

The Role of **ODOR** **THRESHOLDS** in Protecting Worker & Community Health

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ODOR COMPLAINTS are one of the most common and challenging issues encountered in workplace and community environments. The human sense of smell is one of the most ancient and fundamental sensory systems, providing a way to detect chemical and biological hazards and to monitor the environment, food and water. However, in occupational EHS, odors are not always a reliable indicator of risk. On one hand, odors can serve as an early warning signal that hazardous contaminants are present. On the other hand, some odors can be detected well below levels that pose a health risk but may result in nuisance complaints, stress and reduced quality of life. For safety professionals, understanding the scientific basis of odor perception and odor thresholds is essential for appropriately interpreting odor complaints, assessing potential risks and applying odor data in workplace and community contexts.

The Science of Odor Perception

Olfaction, or odor detection, begins when volatile molecules enter the nasal cavity, cross the mucous lining and reach specialized receptors in the olfactory epithelium. There, nerve cells called receptor neurons bind the odorants and transmit signals through the olfactory nerve (Figure 1, p. 20) to the olfactory bulb and then to the brain (Auffarth, 2013; Martini, 1998). Humans possess thousands

of receptors that allow us to tell the difference between many kinds of chemicals (Breer et al., 2017). However, odor perception is not the only way we sense chemicals. The nasal cavity also contains trigeminal nerve endings (Figure 2, p. 21) that detect irritant properties of chemicals such as pungency, burning or cooling sensations (Lehocky et al., 2024). Capsaicin, the active component in chili peppers and pepper spray, is a classic example of a trigeminal stimulant with virtually no olfactory component. But Figure 2 also displays the interconnection of the trigeminal nerve branches between the eyes, nose and mouth, which explains why eating a hot chili pepper can make your eyes water. Many airborne chemicals stimulate both the olfactory (odor) and trigeminal (irritation) systems, though not always simultaneously. This explains why a compound may be perceived as an odor but not cause irritation, or vice versa.

Odor Characteristics

Human odor perception is not a single property but a combination of several characteristics that influence how a smell is experienced and described. Four major attributes are commonly used to describe how odors are perceived: threshold, intensity, character and hedonic tone (Lehocky et al., 2024).

“Odor threshold” is generally defined as the concentration at which 50% of a test population can detect or recognize an odorant (ASTM International, 2019). Two types of odor thresholds are reported in the literature. Detection thresholds reflect the perception that something is present without identifying what it is, whereas recognition thresholds represent the concentration at which the odor can be correctly identified (Doty, 2017). Intensity refers to how strong the odor is once it is detectable (Burdack-Freitag et al., 2017). Character describes the qualitative nature of the odor, such as “fruity,” “sulfurous,” “floral” or “chemical” (Dravnieks, 1985). Hedonic tone describes pleasantness or unpleasantness and reflects not only sensory properties but also personal experience,

KEY TAKEAWAYS

- Odor perception is complex and can vary widely among individuals and populations.
- Odor thresholds differ from irritation thresholds and must be used carefully and in combination with toxicological and exposure data.
- Occupational exposures and health conditions, including viral infections, age and smoker status, can influence a person's sensitivity to odors.
- Effective odor investigations require a systematic approach and clear communication of potential risks.



context and cultural influences, thus it can vary from person to person (Burdack-Freitag et al., 2017; Seubert et al., 2017). Examples of hedonic tone descriptors include “musty,” “moldy” and “fishy.”

In contrast, irritation thresholds describe the lowest concentrations at which chemicals cause physical eye, nose or respiratory irritation (e.g., painful watery eyes, runny nose, sneezing; Nielsen et al., 2007). These responses are caused by the trigeminal nerve rather than the olfactory system. The distinction is important for occupational EHS practice: many chemicals are detectable by smell at levels well below those that cause physiological irritation, while others may produce irritation at concentrations that remain undetectable by odor (Cometto-Muñiz & Cain, 1990, 1993). When people describe an odor as “irritating,” they may be referring to either unpleasantness or true physical pain and irritation. For example, a strong perfume or air freshener may be described as “irritating” because the smell is overpowering or perceived as unpleasant. However, a chemical odor such as ammonia can actually cause physical irritation in the eyes and nose. Investigators should attempt to distinguish carefully between these kinds of reports because the responses involve different biological pathways (olfactory vs. trigeminal) and different implications for risk.

For many nonreactive compounds, irritation thresholds are generally higher than odor detection thresholds (meaning that a substance can often be smelled before it causes irritation), although the relationship is not consistent across all chemicals (Cometto-Muñiz & Cain, 1990, 1993). Because irritation thresholds reflect physiological responses more directly related to potential adverse effects, they are often more useful than odor thresholds for the establishment of occupational exposure limits (Nielsen & Wolkoff, 2017).

Variability in Olfactory Function

Human olfaction, or our sense of smell, is highly variable from person to person. This limits how precisely published odor thresholds can predict what workers or community members will notice. Some people have normal smell (normosmia; Hummel et al., 2017), while others can have a complete loss of smell (anosmia; Frasnelli & Manescu, 2017). Other conditions include reduced sensitivity (hyposmia), or heightened sensitivity (hyperosmia; Frasnelli & Manescu, 2017; Hummel et al., 2017). During the COVID-19 pandemic, many experienced distorted smells (parosmia; Lerner et al., 2021) and phantom smells (phantosmia; Saltagi et al., 2018). Age plays a significant role in odor sensitivity: children detect odors at lower concentrations than adults, and odor thresholds rise as we get older (Cain & Gent, 1987; Doty & Kamath, 2014). Smoking reduces odor sensitivity (Cain & Gent, 1987; Hayes & Jinks, 2012), and some medical conditions such as diabetes, Alzheimer’s disease and Parkinson’s disease can impair olfaction (Hummel et al., 2017). Pregnancy and hormones may heighten sensitivity, although studies are not always consistent (Cameron, 2014; Navarrete-Palacios et al., 2003). Stress and emotion can also influence odor thresholds; anxiety can lower them, while anger may raise recognition levels (Hoenen et al., 2017).

Viral infections have long been recognized as a leading cause of acquired anosmia, and people often do not fully recover after such infections (Suzuki et al., 2007; van Riel et al., 2015). The COVID-19 pandemic showed how common this problem can be, as sudden loss or reduction of smell became a clear sign of infection (Lechien et al., 2020; Moein et al., 2020). Even before the COVID-19 pandemic, olfactory loss from all potential causes was estimated to affect 3% of adults age 40 years or older and up to 22% of those age 60 years or

older (Boesveldt et al., 2017). While many patients exposed to SARS-CoV-2 regain olfactory function within weeks, an estimated 4% to 12% experience persistent dysfunction, including reduced sensitivity (hyposmia) and distortions such as parosmia, where familiar odors smell different (Tan et al., 2022; Zazhytska et al., 2022). In practice, this means that some workers or occupants may not detect odors reliably even when an odorant is present, while others may perceive the same odor differently.

Because of these variations in olfactory sensitivity, published odor thresholds should not be treated as precise predictors of what all workers or community members will perceive. Most published thresholds are determined using panels of healthy, nonsmoking adults that have been screened to exclude pregnancy, anosmia and other conditions affecting olfaction (Cancho et al., 2001; Cometto-Muñiz et al., 2005; Lehocky et al., 2024). In contrast, the working and general population consists of people of different ages, health conditions, smoking histories, and prior exposures that can impact smell sensitivity and perception. Odor threshold values themselves are typically reported as averages, meaning some individuals may detect a chemical at concentrations well below the published value, while others may not detect it until concentrations are much higher (Lehocky et al., 2024). As a result, relying on a single published odor threshold value may be misleading and may not reflect the full range of real-world responses across workers or communities. Instead, the value should be considered as a starting point.

Environmental & Occupational Influences

Beyond individual factors, environmental conditions and concurrent occupational exposures can influence odor perception. For example, chronic exposure to some metals, solvents and corrosive gases can impair olfactory function (Lehocky et al., 2024; Sullivan, 2001). Repeated exposure to an odor can

also lead to adaptation, increasing detection thresholds in the short term while lowering odor recognition thresholds as a person becomes familiar with the odor (Cometto-Muñiz & Cain, 1995; Fjaeldstad et al., 2017). Mixtures further complicate perception, as odorants may interact additively or synergistically or mask each other. Often, mixtures are perceived as a single substance rather than the distinct individual components (Teixeira et al., 2016).

Determining Odor Thresholds

Odor threshold testing is conducted using controlled generation of test atmospheres and procedures that evaluate how human subjects detect and recognize odors under standard conditions. Panels are composed of individuals recruited and screened for normal olfactory function and the absence of conditions that are known to affect sensitivity to odors. Standards for odor threshold determination have been developed internationally to improve consistency and reliability. For example, ASTM E679 uses a forced-choice, ascending concentration series method (ASTM International, 2019). In Europe, EN 13725:2022 specifies procedures for controlled dilution methods to determine the point at which a panelist can detect a smell (European Committee for Standardization, 2022). Together, these standards provide a widely accepted framework for odor testing that attempts to ensure reproducibility and comparability of results across laboratories (Lehocky et al., 2024). However, the controlled conditions and selected test populations used in these methods differ from real-world environments, which should be considered when applying these values in practice.

Applications in Occupational Health Indoor Air Quality

Odors are one of the leading triggers of indoor air quality complaints. The presence of an odor does not necessarily indicate a health risk, because in many cases, odor thresholds are well below occupational exposure limits (Lehocky et al., 2024). However, even when chemical concentrations are far below occupational exposure limits, the presence of odors can affect comfort, increase stress and, in some cases, directly cause symptoms. Unpleasant odors are known to impair mood, induce stress and negatively affect performance (Schiffman & Williams, 2005). Chronic exposure to indoor malodors has been linked to cardiovascular strain, exacerbation of asthma, and impacts on performance and cognition (Dalton et al., 2020). Odor detection alone is not a reliable indicator of risk, but odors can contribute to stress and discomfort even in the absence of a hazardous exposure.

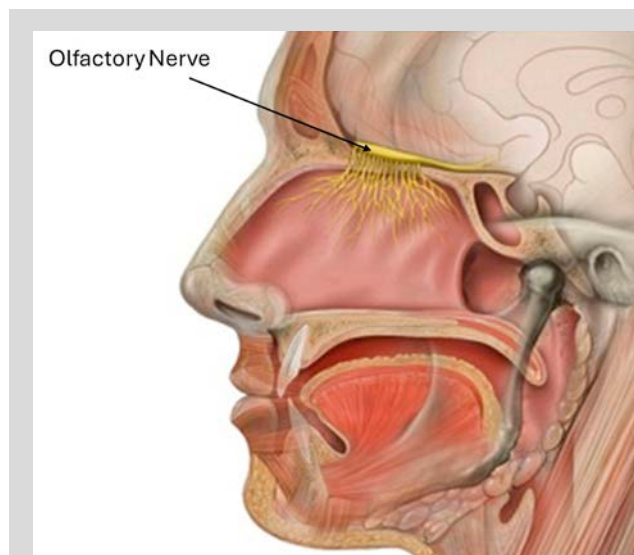
Respiratory Protection

Historically, odor thresholds were used as indicators of respirator cartridge breakthrough. However, OSHA's respiratory protection standard (29 CFR 1910.134) now prohibits relying on odor as the primary indicator of respirator cartridge breakthrough (OSHA, 2008). Variability in thresholds, adaptation and anosmia make odor unreliable for this purpose. Cartridge change schedules must be based on objective criteria, not subjective odor detection.

Workplace Exposures

Occupational exposure to chemicals can alter olfactory function, but the effects vary depending on the substance and

FIGURE 1
OLFACTORY NERVE



Note. "Head olfactory nerve" by Patrick J. Lynch, reprinted under Creative Commons Attribution 2.5 License 2006 via Wikimedia Commons. <https://bit.ly/4iOSTK3>

exposure conditions. Occupational studies have repeatedly shown that the effects of chemical exposure on olfactory sensitivity are highly substance-specific (Lehocky et al., 2024). For example, petroleum tank cleaners exposed to solvent mixtures exhibited reduced olfactory sensitivity with elevated detection thresholds and increased annoyance ratings when compared with unexposed controls (Ahlström et al., 1986). While some solvent-exposed populations have shown measurable reductions in olfactory performance (Schwartz et al., 1989), long-term exposure to styrene did not significantly impair olfactory function in workers (Dalton et al., 2007), suggesting that not all volatile organic compounds have effects on sensory detection. Cadmium-exposed workers demonstrated clinically significant anosmia and hyposmia, with deficits persisting even after exposure stopped (Mascagni et al., 2003). These findings show that some metals and solvents can cause a reduction in the olfactory system's ability to function, while other agents may not.

For occupational EHS professionals, these results highlight the importance of context in interpreting odor complaints. Odor detection alone does not necessarily signal hazardous exposure, as perception may occur far below levels of toxicological concern. At the same time, perception of nuisance odors or malodors should not be dismissed or ignored because they sometimes coincide with or precede health-relevant or hazardous exposures. Odor thresholds are best used as supplementary information, interpreted alongside toxicological data, quantitative exposure measurements and consideration of individual variability (Lehocky et al., 2024). This integrated approach ensures that nuisance odor complaints are investigated so that potentially hazardous conditions are evaluated and stopped early on.

Investigating Odors

While odor thresholds provide useful scientific context, occupational EHS professionals often face the more immediate challenge of responding to odor complaints. Investigations require a combination of scientific understanding, systematic field methods and clear communication with affected individuals. Unlike routine industrial hygiene monitoring, odor complaint investigations are often prompted by subjective perceptions, occur under uncertain conditions, may occur only transiently and may involve multiple potential sources. As a result, effective investigations rely on a structured approach that integrates information about the people affected, the pathways and pressures by which odors move through the environment, and ultimately the potential source of the odor (the pollutant; Krause et al., 2026).

Investigating nuisance odor complaints begins with the affected people and their experience of the odor (see Figure 3, p. 22). Interviewing affected workers or community members helps to establish when, where and how often the odor is noticed. Interviews also help to characterize the nuisance odorant (e.g., sulfurous, sweet, solvent-like) as well as its perceived intensity (Dalton, 2000; Dravnieks, 1985). Documenting these reports in detail allows investigators to identify spatial or temporal patterns that can point toward specific processes, operations or building systems. For example, odors reported during specific shifts or days often point to specific processes while location-specific complaints may reflect how the odor is moving through the space. Next, investigators should assess the air movement pathways and

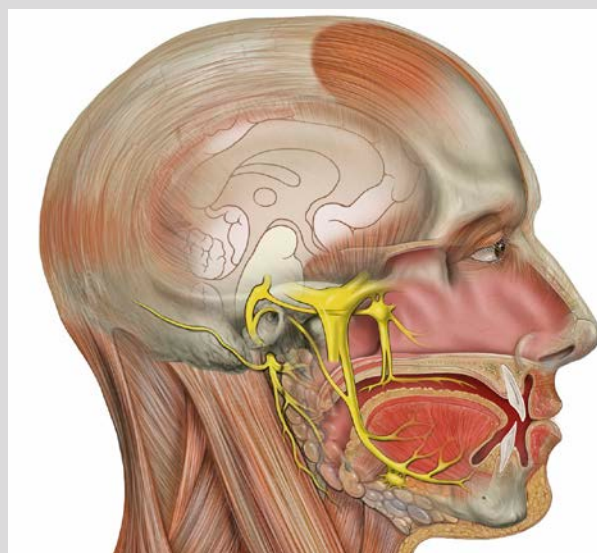
pressure relationships. Pressure differentials, ventilation design and airflow patterns frequently explain how odors move from one area to another, even when the odor source is far from those who perceive it (Nielsen & Wolkoff, 2017). Identifying whether odors are transported via return air systems, infiltration from outdoors or localized exhaust failures helps narrow the investigation. Removing a source, stopping a process, changing airflow or blocking a pathway can often help confirm whether a suspected source is causing the odor and aid the EHS professional in finding a possible solution to the problem.

The next step is to identify the potential pollutant, or source of the odor. This involves developing a working hypothesis based on observations, reported odor characteristics and knowledge of activities, materials and processes in the area. Investigators should walk the space while the odor is present, when possible, and consider both routine and nonroutine sources. These could include cleaning, maintenance, waste handling or recent construction. Building systems and outdoor influences should also be evaluated. At this stage, the goal is not necessarily to determine the exact chemical substance but to narrow the list of likely sources and begin ruling them in or out through observation and controlled changes.

Sampling and measurement can play a role, but their usefulness is often limited by the fleeting nature of odors. Chemical concentrations may fall below detection limits or fluctuate rapidly, making it unlikely that grab samples will fully capture the exposure. Targeted sampling is most useful when investigators have already identified a likely source and seek to confirm or quantify emissions.

In a case study example performed by one of the authors, workers in a machine shop reported a new odor during routine operations. The investigation began with speaking with

FIGURE 2 TRIGEMINAL NERVE



Note. "Head deep facial trigeminal" by Patrick J. Lynch, reprinted under Creative Commons Attribution 2.5 License 2006 via Wikimedia Commons. <https://bit.ly/4yEzn2K>

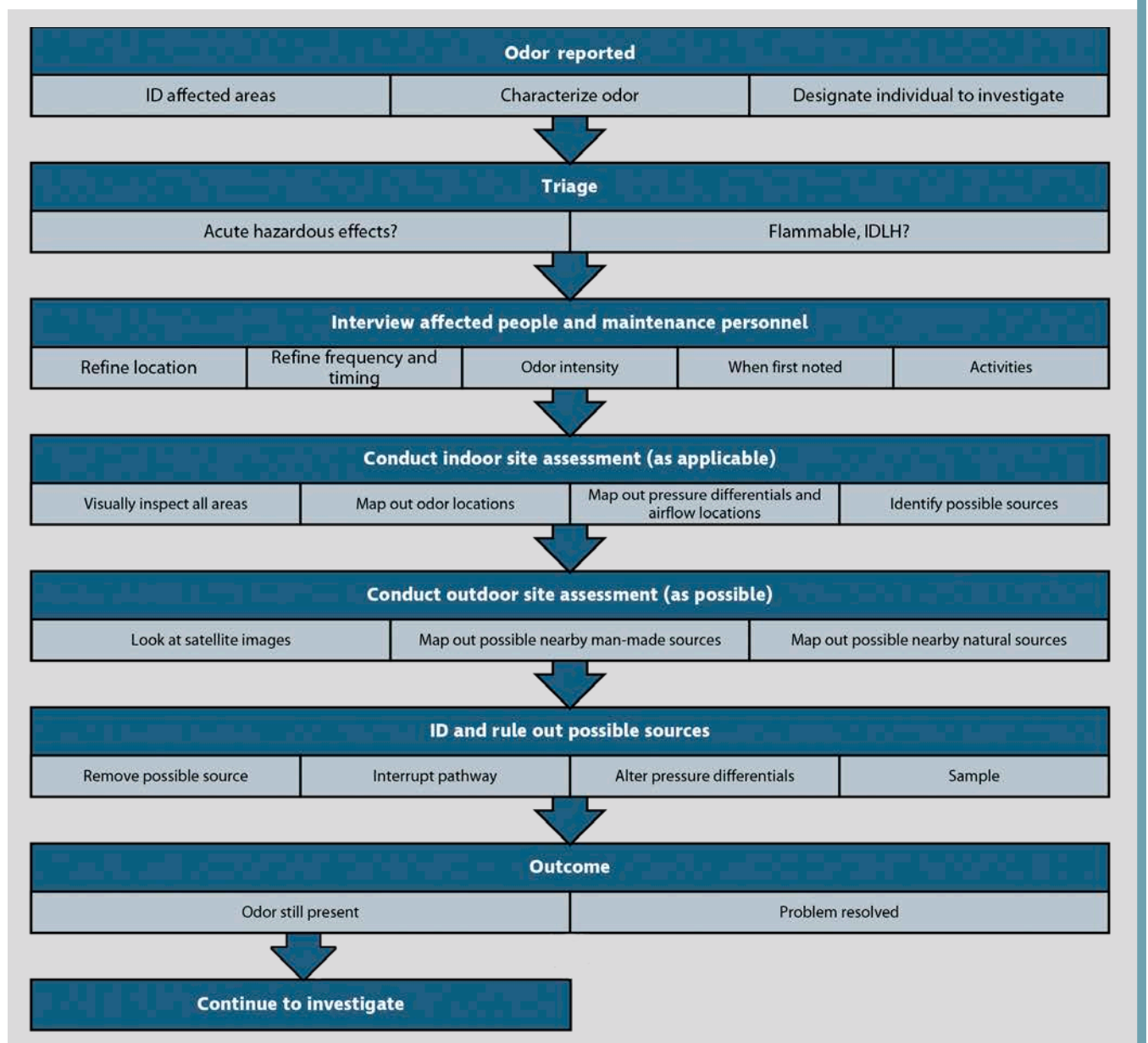
workers to understand when the odor started and how it differed from past conditions. The investigation next considered potential sources, where it was discovered that a new product had been introduced as part of a “green” reformulation. The previous product contained ethyl benzene and xylenes, which have odor thresholds in the ppm range, and the reformulated product contained n-Butyl acetate, which has odor thresholds reported in the ppb range (i.e., 100 to 1,000 times lower). In this case, sampling was performed as a follow-up and air monitoring showed that concentrations remained below occupational exposure limits. For this example, odor thresholds helped explain the change in perception without indicating an increase in risk. Follow-up actions focused on communicating the reason for the change in odor, evaluating product

alternatives if needed and ensuring that ventilation remained effective. Explaining the relationship between odor detection and exposure limits helped address worker concerns and clarified that the presence of odor did not necessarily indicate a hazardous condition.

Odor Thresholds & Risk Communication

Odor complaints present a unique challenge for occupational EHS professionals because workers and community members may interpret odors as evidence of danger even when exposures are well below hazardous levels. In reality, some of the most hazardous gases (e.g., carbon monoxide) are completely odorless, while other compounds may be perceived at concentrations far below levels of health concern. The presence

FIGURE 3
SYSTEMATIC APPROACH TO INVESTIGATING NUISANCE ODOR COMPLAINTS



of an odor does not necessarily indicate risk, and the absence of an odor does not guarantee safety.

Addressing this gap requires clear, transparent communication. EHS professionals must explain the difference between odor perception and toxicological significance, while recognizing individual variability in sensitivity. For example, in an office setting where occupants report a “chemical” odor following cleaning, actual airborne concentrations of the chemicals used may be well below occupational exposure limits. Even so, the odor may cause concern or symptoms such as a headache. In this situation, the role of the practitioner is to explain what is known about the exposure and what actions are being taken to investigate and reduce the odor. Clear documentation of investigative steps and transparent explanation of findings helps professionals address concerns and maintain trust with those experiencing the odors. This approach recognizes that odor complaints are not only technical issues, but perception and communication challenges. By combining subjective reports, environmental assessment, targeted sampling where appropriate and careful risk communication, safety professionals can respond effectively to odor complaints and integrate them into a broader occupational health strategy.

Conclusion & Recommendations

Odor thresholds play an important but complex role in occupational and environmental safety and health. They are based on the biology of olfaction and are affected by individual and environmental variability. While odor detection may serve as an early warning of exposure to a hazard, it is neither sufficient nor reliable as a measure of risk. Understanding the difference between odor detection, recognition and irritation thresholds is critical for accurate interpretation. For practitioners, odor thresholds should be considered alongside toxicity data, analytical exposure assessments and other relevant contextual factors. In indoor air quality investigations and workplace exposure assessments, they provide useful supplementary information but should be used with caution. Ultimately, integrating odor science into occupational EHS practice requires both technical understanding and careful risk communication. By grounding decisions in science while considering how people perceive and interpret odors, professionals can better navigate the complexity of odor perception, exposure and safety. **PSJ**

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