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Department of the Environment and Water Resources

National Pollutant Inventory

Emission estimation technique manual

for

Beer and ready-to-drink alcoholic beverage manufacturing
Version 1.2
March 2007

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Disclaimer

The manual was prepared in conjunction with Australian states and territories according to the National Environment Protection (National Pollutant Inventory) Measure.
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Modifications to the beer and ready-to-drink alcoholic beverage manufacturing emission estimation technique (EET) manual

Version 1.2 March 2007

Page	Outline of alteration
1	ANZSIC 2006 codes included.
1	Included comments regarding additional reporting materials for boilers, engines, fuel and organic liquid storage and fugitive emissions; provided a list of data required for reporting.
3-4	Updated figures in accordance with suggestions from industry.
5	Removed table of likely air emissions, as emissions mostly relate to boilers. Emissions of these substances will be addressed in the boiler manual.
7-12	Created a section relating to determining if ethanol or TVOCs require reporting. Rearranged emission estimation techniques section.
13	Updated references.
14	Updated Appendix A: terms and abbreviations.
15	Moved emission factors table to Appendix B.

Version 1.1 May 2005

Page	Outline of alteration
Throughout	Added reference to ready-to-drink beverage to highlight that the manual now also covers this product.
Page 1	Updated the introduction highlighting that the manual now includes details about determining emissions from ready-to-drink (RTD) beverage manufacturing.
Pages 2 and 3	Updated figures for this manual.
Table 2, page 9	Rearranged the table by providing emission factors in terms of kilograms, not grams. Also rounded emission factors to two significant figures. Highlighted that factors also apply for RTD beverages.
Example 2, page 10	Updated example to reflect altered emission factors and highlighted that determining ethanol emissions also determines the total volatile organic compounds (TVOCs) emissions.
Table 2 page 10 and reference list	Added the reference from Tony Oliver at Carlton and United Beverages.

EMISSION ESTIMATION TECHNIQUES
FOR
BEER AND READY-TO-DRINK ALCOHOLIC BEVERAGE MANUFACTURING

TABLE OF CONTENTS

BEER AND READY-TO-DRINK ALCOHOLIC BEVERAGE MANUFACTURING

LIST OF FIGURES, TABLES, EXAMPLES AND EQUATIONS

1 Introduction

The purpose of all emission estimation technique (EET) manuals is to assist Australian manufacturing, industrial and service facilities to report emissions of listed substances to the National Pollutant Inventory (NPI). This manual describes the procedures and recommended approaches for estimating emissions generated from beer and ready-to-drink (RTD) alcohol manufacture.

The manual covers beer and RTD alcohol manufacturing activities:

EET MANUAL		Beer and ready-to-drink alcoholic beverage manufacturing
ANZSIC CODE	1993	2182 and 2184 (2184 relates to ready-to-drink beverage manufacturing in this manual. See other NPI manuals for other types of facilities that relate to this code, e.g. wine and spirit manual)
	2006	1212 (beer manufacture) 1213 (spirit-based mixed drinks) 1214 (beverage n.e.c. alcoholic, manufacturing) 7320 (packaging services e.g. bottling or rebottling spirits)

Note that the ANZSIC code is part of NPI reporting requirements.

This manual has been developed through a process of national consultation involving state and territory environmental authorities and key industry stakeholders. Particular thanks are due to the Australian Associated Brewers Inc. (AAB), Fosters Group Ltd, J Boag and Son Brewing Ltd, and Coopers Brewery Ltd for their assistance in the development of this manual (Version 1.2).

1.1 Information required to produce an annual NPI report

The following data will need to be collated throughout the reporting period:

- annual beer and RTD beverage production (litres per year) *and*
- alcohol content of the beer and RTD beverages (% volume).

If a boiler or any on-site vehicles are used, the additional data will need to be collated:

- type and amount of fuel burned
- pollution control devices employed *and*
- volume and throughput of fuels or organic liquids stored on site.

1.2 Additional reporting materials

This manual is written to reflect the common processes employed in beer and ready-to-drink alcoholic beverage manufacturing. In many cases it will be necessary to refer to other EET manuals to ensure a complete report of the emissions for the facility can be made. Other applicable EET manuals may include, but are not limited to:

- combustion in boilers
- combustion in engines
- fuel and organic liquid storage
- fugitive emissions

2 Process description

The following section presents a brief description of the beer and ready-to-drink (RTD) alcoholic beverage manufacturing industry, and identifies the likely sources of emissions.

Beer is a beverage of low alcoholic content made by fermentation of malted, starchy cereal grains. Barley is the principal grain used. The production of malt beverages, or beer, comprises four main stages: brewhouse operations, fermentation, ageing or maturation, and packaging. Figures 1 and 2 illustrate the brewing processes and highlight likely emission points. RTD beverage manufacturing involves mixing spirits and soft drink and filling cans, bottles or kegs.

Figure 1: typical beer production facility
(adapted from USEPA AP-42 Section 9.12, 1996)

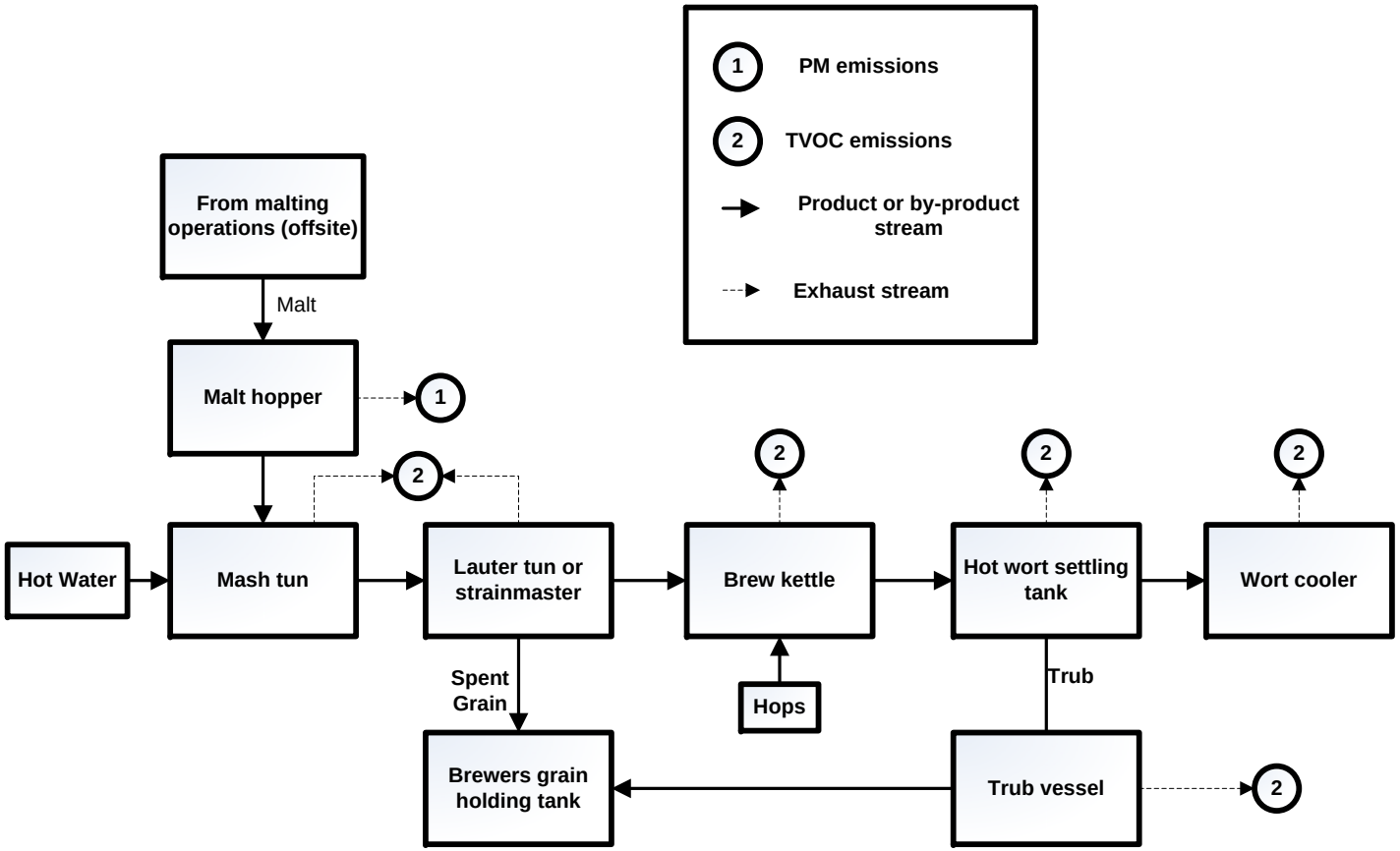
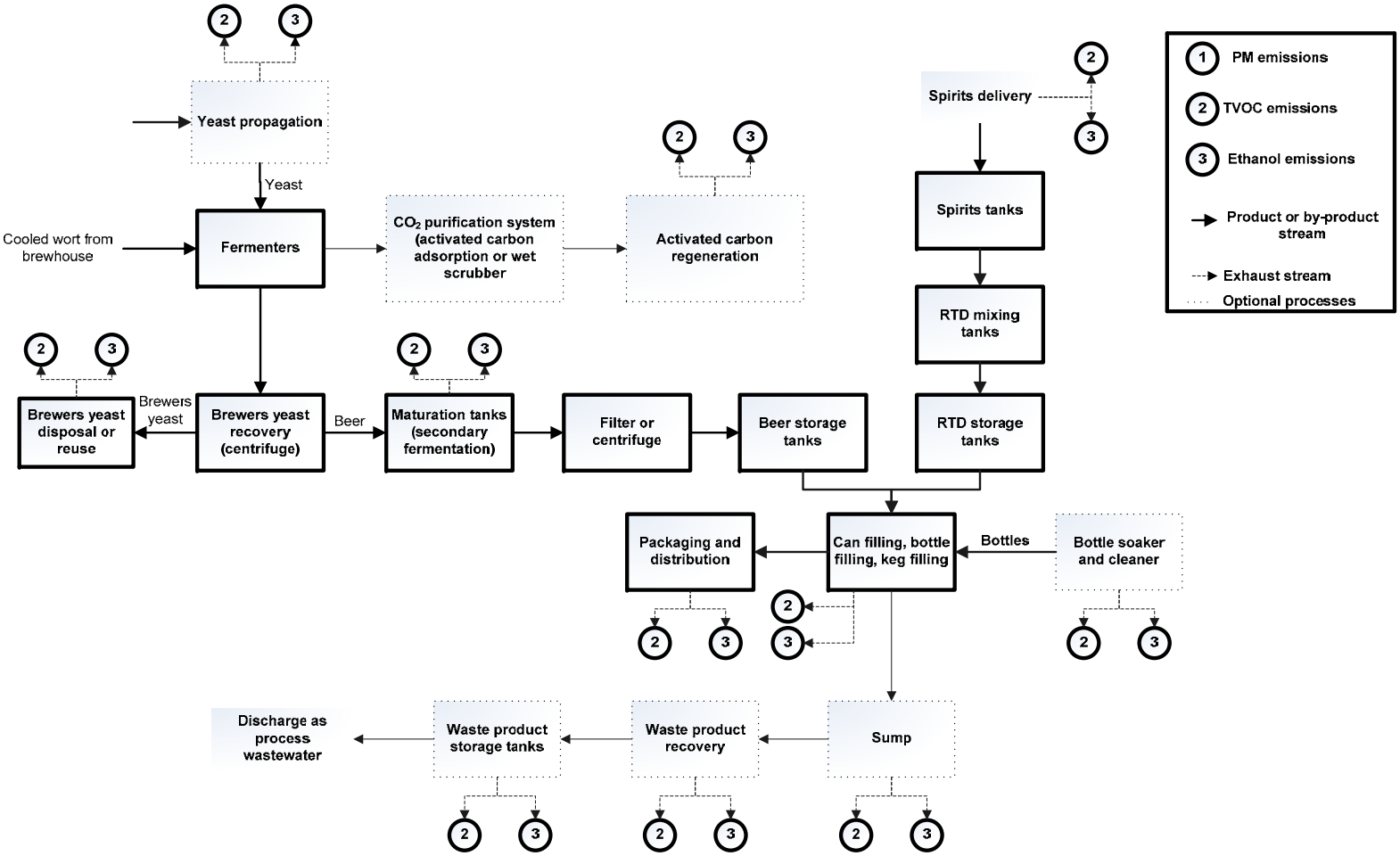


Figure 2: beer fermentation and beer and RTD filling operations
(adapted from USEPA AP-42 Section 9.12, 1996)



3 Emission Sources

3.1 Emissions to air

Air emissions may be categorised as fugitive emissions or point-source emissions.

3.1.1 Fugitive emissions

These are emissions not released through a vent or stack. Examples of fugitive emissions include dust from stockpiles, volatilisation of vapour from vats and open vessels, or spills and materials handling. Emissions emanating from ridgeline roof-vents, louvers, and open doors of a building as well as equipment leaks, such as from valves and flanges are also examples of fugitive emissions. Emission factor EETs are the usual method for determining losses through fugitive emissions.

3.1.2 Point source emissions

Point source emissions are those that are exhausted through a single point source into the atmosphere. Such emissions are usually exhausted from a vent or a stack.

Generally, post-fermentation processes emit ethanol. However, small quantities of other total volatile organic compounds (TVOCs), may also be emitted from fermenters and post-fermentation.

It is expected that in the preparation of beer and RTD alcohol beverage manufacturing, fuel may be combusted in a boiler. For determining emissions from burning fuel, refer to the NPI *Combustion in Boilers* manual.

Air emission control technologies- such as electrostatic precipitators, fabric filters or baghouses, and wet scrubbers- are commonly installed to reduce the concentration of particulates in processing off-gases before emission through a stack. The collection efficiency of the abatement equipment needs to be considered where such equipment has been installed, and where emission factors from uncontrolled sources have been used in emission estimations. Guidance on applying collection efficiencies to emission factor equations is provided in Section 5: Emission estimation techniques.

3.2 Emissions to water

Emissions of substances to water can be categorised as discharges to:

- surface waters (lakes, rivers, dams, estuaries)
- coastal or marine waters *and*
- stormwater runoff.

Emissions of toxic substances to waterways may pose environmental hazards. Most facilities emitting NPI-listed substances are required by their relevant state or territory environment agency to closely monitor and measure these emissions. These existing sampling data can be used to calculate annual emissions to the NPI.

If no wastewater monitoring data exists, emissions to process water can be calculated based on a mass balance or using emission factors.

3.3 Emissions to land

Emissions of substances to land include solid wastes, slurries, sediments, spills and leaks, and such emissions may contain NPI-listed substances. Emission sources can be categorised as:

- surface impoundments of liquids and slurries *and*
- unintentional leaks and spills.

Some breweries and bottling facilities may use treated wastewater for irrigation. This wastewater need only be considered for NPI reporting if it contains an NPI-listed substance. For NPI purposes this is categorised as an emission to land.

4 Determining if ethanol or TVOCs need to be reported to the NPI

"Usage" of NPI substances is a determinant of whether the NPI threshold has been tripped.

The usage of each of the substances listed as Category 1 and 1a under the NPI must be estimated to determine whether the 10 tonnes (or 25 tonnes for TVOCs) reporting threshold is exceeded. If the threshold is exceeded, emissions of these Category 1 and 1a substances must be reported for all operations, processes or activities relating to the facility, even if the actual emissions of the substances are very low or zero.

Usage is defined as the handling, manufacture, import, processing, coincidental production or other uses of the substances.

4.1 Ethanol

For the purposes of NPI reporting, a brewery or RTD beverage production facility is required to report ethanol and TVOC emissions arising from beverage manufacture where ethanol use exceeds 10 tonnes per year. Ethanol is a volatile organic compound (VOC). TVOCs emissions must also be reported if the TVOCs reporting threshold (25 tonnes) is exceeded. Note that ethanol is not the only source of TVOCs. Other sources may include fuel combustion and fuel and organic liquid storage. Consult *The NPI Guide* for more information about reporting thresholds.

The amount of ethanol used in beer and RTD beverage making equals the amount purchased plus the amount manufactured on site minus the amount leaving in bottles, cans or kegs. As quantities emitted are a small fraction of the total ethanol "used", a simple way of estimating ethanol "use" is to determine the quantity of ethanol in the beer or RTD beverage produced, using Equation 1.

Equation 1: determining usage of ethanol or TVOC in the reporting period

$$U_{ethanol} = P_{product} \times (AC \div 100) \times (0.79 \div 1000)$$

Where:

$U_{ethanol}$	=	usage of ethanol in reporting period, tonnes/year
$P_{product}$	=	annual beer or RTD beverage production, L/year
AC	=	alcohol (ethanol) content, % (v/v)
0.79	=	density of ethanol, kg/L
1000	=	conversion factor, kg to tonnes

If the facility produces different types of beverages with varying alcohol contents, the $U_{ethanol}$ for each type of beverage will have to be calculated. The annual ethanol "use" will be the total of all $U_{ethanol}$. If the total "use" exceeds 10 tonnes/year, the facility will need to report.

Example 1 demonstrates the application of Equation 1, to determine whether the use of ethanol needs to be reported to the NPI.

Example 1: determining ethanol "use" to see if ethanol needs to be reported to the NPI.

A facility operator needs to report ethanol to the NPI if the facility exceeds the NPI reporting threshold for ethanol. The ethanol threshold is 10 tonnes.

A brewery produces 1 million litres of beer per year with an alcohol content of 7% by volume.

$P_{Product}$ = 1 000 000 L/year
AC = 7% by volume

Using Equation 1

$U_{ethanol} = P_{Product} \times (AC \div 100) \times (0.79 \div 1000)$
$= 1\,000\,000 \times (7 \div 100) \times (0.79 \div 1000)$
= 55.3 tonnes/year of ethanol emitted.

As this is greater than 10 tonnes, the facility exceeds the ethanol usage threshold and is required to report the estimated emissions of ethanol to the NPI. Note that in this example, the TVOCs threshold (25 tonnes/year) is also exceeded, and emissions of TVOCs must also be reported.

4.2 Total volatile organic compounds (TVOCs)

If the TVOCs threshold (25 tonnes/year) is tripped, then facilities must report the emission of TVOCs for the entire site. Ethanol and nearly forty other NPI substances are volatile organic compounds (VOCs). This is further described in the NPI's *Fuel and Organic Liquid Storage* manual. If TVOCs need to be reported, the amount reported will be at least as large as the emissions of ethanol.

Other sources of TVOC emissions that need to be considered in emissions estimation include fuel combustion and fuel storage tanks. The *NPI Guide* provides more information about NPI reporting and determining which substances need to be reported.

5 Emission estimation techniques (EETs)

The emissions to air, land and water for every NPI substance that trips a threshold must be reported from all point and fugitive sources on the facility. The reporting list and detailed information on thresholds are contained in *The NPI Guide*.

There are five types of emission estimation techniques (EETs) that may be used to calculate emissions from your facility. These are:

- sampling data or direct measurement
- mass balance
- fuel analysis or engineering calculations
- emission factors *and*
- an approved alternative.

Select the EET (or mix of EETs) that is most appropriate for your purposes. For example, you might choose a mass balance to estimate fugitive losses from pumps and vents, direct measurement for stack and pipe emissions, and emission factors when estimating losses from storage tanks and stockpiles.

Generally, the beer and RTD alcoholic beverage manufacture industry report emissions for ethanol and TVOCs using the emission factor method.

If you estimate your emission by using any of these EETs, your data will be displayed on the NPI database as being of "acceptable reliability". Similarly, if your relevant environmental authority has approved the use of EETs that are not outlined in this handbook, your data will also be displayed as being of acceptable reliability.

This manual seeks to provide the most effective emission estimation techiniques for the NPI substances relevant to the beer and RTD alcoholic beverage manufacture industry. The absence of an EET for a substance in this manual does not necessarily imply that an emission should not be reported to the NPI. The obligation to report on all relevant emissions remains if reporting thresholds have been exceeded.

You are able to use emission estimation techniques that are not outlined in this document. You must, however, seek the consent of your state or territory environmental agency. For example, if your company has developed site-specific emission factors, you may use these if approved by your environmental agency.

You should note that the EETs presented in this manual relate principally to average process emissions. Emissions resulting from non-routine events are rarely discussed in the literature, and there is a general lack of EETs for such events. However, it is important to recognise that emissions resulting from significant operating excursions and/or accidental situations (e.g. spills) will also need to be estimated. Emissions to land, air and water from spills must be estimated and added to process emissions when calculating total emissions for reporting purposes. The emission resulting from a spill is the net emission, i.e. the quantity of the NPI reportable substance spilled, less the quantity recovered or consumed during clean up operations.

5.1 Emission factors

An emission factor is a tool that is used to estimate emissions to the environment. In this manual, it relates to the quantity of substances emitted from a source to some common activity associated with those emissions. Emission factors are usually expressed as the weight of a substance emitted multiplied by the unit weight, volume, distance or duration of the activity emitting the substance (e.g. kilograms of ethanol per kilolitre (1000 litres) of beer or RTD beverage produced).

The emission factors relevant to beer and RTD beverage manufacturing are tabulated in Appendix B. You must ensure that you estimate emissions for all substances relevant to your process.

The general equation of emission factors used to estimate a facility's emissions is shown below:

Equation 2: calculating emissions using emission factors

$$E_{kpy,i} = (A \times OpHrs) \times EF_i \times [1 - (CE_i \div 100)]$$

Where:

$E_{kpy,i}$	=	emission rate of pollutant i, kg/yr
A	=	activity rate, t/hr
OpHrs	=	operating hours, hr/yr
EF_i	=	uncontrolled emission factor for pollutant i, kg/kL
CE_i	=	overall control efficiency of pollutant i, %

When using emission factors, you should be aware of the associated emission factor rating (EFR) code and what the rating implies. An A or B rating indicates a greater degree of certainty than a D or E rating. Some emission factors are rated U, in that the reliability of the emission factor is unrated. The main criterion affecting the uncertainty of an emission factor remains the degree of similarity between the process selected in applying the factor and the target process from which the factor was derived.

The EFR system is:

A	Excellent
B	Above average
C	Average
D	Below average
E	Poor
U	Unrated

Example 2: using emission factors to determine emissions of ethanol
For the bottle filling line, 0.066 kg of ethanol is emitted for every 1000 litres of beer bottled (Appendix B). It is assumed that the brewery bottles 200 ML of beer per year.

Emission reduction efficiency for ethanol is effectively zero, with all ethanol produced emitted to air, therefore $CE_{ethanol} = 0$.

Emissions of ethanol and TVOCs can be estimated from Equation 2.

For ethanol:

$EF_{ethanol}$	=	0.066 kg/kL	
Beer bottled (A)	=	200 ML/year =	200 000 kL/year

$E_{ethanol}$	=	$A \times EF_{ethanol} \times [1 – (CE_{ethanol} \div 100)$
	=	200 ML/year × 0.066 kg/kL × [1 – 0]
	=	200 000 kL × 0.066 kg/kL
	=	13 200 kg/year of ethanol emitted
	=	13.2 tonnes/year of ethanol emitted.

Determining TVOCs for bottle filling is the same as above. The emission factors for ethanol and TVOCs are the same because ethanol makes up nearly all the TVOCs from beer and RTD beverage production.

This example is from only one part of the beer and RTD manufacture process. You should ensure that you report for all parts of the process (e.g. if a boiler is used, or for on-site vehicles).

5.2 Sampling data or direct measurement

You may wish to use direct measurement in order to report to the NPI, particularly if you already do so in order to meet other regulatory requirements. If this is the case, additional sampling and measurement is not required for NPI reporting purposes.

5.3 Mass balance

A mass balance identifies the quantity of the substance going in and out of an entire facility, process or piece of equipment. Emissions can be calculated as the difference between input and output of each listed substance. Accumulation or depletion of the substance within the equipment should be accounted for in your calculation.

5.4 Engineering calculations

An engineering calculation is an estimation method based on physical/chemical properties (e.g. vapour pressure) of the substance, and mathematical relationship (e.g. ideal gas law).

5.5 Continuous Emission Monitoring System (CEMS) data

A continuous emission monitoring system provides a continuous record of emissions over time, usually by reporting pollutant concentration.

Once the pollutant concentration is known, emission rates are obtained by multiplying the pollutant concentration by the volumetric gas or liquid flow rate of that pollutant.

It is important to note that prior to using CEMS to estimate emissions, you should develop a protocol for collecting and averaging the data in order that the estimate satisfies your relevant environmental authority's requirement for NPI emissions estimations.

5.6 Predictive Emission Monitoring (PEM)

Predictive emission monitoring is based on developing a correlation between pollutant emission rates and process parameters. A PEM allows facilities to develop site-specific emission factors, or emission factors more relevant to their particular process.

Based on test data, a mathematical correlation can be developed which predicts emissions using various parameters.

5.7 Approved alternative estimation methods

An alternative emission estimation technique may be used if it has first been approved in writing by a NPI representative in the state or territory in which the facility is based.

Contact details for state and territory NPI representatives can be found on the NPI website.

6 References

Memo from Carlton and United Beverages Group, 2005.

National Pollutant Inventory, 2005. *Emission Estimation Techniques Manual for Beer and Ready to Drink Alcoholic Beverage Manufacturing (Version 1.1).* Australian Government Department of the Environment and Heritage. Canberra, Australia.

USEPA. October 1996. *Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area sources, Fifth Edition. Emission Factor Documentation for AP-42. Section 9.12.1. Malt Beverages. Final Report.* U. S. Environmental Protection Agency. Office of Air Quality Planning and Standards. Research Triangle Park, NC, USA.

Verbal communications with representatives of Coopers Brewery Ltd, Fosters Group Ltd, J. Boag and Son Brewing Ltd. and Australian Associated Brewers, 20 December 2006.

Appendix A: Terms and abbreviations

Term	Definition
% (v/v)	Percentage volume of one component in a solution
ANZSIC	Australian and New Zealand Standard Industrial Classification
kg/kL	Kilograms per kilolitre
kg/L	Kilograms per litre
kL	Kilolitres (1000 Litres)
CEMS	Continuous Emission Monitoring System
EET	Emission Estimation Technique
EFR	Emission Factor Rating
L	Litres
ML	Megalitres (1 000 000 L)
NPI	National Pollutant Inventory
PEM	Predictive Emission Monitoring
RTD	Ready-to-drink
TVOCs	Total Volatile Organic Compounds
Usage	Handling, manufacture, import, processing, coincidental production or other uses of the substances.
VOC	Volatile Organic Compound

Appendix B: Emission factors for ethanol and TVOCs emissions from beer and RTD beverage manufacturing

Process emission source	Ethanol (kg/kL product packaged, unless otherwise specified)	TVOCs (kg/kL product packaged, unless otherwise specified)	Rating[3]
Bottle filling[1]			
Bottle filling line (sterilised and unsterilised)	0.066	0.066	U
Bottle soaker and cleaner (currently not used in Australia)	0.091 kg/1000 cases (of bottles washed))	0.091 kg/1000 cases (of bottles washed))	U
Can filling[1,2]			
Can crusher with pneumatic conveyer	10 kg/kL product recovered	10 kg/kL product recovered	U
Can filling line (sterilised and unsterilised)	0.054	0.054	U
Fermenter venting (closed fermenter)	0.0077	0.0077	U
Keg filling[1]			
Keg filling line	0.0027	0.0027	U
Cellaring[1]			
Cellaring	0.0022	0.0022	U
Ready-to-drink (RTD) beverages – mixing technique[2]			
Filling alcohol storage tanks	0.052 kg/kL ethanol received	0.052 kg/kL ethanol received	U
Make-up area	0.036 kg/kL ethanol used	0.036 kg/kL ethanol used	U
Filling (sterilised and unsterilised)	0.066	0.066	U
Ready-to-drink (RTD) beverages – cider fermentation technique[2]			
Fermentation	0.013	0.013	U
Cross blend tanks (storage)	0.0012	0.0012	U
Dilution tank	0.0007	0.0007	U
Filling	0.004	0.004	U

Notes:

1. Reference: USEPA AP-42 Section 9.12.1, 1996
2. Reference: Memo form Carlton and United Beverages Group, 2005
3. Details on the emission factor rating (EFR) can be found in this manual at Section 5.1.

The basis is ethanol in the solution. For example, if the solution was 65% (v/v) ethanol, the factor in terms off the solution would be 0.65 × the EF provided.