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Managing Wastewater Treatment Odors

Mitigating odors through exhaust dilution

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By Paul A. Tetley

The generation of odoriferous exhaust often is a necessary evil associated with wastewater treatment at chemical processing facilities. Although many communities once were tolerant of odors caused by chemical industry activities, they are less tolerant today. More municipalities are either passing laws that restrict odoriferous exhaust or at least calling attention to situations in which wastewater is being processed and a visible exhaust stream is apparent.

Although many methods exist to eliminate most — if not all — odors emanating from wastewater treatment facilities, one relatively new technology has not received as much recognition as the others. This article discusses that technology — exhaust dilution — and explains how it controls odors through the use of roof-mounted mixed-flow impellers.

A mixed-flow impeller system mounted on the roof of a wastewater treatment facility treats odors through dilution.

Defining odors

One of the complicating factors concerning odor generation is that individual odor perception varies greatly. Those people who are most sensitive to an odor can be as many as 10,000 times more sensitive to that odor than those who are least sensitive to it, according to the American Industrial Hygiene Association (AIHA). Emissions causing wastewater treatment odors can be either toxic or nontoxic, with toxic emissions regulated by the U.S. Environmental Protection Agency (EPA), the U.S. Occupational Safety and Health Administration (OSHA) and other government agencies. Nontoxic emissions generally are considered completely safe (or safe in the amounts likely to be generated), although even "safe" materials might have limits beyond which their emissions are regulated.

Treatment considerations

Among the many methods to manage wastewater treatment odors are those using chemical additives such as potassium permanganate, sodium hypochlorite or chlorine, as well as those employing precipitators, scrubbers, thermal oxidizers, charcoal filters or other expensive hardware to treat process exhaust prior to discharge. However, mixed-flow impeller technology has been increasing in popularity over the past few decades.

Mixed-flow technology dilutes exhaust gas flow by mixing it with outside ambient air. Although this is an efficient method for controlling odor, particularly when compared to other methods such as wet scrubbing, charcoal filtration and thermal oxidation, its efficacy is much harder to predict quantitatively with regard to the precise amount of chemical materials that will be removed from the exhaust stream. Hence, the issue of odor perception might need to be addressed.

A combination of one or more methods of odor control is required in some situations, depending on the materials being treated. In addition, atmospheric conditions sometimes determine which approach or approaches might be best suited for an application.

For most applications, however, mixed-flow impeller technology prevents offensive odors from permeating neighboring buildings and neighborhoods. In addition, mixed-flow impeller fans are low profile and eliminate the negative connotations — the perception of pollution — typically associated with tall exhaust stacks.

Understanding dilution

The theory of mixed-flow technology is simple: To eliminate odors, fresh air is mixed with the wastewater process exhaust gases until a suitable concentration (in parts per million [ppm] or milligrams per cubic meter [mg/m^3]) is reached and the odor is no longer perceptible or objectionable. This dilution can be achieved in one of two ways — directly, by dilution of the exhaust stream (plume) before it leaves the exhaust fan, or indirectly, by dilution of the fan's exhaust stream by the atmosphere before the exhaust reaches the property line, nearby air intakes or sidewalks.

Direct-dilution is the most efficient and cost-effective method. It is accomplished through the use of a mixed-flow impeller fan, which draws odor-laden exhaust into a ductwork system and carries it to the highest point of the building's roof. At the roof, fresh air is drawn into the exhaust fan to mix with and dilute the odoriferous exhaust gases generated by the wastewater treatment process.

This technique is most effective when the resulting mixture of process exhaust and outside air is ejected from the fan upward at a high velocity. In fact, wind tunnel studies have found direct dilution is most effective when the diluted air stream is projected upward at velocities in excess of 3,000 feet per minute (fpm).

To achieve a comparable efficiency, albeit at a substantially higher cost, another solution would require a centrifugal-type belt-driven exhaust fan ducted to a dedicated steel stack as tall as 100 feet (ft.) to disperse the plume of odor from the fan. The cost and complexity of such a structure, as well as the less-than pleasing aesthetics associated with it, reduce the structure's appeal. In addition, for retrofit situations in which employees or neighbors previously have complained of an odor, a tall stack can be a daily reminder of the odor's presence.

Direct dilution is most effective when the mixture of process exhaust and outside air is ejected from the fan upward at a high velocity.

Mixed-flow impeller fans draw in nearly twice the amount of fresh air as exhaust air into the fans' exhaust and send it in a "jet plume" at an exit velocity as great as 5,000 fpm. The jet velocity causes large amounts of outside air to be drawn into the plume. This injection of fresh air causes immediate odor relief by dilution, and sends the odor-laden gas/air mixture high into the atmosphere.

In most cases, this type of system eliminates odor problems in the neighborhood; however, it can be combined with one or more of the other available odor control methods if necessary. For example, certain pollutants might not be dispersed effectively by dilution alone, and the addition of chemicals such as potassium permanganate, sodium hypochlorite or chlorine could help dilute and/or diminish the odor. In some cases, chemicals, mixed-flow technology fans and carbon scrubbers work together to treat odors from a wastewater treatment pumping station, for example. Considerations such as ambient air temperature and humidity also come into play in odor-control technology selection; odors are perceived more easily under certain atmospheric conditions than others.

Dilution levels will vary, depending on the chemical content of the wastewater being treated. For example, mer-

The low-profile design of a mixed-flow impeller system can be a benefit to facilities situated near residential neighborhoods or in other locations where aesthetics are important.

captan and hydrogen sulfide emission-related odors, irritating even at extremely low concentrations, will require substantially more dilution than will typical municipal wastewater emission-related odors.

Technology benefits

Mixed-flow fans are substantially shorter than the tall, often unsightly stacks typically used with conventional centrifugal fans. In addition, low-profile mixed-flow impeller fans do not require structural reinforcements on the roof, and do not call for complex, expensive mounting/stabilizing hardware such as elbows, flex connectors, guy wires or spring vibration isolators. Their simplicity can reduce installation time and costs significantly.

Moreover, mixed-flow impeller fans typically consume approximately 25 percent less energy than conventional centrifugal fans, and offer faster payback, as well. Typical energy reduction is $0.44 per cubic foot per minute (cfm) at $0.10/kilowatt-hour, providing an approximately two-year return on investment.

Their lower noise levels — particularly in the lower octave bands — also might be advantageous in some locations. When noise is still an issue, however, accessories such as acoustical fences and acoustical silencer nozzles can be used.

They conform to all applicable American National Standards Institute/AIHA Z9.5 laboratory ventilation guidelines, as well as to American Society of Heating, Refrigeration and Air-Conditioning Engineers 110 standards and National Fire Protection Association 45 standards, and are Underwriters Laboratories-listed.

Under normal conditions, the systems are designed to operate continuously for years without maintenance. Direct-drive motors have lifetimes of 200,000 hours. Nonstall characteristics of the system's mixed-flow wheels permit variable-frequency drives to be used for added variable-air-volume savings, built-in redundancy and design flexibility.

The systems are available with a variety of accessories that add value and further reduce noise and energy costs.

The final decision

Although much literature exists on handling odoriferous exhaust at chemical processing facilities, determining the best method for relief generally is based on the compounds causing the odor and their concentrations, as well as on factors such as exhaust flowrates, atmospheric conditions and even building configurations. Mixed-flow impeller technology, however, should be considered as the first line of defense at many chemical facilities because of its lower cost, reduced noise, simple installation and other advantages.

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Additional Odor Control Considerations

When evaluating dilution, either alone or combined with another odor control technology, the chemical plant should remember to:

- Direct odor-laden air upward, and include rain protection that prevents downward flow (no rain caps, goosenecks or flapper dampers).
- Use as high a stack exit velocity as possible (at least 3,000 fpm).
- Locate exhaust fans on the highest usable roof with regard to duct connections.
- Use a combination of extra fresh air from the roof into the stack flow along with stack height to achieve desired odor detection levels at the property line or supply air intakes.

Keep in mind that dilution applies to the control of odor problems emanating from constituents that are not subject to further regulatory requirements. Volatile organic compound and hazardous air pollutant emissions, for example, require additional treatment.

The cost for some types of control equipment is dependent on airflow rates (in cubic ft/meter). Thus, if additional controls are required, dilution could result in higher costs unless the other system is placed upstream of the dilution fan.

Other odor-control methods include:

- Prevention — eliminating the source of the odor or substituting a non-odor-causing material.
- Minimization — reducing the amount of odor-causing material or causing it to evaporate at a slower rate.
- Masking — adding a pleasant odor to the air to hide or mask the objectionable odor. Masking usually is too costly to be used very often in chemical facilities.

Some specific prevention and minimization strategies include:

- Eliminating the pollution source.
- Changing the raw materials and/or fuels.
- Modifying process operations.
- Recycling the exhaust instead of venting it to the atmosphere.
- Minimizing the entrainment of pollutants into the gas stream.
- Reducing the number of system locations where materials can become airborne.
- Recycling a portion of the process gas.
- Designing hoods to exhaust the minimum quantity of air necessary to ensure odoriferous pollutant capture.

Odor-control technology selection depends on the compounds causing the odors and their concentrations, as well as on the air stream's flowrate, moisture content and variability.