Indoor air quality (IAQ) is a constantly changing interaction of biological, chemical, and physical factors. One sign of poor IAQ is the presence of unpleasant odors. In a number of recently documented cases, “sick building syndrome,” a term used to describe buildings with hazardous air contaminants, has been cited as the primary culprit in the shutdown of workplaces for extensive cleanings and renovations. Proper IAQ management, including odor control, can prevent such shutdowns, and ultimately save companies millions. The methods used for odor investigations and odor abatement in commercial and industrial facilities are described in this article.

To shorten the cycle from an odor complaint to the resolution of the problem, it is very helpful to have good documentation for the building. Building owners or operators should consider developing an IAQ Profile—a description of the features of the building’s structure, function, and occupancy that affect air quality—to serve as an owner’s manual or reference specific to the building. By collecting and reviewing existing records; conducting a walk-through inspection of the building; talking with maintenance and facility engineers; and compiling detailed data on the HVAC system, pollutant pathways, pollutant sources and building occupancy, the four key IAQ profile questions can be answered:

1. How was the building originally intended to function?
2. Is the building functioning as designed?
3. What changes in layout and use have occurred since the original design and construction?
4. What changes may be needed to prevent future IAQ problems from developing?

Once completed, the IAQ Profile will help identify potential problem areas and prioritize budgets for maintenance and future modifications.

Odor investigation and abatement includes some measure of trial and error, and no two cases are alike. In some instances a relocation of chemicals will solve the problem. However, some situations can require ventilation installation, process controls, or an air pollution system. With a building’s IAQ Profile in hand, the organization can focus on the scent in
question. Odor problems are typically easier to identify and solve in a commercial facility compared to an industrial facility due to the limited number of potential odor sources.

Assessing building air quality and odors in industrial facilities

In addition to the odor sources listed for commercial settings, industrial facilities can have further causes or sources for odor. The sources of an odor in an industrial setting may include any of the sources listed above for commercial facilities, plus the following:

- Vapors released from processes
- Accidental chemical spills
- Chemical reactions
- Raw material storage
- Process equipment maintenance
- Process waste materials

Typically, a light manufacturing facility has adjacent office space. Such cojoined buildings increase energy efficiency and fuel cost savings, but can also create elevated indoor air contaminant and odor levels, and cause increased worker complaints, illnesses, and sick days. Because the air used in office environments is shared with their adjoining light industrial and manufacturing plants, the approach to odor investigations and abatement becomes even more complex and critical. Factors such as the wide variety of prevalent chemicals and the necessity for local exhaust ventilation to remove contaminants are of primary importance.

Manufacturing equipment requires well-designed and enclosed local exhaust ventilation to properly capture contaminants by using the least air flow. The local exhaust air flow should be matched with an equal amount of tempered make-up air to ensure ventilation system operational efficiency. The exhaust and makeup air systems should be operated to maintain a slight negative pressure in the manufacturing plant relative to the office environment. This balance will help prevent air being drawn into and contaminating the office environment through doors, ceiling plenums, cracks, and other leakage points.

Another key factor to consider is the proximity of the exhaust stacks to outside air intakes. These should be positioned to minimize the chances of contaminated exhaust air being drawn into the air intakes of the office HVAC systems. Any modifications to either the office or manufacturing facilities, no matter how slight, must consider subsequent ventilation system modifications so as to guard against negative consequences to the air balances.

Minimizing worker exposure to the chemicals that are present in industrial facilities is regulated by the Occupational Safety and Health Administration (OSHA). Maintaining exposures below the regulated levels (Threshold Limit Values, as published by the American Conference of Industrial Hygienists and Permissible Exposure Limits established by OSHA) may not eliminate all unpleasant smells. In cases where air from the manufacturing area is allowed to enter the office area, odor problems may arise even if the manufacturing area is in full compliance with the OSHA worker exposure levels.

Conducting the odor investigation

Odor investigations for both commercial and industrial facilities should include the following tasks, conducted in roughly this order:

1. Interview people with knowledge of the odors, building systems, manufacturing systems, and/or material storage to attempt to narrow down the possibilities.
2. Review building documentation, including IAQ Profile if available and Material Safety Data Sheets for suspected chemicals.
3. Conduct a site walk-through to attempt to identify the sources of the odors.
4. Research odor thresholds for each of the chemicals of concern. An odor threshold identifies the concentration required for humans to register a chemical's scent. If a threshold is low, its scent would be detectable at low concentrations in the air, while a higher threshold would require the presence of larger chemical quantities for its detection.
5. Develop a sampling plan, if necessary, to identify the specific chemical compounds or classes of compounds responsible for the odors. Some common sampling techniques include the following:

- Photoionization detectors to provide real-time measurement of volatile organic compounds (VOCs). These are used to survey the area and identify the locations where the odor is strongest.
- Determination of VOCs in air collected in specially prepared canisters and analyzed by gas chromatography/mass spectrometry. This is known as Method TO-15.
• Charcoal tubes and sample pumps to obtain multiple samples at lower cost than TO-15 for conducting a VOC scan.

6. Isolate and identify the sources of the odors and start developing abatement strategies.

7. Involve all interested parties in the assessment and the proposed resolution to ensure agreement on the problem and the solution.

**Odor abatement**

Once the source of the odor has been identified, the facility must enact a solution or series of solutions. As previously stated, the complexity of these resolutions can vary. For example, in a scenario in which toluene was being stored in uncovered drums, the solution could be as simple as sealing the drums whenever they are not in use. If this does not resolve the problem, an additional resolution, such as ventilation of the storage area, may be required. However, in a more serious instance, such as where a new chemical process is vented to the outside is causing odors in the surrounding neighborhood, the facility might require a more costly and complex solution, such as the installation of an air pollution control system for odor abatement. These odor abatement systems include carbon adsorbers, wet scrubbers, and thermal oxidizers. While these systems can reduce or eliminate the odors released into the atmosphere, they require substantial time and money to design and install. They also often require that air permits be obtained from the regulatory agency prior to installation.

The following examples of other odor abatement strategies illustrate the wide variety of problems and solutions for odors:

1. Substituting a less odorous chemical in a manufacturing process
2. Cleaning up the area where a chemical spill led to the odor
3. Improving the local exhaust ventilation systems at the source of the odor
4. Modifying housekeeping practices to improve cleanliness and reduce the use of odorous cleaning materials
5. Redesigning the HVAC systems to minimize the potential for drawing odors into the facility from outside
6. Conducting a mold remediation and eliminating the sources of water infiltration
7. Isolating waste materials from building occupants

Some odor-abatement strategies require follow-up activities to prevent the reoccurrence of the odor problem. These ongoing activities could include periodic inspections, HVAC system maintenance, and worker training.

**Conclusion**

Odor investigations and abatement strategies vary greatly in scope and complexity. Commercial facilities have a wide variety of potential causes for unpleasant odors. Industrial facilities have numerous additional odor-producing activities associated with manufacturing and waste disposal activities. Building owners can be well served by the development of an Indoor Air Quality Profile for their facilities so that when odor problems arise, their resolution can be expedited.

For more complex odor mitigation projects, especially those involving the installation of air pollution control systems or the modification of HVAC systems, outside consulting and engineering assistance are invaluable.

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