B.14 SPRAY DRYER[25,26,27]

B.14.1 Background

Spray dryers are control devices that reduce acid gas emissions. A spray dryer system consists of a slurry atomizer, reaction chamber, and a PM collection unit. The slurry is made of alkali sorbent (typically lime) and water. This slurry is injected into the flue gas in the reaction chamber to remove SO_2, HCl, and HF. The lime slurry rate is determined stoichiometrically by the acid gas content. The PM collection unit is usually a fabric filter. The atomized slurry droplets cool the emission gas stream and the hydrated lime reacts with acid gas to form calcium salts. Lower emission stream gas temperatures increase the sorbent reactivity and increase the removal of acid gas; however the temperature must be high enough to ensure the slurry and reaction products are dry before collection in the fabric filter. The residence time in the reaction chamber ranges from 5 to 15 seconds. Smaller droplet size increases the surface area for reaction between the lime and acid gas. The acid gas reduction efficiency is affected by the slurry feed rate, the residence time or reaction time between the sorbent and gas stream, emission stream gas temperature, slurry reactor outlet temperature (fabric filter inlet temperature), slurry droplet size, and the other parameters discussed for fabric filters in section B.1.

B.14.2 Indicators of Spray Dryer Performance

The primary indicators for spray dryer performance include the outlet acid gas concentration, alkali feed rate to the slurry mixing tank, water feed rate to the slurry mixing tank, slurry feed rate, slurry droplet size, fabric filter inlet temperature, and the primary indicators that are discussed in section B.1 for fabric filters. Other parameters that can indicate spray dryer performance include spray dryer inlet gas temperature (process exhaust temperature), exhaust gas flow rate, and the other indicators for fabric filters that are discussed in section B.1 Table B-14 lists these indicators and illustrates potential monitoring options for spray dryers.

Outlet acid gas concentration. The most direct single indicator of spray dryer performance is the acid gas concentration at the outlet of the unit.

Alkali feed rate to slurry mix tank. The alkali feed rate is a key indicator of spray dryer performance. The alkali is dissolved in water for slurry injection to the spray dryer; the slurry feed rate is determined by stoichiometry of alkali to the acid gas content in the emission stream. The alkali feed rate must be at a sufficient level to generate the desired alkali concentration in the slurry.

Water feed rate to slurry mix tank. Water feed rate is a key indicator of spray dryer performance. Water is used to dissolve the alkali for slurry injection to the spray dryer; the slurry feed rate is determined by stoichiometry of alkali to the acid gas content in the emission stream. The water feed rate must be at a sufficient level to generate the desired alkali concentration in the slurry and to generate appropriate cooling of the gas stream.

Slurry feed rate. Slurry feed rate is a key indicator of performance provided the slurry is maintained at a constant concentration, the slurry is properly distributed and atomized, and the liquid-gas interface is maintained. The alkali feed rate is determined by stoichiometry with the acid gas content; the alkali is dissolved in water for injection to the spray dryer. The slurry concentration and feed rate must be maintained to assure sufficient alkali to react with acid gas and to assure sufficient water for cooling the gas stream. In general, higher slurry feed rates are indicative of higher levels of control up to a critical point, above which the slurry feed rate results in excess alkali sorbent injection that may overload the particulate control device (e.g., fabric filter) and contribute to increased particulate matter emissions. Also, a slurry feed rate that is too high may result in the addition of sufficient water to cool the emission stream below the dew point temperature, causing condensation and operational problems with the system (e.g., blinding of the fabric filter bags).

Fabric filter inlet temperature. Most fabric filters are designed to operate within a specified temperature range based on the type of bags used. High inlet temperatures can damage the bags. However, cooling to too low a temperature may result in moisture condensation that will cause caking or blinding of the fabric filter bags or acid gas condensation that may corrode the fabric filter housing and other metal components.

Spray dryer inlet gas temperature (process exhaust temperature). For thermal processes, increases in the spray dryer inlet gas temperature may indicate that additional cooling of the gas stream is necessary, i.e., additional slurry injection. Increases in temperature reduce the reactivity of the sorbent with the acid gas and may cause an increase in acid gas emissions. This temperature must be maintained within an optimal range to promote the reaction and to ensure that a dry gas stream enters the fabric filter.

Slurry droplet size. The slurry is sprayed into the reaction chamber through the slurry atomizer. Smaller particles increase the surface area of the slurry and promote reaction with acid gas. The pressure differential across the slurry atomizer feed is a surrogate indicator for both the droplet size and the slurry feed rate. This pressure should be maintained within design limits to ensure the slurry is properly atomized.

Indicators for fabric filters. See section B.1.

B.14.3 Illustrations

14a: Monitoring alkali feed rate to slurry mix tank, water feed rate to slurry mix tank, fabric filter inlet temperature, opacity, and fabric filter pressure differential.

B.14.4 Bibliography

TABLE B-14. SUMMARY OF PERFORMANCE INDICATORS FOR SPRAY DRYING

		Approach No.	**1**
		Illustration No.	**14a**
		Example CAM Submittals	
Parameters	**Performance indication**	**Comment**	
Primary Indicators of Performance			
Outlet acid gas concentration	Direct measure of outlet acid gas concentration. Most direct single indicator of spray dryer performance.		
Alkali feed rate to slurry mix tank	Indicates whether sufficient alkali to react with acid gas is being added to the system. Increases in alkali feed rate may cause overloading of the fabric filter. Decreases in alkali feed rate may cause a reduction in performance.		X
Water feed rate to slurry mix tank	Indicates that water to provide the correct alkali concentration is being added. Also indicates whether sufficient cooling water is being added. Increases in water feed rate may cause a slurry with dilute concentration and overcool the gas stream. Decreases in water rate may result in an increase in the reaction chamber temperature, causing a decrease in sorbent reactivity or temperatures exceeding the design of the fabric filter system.		X
Slurry feed rate	Low feed rate may indicate insufficient alkali to react with acid gases and insufficient water injection to cool the gas stream to the fabric filter design temperature. Increases in feed rate may cause excess PM and overloading of the PM control system or excess moisture and cooling of the emission gas stream to below the dew point temperature.		
Fabric filter inlet temperature	Indicator of potential for overheating of bags or condensation. High temperatures can destroy the bags or shorten bag life; high temperatures indicate a need for additional cooling water (in the slurry) injection. Too low a temperature can cause condensation, which can result in bag blinding or increased corrosion of structural components.		X
Opacity	Increased opacity/VE denotes performance degradation. COMS, opacity observations, or visible/no visible emissions.		X
Other Performance Indicators			
Pressure differential	Indicator of blinding or malfunction of cleaning cycle. Sudden increase in pressure differential can indicate bag blinding; also can indicate if cleaning mechanism is operating properly.		X
Comments: None.			

CAM ILLUSTRATION
No. 14a. SPRAY DRYER FOR ACID GAS CONTROL

1. APPLICABILITY

1.1 Control Technology: Spray drying [067]
1.2 Pollutants
Primary: Sulfur oxides (SO_X), hydrogen chloride (HCl), hydrogen fluoride (HF)
Other:
1.3 Process/Emissions units: Combustors, kilns, furnaces, boilers

2. MONITORING APPROACH DESCRIPTION

2.1 Parameters to be Monitored: Alkali feed rate to slurry mixing tank, water feed rate to slurry mixing tank, fabric filter inlet temperature, opacity, and fabric filter pressure differential.
2.2 Rationale for Monitoring Approach
- Alkali feed rate to slurry mixing tank: Removal of acid gas components is dependent on sufficient alkali feed to the system.
- Water feed rate to slurry mixing tank: Removal of acid gas components and cooling of the emission stream depend on sufficient water feed to the system.
- Fabric filter inlet temperature: Excessive temperature can lead to leaks, breakdown of filter material, and reduced life of filter; temperatures below the dewpoint of the exhaust gas stream may cause condensation that damages the filter bags.
- Opacity or VE: An increase in opacity or changes in VE observations indicate process changes, changes in baghouse efficiency, or leaks.
- Fabric filter pressure differential: Indicates proper operation of the fabric filter; decrease in pressure differential indicates bag failure; increase in pressure differential indicates fabric blinding.

2.3 Monitoring Location
- Alkali feed rate to slurry mixing tank: At alkali feed line on the slurry mix tank.
- Water feed rate to slurry mixing tank: At water injection line on the slurry mix tank.
- Fabric filter inlet temperature: At fabric filter inlet duct.
- Opacity or VE: Per RM 9 (opacity) or RM 22 (VE) requirements.
- Fabric filter pressure differential: Across inlet and outlet of each compartment.

2.4 Analytical Devices Required
- Alkali feed rate to slurry mixing tank: If measured by weight, use of a scale, weigh tank, load cells, or other weight monitor; if measured by volume, use of in-line flow meters; see section 4.4 (Flow) for additional information on devices.
- Water feed rate to slurry mixing tank: In-line flow meters; see section 4.4 (Flow) for additional information on devices.
- Fabric filter inlet temperature: Thermocouple, TRD, or other temperature sensing device; see section 4.2 (Temperature) for additional information on devices.

- Opacity or VE: Trained observer using RM 9 or visible/no visible emissions observation techniques (RM 22-like).
- Fabric filter pressure differential: Pressure transducers, differential pressure gauges, manometers, other methods and/or alternative instrumentation as appropriate; see section 4.3 (Pressure) for additional information on devices.

2.5 Data Acquisition and Measurement System Operation

- Frequency of measurement: Hourly, or monitored continuously on strip chart or data acquisition system; for opacity or VE, daily or as weather permits.
- Reporting units:
  - Alkali feed rate to slurry mixing tank: Weight in pounds per hour (lb/hr), or other unit of mass.
  - Water feed rate to slurry mixing tank: Volume in gallons per hour (gal/hr) or other units.
  - Fabric filter inlet temperature: Degrees Celsius or Fahrenheit (C or F).
  - Opacity or VE: Percent opacity or visible/no visible emissions.
  - Fabric filter pressure differential: Inches of water column (in. w.c.).
- Recording process: Operators log data manually, or recorded automatically on strip chart or data acquisition system; observers complete opacity or VE observation forms and log into binder or electronic database as appropriate.

2.6 Data Requirements

- Stoichiometric calculations.
- Baseline alkali feed rate to slurry mixing tank, water feed rate to slurry mixing tank, fabric filter inlet temperature, opacity or VE, and fabric filter pressure differential measurements concurrent with emissions test.
- Historical plant records on alkali feed rate, water feed rate, fabric filter inlet temperature, opacity observation, and fabric filter pressure differential measurements. (No data are needed if indicator is "any visible emissions.")

2.7 Specific QA/QC Procedures: Calibration, maintenance, and operation using procedures that take into account manufacturer's specifications.

2.8 References: 9, 14.

3. COMMENTS

3.1 Data Collection Frequency: For large emission units, a measurement frequency of once per hour would not be adequate; collection of four or more data points each hour is required. (See Section 3.3.1.2.)

3.2 In lieu of opacity and pressure differential for the fabric filter, see section B.1 for other monitoring approaches, such as bag leak detector, that provide a higher level of confidence than opacity for fabric filter.