A.4 SCRUBBER FOR VOC CONTROL--FACILITY D

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EXAMPLE COMPLIANCE ASSURANCE MONITORING:
SCRUBBER FOR VOC CONTROL--FACILITY D

I. Background

A. Emissions Unit

Description:	Process tanks
Identification:	B-352-1, Vent A
Facility:	Facility D Anytown, USA

B. Applicable Regulation, Emission Limit and Monitoring Requirements

Regulation No.:	Permit
Regulated pollutant (PSEU)	VOC
Emission limit:	99 percent reduction
Monitoring requirements:	Continuously monitor water flow rate.

C. Control Technology: Packed bed scrubber

II. Monitoring Approach

The key elements of the monitoring approach for VOC, including the indicators to be monitored, indicator ranges, and performance criteria, are presented in Table A.4-1.

TABLE A.4-1. MONITORING APPROACH

	Permit Indicator No. 1
I. Indicator	Water flow rate
Measurement Approach	The water flow rate is monitored with an orifice plate and differential pressure gauge.
II. Indicator Range	An excursion is defined as a daily average scrubber water flow rate of less than 1.2 gal/min. Excursions trigger an inspection, corrective action, and a reporting requirement.
III. Performance Criteria A. Data Representativeness[a]	The orifice plate is installed in the scrubber water inlet line. The minimum accuracy is ± 0.05 gal/min.
B. Verification of Operational Status	NA
C. Quality Assurance and Control Practices	Weekly zero and quarterly upscale pressure check of transmitter.
D. Monitoring Frequency	Measured continuously.
Data Collection Procedures	Recorded once per minute.
Averaging Period	Hourly averages of 60 1-minute flow rates are calculated. A daily average of all hourly readings is calculated and recorded.

[a]Values listed for accuracy specifications are specific to this example and are not intended to provide the criteria for this type of measurement device in general.

JUSTIFICATION

I. Background

The PSEU includes the tanks in the acetic anhydride department. Emissions from seven tanks are vented to a packed bed water scrubber. Six of these tanks are batch filled and one is continuously filled. The scrubber is used to reduce VOC emissions. Maximum emissions from these tanks are 39 lb/hr. Based on the PSEU design, bypass of the control device is not possible.

II. Rationale for Selection of Performance Indicators

The emissions from the process tanks are controlled using a packed bed water scrubber using once-through water. The performance indicator selected is liquid flow to the scrubber. To achieve the required emission reduction, a minimum water flow rate must be supplied to absorb the given amount of VOC in the gas stream, given the size of the tower and height of the packed bed. The L/G ratio is a key operating parameter of the scrubber. If the L/G ratio decreases belowz 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 the required L/G ratio is achieved at all times.

III. Rationale for Selection of Indicator Ranges

The minimum water flow is based on engineering calculations using ASPEN® programming and historical data. Computer simulation (modeling) of the scrubber system was performed for the maximum gas flow rate and VOC loading to the scrubber; the water flow rate necessary for achieving control at this gas flow rate was determined. The scrubber was modeled using an equilibrium-based distillation method and two ideal stages were assumed. Ideal behavior of the gas phase was assumed; liquid phase activity coefficients were estimated from an in-house vapor-liquid equilibria data base (parameters regressed from actual vapor-liquid equilibria data and UNIFAC) using the Wilson equations for binary systems. The minimum water flow rate to the scrubber (calculated based on maximum VOC emissions and gas flow rate) was determined to be 1.1 gal/min. The water flow rate to the scrubber must be maintained at this level or higher to achieve 99 percent emission reduction.

Monitoring data were reviewed to determine the minimum scrubber water flow rate maintained during normal operation of the process tanks and scrubber. Daily average data for a 60-day period (January 17 through March 17, 1997) were reviewed. The daily average flow rate ranges from 1.18 to 1.39 gal/min with 95 percent of the values equal to or greater than 1.2 gal/min; if values greater than 1.15 are rounded to 1.2, then 100 percent of the daily averages are equal to or greater than 1.2 gal/min. Attachment 1 lists the daily average values for the 60-day period. Hourly average data for a 30-day period (February 17 through March 17) also were reviewed. The hourly averages for this period range from 1.19 to 1.21. The scrubber has been consistently operated with both the hourly and daily average water flow rate equal to or greater than 1.2 gal/min.

The selected indicator range is a minimum daily average water flow rate of 1.2 gal/min (defined as greater than 1.15 gal/min). 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 was selected by establishing the excursion level at the minimum water flow rate that has been established as the operational level and has been consistently maintained at all times as indicated by 2 months of monitoring data. This water flow rate is above the minimum level (1.1 gal/min) necessary to achieve compliance during maximum gas flow and VOC loading to the scrubber, as established through modeling. A daily average, rather than an hourly average, was selected for the indicator range because the historical data indicate that the flow rate is very constant with little hourly variation. Consequently, the daily average is a sufficient indicator of performance. No performance test has been conducted on the scrubber.

Attachment 1.
Daily average water flow to Vent A scrubber in gal/min.

DATE	TIME	32FC80
01/17/97	0:00	1.183
01/18/97	0:00	1.392
[illegible]19/97	0:00	1.211
01/20/97	0:00	1.200
01/21/97	0:00	1.200
01/22/97	0:00	1.200
01/23/97	0:00	1.200
01/24/97	0:00	1.200
01/25/97	0:00	1.200
01/26/97	0:00	1.200
01/27/97	0:00	1.200
01/28/97	0:00	1.200
01/29/97	0:00	1.200
01/30/97	0:00	1.200
01/31/97	0:00	1.200
02/01/97	0:00	1.200
02/02/97	0:00	1.200
02/03/97	0:00	1.200
02/04/97	0:00	1.200
02/05/97	0:00	1.200
02/06/97	0:00	1.200
02/07/97	0:00	1.200
02/08/97	0:00	1.200
02/09/97	0:00	1.200
02/10/97	0:00	1.200
02/11/97	0:00	1.200
02/12/97	0:00	1.200
[illegible]13/97	0:00	1.200
02/14/97	0:00	1.200
02/15/97	0:00	1.200
02/16/97	0:00	1.200
02/17/97	0:00	1.200
02/18/97	0:00	1.200
02/19/97	0:00	1.200
02/20/97	0:00	1.200
02/21/97	0:00	1.200
02/22/97	0:00	1.200
02/23/97	0:00	1.200
02/24/97	0:00	1.199
02/25/97	0:00	1.200
02/26/97	0:00	1.200
02/27/97	0:00	1.200
02/28/97	0:00	1.200
03/01/97	0:00	1.200
03/02/97	0:00	1.200
03/03/97	0:00	1.200
03/04/97	0:00	1.200
03/05/97	0:00	1.200
03/06/97	0:00	1.200
03/07/97	0:00	1.200
03/08/97	0:00	1.200
03/09/97	0:00	1.200
[illegible]0/97	0:00	1.200
03/11/97	0:00	1.200
03/12/97	0:00	1.200
03/13/97	0:00	1.200
03/14/97	0:00	1.199
03/15/97	0:00	1.200
03/16/97	0:00	1.200
03/17/97	0:00	1.200

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A.4b PACKED BED SCRUBBER FOR VOC CONTROL OF A BATCH PROCESS – FACILITY Q

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EXAMPLE COMPLIANCE ASSURANCE MONITORING:
PACKED BED SCRUBBER FOR VOC CONTROL – FACILITY Q

I. Background

A. Emissions Unit

Description:	Batch mixers and tanks used in a chemical process
Identification:	Scrubber B-67-2
Facility:	Facility Q Anytown, USA

B. Applicable Regulation, Emissions Limit, and Monitoring Requirements

Regulation:	Permit, State regulation
Emissions limit:	
VOC:	3.6 pounds per hour
Monitoring requirements:	Inlet water flow, acetic acid concentration in scrubber underflow

C. Control Technology

Packed bed scrubber

II. Monitoring Approach

The key elements of the monitoring approach for VOC are presented in Table A.4b-1. The selected indicators of performance are the scrubber inlet water flow rate and the acetic acid concentration in the scrubber water underflow. The scrubber inlet water flow rate is measured continuously and recorded twice daily. The scrubber water underflow is sampled twice daily; the acetic acid concentration of each sample is determined by titration.

TABLE A.4b-1. MONITORING APPROACH

	Indicator No. 1	Indicator No. 2
I. Indicator	Scrubber inlet water flow rate.	Acetic acid concentration in underflow.
Measurement Approach	The scrubber inlet water flow rate is measured using a radiometer.	A sample of the underflow is taken and the acetic acid concentration determined by titration.
II. Indicator Range	An excursion is defined as any operating condition where the scrubber inlet water flow rate is less than 4 gpm. An excursion will trigger an investigation of the occurrence, corrective action, and a reporting requirement.	An excursion is defined as any operating condition where the underflow acetic acid concentration is greater than 10 percent. An excursion will trigger an investigation of the occurrence, corrective action, and a reporting requirement.
III. Performance Criteria A. Data Representativeness	The scrubber inlet water flow rate is measured using a variable area flow meter (radiometer) located in the scrubber water inlet line. The minimum acceptable accuracy of the meter is ±5 percent of the measured value and the range is 0 to 15 gpm.	The acetic acid concentration in the scrubber water effluent is measured by titrating a water sample extracted from the scrubber underflow.
B. Verification of Operational Status	NA	NA
C. Quality Assurance and Control Practices	Annual calibration and cleaning of radiometer. Acceptance criteria: ±5 percent of the measured value.	Only trained personnel perform sampling and titration. Laboratory QA/QC procedures are followed. Calibration standards are prepared to ensure the sample titration is being performed accurately.
D. Monitoring Frequency	The scrubber inlet water flow rate is measured continuously and recorded twice daily.	The scrubber water outlet acetic acid concentration is measured twice daily.
Data Collection Procedures	The scrubber inlet water flow rate is recorded twice daily. (The post-control emissions from this unit are less than the major source threshold, so continuous monitoring and recording is not required.)	A water sample is taken and titrated manually with phenolphthalein and NaOH solution. (The post-control emissions from this unit are less than the major source threshold, so continuous monitoring and recording is not required.)
Averaging Period	None.	None.

MONITORING APPROACH JUSTIFICATION

I. Background

The pollutant specific emissions unit (PSEU) consists of process equipment in the cellulose esters division controlled by a packed bed scrubber. The process consists of batch mixers that are used to convert cellulose into cellulose ester. Each mixer may be started at a different time and may be used to make several batches per day. While in the mixers, the intermediate product is dissolved in acetic acid. The ester solution is transferred to storage tanks before being pumped into the next step in the process. A vent system collects the vapors from the mixers and tanks and a fan operated at constant speed pulls the vapors through the vent lines and into the scrubber. It is not possible for the gas to bypass the scrubber. The VOC load to the scrubbers in this division primarily consists of acetic acid (and other carboxylic acids).

The scrubber is 4 feet in diameter and has about 8 feet of 2-inch packing. Fresh water is sprayed at the top of the packing at 4 to 6 gpm; water from the underflow is recirculated to the middle of the scrubber. The normal exit gas flow rate is approximately 1800 acfm.

II. Rationale for Selection of Performance Indicators

A packed bed scrubber is used to reduce VOC emissions from part of a chemical manufacturing process. Both batch mixers and process tanks are vented to this scrubber. The processes in this area of the facility are mostly semi-batch operations, so the production rate at any one time varies. Therefore, it is difficult to relate the production rate to the VOC load vented to this scrubber.

To comply with the applicable emission limit, a minimum water flow rate must be supplied to the scrubber to absorb a given amount of VOC 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 help ensure that the required L/G ratio is achieved at all times. The concentration of acetic acid in the scrubber underflow can be related to the water flow rate and acetic acid emissions, based on emissions test results and process modeling.

III. Rationale for Selection of Indicator Ranges

The indicator ranges were selected based on engineering calculations using ASPEN® process modeling software, emissions test data, and historical data. Computer modeling of the scrubber system was performed for the maximum allowable VOC concentration in the scrubber exhaust; the inlet water flow rate necessary for achieving adequate control was determined for several concentrations of acetic acid in the underflow. The scrubber efficiency was calculated using data obtained from emissions testing. The scrubber was modeled using an equilibrium-based distillation method and ideal behavior of the gas phase was assumed; liquid phase activity coefficients were estimated from a Wilson parameter fit of vapor-liquid equilibria data. It was assumed that the control device delivers three actual stages of counter-current mass transfer with a recycle stream pumped from the effluent to the center of the column to ensure adequate distribution of the liquid over the packing. The engineering model was calibrated for accuracy using the results of source testing conducted while at normal operating conditions.

Figure A.4b-1 is a plot of the modeled operating conditions (inlet water flow and scrubber underflow acetic acid concentration) necessary to maintain compliance. The line represents the operating conditions at maximum allowable emissions (3.6 lb VOC/hr); the scrubber's VOC emissions are below the limit when the scrubber is operated at conditions that fall below this line. For example, operating at a scrubber water flow rate of 4 gpm with an acetic acid concentration in the scrubber underflow of 12 percent provides a margin of compliance with the permitted VOC emission rate. The selected indicator ranges for inlet water flow and underflow acetic acid concentration were chosen based on the compliance curve and normal operating conditions. The indicator range (acceptable operating range) is defined as any operating condition where the scrubber inlet water flow is greater than 4 gpm and the scrubber underflow acetic acid concentration is less than 10 percent.

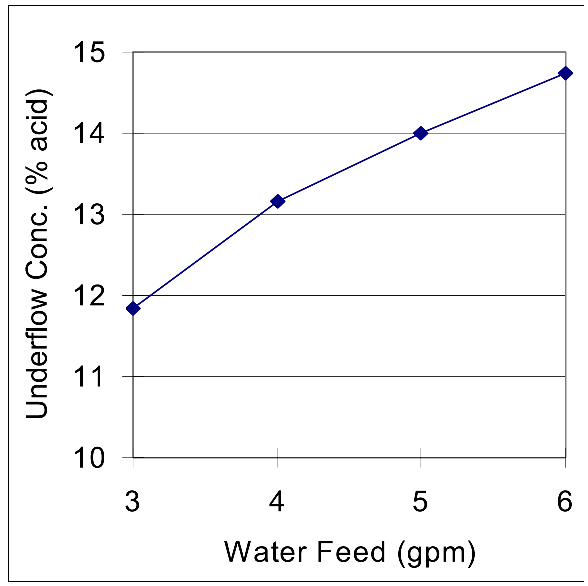

Figure A.4b-1. Compliance curve.

The 4 gpm level was chosen because it is the lower end of the preferred operating range. The 10 percent value was chosen because it is less than any point on the compliance curve (see Figure A.4b-1), and the 1997 historical data show that all measured concentration data were less than 8.4 percent (typical values were between 2 and 6 percent). When an excursion occurs (scrubber inlet water flow of less than 4 gpm and/or scrubber underflow acetic acid concentration of greater than 10 percent), 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 scrubber typically operates at a water flow rate of 4 to 6 gpm. Figure A.4b-2 shows scrubber water flow data collected in 1997. The range for the 1997 data is 3 to 9.5 gpm; the mean scrubber water flow rate was 5.3 gpm. There are four values less than 4 gpm, indicating four excursions. The bulk of the data falls between 5 and 6 gpm. Corrective action typically is taken (the flow is increased) when the scrubber water flow begins to fall below 5 gpm in order to avoid an excursion.

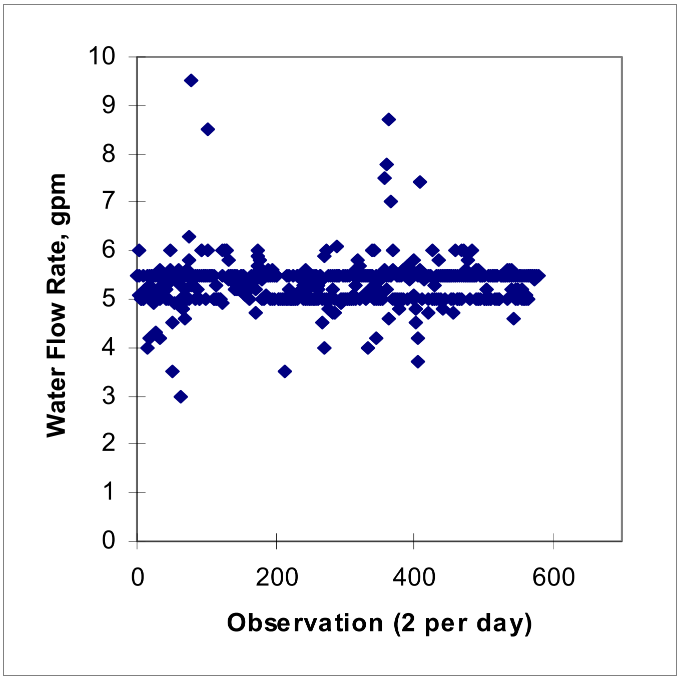

Figure A.4b-2. 1997 scrubber water flow rate data.

Historical data from 1997 show the acetic acid concentration in the underflow is typically less than 6 percent. Figure A.4b-3 shows scrubber underflow acetic acid concentration data for 1997. The maximum concentration was 8.4 percent, which is within the CAM indicator range. The mean concentration was 3.9 percent. The values decrease toward the end of the year because production was decreased due to temporary changes in the market for a key product. This further verifies the correlation between the acid concentration in the underflow and the VOC load to the scrubber. Because historical data show that the scrubber routinely operates within the indicator range, there is not much variability in the data during typical production periods, and the post-control emissions from this scrubber are below the major source threshold, the water flow rate and acid concentration are recorded only twice daily.

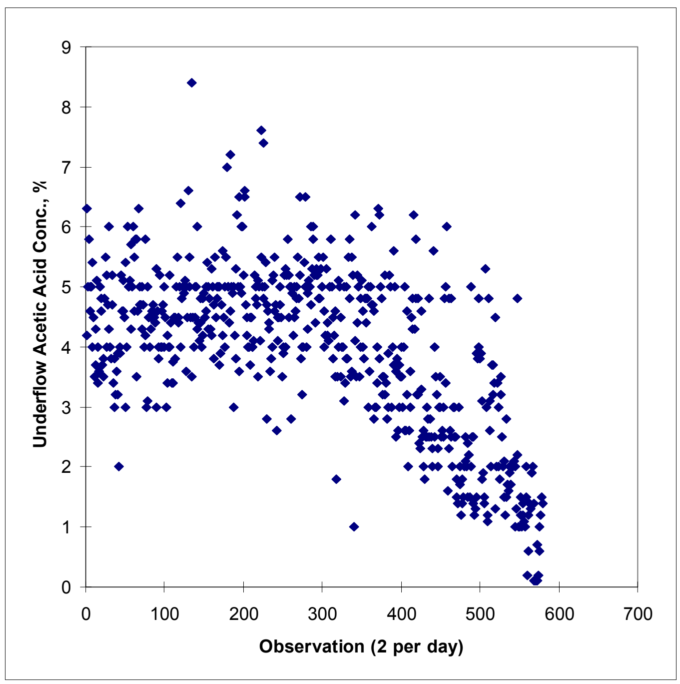

Figure A.4b-3. 1997 underflow acetic acid concentration data.

An emissions test was conducted on this scrubber in December 1994. An acetic acid sampling train validated using EPA Method 301 was used to measure acetic acid emissions and EPA Methods 1 through 4 were used to determine vent gas volumetric flow rates. The permitted emission limit is 3.6 lb VOC/hr. The average emissions during testing were 0.2 lb/hr, well below the emissions allowed for this scrubber. The inlet water flow rate was 5 gpm and the average scrubber underflow acetic acid concentration was 5 percent. The test parameters and measured emissions and underflow concentration were used in the ASPEN® computer model to calculate the efficiency of the scrubber. The model was then used with that same efficiency to generate the compliance curve in Figure A.4b-1.

Figure A.4b-4 shows the underflow acetic acid concentration versus the scrubber water flow rate for 1997. There were four excursions in 1997; the flow rate was less than 4 gpm during those excursions, but the underflow acid concentration was always less than 10 percent.

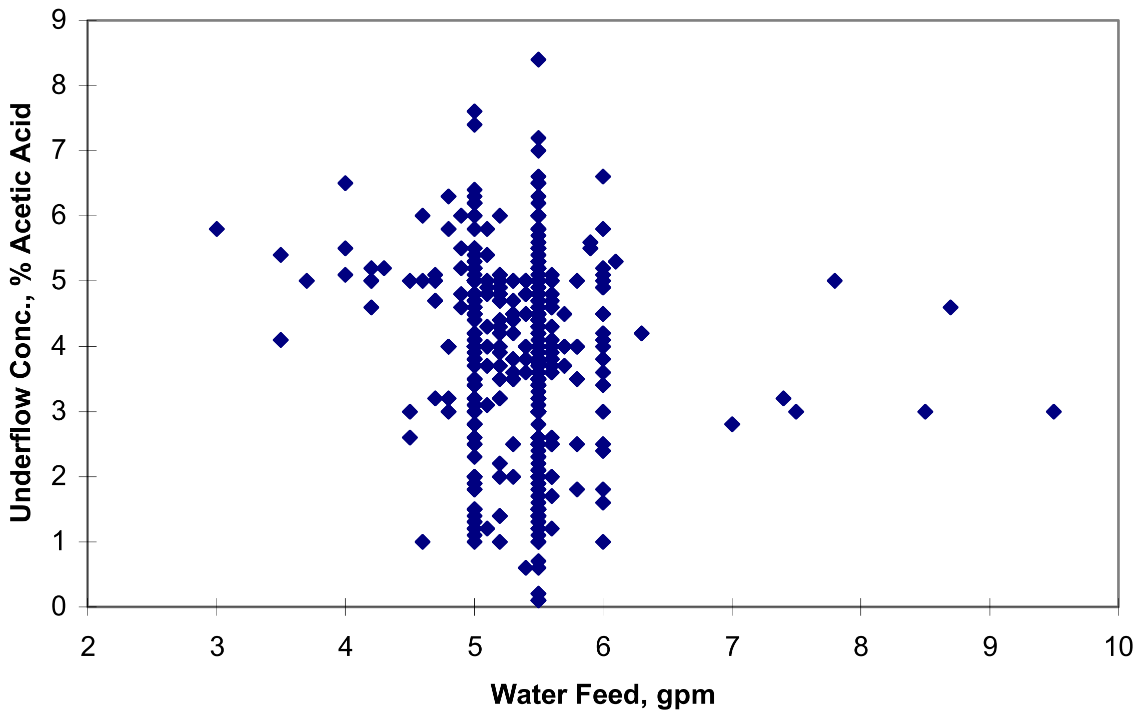

Figure A.4b-4. 1997 underflow acetic acid concentration vs. scrubber water flow.
(2 measurements per day)