

INTRODUCTION

Environmental scrubbers are used in many industrial processes for the removal of potentially harmful and polluting gas emissions. Gases that must be removed include a wide variety of by-product and waste gases such as hydrochloric acid (HCl), hydrogen sulfide (H₂S), chlorine (Cl₂), and sulfur dioxide (SO₂) from combustion by utilities and industrial process plants.

APPLICATION

Wet scrubbers operate by spraying the incoming gas stream with a scrubbing solution containing a neutralizing chemical, which destroys the harmful gas. This process is illustrated below. 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. Monitoring pH and Conductivity can be used to control scrubber solution strength/concentration.

Control of the scrubbing solution strength can be achieved by either of the following methods:

- **Continuous Scrubbing:** Continuous 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.
- **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.

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 reviewed separately, the applications best suited for pH and conductivity are as follows:

pH Control

A measurement of pH is often the choice for scrubbers

using continuous blowdown and replenishment. Acidic gas scrubbing, such as hydrochloric acid (HCl), 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, 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 attack 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.

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 (Cl_2), 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

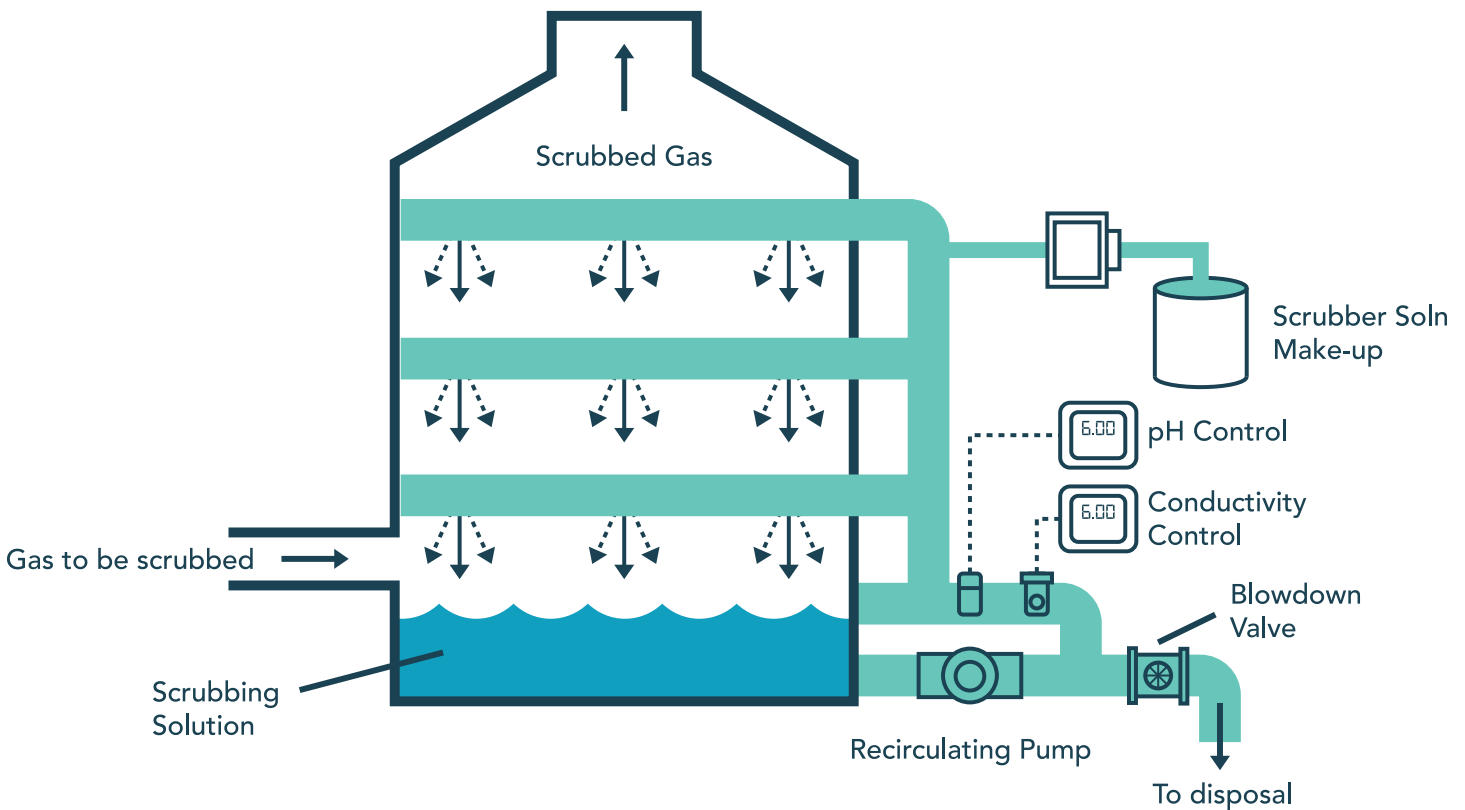
check a grab sample.

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

SENSORS AND INSTRUMENTATION

Most pH sensors will tend to coat in scrubbing applications, especially in applications that use lime ($\text{Ca}(\text{OH})_2$) 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 self-cleaning pH & ORP, or differential pH & ORP electrodes, is recommended. Cleaning frequency is reduced and much time can be saved.

It is recommended to avoid using pH for scrubbers using strong caustic (10-15%) scrubbing solutions. This can damage the pH glass and shorten sensor life. Choose materials of construction of pH electrodes based on



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the chemicals being scrubbed and any possible by-products (CPVC or PVDF).

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.



Information to Know Before Selecting a Sensor

It's important to gather information about the scrubber application prior to selecting sensors.

1. Gas or gases being scrubbed (chemical name and formula)

2. Scrubbing chemical and desired concentration range
3. Scrubbing method employed:
 - Maintaining scrubbing chemical concentration via continuous blowdown and replenishment
 - Allowing scrubbing chemical to deplete down to a certain concentration range

Sensor Installation

Electrode installation depends on piping system 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 position 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.

Some scrubber configurations are best suited for monitoring the scrubbing solution concentrations in a tank or sump. Submersible sensor configurations using convertible mounting threads make this a simple installation with inexpensive CPVC piping coupled to process sensors.

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 |
| Hydrogen Chloride | Caustic (strong) | Conductivity |
| | Caustic (10-15%) | Conductivity |
| Hydrogen Sulfide | Caustic (10-15%) | Conductivity |
| | Sodium Hypochlorite (NaOCl) | Conductivity, ORP |

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