Ventilation and Odor Control in Dewatering Buildings

James S. McMillen, P.E.
Perkins Engineering Consultants, Inc.
6001 Interstate 20 West, Suite 219
Arlington, Texas 76017
jmcmillen@perkinsconsultants.com

Coauthors:
Ricardo J. Azcarate, P.E., President, Azcarate & Associates, Dallas Texas
Tim Gallia, Project Manager, Azcarate & Associates, Dallas Texas

ABSTRACT

Selecting the appropriate ventilation and odor control airflow rates for wastewater treatment plant structures is part art and part science. Available design guidance is minimal and most airflow rates are selected with a healthy amount of engineering judgment. This can be particularly important when selecting airflow for occupied spaces where wastewater or biosolids are exposed to the indoor atmosphere. The life, health and safety aspects of providing fresh air in occupied spaces is critical and the corresponding odor control demands can be expensive.

In many occupied facilities, the default design is usually 12 air changes per hour. Historically, TCEQ, NFPA and other organizations have selected 12 air changes per hour as the minimum air exchange rate to provide a safe atmosphere. Recent experience has shown that much higher air exchange rates and other measures may be needed to provide an adequate building environment, particularly in solids handling facilities and in other structures where wastewater or biosolids are exposed to the indoor environment.

This paper will present background and case studies of several wastewater treatment plants. Ventilation rates, fume capture effectiveness, supply air configuration, and personnel safety issues will be explored. Best practices for improving occupies space atmospheres will be discussed.

KEYWORDS

Ventilation; dilution; capture velocity; odor; odor control; dewatering; solids; gravity belt press; gravity belt thickener.

INTRODUCTION

Selecting and designing appropriate ventilation systems for dewatering facilities requires adherence to minimum standards published by regulatory authorities but also requires engineering judgment. Typical guidance focuses on airflow rates to achieve a minimum number of air changes per hour in a building or room. Experience has shown that
defaulting to six or twelve air changes per hour may not provide a non-hazardous atmosphere in a dewatering area. Although the minimum regulatory requirements should be followed, additional design practices beyond diluting the room air can reduce capital and operation costs for ventilation and odor control.

Designing for an air changes per hour criteria will typically involve supplying, exhausting and treating large volumes of air. This has a correspondingly high cost in equipment, electricity and treatment chemicals. Other methods are available for improving the atmosphere can reduce the volume of air and the associate cost. Typical methods would include containing the odorous air at the source and treating it separately from the room ventilation or arranging supply and exhaust plenum to remove the foul air without a high level of dilution.

Containment of hazardous gases is always the best first practice and can reduce dilution air requirements for the entire space drastically. As an example, laboratories use capture exhaust hoods to contain and capture hazardous gases but these hoods almost totally enclose the hazard. It has been observed that hoods over belt presses without some sort of walls extending to near the floor to capture and contain the hazardous gases offer very little benefit since the capture velocities are very low and sometimes non-existent at the bottom of the hoods.

The primary air contaminant and health concern in dewatering operations is the presence of hydrogen sulfide. Other contaminants that may cause concern are ammonia (from the lime stabilization process), methane (as a fire hazard) and humidity (which can accelerate corrosion). Several authorities publish exposure limits for these compounds; Figure 1 below lists some exposure limits.

<table>
<thead>
<tr>
<th></th>
<th>H₂S, ppm⁶</th>
<th>NH₃, ppm⁶</th>
</tr>
</thead>
<tbody>
<tr>
<td>OSHA²</td>
<td>General Industry 20</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Construction Industry 10</td>
<td>---</td>
</tr>
<tr>
<td>ACGIH³</td>
<td>--- 1</td>
<td>--- 25</td>
</tr>
<tr>
<td>NIOSH⁴</td>
<td>--- 10</td>
<td>--- 25</td>
</tr>
<tr>
<td>IDLH⁵</td>
<td>--- 100</td>
<td>--- 300</td>
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</tbody>
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¹http://www.osha.gov/dts/chemicalsampling/toc/toc_chemsamp.html
²Occupational Safety and Health Administration
³American Council of Industrial Hygienists
⁴National Institute for Occupational Safety and Health
⁵Immediately Dangerous to Life and Health
⁶Limits may be higher for short term exposure

For the most cost efficient and effective design, the following procedure should be followed:

1. A minimum air exchange rate should be set to follow the regulatory requirements.
2. If NFPA 820 (see below) requires higher airflows to lower the electrical classification, perform a cost analysis and select a higher airflow if economically favorable. Otherwise, consider a lower airflow and design the electrical system appropriately.
3. Determine if appropriate room air quality can be achieved with the selected airflow. If not, select a higher airflow or use additional control methods to
improve the air quality. Reevaluate the electrical classification in light of the final airflow.

**DESIGN CRITERIA**

Several organizations and regulatory authorities provide guidance for selecting airflows. These include TCEQ, OSHA, NFPA and others.

**TCEQ:** In Texas, the regulatory authority for wastewater treatment is the Texas Commission on Environmental Quality (TCEQ). Rules are promulgated in 30 TAC 217 Design Criteria for Domestic Wastewater Systems. Ventilation and odor control for Sludge Treatment Units rules are given in §217.246. The rule states:

“(a) A design must include sufficient ventilation to eliminate an accumulation of fumes or gases at a level that might be a health hazard or a threaten air quality.

(b) An enclosed area that may be accessed by staff must have automatic mechanical ventilation.

(1) A continuous ventilation system must provide at least six complete air exchanges per hour.

(2) An intermittent ventilation system must provide at least 30 complete air exchanges per hour;

(c) A sludge processing unit must be designed to prevent nuisance odors.”

As discussed below, providing six air changes per hour may not be sufficient in reducing hydrogen sulfide levels to a nonhazardous level.

**OSHA:** Although the Occupational Safety and Health Administration (OSHA) regulations do not apply to any state or subdivision of a state (exempted by section (2) (5) of the Occupational Safety and Health Act of 1970), OSHA standards are typically referred to as a standard of practice by designers. The primary standards used are the Permissible Exposure Limits (PEL’s) for various compounds (See Figure 1 above).

**NFPA:** National Fire Protection Association (NFPA) Standard for Fire Protection in Wastewater Treatment and Collection Facilities (NFPA 820) sets electrical classification requirements for treatment processes. These classifications depend on the hazards that may be present and the ventilation provided. It should be emphasized that the standard does not apply to toxicity and biological hazards.

**Figure 2 – NFPA 820 Table 6.2**

As seen in Figure 2, a continuous ventilation rate of 6 air changes per hour or more will render an enclosed dewatering room unclassified from a National Electric Code.
perspective. Again, six changes per hour may not be sufficient for health and safety purposes but provides a typical starting point for ventilation rates.

Although a great deal of attention is paid to criteria such as the number of air changes per hour, the most efficient designs will also focus on containing odor at the source. By capturing odor as it’s created, a lower air flow is needed compared to a typical full building exhaust. In other words the building airflow may only need to be six or twelve air changes per hour if the dewatering press is enclosed and exhausted separately. Guidance can be found from organizations such as ACIGH and ASHRAE.

ACIGH: The American Council of Industrial Hygienists (ACIGH) publishes the reference *Industrial Ventilation: A Manual of Recommended Practice for Design*. Although not regulatory in nature, several design practices have been adopted in the industry to improve air quality and lower costs. Examples would include the use of hoods to capture air from a gravity belt press to exhaust for separate treatment.

ASHRAE: Although primarily concerned with climate control in buildings, the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) is the primary authority in air movement. Often overlooked is the need for an appropriate capture velocity to entrain air contaminants. ASHRAE recommends capture velocities for certain operations. Most dewatering process will fall into the range of 100 to 500 feet per minute (fpm) air velocity to adequately capture contaminants.

VENTILATION PRACTICES

Focusing on providing fresh air into the “breathing zone” of building occupants can also reduce the volume of air. It has been observed that the air distribution and collection system design and distribution can have a larger impact on the hazardous gas concentration levels within the breathing zones than pure dilution alone. While the capture rate drops off drastically within short distances of exhaust hoods or exhaust registers the supply air is capable of pushing contaminants long distances. If containing the source of emissions is not possible, a push-pull arrangement has proven to have the highest success rate of removing contaminants with the supply air pushing the contaminants down toward low wall exhausts.

At two locations at WWTP #2 (see below), the H$_2$S concentrations near the presses were observed to be as high as 40-100 PPM with either 20 or 12 air changes per hour. H$_2$S readings of 12-14 ppm were observed at the same buildings within the fresh air envelope where the supply air registers were directing outside air into the building. Supplying fresh air into and along the aisle spaces (worker areas) around the presses and toward low-point exhaust resulted in much lower concentrations of H$_2$S than can be accomplished by dilution alone in the breathing zone. Without attention to the delivery of air, H2S readings as high as 100 ppm would theoretically have required increasing the ventilation rate to 60 air changes per hour based on dilution alone to keep H$_2$S concentrations within acceptable limits. Also, careful consideration must be given to the quantity, location, velocity, and direction of throw for the supply registers to cover as
much of the aisle spaces as possible while not excessively “stirring” the air and returning entrained contaminants back up into the breathing zone.

The key: aim fresh supply air to the occupant breathing zones and exhaust from the source of the hazardous gases.

**ODOR CONTROL PRACTICES**
Ventilation and odor control in dewatering buildings must be coordinated for proper function. Typically a slightly higher exhaust flow rate is used compared to the supply flow rate. This allows for a slight vacuum in the building to prevent odorous air from escaping from the building.

When feasible, containment of the odor source should be the primary goal of a designer. This will reduce the airflow, and associated costs, of the odor control system. Most manufacturers of dewatering equipment offer enclosures for their systems.

**Figure 3 – Ashbrook® AquaBelt® with Cover**

Using the manufacturer’s enclosure can provide a well-sealed, minimized system and still accommodate operation and maintenance activities. When retrofitting a system, consider constructing a rigid enclosure if space is available.

A typical design will use air capture hoods located above the belt face and may include PVC strip curtains. Strip curtains help contain air from the lower areas of the press and while allowing for operation and maintenance activities. Hoods are most effective when located close to the belt face.

**Capture Velocity**: The most important, and most overlooked, facet of hood design is the capture velocity of the hood. The capture velocity is the velocity of air currents in the hood zone of influence. According to ASHRAE, capture velocities should be in the range of 100 to 500 fpm for operations similar to those found in dewatering.

Velocities drop off rapidly as the distance from the hood face increases. For an unflanged hood, the air velocity twelve inches from the hood face is less than 10% of the hood face velocity. Given the size of a typical dewatering press, odor capture is unlikely to be effective at any location beyond the belt face for any reasonable airflow. Using strip curtains or other enclosures will help contain the odorous air and allow it to be captured by the hood.
**Odor Control Facilities:** After the odor control airflow and contaminant concentrations are determined, selecting the odor control equipment is straightforward. If space is available, an in-ground odor control biofilter typically offers the lowest long-term costs. Using a variable frequency drive or two-speed motor can lower energy costs if the dewatering activities do not occur on a 24-hour basis. Typically, a minimum airflow of six air changes per hour should be maintained even when not dewatering.

If space is not available, using a chemical scrubber may be the best alternative, particularly if dewatering occurs on an intermittent basis. Like a biofilter, using a VFD or two-speed motor can reduce the operating costs. Chemical usage is minimal when not dewatering.

Bioscrubber or biotrickling filters are typically not the best option for dewatering facilities due to the high airflow needed and intermittent operation.

**Drains:** Consideration must be given to H₂S leakage into the building via floor drains. High H₂S levels were observed at the certain floor drains in the dewatering building at WWTP #3. Smoke testing demonstrated that air was flowing into the building from the floor drain. The floor drains did not have p-traps or check valves between the floor drain and manhole where the drain pipe discharged to. Typically, some engineers prefer not to provide p-traps in the floor drains due to the risk of solids building up in the p-trap and plugging up the drain line. Floor drains with removable covers that can be capped when not in use; p-traps with flushing lines and accessible cleanouts and/or check valves in the drain lines will help minimize H₂S leaking back into the building.

**SURVEY OF FACILITIES**

Three municipal wastewater treatment plants were investigated to determine odor control practices for the dewatering facilities. A brief description of each facility is below.

**WWTP #1:**

WWTP #1 was retrofitted with gravity belt thickeners to thicken primary sludge. Recognizing early on that the existing ventilation system would not accommodate the increased H₂S levels in the room, the owner elected to use a combination of hoods over the belt to exhaust air and plastic strip curtains to contain odor. Figure XX below shows the hood and strip curtains.
Field measurements on an operating press showed that H$_2$S exceeded 100 ppm just inside the strip curtain and was less than 5 ppm just outside the curtains. The plastic curtain strips typically accumulate splash from the thickener and wash down process and eventually need replacement. Plant personnel report that the curtains are changed out every three months at a material cost of approximately $200.

**WWTP #2:**
WWTP #2 was designed for 18 air changes per hour with hoods over the belt filter and gravity thickener presses. Fresh air ventilation is provided by overhead duct with air distribution directed both into the worker breathing zone and into the room.

Foul air is exhausted from both the hoods and duct located near ground level. As H$_2$S is heavier than air, it will tend to settle in low areas absent any disturbances. Field testing indicated that H$_2$S levels under the hoods varied from approximately 25 ppm to over 100
ppm. Ambient air concentrations in the room were consistently below 10 ppm except for areas immediately adjacent to the presses.

**WWTP #3:**
WWTP #3 was designed for 12 air changes per hour with hoods over the belt filter presses. Plastic strip curtains extend from the hoods to the belt table at the top of the presses. Figure XX below shows the arrangement.

*Figure 6 – WWTP #3 Belt Filter Press*

Ambient H₂S concentrations in the room frequently exceed 100 ppm. Smoke testing indicated that air from the lower levels of the press is not contained by the hood and curtain arrangement. Operators have objected to extending the curtains due to interference with operation and wash down of the press. Due to the congested space, alternate containment designs are not feasible. The owner is in the process of increasing the airflow to 24 air changes per hour, adding additional exhaust locations, and reconfiguring the supply air duct to provide fresh air directly to the breathing zone. It was also determined that no traps were present on the building drains. Check valves are being added to prevent odor from the plant drain system from entering the building.

**CONCLUSION**
Several different options exist for supply and exhaust ventilation in dewatering buildings. By containing and exhausting odors at the source, the cost of ventilation and odor control systems can be reduced.