11.4 COOLING TOWERS

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Process Description

This permit handbook chapter describes the permitting procedures for cooling towers. A detailed description of cooling towers is provided in Chapter 13.4 Wet Cooling Towers of EPA's AP-42.

A cooling tower relies on the latent heat of water evaporation to exchange heat between the process and the air passing through the tower. In a cooling tower, warmer water is brought into direct contact with the cooler air. When the air enters the cooling tower, its moisture content is generally less than saturation. When the air exits, it emerges at a higher temperature and with moisture content at or near saturation. Even at saturation, cooling can take place since a temperature increase results in an increase in heat capacity which allows more sensible heat to be absorbed.

There are two main types of cooling towers: natural draft and mechanical draft cooling towers. A natural draft cooling tower receives its air supply from natural wind currents that results in a convection flowing up the tower. This air convection cools the water on contact. Due to the tremendous size of these towers (500 feet high, 400 foot diameter at the base) they are generally used for flow rates above 200,000 gal/min which are generally only used in utility power stations in the United States. It is generally loaded at about 2 to 4 gal/(min ft^2) or 1.4 to 2.7 L/(s m^2). Currently there are no natural draft cooling towers operating within the District.

A mechanical draft cooling tower is much more widely used. A mechanical draft cooling tower employs large fans to either force or induce a draft. This increases the contact time between the water and the air maximizing the heat transfer. A forced draft tower has the fan mounted at the base, forcing air in at the bottom and discharging air at low velocity through the top. An induced draft tower uses fans to create a draft that pulls air through the cooling tower fill. Mechanical draft cooling towers may also employ a crossflow or counterflow design. A crossflow (XF) tower is designed so that the air and water is mixed at a 90 degree angle. A counterflow (CF) design allows vertically falling water to mix with vertically rising, cooling air at an angle of 180 degrees. Generally crossflow and counterflow cooling towers have similar drift loss. A typical mechanical draft cooling tower has a loading capacity of 2 to 6 gal/(min ft^2) or 1.4 to 4.1 L/(s m^2).

Drift eliminators are often used to reduce the amount of drift in the exiting air flow. There are four main types of drift eliminators: blade-type; herringbone; waveform; and cellular or honeycomb. Blade-type and herringbone drift eliminators are usually the least efficient; waveform drift eliminators are typically moderately efficient; cellular units are the most efficient. The velocity of the airflow in the fill is typically 300 to 700 feet per minute. Drift rates are highest when the air velocity is at either end of the range. Important design considerations for drift eliminators include the air velocity and pressure drop through the eliminators, as well as provisions from reducing or eliminating droplet reentrainment and air leakage. Better drift eliminators expand the range of airflow rates that produce minimum drift rates and reduce the effect of substantially higher or lower airflow rates on the drift rate.

Completeness Determination

The following District forms should be completed and information and fees provided for coating operations. Use the Completeness Determination Checklist to verify completeness. Use the Data Form Guidance to ensure that the forms are completed correctly. Use the Fee Calculation Guidance to ensure that the fees are calculated accurately.

1. Form P101-B (one for facility).
2. Form G (one per source).
3. If Health Risk Screening is triggered, Form HRSA (one per source).
4. Fees, calculated per Regulation 3 (Schedule F).

Emission Calculations

Most of the emissions from cooling towers are a result of drift droplets, liquid water entrained in the air stream which are carried out of the tower. The amount of drift escaping the cooling tower depends on the type and model, the capacity, the velocity of the air, the temperature of the inlet and outlet flow, and the density of the air in the cooling tower. Drift loss can usually be obtained by requesting the drift loss from the manufacturer or vendor. Drift droplets can be reduced to less than 0.1 % by effectively using an eliminator. Due to safety reasons, a cooling tower is often designed, if necessary, to allow leakage to the cooling water side of the heat exchanger. These leaks within the system may result in hydrocarbon emissions.

The water transfer system, including pumps, valves, and piping is generally not subject to the fugitive emissions regulations. These components are typically exempt by definition since the system should normally contain only water containing little or no volatile organic compounds (VOCs).

Major emission constituents are organic compounds, particulate matter (PM10), salts, and any other chemicals that may either are present in the stream being cooled or that may be added to the circulating water. The visible emissions (the plume) mainly consist of water vapor. Precipitation of the plume may occur near the vicinity due to adiabatic cooling. Interaction of nearby stacks and the cooling tower plume may also occur causing changes in pH and other problems.

1. Particulate Matter < 10 microns (PM10)

The operator/owner can usually obtain the drift loss by requesting the drift loss from the manufacturer or vendor. The operator/owner should also provide the manufacturer's written documentation for the premise, basis, and justification for the drift loss that was determined. If the applicant fails to provide the drift loss, then the 0.02 % value should be used in these calculations for the drift loss value. Per the August 1993 EPA publication titled "Chromium Emissions from Industrial Process Cooling Towers - Background Information for Proposed Standards", typical drift loss rates for cooling towers range from 0.001 to 0.02 %. The drift loss of an induced draft cooling tower is typically 0.02 % (AP-42 Table 13.4-1, 1/95). The drift loss of a natural draft cooling tower is typically 0.00088 % (AP-42 Table 13.4-1, 1/95). The drift loss is a function of air velocity through the fill material, recirculation rate, type of fill material and drift eliminator used. Source testing is not normally recommended since there are no source test procedures that comply with District standards.

Typically, the operators of cooling towers have readily available the TDS content of the water due to reporting requirements of agencies responsible for regulating water quality. Typical cooling tower capacities range from 3,200 to 90,000 gallons/minute. Power plant cooling towers can be much larger than this.

Method 1: Total Dissolved Solids (TDS) of the circulating water is provided.

Information obtained from the applicant for a cooling tower (usually this is supplied by the cooling tower vendor to the applicant):

Capacity of the cooling tower, gallons/minute
Operating time
Total dissolved solids (TDS) of the circulating water, ppm by wt.
Drift loss (percentage of liquid water emitted to the air), %
Density of water = 8.34 lb/gallon

A conservatively high PM10 emission factor can be obtained by multiplying the drift loss by the TDS fraction in the circulating water and by assuming that, once the water evaporates, all remaining solid particles are within the PM10 size range.

PM10 Emissions = (capacity) x (TDS) x (drift loss) x (density of water) x (operating hours)

Method 2: Total Dissolved Solids (TDS) of the makeup water and the cycles of concentration is provided.

Information obtained from the applicant for a cooling tower (usually this is supplied by the cooling tower vendor to the applicant):
Capacity of the cooling tower, gallons/minute
Operating time
Total dissolved solids (TDS) of the make-up water, ppm by wt.
Cycles of concentration ratio
Drift loss (percentage of liquid water emitted to the air), %
Density of water = 8.34 lb/gallon

If the TDS content of the water is not available, a source-specific TDS content can be estimated by obtaining the TDS data for the make-up water and multiplying them by the cooling tower cycles of concentration. The cycles of concentration ratio is the ratio of a measured parameter for the cooling tower water to that parameter for the make-up water.

PM10 Emissions = (capacity) x (Concentration ratio) x (cooling water TDS) x (drift loss) x (density of water) x (operating hours)

Method 3: No TDS is provided and the cooling tower is an induced draft type.

Information obtained from the applicant for a cooling tower (usually this is supplied by the cooling tower vendor to the applicant):
Capacity of the cooling tower, gallons/minute
Operating time

If neither of the TDS data is available and the cooling tower is an induced draft type (SCC 3-85-001-01, 3-85-001-20, 3-85-002-01) use the arithmetic average factor of 0.019 lb PM10 per 1000 gallons of cooling water (AP-42 Table 13.4-1, 1/95) as the emission factor. This average corresponds to an effective cooling tower recirculating water TDS content of approximately 11,500 ppm for induced draft towers.

PM10 Emissions = (capacity) x (emission factor) x (operating time)
(induced draft)

2. Precursor Organic Compounds (POC)
Only cooling towers that use process water (water containing organics) will emit POCs. For those towers that do not use process water, no POC emissions will be assumed to be emitted.

Obtained from the applicant (usually this is supplied by the cooling tower vendor to the applicant)
Cooling water capacity of the cooling tower, gallons/minute
Refinery feed rate, gallons/minute
Operating time

If the cooling water rate is unknown (in gallons) assume it is 40 (AP-42, Table 5.1-2, 1/95) times the refinery feed rate (in gallons). Refinery feed rate is defined as the crude oil feed rate to the atmospheric distillation column. Unless the facility can demonstrate an more appropriate emission factor for the tower, the emission calculation shall be conducted using one of the following emission factors for either uncontrolled or controlled cooling towers [controlled means minimization of hydrocarbon leaks into the cooling water system and monitoring of cooling water for hydrocarbons]:

EPA AP-42 Fugitive Emission Factor for Uncontrolled Cooling Towers at Petroleum Refineries, Table 5.1-2, January 1995 = 6 lb/million gallon cooling water.
EPA AP-42 Emission Factor for Controlled Cooling Towers at Petroleum Refineries, Table 5.1-2, January 1995 = 0.7 lb/million gallon cooling water.

POC Emissions = (capacity) x (EF) x (operating time)
(controlled)

3. Toxic Air Contaminant Emission Estimation - cooling tower
The toxic air contaminant emissions will be dependent on the type of water treatment chemical used by the applicant for corrosion inhibition and to discourage algae growth. In many cases, bromine is used for this purpose. The maximum concentration of the water chemical treatment is typically obtained from the applicant.

Method 1: Estimate from concentration in circulating water.

Information obtained from the applicant (usually this is supplied by the cooling tower vendor to the applicant):
Capacity of the cooling tower, gallons/minute
Operating time
Maximum Bromine content of the circulating water, ppm by wt.
Drift loss (percentage of liquid water emitted to the air), %
Density of water = 8.34 lb/gallon

Bromine Emissions = (capacity) x (maximum ppm, bromine) x (drift loss) x (density of water)

Method 2: Estimate from concentration in makeup water and the cycles of concentration are provided.

Information obtained from the applicant for a cooling tower (usually this is supplied by the cooling tower vendor to the applicant):
Capacity of the cooling tower, gallons/minute
Operating time
Maximum Bromine content of the makeup water, ppm by wt.
Cycles of concentration ratio
Drift loss (percentage of liquid water emitted to the air), %
Density of water = 8.34 lb/gallon

If the TDS content of the water is not available, a source-specific TDS content can be estimated by obtaining the TDS data for the make-up water and multiplying them by the cooling tower cycles of concentration. The cycles of concentration ratio is the ratio of a measured parameter for the cooling tower water to that parameter for the make-up water.

PM10 Emissions = (capacity) x (Concentration ratio) x (cooling water TDS) x (drift loss) x (density of water) x (operating hours)

Applicable Requirements
Regulation 2, Rule 1, Section 128.4 exempts from permits "water cooling towers and water cooling ponds not used for evaporative cooling of process water, or not used for evaporative cooling of water from barometric jets or from barometric condensers." The District's policy has interpreted process water to be water that contains organics. On May 17, 2000 Regulation 2, Rule 1, Section 319 was amended to require permits for any source with an emission rate of any regulated air pollutant from the source greater than 5 tons per year, after abatement. This includes cooling towers that had been previously exempt. Along with this, Section 93103, Subchapter 7.5, Chapter 1, Part III, Titles 17 and 26, Code of California Regulations and District Regulation 11-10-301 prohibits hexavalent chromium-containing compounds from being added to the circulating water. As a result, all cooling towers are subject to Regulation 11-10; therefore the exemption in Regulation 2-1-103 is also not applicable.

A cooling tower is defined by District Regulation 11-10-201 as "any open water recirculation device that uses fans or natural draft to draw or force air to contact and cool water by evaporation." They are often referred to as evaporative or wet cooling towers. Air emissions typically result from entrainment of liquid water in the air stream which is carried out of the tower as drift droplets. Drift droplets are any water

droplets and dissolved and suspended solids they contain that are entrained in the air and emitted from the cooling tower stack. Generally the concentration of the dissolved solids in the drift is the same as that in the circulating cooling water. Drift in the exiting airflow can be reduced with various types of drift eliminators. A non-evaporative or dry cooling tower has negligible emissions because there are no drift droplets.

Although the bacterium Legionella pneumophila (the bacterium that causes Legionnaire's Disease) is not regulated by the District, it is suggested that the facility follow the guidelines and recommendations made by the Cooling Technology Institute in their February 2000 report titled "Legionellosis, Guideline: Best Practices for Control of Legionella" in order to minimize the risks associated with this bacterium. It is also suggested that the facility contact their local public health officer to obtain procedures for handling this bacterium.

Cooling towers are exempt from Regulation 8, Rule 2, per Section 8-2- 114 exempts cooling towers from Section 8-2-301 provided best modern practices are used. The permit engineer shall ensure that the cooling tower uses best modern practices in its operations.

NESHAP
Subpart Q of 40 CFR Part 63 is the National Emission Standard for Hazardous Air Pollutants for Industrial Process Cooling Towers. The requirements of this NESHAP were also implemented as Regulation 11-10. Both ban the use of hexavalent chromium chemicals in cooling towers. The permit engineer shall ensure that the cooling tower complies with these requirements.

Best Available Control Technology (BACT)
Because these types of operations are somewhat unique, BACT for Cooling Towers is currently NOT specified in the BACT/TBACT Workbook. As a result, any Cooling Tower, which triggers BACT, shall require a cost-effectiveness determination for add-on organic abatement. Inform the BACT Coordinator of updates to the BACT/TBACT Workbook.

California Environmental Quality Act (CEQA)
Permit applications which are reviewed following the specific procedures, fixed standards and objective measurements set forth in this chapter (11.9) are classified as ministerial and will accordingly be exempt from CEQA review per Regulation 2-1-311. However, if BACT1, NSPS, or NESHAP requirements, then CEQA review is also triggered because elements of discretion are required. The permit evaluator shall follow the CEQA instructions specified in the Permit Evaluation Guidance in the permit handbook.

In addition to the above-mentioned source-specific applicable requirements, other requirements may also be applicable depending on the facility, its application emissions, and its source location:

- ❑ Offsets
- ❑ Prevention of Significant Deterioration
- ❑ School Notification
- ❑ Risk Screening Analysis

Permit Conditions
Standardized conditions for cooling towers are available from the Permit Condition Guidance. Refer to the Evaluation Report Template Guidance to obtain the Microsoft Word formatted permit conditions for this source category.