A.16 CONTROL DEVICE (BOILER) BYPASS – FACILITY R

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EXAMPLE COMPLIANCE ASSURANCE MONITORING
CONTROL DEVICE (BOILER) BYPASS – FACILITY R

I. Background

A. Emissions Unit

Description:	APCD (boiler) bypass valve
Identification:	East and West boilers
Facility:	Facility R Anytown, USA

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

Regulation:	Permit, State regulation
Emissions Limits: CO:	 200 ppm
Monitoring Requirements:	Temperature downstream of bypass valve.

C. Control Device

Two boilers in parallel.

II. Monitoring Approach

The key elements of the bypass monitoring approach are presented in Table A.16-1. The selected indicators are the temperatures in the horizontal and vertical portions of the bypass line downstream of the boiler bypass valve. The temperatures are measured continuously; instantaneous temperature values are recorded every 15 minutes.

Note: This compliance assurance monitoring example is presented as an illustration of one approach to monitoring for control device bypass. The example presents only the parameters monitored to ensure the control device is not being bypassed. Parameters to ensure the control device is operating properly also are monitored, but are not discussed in this example.

TABLE A.16-1. BYPASS MONITORING APPROACH

I. Indicator	Vertical and horizontal bypass line temperatures
Measurement Approach	Thermocouples downstream of bypass valve.
II. Indicator Range	An excursion is defined as a vertical line temperature of greater than 550˚F or a horizontal line temperature of greater than 250˚F. An excursion shall trigger an inspection, corrective action as necessary, and a reporting requirement.
III. Performance Criteria A. Data Representativeness	Gas temperature is measured using thermocouples in two locations downstream of the bypass valve, prior to the common exhaust stack. The minimum accuracy of the thermocouples is 2.2˚C (±4˚F) or ±0.75 percent of the temperature measured in ˚C, whichever is greater.
B. Verification of Operational Status	NA
C. QA/QC Practices and Criteria	The thermocouples are checked annually with a redundant temperature sensor. Acceptance criteria: ±15˚F of the measured value.
D. Monitoring Frequency	The temperatures are measured and recorded every 15 minutes.
Data Collection Procedures	The temperatures are recorded by the computer control system every 15 minutes.
Averaging period	None.

MONITORING APPROACH JUSTIFICATION

I. Background

The FCCU regenerator flue gas contains approximately 10 percent CO by volume, and is referred to as "CO gas." The CO gas is routed to two tangentially-fired boilers (East and West) in parallel, designed with sufficient residence time, turbulence, and temperature to fully combust the CO to CO_2. The exhaust from each boiler enters a common stack, where an emission limit of 200 ppm CO must be met. The FCCU regenerator is equipped with piping that enables the CO gas to bypass the boilers and flow directly to the common stack. Use of the bypass line is essential for the safe operation of the boilers during startup and shutdown periods. The piping is equipped with a butterfly valve. The position of this valve is monitored by the computer control system, and is kept fully closed during normal operation. The operators routinely pack the valve with ceramic fiber insulation to prevent leaks. A process schematic is shown in Figure A.16-1.

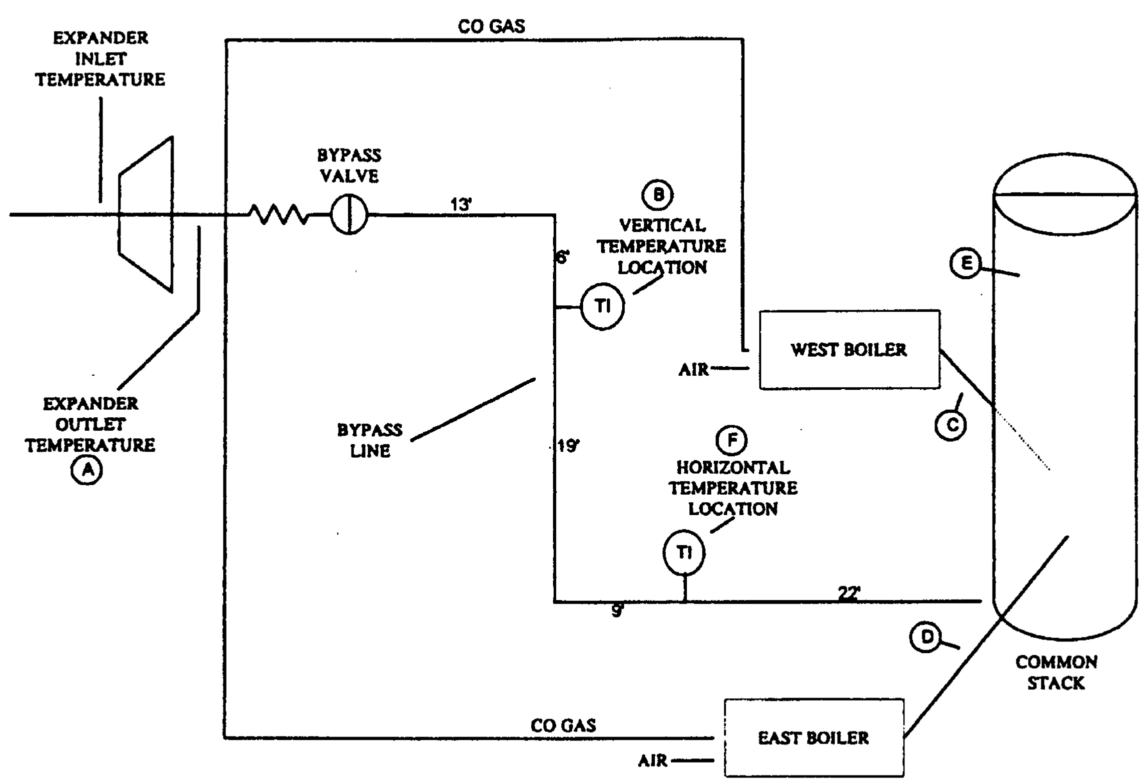

Figure A.16-1. Process schematic.

II. Rationale for Selection of Performance Indicator

Although the bypass valve position is computer-controlled, it has a tendency to leak if not tightly packed with insulation. Therefore, the operators need an indicator to detect leakage of the valve that might cause excess CO emissions. Testing was performed to determine the effect of boiler load on CO emissions. The results showed the boilers emitted negligible CO regardless of operating load. The effect of a leaky valve on CO emissions (measured in the stack) and the gas temperature downstream of the bypass valve then was examined. The results showed that as the amount of valve leakage increases and the CO concentration in the common stack increases, the temperature downstream of the valve also increases because of the high temperature of the CO gas (the temperature of the CO gas upstream of the valve is approximately 960˚F). Therefore, the selected indicator of a leaky or open bypass valve is the temperature downstream of the bypass valve.

III. Rationale for Selection of Indicator Range

A test program was conducted to determine the relationship between the gas temperature downstream of the bypass valve and the CO emissions. The gas temperature in the bypass line and the CO concentration in the common stack were measured at baseline conditions (no leakage) and for eight different leak conditions. Temperature was measured at two locations: the vertical section of the bypass line (19 feet downstream of the valve) and the horizontal section of the bypass line (47 feet downstream of the valve). During normal conditions, when the CO level in the common stack was less than 50 ppm, the temperature in the vertical section was roughly 410˚F, while the temperature in the horizontal section was 110˚F.

To induce leakage of the valve, the valve was opened 5 percent on day 1 and 3 percent on day 2, and immediately closed. The packing material broke loose during each opening. On inducing the leaks, the temperature downstream of the valve rose quickly and eventually reached a stable temperature. To evaluate the effect of adding packing to the valve on downstream temperatures and CO levels in the common stack, the valve was progressively packed with ceramic fiber insulation and allowed to stabilize. The level of CO in the stack and the downstream temperatures decreased with the amount of insulation added.

For each of the seven test runs or conditions, multiple data points were collected and recorded for the temperatures and the CO concentrations. Rather than calculating the average as the representative value for each run as is traditionally done with performance test data, a percentile measure was determined from the data for each run. The percentile value for temperature and for CO concentration were selected independently. All of the temperature readings for the run were ranked from lowest to highest, and the value that coincides with the 5th percentile for all of the temperature readings for that run was selected. Then, all of the CO concentration readings for the run were ranked lowest to highest, and the value that coincides with the 95th percentile for all of the CO concentration readings for that run was selected. These percentile values were selected to represent the test run instead of an average value. Table A.16-2 shows a summary of the readings for each test condition or run; both the average values and the percentile values are shown. Table A.16-2 shows data for the vertical duct temperature, horizontal duct temperature, and CO concentration for each test condition.

Figures A.16-2 and A.16-3 show the relationship between CO emissions and the gas temperature at the horizontal and vertical locations. The 5^{th} percentile temperature readings reflect levels at the lower end of the range for each condition that can alert the boiler operator to bypass valve leakage. Conversely, since the CO levels varied during each test condition, the 95^{th} percentile CO levels for each test condition were selected to be conservative (on the high side). For added confidence, indicator ranges were developed for both measurement locations (it is expected that the two thermocouples will not fail at the same time). Based on the data collected during testing, an excursion is defined as a vertical duct temperature of greater than 550˚F or a horizontal duct temperature of greater than 250˚F. An excursion will trigger an inspection, corrective action as necessary, and a reporting requirement.

TABLE A.16-2. SUMMARY OF TEMPERATURE AND CO EMISSIONS LEVELS DURING TEST CONDITIONS

Condition	Test Period (minutes)	Vertical Temperature Readings (°F)		Horizontal Temperature Readings (°F)		CO Level (ppmvd at 50% excess air)	
		Average	5^{th} Percentile	Average	5^{th} Percentile	Average	95^{th} Percentile
Baseline -- Normal operation, minimal leakage	222	410	405	112	109	39.5	44.5
Open1 -- Open/close bypass valve to force leakage (day 2)	8	*Transient Data Period*					
Leak -- Monitoring period following valve open/close	98	683	641	463	426	351	358
Pack1 -- Monitoring period after one tube of packing was injected into valve	10	*Transient Data Period*					
Pack2 -- Monitoring period after a second tube of packing was injected	57	676	671	453	449	229	230
Pack3 -- Monitoring period after a third tube of packing was injected	1084	634	629	341	307	169	191
Pack 45 -- Monitoring period after a fourth and fifth tube of packing was injected	176	482	443	179	160	30.0	35.7
Open 2 -- Close/open bypass valve to force leakage a second time (day 3)	9	*Transient Data Period*					
Leak 2 -- Monitoring period following valve open/close #2	105	641	604	443	411	242	248
Pack1X -- Monitoring period after one tube of packing was injected into valve after Leak 2	20	*Transient Data Period*					
Pack 2X -- Monitoring period after a second tube of packing was injected into valve after Leak2	122	588	577	397	389	123	127

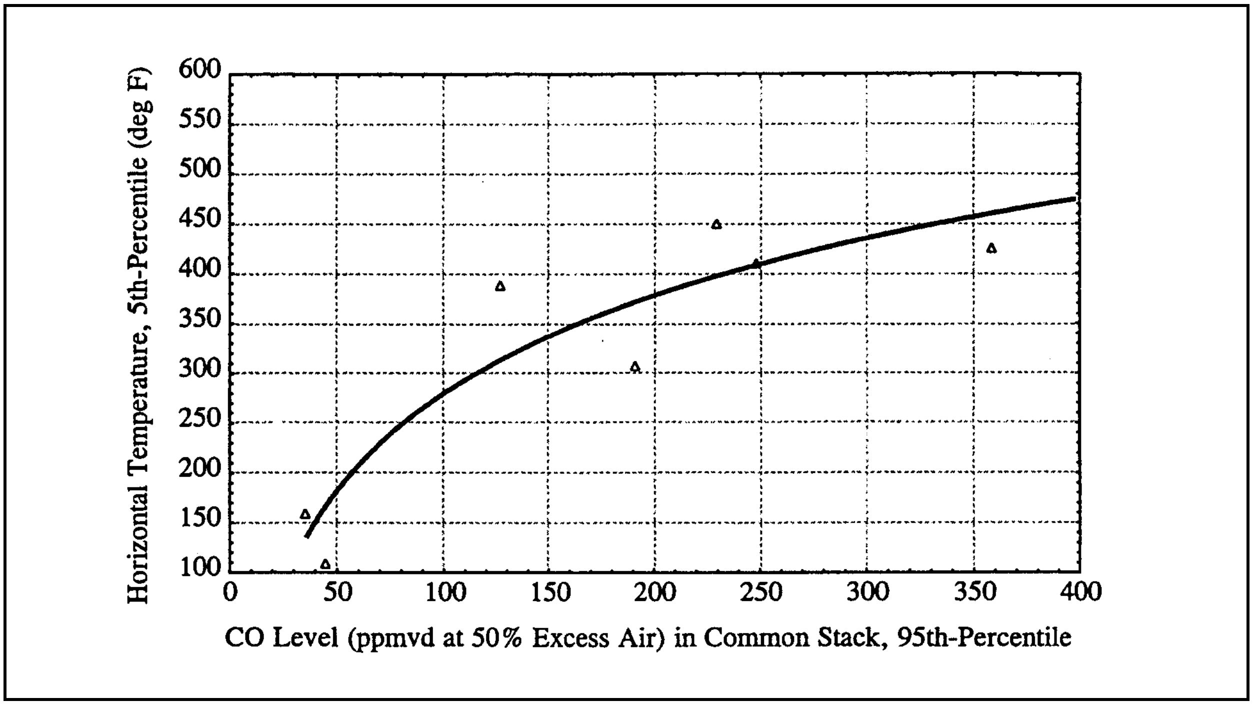

Figure A.16-2. CO Level (95th Percentile) in the Common Stack vs. Horizontal Temperature Measurement (5th Percentile).

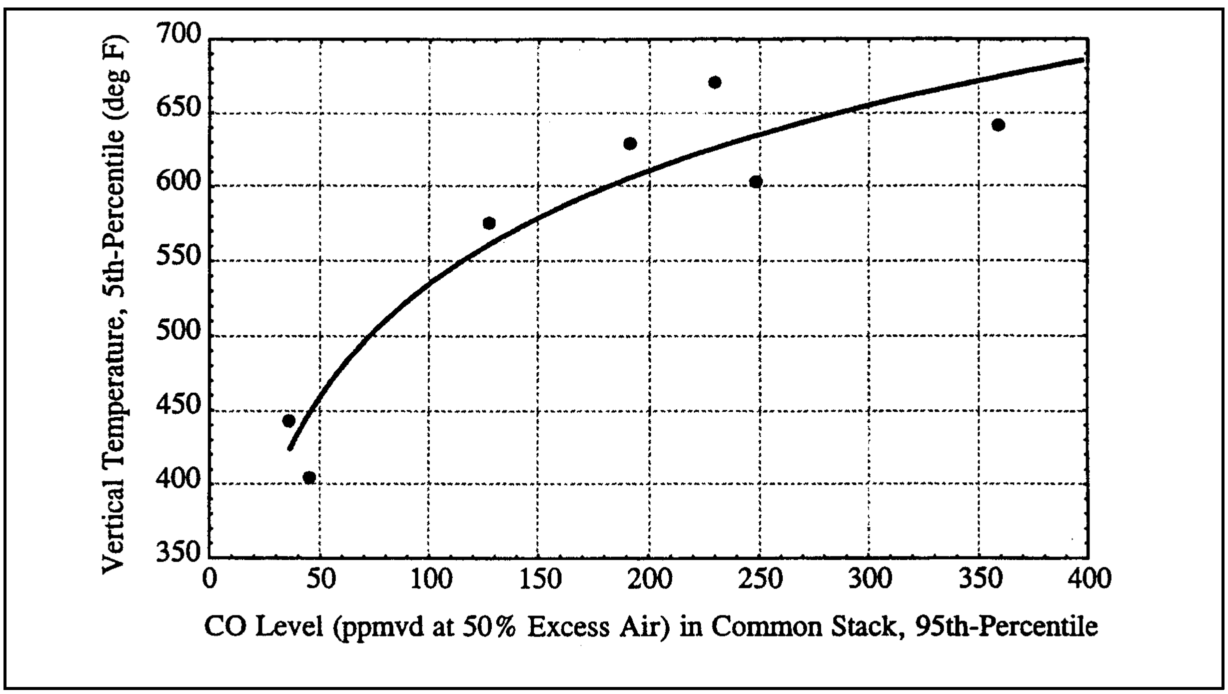

Figure A.16-3. CO Level (95th Percentile) in the Common Stack vs. Vertical Temperature Measurement (5th Percentile).

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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 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 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 weekly.	Monitoring equipment and process downtime is recorded in a log. The flow sensor is calibrated quarterly.
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

Because 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.

Comment: During the review period, one commenter suggested that this example is not complete and sufficient data to establish indicator ranges were not available. We believe this example is appropriate. State agencies are likely to receive CAM submittals, which propose indicator ranges based upon limited historical data or data from similar sources before performance testing has been conducted or additional historical monitoring data can be collected. The CAM rule, 40 CFR part 64, paragraphs 64.4(d) and (e) discuss the submittal of a schedule to obtain additional information, as is shown in this example. The draft (or final) permit can be written to accommodate a revision to the indicator range based upon the performance test results.

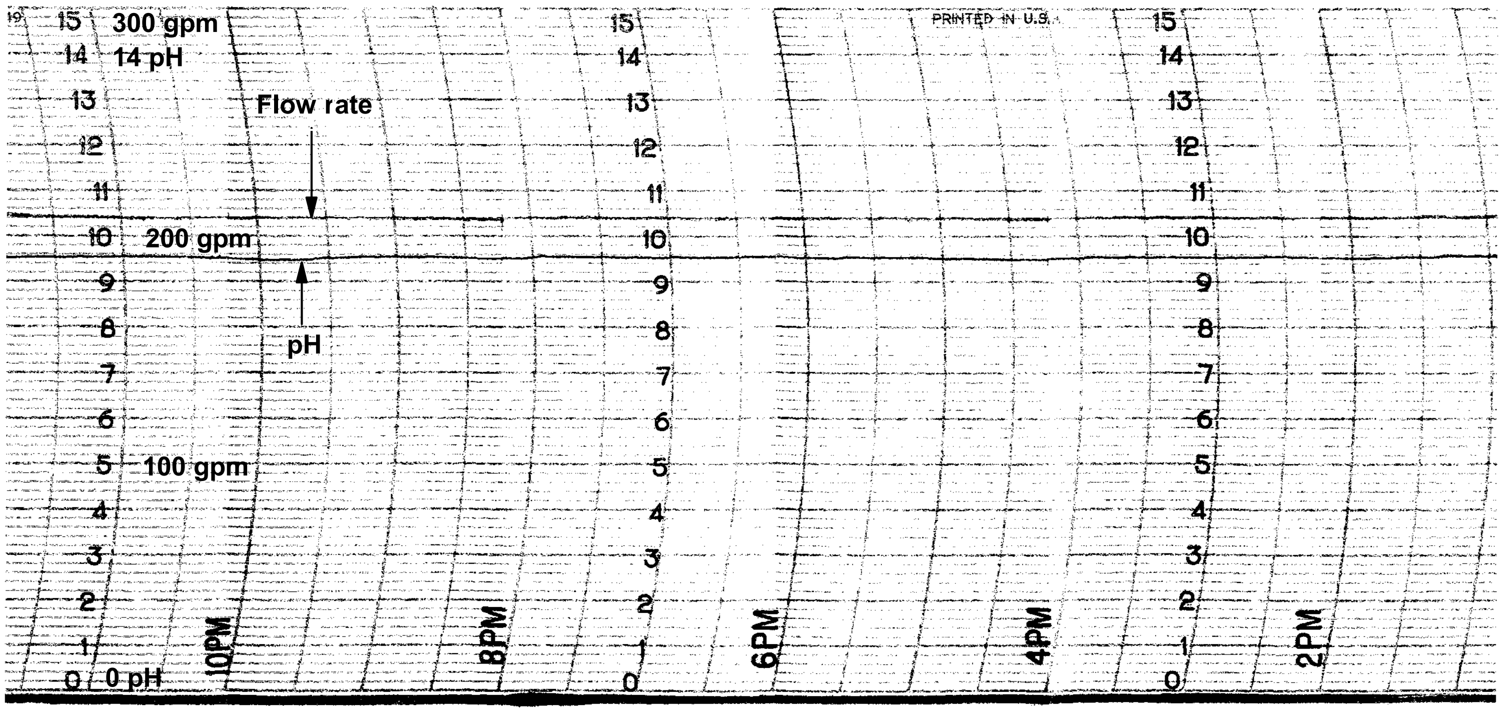

Figure 1. Typical scrubber flow rate and pH.

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

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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 Anytown, USA

B. Applicable Regulation, Emissions Limit, and Monitoring Requirements

Regulation:	40 CFR 60, Subpart Db; State regulation
Emissions Limits:	
NO_x:	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 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). Annual relative accuracy test of the PEMS (acceptance criteria: <20 percent). 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. 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)

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.