Cannabis plants naturally emit terpenes, which are volatile organic compounds (VOCs), as they grow. Marijuana Infused Product (MIP) facilities also emit VOCs from solvent evaporation during extraction processes. VOCs react with oxides of nitrogen in the presence of sunlight to create ground-level ozone, a pollutant that is dangerous to human health and the environment. Controlling emissions of VOCs from cultivation and MIP facilities helps improve air quality, which is especially important in urban areas and from May to September, when ground-level ozone levels often exceed health standards.

This guide provides recommended best management practices to improve air quality impacts and reduce VOC emissions from cannabis industry operations.

**CARBON FILTRATION**

Installing control technologies can reduce the amount of VOC emissions released from cultivation and MIP processes while simultaneously controlling odors. Carbon filtration is currently the best control technology for reducing VOC emissions from cannabis cultivation and MIP facilities. Best management practices for carbon filtration include:

- Design and invest in a carbon filtration system appropriate to your facility and don’t exceed the maximum rated cubic feet-per-minute rating for air circulation through the filter.
- Choose a filter with a high VOC removal efficiency.
- Inspect and conduct regular maintenance of HVAC systems and carbon filters.
- Make sure that all operations are conducted within sealed infrastructure, and check regularly to ensure there are no leaks.
- Have a documented system in place to respond to odor complaints.
- Develop training for staff members to ensure best practices are being implemented as a part of the routine facility operating procedure.

In Denver, an odor ordinance requires that cultivation facilities control the odor impacts of their growing operations. Denver Revised Municipal Code, Chapter 4 - Air Pollution Control, Section 4-10.

**SOLVENT EXTRACTION**

Only certain solvents are permitted for use in Colorado MIP facilities: butane, propane, CO₂, ethanol, isopropanol, acetone, heptane and pentane. All but CO₂ release VOCs when they evaporate. The disposal of solvents by evaporation or spillage is prohibited. Best management practices for solvent extraction include:

- Regularly inspect all solvent storage devices and extraction system to prevent leaks.
- Be careful to prevent leaks during the transfer of solvents between containers and systems at all stages of the production processes.
- Ensure that solvent is always kept in a closed-loop extraction system or sealed container.
- Maintain an inventory of all solvents and their use over time.

Air quality regulations may apply to MIP facilities, depending on the annual amount of solvent lost to evaporation: www.colorado.gov/pacific/cdphe/greencannabis/air-quality

**BENEFITS OF VOC/ODOR CONTROL**

- Reduces community odor complaints and improves neighborhood relations.
- Improves public and environmental health by helping to reduce local ozone concentrations.
- Enhances your brand image with environmental stewardship.
- Helps to shift the cannabis industry at large toward sustainable and environmentally conscious business practices.
The cannabis industry directly impacts air quality in two predominant operations:

1. Plant growth cultivation
2. Marijuana Infused Product (MIP) facilities

At cultivation facilities, the natural growth of cannabis plants and other processes emit terpenes, which are Volatile Organic Compounds (VOCs) known for their strong odors. At MIP facilities, the evaporation of solvents and other processes in the production cycle results in Volatile Organic Compound (VOC) emissions. VOCs alone do not typically pose a direct threat to human health or the environment.

However, they do contribute to ground-level ozone by chemically reacting with other types of pollution, specifically, nitrogen oxides (NOx) in the presence of sunlight. Ozone is an air pollutant that is harmful to human health and negatively impacts the environment; therefore, it is important that the cannabis industry mitigate VOC emissions in their processes. This chapter provides recommended best management practices to improve air quality impacts and reduce VOC emissions from cannabis industry operations.

In Colorado’s Front Range, cultivation and MIP facilities are generally in dense urban areas near heavily trafficked highways and other industrial sources of NOx pollution. Because VOCs require the presence of NOx and sunlight to form harmful ozone, VOCs from these facilities have a greater impact on ozone formation than facilities in rural areas. This makes mitigating VOC emissions from the cannabis industry especially important in these regions. Fortunately, most odor control practices at cultivation and MIP facilities also substantially reduce VOC emissions. The correct operation and maintenance of odor control systems at cultivation and MIP facilities is a best management practice for reducing air quality impacts from the cannabis industry.
CULTIVATION FACILITIES

As cannabis plants grow, they release a distinctive range of odors which are made up of different types of VOCs called terpenes. Activities during the cultivation or production cycle that release significant odors also release elevated VOCs during that time. Installing control technologies can reduce the amount of VOC emissions released from the cultivation process and control odors in compliance with the Denver city and county odor ordinance. Highly reactive, ozone-forming terpenes commonly emitted from cannabis cultivation include: pinene, limonene, myrcene, and terpinolene.

CARBON FILTRATION - BEST OPTION FOR CONTROLLING ODORS AND VOCs

Carbon filtration is currently the best control technology for reducing VOC emissions from cannabis cultivation facilities. Carbon filters are simple to install, inexpensive, effective, and reliable when properly maintained and replaced. These filters work by using an absorption process where porous carbon surfaces chemically attract and trap VOCs along with other gas phase contaminants. As the filter ages, less carbon surface area is available to trap VOCs; at this point the filter will need to be replaced. Depending on the filter load, most carbon filters will last 6-12 months in a commercial cultivation environment and should be replaced according to the manufacturer’s recommendations.

Benefits:

• Improve indoor air quality by capturing airborne gas phase contaminants and odors.
• Control the odor impacts of the facility: A properly installed and maintained carbon filtration system is highly effective at controlling odors. This satisfies the requirements of the odor ordinance in Denver and improves community relations as well as business reputation.
• Control VOC emissions: a carbon filtration system will control odors and can remove VOC emissions. This improves public health and the environmental impacts of the facility.

Recommended best practices:

• Design and invest in a carbon filtration system that meets the specific needs of your facility. It is recommended that you work with an HVAC consultant with cannabis industry experience.
• Get information from the manufacturer about the effectiveness of the filter at removing VOCs and choose a filter with a high efficiency rate.
• Do not exceed the maximum rated cubic feet-per-minute rating for air circulation through the filter. If you exceed this max flow rate, the passing air will not have enough “contact time” with the carbon, and the filter will not be effective at removing VOCs.
• Regularly inspect your filter and replace the filter if it is releasing a smell near the filter effluent, or has reached its lifespan according to the manufacturer’s specifications.
• Time your filter-replacement schedule so that filters are replaced in early May, the beginning of the ozone season. This ensures that the filter is at peak performance for VOC removal during the high ozone season, resulting in the greatest public health benefits.
• Using a pre-filter can help preserve the life span of your carbon filter, because it can capture particles before they take up surface area on the filter. Pre-filters should be replaced about every 6-8 months for proper air flow.
BIOFILTERS AND CHEMICAL ODOR TECHNOLOGY

Biofilters are an emerging odor technology that could prove to be more cost effective and less resource intensive than carbon filtration once it is refined in the future.

These filters use an organic medium, such as wood chips, that are inoculated with bacteria and consume odorous molecules. Research is currently being conducted on biofilters that contain bacteria that will consume terpenes and will not harm the cannabis plants. Biofiltration is successful at treating biodegradable VOCs, but it requires a large footprint and careful operation control.

**Odor absorbing neutralizers:** use oils and liquids from plant compounds and mist them into the exhaust air at cultivation facilities to neutralize odorous VOCs. Contact your odor control supplier about the effectiveness of VOC reduction, as it will vary (20%-90%) by product and contact time.

**Masking and counteractive agents:** use chemical odor control technologies that are misted at the cultivation facility’s exhaust. The use of these agents is subject to Colorado’s air quality regulations. Higher VOCs are associated with this technology, which lead to more severe impacts of air quality and are not recommended in urban areas.

**Ozone generators:** are mostly used for sanitization purposes and have also been used in industrial settings to control strong odors. These generators are harmful to humans and can damage or destroy crops because they are a direct emission source of ozone pollution; therefore, ozone generators are not recommended as a best practice for odor control.

**Recommended best practices:**

- Regularly inspect and perform maintenance checks on your HVAC system and ducting to ensure it is operating optimally and that the airflow is properly controlled. Keep windows and doors closed in cultivation areas, and inspect the infrastructure for potential leaks.

- For greenhouses, “sealing” the grow space and circulating inside air for one week’s time is a common practice that allows the VOC concentration to build up within the greenhouse. When it is time to “purge” the greenhouse by bringing in fresh air, do this at a time when the potential for ozone formation is lowest (e.g., evenings, windy days, and cloudy days). Avoid purging air during times that have the highest risk of ozone formation (e.g., mornings, sunny and hot days, and stagnant weather).
• Make sure that the temperature and relative humidity are under control within tolerance levels of the cultivation room. High temperature and humidity will perpetuate any odor issues the facility is producing; this is especially true during the flowering phase of cultivation. Proper air circulation is critical for maintaining temperature and humidity control.

• Have a documented system in place for recording and responding to odor complaints in compliance with Denver’s Odor Ordinance.

• Purchase a “scentometer” or Nasal Ranger to be able to quantify odors and record “defensible data” from self-testing. This can be used to determine if your operation is meeting local odor regulations.

• The harvesting phase results in a higher emission of VOCs than other cultivation phases. Time the harvesting phase to minimize its ozone impact, with respect to time of day, time of year and periods with high forecasted ozone. Minimize emissions during the morning and early afternoon, and during the summer.

• Develop training and allocate responsibilities for staff members to ensure best practices are being implemented consistently and continually as a part of the routine facility operating procedure.

• Communicate and coordinate with other cannabis cultivators to learn what solutions are the most practical and effective.

MIP FACILITIES AND EXTRACTION PROCESSES

MIP facilities manufacture marijuana concentrates and infused products such as edibles, ointments, and tinctures.

These methods can be divided into two main categories: solvent and solventless extractions. Solvent extraction methods apply a chemical to remove terpenes and cannabinoids from the plant, which results in a variety of different products. Solventless extraction methods involve the use of physical methods to create concentrates.

The processing of plants where solvents are used to extract cannabis concentrates is considered a manufacturing process that is subject to state air quality regulations. The applicability of the air quality regulations will depend on the annual amount of VOC emissions quantified in tons emitted per year. It is the responsibility of the business to calculate an estimate of their VOC emissions from solvent extraction. For specific guidance on air quality requirements for MIP facilities and how to calculate emissions, visit: www.colorado.gov/cdphe/greencannabis.

The Colorado Small Business Assistance Program can also help you calculate your annual air emissions for free by calling 303-692-3175.
Regulatory Applicability

- CCR 212-1 M 605 D4 requires a professional-grade, closed-loop extraction system capable of recovering the solvent, with the exception of ethanol and isopropanol solvent-based systems (CCR 212-1 M 605 E). The disposal of VOCs by evaporation or spillage is prohibited under 5 CCR 1001-9 Regulation 7 V.A.

- CCR 212-2 R 605 A2 delineates the solvents that are permitted for use. The rule states: “A Retail Marijuana Products Manufacturing Facility may also produce Solvent-Based Retail Marijuana Concentrate using only the following solvents: butane, propane, CO₂, ethanol, isopropanol, acetone, heptane and pentane. The use of any other solvent is expressly prohibited unless and until it is approved by the Division.”

- All permitted solvents besides CO₂ are VOC-based and result in direct VOC emissions when evaporated. The law is the same for medical marijuana concentrate production and is provided in CCR 212-1 M 605 A2. This list of solvents was formulated with the health and safety of workers in mind, and using any other solvent is a violation of the law and could also lead to negative air quality impacts. CCR 212-1 M 605 D5 requires that all solvents used are food grade or at least 99% pure.

Recommended best practices:

- Regularly inspect and maintain all storage devices of solvents to prevent leaks.

- Conduct regular maintenance and inspection of the extraction system to ensure that it is functioning properly, without direct leaks of the solvent.

- Take caution to prevent leaks during the transfer of solvents between containers and systems at all stages of the production processes.
Limiting activities that emit VOCs and making sure that odor control systems are optimally operating during high ozone periods can substantially improve the air quality impacts of cannabis facilities. It is recommended that an employee committee is designated to develop and implement a BMP plan specific to the facility needs. Establishing and communicating BMPs through adequate training can help ensure that this becomes an integrated part of the routine operation in cannabis facilities. Colorado’s cannabis industry can adopt BMPs that improve their air quality impacts, bolster their reputations as stewards of the environment, and control their odor, as well as air quality emissions.

CONCLUSION

Limiting activities that emit VOCs and making sure that odor control systems are optimally operating during high ozone periods can substantially improve the air quality impacts of cannabis facilities. It is recommended that an employee committee is designated to develop and implement a BMP plan specific to the facility needs. Establishing and communicating BMPs through adequate training can help ensure that this becomes an integrated part of the routine operation in cannabis facilities. Colorado’s cannabis industry can adopt BMPs that improve their air quality impacts, bolster their reputations as stewards of the environment, and control their odor, as well as air quality emissions.

• Never dispose of a solvent through direct evaporation or spillage; ensure that the solvent is always recovered and kept in a closed-loop extraction system or designated container
• Maintain an inventory of all solvent liquids and ensure that the facility operating procedure allocates responsibility to keep an updated list.
• Develop training and allocate responsibilities for staff members to ensure best practices are being implemented consistently and continually as a part of the routine facility operating procedure