

Coffee Roasting

An Overview of Air Quality Regulations

The roasting of coffee beans is a common activity that occurs throughout Colorado at a wide variety of facilities ranging from small gourmet coffee shops to larger commercial operations. The associated coffee roasting equipment ranges from small 25 pound per hour batch roasters located at gourmet coffee shops to industrial, four ton per hour, re-circulating, continuous roasters at larger facilities. The air pollutant emissions resulting from coffee roasting operations include particulate matter (PM), volatile organic compounds (VOCs), organic acids, and natural gas combustion byproducts such as NO_x, CO, and CO₂. The odorous and visible emissions (smoke) resulting from the roasting process have the most obvious and direct impact on the public.

This fact sheet provides an overview of the coffee roasting process and the air quality requirements affecting coffee roasting operations in Colorado. The Air Pollution Control Division (APCD or the Division) at the Colorado Department of Public Health and Environment (CDPHE) administers and enforces these requirements. For more information on air quality requirements, contact the APCD at 303-692-3100 or visit the Division's website at www.cdphe.state.co.us/ap/stationarylibrary.html.

➤ *Coffee Roasting Processes and Emissions*

The roasting of coffee beans typically consists of the following processes.

A. Roasting

After screening to remove dirt and other debris, green coffee beans are transferred to feed hoppers that charge beans to the roaster. The roaster may operate on a batch or continuous basis. Roasting temperature typically ranges from 700°F to 1000°F with roasting times ranging from 5 to 20 minutes depending on the desired coffee bean color and flavor. Roasters are typically horizontal rotating drums that tumble the green coffee beans in a current of hot combustion gases; the roasters can be indirect- or direct-fired. Indirect-fired roasters are roasters in which the burner flame does not contact the coffee, although combustion gases from the burner do contact the beans. Direct-fired roasters contact the beans with the burner flame and the combustion gases.

Gaseous and particulate matter (PM) emissions occur during the roasting process. The gaseous emissions result from the breakdown of the sugars and oils present in the green coffee beans. These gaseous emissions include aldehydes (e.g., formaldehyde, acetaldehyde), organic acids, phenols, and other hydrocarbons. In addition, nitrogen oxides and carbon monoxide emissions occur as a result of the combustion of natural gas, which is typically used to fuel the roaster. Air emissions from the combustion of natural gas used to fuel the roaster are only taken into account if they exceed reporting requirements outlined in Colorado Regulation

No. 3, Part A, Section II.D.1.k. Fuel burning equipment that uses gaseous fuel is exempt from reporting under this regulation if it has a design rate (input capacity) less than or equal to five million British thermal units (BTU) per hour.

Particulate emissions are composed primarily of coffee chaff (the outer skin of the coffee cherry) that is released when the coffee beans swell during roasting. Most of the chaff released during roasting is light enough to be carried off with the roaster exhaust. The emission factors for roasting operations are listed in Table 1. The Division generally assumes that all PM is equal to PM₁₀ in particulate emissions calculations. Emissions information from the manufacturer should be utilized if available.

B. Quenching

When the beans reach the desired color, they are immediately quenched with a water spray to halt the roasting process. Due to the elevated temperature of the roaster, the water applied is emitted as steam. The primary emission from the quenching process is steam. The steam contains primarily particulate matter and may contain trace amounts of the pollutants emitted during the roasting process. Air emissions from this process are considered to be minimal.

C. Cooling

The beans are then transferred to an enclosed cooler, where ambient air is blown over and/or through the beans as they are stirred or agitated to facilitate the cooling process. In the case of small batch-type roasters, this step is carried out in an open bin (referred to as a cooler car) equipped with a rotating stirring arm and blower to facilitate the cooling process. Some chaff is emitted during the cooling process, although the majority of chaff emissions occur at the roaster. Particulate emission factors for the cooling process are listed in Table 1.

D. Destoning

The cooled beans are then transferred to a destoner, which is essentially an air classifier that separates the beans from heavier material such as stones, metal fragments, and other waste materials that were not removed during the initial cleaning process. In the case of small batch-type roasting operations, operators typically rely on the initial cleaning process and do not mechanically destone the beans after roasting. The primary pollutant emitted during the cooling and destoning processes is particulate matter as coffee chaff. The majority of chaff is composed of large flaky particles exceeding 100 microns in diameter. Cyclone collectors used to control cooling or destoning emissions typically achieve a particulate matter collection efficiency ranging from 70% to 90% by weight. Particulate emission factors for a separate, independently operated cooler and/or destoner are listed in Table 1.

E. Green Bean Handling

Green Bean handling includes unloading, pneumatic conveying, cleaning/screening, blending, and loading operations. These processes result in the emission of large particulate matter (>100 microns) that are composed of coffee chaff, dirt, fibers, and other debris associated with the green bean harvesting, packing, and shipping processes. Particulate emission factors for these processes are listed in Table 1.



F. Grinding

Roasted beans are typically pneumatically conveyed to hoppers that feed multi-stage grinders. Ground coffee and whole coffee beans are packaged into various sizes for consumer and commercial distribution. Because the particulate emissions resulting from grinding and packaging operations are not typically vented to the atmosphere, they are assumed to be negligible.

G. Decaffeination

Decaffeination is the process of extracting caffeine from green coffee beans prior to roasting. Several methods of decaffeination are used in Colorado including supercritical carbon dioxide (CO₂) extraction, water extraction, and solvent extraction using oil (extracted from roasted coffee), methylene chloride, or ethyl acetate as a solvent. Not all coffee roasting operations have decaffeination operations. Decaffeinated green coffee beans are purchased by many facilities that produce decaffeinated coffee. For facilities that have decaffeination operations, air emissions would vary depending upon the extraction process. There may be reportable emissions of VOC or hazardous air pollutants (HAPs) from a solvent extraction process. Guidance is available on calculating air emissions for VOCs and HAPs on the Division's website at www.cdphe.state.co.us/ap/stationarylibrary.html.

H. Control Equipment

Typically particulate matter emissions from the roaster, cooler, destoner, and green bean handling equipment are controlled by high-efficiency cyclones. Because the majority of particulate matter emitted is larger than 100 microns in diameter, these cyclones are very effective in capturing the particulate matter emitted. Collection efficiencies range from 70% to 90% by weight.

Catalytic or thermal oxidizers that are downstream of cyclones typically control gaseous emissions from coffee roasters. Re-circulating roasters have reduced air emissions since they redirect a portion of the roaster exhaust back through the burners, resulting in the oxidation of some of the pollutants. The Division typically uses 95% control efficiency for oxidizers.

The following table (Table 1) lists the emission factors used by the Division for coffee roasting operations.



Table 1
Emission Factors for Coffee Roasters

Source	PM (lb/ton)	VOC (lb/ton)	NOx (lb/ton)	Formaldehyde (lb/ton) ^d
Batch Roaster	4.2 ^c	0.86 ^b	0.1 ^c	0.054
Batch Roaster abated by Thermal Oxidizer	0.12 ^b	0.047 ^b	0.1 ^c	N/D ^a
Continuous Roaster	0.66 ^b	1.4 ^b	0.1 ^c	0.088
Continuous Roaster abated by Thermal Oxidizer	0.092 ^b	0.16 ^b	0.1 ^c	N/D ^a
Continuous cooler with cyclone	0.028 ^b	--	--	--
Independent Cooler/Destoner	1.4 ^e	--	--	--
Screening, handling, and storage system with fabric filter	0.059 ^b	--	--	--

^a Factor will vary depending upon destruction efficiency of abatement device. Assume destruction efficiency of 90% by weight unless otherwise specified by the manufacturer. N/D means no data is available.

^b Factor taken from EPA AP-42, Chapter 9.13, 9/95. Emission factors are based on green coffee bean feed e.g. tons per year of coffee bean feed x emission factor divided by 2000 pounds per ton = tons of pollutant emitted per year controlled or uncontrolled (depends upon the emission factor).

^c Factor taken from EPA AP-42, Chapter 6.2-1, 2/72. Other byproducts of combustion from the roasting process are not listed as emissions from these pollutants are negligible e.g., Sulfur dioxide, Carbon monoxide.

^d Factor taken from the Toxic Air Contaminant Emission Inventory, San Francisco Bay, April 1990. Emissions of the toxic compounds acrolein, acetaldehyde, and organic acids may be present in coffee roaster exhaust streams; however, the amounts of these emissions have not been substantiated enough to include in this guidance.

^e Factor taken from the Bay Area Air Quality Management District Permit Handbook, Coffee Roasting Operations, San Francisco Bay, May 15, 1998.

➤ **Air Pollutant Emission Notices (APENs)**

The form titled, "General Air Pollutant Emission Notice" is available from the Division and downloadable at: <http://www.cdphe.state.co.us/ap/downloadforms.asp>. Use the APEN form to report information about your facility, the process, fuel information, and air emissions. APENs are valid for five years. The current APEN filing fee is \$152.90 and must be submitted with the General APEN form (fees are subject to change on an annual basis). If the APEN for your



facility is more than five years old, or if your facility is operating under a new name or new ownership, it may be time to submit a new APEN to the Division.

In general, an Air Pollutant Emission Notice is required for an emission source with uncontrolled actual emissions of any criteria pollutant equal to or greater than the quantity listed in Table 2 below.

Table 2 Air Pollutant Emission Notice Reporting Thresholds (tons per year)	
Area	Uncontrolled Actual Emissions ^a
Attainment	2
Nonattainment ^b	1

^aCriteria pollutants include primarily volatile organic compounds (VOCs), Particulate Matter (PM, PM10), Carbon monoxide, Sulfur dioxide, Nitrogen oxides, and Lead. Additional criteria pollutants are listed in Colorado Regulation No. 3 Part A.

^bAt the time of this writing there are no nonattainment areas in Colorado.

The form titled, “Air Pollution Control Division Construction Permit Application” must be submitted with the General APEN form. This form provides general information about the coffee roasting company, potential start up date, and transfer of ownership information, if applicable. Only one application form is necessary for each facility. This form is also downloadable at the address listed above.

To expedite the application process, it is recommended that you submit a narrative description of the facility operations, a map of the facility indicating sources, conveyor systems, control devices, and emission stacks within the facility property lines.

➤ Air Permits

The APCD will use the information provided on your APEN to determine if you need an air permit and/or to prepare or update your air permit. Air permits will be issued for the level of production requested on the APEN form. Please consider this when completing your application and allow room for future growth. Air permit reporting thresholds for criteria pollutants are listed in Table 3. If you meet or exceed these thresholds, you will be required to obtain an air permit for that source(s) of air emissions.

If your coffee roasting operations require an air permit, the APCD will use the information provided in your APEN to determine the specific terms and conditions for your permit. In Colorado, air permits are issued in two phases: Initial Approval and Final Approval.

- An **Initial Approval** (IA) permit allows a business to construct the facility and begin operation.

- A **Final Approval** (FA) permit is issued after a business certifies that the facility is in compliance with the conditions of the Initial Approval permit. The information required to certify compliance may include, but is not limited to, opacity observations, recordkeeping, and various case-specific requirements. Information on how to self-certify compliance with an IA permit may be found at the Division’s website at <http://www.cdphe.state.co/ap/downloadforms.asp>

Table 3 Permit Reporting Thresholds (tons per year - Uncontrolled Actual Emissions)		
Criteria Pollutant	Attainment Area	Nonattainment Area ^a
Volatile Organic Compounds	5	2
PM	10	5
PM10	5	1
Nitrogen oxides	10	5

^aAt the time of this writing, there are no nonattainment areas in Colorado.

Coffee roasting operations may require a 30-day public comment period (where a public notice is published in a local newspaper and written comments from the public are requested) prior to issuance of the Initial Approval air permit due to the potential for violation of Colorado Regulation No. 2 (odor emissions) if controls are not properly operated. This determination is made during the preliminary analysis of all application materials.

More information on air emissions reporting and air permitting requirements can be found in the guidance document, “Reporting Your Air Emissions and Applying for Air Permits Step-by-Step for Colorado Small Businesses.” This document is available on the Division’s website at <http://www.cdphe.state.co.us/ap/stationarylibrary.html>

Specific air permit conditions are listed in your air permit. These conditions may include an emission limit for coffee bean production (pounds or tons per year) and annual air emission limits for specific pollutants. You should routinely compare your actual production rate and/or air pollutant emission calculations to your air permit limit(s) and maintain records as required to show compliance with these conditions. If you need to increase an air permit limit, you can do so by submitting a new APEN to the Division.

Other requirements may be listed in your air permit. You should be able to show compliance with these conditions upon request by the Division. The following are other typical permit requirements for coffee roasting operations:

- Visible emissions or opacity (smoke) from coffee roasting operations must not exceed 20% during normal operation of the source. This means that during roasting operations, a certified opacity observer can see at least 80% of the background (sky) through the



stack emissions (according to EPA Method 9). There may be other opacity provisions for start up or maintenance of roasting equipment.

- Coffee roasters are subject to the odor requirements of Regulation No. 2. Detectable odors, which can be a problem during roasting operations, are not allowed to emanate from a property and cause a potential nuisance to neighbors.
- Each roaster must be equipped with a cyclone capable of reducing uncontrolled emissions of particulate matter by at least 70%.
- Each roaster must be equipped with an afterburner capable of reducing uncontrolled emissions of VOC by at least 95%.
- Cyclones and afterburners must be operated and maintained according to the manufacturer's recommendations.
- The permit number must be marked on the subject equipment for ease of identification.

➤ **Applicable Fees**

APEN Filing Fee:

A filing fee of \$152.90 is required for each APEN.

Annual Emission Fee:

All sources required to file an APEN(s), must pay annual air emission fees. The APCD bills each source subject to an APEN an annual fee of \$22.90 per ton of criteria pollutants emitted and \$152.90 per ton of non-criteria (hazardous air pollutants) emitted. Invoices are mailed in March through June of each year. Fees are subject to change by the legislature on an annual basis.

Permitting Fee:

The air permitting fees are based on the amount of time it takes the APCD to process the application. The current processing fee is \$76.45 per hour. Fees are subject to change.

➤ **Air Inspections and Enforcement**

The APCD enforcement staff conducts routine inspections of coffee roasting operations to ensure that reported emission controls are in place and operational, and that the facility is in compliance with their air permit. The APCD also reviews annual VOC emission reports to ensure compliance with the air permit requirements. When a permit violation or noncompliance issue leads to enforcement proceedings, corrective action is required and fines up to \$15,000 per day can be assessed.

➤ ***Additional Resources and Information***

Specialty Coffee Association

www.scaa.org

Small Business Development Center (SBDC)

Assistance in Starting a Small Business

Small Business Hotline

(303) 592-5920

www.coloradosbdc.org

Occupational Health & Safety Association (OSHA) Consultation Program

(970) 491-6151

www.bernardino.colostate.edu/public

➤ ***Help is Available***

The Colorado Small Business Assistance Program (SBAP) provides free services to small businesses seeking help in understanding and complying with air, hazardous waste, and other environmental regulations. If you need assistance, please feel free to contact our program.

**Small Business Assistance Program
Colorado Department of Public Health and Environment**

Home Page: www.cdphe.state.co.us/ap/sbap.asp

Program Contact:

(303) 692-3175 or (303) 692-3148

