METTLER TOLEDO APPLICATION NOTE

pH And Conductivity Measurements For Scrubbers

BACKGROUND

Industrial scrubbers are used for the removal of potentially harmful and polluting gas emissions from various processes. The gases removed by scrubbing include sulfur dioxide (SO_2) from combustion by utilities and industrial users, and a variety of by-product or waste gases such as chlorine (Cl_2), hydrogen chloride (HCl) and hydrogen sulfide (H_2S) by producers and users.

THE PROCESS

Scrubbers operate by spraying the gas stream with a solution that contains a scrubbing chemical which dissolves or destroys the harmful gas. This process is illustrated in Fig. 1.

The effectiveness of the scrubbing solution in removing the harmful gas depends upon the concentration of the scrubbing chemical, which is continuously depleted during scrubber operation. To ensure the effectiveness of the scrubber, the concentration of the scrubbing chemical must be maintained. Conductivity and pH can be used to monitor the strength of the scrubber solution.

Scrubbers can include multiple scrubbing operations, i.e., more than one individual scrubber and solution. Control of the solution strength (concentration) generally is accomplished by one of two methods:

The first is the batch type scrubber, which operates using an initial high concentration of scrubbing chemical that is allowed to deplete to near exhaustion, followed by blowdown and replenishment by fresh, full strength scrubber solution.

The second method is to maintain a certain concentration of scrubbing chemical by continual replenishment and blowdown.

The chemical composition of the scrubber solution at any point in time will depend upon how it is being controlled and upon the scrubbing chemical and the gas being scrubbed. By-products are formed from the reaction of the scrubbing chemical and the gas being scrubbed.

The choice between pH and conductivity will ultimately depend upon the scrubber solution composition and its changes during the scrubber operation. While each scrubber application should be looked at individually, the situations best suited for conductivity and pH can be outlined as follows:

Applying Conductivity

Conductivity measurement is best suited to measuring the concentration of the scrubber chemical in batch scrubbers.

Conductivity is non-specific and will respond to both the scrubbing chemical and the scrubbing by-products. As the scrubbing chemical is depleted, its contribution to the scrubber solution conductivity will decrease. At the same time, the concentration of the by-products builds up, and their contribution to the total conductivity increases.

If there is a measurable change in conductivity (usually a decrease) as the scrubbing chemical is depleted, then the scrubbing chemical concentration can be measured. A good example of this is batch scrubbing of chlorine gas (Cl_2) using strong caustic (10-15% NaOH).

Difficulties can arise, however, when more than one gas is being scrubbed. Depending upon the relative proportions of the gases, the by-products formed will differ, leading to variations in the conductivity back-ground. Deriving concentration from conductivity can be difficult or impossible, although a conductivity measurement may still provide a useful alarm point to alert the operator to check a grab sample.

In scrubbers where the scrubbing chemical concentration is maintained by continual replenishment and blowdown, conductivity can be used to initiate blow-down to prevent high dissolved solids build-up.

Applying pH

A pH measurement is often the choice for scrubbers using continual blowdown and replenishment. Scrubbing of acid gases such as sulfur dioxide (SO_2) is controlled by maintaining an excess concentration of a basic scrubbing chemical such as caustic (NaOH) or lime (CaO). Since pH is specific to hydrogen ion (H^+), which is related to the concentration of basic scrubbing chemical, it can be used with minimal effects from the build up of by-products in the scrubber solution.

A common misapplication is to use a pH measurement in a batch scrubber using strong caustic (10-15% NaOH). The initial caustic concentration is off scale (greater than 14 pH) and can destroy the glass electrode. The pH response follows a strong acid/strong base titration curve, which results in a reading that only drops back on-scale near the point of complete exhaustion of the caustic, followed by a sudden drop at the exhaustion point.

ORP (Oxidation-reduction potential) measurement may also be used along with a pH measurement if the scrubbing reaction involves an oxidation and reduction reaction. In general, ORP measurement is limited to indicating the complete exhaustion of a particular chemical and is not a good indication of concentration.

Additional Applications of pH and Conductivity

The scrubbing chemical in a spent scrubber solution is sometimes regenerated on-site for reuse in the scrubber. An example is the regeneration of caustic (NaOH) in spent sulfur dioxide (SO_2) scrubbing solution from sodium sulfate (Na_2SO_4) using lime (CaO). Conductivity can be used to measure the concentration of the caustic produced.

The by-products from the scrubbing reaction in spent scrubber solution can sometimes be recycled for use in the plant or sold. These include sodium hypochlorite (NaOCl) from chlorine scrubbing with caustic; gypsum ($CaSO_4$) from sulfur dioxide scrubbing with lime; and ammonium sulfate ($\{NH_4\}_2SO_4$), as a raw material for fertilizers, from sulfur dioxide scrubbing with ammonium hydroxide (NH_4OH). Both pH and conductivity can be used in the processing of these by-products.

INSTRUMENTATION

Conductivity

Toroidal conductivity sensors should be used for scrubber solution measurements because of their resistance to fouling and corrosion. The sensor should be located where it will be exposed to a representative sample. The InPro® 7200 Toroidal Conductivity Series sensors are generally applicable to scrubbers. In batch scrubbers, where concentration measurement is desired (typically caustic scrubbers), the Model CondI 7100 Toroidal Conductivity Analyzer can be used. The best way to monitor the process using the analyzer is to measure the conductivity of the scrubber solution over at least 3 cycles, then use the conductivity data gathered along with concentration data from titrations to develop the conductivity/concentration curve to be input into the Model CondI 7100 Toroidal Conductivity Analyzer.

pH

The biggest problem encountered in scrubber applications is sensor coating, especially in applications using lime as the scrubbing chemical. To minimize coating effects, the sensor should be mounted so as to be exposed to a high sample flow rate. In more extreme cases, a flow-powered cleaner or jet spray cleaning can reduce the need for manual cleaning, depending upon the nature of particulates present. Since the scrubbing solutions in pH applications are usually basic, a pH electrode with high-alkalinity membrane glass should be used to allow pH measurement above 10 pH without a sodium error. An InPro® 4200 pH sensor with Xerolyt® solid polymer reference system is the recommended sensor in conjunction with the InTrac® 787 Hot Tap Retractable housing and the Model 2100 pH analyzer.

Measuring pH is not recommended in batch scrubbers using strong caustic (10-15% NaOH).

The effects on the pH measurement of the by-products of the scrubbing reaction should be considered. Strongly oxidizing solutions, which can poison the reference electrode, can sometimes result.

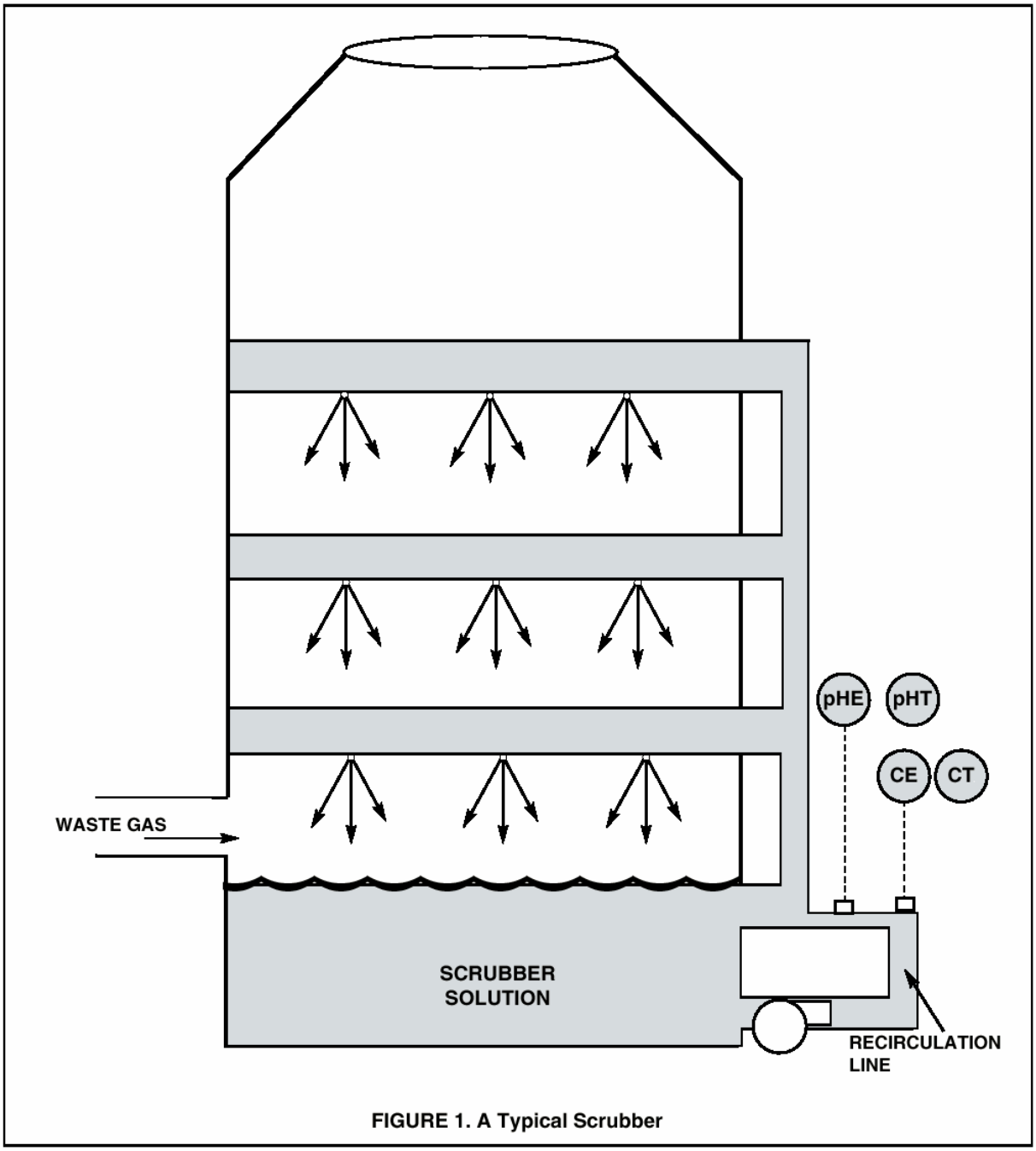

FIGURE 1. A Typical Scrubber

Ref: RA ADS 2800-23

PRODUCTS

For Conductivity Measurement:

Model CondI 7100 Toroidal Conductivity Analyzer

- Measures conductivity, resistivity and % concentration
- Detachable front panel and plug-in terminals for ease of installation
- All functions accessible through the keypad for increased ease of use
- Continuous sensor and transmitter diagnostics to monitor performance
- FM certification for Class I, Div 1 & 2 Environments
- 3 year warranty

InPro® 7200 Toroidal Conductivity Sensors

- Recommended for high accuracy measurement in high conductivity processes
- Choice of materials of construction for increased chemical compatibility
- High temperature range option suitable for CIP and Boiler Blowdown applications
- FM approved for electrical safety

For pH Measurement:

2100 pH Analyzer

- Detachable front panel and plug-in terminals for ease of installation
- All functions accessible through the keypad for increased ease of use
- Continuous sensor and transmitter diagnostics to monitor performance
- FM certification for Class I, Div 1 & 2 Environments and CSA General Purpose Approval
- 3 year warranty

InPro® 4200 Solid Polymer pH Electrode

- Patented Xerolyt solid polymer reference system maintains a stable potential for accurate and repeatable pH measurement and low maintenance
- Open junction eliminates reference clogging and extends sensor life
- High pressure resistance eliminates requirement for pressurizable housing
- Integral RTD for higher measurement accuracy
- Rugged IP67 rated quick connect VarioPin connector

InTrac® 787 Hot Tap Retractable Housing

- Fast and easy sensor maintenance or replacement without process interruption
- Double o-ring process seals
- Integrated blow-out protection
- Mechanical linkage ensures safe operation
- Self-wiping retractable tube reduces o-ring wear