Asphalt Odor Management Tool

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November 2025

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EXECUTIVE SUMMARY

The Asphalt Institute has developed the Asphalt Odor Management Tool to assist its members and others in understanding and managing odors from stationary sources like asphalt roofing shingle plants, hot-mix asphalt plants, terminals, and refineries. The tool does not cover mobile and in situ operations such as road construction and roofing installation.

The document delves into the complexity of odor perception and monitoring, typical odor sources found in the asphalt industry, methods for assessing and controlling odors, and resources for community involvement and outreach.

Key topics covered in the document include:

- **Odor Perception:** Description of how the olfactory system works.
- **Odor Detection Thresholds**: The lowest concentration at which an odor can be detected, varying widely among individuals.
- **Odor Characterization**: Parameters like concentration, intensity, character, and hedonic tone used to describe human responses to odors.
- **Chemistry of Asphalt Odors**: The chemical composition of asphalt odors, categorized into groups like sulfur-containing compounds, heterocyclic compounds, and aromatic compounds.
- **Odor Generation and Transport**: Factors affecting odor generation and transport, including source type, release method, meteorological conditions, and topography.
- **Odor Monitoring Options**: Methods for quantifying and measuring odors, including human perception methods and chemical surrogates.
- **Odor Control Options**: Technologies for capturing, neutralizing, or masking odors, such as incineration, ozone, biological filters, and adsorption.
- **Odor Control Plan Development**: Steps for creating site-specific odor control plans, including facility description, odor-emitting sources, control strategies, and complaint management systems.
- **Community Outreach**: Strategies for engaging with the community to address odor concerns and build trust.

The document emphasizes the importance of a holistic approach to odor management, combining qualitative and quantitative assessments, effective control technologies, and proactive community engagement.

1.0 INTRODUCTION

It is estimated that 70% to 80% of the complaints issued to regulatory agencies concerning air pollution involve an odor component. Odor is not regulated as a pollutant by the Clean Air Act; however, it may be regulated at the state or local level through various types of odor laws, whether it is called an ordinance, rule, regulation, or policy. Odors are also frequently regulated by Municipal or City level statutes, so it is important to refer to the local requirements specific to a subject facility. A summary of various odor regulations throughout the United States is provided in Appendix A.

Odor laws address community odor issues in several ways and methods that use various criteria:

1) Annoyance (subjective categories)
2) Complaint criteria (number of complaints)
3) Ambient odor concentration/detection threshold (various methods)
4) Ambient odor intensity (analytical testing)
5) Ambient odorant criteria (i.e., chemical surrogate)
6) Episode duration-frequency criteria ("odor-hours")
7) Source emission criteria (chemical surrogate at source)
8) Best available control technology criteria (i.e., industry standard)

In the absence of odor laws, citizens and communities often find remedies and relief in basic common-law nuisance lawsuits. Due to this regulatory approach, sources of odors may face complex permitting scenarios when addressing potential offsite odors/impacts.

In response to recent scrutiny on odors, the Asphalt Institute (Institute) has published this Asphalt Odor Management Tool (Tool) to provide its members and others with a resource summarizing information related to odors from asphalt industry facilities and activities, including odor monitoring and quantification, odor reduction strategies, and resources for community involvement and outreach.

This Tool focuses on odors from stationary sources, such as asphalt roofing shingle plants, hot-mix asphalt plants, terminals, and refineries. Asphalt fumes and odors from mobile and in situ operations, including road construction and repair, roofing installation, and asphalt transportation, are not assessed.

2.0 WHAT IS ODOR?

Odor is a perception and is dependent not only on the relative chemistry and structure of odor molecules, but also on receptor factors such as sex, age, culture, social context, and personal experience. Odor perception is complex as responses to odors are inherently subjective and the nature and composition of odorants can vary greatly. In addition, different societies have varying levels of acceptance for odors in their communities.

2.1 OLFACTORY SYSTEM

People can discriminate more than 10,000 odors, even though there are only about 400 odor receptors in the nose (Coker). An odor can generally be perceived if several criteria are met (Govind).

- There is an odor generating source present,
- The odorant molecule(s) is a volatile organic compound (VOC),
- The odorant's molecular weight is less than 300 Daltons,
- The odorant's vapor pressure is greater than 0.01 kilopascals (kPA) at 20 °C, and
- The odor molecule has moderate-to-high hydrophobicity.

When a person inhales odorous molecules, the molecules enter the nasal canal and reach the olfactory epithelium, near the top of each nostril. At this location, the molecules dissolve in the mucus layer covering the epithelium and contact olfactory sensory neurons (millions), which express odor receptor(s) (~400) (Alila Medical Media). The combination of activated neurons and odor receptors sends a signal to the olfactory bulb where it is deciphered and subsequently perceived by the brain as an odor. When you have a cold, your sense of smell is diminished because molecules have a harder time reaching the odor receptors through the mucus layer covering the epithelium. See Figure 1.

Studies on the interactions between individual odor receptors and multiple chemical odorants found that:

- An odor receptor can recognize many odorant molecules, and
- An odorant molecule can bind to and be detected by multiple odor receptors.

Due to the number of potential combinations of odor molecules and receptors, the brain can differentiate between a large number of odorants simultaneously. Although there are only a few hundred active odor receptors, humans can recognize over 10,000 different odors. This combination is referred to as the "Receptor Code". The receptor code is essentially the unique pattern of activated receptors for a specific odorant.

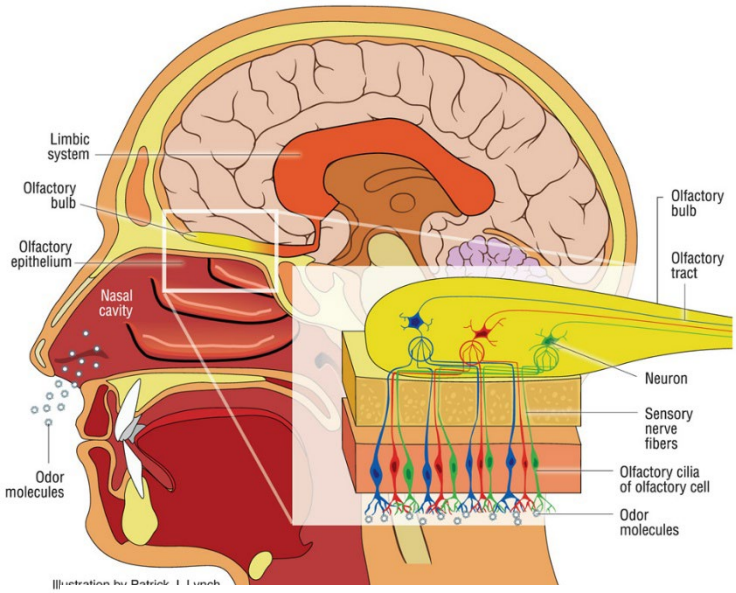


Figure -1: Human Olfactometry System (Coker)

2.1.1 Chemical Concentration and Mixture Effects

Researchers have found that changes in odorant concentration alter its receptor code in the olfactory system. This explains why, for some chemicals, a substance smells different at varying concentrations. As the concentration of an odorant increases, the set of olfactory receptors activated also changes, leading to a different perception of the smell, even for the same odorant molecule. Additionally, research has shown that some neurons in the olfactory cortex only respond when two odorants are present and not when each component is present alone, explaining why mixtures can have smells that are not simply the sum of the component molecules (Zou and Buck).

2.2 ODOR DETECTION THRESHOLD

The odor detection threshold (ODT) is the lowest concentration of an odorant that can be detected by a person. The concentration is established through testing conducted on human subjects in a laboratory setting and is commonly listed as the lowest concentration at which 50% of test subjects perceive an odor. The lower the detection threshold, the more potent the odor is. For example, hydrogen sulfide (rotten egg odor) can be detected at a concentration as low as 0.0005 parts per million by volume (ppmv), while some butanes (natural gas odor character) are not detected until a concentration over 5,000 ppmv.

Because sensitivity to odor is subjective and varies from person to person, detection thresholds established for compounds vary and, for this reason, are frequently listed as a range of concentrations. Examples of ODTs for compounds commonly found in the asphalt industry are provided in the tables in Section 4.0.

2.3 ODOR CHARACTERIZATION

Concentration alone does not describe the entire human response to an odor. Various qualitative and quantitative parameters are used to illustrate the human perception to odors. A summary of parameters that can be used to further describe an odor is provided in Table 2-1.

Table 2-1 Summary of Odor Characterization Parameters

Parameter	Description
Concentration	Odor concentration is quantified by determining the amount of dilution required to bring the odorous air sample to a detection threshold.
Intensity	Odor intensity refers to the perceived strength of the odor. A quantitative measurement of intensity requires comparison of the odor to a standard, typically n-butanol in odor-free air. The intensity is expressed in terms of micrograms per cubic meter of n-butanol and is related to concentration through a power function. A qualitative scale can also be used to describe intensity with zero being not perceptible to 6 being extremely strong.
Character	Odor character describes what the substance smells like. Examples of odor character include fishy, hay, nutty, oily, creosote, turpentine, rancid, sewer, sweet, ammonia, wet grass, burnt hair, etc.
Hedonic Tone (Offensiveness)	Hedonic tone is a subjective judgment on the relative pleasantness or unpleasantness of an odor. Hedonic tone can be assessed on a graded scale from -4 (extremely unpleasant) to +4 (extremely pleasant) and 0 being neutral (neither pleasant or unpleasant)

3.0 CHEMISTRY OF ASPHALT ODORS

Asphalt is an end product from crude oil refining and is generally the last cut in the process after naphtha, gasoline, kerosene and other fractions are removed. The storage and processing of asphalt at elevated temperatures typically encountered in the asphalt industry causes volatilization (release) of a range of hydrocarbons and other gases. Due to the variability in crude oil sources, refinery processes, and asphalt blending, the chemical composition of the gases varies between regions and sources.

Odors perceived from asphalt fumes can be impacted by one dominant compound and/or the result of a combined effect of multiple compounds. The majority of compounds detected in asphalt fumes with the potential to generate odors can be categorized into the following eight groups (Lange and Stroup-Gardiner).

- Sulfur Containing – Very High Odor Potential
- Heterocyclic – High Odor Potential
- Aromatics – Low to Moderate Odor Potential
- Aliphatic Hydrocarbons – Low Odor Potential
- Chlorinated Compounds – Low Odor Potential
- Phthalates – Low Odor Potential
- Organic Acids – Very Low Odor Potential
- Polyaromatic Hydrocarbons (PAHs) – Very Low Odor Potential

The assessment of relative odor potential listed above is based off the class of compounds relative emission rate and the class of compounds odor detection threshold as presented in the research conducted by Lange (Lange and Stroup-Gardiner). Further discussion on the results is provided in the following sections.

3.1 HIGH ODOR POTENTIAL

3.1.1 Sulfur Containing Compounds

Nineteen sulfur containing compounds were detected in asphalt fumes during testing conducted by Lange (Lange and Stroup-Gardiner). Due to the very low odor detection thresholds of sulfur containing compounds, these compounds have a significant potential to generate odors. A summary of various compounds and their odor character is shown below. Note, the odor character is compound specific and does not describe the combined odor that may be perceived for a mixture of compounds.

Table 3-1 - Sulfur Containing Compounds in Asphalt Fumes with Potential to Generate Odor

Compound	ODT (ppm)	Odor Character
Butanethiol	0.0000027 – 4.9	Skunk
Carbon Disulfide	0.013-32	Vegetable, sulfide, medicinal
Dimethyl Disulfide	0.00029-1.45	Garlic, putrid, asparagus
Ethanethiol	0.0000087 – 18	Rotten cabbage
Hydrogen Sulfide	0.00004 – 1.4	Rotten eggs
Methanethiol	0.00000000000051– 0.56	Rotten cabbage, garlic

(Lange and Stroup-Gardiner)
(Murnane, Lehocky and Owens)

3.1.2 Heterocyclic Compounds

A heterocyclic compound is a cyclic compound (ring) that has atoms of at least two different elements as members of its ring(s). Two heterocyclic compounds were detected in the testing conducted by Lange (Lange and Stroup-Gardiner); dibenzofuran and quinoline. Quinoline has an odor detection threshold and typical asphalt concentration that creates the potential to generate odors.

Table 3-2 - Heterocyclic Compound in Asphalt Fumes with Potential to Generate Odor

Compound	ODT (ppm)	Odor Character
Quinoline	0.0057-5.3	Peculiar

(Lange and Stroup-Gardiner)
(Murnane, Lehocky and Owens)

3.2 LOW TO MODERATE ODOR POTENTIAL

3.2.1 Aromatic Compounds

Aromatic compounds are organic compounds that consist of a series of atoms connected to form a ring. Examples of aromatic compounds include benzene, toluene and xylene. Testing conducted by Lange (Lange and Stroup-Gardiner) identified seven aromatic compounds detected in asphalt headspace gas samples. Three of these compounds have odor detection thresholds and typical asphalt concentrations that create the potential to generate odor.

Table 3-3 - Aromatic Compounds in Asphalt Fumes with Potential to Generate Odor

Compound	ODT (ppm)	Odor Character
Phenol	0.0045-1.95	Medicinal, acid, ink, creosote, burnt organic matter
Styrene	0.0028-61	Sharp, sweet
Toluene	0.021-157	Sour, Burnt

(Lange and Stroup-Gardiner)
(Murnane, Lehocky and Owens)

3.3 LOW ODOR POTENTIAL

3.3.1 Aliphatic Hydrocarbons

Aliphatic hydrocarbons are organic compounds consisting of a chain of carbon and hydrogen atoms. Examples include pentane, hexane and heptane. Testing conducted by Lange identified twenty aliphatic hydrocarbons routinely detected in asphalt headspace gas samples. Three of the compounds had average detections above the respective odor detection threshold and therefore are considered a potential source of odors from asphalt fumes.

Table 3-4 Aliphatic Hydrocarbons in Asphalt Fumes with Potential to Generate Odor

Compound	ODT (ppm)	Odor Character
1,3-Butadiene	0.099-76	Aromatic, rubber, gasoline like
n-Decane		Gasoline-like
n-Decene	6.45	Pleasant Odor

(Lange and Stroup-Gardiner)
(Murnane, Lehocky and Owens)

3.3.2 Chlorinated Compounds

Testing conducted by Lange (Lange and Stroup-Gardiner) identified twelve chlorinated compounds detected in asphalt headspace gas samples[1]. Two of these compounds have odor detection thresholds within typical asphalt concentrations that create the potential to generate odors:

Table 3-5 - Chlorinate Compounds in Asphalt Fumes with Potential to Generate Odor

Compound	ODT (ppm)	Odor Character
2-Chlorotoluene	0.18-0.27	Aromatic
1,2,4-Trichlorobenzene	2.96	Aromatic

(Lange and Stroup-Gardiner)
(Murnane, Lehocky and Owens)

3.3.3 Phthlates

Phthlates are esters of phthalic acid, which are commonly used as plasticizers. Four phthalate compounds were detected during testing conducted by Lange (Lange and Stroup-Gardiner). Phthalates are not found naturally in asphalts; however, they may be byproducts from asphalt oxidation or potentially from asphalt additives. No odor thresholds are reported for these compounds but subjective reports of asphalts occasionally having a plastic aroma led to their inclusion as a possible source of odors in asphalts.

3.4 VERY LOW ODOR POTENTIAL

3.4.1 Organic Acids

Four organic acids were detected in the testing conducted by Lange (Lange and Stroup-Gardiner); acetic acid, proprionic acid, butyric acid, and hexanoic acid. The acids were detected at concentrations below the respective odor detection thresholds. Therefore, it is unlikely these compounds will contribute to potential odors in the asphalt industry (Lange and Stroup-Gardiner).

3.4.2 Polycyclic Aromatic Hydrocarbons (PAHs)

Polycyclic aromatic hydrocarbons (PAHs) are aromatic hydrocarbons that consist of more than one aromatic ring (fused aromatic rings). Testing conducted by Lange detected eight out of fifteen PAHs above laboratory detection limits. Due to the low detections and lack of odor detection data, Lange concluded PAHs are not likely attributed to asphalt odors (Lange and Stroup-Gardiner).

[1] Samples from headspace vials in laboratory setting.

4.0 ASPHALT ODOR GENERATION AND TRANSPORT

There are many factors that impact the generation and transport of odors, including the source of odors, the method by which odors are emitted into the atmosphere, and the location of the facility relative to the public. Discussion on typical sources encountered in the asphalt industry and factors that affect odor transport are provided below.

4.1 POTENTIAL ASPHALT ODOR SOURCES

Asphalt odors can be produced and emitted from asphalt processing, storage, transportation, application, and product manufacturing facilities. The rate of generation and strength of odors can be impacted by factors including temperature, pressure, type of manufacturing process, and the efficiency of the capture and control technology installed. Examples of specific process equipment that can emit asphalt odors are discussed below:

- Loading Operations: Loading of liquid asphalt into a truck, railcar, or vessel can generate asphalt odors as the vapors in the vessel are displaced by the liquid being loaded. The odors can be emitted through the vent and/or other tank penetrations.
- Unloading Operations: Odors can be generated from the unloading of liquid asphalt through open hatches on trucks, railcars, vessels, and storage tanks. The hatches are typically opened to avoid vacuum accumulation in the vessel vapor space as the liquid is pumped out. Prior to and after loading, asphalt odors may be emitted through the open hatches.
- Storage Tanks: Odors can be emitted through the storage of liquid asphalt in storage tanks or process vessels. Asphalt odors in the vapor space of the tank can be emitted from the tank vent during loading as liquid asphalt is loaded into the tank. Odors can also be emitted as the vapor space expands and contracts in the tank with changing temperature and barometric pressure throughout the day. The majority of odors from asphalt storage will occur when the vessel is filled, likely on an intermittent schedule.
- Hot Mix Asphalt Plant Mixers: Mixers are used at hot mix asphalt paving facilities to combine asphalt cement with aggregate and other inorganic fillers. The agitation of the materials and elevated temperatures typically associated with this mixing operation can increase the potential for asphalt odors. There is a higher potential for odors to be generated from drum mixers compared to batch mixers due to the elevated temperature from the dryers incorporated in the drum mixers.
- Cements and Coating Mixers: Mixers are used to combine asphalt with additives, such as solvents, polymers, stabilizers, and recycled materials. The agitation that occurs during the mixing process can increase the potential for volatilization (release) of asphalt fumes and odors. The temperature of the mixing process will also impact the potential for odors with higher odor potential at elevated temperatures.
- Oxidizers (Blowstills): During asphalt blowing, also known as oxidation, hot air is blown/bubbled through liquid asphalt in a process vessel to oxidize the material and change the softening point and penetration rate. Asphalt odors can be generated during the blowing process. The blown air is typically routed to an air pollution control device for incineration or combustion, which may sequentially reduce odors.

- **Saturators:** There is a high potential for asphalt odors to be generated from asphalt saturators due to the volume of asphalt and elevated temperatures at which saturators are operated. Due to federal air regulations, asphalt fumes from saturators are typically routed to an air pollution control device that utilizes a form of incineration or oxidation to control emissions.
- **Coaters:** Odors will be emitted from asphalt coaters as the hot asphalt coating is applied to a substrate, such as a fiberglass mat, and recycled through the system. Enclosures around shingle production lines route a portion of the fumes to an air pollution control device. If fumes are routed to a coalescing filter, or equivalent, odor reduction will not be significant. If fumes are routed to an incineration or oxidation unit, a notable reduction in odors can be expected.
- **Laminate/Sealant Application:** Odors can be generated from process equipment used to apply laminate and sealants during asphalt roofing manufacturing. However, these systems will typically generate less odors compared to a coater or saturator. Similar to a coater, a portion of fumes may be captured and routed to an air pollution control device with the remainder emitted as fugitive odors from the shingle production line.
- **Cooling Sections:** Recent studies have shown potential for asphalt fumes to be released through cooling section vents. The concentration of fumes in these streams is lower than upstream processes, due to the decreased temperatures and reduced surface area of exposed asphalt; however, the flowrates for cooling section vents can be high. Due to the high volume from cooling section vents, it is not common for the air stream to be processed through pollution control/odor reduction units.
- **Mist Eliminators:** Mist eliminators are common air pollution control devices used in the asphalt industry. They are primarily used to reduce particulate matter in asphalt fumes to comply with federal air pollution control regulations. While there may be a small reduction in odor between the inlet and outlet of a mist eliminator due to the capture of particulates in the filters, they can still be a significant source of asphalt odors.
- **Baghouses:** Baghouses may be used to control particulate matter from aggregate application on roofing production lines. Recent studies have shown that a portion of fumes generated in asphalt coaters are emitted through the dust capture system on the aggregate application system (blender) after the coater. The fumes from the coater are drawn by the speed of the process line toward the aggregate application process and collected by associated emission capture systems. These systems are frequently routed to particulate control devices, such as a baghouse with odors from the coater emitted through the emission control device.
- **Shingle Production Line Fugitive Odors:** A portion of odors emitted by a coater will not be captured and will be emitted as fugitive odors from the shingle production line. The temperature of the hot asphalt causes fumes/odors to rise and accumulate toward the top of the building/enclosure. The fumes may be released through building ventilation fans and doors, or retained in the enclosure. Due to the multiple release points and volume of air that may require treatment, fugitive odors can be difficult to collect and process for odor reduction.

- **Fugitive Odor Sources**: Odors can be emitted as uncaptured fugitive losses through leaks from production equipment, including flanges, valves, pump seals, or from damage to vessels/piping. The rate of fugitive losses and associated odors is impacted by the temperature and pressure of the operating vessel/pipe segment with increased fugitives/odors occurring at higher temperature and pressure.

4.2 ODOR TRANSPORT

A method to visualize odors moving from a source is to think of a smoke plume. The smoke is emitted and transported away by prevailing wind and is diluted through this process. Odor plumes move in a similar manner away from a source, spreading vertically and horizontally in the atmosphere (Douglas Hamilton). Primary factors that impact the transport of odor from a stationary source include the method of release of the odors, meteorological conditions, and the local topography/location of the facility.

4.2.1 Method of Release

Odors generated in the asphalt industry are emitted through various types of release points including stacks, vessel hatches, process vents, and openings in buildings or enclosures, such as doorways and ventilation points. The following characteristics can impact the transport of odor from a release point.

- **Odor Emission Rate (Odor Strength):** The odor emission rate is a function of the concentration of the odorous stream and the volumetric flow rate of the release. Higher process temperatures generally increase the strength of odors as more constituents within asphalt evaporate as temperature increases. In general, the higher the odor strength, the higher the ground-level odor concentration can be at a downwind location.
- **Release Velocity:** The velocity of a release impacts both the distance the odorous molecules travel and the potential for mixing/dilution with ambient air. The faster the release, the further the odors may travel; however, there is more potential for dilution/mixing with ambient air at higher release velocities, which can decrease perceived ground-level impacts. In general, the higher the exit velocity, the lower the ground-level concentration may be at a downwind location; however, the distance odor can travel may be longer.
- **Orientation of Release:** The direction/orientation of an odor release impacts the transport of odor from the source. A vertical release provides the greatest potential for mixing and dilution. A horizontal release, such as a ventilation fan on the side of a building, will have limited vertical movement and reduced potential for mixing and dilution. Rain caps and hoods/enclosures around release points can also reduce the vertical movement and mixing of odor releases.
- **Release Height**: The height of the release will impact the amount of mixing/dilution with ambient air. A higher release point will generally lead to more mixing/dilution of an odorous source, which can decrease perceived ground-level odors. As will be discussed in Section 4.2.3, the release height can also be modified to avoid downwash from buildings, structures, and/or topography.
- **Release Temperature**: Although not as significant as release height or velocity, the release temperature of an odorous source can impact the transport of odor. In general, the hotter the

release temperature, the more buoyant the stream will be, which will increase the potential for mixing/dilution with ambient air.

4.2.2 Meteorological Conditions

The local meteorology impacts how odors are transported and mixed in the ambient air. Factors such as wind speed and direction, and atmospheric stability will impact how odors are transported from a source.

- **Wind Speed**: Higher wind speed creates more mixing/dilution in the atmosphere and can reduce the potential for downwind odor impacts. Low wind speeds are more likely to create conditions for offsite odors.
- **Wind Direction**: The direction the wind blows directly impacts where the odorous release will travel. A turbulent condition, with frequent change in wind direction, can promote mixing/dilution of odors.
- **Atmospheric Stability**: The stability of the atmosphere influences the vertical movement of an emitted stream, which impacts the ability of the stream to mix/dilute with ambient air. In general, stable atmospheric conditions inhibit the vertical mixing of an emitted stream trapping odors close to the ground, and unstable conditions improve mixing and odor dilution.

The figure to the right depicts how atmospheric conditions affect the shape of an odor plume and the potential for mixing and dilution.

Stable atmospheric conditions commonly occur in the early morning hours, before sunrise, which is associated with an increase in potential for offsite odors during these periods.

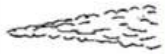
Atmospheric Stability		Weather Factors	Side View (Vertical Dispersion)	Top View (Horizontal Disperson)	Potential for Mixing/Dilution
UNSTABLE	Daytime	Strong solar radiation with light winds			Excellent (EX)
		Moderate solar radiation with moderate winds			Good (G)
NEUTRAL	Day or Night	Overcast or stong winds			Moderately Good (MG) Moderately Poor (MP)
STABLE	Nighttime	Mostly cloudy with light winds or mostly clear with moderate winds			Poor (P)
		Mostly clear with light winds			Very Poor (VP)

Figure 2: Behavior of Odor Plume as Function of Atmospheric Conditions (Douglas Hamilton)

4.2.3 Topography and Facility Structures

Topography and facility structures, such as buildings and large process/storage vessels, can alter the movement of wind/air around the facility and create additional surface roughness which can increase turbulence and impact the transport of odor from a source.

- **Topography**: The topography surrounding a stationary source affects local wind patterns and surface roughness which impacts the direction odors are transported and the potential for mixing and dilution. As stated by Douglas (Douglas Hamilton) obstacles to wind flow such as hills, trees and buildings increase the roughness of the terrain and, accordingly, the dispersion in the odor plume. Mixing is increased if winds carry the odor upslope or up-valley. Downslope or down-valley winds lead to less dispersion and tend to concentrate odors in lower lying areas.
- **Facility Structures**: Similar to topographic features, facility structures alter the flow of wind around a source. As wind blows over/around a building/structure, a low-pressure area develops on the downwind side of the structure which pulls air toward the ground. Odor releases on the downwind side of this building/structure, will be affected and drawn toward the ground causing an increase in ground-level odors. Increasing the release height of an odor source in the vicinity of a building is one method to counteract the effects of building downwash.

5.0 ODOR MONITORING OPTIONS

Odor is a perception and varies among individuals. Known methods of quantifying and measuring odor are limited, and each method is associated with a series of pros and cons related to use case, quantification, and cost. Methods of assessing odors vary between those that utilize human perception and those that utilize chemical surrogates. This section will go into depth on each.

5.1 ODOR MONITORING VIA HUMAN PERCEPTION

A summary of the methods odor can be perceived/measured by humans is provided in the table below with further details in the following sections.

Table 5-1: Summary of Odor Perception Methods Via Humans

Odor Perception Method:	Measurement Units:	Benefits:	Limitations:
Direct Observation	None, scale of odor perception (i.e 1-5)	Inexpensive, observations can be made anywhere a human can be present.	Objective, qualitative only, significant potential for bias.
Field Olfactometer	Dilutions to Threshold Ratio	Relatively inexpensive, field deployable, somewhat quantitative.	Limited quantitate value, requires trained personnel, subject to bias, olfactory conditioning probable, does not determine source of odor.
Odor Panel (i.e. ASTM E679)	Dilutions to Threshold Ratio, Intensity, Character	Highly quantitative, panelists are unbiased, panelists do not know source type or location, vetted American Society of Testing and Measurements Method (ASTM). Repeatable and proven.	Logistically constraining as odor panel needs to be reserved in advance of measurements, samples should be analyzed soon (within 36 hours) after sampling. Observations are conservative (higher) than that of general population. Can be expensive if large number of samples are necessary.

5.1.1 Direct Observation

The human nose is, to this day, the most suitable 'sensor' for odor. There is currently no substitute for assessing odor perception of complex sources other than direct human perception. Direct observation, however, is highly subjective. An individual is subject to biases such as background odor, familiar odors, or simply being an individual with either a heightened or decreased sensitivity to smell, among other biases. Additionally, these observations are only qualitative and do not provide a quantitative measurement that is repeatable.

5.1.2 Field Olfactometers

Olfactometers operate on the principle of diluting odors. The amount of dilution required to reduce an odor sample below detection represents the strength of an odor.

The Nasal Ranger® and Scentometer are specific types of olfactometers commonly used by regulators and others for field assessments. They are portable devices used to provide a quantitative measurement of the odor concentration. The odor concentration is determined by the

Dilutions-to-Threshold ratio, or D/T. This ratio is a measure of the volume of carbon filterer (Clean) air needed to make a volume of odorous air non-detectable.

$$\frac{D}{T} = \frac{\text{Volume of "Clean Air"}}{\text{Volume of Odorous Air}}$$

To use the olfacometer, the user inhales through the device and determines if an odor is detected. Testing begins at a low dilution rate (small amount of odorous air added to “clean air”) and continues incrementally until the user detects an odor. The level of dilution at the point is noted as the D/T measurement. Users of the field olfactometers should be trained and certified via a specific training course provided by their respective manufacturers.

While field olfactometers are portable and offer multiple field use examples, there are some biases inherent to this method that are not present in olfactometry performed through the use of an odor panel, discussed in Section 5.1.3. Because field olfactometers are deployed and used in the field, the operator is subject to field conditions and has already biased themself, their nose, and olfactory senses with the ambient air on location. In many cases, the human nose can become accustomed to an odor after a period of exposure and become “nose-blind” to the odor(s) under evaluation. Thus, using the Nasal Ranger® or field Scentometer to determine in-field D/T can have a low bias on the results.

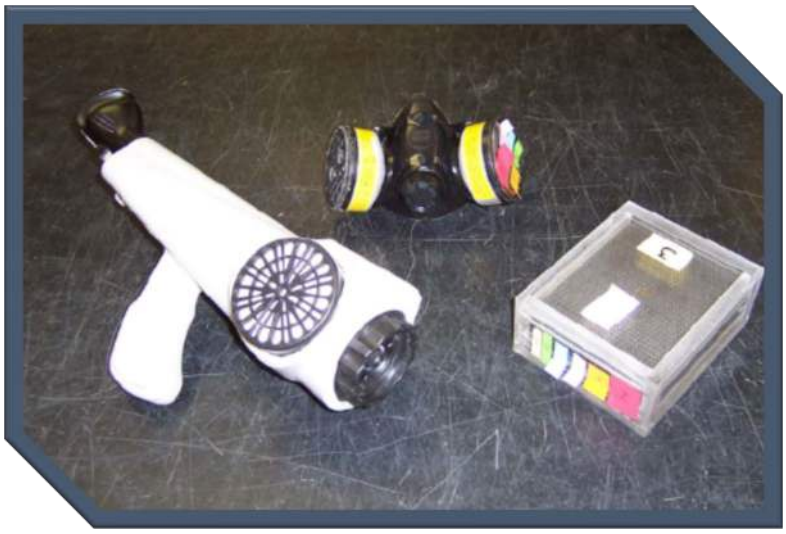


Figure 3: Examples of Field Olfactometers (Nasal Ranger, Facial Mask, Box Scentometer)

5.1.3 Odor Panel

Using an odor panel removes the field environment bias seen with usage of the field olfactometers. An odor panel uses a stationary olfactometer that operates on the same principle as the field olfactometer. Laboratory olfactometers generally have four to six stations for human panelists. The stations are equipped with two to three sniff ports. One random sniff port produces a stream of diluted odorous air, while the other port(s) produce a stream of pure air. Testing begins at low dilutions, and panelists are asked to determine which port contains the odorous air. The dilution at which at least half the panel correctly and confidently identifies the correct port determines the D/T measurement of that sample. This is an objective method developed to establish odor concentration using human assessors.

The major constraint to using an odor panel is logistics. Generally, panels need to be booked in advance, and they can only handle a certain number of odor samples due to both time and panelist fatigue. Additionally, odor samples have a hold time of 36 hours, so samples must be shipped to the odor lab via overnight courier, which can be costly.

5.2 ODOR MONITORING VIA CHEMICAL SURROGATE

If there is a known correlation between odor and a chemical surrogate, samples can be analyzed for the chemical surrogate in lieu of measurement of odor. A summary of methods to assess odor through chemical surrogates is provided in the table below with further details in the following sections.

Table 5-2: Summary of Odor Assessment Via Chemical Surrogate

Analytical Measurement	Measurement Units:	Benefits:	Limitations:
Time Averaged Samples with Follow-up Analysis via Analytical Laboratory	Dependent on method	Many compounds can be detected to parts per billion level accuracy.	Costs are per sample and can be expensive. The sample only represents the time and location the sample was collected. Field labor dependent and requires sampling expertise.
Total VOC Detection w/ Photoionization Detectors (PID)	Parts per billion	Inexpensive analyzer measures for total VOCs. Fast response time and is capable of real-time measurements.	Does not differentiate between VOCs. Calibrated based on single VOC that may be very different from compounds of interest. Responds to VOCs that can exist in high background concentrations. Many VOCs are not significant contributors to odors.
Field Deployable Gas Chromatography w/ Various Detectors	Parts per billion	Accurately identifies and quantifies concentrations of multiple target compounds. Can collect and measure samples every 10 minutes depending on the specific compounds of interest. Can be adapted to measure at multiple sampling locations.	Limited detection to compounds of similar retention times under current configuration. Calibration standards are field-generated or need to be created by certified labs relative to the compounds of interest. The system currently does not detect organosulfur compounds of interest. The concentration of measured VOCs relative to odor concentration is not always suitably correlated.
Electronic Noses (electrochemical sensors)	10-100 Parts per billion	Measures multiple chemical constituents that are known to be odiferous.	May not be able to detect all the compounds emitted by source known to be part of the odor profile.

5.2.1 Analytical Lab Analysis

There are a limited number of accepted standardized analytical methods performed by accredited laboratories for compounds that are known to be odiferous. Sulfonated compound analysis using ASTM D-5524 and speciated VOC analysis using EPA T0-15 are examples. With these methods, samples can be tested for multiple compounds and down to a relatively low detection limit. This is important as many odiferous compounds have very low odor detection thresholds. It is important that the sample collection and analytical method are compatible with the odor detection threshold of

the target compound(s). However, each sample is only representative of a snapshot in time and does not show real-time or immediate results.

5.2.2 Photoionization Detectors (PID)

PIDs are field measurement tools that detect VOCs that can be used for processes where a correlation between odor and VOCs exists. They produce real-time readings and are generally used during first responses for many use cases, such as detecting a potential leak in the system or qualitative assessment of the presence of VOCs. However, while they are fast responding and can detect multiple VOCs, they cannot speciate and differentiate the compounds detected from each other. This may be ineffective in cases where there are multiple background compounds present.

5.2.3 Portable Gas Chromatograph (GC)

Portable gas chromatographs (GC) can be deployed in the field to speciate VOCs. This can be useful when a specific VOC is responsible for the odors perceived from a process. However, while this method can identify and quantify individual VOCs, there are limitations to this method. GCs can only quantify predetermined, thermally stable compounds. Compounds with similar retention times can elute from the chromatographic column at the same time resulting in overlapping peaks, which makes it challenging to accurately identify the individual compounds. Additionally, the VOCs identified may or may not be contributors to the odor profile. This method may not be real-time, but readings can be generated in field, and samples can be collected and analyzed roughly every ten minutes. This method provides a middle ground between real-time sampling and discrete grab samples.

5.2.4 Electronic Nose

The electronic nose (e-Nose) is a type of electrochemical device that uses sensors that generate signal patterns to characterize odors. These sensors detect and react to different molecules, which create response patterns due to changes in electrical properties that are then interpreted and analyzed. Most e-Noses use chemical sensor arrays that react to volatile compounds, and the adsorption of these compounds causes a physical change of the sensor, which is then translated by the electronic interface into a digital value. E-Noses have been used in the evaluation of odors related to the food, health, drug, safety, crime, and the environmental and agricultural sectors. Similar to GCs, e-Noses analyze for a predetermined list of compounds, and if the odor causing compound is not on that list, the e-Nose may not detect an odor.

6.0 ASPHALT ODOR IMPACT ASSESSMENTS

An odor impact assessment can vary from a simple evaluation to address one complaint to a full detailed assessment of facility wide impacts to address persistent nuisance odors. The type of assessment will depend on the quality and quantity of information required to satisfy regulations, stakeholders, or the surrounding community. A description of escalating assessment options is shown in the figure below.

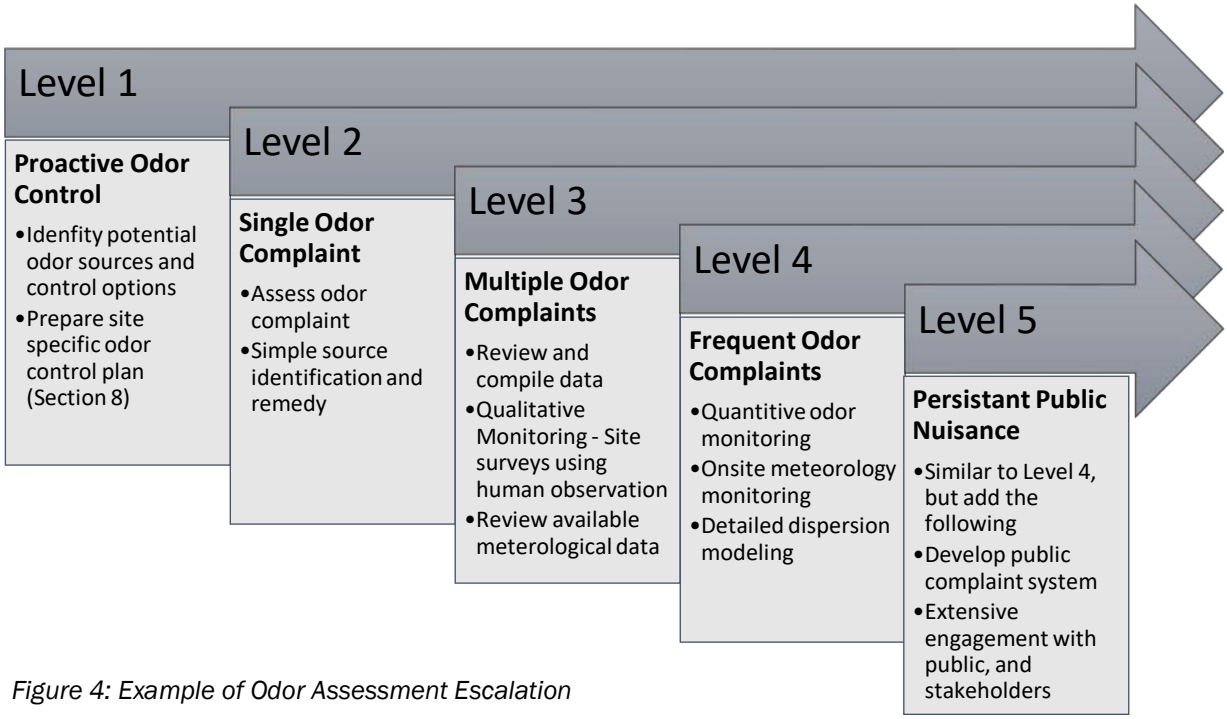


Figure 4: Example of Odor Assessment Escalation

6.1 QUALITATIVE ASSESSMENT

A holistic approach to assess odors can be completed through evaluation of the frequency, intensity, duration, offensiveness, and location of observed odors, referred to as the FIDOL factors.

- **Frequency** – How often is an odor detected, whether it is continuous, intermittent, or occasional
- **Intensity** – What is the perceived strength of the odor, ranging from weak to strong
- **Duration** – How long does each odor event last, whether it be brief, lasting or prolonged
- **Offensiveness** – What is the pleasantness/unpleasantness of the odor
- **Location** – Where does the odor originate and where is it perceived

An evaluation of FIDOL factors can be used as a qualitative assessment to determine if additional corrective actions are warranted or if there is risk of odor impacts in the future. Examples of possible FIDOL field investigation results are presented in Table 6-1 on the following page (Council).

Table 6-1 : Example FIDOL Field Investigation Results

Possible Field Investigation Finding	FIDOL Assessment	Possible Conclusion/Risk
No odor was detected	FIDOL	No additional assessment required/No to minimal risk
An odor was detected, but do not consider it would be offensive or objectionable in this location for any duration or frequency	FIDOL	No additional assessment required/minimal risk
An odor was detected, and consider that it would be offensive if it became continuous	FIDOL	Additional assessment may be required/Moderate to high risk
An odor was detected, and consider that it would be offensive and objectionable if it occurred frequently	FIDOL	Additional assessment may be required/Moderate to high risk
An odor was detected, and consider it to be offensive and objectionable even in short durations	FIDOL	Additional assessment required/High risk

Green: The factor was assessed and not found to be objectionable
Red: The factor was assessed and found to be objectionable
Grey: The factor cannot be assessed or is variable

6.2 QUANTITATIVE ASSESSMENT

Since odor is a subjective human response, a quantitative odor impact assessment provides an objective approach towards understanding how on-site release of odors potentially impact off-site receptors. A quantitative odor impact assessment can include the following steps:

- Source identification
- Sample collection and analysis
- Odor emission rate estimates
- Odor impact modeling

6.2.1 Odor Source Identification

Asphalt odor emission sources can be identified using process flow diagrams, piping and instrumentation diagrams, air permits, annual emission reports, source testing reports, EPA's AP-42 Compilation of Air Emissions Factors from Stationary Sources, and site walks. See Section 4.1 for typical sources encountered in the asphalt industry. Below is a list of typical information compiled for identified odor sources:

- Location
  - Coordinates
  - Proximity to buildings/structures
- Release height
- Release parameters
  - Surface area/diameter
  - Velocity or flowrate
  - Temperature and pressure
  - Release configuration details (rain cap, horizontal release, partial enclosure, etc.)
- Operating schedule (by hour, days of the week, monthly)
  - Continuous, hourly fluctuations, seasonal fluctuations, etc.

6.2.2 Sample Collection and Analysis

Once a list of potential odor sources is identified, samples are collected to analyze the odor concentration of the source(s). Samples are typically collected using an air displacement sampler (commonly referred to as a lung sampler) and Tedlar bags. The collected samples are analyzed via an odor panel for odor concentration in terms of D/T, as described under Section 5.1.3. During onsite sample collection, the source specific data listed in Section 6.2.1 should also be measured and/or confirmed. Additional data that may be collected that can assist in the odor assessment are below:

- Meteorological conditions during sample collection: wind direction, speed, atmospheric condition, precipitation
- Operating conditions during sample collection: what equipment is operating, operating throughputs, equipment condition (obvious issues)
- Ambient upwind and downwind samples for odor analysis
- Measurements/analysis of potential odor surrogates: handheld hydrogen sulfide analyzer, handheld VOC analyzer, sample collection for lab analysis for potential surrogates

6.2.3 Odor Emission Rate

The odor emission rate, source strength, is calculated for the identified odor sources by multiplying the odor concentration (in units of D/T) by the volumetric flow rate of the release point. Volumetric flow rate for a point source (e.g., stack or vent) is:

- Calculated by the product of the air velocity in the stack/vent/duct and the cross-sectional area; or
- Obtained from equipment specifications, source testing reports, permit applications, or other documentation.

Volumetric flow rate for a non-point source (e.g., fugitive sources) is estimated using engineering calculations and/or advanced measurement techniques such as a sampling hood (flux chamber).

6.2.4 Odor Dispersion Modeling

An atmospheric dispersion model is used to estimate off-site odor concentrations resulting from the odor generating source(s) at the facility. The American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) is an often used model by regulators, environmental consultants, and professionals for odor dispersion modeling. Required input data for AERMOD includes:

- Odor source parameters (i.e., emission rate, dimensions, flowrate, temperature, pressure)
- Odor source operating parameters (continuous, daily limits, seasonal limits, annual limits)
- Building downwash parameters (building dimensions and heights)
- Meteorological data (upper air and ground level – sources from National Weather Stations)
- Topographic data (i.e., National Elevation Dataset terrain data files)
- Receptors (locations the model will calculate odor concentration at – user specified)
- Model options (specifics on dispersion options selected by user)

Model Results

AERMOD estimates the maximum odor concentration (D/T) for the receptors (locations) included in the model. The model can be configured to output combined impacts from a facility as well as the odor impacts from individual onsite sources. The peak offsite odor concentration can be identified and then compared to an appropriate nuisance odor threshold for the region. An example odor model plot is shown in the figure below.

Figure 5: Example of Odor Dispersion Model Plot

Model Limitations

A limitation and challenge when using air dispersion models to estimate odor impacts is the time and space resolution the model is based on (Nicola Pettarin). The smallest increment of time typical air dispersion models calculate results on is one hour, while it takes a few seconds for a person to inhale and perceive an odor. This can create a large discrepancy between what the model will estimate and what a person may perceive. Furthermore, a modeled hourly average will not mimic a short-term increase in odors from a source, such as unloading asphalt in a tank over a ten-minute period. During the ten minutes of unloading, there can be an increase in odors from the activity that will not be seen in the model results.

7.0 ODOR CONTROL OPTIONS

Effective odor reduction should be designed specifically to the type of source as well as the chemical composition of the odors. The following sections provide information on general odor control technologies.

7.1 ODOR CAPTURE

The first step to controlling odor typically requires capturing and transporting the odorous compounds to the chosen odor reduction device. Capture and transport of odors from stacks and process vents to a control device can generally be accomplished with enclosed ducting/piping systems, provided the volume to be captured is manageable. As an example, capturing odors from cooling section stacks is technically feasible; however, treating the large volume of air anticipated from a cooling section is likely not plausible. Capture of fugitive sources can be challenging for various reasons, some of which are discussed below:

- **Production Line Fugitives**: Construction and operation of a capture system to collect fugitive asphalt odors from a production line can be difficult due to the need to move material in and out of the enclosure and operator requirements to maintain and run the system. Capture systems are commonly used on these production lines; however, the capture efficiency (percent of asphalt fumes collected) can vary greatly depending on the design, operating conditions, and maintenance.
- **Building Fugitives**: Asphalt odors emitted within a building, whether through fugitive losses from a production line, or from an interior process vent, may be released through openings in the building, such as doors and roof vents. Capturing odors from these openings may not be warranted due to the number of openings and large volume of air that would need to be collected and subsequently treated.

Where odor capture is not warranted, a facility may consider the use of odor neutralizing or masking agents, as discussed under Section 7.2.3, which can be applied at the point of release.

7.2 ODOR CONTROL TECHNOLOGIES

To achieve odor control, the chemical nature of the odor compounds can be changed to make them less odorous, the odorous compounds can be removed, or other compounds can be added to neutralize the odor perception. A brief description of odor control technologies is provided below and additional details, including pros and cons of each, are provided in Table 7-1. A brief description of odor control options relative to source type is provided on Table 7-2.

7.2.1 Change Chemical Structure

Changing the chemical structure of the odorant to a less odorous compound typically requires energy input (heat), an oxidizer, or biological activity to break the bonds between the elements of the odorous compound(s). Below is a list of some common technologies that change the chemical structure of odor compounds.

- **Incineration** such as combustion in flares or thermal oxidizers convert odorous compounds into carbon dioxide, nitrogen, water and ancillary compounds.
- **Ozone** is a powerful oxidant that can break apart odorous molecules resulting in less odorous compounds.

- **Non-Thermal Plasma** uses electrically charged particles (plasma) that interact with odorous compounds and breaks them apart into less odorous compounds.
- **Biological Filters** use microorganisms that feed off odor-causing compounds to remove the odorant from the stream. The microorganisms biologically metabolize the compound releasing less odorous compounds.

7.2.2 Remove or Filter Odor

Removing or filtering the odor from the stream reduces the concentration of odorous compounds. Below is a list of some common technologies that reduce odors through filtration.

- **Adsorption** captures odorous molecules in the pore space of adsorbent materials, such as activated carbon or zeolite, thus reducing the odors in the process stream.
- **Chemical/Wet Scrubbers** use highly reactive chemicals such as acids, caustics, and surfactants to react with the odorous compounds and remove them from the process stream.

7.2.3 Neutralize or Mask Odor

Neutralizing and masking agents do not reduce or remove odorous compounds but rather alter how the odorous compound is perceived or not perceived by a person.

- **Odor Neutralizers** include compounds that adhere to odor molecules and change how the olfactory system recognizes the molecule, thus changing a person's perception of odor to that stream.
- **Masking Agents** are similar to perfume in that they contain synthetic fragrance that is intended to "hide" odors. In some situations, the masking agents may bind to olfactory receptors, thereby inhibiting the receptor's ability to bind to odorous molecules.

Table 7-1: Odor Control Technologies Summary Table

Odor Control Technology	How It Works	Pros	Cons
Thermal & Catalytic Converters	• The system burns odorous gases. The gas is passed over (or through) catalytic materials, converting residual gases into compounds like carbon dioxide, nitrogen, and water.	• There has been widespread development for different catalytic mediums, mainly for "reduction" and "oxidation" catalysts	• Can introduce many toxins and noxious substances into the air • Even for well-designed and operated systems, there is a need for catalyst saturation and sterilization
Incineration (catalytic, recuperative, regenerative)	• Odor-causing waste and gas are burned at high temperatures destroying process odors.	• Incinerators are one of the most positive and proven methods for destroying VOCs with efficiencies up to 99.9999% • Recuperative incinerators usually more economical than straight thermal incinerators because they recover about 70% of the waste heat • The incineration process is effective against organic odors	• High initial cost • Supplemental fuel • Dangerously high temperatures, usually around 1472°F (800°C), are needed to destroy gas • Expensive, not always effective, and generally introduces toxins and additional odors into the atmosphere • Additional air is sometimes required and can cause volatile gases to be released from the waste gas • Not well suited to streams with highly variable flow because of reduced residence time and poor mixing during increased flow conditions • May not be suited for sulfur containing compounds due to formation of highly corrosive acid gases
Ozone	• Generators create ozone molecules, which are highly reactive to organic material. • break apart odorous molecules resulting in less odorous compounds.	• Ozone is a powerful oxidant and anti-microbial •	• Can cause side effects if used around people; treated areas must be evacuated while in use and hours afterward • Extremely caustic and could damage items or react to other chemicals in treatment areas • Not effective on inorganic odors

Odor Control Technology	How It Works	Pros	Cons
Chemical Scrubbers / Packed Tower Wet Scrubber	Odors are added to highly reactive chemicals, such as acids, caustics, oxidizers, and surfactants. The odorous compounds chemically react with the solution, removing odors.	• Mechanics can be monitored and carefully controlled • Systems are popular: known technology with standard, "textbook" designs • System efficiency not dependent on nozzle performance • Effective removal performance at high H2S concentrations • Economically treats large volumes of air • Relatively small footprint	• Expensive to build; must be operated by trained personnel and serviced in protective gear • Must be designed for a specific application, with careful considerations for dangerous exhaust gas • Chemicals used are considered reactive, hazardous, and must be neutralized before disposal • Requires periodic cleanings • Removes few/no VOCs • Relatively tall which may create aesthetic issues
Adsorption (Carbon Filters)	Gas particles from the air penetrate the pores of an adsorbent material, such as activated carbon, zeolite, or silica gel, and removes odors from the air as it passes through.	• Carbon is porous and has a large surface area, which allows it to absorb odors in the air • Activated Carbon is a common adsorbent for organic odor removal • Activated Carbon is used to remove sulfur bearing compounds, aldehydes, and ketones • No chemical storage or recirculation pumps • Simple operation and maintenance • Cost effective removal at < 5 ppm H2S • Can remove a wide range of compounds compared to wet scrubbers • Removes VOCs	• Reversible in nature, which allows odors to return if heated • Spent media disposal can be messy and expensive, especially when it contains hazardous compounds • Adsorbents are consumable and must be re-activated or replaced • As influent concentration increases, carbon bed life expectancy decreases
Biological Filters	Contaminated air passes through soil, compost, wood chips, or other organic material. As the odorous air flows through the material, pollutants (including odor molecules) transfer into a thin biofilm on its surface. Microorganisms in the biofilm eliminate odors.	• Bacteria used are naturally occurring and can metabolize many organic odor-causing compounds. • Works on odors that are biodegradable and water-soluble • Easy to maintain and do not require chemical addition • Can also remove VOCs	• Large units with massive footprints are needed to treat airflow • Microbes must interact with the odorous compounds over long periods • Material must be replaced, causing odors to go untreated during downtime. Typical rebuild is 3-5 years

Odor Control Technology	How It Works	Pros	Cons
Biological Oxidation (Scrubber)	Air is forced upward through an adsorption column filled with synthetic material. Water containing microorganisms circulates through the system, feeding off odor-causing compounds and releasing clean air.	• These units work well to reduce odors caused by ketones, alcohols, and ethers. • Requires lower detention times (8 to 15 seconds for H_2S). • Media can be stacked higher. • Inert media have a long bed life. • Reduces potential footprint and requirements for media replacement.	• Equipment needed to recirculate water in bioscrubbers makes for expensive up-front and operating costs. • Requires selection of lab-developed bacterial strain.
Fabric Filter (mechanical shaker, pulse-jet, reverse-air)	Gas is passed through a tightly woven fabric, causing particulate matter (PM) in the flue gas to be collected on the fabric by sieving and other mechanisms.	• High collection efficiencies (95%+) • Corrosion and rusting are not typical problems • Operation is relatively simple • Typically, does not require high voltage • Available in a large number of configurations • Useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators	• Potential for flammable dust • High temperatures require special refractory mineral or metallic fabrics which can be expensive • Relatively high maintenance requirements (e.g., periodic bag replacement) • Fabric life may be shortened at elevated temperatures and in the presence of acid or alkaline particulate or gas constituents • Cannot be operated in most environments • Tarry adhesive components may cause crusty caking or plugging • May not remove all odorous compounds
Odor Neutralizers (e.g., Ecosorb)	• Odor neutralizer chemical processes involved are adsorption, absorption, gas solubility and reaction: ○ Contact: Ecosorb is delivered into an area affected by odors and attracts to odor molecules ○ Adsorption: Ecosorb attaches to odor molecules ○ Absorption: Ecosorb surrounds odor moleculres, neutralizing their smell	• Natural ingredients – no hazardous materials • Variety of application methods (vapor phase, atomization, additive) • By adding a small amount of Ecosorb® additive to any phase of asphalt use or production — from manufacturing to storage to transportation to use — odors are reduced and even eliminated. Odor control by suppression before it's airborne	• On-going costs of the odor neutralizer • Need to select the odor neutralizer that best reduces odors • If dispersing, need the odor neutralizer plume to intersect the odor plume

Odor Control Technology	How It Works	Pros	Cons
Masking Agents	Chemicals are sprayed into the air, using synthetic fragrances to "hide" odors.	• Masking agents can come in many scents and cover a broad range of odors • They can be used outside facilities so they do not impact finished goods and can come in non-hazardous formulas	• Give an immediate cover to odors, but the odors eventually return as the fragrance and odor molecules separate • May use hazardous chemicals and are delivered by harmful aerosols • Can trigger public awareness to a potential odor event when masking agents (cherry, vanilla, etc.) are released, especially when used intermittently

Table 7-2: Odor Control Options Relative to Source Type

Source Type	Control Method	Footprint	Vendors	Odor Control Benefit (%)		Capital Expense
				High	Low	
Stacks	Non Thermal Plasma Oxidation	Small - Placed on Stacks	IONOX	90%	65%	Moderate
	Regenerative Thermal Oxidizers (RTO)	Large	Tann Corporation	99%	80%	High
			Anguil	99%	80%	High
			Catalytic Products	99%	80%	High
			Durr Canada	99%	80%	High
	Regenerative Catalytic Oxidizers (RCO)		Anguil	95%	80%	High
	Bio Filters	Large Footprint	Evoqua	95%	70%	Medium
			Envirogen	95%	70%	Medium
	Bio-Scrubber/Bio Trickling Filter	Vertical Design	Evoqua	95%	70%	Medium
			Envirogen	95%	70%	Medium
	Chemical Scrubber	Horizontal or Vertical Design, Compact	Valkyrie System by Streamline	95%	75%	Medium
	Molecular Filtration - Carbon	Horizontal or Vertical Design, Larger than Chemical	Carbon Bulk	95%	80%	Medium
			General Carbon	95%	80%	Medium
			Camfil	95%	80%	Medium
	Invenity Scrubber Systems	Horizontal or vertical Design, Larger than Chemical	Envinity Systems	98%	80%	Medium
	Vapor Phase Neutralizer or Mask	Small footprint	OMI	Not Available	Not Available	Low
			FogCo	Not Available	Not Available	Low

Source Type	Control Method	Footprint	Vendors	Odor Control Benefit (%)		Capital Expense
				High	Low	
Vents	Internal Treatment - Scrubber Towers		Envenity, Camfil	90%	70%	Medium
	Misters		Byers Scientific	Not Available	Not Available	Low
	Vapor Phase		OMI	Not Available	Not Available	Low
		Iodine Based Solution	Fog Co	Not Available	Not Available	Low
Fugitive	Misters	Small - 6'X6	Multiple	Not Available	Not Available	Low
	Vapor Phase		OMI	Not Available	Not Available	Low
			Fog Co	Not Available	Not Available	Low
Product Feedstock Treatment	Additive To Treated	Chemical Tanks, Pumps	OMI	Not Available	Not Available	Low
	Ph Control	Chemical Tanks, Pumps	Various	Not Available	Not Available	Low
	Talon Sulfide Elimination System	Chemical Tanks, Pumps	Streamline	Not Available	Not Available	Low

8.0 ODOR CONTROL PLAN DEVELOPMENT

Odor control plans contain procedures to reduce odors and methods for managing odor complaints.

8.1 TYPICAL PLAN DEVELOPMENT

The following provides a description of the information included in site-specific odor control plans.

8.1.1 Facility Description and Location

A site-specific odor control plan includes a description of the facility and surrounding area. The facility information includes a summary of the property size, the type of activities conducted onsite, and a general summary of onsite structures. A description of the surrounding properties and land use, with close attention to potential receptors, such as residential areas, schools and day cares, is also included. The presence of other potential odor-generating sites in the vicinity of the facility can also be discussed.

8.1.2 Odor-Emitting Sources

The odor control plan includes a list of odor generating processes. The following information, where available, for the identified processes is useful for inclusion.

- Description of odor characteristics
- Odor release method (stack, vent, building fugitives, etc.)
- Location of odor release point/proximity to sensitive neighbors
- Operating schedule (continuous, intermittent, seasonal)

8.1.3 Odor Control Strategies and BMPs

The odor control plan describes the odor control technologies for the odor generating sources or explains why odor control is not warranted. The Plan includes a description of the odor control technology, a summary of operating and maintenance requirements for proper operation of the odor control, and best management practices (BMPs) the facility implements to reduce potential for offsite odor impacts.

8.1.4 Complaint Management System

The odor management plan includes procedures for responding to odor complaints. This includes identification of site specific personnel responsible for managing complaints, and a tiered approach for responding to and mitigating complaints. An example of sections that may be included in complaint management system is provided below.

- Method for submittal of complaints
- Roles and responsibilities of facility staff
- Compliance response process
    - Level 1 response - initial assessment and corrective actions
    - Level 2 response - diagnostic assessment and corrective actions
    - Level 3 response - analytical assessment and corrective actions
    - Level 4 response - comprehensive controls analysis and corrective actions

Complaint submittal systems can be as simple as contact information and forms for the population to use to sophisticated interactive online dashboards that allow the facility to view and manage community complaints. The figure to the right shows a web-based odor submittal system and an example odor complaint response form is provided in Appendix B.

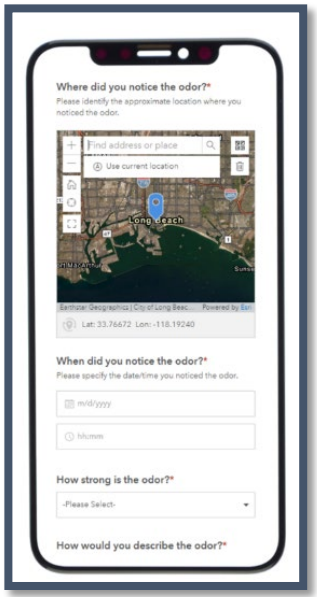


Figure -6: Example Online Odor Submittal System (SCS)

8.2 EXAMPLE ODOR CONTROL PLAN OUTLINE

The following is an example outline of an effective and comprehensive odor control plan.

1) Introduction and Source Identification
   - Facility Name
   - Facility Address
   - Vicinity Map
   - Site Map/Process Flow Diagram
   - Description of Operations and Layout
2) Description of Odor Emitting Activities or Processes
   - Identification of odor Emitting Activities and Processes
   - Identification of Chemical Odorants
   - Material Storage/Waste Generation
   - Processes
   - Operational/Production Schedules
   - Fume hHoods and Stacks
   - Fugitive Sources
3) Description of Methods Used for Odor Control
   - Administrative Controls
   - Engineering Controls
   - Process Parameters for Proper Operation
   - Maintenance Requirements
   - Staff Training
4) Complaint Management Procedures
   - Facility Contact Information
   - Complaint Management System
   - Procedures for Response
   - Community Outreach
5) Corrective Action Plan

9.0 COMMUNICATION PLAN AND PUBLIC OUTREACH

Community outreach serves to educate the public about a facility and establishes a partnership between facility operators and members of the public that can work together to resolve issues. The facility's relationship with the community may not be limited to odors issues and may require expansion to address a broad spectrum of potential concerns such as, but not limited to, traffic, noise, dust, and other environmental topics.

9.1 TYPICAL COMMUNITY CONCERNS

When a person encounters an odor, particularly an offensive odor, a frequent initial concern is that the exposure to whatever is causing the odor will make them sick. This perception is evident not only for short term exposure (on the scale of minutes) but also for longer term exposures (days and months). In addition to health issues, people commonly believe that when odor impacts occur, their property values will suffer.

It is also not uncommon for people to blame the wrong facility for odors. People respond to impacts based on what they see and sense and may not rely on facts (for example is the wind blowing in a direction that would connect your facility with the complaint locations, is the plume they see steam and not smoke, etc.). If real-time accurate information is available and conveyed between the community and the facility about detected odors, effective and meaningful solutions can be tailored to mitigate impacts.

9.2 USEFUL INFORMATION

9.2.1 Conveyance of Regulatory Compliance

Compliance with regulatory conditions and conveying the facility's vision of compliance to the local population is important. This needs to be as clear and concise as possible so the public understands what compliance means including what information is used to assess compliance. It is important to share this data with the public in a way that is understandable and visual. If possible, illustrate how the community has helped in attaining compliance with regulatory issues.

9.2.2 Measuring Success

When it comes to odor issues, success is not just measured against compliance with regulatory conditions. Progress toward success is also measured with ongoing data collection that reflects true odor impacts and complaints on an ongoing basis. The following actions can be taken as complaints are received to assess odor impacts to the surrounding community.

- Odor Complaint Statistics and Trends – Once odor complaints are made, the data can be analyzed in manner that may reveal trends. Odor complaint data can include time of day, day of week, and location with respect to the facility. It can then be compared with reliable local wind speed and wind direction data occurring during the period that coincides with the complaints. Mapping the complaint data in this way will provide a picture of when and how the odors occur and relative to what upwind sources.
- Odor Sampling and Measurements – Once trends of odor complaint statistics are compiled, the facility can develop an odor sampling and measurement program. This would include conducting field measurements of air samples downwind of the facility to evaluate the odor concentration, intensity, and chemical composition of the odors.

As the measurement programs proceed in time, the results should be analyzed and presented to illustrate the trends and conclusions from the data. Input should be received from the community and considered as mitigations are designed and applied.

9.3 KEY ELEMENTS OF COMMUNITY OUTREAH

9.3.1 The Goal of Community Outreach

The ultimate goal of a community outreach program is to establish a partnership with the surrounding neighbors to work together to resolve problems. This involves building trust between the facility and the community. Once that trust is established, solving odor problems will be possible through effective and realistic mitigations and controls.

Effective community outreach includes meaningful and open discussion of problems, the conveyance of regulatory compliance, open dialog of measured data and observations, and review of tailored solutions of which the community feels that they were a significant contributor. A successful public relations program makes the community feel they are a valued partner in the facility operation and compliance.

9.3.2 Engaging with the Community

Connecting with the surrounding community is best accomplished through comprehensive outreach that is able to reach all levels of the population. There is no common or primary way that people communicate and access information, so it is the responsibility of the facility to provide information in a variety of ways. This includes, but not limited to, the following:

- In person town Hall meetings and presentations
- Zoom or Teams meetings that people can attend via computer link
- Focus group meetings with small numbers of people; perhaps people from individual neighborhoods or logical segments or subsets of the overall community.
- Educational seminars on specific topics concerning odors
- Summary status letters and flyers sent to the community also provided via social media
- Light social events within the community sponsored by the facility

Communication with facility neighbors is not a short-term venture or a one-time event. It is an ongoing process to engage the public to your facility and to have them feel they are a part of the success. Neighbor interaction should be regular, ongoing and as frequent as necessary to maintain communications. It is important to make the process interesting so that a maximum number of people from the community will remain engaged.

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Appendix A

Summary of State Odor Regulations

State	Regulatory Citation	Regulation	Limit
Alabama	Section 45-34-171.01	No relevant **Odor** regulations could be located in the ADEM regulations or Alabama Administrative Code. The following regulations or similar variation exists for several counties: (a) It is unlawful and constitutes a public nuisance for the owner or other person in charge or in control of a building, lot, junkyard, or other premises, within the unincorporated territory of Henry County to fail to keep the lot, junkyard, or premises clean and free from garbage, refuse, litter, junk, debris, salvaged materials, household furniture, trash, used motor vehicle tires, inoperable motor vehicles, kitchen and other household appliances, rags, paper, cardboard, and other nondecorative matter, including any materials within which water may accumulate or which may shelter or encourage the growth of insects or rodents, or materials which generate obnoxious **ODOR**s, or which offend the esthetics of the community, and which thereby cause a substantial diminution in the value of other property nearby or which threaten the health and safety of any citizen. (b) This part shall not apply to any company, corporation, or business currently operating, whose primary purpose of business is to burn or incinerate wood materials, salvage materials, building refuse, waste products, timber stumps, trees, or brush and other debris that results from clearing land, cutting timber, or refurbishing or constructing buildings. This part shall not apply to farm buildings or farm equipment and farm materials stored around farm buildings on a farm.	No
Alaska	18 AAC 50	No relevant **Odor** regulations could be located in the ADEC regulations or the Alaska Administrative Code.	No
Arizona	Arizona Administrative Code R18-2-730 D. and G	Arizona/ADEQ does not have an **Odor** limit. No person shall emit gaseous or **Odorous** materials from equipment, operations or premises under the person's control in such quantities or concentrations as to cause air pollution. Where a stack, vent or other outlet is at such a level that fumes, gas mist, **Odor**, smoke, vapor or any combination thereof constituting air pollution is discharged to adjoining property, the Director may require the installation of abatement equipment or the alteration of such stack, vent, or other outlet by the owner or operator thereof to a degree that will adequately dilute, reduce or eliminate the discharge of air pollution to adjoining property.	No
	Maricopa County Air Pollution Control Regulations Regulation III Rule 320 Maricopa County (Cont.)	300 STANDARDS: No person shall emit gaseous or **Odorous** air contaminants from equipment, operations or premises under his control in such quantities or concentrations as to cause air pollution. 304 HYDROGEN SULFIDE: No person shall emit hydrogen sulfide from any location in such a manner or amount that the concentration of such emissions into the ambient air at any occupied place beyond the premises on which the source is located exceeds 0.03 parts per million by volume for any averaging period of 30 minutes or more. 306 SULFUR FROM OTHER INDUSTRIES: No person shall discharge into the atmosphere from any industry, reduced sulfur, which includes sulfur equivalent from all sulfur emissions including but not limited to sulfur	0.03 ppm H2S for 30-min avg. period

State	Regulatory Citation	Regulation	Limit
Arizona (Cont.)		dioxide, sulfur trioxide and sulfuric acid, in excess of ten percent of the sulfur entering the process as feed. 307 **ASPHALT** KETTLES AND DIP TANKS: 307.1 No person shall operate an **Asphalt** kettle or dip tank unless the owner or operator controls air contaminant emissions by good modern practices, including but not limited to: a. Maintenance of temperature below both the **Asphalt** flash point and the maximum temperature recommended by the **Asphalt** manufacturer through the use of automatic temperature controls. b. Operation of the kettle or dip tank with the lid closed except when charging. c. Pumping or drawing the **Asphalt** through cocks without dipping. d. Firing of the kettle or dip tank with a clean burning fuel. e. Maintaining the kettle or dip tank in clean, properly adjusted and good operating condition. 307.2 The visible emissions from the operation of an **Asphalt** kettle or dip tank shall comply with the provisions of Rule 300.	
	Pima County Code 17.16.020 - 17.16.030	17.16.020 Noncompliance with applicable standards. A. No person shall cause or permit the planning, construction, installation, erection, modification, use, or operation of an emission source which will cause or contribute to a violation of a performance standard established in this title. 1. The actual emission rates of all identical or reasonably similar emission sources under the control of the same source operator at a contiguous geographical area shall be summed to determine compliance with a mass-emissions discharge standard. 2. A source shall comply with a discharge standard over the full range of the source's operating rates. B. Where a stack, vent or other outlet is at such a level that fumes, gas mist, **Odor**, smoke, vapor or any combination thereof constituting air pollution are discharged to adjoining property, the control officer may require the installation of abatement equipment or the alteration of such stack, vent or other outlet by the owner or operator thereof to a degree that will adequately reduce or eliminate the discharge of air pollution to adjoining property. 17.16.030 **Odor** limiting standards. No person shall emit gaseous or **Odorous** materials from equipment, operations or premises under his control in such quantities or concentrations as to cause air pollution.	No
Arkansas	Reg. 18.801	Prohibition of the Emission of Air Contaminants Such as to Constitute Air Pollution No person shall cause or permit the emission of air contaminants, including **Odor**s or water vapor and including an air contaminant whose emission is not otherwise prohibited by this Code, if the emission of the air contaminant constitutes air pollution.	No
California	17 CCR Division 3	The California Air Resources Board (CARB) regulates Hydrogen Sulfide **Odor**s as part of the California Ambient Air Quality Standards	0.03 ppm for 1-hr averaging period

State	Regulatory Citation	Regulation	Limit
	The Bay Area Air Quality Management District (BAQMD) Regulation 7	Citizen Complaints: The limitations of this Regulation shall not be applicable until the APCO receives **Odor** complaints from ten or more complainants within a 90-day period, alleging that a person has caused **Odor**s perceived at or beyond the property line of such person and deemed to be objectionable by the complainants in the normal course of their work, travel or residence. When the limits of this regulation become effective as a result of citizen complaints described above, the limits shall remain effective until such time as no citizen complaints have been received by the APCO for 1 year. The limits of this Regulation shall become applicable again when the APCO receives **Odor** complaints from five or more complainants within a 90-day period. **Odor** Free Air: Air which as been passed through a drying agent followed by two successive beds of activated carbon. General Limit on **Odorous** Substances: A person shall not discharge any **Odorous** substance which remains **Odorous** after dilution with **Odor**-free air as specified in Table I. Samples shall be collected and analyzed as prescribed in Section 7-400. Limit on **Odorous** Substances at or Beyond Property Line: A person shall not discharge any **Odorous** substance which causes the ambient air at or beyond the property line of such person to be **Odorous** and to remain **Odorous** after dilution with four parts of **Odor**-free air. Limit on **Odorous** Compounds: A person shall not discharge concentrations of **Odorous** compounds in excess of those specified in Table II, except that this Section shall not apply to kraft mills.	Yes. Limits exist for **Odorous** substances beyond the property line and after dilution for: Dimethylsulfide, Ammonia, Mercaptans, Phenolic Compounds, Trimethylamine

State	Regulatory Citation	Regulation	Limit
California (Cont.)	Lassen County Air Pollution Control District Rule 4:17 - Reduction of **Odorous** Matter	A person shall not operate or use any article, equipment or other contrivance for the reduction of animal matter, agricultural material, etc., unless all gases, vapors, and gas-entrained effluent which contain **Odorous** material are: a. Incinerated at temperatures of not less than 1200 degrees Fahrenheit for a period of not less than 0.3 seconds, or b. Processed in such a manner determined by the Control Officer to be equally, or more, effective for the purpose of air pollution control than (a) above. A person incinerating or processing gases, vapors or gas-entrained effluent pursuant to this Rule shall provide, properly install and maintain in calibration, in good working order and in operation, as specified in the Authority to Construct or Permit to Operate or as specified by the Control Officer, devices for indicating temperatures, pressure or other operating conditions. For the purpose of this Rule, "reduction" is defined as any heated process, including rendering, cooking, drying, dehydration, digesting, evaporating and protein concentrating. The provisions of this Rule shall not apply to any article, machine, equipment or other contrivance used exclusively for the processing of food for human consumption.	No
	Santa Barbara Air Pollution Control District Rule 310	A person shall not discharge into the atmosphere from any single source or any number of sources within one contiguous property, hydrogen sulfide or organic sulfides or a combination thereof which results in ground level concentrations at any point at or beyond the property line in excess of amounts shown in the following table, expressed in ppm, by volume, as hydrogen sulfide.	0.06 ppm for 3-min average time; 0.03 ppm for 1-hr averaging time.

State	Regulatory Citation	Regulation	Limit
Colorado	REGULATION NUMBER 2 **ODOR** EMISSION, 5 CCR 1001-4	I. No person, wherever located, shall cause or allow the emission of **Odorous** air contaminants from any single source such as to result in detectable **Odor**s which are measured in excess of the following limits: I.A. For areas used predominantly for residential or commercial purposes it is a violation if **Odor**s are detected after the **Odorous** air has been diluted with **seven (7)** or more volumes of **Odor** free air. I.B. In all other land use areas, it is a violation if **Odor**s are detected after the **Odorous** air has been diluted with **fifteen (15)** or more volumes of **Odor** free air. I.C.1. When the source is a manufacturing process, the source shall have an affirmative defense to a violation of Sections I.A. and I.B., Part A, of this Regulation Number 2, provided that the source demonstrates that it is utilizing the best practical treatment, maintenance, and control currently available in order to maintain the lowest possible emission of **Odorous** gases. In determining whether the source has met its burden of utilizing the best practical control methods, the source need not consider any method which would result in an arbitrary and unreasonable taking of property or in the practical closing of any lawful business or activity, if such would be without corresponding public benefit. I.C.2. For all areas it is a violation when **Odor**s are detected after the **Odorous** air has been diluted with **one hundred twenty seven (127)** or more volumes of **Odor** free air in which case provisions of Section I.C.1., Part A, of this Regulation Number 2 shall not be applicable. II. For the purposes of this Part A of Regulation Number 2, two **Odor** measurements shall be made within a period of one hour, these measurements being separated by at least fifteen (15) minutes. These measurements shall be made outside the property line of the property from which the emission originates. III. For the purposes of this Part A of Regulation Number 2, personnel for evaluating **Odor**s shall be selected using a "detectability rating test" as outline in "Selection and Training of Judges for Sensory Evaluation of the Intensity and Character of Diesel Exhaust **Odor**s." IV. An instrument, device, or technique designated by the Colorado Air Pollution Control Division may be used in the determination of the detectability of an **Odor** and may be used as a guide in the enforcement of this Part A of Regulation Number 2. V. The provisions of this Part A of Regulation Number 2 shall apply throughout the State of Colorado. Except that this Part A of Regulation Number 2 shall not apply to housed commercial swine feeding operations, or to agricultural production that is not considered a major stationary source.	7 D/T Residential and commercial areas 15 D/T In all other areas 127 D/T Manufact. Process

State	Regulatory Citation	Regulation	Limit
Connecticut	Sec. 22a-174-23.Control of **Odor**s	Control of **Odor**s (a)(1) No person shall cause or permit the emission of any substance or combination of substances which creates or contributes to an **Odor**, in the ambient air, that constitutes a nuisance. (2) An **Odor** constitutes a nuisance if present with such intensity, characteristics, frequency and duration that:(A) It is, or can reasonably be expected to be, injurious to public health or welfare, or(B) It unreasonably interferes with the enjoyment of life or the use of property, considering the character and degree of injury to, or interference with, the health, general welfare, property, or use of property of the people affected, and the location of the pollution source and character of the area or neighborhood affected. Whether the source of the emissions was present in the location first shall not be a consideration. (3) Except as provided in subsection (b) of this section, in determining whether an **Odor** constitutes a nuisance the commissioner shall review information gathered from any source of information, including but not limited to citizen complaints and site inspections or surveys. (b) **Odor** in the ambient air shall be deemed to constitute a nuisance if a representative of the commissioner or at least fifty percent of any group of representatives of the commissioner determines, based upon at least three samples or observations in a one hour period, that after a dilution of seven parts clean air to one part sampled air, the **Odor** is equal to or greater than the **Odor** detection threshold. Each of the three or more samples or observations shall be separated by at least fifteen minutes. The burden of rebutting the presumption of nuisance created by this subsection shall be on the owner or operator of the source. (c) **Odor** in the ambient air shall be deemed to constitute a nuisance if any substance or combination of substances is present at a concentration in excess of any concentration stated in Table 23-1 of this section. The burden of rebutting the presumption of nuisance created by this subsection shall be on the owner or operator of the source. (d) The commissioner may determine that an ambient **Odor** which does not exceed the limits set forth in subsections (b) or (c) of this section nevertheless constitutes a violation of subsection (a) of this section. (e) If the commissioner finds that a violation of this section has occurred and reasonably suspects that a certain source has caused or contributed to such violation, the commissioner may issue an order requiring the owner and/or operator of such source to investigate whether it has caused or contributed to such violation. The commissioner may reasonably suspect that a source has caused or contributed to a violation based upon one (1) or more of the following: citizen complaints; comparisons of **Odor**s upwind and downwind of the source; material handling and storage practices; methods of operation; site inspections; surveys; information gathered from any other source; or actual or estimated stack emissions, fugitive emissions or ambient pollutant concentrations. (f) The commissioner may use air quality modeling techniques to calculate ambient pollutant concentrations. The commissioner shall not use air quality modeling results as the sole basis for finding a violation of this section, unless the commissioner has received ten or more written complaints within ninety (90) consecutive days from separate households. (g) Any person who is required to undertake an investigation or remediation pursuant to this section shall assure that all samples and measurements taken in any investigation and remediation are representative of the activity required to be sampled. In calculating	7 D/T

State	Regulatory Citation	Regulation	Limit
Connecticut (Cont.)		ambient air quality impacts, such person shall use applicable air quality models, data bases or other techniques approved in writing by the commissioner for the subject source and any other source which is included in the analysis. (h) Notwithstanding the provisions of section 22a-174-3a(c)(2) of the Regulations of Connecticut State Agencies, in acting on an application for a permit, the commissioner need not perform or review modeling to determine that a proposed source will operate in compliance with subsection (c) of this section. (i) Nothing in this section shall permit emission of any pollutant in violation of any other section, and compliance with any other section shall not constitute compliance with this section. (j) An agricultural or farming operation shall be exempt from the provisions of this section to the extent provided by Section 19a-341 of the General Statutes. (k) The provisions of this section shall not apply to mobile sources or structures which are occupied solely as a dwelling and contain six or fewer dwelling units	
Delaware	Title 7 1100 Division of Air Quality 1119 Control of **Odorous** Air Contaminants	1.0 General Provisions1.1 The purpose of this regulation is to control **Odorous** air contaminants which significantly effect the citizens of the State outside the boundaries of the air contaminant source.1.2 Methods for determining a condition of air pollution due to an **Odorous** air contaminant may include, but are not limited to, scentometer tests, air quality monitoring, and affidavits from affected citizens and investigators.2.0 RequirementsNo person shall cause or allow the emission of an **Odorous** air contaminant such as to cause a condition of air pollution.	No
District of Columbia	20 DCMR § 903	903.1 An emission into the atmosphere of **Odorous** or other air pollutants from any source in any quantity and of any characteristic, and duration which is, or is likely to be injurious to the public health or welfare, or which interferes with the reasonable enjoyment of life and property is prohibited. 903.2 Any stationary source that falls within the following categories regulated by the District of Columbia Air Pollution Control Act of 1984 (the "Act"), effective March 15, 1985 (D.C. Law 5-165; D.C. Official Code § 8-101.05) shall submit an **Odor** Control Plan (OCP): (a) Cultivation and dispensing of medical marijuana, as described in Section 7 of the Legalization of Marijuana for Medical Treatment Initiative of 1999, effective July 27, 2010 (D.C. Law 18-210; D.C. Official Code § 7-1671.06), and any other marijuana cultivation, processing, or dispensing operation licensed under District law; (b) Painting operations subject to the requirements of 20 DCMR §§ 718 and 1409; (c) Trash transfer stations; (d) **Asphalt** processing plants; (e) Wastewater treatment facilities and systems; and (f) Commercial solid fuel-fired cooking operations. The Department may, through the issuance of an administrative order, require an owner or operator of a stationary source of **Odorous** air pollutants, not required to operate under an OCP by § 903.2, to submit an OCP to the Department if: (a) The source emits **Odorous** air pollutants that are detected by a trained	Required to develop Odor Control Plan

State	Regulatory Citation	Regulation	Limit
District of Columbia (Cont.)		inspector using a field olfactometer when one (1) volume of **Odorous** air has been diluted with two (2) or more volumes of **Odor**-free air, as measured at a location or locations where it is likely **Odorous** air pollutants will be detected given the prevailing atmospheric conditions; or (b) The Department receives three (3) or more complaints about the source from distinct addresses within the District, which includes distinct units, apartments, or suites at a single street address, within a thirty (30) day period; provided, that [regulation truncated due to length. See the comments section for link to regulation]	
Florida	62-296.320 (2)	Objectionable **Odor** Prohibited – No person shall cause, suffer, allow or permit the discharge of air pollutants which cause or contribute to an objectionable **Odor**.	No
Georgia	Chapter 391-3-1	No relevant **Odor** regulations could be located in the Georgia DNR/EPD regulations or in the Official Code to Georgia.	No
Hawaii	HAR Title II Chapters 59 and 60.	No relevant **Odor** regulations could be located in the Hawaii Administrative Regulations.	No
Idaho	IDAPA 58.01.01	IDEQ does not regulate **Odor**s. **Odor** regulations were repealed.	No
Illinois	IAC Title 35 Subtitle A, Chapter I	The IEPA has **Odor** regulations (Part 245) but only for rendering plants.	No
Indiana	IC 13-30-2-1	Sec. 1. A person may not do any of the following: (1) Discharge, emit, cause, allow, or threaten to discharge, emit, cause, or allow any contaminant or waste, including any noxious **Odor**, either alone or in combination with contaminants from other sources, into: (A) the environment; or (B) any publicly owned treatment works; in any form that causes or would cause pollution that violates or would violate rules, standards, or discharge or emission requirements adopted by the board under the environmental management laws.	No
Iowa	IAC 567 Title II	N/A - IDNR does not regulate **Odor**s.	No
Iowa	Linn County Code of Ordinances Article III Sec. 10-64 Linn County (Cont.)	Sec. 10-64. - Emissions of objectionable **Odor**s. (a) No person shall cause or permit the emission of any objectionable **Odorous** matter into the ambient air. (b) Upon receipt of a legally petitioned complaint concerning **Odor**, the air pollution control officer shall make an investigation as set forth in subsection (c) of this section. (c) An objectionable **Odor** will be deemed to be objectionable as defined in section 10-55 or when it has been substantiated by the air pollution control officer. The air pollution control officer shall consider the complaint valid when **Odor** is detectable: (1) On or adjacent to residential, recreational, or institutional, retail sales, hotel, premises, after ambient air is diluted with four volumes of **Odor**-free air; (2) On or adjacent to industrial premises, after ambient air is diluted with 20 volumes of **Odor**-free air; and (3) On or adjacent to premises other than those herein before designated after ambient air is diluted with eight volumes of **Odor**-free air. The sampling of ambient air to establish that an objectionable **Odor** exists	4 D/T (residential/commercial); 20 D/T (industrial); 8 D/T (other)

State	Regulatory Citation	Regulation	Limit
(Cont.)		shall be at or beyond the property line of the emission source or at or near a location of human habitation. For field measurements, dilution methods for determining **Odor** concentrations shall be in accordance with test procedures employed in the use of the Barnebey-Cheney Scentometer Model 1-3 or its equivalent. (d) If a violation is determined to exist, then the air pollution control officer shall, by an appropriate order, require the elimination of said objectionable **Odor** in accordance with the installation, permitting, and variance procedures set forth in this article.	
	Linn County Code of Ordinances Article III Sec. 10-55	Objectionable **Odor** means an **Odor** that is believed to be objectionable by 30 percent or more of a random sample of the people exposed to such **Odor**, with the sample size of at least 30 people, or 75 percent of those exposed if fewer than 30 people are affected. Objective means a certain specified degree, quality or characteristic expected to be attained. **Odor** means that which produces response of the human sense of smell to an **Odorous** substance. **Odorous** substance means a gaseous, liquid, or solid material that elicits a psychological response by the human sense of smell. **Odorous** substance source means any equipment, installation operation, or material which emits **Odorous** substances; such as, but not limited to, a stack, chimney, vent, window, opening, basin, lagoon, pond, open tank, storage pile, or inorganic or organic discharges.	
Kansas	K.A.R 28-19 and KSA 65-30	N/A - KDHE Bureau of Air does not regulate **Odor**s.	No
	Wichita, KS Code of Ordinances Sec. 7.42.040	Emission of an objectionable **Odorous** air contaminant or contaminants shall be deemed a violation of this chapter if **Odor**s are detected at or above 7 D/T (dilution to threshold) at any point located beyond the property line of the source of the emission.	7 D/T
	Wyandotte County - Unified Government Sec. 3-22	(a) No person shall cause or permit **Odorous** emissions so as to cause air pollution. (b) An **Odor** occurrence shall be deemed a violation when a complaint from one person or more is received and substantiated at the point of complaint within one business day by observations of the director or their designee. The director shall deem the complaint valid only if the director or their designee finds the occurrence of sufficient duration or frequency so that the director or their designee can make two measurements of olfactometer **Odor** strength within a period of one hour, these measurements being separated by at least 15 minutes. (c) **Odor** measurement shall be made with a Nasal Ranger Field Olfactometer any other instrument, device, or technique designated by the director as producing equivalent results.	No
Kentucky	401 KAR 53:010 Section 4	**Odor**s - A mixture of one (1) volume of ambient air and seven (7) volumes of **Odor**less air shall have no detectable **Odor** at any time.	7 D/T
	KEEC Website	**Odor** violations are documented when an inspector can smell the **Odor** through a sniffing device known as a Nasal Ranger or Scentometer.	
Kentucky (cont.)	Louisville Metro APCD Regulation 1.13	For Louisville/Jefferson County Only 2.1 No person shall emit or cause to be emitted into the ambient air such quantities of air contaminants or other material that creates an objectionable **Odor** beyond the person's property line. An **Odor** will be deemed objectionable when documented investigation by the District	No

State	Regulatory Citation	Regulation	Limit
		includes, as a minimum: observations on the **Odor**'s nature, intensity, duration, and location, and evidence that the **Odor** causes substantial injury, detriment, nuisance, or annoyance to any considerable number of persons, or to the public. 2.2 An instrument, device, or technique may be used by the District in the determination of the intensity of an **Odor** and may be used in the enforcement of this regulation. 2.3 An owner or operator of any business or any machine, device, equipment, or facility that emits into the ambient air any **Odorous** matter or vapors, gases, dusts, or any combination thereof that creates objectionable **Odor**s shall provide, properly install, and maintain in good working order and in operation the control devices or procedures approved by the District. 2.4 Abatement or control requirements may include, but are not limited to, the following: 2.4.1 The use of catalytic incinerators, afterburners, scrubbers, absorbers, or other methods approved by the District, 2.4.2 The removal and disposal of **Odorous** materials, or 2.5 The use of methods in handling and storage of **Odorous** materials that minimize emissions. 2.6 The District may order that a building or buildings in which processing, handling, or storage of any **Odorous** materials is performed be tightly closed and ventilated so that the **Odorous** air, gases, or gas-borne materials leaving the buildings are treated by incineration or other effective means for removal or destruction of **Odorous** matter or other contaminants before discharge into the open air. 2.7 An owner or operator incinerating or processing gases, vapors, or gas-entrained effluents pursuant to this regulation shall provide, properly install, and maintain in good working order and in operation, devices as approved by the District for indicating temperatures, pressures, or other operating conditions. 2.8 **Odor**-producing materials shall be stored, transported, and handled in a manner so that accumulation of these materials resulting from spillage or other escape is prevented. SECTION 3 Reporting Accidental and Other Infrequent Emissions 3.1 Accidental and other infrequent discharges that cause or contribute to objectionable **Odor**s shall be reported by telephone to the District by the owner or operator. These reports shall be made within 1 hour of the discharge. The owner or operator shall also comply with all applicable notification and reporting requirements pursuant to Regulation 1.07 Emissions During Startups, Shutdowns, Malfunctions, and Emergencies.	
Louisiana	LAC Title 33 Part III Chapter 29	D. Standard. Limit on **Odorous** Substances at or beyond Property Lines. A person shall not discharge an **Odorous** substance which causes a perceived **Odor** intensity of six or greater on the specified eight point butanol scale when determined by the department's test method. (method 41) E. Exemptions. The following buildings, materials and operations are	≥ 6 on 8 Point Butanol Scale

State	Regulatory Citation	Regulation	Limit
		exempted from the provisions of this regulation: 1. single family dwellings; 2. restaurants; 3. other establishments for the purpose of preparing food for human consumption; 4. materials **Odor**ized for safety purposes; 5. materials possessing strong **Odor**s for reasons of public health and welfare where no suitable substitute is available and where best modern practices are employed; 6. agricultural, fiber, timber, poultry, seafood or fisheries production, unless such **Odor**s are detected in concentrations or intensities above that normally detected from these processes or byproducts when using applicable air pollution control devices; and 7. emission points regulated under the Total Reduced Sulfur (TRS) emission standard (LAC 33:III.2301.D.3).	
Maine	Title 17 Chapter 91, Subchapter 3	MDEP does not have a relevant **Odor** regulation. Maine has the following nuisance law:§2802. Miscellaneous nuisances - The erection, continuance or use of any building or place for the exercise of a trade, employment or manufacture that, by **noxious exhalations**, **offensive smells** or other annoyances, becomes injurious and dangerous to the health, comfort or property of individuals or of the public;....., are public nuisances.	No
Maryland	Maryland Title 26.11.06.09	A person may not cause or permit the discharge into the atmosphere of gases, vapors, or **Odor**s beyond the property line in such a manner that a nuisance or air pollution is created.	No
Massachusetts	310 CMR 7.09: U Dust, **Odor**, Construction, and Demolition	(1) No person having control of any dust or **Odor** generating operations such as, but not limited to **Asphalt** batching plants, **Asphalt** roofing materials manufacturing plants, **Asphalt** blowing plants, foundries, chemical products manufacturing plants, incinerators, fuel utilization facilities, petroleum products manufacturing plants, aggregate manufacturing plants, food preparation or processing facilities, wood products plants, dry cleaning establishments, paint and varnish manufacturing plants, paper manufacturing plants, leather manufacturing plants, concrete batching plants, metal coating and treating plants, land clearing operations, construction work, dump operations, agricultural operations and street sweeping shall permit emissions therefrom which cause or contribute to a condition of air pollution.	No
Michigan	R 334 & 336	No relevant **Odor** regulations could be located in the EGLE regulations or the Michigan Administrative Code.	No
Minnesota	116.064	Subd. 2.Application. This section applies to facilities that are located in the counties of Anoka, Carver, Dakota, Hennepin, Ramsey, Scott, or Washington. Subd. 3.Prohibition. No person may cause or allow emission into the ambient air of any substance or combination of substances in quantities that produce an objectionable **Odor** beyond the property line of the facility that is the source of the **Odor**. Subd. 4.**Odor** complaints; investigation. (a) The agency must conduct a site investigation of any facility against which ten or more verifiable **Odor**	No

State	Regulatory Citation	Regulation	Limit
Minnesota (Cont.)	116.064 (Cont.)	complaints have been submitted to the agency or to local government officials within 48 hours. The investigation must include: (1) an interview with the owner or operator of the facility against which the complaint was made; (2) a physical examination of the facilities, equipment, operations, conditions, methods, storage areas for material inputs, chemicals and waste, and any other factors that may contribute to or are designed to mitigate the emission of **Odor**s; and (3) testing at locations identified in the **Odor** complaints and at other locations beyond the property line of the facility that is the source of the **Odor** using a precision instrument capable of measuring **Odor**s in ambient air. (b) The commissioner, based upon the agency's site investigation and the results of **Odor** testing and considering the nature, intensity, frequency, and duration of the **Odor** and other relevant factors, shall determine whether the **Odor** emitted from the facility constitutes an objectionable **Odor**. In making the determination, the commissioner may consider the opinions of a random sample of persons exposed to samples of the **Odor** taken from ambient air beyond the property line of the facility that is the source of the **Odor**. (c) The agency must notify officials in local jurisdictions: (1) of **Odor** complaints filed with the agency regarding properties within the local jurisdiction; (2) of any investigation of an **Odor** complaint conducted by the agency at a facility within the local jurisdiction and the results of the investigation; (3) that **Odor** complaints filed with respect to properties located within those jurisdictions must be forwarded to the agency within three business days of being filed; and (4) of any additional actions taken by the agency with respect to the complaints.Subd. 5.Objectionable **Odor**; management plan. (a) If the commissioner determines under subdivision 4 that the **Odor** emitted from a facility is an objectionable **Odor**, the commissioner shall require the owner of the facility to develop and submit to the agency for review within 90 days an **Odor** management plan designed to mitigate **Odor** emissions. The agency must provide technical assistance to the property owner in developing a management plan, including: (1) identifying **Odor** control technology and equipment that may reduce **Odor** emissions; and (2) identifying alternative methods of operation or alternative materials that may reduce **Odor** emissions. The commissioner may grant an extension for submission of the **Odor** management plan for up to an additional 90 days for good cause. (b) An **Odor** management plan must contain, at a minimum, for each **Odor** source contributing to **Odor** emissions: (1) a description of plant operations and materials that generate **Odor**s; (2) proposed changes in equipment, operations, or materials that are designed to mitigate **Odor** emissions; (3) the estimated effectiveness of the plan in reducing **Odor** emissions; (4) the estimated cost of implementing the plan; and (5) a schedule of plan implementation activities. (c) The commissioner may accept, reject, or modify an **Odor** management plan submitted under this subdivision. (d) If the commissioner, based upon the same factors considered under subdivision 4, paragraph (b), determines that implementation of the **Odor** management plan has failed to reduce the facility's **Odor** emissions to a level where they are no longer objectionable **Odor**s, the commissioner	

State	Regulatory Citation	Regulation	Limit
		shall order the facility owner to revise the **Odor** management plan within 90 days of receipt of the commissioner's order. If the revised **Odor** management plan is not acceptable to the commissioner or is implemented but fails to reduce the property's **Odor** emissions to a level where they are no longer objectionable **Odor**s, the commissioner may impose penalties under section 115.071 or may modify or revoke the facility's permit under section 116.07, subdivision 4a, paragraph (d).	
Mississippi	Title 11 Part 2 Chapter 1 Rule 1.3 C. (2)	When dust, fumes, gases, mist, **Odorous** matter, vapors, or any combination thereof escape from a building or equipment in such a manner and amount as to cause a nuisance to property other than that from which it originated or to violate any other provision of this regulation, the Commission may order such corrected in a way that all air and gases or air and gasborne material leaving the building or equipment are controlled or removed prior to discharge to the open air.	No
	Title 11 Part 2 Chapter 4 Rule 4.1	There shall be no **Odorous** substances in the ambient air in concentrations sufficient to adversely and unreasonably: A. affect human health and well-being; B. interfere with the use or enjoyment of property; or C.affect plant or animal life. In determining that concentrations of such substances in the ambient air are adversely and unreasonably affecting human well-being or the use or enjoyment of property of plant or animal life, the factors to be considered by the Commission will include, without limiting the generality of the foregoing, the number of complaints or petitioners alleging that such a condition exists, the frequency of the occurrence of such substances in the ambient air as confirmed by the Department of Environmental Quality staff, and the land use of the affected area.	
Missouri	10 CSR 10-6.165 (3)	(3) General Provisions. No person may cause, permit, or allow the emission of **Odorous** matter in concentrations and frequencies or for durations that **Odor** can be perceived when one (1) volume of **Odorous** air is diluted with seven (7) volumes of **Odor**-free air for two (2) separate trials not less than fifteen (15) minutes apart within the period of one (1) hour. This **Odor** evaluation shall be taken at a location outside of the installation's property boundary.	7 D/T
Missouri (Cont.)	Kansas City, MO Code of Ordinances Sec. 8-7	The following applies to Kansas City, MO only: (a) Emission limitations. (1) No person may cause, permit or allow the emission of noxious **Odor** in such concentrations and frequencies or for such durations that such **Odor** can be perceived beyond the property line of the **Odor** source when one volume of **Odorous** air is diluted with seven volumes of **Odor** free air. (2) No person may cause, permit or allow the emission of noxious **Odor** in such concentrations and frequencies or for such durations that such **Odor** can be perceived at the point of complaint in a residential area when one volume of **Odorous** air is diluted with two volumes of **Odor** free air. (3) No person may cause, permit or allow the emission of noxious **Odor** in such concentrations and frequencies or for such durations that such **Odor** can be perceived at the point of complaint within any building open to the public when one volume of **Odorous** air is diluted with two volumes of **Odor** free air. (b)Method of measurement. These measurements may be made with a scento-meter as manufactured by the Barnebey-Cheney Company or by a similar device, as recognized by the director that will give equivalent results. (c)Exemptions. The provisions of this rule shall not apply to the emission of **Odorous** matter from the raising and harvesting of crops nor from the feeding, breeding, and management of livestock or domestic animals or fowl.	7 D/T beyond property line; 2 D/T (residential); 1 D/T (within public building)

State	Regulatory Citation	Regulation	Limit
Montana	Rule 17.8.315	MDEQ does not regulate **Odor**s. **Odor** regulations were repealed.	No
Nebraska	Title 129	N/A.	No
Nevada	NAC 445B.22087 / NRS44B.210	1. No person may discharge or cause to be discharged, from any stationary source, any material or regulated air pollutant which is or tends to be offensive to the senses, injurious or detrimental to health and safety, or which in any way interferes with or prevents the comfortable enjoyment of life or property. 2. The Director shall investigate an **Odor** when 30 percent or more of a sample of the people exposed to it believe it to be objectionable in usual places of occupancy. The sample must be at least 20 people or 75 percent of those exposed if fewer than 20 people are exposed. 3. The Director shall deem the **Odor** to be a violation if he or she is able to make two **Odor** measurements within a period of 1 hour. These measurements must be separated by at least 15 minutes. An **Odor** measurement consists of a detectable **Odor** after the **Odorous** air has been diluted with eight or more volumes of **Odor**-free air.	30% or group of 20 people or 75% percent for groups of less than 20 people find the **Odor** objectionable
	Clark County Section 43	Clark County Only: An **Odor** occurrence shall be deemed a violation when a complaint is received and substantiated within two hours by the CONTROL OFFICER. The CONTROL OFFICER shall deem the **ODOR** occurrence a violation if he is able to detect the **ODOR** twice within a period of one hour, if the **ODOR** is of such a nature as to cause a nuisance, and these detections being separated by at least 15 minutes.	No
New Hampshire	New Hampshire Code of Administrative Rule and New Hampshire Statutes Chapter 125-I	NDHES does not regulate **Odor**s.	No
New Jersey	NJAC Title 7:27-5	(a) General provisions Notwithstanding compliance with other subchapters of this chapter, no person shall cause, suffer, allow or permit to be emitted into the outdoor atmosphere substances in quantities which shall result in air pollution as defined herein. (b) The provisions of subsection (a) of this section shall not apply to the use of economic poisons. “Air pollution” means the presence in the outdoor atmosphere of one or more air contaminants in such quantities and duration as are, or tend to be, injurious to human health or welfare, animal or plant life or property, or would unreasonably interfere with the enjoyment of life or property throughout the State and in such territories of the State as shall be affected thereby and excludes all aspects of employer-employee relationship as to health and safety hazards.	No
New Mexico	20 NMAC	NMED does not regulate **Odor**s.	No
New York	6 CRR-NY 211.1	No person shall cause or allow emissions of air contaminants to the outdoor atmosphere of such quantity, characteristic or duration which are injurious to human, plant or animal life or to property, or which	No

State	Regulatory Citation	Regulation	Limit
		unreasonably interfere with the comfortable enjoyment of life or property. Notwithstanding the existence of specific air quality standards or emission limits, this prohibition applies, but is not limited to, any particulate, fume, gas, mist, **Odor**, smoke, vapor, pollen, toxic or deleterious emission, either alone or in combination with others.	
	New York City Administrative Code § 24-141	**New York City** has the following regulation: Emission of **Odorous** air contaminants. No person shall cause or permit the emission of an **Odorous** air contaminant or steam or water vapor, if the air contaminant or steam or water vapor causes or may cause detriment to the health, safety, welfare or comfort of any person, or injury to plant and animal life, or causes or may cause damage to property or business, or if it reacts or is likely to react with any other air contaminant or natural air, or is induced to react by solar energy to produce a solid, liquid or gas or any combination thereof which causes or may cause detriment to the health, safety, welfare or comfort of any person, or injury to plant and animal life, or which causes or may cause damage to property or business.	No
North Carolina	15A NCAC 02D .1806	(c) Applicability. With the exemptions in Paragraph (d) of this Rule, this Rule shall apply to all operations that produce **Odorous** emissions that can cause or contribute to objectionable **Odor**s beyond the facility's boundaries. (e) Control Requirements. The owner or operator of a facility subject to this Rule shall not operate the facility without implementing management practices or installing and operating **Odor** control equipment sufficient to prevent **Odorous** emissions from the facility from causing or contributing to objectionable **Odor**s beyond the facility's boundary. (f) **Odor** management plan. If the Director determines that a source or facility subject to this Rule is causing or contributing to objectionable **Odor**s beyond its property boundary by the procedures described in Paragraph (i) of this Rule, the owner or operator shall develop and submit an **Odor** management plan within 60 days of receipt of written notification from the Director of an objectionable **Odor** determination.	No
North Dakota	33.1-15-16	33.1-15-16-01. General provisions. 1. An **Odor** will be considered objectionable when a department certified inspector or at least thirty percent of a randomly selected group of persons, or an **Odor** panel exposed to the **Odor** would deem that **Odor** objectionable if the **Odor** were present in their place of residence.33.1-15-16-02. Emissions of **Odorous** substances restricted.1. In areas located within a city or the area over which a city has exercised extraterritorial zoning as defined in North Dakota Century Code section 40-47-01.1, a person may not discharge into the ambient air any objectionable **Odorous** air contaminant that measures seven **Odor** concentration units or higher outside the property boundary where the discharge is occurring.	No, but **Odor** is objectionable if ≥30% of a randomly selected group of persons, or an **Odor** panel exposed to the **Odor** deem the **Odor** objectionable
		33.1-15-16-02. Emissions of **Odorous** substances restricted. 2. In areas located outside a city or outside the area over which a city has exercised extraterritorial zoning as defined in North Dakota Century Code section 40-47-01.1, a person may not discharge into the ambient air any objectionable **Odorous** air contaminant that causes **Odor**s that measure seven **Odor** concentration units or higher as measured at any of the	7 D/T per the locations/scenarios listed in 33.1-15-16-02 a-c.

State	Regulatory Citation	Regulation	Limit
		following locations: a. Within one hundred feet [30.48 meters] of any residence, church, school, business, or public building, or within a campground or public park. An **Odor** measurement may not be taken at the residence of the owner or operator of the source of the **Odor**, or at any residence, church, school, business, or public building, or within a campground or public park, that is built or established within one-half mile [.80 kilometer] of the source of the **Odor** after the source of the **Odor** has been built or established; b.At any point located beyond one-half mile [.80 kilometer] from the source of the **Odor**, except for property owned by the owner or operator of the source of the **Odor**, or over which the owner or operator of the source of the **Odor** has purchased an **Odor** easement; or	
Ohio	Rule 3745-15-07	The emission or escape into the open air from any source or sources of **Odor**s whatsoever that is subject to regulation under Chapter 3745-17, 3745-18, 3745-21, or 3745-31 of the Administrative Code and is operated in such a manner to emit such amounts of **Odor** as to endanger the health, safety, or welfare of the public, or cause unreasonable injury or damage to property, is hereby found and declared to be a public nuisance. It shall be unlawful for any person to cause, permit or maintain any such public nuisance.	No
Oklahoma	OAC Title 252:100	ODEQ does not have state or federal regulations for **Odor**s	No
Oregon	Or. Admin. R. 340-208-0310	Nuisance Control Requirements: Determining Whether A Nuisance Exists (1) In determining whether a nuisance exists, DEQ may consider factors including, but not limited to, the following: (a) Frequency of the emission; (b) Duration of the emission; (c) Strength or intensity of the emissions, **Odors** or other offending properties; (d) Number of people impacted; (e) The suitability of each party's use to the character of the locality in which it is conducted; (f) Extent and character of the harm to complainants; (g) The source's ability to prevent or avoid harm. (2) Compliance with a best work practices agreement that identifies and abates a suspected nuisance constitutes compliance with OAR 340-208-0300 for the identified nuisance. For sources subject to 340-216-0020 or 340-218-0020, compliance with specific permit conditions that results in the abatement of a nuisance associated with an operation, process or other pollutant emitting activity constitutes compliance with 340-208-0300 for the identified nuisance. For purposes of this section, "permit condition" does not include the general condition prohibiting the creation	No

State	Regulatory Citation	Regulation	Limit
		of nuisances. .	
	Lane Regional Air Protection Agency Title 49	Applies to Lane County Only Section 49-010 Nuisance Prohibited (1) No person may cause or allow air contaminants from any source subject to regulation by LRAPA to cause a nuisance. (2) Upon determining that a nuisance may exist, LRAPA will provide written notice to the person creating the suspected nuisance. LRAPA will endeavor to resolve observed nuisances in keeping with the policy outlined in 15-001. If LRAPA subsequently determines that a nuisance exists under 49-020 and proceeds with a formal enforcement action pursuant to title 15, the first day for determining penalties will be no earlier than the date of this written notice. Section 49-020 Determining Whether a Nuisance Exists (1) In determining whether a nuisance exists, LRAPA may consider factors including, but not limited to, the following: (a) Frequency of the emissions; (b) Duration of the emissions; (c) Strength or intensity of the emissions, **Odor**s, or other offending properties of the emissions; (d) Number of people impacted; (e) The suitability of each party's use to the character of the locality in which it is conducted; (f) Extent and character of the harm to complainants; and (g) The source's ability to prevent or avoid harm. (2) Compliance with a best work practices agreement that identifies and abates a suspected nuisance constitutes compliance with 49-010 for the identified nuisance. For sources subject to 37-0020 or OAR 340-218-0020, compliance with specific permit conditions that results in the abatement of a nuisance associated with an operation, process or other pollutant-emitting activity constitutes compliance with 49-010 for the identified nuisance.	No
Pennsylvania	PA. Code Title 25 Article III	PDEP does not regulate **Odor**s.	No
Rhode Island	250-RICR-120-05-17	17.5 Prohibitions No person shall emit or cause to be emitted into the atmosphere any air contaminant or combination of air contaminants which creates an objectionable **Odor** beyond the property line of said person. 17.6 **Odor** Evaluations A staff member of the Department shall determine by personal observation if an **Odor** is objectionable, taking into account its nature, concentration, location, duration and source.	No
South Carolina	SCCR Chapter 61 Regulation 61-62	SCDHEC does not regulate **Odor**s.	No
South Dakota	SDCL Chapter 34A-1 and SDAR 74:36	SCDDANR does not regulate **Odor**s	No
Tennessee	TCA Title 4, Chapter 1200-03 and Chapter 0400-30	SCDDANR does not regulate **Odor**s	No
	Metropolitan Govt. of Nashville	Nashville Davidson County Only No person shall cause, suffer, allow or permit any emission of gases,	No

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	and Davidson County Code of Laws Section 10.56.170	vapors or objectionable **Odor**s beyond the property line from any source whatsoever which causes injury, detriment, nuisance or annoyance to any considerable number of persons or to the public, or which causes or has a natural tendency to cause injury or damage to business or property.	
	Chattanooga Ordinances /Chattanooga Air Pollution Control Ordinance Sec 4.8	The following applies for **Odor** producing equipment as included as part of installation permit/certificate of operation. Each unit shall be assessed a fee of three hundred eighty-five dollars ($385.00). (NOTE: Examples of this type of equipment include: tar and **Asphalt** kettles, varnish and paint heating kettles, and rendering kettles.)	No
Texas	TAC Title 30 Part 1 Chapter 101 Subchapter A Rule 101.4	TCEQ does not list **Odor**s in the Nuisance Rule 101.4 and does not define the term air contaminant. The TCEQ website indicates it treats **Odor** complaints as nuisances. See the following definition listed in Title 30 of a nuisance: No person shall discharge from any source whatsoever one or more air contaminants or combinations thereof, in such concentration and of such duration as are or may tend to be injurious to or to adversely affect human health or welfare, animal life, vegetation, or property, or as to interfere with the normal use and enjoyment of animal life, vegetation, or property.	No
Utah	Utah Code Title 19 Chapter 2 and UAC Title R307	UDAQ does not regulate **Odor**s	No
Vermont	Chapter 5 Subchapter II Section 5-241 (2) - (3)	**Odor**s A person shall not discharge, cause, suffer, allow, or permit any emissions of objectionable **Odor**s beyond the property line of a premises. Control of **Odor** from Industrial Processes (a) No person shall operate or use any device, machine, equipment or other contrivance for an industrial process which as determined by the Air Pollution Control Officer is an **Odoriferous** process per se, unless all gases, vapors, and gas entrained effluents from such facility are incinerated at a temperature of 871 degrees C (1600 degrees F) for a period of not less than five-tenths (0.5) second, or processed in such manner as determined by the Air Pollution Control Officer to be equally or more effective for the purpose of air pollution control. (b) Effective devices and measures shall be installed and operated in a manner such that no vent, exhaust pipe, blowoff pipe or opening of any kind shall discharge into the open air or atmosphere any **Odorous** matter, air contaminants, dusts or any combination thereof which create **Odor**s or other nuisances. (c) **Odor**-producing materials shall be confined and handled in a manner such that **Odor**s produced within or outside the plant from such materials are controlled. Accumulation of **Odor**-producing materials resulting from spillage or other means is prohibited. (d) **Odor**-bearing air contaminants arising from materials in process shall be confined at the point of origin so as to prevent liberation of **Odorous**	No

State	Regulatory Citation	Regulation	Limit
		matter into the workroom and the confined air contaminants shall be treated before discharge to the atmosphere, as required in section a. (e) Whenever air contaminants escape from a building or buildings used for processing, handling or storage of materials used in the industrial processes specified in section a in such manner and amount as to cause a nuisance or to violate these regulations, the Air Pollution Control Officer shall order that said building or buildings be tightly closed and ventilated in such a way that all air contaminants are treated by incinerator or other means effective for their removal or destruction before discharge to the open air.	
Virginia	9VAC5-40-140, 9VAC5-40-150	Standard for **Odor** No owner or other person shall cause or permit to be discharged into the atmosphere from any affected facility any emissions which cause an **Odor** objectionable to individuals of ordinary sensibility. Determination of violation A. The determination of objectionable **Odor** shall be made after a thorough review of all data or evidence relating to the situation which may be obtained by an investigation directed by the board. As a part of the investigation, the board, at its discretion, may hold a public hearing in accordance with 9 VAC 5-20-40 A 1 to hear complaints. The investigation may also include use of an **Odor** panel survey and other methods approved by the board, or both. B. Upon determination that an **Odor** violates 9 VAC 5-40-140 the owner shall use such measures as approved by the board for the economically and technologically feasible control of **Odorous** emissions.	No
Virginia (Cont.)	9VAC5-50-140, 9VAC5-50-150	Standard for **Odorous** emissions. A. The owner shall use the best available control technology as approved by the board for the control of **Odorous** emissions. B. No owner or other person shall cause or permit to be discharged into the atmosphere from any affected facility and **Odorous** emissions in excess of that resultant from using best available control technology, as reflected in any condition that may be placed upon the permit approval for the facility. Determination of violation A. The determination of violation shall be made after a thorough review of all data or evidence relating to the situation which may be obtained by an investigation directed by the board. As a part of the investigation, the board, at its discretion, may hold a public hearing in accordance with 9VAC5-20-40 A 1 to hear complaints. The investigation may also include use of an **Odor** panel survey or other methods approved by the board, or both. B. If the discharge of **Odorous** emissions is due to the failure of the owner or other person to meet any conditions of a permit issued under 9VAC5 Chapter 80 (9VAC5-80 10 et seq.), the board will automatically consider the emissions to be in violation of 9VAC5-50-140 and proceed accordingly.	No
Washington	WAC 173-400-040	(5) **Odor**s. Any person who shall cause or allow the generation of any **Odor** from any source or activity which may unreasonably interfere with any other property owner's use and enjoyment of her or his property must use recognized good practice and procedures to reduce these **Odor**s to a reasonable minimum. 6)Emissions detrimental to persons or property. No person shall cause or allow the emission of any air contaminant from any source if it is	No

State	Regulatory Citation	Regulation	Limit
		detrimental to the health, safety, or welfare of any person, or causes damage to property or business.	
	Regulation of Northwest Clean Air Agency (Island, Skagit and Whatcom counties) Section 535	SECTION 535 - **ODOR** CONTROL MEASURES 535.1 Appropriate practices and control equipment shall be installed and operated to reduce **Odor**-bearing gasses emitted into the atmosphere to a reasonable minimum. 535.2 The Board or Control Officer may establish requirements that the building or equipment be enclosed and ventilated in such a way that **Odor**-bearing gasses are effectively treated for removal or destruction of **Odorous** matter or other air contaminants before emission to the atmosphere. 535.3 Any person who shall cause or allow the generation of any **Odor** from any source which may unreasonably interfere with any other property owner's use and enjoyment of his or her property must use recognized best practices and control equipment to reduce these **Odor**s to a reasonable minimum. 535.4 **Odor** emissions detrimental to persons or property. No person shall cause or permit the emission of any **Odorous** air contaminant from any source if it is detrimental to the health, safety, or welfare of any person, or causes damage to property or business.	No
Washington (Cont.)	Spokane Regional Clean Air Agency Regulation I, Article VI, Section 6.04	Applies to Spokane County Only **Odor**s. With respect to **Odor**, the Agency may take enforcement action, pursuant to Chapter 70A.15 RCW, under this section if the Control Officer or authorized representative has documented all of the following: (1) The detection by the Control Officer or authorized representative of an **Odor** at a Level 2 or greater, according to the following **Odor** scale: (a) Level 0 – no **Odor** detected, (b) Level 1 – **Odor** barely detected, (c) Level 2 – **Odor** is distinct and definite, any unpleasant characteristics recognizable, (d) Level 3 – **Odor** is objectionable enough or strong enough to cause attempts at avoidance, and (e)Level 4 – **Odor** is so strong that a person does not want to remain present. (2) An affidavit from a person making a complaint that demonstrates that they have experienced air contaminant emissions in sufficient quantities and of such characteristics and duration so as to unreasonably interfere with their enjoyment of life and property (the affidavit should describe or identify, to the extent possible, the frequency, intensity, duration, offensiveness, and location of the **Odor** experienced by the complainant); and (3) The source of the **Odor**. (E) **Odor** Violation. With respect to **Odor**, the Agency will determine whether or not a violation of Article VI, Section 6.04(C) has occurred based on its review of the information documented under Section 6.04(D), as well as any other relevant information obtained during the investigation.	No
West Virginia	45CSR4 Title 45 Series 4 §45-4-3.	Objectionable **Odor** Prohibited. 3.1. No person shall cause, suffer, allow or permit the discharge of air pollutants which cause or contribute to an objectionable **Odor** at any location occupied by the public. 3.2. The Barnebey-Cheney Scentometer or any other instrument, device, or technique designated by the Director may be used as a guide in the	No

State	Regulatory Citation	Regulation	Limit
		enforcement of the rule and may be used in the determination of the objectionability of an **Odor**. Notice of Violation. 5.1. No person shall be considered in violation of this rule unless notified that he is discharging an air pollutant or air pollutants which causes or contributes to an objectionable **Odor**.	
Wisconsin	NR 429.03	**Mal**Odorous emissions.General limitations. No person may cause, allow or permit emission into the ambient air of any substance or combination of substances in such quantities that an objectionable **Odor** is determined to result unless preventive measures satisfactory to the department are taken to abate or control such emission.(2) Objectionable **Odor** tests. An **Odor** shall be deemed objectionable when either or both of the following tests are met:(a) Upon decision resulting from investigation by the department, based upon the nature, intensity, frequency and duration of the **Odor** as well as the type of area involved and other pertinent factors.(b) Or when 60% of a random sample of persons exposed to the **Odor** in their place of residence or employment, other than employment at the **Odor** source, claim it to be objectionable and the nature, intensity, frequency and duration of the **Odor** are considered.(3) Abatement or control requirements. Abatement or control requirements may include but are not limited to:(a) Use of catalytic incinerators, after burners, scrubbers, adsorbers, absorbers or other methods approved by the department.(b) The removal and disposal of **Odorous** materials.(c) The use of methods in handling and storage of **Odorous** materials that minimize emissions.(d) The following of prescribed standards in the maintenance of premises to reduce **Odorous** emissions.(e) Use of best available control technology to reduce **Odorous** emissions.	No
Wyoming	020-2 Wyo. Code R. § 2-11 Chapter 2 Section 11	Section 11. Ambient standards for **Odor**s. (a) The ambient air standard for **Odor**s from any source shall be limited to: (i) An **Odor** emission at the property line which is undetectable at seven dilutions with **Odor** free air as determined by a scentometer as manufactured by the Barnebey-Cheney Company or any other instrument, device, or technique designated by the Division as producing equivalent results. The occurrence of **Odor**s shall be measured so that at least two measurements can be made within a period of one hour, these determinations being separated by at least 15 minutes. (b) No person shall operate or use any device, machine, equipment, or other contrivance for the reduction of animal matter unless all gases, vapors and gas entrained effluents from such facility are incinerated at a temperature of not less than 1200 degrees Fahrenheit for a period not less than 0.3 second, or processed by condensation or such manner as determined by the Division to be equally or more effective for the purpose of controlling such emissions. (i) A person incinerating or processing gases, vapors, or gas entrained effluents pursuant to this rule shall provide, properly install, and maintain in good working order and in operation, devices as specified by the Division for indicating temperature, pressure, or other operating conditions. (ii) Effective **Odor** control devices, systems, or measures shall be installed and operated such that no vent, exhaust pipe, blowoff pipe, or opening of any kind shall discharge into the outdoor air any **Odorous** matter, vapors, gases, or dusts, or any combination thereof, which create **Odor**s in areas adjacent to the plant in excess of the limits described in Chapter 2,	7 D/T

State	Regulatory Citation	Regulation	Limit
		Section 11(a)(i) of this regulation. c) **Odor** producing materials shall be stored, transported, and handled in a manner that: (i) **Odor**s produced from such materials are confined and that accumulation of such materials resulting from spillage or other escape is prevented. (d) Whenever dust, fumes, gases, mist, **Odorous** matter, vapors, or any combination thereof escape from a building used for processing animal matter in such manner and amount as to cause a violation of Subsection (a)(i) of this regulation, the Division may require that the building or buildings in which processing, handling, and storage are done be tightly closed and ventilated in such a manner that all airborne effluent materials leaving the building be treated by an effective means for removal or destruction of **Odorous** matter before release to the open air.	

Appendix B

Example Odor Complaint Form

Odor Complaint Response Form	
Facility Name & Location	
Primary Odor Contact at Facility	
Date / Time Complaint Receieved	
Complaintant Information	
Name	
Contact Number	
Email	
Location of Odor Detected	
Odor Type	
Strength of Odor (1-10 Scale | 1 = no smell, 10 = overwhelming odor)	
Odor Direction (What direction was the odor observed to be coming from)	
Was weather unusual during odor detection event?	
Odor character description	
Site Conditions & Specifics Related to Odor Complaint	
Wind Direction at time (Use MET Data)	
Barometric Pressure	
Action Taken	
Action Taken (Consult Tiered Response)	
NOTES: Person Conducting the Inspection: Date of Inspection: Time of Observation : Wind Direction (at the surveyor's location): N, NE, E, SE, S, SW, W, NW Barometric Pressure: Measured in HG as recorded at the onsite weather station Odor Intesity: (S)Strong, (M)Medium; (Sl) Slight	