plates are not cleaned, or rapped, appropriately. If the collection plates are not cleaned, the current drops. Thus, since the power is the product of the voltage and the current, monitoring the power input will provide a reasonable assurance that the ESP is functioning properly. In other words, problems that would be detected by monitoring other parameters individually also will be manifested in the power input.

## III. Rationale for Selection of Indicator Ranges

The total power input to the ESP is the sum of the products of the secondary voltage and secondary current for each field. An excursion is defined as an hourly average ESP power input less than 15 kW. When an excursion occurs, corrective action will be initiated, beginning with an evaluation of the occurrence to determine the action required to correct the situation. All excursions will be documented and reported.

The indicator range for the ESP power was selected based upon the level indicated from recent operation. The normal operating voltage is set at the highest level achievable without having an excessive spark rate. Based on field experience, power levels less than 5 kW during normal operation result in opacity readings that approach 20 percent (typically the opacity of the ESP exhaust is less than 5 percent). During abnormal operation or malfunction, the ESP power levels are appreciably lower than normal operational levels. Table A.25-2 shows that during normal operating conditions, the total ESP power input for boiler No. 2 typically is between 18 and 22 kW. If one field in the ESP goes out of service, the total power input drops below 15 kW.

The opacity normally is below 5 percent. The opacities were measured using a continuous opacity monitor installed in the boiler exhaust stack; however, the equipment does not meet the criteria in 40 CFR 60, Appendix B, Performance Specification 1. Therefore, it is not used for compliance monitoring. In addition, compliance with the boiler's 20 percent opacity limit would not necessarily indicate compliance with the PM limit, and continuous opacity monitoring is not required of this source.

TABLE A.25-2. BOILER NO. 2 NORMAL OPERATING CONDITIONS

| Time | Total ESP Power (kW) | Boiler Load (lb/hr) | Opacity, percent |
|---|---|---|---|
| 1:00 AM | 21 | 46,000 | 1.9 |
| 3:00 AM | 21 | 47,000 | 2.0 |
| 5:00 AM | 18 | 50,000 | 1.9 |
| 7:00 AM | 18 | 47,000 | 2.0 |
| 9:00 AM | 21 | 46,000 | 1.9 |
| 11:00 AM | 22 | 44,000 | 1.7 |
| 1:00 PM | 21 | 44,000 | 1.7 |
| 3:00 PM | 20 | 44,000 | 2.1 |
| 5:00 PM | 21 | 46,000 | 1.9 |
| 7:00 PM | 21 | 50,000 | 1.9 |
| 9:00 PM | 21 | 47,000 | 2.0 |
| 11:00 PM | 21 | 46,000 | 1.9 |

The PM emissions measured during the most recent performance tests are between 4 and 22 percent of the emissions limit (0.137 lb/mmBtu); each ESP has a large margin of compliance with the PM limit. Table A.25-3 presents data from the past six performance tests.

TABLE A.25-3. PERFORMANCE TEST DATA

| Boiler No. | Test Date | Average PM Emission Rate (lb/mmBtu) | Percent of Allowable PM Emissions Rate (%) | Average load (lb steam/hr) | Capacity (lb steam/hr) |
|---|---|---|---|---|---|
| 2 | 1997 | 0.020 | 14.6 | 47,600 | 50,000 |
| 1 | 1997 | 0.030 | 21.9 | 115,500 | 120,000 |
| 2 | 1994 | 0.017 | 12.4 | 51,800 | 50,000 |
| 3 | 1994 | 0.015 | 10.9 | 120,900 | 120,000 |
| 2 | 1991 | 0.006 | 4.4 | 51,400 | 50,000 |
| 1 | 1991 | 0.013 | 9.5 | 114,500 | 120,000 |

# A.27 FLUE GAS RECIRCULATION (FGR) FOR $NO_X$ CONTROL--FACILITY HH

# EXAMPLE COMPLIANCE ASSURANCE MONITORING
# FLUE GAS RECIRCULATION FOR $NO_X$ CONTROL: FACILITY HH

I. Background

A. Emissions Unit

| | |
|---|---|
| Description: | 187 mmBtu/hr boiler |
| Identification: | Unit 026 |
| Facility: | Facility HH<br>Anytown, USA |

B. Applicable Regulation, Emissions Limit, and Monitoring Requirements

| | |
|---|---|
| Regulation: | 40 CFR 60, Subpart Db; State regulation |
| Emissions Limits:<br>$NO_X$: | <br>0.20 lb/mmBtu |
| Monitoring Requirements: | $NO_x$ predictive emissions monitoring system (PEMS), position of flue gas recirculation damper |

C. Control Technology: Flue gas recirculation (FGR)

II. Monitoring Approach

The key elements of the monitoring approach, including the indicators to be monitored, indicator ranges, and performance criteria are presented in Table A.27-1. The parameters monitored are the exhaust gas oxygen concentration, fuel flow, and the FGR damper position.

## TABLE A.27-1. MONITORING APPROACH

| | Indicator No. 1 | Indicator No. 2 | Indicator No. 3 |
|---|---|---|---|
| I. Indicator | Fuel flow rate | Boiler exhaust $O_2$ concentration | FGR damper position |
| Measurement Approach | The hourly fuel flow rate is monitored as an input to the PEMS model.[1] Fuel heat content is obtained from the fuel supplier. (Steam output is used to predict heat input if fuel flow data are unavailable.) | The boiler exhaust gas $O_2$ concentration, used as a check of the boiler operating condition, is measured at the boiler outlet. | The position of the FGR damper is determined by the notch indicator. |
| II. Indicator Range | An excursion is defined as predicted $NO_x$ emissions greater than 0.05 lb/mmBtu (rolling 30-day average). Excursions trigger an inspection, corrective action, and a reporting requirement. | An excursion is defined as a boiler exhaust oxygen concentration greater than 3.3 percent (rolling 30-day average). Excursions trigger an inspection, corrective action, and a reporting requirement. | An excursion occurs when the FGR damper is closed further than 4 notches from the bottom. Excursions trigger an inspection, corrective action, and a reporting requirement. |
| III. Performance Criteria<br>A. Data Representativeness | Fuel oil flow rate is measured with a positive displacement flow meter with a minimum accuracy of ±0.5 percent of the flow rate. The natural gas flow rate is measured with an orifice plate flow meter with a minimum accuracy of ±1 percent of the flow rate. | The in-situ $O_2$ monitor has a minimum accuracy of <2 percent calibration error to zero and upscale reference gases. | The FGR damper position is checked visually by an operator. |
| B. Verification of Operational Status | NA | NA | NA |
| C. QA/QC Practices and Criteria | Annual calibration of fuel flow meters (acceptance criteria: ±1 percent).<br>Annual relative accuracy test of the PEMS (acceptance criteria: <20 percent).<br>Data availability criteria: 75 percent of the operating hours and the operating days. | Weekly zero and upscale calibration of $O_2$ monitor. | None. |
| D. Monitoring Frequency | Fuel flow rate is monitored continuously. The $NO_x$ emission rate is calculated hourly and daily using the PEMS model. | The boiler exhaust $O_2$ concentration is monitored continuously. | The position of the FGR damper is checked by an operator on a daily basis. |

(TABLE A.27-1. Continued.)

| | Indicator No. 1 | Indicator No. 2 | Indicator No. 3 |
|---|---|---|---|
| Data Collection Procedures | The data acquisition system (DAS) records the hourly and 30-day rolling $NO_x$ emission rates calculated using the PEMS model. | The DAS records the exhaust gas $O_2$ concentration hourly. | The position of the FGR damper is recorded daily in the boiler operating log. |
| Averaging period | Fuel flow rate: Hourly.<br>$NO_x$ emission rate: Hourly and 30-day rolling. | Hourly and 30-day rolling. | NA. |

[1] PEMS algorithm:

heat input, mmBtu/hr = fuel flow rate * fuel heat content

For heat input values equal to or greater than 45 mmBtu/hr:

$NO_x$, lb/hr = 0.0002 * (heat input, mmBtu/hr)$^2$ + 0.0101 * (heat input, mmBtu/hr) + 0.8985

$NO_x$, lb/mmBtu = ($NO_x$, lb/hr) / (mmBtu/hr)

For heat input values less than 45 mmBtu/hr:

$NO_x$, lb/hr = 0.0379 * (heat input, mmBtu/hr)

$NO_x$, lb/mmBtu = ($NO_x$, lb/hr) / (mmBtu/hr)

DRAFT

# MONITORING APPROACH JUSTIFICATION

## I. Background

The pollutant specific emissions unit is a 187 mmBtu/hr boiler fired with fuel oil and natural gas. The boiler is equipped with low-$NO_x$ burners and FGR and is subject to 40 CFR 60, Subpart Db. A PEMS is used in lieu of a continuous emissions monitoring system (CEMS) to calculate $NO_x$ emissions. The parameters monitored for this PEMS are based on this specific application. Other PEMS might be designed to monitor different combinations of operating parameters to meet the accuracy criteria.

## II. Rationale for Selection of Performance Indicators

A properly designed, operated, and validated PEMS provides accurate emissions data. This PEMS was developed from data collected over a 30-day period. An additional 75-day PEMS/CEMS comparison was conducted to verify the validity of the PEMS model. During the 75-day test, measured $NO_x$ emissions averaged 2.8 lb/hr and predicted emissions averaged 3.0 lb/hr.

The limits on boiler exhaust $O_2$ concentration and the FGR damper position are to ensure the boiler operates within the operating envelope used during the PEMS development. A definite correlation exists between boiler $O_2$ and $NO_x$. As the combustion process is starved for air (i.e., fuel rich with low $O_2$) the combustion temperature is lower and the amount of $NO_x$ produced is lower. During the PEMS development, the position of the FGR damper was found to have an impact on $NO_x$ emissions. The position of the FGR damper is an indication of the amount of air recirculated to the primary combustion zone. As the damper is moved toward the closed position, the $NO_x$ emissions increase.

## III. Rationale for Selection of Indicator Ranges

For the $NO_x$ emission rate, an excursion is defined as predicted $NO_x$ emissions greater than 0.05 lb/mmBtu (rolling 30-day average). This boiler is operated with a large margin of compliance and the indicator range is set at 25 percent of the $NO_x$ emissions limit so corrective action may be taken before the 0.20 lb/mmBtu emission limit is exceeded. During the 30-day emission test, the average $NO_x$ emission rate was 0.0373 lb/mmBtu and no single hourly average exceeded 0.05 lb/mmBtu or 9.34 lb/hr.

For the boiler exhaust oxygen concentration, an excursion is defined as a concentration greater than 3.3 percent (rolling 30-day average). Since, during the 30-day development and 75-day verification periods, the average $O_2$ did not exceed 3.3 percent (except for startup and shutdown), the assumption that the PEMS maintains its accuracy at $O_2$ levels below 3.3 percent is reasonable. For the FGR damper, an excursion occurs when the FGR damper is closed further than 4 notches from the bottom. Because the FGR damper was set at notch position 4 during the PEMS development testing, the FGR damper must be closed no further than that position in order to maintain the accuracy of the PEMS. If the FGR damper is closed further than notch 4, less flue gas will be returned to the boiler and the PEMS will predict $NO_x$ emissions that are lower than the actual emissions.

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