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# Solving the air quality challenge

**Damion Adams, Kevin Bley and Jeremias Shreyer, CECO Environmental, USA,** review the technologies available to the industry to ensure compliance with air quality standards during fertilizer production.

As the world population continues to expand, and as more societies move from being predominantly rural to increasingly urban, agriculture must become more productive and more land must be brought under cultivation to meet the growing demand for food for the non-farming population. Fertilizers are critical to this effort. At the same time, as air quality becomes a major concern in more and more countries, fertilizer producers face increasingly strict and complex regulatory environments.

As recently as the 1990s, inadequately controlled emissions of nitrogen oxides ($NO_X$) and sulfur oxides ($SO_X$), gaseous ammonia, and other hazardous compounds were causing serious public health problems in areas surrounding fertilizer plants. In developing countries, lax oversight combined with irresponsible management has led to at least one major disaster. Detailed, rigorous regulation is therefore essential.

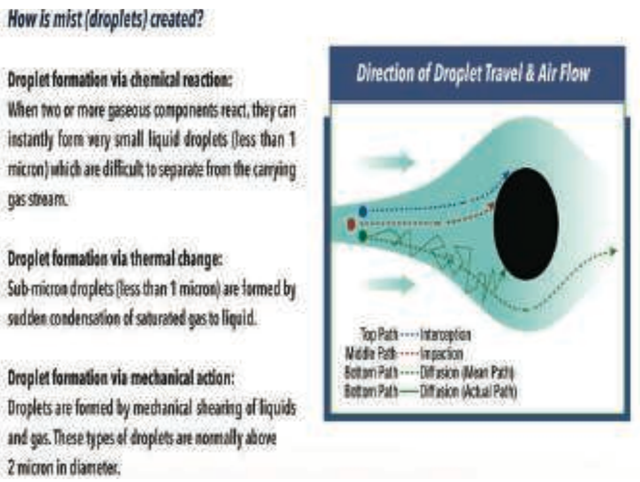


**Figure 1.** How mist droplets are created.

**Figure 2.** Industrial cyclone.

At the same time however, the fertilizer production industry must expand its capacity to meet the increasing demand – and remain in compliance.

Fortunately, there is a range of technologies that can be deployed to meet new regulatory standards while allowing fertilizer companies to continue profitable growth. Some of the largest fertilizer production companies in the world are utilising some of the technologies discussed in this article, including CECO Filters, to manage particulate matter (PM) for example. Other technologies discussed include venturi scrubbers for particulates with high moisture content, fabric-based and fibre-based filter systems for mist collection, packed-bed filtration for acid-related gases and for odour control, and baghouses for dust and other dry particulates.

## Operating principles of industrial scrubbers

Scrubbers are one of the primary technologies used to control gaseous emissions from fertilizer production, and there are two major types: dry and wet. Dry scrubbers inject a dry reagent or slurry into a dirty exhaust stream to capture acid gases. The resulting sludge is collected at the bottom of the chamber for safe disposal.

Wet scrubbers use liquid to achieve the same goal. One type of wet scrubber commonly used in the fertilizer industry is the venturi scrubber. In these devices, the dirty gas is forced at high velocity through a venturi, a narrowing tube ending in a single nozzle, into a chamber where it collides with a fine mist of scrubbing water. The tiny water droplets, only a few microns in diameter (Figure 1), capture particles through impaction (the heavier particles collide with droplets) and diffusion (the lightest particles eventually collide with droplets through Brownian motion within the pressurised stream). The resultant particle-entrained mist is fed through a cyclonic separator, which uses centrifugal and inertial force to separate out the droplets of solution from the gas stream. This limits the concentration of solids and allows the water to be recirculated back into the venturi section. Other types of wet scrubber, involving two or three stages, are used to extract compounds such as $NO_X$ or $SO_X$ from exhaust streams through a reaction between the pollutants and droplets of a reagent solution. The resulting liquid is collected in a tank for disposal. For example, in the packed-bed scrubber, which is particularly suited to highly acidic effluent, the contaminated gas flows through a specially designed chemically inert packing medium that is wetted with recirculated liquid. The liquid solvent absorbs the gas pollutant by physical or chemical means. A blowdown of additional water from the reservoir at the top of the unit removes contaminant products before they precipitate.

## Industrial cyclones

Industrial cyclones utilise centrifugal force to capture, recover or remove large and high-volume particulate matter dust from industrial applications (Figure 2). Many of the largest fertilizer companies use industrial scrubbers in the management of particulates from phosphate.

## Filtration used in fertilizer production

Compounds from fertilizer production, whether destined for recycling or for disposal, can be captured through various types of filtration system. In one type, used primarily for the capture and recycling of ammonium nitrate (AN), as well as to control emissions of pollutants, the filter separators move gas containing entrained solids and liquids through narrow tubes arranged in parallel either horizontally or vertically. These tubes, containing the filter media, are where solids and bulk liquids are removed and where coalescing takes place. In the case of AN, the waste nitric acid and ammonia in the gas are fed into a reactor, where they generate more of the compound. The resultant solution, in the form of fine droplets, is then fed into an evaporator, where the AN is concentrated via heating.

The remaining water from the evaporator, which still contains AN as well as some waste nitric acid and ammonia, is fed into a mist extractor as steam.
Mist extractors work in various ways. One of the most frequently used types is the candle filter, also known as a fibre-bed filter, which is typically a vertical chamber containing one or more arrays of fibrous filter material packed between two concentric porous cylinders.
The gas-and-droplet stream is fed into the filter at right angles to the axis of each cylinder, where the aerosolised droplets are captured and held by the fibres, while the cleaned gas exits through the other side. The collected liquid particles are coalesced into larger droplets on the filter's fibre surface and drained from the media by gravity once the mass of the particles is great enough to allow the droplets to flow. The fine-fibre filter material captures virtually all the AN, ammonia, and nitric acid from the mist: collection efficiencies as high as 99.9% can be achieved. The cleaned gas is then fed into the venting system.

For reasons of cost or space, operators may not want to replace an entire scrubber. A solution, offered by CECO Environmental, is to take advantage of the unused space inside the annular area of a standard filter element, and increase the surface area of the fibre-bed 'filling' by up to 60% along with the gas throughput, without the need for a larger vessel. For new installations, this double packing allows the vessel housing to be much smaller, saving CAPEX. Where the goal is simply to remove a chemical from effluent gas in order to control pollution, remove odour, or minimise the opacity of the plume from the stack, the same basic technologies, such as packed-bed scrubbing, can be employed singly or in combination as mist eliminators.

The granulated dry fertilizer product presents its own pollution issue: dust. Dust can pose a respiratory hazard to both plant workers and plant neighbours. Like any flammable particulate suspension in the air, its presence also creates a risk of explosion. This problem can be addressed by using a baghouse, a chamber containing long, cylindrical bags or tubes made of woven or felted fabric as a filter medium. Dust-laden air is directed into the baghouse compartment, and the air is pushed or drawn through the bags so that a layer of dust builds up on the filter fabric surface until it completely blocks the air flow. When there is enough of a pressure drop in the chamber, the cleaning process begins. This can be done either while the baghouse is actively filtering or when it is offline. Filtering resumes when the compartment is clean. Analogously to the operation of wet scrubbers, dust particles can accumulate on the medium through inertia as they flow perpendicular to the fibres of the bag, through interception as they collide with the fibres, through diffusion of very small particles caused by Brownian motion, and by electrostatic charge on the particles and the filter that makes them cling together.
A combination of these mechanisms results in the formation of a dust cake on the filter, which eventually increases the resistance to gas flow.

## Operating principles of regenerative thermal oxidisers

One method for cleaning volatile organic compound (VOC) laden air is for it to be directed by a poppet valve mechanism to flow through one or more beds into the combustion chamber. These beds have been previously heated and because of the intimate contact between the air and ceramic material, very high rates of heat transfer are produced. This results in the air being preheated very closely to the required oxidation temperature by the time it reaches the combustion chamber.

The air then enters the combustion chamber, where a small amount of heat is added by a fuel-fired burner to combustion temperatures. The thermal oxidation process then takes place and the pollutants are destroyed.

The clean air next exits the combustion chamber through another bed or beds that have been previously cooled. As the air passes through these beds it is cooled by the same heat transfer process. The air then exits the regenerative thermal oxidiser (RTO) system at a temperature only slightly higher than the inlet temperature.

After several minutes the first set of beds (inlet) becomes depleted of heat while the second set of beds (outlet) becomes saturated with heat. At this point the flow of air through the beds is reversed, with the formerly inlet beds acting as the outlet beds and the outlet beds now acting as the inlet beds. In this way each bed periodically extracts heat from the clean gas stream exiting the combustion chamber and then releases this heat into the polluted gas entering the combustion chamber. This method is known as thermal regeneration. The combination of thermal oxidation and regenerative heat recovery allows the RTO system to efficiently destroy VOC laden air with reasonable operating costs.

## Conclusion

Many industrial manufacturers have been using air quality technology to remove the majority of VOCs, particulates and other harmful airborne toxins for decades.
As fertilizer production grows and scales up to meet the growing demand for food around the world, there will be a need to understand and apply air quality technologies. **WF**