APPLICATION NOTES

pH and Conductivity Measurement for Wet Scrubbers

Introduction
Industrial scrubbers are used for the removal of potentially harmful and polluting gas emissions. Gases that must be removed include sulfur dioxide (SO2) from combustion by utilities and industries and a wide variety of by-product and waste gases such as chlorine (Cl2), hydrogen chloride (HCl) and hydrogen sulfide (H2S).

Application
Wet scrubbers operate by spraying the incoming gas stream with a scrubbing solution containing a scrubbing chemical, which destroys the harmful gas. This process is illustrated in Fig. 1.

The effectiveness of the scrubbing solution in removal of harmful gases depends on the concentration of the scrubbing chemical, which is continuously being depleted during the process. Scrubbing chemical concentration must be maintained to ensure effectiveness of the scrubber. Conductivity and pH can be used to monitor scrubber solution strength/concentration.

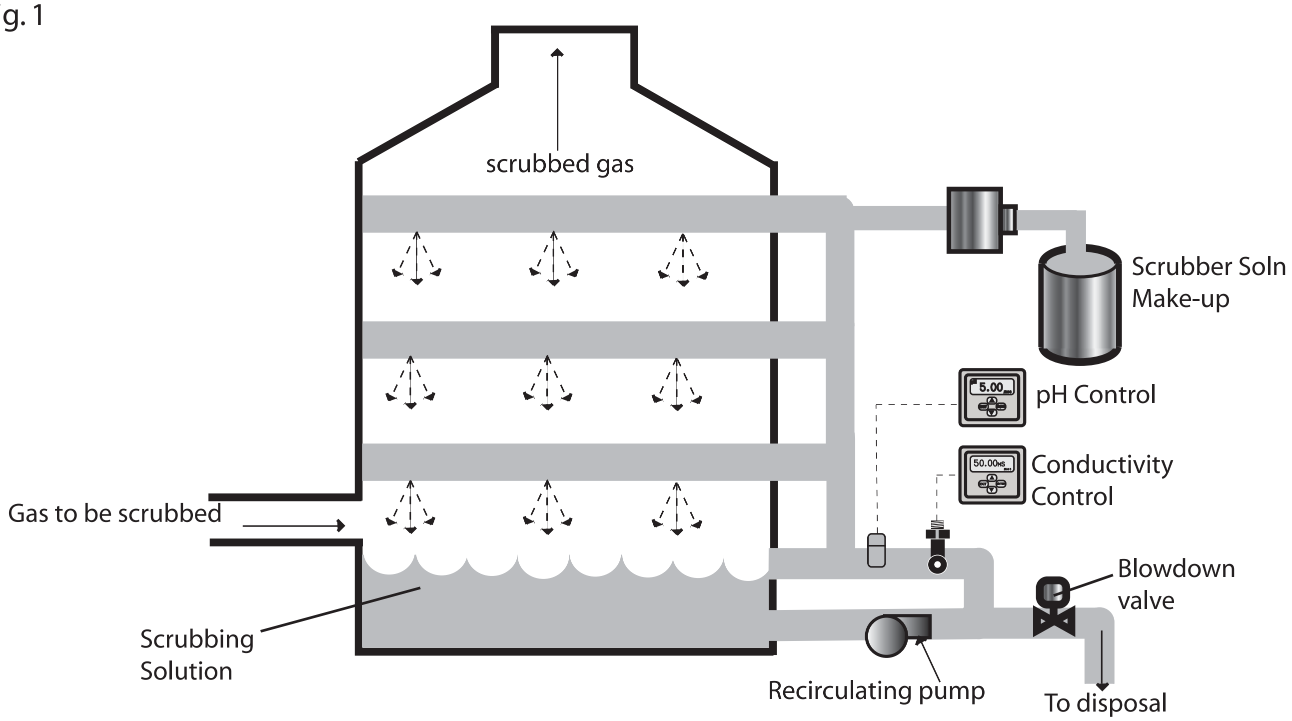
Control of the solution strength (concentration) can be achieved by either of the following methods:

1) Batch Scrubbing: Starts with an initially high concentration of scrubbing Chemical, that is allowed to reach near depletion, followed by blowdown and replenishment by fresh, full strength scrubber solution.

2) Continual Scrubbing: Continual replenishment and blowdown

Scrubber solution composition at any time will depend upon how it is being controlled and, the scrubbing chemical and gases being scrubbed.

Fig. 1



The choice whether to control with pH or conductivity will depend on the scrubber solution composition and how it changes during the scrubber operation. While each application should be evaluated individually, the applications best suited for conductivity and pH are as follows:

Conductivity Control

Conductivity is best suited to measure scrubber solution concentration of scrubber chemical in batch scrubbers. Conductivity is non-specific and will respond to both conductive scrubbing chemicals and 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 is building up and their contribution to the total conductivity is increasing.

If a measurable decrease in conductivity is detected as the scrubbing solution is depleted, then the scrubbing chemical concentration can be measured. One example of this is batch scrubbing of chlorine gas (Cl2), using strong caustic (10-15% NaOH).

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

In continual replacement scrubbers, conductivity can be used to initiate blowdown to prevent high dissolved solids build up.

pH Control

pH control is often the choice for scrubbers using continuous blowdown and replenishment. Acidic gas scrubbing, such as sulfur dioxide (SO_2), is controlled by maintaining an excess concentration of a basic scrubbing chemical, such as caustic (NaOH) or lime ($Ca(OH)_2$). Since pH is specific to hydrogen ion concentration (H+), which is related to the concentration of the basic scrubbing chemical (high pH means low H^+ concentration), it can be used to control scrubbing with minimal effects from scrubber by-products. If the scrubber uses strong caustic (10-15% NaOH), pH control is not suggested since the exposure of the pH glass to high concentration of caustic will cause dissolution of the pH glass, thus destroying the electrode. The pH response curve follows a strong acid/base titration curve, which results in a reading that only drops back on-scale near a 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 in addition to pH measurement if the scrubbing reaction involves an oxidation or reduction change. It can only be used to determine the complete exhaustion of a particular chemical and is not recommended as a means to determine concentration of scrubbing solution or by-products.

The scrubbing chemical in 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 scrubbing solution from sodium sulfate (Na_2SO_4) using lime ($Ca(OH)_2$). Conductivity can be used to measure the concentration of the caustic produced in this reaction. Scrubbing reaction by-products can also be used in the plant or sold. These include sodium hypochlorite (NaOCl) from chlorine gas scrubbed with caustic; Ammonium sulfate (NH_4HSO_4) for use as fertilizer from Sulfur dioxide (SO_2) scrubbing with ammonium hydroxide (NH_4OH).

SCRUBBER INFORMATION TO KNOW BEFORE CHOOSING A SENSOR:

1) Gas or gases being scrubbed (chemical name and formula)
2) Scrubbing chemical and concentration range
3) Scrubbing chemical concentration maintained by:
    a) continual blowdown
    b) deplete down to certain range

Sensors and Instruments

Toroidal conductivity sensors and instruments should be used for scrubber control since the sensors are highly resistant to fouling. They are also recommended due to the high conductance of many of these scrubbing solutions and by-products. pH sensors will tend to coat in scrubbing applications, especially in applications that use lime ($Ca(OH)_2$) as the scrubbing chemical. To minimize coating effects, make sure that the sensor is mounted in a high flow area (in-line >3ft/sec velocity is suggested). The use of flat-surface, seld-cleaning pH & ORP electrodes are recommended. Cleaning frequency is reduced and much time can be saved. Do not use pH for scrubbers using strong caustic 10-15%). This will damage the pH glass. Choose materials of construction of pH electrodes based on the chemicals being scrubbed and any possible by-products (CPVC or PVDF).

APPLICATION NOTES (CONT.)

Electrode installation

Electrode instatllation depends on piping sytem dimensions. Piping up to 2" diameter can use in-line electrode mounting. It is suggested to install a by-pass line with isolation valves so that the scrubber does not need to be stopped to remove or maintain the electrode. For piping with >2" diameter a wet-tap installation is offered. This allows the customer to directly insert and retract the electrode into the line to take advantage of the turbulent flow or postiion the electrode near the pipe wall. A saddle and 1" or larger full-port ball valve are required for installation. No tools are required for electrode maintenance.

Products for Wet Scrubber Monitoring

Toroidal Conductivity Sensor:

Model TCS-1000 offers no maintenance control of scrubber chemical concentration via conductivity.

In-line pH and ORP Sensors:

Models are available for 3/4", 1" or 2" in-line mounting. Sensors require no tools to install and can be changed in seconds. Mounting hardware with integral temperature sensor for ATC saves money!

Insertion mount pH and ORP Sensors:

Models are available with 12", 18" or 24 " maximum insertion depth. No need to stop flow to change sensor. No tools are required to install sensors and they can be changed in seconds. Mounting hardware with integral temperature sensor for ATC saves money!

Typical Scrubber Applications

Gas	Scrubber Solution	Measurement
Chlorine	Caustic (10-15%)	Conductivity
	White Liquor	pH,ORP
Sulfur Dioxide (SO_2)	Lime (CaO)	pH
	Magnesium Oxide (MgO)	pH
	Caustic (weak)	pH
	Caustic (strong)	Conductivity
Hydrogen Chloride	Caustic (10-15%)	Conductivity
Hydrogen Sulfide	Caustic (10-15%)	Conductivity
	Sodium Hypochlorite (NaOCl)	Conductivity, ORP

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