SLY® AIR POLLUTION CONTROL

The Complete Guide to
Getting Started with Wet Scrubbers

SLY AIR POLLUTION CONTROL

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Wet Scrubber Guide

Intro: What is a Wet Scrubber?

Air quality control is vital to the health and safety of your facility. Most industrial applications create dust or other pollutants that need to be removed from your airstreams in order to protect your workers and guarantee the safety of your products.

When it comes to improving your air quality control, wet scrubbers are one of the main types of equipment that you can use to manage dust and other pollutants. A wet scrubber, also known as a wet dust collector, works differently than a conventional baghouse or dry dust collector. Rather than using a filter bag or cartridge, wet scrubbers rely on a scrubbing fluid to remove harmful gases, vapors, dust and other pollutants.

Wet scrubbers are known for their high collection efficiencies, commonly reaching over 99 percent efficiency. Their scrubbing fluid can remove both solid and liquid particles from your airstream, soaking up the contaminants in the scrubbing fluid itself, which can then be disposed of. You can modify a wet scrubber's efficiency and performance by controlling the size of water droplets of your scrubbing fluid. The smaller the droplet size of your scrubbing fluid, the more efficient the wet scrubber, enabling cleaner, safer and more productive plant operations.

Is a Wet Scrubber Right for Me?

Wet scrubbers are great for a wide variety of industrial applications. Food production, plastics, processing and machining, pharmaceuticals and many other industrial applications are well suited for wet scrubbers.

To find out if a wet scrubber is right for your specific operation, you will want to take a look at the characteristics of the dust or other pollutant that you need managed and the overall requirements of your system. If you qualify with any of the following, a wet scrubber may be right for you:

Fine Particulate and Mists

Wet scrubbers are extremely efficient when dealing with finer particles and mists. Scrubbers with ultra-fine droplets can easily entrap smaller particles and hold them in the solution for removal. If your pollutant is a mist, the more reason you have to choose a wet scrubber over a typical baghouse or dry dust collector.

Soluble Particles

If the particles that you need to be removed are dissolvable in water, then the scrubbing fluid of a wet scrubber is often the perfect dust management solution. The scrubbing fluid will seamlessly trap dissolved particles, creating a solution for recycling or disposal.

Wet, Sticky or Gummy Particulate

Wet, sticky or gummy particulate can clog a standard baghouse, creating a significant ongoing maintenance issue. Since wet scrubbers are already using a scrubbing fluid, wet or sticky particulate is not an issue.

Humid Air

Wet scrubbers are great for applications with humid air for similar reasons as to why they are suitable for wet particulate. Any moisture caused by the humidity will easily mix in with the scrubbing fluid and become a non-issue.

It is important to note that humid air can happen independently of wet or sticky particulate. Sand drying applications are a great example. While these processes mostly deal with dry particulate, the humid air for the environment can cause condensation to form within your collector. Sand and similar particulate are also highly abrasive, causing excessive wear on standard dust collectors and filter bags. In these applications, wet scrubbers can both easily handle the humid air and remove the risk of abrasion by mixing the particulate with water.

Mixes of Particulate, Vapors and Gases

One thing that sets wet scrubbers apart is their ability to handle both particulate and gases/vapors in a single dust collection system. If you are dealing with multiple states of contaminants, a wet scrubber can help you easily manage all of them without additional equipment.

When Should I Not Use a Wet Scrubber?

Wet scrubbers may still be a good choice for operations with dust characteristics and requirements other than the ones presented here. Talking with a dust collection expert can help to determine if a wet scrubber is right for you. However, ***wet scrubbers should not be used if you have water-reactive dust or extremely heavy dust loadings.***

Wet Scrubbers and Handling Combustible Dust

For many industrial applications, dust explosions are a significant risk when trying to handle harmful pollutants. These catastrophic events can lead to loss of life and shut down a plant or facility.

With the Imperial Sugar Refinery explosion in Port Wentworth and hundreds of other dust explosions happening over the years, this is not a rare issue. For a dust explosion to happen, it needs five key elements:

- A combustible fuel (dust)
- Significant dispersion of dust particles
- Heat or an ignition source (a flame, friction or static electricity)
- Free oxygen (O_2)
- Confined spaces

One of the key factors here is if your dust is combustible or not. According to the National Fire Protection Association (NFPA), combustible dust can be any solid material that is composed of distinct particles smaller than 500 microns that become a fire hazard when suspended in an oxidizing medium like air. Even if you are only working with solid, noncombustible products, manufacturing processes like grinding, mixing, blasting and sawing can create combustible dust.

Since wet scrubbers use a scrubbing fluid to remove particulate and harmful contaminates, they are inherently an excellent choice for handling combustible dust. While baghouses will require special equipment such as explosion venting or chemical suppression systems, the scrubbing fluid of wet dust collectors already mitigates the risk of an explosion by eliminating friction, reducing dust dispersion and preventing direct dust-to-oxygen contact.

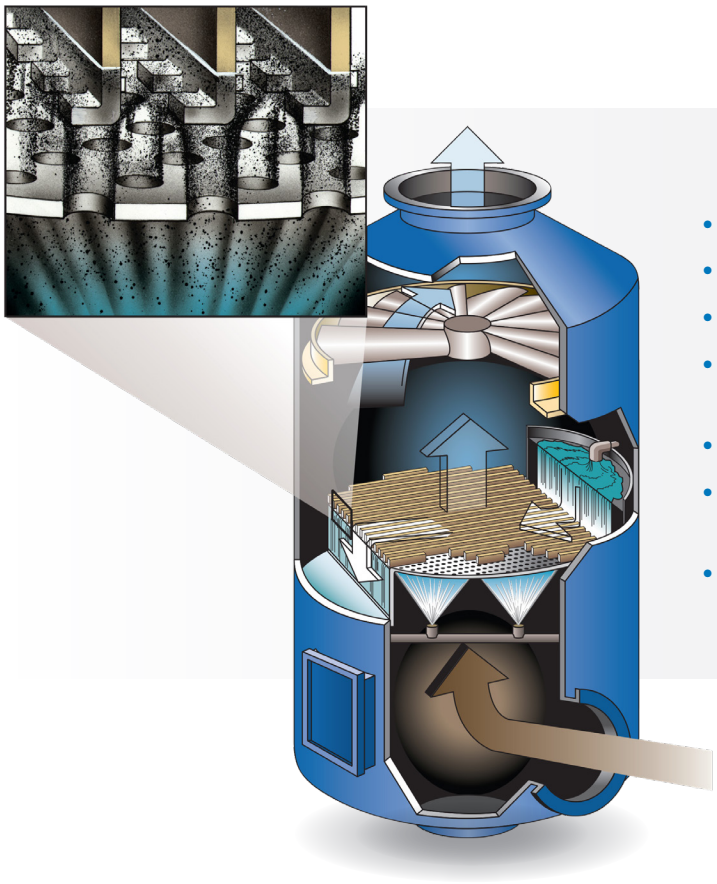
So long as your dust is not water-reactive, wet scrubbers are perfect for mitigating the risk of a dust explosion. However, while wet scrubbers almost entirely eliminate the risk of an explosion within the collector itself, you still need to be concerned about any processes or equipment upstream or downstream of the scrubber. Performing an NFPA-mandated Dust Hazard Analysis (DHA) will help highlight any other areas in your system that should be monitored. For more information on using wet scrubbers to handle combustible dust, see NFPA 484, the Standard for Combustible Metals.

How Does a Wet Scrubbing System Work?

While your scrubbing system will vary based on the type of wet dust collector you choose, a basic system cleans processed air by first drawing it through a mist of water. Then, separators remove the water droplets that have any dust or particles present. Aerosols and gaseous pollutants are removed either by absorption or through chemical reactions with the water solution. After removing these contaminants, clean air is then exhausted to the atmosphere.

While water is the most common type of scrubbing fluid, other liquids may be used as absorbing solutions to remove certain contaminants. Changing the chemical composition of the fluid can change its charge. Since pollutants differ in their charge, the charge of your scrubbing fluid can be manipulated so that those pollutants will bind most effectively to the fluid for easy removal. A caustic solution (sodium hydroxide, NaOH) is typically used for acid-gas control like HCl or SO2, with sodium carbonate (Na_2CO_3) and calcium hydroxide (slaked lime, $Ca[OH]_2$) other options as well.

The next section will detail the specific types of scrubbers and how they build upon the basic scrubbing system. However, many wet scrubbing systems will share the following components:



- **Ductwork fans**
- **A scrubbing vessel**
- **A saturation chamber**
- **An entrainment separator or mist eliminator**
- **Pumping**
- **Scrubbing liquid treatment and/or reuse system**
- **Exhaust stacks**

Types of Wet Scrubbers: How Do I Pick the Right One?

Once you know that a wet scrubber is right for you, you will want to choose one that is best suited for your unique application. Different dusts and operating environments are better suited for certain scrubbers than others.

A big thing to keep in mind when specifying a wet scrubber is its energy usage. Energy usage translates to operating costs, so it is best to specify a scrubber that is not under- or over-engineered for your application. Generally speaking, there are three different energy usage levels for wet scrubbers:

Low Energy

A low energy wet scrubber is great for removing particles greater than 5-10 micrometers in diameter. Low energy wet scrubbers utilize pressure drops of less than 5 inches of water column.

Medium Energy

A medium energy scrubber is great for handling micrometer-sized particles but suffers efficiency losses when managing sub-micrometer particles. Medium energy wet scrubbers have pressure drops from 5 to 15 inches of water column.

High Energy

In order to deal with the smallest particulate, you need a high energy scrubber. A high energy scrubber can remove sub-micrometer particles with a pressure drop of 15 to over 40 inches of water column.

Four Main Types of Wet Scrubbers

Of the main wet scrubbers on the market today, there are four main types of scrubbers to choose from. Each offers its own advantages and disadvantages that are inherent to its design, making finding the right choice imperative to optimizing the collection efficiencies, performance and reliability of your scrubber.

Venturi Scrubbers

One of the most popular wet scrubbers, Venturi scrubbers are designed for small particulate removal down to the submicron range. They are the most common type of high energy scrubber, though they can also be operated as a medium energy scrubber.

Venturis use the differential momentum between their free-flowing scrubbing fluid and gases moving at a high velocity to create droplets that entrap a variety of small contaminants. When designed correctly, Venturis can achieve high collection efficiencies of over 99 percent for particles with a diameter 1 µm and larger.

Key features of Sly's Venturi scrubbers include:

- Fine particulate and mist collection
- Adjustable throat offers fine-tuning capabilities to maximize efficiency
- High collection efficiency for sub-micron particulates
- Water recirculation averages 8 GPM per 1000 CFM
- Pressure drops from 12" w.g. to 40" w.g.
- Capacities up to 76,000+ CFM per unit

Impingement Plate Scrubbers

Also referred to as tray-tower scrubbers, Impingement wet scrubbers are the go-to choice for removing particles larger than 5 µm, as well as soluble gases. Impingement wet scrubbers use horizontal perforated trays with a staged design to enhance the gas-liquid contact between the scrubbing fluid and your airstream's contaminants. Impingement scrubbers allow for efficient dust collection with low water recirculation, minimized energy usage and minimal pressure drop.

Sly's Impinjet® wet scrubber improves upon standard tray-tower scrubbers by using impingement baffles above each hole in the tray design. These wetted baffles create tiny water droplets around 100 microns in diameter to better scrub the gas and entrap particles, improving collection efficiencies.

Key features of Sly's Impinjet scrubbers include:

- High collection efficiencies of 99% or more for particles 5 microns or larger
- "Buildable" staged design, with the option to add stages to improve efficiency
- Water recirculation as low as 3 GPM per 1000 ACFM
- Low maintenance needs and no moving parts
- Oversized access doors to easily service plates and sprays
- Airflow capacities of 200,000+ CFM

Sly's Venturi/Impinjet combination scrubber can achieve extremely high collection efficiencies of over 99.99% when paired to the right application.

Eductor Scrubbers

If you have a smaller application or a low amount of airflow, then an Eductor scrubber may be right for you. Eductor scrubbers are typically used to remove soluble gases and particulate by inducing a flow of gas using high pressure liquid. Great for more difficult pollutants, these scrubbers can be used for direct-contact condensation and offer a high liquid flow rate. Their high liquid flow rate makes them a good solution for collecting sticky/gummy particulate or gases that decompose when they come into contact with water.

Key features of Sly's Eductor scrubbers include:

- Versatile designs for smaller applications
- Easily staged with other types of scrubbers or additional Eductor scrubbers
- Tank access door
- Flanged inlet and outlet
- Integral recirculation reservoir
- Anchor and lifting lugs
- Scrubbers and separation tanks are available for gas flows up to 5,000 CFM

Packed Tower Scrubbers

Also called packed column or packed bed scrubbers, packed tower scrubbers are specifically designed for the chemical scrubbing of gaseous contaminants. The internal packing of the scrubber provides a large, wetted surface area for contaminated gas streams to come into contact with the circulating scrubbing fluid, causing the gas to get absorbed or react with the scrubbing fluid. The scrubbing fluid can then be recirculated to help achieve desired outlet emissions.

Key features of Sly's Packed Tower scrubbers include:

- Stainless steel, FRP, or high alloy construction
- Easy to use instrumentation and controls
- Integrated chemical feed system
- Exhaust fan and recirculation pump

Scrubber	Primary Uses
Venturi Scrubbers	Ultra-fine particulates, submicron particles, fumes and liquid aerosols
Impinjet Scrubbers	Particles 5 microns or larger, mixes of particulate and gases/vapors, heat recovery and applications with high hydraulic loadings
Eductor Scrubbers	Sticky/gummy particulate, as well as gases that decompose with water, such as SiCl4 and H2SiF6
Packed Tower Scrubbers	Gas-phase emissions like sulfur dioxide and other odors/acids

Sizing Your Scrubber

In addition to selecting the right type of wet scrubber, you need to size your wet scrubber to your application. Various factors come into play here, including gas flow rate, temperature, pressure, gas composition, humidity, contaminant loading and your desired outlet conditions.

Here, you will want to keep in mind the effects of saturated air since any gas streams that exit your scrubbing system will be fully saturated. This can result in a change in volume, temperature and density, particularly if the air that entered the scrubber was not fully saturated.

The overall diameter and size of your scrubber will be a function of the velocity of saturated gas through the scrubber shell. By using the moisture content of your gas stream and your inlet temperature, the saturation temperature and saturated volume content can be calculated.

Here is an example of sizing a wet scrubber:

Scrubber Conditions: 10,000 ACFM @ 450°F containing 0.15# H2O/# dry air

Chart 1 shows a correction factor of 0.75. Inlet volume x correction factor = outlet volume or 10,000 x 0.75 = 7500 ACFM. That means that this scrubber would be sized for this saturated outlet volume.

When using an Impinjet scrubber, its maximum capacity is based on a shell velocity of 500 feet per minute. Dividing the corrected or saturated volume by 500 yields the overall tower cross-sectional area, which can be used to determine the diameter.

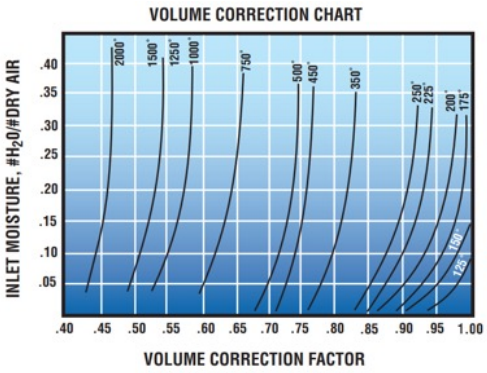


Chart 1

Plugging this in yields:

$(7500\ ft^3/min) / (500\ ft/min) = 15\ ft^2$

$Area = 15\ ft^2 = (\pi D^2) / 4$

D = Diameter = 4.37 ft = 52.4 inches

This calculated diameter becomes the reference point for your scrubbing equipment selection. You can then use **Chart 2** to approximate particulate efficiencies for a Venturi or Impinjet scrubber.

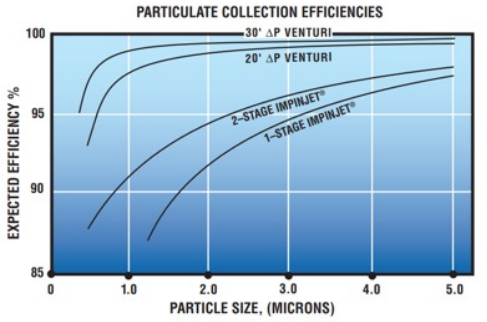
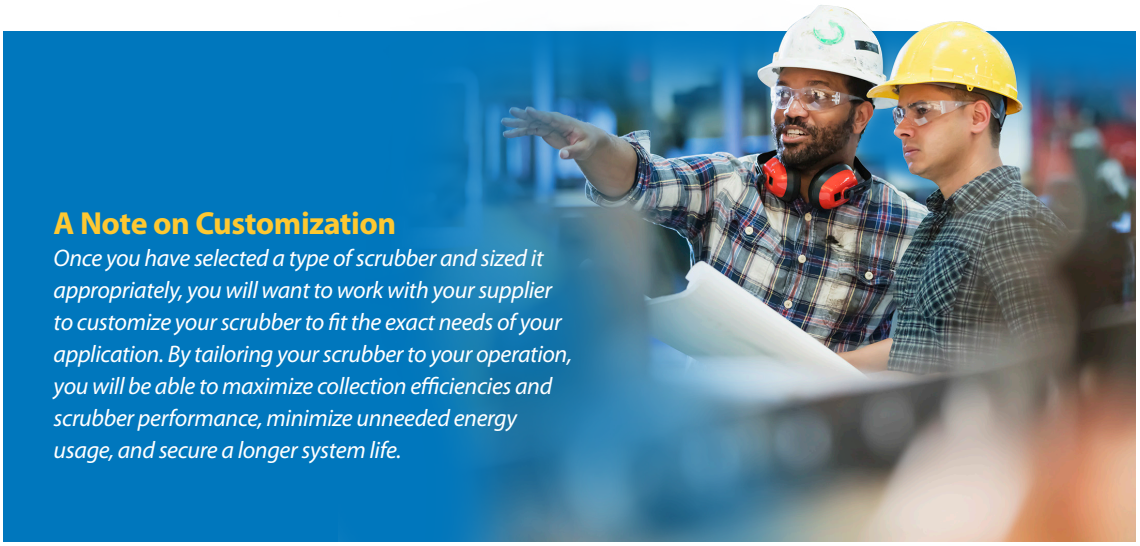


Chart 2

Determining the number of stages that you would need for an Impinjet requires a highly complex calculation with too many variables to be defined simply within a chart. However, the main variables include gas volume, temperature, particle size and moisture content, along with your process description and the type of contaminant(s) you have. Sly's experts can easily perform these calculations for you to ensure you size your scrubber correctly.



A Note on Customization

Once you have selected a type of scrubber and sized it appropriately, you will want to work with your supplier to customize your scrubber to fit the exact needs of your application. By tailoring your scrubber to your operation, you will be able to maximize collection efficiencies and scrubber performance, minimize unneeded energy usage, and secure a longer system life.

Ongoing Upkeep and Maintenance

Once you have the perfect wet scrubber installed in your facility, you will want to perform routine maintenance on your dust collection system to ensure that everything stays working properly. Neglecting the appropriate upkeep and maintenance can lead to lower collection efficiencies, performance losses and damage to your scrubber.

While the exact frequency will vary depending on your scrubber and your application, Sly recommends a consistent inspection schedule, focusing on the main problem areas. Due to their unique means of dust collection, most wet scrubbing systems are prone to certain operating issues. The most common problems include:

- Inadequate liquid flow
- Liquid re-entrainment
- Corrosion or abrasion
- Scaling
- Tears, leaks or structural damage (duct or joint warpage)
- Poor gas-liquid contact
- Plugged or clogged parts (nozzles/beds/mist eliminators)

In order to make sure that the above never become a problem, the key aspects of your scrubber that you should monitor are:

Structural Integrity

A stable, well-installed scrubber will lead to reliable system performance. On the other hand, a wet scrubber with compromised structural integrity can quickly lead to problems. Whether it's from structural damage or misaligned equipment, a compromised scrubber can reduce equipment life cause health concerns.

***Key takeaway:** conduct a comprehensive inspection at least once annually, paying attention to any welds, flange seals and joints.*

Ductwork

The ducts of your air quality control system are what allow particulate to reach your scrubber. Over time, particulate can accumulate within your ductwork, negatively impacting the performance and efficiency of your scrubber. This is a problem best avoided or caught early on, as significant dust accumulation can wear away the ductwork itself, creating an even bigger issue and maintenance hassle.

***Key takeaway:** monitor system pressure and periodically inspect the entire length of your system's ductwork for any dust accumulation.*

Auxiliary Equipment/Systems

Your air quality control system is about more than just the wet scrubber itself. Exhaust fans, inlet/outlet dampers, and other auxiliary equipment must be inspected and maintained in order to ensure high collection efficiencies and system life.

***Key takeaway:** include all auxiliary equipment and complementary systems in your inspection and maintenance routine.*

When anything goes wrong with these areas, you will want to perform quick repairs to ensure that a larger problem does not develop. So long as you follow your recommended inspection schedule and take a proactive approach to maintenance, your wet scrubbing system should last its lifetime while maintaining high collection efficiencies and stable performance metrics.

The Sly Advantage: **Wet Scrubber Expertise**

Better Wet Scrubbers at Sly: THE Experts in Air Quality Control

Here at Sly, as an OEM with nearly 150 years of experience in air quality control, we can help you find the perfect wet scrubber for your application. Our quality lines of base equipment, combined with our expertise in customizing our solutions to fit your specific needs, leads to one thing – better wet scrubbers.

We also have the industry experience to better understand your specific application and all of your dust collection requirements. That all starts with asking the right questions. Some of the things that we might ask include:

- *Do you have a particulate issue, a gas-phase contaminant issue or both?*
- *How much dust are you generating? Specifically, how much dust is coming to the scrubber?*
- *What are the physical characteristics of your dust? Are the particles dry or wet/sticky? Do they float or sink when put in water?*
- *What is the particle size distribution or average minimum particle size of your dust?*
- *Do you want to recover and recycle any captured dust that the scrubber captures?*

Once we know more about your process, our experts build off our past experience to ensure you get the best wet scrubbing system for your needs. Only with that initial understanding of the problem can a supplier create the perfect dust collection system for your unique needs.

By optimizing the performance, collection efficiencies and energy usage of your scrubber, Sly can help you achieve the best dust collection system possible, enabling a safer and more productive facility.