Example Odour Control Report for a Brewery

**Sample Brewery Company**

**Anytown, ON**

# Introduction and Scope of Odour Control Reports

## Purpose of the Example Odour Control Report

A person engaging in an activity prescribed for the purposes of the Environmental Activity and Sector Registry (EASR) by Ontario Regulation 1/17 (Air Emission EASR regulation) is required to have available at all times an Odour Control Report (OCR) if any of the circumstances set out in paragraph 5 of Section 24 of the regulation exists at the facility. If an OCR is required, the facility must prepare a facility-specific OCR that includes all the administrative and technical requirements set out in Section 27 of the Air Emissions EASR Regulation. In order to provide appropriate guidance materials and tools for facilities tasked with preparing an OCR, a total of six example OCRs have been developed by the Ministry of Environment and Climate Change (MOECC). One OCR is available for each activity with NAICS Codes listed in Table 3 – Odour – Processes and Setback Distances of the EASR publication, and for each specific process listed in Table 4 – Odour – Processes and Setback Distances, as follows:

* Dog and Cat Food Manufacturing NAICS 311111 and Cooking or Drying Animal Products
* Sugar Manufacturing NAICS 311310
* Breweries NAICS 312120
* Spraying Operation (≥ 10 L/hr) and Printing (> 400 kg/hr ink usage)
* Wastewater Treatment – Lagoons, Uncovered Clarifiers, Sludge Management
* Food Frying

The Dog and Cat Food Manufacturing and Cooking or Drying Animal Products OCR was prepared such that it is applicable to NAICS 311111 listed in Table 3 and Cooking or Drying Animal Products, a Table 4 process. One combined OCR for Spraying Operations (Painting) and Printing was prepared. Where appropriate, the wastewater treatment OCR may be combined with the other OCRs.

The purpose of the example OCRs is to simplify the level of effort required by facilities when developing an OCR. These example OCRs contain useable information and are presented in a recommended OCR format.

Some sections in the example OCRs can be used as a draft for facilities, particularly with respect to the jurisdictional review and odour control options provided in Section 4. This information can be incorporated by facilities into their site-specific OCR. It is imperative, however, that the information be reviewed and validated as it reflects information available at the time this example OCR was prepared (January 2017). There may be advancements in control technologies or other changes to the sector or process that would need to be considered. It is the responsibility of the person preparing an OCR for a facility to ensure that the information, including the jurisdictional review and odour control options is complete.

As well, a number of sections of the OCR will require site-specific inputs and considerations, in particular, Section 2 where unique attributes at a specific facility should be detailed, Section 5 which presents the assessment of control option technical feasibility, and Section 6 which summarizes the status of current odour control measures at the facility.

These example OCRs include narrative guidance text boxes throughout for instructional purposes, as well as Appendices with further guidance materials and resources.

As the manufacturing processes may differ between facilities, this report should not be considered comprehensive for all facilities that require an OCR. A facility-specific OCR must be prepared to include all odorous sources at a facility and all different types of equipment as well as the materials being used. All reasonable effort must be made to identify odour reduction measures and procedures that are available from publicly accessible resources.

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# Statements of Certification

## Licensed Engineering Practitioner

I confirm that based on the information provided to me, the information in the report is accurate as of the date it is signed and sealed.

Signature:

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Name of Licensed Engineering Practitioner:

PEO License Number:

Date:

## Facility Representative

I confirm that all information provided to the Licensed Engineering Practitioner in order to prepare this report was complete and accurate, and I have the authority to bind the company.

Signature:

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Name of Facility Representative:

Position in the Company:

Date:

# Introduction

## Odour Control Report for a Brewery

This Odour Control Report for the Sample Brewery Company (the ‘OCR’), a facility dedicated to beer production, was prepared to comply with the odour requirements of Ontario Regulation 1/17- Activities Requiring Assessment of Air Emissions (the ‘Air Emissions EASR Regulation’) for facilities that meet the following criteria:

* The facility is required to register their activities in the EASR under the Air Emissions EASR Regulation;
* The facility has completed an odour screening report in accordance with Section 25 of the Air Emissions EASR Regulation;
* The facility is a brewery with NAICS Code 312120, and has a design capacity greater than 20 million litres per year, which is an activity set out in Table 3 of Chapter 4 of the “Environmental Activity and Sector Registry – Limits and Other Requirements” (EASR Publication) published by the Ministry of Environment and Climate Change (MOECC), and available on a government website; and,
* The distance between the facility and the closest point of odour reception is less than the distance set out opposite the process in Table 3 (Chapter 4 of the EASR publication explains what a point of odour reception is and how the distance between a point of odour reception and the facility must be measured).

A facility is required to prepare an OCR if any of the circumstances set out in paragraph 5 of Section 24 of the Air Emissions EASR Regulation exist at the facility. If an OCR is required, the facility must prepare a site-specific OCR that includes all the administrative and technical requirements set out in Section 27 of the Air Emissions EASR Regulation.

While this example OCR report pertains to industrial processes which engage in Beer Manufacturing, it can also be used to assist facilities outside of this sector that have similar sources and emissions of odour in preparing their OCRs.

A facility is required to prepare a Best Management Practices Plan for Odour (BMPP) if any of the circumstances set out in paragraph 3 of Section 24 of the Air Emissions EASR Regulation exist at the facility at the time the most recent odour screening report is prepared. BMPPs must be prepared on a facility-basis. In this example, the Sample Brewery Company must, in addition to this OCR, develop and implement a BMPP. Best Management Practices (BMPs) are practices or procedures to prevent or minimize odorous effects. These may be general in nature and applicable to a wide range of facilities, or they may be facility-specific and intended to help reduce odorous releases from process operations or activities at an individual site. These practices are most easily implemented and most effective if they are incorporated into Standard Operating Procedures (SOPs) and training programs and workers are assigned responsibility and accountability. BMPs in general would not require additional engineering or significant process modifications or the installation of pollution control equipment.

Senior management at the facility must participate in the development of the OCR, and support the Licensed Engineering Practitioner by providing comprehensive and accurate information regarding site processes, activities, and emissions. The accuracy and completeness of the information provided for the preparation of the OCR must be certified by a representative of the facility.

## Sector Description

Brewing is one of Canada’s oldest industries. The beer industry is dominated by three major multinational companies; however, the vast majority of breweries produced less than 2,000 hectolitres (hL[[1]](#footnote-1)) per year; many of these fall under the general classification of microbrewery at less than 1,800 hL per year.

There are approximately 60 breweries across Canada that produce more than 15,000 hL annually. Twelve breweries in Canada report to the NPRI in 2015, of which two are located in Ontario.

It is not a mandatory requirement of the OCRs to include a sector description. However, it is recommended that a facility demonstrates that the activities and operations carried out at their site are consistent with other facilities in their sector (Section 1.4), and to highlight the differences or aspects of operations that are unique to their operation (Section 2.6).

## Odour Control Report for Sample Brewery Co.

An OCR is required for Sample Brewery Co., a large brewery with NAICS Code 312120 that produces more than 20 ML/year; the NAICS code and production rate trigger the requirement for an OCR. The closest point of odour reception is less than 300 metres from the nearest source of odour at the facility.

Chapter 4 of the EASR publication explains what a point of odour reception is and how the distance between a point of odour reception and the facility must be measured. The required setback distance for Breweries is 500 metres as listed in Table 3 of the EASR Publication.

## Odour Control Report Content

This OCR for the Sample Brewery Co. has been prepared in accordance with the Air Emissions EASR Regulation, and therefore includes the following required elements:

* Legal name of each facility owner and name under which the owner carries on business, if different from the legal name;
* If the facility operator is not an owner of the facility, the legal name of each facility operator and name under which each operator carries on business, if different from the legal name;
* Facility address;
* A facility description and a detailed process description;
* Measures and procedures used by facilities in this sector, or at facilities with similar sources of odour or activities, to prevent or minimize the discharge of odour, including control equipment, engineering controls, process optimization, pollution prevention, or other associated measures. In many cases, these measures were intended to abate specific contaminants but have the net effect of reducing odour emissions. For example, wet particulate matter control units such as scrubbers or rotoclones could serve to control odours;
* An analysis of the technical feasibility of implementing the measures and procedures identified, or potential combinations thereof at the facility;
* For the control measures identified as technically feasible but not implemented, rationale for why the control measures are not implemented at the facility to prevent or minimize odour;
* A discussion of the adequacy of measures and procedures currently implemented and set out in the BMPP, to prevent or minimize odour effects from the facility;
* A statement by the Licensed Engineering Practitioner confirming that based on the information provided to the practitioner, the information in the report is accurate as of the date it is signed and sealed; and,
* A statement signed by the person engaging in the prescribed activity confirming that all information the person gave to the Licensed Engineering Practitioner in order to prepare the report was complete and accurate.

# Facility Description

## Site Location and Location of Points of Odour Reception

The facility is located at 100 Sample Drive, in Anytown, Ontario.

The UTM co-ordinates for the facility are:

* Zone – 17
* UTM Easting - 723000 m
* UTM Northing - 4840000 m

Sample Brewery Co. is located in an industrial area that lies adjacent to a residential development. The closest point of odour reception is a residence located 200 metres from the fenceline of the facility and 300 metres from the nearest odour source at the facility, which is less than the required setback distance of 500 metres from Table 3 of the EASR Publication. There are other residences, as well as a public sports field, within 500 metres of the facility.

## Facility Owner Legal Name and Contact Information

Legal name of the owner: Mr. Ben Malterson

Contact Information: 519-123-4567; [b.malterson@samplebreweryco.com](mailto:b.malterson@samplebreweryco.com)

## Facility Operator Legal Name and Contact Information

The facility is operated by the owner.

The Air Emissions EASR Regulation requires that the OCR sets out the legal name of each owner of the facility, and the name under which each owner carries on business, if it is not the owner’s legal name. Further, if the person who operates the facility is not an owner, the report must set out the legal name of each person who operates the facility and the name under which each operator carries on business, if it is not the operator’s legal name.

## Production Rate and Operating Hours

The facility produces up to 30 ML of beer annually.

The operating hours are typically 24 hours per day, 7 days per week. There is one week of scheduled shutdown per year.

## Facility Complaint History

The facility maintains accurate records of all complaints received and the measures taken to investigate and respond to each complaint following the process outlined in the facility BMPP. This includes complaints made to the facility directly, as well as those made to the local MOECC office. There have been no complaints received over the last 5 years.

It may be beneficial for a facility to document all complaints received and their resolution in the OCR. Some complaints may have been resolved or were the result of a process upset. Resolved complaints could lead to changes or improvements in the facility’s BMPP for odour. However, documenting complaints in an OCR is not a legal requirement.

## Unique Facility or Process Attributes

Each brewery is unique, and there are process attributes that are unique to a given facility. Brewery emissions are also affected by the brewing recipes.

At the Sample Brewery Co., the following processes, activities, or sources may be considered unique when compared to a typical large brewery:

* In-house malting is conducted;
* Ethanol recovery from waste beer is achieved via distillation as a saleable by-product; and,
* There are no outdoor stockpiles of raw materials or wastes.

Each brewery is unique and source to source variations in process, source configurations or location at the facility can significantly affect emissions and off-property impacts. The emission variations result from differences in the raw materials, the type and age of equipment used, total production, etc. All of these factors and production details need to be clearly described in the OCR.

# Process Description

## General Process Description

At the Sample Brewery Co., beer production involves the following main process stages:

* Bulk materials handling and storage;
* Malting;
* Brewhouse operations;
* Fermentation and aging;
* Filling room operations;
* Ethanol recovery by distillation;
* CO2 purification; and,
* Auxiliary services.

### Bulk Materials Handling and Storage

The bulk handling of materials includes the following:

* Storage silos for dry malt and grains, dry brewers grain, dry waste yeast feed, and other aggregates (diatomaceous earth, lime);
* Large liquid holding and storage tanks for ingredients, process intermediates, or product; and,
* Sumps and trenching to collect spillage in the brewhouse, fermentation, or filling rooms.

### Malting

Smaller breweries typically purchase malted grain (malt) from malting operations, and store dry malt in silos. Larger breweries, such as the Sample Brewery Co., conduct in-house malting. The malting process starts with steeping grain in water to soften, germination in tanks, and roasting in a kiln to halt germination and dry the malt. The malt is ground and stored in hoppers or silos.

### Brewhouse Operations

The milled malt is fed to the mash tun with hot water for mashing, which converts grain starches to a slurry of fermentable sugars called mash. The Sample Brewery Co. uses a mash infusion technique, while other breweries may use an alternate process such as decoction or double mashing. All three processes require elevated temperatures. The mash is strained in a lauter tun, which separates insoluble grain residues from the mash. Strainmasters are used in some large breweries in place of lauter tuns. The product of the lauter tun is called wort. The recovered brewer’s grain is a saleable animal feed by-product.

A brew kettle is used to boil the wort for 90 to 120 minutes, during which time hops are added. This boiling is followed by straining out of the hops and then settling out of the remaining insoluble material called trub. Trub is recovered and combined with the brewer’s grains for drying as a saleable by-product. After settling, hot wort is pumped to either a single or a two-stage cooling system, followed by yeast addition as cooled wort is pumped to the fermenters.

### Fermentation, Aging, and Secondary Fermentation

Fermentation takes place in large tanks with capacities over 1,000 barrels (117,000 L) for medium to large breweries (such as Sample Brewery Co.). The tanks are closed to the atmosphere; however, some breweries may operate with open tanks. Fermentation is a biological process in which yeast converts sugars into ethyl alcohol (ethanol), carbon dioxide (CO2), and water. The type of yeast used and the length of the fermentation process vary among breweries and types of beer. After primary fermentation, waste yeast is typically removed from the liquid by centrifuges, or other means. The liquid is pumped to low-temperature aging tanks, and a small quantity of freshly fermenting wort may be added. Viable yeast may be recovered for reuse in the fermentation process; waste yeast may be distilled to recover residual alcohol, sold to animal feed processors, or disposed of with process wastewater. After the beer is aged, centrifugation and/or filtration with diatomaceous earth filters are used to remove solids and the product is pumped to beer storage tanks and to the filling lines.

### Filling Room

Packaging facilities typically include canning, bottling, and keg filling. At Sample Brewery Co., beer may be pasteurized after canning or bottling, or sterile filling lines may be used to package non-pasteurized product. The final steps in the process are labeling, packaging for distribution, and shipping.

### CO2 Recovery and Purification

At the Sample Brewery Co., carbon dioxide that is released as a product of the fermentation is captured and directed to a recovery plant where it is purified for use later in the process to carbonate the beer, purge process tanks, and other functions. CO2 purification is achieved by water scrubbers and/or activated carbon adsorption systems to remove impurities. The scrubber water is a process wastewater, and the spent activated carbon is regenerated on-site.

### Ethanol Recovery

Ethanol may be recovered from beer that spills during packaging, from damaged cans and bottles or waste yeast recovered following fermentation. Distillation, using a combination of a stripping column and a distillation still or other configurations, may be used to separate ethanol from water and other impurities in the waste streams. The recovered ethanol may be pure enough for sale as a by-product or potentially used in the plant as a fully combustible auxiliary fuel.

### Auxiliary

The auxiliary equipment and processes are those of any large manufacturing facility, and include:

* Large combustion boilers for process heat and building heating;
* Small unit heaters, radiant heaters, make-up air units, or other HVAC;
* Quality assurance / quality control laboratory;
* Cooling systems using ammonia or other refrigerant;
* Maintenance welding and painting;
* Solid waste collection and trash compaction; and,
* General (non-process) building exhausts (office space, cafeteria, and washrooms).

## Identification of Odorous Contaminants

In this brewery the expected odorous contaminants are various Volatile Organic Compounds (VOCs) released during the fermentation process and sulphur containing compounds generally related to anaerobic decomposition of organic materials on-site as well as specific process operations.

Ethanol is the predominant VOC emitted. In addition to ethanol, there are air emissions of VOCs such as other alcohols, aldehydes, organic acids, esters, dimethylsulphide, phenolics, and others from the brewing processes, fermentation, product storage, and from waste storage and handling.

Sulphur containing compounds, including hydrogen sulphide, may be generated and emitted to atmosphere due to the anaerobic decomposition of organic materials and waste products. Some sulphides are emitting during wort boiling.

The intention of the OCR is to focus efforts on odour emissions that are associated with facilities that have these activities. The speciation of odour in the exhaust gases by specific contaminant is not required.

However, a better understanding of the nature of the odour and the expected chemical composition of odorous emissions may be useful, if available, in determining which control options have been proven effective on similar processes. For example, control options for VOC odours may not be effective or technically feasible on odours from sulphur-containing emissions. This detail also allows for discussion of the offensiveness of the odour and the identification of potential contaminants with low odour detection thresholds.

## Identification of Odour Sources and Source Groupings

Each odour source at Sample Brewery Co. has been classified as a primary odour source, secondary source, or a negligible odour source based upon the source’s odour emission rate and the relative contribution to potential off-site odour effects. For each odour source, a general description of the associated process, unit operation, equipment, or activity, expected contaminants in the exhaust gas, typical odour loadings, factors which may affect the odour loading, and potential constraints were provided, where applicable. The key parameters are presented in tabular format.

For this sector, VOC emissions are the predominant source of odours. H2S and other sulphurous compounds may also be odorous; however, these odours are very distinct from typical brewery odours.

Dispersion modelling is not a requirement of the OCR. If no previous odour assessment with dispersion modelling has been completed for the facility, other methods of assessing the relative significance of odour sources may be employed to identify odour sources.

If dispersion modelling for odour has previously been completed, the model output should be reviewed as it may be useful in assessing odour effects and classifying sources as primary, secondary, or negligible. Even if accurate emission data are not available, dispersion modelling for odour and the use of a dilution factor is an effective tool in ranking odour sources by considering the dispersion (i.e. dilution) characteristics of different sources such as tall stacks and wall mounted vents. A dilution or dispersion factor is the modelled odour strength or concentration at a receptor (OU/m³) divided by the source strength as an emission rate (odour units per second OU/s) that can be used for screening purposes to evaluate the effects of odour emissions from one individual odour source at an odour receptor.

**Estimating Odour Loading (Concentration OU/m³ and Emission Rates OU/s)**

Estimating the odour loading from sources may be done using emission factors, data from similar processes at other facilities, or source measurement. In many cases the only available emission factors are for VOCs as little data on odour loadings is publicly available and difficult to apply on a generalized basis. The odour and VOC emissions may not be directly proportional; however, these values will also assist in site-specific determination of the VOC concentration and emission rate for individual sources to allow for comparisons, ranking of sources, and discussion of the suitability of control measures.

Odour measurement at the source may be conducted on-site to determine the odour concentration and emission rate in OU/m³ and OU/s, respectively. Odour sampling methodology is published in the MOECC Source Testing Code, and odour concentrations are frequently measured using an olfactometer. An odour unit (OU) is a measure of the intensity or strength of an odour. One odour unit is the level at which half the population would detect or respond to an odour, and the odour concentration, in OU/m³, refers to the number of times the sample must be diluted to reach 1 OU.

Individual sources identified as primary or secondary sources are presented, or, where possible, sources are grouped where it is reasonable to do so. Grouping is useful when sources are associated with the same process stage, same production area, or have similar odour and exhaust characteristics. These sources may be combined and directed to individual pollution control equipment or dealt with as an aggregate.

### Primary Sources of Odour

The primary odour sources from the Sample Brewery Co. were identified based upon a previous odour survey conducted to rank the sources by potential for off-site effects. The previous odour survey is up to date and reflects current operations.

The following are considered to be the major odour sources from the Sample Brewery Co.:

* Brew Kettle for Wort Boiling – Intermittent odorous emissions affected by a number of operating conditions, including wort temperature, time, temperature of the heat transfer fluid or water used for condensing vapours, pressure setting of relief valves, production scheduling, and time taken to empty wort from brew kettle;
* Fermentation Vessels – Continuous, low concentration and low emission rates of CO2/ethanol vapours, affected by factors such as temperature, strain of yeast, and ability of the CO2 recovery system to capture the VOCs by carbon absorption;
* Brewer’s or Distillers Grain, Trub, and Brewer’s Yeast Dryers – Continuous odour emissions from VOCs affected by drying temperature and the amount of air recirculation; and,
* Activated Carbon Regeneration – Low volumes of high concentration odours released intermittently. The desorption temperature and flow rate are the main parameters that would affect the release of odorous VOCs during the regeneration cycle.

These sources are described in Table 1A.

Wastewater collection, handling, treatment, and discharge, may potentially be a significant source of odour at breweries. Due to the complexity of wastewater treatment and odour control measures, a separate sample Wastewater OCR has been developed to provide guidance with systems operated to achieve the requirements of municipalities for liquid discharge to the sanitary sewers or the requirements for direct discharge that would likely involve advanced treatment systems.

The example OCR for industrial wastewater handling and treatment should be reviewed if applicable as it pertains to the potential to generate odours from wastewater processes. If wastewater is identified as a source of odours, the overall OCR for the facility should include both the sector specific and wastewater aspects.

### Secondary Sources of Odour

The secondary odour sources are presented in Table 1B and have the potential to contribute to odour effects, but not to the same extent as those deemed primary sources of odour.

The secondary sources of odour at the Sample Brewery Co. include:

* Malt Kiln;
* Brewhouse – Includes the Holding Kettle, Mash Tun and Lauter Tun, Cereal Cooker/Mash Cooker, Hot Wort Settling Tank, Wort Cooler and Hot Trub Vessel;
* Fermentation Support Activities – Yeast Propagation, Aging Tanks (Secondary Fermentation), Chip Washers, Filter and Centrifuge;
* Filling and Storage – Filling Lines; Can or Bottle Crusher; Waste Beer Recovery and Beer Sump, Beer Storage Tanks; and,
* Spent grain, trub, and yeast handling and storage.

### Sources Not Considered Odorous

The following air emissions sources are not considered as significant odour sources at most breweries, including the Sample Brewery Co.:

* Handling and storage of dry grains;
* Boilers;
* HVAC equipment (comfort heating and cooling);
* Chillers and refrigeration equipment;
* Parts washers;
* Product label gluing;
* Laser / ink printing;
* Cafeteria exhausts and other employee comfort areas; and,
* Office Areas.

All potentially odorous sources have been included in the BMPP for the facility.

All potentially odorous sources should be included in the BMPP for the facility, if applicable. For Sample Brewery Co., the product label gluing was included in their BMPP to ensure proper management of glues and glue residues. There is no odour associated with the other insignificant sources.

**Table 1A - Odour Source Identification Table for Sample Brewery Co. (Primary Odour Sources)**

| **Source Description** | **Odorous Contaminants** | **Odour Loading** | **Exhaust**  **Characteristics** | **Flow Rate** | **Continuous or Intermittent Discharge** | **Current Odour Control Measures** |
| --- | --- | --- | --- | --- | --- | --- |
| Brew Kettle | VOCs  H2S | High | Dedicated Vertical Stack | Low | Intermittent | Condenser |
| Fermentation Vessels | VOCs  (90% ethanol) | High | Dedicated Vertical Stack | Low | Continuous | Capture and CO2 Recovery |
| Brewer’s Grain, Trub and Yeast Dryers | VOCs | High | Dedicated Vertical Stack | High | Continuous | Thermal oxidizer |
| Activated Carbon Regeneration (CO2purification circuit) | VOCs | High | Dedicated Vertical Stack | Low | Intermittent | Vertical stack  Process Controls  BMPs |

**Table 1B - Odour Source Identification Table for Sample Brewery Co. (Secondary Odour Sources)**

| **Source Description** | **Odorous Contaminants** | **Odour Loading** | **Exhaust**  **Characteristics** | **Flow Rate** | **Continuous or Intermittent Discharge** | **Current Odour Control Measures** |
| --- | --- | --- | --- | --- | --- | --- |
| Malt Kiln | VOC | Low | Vertical Stack | High | Continuous | BMPP |
| Brewhouse Sources | VOC | Moderate | Passive Vents  Pressure Relief Valves | Low | Intermittent | BMPP |
| Fermentation Sources | VOC | Moderate | Vertical Stacks  Horizontal Exhausts  Passive Vents | Low | Continuous | BMPP |
| Filling and Storage | VOC | Moderate | Vertical Stack  General Exhausts | Moderate | Continuous | BMPP |
| Brewer’s grain, trub, and yeast handling and storage | VOC | Low / Moderate | Outdoor Silo Bin Vent  Fugitive Emissions | Low | Intermittent | BMPP |

**Site-specific Source Description**

General indicators of the odour loading, stack parameters, and exhaust gas flow rate are provided in Tables 1A and 1B. Facilities should ensure that all available source and stack data, available through their Emission Summary and Dispersion Modelling (ESDM) report, is used to describe the odour sources as accurately as possible

# Sector Odour Control Measures

This section of the OCR is provided as a summary of general industry practices and BMPs for breweries that are considered when dealing with uncontrolled or problematic odour sources, where appropriate.

In Ontario, the need to implement odour control measures depends upon many factors, including the presence of odour receptors, a history of odour complaints, or siting in an area with multiple industrial sources. In the absence of off-site odour impacts, there is typically no reason for additional control equipment, engineering controls, or abatement measures specific to odour.

A review of publicly available information was completed to identify what measures and procedures are in use to control air emissions. Sources included Environmental Compliance Approvals (ECAs) for Ontario facilities, European Union BAT reference documents (BREFs) and associated guidance materials, US EPA Title V Permits and Reasonably Available Control Technology (RACT) Analysis documents, among others. In many cases, the control measures were implemented to reduce total VOC discharges, which had the added benefit of reducing odour emissions. A review of measures that can be used on similar sources was also completed to identify any that are potentially transferrable.

The odour control measures identified in this section have been demonstrated to be effective at breweries. Current practices for odour controls range from the implementation of BMPs for smaller processes to control equipment on all odorous sources at larger operations or those that have closer odour receptors.

A review of a number of facilities or organizations within Ontario, the US, the EU, and Australia was conducted to identify what measures, if any, have been implemented.

## Current Practices at Breweries

The odour control measures and procedures identified are currently in use at processes similar to each odour source or source grouping identified at Sample Brewery Co. and are presented in Table 3 for the primary sources and Table 4 for the secondary sources.

### Ontario

Information on three facilities in Ontario with MOECC ECAs was available through the MOECC Access Environment database of historical and current approvals. No data is available concerning the total number of breweries with MOECC approval in Ontario. The publicly available data was reviewed, and the following was found:

* One facility operates a closed loop carbon dioxide recovery system complete with one scrubber and two activated carbon beds during indirect steam and hot air regeneration and an evaporative condenser. The facility operates at a maximum production rate of up to 3.5 million hectolitres per year**.** This facility is located in an urban setting in a mix of industrial and commercial properties with the closest odour receptor at approximately 180 metres from the odour sources.
* One facility operates a Mini Brewery at a maximum production rate of up to 2.5 million litres per year, consisting of grain milling, brewing and fermentation with all processing and support activities. However the environmental permit does not provide details on the emission control or discharge parameters. This facility is located in a mixed use area with industrial and residential land uses. The nearest odour receptor is approximately 200 metres from the property line.
* One facility operates two carbon dioxide exhaust systems with independent stacks, a spray scrubber with stainless steel mist eliminator to control the emissions from the wort kettles, two additional spray scrubbers, each equipped with stainless steel mist eliminators to control emission for each of the brew kettles and independent stack exhausts for the facility with a production rate of up to 7.5 million hectolitres per year**.** This facility is located in a highly industrial urban location with the nearest odour receptor more than 2 kilometres from the property line.
* One facility operating with a production limit of 429,000 litres per week and has an odour abatement and heat recycling unit for the brewhouse which incinerates the odours in the kettle combustion chamber. Details of CO2 recovery are not available for this facility. This facility is located in a rural-commercial setting with the nearest odour receptors less than 100 metres from its operations.

Sample Brewery Co. is considered to be a relatively large production facility. Though production data for other facilities is limited, it can be inferred that the more stringent emission controls in Ontario and other jurisdictions are a result of either significantly larger scale operations or where site-specific issues have warranted more extensive controls. However, facilities developing an OCR should consider all relevant controls for facilities of various sizes and specific locations.

### Other provinces

There are several other large breweries in Canada; however, no publicly available guidance, regulatory requirements, odour emission inventories or permits for these facilities were available that provide details on emissions sources or odour control measures.

### United States

It is important to note that “odour” is not a regulated emission in the US. The following discussions consider controls required for volatile organic emissions (VOCs). Some of these control systems and requirements will also reduce odour emissions.

In the US, Title V operating permits are federally mandated for major stationary sources of air pollution with actual or potential emissions at or above the major source threshold for specified air pollutants defined by regulation (the major source threshold list can be found at the [Air Toxics Web Site](https://www3.epa.gov/airtoxics/pollsour.html)). The permitting is administered by state or district agencies. A limited number of smaller sources also require Title V permitting.

In addition to the requirement for operating permits, New Source Review (NSR) is a Clean Air Act program that requires industrial facilities to install modern pollution control equipment when they are built or when making a change that increases emissions significantly. The NSR permitting varies depending upon the attainment status of the district in which the facility is located. For major sources, Best Available Control Technology (BACT) would be required in attainment areas under the Prevention of Significant Deterioration program, Lowest Achievable Emission Rate (LAER) in non-attainment areas, there are no specified controls for minor sources or minor modifications to major sources. No documentation is available for facilities that do not trigger Title V permit or NSR requirements.

Information on five large facilities with major sources in five US states was available from their Title V permitting posted on state environmental agency websites. The list demonstrates the range of potential control measures that have been installed to control either boiler emissions or particulate matter and are therefore not specific to odour control. It should be noted that all five have some form of pollution control equipment installed but none are identified as odour controls. It is not intended to suggest that control measures are required on any or all brewery sources identified. The list is based on available data for breweries. It is not known if all facilities have appropriate permits, meet operational criteria or if the state from which they operate provide public access to permitting documentation. The data reviewed indicated that:

* One facility has a flare, three carbon dioxide regeneration systems, and a scrubber system.
* One facility has multiple condensers, a carbon dioxide adsorption system, caustic scrubbers, and a flare for control of production emissions listed on their Title V permit. A biofilter has been installed to treat air emission sources from wastewater treatment. The exhaust from the biofilters is directed to carbon filters for polishing prior to release to the atmosphere.
* One facility has the following processes listed in its permit as “equipment that does not have unit specific limitations at the time of permit issuance” therefore details on abatement or control measures are not provided: brew kettles, wort kettles, mash cookers, lauter tuns, pasteurizers and packaging. There is a carbon dioxide regeneration system specified in the permit.
* One facility has a Tile V permit as it has the potential to emit VOCs at a rate exceeding the threshold of 50 tons per year for a major source. As such, there are conditions requiring documentation of technological or economic reasons to use process specific reasonably available control technology (RACT) demonstrations for sources of VOCs which are acceptable to the State and have been submitted to the EPA for approval. The RACT documents could not be found on publicly accessible search platforms and the permit does not provide specific details.
* One facility has a distillation and condenser capture system, a carbon dioxide recovery system and a bio-energy recovery system with a flare identified in its Title V permit. It is located in an attainment area for VOCs, SO2 and NOx. Insignificant emissions are assigned to the mash cooker, wort straining, waste beer sumps, brew kettles, wort receivers, fermenters and storage tanks in general.

The information on control measures provided in the publicly accessible Title V permits from state or district environmental agencies are for facilities identified as major sources. Small and medium sized facilities are unlikely to reach the release-based thresholds that would trigger requirement of a Title V permit. The odour control measures required, if any, depend upon production levels at the facility. Caution should be used when comparing controls from large facilities as the control measures identified may not be appropriate for smaller facilities.

### European Union

The Best Available Techniques (BAT) for European food, drink, and milk industries (FDM) are published in a Best Reference Document on Best Available Techniques (BREF). The BAT conclusions are presented in two tiers. The first tier lists BAT for common activities and processes in the FDM sector, and the second tier includes additional BAT for some specific activities or processes within the FDM (BREF, 2006).

There is one BAT specific to breweries; the capture and condensing of vapours from wort boiling with heat recovery.

In addition to the BAT for the wort boiling, abatement techniques are described that target VOC odours including absorption, biological treatment, thermal treatment, non-thermal plasma, and condensation. The BREF document does not provide specific guidance on where these other specific abatement techniques would be appropriate or effective for brewing.

The general FDM BAT also include a number of broader environmental management techniques, not specific to beer brewing, such as the implementation of an Environmental Management System (EMS) and the prevention of accidental releases. Application of an air emissions control strategy that combines process optimization, BMPs and the use of abatement techniques is also BAT for the FDM Sector.

### Australia and New Zealand

Environment Australia publishes guidance materials for the purpose of supporting emission estimation for the federal reporting program. The document states that air emission control technologies, such as dispersion, scrubbing, incineration, adsorption on to a solid, and biofiltration are commonly considered on point sources from process industries in general. This guidance does not provide details of air emissions control technologies commonly installed at breweries.

The individual Australian territories have also published technical handbooks to guide the management of odours; however, there are no specifics on control measures or abatement techniques that are appropriate or applicable to brewing. The installation of control equipment, increasing of stack heights, or other measures to reduce odour effects is determined on a case-by-case basis that depends on whether a source is new, modified, or existing, and the proximity of nearby residents (odour receptors).

There was no facility-specific information available on emission or odour controls for breweries.

### Additional Control Measures Suitable for Brewing Activity

In addition to the most common approaches to controlling odours at breweries, other alternative control measures that may be effective but are not as widely used have been identified in Table 2.

**Table 2 – Potential Alternative Odour Control Measures for Sample Brewery Co.**

| **Control Measure** | **Applicability and Limitations** |
| --- | --- |
| Thermal Treatment | Recuperative, regenerative or catalytic oxidizers may be feasible, and some waste heat may be recovered. With direct-fired thermal oxidation, exhaust gas may be directed to a boiler, dryer burner or to a flare. |
| Adsorption | Activated carbon or other sorbent material may be used to remove VOCs and other odorous compounds from waste gas. Fluidized or packed bed designs available. Activated carbon filters can control odours from outdoor silo bin vent outlets. |
| Biofilter | Process exhausts are directed to a conditioning system and biofilter where microorganisms biologically degrade the organic compounds. |
| Oxidation Scrubbers | Wet scrubbers use an oxidizing agent such as hydrogen peroxide, bleach, or others, as the scrubbing solution. |
| Ozonation | Concentrated ozone injected into waste gas stream to oxidize VOCs. |
| Non-Thermal Plasma | Activated oxygen injected into waste gas stream to oxidize VOCs. |
| Process Optimization:  Decreased temperature of condenser heat-transfer liquid | Increase VOC removal efficiency by decreasing temperature of cooling water used in condenser or using an alternate, lower temperature refrigerant. |
| Process Optimization:  Production Scheduling | Scheduling of process stages or activities/production runs to avoid simultaneous odour releases from multiple sources. |
| Process Optimization:  Enhance Automation | Reduce leaks, spills, manual transfers and other potential sources of odour. |

## Control Measures for Primary Sources at Sample Brewery Co.

The primary sources of odour for the Sample Brewery Co. are the wort boiling, fermentation processes, and the drying of brewer’s grain, trub, and yeast, and the thermal regeneration of the activated carbon used for CO2 recovery and purification. These sources are typically controlled with specific control equipment or technologies combined with BMPs and process optimization to minimize odorous emissions.

Table 3 provides the methodology, equipment and techniques implemented at other facilities to control the odours from these primary sources.

The control measures considered include the following:

* Installation of control equipment;
* Process optimization;
* Stack or discharge optimization;
* Engineering controls (odour capture, combined exhausts, recirculation, as examples);
* Pollution prevention; and,
* BMPs.

Where appropriate, measures from other industrial sectors are considered if the technology or measure may be transferrable to this sector.

Even though odour control measures are designed for specific applications, not all implementations are successful.  This section of the OCR is provided as guidance on general industry practices for the sector. It is possible that some measures may not be effective at odour control due to site-specific process or exhaust conditions. The selection of odour control measures requires engineering, and possibly pilot testing, to ensure odour reduction is achieved.

The measures presented in Tables 3 and 4 are examples that reflected the information available at the time the sample OCR was prepared. It is the responsibility of the facility to ensure that the odour control measures presented in the OCR are reviewed and updated as needed to reflect current information on control measures and best practices.

Further information on the control equipment is provided as an Appendix to this example OCR.

The measures presented have been demonstrated as reasonable and effective to prevent or minimize the discharge of odour, and will be carried forward to assess technical feasibility at the Sample Brewery Co.

**Table 3 –Potential Odour Control Measures for Sample Brewery Co. Primary Sources**

| **Odour Source** | **Control Measure** | **Applicability** |
| --- | --- | --- |
| All Primary Sources | Stack Optimization | Effective stack design will improve dispersion to reduce off-site effects with vertical, unimpeded discharge at optimal stack height and velocity, as well as potentially combining individual exhausts to common tall stacks. |
| Fermentation Vessels  Carbon Regeneration | Engineering Controls:  Emission Capture | Improved emission capture from specific processes or operations to reduce the fugitive emissions and increase capture for further control measures. Unit specific ventilation capture would reduce the need to treat larger volumes of building ventilation exhausts. |
| Brew Kettle | Condenser with Heat Recovery | Condensation of vapour phase VOCs and collection of liquid phase stream. Efficiency may be increased by using colder heat transfer liquids. |
| Brew Kettle  Fermentation Vessels | Wet Scrubber | Wet scrubbing condenses VOCs in warm exhaust gas. VOC solubility in water may be limited, but scrubber acts as a condenser.  The use of a wet scrubber on the fermentation exhausts may allow recovery of CO2 for reuse or sale. |
| All Primary Sources | Thermal treatment | Thermal oxidation is highly effective at removing odorous VOCs. Odorous exhaust flow may be flared, directed to the site boiler or dryer combustion chamber for incineration, or to a thermal oxidizer. |
| All Primary Sources | Carbon Adsorption | Activated carbon effective on low VOC concentration, unsaturated exhaust streams.  Activated carbon scrubbing of the fermentation exhaust generates can purify the CO2 for reuse or sale. |
| All Primary Sources | Oxidation Scrubber | Wet scrubbers that use an oxidizing agent such as hydrogen peroxide, bleach, or others, as the scrubbing solution. |
| All Primary Sources | Biofilter | Process exhausts are directed to a conditioning system and biofilter where microorganisms biologically degrade the organic compounds. |
| All Primary Sources | Ozonation | Concentrated ozone injected into exhaust gases to oxidize VOCs. |
| All Primary Sources | Non-Thermal Plasma (NTP) | Activated plasmas gas is injected into waste gas stream to oxidize VOCs. |
| All Primary Sources | Process Optimization:  Brewing Process Conditions | Optimizing time, temperature, and pressure of batch while adhering to the beer recipe.  Specific to brewing, cooler temperatures in fermenters will reduce the ethanol volatilization, and the yeast strain used may have an effect on odour emissions.  The temperature of the recovery cycle for the activated carbon used for CO2 recovery may affect the odour emission rate, odour concentration, and off-site odour effects. |
| All Primary Sources | Process Optimization:  Scheduling | Scheduling of process stages or activities/production runs to avoid simultaneous odour releases from multiple sources beyond what is described in the current BMPP.  Specific to the brewery, carbon regeneration can be avoided weather conditions that are unfavourable for good air dispersion. |
| All Primary Sources | Process Optimization:  Enhanced Automation | Use of tank volume monitoring, transfer flow monitoring in conjunction with automated shut-off to avoid overfills or spills. Reduced ingredient/product wastage and less potential for human error results in potential of reduced fugitive odour emission sources. |
| All Primary Sources | Best Management Practices | Develop SOPs and train employees on BMPs for process and control equipment maintenance and operation, good housekeeping, spill prevention and response, reducing chemical and cleaner usage, and managing wastes beyond what is described in the current BMPP. |

## 4.3 Control Measures for Secondary Sources at Sample Brewery Co.

There are a number of secondary sources identified at Sample Brewery Co. The odour sources or source groups and the associated control measures, as well as potential alternative control measures, are provided in Table 4.

**Table 4 – Potential Odour Control Measures for Sample Brewery Co. Secondary Sources**

| **Odour Source** | **Control Measure** | **Applicability** |
| --- | --- | --- |
| All Secondary Sources | Stack Optimization | Effective stack design will improve dispersion to reduce off-site effects with vertical, unimpeded discharge at optimal stack height and velocity, as well as potentially combining individual exhausts to common tall stacks. |
| All Secondary Sources | Engineering Controls:  Emission Capture and Containment | Improved emission capture to reduce the fugitive emissions and increase capture for control measures.  Sources associated with fermentation process, beer filling, and storage may be captured and directed to CO2 Recovery System.  The use of covered conveyors for spent grain, trub, and yeast handling may reduce fugitive odour emissions and may allow for collection and treatment of odours.  A closed-loop silo filling system may prevent odour emissions from dry spent grain and yeast storage.  Closed tanks with pressure relief valves or double-acting air vent valves may be preferable to open, passive vents. |
| All Secondary Sources | Wet Scrubber or Condenser | Wet scrubbing condenses VOCs in warm exhaust gas. VOC solubility in water may be limited, but scrubber acts as a condenser.  The use of a wet scrubber may allow recovery of CO2 for reuse or sale.  A condenser would achieve similar VOC control as a wet scrubber. |
| All Secondary Sources | Thermal Treatment | Thermal oxidation is highly effective at removing odorous VOCs. Odorous exhaust flow may be flared, directed to the site boiler or dryer combustion chamber for incineration, or to a thermal oxidizer.  It may be possible to retrofitting the malt kiln to recirculate air and direct a portion to the kiln burner for incineration. |
| All Secondary Sources | Carbon Adsorption | Activated carbon effective on low VOC concentration unsaturated exhaust streams. Activated carbon scrubbing of the fermentation exhaust generates purified CO2 for reuse or sale. |
| All Secondary Sources | Oxidation Scrubber | Wet scrubbers that use an oxidizing agent such as hydrogen peroxide, bleach, or others, as the scrubbing solution. |
| All Secondary Sources | Biofilter | Process exhausts are directed to a conditioning system and biofilter where microorganisms biologically degrade the organic compounds. |
| All Secondary Sources | Ozonation | Concentrated ozone injected into exhaust gases to oxidize VOCs. |
| All Secondary Sources | Non-Thermal Plasma (NTP) | Activated plasmas gas is injected into waste gas stream to oxidize VOCs. |
| All Secondary Sources | Process Optimization:  Maintaining cool temperatures in process units, filling area, and storage tanks | Low temperatures reduce volatilization of ethanol and other VOCs.  The temperature of malting may be optimized to reduce odour emissions while maintaining the quality of the malted product. |
| All Secondary Sources | Process Optimization:  Scheduling | Scheduling of process stages or activities/production runs to avoid simultaneous odour releases from multiple sources beyond what is described in the current BMPP.  Specific to the brewery, carbon regeneration can be avoided weather conditions that are unfavourable for good air dispersion. |
| All Secondary Sources | Process Optimization:  Enhanced Automation | Use of tank volume monitoring, transfer flow monitoring in conjunction with automated shut-off to avoid overfills or spills. Reduced ingredient/product wastage and less potential for human error results in potential of reduced fugitive odour emission sources. |
| All Secondary Sources | Best Management Practices | Develop SOPs and train employees on BMPs for process and control equipment maintenance and operation, good housekeeping, spill prevention and response, reducing chemical and cleaner usage, and managing wastes beyond what is described in the current BMPP.  Minimizing quantities of waste beer, spent grains and yeast on-site, and storage in such a manner that prevents fermentation and spoilage helps prevent odour emissions. |

# Feasibility Assessment

The control measures identified in Section 4 have been shown to be effective in preventing or reducing odour effects at breweries with similar sources and/or other similar operations/processes. There are, however, site-specific limitations that would affect the ability of the facility to implement particular measures or procedures.

The results of the facility technical evaluation for the feasibility of implementation of the potential measures and procedures are summarized below in the form of a table (Table 5). Those justified as not technically feasible are not considered further in the OCR. Those measures deemed technically feasible are discussed in Section 6 (Discussion of Feasible Measures and Procedures). It should be noted that most of the technically feasible control measures described in Table 5 may be used in combination to achieve greater odour reduction. An example of this is the use of both control equipment and stack optimization. In general, any BMPP, process optimization, engineering control or stack optimization can be used in combination. In some cases, combinations of control equipment may also be feasible (e.g. using a carbon filter as a polishing step in combination with another type of control equipment). However, multiple end-of-pipe control equipment is uncommon for these types of sources.

It is a requirement of the Air Emissions EASR Regulation to provide an analysis of the odour control measures and procedures, and potential combinations of them, to determine which would be technically feasible to implement at the facility in order to prevent or minimize the discharge of odour. Table 5 summarizes the individual control measures and the findings of the feasibility assessment for Sample Brewery Co. The feasibility assessment must consider potential combinations of the control measures identified.

The technical feasibility of a control measure is a factor of the effectiveness of the mitigation, safety considerations, physical implementation as well as consideration of the impact of the other processes at the facility that could be detrimentally impacted. Although a control measure could be implemented on one specific odour source, the treatment could generate a new waste stream that contains a difficult substance to handle or cause a synergistic effect that results in a new odour source associated with a solid or liquid carrier.

The Sample Brewery Co. has previously implemented a significant number of control measures at its operations. Combinations of stack optimization, BMPPs, process optimizations and engineering controls are utilized throughout the operations.

The ability to isolate an odour source and direct the exhaust gases to an optimized stack, process optimization, and/or the implementation of BMPs for odour are the preferred approaches for odour control for the Sample Brewery Co. Where possible, maintaining a negative pressure in a specific process area will allow for isolation of an odour source that can be discharged from an optimized stack or, if need be, controlled; this will help to prevent or minimize poorly dispersing fugitive odour releases.

It may be possible and beneficial to combine exhaust streams to one common exhaust; however, this must be evaluated as there are potential synergistic effects (e.g. back pressure on some ventilation areas, increased flows causing increased pressure drop through the system that cannot be handled by the fan and stack design). If there is no net negative impact to the operations resulting from the combining of individual sources to one common stack, this may allow for the design of one unimpeded vertical discharge at an optimized height and exhaust velocity to enhance odour dispersion, or the installation of control equipment on one combined source.

Non-thermal plasma and ozonation are both energy intensive, and considered to be emerging technology and there is limited documentation on demonstrated control efficiency or applicability on VOC and odour destruction for breweries. There are limitations to both of these technologies as the control medium must come into direct contact with the odorous substance or contaminant to complete the reaction. If there is moisture or particulate matter in the air flow to be treated, the odorous compounds may not have the contact residence time or sufficient exposure to the ozone to completely react. The majority of sources have high moisture content so additional pre-treatment systems would be necessary.

The use of caustic solutions in an oxidizing scrubber would generate a new liquid waste stream that must be treated as an additional wastewater; however, the oxidizing agents make this wastewater incompatible with the current system that incorporates recirculation of water within the process to avoid losses of saleable by-products such as spend grains, trub, and yeast. The oxidizers are also hazardous to the yeasts used in beer fermentation. Oxidation scrubbers using caustic require the balance of oxidation chemicals and can result in the emission of odours if not maintained properly.

**Technical Feasibility Assessment**

The feasibility assessment requires an analysis of the measures and procedures identified, as well as potential combinations thereof. This assessment should be undertaken in conjunction with facility management to determine which would be technically feasible to implement. This discussion would take process or site-specific constraints into account. Technical feasibility can consider commercial viability of the control for the specific source, experience and use in the industry or for similar sources, other environmental considerations (wastewater impacts), availability of materials (e.g. if natural gas is not available, RTOs are not technically feasible), and site-specific considerations (e.g. space).

**Economic Feasibility**

The intention of the OCR is to establish technical feasibility of odour control measures and procedures. The discussion of economic feasibility is important; however, a complete economic assessment is not required as part of the OCR.

The MOECC provides guidance on undertaking an economic feasibility study in the “Guide to Requesting a Site-Specific Standard, Version 2.0”. The US EPA also provides site-specific guidance for consideration of economic hardship and cost-effectiveness of pollution abatement in the Economic Impact Analysis and Industry Profiles by Sector Resource Documents published by the US EPA Office of Air Quality Planning and Standards (2016). These references can be used as a basis for developing an economic feasibility assessment, if needed.

**Table 5 – Summary of Feasibility Assessment for Sample Brewery Co.**

| **Odour Source** | **Description of Control Measure** | **Technically Feasible?** | **Notes** |
| --- | --- | --- | --- |
| All Primary and Secondary Sources | Stack Optimization | Technically Feasible –  previously implemented | The stacks associated with the primary sources all have vertical, unimpeded discharge. Further improvements to these stacks, and those associated with other sources, would be evaluated should additional measures be needed to control off-site odour impacts. |
| All Primary and Secondary Sources | Engineering Controls:  Emission Capture and Containment | Technically Feasible –  previously implemented on some sources | The facility will review the system with the objective of identifying opportunities for improved odour capture to prevent fugitive odour emissions through general building ventilation, such as:   * Capture of additional odours from fermentation and other sources for CO2 Recovery System. * The use of covered conveyors and closed-loop silo filling for spent grain, trub, and yeast handling and storage. * Replacement of open, passive vents with pressure relief valves or double-acting air vent valves. |
| Brew Kettle | Condenser with Heat Recovery | Technically Feasible –  previously implemented | The facility will review the brew kettle condenser operation to determine whether it is possible to operate with lower temperature heat transfer fluid. |
| All Primary and Secondary Sources | Wet Scrubber | Technically Feasible | The use of a wet scrubber to control odours from other sources will be evaluated should additional measures be needed. |
| All Primary and Secondary Sources | Thermal Treatment | Technically Feasible –  previously implemented on Brewer’s Grain and Yeast Dryers | Sample Brewery Co. will evaluate the potential of directing other odour emissions to the thermal oxidizer associated with the dryers.  It may be possible to retrofitting the malt kiln to recirculate air and direct a portion to the kiln burner for incineration. |
| All Primary and Secondary Sources | Carbon Adsorption | Technically Feasible –  previously implemented on fermentation vessels | The use of carbon adsorption control on other sources will be evaluated should additional odour control measures be needed.  Activated carbon scrubbing of the fermentation exhaust generates purified CO2 for reuse or sale.  The use of carbon filter cloths over low-flow or passive vents to reduce VOC contaminants is not feasible due to exposure to precipitation, freeze/thaw cycles, and winds. |
| All Primary and Secondary Sources | Oxidation Scrubber | Technically Not Feasible | The use of a wet scrubber with an oxidizing agent in the scrubbing solution would generate a wastewater stream that is incompatible with the current wastewater collection system that incorporates recirculation of water within the process to avoid losses of saleable by-products such as spend grains, trub, and yeast. The oxidizers are also hazardous to the yeasts used in beer fermentation. |
| All Primary and Secondary Sources | Biofilter | Technically Feasible | The installation of a biofilter will be evaluated should additional odour control measures be needed, with consideration given to smaller biofilter designs as the available space is insufficient for a traditional biofilter. |
| All Primary and Secondary Sources | Ozonation | Technically Not Feasible | Ozonation is an emerging technology and there is limited documentation on demonstrated control efficiency or applicability on VOC and odour destruction. |
| All Primary and Secondary Sources | Non-Thermal Plasma (NTP) | Technically Not Feasible | NTP is an emerging technology and there is limited documentation on demonstrated control efficiency or applicability on VOC and odour destruction. It is also not suitable for exhaust gases with high moisture content. |
| All Primary and Secondary Sources | Process Optimization:  Brewing process conditions | Technically Feasible –  previously implemented | The facility will review the process with the objective of identifying additional opportunities for optimization and odour reduction, such as:   * Optimizing time, temperature, and pressure of batch while adhering to the beer recipe. * Cooler temperatures in fermenters will reduce the ethanol volatilization. * The yeast strain used may have an effect on odour emissions. * The temperature of the recovery cycle for the activated carbon used for CO2 recovery may affect the odour emission rate, odour concentration, and off-site odour effects. |
| All Secondary Sources | Process Optimization:  Maintaining cool temperatures in process units, filling area, and storage tanks | Technically Feasible –  previously installed on beer storage tanks | A cooling system has been installed to decrease the odour emissions associated with beer at warmer temperatures and the associated increase in off-gassing.  Sample Brewery Co. will evaluate temperature reductions in other strategic production areas and process units, such as the waste beer collection system, should additional odour control measures be needed. |
| All Primary and Secondary Sources | Process Optimization:  Scheduling | Technically Feasible –  previously implemented | The BMPP for odour and the site operations plan detail the strategic scheduling of activities to avoid simultaneous releases from multiple odorous sources, where possible.  Should it be deemed necessary, carbon regeneration could be scheduled to avoid weather conditions that are unfavourable for good air dispersion. This is not part of the current BMPP. |
| All Primary and Secondary Sources | Process Optimization:  Enhanced Automation | Technically Feasible –  previously implemented | Automated controls and monitoring have been installed on a number of the process units. Should additional odour control measures be needed, the system would be reviewed to identify opportunities for added or improved automation. |
| All Primary and Secondary Sources | Best Management Practices | Technically Feasible –  previously implemented | SOPs have been developed and employees trained in BMPs for process and control equipment maintenance and operation, good housekeeping, spill prevention and response, reducing chemical and cleaner usage, and managing wastes.  Of specific note, the scheduling of spent grains and yeast shipments for livestock feed will be reviewed to minimize on-site storage requirements beyond what is described in the current BMPP. |

Many of the technically feasible control measures described in Table 5 may be used in combination to achieve greater odour reduction. An example of this is the use of both control equipment and stack optimization. In some cases, combinations of control equipment may also be feasible.

# Adequacy of Current Odour Control Measures and BMPP

This section of the OCR provides the rationale for why the technically feasible measures identified are required or not necessary at this time, to adequately prevent or minimize the discharge of odour from the facility.

The Sample Brewery Co.’s Best Management Practices Plan (BMPP) for Odours was prepared in 2010, and most recently updated in 2017 to be compliant with the Air Emissions EASR. The odour BMPP was signed, dated and sealed by Ms. J. Engineer on Feb 2, 2017 (PEO License 1234-9999). The BMPP documents all feasible measures that have been implemented to prevent or minimize odours from process stages, activities, or material storage. In addition to BMPs, control measures that are in place to mitigate odours are detailed in the BMPP.

In 2010, a site-wide odour assessment was prepared as part of an ECA application process. This assessment identified, quantified, and ranked all odorous sources for the potential to cause an off-site odour effect. It was determined that with the control measures and BMPs there were no appreciable odour effects off-site based upon the existing operations, control measures, and the effective implementation of the BMPP.

Sample Brewery Co. implemented a Good Neighbour Policy in 2005, which includes measures to prevent off-site odour effects. There have been no odour complaints in the past 5 years that were directly related to the operation of the facility under normal operational conditions and site parameters. Any excursions in normal operations (e.g. spills, emergency situations) or specific operational issues that were successfully addressed with an odour strategy (i.e. BMPP updates) and/or control technology within the last 5 years were not considered.

In the absence of odour complaints, and based upon quarterly odour surveys conducted in the residential areas and at other odour receptors (adjacent sports fields), additional measures to control odours are not warranted at this time since the following key measures are already in place and are considered to be effective:

* For each of the primary sources identified, Sample Brewery Co. has previously implemented at least one of the technically feasible control measures described in Section 4. The CO2 recovery is done with a carbon filter system, which allows not only the capture of the CO2 for reuse in the process, but also captures the odour compounds which significantly reduces the overall site odour emissions;
* Sample Brewery Co. previously implemented enhanced handling practices of the waste beer by installing a closed loop system and chilling the liquid. This reduced the fugitive emissions associated with the off-spec beer by maintaining containment as it is conveyed from the multiple collection points to the storage tanks and the chilling reduces off-gassing; and,
* For the secondary sources, the prevention of fugitive emissions and the implementation of a BMPP are effective in preventing off-site odour effects. The low flow rates, low to moderate odour concentrations, and in some cases the intermittent nature of the releases do not warrant additional control measures.

The intention of odour management and control is to prevent or minimize odour effects at odour receptors off-site. The absence of off-site odour effects, supported by five years without an odour complaint, demonstrates that the current odour control measures and BMPs are effective.

**Historical Odour Management**

A facility’s success with BMPP, good community relations, and no complaint history, or a history where the facility responds quickly and mitigates the situation with respect to odours, can be considered a reasonable rationale for not implementing additional odour control measures.

It is recommended that the facility contact the MOECC District Office to confirm that no odour complaints have been registered, and incorporate any feedback provided into this section of the OCR.

However when a facility is facing on-going challenges with its surrounding community, there are upset conditions that result in complaints and the BMPP is not meeting expectations, the facility needs to consider implementing other options. An initial review should be done of the site operations to identify the major odour source(s) and evaluate the current BMPs and/or control actions being taken. Consideration of alternative BMP-BAT-BREF actions as well as re-evaluating current activities can assist in identifying the root cause of the odour issue. If the revised BMP does not mitigate the odour situation, further consideration of control optimization, technologies and equipment should be completed.

* 1. **Control Measures or Procedures to be Evaluated for Implementation**

At this time, there are no additional emission controls or procedures that are scheduled to be implemented. However, the facility has committed to assessing the feasibility of the technically feasible control measures should odour complaints be received in the future that are the result of the brewing activities.

Should the facility determine that an odour source is developing into a potential off-site issue, the BMPs would be reviewed to determine whether additional BMPs may be incorporated into the facility’s SOP policy with appropriate employee training, monitoring, maintenance and reporting. Control technologies to manage the odour source issues would also be evaluated should further complaints be encountered and BATs, BMPs, optimization, controls and SOP are not successful.

This site also has several control technologies in operation for specific production equipment and/or emission streams. It would be beneficial to utilize the existing control technology by connecting more of the uncontrolled odour sources.

The next phase of evaluations would include the BMPs, Process Optimization, Engineering Controls, and then control technologies to manage the odour source issues.

Table 6 provides control measures that will be evaluated for implementation at the Sample Brewery Co. should odour emissions become an issue for the operations and facility.

This section presents the control measures that were found to be technically feasible and could be further considered by Sample Brewery Co. should additional odour control measures be needed in the future. Table 6 also presents those measures that are under consideration to be implemented, even though there have been no odour complaints.

**Table 6 –Control Measures or Procedures to be Evaluated for Implementation**

| **Odour Source** | **Control Measure** | **Applicability** |
| --- | --- | --- |
| All Primary and Secondary Sources | Stack Optimization | Further improvements to the stacks associated with other sources would be evaluated, including extending the current main stack. |
| All Primary and Secondary Sources | Engineering Controls:  Emission Capture and Containment | The facility will review the system with the objective of identifying opportunities for improved odour capture to prevent fugitive odour emissions, such as:   * Capture of additional odours from fermentation and other sources for CO2 Recovery System. * The use of covered conveyors and closed-loop silo filling for spent grain, trub, and yeast handling and storage. * Replacement of open, passive vents with pressure relief valves or double-acting air vent valves. |
| All Primary and Secondary Sources | Wet Scrubber | The use of a wet scrubber to control odours from other sources will be evaluated. |
| All Primary and Secondary Sources | Thermal Treatment | Sample Brewery Co. will evaluate the potential of directing other odour emissions to the thermal oxidizer associated with the dryers.  It may be possible to retrofitting the malt kiln to recirculate air and direct a portion to the kiln burner for incineration.  Installation of a new thermal treatment unit would also be considered. |
| All Primary and Secondary Sources | Carbon Adsorption | The use of carbon adsorption control on other sources will be evaluated should additional odour control measures be needed. |
| All Primary and Secondary Sources | Biofilter | The installation of an engineered biofilter will be evaluated should additional odour control measures be needed, with consideration given to smaller biofilter designs as the available space is insufficient for a traditional biofilter. |
| All Primary and Secondary Sources | Process Optimization:  Scheduling | Carbon regeneration may be scheduled to avoid weather conditions that are unfavourable for good air dispersion. |
| All Primary and Secondary Sources | Process Optimization:  Brewing process conditions | The facility will review the process with the objective of identifying additional opportunities for optimization and odour reduction, such as:   * Optimizing time, temperature, and pressure of batch while adhering to the beer recipe. * Cooler temperatures in fermenters will reduce the ethanol volatilization. * The yeast strain used may have an effect on odour emissions.   The temperature of the recovery cycle for the activated carbon used for CO2 recovery may affect the odour emission rate, odour concentration, and off-site odour effects. |
| All Secondary Sources | Process Optimization:  Maintaining cool temperatures in process units, filling area, and storage tanks | Temperature reductions in other strategic production areas and process units, such as the waste beer collection system to further reduce odour emissions. |
| All Primary and Secondary Sources | Process Optimization:  Enhanced Automation | Facility automated controls and monitoring systems would be reviewed to identify opportunities for improvements. |
| All Primary and Secondary Sources | Best Management Practices | The BMPP is already reviewed on a routine and scheduled basis to ensure it is effective. Modifying the schedule for spent grains and yeast shipments for livestock feed will be reviewed to minimize on-site storage requirements. |

# Appendix A – Supplemental Guidance for Developing a Facility‑Specific OCR

**A.1 Identification of Odour Sources and Source Groupings**

Once a complete inventory of air emissions sources has been prepared, it is necessary to identify which of these sources should be classified as primary odour sources, secondary or minor sources, and negligible odour sources based upon their relative contribution to potential odour effects. This can be done in a number of ways, and often involves some level of judgment based upon process knowledge and experience.

It must be emphasized that the identification of odorous air emissions sources is very specific to each facility. What may be a potentially odorous source at one facility may not have any potential for odour at another. As an example within the brewing industry, the operation of a jacketed kettle with pressure relief valve is an odour source if it is used for wort boiling, but may not be odorous if it is used for boiling other liquids in other industries.

For each odour source, a general description of the associated process, unit operation, equipment or activity, expected contaminants in the exhaust gas, typical odour loadings, factors which may affect the odour loading, and potential constraints should be identified, where available. These details are necessary in order to properly assess any potential control or BMP for its technical feasibility. An odour source summary table is an effective way to summarize the odorous emission sources for further assessment, and will be useful should odour dispersion modelling be required.

Published emission factors are useful in quantifying odour loadings from common sources; however, when evaluating site potential emissions or impacts, these factors should be used by someone with technical experience. In many cases the only available emission factors are for VOCs as little data on odour loadings is publicly available. The odour and VOC emissions may not be directly proportional; however, these values will also assist in site-specific determination of the VOC concentration and emission rate for individual sources to allow for comparisons, ranking of sources, and discussion of the suitability of control measures.

Site-specific details of why the facility is unique or different from other breweries should be provided in order to help in identifying sources and determining their relative contribution to facility odour classifying sources.

The location and characteristics of the discharge point must also be considered when determining which sources are major sources of odour at the facility, which are minor, and which are negligible.

The odour source inventory is another tool to consider sources that may become odorous under upset or unexpected conditions; however, these situations are more commonly addressed by BMPs. For example, the discharge from a scrubber may not be odorous when the scrubber is operating effectively; however, scrubber malfunction, insufficient liquid flow rate or insufficient makeup rate may result in odorous discharges.

It may be effective to group sources for the purposes of the OCR if they are associated with the same process stage, same production area, and have similar odour and exhaust characteristics. These sources may be combined and directed to individual control equipment or dealt with as an aggregate.

Wastewater collection, handling, treatment, and discharge, may potentially be a significant source of odour. An example OCR has been prepared that is specific to industrial wastewater, and if applicable, this OCR should be reviewed.

## A.2 Quantifying Odour Loadings and Odour Source Ranking

There are a number of reference documents that may provide expected odour emissions, emission factors for odour or VOCs, or other data that may reasonably be used to describe sources at the facility.

* VOC emission factors are published by the US EPA in Section 9.12.1 Malt Beverages. The raw data published in the background document (Table A-1) may, however, be more useful in discussions of relative odour releases;
* The Australian Emission Estimation Technique guidance also provides a few useful factors for process stages (Table A-2); and
* Select emission factors have also been published by the European Union in the European Monitoring and Evaluation Programme / European Environment Agency (EMEP/EEA) Air Pollutant Emission Inventory Guidebook (Table A-3).

**A.3 Identifying Primary or Secondary Odour Sources**

In order to classify the sources as primary or secondary, it would be helpful to rank the sources in terms of their potential to cause off-site odour impacts and prioritize accordingly. The ranking could be done on the basis of potential odour emissions (strength of odour), offensiveness of odour, frequency of occurrence and source configuration. The source ranking may be supported by screening level dispersion modelling for each significant source to determine the amount of dilution (i.e. dispersion) for each source. For example a tall stack source would provide much greater odour dilution at off-site locations than a horizontal exhaust at the property boundary.

**A.4 Sources Not Considered Odorous**

There are a number of sources at facilities that are not identified as odour sources for the purposes of the OCR. These sources either:

* Do not emit odorous contaminants, such as heating and cooling equipment and process boilers; or,
* Discharge of odours that are not of the same characteristic that is generally attributed to the sector and have no appreciable off-site impacts.

Examples of such sources may include trash compaction, cafeteria exhausts, parts washers, product label gluing, laser / ink printing, or ammonia leaks from refrigeration equipment.

**A.5 Indoor Fugitive Emissions**

BMPs are generally more appropriate for the prevention or mitigation of odours from general building exhausts and indoor fugitive sources. At specific facilities, BMPs may prove inadequate for some sources, and the installation of capture hoods or fume collection may be necessary. Once the odours are captured, they may then be directed to control equipment, or other measures may be implemented to reduce the potential off-site odour effects.

**A.6 Excess Emissions Due to an Upset or Abnormal Condition**

An upset or abnormal condition may arise due to sudden and reasonably unforeseeable events beyond the control of the facility. These situations require immediate corrective action to restore normal operation. The identification of all possible odour sources during upset or emergency conditions is beyond the scope of the OCR. It is expected that the facility will include the preventive maintenance, accident prevention, spill containment, and effective response to upset conditions in the BMPP.

**A.7 Control Measures and Procedures**

**Pollution Control Equipment**

Often referred to as end-of-pipe or add-on controls, exhaust gases are directed to pollution control equipment to capture or destroy the odorous contaminants. Equipment that captures the contaminants often results in the generation of a new waste stream that could be either solid, liquid, or gas that may still be odorous. An example of a gaseous waste stream is air discharged during the regeneration cycle of an activated carbon bed or tower. These activities may also reduce odours or change the character of the odours making them less intense or offensive.

Destruction of VOCs in the waste stream may be achieved by thermal oxidation, catalytic oxidation, chemical oxidation, or other chemical reaction. This type of pollution control unit may result in the permanent removal of airborne contaminants that are odorous.

**Engineering Controls or Process Changes for Pollution Prevention**

Although there may be some redundancy between these measures and those outlined as BMPs in the facility BMPP, the measures detailed here are differentiated from BMPs as they require actual modifications or engineering changes. In contrast, BMPs are by definition, practices or procedures would not require additional engineering or significant process modifications, or the installation of additional control equipment.

The following are examples of measures that have been shown effective in odour mitigation:

* Optimized stack design to improve dispersion;
* Process or building fugitive odour capture to prevent fugitive odours from roof exhausts or building doors, windows, louvers, or vents;
* Process optimization and control, including adjustments to pressure and temperature on pressure vessels, monitoring aeration of waste stream or improving aeration/agitation, or others; and,
* Reducing cooling water temperature of condensers to improve odour control efficiency.

**Masking Agents or Odour Modification**

Although the applicability to this sector may be limited, there are chemical additives, masking agents, deodorants, and odour neutralizers that may be employed to either theoretically reduce the odour loading or alter the nature of the odour to change its character or hedonic tone.

Masking agents, also called deodorizers, contain perfumes to superimpose a pleasant odour upon an unpleasant one. Although this approach can be considered an alternative for managing odour complaints, it should be considered on a site-specific case and potentially bench tested as it has been found in some cases that the deodorant or making agent may itself become an odour nuisance or the impact on odour receptors has not changed.

Neutralizers differ from masking agents as they are able to react with the odour molecules and are generally dispersed as a fine aerosol into the odorous gas.

**Best Management Practices**

BMPs are practices or procedures that in this context are intended to prevent or minimize odorous effects. These may be general in nature and applicable to a wide range of facilities, or they may be facility-specific and intended to help reduce odorous releases from process operations or activities at an individual site.

The facility is required to prepare a BMPP which will outline operational practices and other measures that will be carried out in order to reduce odour emissions or odour effects.

The intention of the OCR is to identify process controls, engineering controls, or add-on control measures. Specific BMPs for the odorous sources identified should be presented if they are currently implemented at similar facilities or recommended in applicable Codes of Practice.

# Appendix B – Control Equipment Factsheets

Appendix B provides general information on the control measures identified in this example OCR. Details such as whether the control measure is considered to be in the developmental stage, where it may be applicable, and what limitations may exist, are given. Facilities may also consider contacting equipment suppliers for further information to determine whether a particular control measure may be technically feasible at their site.

This information is provided in order to show what information may be considered when assessing the feasibility of a control measure.

Including this level of detail on potentially feasible control measures is not a requirement of the OCR and is provided as reference material only.

## B.1 Thermal Treatment

### B1.1 Technologies

* Flaring
* Thermal Incineration in Boiler or other combustion unit
* Regenerative Thermal Oxidizer (RTO)
* Recuperative Thermal Oxidizer
* Catalytic Oxidation

### B1.2 Emission Characteristics

* Gaseous Pollutants (Odour, VOCs)

### B1.3 Air Emission Sources

Common Applications:

* Petroleum and Coal Products
* Lumber
* Printing
* Food Processing
* Surface Coating
* Paint Manufacturing

### B1.4 Description

Thermal treatment uses high temperatures to oxidize VOCs, as well as some particulate matter. The conventional type of thermal oxidizers have a direct flame in contact with the airflow. RTOs use ceramic packed beds to preheat and partially oxidize VOCs prior to incineration to increase efficiency, and catalytic oxidizers use a catalyst material rather than ceramic in the packed beds. Recuperative units incorporate a heat exchanger to recover heat for the purpose of preheating the incoming air.

### B1.5 Applicability and Performance

A properly designed and operated thermal oxidizer or flare can achieve a destruction efficiency of 95-100%, with most achieving more than 99% VOC control. Thermal oxidation is generally used for the treatment of low gas flowrates, with notable cost increases associated with heating greater volumetric flowrates. It may be suitable for malodorous streams with variable contaminant concentrations and some variability in flowrate. Some form of heat recovery is nearly always warranted to reduce operating costs and fuel consumption. Flaring may be appropriate if gas flowrate fluctuates significantly. A concentrator may be used prior to an RTO or other oxidizer for large air flows of low VOC concentration to minimize supplemental fuel requirements.

It may be possible to direct malodorous gases to an existing on-site boiler for thermal treatment, particularly if the volume of waste gas is notably less than the combustion air requirements.

### B1.6 Limitations

Supplemental fuel may be needed if the heating value of the gas is insufficient to sustain the incinerator temperature, and may be significant if the exhaust gas stream is variable or VOC concentrations are low. Water vapour present in the airstream may quench the flame, resulting in poor combustion. For safety reasons, organics present in the waste gas must be well below the respective lower explosive limit (LEL); if the organic concentration is above the relevant explosive limits, a flameless type of system may be appropriate. Pre‑treatment for particulate material removal may be required. By-products, including NOx, SO2, GHGs, acid gases and other pollutants may be generated depending upon the composition of the waste gas to be treated. When halogenated VOCs are present, the potential for dioxins formation exists.

### B1.7 References

European Commission. 2006. Integrated Pollution Prevention and Control Reference Document on Best Available Techniques in the Food, Drink and Milk Industries (EU BREF) Section 4.4.3.11 Thermal Treatment of Waste Gases

US EPA. Air Pollution Control Technology Fact Sheets: Flares EPA-452/F-03-019, Thermal Incinerators EPA-452/F-03-022, and Catalytic Incinerators EPA-452/F-03-018.

## B.2 Condensers

### B2.1 Technologies

* Heat recovery unit, refrigerated condenser, water-cooled condenser

### B2.2 Emission Characteristics

* Condensers are most effective on hot exhaust gases with high VOCs concentrations, or water soluble compounds.

### B2.3 Air Emission Sources

Common Applications:

* Petroleum refining and petrochemical manufacturing
* Food manufacturing and cooking
* Breweries
* Pharmaceutical manufacturing
* Fish processing
* Chemical / Solvent manufacturing and use.

### B2.4 Description

Condensation is the process of converting a gas or vapour to a liquid and is achieved by heat transfer. This technology is frequently utilized for heat recovery from very hot processes.

### B2.5 Applicability and Performance

Condensers are simple and relatively inexpensive and typically use water or air as the heat transfer fluid, although refrigerants may be used to achieve lower temperatures to improve removal efficiency or target VOCs with lower vapour pressures.

Condensers are frequently used as a pre-treatment upstream of adsorbers, absorbers, or incinerators to reduce the loading to the control equipment and often to recover solvents or organics that may be reused.

### B2.6 Limitations

A liquid waste stream is generated. Control is limited for VOCs with high vapour pressures. Condensers may be prone to fouling if there is particulate matter in the exhaust gas stream.

### B2.7 References

Air & Waste Management Association. 1992. Air Pollution Engineering Manual.

European Commission. 2006. Integrated Pollution Prevention and Control Reference Document on Best Available Techniques in the Food, Drink and Milk Industries (EU BREF) Section 4.4.3.5 Dynamic Separation Techniques.

## B.3 Absorption

### B3.1 Technologies

* Wet Scrubbers (packed bed absorber, plate absorber, and spray scrubber)

### B3.2 Emission Characteristics

* Wet scrubbers are most effective on exhaust gases with high concentrations of VOCs or water soluble compounds, and to a lesser degree particulate matter.

### B3.3 Air Emission Sources

Common Applications:

* Food manufacturing and cooking
* Mineral processing
* Fertilizer plants
* Asphalt plants

### B3.4 Description

The process involves a mass transfer between a soluble gas and a liquid solvent such as water. The addition of an oxidizing agent to the scrubbing solution may increase odour removal efficiency by reacting with the odorous compounds. Sodium hypochlorite, hydrogen peroxide, ozone, potassium permanganate, acids, and caustics are frequently used as the scrubbing medium.

### B3.5 Applicability and Performance

Primarily used for inorganic fumes and gases, VOCs, and particulate matter. The control efficiency for VOCs varies depending upon the type of scrubber, and a range of 70 to 90% control is expected. Wet scrubbers have relatively low capital and operating costs compared with other treatment technologies, as well as relatively small space requirements. Absorption units can handle gases with high temperature and high moisture contents.

### B3.6 Limitations

The requirements for the scrubber outlet concentrations affect the scrubber design (liquid flowrate, scrubber dimensions), and may result in unreasonably tall towers or long liquid-gas contact times and excessive liquid volumes. A liquid waste stream is generated. Spray chambers are not generally suitable for odour or VOC control.

### B3.7 References

Air & Waste Management Association. 1992. Air Pollution Engineering Manual.

European Commission. 2006. Integrated Pollution Prevention and Control Reference

Document on Best Available Techniques in the Food, Drink and Milk Industries (EU BREF) Section 4.4.3.8 Absorption.

US EPA. Air Pollution Control Technology Fact Sheets: Packed Bed / Packed Tower Wet Scrubber EPA-452/F-03-015, Spray Tower Wet Scrubber EPA-452/F-03-016.

## B.4 Biofiltration

### B4.1 Technologies

* Biological Treatment (beds, trickling filters, bioreactors)

### B4.2 Emission Characteristics

* Gaseous air pollutants (odour, VOCs, H2S) of consistent air flow rate and limited fluctuation in loading.

### B4.3 Air Emission Sources

Common Applications:

* Meat and Fish
* Coffee processing
* WWTP
* Beer yeast drying
* Oil mills
* Cocoa production
* Pump stations
* Animal feed production
* Organic processing

### B4.4 Description

The most common type of biological treatment is the biofilter where pollutants are absorbed onto a filter and degraded by microorganisms living on the filter media.

There are a variety of biofilter styles: in-ground, in-vessel, open-bed, or up-flow systems.

The filter medium may be a blend of wood chips, compost, bark nuggets or inert materials designed to maintain porosity with high surface area to provide good contact between the contaminants and the biologically active micro-organisms.

### B4.5 Applicability and Performance

Properly designed and maintained biofilters can remove most organic contaminants, H2S and reduced sulfur compounds but can produce a slight residual “earthy” odour. An operational and balanced biofilter can achieve relatively high odour removal efficiency at relatively low operating cost compared with other treatment techniques, with odour removal efficiencies greater than 90% reported. The operation and efficiency of a bioreactor is affected by temperature, pH, moisture, gas composition and pollutant concentration, macronutrient feeding, residence time, compacted bed media, and gas channeling. A biofilter may be designed to treat a wide range of air flowrates that ensure appropriate residence time, typically 20 to 40 seconds. Moisture may be added to the gas by pre-humidification.

### B4.6 Limitations

* Particulate matter and oils may need to be removed upstream of the filter to avoid clogging that may result in a large pressure drop and reduction in operational efficiency.
* Significant fluctuations in contaminant concentrations may be problematic.
* Biofilters generally have large space requirements compared to other control technologies.
* There may be a significant energy demand, particularly if preheating or humidification is required.
* Channeling through the biofilter may result in reduced control efficiency.
* Biofilters require temperature regulation, as temperatures over 40 °C may be problematic as the micro-organisms may become sterilised and the filter bed would require re-seeding, and biological degradation decreases notably below 10 °C.
* The pH of the filter material must be maintained, typically between 6.5 and 7.5, which may require alkali addition.
* A typical lifetime of an organic based filter bed is 3 to 5 years for most filter materials.

### B4.7 References

European Commission. 2006. Integrated Pollution Prevention and Control Reference Document on Best Available Techniques in the Food, Drink and Milk Industries (EU BREF) Section 4.4.3.10.1 Biofilter.

Water Environment Research Foundation WERF. 2007. Minimization of Odours and Corrosion in Collection Systems, Section 8.5 Biofilters.

US EPA. 2003. Using Bioreactors to Control Air Pollution EPA-456/R-03-003.

## B.5 Carbon Adsorption

### B5.1 Technologies

* Packed beds, fluidized beds, filter cartridges

### B5.2 Emission Characteristics

* Gaseous Pollutants (Odour, VOCs, H2S)

### B5.3 Air Emission Sources

Common Applications:

* Paint Spraying
* Printing
* Plastic film coating
* Dry cleaning
* Degreasing
* Pharmaceuticals
* Wastewater treatment
* Food manufacturing
* Asphalt processing
* Chemical manufacturing
* Transfer systems

### B5.4 Description

Adsorption is a unit process involving the capture of substances (primarily VOCs), from relatively low concentrations in air/water streams, onto a fine particulate active surface, with resins and activated carbon being the most common materials used. The adsorbed material is physically contained within the filter. Once saturated, the physical content of the filter will require regeneration. Reactivating the carbon requires the substances to be desorbed and this can be done by heat or vacuum. Generally, the maintenance of most carbon adsorption systems are done by a third-party or would require an additional control system to capture, contain and dispose of the absorbed substances. Carbon adsorbers are used for the cleaning of ventilated air and the treatment of malodourous process emissions.

### B5.5 Applicability and Performance

Carbon adsorption is suitable for a range of air flow rates and temperatures; however, high moisture content will significantly impact the maintenance requirements of the carbon. The control of VOC emissions and typically associated odours by carbon adsorption can achieve removal efficiencies of 80 – 99 %.

### B5.6 Limitations

Carbon adsorption is not considered applicable where dust or condensable material is present as it can seriously interfere with the efficiency of a carbon bed and will increase the operating pressure drop. It is also not applicable at a temperature above 40 °C due to the risk of fire. The efficiency of activated carbon is reduced at a relative humidity above 75 % as the moisture will be adsorbed as well as the contaminants, except for water soluble compounds such as the lower amines and hydrogen sulphide. This preferential absorbance of water can lead to condensation within the bed, thus making the carbon inactive.

The components for a carbon adsorption system consists of the filter or filter column and the fan or blower system. On-site regeneration is not normally economical, so the carbon is typically replaced when its adsorption efficiency begins to decrease, but prior to breakthrough. In addition to capital costs, operating and maintenance costs are notable due to requirement to recharge carbon and the energy requirements.

### B5.7 References

European Commission. 2007. Integrated Pollution Prevention and Control Reference Document on Best Available Techniques on Surface Treatment using Organic Solvents (EU STS BREF) Section 20.11.6.1 Adsorption Using Activated Carbon or Zeolites.

US EPA. 1999. CATC Technical Bulletin: Choosing an Adsorption System, EPA-456/F-99-004.

## B.6 Non-Thermal Plasma (NTP)

### B6.1 Technologies

* Corona or Photocatalytic Reactors

### B6.2 Emission Characteristics

* Cold plasma reactors and photocatalytic reactors are considered an emerging technology. There is limited performance data available, and the economics of the processes are unknown at this time.

### B6.3 Air Emission Sources

Common Applications:

* Food and Drink Manufacturing
* Extruders
* Dryers
* Coolers
* Hammer mills

### B6.4 Description

Non-thermal plasma treatment is an odour abatement technique that plasma to create a highly reactive treatment zone that the waste gas passes through. The plasma contains a collection of ions, electrons, charge-neutral gas molecules and other species in varying degrees of excitation. These radicals in the NTP react with the pollutants in the malodorous air stream, producing less malodorous compounds. The most active radicals in this process are nitrogen, oxygen, and hydroxyl based compounds which originate from nitrogen, oxygen and water in the waste gas. Industrial treatment systems are based on electrical discharge, where high voltages (up to 40 kV) are used to create NTP.

### B6.5 Applicability and Performance

The technique has been proven to reduce the odour emissions by 75 – 96%, with higher control efficiencies for VOCs. This technique performs better when treating high VOC. The NTP equipment requires little space when compared to other control measures. Multiple NTP modules can be installed in parallel for higher gas volumes. There is a low pressure drop associated with the NTP, and it can be installed either on either the side of the air extraction fan.

### B6.6 Limitations

Temperature affects the performance of the plasma, with an operating range up to 70°C reported as optimal. Above 80 °C, the performance of the technique may drop significantly. Significant amounts of water condensing on the equipment may be problematic, as well as high particulate matter concentrations. Since high voltages are required to sustain the plasma, there are high operating costs from the power requirements.

### B6.7 References

European Commission. 2006. Integrated Pollution Prevention and Control Reference Document on Best Available Techniques in the Food, Drink and Milk Industries (EU BREF) Section 4.4.3.12 Non-Thermal Plasma Treatment.

Water Environment Research Foundation WERF. 2007. Minimization of Odours and Corrosion in Collection Systems, Section 8.10 - Cold Plasma & Photocatalytic Reactors.

## B.7 Ozonation

### B7.1 Technologies

* This technology is considered an emerging technique.

### B7.2 Emission Characteristics

* Odorous exhaust gases.

### B7.3 Air Emission Sources

* Reported installations to treat HVAC return air in smoking rooms.

### B7.4 Description

Ozone is injected to exhaust gas dust or stack in order to react with, and break down, odorous compounds.

### B7.5 Applicability and Performance

There is limited performance data available, and the economics of the processes are unknown at this time.

### B7.6 Limitations

Ozone is less reactive in the gas phase than in liquid phase. Applications of ozone use for water treatment are more common. Hot, humid airflows may not be suitable for ozone treatment systems. Insufficient VOC-ozone contact time may result in incomplete VOC reactions and emissions may still be odorous. Excess ozone may be harmful.

### B7.7 References

European Commission. 2006. Integrated Pollution Prevention and Control Reference Document on Best Available Techniques in the Food, Drink and Milk Industries (EU BREF) Section 4.4.3.8 Absorption.

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1. hL – hectolitre, a common measure in the industry. Equivalent to 100 litres [↑](#footnote-ref-1)